(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 265 986 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.10.2023 Bulletin 2023/43

(21) Application number: **22168840.1**

(22) Date of filing: **19.04.2022**

(51) International Patent Classification (IPC):
F25D 17/02 *(2006.01)* ***F25D 25/00*** *(2006.01)*
F25D 25/02 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F25D 17/02; F25D 25/005; F25D 25/028;
F25D 11/003; F25D 2400/32; F25D 2400/38

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) SYSTEM AND METHOD FOR TEMPERATURE-CONTROLLED STORAGE AND/OR TRANSPORT OF A PRODUCT

(57) The present invention relates to a system for temperature-controlled storage and/or transport of a product, comprising:
- a plurality of thermally-insulated product containers, each comprising a thermally insulated product receiving chamber, which is at least partly lined with a heat-conductive plate, wherein part of the heat-conductive plate is exposed to an outside of the product container;
- at least one storage rack for supporting the product containers,
comprising a hollow frame formed by a plurality of hollow tube elements of heat-conductive material, which are connected to each other to define a fluid flow path between a fluid inlet and a fluid outlet of the hollow frame, wherein the frame provides a support for the product containers and a structure giving shape and strength to the rack; and
- a temperature-regulating device, configured to cool or heat a heat-transfer fluid, wherein the device comprises a device inlet for the heat-transfer fluid and a device outlet for cooled or heated heat-transfer fluid and wherein the device outlet is fluidly connectable to the fluid inlet of the hollow frame and wherein the device inlet is fluidly connectable to the fluid outlet of the hollow frame,
wherein the part of the heat-conductive plate that is exposed to an outside of the product container can be brought in direct heat-conductive contact with the support for the product containers when the product container is placed on the support.

The invention further relates to a method for temperature-controlled storage and/or transport of a product using such system.

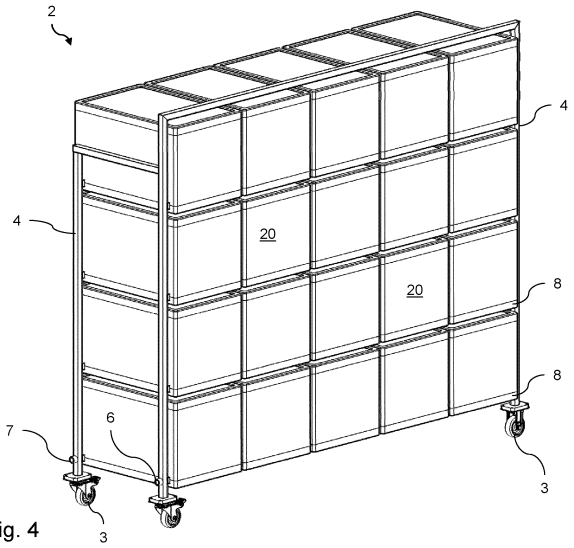

Fig. 4

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Description

Field of the invention

[0001] The present invention relates to a system for temperature-controlled storage and/or transport of a product, for example of a perishable food product or a medicament that has to be kept at ambient or low temperature or in a frozen condition. The present invention further relates to a method for temperature-controlled storage and/or transport of a product.

Background of the invention

[0002] At present, it has become a trend to deliver food products or medicaments at the homes of consumers, instead of requiring consumers to pick up the products at a retail location such as a shop or pharmacy. For products that have to be delivered in ambient, cooled or frozen condition, small-scale distribution or last mile delivery from a central warehouse or a store to the customer, is often done in thermally-insulated containers that contain ice packs, ice blocks, or dry ice to control the temperature of the products in the containers.

[0003] The use of separate items for passive cooling, such as ice packs, ice blocks, or dry ice, however, has many disadvantages. It requires additional handling and equipment for freezing the items, and additional handling for putting the items in the containers and recollecting them. The items add substantial weight to the product containers to be delivered, reduce the effective product storage volume in the product container, and may cause freeze- or mechanical damage to the products in the container.

[0004] Alternatively, products can be transported in a temperature-controlled cargo space of a vehicle. Such temperature-control is, however, relatively energy consuming and expensive since the entire cargo space that has to be kept at a certain temperature. Moreover, such temperature-control is inefficient for delivery to individual customers, in particular in an urban environment, since such delivery requires the cargo space doors to be opened many times.

[0005] In FR 2 689 222 A1 is disclosed a system for controlling the temperature of products during transport. The system comprises a large, mobile, thermally-insulated container that can contain several trays with food products. The container comprises a reservoir with fluid coolant. At a stationary charging station, the fluid coolant in the container is actively cooled by engaging the thermally-insulated container to a stationary cooling device. The mobile container is then detached from the cooling device. During transport, the fluid coolant passively cools the container content by diffusing its 'cold' into the container, so that the products in the container can be kept at a low temperature for several hours.

[0006] The system of FR 2 689 222 A1 does not provide active cooling of the container content during transport. The time during which products can be kept cool is thus limited. Furthermore, the system of FR 2 689 222 A1 requires engagement of each container to a stationary cooling device with an evaporator. This makes the system relatively complex and expensive and unsuitable for delivery of a relatively small number of products to several customers, as is typically the case in urban delivery to consumers.

[0007] In EP 0 413 729 B1 to disclosed a portable thermoelectrically-operated heating and cooling unit to which a detachable food appliance can be connected to cool or warm food therein. The detachable food appliance may for example be a food storage container, a bottle heating and cooling assembly, or an ice cube maker. The portable thermoelectrically-operated heating and cooling unit of EP 0 413 729 B1 is suitable for cooling or heating with an electric source from either a vehicle battery through the cigarette lighter or from any outlet alternating current source within a household. The assembly of portable thermoelectrically-operated heating and cooling unit and detachable food appliance provides direct thermoelectrically cooling or heating, for example by means of a Peltier elements, of a single household appliance. Such assembly is not suitable for temperature-controlled transport of perishable products in several product containers, such as is required for small-scale distribution to retailers or for last mile delivery of food products or medicaments to consumers.

[0008] There is a need for a system for temperature-controlled storage and/or transport of products that overcomes above-mentioned problems and drawbacks.

Summary of the invention

[0009] The inventors have found a novel system for temperature-controlled storage and/or transport of a product comprising at least one storage rack comprising a hollow frame formed by a plurality of hollow tube elements of a heat-conductive material, such as e.g. a metal, that define a fluid flow path for a heat-transfer fluid. The fluid flow path in the hollow frame has an inlet and an outlet that are connectable to the outlet and inlet, respectively, of a temperature-regulating device so that cooled or heated heat-transfer fluid from the temperature-regulating device can circulate through the hollow frame of the storage rack. The system also comprises a plurality of thermally-insulated product containers, each comprising a product receiving chamber for the product(s) to be stored or transported under temperature-controlled conditions, wherein the product receiving chamber is at least partly lined with a heat-conductive plate, which plate is in direct heat-conductive contact with the hollow frame of the storage rack through which the heat-transfer fluid circulates when the product container is placed on the rack for storage or transport. The hollow frame of the storage rack serves several purposes. It provides both a support for the product containers and a structure giving shape and strength to the support rack, and it transfers

heat or cold to the product containers via the heat-transfer fluid flowing through it to control the temperature in the product containers supported on it.

[0010] Accordingly, the present invention provides in a first aspect a system for temperature-controlled storage and/or transport of a product, comprising:

- a plurality of thermally-insulated product containers, each comprising a thermally insulated product receiving chamber, which is at least partly lined with a heat-conductive plate, wherein part of the heat-conductive plate is exposed to an outside of the product container;
- at least one storage rack for supporting the product containers,
  comprising a hollow frame formed by a plurality of hollow tube elements of heat-conductive material, which are connected to each other to define a fluid flow path between a fluid inlet and a fluid outlet of the hollow frame, wherein the frame provides a support for the product containers and a structure giving shape and strength to the rack; and
- a temperature-regulating device, configured to cool or heat a heat-transfer fluid, wherein the device comprises a device inlet for the heat-transfer fluid and a device outlet for cooled or heated heat-transfer fluid and wherein the device outlet is fluidly connectable to the fluid inlet of the hollow frame and wherein the device inlet is fluidly connectable to the fluid outlet of the hollow frame,

wherein the part of the heat-conductive plate that is exposed to an outside of the product container can be brought in direct heat-conductive contact with the support for the product containers when the product container is placed on the support.

[0011] The temperature-controlled storage and/or transport system according to the invention advantageously provides a system that can be used without separate items for passive cooling or heating, such as ice packs, ice blocks, or dry ice, in the product containers.

[0012] The system according to the invention is particularly suitable for temperature-controlled transport of products in a vehicle with a cargo space, such as for example a cargo van or a delivery truck, as typically used for urban delivery of products to consumers. The storage rack is relatively light-weight since it has a frame formed by hollow tube elements and is particularly suitable to be provided with wheels to be wheeled in and out the cargo space of such vehicle. The system is such that the temperature-regulating device can be located at a certain distance of the storage rack, preferably outside the space wherein the storage rack carrying product containers is located, such as the cargo space of a vehicle, so that any heat or cold generated by the temperature-regulating device is not released in the same space as the products to be kept at a controlled temperature are present. Thus, energy consumption is minimized.

[0013] The present invention provides a benefit over existing storage and transportation systems in that the containers themselves are relatively simple. Except for the heat-conductive plate lining the product receiving chamber, the product containers do not need to comprise or contain any other means for passive or active cooling (or heating), since the hollow frame of the storage rack serve the purpose of transferring cold or heat to the containers. Thus, the containers can be relatively light and its volume can be used more efficiently for storing and/or transporting products.

[0014] In a second aspect, the invention provides a method for temperature-controlled storage and/or transport of a product, using a system as disclosed herein, the method comprising the steps of:

a) placing the product in the product receiving chamber of the thermally-insulated product container;
b) placing the product container with product on the support of the storage rack such that at least part of the heat-conductive plate exposed to an outside of the product container is in direct heat-conductive contact with the support;
c) fluidly connecting the device outlet to the fluid inlet of the hollow frame and the device inlet to the fluid outlet of the hollow frame; and
d) circulating cooled or heated heat-transfer fluid from the temperature-regulating device through the fluid flow path in the hollow frame of the storage rack back to the temperature-regulating device.

[0015] The method is user-friendly, requiring relatively little handling. The method only requires placing the product containers filled with product on the storage rack and fluidly connecting the storage rack to the temperature-regulating device to effect circulation of heat-transfer fluid with a set temperature through the hollow frame of the storage rack. Thus, all containers placed on the hollow frame of the rack are temperature-controlled.

Detailed description of the invention

[0016] The system for temperature-controlled storage and/or transport of a product according to the invention comprises a plurality of thermally-insulated product containers, at least one support rack for supporting the product containers, and a temperature-regulating device.

[0017] Each of the product containers comprises a thermally-insulated product receiving chamber. The product receiving chamber is at least partly lined with a heat-conductive plate. Part of the heat-conductive plate is exposed to an outside of the product container, so that it can be brought in direct heat-conductive contact with the support provided by the hollow frame of the storage rack when the product container is placed on the support.

[0018] Preferably, each of the product containers is the same in size, shape, construction and materials used. The product container may have any suitable shape,

preferably the container is in the shape of a rectangular or square box. Preferably, the container has side walls, more preferably four side walls placed at right angles relative to each other. The side walls preferably comprise or consist of thermally-insulating material. The product container may comprise a lid, preferably a top lid, for opening the container to place any products into the product receiving chamber or to remove any products from it. The lid is preferably made of thermally-insulated material. Any suitable thermally-insulating material may be used for the side walls and/or the lid, for example expanded polystyrene (often referred to as polystyrene foam) or polyurethane foam. Expanded polystyrene is a particularly preferred thermally-insulating material, since it combines good thermal insulation properties with a relatively low weight.

[0019] Preferably, the container has a bottom wall that is at least partly formed by the heat-conductive plate that at least partly lines the product receiving chamber. The container bottom wall may comprise thermally-insulating material. If the container bottom wall comprises thermally-insulating material, such material preferably contains an opening for exposing part of the heat-conductive plate to the outside at the lower end of the container so that it can be brought in heat-conductive contact with the support of the storage rack when the container is placed on the support.

[0020] The heat-conductive plate preferably at least lines the bottom surface of the product receiving chamber, more preferably the bottom and part of any side surfaces of the product receiving chamber. The plate may for example be in the form of a bottom plate lining the bottom surface of the product receiving chamber, an U-shaped plate lining the bottom surface and at least part of two side surfaces, or a double U-shaped plate lining the bottom surface and at least part of four side surfaces of the product receiving chamber. Preferably, the heat-conductive plate is exposed to an outside of the product container at the lower end of the container. The heat-conductive plate preferably is composed of a single sheet that may be bent in an U-shape or double U-shape if lining both the bottom surface and part of a side surface of the product receiving chamber. Alternatively, the heat-conductive plate may be composed of multiple sheets that are heat-conductively connected to each other, for example by a welded or brazed joint. The heat-conductive plate may comprise one or more additional surfaces that project into the product receiving chamber to increase the surface area of the heat-conductive plate inside the product receiving chamber to increase heat exchange capacity. The additional surface may for example form a vertical separation wall in the product receiving chamber.

[0021] The heat-conductive plate preferably is a metal plate, more preferably a plate made of an aluminium alloy. Aluminium alloy in particular offers a suitable balance between a relatively large thermal conductivity and a relatively low weight.

[0022] The heat-conductive plate may have any suitable thickness, preferably a thickness in the range between 1 mm and 5 mm, more preferably of from 1.5 to 4 mm.

[0023] Preferably, the product container is composed of four side walls of thermally-insulating material connected to each other at square angles and a metal heat-conductive plate insert, preferably an U-shaped or double U-shaped metal plate insert that tightly fits within the four side walls. By sliding the metal plate insert into the four side walls, a product container is formed with a product receiving chamber that is lined at its bottom end and at part of its side walls with the metal plate. The top end of the container may be opened and closed with a top lid, preferably a top lid of the same thermally-insulated material as the side walls. In order to prevent the metal insert from sliding out of the four side walls via an open lower end of the container, the side walls may comprise an inwardly protruding ridge for supporting the metal insert. The shape of the U-shaped or double U-shaped metal plate insert may be adapted to engage with the inwardly protruding ridge. Such an inwardly protruding ridge is preferably located at two opposing side walls or at all four side walls of the product container.

[0024] The system comprises at least one storage rack for supporting the product containers. The storage rack comprises a hollow frame formed by a plurality of hollow tube elements of heat-conductive material. The tube elements are interconnected to define a fluid flow path for a heat-transfer fluid between a fluid inlet and a fluid outlet of the hollow frame. The hollow frame provides a support for the product containers and provides shape and strength to the rack. During normal operation of the system, cooled or heated heat-transfer fluid from the temperature-regulating device flows through the fluid flow path defined by the hollow frame of the storage rack for temperature control of product in any product container placed on the support provided by the hollow frame and in heat-conductive contact with the support via the heat-conductive plate exposed to an outside of the container.

[0025] The tube elements are made of heat-conductive material, preferably of metal, more preferably of an aluminium alloy. The tube elements may for example be aluminium alloy extrusion profiles. The hollow frame is formed by connecting the plurality of tube elements to each other, for example by welding.

[0026] The tube elements may have any suitable shape. Preferably, the tube elements are square or rectangular tube elements in order to maximise the surface area of heat-conductive contact between the support and the heat-conductive plate exposed to the outside of any product containers placed on the support.

[0027] The hollow frame of the storage rack is preferably configured to support in the range of from 4 to 50 product containers, more preferably of from 8 to 40 product containers, even more preferably of from 16 to 30 product containers, in such a way that each container can be brought in direct heat-conductive contact with the

support provided by the hollow frame. The hollow frame may support the multiple product containers in a row, i.e. next to each other, and/or above each other, preferably in several rows above each other. The hollow frame may for example be configured to support 20 product containers in four rows above each other, wherein five product containers are supported in each row.

[0028] Preferably, the hollow frame of the storage rack is configured such that it can support product containers with no or only a small gap between adjacent product containers. Thus, loss of cold or heat is avoided and the energy needed for temperature-control of the products in the containers is minimized and thermal insulation of the product receiving chambers is improved. If the hollow frame can support containers in several support rows above each other, the hollow frame is preferably configured such that the distance between the top end of a product container in a support row and the part of the hollow frame providing the above support row is minimized for the same reason.

[0029] The fluid flow path defined by the hollow frame is configured such that under normal operation of the system, heat-transfer fluid flows through the entire fluid flow path. Not all of the heat-transfer fluid supplied via the fluid inlet may flow through the entire fluid flow path (in other words: heat-transfer fluid may have different trajectories through the fluid flow path), but the fluid flow path is configured such that the hydraulic resistance of any possible trajectory of heat-transfer fluid is substantially equal so that there is an equal flow of heat-transfer fluid at any point in the fluid flow path and the heat-conductive capacity of the frame via the heat-transfer fluid flowing though the frame is the same at any location of the frame. It will be appreciated that the length, diameter, and shape of the fluid flow part and the positions of the fluid inlet and the fluid outlet will affect the hydraulic resistance. It is within the skills of the skilled person to configurate a fluid flow path with such substantially equal hydraulic resistance of any possible trajectory of heat-transfer fluid.

[0030] Preferably, the hollow frame defines one fluid flow path between one fluid inlet and one fluid outlet of the hollow frame.

[0031] The fluid inlet and the fluid outlet may be positioned at any suitable location of the hollow frame.

[0032] The storage rack preferably comprises thermally-insulating material configured such that the hollow frame is partly embedded in the thermally-insulating material. More preferably, the hollow frame is partly embedded in thermally insulating material, in such a way that it comprises container locations for supporting a product container at which the heat-conductive material of the tube elements is exposed (not embedded in thermally-insulating material) for direct heat-conductive contact with the part of the heat-conductive plate that is exposed to an outside of the product container. In other words, at such container locations a top surface of the support provided by the hollow frame is exposed and can be brought in direct heat-conductive contact with the exposed heat-conductive plate at the outside of the product container, typically at its lower end, when the product container is placed on the support at the contained location. The thermally insulating material is configured to thermally insulate the hollow frame where it will not be in heat-conductive contact with the product container.

[0033] The part of the heat-conductive plate exposed to an outside of the product container may have a surface area that is larger than the surface area of the hollow frame that is in direct heat-conductive contact with such exposed part when the product container is placed on the support. In order to prevent leakage of cold or heat, the part of the exposed heat-conductive plate not in direct contact with the hollow frame may be covered by thermally-insulated material, for example by providing the hollow frame with thermally-insulated material between tube elements that support a product container.

[0034] The thermally-insulating material comprised in the storage rack may be any suitable thermally-insulating material, for example expanded polystyrene or polyurethane foam. Expanded polystyrene is a particularly preferred thermally-insulating material, since it combines good thermal insulation properties with a relatively low weight.

[0035] Preferably, the storage rack is a mobile storage rack, comprising one or more wheels. A mobile storage rack is a benefit when the system is used in a vehicle, since multiple product containers can be moved into the vehicle simultaneously, by simply wheeling the storage rack with product containers into a cargo space of the vehicle.

[0036] The system comprises a temperature-regulating device, configured to cool or heat a heat-transfer fluid, wherein the device comprises a device inlet for the heat-transfer fluid and a device outlet for cooled or heated heat-transfer fluid. The device outlet is fluidly connectable to the fluid inlet of the hollow frame and the device inlet is fluidly connectable to the fluid outlet of the hollow frame.

[0037] During use of the system, the respective inlets and outlets are fluidly connected so that heat-transfer fluid can circulate from the temperature-regulating device through the fluid flow path defined by the hollow frame of the storage rack and back to the temperature-regulating device. The fluid connection between the respective inlets and outlets may for example be established by means of a flexible conduit such as a hose. At the respective inlets and outlets, quick connectors may be provided to minimize time required to establish the connections and to improve user-friendliness.

[0038] The temperature-regulating device may be configured to supply the heat-transfer fluid at its device outlet at a set temperature. It will be appreciated that the set temperature is *inter alia* determined by the desired temperature in the product container and the temperature of the surroundings of the support rack supporting the product container.

[0039] The system may comprise a pump or other means for circulating the heat-transfer fluid, preferably a pump in the temperature-regulating device.

[0040] Any suitable heat-transfer fluid may be used. Preferably, the heat-transfer fluid is a liquid. Suitable heat-transfer fluids are known in the art and include alcohol-water mixtures or aqueous salt solutions (often referred to as brines). Examples of suitable alcohol-water mixtures are mixtures of ethylene glycol, diethylene glycol and/or propylene glycol and water.

[0041] Temperature-regulating devices are well known in the art. Any suitable temperature-regulating device may be used.

[0042] The temperature-regulating device preferably is a cooling device. Such cooling device is configured to supply cooled heat-transfer fluid at its device outlet. State of the art cooling devices typically cool a heat-transfer fluid by evaporating a so-called refrigerant.

[0043] The power needed to operate the temperature-regulating device may be supplied by a battery or other power source.

[0044] The temperature-regulating device may be located at any suitable location. During operation of the system, i.e. when heat-transfer fluid is circulated through the hollow frame of the storage rack to control the temperature of any products in the product receiving chamber of any of the product containers, the temperature-regulating device is preferably located at a distance from the at least one storage rack or in a space other than the space where the at least one storage rack is located. Thus, undesired heating or cooling of the direct environment of the product containers and the storage rack by heat or cold discharged from the temperature-regulating device is avoided.

[0045] In one embodiment, the system is a system for temperature-controlled transport of a product and comprises a vehicle comprising the temperature-regulating device and a cargo space for containing the at least one storage rack. The temperature-regulating is preferably located outside the cargo space to prevent undesired heating or cooling of the cargo space. Alternatively, the temperature-regulating device may be located in the cargo space, whilst discharging any heat or any cold produced by the temperature-regulating device outside the cargo space. Preferably, the cargo space is large enough to comprise at least two storage racks, more preferably in the range of from 2 to 4 storage racks. The at least one storage rack preferably is a mobile storage rack comprising one or more wheels, so that it can be wheeled into the cargo space.

[0046] The vehicle may be any suitable vehicle for transporting products, preferably a road vehicle such as a cargo van or a delivery truck. The vehicle preferably is an electrically-driven vehicle. Such electrically-driven vehicle is particularly suitable for urban delivery to customers. Since the system according to the invention is energy-efficient, it is possible to use an electrically-driven vehicle with acceptable battery charging frequency.

[0047] The product may be any product to be stored or transported under temperature-controlled conditions. Preferably, the product is a food product or a medicament.

[0048] In a second aspect, the invention provides a method for temperature-controlled storage and/or transport of a product using the system according to the first aspect of the invention.

[0049] The present method may have one or more of the features and/or benefits disclosed herein in relation to the system according to the first aspect of the invention.

[0050] In step a) of the method according to the invention, the product to be stored and/or transported is placed in the product receiving chamber of the thermally-insulated product container. More than one product may be placed in the product receiving chamber of one product container and product(s) may be placed in more than one product container. This step a) may take place in a temperature-controlled environment, for example in a cooled warehouse so that the product(s) already have a desired temperature, thus minimizing the energy needed during the temperature-controlled storage or transport. Once the product(s) have been placed in the product receiving chamber, the product receiving chamber is closed, typically by means of a thermally insulated top lid.

[0051] In step b) of the method according to the invention, any product containers filled with product in step a) are placed on the support provided by the hollow frame of the storage rack, such that at least part of the part of the heat-conductive plate that is exposed to an outside of the product container is in direct heat-conductive contact with the support. More than one product container with product may be placed on one storage rack. Preferably, the maximum number of filled containers is placed on a storage rack so that open space between product containers is minimized in order to minimize loss of cold or heat to the environment. In step b), product containers with product may be placed on more than one storage rack.

[0052] In step c), the device outlet of the temperature-regulating device is fluidly connected to the fluid inlet of the hollow frame and the device inlet of the temperature-regulating device is fluidly connected to the fluid outlet of the hollow frame. Once the respective inlets and outlets are connected in step c), cooled or heated heat-transfer fluid is circulated from the temperature-regulating device through the fluid flow path in the hollow frame of the storage rack back to the temperature-regulating device (step d)). This circulation of heat transfer fluid may be carried out by means of a pump, for example a pump in the temperature-regulating device.

[0053] Step c), optionally in combination with step d) may be carried out after step b), prior to step b), or prior to step a). During step b), the fluid flow path in the hollow frame of the storage rack may already be filled with heat-transfer-fluid, either with stagnant (if steps c) and d) have not yet been carried out) or with circulating heat-transfer fluid (if steps c) and d) have been carried out before step

b)).

[0054] If the method is a method for temperature-controlled transport of a product, in particular cooled transport, and the system comprises a vehicle comprising the temperature-regulating device and a cargo space as disclosed herein, steps a) and b) preferably take place outside the cargo space of the vehicle, for example at a storage location, preferably in a cooled environment such as a cooled warehouse. Thereafter, the storage rack(s) supporting the filled product container(s) are placed in the cargo space of the vehicle, preferably wheeled into the cargo space of the vehicle. Once the storage rack(s) are placed in the cargo space, steps c) and d) are carried out. If the temperature-regulating device is located outside the cargo space, typically at an outer surface of the vehicle, for example above the driver cabin, the temperature-regulating device is at some distance of the storage rack(s) and conduits, preferably flexible conduits, may be used to fluidly connect the respective inlets and outlets.

[0055] By circulating cooled or heated heat-transfer-fluid through the hollow frame of the storage rack, product(s) in the product container(s) placed on the support provided by the hollow frame will be kept at a desired temperature during storage or transport.

[0056] The method may further comprise a step of removing one or more product containers from the storage rack, in order to retrieve or deliver the product(s) that are contained therein.

[0057] Any emptied product container(s) may need to be brought back to a warehouse or other location for refilling with products. To this effect, the emptied product container(s) may be placed back on the storage rack. To avoid loss of cold or heat by heat transfer to an empty product container, any empty product container(s) are preferably placed back on the storage rack without making direct heat-conductive contact with the hollow frame of the storage rack. This may be done by placing any empty product container(s) upside down on the storage rack, so that the part of the heat-conductive plate exposed to the container outside faces away from the hollow frame of the storage rack. The thermally-insulated top of the product container, typically the thermally-insulated top lid, now minimized heat-transfer between the support and the container. Alternatively or additionally, the thermally-insulated top lid of the container may be removed from the container and placed between the support provided by the hollow frame and the container bottom.

[0058] The temperature-regulating device may supply the heat-transfer fluid at its device outlet at a set temperature.

[0059] In the method according to the invention, the temperature-regulating device preferably is a cooling device. If the device is a cooling device, the heat-transfer fluid preferably has a set temperature in the range of from -20 °C to +5 °C upon passing the fluid inlet of the hollow frame, more preferably a temperature in the range of from -10 °C to 0 °C.

[0060] In the method, preferably no passive cooling or heating means other than the heat-conductive plate partly lining the product receiving chamber are contained in the product receiving chamber of the product container.

Brief description of drawings

[0061] Further characteristics of the invention will be explained below, with reference to embodiments, which are displayed in the appended drawings, in which:

Figure 1 shows a mobile storage rack of an embodiment of a system according to the present invention,
Figure 2 shows the mobile storage rack of Figure 1 with thermally-insulating elements,
Figure 3 shows a close up view of a container location of the mobile storage rack in Figure 2,
Figure 4 shows the mobile storage rack with thermally-insulating elements of Figure 2 with a plurality of product containers placed on it,
Figure 5 shows a cross-sectional view of a product container placed on the mobile storage rack of Figure 4,
Figure 6 shows an exploded-view of a product container and a thermally-insulated element,
Figure 7 shows a cross-sectional view as Figure 5, with the product container lifted from the storage rack, and
Figure 8 depicts a schematic overview of an embodiment of the system according to the present invention.

[0062] Throughout the figures, the same reference numerals are used to refer to corresponding components or to components that have a corresponding function.

Detailed description of embodiments

[0063] Figure 1 schematically depicts a mobile storage rack 2 comprising four wheels 3 and a hollow frame 4 formed of rectangular hollow metal tube elements welded to each other. The tube elements are welded to each other such that a fluid flow path (not shown) is defined inside hollow frame 4 between fluid inlet 6 and fluid outlet 7. Hollow frame 4 is configured such that if fluid is supplied to the fluid flow path inside the hollow frame, there is fluid flow in the entire fluid flow path, i.e. through the entire hollow frame 4.

[0064] In Figure 2 is shown the storage rack 2 of Figure 1 with thermally-insulating elements 8 of expanded polystyrene attached to hollow frame 4 to cover open space between parts of hollow frame 4 that provide a support for a product container. Thus, the part of the exposed heat-conductive plate of a product container placed on hollow frame 4 that is not in direct contact with hollow frame 4 is thermally insulated. The thermally insulating elements 8 are also covering the sides of the support

provided by hollow frame 4 that is not in direct contact with the product container when placed on hollow frame 4. In Figure 3 is shown in more detail how hollow frame 4 is provided with thermally insulating elements 8, i.e. by covering the lower and side surfaces and exposing the top surface of tube elements of hollow frame 4 that support product containers when placed on it.

[0065] In Figure 4 is shown the storage rack 2 of Figure 2 with twenty product containers 20 placed on the support provided by hollow frame 4.

[0066] In Figure 5 is shown a cross-sectional view of product container 20 placed on hollow frame 4 that is provided with thermally insulating element 8. Product container 20 comprises product receiving chamber 21, side walls 23 of thermally insulating material, and top lid 24 of thermally insulating material. Product receiving chamber 21 is partially lined with a metal plate (22, 25, 27). Part 22 of the metal plate forms the bottom surface of product receiving chamber 21, parts 25 of the metal plate line part of the side surfaces of product receiving chamber 21. Part 22 of the metal plate is exposed to the outside of container 20 so that part of it is in direct heat-conductive contact with hollow frame 4. Side wall 23 has an inwardly protruding ridge 26 and part 27 of the metal plate is formed horizontally such that it can engage with inwardly protruding ridge 26 of side wall 23 to prevent the metal plate from sliding out of side walls 23 when the container 20 is not supported on hollow frame 4 (as can be seen more clearly in Figure 7).

[0067] In Figure 6, an exploded view of product container 20 and thermally insulating element 8 is shown. In this embodiment of the container, opposed side walls 23' of container 20 are provided with apertures 28, configured to engage with the tube elements of hollow frame 4 when product container 20 is placed on hollow frame 4, to prevent product container 20 from sliding or from falling off storage rack 2.

[0068] In Figure 7 is shown that if container 20 is lifted from hollow frame 4, metal plate (22, 25, 27) is prevented from sliding out of side walls 23, since horizontal lips 27 of the metal plate engage with the inwardly protruding ridge 26 of side walls 23. Thermal insulating element 8 is provided with a recess 9 that can engage with the bottom contour 29 of side walls 23 to prevent product container 20 from sliding or from falling off hollow frame 4 ((as can be seen more clearly in Figure 5).

[0069] In Figure 8 is schematically shown a system a according to the invention showing a support rack 2 with product containers 20 and cooling device 50. Cooling device 50 has a pump (not shown) that is configured to circulate a flow of heat-transfer fluid through the fluid flow path in the hollow frame of storage rack 2. Cooling device 50 has a device outlet 51 for cooled heat-transfer fluid, which is connected to fluid inlet 6 of the hollow frame of storage rack 2 via a feed conduit 61. Cooling device 50 further has a device inlet 52 for a return flow of heat-transfer fluid. Device inlet 52 is connected to fluid outlet 7 of the hollow frame of storage rack 2 via a return conduit 62.

[0070] Flow of heat-transfer flow through the fluid flow path in hollow frame of support rack 2 between inlet 6 and outlet 7 is schematically indicated with arrows F. System 1 in Figure 8 comprises a vehicle (not shown), in which cooling device 50 is located outside a cargo space 100. Storage rack 2 is placed inside cargo space 100.

[0071] Cooling device 50 is located outside cargo space 100 and is configured to discharge heat outside cargo space 100. As such, it is prevented that cargo space 100 itself is heated and that a temperature gradient between cargo space 100 and the product receiving chambers in product containers 20 would become larger.

[0072] With storage rack 2 being movable out of cargo space 100, it is beneficial that it can be uncoupled from cooling device 50. According to the present embodiment, the fluid connection between conduits 61, 62 and fluid inlet 6 and fluid outlet 7 of storage rack 2, respectively, is established by means of quick connectors (not shown).

Claims

1. A system for temperature-controlled storage and/or transport of a product, comprising:

- a plurality of thermally-insulated product containers, each comprising a thermally insulated product receiving chamber, which is at least partly lined with a heat-conductive plate, wherein part of the heat-conductive plate is exposed to an outside of the product container;
- at least one storage rack for supporting the product containers, comprising a hollow frame formed by a plurality of hollow tube elements of heat-conductive material, which are connected to each other to define a fluid flow path between a fluid inlet and a fluid outlet of the hollow frame, wherein the frame provides a support for the product containers and a structure giving shape and strength to the rack; and
- a temperature-regulating device, configured to cool or heat a heat-transfer fluid, wherein the device comprises a device inlet for the heat-transfer fluid and a device outlet for cooled or heated heat-transfer fluid and wherein the device outlet is fluidly connectable to the fluid inlet of the hollow frame and wherein the device inlet is fluidly connectable to the fluid outlet of the hollow frame,

wherein the part of the heat-conductive plate that is exposed to an outside of the product container can be brought in direct heat-conductive contact with the support for the product containers when the product container is placed on the support.

2. A system according to claim 1, wherein each of the

product containers comprises a lid, preferably a top lid, more preferably a thermally insulated top lid.

3. A system according to claim 1 or 2, wherein the heat-conductive plate is exposed to an outside of the product container at the lower end of the product container.

4. A system according to any one of the preceding claims, wherein the heat-conductive plate is a metal plate, preferably a plate of an aluminium alloy.

5. A system according to any one of the preceding claims, wherein the heat-conductive material of the tube elements is a metal, preferably an aluminium alloy.

6. A system according to any one of the preceding claims, wherein the hollow tube elements are square or rectangular hollow tube elements.

7. A system according to any one of the preceding claims, wherein each of the at least one storage rack is configured to support in the range of from 4 to 50 product containers, preferably of from 8 to 40 product containers, more preferably of from 16 to 30 product containers.

8. A system according to any one of the preceding claims, wherein the hollow frame is partly are embedded in thermally-insulating material, in such a way that the hollow frame comprises container locations for supporting a product container at which the heat-conductive material of the tube elements is exposed for direct heat-conductive contact with the part of the heat-conductive plate that is exposed to an outside of the product container, when the product container is placed on the support at the container location.

9. A system according to any one of the preceding claims, wherein the storage rack is a mobile storage rack, comprising one or more wheels.

10. A system according to any one of the preceding claims , wherein the temperature-regulating device is a cooling device.

11. A system according to any one of the preceding claims, wherein the system comprises a vehicle, the vehicle comprising the temperature-regulating device and a cargo space for containing the at least one storage rack, wherein the temperature-regulating device is preferably located outside the cargo space.

12. A system according to any one of the preceding claims , wherein the product is a food product or a medicament.

13. A method for temperature-controlled storage and/or transport of a product, using a system according to any of the claims 1 to 12, the method comprising the steps of:

a) placing the product in the product receiving chamber of the thermally-insulated product container;
b) placing the product container with product on the support of the storage rack such that at least part of the heat-conductive plate exposed to an outside of the product container is in direct heat-conductive contact with the support;
c) fluidly connecting the device outlet to the fluid inlet of the hollow frame and the device inlet to the fluid outlet of the hollow frame; and
d) circulating cooled or heated heat-transfer fluid from the temperature-regulating device through the fluid flow path in the hollow frame of the storage rack back to the temperature-regulating device.

14. A method according to claim 13, wherein the system according to claim 12 is used, further comprising the step of:
e) placing the storage rack in the cargo space after steps b) and prior to step c).

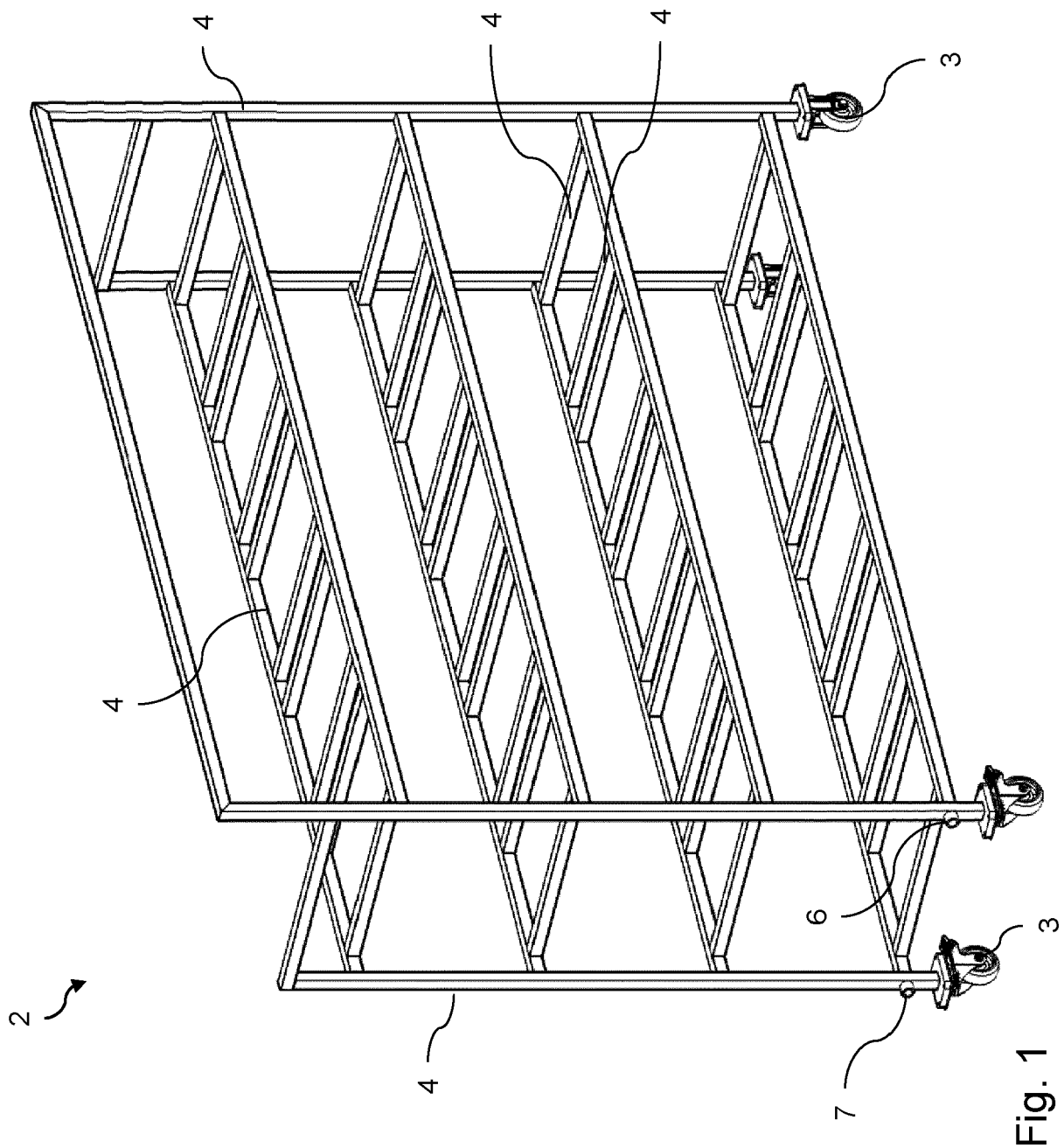

Fig. 1

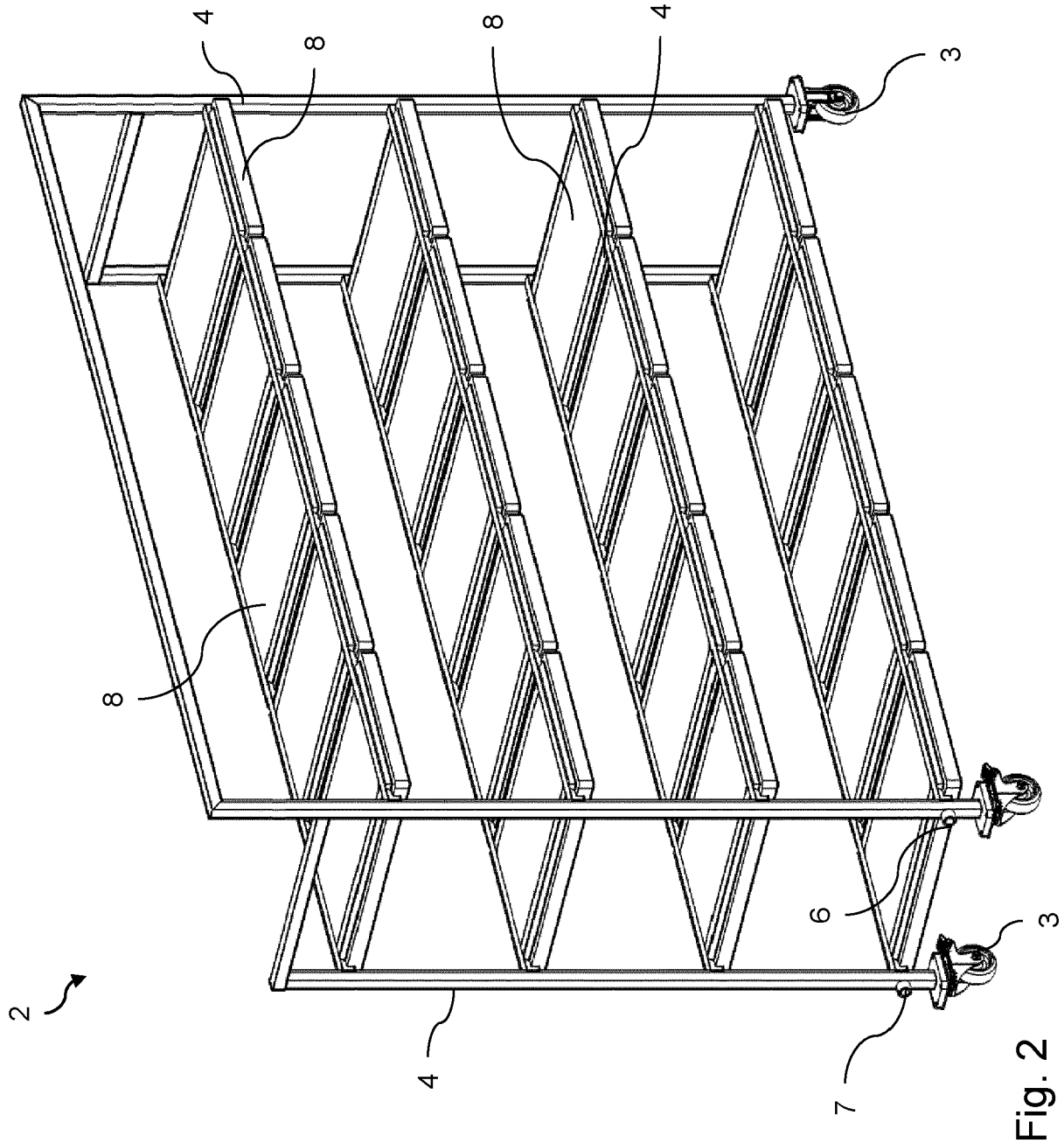

Fig. 2

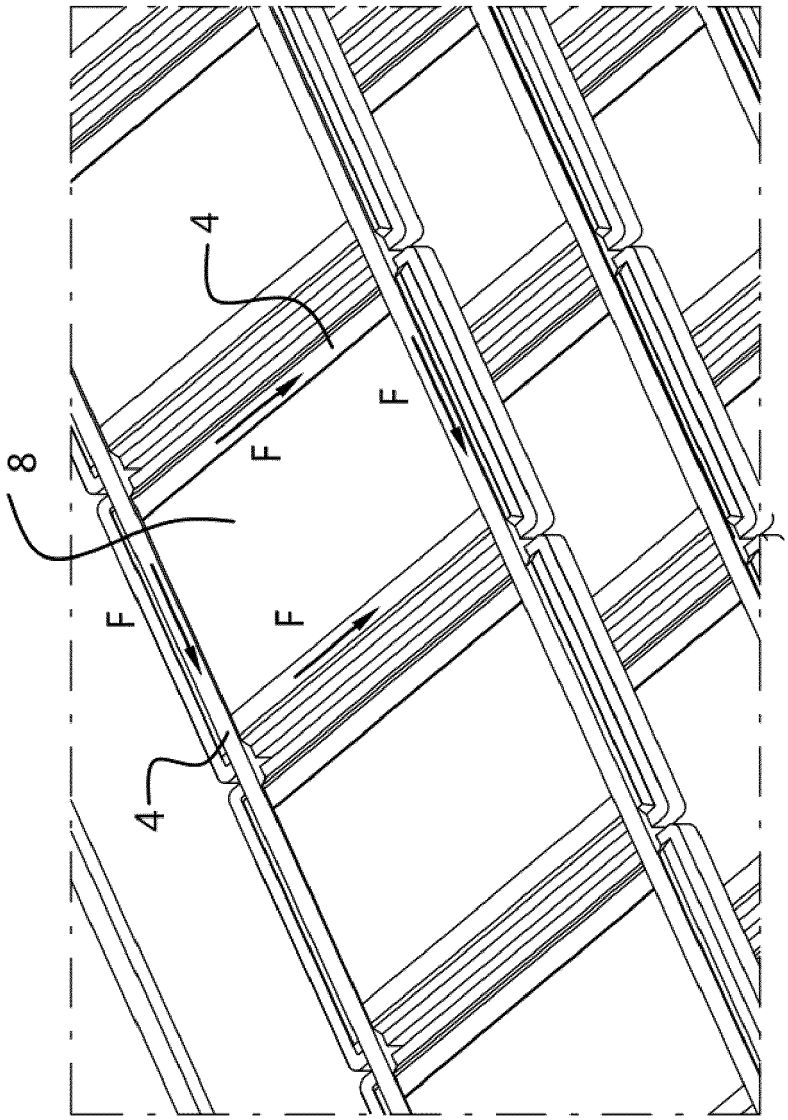

Fig. 3

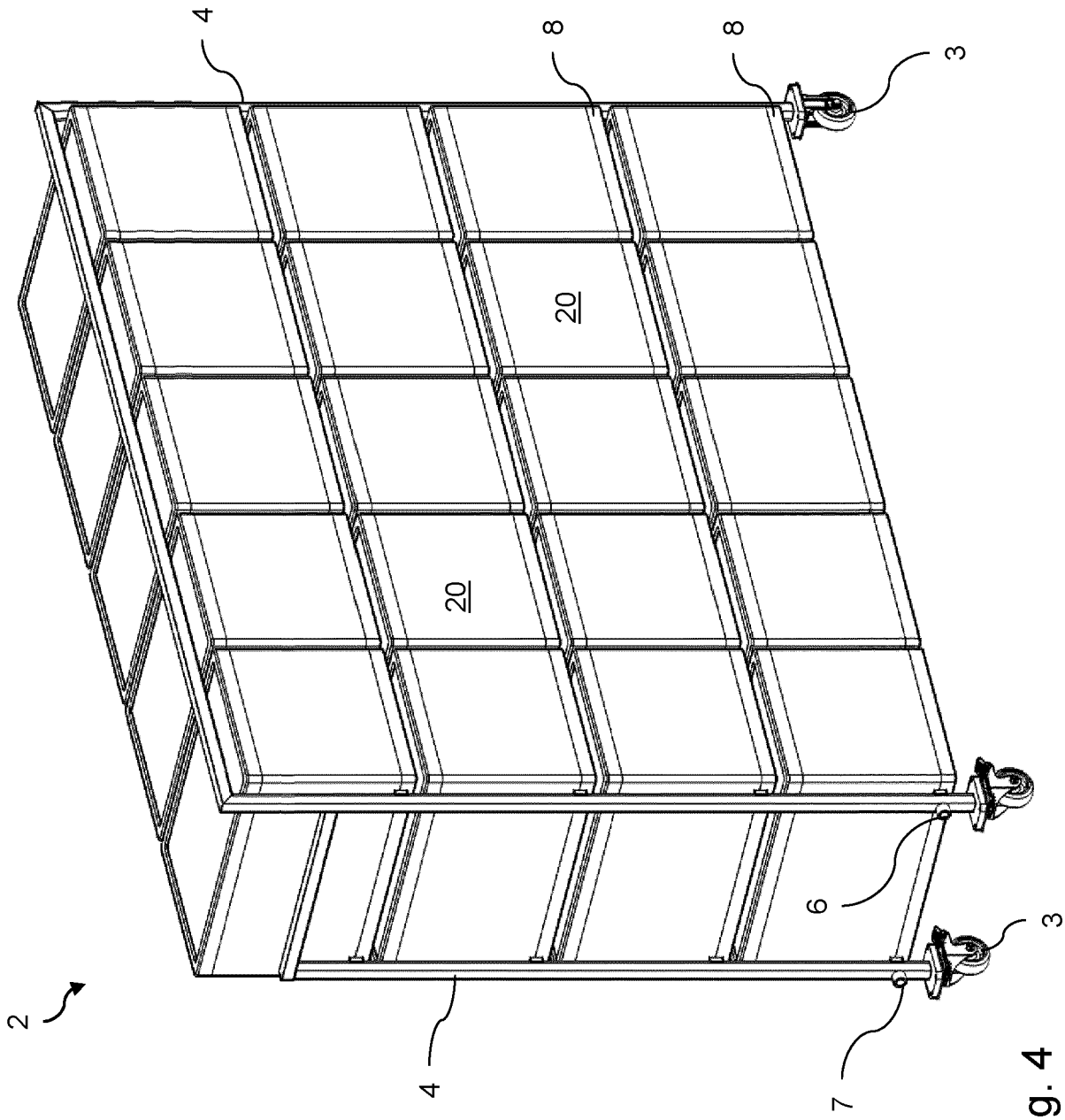

Fig. 4

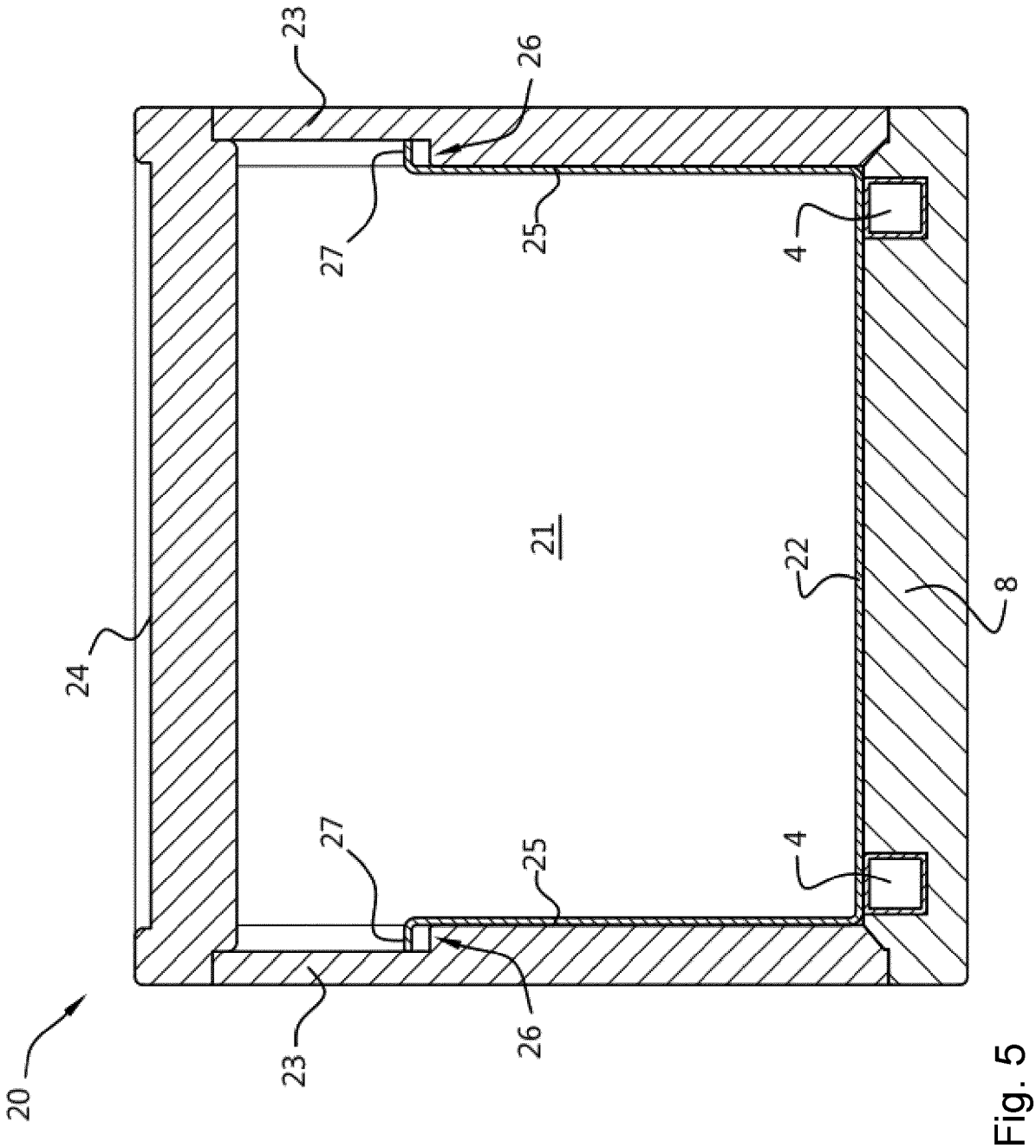

Fig. 5

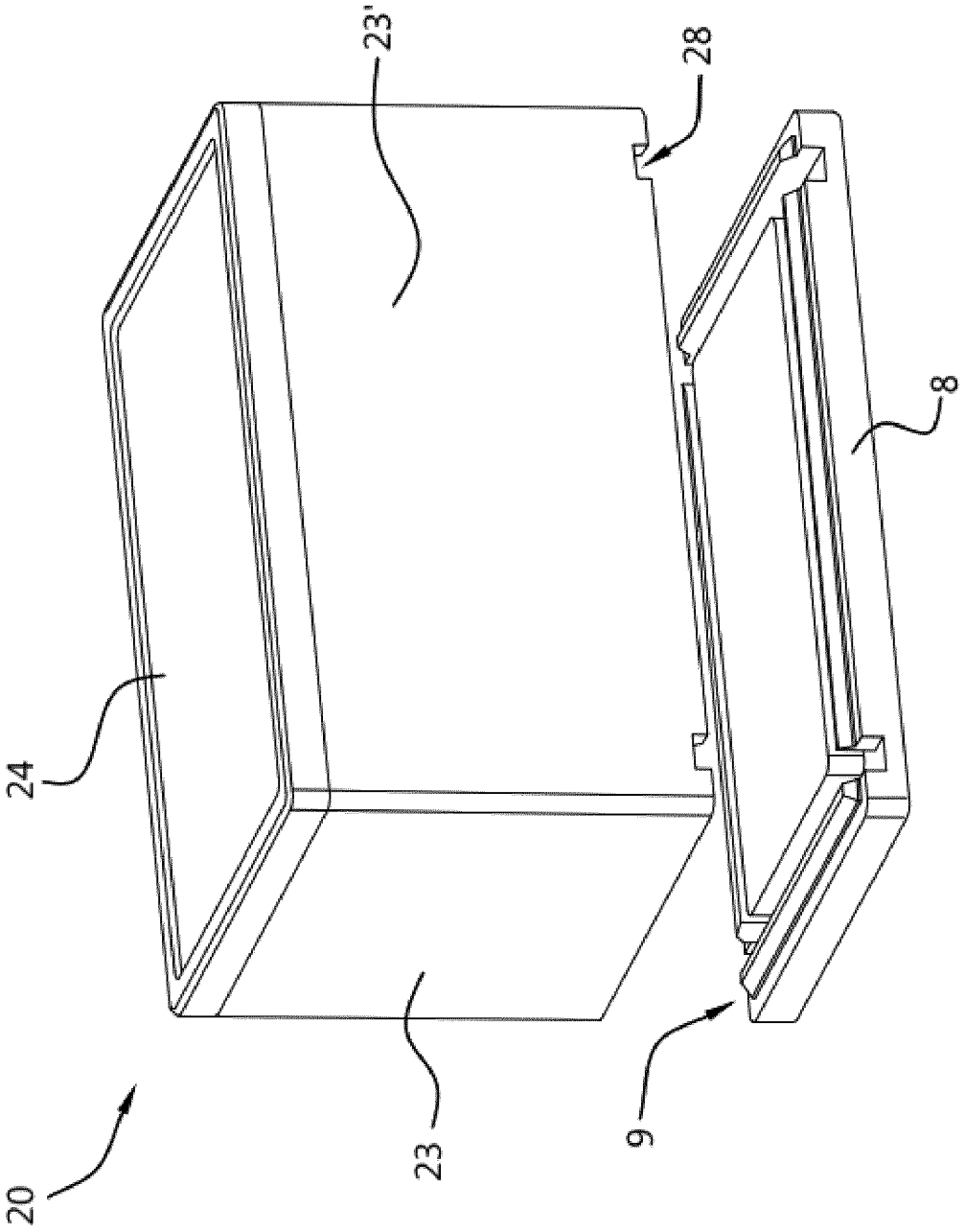

Fig. 6

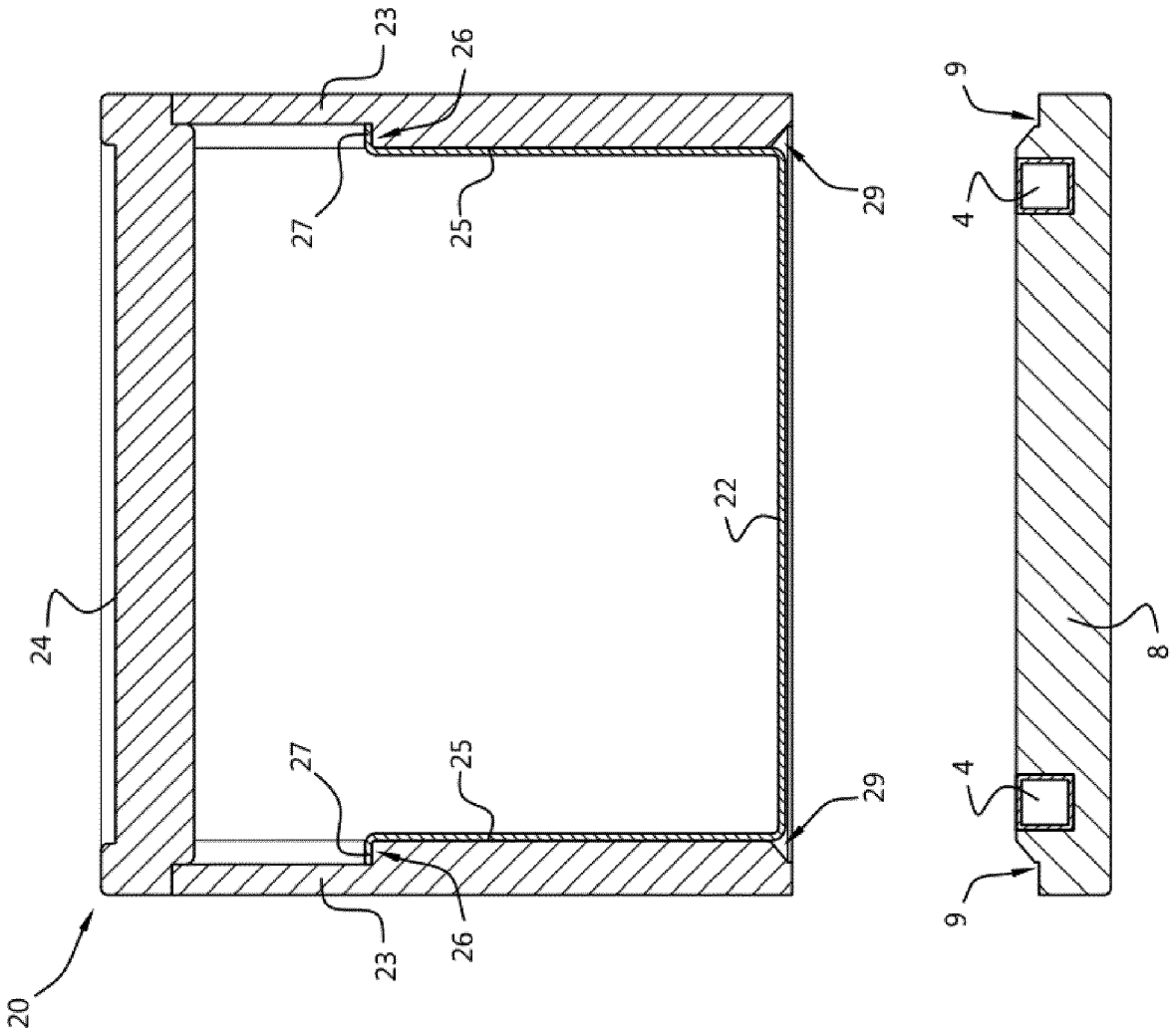

Fig. 7

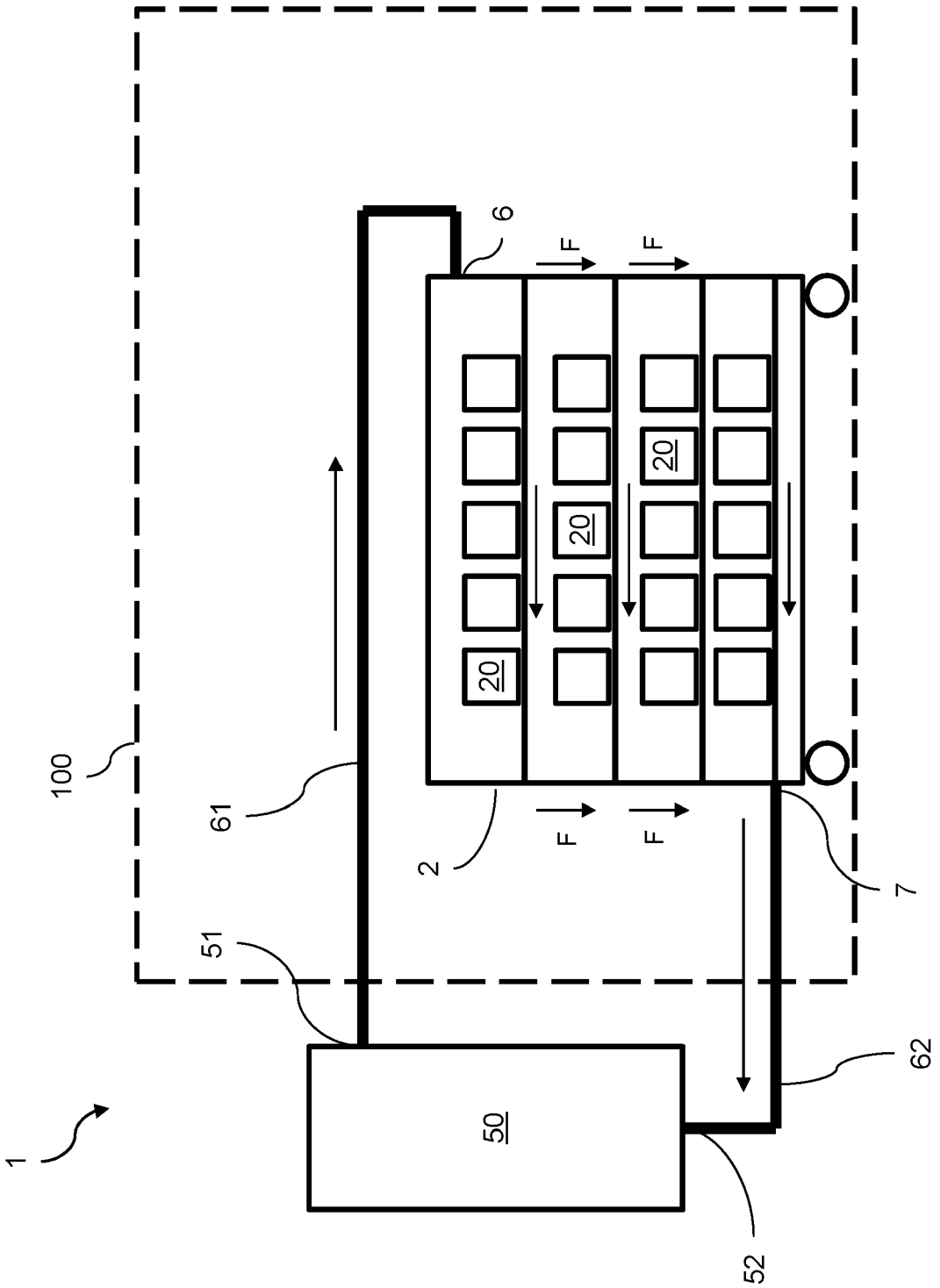

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 8840

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Place of search	Date of completion of the search	Examiner
The Hague	19 September 2022	Bejaoui, Amin

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