SPANDEX FABRIC AND METHOD OF MAKING THE SAME

Filed April 28, 1967 2 Sheets-Sheet 1

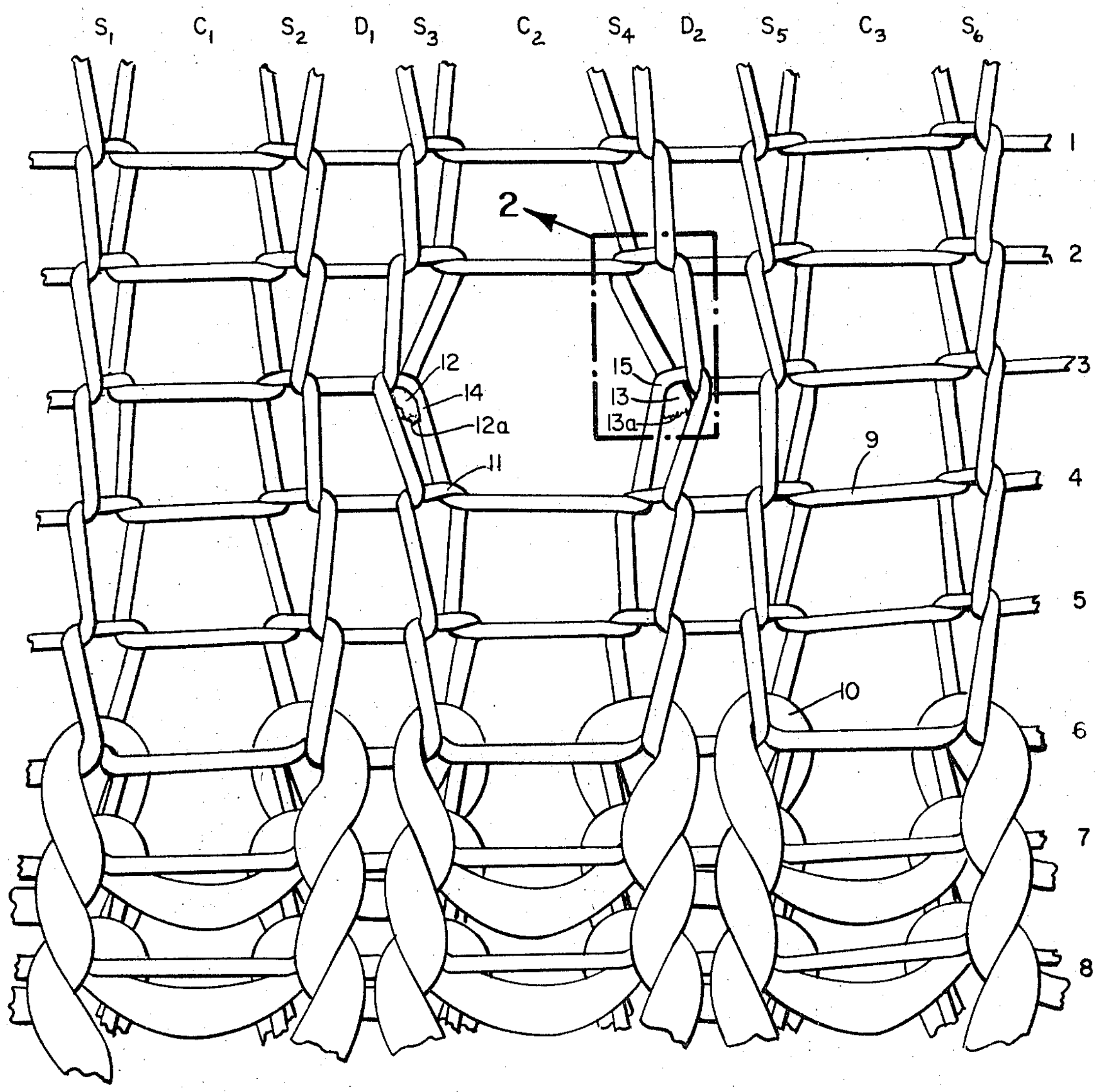

Fig. 1

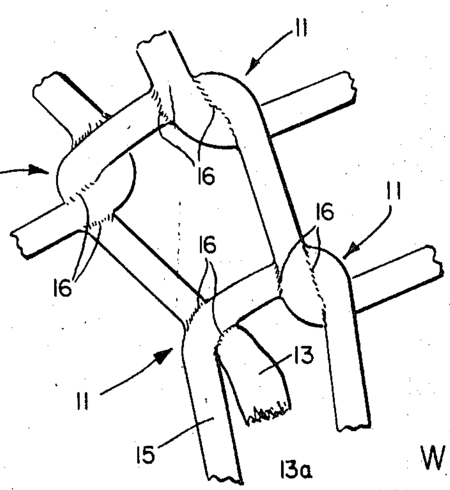

Fig. 2

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SPANDEX FABRIC AND METHOD OF MAKING THE SAME

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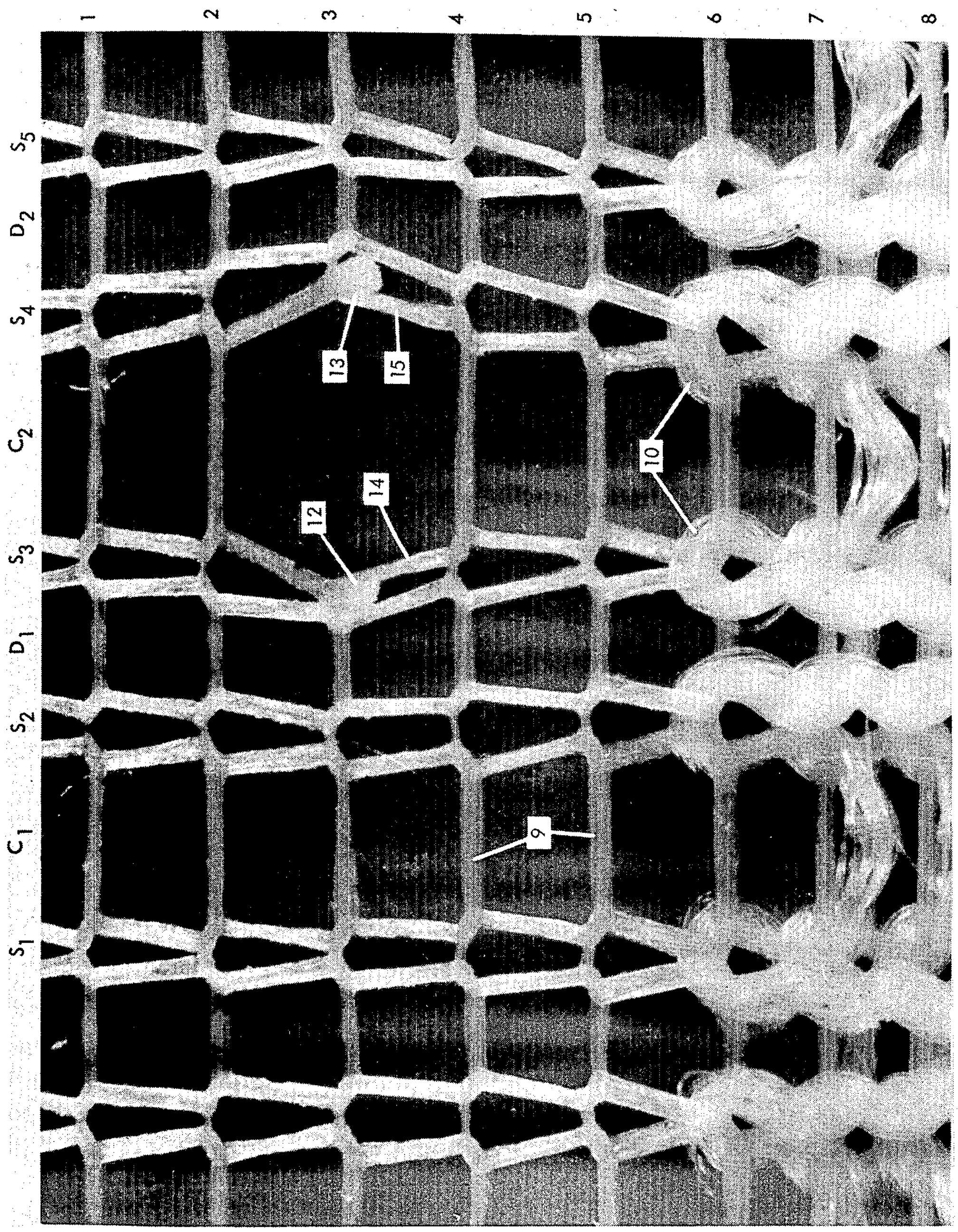

FIG. 3

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United States Patent Office

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SPANDEX FABRIC AND METHOD OF MAKING THE SAME

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U.S. Cl. 161—89 9 Claims

ABSTRACT OF THE DISCLOSURE

Fabric having concatenated loops of spandex yarn and of at least one other yarn is made non-run and given true shape stability without loss of elasticity, stretchability, flexibility and fitability, by being autoclaved in the presence of steam to produce fusion between contacting portions of the spandex yarn only.

SUMMARY OF DISCLOSURE

(A) The prior art

Although it is one of the oldest arts, knitting has increasingly been the object of extremely active research and development efforts.

Notwithstanding this great amount of effort and the sophisticated modern scientific techniques and tools employed, neither the knitting industry nor allied industries, such as the fiber producers, have been able to develop knitted fabric which will not run, which has elasticity and shape stability. This combination of properties is particularly desirable in knitted hosiery, underwear and figure-control garments, and in many other types of knitted fabrics and garments.

The prior art has been unable to obtain knitted fabrics combining the three properties in question and recent efforts have been confined to attempts to produce specialized fabrics which emphasize on of the features alone. This approach obviously has not resolved the problem and the steps necessary to obtain one isolated feature often are at the expense of, or prevent, the attainment of the other properties. The attempt to attain non-run stockings illustrates this point.

In the ladies' hosiery field, the occurrence of runs or ladders has always been a serious drawback. The amount of research effort devoted to solving this particular problem has been tremendous and the proposed solutions have covered a wide variety of approaches.

For example, the concept of applying adhesives to stockings to impart run-resistant properties has been the subject of a relatively large number of patents, none of which have been used commercially on any significant scale. See for example, U.S. Patent 2,962,384 which itself reviews a number of such patents.

In recent years, a great deal of effort has been concentrated upon designing special stitch structures to impede the wale-wise withdrawal of knitted loops which is characteristic of a run in knitted fabric. Although some of these stitch structures have proved to offer a satisfactory degree of run-resistance, they are not completely immune to runs, i.e. they are not "non-run" fabrics. They are, in addition, subject to certain drawbacks and particularly the fact that the stitch structure reduces the elasticity of the fabric, often to the extent that breaks occur under stress of wearing. In addition, such fabrics are expensive and difficult to manufacture.

In the past, the idea of achieving non-run characteristics by fiber bonding has been discussed in speculative terms. In the one or two instances where fiber-to-fiber bonding has been attempted, the results have been totally unsatisfactory from a commercial point of view. For

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example, U.S. Patent 2,308,593 discloses fabric knitted from yarn which is spun from at least two different types of fiber, each having different solubility properties. When the fabric is treated with a particular solvent, one of the fibers partially dissolves and becomes sticky. Where two such fibers are lying adjacent to each other in the fabric, they will stick together. For various reasons, including those pointed out in U.S. Patent 2,962,384, this method has not proved workable.

U.S. Patent 3,271,220 discloses a method of bonding resinous fibers, such as nylon to nylon, by radiation from a high energy light pulse source. This technique is not deemed applicable to fabric having two or more different types of fibers in plated or other adjacent relationship. Furthermore, although this method can produce a structure wherein most of the fiber junctions are bonded, the bonding produces such radical inelasticity that the fabric has no stretch for practical purposes. Such fabric definitely has no utility in the important fields of hosiery and underwear, and it is doubtful whether it has use in any normal type of garment. The inelasticity of the fabric is a defect which is recognized in said Patent 3,271,220 and the suggestion is made therein that in order to produce stockings, nylon fiber intersections should be bonded at random. It is unclear how random bonding could be achieved under ordinary mill conditions, and it is obvious by definition that a stocking with random bonding would be subject to runs.

The U.S. Patent 3,271,220 referred to above is of interest, however, because it discusses a problem which has plagued those who have considered fiber-to-fiber bonding. Thus, said patent states that the fibers cannot be subjected to longer periods of heating using conventional heating equipment at temperatures normally thought necessary for fusion because they will be destroyed or permanently damaged. This is the reason why the patent employs a transient heating effect in the form of a short duration light pulse.

Nylon, polyester and polypropylene, for example, have melting points in the range of 338° F.–482° F. In order to obtain the fusion resulting in fiber-to-fiber bonding, it has been thought that treatment necessarily would have to be carried on at a temperature very close to the melting point. Since this would melt, permanently discolor or permanently damage these synthetic fibers, plus destroying other synthetic fibers and all natural fibers in the fabric, there appeared to be no point in pursuing fiber-to-fiber bonding by the prolonged application of heat.

The very important elastometric fiber spandex did not receive serious consideration for fiber-to-fiber bonding because it has a melting point of approximately 482° F.

Thus, the prior art has failed to produce a truly non-run knitted fabric and those fabrics which have a certain degree of non-run performance are without the other important characteristics of elasticity and/or shape stability.

To achieve elasticity in knitted fabrics beyond that which the knit construction itself affords, there have been introduced in recent years numerous types of synthetic yarns which have been treated by crimping and other methods to impart "stretch." However, these yarns are not elastic even when so treated and the degree of "stretch" which is imparted is actually quite limited as is their power of recovery.

Of course, both bare and covered rubber has long been used to give knitted fabrics elasticity such as in the tops of men's hosiery, in support hosiery, and in figure-support garments. However, rubber is extremely difficult to knit into a fabric and almost tends to pull out of fabrics after relatively short periods of wear. Moreover, rubber is subject to serious deterioration when subjected to repeated washing or dry-cleaning. Of course, the use of rubber gives neither non-run nor shape stability characteristics to a fabric.

Spandex, which is a generic term for manufactured fibers in which the fiber forming substance is a long chain of synthetic polymer comprised of about 85% or more of segmented polyurethane, has been employed in recent years to give elasticity to knitted fabrics. Spandex is far superior to natural rubber in terms of elasticity, shelf-life, dye-acceptance and stability to oil, dry-cleaning chemicals, sea-water, sunlight and ultra-violet. Spandex, like natural rubber, however, is very difficult to handle during knitting. Moreover, because it is knit in under tension and has excellent power of recovery, it tends to withdraw from the stitches into which it is initially drawn. In fact, in certain important applications such as elastic tops for men's hose, no really successful method for locking in the spandex has ever been developed.

(B) The present invention

Notwithstanding all of the foregoing, I have discovered that spandex yarn concatenated to spandex yarn can be successfully fused to form a truly non-run fabric with excellent elastic and shape stability properties if heat-treated in a particular manner. This discovery, in brief, is that if spandex yarn is linked or concatenated to spandex yarn under tension in a fabric and the fabric heated, the spandex junctions will fuse at temperatures far below the melting point of spandex (482° F.) and also well below the tackiness point of spandex (about 350° F.). At the present time, I do not understand why this phenomenon occurs. Indeed, that fusion takes place at such low temperatures that the process is not only not obvious but on its face would seem impossible in view of the much higher melting and tackiness temperatures of spandex.

In any event, I have found that fusion will take place upon steam autoclaving about as low as 230° F. (and probably at slightly lower temperatures if enough time is employed) and that excellent results are obtained in the range of about 250° F.–290° F. when the fabric is heated for about 15–30 minutes. This is, of course, a discovery of truly basic importance since it makes it possible to achieve fiber-to-fiber bonding to create a non-run elastic and shape-stable fabric or garment at temperatures low enough so that neither the spandex nor the other types of fibers which are knit in with the spandex will degenerate or be otherwise harmed.

The drawings:

A more complete understanding of this invention can be obtained by reference to the accompanying illustrations wherein:

FIG. 1 is a view of a portion of knitted fabric according to this invention;

FIG. 2 is an enlargement of the knitted loops bounded by the dot-dash rectangle identified by the numeral **2** in FIG. 1;

FIG. 3 is a photograph of the fabric of this invention under tension.

DETAILED DESCRIPTION

The portion of the fabric shown in FIG. 1 comprises a matrix or grid of knitted stitches of spandex yarn **9** in courses **1–8**. In courses **6–8**, a body yarn **10** is shown knit with the spandex. Body yarn **10** can be any one or more of the wide variety of synthetic yarns such as rayon, nylon, Orlon, Acrylon, Agilon, Dacron, etc. or a natural fiber such as wool or cotton. In the type of fabric shown in FIG. 1, the body yarn **10** actually was knit at the same feed as the spandex yarn **9** in such a manner that it is plated to one side of all the cylinder loops and to the other side of all dial loops.

The fabric portion in FIG. 1 has been stretched in order to clearly illustrate the manner in which the spandex loops concatenate with each other to form multiple junctions **11**, where the spandex yarn from one course lies across the spandex yarn from another course.

The fabric illustrated in FIG. 1 is essentially a tracing of the fabric shown in the photograph of FIG. 3. This fabric was treated in the following manner after knitting. First, it was wound into a roll under substantially uniform tension. The roll was then placed in an autoclave and was subjected to the following heating technique:

(1) Vacuum (28" of mercury): 6 min.
(2) Steam 27.162 p.s.i.g. 270° F.: 5 min.
(3) Exhaust to approximately 2 p.s.i.g.
(4) Steam 27.162 p.s.i.g. 270° F.: 5 min.
(5) Exhaust to approximately 2 p.s.i.g.
(6) Steam 27.162 p.s.i.g. 270° F.: 5 min.
(7) Exhaust to approximately 2 p.s.i.g.
(8) Steam 27.162 p.s.i.g. 270° F.: 5 min.
(9) Exhaust to approximately 2 p.s.i.g.
(10) Steam 27.162 p.s.i.g. 270° F.: 5 min.
(11) Exhaust to approximately 2 p.s.i.g.
(12) Steam 27.162 p.s.i.g. 270° F.: 5 min.
(13) Exhaust to approximately 2 p.s.i.g.
(14) Vacuum (28" of mercury): 6 min.

After the above heat treating process, the fabric was steamed and pressed for appearance.

The foregoing treatment of the fabric causes the spandex to fuse to spandex. In order to demonstrate this, I have severed one cylinder loop in course **3** of wale C–2, as shown in FIG. 1. The jagged ends of the spandex loop thus cut are indicated by the numerals **12** and **13**. Even though the cylinder loop was cut, the legs of the loop **12** and **13** did not withdraw from their adjoining sinker loops **14** and **15** respectively and as a result, a run did not occur in the fabric. Instead, the free legs **12** and **13** of the former cylinder loop have merely contracted into relatively small nubs, indicating that the spandex was under tension.

The spandex forming the fabric of FIGS. 1–3 is under tension, as indicated by the manner in which the sinker loops bow outwardly in sinker wales **S3** and **S4**. This distortion, of course, is a result of the tension release resulting from the severing of the cylinder loop.

As indicated, the reason that the legs **12** and **13** of the severed cylinder loop did not withdraw from their adjacent sinker loops **14** and **15** is that the base of these legs was fused to the spandex forming the sinker wales **14** and **15**.

To illustrate the fusion which took place upon the heat treatment of the fabric shown in FIGS. 1 and 3, an enlarged view of the portion **2** in FIG 1 is shown in FIG. 2. This view shows clearly that the spandex of leg **13** has fused as at **16** to the spandex of the sinker loop **15**. I have found that if a fabric is properly processed according to the method of my invention, the cut legs of spandex will not pull away from the welded junctions **16** under the stress imposed by wearing the fabric, and not even at significantly greater stresses.

The fabric shown in the photograph FIG. 3 actually was knit with spandex and the body yarn **10** in all eight courses shown. However, after processing through the heating cycle described above, the body yarn **10** was removed from the courses **1–5**. This not only serves to expose the nature of the spandex mesh or matrix, but it is clear proof that the fusion of spandex to spandex takes place even when the spandex is knit with another yarn.

Thus, with this invention, the non-spandex yarn is not bonded anywhere in the fabric, either to itself or to the spandex yarn. The spandex yarn, fused only at the points where spandex yarn concatenates with spandex yarn, provides an elastic matrix or grid which stretches and relaxes as required during wear, thus providing an improved non-run structure having the full and complete flexible response to body movement so desired of knitted structures. For the first time, an effective non-run knitted fabric is provided without loss of the important characteristics of flexibility, stretchability and fitability.

The spandex fabric processed according to my invention, therefore is a true non-run fabric. When another yarn (or yarns) is knit in with the spandex, as is illustrated in FIG. 1, the non-run mesh or matrix formed by the spandex yarn **9** effectively prevents runs from occurring in the fabric even through the body yarn **10** itself may be severed. In most cases, the spandex is knit into the fabric under such tension that the loops of spandex actually contract about the body yarn **10** and this locking action, plus the inability of the matrix of spandex to run, effectively prevents the body yarn **10** from running also.

It should be carefully noted that the 14 step heat treating cycle which has been previously described is given by way of example only and does not restrict the broad scope of this invention. In fact, the multi-step treatment is simply one which after experimentation appears to be very suitable for use in producing a commercial fabric of the type shown in FIG. 3 with the particular brand (Chemstrand) of spandex which was used to form the fabric of FIG. 3. Thus, the number of cycles, the time and temperature, etc. are subject to variation since the optimum results depend on the brand of spandex used, the type of knit or other fabric construction, the kind of heat and the amount of stretch imposed on the fabric during the processing. In general, however, the multi-stage method appears preferable for most commercial brands of spandex including Numa, Lycra and Chemstrand.

Basically, I have discovered that when a fabric including spandex concatenated to spandex under tension is subjected to heat, the spandex yarns will fuse to each other at their points of contact, and that apparently because of the tension involved, the fusion can be produced at temperatures less than the melting point of spandex (482° F.) and the tackiness point of spandex (about 350° F.)

After many experiments, I have concluded that the practical temperature range for carrying out the process according to this invention is from about 230° F. to about 290° F.–300° F. Below 230° F., I have found that the spandex will not fuse even when constantly heated for several hours. Thus, although it might be possible to obtain fusion if the spandex were heated for days, the practical lower limit of the temperature range is at 230° F.

Regarding the top of the temperature range, I have found out that when the treatment is carried on in an autoclave at temperatures approaching about 300° F., the body yarn (cotton, nylon, rayon, etc.) will discolor. At this temperature, also, wool degenerates and becomes so weak that it tears easily. Thus, even though the spandex may fuse at temperatures, above about 300° F., the discoloration, weakening and other types of degeneration which occurs in common types of body yarns (and at high enough temperatures in the spandex also) makes the use of such elevated temperatures prohibitive for practical purposes.

I have found that for most brands of spandex and most types of body yarns, excellent results are obtained by subjecting the fabric to steam at a temperature of from about 250° F.–290° F. in an autoclave for about 30 minutes. As the fourteen step cycling process given in the beginning indicates, I have found it very advantageous to use about five or six 5 minute periods when steam is injected into the autoclave alternated with exhausting the autoclave to vacuum. Apparently, the creation of the vacuum at the end of the exhausting steps in this type of cycling process ensures that the steam penetrates completely through the fabric when it is next injected. Of course, the desired fusion of spandex can be obtained in one step if desired.

Although, as I have stated, the most successful results have been obtained by processing which involves a total of about 30 minutes heating at a temperature range of about 250° F.–290° F., it is clear that the total heating time may be cut down to about 15 minutes by the use of somewhat higher temperatures (below the 300° F. top limit) or that somewhat lower temperatures (above the 230° F. bottom limit) may be used if heating a longer time. Further, the total length of time and/or number of cycles required to process a given fabric batch is affected by the amount of fabric being processed in the batch.

Although the use of steam as a vehicle for heat is preferred, the use of other types of heat, including dry hot air can accomplish the fusion of spandex to spandex of this invention. The spandex should be under enough tension to provide a firm contact at the points where the spandex fibers touch. In certain fabric constructions sufficient contact exists, without the need of imposing external tension, as in fabrics in which the spandex is knit under high tension and in which the stitch structure is such that the spandex remains under considerable tension when the fabric is relaxed. When such "internal" tension does not thus exist, or when it is desired to supplement the same, fabric may be put under tension by external means, e.g., as it is wound on a roll or by other devices such as a tenter frame. Optimum results are obtained when uniform tension is used.

When the fabric has been made into a stocking or garment prior to processing, the stocking or garment may be placed over a form to obtain the desired size or shape required while at the same time establishing sufficient tension for fusion. Thus, the required stress is placed upon the spandex while at the same time the use of a contoured form results in the setting of the fabric into a desired shape by the end of the processing.

It should be noted that with this invention it is now possible to ensure that the spandex does not slip out of a knitted fabric. Thus, for example, the tops of men's stockings can be formed using a construction similar to or identical with that shown in FIG. 1 and, by being treated with the method of this invention, the spandex will not withdraw from the top.

Thus, it is possible for the first time to produce a fabric and garments made therefrom combining the two qualities of non-run and elasticity.

The method of this invention also produces fabrics and garments having a desirable degree of shape stability. That is, spandex is a thermoplastic material which is set upon the application of heat in the ranges contemplated by this invention. As a result of the setting, the fabric or garment will tend to maintain the shape or dimension to which it was held during treatment. Accordingly, the fabric or garment has shape stability. This shape stability is enhanced by another characteristic of the invention, namely, that the bonded spandex mesh strongly resists shrinkage.

I have found, furthermore, that the amount of spandex may be proportioned either to give the finished product a powerful elastic quality suitable for foundation garments or support goods or minimized to produce fabrics with relatively light or "soft" recovery characteristics suitable for underwear, outerwear, stretch hosiery and many other uses. Although a simple rib knit construction has been illustrated, it will be understood that this invention can be utilized in many other knit constructions and other methods of concatenating fibers to form a fabric. Thus, for example, a plain jersey stitch with a spandex and a body yarn knit at every feed and heat treated as described gives the non-run and other characteristics described for the ribbed fabric which is shown. Also, a fabric of either rib or plain construction can be knit with spandex merely in portions of the fabric to form non-run areas and run guard barriers. For example, non-run bands can be formed by knitting two or more adjacent courses of spandex, then knitting only body yarn for a selected number of courses, and then knitting spandex for a selected number of courses, etc. Also, spandex can be knit in alternate courses with tuck stitches "joining" the courses at selected intervals to provide the spandex to spandex interlinking or concatenation required for fusion.

Another advantage of the present invention is that fabrics treated according to the method of the invention can be cut into very narrow strips which will not run or ravel and which are useful as tapes, bindings, bandages, etc.

The thermosetting of the spandex which results when the fabric or garment is treated according to the method of the present invention also makes it possible to permanently set a crease into the fabric without the use of resins or other chemicals. As previously noted, the shape stability which is given to the fabric prevents the fabric from curling. This factor plus the non-run quality of the fabric makes it very easy to cut and work within the mill.

It is to be clearly understood that the terms and expressions used herein are employed as terms of description, and not of limitation, and that I have no intention of using such terms and expressions to exclude any equivalents of the method or other portions of the invention described. It is also to be clearly understood that what is specifically shown and described herein represents a preferred embodiment only of the invention, and that various changes and equivalents may be resorted to without departing from the principles of the invention or the scope of the claims hereof. Accordingly, it is intended to claim the present invention in generic terms and also in terms which are directed to particular embodiments, as indicated in the appended claims.

What is claimed is:

1. A fabric having concatenated loops comprising both spandex yarn and another yarn of a different material wherein only contacting portions of spandex yarn are fused together.

2. A fabric comprising a matrix of inter-connected spandex yarn and having another yarn of a different material incorporated in the spandex yarn matrix yarn, wherein only the spandex yarn is fused to spandex yarn at the inter-connections.

3. A fabric comprising a matrix of spandex yarn concatenated to spandex yarn so that portions of the spandex yarn are in contacting relationship, and having another yarn of a different material incorporated with the spandex yarn matrix, wherein fusion exists only between those portions of the spandex yarn which are in contacting relationship.

4. A fabric comprising a knit matrix of spandex yarn, said matrix including junctions at which spandex yarn is in contact with spandex yarn, and having another yarn of a different composition incorporated in the spandex yarn matrix, wherein substantially all of the spandex yarn junctions are fused and wherein the other yarn is un-fused.

5. The invention of claim 3 wherein the fabric is in the form of a garment.

6. The invention of claim 3 wherein the fabric is incorporated in a stocking.

7. The invention of claim 4 wherein the fabric is in the form of a garment.

8. The invention of claim 4 wherein the fabric is incorporated in a stocking.

9. A garment including a fabric comprising a matrix of inter-connected spandex yarn, and another yarn of a different material integrated with the spandex yarn, wherein only the spandex yarn is fused to spandex yarn at the inter-connections.

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U.S. Cl. X.R.

28—73; 66—202; 161—76, 92

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(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,578,546 Dated May 11, 1971

Inventor(s) William F. Morancy

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 7, line 35, delete "yarn", second occurrence

Signed and sealed this 3rd day of August 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents