This invention is concerned with elastic fabric knitted by the so-called "seamless" or "circular" single needlebed 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 hitherto 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 in 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 tatches. 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 inlay needles used in inlaying 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 styled 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 selected 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 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>
<thead>
<tr>
<th>Fabric I</th>
<th>Fabric II</th>
<th>Fabric III</th>
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TABLE I

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<td>T</td>
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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 multifilament 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 overwear machine made by the Supreme Knitting Machine Co., Inc. of Ozone Park, New York, and which has individual needle control is quite satisfactory. The AMP stock knitting 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 AMP 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.

Refer once more to the drawings: In FIGURE 1 which represents the unstretched back in FIGURE 2 which represents the stretched front of a one-way stretch fabric with moderate run resistance, the fabric 10 comprises courses 12a, 12b, 12c, 12d, 12e and 12f. These are courses in which every needle knits a short stitch. Each of these courses is followed by a knit and tuck course 14a, 14b, 14c, 14d, 14e and 14f of relatively long stitches. The stitches of the knit courses 12a, 12b, etc. are distorted by the knit and tuck following course; those (of which 13 is typical) immediately followed in the same way by a tuck stitch in the next course being elongated by robbing yarn from the knitted stitches 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 11a, 11b, 11c, 11d, 11e and 11f 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 21a, 21b, 21c, 21d, 21e and 21f 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 22a, 22b, 22c, 22d, 22e, 22f and 22g again are knitted with short stitches. Again the robbing action due to knit and tuck stitch courses 23a, 23b, 23c, 23d, 23e, 23f and 23g 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 alternating 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 31a, 31b, 31c, and 31d is substantially linear. This fabric is typical of stock fabric of the invention. Preferably the courses 33a, 33b, 33c, and 33d 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 32a, 32b, 32c, and 32d 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 in 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 turned wells 51 and 52 may be made similar to the well of a stocking or alternatively either or both may be made similar to the body 30.

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

In FIGURE 8, a modified cam ring layout 60 for the Scott & Williams AMF 33% stocking knitting machine is shown. Machines of this design can be used 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 61a which catches the elastomeric inlay yarn and pushes it behind the non-selected needles.

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 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 knit stitch courses, a monofilament yarn for the knit and tuck stitches at the left-hand feed 93, and a bare or comparatively 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 using the center and left-hand feeds and preferably with 50 denier nylon yarn with 10 turns S twist. When the shad-

ow welt is completed, the knitting machine is prepared to produce the elasticized leg and foot portion of the elastic stocking. This preparation includes a change 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 93 is out of action and the non-selected needles are raised by the movable end cam 92 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 clear 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 75 where the both selected and non-selected needles. Immediately thereafter, 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 hand and then passes over the binder, the latter receiving the tail of the 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 61a 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 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 low 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 lifter 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 car-
ries 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 stitching
is then knitted down to the ring toe at which point the
elastomeric 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 unde-
formed length within 5 minutes after removal of the forces
causing its elongation. Thermoplastic polymers and co-
polymers 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 bonding methods which
are well understood. Suitable thermoplastic polymers
which are representative of which the invention is by
no means limited, are the elastomeric polyamides, the
elastomeric polyurethanes, the elastomeric halogenated
polycylenes and the elastomeric polyvinyls. Natural rub-
ber and other synthetic rubbers whose thermostability
has been removed by curing may be used even though
there is something to be desired in the counter appear-
ance of garments made from such non-thermoplastic elas-

tomeric yarns.

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 elas-
omeric yarn inlaid into a modified jersey-knit textile yarn
structure comprising alternate spiraloid courses of tightly
knit plain stitches of yarn of relatively greater shrink-
ability and intermediate spiraloid courses of more loosely
knit alternating plain and tuck stitches of yarn of rela-

tively lesser shrinkability and where in 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
elastomeric yarn is a bare spandex yarn and the textile
yarn is a yarn selected from the group consisting of nylon
and polypropylene.
8. The elastic fabric tube of claim 1 in which the
structure comprises a tubular garment.
9. The elastic fabric tube of claim 1 in which the
structure comprises a stocking.
10. The elastic fabric tube of claim 1 in which the
structure comprises a girdle.
11. A tubular-knit elastic stocking having a limited
degree of walewise stretch and a more pronounced degree
of coursewise 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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