Nov. 29, 1966 H. KNOHL 3,287,938

RUN-RESISTANT ELASTIC FABRIC

Filed Dec. 6, 1963 4 Sheets-Sheet 1

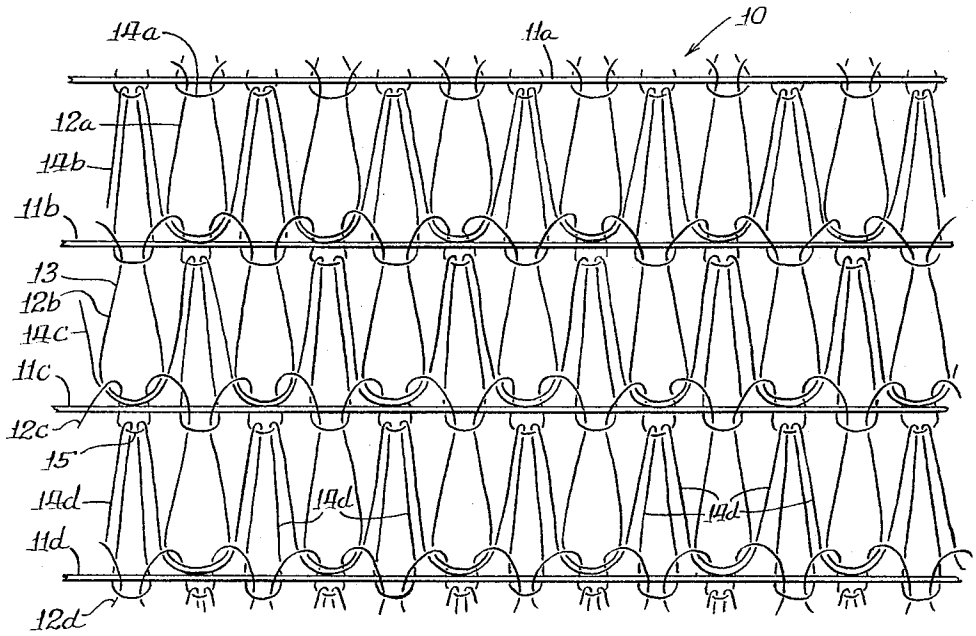

Fig. 1.

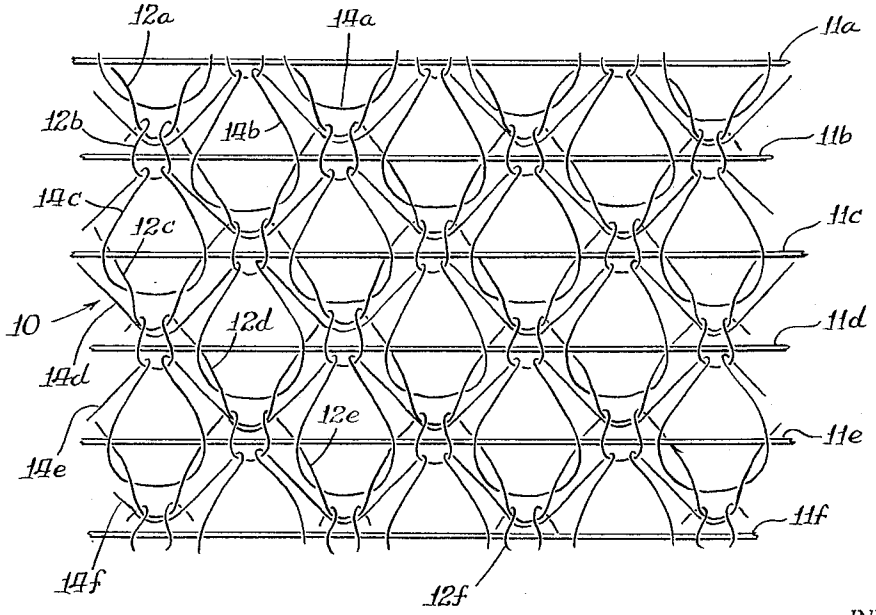

Fig. 2.

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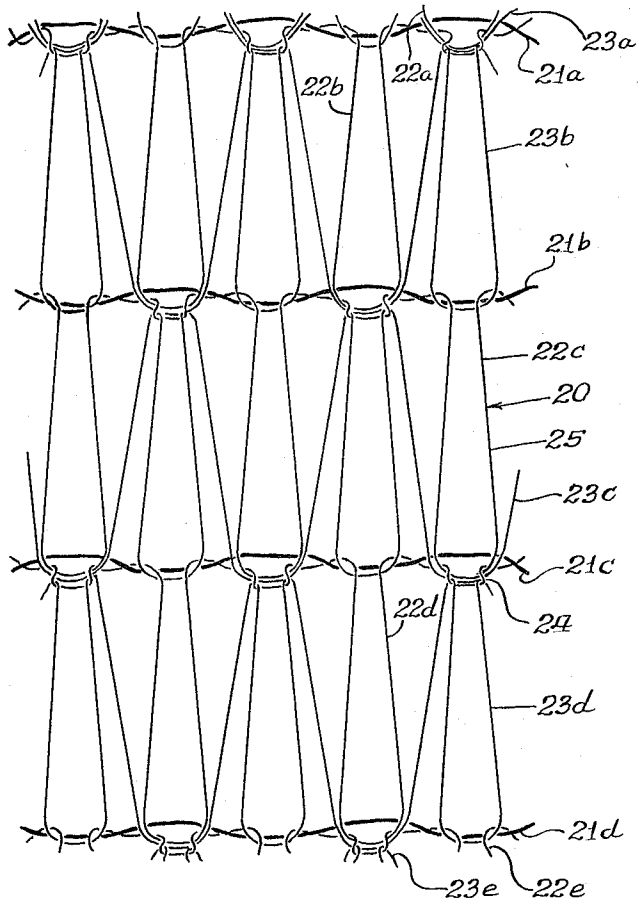
Fig. 3.



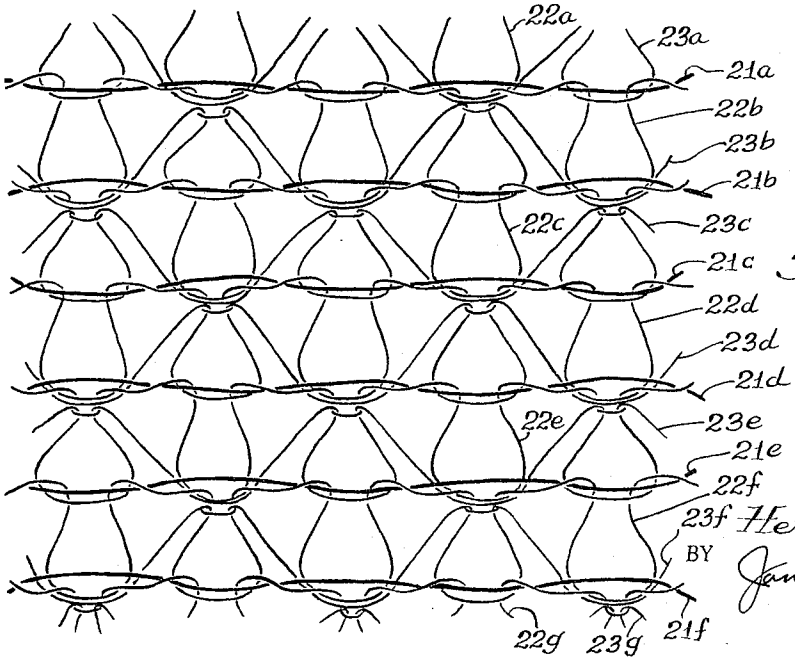


Fig. 4.

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RUN-RESISTANT ELASTIC FABRIC

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Fig. 5.

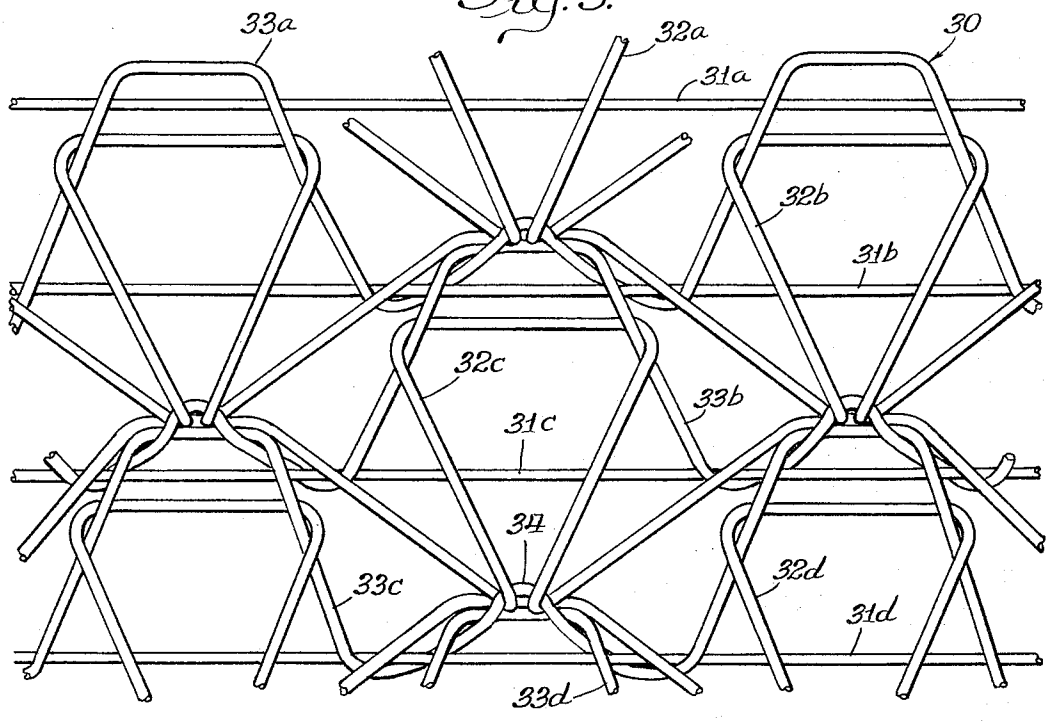


Fig. 6.

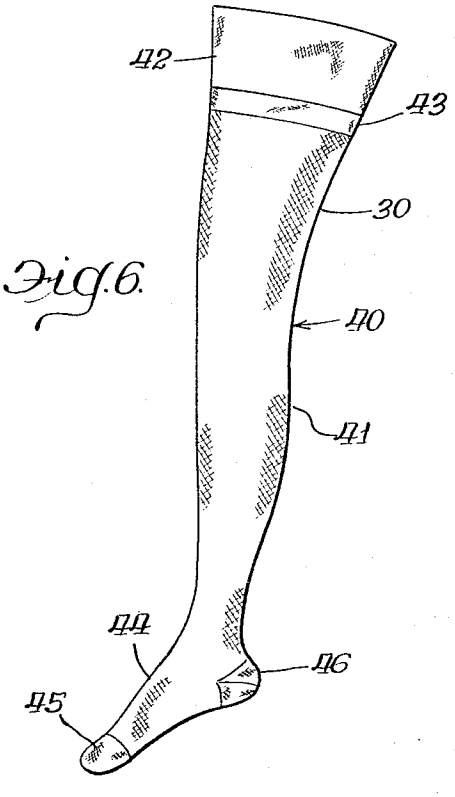
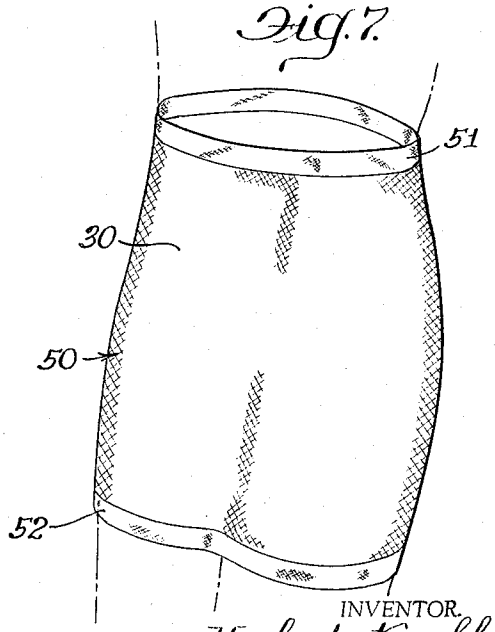


Fig. 7.



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RUN-RESISTANT ELASTIC FABRIC

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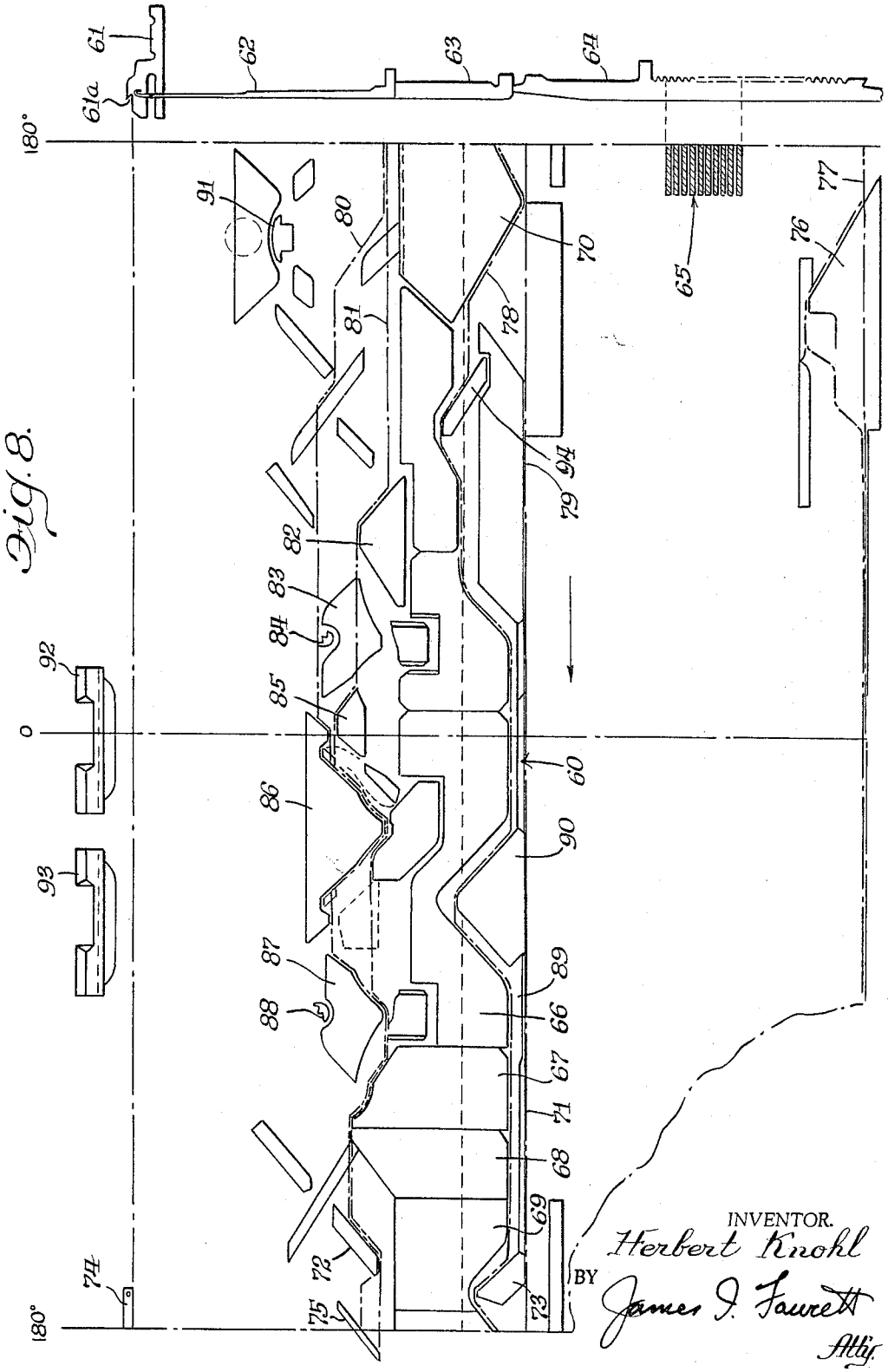

Fig. 8.

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United States Patent Office

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3,287,938

RUN-RESISTANT ELASTIC FABRIC

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Filed Dec. 6, 1963, Ser. No. 328,599
14 Claims. (Cl. 66—190)

This invention is concerned with elastic fabric knitted by the so-called "seamless" or "circular" single needle-bed knitting system with provision for knitting plain jersey stitches, tuck stitches and floated yarn combinations and also with provision for inlaying elastic yarn. The invention is particularly concerned with circular knit inlaid elastic yarn fabrics and garments of such fabrics which display considerable run-resistance in addition to coursewise elastic stretch and optionally, restricted longitudinal or walewise stretch.

Run-resistance in inlaid elastic yarn fabric of the jersey and modified jersey stitch type has never been provided heretofore to my knowledge although obviously it is a very desirable characteristic for any knitted fabric.

In knitting the less complicated run-resistant fabrics of this invention, it is desirable to utilize a machine with at least two knitting stations and an inlay station which latter may be a converted knitting station. As needle selections and feeds are added including at least these three functional stations, a variety of other run-resistant fabric constructions become obviously possible.

In general, the fabrics of this invention are knitted in a repeating series of four courses not including the inlay, although with some variations, such as Fabrics III, VI, IX and XII of Table I which generally are not preferred, there are two courses not including the inlay in each repeating series. In a typical four course repeating series, all of the needles knit in one course, alternate needles knit and intermediate needles tuck in the second course, all the needles knit in a third course and in the fourth course alternate needles tuck and intermediate needles knit. The fifth course is similar to the first course and the entire sequence is repeated. Obviously, the order of courses may be varied and in Table I several variations of order are indicated together with the sequence of the elastomer inlay.

The preferred construction for the inlay is that in which an elastomeric yarn is inlaid after every two courses but in some instances it may be desirable to inlay a yarn after every course or alternatively after every third or fourth course or even at farther intervals apart.

For purposes of this invention an elastomeric yarn is defined as any yarn having an elastomeric portion such as uncovered multifilament and uncovered monofilament yarn of elastomeric material or uncovered spun yarn of elastomeric fibers or any of these covered with one or more wrapping yarns which may be either relatively non-elastic or of the stretch or torque type. The size and materials of the elastomeric and other various yarns used are relatively determined in accordance with the type of garment to be made. The elastomeric portion of the elastomeric yarn may vary for instance in deniers from 10 to 500. Where a very sheer garment is desired bare elastomeric yarns and fine nylon or polypropylene might suitably be selected whereas coarser yarns such as heavy nylon, cotton or wool might be appropriately used with covered elastomeric yarns for making coarser garments, such as sports garments.

In inlaying the elastomeric yarns into the fabric, it is preferable to take the yarn into the hook of every other needle as it is raised to the tuck position. However, other patterns of inlay may be used. That is, a sequence of successive needles rather than every other

needle may be raised to tuck position to take elastomeric yarn. Conversely only one needle in three or four may be raised to tuck position to take elastomeric yarn in its hook. In any event, the needles which do not take elastomeric yarn in their hooks, rise after such yarn has been taken and pass in front of the elastomeric yarn held in the hooks of the other needles, the yarn sliding down the back of the needle shanks. The needles with elastomeric yarn in their hooks also rise and the elastomeric yarn slides down the front of these hooks and over the latches. This yarn is cast off when the next stitch is cast off the needle.

The sequence in which the elastomeric yarn is inlaid is not critical but the sequence does have some effect on the character of the fabric produced. For instance, there is a difference in walewise stretch in fabric in which the yarn is inlaid just following a course in which all the needles knit from that of fabric inlaid just following an alternate knit and tuck course.

But the greatest degree of walewise elasticity occurs when the same needles which knit in a knit and tuck course are raised to tuck position and used for inlaying a following elastomeric yarn. In a course repeat of four courses exclusive of inlays, there are generally two inlays. When both inlays are of the type which produces the optimum walewise elasticity the fabric has optimum walewise elasticity. When only one of the inlays has optimum elasticity a lesser degree of walewise elasticity in the fabric results. At the extreme is a fabric with very little or no walewise elasticity produced when the needles which tuck in a knit and tuck course are raised to tuck position to take the inlay yarn following the knit and tuck course. These two fabrics are illustrated in the drawings in which:

FIGURE 1 is an enlarged back view of a section of fabric of the invention wherein the elastomeric yarn is inlaid just prior to the course in which all the needles knit, the tuck position needles used in inlaying being the tuck position needles used in the alternate knit and tuck course just knitted.

FIGURE 2 is the enlarged front side of the fabric of FIGURE 1 showing the fabric stretched coursewise.

FIGURE 3 is an enlarged front view of a section of fabric of the invention wherein the elastomeric yarn is also inlaid just prior to the course in which all the needles knit, the tuck position needles used in inlaying the elastomeric yarn being the same needles in the knit position in the just previously knitted alternate knit and tuck course.

FIGURE 4 is the enlarged back side of the fabric of FIGURE 3 showing the fabric stretched coursewise.

FIGURE 5 is an illustration of the outer side of a typical stocking fabric of the invention in the stretched condition and very much enlarged. This stylized drawing illustrates the general species shown in FIGURES 3 and 4 which is the preferred species.

FIGURE 6 is an illustration of a typical stocking made in accordance with the invention.

FIGURE 7 is an illustration of a typical girdle made in accordance with the invention.

FIGURE 8 is an illustration of a typical cam ring layout showing the action of the needles in succession as they progress from right to left around the knitting circle.

The fabrics of this invention all display a degree of run-resistance, some being more effectively run-resistant than others. The fabric of FIGURES 1 and 2 is less run-resistant than that of FIGURES 3 and 4. The latter fabric has a greater degree of walewise stretch as well.

In general, the run-resistance of the fabric is accomplished by the use of alternate courses of long stitches and courses of short stitches, the latter courses being the

courses in which all of the needles knit. In some cases where the materials are not dictated by other circumstances, the short stitches of courses in which all of the needles knit may be of yarn which will shrink in one of the finishing operations, thus making the short stitches still tighter and hence increasing the run-resistance even more. In this connection, when dealing with a nylon knitted structure, a multifilament nylon 6 yarn is preferred for the short stitches while a monofilament nylon 66 yarn is preferred for the knit and tuck course.

A number of fabric variations are indicated in the table below wherein the alternate and intermediate needles are indicated by the letters AN and IN; the letter K indicates knit; the letter F indicates float; the letter T indicates tuck and the letter *e* indicates the elastomeric yarn.

TABLE I

	Fabric I		Fabric II		Fabric III		Fabric IV		Fabric V		Fabric VI	
	AN	IN	AN	IN	AN	IN	AN	IN	AN	IN	AN	IN
Course 1	K	K	K	K	K	K	K	K	K	K	K	K
Course 2	T	K	T	K	T	K	T	K	T	K	T	K
Inlay	F_e	T_e	F_e	T_e	F_e	T_e	F_e	T_e	T_e	F_e	T_e	F_e
Course 3	K	K	K	K	K	K	K	K	K	K	K	K
Course 4	K	T	K	T	T	K	T	K	K	T	T	K
Inlay	F_e	T_e	T_e	F_e	F_e	T_e	T_e	F_e	F_e	T_e	T_e	F_e

	Fabric VII		Fabric VIII		Fabric IX		Fabric X		Fabric XI		Fabric XII	
	AN	IN	AN	IN	AN	IN	AN	IN	AN	IN	AN	IN
Course 1	T	K	T	K	T	K	T	K	T	K	T	K
Course 2	K	K	K	K	K	K	K	K	K	K	K	K
Inlay	F_e	T_e	F_e	T_e	F_e	T_e	F_e	T_e	T_e	F_e	T_e	F_e
Course 3	K	T	K	T	T	K	T	K	K	T	T	K
Course 4	K	K	K	K	K	K	K	K	K	K	K	K
Inlay	F_e	T_e	T_e	F_e	F_e	T_e	T_e	F_e	F_e	T_e	T_e	F_e

Machines suitable for knitting the fabric of this invention generally are single needle-bed circular machines with at least some control of alternate needles and which, as has been indicated, preferably have at least two knitting stations and an additional station for inlaying the elastomeric yarn. A number of multifeed machines which may be readily adapted with well-known equipment for inlaying elastic yarn are suitable for knitting the fabric of the invention or particular garments utilizing the fabric structure of the invention. A machine with fairly coarse needles such as the Supreme underwear and outerwear machine made by the Supreme Knitting Machine Co., Inc. of Ozone Park, New York, and which has individual needle control is quite satisfactory. The AMF stocking machine made by Scott and Williams, Inc., Laconia, N.H., may be modified so as to provide either very fine tubular material or a complete stocking or other tubular garment, such as a wristlet or an elbow or knee guard. The modification for the AMF machine consists in providing a yarn finger for the elastomeric yarn which directs yarn to previously selected alternate needles raised to the low tuck position by the alternate intermediate jacks. It is necessary to modify the intermediate jack race on this machine to keep separate the alternate intermediate jacks previously selected to knit on the alternate knit and tuck course. A cam in the intermediate jack race raises the selected alternate needles to low tuck position where they take the elastomeric yarn and are drawn down by an auxiliary draw down cam, the sinkers retaining the elastomeric yarn in this position as the needles rise. As the needles rise for the course in which they all knit, the elastomer passes behind the old non-selected needles (which are the new selected needles for the next round) thus being in front of the selected needles and behind the non-selected needles. With the Scott and Williams machine indicated, the selective mechanism causes the selected needles to change so that in one course the odd needles are selected and in the next the even needles.

This has the effect of giving a 4-course repeat with only two knitting stations.

Referring once more to the drawings:

In FIGURE 1 which represents the unstretched back and in FIGURE 2 which represents the stretched front of a one-way stretch fabric with moderate run resistance, the fabric **10** comprises courses **12***a*, **12***b*, **12***c*, **12***d*, **12***e* and **12***f*. These are courses in which every needle knits a short stitch. Each of these courses is followed by a knit and tuck course **14***a*, **14***b*, **14***c*, **14***d*, **14***e* and **14***f* of relatively long stitches. The stitches of the knit courses **12***a*, **12***b*, etc. are distorted by the knit and tuck following course; those (of which **13** is typical) immediately followed in the same wale by a tuck stitch in the next course being elongated by robbing yarn from the knitted stitches **15** on either side making the latter very tight. It is these extremely tight stitches which account for much of the run resistance of the fabric. In FIGURE 2 which shows the front of the fabric stretched coursewise which is the condition of normal wear, the pattern of the tightly drawn knitted stitches is clearly shown.

In this particular fabric, which is Fabric V in Table I, the elastomeric yarn inlays **11***a*, **11***b*, **11***c*, **11***d*, **11***e* and **11***f* are seen to be substantially linear. This lack of distortion in the elastomeric yarn probably accounts for the lack of walewise stretch of the fabric.

In FIGURE 3 which illustrates the unstretched front side of a two-way stretch fabric and in FIGURE 4 which illustrates the same fabric **20** stretched coursewise, it is clear that the elastomeric yarn **21***a*, **21***b*, **21***c*, **21***d*, **21***e* and **21***f* is inlaid in such a manner that it assumes a sine wave position in the fabric rather than a linear position. In this fabric which is Fabric II in Table I the knitted stitch courses of **22***a*, **22***b*, **22***c*, **22***d*, **22***e*, **22***f* and **22***g* again are knitted with short stitches. Again the robbing action due to knit and tuck stitch courses **23***a*, **23***b*, **23***c*, **23***d*, **23***e*, **23***f* and **23***g* elongates those stitches followed in the same wale by a tuck stitch at the expense of the adjacent knit stitches of the same course. The courses in which all of the stitches are knitted stitches thus have a very tight stitch **24** alternated with a relatively loose stitch **25**. One embodiment of this particular fabric may be stretched coursewise to 350% of its original relaxed state and lengthwise to 150% of its original lengthwise relaxed state when inlaid with bare 100 denier Spandex yarn and knitted on a machine with 20 needles to the inch using 120 denier rayon in the knitted stitches. One embodiment of the fabric of FIGURES 1 and 2 when made with the same yarns may be stretched coursewise to 425% of its original relaxed state and lengthwise to only 112% of its relaxed length.

In FIGURE 5, a typical fabric **30** of the invention is shown very much enlarged and stretched coursewise un-

til the elastomeric yarn **31***a*, **31***b*, **31***c*, and **31***d* is substantially linear. This fabric is typical of stocking fabric of the invention. Preferably the courses **33***a*, **33***b*, **33***c* and **33***d* consisting of all short knitted stitches are of multifilament yarn such as nylon 6 yarn which shrinks somewhat in the finishing process thus making the tight stitches **34** still tighter. The knit and tuck courses **32***a*, **32***b*, **32***c* and **32***d* are preferably of monofilament yarn such as nylon 66. This fabric is shown inverted from its position in a stocking as viewed on the leg.

In FIGURE 6, an illustration of a typical stocking **40** is shown to reduced scale. The fabric of this garment from the shadow welt **43** to the toe **45** excepting the heel **46** is similar to that in FIGURE 5. The welt **42**, the shadow welt **43**, the heel **46** and the toe **45** are made using any of the typical yarns used for that purpose in streetwear stockings.

In FIGURE 7, an illustration of a typical girdle **50** is shown to reduced scale. The body **30** is made of fabric similar to that in FIGURE 5. The turned welts **51** and **52** may be made similar to the welt of a stocking or alternatively either or both may be of fabric similar to the body **30**.

In FIGURE 8, a modified cam ring layout **60** for the Scott & Williams AMF 3¾ stocking knitting machine is shown. Machines including the modifications for knitting stockings containing the fabric of this invention may be obtained from Scott & Williams Inc., Laconia, N.H., the manufacturer of the basic AMF knitting machine.

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 **61***a* 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 lowering cam **75** lowers the selected needles and correspondingly the cam **70** is modified to lower the selected intermediate jacks to the same race as the non-selected intermediate jacks. Knitting the fabric of this invention preferably comprises using a multifilament yarn at the center feed **92** for the short knitted stitch courses, a monofilament yarn for the knit and tuck stitches at the left-hand feed **93**, and a bare or covered Spandex or other elastomeric yarn at the inlay finger **74**.

In knitting a stocking on the modified AMF machine in which the body portion is to be of fabric of this invention but the other portion, such as the welt, the shadow welt, the heel and toe are to be conventional for streetwear 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 of 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 is out of action and the non-selected needles are at tuck height and hence do not clear. The selected needles, however, are raised to low clear by the intermediate jack clear cam **90** and take yarn at the left-hand feed **93** and draw it down initially into the hooks of the non-selected needles. As the lower tip of the left-hand stitch cam **87** is reached, the selected needles cast off a stitch but the non-selected needles not having been cleared continue to hold the loops drawn by the center stitch cam of yarn from the main feed **92** as well as yarn from the left-hand feed. 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. When the needle passes the binder, the latter releases the tail of elastomeric yarn. (This tail is caught up by the needles and locked in to the knitted structure as one or more tuck loops when it passes the center stitch cam **86**.) 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 lowering cam **75**. 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-selected needles. As the new selected needles rise to high clear, they clear the loop of yarn from the center feed and the 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 stitch cam, a loop of the yarn from the main feed is drawn and the stitch consisting of a loop of yarn from the main feed drawn on the previous rotation and the tuck yarn from the left-hand feed is cast off at the lowest point of the center stitch cam. The very tight stitch **34** in FIGURE 5 results. 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 caught up by the needles and locked into the knitted structure as one or more tuck loops 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 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 tucked 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 tucked in as before. The toe is finished by any of the conventional methods using any of the conventional yarns.

Elastomeric portions of the elastomeric yarns useful in this invention are not critical except that the elastomeric yarn should be capable of elongation 50% beyond its relaxed condition with substantial return to its unelongated length within 5 minutes after removal of the forces causing its elongation. Thermoplastic polymers and copolymers which are elastomeric are generally preferred because when elastomeric yarns of such thermoplastic polymers and copolymers are used in conjunction with thermoplastic textile yarns, the fabric produced may be shaped in the presence of heat by boarding methods which are well understood. Suitable thermoplastic polymers which are representative but to which the invention is by no means limited, are the elastomeric polyamides, the elastomeric polyurethanes, the elastomeric halogenated polyolefins and the elastomeric polyvinyls. Natural rubber and other synthetic rubbers whose thermoplasticity has been removed by curing may be used even though there is something to be desired in the counter appearance of garments made from such non-thermoplastic elastomers.

By the expression "modified jersey-knit structure" is meant a structure including plain and tuck stitches.

I claim:

1. A tubular-knit elastic fabric tube including an elastomeric yarn inlaid into a modified jersey-knit textile yarn structure comprising alternate spiraloid courses of tightly knit plain stitches of yarn of relatively greater shrinkability and intermediate spiraloid courses of more loosely knit alternating plain and tuck stitches of yarn of relatively lesser shrinkability and wherein the elastomeric yarn is incorporated as a tuck yarn in stitches which have no other tuck yarn.

2. The elastic fabric tube of claim **1** in which the tuck stitches of next adjacent intermediate courses occur in different wales.

3. The elastic fabric tube of claim **1** in which the elastomeric yarn is bare.

4. The elastic fabric tube of claim **1** in which the elastomeric yarn is covered with one or more windings of another yarn.

5. The elastic fabric tube of claim **1** in which the elastomeric yarn is inlaid immediately after the courses of plain and tuck stitches.

6. The elastic fabric tube of claim **1** in which the elastomeric yarn is inlaid after every second course of knitted fabric.

7. The elastic fabric tube of claim **1** in which the structure comprises a tubular garment.

8. The elastic fabric tube of claim **1** in which the structure comprises a stocking.

9. The elastic fabric tube of claim **1** in which the structure comprises a girdle.

10. The elastic fabric tube of claim **1** in which the elastomeric yarn is a bare spandex yarn and the textile yarn is a yarn selected from the group consisting of nylon and polypropylene.

11. A tubular-knit elastic stocking having a limited degree of walewise stretch and a more pronounced degree of circumferential stretch comprising a welt and shadow welt, a modified jersey-knit textile yarn body and foot structure of alternate courses of tightly knit plain stitches of yarn of relatively greater shrinkability and intermediate courses of more loosely knit alternating plain and tuck stitches of yarn of relatively lesser shrinkability, and a toe, said body and foot structure incorporating an inlaid elastomeric yarn incorporated as a tuck yarn in stitches which have no other tuck yarns.

12. The stocking of claim **11** in which body and foot structure is interrupted in the heel area by removal of the elastomeric yarn from that area.

13. The stocking of claim **11** in which the elastomeric yarn is covered by one or more windings of a textile yarn.

14. The stocking of claim **12** in which the elastomeric yarn is bare.

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