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(54) REFRIGERATING APPLIANCE HAVING AN EVAPORATOR

(57) A refrigerating appliance (10) includes at least one compartment (14, 15) having an open face (16, 17). A closure (18, 19) is movable relative to the open face (16, 17) to selectively close the open face (16, 17). An evaporator assembly (50) is provided within the compartment (14, 15). A multilayer de-icing composite (100) having thermoresistive heating capabilities is provided on at least a portion of the evaporator assembly (50).

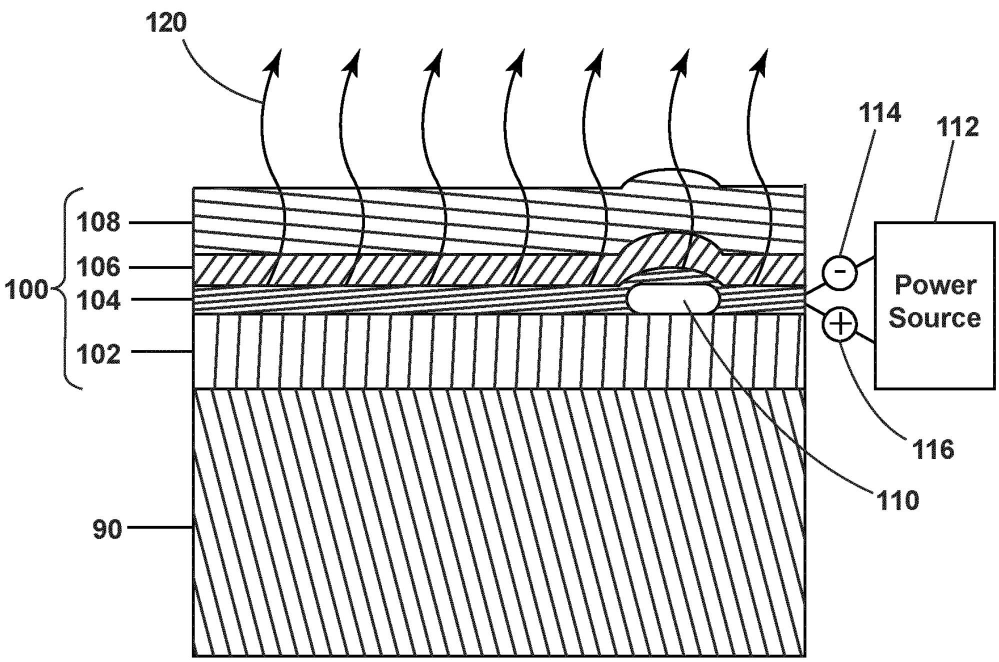

FIG. 6

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Description

TECHNICAL FIELD

[0001] The present disclosure generally relates to a refrigerating appliance, and more specifically to an evaporator for a refrigerating appliance.

BACKGROUND

[0002] In a refrigerating appliance or other appliance for storing food substances and containers of food substances, which can be found within a kitchen environment, garages, bars, restaurants, and other places, there can be numerous containers of various types, sizes, and shapes that are configured to store all matter of food substances and food items. Such a refrigerating appliance can include a cabinet defining an interior, which can be provided as at least one compartment having an open face.

[0003] The at least one compartment of the refrigerating appliance can be provided as one or more refrigerator compartments or can be provided as at least one refrigerator compartment and at least one freezer compartment. In the case that the at least one compartment includes at least the refrigerator compartment and the freezer compartment, the different compartments can be cooled to different temperatures by the operation of a refrigeration system. Such refrigeration systems for maintaining refrigerating or freezing temperatures within the compartments can utilize a compressor, an evaporator, a condenser, and an expansion device, in a closed system. During the operation of the refrigerating appliance and the refrigeration system to maintain the refrigerating or freezing temperature within the compartment, ice build-up can occur on surfaces of the evaporator. In order to facilitate optimal operation of the refrigerating appliance, defrosting or de-icing can be performed in order to melt the ice build-up on the evaporator. The defrosting or de-icing is typically accomplished by temporarily applying heat to the evaporator.

BRIEF SUMMARY

[0004] In one aspect, the present disclosure relates to a refrigerating appliance comprising at least one compartment having an open face, a closure movable relative to the open face to selectively close the open face, an evaporator assembly provided within the compartment, and a multilayer de-icing composite having thermoresistive heating capabilities, the multilayer de-icing composite provided on at least a portion of the evaporator assembly and comprising an insulating layer, a heater layer abutting the insulating layer, a thermally transmissive liquid-impermeable barrier layer abutting the heater layer, and a thermally transmissive protective layer abutting the liquid-impermeable barrier layer.

[0005] In another aspect, the present disclosure relates to a method of de-icing an evaporator assembly for a refrigerating appliance, the method comprising providing a multilayer de-icing composite having thermoresistive heating capabilities on at least a portion of the evaporator assembly, the providing a multilayer de-icing composite comprising providing an insulating layer, providing a heater layer to abut the insulating layer, providing a thermally transmissive liquid-impermeable barrier layer to abut the heater layer, and providing a thermally transmissive protective layer to abut the liquid-impermeable barrier layer, and energizing, by a controller of the refrigerating appliance, at least one heating element that is thermally coupled to the heater layer to thermoresistively heat and de-ice at least a portion of the evaporator assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] In the drawings:

FIG. 1 illustrates a perspective view of a refrigerating appliance according to an aspect of the present disclosure.

FIG. 2 illustrates a schematic view of a refrigeration system that can be provided within the refrigerating appliance of FIG. 1.

FIG. 3 illustrates a front cross-sectional view of an evaporator assembly, including an evaporator, that can be provided within the refrigeration system of FIG. 2.

FIG. 4 illustrates a side cross-sectional view of the evaporator assembly of FIG. 3.

FIG. 5 illustrates a perspective view of an example of the evaporator of FIG. 3.

FIG. 6 illustrates a schematic view of a multilayer de-icing composite including a heating element that can be provided on at least a portion of the evaporator assembly of FIG. 3.

FIG. 7 illustrates a schematic view of an example of the heating element of FIG. 6.

FIG. 8 illustrates a schematic view of another example of the heating element of FIG. 6.

FIG. 9 illustrates a schematic view of another example of the heating element of FIG. 6.

DETAILED DESCRIPTION

[0007] FIG. 1 illustrates a refrigerating or food storage appliance or refrigeration apparatus, illustrated herein as a refrigerating appliance 10 that can be provided within a storage and consumption environment, such as a kitchen. The refrigerating appliance 10 comprises a cabinet 12 at least partially defining an interior, which can be provided as at least one compartment 14, and illustrated herein, by way of non-limiting example, as a first compartment 14 and a second compartment 15, that can hold a plurality of containers 31 or other food items. Each of the first and second compartments 14, 15 can include and at least partially define an open face 16, 17, respectively, such that the first compartment 14 includes the open face 16 while the second compartment 15 includes the open face 17. The open faces 16, 17 can also function as access openings to the first and second compartments 14, 15, respectively. Each of the first and second compartments 14, 15 can further include at least one closure, illustrated herein as doors 18, 19, respectively, such that the first compartment 14 includes the door 18 while the second compartment 15 includes the door 19. The doors 18, 19 further at least partially define the first and second compartments 14, 15 when the doors 18, 19 selectively close the open faces 16, 17, respectively.

[0008] The doors 18, 19 are coupled to or movably mounted to the cabinet 12 and configured to be movable relative to the open faces 16, 17 between an opened position, as shown, and a closed position (not shown), so as to selectively open or close the open faces 16, 17, respectively, and to selectively provide access into the compartments 14, 15 through the open faces 16, 17. By way of non-limiting example, the doors 18, 19 can be rotatable between the closed position and the opened position relative to the cabinet 12, and further the doors 18, 19 can be hingedly coupled to the cabinet 12 for movement between the opened position and the closed position.

[0009] As illustrated herein, the refrigerating appliance 10 can include side-by-side compartments 14, 15 at least partially defined by side walls 22 and separated by a center partition or center wall 24, though it will be understood that upper and lower compartments 14, 15 can also be included. By way of non-limiting example, the side-by-side compartments 14, 15 can comprise one refrigerator compartment 14 at least partially defining the refrigerator open face 16 and closable by the refrigerator door 18 and one freezer compartment 15 at least partially defining the freezer open face 17 and closable by the freezer door 19. The compartments 14, 15 can be cooled to the different refrigerating and freezer temperatures by operation of a refrigeration system 32 (FIG. 2). The temperature differential between the compartments 14, 15 can be maintained through the separation of the compartments 14, 15 by the intervening insulated partition, herein the center wall 24.

[0010] While the compartments 14, 15 are illustrated herein as the side-by-side refrigerator compartment 14 and freezer compartment 15, it will be understood that other arrangements of compartments 14, 15 is contemplated. For example, both of the compartments 14, 15 can be provided as refrigerator compartments 14, 15, such as with an optional lower portion, which can further optionally include at least one drawer 26, being provided as a freezer compartment or portion. The number and arrangement of refrigerated compartments 14, 15, either a chilled compartment 14, 15 or a freezing compartment 14, 15 are not germane to the present disclosure and are given by way of non-limiting example in order to illustrate one possible environment. While the refrigerating appliance is illustrated as a side-by-side, front-opening refrigerating appliance 10, the aspects of the present disclosure can have applicability in other refrigerating appliances, non-limiting examples of which include stacked style freezer-on-top or freezer-on-bottom refrigerators, drawer-style refrigerators or freezers, beverage coolers, free-standing refrigerators, build-in refrigerators, display refrigerators, a storage or refrigerating cabinet, a storage or refrigerated drawer, a beverage storing appliance, a freezer, a wine cellar, etc.

[0011] At least one of the compartments 14, 15 can include at least one shelf 30 provided within the compartment 14, 15. In addition, or alternatively, the shelf 30 can be provided such that the at least one drawer 26 is slidably mounted directly beneath the shelf 30, with the shelf 30 selectively closing an open top of the drawer 26. The shelves 30 can be adapted for slidable, tiltable, a combination thereof, or any other suitable type of movement, out of and into the compartment 14, 15, such as via shelf guides 28.

[0012] The at least one shelf 30 is configured to provide a support surface upon which food items and containers 31 can be placed to be stored and refrigerated. The containers 31 can be any sort of container 31 for holding a food substance. The containers 31 can be commercially available containers 31 that are obtained by a user already containing a food substance, or storage containers 31 into which a food substance is placed by a user for refrigerated storage outside of the original packaging. Containers 31 can be transparent or opaque, with any suitable level of opacity being contemplated. The food substance within the containers 31 can be any food substance, non-limiting examples of which include liquids, solids, gelatinous substances, mixtures, dry goods, etc. In one example, the containers 31 are used to contain food substances that are non-solid, non-limiting examples of which can include milk, juices, other beverages, ketchup, other condiments, mayonnaise, jellies, sauces, creams, etc.

[0013] The refrigerating appliance 10 further comprises a control assembly, illustrated herein as a controller or a control unit 20, for controlling the operation of the refrigerating appliance 10 and coupled with various working components of the refrigerating appliance 10 to control the operation of the working components and to implement cycles of refrigeration. While the control unit 20 is illustrated herein as being provided within the door 18, it will be understood that any suitable location can be used for the control unit 20, including within the cabinet 12 rather than within the door 18, 19. The control assembly can further include a user interface (not shown) that can be operably coupled with the control unit 20 and can provide an input and output function for the control unit 20.

[0014] Other communications paths and methods can also be included in the refrigerating appliance 10 and can allow the control unit 20 to communicate with a user in a variety of ways. For example, the control unit 20 can be configured to send a text message to the user, send an electronic mail to the user, or provide audio information to the user either through the refrigerating appliance 10 or utilizing another device such as a mobile phone.

[0015] The control unit 20 can include a machine controller and any additional controllers provided for controlling any of the components of the refrigerating appliance 10. For example, the control unit 20 can include the machine controller and a refrigeration system controller. Many known types of controllers can be used for the control unit 20. It is contemplated that the controller is a microprocessor-based controller that implements control software and sends/receives one or more electrical signals to/from each of the various working components to implement the control software. As an example, proportional control (P), proportional integral control (PI), and proportional derivative control (PD), or a combination thereof, a proportional integral derivative control (PID), can be used to control the various components of the refrigerating appliance 10.

[0016] Referring now to FIG. 2, the refrigeration system 32 is shown in schematic form and can be provided as a closed refrigeration system 32 comprising a compressor 34, a condenser 36, an optional heat exchanger 38, and an evaporator 60. The compressor 34 and the condenser 36 can be fluidly coupled through a high-pressure vapor line 40. The condenser 36 and the evaporator 60 can be fluidly coupled through a high-pressure liquid line 42, a high-pressure liquid capillary tube 46, and a low-pressure liquid/vapor tube 48. The low-pressure liquid/vapor tube 48 can include or can act as an expansion valve for the refrigeration system 32, such as by the low-pressure liquid/vapor tube 48 having a larger size or diameter than the high-pressure liquid capillary tube 46, allowing the low-pressure liquid/vapor tube 48 to effect expansion of the high-pressure liquid into the low-pressure vapor. The evaporator 60 and the compressor 34 can be fluidly coupled through a low-pressure liquid/vapor suction line 44.

[0017] The tubes 46, 48 and the suction line 44 can pass through the heat exchanger 38. Within the heat exchanger 38, the tubes 46, 48 and the suction line 44 can be in thermal juxtaposition. Heat energy can be transferred from the low-pressure liquid/vapor in the suction line 44 to the tubes 46, 48 along the juxtaposed portions, thereby contributing to the efficiency of the refrigeration system 32 by optimal conversion of the high-pressure liquid to the low-pressure vapor.

[0018] Referring now to FIG. 3, a cross-sectional portion of an evaporator assembly 50, which includes the evaporator 60, is illustrated. The evaporator assembly 50 can be provided at any suitable location within the cabinet 12. Typically, the evaporator assembly 50 is located in a rear portion of the cabinet 12 and/or a bottom portion of the cabinet 12, behind and/or beneath one or more of the compartments 14,15. By way of non-limiting example, the evaporator assembly 50 can be provided adjacent a wall, which can be the side wall 22, the center wall 24, or a rear wall, of the cabinet 12. One or more air ducts, such as an evaporator duct 56, can fluidly couple the evaporator assembly 50 to one or both of the compartments 14, 15 such that cooled air can be recirculated over the evaporator 60 and into one or both of the compartments 14, 15.

[0019] The evaporator assembly 50 comprises an evaporator housing 52 and the evaporator 60 provided within the evaporator housing 52. The evaporator assembly 50 further comprises an evaporator fan 54 at least partially received within the evaporator duct 56. The evaporator duct 56 can include or can be fluidly coupled with at least one evaporator air outlet 58. The evaporator fan 54 can be configured to drive, whether by pushing or pulling, air flow from the evaporator 60 through the evaporator duct 56 and through the at least one evaporator air outlet 58. Further still, the evaporator assembly 50 comprises a heat shield 70 provided adjacent to at least a portion of the evaporator 60 and a drain pan housing 80.

[0020] FIG. 4 illustrates a side view of the evaporator assembly 50. The evaporator 60 can be provided between, and at least partially enclosed by, the wall of the cabinet 12 and the evaporator housing 52. A drain pan 82 can be provided within or at least partially received by the drain pan housing 80. The evaporator assembly 50 further comprises at least one evaporator air inlet 74. In one example, the at least one evaporator air inlet 74 is provided at a lower portion of the evaporator assembly 50, adjacent the drain pan housing 80 and the drain pan 82. A defrost heater 72 can optionally be provided behind the heat shield 70. In one example, the defrost heater 72 can be provided between the at least one evaporator air inlet 74 and the evaporator 60 such that air entering the evaporator assembly 50 through the at least one evaporator air inlet 74 passes over the defrost heater 72, such that the air can be heated by the defrost heater 72 prior to reaching the evaporator 60 to aid in de-icing of the evaporator 60. The heated air can then be drawn upwardly through the evaporator 60 by the operation of the evaporator fan 54 to enter the evaporator duct 56 and then to exit the evaporator assembly 50 by flowing through the at least one evaporator air outlet 58.

[0021] FIG. 5 illustrates an enlarged view of the evaporator 60. The evaporator 60 comprises a plurality of evaporator coils 62 and a plurality of evaporator fins 64. In one example, the evaporator coils 62 can extend generally orthogonally to the evaporator fins 64 such that the evaporator coils 62 and the evaporator fins 64 intersect one another. By way of non-limiting example, the evaporator coils 62 can extend substantially horizontally while the evaporator fins 64 extend substantially vertically. The evaporator fins 64 can be coupled to the evaporator coils 62 such that the evaporator coils 62 pass through the evaporator fins 64, or the evaporator fins 64 can be otherwise coupled to or provided on the evaporator coils 62. The evaporator 60 further comprises a first coil end 66 and a second coil end 68 coupled with the refrigeration system 32. In one example, both the evaporator coils 62 and the evaporator fins 64 can be formed of a metal, such as, by way of non-limiting example, aluminum.

[0022] During operation of the refrigeration system 32, and specifically referring to the evaporator assembly 50, frost or ice can build up on the evaporator 60, such as on at least one of the evaporator coils 62 or the evaporator fins 64, which can impair the function and performance of the evaporator 60. De-icing or de-frosting the evaporator 60 can remove the frost or ice. In one example, de-icing or de-frosting of the evaporator 60 can be effected by operation of the defrost heater 72, which can be configured to heat air provided to the evaporator 60 to melt the ice or frost from the evaporator 60. However, such a process can be slow, inefficient, and/or can result in uneven de-icing or de-frosting of the evaporator 60.

[0023] To improve the process of de-icing or de-frosting the evaporator 60, and in addition to or in place of the defrost heater 72, FIG. 6 illustrates a multilayer de-icing composite 100 having thermoresistive heating capabilities and configured to perform de-icing of at least a portion of the evaporator assembly 50 by thermoresistively heating the portion of the evaporator assembly 50. The multilayer de-icing composite 100 can be provided on a variety of surfaces 90 of the evaporator assembly 50 for de-icing of the evaporator 60. In one example, the multilayer de-icing composite 100 can be provided on any substrate or surface 90. The multilayer de-icing composite 100 can be provided on surfaces 90 of various compositions, and further is ideally suited to be applied to surfaces 90 formed of aluminum. Non-limiting examples of such surfaces 90 within the evaporator assembly 50 can include the evaporator 60, the evaporator coils 62, the evaporator fins 64, the evaporator housing 52, the heat shield 70, the drain pan housing 80, or the drain pan 82. It will be understood that the multilayer de-icing composite 100 can be provided on any suitable surface 90 such that the multilayer de-icing composite 100 is provided on at least a portion of the evaporator assembly 50, such as a portion that is adjacent to the evaporator 60, and in particular that is directly adjacent the plurality of evaporator fins 64. By way of non-limiting example, the multilayer de-icing composite 100 can be a multilayer de-icing coating 100 that can be coated onto the surface 90. By way of further non-limiting example, the multilayer de-icing composite 100 can be provided as a nanocoating, and specifically as a thermoresistive nanocoating.

[0024] The multilayer de-icing composite 100 can comprise an insulating layer 102, a heater layer 104 abutting the insulating layer 102, a thermally transmissive and liquid-impermeable barrier layer 106 abutting the heater layer 104, and a thermally transmissive protective layer 108 abutting the liquid-impermeable barrier layer 106. The multilayer deicing composite 100 can further comprise at least one heating element 110 that is operably coupled and/or thermally coupled to the multilayer de-icing composite 100 and configured to provide the thermoresistive heating capabilities of the multilayer de-icing composite 100. The at least one heating element 110 can further be operably coupled with a power source 112 by at least a first wire 114 and a second wire 116 to complete an electrical circuit between the power source 112 and the at least one heating element 110. The first and second wires 114, 116 can be any suitable type of electrically conductive coupler, such as nanowires having, by way of non-limiting example, a diameter of 2-4 nanometers. In one example, the first wire 114 can be coupled to a negative power terminal (not shown) of the power source 112 while the second wire 116 can be coupled to a positive power terminal (not shown) of the power source 112. The power source 112 can be further operably coupled with a controller, such as the control unit 20 of the refrigerating appliance 10.

[0025] The insulating layer 102 can be provided directly onto the surface 90, though it will be understood that the insulating layer 102 could be provided indirectly on the surface 90, such as by having an intervening layer or other component(s) provided between the surface 90 and the insulating layer 102. The insulating layer 102 can be configured to prevent thermal transfer between the multilayer de-icing composite 100 and the surface 90. Further, the insulating layer 102 can act as a primer layer to promote adherence of the insulating layer 102, and thus of the multilayer de-icing composite 100, to the surface 90. By way of non-limiting example, the insulating layer 102 can be coated onto the surface 90, though it will be understood that any suitable method of application can be used, other non-limiting examples of which can include laminating, spray coating, dip coating, or simply layering. The insulating layer 102 can comprise any suitable material that is thermally insulating and has sufficient dielectric strength to withstand high voltage, such as, by way of non-limiting example, at least 1250V. By way of non-limiting example, the insulating layer 102 can comprise an aluminum oxide.

[0026] In one example, the at least one heating element 110 can be provided on the insulating layer 102, either directly or indirectly, or abutting the insulating layer 102, such as being positioned between the insulating layer 102 and the heater layer 104. However, it will also be understood that the at least one heating element 110 can be provided on the heater layer 104 or between the heater layer 104 and the thermally transmissive and liquid-impermeable barrier layer 106, so long as the at least one heating element 110 is electrically and thermally coupled with the heater layer 104 for providing heat from the heater layer 104, and specifically such that the at least one heating element 110 is configured to provide heat to the heater layer 104 that can then be provided or thermally transferred outwardly from the heater layer 104.

[0027] The at least one heating element 110 can be provided as a copper electrode, though it will be understood that any suitable type of heating element 110 can be used. Additionally, the at least one heating element 110 can comprise only a single heating element 110, to which both the first wire 114 and the second wire 116 can be coupled. Alternatively, the at least one heating element 110 can comprise at least two heating elements 110, wherein the first wire 114 is coupled to a first heating element 110 and the second wire 116 is coupled to a second heating element 110. In the case that more than one heating element 110 is included, the heating elements 110 can be provided adjacent one another, even abutting one another, or the heating elements 110 can be spaced from one another.

[0028] The heater layer 104 can be provided on and to at least partially abut the insulating layer 102. In one example, the heater layer 104 can directly abut the insulating layer 102, except where the at least one heating element 110 is provided between the two layers 102, 104, though it will also be understood that an intervening layer or component(s) can be provided between the insulating layer 102 and the heater layer 104. By way of non-limiting example, the heater layer 104 can be coated onto the insulating layer 102, as well as onto the at least one heating element 110, though it will be understood that any suitable method of application can be used, other non-limiting examples of which can include laminating, spray coating, dip coating, or simply layering. The heater layer 104 can comprise carbon nanoparticles, such as carbon nanotubes and graphene carbon nanotubes, which serve as an excellent conductor and can have a refractive index that gradually changes as the carbon nanotubes are exposed to infrared heat waves. Blending the carbon nanotubes with a high-temperature blending polymer agent can further improve conduction of the heater layer 104. In one example, such a polymer can include a polyurethane polymer, such as a two-system-based polyurethane polymer. The performance of the heater layer 104 can be further optimized through efficient utilization and selection of the carbon nanotubes, such as by ensuring that natural bundles of the carbon nanotubes are dispersed and that an appropriate functional group for the carbon nanotubes is used.

[0029] The thermally transmissive and liquid-impermeable barrier layer 106 can be provided on and to at least partially abut the heater layer 104. The thermally transmissive and liquid-impermeable barrier layer 106 can be provided directly onto the heater layer 104, though it will be understood that the thermally transmissive and liquid-impermeable barrier layer 106 could be provided indirectly on the heater layer 104, such as by having an intervening layer or other component(s) provided between the heater layer 104 and the thermally transmissive and liquid-impermeable barrier layer 106. By way of non-limiting example, the thermally transmissive and liquid-impermeable barrier layer 106 can be coated onto the heater layer 104, though it will be understood that any suitable method of application can be used, other non-limiting examples of which can include laminating, spray coating, dip coating, or simply layering. The thermally transmissive and liquid-impermeable barrier layer 106 can be configured to thermally transmit heat generated from the heater layer 104, as well as to prevent liquid from penetrating through the thermally transmissive and liquid-impermeable barrier layer 106 to reach the heater layer 104 and/or the at least one heating element 110.

[0030] The thermally transmissive protective layer 108 can be provided on and to at least partially abut the thermally transmissive and liquid-impermeable barrier layer 106. The thermally transmissive protective layer 108 can be provided directly onto the thermally transmissive and liquid-impermeable barrier layer 106, though it will be understood that the thermally transmissive protective layer 108 could be provided indirectly on the thermally transmissive and liquid-impermeable barrier layer 106, such as by having an intervening layer or other component(s) provided between the thermally transmissive and liquid-impermeable barrier layer 106 and the thermally transmissive protective layer 108. By way of non-limiting example, the thermally transmissive protective layer 108 can be coated onto the thermally transmissive and liquid-impermeable barrier layer 106, though it will be understood that any suitable method of application can be used, other non-limiting examples of which can include laminating, spray coating, dip coating, or simply layering. The thermally transmissive protective layer 108 can be configured to thermally transmit heat that has been provided from the heater layer 104 and through the thermally transmissive and liquid-impermeable barrier layer 106, as well as to provide further protection for the heater layer 104 and the at least one heating element 110, for example, protection against corrosion or impact. The thermally transmissive protective layer 108 can comprise any suitable material that can withstand high voltage, such as at least 1250V, non-limiting examples of which include polyurethane-based materials that can include a variety of additives for optimized performance parameters.

[0031] Turning now to the operation of the multilayer de-icing composite 100, the controller, such as the control unit 20 of the refrigerating appliance 10 can cause the at least one heating element 110 to be energized. Specifically, the control unit 20 can energize the power source 112 that is operably coupled to the at least one heating element 110, in order to cause the at least one heating element 110 to, in turn, be energized to thermoresistively heat the heater layer 104 to which the at least one heating element 110 is thermally coupled. As electrical current provided from the at least one heating element 110 by the power source 112 is provided to the heater layer 104, the carbon nanotubes conduct the electrical current by electron flow. When the electrical current and electron flow reaches or contacts the polymer, the polymer acts as an insulator to limit, inhibit, or interrupt further electron flow, causing the slowed or flow-limited electrons to heat up as they lose the energy of the electron flow, generating heat that can be provided outwardly from the heater layer 104. By optimizing the balance or relative concentrations of the conductive carbon nanotubes and the thermally insulating polymer, a performance of the heater layer 104 can be achieved to raise the temperature of the heater layer 104 in such a way that highly uniform surface heating through the thermoresistive heating capabilities of the heater layer 104 can be realized while requiring relatively less usage of electrical power from the power source 112 as compared to conventional coil heating elements, such as the defrost heater 72.

[0032] When the heater layer 104 is energized to be thermoresistively heated in this manner, the insulating layer 102 prevents thermal transfer, transmitting, or transmission of the heat inwardly from the heater layer 104 to the surface 90. Since the thermally transmissive and liquid-impermeable barrier layer 106 and the thermally transmissive protective layer 108 are both configured to thermally transfer or transmit heat, the heat provided from the heater layer 104 can accordingly be transmitted outwardly from the heater layer 104 through the thermally transmissive and liquid-impermeable barrier layer 106, and then further outwardly through the thermally transmissive protective layer 108 in the direction shown by the arrows 120. In this manner, the multilayer de-icing composite 100 is configured to thermoresistively heat and de-ice the at least a portion of the evaporator assembly 50 by providing heat to the at least a portion of the evaporator assembly 50 to which the multilayer de-icing composite 100 is provided adjacent. In particular, when the multilayer de-icing composite 100 is provided directly on a portion of the evaporator assembly 50 or on an entire surface 90 that is adjacent to and coextensive with at least a portion of the evaporator assembly 50, the multilayer de-icing composite 100 can provide uniform and consistent de-icing to the portion of the evaporator assembly 50.

[0033] FIG. 7 illustrates an example of a coupling of the at least one heating element 110 with the power source 112. In this example, the at least one heating element 110 is provided as a copper electrode, such as a copper strip. A connector 130, illustrated herein as a spade connector 130 directly abuts and is conductively coupled to the at least one heating element 110. The spade connector 130 can be coupled to the at least one heating element 110 by any suitable method or material, non-limiting examples of which include a fastener or by soldering the spade connector 130 to the at least one heating element 110. The attachment of the spade connector 130 to the at least one heating element 110 can be completed prior to applying the heater layer 104. The spade connector 130 can in turn be coupled with the power source 112 via at least one of the first wire 114 and the second wire 116.

[0034] FIG. 8 illustrates another example of a coupling of the at least one heating element 110 with the power source 112. In this example, the at least one heating element 110 is provided as a copper electrode, such as a copper strip. The first wire 114, which can be provided as a coated first wire 114 for insulation, can have an exposed end portion 118 that is uncoated for conductive coupling with the at least one heating element 110. The end portion 118 of the first wire 114 can be soldered to the at least one heating element 110 via a soldered connection 132 that directly abuts and is conductively coupled to the at least one heating element 110. In this way, the at least one heating element 110 is coupled with the power source 112 via the first wire 114 and the soldered connection 132. The soldered connection 132 can be completed prior to applying the heater layer 104.

[0035] FIG. 9 illustrates another example of a coupling of the at least one heating element 110 with the power source 112. In this example, the at least one heating element 110 is provided as a copper electrode, such as a copper strip, and can comprise a first heating element portion 110a that abuts and extends along at least a portion of the insulating layer 102, as well as a second heating element portion 110b that can extend outwardly from the first heating element portion 110a and away from the insulating layer 102. In one example, the second heating element portion 110b can extend substantially orthogonally from the first heating element portion 110a. The first wire 114, which can be provided as the coated first wire 114 for insulation, can have the exposed end portion 118 that is uncoated for conductive coupling with the at least one heating element 110, and specifically with the second heating element portion 110b of the at least one heating element 110. The end portion 118 of the first wire 114 can be soldered to the at least one heating element 110, and in particular to the second heating element portion 110b, via the soldered connection 132 that directly abuts and is conductively coupled to the second heating element portion 110b or to the at least one heating element 110. A heat shrink 134 can be provided about and to surround the coupling of the second heating element portion 110b and the end portion 118 of the first wire 114 to provide further protection to the soldered connection 132 as the soldered connection 132 in this aspect can extend beyond the heater layer 104. In this way, the at least one heating element 110 is coupled with the power source 112 via the first wire 114 and the soldered connection 132. The soldered connection 132 can be completed prior to or after applying the heater layer 104.

[0036] The aspects of the present disclosure as described herein set forth a multilayer deicing composite and associated method for thermoresistively heating and de-icing at least a portion of an evaporator assembly for a refrigerating appliance. The multilayer de-icing composite can be a process-friendly nanocoating that is lightweight, extremely stable and durable, corrosion-resistant, and can provide uniform heating across a variety of surfaces and profiles, as well as having superior electrical conductivity for static dissipation to avoid electrostatic discharges. Traditional methods of de-icing a refrigerator evaporator, such as the use of coil heating elements, can result in uneven de-icing and spots where ice can remain and build up, causing detrimental effects to the operation of the evaporator. The methods and multilayer de-icing composite of the present disclosure provides for de-icing of the evaporator in a manner that will result in uniform heating and de-icing, reducing or eliminating undesired areas of ice build-up. In addition, a multilayer de-icing composite including carbon nanotubes, for example, has improved efficiency over coil heating elements, in particular due to decreased dissipation losses as compared to coil heating elements. In one non-limiting example, the multilayer de-icing composite can have thermal dissipation losses of less than 5%. The multilayer approach additional provides improved protection of the heating elements against moisture, humidity, and the harsh operating environment for electrical components.

[0037] In addition, the multilayer de-icing composite can be easily applied to existing components of the evaporator assembly. In one example, the multilayer de-icing composite can be applied to the evaporator itself, such as to the evaporator fins. While this approach may provide the most direct and thorough de-icing and heating capabilities, applying the multilayer de-icing composite to such a non-uniform surface or geometry may be labor-intensive. Thus, in another example, the multilayer de-icing composite may instead, or in addition, be applied to an adjacent component of the evaporator assembly, such as to the evaporator housing, heat shield, or drain pan, where the multilayer de-icing composite can be easily applied to such a surface having a relatively uniform geometry. In addition to being provided on a metal substrate, such as aluminum, the multilayer de-icing composite can also be applied to plastics, composites, other metals, ceramics, and even fabrics.

[0038] To the extent not already described, the different features and structures of the various aspects can be used in combination with each other as desired. That one feature may not be illustrated in all of the aspects of the disclosure is not meant to be construed that it cannot be, but is done for brevity of description. Thus, the various features of the different aspects can be mixed and matched as desired to form new aspects, whether or not the new aspects are expressly described. Combinations or permutations of features described herein are covered by this disclosure. In addition to the concepts covered by the below claims, the following concepts can also provide the basis for claims in any possible combinations:

[0039] A refrigerating appliance comprising at least one compartment having an open face, a closure movable relative to the open face to selectively close the open face, an evaporator assembly provided within the compartment, and a multilayer de-icing composite having thermoresistive heating capabilities, the multilayer de-icing composite provided on at least a portion of the evaporator assembly and comprising an insulating layer, a heater layer abutting the insulating layer, a thermally transmissive liquid-impermeable barrier layer abutting the heater layer, and a thermally transmissive protective layer abutting the liquid-impermeable barrier layer.

[0040] A refrigerating appliance wherein the evaporator assembly comprises an evaporator having a plurality of evaporator fins and a drain pan positioned adjacent the evaporator.

[0041] A refrigerating appliance wherein the at least a portion of the evaporator assembly on which the multilayer de-icing composite is provided is the plurality of evaporator fins.

[0042] A refrigerating appliance wherein the at least a portion of the evaporator assembly on which the multilayer de-icing composite is provided is the drain pan.

[0043] A refrigerating appliance wherein the drain pan is positioned directly adjacent the plurality of evaporator fins to thermoresistively heat the plurality of evaporator fins.

[0044] A refrigerating appliance wherein the at least a portion of the evaporator assembly on which the multilayer de-icing composite is provided comprises an aluminum substrate for the multilayer de-icing composite.

[0045] A refrigerating appliance wherein the multilayer de-icing composite de-ices at least a portion of the evaporator assembly.

[0046] A refrigerating appliance wherein the multilayer de-icing composite is a nanocoating.

[0047] A refrigerating appliance wherein the heater layer comprises carbon nanotubes.

[0048] A refrigerating appliance wherein the heater layer is coupled to at least one heating element for providing heat from the heater layer.

[0049] A refrigerating appliance wherein the at least one heating element is a copper electrode.

[0050] A refrigerating appliance further comprising a controller operably coupled with the evaporator assembly, wherein the at least one heating element is coupled to a power source, the power source further operably coupled with the controller.

[0051] A refrigerating appliance wherein the multilayer de-icing composite is configured to transmit heat outwardly through the liquid-impermeable barrier layer and the protective layer while preventing transmission of heat inwardly through the insulating layer.

[0052] A refrigerating appliance wherein the refrigerating appliance is one of a refrigerator, a storage or refrigerating cabinet, a storage or refrigerated drawer, a beverage storing appliance, a freezer, or a wine cellar.

[0053] A method of de-icing an evaporator assembly for a refrigerating appliance, the method comprising providing a multilayer de-icing composite having thermoresistive heating capabilities on at least a portion of the evaporator assembly, the providing the multilayer de-icing composite comprising providing an insulating layer, providing a heater layer to abut the insulating layer, providing a thermally transmissive liquid-impermeable barrier layer to abut the heater layer, and providing a thermally transmissive protective layer to abut the liquid-impermeable barrier layer, and energizing, by a controller of the refrigerating appliance, at least one heating element that is thermally coupled to the heater layer to thermoresistively heat and de-ice at least a portion of the evaporator assembly.

[0054] A method of de-icing an evaporator assembly for a refrigerating appliance wherein the energizing the at least one heating element further comprises energizing, by the controller, a power source that is operably coupled to the at least one heating element.

[0055] A method of de-icing an evaporator assembly for a refrigerating appliance wherein the providing the multilayer de-icing composite on the at least a portion of the evaporator assembly comprises providing the multilayer de-icing composite on a plurality of evaporator fins of the evaporator assembly.

[0056] A method of de-icing an evaporator assembly for a refrigerating appliance wherein the providing the multilayer de-icing composite on the at least a portion of the evaporator assembly comprises providing the multilayer de-icing composite on a drain pan positioned adjacent an evaporator of the evaporator assembly.

[0057] A method of de-icing an evaporator assembly for a refrigerating appliance wherein the multilayer de-icing composite is a nanocoating and the heater layer comprises carbon nanotubes.

[0058] A method of de-icing an evaporator assembly for a refrigerating appliance wherein the thermoresistively heating and de-icing the at least a portion of the evaporator assembly comprises transmitting heat outwardly through the liquid-impermeable barrier layer and the protective layer while preventing transmission of heat inwardly through the insulating layer.

[0059] This written description uses examples to disclose aspects of the disclosure, including the best mode, and also to enable any person skilled in the art to practice aspects of the disclosure, including making and using any devices or systems and performing any incorporated methods. While the aspects of the present disclosure have been specifically described in connection with certain specific details thereof, it is to be understood that this is by way of illustration and not of limitation. Reasonable variation and modification are possible within the scope of the forgoing disclosure and drawings without departing from the spirit of the present disclosure, which is defined in the appended claims. Hence, specific dimensions and other physical characteristics relating to the aspects of the present disclosure are not to be considered as limiting, unless expressly stated otherwise.

Claims

1. A refrigerating appliance (10) comprising:

at least one compartment (14, 15) having an open face (16, 17);
a closure (18, 19) movable relative to the open face (16, 17) to selectively close the open face (16, 17);
an evaporator assembly (50) provided within the compartment (14, 15); and
a multilayer de-icing composite (100) having thermoresistive heating capabilities, the multilayer de-icing composite (100) provided on at least a portion of the evaporator assembly (50) and comprising:

an insulating layer (102);
a heater layer (104) abutting the insulating layer (102);
a thermally transmissive liquid-impermeable barrier layer (106) abutting the heater layer (104); and
a thermally transmissive protective layer (108) abutting the liquid-impermeable barrier layer (106), wherein the heater layer (104) is coupled to at least one heating element (110) for providing heat from the heater layer (104).

2. The refrigerating appliance (10) of claim 1 wherein the evaporator assembly (50) comprises an evaporator (60) having a plurality of evaporator fins (64) and a drain pan (82) positioned adjacent the evaporator (60).

3. The refrigerating appliance (10) of claim 2 wherein the at least a portion of the evaporator assembly (50) on which the multilayer de-icing composite (100) is provided is the plurality of evaporator fins (64).

4. The refrigerating appliance (10) of any of claims 2-3 wherein the at least a portion of the evaporator assembly (50) on which the multilayer de-icing composite (100) is provided is the drain pan (82).

5. The refrigerating appliance (10) of any of claims 2-4 wherein the drain pan (82) is positioned directly adjacent the plurality of evaporator fins (64) to thermoresistively heat the plurality of evaporator fins (64).

6. The refrigerating appliance (10) of any of claims 1-5 wherein the at least a portion of the evaporator assembly (50) on which the multilayer de-icing composite (100) is provided comprises an aluminum substrate (90) for the multilayer de-icing composite (100).

7. The refrigerating appliance (10) of any of claims 1-6 wherein the multilayer de-icing composite (100) de-ices at least a portion of the evaporator assembly (50).

8. The refrigerating appliance (10) of any of claims 1-7 wherein the multilayer de-icing composite (100) is a nanocoating.

9. The refrigerating appliance (10) of any of claims 1-8 wherein the heater layer (104) comprises carbon nanotubes.

10. The refrigerating appliance (10) of claim 1 wherein the at least one heating element (110) is a copper electrode.

11. The refrigerating appliance (10) of any of claim 10 further comprising a controller (20) operably coupled with the evaporator assembly (50), wherein the at least one heating element (110) is coupled to a power source (112), the power source (112) further operably coupled with the controller (20).

12. The refrigerating appliance (10) of any of claims 1-11 wherein the refrigerating appliance (10) is one of a refrigerator, a storage or refrigerating cabinet, a storage or refrigerated drawer, a beverage storing appliance, a freezer, or a wine cellar.

13. A method of de-icing an evaporator assembly (50) for a refrigerating appliance (10), the method comprising:

providing a multilayer de-icing composite (100) having thermoresistive heating capabilities on at least a portion of the evaporator assembly (50), the providing the multilayer de-icing composite (100) comprising:

providing an insulating layer (102);
providing a heater layer (104) to abut the insulating layer (102);
providing a thermally transmissive liquid-impermeable barrier layer (106) to abut the heater layer (104); and
providing a thermally transmissive protective layer (108) to abut the liquid-impermeable barrier layer (106); and

energizing, by a controller (20) of the refrigerating appliance (10), at least one heating element (110) that is thermally coupled to the heater layer (104) to thermoresistively heat and de-ice at least a portion of the evaporator assembly (50).

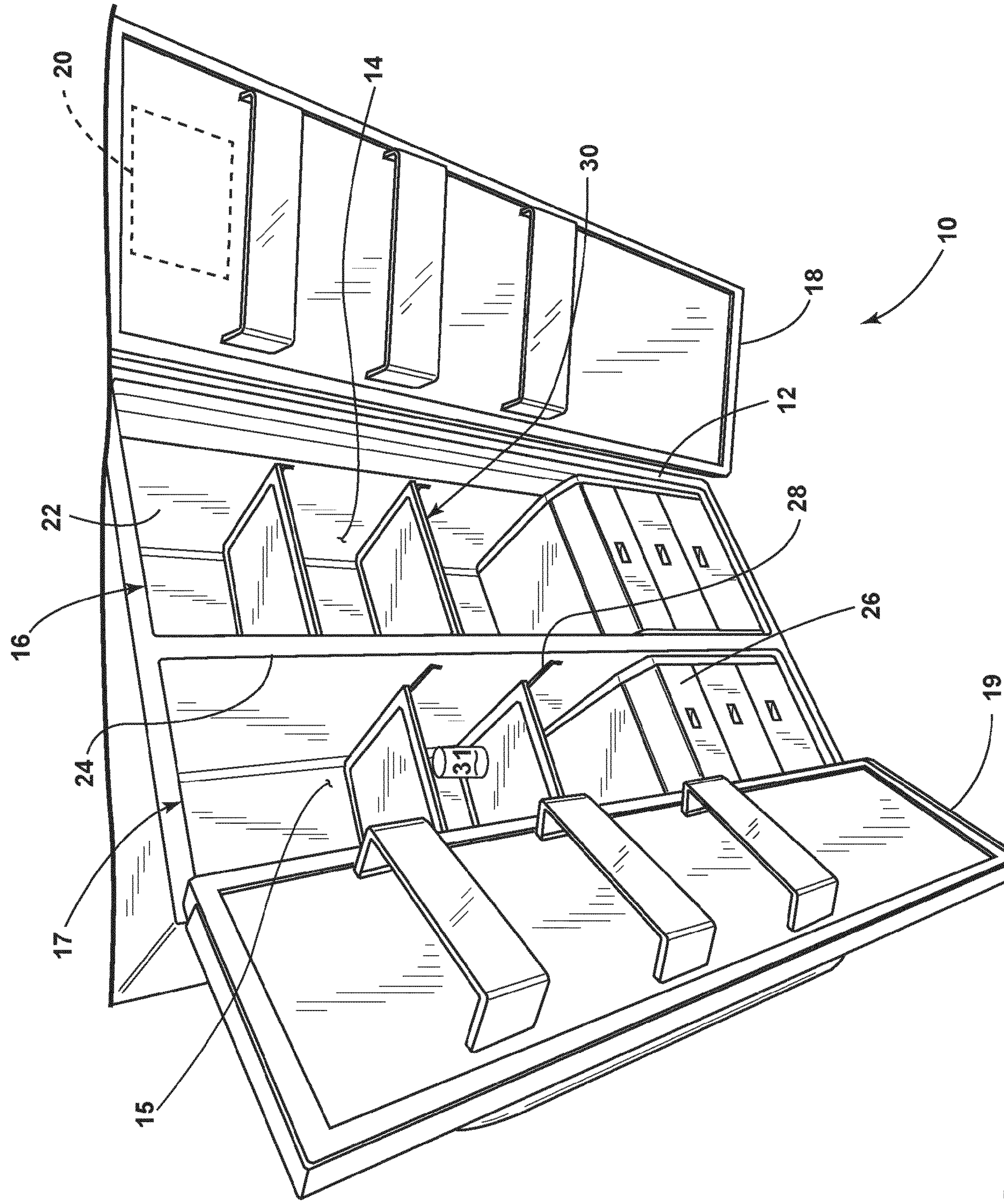

FIG. 1

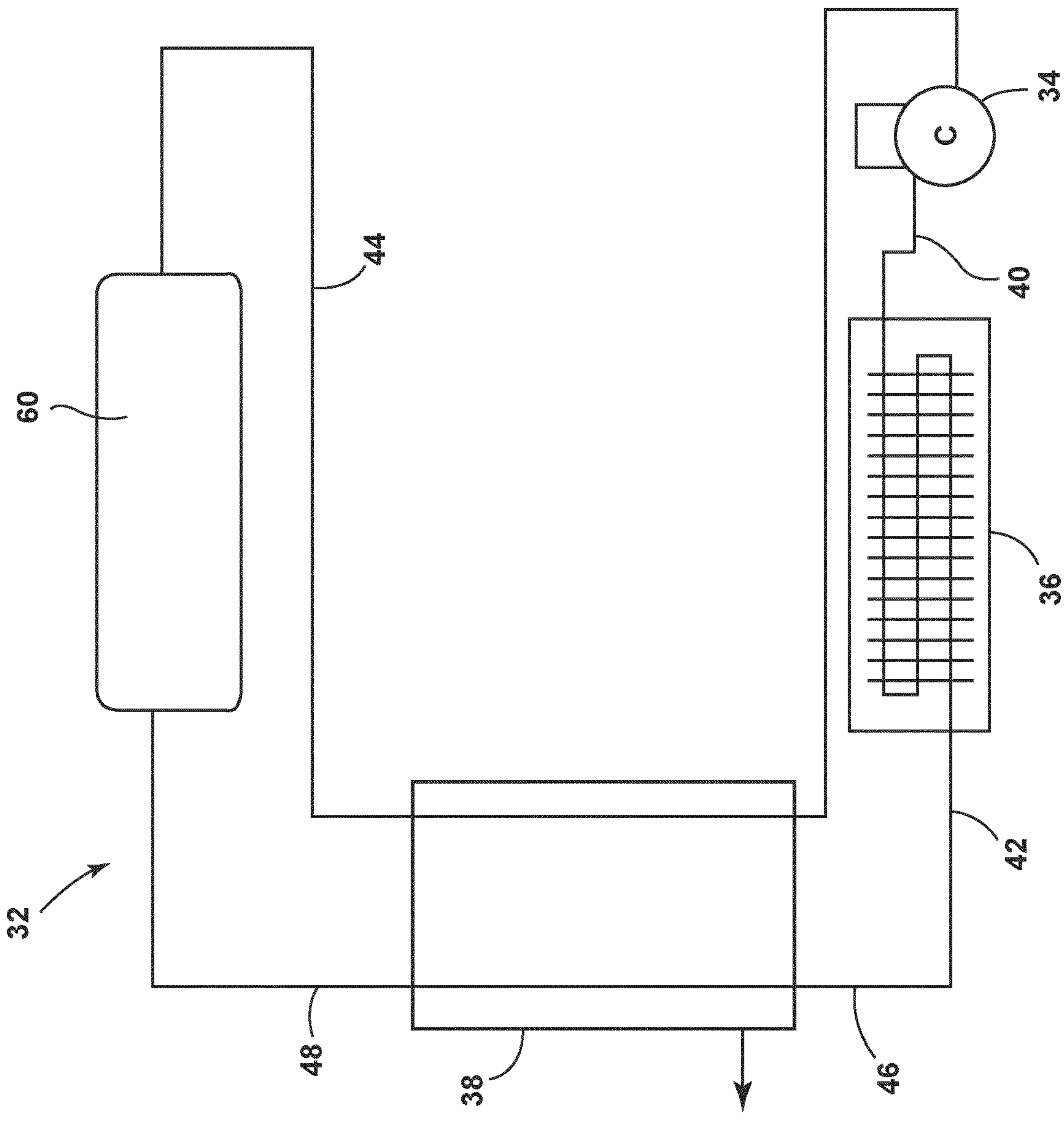

FIG. 2

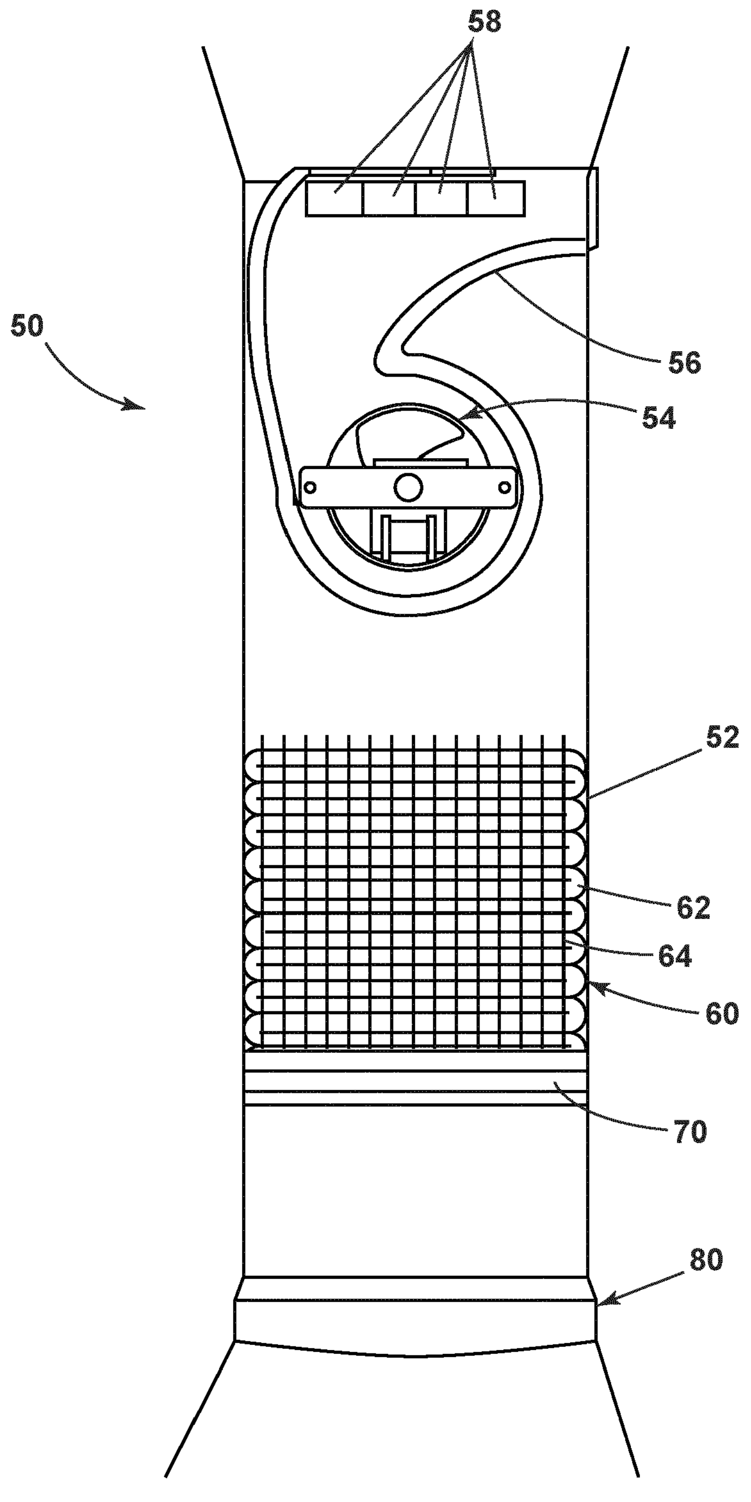

FIG. 3

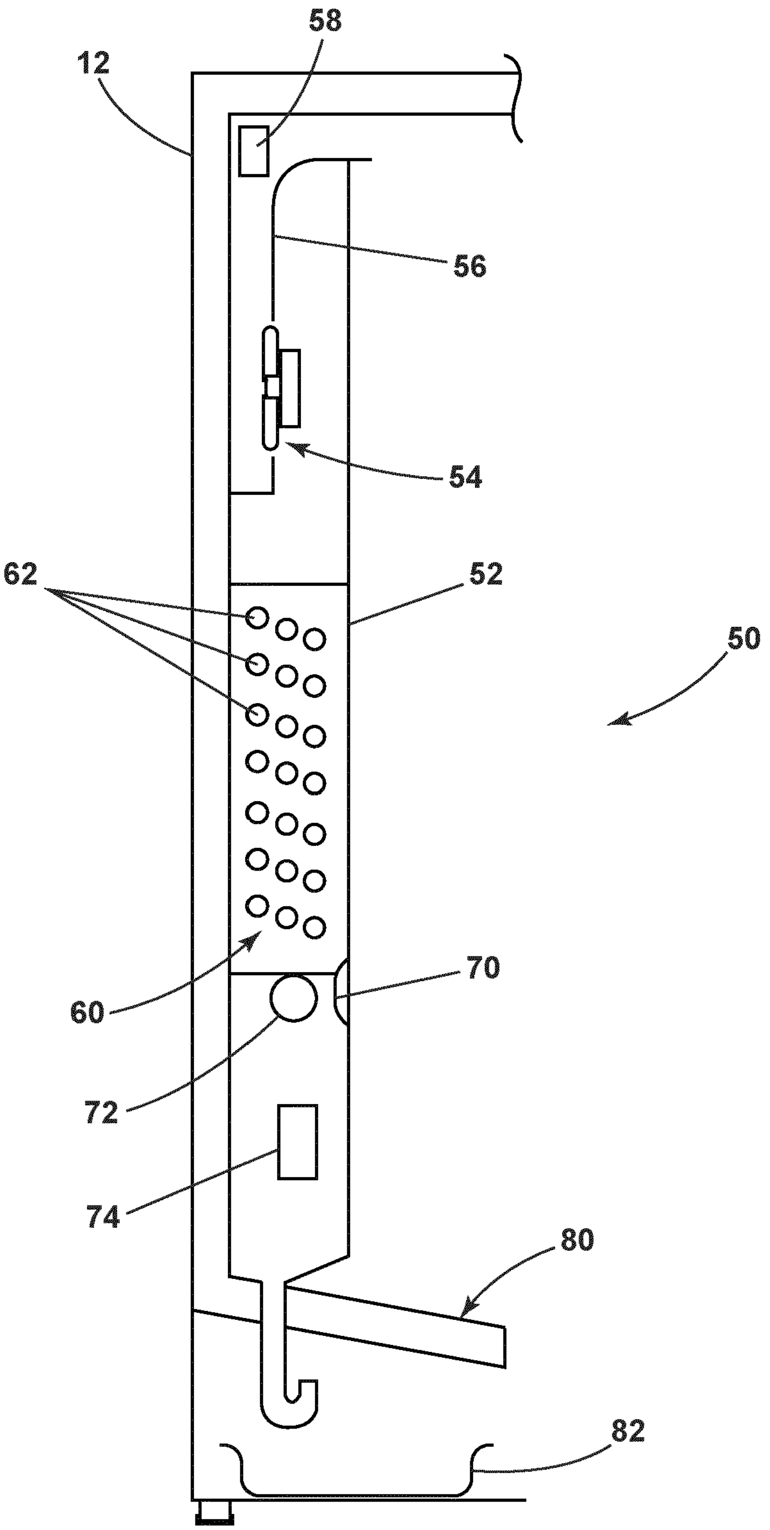

FIG. 4

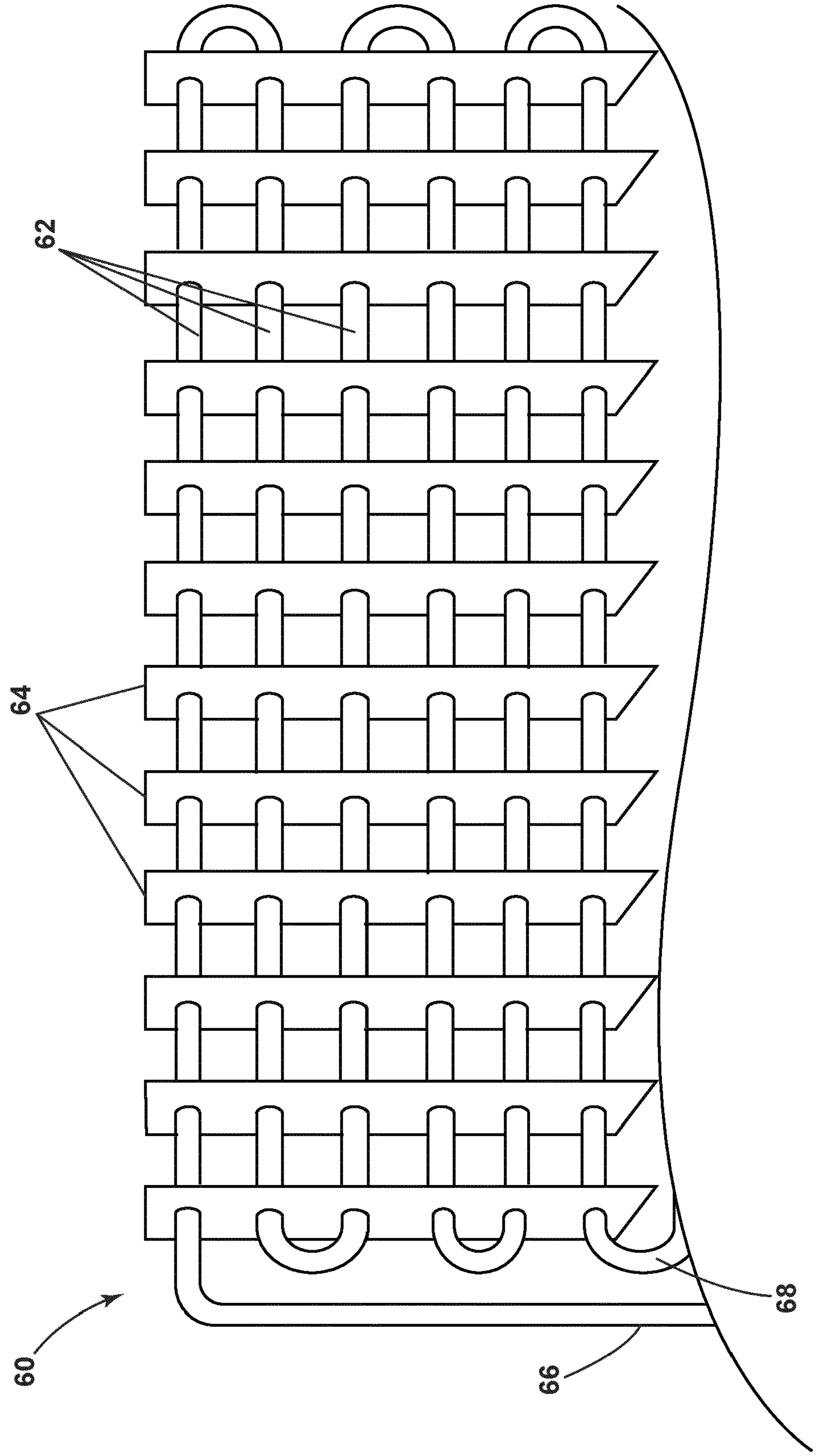

FIG. 5

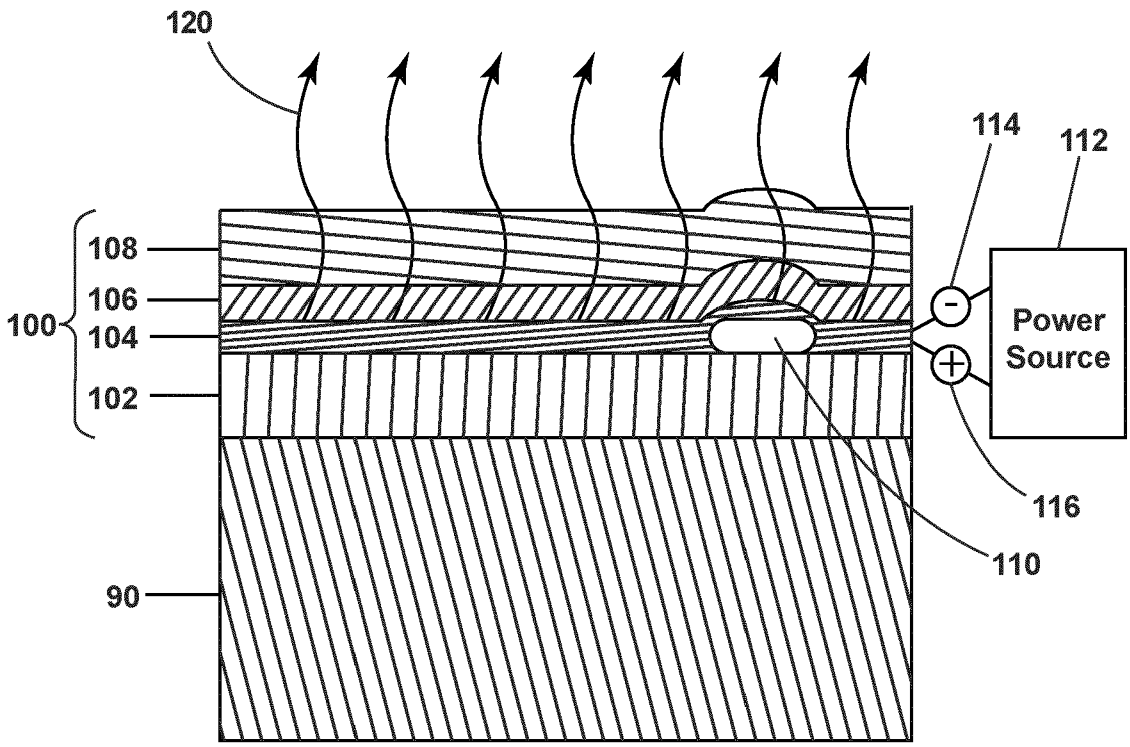
120
114
112
108
106
100
104
102
Power Source
116
110
90

FIG. 6

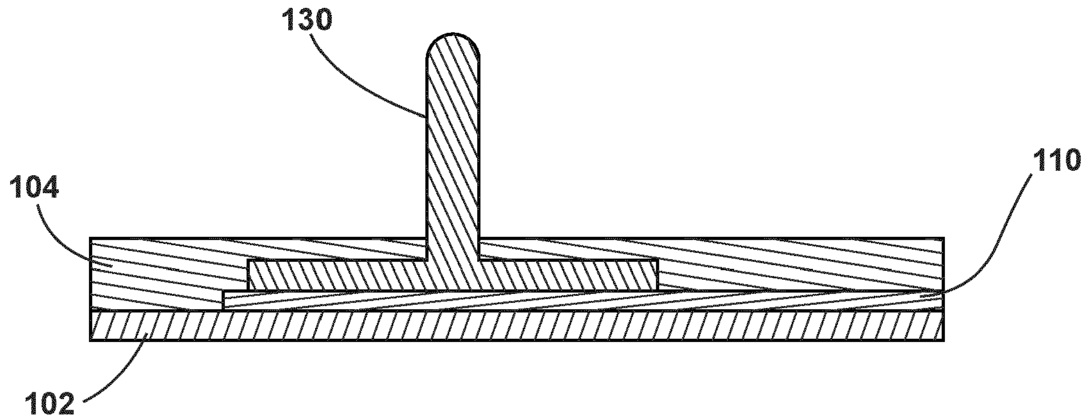
130
110
104
102

FIG. 7

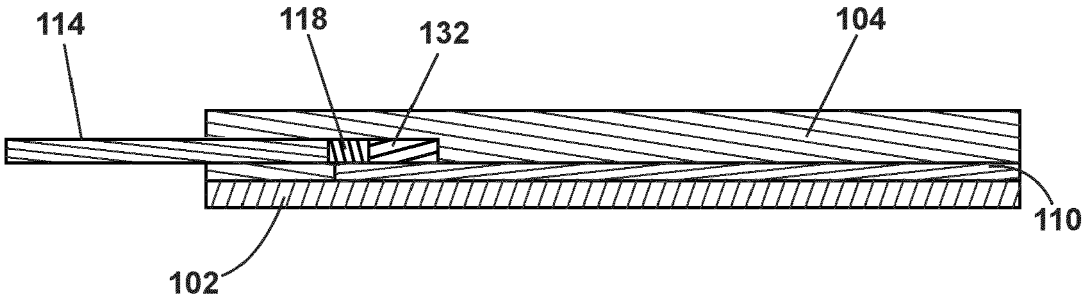

FIG. 8

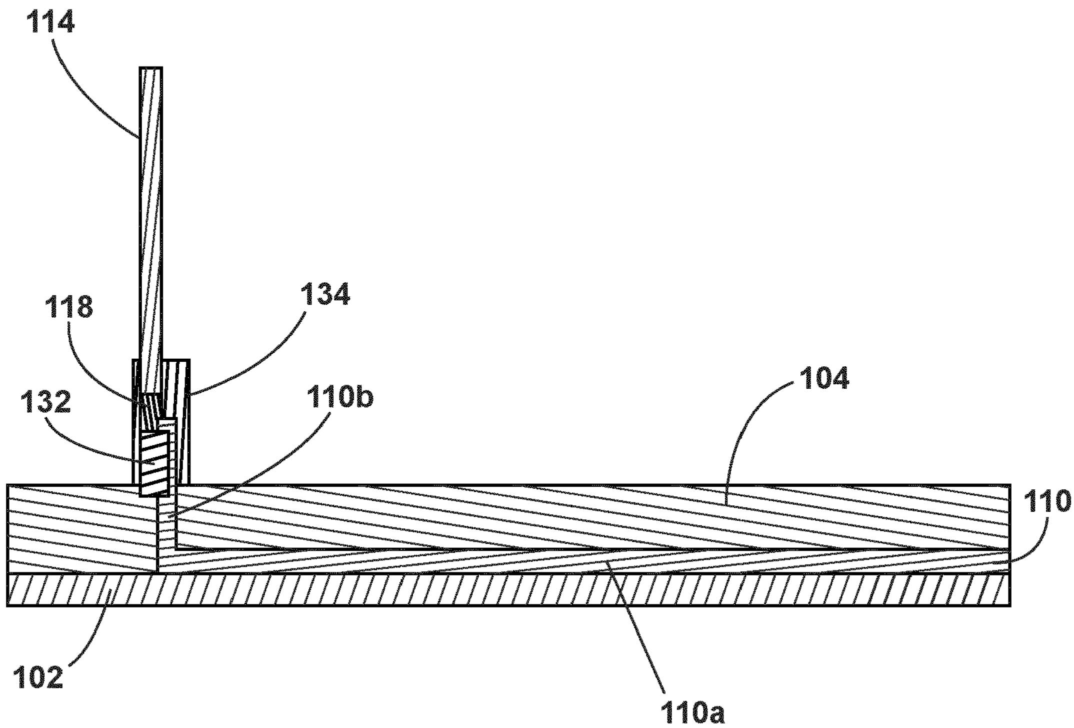

FIG. 9

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Place of search	Date of completion of the search	Examiner
The Hague	5 March 2021	Vigilante, Marco

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