



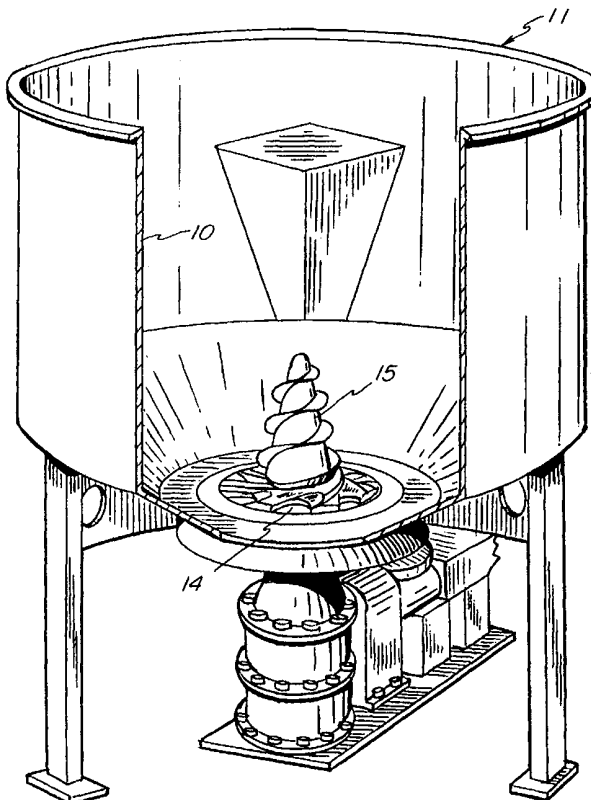
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |    |                                                                                                                                                                                                     |
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| (51) International Patent Classification <sup>6</sup> :<br>D21C 9/00, D21H 11/12                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | A1 | (11) International Publication Number: WO 00/09799<br>(43) International Publication Date: 24 February 2000 (24.02.00)                                                                              |
| (21) International Application Number: PCT/US99/18652<br>(22) International Filing Date: 17 August 1999 (17.08.99)<br><br>(30) Priority Data:<br>60/096,812 17 August 1998 (17.08.98) US<br><br>(71) Applicant (for all designated States except US): THERMO BLACK CLAWSON INC. [US/US]; 605 Clark Street, P.O. Box 160, Middletown, OH 45042 (US).<br><br>(72) Inventors; and<br>(75) Inventors/Applicants (for US only): SIERON, Michael, A. [US/US]; 271 Walnut Grove Drive, Dayton, OH 45458 (US). KING, Kirk, A. [US/US]; 5334 Windbrook Trail, Beckett Ridge, Westchester, OH 45069 (US). HAYWOOD, Steven, T. [US/US]; 4110 Meadow Court Drive, Memphis, TN 38135 (US).<br><br>(74) Agents: PEACOCK, Bruce, E. et al.; Biebel & French, 35 East First Street, Dayton, OH 45402 (US). |    | (81) Designated States: BR, CA, CN, IN, JP, MX, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).<br><br>Published<br>With international search report. |

(54) Title: PULPER AND COUNTER-CURRENT WASHER SUGAR CANE EXTRACTION

## (57) Abstract

A process for extracting a sugar rich liquor from sugar cane. The sugar cane is first treated by pulping it in a tub type pulper (11) having a rotating impeller (15). The contents of the pulper are extracted through the bed plate (14) of the extractor and are forwarded to form a mat on a moving belt extractor of the type having a foraminous belt. Negative pressure is applied below the belt to assist the extraction of the liquid component through the belt. The material passes through several separation zones as it travels on the belt with liquid applied to the mat from a region above the belt.



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**PULPER AND COUNTER-CURRENT WASHER**  
**SUGAR CANE EXTRACTION**

This invention relates to a processes and apparatus for sugar  
5 extraction from cane, and more particularly to an efficient diffusion extraction  
process.

**BACKGROUND OF THE INVENTION**

In present day diffusion processes, the entire cane is usually subject  
10 first to a cutting or shredding process by which the cane cells in the pith and rind are  
ruptured open, or at least in which a substantial number of such cells are ruptured.  
The finely divided cane is then subjected to diffusion, where the refined pulp  
material is applied to one of a number of different diffusers at a relatively high  
consistency, such as about 8%-12% solids or higher. Heated water or steam is  
15 applied and juices and liquids are extracted in a tank or on a conveyor belt. In some  
instances, the extracted material flows in a countercurrent manner against the  
direction of travel of the refined cane material. Extraction in such diffusers is by  
gravity combined, in some cases, with mechanical pressing.

The term "diffusion" has been applied to various apparatus and  
20 methods by which a shredded, sliced, ground or refined cane or, in some instances,  
bagasse, is subjected to extraction by contact with heated fluid. In a true diffusion  
process, the plant cell is not ruptured and advantage is taken of the property of the  
dissolved crystals passing through the cell wall when water or other solution is more  
dilute than that in the cell. Following diffusion, all solutions in contact with cells  
25 tend to achieve equal concentrations with the fluid in the cell.

Current refining practice has been to treat the cane in such a manner  
that, to a large extent, the cells are ruptured, and the sugar removal more nearly  
resembles a washing process called lixiviation. Apparently, both diffusion and  
lixiviation occur at the same time, but the term "diffusion" has become generically  
30 applied to such extraction processes and equipment quite apart from the fact that  
limited actual diffusion may be taking place.

While a great deal of attention has been paid to the construction and

operation of diffusion equipment, this equipment still operates principally upon through-flow arrangements which depend upon gravitational drainage, at relatively high consistency and therefore the efficiency and production rates are accordingly limited.

5

### SUMMARY OF THE INVENTION

Substantially improved production rates and efficiency can be obtained by adapting certain processing equipment that has already been developed and used in the preparation of papermaker's pulp. The cane is "refined" or  
10 macerated in a tub type pulper known in the industry as a hydropulper. In a hydropulper, material to be pulped is placed in a tub in which a specially designed impeller or rotor is mounted at the tub bottom above a perforated bedplate. Heated dilution water is added and the pulped material is extracted through the bedplate after a sufficient period of time has elapsed. The pulper, may be made according to U.S.  
15 Patent Nos. 4,725,007 and 4,109,872 incorporated herein by reference. The impeller or rotor is preferably a "MidCon" rotor of Thermo Black Clawson, Inc. according to U.S. Patent No. 4,725,007 incorporated herein by reference. The hydropulper is highly efficient in reducing the fibrous content of the cane and breaking open the cell structure, permitting release of the sugar juices into the slurry.

20 The pulping takes place at relatively high consistencies (approximately 8-10%) and uses recycled washer water from the counter-current washer's formation and first stage wash zones. The pulping will continue until a major portion of the sugar content is dissolved in the liquid content, such as up to 30 minutes or more at 75°C so that about 70%-90% of the sugar content has been  
25 extracted into the liquid phase.

When the pulping is completed, the slurry is extracted through the perforated pulper bedplate and it is applied through a head box onto the top side of the continuously moving belt of a flat bed fordriner type counter-current displacement type washer. Such a washer employs an endless foraminous belt,  
30 (often called a "wire"), a head box which delivers the suspension to the on-running or upstream end of the horizontally traveling upper run of the belt while at the

relatively low consistency of about 2%-4% solids and at the elevated temperature. The pulped material is thus deposited on the upstream end of the run of the belt where a mat is formed as the sugar-rich liquid drains through the belt and is withdrawn for further processing.

5           The belt run downstream from the formation zone is divided into a series of displacement zones to which liquid is supplied as from showers from above for drainage through the mat and through the belt and into receptacles below the belt. Fresh washing liquid or heated water is applied at the last of these zones at the downstream end of the belt run, and the liquid drained from the last zone is collected  
10 and delivered to the zone immediately upstream from the last zone, and these steps are repeated for each of the other zones to affect counter current extraction from the pulp.

          The entire apparatus is enclosed in a hood. A series of receptacles are positioned below the upper run of the belt in sealed relation with the hood. Suction  
15 or vacuum is applied to these receptacles. The vacuum from below and the air pressure above augment the action of gravity in forcing the liquor to flow through the pulped mass on the wire. A particular feature of the apparatus is that of recycling the gases and vapors drawn through the belt back to the hood to increase the pressure differential across the belt. The above-described apparatus is more fully described in  
20 the patents of Ericsson, U.S. 4,154,644, issued May 15, 1979 and Parks et al., U.S. 5,367,894, issued November 29, 1994, which patents are incorporated herein by reference.

          Preferably, immediately downstream of the final extraction stage, the pulp mass is subjected to pressure extraction by pressing one or more rolls above the  
25 belt against rolls within the belt loop, such as shown in U.S. 5,367,894. This provides mechanical extraction of liquid from the mat on the belt so that the pulp or bagasse remainder exits the apparatus having given up most of its liquid content, to the range of about 40% consistency. Thus, in the pressing stage, more than 70% of the liquid remaining in the pulp is expressed therefrom and captured. If desired, lime  
30 or other agents may be added to the pulp and liquid within the countercurrent extraction equipment.

A principal advantage of the use of the combination of the hydropulper and counter current extraction washer resides in the fact that the hydropulper releases 70% or more of the sugar content of the cane into the liquid content within the hydropulper. When this is extracted through the hydropulper bed plate with the pulped cane and applied to the head box of the belt type extractor, the suspension is at about 2%-4% percent solids. On the belt it increases from 2%-4% up to about 15% solids before final pressing. This extraction is of high efficiency by reason of the fact that it is accomplished with a pressure differential including a negative pressure head or vacuum below the belt. This translates into a high degree of extraction coupled with a high processing rate compared to that of diffusion extractors dependent upon gravity alone for separation. Since the pulp slurry applied to the belt is at low consistency and in a thin layer (1" or less), the sugar remaining in the mat after draining is much less than in conventional extraction systems where the consistency is 12%-15% and the fiber depth is measured in feet. Accordingly, there remains much less sugar to be extracted at this point, as compared to conventional systems.

#### BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a sectionalized and somewhat diagrammatic view of a pulper used in this invention;

Fig. 2 is an enlarged sectional view of a portion of the pulper tub bottom including a portion of the bedplate of the pulper of Fig. 1; and

Fig. 3 is a diagrammatic view of the belt-type extractor used in this invention.

#### DESCRIPTION OF PREFERRED EMBODIMENT

Referring to the drawings which illustrate the preferred apparatus for the practice of the process of this invention, cut cane to be pulped is applied to the interior of the tank or tub 10 of a pulper 11. As previously noted, the pulper is better known as a hydropulper and may be constructed in accordance with the teachings of U.S. Patents 4,109,872 of August 29, 1978 and U.S. Patent 4,725,007 of February

16, 1988. The hydropulper 11 thus includes a tank 10 with a bottom wall 13. The center portion of the bottom wall supports an annular extraction bedplate 14. A "MidCon" rotor or impeller 15 is mounted for rotation on a shaft 16 and positioned immediately above the extraction bedplate 14. An extraction chamber 17 is formed  
5 below the bedplate 14. When the impeller is rotated, a circulatory motion is created in the tank 10 as shown by the arrows 18. The operation of the rotor vanes with respect to the bedplate creates a strong defibering action. The tub content is then withdrawn through the outlet 20.

The temperature of the slurry formed in the tank 10 should be  
10 maintained in the order of about 75°C or higher. The pulper is operated to reduce the size particles of the pieces of cane to the point where individual pieces are no longer discernable, and the mass has a smooth and fine characteristic of a slurry of fibers in water. The consistency during pulping may be between about 8-10% solids-to-liquid. Grab samples can be taken to determine the extent of reduction of the  
15 fibers which, in any case, are substantially smaller than the openings 24 in the bedplate 14. If desired, a portion of the material of the slurry in the tank 10 may be extracted while running through the tank outlet 20 and recirculated into the tank to enhance or increase the defibering action of the rotor 15.

The pulping process will continue until approximately 70% or more  
20 of the sugars have been extracted by diffusion and by mechanical washing, into the liquid phase of the slurry. In the typical hydropulper installation, this may take between about 20 to 40 minutes of operation.

At the appropriate time, the slurry within the tank 10 may be withdrawn and applied to the belt-type washer extractor 30 diagrammatically  
25 illustrated in Fig. 3. The slurry should be diluted so as to preferably leave the hydropulper 10 at a relatively low consistency of between about 2%-4% solid component.

In the belt-type washer, a frame, not illustrated, supports an endless foraminous wire or belt 32 in a closed loop to define a substantially horizontal upper  
30 run 33 leading from a breast roll 34 at the upstream end of the upper run 33 and terminating at a couch roll 35 at the off-running or downstream end of the run. The

couch roll 35 commonly is the main drive roll for the belt 32, while the return run goes over conventional tensioning rolls 36 and guide rolls 37 to return to the on-running end.

A head box 40 deposits slurry from the hydropulper 10 onto the upper surface of the wire 32 to a rather substantial thickness (approximately 1" thick) to form on such upper surface a mat 42 of pulped fibers. This mat passes through an initial extraction zone 45 and then through a series of supplemental extraction zones 46-50.

The extraction zones are defined by a series of vacuum receptacles 52-57 located in general alignment inside the wire loop under the wire 32. A negative pressure is drawn on each of the receptacles by suction fans or blowers diagrammatically shown at 60. The hood 62 encloses all of the zones 45-50 while the fans 60 create a negative pressure in each of the zones immediately below the horizontal run 33 of the wire 32 for enhancing the rate of withdrawal of the liquid phase through the mat 42.

For each of the zones 46-50 there is a shower 65 located in the hood 62 above the wire and above the mat 42 in such a manner that the shower impacts the mat material substantially at the point where the material enters the respective zone. The showers 50 are operated in a counter-current manner, as more particularly described in the previously referenced U.S. Patent 5,367,894 in such a manner that the shower associated with the zone 57 will typically apply a hot water film, while the preceding showers, will, in turn, be connected to liquid material drawn through the associated extraction pans 53-57. The flows from the pans associated with each of extraction zones 46-50 are augmented by pumps 66 connected to draw fluid from the respective pans and apply the same to the respective showers 65 in a counter-current manner. Preferably, the elevated temperature as described above is maintained throughout the system for the liquid phase. The mat 42, after initial draining at the zone 45 will have an increasing consistency so that the mat will exit the zone 52 at about 15% solids into a press section. This initial extraction is sugar rich and is sent by pump directly to additional sugar processing 100.

The press section 70 employs a pressing belt 75 in which an upper

carriage 76 carries rolls 77 and 78 running on the inside of the belt loop 40. These rolls co-act with the rolls 35 and 83 carried on a carriage 85 within the belt loop for the belt or wire 32. A mechanical pressing action is applied at the press section 70 through the belt 75 to force a substantial degree of the liquid phase out of the mat 42, and the liquid phase component is collected in a collector 90 where it may be directed by a pump 92 back to the second shower head 65. Alternatively, this liquid phase may be added to that extracted from zones 52 and 53 to downstream sugar processing stages 70. Accordingly, the fiber mass 95 which comes off the belt 32 couch roll 35 is almost entirely free of sugar content and is relatively dry having less than approximately 40% moisture content.

The counter-current washing augmented by vacuum at each of the zones provides an efficient means by which the residual sugar content in the mat 42 is stripped and removed.

Accordingly, the pulping in a bath-type pulper effectively removes a major portion of the sugar content while leaving a non-pulpable fiber phase in the slurry with a dilute sugar concentration. The liquid phase is substantially removed immediately using belt-type extraction with vacuum augmentation while the remaining portion of the sugar content is subjected to counter-current wash and extraction, with a final mechanical pressing stage for final extraction, leaving a pressed bagasse component substantially free of its sugar content. The method of extraction including the hydropulper and the counter-current extraction uses less energy than is required to process the same amount of cane through conventional roller presses.

## STATEMENTS OF THE INVENTION

1. The process of extracting a sugar rich liquor from sugar cane comprising the steps of pulping the sugar cane in water in a tub type pulper with a rotating impeller at an elevated temperature to reduce the cane to a pulp and fracture the cells to release the sugar content into the liquid phase, extracting the contents of the pulper through an extraction bed plate, applying said extracted material to the head box of a moving belt type extractor and applying said suspension onto a

foraminous belt, applying a negative air pressure below said belt to augment the extraction of liquid content from said pulp through said belt leaving a mat of pulp on said belt at a substantially higher consistency, and subjecting said mat to repeated zones of separation in which liquid is applied to the mat from a region above the mat and extracting liquid in corresponding zone below the mat at a region of lower than atmospheric pressure.

2. The process of the preceding statement in which said belt carries said mat through a plurality of extraction zones in which the liquid extracted from the last of said zones is applied to the preceding zones in a counter current manner.

3. The process of extracting sugar component from sugar cane comprising the steps of cutting the sugar cane into small pieces and applying said small pieces to a tank type pulper in which a rotor at the bottom of the pulper tank is positioned to run against a perforated bedplate, adding water at an elevated temperature to said tank while operating said pulper to achieve a consistency of solid contents to liquid of about 8%-10%, continuing to operate said pulper rotor until at least about 70% of the sugar content of the cane is dissolved in the liquid phase, and draining said pulper through said bedplate and separating the liquid phase from the non-liquid phase.

4. The process of the preceding statement in which the water is added to achieve a pulp temperature at least about 75°C.

5. The process of statement 3 or 4 in which the content of the pulped cane in the pulper tank is diluted to a consistency of about 2-4% and is applied to the head box of a moving belt type extractor, onto a on-running end of a moving wire, including the further steps of applying a negative air pressure below the wire to augment the extraction of liquid content through the wire such that the consistency of the mat of pulp formed on the wire increases from about 2-4% at the on-running end to about 15% at the off-running end while subjecting the mat to repeated zones of separation in which liquid is applied to the mat from a region above the mat and extracted from extraction zones below the mat, and sending the extracted sugar rich liquor for further processing.

6. The process of the preceding statement in which the mat on the wire is pressed between rollers at the off-running end of the wire for a final pressure extraction of liquid from the mat leaving a bagasse mat on the wire having a consistency of about 40%.

--CLAIMS--

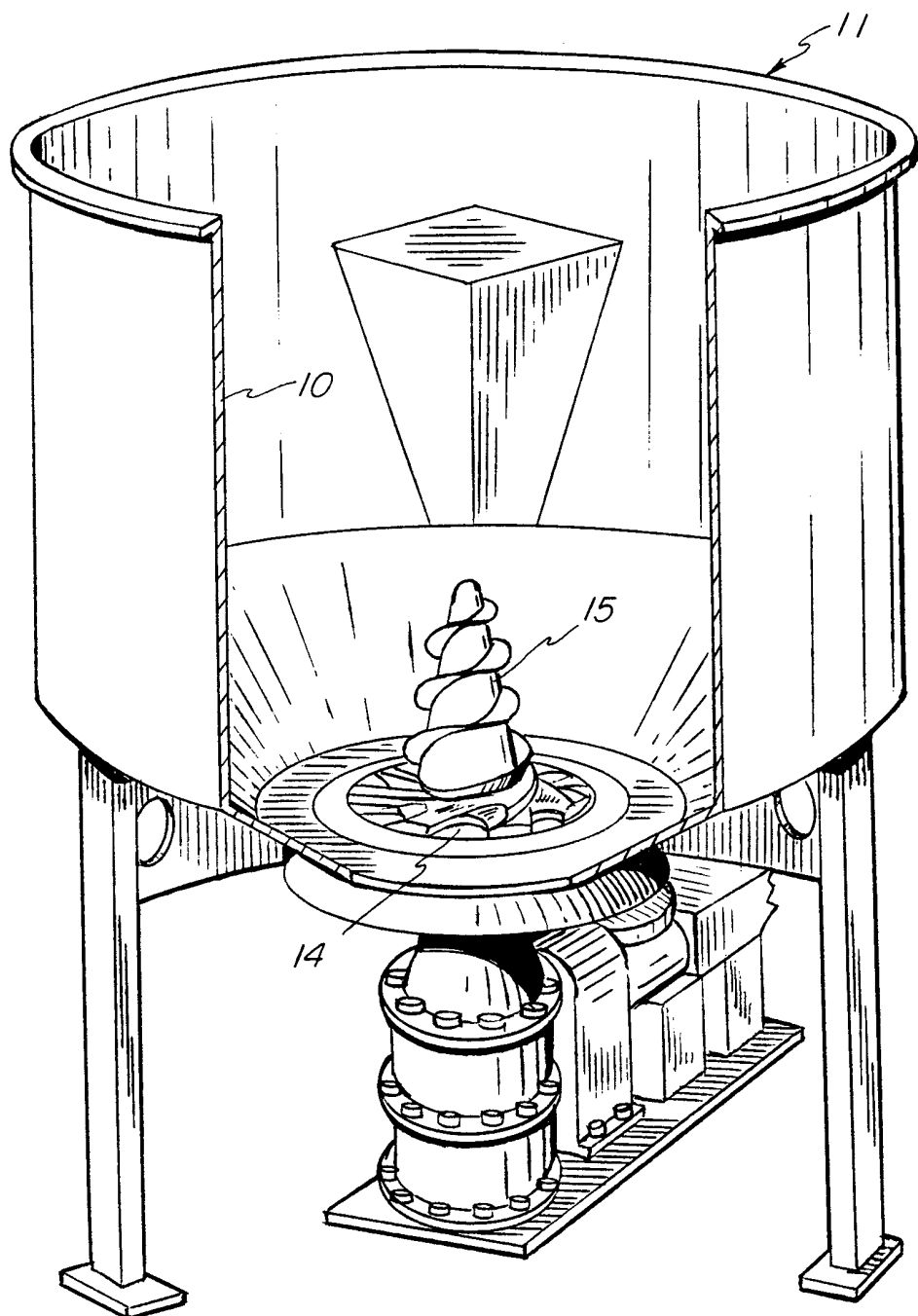
1. The process of extracting a sugar rich liquor from sugar cane comprising the steps of pulping the sugar cane in suspension in water in a tub type pulper with a rotating impeller at an elevated temperature to reduce the cane to a pulp and fracture the cells to release the sugar content into the liquid phase of said suspension,  
5 extracting the contents of the pulper through an extraction bed plate, applying said extracted material to the head box of a moving belt type extractor and applying said suspension onto a foraminous belt, applying a negative air pressure below said belt to augment the extraction of liquid content from said pulp through said belt leaving a mat of pulp on said belt at a substantially higher consistency than said suspension,  
10 and subjecting said mat to repeated zones of separation in which liquid is applied to the mat from a region above the mat and extracting liquid in corresponding zone below the mat at a region of lower than atmospheric pressure.
2. The process as recited in claim 1 in which said belt carries said mat through a plurality of extraction zones in which the liquid extracted from the last of said zones is applied to the preceding zones in a counter current manner.
3. The process of extracting sugar component from sugar cane comprising the steps of cutting the sugar cane into small pieces and applying said small pieces to a tank type pulper in which a rotor at the bottom of the pulper tank is positioned to run against a perforated bedplate, adding water at an elevated temperature to said tank  
5 while operating said pulper to achieve a consistency of solid contents to liquid of about 8%-10%, continuing to operate said pulper rotor until at least about 70% of the sugar content of the cane is dissolved in the liquid phase, and draining said pulper through said bedplate and separating the liquid phase from the non-liquid phase.
4. The process as recited in claim 3 in which the water is added to achieve a pulp temperature at least about 75°C.

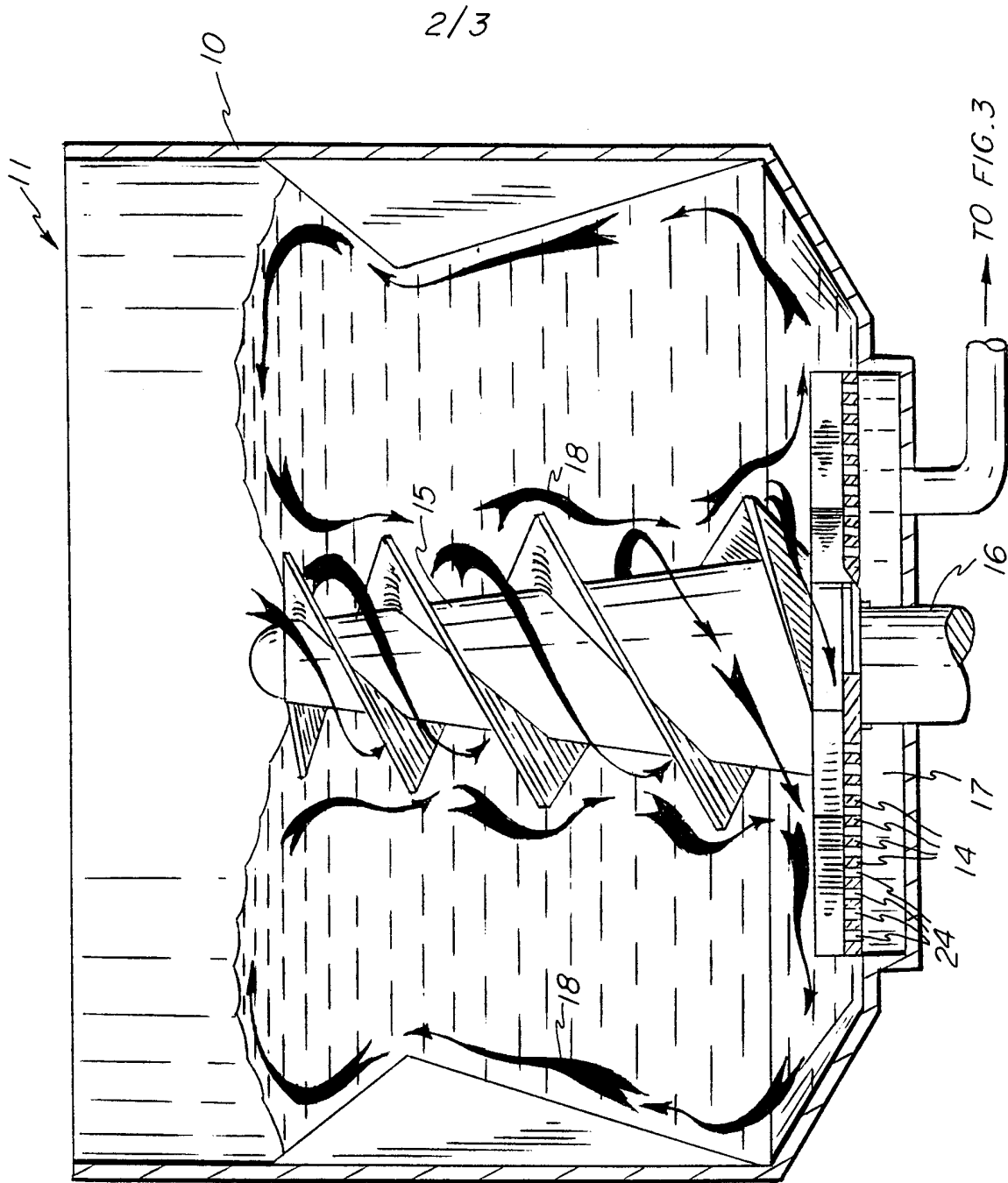
5. The process as recited in claim 3 or 4 in which the content of the pulped cane in the pulper tank is diluted to a consistency of about 2-4% and is applied to the head box of a moving belt type extractor, onto a on-running end of a moving wire, including the further steps of applying a negative air pressure below the wire to augment the extraction of liquid content through the wire such that the consistency of the mat of pulp formed on the wire increases from about 2-4% at the on-running end to about 15% at the off-running end while subjecting the mat to repeated zones of separation in which liquid is applied to the mat from a region above the mat and extracted from extraction zones below the mat, and sending the extracted sugar rich liquor for further processing.

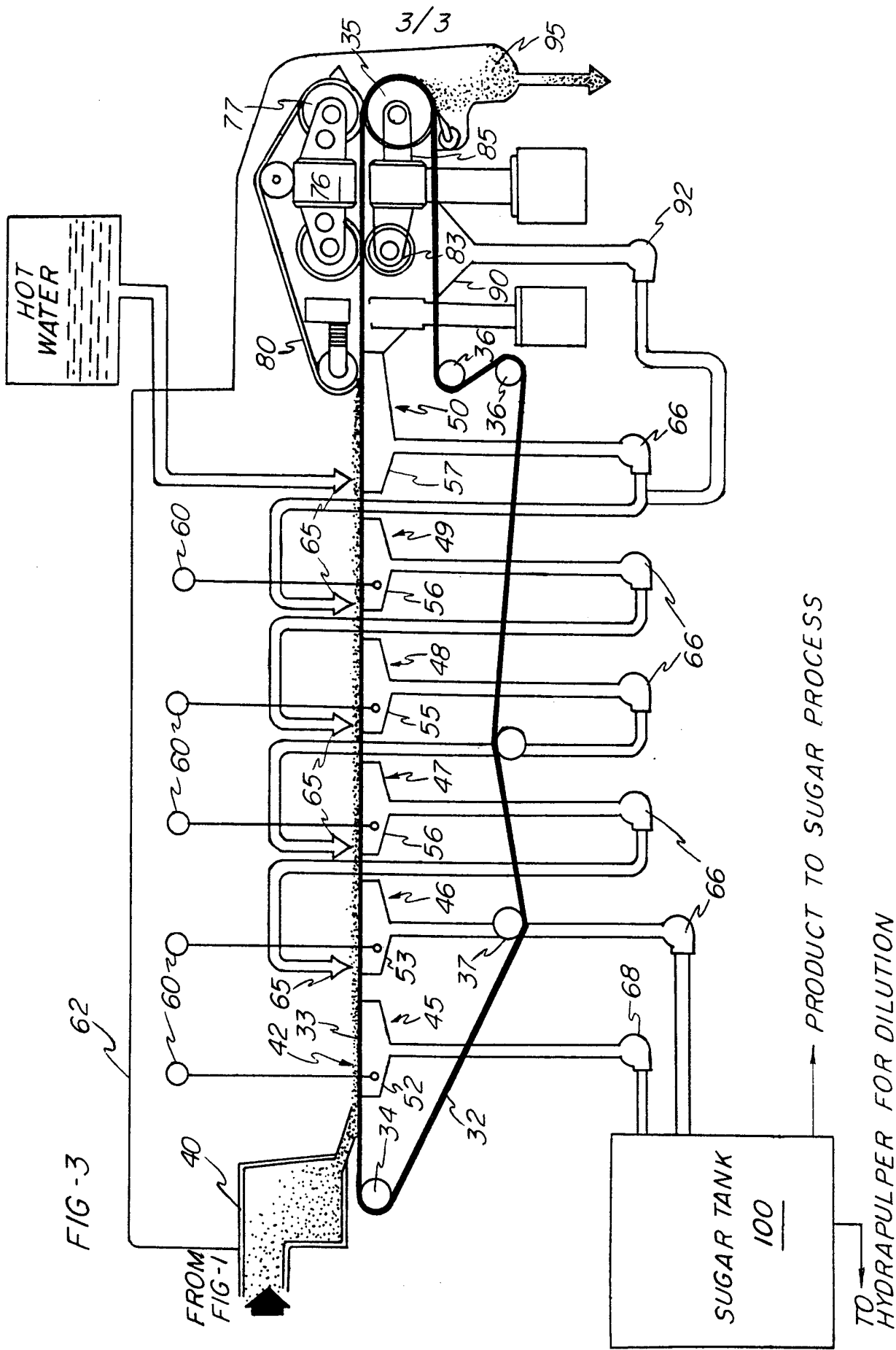
6. The process as recited in claim 5 in which the mat on the wire is pressed between rollers at the off-running end of the wire for a final pressure extraction of liquid from the mat leaving a bagasse mat on the wire having a consistency of about 40%.

FIG -1

1/3







## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US99/18652

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :D21C 9/00; D21H 11/12

US CL :162/4, 60, 96

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 162/4, 60, 96, 202, 205

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

None

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

None

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages       | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------------|-----------------------|
| Y         | US 4,260,452 A (KRUGER et al) 07 April 1981, col.5, lines 36-60 and col. 7, lines 52-59. | 1-6                   |
| Y         | US 5,367,894 A (PARKS et al) 29 November 1994, Figure 1.                                 | 1-6                   |
| Y         | US 4,725,007 A (CHUPKA) 16 February 1988, Figure 1.                                      | 1-6                   |



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

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