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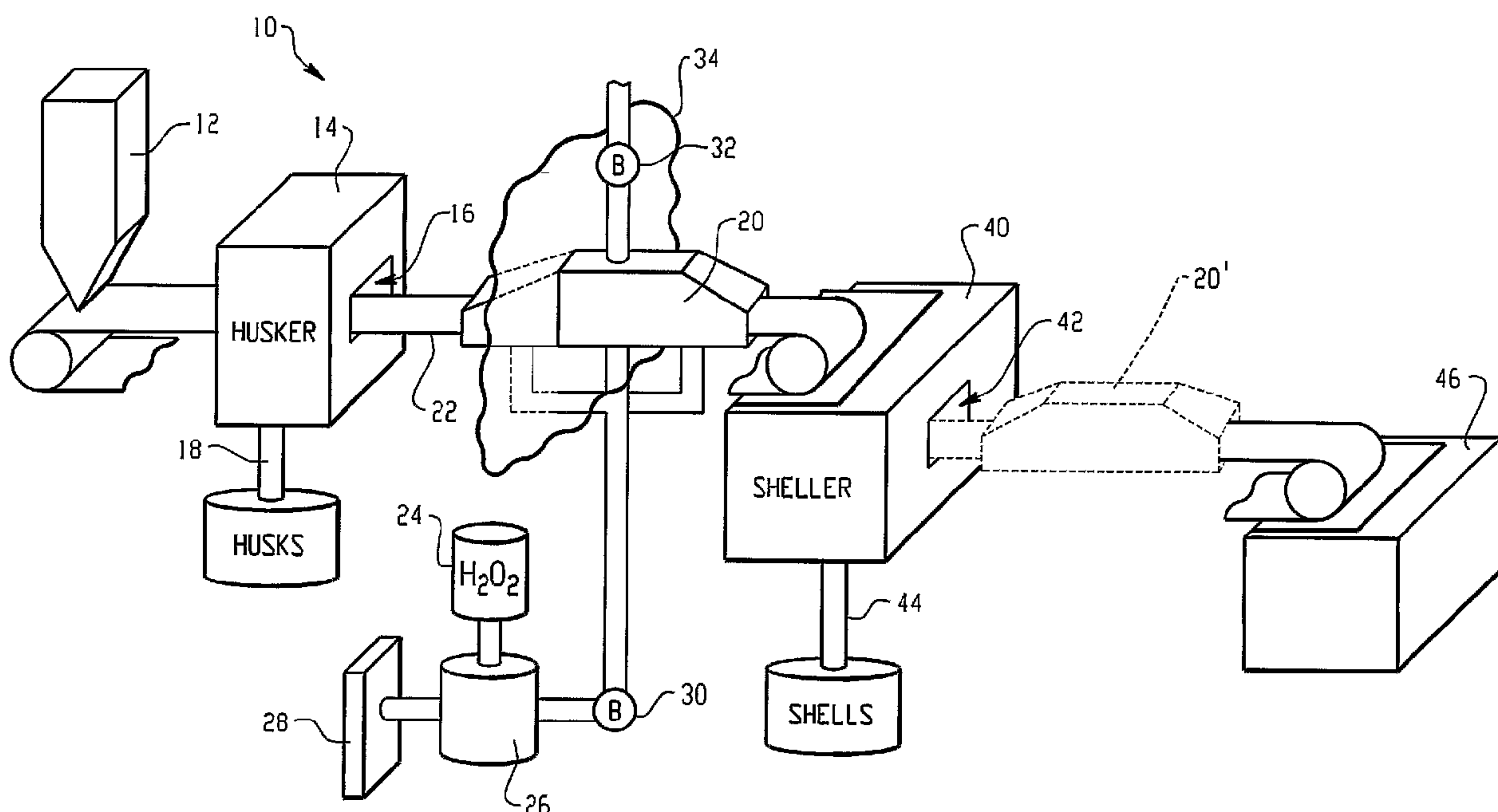
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(54) Titre : NETTOYAGE ANTISEPTIQUE A BASSE TEMPERATURE DE PATHOGENES HUMAINS SUR LES
SURFACES DE PRODUITS ALIMENTAIRES ET D'EMBALLAGES DE PRODUITS ALIMENTAIRES

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



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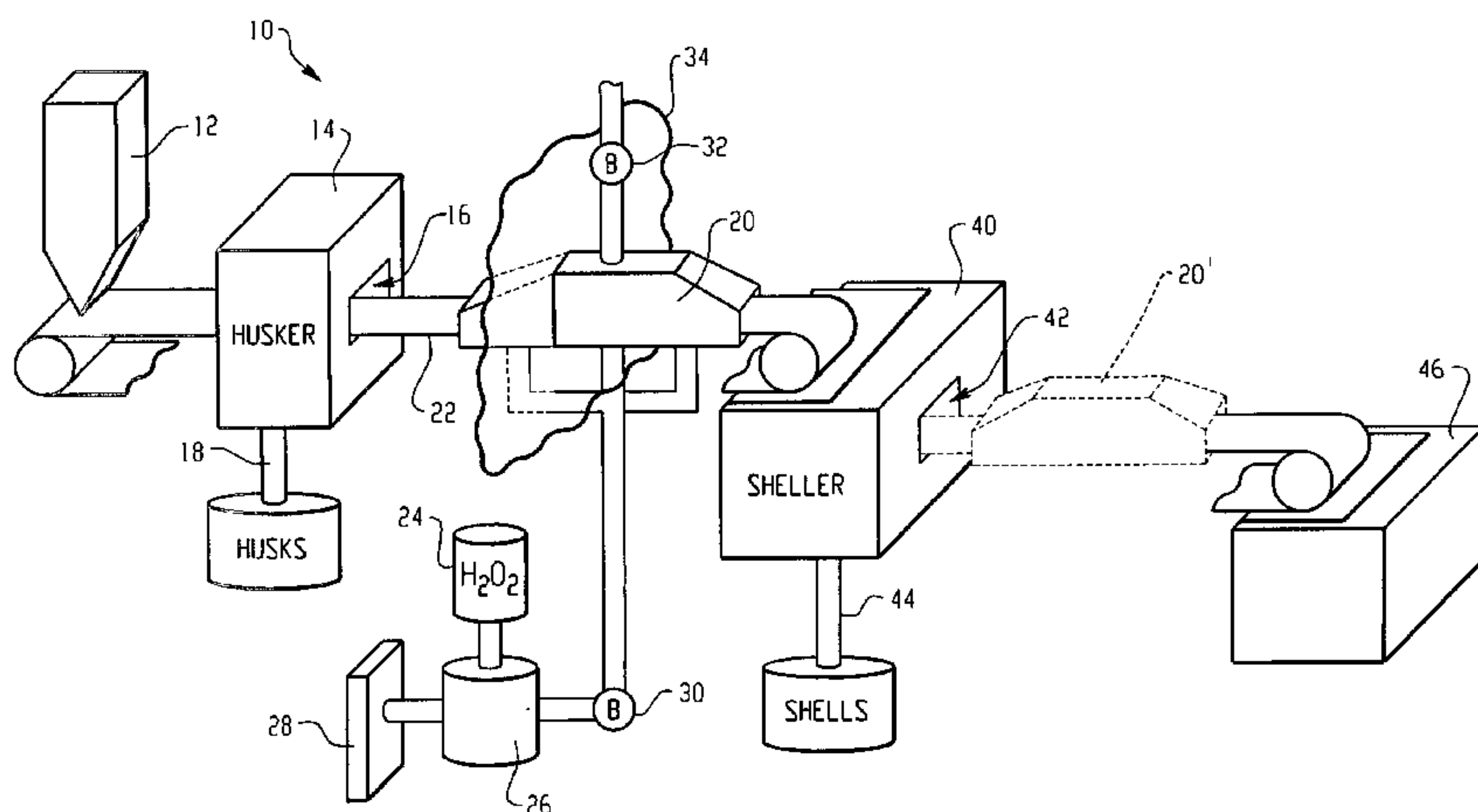
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(54) Title: LOW TEMPERATURE SANITIZATION OF HUMAN PATHOGENS FROM THE SURFACES OF FOOD AND FOOD PACKAGING



(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.

WO 2004/010798 A1

**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. 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 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 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 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 after husking, the shell provides a pathogen impermeable package

-2-

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 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 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 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 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 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 between 0.1 and 10 mg/L of air and good results have been obtained with a concentration of about 1.8 milligrams 20 per liter of air or greater. More specifically to the preferred embodiment, liquid 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 or dehumidifier **28** prior to being supplied to the 25 vaporizer **26** and blown by a blower **30** into the sanitization chamber **20**.

An exhaust blower **32** draws peroxide vapor and water vapor from the sanitization chamber and exhausts them to the atmosphere. The exhaust blower **32**, preferably, is operated at 30 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 into the working atmosphere. Because the almonds are still in the shell and protected, the treatment chamber **20** can tumble or 35 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 microbe impermeable barrier wall **34** is maintained across the hulling and shelling facility **10** with one side of the wall being

-5-

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 pretreated with a gaseous antimicrobial
15 agent and sealed against airborne pathogens. By 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
20 pathogens. Because the husking and shelling operations 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.

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

A sanitization or treatment chamber **60** penetrates the barrier wall **56** such that its inlet receives untreated nuts on the conveyer **54** and its outlet discharges sanitized nuts or other food products on the conveyor **54** which continues
35 downstream. The use of the barrier wall and treatment chamber **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

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 less than 30 seconds. Good results have been obtained with a treatment time of 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

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

The sanitized almonds or other food products are passed to downstream processing equipment **70**. This equipment 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, 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 **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 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 **90** which converts hydrogen peroxide vapor to water vapor and discharges the water vapor through a discharge duct **92**.

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 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 vapor. Again, a 3 log reduction was achieved in 15 seconds. Although tests were conducted at 5 logs, naturally infected

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, and more preferably at temperatures 5 below room temperature. Higher temperatures tend to cause 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 10 treated product. Further, hydrogen peroxide vapor does not 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 15 the safe shelf time for the products.

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 20 spices. The processes are also amenable to dehydrated and dried vegetables and fruits.

-9-

**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

1. A method of sanitizing human pathogens
5 from surfaces of nuts, the method comprising:
moving the nuts continuously on a porous belt;
while the nuts are moving on the belt, killing
human pathogens on the nuts by treating the nuts with a
gaseous oxidizing agent near atmospheric pressure;
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
20 the nuts are exposed to the gaseous oxidizing agent for
a duration of less than 30 seconds.
3. The method as set forth in claim 2 wherein
the nuts are exposed to the gaseous oxidizing agent for
25 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.
30
5. The method as set forth in any one of
claims 1-4 wherein the nuts are exposed to air
concentrations of the gaseous oxidizing agent between 0.1
and 10 mg/L.
35
6. The method as set forth in claim 5 wherein
the gaseous oxidizing agent includes hydrogen peroxide.

-10-

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

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

8. The method as set forth in claim 1 wherein after being treated with the gaseous oxidizing agent, sanitizing the nutmeats by subjecting the nutmeats to a
10 thermal processing step which raises a temperature of the nutmeats.

9. The method as set forth in any one of claims 1-8 wherein the step of treating the nuts with the
15 gaseous oxidizing agent includes:

flowing the gaseous oxidizing agent up through the porous belt with sufficient force to vibrate the nuts.

20 10. The method as set forth in any one of claims 1-9 further including:

vaporizing a liquid to generate the gaseous oxidizing agent;

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

an exhaust for exhausting the gaseous oxidizing
30 agent from the chamber.

11. The method as set forth in claim 10 wherein the gaseous oxidizing agent and air are exhausted from the chamber at a flow rate relative to a flow rate
35 at which the gaseous oxidizing agent is supplied to the chamber such that a negative pressure is maintained in the chamber.

-11-

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

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

13. The method as set forth in claim 10
10 wherein the gaseous oxidizing agent is gaseous hydrogen peroxide.

14. The method as set forth in claim 13 wherein the gaseous hydrogen peroxide is maintained in
15 the chamber at a concentration of 1.8 mg/liter.

15. The method as set forth in claim 13 wherein the chamber has a length which is commensurate with a distance that the belt travels in 15-30 seconds.
20

16. The method as set forth in claim 13 wherein during the vaporizing step, the gaseous hydrogen peroxide is entrained in air and further including:
dehumidifying the air in which the gaseous
25 hydrogen peroxide is entrained prior to supplying the air to a vaporizer.

17. The method as set forth in any one of claims 1-16 further including:
30 treating packaging materials with a gaseous antimicrobial agent;
packaging the nuts in the treated packaging.

18. An apparatus for sanitizing human
35 pathogens from surfaces of agricultural nuts, the apparatus comprising:
a porous belt on which the nuts are

-12-

continuously moved;

a chamber through which the porous belt moves continuously;

a means for supplying a gaseous oxidizing agent
5 which kills human pathogens to the chamber to expose the
nuts on the porous belt in the chamber to the gaseous
oxidizing agent;

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

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

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

19. The apparatus as set forth in claim 18,
wherein the means for supplying the gaseous oxidizing
20 agent includes:

a dryer for drying incoming air;

a vaporizer for vaporizing liquid hydrogen
peroxide; and

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

20. The apparatus as set forth in claim 19,
further including:

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

21. The apparatus as set forth in any one of
35 claims 18-20, wherein the nuts are almonds and wherein
the husking machine removes husks from almonds, the
husking machine being disposed upstream from the chamber

-13-

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.

5 22. The apparatus as set forth in any one of claims 18-20, further including:

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

10 23. The apparatus as set forth in claim 22, further including:

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

15

 24. A method of sanitizing human pathogens from surfaces of almonds, walnuts, or other nuts, the method comprising:

 removing husks from the nuts leaving nuts in
20 their shells;

 moving the nuts in their shells continuously on a mesh belt;

 while the nuts in their shells are moving on the belt, sanitizing the shells by treating the nuts in
25 their shells with a gaseous oxidizing agent such that the shells are sanitized;

 after exposing the nuts in their shells to the gaseous oxidizing agent, removing the sanitized shells from the nuts leaving nutmeats;

30 after removing the sanitized shells, sanitizing the nutmeats by exposing the nutmeats to the gaseous oxidizing agent which kills human pathogens on the nutmeats.

35 25. A method of sanitizing human pathogens from surfaces of almonds, the method comprising:

 moving in-shell almonds through a microbe

-14-

impermeable barrier;

as the in-shell almonds move through the
microbe impermeable barrier, killing microbes on shells
of the almonds, the microbe impermeable barrier
5 protecting the in-shell almonds that have moved through
the microbe impermeable barrier from recontamination by
airborne pathogens;

after killing microbes on the shells,
deshelling the almonds and separating the shells from
10 nutmeats;

moving the nutmeats continuously on a mesh
belt;

while the nutmeats are moving on the belt,
contacting the nutmeats with a gaseous oxidizing agent
15 near atmospheric pressure, the contacting of the nutmeats
with the gaseous oxidizing agent being performed on all
almond nutmeats entering a downstream production region
to prevent downstream cross-contamination.

20 26. A method of sanitizing human pathogens
from surfaces of agricultural food products, the method
comprising:

moving the food products continuously on a mesh
belt through a treatment chamber having an inlet through
25 which the mesh belt carries the food products into the
chamber and an outlet through which the mesh belt carries
the food products out of the chamber;

while the food products are moving through the
chamber on the belt, supplying a gaseous oxidizing agent
30 which kills human pathogens;

exhausting the gaseous oxidizing agent from
the chamber at a flow rate relative to a flow rate at
which the gaseous oxidizing agent is supplied to the
chamber such that a negative pressure is maintained in
35 the chamber;

providing a curtain of air across the chamber
inlet and outlet to (a) prevent the gaseous oxidizing

-15-

agent from escaping to surrounding areas and (b) to prevent humidity and ambient air from entering the chamber through the inlet and outlet.

5 27. A method of sanitizing human pathogens from surfaces of nutmeats, the method comprising:

 moving the nutmeats continuously on a mesh belt;

 while the nutmeats are moving on the belt,
10 killing human pathogens on the nutmeats by treating the nutmeats with a gaseous oxidizing agent near atmospheric pressure;

 treating packaging materials with a gaseous antimicrobial agent;

15 packaging the treated nutmeats in the treated packaging.

 28. An apparatus for sanitizing human pathogens from surfaces of agricultural food products,
20 the apparatus comprising:

 a mesh belt on which the food products are continuously moved;

 a chamber through which the mesh belt moves continuously, the chamber having an inlet through which
25 the mesh belt carries the food products into the chamber and an outlet through which the mesh belt carries the food products out of the chamber;

 a means for supplying a gaseous oxidizing agent to the chamber, which gaseous oxidizing agent kills human
30 pathogens; and

 a means for exhausting the gaseous oxidizing vapor from the chamber at a flow rate relative to the flow rate at which the gaseous oxidizing agent is supplied to the chamber such that a negative pressure is
35 maintained in the chamber;

 a means for providing a curtain of air across the chamber inlet and outlet to (a) prevent the gaseous

-16-

oxidizing agent from escaping to surrounding areas and (b) to prevent humidity and ambient air from entering the chamber through the inlet and outlet.

5 29. An apparatus for sanitizing human pathogens from surfaces of almonds, the apparatus comprising:

 a means for moving in-shell almonds through a microbe impermeable barrier;

10 a means for killing microbes on shells of the almonds as the shells move through the microbe impermeable barrier, the microbe impermeable barrier being configured to protect the in-shell almonds which have passed through the microbe impermeable barrier from
15 recontamination by airborne pathogens;

 a means for deshelling the almonds after killing microbes on the shells and separating the shells from nutmeats;

 a means for moving the nutmeats continuously on
20 a mesh belt;

 a means for contacting the nutmeats with a gaseous oxidizing agent while the nutmeats are moving on the belt at near atmospheric pressure, which gaseous oxidizing agent kills human pathogens, the contacting of
25 the nutmeats with the gaseous oxidizing agent being performed on all almond nutmeats entering a downstream production region to prevent downstream cross-contamination.

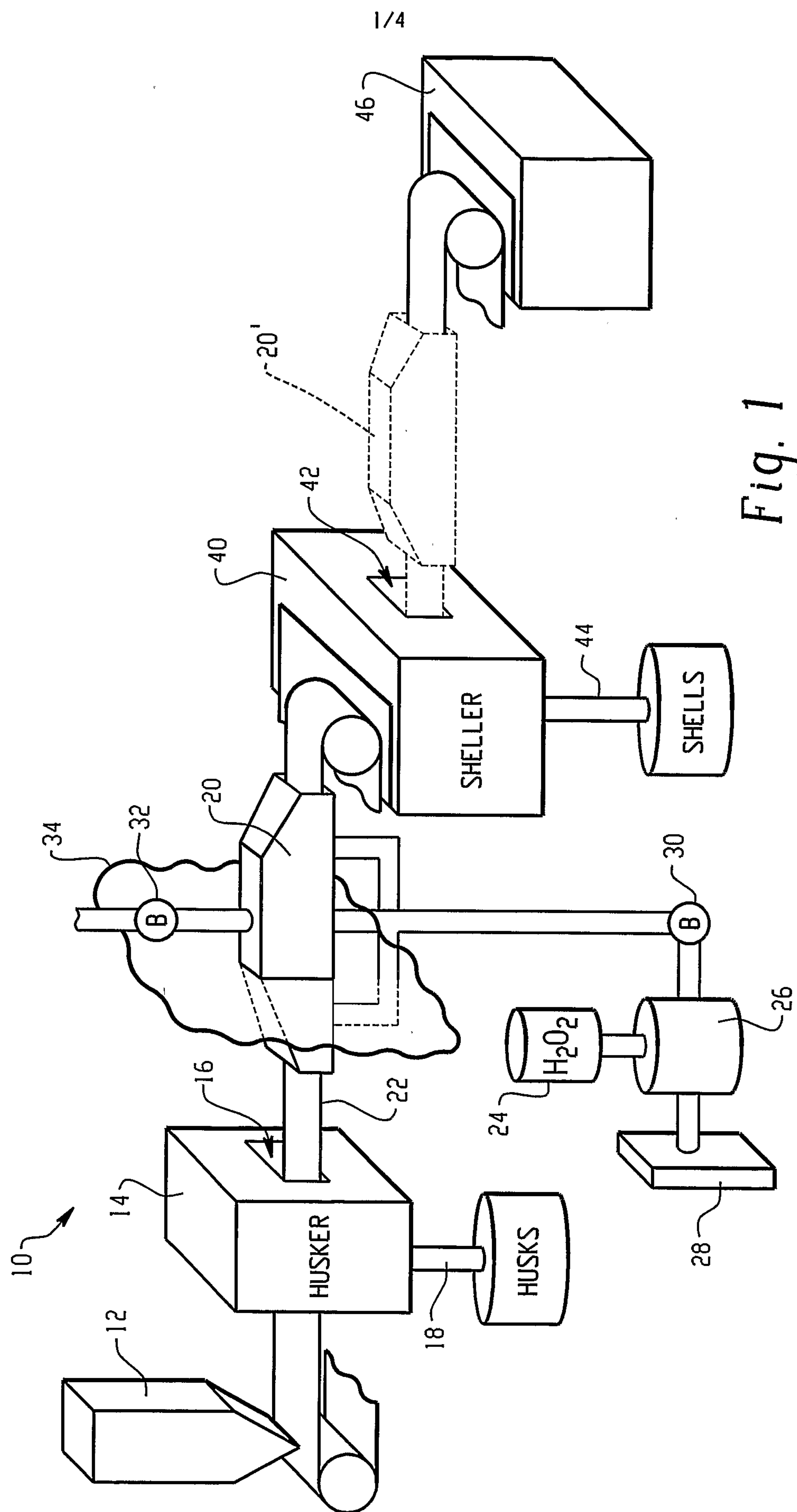


Fig. 1

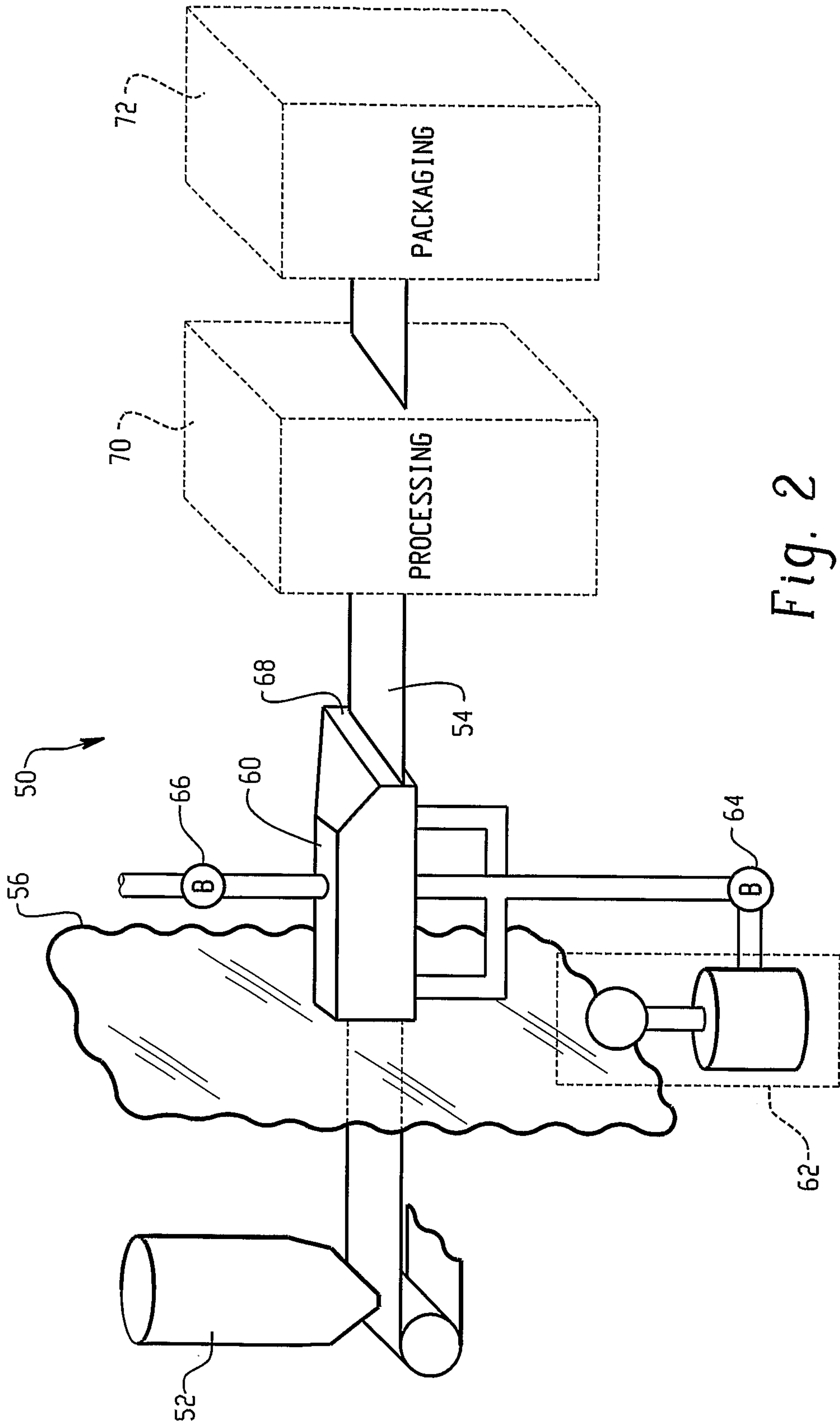
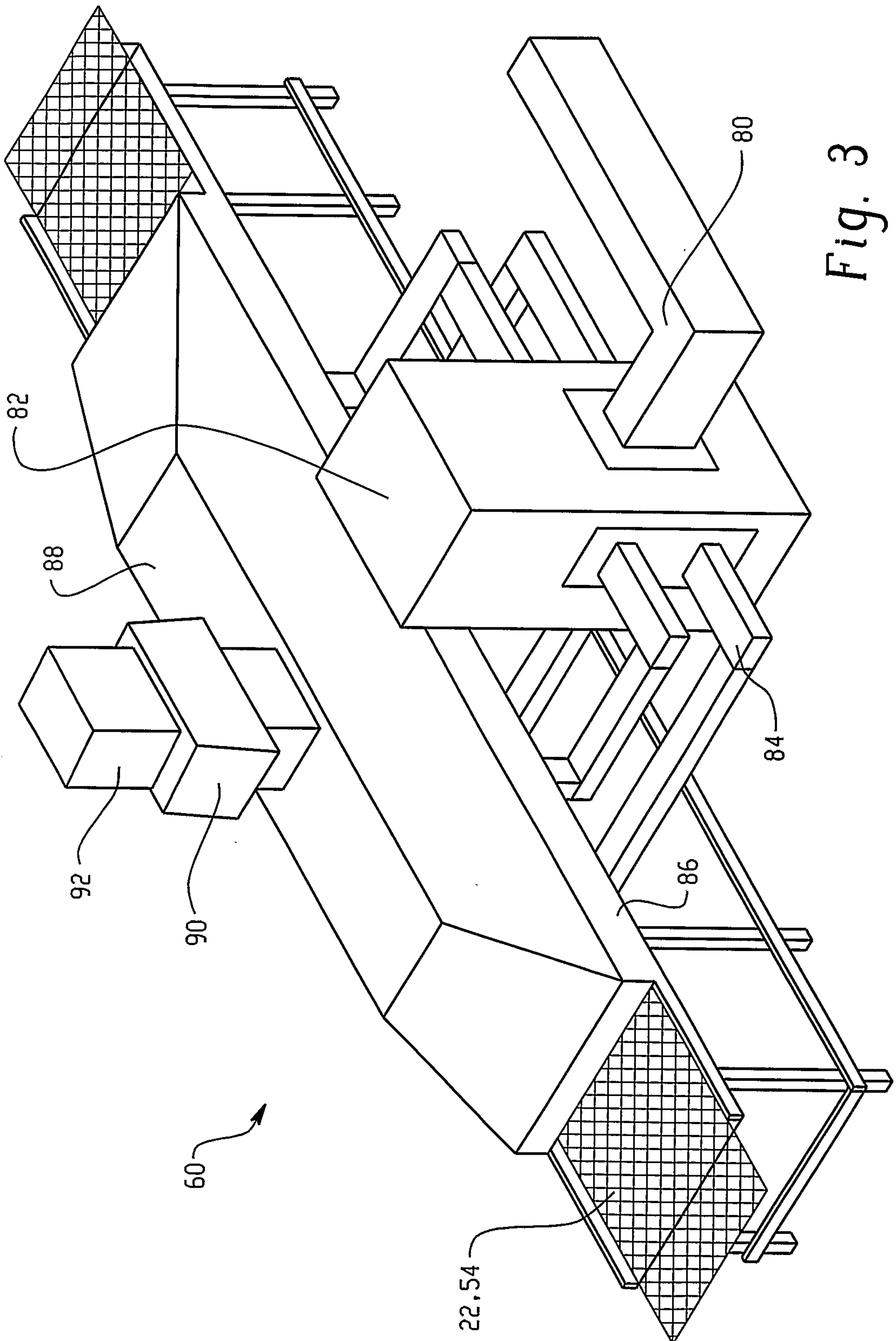
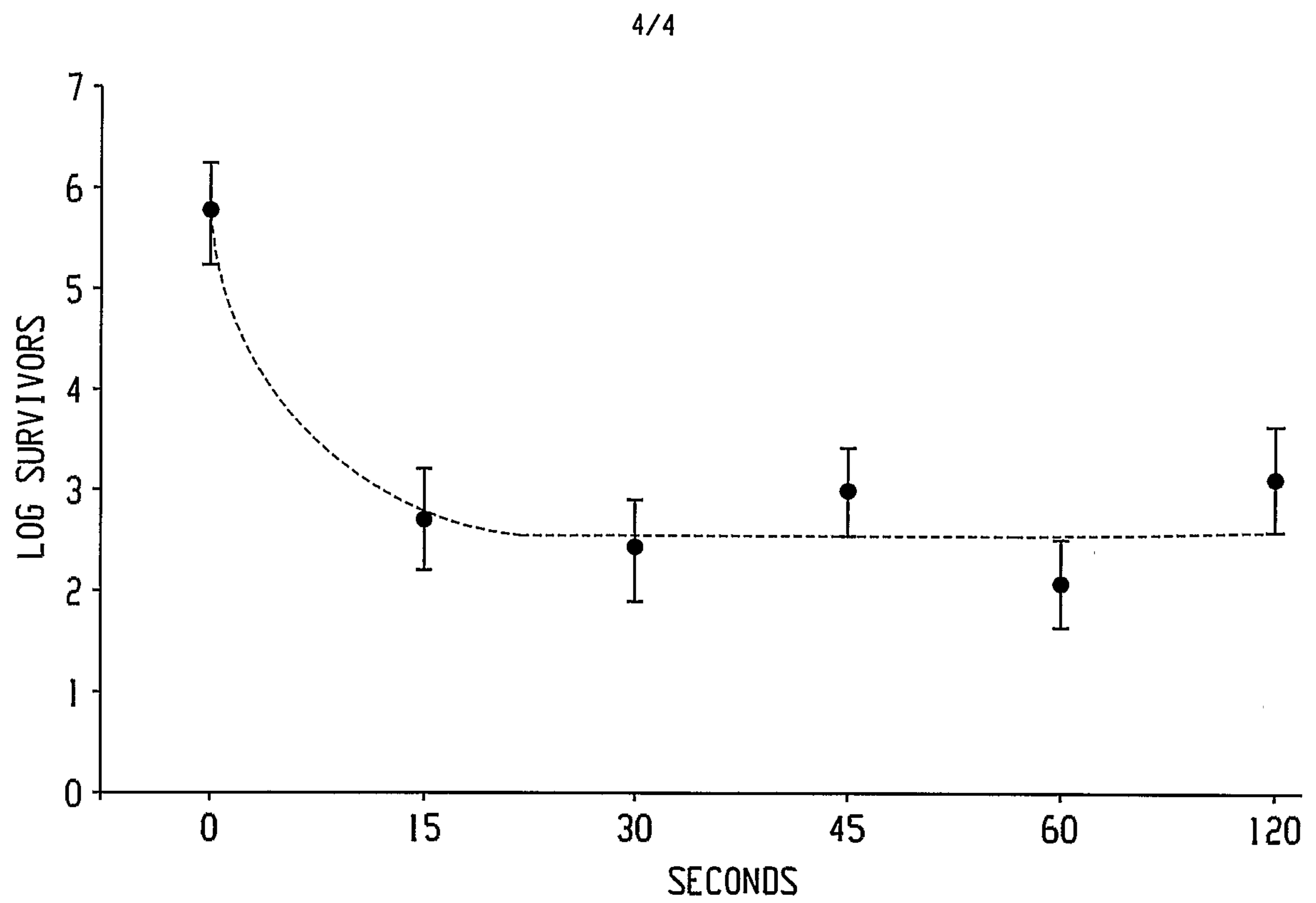
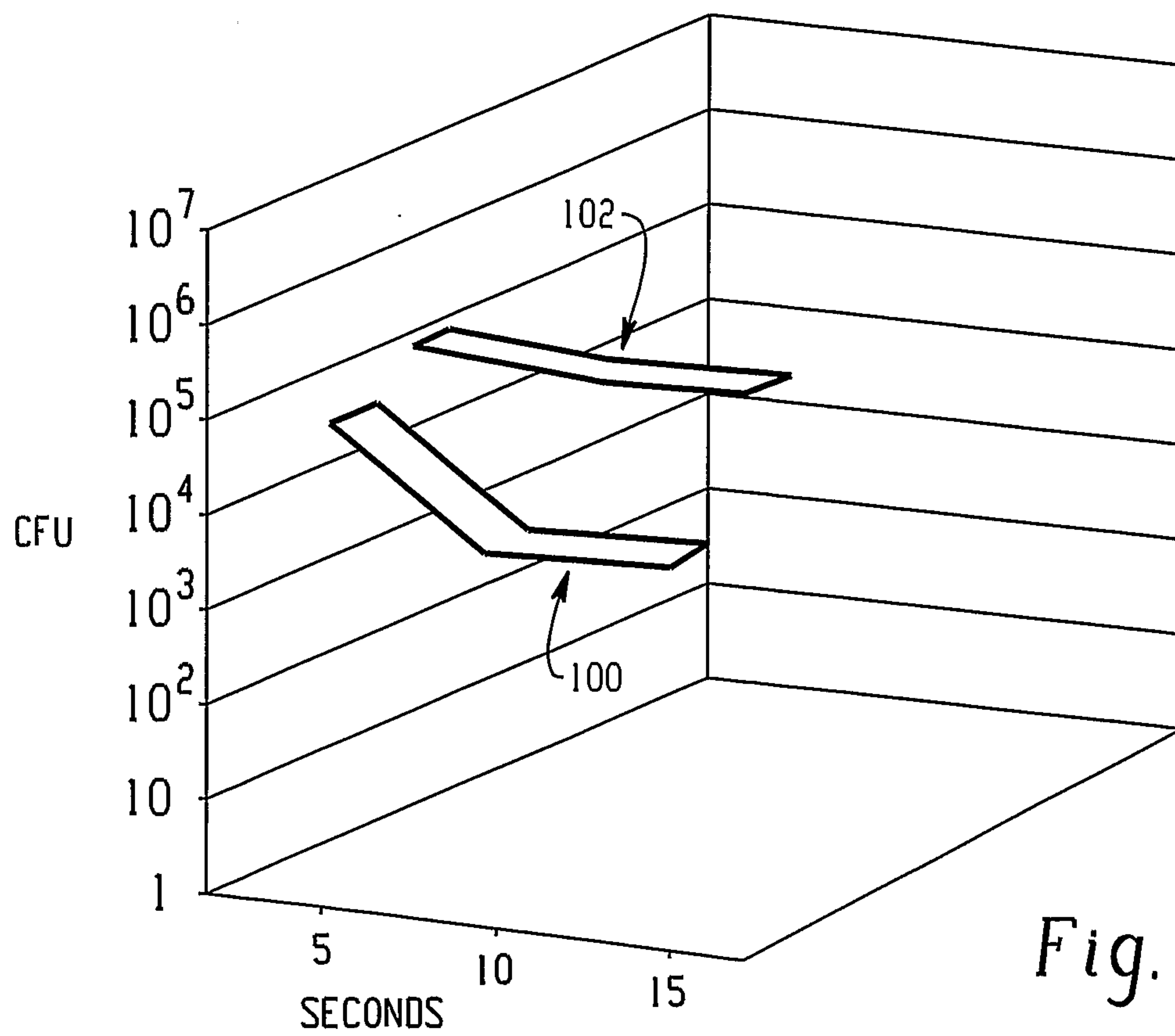


Fig. 2

3/4



*Fig. 4**Fig. 5*

