



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**29.03.2017 Bulletin 2017/13**

(51) Int Cl.:  
**D03D 13/00** (2006.01) **A47G 9/02** (2006.01)  
**D03D 15/00** (2006.01) **D03D 1/00** (2006.01)

(21) Application number: **16190597.1**

(22) Date of filing: **26.09.2016**

(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**  
Designated Extension States:  
**BA ME**  
Designated Validation States:  
**MA MD**

(72) Inventors:  
• **Goenka, Dipali**  
**400013 Mumbai (IN)**  
• **Palit, Subrata**  
**400013 Mumbai (IN)**

(74) Representative: **Chapman, Alan Gareth**  
**Avidity IP**  
**Broers Building**  
**Hauser Forum**  
**21 JJ Thomson Avenue**  
**Cambridge CB3 0FA (GB)**

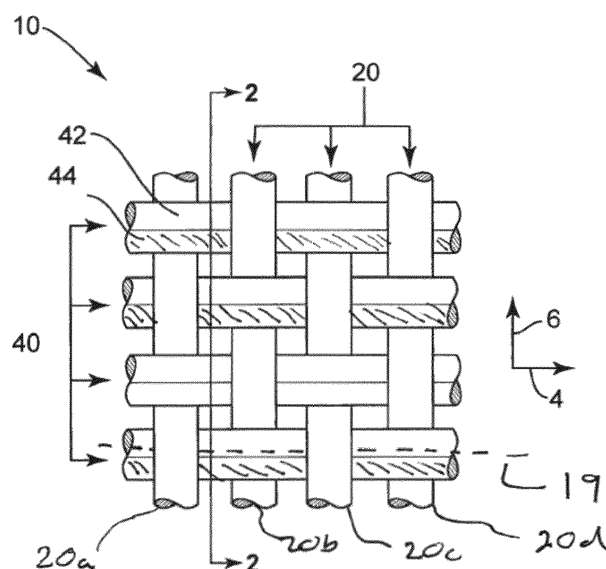
(30) Priority: **25.09.2015 US 201562232445 P**  
**23.09.2016 US 201615274915**

(71) Applicant: **Welspun India Limited**  
**Mumbai 400013 (IN)**

(54) **CHAMBRAY FABRIC, BEDDING ARTICLES, AND RELATED MANUFACTURING METHODS**

(57) A woven chambray fabric, including a method and system for forming same includes a plurality of warp yarns, each warp yarn including natural fibers. The woven fabric includes a plurality of weft yarns interwoven with the plurality of warp yarns. Each weft yarn defines a weft yarn assembly that has a first weft yarn, a second weft yarn that extends alongside the first weft yarn, and

a plurality of consolidation regions where the first weft yarn and the second weft yarn are coupled to each other. The first weft yarn is a spun staple yarn that includes natural fibers and the second weft yarn is a dyed continuous filament yarn. The second weft yarn is dyed a color that is different from a color of the first weft yarn and each warp yarn so as to define the woven chambray fabric.



**FIG. 1**

## Description

### CROSS-REFERENCE TO RELATED APPLICATIONS

5 [0001] The present application claims priority to, and the benefit of, U.S. Provisional Application No. 62/232,445, filed September 25, 2015, the entire disclosure of which is incorporated by reference into this application.

### TECHNICAL FIELD

10 [0002] The present disclosure relates to a chambray fabric, bedding articles including a chambray fabric, and related methods of manufacturing same.

### BACKGROUND

15 [0003] A typical chambray fabric formed with a colored warp yarns and undyed weft yarns. In some cases, the weft yarns are dyed a color that is lighter than the color the warp yarns are dyed. The warp yarns may be package dyed or dyed on the warp beam and then woven into fabric with the undyed filling yarns to achieve the desired effect. Chambray fabric can also be made in reverse with undyed or white warp yarns and colored weft yarns. In either version, the warp and weft yarns are normally made of 100 % cotton fibers. Coloring agents typically include reactive or vat dyes.

### SUMMARY

25 [0004] Typical chambray fabrics have poor colorfastness to ingredients common in consumer products, such as, for example, cosmetic or household products. There is a need for woven chambray fabrics and related bedding articles that are colorfast to one or more ingredients in cosmetic and/or household products. An embodiment of the present disclosure is a woven chambray fabric that includes a plurality of warp yarns with each warp yarn including natural fibers. The woven fabric includes a plurality of weft yarns interwoven with the plurality of warp yarns. Each weft yarn defines a weft yarn assembly that has a first weft yarn, a second weft yarn that extends alongside the first weft yarn, and a plurality of consolidation regions where the first weft yarn and the second weft yarn are coupled to each other. The first weft yarn is a spun staple yarn that includes natural fibers and the second weft yarn is a dyed continuous filament yarn. The second weft yarn is dyed a color that is different from a color of the first weft yarn and each warp yarn so as to define the woven chambray fabric.

30 [0005] Another embodiment of the present disclosure is a coordinated bedding system. The system includes a plurality of bedding articles that are formed from a woven chambray fabric. The bedding articles include one or more of a flat sheet, a fitted sheet, a pillow case, a sham, a comforter, a duvet, a bed-skirt, and/or a blanket.

35 [0006] Another embodiment of the present disclosure is a method of manufacturing a woven chambray fabric. The method includes forming a yarn assembly that includes a first yarn, a second yarn that extends alongside the first yarn, and a plurality of consolidation regions where the first yarns and the second yarns are coupled together. The first yarn is a spun staple yarn that includes natural fibers and the second yarn is a continuous filament yarn. The method includes weaving a plurality of warp yarns with a plurality of the yarn assemblies to form the woven fabric. The warp yarns include natural fibers. The method includes applying color to the second yarn. Applying color to the second yarn can occur before weaving. Alternatively, applying color to the second yarn can occur after weaving.

### BRIEF DESCRIPTION OF THE DRAWINGS

45 [0007] The foregoing summary, as well as the following detailed description of illustrative embodiments of the present application, will be better understood when read in conjunction with the appended drawings. For the purposes of illustrating the present application, there is shown in the drawings illustrative embodiments of the disclosure. It should be understood, however, that the application is not limited to the precise arrangements and instrumentalities shown.

50 Figure 1 is a plan view of a woven fabric according to an embodiment of the present disclosure.

Figure 2 is cross-sectional view of the woven fabric taken along line 2-2 in Figure 1.

55 Figure 3 is a schematic of a weft yarn assembly used as the fill or weft yarn in the woven fabric illustrated in Figures 1 and 2,

Figures 4 and 5 are schematics of a winding apparatus and yarn consolidation apparatus used to weft yarn assembly

shown in Figure 3.

Figure 6 is a schematic process flow diagram for manufacturing the pillow article illustrated in Figure 1.

Figure 7 is a schematic process flow diagram for manufacturing the pillow article illustrated in Figure 1.

## DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

**[0008]** Embodiments of the present disclosure include a woven chambray fabric, bedding articles, and a coordinated bedding system comprising a plurality of bedding articles. A bedding article may be a flat sheet, a fitted sheet, a pillow case, a sham, a comforter, a duvet, a bed-skirt, and/or a blanket. The bedding articles include woven chambray fabrics 10 constructed in accordance with the present disclosure.

**[0009]** Turning to Figures 1 and 2, the woven chambray fabric 10 has a plurality of warp yarns 20 and a plurality of weft yarns 40 interwoven with the plurality of warp yarns 20 to define the woven chambray fabric 10. Each weft yarn 40 defines a weft yarn assembly that includes a first weft yarn 42, a second weft yarn 44 that extends alongside the first weft yarn 42, and a plurality of consolidation regions 46 where the first and second weft yarns 42 and 44 are coupled together. The woven chambray fabric 10 includes face 12 and back 14 opposite the face 12 along direction 8. The warp yarns 20 extend along a warp direction 6 (sometimes referred to as a machine or longitudinal direction) and the weft yarns 40 extend along a weft direction 4 (sometime referred to as a lateral or cross direction). In accordance with the illustrated embodiment, the warp yarns 20 may be spun staple yarns that include natural fibers (e.g. cotton fibers). Furthermore, the first weft yarn 42 may be spun staple yarns that include natural fibers (e.g. cotton fibers) and the second weft yarn 44 is a dyed continuous filament yarn. To create a chambray effect in the woven chambray fabric 10, the second weft yarn 44 is dyed a color that is different from a color of the first weft yarn 42 and each warp yarn 20. The color difference between a) the second weft yarns 44 and b) the first weft yarns 42 and warp yarns 20 creates a chambray color effect in the finished fabric. In one example, the warp yarns 20 and first weft yarn 42 are bleached or substantially white yarns while the second weft yarn 44 is a color that contrasts to the color of the warp yarns 20 and first weft yarn 42.

**[0010]** The woven chambray fabric 10 is well suited for bedding applications. The presence of natural fibers (e.g. cotton) results in soft, supple fabrics with good hand and drape-- characteristics that are desirable in bedding articles. The presence of continuous filament yarns in the weft can improve fabric durability, e.g. wash durability, which is also a desirable attribute in bedding articles. And the chambray color effect is not diminished by exposure to various ingredients found in consumer products. Rather, the woven chambray fabric 10 is colorfast against one or more ingredients found in cosmetic and household products. For example, the woven chambray fabric 10 is colorfast against cosmetics chemicals, such as benzoyl peroxide, retinol, and salicylic acid, as will be described further below. The woven chambray fabric 10 is also colorfast against chlorine bleach and non-chlorine bleach. Thus, long-term use of bedding articles that include woven chambray fabric 10 should not result in color changes when exposed to these common household chemicals. Improved durability, in combination with the colorfast properties, extends the useful life bedding articles, decreasing the overall cost of use for the consumer.

**[0011]** The woven chambray fabric 10 can have wide range of designs. The woven chambray fabric 10 can have a number of different woven structures each having a woven design repeat. As used herein, a woven design repeat includes at least a first warp yarn 20a, a second warp yarn 20b, and at least one weft yarn 40. For example, a plain weave fabric has a woven design repeat that includes two adjacent warp yarns 20 and two adjacent weft yarns 40. Depending on the particular design, woven design repeats may repeat along: a) the weft direction 4; b) the warp direction 6; or c) both the weft direction 4 and warp directions 6. Some exemplary woven structures include, but are not limited to: plain weaves; basket weaves, rib weaves (e.g. 2x1 rib weave; 2x2 rib weave; or 3x1 rib weave) twill weaves; oxford weaves; percale weaves, satin weaves (e.g. satin dobby base, satin stripe satin 5/1, satin 4/1 satin; 4/1 satin base strip; 4/1 stain swiss dot; 4/1 down jacquard; 5/1 satins), or sateen weaves. In one example, the woven fabric is a plain weave. In another example, the woven fabric is a basket weave. In another example, the woven fabric is a rib weave. In another example, the woven fabric is a twill. In another example, the woven fabric is an oxford weave. In another example, the woven fabric is a satin weave. In another example, the woven fabric is a percale weave. Furthermore, a number of exemplary satin constructions are possible. For instance, in one satin weave example, the woven fabric is a 4/1 satin. In another example, the woven fabric is a 4/1 satin dobby diamond weave. In another example, the woven fabric is a 4/1 satin dobby stripe. In yet another example, the woven fabric is a 4/1 satin jacquard weave. In another example, the woven fabric is a 5/1 satin. In still another example, the woven fabric may be a 6/1 satin. In another example, the woven fabric is a 7/1 satin. In yet another example, the woven fabric is an 8/1 satin. In another example, the woven fabric is a 9/1 satin. And in another example, the woven fabric is a 10/1 satin.

**[0012]** The present disclosure can utilize co-insertion techniques to insert multiple weft yarns 40 along a weft insertion path 19 in a single weft insertion event during weaving, as will be further detailed below. The weft insertion path 19 of weft yarn 40 is shown in dashed lines in Figure 1. The weft insertion path 19 extends along the weft direction 4 around

the warp yarns 20 across an entirety of the width of the woven chambray fabric 10. As illustrated, the weft insertion path 19 extends under (with respect to the sheet) warp 20a, over warp yarn 20b, under warp yarn 20c, and over warp yarn 20d. A person of skill in the art will appreciate that the weft insertion path 19 varies from one woven design to another woven design. A "co-insertion" technique is when multiple pick or weft yarns are inserted into the warp shed at one time during weaving. Co-insertion may also include inserting three or more yarns supplied from the three or more different yarn packages into the shed during weaving. The weft yarns inserted via co-insertion are referred to as a weft yarn group. A weft yarn group extends through the warp yarns along the weft insertion path 19. In one example, the woven chambray fabric 10 has between two (2) weft yarns and eight (8) weft yarns per group that are inserted into the shed during a single insertion event along the weft insertion path 19. By inserting groups of weft yarns into the shed during a weft insertion event, it is possible to attain increased weft (or pick or fill) densities and therefore higher thread counts. However, it should be appreciated that a single weft yarn 40 can be inserted along weft insertion path 19 in a single weft insertion event.

**[0013]** The woven chambray fabric 10 has thread counts suitable for bedding applications. The thread count of the woven fabrics made in accordance with present disclosure are typically greater than about 100 and can be as high as about 1000 (or even higher). The thread count as used herein is the total number of yarns in square inch of fabric. Plied yarns are considered one yarn for the purpose of determining thread count.

**[0014]** The woven chambray fabric 10 can have a range of warp end densities that are suitable for bedding articles. In accordance with an embodiment of the present disclosure, the woven fabric has a warp end density between about 50 warp ends per inch and about 350 warp ends per inch. Warp end density may be referred to as ends per inch or EPI. In one example, the warp end density is between about 50 and 150 warp ends per inch. In another example, the warp end density is between about 150 and 250 warp ends per inch. In another example, the warp end density is between about 250 and 350 warp ends per inch.

**[0015]** The woven chambray fabric 10 can have a range of weft end densities suitable for bedding articles. In accordance with an embodiment of the present disclosure, the weft yarns are arranged to define a weft end density between about 50 weft yarns per inch and about 700 weft yarns per inch (or more). Weft end density may be referred to as picks per inch or PPI. In one example, the weft yarn density is between about 100 and about 700 weft yarns per inch. In one example, the weft yarn density is between about 100 and about 400 weft yarns per inch. In another example, the weft yarn density is between about 400 and about 500 weft yarns per inch. In another example, the weft yarn density is between about 500 and about 700 weft yarns per inch. The weft yarn density as used herein refers to the total number of separate weft yarns along a length of the woven fabric. For example, a weft yarn density of about 50 picks per inch refers to the 50 total weft yarns per inch of woven fabric. If the weft yarn groups are inserted during a single weft insertion event and each group includes three (3) weft yarns, then there would be about 16 total weft yarn groups per inch of fabric and 48 picks per inch. In accordance with one embodiment of the present disclosure, the plurality of warp yarns define a warp end density between about 50 warp ends per inch to about 250 warp ends per inch, and the weft yarns 40 define a weft density between about 50 wefts per inch and about 150 wefts picks per inch.

**[0016]** The type and content of the warp yarns 20 and weft yarns 40 are described next. In accordance with an embodiment of the present disclosure, the warp yarns 20 may be spun staple yarns that include natural fibers, e.g. cotton fibers. For example, the weft yarns may be exclusively cotton fibers, a blend of cotton fibers and one or more other natural fibers, and/or synthetic fibers. For instance, other natural fibers include silk, linen, flax, bamboo, hemp, wool, and the like. Other synthetic fibers may include, but are not limited to, rayon fibers (e.g. Modal, Lyocell) or thermoplastic fibers could be used blend yarns, such as polyethylene terephthalate (PET) fiber, polylactic acid (PLA) fiber, polypropylene (PP) fibers, polyamide fibers, and microfiber staple fibers.

**[0017]** The warp yarns 20 can include any type of spun staple yarn. For example, the warp yarns can be ring spun yarns, open end yarns, rotor spun yarns, vortex spun yarns, core spun yarns, jet spun yarns, or compact spun yarns. In another embodiment, the warp yarns can be Hygro cotton® brand yarns marketed by Welspun India Limited. Furthermore, yarns can be formed as disclosed in U.S. Patent No. 8,833,075, entitled "Hygro Materials for Use In Making Yarns And Fabrics," (the 075 patent). The 075 patent is incorporated by reference into present disclosure. Preferred warp yarns are ring spun yarns. The warp yarn 20 can, however, be any type of spun yarn structure. In alternative embodiment, the warp yarn can be a continuous filament yarn.

**[0018]** The warp yarns 20 have a range of counts for the fiber and yarn types described above. For instance, the warp yarn 20 can have a count in the range between about 8 Ne (664 denier) to about 120 Ne (44.3 denier). In certain examples, the warp yarn count is between 20 Ne (266 denier) and about 120 Ne (44.3 denier). In one example, the warp yarn count is between 20 Ne (266 denier) and about 100 Ne (53.1 denier). In one example, the warp yarn count is between 20 Ne (266 denier) and about 60 Ne (88.6 denier). In another example, the warp yarn count is between 20 Ne (266 denier) and about 40 Ne (133 denier). In another example, the warp yarn count is 20 Ne (266 denier) and about 30 Ne (177 denier). In one example, the warp yarn is 2-ply yarn. In another example, the warp yarn is a 3-ply yarn.

**[0019]** Referring to Figure 3, each weft yarn 40 defines weft yarn assembly. The weft yarn assembly includes a first weft yarn 42 is a spun staple yarn and the second weft yarn 44 is a dyed continuous filament yarn. The second weft

yarn 44 may be referred to as a "dyed second weft yarn". The first and second yarns 42 and 44 are consolidated into a weft yarn assembly via a plurality of consolidation regions 46 where the first weft yarn 42 is coupled to the second weft yarn 44, as further detailed below. The first and second weft yarns 42 and 44 are substantially parallel with respect to each other along a length L of the weft yarn assembly that extends between adjacent consolidation regions 46. In one example, the length L is at least 0.25 cm. In another example, the length L is between about 0.25 cm to about 3.00 cm. In another example, the length is between about 1.00 cm and about 2.50 cm.

**[0020]** The first weft yarn 42 can be formed from primarily from natural fibers. In accordance with the illustrated embodiment, the natural fibers are cotton fibers. However, in alternative embodiments, the first weft yarn 42 can include cotton fibers blended with other natural or synthetic fibers. In such an example, the natural fibers could include silk, linen, flax, bamboo, hemp, wool, and the like. The first weft yarn can include cotton and synthetic fibers. Synthetic fibers include, but are not limited to, rayon fibers (e.g. Modal, Lyocell) or thermoplastic fibers, such as polyethylene terephthalate (PET) fiber, polylactic acid (PLA) fiber, polypropylene (PP) fibers, polyamide fibers, and microfiber staple fibers.

**[0021]** The first weft yarn 42 is a spun staple yarn. The first weft yarns 42 can be ring spun yarns, open end yarns, rotor spun yarns, vortex spun yarns, core spun yarns, jet spun yarns, or compact spun yarns. In one example, the first weft yarn can be a Hygro cotton® brand yarn. In one preferred embodiment, the first weft yarn 42 is a ring spun yarn formed from cotton fibers. However, the first weft yarn is not limited to ring spun yarns made exclusively from the cotton fibers.

**[0022]** The first weft yarn 42 can have a range yarn counts. For instance, the first weft yarn 42 can have a count in the range between about 8 Ne (664 denier) to about 120 Ne (44.3 denier). In certain examples, the first weft yarn count is between 20 Ne (266 denier) and about 120 Ne (44.3 denier). In one example, the first weft yarn count is between 20 Ne (266 denier) and about 100 Ne (53.1 denier). In one example, the first weft yarn count is between 40 Ne (133 denier) and about 100 Ne (53.1 denier). In one example, the first weft yarn count is between 40 Ne (133 denier) and about 80 Ne (66.4 denier). In one example, the first weft yarn count is between 40 Ne (133 denier) and about 60 Ne (88.6 denier). In one example, the first weft yarn count is between 60 Ne (88.6 denier) and about 80 Ne (66.4 denier). In one example, the first weft yarn count is between 60 Ne (88.6 denier) and about 100 Ne (53.1 denier). In one example, the first weft yarn count is between 20 Ne (266 denier) and about 60 Ne (88.6 denier). In another example, the first weft yarn count is between 20 Ne (266 denier) and about 40 Ne (133 denier). In another example, the first weft yarn count is 20 Ne (266 denier) and about 30 Ne (177 denier). In one example, the first weft yarn has a count of about 20 Ne (266 denier). In one example, the first weft yarn count is about 30 Ne (177 denier). In one example, the first weft yarn count is about 40 Ne (133 denier). In another example, the first weft yarn count is about 60 Ne (88.6 denier). In another example, the first weft yarn count is about 70 Ne (75.9 denier). In another example, the first weft yarn count is about 80 Ne (66.4 denier). In another example, the first weft yarn count is about 100 Ne (53.1 denier). In another example, the first weft yarn has a count of about 120 Ne (44.3 denier).

**[0023]** The second weft yarn 44 is a dyed continuous filament yarn. Continuous filament yarns are formed by typical melt-spinning processes. As such, the second weft yarn 44 can be textured with false twist imparted via air jet texturing apparatus as is known in the art. The second weft yarn 44 can be formed to have a range of filaments per yarn as well as a range denier per filament (dpf). In one example, the second weft yarn 44 is a dyed continuous filament yarn formed from polyethylene terephthalate (PET) filaments.

**[0024]** The dyed continuous filament yarn 44 (sometimes referred to as the "dyed yarn") can have one of several different yarn types based on how color is applied to the yarn. The dyed continuous filament yarn 44 may be a "dope-dyed" yarn, a "package-dyed" yarn, or a "yarn-dyed" yarn. A "dope-dyed" yarn is yarn with dye molecules or pigments disposed uniformly throughout the internal morphology of the fibers (filaments). A dope dyed yarn is a yarn that has dyes applied in the masterbatch during filament extrusion. A "package-dyed" means yarns that have dyes applied after yarn formation and before fabric formation, yet have dye molecules disposed in the internal morphology of filament or fiber structure. The phrases "yarn dyed yarn," "yarn dyed weft yarn" or "yarn dyed continuous filament yarn" means yarns that have dyes applied after fabric formation) yet have dye molecules within the internal morphology of filament or fiber structure. A dope-dyed yarn as used herein is a structural term that is distinguished from a "package dyed" yarn and a "yarn dyed yarn." A dope-dyed yarn would have better and more uniform color penetration through the yarn cross-section and along the length of the yarn. In contrast, a package dyed yarn and a yarn-dyed yarn would have nonuniform color penetration through the yarn cross-section and along the length of the yarn. Accordingly, the second weft yarn 44 can be a dope-dyed continuous filament yarn that includes pigments. In another example, the second weft yarn 44 can be a package dyed yarn that includes disperse dyes applied to yarn via a package dyeing process (not shown). In another example, the second weft yarn 44 can be a yarn dyed yarn where color is applied after fabric formation with, for example, disperse dyes. It should be appreciated that a number of colorants can be used to form the dope-dyed yarn, the package dyed yarn, or the yarn-dyed yarn as described in the present disclosure.

**[0025]** The second weft yarn 44 can have a range of counts. In accordance with the illustrated embodiment, the second weft yarn 44 has count between 60 denier (88.6 Ne) to about 150 denier (55.4 Ne). In one example, the second weft yarn 44 has count between 60 denier (88.6 Ne) to about 120 denier (44.3 Ne). In another example, the second weft yarn

44 has count between 60 denier (88.6 Ne) to about 110 denier (48.3 Ne). In another example, the second weft yarn 44 has count between 60 denier (88.6 Ne) to about 100 denier (53.1 Ne). In another example, the second weft yarn 44 has count between 60 denier (88.6 Ne) to about 80 denier (66.4 Ne). In another example, the second weft yarn 44 has count between 80 denier (66.4 Ne) to about 120 denier (44.3 Ne). In another example, the second weft yarn 44 has count between 80 denier (66.4 Ne) to about 110 denier (48.3 Ne). In another example, the second weft yarn 44 has count between 90 denier (59.1 Ne) to about 110 denier (48.3 Ne). The second weft yarn can particular counts among the ranges described above. For instance, the second weft yarn 44 has a count of about 60 denier (88.6 Ne). In another example, the second weft yarn 44 has a count of about 70 denier (75.9 Ne). In another example, the second weft yarn 44 has a count of about 75 denier (70.9 Ne). In another example, the first weft yarn 42 has a count of about 80 denier (66.4 Ne). In another example, the second weft yarn 44 has a count of about 90 denier (59.1 Ne). In another example, the second weft yarn 44 has a count of about 100 denier (53.1 Ne). In another example, the second weft yarn 44 has a count of about 110 denier (48.3 Ne). In another example, the second weft yarn 44 has a count of about 120 denier (44.3 Ne). In another example, the second weft yarn 44 has a count of about 130 denier (40.9 Ne). In another example, the second weft yarn 44 has a count of about 140 denier (38 Ne). In another example, the second weft yarn 44 has a count of about 150 denier (35.4 Ne).

**[0026]** The warp yarns 20 and weft yarns 40 may be selected to achieve a desire fiber content. In accordance with an embodiment of the present disclosure, the warp yarns include natural fibers, the first weft yarn 42 includes natural fibers, and the second warp yarn is a dyed continuous filament yarn. In one example, the woven chambray fabric 10 is between 50 % to about 80 % by weight of natural fibers, with the balance comprising the synthetic fibers (based on dyed continuous filament yarn). In one preferred example, natural fibers are cotton fibers. In such an example, the woven chambray fabric 10 is between 50 % to about 80 % by weight of cotton fibers. In another preferred example, the woven chambray fabric 10 is between 60 % to about 80 % by weight of cotton fibers. In another preferred example, the woven chambray fabric 10 is between 70 % to about 80 % by weight of cotton fibers. The specified ranges are exemplary and indicate the fiber content of woven chambray fabrics that have desirable attributes. The fiber content could vary outside of the stated ranges and fall within the inventive concepts set forth in the present disclosure.

**[0027]** Turning to Figures 4 and 5, another embodiment of the present disclosure is textile manufacturing system that includes a yarn winding apparatus 400 and a weft yarn assembly device 500. The yarn winding apparatus 400 is configured to wind a first weft yarn 42 and a second weft yarn 44 onto a multiple yarn package 402. The multiple yarn package 402 can be used to present the first and second yarns 42 and 44 to the weft yarn assembly device 500 to consolidate the two yarns together. The yarn winding apparatus 400 and a weft yarn assembly device 500 will described next.

**[0028]** Referring to Figure 4, the yarn winding apparatus 400 includes first holder 410 and a second holder 412 for a first yarn package 420 and a second yarn package 422, respectively. The first yarn package 420 and the second yarn package 422 include the first weft yarn 42 and the second weft yarn 44, respectively. The winding apparatus 400 also include first and second yarn guides 430 and 432 configured to receive the first and second yarns 42 and 44 from the respective first and second yarn packages 420 and 422, respectively. Further included are first guide rollers 440 and second guide rollers 450 positioned in a downstream direction D with respect to the first guide rollers 440. The first and second guide rollers 440 and 450 are direct the first and second yarns 42 and 44 in the downstream direction D to a winder 460.

**[0029]** The winder 460 is a multiple yarn package winder 460 that supports a package core 462. The first and second yarns 42 and 44 are wound in a parallel relationship with respect to each other onto the package core 462 by the winder 460. The winder 460 is configured to wind the first and second yarns on the package core 462 within a predetermined range of wind angles so to define the multiple yarn package 420. The winder 460 can be a precision winder or a random winder as is known in art.

**[0030]** Referring to Figure 5, the weft yarn assembly device 500 includes a package holder 510 that holds position a multiple yarn package 402. The multiple yarn package 402, as discussed above, may include at least a first weft yarn 42 and a second weft yarn 44 wound in a substantially parallel relationship with respect to each other. The yarn assembly device 500 includes a yarn consolidator 530 that is configured to couple the first weft yarn 42 to the second weft yarn 44 at predefined intervals to define a weft yarn assembly 40. In one example, the yarn consolidator 530 is air punching device configured to eject fluid into the first and second yarns 42 and 44 to as to entangle the yarns together at the consolidation regions. The yarn assembly device 500 further includes a winder 560 configured to wind the weft yarn assembly 40 into a composite yarn package 502 at a predetermined wind angle. The winder 560 can be a precision winder or a random winder as is known in the art. The yarn assembly device 500 includes a first pair of guide rollers 520 located between the package holder 510 and the yarn consolidator 530. The first pair of guide rollers 520 configured to direct first and second yarns 42 and 44 toward the yarn consolidator 530. A second pair of guide rollers 540 is located between the yarn consolidator 530 and the winder 560. The second pair of guide rollers 540 configured to direct the weft yarn assembly to the winder. One or more additional yarns guides 550 can be used direct the weft yarn 40 to the winder 560.

**[0031]** Turning to Figure 3, a method of making woven chambray fabric 10 according to an embodiment of the disclosure includes yarn formation 210 for the warp yarns 20 and weft yarns 40. Yarn formation 210 for the warp yarns can include staple yarn formation or spinning 212 and optionally filament yarn formation 214 (where applicable). Staple yarn formation 212 may utilize any number of yarn formation systems and sub-systems. For instance, staple yarn formation may include bale opening, carding, optionally combing, drafting, roving, and yarn spinning (yarn spinning processes are not illustrated) to the desired count and twist level. In some cases, the warp yarns can be plied into 2-ply, 3-ply, or 4-ply configurations. After yarn spinning, the warp yarns are wound into the desired yarn packages for warping 220. In one example, ring spinning is the preferred spinning system. However, the warp yarns can be formed using open end spinning systems, rotor spun spinning systems, vortex spinning systems, core spinning yarns, jet spinning yarns, or compact spinning systems. Furthermore, the spinning system may include methods to form the Hygro cotton®, as disclosed in the 075 patent. The 075 patent is incorporated by reference into present disclosure.

**[0032]** During yarn formation 210, the first weft yarn 42 can may be formed using similar yarn spinning systems used to form the warp yarns, where appropriate. The first weft yarn 42 can be formed using any spun spinning system, similar to the warp yarns 20 described above. As needed, the first weft yarn 42 may be a plied yarn. For instance, the first weft yarn 42 can be a 2-ply, 3 ply, or 4-ply yarn. The second weft yarn 44 is a continuous filament yarn formed using a melt spinning system.

**[0033]** During filament formation, polymer resins are melted and extruded through orifices at temperatures that approach the polymer melting temperature ( $T_m$ ). From the orifices, the filaments may be slightly tensioned by passing over one or more godets before being wound onto desired yarn packages. Additional bulking or texturizing steps may be included to increase the bulk and impart "false twist" to the texture to the second weft yarns 44. The second weft yarn 44 may formed during filament formation 214. In some embodiments, colorants are added the to the masterbatch of the polymer resin. Colorant loaded polymer resin then extruded as dyed filaments. Thus, filament formation can form a dope dyed continuous filament yarn as described above. In one example, the second weft yarn 44 is a dope dyed PET yarn. In an alternative embodiment, filament yarn formation may include package dyeing the continuous filament yarn (e.g. if dope-dyeing is not used).

**[0034]** Following weft yarn spinning, a weft yarn assembly is prepared in winding 216 and consolidation 218 operations. Winding 216 includes use of a yarn winding apparatus 400 (Figure 4) configured to wind a first weft yarn 42 and a second weft yarn 44 onto a multiple yarn package 402 such that the first and second yarns are arrange substantially parallel with respect to each other. Consolidation 218 uses of the weft yarn assembly device 500 (Figure 5) to couple the first and second weft yarns 42 and 44 together. In accordance with the illustrated embodiment, consolidation 218 couples the first and second weft yarns 42 and 44 together with an air punch device 530 (Fig. 5). As illustrated, the air punching device 530 ejects fluid, e.g. air, into the path of the first and second yarns 42 and 44 to entangle the fibers (or filaments) of first weft 42 with the filaments of the second yarn 44. The first and second yarns 42 and 44 are air punched together at 0.25 cm to 3.0 cm spaced apart intervals depending on requirements. Winding 216 and consolidation 218 are used to arrange the first and second yarns 42 and 44 substantially parallel with respect to each other along a length of the yarn assembly 40 between adjacent consolidation regions 46.

**[0035]** Warping 220 follows the yarn formation 210. Warping 220 is where warp yarn ends are removed from their respective yarn packages, arranged in a parallel form, and wound onto a warp beam. Warping 220 also includes a sizing step where a sizing agent is applied to each warp yarn to aid in fabric formation. Warping 220 results in a warp beam of warp yarns prepared for weaving. The warp beam can be positioned on a mounting arm of a weaving loom so that the warp yarns can be drawn through the loom components, as further described below.

**[0036]** Continuing with Figure 3, after warping 220, weaving 240 operation forms a woven fabric with a weaving loom. More specifically, in weaving 240, the warp yarns are drawn-in (not shown) through various components of a weaving loom, such as drop wires, heddle eyes attached to a respective harness, reed and reed dents, in a designated order as is known in the art. After drawing-in is complete, fabric formation phase can begin.

**[0037]** During the formation phase of the weaving 240, the weft yarns 40 are interwoven with the warp yarns 20 to define the desired woven construction. The formation phase creates shed with the warp yarns 20 that the weft yarns 40 can be inserted through across the width direction of the machine to create the desired woven fabric construction. For instance, shedding motions can include cam shedding, dobby shedding, or jacquard shedding motions, each of which can cause the selective raising and lowering of warp ends to create an open shed for weft insertion. The formation phase can utilize different weft insertion techniques, includes air-jet, rapier, or projectile type weft insertion techniques. In each weft insertion event, one or composite yarns 40 are inserted through the shed. For instance, the weaving step can utilize a co-insertion so that multiple groups of weft yarn inserted through the shed during a single weft insertion event, as described above. The weaving step 240 can further include weaving one or more selvedge edges along a length L of the woven fabric. It should be appreciated that various woven constructions can made during weaving 240, including, but not limited to: plain weaves; basket weaves, satins; rib weaves; twill weaves, oxford weaves; percale weaves; and sateens.

**[0038]** After weaving 240, the woven fabric passes through desizing and bleaching 250. Desizing may be accomplished

with enzymes as is known in the art. Bleaching may include typical bleaching agents, such as hydrogen peroxide bleaching. In the bleaching process the fabric may be treated with the exemplary composition shown in the table 1 below.

Table 1

| <b>Component</b>    | <b>Level</b>                           |
|---------------------|----------------------------------------|
| Caustic Soda        | 10-30 gpl                              |
| Hydrogen peroxide   | 14 -50 gpl                             |
| Peroxide Stabilizer | 4-15 gpl                               |
| Wetting agent       | 2 gpl -10 gpl                          |
| Sequestering agent  | 2 gpl- 6 gpl                           |
| pH target           | 8-13                                   |
| Parameters          | Temp: 98 °C<br>Dwell time 8-15 minutes |

In accordance with the illustrated embodiment, such as when the warp yarn 20 and the first weft yarn 42 are cotton yarns, the bleaching process bleaches the cotton warp yarns 20 cotton weft yarns 42. The dyed continuous filament yarn 44 of weft yarn 40 remains as is in the woven fabric and gives final chambray color effect as described herein. Step 250 may also include an optional singeing step.

**[0039]** Next, an optional fabric finishing 270 operation applies a composition including one or more of the functional agents to the woven fabric, such as a softener. In one example, the finish composition may contain micro silicone at about 5-20 gpl, a macro silicone at about 5 -20 gpl, and /or a polyethylene emulsion at about 5-20 gpl. Functional finishes are optional. Finishing includes a drying phase that is used to remove excess moisture from the woven fabric and the composition. During the drying phase, the woven fabric is advanced through a heating machine. The drying phase may include convection, heated steam, infrared, hot air, surface rolls, hot oil can, through-air ovens and the like. After drying, the woven fabric may be optionally sanforized and calendared to adjust the hand and better control shrinkage.

**[0040]** After finishing 270, the woven chambray fabric 10 may be assembled 280 into bedding articles. Article assembly 280 may include material handling a roll goods to present to cutting, hemming, and or folding machines that are used to prepare the articles. In one example, article assembly 280 includes cutting a panel of woven chambray fabric to the appropriate length and width dimensions for the intended articles, such as the flat sheet or pillow case. The outer edges of the panel may be hemmed or surged to create finished edge. Secondary components can be attached to the panel at this stage. For example, ribbing, block hems, or binding can be sewn or otherwise attached to the panel. For fitted sheets, elastic materials are secured the at least the corner regions along the edge of the panel. For comforters can be cut to size and combined with desired batting or fill (e.g. fiber, feather, etc.). Accordingly, article assembly 280 includes forming one or more bedding articles of a bedding system. The bedding articles include at least one of a flat sheet, a fitted sheet, a pillow case, a sham, a comforter, a duvet, a bed-skirt, and a blanket.

**[0041]** After the assembling step, a packaging step 290 places the bedding article in suitable packaging for shipment. The packaging 290 may include automatically folding the formed articles, which are in panel form, into a folded configuration. The folded article is then placed in an outer package for shipment.

**[0042]** Turning to Figure 7, an alternative embodiment of the present disclosure is a method 300 used to form a woven chambray fabric 10 whereby color is applied to the second weft yarn 44 after fabric formation. The alternative method 300 is substantially the same as method 200 described above and illustrated in Figure 6. Similar reference numbers will be used to refer to steps or operations that are common to method 200 shown Figure 6 and method 300 shown in Figure 7. Referring to Figure 7, in accordance with the alternative embodiment, yarn formation 310 includes spun yarn formation 312, which can produce the first weft yarn 42 as a spun staple yarn of natural fibers (e.g. cotton). Spun yarn formation 312 can also produce warp yarns 20 as spun staples yarns of natural fibers (e.g. cotton). Filament yarn formation 314 is similar to filament yarn formation 212. However, in accordance with the alternative embodiment, coloring agents are not added to the polymer melt during yarn formation. Rather, during yarn formation 310, the polymer melt is extruded into an "undyed" continuous filament yarn. The undyed continuous filament yarn is wound into a suitable package during winding. The first weft yarn 40 and the undyed" continuous filament yarn are consolidated during yarn consolidation 218 to yield a yarn assembly. The yarn assembly, which includes the undyed weft yarn 42, is used form a woven fabric during fabric formation 240. After fabric formation 240, the woven fabric progresses through desizing and bleaching 250 and optionally through an optional mercerization process (not shown). Here, the bleaching phases bleach the cotton yarns.

**[0043]** After desizing and bleaching, coloring agents are applied to the woven fabric in dyeing operation 360. In

accordance with the embodiment illustrated, the dyeing operation 360 applies color to the undyed continuous filament yarn, i.e. the second weft yarn 44 in the yarn assembly. The dyeing operation is carried out in such way that coloring agents are not applied or affixed to, the first weft yarn 42 or the warp yarns 20. For instance, in an example where the first weft yarn 42 and the warp yarns 20 made of spun staple yarns comprised of cotton fibers, and the continuous filament yarn is comprised of PET, the dyeing operation can use disperse dyes to apply color the PET continuous filament yarn. Because disperse dyes are suitable color agents for PET but not for cotton fibers, the dyeing operation does not apply color to the first weft yarn 42 and the warp yarns 20.

**[0044]** In accordance with the illustrated embodiment, the dyeing operation 360 used to apply color to the continuous filament yarn is a thermosol dyeing operation. A thermosol dyeing operation a) dye application, b) drying and pre-heating; c) thermo-fixing of the dyes to fabric, and d) after-treatment, which includes removing any un-fixed dyes from the fabric. Thermosol dyeing utilizes disperse dyes, as explained below.

**[0045]** Dye application includes pad-applying a dye composition onto to woven fabric using a pad-applicator. The composition includes disperse dyes and one or more auxiliaries. The auxiliaries may include, but are not limited to, a dispersing agent, a wetting agent, an anti-migrating agent, a pH stabilizer (e.g. a buffering salt, such as monosodium phosphate), and a diffusion accelerant.

**[0046]** The drying and pre-heating phase removes any excess water from the composition and the fabric and gradually dries the woven fabric.

**[0047]** The thermo-fixing phase exposes the woven fabrics to temperatures between 190°C and 210°C (or higher) thermosol machine. The thermo-fixing phase causes the internal morphology of the filaments to open so that disperse dye molecules can migrate into the fiber structure. The fabric is exposed to elevated temperatures for a limited period of time. A person of ordinary skill would understand that the time-temperature profile can be modified as needed based on the application and the shade requirements.

**[0048]** After the thermo-fixing phase, excess or unfixed dyestuffs can be removed via the washing or reduction clearing phase. In one example, a reduction clearing phase can use a composition that includes caustic soda (10-30 gpl) and sodium hydrosulphite (10-30 gpl) at predetermined temperatures, e.g. between 98-105°C. The fabric is then dried again to remove any excess moisture applied during the after-treatment phase.

**[0049]** Dye operation 360 therefore applies color the continuous filament yarn 44 while the first weft yarn 42 and the warp yarns 20 remain white or bleached. Because color is applied the second weft yarn 42 and no color is applied to the first weft yarn 42 and the warp yarns 20 and remain white, the woven fabric provides a "Chambray" effect. The dyeing operation 360 applies color the woven fabric, and the second weft yarn 44, after fabric formation. Accordingly, the second weft yarn 44, when woven and then dyed, can be referred to as a "yarn dyed weft yarn" or "yarn dyed continuous filament yarn," as those terms are described in the present disclosure. As described above, the phrases "yarn dyed yarn," "yarn dyed weft yarn" or "yarn dyed continuous filament yarn" means yarns that have dyes applied after yarn formation (or fabric formation) yet have dye molecules disposed within the internal morphology of filament or fiber structure. In contrast method 200, utilizes dope dyed weft yarn 44, in which pigments are applied to masterbatch during filament extrusion.

**[0050]** Continuing with Figure 7, after the dyeing operation 360, the woven fabric is proceeds to finishing 270, bedding article assembly 280, and then packaging 290, similar to the final stages of method 200 described above.

**[0051]** The method 200 and method 300 as described above can be used to form woven chambray fabrics with the following exemplary constructions, noted as example A through example L below. In the examples A through L, each fabric construction includes one of several types of dyed weft yarns. In other words, for each example A-L shown below, the exemplary fabric was formed with second weft yarns 44 being either a) dope dyed, b) package dyed, or c) yarn dyed. This is noted in the examples with the parenthetical "(dope dyed/package dyed/yarn dyed yarn)." The examples A-L are suitable for bedding articles and colorfast to one or more household or cosmetic ingredients.

#### **Example A**

**[0052]**

|                          |                                                                                                                                                                      |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Weave</b>             | 1x1 Plain Weave                                                                                                                                                      |
| <b>Thread Count (TC)</b> | 150                                                                                                                                                                  |
| <b>Warp Yarn</b>         | 30 Ne Cotton                                                                                                                                                         |
| <b>Weft Yarn</b>         | Weft Yarn Assembly Count: 32 Ne<br>1 <sup>st</sup> Weft Yarn: 80 Ne (undyed cotton)<br>2 <sup>nd</sup> Weft Yarn: 100 denier (dope dyed/package dyed/yarn dyed yarn) |
| <b>EPI</b>               | 76                                                                                                                                                                   |

**EP 3 147 395 A1**

(continued)

|            |    |
|------------|----|
| <b>PPI</b> | 68 |
|------------|----|

**Example B****[0053]**

|                          |                                                                                                                                                                      |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Weave</b>             | Plain Weave                                                                                                                                                          |
| <b>Thread Count (TC)</b> | 180                                                                                                                                                                  |
| <b>Warp Yarn</b>         | 40 Ne Cotton                                                                                                                                                         |
| <b>Weft Yarn</b>         | Weft Yarn Assembly Count: 32 Ne<br>1 <sup>st</sup> Weft Yarn: 80 Ne (undyed cotton)<br>2 <sup>nd</sup> Weft Yarn: 100 denier (dope dyed/package dyed/yarn dyed yarn) |
| <b>EPI</b>               | 100                                                                                                                                                                  |
| <b>PPI</b>               | 70                                                                                                                                                                   |

**Example C****[0054]**

|                   |                                                                                                                                   |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Weave             | Plain Weave                                                                                                                       |
| Thread Count (TC) | 200                                                                                                                               |
| Warp Yarn         | 40 Ne Cotton                                                                                                                      |
| Weft Yarn         | Weft Yarn Assembly Count: 32 Ne                                                                                                   |
|                   | 1 <sup>st</sup> Weft Yarn: 80 Ne (undyed cotton)<br>2 <sup>nd</sup> Weft Yarn: 100 denier (dope dyed/package dyed/yarn dyed yarn) |
| EPI               | 100                                                                                                                               |
| PPI               | 90                                                                                                                                |

**Example D****[0055]**

|                   |                                                                                                                                                                      |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Weave             | 4/1 Satin base Dobby Dots/Diamond :                                                                                                                                  |
| Thread Count (TC) | 265                                                                                                                                                                  |
| Warp Yarn         | 60 Ne Cotton                                                                                                                                                         |
| Weft Yarn         | Weft Yarn Assembly Count: 32 Ne<br>1 <sup>st</sup> Weft Yarn: 80 Ne (undyed cotton)<br>2 <sup>nd</sup> Weft Yarn: 100 denier (dope dyed/package dyed/yarn dyed yarn) |
| EPI               | 165                                                                                                                                                                  |
| PPI               | 90                                                                                                                                                                   |

**Example E****[0056]**

## EP 3 147 395 A1

|                   |                                                                                                                                                                     |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Weave             | 4/1 Satin base Dobby Stripes                                                                                                                                        |
| Thread Count (TC) | 265                                                                                                                                                                 |
| Warp Yarn         | 60 Ne Cotton                                                                                                                                                        |
| Weft Yarn         | Weft Yarn Assembly Count: 32 Ne<br>1 <sup>st</sup> Weft Yarn: 80 Ne (undyed cotton)<br>2 <sup>nd</sup> Weft Yarn:100 denier (dope dyed/package dyed/yarn dyed yarn) |
| EPI               | 165                                                                                                                                                                 |
| PPI               | 90                                                                                                                                                                  |

### Example F

[0057]

|                   |                                                                                                                                                                     |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Weave             | 4/1 Satin base Dobby various Jacquard                                                                                                                               |
| Thread Count (TC) | 265                                                                                                                                                                 |
| Warp Yarn         | 60 Ne Cotton                                                                                                                                                        |
| Weft Yarn         | Weft Yarn Assembly Count: 32 Ne<br>1 <sup>st</sup> Weft Yarn: 80 Ne (undyed cotton)<br>2 <sup>nd</sup> Weft Yarn:100 denier (dope dyed/package dyed/yarn dyed yarn) |
| EPI               | 165                                                                                                                                                                 |
| PPI               | 90                                                                                                                                                                  |

### Example G

[0058]

|                   |                                                                                     |
|-------------------|-------------------------------------------------------------------------------------|
| Weave             | Plain Weave                                                                         |
| Thread Count (TC) | 150                                                                                 |
| Warp Yarn         | 30 Ne Cotton                                                                        |
| Weft Yarn         | Weft Yarn Assembly Count: 32 Ne<br>1 <sup>st</sup> Weft Yarn: 80 Ne (undyed cotton) |
|                   | 2 <sup>nd</sup> Weft Yarn:75 denier (dope dyed/package dyed/yarn dyed yarn)         |
| EPI               | 76                                                                                  |
| PPI               | 68                                                                                  |

### Example H

[0059]

|                   |                                                                                                                                                                    |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Weave             | Plain Weave                                                                                                                                                        |
| Thread Count (TC) | 180                                                                                                                                                                |
| Warp Yarn         | 40 Ne Cotton                                                                                                                                                       |
| Weft Yarn         | Weft Yarn Assembly Count: 38 Ne<br>1 <sup>st</sup> Weft Yarn: 80 Ne (undyed cotton)<br>2 <sup>nd</sup> Weft Yarn:75 denier (dope dyed/package dyed/yarn dyed yarn) |

**EP 3 147 395 A1**

(continued)

|     |     |
|-----|-----|
| EPI | 100 |
| PPI | 70  |

**Example I****[0060]**

|                   |                                                                                                                                                                     |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Weave             | Plain Weave                                                                                                                                                         |
| Thread Count (TC) | 200                                                                                                                                                                 |
| Warp Yarn         | 40 Ne Cotton                                                                                                                                                        |
| Weft Yarn         | Weft Yarn Assembly Count: 38 Ne<br>1 <sup>st</sup> Weft Yarn: 80 Ne (undyed cotton)<br>2 <sup>nd</sup> Weft Yarn: 75 denier (dope dyed/package dyed/yarn dyed yarn) |
| EPI               | 100                                                                                                                                                                 |
| PPI               | 90                                                                                                                                                                  |

**Example J****[0061]**

|                   |                                                                                                                                                                     |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Weave             | 4/1 Satin base Dobby Dots/Diamond:                                                                                                                                  |
| Thread Count (TC) | 265                                                                                                                                                                 |
| Warp Yarn         | 60 Ne Cotton                                                                                                                                                        |
| Weft Yarn         | Weft Yarn Assembly Count: 38 Ne<br>1 <sup>st</sup> Weft Yarn: 80 Ne (undyed cotton)<br>2 <sup>nd</sup> Weft Yarn: 75 denier (dope dyed/package dyed/yarn dyed yarn) |
| EPI               | 165                                                                                                                                                                 |
| PPI               | 90                                                                                                                                                                  |

**Example K****[0062]**

|                   |                                                                                     |
|-------------------|-------------------------------------------------------------------------------------|
| Weave             | 4/1 Satin Base Dobby Stripes                                                        |
| Thread Count (TC) | 265                                                                                 |
| Warp Yarn         | 60 Ne Cotton                                                                        |
| Weft Yarn         | Weft Yarn Assembly Count: 38 Ne<br>1 <sup>st</sup> Weft Yarn: 80 Ne (undyed cotton) |
|                   | 2 <sup>nd</sup> Weft Yarn: 75 denier (dope dyed/package dyed/yarn dyed yarn)        |
| EPI               | 165                                                                                 |
| PPI               | 90                                                                                  |

**Example L****[0063]**

|                   |                                                                                                                                                                     |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Weave             | 4/1 Satin base Dobby Jacquard                                                                                                                                       |
| Thread Count (TC) | 265                                                                                                                                                                 |
| Warp Yarn         | 60 Ne Cotton                                                                                                                                                        |
| Weft Yarn         | Weft Yarn Assembly Count: 38 Ne<br>1 <sup>st</sup> Weft Yarn: 80 Ne (undyed cotton)<br>2 <sup>nd</sup> Weft Yarn: 75 denier (dope dyed/package dyed/yarn dyed yarn) |
| EPI               | 165                                                                                                                                                                 |
| PPI               | 90                                                                                                                                                                  |

**[0064]** Several exemplary woven chambray fabrics made in accordance with the present disclosure were evaluated to determine their suitability for bedding uses. Table 2 below summarizes the structural attributes of these exemplary fabrics. In accordance with the present disclosure, it is believed that the woven chambray fabrics as described herein are durable, soft, and exhibit colorfast properties to various household and cosmetic compounds commonly found in a consumer's home. Exemplary woven chambray fabrics were tested to determine a) appearance changes (smoothness) due to repeated launderings using "Appearance of Apparel and Other Textile End Products after Repeated Home Laundering, AATCC Test Method 143-2006;" b) colorfastness to benzoyl peroxide; c) colorfastness to chlorine using "Quick Methods for Colorfastness to Chlorine and Non-Chlorine Bleach, AATCC TS-001;" d) colorfastness to non-chlorine bleach using "Quick Methods for Colorfastness to Chlorine and Non-Chlorine Bleach, AATCC TS-001;" and e) colorfastness to active cosmetic ingredients found in several cosmetic products. For all colorfastness data compiled herein, colorfastness was determined by assigning a value between 1.0 to 5.0 after the sample was subjected to the specified test condition, as is known to a person of skill in the textile arts. A rating of 1.0 means that there has been a significant shade change after the sample is subjected to the specified test condition. A rating of 5.0 indicates no or minimal shade change after the sample has been subjected to the specified test condition. Shade change ratings of 4.0 or higher are indicative more colorfast materials compared to samples where a shade change rating of 3.0 or lower is observed.

**[0065]** Table 2 includes woven construction, total thread count, warp yarn fiber type, weft yarn assembly construction, color, and % of total fiber in the fabric (by weight). For each example, the first weft yarn is spun staple yarn comprising cotton fibers, and the second weft yarn is dyed continuous filament yarn formed from PET. The second weft yarns in examples 1, 3, 5, 7, and 9 are dope dyed continuous filament yarns. The second weft yarns in examples 2, 4, 6, and 8 are yarn-dyed continuous filament yarns as that phrase is defined in the present disclosure. The color indicated is therefore the color applied to the second weft yarn in each example.

**Table 2 Woven Chambray Fabrics Test Samples**

| Ex. | Woven Design | Thread Count | Warp Yarn | 1st Weft Yarn | 2nd Weft Yarn | Color       | % Cotton |
|-----|--------------|--------------|-----------|---------------|---------------|-------------|----------|
| 1   | Percale      | 180          | Cotton    | Cotton        | PET           | Blue        | 70%      |
| 2   | Percale      | 180          | Cotton    | Cotton        | PET           | Lt. Blue    | 70%      |
| 3   | Percale      | 180          | Cotton    | Cotton        | PET           | Deep Purple | 70%      |
| 4   | Dobby Dot    | 265          | Cotton    | Cotton        | PET           | Green       | 70%      |
| 5   | Dobby Dot    | 265          | Cotton    | Cotton        | PET           | Blue        | 70%      |
| 6   | Diamond      | 265          | Cotton    | Cotton        | PET           | Lt. Purple  | 70%      |
| 7   | Diamond      | 265          | Cotton    | Cotton        | PET           | Mauve       | 70%      |
| 8   | Sateen       | 265          | Cotton    | Cotton        | PET           | Umber       | 70%      |
| 9   | Sateen       | 265          | Cotton    | Cotton        | PET           | Blue        | 70%      |

**[0066]** Table 3 below contains data for example 1. The impact of laundering on fabric appearance for example 1 was evaluated under AATCC 143-2006 (Test No. 1 (III) A (ii)). As shown in Table 3 below, after 5 washes a smoothness rating of 3.5-4.0 was observed. After 10 washes, a smoothness rating of 3.5-4.0 was observed. Colorfastness to benzoyl peroxide was determined by exposing the example to benzoyl peroxide for 8 hours. The shade change was observed at the conclusion of the 8 hour period. In this case, a shade change rating of 4-4.5 was observed for example 1. Example

1 was evaluated to determine colorfastness to chlorine bleach under test method AATCC TS-001. In this case, a shade change rating of 4.0 was observed for chlorine bleach. Finally, example 1 was also evaluated to determine colorfastness to non-chlorine bleach under test method AATCC TS-001. A shade change rating of 4.0/4.5 was observed for non-chlorine bleach. Example fabric 1 has suitable appearance to repeated laundering and was found to be colorfast to benzoyl peroxide, chlorine, and non-chlorine bleach.

Table 3 Test Data for Example Fabric 1

| Test                                                | Shade Rating |
|-----------------------------------------------------|--------------|
| Appearance Changes (smoothness) after 5 washes      | 3.5/4.0      |
| Appearance Changes (smoothness) after 10 washes     | 3.5/4.0      |
| Colorfastness to benzoyl peroxide                   | 4.5          |
| Colorfastness to chlorine (AATCC TS-001)            | 4.5          |
| Colorfastness to non-chlorine bleach (AATCC TS-001) | 4.5          |

[0067] Table 4 below contains data for examples 2-9 (summarized in table 2) related to colorfastness to active ingredients in various cosmetic products. Under this test, each exemplary fabric 2-9 was exposed to the cosmetic materials listed in the far left column in table 4 for 24 hours. After 24 hours of exposure, the shade change of each example was evaluated. As shown in table 4, a shade rating of at least 4.5 was observed for each example 2-9, for all cosmetic products evaluated. The shade change rating indicates that the exemplary woven chambray fabrics are colorfast to the cosmetic products and their active ingredients. Furthermore, it may be observed that the colorfastness to cosmetics ingredients is consistent across different embodiments of the yarn assembly. For instance, it would appear that woven fabrics are colorfast to cosmetic ingredients when the second weft yarn is a dope dyed continuous filament yarn. Alternatively, the woven chambray fabrics are colorfast to cosmetic ingredients when the second weft yarn is a yarn-dyed continuous filament yarn.

Table 4 Colorfastness Shade Ratings for Active Ingredients in Cosmetics Products

| Cosmetic(Ingredient)                                        | Examples |     |     |     |     |     |     |     |
|-------------------------------------------------------------|----------|-----|-----|-----|-----|-----|-----|-----|
|                                                             | 2        | 3   | 4   | 5   | 6   | 7   | 8   | 9   |
| Clean & Clear Adv. Acne Spot Treatment (2 % Salicylic Acid) | 4.5      | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| Clean & Clear Persa Gel 10 (10% Benzoyl Peroxide)           | 4.5      | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| Roc Retinol Correxion Deep Wrinkle Night Cream (Retinol)    | 4.5      | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| Arm & Hammer Teeth Whitening Booster (Hydrogen Peroxide)    | 4.5      | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |

[0068] While the disclosure is described herein using a limited number of embodiments, these specific embodiments are not intended to limit the scope of the disclosure as otherwise described and claimed herein. The precise arrangement of various elements and order of the steps of articles and methods described herein are not to be considered limiting. For instance, although the steps of the methods are described with reference to sequential series of reference signs and progression of the blocks in the figures, the method can be implemented in a particular order as desired.

## Claims

1. A woven chambray fabric, comprising:

a plurality of warp yarns, each warp yarn including natural fibers;  
a plurality of weft yarns interwoven with the plurality of warp yarns, each weft yarn defining a weft yarn assembly, the weft yarn assembly having a first weft yarn, a second weft yarn that extends alongside the first weft yarn, and a plurality of consolidation regions where the first weft yarn and the second weft yarn are coupled to each other, and the first weft yarn is a spun staple yarn that includes natural fibers and the second weft yarn is a dyed continuous filament yarn, wherein the second weft yarn is dyed a color that is different from a color of the

first weft yarn and each warp yarn so as to define the woven chambray fabric.

2. The woven chambray fabric of claim 1, wherein the woven fabric is substantially colorfast to one or more cosmetic ingredients, and preferably wherein the one or more cosmetic ingredients include benzoyl peroxide, retinol, and salicylic acid.
3. The woven chambray fabric of claim 1, wherein the woven fabric is substantially colorfast to chlorine bleach and non-chlorine bleach.
4. The woven chambray fabric of claim 1, wherein the second weft yarn is either a dope dyed continuous filament yarn or is a not a dope dyed continuous filament yarn.
5. The woven chambray fabric of claim 1, wherein the second weft yarn includes continuous filaments that have an internal filament morphology, wherein the second weft yarns have dye molecules that are integrated into the internal filament morphology.
6. The woven chambray fabric of claim 1, wherein the natural fibers of the warp yarns are cotton fibers.
7. The woven chambray fabric of claim 1, wherein the warp yarns include any of a blend of the natural fibers and a blend of the natural fibers and synthetic fibers.
8. The woven chambray fabric of claim 1, wherein the natural fibers of the first weft yarn are cotton fibers.
9. The woven chambray fabric of claim 1, wherein the second weft yarn is a polyethylene terephthalate (PET) continuous filament yarn.
10. The woven chambray fabric of claim 1, where each warp yarn has a yarn count in a range between about 20 Ne to about 120 Ne.
11. The woven chambray fabric of claim 1, wherein each weft yarn assembly has a count in a range between about 20 Ne to about 120 Ne.
12. The woven chambray fabric of claim 1, wherein the first weft yarn has a count between about 60 Ne and about 120 Ne, and the second weft yarn has a count in between about 50 denier and about 200 denier.
13. The woven chambray fabric of claim 1, wherein the natural fibers of the warp yarns are cotton fibers, and the natural fibers of the first weft yarn are cotton fibers, such that, the woven fabric is between 50 % to about 80 % by weight of cotton fibers.
14. The woven chambray fabric of claim 1, further comprising of a total thread count from 100 to 1000, preferably wherein the total thread count is from any one of 100 to 500, 500 to 700, and 700 to 1000.
15. The woven chambray fabric of claim 1, further comprising a) from 50 warp ends per inch to 350 warp ends per inch, and b) from 50 weft ends per inch to 700 weft end per inch.
16. The woven chambray fabric of claim 1, wherein the first weft yarn and the second weft yarn are substantially parallel with respect to each other along a length of the weft yarn assembly that extends between adjacent consolidation regions, preferably wherein the length is between about 0.25 cm to about 3.00 cm, and more preferably wherein the length is between about 1.00 cm and about 2.50 cm.
17. The woven chambray fabric of claim 1, wherein the consolidation regions are where the first weft yarn and the second weft yare are entangled with each other.
18. A method of manufacturing a woven chambray fabric, the method comprising the steps of:

forming a yarn assembly that includes a first yarn, a second yarn that extends alongside the first yarn, and a plurality of consolidation regions where the first yarns and the second yarns are coupled together, wherein the first yarn is a spun staple yarn that includes natural fibers and the second yarn is a continuous filament yarn; and

weaving a plurality of warp yarns with a plurality of the yarn assemblies to form the woven fabric, wherein the warp yarns include natural fibers.

5      **19.** The method of claim 18, wherein the step of forming the yarn assembly includes coupling the first and second yarns together with an air punch device so as to define the plurality of consolidation regions.

10      **20.** The method of claim 18, wherein the step of forming the yarn assembly includes arranging the first and second yarns so as to be substantially parallel with respect to each other along a length of the yarn assembly between adjacent consolidation regions.

15      **21.** The method of claim 18, further comprising applying color to the second yarn prior to weaving, and preferably wherein applying color to the second yarn prior to weaving includes dope dyeing the second yarn.

20      **22.** The method of claim 21, wherein the second weft yarn is a polyethylene terephthalate (PET) yarn, wherein applying color to the second yarn prior to weaving includes applying disperse dyes to the second yarn.

25      **23.** The method of claim 18, further comprising applying color to the second yarn after weaving.

30      **24.** The method of claim 23, wherein the second weft yarn is a polyethylene terephthalate (PET) yarn, and applying color to the second yarn after weaving includes applying disperse dyes to the woven fabric.

35

40

45

50

55

60

65

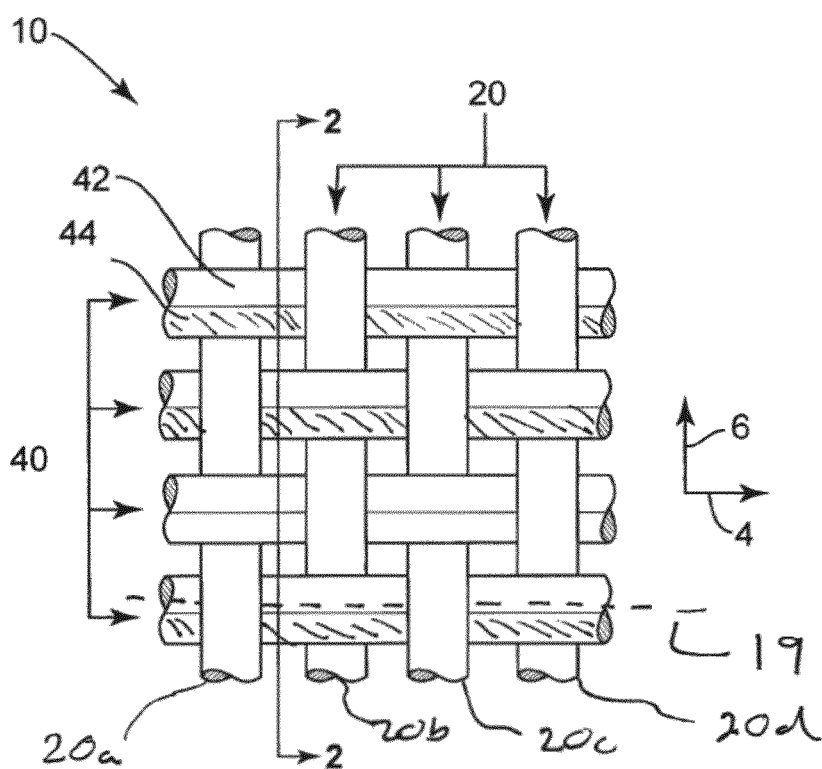


FIG. 1

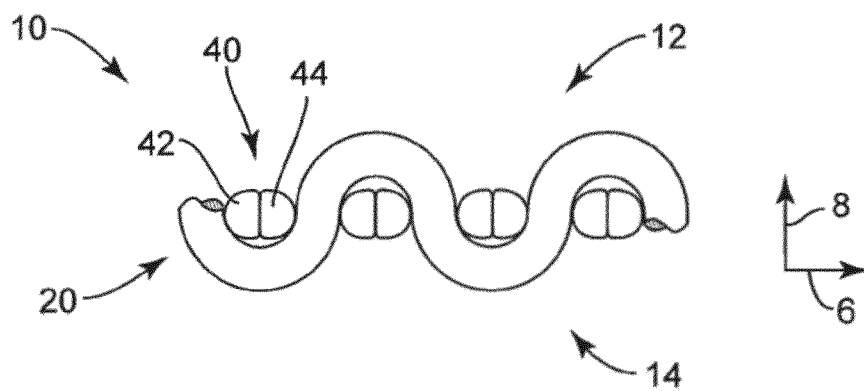
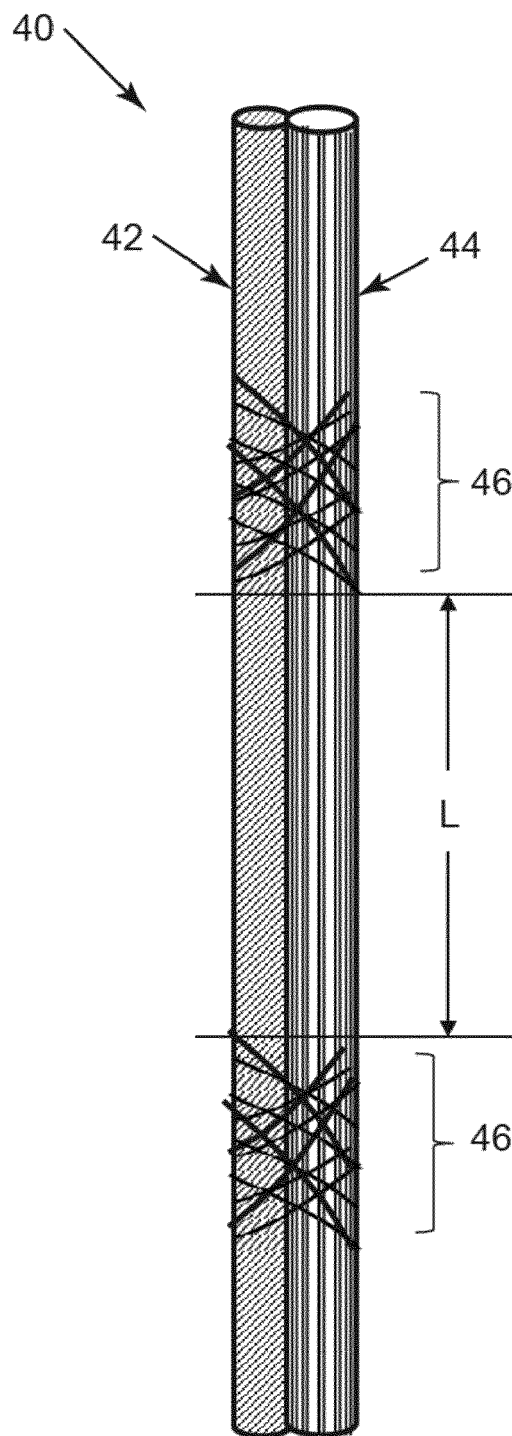


FIG. 2



**FIG. 3**

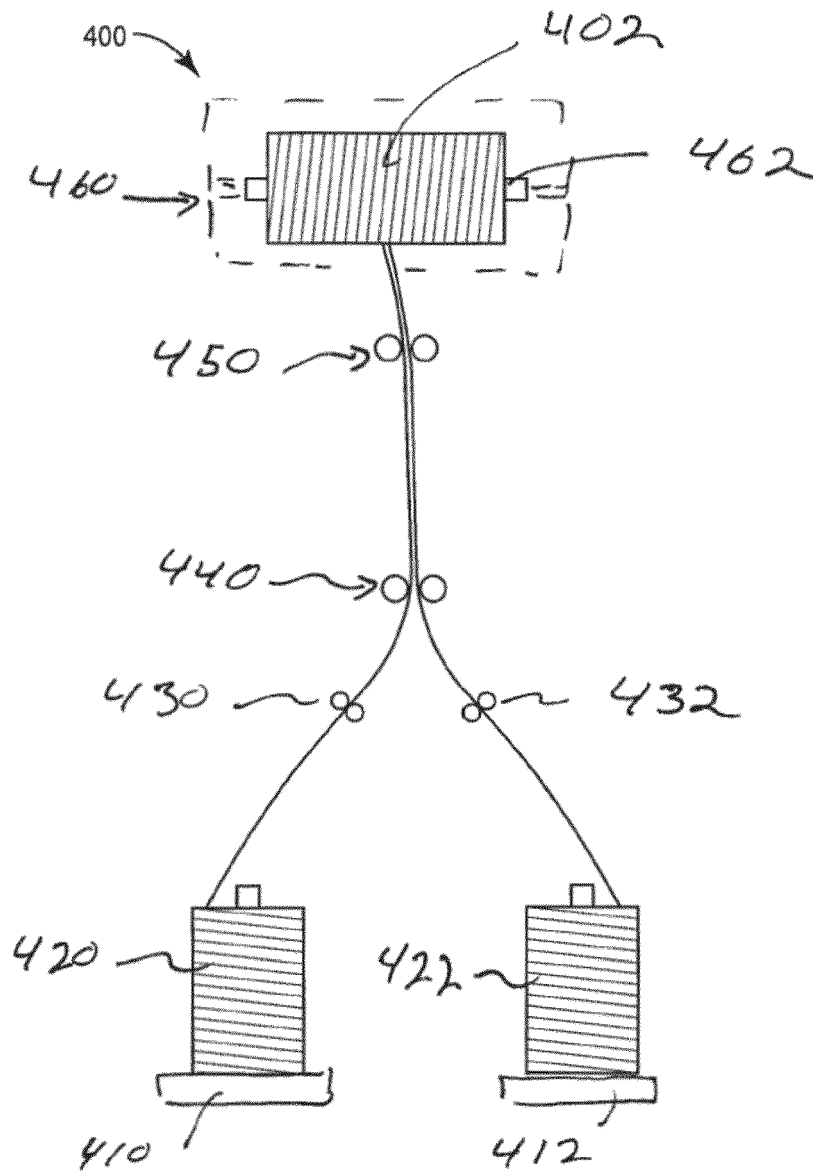


FIG. 4

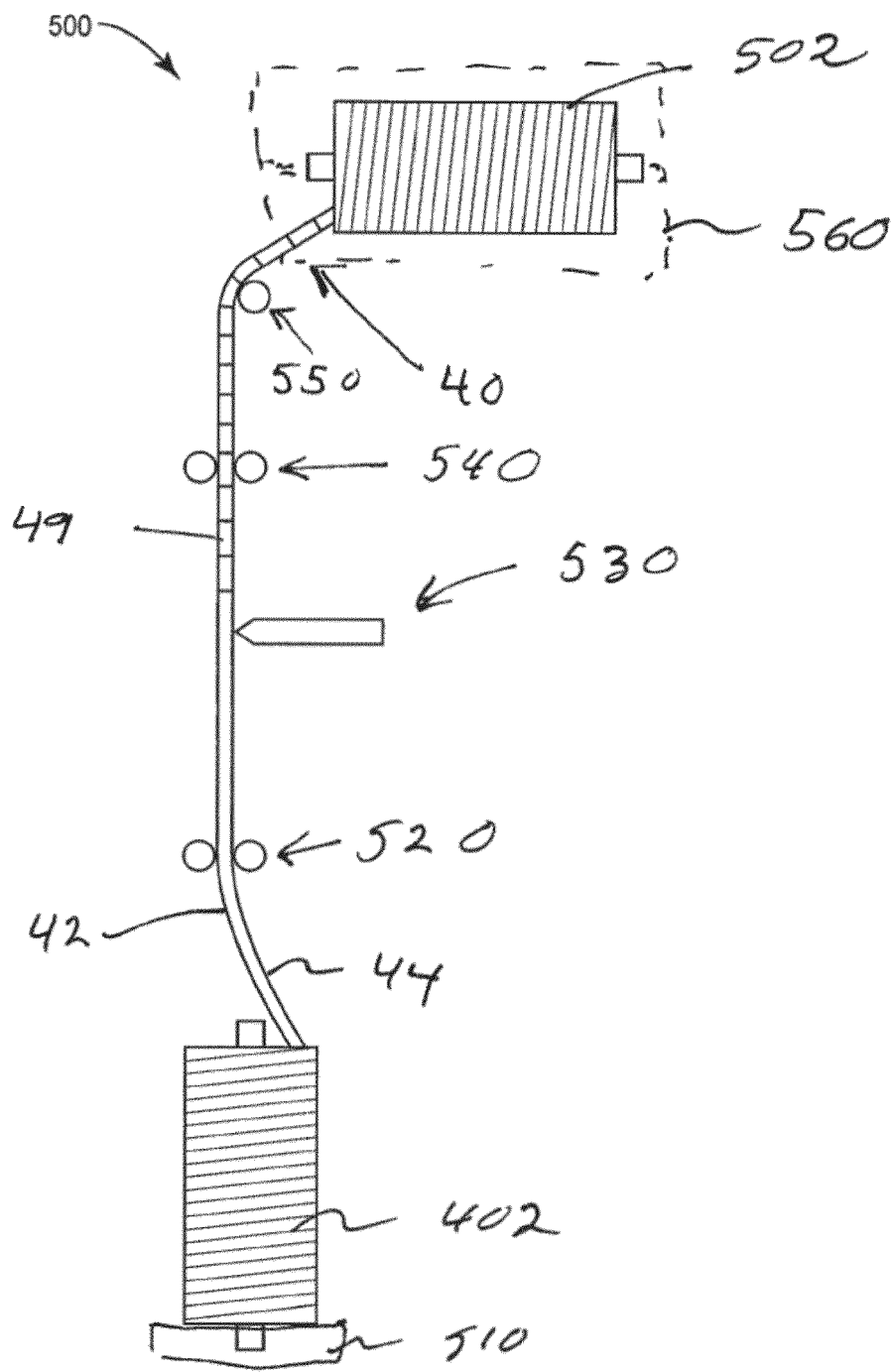


FIG. 5

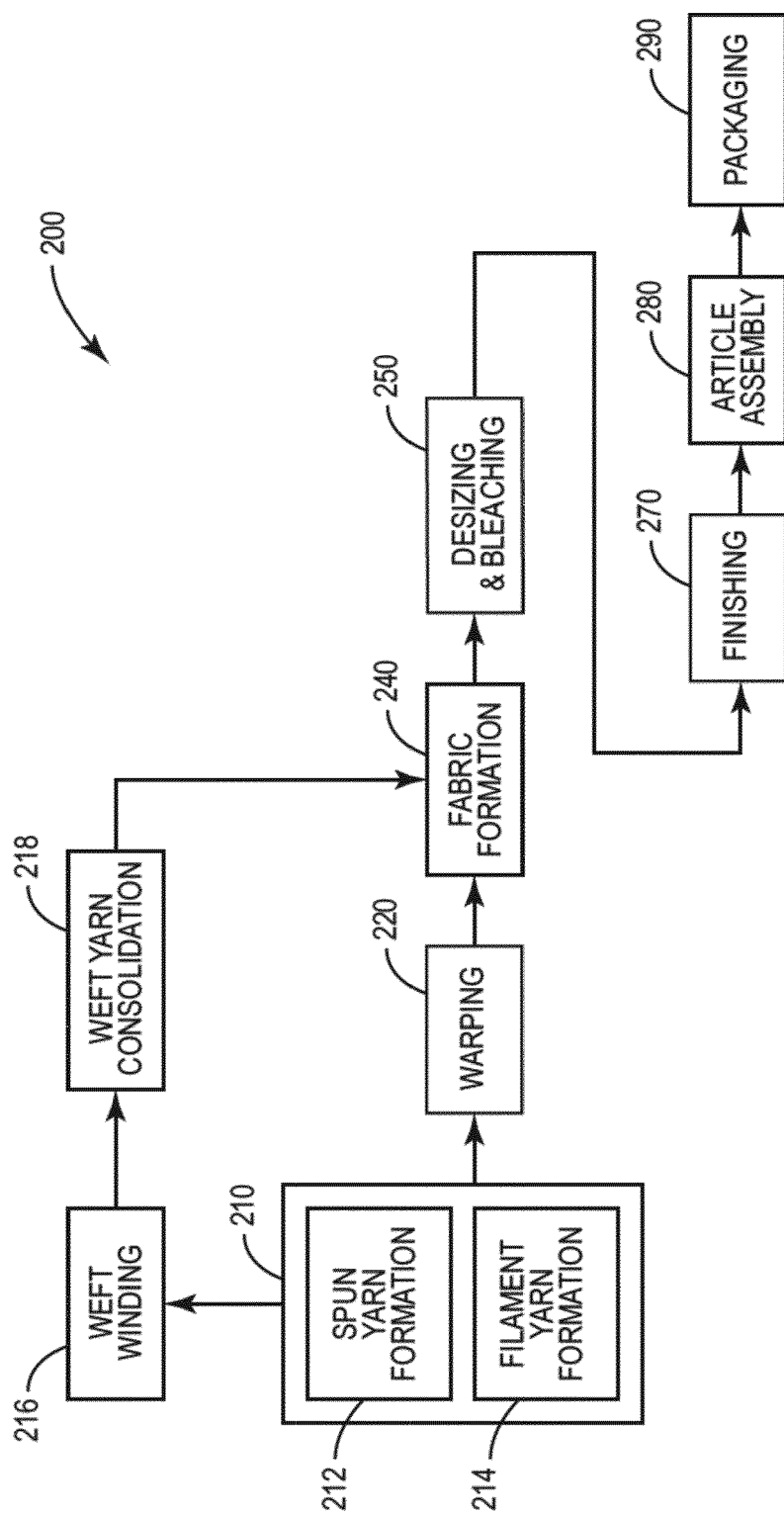


FIG. 6

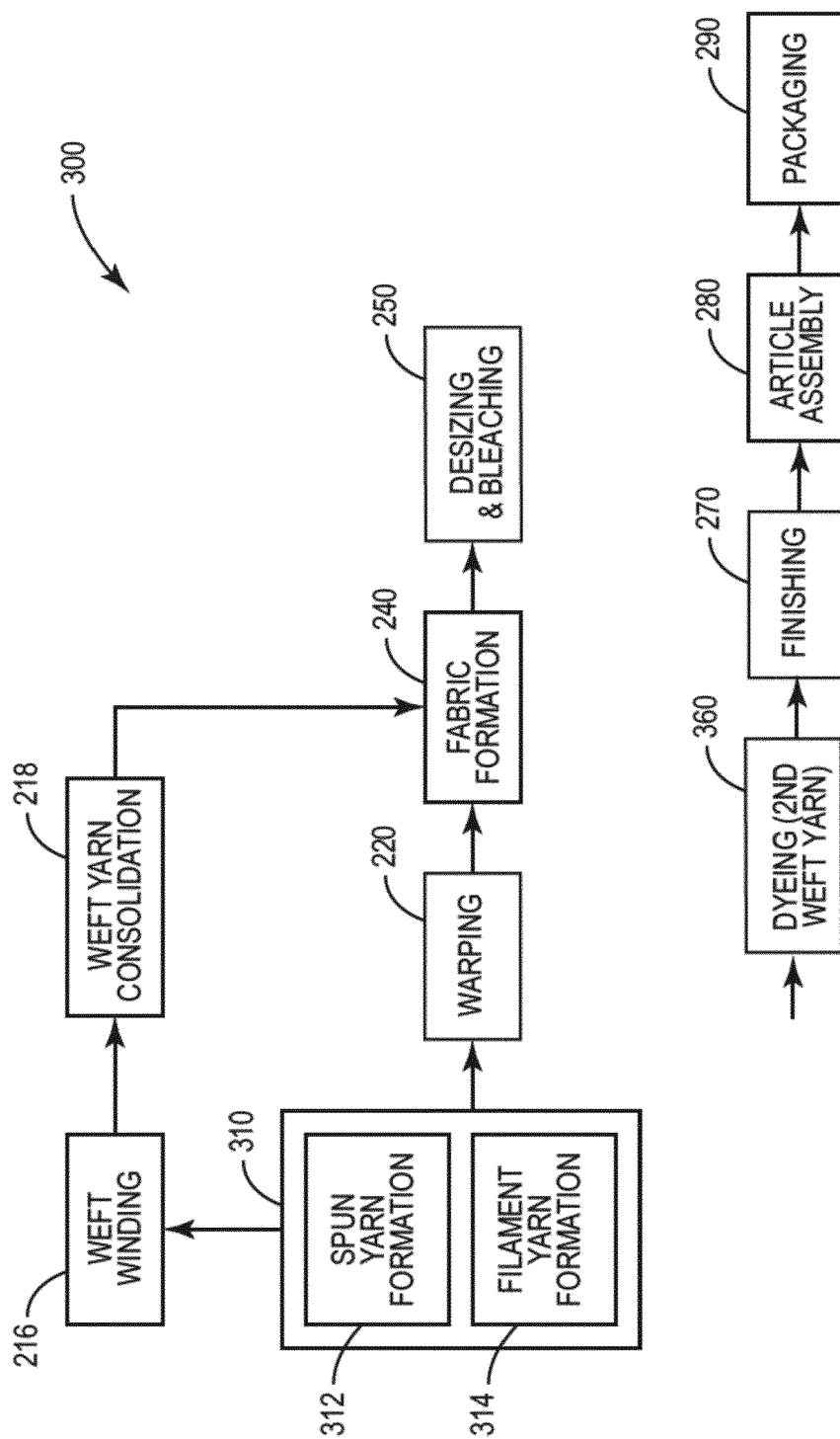


FIG. 7



## EUROPEAN SEARCH REPORT

Application Number  
EP 16 19 0597

5

10

15

20

25

30

35

40

45

50

55

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                          |                                                            |                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|--------------------------------------------------------|
| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                                                                                            | Relevant to claim                                          | CLASSIFICATION OF THE APPLICATION (IPC)                |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | JP H08 60474 A (KAWABOU TEKISUCHIYAADE KK)<br>5 March 1996 (1996-03-05)                                                                                                                  | 1-5,<br>9-14,16,<br>19,25,<br>27,<br>29-33,35              | INV.<br>D03D13/00<br>A47G9/02<br>D03D15/00<br>D03D1/00 |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | * abstract;<br>paragraph [0022]; figures 1-3 *                                                                                                                                           | 6-8,15,<br>17,18,<br>26,28,34                              |                                                        |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | -----<br>US 4 352 380 A (OWEN JAMES G ET AL)<br>5 October 1982 (1982-10-05)<br><br>* column 2, line 61 - column 3, line 7;<br>figures 1-7 *<br>* column 3, line 63 - column 6, line 30 * | 6-8,15,<br>17,18,<br>26,28,34                              |                                                        |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | -----<br>JP 2006 257592 A (TORAY INDUSTRIES)<br>28 September 2006 (2006-09-28)<br>* abstract; figures 1,2 *                                                                              | 1-35                                                       |                                                        |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | -----<br>US 2003/190853 A1 (LOVINGOOD SCOTT A [US])<br>9 October 2003 (2003-10-09)<br>* the whole document *                                                                             | 1-35                                                       | TECHNICAL FIELDS<br>SEARCHED (IPC)                     |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | -----<br>US 2006/177658 A1 (SHIGEMURA YUKIHIRO<br>[JP]) 10 August 2006 (2006-08-10)<br>* the whole document *                                                                            | 1-35                                                       | D03D<br>A47G                                           |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | -----<br>US 2015/176160 A1 (LEE IVY SAU CHUN [HK]<br>ET AL) 25 June 2015 (2015-06-25)<br>* the whole document *                                                                          | 1-35                                                       |                                                        |
| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                          |                                                            |                                                        |
| Place of search<br><b>Munich</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                          | Date of completion of the search<br><b>3 February 2017</b> | Examiner<br><b>Iamandi, Daniela</b>                    |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                                                                                                                                                                          |                                                            |                                                        |

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 16 19 0597

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

03-02-2017

10

15

20

25

30

35

40

45

50

55

| Patent document<br>cited in search report |    | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|-------------------------------------------|----|---------------------|----------------------------|---------------------|
| JP H0860474                               | A  | 05-03-1996          | NONE                       |                     |
| US 4352380                                | A  | 05-10-1982          | NONE                       |                     |
| JP 2006257592                             | A  | 28-09-2006          | NONE                       |                     |
| US 2003190853                             | A1 | 09-10-2003          | NONE                       |                     |
| US 2006177658                             | A1 | 10-08-2006          | CN 1791711 A               | 21-06-2006          |
|                                           |    |                     | JP 4155853 B2              | 24-09-2008          |
|                                           |    |                     | JP 2004285501 A            | 14-10-2004          |
|                                           |    |                     | US 2006177658 A1           | 10-08-2006          |
|                                           |    |                     | WO 2004083504 A1           | 30-09-2004          |
| US 2015176160                             | A1 | 25-06-2015          | NONE                       |                     |

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**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**

- US 62232445 A [0001]
- US 8833075 B [0017]