United States Patent [19]

Nishijima et al.

[11] **3,781,174**

[45] **Dec. 25, 1973**

[54] **CONTINUOUS PROCESS FOR PRODUCING REFINED SUGAR**

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[73] Assignee: **Hitachi Shipbuilding and Engineering Co., Ltd.,** Osaka, Japan

[22] Filed: **Oct. 13, 1971**

[21] Appl. No.: **188,851**

[30] **Foreign Application Priority Data**

Oct. 16, 1970 Japan.................................. 45/90153

[52] **U.S. Cl.**.................... **127/46 A,** 127/42, 127/50, 127/54, 204/180 P

[51] **Int. Cl.**....... **C13d 3/06,** C13d 3/14, C13d 3/18

[58] **Field of Search**...................... 127/42, 46 R, 52, 127/46 A, 61; 204/180 P

[56] **References Cited**

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[57] **ABSTRACT**

A continuous process for producing refined sugar from juice extracted from sugarcane or other raw material comprises removing part of the impurities and part of the coloring matter in the juice by the use of a continuous carbonation process, decolorizing the juice by the use of granular active carbon, further removing the impurities and coloring matter remaining in the juice by using a combination of ion-exchange resin and ion-exchange membrane electrodialysis, concentrating the purified juice, and crystallizing the concentrated juice to form refined sugar.

8 Claims, 2 Drawing Figures

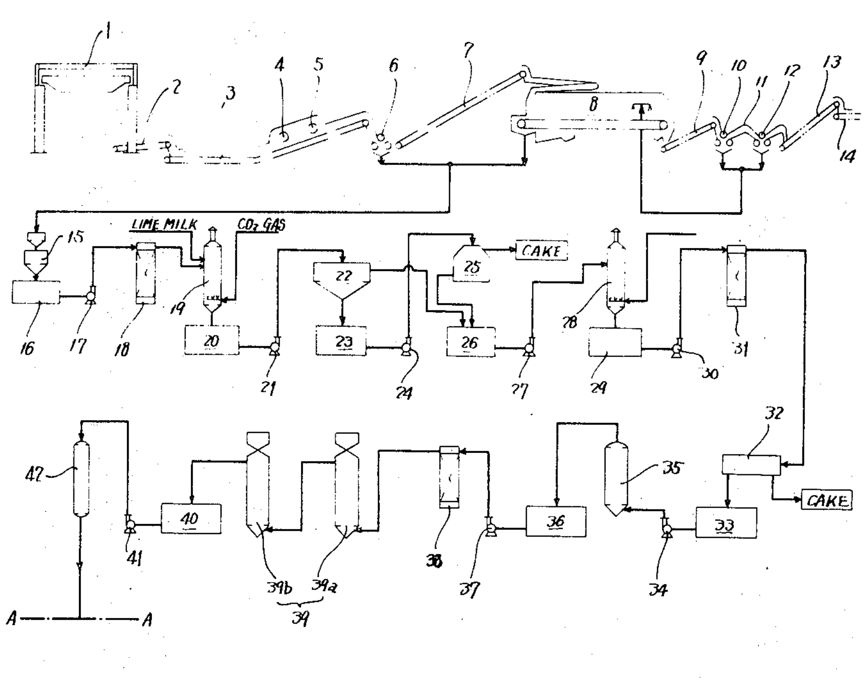


FIG. 1

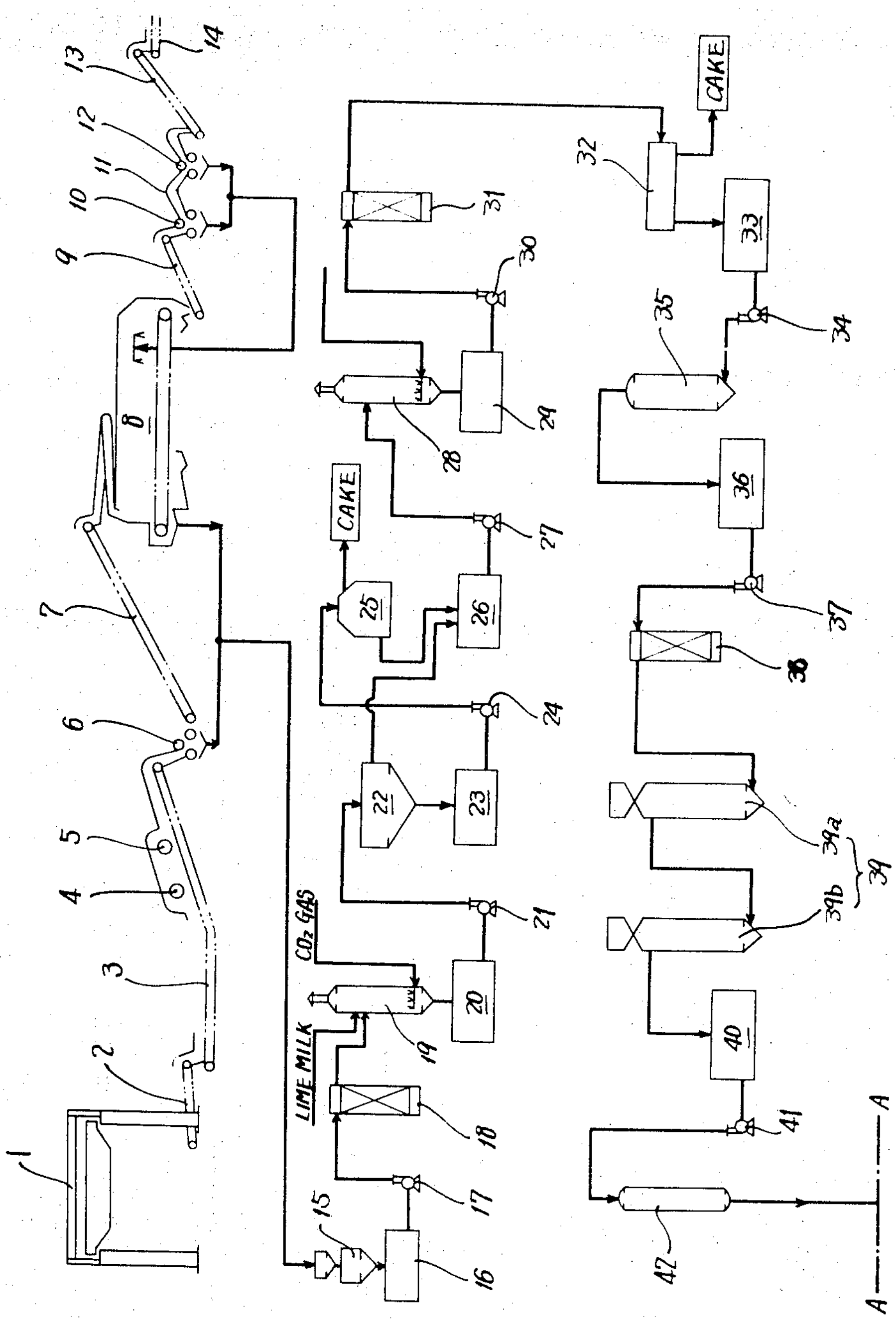
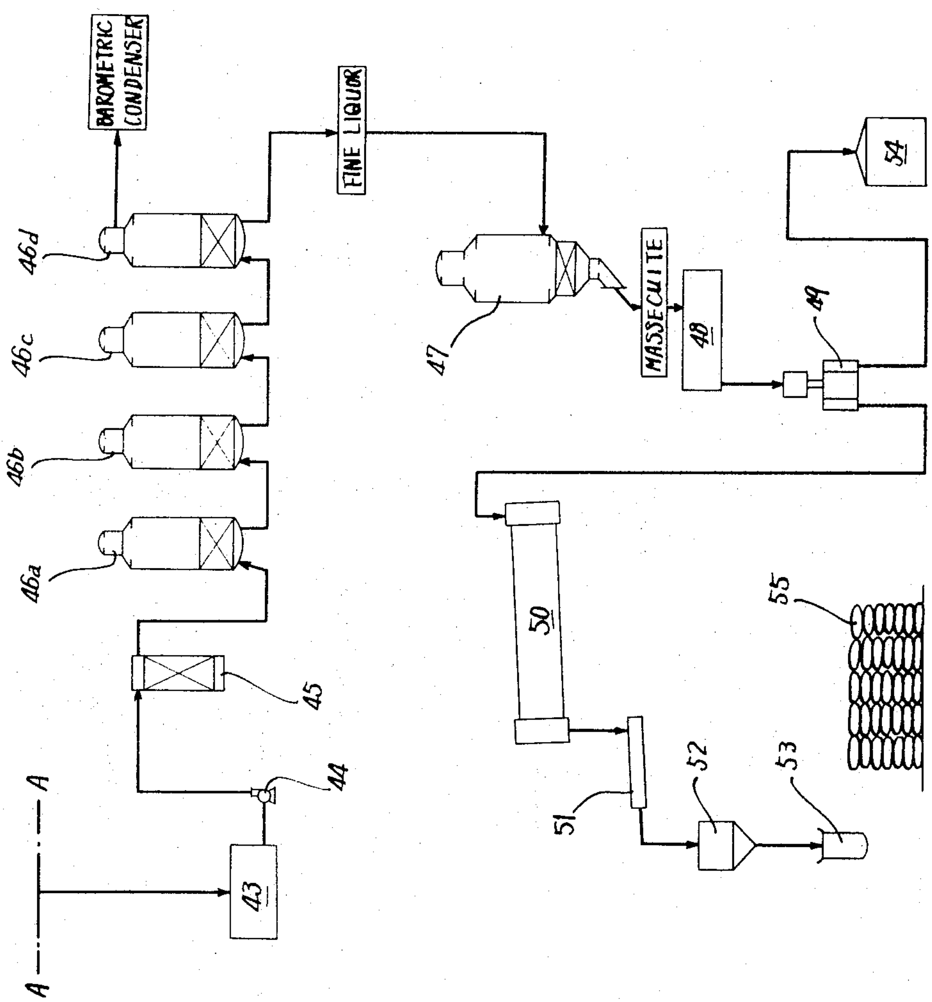


FIG. 2


BAROMETRIC CONDENSER
FINE LIQUOR
MASSECUITE
46a
46b
46c
46d
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A

CONTINUOUS PROCESS FOR PRODUCING REFINED SUGAR

BACKGROUND OF THE INVENTION

Heretofore, plantation refined sugar has been produced by first producing raw sugar which is melted and processed by means of sugar refining equipment installed either in a raw-sugar plant or at a place adjacent thereto.

The refined sugar producing process according to the present invention applies a high degree of refinement directly to a juice extracted from sugarcane or other raw material, without requiring recrystallization as in the conventional process. In the conventional process, the juice extracted from the raw material is subjected to a fractional liming process for clarification, and the clarified juice is concentrated and crystallized to produce raw sugar. The raw sugar is then remelted, decolorized by the use of granular active carbon, and purification is effected by the recrystallization process to remove the impurities (ash, organic non-sugar, etc.) contained in the juice.

In the present invention, a continuous carbonation process is applied to the extracted juice and the resulting carbonated juice is filtered. After the filtrate is decolorized by granular active carbon, the impurities in the juice are removed by the use of a combination of ion-exchange resin and ion-exchange membrane electrodialysis to provide the refined juice, which is then crystallized, thereby directly producing refined sugar.

The present invention is superior to the conventional process in several respects. In the present invention, salts and organic non-sugars in the juice are removed by the chemical process occuring with the use of ion-exchange resin, whereas in the conventional process such impurities are removed by the recrystallization process, i.e., physical means, and hence the conventional process necessitates the remelting of the crystallized raw sugar and then recrystallizing the same. Sugar boiling, curing and purging steps are necessary for both the production of raw sugar and the refined sugar.

Since the process of the present invention is capable of directly producing refined sugar, the sugar boiling, curing and purging steps required in the conventional production of raw sugar become unnecessary; or in other words, no steps other tan those required for the production of refined sugar are necessary in the process of the invention. As a result of the invention, the installation and operation costs of a sugar refining plant can be greatly reduced, and a high yield of a product high in purity can be obtained.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a portion of a flow diagram illustrating an embodiment of the present invention; and,

FIG. 2 is a continuation of the flow diagram of FIG. 1, both Figures being connected together at line A—A theeon.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 sugarcane is transferred by a cane yard crane **1**, a cane feeding table **2** and a cane carrier **3** to cane cutters **4** and **5**, where it is cut up. The cane is then squeezed in a pre-extraction mill **6** and conveyed by a diffuser inlet conveyor **7** to a cane diffuser **8**. The juice resulting from diffusion and extraction is passed

through a juice weigher **15** to a receiving tank **16** and then introduced by a pump **17** into a juice heater **18**.

The squeezed cane discharged from the cane diffuser **8** by a diffuser outlet conveyor **9** is passed through a first dewatering mill **10** and an intermediate carrier **11** into a second dewatering mill **12**. Liquid from both dewatering mills **10** and **12** is used as an additive liquid for the cane diffuser **8**. The juiceless remains of the sugarcane, bagasse, is taken out by a bagasse elevator **13** and carrier **14** to be used as fuel for boilers. All the steps described above are conventional and may be replaced by other conventional steps equivalent thereto.

The steps of the process of the invention will now be described. The extracted juice introduced into the juice heater **18** is heated to about 55° C and is subjected to carbonation in a first carbonator **19**, with the addition to the juice of milk of lime and carbon dioxide gas. The carbonated juice is fed to a thickener **22** through a first carbonated juice tank **20** by a pump **21**. In the thickener **22**, the carbonated juice is separated into supernatant liquid (hereinafter referred to as clarified juice) and the precipitate of calcium carbonate (hereinafter referred to as mud), the former being received in a clarified juice tank **26** and the latter in a muddy juice tank **23**.

The mud is fed by a pump **24** from the tank **23** into a muddy juice separator **25** and separated into clarified juice and cake. The clarified juice resulting from separation in the muddy juice separator is received by the same clarified juice tank **26** as is the clarified juice from the thickener **22**. Then, the clarified juice from both the thickener and the muddy juice separator is fed by a clarified juice pump **27** into a second carbonator **28**, where the clarified juice is carbonated, and passed into a second carbonated juice tank **29**. A pump **30** feeds the carbonated juice from the tank **29** to a heater **31**, where the juice is heated to about 80° C to facilitate filtration, and is then passed through a check filter **32** for removal of the resulting calcium carbonate. In this way, the greater part of the impurities and part of the coloring matter are removed from the juice by the use of a continuous carbonation process.

Filtered juice from the filter **32** is received in a filtrate juice tank **33** and is fed by a pump **34** into decolorizing equipment **35**, where the juice is decolorized by granular active carbon, and the decolorized juice is received in a tank **36**.

Decolorized juice from the tank **36** is fed by a pump **37** through an ion-exchange membrane **38** and into a purification tank **39** having a cation tower **39***a* and an anion tower **39***b*. Removal of the impurities — decoloration and dechlorination refinement — is effected by a combination of the ion-exchange membrane **38** and ion-exchange membrane electrodialysis, and the resulting refined juice is received in a tank **40**. In commercial practice, small amounts of salts may pass through this purification equipment, and so the juice is fed to a monobed ion exchange tower **42** by a pump **41** in order to apply complete dechlorination thereto and the pH is adjusted in order to prevent inversion from taking place in the concentration and crystallization steps.

The sequence of these juice purification processes by the ion exchange method is reversible; that is, the decolorized juice from the tank **36** may be first fed to the ion exchange resin towers **39**a and **39**b, then through the monobed ion exchange tower **42**, and finally through the ion exchange membrane apparatus **38** to a tank **43** (FIG. **2**).

The refined juice, received in the tank **43,** is introduced by a pump **44** into a pre-heater **45** and the heated juice is evaporated and concentrated by multi-effect evaporators **46***a*—**46***d* to form a refined juice of high purity. Alternately, this concentrating step may be performed by arranging the first three evaporators **46***a*, **46***b*, and **46***c* immediately after the decolorized juice tank **36** of FIG. **1.** In other words, a portion of the concentrating step may be performed prior to the purifying step with results comparable to those obtained by the arrangement illustrated.

The refined juice derived from the last evaporator **46***d* is received by a vacuum pan **47** and the massecuite cured therein is collected in a tank **48** and introduced into a centrifugal machine **49,** where the massecuite is fractionated into sugar and molasses. The molasses is stored in a molasses tank **54,** while the sugar is dried and cooled by a sugar dryer and cooler **50** to crystallize the sugar. Thereafter, the sugar is passed through a sugar sieve **51** for adjutment of grain size and then delivered through a sugar bin **52** into sugar bagging equipment, where the sugar is bagged to provide bagged products **55.**

To further illustrate the process, cane sugar juice having undergone the usual carbonation treatment, and maintained at a temperature of 70°–80° C, was supplied at the rate of 1.5 – 2.8 M^3/hr./ton carbon to a continuous type sugar cane juice decolorizing tower packed with granulated active carbon amounting to about 1/10 of the solid contained in a daily processed amount of sugar juice. After being thus decolorized the juice was cooled to about 20° C by a heat exchanger and a cooler and was then passed through a strong acidic cation exchange resin tower, a medium basic anion exchange resin tower and a strong basic anion exchange resin tower. These resin towers were counter bed type continuous exchange towers adapted to provide a high efficiency of ion exchange and operate with a decreased amount of resin. Examples of resins used are as follows:

strong cation exchange resin	Amberlite IR-124 or 252
medium anion exchange resin	Amberlite IRA-68 or 93
strong anion exchange resin	Amberlite IRA-401 or 411

If the resin towers are provided with means for protecting the sugar juice from contamination by germs, the sugar juice may be passed therethrough at about 50° C. In this case, strong anion resin type -II (DIAION SA-20, Amberlite IRA-411, etc.) may be used in the first stage and week anion resin (Amberlite C-50, etc.) may be used in the second stage.

The sugar juice having a substantial amount of non-sugar matter (ash and organic non-sugar) thus removed therefrom may be used in this state to produce white sugar of good quality, and if the resin towers are designed to reduce the ash to 20 percent or less or the original ash content, it is possible to expect 95 percent or more of purified juice purity. But, in this invention, considering the running cost for regeneration and com-

plement of resins, the resin tower is planned to eliminate 5 percent – 60 percent of the ash from the juice and the remainder of the purification is accomplished by the combination of the ion exchange resin tower and the ion exchange membrane apparatus. The sequence of these processes is reversible, that is, the juice from the granular carbon tower is first fed to the ion exchange membrane apparatus where about 50 percent – 60 percent of the minerals in the juice are eliminated, and as the following stage, this predemineralized juice is treated in the continuous ion exchange resin towers. With either sequence, 95 percent – 98 percent of juice purity is expected.

As an example of the membrane apparatus used, mention may be made of an apparatus in which a combination of SCRION C-100 and SCRION A-100 membranes, both 900mm × 900mm in size, is installed in such number as required for a demineralization rate of 6–7 equivalents/hr. for each pair of membranes. (current density: 1 A/dm^2)

The results of analysis of the juice in the individual stages comprising these combined processes are shown in the following table. From this table, it is apparent that the quality of clarified juice and syrup obtained by the process of the present invention is almost the same as the quality of the fine liquor of the conventional sugar refinery.

	Ref. brix	App. purity	Stammer color	Ash, mg./l. as $CaCO_3$	Electro-coductance	pH	CaO, mg./l.
Filtered 2nd carbonated j.	13.0	88.0	23.2	5,120	4,320	8.2	250
Carbon decolored j.	12.5	90.5	2.8	5,200	4,050	7.0	250
Predemineralized j. by ion exchange	11.2	96.5	0.3	2,100	2,480	7.2	26
Final demineralized j. by electrodialysis	11.0	97.2	0.4	105	390	6.6	-------
Syrup	65.2	97.6	0.5	-------	-------	6.2	-------

Note: **1** In this experiment, substantially the same results will be obtained even if the order of the ion-exchange and electro dialysis processes is reversed, but the apparatus for electrodialysis shall be a larger scale than the other.

2 The amount of mineral matter removed by the electrodialysis is about 150–200 equivalent per 1 KWH of electrical consumption.

3 The amount of regenerant for ion exchange resin per equivalent of mineral matter removed is as follows.

95% NaOH	45–50g
33% HCl	270–300 g

We claim:

1. A continuous process for refining sugar from the juice extracted from a raw material such as sugarcane comprising the steps of:

a removing part of the impurities and part of the coloring matter from the juice by the use of a continuous carbonation process;

b carrying out the decoloration of the juice;

c further purifying the juice by employing the following treatments in either order desired,

1 a cation and an anion ion-exchange resin treatment, and

2 an ion-exchange membrane electrodialysis treatment, wherein the first treatment employed is limited to exchange only a portion of the cation ions of the juice;

d Concentrating the juice; and,

e crystallizing the concentrated juice to form refined sugar.

2. A process according to claim **1** wherein a portion of the step (d) of concentrating the juice is performed prior to the step (c) of further purifying the juice.

3. A process according to claim **1** wherein the step (a) of removing part of the impurities and part of the coloring matter from the juice is carried out by adding milk of lime and carbon dioxide gas to the juice, separating the carbonated juice into clarified juice and cake, carbonating the clarified juice, and filtering the carbonated clarified juice.

4. A process according to claim **1** wherein the step c) of further purifying the juice includes the employment of a dechlorination treatment.

5. A process according to claim **1** wherein the step (c) of further purifying the juice is carried out by passing the juice through an ion-exchange membrane, a cation tower and a anion tower.

6. A process according to claim **5** wehrein the purified juice from the cation and anion towers is dechlorinated, by using an anion exchange resin treatment.

7. A process according to claim **1** wherein the step (d) of concentrating the juice is carried out by passing the juice through a multi-effect evaporator.

8. A process according to claim **7** wherein a portion of the step (d) of concentrating the juice is performed prior to the step (c) of further purifying the juice.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,781,174

DATED : December 25, 1973

INVENTOR(S) : Yoshiaki Nishijima et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the title page, item [30] the Serial No. of the corresponding application in Japan should read --45-91053--.

Signed and Sealed this

nineteenth **Day of** *July 1977*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3781174 Dated December 25, 1973

Inventor(s) Yoshiaki Nishijima and Kazutaka Adachi

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 47, change "tan" to --than--;

Column 1, line 59, change "theeon" to --thereon--;

Column 3, line 24, after "equipment" insert --53--; and,

Column 4, line 2, change "5" to --50--.

Signed and sealed this 23rd day of April 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents