



(86) Date de dépôt PCT/PCT Filing Date: 2011/07/05
(87) Date publication PCT/PCT Publication Date: 2012/01/12
(45) Date de délivrance/Issue Date: 2017/04/11
(85) Entrée phase nationale/National Entry: 2012/11/28
(86) N° demande PCT/PCT Application No.: JP 2011/065375
(87) N° publication PCT/PCT Publication No.: 2012/005246
(30) Priorité/Priority: 2010/07/06 (JP2010-154233)

(51) Cl.Int./Int.Cl. *C12P 1/00* (2006.01),
C12M 1/00 (2006.01), *C12P 19/00* (2006.01),
C12P 7/02 (2006.01), *C12P 7/08* (2006.01),
C12P 7/10 (2006.01), *C13K 1/02* (2006.01)

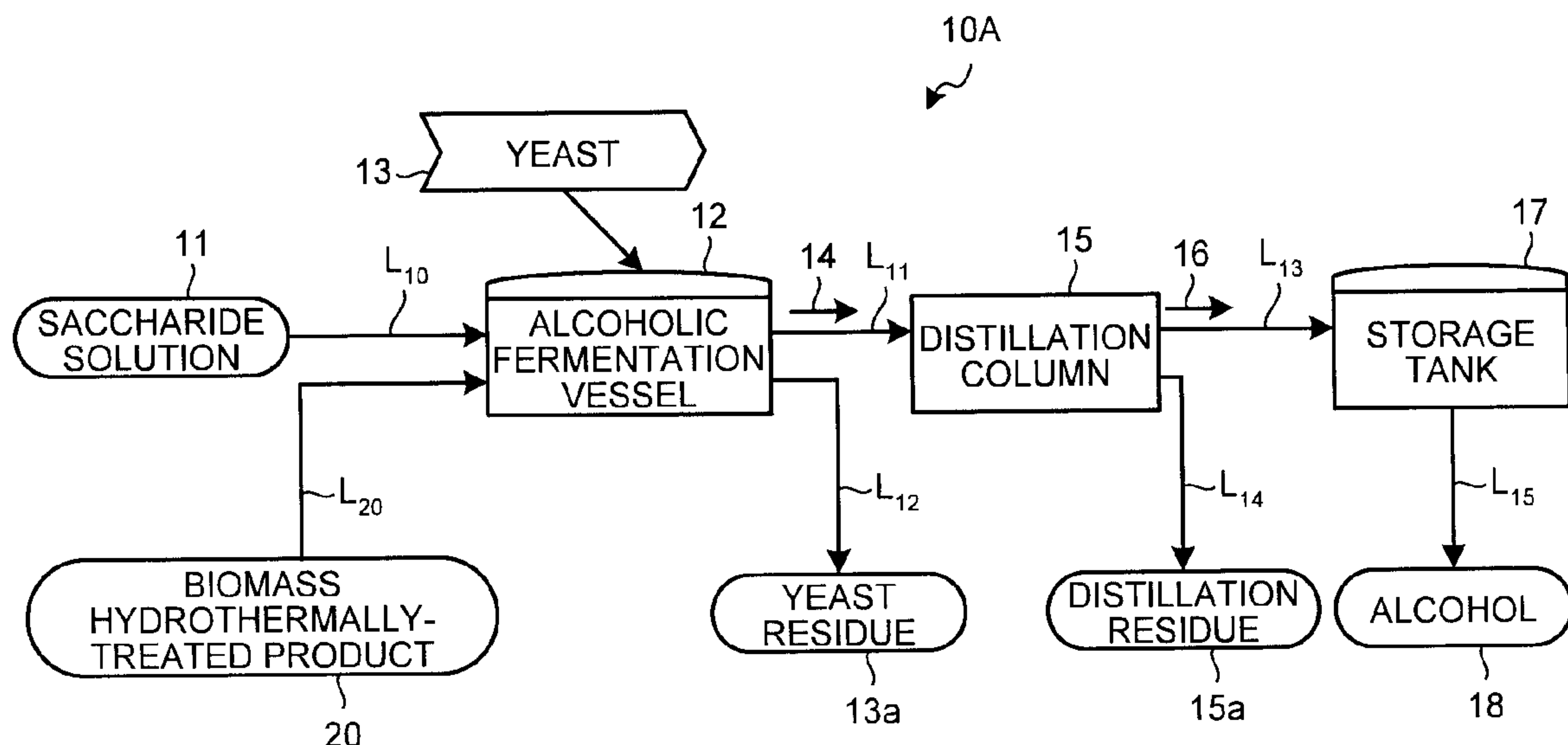
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(54) Titre : SYSTÈME DE FERMENTATION UTILISANT UNE SOLUTION SUCREE ET PROCEDE DE FERMENTATION
UTILISANT UNE SOLUTION SUCREE

(54) Title: FERMENTATION SYSTEM AND FERMENTATION METHOD USING SACCHARIDE SOLUTION



(57) Abrégé/Abstract:

An alcohol production system that produces alcohol by alcoholic fermentation using a saccharide solution, including an alcoholic fermentation vessel in which the saccharide solution is fermented by adding yeast to produce alcohol, which is an organic feedstock, and a biomass-hydrothermally-treated-product adding means that adds a biomass hydrothermally-treated product obtained by hydrothermally treating a biomass feedstock to the alcoholic fermentation vessel. The alcohol production system can improve alcoholic fermentation efficiency and realize cost reduction without adding only a mineral salt from outside.

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ABSTRACT

An alcohol production system that produces alcohol by alcoholic fermentation using a saccharide solution, including an alcoholic fermentation vessel in which the saccharide solution is fermented by adding yeast to produce alcohol, which is an organic feedstock, and a biomass-hydrothermally-treated-product adding means that adds a biomass hydrothermally-treated-product obtained by hydrothermally treating a biomass feedstock to the alcoholic fermentation vessel. The alcohol production system can improve alcoholic fermentation efficiency and realize cost reduction without adding only a mineral salt from outside.

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DESCRIPTION

FERMENTATION SYSTEM AND FERMENTATION METHOD USING SACCHARIDE
SOLUTION

Field

- 5 [0001] The present invention relates to a fermentation system using a saccharide solution that improves fermentation efficiency at the time of causing alcoholic fermentation by using a saccharide solution, for example.

Background

- 10 [0002] Conventionally, a production technique of ethanol or the like in which after biomass such as wood is saccharified by diluted sulfuric acid or concentrated sulfuric acid, the biomass is solid-liquid separated, and a liquid phase is neutralized and used as raw materials for ethanol fermentation
15 or the like has been used in practice (Patent Literature 1, Patent Literature 2).

Furthermore, it is also conceivable to produce chemical raw materials (for example, lactic acid fermentation), using saccharide as a starting material.

- 20 The biomass refers to accumulation of organisms or organic matters derived from organisms integrated in a circulatory system of materials of the global biosphere (Japanese Industrial Standards Committee, "Biotechnology-Vocabulary", JIS K 3600 1258, 2010/10/01).

- 25 [0003] As a method of improving alcoholic fermentation, for example, it has been proposed to use yeast that is rich in

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minerals or concentrated with minerals as a nutrient source for alcoholic fermentation (Patent Literature 3).

Citation List

Patent Literatures

5 [0004] Patent Literature 1: Japanese Patent Application
National Publication No. H9-507386

Patent Literature 2: Japanese Patent Application
National Publication No. H11-506934

Patent Literature 3: Japanese Patent Application
National Publication No. 2002-516115

Summary

Technical Problem

5 [0005] However, in the proposal in Patent Literature 3,
there is a problem that a mineral salt needs to be supplied
from outside as a method of concentrating minerals. That
is, although there are methods such as directly supplying a
mineral salt to an alcoholic fermentation vessel and
10 indirectly supplying thereto via yeast cultivation,
addition of a mineral salt from outside becomes essential
in either method.

Accordingly, there has been a strong demand for a
fermentation system and a fermentation method using a
15 saccharide solution capable of improving fermentation
efficiency and realizing cost reduction at the time of
fermenting, for example, alcohol from a saccharide solution,
without adding only a mineral salt from outside.

[0006] The present invention has been achieved to solve
20 the above problems, and an object of the present invention
is to provide a fermentation system and a fermentation
method using a saccharide solution capable of improving
fermentation efficiency at the time of fermenting, for
example, alcohol from a saccharide solution.

25 Solution to Problem

[0007] In order to solve the problems, according to a
first aspect of the invention, there is provided a
fermentation system using a saccharide solution, which is
an alcohol production system that produces alcohol by
30 fermentation of the saccharide solution, the fermentation
system including: a fermentation vessel for fermenting the
saccharide solution by adding yeast so as to produce an
organic feedstock; and a biomass-hydrothermally-treated-

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product adding unit for adding biomass hydrothermally-treated product obtained by hydrothermally treating a biomass feedstock to the fermentation vessel.

[0007a] More specifically, the present invention relates to a fermentation system using a saccharide solution, which produces an organic feedstock by fermenting the saccharide solution, the fermentation system comprising: a fermentation vessel for fermenting, as a starting material, a carbohydrate-derived saccharide solution from one or more carbohydrate-based materials selected from the group consisting of a syrup, sugar cane, cassava, and corn by adding yeast so as to produce a fermentation liquor; a piping for supplying the carbohydrate-derived saccharide solution to the fermentation vessel; and a cellulosic biomass-hydrothermally-treated-product adding unit for adding a cellulosic biomass hydrothermally-treated product obtained by hydrothermally treating a cellulosic biomass feedstock to the fermentation vessel, so as to increase a fermentation rate of the carbohydrate-derived saccharide solution.

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[0008] According to a second aspect of the invention, there is provided a fermentation system using a saccharide solution according to the first aspect, wherein the biomass hydrothermally-treated product is either one or both of a solid residual fraction and a hydrothermally treated fraction.

[0009] According to a third aspect of the invention, there is provided a fermentation system using a saccharide solution according to the first or second aspect, including an addition piping for adding either one or both of a fermentation residual fraction and a distillation residual fraction to the fermentation vessel individually or in addition to the biomass hydrothermally-treated product.

[0010] According to a fourth aspect of the invention, there is provided a fermentation system using a saccharide solution according to the third aspect, wherein either one or both of the alcoholic fermentation residual fraction and the distillation residual fraction are hydrothermally treated by a hydrothermal decomposition device, and a hydrothermally treated product is then added to the fermentation vessel.

[0011] According to a fifth aspect of the invention, there is provided a fermentation system using a saccharide solution according to the first aspect, wherein the biomass hydrothermally-treated product is a saccharified feedstock of an organic-feedstock production system using a cellulosic biomass feedstock.

[0012] According to a sixth aspect of the invention, there is provided a fermentation system using a saccharide solution according to the fifth aspect, including an

addition line for adding a treatment residue of the organic-feedstock production system using the cellulosic biomass feedstock to the fermentation vessel.

[0013] According to a seventh aspect of the invention,
5 there is provided a fermentation system using a saccharide solution according to the fifth or sixth aspect, wherein the organic-feedstock production system using the cellulosic biomass feedstock includes: a hydrothermal decomposition device for hydrothermally decomposing a
10 biomass feedstock by feeding the biomass feedstock into countercurrent contact with pressurized hot water and by transferring a lignin component and a hemicellulose component into pressurized hot water, so as to separate the lignin component and the hemicellulose component from a
15 biomass solid; a first enzymatic saccharification tank for treating cellulose in a solid residual fraction discharged from the hydrothermal decomposition device with an enzyme so as to enzymatically decompose cellulose into a saccharide solution containing hexose with a first enzyme;
20 and a first fermentation device for producing either one of alcohol, petroleum substitutes, or amino acids by fermentation treatment, by using a first saccharide solution obtained in the first enzymatic saccharification tank.

25 [0014] According to a eighth aspect of the invention, there is provided a fermentation system using a saccharide solution according to the seventh aspect, further including: a second enzymatic decomposition device for treating the hemicellulose component in a hydrothermally
30 extracted fraction from the hydrothermal decomposition device with an enzyme so as to enzymatically decompose hemicellulose into a saccharide solution containing pentose; and a second fermentation device for producing

either one of alcohol, petroleum substitutes, or amino acids by fermentation treatment, by using a second saccharide solution obtained by the second enzymatic decomposition device.

5 [0015] According to a ninth aspect of the invention, there is provided a fermentation system using a saccharide solution according to the seventh aspect, further including: a sulfuric-acid decomposition device for decomposing the hemicellulose component in a hydrothermally
10 extracted fraction from the hydrothermal decomposition device with sulfuric acid into a second saccharide solution containing pentose; and a second fermentation device for producing either one of alcohol, petroleum substitutes, or amino acids by fermentation treatment, by using a second
15 saccharide solution obtained by the sulfuric-acid decomposition device.

[0016] According to a tenth aspect of the invention, there is provided a fermentation system using a saccharide solution according to the seventh, wherein the hydrothermal
20 decomposition device includes: a hydrothermal decomposition device body for gradually moving a biomass feedstock in a consolidation state; and a hot-water supply unit for supplying pressurized hot water into the hydrothermal decomposition device body, and wherein the biomass
25 feedstock and the pressurized hot water are hydrothermally decomposed while being brought into countercurrent contact with each other, the lignin component and the hemicellulose component are transferred into the pressurized hot water, so as to separate the lignin component and the
30 hemicellulose component from the biomass feedstock, thereby obtaining a hydrothermally extracted fraction containing the lignin component and the hemicellulose component and a solid residual fraction containing cellulose.

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[0017] According to a eleventh aspect of the invention, there is provided a fermentation method using a saccharide solution for producing an organic feedstock by fermenting the saccharide solution, the fermentation method including: adding
5 a biomass hydrothermally-treated product obtained by hydrothermally treating a biomass feedstock to a fermentation vessel so as to ferment the organic feedstock.

[0017a] More specifically, the present invention relates to a fermentation method using a saccharide solution for producing
10 an organic feedstock by fermenting the saccharide solution, the fermentation method comprising the steps of: fermenting, as a starting material, a carbohydrate-derived saccharide solution from one or more carbohydrate-based materials selected from the group consisting of a syrup, sugar cane, cassava, and corn by
15 adding yeast so as to produce a fermentation liquor; and hydrothermally-treating a cellulosic biomass feedstock to obtain a cellulosic biomass hydrothermally-treated product; wherein the step of fermenting the carbohydrate-derived saccharide solution includes the steps of: adding the yeast to
20 the carbohydrate-derived saccharide solution for fermenting thereof; fermenting the carbohydrate-derived saccharide solution with the yeast so as to produce the fermentation liquor; and adding the cellulosic biomass hydrothermally-treated product to the carbohydrate-derived saccharide
25 solution, so as to increase a fermentation rate of the carbohydrate-derived saccharide solution.

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[0018] According to a twelfth aspect of the invention, there is provided a fermentation method using a saccharide solution according to the eleventh aspect, wherein the biomass hydrothermally-treated product is either one or both of a hydrothermally treated fraction and a solid residual fraction.

[0019] According to a thirteenth aspect of the invention, there is provided a fermentation method using a saccharide solution according to the eleventh or twelfth aspect, wherein the biomass hydrothermally-treated product is a saccharified feedstock of an organic-feedstock production system using a cellulosic biomass feedstock.

[0020] According to a fourteenth aspect of the invention, there is provided a fermentation method using a saccharide solution according to the eleventh or twelfth aspect, wherein either one or both of a fermentation residual fraction and a distillation residual fraction are added to the fermentation vessel individually or in addition to the biomass hydrothermally-treated product.

[0021] According to a fifteenth aspect of the invention, there is provided a fermentation method using a saccharide solution according to the fourteenth aspect, wherein either one or both of the alcoholic fermentation residual fraction and the distillation residual fraction are hydrothermally treated, and then added to an alcoholic fermentation vessel.

[0022] According to a sixteenth aspect of the invention,

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there is provided a fermentation method using a saccharide solution according to the thirteenth aspect, wherein a treatment residue of the organic-feedstock production system using the cellulosic biomass feedstock is added to the
5 fermentation vessel.

Advantageous Effects of Invention

[0023] According to the present invention, alcoholic fermentation efficiency can be improved and cost reduction can be realized without adding only a mineral salt from outside.

10 Brief Description of Drawings

[0024] FIG. 1 is a schematic diagram of an alcohol production system according to a first embodiment.

FIG. 2 is a schematic diagram of another alcohol production system according to the first embodiment.

15 FIG. 3 is a schematic diagram of another alcohol production system according to the first embodiment.

FIG. 4 is a schematic diagram of an alcohol production system according to a second embodiment.

20 FIG. 5 is a conceptual diagram of a biomass hydrothermal-decomposition device according to the embodiment.

FIG. 6 is a conceptual diagram of another biomass hydrothermal-decomposition device according to the embodiment.

FIG. 7 is a schematic diagram of an alcohol production system according to a third embodiment.

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FIG. 8 is a schematic diagram of another alcohol production system according to the third embodiment.

FIG. 9 is a schematic diagram of another alcohol production system according to the fourth embodiment.

5 FIG. 10 is a schematic diagram of another alcohol production system according to the fourth embodiment.

Description of Embodiments

[0025] The present invention will be explained below in detail with reference to the accompanying drawings. The present invention is not limited to the following

5 embodiments. In addition, constituent elements in the following embodiments include those that can be easily anticipated by persons skilled in the art or that are substantially equivalent.

First embodiment

10 [0026] An alcohol production system and an alcohol production method are exemplified and explained as a fermentation system and a fermentation method using a saccharide solution according to an embodiment of the present invention with reference to the drawings. FIG. 1

15 is a schematic diagram of an alcohol production system according to a first embodiment.

As shown in FIG. 1, an alcohol production system 10A according to the first embodiment produces alcohol by fermentation of a saccharide solution 11. The alcohol

20 production system 10A includes an alcoholic fermentation vessel 12 in which the saccharide solution 11 is fermented by adding yeast 13, thereby fermenting alcohol, which is an organic feedstock, and a biomass-hydrothermally-treated-product adding means (not shown) that adds a biomass

25 hydrothermally-treated product 20 obtained by hydrothermally treating a biomass feedstock to the alcoholic fermentation vessel 12 through a supply piping L₂₀.

[0027] The saccharide solution 11, which is an alcoholic

30 fermentation feedstock, is fed to the alcoholic fermentation vessel 12 through a saccharide-solution supply piping L₁₀, and fermentation treatment is performed under predetermined conditions by the yeast 13 to be added.

For example, as the saccharide solution 11, syrup, a saccharide solution from sugar cane, a saccharide solution from cassava, and a saccharide solution from corn can be exemplified. However, the present invention is not limited thereto.

An alcoholic fermentation liquor 14 produced by alcoholic fermentation is fed to a distillation column 15 through a fermentation-liquor supply piping L₁₁, where distillation is performed.

10 A distilled distillate 16 is refined by a refinery (not shown), and fed to a storage tank 17 through an alcohol supply piping L₁₃. Alcohol 18 as a product is supplied from the storage tank 17, as required, through a supply piping L₁₅.

15 [0028] A yeast residue 13a in the alcoholic fermentation vessel 12 is discharged from a yeast-residue discharge line L₁₂. A distillation residue 15a in the distillation column 15 is discharged through a distillation-residue discharge line L₁₄.

20 [0029] The biomass hydrothermally-treated product 20 refers to a treated product obtained by hydrothermally decomposing a biomass feedstock by a hydrothermal decomposition device. Particularly, a cellulosic biomass feedstock is hydrothermally decomposed by the hydrothermal decomposition device, thereby obtaining the biomass hydrothermally-treated product 20 by extracting minerals and mineral salts abundantly contained in cellulosic biomass from a solid phase (biomass) to a liquid phase. Details of the hydrothermal decomposition device are
25
30 described later.

For example, as the cellulosic biomass feedstock, rice straw, wheat straw, corn stover (cornstalk), corn cob (corn core), and EFB (empty fruit brunch of oil palm tree) can be

exemplified. However, the present invention is not limited thereto.

In the present invention, not only a hydrothermally extracted fraction but also a solid residual fraction from the hydrothermal decomposition device can be supplied to the alcoholic fermentation vessel 12.

This is because minerals and mineral salts are not extracted into the hydrothermally extracted fraction and remain in the solid residual fraction, and thus minerals and mineral salts are efficiently used.

[0030] As minerals and mineral salts referred to in the present invention, nitrogen, phosphorus, sulfur, calcium, magnesium, iron, nickel, cobalt, chromium, zinc, copper, manganese, selenium, molybdenum, boron, and the like can be exemplified, which are contained in the biomass hydrothermally-treated product and supplied to the alcoholic fermentation vessel.

[0031] As a result, the biomass hydrothermally-treated product 20 of either one or both of the hydrothermally extracted fraction and the solid residual fraction from the hydrothermal decomposition device are added, thereby enabling to increase the concentration of minerals and mineral salts at the time of alcoholic fermentation, and improve the alcoholic fermentation rate.

[0032] FIG. 2 is a schematic diagram of another alcohol production system according to the present embodiment.

As shown in FIG. 2, an alcohol production system 10B according to the first embodiment further includes addition pipings L_{16} and L_{17} for adding the yeast residue 13a as an alcohol fermentation residual fraction, and the distillation residue 15a as a distillation residual fraction to the alcoholic fermentation vessel, in the alcohol production system according to the first embodiment.

Therefore, minerals and mineral salts remaining in the yeast residue 13a and the distillation residue 15a can be efficiently used. Accordingly, by adding the yeast residue 13a and the distillation residue 15a in addition to the biomass hydrothermally-treated product 20, the concentration of minerals and mineral salts at the time of alcoholic fermentation can be increased and the alcoholic fermentation rate can be improved.

In the present embodiment, the yeast residue 13a and the distillation residue 15a are added simultaneously. However, the present invention is not limited thereto, and only one of the yeast residue 13a and the distillation residue 15a can be added.

[0033] FIG. 3 is a schematic diagram of another alcohol production system according to the present embodiment.

As shown in FIG. 3, an alcohol production system 10C according to the first embodiment includes a hydrothermal decomposition device 21 that hydrothermally decomposes the yeast residue 13a and the distillation residue 15a in the alcohol production system 10B shown in FIG. 2.

The hydrothermal decomposition device 21 can extract minerals and mineral salts remaining in the yeast residue 13a and the distillation residue 15a into a hot water side and supply a hydrothermally treated product 22, which is a hydrothermal extract thereof, to the alcoholic fermentation vessel 12 through an addition piping L₁₈, to increase the concentration of minerals and mineral salts at the time of alcoholic fermentation and improve the alcoholic fermentation rate. At this time, a solid content, which is a reaction residue, can be also supplied together with the hydrothermally treated product 22.

[0034] In the present embodiment, a case of alcoholic fermentation in which alcohol as an organic feedstock is

fermented by using the saccharide solution 11 is explained. However, the fermentation system and the fermentation method using the saccharide solution according to the present invention are not limited thereto. As a product

5 obtained by fermentation treatment, petroleum substitutes, which become raw materials for chemical products or amino acids, which become food ingredients and feedstuffs, other than alcohol (ethanol, methanol, and the like) as the organic feedstock can be obtained by a fermentation device.

10 [0035] As chemical products derived from the saccharide solution 11, for example, there can be mentioned LPG, automotive fuel, aircraft jet fuel, kerosene petroleum, diesel oil, various types of heavy oil, fuel gas, naphtha, ethylene glycol as a naphtha cracked product, ethanolamine,

15 lactic acid, alcohol ethoxylate, vinyl chloride polymer, alkylaluminium, PVA, vinyl acetate emulsion, polystyrene, polyethylene, polypropylene, polycarbonate, MMA resin, nylon, and polyester. Accordingly, a saccharide solution derived from biomass can be efficiently used as a

20 substitute of chemical products derived from crude oil, which is depleting fuel, and raw materials for producing the substitute.

Second embodiment

[0036] An alcohol production system and an alcohol

25 production method according to another embodiment of the present invention are explained with reference to the drawings. FIG. 4 is a schematic diagram of the alcohol production system.

As shown in FIG. 4, in an alcohol production system

30 10D according to a second embodiment, the biomass hydrothermally-treated product 20 is a saccharified feedstock (a solid residual fraction 35 or a hydrothermally extracted fraction 36) for an alcohol production system 30A

using a cellulosic biomass feedstock 31.

[0037] The alcohol production system 30A using the cellulosic biomass feedstock 31 includes a grinder 32 that grounds the cellulosic biomass feedstock 31, a hydrothermal
5 decomposition device 34 that hydrothermally decomposes a biomass-feedstock ground product 33 while feeding the biomass-feedstock ground product 33 into countercurrent contact with pressurized hot water, and transfers a lignin component and a hemicellulose component into pressurized
10 hot water, to separate the lignin component and the hemicellulose component from a biomass solid, a first enzymatic saccharification tank (C6) 37 in which cellulose in the solid residual fraction 35 discharged from the hydrothermal decomposition device 34 is enzymatically
15 treated with a first enzyme (cellulase) 38 to obtain a first saccharide solution 39 containing hexose, a first ethanol fermentation vessel (C6) 40 for producing alcohol by fermentation treatment using first yeast (C6) 41, by using the first saccharide solution (hexose) 39 obtained in
20 the first enzymatic saccharification tank 37, and a distillation vessel 43 for refining a first alcoholic fermentation liquor 42 to separate the first alcoholic fermentation liquor 42 into ethanol 46, which is a distillate 44 as a target product, and a distillation
25 residue 47. Reference sign 45 denotes a storage tank, and L₃₀ to L₃₄ denote supply pipings.

[0038] The solid residual fraction 35 and the hydrothermally extracted fraction 36 from the alcohol production system 30A using the cellulosic biomass
30 feedstock 31 are supplied to the side of the alcoholic fermentation vessel 12 through supply pipings L_{20a} and L_{20b}, and mixed with each other along the way and added to the alcoholic fermentation vessel 12 through the piping L₂₀.

[0039] As a result, by adding the biomass hydrothermally-treated product 20 of either one or both of the solid residual fraction 35 and the hydrothermally extracted fraction 36 from the hydrothermal decomposition device 34, the concentration of minerals and mineral salts at the time of alcoholic fermentation can be increased, and the alcoholic fermentation rate can be improved. The hydrothermally extracted fraction 36 can be discarded or can be supplied to the enzymatic saccharification tank 37. When the hydrothermally extracted fraction 36 is supplied to the enzymatic saccharification tank 37, after the first saccharide solution (hexose) 39 is obtained from the solid residual fraction 35, ethanol can be obtained, and after a hemicellulose component transferred into the hydrothermally extracted fraction 36 is treated with a second enzyme to obtain a saccharide solution containing pentose, ethanol can be obtained.

[0040] An example of the hydrothermal decomposition device 34 is explained here.

FIG. 5 is a conceptual diagram of a biomass hydrothermal-decomposition device according to the present embodiment.

As shown in FIG. 5, a biomass hydrothermal decomposition device 34A according to the present embodiment includes a biomass supply device 61 that supplies the cellulosic biomass feedstock (hereinafter, "biomass feedstock") 31 under from a normal pressure to an increased pressure, a reactor 64 that transports the supplied biomass feedstock 31 from one side (a lower side in the present embodiment) to the other side (an upper side) inside the device body by a screw means 62, supplies pressurized hot water 63 from the other side (an upper side) different from a supply port of the biomass feedstock

31 into the device body, hydrothermally decomposes the biomass feedstock 31 while feeding the biomass feedstock 31 and the pressurized hot water 63 into countercurrent contact with each other, and transfers a lignin component and a hemicellulose component into the hydrothermally extracted fraction 36, which is pressurized hot water to be discharged, to separate the lignin component and the hemicellulose component from the biomass feedstock 31, and a biomass discharge device 65 that discharges the solid residual fraction 35 as a solid content of biomass from the other side of the device body under from an increased pressure to a normal pressure. In FIG. 5, reference sign 66 denotes a dehydrated solution, 67 denotes pressurized nitrogen, and 68 denotes a temperature jacket.

[0041] In the present embodiment, the biomass feedstock 31 is supplied from the lower side. However, the present invention is not limited thereto, and the biomass feedstock 31 can be supplied from the upper side, and at this time, the pressurized hot water 63 is supplied from the lower side.

As the biomass supply device 61 that supplies the biomass feedstock 31 under from a normal pressure to an increased pressure, for example, a screw feeder, a piston pump, and a slurry pump can be mentioned.

[0042] The hydrothermal decomposition device 34A is a vertical device in the present embodiment. However, the present invention is not limited thereto, and the hydrothermal decomposition device 34A can be an inclined device or a horizontal reactor.

[0043] The reason why the hydrothermal decomposition device 34A is formed as a vertical device or an inclined device is that gas generated in hydrothermal decomposition reaction and gas brought with the biomass feedstock can be

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discharged from the upper side quickly, which is preferable. Because a decomposition product is extracted by the pressurized hot water 63, the concentration of the extracted product increases from above downward, which is preferable from the
5 viewpoint of extraction efficiency.

[0044] The biomass is not particularly limited to any type of material, and refers to accumulation of organisms or organic matters derived from organisms integrated in the circulatory system of materials of the global biosphere (see Japanese
10 Industrial Standards Committee, "Biotechnology-Vocabulary", JIS K 3600 1258, 2010/10/01). However, in the present invention, it is particularly preferable to use a woody material, for example, hardwood and herbaceous lignocellulose resources, agricultural waste, and food waste.

15 [0045] Although the grain diameter of the biomass feedstock 31 is not particularly limited to any size, it is preferred that the biomass feedstock 31 is ground to 5 millimeters or less.

In the present embodiment, before supply of biomass,
20 pretreatment can be performed by using a grinder as a pretreatment device, for example. In addition, biomass can be cleaned by a cleaning device.

When rice husk is used as the biomass feedstock 31, the biomass feedstock 31 can be supplied directly to the
25 hydrothermal decomposition device 34A without being ground.

[0046] It is preferred that the reaction temperature in the hydrothermal decomposition device 34A is in a range from 180 to 240°C, and more preferably from 200 to 230°C.

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This is because the hydrothermal decomposition rate is low at a temperature lower than 180°C and a long decomposition time is required, leading to a size increase of the device, which is not preferable. On the other hand, at a
5 temperature exceeding 240°C, the decomposition rate

becomes excessive, thereby increasing transfer of the cellulose component from a solid side to a liquid side and promoting excessive decomposition of hemicellulose saccharide, which is not preferable.

5 The hemicellulose component starts to dissolve at a temperature of about 140°C, cellulose starts to dissolve at a temperature of about 230°C, and the lignin component starts to dissolve at a temperature of about 140°C. However, it is preferred to set the temperature in a range
10 from 180°C to 240°C at which cellulose remains on the solid side and the hemicellulose component and the lignin component have a sufficient decomposition rate.

[0047] Furthermore, it is preferable to set the reaction pressure to a pressure higher than a saturated vapor
15 pressure of water at each temperature by 0.1 to 0.5 megapascal, at which the inside of the body becomes a pressurized hot water state.

It is also preferable that the reaction time is 20 minutes or less, and more preferably, from 3 minutes to 10
20 minutes. This is because if the reaction is performed too long, a rate of excessive decomposition products increases, which is not preferable.

[0048] In the present invention, it is preferable that the flowage of the pressurized hot water 63 and the biomass
25 feedstock 31 in the body of the hydrothermal decomposition device 34A is a so-called "countercurrently contacted", in which the biomass feedstock 31 and the pressurized hot water 63 are brought into contact with each other, stirred, and caused to flow in countercurrent contact with each
30 other.

[0049] In the hydrothermal decomposition device 34A, the solid content of the biomass feedstock 31 is supplied from

the bottom side, while the pressurized hot water 63 is supplied from the top side, and each moves opposite to each other. Accordingly, the pressurized hot water 63 (hot water, a solution in which the decomposition product is dissolved) moves while seeping into solid particles, in a counterflow with respect to the biomass feedstock 31 as solids.

[0050] At the time of the countercurrent contact with each other, when the biomass feedstock 31 as solids is decomposed by the pressurized hot water 63, the decomposition product thereof is dissolved and transferred to the side of the pressurized hot water 63, and at this time, minerals and mineral salts are eluted.

[0051] In the present invention, there is a gaseous portion in the reactor 64, and thus the pressurized nitrogen (N₂) 67 is supplied to the inside thereof.

[0052] The temperature of the biomass feedstock 31 in the hydrothermal decomposition device 34A can be increased by direct heat exchange, by feeding the biomass feedstock 31 into contact with the pressurized hot water 63 in the device body. The temperature of the biomass feedstock 31 can be increased by using steam or the like from outside, as required.

[0053] In the present invention, discharge of components is started sequentially from a component easily solubilized in the pressurized hot water 63 by feeding the biomass feedstock 31 and the pressurized hot water 63 into countercurrent contact with each other, and a temperature gradient occurs from an input portion of the biomass feedstock 31 to an input portion of the hot water, thereby suppressing excessive decomposition of the hemicellulose component, and as a result, pentose components can be recovered efficiently.

Furthermore, by feeding the biomass feedstock 31 and the pressurized hot water 63 into countercurrent contact with each other, heat recovery can be performed, which is preferable from the viewpoint of system efficiency.

5 [0054] FIG. 6 is a conceptual diagram of another biomass hydrothermal-decomposition device according to the present embodiment. As shown in FIG. 6, a biomass hydrothermal decomposition device 34B according to the present embodiment includes a biomass supply device 71 that
10 supplies a biomass feedstock (in the present embodiment, for example, wheat straw) 31 under from a normal pressure to an increased pressure, a reactor 72 that gradually moves the supplied cellulosic biomass feedstock 31 from one end of upper and lower ends (a lower end in the present
15 embodiment) inside a vertical device body (hereinafter, "device body") in a consolidation state, supplies pressurized hot water 63 from the other end (an upper end in the present embodiment) different from the supply port of the biomass feedstock 31 into the device body,
20 hydrothermally decomposes the biomass feedstock 31 while feeding the biomass feedstock 31 and the pressurized hot water 63 into countercurrent contact with each other, and transfers a lignin component and a hemicellulose component into the pressurized hot water 63, to separate the lignin
25 component and the hemicellulose component from the biomass feedstock 31, and the biomass discharge device 65 that discharges the solid residual fraction 35 as a solid content of biomass from the supply port side of the pressurized hot water 63 of the device body under from an
30 increased pressure to a normal pressure. Reference signs V_{11} to V_{15} denote ON-OFF valves.

As the biomass supply device 71 that supplies biomass under from a normal pressure to an increased pressure, for

example, a pumping means such as a piston pump and a slurry pump can be mentioned.

[0055] In the present embodiment, a fixed stirring means 73 that stirs the biomass feedstock 31 in a consolidation state of a so-called "plug flow" is provided in the device body, so that the biomass feedstock 31 fed into the device body is stirred by a stirring function or behavior at the time of moving the biomass feedstock 31 fed therein in an axial direction.

10 [0056] By providing the fixed stirring means 73, mixing with the pressurized hot water 63 on a solid surface and in the solid advances, thereby promoting the reaction.

[0057] In the present invention, it is preferable such that the flowage of the pressurized hot water 63 and the biomass feedstock 31 in the device body of the hydrothermal decomposition device 34B is a so-called "counterflow", in which the biomass feedstock 31 and the pressurized hot water 63 are brought into contact with each other, stirred, and caused to flow in countercurrent contact with each other.

20 [0058] Because the hydrothermal decomposition device 34B performs hydrothermal decomposition by the plug flow method, the configuration thereof is simple, and the biomass feedstock 31 as a solid moves parallel to a tube central axis, while being stirred vertically with respect to the tube central axis. Meanwhile, the pressurized hot water 63 (hot water, a solution in which the decomposition product is dissolved) moves while seeping into solid particles, in a counterflow with respect to the solid.

30 [0059] In the plug flow, a uniform flow of the pressurized hot water 63 can be realized. This is because when the biomass feedstock 31 as a solid is dissolved by the pressurized hot water 63, the decomposition product

dissolves on the hot water side. The vicinity of the decomposition product has a high viscosity, and hot water preferentially moves to the vicinity of an undecomposed portion, to decompose the undecomposed portion subsequently.

5 Accordingly, hot water flows uniformly to realize uniform decomposition.

[0060] Furthermore, due to the tube wall resistance on an inner surface of the device body in the hydrothermal decomposition device 34B, the solid density on an outlet
10 side of the biomass feedstock 31 decreases more as compared to that on an inlet side of the biomass feedstock 31 in the device body. In addition, because the solid residual fraction 35, which is a solid content of biomass, decreases due to decomposition, the percentage of the pressurized hot
15 water 63 increases, and a decomposition component in a liquid is excessively decomposed due to an increase in a liquid residence time. Accordingly, at least the fixed stirring means 73 is provided.

Third embodiment

20 [0061] An alcohol production system and an alcohol production according to another embodiment of the present invention are explained with reference to the drawings. FIG. 7 is a schematic diagram of an alcohol production system according to a third embodiment.

25 As shown in FIG. 7, an alcohol production system 10E according to the third embodiment produces alcohol from the hydrothermally extracted fraction 36 of the saccharified feedstock in an alcohol production system 30B using the cellulosic biomass feedstock 31, in the system of the
30 second embodiment.

[0062] That is, the alcohol production system 10E includes a second enzymatic saccharification tank 51 in which a hemicellulose component transferred to the

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hydrothermally extracted fraction 36 discharged from the hydrothermal decomposition device 34 in the alcohol production system 30B using the cellulosic biomass feedstock 31 is treated with a second enzyme 52 to obtain a saccharide solution 53

5 containing pentose, and a second ethanol fermentation vessel 55 for producing alcohol by fermentation treatment using second yeast (C5) 54, by using the second saccharide solution (pentose) 53 obtained in the second enzymatic saccharification tank 51, to produce ethanol 46, which is the distillate 44 as a target
10 product, by refining a second alcoholic fermentation liquor 56. Reference signs L₃₆ to L₃₇ denote supply pipings.

[0063] FIG. 8 is a configuration diagram of an alcohol production system using another cellulosic biomass feedstock.

As shown in FIG. 8, another alcohol production system
15 10F according to the third embodiment performs saccharification by sulfuric acid decomposition, as a method other than saccharification with an enzyme, at the time of saccharification of the hydrothermally extracted fraction 36 in an alcohol production system 30C using the cellulosic biomass feedstock 31.
20 That is, a sulfuric-acid decomposition device 80 is used, which supplies sulfuric acid to the hydrothermally extracted fraction 36, to decompose the hemicellulose component in the hydrothermally extracted fraction 36 with sulfuric acid into the second saccharide solution 53 containing pentose.

25 [0064] As decomposition conditions in the sulfuric-acid decomposition device 80 according to the present invention, the sulfuric acid concentration is from 0.1 to 5% by weight, preferably from 1 to 4% by weight, a decomposition temperature is from 100 to 140°C, preferably about 120°C, and a decomposition
30 time is from 30 minutes to 3 hours,

preferably about 1 hour. This is because, if these numbers are outside the above ranges, excellent decomposition of hemicellulose cannot be performed.

Fourth embodiment

5 [0065] An alcohol production system and an alcohol production according to another embodiment of the present invention are explained with reference to the drawings. FIG. 9 is a schematic diagram of an alcohol production system according to a fourth embodiment.

10 As shown in FIG. 9, an alcohol production system 10G according to the fourth embodiment uses a treatment residue from an alcohol production system 30D using the cellulosic biomass feedstock 31.

As shown in FIG. 9, the solid residual fraction 35 and
15 the hydrothermally extracted fraction 36 from the alcohol production system 30D using a cellulosic biomass feedstock are supplied to the side of the alcoholic fermentation vessel 12 through supply pipings L_{20a} and L_{20b}, mixed with each other along the way, and added to the alcoholic
20 fermentation vessel 12 through the piping L₂₀. At the same time, the first saccharide solution (hexose) 39, the first alcoholic fermentation liquor 42, the distillation residue 47, the second saccharide solution (pentose) 53, and the second alcoholic fermentation liquor 56 are respectively
25 supplied to the side of the alcoholic fermentation vessel 12 through pipings L_{40a}, L_{40b}, L_{40c}, L_{40d}, and L_{40e}. These are mixed with each other along the way and at least one treated product is added into the alcoholic fermentation vessel 12.

30 [0066] Another alcohol production system 10F according to the fourth embodiment shown in FIG. 10 uses a treatment residue from an alcohol production system 30E using the cellulosic biomass feedstock 31.

As shown in FIG. 10, the solid residual fraction 35 and the hydrothermally extracted fraction 36 from the alcohol production system 30E using a cellulosic biomass feedstock are supplied to the side of the alcoholic fermentation vessel 12 through the supply pipings L_{20a} and L_{20b}, mixed with each other along the way, and added to the alcoholic fermentation vessel 12 through the piping L₂₀. At the same time, the first saccharide solution (hexose) 39, the first alcoholic fermentation liquor 42, the distillation residue 47, the second saccharide solution (pentose) 53, and the second alcoholic fermentation liquor 56 are respectively supplied to the side of the alcoholic fermentation vessel 12 through the pipings L_{40a}, L_{40b}, L_{40c}, L_{40d}, and L_{40e}. These are mixed with each other along the way and at least one treated product is added into the alcoholic fermentation vessel 12.

[0067] As a result, by circulating the first saccharide solution (hexose) 39, the first alcoholic fermentation liquor 42, the distillation residue 47, the second saccharide solution (pentose) 53, and the second alcoholic fermentation liquor 56 from the alcohol production system 30D or 30E using a cellulosic biomass feedstock in the alcoholic fermentation vessel 12, the concentration of minerals and mineral salts in alcoholic fermentation can be increased, and the alcoholic fermentation rate can be improved. At the same time, the amount of minerals and mineral salts added from outside of the system can be decreased.

[0068] In the present embodiment, as a target product of the fermentation treatment by the alcohol production systems 30A to 30E using the cellulosic biomass feedstock 31, ethanol or alcohol, which is an organic feedstock, has been exemplified. However, the present invention is not

limited thereto, and petroleum substitutes, which become raw materials for chemical products or amino acids, which become food ingredients and feedstuffs, other than alcohol can be obtained by the fermentation device.

5 [0069] As the chemical products derived from a saccharide solution, for example, there can be mentioned LPG, automotive fuel, aircraft jet fuel, kerosene petroleum, diesel oil, various types of heavy oil, fuel gas, naphtha, ethylene glycol as a naphtha cracked product, ethanolamine,
10 lactic acid, alcohol ethoxylate, vinyl chloride polymer, alkylaluminium, PVA, vinyl acetate emulsion, polystyrene, polyethylene, polypropylene, polycarbonate, MMA resin, nylon, and polyester. Accordingly, the saccharide solution derived from biomass can be efficiently used as a
15 substitute of chemical products derived from crude oil, which is depleting fuel, and raw materials for producing the substitute.

Reference Signs List

[0070] 10A to 10H alcohol production system
20 11 saccharide solution
12 alcoholic fermentation vessel
13 yeast
13a yeast residue
14 alcoholic fermentation liquor
25 15 distillation column
15a distillation residue
18 alcohol
20 biomass hydrothermally-treated product
30A to 30E alcohol production system using cellulosic
30 biomass feedstock
34 hydrothermal decomposition device
35 solid residual fraction
36 hydrothermally extracted fraction

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CLAIMS:

1. A fermentation system using a saccharide solution, which produces an organic feedstock by fermenting the saccharide solution, the fermentation system comprising:

5 a fermentation vessel for fermenting, as a starting material, a carbohydrate-derived saccharide solution from one or more carbohydrate-based materials selected from the group consisting of a syrup, sugar cane, cassava, and corn by adding yeast so as to produce a fermentation liquor;

10 a piping for supplying the carbohydrate-derived saccharide solution to the fermentation vessel; and

a cellulosic biomass-hydrothermally-treated-product adding unit for adding either one or both of a cellulosic biomass hydrothermally-treated product obtained by
15 hydrothermally treating a cellulosic biomass feedstock and a solid residue to the fermentation vessel, so as to increase a fermentation rate of the carbohydrate-derived saccharide solution.

2. The fermentation system according to claim 1, further
20 comprising an additional piping for adding either one or both of a fermentation residual fraction and a distillation residual fraction to the fermentation vessel individually or in addition to the cellulosic biomass hydrothermally-treated product, so as to increase a fermentation rate of the carbohydrate-derived
25 saccharide solution.

3. The fermentation system according to claim 2, wherein either one or both of the fermentation residual fraction and

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the distillation residual fraction are hydrothermally treated by a hydrothermal decomposition device, and a hydrothermally treated product is then added to the fermentation vessel.

4. The fermentation system according to claim 1, wherein
5 the cellulosic biomass hydrothermally-treated product is a saccharified feedstock of an organic-feedstock production system using a cellulosic biomass feedstock.

5. The fermentation system according to claim 4, further
comprising an additional piping for adding a treatment residue
10 of the organic-feedstock production system using the cellulosic biomass feedstock to the fermentation vessel, so as to increase a fermentation rate of the carbohydrate-derived saccharide solution.

6. The fermentation system according to claim 4, wherein
15 the organic-feedstock production system using the cellulosic biomass feedstock comprises:

a hydrothermal decomposition device for
hydrothermally decomposing the cellulosic biomass feedstock by
feeding the biomass feedstock into countercurrent contact with
20 pressurized hot water and by transferring a lignin component and a hemicellulose component into pressurized hot water, so as to separate the lignin component and the hemicellulose component from a cellulosic biomass solid;

a first enzymatic saccharification tank for treating
25 cellulose in a solid residual fraction discharged from the hydrothermal decomposition device with an enzyme so as to enzymatically decompose cellulose into a saccharide solution containing hexose with a first enzyme; and

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a first fermentation device for producing either one of alcohol, petroleum substitutes, or amino acids by fermentation treatment, by using a first saccharide solution obtained in the first enzymatic saccharification tank.

5 7. The fermentation system according to claim 6, further comprising:

a second enzymatic saccharification tank for treating the hemicellulose component in a hydrothermally extracted fraction from the hydrothermal decomposition device with an
10 enzyme so as to enzymatically decompose hemicellulose into a saccharide solution containing pentose; and

a second fermentation device for producing either one of alcohol, petroleum substitutes, or amino acids by fermentation treatment, by using a second saccharide solution
15 obtained by the second enzymatic decomposition device.

8. The fermentation system according to claim 6, further comprising:

a sulfuric-acid decomposition device for decomposing the hemicellulose component in a hydrothermally extracted
20 fraction from the hydrothermal decomposition device with sulfuric acid into a second saccharide solution containing pentose; and

a second fermentation device for producing either one of alcohol, petroleum substitutes, or amino acids by
25 fermentation treatment, by using a second saccharide solution obtained by the sulfuric-acid decomposition device.

9. The fermentation system according to claim 6, wherein

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the hydrothermal decomposition device comprises:

a hydrothermal decomposition device body for gradually moving the cellulosic biomass feedstock in a consolidation state; and

5 a hot-water supply unit for supplying pressurized hot water into the hydrothermal decomposition device body, and wherein the cellulosic biomass feedstock and the pressurized hot water are hydrothermally decomposed while being brought into countercurrent contact with each other, the lignin
10 component and the hemicellulose component are transferred into the pressurized hot water, so as to separate the lignin component and the hemicellulose component from the cellulosic biomass feedstock, thereby obtaining a hydrothermally extracted fraction containing the lignin component and the hemicellulose
15 component and a solid residual fraction containing cellulose.

10. A fermentation method using a saccharide solution for producing an organic feedstock by fermenting the saccharide solution, the fermentation method comprising the steps of:

fermenting, as a starting material, a carbohydrate-
20 derived saccharide solution from one or more carbohydrate-based materials selected from the group consisting of a syrup, sugar cane, cassava, and corn by adding yeast so as to produce a fermentation liquor; and

hydrothermally-treating a cellulosic biomass
25 feedstock to obtain a cellulosic biomass hydrothermally-treated product;

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wherein the step of fermenting the carbohydrate-derived saccharide solution includes the steps of:

adding the yeast to the carbohydrate-derived saccharide solution for fermenting thereof;

5 fermenting the carbohydrate-derived saccharide solution with the yeast so as to produce the fermentation liquor; and

adding either one or both of the cellulosic biomass hydrothermally-treated product obtained by hydrothermally
10 treating the cellulosic biomass feedstock and a solid residue to the carbohydrate-derived saccharide solution, so as to increase a fermentation rate of the carbohydrate-derived saccharide solution.

11. The fermentation method according to claim 10,
15 wherein the cellulosic biomass hydrothermally-treated product is a saccharified feedstock of an organic-feedstock production system using a cellulosic biomass feedstock.

12. The fermentation method according to claim 10,
wherein either one or both of a fermentation residual fraction
20 and a distillation residual fraction are added to the carbohydrate-derived saccharide solution individually or in addition to the cellulosic biomass hydrothermally-treated product, so as to increase a fermentation rate of the carbohydrate-derived saccharide solution.

25 13. The fermentation method according to claim 12,
wherein either one or both of the alcoholic fermentation residual fraction and the distillation residual fraction are

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hydrothermally treated, and then added to the carbohydrate-derived saccharide solution.

14. The fermentation method according to claim 11,
wherein a treatment residue of the organic-feedstock production
5 system using the cellulosic biomass feedstock is added to the
carbohydrate-derived saccharide solution.

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FIG.1

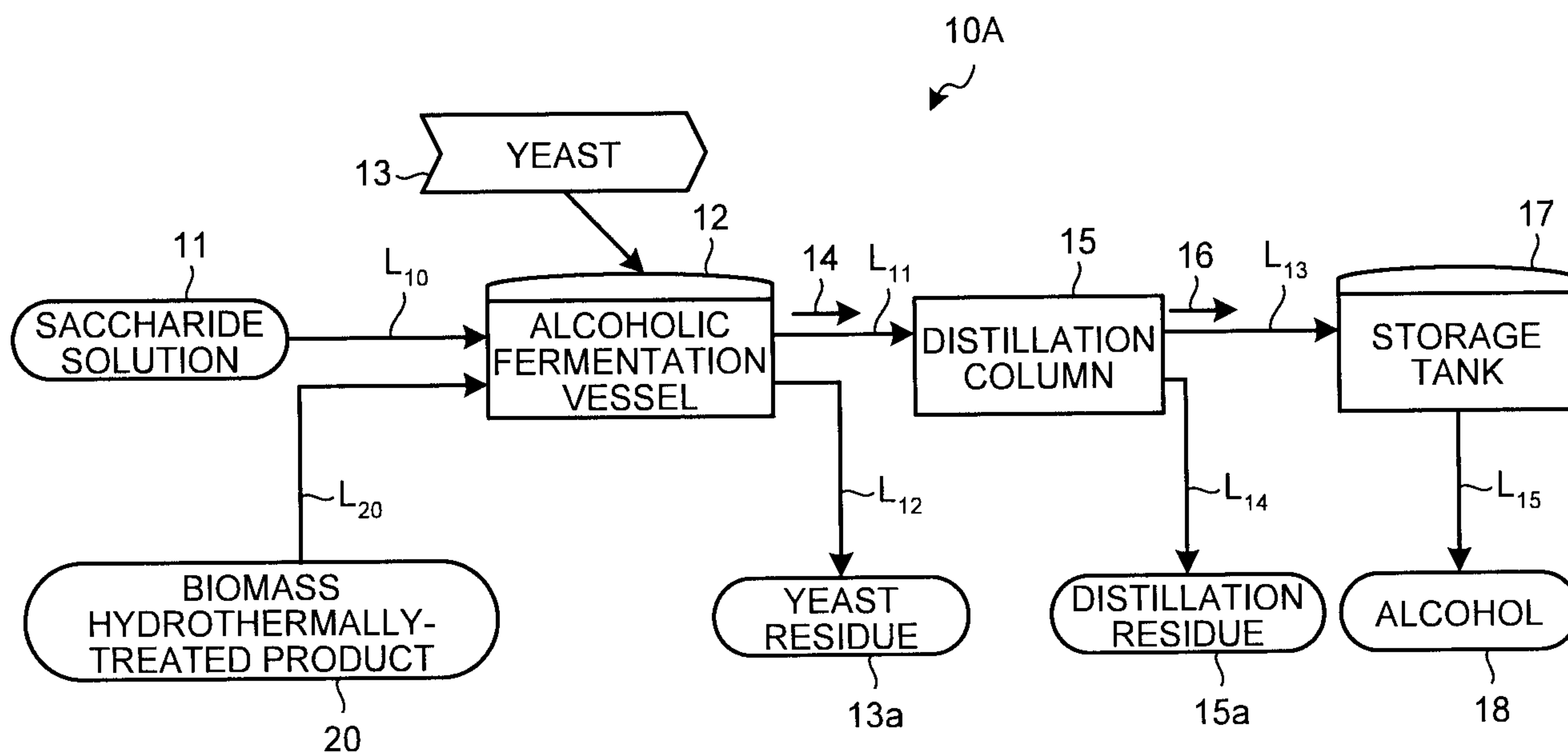


FIG.2

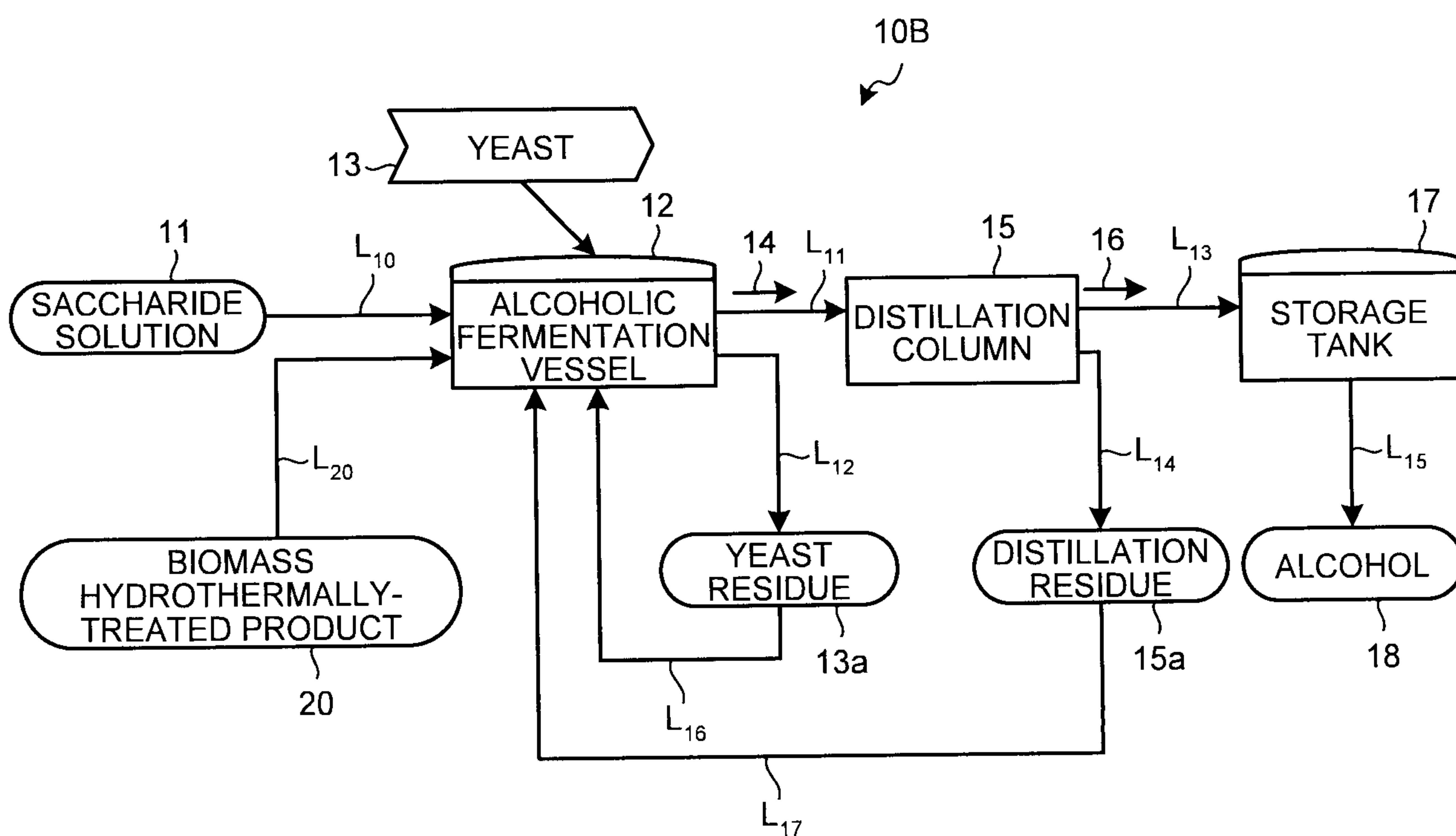


FIG.3

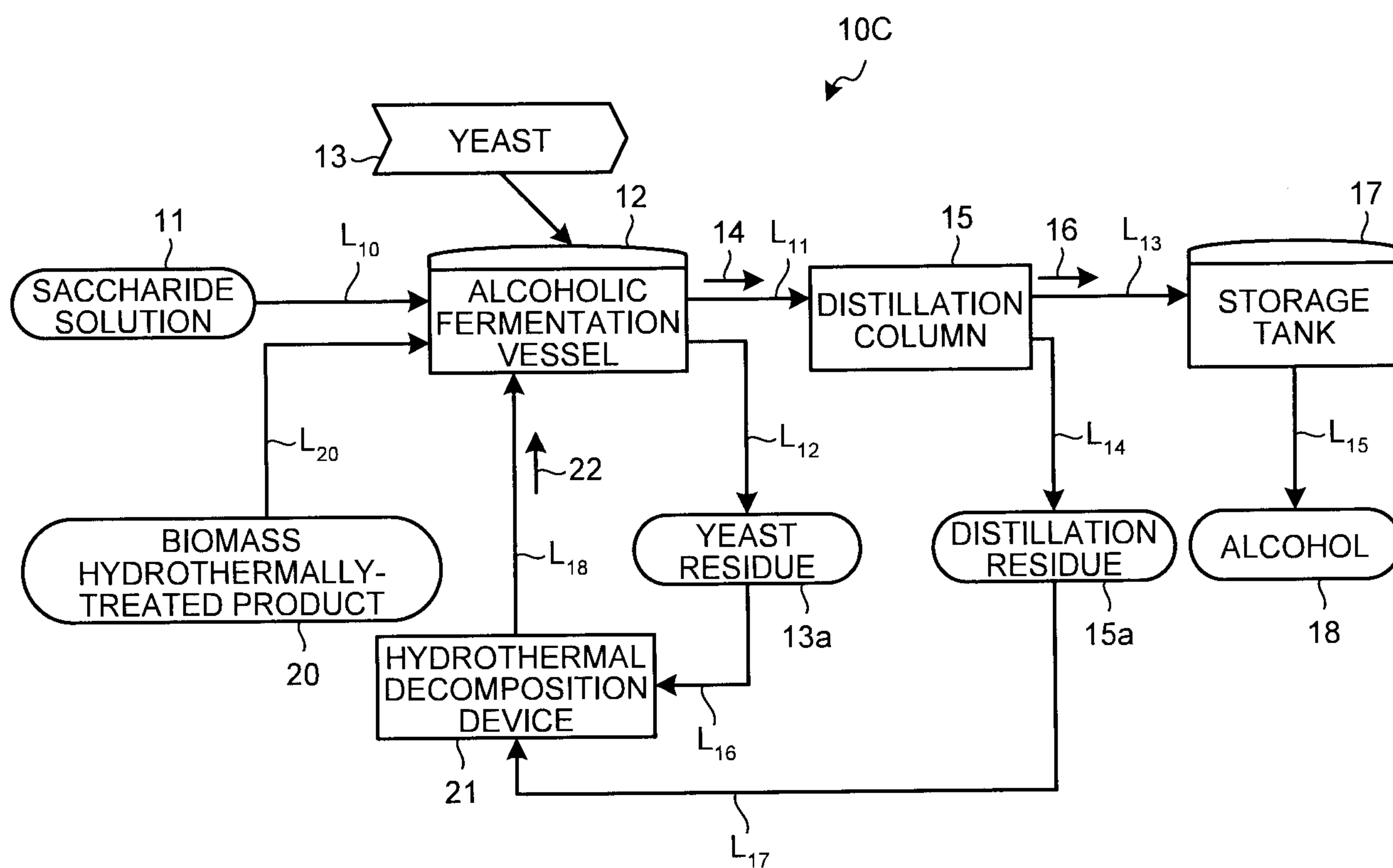


FIG.4

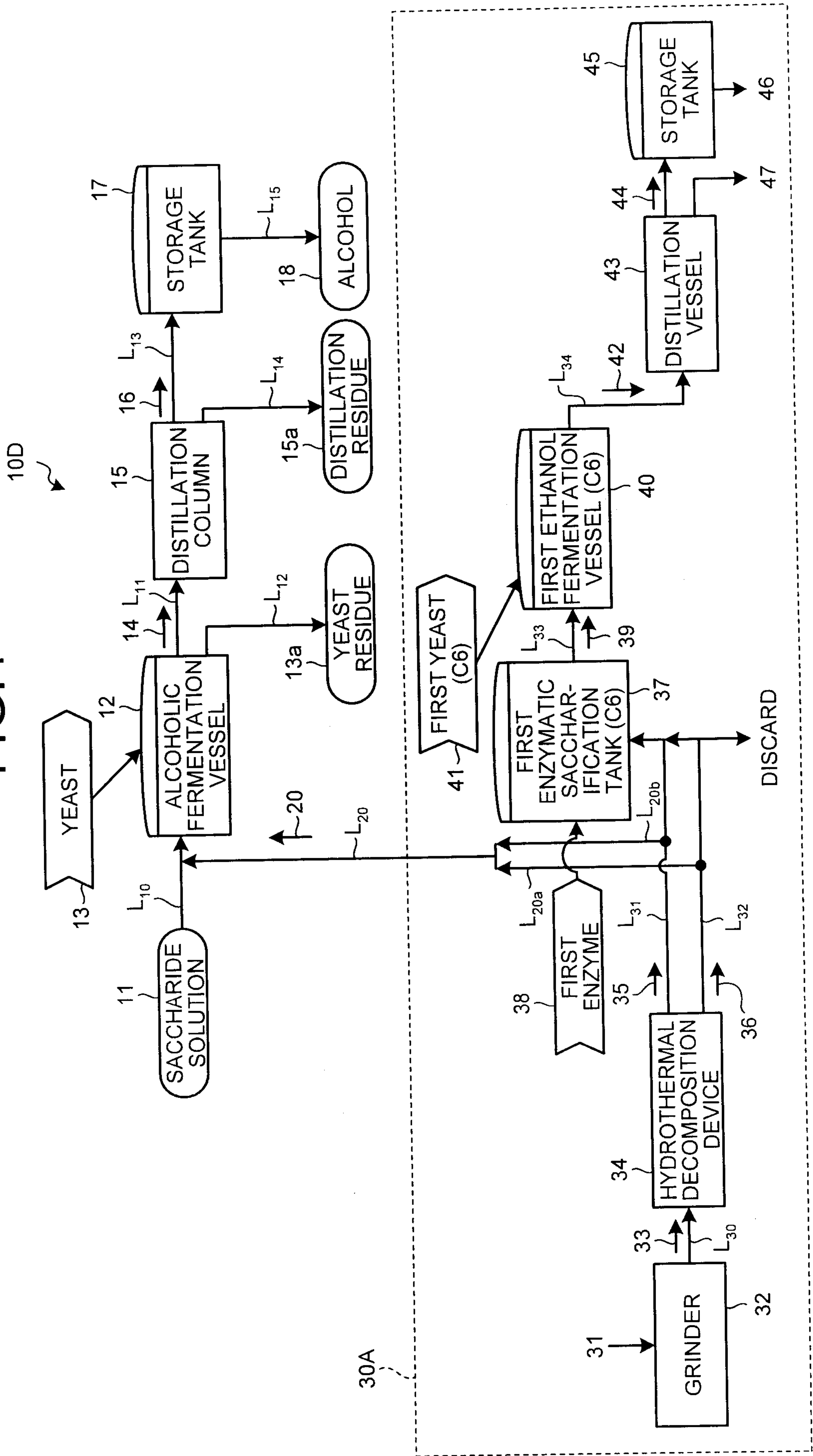
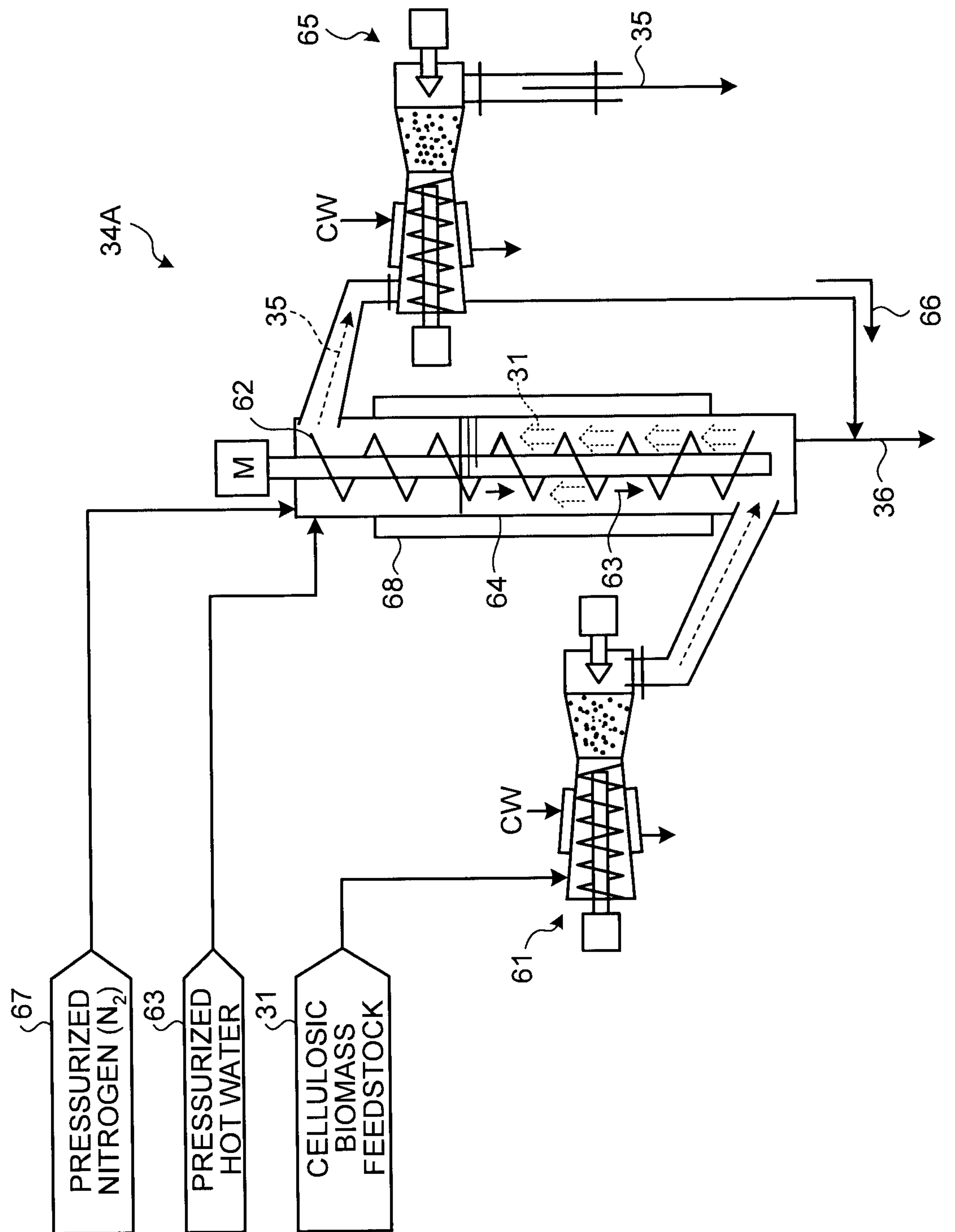


FIG. 5



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FIG.6

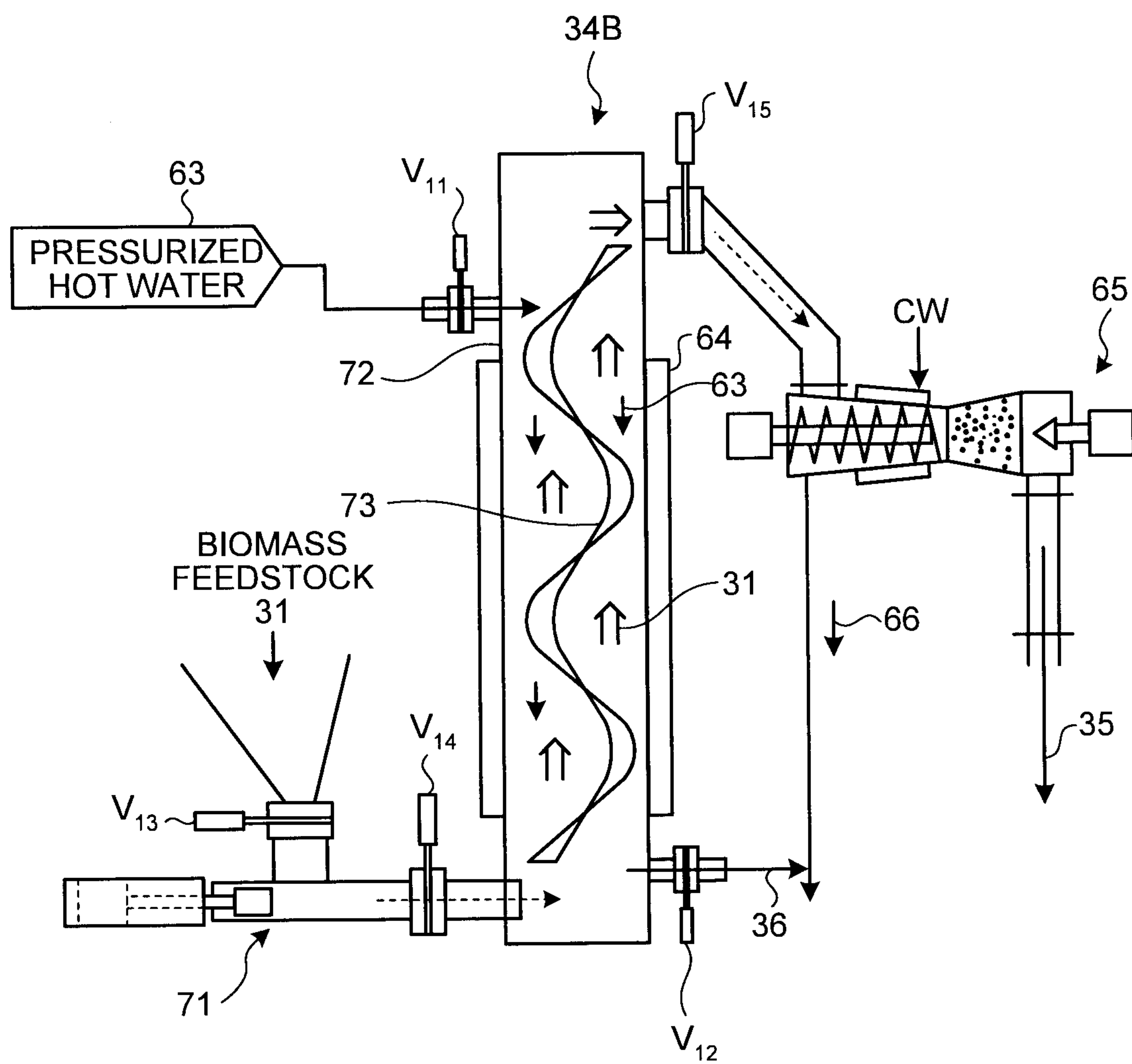


FIG. 7

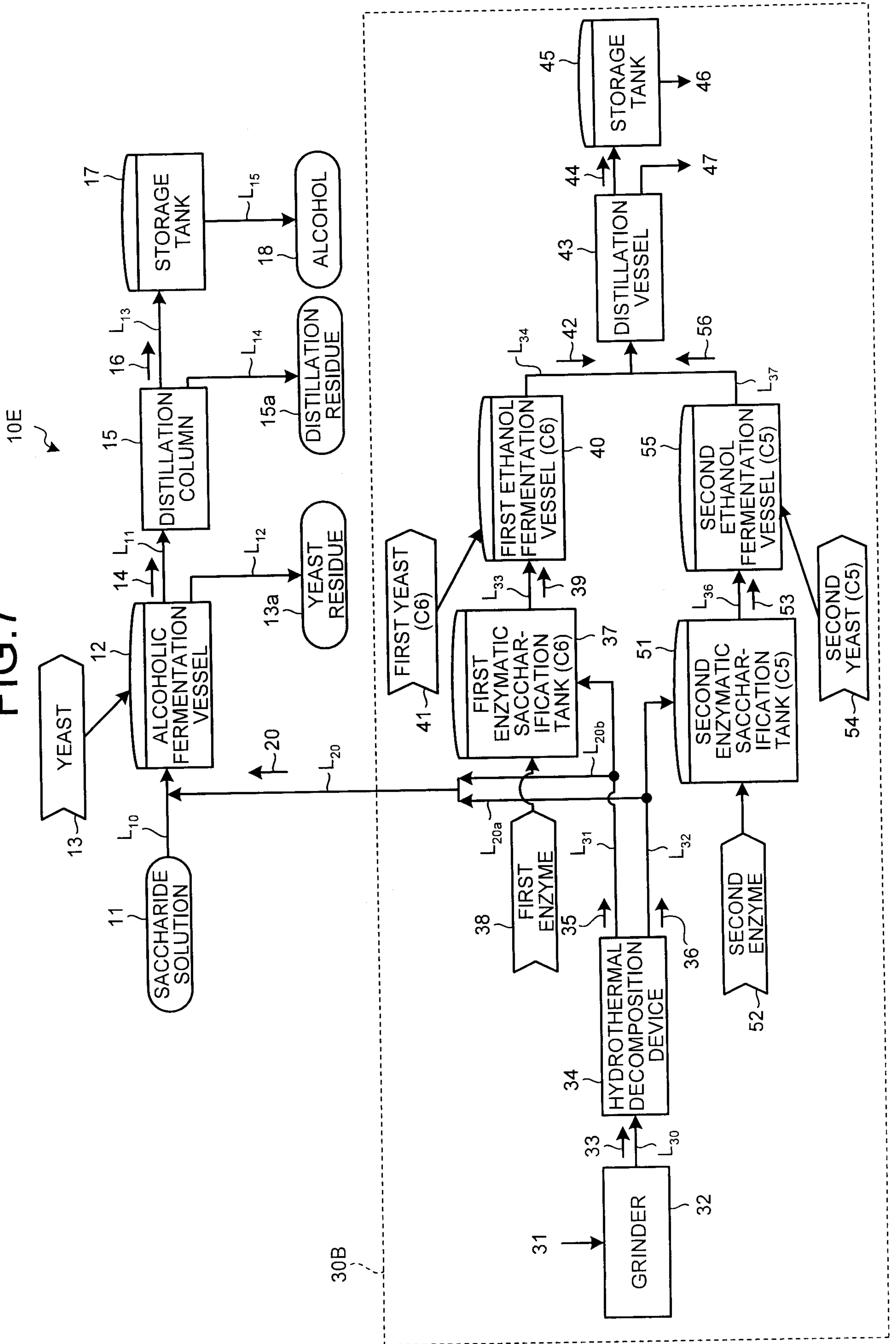
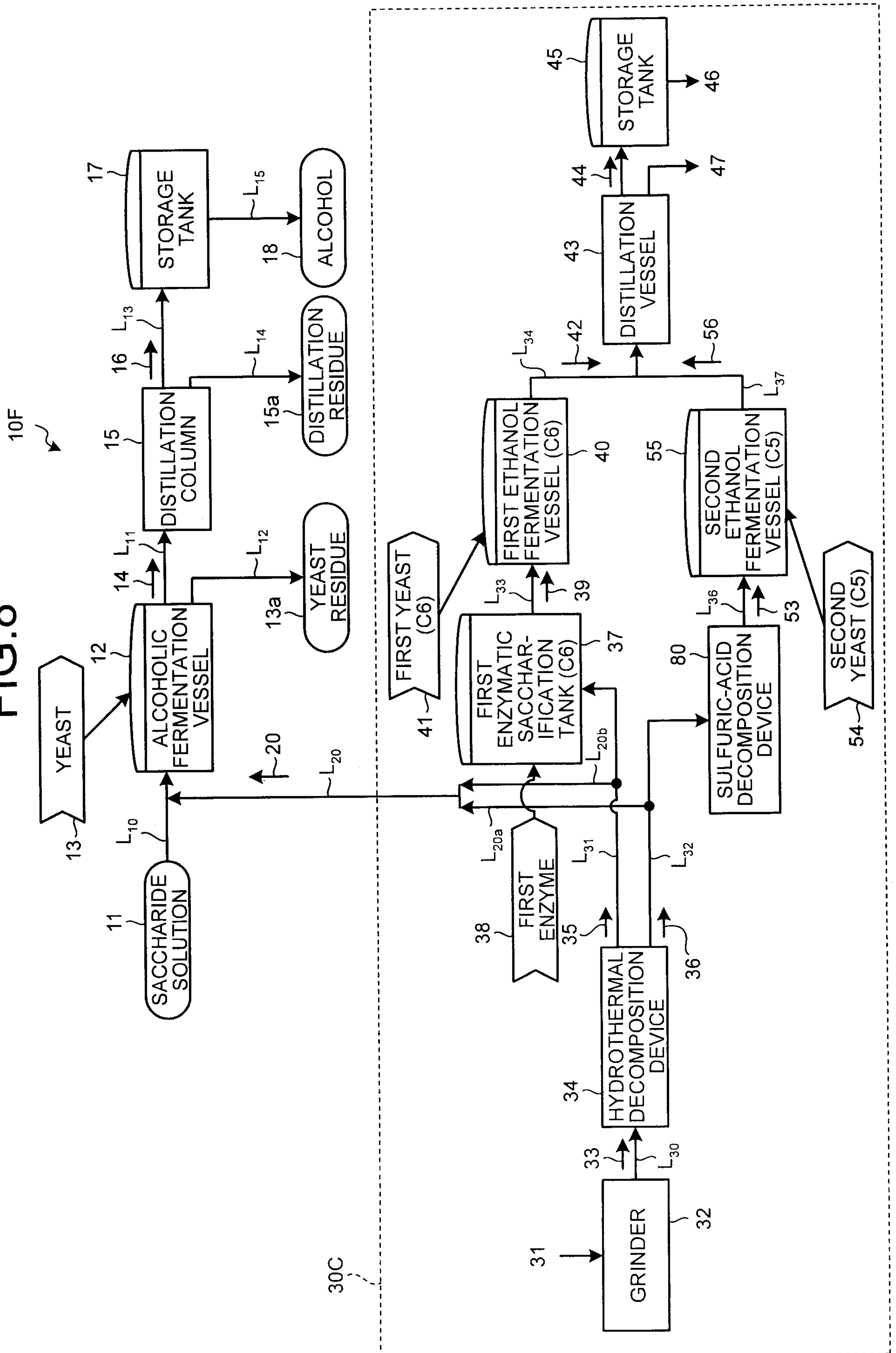


FIG. 8



F/G/G

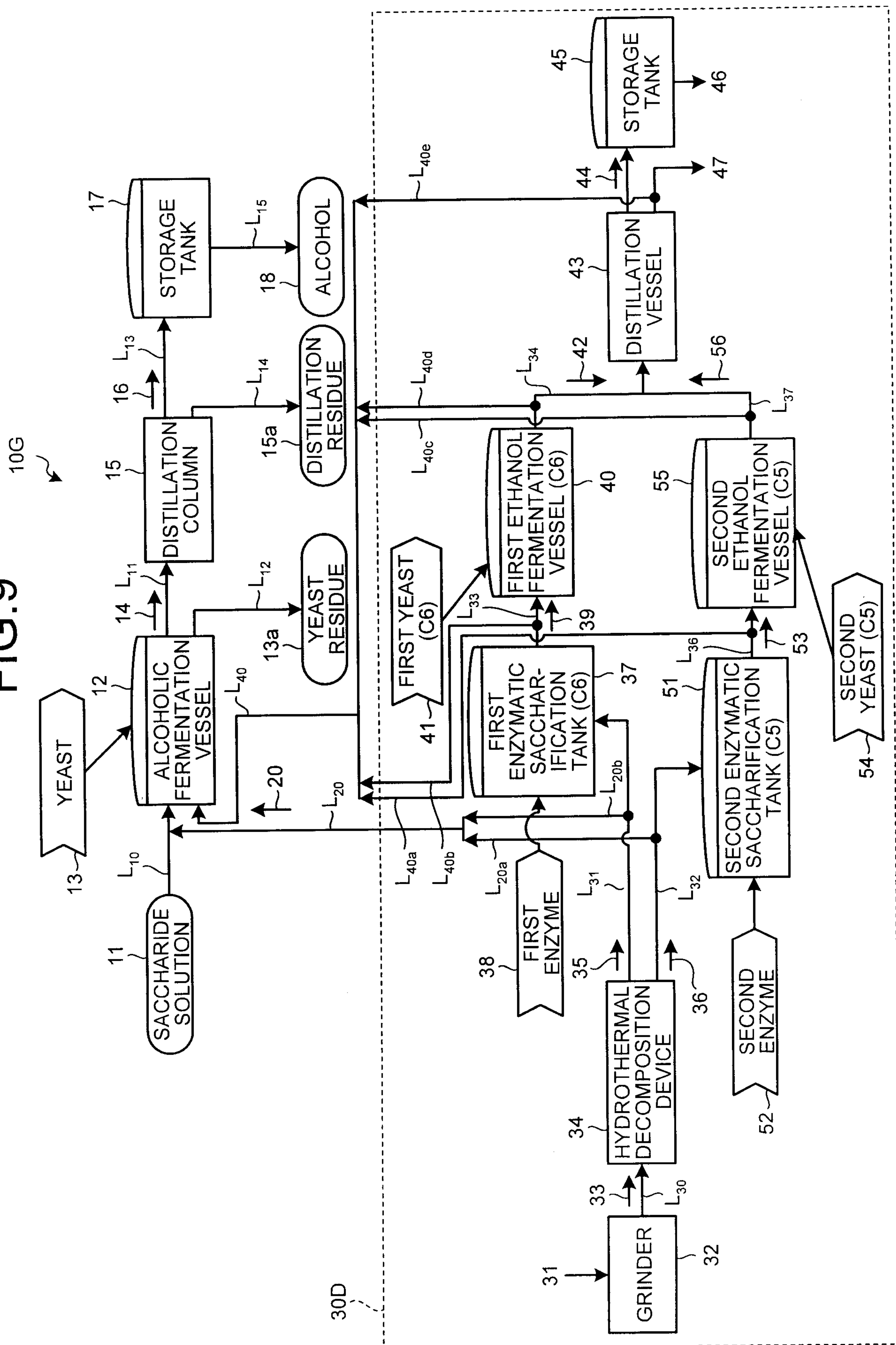
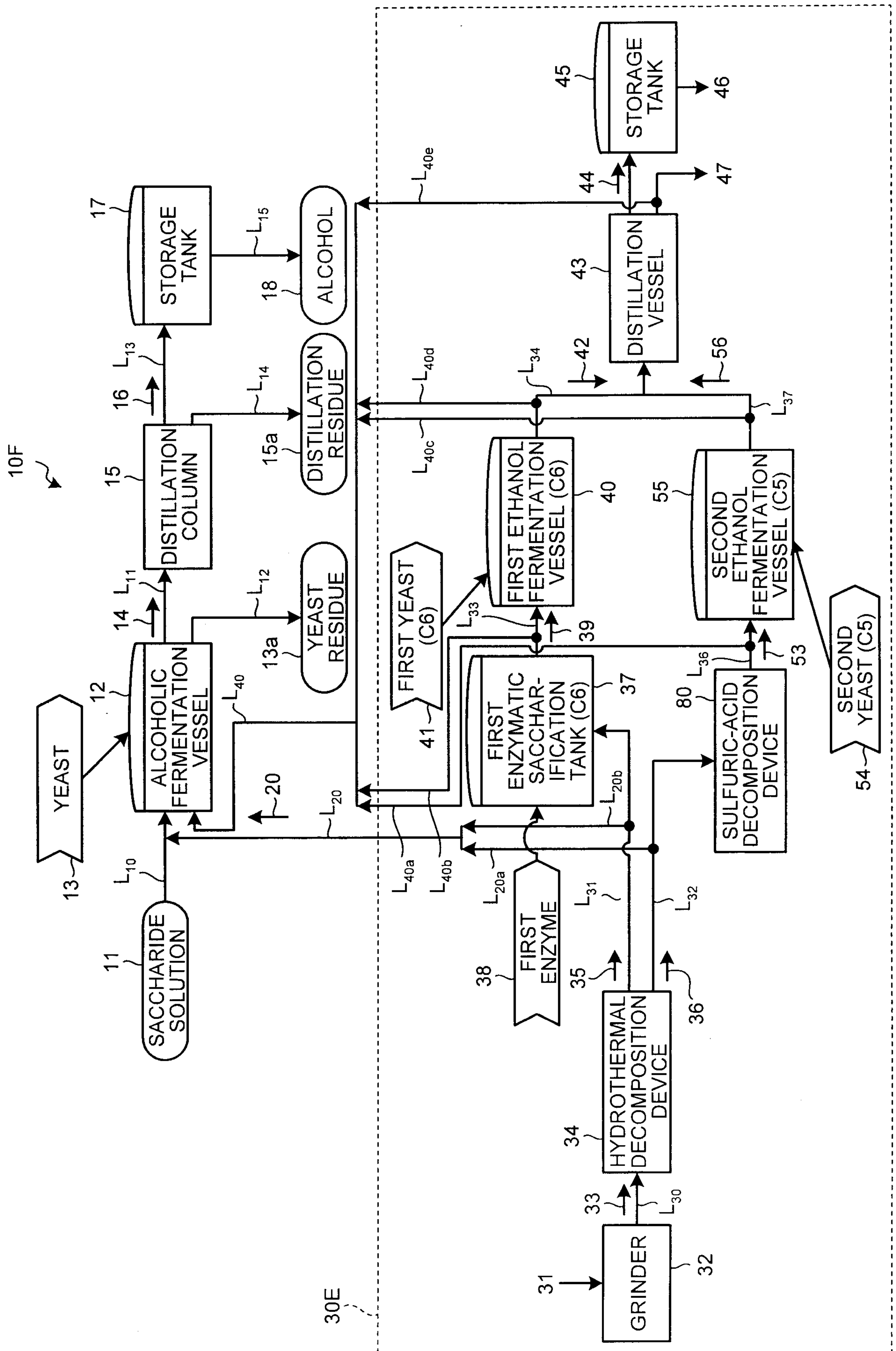


FIG. 10



1	MEVPPRLSHV	PPPLFPSAPA	TLASRSLSHW	RPRPPRQLAP	LLPSLAPSSA
51	RQGARRAQRH	VTAAQQPSRLA	GGAAIKGGRR	RRPDLFRRHF	KSSSIQRSAA
101	AAAATRRTARQ	HPPADSSVTM	EDMNEYSNIE	EFAEGSKINA	SKNQQDDGKM
151	FIGGLSWDTS	KKDLTEYLSR	FGEVVDCTIK	TDPVTGRSRG	FGFVLFKDAA
201	SVDKVLELKE	HKLDGKLIDP	KRAKALKGKE	PPKKVFVGGL	SPDTSEEQIK
251	EYFGAFGEIE	NIELPMDTKT	NERRGFCFIT	YTDEEPVKKL	LESRYHQIGS
301	GKCEIKVAQP	KEVYRQQQQQ	QKGGRGAAAG	GRGGTRGRGR	GQGQNNWNQGF
351	NNYYDQGYGN	YNSAYGGDQN	YSGYGGYDYT	GYNYGNYGYG	QGYADYSGQQ
401	STYGKASRGG	GNHQNNYQPY			