April 13, 1937. R. K. MILLS 2,076,910

KNITTED FABRIC

Original Filed April 11, 1934 4 Sheets-Sheet 1

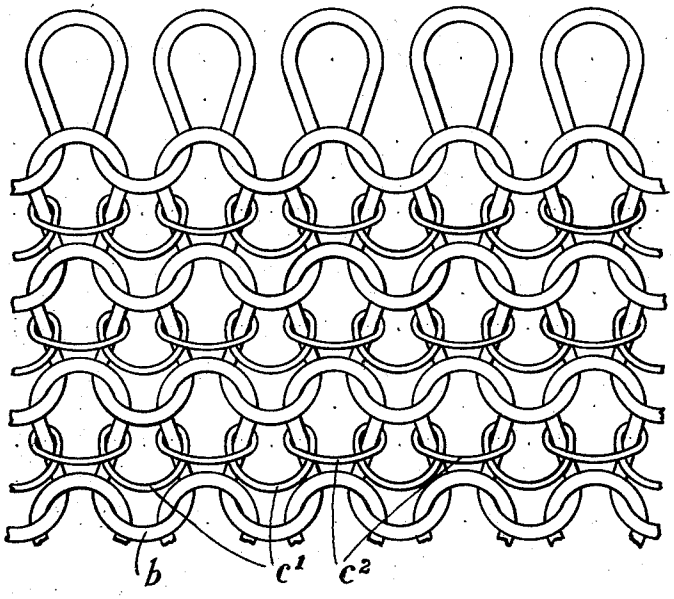


Fig. 1.

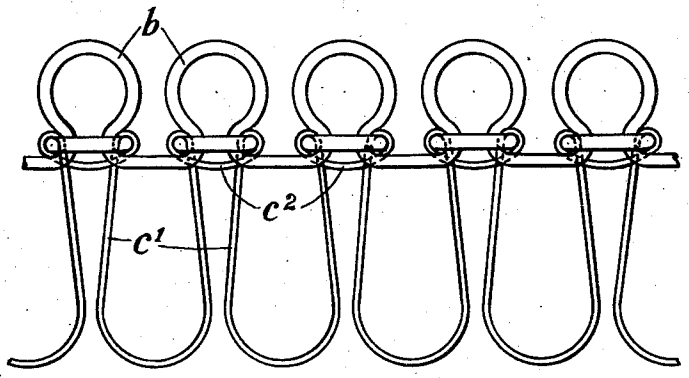


Fig. 2.

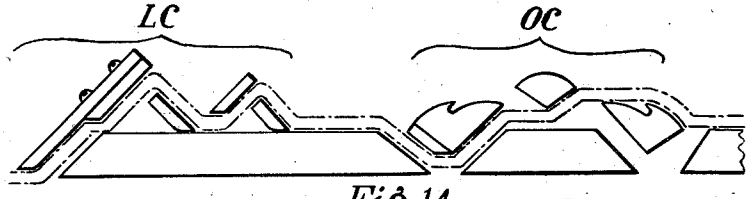


Fig. 14.

R.K. MILLS
INVENTOR.

By Barker & Collings.
ATTORNEYS.

April 13, 1937. R. K. MILLS 2,076,910

KNITTED FABRIC

Original Filed April 11, 1934 4 Sheets-Sheet 2

Fig. 3.

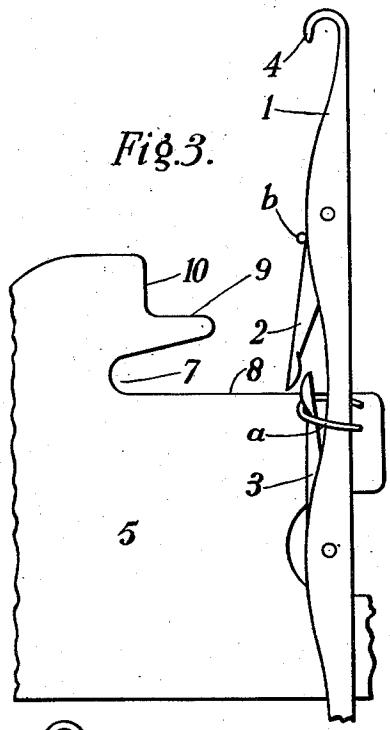


Fig. 4.

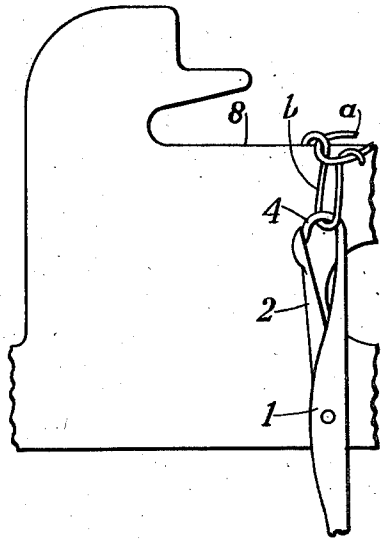


Fig. 5.

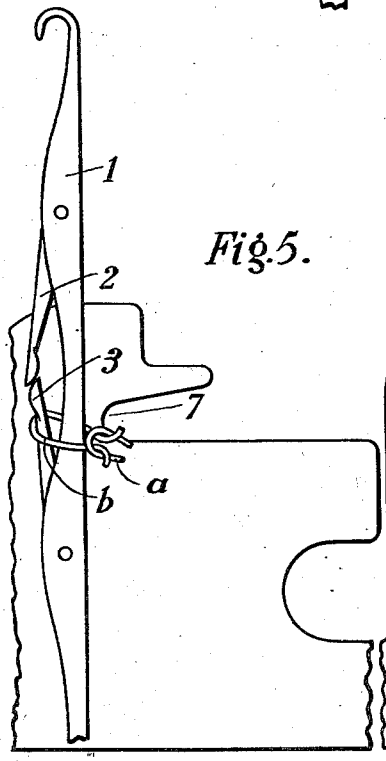
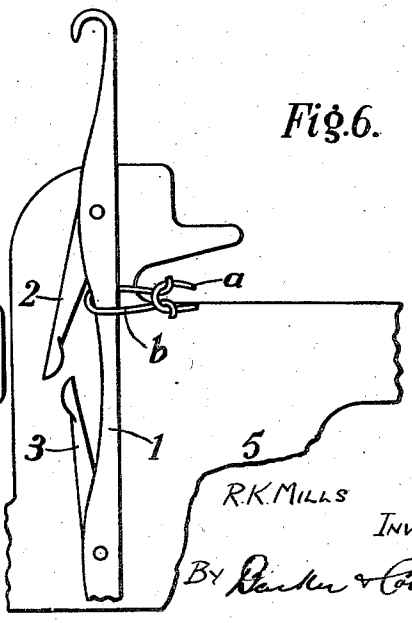


Fig. 6.



R.K. Mills

INVENTOR.

By Stocker & Collings

ATTORNEYS

April 13, 1937. R. K. MILLS 2,076,910

KNITTED FABRIC

Original Filed April 11, 1934 4 Sheets-Sheet 3

Fig. 7.

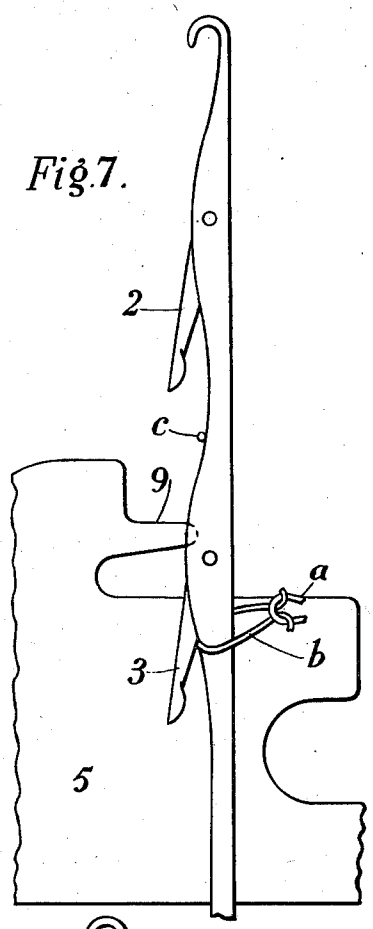


Fig. 8.

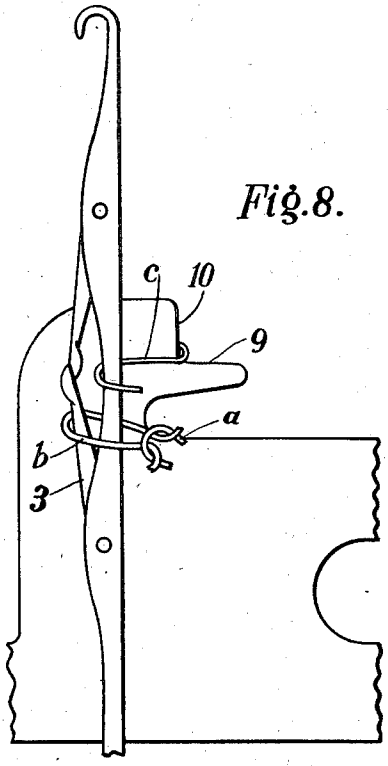


Fig. 9.

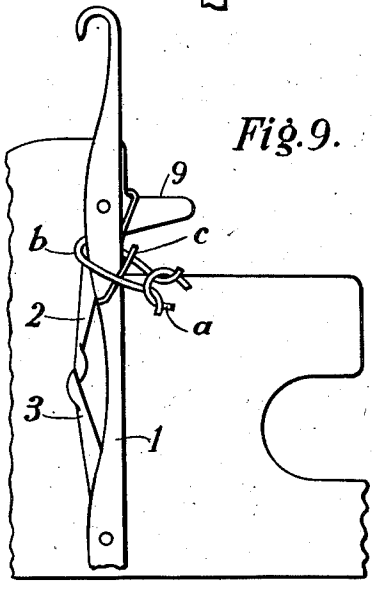
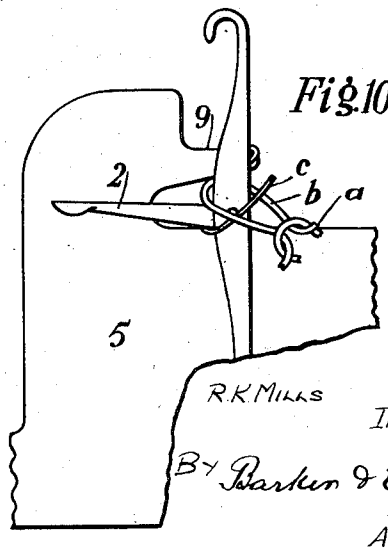


Fig. 10.



R. K. Mills
Inventor
By Barker & Collings
Attorneys

April 13, 1937. R. K. MILLS 2,076,910

KNITTED FABRIC

Original Filed April 11, 1934 4 Sheets-Sheet 4

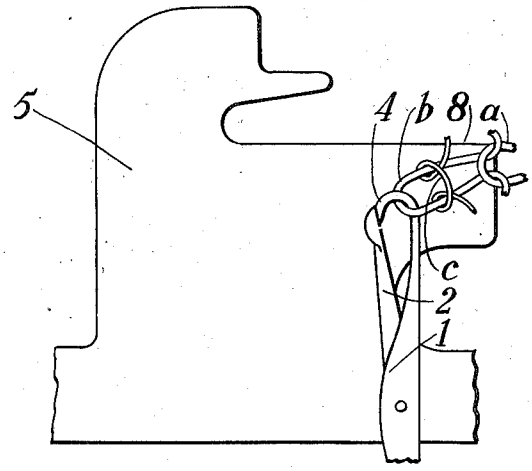


Fig. 11.

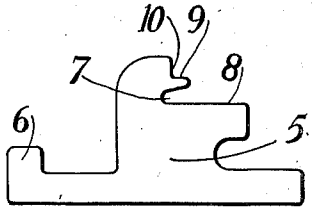


Fig. 12.

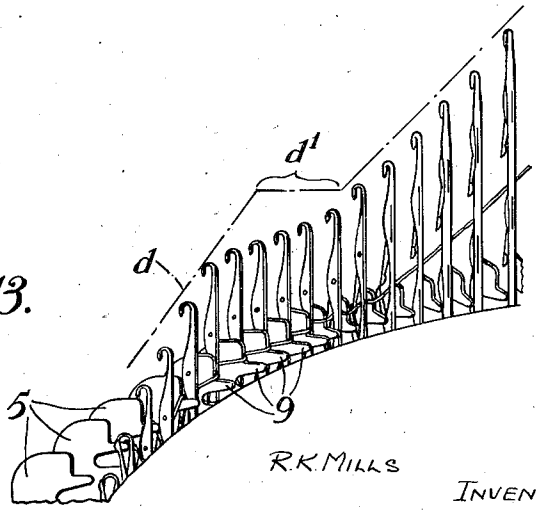


Fig. 13.

R. K. MILLS
INVENTOR

By Parker & Collings
ATTORNEYS.

Patented Apr. 13, 1937

2,076,910

UNITED STATES PATENT OFFICE

2,076,910

KNITTED FABRIC

Robert Kirkland Mills, Sherwood, Nottingham, England

Original application April 11, 1934, Serial No. 720,105. Divided and this application February 25, 1935, Serial No. 8,149. In Great Britain April 18, 1933

5 Claims. (Cl. 66—169)

This invention relates to knitted fabrics and the invention covered by this case is a division of an application filed by the applicant on the 11th day of April 1934 under Serial No. 720,105.

The invention refers to ladder-resistant fabric of the type having predetermined of its stitch loops locked or tied by weft thread (thread running weft-wise of the fabric) which does not itself constitute a stitch-forming thread. More particularly the type of fabric to which the invention refers is that which is rendered wholly or in part ladderproof or ladder-resisting by the embodiment therein of locked or tied stitches each comprising a stitch loop having a locking thread (or plurality of threads) extending across said stitch loop and completely encircling each side bar or portion of said loop. This fabric, is, by virtue of its ladder-resistant qualities, particularly suitable for ladies' stockings, but has, of course, a much wider application.

Now a disadvantage heretofore associated with this type of knitted fabric is that the locking of the stitch loops reduced the normal elasticity of the fabric in a weft-wise direction, i. e. in a direction at right angles to the stitch wales, and also that the major part of the strain on the fabric in a weft-wise direction is taken by the stitch-locking thread.

The strength of the fabric (resistance to fracture) has been largely determined by or limited to the strength of the locking thread, and unless exceptionally strong locking thread is employed, the fabric is very liable to split or break under tension.

The main object of the present invention is to provide a locked fabric of the type referred to wherein elasticity in a weft-wise direction is fully maintained and at the same time maintain fully, and in many cases appreciably increase the strength of the fabric (resistance to thread breakage), such result being obtained without exerting excess strain on any thread during fabric production; and continued and lengthy experiments have now proved that such a fabric can only be obtained if the amount of stitch-locking thread introduced into the fabric over any predetermined or given number of successively formed stitches is not less than the amount of ordinary stitch thread introduced.

The present invention therefore consists primarily in the provision of a non-ladder or ladder-resisting knitted fabric of the kind referred to characterized in that the amount or length of stitch-locking thread associated with any given number of successively formed stitches is equal to or preferably greater than the amount or length of thread forming said stitches.

In one particular embodiment the invention provides a fabric of the type referred to which is characterized in that strains on the fabric in a weft-wise direction are imparted in equal or substantially equal proportions to the ordinary stitch thread and the stitch-locking thread.

For the purpose of more fully describing the nature of this invention reference will now be made to the accompanying drawings, wherein:—

Fig. 1 shows a portion of fabric in accordance with this invention.

Fig. 2 shows a modified form of fabric.

Figs. 3 to 11 show successive steps in the production of the fabric according to Fig. 1.

Fig. 12 shows a sinker employed in producing the fabric.

Fig. 13 shows in perspective the co-operation between the needles and sinkers while making locked stitches.

Fig. 14 is a development of the needle-operating cams.

A convenient method of producing the improved fabric on a circular latch needle machine will now be described. The needles 1 have two latches 2, 3 so spaced one below the other on the shank that the lower latch 3 when raised abuts against the end of the upper latch 2 when the latter is in the lowered position, so that said upper latch (which is arranged to abut against and close the hook 4 in the usual manner) may be held open by the lower latch. For each such plural latch needle there is a sinker 5 which is movable backwards and forwards between the needles in the usual manner (by means of a butt 6 working in a cam track) and is provided with a throat 7 to receive and control the loop which is to be locked, and below said throat with a belly or nose 8 of normal shape; see Fig. 12. Above this throat 7 there is a narrow forwardly projecting neb or nose 9 which has a straight top edge and above and at the rear of this neb 9 there is a part or catch with a vertical edge 10, the function of which is to form, divide or measure loops of the locking thread. It is important that the throat 7 shall be cut deeper into the sinker 5, that is to say extend further back, than the vertical edge 10 of the catch so that loops of the locking thread may be sunk by the advance of the sinkers without straining the loops to be locked, which are accommodated in the sinker throats 7.

Suitably spaced around the needle cylinder 11 of the machine are two different types of needle-operating or stitch cams one O. C. for producing

ordinary knitted stitches to be locked and the other L. C. for producing locked stitches, (see Fig. 14). The two types of cams operate in succession upon the needles, and considering the movement of one needle, the successive steps in the production of a locked stitch will now be described with reference to Figs. 3 to 11. In Fig. 3 the needle is moved by the ordinary stitch cams O. C. to a position wherein the old stitch loop *a* is cleared below the top latch 2 and a thread *b* is fed into the hook 4, the needle being then lowered to knock over and produce an ordinary stitch *b* (Fig. 4) the length or size of said stitch *b* being determined by the extent to which same is drawn down over the belly or nose portion 8 of the sinker, i. e. by the distance to which the hook 4 passes below the top edge of said portion. During this movement the sinkers 5 (one of which is shown) are retracted in the customary manner by any known or suitable type of sinker cam (not shown). The needle is then operated upon by the locked stitch cams L. C. and is first raised thereby from the normal lowered position until the previously formed stitch loop *b* is brought on to the raised bottom latch 3 to the position shown in Fig. 5. During this upward movement of the needle 1 to bring said loop *b* to this position, the top latch 2 is, of course, swung down and its end therefore overlies the end of the raised bottom latch 3. The needle is then lowered somewhat so that the said loop *b* (which is to be locked) passes underneath the top latch 2 to the position shown in Fig. 6; and next the needle is raised to clear the loop down below the bottom latch 3, by which movement the said bottom latch is opened; (see Fig. 7). With the needle in this position a thread *c*, which may be termed the "locking thread", is fed across the needle in the space between the two latches, above the nebs 9 of the sinkers 5, which are now being advanced between the needles. During the forward movement of the sinkers, the locking thread *c* is engaged and drawn by the vertical edges 10 thereof. The needle is then lowered by the stitch cam, during which movement the stitch loop *b* which is to be locked causes the bottom latch 3 to swing up and to hold the top latch 2 in its lowered position so that the loop of the locking thread *c* on the needle is enclosed between the two latches; (Fig. 8). As the sinker loop of the locking thread is held by the angular recess in the sinker neb 9, continued downward movement of the needle draws the loop *c* through the previously formed loop *b*, which latter passes up over the top latch 2 (Fig. 9) with the result that the said top latch is swung up by the loop *c* of the locking thread, (Fig. 10), the sinker meanwhile being retracted. On the final part of the downward movement of the needle the previously formed loop *b* is enclosed in the hook 4, and the loop *c* of the locking thread is cast off over and around the old stitch loop *b* which is retained in the hook; see Fig. 11; the sinker having by this time been withdrawn to disengage the loop *c* from the neb 9. By this means a long loop is drawn from the locking thread *c* because said loop is drawn over the nebs 9 of the sinkers 5 to each side of any needle 1 under consideration, while the loop *b* to be locked is, during the formation of said loop and during the descent of the needle to draw the locking loop through it, held over the bellies or noses 8 of said sinkers, and as clearly shown in Figs. 8, 9, and 10 is in no way strained while drawing said locking loop.

It will be understood that there is a thread feed for each set of cams O. C. and L. C. (ordinary stitch and locked stitch cams), so that after a needle has produced an ordinary stitch at the ordinary cams said needle passes on to the locking cams where said stitch is locked in the manner before-described, and upon subsequent arrival of the needle at the ordinary cams, a normal stitch is drawn through the locked stitch and the latter is cast off.

The above-described operations result in a locked fabric of the kind referred to, in which each of the loops of locking thread *c* extends when the fabric is relaxed in a curve or loop of substantial length or curvature from thread bar to thread bar of locked loops *b*, both across the loops and across the wales between said loops, as shown in Fig. 1, so that such loops incorporate a sufficient length of thread to permit of the fabric stretching in a normal manner. By virtue of the additional draw imparted to the sinker loops of the locking thread, these loops are somewhat longer or more pronounced in the finished fabric than the locking thread stitch loops; this effect being clearly shown in Fig. 1 where c^1 indicates the longer sinker loops and c^2 the shorter stitch loops.

By virtue of relaxing or lengthening the loops of locking thread *c* the strength of the fabric, i. e. resistance to thread breakage under strain, is considerably increased, as by suitably determining the relative lengths of the loops *b* and *c* the strength of the thread *c* can be added to that of the thread *b*. It will be appreciated that this would not be the case if the loops of locking thread *c* were so tightly drawn as to extend approximately straight across the stitch loops *b* and the stitch wales, as in the latter case transverse stretch (tension in the direction of the stitch courses) would necessarily first be taken only by the locking thread *c* and not by the combined threads *b* and *c* as is possible in the present invention. Additionally, the relaxation of the thread *c* so that same does not receive the full force of imparted tension permits the employment of a locking thread which is appreciably finer or thinner than the ordinary stitch thread *b* without in any way weakening the fabric, i. e. without reducing its tensile strength; in fact even with a comparatively thin locking thread, the strength of the fabric is increased as compared with ordinary (unlocked) knitted fabric which is knitted with yarn of the same count as the ordinary stitch thread *b* of a locked fabric.

The set of ordinary stitch cams O. C. and the locking stitch cams L. C. and also the sinker cams operating in conjunction therewith are advantageously so designed that during the thread draw, the sinkers co-operating with a small group of adjacent needles, e. g. five needles, are maintained fully advanced and said group of needles are also maintained at an equal height immediately prior to the delivery of the drawn or sunk loops from the sinkers to the needles. This ensures a uniform amount of each thread (stitch thread and locking thread) being delivered to each needle and equalizes the loops of said threads on the needles, thereby also rendering more uniform than heretofore the distribution of the two threads over the needles in knitting a complete course. At the locking thread feed this "dwell" in the needles and sinkers is provided substantially midway in the downward or thread-drawing movement of the needles. In Fig. 13 is shown the

operation of the needles and sinkers at the locking thread feed, and the broken line *d* illustrates the track traversed by the needles over the locking stitch cams during the thread-drawing operation, the position of the "dwell" being shown at *d'*. Where sinkers are employed of the type shown in Fig. 12 having a flat topped nose portion **8**, it may not be required to provide a specially shaped sinker cam with a short straight portion for producing the "dwell" and maintaining a group of adjacent sinkers advanced to a uniform extent during the operation of drawing over said noses the ordinary stitch thread so long as the needle-operating cam is designed to maintain the needle group at a uniform height, i. e. fully lowered, while the thread is being drawn over said noses. If, however, the sinkers have inclined noses over which the stitch thread is drawn, the sinker cam will be provided with a short straight portion to obtain the required "dwell".

During the production of the fabric gradual or progressive decrease or increase of the size of the locking stitches can be effected.

Considering for example the manufacture of seamless stockings, it is usual to incorporate means on the machine for gradually tightening the stitches as the knitting proceeds down the leg towards the heel, such operation being known as "stiffening"; and during this stiffening process the locking stitches are also progressively tightened. This is advantageously effected by gradual adjustment of the sinker cam at the position of the locking thread feed; and one convenient method of accomplishing this is fully described in the specification of my aforementioned application for patent Serial No. 720,105.

It is, of course, to be understood that slackening or lengthening of the locking thread can be accomplished with the same facility as the tightening thereof.

Chenille or pile fabric can also be readily made by lengthening the locking thread loops to an extent sufficient to produce a pile. One method of doing this is by lengthening or deepening the throat **7** in the sinkers **5** and advancing said sinkers to an increased degree; and if desired the edge **10** of the neb **9** controlling the locking thread loops may also be provided at a more forward position on the sinkers.

As will be clearly understood from the foregoing, the relative amounts of ordinary stitch thread and locking thread fed per course of stitches can readily be determined to meet particular requirements or produce desired effects; e. g. to ensure that both threads share strain or tension applied to the fabric in the direction of the stitch courses. For instance, when knitting seamless silk stockings on a 3¾ inch diameter machine employing 348 needles, the ratio of the ordinary stitch thread to the locking stitch thread is advantageously 37 to 38; in other words, 37 inches of pure silk yarn is fed at the ordinary stitch feeder and 38 inches of similar yarn at the locking stitch feeder in each stitch course irrespective of the diameter or count of yarn.

I claim:—

1. Non-ladder or ladder-resistant knitted fabric having predetermined of its stitch loops locked or tied by weft thread which is coiled completely round each side bar or leg of a stitch loop and extends across same but does not itself constitute a stitch-forming thread and wherein the amount or length of stitch-locking thread associated with any given number of successively formed stitches is at least equal to and preferably greater than the amount or length of thread forming said stitches.

2. Non-ladder or ladder-resistant knitted fabric of the kind referred to wherein predetermined of its stitch loops are locked or tied by weft thread which is coiled completely around each side bar or leg of a stitch loop and extends across the same but does not itself constitute a stitch-forming thread and strains on the fabric in a weftwise direction are thereby imparted in equal or substantially equal proportions to the stitch-forming thread and the stitch locking thread.

3. Non-ladder or ladder-resistant knitted fabric according to claim 1 wherein the size or length of the stitch-locking loops and of the stitch loops locked thereby varies.

4. Non-ladder or ladder-resistant knitted fabric according to claim 1 wherein the size or length of the stitch-locking loops and of the stitch loops locked thereby gradually and progressively varies.

5. Non-ladder or ladder-resistant knitted fabric of the type referred to wherein predetermined of its stitch loops are locked or tied by weft thread which is coiled completely around each side bar or leg of a stitch loop and extends across the same but does not itself constitute a stitch-forming thread and wherein the threads from which the locking stitch loops are formed have sinker loops of substantial length projecting from the fabric face to constitute a pile.

ROBERT KIRKLAND MILLS.