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APPARATUS FOR COMPACTION OF FORMED SHEET FOR IMPROVED PROPERTIES

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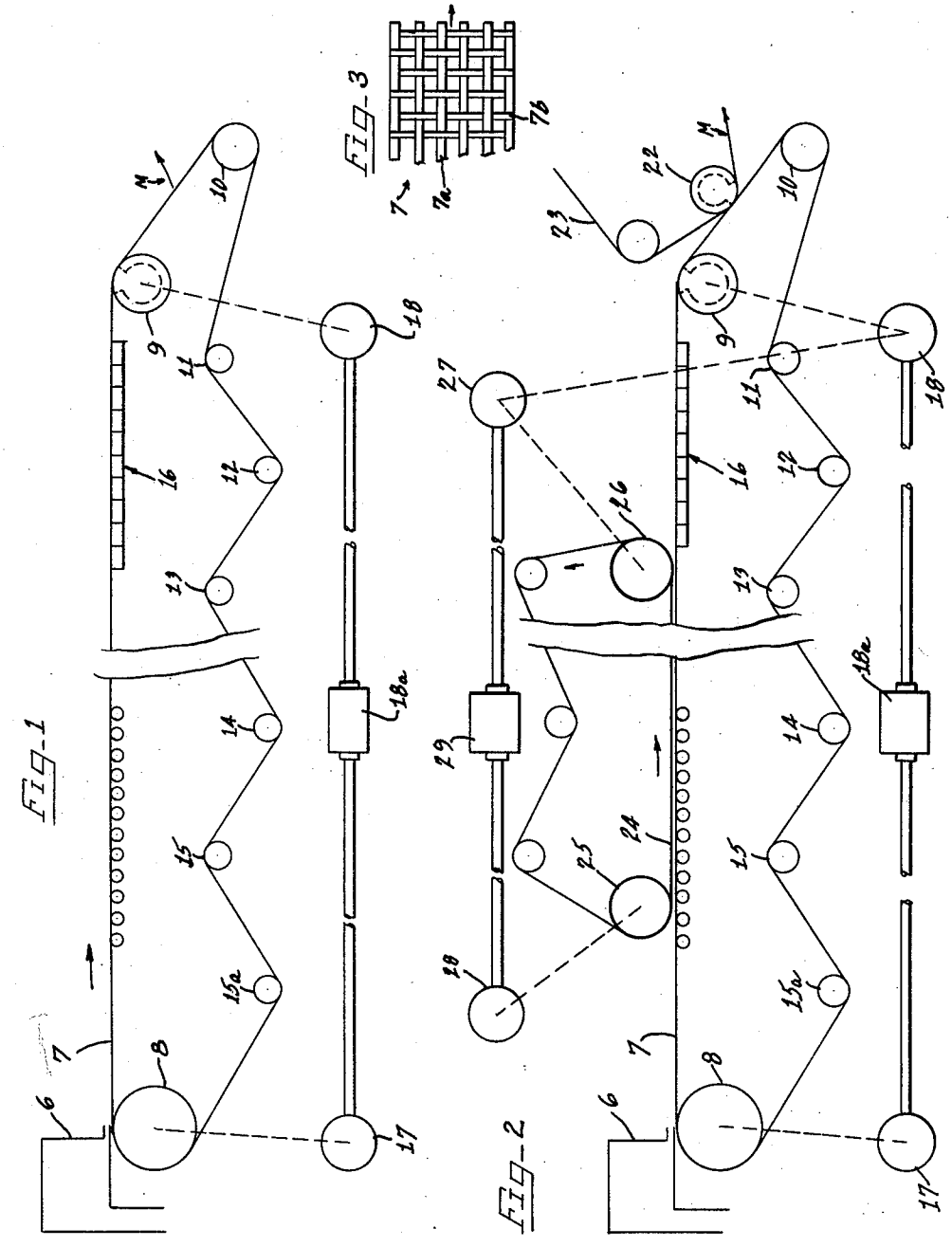

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APPARATUS FOR COMPACTION OF FORMED SHEET FOR IMPROVED PROPERTIES

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This invention relates to the production of paper and is more particularly directed to improved methods and means for compaction of formed paper webs and related web materials.

Heretofore it has been customary in the prior art to employ Fourdrinier machines having wires made of an annealed copper, brass, or a Phosphor bronze, very finely drawn and woven into a wire mesh web. The mesh of the web is normally determined by the particular end product to be formed on the paper making machine.

It has been generally thought that the Fourdrinier wire must, of necessity, be constructed of metal wire and that because of the inherent limitations in such wire, certain operational safeguards had to be taken in order to form acceptable sheets or mats on the wire. For example, bruises or kinks in the wire soon cause them to wear or break through, thereby seriously shortening their use life.

Emphasis has been given in recent years to improving the formation of the paper sheet or mat on the Fourdrinier wire and, for this purpose, shakers, deckles, tube or table rolls, suction boxes, dandy rolls, and improved couch rolls have been designed with the view toward obtaining better quality paper sheet or mat on the wire. Thus, as a result of this common belief that the Fourdrinier wire must be constructed of metal wire which impose stringent operating conditions, all previous attempts to improve the characteristics of the paper on the wire have taken the form of independent apparatus acting through or on the wire and paper mat or web. As far as I am aware, no attempts have been made to improve the characteristics of the web by changing the characteristics of the Fourdrinier wire.

By employment of my invention, wherein a Fourdrinier wire, constructed of a material having elastic properties preferably comprising a fabric matrix woven of longitudinally extending plastic yarns or filaments and preferably with transverse metal wire for the weft or shoot elements, is appropriately stretched over a breast and a couch roll, and the tension thereon is progressively reduced at the couch roll, I provide simple and effective means for producing paper webs and related web materials compacted on the forming wire to a degree heretofore considered unobtainable in the art having improved strength, flexibility and elongation characteristics.

It is therefore an object of the present invention to provide means for improving the properties of paper web and related web materials on paper making machines.

It is another object of the present invention to provide improved means for compacting paper web and related web materials.

It is another object of the present invention to provide means for improving the characteristics of paper web and related web materials by controlled contraction of an elastic Fourdrinier wire.

A still further object of the present invention is to produce paper webs and related web materials having strength flexibility and elongation characteristics heretofore considered unobtainable on Fourdrinier machines.

It is still another object of the present invention to provide a new and improved Fourdrinier wire permitting compaction of paper web and related web material thereon.

It is another object of the present invention to provide an elastic Fourdrinier wire consisting of a fabric woven with longitudinally extending plastic yarn or filaments and with metal wires as transverse weft or shoots.

It is a further object of the present invention to provide a new and novel method of compacting paper web and related web materials on a Fourdrinier machine.

Another object of the present invention is to provide means for improving the characteristics of paper web and related web materials by fiber compaction which are simple and compact in construction, and efficient and high speed in operation.

These and other objects, features and advantages of the present invention will become more apparent upon a careful consideration of the following detailed description, when taken in conjunction with the accompanying drawing illustrating preferred embodiments of the concepts of my invention, wherein like reference characters and numerals refer to like or corresponding parts throughout the several views.

On the drawings:

FIGURE 1 is a partially diagrammatic view in side elevation of apparatus found useful in the practice of my invention;

FIGURE 2 is a partially diagrammatic view illustrating another embodiment of apparatus found useful in the practice of my invention; and

FIGURE 3 is an enlarged fragmentary view illustrating a Fourdrinier wire constructed in accordance with the principles of the present invention.

Briefly stated, the present invention contemplates a Fourdrinier wire having elastic properties constructed preferably of a fabric woven of longitudinal plastic yarn or filaments and transverse metal wires for the weft or shoot wires which traverses a breast roll and a couch roll and carries the paper web or related web material while the wire is stretched under a tension provided by means controlling operational speed of the breast roll as a function of the operational speed of the couch roll.

With the elastic Fourdrinier wire under longitudinal tension and elongation, the formation of the paper web or related web material is completed near the dry end of the Fourdrinier machine where the fluid state of the mat is reduced and the mat transformed into a water filled fiber network web. In this state, the mat or web has an inherent degree of plasticity and is capable of resisting shear forces. At the dry end of the Fourdrinier machine the mat or web passes over the driving suction couch roll where the tension in the Fourdrinier wire is progressively reduced to the minimum or base tension, and the web, constrained by the suction pressure forces of the couch roll, is thereby correspondingly contracted in a plane parallel to width of the wire. The contraction forces within the web itself, cooperating with the suction pressure forces of the couch roll, tend to crowd the fibers and fibrils of the paper mat closer together thereby enhancing the desired mechanical entanglement of the paper web or related web material. In addition the compression of the web and entanglement of the fibers and fibrils of the web assist in removing additional water at the couch roll. The paper web or related web material resulting from such treatment has an increased strength and marked flexibility not found in paper webs formed on the conventional metal wire Fourdrinier machine.

The resulting paper web or related web material is not comparable to crepe paper but is a paper substantially as smooth after having been compacted as before. In other words, the compaction of the web by the practice of my invention produces a resulting paper web or related web product having the same desirable characteristics of paper formed on the conventional metal Fourdrinier wire but with increased strength, compactness, and elasticity flexibility.

Apparatus found useful in the practice of my inven-

tion, as appears in FIG. 1, includes a conventional pulp or stock formation device 6 from which the pulp is fed onto a Fourdrinier wire 7 in the form of an endless loop which traverses a breast roll 8, a driven couch roll 9, which is preferably a suction couch roll, as shown, and a plurality of guide rolls 10 through 15*a*. A plurality of conventional suction boxes 16 are provided for the extraction of water from the web through the wire aiding in web compaction.

Tension is applied to the top side of the wire carrying the mat M longitudinally in the direction of travel of the web by providing tension control means. The degree of tension applied to the elastic wire will, of course, depend upon the end product desired. For instance, for board as compared with lightweight paper, the tension will be comparatively greater. Means to provide wire tension may take the form of brake means 17 controlling operation of the breast roll 8. The brake means 17 may be connected to the main drive shaft of the couch roll drive means 18 by a differential gear arrangement indicated by the numeral 18*a*. Alternately, the tension control may be provided by electrical drive means employing the well known regenerative braking methods or, by a simple gear arrangement connecting the breast roll to the main couch drive to provide the desired degree of roll speed differential required for the particular application involved.

It will be noted from prior Hornbostel et al. U.S. Patent No. 2,992,965 that, even with no brake on the breast roll or with substantially no tension change in the wire at the breast roll, there is a minute amount of stretching of the wire between the breast roll and the couch roll primarily as the tension in the wire changes when it is driven under the so-called "loaded conditions," i.e., with a web forming thereon over the suction boxes. This prior patent teaches that this minute amount of stretching is significant in that it should not be eliminated by driving the normally loaded wire at the couch roll because this causes a very small amount of decrease in the tensioned wire to take place while the wire is in contact with the suction couch roll, thus causing the wire wear. The stretching and the consequent reduction in stretching or elongation of the wire described in this patent are significant factors insofar as wire wear is concerned, but they are practically imperceptible for most other purposes in the operation of the paper machine and they do not constitute the type of stretching or elongation of the wire that is contemplated in the present invention. This is so because the present invention positively calls for brake means 17 controlling the operation of the breast roll, or equivalent means which will actually cause a deliberate and functional stretching of the wire to the extent that it is functionally elongated for the purposes set forth in greather detail in this specification. As is pointed out in the prior patent the nominal operating conditions of paper machines under so-called "normal load conditions" do not call for any braking means functioning in conjunction with the breast roll to deliberately create additional wire elongation and/or tensioning which results in stretching. The prior patent thus describes the so-called conventional conditions of a loaded paper machine being driven by rolls in a particular manner described in said prior patent. The instant invention, in contrast, calls positively for brake means 17 or their equivalent to effect a substantial elongation or wire stretching between the braked breast roll and the driven couch roll, with a consequent and subsequent contraction of the elongated or stretched wire that is again of substantial and functional significance for the purposes described in detail herein.

As aforesaid, the Fourdrinier wire 7 in the form of an endless loop may be constructed of any material having elastic properties which will provide the necessary stretch elongation required for compacting the mat thereon. The wire is preferably constructed of a plastic material comprising a pervious fabric having longitudinal plastic yarn or filaments extending in the direction of travel of the web and with metal wires as the transverse weft or shoot wires.

The non-metallic fabric filler or shoots employed, will, of course, be chosen on the basis of its adaptability for the paper making purposes involved. The longitudinal cords of the wire are preferably constructed of yarn or filament having elastic properties, such as the natural and synthetic plastics from which textile fibers having elastic memories are prepared or possibly a resilient cotton yarn.

The transverse weft or shoot fibers or filaments of the wire, i.e., those transverse to the direction of travel of the web, may also be constructed of similar material having elastic properties; however, I prefer to employ a metal wire for such transverse cords or filaments since improved transverse stability of the wire is obtained whereas a wire consisting of both longitudinal and transverse materials having elastic properties would tend to reduce in width as the longitudinal elongation occurs. It will be noted that by employment of the plastic material in the Fourdrinier wire a lighter weight wire may be constructed.

A preferred form of wire is shown in FIG. 3 wherein the longitudinal yarn or filaments 7*a* (arrow) consist of plastic material having the desired elastic properties and the transverse yarn or filaments 7*b* are constructed or metal wire. The elastic forming wire itself is of such strength as to withstand the tension applied thereto and to permit continued application of suction forces therethrough.

Thus with the elastic Fourdrinier wire placed under a tension sufficient to stretch it by employment of the brake means 17 for breast roll 8, paper stock may be fed from the forming apparatus 6 onto the wire 7. The matting stock traverses the suction boxes 16 while on the stretched wire and is then led over couch roll 9. Couch roll 9 is preferably a suction couch roll, and, as the matting stock passes over the suction couch roll to be removed, as for example, by a transfer felt (not shown), the tension on the elastic wire is gradually reduced to the minimum or base tension which exists on the bottom side of the wire as it traverses guide roll 10 through 15*a*. The formation therefore of the web takes place on the wire while it is in the stretched condition and is completed to an extent before the passage thereof over driving suction couch roll 9.

As the tension on the wire is progressively reduced the fibers of the web are distorted by contraction and to a degree the distorted fibers are forced into the void spaces within the paper web thereby entangling the fibers and fibrils. The inherent adhesion of the fibers and fibrils of the web causes them to further entangle into a coherent compact mass. The suction couch roll, by withdrawing water from the paper web, assists in the compression and compaction of the fibers and fibrils not only by withdrawing water from the web but also by holding the web in suction engagement with the wire.

The compressed web is then transferred from the wire at a point preferably where the wire tension has been reduced to the minimum or base tension to a felt (not shown). It has been our experience that while open draw operation results in a paper product having greater strength and flexibility than web made on conventional Fourdrinier wires, it is preferabe to remove the web from the elastic wire by employment of a suction pickup roll to maintain the contraction of the web at the optimum level.

After having been transferred to the transfer felt, the natural and inherent adherence of the compressed fibers and fibrils maintain the web in the compacted condition.

It will be appreciated that the differences in local or spot density normally encountered with paper webs formed on a conventional Fourdrinier wire are not found in the product made in accordance with the present invention. Thus a paper web having a substantially uniform density throughout may be prepared which has enhanced desirable characteristics for such applications as printing, coating and glossing. Furthermore, the bulk or thickness of the web is not materially reduced as a result of the contraction thereof. The bulk or thickness of the web need not be materially increased, since the web compaction may be

controlled by regulating wire tension release. Paper web products made in accordance with my invention exhibit a marked increase in elasticity and resiliency in addition to increased strength, flexibility and elongation. Thus end products, such as board, bag, tissue, creping and the like may be prepared from the compacted web material obtained by the practice of my invention.

The particular tension applied to the elastic wire and consequently the speed differentials between breast roll **8** and couch roll **9** will depend primarily upon the type of paper web being formed on the wire. In addition to control of wire tension, the rate of reduction in tension at the couch roll will depend similarly upon the end product desired and the compaction thereof necessary to achieve the desired characteristics of the end product.

As appears in FIG. 2, an alternate embodiment of apparatus found useful in the practice of my invention comprises a standard stock formation apparatus **6** and the elastic Fourdrinier wire **7** traversing breast roll **8** and couch roll **9**, which is preferably of the suction type. Guide rolls **10** through **15***a* and suction boxes **16** may also be provided in the usual manner. Brake means **17** are provided, and the tension applied to the wire **7** by breast roll **8** under the influence of brake means **17** through gearing apparatus **18***a* connected to the couch roll **9** for maintaining the desired degree of speed differential between breast roll **8** and couch roll **9**. A suction pickup roll **22** is shown for transferring the web after contraction thereof to appropriate transfer means, such as a transfer felt **23**.

Brake means **17** for applying tension on the forming wire are employed for regulating the differential speed required between couch roll **9** and breast roll **8** to achieve the desired stretch on the web forming wire **7**.

In addition, means may be employed to assist in reducing the amount of water in the mat or paper web being formed on the wire **7**. Such means may take the form of a wire **24**, similar in construction and operation to wire **7**, which, as shown, traverses the roll **25** and driven roll **26**. Roll **26** may be driven as by drive means **27**, and the tension on the top wire **24** may be controlled by regulating the speeds of roll **25** by brake means **28** connected to the drive means **27** of driven roll **26** through a differential gear arrangement **29** which may be similar in construction and operation to gear means **18***a*.

To prevent relative slippage between top wire **24** and forming wire **7** which would otherwise occur within the web material if the surface speeds of wires **7** and **24** were different while under tension, speed equalization of the respective driven and driving rolls of wires **7** and **24** may be obtained by coupling drive means **18** and **27**, thus synchronizing their speeds to thereby regulate the tension applied to wires **7** and **24** through the action of brake means **17** and **28** coupled to the respective drive means **17** and **27** through the gearings **18***a* and **29** respectively. By thus coupling the drive rolls of wires **7** and **24**, the speeds of the wires will be identical, thereby preventing relative web slippage therebetween and the wires **7** and **24** will be traveling with the same surface speeds.

As the forming web, pressed by wire **7** against wire **24**, reaches the driven roll **26**, a substantial amount of the water therein has been removed and the natural adhesion of the fibers in the web tend to hold the mat in an integral entanglement. By positioning the suction boxes **16**, as shown, the suction forces, acting on the web as it leaves contact with wire **24** adjacent the driven roll **26**, tend to initially crowd the fibers closer together in an entangled condition and further assist in removing additional water from the web. The web then passes over the driving suction couch roll **9** where the tension on the wire is progressively reduced, and, the wire, in contracting, causes a corresponding contraction of the web distorting the fibers and fibrils of the web still further, and, the thus distorted fibers and fibrils are forced further into the void spaces within the paper web thereby further mechanically entangling the fibers and fibrils.

The compressed web is then transferred from the wire to the transfer felt **23** at a point of reduced wire tension, preferably where the wire tension has been reduced to the minimum or base tension to the transfer felt **23**.

The natural and inherent adherence of the compressed fibers and fibrils will maintain the web in the compacted condition after having been transferred to the transfer felt.

Thus by employment of the top wire, the amount of water in the web on the forming wire may be considerably reduced, and thereby subsequent treatment of the web by specialized apparatus on the paper making machine facilitated, depending upon the particular end product desired.

Although various minor modifications might be suggested by those versed in the art, it should be understood that I wish to embody within the scope of the patent warranted hereon all such embodiments as reasonably and properly come within the scope of my contribution to the art.

I claim as my invention:

1. Apparatus for compacting paper web material and related web materials on a Fourdrinier machine comprising: an elastic Fourdrinier wire adapted to traverse a breast roll spaced-apart from a driven couch roll; suction means intermediate said breast roll and said couch roll whereby water may be withdrawn through said wire from a web material being formed thereon; means for regulating the relative speeds of said breast roll and said couch roll whereby said breast roll applies a tension on said wire stretching said wire in the direction of wire travel to said couch roll, said wire contracting during its contact with and travel over said couch roll in the direction of wire travel to said breast roll whereby web forming slurry deposited on said wire while it is in a stretched condition is compacted while said wire is contracting; a second elastic wire adapted to traverse at least two wire support means positioned above said elastic Fourdrinier wire for pressing a web being formed on said Fourdrinier wire to thereby remove water therefrom, and means to control the surface speed of said second wire, said speed regulating means for the breast and couch rolls including braking means operatively connected to said breast roll whereby the breast roll speed differential relative to that of the wire and the couch roll is positively maintained and stretching of the wire as a consequence is positively controlled and the amount of stretching is over and beyond the nominal wire stretching inherent in the driving of wire under conditions of load otherwise specified in this claim.

2. Apparatus for compacting paper web material and related web materials on a Fourdrinier machine comprising an elongatable Fourdrinier wire adapted to traverse a breast roll spaced apart from a driven couch roll, suction means intermediate said breast roll and said couch roll whereby water may be withdrawn through said wire from a web material being formed thereon, brake means for sufficient positive and material braking of said breast roll to substantially reduce the speed of said breast roll below that of said couch roll and to sufficiently tension said wire to cause a substantial elongation of said wire in a direction of wire travel to said couch roll with said wire being adapted to contract during its contact with and travel over said couch roll in the direction of wire travel returning back to said breast roll, whereby web forming slurry deposited on said wire while it is in the aforesaid elongated condition between the breast roll and couch roll is compacted while said wire is contracting.

3. Apparatus for compacting paper web material and related web materials on a Fourdrinier machine comprising an elongatable Fourdrinier wire adapted to traverse a breast roll spaced apart from a driven couch roll, suction means intermediate said breast roll and said couch roll whereby water may be withdrawn through said wire from a web material being formed thereon, positive drive means operatively connected with the forming wire to drive the same in a return run back from the couch roll to the

breast roll and to maintain the couch roll at a predetermined speed, brake means for sufficient positive and material braking of said breast roll to substantially reduce the speed of said breast roll below that of said couch roll and to sufficiently increase tension in the wire above any tension increase in the wire caused by moving the wire with the web thereon over said suction means and to said couch roll to cause a substantial elongation of said wire in the aforesaid direction of wire travel toward said couch roll with said wire being adapted to contract during its travel over the couch roll in association with the aforesaid positive drive means, with such contraction occurring in the direction of wire travel in the aforesaid return run from the couch roll to the breast roll, whereby web forming slurry deposited on the wire while it is in an elongated condition is compacted while said wire is undergoing the aforesaid contraction, and means for removing the contracted web thus formed from the contracted forming wire.

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