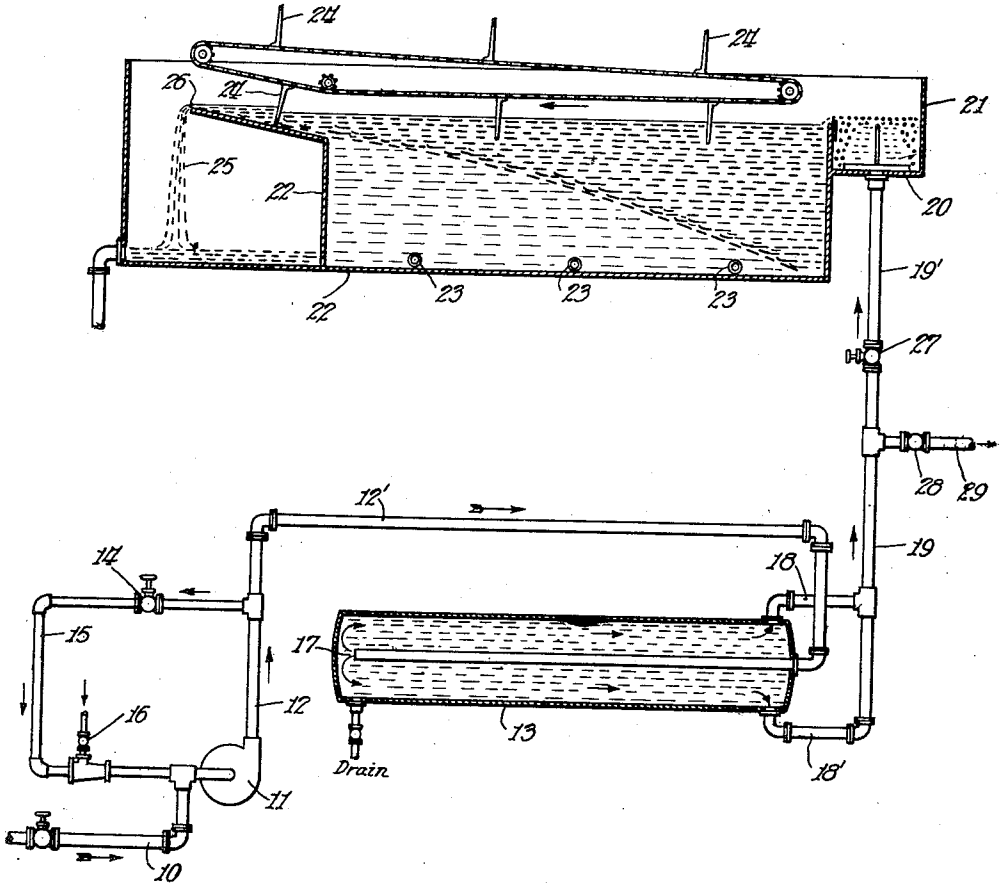
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PROCESS FOR REMOVING DIRT FROM WOOD PULP

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PROCESS FOR REMOVING DIRT FROM WOOD PULP

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The present invention relates to an improved process for removing various types of dirt specks, including grit, pipe scale, bark and knot specks, etc. from wood pulp. More specifically, the present invention is directed to the removal from mechanical or groundwood pulp of that type of dirt which is formed in situ in the grinding process, i. e. dark colored specks which are formed by the comminution of knots and bark present on and imbedded in the pulp wood logs.

Mechanical or groundwood pulp, unlike chemical pulps such as the sulfite and kraft cooked pulps, contains in addition to the cellulose fibers all of the wood, including the complex lignin and hemi-cellulose materials. It is produced by pressing a peeled or barked pulp wood log against the surface of a revolving stone, the rotating axis of the stone being substantially parallel with the grain or fiber direction of the log. The abrasive or cutting action of the grit of the stone combined with the pressure and temperatures created on grinding results in the cutting and breaking of the wood from the parent log. In the process the entire log, including the knots, etc., is reduced to fine fibrous fragments. The knots, at least at their outer periphery, are most generally discolored with stains or pitchy material which when reduced to a fine particle size results in what is commonly called "dirt specks" in the mechanical pulp. With certain species used for groundwood, notably poplar, the knots are frequently partially encased with bark which results in the groundwood pulp being further contaminated with additional dark colored dirt specks.

In contrast to groundwood, the chemical pulps do not generally contain excessive amounts of dirt, hence do not require special treatments to remove the dirt specks coming from the above described knots and bark. In producing a chemical pulp, e. g. a sulfite pulp, the logs are chipped prior to the chemical cooking process with the result that many of the knots are broken out as whole knots or at least as large pieces. These large pieces are removed by the chip screens and do not get into the digester where the chips are cooked. In the event that small chips or pieces of knots and bark do get into the digester, they go through the cooking process more or less unchanged as far as size is concerned and are removed from the pulp by the knotter screens. The dirt particles in chemically cooked pulp that do pass through the screens and finally remain in the pulp are relatively few in number as compared with the amount of dirt which would have resulted from producing groundwood pulp from the same quality of pulp wood logs. Also, chemically cooked dirt specks, unlike uncooked groundwood dirt specks, are rendered unnoticeable during the bleaching operations used to bleach chemical pulps.

In order to produce a groundwood pulp which is sufficiently clean, i. e. free of dirt specks, to be used in the better grade of papers or tissues, it is necessary (*a*) to remove the contaminating source prior to the groundwood process or (*b*) to remove the dirt from the pulp after the wood with its associated dirt-forming barky knots has gone through the grinding process. The removal of the sources of the dirt such as by the selection of only the highest quality of wood for use in the groundwood process is very costly and wasteful of wood and has proven commercially impractical. In view of this, attempts have been made to remove knots and their encasing bark by various cleaning operations in the wood room prior to grinding. Knot saws and knot drills have been tried, for

example, but have proved unsatisfactory as the logs contain numerous hidden knots which are not visible on the surface. Spruce, one of the species most commonly used in the groundwood process, also contains an extremely large number of "pin" knots, the removal of even a majority of which would be impractical. Poplar, another pulp wood species, contains fewer knots than spruce but the knots are generally much larger and frequently are ingrown so that only a bump appears on the surface, masking a large diameter knot with encrusted bark. In addition to requiring much manipulation resulting in excessive labor costs, wood cleaning operations, like selection, have also proven to be wasteful of wood. Practical operating experience has demonstrated that it is not possible to produce a groundwood of the desired dirt-free quality level by either selection or cleaning of the wood prior to grinding in the groundwood process.

In view of the above, the art has made many attempts to remove or bleach out the dirt specks from groundwood per se, i. e. from the wood after the grinding operation. These have included screening operations and in particular chemical treatments. The use of screens has proven unsatisfactory as the knots and bark are reduced to a fine state of sub-division during grinding and the resulting dirt specks have been found to pass through the screens with the finely divided clean wood. The chemical treatments employed have been of the bleaching type. Illustrative procedures are described in the following U. S. patents: 1,991,824 and 2,450,034 (zinc hydrosulfite); 2,187,016 and 2,199,376 (alkaline peroxide); and 2,474,034 (alkaline hypochlorite). The processes described in these patents, as well as the multiple bleaching stage operations used to bleach chemical pulp, bleach the fibers and improve the brightness or color of the groundwood but do not remove or even appreciably improve the color of the knot and bark specks. The alkaline hypochlorite process described in Patent 2,474,034, for example, removes (bleaches) dirt specks caused by heart or fungi rot but does not remove or bleach out the color of the relatively large objectionable specks caused by knots and bark.

The quality level of groundwood from the standpoint of the number of permissible dirt particles per unit area depends upon the size of the dirt specks and on the end use of the finished sheet of paper containing the groundwood. If the groundwood is to be used in the production of a high grade white printing paper, the fewer dirt specks it contains the better. In specifying dirt sizes a Dirt Estimation Chart has been developed by d'a Clarke and is now used generally in the paper industry. In this classification chart various shapes are grouped together according to the area of the dirt particle. There are four classifications having the range of areas given below:

Class 1—0.04–0.1 mm.^{2}
Class 2—0.1–0.5 mm.^{2}
Class 3—0.5–1.5 mm.^{2}
Class 4—1.5–5.0 mm.^{2}

In the better classes of book paper which are used in magazine publications carrying multi-colored advertisements, an appreciable number of class 1 specks is permissible, a few class 2 specks are allowable in an 8½x11 sheet, while classes 3 and 4 dirt specks should be entirely absent. Experience in producing groundwood, especially from poplar which contains bark encased knots, has established that the pulp contains some class 3 and 4 dirt specks and a very large number of class 1 and 2 specks.

During the research investigation leading to the present invention, attempts using various physical and chemical methods were tried as in the past to remove or bleach out the dirt specks from groundwood. The physical methods which were tried were based upon gravitational and centrifugal principles. Processes employing these principles proved satisfactory for removing pieces of grit, pipe scale and the like which have densities appreciably different than the groundwood pulp. These processes, however, failed to solve the primary problem as they did not give the desired separation of particles of bark and knots from the groundwood. Careful measurements of the densities of encased bark and knots and

sound wood have demonstrated why the desired separation is not accomplished. The values obtained by isolating encased bark and knots and 100% sound poplar wood and grinding separately, followed by a screening and collecting the particles which passed a 40 mesh screen and were retained on a 60 mesh screen, are given below in Table I. The samples were all soaked in water for several days and evacuated to insure thorough saturation with water.

TABLE I

	Specific gravity
Encased bark	1.51
Knots	1.50
100% sound wood	1.50

An analysis of this data makes a separation based upon density differences appear impossible. Experience has borne this out as none of the physical processes known heretofore give the desired degree of cleanliness, i. e. remove the objectionable bark and knot specks from groundwood pulp.

The attempts to solve the problem by chemical means have likewise been unsuccessful. Illustrative results obtained using 100 per cent poplar bark and knot particles with the alkaline hypochlorite bleaching process described in Patent No. 2,474,034 using 30 per cent available chlorine, are tabulated below as brightness values as measured on the General Electric Brightness Tester.

TABLE II

Brightness values

	Unbleached	Bleached
Bark Around Knots	9.9	11.3
Knots	20.2	28.3

The 30 per cent available chlorine employed is about 2.5–3.0 times the quantity ordinarily recommended for bleaching poplar. With less available chlorine the improvements in brightness values, if any, were less than those obtained using the abnormally large quantities of available chlorine. It is obvious from these results, as groundwood should have a brightness of 70–78 to be used in the better grades of printing papers, that bleached bark and knots with brightness values of about 11 and 28, respectively, will show up as dirt specks or blemishes and present a very unsightly appearance in the finished sheet.

The attempts to solve this problem were made by the paper industry because groundwood imparts desirable printing properties to paper and is a preferred type of pulp for many uses. It is also relatively easy to prepare and bleach and compared to chemical pulp, is relatively low in cost. However, up until the present invention, groundwood pulps, and particularly groundwood pulps prepared from low cost woods such as poplar which provides a relatively strong pulp of superior opacity, have not been given widespread use in the high grade papers, better printing papers, etc., due to the failure of the art to provide a commercially practical method for removing objectionable bark and knot specks from pulp.

The principal object of the present invention is to provide a commercially practical process for separating dirt specks from wood pulp.

Another object of the present invention is to provide a process for making groundwood which is contaminated with dirt specks and not suitable for use in high grade papers, adaptable for use in the manufacture of such papers.

A more specific object of the present invention is to provide an improved process for separating discolored bark and knot specks, formed in situ during the grinding operation, from groundwood.

Other objects of the present invention will be apparent as the description proceeds.

The process of the present invention is based on the discovery that in a dilute aqueous wood pulp, and particularly a groundwood pulp suspension, finely divided air bubbles are selectively occluded by or attached to the pulp and not to dirt specks, including dirt specks derived from bark and knots formed in situ during the grinding operation. The occlusion of the bubbles on the pulp has been found to be adequate to impart a temporary buoyancy to the pulp causing it to float to the surface of the suspension.

The reason for the selective occlusion of air bubbles on the pulp resulting in increased buoyancy is not fully understood. The phenomenon is believed, however, to be at least in part a physical process as it is not permanent. A chemical process may also be involved, particularly with groundwood pulp which is made up of lignin and other complex substances in addition to cellulose fibers.

The air bubbles used in the process of the present invention may be formed in or introduced into the aqueous pulp suspension by various methods known in the art. In one of the preferred methods, the air bubbles are formed by dissolving air under pressure in the pulp suspension by maintaining the pulp under pressure in the presence of excess air followed by a reduction of the pressure with or without the application of vacuum. This results in the formation or release of extremely small bubbles of air in situ and may be readily carried out in a pressurized tank of the type discussed in detail below. The air may also be introduced into the suspension by rapidly agitating or beating of the pulp suspension with stirring or mixing equipment which produces a vortex and brings air into the suspension. Other means of air dispersal in place of the pressure or agitation methods may also be used, as, for example, the introduction of the air into the suspension through porous plates and the like, cascading of the pulp suspension, etc. Any type of aerating equipment may be employed as long as it brings fine air bubbles into intimate contact with the pulp in the pulp suspension.

The density differential between the pulp with occluded air and the dirt particles has been found to be sufficiently wide and to persist for a sufficiently long time to permit their separation with equipment based upon gravitational or centrifugal principles or a combination of both principles. As previously stated, these principles cannot be utilized satisfactorily for separating pulp from bark and knot dirt without the use of air since under these conditions the densities of the pulp and dirt are too close. (See Table I above.)

The gravitational principles which may be employed to effect the separation after the treatment of the pulp suspension with air are settling basins, rifflers and various types of "save-alls." A well known "save-all" is the Sveen-Pedersen Saveall employing a pressurized tank and flotation chamber described in detail at pages 37–41 in the Paper Trade Journal of August 11, 1949. The centrifugal types of equipment which may be used to effect separation of the treated pulp from dirt include low speed centrifuges, and the Vortrap and Dirtec type of equipment described in TAPPI, vol. 32, No. 10, pages 454–457 of October 1949, and references cited therein.

The single figure of the drawing is a schematic view illustrating one method of practicing the invention.

The following examples will serve to illustrate the present invention.

EXAMPLE I

This example employs the equipment illustrated in the drawing. An aqueous slurry of unbleached poplar groundwood at about 0.25% consistency and contaminated with bark and knot dirt specks enters the system through conduit or pipe **10** and, except for the portion recycled, is pumped continuously by pump **11** through conduits **12** and **12'** into a ten gallon retention or pressure tank **13** where it is maintained at a pressure of about 80 lbs./in. sq. for about 1.5 minutes. The portion of the slurry recycled and which may be controlled by valve **14** passes by way of pipe **15** to pump **11**. Air is injected into the stock at the rate of about 0.15 ft.^{3}/min. by means of a venturi **16** in line **15**. As the stock enters the retention tank **13** at **17** and leaves at the other end through pipes **18** and **18'**, there is little or no channeling. The rate of flow is also about 6.5 gals./min. which is adequate to keep the stock under pressure in the tank for about 1.5 minutes.

The stock flows from the pressure tank **13** through pipes **18** and **18'** and pipe **19** and as valve **27** is in opened position and valve **28** is in closed position, then flows by way of pipe **19'** through an inlet disc valve or orifice shown at **20** into a surrounding compartment or inlet chamber **21** where the pressure is reduced to atmospheric pressure. This results in the release in situ of a large number of extremely fine bubbles of air. The aerated

stock then flows from compartment 21 into a flotation chamber or settling basin 22 equipped with a standard constant level device (not shown) for removing clarified water and dirt from the bottom as indicated at 23. The flotation chamber 22 is also provided with slowly moving skimming or scraper blades 24 for removing the pulp 25 which rises to the top. The clean pulp as it leaves the settling basin at 26 is at a consistency of about 2.33% and is ready for use in the manufacture of high grade papers.

EXAMPLE II

About three parts by weight of unbleached poplar groundwood contaminated with bark and knot dirt specks is first suspended in a mixing tank in about 1,000 parts of water. Air is next whipped into the resulting slurry which is at about a 0.3 per cent consistency by stirring for about one minute with a high speed mixer. The aerated stock is then pumped from the mixing tank to a settling tank where the dirt specks settle to the bottom and the pulp with occluded air bubbles rises to the top and is removed. While the use of this equipment is not generally preferred in commercial operations, tests have demonstrated that it is adequate to remove the objectionable class 4 specks, about 60–70 per cent of the class 3 specks and 45–50 per cent of the class 2 specks.

EXAMPLE III

This example employs the pressurized tank and flotation chamber of Example I and follows the same procedure as Example I. In place of unbleached groundwood used in Example I, the present example employs bark and knot contaminated alkaline hypochlorite bleached poplar groundwood bleached in accordance with the process described in U. S. Patent 2,474,034. The bleached groundwood at a consistency of about 0.2% is first aerated in the pressurized tank right after the completion of the alkaline bleach, i. e. prior to acidification or neutralization, while at an alkaline pH of about 9–10. The clean groundwood recovered from the flotation chamber is substantially free from objectionable dirt specks and is of the type desired for use in the manufacture of the better grades of printing papers.

EXAMPLE IV

This example employs the pressurized tank of Example I in combination with a Vortrap. A dilute suspension (0.4% consistency) of unbleached poplar groundwood contaminated with bark and knot dirt specks is first aerated in the pressurized tank 13 in accordance with the procedure of Example I. As valve 27 is placed in closed position and valve 28 is placed in open position, the stock instead of going to the inlet and flotation chambers as in Example I, passes through pipes 18, 18' and 19 and then pipe 29 where it is fed directly into a 1" Vortrap (not shown) which passes 25–30 gals. per minute at an inlet pressure of 60 lbs./sq. in. The clean pulp collected at the discharge of the Vortrap is of the same quality as that obtained in Example I.

Unbleached groundwood which has been properly aerated will float equally well in a flotation chamber under neutral, acidic or mildly alkaline conditions. However, as unbleached groundwood tends to become brownish in color in the presence of alkali, pH values of above about 8 should be avoided when treating unbleached groundwood. Alkaline bleached groundwood is less sensitive to color change than unbleached groundwood and as it floats more rapidly at the alkaline pH values, the use of a pH range of about 8–11 is preferred for the flotation of alkaline bleached groundwood. In practice it has been found best to aerate the bleached groundwood after the completion of the alkaline bleach and before the second stage or acidifying or neutralizing step of the bleaching process. Acids such as sulfur dioxide, hydrochloric acid, etc. and alkalies such as caustic soda may be added to the pulp to obtain the desired pH.

Investigations have demonstrated with gravitational separation as in the case of a flotation chamber, that the consistency of the pulp should preferably be about 0.20–0.25 per cent and should not exceed about 0.35 per cent for optimum results. With centrifugal equipment such as the Vortrap, higher consistencies up to about one per cent may be employed. Lower consistencies may also be employed with either gravitational or centrifugal separation, although the use of highly diluted suspensions with consistencies much below 0.20 has been found impractical in mill operations.

Investigations have also demonstrated that the aeration of the pulp and subsequent separation of dirt from pulp may be advantageously carried out at the normal temperatures encountered with slush groundwood in the paper mill. These temperatures range from about 30–50° C. Lower temperatures may be used, as for example when lapped pulp is repulped with fresh or cold water, but under these conditions the desired flotation of the aerated pulp takes place more slowly.

The time required for obtaining the optimum amount of aeration of the groundwood slurry depends upon the aeration method employed, temperature of the pulp, etc. In a pressurized retention tank of the type employed in Example I at about 40–80 lbs./in. sq., and a temperature of about 30–50° C., the stock should remain in the tank for at least about one minute. Optimum aeration times for particular equipment may be readily ascertained by preliminary experimental test. Also, although the invention is applicable to other types of pulp, it is of special value for treatment of groundwood pulp as described herein.

The process of the present invention may be carried out without added chemicals. Small amounts of surface active agents which lower the interfacial tension, such as 1–5 per cent (based on the weight of the oven dry pulp) of the aliphatic alcohol sulfate wetting or dispersing agents sold under the trade name "Duponol" may, however, be added to the pulp before aeration if desired to effect a more rapid flotation of the pulp. Small amounts of flocculating agents such as 1–5 per cent (based on the weight of the oven dry pulp) of alum either alone or in conjunction with the surface active agents may also be used if desired to increase the rate of flotation of the pulp. The use of added chemicals, however, is not necessary in the present invention, and in any event, the use of chemicals which produce froth or foam should be avoided as they carry the bark and knot specks along with the pulp and prevent the desired separation. The use of chemicals which produce froth or foam should also be avoided as they give trouble in subsequent papermaking operations.

We claim:

1. The method of improving the characteristics of groundwood pulp containing wood fiber contaminated with dirt particles, including discolored bark and knot specks, which comprises effecting the addition of air to a dilute aqueous suspension of said pulp, increasing the pressure on said suspension, and then passing said suspension into a pressure release zone, the amount of air introduced into said suspension prior to movement of said suspension into said pressure release zone being substantially in excess of the amount of air which the suspension will retain under the conditions prevailing in said release zone, whereby the release of air in said suspension in said release zone effects flotation of said wood fibers within said suspension and movement of dirt particles in the opposite direction, and separating the floated fibers from the contaminants.

2. The method of improving the characteristics of groundwood pulp containing wood fibers contaminated with dirt particles, including discolored bark and knot specks, which comprises aerating a dilute, aqueous suspension of said pulp by entraining air in said suspension and by passing said suspension and entrained air into a pressure zone, passing the resulting air-containing suspension into a second zone which is maintained under such conditions that the maximum pressure in said suspension while it is in said second zone is substantially less than the pressure existing in said pressure zone, thereby effecting release of very small air bubbles through said pulp suspension and flotation of said fibers within said suspension, and separating the floated fibers from the remaining contaminants.

3. The method of improving the characteristics of poplar groundwood pulp containing wood fibers contaminated with dirt particles, including bark and knot specks, which comprises effecting the addition of air to a dilute aqueous suspension of said pulp by entraining air in said suspension and by passing said suspension and entrained air into a pressure zone which is maintained at a pressure within the range of from about 40 to 80 pounds per square inch, passing the resulting air-containing suspension into a second zone which is maintained under such

conditions that the maximum pressure in said suspension while it is in said second zone is substantially less than the pressure existing in said pressure zone, thereby effecting the release of very small air bubbles through said suspension and flotation of said wood fiber within said suspension, the amount of air added to said suspension prior to movement of said suspension into said second zone being substantially in excess of the amount of air which the suspension will retain under the conditions prevailing in said second zone, and separating the floated fiber from the remaining contaminants.

4. The method of improving the characteristics of groundwood pulp containing wood fibers contaminated with dirt particles, including discolored bark and knot specks of such size relative to the size of the fiber that it is not practical to remove the specks by screening, which comprises effecting the addition of air to a dilute, aqueous suspension of said pulp by entraining air in said suspension and by passing said suspension and entrained air into a pressure zone which is maintained at a pressure within the range of from about 40 to 80 pounds per square inch, said suspension being maintained in said pressure zone at least about one minute, passing the air-containing suspension into a pressure release zone maintained under such conditions that the maximum pressure in said suspension, while it is in said pressure release zone, is substantially less than the pressure existing in said pressure zone, thereby effecting release of very small air bubbles throughout said suspension, flotation of wood fibers within said suspension, and movement of the contaminating dirt particles in a direction opposite to the direction of movement of said wood fibers, the amount of air added to said suspension prior to movement of said suspension into said pressure release zone being substantially in excess of the amount of air which the suspension will retain under the conditions prevailing in said pressure release zone, and thereafter separating the floated fiber from the remaining contaminants.

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