June 8, 1965 J. T. ROOS 3,188,372

MACHINE AND METHOD FOR COMPACTING MATERIALS

Filed Aug. 25, 1961

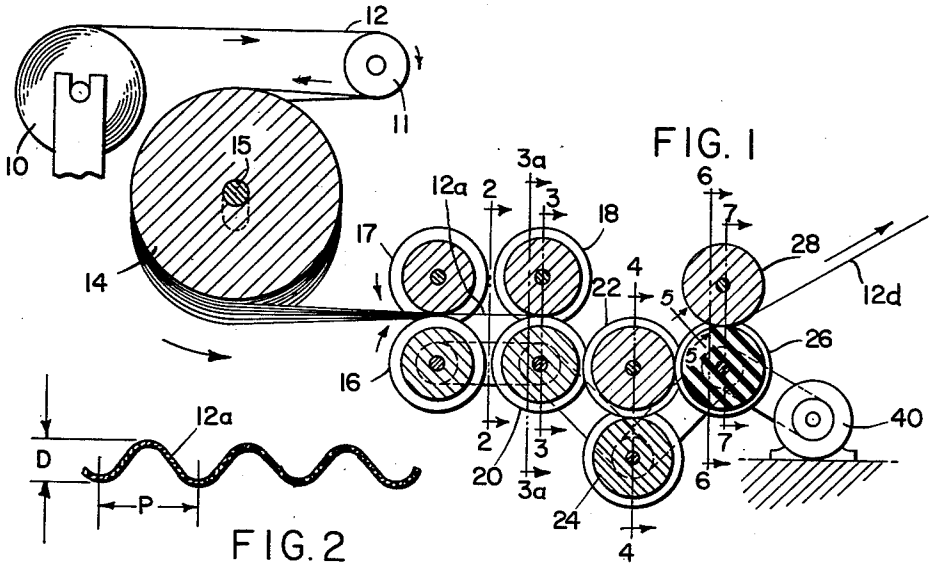


FIG. 1

FIG. 2

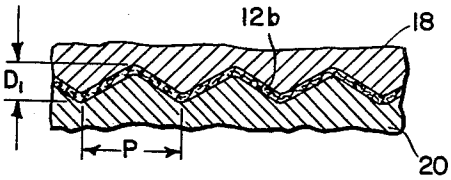


FIG. 3

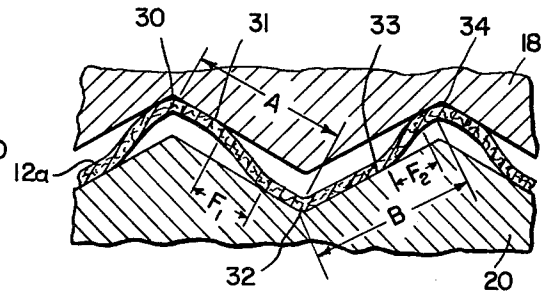


FIG. 3a

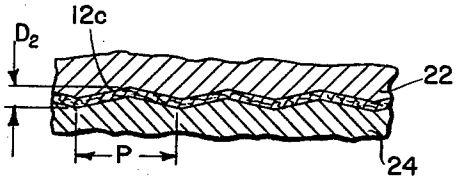


FIG. 4

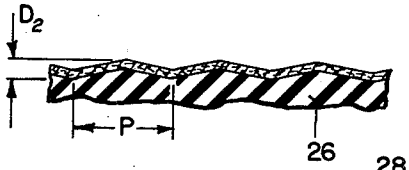


FIG. 5

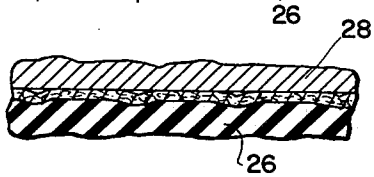


FIG. 6

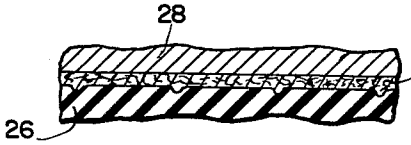


FIG. 7

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MACHINE AND METHOD FOR COMPACTING MATERIALS

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This invention relates to the treatment of materials, and more particularly to compacting together and rearranging the fibers or other components of webs of paper and other deformable sheet materials by the application of compressive forces.

Web materials have heretofore been compacted by forming regular, fine corrugations in them and then crushing these corrugations between smooth moving surfaces. The crushing forces compact the fibers and impart a fine, almost invisible crepe whereby webs may be thickened and made stretchy. For this treatment the corrugations must be dimensioned and shaped to avoid pleating under the crushing action, taking in consideration the thickness, stiffness and the other physical characteristics of the web material.

For materials which can be treated there has been a limit on the degree of treatment obtainable due to a practical limit on the fineness of grooving which can be practically formed in refining rolls which are employed in forming the web corrugations.

Whether a given material could be treated to the desired degree according to this process has depended on whether corrugations of the requisite small size could be formed.

The purpose of this invention is to provide for improved treating of web material by the crushing of corrugations. One objective is to provide a treatment whereby a greater degree of compaction and stretchiness can be efficiently and uniformly obtained than could be obtained by the above described process. Another objective is to provide a means for treating materials which have not been susceptible to treatment with that process. Another objective is to provide a machine which is simple and economical to manufacture and operate.

I have discovered that these and other objectives can be realized through the use of specially shaped and arranged crushing surfaces.

In the prior art process of crushing the corrugations with pairs of smooth squeeze rolls, peaks and valleys of the corrugated form, which sometimes are referred to herein as the "extremities," are engaged by the rolls with forces that crush the increments of material extending therebetween. It has been observed of this process that the operation has been interrupted with slight changes in the character of the material, in the lengths of the increments or in the angular relation of the increments to the forces applied, resulting in unwanted pleats. I have realized that with the smooth rolls the pleats occur due to buckling of the peak-to-valley increments, substantially in accordance with Euler's formula for slender columns, and my present invention provides for avoiding this buckling by imparting support to the increments during the crushing. As will be explained below, this permits the length and angle of the increments to be successfuly varied over a wide range, enabling the treating to a high degree of a wide variety of materials. It permits a single initial web corrugation shape to be employed for many materials whereby control of the process and changeover from one to another material are greatly simplified, and it permits the treating of many materials previously regarded to be unsuitable because of inability to corrugate to the requisite fineness.

Broadly stated, the machine of the invention comprises an improved squeeze nip at the discharge side of a corrugating means, the nip having at least one nip surface fluted, providing ridges and grooves in a pitch pattern corresponding to the pitch of the corrugations in the oncoming web. The grooves, however, are shallower in the nip pressure zone than are the web corrugations so that the space containing each web increment is forcibly decreased as the web moves into the nip. The nip surfaces thus apply compressive forces to the ends of peak-to-valley increments while deflection of these increments is restrained by partial support offered by the walls of the flutes whereby buckling is prevented. This forces the increments to stand up to the compressive forces, so that the fibers are compacted and local or fine creping rather than an over-all buckling occurs.

One or more pairs of intermeshed, hard, fluted rolls having groove depths less than the depths of the corrugations in the oncoming web can be employed for many applications; these have the advantages of locking the web in position and of long wear life as a slight running clearance can be maintained between the rolls.

A fluted roll of resilient material can be employed which in its undeformed condition has ridges and grooves corresponding in depth to those of the oncoming web. These can engage the web as it moves towards the nip, holding the web corrugations in shape. In the nip region these ridges can be deformed by the second roll to apply the desired compressive forces on both the peaks and valleys while providing side support to the web increments. The second roll may be a smooth cylindrical roll, or an intermeshed hard fluted roll of lesser groove depth or an intermeshed resilient fluted roll of the same or lesser groove depth.

In the treatment of the invention, when it is desired to move the web through successive crushing treatments, it is advantageous to support the web continually between treatments by engaging one side or the other of the corrugated web with a fluted roll, whereby the web is continually properly positioned and held in its corrugated form.

Further objects, features and advantages of the invention will become apparent from the following detailed description of a presently preferred embodiment thereof taken in conjunction with the accompanying drawings in which:

FIG. 1 is a partially diagrammatic sectional view through the center line of a machine for treating material according to the invention;

FIGS. 2, 3, 3*a*, 4, 5, 6 and 7 are cross-sectional views taken on the corresponding lines of FIG. 1 illustrating the changes in the web corrugations as the material proceeds through the machine, all of these figures excepting FIG. 3*a* being on the same scale, while 3*a* is on a larger scale;

Referring particularly to FIG. 1, a stock roll **10** is rotatable mounted on a fixed pedestal for supplying the web. A web **12** passes from this roll over an idler **11** to a corrugating means here comprising two devices, the first being a side-by-side series of rotatable discs **14** mounted on a curved axis **15** over which the web is caused to pass from convex to concave side for the purpose of gathering the web widthwise into corrugations. The second device is a nip pair of meshed fluted rolls **16, 17**, adapted to receive the gathered web as it moves from the concave side of the curved roll arrangement, these rolls being adapted to form the web corrugation to the desired pitch and groove depth, the grooves in the roll and in the web corresponding in size.

From this corrugating means the now corrugated web **12***a* passes to a means for crushing the corrugations comprising pairs of squeeze rolls **18** and **20**, **22** and **24**, and **26** and **28** through which the web passes in succession, emerging in its conditioned form at **12***d*. Selected rolls in this arrangement are suitably driven to maintain tension

forces on the web for drawing it around the gathering disc assembly from convex to concave side and through the successive roll pairs. As illustrated in this embodiment, this is achieved by a single drive motor 40 provided with belts arranged to drive rolls 16, 20, 24, 25.

Referring to FIG. 2, the corrugated web 12*a* has a longitudinal corrugated pattern having a pitch P and a corrugation groove depth D as it emerges from between rolls 16 and 17 of the corrugating means.

The roll pair 18, 20, the first pair of crushing rolls, comprises two fluted rolls having intermeshed ridges and grooves as shown in FIG. 3 corresponding in pitch to the pitch of the corrugations in the web being fed thereto. The depth of the roll grooves define a corrugated form passage at the line of centers of the rolls having a depth D_1, less than the depth D of the uncrushed corrugated web 12*a*. The corrugated web moves into the pressure zone of the nip where it is crushed, in accordance with the following explanation:

Referring to FIG. 3*a*, the web 12*a* is shown between the fluted rolls 18 and 20 in the pressure zone, at a point, approaching but slightly in advance of the line of centers of these rolls. The corrugations in the web have a greater amplitude than the corrugated-form passage defined between the two rolls at this point, and the increments, e.g., increment A extending between successive peak 30 and valley 32 and increment B extending between valley 32 and peak 34 of the corrugated web, are subjected to compressive forces exerted by corresponding portions of the two rolls.

According to Euler's slender column formula, if the forces acting at the opposite ends of such an increment be too great, the increment, tends to structurally fail by buckling. But as shown in FIG. 3*a*, when deflection of increment occurs between the fluted rolls, at least one side of it such as at 31 or 33 engages one or the other of the corresponding sloped walls of the roll fluting. Peak to valley increments are thereby supported so that they no longer behave as slender columns but instead they are positioned to receive large compressive forces without buckling or pleating as the material progresses to the line of centers of the roll pair. As shown in the figure, only a fraction F_1 and F_2 of each increment is without support.

As shown in FIG. 3, at the line of roll centers, the web 12*b* retains corrugations having a pitch P, but the depth of the corrugations has been decreased less than D to D_1, the web material having been compacted or finely creped so that the web thickness is increased while its width is decreased. Thus, by comparison of FIG. 2 with FIG. 3 it will be seen that the amplitude of the corrugated form has decreased while the pitch or frequency has remained constant.

A second roll pair 22 and 24 is arranged to treat the web as it moves from the roll pair 18 and 20. As indicated in FIG. 4, rolls 22, 24 are provided with intermeshed flutes having a pitch P corresponding to the pitch of the corrugations in the web 12*b*, while the depth of the flutes D_2 is less than the depth D_1 of the preceding roll pair.

Roll 22 is mounted in an intermeshing relation to roll 20, and roll 24 is mounted below roll 22. With this arrangement the web moves in contact with roll 20 after passing through the nip of rolls 18 and 20, and when it ultimately leaves roll 20, it is immediately transferred to roll 22 so that the web is continuously engaged on at least one side by at least one roll throughout its movement between the nips. As noted above, this continuous engagement maintains alignment of the web and restrains any tendency for the web to expand widthwise. The web moves with roll 22 into the nip between that roll and roll 24 and is further crushed as above to a corrugation depth D_2 at the center line of the nip as shown in FIG. 4 at 12*c*.

A third crushing is accomplished in this embodiment

by rolls 26 and 28. Roll 26 is a resilient roll having flutes corresponding in depth D_2 and pitch P to those of roll 22, and intermeshed therewith. Roll 28 is provided with a substantially smooth, hard surface. The web, which in this embodiment now has very small corrugations moves through the nip of rolls 26 and 28. As shown in FIGS. 6 and 7, the resilient fluting is progressively deformed as it approaches the center line of the nip, whereby the corrugations are crushed into a substantially planar condition 12*d* as shown in FIG. 7. The web then moves from the nip in contact with smooth roll 28. In an alternative arrangement upper as well as the lower roll may be provided with small intermeshed flutes and the web can thereby be supported on both sides as the corrugations therein are crushed.

It is possible to subject a traveling web to a repeat of the process, positioning the corrugations differently in the second run to even the treatment over all portions of the web in the event a first pass does not do so.

In other embodiments of the invention, a single pair of rolls can be employed having either resilient or hard surfaces. Where the treatment does not wholly remove the corrugations, the treated web can be subjected to a widthwise distending action.

Pressing surface flutes are required on only one side of the web as when the operating conditions create a tendency to buckle only in the direction of one side, or where friction on one side prevents creep, as may occur with rubber rolls.

Examples, but not by way of limitation, of advantageous uses which may be made of the apparatus and method of invention include: producing controlled elasticity in the widthwise direction of various sheet materials; increasing softness or pliability of sheet materials, for example, disposable diaper material and leather; increasing absorbency of toweling; increasing the efficiency of various filter materials; creping some sheets without the necessity of conditioning for plasticity; simultaneous creping of multiple sheets such as multi-wall bagging and electrical insulation; creping of certain sheet materials, such as metallic foils, wire cloth and plastic films, impossible or extremely difficult to crepe by conventional methods; providing sheet materials with desired surface characteristics both functional and decorative; rearrangement of fibers and components of fibrous webs such as bats of wool or cotton as, for example, to equalize tensile strength in both directions and stabilizing the same; modifying the physical characteristics of woven and nonwoven fabrics and knit fabrics; for example, softening and stabilizing and improving the drape or other desired qualities, including relaxation of any internal strain; creping at substantially higher speeds than possible by conventional methods; imparting elasticity in the cross-direction to webs such as paper which ordinarily have the least tensile strength widthwise; imparting unusually higher degrees of stretch to materials for use in wrappings and the like to facilitate molding around the objects to be wrapped.

It will be understood that certain of the specific details of the invention can be varied within its spirit and scope.

What is claimed is:

1. A machine for treating a traveling web comprising, in combination, means for first imparting to the web regular longitudinal corrugations and fluted means for crushing said corrugations comprising at least one pair of opposed press surfaces forming a nip located at the discharge side of said first named means, at least one of said press surfaces having alternate ridges and grooves corresponding in number to said corrugations and aligned to intermesh with said corrugations, said ridges and grooves having a pitch corresponding to that of the corrugations, and providing groove spaces of shallower depth than those of said corrugations at least at the nip for exerting oppositely acting compressive forces on successive opposite extremities of the corrugations to treat web

increments extending between said extremities, while at least partially supporting the sides of said increments against buckling.

2. The machine of claim 1 wherein said press surface having alternate ridges and grooves is formed of resilient material and the second press surface of said nip is adapted to deform resiliently said first mentioned surface at the nip.

3. The machine of claim 2 wherein said second press surface is comprised of relatively hard material having a relatively smooth surface.

4. The machine of claim 1 wherein each of said press surfaces comprises a fluted squeeze roll provided with alternate circumferential ridges and grooves corresponding in pitch to the corrugations produced by said first-named means, said surfaces being intermeshed, defining therebetween a corrugated-form nip passage having a substantially smaller amplitude than that of the corrugations produced by said means.

5. The machine of claim 4 wherein each of said squeeze rolls is comprised of hard material and wherein said rolls are adapted to rotate with running clearance.

6. The machine of claim 1 wherein press surfaces forming a second nip are positioned at the discharge side of said first mentioned nip, at least one of said surfaces defining said second nip having ridges and grooves of the same pitch, but providing groove spaces of shallower depth than those at said first nip to further crush corrugations in said web.

7. The machine of claim 6 wherein said press surfaces are arranged to define a web path extending from said first nip to said second wherein at every point therealong said web is intermeshed with at least one press surface having ridges and grooves of corresponding pitch for maintaining alignment between said web and said press surfaces and preventing widthwise expansion of said web.

8. The process of treating a traveling web comprising forming longitudinal corrugations in said web as it travels

and passing the thus corrugated web through a nip of opposed traveling press surfaces for crushing the corrugations without pleating, at least partially supporting the corrugations at least at one surface of said web as it passes through said nip by causing the corrugations of the web to intermesh with ridges and grooves in a press surface having the same pitch and a lesser amplitude at the nip than the corrugations of the web, thereby preventing buckling of the web increments extending between successive, opposite extremities of the corrugations while these increments are crushed by applying compressive forces to said extremities with corresponding portions of said press surfaces.

9. The process of claim 8 wherein said ridges and grooves in said one press surface are comprised of resilient material which when undeformed, substantially correspond in depth to the corrugations of the web, and the pressure between said press surfaces at said nip is maintained at a value sufficient to deform said ridges and grooves to a shallower depth as they pass with the web through the nip.

10. The process of claim 8 wherein each press surface carries alternate ridges and grooves into intermeshed contact with the corresponding sides of the web, said surfaces forming at the nip a web passage corresponding in pitch with but having a lesser amplitude than that of the corrugated web being fed to the nip.

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