US 20140345304A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2014/0345304 A1**

(43) **Pub. Date: Nov. 27, 2014**

Leung et al.

(54) **MOBILE APPARATUS AND METHOD FOR RAPIDLY PRE-COOLING PRODUCE**

(71) Applicant: **Tigon Systems Incorporated**, Richmond (CA)

(72) Inventors: **David Joe Yee Leung**, Richmond (CA); **Thomas King Fu Leung**, Richmond (CA)

(21) Appl. No.: **14/285,620**

(22) Filed: **May 22, 2014**

Related U.S. Application Data

(60) Provisional application No. 61/827,365, filed on May 24, 2013.

Publication Classification

(51) **Int. Cl.**

F25D 15/00 (2006.01)

F25D 17/00 (2006.01)

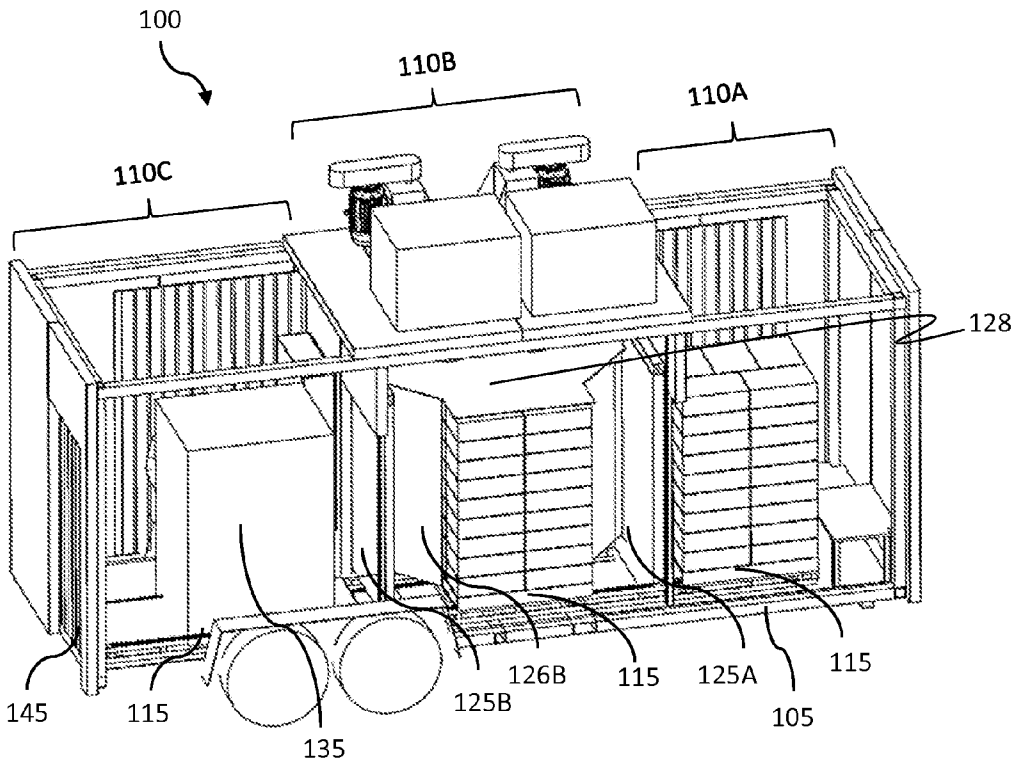
(52) **U.S. Cl.**

CPC ***F25D 15/00*** (2013.01); ***F25D 17/005*** (2013.01)

USPC **62/63**; 62/440; 62/380; 62/419

(57) **ABSTRACT**

An integrated mobile apparatus pre-cools produce prior to shipment, for example, to purchasers or to a cold storage facility. The apparatus comprises a preparation chamber for receiving and arranging produce on a movable carrier, a cooling chamber for receiving the produce from the preparation chamber, and a shipping chamber for receiving the produce from the cooling chamber. The chambers are preferably housed in a single enclosure and are arranged linearly, with the cooling chamber interposed between the preparation chamber and the shipping chamber. A method for pre-cooling produce prior to shipment comprises (a) arranging the produce on a movable carrier located within the preparation chamber, (b) conveying the carrier from the preparation chamber to the cooling chamber, (c) cooling the produce in the cooling chamber, (d) conveying the cooled produce to the shipping chamber, and (e) unloading the produce from the shipping chamber on to a vehicle.



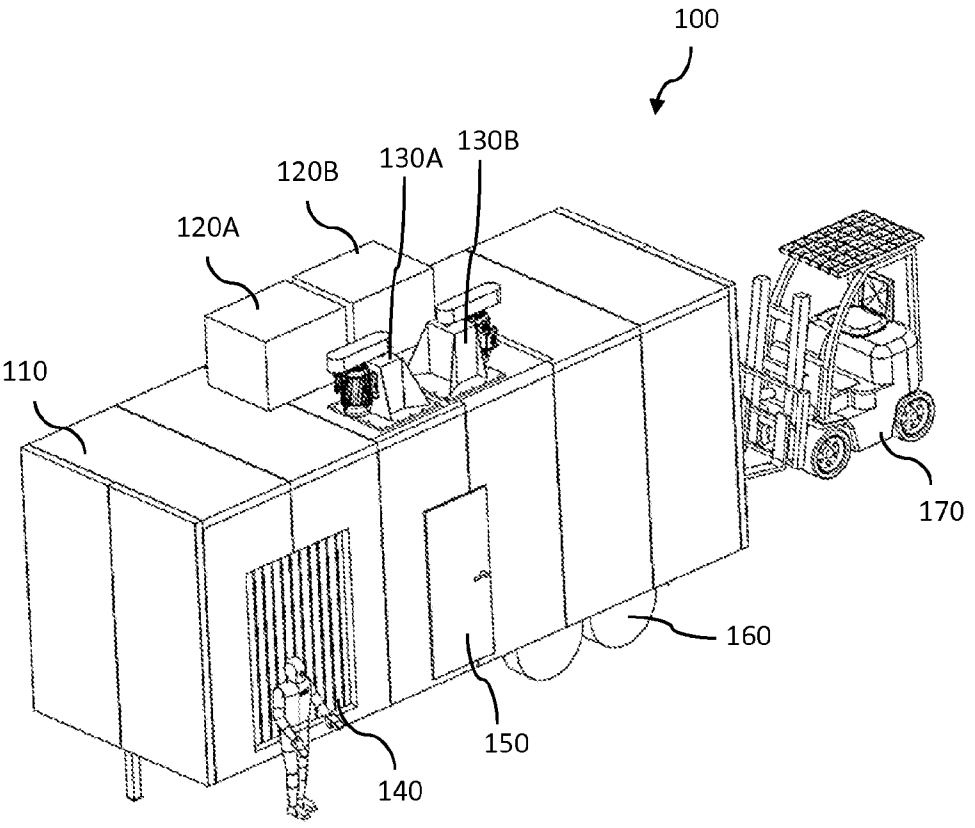


FIG. 1

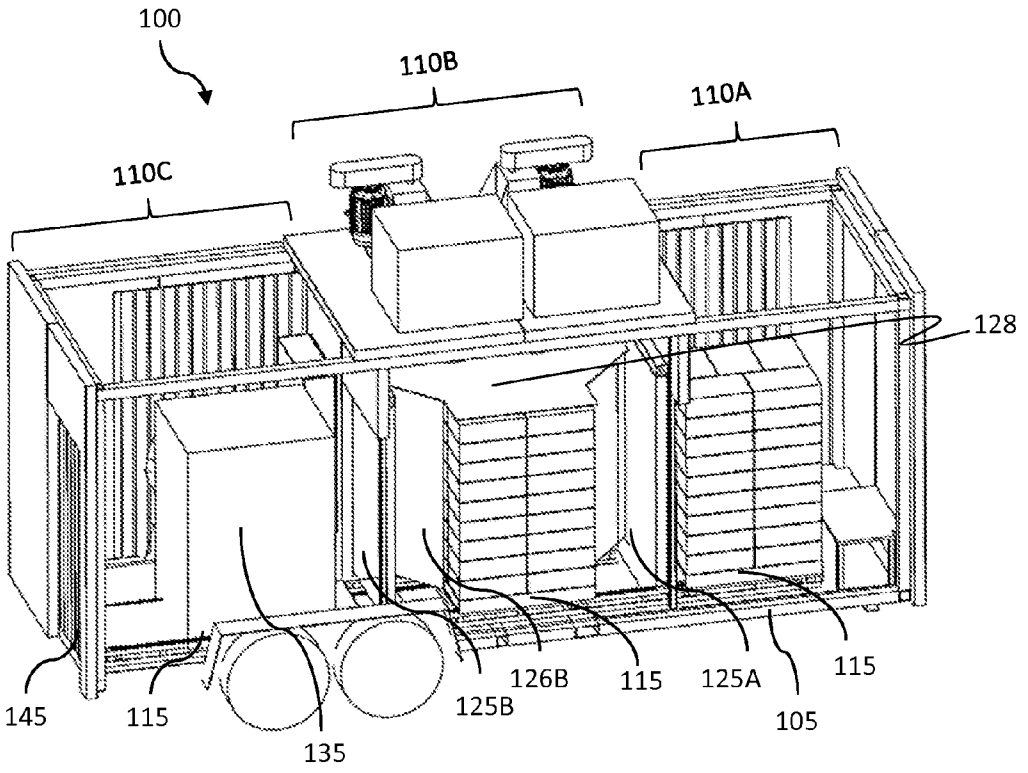


FIG. 2

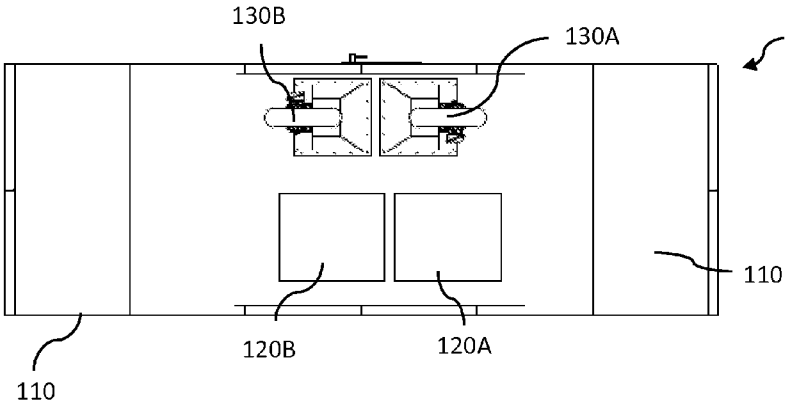


FIG. 3A

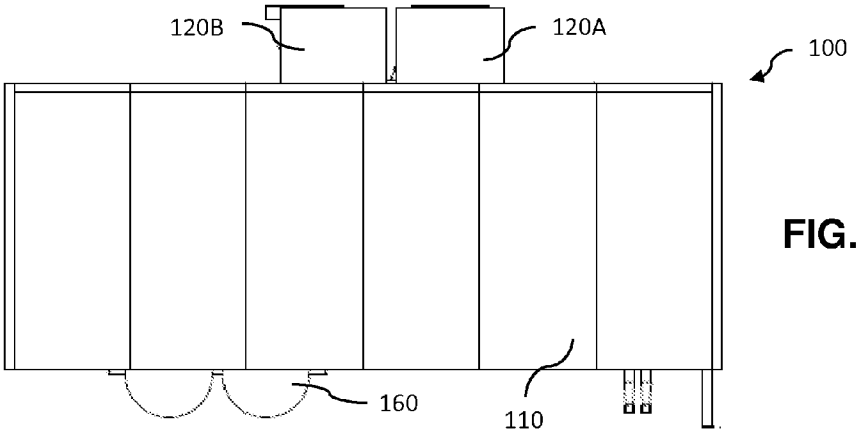


FIG. 3B

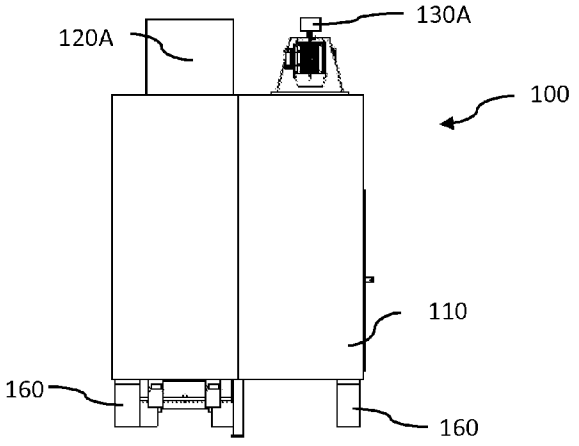


FIG. 3C

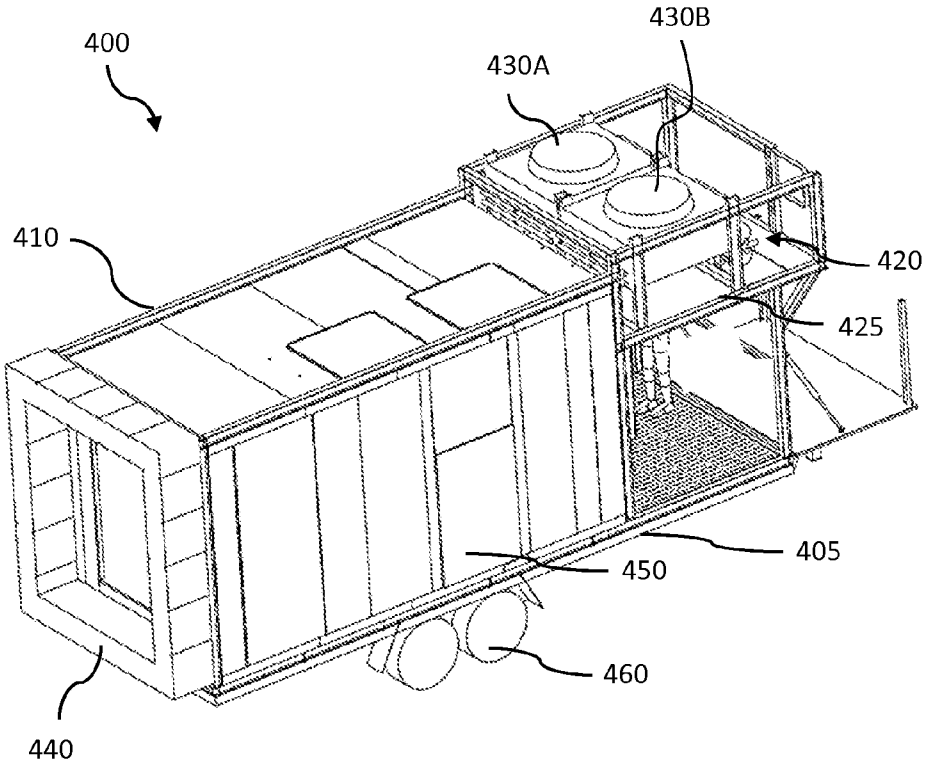


FIG. 4

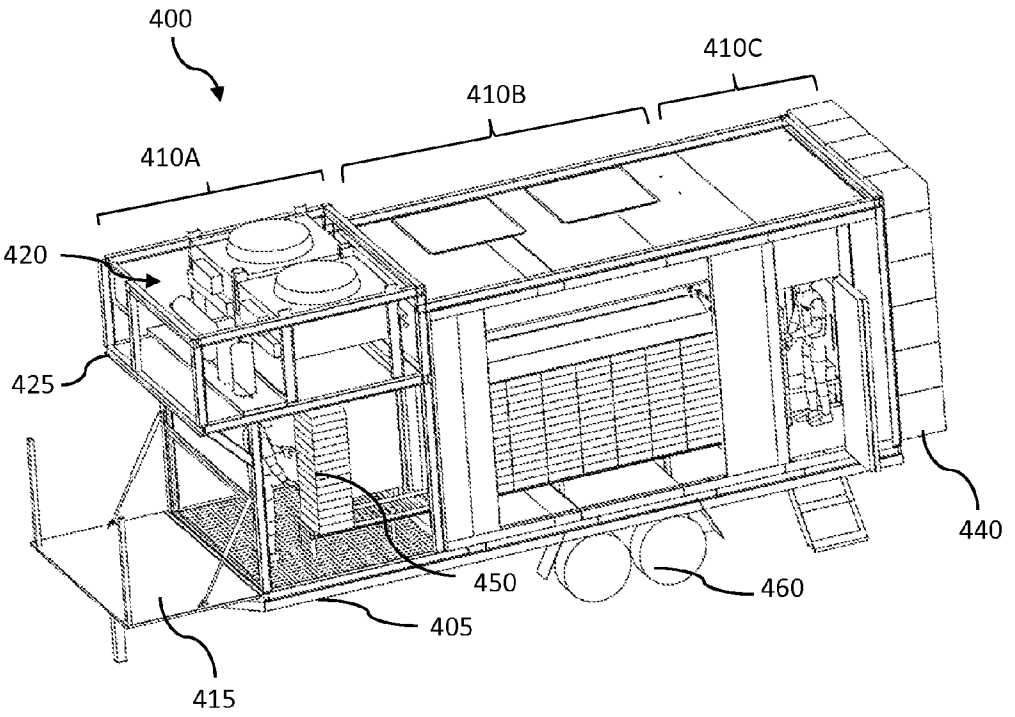


FIG. 5

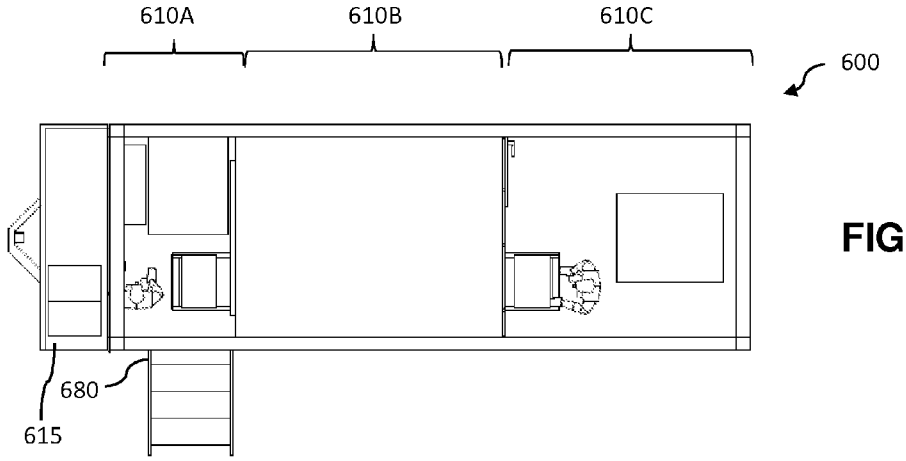


FIG. 6A

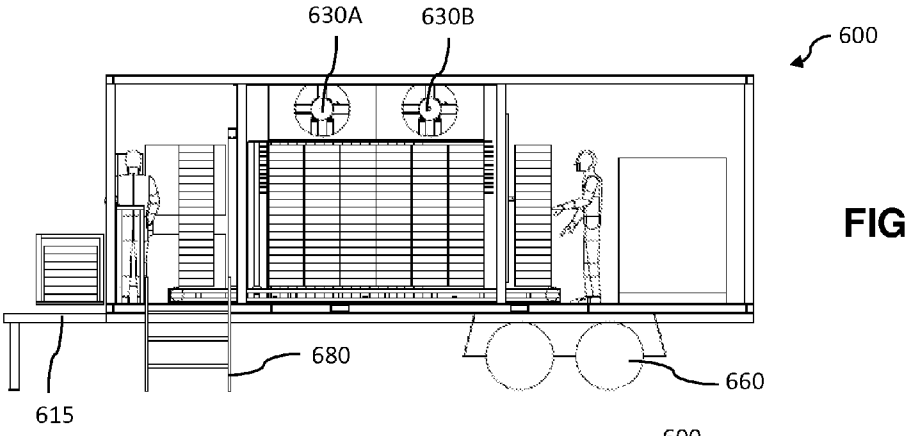


FIG. 6B

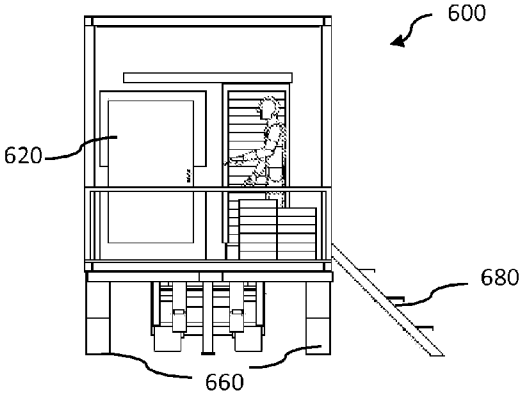


FIG. 6C

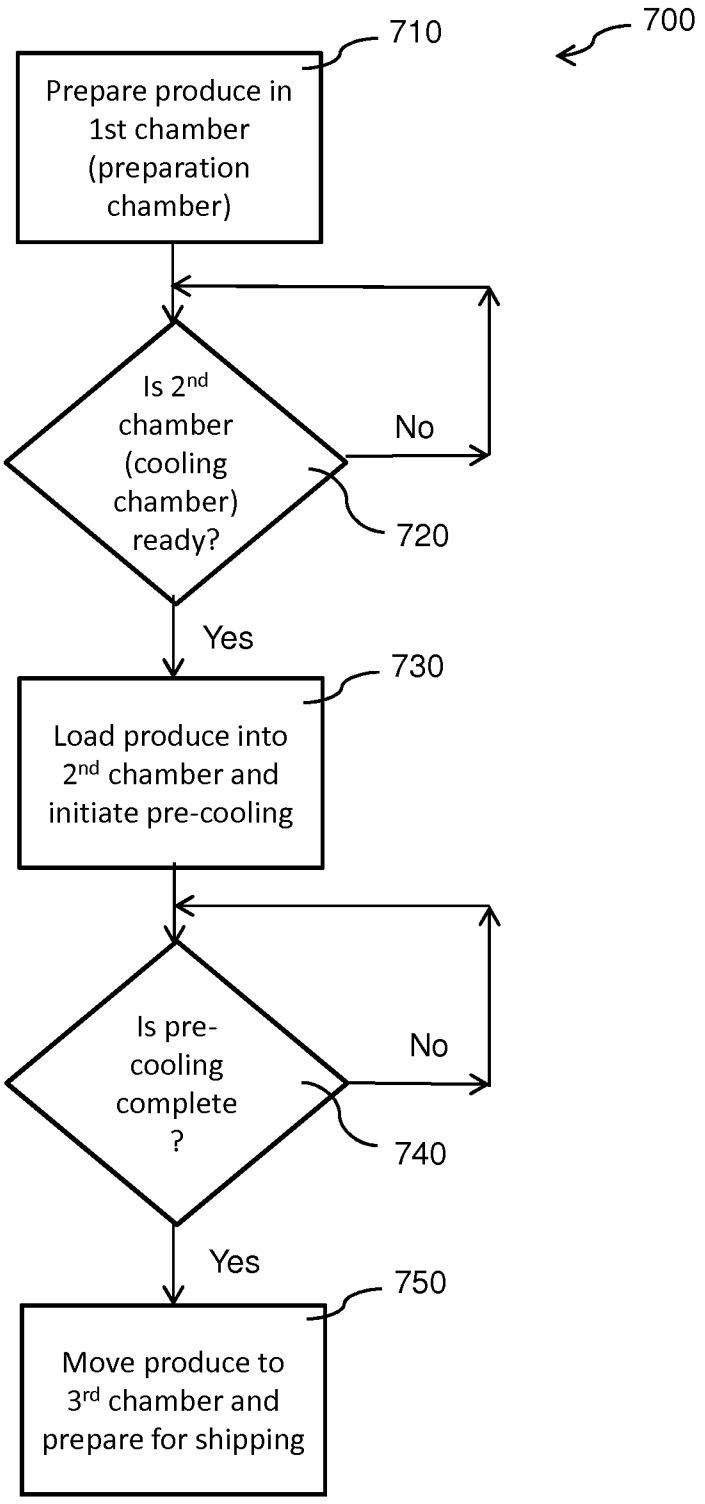

700
710
Prepare produce in 1st chamber (preparation chamber)
Is 2nd chamber (cooling chamber) ready?
No
720
Yes
730
Load produce into 2nd chamber and initiate pre-cooling
Is pre-cooling complete ?
No
740
Yes
750
Move produce to 3rd chamber and prepare for shipping

FIG. 7A

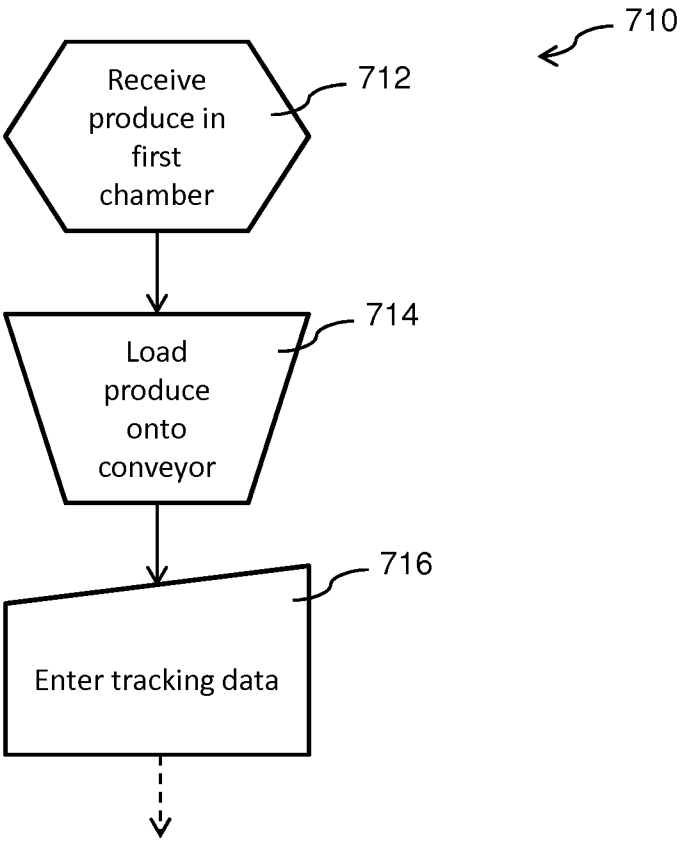

710
Receive produce in first chamber
712
Load produce onto conveyor
714
Enter tracking data
716

FIG. 7B

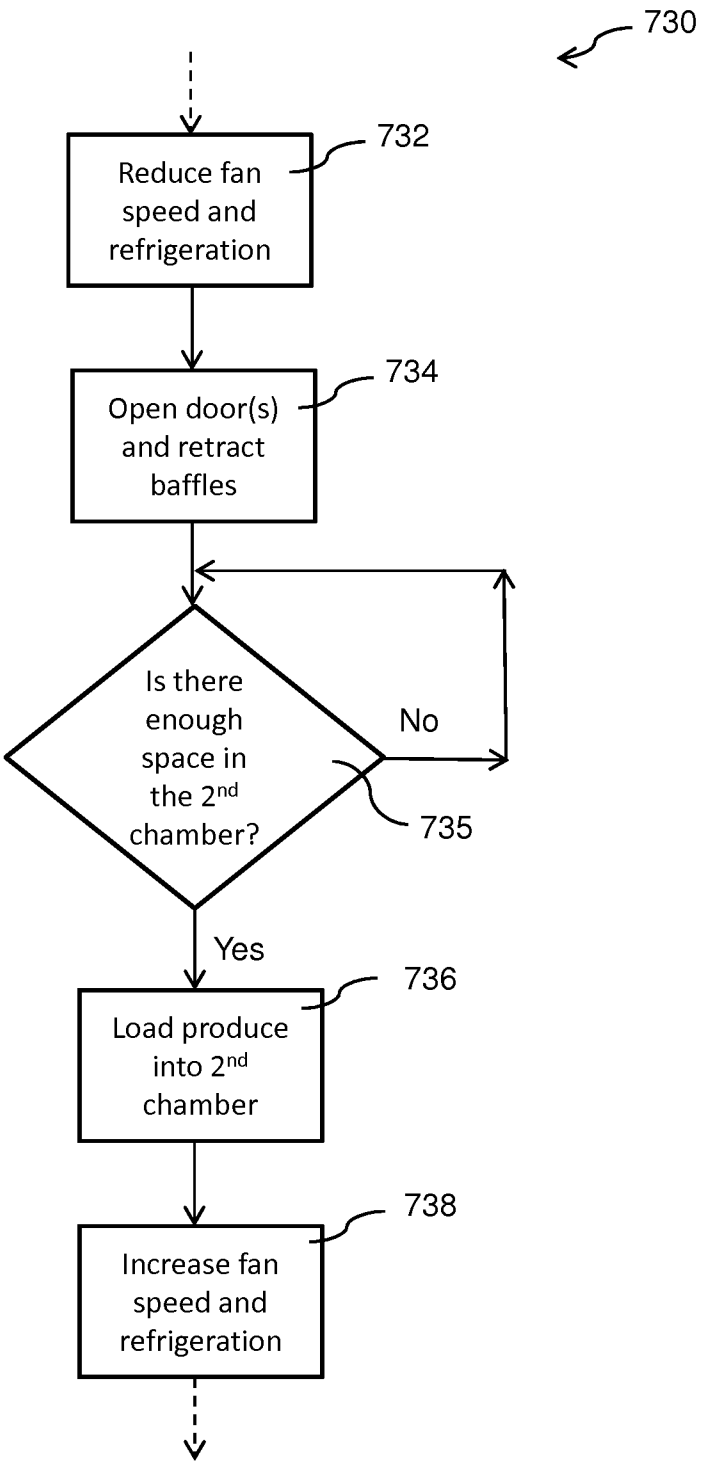

730
732
Reduce fan speed and refrigeration
734
Open door(s) and retract baffles
Is there enough space in the 2nd chamber?
No
735
Yes
736
Load produce into 2nd chamber
738
Increase fan speed and refrigeration

FIG. 7C

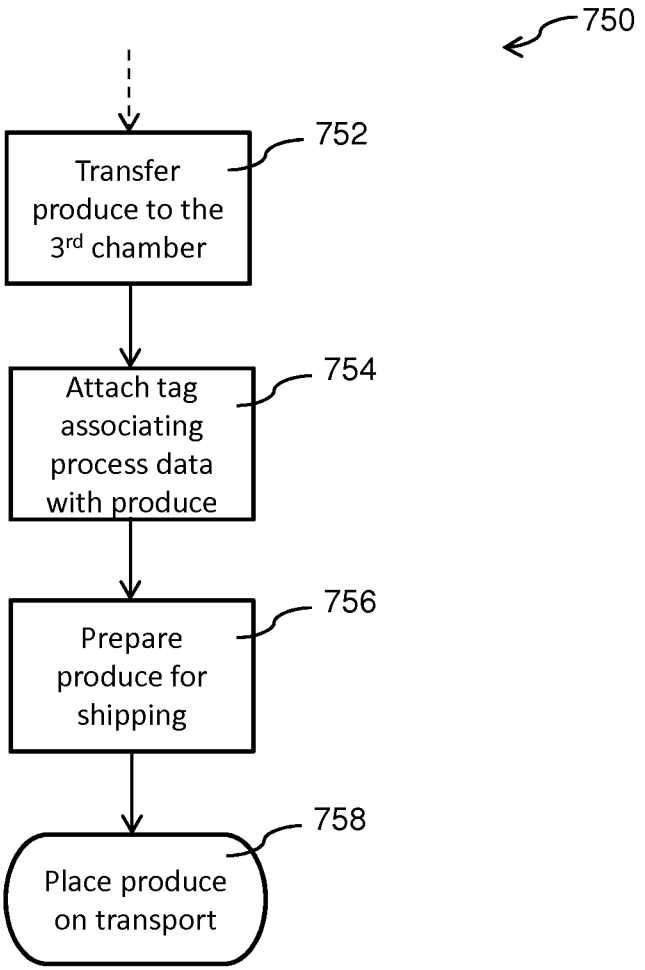

750
752
Transfer produce to the 3rd chamber
754
Attach tag associating process data with produce
756
Prepare produce for shipping
758
Place produce on transport

FIG. 7D

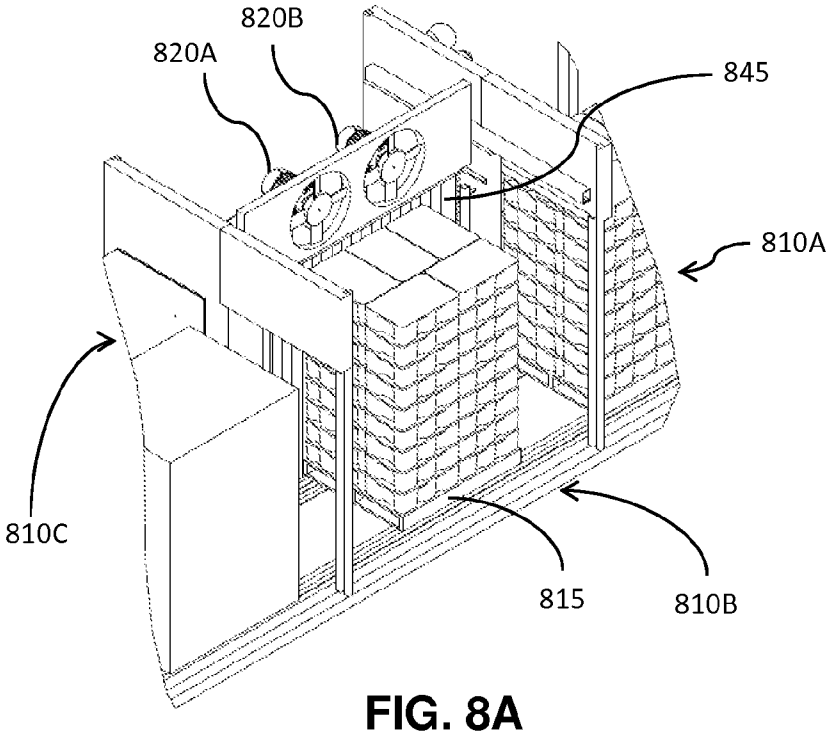

820B
820A
845
810A
810C
815
810B

FIG. 8A

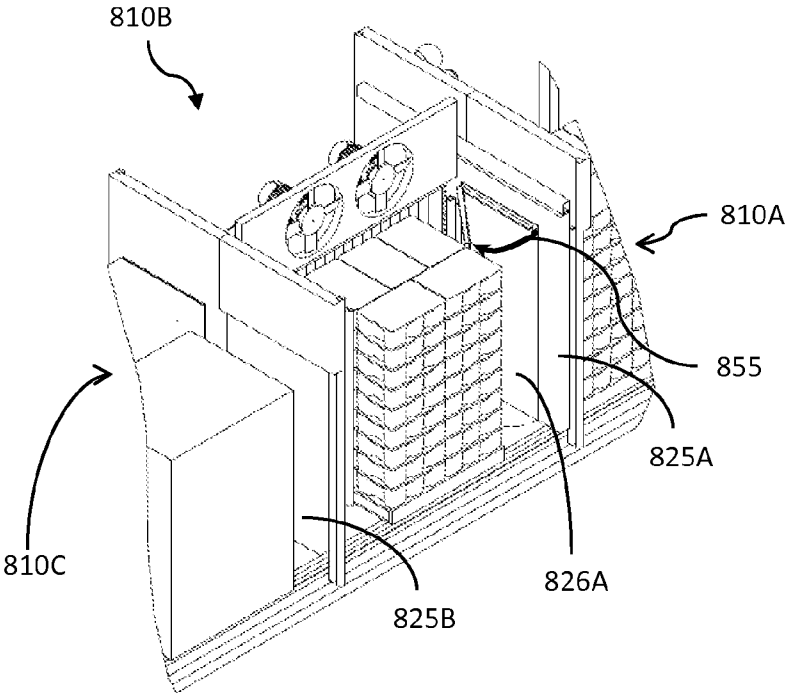

810B
810A
855
825A
810C
826A
825B

FIG. 8B

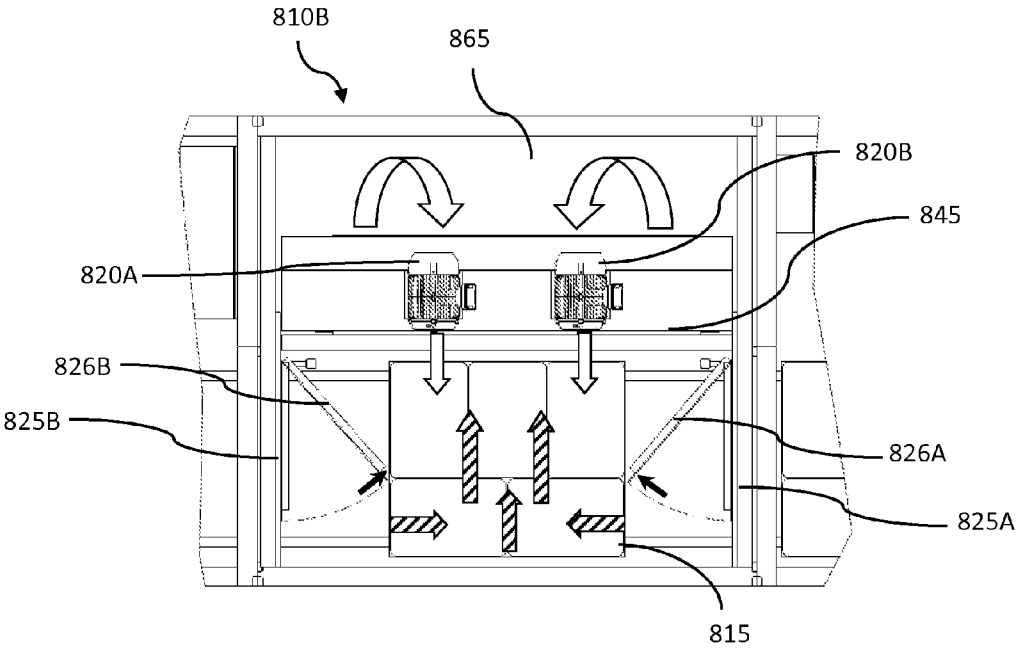


FIG. 8C

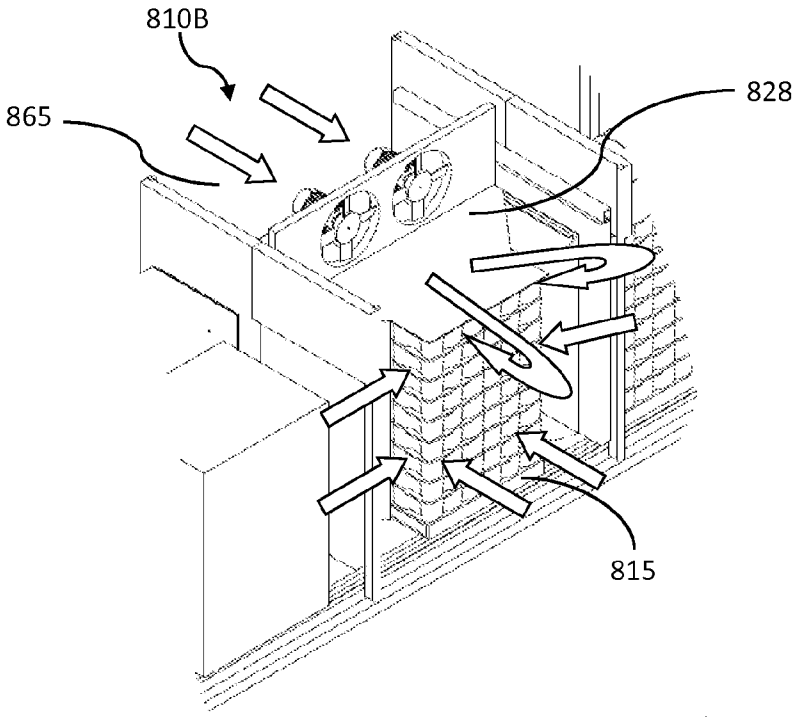


FIG. 8D

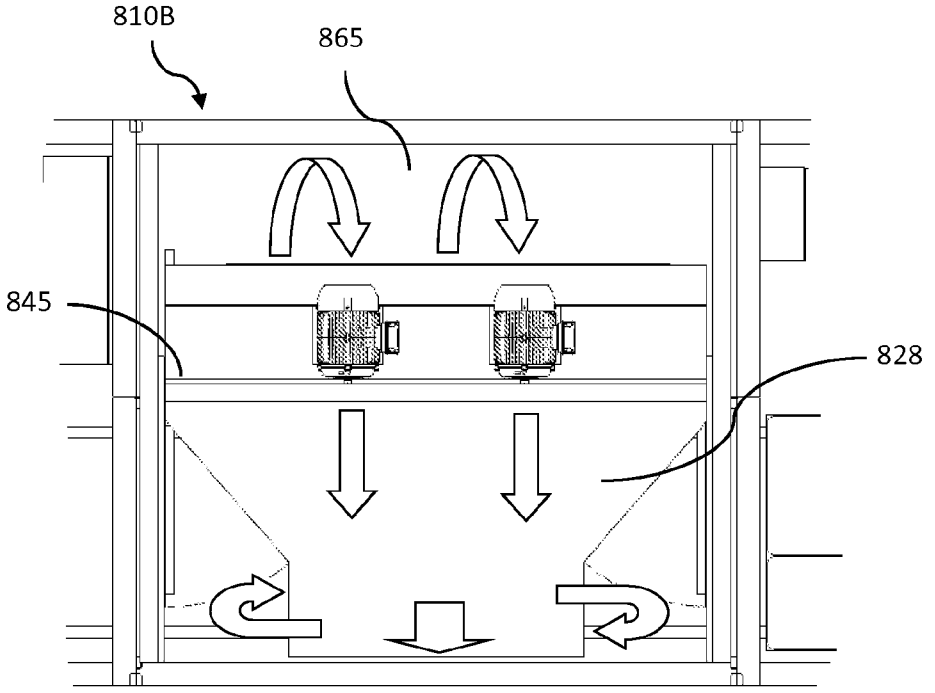


FIG. 8E

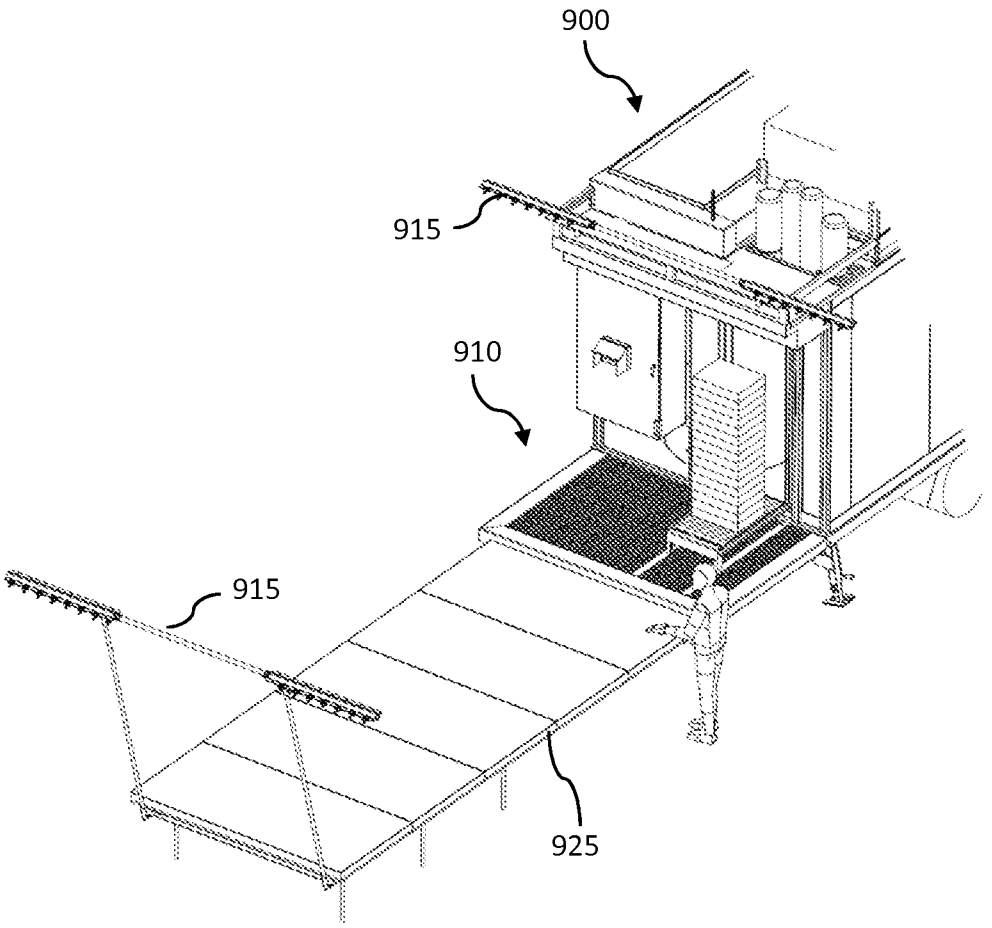


FIG. 9

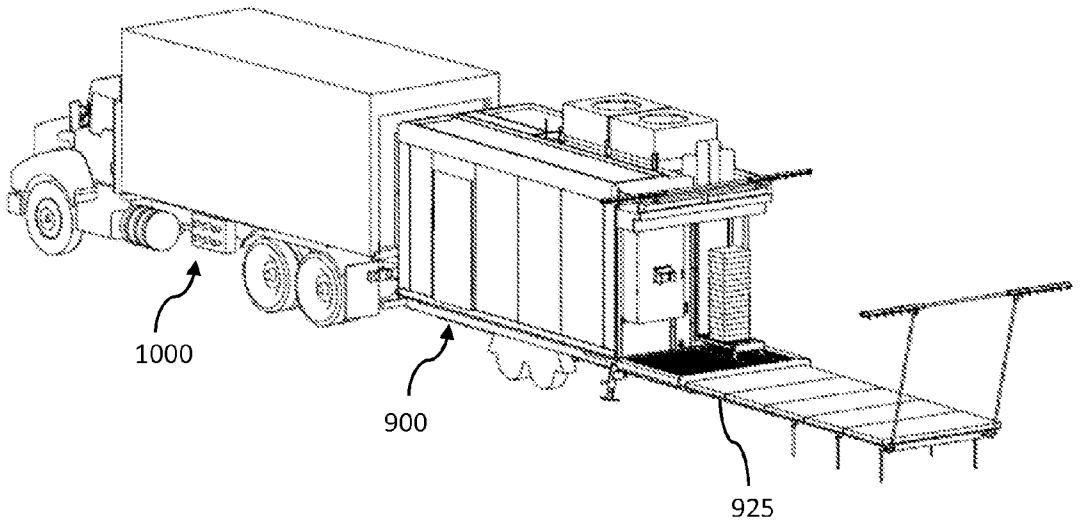


FIG. 10

MOBILE APPARATUS AND METHOD FOR RAPIDLY PRE-COOLING PRODUCE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims priority benefits from U.S. provisional patent application Ser. No. 61/827,365 filed on May 24, 2014, entitled "Mobile Apparatus And Method For Rapidly Pre-Cooling Produce". The '365 provisional application is hereby incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to apparatuses, systems and methods for refrigeration, and in particular the chilling of freshly picked fruits and vegetables

BACKGROUND OF THE INVENTION

[0003] Chilling freshly picked fruit and vegetables (also known as pre-cooling) is common practice especially among large producers. Pre-cooling has been shown to improve the shelf-life of perishable produce such as fruit and vegetables. It is widely accepted that the removing of field heat as soon as possible after harvesting preserves quality and extends shelf-life.

[0004] Pre-cooling is different than cold storage. The temperature in cold storage is maintained at a fixed low temperature. In pre-cooling, heat is removed from the produce quickly and efficiently after harvesting. Produce starts to deteriorate after harvesting because of enzymatic and other processes. Rapid pre-cooling followed by cold storage significantly slows these processes.

[0005] Methods of pre-cooling include room cooling, forced-air cooling, hydro-cooling, ice cooling and vacuum cooling. Methods should be capable of reducing the temperature of the harvested produce and counteracting normal heat gain occurring within the pre-cooling facility or apparatus.

[0006] Forced-air cooling can be used for crops or produce arranged in pallets. In forced-air cooling, chilled air is made to flow through the pallets bringing the chilled air into direct contact with the produce and enhancing performance over room cooling, for example. The chilled air can be made to flow in different directions relative to the pallets, for example horizontally from one side of a pallet to the other, or vertically from the bottom of the pallet to the top or vice versa.

[0007] Various mobile pre-cooling systems are known. Some are based on standard 40-foot container equipped with fans and refrigeration equipment. These are used for batch cooling of large quantities of produce (for example, 8-10 pallets per cycle). Typically, the pallets are loaded into the container for pre-cooling which takes several hours, and then removed for transportation to cold storage. Other systems involve the use of a docking module in which refrigeration and air circulation equipment is housed on a skid or trailer. A 48-foot trailer can house up to three cooling modules, each with an associated docking port. A shipping vehicle is loaded with warm produce and is backed against one of the docking ports and the cooling module is started. This system requires no modification to the shipping vehicle, however cooling times are long (typically 3-10 hours) and the shipping vehicle is idle while the produce is being pre-cooled. Such systems generally do not have sufficient refrigeration capacity and adequate air-flow to pre-cool produce in 20- or 40-foot refrigerated highway trailer shipping vehicles.

[0008] Most of these "mobile" cooling systems are very large and, although they can be re-located, they cannot be deployed in the field close to harvesting operations, and they are not suitable for smaller operations (for example, with a single picking crew). Preparation of multiple pallets of produce for batch cooling in these systems would take too long, resulting in post-harvest deterioration of the produce.

[0009] The present apparatus and method relate to a compact, self-contained mobile pre-cooling apparatus that can be deployed in the fields directly where the produce is being picked. It allows for substantially continuous throughput or operation, with short processing times for pre-cooling the produce. Multiple mobile forced-air chilling units can be deployed on a farm or in a region, each operable by a single picking crew. A refrigerated shipping vehicle can circulate between the units picking up pre-cooled produce for delivery to a cold storage facility, and subsequent distribution. The present apparatus and method can include the capability to track produce and to record information related to its harvesting, pre-cooling and cold storage.

SUMMARY OF THE INVENTION

[0010] An integrated mobile apparatus pre-cools produce prior to shipment, for example, to purchasers or to a cold storage facility. The apparatus comprises:

[0011] (a) a transportable platform;

[0012] (b) a preparation chamber mounted on the platform for receiving and arranging a quantity of produce on a movable carrier;

[0013] (c) a cooling chamber mounted on the platform for receiving the quantity of produce on the movable carrier from the preparation chamber, the cooling chamber comprising:

[0014] (1) a refrigeration surface;

[0015] (2) a circulation system for directing a chilling fluid between the refrigeration surface and the quantity of produce on the movable carrier;

[0016] (d) a shipping chamber mounted on the platform for receiving the quantity of produce on the movable carrier from the cooling chamber, the shipping chamber having an opening for facilitating unloading of the quantity of produce.

[0017] In a preferred embodiment of the apparatus, the preparation chamber, the cooling chamber and the shipping chamber are housed in a single enclosure. The preparation chamber, the cooling chamber and the shipping chamber are preferably arranged linearly, with the cooling chamber interposed between the preparation chamber and the shipping chamber. The platform preferably has wheels mounted on a lower surface thereof for facilitating transportation of the apparatus from one location to another.

[0018] In a preferred embodiment of the apparatus, the apparatus comprises inter-chamber doors for separating the cooling chamber from the preparation chamber and the shipping chamber. The apparatus preferably comprises a conveyer mechanism for facilitating conveyance of the movable carrier between chambers. The conveyor mechanism can comprise:

[0019] (1) gravity rollers, such that the movable carrier is conveyed between chambers on the rollers at least partially by action of gravity;

[0020] (2) mechanized rollers, such that the movable carrier is conveyed between chambers on the rollers by at least one of pneumatic, hydraulic and electromechanical power; and

[0021] (3) at least one belt, whereby the movable carrier is conveyed between chambers on the at least one belt.

[0022] In a preferred embodiment of the apparatus, the movable carrier can comprise one of (i) a pallet on which the quantity of produce is carried and (ii) a plurality of stacked flats in which the quantity of produce is carried.

[0023] In a preferred embodiment of the apparatus, the refrigeration surface can comprise at least one evaporative coil. The at least one evaporative coil preferably extends from an on-board refrigeration unit. The on-board refrigeration unit is preferably powered by an onboard or trailer-mounted generator. The circulation system preferably comprises at least one fan. The chilling fluid is preferably air.

[0024] In a preferred embodiment of the apparatus, the cooling chamber comprises baffles for improving flow of the chilling fluid around the quantity of produce. The baffles are preferably retractable. The apparatus preferably further comprises inter-chamber doors for separating the cooling chamber from the preparation chamber and the shipping chamber, and the retractable baffles provide are hinged or otherwise movably coupled to the inter-chamber doors. The baffles are preferably actuated by opening and closing of the inter-chamber doors. When the doors are closed, the baffles are preferably deployed to rest against the movable carrier in the cooling chamber, and when the doors are opened, the baffles preferably retract clear of the movable carrier.

[0025] In a preferred embodiment of the apparatus, a control system is capable of depowering the circulation system to a low power state to conserve power and maintain temperature of the quantity of produce within a desired range within the cooling chamber.

[0026] In a method for pre-cooling a quantity of produce in an integrated mobile apparatus, prior to shipment (for example, to purchasers or to a cold storage facility), the integrated mobile apparatus comprises a transportable platform having mounted thereon a preparation chamber, a cooling chamber and a shipping chamber. The cooling chamber comprises a refrigeration surface and a circulation system for directing a chilling fluid between the refrigeration surface and the quantity of produce. The pre-cooling method comprises:

[0027] (a) arranging the quantity of produce on a movable carrier located within the preparation chamber;

[0028] (b) conveying the movable carrier from the preparation chamber to the cooling chamber;

[0029] (c) cooling the quantity of produce in the cooling chamber;

[0030] (d) conveying the cooled quantity of produce to the shipping chamber;

[0031] (e) unloading the quantity of produce from the shipping chamber.

[0032] In a preferred embodiment of the method, the preparation chamber, the cooling chamber and the shipping chamber are housed in a single enclosure. The preparation chamber, the cooling chamber and the shipping chamber are preferably with the cooling chamber interposed between the preparation chamber and the shipping chamber, so that the produce is conveyed substantially linearly through the integrated mobile pre-cooling apparatus as the steps of the method are performed.

[0033] In a preferred embodiment of the method, the preparation step (a) further comprises labeling of the quantity of produce with tracking data. The tracking data preferably comprises at least one of source identification, purchaser identification, harvest date and time, pick-up date and time, in-feed temperature, weight of the quantity of produce, and crew identification.

[0034] In a preferred embodiment of the method, the cooling step (c) further comprises sensing a temperature of the quantity of produce such that the cooling is terminated when the temperature reaches a predetermined temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] FIG. **1** is a perspective view of an embodiment of a mobile forced-air chiller having three chambers.

[0036] FIG. **2** is a perspective view of the mobile forced-air chiller of FIG. **1** showing the interior.

[0037] FIG. **3**A is a simplified schematic plan view of the mobile forced-air chiller of FIG. **1**.

[0038] FIG. **3**B is a simplified schematic side view of the mobile forced-air chiller of FIG. **1**.

[0039] FIG. **3**C is a simplified schematic end view of the mobile forced-air chiller of FIG. **1**.

[0040] FIG. **4** is a perspective view of another embodiment of a mobile forced-air chiller.

[0041] FIG. **5** is a perspective view of the mobile forced-air chiller of FIG. **4** showing the interior.

[0042] FIG. **6**A is a simplified schematic plan view of another embodiment of a mobile forced-air chiller.

[0043] FIG. **6**B is a simplified schematic side view of the mobile forced-air chiller of FIG. **6**A.

[0044] FIG. **6**C is a simplified schematic end view of the mobile forced-air chiller of FIG. **6**A.

[0045] FIG. **7**A is a flow chart describing steps in a method for pre-cooling produce using a mobile forced-air chiller.

[0046] FIG. **7**B is a flow chart describing steps in a method for preparing freshly-picked produce for pre-cooling in a mobile forced-air chiller.

[0047] FIG. **7**C is a flow chart describing steps in a method for loading produce into a second (cooling) chamber in a mobile forced-air chiller, and initiating pre-cooling.

[0048] FIG. **7**D is a flow chart describing steps in a method for moving produce to the third chamber in a mobile forced-air chiller once pre-cooling is complete, and preparing it for shipping.

[0049] FIG. **8**A shows a cooling chamber located between a first chamber and a third chamber of a mobile forced-air chiller, with both inter-chamber doors in an open position.

[0050] FIG. **8**B shows a cooling chamber with both inter-chamber doors in a closed position, and illustrates a baffle system for improved air-flow within the cooling chamber of a mobile forced-air chiller.

[0051] FIG. **8**C is a plan view of a cooling chamber showing inter-chamber doors closed and two baffles in a deployed position, with arrows indicating the air-flow path.

[0052] FIG. **8**D shows a cooling chamber with inter-chamber doors closed and three baffles in a deployed position, with arrows indicating the air-flow path.

[0053] FIG. **8**E is a plan view of a cooling chamber with inter-chamber doors closed and three baffles in a deployed position, with arrows indicating the air-flow path.

[0054] FIG. **9** is a partial perspective view of another embodiment of a mobile forced-air chiller with a retractable work surface.

[0055] FIG. **10** is a perspective view of the mobile forced-air chiller of FIG. **9** and a truck docked against the shipping chamber of the mobile chiller.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT(S)

[0056] The present apparatus and method relate to a compact, mobile pre-cooling apparatus that can be deployed directly in the fields or orchards where produce is being picked. It can be easily moved from one location to the next (for example, it can be towed by a tractor or truck). It allows for substantially continuous throughput or operation, with short processing times for pre-cooling the produce.

[0057] The present apparatus and method is particularly suitable for pre-cooling delicate crops such as strawberries, cane berries, peaches and cherries, which are not suitable for exposure to water or vacuum chilling. For fruits such as strawberries, pickers generally place the fruit directly into plastic clam-shell packs or plastic baskets which are then arranged in a single layer in a cardboard carton or "flat". The present apparatus can be sized and configured for pre-cooling of one or more individual stacks of flats (for example, 19 flats stacked one on top of another), or a single pallet loaded with several stacks of flats.

[0058] The present mobile apparatus is integrated such that the preparation chamber, the cooling chamber and the shipping chamber are mounted on a transportable platform. In preferred embodiments the preparation chamber, the cooling chamber and the shipping chamber are housed in a single enclosure on the transportable platform. The preparation chamber, the cooling chamber and the shipping chamber are preferably arranged linearly, with the cooling chamber interposed between the preparation chamber and the shipping chamber. The produce can then be conveniently conveyed substantially linearly through the mobile forced-air chiller (from one end to the other) moving between the three chambers as the produce is prepared for pre-cooling, is pre-cooled, and is then prepared for shipping.

[0059] In some embodiments, the preparation chamber is an open work space that is not completely enclosed by walls, as shown in some of the embodiments described below.

[0060] FIG. **1** is a perspective view of an embodiment of a mobile forced-air chiller having three distinct chambers integrated within a single enclosure. Mobile forced-air chiller **100** comprises enclosure **110**. In one embodiment, enclosure **110** is about 7.5-8 m long, about 2.6 m wide and about 3.6-4 m high. Chiller **100** further comprises roof-mounted onboard refrigeration condensing units **120**A and **120**B, and centrifugal fans **130**A and **130**B. Chiller **100** further comprises an entrance **140** to a first chamber where an operator receives the produce and prepares it for pre-cooling. Entrance **140** can comprise a door or a curtain, for example. Preparation can include stacking of flats, labeling and electronic entry of data to track the produce, for example. Chiller **100** further comprises an external door **150** allowing access to a second chamber where the produce is cooled. Door **150** can provide direct access from outside to the second chamber for maintenance, for example. Chiller **100** further comprises wheels **160**, and is mobile and compact and can be deployed in the field close to harvesting operations. After pre-cooling in the second chamber, produce is moved to a third chamber from where it can be unloaded and shipped to cold storage for example. FIG. **1** shows a forklift **170** for unloading produce from chiller **100**.

[0061] FIG. **2** is a perspective view of the mobile forced-air chiller of FIG. **1** showing the interior. Mobile forced-air chiller **100** comprises three chambers **110**A, **110**B and **110**C mounted on transportable platform **105**. Chamber **110**A is the first chamber in which the produce is prepared for pre-cooling. Chamber **110**A provides a suitable environment for receiving and preparing the produce for pre-cooling. Chamber **110**A can optionally be cooled. An operator in chamber **110**A can receive the produce and arrange it in stacks and optionally place multiple stacks on a pallet. Chamber **110**A can comprise an electronic data entry system to record information about the produce to be chilled and to provide tracking data for subsequent use. The embodiment shown in FIG. **2** shows a pallet **115** loaded with 5 stacks of flats in each of the chambers **110**A, **110**B and **110**C. The pallet is transferred from first chamber **110**A to second chamber **110**B. The transfer can be achieved by manually pushing the stack or pallet into second chamber **110**B for example by means of a gravity roller conveyor, or automatically by means of a powered conveyor.

[0062] Second chamber **110**B is a cooling chamber in which high-velocity, high-pressure fans **130**A and **130**B (shown in FIG. **1**) circulate chilled air over an evaporator coil and through stacks on the pallet to cool them. Refrigeration of the forced air is provided by on-board refrigeration units **120**A and **120**B (shown in FIG. **1**) and one or more associated evaporator coils (not visible in FIG. **2**). Refrigeration units **120**A, **120**B and fans **130**A, **130**B can receive power from a remote power source such as a generator, or from an onboard generator (not shown in FIG. **2**), or from a mobile generator mounted on a separate trailer.

[0063] Cooling chamber **110**B can be equipped with an automated or mechanized baffle system. Inter-chamber sliding doors **125**A and **125**B separate chamber **110**B from chambers **110**A and **110**C, respectively. Baffles (such as lateral baffle **126**B visible in FIG. **2**) are hinged to the inter-chamber sliding doors on one end and a track system on the other end. The operation is such that the opening and closing of inter-chamber sliding doors **125**A and **125**B actuates the baffles. When the sliding doors are closed the baffles are deployed to rest against the pallet in cooling chamber **110**B. When the sliding doors open the baffles retract so that they are clear of the pallet so that it can be moved from one chamber to the next. These baffles, as well as adjustable baffles above and below the pallet, can be used to provide improved air-flow around the produce. An upper baffle **128** is visible in FIG. **2**. An exemplary baffle system for improved air-flow is described in further detail below in reference to FIGS. **8**A-E.

[0064] When pre-cooling is complete (for example, when the temperature of the produce reaches a predetermined temperature), the operator can be alerted or notified. The produce is then transferred from second chamber **110**B to third chamber **110**C via inter-chamber door **125**B. The transfer can be achieved by manually moving the pallet from second chamber **110**B to third chamber **110**C, or by means of an automatic conveyor.

[0065] In the event the produce is to be held longer in second chamber **110**B, fans **130**A and **130**B can automatically depower to a low power state to conserve power and maintain the temperature of the produce within a desired range, while reducing the risk of drying damage. In some embodiments, the temperature is monitored on both sides of the evaporator coil. Information is sent back to a programmable logic controller (PLC) where an algorithm analyzes the

information and makes adjustments to the operation of refrigeration units **120**A and **120**B and fans **130**A and **130**B. In third chamber **110**C, the operator can prepare the pallet for shipping to cold storage by placing an insulating cover **135** over it and strapping the cover down. FIG. **2** shows a pallet **115** with a cover **135** on it in chamber **110**C.

[0066] Third chamber **110**C can be kept cool to prevent the pre-cooled produce from being exposed to warm air prior to being covered by the insulating cover **135**. The stack(s) or pallet **115** can be removed from chamber **110**C, for example, by means of a forklift (such as forklift **170** in FIG. **1**), or loaded directly into a shipping vehicle, such as a truck, positioned adjacent to third chamber **110**C. Exterior access to chamber **110**C can be through a curtain or door **145**. The three chambers **110**A, **110**B and **110**C can be located adjacent to each other within enclosure **110** and can be mounted on a trailer or in the back of a truck. The three chambers are separated by insulated walls, with inter-chamber sliding doors **125**A and **125**B (or hinged swing doors or other types of doors, curtains or retractable screens) to allow the produce to enter and exit the chambers.

[0067] In the present approach, the produce is conveyed from one stage to the next through the three chambers, from one end of the platform and/or enclosure to the other, rather than being loaded in and out at the same location. This integrated 3-chamber configuration allows for substantially continuous throughput, where produce can be prepared for pre-cooling in chamber **110**A, at the same time as produce is being cooled in chamber **110**B, and at the same time as produce is awaiting pick-up or being unloaded from chamber **110**C. Depending on the rate of picking and supply of freshly harvested produce, cooling chamber **110**B can be operated substantially continuously (rather than intermittently) with a new stack or pallet being introduced into chamber **110**B as soon as the previous stack or pallet is transferred into chamber **110**C. This allows for efficient operation of the system, and can significantly reduce the wait time for the produce to be cooled after picking. It can also significantly reduce the time the produce spends at an elevated temperature, such as the ambient temperature outside the mobile chiller.

[0068] FIG. **3**A is a simplified schematic plan view of the mobile forced-air chiller of FIG. **1**. FIG. **3**B is a simplified schematic side view of the mobile forced-air chiller of FIG. **1**. FIG. **3**C is a simplified schematic end view of the mobile forced-air chiller of FIG. **1**. As described above, mobile forced-air chiller **100** comprises enclosure **110**, refrigeration units **120**A and **120**B, fans **130**A and **130**B, and wheels **160**.

[0069] FIGS. **4** and **5** are perspective views of another embodiment of a mobile forced-air chiller **400**, with FIG. **4** showing the exterior and FIG. **5** showing the interior. In this embodiment, some components are in a different location than on the mobile chiller illustrated in FIGS. **1-3**. Chiller **400** comprises platform **405** with wheels **460** and enclosure **410**. An external door or port **450** allows access to a second chamber **410**B where the produce is cooled. Chiller **400** comprises a docking mechanism **440** that allows for a shipping vehicle (not shown) to back up against chiller **400**, allowing for direct transfer of chilled produce from a third chamber **410**C directly into the shipping vehicle. The docking mechanism **440** provides a seal or interface that can reduce the amount of external hot air that can infiltrate into the third chamber and shipping vehicle.

[0070] As shown more clearly in FIG. **5**, mobile forced-air chiller **400** comprises three chambers **410**A, **410**B and **410**C similar to those described above for forced-air chiller **100** of FIGS. **1-3**. On-board refrigeration equipment **420** is housed on a raised platform **425** above the preparation area of first chamber **410**A. As shown in FIG. **5**, a drop-down platform extension **415** can be used to provide additional work space adjacent to chamber **410**A when the trailer is not in motion. FIG. **5** shows an operator preparing a stack of flats **460** in first chamber **410**A. Multiple stacks are being pre-cooled in cooling chamber **410**B. In this embodiment the produce is fed through cooling chamber **410**B on a conveyor in vertical stacks in a single file. As described above for chiller **100** of FIG. **1**, cooling chamber **410**B can be equipped with an automated baffle system to provide improved air-flow around the produce. Once pre-cooling is complete, produce is transferred from second chamber **410**B to third chamber **410**C. In third chamber **110**C, the operator can prepare stacks or a pallet of stacks for shipping as described above. Stack(s) or pallet can be directly loaded into a shipping vehicle docked against docking mechanism **440** of chamber **410**C.

[0071] FIG. **6**A is a simplified schematic plan view of another slightly different embodiment of a mobile forced-air chiller **600** having 3 chambers **610**A, **610**B and **610**C, and wheels **660**. Drop-down steps **680** provide easy operator access to preparation chamber **610**A. FIG. **6**B is a simplified schematic side view of mobile forced-air chiller **600** showing axial fans **630**A and **630**B mounted within cooling chamber **610**B. Drop-down platform extension **615** can be used to provide additional work space adjacent to chamber **610**A as shown in FIG. **6**B. FIG. **6**C is a simplified schematic end view of mobile forced-air chiller **600** showing refrigeration equipment **620**.

[0072] Multiple mobile forced-air chilling units as described herein can be deployed on a farm or in a region, each operable by a single picking crew. A refrigerated shipping vehicle can circulate between the units picking up pre-cooled produce for delivery to a centralized cold storage facility, and subsequent distribution.

[0073] FIGS. **7**A through **7**D are flow charts describing a method for pre-cooling produce using a mobile forced-air chiller such as the embodiments described herein. The method for pre-cooling can be automated.

[0074] FIG. **7**A is a flow chart describing basic steps in a method **700** for pre-cooling produce using a mobile forced-air chiller comprising three chambers. In step **710**, freshly-picked produce is prepared for pre-cooling. Further details of step **710** are described below in reference to FIG. **7**B. Preparation takes place in a first chamber, also referred to as the preparation chamber. When step **710** is complete, the method advances to step **720** to determine whether the produce can be transferred from the first chamber to the second chamber, also referred to as the cooling chamber. When the cooling chamber is ready, the method advances to step **730** where the produce is moved into the cooling chamber and the pre-cooling operation is initiated. Further details of step **730** are described below in reference to FIG. **7**C. In step **740**, the method determines whether the pre-cooling is complete and, if it is, then proceeds to step **750**. Completion of pre-cooling can be determined by temperature sensors reaching a pre-set temperature or temperature differential, for example. In step **750**, the produce is moved from the cooling chamber to the third chamber, also referred to as the shipping chamber, and is prepared for shipping. Further details of step **750** are described below in reference to FIG. **7**D.

[0075] FIG. **7**B illustrates possible steps in method **710** for preparing freshly-picked produce for pre-cooling. At step **712**, the produce is received in the first chamber, and the method advances to step **714** where the produce is loaded onto a conveyor. This step can involve tagging or labeling the produce, and arranging it in stacks of flats and/or on a pallet. Once the produce is on the conveyor, the method advances to step **716** where tracking data is entered. Tracking data can include a source ID, a customer ID, harvest time and date, and/or pick-up time. Tracking data can also include, for example, the in-feed temperature (namely, the temperature of the produce to be fed into the cooling chamber), the time of data, weight of the produce and a crew ID.

[0076] FIG. **7**C illustrates possible steps in method **730** for loading the produce into the second chamber and initiating pre-cooling. At step **732**, the fan speed and level of refrigeration are reduced, and the method advances to step **734** where the door between the first and second chamber is opened and the baffles retracted, if present. At step **735**, it is determined whether there is enough space in the second chamber for the load, before advancing to step **736** where the produce is loaded into the second chamber and the doors between the first and second chamber, and the second and third chamber are closed (if they were open), and the baffles (if present) are deployed. Once the produce is loaded into the second chamber, the door(s) are closed and the method advances to step **738** where the fan speed and level of refrigeration are increased to initiate the pre-cooling. Step **735** can be done before step **734** in some embodiments of the method.

[0077] FIG. **7**D illustrates possible steps in method **750** for moving the produce to the third chamber once pre-cooling is complete, and preparing it for shipping. At step **752**, the produce is transferred from the second chamber to the third chamber, and the method advances to step **754** where process data is associated with the produce, and a tag identifying the process data can be attached to the produce. Once the tag is attached, the method advances to step **756** where the produce is prepared for shipping. Preparation for shipping at step **756** can include for example installing insulated covers over the produce to help maintain the temperature of the pre-cooled produce until it reaches a cold storage facility. When the produce is ready for shipping, the method advances to step **758** where the produce is placed on the transport, for example, to take the produce to a cold storage facility.

[0078] Method **700** illustrated in FIGS. **7**A through **7**D can comprise manual and/or automated steps. Conveyance of the produce between chambers can be automated, for example. Pre-cooling can also be automated. Temperature and operation of the fans and refrigeration units can be controlled automatically, for example through the use of predetermined set points and target pre-cooling rates. Automation can be implemented using an electronic user interface and a built-in maintenance scheduler.

[0079] The cooling chamber can comprise baffles. In some embodiments, the baffles can be mechanized. The baffles may need to be retracted and deployed at different times during operation of the system.

[0080] FIGS. **8**A-E illustrate a baffle system for improved air-flow within the cooling chamber of a mobile forced-air chiller. FIG. **8**A shows a cooling chamber **810**B located between first chamber **810**A and third chamber **810**C, with both inter-chamber sliding doors in an open (retracted) position. A pair of axial fans, **820**A and **820**B, are located within cooling chamber **810**B above an open mesh or grid "wall" comprising evaporative coil **845** which is part of the refrigeration system. FIG. **8**A shows a pallet **815** loaded with 5 stacks of flats positioned directly in front of evaporative coil grid **845** in chamber **810**B. FIG. **8**B shows cooling chamber **810**B with both inter-chamber sliding doors **825**A and **825**B in a closed position. FIG. **8**B also shows a lateral baffle **826**A which is hinged (or otherwise coupled) to inter-chamber sliding door **825**A so that, when inter-chamber sliding door **825**A is moved into a closed position, baffle **826**A pivots towards the pallet of flats **815** as indicated by arrow **855**. A similar baffle **826**B is deployed by closing inter-chamber door **825**B. FIG. **8**C is a plan (top) view of chamber **810**B showing baffles **826**A and **826**B that have moved (as indicated by the two small black arrows) into a deployed position when inter-chamber doors **825**A and **825**B are closed. FIGS. **8**D and **8**E show also show an upper baffle **828** positioned above loaded pallet **815**. A lower baffle (not shown) can also be used below the pallet to provide improved air-flow around the produce.

[0081] The arrows in FIGS. **8**C, **8**D and **8**E indicated how air-flow is directed around and through the stacks of flats in cooling chamber **810**B. Air exiting fans **820**A and **820**B passes over the top of the stacks of flats on pallet **815**. Then (as indicated by the shaded arrows in FIG. **8**C) the air flows down and is drawn through the two ("front") stacks that are further away from evaporative coil grid **845**, from the front and sides, and then through the back row of stacks. The air, carrying field heat from the produce, then passes through evaporative coil grid **845** and is thereby cooled. The cooled air passes into a recirculation space **865** behind evaporative coil grid **845** and then back through fans **820**A and **820**B. Baffles **826**A and **826**B provide that sufficient cooled air is drawn through the flats in the front two stacks, rather than tending to by-pass the front row of stacks in favor of a shorter path through the back row of stacks. Similarly upper baffle **828** reduces "short-circuiting" of the air through the stacks that are closer to the fans. Such a baffle system can be used to promote more efficient and/or more uniform pre-cooling of the produce.

[0082] FIG. **9** is a partial perspective view of another embodiment of a mobile forced-air chiller **900** comprising a sliding, retractable work surface **925** that can provide additional work space adjacent to preparation chamber **910**. Supports **915** allow an overhead canopy or shade cover (not shown) to be installed over work surface **925**

[0083] FIG. **10** is a perspective view of the mobile forced-air chiller **900** of FIG. **9** with retractable work surface **925** deployed, and a truck **1000** docked against mobile chiller **900**.

[0084] The apparatus and method described herein can operate with variable sized loads. Small loads generally have shorter pre-cooling times, and can be processed more quickly than in larger or less flexible pre-cooling arrangements. In some embodiments of the technology described herein, pre-cooling cycle times can be in the range 30 minutes to 70 minutes.

[0085] The mobile chiller can comprise an automated control system. The automated control system can comprise an on-board electronic processor and custom software. The automated control system can be configured to manage process data associated with the produce, as well as manage the operation of the refrigeration system, fan system and conveyor system.

[0086] Process and tracking data associated with the produce can be gathered by suitable means such as an optical (barcode) scanner, radio frequency identification tag scanner, and or manual entry via a touch screen interface. Process data

can be used to identify and associate the individual produce containers with a flat, stack and pallet. External temperature probes can measure and record the temperature of the produce entering the cooling chamber region. Scales can be situated at the entrance to and exit from the cooling chamber to measure the weight of produce entering and leaving the cooling chamber. The weight loss during pre-cooling can be determined from the measurements.

[0087] Temperature sensors in the cooling chamber can be used to monitor the temperature of the chamber during pre-cooling. Timers can be used to determine the time taken to achieve the desired pre-cooling of the produce. Exit temperature probes can measure and record produce exit temperatures. The temperature measurement data described above can be recorded and associated with each load. The information can be electronically transferred to a central location via wireless communication or direct connection. The information can also be printed out and attached by means of a tag or label to the pallets or flats.

[0088] An automated control system can automate the movement of the produce through the three chambers of the mobile chiller. A conveyor generally spans all three chambers. In the preparation chamber, an operator can build a stack or a pallet directly on the conveyor, and input the desired tracking data. Once the preparation is complete, the operator can initiate the pre-cooling cycle by pressing a button. At this point, the operator can push the stack or pallet into the cooling chamber. If the system is a manual system, and the cooling chamber is already occupied by pre-cooled produce, then the action of pushing the stack or pallet into the cooling chamber can be configured to cause a pallet or one or more stacks that are in the cooling chamber to be pushed into the shipping chamber. If the system is an automated system, the inter-chamber doors can open and cause baffles to retract. An automated conveyor can convey the warm produce into the cooling chamber while delivering pre-cooled produce already in the cooling chamber into the shipping chamber. The inter-chamber doors can close and deploy baffles in the cooling chamber.

[0089] During pre-cooling of the produce, the automated control system can monitor the temperature at various locations within the cooling chamber. Measurements can be taken, for example, in the air stream upstream of the pallet or stack, between the pallet and the evaporator coil, and/or at the exit of the evaporator coil. Once a predefined temperature or temperature differential is reached, or a predetermined period of time has elapsed, the pre-cooling is complete and the produce is ready to be removed from the cooling chamber. At this time, if the operator is ready, the pallet or stack can be released for further processing. Alternatively, the system can automatically de-power the pre-cooling system to a holding temperature and fan speed that requires less power and is less damaging to the produce.

[0090] The automated control system can comprise an internal maintenance scheduler that, after a certain period of operation, can automatically prompt the operator for various mechanical servicing. If the automated control system comprises a remote communication package, then a signal can be sent by wireless transmission to the fleet operator of the mobile chiller to indicate the unit may require servicing, maintenance or remote trouble-shooting, for example.

[0091] While particular elements, embodiments and applications of the present invention have been shown and described, it will be understood, that the invention is not limited thereto since modifications can be made by those skilled in the art without departing from the scope of the present disclosure, particularly in light of the foregoing teachings.

What is claimed is:

1. An integrated mobile apparatus for pre-cooling produce, the apparatus comprising:

(a) a transportable platform;

(b) a preparation chamber mounted on said platform for receiving and arranging a quantity of produce on a movable carrier;

(c) a cooling chamber mounted on said platform for receiving said quantity of produce on said movable carrier from said preparation chamber, said cooling chamber comprising:

(1) a refrigeration surface;

(2) a circulation system for directing a chilling fluid between said refrigeration surface and said quantity of produce on said movable carrier;

(d) a shipping chamber mounted on said platform for receiving said quantity of produce on said movable carrier from said cooling chamber, said shipping chamber having an opening for facilitating unloading of said quantity of produce.

2. The apparatus of claim **1**, wherein said preparation chamber, said cooling chamber and said shipping chamber are housed in a single enclosure.

3. The apparatus of claim **1**, wherein said preparation chamber, said cooling chamber and said shipping chamber are arranged linearly, said cooling chamber being interposed between said preparation chamber and said shipping chamber.

4. The apparatus of claim **1**, wherein said platform has wheels mounted on a lower surface thereof for facilitating transportation of said apparatus from one location to another.

5. The apparatus of claim **1**, wherein said apparatus comprises inter-chamber doors for separating said cooling chamber from said preparation chamber and said shipping chamber.

6. The apparatus of claim **1**, wherein said apparatus comprises a conveyer mechanism for facilitating conveyance of said movable carrier between said chambers.

7. The apparatus of claim **6**, wherein said conveyor mechanism comprises gravity rollers, whereby said movable carrier is conveyed between chambers on said rollers at least partially by action of gravity.

8. The apparatus of claim **6**, wherein said conveyor mechanism comprises mechanized rollers, whereby said movable carrier is conveyed between chambers on said rollers by at least one of pneumatic, hydraulic and electromechanical power.

9. The apparatus of claim **6**, wherein said conveyor mechanism comprises at least one belt, whereby said movable carrier is conveyed between chambers on said at least one belt.

10. The apparatus of claim **1**, wherein said movable carrier comprises one of (i) a pallet on which said quantity of produce is carried and (ii) a plurality of stacked flats in which said quantity of produce is carried.

11. The apparatus of claim **1**, wherein said refrigeration surface comprises at least one evaporative coil.

12. The apparatus of claim **11**, wherein said at least one evaporative coil extends from an on-board refrigeration unit.

13. The apparatus of claim **12**, wherein said on-board refrigeration unit is powered by an onboard or trailer mounted generator.

14. The apparatus of claim **1**, wherein said circulation system comprises at least one fan.

15. The apparatus of claim **1**, wherein said chilling fluid is air.

16. The apparatus of claim **1**, wherein said cooling chamber comprises baffles for improving flow of said chilling fluid around said quantity of produce.

17. The apparatus of claim **16**, wherein said baffles are retractable.

18. The apparatus of claim **17**, wherein said apparatus further comprises inter-chamber doors for separating said cooling chamber from said preparation chamber and said shipping chamber, and said retractable baffles provide are movably coupled to said inter-chamber doors.

19. The apparatus of claim **18**, wherein opening and closing of said inter-chamber doors actuates said baffles.

20. The apparatus of claim **19**, wherein, when said doors are closed, said baffles are deployed to rest against said movable carrier in said cooling chamber, and when the doors are opened, said baffles retract clear of said movable carrier.

21. The apparatus of claim **1**, wherein said apparatus comprises a control system capable of depowering said circulation system to a low power state to conserve power and maintain temperature of said quantity of produce within a desired range.

22. A method of pre-cooling a quantity of produce in an integrated mobile apparatus comprising a transportable platform having mounted thereon a preparation chamber, a cooling chamber and a shipping chamber, said cooling chamber comprising a refrigeration surface and a circulation system for directing a chilling fluid between said refrigeration surface and said quantity of produce, said method comprising:

(a) arranging said quantity of produce on a movable carrier located within said preparation chamber;

(b) conveying said movable carrier from said preparation chamber to said cooling chamber;

(c) cooling said quantity of produce in said cooling chamber;

(d) conveying said cooled quantity of produce to said shipping chamber;

(e) unloading said quantity of produce from said shipping chamber.

23. The method of claim **22**, wherein said preparation chamber, said cooling chamber and said shipping chamber are housed in a single enclosure.

24. The method of claim **22**, wherein said cooling chamber is interposed between said preparation chamber and said shipping chamber, and wherein the produce is conveyed substantially linearly through said integrated mobile apparatus as the steps of said method are performed.

25. The method of claim **22**, wherein said preparation step (a) further comprises labeling of said quantity of produce with tracking data.

26. The method of claim **25**, wherein said tracking data comprises at least one of source identification, purchaser identification, harvest date and time, pick-up date and time, in-feed temperature, weight of said quantity of produce, and crew identification.

27. The method of claim **22**, wherein said cooling step (c) further comprises sensing a temperature of said quantity of produce such that said cooling is terminated when said temperature reaches a predetermined temperature.

* * * * *