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Kawamura et al. [45] **Dec. 23, 1975**

[54] **PROCESS FOR TREATING FIBROUS ARTICLES WITH AN AQUEOUS TREATING LIQUID**

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[73] Assignee: **Toray Industries, Inc.,** Japan

[22] Filed: **Mar. 11, 1974**

[21] Appl. No.: **450,109**

Related U.S. Application Data

[62] Division of Ser. No. 234,152, March 13, 1972, abandoned.

[30] **Foreign Application Priority Data**

Mar. 15, 1971 Japan 46-13678

[52] **U.S. Cl.** **8/155.2;** 8/150; 68/20; 68/184; 68/187

[51] **Int. Cl.²** **D06B 5/16;** D06B 21/00

[58] **Field of Search** 8/150, 154, 155, 155.1, 8/155.2, 156; 68/20, 184, 187, 189

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[57] **ABSTRACT**

Fibrous articles are uniformly treated under low compression by charging them into a treating chamber defined between horizontal upper and lower partitions in a stratiform with a normal thickness satisfying the following relationship:

$$L_1 \geqq 0.9 L_2$$

wherein L_1 is the thickness of the treating chamber and L_2 is the normal thickness of the stratum of the fibrous articles in the treating liquid, and by flowing the treating liquid through the stratum of the fibrous articles along the thickness thereof in alternate directions.

12 Claims, 10 Drawing Figures

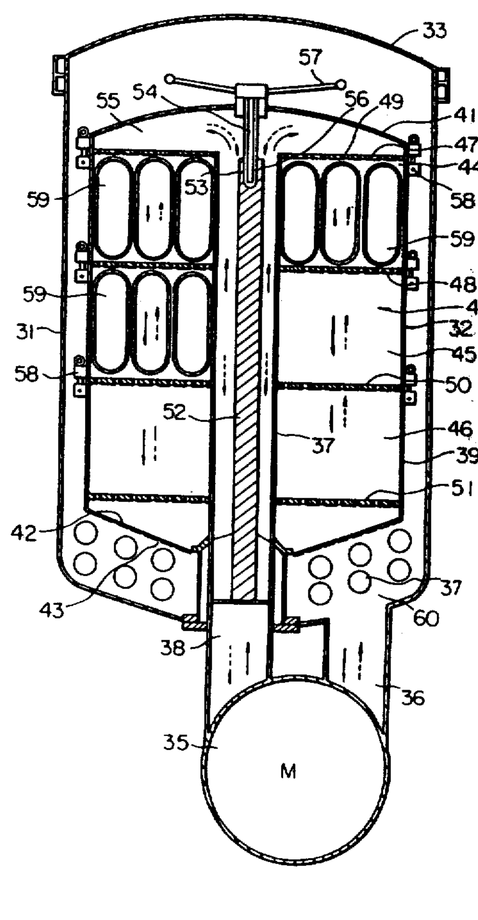

Fig. 1
PRIOR ART

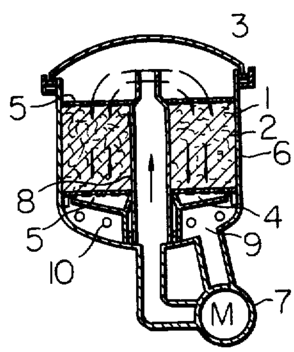

Fig. 2
PRIOR ART

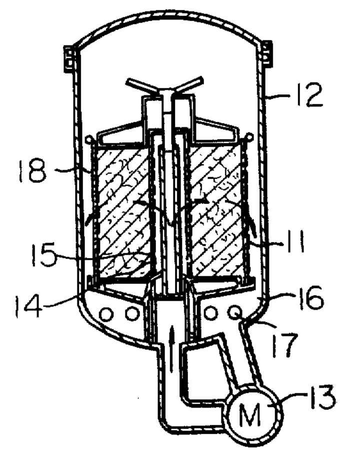

Fig. 3
PRIOR ART

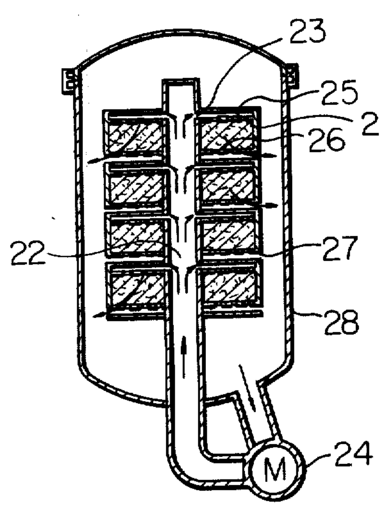

Fig. 4

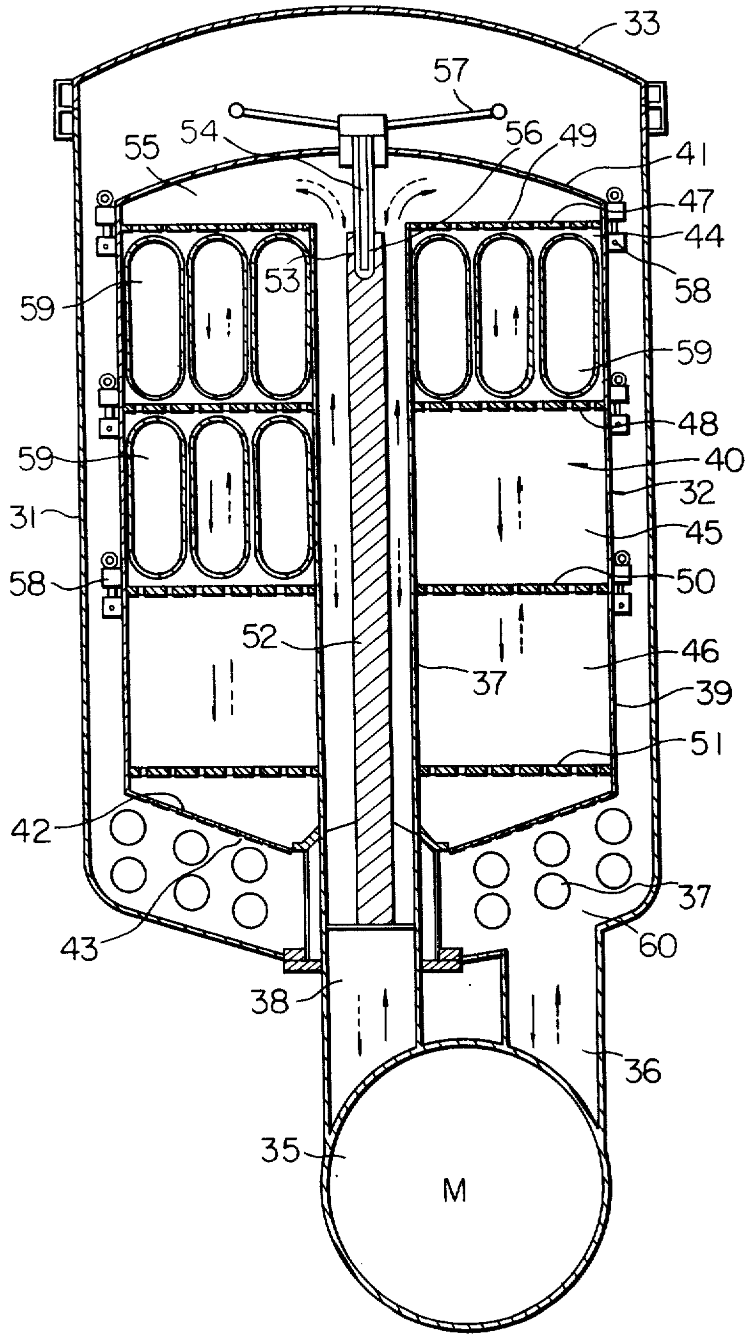
33
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Fig. 5

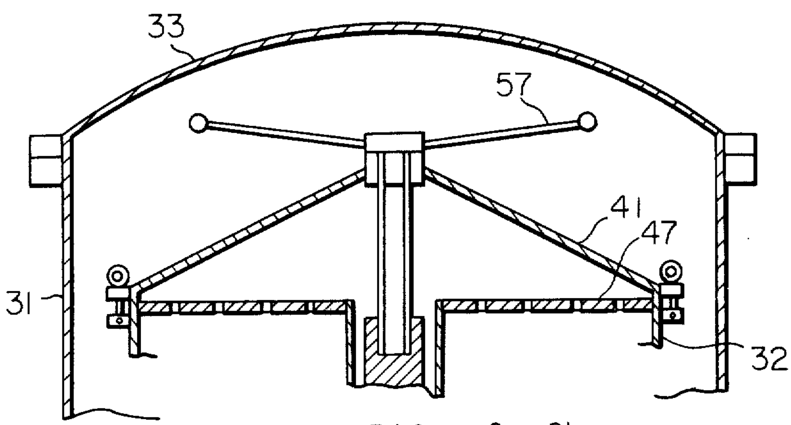
33
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Fig. 6

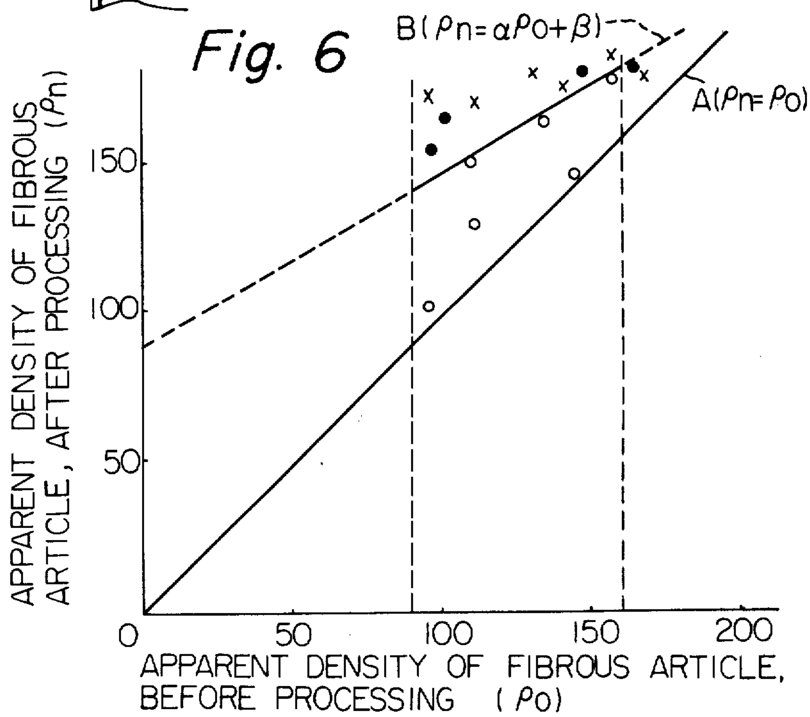

B(ρn=αρo+β)
A(ρn=ρo)
APPARENT DENSITY OF FIBROUS ARTICLE, AFTER PROCESSING (ρn)
150
100
50
0
50
100
150
200
APPARENT DENSITY OF FIBROUS ARTICLE, BEFORE PROCESSING (ρo)

Fig. 7

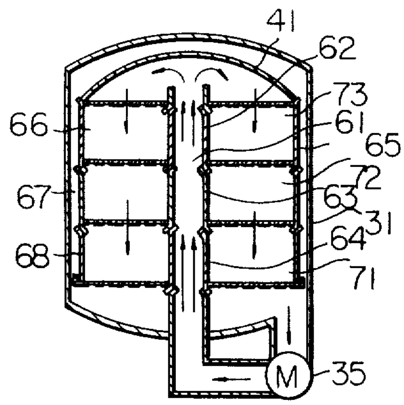


Fig. 8

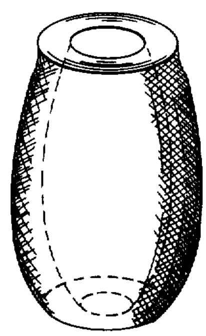


Fig. 9

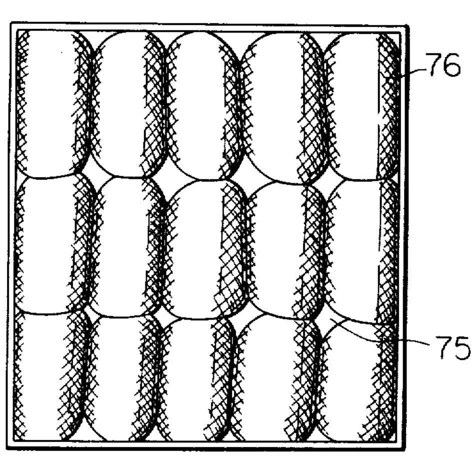
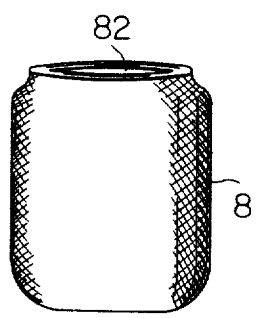


Fig. 10



PROCESS FOR TREATING FIBROUS ARTICLES WITH AN AQUEOUS TREATING LIQUID

This is a division, of application Ser. No. 234,152, filed Mar. 13, 1972, and now abandoned.

The present invention relates to a process for treating fibrous articles with an aqueous treating liquid, more particularly, relates to a process for uniformly treating fibrous articles with an aqueous treating liquid under low compression for the fibrous articles.

The term "fibrous articles" used herein includes loose fibers, filament tows, fiber slivers, hank-formed yarns, muff-formed yarns, knitted fabrics, knitted pieces and bulky woven fabrics. Also, the term "aqueous treating liquid" used herein includes aqueous dyeing liquids, aqueous scouring liquids, aqueous bleaching liquids, and aqueous oiling liquids.

Generally, in order to treat the fibrous article, especially, bulky fibrous articles with an aqueous treating liquid, various batch-type treating apparatus are used. For example, in the so-called package dyeing machine, the fibrous articles are charged into a basket-formed carrier, and the treating liquid fed through numerous apertures formed on an inside cylinder extending along the vertical axis of the carrier flows substantially horizontally through the fibrous articles. In an another method, a dyeing machine which is provided with a carrier having an outside cylinder and a plurality of inside cylinders extending in the same direction as the axis of the carrier, is used. In this machine, the inside cylinders have numerous apertures through which the treating liquid flows. The fibrous articles are charged into spaces formed between the outside cylinder and the inside cylinders, and the treating liquid is forced to flow horizontally through the fibrous articles. In the case where the muff formed yarn is charged into the carrier having a plurality of inside cylinders, the inside cylinders are inserted into the muffs through hollows of the muffs so that a plurality of muffs are superposed along the inside cylinders. In another type of dyeing machine, the inside cylinders extend horizontally so that the muffs are hung on the inside cylinder. However, the above-stated conventional processes have the following disadvantages.

1. The fibrous articles are frequently non-uniformly treated. Especially, in the case where the basket-formed carrier is used, if the filling density of the fibers articles is less than 0.15 g/cm³, the upper and lower portions of the fibrous articles in the carrier are treated differently from each other. Accordingly, in order to uniformly treat the fibrous articles, they have to be charged at a filling density greater than 0.15 g/cm³. However, if the fibrous articles are charged at the large filling density of 0.15 g/cm³ or more, this results in undesirable deformation and low bulkiness of the fibrous articles. In this case, even if the fibrous articles are treated with an amount of oiling agent, the resultant articles have undesirable high stiffness and rough hand feeling.

2. In the case where the muff-formed yarns surrounding the inside cylinders shrink during the process, it is necessary to change the diameter of the inside cylinder in response to the shrinkage of the yarn. For example, the relationships between the initial diameter of the muff, shrinkage of yarn, diameter of the treated muff and diameter of the inside cylinder to be used for the muff are shown in Table 1.

Table 1

No.	Initial diameter of muff (mm)	Shrinkage of yarn by steaming at 100°C for 10 minutes (%)	Final diameter of treated muff (mm)	Diameter of inside cylinder
1	300	10	160	140
2	300	20	130	110
3	300	28	100	80

When a dyeing machine provided with a plurality of inside cylinders having a diameter of 140 mm is used for treating numerous muffs prepared from a yarn with a shrinkage of 10% and having a diameter of 300 mm, the muffs can be uniformly treated. However, it is undesirable that the same dyeing machine is used for the muffs prepared from yarn having a shrinkage of 28%, because the final diameter of the muffs is smaller than the diameter of the inside cylinder. For such muffs, it is necessary to use inside cylinders having a diameter smaller than 100 mm.

On the other hand, if the muffs of 10% shrinkage yarn are treated with inside cylinders of 80 mm diameter, the muffs tend to be undesirably deformed during the process due to the large clearance between the inside cylinder and the muffs. This deformation of the muffs frequently results in non-uniform treatment of the muffs and entanglement of the yarn or irregularity of yarn winding in the muffs.

As stated above, the changing of the inside cylinder in response to the diameter of the muffs and shrinkage of the yarn results in low efficiency in the treating process.

3. During processing with the conventional apparatus as stated above, if the fibrous articles are free from compression, frequently the process is accompanied by non-uniform flow of the treating liquid due to the formation of undesirable channels between the fibrous articles themselves, or between the fibrous articles and the carrier wall.

For example, a high shrinkage acrylic yarn of a metre count of 2/48' was formed into a racket muff having a weight of 1.5 kg using a rocket winder, and then steamed at 100°C for 10 minutes so as to convert the yarn to a high bulky yarn. The resultant high bulky yarn muffs were treated under various conditions indicated in Table 2.

Table 2

Initial length (A) of muff before processing (mm)	Length (B) of shrunk muff set around the inside cylinder (mm)	Compression ratio $\frac{A-B}{A} \times 100$ (%)	Remarks
380	380	0	Unevenly treated
380	350	8	Sometimes unevenly treated
380	330	13	Uniformly treated

As Table 2 shows, in the conventional apparatus, it is preferable that the muffs having a length of 380 mm are compressed to a length of 330 mm in order to uniformly treat them. However, such compression for the fibrous articles results in undesirable deformation thereof. For example, the bulky yarn is converted to a flat yarn of small volume by the high compression.

4. If the conventional apparatus as stated above is applied for treating fibrous articles consisting of a single yarn of a metre count of 1/60ᶜ to 1/50ᶜ, irregularity of yarn winding in the article and formation of fluffs on the yarn frequently results. This causes frequent breakage of yarn in the unwinding or rewinding step.

An object of the present invention is to provide a process for treating fibrous articles with an aqueous treating liquid under a relatively low compression of said fibrous articles while maintaining the bulkiness of said fibrous article.

Another object of the present invention is to provide a process for treating fibrous articles with an aqueous treating liquid while preventing said fibrous articles from fluffing and entanglement.

A further object of the present invention is to provide a process for treating fibrous articles with an aqueous treating liquid at high efficiency to produce a product having uniform quality.

The above-stated objects of the present invention are accomplished by utilizing the process of the present invention.

The process of the present invention comprises the steps of charging fibrous articles into at least one treating chamber and circulating an aqueous treating liquid through the treating chamber and the charged fibrous articles, and characterized in that the fibrous articles are charged into the treating chamber defined between horizontal upper and lower partitions in a stratiform extending horizontally and having a normal thickness in the treating liquid satisfying the following relationship:

$$L_1 \geqq 0.9L_2$$

wherein L_1 is the distance between the upper and lower partitions and L_2 is a normal thickness of the stratum of fibrous articles in the treating liquid, and the treating liquid flows through the upper partition, the stratum of fibrous articles and the lower partition through the thickness of the stratum of fibrous articles in alternate directions, whereby the stratum of fibrous articles is uniformly processed under a low compression.

The process of the present invention can be carried out by using an apparatus which comprises an outside tank, an inside casing removably located in the outside tank, means for fixing the inside casing to the outside tank, and a pump for circulating, in alternate directions, the aqueous treating liquid connected to the outside tank and the inside casing, and characterized in that the inside casing comprises an inside cylinder defining a path for the treating liquid and connected to the circulation pump, an outside wall defining a treating space between the inside cylinder and the outside wall, a header for closing the upper end of the treating space and facing the upper end of the inside cylinder, and a bottom means through which the treating space is connected to the outside tank, and the treating space includes at least one treating chamber defined with horizontal upper and lower partitions through which the treating liquid flows in the direction of the thickness of the treating chamber.

The features and advantages of the present invention will be apparent from the following description and the accompanying drawings, in which:

FIG. 1 is a cross-sectional schematic view of a conventional apparatus for treating fibrous articles,

FIG. 2 is a cross-sectional schematic view of another conventional apparatus for treating fibrous articles,

FIG. 3 is a cross-sectional schematic view of a further conventional apparatus for treating fibrous articles,

FIG. 4 is a cross-sectional schematic view of an embodiment of the apparatus for practicing the present invention,

FIG. 5 is a cross-sectional schematic view of an inside header of another embodiment for practicing the apparatus of the present invention,

FIG. 6 is a graph showing the relationship between the apparent densities of fibrous articles before and after processing,

FIG. 7 is a cross-sectional schematic view of another embodiment of the apparatus for practicing the present invention,

FIG. 8 is a model view of muff-formed yarn usable for the process of the present invention,

FIG. 9 is a model view showing arrangement of muffs in a treating chamber for practicing the apparatus of the present invention, and

FIG. 10 is a model view of muffs treated in accordance with the process of the present invention.

The conventional process of treating the fibrous articles with a treating liquid is effected by using the conventional apparatus as shown in FIGS. 1 to 3. Referring to FIG. 1, the fibrous articles 1 to be treated are charged into a treating space 2 in a tank 6 defined by an upper partition 3 and lower partition 4 each having numerous apertures 5. A treating liquid is fed by pump 7 into the tank 6 through an inside cylinder 8, and flows downwardly through the upper position 3, the charged fibrous articles and the lower partition 4 and returns to the pump 7 through a bottom portion 9 of the tank 6 including a heater 10. In this apparatus, the charged fibrous articles have too great a thickness for uniformly flowing the treating liquid therethrough. This large thickness of the fibrous articles results in a large compression of the fibrous articles positioned in the lower portion of the treating space 2. The fibrous articles thus compressed have an undesirable appearance and hand feeling. Further, the apparatus of FIG. 1 is inconvenient for charging, discharge and transfer of the fibrous articles.

Referring to FIG. 2, the fibrous article is charged into an inside casing 11 received in an outside tank 12 and having numerous apertures 18. The treating liquid is fed by way of a pump 13 into the inside casing 11 through an inside cylinder 14 having numerous apertures 15, and flows to the outside tank 12 through the fibrous articles in the inside casing 11. Then, the treating liquid returns to the pump 13 through the bottom portion 16 of the outside tank 12 having therein a heater 17. In this apparatus, the treating liquid tends to flow non-uniformly through the charged fibrous articles. Accordingly, the treated fibrous articles have non-uniform qualities in hand feeling, appearance and color. Especially, polyester fiber yarns or acrylic fiber yarns tend to lose crimps thereon or develop differences in hand feeling thereof during the treatment.

Since the apparatus has the inside casing 11 capable of being separated from the outside tank 12, it is possible to transfer the charged fibrous articles together with the inside casing 11. However, an amount of the treating liquid remains at the bottom of the inside casing 11. Therefore, it is impossible to uniformly dry the treated articles even when the inside casing 11 containing the fibrous articles is put in a dryer chamber.

Referring to FIG. 3, a plurality of treating chambers 21 received in an outside tank 28 are connected to an inside cylinder 22 through the corresponding apertures 23. The treating liquid is fed by means of a pump 24 into the treating chambers 21 through the inside cylinder 22 and apertures 23, and flows to the outside tank 28 through an upper partition 25 having apertures, the charged fibrous articles, a lower partitions 26 having apertures and apertures 27 formed on the outside wall of the treating chamber 21. The treating liquid in the outside tank 28 returns to the pump 24. In this apparatus, it is difficult to uniformly distribute the treating liquid to all the treating chambers through the apertures 23 of the inside cylinder 22. Generally, the treating liquid flows at a large flow rate through the lower chamber but at a small flow rate through upper chamber. This results in non-uniform qualities in hand feeling and density of the treated fibrous articles. Further, the apparatus of FIG. 3 has the disadvantage of a small volume capacity for the fibrous articles due to the existence of numerous passages for the treating liquid.

In order to overcome the above-stated disadvantages of the conventional apparatus, the process of the present invention is carried out using apparatus, for example, as shown in FIG. 4. Referring to FIG. 4, an outside tank 31 removably contains an inside casing 32 therein and if necessary, is closed by a header 33. The bottom 34 of the outside tank 31 is connected to a circulation pump 35, which is capable of rotating in alternate directions, through a conduit 60. The bottom 34 contains therein a heater 36 for heating the treating liquid to a desired temperature. The inside casing 32 comprises an inside or inner cylinder 37 having a top end opening into the inside casing 32 and a bottom end connected to the pump 35 through a conduit 38, an outside or outer cylinder 39 defining a treating space 40 between the inside surface of the outside cylinder 39 and the outside surface of the inside cylinder 37, a header 41 for closing the upper end of the treating space 40 and a bottom means 42 having numerous apertures 43 through which the treating space 40 is fluidly connected to the outside tank 31.

In the apparatus of FIG. 4, the treating space 40 is divided into three treating chambers 44, 45 and 46 independent of each other. The treating chamber 44 is defined by the inside surface of the outside cylinder 39, the outside surface of the inside cylinder 37, and two horizontal partitions 47 and 48 each having a plurality of apertures 49 through which the treating liquid can flow.

The horizontal partition 47 defines the upper end of the treating chamber 44 and the horizontal partition 48 defines the lower end thereof. In the same way, the horizontal partition 48 defines the upper end of the treating chamber 45, a horizontal partition 50 defines the lower end of the treating chamber 45 and the upper end of the treating chamber 46 and a horizontal partition 51 defines the lower end of the treating chamber 46. That is, the treating space 40 includes three chambers 44, 45 and 46 defined by the upper partition 47, intermediate partitions 48 and 50 and the lower partition 51. The treating chambers 44, 45 and 46 are fixed to each other by a fastening means 58.

A spindle 52 extends upward from the bottom of the outer tank 31 through the inside cylinder 37. The top end portion 53 of the spindle 52 is threaded. A bolt 54 extends into the upper portion 55 of the treating space 40 through the inside header 41. The bottom end portion 56 is threaded so as to engage with the threaded portion of the spindle 52. The spindle 52 and the bolt 54 are fixed to each other by rotating a handle 57 connected to the top end of the bolt 54.

In the apparatus shown in FIG. 4, the treating liquid supplied into the outside tank 31 is circulated by way of pump 35 through the conduit 38, inside cylinder 37, through the treating space 40, bottom portion 34 of the outside tank 31 and conduit 36, in alternate directions. The lower surface of the inside header 41 inclines downward from the center to the periphery thereof. When the treating liquid circulates along the path shown by solid arrows in FIG. 4, the treating liquid which is fed through the inside cylinder 37 is ejected toward the lower surface of the inside header 41 through the top end of the inside cylinder 37 and then uniformly distributed into the treating space 40 along the inclined lower surface of the inside header 41. In the apparatus of FIG. 4, the cross-sectional profile of the inside header 41 shows that the lower surface of the inside header 41 is shaped substantially in a partial sphere. The lower surface may take the shape of a part surface of a cone as shown in FIG. 5. The treating liquid distributed into the upper portion 55 successively flows down into the treating chambers 44, 45 and 46 through the apertures 49 of the partitions 47, 48 and 50 and leaves the treating chamber 46 from the lowest partition 51. The treating liquid afterward flows from the bottom means 42 into the outside tank 31 through the apertures 43. Then, the treating liquid returns to the pump 35 through the conduit 36. In the above-stated circulation, the treating liquid uniformly passes through the treating chambers 44, 45 and 46 so as to uniformly treat the fibrous articles 59 charged into the treating chambers. When the treating liquid is circulated in the direction shown by dotted arrows, the treating liquid uniformly flows upward through the treating chambers 46, 45 and 44 containing the fibrous articles 59. In the process of the present invention, it is important that the fibrous articles are charged into the treating chamber in a stratiform extending horizontally with a normal thickness in the treating liquid satisfying the following relationship:

$$L_1 \geqq 0.9L_2$$

wherein L_1 is the distance between the upper and lower partitions and L_2 is a normal thickness of the stratum of fibrous articles in the treating liquid, and the treating liquid flows through the stratum of fibrous articles along the thickness of the stratum of the fibrous articles in alternate directions.

The term "normal thickness of stratum of fibrous articles" used herein refers to the thickness of the stratum of fibrous articles under the condition where the stratum of fibrous articles is under no pressure or stretching forces.

By the above-stated process of the present invention, the stratum of fibrous articles charged in the treating chambers is uniformly treated under a low compression.

The inside header 41 may be provided with one or more apertures for connecting the upper portion 55 of the treating space 40 to the outside tank 31 so as to flow air or gas therethrough. This is effective for removing air or gas initially contained in the fibrous article. Further, this aperture is effective for leveling the treating liquid in the outside tank 31 and the inside casing 32. The inside header 41 may have means for measuring static pressure in the treating space 40. This means is effective for determining the resistance of the stratum of fibrous articles to the flow of the treating liquid therethrough.

The upper end portion of the outside cylinder **39** of the inside casing **32** may have one or more apertures for the same purpose as that of the inside header **41.** Needless to say, it is necessary that the size of the apertures be small enough to prevent the charged fibrous articles from receiving non-uniform treatment.

In the process of the present invention, the resistance of the stratum of fibrous articles to the flow of the treating liquid therethrough depends on the thickness of the stratum and the filling density of the fibrous articles. Accordingly, if the thickness of the stratum of fibrous articles and the filling density are suitably established, it is possible to carry out the treatment under a low compression of the fibrous articles. Therefore, the fibrous articles have to be charged at ordinary thickness in the treating liquid satisfying the relationship:

$$L_1 \geqq 0.9L_2$$

If L_2 is larger than $L_1/0.9$, undesirable deformation of the fibrous articles results.

Further, it is preferable that the stratum of the fibrous article in the treating liquid has a thickness satisfying the relationship:

$$L_1 \geqq 0.95L_2$$

in order to prevent the deformation of the fibrous articles. Moreover, it is preferable that the thickness of the stratum of the fibrous articles in the treating liquid satisfies the following relationship:

$$L_1 = L_2$$

Also, it is preferable that the thickness of the stratum of the fibrous articles in the treating liquid satisfies the following relationship:

$$L_1 < 1.5L_2$$

in order to prevent the fibrous articles from receiving nonuniform treatment. Also, it is desirable that the thickness of the stratum of the fibrous articles has an ordinary thickness in atmosphere the same as or smaller than the distance between the upper and lower partitions. In any case, the treating liquid flows through the stratum of the fibrous article through the thickness thereof.

In FIG. **4,** the fibrous articles **59** are charged separately into the three chambers **44, 45** and **46.** If fibrous articles of the same quality as in FIG. **4** are charged into the apparatus as shown in FIG. **1** in the same filling density, and the same treating liquid flows at the same flow rate as in FIG. **4,** the resistance of the stratum of the fibrous article to the flow of the treating liquid is substantially equal to the total of the resistances of the three strata of FIG. **4.** However, it is obvious that the fibrous articles located in the lower portion of the treating space **2** of FIG. **1** are subjected to a compression larger than the fibrous articles located in the lower portion of the treating chambers **44, 45** and **46** of FIG. **4,** because the thickness of the stratum in FIG. **1** is greater than that of FIG. **4.** This large compression results in large filling density of the stratum and high resistance of the fibrous articles to the flow of the treating liquid therethrough.

Therefore, after treating, the fibrous articles located in the lower portion have a hand feeling, appearance, and bulkiness, remarkably different from those located in the upper portion.

In order to carry out the circulation of the treating agent under a low pressure, it is desirable that the stratum of the fibrous articles have a resistance of 0.2 to 0.5 kg/cm² to the flow of the treating liquid therethrough. Further, in order to adjust the resistance to the flow of the treating liquid within the above range, it is preferable that the thickness of the treating chamber is in a range from 200 to 500 mm and the stratum of fibrous articles has an apparent density in atmosphere of 0.09 to 0.16 g/cm³. Further, it is preferable that after the process is finished the stratum of the fibrous articles has an apparent density in atmosphere satisfying the following relationship:

$$\rho n/\rho o = 1.0 \text{ to } (\alpha + \beta/\rho o)$$

wherein ρn is the apparent density of the stratum of fibrous articles in atmosphere after processing, ρo is the apparent density of the stratum of fibrous articles in atmosphere before processing, α is 0.6 to 0.63 and β is 80 to 90.

Generally, when bulky fibrous articles, for example hank-formed or muff-formed acrylic yarns or polyester or polyamide textured yarns, are treated by circulating the treating liquid through the bulky articles, the apparent density of the bulky articles increases with advance of processing. This tendency increases with the increase of filling density of the fibrous article in the treating chamber. The high density of the treated fibrous articles results in a flattened shape and low bulkiness thereof. If the fibrous articles are charged in a low filling density, for example, smaller than 0.09 g/cm³, the treating liquid flows non-uniformly through the charged fibrous articles so as to result in non-uniform treatment.

In order to uniformly treat the fibrous articles, it is preferable that the treating liquid flows through the stratum of the fibrous articles at a flow rate of 10 to 30 liters/min per kg of the fibrous articles.

If the flow rate is less than 10 liter/min per kg of the fibrous articles, the fibrous articles are frequently nonuniformly treated. And, if the flow rate is greater than 30 liters/min per kg of the fibrous articles, the fibrous articles are subjected to a large compression.

Referring to FIG. **6,** on line A, the apparent density of the fibrous articles after processing (ρn) equals the apparent density of the fibrous articles before processing (ρo). This shows the ideal condition. In the case where an acrylic high bulky yarn is treated in accordance with the present invention at a flow rate of 10 to 30 liters/min/kg fibrous article, the relationships between ρn and ρo is shown by circles (o) in FIG. **6.** In the case where the acrylic high bulky yarn is treated at a flow rate greater than 30 liters/min/kg fibrous articles, the relationship between ρo and ρn is shown by points (·) in FIG. **6.** Further, in the case where the acrylic high bulky yarn is treated using the apparatus shown in FIG. 1 at a flow rate of 10 to 30 liters/min/kg fibrous aritcle, the relationship between ρo and ρn is shown by crosses (x) in FIG. **6.** FIG. **6** shows that the circles (o) are nearer the ideal line A than the points (·) or the crosses (x). That is, the high bulky yarn which has been treated in accordance with the process of the present at a flow rate of 10 to 30 liters/min/kg fibrous article, has a higher apparent density after processing. Therefore, as FIG. **6** shows, it is desirable that the fibrous articles have apparent densities before and after processing ranging between the ideal line A ($\rho n = \rho o$) and the line B ($\rho n = \alpha\rho o + \beta$) wherein α is **0.62 - 0.63** and β is 80 to 90. α and β vary depending the kind, thickness and shrinkage of the fibrous articles.

The apparatus for carrying out the process of the present invention may include only one treating chamber or may include two or more.

Also, in the case where the apparatus includes two or more treating chambers, the thickness of the treating chambers may be the same as or different from each other, and the treating chambers may be separated from each other.

Referring to FIG. 7, the inside cylinder **61** is divided into three parts, upper cylinder **62**, intermediate cylinder **63**, and lower cylinder **64**, and the outside cylinder **65** is divided into three parts, upper cylinder **66**, intermediate cylinder **67** and lower cylinder **68**.

Therefore, the treating chambers **71**, **72** and **73** can be successively superposed, and if desired, one or two of the treating chambers can be removed so as to use only two or one treating chamber.

The process and apparatus can be applied to various fibrous articles such as loose fibers, filament tows, fiber slivers, hank-formed yarns, muff-formed yarns, knitted fabrics, knitted pieces and bulky woven fabrics. Especially, the process and apparatus of the present invention can be utilized for treating high bulky articles such as woolen articles, synthetic polyester or polyamide textured yarn articles and acrylic fiber high bulky yarn articles. Particularly, muff-formed acrylic fiber high bulky yarns can be advantageously treated by the process and apparatus of the present invention.

The acrylic fiber muffs are treated by steam so as to develop high bulkiness. The bulky muffs are formed in a hollow cylinder as shown in FIG. **8** or in a substantially nonhollow cylinder. In the process of the present invention, it is preferable to use the non-hollow cylinder-formed muffs due to high density thereof. The muffs are charged into the treating chamber by aligning them on the bottom partition in a stratiform. In this charging, some spaces are formed between the muffs as shown in FIG. **9**. Referring to FIG. **9**, the spaces **75** formed between muffs **76** causes non-uniform flow of the treating liquid and thus non-uniform treatment of the muffs results.

In order to avoid the above-stated disadvantages, it is preferable that the spaces **75** are filled by fillers which are made of a material selected from natural or synthetic resins, metallic materials or wood through which the treating liquid can not flow. The fillers may be previously fixed in the treating chamber or may be inserted between the muffs charged into the treating chamber so as to close the spaces. By filling the fillers, the treating liquid can uniformly flow through the muffs with a uniform resistance to the flow of treating liquid. Accordingly, the treated muffs have a uniform quality in bulkiness.

In the treatment of the acrylic fiber bulky yarn muffs, it is preferable that the stratum of the charged muffs has a resistance to the flow of the treating liquid of 0.2 to 0.5 kg/cm^2. If the resistance is larger than 0.5 kg/cm^2, the treated yarn has a low bulkiness and undesirable stiff hand feeling. In some case, when the muffs are dyed at a resistance of 0.45 kg/cm^2 to 0.5 kg/cm^2 and then subjected to gradual cooling at a resistance of 0.3 kg/cm^2 or smaller, the resultant muffs have a good hand feeling and bulkiness. Further, it is more preferable in order to obtain muffs having superior bulkiness and hand feeling that the muffs are dyed at a resistance of 0.3 kg/cm or smaller.

The acrylic fiber bulky yarns may be muff-formed by the filling winding method.

Recently, use of the muff of yarns has remarkably increased due to the advantages that the muff can contain much more yarn than the hank, and can be easily handled and is effective for decreasing cost. Further, due to improvement of winders for making muffs, the muffs can be prepared at a high velocity twice that of the conventional hank preparation. Therefore, it is obvious that the use of muffs is much more economically beneficial than the conventional hank. Also, in the field of weft knitting sweaters and stockings where the yarn is knitted at a relatively high velocity, the muff-formed yarn has the economical advantages that the muff-formed yarn can be used as a yarn-feeding package by setting the muff to expand and thus can be directly knitted without re-winding. This is effective for shortening the knitting process. In the conventional process, the muffs are charged into a carrier of a package dyeing machine which carrier comprises one or more vertical or horizontal cylinders having numerous apertures through which the treating liquid flows, in a method whereby a plurality of muffs are superposed around the vertical cylinder by inserting the cylinder into the hollows of the muffs. The treating liquid fed through the apertures of the cylinder flows through the muffs while outwardly extending them. The muffs treated by the above-stated conventional process have hollows of a diameter of 60 to 150 mm. Such hollow muffs can be directly fed to a knitting process. However, the hollow muffs treated by the conventional process have the disadvantage that the yarn located in the inside surface portion of the muff is frequently undesirably flattened due to pressure and abrasion between the inside surface of the muff and the outside surface of the cylinder. Sometimes, the yarn located in the inside surface portion of the muff is fluffed or stretched by pressure of the treating liquid which flows outwardly from the cylinder to the muff so as to expand the muff outwards. This results in low bulkiness of the yarn. Further, when the muff is expanded outward by the treating liquid pressure, a clearance of about 2 cm is formed between the cylinder and the muff. The clearance causes a turbulent flow of the treating liquid, and the turbulent flow results in formation of fluffs on the yarn located in the inside surface portion of the muff. If the turbulent flow is vigorous, this results in frizzing of the yarn due to entanglement of the fluffs on the yarn. Such frizzing of the yarn and the entanglement of the fluffs produces difficulty in unwinding the yarn from the treated muff. Further, the hollow of the treated muff causes a decrease of the number of the muffs filled in a predetermined space, and this results in increase of transportation cost for the muffs.

In order to eliminate the above-stated disadvantages of the conventional process, the treated muff is given a pressed form as shown in FIG. **10** and has a thickness of 90 to 200 mm. Referring to FIG. **10**, the muff **81** has a flat hollow **82**. Sometimes, the muff may have substantially no hollow. A muff so treated having a flat hollow or no hollow and a thickness of 90 to 200 mm can be favorably supplied to a knitting or waving process at a low transportation cost.

The muff is preferably prepared by a filling winding process. The muff thus wound can be readily unwound without difficulty.

The desirable thickness of the treated muff is variable within the range of 90 to 200 mm depending on the amount and thickness of the yarn to be wound and the diameter of bobbin used. Table 3 shows thicknesses of some high bulky yarn muffs treated in accordance with the process of the present invention.

Table 3

Item Yarn	Shrinkage (%)	Meter count	Diameter of bobbin (mm)	Weight of muff (kg)	Thickness of treated muff (mm)
Regular	12	1/60	200	10	90
acrylic	12	1/60	250	10	80
yarn					
Middle	18	1/48	200	10	100
bulky	18	1/48	250	10	90
acrylic	22	2/48	200	10	160
yarn	22	2/48	300	15	140
High	28	2/48	300	15	160
bulky	28	2/48	300	20	180
acrylic	28	2/32	300	10	180
yarn	28	2/32	300	20	200

The process and apparatus of the present invention may be applied to dye fibrous articles with an aqueous liquid containing at least one dye and, if desired, at lease one auxiliary agent, for example, dispersing agent, levelling agent, acid, alkali, reducing agent, oxidizing agent, carrier for dye and the like. After dyeing, the process and apparatus of the present invention may be used for finishing or oiling the dyed fibrous articles with an aqueous liquid containing at least one oiling agent.

In the oiling for the fibrous articles in accordance with the process of the present invention, it is desirable that the dyed fibrous articles are charged into the treating chamber of the apparatus at a filling density of 0.09 to 0.14 g/cm³ and that the oiling liquid flows at a temperature of 40° to 60°C through the fibrous articles at a flow rate satisfying the following relationship:

$$Q_2/Q_1\ 1 = 0.8 \sim 1.8$$

wherein Q_1 is the flow rate of the dyeing liquor in the previous dyeing process and Q_2 is the flow rate of the oiling liquid.

Generally, the higher the flow rate of the oiling liquid, the higher the amount of the oiling agent absorbed on the fibrous article. However, if the ratio Q_2/Q_1 is smaller than 0.8, the amount of the oiling agent absorbed on the fibrous articles is too small, and if the ratio Q_2/Q_1 is greater than 1.8, the resultant fibrous articles have a low bulkiness. In any case, it is preferable that Q_1 is 10 to 30 liters/min/kg fibrous article.

As stated above, the process and apparatus of the present invention have the following advantages.

1. The treating operations are easy. The fibrous articles can be charged into the treating chamber by merely aligning them on the lower partition at a predetermined thickness and filling density. Since the charged fibrous articles do not rub against each other, the surface of the fibrous article remains in a smooth condition even after the processing.

2. The fibrous articles can be kept under a low compression. This prevents the fibrous articles from undesirable deformation.

3. In the fibrous article entanglement and frizzing of the yarn or filaments is prevented.

4. Fibrous articles having high bulkiness or high stretchability can be obtained. Particularly, high bulky single yarn articles can be treated. Such high bulky single yarn articles are very difficult of treatment by the conventional processes due to formation of fluffs, deformation of the article or entanglement of yarn. The high bulky single yarn article treated by the process and apparatus of the present invention can be unwound at a high velocity without yarn breakage.

5. The treated fibrous article has a good hand feeling and elegant appearance.

Further, the apparatus of the present invention can be utilized for drying the treated fibrous articles charged in the treating chamber. In this case, after the treating liquid is discharged from the apparatus, hot air is circulated through the treating chamber for the necessary time. This drying is valuable for maintaining the treated fibrous articles in the desired form. Since the treating chamber has a lower partition through which the treating liquid can flow down, the treating liquid is readily separated from the fibrous articles in the treating chamber.

The following examples are intended to illustrate the application of the present invention but are not intended to limit the scope thereof in any way.

EXAMPLE 1

An acrylic fiber yarn (Toraylon: trade mark of acrylic fiber made by Toray Industries, Inc., Japan) of 2/48 metric count having a shrinkage of 28% at 100°C was formed into rocket muffs each having a weight of 1.5 kg by means of a rocket muff winder. The muffs were preshrunk by steaming them at 100°C for 20 minutes.

The muffs thus preshrunk were charged into treating chambers having a thickness (depth) of 300 mm of the dyeing apparatus as shown in FIG. 4 in stratiform at an apparent density of 0.10 g/cm³. The strata of the muffs had a normal thickness of 280 mm in the dyeing liquid. The horizontal partitions defining the treating chambers each had numerous apertures the total area of which was 35% of the whole area of the partition. Spaces between the charged muffs were filled up by stainless steel fillers so as to obstruct the flow of the dyeing liquid through the spaces.

A predetermined amount of water was fed into the dyeing apparatus and heated to 70°C. When the temperature of water rose to 70°C, the following dyeing composition was dissolved into water in the apparatus.

2.0% based on the weight of the muffs	Cathilon Navy Blue RH (C.I. Basic Blue 93)
0.5% based on the weight of the muffs	Cathilon Blue GLH (C.I. Basic Blue 65)
0.3% based on the weight of the muffs	Cathilon Pink BH (C.I. Basic Red 3)
0.6% based on the weight of the muffs	Cathiogen PAN
1.0% based on the weight of the muffs	Cathiogen AN Super
2.0% based on the weight of the muffs	Acetic Acid (99%)
0.5% based on the weight of the muffs	Sodium Acetate

Note: Cathilon Navy Blue RH, Cathilon Blue GLH and Cathilon Pink BH are trade marks of basic dyes for acrylic fibers made by Hodogaya Chemical Co., Ltd., Japan.

Cathiogen PAN and Cathiogen AN Super are trade marks of levelling agents for basic dyes for acrylic fibers made by Daiichi Kogyo Seiyaku Kabushiki Kaisha, Japan.

The dyeing liquid was heated to 80°C for 10 minutes, and to 100°C for 60 minutes and maintained at 100°C for 40 minutes to dye the muffs. After dyeing, the dyeing liquid was cooled to 50°C for 30 minutes. During the process, the dyeing liquid was circulated through the muff strata through the thickness of the strata in alternate directions. The direction of the circulation was changed at time intervals of 10 minutes. The flow rate of the dyeing liquid was adjusted so that the strata of the muffs had a resistance of 0.25 kg/cm² to the flow of the dyeing liquid. After cooling, the muffs were rinsed with cold water and treated with an aqueous liquid containing 3% of Taflon Parma A sol (trademark of a softening agent made by Daiichi Kogyo Seiyaku Kabushiki Kaisha, Japan) at 50°C for 20 minutes.

The dyed muffs were discharged from the treating chambers and dried. During the above-stated treatments, the muffs were processed without undesirable deformation, entanglement or fluffing of yarn. The dried muffs were backwound into cones at a winding speed of 350 m/min without breakage or creation of large tension in the yarn.

The cone had a volume of 38 cm³/g. For comparison, the same yarn as stated above was formed into a hank and dyed under no tension and no pressure in the laboratory. The dyed yarn was wound into a cone in same way as above. The comparison cone had a volume of 39.5 cm³/g. That is, the yarn processed in accordance with the present invention had a bulkiness substantially similar to that of the yarn processed in the laboratory under no tension and no pressure.

The backwound yarn was knitted into a fabric. The resultant fabric had a uniform hue, hand feeling and appearance. For comparison, the same procedure as the present example was repeated except that the treating chamber was adjusted to a thickness of 240 mm. Accordingly, the strata of the muffs were compressed to a thickness of 240 mm. The resultant muffs were wound into cones. The cones had a volume of 32.5 cm³/g. The knitted fabric from the comparison yarn had a low bulkiness and rough hand feeling.

For further comparison, the same procedure as the present example was repeated except that the treating chamber was adjusted to a thickness of 430 mm. Accordingly, the clearance between the stratum of the muffs and the upper partition was 150 mm. By the same process, the resultant muffs were deformed and non-uniformly dyed.

EXAMPLE 2

The procedure of Example 1 was repeated except that the resistance to the dyeing liquid flow was adjusted to 0.38 kg/cm² during dyeing and to 0.28 kg/cm² during cooling after dyeing, and the cooling of the dyeing liquid was effected from 100°C to 50°C over 30 minutes. The dyed muffs were treated with the same softening agent as Example 1. The dyed muffs had the same appearance as Example 1. The yarn of the muffs was backwound into cones. The cones had a volume of 36.5 cm³/g which is a little smaller than that of Example 1.

The yarn was knitted by means of a weft knitting machine into a fabric. The resultant fabric had a bulkiness and appearance similar to those of Example 1.

EXAMPLE 3

The procedure of Example 1 was repeated except that the resistance to the dyeing liquid was adjusted to 0.46 kg/cm² during both dyeing and cooling. The dyed muffs were treated with the same softening agent as Example 1. The resultant muff had a thickness smaller by 3.5 cm than that of Example 1. The yarn of the muffs can be rewound into cones without difficulty. The cones had a volume of 34 cm³/g. The knitted fabric from the yarn had a uniform hue and appearance and a good hand feeling, but the bulkiness of the fabric was a little smaller than that of Example 1.

EXAMPLE 4

A Toraylon acrylic fiber yarn of 1/60 metric count having a shrinkage of 18% at 100°C was formed into rocket muffs each having a weight of 1.3 kg. The muffs were preshrunk by steaming at 100°C for 20 minutes. The preshrunk muffs were charged into treating chambers having a thickness of 250 mm in a stratiform at an apparent density of 0.12 g/cm³. The strata of the muffs had a normal thickness of 240 mm in the dyeing liquid. The partitions had numerous apertures of total area of 35% of the whole area of the partition. Spaces between the muffs were filled up with polypropylene fillers.

The muffs were dyed with the following aqueous dyeing composition.

0.8% based on the weight of muffs	Cathilon Pure Blue 5GH (C.I. Basic Blue 3)
1.7% based on the weight of muffs	Cathilon Yellow 3GLH (C.I. Basic Yellow 11)
0.8% based on the weight of muffs	Cathilon Blue 3RLH (C.I. Basic Blue 47)
0.8% based on the weight of muffs	Cathiogen PAN
1.0% based on the weight of muffs	Cathiogen AN Super
2.0% based on the weight of muffs	Acetic Acid (99%)
0.5% based on the weight of muffs	Sodium Acetate

Note: Cathilon Pure Blue 5GH, Cathilon Yellow 3GLH and Cathilon Blue 3RLH are trade marks of basic dyes for acrylic fibers made by Hodogaya Chemical Co., Ltd., Japan.

The dyeing and cooling processes were carried out by the same method as Example 1. During the dyeing and cooling, the resistance of the muff stratum to the dyeing liquid flow was adjusted to 0.25 kg/cm². After cooling, the muffs were rinsed with water and then treated with an aqueous oiling liquid containing 1.0% of Taflon parma A sol at 50°C for 20 minutes.

It was clear that the resultant muffs were treated without undesirable deformation, entanglement and fluffing of the yarn. The muffs were backwound into cones at a winding speed of 320 m/min with few breakages of the yarn. The yarn was knitted into a triple interlock jersey. The resultant jersey had clear stitches uniform hue and elegant hand feeling and bulkiness.

EXAMPLE 5

A polyethylene terephthalate high bulky spun yarn of metric count of 2/33 having a shrinkage of 9.5% in boiling water was formed into rocket muffs each having a weight of 1.5 kg by filling winding. The muffs were preshrunk by steaming at 100°C for 20 minutes. The preshrunk muffs were charged into the treating chambers of the apparatus as shown in FIG. 7. The treating chambers had a thickness depth of 200 mm and the strata of the muffs had a normal thickness of 210 mm and an apparent density of 0.125 g/cm³ set by adjusting the upper partition of the treating chamber.

The muffs were dyed with the dyeing liquid containing the following composition at 130°C for 60 minutes at a flow rate of 25 litres/min/kg muff.

Composition	
3% based on the weight of muffs	Dianix Fast Blue RN (Disperse Blue 91)

-continued

1.5% based on the weight of muffs	Dianix Fast Blue GN (Disperse Blue 90)
1.0% based on the weight of muffs	Sunsolt No. 1200

Note: Dianix Fast Blue RN and Dianix Fast Blue GN are trade marks of disperse dyes made by Mitsubishi Kasei, Japan.
Sunsolt No. 1200 is the trade mark of the nonionic levelling agent for polyester fiber made by Nikka Chemical Co., Ltd., Japan.

The dyed muffs were washed with hot water, rinsed with cold water and then cleared by treating with an aqueous solution containing the following composition at 80°C for 20 minutes.

Composition	
2 g/l	Amiladin
2 g/l	Sodium hydroxide
2 g/l	Sodium dithionite

Note: Amiladin is the trade mark of a detergent for polyester fiber made by Daiichi Kogyo Seiyaku, Japan.

The cleared muffs were treated with an aqueous solution containing 4 g/l of Taflon No. 320 A (trade mark of a softening agent made by Daiichi Kogyo Seiyaku, Japan).

After the solution was discharged from the apparatus, the muffs were dried by blowing hot air through the treating chambers.

For comparison, the same muffs were dyed in a basketformed carrier of the apparatus as shown in FIG. 1 at an apparent density of 0.123 g/cm³ using the same method as the present example. The processed muffs were dehydrated by a centrifugal separator and then dried in a cabinet-type dryer. The apparent filling densities of the muffs of the present and comparison examples are shown in Table 4.

Table 4

Process \ Item	Apparent filling density g/l: Before processing (ρo)	After dyeing	After clearing	After oiling (ρn)	$\rho n/\rho o$	Bulkiness (cm³/g)
Example 5	125	128	129	130	1.04	27.4
Comparison	123	165	170	172	1.40	24.3

When the apparent filling density (ρo) of the muff is 123 g/l, it is preferable that the ratio $\rho n/\rho o$ is less than

$$1.362\ \left(=0.63+\frac{90}{123}\right).$$

Table 4 shows that the process of the present example results in a ratio of $\rho n/\rho o$ smaller than that of the comparison example. This shows that the muffs processed in accordance with the present invention have a bulkiness higher than that of the conventional process.

EXAMPLE 6

A polyethylene terephthalate spun yarn of 1/48 metric count having a shrinkage of 9.0% in boiling water was formed into hanks. The hanks were preshrunk by steaming at 100°C for 20 minutes. The hanks were reprocessed by the same method as Example 5. For comparison, the same hanks were processed by the same method as the comparison process of Example 5. The resultant hanks of the present and comparison examples had the apparent filling densities as shown in Table 5.

Table 5

Process \ Item	Apparent filling density (g/l): Before processing (ρo)	After dyeing	After clearing	After oiling (ρn)	$\rho n/\rho o$	Bulkiness (cm³/g)
Example 6	150	157	160	162	1.08	21.9
Comparison	151	179	180	188	1.98	19.8

In the case where ρo is 151, it is preferable that the ratio $\rho n/\rho o$ is less than

$$1.226\ \left(=0.63+\frac{90}{151}\right).$$

EXAMPLE 7

An acrylic fiber spun yarn of 1/60 metric count having a shrinkage in boiling water was formed into rocket muffs by filling winding. The muffs were shrunk by steaming at 100°C for 20 minutes. The shrunk muffs were processed by the same procedure as Example 5 except that the flow rate of the dyeing liquid was 10 litres/min/kg muff, the dyeing was carried out using the same dyeing liquid as Example 1 at 100°C for 60 minutes and the oiling was carried out at 40°C for 20 minutes. The processed muffs were dried in the treating chambers by blowing hot air therein. For comparison, the muffs were processed in a basket-formed carrier of the apparatus of FIG. **2** in the same way as above. The resultant muffs had apparent densities as shown in Table 6.

Table 6

Process \ Item	Apparent filling density (g/l): Before processing (ρo)	After dyeing	After oiling (ρn)	$\rho n/\rho o$	Bulkiness (cm³/g)
Example 7	95	100	105	1.11	32.4
Comparison	100	158	165	1.65	27.6

In the case where ρo is 100, it is preferable that $\rho n/\rho o$ is less than

$$1.53\ \left(=0.63+\frac{90}{100}\right).$$

EXAMPLE 8

An acrylic fiber spun yarn of 2/42 metric count having a shrinkage of 28% in boiling water was formed into rocket muffs by filling winding. The rocket muffs were preshrunk by steaming at 100°C for 20 minutes. The preshrunk muffs were processed by the same procedure as Example 7.

For comparison, the muffs were processed at a flow rate of the treating liquids of 50 l/min/kg muff.

The resultant muffs had apparent filling densities as shown in Table 7.

Table 7

Item	Apparent filling density (g/l)				
Process	Before processing (ρo)	After dyeing	After oiling (ρn)	$\rho n/\rho o$	Bulkiness (cm³/g)
Example 8	100	110	112	1.12	34.0
Comparison	100	150	160	1.60	28.2

In the case where ρo is 100, it is preferable that $\rho n/\rho o$ is less than

$$1.53 \left(= 0.63 + \frac{90}{100}\right).$$

Although, both the muffs of the present example and the comparison example were uniformly dyed, the comparison muffs had a low bulkiness and the yarn of the comparison muffs was flattened.

EXAMPLE 9

An acrylic fiber yarn of 2/48 metric count having a shrinkage of 28% in boiling water was formed into hanks and then preshrunk by steaming at 100°C for 20 minutes. The hank was processed by the same procedure as Example 1. In the process, the apparent filling density of the hanks before processing was 100 g/l, and both the dyeing liquid and the oiling liquid flowed at a flow rate of 13.2 l/min/kg hank (Q_1 and Q_2) in alternate directions at time intervals of 5 minutes.

For example, the same hanks as above were processed by the same procedure as above except that the initial apparent filling density of the hanks was 80 g/l.

The evenness of dyeing and bulkiness of the hanks and amount of the oiling agent absorbed on the yarns of the resultant hanks are shown in Table 8.

Table 8

Item	Initial	Flow rate (l/min/kg hank)					Amount of oiling
Process	apparent filling density (g/l)	Dyeing liquid (Q_1)	Oiling liquid (Q_2)	Q_2/Q_1	Evenness of dyeing	Bulkiness (cm³/g)	agent absorbed on yarn (%)
Example 9	100	13.2	13.2	1.0	even	32.8	0.26~0.30
Comparison	80	13.2	13.2	1.0	non-even	34.0	0.29~0.32

As Table 8 shows, the hanks processed at the initial apparent filling density of 80 g/l were non-uniformly dyed whereas the hanks had a high bulkiness and a high absorption of the oiling agent.

EXAMPLES 10 to 13

An acrylic fiber yarn of 2/60 metric count having a shrinkage of 18% in boiling water was formed into rocket muffs using a cake rocket winder, and then preshrunk by steaming at 100°C for 20 minutes. The preshrunk muffs had an apparent density of 101 g/l.

The muffs were charged into the same treating chamber as Example 1 at apparent filling densities as shown in Table 9 and processed in the same procedure as Example 4. In the process, the flow rate (Q_1) of the dyeing liquid and the flow rate (Q_2) of the oiling liquid were altered as shown in Table 9.

The resultant muffs had evenness of dyeing, bulkiness and oiling agent absorption as shown in Table 9.

Table 9

Item		Flow rate (l/min/kg muff)					
Process	Apparent filling density (g/l)	Dyeing liquid (Q_1)	Oiling liquid (Q_2)	Q_2/Q_1	Evenness of dyeing	Bulkiness (cm³/g)	Oiling agent absorption (%)
Example 10	105	12	12	1.0	good	32.4	0.33~0.37
Example 11	125	12	16	1.33	"	31.8	0.31~0.36
Example 12	150	16	25	1.56	"	29.4	0.31~0.35
Example 13	150	16	16	1.0	"	29.2	2.0~0.71
Comparison	125	12	23	1.92	"	27.0	0.31~0.36

In the comparison example where Q_2/Q_1 is 1.92, the resultant muffs had a low bulkiness.

EXAMPLES 14 and 15

An acrylic fiber yarn of 2/48 metric count having a shrinkage of 28% in boiling water was formed into hanks and then preshrunk by steaming at 100°C for 20 minutes.

The hanks were processed by the same procedure as Example 9 under the conditions shown in Table 10.

The resultant hanks had evenness of dyeing, bulkiness and oiling agent absorption as shown in Table 10.

Table 10

Item Process	Apparent filling density (g/l)	Flow rate (l/min/kg hank) Dyeing liquid (Q_1)	Oiling liquid (Q_2)	Q_2/Q_1	Even-ness of dyeing	Bulki-ness (cm^3/g)	Oiling agent absorption (%)
Example 14	95	7.0	6.1	0.85	good	33.0	0.26~0.31
Example 15	138	28.0	49.1	1.7	"	32.5	0.27~0.30
Com-parison	95	9.0	17.1	1.9	"	28.0	0.25~0.29

In the comparison example where Q_2/Q_1 is 1.9, the resultant hanks had a low bulkiness.

What we claim is:

1. A process for treating fibrous articles consisting of bulky yarns with an aqueous treating liquid, comprising:
   a. providing a stratiform treating chamber having a thickness L_1 defined by a pair of horizontally extending partitions having apertures therethrough to permit the flow of treating liquids through the treating chamber along the thickness dimension;
   b. providing fibrous articles, consisting of bulky yarns, to be treated;
   c. charging the treating chamber with the fibrous articles to form a stratum of fibrous articles having an uncompressed thickness in the atmosphere less than L_1, an apparent density in the atmosphere of about 0.09 to 0.16 g/cm^3, and an uncompressed thickness L_2 in the treating liquid, where $L_1 < 1.5L_2$,

   in order to effect a resistance to the flow of the treating liquid through the treating chamber of about 0.2 to 0.5 Kg/cm^2; and
   d. flowing the treating liquid through the treating chamber in alternate directions along the thickness dimension at a flow rate of about 10 to 30 litres/-min per Kg of fibrous articles within the treating chamber for a period of time sufficient to change the apparent density of the stratum of fibrous articles according to the relationship $\rho n/\rho o = 1.0$ to $(\alpha + \beta/\rho o)$

   where ρn is the apparent density of the stratum of fibrous articles in the atmosphere after treatment, ρo is the initial apparent density of the stratum of fibrous articles in the atmosphere before treatment, α is about 0.62 to 0.63 and β is about 80 to 90.

2. A process according to claim 1, further comprising, drying the fibrous articles after said flowing the treating liquid through the treating chamber.

3. A process as claimed in claim 2, wherein said drying comprises blowing hot air through said treated stratum of fibrous articles in said treating chamber.

4. A process for treating muffs consisting of bulky yarns with an aqueous treating liquid, comprising:
   a. providing a stratiform treating chamber having a thickness L_1 defined by a pair of horizontally extending partitions having apertures therethrough to permit the flow of treating liquids through the treating chamber along the thickness dimension;
   b. providing muffs having a transverse dimension of about 90 to 200 mm, and consisting of bulky yarns, to be treated;
   c. charging the treating chamber with the muffs to form a stratum of muffs having an uncompressed thickness in the atmosphere less than L_1, an apparent density in the atmosphere of about 0.09 to 0.16 g/cm^3, and an uncompressed thickness L_2 in the treating liquid, where $L_1 < 1.5L_2$,

   in order to effect a resistance to the flow of the treating liquid through the treating chamber of about 0.2 to 0.5 Kg/cm^2; and
   d. flowing the treating liquid through the treating chamber in alternate directions along the thickness dimension at a flow rate of about 10 to 30 litres/-min per Kg of muffs within the treating chamber for a period of time sufficient to change the apparent density of the stratum of muffs according to the relationship $\rho n/\rho o = 1.0$ to $(\alpha + \beta\rho o)$

   where ρn is the apparent density of the stratum of muffs in the atmosphere after treatment, ρo is the initial apparent density of the stratum of muffs in the atmosphere before treatment, α is about 0.62 to 0.63 and β is about 80 to 90.

5. A process as claimed in claim 1, wherein said fibrous articles are selected from the group consisting of loose fibers, filament tows, fiber slivers, hank-formed yarns, muff-formed yarns, knitted fabrics, knitted pieces and bulky woven fabrics.

6. A process as claimed in claim 1, wherein said providing fibrous articles comprises providing a plurality of muff-formed yarns, and wherein said charging the treating chamber includes filling spaces between said yarn muffs with fillers, whereby said aqueous treating liquid passes through said yarn muffs only.

7. A process as claimed in claim 6, wherein said filling spaces between said yarn muffs with filler includes selecting the filler from the group consisting of natural and synthetic resins, metallic materials and wood.

8. A process as claimed in claim 4, wherein said muff consists of an acrylic bulky yarn.

9. A process as claimed in claim 4, wherein said muff is provided by winding said bulky yarn by the filling winding method.

10. A process as claimed in claim 1, wherein said treating comprises dyeing and said aqueous treating liquid contains at least one dye.

11. A process as claimed in claim 1, wherein said treating comprises oiling and said aqueous treating liquid contains at least one oiling agent.

12. A process as claimed in claim 11, wherein said oiling liquid is circulated at a temperature of 40° to 60°C at a flow rate of 0.8 to 1.8 times that of said dyeing liquid.

* * * * *