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54 **Paper machine polymer systems and methods for their use.**

57 A process for the preparation of paper suitable for use as cover sheets for the production of gypsum wallboard which comprises forming a suitable aqueous slurry of paper pulp, passing the slurry through papermaking apparatus wherein successively are added a neutral size material and a retention aid, and wherein the slurry is additionally passed through a machine chest, a plurality of fan pumps, apparatus for forming the paper and subsequently drying the paper, the improvement which comprises the step of introducing a high molecular weight low cationic charge density retention aid polymer into the slurry immediately at the discharge situs of the fan pumps, whereby contaminants present in the slurry are retained and are not deposited on the surfaces of the papermaking apparatus. In a improved embodiment, a small amount of the high molecular weight low charge density polymer is utilized to replace cationic starch to act as a retention aid for the neutral size material, and a low molecular weight high charge density polymer is introduced into the machine chest as a coagulant to further promote the retention of contaminants present in the slurry to avoid their being deposited on the surfaces of the paper-making machine.

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PAPER MACHINE POLYMER SYSTEMS AND METHODS FOR THEIR USE

BACKGROUND OF THE INVENTIONField of the Invention

5 The present invention relates to a system for making paper to be used as cover sheets for gypsum wallboard, and more particularly refers to a polymer system for use in making such paper and to a novel method for applying the system.

Description of the Prior Art

10 Gypsum wallboard is conventionally fabricated by depositing an aqueous slurry between two paper cover sheets, setting the slurry and drying the finished product. In the past, paper for utilization as paper cover sheets was prepared by utilizing an acid size, alum and rosin. This sizing system was satisfactory and produced suitable paper for cover sheets. It was subsequently found, however, that when a neutral size material was
15 utilized together with a cationic starch, a paper having greater strength was produced. However, when the system was utilized with waste paper furnish, it was found that contaminated material was deposited on the paper-making machine.

SUMMARY OF THE INVENTION

20 It is an object of the present invention to provide a paper suitable for use in the production of gypsum wallboard having great strength.

It is a further object to provide a paper of the type described which is produced by using a neutral sizing material.

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It is still further an object to provide a paper suitable for use in making gypsum wallboard with waste paper furnish which does not result in deposition of contaminants in the paper-making machine.

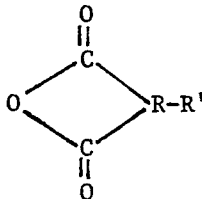
It is an additional object to provide such a paper in which some or
5 all of the expensive cationic starch commonly utilized is eliminated.

These and other objects, advantages and functions of the invention will be apparent on reference to the specification.

According to the invention, paper suitable for use in the production of gypsum wallboard is prepared from waste paper furnish and utilizing a
10 neutral size such as an alkenyl succinic anhydride by eliminating a portion or all of the cationic starch conventionally used with such neutral sizes by incorporating into the pulp furnish slurry one or more cationic polymers at particularly selected places of the paper-making apparatus. Through the use of the present system and process excellent
15 paper is provided and contamination of the paper-making machine is avoided.

Waste paper such as waste news, sections, mixed waste or old corrugated paper conventionally contain contaminants such as wax, asphalt, hotmelt glues and adhesives. When pulp furnish prepared from these
20 materials is utilized to form paper, they often deposit at various places of the paper-making machine and cause contamination that must be periodically removed. This results in an added expense to the paper-making process. Moreover, the cationic starch conventionally used together with alkenyl succinic anhydride neutral sizes is quite ex-
25 pensive and a considerable reduction in cost could be achieved if the use of these materials was reduced or discontinued completely.

The alkenyl succinic anhydride neutral size conventionally used for sizing gypsum wallboard paper is disclosed in U.S. Patent No. 3,102,064, which also discloses the use of a cationic starch as a retention aid. The
30 general formula of the material is as follows:



35

wherein R is selected from the group consisting of dimethylene and trimethylene radicals, and wherein R' is a hydrophobic group containing more than 5 carbon atoms selected from the group consisting of alkyl, alkenyl, aralkyl and aralkenyl groups.

5 Newslined paper is paper that is put on the back face of the gypsum wallboard which is mounted on the inside of the wall in contact with the supporting frame members. Consequently, it need not have the high grade surface required on the facing side of the wallboard. Newslined paper is typically comprised of low grade materials which are unsuitable for paper
10 which is applied to the face of the wallboard. The low grade constituents are old corrugated container stock which contains many plastics, hotmelt adhesives, wax and other contaminants which may cause bleed-through and are unsuitable for the outer or front face of the wallboard. The newslined is also comprised of sections which are highly coated, thereby creating
15 contamination problems. Newslined can also be inserts cut out of newspapers that are highly coated or printed with rotogravure.

 A substantial cost savings may be accomplished by replacing all or part of the cationic starch. According to the invention the replacement is made by adding a cationic polymer. Basically the cationic density of
20 the material relates to a number of reactive groups on a given length of a molecule. The greater the number, the greater is the cationic density and the greater will be the cationic charge on the retention aid molecule, and this will increase what is known as its coagulating effect. In the present invention the preferred cationic polymer a material of low
25 cationic charge density is preferred. This means that the frequency of cationic charges on a molecule is lower and, therefore, it has a lower overall charge density. The material used in connection with a high molecular weight molecule creates flocculating conditions, where the cationic charge causes the molecule to be attracted to anionic groups.
30 However, the process does not require a very high charge density in order to accomplish the present purpose, but the process depends more on the length of the molecule, and under these conditions the effect which is achieved is flocculation. The cationic charge density is given herein in terms of mole percent.

The present invention may be practiced in either one of two embodiments. In the first embodiment a high molecular weight cationic polymer having a low charge density is introduced into the paper-making process at the discharge of the fan pumps in highly dilute form (for example
5 0.1% concentration). A portion of the cationic starch solution conventionally utilized as a retention aid is eliminated, and only the primary starch or the starch going through the emulsifier for the purpose of providing a cationic charge to retain the neutral size is utilized. By inserting the retention aid polymer only at the discharge of the fan
10 pumps, contamination of the paper-making apparatus is avoided. Additionally a savings in the cost of the eliminated cationic starch is realized.

In a second embodiment of the invention, the two polymer system, in addition to adding a high molecular weight low charge cationic polymer to the discharges of the fan pumps, the entire cationic starch addition
15 is replaced with a primary solution of the same high molecular weight low charge density cationic polymer applied through the emulsifier, and an additional dilute solution of a low molecular weight, high charged density cationic polymer is applied to the machine chest. This results in a substantial savings by eliminating the expensive cationic starch,
20 and results in a clean operating paper-making machine system. Because contamination is avoided, it is not necessary to use a liner stock system sometimes utilized to keep the top press rolls from becoming filled with contaminants. The use of the second polymer, a low molecular weight high charge density cationic polymer coagulant in the machine
25 chest provides cations to counter the anionic trash present in the slurry.

Although the following discussion is not intended to be limiting in any manner, it is believed that what happens with regard to the addition of second polymer to the machine chest is that the strong coagulating
30 power of the polymer causes contaminant particles to coagulate and agglomerate into large particles with eventually considerably reduced tackiness. These larger particles are better retained in the forming web and hence are carried away in the sheet rather than becoming deposited on the paper machine surfaces. It is believed to be fortuitous
35 that the coagulating action occurs in the machine chest, because here the tile surfaces of the machine chest are far less prone to have con-

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taminant plate-out than the rubber coverings of the press rolls, the wire mesh of the cylinders or the fabric of the press felts.

It is believed that in the single cationic polymer system excellent performance is accomplished because the high molecular weight low cationic charge polymer introduced at the discharges of the fan pumps ties the contaminant particles into the forming web without causing them to plate-out on the paper machine equipment. In this bridging type action where the charge density of the polymer is not great, increasing molecular weight of the polymer (more bridging) in close proximity to the forming cylinders (after the fan pumps) is important in tying the contaminants into the forming web without causing them to coagulate and plate-out.

The following examples are provided to illustrate general paper-making processes, and including prior process as well as improved processes of the present invention,. They are provided for illustrative purposes and are not intended to be limiting in any manner.

EXAMPLE 1

GENERAL PROCESS FOR MAKING PAPER FOR GYPSUM WALLBOARD USE

A blend of varying ratios of hard and soft stocks, such as old corrugated stock and sections, respectively, on newslined paper, is pulped, cleaned and refined, and then discharged into a 25,000 gallon tile-lined machine chest. A low molecular weight, high charge density cationic coagulant polymer is added to the paper stock in the machine chest, where applicable, at the rate of about 0.15 to 0.45 dry lb. of polymer per ton of paper. This coagulant serves to coagglomerate fine contaminant particles into larger, more readily retained particles at a point where the agglomeration would not cause plating out of the contaminant on the paper machine surfaces. The resulting stock called "machine furnish" is then pumped at 3-1/2% oven dry consistency to the fan pump inlets of the forming section of the paper machine where the furnish is divided into 7 separate flows corresponding to their introduction to 7 separate fan pumps.

A neutral size emulsion, comprising an ASA (alkenyl succinic anhydride) size emulsified in either a cationic starch or a cationic polymer solution, is added to the machine furnish in the thick stock down legs just prior to

entering the inlet piping to the fan pumps. The function of the cationic starch or the cationic polymer is to cause the size to adhere to the anionically-charged cellulose fibers of the machine furnish in order to provide sizing after subsequent heat curing. The ASA size is added at rates varying between 2.5 and 5.5 dry lb/ton of paper depending on sizing propensity of the furnish and effectiveness of size retention on the paper machine. The flows of machine furnish mixed with size emulsion is diluted to approximately 0.5 to 1.5% consistency with recycled white water from the paper machine, and are then pumped by the fan pumps to the continuously moving forming cylinders of the paper machine. According to the invention, into the discharges of the fan pumps a high high molecular weight, low charge density cationic flocculant polymer is pumped at the rate of 0.40 to 1.35 dry lb/ton of paper for use as a retention aid. The retention aid is mixed with the dilute machine furnish by means of turbulence created by elbows in the approach piping from the discharges of the fan pumps to the forming cylinders. The retention aid serves to improve the retention of cellulose fines and agglomerated contaminant particles which, if poorly retained in the sheet, could become embedded in paper machine surfaces such as carrying and press felts, forming wires and press roll covers.

The machine furnish is formed on the forming cylinders into separate plies which are joined together on a continuously moving carrying felt. The water drained through the wire covers of the cylinders is caused to flow back to the separate fan pumps for dilution of the pulp. A seven ply sheet is formed at 23-25% solids consistency and is carried on continuously moving felts through the press section of the paper machine, where the solids content of the sheet is increased to 40-45%. The sheet by itself is then passed into the dryer section where it is dried to 1.0-2.5% moisture content on continuously turning drying cylinders loaded to a minimum steam pressure of 25 psig for proper curing of the ASA size.

The dried sheet of paper, after leaving the dryer section, passes through a wet calender stack where water is applied to both faces of the sheet for finish by water addition to the rolls at the calender stack via water boxes attached to the calender stack rolls. The sheet

of paper then passes through a following dry calender stack where the caliper or thickness uniformity is improved. After leaving the dry stack the sheet of paper is wound into a set of paper on a reel. Later the set is slit and wound on a winder into separate rolls for
5 later conversion to gypsum board.

When the type of paper produced or the furnish conditions make it necessary, a parallel stock system to the filler stock system, called the liner system is run to provide a two-ply liner on top of the filler stock. Two of the afore-mentioned cylinders are utilized
10 for this purpose. The filler portion of the paper, as a result, consists of five plies. Where the contaminant level in the paper stock furnish causes a high level of contaminant deposition on the paper machine press rolls and carrying and press felts, the liner system is run utilizing paper stock from clean, cut-up rolls of paper.
15 The liner so formed alleviates the press roll deposition problem and allows continued operation of the paper machine. Without this modification, the press rolls would soon be covered with sticky contaminant causing picking of the sheet and eventual sheet breaks.

The problems encountered with contaminant deposition as described
20 above are very typical and frequent while a cationic starch is being added through the ASA size emulsifier and no retention aid is being utilized in the fan pump discharges, and no coagulant is being added to the machine chest. For this reason, under the above conditions the liner system is utilized continuously. Applying the retention aid after
25 the fan pumps, according to the invention eliminates the deposit problem, as will be discussed below, and permits a significant reduction in the rate of total cationic starch usage.

When the high molecular weight, low charge density flocculant polymer is added through the emulsifier in place of the remaining
30 cationic starch, the paper machine deposits again begin to occur. Adding the low molecular weight high charge density cationic coagulant polymer to the machine chest, as in the two polymer embodiment, helps to alleviate the contaminant deposition when the cationic starch is completely replaced with the flocculant, as is discussed below. When
35 either the one polymer system method or the two polymer system method are run, the liner system is not required.

The following example illustrates a process where no retention aid polymer was used, as in prior art processes.

EXAMPLE 2

PAPER PRODUCED WITHOUT ADDITION OF POLYMER AFTER FAN PUMPS

(PRIOR ART)

5 Paper was produced without the addition of any cationic polymer after the fan pumps and had the composition shown below in Table I. The cationic starch solution was pumped through the emulsifier with the ASA size, and was mixed with additional starch solution after the emulsifier.
10 The dilute ASA size emulsion was then pumped to the thick stock lines to the fan pump inlets. Under these process conditions and with the resulting contaminated condition of the furnish a total of 12.5 lb/ton of cationic starch and 5.0 lb/ton of ASA size were required to provide adequate paper sizing, and the liner system had to be run utilizing cut up clean
15 rolls of the same approximate fiber composition as run in the filler stock.

TABLE I

COMPOSITION OF NEWSLINED PAPER PRODUCED WITH NO POLYMER

		Dry lb/ton	% Dry Weight
20	<u>Constituent</u>	<u>of Paper</u>	<u>of Paper</u>
	Cationic Starch Through Emulsifier	3.50	0.175
	Cationic Starch After Emulsifier	9.00	0.450
	ASA Sizing Agent	5.0	0.250
	Soft Stock as Sections		34.000
25	Hard Stock as Old Corrugated Container		65.125

EXAMPLE 3

PAPER PRODUCED WITH ONE CATIONIC POLYMER

RETENTION AID ADDED AFTER FAN PUMPS

30 Paper was prepared by the use of one cationic polymer retention aid applied immediately after the fan pumps and had the composition shown in Table II below. In this example, the cationic starch solution added to

the ASA-starch emulsion after the emulsifier was shut off and was replaced with clarified process water. A high molecular weight, low charge density cationic polymer was added at the rate of 0.5 dry lb/ton paper to the discharge of the fan pumps pumping dilute machine furnish to the forming cylinders. The results of this mode of paper manufacture were that cationic starch usage, was decreased by 9.0 lb/ton or 72% of the usage of Example 2 above. The neutral sizing rate was reduced by 0.5 lb/ton or 10% of Example 2's usage and use of the liner system with its attendant electrical power consumption was eliminated. The paper machine press rolls remained clean with no assistance from the liner system.

TABLE II
ONE POLYMER SYSTEM
PAPER COMPOSITIONS WITH NEWSLINED PAPER

	<u>Constituent</u>	<u>Dry lb/ton of Paper</u>	<u>% Dry Weight of Paper</u>
15	Cationic Starch Through Emulsifier	3.50	0.175
	ASA Sizing Agent	4.50	0.225
	Cationic Polymer After Fan Pump	0.50	0.025
	Soft Stock as Sections		34.000
20	Hard Stock as Old Corrugated Containers		65.575

The following Example 4 illustrates the preparation of a two polymer system using newslined paper according to a further embodiment of the invention.

EXAMPLE 4
TWO POLYMER SYSTEM NEWSLINED PAPER

Paper produced with the two cationic polymers had the composition illustrated in Table III below. In this example, in addition to the polymer added to the fan pump discharge as in Example 3 above, 0.25 dry lb/ton of a low molecular weight, high charge density cationic coagulant polymer was added to the filler system machine chest. Initially, the primary purpose of the coagulant addition was to trap anionic trash

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which consumed a disproportionate share of the cationic size emulsion and reduced the efficiency of sizing. It was discovered that its effect on coagulating furnish contaminant particles was beneficial. This discovery permitted using the afore-mentioned high molecular weight low charge density cationic flocculant polymer in place of the cationic starch in the ASA size emulsifier. It was found that earlier replacement of the cationic starch by this polymer without prior addition of the coagulant into the machine chests caused deposition of contaminant on the paper machine.

In this example all of the remaining cationic starch utilized in the one polymer system was replaced with only 0.15 lb/ton of the polymer flocculant, thus saving an additional 3.5 lb/ton of cationic starch. As in the one polymer system, the high molecular weight, low charge density cationic flocculant was added to the fan pump discharges. The beneficial results of this mode of operation was in the elimination of the use of the expensive cationic starch while still avoiding contaminant deposition. Additionally, a further reduction in ASA sizing rate of 0.5 lb/ton was obtained. Use of the liner system with its significant electrical consumption was also eliminated.

20

TABLE III
TWO POLYMER SYSTEM PAPER COMPOSITION
NEWSLINED PAPER PRODUCED

	<u>Constituent</u>	<u>Dry lb/ton of Paper</u>	<u>% Dry Weight of Paper</u>
25	Cationic Coagulant Polymer		
	Added to Machine Chest	0.25	0.0125
	Cationic Polymer Through		
	Emulsifier	0.15	0.0075
	ASA Sizing Agent	4.00	0.2000
30	Cationic Polymer After Fan Pump	0.50	0.0250
	Soft Stock as Sections		34.0000
	Hard Stock as Old Corrugated Containers		65.7550

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The following examples illustrate the preparation of the various ingredients used in the present invention.

EXAMPLE 5

PREPARATION OF CATIONIC STARCH - ASA EMULSION

5 A pregelled powdered or flaked cationic potato starch was wetted out with fresh water in a hopper-type eductor and was discharged into an agitated mixing tank where full solubility of the starch was achieved over 30-60 minutes, and the starch solution concentration was adjusted to 3%. The completed batch of starch solution was transferred to the holding
10 tank and was pumped at a rate of 3.5 to 4.0 dry lb/ton of paper through a turbine pump size emulsifier, where it served as the size emulsifying medium. An oily ASA (alkenyl succinic anhydride) sizing agent was added at a rate of 3.5 to 5.0 lb/ton of paper to the starch solution just prior to the emulsifier. After emulsification, the solids content of the emul-
15 sion was 6.0% including starch solids.

 The thick-size starch emulsion flowed to the inlet of an eductor where the emulsion was diluted with clarified water at a rate sufficient to lower the solids content of the emulsion to 0.35% solids. The dilute emulsion was then metered through orifices and was then injected into the
20 thick paper machine stock slurry just prior to its entry into the suction of the fan pumps. Subsequently, the thick stock was mixed and diluted with white water drainings from the forming cylinders in the fan pumps.

EXAMPLE 6

PREPARATION OF RETENTION AID POLYMER OF INVENTION

25 The high molecular weight low charge density cationic emulsion polymer, designated herein as polymer "A", consisting of 28-31% polymer solids, 40-43% water and 23-26% hydrocarbon oil was inverted to a 1-3% solids aqueous solution in agitated mixing and holding tanks. The polymer solids consisted of a copolymerization product of acrylamide monomer and
30 cationic trimethyl ammonium chloride methacrylate where the cationic charge density of 7.5 mol percent was provided by quaternary amide groups attached to the polymer. The mean average molecular weight of the polymer was 2,000,000. Wetting out of the polymer was accomplished

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in hopper-type eductors with fresh water.

The moderately dilute aqueous polymer solution was pumped through a rotameter and thence to a mixing eductor with a variable speed, non-pulsing type constant displacement gear pump. Mill clarified water was used as the motivating fluid in the eductor to raise the dilute polymer line pressure to approximately 60 psig pressure and to lower the polymer solids concentration to approximately 0.1% solids.

For addition to paper, the dilute polymer was metered at the rate of 0.40 to 1.35 dry lb/ ton into the dilute paper machine stock slurry just before the forming cylinders at the discharges of the forming cylinder fan pumps. The metering was accomplished through orifices, and introduction of the polymer into the dilute machine stock slurry was done through inlet quills set into the fan pumps discharge piping.

The dilute polymer was mixed with the dilute machine stock slurry in the turbulence that occurs after each bend in the piping before the machine stock reaches the forming cylinders. The dilute machine stock slurry was then formed by drainage through the forming cylinder wires into plies which were co-joined onto a carrying felt. The joined plies were transferred as a web onto another carrying felt, and the web was then pressed between press rolls and contacted by several hot dryer rolls in a dryer section to remove all but the last 2-5% of the moisture from the web.

The sheet was run between steel rolls to provide smoothness and uniform thickness. The paper was wound on a reel and was later slit and rewound on a reel into rolls that were shipped to the market or to the converting stage for making gypsum board.

The following example illustrates the preparation and use of the additional materials for the two polymer system.

30

EXAMPLE #7

PREPARATION OF CATIONIC POLYMER COAGULANT FOR TWO POLYMER SYSTEM

A cationic quaternary amine polymer, designated herein as polymer "B", of very high charge density of 100 mol percent and a low mean average molecular weight of approximately 200,000 was added at the rate of 0.15-0.45 dry lb/ton of paper to the machine chest dilute at 10% of

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the as-received concentration. This polymer was added to the machine chest and utilized to neutralize colloidal anionic furnish components that would have consumed disproportionate amounts of cationically charged size. The polymer served to coagulate dispersed contaminant particles in the machine chest. If such coagulation were to have occurred on the paper machine proper, substantial deposits of contaminants would have been prone to occur on the paper machine components such as the top press rolls, cylinder wires and press felts.

EXAMPLE 8

10 PREPARATION OF CATIONIC - SIZE EMULSION FOR TWO POLYMER SYSTEM

Emulsion polymer, termed "A" in Example 6 related to the one polymer system, was adjusted to a 0.18% solids content solution directly by wetting the polymer with fresh water in a hopper eductor followed by strong agitation in a mix tank. The dilute polymer was transferred to a holding tank and was then pumped through a variable speed gear pump to a turbine pump size emulsifier at a rate of 0.10-0.15 dry lb/ton of paper where it served as the size emulsifier medium. An oily ASA (alkenyl succinic anhydride) sizing agent was added to the polymer solution at a rate of 2.5-5.0 lb/ton just prior to the emulsifier. After emulsification the solids content of the emulsion was 6.2% including polymer solids.

The thick size-polymer emulsion flowed to the inlet of an eductor where the emulsion was mixed with a volume of clarified process water equal in volume to 30 times the volume of the emulsion, thus providing a dilute emulsion of 0.19% solids concentration. This dilute emulsion under approximately 60 psig pressure was metered to the thick stock slurry lines ahead of the forming cylinder fan pumps through orifices. The dilute emulsion was added to the thick stock slurry through injection quills set into the thick stock slurry lines. The thick stock slurry was diluted with recycled white water drainage from the forming cylinders and then was pumped to the forming cylinders as dilute machine stock slurry.

EXAMPLE 9PREPARATION AND USE OF RETENTION AID POLYMER

This polymer was formed and introduced in the same manner as in Example 6 above.

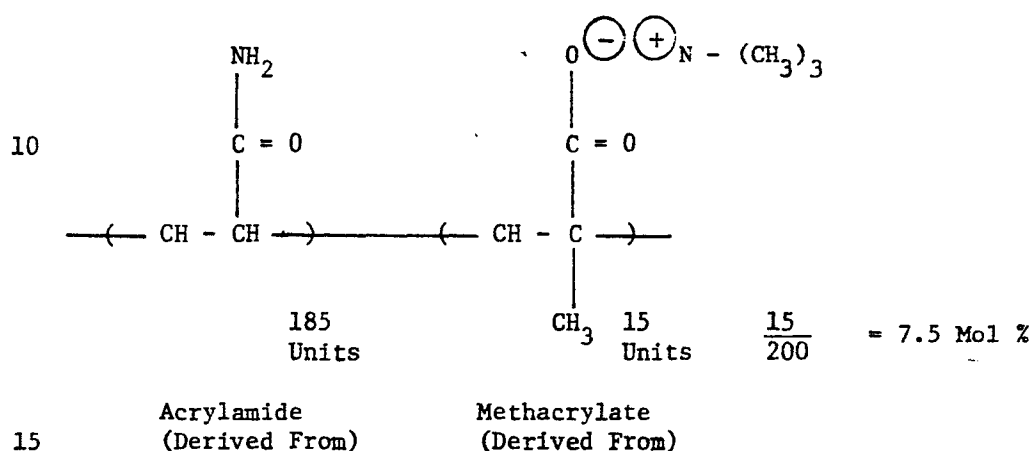
EXAMPLE 10STARCH - SIZE EMULSIFYING SYSTEM

5 A pregelled powdered or flaked cationic potato starch was wetted out with fresh water in a hopper type eductor and was discharged into an agitated mixing tank where full solubilization of the starch was
10 permitted to occur over 30-60 minutes, and the starch solution concentration was adjusted to 3%. The completed batch of starch solution was transferred to the holding tank and was pumped with a centrifugal pump to a turbine pump emulsifier at a rate of 2.5-5.0 lb/ton. ASA size as previously discussed was added at a rate of 4.5 to 5.5 lb/ton
15 to the starch solution before emulsification in the starch solution as emulsifying medium.

The size emulsion concentration leaving the emulsifier was 6%. The size emulsion was mixed with a continuous flow of more starch solution equal to a rate of 6 to 11.5 dry lb/ton of starch in an
20 eductor to provide a dilute emulsion solids concentration of 4%. The dilute size emulsion was then metered to separate forming cylinders through separate rotameters for each forming cylinder. The starch-size emulsion then flowed to injection quills in the thick stock lines to the fan pump suctions where it was added to the thick stock. The sheet of
25 paper was then formed as described above.

DESCRIPTION OF MATERIALS USED IN THE PRESENT INVENTION
IN BOTH THE ONE POLYMER AND TWO POLYMER EMBODIMENTS

The retention aid polymer added to the discharge of the fan pumps according to the invention is a copolymerization product of acrylamide monomer and cationic trimethyl ammonium chloride methacrylate. The material has a cationic charge density of 7.5 mol percent. Materials having a mean average molecular weight of from 2,000,000 to 4,000,000 may be utilized. The structure of the polymer is as follows:



The formula product above is furnished commercially by the manufacturer Dow Chemical Company, Midland, Michigan in the following form:

28-31%	Polymer Solids
40-43%	Water
23-26%	Hydrocarbon Oil

Other materials that may be utilized are Betz 1260 or 1264 which are copolymers of a quaternary amine and acrylamide with a mean average molecular weight of 5×10^6 . The polymer has a cationic charge density of 20 mol percent. The amine provides the cationicity.

1260 is a dry material and 1264 is an emulsion polymer of 30% active polymer solids content.

Another material which may be utilized is Hercules Reten 210 which is an acrylamide/quaternary ammonium salt monomer copolymerization product which has a molecular weight in the range of $9-10 \times 10^6$, a cationic charge density 7.5 Mol percent, and is supplied as a dry powder.

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With respect to the two polymer system embodiment, the cationic polymer coagulant is a cationic quaternary amine polymer of 200,000 mean average molecular weight and 100 Mol percent charge density. It is supplied at low solids in solution under the trademark Nalco 7625, and
5 supplied by Nalco Chemical Co., Oak Brook, Illinois.

Alternatively a Dow coagulant under the trademark Polymeric PC Copolymer formed of acrylamide and cationic monomer 50/50 by weight, can be used. The cationic monomer is a quaternary methyl ammonium chloride salt with the monomer part cyclic in structure. The cationic
10 charge density is 7 mol percent, the range of molecular weight is $1.0-1.5 \times 10^6$. It is supplied as an 8% aqueous solution.

Still another coagulant which may be used is sold under the trademark Quaker 3015 and has a basic structure of polyamino/amide with a molecular weight range of from 200,000-300,000 and a cationic charge density of 50
15 mol percent. It is supplied as a liquid solution containing 38% solids.

The gypsum board paper produced above utilizing the two-polymer system processes was subjected to a number of quality control tests to make sure that it met minimum standards required for proper conversion to wallboard. Table IV below provides test data obtained by testing
20 wallboard produced by using the paper produced by the methods described above. In the table, tests of both manila and newslined gypsum board paper met the indicated standards per test. The sizing or water resistance of both papers as indicated by the saturations and cobb water resistance tests was good. Sheet strength in terms of ply bond and
25 tensile strength were also good. The manila paper tested above was made up of 2 plies of a flyleaf liner stock applied to 5 plies of a filler stock consisting of box plant kraft cuttings and waste news. The newslined paper was made up of 7 plies of a blend of old corrugated container stock and waste stock.

30 The gypsum board papers described above were converted into gypsum board on a conventional board line where stucco slurry was spread onto the inside face of the manila where the flyleaf topline was face down.

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a forming roll or forming plate on a continuously moving forming belt. The board when fully set was cut into 8 foot lengths, inverted and conveyed to a drying kiln where it was dried by forced convection drying. The board after leaving the drying kiln was inspected and tested, and then made into bundles and shipped.

5 Gypsum board produced as discussed above must meet a variety of quality tests in order to reach the market. The covering papers must bond well to the gypsum board core, and the board must possess adequate transverse strengths. The dry bond test is conducted by first drying
10 the finished board for one hour at 110°F in a forced convection oven, and then subjecting the board to a force sufficient to break the bond between the paper and the board core. The applied force or weight at failure is the measure of bond strength. The bond failure is designated as the percentage of the tested board surface that becomes exposed or
15 has no fiber covering after the bond has been broken. In reference to Table IV it is apparent that both manila and newslined paper bonded well to the gypsum core because the bond strengths fall within the desired range and the bond failure test shows zero bond failure for both papers.

20 Transverse strength tests were conducted by first conditioning the finished board for 16 hours in a 70°F and 50% relative humidity environment, and then applying a downward force in the center of the specimen supported at its opposing outer edges. The face positioned downward is the face which is tested. Force applied at failure is the measurement of transverse strength.

25 Referring to Table IV it is evident that the gypsum board met both machine-direction and across-direction minimum transverse strength standards on the sides faced with the manila and newslined paper.

The various paper and board tests indicate that the polymer-treated paper, as produced in the two-polymer system processes, makes acceptable
30 gypsum board. Additionally, it permits the elimination of expensive cationic starch.

TABLE IVPolymer Treated Paper Tests Results

		<u>Manila</u>	<u>Newslined</u>
	Caliper, mils	16	16
5	Basis Weight, lb/1000 ft. ²	55.9	53.1
	Porosity, seconds	86.0	19.4
	Saturation, minutes (Minimum, 6.0)	120+	120+
	Cobbs, grams (Maximum, 1.0)	0.70	0.66
	Ply Bond, lb/in. (Minimum, 60.0)	63.9	64.8
10	<u>Tensile, lb/in.</u>		
	Machine-Direction (Minimum, 80.0)	86.7	88.7
	Cross-Direction (Minimum, 23.0)	25.0	25.7

Results of Tests on Gypsum Board Prepared With Polymer-Treated Paper

	Dry Bond Strength, lb. force		
15	(Desired range, 9-15 lb. force)	11.0	11.3
	Dry Bond Failure, %	0	0
	<u>Transverse Strength, lb. force</u>		
	Machine-Direction (Minimum, 40.0)	40.0	46.3
	Across-Direction (Minimum, 110.0)	112.5	150.0

- 20 The method of the present invention offers several advantages over prior art methods utilizing a neutral size for making paper suitable for gypsum wallboard. In the one-polymer method a high molecular weight low charge density retention aid polymer is added immediately after the fan pumps instead of at a prior position. This results in the prevention of
- 25 the deposition of contaminants on the cylinder wires, press and carrying felts and for press rolls of the paper-making machine. Additionally, it permits a reduction in the use of a cationic starch retention aid, a material which is considerably more expensive on a total use basis than the polymers utilized. In the two-polymer method, a high molecular low
- 30 charge density polymer of the same type is added immediately after the fan pumps, obtaining the benefits described with regard to the one-polymer method.

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Additionally, a small amount of the same polymer is introduced into the emulsifier, thereby completely replacing the use of the cationic starch. Additionally, a low molecular weight high charge density polymer is added to the machine chest in order to further cause agglomeration of

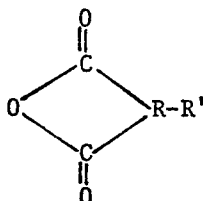
5 contaminant products present in the slurry. As a result of the use of the two-polymer system, contamination is avoided and the use of the cationic starch is completely eliminated. Additionally, because the apparatus is maintained in clean condition and the resulting paper is clean, a paper liner need not be applied to the surfaces of the paper.

10 It is to be understood that the invention is not to be limited to the exact details of operation or materials described, as obvious modifications and equivalents will be apparent to one skilled in the art.

CLAIMS

1. In a process for producing paper in a paper-making apparatus suitable for use in the production of gypsum wallboard, the process comprising preparing a pulp slurry, introducing a neutral size material and a cationic retention material into the slurry, passing the slurry through a plurality of fan pumps and forming and drying the paper, the improvement which comprises the step of introducing a high molecular weight low cationic charge density retention aid polymer into the slurry immediately at the discharge situs of the fan pumps, whereby any contaminants present in this slurry are retained therein and do not deposit out on the walls of the paper-making apparatus.

2. A process according to Claim 1, when said neutral size material has the structural formula:



wherein R is selected from the group consisting of dimethylene and trimethylene radicals, and wherein R' is a hydrophobic group containing more than 5 carbon atoms selected from the group consisting of alkyl, alkenyl, aralkyl and aralkenyl groups.

3. A process according to Claim 2, wherein said cationic retention material is a cationic starch.

4. A process according to Claim 2, wherein said high molecular weight low cationic charge density retention aid polymer is a copolymerization product of acrylamide monomer and cationic trimethyl ammonium chloride methacrylate, having a mean average molecular weight of from about 2,000,000 to about 4,000,000, and a cationic charge density of 7.5 mol percent.

5. A process according to Claim 4, wherein said high molecular weight low charge density polymer is added in an amount of from 0.40-1.35.

6. A process according to Claim 1, wherein said cationic starch for the neutral size is added in an amount of 2.5-4.0 dry lb./ton.

7. A process according to Claim 1, which additionally comprises passing said slurry into a machine chest, wherein a low molecular weight
5 high cationic charge density polymer coagulant is introduced in said machine chest.

8. A process according to Claim 7, wherein additionally a portion of said high molecular weight low cationic charge density polymer is introduced into an emulsifier and then into said aqueous slurry to replace said
10 cationic starch as a retention aid.

9. A process according to Claim 7, wherein said low molecular weight high density cationic charge polymer is a cationic quaternary amine polymer having a mean average molecular weight of about 200,000 and a charge density of about 100 mol percent.

15 10. A process according to Claim 9, wherein said cationic coagulant polymer added to said machine chest in the amount of about 0.15-0.45 dry lb./ton.