

5 cooling fluid from flowing into the tank of the cooling bath containing the cooling fluid.

10 Reference to any prior art in the specification is not an acknowledgement or suggestion that this prior art forms part of the common general knowledge in any jurisdiction or that this prior art could reasonably be expected to be combined with any other piece of prior art by a skilled person in the art.

15 By way of clarification and for avoidance of doubt, as used herein and except where the context requires otherwise, the term "comprise" and variations of the term, such as "comprising", "comprises" and "comprised", are not intended to exclude further additions, components, integers or steps.

Description of the invention

20 ~~The objective of the present invention is to~~At least preferred embodiments of the present disclosure may provide a cooling system for computing devices that resolves address one or more of the cited drawbacks and ~~may provides~~ one or more of the advantages described below.

25 According to an aspect of the invention, there is provided a cooling system for immersed computing devices, comprising:

30 - a cooling bath tank that contains a cooling fluid that flows through the inside thereof from at least one outlet to at least one inlet, in which said cooling bath tank is designed and arranged to enable at least a first portion of at least one computing device to be cooled to be inserted therein, said computing device being at least partially immersed in the cooling fluid contained therein, and

35 - at least one cooling unit designed to collect and cool the cooling fluid flowing out of said at least one inlet and to return the cooling fluid, once cooled, through said at least one outlet into said cooling bath tank, the at least one cooling unit designed to be inserted into said cooling bath tank, to be at least partially immersed in the cooling fluid contained therein, and to be removed therefrom, and including a casing with projections designed and arranged to be supported at least by supports projecting inwards from internal walls of the cooling bath tank when the at least one cooling unit is inserted into the cooling bath tank, the casing having a first compartment fluidly connected with the at least one outlet and a second

compartment housing a heat exchanger that are fluidly isolated from one another, said first compartment having an inlet to enable the cooling fluid coming out of the at least one outlet in the cooling bath tank to enter said first compartment,

wherein said first compartment has a first sub-compartment and a second sub-compartment fluidly connected with the at least one outlet, in which said first sub-compartment at least partially houses a fluid pump comprising a suction inlet therein that is immersed in the cooling fluid that has entered through said inlet of the first compartment and that is designed and arranged to pump said cooling fluid to the inlet of the first circuit of the heat exchanger that is housed in said second compartment and designed to cool the fluid flowing through said first circuit by means of a refrigerant fluid that is flowing through a second circuit of the heat exchanger, enabling the cooled down cooling fluid flowing through said first circuit of said heat exchanger to flow to the second sub-compartment through cooling-fluid outlet arranged therein.

~~To achieve this objective and according to a first aspect, the present invention provides~~There is also disclosed a cooling system for immersed computing devices comprising:

- a cooling bath tank that contains a cooling fluid that flows through the inside thereof from at least one outlet to at least one inlet, in which the cooling bath tank is designed and arranged to enable at least a first portion of a computing device to be cooled to be inserted therein, said computing device being at least partially immersed in the cooling fluid contained therein, and
- at least one cooling unit designed to collect and cool the cooling fluid flowing out of the at least one inlet and to return the cooling fluid, once cooled, through the at least one outlet into the cooling bath tank,

~~The cooling system according to the present invention is characterized in that~~wherein the at least one cooling unit is designed to be inserted into the cooling bath tank, being at least partially immersed in the cooling fluid contained therein, and to be removed therefrom.

According to embodiments~~the present invention~~, the user of the cooling system can insert and/or remove the cooling unit from the cooling bath tank to perform maintenance work on the components of said unit without having to drain the cooling fluid from the cooling bath tank. Furthermore, during maintenance of the faulty cooling unit, the user can easily replace this cooling unit with another to enable the cooling bath tank to continue operating.

According to one embodiment, the cooling unit includes a casing with projections designed and arranged to be supported at least by supports projecting inwards from internal walls of the cooling bath tank when the cooling unit is inserted in the cooling bath tank.

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The projections from the casing of the cooling unit are therefore positioned above the supports of the internal walls of the cooling bath tank, which may enable ~~ing~~ easy insertion and/or removal of the cooling unit from inside the cooling bath tank. Furthermore, the projections and supports may enable the cooling unit to be supported simply and easily.

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According to embodiments, ~~The~~ casing is substantially symmetrical about a transverse axis and fits the perimeter of the internal section of the cooling bath tank. ~~Advantageously~~ According to embodiments, this casing has two substantially symmetrical projections arranged on opposite sides of the casing above the supports of two opposite walls of the cooling bath tank.

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Preferably, the supports are supports extending longitudinally along said internal walls of the bath tank.

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Since the supports extend longitudinally along the internal walls of the cooling bath tank, the cooling unit can be placed in any position along the inside of the cooling bath tank, depending on the requirements of the user. For example, when the cooling bath tank is being transported, the cooling unit can be positioned in a central portion of the tank so that the center of gravity of the assembly can be in said central portion.

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~~Advantageously~~ According to embodiments, the supports of the internal walls of the cooling bath tank project outwards.

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According to an alternative embodiment, the supports are also used to support projections from a computing device to be cooled that is designed to be inserted into the cooling bath tank, and removed therefrom.

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According to one embodiment, the casing has a first compartment and a second compartment that are fluidly isolated from one another, in which the first compartment has an inlet to enable the cooling fluid coming out of the at least one outlet in the cooling bath tank to enter said first compartment.

The first compartment of the casing is therefore designed to receive the cooling fluid once the temperature of said fluid has increased after cooling the computing devices.

Furthermore, this first compartment conveys the cooling fluid, once the temperature thereof has dropped, to the cooling bath tank to cool the computing devices. Thus, the cooling fluid remains inside the cooling bath tank, maintaining a constant volume therein.

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According to one embodiment, the cooling fluid enters the cooling bath tank through the lower portion of said tank, via a distribution wall arranged parallel to the base of said cooling bath tank. This creates a distribution volume in which the cooling fluid accumulates. The cooling fluid enters said tank through orifices in the distribution wall and is conveyed towards the computing devices. This distribution wall has at least one mechanism connected operationally to a drain valve of the cooling unit, enabling the cooled cooling fluid to enter said distribution volume.

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Preferably, the first compartment houses a fluid pump that is immersed in the cooling fluid that has entered through the inlet of the first compartment and that is designed and arranged to pump said cooling fluid to an inlet of the first circuit of a heat exchanger that is housed in said second compartment and designed to cool the cooling fluid flowing through the first circuit.

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The fluid pump then pumps the cooling fluid in the first compartment to a first circuit of a heat exchanger to be cooled by a refrigerant fluid flowing through a second circuit of the heat exchanger.

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Optionally, the first compartment can house more than one fluid pump designed to be activated in the event of failure of one of the fluid pumps. This may enables the cooling system to continue working if one of the fluid pumps fails.

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Preferably, the motor of the fluid pump immersed in the cooling fluid is positioned in a lower portion of the first compartment of the casing.

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Also preferably, the refrigerant fluid flowing through the second circuit of the heat exchanger is water at a temperature below the temperature of the cooling fluid. Another type of fluid having the same physical characteristics and enabling the cooling fluid to be cooled could nonetheless be used in the present invention.

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According to one embodiment, the first compartment has a first sub-compartment and a second sub-compartment, in which the first sub-compartment has the inlet to enable entry of the cooling fluid therein, and in which the first circuit of the heat

exchanger has at least one cooling-fluid outlet arranged in the second sub-compartment.

This may enables the cooling fluid coming from the heat exchanger to flow through a second sub-compartment, preferably located in the lower portion of the casing of the cooling unit, before flowing out of the outlet to the cooling bath tank.

Preferably, the first and second sub-compartments communicate with one another via a through-hole that is designed and arranged to enable a portion of the fluid pump to pass from the first sub-compartment into the second sub-compartment, such that the portion of the fluid pump is housed in the second sub-compartment.

This means that the first and second sub-compartments are in communication, enabling passage of a fluid pump so that a portion of said pump is housed in the first sub-compartment and another portion is housed in the second sub-compartment.

~~Advantageously~~ According to an embodiment, the through-hole has a moveable part arranged to move between:

_____ - an operating position in which said part supports the portion of the fluid pump that has passed through the through-hole, and in which said moveable part is positioned inside the second sub-compartment together with a lower portion of the fluid pump, and

_____ - a blocking position in which said part covers the through-hole, which is adaptable when not bearing the fluid pump.

The moveable part may therefore enables a portion of the fluid pump to pass into the second sub-compartment to be cooled. When said fluid pump is removed, for example for maintenance, the moveable part is moved to prevent the fluid in the second sub-compartment from flowing into the first sub-compartment, or vice versa, through the through-hole.

~~Also advantageously~~, the through-hole ~~has~~ may have a gasket about the inner perimeter thereof that may prevents the cooling fluid from flowing between the first sub-compartment and the second sub-compartment when in contact with the moveable part when said part is in a blocking position, or when in contact with the outer perimeter of the fluid pump when the moveable part is in an operating position.

The gasket may thus prevent the cooling fluid from flowing from the second sub-compartment to the first sub-compartment, or vice versa, since this gasket remains in contact with the moveable part when said moveable part is in a blocking position. Furthermore, when the moveable part is in an operating position, the outer perimeter of the gasket is in contact with the outer perimeter of the fluid pump which may ~~to~~ prevent the fluid flowing from the second sub-compartment to the first sub-compartment, or vice versa.

Preferably, the second sub-compartment may include a deflector arranged to guide the cooling fluid entering from the outlet towards the portion of the fluid pump arranged inside the second sub-compartment, such that the cooling fluid comes into thermal contact with the outside of the portion of the fluid pump to cool same.

The deflector may thus enable the cooling fluid coming from the outlet to cool the portion of the fluid pump arranged in the second sub-compartment to be directed.

~~Advantageously~~ According to an embodiment, the fluid pump includes an upper portion of the fluid pump that is housed in the first sub-compartment and that includes a suction inlet for the cooling fluid in the first sub-compartment, and a lower portion of the fluid pump to be cooled that is housed in the second sub-compartment. The cooling fluid coming from the heat exchanger then cools the lower portion of the fluid pump in the first sub-compartment, before flowing out of the outlet to the cooling bath tank.

According to one embodiment, the lower portion of the fluid pump includes a motor that is located in the second sub-compartment to be cooled by the cooling fluid therein.

Preferably, the inlet of the first compartment is positioned in an upper region of the casing, which is positioned such that the cooling fluid overflows into said inlet once the cooling unit has been inserted into the cooling bath tank.

Thus, when the cooling system is in use, the cooling fluid coming from the cooling bath tank enters the cooling unit through an inlet positioned in an upper region of the casing. The cooling fluid overflows an overflow wall arranged inside the cooling bath tank to reach this location and the inlet of the cooling unit.

According to one embodiment, the cooling bath tank has a first sub-tank and a second sub-tank that are fluidically isolated from one another, in which said first

sub-tank is arranged inside said second sub-tank and designed to receive at least said at least one cooling unit, and at least said first portion of at least said computing device.

- 5 Preferably, the first sub-tank is joined to the second sub-tank and has an external volume that is less than the internal volume of the second sub-tank, thereby forming a separation volume between the first sub-tank and the second sub-tank.

10 The cooling bath tank is thus divided into two sub-tanks, with a separation volume between the two sub-tanks. The first sub-tank contains the cooling fluid in which the computing devices and the cooling unit are immersed. The second sub-tank acts as external casing for the cooling bath tank. The separation volume between the two sub-tanks is fluidically isolated from the first sub-tank, thereby acting as a heat insulator for the cooling fluid inside the first cooling bath sub-tank.

15 Optionally, the separation volume between sub-tanks contains a thermal insulator, for example rock wool or glass wool, to reduce transmission of the heat accumulated by the cooling fluid in the first sub-tank to the outside of the cooling bath tank.

20 According to one embodiment, the separation volume is in fluid communication with a leak aperture of the second compartment of the casing to drain thereto any fluid leaks, thereby preventing such fluid leaks from entering the first sub-tank.

The leak aperture may therefore ensure that the fluid leak flows into the first sub-tank, thereby potentially preventing the fluid leak from coming into contact with the
25 computing devices and causing damage. Furthermore, the cooling fluid is not diluted by the fluid leak, which could cause the cooling system to malfunction. Alternatively, the fluid leak is drained to the outside of the cooling bath tank through a leak aperture that communicates with the outside of same.

30 The fluid leak can be refrigerant fluid from the second circuit of the heat exchanger. Preferably, the refrigerant fluid is water at a temperature below the temperature of the cooling fluid. Another type of fluid having the same physical characteristics and enabling the cooling fluid to be cooled could nonetheless be used in the present invention.

35 According to one embodiment, the cooling system has conveyance means designed and arranged to move at least one computing device or one cooling unit from an immersed position to a maintenance position, and vice versa.

The cooling system may therefore ~~have~~ conveyance means to help the user to insert and remove the computing devices or the cooling units from inside the cooling bath tank, for example for maintenance or replacement.

5 Preferably, the cooling bath tank includes conveyance guides arranged longitudinally on at least one outside face of at least one perimeter wall of said tank, and in which the conveyance means include a moveable conveyor coupled in a guided manner to the conveyance guides to enable longitudinal movement in both senses along said guides, to the position of the computing device or the cooling unit
10 to be moved.

These conveyance guides may enable the moveable conveyor to be positioned above a computing device or a conveyance unit to move same. Furthermore, the conveyance guides may enable the moveable conveyor to be moved in both senses
15 in a longitudinal direction to move the computing device or the cooling unit when same is in a maintenance position.

According to one embodiment, the conveyance guides are arranged on opposite walls of the cooling bath tank such that, depending on the desired position of the cooling system, the moveable conveyor can be coupled in a guided manner to the
20 most suitable wall of the tank for the user.

Optionally, the conveyance guides are arranged such that, when a plurality of cooling systems are arranged in a line, these conveyance guides are operationally
25 connected to the conveyance guides of the adjacent cooling systems, such that a single moveable conveyor can be used for a plurality of cooling systems arranged in a line.

According to one embodiment, the cooling bath tank has conveyance guides on at least two mutually perpendicular faces of said tank, such that said moveable conveyor can move along both conveyance guides by performing a 90° turn.
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Preferably, the moveable conveyor includes lifting/lowering means designed to be joined removably to the computing device or the cooling unit to be moved, and to
35 move same upwards or downwards in a direction Z orthogonal to said longitudinal direction to convey same from the immersed position to said maintenance position, and vice versa. Advantageously, the lifting/lowering means include a cable that is removably connectable to the computing device or the cooling unit to be moved, and that is connected operationally to said drive means to perform said lifting or lowering

movement thereof. Alternatively, these lifting means include a rigid element for actively moving the computing device or the cooling unit to be moved to perform said upwards or downwards movement thereof.

5 This may enables the moveable conveyor to move the computing device or the cooling unit from an immersed position to a maintenance position, and vice versa, easily and simply for the user.

10 Optionally, the lifting/lowering means are designed to be joined removably to joining elements arranged on the computing device or the cooling unit to be moved, and to move same upwards or downwards.

According to one embodiment, the lifting/lowering means include retaining elements designed to removably join the computing devices to the cooling bath tank.
15 Preferably, the retaining elements are designed so that, when the lifting/lowering means are joined to said joining elements, the retaining elements are in a position in which the computing device is uncoupled from a portion of the cooling bath tank. Nonetheless, when the lifting/lowering means are not joined to said joining element, the retaining elements are in a position in which the computing device is coupled to
20 a portion of the cooling bath tank.

The lifting/lowering means may thus enable easy insertion and removal of the computing devices and, in turn, may ensure that the computing devices cannot move freely inside the cooling bath tank when the cooling bath tank is being moved.
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Short description of figures

The attached schematic drawings show a practical embodiment and are provided by
30 way of non-limiting example to aid comprehension of the foregoing.

Figure 1 is a perspective view of an embodiment of the cooling system.

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CLAIMS

1. A cooling system ~~(1)~~ for immersed computing devices, comprising:

5 _____ - a cooling bath tank ~~(3)~~ that contains a cooling fluid that flows through ~~the~~
an inside thereof from at least one outlet ~~(18)~~ to at least one inlet ~~(19)~~, in which said
cooling bath tank ~~(3)~~ is designed and arranged to enable at least a first portion of at
least one computing device ~~(6)~~ to be cooled to be inserted therein, said computing
device being at least partially immersed in the cooling fluid contained therein, and

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_____ - at least one cooling unit ~~(5)~~ designed to collect and cool the cooling fluid
flowing out of said at least one inlet ~~(19)~~ and to return the cooling fluid, once cooled,
through said at least one outlet ~~(18)~~ into said cooling bath tank ~~(3)~~, the at least one
15 cooling unit designed to be inserted into said cooling bath tank, to be at least partially
immersed in the cooling fluid contained therein, and to be removed therefrom, and
including a casing with projections designed and arranged to be supported at least
by supports projecting inwards from internal walls of the cooling bath tank when the
cooling unit is inserted into the cooling bath tank, the casing having a first
20 compartment fluidly connected with the at least one outlet and a second
compartment housing a heat exchanger that are fluidly isolated from one another,
said first compartment having an inlet to enable the cooling fluid coming out of the
at least one outlet in the cooling bath tank to enter said first compartment

_____ wherein said first compartment has a first sub-compartment and a second
25 sub-compartment fluidly connected with the at least one outlet, in which said first
sub-compartment at least partially houses a fluid pump comprising a suction inlet
therein that is immersed in the cooling fluid that has entered through said inlet of the
first compartment and that is designed and arranged to pump said cooling fluid to
the inlet of the first circuit of the heat exchanger that is housed in said second
30 compartment and designed to cool the fluid flowing through said first circuit by
means of a refrigerant fluid that is flowing through a second circuit of the heat
exchanger, enabling the cooled down cooling fluid flowing through said first circuit
of said heat exchanger to flow to the second sub-compartment through cooling-fluid
outlet arranged therein.

35 characterized in that said at least one cooling unit (5) is designed to be inserted into
said cooling bath tank (3), to be at least partially immersed in the cooling fluid
contained therein, and to be removed therefrom.

2. The system (1) as claimed in claim 1, in which the at least one cooling unit (5) includes a casing (7) with projections (21) designed and arranged to be supported at least by supports (20) projecting inwards from internal walls of the cooling bath tank (3) when the cooling unit (5) is inserted into the cooling bath tank (3).

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3. The system (1) as claimed in claim 2, in which said supports (20) are supports that extend longitudinally along said internal walls of the cooling bath tank (3).

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4. The system (1) as claimed in claim 2 or 3, in which said casing (7) has a first compartment (7a) and a second compartment (7b) that are fluidly isolated from one another, in which said first compartment (7a) has an inlet (19) to enable the cooling fluid coming out of the at least one outlet (18) in the cooling bath tank (3) to enter said first compartment (7a).

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5. The system (1) as claimed in claim 4, in which said first compartment (7a) houses a fluid pump (11) that is immersed in the cooling fluid that has entered through said inlet (19) of the first compartment (7a) and that is designed and arranged to pump said cooling fluid to the inlet of the first circuit of a heat exchanger (24) that is housed in said second compartment (7b) and designed to cool the fluid flowing through said first circuit.

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6. The system (1) as claimed in claim 5, in which said first compartment (7a) has a first sub-compartment (7a1) and a second sub-compartment (7a2), in which said first sub-compartment (7a1) has said inlet (19) to enable the cooling fluid to enter said first sub-compartment, and in which said first circuit of said heat exchanger (24) has a cooling fluid outlet (40) arranged in the second sub-compartment (7a2).

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27. The system (1) as claimed in claim 16, in which said first sub-compartment (7a1) and second sub-compartment (7a2) communicate with one another via a through-hole (29) that is designed and arranged to enable a portion of the fluid pump (11) to pass from the first sub-compartment (7a1) into the second sub-compartment (7a2), such that the portion of the fluid pump (11) is housed in the second sub-compartment (7a2).

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38. The system (1) as claimed in claim 27, in which said through-hole (29) has a moveable part (28) arranged to move between:

- an operating position in which said part supports the portion of the fluid pump (11) that has passed through the through-hole (29), and in which said moveable part (28) is positioned inside the second sub-compartment (7a2) together with a lower portion of the fluid pump (11), and

_____ - a blocking position in which said part covers the through-hole (29), which is adaptable when not supporting the fluid pump (11).

49. The system (1) as claimed in claim 38, in which said through-hole (29) has a gasket about the inner perimeter thereof that prevents the cooling fluid from flowing between the first sub-compartment (7a1) and the second sub-compartment (7a2) when in contact with the moveable part (28) when said part is in a blocking position, or when in contact with the outer perimeter of the fluid pump (11) when the moveable part (28) is in an operating position.

510. The system (1) as claimed in any one of claims 27 to 49, in which the second sub-compartment (7a2) includes a deflector (31) arranged to guide the cooling fluid entering from the outlet (40) towards the portion of the fluid pump (11) arranged inside the second sub-compartment (7a2), such that the cooling fluid comes into thermal contact with the outside of said portion of the fluid pump (11) to cool same.

611. The system (1) as claimed in any of claims 27 to 510, in which said fluid pump (11) includes an upper portion of the fluid pump (11) that is housed in the first sub-compartment (7a1) and that includes a suction inlet for the cooling fluid housing said first sub-compartment (7a1), and a lower portion of the fluid pump (11) to be cooled that is housed in the second sub-compartment (7a2).

712. The system (1) as claimed in any one of claims 4 to 11 preceding claim, in which said inlet (19) of the first compartment (7a) is positioned in an upper region of the casing (7), which is positioned such that the cooling fluid overflows into said inlet (19) once the cooling unit (5) has been inserted into the cooling bath tank (3).

813. The system (1) as claimed in any of the preceding claims, in which said cooling bath tank (3) has a first sub-tank (3a) and a second sub-tank (3b) that are fluidically isolated from one another, in which said first sub-tank (3a) is arranged inside said second sub-tank (3b), has an external volume that is less than the internal volume of the second sub-tank such as to create a separation volume between said first and second sub-tank in fluid communication with a leak aperture of said second compartment of said casing to drain thereto any fluid leaks, thereby preventing such

fluid leaks from entering the first sub-tank, and designed to receive at least said at least one cooling unit ~~(5)~~, and at least said first portion of at least said computing device ~~(6)~~.

5 ~~14. The system (1) as claimed in claim 13, in which said first sub-tank (3a) is joined to said second sub-tank (3b) and has an external volume that is less than the internal volume of the second tank (3b) such as to create a separation volume (14) between said first sub-tank (3a) and said second sub-tank (3b).~~

10 ~~15. The system (1) as claimed in claim 14, in which said separation volume (14) is in fluid communication with a leak aperture of said second compartment (7b) of said casing (7) to drain thereto any fluid leaks, thereby preventing such fluid leaks from entering the first sub-tank (3a).~~

15 ~~16. The system (1) as claimed in claim 1, including conveyance means designed and arranged to move at least said at least one computing device (6) from an immersed position to a maintenance position, and vice versa.~~

20 ~~17. The system (1) as claimed in claim 16, in which said conveyance means are designed and arranged to move the at least one cooling unit (5) from an immersed position to a maintenance position, and vice versa.~~

25 ~~18. The system (1) as claimed in claim 16 or 17, in which said cooling bath tank (3) includes conveyance guides (13) arranged longitudinally on at least one outside face of at least one perimeter wall of said tank, and in which said conveyance means include a moveable conveyor (12) coupled in a guided manner to said conveyance guides (13) to enable a longitudinal movement in both directions along said guides, to the position of the computing device (6) or the cooling unit (5) to be moved.~~

30 ~~19. The system (1) as claimed in claim 18, in which said moveable conveyor (12) includes lifting/lowering means designed to be joined removably to the computing device (6) or the cooling unit (5) to be moved, and to move same upwards or downwards in a direction Z orthogonal to said longitudinal direction to move same from said immersed position to said maintenance position, or vice versa.~~

35 ~~20. The system (1) as claimed in claim 19, in which said lifting/lowering means include a cable that is removably connectable to the computing device (6) or the cooling unit (5) to be moved, and that is connected operationally to drive means to perform said lifting or lowering movement thereof~~

5 21. The system (1) as claimed in claim 19 or 20, in which said lifting/lowering means are designed to be joined removably to joining elements (39) arranged on the computing device (6) or the cooling unit (5) to be moved, and to move same upwards or downwards.

22. The system (1) as claimed in claim 21, in which said joining elements (39) are designed to removably join the computing devices (6) to the cooling bath tank (3).

10 23. The system (1) as claimed in claim 22, in which said joining elements (39) include retaining elements (41) that are designed to removably join the computing devices (6) to the cooling bath tank (3).