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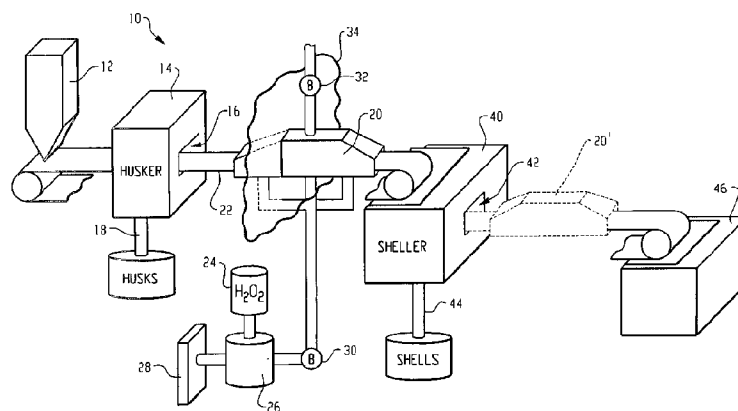
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(54) Title: LOW TEMPERATURE SANITIZATION OF HUMAN PATHOGENS FROM THE SURFACES OF FOOD AND FOOD
PACKAGING



(57) **Abstract:** Almonds, other nuts, grains, dried or dehydrated fruits or vegetables, and other agricultural foodstuffs resting on a porous mesh conveyor belt (22, 54) pass continuously through a chamber (20, 60) in which they are contacted by a gaseous oxidizing agent at atmospheric pressure as the conveyor belt and food products move continuously through the chamber. In one embodiment, the chamber is disposed through a barrier (56) which isolates a raw product receiving region from downstream processing facilities to prevent cross-contamination downstream. In another embodiment, the chamber (20) is disposed through a barrier (34) which separates a husker (14) from a downstream Sheller (40) such that the shells are sanitized prior to releasing the nutmeats from the shells. In the preferred embodiment, the gaseous oxidizing agent is hydrogen peroxide at a 1.8 mg/liter concentration which flows up through the belt vibrating the food products without scarring them as the belt conveys the food products through the chamber for a duration of about 15 seconds to achieve a 3 log reduction in human pathogens.

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**LOW TEMPERATURE SANITIZATION OF HUMAN PATHOGENS
FROM THE SURFACES OF FOOD AND FOOD PACKAGING**

Background of the Invention

The present invention relates to the killing of microorganisms on food items, without degrading the food items. The invention finds particular application in conjunction with almonds and will be described with particular reference thereto.

5 However, it is to be appreciated, the invention will also find application in conjunction with other types of nuts, seeds, dehydrated fruits, and other agricultural products.

To promote the growth of agricultural products, fertilizer is typically added to the soil. Manure, a commonly

10 used fertilizer, can carry human pathogens, such as *Salmonella*, *E-coli*, and *Listeria*. When food items come into contact with the soil during harvesting, or with equipment that has contacted the soil, the food items can pick up the human pathogens on their surface. As the harvested food items are gathered

15 together, the pathogens can be passed from surface to surface by direct contact.

When harvesting almonds, for example, it is common to shake the trees dropping the almonds (in their shells and husks) to the ground. The almonds are then collected from the

20 ground. In a first operation, the husks are removed from the almonds, leaving the almonds in their shells. Some almonds are sold in their shells, and others are deshelled prior to packaging. The removed husks would be expected to be the carriers of any human pathogens picked up from the soil. Even

25 after husking, the shell provides a pathogen impermeable package

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for the nutmeat. Conventional, mechanical shelling operations raise a significant amount of dust, sending dust-sized portions of the shell and any pathogens which might be thereon airborne.

5 Subsequently, the shelled nutmeats undergo various sorting operations. Some of the nutmeats are cooked, which would also be expected to kill any surface pathogens. Other nutmeats are packaged and sold raw. Although the chances of human pathogens being present on
10 the packaged nutmeats might appear relatively remote, there have been recent recalls of almonds for *Salmonella* contamination.

One solution to the contamination problem is found in the present assignee's U.S. Patent Nos. 5,460,845
15 and 5,535,667. These patents describe a batch process in which almonds and other food items are exposed to hydrogen peroxide vapor in a vacuum chamber for periods of about a half hour to one hour. These patents also describe limited kill rates at somewhat shorter periods of exposure
20 at atmospheric pressure.

Although effective, such batch processing techniques are not readily compatible with modern processing plants in which each processing line processes about 10,000 kilograms of food product per hour or more.

25 The present invention overcomes the above-referenced problems and others.

Summary of the Invention

In accordance with one aspect of the present
30 invention, a method of sanitizing human pathogens from surfaces of nuts is provided. The method includes moving the nuts continuously on a porous belt. While the nuts

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are moving on the belt, the nuts are treated with a gaseous oxidizing agent near atmospheric pressure for a sufficient duration to kill human pathogens. Prior to treating the nuts with the gaseous oxidizing agent, husks
5 are removed from the nuts. After exposing the nuts to the gaseous oxidizing agent, shells of the nuts are separated from their nutmeats. The nuts and nutmeats, both before and after shelling, are isolated from recontamination by airborne pathogens and from contacting pathogen bearing
10 nuts.

In accordance with another aspect of the present invention, an apparatus for sanitizing human pathogens from surfaces of nuts is provided. The apparatus includes a porous belt on which the nuts are continuously moved. A
15 chamber is provided through which the porous conveyor belt moves continuously. A means supplies a gaseous oxidizing agent to the chamber. The chamber has a length relative to the conveying speed of the belt such that the nuts remain in the chamber for a sufficient duration to kill
20 human pathogens. A husking machine removes husks from nuts, prior to treatment of the nuts with the gaseous oxidizing agent. A deshelling machine shells the nuts after exposing the nuts to the gaseous oxidizing agent. A pathogen barrier isolates regions upstream of the chamber
25 from regions downstream of the chamber.

One advantage of the present invention resides in its speed.

Another advantage of the present invention is that it provides a flow-through sanitization system which
30 can process food products at the same rate that they are moving along conventional processing assembly lines.

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Another advantage is that the present invention kills human pathogens in 30 seconds or less.

Another advantage of the present invention is
5 that it does not alter the taste of the food products.

Another advantage of the present invention is that it does not alter the value of almonds by changing the appearance of the brown skin or pellicle.

Still further advantages and benefits of the
10 present invention will become apparent to those of ordinary skill in the art upon reading and understanding the following detailed description of the preferred embodiments.

15 Brief Description of the Drawings

The invention may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for purposes of illustrating preferred embodiments and are
20 not be construed as limiting the invention.

FIGURE 1 is a diagrammatic illustration of a husking and shelling line in accordance with the present invention;

FIGURE 2 is a diagrammatic illustration of a
25 processing line for shelled nuts or other foods products in accordance with the present invention;

FIGURE 3 is a detailed illustration of a preferred treatment chamber of FIGURES 1 and 2;

FIGURE 4 illustrates bacterial concentration
30 reduction in 15 second intervals;

FIGURE 5 illustrates bacterial concentration reduction relative to a 10^5 control.

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Detailed Description of the Preferred Embodiments

At harvest time, almonds or other shelled food products are received in bulk at a dehusking and deshelling facility **10**. The bulk almonds are emptied into a large hopper
5 or other supply **12** from which almonds or other foods products are supplied to a husk removing machine **14**. The husk removing machine discharges almonds in the shell at one output **16** and outputs the husks through a second output **18**. The husks are removed from the facility and sold for other agricultural uses,
10 such as additives to livestock feed. The almonds in the shell from the outlet **16** are conveyed to a first sanitization chamber **20** on a mesh conveyor belt **22**.

The sanitization chamber **20** exposes the almonds in the shell to a gaseous oxidizing agent such as ozone, vaporized
15 liquid oxidants, condensed oxidants, plasma, or the like and combinations thereof. In the preferred embodiment, the gaseous oxidizing agent is in the form of hydrogen peroxide vapor in a concentration of about 1.8 milligrams per liter of air or greater. More specifically to the preferred embodiment, liquid
20 hydrogen peroxide from a liquid hydrogen peroxide source **24** is fed to a vaporizer **26** at a controlled rate. In some cases, it is advantageous if air is dried by a dryer **28** and blown by a blower **30** into the sanitization chamber **20**.

An exhaust blower **32** draws peroxide vapor and water
25 vapor from the sanitization chamber and exhausts them to the atmosphere. The exhaust blower **32**, preferably, is operated at a speed relative to the feed blower **30** such that the treatment chamber is maintained at a negative pressure relative to atmosphere so that the vapor hydrogen peroxide does not escape
30 into the working atmosphere. Because the almonds are still in the shell and protected, the treatment chamber **20** can tumble or agitate the almonds, use a stronger concentration of the gaseous oxidizing agent, and can even use oxidizing agents which would leave a residue or adversely affect taste. Preferably, a
35 microbe impermeable barrier wall **34** is maintained across the hulling and shelling facility **10** with one side of the wall being

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on the input to the treatment chamber 20 and the other side on the output. The chamber 20 has a length, relative to the conveyor belt speed, such that the almonds take 15-30 seconds to traverse the chamber.

5 From the sanitization chamber 20, the almonds are conveyed to a shelling machine 40 which removes the shells from the almonds. The nutmeats are discharged from a first outlet 42 and the shell fragments are discharged through a second outlet 44. Optionally or alternately, a second sanitizing
10 chamber 20' of the structure described above is disposed after the nutmeat outlet 42. A packaging machine 46 packages the shelled almonds in relatively large containers, such as 50 lb bags, drums, pallet sized containers, and the like. Preferably, the bulk containers are sealed against airborne pathogens. By
15 sanitizing the portion of the husking and shelling facility 10 which is downstream from the barrier wall prior to the receipt of almonds and by sanitizing all of the almonds in the shell entering the area, all of the packaged nutmeats should be free of human pathogens. Because the husking and shelling operations
20 are commonly performed only around harvest time and the packaging and production lines run year-round, the containers of shelled almonds are typically stored anywhere from a few hours until the next harvest season.

 With reference to FIGURE 2, at a packaging facility
25 50, the shelled nutmeats are received in a hopper 52 or other supply and fed at a controlled rate onto a mesh conveyor 54 preferably in a layer one nut thick. A barrier wall 56 surrounds the hopper 52 and isolates the area of the hopper from the remainder of the production facility.

30 A sanitization or treatment chamber 60 penetrates the barrier wall 56 such that its inlet receives untreated nuts on the conveyor 54 and its outlet discharges sanitized nuts or other food products on the conveyor 54 which continues downstream. The use of the barrier wall and treatment chamber
35 60 at the entrance to the processing facility assures that only treated nuts or food products enter the facility. This prevents cross contamination downstream. For example, nuts which are

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roasted go through a heating process which would normally kill the human pathogens. However, if the roasted nuts should come in contact with a contaminated, not yet roasted nut, or even a worker who had come in contact with a not yet roasted nut, human pathogens can be transferred to the previously sanitized roasted nuts. When every nut in the facility is sanitized, the chances of cross-contamination are minimized.

The treatment chamber 60, like the treatment chamber 20, includes a source 62 of a gaseous oxidizing agent, such as an ozone source, other vapor sterilant source, or a plasma source. Again, a source of liquid hydrogen peroxide of about 35% concentration and a vaporizer are preferred. A blower 64 supplies the gaseous oxidizing agent into the treatment chamber 60. The gaseous oxidizing agent, after moving among the food product, passes to an exhaust where a blower 66 exits the gas to atmosphere. Again, the relative speed of blowers 64 and 66 are preferably such that a slight negative pressure is maintained in the treatment chamber. More preferably, air curtains 68 are provided at the inlet and the outlet. The air curtains prevent the gaseous sanitizing agent from escaping from the chamber into the surrounding processing facilities and prevent contaminants from the surrounding facilities which could alter the sanitization process from entering the chamber. For example, if excess humidity from the production facility entered the treatment chamber, the water vapor could dilute the treatment gas or could alter the vapor pressure in the chamber, permitting condensation to occur.

The treatment chamber 60 has a length which is calculated such that at the normal movement speed of the conveyor belt 54, the food products dwell in the chamber for a prescribed treatment time, preferably 15-30 seconds. The flow of the gaseous oxidizing vapor through the chamber is sufficiently vigorous that the food products vibrate on the mesh conveyor belt, changing their points of contact and permitting all portions of the surface to be treated with the oxidizing vapor. Yet, the gaseous oxidizing agent flow is preferably not so vigorous that the food products are agitated to the point

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that they can become scarred or otherwise lose cosmetic appeal, hence value.

The sanitized almonds or other food products are passed to downstream processing equipment 70. This equipment
5 includes sorting stations for sorting the food products by quality, e.g., broken versus unbroken nuts, nuts with whole unscarred pellicles versus nuts without, and the like. The sorted nuts are conveyed to various processing lines. For example, some pass to roasting stations where they are roasted,
10 salting stations where salt or other spices are added, and the like as is conventional in the food processing arts. Finally, a packaging machine 72 packages metered amounts of the processed food product into appropriate consumer packages.

With reference to FIGURE 3, the sanitizing systems
15 20 and 60 preferably include an inlet duct 80 which supplies air to a housing 82 which houses an appropriate dryer for the incoming air, liquid peroxide supply, vaporizer, and blower. Vapor output tubes 84 supply the generated vapor to distributed portions of a lower manifold 86. The vapor is moved upward
20 through the mesh conveyor belt 54 into an upper manifold 88. Vapor from the upper manifold 88 is pulled by a blower through a catalytic destroyer which converts hydrogen peroxide vapor to water vapor and discharges the water vapor through a discharge duct 92.

25 With reference to FIGURE 4, sample almonds were inoculated with 3.7×10^8 inoculum of salmonella bacteria to achieve an initial bacterial concentration of about 10^6 . These almonds were treated with 1.8 milligram/liter concentration of hydrogen peroxide vapor at 33-34° C. FIGURE 4 illustrates the
30 log reduction at 15 second intervals. It will be seen that 15 seconds produces about a 3 log reduction. Similarly, FIGURE 5 shows the relative reduction of a test sample 100 at 5 second intervals from a 10^5 initial bacterial concentration, relative to a control 102 that was not subject to the hydrogen peroxide
35 vapor. Again, a 3 log reduction was achieved in 15 seconds. Although tests were conducted at 5 logs, naturally infected

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almonds are more apt to have an initial bacterial count in the order of 10^2 - 10^3 *Salmonella*.

The oxidizing agent treatment is preferably conducted at temperatures below 40° C. Higher temperatures tend to cause
5 cooking of oil in the nuts and other food products, altering flavor. Hydrogen peroxide vapor is also preferred. Exposure to concentrations of 1.8 mg/liter for periods of many minutes have been shown to have no adverse organoleptic effect on the treated product. Further, hydrogen peroxide vapor does not
10 require an aeration zone. Although 15 seconds provides sanitization of human pathogens, longer exposure times can also be used to kill spores and achieve a higher level of kill. Such higher levels of kill would improve not only safety, but also the safe shelf time for the products.

15 Although described with particular reference to almonds in the preferred embodiment, it is to be appreciated that similar concerns and treatment parameters are also effective on a wide variety of nuts and grains, seeds, and spices. The processes are also amenable to dehydrated and dried
20 vegetables and fruits.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of sanitizing human pathogens from surfaces of nuts, the method comprising:

moving the nuts continuously on a porous belt;

5 while the nuts are moving on the belt, treating the nuts with a gaseous oxidizing agent near atmospheric pressure for a sufficient duration to kill human pathogens on the surfaces of the nuts;

10 prior to treating the nuts with the gaseous oxidizing agent, removing husks from the nuts;

after exposing the nuts to the gaseous oxidizing agent, separating shells of the nuts from their nutmeats; and

15 isolating nuts and nutmeats, both before and after shelling, from recontamination by airborne pathogens and from contacting pathogen bearing nuts.

2. The method as set forth in claim 1 wherein the nuts are exposed to the gaseous oxidizing agent for a duration of less than 30 seconds.

20 3. The method as set forth in claim 2 wherein the nuts are exposed to the gaseous oxidizing agent for at least 15 seconds.

4. The method as set forth in any one of claims 1-3 wherein the nuts are exposed to the gaseous oxidizing agent at a temperature below 40° C.

5. The method as set forth in any one of claims 1-4 wherein the nuts are exposed to the gaseous oxidizing agent at refrigeration temperatures.

5 6. The method as set forth in any one of claims 1-5 wherein the nuts are exposed to air concentrations of the gaseous oxidizing agent between 0.1 and 10 mg/L.

7. The method as set forth in claim 6 wherein the gaseous oxidizing agent includes hydrogen peroxide.

10 8. The method as set forth in claim 1 further including:

treating the nutmeats with the gaseous oxidizing agent on all nutmeats entering a production region to prevent downstream cross-contamination.

15 9. The method as set forth in claim 1 wherein after being treated with the gaseous oxidizing agent, at least some of the nutmeats are subject to a thermal processing step which raises the nutmeats to a sufficient temperature for a sufficient duration to effect sanitization of human
20 pathogens in the nutmeats.

10. The method as set forth in any one of claims 1-9 wherein the step of treating the food product with the gaseous oxidizing agent includes:

25 flowing the gaseous vapor sterilant up through the mesh belt with sufficient force to vibrate the food product but with a flow rate which is insufficient to agitate the nuts to the point of physical scarring.

11. The method as set forth in any one of claims 1-10 further including:

vaporizing a liquid to generate the gaseous oxidizing agent;

5 supplying the gaseous oxidizing agent to a treatment chamber having an inlet through which the belt carrying the food product enters the chamber and an outlet through which the belt carrying the food product exits the chamber; and,

10 an exhaust for exhausting the gaseous oxidizing vapor from the chamber.

12. The method as set forth in claim 11 wherein the gaseous oxidizing agent vapor and air are exhausted from the chamber at a flow rate relative to a flow rate at which the
15 gaseous oxidizing agent is supplied to the chamber such that a negative pressure is maintained in the chamber.

13. The method as set forth in claim 11 further including:

providing a curtain of air across the chamber inlet and
20 outlet to (a) prevent gaseous oxidizing agents from escaping to surrounding areas and (b) to prevent humidity and ambient air from entering the chamber through the inlet and outlet.

14. The method as set forth in claim 11 wherein the oxidizing agent is hydrogen peroxide.

25 15. The method as set forth in claim 14 wherein the gaseous hydrogen peroxide is maintained in the chamber at a concentration of about 1.8 mg/liter.

16. The method as set forth in claim 14 wherein the chamber as a length which is commensurate with a distance that the belt travels in 15-30 seconds.

17. The method as set forth in claim 14 wherein during the vaporizing step, the gaseous hydrogen peroxide is entrained in air and further including:

dehumidifying the air in which the gaseous hydrogen peroxide is entrained prior to supplying the air to the vaporizer.

18. The method as set forth in any one of claims 1-17 further including:

treating packaging materials with a gaseous antimicrobial agent;

packaging the nuts in the treated packaging.

19. An apparatus for sanitizing human pathogens from surfaces of agricultural nuts, the apparatus comprising:

a porous belt on which the nuts are continuously moved;

a chamber through which the porous conveyor belt moves continuously;

a means for supplying a gaseous oxidizing agent to the chamber, the chamber having a length relative to the conveying speed of the belt such that the nuts remain in the chamber for a sufficient duration to kill human pathogens on the surface of the nuts;

a husking machine for removing husks from nuts, prior to treatment of the nuts with the gaseous oxidizing agent;

a deshelling machine for shelling the nuts after exposing the nuts to the gaseous oxidizing agent; and

a pathogen barrier which isolates regions upstream of the chamber from regions downstream of the chamber.

20. The apparatus as set forth in claim 19, wherein the means for supplying the gaseous oxidizing agent
5 includes:

a dryer for drying incoming air;

a vaporizer for vaporizing liquid hydrogen peroxide;

and

a blower for blowing the vaporized hydrogen peroxide
10 into the chamber.

21. The apparatus as set forth in either one of claims 19 and 20, further including:

conduits for conveying the vaporized hydrogen peroxide to a lower portion of the conveyor belt below the belt such
15 that the vaporized hydrogen peroxide is drawn upward through the belt.

22. The apparatus as set forth in any one of claims 19-21, wherein the nuts are almonds and wherein the husking machine removes husks from almonds, the husking machine
20 being disposed upstream from the chamber and wherein the deshelling machine is disposed downstream from the chamber such that the shelling machine shells the almonds which have passed through the chamber.

23. The apparatus as set forth in any one of claims
25 19-22, further including:

a supply which supplies a single layer of the nuts to the mesh belt upstream of the chamber.

24. The apparatus as set forth in claim 23, further including:

packaging machines disposed downstream from the chamber for packaging the nuts discharged from the chamber in
5 consumer packages.

25. A method of sanitizing human pathogens from surfaces of nuts substantially as herein described in the Detailed Description of the Preferred Embodiments with reference to the Drawings.

10 26. An apparatus for sanitizing human pathogens from surfaces of nuts substantially as herein described in the Detailed Description of the Preferred Embodiments with reference to the Drawings.

15

DATED THIS TWENTY-FOURTH DAY OF JANUARY 2005

STERIS, INC.

BY

PIZZEYS PATENT AND TRADE MARK ATTORNEYS

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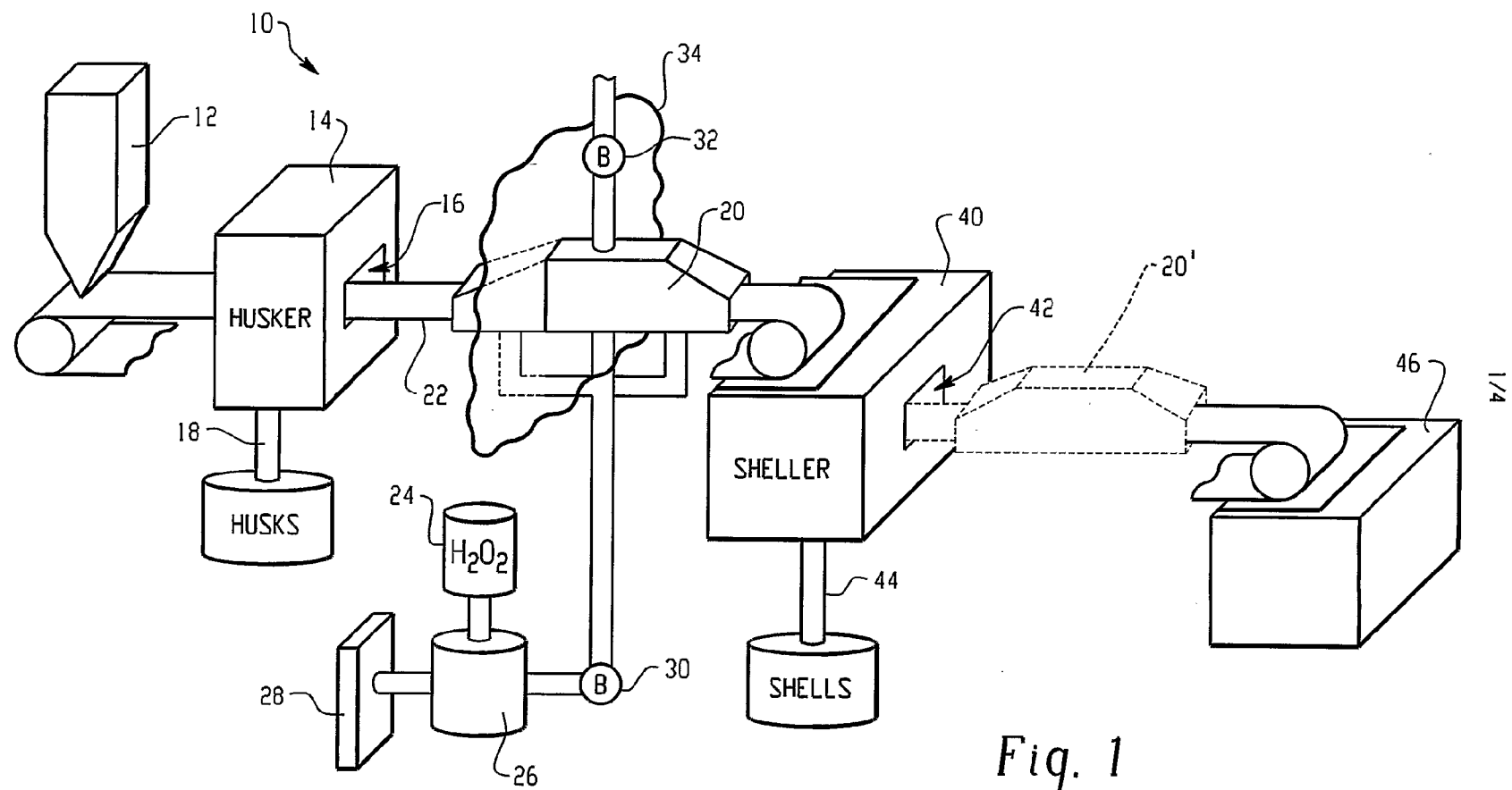
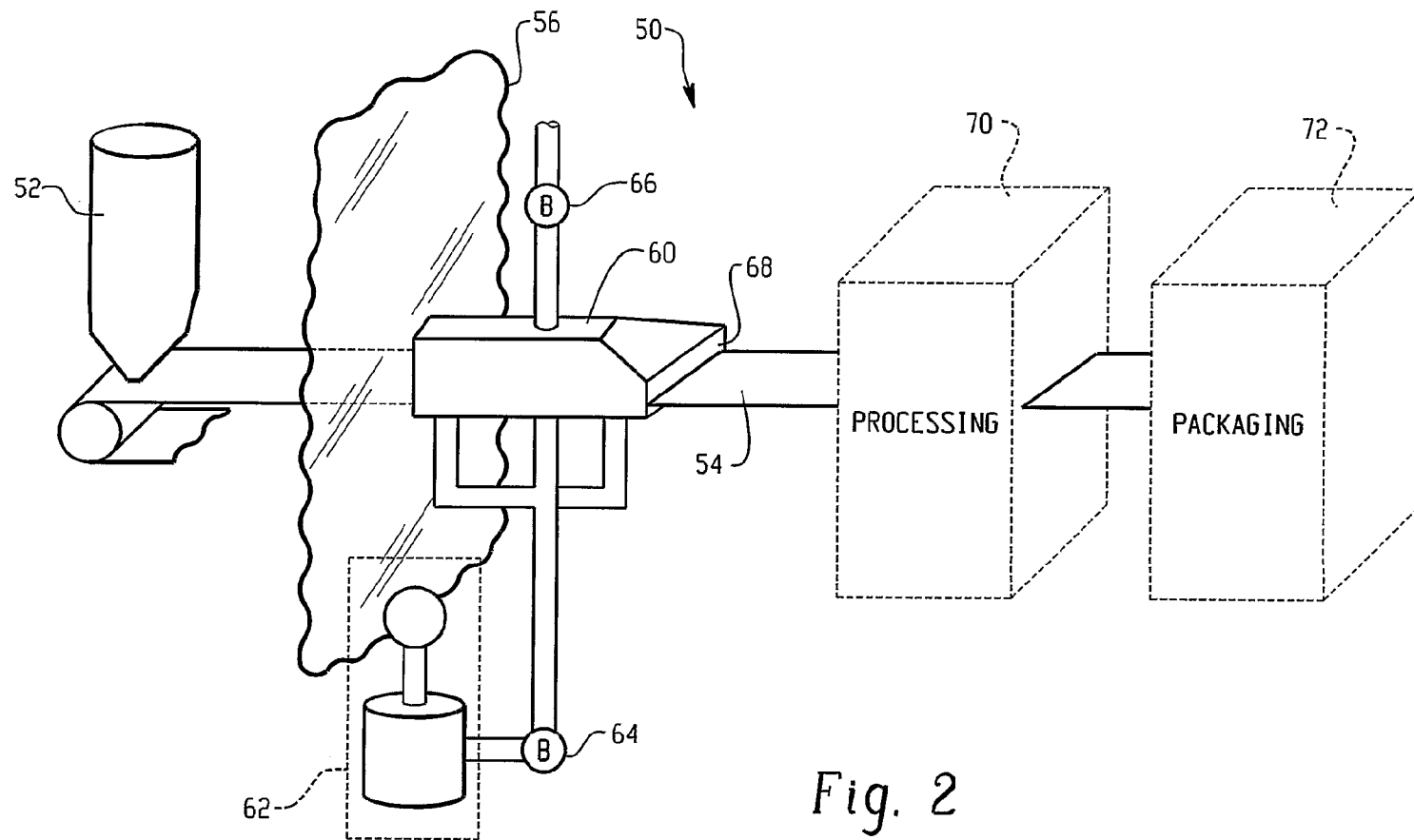
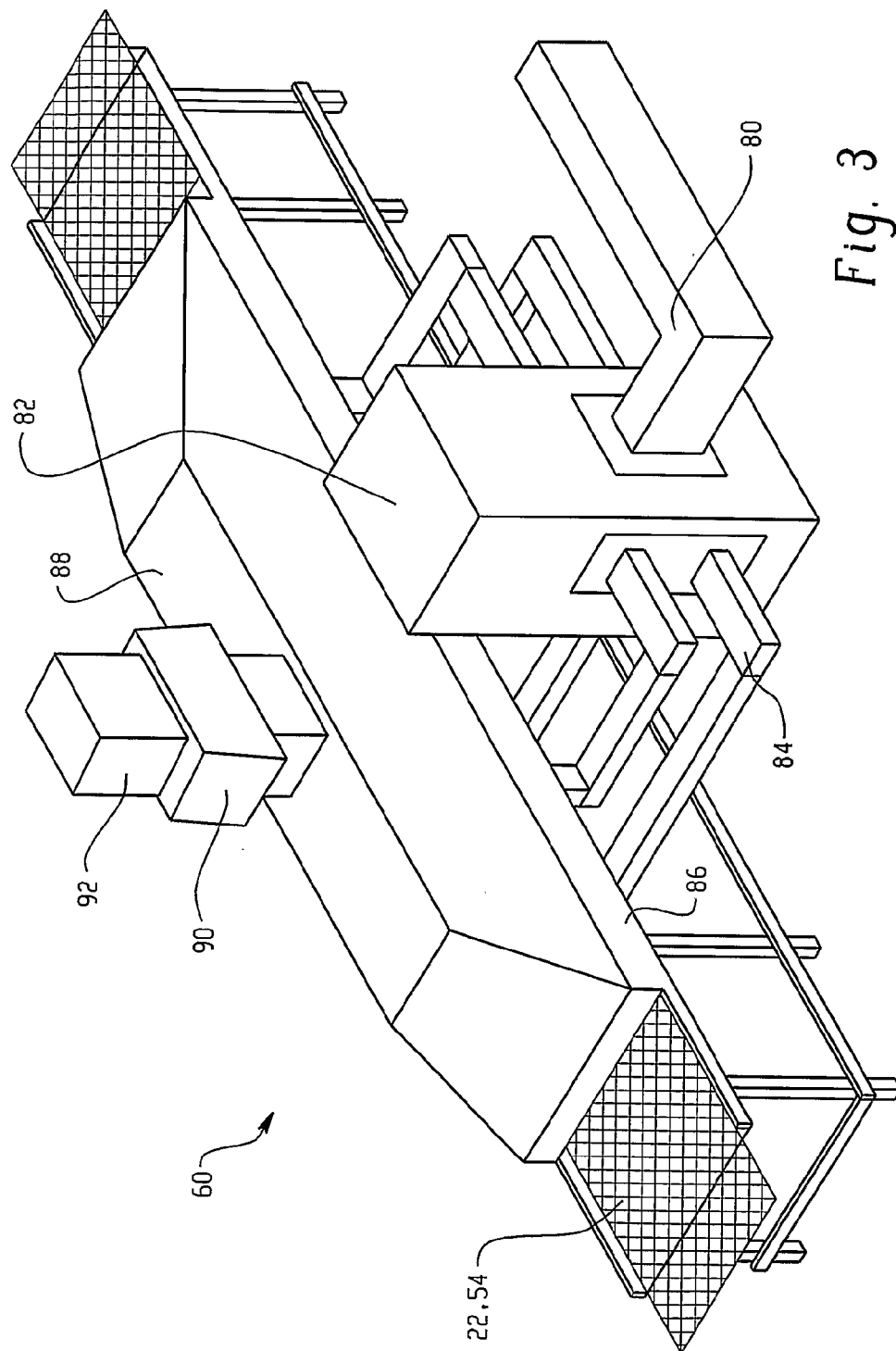
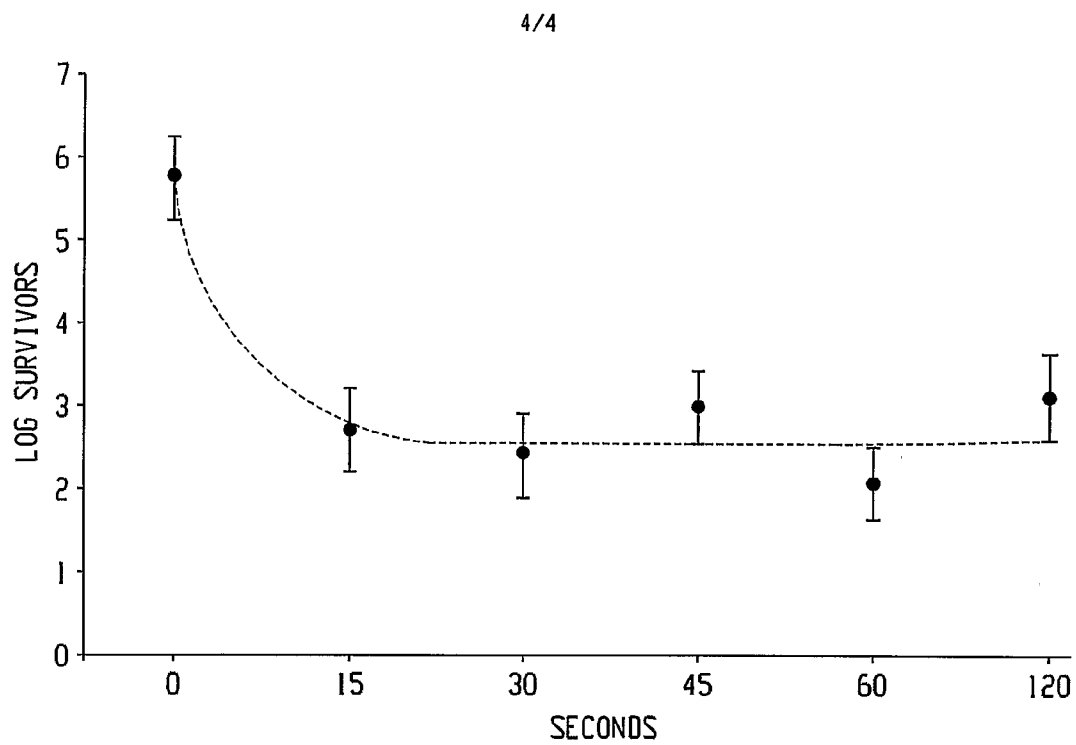
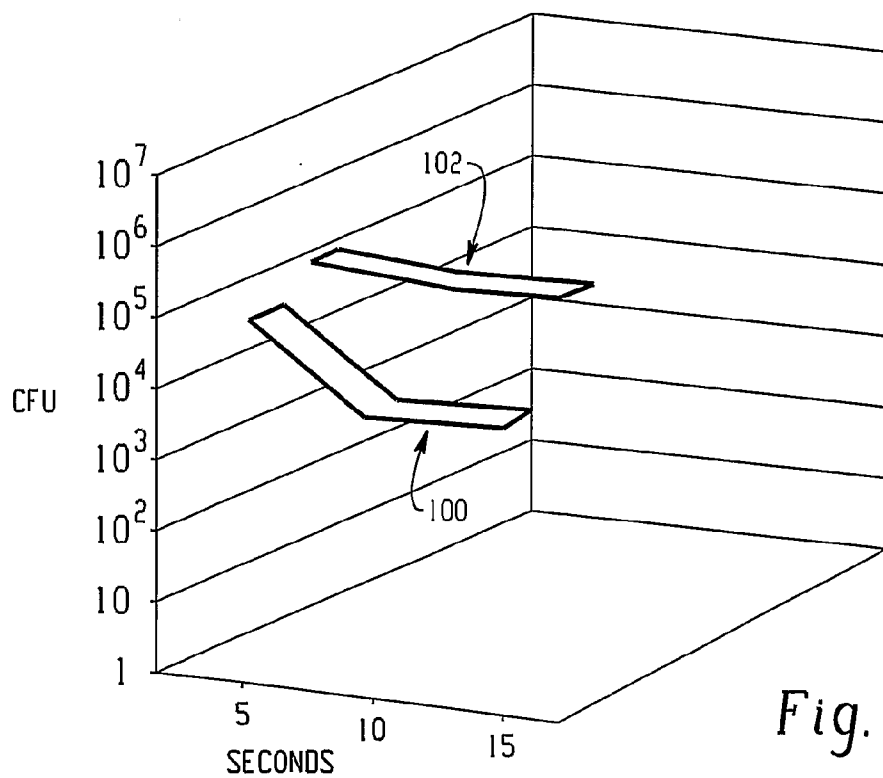


Fig. 1





*Fig. 4**Fig. 5*