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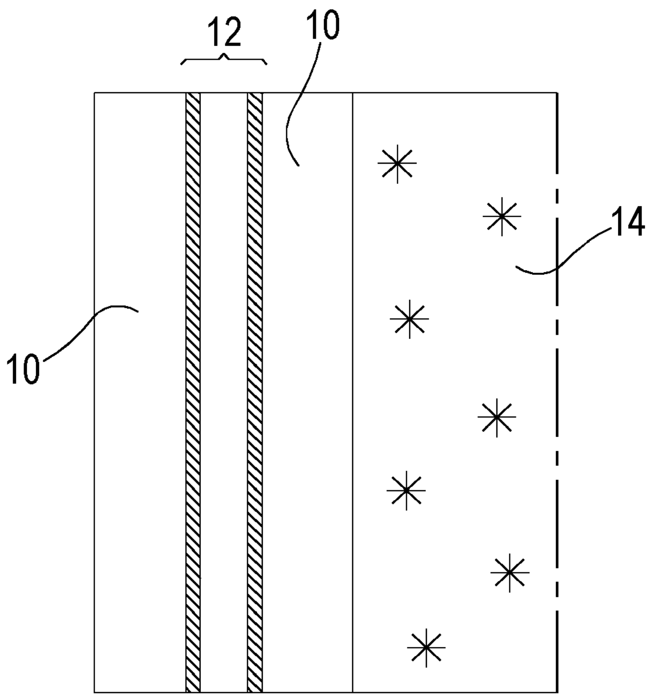
(54) **REFRIGERATING UNIT FOR A REFRIGERATOR, REFRIGERATOR AND ASSOCIATED METHOD**

(57) The invention relates to a refrigerating unit for a refrigerator (1), the refrigerating unit comprising: at least one evaporator (12), configured for being installed in said refrigerator (1) and for causing, in use, a cooling of an inner compartment (2) of said refrigerator (1); at least an active defrosting device comprising at least a first electromechanic transducer (10), arranged in correspondence of said at least one evaporator (12), the at least a first electromechanic transducer (10) being configured to cause, when electrically fed, a discontinuous vibration in correspondence of said at least one evaporator (12), assisting an at least partial removal of ice and/or frost (14) deposited in correspondence of said at least one evaporator (12).

FIG.2



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Description

Field of the invention

[0001] The present invention refers to the field of refrigerators and components thereof. The present invention further refers to the field of the electromechanical transducers.

Background art

[0002] Known refrigerators comprise at least one thermally isolated chamber which is cooled by at least one evaporator of a refrigerator unit. Such refrigerator unit further comprises a condenser and a compressor, operatively connected to the evaporator and to the condenser. A fluid is made to circulate into the condenser and the evaporator by means of said compressor to cool (heat removal) the thermally isolated chamber and determine a release of heat at the condenser. The condenser is arranged in such a way to disperse heat outside said thermally isolated chamber.

[0003] At least one between the evaporator and the condenser may be coupled with a respective ventilator, typically arranged in close proximity thereto.

[0004] It is also known that ice and/or frost may be formed in the thermally isolated chamber, in particular in substantial correspondence of the evaporator. The ice and/or frost acts as a thermal insulating layer penalizing the energetic efficiency of the refrigerator. Ice and/or frost in the thermally isolated chamber results from the condensation of moisture in the air present in the chamber; at least initially ice and/or frost is formed at some spots and/or as a thin substantially continuous layer that progressively grows up and become thicker and thicker unless appropriate intervention takes place.

[0005] While in past a manual removal of ice and/or frost in the chamber was the only way to mitigate the problem, in recent years refrigerators have been developed which have a so-called de-frosting operative configuration, suitable to cause the detachment of the ice and/or frost at the evaporator.

[0006] When ice and/or frost on the evaporator grows over a certain amount, it can hit the blades of the ventilator, making this latter noisy or causing a malfunction thereof, up to stopping it.

[0007] Defrosting devices have been conceived for causing the removal of ice and/or frost. Defrosting devices are known to operate according to one principle (e.g. ultrasonic waves) or combined principles (ultrasonic waves and heating).

[0008] CN104457063B discloses a refrigerator provided with an ultrasonic defrosting device operating at frequencies between 20kHz and 40kHz. The ultrasonic waves produced by ultrasonic defrosting device cause a removal of the frost thus increasing the heat exchange efficiency and reducing the energy consumption.

[0009] A defrosting device operating according to combined principles is disclosed in CN105716352; this document discloses a refrigerator provided with a defrosting device, the defrosting device comprising an ultrasonic oscillating system located at the evaporator and an electric heater.

[0010] Energetic efficiency has recently become a very strict requirement for household appliances, including refrigerators.

[0011] Known defrosting devices suffer from a poor energetic efficiency. More particularly known defrosting heaters have poor thermal properties due to low electrical conductivity, high power consumption, non-uniform heat distribution and may cause corrosion.

[0012] A purpose of the present disclosure is to provide a refrigerator unit, a refrigerator and a method of defrosting a refrigerator suitable to provide high energetic efficiency and optimal ice and/or frost removal.

Summary

[0013] In the subsequent portion of specification, the main aspects concerning the object of the disclosure are described. Such aspects may be combined together, with portions of the description and/or with the claims.

[0014] According to a first, independent, aspect, it is herewith disclosed a refrigerating unit for a refrigerator (1), the refrigerating unit comprising:

- at least one evaporator (12), configured for being installed in said refrigerator (1) and for causing, in use, a cooling of an inner compartment (2) of said refrigerator (1), and
- an active defrosting device comprising at least a first electromechanical transducer (10), the at least a first electromechanical transducer (10) being arranged in correspondence of said evaporator (12), preferably on at least one surface of said evaporator (12), and being configured to cause, when electrically fed, a discontinuous vibration in correspondence of said evaporator (12), assisting an at least partial removal of ice and/or frost (14) deposited in correspondence of said evaporator (12).

[0015] According to a further, non-limiting, aspect, the at least a first electromechanical transducer (10) is arranged in such a way to cause, when electrically fed, a delamination of said ice and/or frost (14) at a contact surface with said evaporator (12).

[0016] According to a further, non-limiting, aspect, the at least a first electromechanical transducer (10) comprises an ultrasonic transducer.

[0017] According to a further, non-limiting, aspect, the discontinuous vibration is in particular a pulsed vibration and/or a variable amplitude vibration and/or variable frequency vibration.

[0018] According to a further, non-limiting, aspect, the at least a first electromechanical transducer (10) is arranged in such a way to cause, when electrically fed, a delamination of said ice and/or frost (14) at a contact surface with said evaporator (12).

[0019] According to a further, non-limiting, aspect, the ultrasonic transducer (10) comprises at least one piezoelectric element, and in particular is a Langevin-type transducer.

[0020] According to a further, non-limiting, aspect, the ultrasonic transducer is configured to generate an ultrasonic vibration having frequency substantially comprised in the range [20 kHz - 70 kHz], preferably in the range [30 kHz - 60 kHz], more preferably in the range [40 kHz - 50 kHz].

[0021] According to a further, non-limiting, aspect, the ultrasonic transducer is configured to trigger excitation frequencies within the range [200 kHz - 500 kHz], and/or is configured to induce, at a substantial correspondence of said evaporator (12), a shear stress lying in the range [0,5 MPa - 1,5 MPa], more preferably in the range [0,7MPa - 1,2MPa], the vibration being optionally a sinusoidal vibration inducing, in use, a stress of flexion and extension on the ice and/or frost (14).

[0022] According to a further non-limiting aspect, the defrosting device comprises at least one heater (18), substantially arranged in correspondence of the evaporator (12), preferably on a surface of the evaporator (12).

[0023] According to a further, non-limiting, aspect, the heater (18) is configured to cause, when activated, a melting of an interfacial layer of said ice and/or frost (14) into contact with said evaporator (12), so as to generate a film of water between said ice and/or frost (14) and said evaporator (12).

[0024] According to a further, non-limiting, aspect, said heater (18) is an electric heater, preferably a metal foil heater and/or a transparent thin-film heater and/or an opaque thin-film heater.

[0025] According to a further, non-limiting, aspect, the heater (18) is configured to be activated in such a way to produce heat pulses, said heat pulses having a time length comprised in the range [0,5 ms - 10 s], preferably in the range [0,7 ms - 8 s], more preferably in the range [1 ms - 5 s].

[0026] According to a further, non-limiting, aspect, the defrosting device is configured to feed said at least a first electromechanical transducer (10) in a substantial simultaneous temporal correspondence with said heater (18) and/or to start feeding said heater (18) before feeding said at least a first electromechanical transducer (10) and/or to keep feeding said heater (18) while said at least a first electromechanical transducer (10) is fed and/or to feed said at least a first electromechanical transducer (10) for an overall time longer than an overall time of feeding of said heater (18).

[0027] According to a further, non-limiting, aspect, the active defrosting device comprises at least a second electromechanical transducer (10), the at least a second electromechanical transducer (10) being arranged in correspondence of said at least one evaporator (12), preferably on at least one surface of said evaporator (12), and being configured to cause, when electrically fed, a discontinuous vibration in correspondence of said evaporator (12), assisting an at least partial removal of ice and/or frost (14) deposited in correspondence of said evaporator (12).

[0028] According to a further, non-limiting, aspect, the second electromechanical transducer (10) is configured to be activated alternatively or simultaneously with the first electromechanical transducer (10).

[0029] According to a further, non-limiting, aspect, the defrosting device comprises a plurality of electromechanical transducers (10) arranged in correspondence of said at least one evaporator (12) according to a predetermined pattern and/or evenly distributed on at least one surface of said evaporator (12).

[0030] According to a further, non-limiting, aspect, the at least one between the first electromechanical transducer (10) and the second electromechanical transducer (10) at least partially surrounds at least a predetermined portion of the evaporator (12).

[0031] According to a further, non-limiting, aspect, said evaporator (12) is provided with a plurality of heat exchanging fins (12f) defining a finned surface and at least one between the first electromechanical transducer (10) and the second electromechanical transducer (10) is arranged in substantial correspondence of said finned surface.

[0032] According to a further, non-limiting, aspect, said heat exchanging fins (12f) are realized in a thermally high-conductive material, optionally thermally high-conductive metal.

[0033] According to a further, non-limiting, aspect, said evaporator (12) is a roll-bond evaporator.

[0034] According to a further, non-limiting, aspect, said at least a first electromechanical transducer (10) is arranged on a surface of said roll-bond evaporator.

[0035] According to a further, non-limiting, aspect, the first and the second electromechanical transducer (10) are arranged on the same surface of said roll-bond evaporator or on distinct surfaces, in particular opposite surfaces, of said roll-bond evaporator.

[0036] According to a further, non-limiting, aspect, the defrosting device is configured to feed said at least a first electromechanical transducer (10), optionally the first and the second electromechanical transducer (10), in a substantial simultaneous temporal correspondence with said heater (18).

[0037] According to a further, non-limiting, aspect, preferably the defrosting device is configured to start feeding said heater (18) before feeding said at least a first electromechanical transducer (10), optionally the first and the second electromechanical transducer (10), and, optionally, to keep feeding said heater (18) while said at least a first electromechanical transducer (10) is fed, optionally while the first and the second electromechanical transducer (10) are fed.

[0038] According to a further, non-limiting, aspect, the defrosting device is configured to feed said at least a first electromechanical transducer (10), optionally the first and the second electromechanical transducer (10), for an overall time longer than an overall time of feeding of said heater (18).

[0039] According to a further, non-limiting, aspect, at least one between the first electromechanical transducer (10), the second electromechanical transducer (10) and the heater (18) is directly attached to said evaporator (12).

[0040] According to a further, non-limiting, aspect, the refrigerating unit comprises a binding layer (16) interposed between the at least one between the first electromechanical transducer (10), the second electromechanical transducer (10) and the heater (18) and the evaporator (12), the binding layer (16) comprising a plastic material, in particular a plastic material including C_4H_8O, more in particular PVB.

[0041] According to a further, non-limiting, aspect, a coating comprising an anti-icing material is applied to at least one surface of the evaporator (12), said coating being preferably nanostructured.

[0042] According to a further, non-limiting, aspect, the at least one electromechanical transducer (10) is configured to cause, when fed, a propagation of said vibration along a predetermined preferential direction or set of directions, in particular along a preferential solid angle of radiation.

[0043] According to a further, non-limiting aspect, the refrigerating unit comprises at least one electric power supply unit configured to be interfaced with an electric power supply unit of the refrigerator; the electric power supply unit causing, in use, a drawing from a feeding line of the refrigerator and/or from said electric power supply unit of the refrigerator, of an amount of electric for electrically feeding at least one or more among the first electromechanical transducer, the second electromechanical transducer, the data processing unit, the at least one heater.

[0044] According to a further, non-limiting, embodiment, said electric power supply comprises at least one between a transformer, a rectifier, preferably a solid-state rectifier, an electric filter, one or more overvoltage and/or overcurrent limiters, preferably including at least one fuse, or a short-circuit protection device.

[0045] According to a further aspect, the present disclosure refers to a refrigerator (1), comprising:

- a refrigerating unit according to one or more of the preceding claims, the refrigerating unit further comprising a compressor (13) and at least one condenser (11), the compressor (13) being connected to said at least one condenser (11) and to said evaporator (12);
- a control unit operatively connected to said defrosting device and to said compressor (13);
- a case (3, 4, 5, 6) defining an inner compartment (2) suitable to be cooled by means of said evaporator (12),

  the refrigerator (1) comprising at least a cooling configuration and a defrosting configuration,

wherein in said cooling configuration said compressor (13) is activated by said control unit to cause a fluid circulation determining a withdrawal of heat from said inner compartment (2) by means of said at least one evaporator (12), wherein in particular said cooling configuration provides for a thermal exchange between said evaporator (12) and at least one wall of said inner compartment (2) or for an air flow cooled by said evaporator (12) and delivered to said inner compartment (2), and/or wherein in said defrosting configuration said defrosting device is activated by said control unit to cause an at least partial removal of ice and/or frost (14) deposited in correspondence of said evaporator (12), wherein in particular said cooling configuration provides for a delamination of said ice and/or frost (14) at a contact surface with said evaporator (12).

[0046] According to a further, non-limiting, aspect, the evaporator (12) is in particular arranged along a substantially vertical direction.

[0047] According to a further, non-limiting, aspect, said at least a first electromechanical transducer (10) is configured to cause detachment and subsequent fall of at least part of said ice and/or frost (14) from the at least one evaporator (12) by gravity.

[0048] According to a further, non-limiting, aspect, the fall of the ice and/or frost (14) is assisted by the film of water generated by the melting of the interfacial melting caused by said heater (18), the film of water allowing the ice and/or frost (14) to slide on said evaporator (12).

[0049] According to a further, non-limiting, aspect, the refrigerator (1) and/or the refrigerating unit, comprises or is operatively associated to a data processing unit configured to operatively control, preferably in at least a partially automated way, the activation of at least one between the first electromechanical transducer (10) and/or the second electromechanical transducer (10) and/or the heater (18).

[0050] According to a further non-limiting aspect, the data processing unit is configured to electronically retrieve at least one of the following data: at least one time of activation of the first electromechanical transducer (10), at least one time of activation of the second electromechanical transducer, a time delay between the beginning of the activation of the first electromechanical transducer (10) with respect to the second electromechanical transducer, at least one time of activation of the heater (18), at least one time delay between the beginning of the activation of the first electromechanical transducer (10) with respect to the heater (18), and/or between the beginning of the activation of the second electromechanical transducer (10) with respect to the heater (18), a cycle time for the activation of at least one between the first electromechanical transducer (10), the second electromechanical transducer (10), the heater (18).

[0051] According to a further, non-limiting, aspect, the data processing unit is configured to be manually controlled to cause the activation of at least one between the first electromechanical transducer (10), the second electromechanical transducer (10), the heater (18).

[0052] According to a further aspect it is herewith disclosed a method of defrosting a refrigerator (1) provided with at least one evaporator (12), configured for being installed in said refrigerator (1) and for causing, in use, a cooling of an inner compartment (2) of said refrigerator (1), the method comprising a step of activation of a defrosting device of said refrigerator (1) in turn comprising at least a step of electric feeding of at least a first electromechanical transducer (10) of said defrosting device, the at least a first electromechanical transducer (10) being arranged in correspondence of said evaporator (12), preferably on at least one surface of said evaporator (12), said electric feeding causes said at least a first electromechanical transducer (10) produce a discontinuous vibration in correspondence of said at least one evaporator (12), the discontinuous vibration assisting an at least partial removal of ice and/or frost deposited in correspondence of said evaporator (12), in particular a delamination of said ice and/or frost (14) at a contact surface with said evaporator (12) and, optionally, causes a detachment and subsequent fall of at least part of said ice and/or frost (14) from the evaporator (12) by gravity.

[0053] According to a further, non-limiting, aspect, the at least a first electromechanical transducer (10) comprises an ultrasonic transducer, in turn comprising at least one piezo-electric element, the ultrasonic transducer being in particular a Langevin-type transducer.

[0054] According to a further, non-limiting, aspect, the discontinuous vibration produced by said at least a first electromechanical transducer (10) is a pulsed vibration and/or a variable amplitude vibration and/or variable frequency vibration.

[0055] According to a further, non-limiting, aspect, the vibration has a frequency substantially comprised in the range [20 kHz - 70 kHz], preferably in the range [30 kHz - 60 kHz], more preferably [40 kHz - 50 kHz].

[0056] According to a further, non-limiting, aspect, the piezo-electric transducer is configured to trigger excitation frequencies within the range [200kHz - 500 kHz].

[0057] According to a further, non-limiting, aspect, the vibration induces, at a substantial correspondence of said evaporator (12), a shear stress lying in the range [0,5 MPa - 1,5 MPa], more preferably in the range [0,7MPa - 1,2MPa], the vibration being optionally a sinusoidal vibration inducing, in use, a stress of flexion and extension on the ice and/or frost (14).

[0058] According to a further, non-limiting, aspect, the method comprises a step of activation of at least one heater (18) of said defrosting device, substantially arranged in correspondence of the evaporator (12), preferably on a surface of the evaporator (12).

[0059] According to a further, non-limiting, aspect, said step of activation of said at least one heater (18) causes a melting of an interfacial layer of said ice and/or frost (14) into contact with said evaporator (12).

[0060] According to a further, non-limiting, aspect, said heater (18) is an electric heater, preferably a metal foil heater and/or a thin-film heater.

[0061] According to a further non-limiting aspect, the step of activation of at least one heater (18) is a step of pulsed activation determining the production of heat pulses by said at least one heater (18).

[0062] According to a further, non-limiting, aspect, said heat pulses have a time length comprised in the range [0,5 ms - 10 s], preferably in the range [0,7 ms - 8 s], more preferably in the range [1 ms - 5 s].

[0063] According to a further, non-limiting, aspect, the step of activation of said defrosting device further comprises a step of electric feeding a second electromechanical transducer (10), arranged in correspondence of said evaporator (12), preferably on at least one surface of said evaporator (12).

[0064] According to a further, non-limiting aspect, said electric feeding causes said second electromechanical transducer (10) produce a discontinuous vibration in correspondence of said evaporator (12).

[0065] According to a further, non-limiting, aspect, the feeding of the second electromechanical transducer (10) takes place alternatively or simultaneously with the step of activation of the first electromechanical transducer (10).

[0066] According to a further, non-limiting, aspect, the feeding of said at least a first electromechanical transducer (10), optionally the first and the second electromechanical transducer (10), takes place in a substantial simultaneous temporal correspondence with said heater (18).

[0067] According to a further, non-limiting, aspect, said heater (18) is fed before feeding said at least a first electromechanical transducer (10), optionally the first and the second electromechanical transducer (10).

[0068] According to a further, non-limiting, aspect, said heater (18) is kept fed while said at least a first electromechanical transducer (10) is fed, optionally while the first and the second electromechanical transducer (10) are fed.

[0069] According to a further, non-limiting, aspect the feeding of said at least a first electromechanical transducer (10), optionally the first and the second electromechanical transducer (10), takes place for an overall time longer than an overall time of feeding of said heater (18).

[0070] According to a further, non-limiting, aspect, the steps of at least one of the aspects herein described are carried out by a data processing unit configured to operatively control, preferably in at least a partially automated way, the activation of at least one between the first electromechanical transducer (10) and/or the second electromechanical transducer (10) and/or the heater (18).

[0071] According to a further non-limiting aspect, the method comprises making the data processing unit electronically retrieve at least one of the following data: at least one time of activation of the first electromechanical transducer (10), at least one time of activation of the second electromechanical transducer, a time delay between the beginning of the activation of the first electromechanical transducer (10) with respect to the second electromechanical transducer, at least one time of activation of the heater (18), at least one time delay between the beginning of the activation of the first electromechanical transducer (10) with respect to the heater (18), and/or between the beginning of the activation of the second electromechanical transducer (10) with respect to the heater (18), a cycle time for the activation of at least one between the first electromechanical transducer (10), the second electromechanical transducer (10), the heater (18).

[0072] According to a further, non-limiting, aspect, the method comprises controlling the data processing unit to cause a manually controlled activation of at least one between the first electromechanical transducer (10), the second electromechanical transducer (10), the heater (18).

[0073] According to a further, non-limiting, aspect, the feeding of said at least one electromechanical transducer (10) causes a propagation of said vibration along a predetermined preferential direction or set of directions, in particular along a preferential solid angle of radiation.

[0074] According to a further, non-limiting aspect, the method comprises feeding at least one or more among the first electromechanical transducer, the second electromechanical transducer, the data processing unit, the at least one heater with at least one electric power supply unit configured to be interfaced with an electric power supply unit of the refrigerator; the method comprising drawing from a feeding line of the refrigerator and/or from said electric power supply unit of the refrigerator, an amount of electric for electrically feeding, optionally through an electric power supply unit of a refrigerating unit, said at least one or more among the first electromechanical transducer, the second electromechanical transducer, the data processing unit, the at least one heater.

[0075] According to a further aspect, it is herewith disclosed a computer program, stored on a non-transitory memory support; the computer program comprising software code portions suitable to be executed by a data processing unit; the software code portions causing, when executed, the execution of the step of the method according to one or more of the aspects herein described.

[0076] According to a further aspect, it is herewith disclosed a memory support, comprising the computer program according to the previous aspect.

Figures

[0077] A brief description of the figures of the present disclosure is herewith provided. The figures whose description is hereinafter provided are used as an aid to visually identify some technical details of some preferred embodiments of the object of the present disclosure, part of the following detailed description.

Figure 1 shows a lateral section view of a refrigerator provided with a refrigerating unit according to the present disclosure.

Figure 2 shows a lateral section view of a non-limiting embodiment of a refrigerating unit provided with a defrosting device.

Figure 3 shows a lateral section view of a further non-limiting embodiment of a refrigerating unit provided with a defrosting device. An electromechanical transducer is arranged between the evaporator and a heater.

Figure 4 shows a lateral section view of a further non-limiting embodiment of a refrigerating unit provided with a defrosting device. A heater is arranged between an evaporator and an electromechanical transducer.

Figure 5 shows a lateral section view of a further non-limiting embodiment of a refrigerating unit provided with a defrosting device. Several electromechanical transducers are shown.

Figure 6 shows a front view of a refrigerating unit wherein a plurality of electromechanical transducers are arranged at predefined position in close correspondence of a finned surface of the evaporator.

Description

[0078] Figure 1 identifies a refrigerator. The refrigerator comprises a case 3, 4, 5, 6 defining an inner compartment 2 suitable to be cooled by means of a refrigerating unit. In detail, the inner compartment 2 is appropriately thermally insulated.

[0079] The case 3 ,4, 5, 6 comprises a front door 3, configured to be opened by the user in order to access the inner compartment 2. The door may be conveniently conceived for being opened and closed by means of a rotation along a substantially vertical axis.

[0080] The case further comprises an upper wall 4 and a bottom wall 5, preferably aligned along parallel planes, both being joined together by respective lateral walls extending preferably on a plane orthogonal with respect to the plane along which the upper wall 4 and the bottom wall 5 are aligned.

[0081] A rear wall 5 joins the upper wall 4, the bottom wall 5 and the lateral walls to seal the rear part of the case. In an embodiment the case is integral, and thus the aforementioned walls are parts of the case indissolubly joined together.

[0082] The refrigerator 1 comprises a refrigerating unit. The refrigerating unit 1 comprises:

- at least one compressor 13,
- at least one evaporator 12,
- at least one condenser 11.

[0083] The compressor 13, the condenser 11 and the evaporator 12 form a closed circuit for a refrigerating fluid (that may be in a substantially liquid and/or in a gaseous form) which by virtue of the energy provided by the compressor is compressed at the condenser 11 thus releasing heat and expands at the evaporator 12 in such a way to cool the inner compartment 2.

[0084] In an embodiment at least one between the evaporator 12 and the condenser 11 is aligned on a substantially vertical plane.

[0085] The condenser 11 is preferably installed at the rear part of the case 3, 4, 5, 6.

[0086] At least one ventilator (not shown) may be operatively coupled to the evaporator 12 and/or to the condenser 11 in such a way to increase the thermal transfer thereof by means of a forced air flow against a target surface or area.

[0087] Due to the specific technical function, the evaporator 12 may be prone to be covered, at least partially, by ice and/or frost; indeed, its surface is in use very cold, typically far below the freezing point of water. As already mentioned in the background art chapter, during the operation ice and/or frost may produce in the inner compartment 2 and/or in substantial correspondence of the evaporator 12; such ice and/or frost impedes an efficient thermal transfer with the inner compartment 2, as ice (water) and air act as thermal insulators.

[0088] In the context of the present disclosure difference is highlighted between frost and ice for the reasons that follow. Ice is intended to be a substantially continuous, dense, portion of solidified water, which typically traps a small amount of air therein. Frost, even if clearly including iced water, assumes the form of a plurality of iced granules that may be provided with a crystalline shape in forms of needles or chips. According to the specific operative conditions that may take place in the inner compartment of the refrigerator (in particular, and not limited to, moisture percentage, pressure and temperature), ice and/or frost 14 may be simultaneously or alternatively present.

[0089] The refrigerating unit of the present disclosure comprises an active defrosting device. The defrosting device is described as "active" since, as it will be apparent from the following portion of description, comprises at least one actively fed device, in particular at least one electrically fed device.

[0090] In a first, simpler, embodiment, the active defrosting device comprises at least a first electromechanical transducer 10, arranged in correspondence of the at least one evaporator 12. The size of the electromechanical transducer 10 may correspond to the size of the evaporator 12 or may be smaller. The transducer may be arranged in a position wherein the presence of ice and/or frost is most likely. As it will be apparent from the following description, the Applicant has conceived embodiments wherein several transducers are present. In such case, the transducers will be arranged preferably at positions wherein the presence of ice and/or frost is most likely.

[0091] Through the device comprising the electromechanical transducer it is possible to carry out a method of defrosting as hereinafter disclosed. The method of defrosting comprises a step of activation of a defrosting device of the refrigerator 1 in turn comprising at least a step of electric feeding of at least a first electromechanical transducer 10 of said defrosting device.

[0092] The at least a first electromechanical transducer 10 is arranged in correspondence of the evaporator 12, preferably on at least one surface of said evaporator 12. Several configurations of reciprocal arrangement between the first electromechanical transducer 10 and the evaporator 12 have been conceived: a first configuration, which is clearly non-limiting, includes the first electromechanical transducer 10 arranged at a substantially central portion of the evaporator 12; a second configuration, still non-limiting, includes the first electromechanical transducer 10 arranged at a side portion of the evaporator 12; such side portion may be a corner portion of the evaporator 12.

[0093] In detail, figure 5 shows a particular embodiment showing a plurality of electromechanical transducers 10 arranged at different portions of a single side of the evaporator 12. This embodiment specifically shows that in case a first and a second electromechanical transducers 10 be present, such transducers may also be arranged on a same side of the evaporator 12.

[0094] Figure 6 shows a particular embodiment of the refrigerating unit according to the present disclosure. The size of the evaporator 12 is relevant, or there is the need of effectively remove ice and/or frost at several specific areas of the evaporator 12; here, four electromechanical transducers are arranged at corner portions of the evaporator 12.

[0095] The electric feeding of the at least a first electromechanical transducer 10 causes said at least a first electromechanical transducer 10 to produce a discontinuous vibration in correspondence of the at least one evaporator 12, the discontinuous vibration assisting an at least partial removal of ice and/or frost deposited in correspondence of said evaporator 12, in particular a delamination of said ice and/or frost 14 at a contact surface with said evaporator 12 and, as a result, in a particular case wherein the evaporator 12 is arranged in a spatial orientation, causes a detachment and subsequent fall of at least part of said ice and/or frost 14 from the evaporator 12 by gravity. As it will be apparent from the following portion of the description, discontinuous vibration produced by said at least a first electromechanical transducer 10 is a pulsed vibration and/or a variable amplitude vibration and/or variable frequency vibration.

[0096] In another embodiment, the defrosting device is provided with a first and a second electromechanical transducer 10. Also the second electromechanical transducer is configured for assisting an at least partial removal of ice and/or frost deposited in correspondence of the at least one evaporator 12. The features of the second electromechanical transducer 10 and of the first electromechanical transducer 10 may be the same. The second electromechanical transducer 10 and the first electromechanical transducer may be arranged at opposite sides of the at least one evaporator 12. This arrangement is schematically represented in figure 2. Alternatively, the first and the second electromechanical transducer 10 may be arranged respectively to act on a first evaporator 12 and on a second evaporator 12 of the refrigerating unit. Such further embodiment may be convenient for refrigerators of considerable size, or whose evaporator (or evaporators) are of a considerable size. Indeed the use of several electromechanical transducers allows to optimize the induction of the vibration on the evaporator (or on the evaporators) with a great surface, reducing the amount of time required to remove certain amounts of ice and/or frost 14, or allowing to effectively detach amounts of ice and/or frost 14 that a single electromechanical transducer 10 would not effectively detach.

[0097] In a preferred, albeit non-limiting, embodiment, the at least one evaporator 12 is provided with a plurality of fins, in particular with a plurality of heat exchanging fins, that in the annexed figures are identified by the reference number 12f. Such heat exchanging fins 12f define a finned surface suitable to allow a dispersion of heat in the space surrounding the evaporator itself. Several materials could be used in principle for the heat exchanging fins of the evaporator 12. In an embodiment, which in any case is not limiting, the heat exchanging fins 12f are realized in a thermally high-conductive material. In an embodiment, such material is a metal. Preferably, such metal includes aluminum or an alloy thereof.

[0098] In a non-limiting embodiment, the evaporator 12 is a roll-bond evaporator. In such a case the first electromechanical transducer 10 or, when present, the second electromechanical transducer, is arranged on a surface of such roll-bond evaporator. More particularly, in the embodiments wherein two distinct electromechanical transducers are present, the first and the second electromechanical transducers may be realized on the same surface of the roll-bond evaporator, or on distinct surfaces of said roll-bond evaporator. Such distinct surfaces may be preferably, albeit in a non-limiting extent, opposite surfaces.

[0099] In fact, in an embodiment the roll-bond evaporator 12 comprises at least a first surface and a second surface mainly planar, opposite one with respect to the other and substantially parallel. The first and the second electromechanical transducer 10 may be arranged on such first and second surface, respectively. In a non-limiting embodiment, the surface of such refrigerators is a surface that may lead.

[0100] A roll-bond evaporator may be realized by at least a couple of superimposed layers of material, e.g. aluminum, within which channels are realized to allow the flow of a liquid or gaseous fluid to convey heat distribution. Roll-bond evaporators are very thin, thermally efficient and may be realized in several shapes.

[0101] In an embodiment, the electromechanical transducer 10 is physically coupled to the at least one evaporator 12; in particular it is arranged on a side of said at least one evaporator 12, in particular on the side of the evaporator 12 which is closer to the inner compartment 2 or which is into the inner compartment 2. In an embodiment, the electromechanical transducer 10 is in physical direct contact with said evaporator 12. This ensures the best possible transmission of vibration in use produced by the electromechanical transducer.

[0102] In a peculiar embodiment, the electromechanical transducer 10 may be shaped in such a way to at least partially, preferably fully, surround a portion of the evaporator 12. In detail the electromechanical transducer 10 may be realized as a sleeve surrounding a portion of the evaporator 12.

[0103] The at least a first electromechanical transducer 10 is configured to cause, when electrically fed, a discontinuous vibration in correspondence of said at least one evaporator 12. Such discontinuous vibration assists an at least partial removal of ice and/or frost deposited in correspondence of the at least one evaporator 12.

[0104] The technical effect of the vibration induced by the first electromechanical transducer 10 on the at least one evaporator is a delamination of said ice and/or frost at a contact surface with the at least one evaporator 12. Hence, especially when such evaporator 12 is arranged vertically, such delamination precedes a fall of the ice and/or frost from the evaporator 12.

[0105] Technical studies carried out by the Applicant have shown that preferably, albeit in a non-limiting extent, the waveform of the vibration induced in use by the first electromechanical transducer 10 on the layer of ice and/or frost 14 is of a sinusoidal shape over one length of the evaporator. Such waveform of the vibration induces a simultaneous stress of flexion and extension on the layer of ice and/or frost 14, and such peculiar stress has proven to be relevantly effective in allowing a detachment of the layer from the evaporator 12.

[0106] The Applicant has conceived a specific embodiment of the refrigerating unit which is provided with at least one heater 18. The heater 18 is an electrically active heater. In a non-limiting embodiment, the heater 18 is activated by means of a DC current.

[0107] According to a specific operative configuration, the heater 18 may be activated in a pulsed fashion. Each pulse has a time length comprised in the range [0,5ms - 10s], preferably in the range [0,7ms - 8s], more preferably in the range [1ms - 5s]. The heater 18 may be realized as a layer juxtaposed directly or indirectly to at least a portion of the evaporator 12.

[0108] In any embodiment wherein more than one electromechanical transducer 10 is present, at least one heater 18 may be present, or several heaters 18 may be arranged at positions substantially corresponding to the positions wherein the electromechanical transducers 10 are provided.

[0109] Several embodiments of the refrigerating unit comprising a heater have been conceived by the Applicant; figure 3 and figure 4 show to non-limiting embodiments wherein the heater 18 is applied to a refrigerating unit provided with two electromechanical transducers 10 arranged at opposite sides of the evaporator 12. It is noted that the heater 18 may be applied to a refrigerating unit 1 provided with a single electromechanical transducer 10.

[0110] Figure 3 shows a configuration wherein the heater 18 lies at an outer face of the electromechanical transducer 10. In correspondence of a portion of the evaporator 12, the cross section of the overall assembly of the refrigerating unit is such that at least one of the two electromechanical transducer 10 (in detail, the electromechanical transducer appearing on the right side of the evaporator 12) is sandwiched between the evaporator 12 and the heater 18. In the embodiment of figure 3, it appears clear that in such portion the electromechanical transducers 10 are in direct contact with the evaporator 12; in detail the electromechanical transducers 10 are in direct contact with the outer face of the evaporator 12.

[0111] Figure 4 shows another embodiment wherein the heater 18 lies at an outer face of the evaporator 12. In correspondence of a portion of the evaporator 12, the cross section of the overall assembly of the refrigerating unit is such that the heater 18 is sandwiched between the evaporator 12 and one of the electromechanical transducers 10. Should a single electromechanical transducer be present, the heater 18 would be sandwiched between the evaporator 12 and the (single) electromechanical transducer 10. In the embodiment of figure 4, thus, the heater 18 is in direct contact with the evaporator 12, in particular in direct contact with the outer face of the evaporator 12. The heater 18 is arranged and substantially lies on a plane substantially parallel to the plane on which, at least locally, the evaporator 12 lies.

[0112] In an embodiment, the refrigerating unit comprises a binding layer which is interposed between the at least one evaporator 12 and the at least one of the first electromechanical transducer 10, the second electromechanical transducer 10 and the heater 18. Figure 4 shows an example of such embodiment. The binding layer comprises a binding material and such binding material comprises a plastic material, in particular a plastic material including C_4H_8O. Preferably, albeit in a non-limiting extent, such binding material comprises PVD (Poly Vinyl Butirrale) that is preferably used by virtue of the strong binding properties, optical transparency, toughness and flexibility. In the annexed figures, the binding layer is identified by the reference number 16.

[0113] In addition to the above features, it may be noted that a coating comprising an anti-icing material may be applied to at least one surface of the evaporator 12. Several types of anti-icing materials may be used, but in a preferred, non-limiting, embodiment, the coating is nanostructured. The usage of an anti-icing coating layer further reduces the amount of ice and/or frost, and/or reduces the strength of the mechanical binding of such ice and/or frost to the evaporator 12. Thus, adding the anti-icing coating layer allows to ease the operation of the at least a first electromechanical transducer 10 and, when present, of the second electromechanical transducer 10 and/or of the heater 18.

[0114] The defrosting device is further equipped, or operatively associated to, a data processing unit. The data processing unit acts as a control unit suitable to control, in use, the operation of the defrosting device and - in some embodiments - of the overall refrigerator.

[0115] The data processing unit may be provided with a particularly programmed general-type data processor or, in contrast or in addition, with an application-specific (ASIC) or dedicated integrated circuit or processor. As well, the data processing unit may be provided with an FPGA or any other electronic integrated circuit suitable to allow the management of the operation of the at least one electromechanical transducer 10, and when present, of the heater 18. When so required, the program for the data processing unit may contain software code portions that when executed cause the execution of the method according to the present disclosure.

[0116] In particular, the data processing unit may control servoactuators conceived to allow the power supply of the electromechanical transducers and/or of the heater. Provided that the transducer and/or the heater may be operated with relevant voltage and/or absorb a significant amount of power, albeit for short times, the separation of the power supply with respect to control signals may be preferable, for safety reasons.

[0117] The data processing unit is configured to operate in a demanding environment; thus it may be covered by an insulating layer, in particular a thermal and/or a water insulating layer.

[0118] In an embodiment, the defrosting device is configured to feed the at least a first electromechanical transducer 10 in a substantial simultaneous temporal correspondence with said heater 18.

[0119] In a specific embodiment, the data processing unit causes the activation of the heater 18 before the first electromechanical transducer 10 is activated. When two electromechanical transducers are present, the data processing unit causes the activation of the heater 18 before the first and the second electromechanical transducers 10 are activated.

[0120] Albeit the following technical feature shall not be considered compulsory, preferably the heater 18 is kept fed while the first electromechanical transducer 10 (or, when present, while also the second electromechanical transducer 10) is fed. A predetermined amount of time of superimposition of feeding for the heater 18 and the first (and, should the case may be the second) electromechanical transducer is stored in a memory associated to, or of, such data processing unit.

[0121] In order to allow a proper detachment of the layers of ice and/or frost, the time during which the first electromechanical transducer 10 (and, when present, the second electromechanical transducer 10) is (are) activated may be longer than the time during which the heater

18 is electrically fed.

[0122] In an embodiment, the defrosting device is configured to activate, through the aforementioned data processing unit, the first and the second electromechanical transducer 10 simultaneously. In another embodiment, the defrosting device is configured to activate the first electromechanical transducer 10 in correspondence of instants of time differing from the instants of time at which the second electromechanical transducer 10 is activated.

[0123] Resuming, the data processing unit may be configured to electronically retrieve at least one of the following data: at least one time of activation of the first electromechanical transducer 10, at least one time of activation of the second electromechanical transducer, a time delay between the beginning of the activation of the first electromechanical transducer 10 with respect to the second electromechanical transducer (such time delay may be actually reduced to zero), at least one time of activation of the heater 18, at least one time delay between the beginning of the activation of the first electromechanical transducer 10 with respect to the heater 18, and/or between the beginning of the activation of the second electromechanical transducer 10 with respect to the heater 18, a cycle time for the activation of at least one between the first electromechanical transducer 10, the second electromechanical transducer 10, the heater 18.

[0124] It may be noted that the use of the data processing unit allows to select an automated activation of the at least one between the first, the second electromechanical transducer 10 and/or of the heater 18. Nonetheless, the Applicant has disclosed a particular configuration of the data processing unit wherein the activation of the above disclosed devices may be forced manually by a user.

[0125] Albeit several types of electromechanical transducers 10 may be used to cause such discontinuous vibration, preferably comprising a piezo-electric transducer is used. In a preferred, non-limiting embodiment, the Applicant has selected a Langevin-type piezo-electric transducer, in order to achieve a high energetic efficiency (absorbed electric power over vibration force). In an embodiment, voltages applied to the piezo-electric transducer reach up to 200V.

[0126] Langevin-type piezo-electric transducers are particularly effective transducers that comprise at least one electrode to feed two piezoelectric elements, and a couple of masses respectively coupled side to side with the respective piezoelectric element. The electrode is typically arranged between the piezoelectric elements, and is configured to feed the piezoelectric elements in a substantially simultaneous way.

[0127] At least one bolt, which is actually a compression bolt, fixes the two masses together and in an embodiment passes through a through-hole of one of the two masses and through an opening of the piezoelectric elements, to end in a typically blind hole on the other mass. In such a way, the piezoelectric elements are compressed, in particular axially compressed, between the two masses. The overall assembly of the piezoelectric elements and of the masses is made resonant in correspondence of an at least one specific and predetermined frequency, which depends on several factors, including the weight and/or the form of the first and of the second mass. The tightening of the compression bolt, determining the aforementioned axial compression, is typically important for a proper propagation of the vibration waveform. The Langevin-type piezo-electric transducer comprises an output face, coupled with one of the two masses, wherein the ultrasonic waveform is in use produced.

[0128] In order to increase the efficiency of the transmission of the vibration, the at least one electromechanical transducer 10 is of a directional type. This means that such electromechanical transducer 10 is configured to diffuse a vibration waveform along a predetermined preferential direction or set of directions, in particular along a preferential solid angle of radiation. Langevin-type piezo-electric transducers, with their specific structural configuration, are a typical example of transducers provided with the above technical feature. The output face is the portion of the transducer wherein the vibration is generated. It may be assumed that a main direction of radiation is a direction substantially orthogonal to the plane of the output face.

[0129] Such piezo-electric transducer is particularly configured to generate an ultrasonic vibration, that is a vibration having frequency substantially comprised in the range [20 kHz - 70 kHz], preferably in the range [30 kHz - 60 kHz], more preferably [40 kHz - 50 kHz]. As well, such piezo-electric transducer is capable to trigger excitation frequencies within the range [200 kHz - 500 kHz].

[0130] In an embodiment, the electromechanical transducer operates with an input power of about 40W to 60W, and 18 - 22 kV/m.

[0131] Such transducers are powerful with respect to the size. Thus their presence requires substantially no design adaptation in refrigerators formerly not provided with a refrigerating unit including electromechanical transducers. The reduced volume of the transducers allows design freedom and does not pose a limitation in a proper positioning of the evaporator 12 relative to the inner compartment 2.

[0132] In use, when the electromechanical transducer is electrically fed, a shear stress force is induced at substantial correspondence of the evaporator 12. For an optimal removal of ice and/or frost, preferably the shear stress is in the range [0,5 MPa - 1,5 MPa], more preferably in the range [0,7MPa - 1,2MPa].

[0133] The shear stress force, in a direction substantially orthogonal to the direction identifying the thickness of the ice and/or frost layer, is important since it causes the production of cracks in the ice and/or frost layer. Such cracking is important, as it determines the separation of a single, substantial continuous layer of ice and/or frost in several parts or tiles, whose detachment from the evaporator 12 is easier.

[0134] The discontinuous vibration is produced by means of pulses; thus, the at least one electromechanical transducer 10 is electrically fed in such a way to produce at least one pulse of vibrations, or more preferably a train of pulses of vibration; each pulse has a time length comprised in the range [0,5ms - 10s], preferably in the range [0,7ms - 8s], more preferably in the range [1ms - 5s].

[0135] Pulsed vibrations have proven to be have an equal or increased effectiveness if compared to continuous vibration for assisting the removal of ice and/or frost from the evaporator 12. Feeding the at least one electromechanical transducer 10 in such a way to cause pulses of vibration implies a less amount of energy, thus a greater energy efficiency, with a contextual no impairment in the effectiveness of ice and/or frost detachment from the evaporator 12.

[0136] In an embodiment, which is still considered not limiting, the refrigerating unit may further include an electric power supply unit particularly configured to interface itself with the electric power supply unit of the refrigerator in order to draw therefrom, or from the feeding line of the refrigerator, a sufficient amount of electric energy to determine the electric supply of one or more among the first electromechanical transducer, the second electromechanical transducer, the data processing unit, the at least one heater. Conveniently, such electric power supply may comprise at least one between a transformer, a rectifier, preferably a solid-state rectifier, an electric filter, one or more overvoltage and/or overcurrent limiters, preferably including at least one fuse, or a short-circuit protection device. Transformers may be advantageously used for feeding the data processing unit, which traditionally requires low voltages, below the traditional 120 Vac or 220-240Vac used for feeding the power utilities of the refrigerator, i.e. at least the compressor.

[0137] The advantages of the refrigerating unit herein described, of the refrigerator herein described and of the method herein described are clear in view of the above description.

[0138] The unit is very effective in removing even thick layers of ice and/or frost. In particular low power consumption relative to the effectiveness of removal of ice and/or frost is obtained.

[0139] The unit is very compact, and provides design freedom for the refrigerator. The unit can be manufactured as a modular unit.

[0140] The unit is capable of inducing a particularly effective waveform of vibration that allows a particularly effective action of detachment of ice and/or frost. In detail, the effectiveness is particularly an effectiveness in the overall time length required to properly cause the detachment of a layer of ice and/or frost. Very positive tests have been performed by the Applicant on clamped aluminum plates simulating an evaporator 12, without coating, covered by a 2mm thick, glaze-type, ice layer obtained in a freezing chamber. A 46 kHz Langevin-type transducer was used, and it was fed with a voltage whose peaks were in the range 150 - 180 V. Highly effective delamination was present from 150V and was kept for voltages higher than 150V.

[0141] The unit does not include movable parts or unreliable glass coatings, which in contrast are subject to the risk of peeling off or delamination in the course of the lifetime of the refrigerator.

[0142] Combined or separate activation of the electromechanical transducer and of the heater may be easily programmed through the data processing unit; therefore, high operative flexibility of the refrigerator may be obtained. In particular, the user is allowed to manually activate at least one between the first electromechanical transducer, the second electromechanical transducer and the heater should he find the presence of an unwanted layer of ice and/or frost.

[0143] Especially when a Langevin-type piezoelectric transducer is employed, tensile stress in the piezoelectric material is much less than the architectures with bonded piezoelectric ceramics. This allows to increase the lifetime of the transducer, whose substitution may not be easily carried out.

[0144] It is noted that the refrigerating unit as above described may be manufactured and/or sold specifically as a kit for producing refrigerators or for updating currently existing or at least partially manufactured refrigerators.

[0145] It is further noted that the refrigerator herein disclosed may belong to the category of household appliances, or in contrast may be an industrial refrigerator. It is thus considered that the refrigerating unit may be suitable to be used or installed in any of the above kinds of refrigerators.

[0146] It is herewith considered that the invention is not limited to the embodiments shown in the figures. For such reason, reference numbers and signs that appear in the claims are provided with the sole scope of increasing the intelligibility of the claims, and shall not be considered limiting the scope of protection thereof.

[0147] It is finally clear that to the object of the present disclosure several adaptations or additions can be carried out, without for this departing from the scope of protection provided by the annexed claims.

Claims

1. A refrigerating unit for a refrigerator (1), the refrigerating unit comprising:

   - at least one evaporator (12), configured for being installed in said refrigerator (1) and for causing, in use, cooling of an inner compartment (2) of said refrigerator (1), and
   - an active defrosting device comprising at least one first electromechanical transducer (10), said first electromechanical transducer (10) being arranged in correspondence of said evaporator (12), preferably on at least one surface of said

evaporator (12), and being configured to cause, when electrically fed, a discontinuous vibration in correspondence of said evaporator (12), assisting an at least partial removal of ice and/or frost (14) deposited in correspondence of said evaporator (12), the discontinuous vibration being in particular a pulsed vibration and/or a variable amplitude vibration and/or variable frequency vibration, wherein in particular the at least a first electromechanical transducer (10) is arranged in such a way to cause, when electrically fed, a delamination of said ice and/or frost (14) at a contact surface with said evaporator (12).

2. The refrigerating unit according to claim 1, wherein the at least one first electromechanical transducer (10) comprises an ultrasonic transducer.

3. The refrigerating unit according to claim 2, wherein the ultrasonic transducer (10) comprises at least one piezo-electric element, and in particular is a Langevin-type transducer.

4. The refrigerating unit according to claim 2 or 3, wherein the ultrasonic transducer is configured to generate an ultrasonic vibration having frequency substantially comprised in the range [20 kHz - 70 kHz], preferably in the range [30 kHz - 60 kHz], more preferably in the range [40 kHz - 50 kHz] and/or is configured to trigger excitation frequencies within the range [200 kHz - 500 kHz], and/or is configured to induce, at a substantial correspondence of said evaporator (12), a shear stress lying in the range [0,5 MPa - 1,5 MPa], more preferably in the range [0,7MPa - 1,2MPa], the vibration being optionally a sinusoidal vibration inducing, in use, a stress of flexion and extension on the ice and/or frost (14).

5. The refrigerating unit according to one or more of the preceding claims, wherein the defrosting device further comprises at least one heater (18), substantially arranged in correspondence of the evaporator (12), preferably on a surface of the evaporator (12), the heater (18) being configured to cause, when activated, melting of an interfacial layer of said ice and/or frost (14) into contact with said evaporator (12), so as to generate a film of water between said ice and/or frost (14) and said evaporator (12), said heater (18) being an electric heater, preferably a metal foil heater and/or a transparent thin-film heater and/or an opaque thin-film heater.

6. The refrigerating unit according to claim 5, wherein the heater (18) is configured to be activated in such a way to produce heat pulses, said heat pulses having a time length comprised in the range [0,5 ms - 10 s], preferably in the range [0,7 ms - 8 s], more preferably in the range [1 ms - 5 s] and/or wherein the defrosting device is configured to feed said at least a first electromechanical transducer (10) in a substantial simultaneous temporal correspondence with said heater (18) and/or to start feeding said heater (18) before feeding said at least a first electromechanical transducer (10) and/or to keep feeding said heater (18) while said at least a first electromechanical transducer (10) is fed and/or to feed said at least a first electromechanical transducer (10) for an overall time longer than an overall time of feeding of said heater (18).

7. The refrigerating unit according to one or more of the preceding claims, wherein the active defrosting device comprises at least a second electromechanical transducer (10), the at least a second electromechanical transducer (10) being arranged in correspondence of said at least one evaporator (12), preferably on at least one surface of said evaporator (12), and being configured to cause, when electrically fed, a discontinuous vibration in correspondence of said evaporator (12), assisting an at least partial removal of ice and/or frost (14) deposited in correspondence of said evaporator (12), the second electromechanical transducer (10) being configured to be activated alternatively or simultaneously with the first electromechanical transducer (10), optionally wherein the defrosting device comprises a plurality of electromechanical transducers (10) arranged in correspondence of said at least one evaporator (12) according to a predetermined pattern and/or evenly distributed on at least one surface of said evaporator (12).

8. The refrigerating unit according to claim 7, wherein at least one between the first electromechanical transducer (10) and the second electromechanical transducer (10) at least partially surrounds at least a predetermined portion of the evaporator (12) and/or

wherein said evaporator (12) is provided with a plurality of heat exchanging fins (12f) defining a finned surface and at least one between the first electromechanical transducer (10) and the second electromechanical transducer (10) is arranged in substantial correspondence of said finned surface and/or

wherein said evaporator (12) is a roll-bond evaporator and said at least a first electromechanical transducer (10) is arranged on a surface of said roll-bond evaporator, optionally wherein the first and the second electromechanical transducer (10) are arranged on the same surface of said roll-bond evaporator or on distinct surfaces, in particular opposite surfaces, of said roll-bond evaporator, and/or wherein the defrosting device is configured to feed said at least a first electromechanical transducer (10), optionally the first and the second electromechanical transducer (10), in a substantial simultaneous temporal correspondence with said heater (18), preferably wherein the defrosting device is configured to start feeding said heater (18) before feeding said at least a first electromechanical transducer (10), optionally the first and the second electromechanical transducer (10), and, optionally, to keep feeding said heater (18) while said at least a first electromechanical transducer (10) is fed, optionally while the first and the second electromechanical transducer (10) are fed, and/or

wherein the defrosting device is configured to feed said at least a first electromechanical transducer (10), optionally the first and the second electromechanical transducer (10), for an overall time longer than an overall time of feeding of said heater (18) and/or

wherein at least one between the first electromechanical transducer (10), the second electromechanical transducer (10) and the heater (18) is directly attached to said evaporator (12) and/or

wherein the refrigerating unit comprises a binding layer (16) interposed between the at least one between the first electromechanical transducer (10), the second electromechanical transducer (10) and the heater (18) and the evaporator (12), the binding layer (16) comprising a plastic material, in particular a plastic material including C_4H_8O, more in particular PVB and/or wherein a coating comprising an anti-icing material is applied to at least one surface of the evaporator (12), said coating being preferably nanostructured.

9. A refrigerator (1), comprising:

- a refrigerating unit according to one or more of the preceding claims, the refrigerating unit further comprising a compressor (13) and at least one condenser (11), the compressor (13) being connected to said at least one condenser (11) and to said evaporator (12);
- a control unit operatively connected to said defrosting device and to said compressor (13);
- a case (3, 4, 5, 6) defining an inner compartment (2) suitable to be cooled by means of said evaporator (12),

the refrigerator (1) comprising at least a cooling configuration and a defrosting configuration,

wherein in said cooling configuration said compressor (13) is activated by said control unit to cause a fluid circulation determining a withdrawal of heat from said inner compartment (2) by means of said at least one evaporator (12), wherein in particular said cooling configuration provides for a thermal exchange between said evaporator (12) and at least one wall of said inner compartment (2) or for an air flow cooled by said evaporator (12) and delivered to said inner compartment (2), and/or wherein in said defrosting configuration said defrosting device is activated by said control unit to cause an at least partial removal of ice and/or frost (14) deposited in correspondence of said evaporator (12), wherein in particular said cooling configuration provides for a delamination of said ice and/or frost (14) at a contact surface with said evaporator (12).

10. The refrigerator (1) according to claim 9, said evaporator (12) being in particular arranged along a substantially vertical direction, wherein said at least a first electromechanical transducer (10) is configured to cause detachment and subsequent fall of at least part of said ice and/or frost (14) from the at least one evaporator (12) by gravity, optionally wherein the fall of the ice and/or frost (14) is assisted by the film of water generated by the melting of the interfacial melting caused by said heater (18), the film of water allowing the ice and/or frost (14) to slide on said evaporator (12).

11. A method of defrosting at least one evaporator (12) configured for being installed in a refrigerator (1) and for causing, in use, a cooling of an inner compartment (2) of said refrigerator (1), the method comprising a step of activation of a defrosting device of said refrigerator (1) in turn comprising at least a step of electric feeding of at least a first electromechanical transducer (10) of said defrosting device, the at least a first electromechanical transducer (10) being arranged in correspondence of said evaporator (12), preferably on at least one surface of said evaporator (12), said electric feeding causing said at least a first electromechanical transducer (10) produce a discontinuous vibration in correspondence of said at least one evaporator (12), the discontinuous vibration assisting an at least partial removal of ice and/or frost deposited in correspondence of said evaporator (12), in particular a delamination of said ice and/or frost (14) at a contact surface with said evaporator (12) and, optionally, causing a detachment and subsequent fall of at least part of said ice and/or frost (14) from the evaporator (12) by gravity.

12. The method according to claim 11, the at least a first electromechanical transducer (10) comprising an ultrasonic transducer, in turn comprising at least one piezo-electric element, the ultrasonic transducer being in particular a Langevin-type transducer, the discontinuous vibration produced by said at least a first electromechanical transducer (10) being a pulsed vibration and/or a variable amplitude vibration and/or variable frequency vibration, wherein the vibration has a frequency substantially comprised in the range [20 kHz - 70 kHz], preferably in the range [30 kHz - 60 kHz], more preferably [40 kHz - 50 kHz] and/or wherein the piezo-electric transducer is configured to trigger excitation frequencies within the range [200kHz - 500 kHz], and/or wherein the vibration induces, at a substantial correspondence of said evaporator (12), a shear stress lying in the range [0,5 MPa - 1,5 MPa], more preferably in the range [0,7MPa - 1,2MPa], the vibration being optionally a sinusoidal vibration inducing, in use, a stress of flexion and extension on the ice and/or frost (14).

13. The method according to claim 11 or 12, comprising a step of activation of at least one heater (18) of said defrosting device, substantially arranged in correspondence of the evaporator (12), preferably on a surface of the evaporator (12), said step of activation of said at least one heater (18) causing a melting of an interfacial layer of said ice and/or frost (14) into contact with said evaporator (12), said heater (18) being an electric heater, preferably a metal foil heater and/or a thin-film heater, wherein the step of activation of at least one heater (18) is a step of pulsed activation determining the production of heat pulses by said at least one heater (18), said heat pulses having in particular a time length comprised in the range [0,5 ms - 10 s], preferably in the range [0,7 ms - 8 s], more preferably in the range [1 ms - 5 s].

14. The method according to one or more of claims 11 to 13, wherein the step of activation of said defrosting device further comprises a step of electric feeding a second electromechanical transducer (10), arranged in correspondence of said evaporator (12), preferably on at least one surface of said evaporator (12), said electric feeding causing said second electromechanical transducer (10) produce a discontinuous vibration in correspondence of said evaporator (12), the feeding of the second electromechanical transducer (10) taking place alternatively or simultaneously with the step of activation of the first electromechanical transducer (10).

15. The method according to claims 13 and 14, wherein the feeding of said at least a first electromechanical transducer (10), optionally the first and the second electromechanical transducer (10), takes place in a substantial simultaneous temporal correspondence with said heater (18), preferably wherein said heater (18) is fed before feeding said at least a first electromechanical transducer (10), optionally the first and the second electromechanical transducer (10), and, optionally, wherein said heater (18) is kept fed while said at least a first electromechanical transducer (10) is fed, optionally while the first and the second electromechanical transducer (10) are fed, and/or wherein the feeding of said at least a first electromechanical transducer (10), optionally the first and the second electromechanical transducer (10), takes place for an overall time longer than an overall time of feeding of said heater (18).

FIG.1

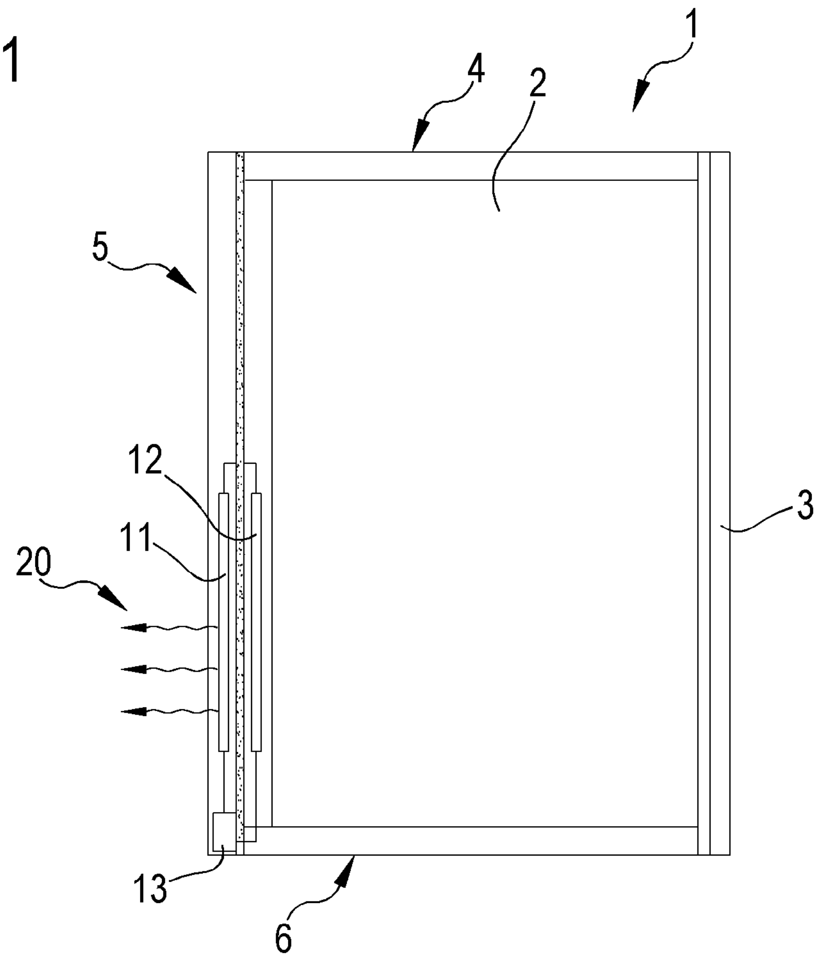
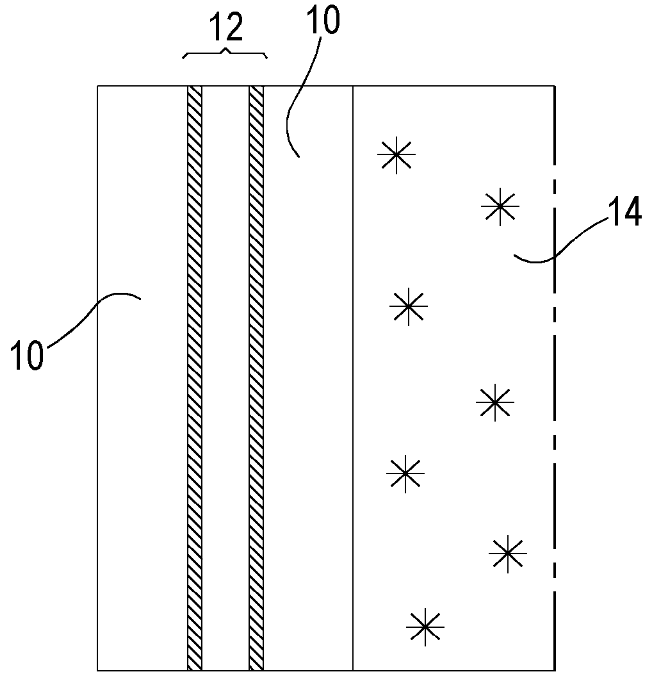


FIG.2



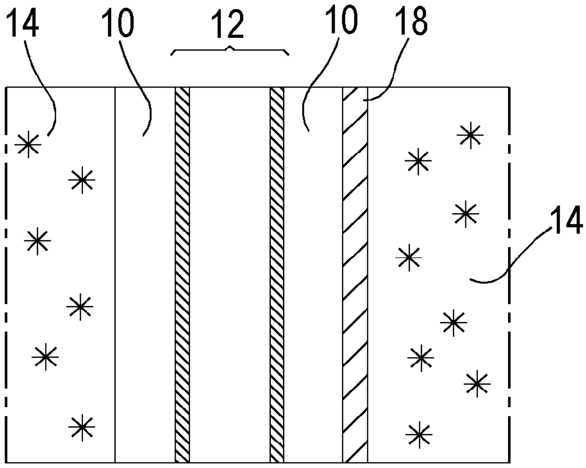
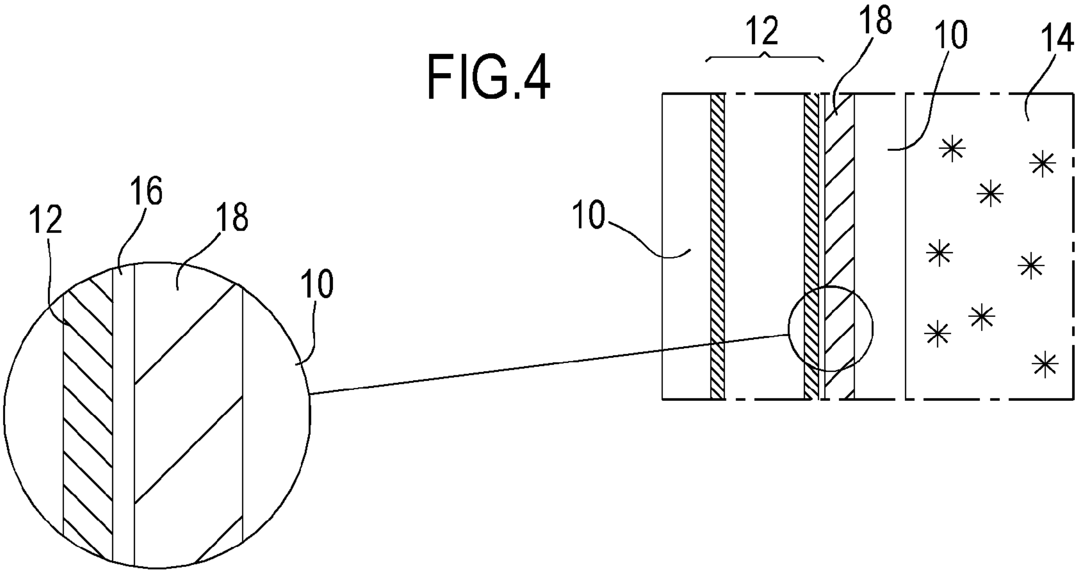


FIG.3

FIG.4



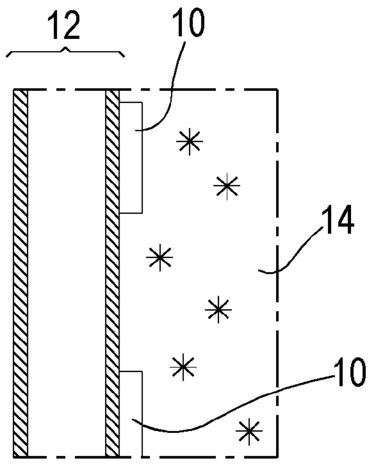


FIG.5

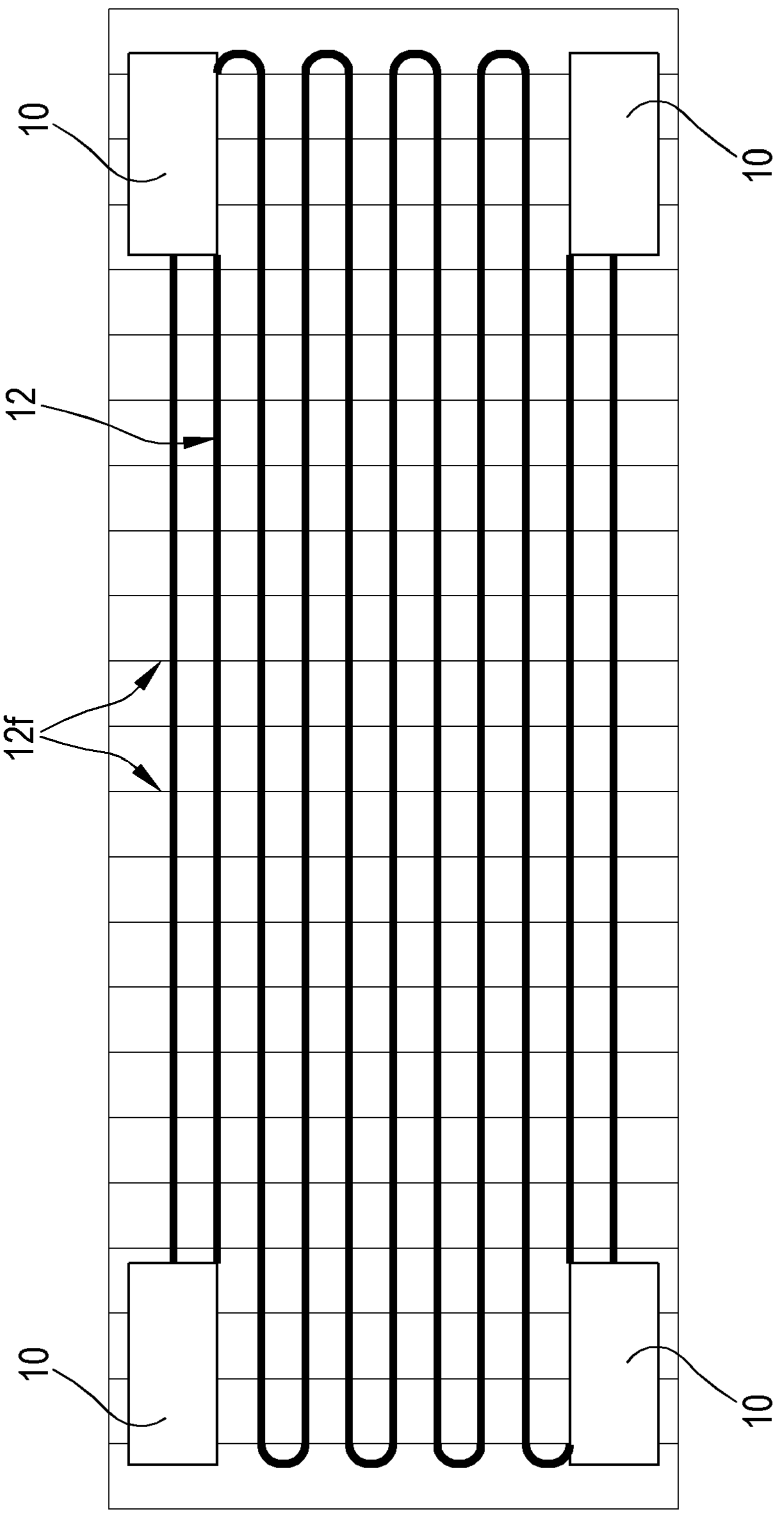


FIG.6

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EUROPEAN SEARCH REPORT

Application Number
EP 22 17 6591

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	12 October 2022	Vigilante, Marco

CATEGORY OF CITED DOCUMENTS

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