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(71) Applicant (for all designated States except US): **HERCO KÜHLTECHNIK HERMANN & CO. GMBH** [DE/DE]; Rudolf-Diesel-Str. 28, 46485 Wesel (DE).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **FOULKE, Guy, L.** [US/US]; 21 Spindle Lane, Hilton Head Island, SC 29926 (US).

(74) Agent: **MANITZ, FINSTERWALD & PARTNER GBR**; Postfach 31 02 20, 80102 München (DE).

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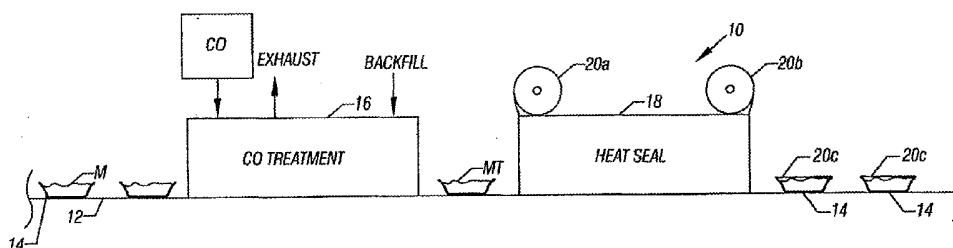
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(54) Title: A METHOD FOR THE TREATMENT OF FRESH MEAT



(57) Abstract: A method for the treatment of fresh meat in intermediate storage is described comprising the steps of storing the fresh meat for a predetermined time in a chamber closable in an air-tight manner, thereby building an atmosphere containing between 0.1% and 10% carbon monoxide (CO) within the closed chamber, increasing the pressure within the closed chamber to a pressure which lies more than 1.1 bar above the atmospheric pressure, replacing the atmosphere containing carbon monoxide and surrounding the fresh meat with an atmosphere of gas or a gas mixture containing no carbon monoxide, and equilibrating the pressure of the atmosphere surrounding the fresh meat to that of the atmospheric pressure. In addition an apparatus for carrying out the method is described. The apparatus comprises an inlet chamber, a main chamber and an outlet chamber which are arranged one after the other, wherein the inlet chamber is connected to the main chamber through an air-tightly sealable opening and the main chamber is connected to the outlet chamber through an air-tightly sealable opening, wherein the inlet chamber comprises an air-tightly sealable inlet opening for supplying pieces of fresh meat to the inlet chamber, and wherein the outlet chamber comprises an air-tightly sealable outlet opening for emitting the pieces of fresh meat from the outlet chamber.

A method for the treatment of fresh meat

The present invention relates to a method for the treatment of fresh meat, in particular for fresh beef, pork, veal, lamb, game, poultry, horsemeat, fish, raw, sausages and ham or any other fresh meat the red color of which should be maintained while it is offered for sale.

Fresh meat may be treated with a gas mixture containing carbon monoxide (CO) in order to give the fresh meat a red color closely approaching the color of the meat soon after cutting. By treating fresh meat with this gas mixture the carbon monoxide reacts with the myoglobin or the oxymyoglobin in the red meat resulting in a stable red pigment, carbon-monoxide myoglobin (carboxymyoglobin), which has substantially the same color as the color of freshly cut meat.

While without treatment the red color of fresh meat can be maintained only for about two or three days with treatment of carbon monoxide the red color can be maintained up to twenty to thirty days depending on the percentage of the carbon monoxide in the gas mixture, the applied pressure, time and temperature. All these parameters have a direct effect on the depth of carbon monoxide penetration into the fresh meat and therefore the amount of generation of carbon-monoxide myoglobin. The depth of the carbon monoxide penetration is very important since too little carbon monoxide penetration will allow the red meat to lose its marketable red color prior to the expiration of the desired shelf live. Conversely, too much carbon monoxide penetration will cause the meat to retain a marketable red color for a time period after which the meat is no longer fit for human consumption due to microbiological factors.

Treatment of fresh meat with carbon monoxide is for example known from US 3,122,748. In this U.S. patent it is described to treat freshly cut meat with carbon monoxide in order to maintain the desired red color of the meat for a longer time. The carbon monoxide treatment is carried out in a pressurized vessel and the cuts are either wrapped after the treatment or before treatment if they are packaged in a permeable film.

However, existing techniques have not gained significant market share. Thus, there is a need for better ways to treat fresh meat with carbon monoxide.

There are two problems in the treatment of fresh meat with carbon monoxide. First it must be ensured that the red color of the meat resulting from the generation of carbon-monoxide myoglobin is not retained for a time period after which the meat is no longer fit for human consumption due to microbiological factors. Second, due to the toxicology of carbon monoxide for the human being, it must be ensured that neither workers performing the treatment and packaging nor the consumer of the meat will be subjected to carbon monoxide.

It is therefore an object of the present invention to provide a secure method for the treatment of fresh meat with carbon monoxide which takes the above-mentioned problems into account.

According to the invention there is provided a method for the treatment of fresh meat in intermediate storage comprising the steps of storing the fresh meat for a predetermining time in a chamber closable in an air-tight manner, thereby building an atmosphere containing between 0.1 % and 10 % carbon monoxide within the closed chamber, increasing the pressure within the closed chamber to a pressure which lies more than 1.1 bar

above the atmospheric pressure, replacing the atmosphere containing carbon monoxide and surrounding the fresh meat with an atmosphere of gas or a gas mixture containing no carbon monoxide, and equilibrating the pressure of the atmosphere surrounding the fresh meat to that of the atmospheric pressure.

Preferably the method comprises the step of maintaining the pressure within the closed chamber at a pressure of more than 1.1 bar above the atmospheric pressure for the intermediate storage. Further preferably the steps of replacing the atmosphere containing carbon monoxide and of equilibrating the pressure of the surrounding atmosphere comprise extracting the atmosphere containing carbon monoxide from the chamber to generate an ambient pressure within the chamber of a pressure less than atmospheric pressure; and ventilating the chamber to allow the internal pressure to equilibrate to that of the atmospheric pressure.

The step of packaging the fresh meat comprises preferably the steps of evacuating the atmosphere surrounding the fresh meat, thereby removing any residual carbon monoxide from the fresh meat, backfilling the evacuated volume with a gas mixture containing no carbon monoxide, and packaging the fresh meat.

With the parameters of the invention it is ensured that the red color of the meat caused by the treatment with carbon monoxide will degrade before the meat is no longer suitable for human consumption due to microbiological spoilage. On the other hand, by replacing the atmosphere containing carbon monoxide and surrounding the fresh meat with an atmosphere of gas or a gas mixture containing no carbon monoxide, in particular by extracting the atmosphere containing carbon monoxide from the chamber and ventilating the chamber it is ensured that workers in charge with the

treatment are not subjected to carbon monoxide. By additionally evacuating the atmosphere surrounding the fresh meat after ventilation of the chamber it is ensured that any residual carbon monoxide is removed from the fresh meat. By this evacuation and the additional backfilling of the
5 evacuated volume with a gas mixture containing no carbon monoxide it is ensured that there is no residual carbon monoxide in the final package - neither in the packaged meat nor in the packaged atmosphere surrounding the meat - so that the consumers of the meat will not be subjected to any carbon monoxide.

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The invention therefore provides a secure method for the treatment of fresh meat with carbon monoxide which takes both the toxicology of carbon monoxide as well as the increasing microbiological spoilage of the meat into account.

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In a preferred embodiment of the invention the fresh meat is placed in a tray and packaged by the steps of evacuating the atmosphere contained within the tray thereby removing any residual carbon monoxide from the fresh meat, backfilling the evacuated tray with a gas mixture containing
20 no carbon monoxide, and closing the tray with a lidding material. In this it is possible that the fresh meat is stored in the chamber while placed in the tray or that the fresh meat is placed in the tray after ventilating the chamber. It is also possible to remove the fresh meat from the chamber after ventilation and forward it to a suitable packaging device or to package the
25 meat after ventilation in the chamber.

The lidding material may for example be a lidding foil or plastic film and may have an oxygen transmission rate of less than 10 cc per 100 square inch per 24 hours, preferably of less than 5 cc per 100 square inch per 24
30 hours in particular of less than 1 cc per 100 square inch per 24 hours.

Similarly, the tray which may be formed from a rigid plastic, such as polypropylene, semi rigid plastic, such as expanded polystyrene, aluminum foil or paperboard, will be produced to have a sufficient oxygen barrier and water vapor barrier to aid in prolonging the shelf life of the fresh meat. In particular the tray material may have an oxygen transmission rate of less than 10 cc per 100 square inch per 24 hours, preferably of less than 5 cc per 100 square inch per 24 hours, in particular of less than 1 cc per 100 square inch per 24 hours.

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The lidding material may also have an oxygen transmission rate of about between 500 cc per 100 square inch per 24 hours and 1000 cc per 100 square inch per 24 hours and preferably of about 750 cc per 100 square inch per 24 hours.

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Preferably the tray has a surface that is heat-seal compatible with that of the lidding material. Further, the step of closing the tray may comprise the step of heat seal and/or hermetically closing the tray with the lidding material. In addition, the step of closing the tray may comprise the step of closing the tray with a non-barrier lidding material.

20

The balance of the atmosphere containing carbon monoxide built up in the closed chamber is preferably nitrogen (N₂) or may be any other suitable gas. The backfilled gas mixture applied after the evacuation of the atmosphere surrounding the fresh meat may contain between approximately 20 % and 50 % preferably approximately 30 %, carbon dioxide (CO₂) and between approximately 50 % and 80 %, preferably approximately 70 % nitrogen (N₂).

25

The pressure within the chamber during the intermediate storage lies preferably between approximately 1.1 and 20, preferably between approximately 1.1 and 15 bar, in particular between approximately 10 and 20 bar, preferably between approximately 10 and 15 bar resulting in a good compromise between a fast and a secure treatment.

The evacuation process is preferably performed to a pressure of less than approximately 50 mbar, preferably of less than approximately 10 mbar, in particular of less than approximately 5 mbar during the packaging of the fresh meat. The more intensive the evacuation is performed the better it is ensured that any residual carbon monoxide is removed from the treated meat.

In addition, it is preferred that the fresh meat is stored in the chamber in a well-cooled state, in particular at a temperature in the range from approximately 0°C to 5°C. Additionally, the treated meat may be cooled during packaging and also during transportation from a central cutting/treating packaging facility to retail distribution centers in order to aid in prolonging the shelf life of the fresh meat.

Preferably, the time for the intermediate storage amounts to between approximately 30 minutes and 7 hours, preferably to between approximately 45 minutes and 2 hours, in particular to approximately 1 hour. Other preferred values for the intermediate storage amount to between approximately 5 minutes and 8 hours, preferably to between approximately 10 minutes and 2 hours, in particular to approximately 15 minutes. By choosing a proper storage time it is ensured that the desired depth of carbon monoxide penetration into the meat is obtained.

According to a further embodiment of the invention it is possible that the packaging of the fresh meat follows almost immediately when the chamber has been ventilated or that between the ventilation of the chamber and the packaging of the fresh meat an intermediate time is provided. The intermediate time may thereby lie in the range of approximately 1 minute and 1 hour, preferably between 1 minute and 30 minutes.

In a preferred embodiment of the invention the step of packaging the fresh meat comprises the step of heat seal and/or of hermetically packaging the fresh meat. The step of packaging the fresh meat may also comprise the step of packaging the fresh meat with a non-barrier lidding material and/or in a flexible film vacuum skin package. The flexible film vacuum film package may thereby comprise two opposing non-barrier films.

In the following the invention is described by reference to the following detailed example.

In a first preparation step of the invention individual retail portions of fresh meat are cut from either primal or sub-primal cuts of fresh meat. The individual retail portions are placed into a preformed tray made e.g. from rigid plastic, semi-rigid plastic, aluminum foil or paperboard. The preformed trays are produced to have a sufficient oxygen barrier and water vapor area to aid in prolonging the shelf life of the fresh meat.

After this preparation step the trays carrying the fresh meat portions are placed into a high-pressure chamber capable of withstanding internal pressures ranging from 5 bar to 20 bar or even more. The internal pressure of the chamber is elevated to the desired pressure which may preferably be about 15 bar. The gas employed to elevate the internal pressure of the chamber shall have a minimum carbon monoxide content of 0.1 %,

preferably of 0.4 %, and a maximum carbon monoxide content of 10 %. The balance of the gas used to elevate the pressure within the chamber may for example be nitrogen (N₂).

- 5 It is possible to extract the environmental atmosphere from the chamber before increasing the pressure by supplying the gas mixture containing carbon monoxide. While for this extraction a vacuum pump may be used it is also possible to simply displace the environmental atmosphere from the chamber by supplying the gas mixture containing carbon monoxide to
10 the chamber while opening an outlet opening through which the environmental atmosphere may be blown out.

- The meat will remain in the pressure chamber for a predetermined period of time, for example between 5 minutes and 8 hours, preferably between
15 10 minutes and 2 hours, at a temperature preferably ranging from 0°C to 5°C, in particular from 0°C to 3 °C.

- Due to the built pressure in the chamber the carbon monoxide penetrates into the meat resulting in the generation of carbon-monoxide myoglobin in
20 the meat thereby producing a stable red pigmentation normally associated with oxymyoglobin.

- After the predetermined time it is preferred to capture and/or reclaim the carbon monoxide remaining in the chamber in order to remove the carbon
25 monoxide from the red meat as far as it is possible and to retain the carbon monoxide from within the chamber in a secondary storage vessel for re-use. This can for example be accomplished by the use of a mechanical vacuum pump employed to evacuate the gas content of the chamber to an ambient pressure within the chamber of a pressure less than atmospheric
30 pressure. In addition, by removing the carbon monoxide from the chamber

it is ensured that the workers opening the chamber after the treatment will not be in contact with carbon monoxide.

After the evacuation process the internal pressure of the chamber will be
5 less than the external atmospheric pressures surrounding the chamber. Therefore, the pressure chamber will be ventilated to allow the internal pressure to equilibrate to that of the external atmospheric pressure.

Subsequently, the trayed meat cuts will be removed from the pressure
10 chamber and transported to a packaging device. In the packaging device the atmosphere contained within the trays is evacuated to a level less than 5 mbar in order to remove any residual carbon monoxide from the meat which penetrated the meat but was not involved in the generation of carbon-monoxide myoglobin. This evacuation is very important in order to
15 ensure that the consumer of the meat will not be subjected to any residual carbon monoxide.

After the evacuation process the evacuated volume is backfilled with a gas
mixture of approximately 25 % carbon dioxide (CO₂) and 75 % nitrogen
20 (N₂).

Subsequently, the preformed tray supporting the treated meat is hermeti-
cally sealed with a lidding material as for example a lidding film which has
an oxygen transmission rate less than about 1 cc per 100 square inches
25 per 24 hours.

The finished individual packages of pretreated meat are then transported
under refrigeration from the central cutting/treating/packaging facility to
retail distribution centers. The treated individual packages which are
30 finally displayed for sale in the customary refrigerated cases cannot con-

tain any residual carbon monoxide and maintain the red color much longer than without the treatment according to the invention.

EXAMPLES

5

The following tests have been carried out to determine the various depths of red color penetration achieved with varying pressures and percentages of carbon monoxide. The tested products were choice sirloin or choice ribeye and for each test the roast was removed from a bag only long enough for one steak to be cut. The roast was then re-vacuum sealed immediately to eliminate as much "bloom-back" as possible from atmosphere.

The following parameters have been used:

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1. 0.4 % CO/balance Nitrogen at 15 bar for 1 hour
2. 0.4 % CO/balance Nitrogen at 10 bar for 1 hour. When the pressure in the chamber reached 10 bar (after 40 minutes) the supply valve was shut of on the tank. This stabilized the pressure in the chamber at 10 bar.
- 20 3. 0.4 % CO/balance Nitrogen at 5 bar for 1 hour. When the pressure in the chamber reached 5 bar (after 20 minutes) it was stabilized using the same technique as in test 2.
4. 5.0 % CO/balance Nitrogen at 5 bar for 1 hour. The pressure was stabilized at 5 bar using the same technique as before.
- 25 5. 5.0 % CO/balance Nitrogen at 15 bar for 7 hour. The pressure was stabilized at 15 bar using the same technique as before.

I all four tests the chamber was ventilated after one hour. The ventilation process took approximately seven minutes each time.

30

PENETRATION RESULTS

GAS MIXTURE	PRESSURE	TIME	PENETRATION DEPTH
0.4 % CO/bal NITROGEN	15 bar	1 hour	0.105"
0.4 % CO/bal NITROGEN	10 bar	1 hour	0.06"/0.07"
0.4 % CO/bal NITROGEN	5 bar	1 hour	0.045"
5.0 % CO/bal NITROGEN	5 bar	1 hour	0.10"/0.11"
5.0 % CO/bal NITROGEN	15 bar	7 hours	0.25"

5

The invention is further described with respect to Figures 1 and 2.

Referring to Figure 1, trays 14, carrying meat M, are conveyed through a carbon monoxide treatment chamber 16 which may be a pressurized tunnel in one embodiment of the present invention. The chamber 16 is coupled to a source of carbon monoxide gas, an exhaust port, and a back-fill port, as indicated in Figure 1. The treated meat MT in the trays 14 then passes out of the carbon monoxide treatment chamber 16 and passes into a packaging and heat sealing machine 18. The machine 18 receives rolls of sealing film 20a which it cuts to shape and heat seals to the flanges of the trays 14 in one embodiment. Thus, the finished products 20c exit from the machine 18. The remaining film is taken up on a roll 20b as indicated.

According to one embodiment of the invention, fresh meat may be exposed to carbon monoxide in an air-tight chamber 16, in an atmosphere containing at least 0.1% to 10% carbon monoxide at a pressure of at least 1.1 bar above the atmospheric pressure for not more than seven hours. In one embodiment, the exposure may be for less than two hours and the exposure may be for about 15 minutes in one particular case. This exposure

time may include time spent ramping up to one or more target pressures and ramping down from those pressures.

5 The carbon monoxide may be extracted from the chamber 16 to generate an ambient pressure within the chamber 16 of less than atmospheric pressure. The chamber 16 may be ventilated to allow the internal pressure to equilibrate to that of the atmospheric pressure. Then, the atmosphere surrounding the fresh meat may be evacuated, thereby removing any residual carbon monoxide from the fresh meat. The evacuated volume
10 may be backfilled with a gas mixture substantially free of carbon monoxide.

In one embodiment, the fresh meat may be placed on a tray 14 covered with a heat sealed film 20c. The film may be a non-barrier material
15 which, as used herein, means that the material transmits oxygen at a rate greater than 200 cc/100 square inches over 24 hours. A non-barrier material transmits 750 cc/100 square inches over 24 hours in one embodiment. A non-barrier film may also be used to cover the resulting package so that oxygen infiltration after carbon monoxide treatment may
20 enhance the red color of the blooming meat.

In another embodiment, the tray 14 may be covered with a barrier film 20c which, as used herein, means that the material transmits oxygen at a rate of less than or equal to 200 cc/100 square inches in 24 hours. In
25 one embodiment, the barrier material transmits oxygen at about 5 cc/100 square inches in 24 hours. In an embodiment using a barrier material, oxygen may be provided within the package initially to enhance the red bloom color. For example, about 1% of the gas provided to the package may include oxygen (O₂) gas and the balance may be nitrogen (N₂). The

use of the barrier film 20c may be particularly advantageous when packaging ground meat.

The red color of the meat caused by the treatment with carbon monoxide may advantageously degrade before the meat is no longer suitable for human consumption due to microbiological spoilage. This generally occurs when the total anaerobic plate count (TPC) exceeds one million colony forming units (CFU/gram). In one embodiment, the meat may have an a* standard value of greater than 10 when it reaches a plate count of greater than one million. The a* color solid may be obtained from Hunter Lab, Reston, VA 20190. Advantageously, the meat has a shelf life, after carbon monoxide exposure, of more than three days.

By extracting the atmosphere containing carbon monoxide from the chamber 16 and ventilating the chamber via the exhaust port, workers involved in the treatment may not be subjected to toxic levels of carbon monoxide. Finally, by additionally evacuating the atmosphere surrounding the fresh meat after ventilation of the chamber, residual carbon monoxide may be removed from the fresh meat. By this evacuation and the additional backfilling of the evacuated volume with a gas mixture substantially free of carbon monoxide, there may be little or no residual carbon monoxide in the packaged meat or in the packaged atmosphere surrounding the meat. As a result, the consumers of the meat may not be exposed to carbon monoxide.

In one embodiment, the fresh meat is placed in a tray 14, and exposed to carbon monoxide under pressure. The atmosphere contained within the tray 14 is evacuated, thereby removing residual carbon monoxide from the fresh meat. The evacuated tray 14 may be backfilled with a gas mixture substantially free of carbon monoxide. The tray 14 may be covered with a

lidding material heat sealed to the tray. A non-barrier lidding material 20c may be formed, for example, of oriented polyolefin. The fresh meat in the tray 14 may be treated in the pressure chamber 16 or the fresh meat may be placed in the tray 14 after treatment and ventilating the chamber 5 16. The fresh meat may be removed from the chamber 16, as indicated at MT in Figure 1, after ventilation and prior to packaging.

The tray 14 may be formed from a rigid plastic, such as polypropylene, semi-rigid plastic, such as expanded polystyrene, aluminum foil, or paperboard. The tray 14 may be a sufficient oxygen barrier and water vapor 10 barrier to aid in prolonging the shelf life of the fresh meat. In particular the tray material may have an oxygen transmission rate of less than 10 cc per 100 square inch per 24 hours, preferably of less than 5 cc per 100 square inch per 24 hours, in particular of less than 1 cc per 100 square 15 inch per 24 hours.

The balance of the treatment atmosphere containing carbon monoxide built up in the closed chamber 16 may be nitrogen (N_2) or may be any other suitable gas or mixture of gases. The backfilled gas mixture applied 20 after carbon monoxide treatment and the evacuation of the carbon monoxide containing atmosphere may contain between approximately 20% and 50%, and, for example, approximately 30%, carbon dioxide (CO_2) and between approximately 50% and 80%, for example, approximately 70% nitrogen (N_2).

25 The pressure within the chamber 16 during the carbon monoxide exposure may be between approximately 1.1 and 15 bar resulting in a good compromise between a fast and a secure treatment.

The post-treatment evacuation process, with a non-barrier film, may be performed to a pressure of less than approximately 50 mbar, and, in one embodiment, at a pressure of less than approximately 10 mbar during the packaging of the fresh meat. With a barrier film, the evacuation process
5 may be performed to a pressure of less than 100 mbar and above 48.46 mbar in one embodiment.

In addition, the inside of chamber 16 may be maintained at a temperature in the range from approximately 0°C to 5°C. Additionally, the treated
10 meat may be cooled during packaging and also during transportation from a central cutting/treating packaging facility to retail distribution centers in order to aid in prolonging the shelf life of the fresh meat.

The exposure time to carbon monoxide may be between approximately 5
15 minutes and 7 hours, for example, between approximately 10 minutes and 2 hours, and, in one particular embodiment, approximately 15 minutes. The exposure time may be chosen to achieve a desired depth of carbon monoxide penetration into the meat.

20 According to a further embodiment of the invention, the packaging of the fresh meat follows almost immediately after ventilation of the chamber 16. The time between treatment and packaging may be in the range of approximately 1 minute to 1 hour in one embodiment.

25 Individual retail portions of fresh meat M may be cut or ground from either primal or sub-primal cuts of fresh meat. The individual retail portions are placed into a preformed tray 14 made e.g., from rigid plastic, semi-rigid plastic, aluminum foil or paperboard as indicated at block 22 in Figure 2. The preformed trays 14 have a sufficient oxygen barrier and
30 water vapor area to aid in prolonging the shelf live of the fresh meat.

After this preparation step, the trays or other carriers transporting the fresh meat portions are placed into a pressure chamber 16 capable of generating internal pressures above 1.1 bar. The internal pressure of the chamber is elevated to the desired pressure, as indicated at 24 in Figure 2, which may be about 15 bar in one embodiment. The gas employed to elevate the internal pressure of the chamber may have a carbon monoxide content of at least 0.1%, for example 5%, and a maximum carbon monoxide content of 10% in one embodiment. The balance of the gas or gases used to elevate the pressure within the chamber may, for example, be nitrogen (N₂).

It is possible to extract the environmental atmosphere from the chamber 16 before increasing the pressure by supplying the gas mixture containing carbon monoxide. A vacuum pump may be used for such an extraction to the environmental atmosphere may be displaced from the chamber by supplying the gas mixture containing carbon monoxide to the chamber and blowing out the environmental atmosphere through a suitable chamber opening.

The meat may remain in the pressure chamber 16 for a predetermined period of time, for example between 5 minutes and 7 hours, as indicated at 26 in Figure 2, and at a temperature preferably ranging from 0°C to 5°C.

Due to the pressure built up in the chamber 16, the carbon monoxide penetrates into the meat resulting in the generation of carbon-monoxide myoglobin (carboxymyoglobin) in the meat. This carboxymyoglobin buildup produces a stable red pigmentation normally associated with oxymyoglobin.

The carbon monoxide remaining in the chamber 16 may be reclaimed in order to remove carbon monoxide from the red meat and to retain carbon monoxide from the chamber for re-use. This can, for example, be accomplished by the use of a mechanical vacuum pump employed to evacuate
5 the gas content of the chamber to an ambient pressure within the chamber of a pressure less than atmospheric pressure as indicated at 28 in Figure 2. In addition, by removing the carbon monoxide from the chamber 16, the workers opening the chamber after the treatment will be less likely to be exposed to carbon monoxide.

10

After the evacuation process, the internal pressure of the chamber 16 may be less than the external atmospheric pressures surrounding the chamber. Therefore, the pressure chamber 16 may be ventilated to allow the internal pressure to equilibrate to that of the external atmospheric pressure as indicated at 30 in Figure 2.

15

Subsequently, the carbon monoxide treated meat cuts MT may be removed from the pressure chamber 16 and transported to a packaging device 18 as indicated at 32. In the packaging device 18, the atmosphere
20 may be evacuated to a level less than 50 mbar to remove residual carbon monoxide, which penetrated the meat, but was not involved in the generation of carbon-monoxide myoglobin as indicated at 34.

After the evacuation process, the evacuated volume may be backfilled with
25 a gas mixture of approximately 30% carbon dioxide (CO₂) and 70% nitrogen (N₂) as indicated at 36.

Subsequently, the preformed tray supporting the treated meat is heat sealed with a lidding material as indicated at 38. The finished individual
30 packages of pretreated meat are then transported under refrigeration from

the central cutting/treating/packaging facility to retail distribution centers.

5 The packaged meat may be exposed to oxygen, as indicated at 40, to enhance the bloom. This may be accomplished via the non-barrier film 20c from the atmosphere in one embodiment. With a barrier film, oxygen (e.g., 1%) may be added into the package with the backfill.

10 The treatment of the fresh meat with carbon monoxide may be carried out discontinuously or at least partially continuously as further described with another embodiment of the invention shown in to Figs. 3, 4 and 5.

15 In Fig. 3 there is shown a conveyor system 50 comprising a conveyor belt on which pieces 51 of fresh meat are transported in a direction of an arrow 52. In addition the conveyor system 50 can be moved parallel to an arrow 53 in opposite directions in order to allow the front end 54 of the conveyor system 50 to be moved into and out of a partially rotatable tube 55.

20 The tube 55 comprises an inlet chamber 56, a main chamber 57 and an outlet chamber 58 which are sequentially arranged one after the other wherein the inlet chamber 56 is separated from the main chamber 57 by a wall 59 and the main chamber 57 is separated from the outlet chamber 58 by a wall 60.

25 In both, the wall 59 and the wall 60 an opening 61, 62 is provided which can be hermetically closed by a closing element, for example a flap 63, 64 which are pivoted around a rotary axis 65, 66, respectively.

While in Fig. 3 the closed position of the flaps 63, 64 is shown in bold face an opening position of both flaps is indicated in each case as dashed line 67, 68.

- 5 In the face side 69 of the tube 55 an inlet opening 70 is provided which is also closable by a flap 71 which is pivoted around a rotary axis 72. The flap 71 is shown in Fig. 3 in bold face in its closed position and as dashed line 73 in its open position.
- 10 On the inside surface of the outer wall 74 of the main chamber 57 a helically wound shoulder 75 is provided which extends about a quarter of the length of the main chamber 57. Adjacent to the shoulder 75 further shoulders 76 are arranged on the inner surface of the outer wall 74 extending in axial direction of the tube 55. Both, the shoulder 75 as well as
- 15 the shoulders 76 may for example have a cross section of approximately triangle form as shown in Fig. 5 for shoulders 76.

The inlet chamber 56 is connected to a supply main 77 in which a valve 78, e. g. a pneumatic valve, is provided. Similarly, an outlet main 79 is

20 connected to the inlet chamber 56 in which a valve 80 is integrated.

In the same way, the outlet chamber 58 is connected to a supply main 81 with a valve 82 as well as to an outlet main 83 with a valve 84. In addition, the outlet chamber 58 is provided with an outlet opening 85 which is

25 arranged at the bottom side of the outlet chamber 58. The outlet opening 85 is closable with an outlet flap 86 the closed position of which is shown in Fig. 3 in bold face whereas the open position is shown as dashed line 87.

In the direction of the axis 88 of tube 55 a supply tube 89 is extending from outside of the tube 55 through the face side 90 thereof and the wall 60 in the main chamber 57. The supply tube 89 extends almost over the length of the whole main chamber 57 and is provided with a plurality of
5 outlet openings 95 developed along the part of the supply tube 89 arranged inside of the main chamber 57. The outer end 91 of the supply tube 89 is provided with a connection unit for connecting the supply tube 89 with a supply main not shown in Fig. 3.

10 The supply tube 89 is hermetically sealed with respect to the face side 90 and the wall 60 in order to ensure that the outer chamber 58 as well as the main chamber 57 can be hermetically closed.

Below the outlet opening 85 a further conveyor system 92 is arranged
15 which is in Fig. 3 also developed as conveyor belt.

The tube 55 is tilted by an angle α with respect to the horizontal indicated by a dashed line 97.

20 As can be seen from the detailed view A shown in Fig. 4 the inlet chamber 56 and the main chamber 57 are separated and rotatably connected with each other. The outer wall 74 of the main chamber 57 is thereby hermetically sealed with the outer wall 93 of the inlet chamber 56 by a labyrinth seal 94. In this way the main chamber 57 can be rotated around the axis
25 88 while the housing of the inlet chamber 56 is fixedly positioned. Instead of the labyrinth seal 94 any other suitable seal can be used in order to ensure that the main chamber 57 is hermetically closed but rotatable with respect to the inlet chamber 56.

A corresponding connection is provided between the main chamber 57 and the outlet chamber 58 to ensure that the main chamber 57 can be rotated while the housing of the outlet chamber 58 is fixedly positioned.

- 5 In the following the use of the apparatus of Figs. 3 to 5 is explained in detail.

In the main chamber 57 an atmosphere containing between 0.1 % and 10 % carbon monoxide is built with a pressure of at least 1.1 bar above the atmospheric pressure. The openings 61 and 62 are closed by the flaps 63, 64 in order to ensure that the carbon monoxide atmosphere cannot escape from the main chamber 57. The carbon monoxide atmosphere is supplied to the main chamber 57 through the supply tube 89 and distributed evenly in the main chamber 57 by means of the outlet openings 95.

10 15 The percentage of carbon monoxide is for example controlled by a control system including a carbon monoxide detector not shown in the Figs.

The pieces 51 of fresh meat are transported to the inlet chamber 56 by the conveyor system 50 which is moved along the arrow 53 that the front end 54 of the conveyor system 50 extends through the inlet opening 70 into the inlet chamber 56. The flap 71 is at this moment positioned in its open position 73.

20

By the movement of the conveyor belt in the direction 52 the pieces 51 of fresh meat are entering the inlet chamber 56 and dropping down to the bottom surface of the inlet chamber 56 as indicated in Fig. 3.

25

If a predetermined number of pieces 51 of fresh meat have been transported into the inlet chamber 56 the conveyor system 50 is retracted and

the flap 71 is closed. Instead of a conveyor belt a conveyor system 50 can also comprise another suitable conveyor unit, e. g. a conveying screw.

After closing flap 71 the valve 78 is opened and inlet chamber 56 is filled
5 with an atmosphere not containing carbon monoxide, e.g. with an N₂ atmosphere. Thereby a pressure is built up in inlet chamber 56 which is greater than the pressure already built in main chamber 57. It may be advantageous to open valve 80 during the beginning of floating the inlet chamber 56 in order to ensure that no rest of carbon monoxide from a
10 previous treatment remains in inlet chamber 56. In order to allow the desired pressure to be built valve 80 is closed after having removed all carbon monoxide from inlet chamber 56.

After building up the desired pressure in the inlet chamber 56 flap 63 is
15 opened in order to allow the pieces 51 of fresh meat to slip into the main chamber 57 due to the tilted arrangement of tube 55.

Since the pressure in inlet chamber 56 is higher than the pressure in the main chamber 57 it is ensured that no carbon monoxide escapes from the
20 main chamber 57 into the inlet chamber 56. Preferably valve 78 is still opened at this moment to ensure that the pressure in inlet chamber 56 is always higher than the pressure in main chamber 57.

The outer wall 74 of main chamber 57 is rotating around the axis 88 by
25 means of a not shown drive unit thereby supporting the movement of the pieces 51 of fresh meat along the inner surface of the outer wall 74 on their way through the inner chamber 57.

In order to avoid that the pieces 51 of fresh meat are moving too fast
30 through the main chamber 57 the helically wound shoulder 75 is provided

which forms a barrier for the pieces 51 of fresh meat slipping into the main chamber 57. During the rotation of the main chamber 57 the helically wound shoulder 75 limits the transportation speed for the pieces 51 of fresh meat to a predetermined transportation speed within the main chamber 57.

During the further movement of the pieces 51 of fresh meat through the main chamber 57 the pieces 51 come in contact with the side walls of the shoulders 76. Due to the rotation of the main chamber 57 the pieces 51 of fresh meat which are in contact with the side walls of the shoulders 76 are rotated around the axis 88 until the respective pieces 51 are dropping over the crest 96 of the shoulders 76 thereby changing its position in the main chamber 57. The pieces 51 of fresh meat are thus automatically turned by the rotation of the main chamber 57 and the shoulders 76 in order to ensure that the carbon monoxide atmosphere reaches all parts of the surface of the pieces 51 of fresh meat.

After a predetermined time which is defined by the angle α and the rotation speed of the main chamber 57 the pieces 51 of fresh meat reach the outlet opening 62 which will be opened by opening the flap 64. The pieces 51 of fresh meat are passing through the opening 62 and entering the outlet chamber 58. After closing the flap 64 the outlet chamber 58 is filled with an gas or gas mixture containing no carbon monoxide, for example with N₂, by opening the valve 82 and supplying a corresponding gas or gas mixture through the supply main 81. In addition, valve 84 is opened in order to discharge the atmosphere containing carbon monoxide which escaped from the main chamber 57 into the outer chamber 58 through the opening 62.

It is also possible that before opening the flap 64 the outlet chamber 58 is already filled with an atmosphere containing no carbon monoxide, for example an N₂ atmosphere with a pressure which is higher than the pressure in the main chamber 57. Thus, it is avoided that an atmosphere
5 containing carbon monoxide will escape from the main chamber 57 into the outlet chamber 58.

After removing all carbon monoxide from the outlet chamber 58 the outlet flap 86 is opened and the pieces 51 of fresh meat collected in the outlet
10 chamber 58 are dropping down to the conveyer system 92 provided below the outlet opening 85. By the conveyor system 92 the pieces 51 of fresh meat treated with carbon monoxide can be transported to a packaging system as described above.

15 With the apparatus according to the invention the treatment of fresh meat with carbon monoxide within the main chamber 57 is developed as continuous process while the pretreatment in the inlet chamber 56 and the subsequent treatment in the outlet chamber 58 are developed as discontinuous processes.

20

According to the desired flow rate it is possible to supply pieces 51 of fresh meat to the inlet chamber 56 even if there are still further pieces 51 of fresh meat in the main chamber 57. It is therefore not necessary to wait until the first portion of pieces 51 of fresh meat left the main chamber 57
25 in order to supply new pieces 51 of fresh meat to the inlet chamber 56 and even into the main chamber 57. In the same way a portion of pieces 51 of fresh meat may already move from the main chamber 57 to the outlet chamber 58 while another portion of pieces 51 of fresh meat are still transported within the main chamber 57.

30

Typical dimensions of the tube 55 may for example be a length of 2 to 10 meters and in particular of about 4 to 6 meters and a diameter of 50 to 200 centimeters, in particular of 80 to 120 centimeters. The rotational speed of the main chamber 57 may for example be 1 to 5 revolutions per minute, in particular 2 to 3 revolutions per minute.

While in the previously described embodiment the transportation of the pieces of fresh meat is achieved due to the tilted rotatable arrangement of the main chamber it is also possible that a transport unit, e.g. a conveyor or the like for transporting the pieces of fresh meat is provided within the main chamber and/or in the inlet and/or outlet chamber.

CLAIMS

1. A method for the treatment of fresh meat in intermediate storage comprising the steps of:
 - 5 a) storing the fresh meat for a predetermined time in a chamber closable in an air-tight manner, thereby
 - a1) building an atmosphere containing between 0.1% and 10% carbon monoxide (CO) within the closed chamber;
 - a2) increasing the pressure within the closed chamber to a
10 pressure which lies more than 1.1 bar above the atmospheric pressure;
 - b) replacing the atmosphere containing carbon monoxide and surrounding the fresh meat with an atmosphere of gas or a gas mixture containing no carbon monoxide; and
 - 15 c) equilibrating the pressure of the atmosphere surrounding the fresh meat to that of the atmospheric pressure.
2. The method of claim 1 comprising the step of maintaining the pressure within the closed chamber at a pressure of more than 1.1 bar
20 above the atmospheric pressure for the intermediate storage.
3. The method of anyone of the preceding claims in which the steps of replacing the atmosphere containing carbon monoxide and of equilibrating the pressure of the surrounding atmosphere comprise:
 - 25 a) extracting the atmosphere containing carbon monoxide from the chamber to generate an ambient pressure within the chamber of a pressure less than atmospheric pressure; and
 - b) ventilating the chamber to allow the internal pressure to equilibrate to that of the atmospheric pressure.

4. The method of anyone of the preceding claims in which the balance of the atmosphere built up in the closed chamber is nitrogen (N₂).
- 5 5. The method of anyone of the preceding claims in which a pressure of approximately between 10 and 15 bar is built up in the closed chamber during intermediate storage.
- 10 6. The method of anyone of the preceding claims in which the pressure within the closed chamber is increased to a pressure which lies between 1.1 and 20 bar above the atmospheric pressure.
- 15 7. The method of anyone of the preceding claims in which the fresh meat is stored in the chamber in a well-cooled state, in particular at a temperature in the range from approximately 0° C to 5° C.
- 20 8. The method of anyone of the preceding claims in which the predetermined time for the intermediate storage amounts to between approximately 5 minutes and 8 hours, preferably to between approximately 10 minutes and 2 hours, in particular to approximately 15 minutes.
9. The method of claim 8 in which the intermediate time is in the range of approximately 1 minute and 1 hour.
- 25 10. The method of anyone of the preceding claims in which the fresh meat are cut into slices before storing in the chamber.
- 30 11. The method of anyone of the preceding claims comprising the step of packaging the fresh meat after equilibrating the pressure of the atmosphere surrounding the fresh meat.

12. The method of claim 11 in which the packaging of the fresh meat follows almost immediately when the chamber has been ventilated.
- 5 13. The method of claim 11 in which between the ventilation of the chamber and the packaging of the fresh meat an intermediate time is provided.
- 10 14. The method of anyone of claims 11 to 13 in which the step of packaging the fresh meat comprises the step of heat seal packaging the fresh meat.
- 15 15. The method of anyone of claims 11 to 14 in which the step of packaging the fresh meat comprises the step of hermetically packaging the fresh meat.
- 20 16. The method of anyone of claims 11 to 15 in which the step of packaging the fresh meat comprises the step of packaging the fresh meat with a non-barrier lidding material.
17. The method of anyone of claims 11 to 16 in which the step of packaging the fresh meat comprises the step of packaging the fresh meat in a flexible film vacuum skin package.
- 25 18. The method of claim 17 in which the flexible film vacuum skin package comprises two opposing non-barrier films.
19. The method of anyone of claims 11 to 18 in which the step of packaging the fresh meat comprises the steps of:

- 5
- a) evacuating the atmosphere surrounding the fresh meat, thereby removing any residual carbon monoxide from the fresh meat;
 - b) backfilling the evacuated volume with a gas mixture containing no carbon monoxide; and
 - c) packaging the fresh meat.
- 10
20. The method of claim 19 in which the fresh meat is placed in a tray and packaged by the steps of:
- a) evacuating the atmosphere contained within the tray thereby removing any residual carbon monoxide from the fresh meat;
 - b) backfilling the evacuated tray with a gas mixture containing no carbon monoxide; and
 - c) closing the tray with a lidding material.
- 15
21. The method of claim 20 in which the tray is evacuated to a pressure of less than approximately 50 mbar, preferably of less than approximately 10 mbar, in particular of less than approximately 5 mbar during packaging of the fresh meat.
- 20
22. The method of claim 20 or 21 in which the fresh meat is stored in the chamber while placed in the tray.
- 25
23. The method of anyone of claims 20 to 22 in which the fresh meat is placed in the tray after ventilating the chamber.
24. The method of anyone of claims 20 to 23 in which the lidding material has an oxygen transmission rate of less than 10 cc per 100 square inch per 24 hours, preferably of less than 5 cc per 100

square inch per 24 hours, in particular of less than 1 cc per 100 square inch per 24 hours.

- 5 25. The method of anyone of claims 20 to 24 in which the lidding material has an oxygen transmission rate of about between 500 cc per 100 square inch per 24 hours and 1000 cc per 100 square inch per 24 hours and preferably of about 750 cc per 100 square inch per 24 hours.
- 10 26. The method of anyone of claims 20 to 25 in which the tray is made from rigid plastic, semi rigid plastic, aluminum foil or paperboard.
27. The method of claim 26 in which the tray is made from polypropylene or polystyrene.
- 15 28. The method of anyone of claims 20 to 27 in which the tray material has an oxygen transmission rate of less than 10 cc per 100 square inch per 24 hours, preferably of less than 5 cc per 100 square inch per 24 hours, in particular of less than 1 cc per 100 square inch per 24 hours.
- 20 29. The method of anyone of claims 20 to 28 in which the tray has a surface that is heat-seal compatible with that of the lidding material.
- 25 30. The method of anyone of claims 20 to 29 in which the tray has a surface that is heat-seal compatible with that of the lidding material.
- 30 31. The method of anyone of claims 20 to 30 in which the step of closing the tray comprises the step of heat seal closing the tray with the lidding material.

32. The method of anyone of claims 20 to 31 in which the step of closing the tray comprises the step of hermetically closing the tray with the lidding material.
- 5 33. The method of anyone of claims 20 to 31 in which the step of closing the tray comprises the step of closing the tray with a non-barrier lidding material.
- 10 34. The method of anyone of claims 19 to 33 in which the backfilled gas mixture contains between approximately 20% and 50%, preferably approximately 30%, carbon dioxide (CO₂) and between approximately 50% and 80%, preferably approximately 70% nitrogen (N₂).
- 15 35. The method of anyone of the preceding claims in which the step of replacing the atmosphere containing carbon monoxide and surrounding the fresh meat comprises transporting the fresh meat from the chamber containing the atmosphere containing carbon monoxide to a further chamber in which an atmosphere different from the atmosphere in the previous chamber can be built up.
- 20 36. The method of claim 35 in which the atmosphere of gas or a gas mixture containing no carbon monoxide is build up in the further chamber.
- 25 37. A method comprising:
treating meat with a carbon monoxide atmosphere for less than 7 hours at a carbon monoxide concentration of above 0.1%.
- 30 38. The method of claim 37 including treating the meat within a tray.

39. The method of claim 38 including covering said tray with a barrier film after treatment of the meat.
- 5 40. The method of claim 38 including covering said tray with a non-barrier film.
41. The method of anyone of claims 37 to 40 including packaging the meat and trapping carbon dioxide within the package.
- 10 42. The method of anyone of claims 37 to 40 including exposing the packaged meat to oxygen.
43. The method of claim 42 including exposing the packaged meat to oxygen after packaging.
- 15 44. The method of claim 42 including exposing the packaged meat to oxygen during packaging.
- 20 45. The method of anyone of claims 37 to 44 including preventing the meat from maintaining a bloomed color for longer than the time that it is fit for human consumption.
46. The method of anyone of claims 37 to 45 including treating said meat with carbon monoxide under pressure.
- 25 47. The method of claim 46 including treating the meat with gas including carbon monoxide at a pressure greater than 1.1 bar above atmospheric pressure.

48. The method of claim 47 including treating said meat with carbon monoxide under pressure of about 15 bar over atmospheric pressure.
- 5 49. The method of anyone of claims 37 to 48 including treating with a gaseous atmosphere including about 5% carbon monoxide.
50. The method of anyone of claims 37 to 49 including covering said meat with a barrier film having a gas transmission rate less than
10 200cc/100 square inches in 24 hours.
51. The method of anyone of claims 37 to 50 including packaging said meat to have a shelf life greater than 3 days with an a* value of greater than 10 at a total anaerobic plate count of one million colony
15 forming units per gram.
52. The method of anyone of claims 37 to 51 including treating with carbon monoxide and nitrogen atmosphere.
- 20 53. The method of anyone of claims 37 to 52 including treating said meat with carbon monoxide for less than two hours.
54. The method of claim 53 including treating the meat with pressurized carbon monoxide for approximately 15 minutes.
25
55. The method of anyone of claims 37 to 54 including packaging said meat in an atmosphere substantially free of carbon monoxide.

56. The method of claim 55 including exposing the treated meat to a pressure lower than atmospheric pressure to drive off excess carbon monoxide.
- 5 57. The method of claim 56 including packaging said meat after removing excess carbon monoxide.
58. A package of fresh meat prepared by the method of anyone of the preceding claims.
- 10 59. Apparatus for carrying out the method according to anyone of the preceding claims comprising an inlet chamber (56), a main chamber (57) and an outlet chamber (58) which are arranged one after the other, wherein the inlet chamber (56) is connected to the main
15 chamber (57) through an air-tightly sealable opening (61) and the main chamber (57) is connected to the outlet chamber (58) through an air-tightly sealable opening (62), wherein the inlet chamber (56) comprises an air-tightly sealable inlet opening (70) for supplying
20 pieces (51) of fresh meat to the inlet chamber (56), and wherein the outlet chamber (58) comprises an air-tightly sealable outlet opening (85) for emitting the pieces (51) of fresh meat from the outlet chamber (58).
60. Apparatus according to claim 59 comprising a supply (89) for supplying a gas or gas mixture, in particular a carbon monoxide atmosphere, to the main chamber (57).
- 25 61. Apparatus according to claim 59 or 60 comprising a supply (77) for supplying a gas or gas mixture, in particular containing no carbon
30 monoxide, to the inlet chamber (56).

62. Apparatus according to claim 59, 60 or 61 comprising a supply (81) for supplying a gas or gas mixture, in particular containing no carbon monoxide, to the outlet chamber (58).
- 5
63. Apparatus according to anyone of claims 59 to 62 comprising a removal orifice (79) for the atmosphere in the inlet chamber (56).
64. Apparatus according to anyone of claims 59 to 63 comprising a removal orifice (83) for the atmosphere in the outlet chamber (58).
- 10
65. Apparatus according to anyone of claims 59 to 64 wherein the main chamber (57) is rotatable arranged around a rotation axis (88).
- 15
66. Apparatus according to anyone of claims 59 to 64 wherein the inlet (56) and/or the outlet (58) chamber are fixedly arranged.
67. Apparatus according to claims 65 or 66 wherein the main chamber (57) is rotatable arranged with respect to the inlet (56) and/or the outlet (58) chamber.
- 20

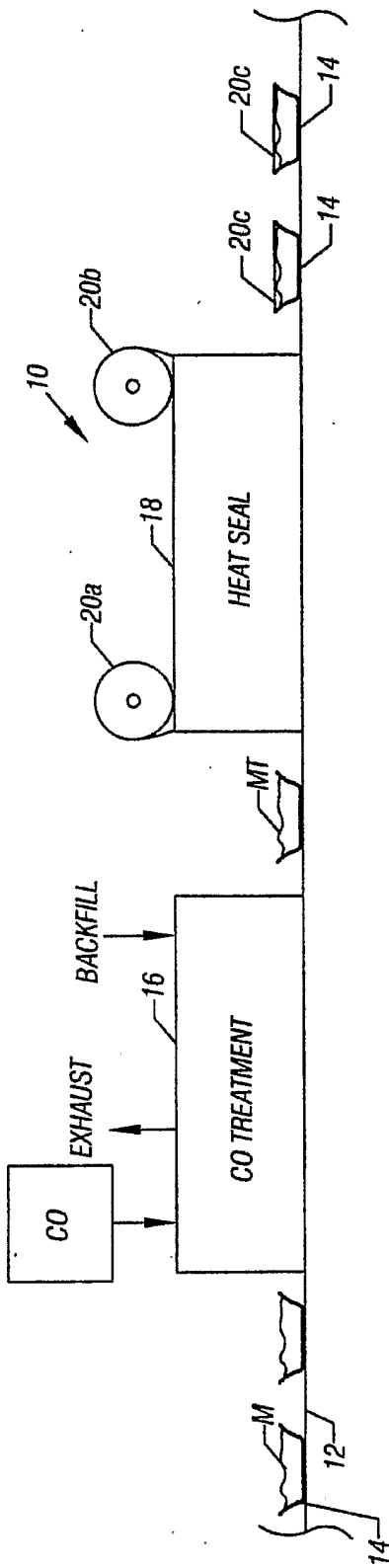


FIG. 1

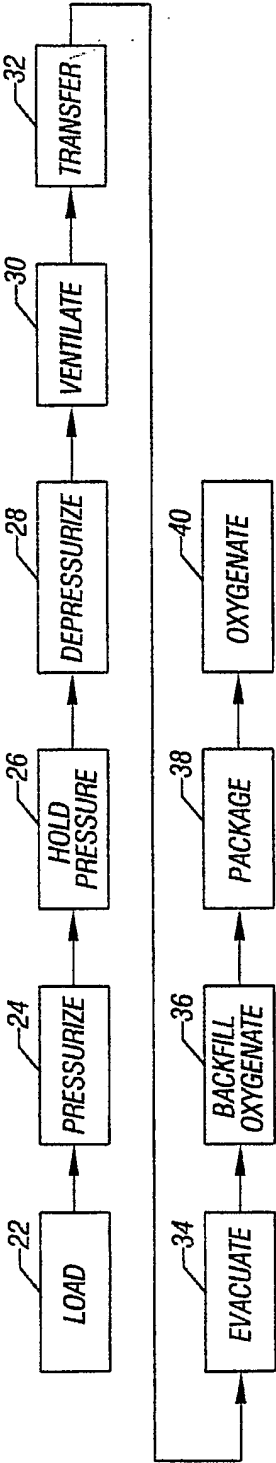


FIG. 2

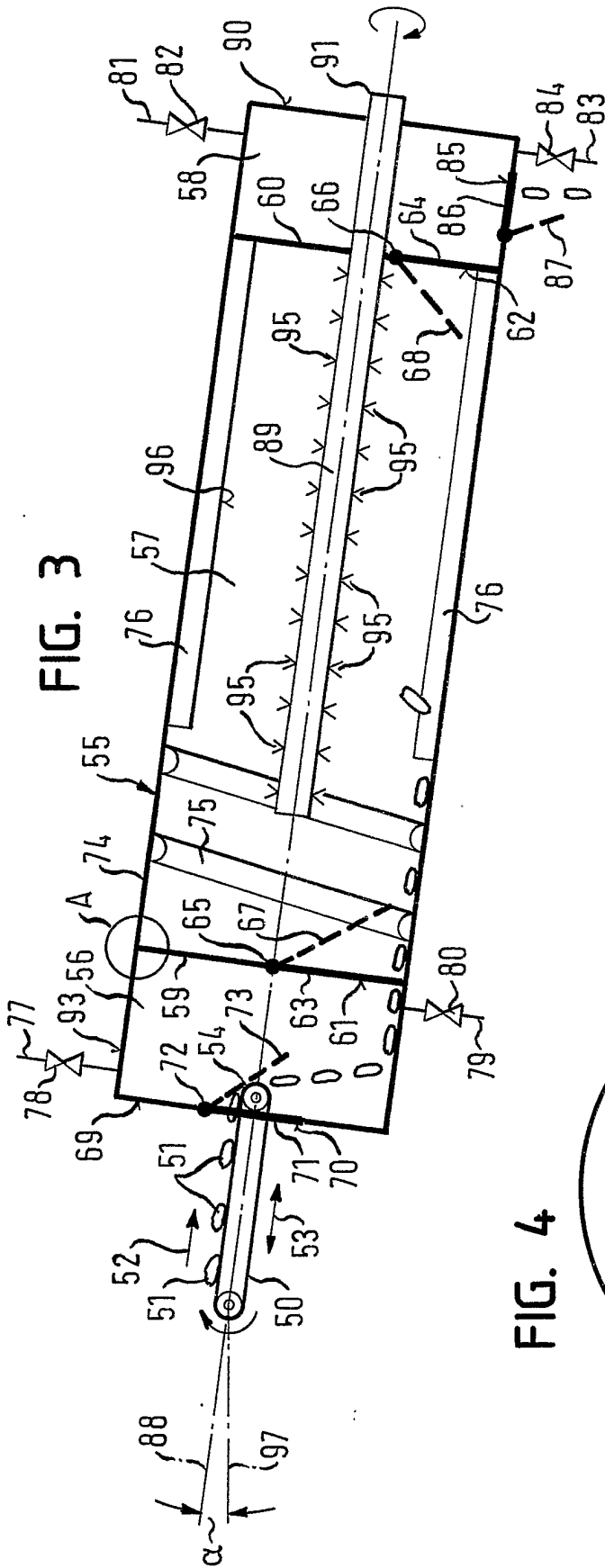


FIG. 4

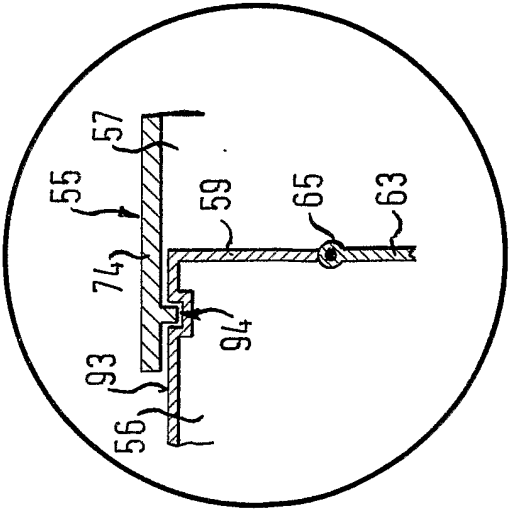


FIG. 5

