

(12) PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU 199672343 B2
(10) Patent No. 706802

(54) Title
A method for production of nutrition physiological valuable products and a plant for accomplishing the method

(51)⁶ International Patent Classification(s)
A23L 001/105

(21) Application No: **199672343**

(22) Application Date: **1996.10.07**

(87) WIPO No: **WO97/12525**

(30) Priority Data

(31) Number	(32) Date	(33) Country
9503473	1995.10.06	SE

(43) Publication Date : **1997.04.28**

(43) Publication Journal Date : **1997.06.19**

(44) Accepted Journal Date : **1999.06.24**

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(56) Related Art
DE 4125969



(51) International Patent Classification ⁶ :
A23L 1/105

A1

(11) International Publication Number:

WO 97/12525

(43) International Publication Date:

10 April 1997 (10.04.97)

(21) International Application Number: PCT/SE96/01266

(22) International Filing Date: 7 October 1996 (07.10.96)

(30) Priority Data:
9503473-2 6 October 1995 (06.10.95) SE

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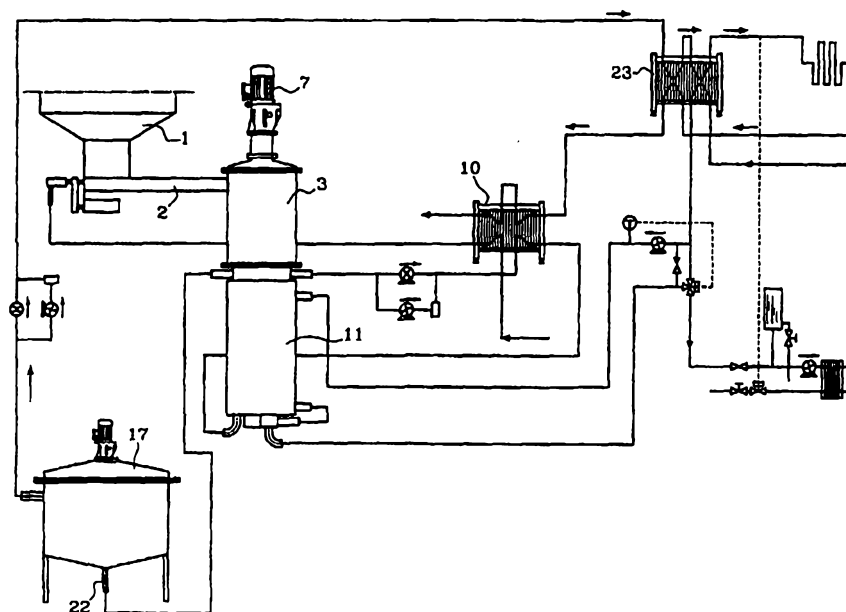
(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published

With international search report.

In English translation (filed in Swedish).

(54) Title: A METHOD FOR PRODUCTION OF NUTRITION PHYSIOLOGICAL VALUABLE PRODUCTS AND A PLANT FOR ACCOMPLISHING THE METHOD



(57) Abstract

The present invention relates to a process for the preparation of nutritionally valuable products from cereals by means of an enzymatic degradation of the starch present in the cereals, whereby the gelatinization and degradation of the starch to soluble dextrines and their continued degradation to more simple oligosaccharides is carried out in one step, as well as a plant for carrying out the process.

A METHOD FOR PRODUCTION OF NUTRITION PHYSIOLOGICAL VALUABLE PRODUCTS AND A PLANT FOR ACCOMPLISHING THE METHOD

Description

Technical field

- 5 The present invention relates to a process for preparing nutritionally valuable products from cereals by means of an enzymatic degradation of the starch present in the cereals to soluble dextrans and in turn their continued degradation to more simple oligosaccharides in one step, as well as a plant for carrying out the process.
- 10 The object of the present invention is to provide a possibility of obtaining nutritionally valuable products from cereals in a simple and rational way, which products are to be used in human and animal applications.

A further object is to obtain a strongly simplified and time-saving process which
15 enables production of products having different amounts of glucose. Hereby different cereals or fractions of cereals can be used as starting materials, such as wheat, oat, barley, rye, maize, sorghum as well as other starch products.

In certain applications the end product can be used directly and does not require
20 drying or further fractionation or drying. In those cases where a dried product is desired, the end product can be dried by spray drying, or varieties thereof, or by a roller dryer. In certain cases the fiber component of the product is separated and dried on its own and used as a high value and pleasant tasting nutritional fibrous product.

25 A further other object of the invention is to provide a production plant for the process of the invention, particularly for a continuous production.

30 Background of the invention

It is known, for instance, from SE-A-7808870-5 to hydrolyze whole cereal grains using protein and starch degradable enzymes. The method disclosed leads to a more complex production process taking 15-30 hrs to carry out to obtain a high content of glucose. These long processing times also leads to the fact that very
35 large plants are needed to be able to produce a larger amount of product. Such a process is further difficult to carry out as a continuous process due to the long retention times. The process according to this prior art technique is primarily based upon

the degradation of the protein present using a proteolytic enzyme at 60°C for 2 hrs to a certain length of the amino acids, then adding an alpha-amylase at 75°C and to treat the starch present for the formation of saccharides for 6 hrs and then

- 5 It has now surprisingly been shown possible to be able to rationalize the production of glucos containing products from cereals by means of the present process and thereby obtaining considerably shortened production times, which means that the process can be developed into a continuous process.
- 10 The present invention further comprises a plant suitable for carrying out the present process.

Description of the present invention

- The present invention is characterized in that the gelatinization and degradation of
15 the starch to soluble dextrins and their continued degradation to more simple oligosaccharides is carried out in one step.

- This is achieved by means of the invention by already in a first phase adding alpha-amylase and amyloglucosidase at the same time as the conditions concerning pH
20 and temperature are so adjusted that the different types of enzymes have a satisfactory activity.

- Hereby a rapid degradation of the starch is obtained avoiding the normally existing, very considerable increase of the viscosity obtained in the beginning of a gelatinization.
25 Simultaneously a very rapid enzymatic degradation of the starch into more simple carbohydrates is obtained and already after a few hours a maximum of the glucose content can be obtained.

- 30 The process further means that the product may contain a mixture of glucose and maltose by choosing a suitable amount of amyloglucosidase and predetermined incubation time.

- As mentioned above crushed whole grains of wheat, oat, barley, rye, maize and
35 sorghum can be used as starting materials. The particle size is hereby not essential to the process as such but is rather determined by the final drying method used alternatively, the fractionation of the end product and application use. Also flours of

these cereals can be used as well as other raw materials rich in starch.

5 The process is carried out in a suitable reaction vessel provided with a stirrer and having means for to maintaining a desired temperature. However, in the present application there is further disclosed a preferred plant for a continuous production which plant comprises a blending and heating unit, heat exchangers, reaction vessels, and end reaction vessel.

10 Generally, the raw material while being stirred is provided with water preheated to 40 to 75°C, preferably 40 to 60°C and provided with alpha-amylase as well as an amyloglucosidase, whereby the temperature of the total mixture is at most 55°C.

15 Suitable alpha-amylases are Termamyl (reg. trademark) 120L (Novo), BAN 240L (Novo) or the corresponding. A suitable amyloglucosidase is AMG 200L (Novo) or the corresponding. These enzymes as mentioned are present in liquid form and are thus easy to add in correct dose. When Termamyl is used less Ca-ions are needed in the solution.

20 When about 30 to 50% of the starch containing raw material has been added an adjustment of the pH is made to 4.5 to 5.5, suitably pH 4.9 using hydrochloric acid or citric acid or another suitable acid. Then the temperature is raised to a range of 60 to 75°C until the reaction product has obtained the composition desired with regard to its glucose content. Simultaneously herewith the gelatinization which is
25 important to the process, is obtained, which however, due to a certain degradation of the starch already has happened does not lead to such an increase of the viscosity that should have been obtained if the starch had not already been partly degraded. Then the enzymes are inactivated by heating of the reaction product to 90 to 95°C, alternatively 125 to 130°C for 30 to 60 sec. depending on the thermosta-
30 bility of the amyloglucosidase used. Simultaneously there is a sterilization of the product.

The end product can now be used directly for certain applications and in other applications first after having been dried, concentration to a suitable water content.
35 Storage of the product can be done in suitable designed vessels depending of the end use. In particular one should consider the maintaining of the sterility. Aseptic packaging is thus possible and suitable.

As mentioned above the end product can also be spray dried or be roller dried. If a fiber fraction is separated off this is preferably dried in a drier using heated air.

- 5 The invention will be described more in detail in the following with reference to some non-limiting examples.

Example 1

Production of a glucose enriched product starting from wheat flour

- 10 As raw material a conventional wheat flour was used, whereby 500 g of wheat flour are added while being stirred to 1000 ml of water heated to about 55°C, which water contains 1.0 ml of Termamyl 120L and 2.0 ml of AMG 200L. When about 50% of the wheat flour had been added pH is adjusted to 4.9 by adding a diluted hydrochloric acid, whereupon, when all the wheat flour had been added, further diluted
15 hydrochloric acid is added to said pH. The temperature of the mixture is then raised to 70 to 75°C, simultaneously as the content of simple carbohydrates formed is successively determined using HPLC. The increase of simple carbohydrates in the soluble part is evident from Figure 1. After 3 hrs at 70°C the incubation is brought to a stop by inactivating the enzymes by heating using micro waves to 95°C, whereby
20 the product is simultaneously being sterilized

After drying a product is obtained having a sweet taste comprising 68% of glucose

Example 2

Production of a glucose enriched product starting from whole wheat

- 25 Whole wheat grains are milled to a particle size of 0.05 to 1.5 mm. 700 g of the wheat are added while being stirred to 1000 ml of water having a temperature of 55°C and comprising 1.0 ml of Termamyl 120L and 2.0 ml of AMG 200L. When about 50% of the wheat has been added pH is adjusted to 4.9 by adding diluted
30 hydrochloric acid and then when all the wheat has been added a further addition of hydrochloric acid. The amount of hydrochloric acid is depending on the buffering capacity of the raw material. The temperature of the mixture was then raised to 70 to 75°C during a continued stirring, whereby the incubation continues. The amount of simple carbohydrates is determined using HPLC. After 3 hrs at 70°C the inuba-
35 tion is stopped and the product is sterilized and the enzymes are deactivated by heating to 95°C.

After drying a sweet product is obtained having a glucose content of 55%.

Example 3

Production of a glucose enriched product starting from oat

- 5 Whole oat grains having been freed from its sticky casing are milled to a fine flour having the approximate particle size as in Example 2. 700 g of the flour are added to 1000 ml of water heated to 55°C and containing 1.5 ml of Termamyl 120L and 2.5 ml of AMG 200L. When about 50% of the flour has been added pH is adjusted by adding hydrochloric acid and pH is then finally adjusted to 4.9 by adding hydro-
- 10 chloric acid when all the oat has been added. The temperature of the mixture was then raised to 70 to 75°C during a continued stirring, whereby the incubation continues. The amount of simple carbohydrates is determined using HPLC. After 3 hrs at 70°C the incubation is stopped, and the product is sterilized, and the enzymes are deactivated by heating to 95°C. The dry content of the soluble part then 71 % con-
- 15 sisted of glucose.

After drying a sweet product having a mild taste of oat is obtained and having a glucose content of 59%.

- 20 In the examples above 33 to 41 % amount of dry content has been used for the mixture of the raw material in the water. This amount can, however, be increased to 50% without any greater problem, whereby the optional need for drying is reduced, as well as the product can more easily be used in the direct production of food stuffs, such as bakery products.

25

In the examples above alpha-amylase has been used together with amyloglucosidase. Alpha-amylase can be used in combination with beta-amylase if so desired.

- The end product can be used as a general food stuff additive in stead of sugar,
- 30 such as in bakery products, ketchup, ice-cream and other products.

The product prepared provides an increased degree of creaminess to the product in which it is used such as in drinks and others.

- 35 As mentioned above the present invention relates to a plant for carrying out the present process as well, during continuous conditions. This part of the invention will be described more in detail with reference to the attached drawing, wherein

FIG. 2 shows a plant in general;

FIG. 3 shows a blending reactor of the plant in cross-section

FIG. 4 shows a reaction reactor of the plant in cross-section;

FIG. 5 shows the reaction reactor of FIG. 4 in cross-section in a plane perpendicular
5 to the rotational axis; and

FIG. 6 shows an end incubation reactor of the plant in cross-section.

A preferred plant for carrying out the process according to the invention is shown in general in FIG. 2. The flour of a suitable origin is fed into a storage container 1, from
10 which container 1 the flour is then fed to a transporting screw 2 up to a prereactor 3. Before the flour is being introduced into the prereactor 3 water is added in a suitable amount and having a suitable temperature in relation to the flour in such a way that the water content is about 50% and the temperature is about 50°C. The enzymes needed for the hydrolysis of the starch present are dissolved or suspended in
15 the water. The prereactor comprises, as shown in FIG. 3, two helical screws 4 and 5, whereby the inner one 4 is mounted directly to the throughgoing shaft 6 which is driven by a motor 7 with a speed of about 100 rpm, and whereby the outer helical screw is mounted to and driven via a paddle stirrer 8 in the lower part of the reactor. Between the two helical screws 4 and 5 there are one or more stationary stirring
20 means 9 which lead to the fact that the starch-water-mixture, which primarily has a very high viscosity not only accompany the screw movement but is mixed as well. As the helical screws have opposite rise but are driven at the same direction will, in the example, the inner helical screw 4 drive the material downwards, while the outer helical screw lifts the material. The contracting movements leads to a very
25 high degree of homogenization of the material. Thus the downwardly directed movement in the centre of the reactor, according to the embodiment, that the material is compressed in order to then become loosened during the raising movement in the periphery of the reactor. After a retention time of "some" minutes the flour-water-mixture is fed out in the form of a slurry from the prereactor whereby the temperature is 48 to 50°C. The slurry is then fed using a pump to a heat exchanger 10
30 where the temperature is raised to about 60°C and then to 70°C, whereupon the slurry is fed to second reactor 11 (FIG. 4). At the heating to 70°C the gelatinization being important to the process takes place, whereby a marked increase in viscosity is obtained. The slurry is introduced in the lower part of this reactor and is transported
35 ed upwards through the reactor by means of the pressure from the pump. The second reactor 11 comprises a jacketed outer surface 12 and a central cylindrical body 13, which is jacketed as well. The reactor further comprises two helical screws

14 and 15, which are driven by a common motor. In the embodiment according to the present FIG. 2, FIG. 3 and FIG. 4 they are driven by the motor 7. In this reactor 11, as well, the helical screws 14 and 15 are contrary rotating, i.e. the one 15, the outer one, presses the material downwardly, while the other, 14, the inner one, lifts the material. The helical screws are arranged in such a way that there is a smaller gap between the jacketed surface 12 and the jacketed surface 13. As these surfaces are hot the material may adhere to these surfaces and in order to eliminate this the respective helical screw is provided with vertical scraping elements 16 which are placed in recesses in their respective helical screw 14 or 15 (FIG. 6). The scraping elements 16 are suitably made of an inert material vis-à-vis the slurry and can be simply exchanged from either side of the reactor, suitably from above. After having passed the reactor 11 during heating by adding heat to the two jacketed surfaces 12 and 13 the slurry is removed from the upper part of the reactor 11. The slurry is hereby transferred to the incubation reactor (FIG. 5) for the final hydrolysis, whereby the retention time in this incubation reactor 17 is about 2 hrs. The incubation reactor 17 comprises a number of concentrically arranged cylindrical walls 18 and 19, whereby every second one, 19, is arranged from the bottom 20 and every second, 18, is arranged from the top 21 of the reactor. The inner cylinder 18 may also consist of shafts. The cylinders 18 and 19 respectively, do not pass through the entire height of the reactor but ends somewhat above the bottom 20 of the reactor, and somewhat below the top 21 of the reactor. The cylinders 18 arranged to the top 21 of the reactor are rotatably arranged via the motor arranged to the upper part of the reactor. The rotation may hereby be either single directed or alternating double directed. The material, the slurry, is introduced centrally in the bottom of the reactor through an inlet 22. As the cylinders do not cover the entire the whole height of the reactors, gaps are formed over, or below the respective cylinder wall above and below, respectively, the slurry can pass such has been marked with arrows in FIG 3. Subsequent to the incubation 17 the slurry is fed by means of a pump to a heat exchanger 23 where the temperature is raised to 110 to 120°C in order to deactivate the enzymes. The slurry is then fed again through the same heat exchanger 23 in order to make use of its heat for heating of later incoming slurry and cooling before it is fed further to the first heat exchanger 10, where the temperature is once again about 50°C. The slurry is being heat exchanged in the final step suitably against cold water which is used as ingoing water in the preparation of a new slurry in the blending step, whereby this water obtains the right temperature for the blending and thereby the hydrolysis.

CLAIMS (PCT/SE96/01266) as amended 98-01-08

1. Process for the preparation of nutritionally valuable products from cereals by means of an enzymatic degradation of the starch present in the cereals, characterized in that the
5 gelatinization and degradation of the starch to soluble dextrans and their continued degradation to more simple oligosaccharides is carried out in one step, whereby the enzymes used for the degradation are added to the cereal raw material via the liquid used for slurring and heating said raw material, the temperature of the ingoing liquid being 40 to 75°C and the amount of water used in the ingoing slurry is 50%.

10 2. Process according to claim 1, characterized in that the temperature of the final slurry is 55°C.

15 3. Process according to claims 1-2, characterized in that temperature of the reaction product after initial blending of the liquid comprising enzymes is raised to 60 to 75°C while gelatinization occurs.

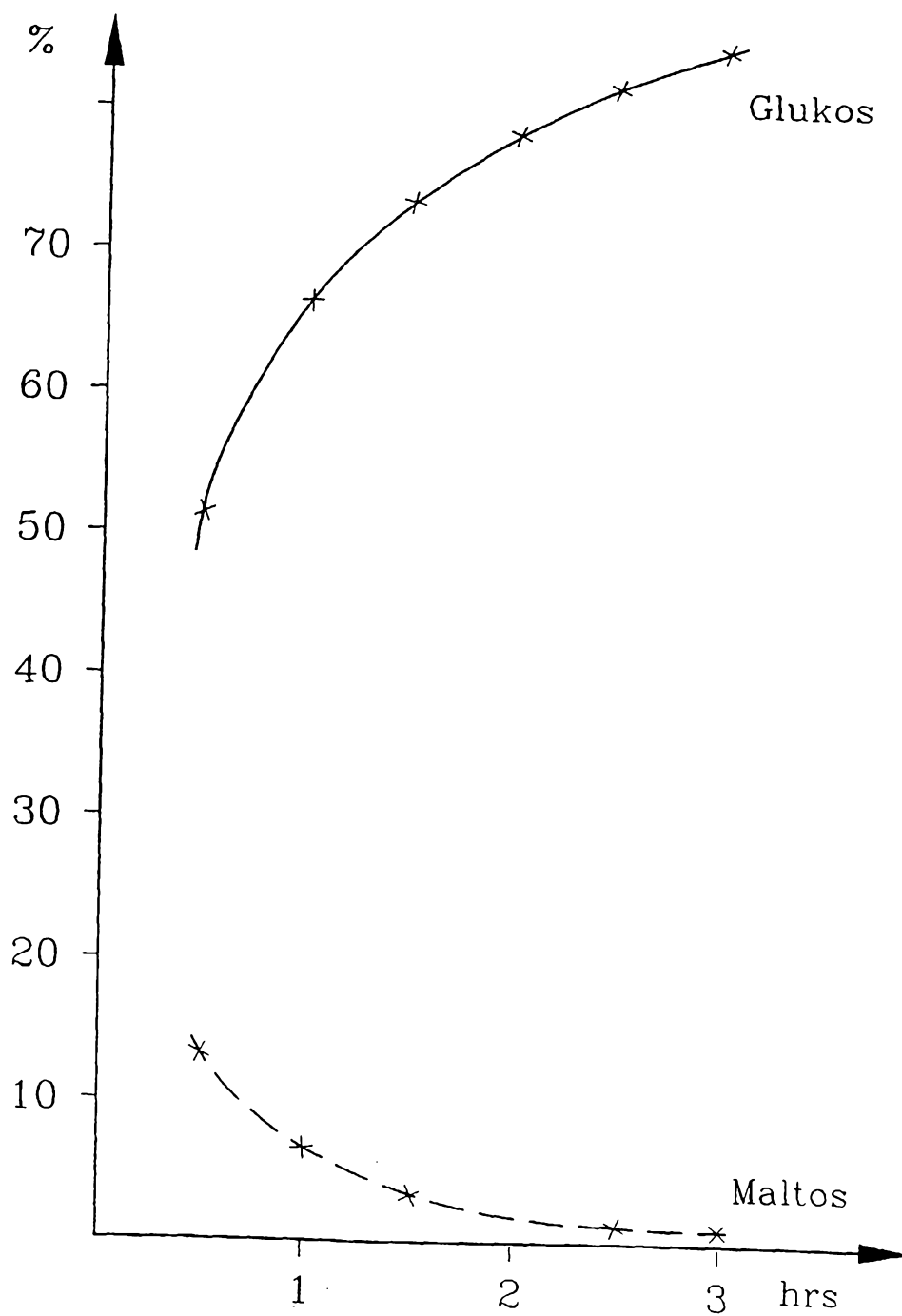
20 4. Plant for carrying out the process of claims 1-3, characterized in that it comprises a blending reactor (3), a reaction reactor (11), and an incubation reactor (17), whereby these reactors (3, 11, 17) are provided with homogenizing stirres (4, 5; 14, 15; 18, 19), whereby the blending and reaction reactors comprise each their contra-acting helical screw stirrers (4, 5; 14, 15).

25 5. Plant according to claim 4, characterized in that the incubation reactor (17) is provided with concentric separating walls (18, 19) which are arranged to the one side (21) of the reactor, and to the other side of the reactor, respectively.



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FIG. 1



Incubation vid 70 C

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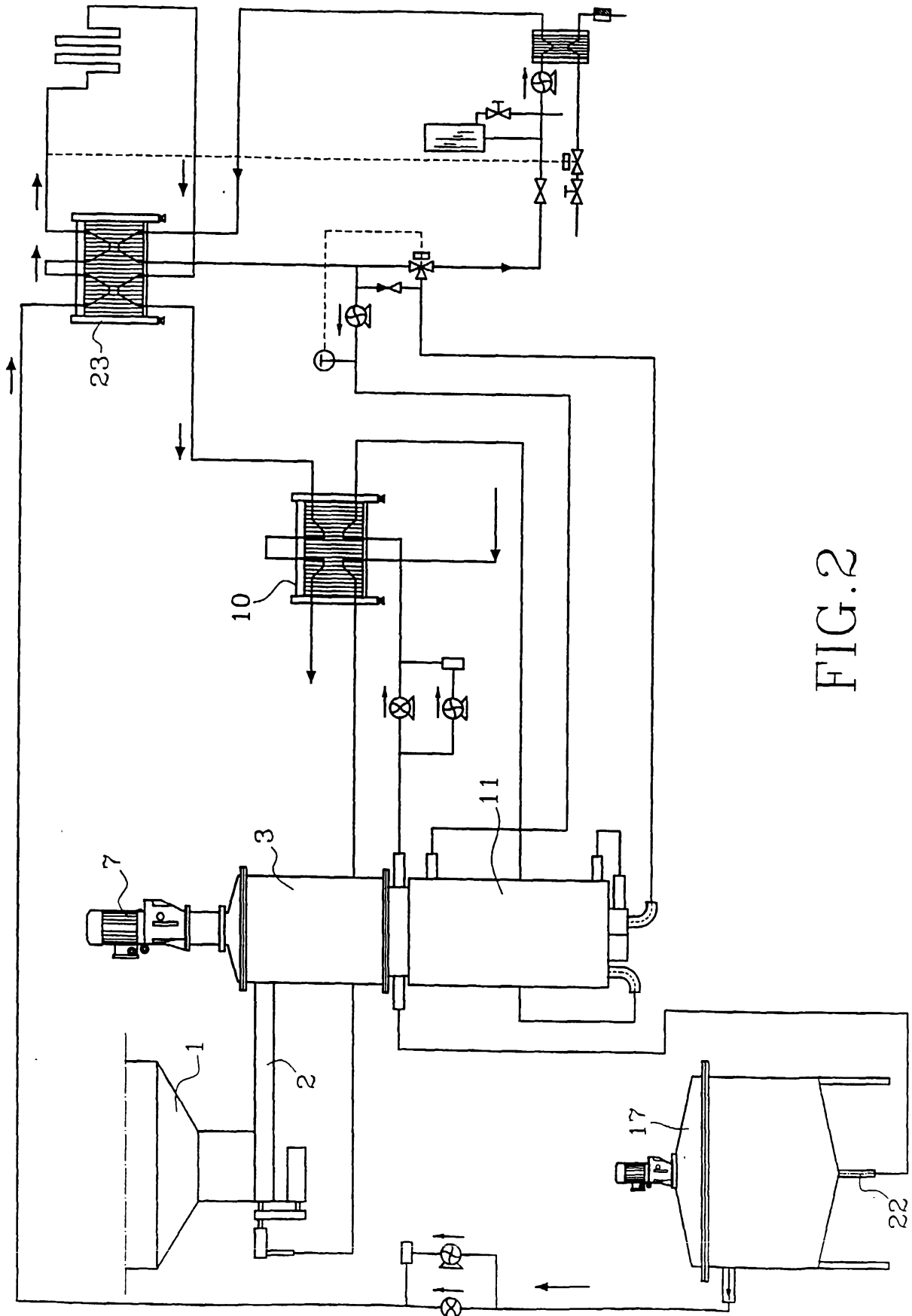
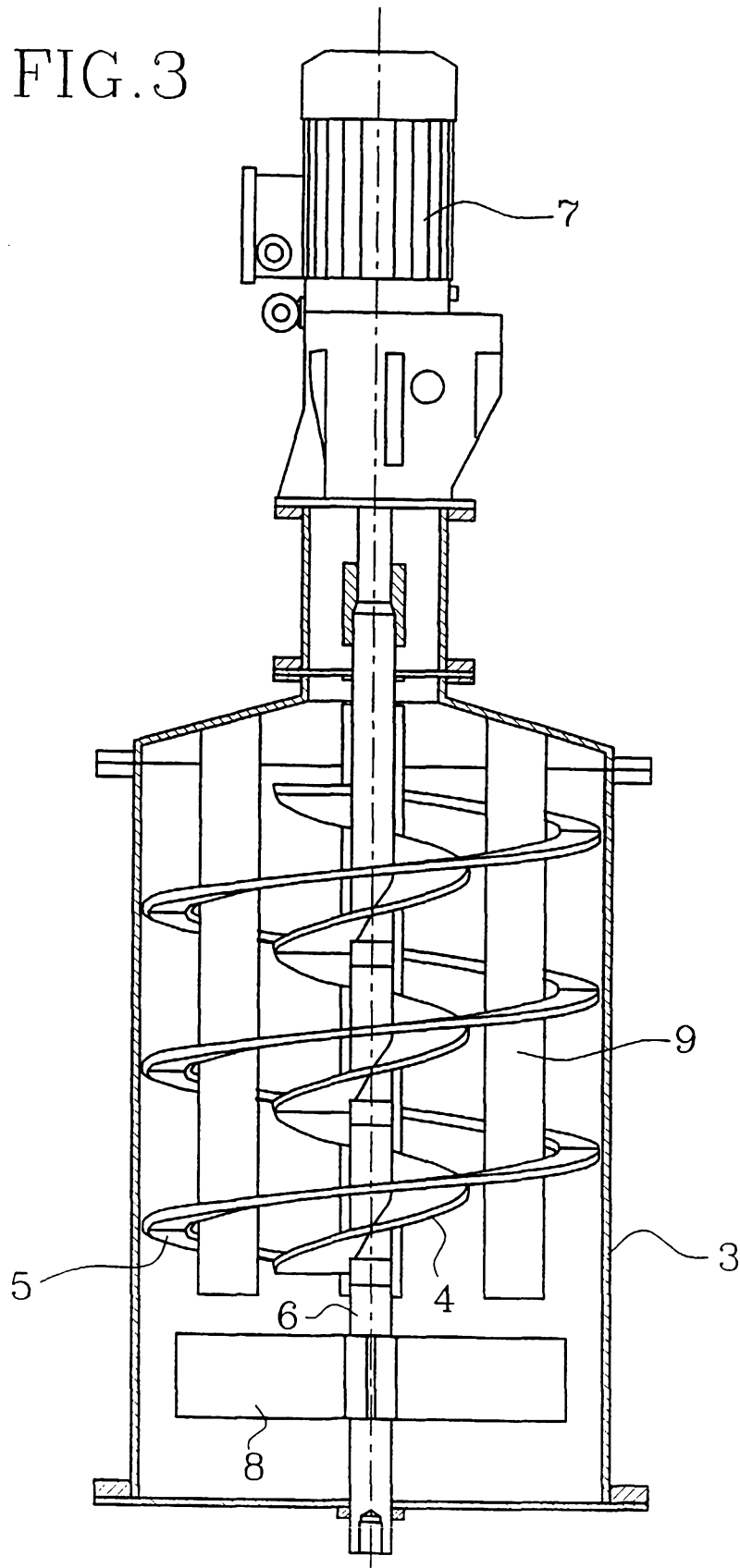


FIG. 2

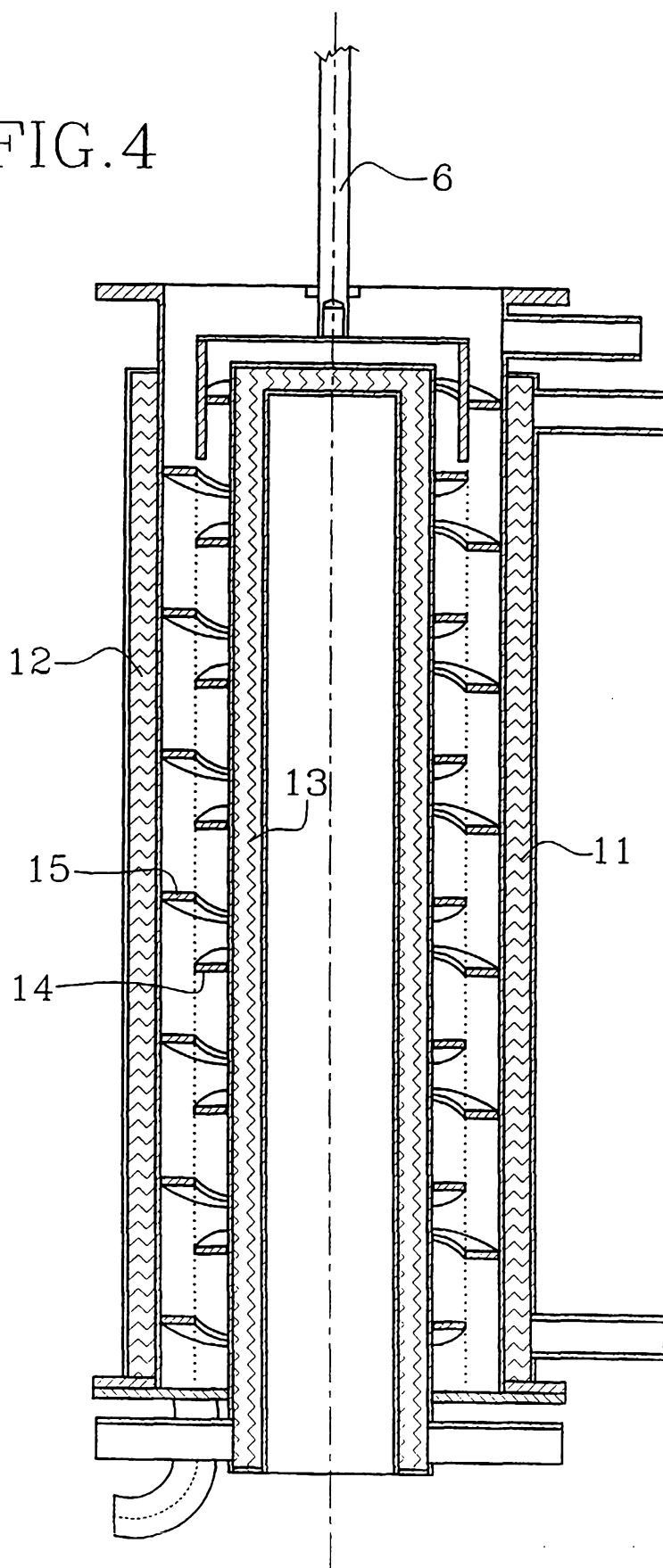
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FIG. 3



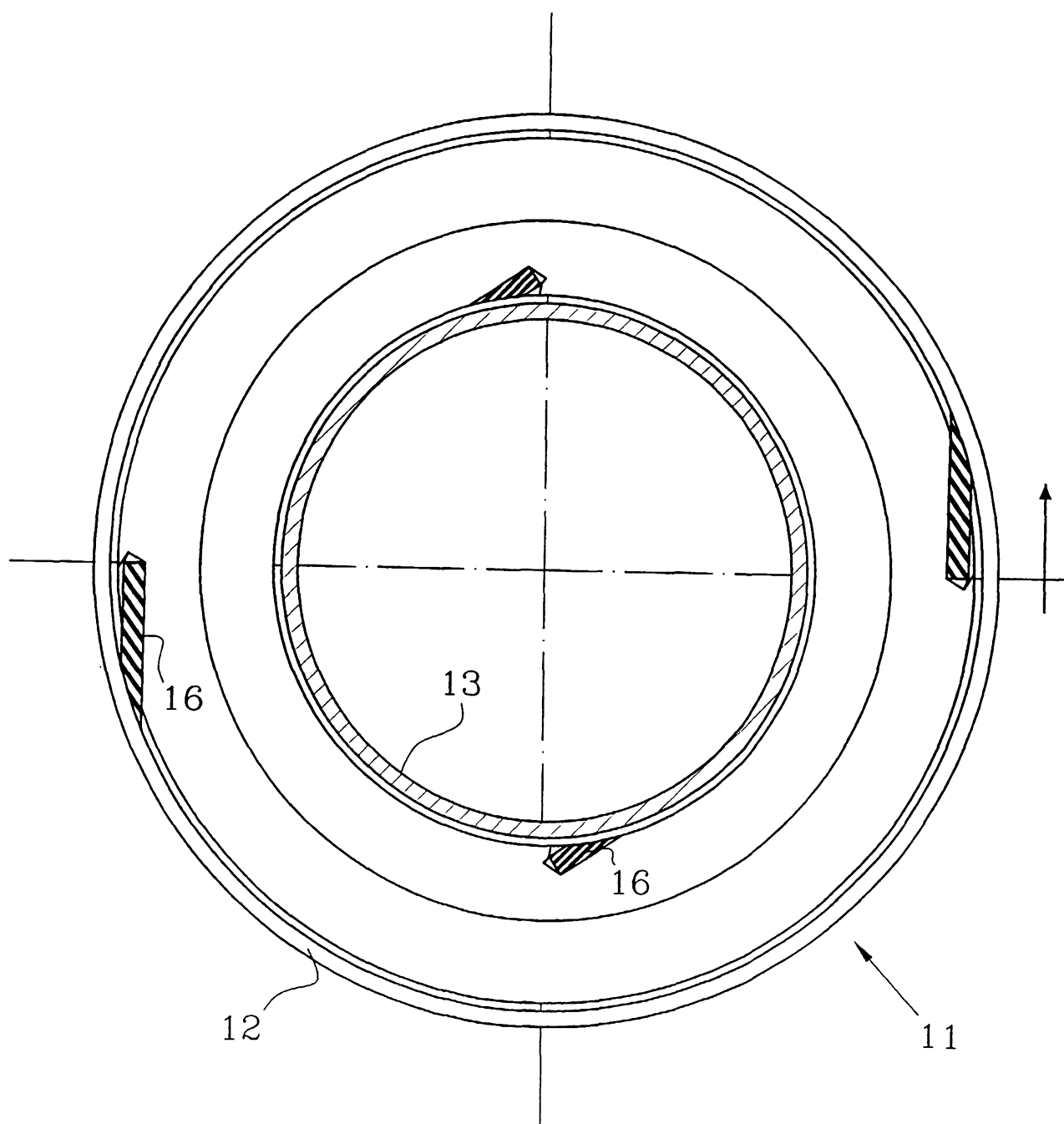
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FIG. 4



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FIG. 5



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FIG. 6

