May 16, 1967 M. B. NEBEL ET AL 3,319,440

KNITTED FABRIC

Filed Feb. 27, 1964 3 Sheets-Sheet 1

FIG. 1

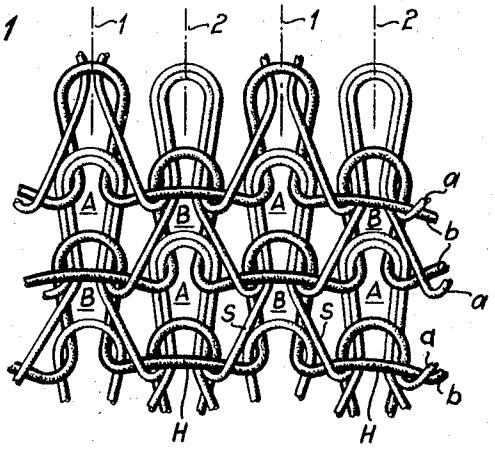
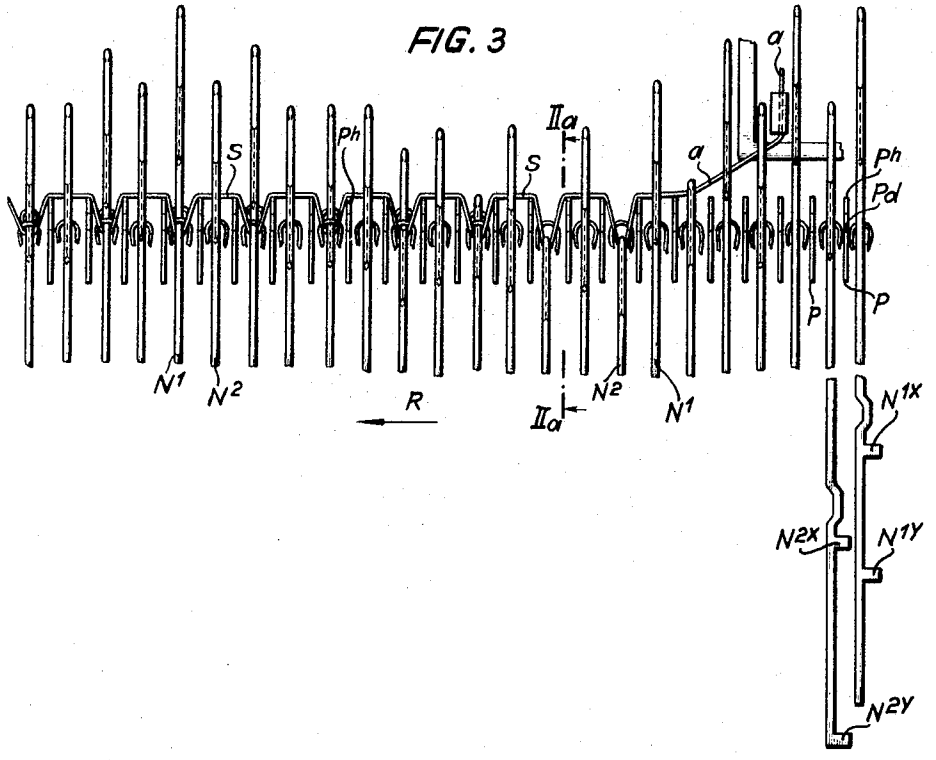


FIG. 3



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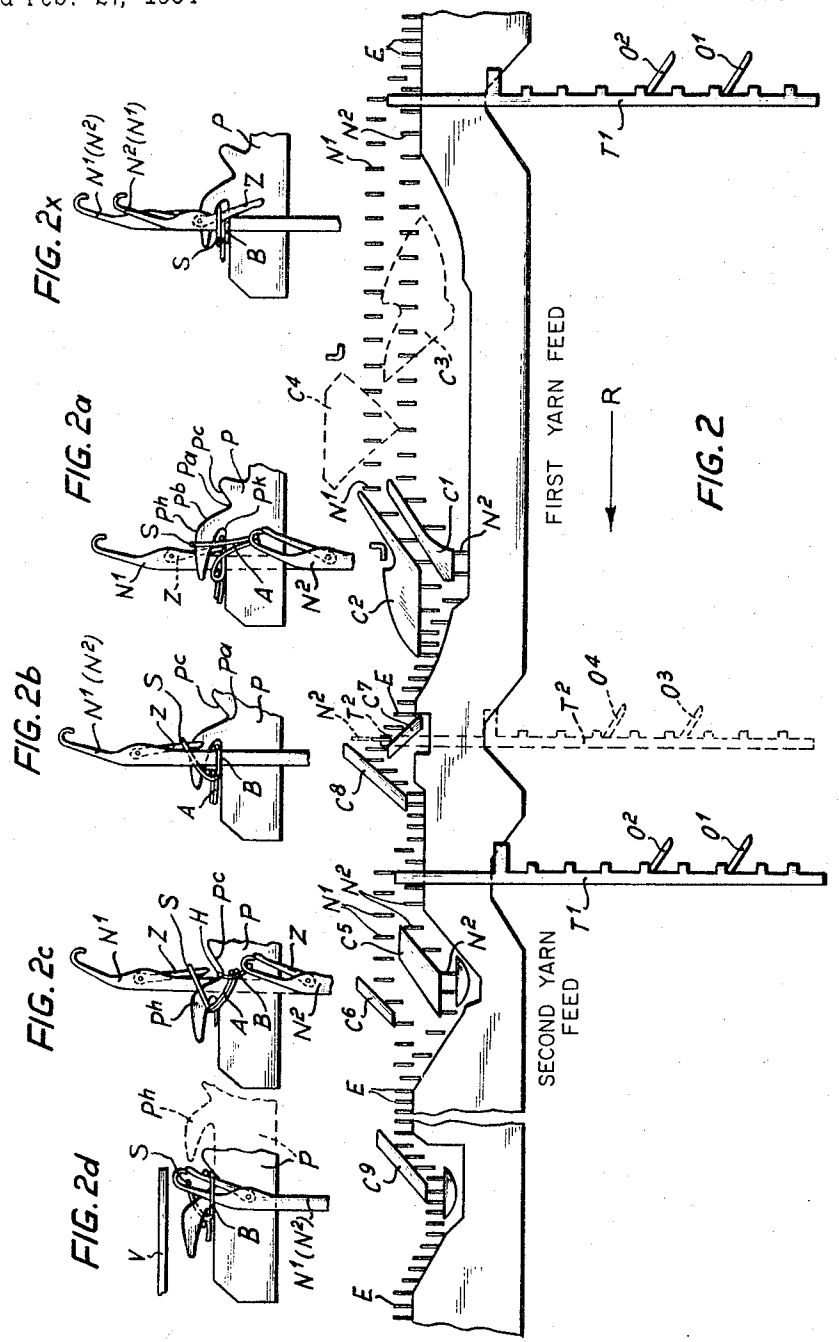

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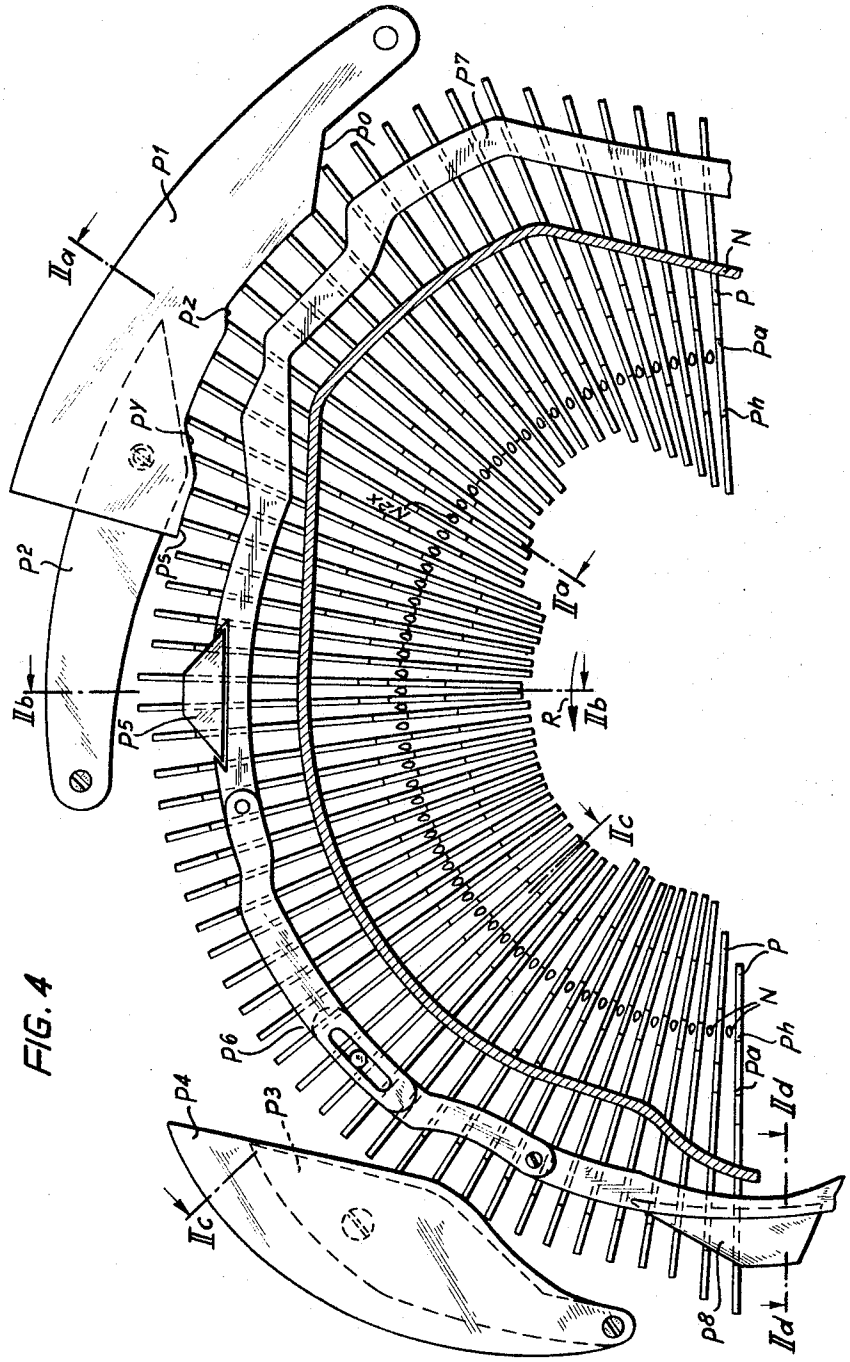

FIG. 4

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KNITTED FABRIC

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14 Claims. (Cl. 66—169)

This invention relates to run-resistant fabrics, and more particularly relates to an improved circular knit run-resistant fabric for stockings, and to methods and apparatus for producing the same.

The primary object of this invention is to provide a new and useful run-resistant knitted fabric for hosiery, particularly ladies' hosiery, having the sheerness, appearance and stretchability of plain knit fabric.

Another object is to provide a novel method of producing such run-resistant fabric on a conventional multi-feed circular knitting machine.

A further object is to provide new and improved apparatus for producing such circular knit fabric on a knitting machine having two separate yarn feeds, or multiples thereof.

Other objects of this invention will become apparent when the following description thereof is read with reference to the accompanying drawings in which:

FIG. 1 illustrates diagrammatically the inside of a preferred form of the run-resistant fabric of this invention;

FIG. 2 comprises a development of the camming for a two feed circular knitting machine for making the fabric of FIG. 1;

FIGS. 2*a*, 2*b*, 2*c*, 2*d* and 2*x* are enlarged fragmentary views in side elevation illustrating the operating positions of the needles and sinkers at different steps of the method of the invention;

FIG. 3 is an enlarged fragmentary schematic view, taken from the inside of the needle cylinder, showing the needles and sinkers of the machine at one of the yarn feeds thereof; and

FIG. 4 is a fragmentary schematic view in top plan showing the sinker cams and the relative positions of the sinkers of the machine.

The run-resistant fabric shown diagrammatically in FIG. 1 is knit of yarns *a* and *b* which alternate wale-wise of the fabric. Yarn *a* is formed into alternate plain stitches A and elongated loops S, while yarn *b* is formed into plain stitches B alternating with floats H. In each instance, the yarn *a* is succeeded wale-wise immediately by yarn *b* in the fabric, so that the plain stitches B of yarn *b* anchor the plain stitches A of the preceding yarn *a*. By reason of this construction, each course of the fabric may be said to consist of the two yarns *a* and *b*.

Preferably, the plain knit stitches A of each pair of adjacent or successive course-wise extending yarns *a* are staggered wale-wise of the fabric by one wale. Thus, the lowermost yarn *a* of FIG. 1 is formed into elongated loops S in wales 1 and into plain knit stitches A in wales 2, whereas the next succeeding yarn *a* is formed into elongated loops S in wales 2 and into plain knit stitches A in wales 1. As a result of this arrangement, the elongated loops S of each yarn *a* are doubled with the plain knit stitches A of the next succeeding yarn *a* in the fabric. Thus, stitches B actually anchor the double stitches SA throughout the fabric.

Similarly, the plain knit stitches B and floats H of each

yarn *b* are staggered wale-wise with respect to the stitches B and floats H of the next successive or adjacent yarn *b* in the fabric. Preferably, the floats H are bound into the fabric by the elongated loops S.

If it is considered that each course-wise extending yarn of the fabric of FIG. 1 comprises a separate fabric course, then it will be seen that the pattern repeat of the fabric is two needle wales in width and four courses in length.

In the preferred construction of the fabric, yarn *a* is of a longer length per fabric course than yarn *b*, but of smaller denier. For example, a highly run-resistant fabric of the character shown in FIG. 1, having the appearance of plain knit fabric, is produced when yarn *a* has, per course, twice or more than twice the length of yarn *b* per course, and has one-half the denier of yarn *b*.

The fabric of FIG. 1, having a longer length of yarn *a* per course than yarn *b*, is highly resistant to runs even when subjected to substantial width-wise or length-wise stress. In such situation, runs are deterred when a yarn is broken, for all practical purposes in the normal use of the fabric, because withdrawal of the double stitches SA, from plain stitches B is precluded.

FIGS. 2–4 illustrate the best mode presently contemplated for carrying out this invention. While, for purposes of illustration, the herein described method and apparatus illustrate the invention as practiced on a two-feed circular knitting machine, it is to be understood that the invention may be practiced on circular knitting machines having multiples of two yarn feeds.

The needles of the machine preferably are divided into two groups, designated N^1 and N^2, which alternate in a 1 x 1 relationship around the needle circle. Needles N^1 are formed with the usual needle butts N^{1x}, and may also have auxiliary butts N^{1y} (FIG. 3). Needles N^2 are formed with the usual butts N^{2x}, and, in addition, may also be formed with auxiliary butts N^{2y}.

Referring now to FIG. 2, it will be seen that the needles, during their stitch formation action, move counterclockwise in the rotative direction R. As the needles approach the first or main yarn feed of the machine, to take yarn *a*, they are divided alternatively by conventional needle selection means into the two needle groups N^1 and N^2, with needles N^1 raised to clear level and needles N^2 disposed at tuck level E (FIG. 2*x*). More particularly, the needles N^1 and N^2 are selected by needle jacks T^1 under the influence of reader cams O^1 or O^2 in the usual manner.

As needles N^1 approach the first yarn feed, at clear level, they have stitches B of the yarn *b* on their shanks or stems below their latches Z. Needles N^2, at tuck level E, have elongated yarn loops S of yarn *a* on their open and downwardly extending latches Z and have floats H, of the next succeeding yarn *b* to the said yarn *a*, and stitches B, of the next preceding yarn *b* to the said yarn *a* (FIG. 1), on the needle shanks below their latches Z (FIG. 2*x*). The stitches B on needles N^1 and the floats H on needles N^2 are formed from the same course-wise extending yarn *b* in the fabric.

While the needles approach the first yarn feed, the sinkers P are advanced into the needle circle by the cam surfaces P^o and P^z of sinker cam P^1 (FIG. 4). As a result, at the first yarn feed, yarn *a* is drawn over the sinker nebs P^h by needles N^2 to form stitches A (FIGS. 2*a*, 3), while yarn *a* is laid over the latches Z of needles N^1 and over the sinkers nebs P^h to form thread loops S.

The first yarn feed is provided with two vertically spaced run-down cams C^1 and C^2 (FIG. 2). Cams C^1 and C^2 are spaced from each other to provide therebetween a

needle butt track corresponding in width to the width of the needle butts N^{1x} and N^{2x}. The conventional reverse stitch cam C^3 and top center cam C^4 are retracted from the needle circle and rendered inoperative.

Yarn *a* is delivered into the hooks of the needles N^1 and N^2 and then needles N^2 are drawn down by run-down stitch cam C^1 to form stitches A and cast off the floats H and the stitches B (FIG. 2*a*). Since elongated loops S are still in the hooks of needles N^2, they are doubled with the newly formed stitches A to form double loops SA. Needles N^1, meanwhile, with the newly formed yarn loops S on their open latches, are drawn down by cam C^2 to a depth intermediate of tuck level E and cast off level (FIG. 2*a*). As a result, stitches B remain on the shanks of the needles N^1 below their latches Z, while the newly formed loops S remain on and above the needle latches. The retention of loops S on the needle latches and separate from loops B on the shanks of needles N^1 is aided by the retention of the sinker nebs P^h within the needle circle (FIG. 4).

After stitches A have been drawn by needles N^2, the sinkers P are further inserted into the needle circle by cam surface P^y of sinker cam P^1 (FIG. 4). Sinker cam surfaces P^y and P^s serve as knockover cams, and aid in casting floats H and stitches B off of needles N^2 during the formation of the new stitches A from yarn *a*. Sinker cam surfaces P^y and P^s advance the sinkers P sufficiently far into the needle circle to position the yarn drawing ledges P^a, behind the sinker nebs P^h, below the hooks of the needles N^1.

After passing stitch cams C^1 and C^2, all needles N^1 and N^2 are raised to tuck level E. Thereupon, all needles are raised to low clear level by cam C^7. As a result, the double thread stitches SA are cleared from the latches onto the stems of needles N^2. However, because the sinker nebs P^h still penetrate the needle circle, the thread loops S are retained on the latches Z of needles N^1. Preferably, at this time, the sinkers P are retracted slightly by sinker cam P^5 (FIGS. 2*b*, 4), so that the highest point of the sinker nebs P^h is positioned below the loops S on needles N^1 and above stitches B on needles N^1 and double stitches SA on needles N^2.

As an alternative, cam C^7 may be omitted and the sinkers not retracted, but allowed to remain as positioned by cam surface P^s. In such case, needles N^2 only are raised, independently of needles N^1, by their jacks T^2 under the influence of reader cams O^3 or O^4 (see broken lines in FIG. 2), to clear level. Consequently, the double stitches SA slip off the latches Z onto the shanks of the needles N^2.

As the needles continue their movement in direction R, they are drawn down by cam C^8 to or slightly below tuck level E. Thereafter, needles N^1 are raised to low clear level, by needle jacks T^1 under the influence of reader cam O^1 or O^2. However, the thread loops S are retained on the latches of needles N^1 by the sinker nebs P^h, which remain within the needle circle (FIG. 4). Needles N^2, meanwhile, remain at or slightly below tuck level E. In these respective positions, the needles N^1 and N^2 advance toward the cams C^5 and C^6, while taking yarn *b* at the second yarn feed.

Needles N^2 take yarn *b* in their hooks and are drawn down by the run-down stitch cam C^5 to form new stitches B and cast off double stitches SA. Cam C^5 is spaced sufficiently far in advance of Cam C^6 to drawn needles N^2 down to cast-off level before needles N^1 reach cam C^6. As a result, needles N^2 cause the yarn *b* to be laid below the latches Z against the shanks of the needles N^1 (FIG. 2*c*) to form floats H.

Needles N^2 retain the yarn floats H under tension against the shanks of needles N^1 until the latter needles have descended sufficiently to enclose the yarn floats H between their latches and shanks. To aid needles N^2 in this function, cam C^5 preferably is formed with a flat bottom of a length sufficient to retain at least three needles N^2, at any moment, at cast-off level.

More particularly, cam C^5 retains needles N^2 at cast-off level until after needles N^1 have passed over cam C^5, advanced to cam C^6, and are caused to descend to tuck level E by the latter cam. This downward movement of needles N^1 ensures the proper positioning of the floats H of yarn *b* between the latches and shanks of the needles N^1.

After cam C^6 has lowered needles N^1 to tuck level E, needles N^2 are raised to tuck level E. At this stage of the process, needles N^1 have yarn loops S on their latches and floats H and stitches B below their latches on their shanks, while needles N^2 have new stitches B on their latches. The floats H on the shanks of needles N^1 and the new stitches B on the latches of needles N^2 are formed from the same course-wise extending yarn *b*, whereas the stitches B on the shanks of needles N^1 are formed from the immediately preceding course-wise extending yarn *b* (see FIG. 1).

As the needles N^2 take and draw yarn *b*, the sinkers P are positioned in respect of the needle circle so that stitches B are drawn by needles N^2 over the yarn sinking ledges P^a behind the nebs P^h (FIGS. 2*c*, 4). To accomplish this, sinkers P either remain in the position to which they had been advanced by cam surfaces P^y and P^s or, if they had been retracted slightly by cam P^5, they are re-advanced under the influence of sinker spring N.

Sinker cam P^4 (FIG. 4) serves as the knockover cam for the second yarn feed. It advances the sinkers P further into the needle circle to aid in casting off double stitches SA from needles N^2.

Because stitches B of yarn *b* are drawn over sinking ledges P^a of sinkers P, and stitches A of yarn *a* are drawn over the sinker nebs P^h, yarn *a* will have a longer length per course of the fabric than yarn *b*. Of course, even if the two yarns were drawn over yarn sinking ledges at the same level, yarn *a* inherently will have a longer yarn length per course than yarn *b*, since the latter contains the floats H, whereas the former contains the inherently longer loops S.

Specially designed sinkers P are employed to carry out the method of the invention. The sinkers are formed with a rearwardly extending edge passing first downwardly from the top of the neb P^h to the sinking ledge P^a, and thence upwardly to a point spaced from the neb, as best shown in FIG. 2*a*. Sinking ledge P^a is the lowest portion of this rearwardly extending edge, and is disposed somewhat lower than sinker throat P^k. The vertical distance between the uppermost point of sinker neb P^h and the yarn sinking ledge P^a may be selectively designed to control the relative lengths per course of the yarns *a* and *b*.

In order to facilitate the usual broken needle detector V (FIG. 2*d*), all needles N^1 and N^2 are drawn below tuck level E a small distance by cam C^9. Preferably, the needles are drawn down to position their hooks proximate the sinker nebs P^h, so that the floats H and stitches B on needles N^1 close the latches Z, but do not cast off. At this time, the sinkers P may may be retracted by sinker cam P^8 to position all yarn loops on the needles below the nebs P^h (see broken lines in FIG. 2*d*). Thereafter, all needles N^1 and N^2 are again raised to tuck level E while proceeding in the rotative direction R to the next yarn feed which, in the embodiment shown, is the main or first yarn feed of the machine.

Before the needles again take yarn, they are selected to interchange their previously described action. More particularly, needles N^2 now are raised to clear level (FIG. 2*x*) to transfer their stitches B onto the needle shanks, while the needles N^1 remain at tuck level E. Needles N^1 now have elongated loops S on their open latches and floats H and stitches B on their shanks below their latches. Meanwhile, the sinkers P have been retracted from the needle circle, by either of sinker cams

P^8 or P^7, and thereafter are re-advanced into the needle circle by cam surfaces P^o and P^z to permit yarn *a* to be drawn over the sinker nebs, as previously described.

It is advantageous to reinsert the sinker nebs P^h into the needle circle gradually, first by cam surface P^o and thereafter, to a further extent, by cam surface P^z. This arrangement will ensure that the tips of the sinker nebs will not re-engage the loops S on the needles, but will pass above those loops, as yarn *a* is drawn into stitches A by the needles N^1 or N^2.

Needles N^1, now at tuck level, take yarn *a*, form double stitches SA and cast off floats H and stitches B, while needles N^2 take yarn *a* to form new elongated loops S on their latches. After needles N^1 and N^2 again pass the two yarn feeds, they are selected to reverse again their yarn formation actions, i.e. to revert to the actions originally described. Thus, after passing each second yarn feed of the machine, the needles, by conventional selecting means, are reversed in their functions to produce double stitches SA, stitches B and floats H in staggered relation throughout the fabric, in the manner shown in FIG. 1.

Because the stitches B are drawn behind the sinker nebs P^h, the floats H underlie the elongated loops S and are bound thereby into the fabric (FIG. 1). If desired, the yarn *b* may be drawn to stitches B on the usual yarn sinking ledge in front of the sinker throats P^k, with appropriate rearrangement of the needle and sinker motions. In such case, floats H would overlie, rather than underlie, loops S in the fabric.

Additionally, if desired, alternate sinkers only may be inserted into the needle circle at the first yarn feed, by appropriate sinker selection means, to draw yarn *a* over the nebs of alternate sinkers only.

It is contemplated that, instead of the needle selection means discussed above for selecting needles N^1 and N^2, modified means may be employed utilizing the auxiliary needle butts N^{1y} and N^{2y}. In such case, the needles N^1 and N^2 would be moved independently of each other by means of additional needle cams (not shown) arranged at different vertical levels of the machine, and acting upon the auxiliary needle butts N^{1y} and N^{2y}.

If desired, in making ladies' hosiery, the heel and toe portions may be made by reciprocatory knitting. In such case, during reciprocatory knitting, cams C^3 and C^4 at the first yarn feed would be reinserted to operative position to act upon the needles. No needle butts would enter the track formed between cams C^1 and C^2 during the forward stroke of the needle cylinder, but all needles N^1 and N^2 would be drawn down to cast-off level by cam C^1. During the reverse stroke of the needle cylinder, the needles would be drawn down by cams C^4 and C^3 in the usual manner. The reciprocatory knit portions of the fabric would, of course, be a plain knit.

It is to be understood that the invention described and shown herein is susceptible of various changes and modifications, which may be made without departing from the general principles or spirit of the inventive concept. Accordingly, it is intended to claim the invention broadly, as well as specifically, in the appended claims.

We claim:

1. A run-resistant knitted fabric composed of at least two yarns, wherein

(a) yarn is formed at spaced intervals course-wise of the fabric into plain stitches in selected wales and into floats in wales intervening between said plain stitches and

(b) yarn is disposed course-wise of the fabric and successive to said intervals of the first mentioned yarn and is formed into plain stitches in the intervening wales and into elongated loops in the selected wales,

(c) the said elongated loops being doubled with the next succeeding plain stitches in the selected wales throughout the fabric.

2. The fabric of claim **1** wherein the second mentioned yarn is of a longer length per course of fabric than the first mentioned yarn.

3. The fabric of claim **1** wherein the two yarns are of different denier.

4. The fabric of claim **1** wherein the first mentioned yarn is of a larger denier than the second mentioned yarn.

5. The fabric of claim **1** wherein the floats and elongated loops are staggered throughout the fabric.

6. A run resistant knitted fabric composed of at least two yarns, wherein

(a) yarn is formed at spaced intervals in the fabric into plain stitches in selected wales and into elongated loops in wales intervening between said plain stitches and

(b) a second yarn is formed successive to the first mentioned yarn intervals into plain stitches in the selected wales and into floats in the intervening wales,

(c) the plain stitches of any two successive intervals of the first mentioned yarn being staggered with respect to each other, whereby the elongated loops of said yarn are doubled with plain stitches formed from said yarn.

7. The fabric of claim **6** wherein the floats are bound in the fabric by the elongated thread loops.

8. A run resistant knitted fabric in which each course thereof is composed of two yarns and wherein

(a) one yarn in each course is formed into plain stitches in selected wales and into floats in wales intervening between the selected wales and

(b) the other yarn in each course is formed into plain stitches in the intervening wales and into elongated loops in the selected wales,

(c) said elongated loops being doubled with plain stitches in the next succeeding course.

9. The fabric of claim **8** wherein:

(a) the second mentioned yarn is of a longer length per course than the first mentioned yarn and

(b) the floats and elongated loops are staggered throughout the fabric.

10. A method of making run-resistant knitted fabric including the steps:

(a) forming a yarn into plain stitches alternating with elongated loops,

(b) next forming a yarn into plain stitches alternating with floats, said floats being formed in the same wales as the elongated loops, and

(c) then forming a yarn into elongated loops alternating with plain stitches and doubling said latter plain stitches with the elongated loops formed by the first mentioned yarn.

11. The method of claim **10** wherein the first and third mentioned yarns are the same yarn.

12. The method of claim **10** wherein the first and third mentioned yarns are formed of a longer yarn length per fabric course than the second mentioned yarn.

13. A method of making run resistant knitted fabric including the steps:

(a) forming a yarn into plain stitches in alternate wales and into floats in the intervening wales,

(b) next forming a yarn into plain stitches in the intervening wales and into elongated loops in the alternate wales,

(c) next forming a yarn into plain stitches in the intervening wales and into floats in the alternate wales,

(d) next forming a yarn into plain stitches in the alternate wales and into elongated loops in the intervening wales and

(e) doubling the elongated loops of the second mentioned yarn with the plain stitches of the last mentioned yarn.

14. A run-resistant knitted fabric composed of two yarns, wherein

(a) double stitches are spaced course-wise of the fabric and staggered wale-wise in the fabric,

(b) said double stitches being composed of the same yarn from two different fabric courses and

(c) plain stitches intervening between the double stitches,

(d) said plain stitches being connected by floats.

References Cited by the Examiner

UNITED STATES PATENTS

2,014,026	9/1935	Nebel	66—169
2,379,649	7/1945	Nebel	66—169
3,080,740	3/1964	Nebel	66—108
3,131,556	5/1964	Nebel	66—178

FOREIGN PATENTS

796,727	6/1958	Great Britain.
366,180	2/1932	Great Britain.
1,059,141	11/1959	Germany.

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