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(54) **INJECTION-MOLDED REFRIGERATOR LINER WITH AIR DUCTS**

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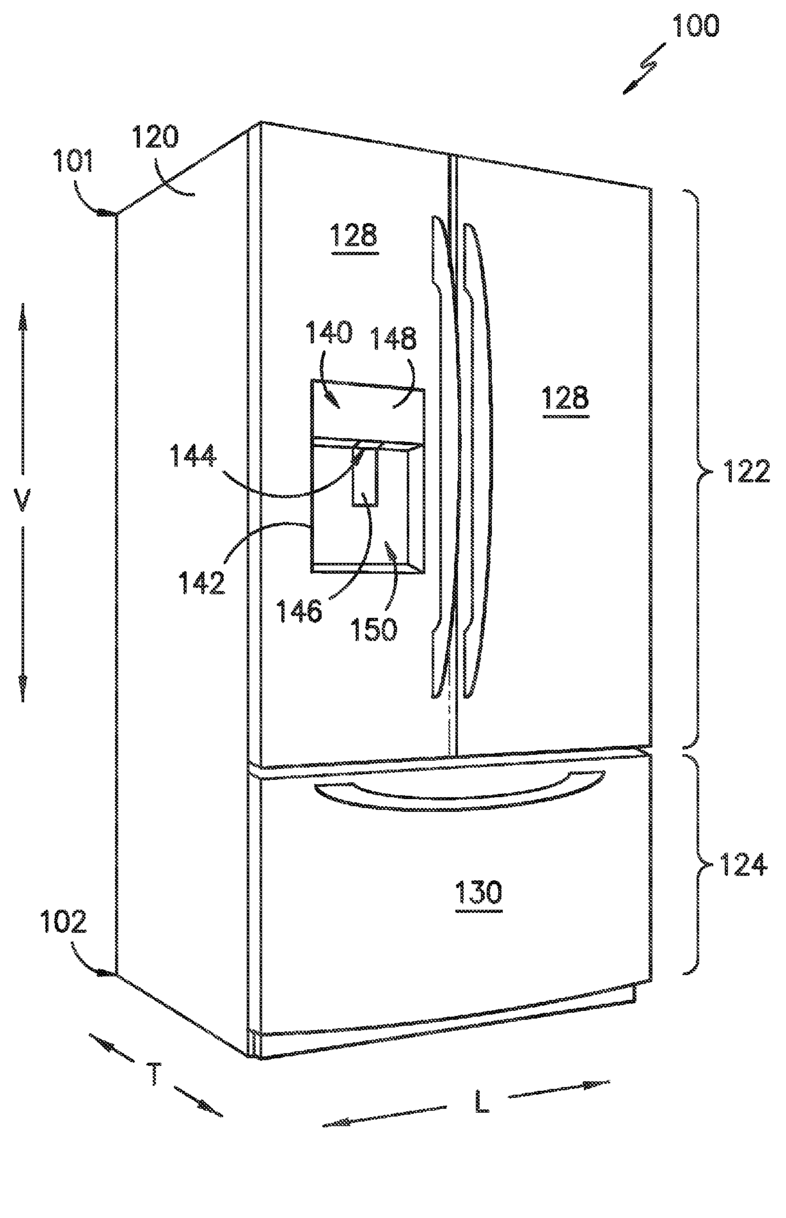
(57) **ABSTRACT**

An injection-molded door liner for a door of a refrigerator appliance is provided. The door liner is injection molded as a single, integral piece and defines an icebox compartment, a cooling air inlet duct, and a cooling air outlet duct. A sealed cooling system circulates cooling air into the icebox compartment through the cooling air inlet duct and the cooling air is returned to the sealed cooling system through the cooling air outlet duct.



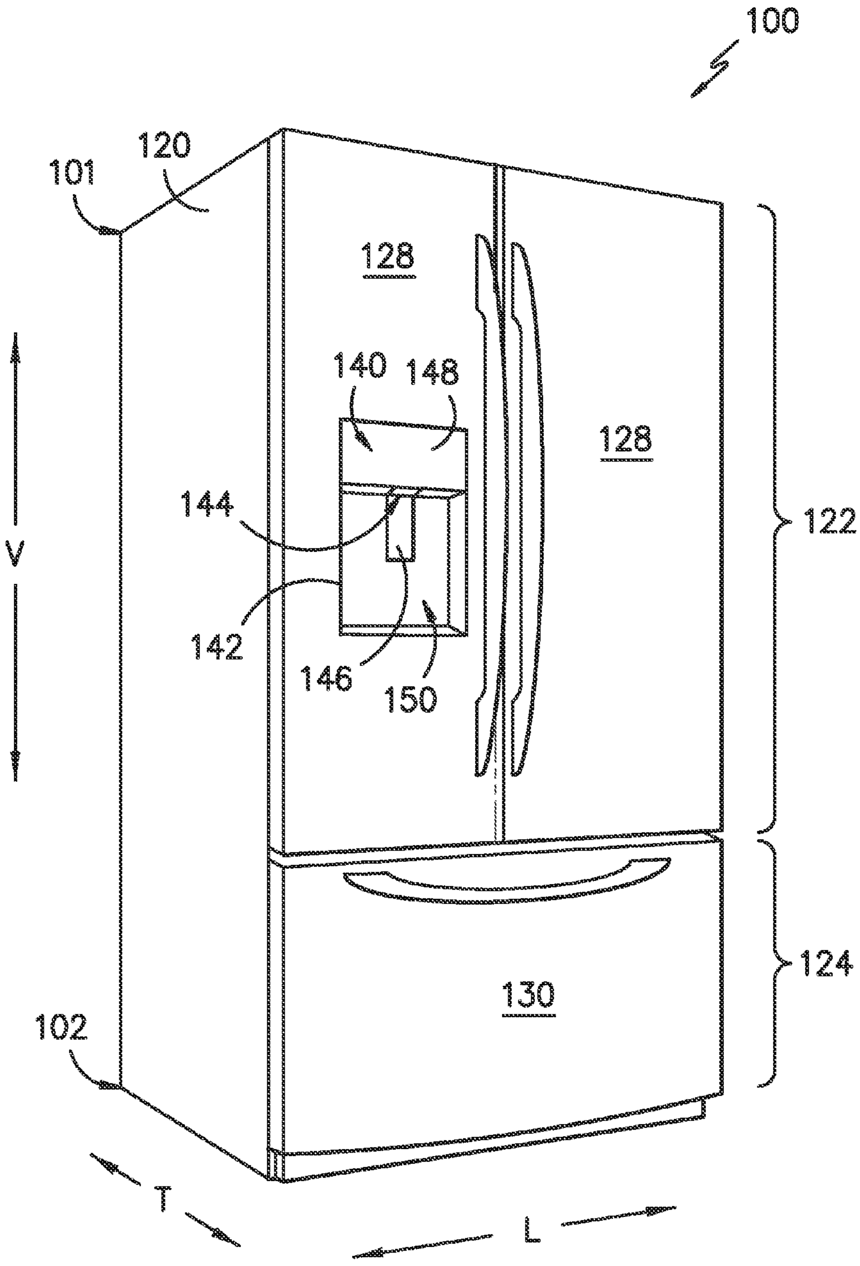


FIG. -1-

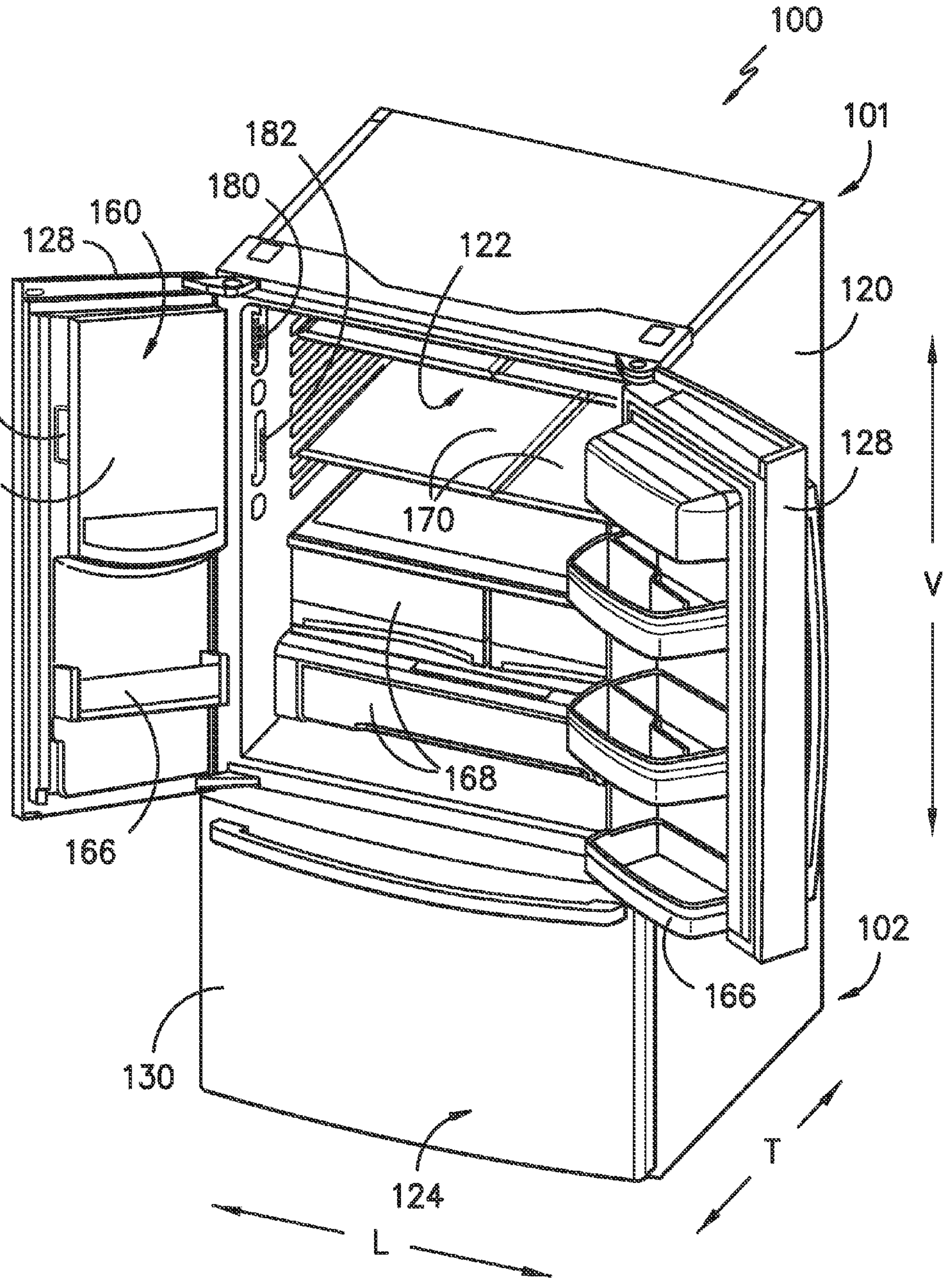

100
101
182
180
160
128
122
120
164
162
128
170
V
168
166
102
166
130
124
T
L

FIG. -2-

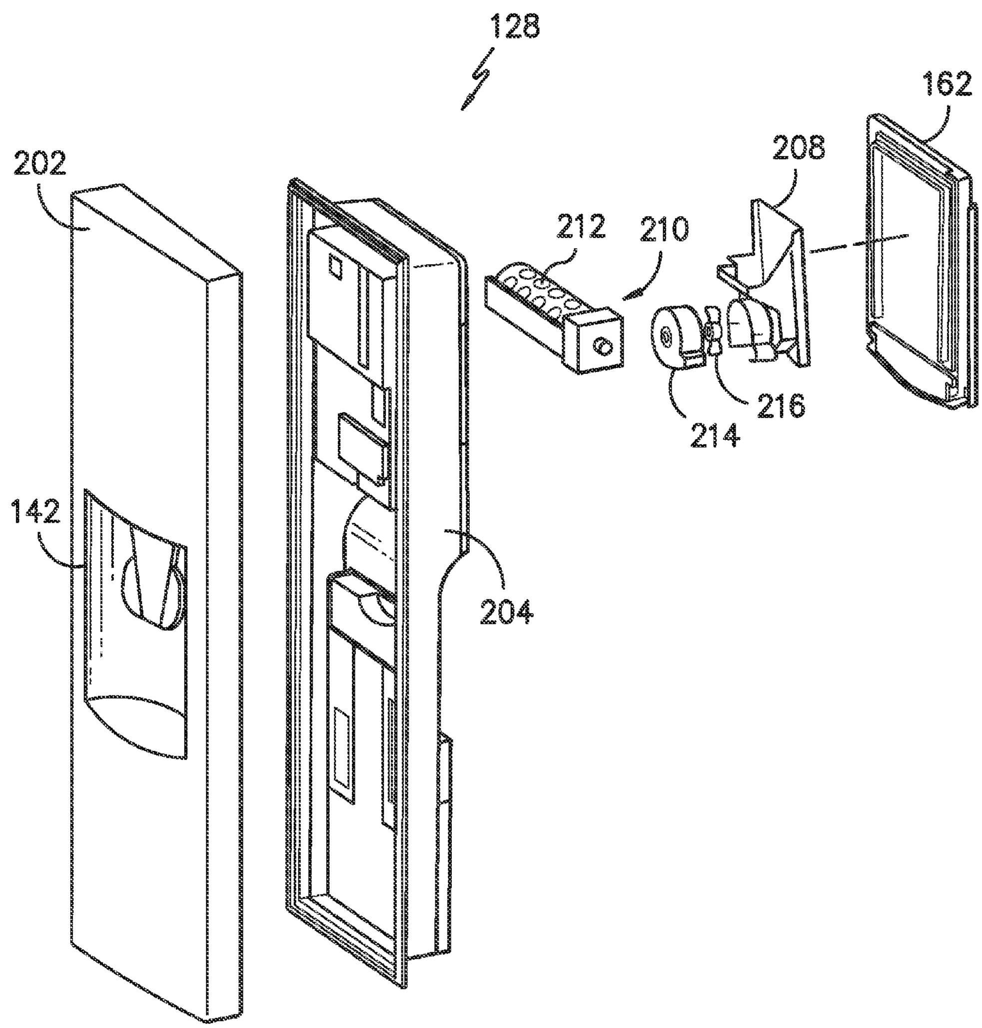


FIG. -3-

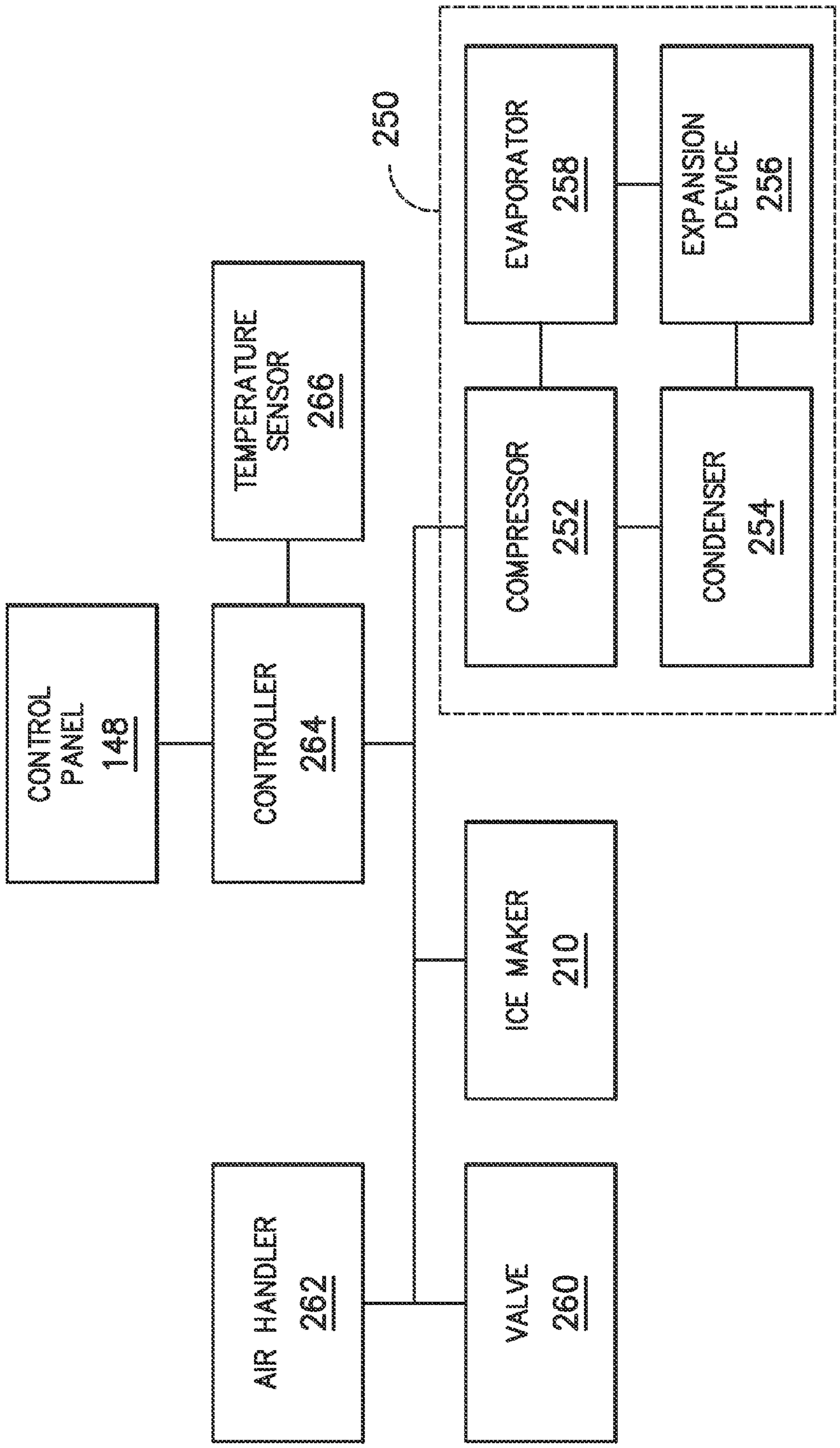

CONTROL PANEL 148
CONTROLLER 264
TEMPERATURE SENSOR 266
250
EVAPORATOR 258
EXPANSION DEVICE 256
COMPRESSOR 252
CONDENSER 254
ICE MAKER 210
AIR HANDLER 262
VALVE 260

FIG. -4-

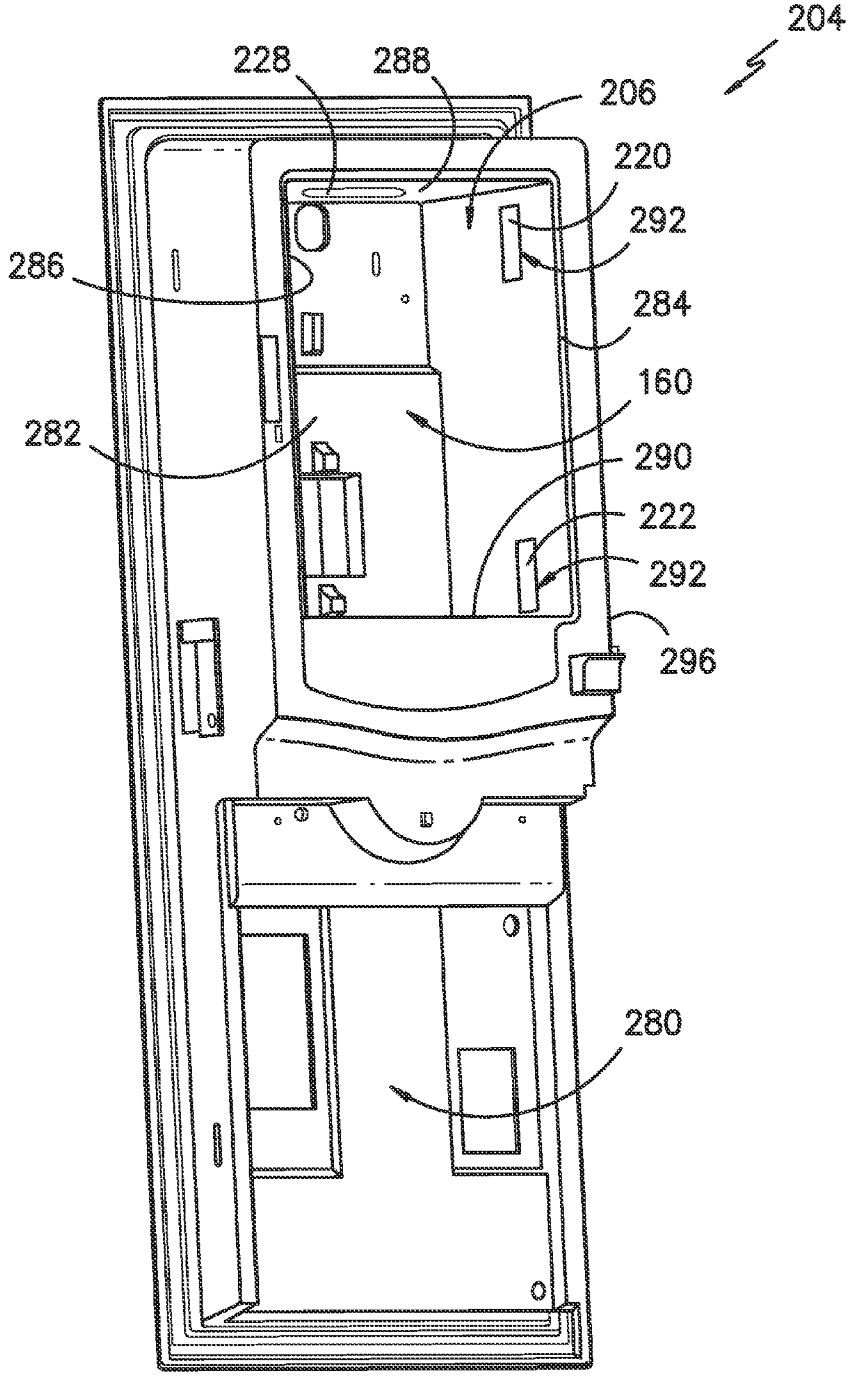


FIG. -5-

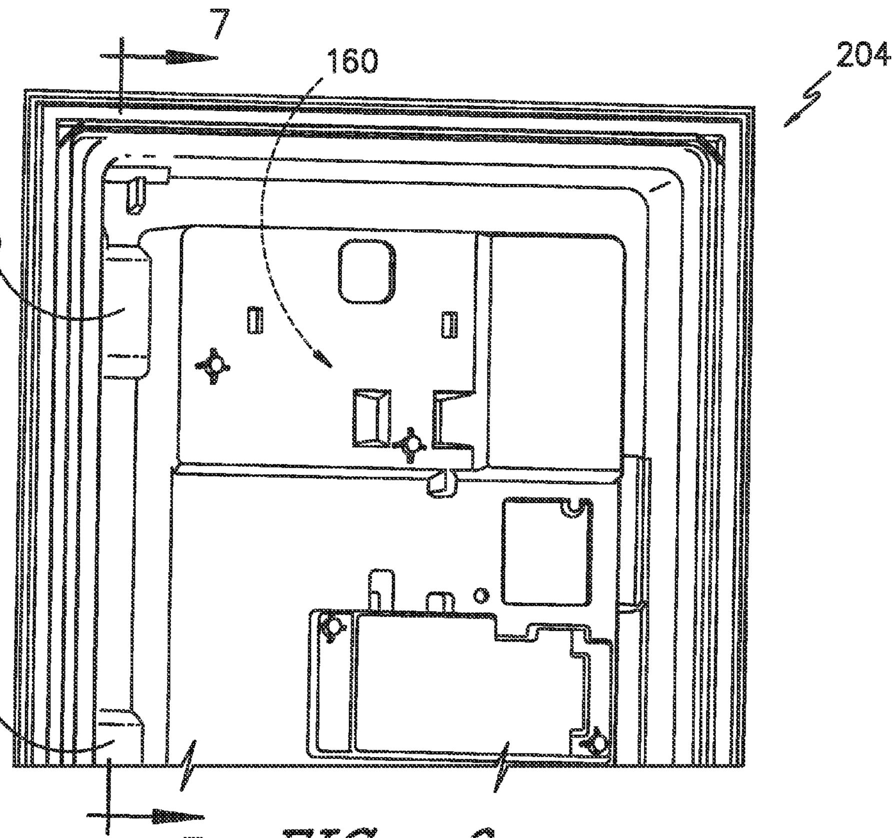


FIG. -6-

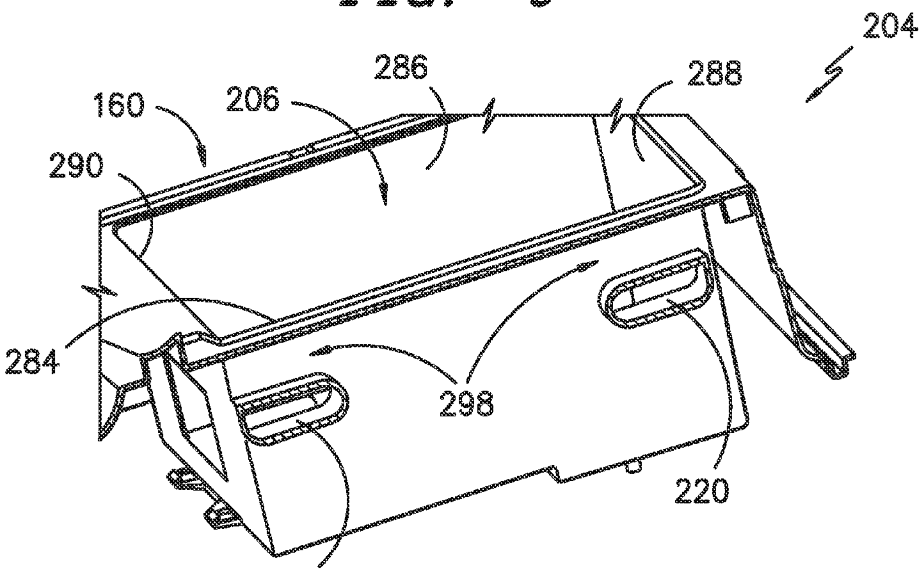


FIG. -7-

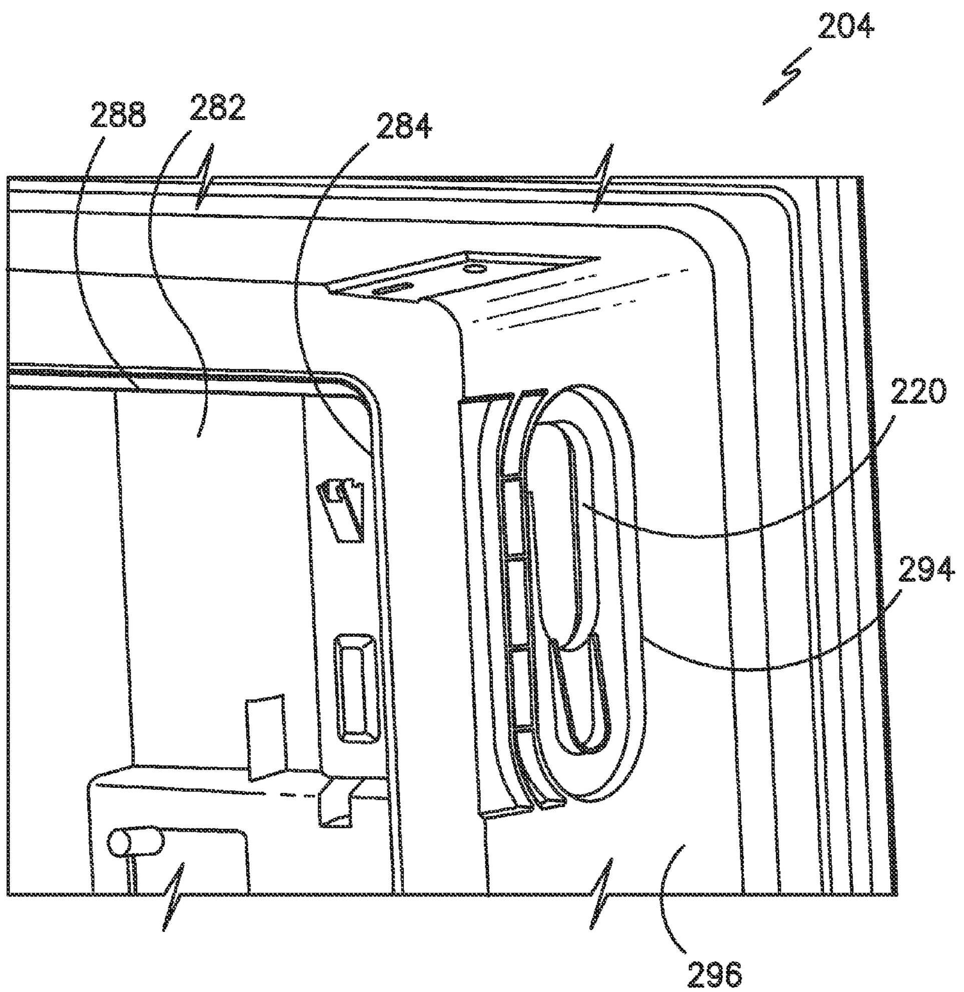


FIG. -8-

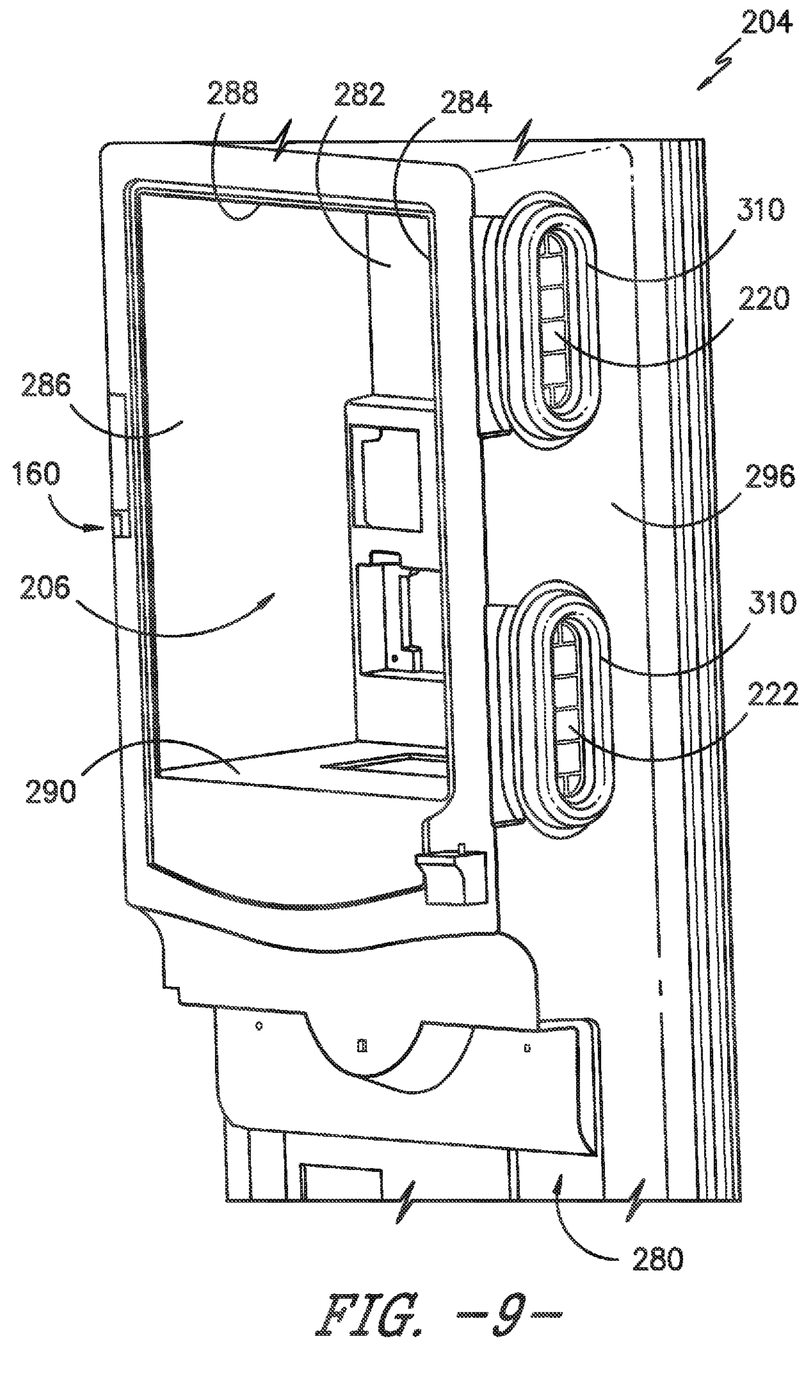


FIG. -9-

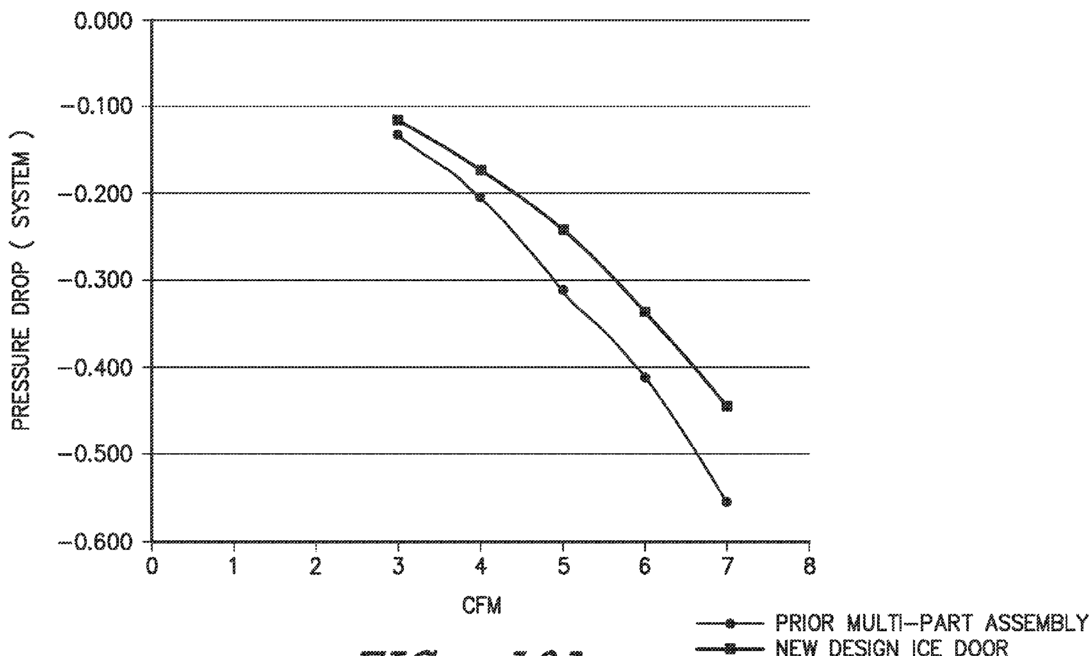

0.000
−0.100
−0.200
−0.300
−0.400
−0.500
−0.600
PRESSURE DROP (SYSTEM)
0
1
2
3
4
5
6
7
8
CFM
PRIOR MULTI−PART ASSEMBLY
NEW DESIGN ICE DOOR

FIG. -10A-

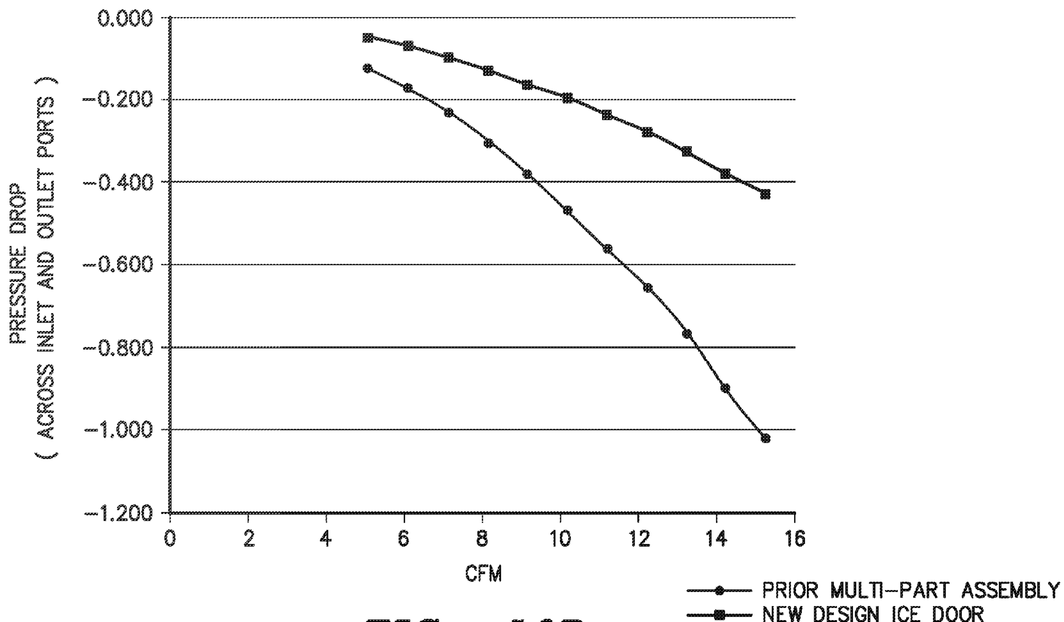

0.000
−0.200
−0.400
−0.600
−0.800
−1.000
−1.200
PRESSURE DROP
(ACROSS INLET AND OUTLET PORTS)
0
2
4
6
8
10
12
14
16
CFM
PRIOR MULTI−PART ASSEMBLY
NEW DESIGN ICE DOOR

FIG. -10B-

INJECTION-MOLDED REFRIGERATOR LINER WITH AIR DUCTS

FIELD OF THE INVENTION

[0001] The present subject matter relates generally to appliances, such as refrigerator appliances, and liners for the same.

BACKGROUND OF THE INVENTION

[0002] Certain refrigerator appliances utilize sealed systems for cooling chilled chambers of the refrigerator appliances. A typical sealed system includes an evaporator and a fan, the fan generating a flow of air across the evaporator and cooling the flow of air. The cooled air is then provided through an opening into the chilled chamber to maintain the chilled chamber at a desired temperature. Air from the chilled chamber is circulated back through a return duct to be re-cooled by the sealed system during operation of the refrigerator appliance, maintaining the chilled chamber at the desired temperature.

[0003] In some refrigerator appliances, an ice maker may be mounted in a fresh food chamber. The ice maker may have a mold body configured to receive water that can freeze over time to form ice cubes. However, because the fresh food chamber is generally maintained at a temperature above the freezing point of water, the ice maker must be contained within a chilled chamber that is maintained at a freezer temperature. In order to achieve this, the ice maker is typically placed in a chilled chamber having an inlet and an outlet. A sealed system has a fan that circulates chilled air through the chamber by delivering the chilled air to the chilled chamber through the inlet and receiving the return air from the outlet.

[0004] A chilled chamber for housing an icemaker may be disposed in the refrigerator door of a bottom mount refrigerator. Such refrigerator doors commonly include an outer door frame, a door liner, and foam insulation. The outer door frame is typically constructed of rigid material such as steel and is stamped or otherwise formed to the desired door shape. The door liner is typically formed from a combination of injection-molded and thermoformed parts. The door liner is then sealed against the outer door frame to form an insulating cavity. Insulating foam is then sprayed inside the cavity to provide insulation and structural support for the door liner.

[0005] The inlet and outlet of the chilled chamber are typically formed by injection-molding or thermoforming a skeleton of the door liner and piercing holes for the inlet and outlet. To complete the formation of the inlet and outlet ducts, a separate thermoformed duct is formed and joined with the door liner. The additional parts require separate design, tooling, procurement, and storage. The joints are typically welded together or joined using tapes and adhesive. However, the holes and joints in the door liner create leak points that cause issues during the foam insulation process. Moreover, the holes may not have sufficient structural integrity, and may separate during the foam insulation process. Indeed, foam leaks around the air ducts of these assemblies are not uncommon, and frequently result in the scrapping of expensive foam door assemblies.

[0006] Accordingly, a refrigerator appliance including an injection-molded door liner that is integrally formed would be useful. More particularly, a door liner for a refrigerator appliance including an icebox defining an inlet and an outlet without requiring assembly of multiple parts would be especially beneficial.

BRIEF DESCRIPTION OF THE INVENTION

[0007] The present subject matter provides an injection-molded door liner for a refrigerator door and a method for forming such a door liner. More particularly, the door liner is injection molded as a single, integral piece and defines an icebox compartment, a cooling air inlet duct, and a cooling air outlet duct. A sealed cooling system circulates cooling air into the icebox compartment through the cooling air inlet duct and the cooling air is returned to the sealed cooling system through the cooling air outlet duct. The door liner simplifies assembly, reduces parts, and minimizes the likelihood of leaks. The door liner thereby reduces costs while increasing refrigerator performance and efficiency. Additional aspects and advantages of the invention will be set forth in part in the following description, or may be apparent from the description, or may be learned through practice of the invention.

[0008] In a first exemplary embodiment, an injection molded door liner for a door of a refrigerator appliance is provided. The door liner includes an icebox compartment defined at least in part by the door liner and having a back wall and a plurality of sidewalls. A cooling air inlet duct is defined by the door liner and is configured to receive cooling air from a sealed cooling system. A cooling air outlet duct is defined by the door liner and is configured to return cooling air to the sealed cooling system. The door liner is injection molded as a single, integral part.

[0009] According to another exemplary embodiment, a refrigerator appliance is provided. The refrigerator appliance includes a cabinet including a liner defining a chilled chamber and a door configured to provide access into the chilled chamber. A door liner is injection molded as a single, integral piece and is mounted in the door. The door liner defines a sub-compartment including an icebox cavity, an inlet for receiving chilled air into the icebox cavity from a sealed cooling system, and an outlet for returning chilled air to the sealed cooling system.

[0010] These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and appended claims. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures.

[0012] FIG. **1** provides a perspective view of a refrigerator appliance according to an exemplary embodiment of the present subject matter.

[0013] FIG. **2** provides a perspective view of the exemplary refrigerator appliance of FIG. **1** with refrigerator doors of the refrigerator appliance shown in an open position to reveal a fresh food chamber of the refrigerator appliance.

[0014] FIG. **3** provides an exploded perspective view of the refrigerator appliance door of FIG. **1** showing a door liner defining an icebox compartment.

[0015] FIG. **4** provides a schematic view of a sealed cooling system of the refrigerator appliance of FIG. **1**.

[0016] FIG. **5** provides a perspective view of a door liner of the exemplary refrigerator appliance of FIG. **1**.

[0017] FIG. **6** provides a rear view of the door liner of the exemplary refrigerator appliance of FIG. **1**.

[0018] FIG. **7** provides a cross-sectional view of the cooling air inlet and outlet ducts defined in the door liner of the exemplary refrigerator appliance of FIG. **1** taken along Line **7-7** in FIG. **6**.

[0019] FIG. **8** provides a close-up, perspective view of a cooling air inlet duct of the door liner of the exemplary refrigerator appliance of FIG. **1**.

[0020] FIG. **9** provides a perspective view of a door liner of the exemplary refrigerator appliance of FIG. **1**.

[0021] FIG. **10**A provides a plot of a measured pressure drop of cooling air as it is circulated through the icebox compartment of the refrigerator appliance of FIG. **1** compared to the pressure drop in a prior design over various cooling air flow rates.

[0022] FIG. **10**B provides a plot of a measured pressure drop of cooling air flowing across the inlet duct and the outlet duct of the icebox compartment of the refrigerator appliance of FIG. **1** compared to the pressure drop in a prior design over various cooling air flow rates.

DETAILED DESCRIPTION

[0023] Reference now will be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

[0024] FIG. **1** provides a perspective view of a refrigerator appliance **100** according to an exemplary embodiment of the present subject matter. Refrigerator appliance **100** includes a cabinet or housing **120** that extends between a top **101** and a bottom **102** along a vertical direction V. Housing also extends along a lateral direction L and a transverse direction T, each of the vertical direction V, lateral direction L, and transverse direction T being mutually perpendicular to one another. Housing **120** defines chilled chambers for receipt of food items for storage. In particular, housing **120** defines fresh food chamber **122** positioned at or adjacent top **101** of housing **120** and a freezer chamber **124** arranged at or adjacent bottom **102** of housing **120**. As such, refrigerator appliance **100** is generally referred to as a bottom mount refrigerator. It is recognized, however, that the benefits of the present disclosure apply to other types and styles of refrigerator appliances such as, e.g., a top mount refrigerator appliance or a side-by-side style refrigerator appliance. Consequently, the description set forth herein is for illustrative purposes only and is not intended to be limiting in any aspect to any particular refrigerator chamber configuration.

[0025] Refrigerator doors **128** are rotatably hinged to an edge of housing **120** for selectively accessing fresh food chamber **122**. In addition, a freezer door **130** is arranged below refrigerator doors **128** for selectively accessing freezer chamber **124**. Freezer door **130** is coupled to a freezer drawer (not shown) slidably mounted within freezer chamber **124**. Refrigerator doors **128** and freezer door **130** are shown in the closed configuration in FIG. **1**.

[0026] Refrigerator appliance **100** also includes a dispensing assembly **140** for dispensing liquid water and/or ice. Dispensing assembly **140** includes a dispenser **142** positioned on or mounted to an exterior portion of refrigerator appliance **100**, e.g., on one of refrigerator doors **128**. Dispenser **142** includes a discharging outlet **144** for accessing ice and liquid water. An actuating mechanism **146**, shown as a paddle, is mounted below discharging outlet **144** for operating dispenser **142**. In alternative exemplary embodiments, any suitable actuating mechanism may be used to operate dispenser **142**. For example, dispenser **142** can include a sensor (such as an ultrasonic sensor) or a button rather than the paddle. A control panel **148** is provided for controlling the mode of operation. For example, control panel **148** includes a plurality of user inputs (not labeled), such as a water dispensing button and an ice-dispensing button, for selecting a desired mode of operation such as crushed or non-crushed ice.

[0027] Discharging outlet **144** and actuating mechanism **146** are an external part of dispenser **142** and are mounted in a dispenser recess **150**. Dispenser recess **150** is positioned at a predetermined elevation convenient for a user to access ice or water and enabling the user to access ice without the need to bend-over and without the need to open refrigerator doors **128**. In the exemplary embodiment, dispenser recess **150** is positioned at a level that approximates the chest level of a user. As described in more detail below, the dispensing assembly **140** may receive ice from an icemaker disposed in a sub-compartment of the fresh food chamber **122**.

[0028] FIG. **2** provides a perspective view of a door of refrigerator appliance **100** shown with refrigerator doors **128** in the open position. Refrigerator appliance **100** includes a sub-compartment, e.g., icebox compartment **160** defined on refrigerator door **128**. Icebox compartment **160** extends into fresh food chamber **122** when refrigerator door **128** is in the closed position. As discussed in greater detail below, an ice making assembly or icemaker **210** and an ice storage bin **208** (FIG. **3**) may be positioned or disposed within icebox compartment **160**. Thus, ice is supplied to dispenser recess **150** (FIG. **1**) from the icemaker **210** and ice storage bin **208** in icebox compartment **160** on a back side of refrigerator door **128**.

[0029] An access door **162** is hinged to refrigerator door **128** or to icebox compartment **160**. Access door **162** permits selective access to icebox compartment **160**. Any manner of suitable latch **164** is configured with icebox compartment **160** to maintain access door **162** in a closed position. As an example, latch **164** may be actuated by a consumer in order to open access door **162** for providing access into icebox compartment **160**. Access door **162** can also assist with insulating icebox compartment **160**, e.g., by thermally isolating or insulating icebox compartment **160** from fresh food chamber **122**.

[0030] According to the illustrated embodiment, various storage components are mounted within fresh food chamber **122** to facilitate storage of food items therein as will be understood by those skilled in the art. In particular, the storage components include bins **166**, drawers **168**, and shelves **170** that are mounted within fresh food chamber **122**. Bins **166**, drawers **168**, and shelves **170** are configured for receipt of food items (e.g., beverages and/or solid food items) and may assist with organizing such food items. As an example, drawers **168** can receive fresh food items (e.g., vegetables, fruits, and/or cheeses) and increase the useful life of such fresh food items.

[0031] As will be discussed below, refrigerator appliance **100** includes an icemaker **210** for producing ice within icebox compartment **160**. In order to maintain icebox compartment **160** at a temperature below the freezing point of water, chilled air supply duct **180** and chilled air return duct **182** may be disposed on a side portion of the housing **120** of the refrigerator appliance **100**. In this manner, the supply duct **180** and return duct **182** may recirculate chilled air from a sealed cooling system **250** through icebox compartment **160**.

[0032] FIG. **3** shows an exploded perspective view of the refrigerator door **128**. As explained above, refrigerator door **128** is an outer door movable between a closed position (FIG. **1**) closing fresh food chamber **122** and an opened position allowing access to the interior of fresh food chamber **122** (FIG. **2**). Refrigerator door **128** may have an outer panel **202** and an injection-molded door liner **204** attached to an inside of outer panel **202**. Insulation (not shown), such as expandable foam can be present between outer panel **202** and door liner **204** in order to assist with insulating fresh food chamber **122** and icebox compartment **160**. For example sprayed polyurethane foam may be injected into a cavity defined between outer panel **202** and door liner **204** after they are assembled.

[0033] Outer panels **202** and door liners **204** may be constructed of or with any suitable materials. Typically, outer panel **202** includes a main body formed of a structurally firm metal material such as steel, stainless steel, painted steel, aluminum, or any other suitably rigid material. Outer panel **202** may also have multiple inner and outer layers (not shown) as is known to provide coloring, fingerprint and smudge avoidance, insulation adhesion, etc. Freezer door **130** may be constructed in a similar manner as refrigerator doors **128**.

[0034] Door liner **204** may be constructed of or with a suitable plastic material. For example, door liner **204** may be injection-molded plastic such as HIPS (high impact polystyrene—injection molding grade) or ABS (injection molding grade), which is typically more rigid than that of a thermoformed liner. Door liner **204** may define icebox compartment **160**, which is formed of injection molded plastic. Accordingly, icebox compartment **160** provides a rigid frame on which various elements can be mounted to refrigerator door **128**.

[0035] Icebox compartment **160** includes an interior area **206** (FIG. **5**) in which an ice storage bin **208** may be removably located. In addition, an icemaker **210** may be disposed within the icebox compartment **160** and may be configured for forming ice which may be stored in ice storage bin **208**. Ice storage bin **208** and icemaker **210** may be readily attached to icebox compartment **160** using, for example, clips, fasteners, or other securing means. Icemaker **210** may include a mold body **212** for receipt of water for freezing. In particular, mold body can receive liquid water and such liquid can freeze therein and form ice cubes. Icemaker **210** can harvest such ice cubes and direct such ice cubes to the ice storage bin **208** positioned within icebox compartment **160**. For example, a motor **214** for driving an auger **216** for assisting in moving ice cubes from ice storage bin **208** can also be mounted directly in icebox compartment **160**. Ice cubes at the bottom of the ice storage bin **208** can enter an ice chute (not shown) and flow through refrigerator door **128** to discharging outlet **144** and flow into a container or cup, e.g., in the manner discussed above. Access door **162** may enclose the interior area **206** of icebox compartment **160** and any items therein.

[0036] Various elements can be attached directly to icebox compartment **160**, as mentioned above. For example, at least one of an ice storage bin **208**, an icemaker **210**, and a motor **214** for driving an auger **216** can be located in and be attached to the icebox compartment **160**. In addition, other suitable electrical, liquid, and mechanical attachments can be provided within icebox compartment **160** in any desirable combination or configuration. Notably, because icebox compartment **160** is made of rigid injection-molded plastic, a more secure attachment and resulting structure can be achieved than if the icebox compartment **160** were simply a thermoformed liner.

[0037] As will be understood by those skilled in the art, ambient air within fresh food chamber **122** is not maintained at a sufficiently low temperature to permit formation of ice by icemaker **210**. Thus, icebox compartment **160** is isolated or insulated from fresh food chamber **122** and includes features for facilitating formation of ice by icemaker **210**. For example, chilled air from a sealed cooling system **250** (described in detail below) of refrigerator appliance **100** may be directed into icebox compartment **160** in order to cool icemaker **210** and/or ice storage bin **208**. In alternative exemplary embodiments, a temperature of air within icebox compartment **160** may correspond to a temperature of air within fresh food chamber **122**, such that ice within ice storage bin **208** melts over time.

[0038] To facilitate formation of ice within icemaker **210**, icebox compartment **160** includes a chilled air inlet duct **220** and a chilled air outlet duct **222**. Chilled air inlet duct **220** and chilled air outlet duct **222** are vertically aligned with chilled air supply duct **180** and chilled air return duct **182**, respectively, positioned on housing **120**. Chilled air ducts **180**, **182** are in fluid communication with freezer chamber **124** and can receive chilled air therefrom and direct chilled air into icebox compartment **160**. Chilled air can assist within formation of ice by icemaker **210** and/or storage of ice within ice storage bin **208**. As an example, chilled air inlet duct **220** can receive chilled air from freezer chamber **124** via chilled air supply duct **180**. Because chilled air within freezer chamber **124** can have a sufficiently low temperature to permit formation of ice, chilled air therefrom can assist or permit icemaker **210** to produce ice despite being positioned adjacent fresh food chamber **122**. To facilitate the flow of chilled air from freezer chamber **124** to icemaker **210**, chilled air outlet duct **222** can direct air within icebox compartment **160** away from icemaker **210**, e.g., back to freezer chamber **124** via chilled air return duct **182**.

[0039] Access door **162** can be used to maintain interior area **206** at a temperature lower than that of fresh food chamber **122**, for example below freezing. Access door **162** can be hinged to door liner **104**, or may simply be removable from door liner **104**. By defining chilled air inlet and outlet ducts **220**, **222** to cool interior area **206**, icebox **160** need not be separately cooled, although a fan or other device may be employed to move cooled air from freezer chamber **124** into the interior area **206**. An ice dispenser outlet (not shown) is provided to feed ice cubes from interior area **206** and ice storage bin **208** through as passageway in outer panel **202** and door liner **204** and through to dispenser **142**.

[0040] As is known in the art, a heating element **228** may be provided in icebox compartment **160** to prevent or reduce undesired condensation in view of the fact that icebox compartment **160** may be located within refrigerator door **128** of fresh food chamber **122**, which is at a different temperature than the sub-freezing temperature inside icebox compartment **160**. Heating element **228** also prevents undesired freezing of any condensation that might form at such location, which may clog the icemaker **210** or might possibly make it more difficult to open access door **162**. Heating element **228** may be a strip resistance heater located in icebox compartment **160**, and may be, for example attached to door liner **204**.

[0041] As shown, icebox compartment **160** is defined by door liner **204** of refrigerator door **128**. However, one skilled in the art will appreciate that icebox compartment **160** may be located on any surface of housing **120**. For example, it could just as easily be located on freezer door **130** of freezer chamber **124** or configured according to other appliance/door designs. In addition, embodiments of the present subject matter may be employed to construct door liners for components other than icebox compartment **160**. For example, the technologies described herein may be used to construct integral cabinets, shelving, and other features for refrigerator appliance **100**.

[0042] FIG. **4** provides a schematic view of certain components of refrigerator appliance **100**. As may be seen in FIG. **4**, refrigerator appliance **100** includes a sealed cooling system **250** for executing a vapor compression cycle for cooling air within refrigerator appliance **100**, e.g., within fresh food chamber **122** and freezer chamber **124**. Sealed cooling system **250** includes a compressor **252**, a condenser **254**, an expansion device **256**, and an evaporator **258** connected in series and charged with a refrigerant. As will be understood by those skilled in the art, sealed cooling system **250** may include additional components, e.g., at least one additional evaporator, compressor, expansion device, and/or condenser. As an example, sealed cooling system **250** may include two evaporators.

[0043] Within sealed cooling system **250**, gaseous refrigerant flows into compressor **252**, which operates to increase the pressure of the refrigerant. This compression of the refrigerant raises its temperature, which is lowered by passing the gaseous refrigerant through condenser **254**. Within condenser **254**, heat exchange with ambient air takes place so as to cool the refrigerant and cause the refrigerant to condense to a liquid state.

[0044] Expansion device (e.g., a valve, capillary tube, or other restriction device) **256** receives liquid refrigerant from condenser **254**. From expansion device **256**, the liquid refrigerant enters evaporator **258**. Upon exiting expansion device **256** and entering evaporator **258**, the liquid refrigerant drops in pressure and vaporizes. Due to the pressure drop and phase change of the refrigerant, evaporator **258** is cool relative to fresh food and freezer chambers **122** and **124** of refrigerator appliance **100**. As such, cooled air is produced and refrigerates fresh food and freezer chambers **122** and **124** of refrigerator appliance **100**. Thus, evaporator **258** is a type of heat exchanger which transfers heat from air passing over evaporator **258** to refrigerant flowing through evaporator **258**.

[0045] Refrigerator appliance **100** further includes a valve **260** for regulating a flow of liquid water to icemaker **210**, e.g., into a mold body of icemaker **210**. Valve **260** is selectively adjustable between an open configuration and a closed configuration. In the open configuration, valve **260** permits a flow of liquid water to icemaker **210**. Conversely, in the closed configuration, valve **260** hinders the flow of liquid water to icemaker **210**.

[0046] Refrigerator appliance **100** also includes an air handler **262**. Air handler **262** is configured for urging a flow of chilled air from freezer chamber **124** into icebox compartment **160**, e.g., via supply and return ducts **180**, **182** and chilled air ducts **220**, **222**, as discussed above. Air handler **262** can be positioned within supply and return ducts **180**, **182** of sealed cooling system **250** and be any suitable device for moving air. For example, air handler **262** can be an axial fan or a centrifugal fan.

[0047] Refrigerator appliance **100** further includes a controller **264**. Operation of the refrigerator appliance **100** is regulated by controller **264** that is operatively coupled to control panel **148**. In one exemplary embodiment, control panel **148** may represent a general purpose I/O ("GPIO") device or functional block. In another exemplary embodiment, control panel **148** may include input components, such as one or more of a variety of electrical, mechanical or electro-mechanical input devices including rotary dials, push buttons, touch pads, and touch screens. Control panel **148** may be in communication with controller **264** via one or more signal lines or shared communication busses. Control panel **148** provides selections for user manipulation of the operation of refrigerator appliance **100**. In response to user manipulation of the control panel **148**, controller **264** operates various components of refrigerator appliance **100**. For example, controller **264** is operatively coupled or in communication with compressor **252**, valve **260**, and air handler **262**, such that controller **264** can operate such components. Controller **264** may also be in communication with a variety of sensors, such as, for example, a temperature sensor **266**. Controller **264** may receive signals from temperature sensor **266** that correspond to a temperature of an atmosphere or air within, e.g., icebox compartment **160**.

[0048] Controller **264** includes memory and one or more processing devices such as microprocessors, CPUs or the like, such as general or special purpose microprocessors operable to execute programming instructions or micro-control code associated with operation of refrigerator appliance **100**. The memory can represent random access memory such as DRAM, or read only memory such as ROM or FLASH. The processor executes programming instructions stored in the memory. The memory can be a separate component from the processor or can be included onboard within the processor. Alternatively, controller **264** may be constructed without using a microprocessor, e.g., using a combination of discrete analog and/or digital logic circuitry (such as switches, amplifiers, integrators, comparators, flip-flops, AND gates, and the like) to perform control functionality instead of relying upon software.

[0049] Referring now to FIG. **5**, a perspective view of door liner **204** of exemplary refrigerator appliance **100**. According to the illustrated exemplary embodiment, door liner **204** is injection molded as a single, integral part and configured to be mounted on refrigerator door **128** of refrigerator appliance **100**. Door liner **204** may define a lower compartment **280** which may receive, for example, a variety of mechanical components used for operating the dispensing assembly **140**. For example, lower compartment **280** of door liner **204** may receive a water tank, one or more valves, or other mechanical components. In such an embodiment, a separate cover (not shown) is typically placed over lower compartment **280** to conceal the mechanical components. Additionally, or alternatively, lower compartment **280** may receive a door storage bin (not shown) or may be used in any other suitable manner.

[0050] The door liner **204** may also define an upper compartment, e.g., icebox compartment **160**. As shown in the illustrated embodiment, icebox compartment **160** is defined by a plurality of walls. More particularly, icebox compartment **160** generally includes a rear wall **282**, a first sidewall **284**, a laterally opposite second sidewall **286**, a top wall **288**, and a bottom wall **290**. As described above, access door **162** (FIG. **2**) can be used to provide selective access to icebox compartment **160**.

[0051] As explained above, refrigerator appliance **100** includes a sealed cooling system **250** for delivering chilled air to icebox compartment **160** defined by door liner **204**. More particularly, icebox compartment **160** defines an inlet—e.g., cooling air inlet duct **220**—which is defined by door liner **204** and may be configured to receive cooling air from the sealed cooling system **250** via supply duct **180**. Similarly, icebox compartment **160** defines an outlet—e.g., cooling air outlet duct **222**—which is defined by door liner **204** and may be configured to return cooling air from the sealed cooling system **250** via return duct **182**. For the embodiment depicted, cooling air inlet duct **220** is defined in first sidewall **284** of door liner **204** proximate to the top wall **288** and cooling air outlet duct **222** is defined in first sidewall **284** of liner **204** proximate to the bottom wall **290**.

[0052] As described above, refrigerator appliance **100** includes air handler **262** to provide a flow of cooling air from sealed cooling system **250** to icebox compartment **160**. More specifically, chilled air travels from supply duct **180** in cabinet **120**, through cooling air inlet duct **220**, and into icebox compartment **160**. The chilled air lowers the temperature in icebox compartment **160** before passing through return duct **182** and back to the sealed cooling system **250** through chilled air outlet duct **222**. In this manner, the sealed cooling system **250** distributes chilled air throughout the icebox compartment **160** to maintain the temperature at freezer temperature so that ice may be formed.

[0053] Referring now to FIGS. **6** and **7**, inlet duct **220** and outlet duct **222** will be described in more detail. Although the inlet duct **220** is used here for the purposes of description, the outlet duct **222** may be similarly formed according to an exemplary embodiment. The inlet duct **220** may extend from a first end **292** proximate to one of the plurality of sidewalls of the icebox compartment—e.g., first sidewall **284**—to a second end **294** proximate to a door mating surface **296** defined by door liner **204**. As shown in the illustrated embodiment, the inlet duct **220** extends in a substantially orthogonal direction from first sidewall **284**. However, inlet duct **220** may alternatively extend from first sidewall **284** in a different direction and/or from a different wall of icebox compartment **160**. Notably, as shown in the illustrated embodiment of FIGS. **6** and **7**, door liner **204** defines a space **298** around each of the inlet duct **220** and the outlet duct **222**, such that the inlet duct **220** and the outlet duct **222** may be surrounded in insulating foam (not shown).

[0054] Referring now to FIGS. **8** and **9**, it can be seen that the second end **294** of inlet duct **220** is disposed at the door mating surface **296**. As shown, the injection molded door liner **204** may define inlet duct **220** and outlet duct **222** such that they each comprise a rectangular profile having radiused corners. Alternatively, inlet duct **220** and outlet duct **222** may each comprise an oblong profile, or any other suitable profile for enhancing cooling airflow and system performance. In addition, by virtue of the injection molding process, the transitions, corners, or edges defining the profile of inlet duct **220** and outlet duct **222** may be molded to have a smooth profile, to have small or large radiused corners, or to have another flow enhancing profile, as desired.

[0055] For example, the second end **294** of the inlet duct **220** may be configured to receive a duct gasket **310** (FIG. **9**). In this regard, injection molded door liner **204** may define a profile that is configured to securely accept door gasket **310**. Alternatively, according to another exemplary embodiment, door liner **204** may be configured to receive a duct bracket (not shown) which is configured to receive the duct gasket **310**. As shown, duct gasket **310** protrudes from door mating surface **296** of door liner **204** and is typically made from a resilient material, e.g., rubber. In this manner, duct gasket **310** may be compressed to form a seal with supply duct **180** when refrigerator door **128** is in the closed position. Similarly, outlet duct **222** may be configured to receive duct gasket **310**, which is compressed to form a seal with return duct **182** when refrigerator door **128** is in a closed position. According to another embodiment, duct gasket **310** may be disposed on housing **120** of refrigerator appliance **100**. In this regard, duct gasket **310** surrounds supply duct **180** and return duct **182**. For this embodiment, door mating surface **296** of door liner **204** may define a profile for receiving the duct gasket **310** and providing a seal between, for example, supply duct **180** and inlet duct **220**.

[0056] Although the exemplary embodiments described above refer to an integral, injection-molded door liner **204** mounted onto refrigerator door **128** and defining an icebox compartment **160**, one skilled in the art will appreciate that aspects of the present subject matter may be used to create liners for different applications. For example, a door liner may be used in different chambers of refrigerator appliance **100**, and may serve purposes other than defining icebox compartment **160**. Exemplary door liners may even be used on other consumer appliances. Indeed, features of the present invention may be used in any application where it is desirable to have an injection-molded part having integral inlet and outlet ports or ducts.

[0057] Now that the construction of refrigerator door **128** and door liner **204** according to an exemplary embodiment has been presented, a method of forming these parts will now be described. Such a method may include fabricating door liner **204** as a unitary liner, e.g., such that door liner **204** is integrally formed of a single continuous piece of plastic, metal or other suitable material. The outer panel **202** of refrigerator is typically cut or stamped and formed from a structurally firm metal material such as steel, stainless steel, painted steel aluminum, or any other suitably rigid material. Door liner **204** is injection molded as a single, integral piece, and defines icebox compartment **160**, cooling air inlet duct **220**, and cooling air outlet duct **222**. Door liner **204** is mounted to the outer panel **202** to form refrigerator door **128** having a hollow cavity. The cavity is then filled with insulating foam.

[0058] Integral formation of the entire door liner **204** requires mold tooling specifically designed to form icebox compartment **160**, as well as inlet and outlet ducts **220**, **222**. Once the mold pieces are in place, the mold is injected with injection-molding grade plastic to form a single-piece door liner. After the injected plastic is solidified, the mold parts are removed to reveal a single-piece door liner having integral cooling ducts.

[0059] By contrast, prior methods of forming a refrigerator door liner have required multiple parts and a complicated assembly process. More specifically, an icebox frame would be separately formed by injection molding or another process. Holes would be formed in the icebox frame to define the first end of each duct. A perimeter liner would be separately formed and have holes punched for defining the opposite, second end of each duct. The icebox frame and the perimeter liner would then be joined together by, e.g., friction welding, or by using tape or adhesive. Finally, a duct portion would be separately formed, and the duct portion would be inserted between the holes in the icebox frame and perimeter liner, and then joined in a manner similar to the icebox frame and perimeter liner. In addition to the manufacturing process being significantly more difficult and time-consuming, the resulting door liners frequently have small leaks through which foam might leak during the foam insulation process. Notably, using the above-described method of forming an integral door liner by injection molding, manufacturing costs may be reduced and the performance of the resulting door liner may be improved, as discussed below.

[0060] Door liner **204** formed according to the above-described method or exemplary embodiments may exhibit significant performance advantages over prior, multi-part liners. From a manufacturing perspective, fewer parts are required to be procured, stored, and assembled. Additionally, assembly is simplified as parts do not need to be joined, taped, sealed, or otherwise assembled. Finally, there are fewer potential leak points where insulating foam might escape during the insulation process. From a performance perspective, because the door liner is produced as one part, as opposed to several parts, the tolerances of the finished door liner assembly can be held tighter, thus contributing to a more robust liner. Furthermore, more design options may be available for the refrigerator appliance due to the more precise part features. For example, the method may permit formation of an icebox defining integral inlet and outlet ports that may be designed for optimal performance. Moreover, the inlet and outlet may be enhanced and exhibit a smooth profile such that frictional losses may be minimized and airflow performance may be optimized.

[0061] Door liners constructed in accordance with the above-described example embodiments have demonstrated improved performance compared to prior designs. For example, FIG. **10**A provides a plot of a measured pressure drop of cooling air as it is circulated through icebox compartment **160** at various flow rates compared to the pressure drop in a prior design. To determine the system pressure drop, the difference between air pressures at two points in the sealed cooling system **250** is determined. The first pressure may be measured, for example, at the air handler **262** outlet, and the second pressure may be measured, for example, at the air handler **262** inlet. As may be seen in FIG. **10**A, the pressure drop experienced by the sealed cooling system **250** is larger for prior designs. Similarly, FIG. **10**B provides a plot of a measured pressure drop of cooling air flowing across inlet duct **220** and outlet duct **222** of icebox compartment **160** compared to the pressure drop in a prior multi-part assembly design. As may be seen in FIG. **10**B, the pressure drop across inlet duct **220** and outlet duct **222** is significantly lower for injection molded door liner **204**, especially at higher flow rates. A lower pressure drop means friction losses within the sealed cooling system **250** are decreased, more cooling air is received in icebox compartment **160**, and the performance and efficiency of the refrigerator appliance **100** is improved.

[0062] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they include structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. An injection molded door liner for a door of a refrigerator appliance, the door liner comprising:

an icebox compartment defined at least in part by the door liner, the icebox compartment having a back wall and a plurality of sidewalls;

a cooling air inlet duct defined by the door liner and configured to receive cooling air from a sealed cooling system; and

a cooling air outlet duct defined by the door liner and configured to return cooling air to the sealed cooling system,

wherein the door liner is injection molded as a single, integral part.

2. The injection molded door liner of claim **1**, wherein the door liner defines a space around each of the inlet duct and the outlet duct, such that the inlet duct and the outlet duct may be surrounded in insulating foam.

3. The injection molded door liner of claim **1**, wherein the cooling air inlet duct and the cooling air outlet duct extend from a first end proximate to one of the plurality of sidewalls of the icebox compartment to a second end proximate to a door mating surface defined by the door liner.

4. The injection molded door liner of claim **3**, wherein the second end of the inlet duct is configured to receive an inlet duct gasket and the second end of the outlet duct is configured to receive an outlet duct gasket.

5. The injection molded door liner of claim **4**, wherein the inlet duct gasket is compressed to form a seal with a cooling air supply duct and the outlet duct gasket is compressed to form a seal with a cooling air return duct when the door is in a closed position.

6. The injection molded door liner of claim **1**, wherein the door liner is between about $1/16$ inch and $3/16$ inch thick.

7. The injection molded door liner of claim **1**, wherein the door liner is about $1/8$ inch thick.

8. The injection molded door liner of claim **1**, wherein the inlet duct and the outlet duct each comprise a rectangular profile having radiused corners.

9. The injection molded door liner of claim **1**, wherein the inlet duct and the outlet duct each comprise an oblong profile.

10. The injection molded door liner of claim **1**, wherein the door liner is disposed in a fresh food chamber and the icebox compartment comprises an ice maker and an ice storage bin.

11. A refrigerator appliance, comprising:

a cabinet including a liner defining a chilled chamber;

a door configured to provide access into the chilled chamber;

a door liner that is injection molded as a single, integral piece and mounted in the door, the door liner defining a sub-compartment, the sub-compartment comprising:

an icebox cavity;

an inlet for receiving chilled air into the icebox cavity from a sealed cooling system; and

an outlet for returning chilled air to the sealed cooling system.

12. The refrigerator appliance of claim **11**, wherein the door liner defines a space around each of the inlet and the outlet, such that the inlet and the outlet may be surrounded in insulating foam.

13. The refrigerator appliance of claim **11**, wherein the inlet and the outlet extend from a first end proximate to the icebox cavity to a second end proximate to a door mating surface defined by the door liner.

14. The refrigerator appliance of claim **13**, wherein the second end of the inlet is configured to receive an inlet gasket and the second end of the outlet is configured to receive an outlet gasket.

15. The refrigerator appliance of claim **14**, wherein the inlet gasket is compressed to form a seal with a chilled air supply duct and the outlet gasket is compressed to form a seal with a chilled air return duct when the door is in a closed position.

16. The refrigerator appliance of claim **11**, wherein the door liner is between about 1/16 inch and 3/16 inch thick.

17. The refrigerator appliance of claim **11**, wherein the door liner is about 1/8 inch thick.

18. The refrigerator appliance of claim **11**, wherein the inlet and the outlet each comprise a rectangular profile having radiused corners.

19. The refrigerator appliance of claim **11**, wherein the inlet and the outlet each comprise an oblong profile.

20. The refrigerator appliance of claim **11**, wherein the icebox cavity comprises an ice maker and an ice storage bin.

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