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SHEET MATERIAL FROM SOLID PARTICLES
SUSPENDED IN LIQUID MEDIA
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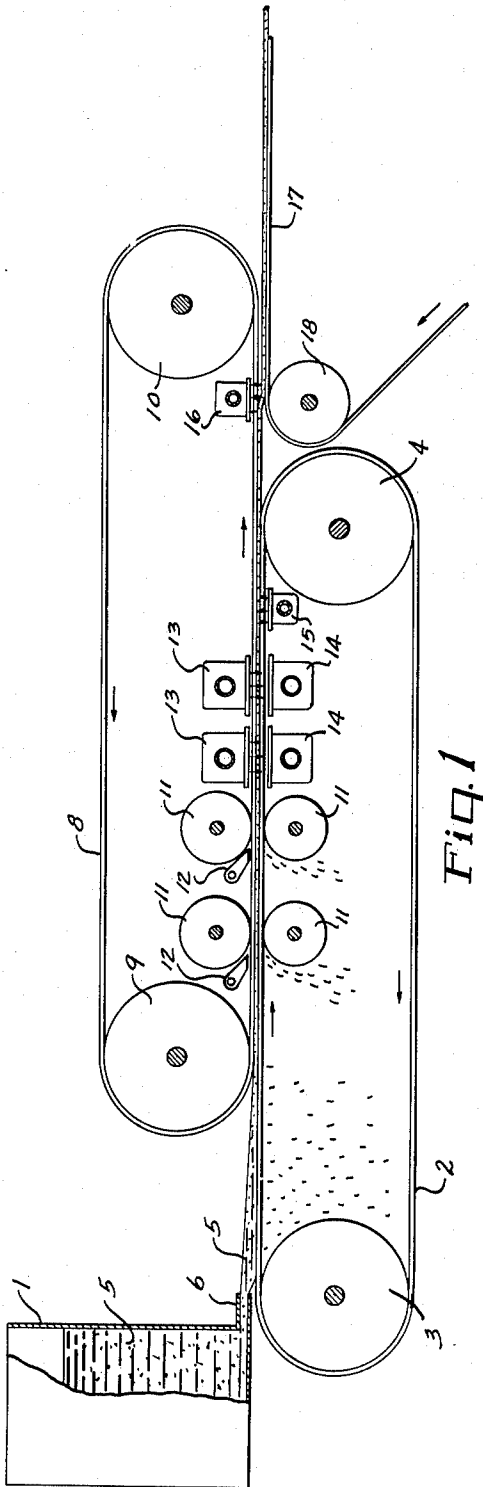


Fig. 1

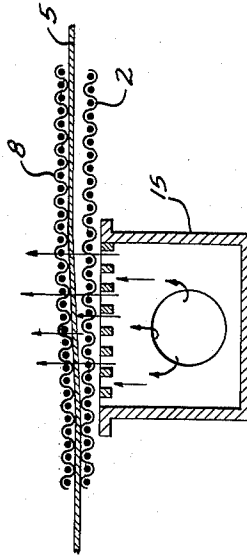


Fig. 2

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METHOD AND APPARATUS FOR THE MANUFACTURE OF SHEET MATERIAL FROM SOLID PARTICLES SUSPENDED IN LIQUID MEDIA

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5 Claims. (Cl. 92—38)

This invention relates to an improved method and apparatus for the manufacture of sheets of material from solid particles initially suspended in liquid media. While my method and apparatus are adapted for use in filtration-type manufacturing operations they are particularly adapted for use in the manufacture of paper from suspensions of wood pulp in water. For this reason, the improved method and apparatus will be described as it applies to the manufacture of paper. The broad objects of the invention are:

(1) To eliminate certain physical limitations inherent in conventional papermaking methods whereby higher speeds and greater economy may be obtained.

(2) To eliminate from the papermaking process the necessity of continually making highly precise and critical adjustments, the adequate execution of which requires rigorous training of highly skilled personnel.

(3) To provide more economical mechanical means for water removal.

(4) To substitute positive-pressure pneumatic means for removing water from the wet paper sheet in lieu of negative-pressure pneumatic means and thereby achieve greater economy.

Since the remarkable advance in papermaking methods attributed to Fourdrinier, improvements in the papermaking process have generally been limited to mechanical refinements of the original Fourdrinier machine. As a result, the following factors inherent in the Fourdrinier method have continued to constitute decisive impediments to a substantial increase in productivity of the papermaking process:

(1) All conventional methods for removing water mechanically from the manufactured sheet have heretofore been operated from the underside of the wire mesh upon which the sheet of paper is formed, because the extremely fragile and delicate wet sheet cannot withstand any direct mechanical action.

(2) Principally because of the above general limitation, means of removing water from the formed sheet of paper have been restricted almost exclusively to negative-pressure pneumatic means disposed within the sheet-forming portion of the machine. These means are severely limited in respect to the intensity of water-removing force which can thus be induced; they are highly uneconomical from a power consumption standpoint; and, in conjunction with the best conventional performance of press sections, they leave an undesirably high percentage of water remaining in the manufactured sheet which must subsequently be removed by means of the extremely expensive process of direct evaporation through the application of heat. This requirement of heat energy represents the greatest single energy cost of the sheet-making process.

(3) The conventional removal of the manufactured sheet from the wire mesh upon which it is formed as heretofore practiced, by pulling it physically from the mesh, represents a major source of distortion and weakening of the sheet.

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(4) In addition, the conventional method of removing the sheet from the wire mesh upon which it is formed requires the sheet to undergo a sharp angular change of direction when it is pulled loose from the wire mesh.

5 This sharp angular change of direction induces a physical stress within the sheet which is proportional to the change of direction and the linear speed of the sheet. As the linear speed of papermaking machines has been increased, this induced accelerative stress has increased and has reached such proportions that any further increase of this stress would cause the sheet to disintegrate.

10 In accordance with my invention, I provide a method and apparatus for making paper wherein, among other features:

15 (a) The original Fourdrinier method is employed to remove from the pulp-water mixture that water which drains freely from the mixture through the wire mesh.

(b) Two endless wire mesh belts are employed between which the wet sheet is conveyed and, while between said belts, is subjected to the pressure of suitably positioned rolls for the mechanical removal of water;

(c) While between the two wire mesh belts, the sheet is further subjected to jets of air from a positive pressure source on one side and to negative pressure on the opposite side to remove more water therefrom; and,

(d) Means are provided for removing the sheet from the wire mesh belt without substantial change of direction.

20 In the accompanying drawing, forming a part of this application, Fig. 1 is a diagrammatic illustration of my invention; and,

Fig. 2 is a detail sectional view of the means for loosening the sheet on the wire.

Referring to the drawing, the headbox 1 contains the water-pulp mixture 5, which flows from the slice 6 onto the moving endless wire mesh belt 2, referred to in the trade as the "wire," which is supported by the breast roll 3 and the couch roll 4. The hydrostatic head in headbox 1 is so adjusted that the pulp-water mixture 5 flows from the slice 6 at a rate equal to the rate of movement of the wire 2. Under the influence of gravity the water flows through the interstices of the wire 2, leaving the pulp of the water-pulp mixture deposited upon the upper surface of the wire 2.

45 A second moving endless wire 8 supported by driven rolls 9 and 10 is mounted over the belt 2 and is so disposed that its lower reach contacts lightly the upper surface of the pulp deposited upon the upper surface of the wire 2. The wire 8, and its associated supporting roll 9, is located at such distance from the head box 1 that sufficient time is permitted for free-draining water to pass through the wire 2 before the surface of the deposited pulp passes underneath the roll 9. It will also be seen that the lower reach of the wire 8 extends beyond the wire 2 in the direction of movement of the sheet. This feature is important, as will later be explained, in that it provides means for disengaging the sheet from the wires without substantial change in its direction of movement.

60 In operation, the wire 8 is caused to move at a speed exactly equal to the speed of wire 2, through the synchronization of the driven rolls 9 and 10 with the driven rolls 3 and 4. This arrangement of apparatus provides that the wet pulp deposited upon the upper surface of wire belt 2 be constrained for its subsequent travel between the wires 2 and 8 so as to constitute moving sandwich-like layers of wire 8—wet pulp—wire 2. This arrangement is an essential and particular part of my invention as it permits the rapid and forceable removal of a substantial portion of the remaining water from the wet pulp which would be impossible if the surface

of the wet pulp were directly exposed to mechanical displacement or disarrangement.

The wires 2 and 8 with the wet pulp sheet between them are caused to pass between a plurality of pairs of pressure rolls 11. Each of the rolls 11 is covered with rubber or similar material so that minor misalignments and irregularities of overall thickness do not crush the wet pulp between the wires 8 and 2. Each pair of such rolls 11 is adjusted to express from the wet pulp a part of the remaining water by direct mechanical action. The water which is expressed downwardly through wire 2 by this action falls downward by gravity. The water which is expressed upwardly through the action of the pairs of press rolls 11 tends to accumulate in front of each of the upper rolls 11. In order to remove this expressed water, a suction manifold 12 is provided immediately in front of each of the upper rolls 11 whereby this expressed water is sucked up from the surface of the wire 8 and carried away from the surface of the wire.

It is important to note that my improved method and apparatus of water removal prevents the wet pulp from being squeezed off the surface of wire 2 which action would occur if the wires 2 and 8 did not operate in synchronism to lock the pulp in place while the water is being expressed by the plurality of pairs of rolls 11. The pressure rolls 11 serve to remove that proportion of water which is held by the fibers mechanically. In order to remove that water which is held within the pulp by capillary action I provide improved pneumatic means.

For this purpose, a plurality of air blast manifolds, or pressure boxes 13 are situated over the upper surface of wire 8 and are so designed that numerous jets of air at high pressure indicated by the arrows, are caused to pass downwardly through the wet pulp between the wires. Suction manifolds 14 are provided immediately under each of the air blast manifolds 13 in order to carry away the additional water which is thus blown from the pulp. A further and essential feature of my invention is that the air blast manifolds 13 and suction manifolds 14 act on the wet pulp while it is held firmly between the wires 2 and 8, otherwise it would be blown apart and the wet sheet of paper ruptured.

After the sheet has passed between the last air blast manifold 13 and suction manifold 14, the sheetmaking and water removal operations for the papermaking machine itself have been concluded. In order to remove the sheet from the wires without pulling it loose physically from the wire mesh in the conventional manner or causing it to undergo a change of direction which introduces undesirable accelerative stresses in the wet and fragile sheet of paper, I provide a pressure box 15 directly underneath the wire 2 and immediately adjacent to supporting roll 4 through which jets of air or other gas form a positive pressure source is continuously directed upwardly through the underside of the mesh of wire 2 and against the underside of the sheet to blow the sheet loose from its intimate attachment to wire 2. It is possible to use this high-energy means to break the sheet loose from its intimate attachment to the wire upon which it was initially formed in my invention because the wire 8 at this point so constrains the sheet of wet and fragile paper that the blast of air or other gas coming through the wire 2 against the sheet cannot rupture the sheet at any reasonable level of pressure source.

After this operation the sheet is still firmly attached to wire 8 but no longer clings to wire 2. I next provide a pressure box 16 immediately above the lower reach of wire 8 beyond the upper reach of wire 2 and immediately adjacent the supporting roll 10 through which a blast of air or other gas is directed downwardly through wire 8 to blow the sheet of wet paper loose and directly onto the surface of a wet press felt 17 which is positioned directly beneath the overhanging end of wire 8 and is partially supported by a press support roll 18 to keep the wet press felt 17 nearly in contact with the undersurface of the wet

sheet. The speed of the wet press felt 17 is synchronized with that of the wet sheet and wire 8. When the sheet of wet paper is blown loose from wire 8 it immediately comes into contact with wet press felt 17 and is thus constrained against being deformed or ruptured by the air blast issuing from pressure box 16. As will be seen from the drawing it is conveyed away by the wet press felt 17 without substantial change in direction of movement. Further processing of the sheet may follow conventional methods.

From the foregoing it will be seen that my improved process and apparatus provides for the manufacture of paper having the following particular advantages over processes and apparatus heretofore employed:

(1) The sheet of paper is held firmly between two wire mesh belts immediately after its initial formation to permit the protection of the extremely fragile surface of the paper from destruction or disarrangement; and to permit the use of definite and highly economical means of water removal at high rates of speed, this method being directly contradictory to the conventional one of depositing the sheet upon a single wire and seeking to induce water removal operations from the opposite side of the wire upon which the sheet of paper is deposited.

(2) A substantial portion of the water held in the wet sheet is removed by direct mechanical action of expressing rolls in lieu of much more expensive pneumatic methods of water removal.

(3) Air, or other gas, at high pressure is used to remove a proportion of water from the wet sheet of paper, this method being contradictory to the conventional one of vacuum-type water removal which is limited as to energy level attainable and which is economically highly inefficient. In the appended claims wherever air is specified it will be understood that any other suitable gas may be employed.

(4) The removal of the wet sheet of paper from the wire belt upon which it is formed is accomplished by air blast to permit detachment without inducing distortion of the sheet.

(5) Sheet supporting and conveying means are used in combination with the sheet removal means to make the detaching operation insensitive to substantial variations of the detaching means and greatly reducing the skill required to perform properly the sheet detaching operation.

(6) My method of removing the sheet of paper from the wire upon which it is formed eliminates the conventional requirement for the sheet to undergo a severe, induced accelerative stress in being removed from the wire and thus removes a basic conventional limitation as to the maximum possible speed at which paper can be made, as well as eliminating that conventional distortion of the sheet which is derived from induced accelerative stresses.

(7) The sheet detaching means used in my invention renders the sheet detaching operation relatively insensitive to even gross irregularities in the thickness or strength of the formed sheet of paper. Attempts to remove sheets containing more than minor thickness variations by conventional means normally result in the rupture of the sheet.

While I have shown my invention as it is applied in one particular manufacturing process, it will be apparent that it is adapted for use in many manufacturing processes which separate solid materials from liquid suspensions thereof and subsequently consolidate the solids into a sheet.

While I have shown my invention in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are specifically set forth in the appended claims.

What I claim is:

1. In the manufacture of paper from a wood pulp-water suspension on a moving foraminous belt, the method of removing the sheet from the belt which comprises superposing a second foraminous belt over the first mentioned belt, moving in the same direction and extending beyond said first mentioned belt in the direction of movement thereof, conveying the paper being formed between said belts whereby it is pressed into the surface irregularities of the belts, subjecting the sheet being formed to an upward blast of air through the lower belt at a point inwardly of the discharge end thereof to loosen the sheet therefrom, subjecting the sheet to a downward blast of air through the upper belt beyond the lower belt and inwardly of the discharge end of said upper belt to remove the sheet therefrom, and conveying the sheet away in a direction parallel to the direction of movement of the belts.

2. In apparatus for separating solids from liquid suspensions and forming a sheet thereof including a moving foraminous belt, and means to feed the suspension onto the belt, the combination of a second moving foraminous belt mounted over the first mentioned belt and extending beyond said first mentioned belt, the lower reach of said second belt being disposed to bear upon the sheet of paper being formed on the first mentioned belt and travel at the same rate as the first mentioned belt whereby the sheet is pressed into the surface irregularities of the belts, mechanical and pneumatic means for removing liquid from the sheet while between the two belts, positive pressure operated means beneath said first mentioned belt and inwardly of the discharge end thereof for loosening the sheet from the first mentioned belt, other positive pressure operated means above said second belt and inwardly of the discharge end thereof for disengaging the sheet from the second belt after it leaves the first mentioned belt and without substantial change in direction of movement of the sheet, and support and conveying means for the sheet after it is disengaged from the second belt.

3. Apparatus as set forth in claim 2 in which the support and conveying means comprises a wet press felt disposed parallel to and directly under the lower reach of the upper belt, and directly beneath said other pressure operated means, said wet press felt moving at the same rate as the said belts.

4. In the manufacture of a sheet of material from a suspension of solid particles in liquid media in which the suspension is fed onto a moving foraminous belt and a sheet is formed thereon, the steps which include removing

liquid by holding the sheet between moving foraminous belts while subjecting the same to mechanical pressure from opposite sides thereof whereby the sheet is pressed into the surface irregularities of the belts, then subjecting the sheet while still between the belts to jets of air from a positive pressure source, loosening the sheet from the lower belt by an upward blast of air inwardly of the discharge end of said lower belt, removing the sheet from the surface irregularities of the upper belt by a downward blast of air inwardly of the discharge end of said upper belt and conveying the sheet away in a direction parallel to the direction of movement of the belts.

5. In the manufacture of a sheet of material from a suspension of solid particles in liquid media in which the suspension is fed onto a moving foraminous belt and a sheet is formed thereon, the method of removing the sheet from the belt which comprises superposing a second foraminous belt over the first mentioned belt, moving in the same direction and extending beyond said first mentioned belt in the direction of movement thereof, conveying the sheet between said belts whereby the sheet is pressed into the surface irregularities of the belts, subjecting the sheet to an upward blast of air through the lower belt inwardly of the discharge end thereof to loosen the sheet therefrom, subjecting the sheet to a downward blast of air through the upper belt beyond the lower belt and inwardly of the discharge end of the upper belt to remove the sheet therefrom, and conveying the sheet away in a direction parallel to the direction of movement of the belts.

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