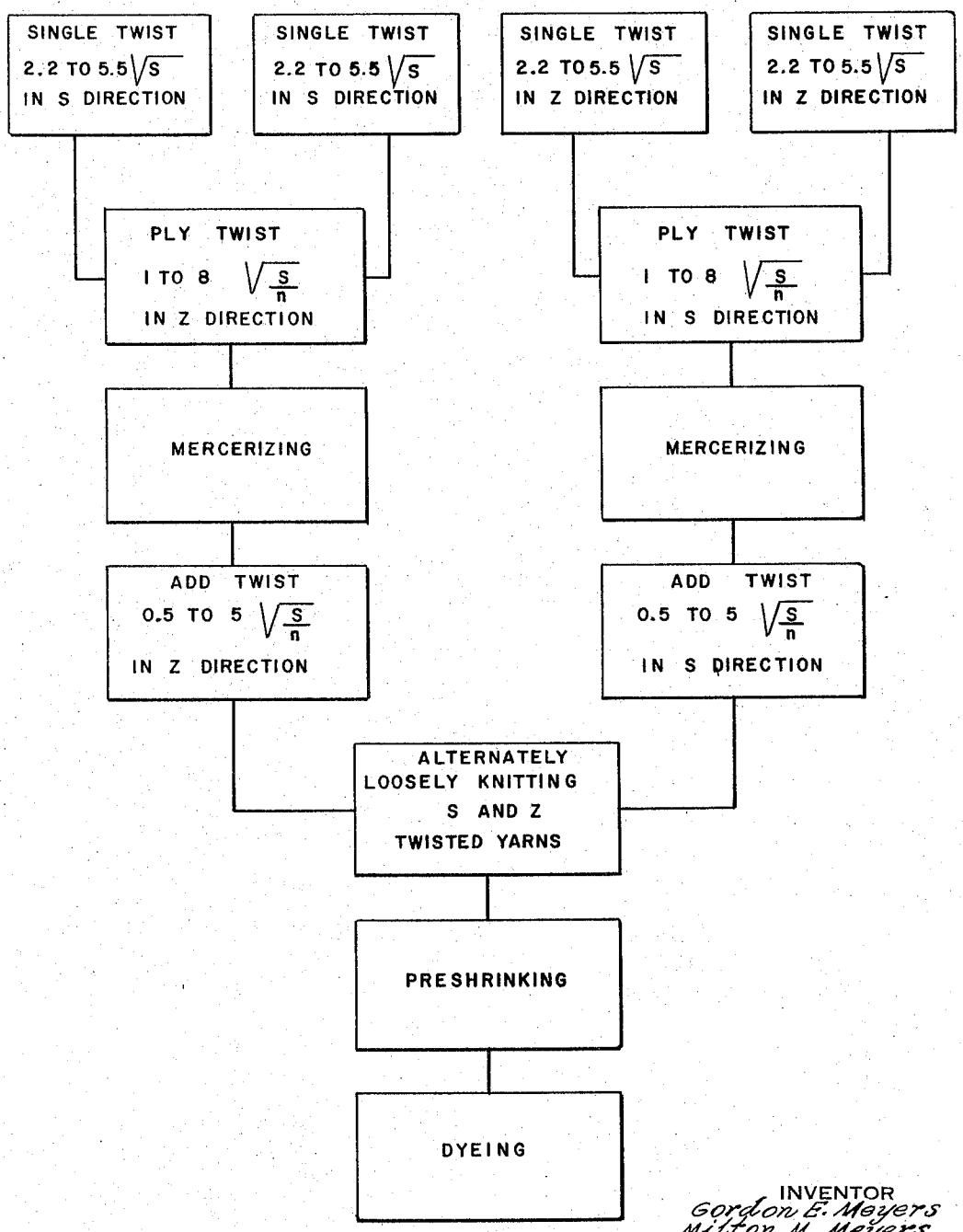
Jan. 24, 1967 G. E. MEYERS ETAL 3,299,486

METHOD OF MAKING STRETCH COTTON KNITTED FABRICS

Filed July 3, 1963 2 Sheets-Sheet 1

Fig. 1.



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Filed July 3, 1963 2 Sheets-Sheet 2

Fig. 2.

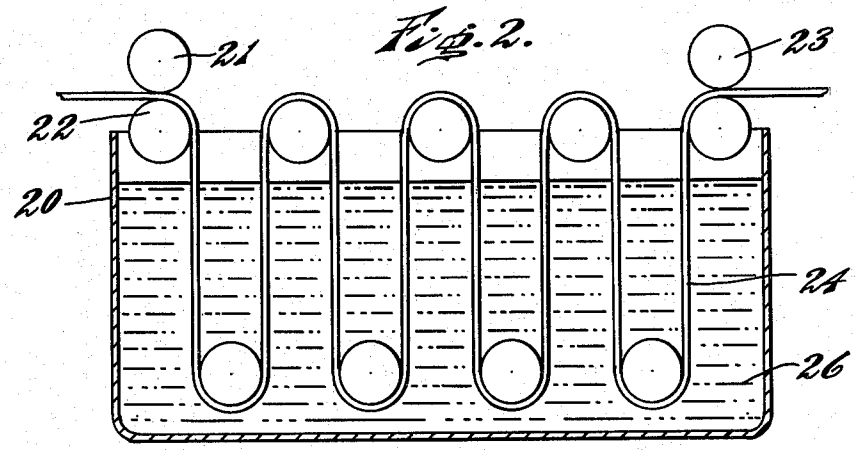


Fig. 3.

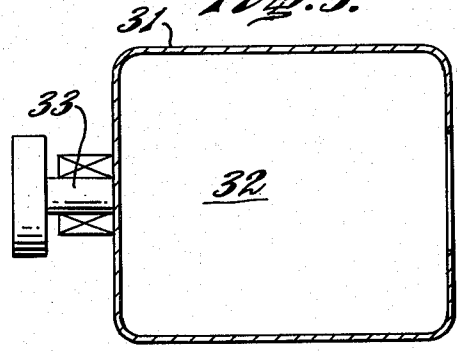


Fig. 4.

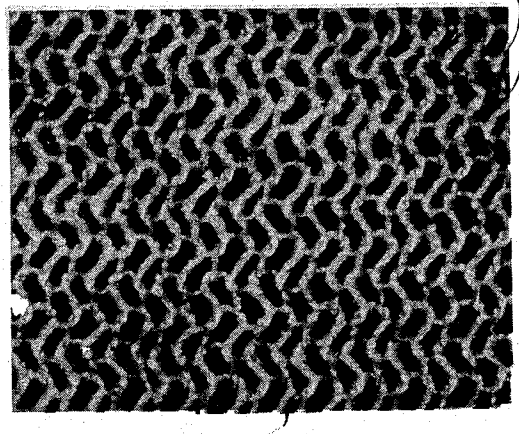
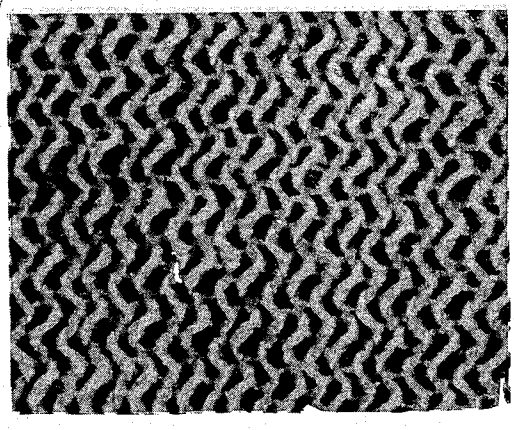


Fig. 5.



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METHOD OF MAKING STRETCH COTTON KNITTED FABRICS

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13 Claims. (Cl. 28—76)

The present invention relates to methods of making knitted cotton clothing for men, women and children, especially knitted cotton stockings, socks, underwear, leotards, athletic clothing, and outer wear including blazers, jackets and sweaters.

A purpose of the invention is to produce an improved stretch knitted fabric suitable for all of the garments referred to and especially for stockings and socks, which will comfortably fit three or four adjoining stocking sizes, and when stretched will recover slowly and apply only a gentle pressure on the body of the wearer, for example, the foot or leg.

A further purpose is to improve the appearance of a stretch cotton garment such as a stocking or sock, especially the lustre or sheen.

A further purpose is to obtain a more pleasant and appealing hand or feel in a stretch cotton knitted garment such as a stocking or sock, the hand being described as crisp or smooth.

A further purpose is to obtain better dye affinity in a stretch cotton knitted garment so that dye will adhere more uniformly.

Further purposes appear in the specification and in the claims.

In the drawings we illustrate a flow chart of the steps of the method, and apparatus which may be used.

FIGURE 1 is a flow diagram showing the steps of the method.

FIGURE 2 is a diagrammatic longitudinal vertical section showing a tension warp mercerizer which may be employed in the present invention.

FIGURE 3 is an axial section of a tumbling device for use in the invention.

FIGURES 4 and 5 are enlarged photographs of the foot portion of a completed mens sock according to the invention, the wales being aligned in the horizontal direction.

Very successful synthetic stretch knitted fabrics have been obtained using nylon or the like. It has not been easy to produce a satisfactory stretch knitted cotton fabric and in many areas the utilization of cotton has markedly decreased, partly for this reason.

Cotton is, however, in many ways a very desirable material for making men's women's and children's clothing and it remains relatively economical. By the invention it is possible to enhance the properties of cotton knitted fabrics by providing stretch properties without corresponding disadvantages which have formerly existed. While the invention is believed to have its widest application in cotton hosiery and socks, it is also applicable to cotton underwear, leotards, sportswear and various forms of outer wear, including blazers, jackets, sweaters and stretch pants.

One great advantage of the invention is that the number of sizes which must be stocked by the retail merchant is greatly decreased. For example, in socks according to the invention, the same sock will fit comfortably any of sizes 10 to 13. Similarly other size ranges as wide as this can be fitted by a single sock. Similar effects are obtained in other garments. This is particularly important in children's clothing where one of the frustrating aspects from the standpoint of the parent is the frequent need to replace by larger sizes.

While the fabrics exhibit desirable stretch properties, they do not bind tightly on the body of the wearer and the recovery after stretch is slow and the pressure is not excessive.

A great advantage is that the appearance is improved, since the fabric has more lustre and sheen.

The hand or feel of the fabric also is preferable to other knitted cotton fabrics, and may be described as crisp and smooth.

The fabric of the invention also provides better affinity for dye and dyes more uniformly.

In the experimental work leading up to the present invention cotton yarn 40/2 was produced having a twist of 30 turns per inch. An attempt was made to knit this into socks on a two feed knitting machine, feeding one yarn having *s* twist in the ply and the other having *z* twist in the ply. The result however was not successful. The yarn was so "lively" that it would not knit properly, and the resulting socks were rough, had a harsh hand and gave a poor appearance.

The socks in this experiment, however, did have good stretch characteristics.

In a further step in the experimental program, the same yarn referred to above was mercerized and then knitted into socks in the manner described. The fabric was "dead" or limp and did not exhibit stretch characteristics.

Size of yarn

In cotton yarn nomenclature, the practice is to place in the numerator a number indicating the size of the individual singles yarn and to place in the denominator a number corresponding to the number of plies. Thus 40/2 means that the single has a weight corresponding to number 40 and there are two plies.

The principles of the invention are applicable to a wide variety of sizes of cotton yarns, anywhere from 1's to 120's, both inclusive, preferably from 20's to 80's, both inclusive, and most desirably from 30's to 60's.

Twist in the single

While the invention is applicable to yarn which is not plied or has only a single ply, the yarn will usually and preferably have from 2 to 6 plies. There will, therefore, be a twist in the single which will normally be different from the twist in the ply.

Where the yarn is plied, the twist in the single is not nearly so important as the twist in the ply but it still is a matter for attention. The twist in the single in accordance with the present recommended practice will conform to the following formula:

$$2.2 \text{ to } 5.5 \sqrt{S}$$

where S is the yarn number, for example 40, corresponding to the single. The twist in the single will preferably be in the range as follows:

$$3 \text{ to } 4.5 \sqrt{S}$$

Number of plies

The invention can be applied where the yarn is used in the single, with the twist as noted, and is not plied. For best results, however, there will be 2 to 6 plies in the yarn.

Twist in the ply

When two or more singles are to be plied together, the ply twist will conform to the following formula:

$$1 \text{ to } 8\sqrt{\frac{S}{n}}$$

where n is the number of plies. The preferable twist in

the ply when the ply twist is opposite to the single twist will conform to the following formula:

$$3 \text{ to } 4.5\sqrt{\frac{S}{n}}$$

In the preferred embodiment of the invention the twist in the singles which are plied to make a ply are always in the same direction, that is always *s* or always *z*. Also in the preferred embodiment the twist in the ply is opposite to the twist in the single so that if the singles are *s* twist, the ply will be *z* twist, and if the singles are *z* twist, the ply will be *s* twist. In exceptional cases the twist in the ply and the twist in the single may be in the same direction, both *s* or both *z*. In this case, the ply twist very much tightens the yarn and it is preferable to use a somewhat slacker ply twist within the range of the above formula, for example:

$$1 \text{ to } 4\sqrt{\frac{S}{n}}$$

In some cases one or more of the singles may be twisted oppositely from the other or others, that is, one single might be *z* twist and the other *s* twist, and the ply twist might be *s* twist. This is an intermediate condition between the case where the ply twist is in the same direction as the twist in the single.

Mercerizing

An important step in the present invention is that the yarn as above described is tension mercerized. This usually is accomplished in a tension mercerizing machine such as a warp mercerizing machine as shown in FIGURE 2 of the drawing, having a tank **20**, driven inlet feed rolls **21**, idler rolls **22** and driven outlet feed rolls **23** preferably driven at the same speed as the inlet feed rolls. The tension in the yarn **24** is created by the mercerizing solution **26**, suitably sodium hydroxide in water having a concentration of 15 to 20% by weight of sodium hydroxide.

The usual mercerizing temperatures employed suitably is in the range of 70 to 130° F., preferably about 90° F., and the machine usually runs at a speed of 20 to 25 yards per minute, so that the yarn is in the mercerizing machine about 5 minutes.

The yarn after mercerizing is desirably neutralized by acid such as sulphuric acid as well known.

Twist after mercerizing

A very important aspect of the invention is that after mercerizing and drying the yarn is twisted to add to the twist existing in the mercerized yarn a twist according to the following formula:

$$0.5 \text{ to } 5\sqrt{\frac{S}{n}}$$

The preferable twist added after mercerizing is according to the following formula:

$$2 \text{ to } 3\sqrt{\frac{S}{n}}$$

It should be emphasized that during mercerizing the yarn effectively loses torque and therefore the twist added after mercerizing is to be added to the twist which existed before mercerizing. The added twist can be in the reverse direction, but should preferably be in the same direction as the former (ply) twist. It will be evident that the yarn manufacture including particularly twist after tension mercerizing in either direction, creates torque in the yarn which after knitting and preshrinking, all according to the invention, cooperate to produce a stretch fabric.

Knitting

It is important that knitting being carried out using at least one yarn having an *s* twist (in the ply if the yarn is plied) and at least one yarn having a *z* twist (in the ply if the yarn is plied). This of course means that at least two different yarns are to be used in knitting the same fabric, but more than two yarns may be employed and as many as 6 or more yarns alternating having *s* and *z* twist in the ply if the yarn is plied, may be used if desired.

The way in which the different yarns will be introduced alternately will depend upon the type of knitting machine. In a circular knitting machine such as a Scott and Williams Knitting Machine Komet, the different yars will be introduced on different feeds, but in some machines the different yarns will be introduced on different carriers as well known in the art. Thus in the garment alternate adjoining courses in some cases have *s* and in some cases have *z* twists. In some cases however two or more courses adjoining may be knitted with the yarn having the *s* twist and then two or more courses adjoining will be knitted with the yarn having the *z* twist, and so on, forming alternate ribs or bands of *s* twist and of *z* twist.

It is important that the knitting be loose and since machine types vary so widely this is described in terms of lengthwise stretch in the goods before dyeing. The knitting must be so loose that the fabric before dyeing can stretch lengthwise under the pull of the hand at least 30% and preferably at least 40%.

In the knitting two or more different yarns **27** and **28** are used, one having *s*-twist in the ply and the other having *z*-twist in the ply. FIGURES 4 and 5 show the completed knitted fabric **30** and are referred to below.

Needless to say, since the fabric will be preshrunk, the size as made will be larger than the size as sold. For example, in order to produce socks which are to be boarded on size 10 forms, the socks are knitted to fit forms which are size 13½ or size 14.

Preshrinking

After the fabric is knitted and preferably before dyeing, the fabric is preshrunk. It is very desirable that this preshrinking be accomplished with relaxation so that the fabric will not become harsh in feel. If however relaxation is not necessary the fabric can be preshrunk as by washing in warm water with a mild soap.

It is important and much preferred however to preshrink and release the fabric by tumbling in a tumble drying machine, FIGURE 3. This is in effect a barrel **31** which has an open interior **32** as well known in the art, turning on a shaft **33**. The tumbling can be carried out at room temperature but is preferably carried out at a temperature of at least 100° F. and preferably 120° F., by heating the tumbling machine. The tumble drying machine ordinarily turns at a speed of 30 to 50 r.p.m. and preferably at about 37 r.p.m. The time in the tumble drying machine should be at 5 to 60 minutes and preferably at least 20 minutes. As a result of the tumbling, socks which were knitted to fit hosiery forms of size 14 shrink in the tumble drying machine to size 9½.

Dyeing

The knitted fabric is then dyed using a standard procedure for paddle machine dyeing. The preferred technique for dyeing is that set forth in Whitaker and Wilcocks, Dyeing with Coal-Tar Dyestuffs (4th edition) chapter 9, page 185 and following.

Drying

After dyeing and extracting it is preferable to dry the knitted fabric before final boarding. This can be accomplished using any suitable type of dryer, but is preferable to accomplish this by placing the knitted fabric back in the tumble drying machine at a temperature of 100 to 250° F. and preferably of about 140° F. just long enough to remove the moisture content to preferably between 15 and 20% on the weight of the fabric.

Final boarding

The fabric is next boarded to the desired size and shape. In the case of socks as above referred to they would be boarded on size 10 hosiery forms.

After several hours following boarding, the socks were tested for stretch by stretching in the range from 10 inches to 14 inches and they had excellent relaxation and very fine stretch characteristics.

The socks also had good luster and sheen and crisp and smooth feel and smooth appearance. The dye retention was excellent.

FIGURE 4 shows the foot of a men's sock as completed according to the present invention. In this figure the fabric is under tension longitudinally or walewise (from left to right) and as noted the successive alternate *s* and *z* ply twisted yarn ends are in this instance somewhat straightened.

FIGURE 5 shows to the same magnification and in the same position the foot of the sock with tension released. It will be noted that the loops are much closer packed and it is the ability of the loops to open up and close under the resilience possessed by the fabric which provides for the stretch.

Example

The method of the invention was used in producing men's socks.

Cotton yarn was used designated 40/2. One end was *s* twisted in the single to a twist of $3.25\sqrt{40}=20.5$ turns per inch and two of these singles were plied and *z* twisted in the ply to a twist of

$$4\sqrt{\frac{40}{2}}=18 \text{ turns per inch}$$

Other yarn ends were *z* twisted in the single to a twist of $3.25\sqrt{40}=20.5$ turns per inch. Two of these *z* twisted singles were plied together and *s* twisted to a twist of

$$4\sqrt{\frac{40}{2}}=18 \text{ turns per inch}$$

The yarns were both mercerized in a warp mercerizer under tension in a water solution of sodium hydroxide at 50° tw. at 90° F. and a speed of 25 yards per minute. After mercerizing and neutralizing with a dilute water solution of sulphuric acid each yarn was dried. Each yarn was then twisted in the same direction as the ply twist 9 added turns per inch. This means that the *z* ply twisted yarn received 9 added turns in the *z* direction, and the *s* ply twisted received 9 turns additional twist in the *s* direction.

The yarn was then knitted into size 14 men's socks on a two feed 200 needle 48 gage Scott and Williams Komet knitting machine, having a 3½" cylinder, and knitting 26 course per inch. One yarn with *s* twist in the ply was fed in one feed and the other yarn with *z* twist in the ply was fed in the other feed. Alternate courses were knitted with the *s* and *z* twisted yarns. The socks stretched more than 30% in length after knitting and before dyeing.

The socks were then tumbled in a tumble drying machine heated to 120° F. turning at 37 r.p.m. for 20 minutes. As a result of this treatment they shrank to size 9½.

The socks were then dyed in a paddle dyeing machine following the standard procedure as set forth above. After dyeing the socks were extracted to a moisture content of 100% on the weight of the goods.

The socks were then put back in the tumbling machine heated to 140° F. just long enough to reduce the moisture content to 20%. The socks were then boarded on size 10 hosiery forms.

The socks were examined after several hours and it was found that the stretch and recovery characteristics were excellent. They were comfortable on the foot over various size ranges between 9 and 13. The socks were very smooth and the lustre and sheen was good. The hand was crisp and smooth.

The socks took the dye well and exhibited excellent dye affinity.

It will be evident that the torque created in the yarn by the twisting after mercerizing, when the fabric is knitted, produces a folding condition of the wales of the fabric, so that the wales are capable of stretching under tension, but when the tension is released will revert to the initial folded condition. Thus an individual wale achieves a zig-zag formation when the fabric is released, but the zig-zag tends to straighten out as tension is applied, tending to lengthen the fabric.

In view of our invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of our invention without copying the method shown, and we therefore claim all such insofar as they fall within the reasonable spirit and scope of our claims.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is:

1. A method of making stretch cotton knitted fabric, which comprises producing cotton yarn of a size between 1's and 120's, twisting the yarn in the single to a twist given by the following formula:

$$2.2 \text{ to } 5.5\sqrt{S}$$

some of said yarn being *s* twisted and some of said yarn being *z* twisted, making up a ply yarn having from 2 to 6 plies of said singles and having a twist in the ply corresponding to the formula:

$$1 \text{ to } 8\sqrt{\frac{S}{n}}$$

some of said ply yarn being *s* twisted and some of said ply yarn being *z* twisted, said ply yarn which is *s* twisted having *z* twist in the single and said ply yarn which is *z* twisted having *s* twist in the single, mercerizing said ply yarn under tension, adding *s* twist to the *s* twisted ply yarn and adding *z* twist to the *z* twisted ply yarn after mercerizing according to the following formula:

$$0.5 \text{ to } 5\sqrt{\frac{S}{n}}$$

knitting both the *s* twisted ply yarn and the *z* twisted ply yarn into the same fabric while feeding these yarns alternately, conducting the knitting so loosely that the knitted fabric has a longitudinal stretch before dyeing of at least 30%, and pre-shrinking the knitted fabric, the nomenclature being as follows:

S=cotton yarn number,
n=number of plies.

2. A method of claim **1**, in which the yarn is of a size between 30's and 60's.

3. A method of claim **1**, in which the yarn is twisted in the single according to the formula:

$$3 \text{ to } 4.5\sqrt{S}$$

4. A method of claim **1**, in which the yarn is twisted in the ply before mercerizing according to the formula:

$$3 \text{ to } 4.5\sqrt{\frac{S}{n}}$$

5. A method of claim **1**, in which the twist is added to after mercerizing according to the formula:

$$2 \text{ to } 3\sqrt{\frac{S}{n}}$$

6. A method of making stretch cotton knitted fabrics, which comprises producing cotton yarn of a size between

1's and 120's, twisting the yarn in the single to a twist given by the formula:

$$2.2 \text{ to } 5.5\sqrt{S}$$

some of said yarn being *s* twisted and some of said yarn being *z* twisted, making up a ply yarn having from 2 to 6 plies of said singles and having a twist in the ply corresponding to the formula:

$$1 \text{ to } 8\sqrt{\frac{S}{n}}$$

some of said ply yarn being *s* twisted and some of said ply yarn being *z* twisted, said ply yarn which is *s* twisted having *z* twist in the single and said ply yarn which is *z* twisted having *s* twist in the single, mercerizing said ply yarn under tension, applying *z* twist to the *s* twisted ply yarn and applying *s* twist to the *z* twisted ply yarn after mercerizing according to the formula:

$$0.5 \text{ to } 5\sqrt{\frac{S}{n}}$$

knitting both the *s* twisted ply yarn and the *z* twisted ply yarn into the same fabric while feeding these yarns alternately, conducting the knitting so loosely that the knitted fabric has a longitudinal stretch before dyeing of at least 30%, and pre-shrinking the knitted fabric, the nomenclature being as follows:

S=cotton yarn number,
n=number of plies.

7. A method of claim **6**, in which the yarn is of a size between 30's and 60's.

8. A method of making stretch cotton knitted fabrics, which comprises producing cotton yarn of the size between 1's and 120's, twisting the yarn in the single to a twist given by the formula:

$$2.2 \text{ to } 5.5\sqrt{S}$$

some of said yarn being *s* twisted and some of said yarn being *z* twisted, making up a ply yarn having from 2 to 6 plies of said singles and having a twist in the ply corresponding to the formula:

$$1 \text{ to } 4\sqrt{\frac{S}{n}}$$

some of said ply yarn being *s* twisted and some of said ply yarn being *z* twisted, said ply yarn which is *s* twisted having an *s* twist in the single and said ply yarn which is *z* twisted having a *z* twist in the single, mercerizing said ply yarn under tension, adding *s* twist to the *s* twisted ply yarn and adding *z* twist to the *z* twisted ply yarn after mercerizing according to the formula:

$$0.5 \text{ to } 5\sqrt{\frac{S}{n}}$$

knitting both the *s* twisted ply yarn and the *z* twisted ply yarn into the same fabric while feeding these yarns alternately, conducting the knitting so loosely that the knitted fabric has a longitudinal stretch before dyeing of at least 30%, and pre-shrinking the knitted fabric, the nomenclature being as follows:

S=cotton yarn number,
n=number of plies.

9. A method of claim **8**, in which the yarn is of a size between 30's and 60's.

10. A method of making stretch cotton knitted fabrics, which comprises producing cotton yarn of a size between 1's and 120's, twisting the yarn in the single to a twist given by the formula:

$$2.2 \text{ to } 5.5\sqrt{S}$$

some of said yarn being *s* twisted and some of said yarn being *z* twisted, making up a ply yarn having from 2 to 6 plies of said singles and having a twist in the ply corresponding to the formula:

$$1 \text{ to } 4\sqrt{\frac{S}{n}}$$

some of said ply yarn being *s* twisted and some of said ply yarn being *z* twisted, said ply yarn which is *s* twisted having *s* twist in the single and said ply yarn which is *z* twisted having *z* twist in the single, mercerizing said ply yarn under tension, applying *z* twist to the *s* twisted ply yarn and applying *s* twist to the *z* twisted ply yarn after mercerizing according to the formula:

$$0.5 \text{ to } 5\sqrt{\frac{S}{n}}$$

knitting both the *s* twisted ply yarn and *z* twisted ply yarn into the same fabric while feeding these yarns alternately, conducting the knitting so loosely that the knitted fabric has a longitudinal stretch before dyeing of at least 30%, and pre-shrinking the knitted fabric, the nomenclature being as follows:

S=cotton yarn number,
n=number of plies.

11. A method of claim **10**, in which the yarn is of a size between 30's and 60's.

12. A method of making stretch cotton knitted fabrics, which comprises producing cotton yarn of a size between 1's and 120's, twisting said yarn in the single to a twist given by the formula:

$$2.2 \text{ to } 5.5\sqrt{S}$$

some of said yarn being *s* twisted and some of said yarn being *z* twisted, mercerizing said yarn under tension, adding *s* twist to the *s* twisted yarn and adding *z* twist to the *z* twisted yarn after mercerizing according to the formula:

$$0.5 \text{ to } 5\sqrt{S}$$

knitting both the *s* twisted yarn and the *z* twisted yarn into the same fabric while feeding these yarns alternately, conducting the knitting so loosely that the knitted fabric has a longitudinal stretch before dyeing of at least 30%, and pre-shrinking the knitted fabric, the nomenclature being as follows:

S=cotton yarn number.

13. A method of making stretch cotton knitted fabrics which comprises producing cotton yarn of a size between 1's and 120's, twisting said yarn in the single to a twist given by the formula:

$$2.2 \text{ to } 5.5\sqrt{S}$$

some of said yarn being *s* twisted and some of said yarn being *z* twisted, mercerizing said yarn under tension, applying *z* twist to the *s* twisted yarn and applying *s* twist to the *z* twisted yarn after mercerizing according to the formula:

$$0.5 \text{ to } 5\sqrt{S}$$

knitting both the *s* twisted yarn and the *z* twisted yarn into the same fabric while feeding these yarns alternately, conducting the knitting so loosely that the knitted fabric has a longitudinal stretch before dyeing of at least 30%, and pre-shrinking the knitted fabric, the nomenclature being as follows:

S=cotton yarn number.

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