

(19)



(11)

EP 3 332 058 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

26.06.2019 Bulletin 2019/26

(51) Int Cl.:

D06B 13/00 (2006.01)

(86) International application number:

PCT/IB2016/054693

(21) Application number: **16757351.8**

(22) Date of filing: **03.08.2016**

(87) International publication number:

WO 2017/025867 (16.02.2017 Gazette 2017/07)

(54) APPARATUS FOR TEXTILE PROCESSING AND METHOD OF MANUFACTURING

VORRICHTUNG ZUR VERARBEITUNG VON TEXTILIEN UND VERFAHREN ZUR HERSTELLUNG

APPAREIL DESTINÉ AU TRAITEMENT DU TEXTILE, ET PROCÉDÉ DE FABRICATION

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

(30) Priority: **08.08.2015 IN 3002MU2015**

(43) Date of publication of application:

13.06.2018 Bulletin 2018/24

(73) Proprietors:

- **Reddy, Konreddy Venkat**
Vadodara 391240 (IN)
- **Vyas, Himalibahen K.**
Vadodara 390002 (IN)

(72) Inventors:

- **REDDY, Konreddy Venkat**
Karjan, Vadodara 391240 (IN)
- **VYAS, Keyurkumar Parshuram**
deceased (IN)

(74) Representative: **Schiweck Weinzierl Koch**

Patentanwälte Partnerschaft mbB
Ganghoferstraße 68 B
80339 München (DE)

(56) References cited:

EP-A1- 0 969 131 WO-A1-99/37844
US-A- 3 688 527 US-A- 4 302 485
US-A1- 2013 031 872

EP 3 332 058 B1

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

CROSS REFERENCE

[0001] The underlying concepts, but not necessarily the language, of the Indian provisional patent application number. **3002/MUM/2015** filed on **August 8, 2015** from which this application claims benefit of priority. The above referred patent application and contents as disclosure therein are made part of this specification and are treated as if disclosed in their entirety in this specification.

TECHNICAL FIELD

[0002] The subject matter generally relates to an apparatus for textile processing and method manufacturing the apparatus. More specifically, the subject matter relates to an apparatus method of manufacturing the apparatus for impregnation of fluids and chemical into yarn and/or textile and/or fabric.

BACKGROUND

[0003] Over a period of time yarns used in textile industry have become finer, denser, stronger and with less hairiness. Denser and stronger yarns can now withstand stressed environment of weaving machines. Yarns are applied with the bonding chemical and/or synthesized and/or natural starch to make them strong enough to withstand stresses of high speed weaving preparatory and weaving machine. This has not only resulted in increased speed of production of textile, but also made possible to increase density of the textile. Both, the yarn and the textile thereof have become so dense that intra-yarn space, i.e. space within yarn and inter-yarn i.e. space in between adjacent yarns, have considerably reduced. Reduced inter-yarn and Intra-yarn spaces are desirable for a number of reasons, such as fine finish and otherwise improvement in other qualities. At the same time, it also limits absorption capacity of yarn and the textile thereof. Limitation on the absorption capacity of the yarn and the textile is undesirable in course of textile processing. A number of processes often get adversely affected by reduced absorption capability of a yarn or textile. Such processes include wet processing such as singeing, desizing, bleaching, mercerizing, dyeing, and washing etc. A number of techniques for increasing the absorption capacity of yarn and the textile have been applied by the industry. However, these techniques are either technology intensive, expensive, less-commercially viable or have problems relating to scaling from laboratory conditions to the industry conditions. Patent documents relating to the Numbers EP 0 969 131 A1, US 3 688 527, and WO99/37844 show some solutions which are discussed in more details with reference to subject matter at the end of the specification.

[0004] Therefore, an apparatus is desirable that addresses the above problems. The subject matter pro-

vides solution to the above and other problems.

SUMMARY

[0005] According to one aspect the subject matter provides an apparatus comprising: a first tank (107) comprises a first and a second wall, a first transducer (107), wherein the first transducer (107) is adapted to transmit ultrasonic waves of a first wavelength into the first tank (101), and the first tank (101) is configured to establish a substantially standing ultrasonic wave pattern of the ultrasonic waves inside the first tank (101), and a disposer (109.1 and 109.2) adapted to dispose a textile (131) into the first tank (101) at a first distance from the first transducer (107), characterized in that the first distance is determined based on the first wavelength and, wherein the first transducer (107) is coupled to the first wall (103) and the second wall (105) is configured to reflect the ultrasonic waves and the first wall (103) and the second (105) are separated from each other to establish the substantially standing wave pattern into the first tank (101) resulting in multiple cavitation zones and wherein the apparatus is configured to operate on a sweep frequency of ultrasonic waves, the sweep frequency is a band of frequencies around a first frequency, wherein the first frequency corresponds to the first wavelength and the disposer (109.1 and 109.2) is configured to dispose the textile (131) at the first distance, the first distance is determined based on the first frequency. In one embodiment, the first transducer (107) and geometry of the first tank (101) are configured to expose the textile (131) to ultrasonic power in a range between 0.2 Watts/cm² and 2 Watts/cm². In a second embodiment, the first transducer (107) and geometry of the first tank (101) are adapted to transmit at least 8 watts/liter of ultrasonic power into the first tank (101). In a third embodiment, the disposer (109.1 and 109.2) comprises a first plurality of rollers (111, 117, 119, 125, 113, 115, 121 and 123) and the first plurality of rollers (111, 117, 119, 125, 113, 115, 121 and 123) are adapted to dispose multiple iterations of the textile (131) through the first tank (101) and each iteration of the textile (131) is separated from adjacent iteration of the textile (131) by a distance, wherein the distance is determined based on the first wavelength. In a fourth embodiment, the disposer (109.1 and 109.2) disposes each of the iterations of the textile (131) at locations that corresponds to locations of antinodes of the substantially standing ultrasonic wave pattern formed in the first tank (101). In a fifth embodiment, a second transducer (207), wherein the second transducer (207) is adapted to transmit ultrasonic waves of a second wavelength into a second tank (201), and the second tank (201) is configured to establish a substantially standing ultrasonic wave pattern of the ultrasonic waves inside the second tank (201); and the disposer (109.1 and 109.2) is configured to dispose the textile (131) sequentially into the first tank (101) and the second tank (201). In a sixth embodiment, the disposer (109.1 and 109.2) is configured to dispose the

textile (131) at a second distance from the second transducer (207) into the second tank (201), wherein the second distance is determined based on the second wavelength and the disposer (109.1 and 109.2) is adapted to dispose multiple iterations of the textile (131) through the second tank (201) and each iteration of the textile (131) is separated from adjacent iteration of the textile (131) by a third distance, wherein the third distance is determined based on the second wavelength and the disposer (109.1 and 109.2) disposes each of the iterations of the textile (131) at locations that corresponds to locations of antinodes of the substantially standing ultrasonic wave pattern formed in the second tank (201). In a seventh embodiment, the second transducer (207) and geometry of the second tank (201) are configured to expose the textile (131) to ultrasonic power in a range between 0.2 Watts/cm² and 2 Watts/cm² and are adapted to transmit at least 8 watts/liter of ultrasonic power into the second tank (201).

[0006] According to another aspect the subject matter provides a method of manufacturing an apparatus comprising: providing a first tank (101) wherein the first tank (101) comprises a first wall (103) and a second wall (105); configuring the second wall (105) to reflect the ultrasonic waves and the first wall (103) and the second (105) are separated from each other to establish the substantially standing wave pattern into the first tank (101) resulting in multiple cavitation zones; providing a disposer (109.1 and 109.2) configured to dispose a textile (131) at a first distance from the first transducer (107) and into the first tank (101), characterized in that the first distance is determined based on a first wavelength; coupling a first transducer (107) to the first wall (103) of the first tank (101), wherein the first transducer (107) is configured to transmit ultrasonic waves of the first wavelength into the first tank (101); and configuring the apparatus to operate on a sweep frequency of ultrasonic waves, the sweep frequency is a band of frequencies around a first frequency, wherein the first frequency corresponds to the first wavelength and the disposer (109.1 and 109.2) is configured to dispose the textile (131) at the first distance, the first distance is determined based on the first frequency. In an eighth embodiment, the method includes configuring the first transducer (107) and geometry of the first tank (101) to: expose the textile (131) to ultrasonic power in a range between 0.2 Watts/cm² and 2 Watts/cm²; and transmit at least 8 watts/liter of ultrasonic power into the first tank (101). In a ninth embodiment, providing the disposer (109.1 and 109.2) includes providing a first plurality of rollers (111, 117, 119, 125, 113, 115, 121 and 123) and adapting the first plurality of rollers (111, 117, 119, 125, 113, 115, 121 and 123) to dispose multiple iterations of the textile (131) through the first tank (101), wherein each iteration of the textile (131) is separated from adjacent iteration of the textile (131) by a distance determined based on the first wavelength. In a tenth embodiment, providing the disposer includes adapting the disposer (109.1 and 109.2) to dispose each

of the iterations of the textile (131) at a location that corresponds to location of an antinode of the substantially standing ultrasonic wave pattern formed in the first tank (101).

BRIEF DESCRIPTION OF DRAWINGS

[0007] The subject matter shall now be described with reference to the accompanying figures, wherein:

FIG. 1 shows a schematic diagram of an apparatus according to one embodiment of the subject matter;

FIG. 1a shows another schematic diagram of an apparatus according to an embodiment of the subject matter;

FIG. 2 shows a schematic diagram of an apparatus according to another embodiment of the subject matter;

FIG. 3 shows a schematic diagram of an apparatus according to yet another embodiment of the subject matter;

FIG. 4 shows more schematic details of an apparatus according to one embodiment of the subject matter; and

FIG. 5 shows a method according an embodiment of the subject matter.

DETAILED DESCRIPTION

[0008] It shall become clear to a person, after reading this specification, that the following discussion is intended only for illustration purpose and not to limit to the described embodiments, and that the subject matter may be practiced without departing from the spirit of the subject matter in other embodiments different than the embodiments discussed herein. The subject matter is being described, for the purpose of explanation only, with the help of an example of an apparatus for impregnation of fluid and de-size chemicals in yarn and textile. However it shall become abundantly clear to a person, after reading this specification, that the subject matter may be practiced in other fluid impregnation applications, for example in bleaching; mercerizing, dyeing, chemical treatment and washing processes. It is also to be understood that the terminology used throughout the preceding and forthcoming discussion is for the purpose of describing particular embodiments only, and is not intended to be limiting. It must be noted that as used herein, the singular forms "a", "an", and "the" include plural references unless the context clearly expressly dictates otherwise. It also to be understood that ultrasonic transducers of wavelength λ are discussed only for the explanation. It shall become abundantly clear to a person skilled in the art,

after reading this specification, that practical transducers produce ultrasonic waves in a wavelength range $\lambda \pm \Delta\lambda$, where $\Delta\lambda$ is small wavelength range around wavelength λ and that the subject matter may be accordingly adapted for the wavelengths $\lambda \pm \Delta\lambda$ without departing from the basic spirit of the disclosed solution. It shall become clear to a person that the text "size" or "bonding chemicals and size" referred in this description unless otherwise stated are used to refer to a layer of bonding chemicals and natural or synthetic starch applied on to yarn before weaving. It should further be understood that throughout following discussion, text "tank", "transducer/s", "disposer", "wavelength" etc. are referred to a general embodiment of the subject matter and applies *mutatis mutandis* to each of the embodiments discussed herein and to other embodiments that may be achieved by practicing the subject matter.

[0009] To fulfill a basic industry need of consistent, low cost, environment friendly, reliable and repeatable process the subject matter provides a solution for impregnation of yarn/textile using ultrasonic technology. The subject matter focuses on geometry of equipment and distance between transducer and textile, location of transducers and providing effective environment to cause impregnation of a fluid into the textile. The subject matter provides the geometry of equipment to establish substantially standing ultrasonic waves and positioning of textile at a predetermined location based on a number of parameters such as, ultrasonic power per square centimeter on textile, ultrasonic power per liter of fluid and contact time of textile and fluid, effective use of reflected ultrasonic waves that form standing wave pattern. Further the subject matter provides solution for handling variety of textiles for example, cotton, wool, polyester and other yarns have different characteristics of absorbency and requirement for impregnation by providing electronically controlled disposing of textile in a tank and electronically controlling positioning of textile and characteristics of ultrasonic waves, such as, sweep characteristics.

[0010] FIG. 1 shows an apparatus 100 according to one embodiment of the subject matter. In that FIG. 1 shows a first tank 101, a first wall 103, a second wall 105, a first transducer 107, blocks 109.1 and 109.2 (disposer), a first plurality of rollers 111, 117, 119, 125, 115, 113, 121 and 123, an inlet 127, an outlet 129 and a textile 131 (also referred to interchangeably as yarn or fabric).

[0011] The apparatus 100 is configured to impregnate the textile 131 with a fluid that is filled in the first tank 101. Generally, the apparatus 100 is employed for impregnating textile 131 with water and other chemicals, for example, de-size chemicals, bleaching chemicals etc. In some embodiments, the textile 131 is impregnated prior to wet processing of the textile 131. It shall become clear to a person in the art, after reading this specification that the apparatus illustrated in FIG. 1 and other FIGURES described herein, may be equally applicable and configurable to impregnate yarn and textile and that there may be additional equipment and hardware not shown in the FIG.

1 and other FIGURES described herein, but may be required for the operations of the apparatus. These additional equipment and hardware may include, but not limited to, recirculation pumps, compressors, additional impregnation sections, chemical dosing pumps for maintaining the chemical concentration in the first tank 101, motor drives for nip rolls and other rollers, level sensors, level controllers, pneumatic valves, programmable logic controllers (PLC), human machine interfaces (HMI) for control and visualization, ultrasonic generators and power supplies.

[0012] Operation of the apparatus 100 may be understood as follows. As shown in FIG. 1. The blocks 109.1 and 109.2 together form a disposer. The textile 131 may be configured to be pulled through the disposer 109.1 and 109.2. The disposer has the first plurality of rollers 111, 117, 119, 125, 113, 115, 121 and 123. It shall be clear to the person, after reading this specification, that a motor (not shown) may roll the textile 131 and cause the textile 131 to pass through the disposer 109.1 and 109.2 as shown in the FIG. 1. Combination of rollers 111, 115, and 113 of the first plurality of rollers causes the textile 131 to make first iteration through the first tank 101 and thereby exposing the textile 131 to the fluid filled in the first tank 101 and the ultrasonic waves which the first transducer 107 introduces into the first tank 101. Similarly, combinations of rollers 113 and 117; 117, 119 and 121; and 121, 123 and 125 of the first plurality of rollers respectively cause the textile 131 to make second, third and fourth iteration through the first tank 101, working in tandem with each other. The each of the first plurality of rollers 111, 117, 119, 125, 113, 115, 121 and 123 depends on the number of iteration that the textile 131 needs make through the first tank 101. The disposer is configured to suspend and/or dispose the textile 131 into the first tank 101 and keep the textile moving continuously. Further technical operation of the apparatus shall become clearer from the subsequent discussion.

[0013] The construction of the apparatus 100 may be understood as follows. The apparatus 100 has the first tank 101. The first tank 101 comprises the first wall 103 and the second wall 105. The first wall 103 is provided with the first transducer 107. The first transducer 107 is coupled to the first wall 103 and the first transducer 107 is configured to generate ultrasonic waves of a first wavelength (λ_1). Material of the first wall 103 and second wall 105 is selected such that they optimally reflect the ultrasonic waves in the first tank 101. Distance between the first wall 103 and the second wall 105 is such that the ultrasonic waves transmitted in the first tank 101 establish a substantially standing wave pattern. In FIG. 1 the distance shown is 3 times the first wavelength (λ_1). It should become clear to a person that for the purpose of this description and for the purpose of brevity, the substantially standing ultrasonic waves are referred to as standing waves, or standing ultrasonic waves.

[0014] Alternatively, based on size of the first tank 101 characteristics of the first transducer 107, the first wave-

length (λ_1) may be determined. In one embodiment, the height of the first tank **101** and the distance between the first wall **103** and the second wall **105** may be determined based on and length of textile (**131**) that travels through the first tank (**101**) and the number of iterations that the textile **131** makes through the fluid of the first tank **101**. In some embodiments, the length of the textile **131** in first tank **101** is determined based on textile web speed in continuous production operation and a duration of time for which the textile **131** and the ultrasonically active fluid is desired to remain in contact (also referred to as "contact time"). Further based on the contact time required for particular textile type, and production speed etc., length of textile **131** in block **100** can be calculated. For example, if T is the contact time and S is the speed of production then length L may be calculated as $L = T \times S$. In the shown example the height of block **100** may be adjusted according to the length L or the width may be adjusted to accommodate number of iterations of the textile **131**.

[0015] The disposer **109.1**, **109.2** disposes the textile **131** in the first tank **101** in such a manner that ultrasonic waves produced by the first transducer **107** travels in substantially perpendicular direction of the textile **131**. The textile **131** is disposed substantially longitudinally across the first tank **101**. It shall become clear, after reading this specification that the distance between the first wall **103** and the second wall **105** of the first tank **101** is substantially close to a number which is equal to the first wavelength (λ_1) multiplied by an integer (n). In one embodiment the integer (n) may depend on the number of iterations of the textile **131** through the first tank **101**. For example, in **FIG. 1** the number of iteration the textile **131** makes through the first tank **101** is 4, and the distance between the first wall **103** and the second wall **105** of the first tank **101** may be 3 times (λ_1) that is the integer (n) is 3. It shall further become clear, after reading this specification that the example of **FIG. 1** shows, that each of the iterations of textile **131** is spaced from each other at least by a first distance which is substantially close to $\lambda_1/2$ which is half of the first wavelength (λ_1).

[0016] In some embodiments, the geometry of the first tank **101** is determined based on the first wavelength (λ_1) and power of ultrasonic waves that need to be transmitted into the first tank **101**. For example if the power needed to be transmitted is 8 Watts/liter, then based on the first wavelength (λ_1) distance between the first wall **103** and the second wall **105** may be determined. Based on the distance between the first wall **103** and the second wall **105**, the first wavelength (λ_1) and characteristics of the first transducer **107** height of the first wall **103**, and second wall **105** may be determined so that 8 Watts/liter of ultrasonic power is transmitted into the first tank **101**. In one example, the vertical height of the first and second walls **103**, **105** and first transducer **107** is selected based on the time for which the textile **131** is desired to be exposed to the ultrasonic waves, the fluid, the first wavelength (λ_1), power/liter of ultrasonic waves transmitted by the first transducer **107** into the first tank **101** and

power/cm² of the ultrasonic waves that the textile **131** is desired to be exposed to. In some embodiments, quality and type of textile **131** may be used to determine the geometry of the first tank **101**. The geometry of the first tank **101** may also be decided by the web width of the textile **131**. The first tank **101** is provided with the inlet **127** and the outlet **129** for allowing entry and exit of the fluid respectively. In one example, the first transducer **107** may be of 25 KHz, 4000 Watt for a surface area of one iteration of textile **131** of 7200 cm square exposed to the first transducer **107**. In this case, the effective Watts/cm² is slightly higher than 0.5 Watts/cm².

[0017] **FIG. 1a** shows another embodiment of an apparatus **700** according to an embodiment of the subject matter. The embodiment shows a first tank **701**, a first wall **703**, a second wall **705**, a first transducer **707**, blocks **709.1** and **709.2**, a first plurality of rollers **711**, **713**, **721** and **725**, an inlet **727**, an outlet **729** and a textile **731**. The discussion of the embodiment **100** of **FIG. 1** applies *mutatis mutandis* for the embodiment **700** shown in **FIG. 1a** the only difference in the two embodiments is configuration of the disposer **109.1**, **109.2** and the blocks **709.1** and **709.2** respectively. From the **FIG. 1a** it may be noticed that the textile **731** is disposed in the first tank **701** and make multiple iterations through the first tank **701**. Each of the iteration is separated from adjacent iteration by a third distant and the third distant is determined by wavelength of ultrasonic waves produced by the first transducer **707**. It shall become clear to a person, after reading this specification that the disposer may have a configuration different than what is shown in **FIG. 1** and **FIG. 1a**, without departing from spirit of the subject matter. Further it should also be understood from **FIG. 1a** that in some embodiments some iteration of textile (e.g. the iteration supported by rollers **717** and **713**) may be disposed in the first tank **701** based on the first wavelength so that most of the iterations of the textile are dispose at distance from the first transducer **707** which is integer multiple of the half of the first wavelength.

[0018] **FIG. 2** shows the subject matter according to another embodiment, in that, the apparatus comprise the block **100** of **FIG. 1** coupled to a block **200**. So far as construction and operation of the block **200** and corresponding reference numerals of block **200** are concerned, discussion of **FIG. 1** applies *mutatis mutandis*. The block **200** is substantially similar to that of the block **100** except that the block **200** comprises second transducer(s) **207**. In some embodiments, the second transducers **207** may generate ultrasonic waves of a second wavelength (λ_2). In some embodiments the second wavelength (λ_2) may be same or is different from the first wavelength (λ_1). In some embodiments, there may be more than two second transducers **207**. In some embodiments, the inlet **127** is coupled to the outlet **229** of block **200**. The textile **131** is sequentially disposed into the first tank **101** and the second tank **201**.

[0019] **FIG. 3** shows another embodiment **300** of the subject matter. In this embodiment **300**, the block **100** of

FIG. 1 is provided with block **200** as described with reference to **FIG. 2** and is further provided with an un-winder **301**, nip rolls **303** and **311**, a block **305**, an outlet **325** of a fluid tank **315**, a fluid source **307**, a degassing tank **317**, a steam inlet **327**, a valve **309** and a winder **313**.

[0020] The operation and construction of the embodiment **300** may be understood as follows. The textile **131** is unwound from the un-winder **301** and is subjected to a 3-stage impregnation process through the blocks **305**, **100** and **200**. Once the textile **131** has been through the blocks **305**, **100** and **200** the textile **131** is transported and wound on the winder **313**. The textile **131** is pulled by the nip rolls **303** and **311**. The nip rolls **303** and **311** may be coupled to prime movers such as electric motors (not shown).

[0021] The block **305** comprises the fluid tank **315** and the outlet **325**. In one embodiment, the fluid tank **315** receives fluid from the block **100** that is the outlet **129** may be coupled to an input of the fluid tank **315**. At block **305** the textile **131** gets wet. Wetting of textile may help in adapting the textile **131** to expose it to ultrasonic cavitation and forming nuclei at its surface. For example, subjecting the textile **305** may remove large bubbles that form on the surface of textile **131** when the textile is introduced into the fluid however, does not remove finer bubbles in the inter-yarn space that get forwarded to block **100** along with the textile **131**. Further wetting may help in removing undesired hard size. A plurality of rollers may be disposed in block **305** to facilitate the textile **131** to pass through the fluid in a plurality of iterations.

[0022] Construction and operation of **FIG. 1** and **FIG. 2** applies *mutatis mutandis* to blocks **100** and **200**. According to one embodiment, block **307** may be provided to supply fluid. The block **307** may comprise the degassing tank **317** and the steam inlet **327**. Providing the degassing tank **317** and the steam inlet **327** improves impregnation using ultrasonic becomes by removing dissolved gasses from fluid. Reduced dissolved gasses in fluid cuts down damping effect and improves cavitation due to ultrasonic waves. The degassing tank **317** is provided with the steam inlet **327** that releases stream of steam bubbles into the fluid causing degassing and adjusting temperature of the fluid. In another embodiment, degassing of the fluid may also be achieved by degassing with ultrasonic. The volume of the degassing tank **317** and the required fluid is provided based on weight of the textile **131** that needs to be impregnated. In some embodiments, the volume of the fluid is based on processing need of the textile **131** in Kg/Hour and fluid required to do that process in Liters/Kg of the textile **131**. In one embodiment, based on the fluid flow from the degassing tank **317**, the de-size chemical and wetting agent are dozed in the block **200**. In some embodiments, the wetting agents may be dozed in block **200** or block **100** or a combination of **100**, **200** and **305** according to the impregnation requirements.

[0023] The degassing tank **317** is coupled to the inlet **227** of the block **200** through the valve **309** which controls

the rate of flow of the fluid to the block **200** and also to the subsequent blocks namely **100** and **305**. In one example, fluid in each block **100**, **305** and **200** flow below fluid level surface of tank of each block **100**, **200** and **305** in each of the blocks **100**, **200** and **305** to reduce possibility of trapping air by fluid while flowing and excess fluid flows from one block to another starting from block **200** to block **100** and then to block **305** and ultimately the fluid exits from the outlet **325**.

[0024] According to one possibility, the block **100**, **200** and **305** may be provided with one or more circulation pumps (not shown). In one possibility, the circulation pump may pump the fluid from the bottom of tank and feed it back into the tank. According to one aspect, the subject matter provides that the circulation pump of respective block **100**, **200** and **305** is configured such that the pump discharges the fluid on top of respective tanks **315**, **101**, and **201** however, level at which the pump discharges the fluid is below the fluid level in respective tanks. In another example, circulating fluid from bottom to top in each block **100**, **200** and **305** may provide uniform concentration of fluid. In some embodiments, the fluid discharge at the top of section is below fluid level surface at low flow rate to avoid possibility of airtrapping in fluid while circulating the fluid within the first tank **101** or the second tank **201**. It should be understood that one or more pumps may be provided for circulating fluid in a given tank. In one embodiment, the ultrasonic power may be effectively utilized by positioning the transducers **107** and **207** such that the ultrasonic waves emitted by the transducer **107** and **207** are in the natural direction of the flow of the fluid which is from block **200** to block **100** and so on, as shown the **FIG. 3**. The ultrasonic streaming in same direction as the flow of fluid helps in localized concentration equalization within the fluid.

[0025] In the illustrated embodiment **300**, it may be seen that there is a single stage of impregnation **305** that operates without ultrasonic transducers and the other two stages namely blocks **100** and **200** employ ultrasonic transducers for impregnating the textile **131**. In some embodiments, a drying operation between the nip roll **311** and winder **313** may be provided.

[0026] In one embodiment, the apparatus **300** is monitored and controlled using programmable logic controllers (PLC) at every stage to ensure consistency and reliability of processes. If there is a change in textile type and process conditions, the logic controllers are suitably programmed to adapt to the changes thereof. Use of PLC provides enhanced consistency and reliability of process. Further, PLC provides flexibility to adapt for changes in textile type and compensate for the changes in process conditions. In one embodiment, a Piezo electric sensor may be used to control the ultrasonic transducer power for automatic adaptation of process needs and textile type.

[0027] In one embodiment, an ultrasonic generator operates with a sweep frequency in a band near to main operating frequency of ultrasonic transducer. In general,

a wavelength of ultrasonic wave inside a fluid may not remain constant due to changes in the industrial operating and environmental factors such as change in temperature or concentration of the fluid. Further, maintaining the distance of the textile **131** substantially precisely at a distance of integral multiples of $\lambda_1/2$ in block **100** may not be practically feasible due to the elastic structure of the textile **131**, movement of the textile **131** around the combinations of rollers **113** and **117**; **117**, **119** and **121**; and **121**, **123** and **125** may give rise to changes in the distance of the textile **131** from the first wall **103**. These issues also arise in the other stages of impregnation such as in block **200**. The subject matter overcomes these practical issues by providing ultrasonic generators and the ultrasonic transducers **107**, **207** that are capable of altering the frequency/wavelength of their operation. That is to say, the adapting the apparatus of the subject matter to operate on a sweep frequency. Consequently the wavelength of operation in a fast and continuous manner to accommodate for the changes in the distance of the textile **131** from the transducers **107,207** and other operating conditions e.g. temperature and concentration. In one embodiment, the frequency and wavelength are changed to accommodate a shift in the position of the textile **131**. By providing a continuously sweeping frequency assist in improving reliability and repeatability of the impregnation process in changing operating conditions. The sweep frequency of the ultrasonic generators may be adapted to changes in the environmental conditions such as slight web movement, temperature changes and fluid concentration changes.

[0028] Furthermore, disposing the textile **131** according to the subject matter into the first tank **101** or the second tank **201** also accounts for the attenuation of the ultrasonic waves. The nature (flexibility and transparency for ultrasonic waves and textile having thickness much less than wavelength) of the textile **131** is such that it leaves the ultrasonic waves substantially unaltered and causes negligible amount of attenuation. This feature enables that a single transducer may be used for exposing the textile **131** to ultrasonic waves/field for multiple time by deploying multiple iterations of the textile **131** through the first tank **101**. This feature increases the contact time of the textile **131**, fluid and ultrasonic field. This reduces number of transducers and power requirement of the transducer, while improving the contact time and hence assisting the solution reach industrially and commercially acceptable standards. Disposing iterations of the textile **131** according to the subject matter ensure substantially uniform, reliable and increased textile contact time while optimizing number of transducers and size of the apparatus.

[0029] Generally, when an ultrasonic based impregnation is tested in laboratory, often it is tested on a piece of a textile, therefore, does not account for challenges relating to up scaling the model on industry scale. One of the challenges that up-scaling of process to industry scale throws is power requirements of industry scale set

up, wherein power is required by the industry scale set up is many times the power required by the lab set up and up scaling of the power requirement becomes prohibitively high. According to another problem faced while up scaling the laboratory set up to industry set up is introducing rollers for continuous feeding of textile. Because, introducing rollers result in increased in size of the set up and therefore, also require increase size, power and number of ultrasonic transducers which is not practical for industry because power requirement of the transducers is prohibitively high for the industry. Furthermore using smaller size of rollers is not desirable as smaller size of roller cause wrinkle issue with the textile. The size of the rollers is about 100 mm to 200 mm which may generally an industry standard. The subject matter addresses the above challenge by effectively introducing the rollers, while disposing the textile **131** at a distance from the source of the ultrasonic as taught with reference to **FIG. 1**, **FIG. 2** and **FIG. 3**. The power of ultrasonic is effectively utilized because, the textile **131** is disposed in accordance with the wavelength of the ultrasonic and size of the tank in which the ultrasonic is radiated on the textile **131** is selected based on the wavelength. The power of the ultrasonic is distributed substantially uniformly, without much attenuation in the first tank **101** because, the size of the first tank **101** is in the order of the multiples of wavelength of the ultrasonic, therefore, standing wave formation and substantially uniform cavitation occurs in the first tank **101**.

[0030] Based on flow rate of fluid in block **200** from dosing pump, the wetting agent and other chemicals may added at block **200**. According one aspect of the subject matter, amount of wetting agent and other chemical required for processing textile according to the subject matter may be considerably lower as compared with conventional methods. In some embodiments, the subject matter may demonstrate reduction in the quantity of wetting agent up to one fifth or up to one fourth of the normal usage in industry. Water flow rate to block **200** from degas tank may be regulated with valve **309** based on textile Kg/Hour rate.

[0031] Diffusion is phenomenon, which occurs in textile, without regards to the volume of the fluid. Further, ultrasonic power required is higher for higher volume of the fluid is used. Therefore, it is desirable to keep the volume of the fluid at its lowest as smaller volume while leave the diffusion unaffected it assist in conserving power of the ultrasonic transducer. While it is desirable that the volume of the fluid is kept at its minimum, however reduction in volume of the fluid must accompany with increase in the velocity of fluid through the tank in order to keep up effective concentration of fluids. However, increased velocity of fluid through the tank diminishes ultrasonic effect. That is beyond certain point further reducing the volume of the fluid in the tanks become counterproductive because the fluid velocity required starts disrupting the effect of ultrasonic on the textile. Providing the size of the tank in the order of the wavelength and

disposing the textile according to the subject matter addresses this conflict between the velocity of fluid, volume of fluid and ultrasonic power and provides an effective solution for impregnation of textile.

[0032] It shall become clear to a person, after reading this specification, majority of ultrasonic effect on textile is with ultrasonic cavitation and micro jets generated with cavitation collapse, apart from pressure wave and acoustic streaming. A saturated layer of fluid is formed near to the textile surface, which prevents fresh fluid to impregnate to equalize fluid concentration within textile and fluid concentration in tank. Ultrasonic cavitation phenomenon breaks this saturated fluid layer near to textile forming a diffusion boundary layer, thus enabling better diffusion for impregnation and also equalization of localized of fluid concentration near to textile. Disposing textile at a distance that is in multiple of $\lambda/2$ is advantageous because, cavitation phenomena are highest at such distances, to which the textile **131** is exposed. Formation and collapsing of cavitation bubbles in close vicinity of the textile **131** or within inter-yarn pores of textile **131** further enhances the impregnation as it creates micro-jets and micro-streaming which shoots fluids in the intra-yarn and inter-yarn space of the textile **131**. The solution given in the subject matter achieves higher contact time of textile with ultrasonically active fluid for continuously moving textile **131**. The same discussion also applied to blocks **100**, **200** *mutatis mutandis*.

[0033] Working of the subject matter according to an embodiment may be understood with the help of illustrative **FIG. 4**. **FIG. 4** shows schematic diagram for the ease of understanding of the subject matter. Shown in **FIG. 4** are: an ultrasonic transducer **503** that produces ultrasonic waves of wavelength λ , a proximal wall **505**, distant wall **501**, textile iterations **502**, **507**, **509**, **511** and/or **519**.

[0034] The transducer **503** is coupled to the proximal wall **505**. In some embodiments, the distance between transducer **503** and the proximal wall **505** is negligible. In some embodiments, when there is a non-negligible distance between the transducer **503** and the proximal wall **505**, the standing wave pattern and the dimensions/configuration of the apparatus is determined by the distance between the transducer **503**, the proximal wall **505** and the distant wall **501**. The proximal wall **505** is selected of a material that can pass the ultrasonic waves from one side with least attenuation in one direction, whereas reflects the waves substantially totally from other side. In some embodiments, the proximal wall **505** is an ultrasonic source. The standing ultrasonic wave pattern is formed between the proximal wall **505** and distal wall **501**. Standing wave pattern of ultrasonic generates highest cavitation phenomenon at positions, which are at a distance that is integer multiples of $\lambda/2$. The distance is determined from the proximal wall **505** or the transducer **503**. Hence the textiles **502**, **507**, **509**, **511** and/or **519** are separated at a distance in multiples of $\lambda/2$ from the transducer **503** as shown in the **FIG. 4**. In some embodiments, the distance between the distant wall **501** and proximal wall **505**

may be an integer multiple of the wavelength λ .

[0035] The standing wave pattern creates pressure antinodes at $(n \times \lambda/2)$ and pressure node at $(2n+1) \lambda/4$. (Where "n" is an integer). This way effective ultrasonic pressure at multiple of $\lambda/2$ distances will be almost twice, giving rise to cavitations at regions where textile **502**, **507**, **509**, **511** and/or **519** are disposed. Further, ultrasonic pressure difference between pressure antinodes at $n\lambda/2$ and pressure nodes at $(2n+1) \lambda/4$ helps in uniform distribution of fluid concentration with low velocity micro-flow. Geometrical placement of yarn/fabric/textile is guided so that yarn/fabric/textile remains at place of pressure antinodes which are higher cavitation zones.

[0036] The textile **502**, **507**, **509**, **511** and/or **519** impregnated according to the subject matter provides a number of advantages as discussed earlier. The above processes are generally governed by physical processes of fluid exchange between textile by convection and diffusion. Generally, impregnation of fluid in-between yarn (inter-yarn) portion of textile results from convection, which is comparatively faster physical process than diffusion. However, impregnation of fluid within yarn (intra-yarn) which is major part of total impregnation and it results from diffusion. That is, the main process of impregnation involves diffusion. The diffusion depends on yarn surface characteristics and is generally difficult to enhance. The subject matter provides solution to this problem by effectively employing the ultrasonic for enhancing both the physical processes of impregnation to textile, convection and diffusion.

[0037] The subject matter provides a number of flexibilities in processing the textile, for example, the amount of absorption of fluid by the textile may be improved without making extensive changes in the system. Generally, existing solutions require repeating the wetting processes or running the textile multiple times through fluid. Current industrial processes are based on method of concentration exchange between the textile and fluid by moving textile multiple times through the fluid. The subject matter provides improvement over these processes. The existing methods not only fail to provide desired results but also, hamper production, waste fluids, water wastage is high, power consuming, result in higher chemical usage and environmentally hazardous effluents, resource intensive in terms of size of equipment, cost of running, infrastructure etc, higher temperatures of process, and higher textile contact time with fluid for increasing impregnation. Therefore, these methods are undesirable.

[0038] Further, there are attempts to enhance diffusion process by increasing flow through textile by high speed fluid jets or higher temperature treatment. However, high speed fluid jets fail to provide uniform impregnation especially when the textile itself is not uniformly weaved and high temperatures tend to damage the textile and are slow process. The subject matter removes requirement of high speed fluid jets or high temperature and provides substantially uniform impregnation.

[0039] The subject matter further addresses challeng-

es related to developing an industry scale application of ultrasonic based impregnation of textile. Industry application of ultrasonic based textile impregnation is challenging because the ultrasonic pressure wave may cause the textile to move. Such characteristic of textile, calls for power requirement of ultrasonic in terms of Watts/cm² instead of normal standard cleaning calculation in Watts/liter. Further, industrial web width and roller size is generally higher than 1800 mm and 100 mm respectively. Therefore, for industry applications up-scaling of ultrasound impregnation apparatus results in ultrasonic power requirements prohibitively higher than what is practical. The subject matter solves this problem by optimally adjusting and selecting geometry of the tank and the transducers, and iterations of textile into the tank, to exploit cavitations caused by the ultrasonic waves such that ultrasonic power required in an unit area of textile (Watts /cm²) for a given contact time is achieved without compromising on the ultrasonic power required in the tank for a give unit of fluid (Watts/liter). Further, the subject matter provide degassing and flow control and direction of flow of fluid which improves effectiveness of ultrasonic based impregnation, as non-degassed fluid generally adversely affect the ultrasonic impregnation. The subject matter also provides flexibility of construction of the apparatus because, the ultrasonic waves operation on the textile is substantially independent of gravity, the tank and transducers may be deployed horizontally or vertically or at any suitable angle, with appropriate adjustments without effecting efficiency of the apparatus.

[0040] FIG. 5 shows a method 600 according to an embodiment of the subject matter. At block 601, the method provides a first tank and at block 603 a first transducer is coupled to the first tank. According to the method the first transducer is configure to transmit ultrasonic waves of a first wavelength into the first tank and the first tank is configured to form a substantially standing ultrasound wave pattern into the first tank. At block 605 the method includes providing a disposer. The dispose is configured to dispose a textile at a first distance from the first transducer and into the first tank. The first distance is determined based on the first wavelength. The block 605 further includes block 615, and block 625. At block 615 the disposer includes providing a first plurality of rollers and adapting the first plurality of rollers to dispose multiple iterations of the textile through the first tank, wherein each of the iterations of the textile is separated from adjacent iteration of the textile by a distance determined based on the first wavelength. At block 625, the method provides adapting the disposer to dispose each of the iterations of the textile at a location that corresponds to location of an anti-node of the substantially standing ultrasonic wave pattern formed in the first tank. At block 607, the method further includes configuring the first transducer and geometry of the first tank to cause the textile to ultrasonic power in a range between 0.2 Watts/cm² and 2 Watts/cm² and transmit at least 8 watts/liter of ultrasonic power into the first tank. At block 609, the method pro-

vides configuring the apparatus to operate on a sweep frequency of ultrasonic waves, the sweep frequency is a band of frequencies around a first frequency, wherein the first frequency corresponds to the first wavelength and the disposer is configured to dispose the first textile at the first distance, the first distance is determined based on the first frequency.

[0041] While the subject matter may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described herein. Alternate embodiments or modifications may be practiced without departing from the spirit of the subject matter. The drawings shown are schematic drawings and may not be to the scale. While the drawings show some features of the subject matter, some features may be omitted. In some other cases, some features may be emphasized while others are not. Further, the methods disclosed herein may be performed in manner and/or order in which the methods are explained. Alternatively, the methods may be performed in manner or order different than what is explained without departing from the spirit of the subject matter. It should be understood that the subject matter is not intended to be limited to the particular forms disclosed. Rather, the subject matter covers all modifications, equivalents, and alternatives within the scope of the subject matter as described above.

[0042] In the above description, while describing the subject matter, some of the proprietary terms as well as some proprietary terms of expression including trademarks or other copyrighted subject matter may have been used, the applicant has taken best care in acknowledge the ownership of the proprietary subject matter. However, if the applicant has inadvertently omitted any such acknowledgement, the applicant states that any such omission is unintentional and without any malicious intention and the applicant states that should any such inadvertent omission is brought to the attention of the applicant, the applicant is willing take actions that the applicant believes are fit to acknowledge such proprietary ownership.

[0043] Patent documents relating to the numbers EP 0 969 131 A1, US 3 688 527, and WO99/37844 show some solutions. While these documents attempt to reach at some solution that employ ultrasound in cleaning, these documents suffer from a number of limitations, including those discussed previously relating to laboratory scale experiments and non-viability on commercial scale and other technical challenges.

[0044] Specifically EP 0 969 131 A1 discloses a device for treating textile, comprising a tank (2) for holding treatment liquid (3), conveyor means (4) for conveying a textile substrate (7) which is to be treated through the tank (2), a transducer (8) for generating ultrasonic vibrations in the treatment liquid (3), an interference element (19) placed opposite the transducer for together delimiting a vibration cavity (13), wherein the transducer (8) together with the interference element (19) is designed to gener-

ate an interference pattern in the vibration cavity (13) of ultrasonic vibrations amplifying each other, in which a concentration area (11) of intensified vibration energy occurs at a distance from the transducer (8) and the interference element (19), in which the conveyor means (4) are designed to guide the textile substrate (7) through the concentration area (11), and in which energy of the ultrasonic vibrations is destined to dissipate by means of cavitation in the concentration area (11) at the location of the textile substrate (7).

[0045] While EP 0 969 131 A1 attempts to employ ultrasonic wave solution in textile industry, it fails to recognize challenges relating to obtaining a stable concentration area (11), in which energy of the ultrasonic vibrations is destined to dissipate by means of cavitation. Because the concentration area (11) is highly susceptible to physical parameters of the medium. The position of concentration area (11) changes with temperature pressure *etc.* In fact in some case, concentration area (11) may not be in a substantially vertically aligned, as envisioned by the EP 0 969 131 A1, due to changes in temperature of the medium at different heights in a given tank. Furthermore, EP 0 969 131 A1 provides a complex solution which employs a number of transducers each focusing in different direction, interfering elements and ultrasound unit 9. The present subject matter solves at least both the problems associated with the EP 0 969 131 A1. The present subject matter configures the walls of the tank itself eliminating need of a separate ultrasonic unit 9 altogether. Further the apparatus of the present subject matter operates on a sweep frequency. These features enable the apparatus to ensure that the textile remains in the cavitation zone, either by adjustment of the rollers that dispose the textile into the tank, or by disposing the textile diagonally/obliquely (as shown in **FIG. 1a**) based on the sweep frequency.

[0046] In addition, the ultrasound unit 9 of EP 0 969 131 A1 requires multiple combinations of transducers and interference elements (the interference element being transducers themselves) and some focusing arrangement to guide the ultrasonic waves in specific direction, into the tank. This arrangement of the EP 0 969 131 A1 not only makes the solution of the EP 0 969 131 A1 practically not workable but also makes it more complex. This is because, when a number of transducers each of them focusing in different directions (see, Fig 1 items 8 of EP 0 969 131 A1) pass a number of ultrasonic waves through a single continuous medium, the medium does not see these waves as separate waves coming from different sources/direction. Instead the medium sees some convolution of waves. More so, no transducer is an ideal transducer which would produce exact same frequency each time. Further the physical parameters of the medium may also alter the frequency of the ultrasound. Practically achieving a standing wave pattern from this convolution of waves is if not impossible then certainly difficult and may be a matter of chance. For the same reason cavitation zone may shift based on a resultant frequency

that the medium observes and physical parameters (temperature etc) of the medium. Therefore obtaining a commercially viable solution using EP 0 969 131 A1 is practically impossible.

[0047] These and other challenges are solved by the present subject matter. The present subject matter could solve these problems because, the present subject matter exploits a number of technical features, e.g. configuring the apparatus to operate on sweep frequency. This feature has been elaborated in paragraph [0033] of the specification in detail with reference to **FIG. 1** and **FIG. 1a**. In that **FIG. 1a** shows an exaggerated embodiment of the present subject matter, in which the textile is disposed in the tank in which at least one iteration is obliquely or diagonally disposed.

[0048] As explained in paragraphs [0023] and [0033] of the specification, the apparatus may be configured to operate based on the sweep frequency and dispose textile using the rollers accordingly in number of ways. It shall become clear to a person in the art that the textile may be kept in the cavitation zone by a number of ways, which may include combination of adjustment of rollers and adjustment of frequency *etc.* In one embodiment, the apparatus may be configured to solve these problems by disposing the textile in a diagonal/oblique manner (shown in **FIG. 1a**) so that the textile traverses maximum part though the cavitation zone, as is understood that the slope of the diagonal/obliqueness may be determined based on the sweep frequency. In yet another embodiment the apparatus may be configured to solve these problems by adjusting the roller positions (see, paragraph [0046]). In a further another embodiment the apparatus may be configured to solve these problems by adjusting the textile positions (see, paragraph [0046]). In another embodiment the apparatus may be configured to solve these problems by (see paragraph [0033]) adaptively selecting or altering the transducer frequency, and adjusting the textile positions (see, paragraph [0046]).

[0049] Furthermore, the EP 0 969 131 A1 also fails commercial viability test because of only single iteration of textile may be treated at a given time, whereas the subject matter efficiently utilizes energy and time by enabling disposing of textile in multiple iterations without compromising on the advantages of cavitation zones and therefore the subject matter provides a better and cheaper solution.

[0050] Similarly, US 3 688 527 discloses, a method and apparatus for cleaning mechanically bonded contaminants from a resilient web in a fluid medium. Here US 3 688 527 diverts from the present subject matter, more often than not the textile is rather delicate and not resilient. It is therefore US 3 688 527 shows a sonotrode type of transducer, generally used for cutting and welding operations. Employing US 3 688 527 in textile industry would only result in damaged textile. It is therefore despite of US 3 688 527 being in public since 1972, industrial scale solution employing ultrasounds to process textile are not available in the market.

[0051] WO99/37844 is another document, the document does not discuss either the problems addressed by the present subject matter or provides a solution thereof. Furthermore, for treating different sides of the textile, the WO99/37844 requires two transducers one for each side of the textile. It does not provide any indication or motivation for disposing the textile based on either sweep frequency or corresponding wavelength.

[0052] It may also be noticed that even a combination of the aforementioned documents would not result in the solution of the present subject matter because none of the cited documents teach, suggest or provide any motivation, alone or in combination, to reach at the subject matter. Emphasis is supplied to the fact that none of the above documents configure the first tank itself by arranging first wall and the second wall of the first tank in manner that substantially standing wave pattern is formed in the first tank. Thereby, the present subject matter eliminates requirement of any separate ultrasound unit 9 of EP 0 969 131 A1 and item 34 of US 3 688 527 respectively require. While WO99/37844 altogether fails to discuss any such feature of obtaining substantially standing wave pattern. This feature, alone, of the present subject matter not only reduces the complexity of design but also makes the present subject matter commercially more advantageous.

[0053] At least for the above reasons the present subject matter is not only superior but also desirable as compared with any of the EP 0 969 131 A1, US 3 688 527 and WO99/37844 or a combination thereof. In fact, it appears that because of the above discussed technical and commercial difficulties with the EP 969 131 A1 and WO99/37844, these documents were not perused till the logical end of the application.

[0054] The present subject matter provides an apparatus comprising: a first transducer (107), characterized in that wherein the first transducer (107) is adapted to transmit ultrasonic waves of a first wavelength into a first tank (101), and characterized in that the first tank (101) is configured to establish a substantially standing ultrasonic wave pattern of the ultrasonic waves inside the first tank (101); and a disposer (109.1 and 109.2) adapted to dispose a textile (131) into the first tank (101) at a first distance from the first transducer (107), wherein the first distance is determined based on the first wavelength and, wherein the first tank (101) comprises a first wall (103) and a second wall (105), the first transducer (107) is coupled to the first wall (103) and the second wall (105) is configured to reflect the ultrasonic waves and the first wall (103) and the second (105) are separated from each other to establish the substantially standing wave pattern into the first tank (101) resulting in multiple cavitation zones and wherein the apparatus is configured to operate on a sweep frequency of ultrasonic waves, the sweep frequency is a band of frequencies around a first frequency, wherein the first frequency corresponds to the first wavelength and the disposer (109.1 and 109.2) is configured to dispose the textile (131) at the first distance,

the first distance is determined based on the first frequency. In one embodiment, the first transducer (107) and geometry of the first tank (101) are configured to expose the textile (131) to ultrasonic power in a range between 0.2 Watts/cm² and 2 Watts/cm². In a second embodiment, the first transducer (107) and geometry of the first tank (101) are adapted to transmit at least 8 watts/liter of ultrasonic power into the first tank (101). In a third embodiment, the disposer (109.1 and 109.2) comprises a first plurality of rollers (111, 117, 119, 125, 113, 115, 121 and 123) and the first plurality of rollers (111, 117, 119, 125, 113, 115, 121 and 123) are adapted to dispose multiple iterations of the textile (131) through the first tank (101) and each iteration of the textile (131) is separated from adjacent iteration of the textile (131) by a distance, wherein the distance is determined based on the first wavelength. In a fourth embodiment, the disposer (109.1 and 109.2) disposes each of the iterations of the textile (131) at locations that corresponds to locations of antinodes of the substantially standing ultrasonic wave pattern formed in the first tank (101). In a fifth embodiment, the apparatus comprises a second transducer (207), wherein the second transducer (207) is adapted to transmit ultrasonic waves of a second wavelength into a second tank (201), and the second tank (201) is configured to establish a substantially standing ultrasonic wave pattern of the ultrasonic waves inside the second tank (201); and the disposer (109.1 and 109.2) is configured to dispose the textile (131) sequentially into the first tank (101) and the second tank (201). In a sixth embodiment, the disposer (109.1 and 109.2) is configured to dispose the textile (131) at a second distance from the second transducer (207) into the second tank (201), wherein the second distance is determined based on the second wavelength and the disposer (109.1 and 109.2) is adapted to dispose multiple iterations of the textile (131) through the second tank (201) and each iteration of the textile (131) is separated from adjacent iteration of the textile (131) by a third distance, wherein the third distance is determined based on the second wavelength and the disposer (109.1 and 109.2) disposes each of the iterations of the textile (131) at locations that corresponds to locations of antinodes of the substantially standing ultrasonic wave pattern formed in the second tank (201). In a seventh embodiment, the second transducer (207) and geometry of the second tank (201) are configured to expose the textile (131) to ultrasonic power in a range between 0.2 Watts/cm² and 2 Watts/cm² and are adapted to transmit at least 8 watts/liter of ultrasonic power into the second tank (201).

[0055] According to another aspect, the present subject matter provides a method of manufacturing an apparatus comprising: providing a first tank (101) wherein the first tank (101) comprises a first wall (103) and a second wall (105); characterizing in that coupling a first transducer (107) to the first wall (103) of the first tank (101), wherein the first transducer (107) is configured to transmit ultrasonic waves of a first wavelength into the first tank

(101); configuring the second wall (105) to reflect the ultrasonic waves and the first wall (103) and the second (105) are separated from each other to establish the substantially standing wave pattern into the first tank (101) resulting in multiple cavitation zones; providing a disposer (109.1 and 109.2) configured to dispose a textile (131) at a first distance from the first transducer (107) and into the first tank (101), wherein the first distance is determined based on the first wavelength; and configuring the apparatus to operate on a sweep frequency of ultrasonic waves, the sweep frequency is a band of frequencies around a first frequency, wherein the first frequency corresponds to the first wavelength and the disposer (109.1 and 109.2) is configured to dispose the textile (131) at the first distance, the first distance is determined based on the first frequency. In a first embodiment, the method includes configuring the first transducer (107) and geometry of the first tank (101) to: expose the textile (131) to ultrasonic power in a range between 0.2 Watts/cm² and 2 Watts/cm²; and transmit at least 8 watts/liter of ultrasonic power into the first tank (101). In a second embodiment, providing the disposer (109.1 and 109.2) includes providing a first plurality of rollers (111, 117, 119, 125, 113, 115, 121 and 123) and adapting the first plurality of rollers (111, 117, 119, 125, 113, 115, 121 and 123) to dispose multiple iterations of the textile (131) through the first tank (101), wherein each iteration of the textile (131) is separated from adjacent iteration of the textile (131) by a distance determined based on the first wavelength. In a third embodiment, providing includes adapting the disposer (109.1 and 109.2) to dispose each of the iterations of the textile (131) at a location that corresponds to location of an antinode of the substantially standing ultrasonic wave pattern formed in the first tank (101).

Claims

1. An apparatus comprising: a first tank (107) which comprises a first and a second wall (103, 105), a first transducer (107), wherein said first transducer (107) is adapted to transmit ultrasonic waves of a first wavelength into said first tank (101), and said first tank (101) is configured to establish a substantially standing ultrasonic wave pattern of ultrasonic waves inside the first tank (101); and a disposer (109.1 and 109.2) adapted to dispose a textile (131) into the first tank (101) at a first distance from said first transducer (107), **characterized in that** said first distance is determined based on said first wavelength and, wherein the first transducer (107) is coupled to the first wall (103) and the second wall (105) is configured to reflect the ultrasonic waves and the first wall (103) and the second (105) are separated from each other to establish the substantially standing wave pattern into the first tank (101) resulting in multiple cavitation zones and wherein the apparatus is configured to operate on a sweep frequency of

ultrasonic waves, the sweep frequency is a band of frequencies around a first frequency, wherein said first frequency corresponds to said first wavelength and the disposer (109.1 and 109.2) is configured to dispose the textile (131) at said first distance, said first distance is determined based on said first frequency.

2. The apparatus of claim 1, wherein the first transducer (107) and geometry of the first tank (101) are configured to expose the textile (131) to ultrasonic power in a range between 0.2 Watts/cm² and 2 Watts/cm².
3. The apparatus of claim 1, wherein the first transducer (107) and geometry of the first tank (101) are adapted to transmit at least 8 watts/liter of ultrasonic power into the first tank (101).
4. The apparatus of any one of claims 1 through 3, wherein the disposer (109.1 and 109.2) comprises a first plurality of rollers (111, 117, 119, 125, 113, 115, 121 and 123) and the first plurality of rollers (111, 117, 119, 125, 113, 115, 121 and 123) are adapted to dispose multiple iterations of the textile (131) through the first tank (101) and each iteration of the textile (131) is separated from adjacent iteration of the textile (131) by a distance, wherein the distance is determined based on the first wavelength.
5. The apparatus of claim 4, wherein the disposer (109.1 and 109.2) disposes each of the iterations of the textile (131) at locations that corresponds to locations of antinodes of the substantially standing ultrasonic wave pattern formed in the first tank (101).
6. The apparatus of any one of claims 1 through 5, comprising a second transducer (207), wherein the second transducer (207) is adapted to transmit ultrasonic waves of a second wavelength into a second tank (201), and the second tank (201) is configured to establish a substantially standing ultrasonic wave pattern of the ultrasonic waves inside the second tank (201); and the disposer (109.1 and 109.2) is configured to dispose the textile (131) sequentially into the first tank (101) and the second tank (201).
7. The apparatus of claim 6 wherein the disposer (109.1 and 109.2) is configured to dispose the textile (131) at a second distance from the second transducer (207) into the second tank (201), wherein the second distance is determined based on the second wavelength and the disposer (109.1 and 109.2) is adapted to dispose multiple iterations of the textile (131) through the second tank (201) and each iteration of the textile (131) is separated from adjacent iteration of the textile (131) by a third distance, wherein the third distance is determined based on the second wavelength and the disposer (109.1 and 109.2) dis-

poses each of the iterations of the textile (131) at locations that corresponds to locations of antinodes of the substantially standing ultrasonic wave pattern formed in the second tank (201).

8. The apparatus of claim 7, wherein the second transducer (207) and geometry of the second tank (201) are configured to expose the textile (131) to ultrasonic power in a range between 0.2 Watts/cm² and 2 Watts/cm² and are adapted to transmit at least 8 watts/liter of ultrasonic power into the second tank (201).

9. A method of manufacturing an apparatus comprising:

providing a first tank (101) which comprises a first wall (103) and a second wall (105);
 configuring the second wall (105) to reflect the ultrasonic waves from a first transducer (107) and the first wall (103) and the second (105) are separated from each other to establish the substantially standing wave pattern into the first tank (101) resulting in multiple cavitation zones;
 providing a disposer (109.1 and 109.2) configured to dispose a textile (131) at a first distance from said first transducer (107) and into the first tank (101), **characterized in that** said first distance is determined based on a first wavelength;
 coupling said first transducer (107) to the first wall (103) of the first tank (101), wherein the first transducer (107) is configured to transmit ultrasonic waves of said first wavelength into the first tank (101); and
 configuring the apparatus to operate on a sweep frequency of ultrasonic waves, the sweep frequency is a band of frequencies around said first frequency, wherein said first frequency corresponds to said first wavelength and the disposer (109.1 and 109.2) is configured to dispose the textile (131) at said first distance, said first distance is determined based on said the first frequency.

10. The method of claim 9, wherein the method includes configuring the first transducer (107) and geometry of the first tank (101) to: expose the textile (131) to ultrasonic power in a range between 0.2 Watts/cm² and 2 Watts/cm²; and transmit at least 8 watts/liter of ultrasonic power into the first tank (101).

11. The method of claim 9, wherein providing the disposer (109.1 and 109.2) includes providing a first plurality of rollers (111, 117, 119, 125, 113, 115, 121 and 123) and adapting the first plurality of rollers (111, 117, 119, 125, 113, 115, 121 and 123) to dispose multiple iterations of the textile (131) through the first tank (101), wherein each iteration of the tex-

tile (131) is separated from adjacent iteration of the textile (131) by a distance determined based on the first wavelength.

12. The method of claim 11, wherein providing the disposer includes adapting the disposer (109.1 and 109.2) to dispose each of the iterations of the textile (131) at a location that corresponds to location of an antinode of the substantially standing ultrasonic wave pattern formed in the first tank (101).

Patentansprüche

1. Vorrichtung, umfassend:

einen ersten Tank (107), der eine erste und eine zweite Wand (103, 105) umfasst,
 einen ersten Wandler (107), wobei der erste Wandler (107) angepasst ist, um Ultraschallwellen einer ersten Wellenlänge in den ersten Tank (101) zu übertragen, und der erste Tank (101) konfiguriert ist, um ein im Wesentlichen stehendes Ultraschallwellenmuster von Ultraschallwellen innerhalb des ersten Tanks (101) herzustellen; und

einen Anordner (109.1 und 109.2), der angepasst ist, um ein Textil (131) in dem ersten Tank (101) in einem ersten Abstand von dem ersten Wandler (107) anzuordnen,

dadurch gekennzeichnet, dass der erste Abstand auf Grundlage der ersten Wellenlänge bestimmt wird, und wobei der erste Wandler (107) mit der ersten Wand (103) gekoppelt ist und die zweite Wand (105) konfiguriert ist, um die Ultraschallwellen zu reflektieren, und die erste Wand (103) und die zweite Wand (105) voneinander getrennt sind, um das im Wesentlichen stehende Wellenmuster in dem ersten Tank (101) herzustellen, was zu mehreren Kavitationszonen führt, und wobei die Vorrichtung konfiguriert ist, um auf einer Wobelfrequenz von Ultraschallwellen zu arbeiten, wobei die Wobelfrequenz ein Band von Frequenzen um eine erste Frequenz herum ist,

wobei die erste Frequenz der ersten Wellenlänge entspricht und der Anordner (109.1 und 109.2) konfiguriert ist, um das Textil (131) in dem ersten Abstand anzuordnen, wobei der erste Abstand auf Grundlage der ersten Frequenz bestimmt wird.

2. Vorrichtung nach Anspruch 1, wobei der erste Wandler (107) und die Geometrie des ersten Tanks (101) konfiguriert sind, um das Textil (131) einer Ultraschallleistung in einem Bereich zwischen 0,2 Watt/cm² und 2 Watt/cm² auszusetzen.

3. Vorrichtung nach Anspruch 1, wobei der erste Wandler (107) und die Geometrie des ersten Tanks (101) angepasst sind, um mindestens 8 Watt/Liter an Ultraschallleistung in den ersten Tank (101) zu übertragen. 5
4. Vorrichtung nach einem der Ansprüche 1 bis 3, wobei der Anordner (109.1 und 109.2) eine erste Vielzahl von Walzen (111, 117, 119, 125, 113, 115, 121 und 123) umfasst und die erste Vielzahl von Walzen (111, 117, 119, 125, 113, 115, 121 und 123) angepasst ist, um mehrere Iterationen des Textils (131) durch den ersten Tank (101) anzuordnen, und jede Iteration des Textils (131) von der benachbarten Iteration des Textils (131) durch einen Abstand getrennt ist, wobei der Abstand auf Grundlage der ersten Wellenlänge bestimmt wird. 10
5. Vorrichtung nach Anspruch 4, wobei der Anordner (109.1 und 109.2) jede der Iterationen des Textils (131) an Orten anordnet, die den Orten von Antinoden des im Wesentlichen stehenden Ultraschallwellenmusters, welches in dem ersten Tank (101) ausgebildet ist, entsprechen. 15
6. Vorrichtung nach einem der Ansprüche 1 bis 5, umfassend einen zweiten Wandler (207), wobei der zweite Wandler (207) angepasst ist, um Ultraschallwellen einer zweiten Wellenlänge in einen zweiten Tank (201) zu übertragen, und der zweite Tank (201) konfiguriert ist, um ein im Wesentlichen stehendes Ultraschallwellenmuster von den Ultraschallwellen innerhalb des zweiten Tanks (201) herzustellen; und der Anordner (109.1 und 109.2) konfiguriert ist, um das Textil (131) sequenziell in dem ersten Tank (101) und dem zweiten Tank (201) anzuordnen. 20
7. Vorrichtung nach Anspruch 6, wobei der Anordner (109.1 und 109.2) konfiguriert ist, um das Textil (131) in einem zweiten Abstand von dem zweiten Wandler (207) in dem zweiten Tank (201) anzuordnen, wobei der zweite Abstand auf Grundlage der zweiten Wellenlänge bestimmt wird und der Anordner (109.1 und 109.2) angepasst ist, um mehrere Iterationen des Textils (131) durch den zweiten Tank (201) anzuordnen und jede Iteration des Textils (131) von der benachbarten Iteration des Textils (131) durch einen dritten Abstand getrennt ist, wobei der dritte Abstand auf Grundlage der zweiten Wellenlänge bestimmt wird und der Anordner (109.1 und 109.2) jede der Iterationen des Textils (131) an Orten anordnet, die den Orten von Antinoden des im Wesentlichen stehenden Ultraschallwellenmusters, welches in dem zweiten Tank (201) ausgebildet ist, entsprechen. 25
8. Vorrichtung nach Anspruch 7, wobei der zweite Wandler (207) und die Geometrie des zweiten Tanks (201) konfiguriert sind, um das Textil (131) einer Ultraschallleistung in einem Bereich zwischen 0,2 Watt/cm² und 2 Watt/cm² auszusetzen und angepasst sind, um mindestens 8 Watt/Liter an Ultraschallleistung in den zweiten Tank (201) zu übertragen. 30
9. Verfahren zur Herstellung einer Vorrichtung, umfassend: 35

(201) konfiguriert sind, um das Textil (131) einer Ultraschallleistung in einem Bereich zwischen 0,2 Watt/cm² und 2 Watt/cm² auszusetzen und angepasst sind, um mindestens 8 Watt/Liter an Ultraschallleistung in den zweiten Tank (201) zu übertragen.

9. Verfahren zur Herstellung einer Vorrichtung, umfassend: 40

Bereitstellen eines ersten Tanks (101), der eine erste Wand (103) und eine zweite Wand (105) umfasst;

Konfigurieren der zweiten Wand (105), um die Ultraschallwellen von einem ersten Wandler (107) zu reflektieren und wobei die erste Wand (103) und die zweite (105) voneinander getrennt sind, um das im Wesentlichen stehende Wellenmuster in dem ersten Tank (101) herzustellen, was zu mehreren Kavitationszonen führt; Bereitstellen eines Anordners (109.1 und 109.2), der konfiguriert ist, um ein Textil (131) in einem ersten Abstand von dem ersten Wandler (107) und in dem ersten Tank (101) anzuordnen, **dadurch gekennzeichnet, dass** der erste Abstand auf Grundlage einer ersten Wellenlänge bestimmt wird; 45

Koppeln des ersten Wandlers (107) mit der ersten Wand (103) des ersten Tanks (101), wobei der erste Wandler (107) konfiguriert ist, um Ultraschallwellen der ersten Wellenlänge in den ersten Tank (101) zu übertragen; und Konfigurieren der Vorrichtung, um auf einer Wobbelfrequenz von Ultraschallwellen zu arbeiten, wobei die Wobbelfrequenz ein Band von Frequenzen um die erste Frequenz herum ist, wobei die erste Frequenz der ersten Wellenlänge entspricht und der Anordner (109.1 und 109.2) konfiguriert ist, um das Textil (131) in dem ersten Abstand anzuordnen, wobei der erste Abstand auf Grundlage der ersten Frequenz bestimmt wird. 50

10. Verfahren nach Anspruch 9, wobei das Verfahren ein Konfigurieren des ersten Wandlers (107) und der Geometrie des ersten Tanks (101) einschließt, um: das Textil (131) einer Ultraschallleistung in einem Bereich zwischen 0,2 Watt/cm² und 2 Watt/cm² auszusetzen; und mindestens 8 Watt/Liter an Ultraschallleistung in den ersten Tank (101) zu übertragen. 55
11. Verfahren nach Anspruch 9, wobei das Bereitstellen des Anordners (109.1 und 109.2) ein Bereitstellen einer ersten Vielzahl von Walzen (111, 117, 119, 125, 113, 115, 121 und 123) und Anpassen der ersten Vielzahl von Walzen (111, 117, 119, 125, 113, 115, 121 und 123) einschließt, um mehrere Iteratio-

nen des Textils (131) durch den ersten Tank (101) anzuordnen, wobei jede Iteration des Textils (131) von der benachbarten Iteration des Textils (131) durch einen Abstand, der auf Grundlage der ersten Wellenlänge bestimmt wird, getrennt ist.

12. Verfahren nach Anspruch 11, wobei das Bereitstellen des Anordners ein Anpassen des Anordners (109.1 und 109.2) einschließt, um jede der Iterationen des Textils (131) an einem Ort anzuordnen, der dem Ort einer Antinode des im Wesentlichen stehenden Ultraschallwellenmusters, das in dem ersten Tank (101) ausgebildet ist, entspricht.

Revendications

1. Appareil comprenant: un premier réservoir (107) qui comprend une première paroi et une seconde paroi (103, 105), un premier transducteur (107), dans lequel ledit premier transducteur (107) est conçu pour transmettre des ondes ultrasonores d'une première longueur d'onde dans ledit premier réservoir (101), et ledit premier réservoir (101) est configuré pour établir un motif d'ondes ultrasonores sensiblement stationnaire d'ondes ultrasonores à l'intérieur du premier réservoir (101); et un dispositif de placement (109.1 et 109.2) conçu pour disposer un textile (131) dans le premier réservoir (101) à une première distance à partir dudit premier transducteur (107), **caractérisé en ce que** ladite première distance est déterminée sur la base de ladite première longueur d'onde et, dans lequel le premier transducteur (107) est couplé à la première paroi (103) et la seconde paroi (105) est configurée pour réfléchir les ondes ultrasonores et la première paroi (103) et la seconde paroi (105) sont séparées l'une de l'autre pour établir le motif de longueurs d'ondes sensiblement stationnaire dans le premier réservoir (101) créant ainsi de multiples zones de cavitation et dans lequel l'appareil est configuré pour fonctionner sur une fréquence de balayage d'ondes ultrasonores, la fréquence de balayage est une bande de fréquences autour d'une première fréquence, ladite première fréquence correspondant à ladite première longueur d'onde et le dispositif de placement (109.1 et 109.2) est configuré pour disposer le textile (131) à ladite première distance, ladite première distance est déterminée sur la base de ladite première fréquence.
2. Appareil selon la revendication 1, dans lequel le premier transducteur (107) et la géométrie du premier réservoir (101) sont configurés pour exposer le textile (131) à une puissance ultrasonore dans une plage allant de 0,2 Watts/cm² à 2 Watts/cm².
3. Appareil selon la revendication 1, dans lequel le pre-

mier transducteur (107) et la géométrie du premier réservoir (101) sont conçus pour transmettre au moins 8 watts/litre de puissance ultrasonore dans le premier réservoir (101).

4. Appareil selon l'une quelconque des revendications 1 à 3, dans lequel le dispositif de placement (109.1 et 109.2) comprend une première pluralité de rouleaux (111, 117, 119, 125, 113, 115, 121 et 123) et la première pluralité de rouleaux (111, 117, 115, 115, 115, 121 et 123) sont conçus pour disposer de multiples itérations du textile (131) à travers le premier réservoir (101) et chaque itération du textile (131) est séparée de l'itération adjacente du textile (131) d'une certaine distance, la distance étant déterminée sur la base de la première longueur d'onde.
5. Appareil selon la revendication 4, dans lequel le dispositif de placement (109.1 et 109.2) dispose chacune des itérations du textile (131) en des emplacements correspondant à des emplacements d'antinodes du motif d'ondes ultrasonores sensiblement stationnaire formé dans le premier réservoir (101).
6. Appareil selon l'une quelconque des revendications 1 à 5, comprenant un second transducteur (207), dans lequel le second transducteur (207) est conçu pour transmettre des ondes ultrasonores d'une seconde longueur d'onde dans un second réservoir (201), et le second réservoir (201) est configuré pour établir un motif d'ondes ultrasonores sensiblement stationnaire des ondes ultrasonores à l'intérieur du second réservoir (201); et le dispositif de placement (109.1 et 109.2) est configuré pour disposer le textile (131) en séquence dans le premier réservoir (101) et le second réservoir (201).
7. Appareil selon la revendication 6, dans lequel le dispositif de placement (109.1 et 109.2) est configuré pour disposer le textile (131) à une deuxième distance du second transducteur (207) dans le second réservoir (201), la deuxième distance étant déterminée en fonction de la seconde longueur d'onde et le dispositif de placement (109.1 et 109.2) est conçu pour disposer de multiples itérations du textile (131) à travers le second réservoir (201) et chaque itération du textile (131) est séparée de l'itération adjacente du textile (131) d'une troisième distance, la troisième distance étant déterminée sur la base de la seconde longueur d'onde et le dispositif de placement (109.1 et 109.2) dispose chacune des itérations du textile (131) aux emplacements correspondant aux emplacements des antinodes du motif d'ondes ultrasonores sensiblement stationnaire formé dans le second réservoir (201).
8. Appareil selon la revendication 7, dans lequel le se-

cond transducteur (207) et la géométrie du second réservoir (201) sont configurés pour exposer le textile (131) à une puissance ultrasonore dans une plage comprise entre 0,2 W/cm² et 2 Watts/cm² et sont conçus pour transmettre au moins 8 watts/litre de puissance ultrasonore dans le second réservoir (201).

9. Procédé de fabrication d'un appareil, comprenant les étapes suivantes:

fournir un premier réservoir (101) qui comprend une première paroi (103) et une seconde paroi (105);

configurer la seconde paroi (105) pour réfléchir les ondes ultrasonores à partir d'un premier transducteur (107) et la première paroi (103) et la seconde paroi (105) sont séparées l'une de l'autre pour établir le motif d'ondes sensiblement stationnaire dans le premier réservoir (101) créant ainsi de multiples zones de cavitation;

fournir un dispositif de placement (109.1 et 109.2) configuré pour disposer un textile (131) à une première distance dudit premier transducteur (107) et dans le premier réservoir (101), **caractérisé en ce que** la première distance est déterminée sur la base d'une première longueur d'onde;

coupler ledit premier transducteur (107) sur la première paroi (103) du premier réservoir (101), dans lequel le premier transducteur (107) est configuré pour transmettre des ondes ultrasonores de ladite première longueur d'onde dans le premier réservoir (101); et

configurer l'appareil pour qu'il fonctionne sur une fréquence de balayage d'ondes ultrasonores, la fréquence de balayage est une bande de fréquences autour d'une première fréquence, ladite première fréquence correspondant à ladite première longueur d'onde et le dispositif de placement (109.1 et 109.2) est configuré pour disposer le textile (131) à ladite première distance, ladite première distance est déterminée sur la base de ladite première fréquence.

10. Procédé selon la revendication 9, dans lequel le procédé comprend la configuration du premier transducteur (107) et de la géométrie du premier réservoir (101) pour: exposer le textile (131) à puissance ultrasonore dans une plage comprise entre 0,2 W/cm² et 2 watts/cm²; et transmettre au moins 8 watts/litre d'énergie ultrasonique dans le premier réservoir (101).

11. Procédé selon la revendication 9, dans lequel la fourniture du dispositif de placement (109.1 et 109.2) comprend la fourniture d'une première pluralité de rouleaux (111, 117, 119, 125, 113, 115, 121 et

123) et l'adaptation de la première pluralité de rouleaux (111, 117, 119, 125, 113, 115, 121 et 123) pour disposer de multiples itérations du textile (131) à travers le premier réservoir (101), dans lequel chaque itération du textile (131) est séparée de l'itération adjacente du textile (131) d'une distance déterminée sur la base de la première longueur d'onde.

12. Procédé selon la revendication 11, dans lequel la fourniture du dispositif de placement comprend l'adaptation du dispositif de placement (109.1 et 109.2) pour disposer chacune des itérations du textile (131) en un emplacement qui correspond à l'emplacement d'un antinode du motif d'ondes ultrasonores sensiblement stationnaire formé dans le premier réservoir (101).

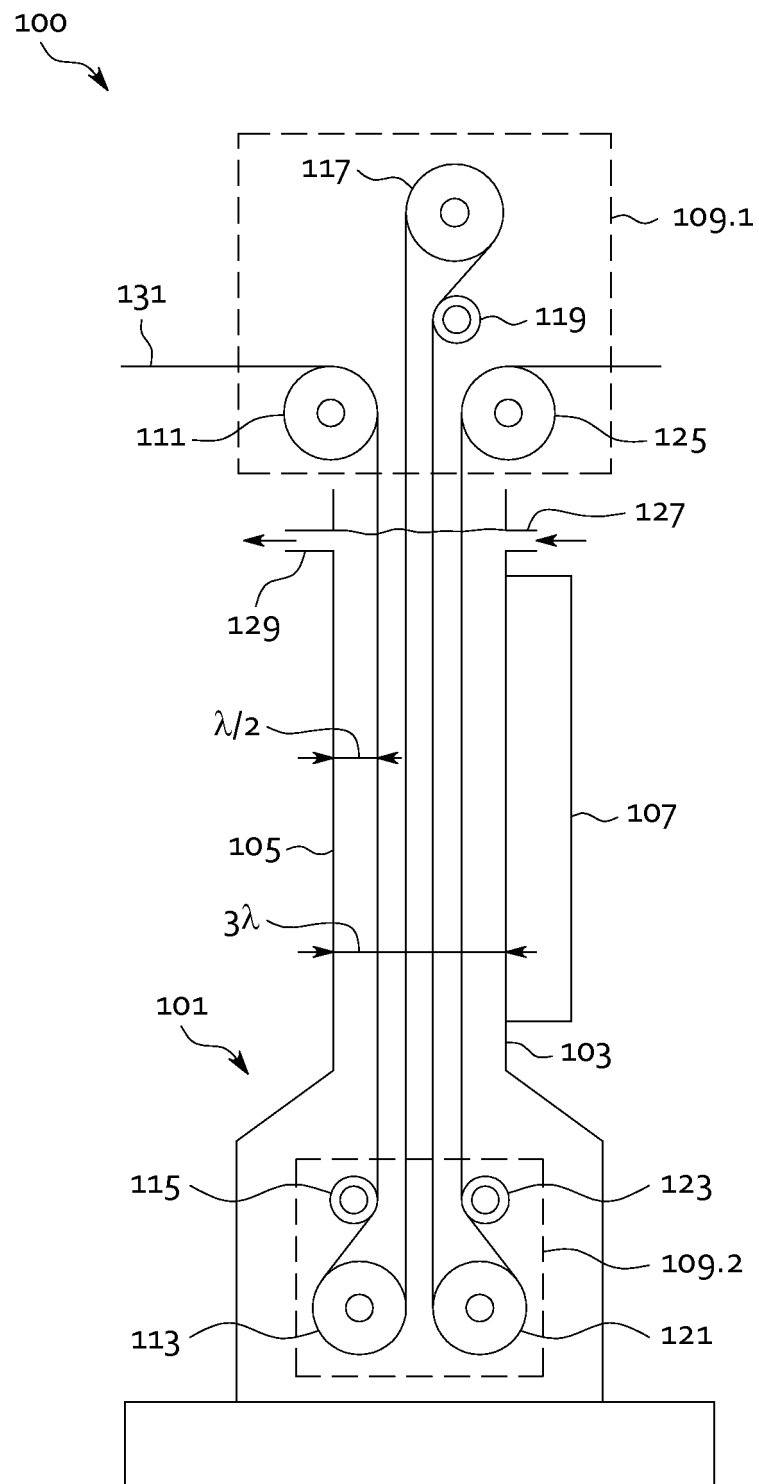


FIG. 1

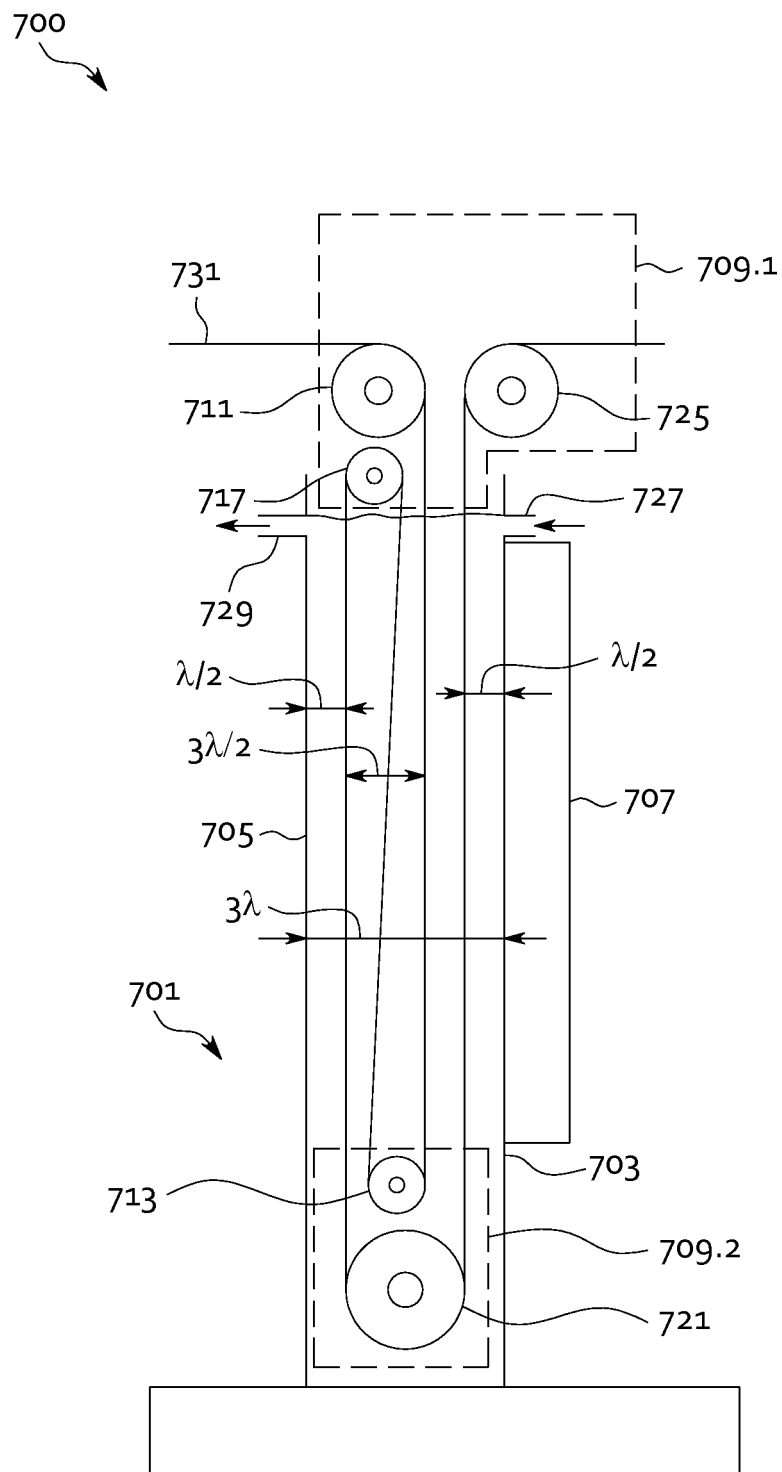


FIG. 1a

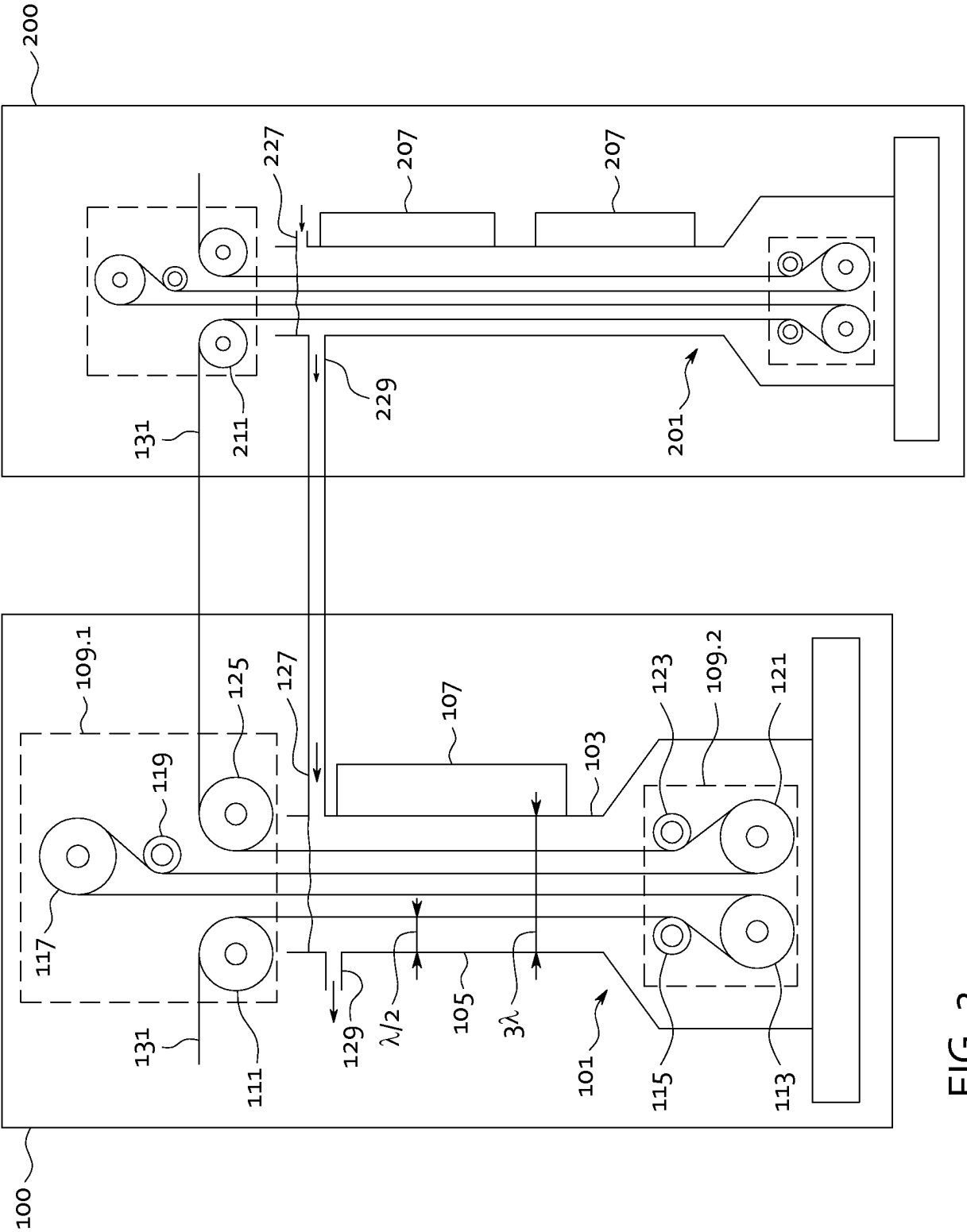


FIG. 2

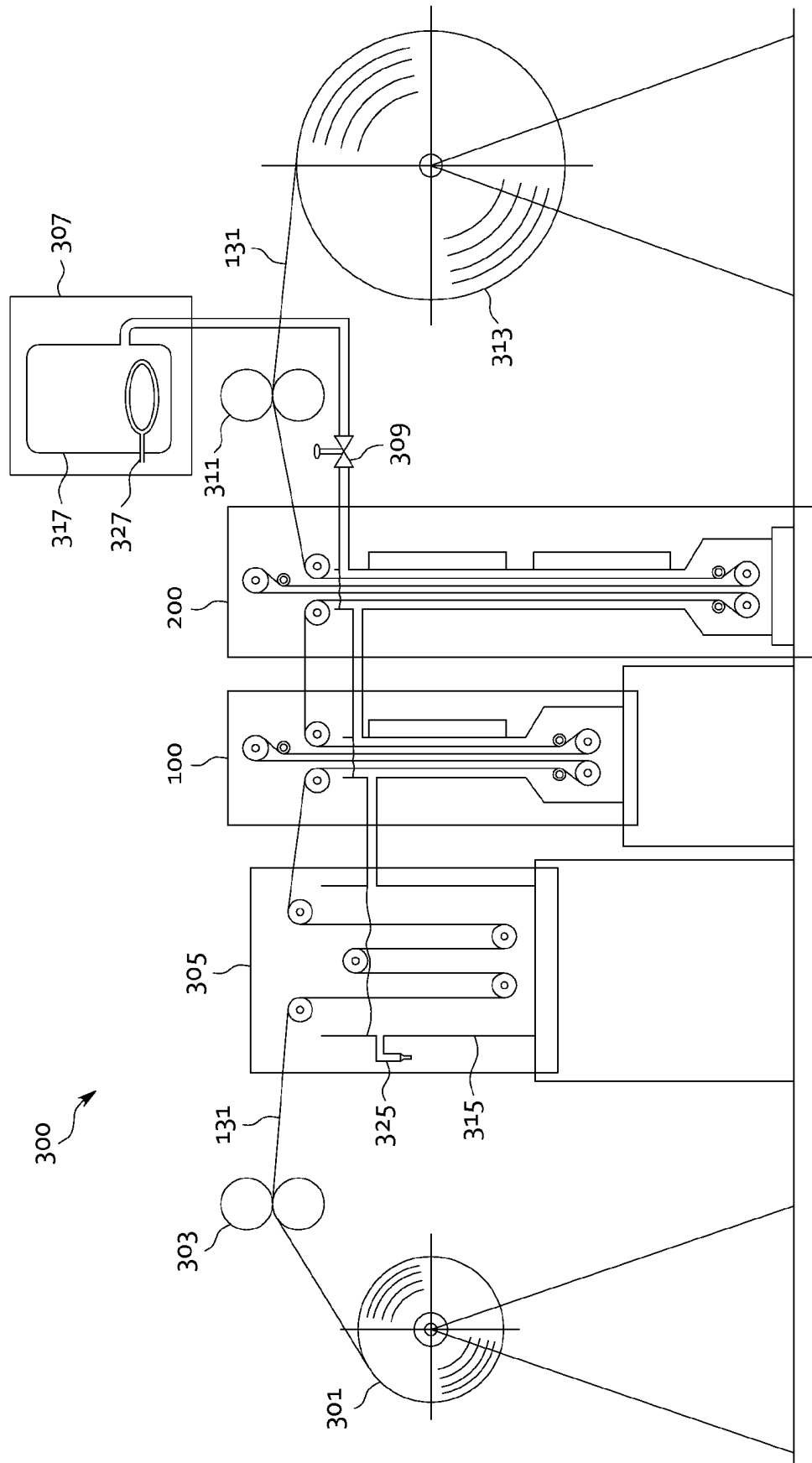


FIG. 3

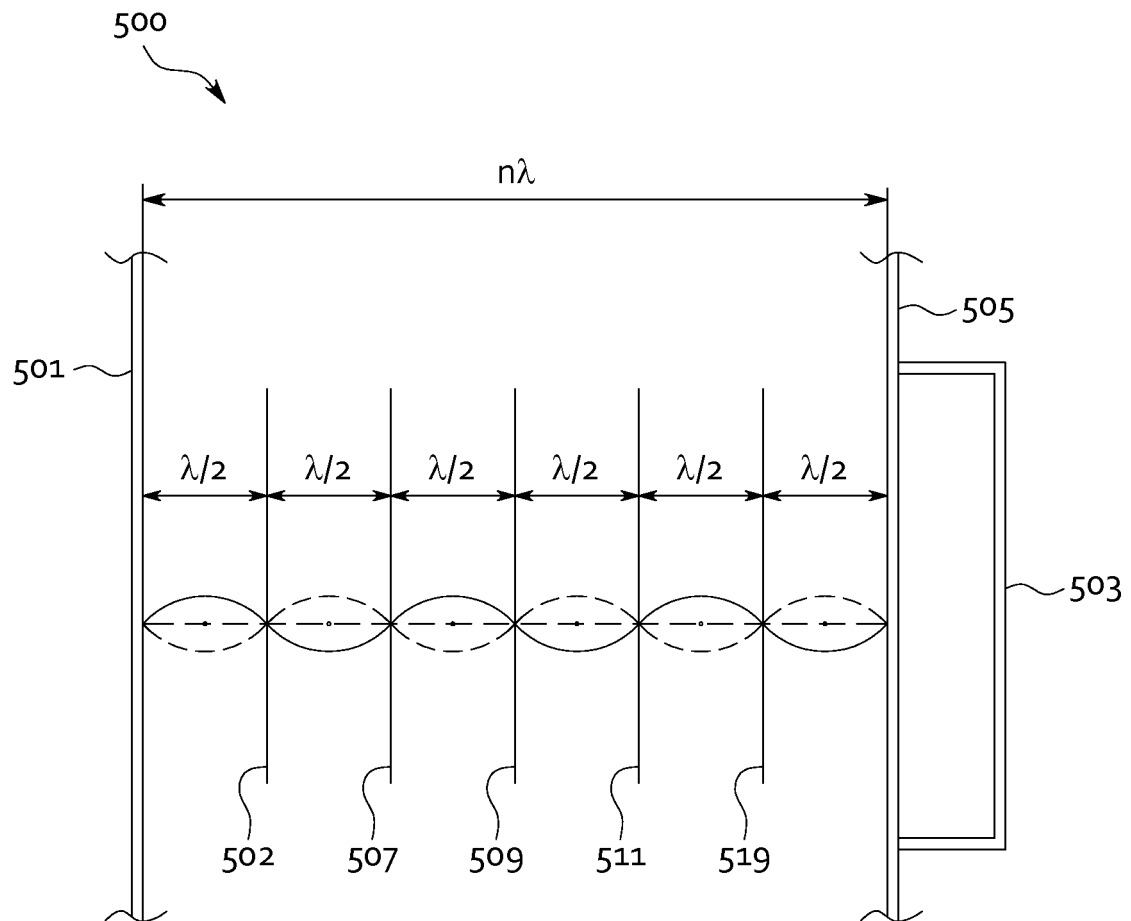


FIG. 4

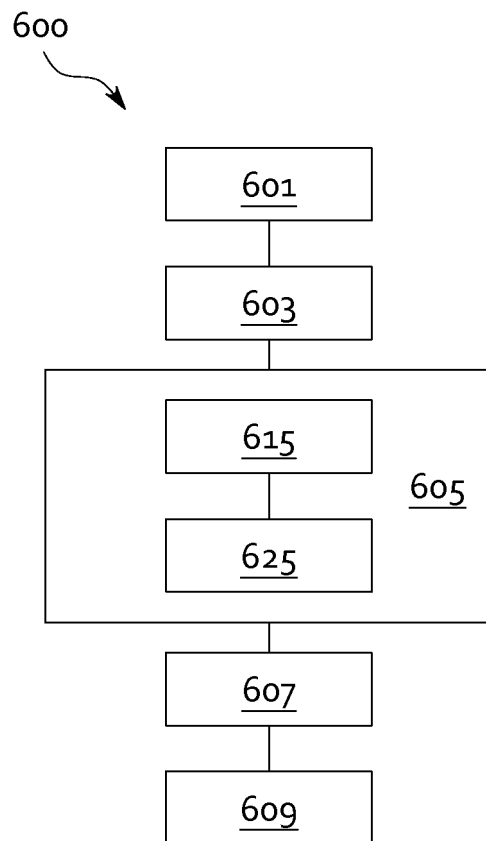


FIG. 5

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 0969131 A1 [0003] [0043] [0044] [0045] [0046] [0049] [0052] [0053]
- US 3688527 A [0003] [0043] [0050] [0052] [0053]
- WO 9937844 A [0003] [0043] [0051] [0052] [0053]
- EP 969131 A1 [0053]