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APPARATUS FOR ALTERING THE SURFACE CONFIGURATION OF A PAPER WEB

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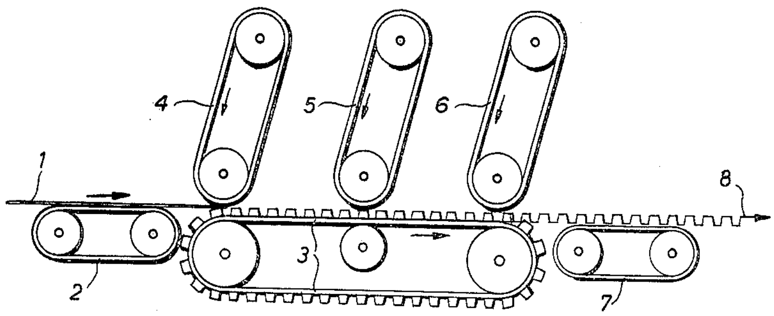

FIG. 1

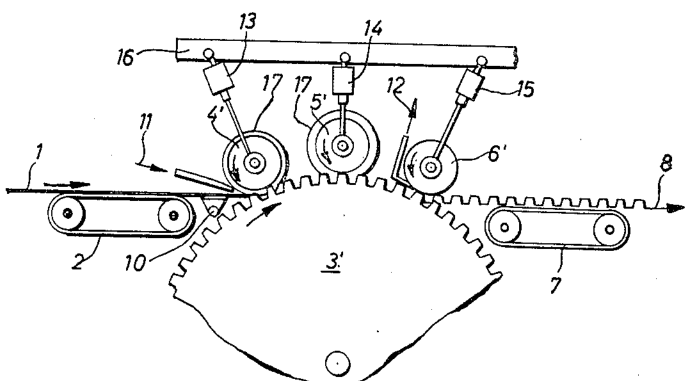

FIG. 2

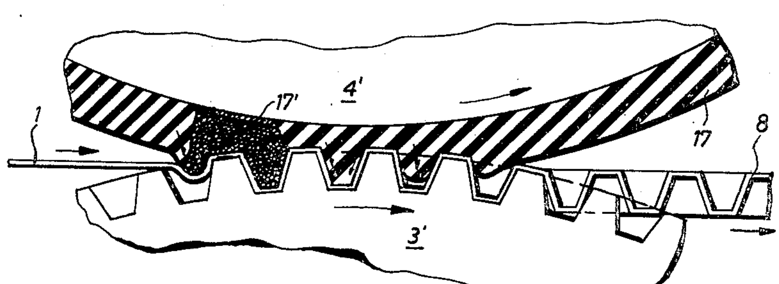

FIG. 3

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1

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ABSTRACT OF THE DISCLOSURE

For imparting a desired surface configuration to a sheet of fibrous material which is in the process of being formed and which is still wet from the formation process, a contoured mold surface made of a hard material and having the configuration to be imparted to the fibrous sheet and an elastic counter surface made of a non-absorbent material, the fibrous sheet being interposable between the mold surface and the counter surface and the counter surface being arranged to urge the sheet against the mold surface so as to impart the desired configuration to the fibrous sheet without imparting high local stresses thereto. The mold surface is preferably constituted by a layer of elastic material provided with sealed, gas-filled spaces whose dimensions are selected to impart the desired degree of elastic deformability to the counter surface.

The present invention relates to the processing of a fibrous sheet, and particularly to the shaping of strips, or sheets, of fibrous material.

The present invention is particularly concerned with techniques for altering the surface configuration of a previously flat fibrous strip which is still wet from the process by which it was fabricated and which has a water content of about 80%. Such strips are normally produced by a paper-making, cardboard-making, or carton-making machine. Such alterations in the configuration of the strip generally take the form of corrugations or waffling and cause the strip to occupy a larger volume and to have improved insulating properties and increased resistance to bending. As a result, such strips find great utility as a packing material.

It is already known to give fibrous strips which are still wet from their fabrication and which have a water content of about 80%, such a configuration by passing them through a roll press between two mating rollers each of which has a suitably contoured surface to impart the desired configuration to the strip. It is also known to carry out this operation using a pair of rollers one of which has a permanently contoured surface, and is known as the mold roller, and the other of which rollers, which is known as the counter roller, has a normally smooth, resilient surface which is deformed by the mold roller so as to assume the shape of the mold roller surface at the point where the two rollers bear upon the fibrous strip. In each case, the contours on the roller surface are imparted to the fibrous strip.

As has been noted above, these shaping operations are carried out when the strips are still wet from the fabrication process and hence the fibres have not yet become bonded together since there is still a considerable amount

2

of water present between the individual fibres. As a result, it has been found that the strips tend to tear easily while they are being subjected to the above-described shaping operations. Specifically, it has been found that although the high water content of the strip prior to the time when the fibres become bounded together renders a high degree of deformation of the strip possible, the strip is highly susceptible to tearing when subjected to high local stresses while still in this state, especially if the dimensions of the deformations are several times as great as the thickness of the orginally flat fibrous strip, or if the fibre structure of the treated material is especially weak when it is still in the highly saturated state such as the case, for example, for thin asbestos cardboards.

It is a primary object of the present invention to overcome these drawbacks.

It is a more specific object of the present invention to permit a fibrous strip, while still in a state where it has an 80% water content, to be deformed by a substantial amount without tearing.

It is another object of the present invention to provide an arrangement for altering the surface configuration of such a fibrous strip without subjecting the strip to tearing.

Basically, the novel results according to the present invention may be achieved by the provision, in an installation having a mold element forming a rigid, contoured mold surface for imparting a similar contoured configuration to a sheet of fibrous material which is still wet from its fabrication process, of at least one pressure applicator for pressing the sheet against the mold surface, this pressure applicator including a layer of elastic material containing a plurality of sealed, gas-filled spaces, the layer defining the counter surface which presses the sheet against the mold surface. Since the gas-filled spaces have a substantially lower resistance to deformation than the elastic material itself, the elastic resistance to deformation of the resulting layer will be made sufficiently small to permit the stresses to which the fibrous strip is subjected to be uniformly distributed and thus to prevent the tearing of the strip.

In addition, it has been found that the ability of a sheet of fibrous material to be given relatively deep contours is enhanced by heating the sheet just prior to imparting the contours thereto. Therefore, the present invention also contemplates a procedure whereby the sheet is heated, preferably by spraying a stream of heated vapor thereon, just prior to undergoing the shaping operation.

Additional objects and advantages of the present invention will become apparent upon consideration of the following description when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a side view of one form of shaping station for shaping fibrous strips according to the present invention.

FIGURE 2 is a side view of another station for shaping station for shaping fibrous strips according to the present invention.

FIGURE 3 is a detail view, partly in cross section, illustrating the mode of operation of a shaping stage according to the present invention.

Referring now to FIGURE 1, there is shown a shaping station according to the present invention for shaping a fibrous strip which is still wet from its fabrication process. The strip **1** is delivered from a suitable fabrication installation (not shown) in a state in which it has a composition of approximately 80% water. The strip **1** is conveyed over a conveyor belt **2** to the shaping station composed of a mold surface **3** and three separate counter surface units **4**, **5** and **6**. In this embodiment, the rigid, contoured surface is constituted by an endless belt **3** with which there are associated suitable driving and support rollers, while the counter surfaces **4**, **5** and **6** are constituted by endless belts of elastic material with which there are associated suitable driving rollers, the belts **4**, **5** and **6** being distributed along the length of belt **3**. There is also provided an output conveying device **7** for conveying the shaped portion **8** of the strip to a suitable dryer (not shown).

The belt **3** can be given any desired contour according to the configuration which is desired to impart to the strip **1**. This belt is driven in the direction of the arrow by any suitable driving means. On the other hand, it is not necessary to provide a positive drive for the belts **4**, **5** and **6** inasmuch as these belts can be driven directly by the belt **3**.

The composition of the belts **4**, **5** and **6** will be described in detail below in connection with the description of FIGURE 3. It may be stated at this point, however, that each of these belts is constituted by a layer of elastic material formed to have a plurality of sealed, gas-filled spaces, or cells, distributed uniformly throughout the belt. The belts **4**, **5** and **6** preferably each has a total gas-filled volume which differs from that of the other belts in order to give each belt a different resistance to elastic deformation. Specifically, it has been found desirable to give the belt **4**, with which the strip **1** first comes into contact, the lowest resistance to deformation and to give the belt **6**, which is the last to act on the strip, the highest resistance to elastic deformation. These variations can be obtained, for example, by varying the concentration of gas-filled spaces in each belt and/or by varying the size of these spaces. In addition, depending on the particular requirements imposed by the material forming the strip **1**, the coefficient of friction of each of the belts **4**, **5** and **6**, as well as their thickness, may be varied over a wide range of values. The pressure with which each of these belts is applied to the strip is controlled by any conventional pressure applying means (not shown).

FIGURE 2 shows another arrangement for shaping a fibrous strip according to the present invention. In this device, the rigid, contoured mold surface is present in the form of a relatively large roller **3'** on whose cylindrical surface the required contours have been formed. The elastic counter surfaces are here constituted by layers of elastic material **17** mounted on rollers **4'** and **5'**. The layers **17** are made of the same material as the belts **4**, **5** and **6** of the device of FIGURE 1. The pressure with which these layers are applied to the strip **1** is controlled by suitable pneumatic control devices **13** and **14**, respectively. In this device, the roller **6'** is not provided with a layer of elastic material, but has a smooth, rigid surface. The pressure with which this roller is applied against the shaped strip is controlled by a suitable pneumatic control means **15**. The roller **6'** will only come in contact with the surface portions of strip **1** which are disposed on the projections of the surface of roller **3'**. At the same time the surface portions of strip **1** which are disposed adjacent the depressions in the contour of rigid roller **3'** will have been smoothed by this latter roller. Such a smoothing operation is generally sufficient for preparing the strip for gluing to additional strips because it is only these surface portions which will actually be glued to the other strips. All of the rollers **4'**, **5'** and **6'** are mounted on a support frame **16** through the intermediary of their respective control means **13**, **14**, and **15**. Again, the rollers **4'**, **5'** and **6'** need not be provided with separate drive means because they may be readily driven directly by the roller **3'**.

The device of FIGURE 2 also includes a vapor nozzle **10** disposed below the strip **1** and just ahead of the first shaping stage **3'–4'** for applying a heated vapor spray to the strip **1** in order to heat the strip and thus facilitate its shaping. There is also provided a spray nozzle **11** for spraying a lubricant, such as resin glue dissolved in water for example, onto the fibrous strip just prior to its passage through the first shaping stage. Finally, there is provided a suitable suction nozzle **12** for conveying water away from the fibrous strip as it is squeezed out by the passage of the strip between rollers **3'** and **6'**.

Referring now specifically to FIGURE 3, there is shown a detail of the rollers **3'** and **4'** and a portion of the layer **17** surrounding roller **4'** according to FIGURE 2. As may be seen, the roller **3'** has a rigid surface which is contoured to impart a series of corrugations to the fibrous strip **1** in order to produce the corrugated shape **8**. The layer **17**, the portion **17'** of which is shown in cross section, is made of an elastic material, such as neoprene, having a plurality of sealed, gas-filled spaces formed therein. Inevitably, some of these spaces will be cut through when the layer **17** is cut to its desired thickness before being placed on the roller **4'**. As a result, portions of some of these spaces will appear on the surface of the layer **17** and will give the layer the previously-described desirable rough surface. It should be noted that each of the spaces which does not extend to the surface of the layer **17** will be completely sealed both from the surface of the layer and from its adjoining spaces. In other words, the spaces in layer **17** do not form an open cellular structure of the type formed in sponge rubber and hence the layer **17** will not absorb water from the fibrous layer in the manner of sponge rubber. The process according to which the layer **17** can be fabricated is well known in the art. For example, this material can be produced by thoroughly distributing a substance such as NH_4HCO_3 throughout a mass of latex and by then heating the composition. During the heating process, the NH_4HCO_3 will enter the gaseous state before the latex is vulcanized.

Due to the presence of the gas-filled cells in layer **17**, this layer will offer very little resistance to deformation when it comes under the influence of the projections in the surface of mold roller **3'**. At the same time, the rough surface which layer **17** presents to the strip **1** effects a uniform distribution of the shaping pressures over the surface of the strip. The small arrows shown on layer **17** represent the manner in which the pressures are transferred from the regions where layer **17** is highly compressed to the regions where it is compressed to a smaller degree, or not at all.

Among the advantages possessed by arrangements according to the present invention is their ability to prevent the tearing of the strips being shaped. Experiments have shown that the tearing of fibrous strips having a high liquid content when undergoing forming operations of the prior art type is caused by the application of high local pressures, or stresses, to the strip when it passes between the two surfaces and by the friction forces applied by these surfaces to the strip. Moreover, it has been found that, in the case where the strip is passed between a contoured mold surface and an originally smooth, elastically deformable counter surface made of a compact material such as soft rubber, if the material of the counter surface has even the slightest elastic resistance to deformation this counter surface will produce unacceptably high local stresses in the wet fibrous strips.

On the other hand, if an attempt is made to decrease the elastic resistance of the counter surface by making it of a material such as sponge rubber, this material will absorb a relatively large amount of water when it is compressed and will release the water as the pressure on it is reduced, this absorption and subsequent release of water acting to introduce undesirable disturbance into the composition of the strip during the shaping process.

Applicant has discovered that these disadvantages can be substantially overcome by constituting the elastic counter surface **17** of a rubber or plastic material, such a neoprene or microcellular rubber for example, incorporating a number of small, completely sealed, gas-filled spaces or cells, which act to reduce the resistance to elastic deformation of the counter surface. By using this form of construction, the high elasticity of a gas can be combined with the lower elasticity of the rubber or plastic material in such a way that the layer forming the counter surface has the properties required for shaping the wet fibrous strip without reducing the tendency of the strip to tear. It has been found to be particularly desirable to provide the layer forming the counter surface with a large number of gas-filled spaces to increase its elasticity for the processing of relatively thin, sensitive fibrous strips, and to provide the layer with a small number of gas-filled spaces to decrease its elasticity for processing relatively thick, sturdy fibrous strips.

In addition, applicant has discovered that a considerable decrease in the local stresses applied to the fibrous strips, and hence a reduction in the tendency of the strips to tear, is obtained by causing the friction existing between the strip and the contoured mold surface **3′** to be considerably smaller than that existing between the strip and the elastic counter surface **17**.

When the friction forces exerted on the strip by the contoured mold carrier are maintained at a low value, the resistance offered by the mold surface to the shaping of the fibrous strip is at a minimum. On the other hand, the relatively high friction forces exerted on the fibrous strip by the rough surface of the highly elastic counter surface, which rough surface is created primarily by the small spaces present on the surface of the layer **17** forming the counter surface, assure that the pressures required for properly shaping the fibrous strip will be distributed substantially uniformly over the entire portion of the strip disposed between the mold surface and the counter surface. Due to the interaction of the two dissimilar surfaces on the fibrous strip, there is obtained an optimum uniform distribution of the shaping stresses over the strip and the occurrence of high stress concentrations at isolated points on the strip is avoided.

It may be appreciated that the coefficients of friction of a single mold surface and counter surface are not optimally suited for every type of fibrous strip which it may be desired to shape. In order to adapt the shaping elements to a strip material whose properties differ from that for which the elements were primarily designed, it is possible, according to another features of the present invention to vary these coefficients of friction by introducing a lubricant, such as water for example, between the mold and counter surfaces and the fibrous strip, in the manner described above in connection with FIGURE 2. In this connection, it should be noted that the water contained in the strip itself is not normally available for such a use because it is held by, and between, the fibres constituting the strip.

In accordance with another feature of the present invention, a lubricant can be selected which will also act to prepare the surface of the subsequently dried strip for further processing. For example, if it is desired to glue the strip to other strips to form a laminated structure, resin glue may be used as a lubricant for wood fibre strips and water-glass additives may be used as the lubricant for asbestos strips.

In certain cases it may be desired to give the strip a shape which requires the application of unusually high stresses thereto. In this case, in accordance with a further feature of the present invention, the deformability of the wet fibre strip can be increased by a substantial amount by heating the strip prior to, or during the shaping operation. It has been found that the heating of the strip greatly facilitates the shaping process since it acts to reduce the viscosity of the water contained in the strip and the brittleness of the fibres forming the strip. This heating can, for example, be performed by spraying heated vapor onto the strip just prior to its passage between the mold surface and the counter surface as described in connection with FIGURE 2.

It may thus be seen that the present invention permits a high degree of shaping to be obtained, or the speed with which the fibrous strip is fed through the shaping arrangement to be increased, by carrying out the shaping operation in a series of two or more stages in which the counter surface of the first stage has the smallest resistance to deformation and the counter surface of the last stage has the largest resistance to deformation. Generally, this can be obtained by providing the counter surface in the first stage with a large total gas-filled volume and by providing the counter surfaces of the succeeding stages with progressively smaller total gas-filled volumes. In any of the devices according to the present invention, the shaping pressure may be applied by any conventional means such as, for example, accurately adjustable pneumatic means. When the shaping process is carried out in a series of stages, the pressure of each stage is preferably adjusted individually.

It may also be seen that the present invention provides for the smoothing of the surface portions of the shaped strip which are to be glued to another strip after drying. This smoothing is preferably effectuated by subjecting the shaped strip to the action of a roller having a smooth, rigid surface, which roller is arranged to apply a suitable smoothing pressure to the strip portions against which it is applied.

Thus, the present invention provides a novel technique for shaping a fibrous strip while the strip is still wet from its fabrication process so as to give the strip a corrugated or waffled configuration without subjecting the strip to tearing. In addition, the novel technique of the present invention permits substantially greater shaping deformations to be imparted to the strip than was possible in the prior art.

It will be understood that the above description of the present invention is susceptible to various modifications, changes, and adaptations.

What is claimed is:

1. In an apparatus having a mold element forming a rigid, contoured mold surface for imparting a similar contoured configuration to a sheet of fibrous material which is still wet from its fabrication process, at least one pressure applicator for pressing the sheet against said mold surface and including a layer of non-absorbent elastic material containing a plurality of sealed, gas-filled spaces, said layer defining the counter surface which presses the sheet against said mold surface.

2. An arrangement as defined in claim **1** wherein said layer of elastic material has a higher coefficient of friction than does the surface of the mold element constituting said mold surface.

3. An arrangement as defined in claim **2** wherein said layer further contains a plurality of pockets comparable in size to said gas-filled spaces and disposed at that surface of said layer which defines said counter surface for increasing the coefficient of friction of said layer.

4. In combination with the arrangement defined in claim **1**, means for introducing a lubricant between said counter surface and the sheet of fibrous material.

5. In combination with the arrangement defined in claim **1**, means for spraying a heated vapor onto the sheet of fibrous material just prior to its passage between said counter surface and said mold surface.

6. Said arrangement as defined in claim **1** wherein there are a plurality of pressure applicators disposed along the length of the mold surface in the direction of the path followed by the sheet of fibrous material, the layer of elastic material associated with the first one of said pressure applicators encountered by the sheet having a smaller resistance to elastic deformation than does the layer of elastic material associated with the last pressure applicator encountered by the sheet of fibrous material.

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