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(54) METHOD, COMPUTER PROGRAM AND CONTROL UNIT FOR DETERMINING WHETHER TO INITIATE A DEFROSTING PROCESS OF A COOLING DEVICE

(57) The present disclosure relates to a computer-implemented method for determining whether to initiate a defrosting process of a cooling device usable in an industrial environment, the method comprising: determining that the defrosting process is to be initiated, comprising one or more of the following steps: determining that a predetermined minimum duration of time that the cooling device is actively cooling is reached; determining that a cooling intensity is larger than or equal to a predetermined cooling intensity value; and/or determining that a predetermined maximum duration of time the cooling device is actively cooling is reached; if it has been determined that the defrosting process is to be initiated: initiating the defrosting process of the cooling device. The present disclosure further relates to a corresponding computer program, control unit, cooling device and system.

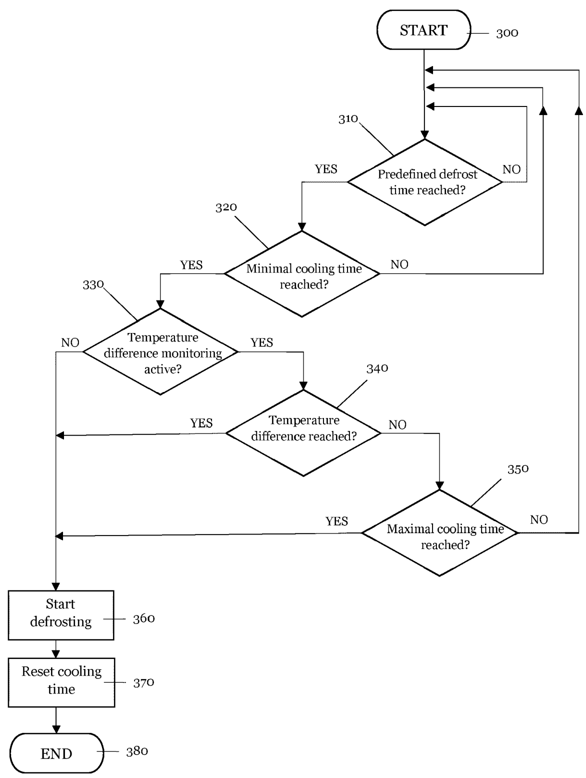

Fig. 3

Description

Technical field

[0001] The present invention relates to a computer-implemented method for determining whether to initiate a defrosting process of a cooling device as well as to a corresponding computer program, control unit, device and system.

Technical background

[0002] Cooling devices, specifically air coolers, operate based on evaporative cooling which is a process that uses the evaporation of a refrigerant to cool the air of cooling rooms and cold stores that are oftentimes used in industrial environments, e.g., in the realm of food and beverage industry or pharma industry. For a refrigerant, such as water or ammonia to change from a liquid to a gaseous state, energy is required. This energy is drawn from the surrounding air of the cooling device decreasing the temperature of the surrounding air in the process. Cooling devices, generally applied in the food and beverage industry or pharma industry often require keeping a room or cold storage at subzero degrees temperatures. In this case water vapor in the air to be cooled may lead to ice formation at the evaporator of the cooling unit.

[0003] Ice buildup compromises the device's ability to effectively cool the air and thus might lead to higher operating temperatures in a zone with a target temperature to be maintained. In order to be able to maintain a desired target temperature, however, more cooling is required due to the ice buildup, which leads to increased energy consumption of the cooling device. In addition, exceeding operating weight due to strong ice formation may cause a dangerously heavy load which may have negative consequences. Due to the increased weight of the cooling device caused by the ice, its anchoring to a wall may become too weak, for example, causing the cooling device to fall off the wall.

[0004] Thus, cooling devices must typically be defrosted from time to time to maintain cooling efficiency and to avoid safety hazards from the excessive weight of the ice buildup. Similar to other thermodynamic processes, defrosting processes are limited in efficiency such that only a fraction of energy used during the defrosting process actually contributes to melting the ice formation. This leads to an increased power consumption of the cooling device. There is a direct correlation between the number of defrost operations and energy consumption of the cooling device. Thus, it is essential to optimize the number of defrost operations to avoid unnecessary defrosting of the cooling device by at the same time ensuring that operation of the cooling device is not negatively affected by ice buildup.

[0005] In conventional methods for controlling the execution of defrosting processes, defrosting processes are performed according to a fixed predefined defrosting schedule. This means that a cooling device, like an air cooler, performs its defrosting processes at one or more predefined points in time. Such a defrosting schedule may be adapted to defrosting processes conducted by other air coolers that cool the same cooling room, plant, or cold storage. The defrosting schedules of two or more cooling devices operating in the same environment may be configured such that their defrosting processes do not overlap, i.e., the defrosting processes of the two or more cooling devices are conducted at different points in time. This ensures consistent cooling of the environment, which is a priority especially in industrial environments where it may be critical if the room temperature fluctuate too much. However, determining the setup of a fixed defrosting schedule (i.e., which cooling device should initiate a defrosting operation at which time) requires expert evaluation and observations during the first months of the environment's operation. While determining the setup of a fixed defrosting schedule for two or more air coolers is reliable and widely applied, it is extremely time consuming. In addition, the fixed schedule may lead to conducting defrosting processes that are not required as the cooling devices are not yet subject to strong ice buildup.

[0006] A further disadvantage of fixed defrosting schedules is the requirement for readjustment of the scheduled defrosting cycles. For instance, after a change of a production profile or a change in the ambient conditions (i.e., changes in temperature between warm and cold seasons) readjustment of the defrosting schedule is needed. In addition, daily changes that are present in modern production plants and warehouse facilities are not taken into account through seasonal readjustments.

[0007] In view of these disadvantages, the presently known fixed scheduling of defrost operations may not always lead to the desired results. There is thus a need to improve the presently used fixed defrosting schedules such that the number of unnecessary defrosting processes is reduced by at the same time essentially maintaining a desired target temperature of a room that is cooled by more than one cooling device.

[0008] Against this background, an object of the present invention is to address one or more or all of the above-mentioned disadvantages.

Summary of the invention

[0009] The above-mentioned objects and other objects, which become apparent from the following description, are solved by the subject-matter of the independent claims. Preferred embodiments are subject of the dependent claims.

[0010] A 1st embodiment of the invention is directed to a computer-implemented method for determining whether to initiate a defrosting process of a cooling device usable in an industrial environment, the method comprising: determining that the defrosting process is to be initiated, comprising one or more of the following steps: determining that a predetermined minimum duration of time that the cooling device is actively cooling is reached; determining that a cooling intensity is larger than or equal to a predetermined cooling intensity value; and/or determining that a predetermined maximum duration of time the cooling device is actively cooling is reached; if it has been determined that the defrosting process is to be initiated: initiating the defrosting process of the cooling device.

[0011] By determining that a minimum duration of time that the cooling device is actively cooling is reached, it is ensured that the defrosting process is only initiated after enough time has passed so that ice formation could have taken place. In contrast, in a fixed defrosting schedule, the defrosting process is initiated at a predetermined point in time. For instance, assume that a cooling device is schedule to defrost once a day at 12 pm. However, since the last defrosting took place, it was not required for the cooling unit to cool at all. In a fixed scheduled defrosting, the cooling unit would still start a defrosting process regardless of whether ice has actually accumulated or not. In contrast, requiring a minimum duration of time that the cooling device has actively cooled ensures that a defrosting process is only initiated if ice could theoretically have been accumulated or build up. Thus, initiating a cooling process only after a minimum duration of actively cooling has been reached may lead to reduced consumption of electrical power by the cooling device, as an unnecessary cooling process may be avoided. A further advantage is the flexibility of the defrosting schedule, in contrast to the conventional fixed schedule defrosting.

[0012] Similarly, initiating a defrosting process if a maximum duration of time that the cooling device is actively cooling is reached, may ensure that the cooling device is not operating for too long without being defrosted. The advantage of carrying out a defrosting process after a certain maximum duration is that a defrosting process is always carried out at some point, regardless of whether a lot or a little cooling has taken place. In this manner, hardware failures of the cooling device such as internal leakage from a valve or the like may be prevented. Having a maximum duration of time as a requirement for initiating a defrosting process can be derived from the fact that even when the general heat load covered by a single cooling device can be very small, a slow formation of ice can still occur. Consequently, taking into account a maximum duration of time that the cooling device is actively cooling may be considered as a safety measure that prevents hardware failure and could improve commissioning of the cooling device. Moreover, considering a maximum duration of active cooling could lead to lower maintenance requirements.

[0013] By determining that a cooling intensity is larger than or equal to a predetermined cooling intensity value, the intensity of the cooling activity is taken into account. The intensity of the cooling activity is correlated to the amount of ice that is formed as the ice buildup may lower the heat transfer between an evaporator of the cooling unit and the surrounding air to be cooled. For instance, a cooling device that is actively cooling but at a very low intensity (e.g., expected temperature -15 °C and current temperature - 14,5 °C), the ice formation is not as prominent as in the case where the cooling unit is actively cooling at a high intensity (e.g., expected temperature -15 °C and current temperature -13 °C). This could prevent a cooling device to initiate a defrosting process when the defrosting process is actually not yet required. Accordingly, an advantage of considering the cooling intensity of the cooling device is reduced power consumption which arises from avoiding unnecessary defrosting. Moreover, the lifetime of the cooling device may be improved due to a reduced overall number of defrosting cycles.

[0014] A further advantage of the present invention relating to a method for determining whether to initiate a defrosting process of a cooling device as described above may be that it does not require retrofitting the cooling device. While alternative approaches would require the installation of sophisticated sensing technology, the current invention leverages already existing components of the cooling device. Using already existing components further facilitates maintenance and commissioning of the cooling device since it does not require the acquisition of additional skills for performing such tasks.

[0015] According to a 2nd embodiment, the step of determining that the defrosting process is to be initiated further comprises: determining that a predefined defrost time is reached.

[0016] Determining that a predefined defrost time is reached ensures that defrosting only takes place at predefined times. This may prevent defrosting from being carried out at undesirable times and thus may provide a certain control of the defrosting processes. This is particularly relevant in industrial set-ups with several cooling devices where constant cooling is required, e.g., in cold storages or cooling rooms of warehouse facilities of the food and beverage industry or the pharma industry that needs to be kept at a certain temperature at all times and is powered by several cooling devices. Food and pharmaceutical processing systems are tailored to transport, store and process food and pharmaceutical products such as medicine, focusing on ensuring safety, improving shelf life, and meeting quality standards essential for consumer satisfaction and public health. Determining predefined defrosting times enables a warehouse facility manager to program the defrosting times of the cooling devices in such a manner that they are staggered and to avoid the scenario in which all cooling devices are undergoing a defrosting process at the same time. In summary, this may provide the security of knowing at what time the cooling unit could theoretically undergoes a defrosting process. This in turn may provide enhanced management of an environment comprising one or more cooling devices.

[0017] According to a 3rd embodiment, determining that the cooling intensity is larger than or equal to the predetermined cooling intensity value further comprises: obtaining an integral temperature value; comparing the integral temperature value against the predetermined cooling intensity value.

[0018] Obtaining an integral temperature value and comparing that value against the predetermined cooling intensity value provides a reliable manner in which to quantify whether the predetermined intensity of the cooling operation has been reached. The intensity of the cooling operation could be derived from various factors. However, temperature may have the advantage of being accurate and reliable factor for the determination of the cooling intensity. This is because temperature can easily be obtained through, for examples temperature sensors. Moreover, temperature measurements may provide the amount of accuracy that is required for the precise determination of the cooling intensity. Another advantage of using temperature as a metric may be that the obtaining of temperature readings is a default for cooling devices emphasizing the compatibility of the present invention with the existing technology and no need for retrofitting the cooling device.

[0019] According to a 4th embodiment, obtaining the integral temperature value further comprises: receiving a first and second temperature value from a temperature sensor arranged in the vicinity of the cooling device; calculating a first difference between the received first temperature value and a target cooling temperature; calculating a second difference between a second temperature value and the target cooling temperature; and accumulating the calculated first and second difference.

[0020] Arranging the temperature sensor in the vicinity of the cooling device may provide the advantage of obtaining an accurate local temperature measurement, i.e., the temperature close to the cooling device is taken into account. This may be beneficial as the temperature close to the cooling devices may best reflect the workload of the cooling device. Calculating the difference between the first received temperature value and a target cooling temperature value and performing the same operation for the second received temperature value may have the advantage of presenting a reliable unit for comparison. In other words, the difference between a measured temperature value and the target temperature value may provide an accurate indicator for cooling intensity of the cooling device. Having several temperature measurements and accumulating the calculated differences may provide a suitable metric for measuring the intensity of the cooling operation of the cooling device.

[0021] According to a 5th embodiment, the first and second temperature value are obtained at different points in time.

[0022] Obtaining the first and second temperature value at different point in time clarifies that the integral value is not just observed at a single moment in time but rather over a time span. This may provide the advantage of obtaining a more accurate result with regards to the cooling intensity of the cooling device. While taking temperature measurements a single point in time may only provide a snapshot into a cooling scenario, taking temperature measurements at multiple points in time provides a more holistic view on the cooling scenario. For instance, the door to a cooling room may be closed at time point A and opened at time point B. Only considering temperature measurements for point A or only considering temperature measurements for point B would distort the quantification of the actual cooling scenario. In contrast, taking into account temperature measurements at point A where the door is closed and at point B where the door is opened (i.e., multiple points in time) may provide the advantage of delivering a more accurate description of the cooling scenario.

[0023] According to a 6th embodiment, the predetermined cooling intensity value is within a range of 1,5 Kelvin Hours and 0,5 Kelvin Hours, and is preferably 1,0 Kelvin Hours.

[0024] Kelvin Hours are a physical unit for quantifying cooling intensity. Thus, indicating the measured cooling intensity in Kelvin Hours may provide compatibility with other methods or systems that use the respective unit. Moreover, Kelvin Hours may ease the understanding of the cooling intensity by personnel. In addition, the mentioned ranges (i.e., between 1,5 Kelvin Hours and 0,5 Kelvin Hours and preferably 1 Kelvin Hours) may provide the advantage of delivering suitable results for evaluating cooling intensity for industrial applications.

[0025] According to a 7th embodiment, the temperature sensor is preferably arranged at a distance to the cooling device of about 0 to 2 meters, more preferably of about 0,5 and 1,5 meters, and most preferred of about 1 meter of the cooling device.

[0026] As previously mentioned, arranging the temperature sensor in the vicinity of the cooling device may provide the advantage of delivering accurate temperature readings. A distance of about 1 meter may provide most accuracy since it is not arranged too far into the room but also not arranged too close to the cooling device. A distance of about 0,5 to 1,5 meters may also provide similar advantages. Finally, a distance of about 0 to 2 meters may also provide similar advantages. If the temperature sensor were arranged further into the cooling area, the measured temperature value may not record the effect of the cooling device accurately. However, a range between 0 and 2 meters provides some flexibility in positioning the temperature sensor as it is not always possible to place the sensor close to the cooling device due to the structure of the area or room to be cooled. For instance, in a cooling area with several cooling devices it might be unclear which cooling device is responsible for the measured temperature. On the other hand, placing the temperature sensor too close to the cooling unit may not accurately reflect the temperature of the cooling area but rather that of the cooling device itself. Consequently, the ranges as suggested above (i.e. 0 to 2, 1,5 to 0,5 and preferably 1 meter) may provide a suitable distance for avoiding the above mentioned scenarios.

[0027] According to an 8th embodiment, the method further comprises: measuring the predetermined minimum duration of time from a last defrost operation.

[0028] Measuring the predetermined minimum duration of time from the last defrost operation ensures that there was no ice present when the measurement for the minimum duration of time was started. Since the minimum duration of time should reflect the minimum amount of time a cooling device has to be actively cooling before ice is able to form, it is crucial to ensure that this time is measured from a point in time where there is no ice present on the cooling device. Accordingly, measuring the predetermined minimum duration of time from a last defrost operation may provide the advantage of accurately measuring the minimal time required for ice to form on the cooling device.

[0029] According to a 9th embodiment, the method further comprises: measuring the predetermined maximum duration of time from a last defrost operation.

[0030] Similar to the minimum duration of time that the cooling device is actively cooling, the maximum duration of time that the cooling device is actively cooling is also measured from the last defrost operation. This again may provide the advantage of ensuring that there is no ice on the cooling device when the maximum time duration measurement starts. This may provide the advantage of measuring the maximum time duration more accurately.

[0031] According to a 10th embodiment, the method further comprises: resetting the time that the cooling device is actively cooling when the defrosting process is initiated, completed or executed.

[0032] Resetting the time that the cooling device is actively cooling when the defrosting process is initiated, completed or executed ensures that the measurements regarding the minimum duration and the maximum duration are performed accurately. Both measurements take into account the time that the cooling device is actively cooling from the last defrost operation. Thus, resetting the time that the cooling device is actively cooling at a specific point in time may provide the advantage of enabling accurate measurements of the previously mentioned time durations.

[0033] According to a 11th embodiment, the cooling device is an air cooler.

[0034] The above-described embodiments are particularly well-suited for air coolers as these kind of cooling devices a typically subject to strong ice formation and thus typically require a large number of defrosting processes to ensure correct and reliable operation.

[0035] A 12th embodiment of the invention is directed to a computer program comprising instructions which, when executed by a computer, causing the computer to carry out the method of any one of the embodiments 1 to 11.

[0036] A 13th embodiment of the invention is directed to a control unit for controlling a defrosting process of a cooling device, the control unit comprising means for performing the method of any one of the embodiments 1 to 11.

[0037] A 14th embodiment of the invention is directed to a cooling device comprising the control unit of embodiment 13.

[0038] A 15th embodiment of the invention is directed to a system comprising a plurality of cooling devices, the system comprising: a first and a second cooling device of the plurality of cooling devices, each comprising a control unit, wherein the control unit comprises means for performing the method of embodiments 1 and 2 and any one of the embodiments 3-11; wherein the predefined defrost time for each of the first and second cooling device is set in a non-overlapping manner.

[0039] The predefined defrost time for each of the first and the second cooling device, preferably air coolers, being set to in a non-overlapping manner may ensure that both cooling devices do not initiate the defrosting process at the same time. Since cooling devices do not cool during a defrost process, this may provide an advantage in situations in which constant cooling must be ensured such as cooling of food and beverages or medical supplies. For instance, if a storage facility needs to be cooled to a certain temperature (e.g., because of the medical supplies that are stored in the facility) and the cooling devices in that facility begin their separate defrosting processes at the same time or in overlapping manners, it may occur that the actual temperature rises over the desired target temperature. Non-overlapping predefined defrost times, as described in the present invention may prevent such situation from occurring.

Brief description of the figures

[0040] Various aspects of the present invention are described in more detail in the following by reference to the accompanying figures without the present invention being limited to the embodiments of these figures.

Fig. 1 illustrates an exemplary cooling scenario according to an embodiment of the present invention;

Fig. 2 illustrates a scheduled defrosting timeline of a first and a second cooling device according to an embodiment of the present invention;

Fig. 3 illustrates a flow chart representing the decision process of whether to initiate a defrosting process according to an embodiment of the present invention;

Fig. 4 illustrates a cooling device according to an embodiment of the present invention;

Fig. 5 illustrates a computer system according to an embodiment of the present invention.

Detailed description of preferred embodiments

[0041] In the following, the invention is described with reference to the accompanying figures in more detail. However, the present invention can also be used in other embodiments not explicitly disclosed hereafter. As detailed below, the embodiments are compatible with each other, and individual features of one embodiment may also be applied to another embodiment.

[0042] Throughout the figures and description, the same reference numerals refer to the same elements, unless stated otherwise. The figures may not be drawn to scale, and the relative size, proportions, and depiction of elements in the figures may be exaggerated for the purpose of clarity, illustration, and convenience. The figures do not limit the scope of the claims but merely support the understanding of the invention.

[0043] Fig. 1 shows an exemplary cooling scenario 100. The aim is to keep the temperature in the room 105 at a target temperature 110. This might for instance be the case in storage facility for medication or food that needs to be stored at a specific target temperature 110. Several cooling devices 120, 130, 140, 150, 160, 170 are installed in the cooling room 105 to achieve the goal of keeping the temperature at the specific target temperature 110. Such a set-up might be common in an industrial setting where the size of the room 105 that is required to be kept at the target temperature 110 is too large to be cooled by a single cooling device. As previously mentioned, while the cooling devices are actively cooling, frost is accumulating, and thus regular defrosting operations are required to maintain efficiency of the cooling devices.

[0044] In the scenario 100 of Fig. 1, a performance-based criterion may be used to assess whether a defrosting process should be initiated. In this case, performance-based criteria my refer to the intensity that the cooling device is actively cooling. This intensity can be measured by comparing the target temperature 110 with an actual temperature that is measure in the vicinity of the cooling device. Fig. 1 shows the temperature sensors 121, 131, 141, 151, 161, 171 that are located in the vicinity of the cooling devices.

[0045] In this example, cooling device A 140 is located in close proximity to the door 101 of the cold storage facility. This means that the temperature that is measured by the temperature sensor 141 of cooling device A 140 shows a higher temperature due to the influx of warm air whenever the door 101 is opened. The temperature measurements from the temperature sensor 141 of cooling device A 140 might for example be -20,5°C measured at time X and -20°C measured at time X + 1. On the other hand, cooling device B 150 is located on the other side of the cold storage facility where the opening and closing of the door 101 does not significantly influence the measured temperature. Accordingly, the temperature measurements from the temperature sensor 151 of cooling device B 150 might for example be -21°C measured at time X and -21°C measured at time X + 1 (i.e., constantly kept hat the target temperature 110). To arrive at the cooling intensity value that is measured in Kelvin Hours, the temperatures that were measured at different points in time are compared to the target temperature 110 and the differences are summed. For cooling device A 140 this results in a difference of 0,5 Kelvin Hours (i.e., actual temperature -20,5°C and target temperature -21°C) + 1,0 Kelvin Hours (i.e., actual temperature -20°C and target temperature -21°C) which is summed up to a total of 1,5 Kelvin Hours. In contrast, for cooling device B 150, this results in a difference of 0 Kelvin Hours (i.e., actual temperature -21°C and target temperature -21°C) + 0 Kelvin Hours (i.e., actual temperature -21°C and target temperature -21°C) which is summed up to a total of 0 Kelvin Hours. From this comparison it can be seen that the cooling intensity of cooling device A 140 is higher than that of cooling device B 150 which makes sense since cooling device A 140 is located closer to the door 101 and is thus exposed to higher temperature fluctuations.

[0046] The cooling intensity of a cooling device is linked to the formation of ice. In other words, the higher the cooling intensity, the more ice accumulates on the cooling device.

[0047] The present embodiment makes use of this fact by measuring the cooling intensity of the cooling device, as described above, and using it as one criterion for determining whether to initiate a defrosting operation of the cooling device. The defrosting process itself may be performed using one or more of standard available methods to defrost a cooler unit in an industrial refrigeration arrangement, such defrosting method may be hot gas defrosting, electric defrosting, chemical defrosting, ultrasonic defrosting etc.

[0048] Note that for the temperature measurements to be accurate, the temperature sensors 121, 131, 141, 151, 161, 171 should be located in the vicinity of the respective cooling devices 120, 130, 140, 150, 160, 170. More specifically, the temperature sensors may be located at a distance of about 0 to 2 meters, preferably at a distance of about 0,5 to 1,5 meters and most preferably at about 1 meter from the cooling device. This distance may provide the advantage of the measured temperature being indicative of the individual cooling intensity of each individual cooling device.

[0049] Fig. 2 shows two scheduled defrosting timelines 210, 220. The upper timeline 210 represents the predefined defrost times for cooling device A 140 and the bottom time line 220 represents the predefine defrost times for cooling device B 150. The two horizontal lines represent time and the vertical lines 211, 212, 213, 221, 222, 223 represent specific point in time at which defrost operations are scheduled.

[0050] It is to note that the specific defrosting times (i.e., 211, 221, 212, 222 etc.) are scheduled in a non-overlapping manner. According to the present embodiment, this means that cooling device A 140 and cooling device B 150 may never perform defrosting operations at the same time. This is particularly relevant in temperature sensitive environments. Referring back to the example discussed in Fig. 1, if the door 101 was opened for a prolonged period of time and all cooling devices were currently performing a defrosting operation, the current rise in temperature could not be countered since all cooling devices are practically disabled at this point. The non-overlapping defrosting schedule as shown in Fig. 2 prevents such a scenario. If the door 101 was opened for a prolonged period of time, there would always be a cooling device that is not currently performing a defrosting operation and could start increasing its cooling activity to manage the sudden temperature rise.

[0051] Fig. 3 shows a flow chart of a method for determining whether to initiate a defrosting process of the cooling device that is usable in industrial environments. It is to note that the sequence of the steps as shown in Fig. 3 is merely an example and that all steps might be executed in a different order or may even be omitted. More specifically, determining that the defrosting process is to be initiated comprises on or more of the steps comprised in the flow chart.

[0052] The flow chart begins at START 300 as shown in the upper right-hand corner and ends at END 380 after resetting the cooling time 370 as shown in the bottom left-hand corner.

[0053] As illustrate in the flow chart of Fig. 3, the first step 310 after starting the method is concerned with determining 210 that a predefined defrost time is reached. With reference to Fig. 2 which describes a timeline 210, 220 of an exemplary defrosting schedule for two cooling devices (cooling device A 140 and cooling device B 150), a predefined defrost time may be a predefined point in time at which a cooling device is schedule to theoretically perform a defrosting operation. Still with reference to Fig. 2, the predefined defrost times are indicated by the vertical lines 211, 212, 213, 221, 222, 223 on the timeline 210, 220. Thus, according to the present embodiment the first step 310 that is shown in the flow charts checks whether a specific point in time is reached (i.e., a vertical line as shown in Fig. 2). If the defrost time has not been reached yet (e.g., the current time is somewhere between two vertical lines in Fig. 2), the check is performed again as indicated by a loop in Fig. 3. If, however, the check is positive and a defrost time is reached, the second step 320 is performed.

[0054] The second step 320 that is illustrated in Fig. 3 checks whether a cooling device has actively been cooling for a minimum duration of time (i.e., whether a minimum cooling time is reached). The minimum duration check is relevant since ice formation can only occur during time period in which a cooling device is actively cooling. Thus, initiating a defrosting process before the cooling device has not actively cooled for a minimum amount of time would not constitute an optimized defrosting schedule and lead to unnecessary defrosting. An exemplary default setting for the minimum duration may be 8 hours, which means that a defrosting cycle is initiated at most every 8 hours and may be available to be changed by a service specialist. The present embodiment is thus simple from a service perspective. It is to note that the minimum time the cooling device is actively cooling is always measured from a last scheduled defrost operation. This ensures that there was no ice present on the cooling device when the timer for the minimum duration was started. The flow chart of Fig. 3 shows that if the minimum duration is not reached, the first step 310 (i.e., determining whether a predefined defrosting time has been reached) is executed. If, on the other hand, the check is positive and the cooling device has actively cooled for a minimum duration, a third step 330 is performed.

[0055] The third step 330 checks whether temperature difference monitoring, which is described in more detail in the fourth step 340, is active for the cooling device. Hence, the process according to Fig. 2 can be executed with or without the steps 340 and 350. The temperature difference refers to the difference in the temperature between the target temperature 110 and the actual temperature that is measured by a temperature sensor 121, 131, 141, 151, 161, 171 that is arranged in the vicinity of a cooling device. An example is provided in Fig. 1. If the temperature difference monitoring is not active, the defrosting process is started 360. However, if the temperature difference monitoring is indeed activated, the fourth step 340 is performed.

[0056] The fourth step 340 is concerned with checking whether a temperature difference is reached (i.e., determining that a cooling intensity is larger than or equal to a predetermined cooling intensity value). The idea behind this step is to include a performance-based metric into the process. The difference in temperature should represent the intensity of the cooling activity of the cooling device. More specifically, it is predetermined at which cooling intensity value the check should result in a positive result. Note that a positive result (i.e., reaching the predefined cooling intensity) triggers the defrosting operation. Exemplary predetermined cooling intensity values may include but are not limited to 1,5 Kelvin Hours, 0,5 Kelvin Hour or preferably 1 Kelvin Hour. The process of measuring the cooling intensity has been described in detail in the example of Fig. 1. In summary, measurements from the temperature sensor 121, 131, 141, 151, 161, 171 that is arrange in the vicinity of the cooling device are compared to a target temperature 110. Those differences are summed up over a period of time and it is checked whether the summed differences exceed the predefined cooling intensity value that is indicated in Kelvin Hours. As mentioned, if this check is positive the defrosting process is initiated. However, if the check is a negative (i.e., summed temperature difference not reaching the predefined cooling intensity) the execution of the fifth step 350 is triggered.

[0057] Similar to the second step 320, the fifth step 350 checks whether a cooling device has actively been cooling for a maximum duration of time (i.e., whether a maximal cooling time is reached). An exemplary default setting for the maximum duration may be 24 hours, which means that a defrosting cycle is initiated at least every 24 hours and may be available to be changed by service specialist. The present embodiment is thus simple from a service perspective. As mentioned above, even if the cooling intensity does not reach a predefined level, there might still be a slow formation of ice on the cooling device. Thus, the maximum time criteria (i.e., mandatory defrost) ensures that a cooling unit is defrosted at regular intervals. This may also be relevant due to safety concerns where ice formation leads to a heavy load on the cooling device and could not only be inefficient in terms of cooling activity but also pose a safety hazard. It is to note that the maximum time the cooling device is actively cooling is always measured from a last scheduled defrost operation. This ensures that there was no ice present on the cooling device at the point in time that the timer for the maximum duration was started. If the maximum time the cooling device has actively cooled is not reached yet, the first step 310 of whether a predetermined defrost time has been reached is executed again. However, if the maximum time the cooling device has actively cooled is reached, the defrosting step 360 is executed.

[0058] As shown in the description above, the defrosting step 360 can be reached through different paths and is not limited to the paths specifically mentioned in this description. The defrosting step itself comprises the operation of defrosting the cooling device.

[0059] Finally, when the defrosting step 360 is initiated, completed or executed, the reset timer step 370 is performed. The reset timer 370 step comprises resetting the time that the cooling device has actively been cooling. This value is relevant for the calculation of the minimum duration and the calculation of the maximum duration.

[0060] Once the reset timer step 370 is concluded the process concludes with END 380. In summary, the flow chart of Fig. 3 demonstrates the flexible method of the present embodiment which automatically adjusts the number of defrost procedures depending on true working conditions (moist air infiltration, ambient temperature, seasonal changes, product load, etc.). It also become obvious that the present embodiment covers all benefits of the conventional methods such as the fixed time schedule method.

[0061] Fig. 4 shows an exemplary illustration of a cooling device 400. In particular, Fig. 4 shows an air cooler that is typically used in combination with a plurality of air coolers in an industrial set-up. A typical use case is described in more detail in Fig. 1 and includes for example the cooling of a warehouse by a plurality of air coolers. It is to note that the present embodiment is not limited to an air cooler but could be directed to any type of cooling device 400.

[0062] A temperature sensor 410, that is arranged in the vicinity of the cooling device is shown on the left-hand side of the cooling device. As described in detail in Fig. 3, the temperature sensor 410 measures the local temperature at different points in time to calculate an integral value and determine the cooling intensity of the cooling device. Moreover, Fig. 4 shows that the air cooler comprises a main body 420 through which the air is circulated by means of a fan (not shown) and an exit 430 that emits the air towards the right-hand side of the cooling device 400 as indicated by the arrow 440. The circulated air may be passed over a heat exchanger arrangement which may be in thermal connection with an evaporator in which a refrigerant agent may boil and extract the heat from the circulated air flow.

[0063] Although not visible in Fig. 4, the air cooler comprises a cooling unit that is configured to execute a computer-implemented method for determining whether to initiate a defrosting process of the cooling device.

[0064] One advantageous of the present embodiment related to a method for determining whether to initiate a defrosting process beside substantial energy consumption reduction may be that the lifetime of the cooling device 400 is increased due to a likely decrease in defrosting cycles. The decreased number of defrosting cycles that may arise may also lead to less commissioning and less maintenance requirements compared to conventional methods that for example used a fixed schedule. For instance, safety measurements that are already implemented to protect from overweight due to excessive ice formation may also be applicable to the present invention. A general advantage of the current invention may be its reliability and simplicity from the perspective of the user or a service worker.

[0065] Fig. 5 illustrates a processing system 500 for executing instruction to perform the method for determining whether to initiate a defrosting process of a cooling device usable in an industrial environment. As illustrated in Fig. 4, the processing system 500 comprises a storage subsystem 501, one or more processors 502, a network interface 503 and a user interface and output device 505. The components of the processing system may be connected via a central bus system 506 illustrates at the arrow in Fig. 4. The bus system 506 may be responsible for providing a secure and reliable manner through which the different components of the processing system may communicate. The storage subsystem 501 may store computer program code that when executed performs the method for determining whether to initiate the defrosting process. The one or more central processing units 502 may be responsible for executing the program code. The user interface and output device 505 may be used to adapt predetermined values such as the value of the minimal duration that a cooling device is actively cooling or the value of the maximum duration that a cooling device is actively cooling.

[0066] The processing system 500 may be sued to implement a control unit for controlling a cooling device.

[0067] Embodiments of the present disclosure may be realized in any of various forms, e.g., in software. For example, in some embodiments, the present invention may be realized as a computer-implemented method, a computer-readable memory medium, or a computer system.

[0068] In some embodiments, a non-transitory computer-readable memory medium may be configured so that it stores program instructions and/or data, where the program instructions, if executed by a computer system, cause the computer system to perform a method, e.g., any of the method embodiments described herein, or, any combination of the method embodiments described herein, or, any subset of any of the method embodiments described herein, or, any combination of such subsets.

[0069] In some embodiments, a computing device may be configured to include a processor (or a set of processors) and a memory medium, where the memory medium stores program instructions, where the processor is configured to read and execute the program instructions from the memory medium, where the program instructions are executable to implement any of the various method embodiments described herein (or, any combination of the method embodiments described herein, or, any subset of any of the method embodiments described herein, or, any combination of such subsets). The device may be realized in any of various forms.

[0070] Although specific embodiments have been described above, these embodiments are not intended to limit the scope of the present disclosure, even where only a single embodiment is described with respect to a particular feature. Examples of features provided in the disclosure are intended to be illustrative rather than restrictive unless stated otherwise. The above description is intended to cover such alternatives, modifications, and equivalents as would be apparent to a person skilled in the art having the benefit of this disclosure.

[0071] The scope of the present disclosure includes any feature or combination of features disclosed herein (either explicitly or implicitly), or any generalization thereof, whether or not it mitigates any or all of the problems addressed herein. In particular, with reference to the appended claims, features from dependent claims may be combined with those of the independent claims and features from respective independent claims may be combined in any appropriate manner and not merely in the specific combinations enumerated in the appended claims.

List of reference signs

[0072]

101 door

105 room

110 target temperature

120, 130, 140, 150, 160, 170, 400 cooling device

121, 131, 141, 151, 161, 171, 410 temperature sensor

210 upper time line

211-213, 221-223 vertical lines

220 bottom time line

300 START

310 first step

320 second step

330 third step

340 fourth step

350 fifth step

360 defrosting step

370 reset timer

380 END

420 main body

430 exit

440 arrow

500 processing system

501 storage subsystem

502 processor(s)

503 network interface

505 user interface and output device

506 bus system

Claims

1. A computer-implemented method for determining whether to initiate a defrosting process of a cooling device usable in an industrial environment (120), the method comprising:

determining that the defrosting process is to be initiated, comprising one or more of the following steps:

determining (320) that a predetermined minimum duration of time that the cooling

device (120) is actively cooling is reached;
determining (340) that a cooling intensity is larger than or equal to a predetermined cooling intensity value; and/or
determining (350) that a predetermined maximum duration of time the cooling device (120) is actively cooling is reached;

if it has been determined that the defrosting process is to be initiated:
initiating (360) the defrosting process of the cooling device (120).

2. The method of claim 1, wherein the step of determining that the defrosting process is to be initiated further comprising:
determining (310) that a predefined defrost time is reached.

3. The method of any one of the preceding claims, determining (340) that the cooling intensity is larger than or equal to the predetermined cooling intensity value further comprising:

obtaining an integral temperature value;
comparing the integral temperature value against the predetermined cooling intensity value.

4. The method of claim 3, wherein obtaining the integral temperature value further comprises:

receiving a first and second temperature value from a temperature sensor arranged in the vicinity of the cooling device (120);
calculating a first difference between the received first temperature value and a target cooling temperature;
calculating a second difference between a second temperature value and the target cooling temperature; and
accumulating the calculated first and second difference.

5. The method of claim 4, wherein the first and second temperature value are obtained at different points in time.

6. The method of any one of the preceding claims, wherein the predetermined cooling intensity value is within a range of 1,5 Kelvin Hours and 0,5 Kelvin Hours, and is preferably 1,0 Kelvin Hours.

7. The method of any one of the preceding claims 4 to 6, wherein the temperature sensor is preferably arranged at a distance to the cooling device (120) of about 0 to 2 meters, more preferably of about 0,5 and 1,5 meters, and most preferred of about 1 meter of the cooling device (120).

8. The method of any one of the preceding claims, the method further comprising:
measuring the predetermined minimum duration of time from a last defrost operation.

9. The method of any one of the preceding claims, the method further comprising:
measuring the predetermined maximum duration of time from a last defrost operation.

10. The method of any one of the preceding claims, the method further comprising:
resetting (370) the time that the cooling device (120) is actively cooling when the defrosting process is initiated, completed or executed.

11. The method of any one of the preceding claims, wherein the cooling device (120) is an air cooler.

12. A computer program comprising instructions which, when executed by a computer, causing the computer to carry out the method of any one of claims 1 to 11.

13. A control unit for controlling a defrosting process of a cooling device (120), the control unit comprising means for performing the method of any one of claims 1 to 11.

14. A cooling device (120) comprising the control unit of claim 13.

15. A system comprising a plurality of cooling devices, the system comprising:

a first and a second cooling device (120) of the plurality of cooling devices, each comprising a control unit, wherein the control unit comprises means for performing the method of claims 1 and 2 and any one of the claims 3-11;
wherein the predefined defrost time for each of the first and second cooling device (120) is set in a non-overlapping manner.

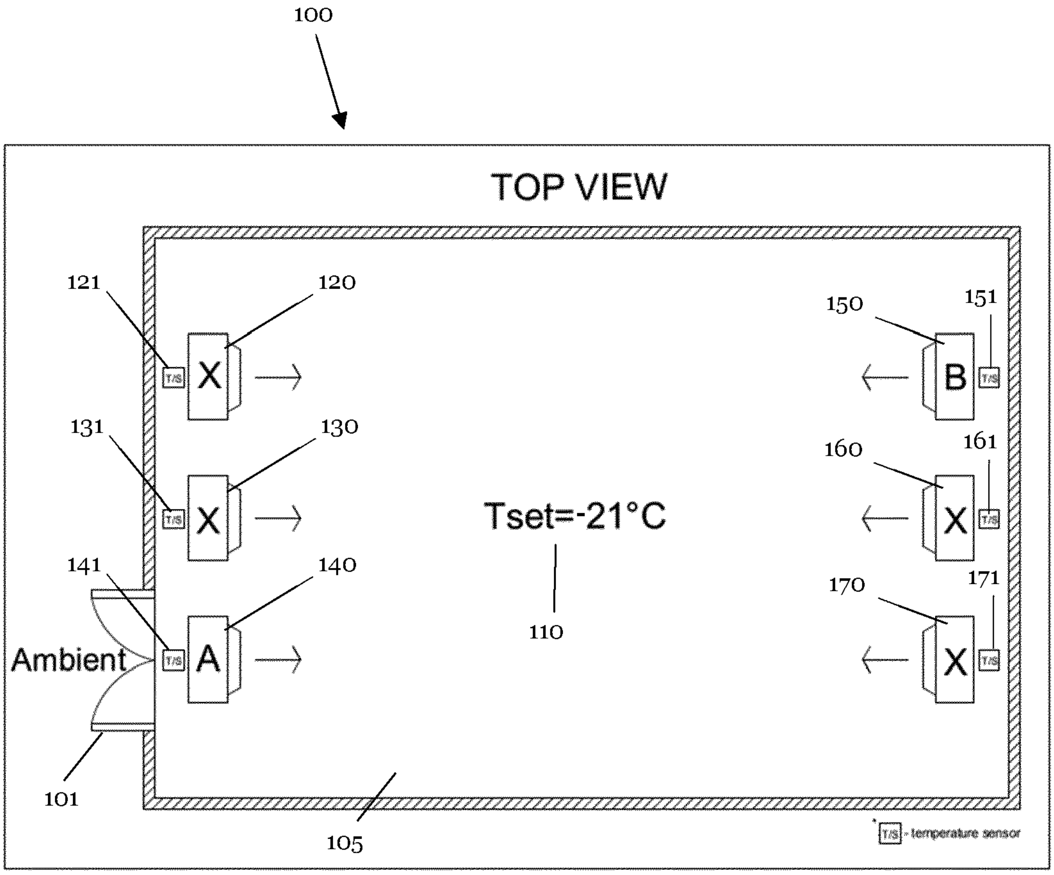
100
TOP VIEW
121
120
131
130
141
140
X
X
A
Ambient
101
105
Tset=-21°C
110
150
151
160
161
170
171
B
X
X
T/S
T/S - temperature sensor

Fig. 1

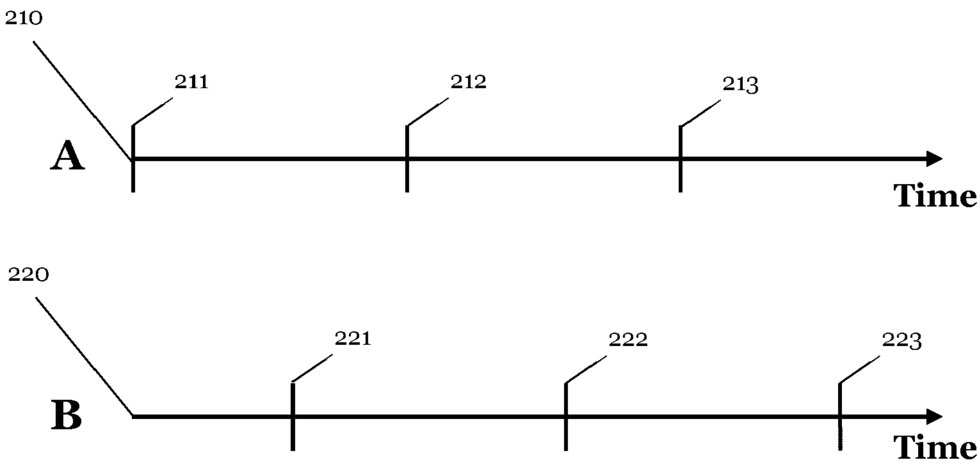

Fig. 2

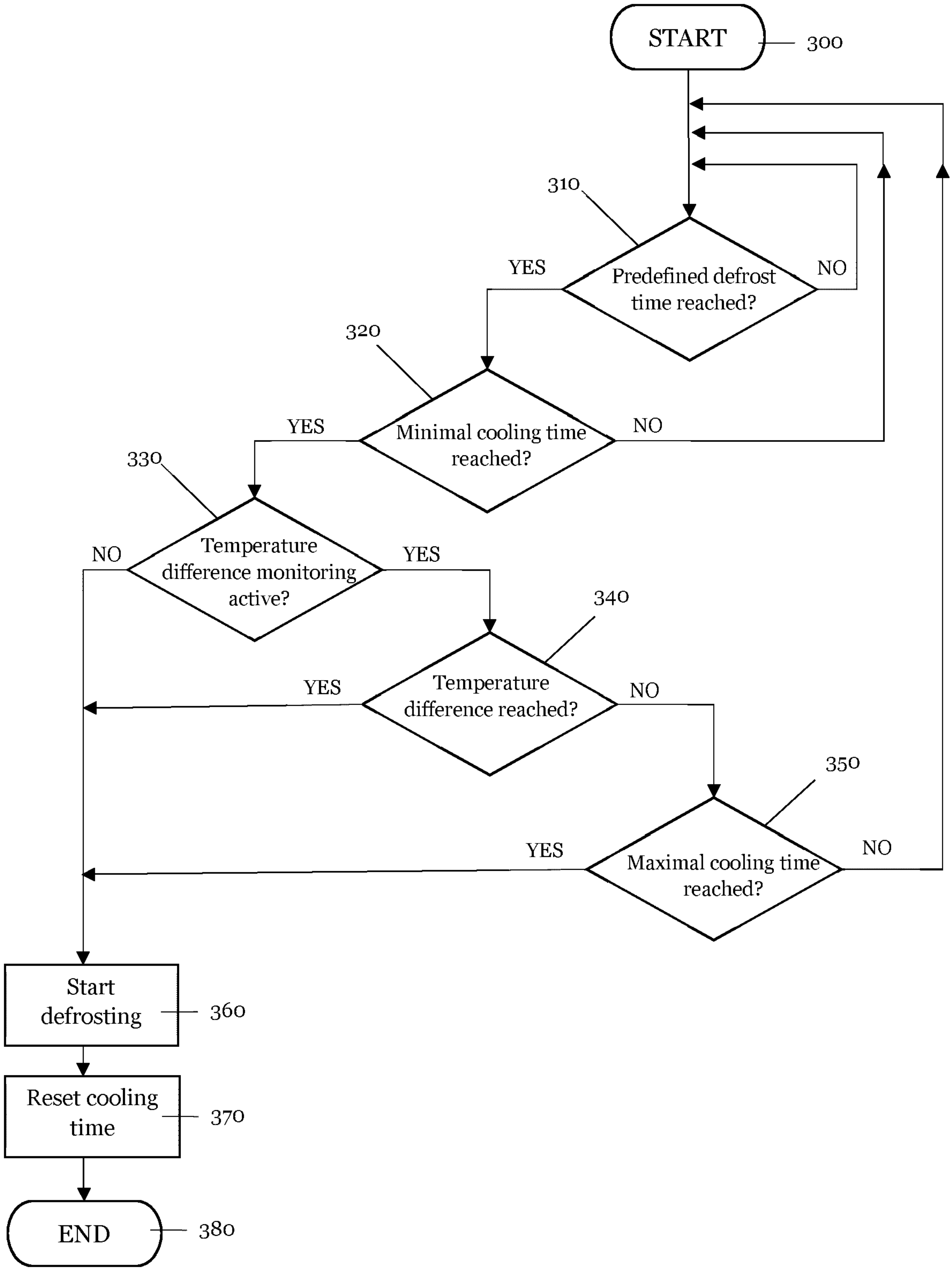
START
300
310
Predefined defrost time reached?
YES
NO
320
Minimal cooling time reached?
YES
NO
330
Temperature difference monitoring active?
NO
YES
340
Temperature difference reached?
YES
NO
350
Maximal cooling time reached?
YES
NO
Start defrosting
360
Reset cooling time
370
END
380

Fig. 3

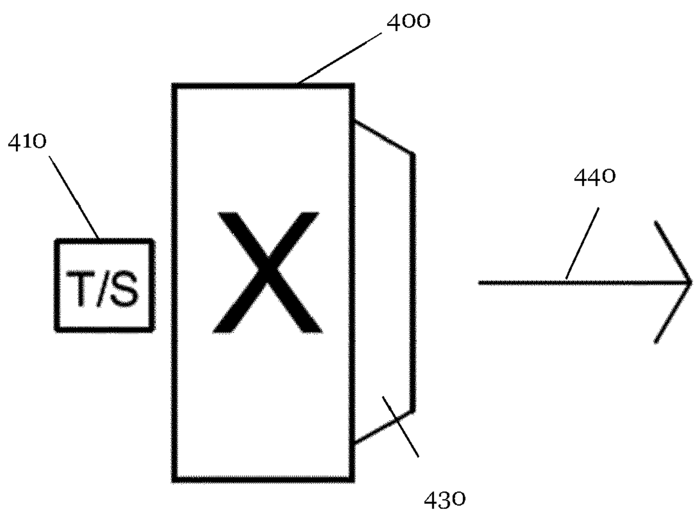

Fig. 4

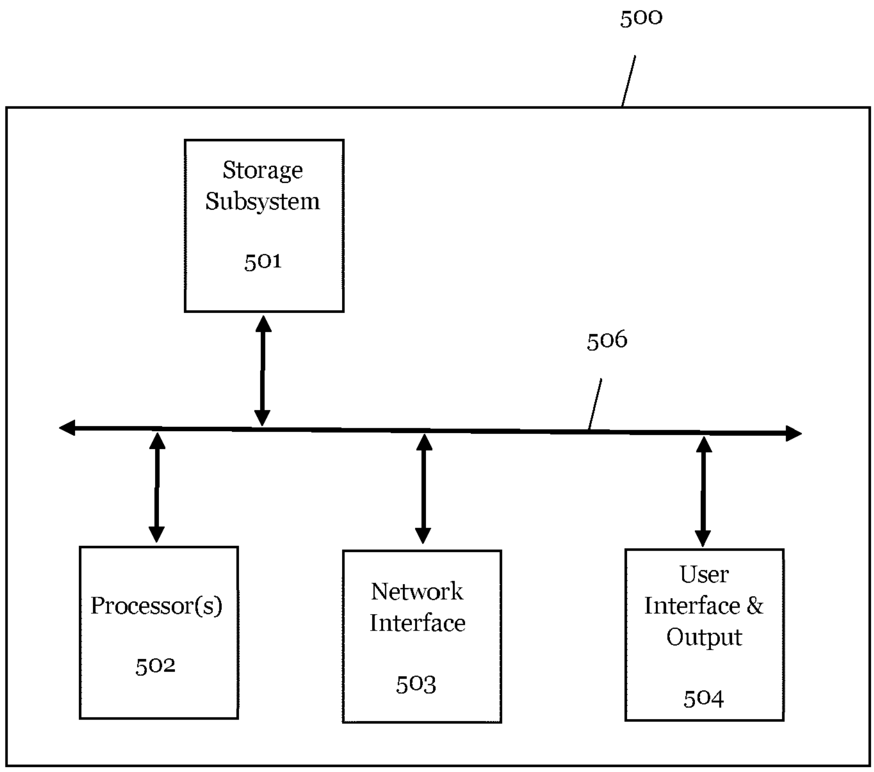
500
Storage Subsystem
501
506
Processor(s)
502
Network Interface
503
User Interface & Output
504

Fig. 5

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 22 0434

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2020/230178 A1 (ELIWELL CONTROLS S R L CON UNICO SOCIO [IT]) 19 November 2020 (2020-11-19)	1,2,8-15	INV. F25D21/00
Y	* figures 2-6 *	3-7	
X	KR 2017 0132939 A (DAYOU WINIA CO LTD [KR]) 5 December 2017 (2017-12-05) * paragraphs [0005], [0025] *	1,2,8-15	
Y	EP 4 148 355 A1 (LG ELECTRONICS INC [KR]) 15 March 2023 (2023-03-15) * figure 11 *	3-7	
A	EP 2 426 443 A2 (SAMSUNG ELECTRONICS CO LTD [KR]) 7 March 2012 (2012-03-07) * paragraph [0006] - paragraph [0007] *	1,2, 8-10, 12-14	

TECHNICAL FIELDS SEARCHED (IPC)

F25D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	16 May 2024	Kuljis, Bruno

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 23 22 0434

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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16-05-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2020230178 A1	19-11-2020	BR 112021022045 A2	28-12-2021
		CN 113825962 A	21-12-2021
		EP 3969826 A1	23-03-2022
		US 2022260301 A1	18-08-2022
		WO 2020230178 A1	19-11-2020
KR 20170132939 A	05-12-2017	NONE	
EP 4148355 A1	15-03-2023	EP 4148355 A1	15-03-2023
		US 2023160625 A1	25-05-2023
		WO 2021225308 A1	11-11-2021
EP 2426443 A2	07-03-2012	CN 102384614 A	21-03-2012
		EP 2426443 A2	07-03-2012
		KR 20120022315 A	12-03-2012
		US 2012055181 A1	08-03-2012

EPO FORM P0459

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