Jan. 31, 1967 H. KNOHL 3,301,018

ELASTIC YARN AND GARMENT INCORPORATING IT

Filed Jan. 26, 1965 5 Sheets-Sheet 1

Fig. 1.

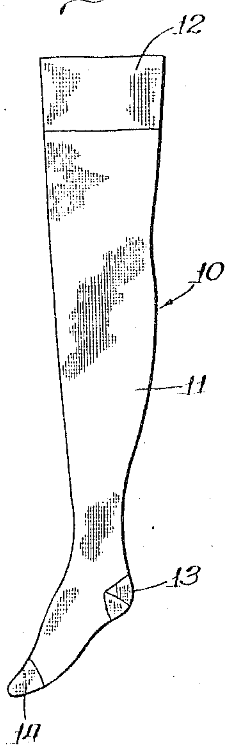


Fig. 2.

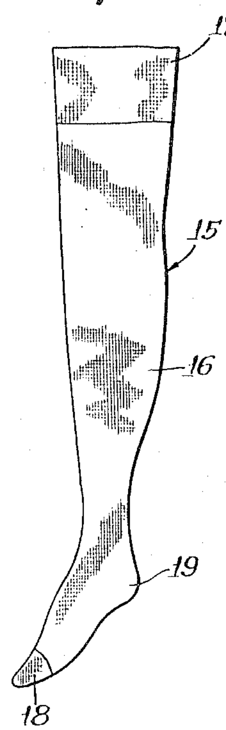


Fig. 3.

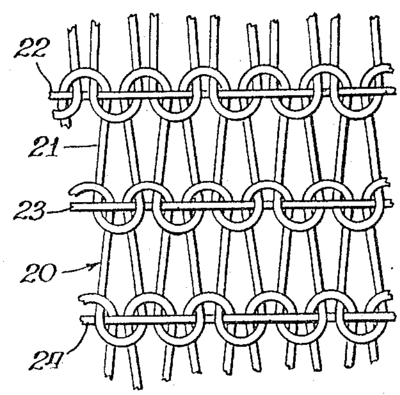


Fig. 4.

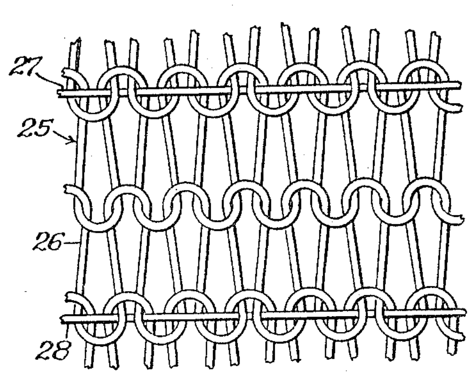
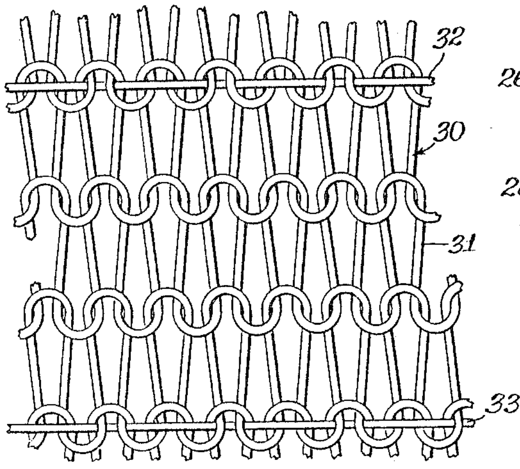


Fig. 5.



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ELASTIC YARN AND GARMENT INCORPORATING IT

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Fig. 6.

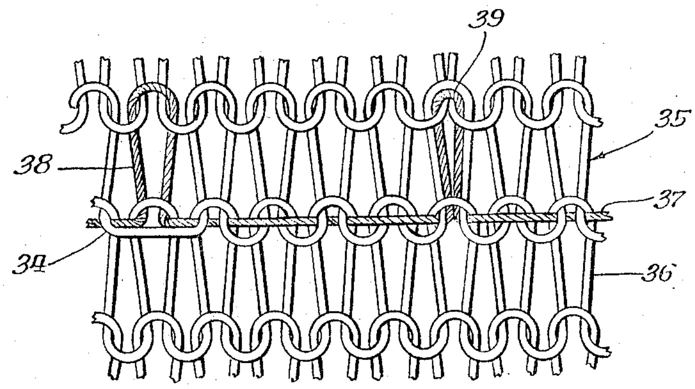


Fig. 7.

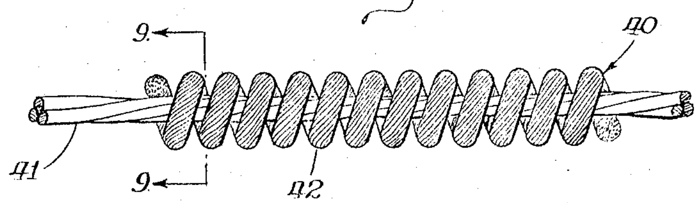


Fig. 8.

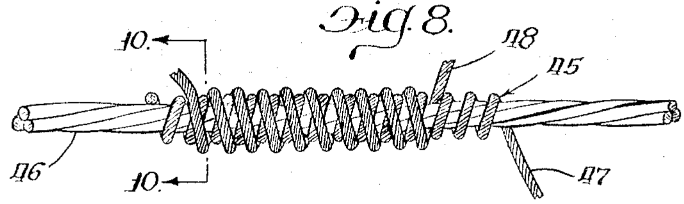


Fig. 9.

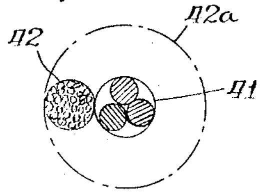
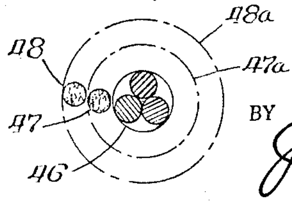


Fig. 10.



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ELASTIC YARN AND GARMENT INCORPORATING IT

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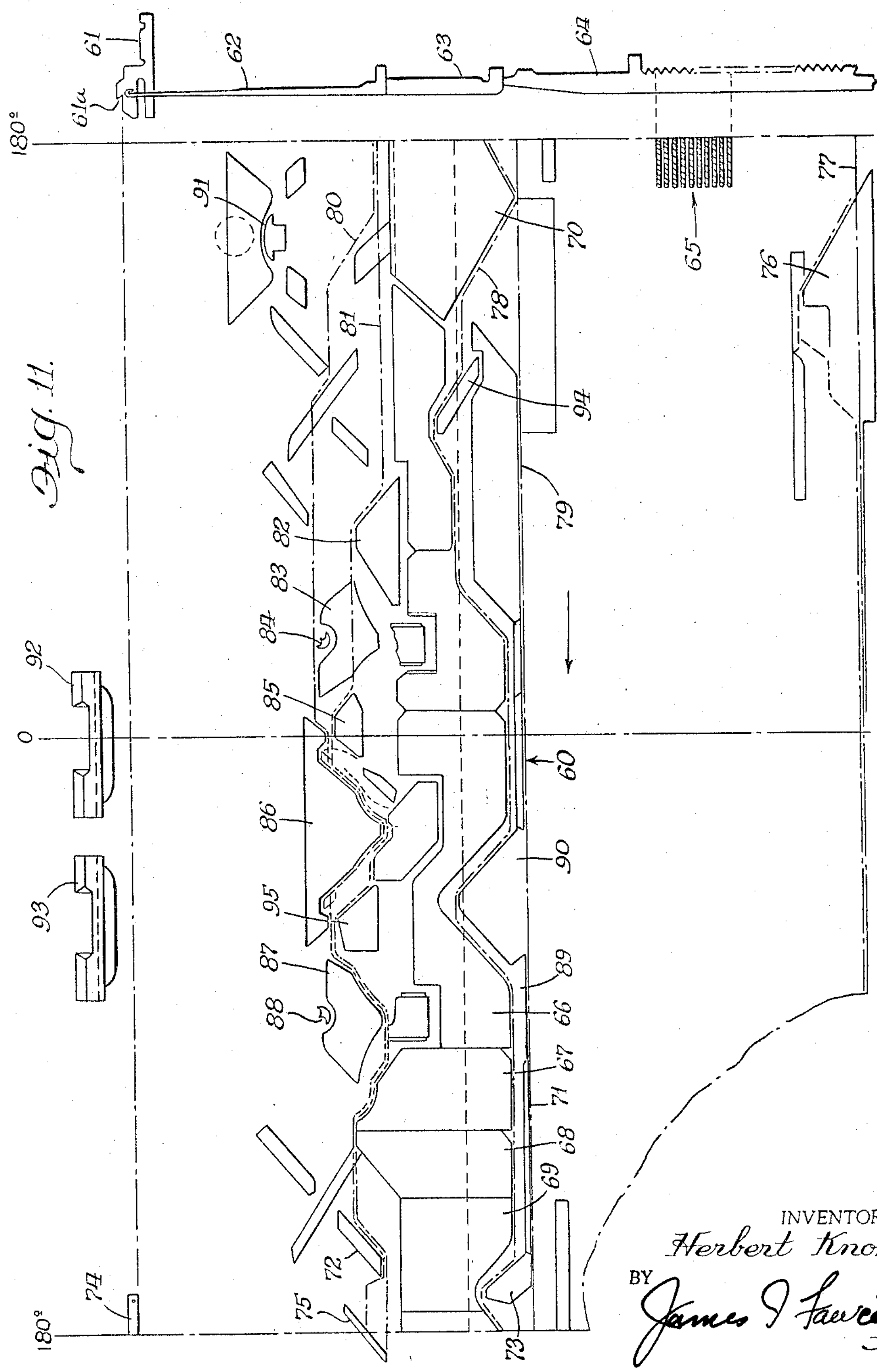

Fig. 11.

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ELASTIC YARN AND GARMENT INCORPORATING IT

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Fig. 12.

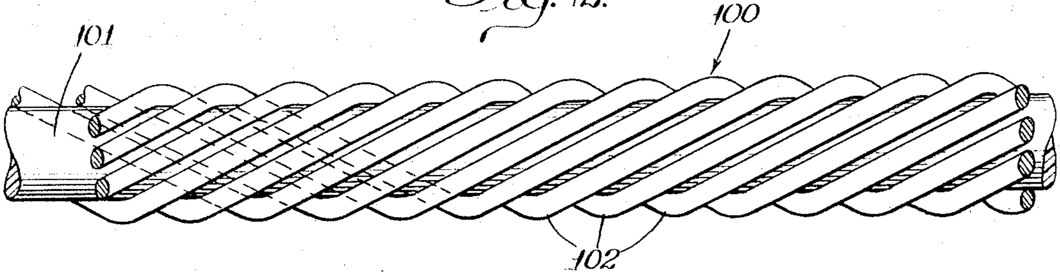


Fig. 13.

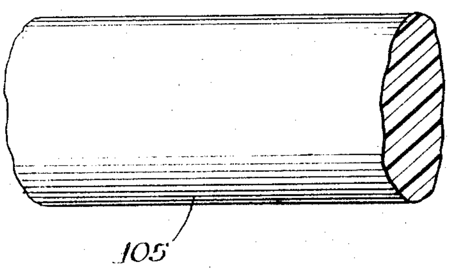


Fig. 13a.

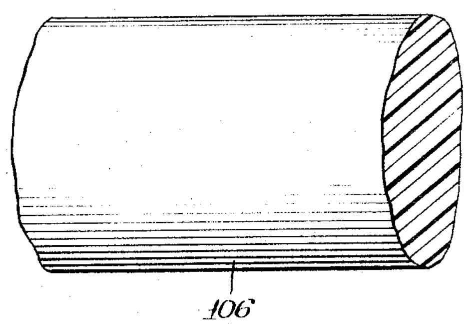
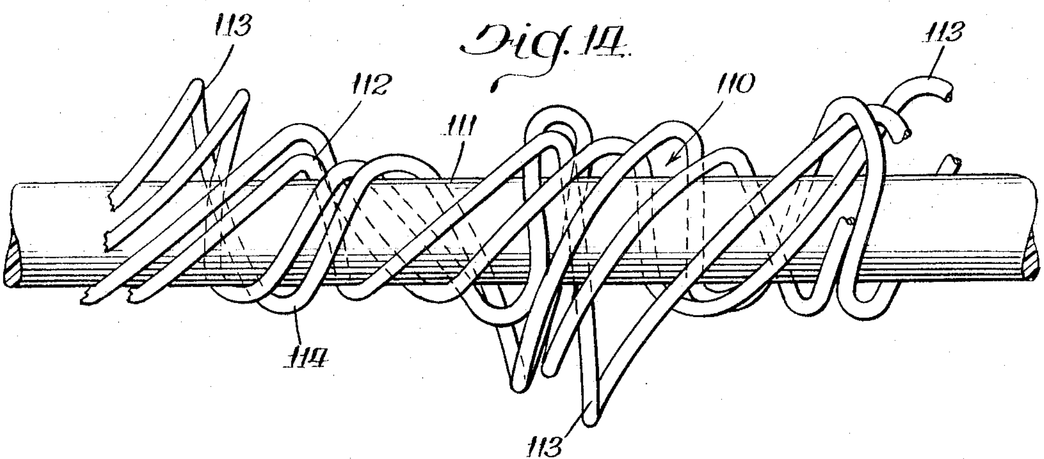


Fig. 14.



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ELASTIC YARN AND GARMENT INCORPORATING IT

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Fig. 15.

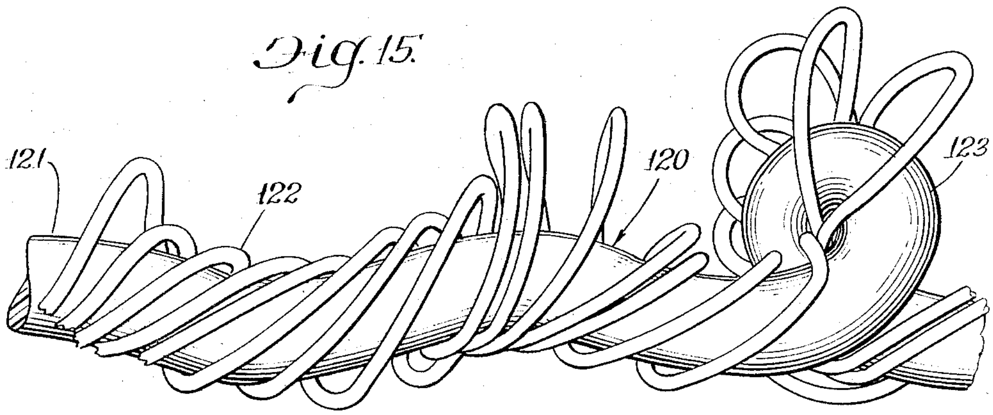


Fig. 16.

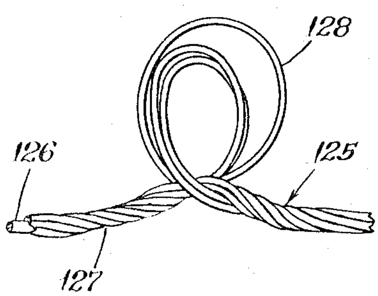
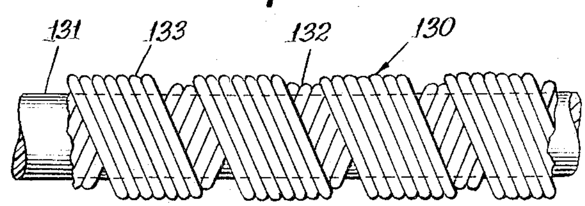


Fig. 17.



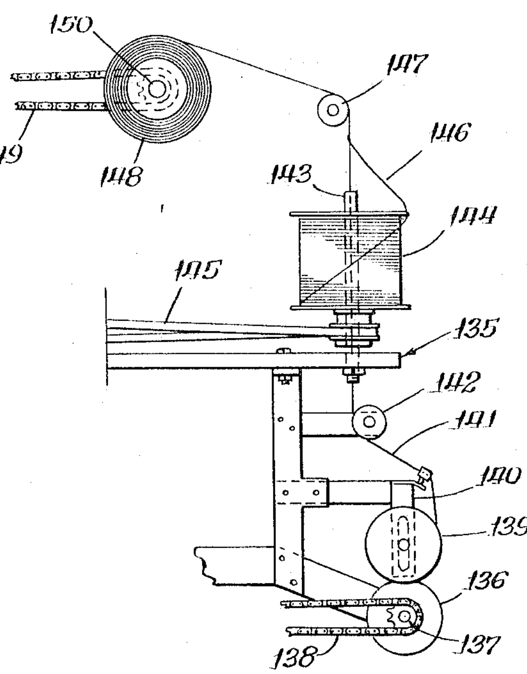


Fig. 18.

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United States Patent Office 3,301,018
Patented Jan. 31, 1967

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3,301,018
ELASTIC YARN AND GARMENT INCORPORATING IT

Herbert Knohl, Seneca, S.C., assignor to The Kendall Company, Boston, Mass., a corporation of Massachusetts

Filed Jan. 26, 1965, Ser. No. 428,185
15 Claims. (Cl. 66—202)

This is a continuation-in-part of U.S. patent application Serial No. 342,882 filed February 6, 1964.

This invention is concerned with elastic yarn and with circular knitted very sheer streetwear jersey stockings which incorporate elastic yarn largely defining the variable shaped limp dimensions in those portions in which it is incorporated and causing the stocking when properly worn to fit snugly in those portions in which it is incorporated. Optionally the elastic yarn may exert sufficient pressures to make the stocking prophylactic or even therapeutic in those portions. More specifically, this invention relates to a very fine covered elastomeric-core yarn of the short stretch variety and to stockings in which such yarn is largely if not entirely inlaid in the knitted stitches of nylon or other durable structural yarn.

In my previous invention disclosed in United States Reissue Patent No. 25,046, whose term runs from December 6, 1960, I disclose among other things a stocking in which the inlaid yarn is a bare elastomeric yarn. Stockings made in accordance with that invention represent perhaps the ultimate in sheerness and appearance, but leave something to be desired from the viewpoint of wear.

It is the primary object of this invention to provide a novel very fine covered elastic yarn and to produce a well-fitting stocking of the circular-knit type inlaid with such elastic yarns which stocking combines the properties of sheerness and wear-resistance.

I have found that certain inlaid yarns of covered elastomer, used in place of the bare elastomer described in my prior patent, significantly improve the wear properties of the stocking without any appreciable adverse effect on the other desirable properties of the stocking.

The yarns I have found useful are "short-stretch" covered elastic yarns, which typically have useful elongations ranging from 100 to 300%. Their short-stretch character results from the prestretching of the elastomeric core during the wrapping or covering operation. This prestretching reduces the diameter of the core so that even with the wrapping yarn in place, the total diameter of the covered yarn may be of the same general order of a comparable bare elastomeric yarn. Furthermore, the prestretching produces a covered yarn of high initial modulus so that despite the small diameter of the core, the yarn is capable of exerting considerable retractive force in the finished stocking.

Short-stretch yarns having elongations in the range of 100–150% are particularly useful because they are typically of small bulk and high modulus.

The structural yarn which forms the framework of knitted stitches can be silk, rayon, or the like, but is preferably thermoplastic, such as nylon or polypropylene. Similarly, the very fine-filament covering yarn preferably should be a low-twist (¼ to 2 turns per inch) strand of strong, durable, abrasion-resistant material and preferably thermoplastic, such as nylon or polypropylene. Usually both the elastomeric core and the covering yarn are multifilament, and preferably the covering should lie in a single filament thickness to form a very thin wear resistant sheath about the core.

The yarns of this invention are preferably wild yarns. That is, there is a minimum tension which varies with the particular yarn under which the yarn must be retained.

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Relaxation of the yarn beyond this point causes the yarn to go out of control and form "e" bends, tails and crunodal loops, all incuding the core yarn.

For purposes of this invention the term jersey or jersey knit is defined as including plain jersey knit stitches, modified jersey knit stitches and these in combination with tucked stitches and floated yarns.

By the term "elastomeric" I mean to include natural and synthetic rubbers as well as other polymers and copolymers which have elastic or rubbery characteristics. Typically, the uncovered elastomeric core will have a useful elongation considerably greater than that of the covered yarn because the core is stretched in the covering operation. The selection of the particular elastomer for the core, the core size, and the degree to which the core is stretched in the covering or wrapping operation will depend on the characteristics desired in the finished stocking; i.e., whether merely a snug-fitting stocking is desired or a stocking that performs a positive support function.

Illustrations of typical stockings of the invention, typical fabrics of the stockings, variations from uniform inlay of elastomeric yarns, typical elastic yarns and a typical cam ring layout for producing the stockings of the invention are shown in the drawings in which:

FIGURE 1 is an illustration of a typical above-the-knee stocking of the invention showing a typical toe and a typical conventional elastomer-free reciprocated heel.

FIGURE 2 is an illustration of a typical above-the-knee stocking of the invention showing a typical toe but with a heel formed by circular knitting and thermoforming and including the elastomeric-core yarn.

FIGURE 3 illustrates the back side of a typical fabric of the invention with the elastomeric-core yarn inlaid into every course and locked into different wales in adjacent courses.

FIGURE 4 illustrates the back side of a typical fabric of the invention showing the elastomeric-core yarn in every other course and locked in the same wales.

FIGURE 5 illustrates the back side of a typical fabric of the invention showing the elastomeric-core yarn in every third course and locked in the same wales.

FIGURE 6 is an illustration of a typical fabric of the invention showing variations in which the elastomeric-core yarn is knitted into the structural fabric as a stitch.

FIGURE 7 is an illustration of one covered yarn of the invention showing a single fine-filament spirally wound yarn covering the elastomeric core.

FIGURE 8 is an illustration of another yarn of the invention showing double coverings spirally wound in opposite directions about the elastomeric core.

FIGURE 9 is a cross-sectional view of the yarn of FIGURE 7 showing the fine filaments of the covering at greater magnification when viewed looking in the direction 9—9. The covering yarn **42** is shown as if the cut had been made at right angles to the axis.

FIGURE 10 is a cross-sectional view of the yarn of FIGURE 8 showing the fine filaments of the two covering yarns in greater detail when viewed looking in the direction **10—10**. The covering yarns **47** and **48** are shown as if the cut had been made at angles to the axes.

FIGURE 11 illustrates a modified cam ring layout for the Scott & Williams 3¾" AMF stocking knitting machine.

FIGURE 12 is an illustration of a preferred wild yarn of the invention shown at dead stretch wherein the low twist single thickness fine filament covering winds as a multifilament band about the elastomeric core.

FIGURE 13 is an illustration approximately to the same scale of the core of FIGURE 12 in the bare relaxed condition considering the core of FIGURE 12 to be elongated to a total length 475% of its relaxed length.

FIGURE 13*a* is an illustration approximately to the same scale as the core of FIGURE 12 in the bare relaxed condition considering the core of FIGURE 12 to be elongated to a total length 650% of its relaxed length.

FIGURE 14 is an illustration of a typical yarn of the invention shown under some tension and in a partially relaxed condition, 25 inches of yarn at dead stretch being relaxed to 10 inches.

FIGURE 15 is an illustration of a typical yarn of the invention under insufficient tension to prevent the formation of crunodal loops including the elastomeric core.

FIGURE 16 illustrates the general appearance of filament loops formed when the yarn is relaxed from dead stretch and the covering has too few turns per inch.

FIGURE 17 illustrates a double wrapped elastic yarn of the invention.

FIGURE 18 illustrates diagrammatically the apparatus for preparing the novel yarns of the invention.

There are apparently at least three factors which cause difficulty with fine covered elastic yarns of the wild type. One of these is the relationship between the core size and the filament size. Normally covering yarns may be applied to large elastic cores (70 denier and above) without difficulty. When the core denier becomes as fine as 40, however, an undesirable change in appearance becomes manifest whenever the covering yarn filaments are as large as 5 denier each. The appearance is still passable when such covering filaments are of nylon 6 whereas when they are of nylon 66 they are so poorly conformable as to be unacceptable. With 70 denier and finer cores, the appearance is very much improved and the fineness is accentuated when the covering yarn filaments are at least finer than 3 denier each and preferably in the range of 1 denier each.

A second factor which causes difficulty with covered elastic yarns of the wild type is the formation of outstanding loops of covering filaments as the yarn is relaxed somewhat from dead stretch. These loops are harmless when they are quite small and do not cause difficulty in knitting. Furthermore, when they are small, they disappear when the stocking or other garment is boarded. When the loops become sufficiently large, however, they not only interfere with the inlaying process by becoming engaged with the sinker nibs but they do not completely disappear when the garment is boarded. Generally pronounced covering filament loops are caused either by coverings which are too wiry because the individual filaments are of too large denier or they are caused by failure to provide a sufficient number of turns of each fine covering filament per inch of dead stretched core or both. If this number is relatively low, the covering filament is inclined to a substantial extent and an individual turn of the covering filament is relatively long. As the yarn contracts from the dead stretch position and the covering turns become closer to the vertical, the length of each turn causes it to stand out very loosely from the core. Furthermore, the twist imparted to the covering causes it to stand out in irregular loops with the covering contacting the core at some points and blossoming out in large filament loops at other points. When these enlarged loops become large enough that the sinker nib will enter into them, it becomes extremely difficult to knit acceptable elastic inlay garments and even after boarding some of the fuzziness caused by covering loops may be apparent in the garment.

A third factor which causes difficulty with covered yarns is the formation of "e" bends or tails including the core in the finished yarn. This is caused when the number of covering filaments per inch of dead stretched core is too great. Apparently when the individual filaments begin to crowd each other as the yarn relaxes from the dead stretch they cause "e" bends and cunodal loops including the core yarn. When this occurs, obviously the yarn is out of control and frequently it is not possible by stretching the yarn to undo the damage. All wild yarns of the type used in this invention have a point where they will go out of control. Where the number of covering filaments per inch of dead stretch core is small, this point where the yarn becomes out of control is very much toward the relaxed end of the yarn. As the number of covering filaments per inch of dead stretch core is increased, the point where the yarn becomes out of control moves toward the dead stretch end so that the usable stretch range becomes narrower and narrower. In knitting stockings, for instance, on the circular knitting machine, there are limitations on how short the usable range for inlay yarns may be.

The wild yarns of this invention are those which permit a 25-inch length at dead stretch to be relaxed at least to 12½ inches and preferably in the range of about 8½ to 10 inches without becoming out of control, that is, without the formation of "e" bends, tails or crunodal loops respectively including the elastomeric core. I have found this range to be necessary in order that inlaid elastic yarn stocking may be produced with proper dimensions in the ankle, calf, knee and thigh portions.

Obviously, where a long stretch core is used, it is possible to retain a satisfactory usable range by moving the point where the yarn goes out of control into higher modulus stretch areas. Thus, the long stretch core can be covered with an increased number of filaments per inch at dead stretch. In this higher modulus area the core has a still further reduced diameter due to stretching and hence the yarn is finer in the usable range than a yarn made from a short stretch core. Likewise, the long stretch core yarn may start with a reduced diameter relaxed core since it is operative at a point in the high modulus portion of hte stretch curve.

I have found that the most efficient and satisfactory covering for the elastomeric cores of the yarns useful in this invention are multifilament yarns composed of very fine individual filaments. When the filaments are of the order of 1 denier, the composite yarn is much more conformable and uniform in its relationship to the core. As an example I have found that a single 30 denier nylon yarn made up of 26 individual filaments makes an excellent single covering for purposes of this invention.

Single coverings have largely been rejected for use in elastic yarns to form the basic knitted structure of elastic stockings because such covered yarns, when so used, cause the stocking to assume a definite twist. But it has been proposed to use right and left hand covered yarns in a multifeed operation in which the tendency to twist in one direction in one course is counteracted by the tendency in the next course to twist in the opposite direction.

But when elastic yarns are inlaid, I find that the single covering has no tendency to cause twist and I find it is unnecessary to stabilize such yarns prior to knitting as is the practice today whether the covering be a single covering or a double covering. I have found it is quite feasible to control such yarns by wrapping them on a cylindrical spool with sufficient tension to prevent the yarn from kinking. When the stocking is knitted the tension on the yarn is never permitted to relax to the point where kinking occurs. After the yarn is introduced into the fabric, the fabric prevents the relaxation until the yarn is stabilized in the boarding operation. Instead of the use of a cylindrical package a stationary conical yarn package with well known controlling devices now used in controlling torque yarns may be utilized.

Examples of typical yarns are as follows:

EXAMPLE A

A 20 denier polyurethane type elastic core (Spandex) having a total length at dead stretch 475% of its relaxed length was covered in a single helical winding with a 7 denier 7 filament nylon low-twist yarn under the following conditions:

Let-off core feed, inches/min.	54.35
Take-up wrapped yarn, inches/min.	210
Spindle, revolutions/min.	16,400
Turns, covering/inch	78
Percent elongation	286

EXAMPLE B

A 40 denier polyurethane type elastic core (Spandex) having a total length at dead stretch of about 480% of its relaxed length was covered in a single helical winding with a 30 denier 26 filament nylon low-twist yarn under the following conditions:

Let-off core feed, inches/min.	75.6
Take-up wrapped yarn, inches/min.	288.5
Spindle revolutions/min.	16,275
Turns, covering/inch	56
Percent elongation	282

Referring once more to the drawings:

In FIGURE 1 the illustrated circular-knit stocking **10** consists of an elastic portion **11** in which the knitted network of structural yarns has covered elastic yarn largely inlaid in the knitted stitches. The welt and shadow welt portion **12** is typical of streetwear stockings as is the toe **14** and the heel **13**.

In FIGURE 2 the illustrated circular-knit stocking **15** consists of an elastic portion **16** in which the knitted network of structural yarns has covered elastic yarn largely inlaid in the knitted stitches. The network and inlay continue in the heel portion **19** which is circular-knit also. The welt and shadow welt **17** and the toe **18** are typical of streetwear stockings. If desired, splicing yarns may be introduced into the heel area to simulate the appearance of a conventional heel.

In FIGURE 3 the back side of a typical fabric **20** of the invention is shown. The network of knitted structural yarn **21** has the covered elastomer portions **22**, **23** and **24** inlaid in every course of knitted stitches. It is to be noted, however, that the elastomer portion **23** is locked into different wales than the elastomer portions **22** and **24**. This is optional and all of the elastomer portions may be locked into the same wales if desired. The portions **22**, **23** and **24** are preferably parts of the same continuous yarn.

In FIGURE 4 the back side of another typical fabric **25** is shown. Again the knitted structure **26** has covered elastomer portions **27** and **28** inlaid in every other course. This fabric, in which the elastomer portions **27** and **28** are preferably parts of the same continuous yarn may be modified to produce a preferred fabric for the elastic fabric portions of the stockings of this invention by causing the portions **27** and **28** to be locked into different wales as for instance is shown in FIGURE 3 with respect to yarns **22** and **23**.

In FIGURE 5 the back side of still another typical fabric **30** is shown. Again the knitted structure **31** has covered elastomeric portions **32** and **33** inlaid in every third course.

In FIGURE 6 a typical fabric **35** is illustrated in which a network of knitted stitches **36** has a covered elastomer **37** partly inlaid and partly knitted-in. Two variations showing the elastomer portion knitted in are shown. At the left the covered elastomer forms a stitch **38** of the network while the portion **34** of the structural yarn is floated across the wale on which the elastomer is knitted. At the right is shown another variation in which the knitted structure is modified only in that the elastomer stitch **39** is tucked and appears with the structural yarn in the same stitch.

In FIGURE 7 a covered yarn **40** of the invention is illustrated showing a single fine-filament spirally wound yarn **42** covering the elastomeric core **41**. The number of filaments of the core is rather optional but a multifilament core is presently preferred. The covering is preferably formed of a multiplicity of very fine filaments each of the order of 1 denier but standard coverings may be utilized with some sacrifice in the fabric's appearance or function.

In FIGURE 8 a typical double covered yarn **45** of the invention is illustrated showing the coverings **47** and **48** wound spirally about the elastomeric core **46**. Again the core might be a monofilament but a multifilament is preferred. The two covering yarns are similar to the covering yarn of FIGURE 7 but with about half the number of filaments.

In FIGURES 9 and 10 the cross-sectional views illustrate how the wrapping yarns tend to maintain their shapes even when the elastomeric core is under compression. The circles *42a*, *47a* and *48a* delineate the outer circumference of the covering yarns involved.

FIGURES 7 to 10 illustrate covering yarns which have sufficient twist to prevent the multifilament yarn from flattening out. If multifilament covering yarns of relatively low twist are used, the yarns appear to become ribbon shaped so that a cross-section of the covered yarn would show the ends of the individual filaments of the covering yarn more or less surrounding the core.

In FIGURE 11 a modified cam ring layout **60** for the Scott & Williams 3¾" AMF stocking knitting machine is shown. The basic AMF machine, manufactured by Scott & Williams Inc., Laconia, N.H., when equipped with an appropriate yarn furnisher is suitable for knitting the stockings of this invention.

To the right of the cam ring layout is shown the relationship of the sinkers **61**, the latch needles **62**, the intermediate jacks **63**, the cylinder jacks **64** and the selector fingers **65**. The sinker **61** has a nib *61a* which catches the elastomeric inlay yarn and pushes it behind the non-selected needles.

In modifying the basic AMF cam ring, it is changed to provide a channel for the intermediate jacks so that the selection made by the selector fingers will continue until a new selection is made by them after one revolution.

Thus, the bottom portion of cam **66** is modified to make its left-hand bottom edge at the same level as its right-hand edge and thus perpetuate the channel **89** for the selected intermediate jacks. Likewise, substituted cams **67**, **68** and **69** perpetuate this channel, cam **69** being cut away at the bottom to correspond to the contour of new cam **73** which is an intermediate jack raising cam. The selected intermediate jacks are caused to rise in the channel provided and thus raise the selected needles to tuck height where they take the elastomeric yarn in their hooks. An elastomeric yarn finger **74**, also added to the basic machine at sinker ledge height, provides this elastomeric yarn. A thin fin cam **71** is inserted to keep the selected and non-selected intermediate jacks separated. The needle lowering cam **72** is modified slightly at its lower right-hand corner to make certain that the non-selected needles are lowered well below tuck height. A new selected needle draw down cam **75** lowers the selected needles. Correspondingly the cam **70** is modified to lower the selected intermediate jacks to the same race as the non-selected intermediate jacks.

In the illustration of FIGURE 12, a covered elastic yarn **100** is shown at dead stretch. The core **101** may be a multifilament rather than the monofilament core illustrated. This core represents a 20 denier elastic strand stretched to a total length of about 475% of its relaxed length. The individual filaments **102** are the filaments of a single 10 denier 7 filament covering having about ½ turn twist per inch. The filament lie snugly against the core at dead stretch as shown.

In FIGURE 13 the diameter of the bare core **105** represents a relaxed 20 denier core at about the same scale as the dead stretch 20 denier core of FIGURE 12.

In FIGURE 13*a* the diameter of a bare core **106** is shown at about the same scale as the stretched core of

FIGURE 12. If the core of FIGURE 12 represents the size of a core stretched to a total length of 650% of its relaxed length, the core of FIGURE 13*a* would represent the approximate relaxed size of the core.

In FIGURE 14 is shown a typical yarn of the invention relaxed from 25 inches dead stretch to 10 inches, that is, to 40% of its dead stretch length. The yarn **110** is shown with the filaments **112** loosely arranged with recurring blossoming **113** to different sides of the yarn.

In FIGURE 15 is shown a wild yarn **120** consisting of a core **121** and a single multifilament winding **122**. This yarn is shown relaxed to the point where a crunodal, loop **123** including the core, has been formed. Further relaxation will convert the "e" bend to a tail of several twists.

In FIGURE 16, the yarn **125** is shown in a partially relaxed condition. The core **126** has been wrapped with too few wrapping yarns per inch at dead stretch. Loops of filaments **128** not including the core are formed all along the partially relaxed length of the yarn.

FIGURE 17 shows a double wrapped yarn **130** in which the core **131** has been relaxed to about 40% of its dead stretch length yet the inner wrap **132** and the outer wrap **133** are perfectly smooth. However, when the yarns per inch at dead stretch are too few, or when core size and filament size are out of proportion, the inner wrap especially tends to protrude in loops through the outer covering wrap.

FIGURE 18 shows a yarn wrapping device **135** in which a let-off roller **136** is driven by a chain drive **138** and a sprocket **137**. The let-off roller in turn drives the cylindrical core strand package **139** by friction contact to unroll the core strand **141**. The shaft of the core strand package moves vertically in the slotted guide **140** with the wound core strand surface in contact with the let-off roller. The core strand **141** passes around the pulley **142** and up through the hollow spindle **143**. The spindle is caused to turn at relatively high speed by the belt drive **145**. The covering yarn package **144** turns with the spindle and throws a loop of yarn **146** which winds about the core placing as many turns of wrapping about the core per inch as the spindle makes revolutions while an inch of the core is passing. The wrapped yarn passes over a pulley **147** (or through an eye) and goes to a take-up roll **148** driven by a chain drive **149** and a sprocket **150**. Alternatively, the yarn may be passed around a take-up roll or through a nip and thereafter partially relaxed before it is wound on the package.

General method of preparing yarns

In preparing the preferred yarns of this invention, the preferred method is to cover the core at as high stretch as is possible without breaking it. The ratio of the let-off speed to the take up speed should be adjusted so as to be of the same order as the ratio of the relaxed core to the fully stretched core. Some safety factor is desirable, however, to avoid annoying breakage when the yarn has some slight variation in dead stretch as is usually the case. For instance, if a 20 denier polyurethane type core having a total length at dead stretch 4.75 times its unstretched length is used, the take-up speed should be approximately 4.5 times the let-off speed. If on the other hand the core has a total length at dead stretch 6.5 times its unstretched length, then the take-up speed should be approxiamtely 6.15 times the let-off speed. Generally, unless the core is very non-uniform, about 5% of the dead stretch is adequate as a safety factor. By "dead stretch" is meant that condition of the core when resistance to further stretching appears to increase sharply and slight further stretching will cause the yarn to break.

The spindle which wraps the covering should operate at such speed that considering the speed the yarn is advancing, that is, the take-up speed, the number of turns of multi-filament covering yarns per inch of dead stretch core should be great enough not to cause the formation of large loops of filaments as a length of dead stretch covered yarn is relaxed to 50% of its dead stretch length. Preferably, the number of turns of multifilament covering yarn should be great enough that such large loops are not formed when a length of dead stretch yarn is relaxed in the range of 30 to 40% from its dead stretch length. As a practical matter, a length of 25 inches at dead stretch is usually selected in testing the yarn. Supposing the yarn core measures .001 inch in diameter at dead stretch then the circumference will measure .00314 inch in that condition. When relaxed from 25 inches at dead stretch to 12½ inches or to 50% of its dead stretch length, the diameter would measure .0014 inch and the circumference about .0044 inch. Now assuming the spindle is traveling fast enough to wrap 50 turns of the plied yarn per inch of dead stretch at the takeup speed, each filament would have a turn length equal to $\sqrt{(.00314)^2+(1/50)^2}$ inch since the length of a helical is $((\text{circumference})^2+(\text{pitch distance})^2)^{1/2}$. In the hypothetical case each filament of the multifilament covering, if fitting the core snugly, would have a turn length of $\sqrt{(.02)^2+}$ at dead stretch and $\sqrt{(.0014)^2+(1/100)^2}$ or $\sqrt{(.01)^2+}$ when relaxed to 50% of its dead stretch length. But the polymeric covering does not fit snugly at 50% stretch under the conditions given but rather has an excess length of approximately .01 inch per turn which would cause the covering to fit loosely at 50% of the dead stretch length. This is irrespective of the number of filaments in the plied covering. This extra material per turn can be adjusted, however, by changing the pitch distance of the covering yarn. Thus, other factors remaining constant, increasing the spindle speed will reduce the excess material in each covering filament turn and vice versa. Likewise, if the spindle speed is kept constant increasing the take-up speed and proportionately the let-off speed (since the yarn core is at dead stretch and would break otherwise) will increase the amonut of extra material and vice versa. As a practical matter, it is desirable to have sufficient excess material to allow for the filament shrinkage which takes place during boarding a garment made from a wild yarn of this invention or in any heat treatment which would convert a wild yarn into a more stable yarn. I have found that yarn with filament loops larger than about .03 inch in diameter present when the yarn is relaxed 50% from dead stretch are generally unsuited for inlaying purposes and while they may be formed into knitted stitches, are unsightly in garments which emphasize sheerness.

There is also the problem mentioned above with wild yarns of the formation of "e" bends, tails and crunodal loops which occur when the yarn is relaxed beyond a certain point. When there are too many covering filaments per inch of dead stretch yarn, the usable elongation is very much restricted, that is, when the yarn is relaxed from dead stretch, crunodal loops including the core are formed before the yarn is relaxed to 50% of its dead stretch length. The usable elongation can be increased by reducing the number of filaments per inch at dead stretch. But inasmuch as it is desirable to have a minimum number of turns of multifilament yarn in order to avoid formation of large filament loops, it is desirable to adjust for filament excess per turn as set forth above and then to adjust the number of filaments per inch in the dead stretch yarn by changing the number of filaments in the multifilament covering yarn. Thus, if the usable elongation is too little with a 26 filament covering but the excess yarn upon relaxation to 50% of dead stretch is about correct to compensate for shrinkage, a yarn with a filament count of less than 26 filaments would be indicated. Obviously, the wild yarns of this invention can be made less wild or even usable when completely relaxed by causing the yarn to be heated in the partially stretched condition so that the thermoplastic turns of covering yarn become set in the coiled position. But this heat treatment also has an effect on the elastomeric core which changes the elastic properties of the core reducing the modulus somewhat. It is preferable therefore to keep the yarn in a stretched condition in the package and until it actually is incorporated into a garment.

The method of knitting the stockings of this invention is described below under the heading "General knitting method."

General knitting method

In knitting a stocking on the modified AMF machine in which the body portion is to be of fabric of this invention but other portions, such as the welt, the shadow welt, the heel and toe are to be conventional for street-wear garments, the following procedure is typical. The make-up, the welt and the shadow welt are knitted in the conventional manner for the AMF machine using the center and left-hand feeds and preferably with 50 denier nylon yarn with 10 turns S twist. When the shadow welt is completed, the knitting machine is prepared to produce the elasticized leg and foot portion of the elastic stocking. This preparation includes an exchange of yarns at the center feed, an exchange of yarns at the left-hand feed and the activation of the controlled elastic yarn furnishing device.

The selector drum is activated taking two racks on every revolution of the cylinder. The pattern is set to select odd needles in one round and even needles in the next round. The non-selected cylinder jacks travel along the path **77** while the selected cylinder jacks rise on the jack raising cam **76** raising the selected intermediate jacks and the corresponding needles causing them to travel along the respective paths **78** and **80**. The non-selected intermediate jacks travel along the line **79** and the non-selected needles travel along the line **81**. The intermediate movable jack raising cam **94** causes the selected intermediate jacks to rise and raise the selected needles to high clear position. The right-hand stitch cam **83** is out of action and the non-selected needles are raised by the movable end cam **82** to tuck height and to low clear by the right-hand clear cam **85**. The selected needles take yarn at the main feed **92** and draw down on the center stitch cam to give yarn to the non-selected needles so that all needles have new yarn in the hooks at the lowest point of the center stitch cam **86** where the previous stitch is cast off. The left-hand clearing cam **95** is in action and the non-selected needles are raised by this cam to low clear and take yarn at the left-hand feed **93**. The selected needles are raised to low clear by the intermediate jack clear cam **90** and also take yarn at the left-hand feed **93**. As the lower tip of the left-hand stitch cam **87** is reached, both the selected and non-selected needles cast off a stitch. The needles advance to the needle lowering cam **72** which lowers both selected and non-selected needles. Immediately thereafter, however, the selected intermediate jacks are raised by new cam **73** and the selected needles rise to tuck height where they take elastomeric yarn from the finger **74** in their hooks. The hook of the first needle carries the elastic yarn along in the direction of the binder. The sinkers **61** move in and catch the elastomeric yarn in the nibs **61***a* as the selected needles with elastomeric yarn in their hooks are drawn down by the new selected needle draw-down cam **75**. When the first needle passes the binder, the latter releases the tail of elastomeric yarn. (This tail is knitted and locked into the knitted structure when it passes the center stitch cam **86**.) The intermediate jacks are drawn down by cams **69** and **70** and at the lowest point of cam **70** all intermediate jacks are at the same level. At this point, however, the selector fingers **65** select cylinder jacks which were non-selected on the previous rotation and the new selected intermediate jacks cause the new selected needles to rise. As they do so they pass in front of the elastomeric yarn held in by nibs of the sinkers. As the new non-selected needles which were the selected needles of the previous rotation rise on the movable end cam **82** and on the right-hand clear cam **85**, the elastomeric yarn slides down in front of these new non-seletced needles. As the new selected needles rise to high clear, they clear the loop of yarn from the left-hand feed. These needles take new yarn from the center feed and draw it down so that the new non-selected needles also take it. As the new selected needles continue to be lowered by the center switch cam, a loop of the yarn from the main feed is drawn and the stitch consisting of a loop of yarn from the left-hand feed is cast off at the lowest point of the center stitch cam. Likewise, a loop of yarn from the main feed is drawn by the new non-selected needles and the previously drawn loop of yarn at the left-hand feed and the elastomeric yarn are cast off.

It is to be understood that the elastomeric yarn is metered into the fabric as it is inlaid in accordance with the teachings in my U.S. Patent Re. 25,046 or in accordance with other known methods to shape the garment as it is being knitted, the relaxed shape of the garment being largely determined by the relaxed circumferences of the rounds of inlaid elastomeric yarns.

When the knitting has progressed to the point where the heel is to be knitted, the elastomeric yarn should be removed if the heel is to be a conventional one. As the elastomeric yarn finger retracts, the elastomeric yarn is taken away from the needle hooks and is drawn into the binder which closes as the yarn is clipped by the knife. The resulting tail of the elastomeric yarn is knitted and locked into the knitted structure at the center stitch cam when the latter is reached. The conventional heel is then knitted in the usual manner by reciprocation using the right and left hand lifters **84** and **88** and the dropper **91**. After the heel has been completed, the elastomeric yarn finger is again activated and the first needle selected to catch the yarn carries it along in the hook in the direction of the binder. When the needle passes the binder, the latter opens and releases the tail. The end tail is locked and knitted in at the main stitch cam as before. The foot of the stocking is then knitted down to the ring toe at which point the elastic yarn finger is inactivated, the elastomeric yarn is severed and the tail is locked and knitted in as before. The toe is finished by any of the conventional methods using any of the conventional yarns.

When the heel is to be of the circular-knit type illustrated in FIGURE 2, the only modification from the ankle portion is a slight increase in the amount of elastomeric yarn metered into the fabric at the point where the conventional heel would normally begin. This increase can readily be accomplished by adjusing the lugs which are operative at this point of the knitting cycle on the variable cam which controls the amount of yarn furnished by the yarn furnisher. About ½ inch of elastomeric yarn over that in the ankle is gradually introduced to the mid point of the heel and then gradually withdrawn so that when the heel is finished the amount of elastomeric yarn metered into the fabric is approximately that of a stocking with a conventional heel. The remainder of the stocking is knitted in the same manner as a stocking with a conventional heel.

The following specific examples are illustrative of the invention:

EXAMPLE 1

A stocking is knitted in accordance with the "General method" up to the point where the yarns are to be exchanged preparatory to production of the elasticized portion of the garment. At this point the yarns on the center feed and on the left-hand feed are replaced each by 2 yarns of 15 denier monofilament nylon yarn while the elastic yarn finger is supplied with an elastic yarn having 135% useful elongation and whose core is a 70 denier Spandex yarn before wrapping with a single covering of 30 denier 26 filament nylon covering. The yarn is unbalanced or wild and sufficient tension is kept on the yarn to prevent its kinking. Any tightness in the elastomer in the ankle section is compensated for by moving the cam 75 vertically downward in its slot to increase the draw-down of the elastic yarn prior to its incorporation as an inlay yarn. The heel incorporated is a conventional one and is knitted as in the "General method" using 50 denier nylon yarn with 7 turns Z twist. Similarly a conventional toe is knitted with the same yarn. The stocking is substantially as sheer as a similar stocking using 70 denier bare Spandex as the inlay yarn and has similar functional properties of slightly higher order than the bare yarn stocking. The fabric is similar to that illustrated in FIGURE 4 but with the elastomer yarn locked in the different wales. The tests indicate that this stocking has an abrasion resistance about 7 times that of the bare inlay stocking.

EXAMPLE 2

Example 1 is repeated except that an elastic yarn having 135% useful elongation whose core is a 30 denier Spandex multifilament before wrapping with a single covering of 30 denier 26 filament nylon covering is substituted as the elastic yarn. The stocking is slightly more transparent than the stocking of Example 1 and slightly less transparent than a similar stocking made with a bare 30 denier Spandex inlay but the abrasion resistance of the covered yarn was approximately 7 times that of the bare yarn stocking.

EXAMPLE 3

Example 1 was repeated but a circular-knit heel was made in accordance with the "General method" instead of the reciprocated heel of Example 1. The two stockings were otherwise similar and had similar properties.

EXAMPLE 4

Example 2 was repeated but a circular-knit heel was made in accordance with the "General method" instead of the heel made by reciprocation in Example 2. Again the stocking had a similar appearance except for the heel and the other properties were similar to those of Example 2.

Throughout this application I use the expression "useful elongation" to indicate the percentage of its original length that a yarn can be stretched while avoiding the breaking point by a practical working margin. For unbalanced or wild elastic yarns I prefer to determine the useful elongation by permitting a predetermined stretched length of the yarn to relax to the point where the surface of the yarn begins to develop bumps or tails. This point is used as the basis for the yarns' original length.

I have also used the term "elastomeric yarn" interchangeably with "elastic yarn" even though, strictly speaking, only the core of the elastomeric yarn is normally elastomeric.

The term "stretched stitch density" as used herein in the specification and claims refers to the average number of structural stitches per square inch in the fully stretched elastic fabric of the stockings of this invention.

The preferred elastic yarns of the invention are those whose elastic cores at dead stretch measure in the range of .00075 inch diameter to .0025 inch diameter and whose coverings have individual filaments finer than 3 denier each and in the range of about ⅓ to about ⅔ of the diameter of the core at dead stretch.

It is a known fact supported by scientific measurements that the denier of a yarn is inversely proportional to the yards per pound and that a known weight of an elastic yarn remains constant when the yarn is stretched. The denier of the stretched yarn multiplied by its stretched length is equal to the denier of the unstretched yarn multiplied by its unstretched length. Thus a 70 denier yarn stretched to 200% of its relaxed length would measure 35 denier and a 20 denier yarn stretched to 200% of its relaxed length would measure 10 denier.

I claim:

1. A finished elastic yarn having a useful elongation in the range between 100 and 300% comprising an elastomeric core having substantially its original modulus elongation and return and not substantially greater than 70 denier or substantially less than 20 denier in its uncovered relaxed state and not substantially greater than 35 denier or substantially less than 10 denier when stretched to 200% of its relaxed length, and helically wound about said core at least one low twist continuous multifilament covering yarn of not more than 30 denier of polymeric material having a denier per filament in the range of about 1 to 1½, said covering yarn being snugly in contact with said core at dead stretch, said elastic yarn being substantially free of crunodal loops including the core and of covering filament loops larger than about .03 inch in diameter in the stretch range between dead streach and 50% of its dead stretch length.

2. The yarn of claim 1 wherein the covering yarn is a low-twist yarn formed of individual filaments of about 1¾ denier each.

3. The yarn of claim 1 wherein the core is a 40 denier core in its uncovered relaxed state.

4. The yarn of claim 1 wherein the multifilament covering yarn is in the form of a single covering yarn and the core is a 20 denier core, in its uncovered relaxed state.

5. The yarn of claim 1 wherein the covering yarn is a low-twist yarn formed of individual filaments of about 1 denier each.

6. The yarn of claim 1 wherein the covering yarn is in the form of two multifilament thermoplastic yarns spirally wound in opposite directions.

7. The yarn of claim 1 wherein the core is a 20 denier elastomeric strand and the covering yarn is a low-twist yarn formed of individual filaments of about 1 denier each.

8. A greige blank stocking including a generally tubular circumferentially stretchable and retractive non-rib circular-knitted portion extending at least above the knee and having a plurality of different relaxed diameters generally corresponding to the corresponding contours of the human leg and primarily of fine structural yarn, forming at least a preponderance of the knitted stiches of said knitted portion and incorporating substantially throughout said portion at least one elastic yarn comprising an elastomeric core having substantially its original modulus, elongation and return and not substantially greater than 70 denier or substantially less than 20 denier in its uncovered relaxed state and not substantially greater than 35 denier or substantially less than 10 denier when stretched to 200% of its relaxed length, and helically wound about said core at least one low twist continuous multifilament covering yarn of not more than 30 denier of polymeric material having a denier per filament in the range of about 1 to 1½, a major portion of said elastic yarn extending as an inlay in at least every third course of the knitted stitches of the non-elastomeric yarns.

9. The stocking of claim 8 wherein the structural yarn is knitted in every stitch of said circular-knitted portion.

10. The stocking of claim 8 wherein the elastic yarn is knit at intervals in the same stitches with stitches of the structural yarn.

11. The stocking of claim 8 wherein the elastic yarn is knitted at intervals so as to appear as the sole yarn in a knitted stitch of the circular knitted portion.

12. The stocking of claim 8 wherein the elastic yarn extends as an inlay in every other course of the knitted stitches of the structural yarn.

13. The stocking of claim 8 wherein the elastic yarn extends as an inlay in every course of the knitted stitches of structural yarn.

14. The stocking of claim 8 wherein the elastomeric core is a multifilament core totaling not more than 40 deniers in its uncovered relaxed state.

15. The stocking of claim 8 wherein the circular

knitted portion extends from the ring toe to the shadow welt excluding the heel.

References Cited by the Examiner

UNITED STATES PATENTS

Re. 25,046	10/1961	Knohl	66—178
2,883,842	4/1959	Knohl	66—178
2,962,885	12/1960	Knohl	66—178
3,009,311	11/1961	Wang	57—152
3,011,302	12/1961	Rupprecht	57—152
3,069,883	12/1962	Burleson et al.	66—178
3,115,745	12/1963	Latham et al.	57—163

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