

March 6, 1934.

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METHOD OF AND APPARATUS FOR HYDRATING CELLULOSE PULP

Filed May 8, 1933

2 Sheets-Sheet 1

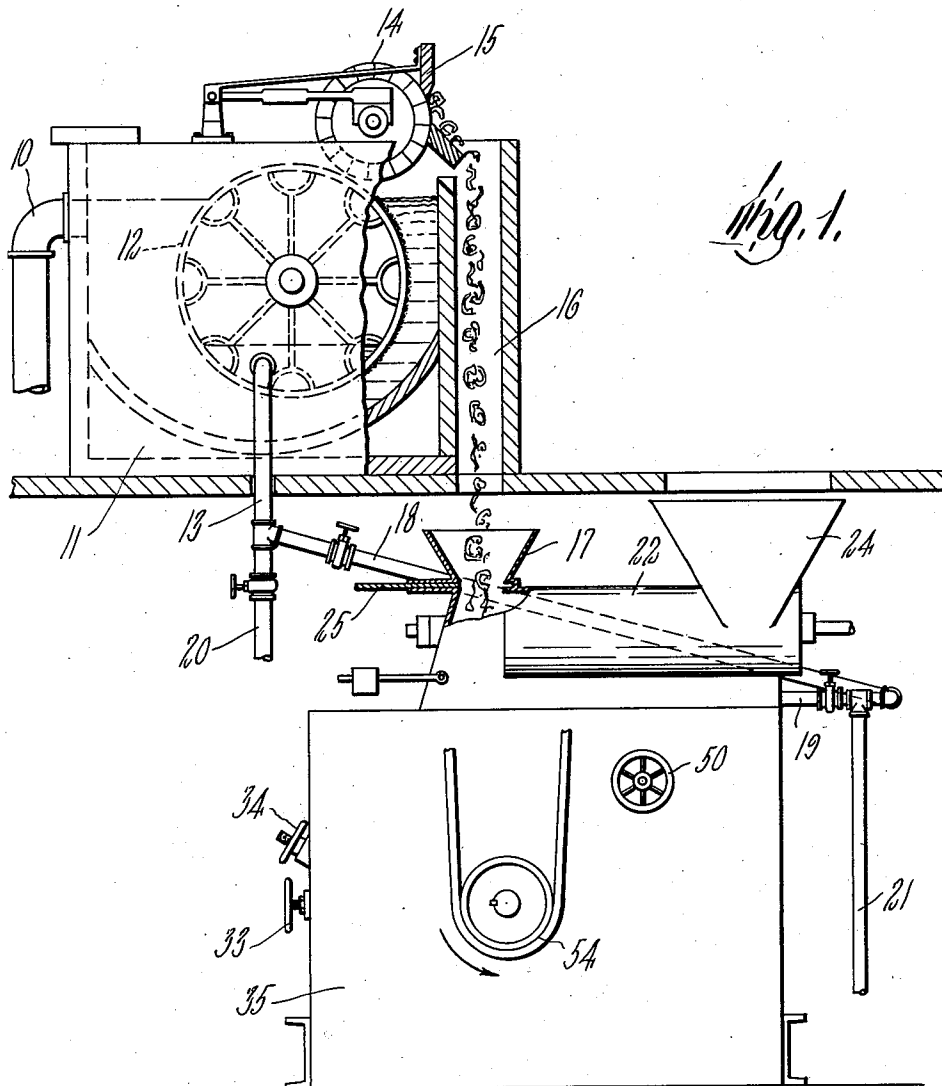


Fig. 1.

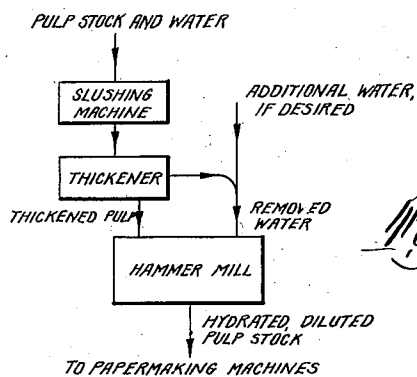


Fig. 2.

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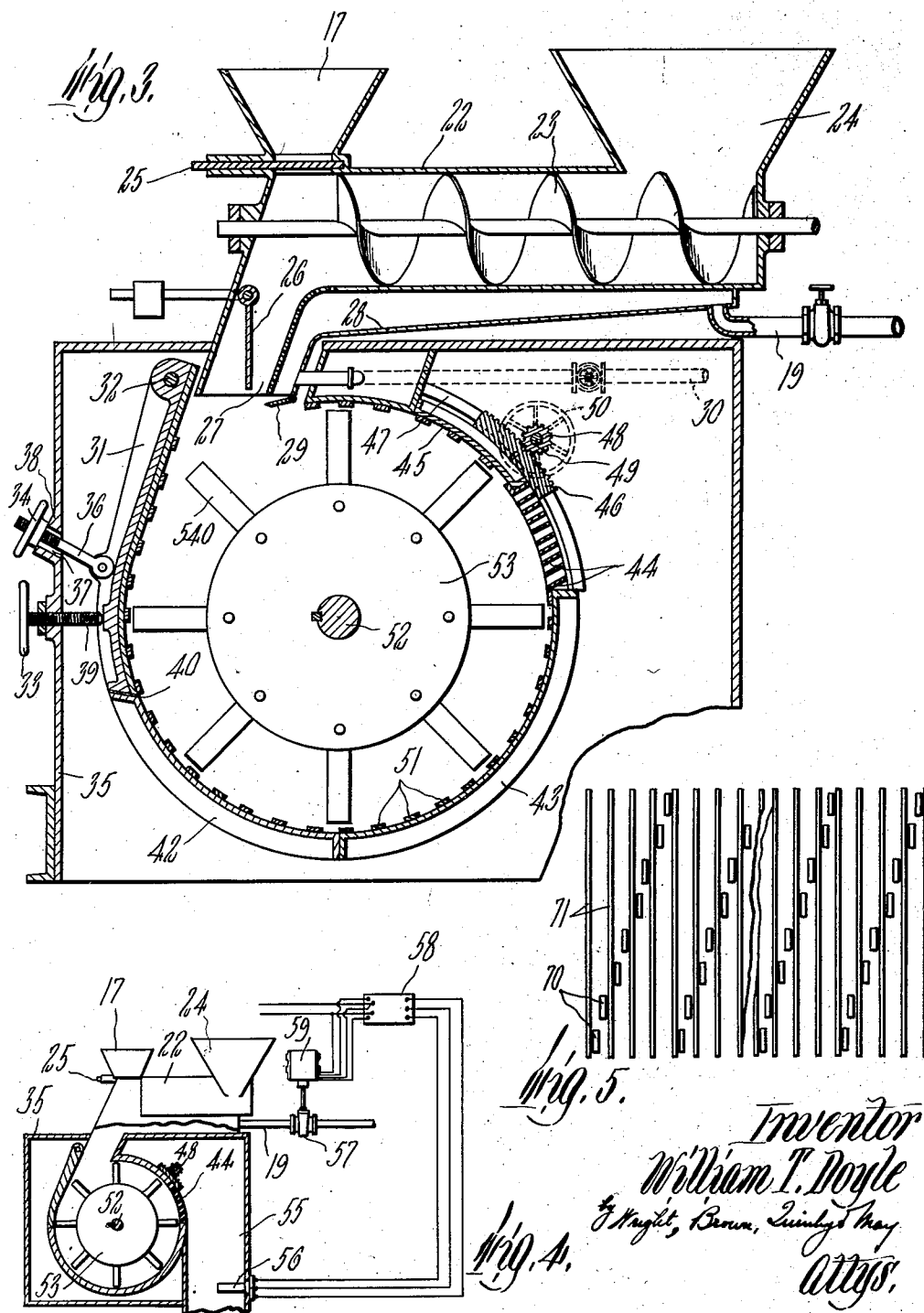
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UNITED STATES PATENT OFFICE

1,949,534

METHOD OF AND APPARATUS FOR HYDRATING CELLULOSE PULP

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Application May 8, 1933, Serial No. 669,804

11 Claims. (Cl. 92—20)

This invention relates to a method of and apparatus for hydrating or beating pulp stock. An object of the present invention is to employ a so-called rotary hammer mill as the hydrating or beating instrumentality in combination with other equipment under conditions such that the pulp stock may be fed as a continuous stream only once through the system and emerge therefrom in a state suitable for delivery to the paper-making machine with little, if any, jordaning or other after-treatment.

I have found that when pulp stock has been slushed with water so as to form a more or less uniform and flowable suspension, the passage of the suspension through a rotary hammer mill has to be repeated a number of times, as disclosed and claimed in my application Serial No. 607,528, filed April 26, 1932, now Patent No. 1,905,161, dated April 25, 1933, before a degree of hydration satisfactory for paper-making is reached therein. This means, of course, that the efficiency and capacity of the hammer mill is cut down even though it may excel the ordinary Hollander or beater engine in these respects.

I have now found that by working with pulp stock which has been thickened to such an extent that it tends to remain largely, if not entirely, in the rotary hammer mill, it is possible to effect the desired hydrating or gelatinizing action on the fibers and also the desired discharge from the hammer mill, provided that diluting water is introduced separately into the hammer mill in appropriate amount. Such practice is highly advantageous in that it enables the progressive feeding of a stream of stock, which has undergone suitable previous disintegration to permit such feeding, into the hammer mill together with a separate stream of a diluting water, preferably part or all of the white water removed from the stock during the thickening operation. While in the hammer mill, the stock undergoes a swift succession of hammering impacts and is simultaneously and intimately mixed with the diluting water to form a hydrated stock suspension of sufficient dilution to issue freely from the restricted discharge opening of the hammer mill. Evidently, one of the reasons why such practice is effective is because the hammers are given an opportunity to work on comparatively thick stock while it is being mixed with the diluting water. Thin stock does not permit of such working thereupon in a hammer mill, as the thin stock is simply circulated through the hammer mill and discharged therefrom without having had its fibers undergo material hammering, combing, or

abrading action. It is well known, on the other hand, that thick stock resists intimate dilution with water and may hence have considerable mechanical energy expended thereupon while it is undergoing such dilution. The fact is that the results realized by feeding the thick stock and diluting water in separate streams into the hammer mill are markedly better than those realized when the thick stock is admixed with the diluting water and the mixture is then introduced into the hammer mill. The work done on the stock while in the hammer mill can be controlled by the temperature of the stock issuing from the hammer mill. To this end mechanism responsive to the temperature of the stock coming from the hammer mill may be provided to regulate automatically those factors which determine the work being done by the hammer mill. Included among these factors are the size of discharge opening, the speed at which the hammer mill is run, and the amount of diluting water introduced into the hammer mill, the automatic regulation of the last-named factor being hereinafter described.

With the foregoing and other features and objects in view, my invention will now be described in greater detail with reference to the accompanying drawings, wherein:

Figure 1 represents a composite view of apparatus embodying the invention and provided with two forms of pulp thickeners.

Figure 2 is a flow sheet illustrating the steps practiced according to my invention.

Figure 3 is a section through the apparatus and only one of the pulp thickeners.

Figure 4 illustrates diagrammatically the apparatus equipped with an automatic water-regulator.

Figure 5 illustrates diagrammatically a preferred hammer and disk arrangement for the rotor of the hammer mill.

As shown in Figure 2, pulp stock and water are initially mixed in a slushing machine to the desired consistency, sent to a thickener, and the thickened stock then delivered to a hammer mill. The water removed during the thickening operation and, if desired, additional water may be delivered together with the thickened stock to the hammer mill wherein it is hydrated and diluted so that it can be sent directly as discharged to the paper-making machine or to refining engines.

The pulp suspension produced in the usual so-called breaker beater or in a slushing machine such as described in my application Serial No. 110

627,547, filed August 5, 1932, now Patent No. 1,910,382, dated May 23, 1933, may have a consistency of about 5%. This suspension may be passed to any suitable form of thickener, for instance, a screw-press or a cylinder mold. The apparatus of Figure 1 includes both forms of thickeners. As shown in this figure, the slushed pulp may be delivered from a pipe 10 into a vat 11 wherein a cylinder mold 12 rotates partially submerged in the pulp suspension. The pulp is picked up on the usual wire cloth forming the periphery of the mold while the excess water drains inside of the mold from which it flows through a drain pipe 13 entering through a side wall of the vat into the pool of water collecting in the lower portion of the mold. The layer of thick pulp picked up by the mold is removed by a couch roll 14 exerting the desired pressure on the mold, whereupon the pulp scraped from the roll 14 by a doctor blade 15 falls down a sluice 16 into a hopper 17 leading to the intake of the hammer mill. The water removed during the thickening operation through the pipe 13 may be passed through a pipe 18 joining with a pipe 19 serving to deliver it into the intake of the hammer mill. When only part of the water removed during the thickening operation is needed in the hammer mill, some may be diverted from the pipe 13 to a waste pipe 20. If desired, however, additional water may be supplied from a pipe 21 to the pipe 19. The feeding of the diluting water may be advantageously done under pressure, as through spray orifices or nozzles which may be arranged to discharge directly onto the thick stock entering into the hammer mill. The discharge of the water may be effected substantially uniformly over a zone of thick stock extending from one end of the casing to the other, as by spacing the spray orifices or nozzles in the hammer mill casing in a line running parallel to the axis of the hammer mill and thus delivering the water sprays or jets on the stock under conditions making for substantial uniformity and smoothness of diluting action on the stock.

The hopper 17 and the pipe 19 may form part of the screw-press assembled with the hammer mill. The press may include a cylindrical casing 22 arranged horizontally and a screw or worm conveyor 23, whose shaft extends axially through the casing and passes through suitable journals in the ends of the casing and which is rotated by suitable means, not shown. A hopper 24 is shown arranged to feed dilute stock into one end of the casing and the hopper 17 to feed pre-thickened stock into the other end of the casing. When the screw-press is running, the hopper 17 may be closed as by a slide valve 25. The stock propelled through the casing is forced downwardly past a pivoted gate valve 26 whose size of opening may be varied, depending upon the degree to which dewatering of the stock is desired. The wall of the casing opposite the gate 26 is apertured to permit the escape there-through of the water squeezed from the stock as it is forced through the constricted outlet 27 into the intake of the hammer mill. The squeeze water is led as a stream into the hammer mill along with the thickened stock by a partition 28 formed as a jacket about the lower wall of the casing 22. At the lower end of the jacket space may be a valve or gate 29 which is adjustable to permit the desired amount of squeeze water to run into the hammer mill. Such water as may be excessive can be permitted to go to waste

through an overflow pipe 30 arranged immediately above the valve 29. When the screw-press is idle and pre-thickened stock is being delivered to the hopper 17, or when more water than that being squeezed by the press is desired in the hammer mill, the valve 29 can be fully opened to permit the desired influx of water from the pipe 19 which is shown communicating with the upper end of the jacket space.

The hammer mill may comprise generally a cylindrical casing within which is a rotor equipped with spaced rows of swingably mounted hammers. The casing shown in Figure 1 is made up of a plurality of sections, the section 31 adjacent to the intake opening being pivoted at its upper end, as at 32, to permit its adjustment toward and away from the hammer ends. A hand wheel 33 may be fixed to the outer end of a screw 39 threaded through the wall 35 of a housing within which the hammer mill is placed, the inner end of the screw bearing against the section 31. A hand wheel 34 may be threaded on a link 36 whose outer end portion passes loosely through an opening 37 in a boss 38 against which the hand wheel bears and whose inner end is pivotally secured to the section 31. It is thus seen that the screw 39 keeps the section 31 from outward movement and that the link 37 keeps it from inward movement and further that any change in the position of the link necessitated by the adjustment of the section is permitted by its looseness of fit in the opening 37. The lower edge 40 of the section 31 may make nice sliding fit with the adjacent edge of a lower section 42 which, together with the next section 43, constitutes substantially the lower half of the casing. The discharge opening of the casing may be afforded by a series of spaced bars 44 spanning the ends of the casing in the arcuate zone between the upper end of the section 43 and the lower end of a section 45 whose upper end is spaced sufficiently from the upper end of the section 31 to furnish an intake opening of the desired size. The size of the discharge opening may be controlled by an arcuate gate 46 whose side edges are slidably fitted in ways 47, whose outer surface is formed as a rack, and whose inner surface fits nicely over the outer edges of the bars 44 over which is designed to slide. The rack is engaged by a pinion 48 fixed to a shaft 49 passing out through the side wall of the housing and having a hand wheel 50 affixed to its end. All of the sections are preferably provided on their internal surfaces with spaced ribs or bars 51 serving to promote the desired brushing and combing action on the pulp. The rotor of the hammer mill shown comprises a shaft 52 to which is keyed a series of spaced disks 53 carrying rows of hammers 540 pivotally secured thereto at their inner end. The rotor may be provided with the usual spacers between disks and be constructed otherwise in any approved manner. It may be rotated as by a belted pulley 54 affixed to the end of the shaft 52 passing through the housing, as shown in Figure 1. The stock issuing from the restricted discharge opening 44 of the hammer mill may enter a sluice 55, as illustrated in Figure 4, wherein it comes into contact with a thermostat 56 forming part of a regulator for controlling the opening of a valve 57 in the water-line 19. There are various regulators on the market for accomplishing this result so that I need not describe the details of any particular one, excepting to say that I may, for example, employ a Minneapolis-Honeywell regulator which includes a re-

lay 58 through which a reversible motor 59 operates to control the extent of opening or closing of the valve 57 according to the temperature of the stock issuing from the hammer mill. Rather than controlling automatically the work done on the stock by mechanism responsive to the temperature of the stock being discharged, it is possible for the operator so to do by turning the hand wheel 50 and thereby varying the overall size of discharge opening of the hammer mill, since, as already indicated, the size of such opening is also a factor determinative of the amount of work done on the stock. It is further possible to control by hand the amount of diluting water introduced along with the thick stock into the hammer mill and thereby to determine the amount of work done on the stock. I have observed that when thick stock alone is introduced into the hammer mill so that no discharge can be had through the restricted discharge opening, the power consumption is relatively low for the reason that the stock is merely propelled or circulated round and round the hammer mill. By running diluting water along with the thick stock into the hammer mill, work is expended in mixing the two as well as in effecting a discharge, the amount of work done being a function of the amount of diluting water employed.

I have already adverted to the fact that the hammer mill has a "restricted discharge opening". By this expression is meant an opening or series of openings of such dimensions that a comparatively non-fluent stock, that is, a stock of a consistency greater than about 5% will not be freely discharged by the discharging force exerted by the mill alone. When dewatering of the stock is done by a screw-press which exerts considerable extraneous feeding pressure on the stock introduced into the hammer mill, a discharge of the stock from the hammer mill may be had at consistencies of as high as about 10% or even greater. A forced discharge at such high consistency is attended by extreme hydration and cutting or bruising of the fibers such as is desired for glassine papers or hard boards. Ordinarily, however, it is desired to produce paper possessed of both high tear resistance and bursting strength such as is producible from a stock whose hydration has been effected while preserving its fibers at maximum length. In such ordinary instance, therefore, the stock is discharged at consistencies downwards of about 5% essentially through the centrifugal action of the mill and such pressure as is exerted upon the stock by the swift movement of the hammers therethrough, although some pressure-feeding of the stock may be desirable in such instances, too. The usual cylinder-mold thickener, from which the thickened stock gravitates under little pressure head into the mill, can be used to good advantage in dewatering the stock going to the mill, when the hydrated stock is to be discharged from the mill at consistencies downwards of about 5%. This form of thickener can dewater the stock to consistencies as high as about 15% to 30%, the particular amount of dewatering done depending upon the pressure exerted upon the cylinder mold by the couch roll and upon the suction created in the interior of the mold or under the layer of pulp deposited on the mold. The dewatering action of a screw-press may be considerably greater, for instance, be sufficient to yield stock of 30% to 50% or even higher consistency.

In any case, the diluting water introduced into the hammer mill along with the thickened stock

is fed at such a rate as to ensure a discharge through the restricted discharge of opening. There may be more water removed during the thickening operation than is necessary for effecting a discharge of the hydrated stock from the hammer mill. Let us assume, for example, that a screw-press being supplied with a 5% stock thickens it to a 30% consistency and that it is desired to discharge such stock under extraneous pressure at a 10% consistency so as to realize extreme hydration. In such case, little more than half of the white water removed during the pressing operation is introduced along with the pressed stock into the hammer mill, the rest being bled off from the system. In another instance, let us assume that the original stock has a consistency of 10% and that it is desired to discharge it from the hammer mill at a consistency of say, 5% or less. In such case, all the white water removed from the stock during the pressing or thickening operation should be fed into the hammer mill and sufficient water added therewith to produce an efflux of the desired 5% or thinner stock from the mill. In still another instance, only the water removed from the original stock during the pressing or thickening operation may be added to the pressed or thickened stock in the hammer mill so as to cause an issuance of hydrated stock from the mill at the same consistency as that of the original stock entering the dewatering instrumentality. In an extreme case, the stock entering the hammer mill may be in a substantially dry, comminuted condition such as can be had by putting sheets of dry pulp through a shredding machine or other suitable disintegrator which reduces the sheets to particles permissive of uniform, stream-feeding into the hammer mill along with a stream of sufficient extraneous water to ensure discharge of the hydrated stock from the mill. The feeding of a stream of comminuted stock so concentrated is, however, less efficient than when the stock is preliminarily disintegrated or slushed in the presence of water and, despite the partial dewatering operation which it then undergoes, is fed as a stream of wet stock carrying at least about 50% water into the hammer mill, as such latter practice makes for greater smoothness of running of the mill and more uniform action upon the stock. In other words, the feeding of substantially dry stock into the hammer mill may give rise to intense localized working on the dry stock and injury to its fibers before it has had an opportunity to become wetted with water. Even in the case of stock which is to be hydrated or gelatinized drastically, as for the manufacture of glassine paper, it is desirable that such energy as is expended on the stock should be put therein while it is wet in order to induce maximum hydration or gelatinization therein.

It might be well to dwell upon some of the characteristics of a hammer mill such as can be successfully used in the practice of my invention. The rotor of such a hammer mill may be run at a speed of about 1800 to 3600 R. P. M. or even higher with its hammer tips removed about one foot from the axis of the rotor and hence moving at a lineal speed of 10,800 to 21,600 feet per minute or even greater. The discharge opening may comprise twelve slots of, say, one-eighth inch width and twenty inch length running parallel with the axis of the rotor. Such slots are preferred over circular or other shaped openings for the reason that the desired over-all discharge area may be realized over a narrower

arcuate zone of the casing while ensuring adequate structural strength in the casing and exposing fewer cutting edges, the latter feature being especially desired when fiber length is to be preserved. The hammer tips moving through the stock are preferably comparatively thin and well-spaced from one another in each row. They may, for example, be of a thickness of one-quarter to one-half inch and be separated from one another about one-half to one inch. It is thus possible to get good relative movement between the stock and the hammer tips moving there-through, and accordingly, to do the desired work on the stock, for if the hammer tips were thick and close together, the tendency would be for the hammers to entrain and carry the stock with little actual work being done on the stock. In other words, the design is such as to effect a swift succession of impacts on the stock with concomitant brushing and combing of its fibers rather than to carry the stock entrapped virtually as solid masses between the successive rows of hammers and, when the hammer tips clear the internal wall of the casing, to leave in effect a static layer of pulp next to the internal wall. It will, of course, be understood that I am using the term "impacts" as applied to the stock in its broad sense to include the blows which the stock receives from the hammers when they clear the internal wall of the casing as well as when they strike the wall. As to the term "hammer mill", I wish it to be understood that while my invention comprehends a hammer mill preferably provided with swingably mounted hammers, as hereinbefore described, it is not limited thereto but is meant to include hammer mills equipped with rigidly mounted hammers and other instrumentalities capable of effecting an equivalent action.

40 An arrangement of hammers and disks for the hammer mill rotor designed to maximize relative movement between the hammer tips and the stock is diagrammatically illustrated in Figure 5. Here the thin hammers 70 are not arranged in straight rows on the successive disks 45 71 but are arranged in diagonal lines so that the hammers in a given diagonal line contact with successive portions of the stock axially of the hammer mill at different times. The disks 50 70 on which the hammers are mounted as already described accomplish in effect a partitioning or separation of the stock into individual stock zones, each of which can be kept in a comparatively quiescent state while other zones are being acted upon by the hammers, thereby con- 55 ducing to maximum relative motion between each stock zone and the hammers associated therewith. When the stock is acted upon as a single mass, movements in one portion of the mass are transmitted more or less to other portions which, 60 when they are impacted by the hammer tips, have less work done thereupon on account of the lessened relative motion between such other portions and the hammer tips.

65 In operating the hammer mill so as to hydrate the stock and at the same time to realize both high tear resistance and strength in the paper made for the hydrated stock, the operating conditions may be quite different from those maintained when drastically hydrated stock such as 70 to enter into glassine paper is to be prepared. In the first case, the hammer mill may be run at relatively low speed with the hammer tips clear of the internal wall of the casing, with 75 the entire discharge area open, and with the

stock being discharged at a consistency of downwards of about 5%. In the second case, the hammer mill may be run at much higher speed with the hammer tips striking up against the internal wall of the adjustable casing section so as to shear the fibers, with only part of the discharge area open, with the stock being discharged at a consistency upwards of about 5%, and with pressure feeding of the stock so as to ensure the desired rate of discharge. 80 85

It is of course possible to vary the features of design and the conditions of operation of the apparatus of the present invention. Indeed, I have discussed typical apparatus and conditions simply to illustrate the application of my invention to various paper-making requirements. The typical hammer mill which I have described as having a rotor of a particular diameter may, for example, be redesigned with a rotor of larger diameter, in which case the lineal speed of the hammer tips might be increased, but this advantage might be more than offset by the lower speed of rotation possible of attainment with the larger sized rotor and the loss of centrifugal force contributing to the discharge of the stock from the hammer mill, which loss might be quite serious when no pressure-feeding of the stock is relied upon to effect such discharge. 90 95 100

It is possible to add to the stock while it is undergoing the hydrating action in the hammer mill according to my invention, various paper-making ingredients, including sizes, precipitants, colorants, loading or filling materials, etc. An advantage of so doing is that intimate admixture of such paper-making ingredients with the stock is effected while the latter is undergoing the desired hydrating or gelatinizing action,—so much so that no subsequent mixing need be effected. In other words, it is possible to condition the paper-making stock to a finished stage in a single continuous operation, by which I mean that the stock as it comes from the hammer mill may be delivered directly to the paper-making machines with little, if any, jordaning. Indeed, the paper-making ingredients may form part of the stream of diluting water or of the stream of pump stock supplied to the hammer mill in accordance with my invention. It is thus seen that it is possible by my invention to achieve continuity of practice as applied not only to the hydration or gelatinization of pulp stock, but as applied also to the sizing, coloring, and loading of the stock, since the sizing, coloring, and loading ingredients may be fed in the desired controlled quantity as continuous streams either into the stream of stock or into the stream of diluting water. 105 110 115 120 125 130

I claim:—

1. A method which comprises disintegrating cellulose pulp stock to permit its feeding as a stream, and progressively feeding a stream of the disintegrated stock in concentrated condition together with a separate stream of diluting water into a rotary hammer mill whose discharge opening is restricted and wherein said stock undergoes a swift succession of hammering impacts and said diluting water is simultaneously and intimately mixed therewith to form a hydrated stock suspension of sufficient dilution to issue from said discharge orifice. 135 140 145

2. A method which comprises disintegrating cellulose pulp stock to permit its feeding as a stream, and progressively feeding under pressure a stream of the disintegrated stock in concentrated condition together with a separate, pressure-fed stream of diluting water into a rotary 150

hammer mill whose discharge opening is restricted and wherein said stock undergoes a swift succession of hammering impacts and said diluting water is simultaneously and intimately mixed therewith to form a hydrated stock suspension of sufficient dilution to issue from said discharge orifice.

3. A method of hydrating cellulose pulp stock for paper-making or the like, which comprises slushing the pulp stock in water, thickening the resulting aqueous suspension, and introducing the thickened suspension together with a separate supply of diluting water into a rotary hammer mill wherein said stock undergoes a swift succession of hammering impacts and said diluting water is simultaneously and intimately mixed therewith to form a hydrated stock suspension issuing from said hammer mill.

4. A method of hydrating cellulose pulp stock for paper-making or the like, which comprises slushing the pulp stock in water, progressively removing part of the water from the resulting aqueous suspension, and progressively feeding the partially dewatered suspension and at least part of the removed water as separate streams into a rotary hammer mill whose discharge orifice is restricted and wherein said stock undergoes a swift succession of hammering impacts and said diluting water is simultaneously and intimately mixed therewith to form a hydrated stock suspension of sufficient dilution to issue from said discharge orifice.

5. A method which comprises disintegrating cellulose pulp stock to permit its feeding as a stream, progressively feeding a stream of the disintegrated stock in concentrated condition under pressure together with a separate stream of diluting water into a rotary hammer mill whose discharge orifice is restricted and wherein said stock undergoes a swift succession of hammering impacts and said diluting water is simultaneously and intimately mixed therewith to form a hydrated stock suspension of sufficient dilution to issue from said discharge orifice, and controlling the work done on said stock while in said hammer mill by the temperature of the stock suspension issuing therefrom.

6. A method which comprises disintegrating cellulose pulp stock to permit its feeding as a stream, progressively feeding a stream of the disintegrated stock in concentrated condition together with a separate stream of diluting water into a rotary hammer mill whose discharge orifice is restricted and wherein said stock undergoes a swift succession of hammering impacts and said diluting water is simultaneously and intimately mixed therewith to form a hydrated stock suspension of sufficient dilution to issue from said discharge orifice, and controlling the

amount of water fed into said hammer mill by the temperature of the stock suspension issuing therefrom.

7. Apparatus of the class described comprising in combination means for partially dewatering a stream of aqueous pulp suspension, a rotary hammer mill having an intake opening arranged to receive said stream of partially dewatered pulp suspension and having a discharge opening, and means for delivering a stream of water into said intake opening along with said stream of partially dewatered pulp suspension.

8. Apparatus of the class described comprising in combination means for partially dewatering a stream of aqueous pulp suspension, a rotary hammer mill having an intake opening arranged to receive said stream of partially dewatered pulp suspension and having a discharge opening, means for delivering a stream of water into said intake opening along with said stream of partially dewatered pulp suspension, and means for varying the amount of work done on said suspension while in said hammer mill.

9. Apparatus of the class described comprising in combination means for partially dewatering a stream of aqueous pulp suspension, a rotary hammer mill having an intake opening arranged to receive said stream of partially dewatered pulp suspension and having a discharge opening, and means for delivering water removed by said first-named means into said intake opening along with said stream of partially dewatered pulp suspension.

10. Apparatus of the class described comprising in combination a hammer mill having intake and discharge openings, means for progressively feeding a pulp suspension through said intake opening into said hammer mill, and mechanism responsive to the temperature of the suspension issuing from said discharge opening for automatically regulating the amount of work done on said suspension while in said hammer mill.

11. Apparatus of the class described comprising in combination means for partially dewatering a stream of aqueous pulp suspension, a rotary hammer mill having an intake opening arranged to receive said stream of partially dewatered pulp suspension and having a discharge opening, means for delivering a stream of water into said intake opening along with said stream of partially dewatered pulp suspension, and mechanism responsive to the temperature of the suspension issued from said discharge opening for automatically controlling the amount of water delivered by said water-delivering means into said intake opening.

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