(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 129 078**
A1

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 84105686.4

(22) Date of filing: 18.05.84

(51) Int. Cl.³: D 21 H 3/38
D 21 H 5/14

(30) Priority: 15.06.83 US 504561

(43) Date of publication of application:
27.12.84 Bulletin 84/52

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI NL SE

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(54) **Manufacture of paper using copolymers of 2-acrylamido-2-methylpropane sulfonic acid for increasing rate of dewatering of high mechanical/thermomechanical pulp furnishes.**

(57) A process for increasing rate of dewatering in the manufacture of paper from an aqueous furnish which comprises at least 40% by weight of mechanical wood pulp, thermomechanical wood pulp, or mixtures thereof, by addition thereto of an aluminum salt, e.g., alum, and a water-soluble copolymer containing from about 2 to about 30 mole percent repeating units derived from 2-acrylamido-2-methylpropane sulfonic acid, from 0 to about 25 mole percent repeating unit derived from acrylic acid, and from about 45 to about 98 mole percent repeating units derived from acrylamide, while maintaining pH of the furnish in the range of from about 3.5 to about 6.5.

EP 0 129 078 A1

MANUFACTURE OF PAPER USING COPOLYMERS OF 2-ACRYLAMIDO-2-METHYLPROPANE SULFONIC ACID FOR INCREASING RATE OF DEWATERING OF HIGH MECHANICAL/THERMOMECHANICAL PULP FURNISHES

Background of the Invention

Field of the Invention

This invention generally relates to a process for increasing rate of dewatering of furnish in the manufacture of paper, and specifically to such a process wherein the pulp constituent of the furnish contains a high content of mechanical and/or thermomechanical pulps.

Description of the Prior Art

In the general practice of papermaking, an aqueous pulp suspension, or "furnish", of cellulosic fibers resulting from pulping of the feed wood stock is hydraulically and mechanically conveyed onto a wire grid or screen which is in motion to produce a wet web of cellulosic fibers. The wet fiber web is dewatered on the screen, by drainage of liquid therefrom, following which the wet web may be further treated, dried, calendared, and subjected to additional treatments as desired.

In general practice, a number of additives are contained in the furnish which is passed to the wire substrate (wet web forming means). These additives may include processing aids for improving operation of the papermaking machinery, as well as chemicals for improvement of the properties of the finished paper product. Suitable processing aids may include retention aids for the retention of filler additives in and on the resultingly formed web

and reduction of loss of paper pulp fines from the furnish during the dewatering step and drainage aids for improving the rate of dewatering of the furnish on the wire forming means. Other additives may include formation aids, flocculants, defoamers, wet and dry strength additives, pitch control agents, slimicides, creping aids, and the like, as is well known to those skilled in the art.

Functional additives may include fillers as mentioned, sizing aids, strenghtening additives and the like. The fillers may include optical brighteners, opacifiers, and pigments. Sizing agents are employed to provide the paper product with resistance to wetting by liquids,such as ink, water and the like, and rosin or waxes are typically employed for such purpose.

Based on considerations of efficiency and ease of processing, it is desirable to add drainage aids to the furnish prior to the wet web formation step, to provide increased capacity or processing rate in the papermaking process in systems where dewatering or liquid drainage is the rate-limiting step in the process.

Although it is desirable to maximize drainage rates in the papermkaing system, the additives which heretofore have been employed for such purpose give rise to low levels of activity when used in newsprint furnishes, which generally are made under strongly acidic and high shear conditions. These include conventional drainage aids containing as anionic substituents -COOH groups, as well as copolymeric additives containing $-SO_3H$ groups.

As used herein, "newsprint furnish" means a furnish for the manufacture of paper and paperboard, particularly newsprint, coating raw stock grades and fine paper grades, containing fines and fillers and made under acid conditions, whose pulp constituent comprises at least 40% by weight of a wood pulp selected from the group consisting of mechanical wood pulp, thermomechanical wood pulp and mixtures thereof.

Accordingly, there is a containing need for im-

proved dewatering additives for newsprint furnishes characterized by stability and high activity.

It is therefore an object of the present invention to provide a process for increasing rate of dewatering in newsprint furnishes at the low pH conditions characteristic of such furnishes.

SUMMARY OF THE INVENTION

The present invention relates to a process for increasing rate of dewatering in the manufacture of paper from a furnish whose pulp constituent comprises at least 40% by weight of a wood pulp selected from the group consisting of mechanical wood pulp, thermomechanical wood pulp, and mixtures thereof comprising:

(a) adding to said furnish prior to said dewatering thereof (1) from about 0.5 to about 5 percent by weight, based on weight of cellulosic fibers in said furnish, of an aluminum salt, and (2) from about 0.01 to about 0.5 percent by weight, based on weight of cellulosic fibers in said furnish, of a water-soluble copolymer containing from about 2 to about 30 mole percent repeating units derived from 2-acrylamido-2-methylpropanesulfonic acid, from 0 to about 25 mole percent repeating units derived from acrylic acid, and from about 45 to about 98 mole percent repeating units derived from acrylamide; and

(b) maintaining pH of said furnish during step (a) and through said dewatering in the range of from about 3.5 to about 6.5.

DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph of drainage change, i.e., the change in amount of drained liquid, in milliliters, for a furnish containing various drainage additives relative to a furnish containing no drainage additives, plotted as a function of furnish pH, for 3% addition of aluminum sulfate (alum) to the furnish.

Fig. 2 is a graph a drainage change, ml, as a function of pH, for 1% alum addition.

Fig. 3 is a graph of drainage change, ml, as a function of alum addition, at pH = 4.5.

Fig. 4 is a graph of drainage change, ml, as a function of pH, showing parametrically the effect of variant levels of alum addition and of elevated temperature.

DETAILED DESCRIPTION OF THE INVENTION

In connection with the present invention, it has surprisingly and unexpectedly been discovered that the use of a water-soluble copolymer containing from about 2 to about 30 mole percent repeating units derived from 2-acrylamido-2-methylpropanesulfonic acid (hereinafter denoted as "AMPS"), from 0 to about 25 mole percent repeating units derived from acrylic acid, and from about 45 to about 98 mole percent repeating units derived from acrylamide, in combination with addition of an aluminum salt, as for example aluminum sulfate (alum), aluminum chloride or aluminum nitrate, at low pH conditions on the order of from about 3.5 to about 6.5 is remarkably effective in increasing the rate of dewatering of a furnish whose pulp constituent comprises at least 40 percent by weight of a wood pulp selected from the group consisting of mechanical wood pulp, thermomechanical wood pulp, and mixtures thereof.

The process of the present invention provides high rate and extent of drainage of newsprint furnishes, under strongly acidic conditions, where conventional anionic or cationic polymers are not effective. As indicated, conventional drainage aids which contain carboxylic acid groups (and those which contain sulfonic acid groups) are ineffective under such acidic conditions and cationic high molecular weight polymers do not produce adequate effect conditions. Although AMPS polymers and copolymers have been taught as drainage aids in the prior art, e.g., German Offenlegungsschrift 2,248,752, in combination with alum at low pH conditions for treatment of hardwood/softwood kraft pulp furnishes, there has been no recognition that such additives could be used in newsprint-type furnishes as contemplated in the present invention since experience has

shown that dewatering aids that work well in bleached pulp furnishes are not effective in groundwood-containing pulps. In view of the fact that most additives which are satisfactory for enhancement of drainage in neutral or alkaline furnish media and kraft pulps are characterized by extremely poor performance in strongly acidic newsprint-type furnishes, it is indeed unexpected that the process of the present invention may be employed to advantage to produce superior levels of drainage.

The AMPS copolymer employed in the present invention contains from about 2 to about 30 mole percent repeating units derived from AMPS, from 0 to about 25 mole percent repeating units derived from acrylic acid, and from about 45 to about 98 mole percent repeating units derived from acrylamide. As used herein, AMPS is intended broadly to refer to 2-acrylamido-2-methylpropanesulfonic acid as well as any suitable salts thereof.

Suitable AMPS copolymers include those containing for example from about 2 to about 20 mole percent repeating units derived from AMPS and from about 80 to about 98 mole percent repeating units derived from acrylamide As used herein, "acrylamide" is intended to be broadly construed to include acrylamide per se as well as acrylamide derivatives, e.g., substituted acrylamides. Such copolymer compositions may be used to particular advantage in furnishes where an aluminum salt, e.g., aluminum sulfate, aluminum nitrate, or aluminum chloride, is added to the furnish in an amount of from about 2 to about 4 percent by weight, based on weight of cellulosic fibers in the furnish. With such weight percent addition of aluminum salt, the pH of the furnish is preferably maintained during the copolymer addition and through the dewatering of the furnish in a range of from about 4.1 to about 6.5.

The aluminum salt is employed in the process of the present invention as a source of polyvalent metal ions, to enhance the effectiveness of the AMPS copolymer and the specific dosage of the aluminum salt which is required in

any given system can readily be determined without undue experimentation by simple tests such as Canadian Standard Freeness (CSP) or Britt jar drainage determinations on the furnish which is to be treated. The preferred aluminum salt is aluminum sulfate (alum).

In systems where the above-described AMPS/acrylamide copolymer is employed with additions to the furnish of the aluminum salt in the amount of from about 0.5 to about 2 percent by weight, based on weight of cellulosic fibers in the furnish, is satisfactory, it is desirable to maintain pH of the furnish during the copolymer addition and through the dewatering in a range of from about 4.8 to about 6.5, to achieve optimal performance of the drainage additives.

Particularly preferred in the broad practice of the present invention are AMPS copolymers containing from about 2 to about 30 mole percent repeating units derived from AMPS, from about 5 to about 25 mole percent repeating units derived from acrylic acid, and from about 45 to 93 mole percent repeating units derived from acrylamide. Such terpolymer system, as discussed hereinafter in greater detail, has been found to provide particularly enhanced drainage performance when the furnish temperature is maintained during the terpolymer/aluminum salt addition and through the dewatering in a range of from about 20 to about 60°C. Most preferably, enhanced performance has been found to be particularly enhanced at elevated temperatures in the range of from about 40 to about 60°C.

The above terpolymer composition has particular utility when the pH of the furnish is maintained during the terpolymer/aluminum salt addition and through the dewatering in a range of from about 4 to about 6.5.

In papermaking systems using the preferred aluminum salt, aluminum sulfate (alum), where the amount of alum employed for optimum drainage enhancement by the terpolymer is in the range of from about 2 to about 4 percent by weight, based on weight of cellulosic fibers in the furnish, the pH of the furnish is desirably maintained through the terpoly-

mer/alum addition and dewatering steps in the range of from about 4.5 to about 6.3. When lower amounts of alum addition are most effective, e.g., in a range of from about 0.5 to about 2 percent by weight addition of alum, based on weight of cellulosic fibers in the furnish, furnish pH is desirably maintained during the terpolymer/alum addition and through the dewatering steps in a range of from about 4.5 to about 5.6. These relationships may vary somewhat for different furnishes, temperature conditions and the presence or absence of recycling in the papermaking system. In practice, the optimum pH conditions can be accurately determined by actual mill trials without undue experimentation.

As indicated, the process of the present invention has particular utility in application to newsprint-type furnishes, whose pulp constituent is mechanical wood pulp and/or thermomechanical wood pulp. Especial utility is realized in application of the process of the invention to stone groundwood mechanical pulps.

Preferably, the AMPS copolymer or terpolymer has a molecular weight of from about two million to about twenty million. Particularly preferred copolymers may for example have a Standard Brookfield viscosity, measured in a 0.20 percent solution at 25°C. in 0.33 M NaCl with a number one spindle rotating at 60 rpm, of 2-10 centipoises.

Although the present invention in preferred practice employs alum as a source of polyvalent metal cations in the treatment of the furnish with AMPS-containing copolymers, it is possible to employ other sources of cationic metal (aluminum) sols having capability to bond with the sulfonic acid groups or carboxylic acid groups as an alternative to the alum constituent. Other aluminum salts having potential utility in combination with the AMPS copolymer at low pH conditions include aluminum chloride and aluminum nitrate.

As indicated, heating of the furnish medium, to maintain same at elevated temperature through the AMPS copolymer/alum addition and dewatering, further improves

the dewaterability of the furnish, presumably because more of the necessary cationic alumina complex forms through olation of aluminum hydroxide groups to an Al^{+}-O-Al^{+} type configuration, which forms at lower pH and is favored by higher stock temperatures.

In the manufacture of newsprint it is of utmost importance to improve drainage or water removal and to minimize pitch deposition problems. Both problems can be alleviated to a great extent by using an appropriate drainage aid which flocculates the groundwood fines as well as retaining the pitch particles on fibers under the strongly acidic conditions characteristic of newsprint furnishes.

Typically, a newsprint furnish will contain approximately 25% of long fiber chemical pulp, such as bleached sulfite or bleached kraft and about 75% by weight of high yield mechanical pulps, such as stone groundwood (GW) or a mixture of stone groundwood and thermomechanical (TMP) pulp. Upon forming a sheet (wet-web) on a high spedd commercial papermaking machine, much of the fine fibers, consisting primarily of the fine fraction of the GW or TMP pulp components, passes through the paper machine wire and characteristically the first pass retention in such systems is low, on the order of about 50-60%. Accordingly, such fines are returned back to the wet-web forming portion of the process system, by recycle of the tray water. By such expedient, the majority of the fines in the initial furnish is finally retained in the sheet after multiple recycles.

High speed paper machines in general are very sensitive to any changes in drainage rate and it is most essential to produce flocculation of fines and pitch particles on long fibers since such flocculation minimizes pitch deposition problems and enhances the rate of water removal. Drainage aids that perform adequately in fine paper grades generally do not produce perceptible beneficial results in newsprint-type furnishes Such inefficiency may be due to the considerable surface area of the high yield pulps (due to the fines content thereof) and the substantially reduced

(inhibited) bonding capacity of the polymeric additives on the lignin-rich fiber surfaces of mechanical pulps.

Another factor which precludes the achievement of good drainage and high fines retention in newsprint-type furnishes is the high hydrodynamic shear of a high speed papermaking machine such as conventionally employed for production of newsprint.

In summary, it has not been possible to translate the performance characteristics of polymeric drainage/retention aid additives in fine paper furnishes (see the aforementioned German Offenlegungsschrift 2,248,752, discussed hereinabove) to furnishes containing high percentages of high yield pulps. Accordingly, the present invention representa a substantial advance in the art, in the provision of a furnish treatment (furnish additive) providing a substantial, surprising and wholly unexpected enhancement in the rate of dewatering of furnishes containing significant content of mechanical wood pulp and/or thermomechanical wood pulp.

The following specific examples illustrate specific aspects of the present invention. These examples are set forth by way of illustration only and are not to be construed as limiting on the scope of the present invention except as set forth in the appended claims. In all examples set forth hereinafter, parts and percentages are by weight unless otherwise specified.

EXAMPLE I

A laboratory drainage test procedure was developed, for use in the examples which follow. It is typically very difficult to obtain accurate measurements of drainage changes in high groundwood content pulps, due to the slow draining character of such pulps. As indicated, the composition of typical commercial newsprint furnishes is approximately 75% by weight groundwood and 25% by weight chemical long fiber pulps. For the measurements carried out in the subsequent examples, the furnish was 50%:50% by weight of each

fiber component, i.e., groundwood and chemical long fiber pulp. The long fiber pulp portion of the furnish consisted of equal parts of bleached softwood and hardwood kraft that had been beated to about 450 CSF. The groundwood portion of this experimental furnish represented a typical stone groundwood, produced for newsprint production by Bowaters Paper Company, Calhoun, Tennessee, at a pH of 4.7 and containing about 1.0 percent by weight of alum, based on the weight of fibers, the alum being added during the groundwood production to reduce pitch deposition in the subsequent papermaking operation.

In each of the tests described hereinafter, the 50:50 percent by weight mixture of the chemical long fiber pulp and groundwood pulp was diluted to 0.5 percent fiber consistency and treated with addition alum, to carry out the process of the present invention, with the pH of such furnish being adjusted by addition of dilute sodium hydroxide to the furnish.

To the furnish stock prepared as described above was added a 0.1% solution of the specific polymer or copolymer drainage additive at a dosage level of 0.025% actual polymer based on total fiber weight. This furnish then was mixed by transferring same from one container to another for six times. A 500 milliliter (ml) aliquot of the treated furnish then was transferred into a drainage tube, equipped with paper machine wire at the bottom end. The furnish was allowed to drain for fifteen seconds and the filtrate collected during such period of time was quantitatively measured. A large increase in the amount of filtrate during a given run relative to the control furnish containing no drainage aid is indicative of significantly improved water release or drainage by the forming web.

In each experiment in the examples to follow, a blank test run was made wherein the furnish contained no additives, other than alum. An increase or a decrease in the amount of collected filtrate, as compared to the

blank, is indicative of an increase or a decrease, respectively, in the rate of drainage of the furnish.

In the evaluations of the process of the present invention for newsprint manufacture, a typical cationic and a typical anionic polyacrylamide retention/drainage aid was included in separate drainage test runs for comparison. These conventional cationic and anionic polyacrylamide additives had molecular weights in the range of 4-15 million.

EXAMPLE II

Figure I is a graph of draingae change, i.e., the change in amount of drained liquid, in milliliters (ml), for a furnish containing various drainage additives relative to a furnish containing no additives (blank), as a function of furnish pH, for 3% addition of alum to the furnish. In Figure I, curve A is the drainage curve for the above-described furnish, containing as the drainage aid a copolymer containing 15% by weight AMPS and 85% by weight acrylamide (AM). Curve B is the drainge curve for a furnish containing 5% by weight AMPS, 10% by weight acrylic acid (AA) and 85% by weight AM. Curve C represents the drainage performance of a furnish containing the aforementioned conventional anionic polyacrylamide drainage/retention agent, and Curve D is the performance curve for a furnish containing the conventional cationic polyacrylamide drainage/retention agent previously described.

As is seen from Figure I that changes in pH dramatically effect the performance of all the furnish compositions tested, particularly the highly anionic AMPS copolymers (Curves A and B) and the anionic polyacrylamide furnish (Curve C). The 15/85 AMPS/AM copolymer (Curve A) produces the best drainage in the pH range of 4.3 to 5.7 of all furnishes tested, while the anionic (carboxyl group-containing) polyacrylamide is relatively unaffected by change of pH in this range. The cationic polyacrylamide (Curve D) has a moderate effect in this pH range. Such pH range and alum dosage (3% by weight) generally is repre-

sentative of process conditions in numerous newsprint mills. With both the AMPS copolymer of Curve A and the AMPS terpolymer of Curve B, the alum added to the finish should be partially neutralized, i.e., in the form of a polymer of cationic alumina. Since excessive flocculation may be undesirable in a given application, the best composition, as between a copolymer of the type represented by Curve A and a terpolymer of the type represented by Curve B may be determined by actual mill trial, as indicated hereinabove. Nonetheless, as clearly shown by the graph, either type of AMPS-containing polymer is more effective than the cationic polyacrylamide (Curve D) heretofore used as a conventional drainage/retention aid.

The anionic polyacrylamide of Curve C becomes highly active only at high pH where the polymer is more structurally extended. High pH conditions, however, are not attractive in newsprint manufacture because of pitch deposition problems associated therewith. On the other hand, if the pH is reduced to extremely low levels, on the order of less than 4.0, the AMPS-containing polymers become significantly less effective, presumably due to the absence of adequate amounts of cationic polymeric alumina which probably provides activated bonding sites for such polymers.

EXAMPLE III

Figure II is a graph of drainage change, ml, as a function of pH, for one percent by weight alum addition to the furnish. The various curves correspond to the same furnish compositions and drainage aids as the correspondingly lettered curves of Figure I.

As seen from the graph, the AMPS-containing copolymers become highly effective when the pH of the furnish is increased to a point (approximately 5-5.5) where as sufficient amount of cationic polymeric alumina is formed. The observed shift in optimum pH, as comapred to the results in Example II is probably due to the lower alum dosage level in this instance relative to Example II, which decreases the effective concentration of the active cationic

alumina. The results shown in Figure II indicate that the optimum operating pH is a function of the available cationic alumina (cationic polymeric Al ions) in the furnish.

EXAMPLE IV

Figure III is a graph of drainage change, ml, as a function of alum addition, at a pH of 4.5. Curve A refers to a furnish containing as the drainage aid a 15 weight percent/85 weight percent AMPS/AM copolymer; Curve B refers to a furnish containing a 5:15:80 weight percent AMPS/AA/AMD terpolymer; and Curve C refers to a furnish employing as the drainage aid an anionic polyacrylamide containing 30 percent free carboxyl groups.

In this experiment, the dosage of alum was varied from 0.5% to 2.0% by weight based on the weight of fibers present in the furnish and pH was controlled at 4.5. The results obtained are consistent with the results shown in Example III in demonstrating at low alum levels (e.g., 0.5 1.0% by weight) the polymer may actually retard drainage. In this furnish system, a minimum of 1.5-2.0% by weight appears to be essential for adequate activation of the AMPS--containing polymers. The carboxyl group-containing anionic polyacrylamide is unaffected by change in the alum content of the furnish.

EXAMPLE V

Figure IV is a graph of drainage change, ml, as a function of pH, showing parametrically the effect of variant levels of alum addition and of elevated temperature. The effect of temperature on the drainage rate to determine whether heat would affect the alum chemistry by favoring formation of oxolated (polymeric) species of alumina at increased temperature.

The parametric alum concentration and temperature conditions are set forth on the draft. The drainage aid employed in all instances was a terpolymer of 5/15/80 weight percent AMPS/AA/AM.

In each run, the furnish was adjusted to the spe-

cific temperature by warming a stainless steel beaker containing the furnish in a steam bath. Once the parametric temperature condition was realized, the furnish was treated with alum and neutralized with an appropriate amount of sodium hydroxide and allowed to equilibrate for five minutes.

WHAT IS CLAIMED IS:

1. A process for increasing rate of dewatering in the manufacture of paper from a furnish whose pulp constituent comprises at least 40% by weight of a wood pulp selected from the group consisting of mechanical wood pulp, thermomechanical wood pulp, and mixtures thereof, comprising:

(a) adding to said furnish prior to said dewatering thereof (1) from about 0.5 to about 5 percent by weight, based on weight of cellulosic fibers in said furnish, of an aluminum salt, and (2) from about 0.01 to about 0.5 percent by weight, based on weight of cellulosic fibers in said furnish, of a water-soluble copolymer containing from about 2 to about 30 mole percent repeating units derived from 2-acrylamido-2-methylpropanesulfonic acid, from 0 to about 25 mole percent repeating units derived from acrylic acid, and from about 45 to about 98 mole percent repeating untis derived from acrylamide; and

(b) maintaining pH of said furnish during step (a) and through said dewatering in the range of from about 3.5 to about 6.5.

2. A process according to Claim 1 wherein said copolymer contains from about 2 to about 20 mole percent repeating units derived from 2-acrylamido-2-methylpropanesulfonic acid and from about 80 to about 98 mole percent repeating units derived from acrylamide.

3. A process according to Claim 2 wherein the addition of said aluminum salt to said furnish is in an amount of from about 2 to about 4 percent by weight, based on weight of cellulosic fibers in said furnish.

4. A process according to Claim 3 wherein pH of said furnish is maintained during step (a) and through said dewatering in the range of from about 4.1 to about 6.5.

5. A process according to Claim 2 wherein the addition of said aluminum salt to said furnish is in an amount of from about 0.5 to about 2 percent by weight, based on weight of cellulosic fibers in said furnish.

6. A process according to Claim 4 wherein pH of said furnish is maintained during step (a) and through said dewatering in the range of from about 4.8 to about 6.5.

7. A process according to Claim 1 wherein said copolymer contains from about 2 to about 30 mole percent repeating units derived from 2-acrylamido-2-methylpropanesulfonic acid, from about 5 to about 25 mole percent repeating units derived from acrylic acid, and from about 45 to about 93 mole percent repeating units derived from acrylamide.

8. A process according to Claim 6 wherein pH of said furnish is maintained during step (a) and through said dewatering in the range of from about 4 to about 6.5.

9. A process according to Claim 1, further comprising maintaining temperature of said furnish during step (a) and through said dewatering in the range of from about 20 to about 60°C.

10. A process according to Claim 6, further comprising maintaining temperature of said furnish during step (a) and through said dewatering in the range of from about 40 to about 60°C.

Fig. 1

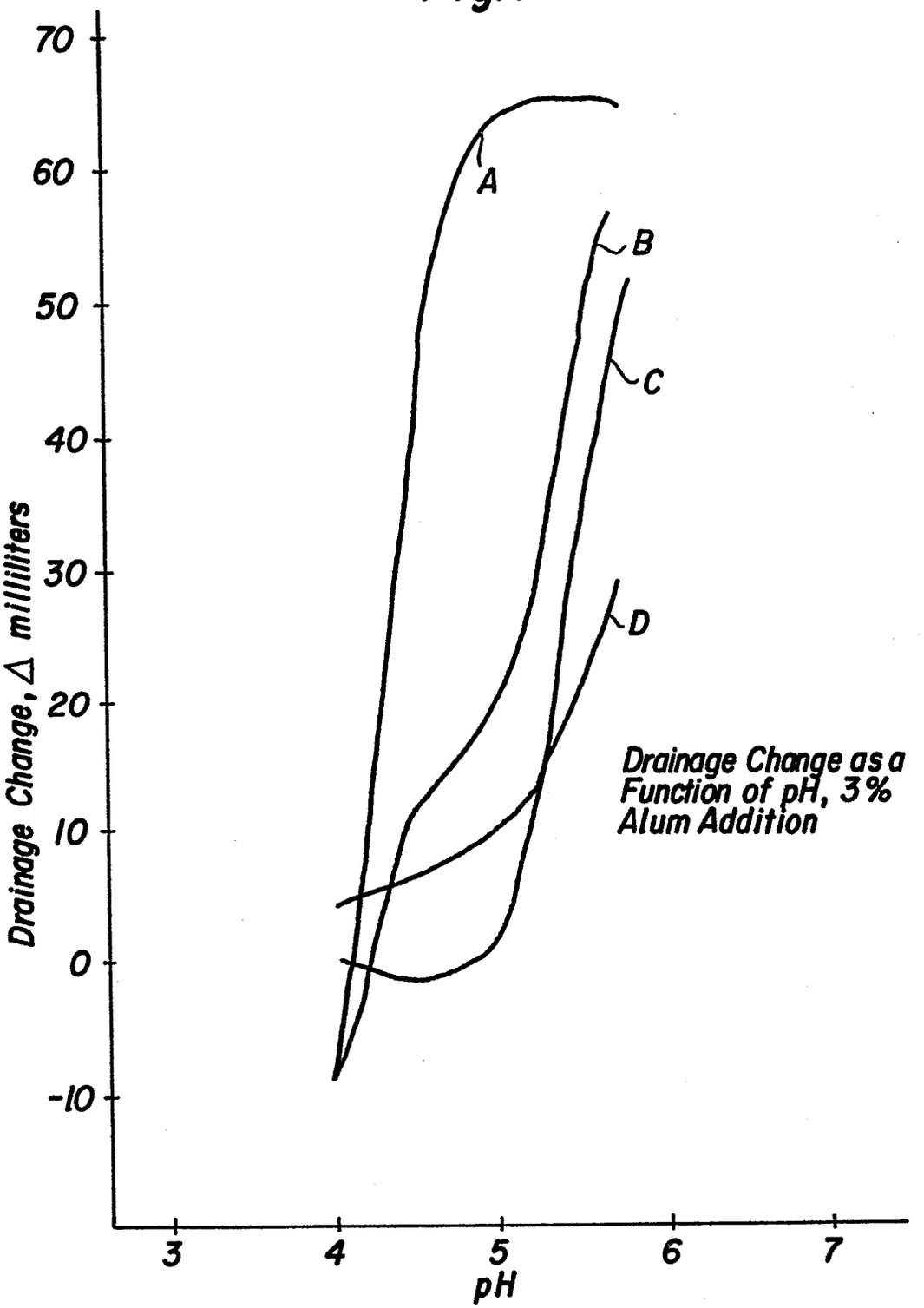

70
60
50
40
30
20
10
0
-10
Drainage Change, Δ milliliters
3
4
5
6
7
pH
A
B
C
D
Drainage Change as a Function of pH, 3% Alum Addition

Fig. 2

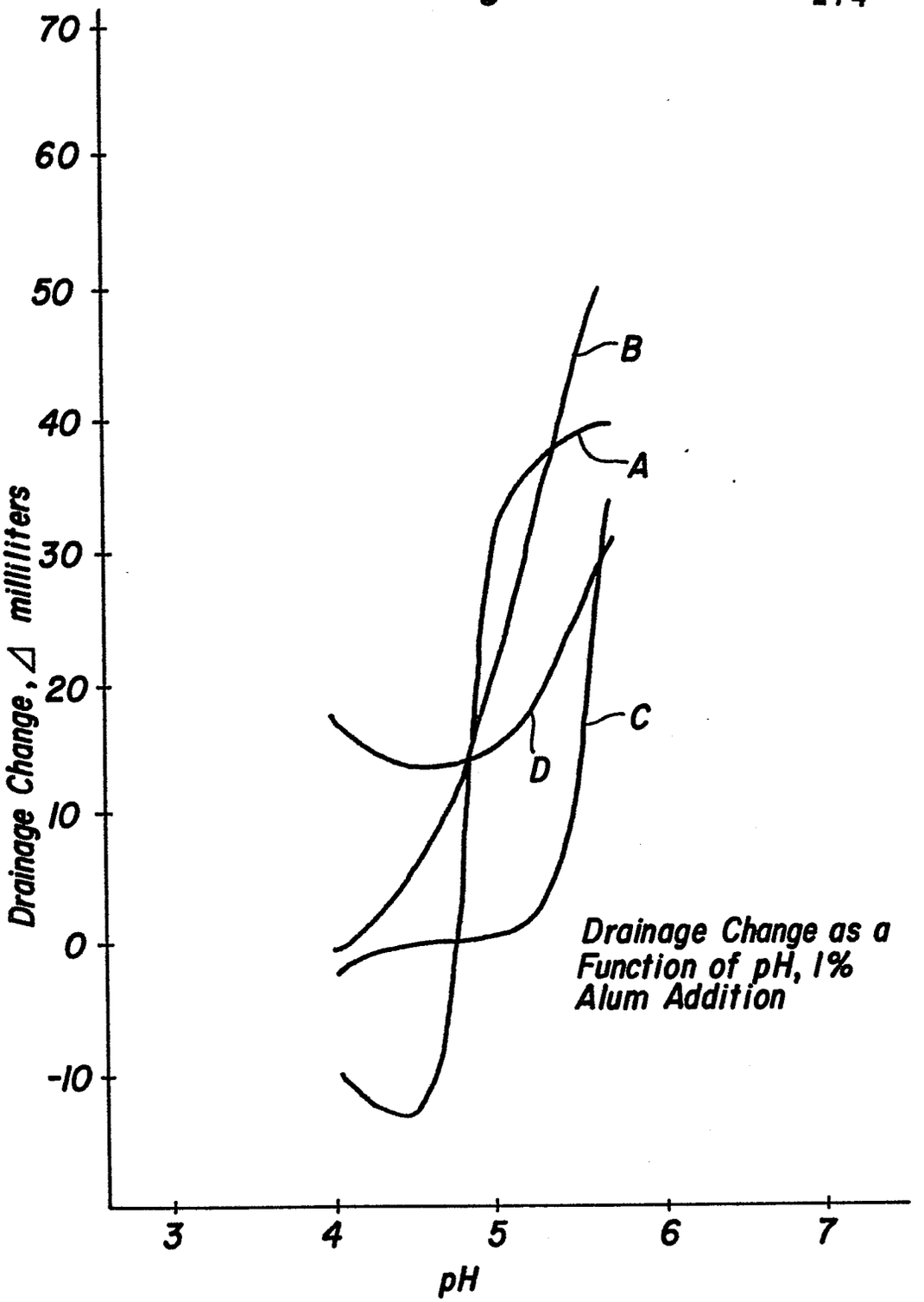

70
60
50
40
30
20
10
0
-10
Drainage Change, Δ milliliters
3
4
5
6
7
pH
A
B
C
D
Drainage Change as a Function of pH, 1% Alum Addition

Fig.3

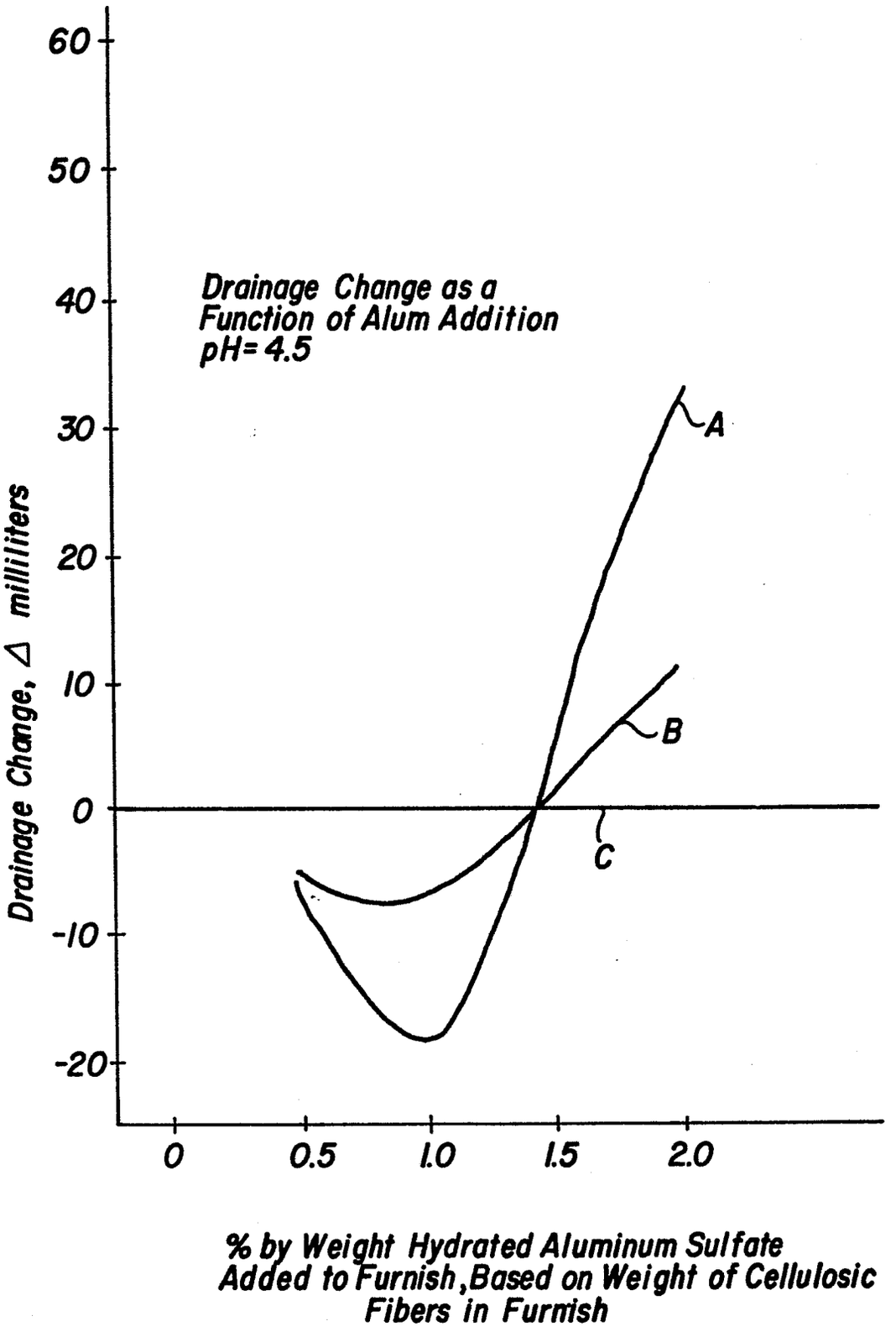
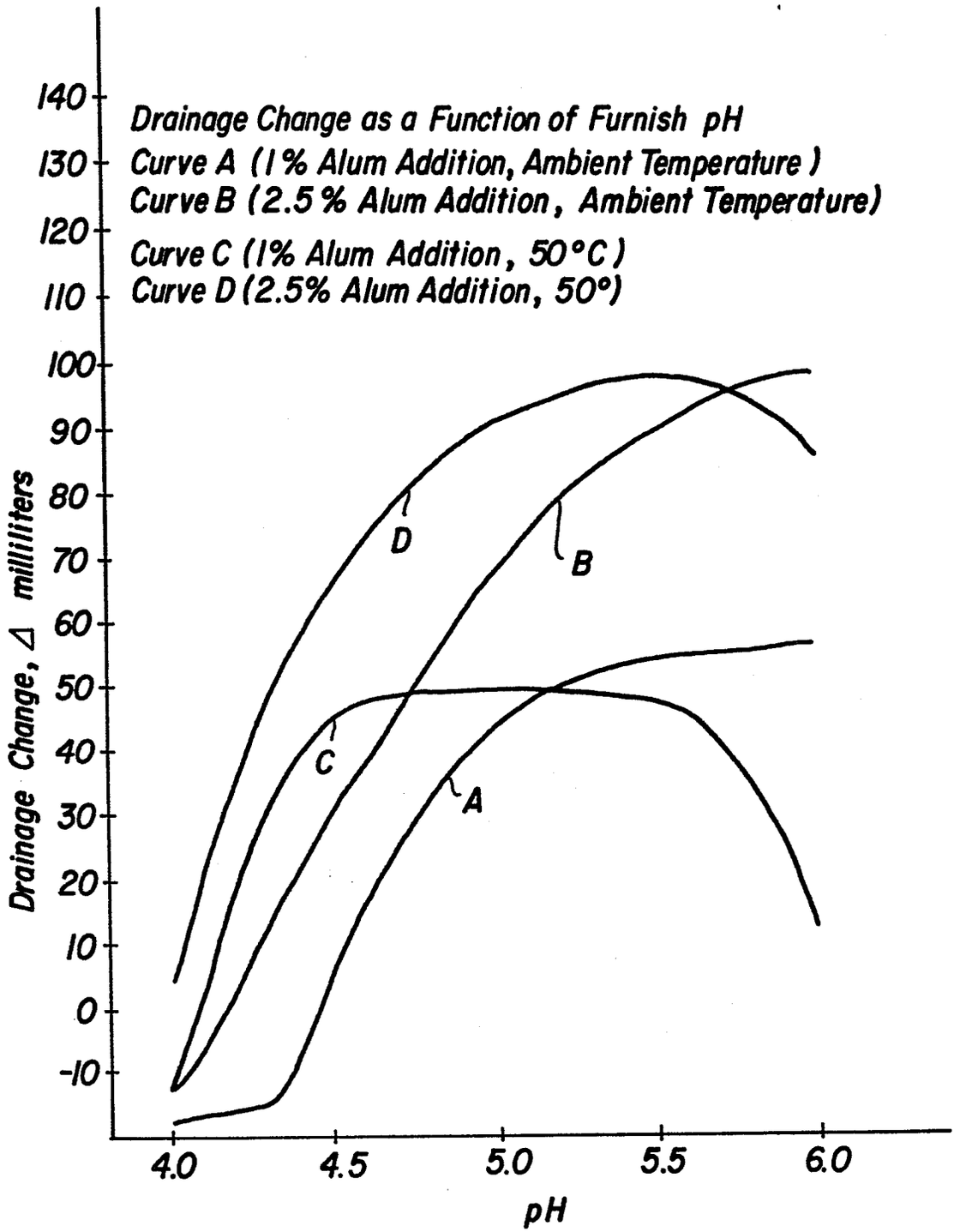

Drainage Change as a
Function of Alum Addition
pH= 4.5
Drainage Change, Δ milliliters
60
50
40
30
20
10
0
-10
-20
A
B
C
0
0.5
1.0
1.5
2.0
% by Weight Hydrated Aluminum Sulfate
Added to Furnish, Based on Weight of Cellulosic
Fibers in Furnish

Fig.4


Drainage Change as a Function of Furnish pH
Curve A (1% Alum Addition, Ambient Temperature)
Curve B (2.5% Alum Addition, Ambient Temperature)
Curve C (1% Alum Addition, 50°C)
Curve D (2.5% Alum Addition, 50°)
Drainage Change, Δ milliliters
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
4.0
4.5
5.0
5.5
6.0
pH
A
B
C
D

0129078

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 84 10 5686

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
D,X	DE-A-2 248 752 (CALGON) * Whole document *	1-5	D 21 H 3/38 D 21 H 5/14
A	ABSTRACT BULLETIN OF INST. OF PAPER CHEMISTRY, vol. 51, no. 8, February 1981, page 853, abstract no. 7953, Appleton, Wisconsin, US; & JP - A - 36 315/80 (OKUMICHI T; ARAKAWA CHEMICAL INDUSTRY LTD.) 13-03-1980	1	

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

D 21 H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	06-09-1984	NESTBY K.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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