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CA 2279283 C 2008/08/26

(11)(21) 2 279 283

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 1998/02/09
(87) Date publication PCT/PCT Publication Date: 1998/08/13
(45) Date de délivrance/Issue Date: 2008/08/26
(85) Entrée phase nationale/National Entry: 1999/07/30
(86) N° demande PCT/PCT Application No.: SE 1998/000225
(87) N° publication PCT/PCT Publication No.: 1998/035091
(30) Priorité/Priority: 1997/02/09 (WOPCT/SE97/00192)

(51) Cl.Int./Int.Cl. *D21C 3/24* (2006.01),
*D21C 3/02* (2006.01)

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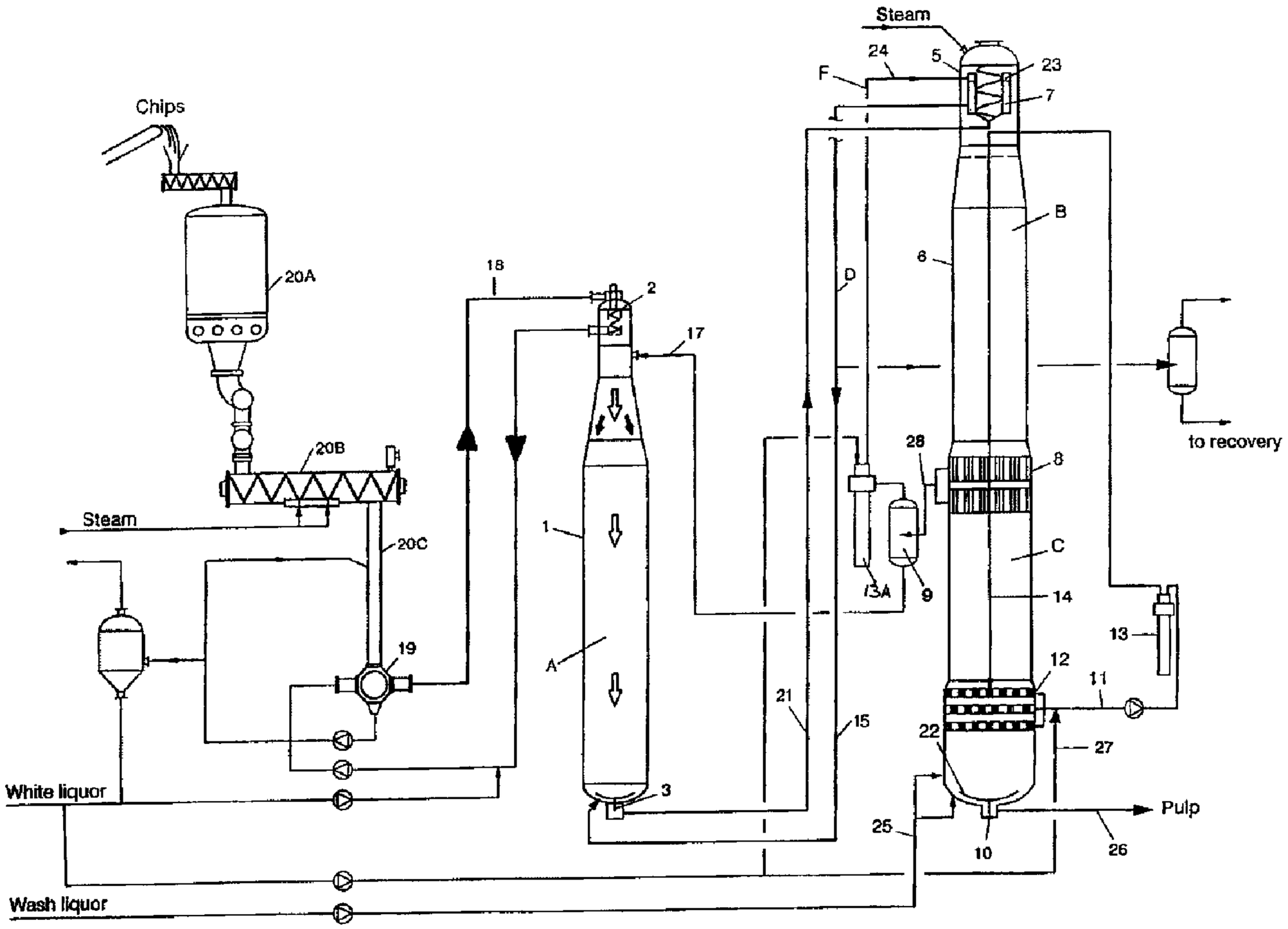
(54) Titre : PROCEDE ET DISPOSITIF DE CUISSON CONTINUE DE PATE
(54) Title: METHOD AND DEVICE FOR THE CONTINUOUS COOKING OF PULP




(57) Abrégé/Abstract:
This invention relates to a new and improved way of continuously cooking fibre material, wherein temperatures and alkaline levels are controlled to be maintained within specific levels in different zones of the digesting process in order to optimise chemical

CA 2279283 C 2008/08/26

(11)(21) 2 279 283

(13) C

(57) Abrégé(suite)/Abstract(continued):
consumption and heat-economy and at the same time achieve very good pulp properties. The fibre material is heated and impregnated by the aid of black liquor to a temperature less than 140 °C and passed in con-current in an impregnation zone (A). The heated and impregnated fibre material is transferred to a con-current cooking zone (B) in the upper part of a digester (6). At least 60 % of the quantity of liquor (F) required for the cooking reaction is supplied in the up-stream end of the con-current cooking zone (B) in order to obtain a level of effective alkali exceeding 35 g/l. The cooking temperature in the con-current cooking zone (B) is lower than 160 °C. Spent liquor (E), with an amount of effective alkali of at least 13 g/l, is withdrawn from a strainer girdle (8). A substantial part of the spent liquor is supplied to the impregnation zone.

**PCT** WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

**(51) International Patent Classification** 6 :
**D21C 3/02, 3/24**

**A1**

**(11) International Publication Number:** **WO 98/35091**

**(43) International Publication Date:** 13 August 1998 (13.08.98)

**(21) International Application Number:** PCT/SE98/00225

**(22) International Filing Date:** 9 February 1998 (09.02.98)

**(30) Priority Data:**
PCT/SE97/00192 9 February 1997 (09.02.97) WO
*(34) Countries for which the regional or international application was filed:* AL et al.

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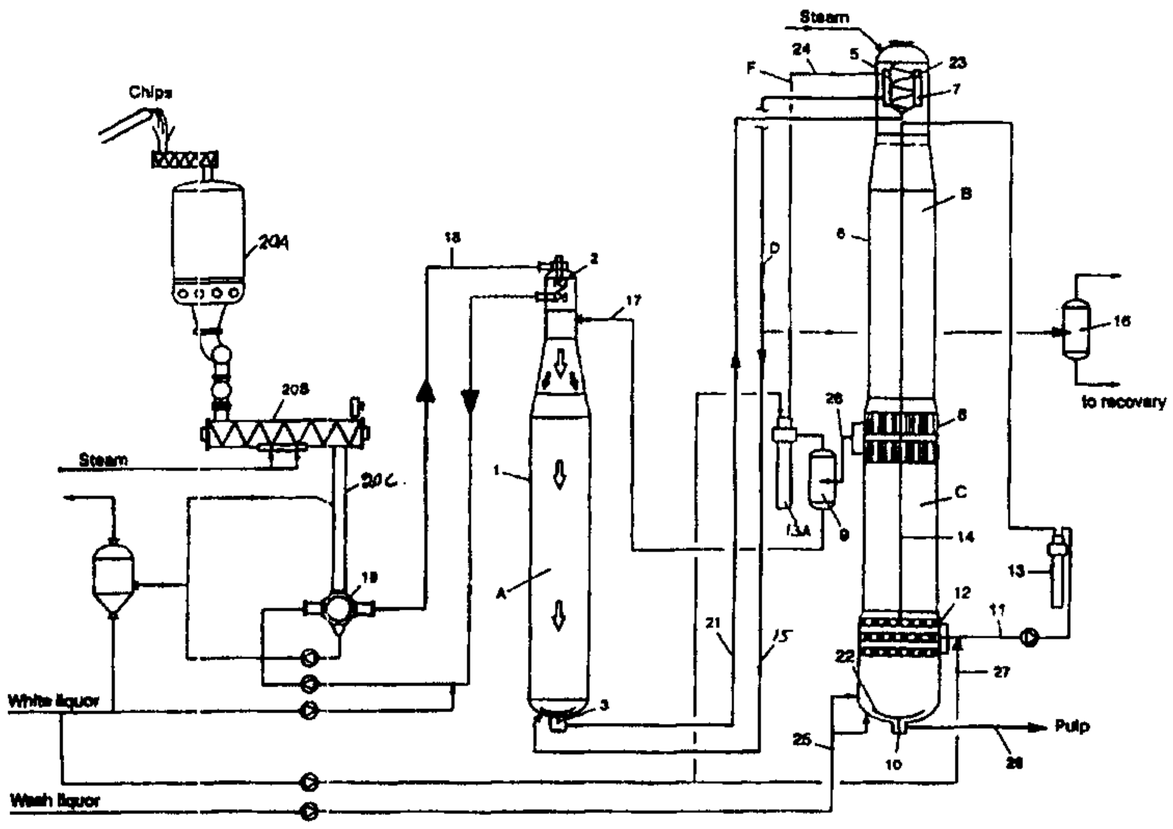
**(81) Designated States:** AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN,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

**Published**
*With international search report.*

**(54) Title:** METHOD AND DEVICE FOR THE CONTINUOUS COOKING OF PULP




**(57) Abstract**

This invention relates to a new and improved way of continuously cooking fibre material, wherein temperatures and alkaline levels are controlled to be maintained within specific levels in different zones of the digesting process in order to optimise chemical consumption and heat–economy and at the same time achieve very good pulp properties. The fibre material is heated and impregnated by the aid of black liquor to a temperature less than 140 °C and passed in con–current in an impregnation zone (A). The heated and impregnated fibre material is transferred to a con–current cooking zone (B) in the upper part of a digester (6). At least 60 % of the quantity of liquor (F) required for the cooking reaction is supplied in the up–stream end of the con–current cooking zone (B) in order to obtain a level of effective alkali exceeding 35 g/l. The cooking temperature in the con–current cooking zone (B) is lower than 160 °C. Spent liquor (E), with an amount of effective alkali of at least 13 g/l, is withdrawn from a strainer girdle (8). A substantial part of the spent liquor is supplied to the impregnation zone.

23402-157



# Method and device for the continuous cooking of pulp

## Technical field

The present invention relates to a novel method for producing pulp, preferably sulphate cellulose, with the aid of a continuous cooking process. The method is preferably directed towards exploiting, in both steam/liquid-phase digesters and hydraulic digesters, the advantages associated with impregnating the chips with the aid of hot black liquor.

## State of the art

Environmental demands has forced our industry to develop improved cooking and bleaching methods. One recent breakthrough within the field of cooking is ITC™, which was developed by us in 1992-1993. ITC™ is described in WO-9411566, which shows that very good results concerning pulp quality could be achieved when using ITC™, which mainly is based on using almost the same temperature (relatively low compared to prior art) in all cooking zones in combination with moderate alkaline levels. The ITC™-concept does not merely relate to the equalisation of temperatures between different cooking zones, but a considerable contribution of the ITC™-concept relates to enabling an equalised alkaline profile also in the lower part of the counter-current cooking zone.

Moreover, it is known that impregnation with the aid of black liquor can improve the strength properties of the fibres in the pulp produced. The aim of the impregnation is, in the first place, thoroughly

to soak each chip so that it becomes susceptible, by penetration and diffusion, to the active cooking chemicals which, in the context of sulphate cellulose, principally consist of sodium hydroxide and sodium sulphide.

If, as is customary according to prior art, a large proportion of white liquor is supplied in connection with the impregnation, no distinct border will exist between impregnation and cooking. This leads to difficulties in optimising the conditions in the transfer zone between impregnation and cooking.

Now it has been found that surprisingly good results can be achieved when:

1. keeping a low temperature but a high alkali content in the beginning of a con-current cooking zone of the digester,
2. withdrawing a substantial part of spent liquor that has passed at least said con-current cooking zone and having a high alkaline content, and
3. supplying a substantial portion of said withdrawn spent liquor having a relatively high amount residual alkali, adjacent the beginning of an impregnation zone.

This leads to a reduced H-factor demand, reduced consumption of cooking chemicals and better heat-economy. On top of that the novel method leads to production of pulp having high quality and a very good bleachability, which means that bleach chemicals and methods can be chosen with a wider variety, than before for reaching desired quality targets (brightness, yield, tear-strength, viscosity, etc.) of a finally bleached pulp.

Furthermore we have found that under certain conditions these good results can also be achieved when slightly moving in a direction opposite the general understanding of the ITC™-teaching, in connection with digesters having a counter-current cooking zone. Rather than trying to maintain almost the same temperature levels in the different cooking zones we have found that if using a digester having both a con-current and a counter-current cooking zone advantages may be gained if the following basic steps are used:

1. keeping a low temperature but a high alkali content in the con-current zone of the digester,
2. keeping about the same temperature but a lower alkaline content in a counter-current zone than in the con-current zone or keeping a higher temperature but a lower alkali content in said counter-current zone
3. withdrawing a substantial part of spent liquor having past at least one digesting zone and having a high alkaline content, and
4. preferably supplying almost all of said withdrawn spent liquor having a relatively high amount residual alkali, adjacent the beginning of the impregnation zone.

Accordingly, the invention provides method of continuously producing pulp in which finely divided fiber material is mixed with liquid to form a slurry, transporting said slurry to an impregnation zone (A) wherein cooking pressure essentially prevails, heating and impregnating said fiber material by aid of hot black liquor to a temperature (T0) less than 140°C and passing the finely divided fiber material in con-current in said impregnation zone (A), separating and withdrawing a substantial part of the free liquid (D) from the slurry, transferring the heated and thoroughly impregnated fiber material to a con-current cooking zone (B) in the upper part of a digester (6), supplying at least 60%, of the quantity of liquor (F) required for the cooking reaction, in an up-stream end of said con-current cooking zone (B), in order to obtain a first level of effective alkaline (EA1) in the beginning of said con-current cooking zone (B), withdrawing spent liquor (E) which has passed at least said con-current cooking zone (B) from at least one strainer girdle (8), and taking pulp out at the bottom of the digester (6), maintaining a higher temperature (T1) in the beginning of said con-current cooking zone (B) than in said impregnation zone (A), wherein the cooking temperature (T1) in said concurrent cooking zone (B) is lower than 160°C, said level of effective alkaline (EA1) exceeds 35g/l, said withdrawn spent liquor has an amount of effective alkaline of at least 13g/l, no substantial part of said withdrawn spent liquor is directly recirculated to a cooking zone, and (a) the amount of black liquor which is supplied adjacent the up-stream end of the impregnation zone (A) exceeds 6 m3/ADT, such that a liquid/wood ratio in the impregnation zone (A) is between 5/1-10/1, (b) a substantial exchange of liquid is performed

between the impregnation zone (A) and the concurrent cooking zone (B) where a maximum of 1,5 m3/ADT is left as free, non exchanged liquid in the slurry, after said separating and withdrawing of free liquid, and (c) spent liquor in an amount exceeding 4 m3/ADT, which is taken from said free liquid (D) as being separated from the end or after the end of the impregnation zone, is passed to recovery.

The invention also provides a two-vessel digesting system for performing the foregoing method, said system comprising an impregnation vessel having an inlet portion and an outlet portion; a digester in fluid communication with the impregnation vessel via a digester line that extends between the digester and the impregnation vessel; a first transfer line between the impregnation vessel and the top of the digester for transporting fiber material to the digester; a separator, comprising a withdrawal space, disposed in connection with the first transfer line for separating a transport liquid from a fiber material; a first screen girdle section disposed in the digester for drawing off an amount of a spent liquor from the digester and so that a first concurrent cooking zone is defined above the first screen girdle section; a second transfer line in fluid communication with the impregnation vessel for supplying a substantial portion of the amount of the spent liquor withdrawn from the first screen girdle section to the inlet portion of the impregnation vessel; a supply line in fluid communication with a supply space adjacent the top of the digester for supplying a cooking liquor; a return line attached to the separator and the outlet portion of the impregnation vessel to conduct the transport liquid from the separator back to first transfer line.

However digesters of the one-vessel type (without a separate impregnation vessel) yield surprisingly good results when the basic principles of the method invention is used.

Moreover preliminary results indicate that the preferred manner of using the invention may be somewhat modified also in other respects but still achieving

very good result, e.g. excluding the counter-current cooking zone.

Additionally, expensive equipment might be eliminated, e.g. strainers in the impregnation vessel, hanging central pipes, etc., making an installation much simpler and considerably cheaper.

**Description of the figures**

In that which follows, reference will be made to the enclosed figures in which:

Fig. 1 shows a preferred embodiment of a continuous two vessel steam/liquid-phase digester arrangement according to the invention, and

Figs. 2A and 2B show two preferred embodiments of a top separator to be used in a steam/vapour-phase digester according to the invention, and

Fig. 3 shows a preferred top separator to be used in an hydraulic digester according to the invention, and

Fig. 4 shows a preferred embodiment of a one vessel hydraulic digester according to the invention, and

Fig. 5 shows a diagram presenting the advantages related to the H-factor when using the invention, and

Fig. 6 shows which conditions were used in the laboratory for one of the ITC-references and one of the cooks according to the invention (so called modified ITC).

Fig. 7 is a schematic flow diagram of a second embodiment of a two vessels steam/liquid phase digester system according to the present invention;

Fig. 8 is a schematic flow diagram of a one vessel steam/liquid phase digester system according to the present invention;

Fig. 9 is a schematic flow diagram of a two vessel hydraulic digester system according to the present invention;

Fig. 10 is a schematic flow diagram of a further one vessel hydraulic digester system according to the present invention;

Fig. 11 shows test data related to peroxide consumption and brightness for the present method compared to a conventional process;

Fig. 12 shows test data related to tensile index and tear index for unbleached pulp according to the present method compared to a conventional process;

Fig. 13 shows test data related to tensile index and tear index for bleached pulp according to the present method compared to a conventional process;

Fig. 14 shows test data related to Cl charge and brightness for the present method compared to a conventional process; and

Fig. 15 shows a further embodiment according to the invention.

Fig. 16 shows a further embodiment according to the invention.

Fig. 17 shows a further embodiment according to the invention.

Fig. 18 shows a further embodiment according to the invention.

Fig. 19 shows a further embodiment according to the invention.

Fig. 20 shows a further embodiment according to the invention.

Fig. 21 shows a further embodiment according to the invention.

Fig. 22 shows a further embodiment according to the invention.

Fig. 23 shows a preferred embodiment of the inlet of an hydraulic vessel according to the invention.

## Detailed description

Figure 1 shows a preferred embodiment of a two vessel steam/liquid-phase digester for producing chemical pulp according to the invention. The main components of the digesting system consist of an impregnation vessel 1 and a steam/liquid-phase digester 6.

The impregnation vessel 1, which normally is totally liquid filled, possesses a feeding-in device 2 at the top, which feeding-in device is of a conventional type, i.e. a top separator with screw-feed device which feeds the chips in a downward direction at the same time as transport liquid is drawn off. At the bottom, the impregnation vessel possesses a feeding-out device 3 comprising a bottom scraper. In addition to this, there is a conduit 17 for adding hot black liquor. As seen the black liquor is preferably supplied at the top of the impregnation vessel. In contrast to conventional impregnation vessels no draw-off screen is located on the impregnation vessel. The chips are fed from the chip bin 20A, through the steaming vessel 20B and the chip chute 20C. Finally a feeding device, preferably a high-pressure feeder 19, feeds the chips via a conduit 18 to the top of the impregnation vessel 1. The feeder 19 is arranged in a known manner to a chute, and is connected to necessary liquid circulations and replenishment.

A conduit 21 for transporting chips leads from the bottom of the impregnation vessel 1 up to the top 5 of the digester 6 having a steam space, wherein the liquid level being indicated by means of a broken line. A supply line for steam at the top provides for heating of the steam space. Conduit 21 opens out at the bottom of a top separator 7 which feeds by means of a screw in an upwardly moving direction. The screen of the separator is used to draw off the liquid D (which is then returned in line 15)together with which the chips are transported up to the top. At the upper edge of the screen (over which edge the chips tumble out), there is arranged an integrated annular ring forming a supply space 23. The annular ring 23 is connected to a conduit 24 which (preferably via a heat-exchanger 13A) leads to a white-liquor container (not shown). A screen girdle section 8 is arranged in conjunction with a step-out approximately in the middle of the digester 6. Draw-off from this screen girdle section 8 can be conducted directly via conduit 17 to the impregnation vessel 1. Preferably, however, the black liquor is drawn off via conduit 28 to a first flash cyclone 9.

At the bottom 10 of the digester, there is a feeding-out device including one scraping element 22.

According to a preferred alternative, "cold-blow" is carried out, the temperature of the pulp being cooled down at the bottom of the digester with the aid of relatively cold (preferably 70-80 °C) liquid ( wash liquid) which is added by means of the scraping element 22 and/or other supply liquid 25 (appropriately annular pipes) at the bottom, and then subsequently conducted upwards in counter-current. With the aim of being able to produce high-quality pulp having a low

and equal kappa number it is essential to distribute chemicals and heat evenly across the digester, so that all fibres in the column are treated under the same conditions. This is achieved by means of a lower circulation loop comprising a conduit 11, screen girdle sections 12, a heat exchanger 13, and a central pipe 14, the lower circulation loop being a so-called ITC circulation. The screen girdle sections 12 (in the shown embodiment consisting of three rows) are arranged at sufficient height above the liquid supply lines 25 at the lower liquid addition point to permit the attainment of a desired flow from the latter liquid-addition point towards the screen section 12. The draw-off from the said screen girdles 12, is recirculated (for displacing black liquor in counter-current to the draw-off screen 8) into the digester with the aid of the central pipe 14 (or alternately a stand pipe from the bottom of the digester) which opens out approximately on a level with the said screen girdle section 12. The heat exchanger 13 for temperature regulation (raising the temperature of the re-introduced liquid) and a pump are also located in the conduit 11 which connects the screen girdle 12 with the ~~pipe~~ 14. The lower recirculation loop is also connected via a branch conduit 27 to the white liquor supply so that fresh alkali can be supplied and, in the form of counter-current cooking, further reducing the kappa number. The digester construction described is notable for the lack of a plurality of central pipes arranged from above and hanging downwards, as well as of feed pipes connected to them and of other necessary parts for the circulations.

A preferred installation according to the invention functions as follows. The chips are fed in a conventional manner into a chip bin 20A, subsequently steamed 20B and thereafter into a chute 20C. A high-

pressure feeder 19 (which in a known manner is supplied with a minor amount of white liquor (~5 of the total amount) in order to lubricate it), with the aid of which the chips are fed into conduit 18 together with transport liquid. The slurry of chips and liquid which is fed to the top of the impregnation vessel in this way have a temperature of about 110 - 120 °C on entry to the impregnation vessel (excluding recirculated transport liquor).

In addition to the actual fibres in the wood, the latter also conveys its own moisture (the wood moisture), which normally constitutes about 50 of the original weight, to the impregnation vessel. Over and above this, some condense is present from the steaming, i.e. at least a part of the steam (principally low-pressure steam) which was supplied to the steaming vessel 20B is cooled down to such a low level that it condenses and is then recovered as liquid together with the wood and the transport liquid.

In the top of the impregnation vessel there is a screw feeder in the feeding-in device 2 which pushes chips from above and downwards. No liquid is recirculated within the impregnation vessel, as is customary. Instead liquid from after the first flash cyclone 9 is supplied.

The chips which are fed out from the bottom of the top screen in the feeding-in device 2 then move slowly downwards in a plug flow through the impregnation vessel 1 in a liquid/wood ratio between 2/1-10/1 preferably between 3/1-8/1, more preferred of about 5/1-7/1. Hot black liquor, which is drawn off from a first flash cyclone 9, is added, via conduit 17, in the top of the impregnation vessel 1. The high temperature of the black liquor (100 - 160 °C),

preferably exceeding 130 °C, more preferred between 130 - 160 °C, ensures rapid heating of the chips. In addition, the relatively high pH, exceeding pH 10, of the black liquor neutralises acidic groups in the wood and also any acidic condensate accompanying the chips, thereby, i.e. counteracting the formation of encrustation, so-called scaling. An additional advantage of the method is that the black liquor supplied into the impregnation vessel has a high content of residual alkali, (EA as NaOH), at least 13g/l, preferably about or above 16g/l and more preferred between 13 - 30g/l in the top of the impregnation vessel. This alkali mainly comes from the black liquor due to the high amount of alkali in the con-current zone of the digester. Furthermore the strength properties of the fibres are positively affected by the impregnation because the high amount of sulphides. The major portion of black liquor is directly (or via one flash) fed to the impregnation vessel 1. A minor amount of the black liquor may be used for transferring the chips from the HP-feeder to the inlet of the impregnation vessel. This minor flow then has to be cooled (not shown) before it is entered into the feeder. The two flows of black liquor are preferably used to regulate the temperature within the impregnation zone, which average temperature would normally not exceed 140 °C. The total supply of black liquor to the impregnation vessel exceeds 80% of the amount drawn off from the draw-off strainers 8, preferably more than 90% and optimally about 100% of the total flow, which normally is about 8 - 12 $m^3$/ADT.

The chips, which have been thoroughly impregnated and partially delignified in the impregnation vessel, are fed to the top of the

digester 6 and conveyed into the upwardly-feeding top separator 7. The chips are thus fed upwards through the screen, meanwhile free transport liquid is withdrawn outwardly through the screen and finally the chips fall out over the edge of the screen down through the steam space. Before or during their free fall, the chips pieces are drained with cooking liquor which is supplied by means of the top separator 7. The white liquor is preferably heated by means of a heat exchanger 13A which preferably is supplied with heat steam from the first flash cyclone 9. The quantity of white liquor which is added here depends on how much white liquor possibly is added else where, but the total amount corresponds to the quantity of white liquor which is required for achieving desired delignification of the wood. Preferably a major part of it is added here, i.e. more than 60%, which also improves the diffusion velocity, since it increases in relation to the concentration difference (chip-surrounding liquid). The thoroughly impregnated chips extra rapidly assimilate the active cooking chemicals by diffusion, since the concentration of alkali (EA as NaOH) is relatively high, at least 20g/l, preferably between 30g/l and 50g/l and more preferred about 40g/l. The chips then move down in the con-current through the digester 6 at a relatively low cooking temperature, i.e. between 130 - 160 °C, preferably about 140 - 150 °C. The major part of the delignification takes place in the first con-current cooking zone.

The retention time in this first cooking zone should be at least 20 minutes, preferably at least 30 minutes and more preferred at least 40 minutes. The liquid-wood ratio should be at lest 2/1 and should be below 7/1, preferably in the range of 3/1 - 5.5/1, more

preferred between 3.5/1 and 5/1. (The liquid wood-ratio in the counter-current cooking zone should be about the same as in the con-current cooking zone.)

The cooking liquid mingled with released lignins, etc., is drawn off at the draw-off screen 8. As mentioned above liquid finally is also supplied in the lower part of the digester which moves in counter-current. It can be describes as the pipe 14 displacing it from the wood upwards towards the draw-off screen 8. This results, consequently, in the delignification being prolonged in the digester 6. The temperature in this lower zone C is preferably higher than in the con-current zone B, i.e. preferably exceeding 140 °C, preferably about 145 - 165 °C, in order to dissolve remaining lignin. The alkali content in the lowermost part of the counter-current cooking zone should preferably be lower than in the beginning of the con-current zone, above 5g/l, but below 40g/l. Preferably less than 30g/l and more preferred between 10 - 20g/l. In the preferred case, the aim is to have a temperature difference of about 10 °C between the cooking zones. Expediently, the lower circulation loop is charged with about 5 - 20%, preferably 10 - 15%, white liquor. The temperature of the liquid which is recirculated in the recirculation loop is regulated with the aid of the heat exchanger 13 so that the desired cooking temperature is obtained at the lowermost part of the counter-current cooking zone.

In the preferred case, "cold-blow" is used, with the temperature of the pulp in the outlet conduit 26 being less than 100 °C. Accordingly, washing liquid having a low temperature, preferably about 70 - 80 °C, is added in a known manner using the scraping element

and liquid supply lines 25 arranged in an outer annular conduit arranged at the bottom.
This liquid consequently displaces the boiling hot liquor in the pulp upwards in counter-current and thereby imparts a temperature to the remaining pulp which can be cold-blown, i.e. depressurised and disintegrated without any real loss of strength.

From tests made in lab-scale, we have found indications that it is desired to keep the alkaline level at above at least 2g/l, preferably above 4g/l, in the impregnation vessel in connection with black liquor, which would normally correspond to a pH of about 11. If not, it appears that dissolved lignins precipitate and even condense.

In Fig. 2A there is shown a preferred embodiment of a separator to be used in connection with one of the embodiments of steam/liquid phase digester systems disclosed herein. It is often preferred to have an upwardly feeding top separator for a steam/liquid phase digester. The separator may comprise a screen basket 61 in which a rotatable screw feeder 62 is positioned. The screw feeder is fixedly attached to a shaft 63 which at its upper end is operatively attached to a drive unit 30. The drive unit 30 is attached to a plate 65 which is attached to the shell of the digester 6.

Circumjacent the screen basket 61 there is arranged a liquid collecting space 67, which may be connected to the return pipe circulation 15. Above the liquid collecting space 67, also circumjacent the screen basket 61, there is arranged a liquid supply space or opening in the integrated annular ring 23 which is connected to the supply line 24 that supplies white liquor (F). The separator has a plurality of inlet apertures 37 defined therein

to subject the fiber chips with white liquor. The inlet apertures preferably has a total area that exceeds 400 mm2. More preferred, the total area of the inlet apertures is at least 500 mm2. Most preferred, the total area of the inlet apertures exceeds 600 mm2 to achieve a sufficient flow into the chip pile. Between the outer peripheral wall 66 of the liquid collecting space 67 and the liquid supply space 23 respectively, and the shell of the digester 6 at the top, there exist an annular space 70 which opens up down into the upper part of the digester 6. The functioning of the top separator may be described as follows.

The thoroughly heated and impregnated chips are transferred by means of the supply line 21 into the bottom portion of the screen basket 61. Here the screw feeder 62 moves the chips upwardly at the same time as the transport liquid D is separated from the chips, by being withdrawn outwardly through the screen basket 61 and further out of the digester through return line 15. More and more liquid will be withdrawn from the chips during their transport within the screen basket 61. Eventually, the chips will reach the level of the supply space 23. Here the desired amount of cooking liquor, preferably white liquor, is added through the supply space 23 and the openings of the inlet apertures 37, having a temperature and effective alkaline content in accordance with the invention.

In order to eliminate the risk of back flowing of the supplied liquid from the supply space 23 into the liquid collection space 67, a minor amount of free liquid (at least about 0.5 m3/ADT) should be left together with the chips, which free liquid will then be mixed with the supplied cooking liquor. Preferably, about one m3/ADT should be left together with the fiber

material. Additionally, the white liquor should be provided at a point that is downstream of the flow of the suspension of the fiber material and the free liquid that is being fed through the screw member.

At the top of the screen basket 61, the chips and the cooking liquor flow over the upper edge 233 thereof and fall into the steam/liquid space 70 and further on to the top of the chips pile within the digester, where the concurrent cooking zone (indicated as B in Figure 1) starts.

A major advantage of the separation device is that they provide for establishing a distinguished change of zones (they enable almost a total exchange of free liquid at this point), which means that for a two vessel system the desired conditions in the beginning of the concurrent zone (indicated as B in Figure 1) can easily be established.

In Figure 2 B there is shown a further embodiment of a separator to be used in connection with a steam/vapour phase digester, as described in figure 1. The separator of Fig. 2 B is almost identical with the one shown in Fig. 2 A except for the existence of a further supply space 25, being positioned below the ~~first~~ supply space 23. This further supply space 25 has as its object to provide for the possibility of supplying a further liquid to the up-moving chip pile. Especially for the possibility of supplying black liquor in order to secure a minimum amount of free liquid flowing upwardly in the chips pile, to eliminate back flow of the cooking liquor supplied above, in supply space 23.

In figure 3 there is shown a preferred embodiment of a separator to be used together with a hydraulic digester. Only a part of the top of the digester (6) is shown. The slurred fibre material (pre-

impregnated or not) is transferred to the top of the digester by means of a transfer line (21) and enters an in-let space (30) of a screw-feeder (31). The screw-feeder (31) is attached to a shaft (32) connected to a drive-unit (33) which is attached to a mounting-plate (34) on the top of the shell of the digester (6). The drive-shaft (32) is rotated in a direction so as to force the screw to feed in a down-ward direction. A cylindrical screen-basket (35) surrounds the screw-feeder (31). The screen-basket (35) is arranged within the shell of the digester (6) so as to form a liquid collecting space (36) between the digester shell and the outer surface of the screen-basket (35). The liquid collecting space (36), which preferably is annular, communicates with a conduit (17) for withdrawing liquid from the liquid collecting space (36), which in turn is replenished by liquid from the slurry within the screen basket (35). The major part of the free liquid within the slurry entering the screen basket is withdrawn into the liquid collecting space (36), but a small portion of free liquid, at least about 0.5 $m^3$/ADT should not be withdrawn from the slurry. Adjacent the outlet end of the screen basket (35) there is arranged inlet apertures 37 in a liquid supply device, preferably comprising an annular distribution ring which opens up into the chips pile for supply of liquid into the fibre material moving down into the digester (6). The inlet apertures (37) of the supply space (23) are replenished by means of line 38 wherein a desired liquid is supplied. If it is a two-vessel hydraulic digester system the liquid supplied through the inlet apertures (37) would be hot cooking liquor having a relatively high amount of effective alkaline, in order to provide for the possibility of establishing a con-current cooking zone (B) having a desired temperature of about 145 - 150 °C, and a

desired content of effective alkaline, e.g. about 45g/l. The invention is also applicable in connection with one vessel digesters of both kinds, as will be exemplified below.

A major advantage with both kinds of the shown separation devices is that they provide for establishing a distinguished change of zones (they enable almost a total exchange of free liquid at this point), which means that for a two vessel system the desired conditions in the beginning of the con-current zone (B) can easily be established.

In Figure 4 it is shown a preferred embodiment for applying the invention to a one-vessel hydraulic digester. The same kind of basic equipment before and in connection with the HP-feeder as shown in fig. 1 is used, which therefore is not described in detail. Further the basically same kind of top separator arrangement as described in figure 3 is mounted at the top of the digester 6. In the middle part of the digester withdrawal strainers (8) are arranged. The lowermost part of the digester is in principle similar to the one shown in figure 1, with a liquid supply line (25) for wash liquid and a blow line (26) for the digested pulp. A short distance above the bottom there is positioned a strainer arrangement (12), for withdrawing liquid, which is heated and to which some white liquor, preferably about 10% of the total amount, is added before it is recirculated by means of a stand pipe (39), which opens up at about the same level as the strainer arrangement (12). In the upper part of the digester there are arranged two further strainer sets (40, 41). The upper strainer (40) is arranged for withdrawing liquid which has passed the impregnation

zone (A). Some of the withdrawn liquid D is taken out via line 46 to a flash tank 47. The other part of the withdrawn liquid is recirculated for re-introducing liquid withdrawn by means of a central pipe (42A) which opens up at a level adjacent the strainer (40). Before the liquor withdrawn from the strainer (40) is re-introduced white liquor can be added there to by means of a supply-line (43A) and thereafter the liquid is heated to the desired temperature by means of a heat exchanger (44A).

The second strainer (41), which is positioned intermediate the upper strainer (40) and the withdrawal strainer (8) is a also part of a re-circulation. The withdrawn liquid is recirculated for re-introducing it by means of a central pipe (42B) which opens up at a level adjacent the strainer (41). Before the liquor withdrawn from the strainer (41) is re-introduced the main part white liquor is added thereto by means of a supply-line (43B) and thereafter the liquid is heated to the desired temperature by means of a heat exchanger (44B).

The digesting process within a digester shown in Figure 4 is as follows. The slurry of chips and transport liquid is transferred, e.g. by means of high pressure feeder, within the feeding line (21) to the top of the digester where it is introduced into the top of the screen basket (indicated as 35 in Figure 3) of the separator, wherein the major part of transport liquid is separated from the chips. At the lower end (indicated as 37 in Figure 3) of the separator impregnation liquor E is supplied by means of line 38. The impregnation liquor is hot black liquor which is taken from the withdrawal screen (8) via the first flash cyclone 9 by means of the supply conduit (38). If all the desired

amount cannot be withdrawn via line 46 to flash tank 47 there is provided for the possibility to also withdraw from the outlet of the first flash tank 9 via line 45. A minor amount of the black liquor withdrawn from flash tank 9 may be used for transferring the chips from the HP-feeder to the inlet of the digester 6. This minor flow then has to be cooled in a cooler 80 before it is entered into the feeder. The two flows of black liquor are preferably used to regulate the temperature within the impregnation zone, which average temperature normally should not exceed 140 °C.

The amount of effective alkaline in the supplied black liquor E is relatively high, at least 13g/l, preferably about 20g/l, which provides for the impregnation zone (A) to be established without any substantial additional supply of white liquor at this position. The chips is then impregnated and heated when moving down towards the upper screen (40), where spent liquor (D) is withdrawn and transferred by means of a conduit (46) to a flash tank (47).

The chips are heated and alkali is introduced by means of the above described cooking circulations in order to obtain desired cooking conditions. In a preferred mode the temperature at the beginning of the con-current zone is about 145 - 160 °C for soft wood and about 140 - 155 °C for hard wood and an alkaline content of about 30 - 50g/l. Thanks to the exothermic reaction of the chemicals the temperature is slightly further increased when the fibre material is moving downwardly in the con-current cooking zone (B).

Liquid having a relatively high content of effective alkaline is withdrawn at the strainers (8) positioned adjacent the middle. The alkaline content of this withdrawn spent liquor (E) would normally exceed 15g/l.

Also liquor from the counter-current zone (C) is withdrawn at this withdrawal strainer (8), since the liquor being introduced by means of the stand pipe (39) moves in counter-current upwardly finally reaching these strainers (8).

In the counter-current zone (C), preferably, a higher temperature is maintained than in the con-current zone (B). This is achieved by means of heating the liquid drawn from the lower withdrawal strainer (12), in a heat exchanger (51) before introducing it through the stand pipe (39). In the preferred case also a minor amount, about 10 - 15% of the total amount, of white liquor is added in this recirculation line, to achieve the desired alkali concentration in the counter-current cooking zone (C).

In the usual manner the pulp is cooled, by means of wash liquid (25) being supplied at the bottom of the digester, which wash liquid moves in counter-current upwardly and subsequently is withdrawn in strainer (12). The cooled finally digested pulp, is then taken out of the digester into the blow-line (26).

As already mentioned, pulp produced in this manner will have higher quality and better bleachability then pulp produced with known methods. In lab-scale tests we have found that about 10 kg of active chlorine can be saved for reaching full

brightness (about 90% ISO), compared to a conventionally cooked pulp.

In figure 5 there is shown a diagram comparing the H-factor for pulp produced according to conventional ITC™-cooking and the invention. The H-factor is a function of time and temperature in relation to the delignification process (degree of delignification) during cooking. The H-factor is used to control the delignification process of a digester, i.e. maintaining a certain H-factor principally leads to the same Kappa number of the produced pulp (remaining lignin content of the fibre material) independent of temperature variations during the cooking. In figure 5 it is shown that the H-factor for pulp produced according to the invention is extremely much lower (about 40 - 50% lower) compared to pulp produced according to ITC™. This means that much lower temperatures may be used for the same retention time in order to reach a certain degree of delignification (Kappa number) and/or that smaller vessels for the cooking within a continuos digester can be used and/or that a lower Kappa number may be achieved with the same kind of basic equipment and/or that higher rate of production can be obtained.

The lower H-factor demand is achieved by a high alkali concentration and a low cooking temperature in the con-current cooking zone, which is shown in fig. 6 which presents one reference ITC-cook (ITC 1770) and one cook according to the invention (modified ITC* 1763). As shown the temperature in the counter-current cooking zone, according to the invention, is higher than in the con-current zone but still lower than the temperature in the counter-current zone in the ITC-reference.

Fig. 7 shows a preferred second embodiment of a two vessel steam/liquid phase digester system for producing chemical pulp according to the present invention, especially in relation to a retrofit of an MCC digester. The main components of the digesting system consist of an impregnation vessel 1b and a steam/liquid-phase digester 6b. Some of the more important differences are described herein.

A first screen girdle section 8b may be disposed at the upper middle portion of the digester 6b. If the digester 6b is an MCC digester, this screen section may be used to withdraw spent liquor that is conducted to a recovery unit. According to the invention, draw-off from this screen girdle section 8b may be conducted directly via the conduit 17b to the impregnation vessel 1b. A second screen girdle section 104b may be arranged below the first screen girdle section 8b (in an MCC digester, the screen girdle section 104b would normally be called the MCC screen). A second concurrent cooking zone C is defined between the sections 8b and 104b. Draw-off from the second screen section 104b, such as spent liquor, i.e., black liquor, may be conducted via a conduit 106b to a first flash tank 108b to recover steam and let pressure off before the liquor is conducted to a recovery unit 110b. Preferably, the spent liquor is also conducted through a second flash tank 112b via a conduit 114b to further reduce the pressure and temperature of the spent liquor before the liquor is conducted to the recovery unit 110b. In the preferred second embodiment, a conduit 124b conducts the spent liquor from the return conduit 15b (preferably at least $4m^3$/ADT; more preferably at least about $5m^3$/ADT) to the second flash tank 112b. The spent liquor from both flash tanks 108b, 112b is then conducted with a conduit 126b to the recovery unit

110b. Conduits 128b and 130b may be connected to the flash tanks 108b, 112b, respectively, to supply steam to the chip bin 20A and the steaming vessel 20B.

A third lower screen girdle section 12b is disposed at the bottom 10b of the digester 6b. A counter-current cooking zone D is defined between the sections 12b and 104b. The girdle section 12b may, for example, include three rows of screens for withdrawing liquid, which is heated and to which some white liquor, preferably about 10% of the total amount of the white liquor in conduit 24b, is added via a branch conduit 117b before it is recirculated by means of a central pipe 123b, which opens up at about the same level as the lowermost strainer girdle 12b.

The draw-off from screen girdles 12b and the white liquor from the branch conduit 117b are preferably conducted via a heat exchanger 120b back to the bottom 10b of the digester 6b. The temperature of this draw off is somewhat lower than in the cooking zone D (e.g., about 140°C), since the liquid is a mix of wash liquid and black liquor. The white liquor is supplied in a counter-current direction via the central pipe 123b to the screen girdle section 12b. The white liquor provides fresh alkali and, in the form of counter-current cooking, further reducing the Kappa number. A conduit 122b is connected to the high pressure steam conduit 102b to provide the heat exchanger with steam to regulate the temperature of the liquid supplied via the standpipe 123b. A blow line 26b is connected to the bottom 10b of the digester for conducting the digested pulp away from the digester 6b.

A select portion of the installation according to the present invention, as shown in Fig. 7, may function as follows. Some of the more important functional differences compared to the embodiment in Fig. 1 are

described below. In the preferred second embodiment, the temperature of the black liquor in the impregnation vessel should be between about 140°C and about 160°C. More preferred, the temperature is between about 140°C and about 155°C. Most preferred, the temperature is between about 140°C and about 150°C.

The retention time in the impregnation zone A should be at least 20 minutes, preferably at least 30 minutes and more preferred at least 40 minutes. However, a shorter retention time than 20 minutes, such as 15-20 minutes may also be used. The volume of the impregnation vessel 1b may be larger than 1/11, preferably larger than 1/10 of the volume of the digester 6b. Additionally, in the preferred embodiment, the volume V of the impregnation vessel 1b should exceed 5 times the value of the square of the maximum digester diameter, i.e., $V = 5D^2$, where D is the maximum diameter of the digester 6b.

After the chips have been passed through the top separator, the chips then move down into the concurrent zones B, C through the digester 6b at a relatively low cooking temperature, i.e., between 130°C to 160°C, preferably about 140°C to 150°C. The major part of the delignification takes place in the first and second concurrent cooking zones B, C.

A further modification would be to have the cooking zone C to be a counter-current zone or a mixture of con/counter-current.

The temperature in the counter-current zone D is preferably higher than in the concurrent zones B, C, i.e., preferably exceeding 140°C, preferably about 145°C to 165°C, in order to dissolve remaining lignin. The alkali content in the lowermost part of the concurrent cooking zone C should preferably be lower than in the beginning of the concurrent zone B, above 5g/l, but

below 40g/l. Preferably less than 30g/l and more preferred between 10-20g/l. In the preferred case, the aim is to have a temperature difference of about 10°C between the first and the second concurrent cooking zones. Expediently, the conduit 116b may be charged with about 5-20%, preferably 10-15%, white liquor from the conduit 24b via the conduit 117b. Below the draw-off screen section 104b is the counter-current zone D that is defined between the screen girdle section 104b and the screen girdle section 12b.

The temperature of the liquid which is recirculated via the pipe 123b up to the screen girdle section 12b is regulated with the aid of the heat exchanger 120b so that the desired cooking temperature is obtained at the lowermost part of the counter-current cooking zone D.

At the lowermost part of the digester, cool wash liquid is added in order to displace, in counter-current, hot liquid which is subsequently withdrawn at the lowermost screen girdle 12b.

Fig. 8 illustrates a preferred embodiment of a one vessel steam/liquid phase digester system of the present invention. Some of the important differences compared to Figs. 1 and 4 are described below. A high-pressure feeder 19h feeds the chips suspended in a transport liquid via a conduit 18h to the top of a digester 6h.

The conduit 18h extends from the feeder 19h up to a top 5h of the digester 6h. The conduit 18h may open up at the bottom of a top separator 7h that feeds by means of a screw in an upwardly moving direction. The separator 7h is preferably identical or very similar to the top separator 7 that is shown in Fig. 1 and described in detail above. The screen of the separator may be used to draw off the transport liquid D (which

is then returned in a return line 15h) together with which the chips are transported from the feeder 19h up to the top 5h of the digester 6h. A first screen girdle section 8h may be disposed immediately below or adjacent the separator 7h. A recirculation line 17h may withdraw liquor and bring it back to a space that is defined between the first screen girdle section 8h and the separator 7h. The recirculation improves the distribution of the liquor in the digester.

A second screen girdle section 51h is disposed below the first screen girdle section 8h so that an impregnation zone A is defined between the screen girdle sections 8h and 51h. We have found indications that it is desirable to keep the alkaline level at above at least 2g/l, preferably above 4g/l, in the impregnation zone A in connection with black liquor, which would normally correspond to a pH of about 11. If not, it appears that dissolved lignin precipitate and even condense. Spent liquor may be withdrawn from the upper screen of the section 51h and conducted with a conduit 111h to a second flash tank 112h. Spent liquor is withdrawn via a conduit 109h from a lower screen of the section 51h and conducted back to the space defined above the first screen girdle section 8h so that the spent liquor may be reintroduced back to the lower screen of the second screen girdle section 51h via a central pipe 105h. The temperature of the spent liquor may be controlled by a heat exchanger 13h. The heat exchanger 13h is in operative engagement with a high pressure steam line 102h via a conduit 122h.

A cooking liquor conduit 24h is operatively attached to the conduit 109h to supply a cooking liquor, such as white liquor, to the conduit 109h. The effective alkali of the liquor in the conduit 109h is at least about 35g/l; more preferably at least about

40g/l; and, most preferably, between about 45g/l and about 55g/l.

Approximately 95% of the total supply of the white liquor in conducted in the conduit 24h and the remaining 5% is supplied to the high pressure feeder 19h via a conduit 132h and a conduit 134h to lubricate the high pressure feeder 19h.

A third screen girdle section 104h may be arranged below the second screen girdle section 51h so that a concurrent cooking zone B is defined between the screen girdle sections 51h and 104h. Draw-off from the third screen section 104h, such as spent liquor, i.e., black liquor, may be conducted via a conduit 106h back to the conduit 17h. The effective alkali of the spent liquor conducted in the conduit 106h is about 13g/l or more. A minor portion of the black liquor in the conduit 106h may be conducted to a first flash tank 108h via a conduit 107h to cool the spent liquor before the liquor is conducted to a recovery unit 110h. Preferably, the spent liquor is also conducted through a second flash tank 112h via a conduit 114h to further reduce the temperature and pressure of the spent liquor before the liquor is conducted to the recovery unit 110h. The spent liquor from both flash tanks 108h, 112h are then conducted with a conduit 126h to the recovery unit 110h. Conduits 128h and 130h may be connected to the flash tanks 108h, 112h, respectively, to provide steam that is sent to the chip bin 20A and the steaming vessel 20B.

At a bottom 10h of the digester 6h, there is a feeding-out device including a scraping element 22h. A fourth lower screen girdle section 12h is disposed at the bottom 10h of the digester 6h so that a concurrent cooking zone C is defined between the sections 104h and 12h. The girdle section 12h may, for example, include

three rows of screens for withdrawing liquid, which is heated and to which some white liquor, preferably about 10% of the total amount of the white liquor in the conduit 24h, is added via a branch conduit 117h before it is recirculated by means of a central pipe 123h, which opens up at about the same level as the lowermost strainer girdle 12h.

The draw-off from screen girdles 12h and the white liquor from the branch conduit 117h are preferably conducted via a heat exchanger 120h back to the bottom 10h of the digester 6h. The conduit 122h is connected to the heat exchanger 120h to provide the heat exchanger 120h with steam to regulate the temperature of the white liquor in the conduit 116h. The temperature of this draw off is normally about 130°C to 140°C. The white liquor is supplied in a counter-current direction via the central pipe 123h to the screen girdle section 12h. The white liquor provides fresh alkali and, in the form of counter-current cooking, further reducing the kappa number. A blow line 26h may be connected to the bottom 10h of the digester for conducting the digested pulp away from the digester 6h.

A preferred installation according to the present invention, as shown in Fig. 8, may be described as follows. The chips are fed into the chip bin 20A and are subsequently steamed in the vessel 20B and, thereafter, conveyed into the chute 20C. The high-pressure feeder 19h, which is supplied with a minor amount of white liquor (approximately 5% of the total amount to lubricate the feeder), feeds the chips into the conduit 18h together with the transport liquid. The slurry of chips and the liquid are fed to the top of the digester 6h and may have a temperature of about 110-120° C when entering the digester 6h (excluding recirculated transport liquor).

Inside the top of the digester 6h, there is the top separator 7h that pushes chips in an upward direction through the separator and then the chips move slowly downwards in a plug flow through the impregnation zone A in a liquid/wood ratio between 2/1-10/1 preferably between 3/1-8/1, more preferred of about 4/1-6/1. The liquor, which is drawn off from the screen girdle section 8h, may be recirculated via the conduit 17h to the space below the top separator 7h. The chips are then thoroughly impregnated in the impregnation zone A.

A spent liquor is withdrawn at the upper segment of the screen section 51h and conducted to the second flash tank 112h. A spent liquor is also withdrawn at the lower segment of the section 51h and reintroduced via the central pipe 105h with the addition of white liquor supplied by the conduit 24h.

The chips move down in the concurrent zone B through the digester 6h at a relatively low cooking temperature, i.e., between 130-160°C, preferably about 140-150° C. The major part of the delignification takes place in the first concurrent cooking zone B.

The temperature in the lower counter-current zone C is preferably higher than in the concurrent zone B, i.e., preferably exceeding 140°C, preferably about 145-165°C, in order to dissolve remaining lignin. The alkali content in the lowermost part of the counter-current cooking zone C should preferably be lower than in the beginning of the concurrent zone B, above 5g/l, but below 40g/l. Preferably less than 30g/l and more preferred between 10-20g/l. In the preferred case, the aim is to have a temperature difference of about 10°C between the concurrent zone B and the counter-current cooking zone C. Expediently, the conduit 116h may be charged with about 5-20%,

preferably 10-15%, white liquor from the conduit 24h via the conduit 117h.

The temperature of the liquid which is recirculated via the pipe 123h up to the screen girdle section 12h is regulated with the aid of the heat exchanger 120h so that the desired cooking temperature is obtained at the lowermost part of the counter-current cooking zone.

Fig. 9 shows a preferred embodiment of a two vessel hydraulic digesting system of the present invention. This embodiment is very similar to the embodiment shown in Fig. 7 except that the digester 6d is a hydraulic digester so that the digester has a downwardly feeding top separator, as shown in Fig. 3. The rest of the digesting system is virtually identical to the other embodiment. If the digester 6d is an MCC digester, the screen section 8d may be used to withdraw spent liquor that is conducted to a recovery unit. Draw-off from this screen girdle section 8d can also be conducted directly via the conduit 17d to the impregnation vessel 1d. A second screen girdle section 104d may be arranged below the first screen girdle section 8d (in an MCC digester, the screen girdle section 104d would normally be called the MCC screen). Draw-off from the second screen section 104d, such as spent liquor, i.e., black liquor, may be conducted via a conduit 106d to a first flash tank 108d to recover steam and let pressure off before the liquor is conducted to a recovery unit 110d.

Fig. 10 illustrates a further embodiment of the digesting system of the present invention. More particularly, the digesting system is a single vessel

hydraulic digester system. Only the significant differences between this embodiment and the embodiments described earlier are detailed below.

A high-pressure feeder 19e feeds the chips suspended in a transport liquid via a conduit 18e to the top of a digester 6e. The conduit 18e may open up at the top of a top separator 7e that feeds by means of a screw in a downwardly moving direction. The separator 7e is preferably identical or very similar to the top separator that is shown in Fig. 3 and described in detail above. The screen of the separator may be used to draw off the transport liquid D (which is then returned in a return line 15e) together with which the chips are transported from the feeder 19e up to the top 5e of the digester 6e. A first screen girdle section 8e may be arranged in conjunction with a step-out approximately in the middle of the digester 6e. Draw-off of spent liquor from a lower portion of the screen girdle section 8e may be conducted via the conduit 17e to an impregnation zone A that is defined between the screen girdle section 8e and the top 5e of the digester 6e. The spent liquor that is withdrawn from an upper portion of the screen girdle section 8e may be conducted via a conduit 111e to a second flash tank 112e.

A cooking liquor conduit 24e is operatively attached to the conduit 17e to supply a major part of the cooking liquor, such as white liquor, to the conduit 17e. The effective alkali of the liquor in the conduit 17e is at least about 35g/l; more preferably at least about 40g/l; and, most preferably, between about 45g/l and about 55g/l. Approximately 95 of the total supply of the white liquor in conducted in the conduit 24e and the remaining 5% is supplied to the high

pressure feeder 19e via a conduit 132e and a conduit 134e to lubricate the high pressure feeder 19e.

A second screen girdle section 104e may be arranged below the first screen girdle section 8e. Draw-off from the second screen section 104e, such as spent liquor, i.e., black liquor, may be conducted via a conduit 106e back to a top portion of the impregnation zone A. The effective alkali of the spent liquor conducted in the conduit 106e is about 10-20 g/l. A portion of the black liquor in the conduit 106e may be conducted to the flash tanks as described in the earlier embodiments. At the bottom of the digester there is a screen girdle section 12e for drawing off a spent liquor. The temperature of this draw off is about 130-150° C. The temperature may depend on how much washing-liquid that has penetrated to the screen is withdrawn. The white liquor is supplied in a counter-current direction via a central pipe 123e to the screen girdle section 12e.

A major portion of the black liquor may directly (or via one flash tank) be fed into the impregnation zone A. The total supply of black liquor to the impregnation zone A may exceed 80% of the amount drawn off from a draw-off screen girdle section 104e, preferably more than 90% and optimally about 100% of the total flow, which normally is about 8-12 $m^3$/ADT.

The chips then move down in the concurrent zone B through the digester 6e at a relatively low cooking temperature, i.e., between 130-160°C, preferably about 140-150°C. The major part of the delignification takes place in the first concurrent cooking zone B.

The temperature in the lower counter-current zone C is preferably higher than in the concurrent zone B, i.e., preferably exceeding 140°C, preferably about 145-165°C, in order to dissolve remaining lignin. The

alkali content in the lowermost part of the counter-current cooking zone C should preferably be lower than in the beginning of the concurrent zone B, above 5g/l, but below 40g/l. Preferably less than 30g/l and more preferred between 10-20g/l. In the preferred case, the aim is to have a temperature difference of about 10°C between the concurrent zone B and the counter-current cooking zone C. Expediently, the conduit 116e may be charged with about 5-20%, preferably 10-15%, white liquor from the conduit 24e via the conduit 117e.

Fig. 11 shows results from TCF bleaching using the cooking process (so called "new concept") of the present invention compared to a conventional reference cooking process. The present invention provides a TCF-bleached pulp having extremely good bleachability a higher brightness is achieved compared to the conventional process for the same amount of peroxide consumption, and also a higher brightness ceiling is obtained.

Fig. 12 shows the tear index relative to the tensile index. The test data that are related to the "new concept" are using the cooking process of the present invention and the conventional cooking process was using in reference ITC-digester.

Similarly, Fig. 13 illustrates test data for the "new concept" (the present invention) and reference ITC-digester. The present invention exhibits better tensile index compared to the conventional method.

Fig. 14 shows the brightness level by using the present invention (new concept) and reference cooked pulp (conventional process). As is evident, the cooking

process of the present invention results in a pulp that is much easier to bleach compared to the conventional cooking process, i.e. consumes less chemicals at a given brightness.

When cooking in accordance with the "new concept" the following significant advantages are gained in comparison to conventional ITC-cooking™;

When cooking softwood:

- Increased tear strength by 10%
- Unchanged beatability
- Improved viscosity by 40 units at kappa number 22
- Increased brightness of unbleached pulp by 2% ISO units
- Increased brightness ceiling of bleached pulp by 0,5 - 1% ISO unit
- Lowered $H_2O_2$ consumption by 15 - 20%
- Reduced knot content by 60%
- Reduced shives content by 55%
- Reduced MP-steam consumption in digester by 10 - 15%

When cooking hardwood:

- Increased tensile index at 500 PFI-revolutions by 8%
- Increased tensile stiffness at 500 PFI-revolution by 8%
- Improved viscosity by 50 units at kappa number 15
- Increased brightness ceiling
- Lowered $H_2O_2$ consumption by 15%
- Reduced knot content by 55%
- Reduced shives content by 50%
- Reduced alkali charge by 10%

Fig. 15 shows a way of running the process in connection with an overloaded two vessel steam/liquid digester. Due to the overload (normally more than 30 ADMT pulp/hour and area as square meter in the final cooking zone (C))such a digester normally has difficulties to obtain a distinguished up-flow in the so called counter-current cooking zone. The final cooking zone C will therefore bee in form of a con-current final cooking zone (C). To run according to the invention this necessitate the existence/retrofit of a withdrawal strainer (12) positioned close to the bottom and retrofit of a withdrawal line 99 from said strainer 12. As can be seen, figure 15 is almost identical to Fig. 1 (no retro-fit), except for withdrawal line 99, which transfers liquor withdrawn from the lowermost screen 12 to recovery. However, a major (more than 50%) portion of the liquor to recovery is still taken from the transport liquid D. The process will lead to a higher wood/liquid ratio in the impregnation zone A than in the con-current cooking zone B, which in turn will have a higher wood/liquid ratio than the final cooking zone C, i.e. w/l A > w/l B > w/l C. In order to achieve cold blow (below 100 C in blow line 26) it is necessary to add a sufficient amount of cold wash liquor via liquid supply line 25 adjacent the bottom of the digester. The wash liquor is normally supplied by means of nozzles, and sometimes preferably also through the scraper 22. This wash liquor will partly flow upwards and displace the hot cooking liquor in the pulp moving downwards below the screen 12, and partly go out in the blowline 26 together with the pulp. If desired also some wash liquor may be added by means of the central pipe 14 in order to radially displace hot cooking liquor. Alternatively the latter can be achieved by means of a stand pipe. This method can also be used in connection with non over loaded

digesters having problems to keep a sufficient up-flow (normally recommended to be at least 1.5 m3/ADMT pulp dilution factor for counter current cooking) in the final cooking zone C.

Fig. 16 describes a further embodiment of a two vessel hydraulic digester according to the present invention. A conduit 24e conducts white liquor to a return line 15e. The temperature of the white liquor may be controlled by a heat exchanger 13e that is adapted to receive steam from a high pressure steam conduit 102e. The return line 15e terminates at a liquid exchanger 31e, which fulfils the same function as a top separator, i.e., it provides a very distinct exchange of treatment zones by almost totally withdrawing a first liquid from the chips and, subsequently, adding a second liquid so that any undesired mixing is avoided, the liquid changer 31e, in turn, has a mid-portion that is connected via a return line 33e to a bottom portion of an impregnation vessel 1e. A slurry of the chips and transport liquid may be conducted from the bottom portion of the impregnation vessel 1e via a conduit 35e to a bottom end of the liquid exchanger 31e after exchange of liquid the chips are transported in a conduit 21e to the top of a digester 6e. A portion of the spent liquor in the return line 33e is diverted and conducted to a second flash tank 114e via a conduit 137e for recovery.

Black liquor is withdrawn from a girdle section 8e of the digester 6e and conducted via a conduit back to a top portion of the impregnation vessel 1e. Spent liquor is also drawn off from a screen girdle section 104e and is conducted to a first flash tank 108e via a conduit 106e.

Fig. 17 shows an embodiment of the present invention which is similar to fig. 16. Only some of the most important differences are described. This embodiment has a digester 6f that does not have a screen girdle section at the top of the digester. Most of the spent liquor is therefore withdrawn from the digester 6f at a screen girdle section 104f and a portion of the spent liquor withdrawn is conducted via a conduit 17f back to an impregnation vessel 1f. The remaining portion of the spent liquor is conducted to a first flash tank 108f via a conduit 106f.

Fig. 18 illustrates an embodiment of the present invention which is similar to the embodiment shown in Fig. 17. Only some of the main differences are described. A high pressure feeder 19g feeds a slurry of chips to a bottom portion of a liquid exchanger 31g. The object of this liquid exchanger is to ensure safe operation of the high pressure feeder at the same time as a high temperature (e.g., 130°C) is maintained at the top of an impregnation vessel 1g, which is achieved by supplying hot black liquor to a conduit 21g via a conduit 17g. After exchange of liquid, the slurry is further conducted to a top of the impregnation vessel 1g via a conduit 18g. Relatively cool transport fluid is returned to the high pressure feeder 19g via a conduit 23g. The temperature of the transport liquid can be kept low thanks to the total exchange of free liquid.

Fig. 19 illustrates a further embodiment of a single vessel hydraulic digester system of the present invention. The chips are fed from a chip bin 20Ah, through a steaming vessel 20Bh and a chip chute 20Ch. A feeding device, preferably a high-pressure feeder 19h

feeds the chips suspended in a transport liquid via a conduit 18h to the top of a digester 6h. The feeder 19h is co-operating with the chute 20Ch, and is connected to the necessary liquid circulations and replenishment.

The conduit 18h extends from the feeder 19h up to a top 5h of the digester 6h. The conduit 18h may open up at the top of a top separator 7h that feeds by means of a screw in a downwardly moving direction. The separator 7h is preferably identical or very similar to the top separator that is shown in Fig. 3 and described in detail above. The screen of the separator may be used to draw off the transport liquid D (which is then returned in a return line 15h) together with which the chips are transported from the feeder 19h up to the top 5h of the digester 6h. A first screen girdle section 8h may be arranged in conjunction with a step-out approximately in the middle of the digester 6h. Draw-off of spent liquor from this first screen girdle section 8h may be conducted via the conduit 17h to an impregnation zone A that is defined between the screen girdle section 8h and the top 5h of the digester 6h. A portion of the spent liquor may be withdrawn from the screen girdle section 8h via a conduit 111h that conducts the spent liquor to a second flash tank 112h.

A cooking liquor conduit 24h is operatively attached to the conduit 17h to supply a major part of the cooking liquor, such as white liquor, to the conduit 17h. A heat-exchanger 13h may heat up the white liquor and the spent liquor to a suitable temperature before the liquor enters the top 5h. The heat exchanger 13h may be in operative engagement with a high pressure steam line 102h. The effective alkali of the liquor in the conduit 17h is at least about 35g/l; more preferably at least about 40g/l; and, most preferably, between about 45g/l and about 55g/l.

Approximately 95% of the total supply of the white liquor in conducted in the conduit 24h and the remaining 5% is supplied to the high pressure feeder 19h via a conduit 132h and a conduit 134h to lubricate the high pressure feeder 19h.

A second screen girdle section 104h may be arranged below the first screen girdle section 8h. Draw-off from the second screen section 104h, such as spent liquor, i.e., black liquor, may be conducted via a conduit 106h back to a top portion of the impregnation zone A. The effective alkali of the spent liquor conducted in the conduit 106h is about 10-20g/l. A portion of the black liquor in the conduit 106h may be conducted to a first flash tank 108h via a conduit 107h to cool the spent liquor before the liquor is conducted to a recovery unit 110h. Preferably, the spent liquor is also conducted through a second flash tank 112h via a conduit 114h to further reduce the temperature and pressure of the spent liquor before the liquor is conducted to the recovery unit 110h. The spent liquor from both flash tanks 108h, 112h are then conducted with a conduit 126h to the recovery unit 110h. Conduits 128h and 130h may be connected to the flash tanks 108h, 112h, respectively, to provide steam that is sent to the chip bin 20Ah and the steaming vessel 20Bh.

At a bottom 10h of the digester 6h, there is a feeding-out device including a scraping element 22h. A third lower screen girdle section 12h is disposed at the bottom 10h of the digester 6h. The girdle section 12h may, for example, include three rows of screens for withdrawing liquid, which is heated and to which some white liquor, preferably about 10% of the total amount of the white liquor in the conduit 24h, is added via a branch conduit 117h before it is recirculated by means

of a central pipe 123h, which opens up at about the same level as the lowermost strainer girdle 12h.

The draw-off from screen girdles 12h and the white liquor from the branch conduit 117h are preferably conducted via a heat exchanger 120h back to the bottom 10h of the digester 6h. The high pressure steam conduit 102h is connected to the heat exchanger 120h to provide the heat exchanger 120h with steam to regulate the temperature of the white liquor in the conduit 116h. The temperature of this draw off is about 130-150°C. The temperature may depend on how much washing-liquor that has penetrated to the screen is withdrawn. The white liquor is supplied in a counter-current direction via the central pipe 123h to the screen girdle section 12h. The white liquor provides fresh alkali and, in the form of counter-current cooking, further reducing the kappa number. A blow line 26h may be connected to the bottom 10h of the digester for conducting the digested pulp away from the digester 6h.

A preferred installation according to the present invention, as shown in Fig. 19, may be described as follows. The chips are fed into the chip bin 20Ah and are subsequently steamed in the vessel 20Bh and, thereafter, conveyed into the chute 20Ch. The high-pressure feeder 19h, which is supplied with a minor amount of white liquor (approximately 5% of the total amount to lubricate the feeder), feeds the chips into the conduit 18h together with the transport liquid. The slurry of chips and the liquid are fed to the top of the digester 6h and may have a temperature up to 110-120° C when entering the digester 6h (excluding recirculated transport liquor).

Inside the top of the digester 6h, there is the top separator 7h that pushes chips in a downward direction then the chips move slowly downwards in a

plug flow through the impregnation zone A in a liquid/wood ratio between 2/1-10/1 preferably between 3/1-8/1, more preferred of about 4/1-6/1. Hot black liquor, which is drawn off from the screen girdle section 104h, may be added, via the conduit 106h, to the top of the impregnation zone A of the digester 6h. The black liquor may also be added to other sections of the digester such as to an intermediate section thereof. The high temperature of the black liquor (100-160° C), preferably exceeding 130° C, more preferred between 130-160° C, ensures rapid heating of the chips flowing through the impregnation zone A. In addition, the relatively high pH, exceeding pH 10, of the black liquor neutralises acidic groups in the wood and also any acidic condensate accompanying the chips, thereby, i.e., counteracting the formation of encrustation, so-called scaling.

An additional advantage of the method of the present invention is that the black liquor supplied into the impregnation zone A has a high content of rest alkali, (effective alkali EA as NaOH), at least 13g/l, preferably about or above 16g/l and more preferred between 13-30g/l in the top of the impregnation zone A. This alkali mainly comes from the black liquor due to the high amount of alkali in the concurrent zone B of the digester 6h. Furthermore, the strength properties of the fibers are positively affected by the impregnation because of the high amount of sulphide. A major portion of the black liquor may directly (or via one flash tank) be fed into the impregnation zone A.

The total supply of black liquor to the impregnation zone A may exceed 80% of the amount drawn off from the draw-off screen girdle section 104h, preferably more than 90% and optimally about 100% of the total flow, which normally is about 8-12 $m^3$/ADT.

The retention time in the impregnation zone A should be at least 20 minutes, preferably at least 30 minutes and more preferred at least 40 minutes. However, a shorter retention time than 20 minutes, such as 15-20 minutes may also be used. The volume of the impregnation zone A may be larger than 1/11, preferably larger than 1/10 of the volume of the digester 6h. Additionally, in the preferred embodiment, the volume V of the impregnation zone A should exceed 5 times the value of the square of the maximum digester diameter, i.e., $V = 5D^{-}$, where D is the maximum diameter of the digester 6h.

The chips, which have been thoroughly impregnated and partially delignified in the impregnation zone A, may be fed to the top of the digester 6h and conveyed into the downwardly-feeding top separator 7h. The chips are thus fed upwards through the screen, meanwhile free transport liquid may be withdrawn outwardly through the separator screen and finally the chips fall down into the digester 6h. Before or during their free fall, the chips pieces are drained with cooking liquor, such as white liquor, which is supplied at the top separator 7h.

The quantity of white liquor that is added at the top separator 7h depends on how much white liquor possibly is added else where. The thoroughly impregnated chips very rapidly assimilate the active cooking chemicals by diffusion, since the concentration of alkali (EA as NaOH) is relatively high, at least 20g/l, preferably between 30g/l and 50g/l and more preferred about 40g/l.

The chips then move down in the concurrent zone B through the digester 6h at a relatively low cooking temperature, i.e., between 130-160°C, preferably about

140-150°C. The major part of the delignification takes place in the first concurrent cooking zone B.

The liquid-wood ratio should be at least 2/1 and should be below 7/1, preferably in the range of 3/1-5.5/1, more preferred between 3.5/1 and 5/1. (The liquid wood-ratio in the counter-current cooking zone should be about the same as in the concurrent cooking zone.)

The temperature in the lower counter-current zone C is preferably higher than in the concurrent zone B, i.e., preferably exceeding 140°C, preferably about 145-165°C, in order to dissolve remaining lignin. The alkali content in the lowermost part of the counter-current cooking zone C should preferably be lower than in the beginning of the concurrent zone B, above 5g/l, but below 40g/l. Preferably less than 30g/l and more preferred between 10-20g/l. In the preferred case, the aim is to have a temperature difference of about 10°C between the concurrent zone B and the counter-current cooking zone C. Expediently, the conduit 116h may be charged with about 5-20%, preferably 10-15%, white liquor from the conduit 24h via the conduit 117h.

The temperature of the liquid which is recirculated via the pipe 123h up to the screen girdle section 12h is regulated with the aid of the heat exchanger 120h so that the desired cooking temperature is obtained at the lowermost part of the counter-current cooking zone.

From tests made in lab-scale, we have found indications that it is desirable to keep the alkaline level at above at least 2g/l, preferably above 4g/l, in the impregnation zone A in connection with black liquor, which would normally correspond to a pH of

about 11. If not, it appears that dissolved lignin precipitates and even condenses.

Fig. 20 illustrates an embodiment of the present invention, which is substantially similar to the embodiment shown in Fig. 19. Chips and a transport fluid is pumped up in a conduit 18i and a conduit 119i to a top section 5i of a digester 6i via a liquid exchanger 33i. The function and operation of the liquid exchanger is similar to the liquid exchanger 31g shown in Fig. 18. As described earlier, liquid is exchanged in the liquid exchanger 33i before the chips enter the top section 5i of the digester 6i.

A portion of the transport liquid may be returned in return line 15i that leads from the top portion 5i to a mid-section of the liquid exchanger 33i and then back to a feeder 19i via a conduit 25i. The conduit 106i conducts the spent liquor withdrawn from a screen girdle section 104i, via conduit 117i, to the conduit 15i. A portion of the liquor in the conduit 106i may be sent to a flash tank 108i.

Fig. 21 also shows an embodiment of the present invention, which is similar to what is shown in Fig. 19. Some of the more important differences are described herein. The eleventh embodiment has a digester 6j having a return line 15j attached to a top portion of the digester 6j. A recirculation line 101j is in fluid communication with the return line 15j so that a portion of the liquid in the return line 15j may be diverted back to the top portion 5j via the line 101j. The temperature of the liquid in the recirculation line 101j may be regulated with a heat exchanger 113j that is operatively engaged with a high pressure steam line 102j. The recirculation line is

used to heat the liquid from the return line 15j before the liquid is introduced. The temperature in the return line 15j must not exceed about 100°C to avoid undesirable flashing in the high pressure feeder.

Similar to the above described embodiments, a flash tank 108j is in fluid communication via a conduit 106j to a screen girdle section so that spent liquor from the section may be conducted to the flash tank 108j. A bottom portion of the flash tank 108j has a conduit 103j connected thereto to conduct a portion of the spent liquor back to a conduit 134j that carries some white liquor from the cooking liquor conduit 132j.

Fig. 22 describes an embodiment of the present invention, which is similar to the embodiment shown in Fig. 21 but it does not have the recirculation line 101j that is associated with the return line. Instead the embodiment includes a digester 6k having an additional screen girdle section 200k that is disposed immediately below a top section 5k. The girdle section 200k has a recirculation line 201k in fluid communication therewith. The recirculation line 201k withdraws cooking liquor from the girdle section 200k and recirculates it back up to a point that is immediately below a top separator 7k disposed inside the top portion 5k. The temperature of the liquor in the line 201k may be controlled by a heat exchanger 203k that is in operative engagement with a high pressure steam line 102k. The main reason for using the recirculation line 201k is to improve the distribution of the white liquor that is withdrawn from the girdle section 200k. The method of recirculating the cooking liquor is often called quench circulation.

Fig. 23 shows a preferred embodiment of a separator to be used together with a hydraulic digester or an impregnation vessel that is part of a digester system, such as the digester system shown in Fig. 1, where there is a need for a heat seal. The advantage of providing the heat seal adjacent the separator is to enable the injection of hot black liquor (above 100°C) into the top of the vessel without risking to operate the high pressure feeder at too high of a temperature. The heat seal reduces or even eliminates the risk of any hot liquor being inadvertently conducted back through the top separator to the high pressure feeder which may damage the feeder. The separator may also be used in a single vessel hydraulic digester if required. Only a top portion of such an impregnation vessel 1 or a digester is shown. The non-impregnated slurred fiber material is transferred to the top of the impregnation vessel or the digester by means of the transfer line 321, which is peripherally attached to the vessel wall of the impregnation vessel 1 and opens up into an inlet space 330. The screw-feeder is attached to a shaft 332 connected to a drive-unit 333 which is attached to a mounting-plate 334 at the top of the shell of the impregnation vessel 1. The drive-shaft 332 is rotated in a direction so as to force the screw to feed the chips and the transport fluid in a downward direction.

The new design eliminates the prior problem in relation to the mounting plate, which prior had to be moulded due to the inlet passing there through. By having a tangentially arranged supply 321 for the chips, the plate 334 may be made from any suitable standard steel (which is much cheaper). Within the inlet space 330 between the top of the screen 335 and the plate 334 the shaft 332 of the rotor would not normally be equipped with screw blades. According to the shown embodiment the top of

the screen 335 is integrated with a cylindrical shell 338 having a flange 339 resting on the top of the vessel. However since large forces are created also the top portion of the screen 335 is supported by the vessel 1 but merely radially, i.e. by means of a snug fit of a collar 341 into a supporting ring 342. In the lowermost part of the screen there is a similar support device 343. However this end of the screen support has to be adjustable, to arrange it co-axially in relation to the screw. This is achieved by having an adjustable (screw/nut member) sliding device 344. It is a big advantage that this adjustment can be done from below the screen (standing on a platform within the vessel). This support 343 also secures the lower part of the screen from being lifted, by means of protruding pieces 345 (four of them) which bear against the "sliding ring" 343 (Normally these parts are welded together once fitted into place, which welds are grinded off before disassembly).

In order to avoid rotation of the screen 335 there are (also, except welds at the bottom) four U-beams 346. Recesses (dotted line) in the beam 346 interacts with a protruding piece 347 of the collar 341.

The screen-basket 335 is arranged within the vessel shell 1 so as to define a liquid collecting space 336 between the digester shell and the outer surface of the screen-basket 335. The liquid collecting space 336, which preferably is annular, communicates with a conduit for withdrawing liquid from the liquid collecting space 336, which in turn is replenished by liquid from the slurry within the screen basket 335. The major part of the free liquid within the slurry entering the screen basket is withdrawn into the liquid collecting space 336, but a small portion of free

liquid, at least about 0.5 m³/ADT should not be withdrawn from the slurry.

Preferably the top section of the vessel 1 has a diameter (d) that is less than a diameter (D) of the vessel at a mid-portion and bottom portion thereof, preferably $d \leq D/2$. Furthermore the length/height of the top section (having d) has to be substantially more than d. Preferably the distance h between the lowermost part of the screen-basket 335 and the transition zone 65 (cylindrical/frustoconical) is equal to or larger than d, more preferred h>1,2 d. The diameter (d) is small to reduce or even avoid any substantial heat transfer to the T-C lines so that the T-C lines may maintain a maximum temperature that is maximum slightly above 100°C, but normally below 100°C. In this way, a heat lock zone is formed between the liquid supply devices (for supplying hot black liquor) and the liquid collecting space 336.

The invention is not limited to that which has been shown above but can be varied within the scope of the subsequent patent claims. Thus, instead of the shown separator used with the hydraulic digester many alternatives may be used, e.g. in stead of an annular supply arrangement a central pipe (as shown in WO-9615313) for supply of liquid at distance downstream of the separator device within chip pile adjacent the top of the digester.

Moreover there are many ways of optimising the conditions even further, e.g. new on-line measuring systems (for example using NIR-spectroscopy) provide for the possibility of exactly measuring specific contents of the fibre material and the liquids entering the digesting system, which will make it feasible to

more precisely determine and control the supply/addition of specific fluids/chemicals and also their withdrawal in order to establish optimised conditions. Different kind of additives can be very beneficial to use, especially for example poly-sulphide which has a better effect in a low temperature environment than in high temperatures. Also AQ (Anthraquinone) would be very beneficial since it combines very well with high alkaline environments.

Furthermore, there are a multiplicity of alternatives for uniformly drenching the chips with white liquor at the top of the digester. For example, a centrally arranged inlet (as described in WO-having a spreading device can be contrived, which device, in a known way, provides a mushroom-like film of liquid, as can a centrally arranged showering element or an annular pipe with slots, etc.

In addition, it will be evident to a person skilled in the art that the number of screen girdles shown is in no way limiting for the invention but, instead, the number can be varied in dependence on different requirements. It is likewise obvious that the invention is in no way limited to a certain screen configuration and it is understood that bar screens can be exchanged by, for example, such as screens having slots cut out of sheet metal. Also in some installations moveable screens are preferred. Furthermore, it will be evident to the person skilled in the art that, in order to amplify the heat economy, measures can be taken which decrease heat losses from the digester, such as, for example, insulation of the digester shell and/or maximisation of the volume in

relation to the outwardly exposed surface, i.e. increasing the cross-sectional area.

The shown system in front of the digester is in no way limiting to the invention, e.g. it is possible to exclude the steaming vessel and have a direct connection between the chip bin (for example, a partly filled atmospheric vessel) and the chip chute. Furthermore, other kind of feeding systems than an HP-feeder may be used, e.g. DISCFLO™-pumps).

In order to improve the distribution of the white liquor added at the top, it is possible to install a so called "quench circulation" which would recirculate a desired amount of liquid from below the top screen 7 back to the annular pipe. For this purpose ordinary screens is not a requirement. Finally, it should be understood that the basic principle of the invention can be applied also in combination with a circulation (strainer and piping) on the impregnation vessel, even if this, of course, reduces the cost advantage.

Further, it should be understood that some advantages of our invention are also achieved in a two zones digester, even if almost the same temperature is maintained in the con-current and the counter-current cooking zones.

CLAIMS:

1. Method of continuously producing pulp in which finely divided fiber material is mixed with liquid to form a slurry, transporting said slurry to an impregnation zone wherein cooking pressure essentially prevails, heating and impregnating said fiber material by aid of hot black liquor to a temperature (T0) less than 140°C and passing the finely divided fiber material in con-current in said impregnation zone, separating and withdrawing a substantial part of the free liquid from the slurry, transferring the heated and thoroughly impregnated fiber material to a con-current cooking zone in the upper part of a digester, supplying at least 60%, of the quantity of liquor required for the cooking reaction, in an up-stream end of said con-current cooking zone, in order to obtain a first level of effective alkaline (EA1) in the beginning of said con-current cooking zone, withdrawing spent liquor which has passed at least said con-current cooking zone from at least one strainer girdle, and taking pulp out at the bottom of the digester, maintaining a higher temperature (T1) in the beginning of said con-current cooking zone than in said impregnation zone, wherein the cooking temperature (T1) in said concurrent cooking zone is lower than 160°C, said level of effective alkaline (EA1) exceeds 35g/l, said withdrawn spent liquor has an amount of effective alkaline of at least 13g/l, no substantial part of said withdrawn spent liquor is directly recirculated to a cooking zone, and (a) the amount of black liquor which is supplied adjacent the up-stream end of the impregnation zone exceeds 6 m3/ADT, such that a liquid/wood ratio in the impregnation zone is between 5/1-10/1, (b) a substantial exchange of liquid is performed

between the impregnation zone and the concurrent cooking zone where a maximum of 1,5 m3/ADT is left as free, non exchanged liquid in the slurry, after said separating and withdrawing of free liquid, and (c) spent liquor in an amount exceeding 4 m3/ADT, which is taken from said free liquid as being separated from an end or after the end of the impregnation zone, is passed to recovery.

2. Method according to claim 1 wherein the cooking temperature (T1) in said con-current cooking zone is lower than 155°C.

3. Method according to claim 1 wherein the cooking temperature (T1) in said con-current cooking zone is between 140 and 150°C.

4. Method according to claim 1 wherein said level of effective alkaline (EA1) exceeds 40g/l.

5. Method according to claim 1 wherein said level of effective alkaline (EA1) is between 45 and 55g/l.

6. Method according to claim 1 wherein said withdrawn spent liquor has an amount of effective alkaline of at least 16g/l.

7. Method according to claim 1 wherein said withdrawn spent liquor has an amount of effective alkaline of more than 18g/l.

8. Method according to claim 1 wherein said withdrawn spent liquor has an amount of effective alkaline of substantially 20g/l.

9. Method according to any one of claims 1 to 8, wherein a substantial part of the withdrawn spent liquor is supplied to the impregnation zone, adjacent the upstream end

related to the liquid stream, of the impregnation zone, which is a con-current zone.

10. Method according to claim 9 wherein in that the temperature of a substantial part of the black liquor which is supplied to the impregnation zone exceeds 100°C.

11. Method according to claim 9 wherein the temperature of a substantial part of the black liquor which is supplied to the impregnation zone is between 120 and 160°C.

12. Method according to claim 9 wherein the temperature of a substantial part of the black liquor which is supplied to the impregnation zone is between 130 and 150°C.

13. Method according to claim 9, wherein the black liquor is passed through a first flash tank, before it is supplied to the impregnation zone.

14. Method according to any one of claims 1 to 8, wherein there also exist a counter-current cooking zone, and that the temperature (T2) in the lowermost part of the counter-current cooking zone essentially exceeds the temperature (T1) in the beginning of the con-current cooking zone, so that the temperature difference ($\Delta T = T2-T1$) is more than 5°C.

15. Method according to claim 14 wherein the temperature difference ($\Delta T = T2-T1$) is between 50 and 20°C.

16. Method according to claim 14 wherein the temperature difference ($\Delta T = T2-T1$) is between 7 and 15°C.

17. Method according to any one of claims 14 to 16, wherein supplying an amount of effective alkaline adjacent

the bottom part of the digester in order to obtain a second level of effective alkaline (EA2) in the lowermost part of the counter-current cooking zone, the amount being lower than said first level of effective alkaline (EA1), in order to obtain a difference of effective alkaline ($\Delta EA = EA1-EA2$) of a least 20g/l.

18. Method according to any one of claims 1 to 16, wherein it relates to a two vessel digesting system, comprising an impregnation vessel and a digester, and that a portion of said withdrawn spent liquor is supplied adjacent the in-let end of said vessel, whereby at least 70% of the withdrawn spent liquor, is supplied to the impregnation vessel.

19. Method according to claim 18 wherein between 90 and 100% of the withdrawn spent liquor is supplied to the impregnation vessel.

20. Method according to any one of claims 1 to 19 wherein the amount of spent liquor which is supplied to the impregnation zone exceeds 7 m3/ADT.

21. Method according to claim 20 wherein the amount of spent liquor which is supplied to the impregnation zone is between 8 and 12 m3/ADT.

22. Method according to any one of claims 1 to 21, wherein the liquid/wood ratio in the impregnation zone is between 5/1 and 9/1.

23. Method according to claim 22 wherein the liquid/wood ratio in the impregnation zone is between 5/1 and 8/1.

24. Method according to claim 18 or 19 wherein a maximum of 1 m3/ADT is left as, non-exchanged liquid in the slurry.

25. Method according to claim 24 wherein a maximum of 0.5 m3/ADT is left as free non-exchanged liquid in the slurry.

26. Method according to claim 18 or 19, wherein the digester is of the steam/vapour-phase type equipped with a top-separator having a screw which feeds upwardly, and that said separator is used to both separate said spent liquor and to supply said cooking liquor.

27. Method according to claim 1 wherein it relates to a digester without any counter-current cooking but a second con-current cooking zone and in that all or substantially all of the liquid withdrawn after the first con-current cooking zone is supplied to the beginning of the impregnation zone and in that an almost total exchange of free liquid is performed between the impregnation zone and the con-current cooking zone and in that liquid to recovery is taken from the liquid having passed zone and in that a further amount of liquid to recovery is taken from a lowermost strainer girdle section 12 after the second cooking.

28. Method according to claim 27 wherein the amount of liquid taken to recovery from after the impregnation zone exceeds the amount taken to recovery from after the second cooking zone, and in that the liquid/wood ratio in the different zones is as follows l/w (impregnation zone) > l/w (con-current cooking zone) > l/w (second con-current cooking zone).

29. The method of claim 1 wherein the finely divided fiber material comprises wood chips.

30. The method of claim 17 wherein the difference of effective alkaline ($\Delta EA = EA1-EA2$) is more than 25g/l.

31. The method of claim 17 wherein the difference of effective alkaline ($\Delta EA = EA1-EA2$) is between 30g/l and 50g/l.

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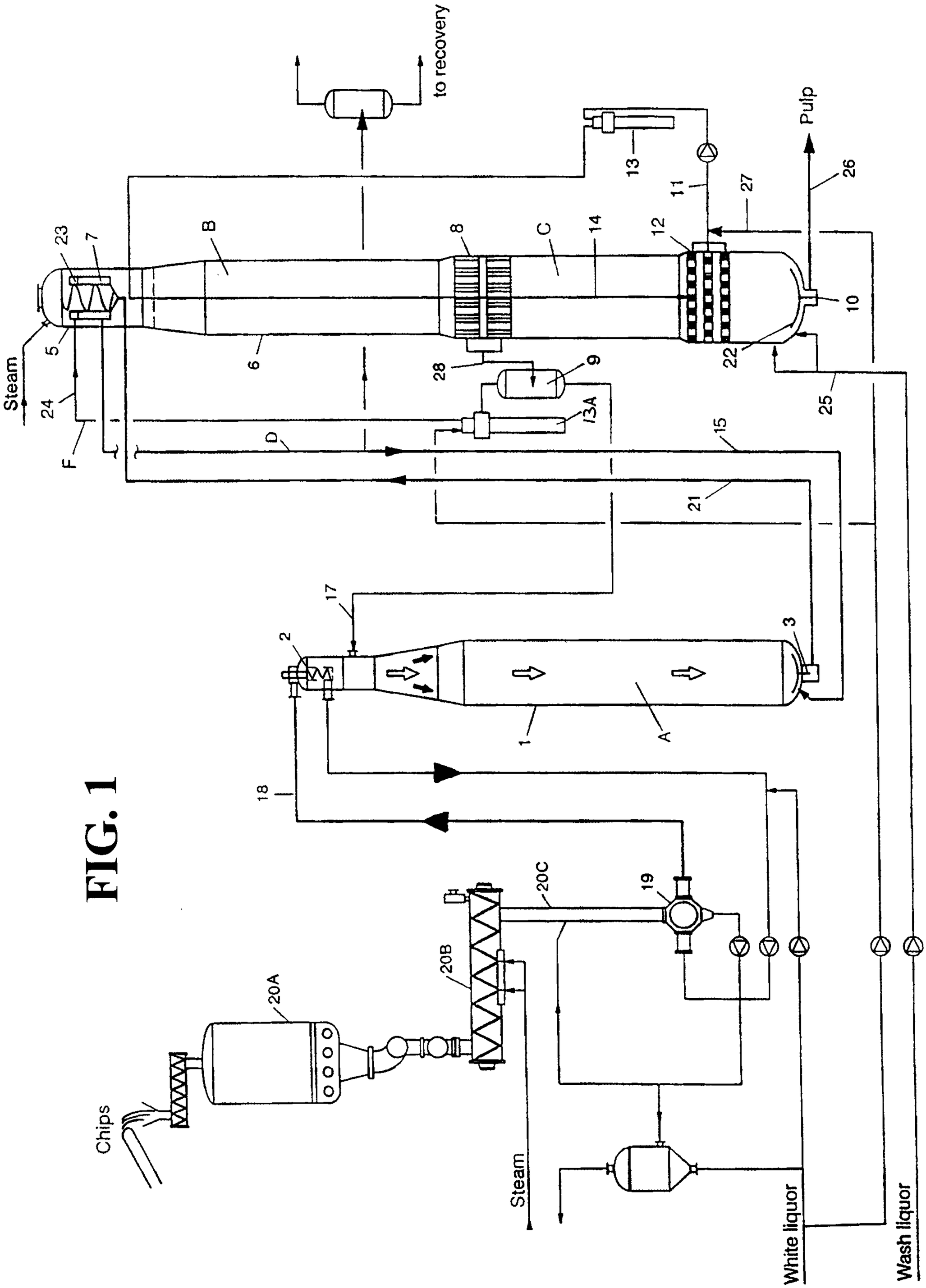
PATENT AGENTS

FIG. 1


to recovery
Pulp
Steam
Chips
White liquor
Wash liquor
A
B
C
D
F
1
2
3
5
6
7
8
9
10
11
12
13
13A
14
15
17
18
19
20A
20B
20C
21
22
23
24
25
26
27
28

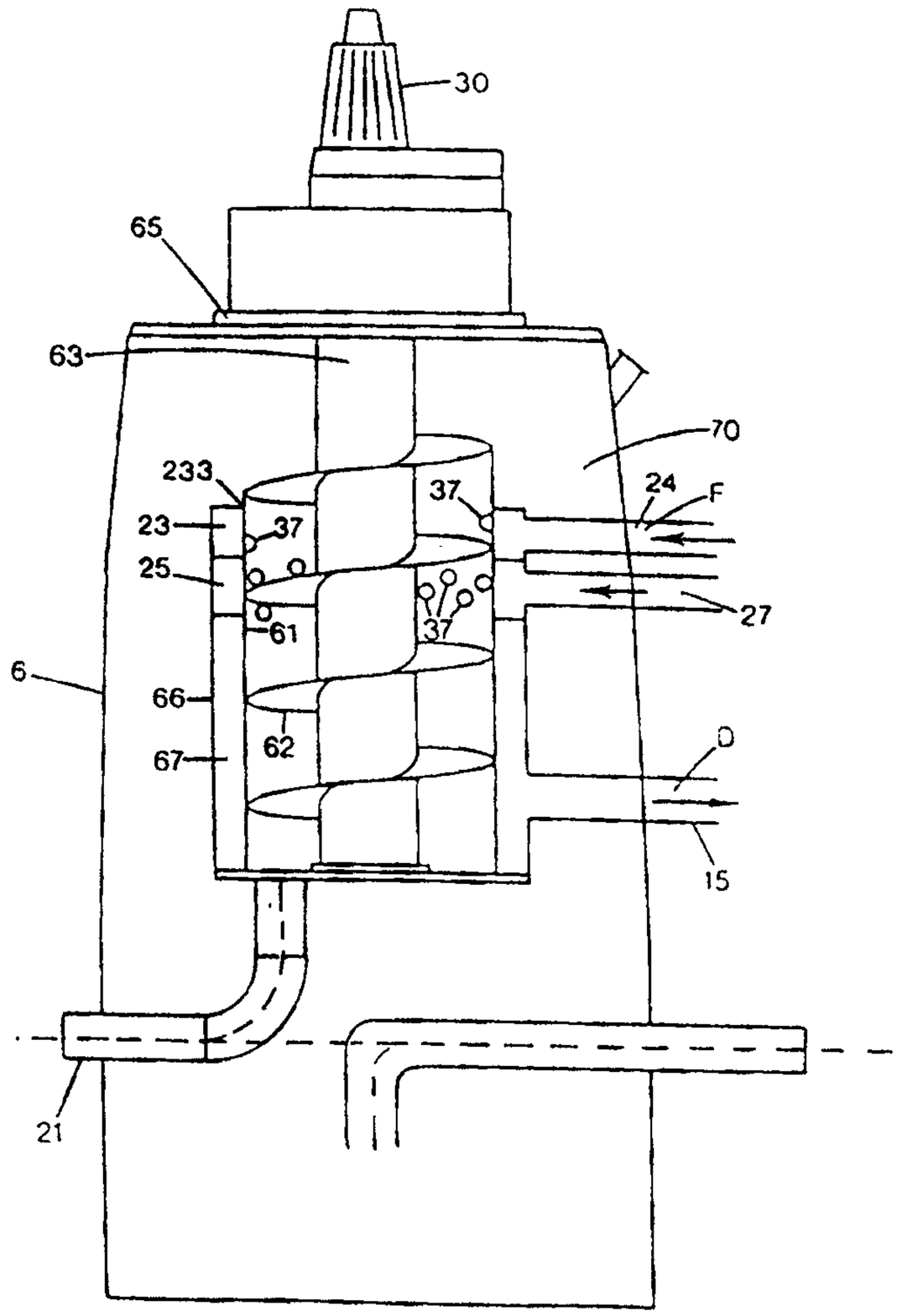

30
65
63
70
233
37
24
F
23
37
25
27
61
37
6
66
62
67
D
15
21

FIG. 2B

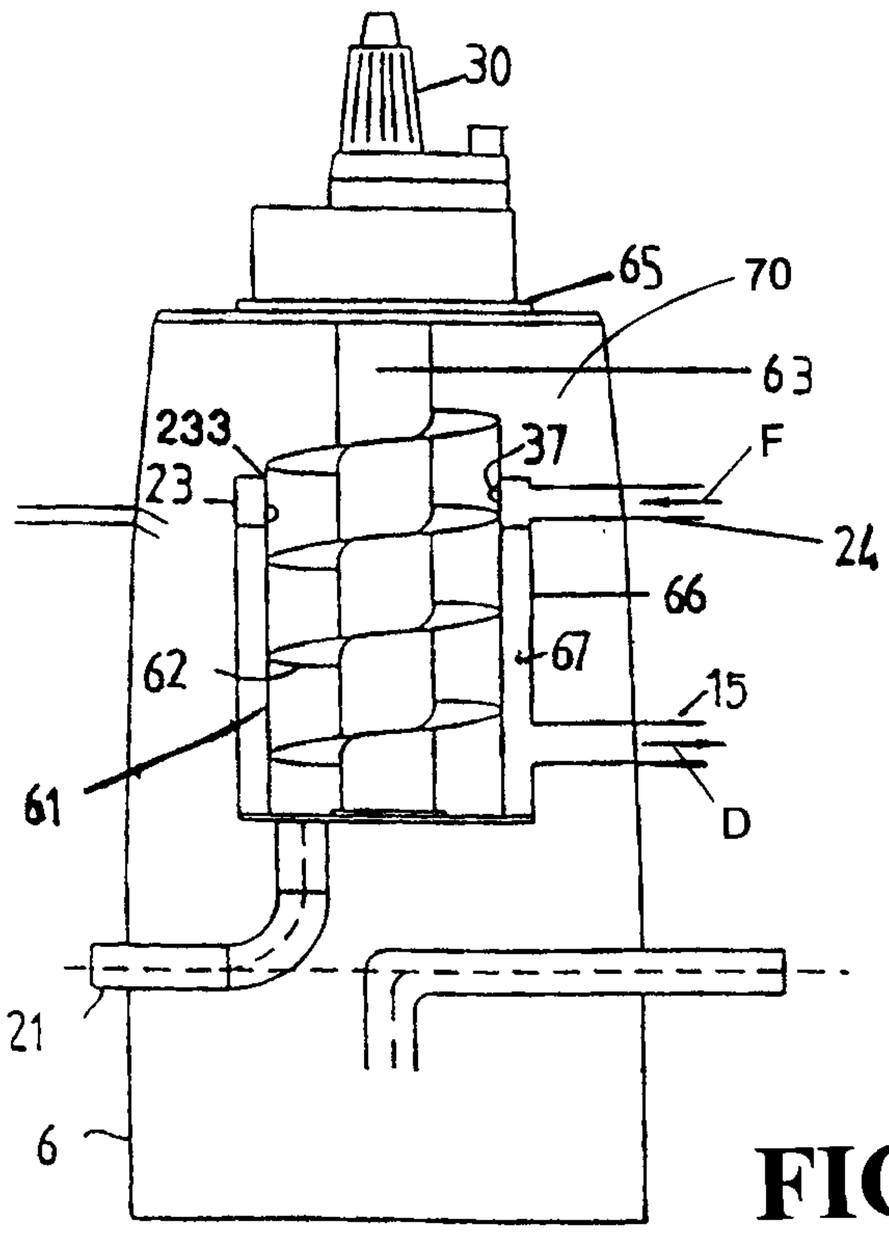

30
65
70
63
233
37
F
23
24
66
67
62
15
61
D
21
6

FIG. 2A

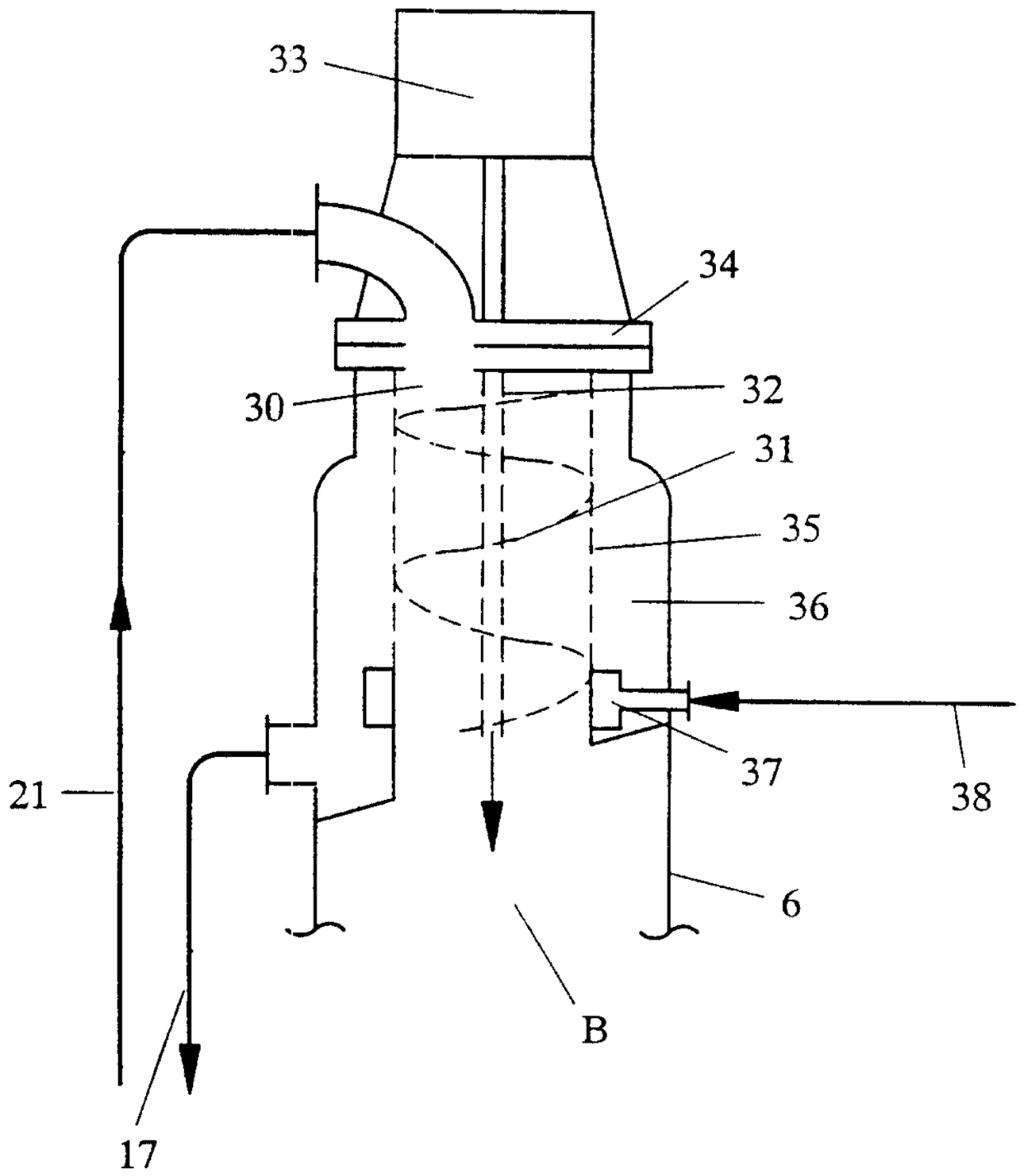



Fig. 3

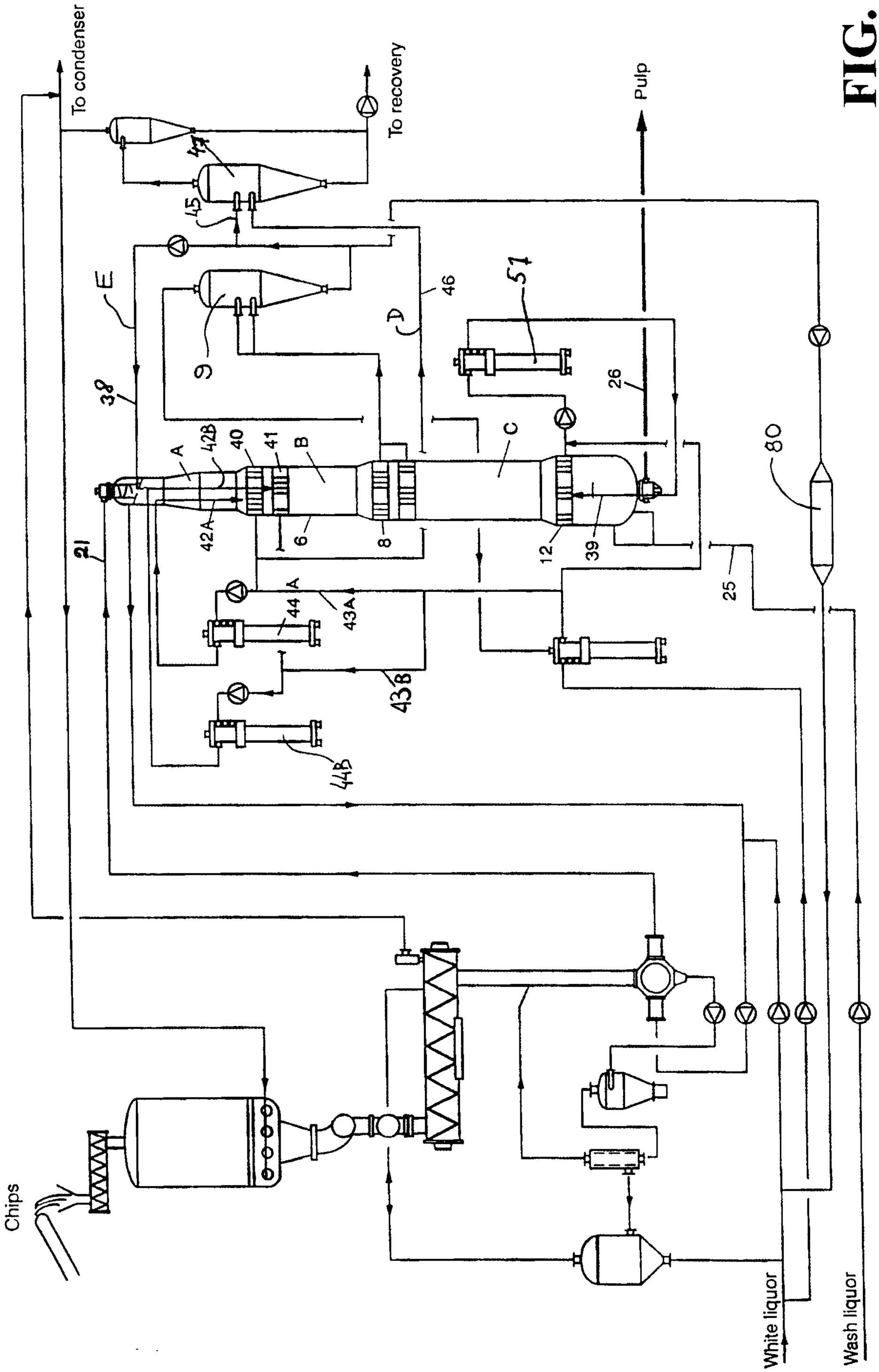

To condenser
To recovery
Pulp
Chips
White liquor
Wash liquor
A
B
C
D
E
6
8
9
12
21
25
26
38
39
40
41
42A
42B
43A
43B
44
44B
45
46
51
80

FIG. 4

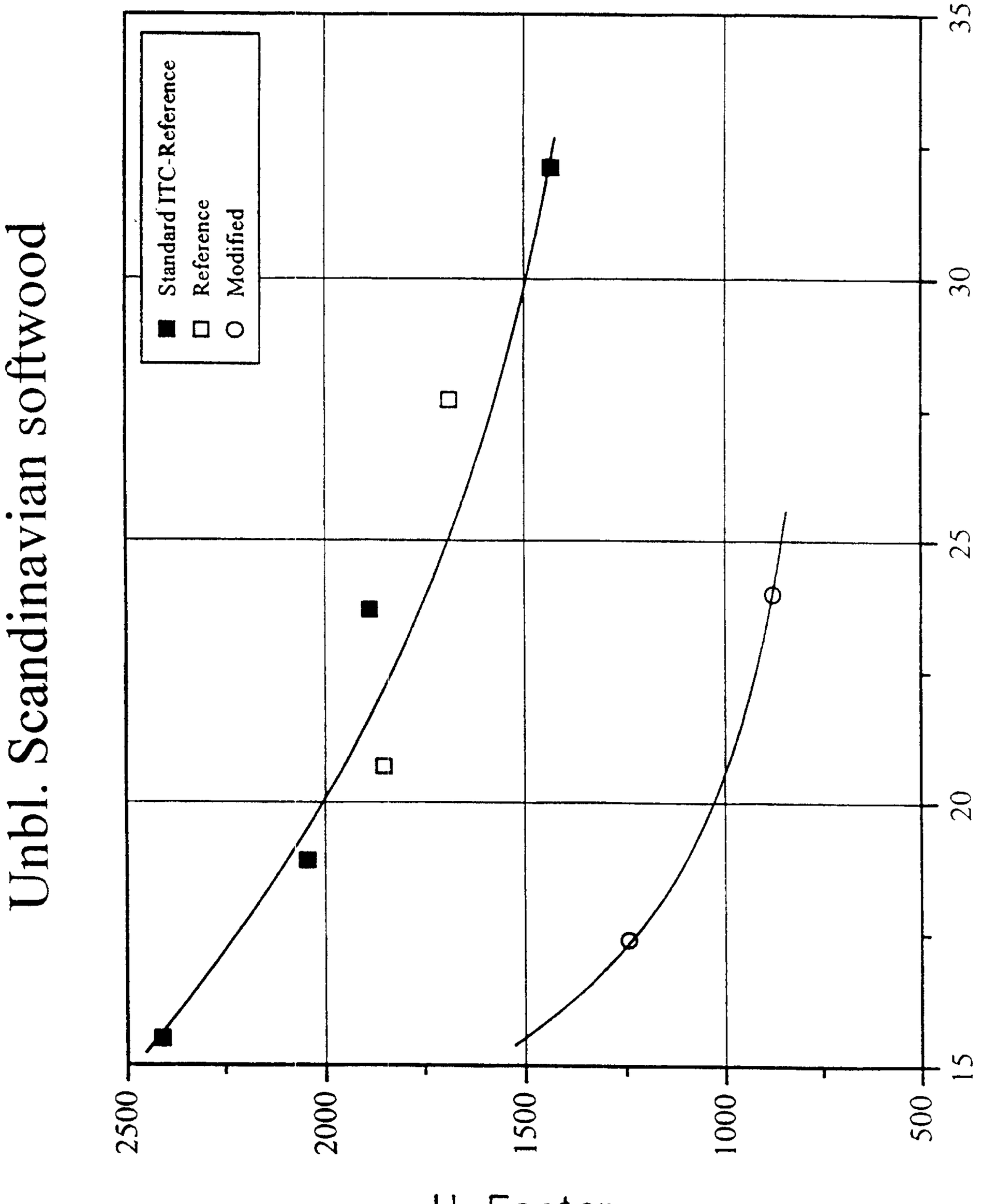

Unbl. Scandinavian softwood
Standard ITC-Reference
Reference
Modified
Kappa No.
15
20
25
30
35
500
1000
1500
2000
2500
H-Factor

Figure 5

Figure 6

# LABORATORY COOKING

| | | |
|---|---|---|
| GENERAL CONDITIONS | | |
| Wood specie: | Scandinavian softwood, chips | |
| Steaming, minutes | 5 | |
| Temperature, °C | 110 | |
| Pressure, bar | 1,0 | |
| Sulfidity, % | 36,4 | |
| | | |
| SPECIFIC CONDITIONS | | |
| | Reference | Modified |
| Cook no. | ITC 1770 | ITC* 1763 |
| IMPREGNATION | | |
| Time, minutes | 45 | 45 |
| Temperature, °C | 125 | 125 |
| Alkali consumption, kg EA/BDMT wood | 99 | 92 |
| CONCURRENT COOKING | | |
| Time, minutes | 120 | 120 |
| Temperature, °C | 160 | 145 |
| Alkali consumption, kg EA/BDMT wood | 63 | 66 |
| COUNTERCURRENT COOKING | | |
| Time, minutes | 150 | 150 |
| Temperature, °C | 160 | 155 |
| Alkali consumption, kg EA/BDMT wood | 15 | 10 |
| | | |
| RESULTS | | |
| H-Factor | 1850 | 874 |
| Alkali consumption, kg EA/BDMT wood | 177 | 168 |

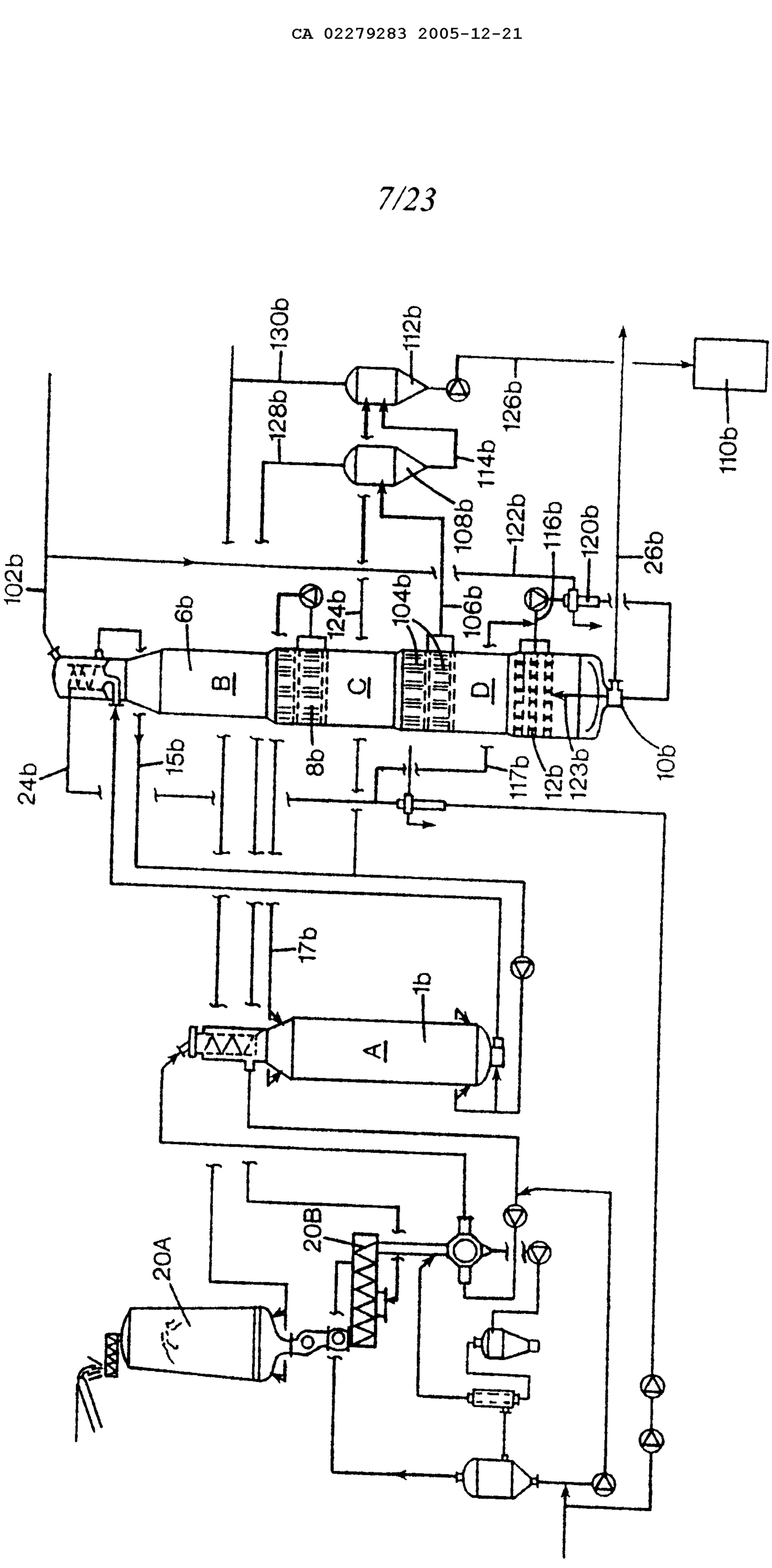

102b
6b
B
C
D
A
1b
17b
15b
24b
8b
104b
106b
108b
124b
128b
130b
114b
112b
126b
122b
116b
120b
26b
110b
117b
12b
123b
10b
20A
20B

FIG. 7

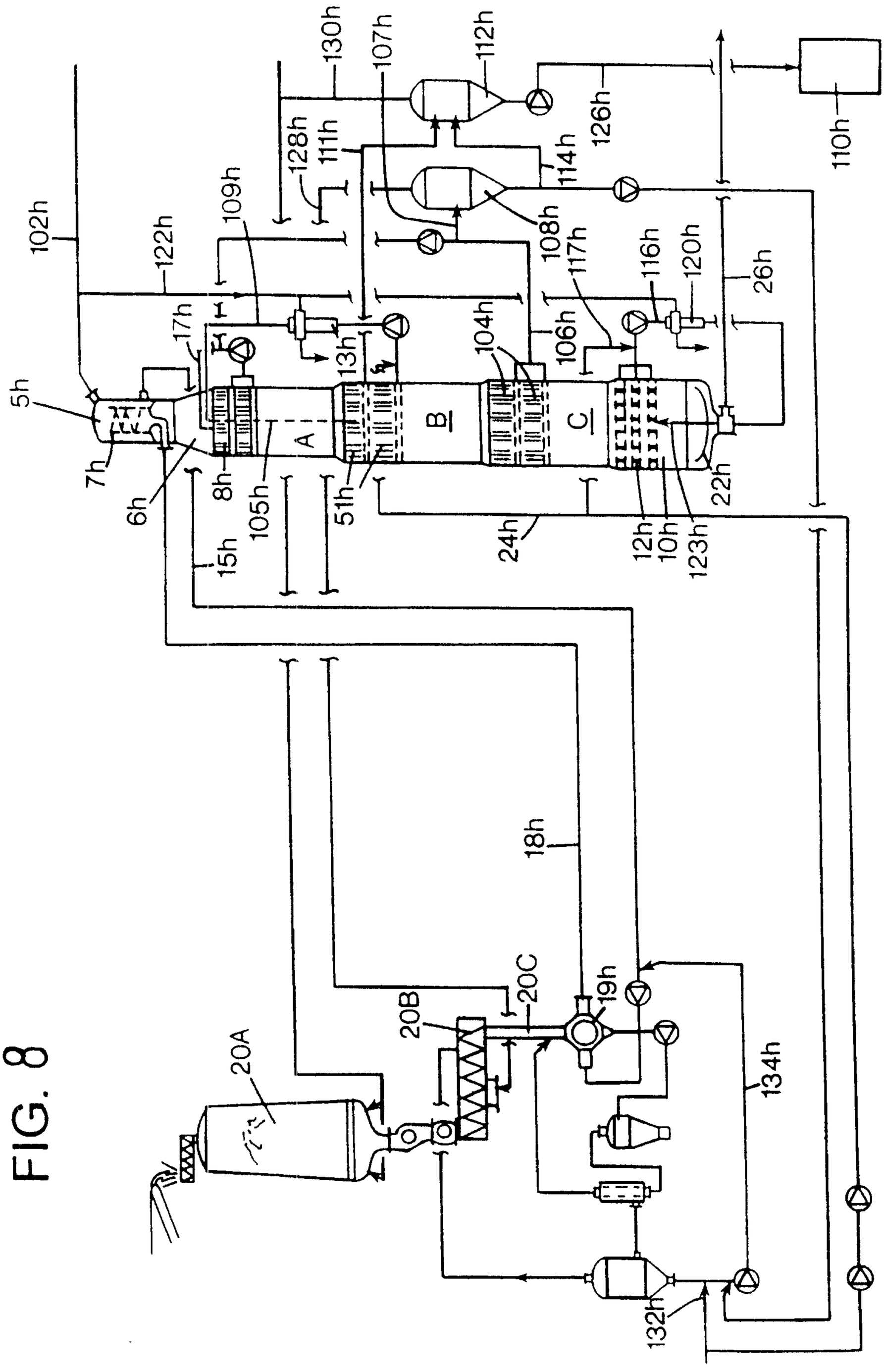

102h
122h
109h
128h
111h
130h
107h
112h
126h
114h
110h
108h
117h
116h
120h
26h
106h
104h
17h
13h
5h
7h
6h
8h
105h
51h
15h
24h
12h
10h
123h
22h
A
B
C
18h
20C
19h
20B
20A
134h
132h

FIG. 8

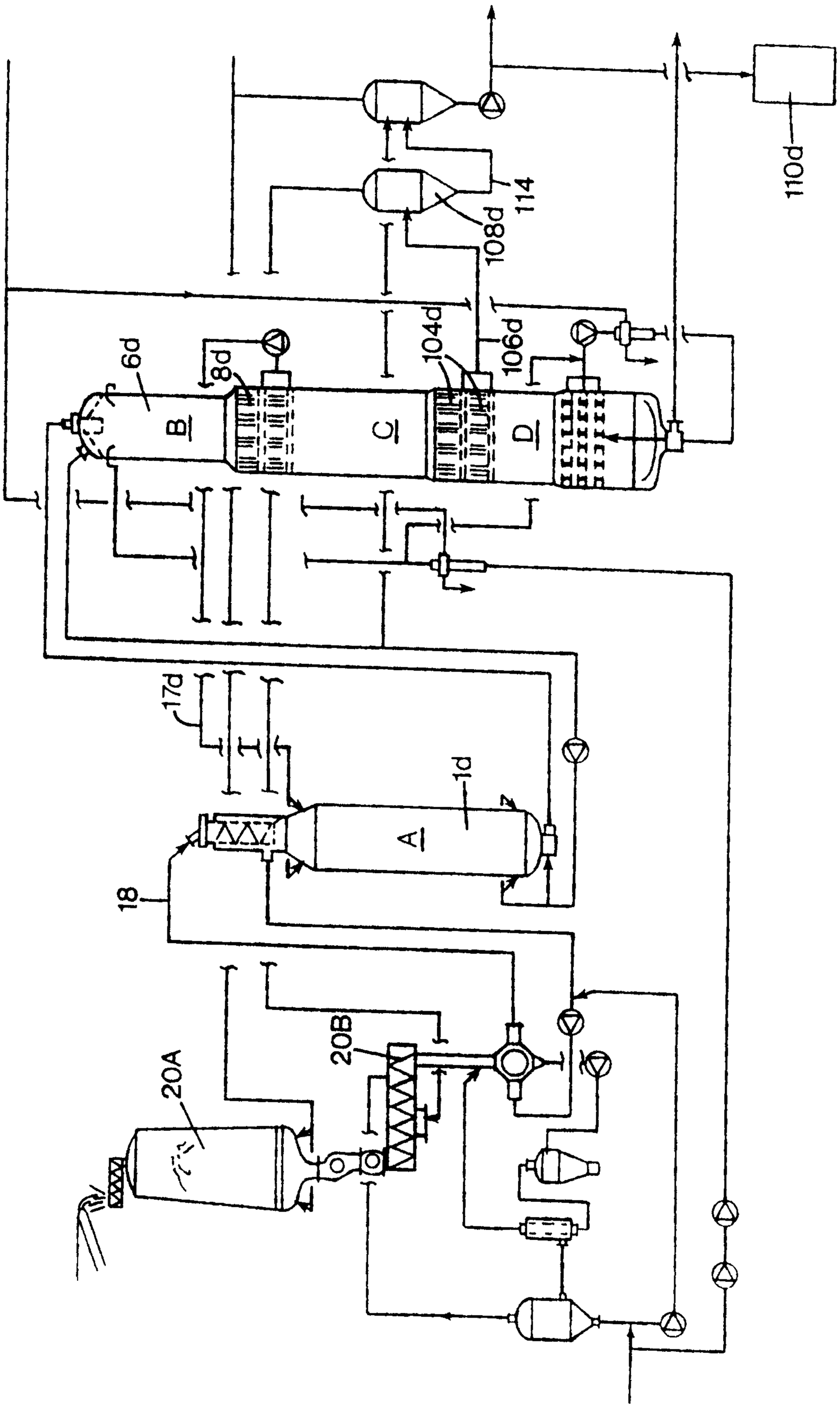



FIG. 9

FIG. 10

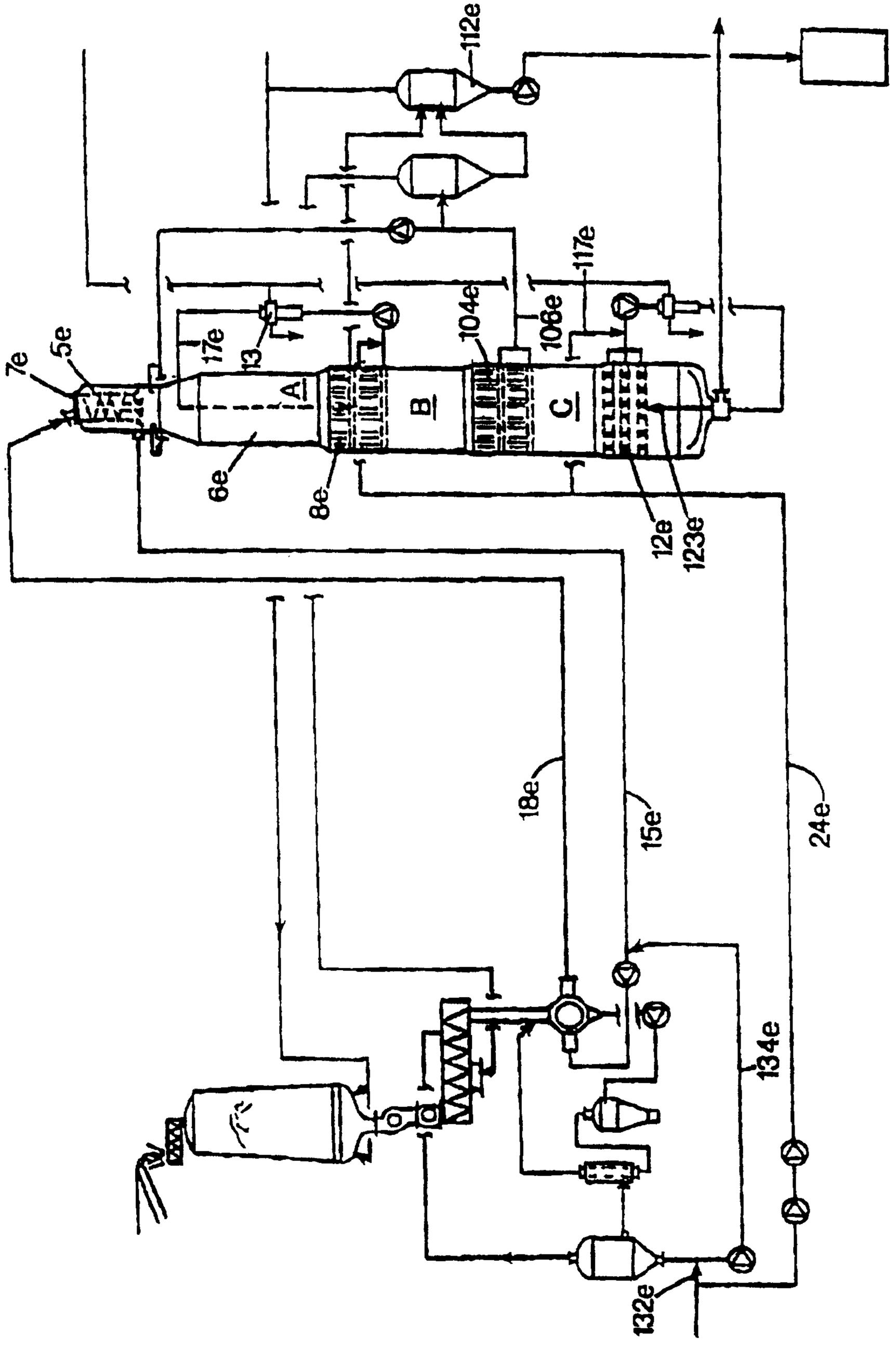
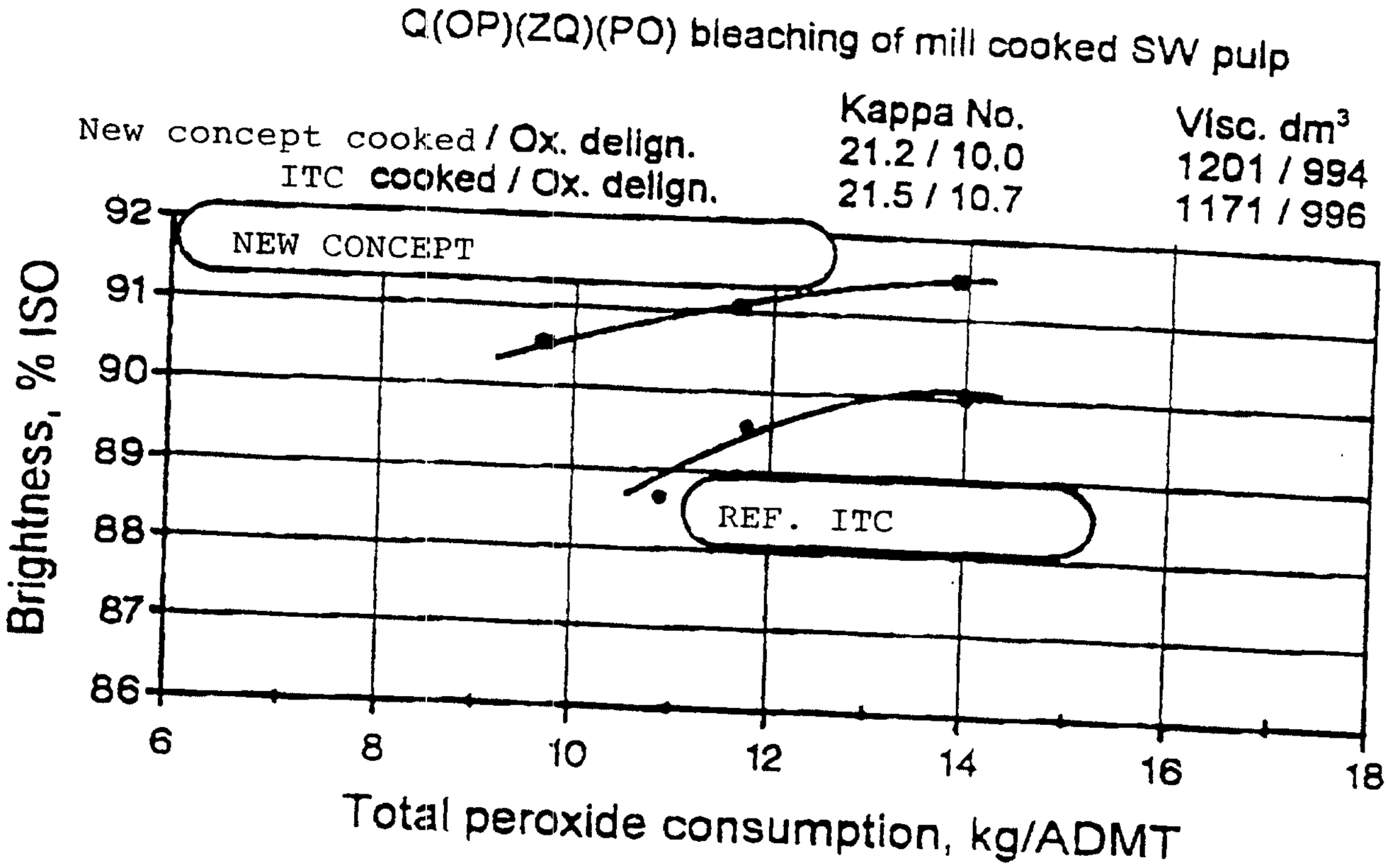

A
B
C
5e
6e
7e
8e
12e
13
17e
18e
104e
106e
112
117e
123e
15e
24e
132e
134e

FIG. 11


Q(OP)(ZQ)(PO) bleaching of mill cooked SW pulp
New concept cooked / Ox. delign.
ITC cooked / Ox. delign.
Kappa No.
21.2 / 10.0
21.5 / 10.7
Visc. dm3
1201 / 994
1171 / 996
NEW CONCEPT
REF. ITC
Brightness, % ISO
92
91
90
89
88
87
86
6
8
10
12
14
16
18
Total peroxide consumption, kg/ADMT

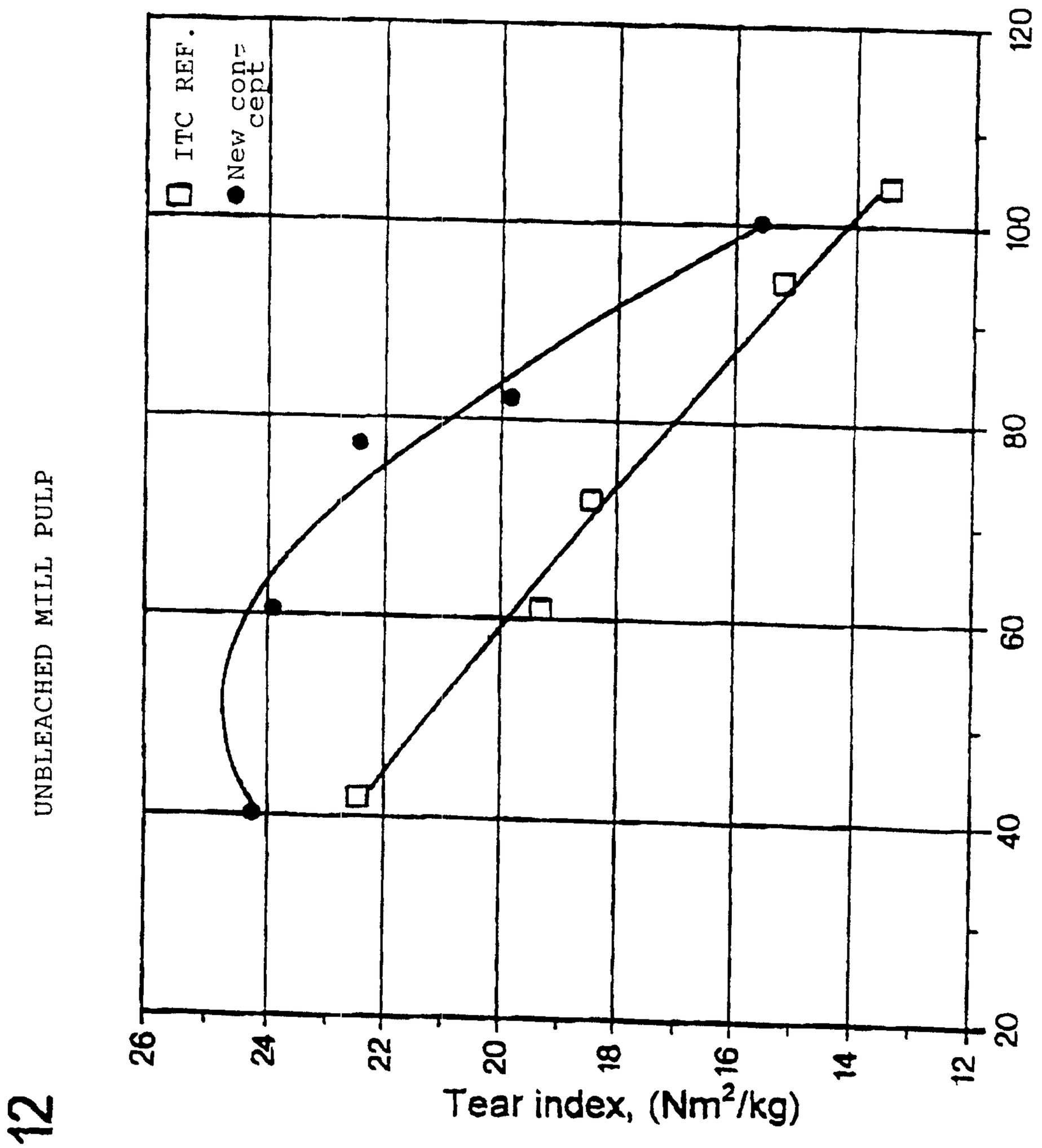

ITC REF.
New concept
UNBLEACHED MILL PULP
26
24
22
20
18
16
14
12
20
40
60
80
100
120
Tear index, (Nm²/kg)
Tensile index, (kNm/kg)

FIG. 12

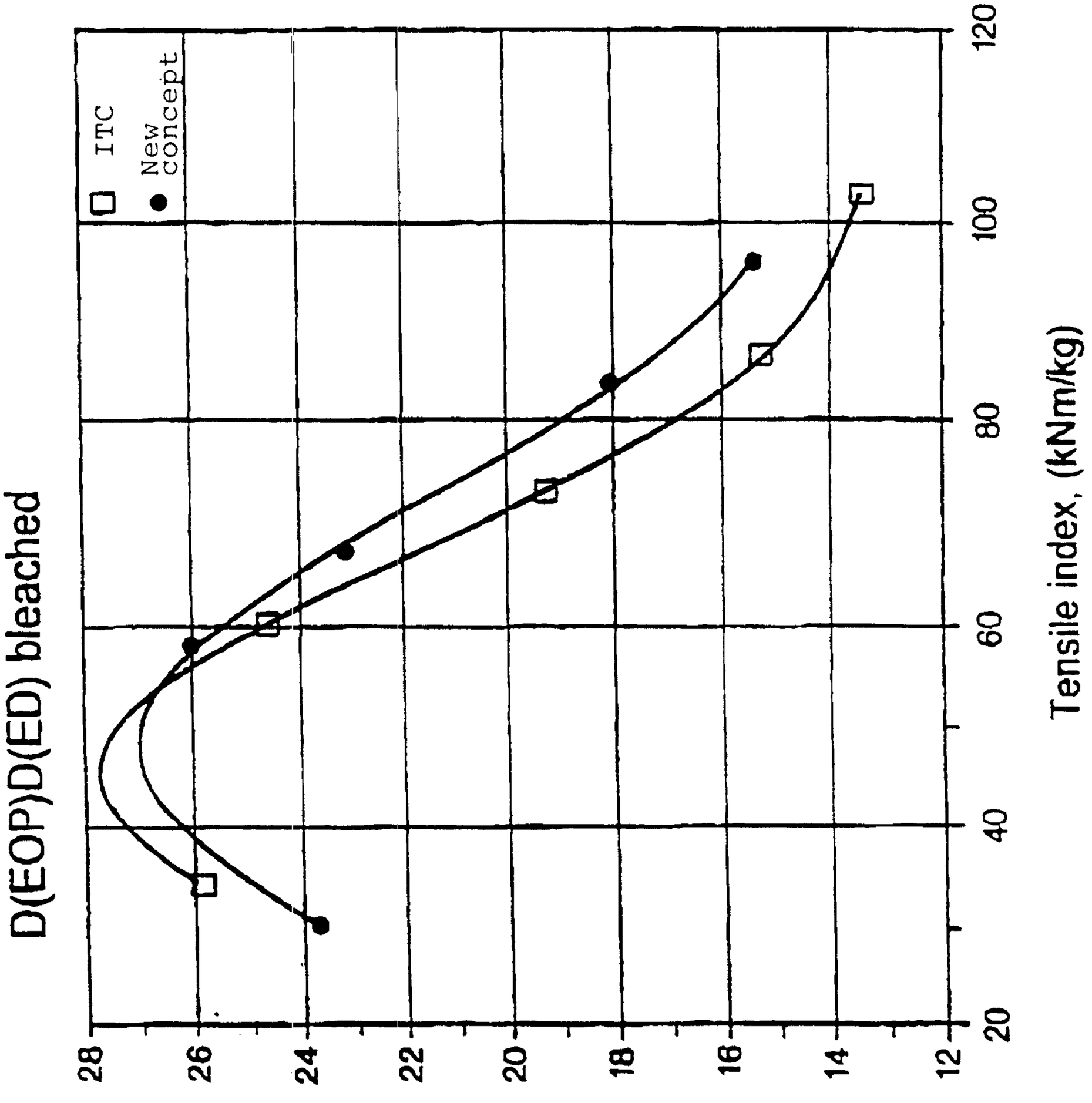

ITC
New concept
D(EOP)D(ED) bleached
Tensile index, (kNm/kg)
Tear index, (Nm²/kg)
28
26
24
22
20
18
16
14
12
20
40
60
80
100
120

FIG. 13

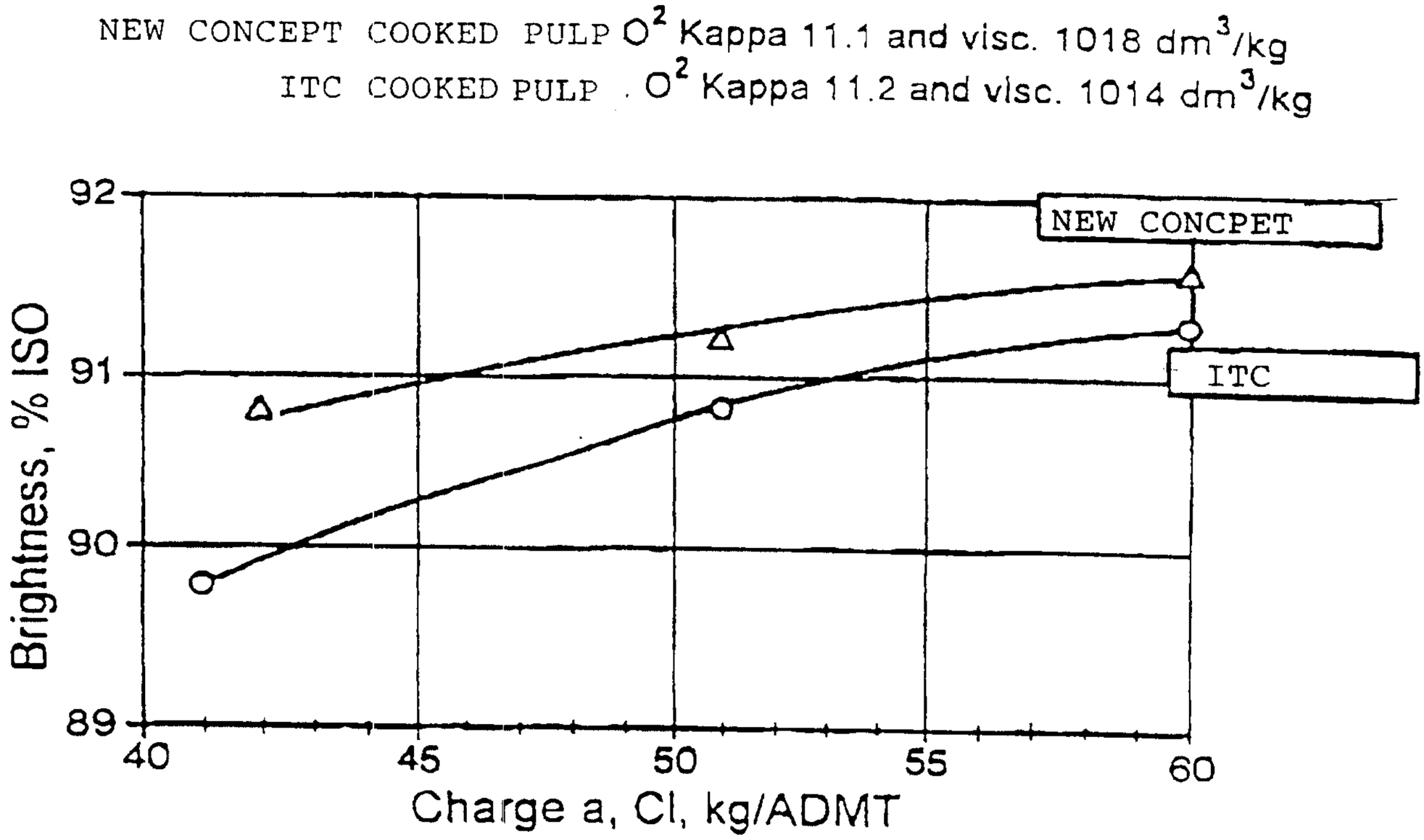

NEW CONCEPT COOKED PULP O2 Kappa 11.1 and visc. 1018 dm3/kg
ITC COOKED PULP . O2 Kappa 11.2 and visc. 1014 dm3/kg
NEW CONCPET
ITC
Brightness, % ISO
92
91
90
89
40
45
50
55
60
Charge a, Cl, kg/ADMT

FIG.14

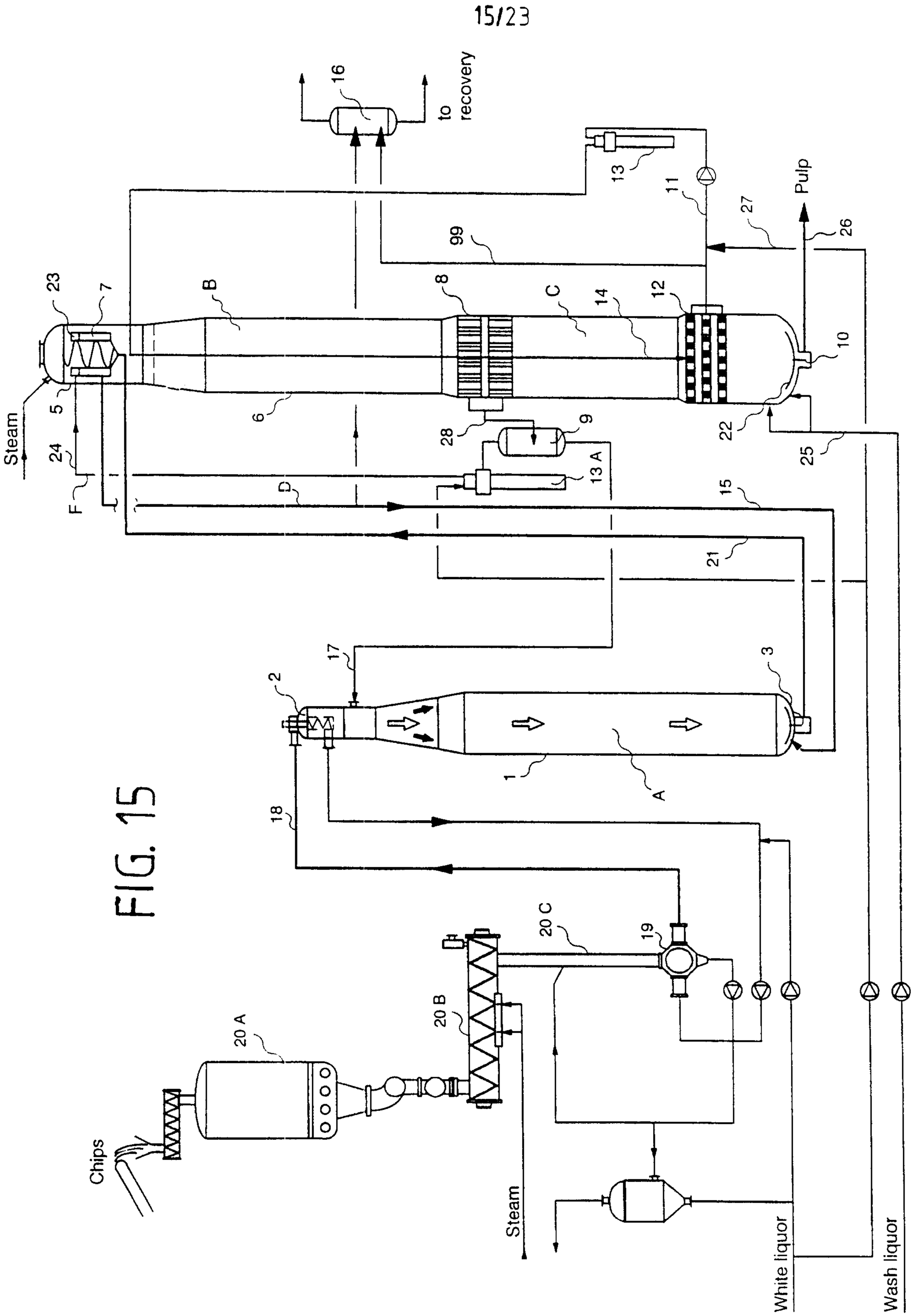

16
to recovery
13
11
27
Pulp
26
99
23
7
B
8
C
14
12
10
Steam
5
6
28
9
22
24
13 A
25
F
D
15
21
17
3
2
1
A
18
20 C
19
20 B
20 A
Chips
Steam
White liquor
Wash liquor

FIG. 15

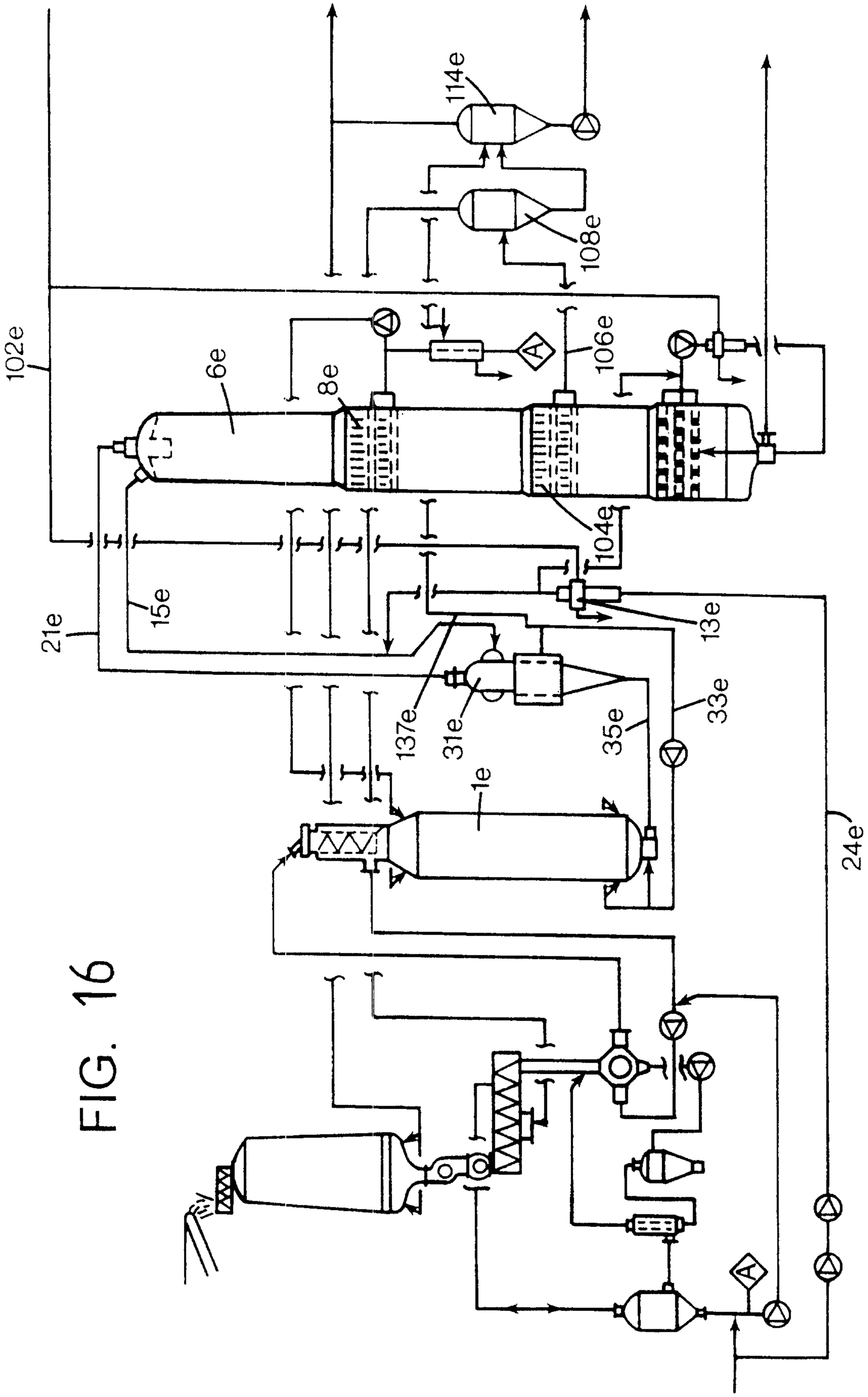

114e
108e
102e
6e
8e
106e
104e
15e
21e
13e
137e
31e
35e
33e
1e
24e

FIG. 16

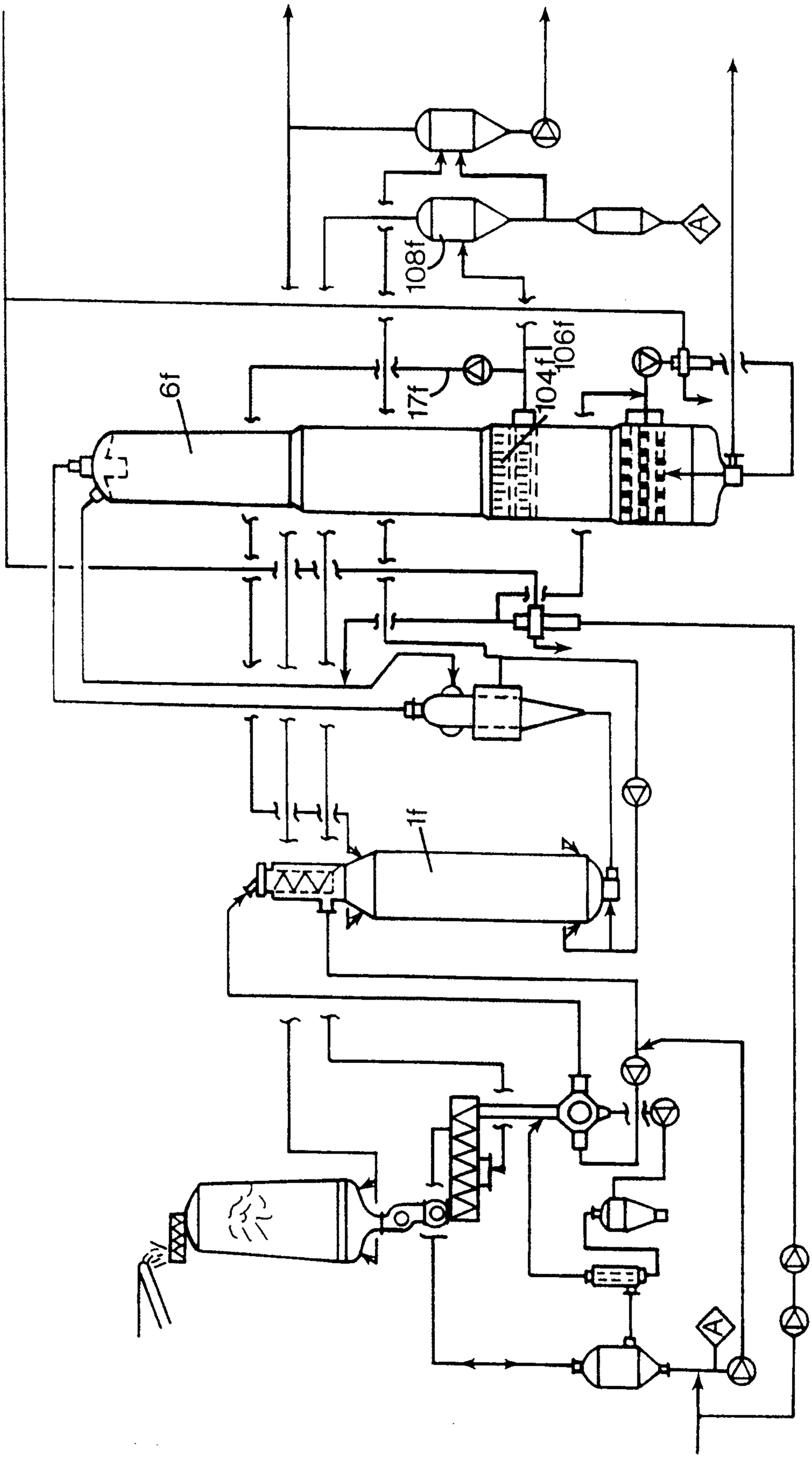



FIG. 17

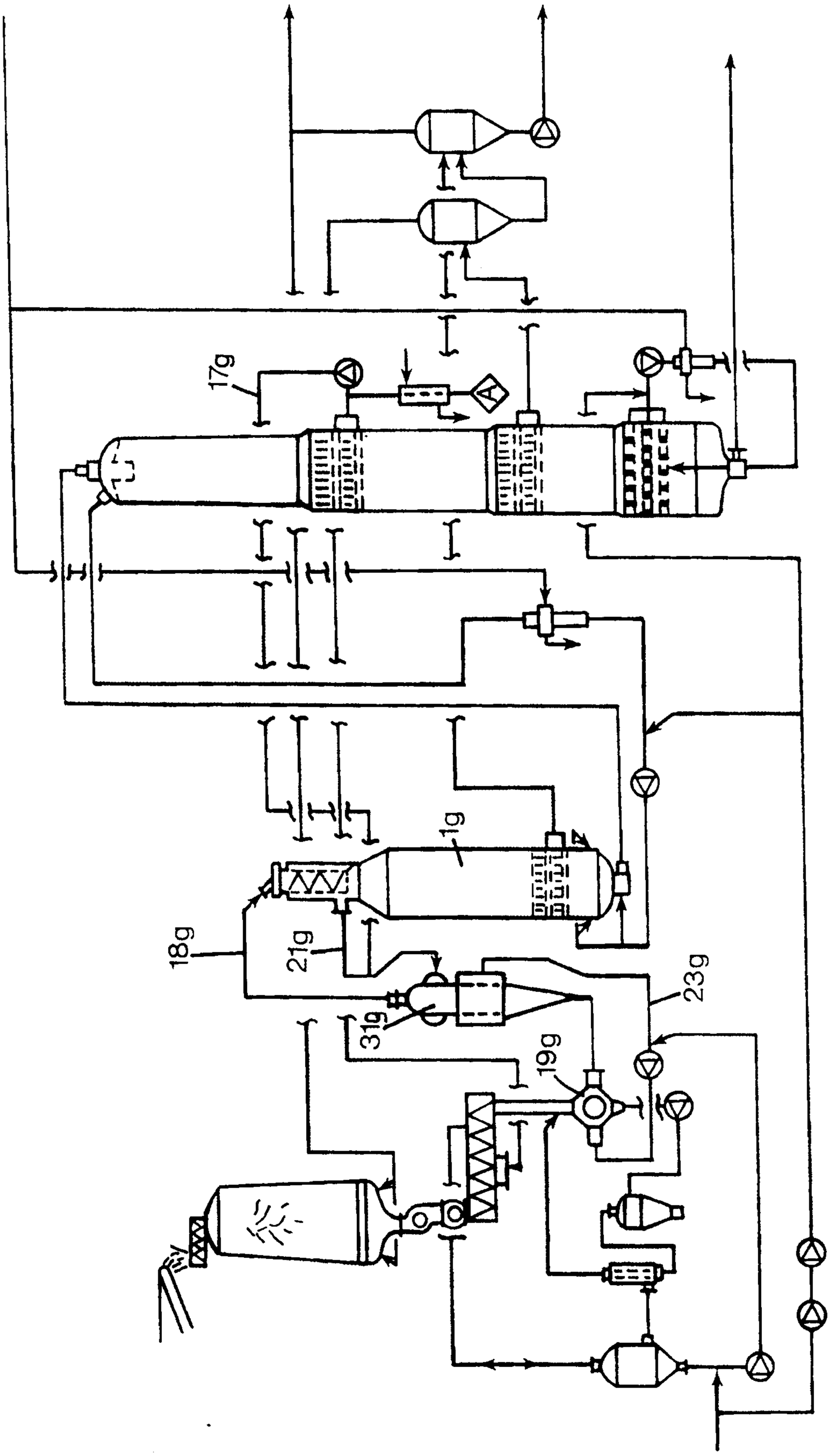



FIG. 18

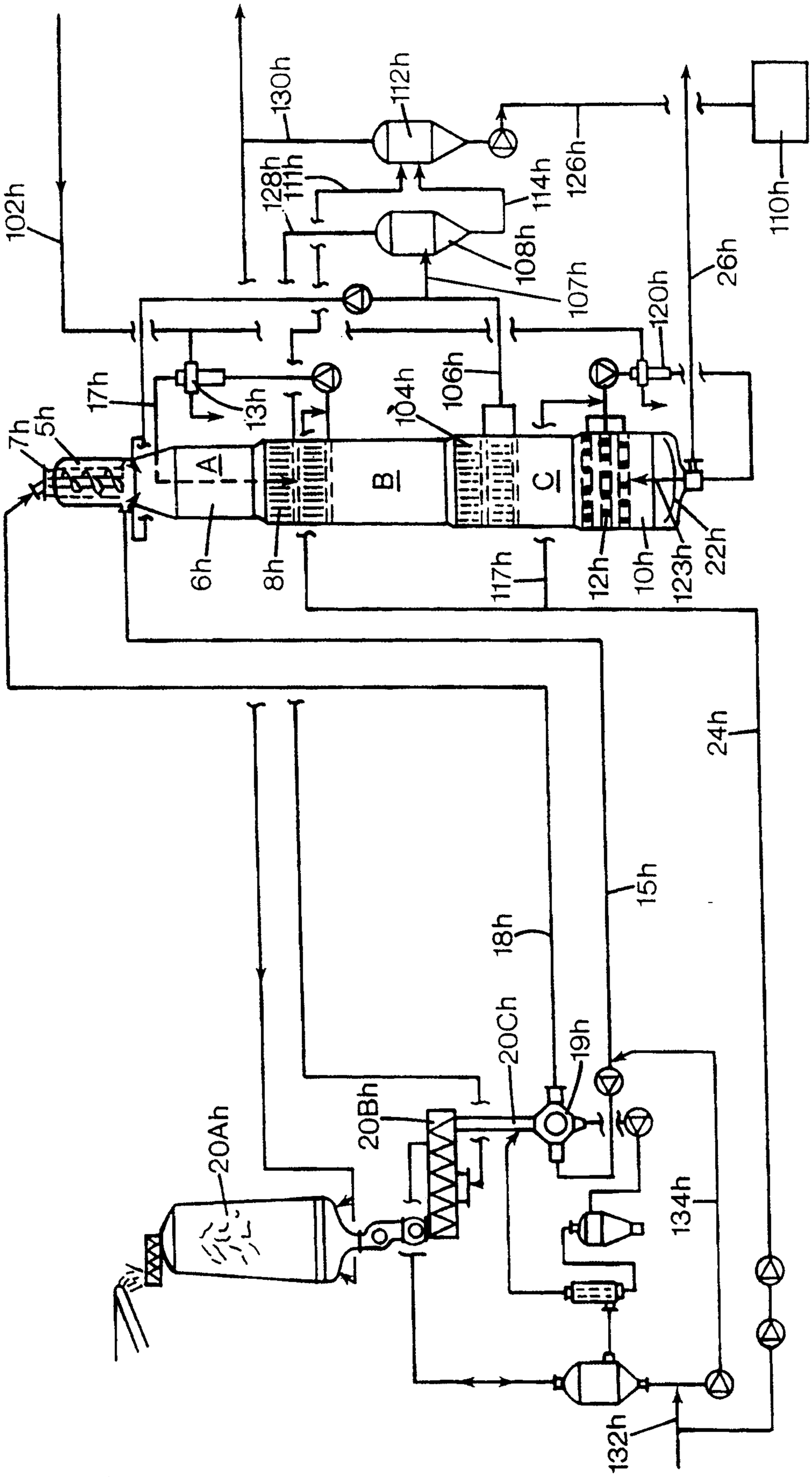

102h
130h
112h
128h
111h
114h
126h
110h
108h
107h
26h
120h
17h
13h
104h
106h
7h
5h
A
B
C
6h
8h
117h
12h
10h
123h
22h
24h
15h
18h
20Ch
19h
20Bh
20Ah
134h
132h

FIG. 19

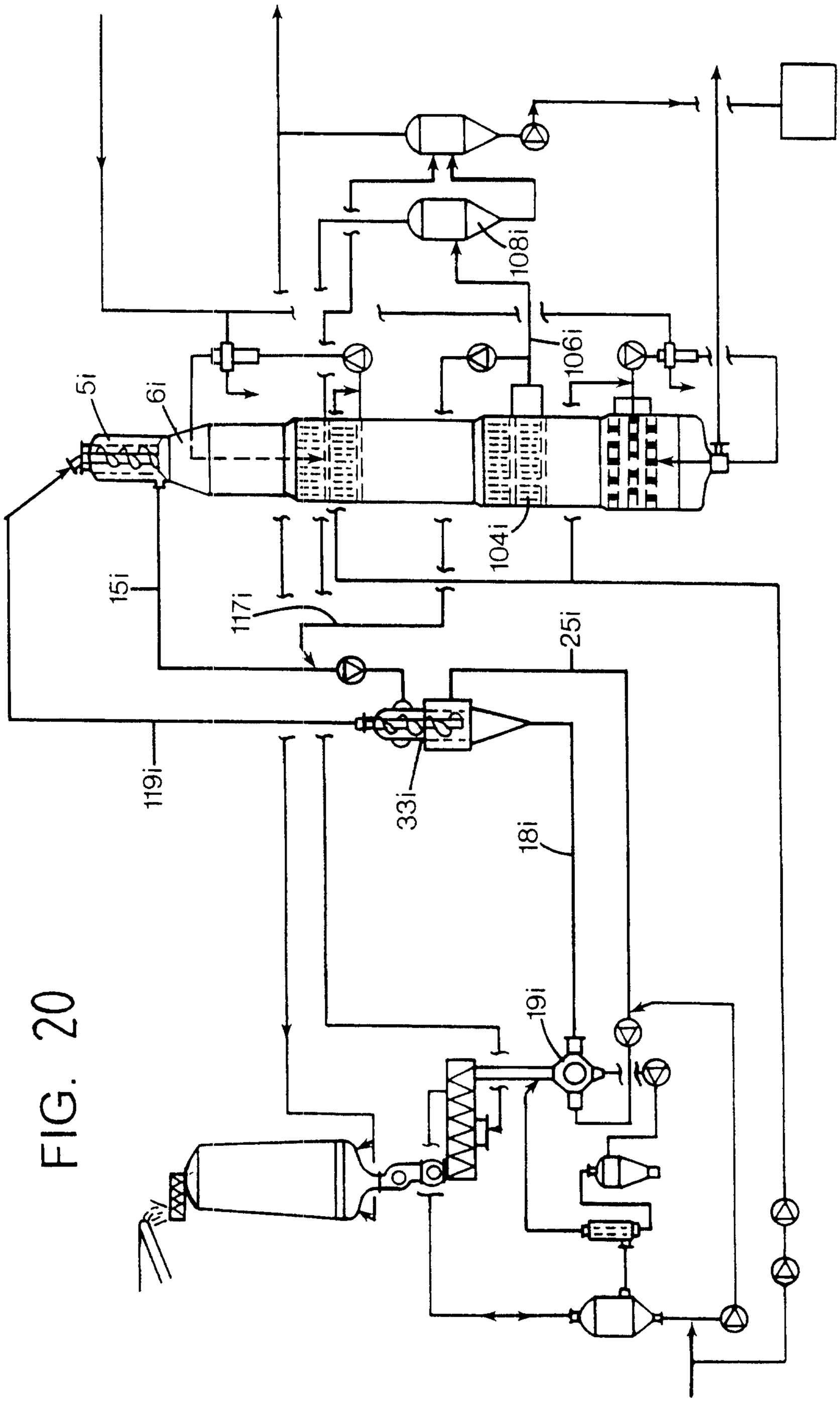



FIG. 20

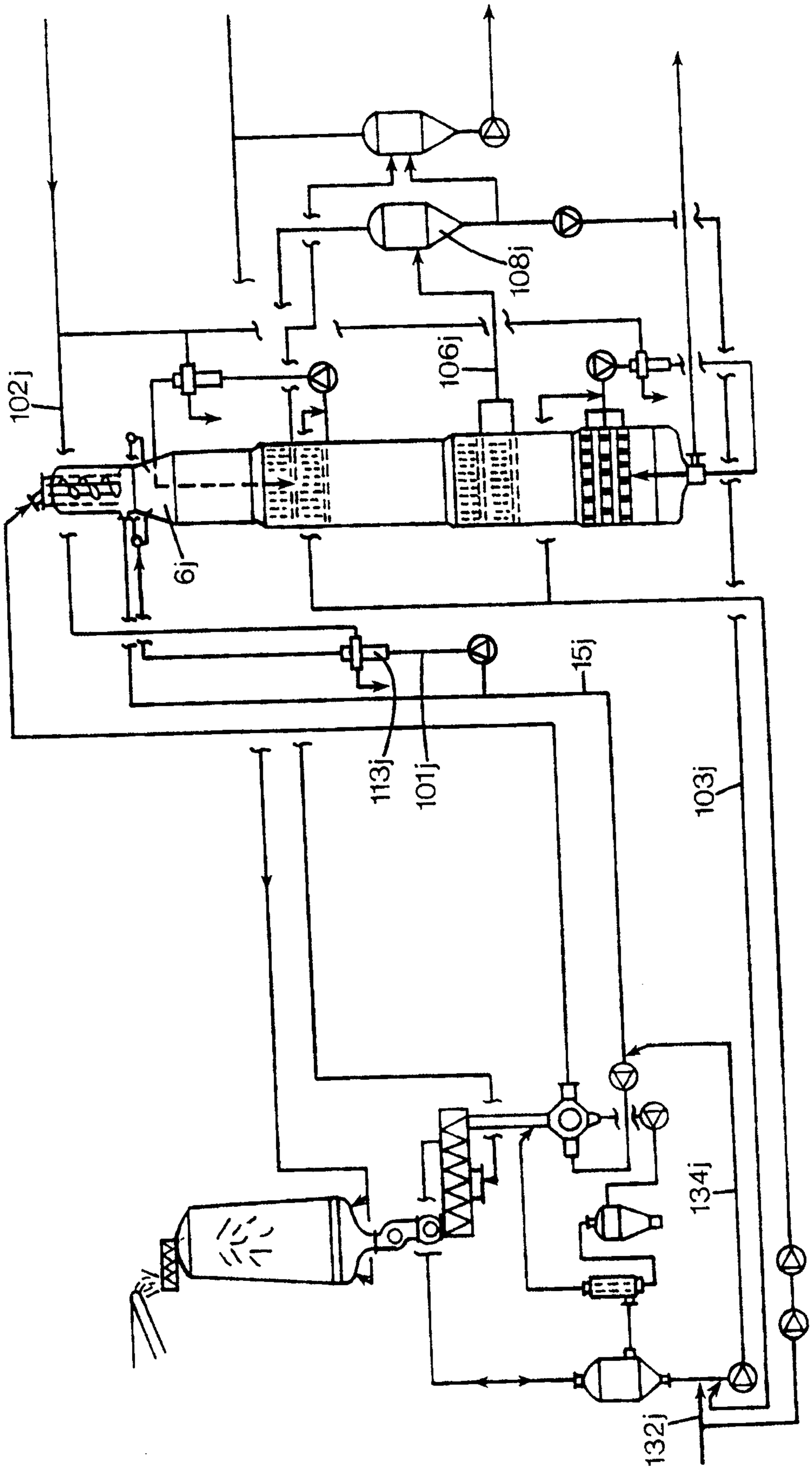



FIG. 21

22/23

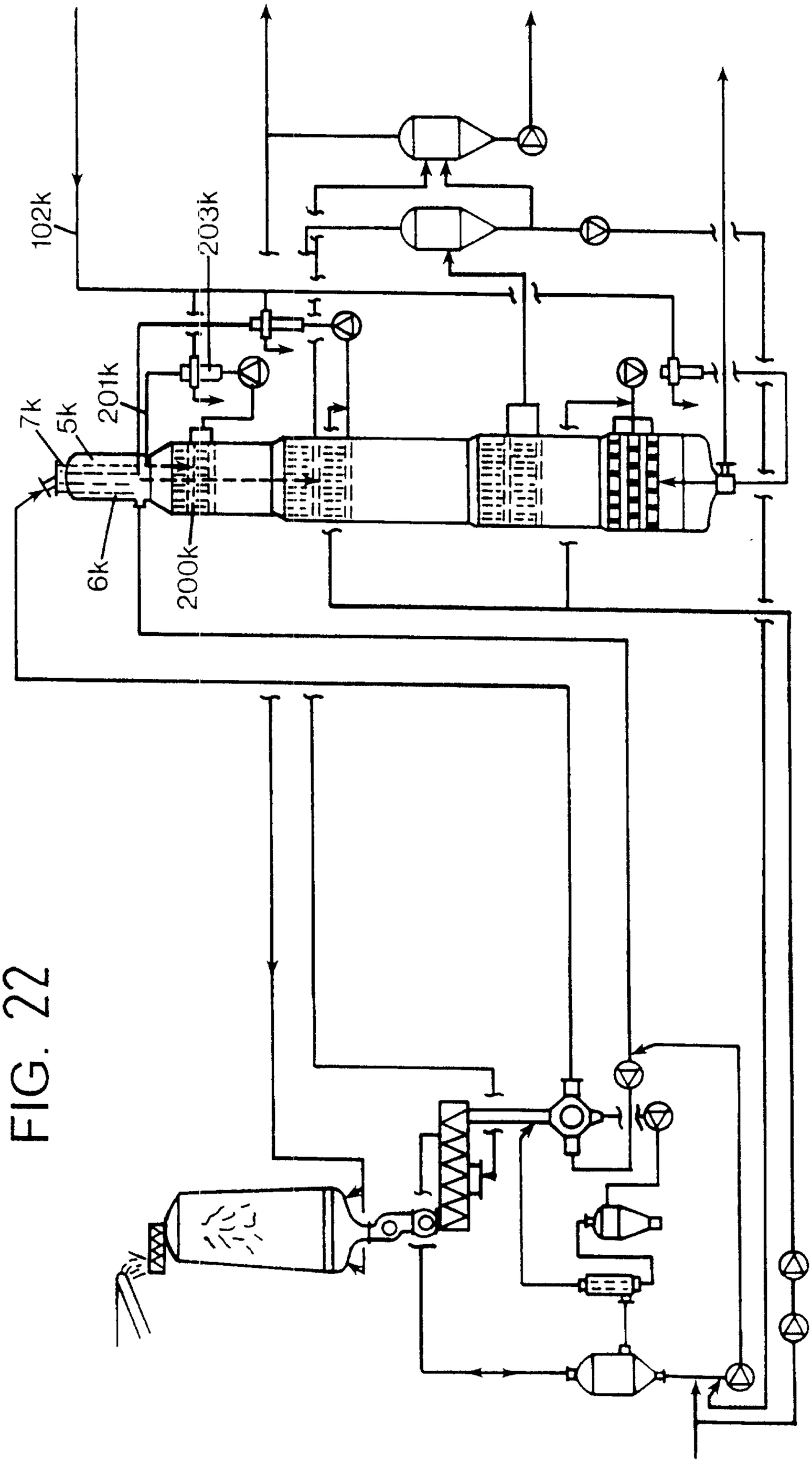



FIG. 22

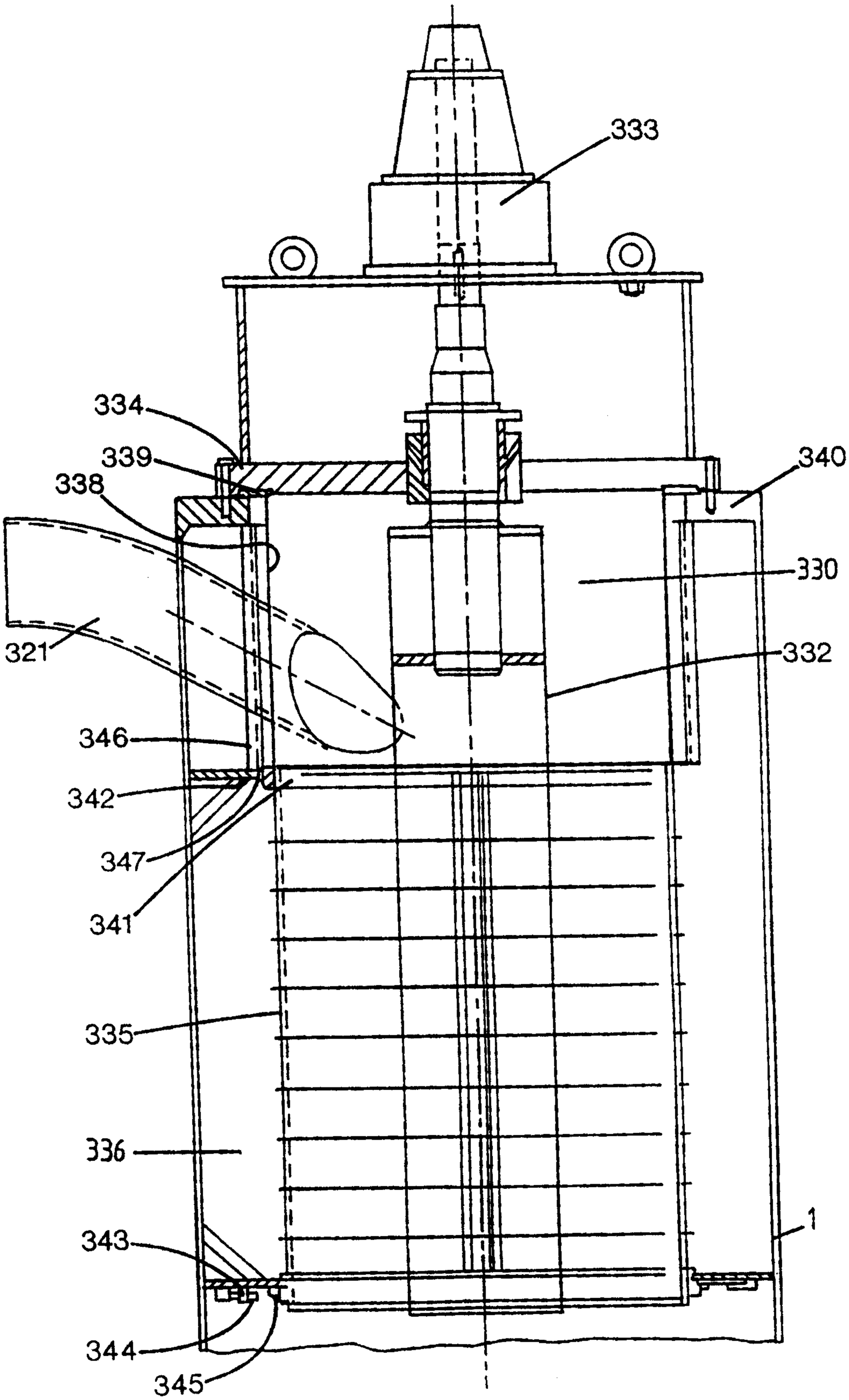
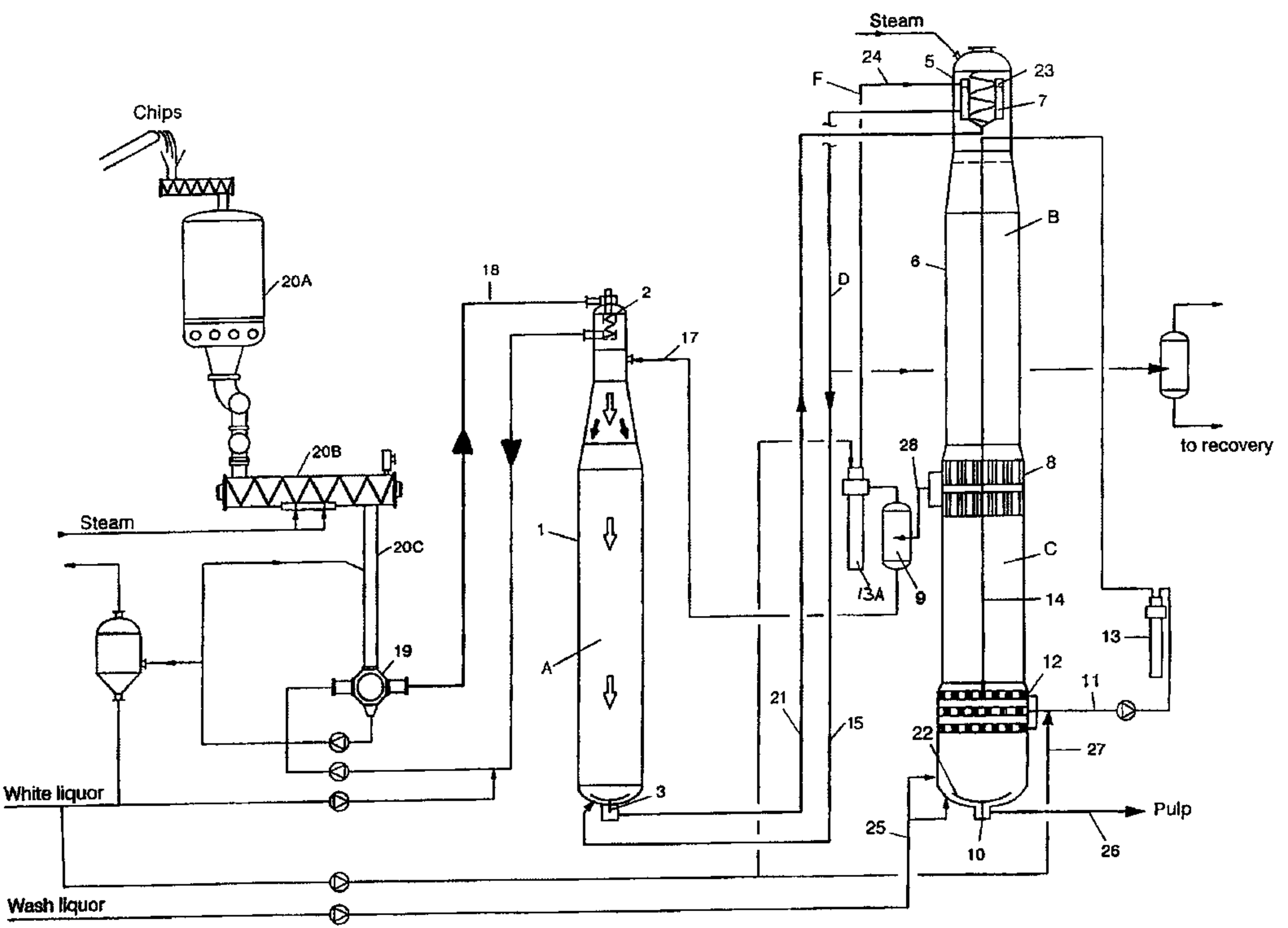

333
334
339
338
340
330
321
332
346
342
347
341
335
336
343
1
344
345

FIG. 23


Chips
20A
20B
Steam
20C
19
White liquor
Wash liquor
18
2
17
1
A
3
Steam
24
5
23
F
7
B
6
D
28
8
C
13A
9
14
13
12
11
21
15
22
27
25
10
26
Pulp
to recovery