

ARRANGEMENT FOR DIRECT LIQUID COOLING OF AN IT INFRASTRUCTURE

The invention is based on an arrangement for direct liquid cooling (DLC) of an IT infrastructure, wherein the arrangement has at least one IT rack with a plurality of slide-in units, arranged one above the other in the vertical direction of the IT rack, for slide-in devices of a direct liquid cooling and/or of an IT infrastructure. Such an arrangement with coolant distribution units designed as slide-in devices is known from U.S. Pat. No. 11,395,443 B2. A similar arrangement is described in US 2007/0274043 A1.

U.S. Pat. No. 9,668,382 B2 and U.S. Pat. No. 11,310,939 B2 describe known coolant distribution units (CDU), in which all the components required for providing a cooled liquid are accommodated in a housing designed as a slide-in device, including, but not limited to: redundant pumps, a heat exchanger, an expansion vessel, a pressure and/or temperature sensor, a three-way valve with bypass valve, an AC power supply, a control unit, a service valve, a filter, an automatic deaerator, a pressure-limiting valve. For the recooling of the CDU, the slide-in device can have a liquid-liquid heat exchanger and a connection for the feed and a connection for the return of cooled liquid. Instead of a liquid-liquid heat exchanger, an air-liquid heat exchanger can be provided, to which air from the surroundings of the slide-in device is applied with a fan, preferably a filter fan, for the recooling of the cooling liquid of the direct liquid cooling.

The known arrangements have the disadvantage that the coolant distribution unit is susceptible to faults and cost-intensive due to its complexity. Accordingly, the replacement in the event of a failure is also associated with high costs.

It is therefore the object of the invention to further develop an arrangement of the type described at the outset in such a way that it is not susceptible to faults and can be replaced in the event of a failure at low costs.

This object is achieved by an arrangement having the features of claim 1. The dependent claims each relate to advantageous embodiments of the invention.

The arrangement can accordingly have a direct liquid cooling with at least two different slide-in devices which are each inserted into one of the slide-in units. In particular, the

assembly which is provided as a coolant distribution unit in the prior art and is designed as a single device, for instance a slide-in device, can be of modular construction, with at least two different slide-in devices which are each inserted into one of the slide-in units. At least two assemblies of the coolant distribution unit can be designed independently of one another and can therefore be exchanged independently of one another.

The direct liquid cooling can have a plurality of assemblies, of which at least two are designed as different slide-in devices. The different slide-in devices can be functional assemblies of a coolant distribution unit (CDU). The combination of the functional assemblies, which is known from the prior art in the case of a coolant distribution unit, can therefore be dissolved in a single assembly housing, wherein a plurality of assemblies which are designed independently of one another are produced. These assemblies can each be designed as a slide-in device with its own housing.

The assemblies which are designed as different slide-in devices can complement one another functionally. In particular, the at least two different slide-in devices have a different function with respect to the direct liquid cooling, preferably a different function of a coolant distribution unit (CDU).

The at least two assemblies which are designed as different slide-in devices can interact in such a way that they jointly have the function of a coolant distribution unit (CDU). By way of example, a first of the two assemblies can be a pump unit and the second assembly can be a coolant distribution unit which has all the functional assemblies of a coolant distribution unit, but no pump. The pump unit can have a plurality of redundant pumps. A plurality of pump units can be provided which each form a slide-in device. The plurality of pump units can be designed redundantly, both with respect to one another and with respect to each pump unit, by virtue of each pump unit having a plurality of pumps.

The slide-in devices, in particular the slide-in devices which form the functional assemblies of a coolant distribution unit, can be selected from: a pump unit (RPU) for coolant, preferably with 2N redundant pumps, a heat exchanger, an expansion vessel, a pressure and/or temperature sensor, a three-way valve with bypass valve, an AC power supply, a control unit, a service valve, a filter, preferably a filter fan, an automatic deaerator, a pressure-limiting valve. The slide-in devices can be provided multiple

times, preferably redundantly with respect to one another, particularly preferably as mutually independent slide-in devices.

The slide-in devices can be designed to be at least partially hot-swap-capable, preferably with respect to a connection to a coolant circuit of the direct liquid cooling and/or a connection to a power supply. By way of example, a power supply, for instance an uninterruptible voltage supply (UPS) or a power supply unit/a power supply unit (PSU) can be designed as a slide-in device, in particular as a hot-swap-capable slide-in device.

A pump unit (reservoir pumping unit—RPU) of the direct liquid cooling can be designed as at least one of the at least two slide-in devices. Preferably, the pump unit has a plurality of the slide-in devices or is formed from a plurality of slide-in devices, wherein the slide-in devices are preferably identical parts. The identical parts preferably have the same function. In the case of a pump unit, the identical parts have a pumping capacity. The identical parts can have the same pumping capacity. The pump units can be connected in series. Their pumping capacities can add up. In the event of a failure of one of the pump units, the remaining pump unit or the remaining pump units can take over the pumping capacity of the failed pump unit.

If the plurality of slide-in devices of the pump unit are identical parts, they can be redundant with respect to their pumping capacity for a coolant of the direct liquid cooling, preferably connected in series. The plurality of slide-in devices of the pump unit can be configured such that, in the event of a failure of one of the plurality of slide-in devices of the pump unit, a required pumping capacity is provided by the remaining slide-in devices of the pump unit.

One of the slide-in devices can be a power supply, preferably a DC voltage supply for slide-in devices accommodated in the slides. The DC voltage supply can have a rectifier and a power distribution, for example a busbar, which runs along a rear side of the IT rack in the height direction of the IT rack and is supplied with a DC voltage by the rectifier. At least one of the slide-in devices of the direct liquid cooling accommodated in the slides can be electrically contact-connected to the power distribution, in particular the busbar. The slide-in device then itself does not require a power supply unit, for instance a power supply unit, as a result of which the slide-in

device is more cost-effective to provide and is less susceptible to faults and has a smaller structural dimension.

In one embodiment, the power distribution can be a busbar, for example a copper busbar, particularly preferably a busbar which is accommodated in a contact protector which has contact openings for the electrical contact-connection of the busbar. The power distribution, in particular the busbar, is particularly preferably designed as a straight strip. The slide-in devices, in particular, but not exclusively, the slide-in devices of the direct liquid cooling, can be operated with DC voltage. A DC voltage supply can be provided in the IT rack, which DC voltage supply extends at least in the vertical direction of the IT rack and with which slide-in devices inserted into the slide-in units can be supplied with DC voltage. The DC voltage supply, in particular the power distribution, for instance a busbar, can have a self-contact-connection. For this purpose, the power distribution, for instance a busbar, and the slide-in devices can have, on their rear side facing the power distribution, complementary contact elements which come into engagement when the slide-in devices are arranged in a position completely inserted into the slide-in units, wherein the electrical contact-connection is disengaged when the slide-in devices are inserted into the slide-in units in a position which is not completely inserted.

The arrangement can be part of an IT cabinet, an IT cabinet row or a data center. The arrangement can therefore be, in particular, part of a switch cabinet housing. The switch cabinet housing can have, in a known manner, in addition to the direct liquid cooling, an air cooling system for the cooling-required components accommodated in the switch cabinet. For this purpose, cooled air can flow through the switch cabinet housing. It can be provided that the switch cabinet housing has an air-liquid heat exchanger on an air outlet side, for example on a front side or a rear side. The heat exchanger can be designed, for example, as a rear door heat exchanger. Therefore, when flowing through the switch cabinet, heated air can be emitted as cooled air into the switch cabinet surroundings. Alternatively or additionally, cooled air can enter the housing, for example in a switch cabinet row in a cold aisle/hot aisle configuration, from a cold aisle via a front or rear side of the switch cabinet and enter the hot aisle as heated air on the opposite side. The cooled air can be emitted into the cold aisle, for example, by an air-liquid heat exchanger arranged in a double floor of the data center. The cooled air can also be provided in a different manner in the cold aisle.

For a further increase in the ease of maintenance of the direct liquid cooling, the direct liquid cooling can be of modular construction, with a plurality of interconnected assemblies which can each be one of the slide-in devices. This enables embodiments of the direct liquid cooling in which assemblies or modules which are particularly susceptible to faults are provided redundantly. Thus, for example, a plurality of pump modules can be provided for the liquid transport. The pump modules can be connected in parallel. Each of the pump modules can have a plurality of pumps which are in turn preferably connected in parallel.

In one embodiment, the direct liquid cooling has at least one pump module which is designed independently of further functional modules of the liquid cooling. The at least one module or one of the modules of the direct liquid cooling can be a slide-in device of the direct liquid cooling. Optionally, the slide-in device can be connected to the DC voltage supply in the manner described above. However, it can also have a dedicated voltage supply, for example a power supply unit.

If the arrangement for supplying a direct liquid cooling system (DLC) with electrical energy is part of a switch cabinet housing, a switch cabinet row or a data center, and furthermore an air cooling system having at least one air-liquid heat exchanger, provision can be made for a return line of the air-liquid heat exchanger to be connected to a feed line of the direct liquid cooling system, in particular to a feed line of a liquid-liquid heat exchanger of the direct liquid cooling system. In this way, it is possible for the heated liquid emerging from the air-liquid heat exchanger to still be used as a heat sink for the recooling of the cooling liquid of the primary circuit of the direct liquid cooling system. This is possible because liquid cooling systems can be operated with a higher feed temperature than the air of an air cooling system flowing through the switch cabinet, in order in particular still to enable an effective heat transfer from the cooling-required component to the liquid of the primary circuit of the liquid cooling system.

In one embodiment, the return line of an air-liquid heat exchanger accommodated in a switch cabinet door can be connected to a feed line of a liquid-liquid heat exchanger of the direct liquid cooling system, in particular to the outer circuit of the direct liquid cooling system. The air-liquid heat exchanger can also assume an alternative position with respect to the switch cabinet, a switch cabinet row or a data center which have the DLC. For example, the air-liquid heat exchanger can be arranged in a double floor of a data center and can be configured to blow cooled air into a cold aisle, which air was

previously conducted out of the hot aisle as heated air and through the double floor and the air-liquid heat exchanger. The heat exchanger can also be part of an inline cooling device which is lined up in a switch cabinet row. The switch cabinet row can, for example, separate a cold aisle from a hot aisle, wherein heated air is sucked in from the hot aisle via the rear side of the inline cooling device, conducted through the air-liquid heat exchanger in the inline cooling device and blown out into the cold aisle as cooled air on the front side.

In one embodiment, the arrangement is part of a switch cabinet housing or an IT rack in which, in addition to the components of the arrangement according to the invention, exclusively components of a liquid cooling system and optionally components of an air-liquid cooling system are arranged. Such a switch cabinet housing or such an IT rack can be part of a switch cabinet row, for example lined up in a row of switch cabinets or IT racks, and can be configured to provide cooled liquid for a liquid cooling system of components accommodated in adjacent switch cabinet housings or in IT racks. Optionally, the switch cabinet housing or IT rack having the arrangement can also have at least one air-liquid heat exchanger for providing cooled air for cooling the said components. The liquid circuit of the air-liquid heat exchanger can be interconnected with a liquid circuit of the outer circuit of a liquid-liquid heat exchanger of the liquid cooling system in the manner described above, in particular in such a way that the return line of the air-liquid heat exchanger is connected to the feed line of the outer circuit of the liquid-liquid heat exchanger. The return line of the outer circuit of the liquid-liquid heat exchanger can be connected to a recooling system, for example to a chiller. The feed line of the chiller can be connected to the feed line of the air-liquid heat exchanger. However, the air-liquid heat exchanger and the liquid-liquid heat exchanger of the direct liquid cooling system can also be designed independently of one another and can each be connected to the recooler for providing cooled liquid. The air-liquid heat exchanger can also be dispensed with and only a liquid cooling system can be realized.

If the arrangement has a DC voltage supply, a plurality of first blind mating plug connectors for the tool-free connection of assemblies of the direct liquid cooling system and/or an IT infrastructure to the power distribution, for example a busbar, can be arranged along a power distribution, in particular a busbar, spaced apart from one another in the height direction. The slide-in devices to be accommodated in the slide-in units can have plug connectors which are complementary to the first blind mating plug

connectors. The plug connectors which are complementary to one another can have self-centring, with the result that, when the slide-in devices are inserted into the slide-in units, a secure contact-connection between the slide-in devices and the busbar is achieved when a completely inserted position of the slide-in devices in the slide-in units is reached.

The direct liquid cooling system can have at least one coolant distributor channel which runs along the rear side of the IT rack in the height direction of the IT rack, wherein a plurality of second blind mating plug connectors for the tool-free connection of assemblies of the direct liquid cooling system and/or an IT infrastructure to the coolant distributor channel are arranged along the coolant distributor channel, spaced apart from one another in the height direction.

The slide-in units can have a linear guide for assemblies of the direct liquid cooling system and/or an IT infrastructure, wherein the linear guide extends parallel to a plug-in direction of the first and/or second blind mating plug connectors.

The direct liquid cooling system can have a plurality of slide-in devices which are each accommodated in one of the slide-in units and of which at least two slide-in devices are designed as redundant slide-in devices, preferably redundant pump units, for example in each case as a reservoir pumping unit (RPU). All of the slide-in devices, but preferably at least one of the slide-in devices of the direct liquid cooling system, can be contact-connected to a power distribution, in particular a busbar, in particular via a dummy coupling plug connection, with the result that a simple replacement is possible in the event of a failure.

One of the slide-in devices can be a rectifier. The rectifier can be designed, for example, as a power supply unit (PSU) which is accommodated as a slide-in device in one of the slide-in units. The PSU can have, on a rear side facing the power distribution, a blind mating plug connector via which the PSU is electrically connected to a power distribution in order to supply the power distribution, for example a busbar of the power distribution, with DC voltage.

The at least one slide-in device of the direct liquid cooling system can be a coolant distribution unit (CDU) or at least one assembly of a coolant distribution unit. Preferably, the coolant distribution unit has a plurality of assemblies which are

designed independently of one another. Preferably, the coolant distribution unit can have at least two redundant assemblies. The redundant assemblies can be designed as identical parts and can be connected in parallel. Particularly preferably, the coolant distribution unit has at least two assemblies with different functionality. The assemblies can each be designed as a slide-in device for accommodation in one of the slide-in units.

Assemblies of the coolant distribution unit (CDU) can be, for example: at least one pump unit for coolant, preferably with 2N redundant pumps, at least one heat exchanger, at least one expansion vessel, at least one pressure and/or temperature sensor, at least one three-way valve with bypass valve, at least one AC power supply, at least one control unit, at least one service valve, at least one filter, preferably a filter fan, at least one automatic deaerator, at least one pressure-limiting valve. Individual assemblies can be designed as their own slide-in device. A plurality of assemblies can form a common slide-in device. The assemblies can be designed to be hot-swap-capable, preferably with respect to a connection to a coolant circuit, if present, and/or a connection to a power supply, if present.

It can be provided that the pump unit of the CDU is designed as its own slide-in device. Preferably, the pump unit has a plurality of slide-in devices. The plurality of slide-in devices of the pump unit can be identical parts. The plurality of slide-in devices of the pump unit can be connected in series with respect to their pumping capacity for the coolant. The plurality of pump units can be configured such that, even in the event of a failure of one of the plurality of pump units, the required pumping capacity can be provided by the remaining pump units. For this purpose, it can be provided that the plurality of pump units are operated in normal operation, i.e. when none of the plurality of pump units has failed, with a reduced pumping capacity. In the event of the failure of one of the pump units, the remaining pump units can upregulate their pumping capacity, such that the pumping capacity omitted by the failure is compensated for. After the failed pump unit has been exchanged, the plurality of pump units can return to normal operation.

In the case of the coolant distribution unit (CDU) which is known from the prior art, all of the abovementioned assemblies, insofar as they are required in the respective application, are frequently arranged in the same housing, and are therefore designed as a single device, such that, in the event of a failure of one of the abovementioned

assemblies, the entire CDU has to be exchanged. This leads to the interruption of the cooling capacity provided by the CDU and therefore, if appropriate, to the failure of the IT infrastructure which is cooled by the CDU.

At least one of the assemblies of the coolant distribution unit, preferably a control device and/or an expansion vessel of the coolant distribution unit, can be arranged outside a housing of the coolant distribution unit (CDU) and inside or outside the IT rack. By way of example, an expansion vessel of the coolant distribution unit can be arranged on a roof of the IT rack.

The at least one assembly of the coolant distribution unit can be a control device of the coolant distribution unit which is electrically connected to the power supply, in particular the busbar, and is preferably designed as a slide-in device which is accommodated in one of the slide-in units.

The at least one assembly of the coolant distribution unit can be an expansion vessel which is fluidically connected, preferably directly, to a coolant distribution channel of the direct liquid cooling system. In this case, the expansion vessel can particularly preferably be arranged outside the IT rack, for example on the roof of the IT rack.

A plurality of assemblies of the coolant distribution unit can be accommodated as individual slide-in devices in each case in one slide-in unit. In this case, the assemblies of the coolant distribution unit which are designed as mutually independent slide-in devices can comprise at least two identical or structurally identical assemblies, preferably a plurality of identical or structurally identical pump units, for example RPU's, of the coolant distribution unit. By way of example, at least two of the identical or structurally identical pump units can be designed as redundant pump units. In order to produce the redundancy, the pump units can be connected in parallel.

The at least one slide-in device can be an assembly of the direct liquid cooling system, in which the slide-in device has a housing in which at least two redundant, preferably parallel-connected, pumps are arranged. The housing can otherwise be at least free of a compressor, an expansion medium and a condenser. Preferably, the housing can be free of all further active components of a refrigerating machine. In this way, an embodiment of the invention can be provided in which the pump units which are particularly susceptible to faults can be exchanged simply and in ongoing operation.

This can be further optimized in that not only one of the slide-in devices with at least two redundant pumps is provided, but also a plurality of these slide-in devices which, particularly preferably in a fluidically parallel-connected manner, apply cooled coolant to a coolant distribution channel.

In one embodiment, in addition to the at least two redundant pumps, a heat exchanger can be accommodated in the housing. In this case, for the component cooling of an IT infrastructure with the redundant pumps, cooling liquid can be conveyed or can be conveyed through an inner circuit of the heat exchanger. When the heat exchanger is a liquid-liquid heat exchanger, an outer circuit of the liquid-liquid heat exchanger can be connected or can be connected to a recooling liquid. Alternatively, in the manner already described, the outer circuit of the liquid-liquid heat exchanger can be connected to the return line of an air-liquid heat exchanger of an existing IT infrastructure.

The housing can have, on an outer side, at least one feed line and a first return line for the connection of the inner circuit to a coolant distribution channel of the direct liquid cooling system. Furthermore, a single-pole or two-pole electrical contact for the electrical connection to the power distribution, for instance a busbar, can be present on the outer side, preferably on a rear side of the housing facing the power distribution. When the heat exchanger is a liquid-liquid heat exchanger, a second feed line and a second return line can preferably be provided for the connection of the outer circuit to a recooling liquid. Preferably, all of the feed lines and return lines and the electrical contact can be designed as blind mating plug connectors.

At least one further slide-in device can be accommodated or can be accommodated in at least one further of the slides. In this case, the at least one further slide-in device can be a server or an uninterruptible power supply (backup battery unit—BBU).

The direct liquid cooling system can have at least one further slide-in device, preferably a coolant-conducting assembly of a coolant distribution unit of the direct liquid cooling system. The slide-in device can be a heat exchanger or can have such a heat exchanger. Furthermore, the slide-in device can be an expansion vessel or can have such an expansion vessel. In this case, the further slide-in device is intended to be accommodated in one of the slides in a contact-free manner with respect to the busbar.

The slide-in devices and the further slide-in devices can have standardized housings which, in particular with regard to their dimensions in the depth direction, and therefore in the insertion direction of the slide-in devices into the slides, have the same dimensions. Furthermore, the first blind mating plug connectors which are formed on the rear sides facing the busbar are preferably designed identically independently of the type of slide-in device.

Exclusively slide-in devices of the direct liquid cooling can be accommodated in the slides of the IT rack. Therefore, the IT rack can be lined up in a switch cabinet row of the components requiring cooling. For this purpose, the IT rack accommodating exclusively slide-in devices of the liquid cooling can have, via suitable interfaces, for example line-up connectors to adjacent IT racks of the switch cabinet row, including fluidic transitions between the IT rack having exclusively the slide-in devices of the liquid cooling and the adjacent IT racks of the switch cabinet row, which can accommodate servers requiring cooling, for example.

At least one of the slide-in devices can be a heat exchanger or can have such a heat exchanger, preferably a liquid-liquid heat exchanger, an expansion vessel, a pump unit, a control device or a DC voltage supply.

Further details of the invention will be explained with reference to the following figures. In the figures:

FIG. 1 shows, in a schematic illustration, direct liquid cooling;

FIG. 2 shows an exemplary embodiment of a slide-in device designed as a pump unit;

FIG. 3 shows an exemplary embodiment of direct liquid cooling with additional rear door air cooling;

FIG. 4 shows in a schematic illustration, an exemplary embodiment of a slide-in device;

FIG. 5 shows a further embodiment of a slide-in device;

FIG. 6 shows yet a further embodiment of a slide-in device;

FIG. 7 shows an embodiment of an arrangement according to the invention in front view (a) and side view (b); and

FIG. 8 shows yet a further embodiment of an arrangement according to the invention in side view of the IT rack.

FIG. 1 shows, in a schematic illustration, direct liquid cooling (DLC). Cooled liquid is provided by a recooling unit 16 which can be designed, for example, as a chiller, with or without a refrigerating machine. For this purpose, the recooling unit 16 has, in particular, an air-liquid heat exchanger and at least one fan, with which ambient air is transported through the air-liquid heat exchanger. The cooled liquid provided by the recooling unit is fed to a coolant distribution unit (CDU), in particular via the feed line of an outer circuit of the CDU. Via a return line of the outer circuit, the liquid provided by the recooling unit leaves the CDU as heated liquid and the outer circuit of the CDU, which at the same time forms the liquid circuit of the recooling unit 16, is denoted by the reference sign 17.

The coolant distribution unit CDU has, in particular, a liquid-liquid heat exchanger and at least one pump, in order to transport liquid through the inner circuit 15 of the CDU. The feed line of the inner circuit of the CDU is connected to a return line of a coolant distribution channel and the return line of the inner circuit 15 of the CDU is connected to a feed line of the coolant distribution channel 7. The coolant distribution channel 7 can have a plurality of connections, spaced apart from one another in the longitudinal direction, therefore in the vertical direction, on the one hand to a feed line of the coolant distribution channel 7, via which cooled coolant is provided, and on the other hand to a return line of the coolant distribution channel 7, via which heated coolant is discharged. The slide-in devices 2 can be, for example, server slides of an IT infrastructure, which are connected to the distribution channel 7, for example, in the manner known from US 2007/0274043 A1. In the slide-in devices, the cooling liquid, which is preferably an electrically nonconductive refrigerant, flows over the components requiring cooling, for example CPUs or GPUs, or another component, which has a high power loss and otherwise a high temperature sensitivity, so that an air cooling system is unsuitable due to the lower thermal conductivity of air compared to liquid.

FIG. 2 shows an exemplary embodiment of a slide-in device, which can be used in an arrangement according to the invention. The slide-in device 2.1 has a housing 13 which can be standardized, for example, with respect to its dimensions, for example at least to the effect that, when the slide-in device 2.1 is inserted into a slide of an IT rack, both a contact-connection of the first and of the second blind coupling plug-in connection 6.1, 6.2 for the electrical contact-connection of the power distribution on the one hand and the fluidic connection to the direct liquid cooling system, in particular a coolant distribution channel, can take place automatically, that is to say in particular without tools. Three redundant pumps 14, which are in particular interconnected in parallel with one another, are arranged in the housing 13. Furthermore, a heat exchanger 12, in particular a liquid-liquid heat exchanger, is arranged in the housing 13. The only active components inside the housing 13 are therefore the pumps 14, which are provided in a triple design and connected in parallel. The pump unit shown in FIG. 2 therefore has a very high failure insensitivity. Owing to the use of the first and of the second blind coupling plug connectors 6.1, 6.2, the entire unit, that is to say the slide-in device 2.1, can be exchanged quickly and without relevant downtimes in the event of a failure of all the pumps or in the event of a decreasing pump power. further redundancy of the direct liquid cooling (DLC) can be achieved by a plurality of the slide-in devices 2.1 which are shown in FIG. 2 being provided at the same time, which slide-in devices 2.1 are in turn connected in parallel with one another, with the result that, even in the event of the failure of all the, in the present case three, pumps 14 of one of the plurality of slide-in devices 2.1, the continued operation of the DLC is secured and downtimes can be substantially completely avoided.

FIG. 3 shows an embodiment in which the arrangement according to the invention is accommodated in a switch cabinet housing which is designed according to the design of an IT cabinet with a plurality of 19-inch slide-in units which are arranged vertically one above the other. The slide-in devices 2.1 in the slide-in units 2 of the IT rack 1 are occupied partially by servers and partially by built-in devices 2.1 of the direct liquid cooling. By way of example, an uppermost slide-in unit 2 of the IT rack 1 is occupied by a DC voltage supply 3 which is provided as a built-in device 2.1. A lower slide-in unit 2 is occupied by a coolant distribution unit (CDU). A coolant distributor channel 7 with its feed line and its return line is arranged on a rear side of the IT rack 1. The feed line and the return line of the coolant distribution channel 7 are connected to the coolant distribution unit CDU. A rear door heat exchanger 200 is connected to the rear side of the IT rack 1. Said rear door heat exchanger has an air-liquid heat exchanger and a

plurality of fans. With the aid of the rear door heat exchanger, cooled air is sucked into the rear door heat exchanger 200 via the front side of the IT rack 1 through the IT rack 1, past the server slides 2.1 requiring cooling, where the heated air passes the air-liquid heat exchanger and is blown out into the surroundings of the housing as cooled air. The feed line of the air-liquid heat exchanger of the rear door cooling device 200 is fed by a recoler 16, for example a chiller. The return line of the air-liquid heat exchanger of the rear door cooling device 200 is connected to a feed line of an outer circuit of the CDU. The heated liquid emitted by the air-liquid heat exchanger therefore serves as a heat sink with respect to the CDU. Arranged in the CDU is a liquid-liquid heat exchanger 12 via which heat is transferred from an inner circuit of the CDU, with which the CDU is connected to the coolant distribution channel 7, to the outer circuit of the CDU.

All the slide-in devices 2.1, apart from the DC voltage supply 3 itself, can be designed as DC devices which are operated, for example, at an operating voltage of 48 V. The entire power distribution inside the IT rack can therefore take place at a DC voltage level which is less dangerous than the mains voltage, as a result of which the operational reliability of the IT rack is increased.

The modular construction of the direct liquid cooling furthermore allows the expansion vessel 10, for example, also to be arranged in a manner which is advantageous for operation on an upper side of the IT rack 1, that is to say in particular above the coolant distribution channel 7.

FIGS. 4 to 6 show different installation stages of a slide-in device 2.1 which is designed as a pump unit (RPU) in the embodiment according to FIG. 4. The RPU shown in FIG. 4 has only two parallel-connected pumps 14 which are accommodated with two power supply units 19, in each case one for each of the pumps 14, in a housing 13. A first blind mating plug connector 6. 1 serves for the connection to the DC voltage source and a pair of second blind mating plug connectors 6. 2 serves for the connection to the inner circuit of the DLC, with the result that, with the pump unit (RPU) shown in FIG. 4, the coolant distribution channel (not illustrated) of the DLC can be supplied with cooled coolant.

In an extension of the embodiment shown in FIG. 4, in the embodiment shown in FIG. 5, not only is a liquid-liquid heat exchanger 12 provided, but, furthermore, the pumps

14 are of triple redundant design. Correspondingly, three power supply units 19 are also provided for the independent supply of the three pumps 14. The embodiment shown in FIG. 5 is suitable, for example, for use in a switch cabinet according to FIG. 3, in which the outer circuit of the CDU is connected to an air-liquid heat exchanger, for example to such a heat exchanger of a rear door cooling device 200.

Deviating in turn from the embodiment according to FIG. 5, in the embodiment in FIG. 6, instead of a liquid-liquid heat exchanger for the recooling of the coolant, an air-liquid heat exchanger 12 and a pair of fans 20 are provided. Otherwise, an expansion vessel 10 is also arranged in the housing. A pair of redundant pumps 14 is fed by a pair of mutually independent power supply units 19.

FIG. 7 shows, in front view (a) and in side view (b), an exemplary embodiment of an arrangement for supplying a direct liquid cooling system with electrical energy. The arrangement has an IT rack 1 which has a plurality of slide-in units 2, arranged one above the other in the vertical direction z, for slide-in devices 2.1 of a direct liquid cooling system. In addition to the slide-in devices 2.1 for the direct liquid cooling system, further slide-in devices 2.1 are also provided, which are designed as servers in the present case. The rectifier PSU is also designed as a slide-in device 2.1. A busbar of a DC voltage supply 3 for the slide-in units 2 or slide-in devices 2.1 accommodated therein extends as the power distribution 5 along the rear side R of the IT rack 1. The busbar is fed by the rectifier PSU, in particular supplied with a DC voltage. The slide-in devices 2.1 of the direct liquid cooling system DLC, insofar as they require a supply with electrical energy, are each accommodated in one of the slide-in units 2 and electrically contact-connected to the busbar. The expansion vessel 10, which does not require an electrical power supply, is arranged at a position which is advantageous from a physical point of view on the upper side, that is to say otherwise outside the IT rack 1. A control device 9 is designed as a separate slide-in device independently of other assemblies of the DLC and is contact-connected directly to the DC voltage supply 3, in particular to the busbar of the power distribution 5. The slide-in devices 2.1 have first blind mating plug connectors 6.1 for the tool-free connection of the slide-in devices 2.1 to the busbar. Complementary blind mating plug connectors can be arranged on the rear side, facing the busbar, of housings of the slide-in devices 2.1. In an analogous manner, second blind mating plug connectors, which are liquid-conducting, can be arranged on the rear side for the connection to a feed line and a return line of the coolant distribution channel 7.

While the embodiment shown in FIG. 7 has both server internals and therefore components requiring cooling and also different assemblies of direct liquid cooling DLC for the cooling of the servers, in the embodiment shown in FIG. 8 the IT rack 1 is equipped exclusively with components of direct liquid cooling DLC. In particular, a plurality of the slide-in devices 2.1 are designed as redundant pump units RPU. These can be designed, for example, as one of the embodiments according to FIGS. 2 and 4. The two slide-in devices 2.1 form the heat exchanger 12 and the expansion vessel 10. The DC voltage supply 3 is also designed as a slide-in device, as is also the control device 9. The DC voltage supply 3 is the only component of the arrangement shown in FIG. 8 which is supplied with mains voltage. Otherwise, the arrangement ensures that all the components and devices for the power distribution, in particular the busbar 5, are at a low DC voltage, for example 48 V.

The features provided in the abovementioned description can be relevant in any desired combination for the realization of embodiments of the invention, wherein the scope of protection is determined solely by the claims.

List of reference numerals:

1	IT rack
2	slide-in unit
2.1	slide-in device
3	DC voltage supply
5	busbar
6.1	first blind mating plug connector
6.2	second blind mating plug connector
7	coolant distribution channel
8	linear guide
9	control device
10	expansion vessel
11	further slide-in device
12	heat exchanger
13	housing
14	pump
15	inner circuit
16	recooler
17	outer circuit
19	power supply unit
20	fan
200	rear door cooling device
BBU	uninterruptible power supply
CDU	coolant distribution unit
DLC	direct liquid cooling
PSU	Rectifier
RPU	Pump unit
R	rear side
x	plug-in direction
z	height direction

Claims:

1. Arrangement for direct liquid cooling (DLC) of an IT infrastructure, wherein the arrangement has at least one IT rack (1) with a plurality of slide-in units (2), arranged one above the other in the vertical direction (z) of the IT rack (1), for slide-in devices (2.1) of a direct liquid cooling (DLC) and/or of an IT infrastructure, characterized in that the direct liquid cooling (DLC) has at least two different slide-in devices (2.1) which are each inserted into one of the slide-in units (2).
2. Arrangement according to claim 1, in which the direct liquid cooling (DLC) has a plurality of assemblies, of which at least two are designed as different slide-in devices (2.1).
3. Arrangement according to claim 2, in which the slide-in devices (2.1) are selected from: a pump unit (RPU) for coolant, preferably with 2N redundant pumps, a heat exchanger, an expansion vessel, a pressure and/or temperature sensor, a three-way valve with bypass valve, an AC power supply, a control unit, a service valve, a filter, preferably a filter fan, an automatic deaerator, a pressure-limiting valve.
4. Arrangement according to one of the preceding claims, in which the slide-in devices (2.1) are designed to be hot-swap-capable, preferably with respect to a connection to a coolant circuit of the direct liquid cooling (DLC) and/or a connection to a power supply.
5. Arrangement according to one of the preceding claims, in which a pump unit (RPU) of the direct liquid cooling (DLC) is designed as at least one of the at least two slide-in devices (2.1).
6. Arrangement according to claim 5, in which the pump unit (RPU) forms a plurality of the slide-in devices (2.1), wherein the slide-in devices (2.1) formed by the pump unit (RPU) are preferably identical parts.
7. Arrangement according to claim 6, in which the plurality of slide-in devices (2.1) of the pump unit (RPU) are identical parts, which are preferably redundant with

respect to their pumping capacity for a coolant of the direct liquid cooling (DLC), preferably connected in series.

8. Arrangement according to claim 6 or 7, in which the plurality of slide-in devices (2.1) of the pump unit (RPU) are configured such that, in the event of a failure of one of the plurality of slide-in devices (2.1) of the pump unit (RPU), a required pumping capacity is provided by the remaining slide-in devices (2.1) of the pump unit (RPU).
9. Arrangement according to one of the preceding claims, in which at least a first of the slide-in devices (2.1) of the direct liquid cooling (DLC) is a coolant distribution unit (CDU) and the second is an assembly of a coolant distribution unit (CDU), wherein the first slide-in device (2.1) is free of the assembly.
10. Arrangement according to claim 9, in which the at least one assembly of the coolant distribution unit (CDU), preferably a control device (9) and/or an expansion vessel (10) of the coolant distribution unit (CDU), is arranged outside a housing (13) of the first slide-in device (2.1) and inside or outside the IT rack (1).
11. Arrangement according to claim 10, in which, in the event that the at least one assembly is arranged inside the IT rack (1), the assembly is one of the at least two slide-in devices (2.1) which are inserted into at least one of the slide-in units (2).
12. Arrangement according to claim 10 or 11, in which the at least one assembly is an expansion vessel (10) which is fluidically connected, preferably directly, to a coolant distribution channel (7) of the direct liquid cooling (DLC), wherein the expansion vessel (10) is particularly preferably arranged outside the IT rack (1).
13. Arrangement according to one of the preceding claims, in which the assemblies of the direct liquid cooling (DLC) designed as individual slide-in devices (2.1) have at least two identical or identically constructed assemblies, preferably a plurality of identical or structurally identical pump units (RPU), of which particularly preferably at least two of the identical or identically constructed pump units (RPU) are designed as redundant pump units (RPU).

14. Arrangement according to one of the preceding claims, in which at least one of the slide-in devices (2.1) has a housing (13) in which at least two redundant, preferably parallel-connected, pumps (14) are arranged, wherein the housing (13) is otherwise at least free of a compressor, an expansion medium and a condenser, and preferably free of all further active components of a refrigerating machine.
15. Arrangement according to claim 14, in which furthermore at least one heat exchanger (12) is accommodated in the housing (13), wherein, for the component cooling of an IT infrastructure with the redundant pumps (14), cooling liquid is conveyed or can be conveyed through an inner circuit (15) of the heat exchanger (12), and wherein, when the heat exchanger (12) is a liquid-liquid heat exchanger, preferably an outer circuit (17) of the liquid-liquid heat exchanger is connected or can be connected to a recooling (16) for cooling liquid.