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(54) Titre : APPAREIL A CHAMBRE A VIDE AVEC NETTOYEUR DE CONVOYEUR A COURROIE
(54) Title: VACUUM CHAMBER APPARATUS WITH CONVEYOR BELT WASHER

(57) Abrégé/Abstract:
A continuous-throughput vacuum chamber apparatus (20), in which the organic material to be treated in the vacuum chamber (34) is carried directly on the conveyor belt (54), has a cleaning station (86) for cleaning the conveyor belt as the belt moves. The cleaning station is external to the vacuum chamber, avoiding contamination of the vacuum chamber by removed material residues or cleaning preparations, and permitting a more thorough cleaning than if the cleaning station were inside the chamber. The invention reduces the need to shut down the vacuum chamber apparatus for cleaning and also makes it possible to monitor the status of contamination of the conveyor belt from the outside of the vacuum chamber. The apparatus (20) may be a vacuum microwave dehydrator.

Abstract

A continuous-throughput vacuum chamber apparatus (20), in which the organic material to be treated in the vacuum chamber (34) is carried directly on the conveyor belt (54), has a cleaning station (86) for cleaning the conveyor belt as the belt moves. The cleaning station is external to the vacuum chamber, avoiding contamination of the vacuum chamber by removed material residues or cleaning preparations, and permitting a more thorough cleaning than if the cleaning station were inside the chamber. The invention reduces the need to shut down the vacuum chamber apparatus for cleaning and also makes it possible to monitor the status of contamination of the conveyor belt from the outside of the vacuum chamber. The apparatus (20) may be a vacuum microwave dehydrator.

VACUUM CHAMBER APPARATUS WITH CONVEYOR BELT WASHER

Field of the Invention

The invention pertains to apparatuses and methods for the treatment of organic materials such as food products in a vacuum chamber of the type in which the organic materials are transported through the vacuum chamber on a conveyor belt.

Background of the Invention

Treatment of organic materials in a vacuum chamber is a known process in the processing of food products and biologically-active materials. An example of such treatment is dehydration, which is usually done in order to preserve the products for storage, or to create a product that is used in the dehydrated form, such as dried herbs and various kinds of chips. Vacuum microwave dehydration is an effective method of dehydration. Examples in the patent literature include WO 2011/085467 A1, Fu et al., published July 21, 2011; WO 2013/010257 A1, Fu et al., published January 24, 2013; and WO 2014/085879 A1, Durance et al., published June 12, 2014. Vacuum microwave-drying is a rapid method that can yield products with improved quality compared to air-dried and freeze-dried products. Because the drying is done under reduced pressure, the boiling point of water and the oxygen content of the atmosphere are lowered, so components sensitive to oxidation and thermal degradation, such as some food and medicinal components, can be retained to a higher degree than by air-drying.

In machines for the treatment of organic materials in a vacuum chamber, including vacuum microwave dehydration, where the process is a continuous-throughput rather than a batch process, the material being treated is typically carried through the vacuum chamber using a conveyor belt. In one type of these machines, the organic material is carried directly on the belt, causing the belt to become contaminated with product residues and require periodic cleaning. This necessitates shutting down the machine and opening up its interior for maintenance access. Production time is lost, and the labour cost of doing the maintenance is incurred. This problem is reduced to some extent in machines which employ containers such as trays to carry the material on the conveyor belt, protecting it from contamination. However, in this container-type prior art machine,

the loaded containers have to be moved in and out of the vacuum chamber, typically through an airlock chamber with two movable doors, and the cycle time required to move them through the vacuum locks is a limitation on the production capacity of the machine. It limits the maximum microwave power and processing speed that can be employed.

The present invention is directed to an improved apparatus which reduces these disadvantages of conventional vacuum chamber machines.

Summary of the Invention

The invention provides a continuous-throughput vacuum chamber apparatus in which the organic material to be treated in the chamber is carried directly on the conveyor belt, avoiding the production limitations of the container-type machines. The apparatus has a cleaning station for cleaning the conveyor belt as the machine operates, reducing the need to shut down the machine for cleaning. The cleaning station is external to the vacuum chamber, avoiding contamination of the chamber by removed material residues or cleaning preparations, and permitting a more thorough cleaning than if the cleaning station were inside the chamber. The apparatus also makes it possible to monitor the status of contamination of the conveyor belt from the outside of the vacuum chamber.

One aspect of the invention provides apparatus for treatment of organic material, comprising: a vacuum chamber for operation at a pressure less than atmospheric; means for producing treatment conditions, such as microwave radiation, within the vacuum chamber; means for continuous loading of the organic material into the vacuum chamber; a conveyor belt for transporting the organic material through the vacuum chamber, the conveyor belt forming a closed loop and extending outside of the vacuum chamber such that one part of the conveyor belt is inside the vacuum chamber and another part is outside the vacuum chamber; means for continuous unloading of the treated organic material from the vacuum chamber; and means for cleaning the conveyor belt during operation of the apparatus, located outside the vacuum chamber.

Another aspect of the invention provides a method for treatment of organic material in a vacuum chamber, comprising the steps of: loading the organic material

continuously onto a conveyor belt inside the vacuum chamber, the vacuum chamber being at a pressure less than atmospheric, the conveyor belt forming a closed loop, one part of the conveyor belt being inside the vacuum chamber and another part being outside of the vacuum chamber; moving the organic material through the vacuum chamber on the conveyor belt; treating the organic material on the moving conveyor belt by exposing it to conditions within the vacuum chamber, such as microwave radiation; unloading the treated organic material continuously from the vacuum chamber; and cleaning the moving conveyor belt at a location outside the vacuum chamber.

Further aspects of the invention and features of specific embodiments of the invention are described below.

Brief Description of the Drawings

Figure 1 is a partly cutaway view of a dehydration apparatus according to one embodiment of the invention.

Figure 2 is an isometric view of the apparatus of Figure 1.

Figures 3A and 3B are sectional views of the conveyor belt inlet and outlet, respectively, of the vacuum chamber.

Figure 3C is a schematic view of the belt washer of the dehydration apparatus.

Figure 4 is an elevational view, partly broken away, of the input end of the apparatus of Figure 1.

Figure 5 is a schematic view of the apparatus of Figure 1.

Figure 6 is a schematic view of a pasteurization apparatus according to another embodiment of the invention.

Detailed Description

Referring first to Figures 1 to 4, in one embodiment, the treatment apparatus of the invention is a vacuum-microwave dehydration apparatus **20**. This comprises a processing unit **22**, in which organic material is vacuum microwave-dried, having

an input end **24** and an output end **26**, with an input module **28** at the input end and an output module **30** at the output end. The input module **28** has a housing **60**, fastened and sealed to the input end **24** of the processing unit **22**. Similarly, the output module **30** includes a housing **62** fastened and sealed to the output end **26** of the processing unit. The processing unit **22** and modules **28**, **30** are supported on a frame **32** with legs.

A vacuum chamber **34** extends the length of the processing unit **22** and the interior of the input and output modules **28**, **30**. Microwave-transparent windows **36**, separated by short panel sections **38**, form the bottom wall of the processing unit portion **22** of the vacuum chamber **34**. The vacuum chamber has a cover **40** and side walls **42**. Microwave chamber modules **44** are arranged below the windows **36**, each module **44** having a microwave generator **46** and a microwave chamber **48**. Each microwave chamber has side walls **50** and a floor **52**, with one of the microwave-transparent windows **36** forming the upper wall of each microwave chamber, separating it from the vacuum chamber **34**. The microwave chambers **48** are not sealed from the atmosphere and are thus air-filled and at atmospheric pressure.

A microwave-transparent conveyor belt **54** for transporting the organic material through the vacuum chamber extends along the windows **36**. The conveyor belt extends into the input and output modules **28**, **30**, and forms a continuous loop. The belt **54** runs over a roller **56** in the input module and over a roller **58** in the output module **30**. The belt **52** is driven by a power-driven roller **90** that engages the belt **52** in the belt-washer, as described below.

The input module **28** has a rotary vacuum valve **64** for feeding the organic material to be dried into the processing unit. The valve **64** is motor-driven and permits the continuous feeding of the material from a hopper **66**, at atmospheric pressure, into the interior of the vacuum chamber, at reduced pressure. Material passing through the valve **64** falls through a chute **68** onto a motor-driven spreader **70**, which is arranged to distribute the material across the conveyor belt **54**.

The output module **30** has a motor-driven rotary vacuum valve **72**, for continuous removal of the dried material from the vacuum chamber. The rotary vacuum valve **72** is arranged below an outlet chute **74** such that dried material dropping off the

end of the conveyor belt **54** as the belt passes around the roller **58** drops into the chute **74** and is gravity-fed into the rotary vacuum valve **72** for release from the apparatus into a container at atmospheric pressure.

Apertures **78**, **82** for airtight passage of the conveyor belt **54** are provided in the output and input modules respectively, whereby a portion **54A** of the continuous loop formed by the conveyor belt is inside the vacuum chamber and a portion **54B** is outside it, at atmospheric pressure. The portion **54B** of the conveyor belt outside the vacuum chamber is supported by rollers **84** on the frame **32** underneath the microwave chamber modules **44**.

As seen in Figure 3B, a vacuum seal **76** is fitted in the aperture **78** in the housing **62** of the output module **30**. After the dried material is dropped from the conveyor belt **54** into the outlet chute, the conveyor belt passes out of the vacuum chamber through the vacuum seal **76**. Likewise, as shown in Figure 3A, a vacuum seal **80** is fitted in the aperture **82** in the housing **60** of the input module **28**, and the conveyor belt passes back into the vacuum chamber **34** through this vacuum seal. The seals **76**, **80** thus permit passage of the conveyor belt out of and back into the vacuum chamber **34** without loss of the vacuum pressure inside the vacuum chamber. The seals **76**, **80** may be solid or inflatable silicon rubber seals, for example as marketed by The Rubber Company. The material of the conveyor belt **54** may be Teflon-coated fiberglass, which minimizes friction with the seals **76**, **80**.

Referring to Figure 3C, a belt washer **86** is attached to the frame **32** outside the vacuum chamber **34**. It is arranged below the vacuum chamber for cleaning of the conveyor belt **54** after it exits the vacuum chamber through the aperture **78** in the output module **34** and before it re-enters through the aperture **82** in the input module **28**. The belt washer has a housing **88** having a cleaning fluid drain **89**, a power-driven roller **90** around which the belt passes, and two power-driven brushes **92**, **94** positioned to brush against each respective side of the belt. A sprayer **96** is arranged to spray a cleaning solution onto the belt as it passes against the brushes. By means of the belt washer **86**, the conveyor belt is cleaned, at atmospheric pressure, after each traverse through the vacuum chamber **34**.

The dehydrating apparatus **20** includes the components conventionally required for the operation of vacuum microwave driers. As illustrated schematically in Figure 5, a vacuum pump **98** is operatively connected through a condenser **100** and via a vacuum distributor **102** to vacuum ports **108** in the vacuum chamber and the input and output modules. The condenser condenses water vapor produced during dehydration of the organic material. A refrigeration unit **104**, comprising a compressor, cooling fan and refrigerant pump, conveys refrigerant to the condenser **100** to maintain the condenser at a desired temperature. A water load system **106** may be provided in the vacuum chamber to absorb extra microwave energy, by means of a water pump and conventional piping within the vacuum chamber. The dehydration apparatus **20** includes a programmable logic controller (PLC) **110**, programmed and connected to control the operation of the system, including controlling the drive motors, the microwave generators, the vacuum pump, the refrigerant pump and the belt washer.

The dehydrating apparatus **20** operates according to the following method. The vacuum pump, refrigerant pump, water pump, microwave generators and the motors to drive the conveyor belt and the rotary vacuum valves are actuated, all under the control of the PLC. The vacuum chamber is brought to reduced pressure. Operating pressures may be in the range, for example, of about 30 to 300 Torr (3.9 to 39.9 kPa), or 0.1 to 30 Torr (0.13 to 4.0 kPa). The organic material, in pieces small enough to be fed through the rotary vacuum valves, is fed into the hopper. Within the vacuum chamber **34**, the material is dehydrated by the radiation from the microwave generators that passes through the windows **36**. The conveyor belt **54** is operated at such speed, and the generators **44** at such power level, that the organic material is dehydrated to the desired moisture level during its traverse through the vacuum chamber. The dried material falls into the outlet chute **74** and is collected outside the unit from the rotating outlet valve **72**. The conveyor belt is washed continuously by the belt washer **86**, after each traverse of the vacuum chamber.

Examples of materials suitable for dehydration by the apparatus **20** include fruit, either frozen or un-frozen, including banana, mango, papaya, pineapple, melon, apples, pears, cherries, berries, peaches, apricots, plums, grapes, oranges, lemons, grapefruit; vegetables, either fresh or frozen, including peas, beans, corn,

carrots, tomatoes, peppers, herbs, potatoes, beets, turnips, squash, onions, garlic; cannabis; pre-cooked grains including rice, oats, wheat, barley, corn, flaxseed; hydrocolloid solutions or suspensions, vegetable gums; vaccines, enzymes, protein isolates; amino acids; injectable drugs, pharmaceutical drugs, natural medicinal compounds, antibiotics, antibodies; composite materials in which a hydrocolloid or gum surrounds and encapsulates a droplet or particle of a relatively less stable material as a means of protecting and stabilizing the less sensitive material; meats, fish and seafoods, either fresh or frozen, and dairy products such as cheese, whey proteins isolates and yogurt.

The inventive arrangement of a conveyor belt washer that is external to a continuous-throughput vacuum chamber also applies to processes in which the organic material is processed in a vacuum chamber by a treatment other than dehydration, for example by heating or pasteurization. Figure 6 schematically illustrates a pasteurization apparatus **200** for the pasteurization of solid food products using microwave radiation and steam for heating. The apparatus **200** is substantially the same as the dehydration apparatus **20**, but includes a steam conduit **202** connected to a source of steam **204**, for feeding steam into the vacuum chamber **34**. A pressure sensor **206** controls the operation of a steam supply valve **208**, to add steam into the vacuum chamber if the pressure drops below a set level. Heating of the material in the vacuum chamber to pasteurize it is done by means of both the steam and the microwave radiation from the microwave generators **46**, under the control of the PLC **110**. The apparatus is otherwise the same as the dehydration apparatus **20**, and is operated in the same manner.

Example 1

Blanched onion rings were processed in a vacuum microwave dehydration apparatus of the type illustrated in Figures 1 to 5. The initial moisture content was 88 wt.%. Processing was done at a microwave power level of 80 kW and a vacuum pressure of 32 Torr. After 25 minutes of processing, the output product had a moisture content of 84 wt.% and a temperature of 28 degrees C. The conveyor belt was continuously cleaned by the belt washer.

Example 2

Pre-dried blueberries having an initial moisture content of 40 wt.% were processed in a vacuum microwave dehydration apparatus of the type illustrated in Figures 1 to 5. Processing was done at a microwave power level of 100 kW and a vacuum pressure of 32 Torr. After 35 minutes of processing, the output product had a moisture content of 3 wt.% and a temperature of 75 degrees C. The conveyor belt was continuously cleaned by the belt washer.

Throughout the foregoing description and the drawings, in which corresponding and like parts are identified by the same reference characters, specific details have been set forth in order to provide a more thorough understanding to persons skilled in the art. However, well known elements may not have been shown or described in detail or at all to avoid unnecessarily obscuring the disclosure. Accordingly, the description and drawings are to be regarded in an illustrative, rather than a restrictive, sense.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the scope thereof. Some examples include the following:

- The belt washer can take many forms, and include additional types of cleaning, such as irradiation.
- The belt washer can be operated intermittently, depending upon the material being treated and the needs of a particular application.
- Piston vacuum valves can be used as the airlock valves instead of rotary vacuum valves.
- The conveyor belt can pass over the vacuum chamber, rather than under it, after exiting the vacuum chamber.
- The microwave generators and window can be above rather than below the vacuum chamber, or both above and below, or the microwave generators can be inside the vacuum chamber.
- The processing unit can include any desired and practical number of modules, including a single module.
- Each microwave chamber module may hold two or more microwave generators rather than only one.

- The means for reducing the pressure in the vacuum chamber can include any means for applying a vacuum to the vacuum chamber, such as connection to the central vacuum system of a plant.

Accordingly, the scope of the invention is to be construed in accordance with the following claims.

Claims

1. An apparatus (20, 200) for treatment of organic material, comprising:

(a) a vacuum chamber (34) for operation at a pressure less than atmospheric;

(b) means (46) for producing treatment conditions within the vacuum chamber;

(c) means (28) for continuous loading of the organic material into the vacuum chamber;

(d) a conveyor belt (54) for transporting the organic material through the vacuum chamber, the conveyor belt forming a closed loop, the conveyor belt extending outside of the vacuum chamber such that a first portion (54A) of the conveyor belt is inside the vacuum chamber and a second portion (54B) of the conveyor belt is outside the vacuum chamber;

(e) means (30) for continuous unloading of the treated organic material from the vacuum chamber; and

(f) means (86) for cleaning the conveyor belt during operation of the apparatus, the means for cleaning being located outside the vacuum chamber.

2. An apparatus for treatment of organic material, comprising:

(a) a vacuum chamber for operation at a pressure less than atmospheric;

(b) a microwave generator for producing treatment conditions within the vacuum chamber;

(c) an inlet for continuous loading of the organic material into the vacuum chamber;

(d) a conveyor belt for transporting the organic material through the vacuum chamber, the conveyor belt forming a closed loop, the conveyor belt extending

outside of the vacuum chamber such that a first portion of the conveyor belt is inside the vacuum chamber and a second portion of the conveyor belt is outside the vacuum chamber;

(e) an outlet for continuous unloading of the treated organic material from the vacuum chamber; and

(f) a belt cleaner for cleaning the conveyor belt during operation of the apparatus, the belt cleaner being located outside the vacuum chamber.

3. An apparatus (20, 200) for treatment of organic material, comprising:

(a) a vacuum chamber (34) for operation at a pressure less than atmospheric, the vacuum chamber having an input end (24) for introduction of the organic material into the vacuum chamber and an output end (26) for removal of the organic material;

(b) means (46) for producing treatment conditions within the vacuum chamber;

(c) means (28) for continuous loading of the organic material into the vacuum chamber at its input end;

(d) a conveyor belt (54) for transporting the organic material through the vacuum chamber from the input end to the output end thereof, the conveyor belt forming a closed loop, the conveyor belt extending through a wall of the vacuum chamber such that a first portion (54A) of the conveyor belt is inside the vacuum chamber and a second portion (54B) of the conveyor belt is outside the vacuum chamber;

(e) means (30) for continuously unloading the organic material from the vacuum chamber at its output end;

(f) means (76, 80) for sealing the wall of the vacuum chamber between the first portion of the conveyor belt and the second portion of the conveyor belt; and

(g) means (86) for washing the conveyor belt located outside the vacuum chamber.

4. An apparatus (20) according to claim 1, wherein the treatment is dehydration, and the means for producing treatment conditions comprises a microwave generator (46) arranged to irradiate the organic material on the conveyor belt inside the vacuum chamber.

5. An apparatus (200) according to claim 1, wherein the treatment is pasteurization, and the means for producing treatment conditions comprises a microwave generator (46) arranged to irradiate the organic material on the conveyor belt inside the vacuum chamber and means (202, 204, 208) for feeding steam into the vacuum chamber.

6. An apparatus (20, 200) according to claim 3, wherein the means for sealing the wall of the vacuum chamber comprises vacuum seals (76, 80) arranged between the first portion of the conveyor belt and the second portion of the conveyor belt.

7. An apparatus (20) for dehydrating organic material, comprising:

(a) a vacuum chamber (34) having an input end (24) for introduction of the organic material and an output end (26) for removal of the organic material;

(b) means (98) for reducing pressure inside the vacuum chamber;

(c) means (46) for radiating microwaves into the vacuum chamber;

(d) means (28) for loading of the organic material into the vacuum chamber;

(e) a conveyor belt (54) for transporting the organic material through the vacuum chamber from the input end to the output end, the conveyor belt forming a closed loop, the conveyor belt extending through a wall of the vacuum chamber such that a first portion (54A) of the conveyor belt is inside the vacuum chamber and a second portion (54B) of the conveyor belt is outside the vacuum chamber;

(f) means (30) for continuously unloading the organic material from the vacuum chamber at its output end;

(g) means (76, 80) for sealing the wall of the vacuum chamber between the first portion of the conveyor belt and the second portion of the conveyor belt; and

(h) means (86) for washing the conveyor belt located outside the vacuum chamber.

8. An apparatus according to claim 1, wherein the means for washing comprises brushes (92, 94) arranged to clean both sides of the conveyor belt

9. A method for treatment of organic material in a vacuum chamber, comprising the steps of:

(a) loading the organic material continuously onto a conveyor belt (54) inside the vacuum chamber, the vacuum chamber being at a pressure less than atmospheric, the conveyor belt forming a closed loop, a first portion (54A) of the conveyor belt being inside the vacuum chamber and a second portion (54B) of the conveyor belt being outside the vacuum chamber;

(b) moving the organic material through the vacuum chamber on the conveyor belt;

(c) treating the organic material on the moving conveyor belt by exposing it to conditions within the vacuum chamber;

(d) unloading the treated organic material continuously from the vacuum chamber; and

(e) cleaning the moving conveyor belt at a location outside the vacuum chamber.

10. A method for treatment of organic material in a vacuum chamber (34), comprising the steps of:

(a) loading the organic material continuously onto a conveyor belt (54) inside the vacuum chamber, the vacuum chamber being at a pressure less than atmospheric, the conveyor belt forming a closed loop, a first portion (54A) of the conveyor belt being inside the vacuum chamber and a second portion (54B) of the conveyor belt being outside the vacuum chamber;

(b) moving the organic material through the vacuum chamber from an input end (24) of the vacuum chamber to an output end (26) thereof on the conveyor

belt;

(c) treating the organic material on the conveyor belt by exposing it to conditions within the vacuum chamber;

(d) unloading the organic material continuously from the vacuum chamber at the output end thereof; and

(e) cleaning the moving conveyor belt at a location outside the vacuum chamber.

11. A method according to claim 9, wherein the treatment is dehydration and the step of treating the organic material comprises irradiating it with microwave radiation.

12. A method according to claim 9, wherein the treatment is pasteurization and the step of treating the organic material comprises irradiating it with microwave radiation and exposing it to steam.

13. A method of cleaning a conveyor belt (54) that transports organic material through a vacuum chamber (34), the vacuum chamber being at a pressure less than atmospheric, the conveyor belt forming a closed loop, a first portion (54A) of the conveyor belt being inside the vacuum chamber and a second portion (54B) of the conveyor belt being outside the vacuum chamber, comprising the steps of:

(a) operating the conveyor belt for continuous movement; and

(b) cleaning the second portion of the moving conveyor belt.

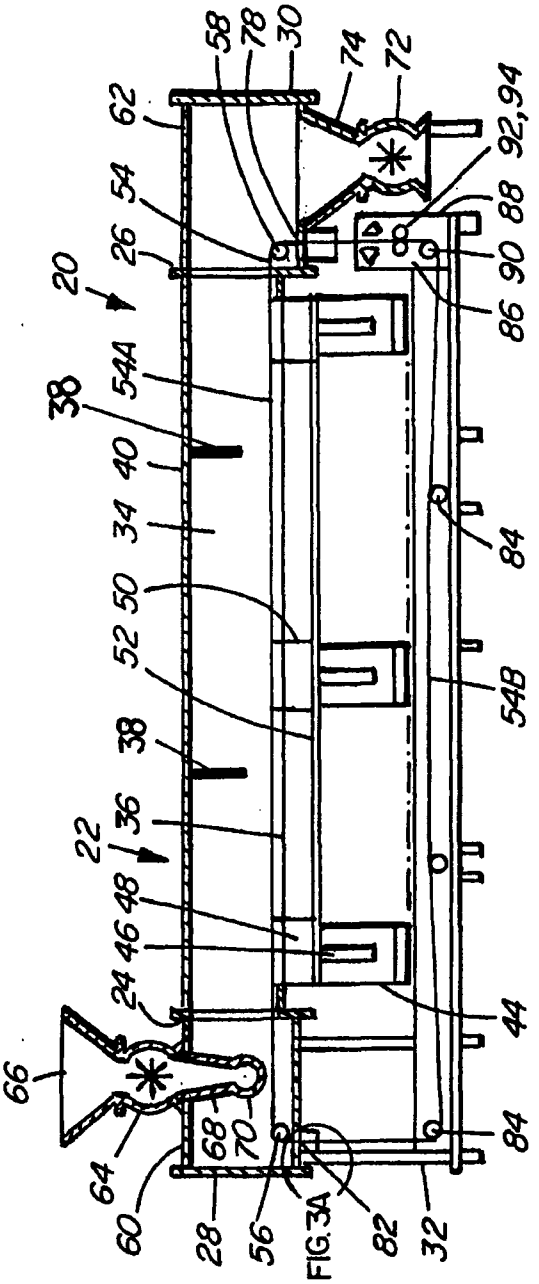

58
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FIG. 3A

FIG. 1

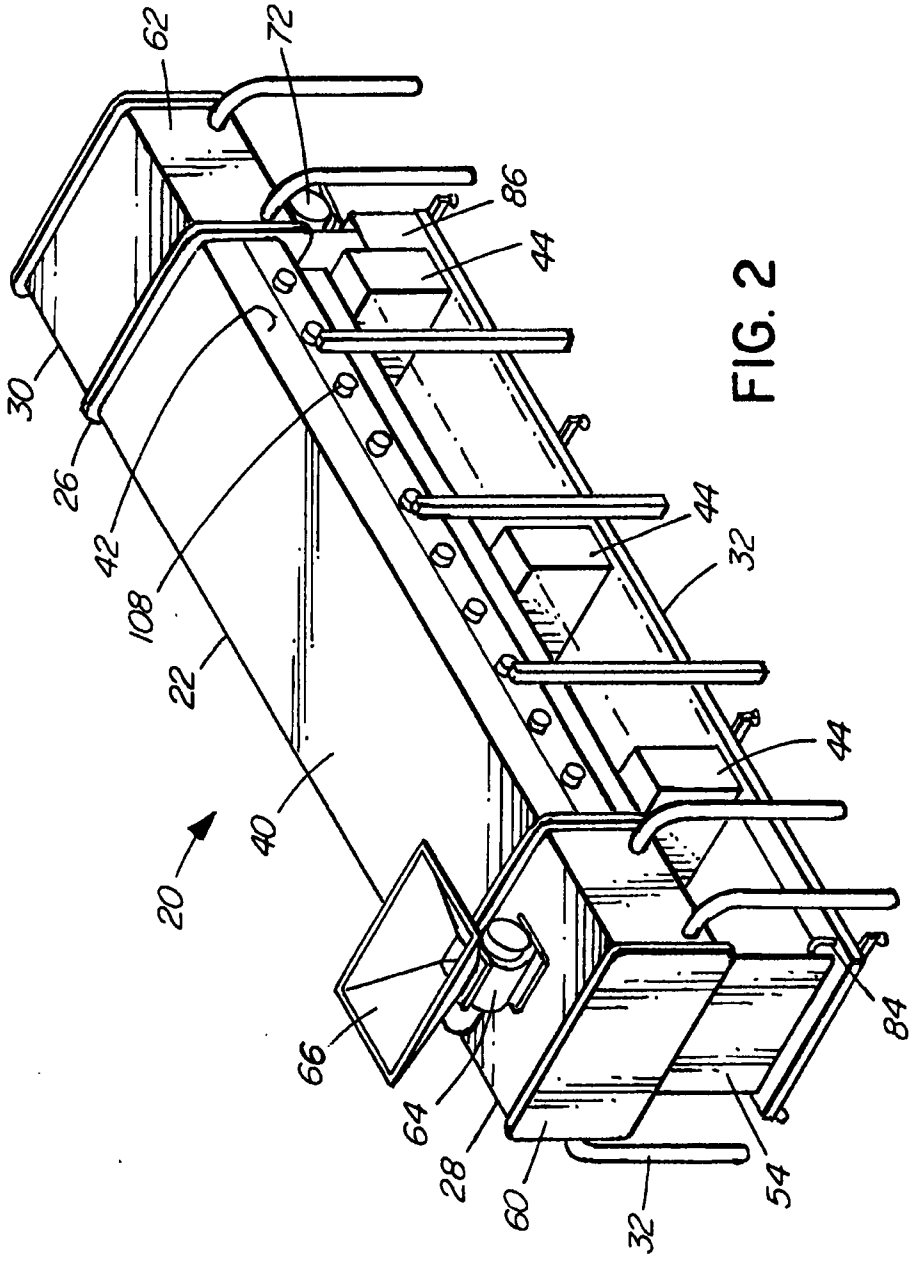


FIG. 2

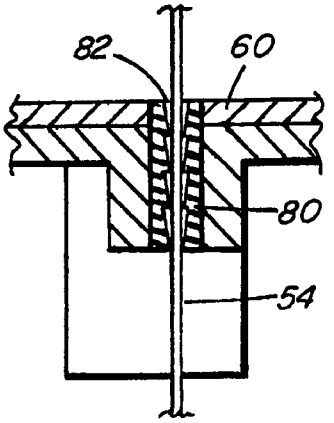


FIG. 3A

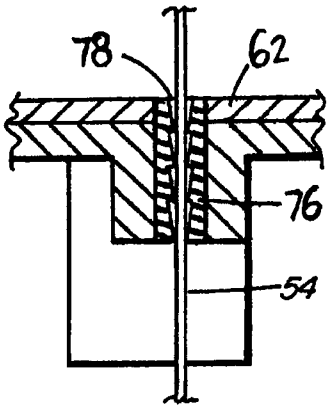


FIG. 3B

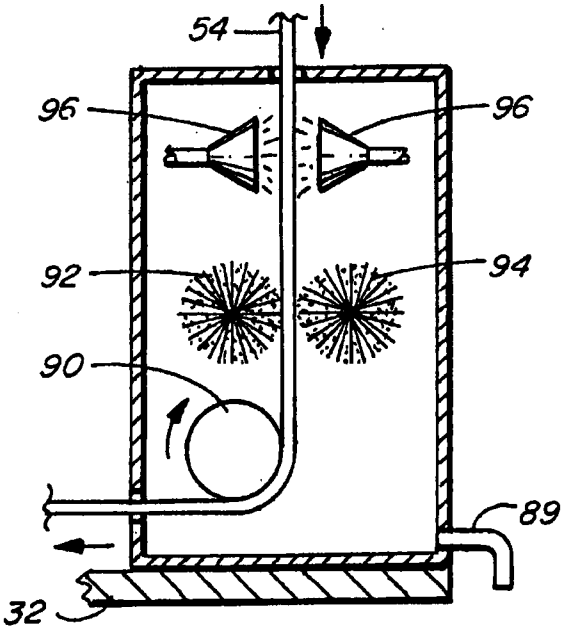


FIG. 3C

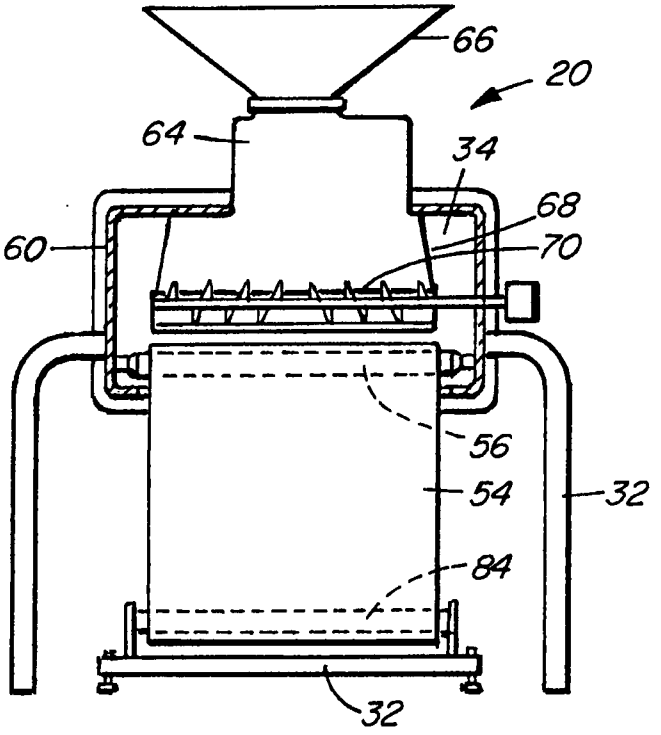


FIG. 4

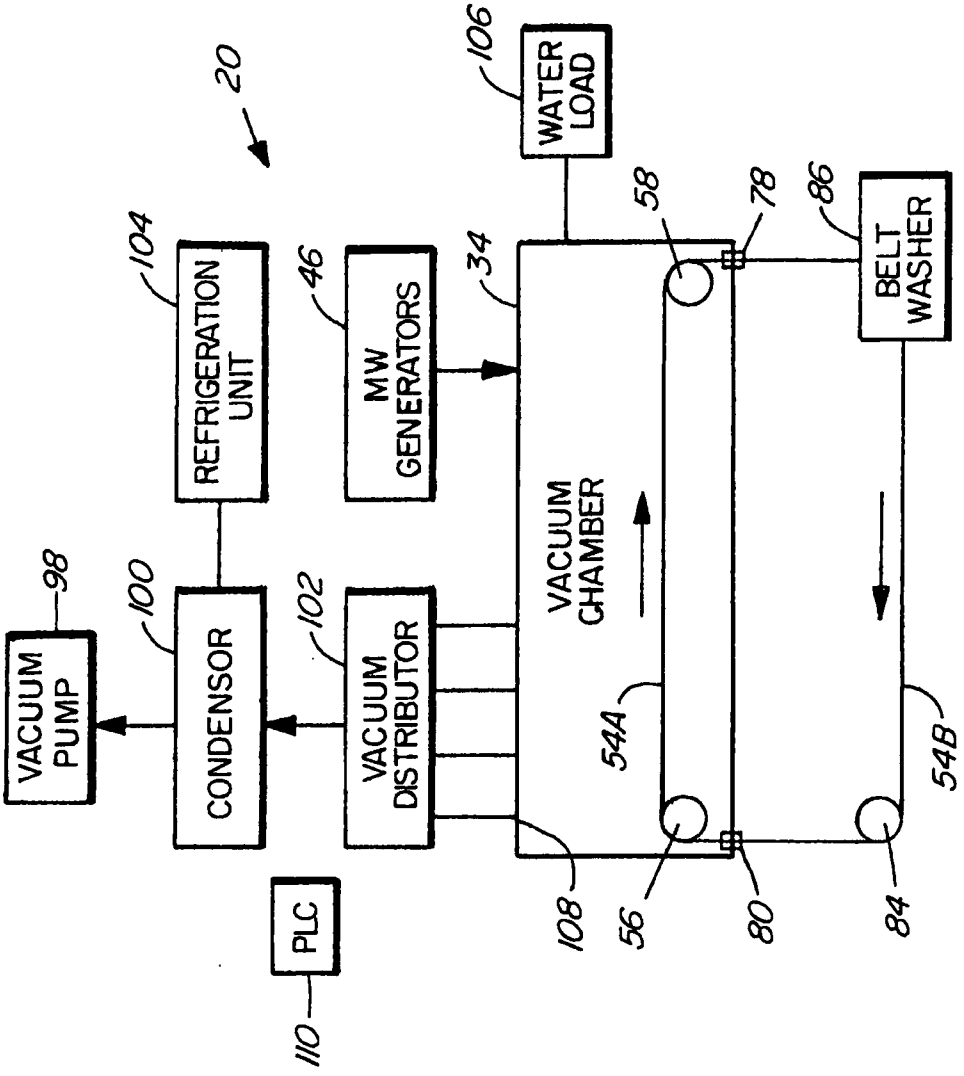

20
106
WATER LOAD
104
REFRIGERATION UNIT
46
MW GENERATORS
34
58
78
86
BELT WASHER
VACUUM CHAMBER
98
100
102
VACUUM PUMP
CONDENSOR
VACUUM DISTRIBUTOR
544
548
108
56
80
84
PLC
110

FIG. 5

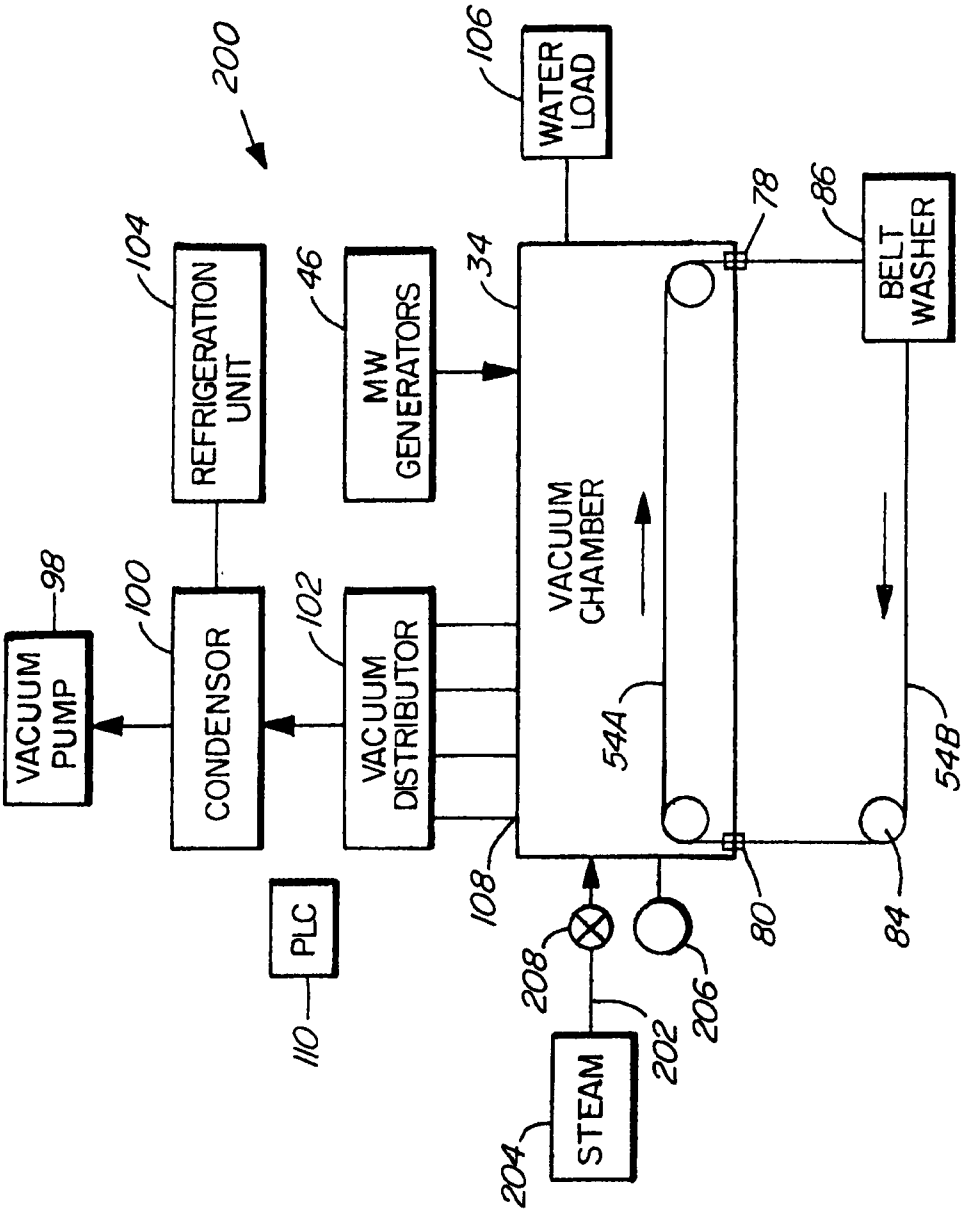

200
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CONDENSOR
VACUUM DISTRIBUTOR
VACUUM CHAMBER
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202
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STEAM

FIG. 6