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(54) Titre : INCIDENCE DE LA TEMPERATURE ET DE LA CHARGE EN ALCALIS SUR LA BRILLANCE DE LA PATE A PAPIER
 (54) Title: IMPACT OF TEMPERATURE AND ALKALI CHARGE ON PULP BRIGHTNESS

(57) **Abrégé/Abstract:**

A method for improving pulp brightness utilizes a combination of a distributed total white liquor charge during the warm fill, hot fill and cooking stages of a batch cooking process and low cooking temperatures during the cooking stage. The high total white liquor charge ranges between 15 % AA - 35 % AA, while the cooking temperatures range between 150 - 168 °C.

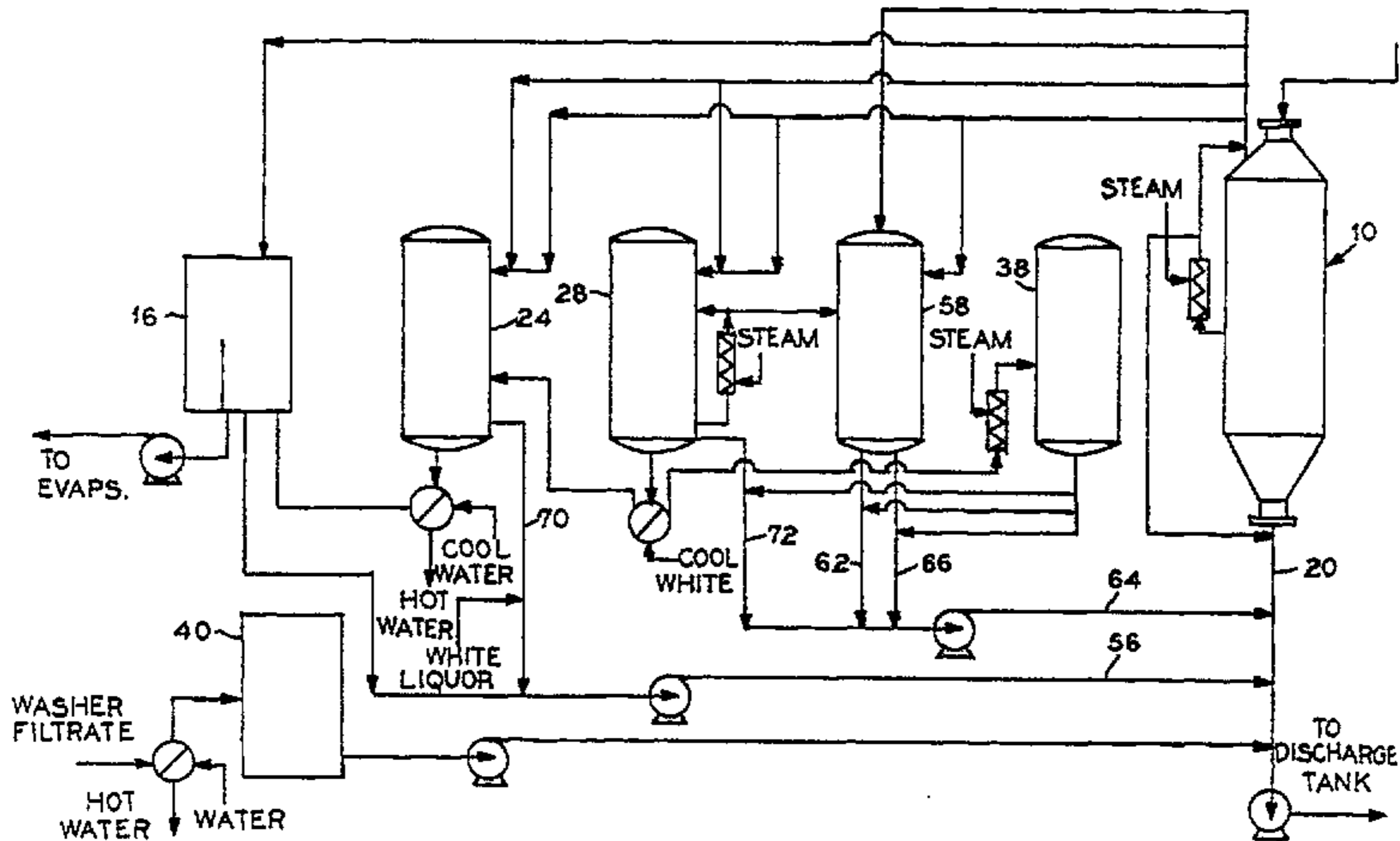




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<p>(21) International Application Number: PCT/US95/02719 (22) International Filing Date: 2 March 1995 (02.03.95) (30) Priority Data: 08/206,496 4 March 1994 (04.03.94) US (71) Applicant: BELOIT TECHNOLOGIES, INC. [US/US]; Suite 512, 300 Delaware Avenue, Wilmington, DE 19801-1622 (US). (72) Inventor: SHIN, Nam, Hee; 82 Raymond Drive, Dalton, MA 01226 (US). (74) Agent: CAMPBELL, Raymond, W.; One St. Lawrence Avenue, Beloit, WI 53511 (US).</p>	<p>(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, 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), ARIPO patent (KE, MW, SD, SZ, UG).</p> <p>Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p> <p style="text-align: center; font-size: 2em;">2184706</p>	

(54) Title: IMPACT OF TEMPERATURE AND ALKALI CHARGE ON PULP BRIGHTNESS



(57) Abstract

A method for improving pulp brightness utilizes a combination of a distributed total white liquor charge during the warm fill, hot fill and cooking stages of a batch cooking process and low cooking temperatures during the cooking stage. The high total white liquor charge ranges between 15 % AA ~ 35 % AA, while the cooking temperatures range between 150 ~ 168 °C.

TITLE:**"IMPACT OF TEMPERATURE AND ALKALI CHARGE
ON PULP BRIGHTNESS"****BACKGROUND OF THE INVENTION**

The present invention relates to a process for improving the final brightness of pulp. More particularly, the present invention relates to modifications in both the cooking temperature and white liquor charge for a rapid displacement heating cooking system.

Rapid Displacement Heating ("RDH") is a low energy batch cooking process for producing kraft pulp. Combining the inherent advantages of batch cooking with the energy efficiencies of a continuous digester, RDH reuses the spent black liquors that are displaced from a cooked digester to pretreat the wood chips in a consequent cook. Thus, both the chemicals and the heat in these spent liquors are recycled to a consequent cook. The pretreatment of fresh wood chips in a consequent cook begins with lower temperature liquors (approximately 80 ~ 130°C), and is followed by high temperature liquors (approximately 130° to 165°C) which heat the digester to the highest possible temperature before raising the temperatures to the final cooking temperature (3170°C) with steam.

RDH and other alkaline cooking processes produce pulp that is relatively dark in color. Greater contrast is usually needed for the many uses of pulp and paper, so pulp is usually bleached to a high brightness in order to make white pulp for writing and printing papers and paperboard. Pulp color arises from changes in the lignin component of the raw material which occur in the pulping process. Unfortunately, with the use of high cooking temperatures and low black liquor strength in the RDH process, low bleachability problems have

occurred following the use of conventional, ECF and TCF bleaching processes. High cooking temperatures and low black liquor strength seem to accelerate condensation reactions, resulting in the condensation of lignin with lignin and other wood extractives. As a result, the bleachability of pulp decreased.

An alternative method is, therefore, needed in the RDH cooking process to eliminate such adverse side reactions and improve pulp bleachability.

SUMMARY OF THE INVENTION

The present invention provides a method for improving pulp brightness. Based on modifications to a batch cooking process utilizing rapid displacement heating, the method of the present invention combines the steps of adding white liquor solution (% active alkalinity (AA) or effective alkalinity (EA)) or NaOH to both the warm fill and initial hot fill stages and cooking wood chips at lower temperatures than previously used in a batch type operation to produce pulp that has improved bleachability. In this regard, a total white liquor charge ranging from 15% AA ~ 35% AA is distributed over the warm, hot and cooking stages in a predetermined amount. If a cool pad is used in practicing the invention, cool white liquor is also added to the black liquor that is released from the cool liquor accumulator. Essentially, white liquor is added to every stage of the batch cooking process prior to the actual cook.

During the cooking of the chips, white and black liquors are present in the digester. Cooking temperatures are low, ranging from 150° ~ 167°C. With the combination of a high AA or EA white liquor charge and low cooking temperatures, final brightness of pulp is improved. As a result, pollutants and bleaching chemical usage are decreased in pulp mill operations.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a schematic view of a digester and its associated equipment used in the current RDH cooking system.

FIGS. 2A, 2B and 2C each illustrate white liquor profiling or the addition of white liquor at various stages of the RDH cooking process. In FIG. 2A, plot A represents the addition of a small amount of white liquor at the beginning of the warm fill mode. Plot B represents the cooking stage and illustrates the presence of white liquor in the digester during the actual cooking of the chips.

FIG. 2B illustrates the continuous addition of white liquor to the black liquor at each stage of the RDH cooking process, beginning with the warm fill and continuing through the end of the hot fill. White liquor, as shown, is also present in the digester during the actual cook.

FIG. 2C illustrates the continuous addition of white liquor at each RDH stage including the addition of white liquor to the washer filtrate from the displacement tank.

FIG. 3 illustrates a Stage 3 RDH system without white liquor addition during the warm and hot fill modes.

FIG. 4 illustrates a Stage 3 RDH system with the addition of white liquor during the warm and hot fill modes.

FIG. 5 illustrates a plot of D1-brightness versus total (D100 + D1) available chlorine charge for the best case and baseline case RDH pulps. Plot A represents RDH pulp R3 (0.225 Kappa factor). Plot B represents RDH pulp R4 (0.27 Kappa factor). Plot C represents RDH pulp R7 (0.225 Kappa factor). Plot D represents RDH pulp R8 (0.27 Kappa factor).

FIG. 5A illustrates a plot of D1-brightness versus D1-chlorine dioxide charge. Plot A represents RDH pulp R3 (0.225 Kappa factor). Plot B represents RDH pulp R4 (0.27 Kappa factor). Plot C represents RDH pulp R7 (0.225 Kappa factor). Plot D represents RDH pulp R8 (0.27 Kappa factor).

FIG. 6 illustrates the D1-brightness versus the total available chlorine charge in the D100- and D1-stages for all 0.225 Kappa factor bleaches. Plot A represents RDH pulp R3. Plot B represents RDH pulp R12. Plot C represents RDH pulp R7.

FIG. 6A illustrates the D1-brightness versus the D1-stage chlorine dioxide charges. Plot A represents RDH pulp R3 (0.225 Kappa factor). Plot B represents RDH pulp R12 (0.225 Kappa factor). Plot C represents RDH pulp R7 (0.225 Kappa factor).

FIG. 7 illustrates the D1-brightness versus the total available chlorine charge in the D100- and D1-stages for all 0.27 Kappa factor bleaches. Plot A represents RDH pulp R4. Plot B represents RDH pulp R12. Plot C represents RDH pulp R8.

FIG. 7A illustrates the D1-brightness versus the D1-stage chlorine dioxide charges. Plot A represents RDH pulp R4 (0.27 Kappa factor). Plot B represents RDH pulp R12 (0.27 Kappa factor). Plot C represents RDH pulp R8 (0.27 Kappa factor).

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

The present invention provides a method for improving pulp bleachability, which is based on modifications to the existing RDH Cooking System for the

digestion of wood chips. More specifically, the method involves the addition of a white liquor charge commencing at the start of the RDH cooking cycle and continuing until the time to temperature stage of the process, at which time the actual cook begins. The method of the present invention is also predicated on the use of somewhat lower cooking temperatures for the actual cook as compared to cooking temperatures commonly used in the RDH pulping process.

In accordance with the present invention, a total white liquor charge ranging between approximately 15%AA ~ 35%AA is distributed over the warm black liquor, initial hot black liquor and cooking stages. When used, the cool pad or cool liquor accumulator also receives a white liquor charge. In addition to the use of a distributed white liquor charge, the present invention utilizes lower cooking temperatures ranging between approximately 150°C ~ 167°C. As a result, pulp is produced which, upon bleaching with any combination of bleaching chemicals, is improved in final brightness.

The operational stages for a typical RDH Cooking System are as follows: (1) chip fill; (2) cool black liquor fill; (3) warm black liquor fill; (4) hot black liquor fill; (5) time to temperature; (6) time at temperature; (7) displacement; and (8) pump out. The basic principles of RDH operation are described in U.S. Patent No. 4,578,149 (issued March 25, 1986). Accordingly, details of RDH operations will be discussed only to the extent necessary for one of ordinary skill in the art to appreciate the modifications in the RDH cooking system, which produce the bleachable grade pulp described herein.

FIG. 1 schematically illustrates the type of apparatus for RDH that is used for the digestion of pulp. It should be understood that this figure illustrates very general features of the cooking apparatus, and modifications and

variations in this system are indeed made as will be discussed in greater detail below. Many instrumentalities such as gauges, pressure vents, pumps and valves have been eliminated from the figures disclosed herein for reasons of simplicity. FIG. 1 is used to illustrate the existing RDH cooking process and to facilitate an understanding of the improvements to the process in accordance with the principles of the present invention.

Referring to FIG. 1, a digester is illustrated at 10 of the type generally used in the chemical digestion of wood chips. The digester 10 has a truncated bottom 12. An inlet valve 14 controls the entry of various reactive liquors into digester 10. Although not shown, the contents of digester 10 can be heated to a final cooking temperature by pumping cooking liquor through a heat exchanger or steam sparger which is connected to digester 10 by a valve-controlled line.

After the wood chips are added to digester 10, cool black liquor (temperature around 70°-95°C) from the cool liquor accumulator (A tank) 16 is pumped by means of pump 18 through line 20 which is controlled by a valve 22 into the bottom of the digester 10 through an inlet valve 14. Next, warm black liquor (temperature between approximately 90°-150°C) from the warm liquor accumulator 24 is pumped out by means of a pump 18 through a valve 22 and through valve 14 into the bottom of digester 10. During this warm liquor fill, some black liquor is displaced from the digester 10 and then returned by a line 26 to the cool liquor accumulator 16. Hot black liquor (temperature between 150°-168°C) is then pumped from the hot liquor accumulator (C tank) 28 by means of a pump 30 which is controlled by a valve 32 into the bottom of the digester 10 utilizing valve 14. During the hot fill, black liquor is displaced from the digester 10 and returned to the warm liquor accumulator 24 and hot liquor accumulator 28 through lines 34 and 36, respectively. During the middle of the hot fill, hot white liquor stored in the hot white liquor accumulator 38 is pumped

out by means of a pump 30 where it combines with the hot black liquor leaving the hot liquor accumulator 28, the combined liquors then passing through a valve 32 and into the base of the digester 10.

After the hot fill is completed, the inlet and outlet valves to the digester 10 are closed as the time to temperature stage commences. Steam is injected into the digester 10 and the temperature is increased to the cooking temperature, which averages approximately 170°C. The temperature of the digester is maintained at about this temperature until the wood chips are digested, depending on white liquor charge and H-factor.

Upon completion of the cooking stage, washer filtrate (temperature approximately 70 ~ 85°C) stored in a displacement tank (D tank) 40 is pumped into the digester 10, utilizing pump 42 and valve 44. The contents are washed and the digester 10 is cooled. As the washer filtrate is added to the digester 10, the spent liquors are displaced and returned to the warm liquor accumulator 24 and the hot liquor accumulator 28 by lines 46 and 48, respectively. The displacement mode is concluded when all washer filtrate is used, which is based on the dilution factor of the washer. After displacement is completed, the digested pulp is then pumped out of the digester 10 to a discharge tank using pump 50.

With the current RDH cooking system, cooking temperatures of greater than 170°C are used for rapid cooking, resulting in the acceleration of condensation reactions. As a result, bleachability problems occurred when the pulp was subjected to conventional, ECF and TCF bleaching processes. The present invention overcomes these problems and improves pulp bleachability by modifying the cooking process for wood chips. This improved RDH process utilizes a combination of higher alkalinity (or white liquor charge) and lower cooking temperatures. More specifically, white liquor is added during the warm

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and initial hot fill stages. This is in contrast to the existing RDH cooking process, wherein white liquor is added only during the middle of the hot fill mode. Further, when a cool pad is used in the present invention, white liquor is added to the cool black liquor leaving the cool liquor accumulator (or A tank). Thus, from the beginning of the RDH cooking process until the time to temperature stage, white liquor is added during each stage to the black liquor. The addition of white liquor at every stage, also called white liquor profiling, is illustrated in greater detail below in FIGS. 2A, 2B and 2C.

In FIG. 2A, plot A illustrates the addition of a small amount of white liquor at the beginning of the warm fill mode when warm black liquor leaves the B tank or warm liquor accumulator and flows to the digester. White liquor can also be added to the A tank or cool pad when used. At the end of the hot fill mode, which utilizes two hot liquor accumulators C1 and C2, the mixture of white and black liquors remains in the digester. Plot B represents the cooking stage and illustrates the presence of white liquor in the digester during the actual cooking of the chips. Black liquor is also present during the cook.

FIG. 2B illustrates the continuous addition of white liquor to black liquor at each stage of the cooking process, beginning with the warm fill through the end of the hot fill mode.

FIG. 2C illustrates the continuous addition of white liquor throughout the various stages, including the addition of white liquor to the washer filtrate from the displacement tank.

The concentration of dissolved organic material in the initial hot fill operation (C1 and C2 tanks containing black liquor) was compared with and without white liquor addition during the warm and hot fill operations. FIG. 3 illustrates a Stage 3 RDH system where no white liquor is added during the

warm and hot fill modes. Only warm black liquor is leaving the warm liquor accumulator (B tank) 24 to flow through line 56 during the warm fill mode and into line 20, which then empties into the digester 10. Although this RDH system contains two hot liquor accumulators 28 (C1 tank) and 58 (C2 tank), respectively, there are RDH pulping processes which utilize only one hot liquor accumulator. In practicing the present invention, it is contemplated that the process of white liquor profiling can be applied to systems having any number of black liquor accumulators.

As shown in FIG. 3, during the initial hot fill mode, hot black liquor leaves the hot liquor accumulators 28 and 58 by lines 60 and 62, respectively, and flows to the digester 10 through lines 64 and 20. During the middle of the hot fill, hot white liquor from the hot white liquor accumulator 38 mixes with the hot black liquor leaving hot liquor accumulator 58 by line 66. The mixture then flows through lines 64 and 20 and into the digester 10.

FIG. 4 illustrates a Stage 3 RDH System with the addition of white liquor during the warm and hot fill modes. First, during the warm fill, white liquor is added to the warm black liquor leaving the warm liquor accumulator 24 by line 70. The warm fill flows through lines 56 and 20 into the digester 10. Either cool or hot white liquor may be used during the warm fill mode. During the initial hot fill mode, hot white liquor from the hot white liquor accumulator 38 is mixed with black liquor leaving hot liquor accumulator 28 by line 72, and is further mixed with the black liquor exiting the second hot liquor accumulator 58 by lines 62 and 66. The mixture of hot white and black liquors flows from the two hot liquor accumulators 28 and 58 through lines 64 and 20 into the digester 10.

The results of the comparison are as follows:

Without White Liquor Addition at Warm and Hot Fill Operations (FIG. 3)

<u>Initial Hot Fill Operation</u>	<u>Total Flow, gal/cook</u>	<u>Dissolved Organic, %</u>
C1 black liquor	20799	13.1
C2 black liquor	8709	14.9

With White Liquor Addition at Warm and Hot Fill Operations (FIG. 4)

White Liquor charges: 1.5% AA at C1 black liquor
 1.5% AA at C2 black liquor

<u>Initial Hot Fill Operation</u>	<u>Total Flow, gal/cook</u>	<u>Dissolved Organic, %</u>
C1 Black liquor	19877	10.1
C2 black liquor	7971	9.8

This case study clearly demonstrates that the concentration of dissolved organic compounds at initial hot fill operation can be adjusted by adding white liquor to the hot fill line. The concentration of dissolved organic compounds in the C1 black liquor and in the C2 black liquor decreases from 13.1% to 10.1% and 14.9% to 9.8%, respectively.

In order to maximize bleachability benefits and extend delignification for the RDH process, warm black liquor (temperatures between approximately 70° and 150°C and its strength between 3 and 20 g/l AA) and hot black liquor (temperatures between approximately 100° and 168°C and its strength between 8 and 30 g/l AA) should be reinforced with any combination of white liquor or NaOH solution.

As shown in the figures presented above, warm and hot black liquor can be modified using white liquor profiling. These liquors can also be modified by sodium hydroxide (NaOH) profiling. The addition of white liquor or NaOH

controls the total dissolved solids (TDS) concentration and black liquor strength using any combination of black liquor, white liquor and NaOH. The washer filtrate displacement stage, in which the black liquor temperature is held between approximately 50° and 105°C and black liquor strength between 1 and 18 g/l AA, can be reinforced with any combination of white liquor or NaOH solution.

By way of example, and not limitation, the following examples serve to further illustrate the present invention in its preferred embodiments.

As shown below, Tables 1, 1A, 2, 2A, 3 and 3A provide the pulping results and conditions for a number of cooks used in preparing the RDH pulps for subsequent bleaching studies. A summary of the pulping results is provided in Table 3B.

TABLE 1

RDH Pulping Conditions and Results - "Best Case"

Cook Number	R1	Post R1	R2	Post R2	R3	Post R3	R4	Post R4
H factor	937		532		475		452	
AA (TAPPI) to Hot Fill, %	16.0		16.0		16.0		16	
Sulfidity (TAPPI), % on AA	30.4		30		30.3		30.2	
Maximum temp, C	160		160		160		160	
Time to max, min	16		20		17		19	
Time at max, min	130		37		60		57	

Kappa, unscreened	7.2		8.9		9.2		9.8	
Kappa, screened	7.1		8.2		8.8	•	9.3	
Total yield, %	46.3		47.3		48.2		1.7	
Total rejects, %	0.9		1.2		1.4		1.7	
Screened yield, %	45.4		46.1		46.8		46.9	
Viscosity, 0.5% CED, cp	26		39		40.7		44.9	
End of Cook Residual:								
AA (Na ₂ O), g/L	28.2		31.6		32.9		31.6	
EA (Na ₂ O), g/L	21.1		24.2		24.2		24.2	
Na ₂ S (Na ₂ O), g/L	14.3		14.9		17.4		14.9	
TTA (Na ₂ O), g/L								
Solids, %	14.8		15.9		16.7		16.8	
Solids, g/L	161		173		183		185	
Sulfidity % on A.A.	51		47.1		52.9		47.1	
HOT FILL:								
Hot liquor charge, L	18		18		18		18	
Charge time, min	13		14		13		13	
Temperature, C								
Top	130		127		127		128	
Bottom	145		141		141		141	

Chemical Conditions in Accumulator:								
AA (Na ₂ O), g/L	22.9	20.6	25.7	21.7	29.2	24.6	27.3	23.6
EA (Na ₂ O), g/L	16.1	15.1	18.1	16.1	20.2	18.3	19.8	17.9
Na ₂ S (Na ₂ O), g/L	13.7	11	15.2	11.2	18	12.7	14.9	11.4
TTA (Na ₂ O), g/L	-	-	-	-	-	-	-	-
Sulfidity, % on A.A.	59.4	53.4	59.1	51.6	61.6	51.2	54.9	48.3
Solids, %	9.5	10.5	11.1	11.9	11.9	13.6	12.7	13.6
Solids, g/L	99.8	111	118	127	127	146	137	146
Total elapsed time, min*	45		43		41		42	

* includes heating time to 145C and time at 145C after initial hot black liquor injection and final hot B/L with W/L mix.

TABLE 1A

RDH Pulping Conditions and Results - "Best Case"

Cook Number	R1	Post R1	R2	Post R2	R3	Post R3	R4	Post R4
<u>WHITE LIQUOR:</u>								
White liquor charge, L	6.04		5.65		5.53		5.52	
Hot B/L, L	5		4.13		5.5		5.8	
Charge time, min	11		11		9		9	
Temperature, C								
Top	140		139		140		139	
Bottom	141		141		144		143	

Chemical conditions in accumulator: (TAPPI)								
AA (Na ₂ O), g/L	98		99.2		10 ⁻ . 2		101. 5	
EA (Na ₂ O) g/L	83.1		84.3		85.8		86.2	
Na ₂ S (Na ₂ O), g/L	-		-		-		-	
TTA (Na ₂ O), g/L								
Sulfidity, %on AA	30.4		30		30.3		30.2	
CHIP CHARGE & LIQUOR PACKING:								
Chip charge, g	3,700		3,500		3,50 0		3,50 0	
Chip Moisture, %	37.3		37.3		37.3		37.3	
O.D. Solids, %	62.7		62.7		62.7		62.7	
WARM FILL:								
Warm Liquor charge, L	24.7		24		24		24	
Exit pH, initial	12.8		13.5		13.3		13.3	
Charge time, min	15		15		15		15	
Temperatur e, C								
Top	100		104		102		100	
Bottom	113		112		111		112	
Chemical conditions in Accumulator:								
AA (Na ₂ O), g/L	23.6	16.4	26.4	17.7	25.7	19.2	28.5	21.1
EA (Na ₂ O), g/L	16.4	10.5	17.4	11.5	18	12.4	18.6	13.6
Na ₂ S (Na ₂ O), g/L	14.3	11.8	18	12.4	15.5	13.6	19.8	14.9
TTA (Na ₂ O), g/L	-	-	-	-	-	-	-	-
Sulfidity, % on A.A.	60.8	71.7	68.3	70.2	60.3	71	69.5	70.6

Solids, %	9	9.25	13.6	12.4	14.3	13.1	14.1	13.1
Solids, g/L	94.3	96.4	147	131	155	141	152	141
Total elapsed time, min*	40		31		34		33	
DISPLACEMENT:								
Displacement Volume, L	32		32		32		32	
Charge time, min	26		26		26		26	
Chemical Conditions in accumulator: (TAPPI)								
AA (Na ₂ O), g/L	9.5		10.1		9		10.1	
EA (Na ₂ O), g/L	9.5		10.1		9		10.1	
Na ₂ S (Na ₂ O), g/L	-		-		-		-	
TTA (Na ₂ O), g/L	-		-		-		-	
Sulfidity, % on A.A.	0		0		0		0	

* includes fill time, heating time to 120C and time at 120C after warm fill.

TABLE 2

RDH Pulping Conditions and Results - "Baseline Case"

Cook Number	R5	Post R5	R6	Post R6	R7	Post R7	R8	Post R8
H factor	116 1		765		831		832	
AA (TAPPI) to Hot Fill, %	10. 0		10.0		10.0		10.0	
Sulfidity (TAPPI), % on AA	30. 2		30.3		30.3		30.2	

Maximum temp, C	170		170		170		170	
Time to max, min	23		27		21	°	21	
Time at max, min	62		35		41		42	
Kappa, unscreene d	7.6		9.7		9.5		8.9	
Kappa, screened	7.2		9.1		8.9		8.8	
Total yield, %	47.3		48.3		48.6		49.1	
Total rejects, %	1.1		1.6		1.7		1.4	
Screened yield, %	46.2		46.7		46.9		47.7	
Viscosity, 0.5% CED, cp	19.5		33.2		33.3		32.2	
End of Cook Residual:								
AA(Na ₂ O), g/L	27.9		25.4		26		25.4	
EA (Na ₂ O), g/L	19.2		18		17.4		17.4	
Na ₂ S (Na ₂ O), g/L	17.4		14.9		17.4		16	
TTA(Na ₂ O), g/L								
Solids, %	19		19.1		19.2		19.1	
Solids, g/L	210		211		213		210	
Sulfidity % on A.A.	62.4		58.3		66.2		63	

HOT FILL:								
Hot liquor charge, L	18		18		18	*	18	
Charge time, min	12		13		12		13	
Temperature, C								
Top	135		137		137		135	
Bottom	153		153		154		155	
Chemical conditions in Accumulator:								
AA(Na ₂ O), g/L	30.4	23.6	26	21.1	26.7	20.5	26.4	20.5
EA (Na ₂ O), g/L	22.3	16.2	18.6	14.3	18	13.6	18.3	13.6
Na ₂ S (Na ₂ O), g/L	16.1	14.9	14.9	13.6	17.4	13.6	16.1	13.6
TTA (Na ₂ O), g/L	-	-	-	-	-	-	-	-
Sulfidity, % on A.A.	53.3	63.6	56.9	64.5	65.2	67.3	61.4	67.3
Solids, %	16.7	17	17.2	17.1	17	17.3	17	16.9
Solids, g/L	183	185	189	187	187	189	186	184
Total elapsed time, min *	46		44		45		44	

* includes heating time to 155C and time at 155C after initial hot black liquor injection and final hot B/L with W/L mix.

TABLE 2A

RDH Pulping Conditions and Results - "Baseline Case"

Cook Number	R5	Post R5	R6	Post R6	R7	Post R7	R8	Post R8
WHITE LIQUOR:								
White liquor charge, L	3.47		3.45		3.46		3.47	
Hot B/L, L	5.4		7		5.6		5	
Charge time, min	9		9		9		9	
Temperature, C								
Top	151		152		151		151	
Bottom	149		147		145		144	
Chemical conditions in accumulator: (TAPPI)								
AA (Na ₂ O), g/L	100.8		101.4		101.2		100.8	
EA (Na ₂ O) g/L	85.6		86		85.9		85.6	
Na ₂ S (Na ₂ O), g/L	-		-		-		-	
TTA (Na ₂ O), g/L	121.6		122.8		123.1		120.6	
Sulfidity, % on AA	30.2		30.3		30.3		30.2	
CHIP CHARGE & LIQUOR PACKING:								
Chip charge, g	3,500		3,500		3,500		3,500	
Chip Moisture, %	37.3		37.3		37.3		37.3	
O.D. Solids, %	62.7		62.7		62.7		62.7	

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WARM FILL:								
Warm Liquor charge, L	24.4		25		25.2		24	
Exit pH, initial	13.1		13.3		13.5		13.3	
Charge time, min	15		15		15		15	
Temperature, C								
Top	109		109		106		106	
Bottom	121		120		118		116	
Chemical conditions in Accumulator: (TAPPI)								
AA (Na ₂ O), g/L	28.1	19.2	27.9	18.6	26.7	19.2	26.7	19.7
EA (Na ₂ O), g/L	18.3	12.4	18	11.2	18	11.8	18.6	12.1
Na ₂ S (Na ₂ O), g/L	19.6	13.6	19.8	14.9	17.4	14.9	16.1	15.1
Sulfidity, % on A.A.	69.8	70.8	71	79.6	65.2	77.1	60.7	77.2
Solids, %	14.5	15.4	15	16	14.7	15.5	14.6	15.9
Solids, g/L	157	167	164	173	159	168	158	172
Total elapsed time, min*	35		33		31		30	
DISPLACEMENT:								
Displacement Volume, L	32		32		32		32	
Charge time, min	26		26		26		26	
Chemical Conditions in accumulator:								
AA (Na ₂ O), g/L	4.3		4.31		4.3		4.3	
EA (Na ₂ O), g/L	3.7		3.7		3.7		3.5	

Na2S (Na2O), g/L	1.24		1.24		1.24	•	1.74
Sulfidity, % on A.A.	27.9		27.9		27.9		27.9
Solids, %	9.7		10.6		10.4		10.3
Solids, g/L	102		112		109		108

* includes fill time, heating time to 120C and time at 120C after warm fill.

TABLE 3

RDH Pulping Conditions and Results - "Best Do-able Case"

Cook Number	R9	Post R9	R10	Post R10	R11	Post R11	R12	Post R12
H factor	484		558		483		494	
AA (TAPPI) to Hot Fill, %	18.9		16.0		16.0		16	
Sulfidity (TAPPI), % on AA	30.6		30.2		29.8		30.4	
Maximum temp, C	160		160		160		160	
Time to max, min	20		20		18		16	
Time at max, min	60		72		62		63	
Kappa, unscreened	9.1		8.9		9.6		10	
Kappa, screened	8.1		8.5		9.2		9.3	
Total yield, %	48.1		48.1		49.1		49.1	
Total rejects, %	1.1		1.2		1.5		1.3	
Screened yield, %	47		46.9		47.6		47.8	
Viscosity, 0.5% CED, cp	33.5		33		39.3		32.1	

End of Cook Residual:								
AA (Na ₂ O), g/L	37.6		32.8		34.1	•	33.5	
EA (Na ₂ O), g/L	28.6		25.3		25.9		25.3	
Na ₂ S (Na ₂ O), g/L	17.9		15.2		16.4		16.4	
Solids, %	18.8		19.1		19.2		19.3	
Solids, g/L	210		212		215		214	
Sulfidity % on A.A.	47.9		45.7		48.1		49	
HOT FILL:								
Hot liquor charge, L	18		18		18		18.7	
Charge time, min	13		13		13		13	
Temperature , C								
Top	129		132		132		132	
Bottom	145		147		147		145	
Chemical conditions in Accumulator:								
AA (Na ₂ O), g/L	27.8	25.9	27.3	25.3	27.1	24.6	26.5	23.4
EA (Na ₂ O), g/L	19.9	18.9	19.9	18.3	20.2	18.3	19.5 7	17
Na ₂ S (Na ₂ O), g/L	15.8	13.4	14.9	13.9	13.9	12.6	13.9	12.6
TTA (Na ₂ O), g/L	-	-	-	-	-	-	-	-
Sulfidity, % on A.A.	56.8	54.1	54.2	55.3	50.9	51.2	52.3	54.7
Solids, %	16.2	16.1	16.7	16.7	17	17.2	17.3	17
Solids, g/L	177	176	182	183	187	189	190	186
Total elapsed time, min*	42		42		42		39	

* includes heating time to 145C and time at 145C after initial hot black liquor injection and final hot B/L with W/L mix.

TABLE 3A

RDH Pulping Conditions and Results - "Best Do-able Case"

Cook Number	R9	Post R9	R10	Post R10	R11	Post R11	R12	Post R12
WHITE LIQUOR:								
White liquor charge, L	6.17		5.81		5.79		5.6	
Hot B/L, L	4.8		5.2		5.0		6.4	
Charge time, min	10		10		10		9	
Temperature, C								
Top	139		140		139		141	
Bottom	139		145		140		144	
Chemical conditions in accumulator: (TAPPI)								
AA (Na ₂ O), g/L	107.3		96.4		96.7		100	
EA (Na ₂ O) g/L	90.8		81.8		82.3		84.8	
TTA (Na ₂ O), g/L	125.8		115.6		117.8		120.9	
Sulfidity, % on AA	30.6		30.2		29.8		30.4	
CHIP CHARGE & LIQUOR PACKING:								
Chip charge, g	3,500		3,500		3,500		3,500	
Chip Moisture, %	37.3		37.3		37.3		37.3	
O.D. Solids, %	62.7		62.7		62.7		62.7	

WARM FILL:								
Warm Liquor charge, L	24.5		24.3		23.9		24.2	
Exit pH, initial	13.3		13.2		13.2		13	
Charge time, min	15		15		15		15	
Temperature, C								
Top	108		106		104		108	
Bottom	121		117		116		118	
Chemical conditions in Accumulator: (TAPPI)								
AA (Na ₂ O), g/L	27.1	21.1	26.5	21.1	26.5	20.8	25.9	20.8
EA (Na ₂ O), g/L	20.5	14.5	18.9	14.1	18.3	13.3	17.7	13.3
Na ₂ S (Na ₂ O), g/L	13.3	13.3	15.2	14.1	16.4	15.2	16.4	15.2
Sulfidity, % on A.A.	48.7	62.6	57.4	66.4	61.9	72.1	63.3	72.1
Solids, %	14.3	14.9	14.8	15.8	15.6	16.1	15	15.6
Solids, g/L	155	161	162	171	170	176	163	170
Total elapsed time, min*	30		30		31		30	
DISPLACEMENT:								
Displacement Volume, L	32		32		32		32	
Charge time, min	26		26		26		26	

Chemical Conditions in accumulator: (TAPPI)								
AA (Na ₂ O), g/L	9.5		9.8		8.8	c	11.4	
EA (Na ₂ O), g/L	8.2		9.2		8.2		10.7	
Na ₂ S (Na ₂ O), g/L	2.5		1.3		1.3		1.3	
Sulfidity, % on A.A.	31.7		13		14.6		13.1	
Solids, %	10.3		10.6		11.2		-	
Solids, g/L	109		112		118		-	

* includes fill time, heating time to 120C and time at 120C after warm fill.

TABLE 3B

PULPING STUDY SUMMARY

COOK NUMBER		
BEST COOK: NEW RDH COOKING PROCEDURE	R3	R4
BASELINE COOK: OLD RDH COOKING PROCEDURE	R7	R8
BEST DO-ABLE COOK: MODIFIED NEW RDH COOKING PROCEDURE	R12	
COOKING CONDITIONS		

	R3	R4	R7	R8	R12
WARM FILL					
EA (g/l) as Na ₂ O	18	18.6	18	18.6	17.7
Solids, %	14.3	14.1	14.7	14.6	15
HOT FILL					
EA (g/l) Na ₂ O	20	19.8	18	18.3	19.6
Solids, %	11.9	12.7	17	17	17.3
COOKING STAGE					
AA Charge, %	16	16	10	10	16
H-FACTOR	475	452	831	832	494
MAXIMUM TEMP. DEGREE C	160	160	170	170	160
DISPLACEMENT					
EA (g/l) as Na ₂ O	9	10.1	3.7	3.5	10.7
Solids, %	0	0	10.4	10.3	10

EXAMPLE 1

The following definitive pulps were produced for the bleaching study:

Case	Cook No.	Kappa	Brightness, TAPPI
"Best"	R3	8.8	45.3
	R4	9.3	45.0
"Baseline"	R7	8.9	40.6
	R8	8.8	41.3
"Best Do-able"	R10	8.5	41.5
	R11	9.2	40.8
	R12	9.3	41.5

Five RDH pulps (R3, R4, R7, R8 and R12) were bleached using an (O)(D100)(EO)(D) sequence. However, each of the five RDH pulps were first oxygen delignified in stirred reactors using the conditions shown below in Table 4.

TABLE 4

OXYGEN DELIGNIFICATION CONDITIONS

	<u>Best Case</u>		<u>Baseline Case</u>		<u>"Do-able"</u> <u>Best Case</u>
	R3	R4	R7	R8	R12
Sample identification					
Species	Aspen	Aspen	Aspen	Aspen	Aspen
Cook type	RDH	RDH	RDH	RDH	RDH
Kappa	8.8	9.2	8.9	8.8	9.3
Viscosity, mPa.s	40.7	44.9	33.3	32.2	32.1
Unbl. brightness, %	45.3	45	40.6	41.3	41.5
O-Stage: 95 psig. 99°C. 12% cons.					
NaOH, %	2	2	2	2	2
O2 time, min	60	60	60	60	60
Final pH	12.8	12.9	12.5	12.5	12.3
Kappa	4.7	5.2	4.7	4.5	5
Viscosity, mPa.s	14.4	13.8	12.6	13.6	12.5
Kappa reduction, %	46.6	43.5	47.2	48.9	50
Yield on raw stock, %	95.2	95.8	94.3	98.8	94.4

For the bleaching studies, a 0.225 kappa factor was used in calculating the chlorine dioxide charge in the D100-stage for pulps R3, R7 and R12. A 0.27 kappa factor was used for pulps R4, R8 and R12. Tables 5 through 10 below show the (D100) (Eo)(D) bleaching conditions and results on the oxygen delignified pulps from these cooks. The chlorine dioxide solution concentration was adjusted by a 0.92 factor to compensate for losses of chlorine dioxide in charging the reactors and polyethylene bags during bleaching.

TABLE 5

Bleaching with (O)(D100)(Eo)D on Optimal RDH Pulp

Kappa factor = 0.225

Sample identification	R3							
Species	Aspen							
Cook type	RDH							
O2 Pulp Kappa	4.7							
Viscosity, mPa.s	14.4							
D-100-Stage: 30 min, 68°C, 4.2% cons.								
Chlorination factor	0.23							
ClO2, % as available Cl ₂ *	1.06							
Actual ClO2, % as avail. Cl ₂	1.15							
Substitution, %	100							
H2SO4, %	1.5							
Final pH	2							
Residual, g/L avail. Cl ₂	0.14							
E0-Stage: 60 min, 74°C, 10% cons.								
NaOH, %	0.8							
O2 pressure, psig	25							
O2 time, minutes	15							
Final pH	12.4							
K No. (25 Ml)	2.3							
Viscosity, mPa.s	13.7							
Yield on raw stock, %	93.5							
D-Stage: 74°C, 210 min, 10% cons.								
Sample number	#1	#2	#3	#4	#5	#6	#7	#8
ClO2 as ClO2, %*	0.1	0.3	0.5	0.7	0.9	1.1	0.9	1.1
Actual ClO2, % ClO2	0.11	0.33	0.54	0.76	0.98	1.2	0.98	1.2
NaOH, %	0	0	0.09	0.16	0.25	0.3	0.33	0.42
H2SO4, %	0.1	0.05	0	0	0	0	0	0
Final pH	4.1	3.4	3.3	3	2.9	2.6	3.6	3.7

Residual as ClO ₂ , %	0.02	0.01	0.01	0.02	0.02	0.02	0	0
Brightness, %ISO	89.7	90.4	91.2	91.5	91.6	92	91.1	91.3
Viscosity, mPa.s	13.1	-	-	11.2	-	-	-	9.2

* Actual ClO₂ concentration x 0.92

TABLE 6

Bleaching with (O)(D100)(Eo)(D) on Optimal RDH Pulp

Kappa factor = 0.27

Sample identification	R4					
Species	Aspen					
Cook type	RDH					
O ₂ Pulp Kappa	5.2					
Viscosity, mPa.s	13.8					
D-100-Stage: 30 min. 68°C. 4.2% cons.						
Chlorination factor	0.27					
ClO ₂ , % as available Cl ₂ *	1.4					
Actual ClO ₂ , % as avail. Cl ₂	1.53					
Substitution, %	100					
H ₂ SO ₄ , %	2					
Final pH	1.9					
Residual, g/L avail. Cl ₂	0.09					
E0-Stage: 60 min. 74°C. 10% cons.						
NaOH, %	0.8					
O ₂ pressure, psig	25					
O ₂ time, minutes	15					
Final pH	12.5					
K No. (25 Ml)	2					
Viscosity, mPa.s	13.3					
Yield on raw stock, %	92.8					

D-Stage: 74°C, 210 min. 10% cons.								
Sample number	#1	#2	#3	#4	#5	#6	#7	#8
ClO ₂ as ClO ₂ , %*	0.1	0.3	0.5	0.7	0.9	1.1	0.9	1.1
Actual ClO ₂ , % ClO ₂	0.11	0.33	0.54	0.76	0.98	1.2	0.98	1.2
NaOH, %	0	0	0.09	0.16	0.25	0.3	0.33	0.42
H ₂ SO ₄ , %	0.1	0.05	0	0	0	0	0	0
Final pH	4.3	3.4	3.4	3.2	2.8	2.7	3.7	3.5
Residual as ClO ₂ , %	0.01	0.01	0.01	0.02	0.01	0.01	0	0
Brightness, %ISO	89.8	90.5	91.2	91.5	91.8	91.8	91.4	91.5
Viscosity, mPa.s	12.5	-	-	11.6	-	-	-	9.8

* Actual ClO₂ concentration x 0.92

TABLE 7

Bleaching with (O)(D100)(Eo)(D) on Baseline RDH Pulp

Kappa factor = 0.225

Sample identification	R7			
Species	Aspen			
Cook type	RDH			
O ₂ Pulp Kappa	4.5			
Viscosity, mPa.s	13.6			
<u>(D100)-Stage: 30 min. 68°C, 4.2% cons.</u>				
Chlorination factor	0.23			
ClO ₂ , % as available Cl ₂ *	1.01			
Actual ClO ₂ , % as avail. Cl ₂	1.1			
Substitution, %	100			
H ₂ SO ₄ , %	2			
Final pH	2.7			
Residual, g/L avail. Cl ₂	0.01			

E0-Stage: 60 min, 74°C, 10% cons.						
NaOH, %	0.8					
O2 pressure, psig	25					
O2 time, minutes	15					
Final pH	12.3					
K No. (25 Ml)	2.3					
Viscosity, mPa.s	13.3					
Yield on raw stock, %	97					
D-Stage: 74°C, 210 min, 10% cons.						
Sample number	#1	#2	#3	#4	#5	#6
ClO2 as ClO2, %*	0.1	0.3	0.5	0.7	0.9	1.1
Actual ClO2, % ClO2	0.11	0.33	0.54	0.76	0.98	1.2
NaOH, %	0	0	0.08	0.2	0.33	0.42
H2SO4, %	0.1	0.05	0	0	0	0
Final pH	4	3.5	3.4	3.4	3.4	3.8
Residual as ClO2, %	0	0	0	0	0	0
Brightness, %ISO	87.6	88.7	89.7	90.3	90.3	90.6
Viscosity, mPa.s	12.6	-	-	11.4	-	9.6

* Actual ClO2 concentration x 0.92

TABLE 8

Bleaching with (O)(D100)(Eo)(D) on Baseline RDH Pulp

Kappa factor = 0.27

Sample identification	R8			
Species	Aspen			
Cook type	RDH			
O2 Pulp Kappa	4.7			
Viscosity, mPa.s	12.6			
(D100)-Stage: 30 min, 68°C, 4.2% cons.				
Chlorination factor	0.27			
ClO2, % as available Cl ₂ *	1.27			
Actual ClO2, % as avail. Cl ₂	1.38			

Substitution, %	100					
H2SO4, %	2					
Final pH	1.9					
Residual, g/L avail. Cl ₂	0.07					
E0-Stage: 60 min. 74°C. 10% cons.						
NaOH, %	0.8					
O2 pressure, psig	25					
O2 time, minutes	15					
Final pH	12.2					
K No. (25 Ml)	2.1					
Viscosity, mPa.s	12.6					
Yield on raw stock, %	94.2					
D-Stage: 74°C. 210 min. 10% cons.						
Sample number	#1	#2	#3	#4	#5	#6
ClO ₂ as ClO ₂ , %*	0.1	0.3	0.5	0.7	0.9	1.1
Actual ClO ₂ , % ClO ₂	0.11	0.33	0.54	0.76	0.98	1.2
NaOH, %	0	0	0.08	0.2	0.33	0.42
H2SO4, %	0.1	0.05	0	0	0	0
Final pH	3.6	3.1	3.1	3.1	3.2	3.6
Residual as ClO ₂ , %	0	0	0	0	0	0
Brightness, %ISO	87	88.7	89.3	90.1	90.5	90.5
Viscosity, mPa.s	12.2	-	-	11.2	-	9.5

* Actual ClO₂ concentration x 0.92)

TABLE 9

Bleaching with (O)(D100)(Eo)(D) on Best "Do-able" RDH Pulp

Kappa factor = 0.225

Sample identification	R12					
Species	Aspen					
Cook type	RDH					
O2 Pulp Kappa	5					
Viscosity, mPa.s	12.5					
D-100-Stage: 30 min. 68°C. 4.2% cons.						
Chlorination factor	0.03					
ClO2, % as available Cl ₂ *	1.13					
Actual ClO2, % as avail. Cl ₂	1.22					
Substitution, %	100					
H2SO4, %	1.5					
Final pH	2					
Residual, g/L avail. Cl ₂	0.04					
E0-Stage: 60 min. 74°C. 10% cons.						
NaOH, %	0.8					
O2 pressure, psig	25					
O2 time, minutes	15					
Final pH	12.7					
K No. (25 Ml)	2.3					
Viscosity, mPa.s	11.9					
Yield on raw stock, %	-					
D-Stage: 74°C. 210 min. 10% cons.						
Sample number	#1	#2	#3	#4	#5	#6
ClO2 as ClO2, %*	0.1	0.3	0.5	0.7	0.9	1.1
Actual ClO2, % ClO2	0.11	0.33	0.54	0.76	0.98	1.2
NaOH, %	0	0	0.08	0.2	0.33	0.42
H2SO4, %	0.1	0.05	0	0	0	0
Final pH	4.1	3.7	3.4	3.4	3.4	3.3
Residual as ClO2, %	0.01	0.01	0.01	0.01	0.01	0.01
Brightness, %ISO	88.9	90	90.8	91	91.6	91.8
Viscosity, mPa.s	11.9	-	-	10.5	-	9.4

* Actual ClO2 concentration x 0.92

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TABLE 10

Bleaching with (O)(D100)(Eo)(D) on Best "Do-able" RDH Pulp

Kappa factor = 0.27

Sample identification	R12					
Species	Aspen					
Cook type	RDH					
O2 Pulp Kappa	5					
Viscosity, mPa.s	12.5					
D-100-Stage: 30 min. 68°C. 4.2% cons.						
Chlorination factor	0.03					
ClO2, % as available Cl ₂ *	1.35					
Actual ClO2, % as avail. Cl ₂	1.47					
Substitution, %	100					
H2SO4, %	2					
Final pH	2.3					
Residual, g/L avail. Cl ₂	0.08					
E0-Stage: 60 min. 74°C. 10% cons.						
NaOH, %	0.8					
O2 pressure, psig	25					
O2 time, minutes	15					
Final pH	12.6					
K No. (25 Ml)	2.2					
Viscosity, mPa.s	12.2					
Yield on raw stock, %	-					
D-Stage: 74°C. 210 min. 10% cons.						
Sample number	#1	#2	#3	#4	#5	#6
ClO2 as ClO2, %*	0.1	0.3	0.5	0.7	0.9	1.1
Actual ClO2, % ClO2	0.11	0.33	0.54	0.76	0.98	1.2
NaOH, %	0	0	0.08	0.2	0.33	0.42
H2SO4, %	0.1	0.05	0	0	0	0
Final pH	3.9	3.4	3.3	3.3	3.3	3.2
Residual as ClO2, %	0.01	0.01	0.01	0.01	0	0.01
Brightness, %ISO	88.9	90	90.8	91.1	91.5	91.8
Viscosity, mPa.s	12.4	-	-	10.7	-	9.5

* Actual ClO2 concentration x 0.92

As shown in FIGS. 5 and 5A, the use of a higher kappa factor did not appear to reduce the D1-stage chlorine dioxide requirements. The best case RDH pulps (R3 and R4) produced 1.5 to 2 points higher brightness than the baseline case RDH pulps (R7 and R8) at equivalent chlorine dioxide charges.

From FIGS. 6 and 6A, it is shown that the best do-able case RDH pulp (R12) produced intermediate brightness between the best case RDH pulp (R3) and the baseline case RDH pulp (R7).

FIGS. 7 and 7A show that the best do-able case RDH pulp (R12) gave intermediate brightness between the best case RDH pulp (R4) and the baseline case RDH pulp (R8).

From the pulp bleaching studies, a summary of the results is shown below in Table 11. The easiest pulps to bleach were the best case pulps. The most difficult to bleach were the baseline case pulps with the bleachability of the best do-able case falling between the first two cases. Results indicated that a combination of high alkalinity (white liquor addition at the warm and hot fill mode plus cooking stage, AA charge between 15% AA and 35% AA) and a low cooking temperature (approximately 150°C ~ 167°C) improves pulp bleachability and, thus, final brightness of pulp. It should be noted that the black liquor strength during the RDH cook should be maintained.

TABLE 11

BLEACHING STUDY SUMMARY

COOK NUMBER

<i>BEST COOK: NEW RDH COOKING PROCEDURE</i>	R3	R4
<i>BASELINE COOK: OLD RDH COOKING PROCEDURE</i>	R7	R8
<i>BEST DO-ABLE COOK: MODIFIED NEW RDH COOKING PROCEDURE</i>	R12	

BLEACHING RESULTS

KAPPA FACTOR 0.225 IN THE D (100% ClO2 SUBSTITUTION)

FINAL BRIGHTNESS, % ISO

	<i>ClO2 CHARGES IN THE LAST D STAGE, %</i>					
	0.1	0.3	0.5	0.7	0.9	1.1
<i>R3 (BEST COOK)</i>	89.7	90.4	91.2	91.5	91.6	92
<i>R12 (BEST DO-ABLE)</i>	88.9	90	90.8	91	91.6	91.8
<i>R7 (BASE-LINE)</i>	87.6	88.7	89.7	90.3	90.3	90.6

KAPPA FACTOR 0.27 IN THE D (100% ClO2 SUBSTITUTION)

FINAL BRIGHTNESS, %ISO

	ClO ₂ CHARGES IN THE LAST D ₀ STAGE, %					
	0.1	0.3	0.5	0.7	0.9	1.1
R4 (BEST COOK)	89.8	90.5	91.2	91.5	91.8	91.8
R12 (BEST DO- ABLE)	88.9	90	90.8	91.1	91.5	91.8
R8 (BASE- LINE)	87	88.7	89.3	90.1	90.5	90.5

It should be understood the various changes and modifications to the presently preferred embodiments described herein will be apparent to those in the art. Such changes and modifications can be made without departing from the spirit and scope of the present invention and without diminishing its attended advantages. It is, therefore, intended that such changes and modifications be covered by the appended claims.

CLAIMS:

1. A batch digesting process of the type using rapid displacement heating to produce delignified pulp, wherein spent liquor produced in a digester as a result of cooking a mass of cellulosic material with cooking liquor is displaced and collected in accumulators as hot black liquor and as warm black liquor so as to conserve and utilize the heat of the spent liquor to preheat another mass of cellulosic material in warm black liquor and hot black liquor displacement type pretreatments with progressively hotter spent liquors prior to cooking, wherein:

white liquor is added to the warm black liquor during the warm black liquor pretreatment and to the hot black liquor during the hot black liquor pretreatment stages and to the cooking liquor during the cooking stage in the digesting process, the total white liquor added having a distributed charge between approximately 15% active alkalinity and about 35% active alkalinity; and

the temperature of the cooking liquor is raised to between 150° ~ 167°C for the cooking stage.

2. The process of claim 1, wherein the white liquor solution is added to the warm black liquor (temperature between 90° and 150°C) and to the hot black liquor (temperature between 150° and 167°C) in a predetermined amount.

3. The process of claim 1, wherein white liquor is added to a cool black liquor (temperature between 70° and 90°C) and the mass of cellulosic material is pretreated with said cool black liquor with white liquor added thereto, before the warm black liquor pretreatment.

4. The process of claim 1, wherein the preferred total white liquor charge is > 20% AA.

5. The process of claim 1, wherein the preferred cooking temperature ranges between 155° ~ 167°C.

6. A method for producing bleachable grade pulp according to the process of claim 1, comprising the steps of:

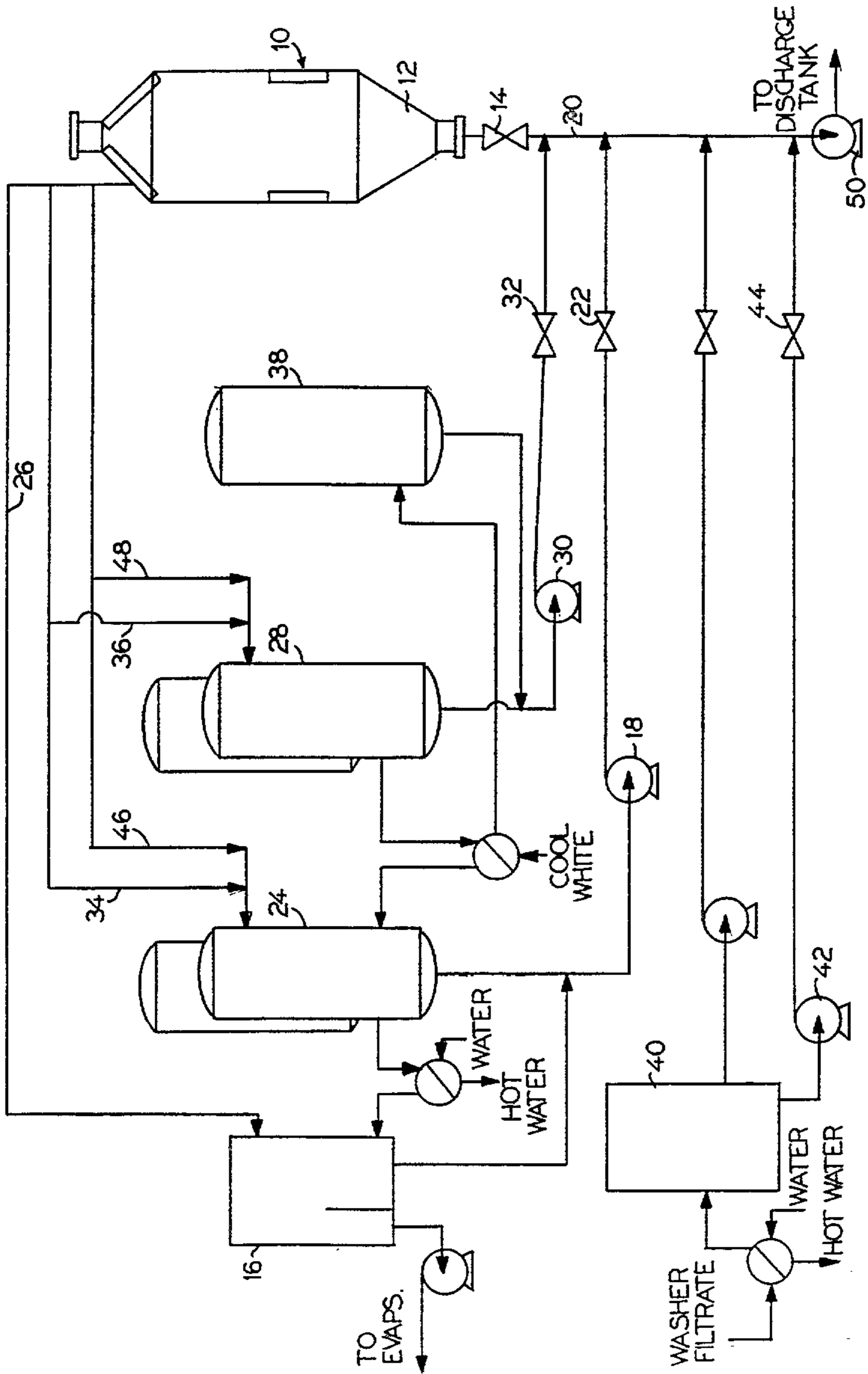
- (a) introducing wood chips into the digester;
- (b) pretreating the chips with a mixture of warm black liquor and white liquor below cooking temperature;
- (c) displacing the mixture from the digester with at least one mixture of a hot black liquor and hot white liquor;
- (d) increasing the temperature of the digester to the cooking temperature;
- (e) maintaining said temperature until the chips are digested;
- (f) displacing the contents of the digester with a liquid filtrate derived from pulp washing; and
- (g) emptying the contents of the digester by applying gas pressure to the interior of the digester or pumping out.

7. The method of claim 6, including the step of pretreating the chips with a mixture of cool black liquor and white liquor (or NaOH solution), before the step of pretreating with warm black liquor.

8. The method of claim 6, wherein the total white liquor used has a total charge ranging between 15% AA ~ 35% AA.

9. The method of claim 6, including the step of displacing the contents of the digester with any combination of washer filtrate and white liquor (or NaOH solution).

FIG. 1



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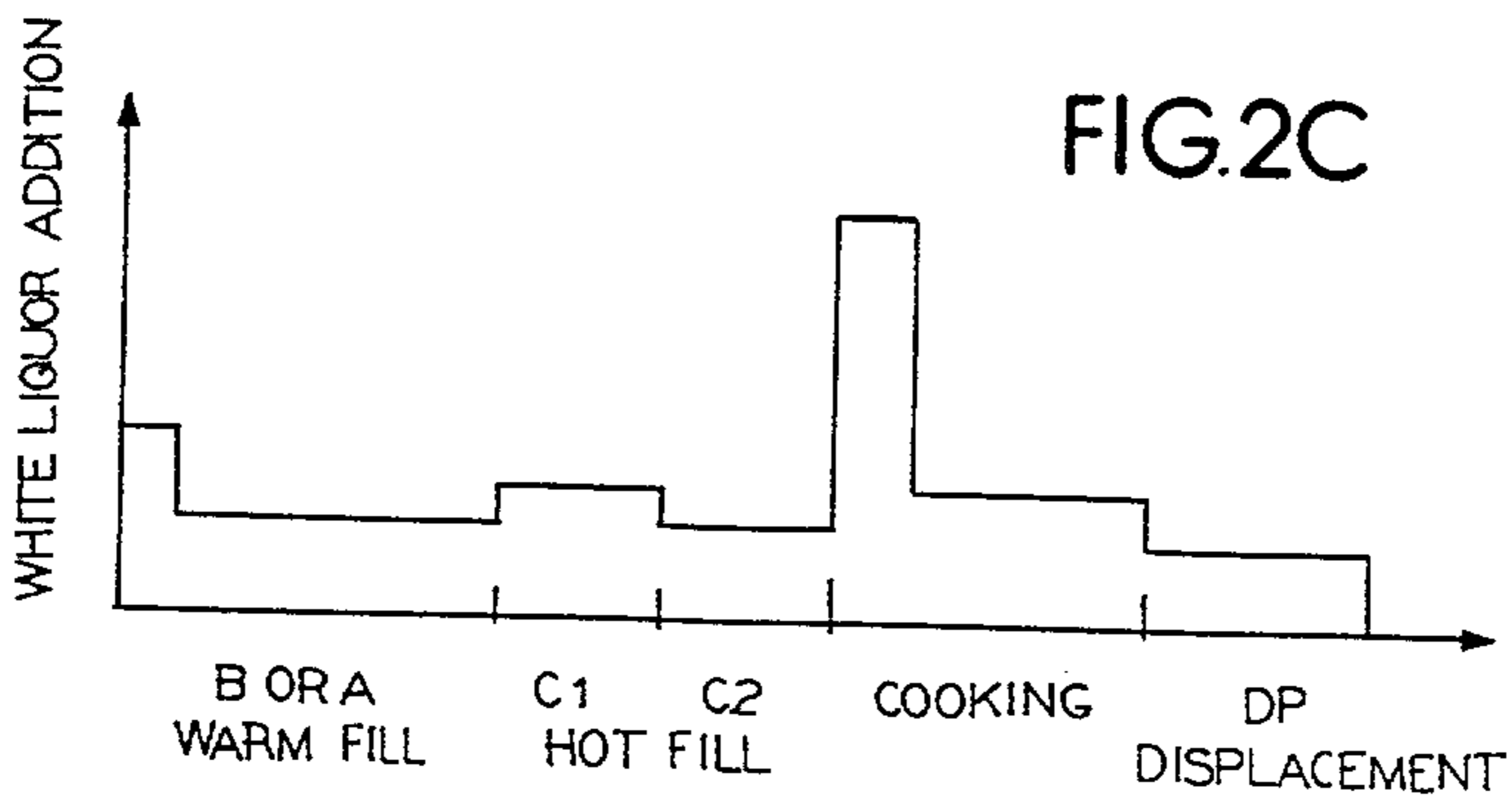
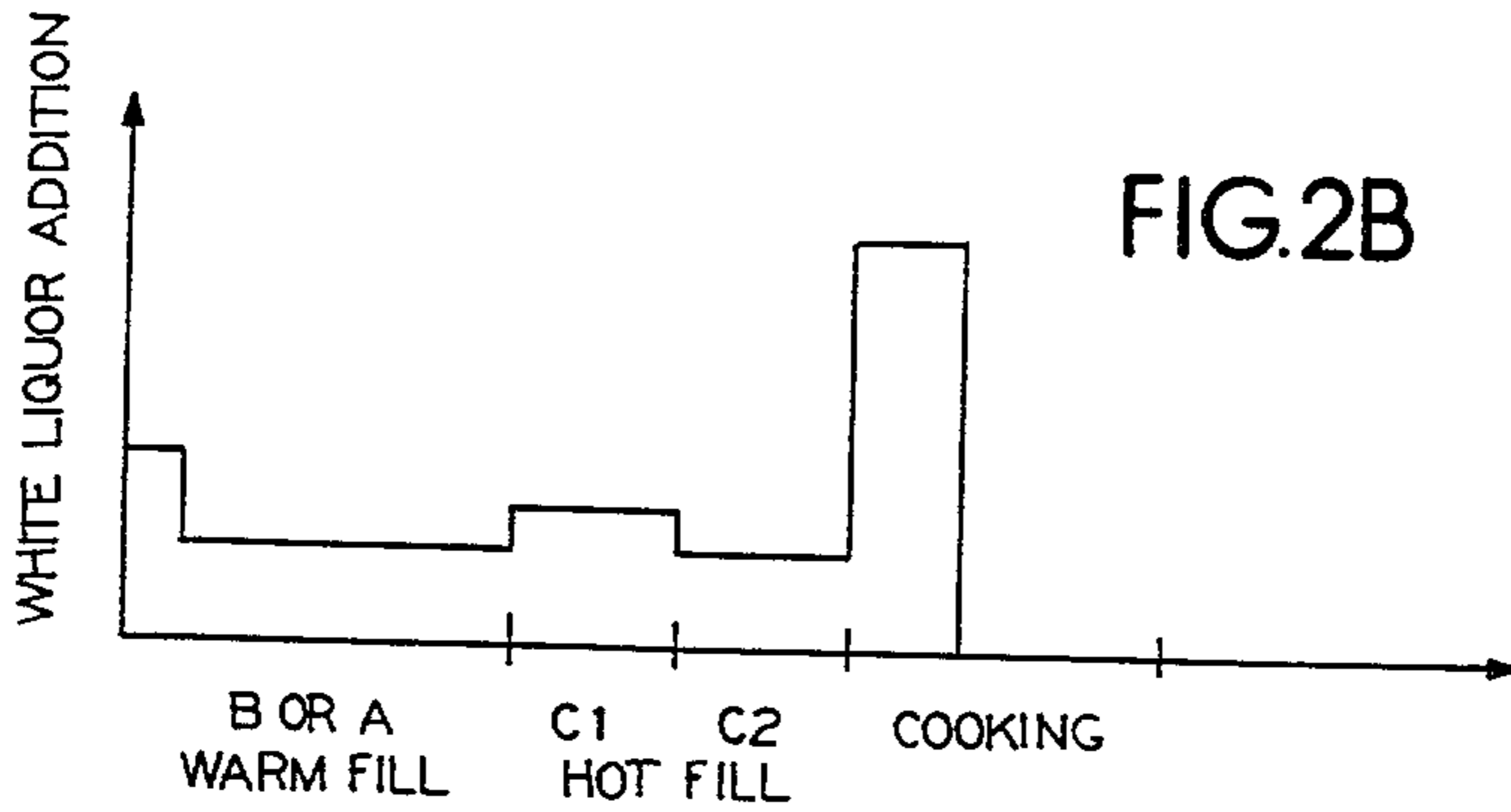
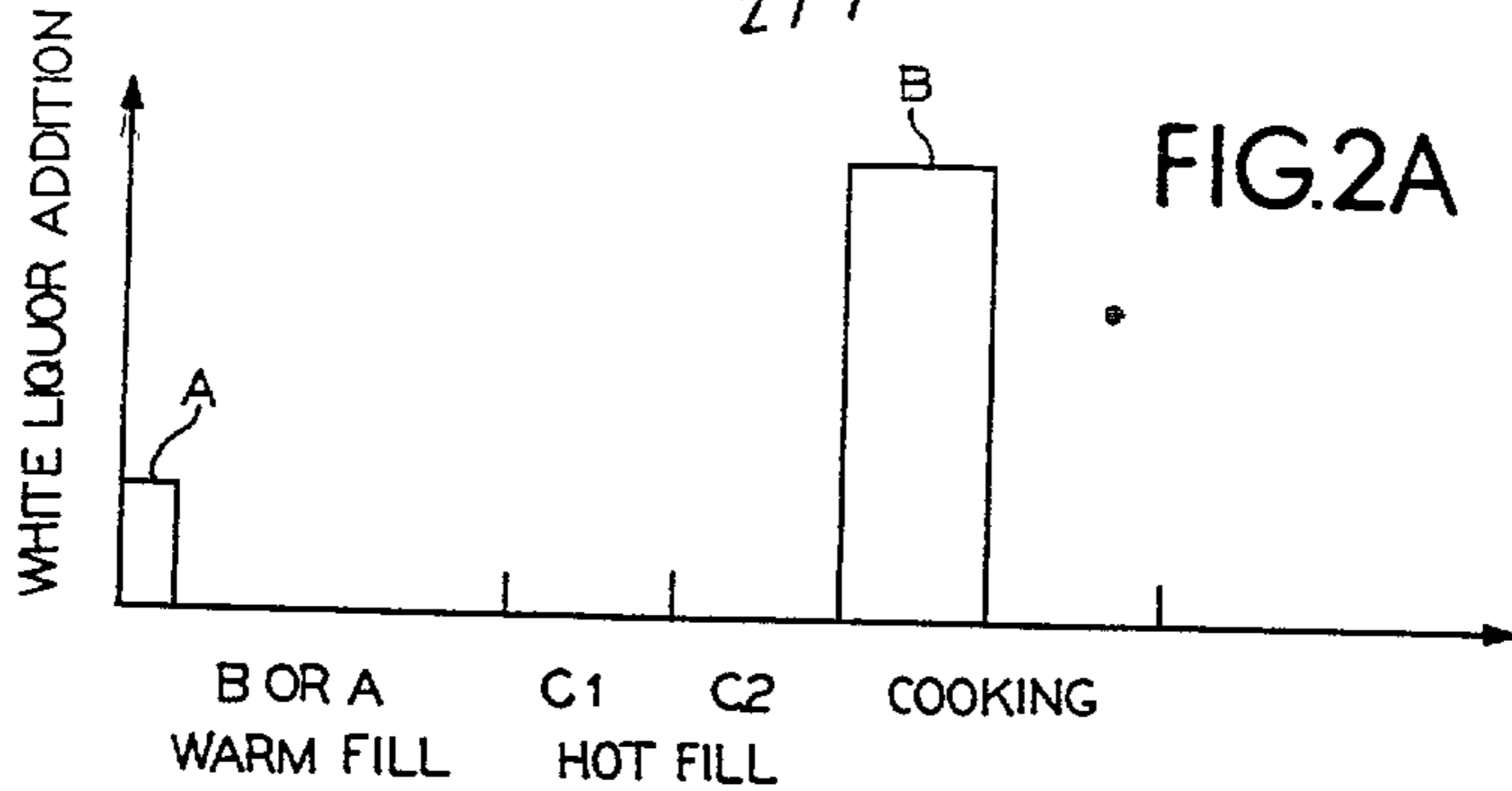


FIG.3

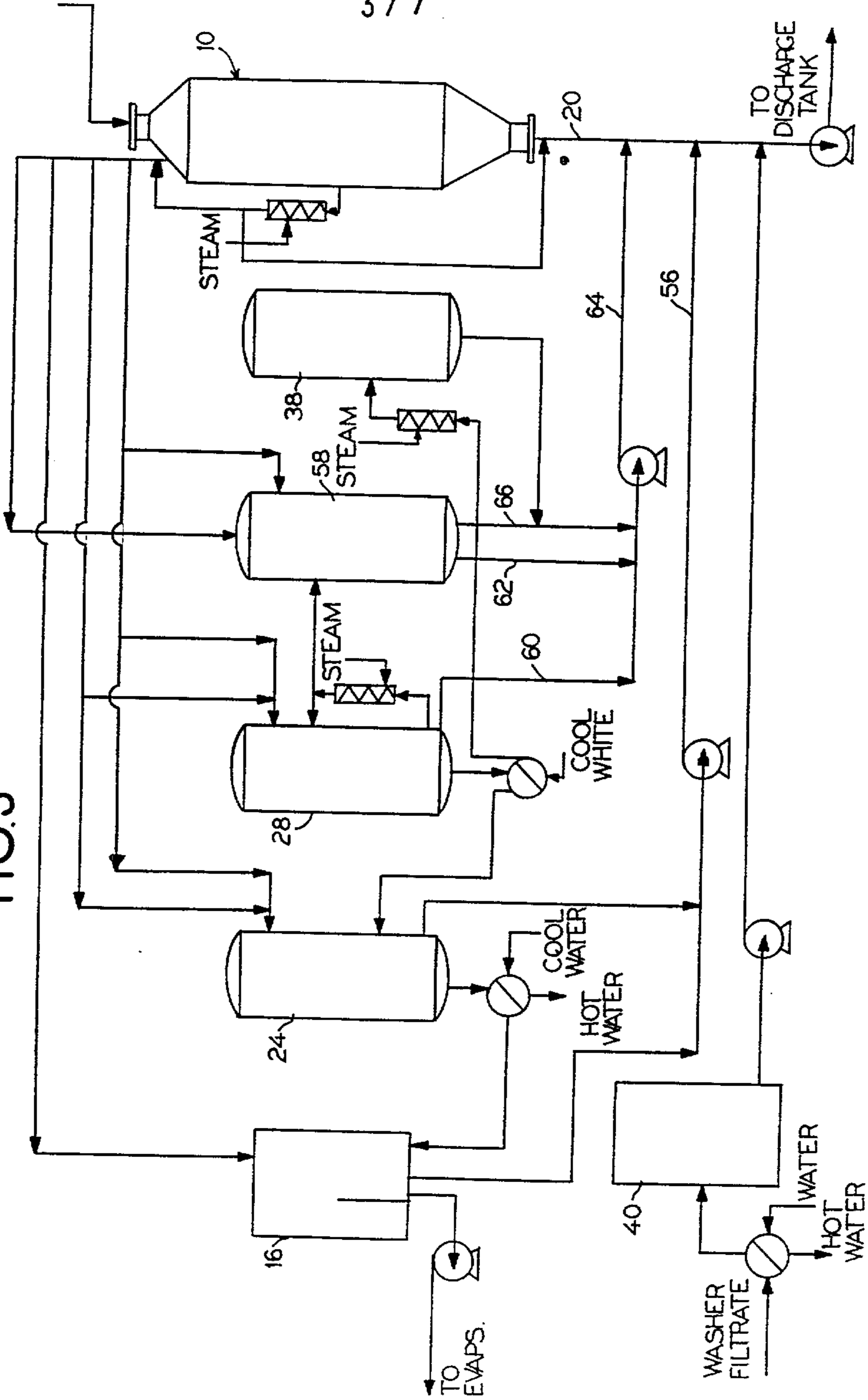


FIG. 4

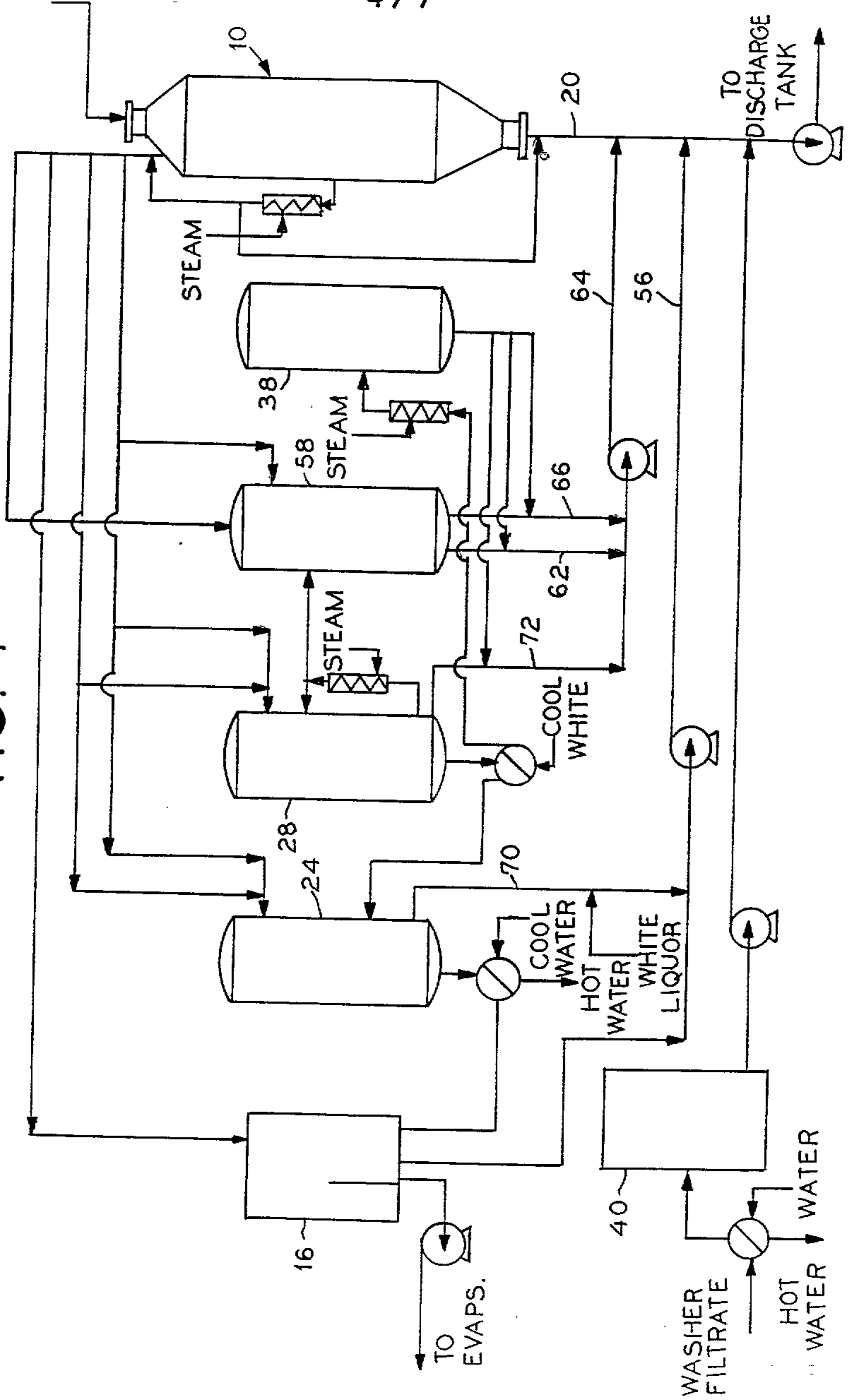


FIG. 5 .

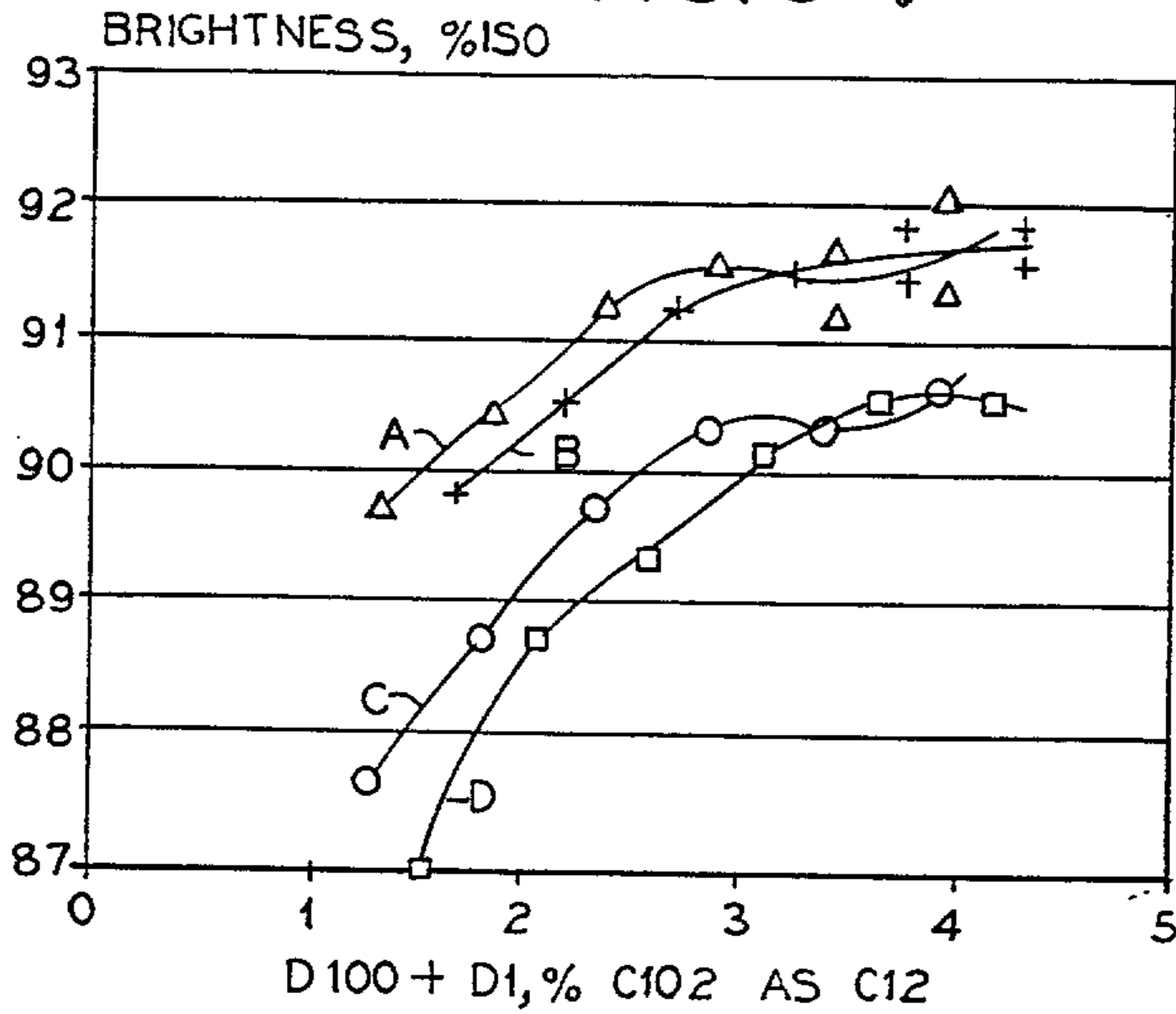


FIG. 5A

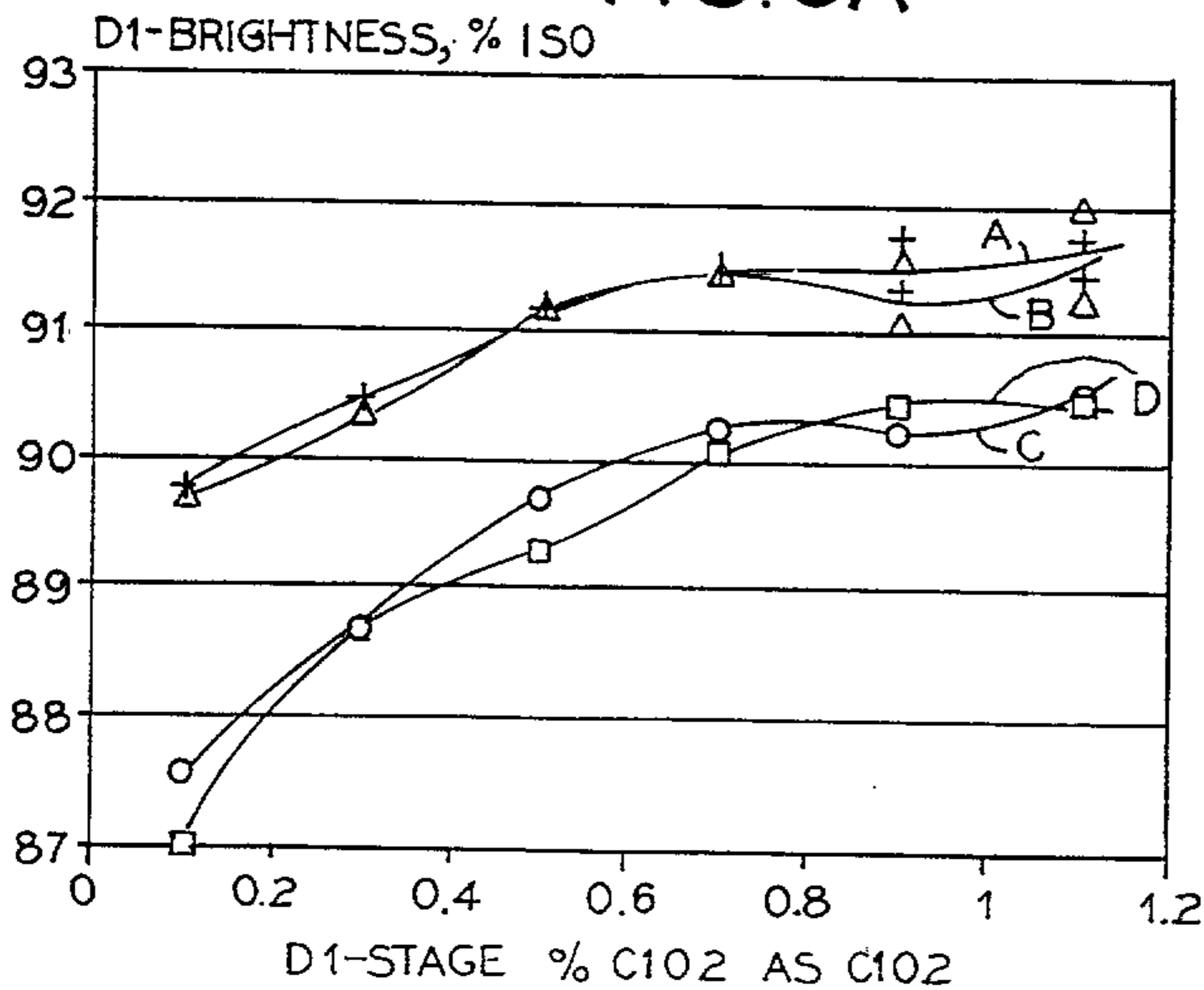


FIG. 6

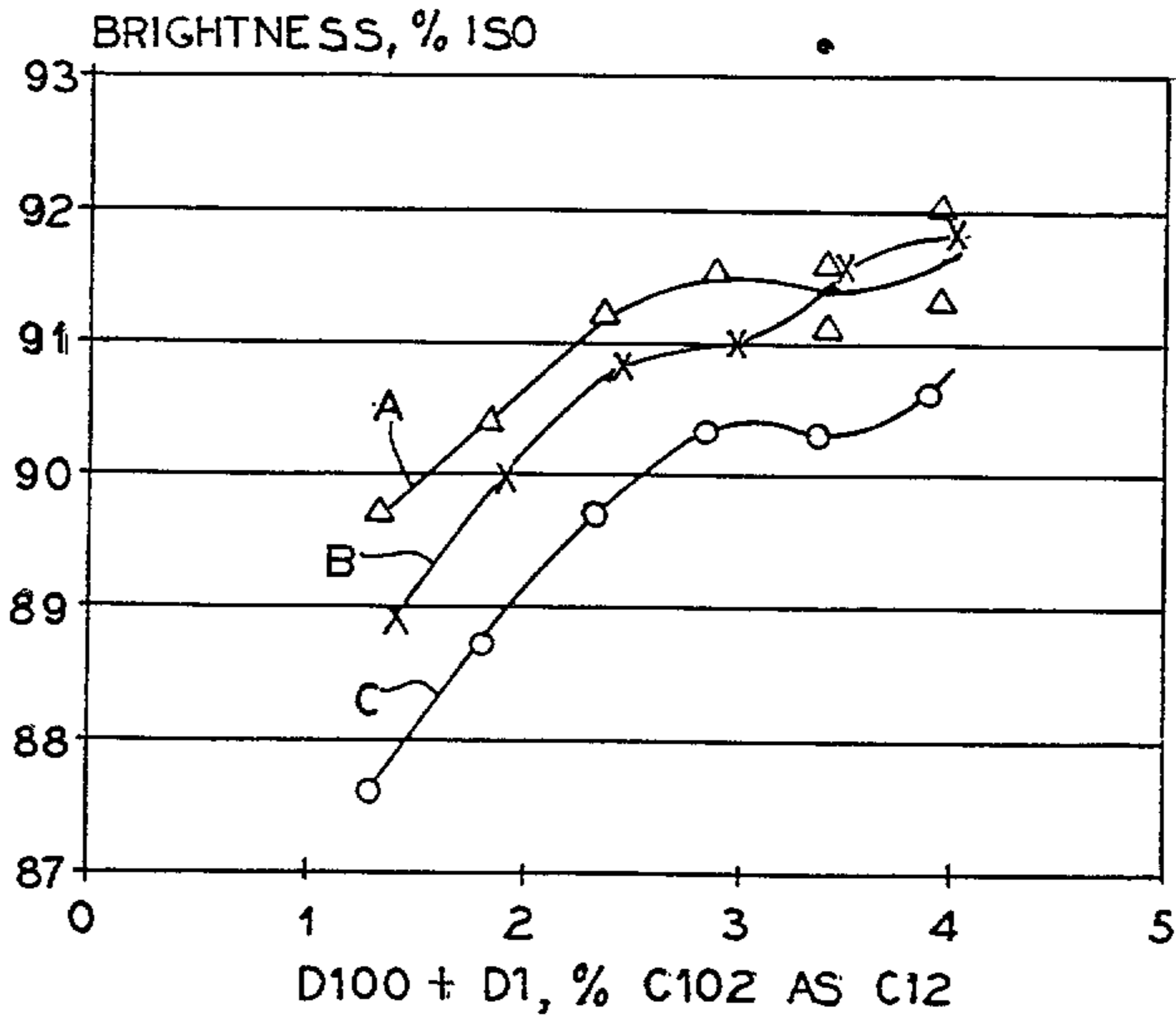


FIG. 6A

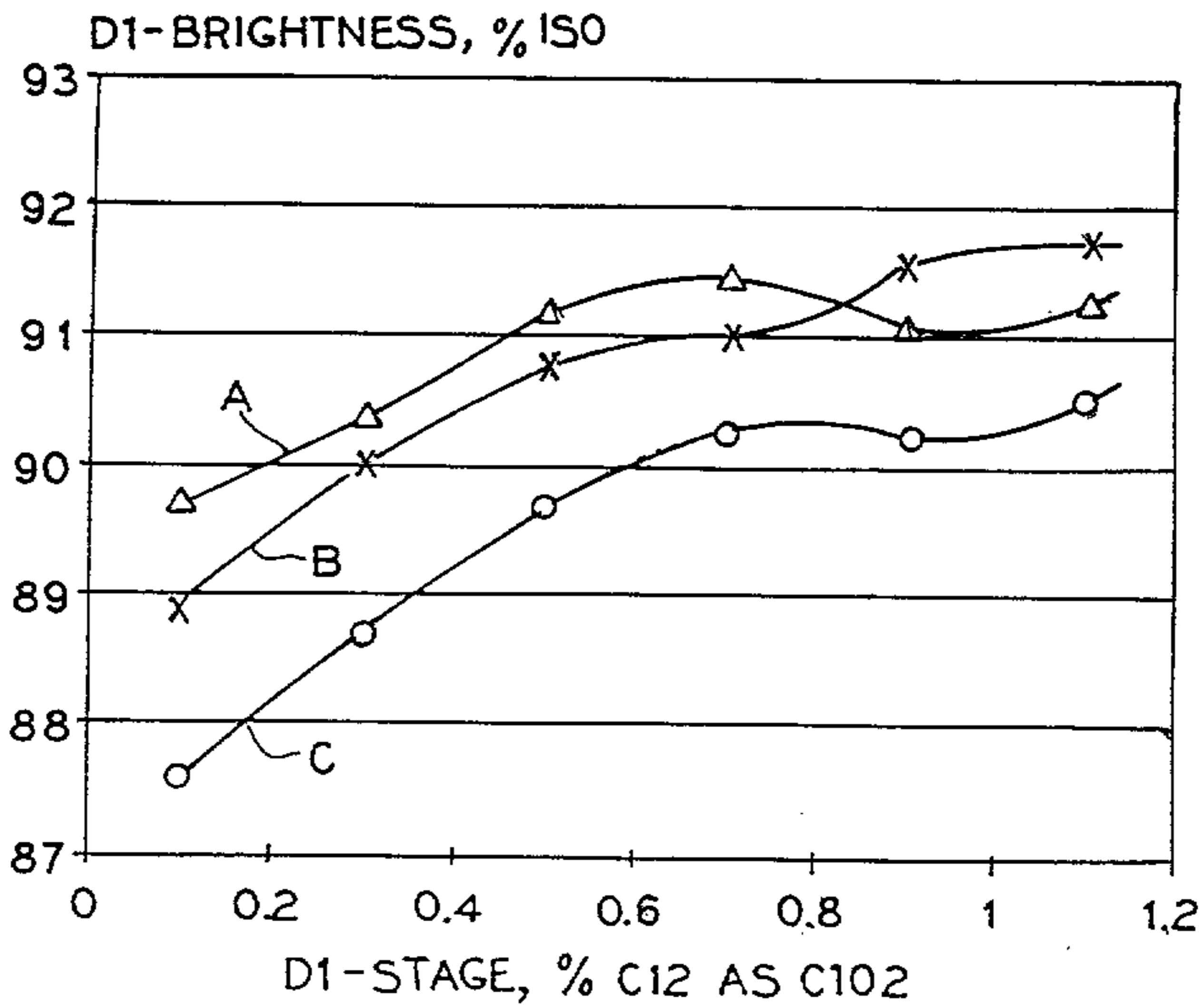


FIG. 7

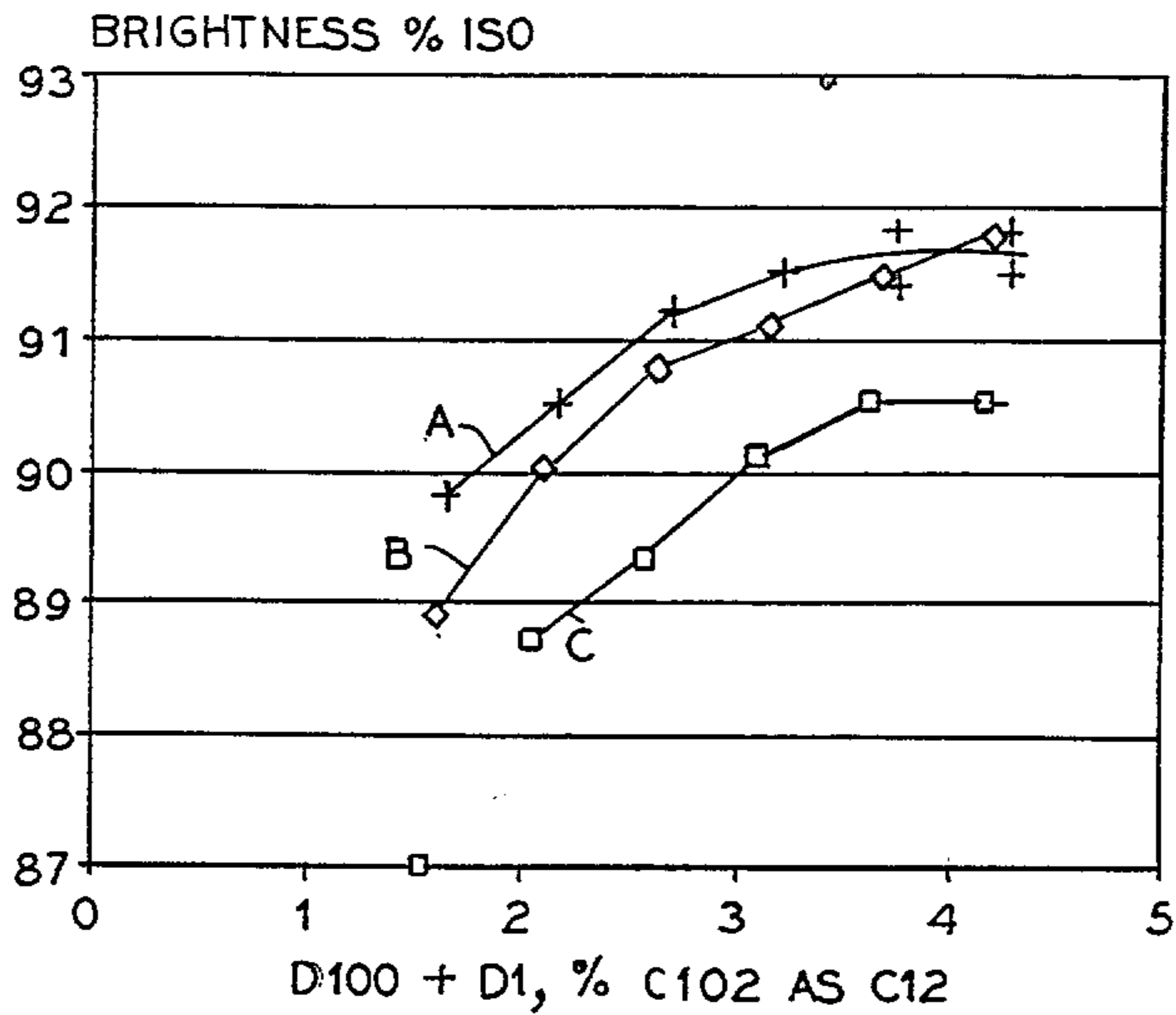


FIG. 7A

