KNITTING:—PROCESSES AND MACHINERY.

A STUDY OF KNITTING

With a Description of Knitting Processes and of the Construction and Operation of the Prominent Knitting Machines.

Knitting forms one of the great divisions of fabric structure, and differs radically in the principle of producing the fabric from that of weaving, being based on the principle of forming a fabric or web by means of a series of interlocking loops, from one or more continuous threads. Different systems of interlocking the loops produce different styles of stitches, each being best suited for certain kinds of fabrics, etc.

The early history of mechanical knitting, *i. e.*, the origin of the stocking frame, the first practical knitting machine, is surrounded with considerable uncertainty, both as to the inventor himself and to his motive or reason for planning such an invention. Some few writers ascribe the invention to one Jean Hindret, a Frenchman, but the weight of authority is in favor of William Lee, an English clergyman, who, it is claimed, perfected the first practical knitting machine in the latter part of the 16th Century. Accepting this latter conclusion as being true, we find ourselves confronted with more or less romantic stories as to the cause of the invention, that is, why Lee, a clergyman, should turn to so prosaic a subject as knitting stockings.

The first of the stories might be taken as showing the power of love, or, that a man in love is capable of doing anything to gain the society of his lady-love. In this version, Lee is represented as being deeply in love with a young lady whose passion for knitting exceeded her love for her suitor; every time Lee visited the young lady, he found her knitting, knitting, and knitting, so that in sheer self-defense, he turned his attention to making a machine that would do the knitting itself and leave his lady-love free to accept his attentions. He succeeded, history says, in inventing a machine that could be operated by one hand, leaving the other hand of the young lady free to be used in the lover's pastime of "holding hands."

The second story is more prosaic, the compelling motive for the invention being necessity, the mother of all inventions, according to the poets. This version goes on to say that Lee was reduced to great poverty by being expelled from his university living, on account of marrying in violation of its rules, and that his wife was compelled to work day and night knitting stockings to help support his family. History does not say whether or not Lee himself worked, but, from the statement that he got his ideas for a knitting machine from watching his wife's daily task, it may be presumed that he did little else, which is a habit of inventors. Possibly he had worked up more trade than his wife could supply with stockings, hence the desire for a machine to supply the demands, the perfection of which took five years of his time. History is also silent as to how the Lee family lived meanwhile, but it may be accepted that his wife continued her knitting by hand; nor is there any reliable account of the effect on the family fortunes of the finally perfected knitting machine.

It must be confessed that both of these stories seem plausible and are strikingly like other "romances of invention," in which the inventor is always either in love and spurred on to great deeds, or else is in the deepest poverty, with a loving wife and large family, who work while he dreams, but, unfortunately, there are some actual facts on record that tend to discredit these romantic versions of the occurrence. The only value they possess, from a historical point, is in their agreement on the name of the inventor, William Lee, and that he was a clergyman. Why a clergyman, of all men should conceive and perfect so radical and so complete an invention, none seem to be able to explain, except as just stated. The real facts in the case seem to be quite different. We find the following statement in Cooper's "Athenæ Cantabrigienses," quoted by Felkin in his history of Lee and his invention:

"William Lee, who was born in Woodborough in Notts, and who is said to have been heir to a good estate, was matriculated as a sizar of Christ's College, in May, 1579. He subsequently removed to St. John's College, and as member of that house proceeded B. A., in 1582-3. We believe that he commenced M. A. in 1586; but on this point there seems to be some ambiguity in the records of the University. In 1589, at which time it is stated he was curate of Calverton, about five miles from Nottingham, he invented the stocking frame."

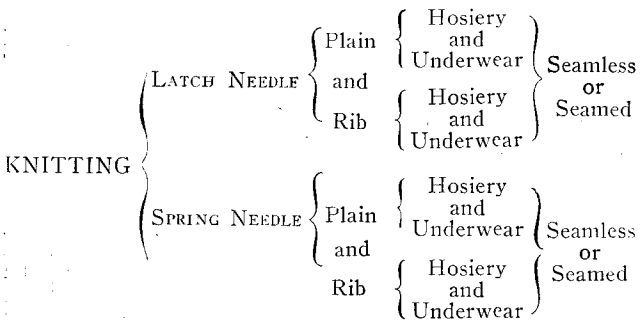
This statement certainly connects Lee more closely with the invention of the stocking frame than the ones previously referred to, since it shows Lee to have been a man of means, which certainly enabled him to defray his living expenses during the time it took him to perfect his machine, and also the expense connected with a great invention. Besides this, it shows Lee to have been a man of college training and education, and these possibly of such an advanced nature as to take the place of practical experience in mechanics, and thus enable him to invent a machine, which, in its originality of conception, surpasses any other inventions in the field of textile machinery. It must be remembered that knitting by hand (as it is claimed Lee saw his lady-love or his wife doing) and mechanical knitting (his invention, *i. e.*, the stocking frame, which is the foundation of every existing hosiery machine) have scarcely a single common feature with each other in their operation.

Other men, since Lee's time, closely connected with prominent improvements in knitting machinery are:

William Cotton, the inventor of "Cotton's Patent," (who was at first a stockinger in a remote Leicestershire village); Samuel Lowe, a foreman in a hosiery factory, (who was the inventor of "striping," "splicing," and "chevening" applications to Cotton's patent); Luke Barton, (who between 1838 to 1840 invented the first effective rotary frame, and, in 1858, in addition to it, an automatic narrowing apparatus); Walter Aiken, of latch needle frame, etc.

The Operation of Knitting is performed by means of knitting needles, there being two general styles in use, *i. e.*, the latch needle and the spring beard needle. The "knitting needle" of the knitting machine must not be confused with the knitting needles used for knitting by hand, as they are radically different, both in construction and operation. Machine knitting needles resemble more nearly the so-called "crochet needles," in having a hook at the working end, while hand knitting needles have no hook, being, in fact, nothing more than a piece of polished wire, blunt at both ends. The method of forming the loops with the machine needle is different entirely from that used for forming loops with the hand needle, but it is similar in principle to the method used with the crochet needle.

The following diagram, based upon the uses of the two kinds of needles, as a foundation for classifying the processes of knitting, will explain itself. It shows the development of the final processes and products through the variations of the two styles of needle.



With reference to knitted fabrics, (exclusive of novelties) the same can be classified in the following three main divisions: (a) Hosiery, (b) Ribbed goods, (c) Flat goods.

Hosiery includes: Full length and half hose, either seamless, full fashioned, or seamed.

Ribbed goods include: Tops for hose and for sleeves and legs of garments, also underwear of various kinds.

Flat goods include: Underwear, full fashioned or else cut and shaped from the piece and sewed up into the garments, etc.

The Latch Needle. Fig. 1 shows us a specimen of a typical latch needle, and in order to acquaint the reader with the technical names of the various portions of this needle, numbers of reference have been given. In this illustration 1 indicates the Hook of the needle, 2 its Latch, held by the Rivet 3 to the Cheek 4 of the needle; 5 is the Throat, 6 the Stem, 7 the Butt, 8 the Shank and 9 the Back-Shank of the needle. The needles, as used in the different makes of machines, vary somewhat in shape of construction, more particularly with reference to the Stem, Butt and Shank.

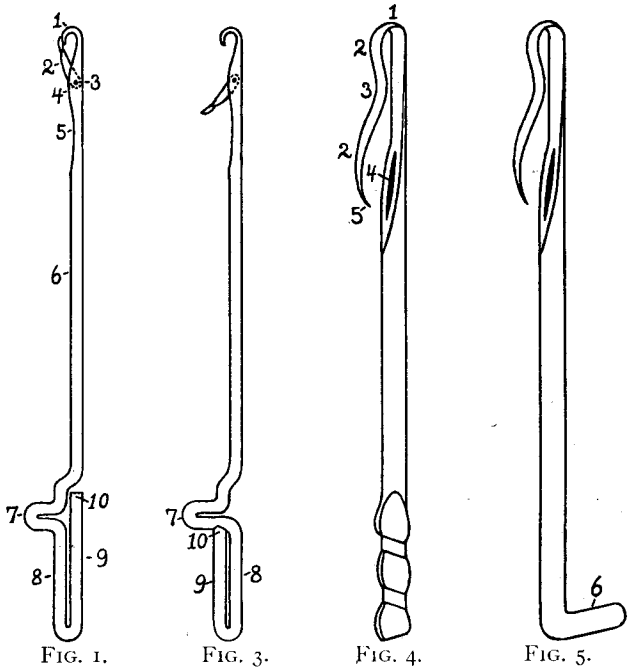


Fig. 1. Fig. 3. Fig. 4. Fig. 5.

The most important function of the latch needle is the free and easy working of the latch, *i. e.*, the proper rivet used. A few years ago, the Dodge Needle Co. patented an improved method of riveting their needles. which is shown (enlarged as compared with Fig. 1) in diagram Fig. 2, *a* is the rivet, *b* the cheek of the needle. It consists of a sunken-head rivet which takes the head of the rivet out of the way of

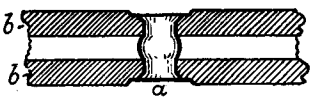


Fig. 2.

the fibres of the yarn as fed to the needles, with the result that no roughening of the yarn by a swollen or protruding rivet (as may be the case with a flush head rivet) will take place, in turn resulting in a smoother surface to the knitted fabric.

Another improvement to knitting needles, made by this same firm, consists in providing a "Lock Back-Shank" to the needles, in order to prevent the displacement of the bent-over part, *i. e.*, the back of the needle, during the operation of the machine, and which, if it occurs, will be the reason for the needle to bind in its slot, and, in turn, in many instances will be the cause of needles breaking, damaged goods, and besides, a loss in production. Fig. 3 shows this Lock Back-Shank, and by comparing with Fig. 1, it will explain itself (see number of reference 10 in both illustrations, as referring to the end portion of the back-shank).

There are some makes of latch needles met with, which differ, with reference to the shape of their shank, with those described. The principle of the head portion of the needle, in all cases, however, remains undisturbed. The shape of the latch needle used in connection with the different makes of knitting machines we will illustrate when taking up the construction of the different machines.

The Spring Needle, also called the spring beard needle, is shown in diagram Fig. 4, the same referring to a typical specimen of such a needle, that shown being what is known as a "not leaded" needle.

Numerals of reference accompanying the diagram indicate thus: 1 the Head, 2 the Spring Beard, 3 its Crimp, and 4 the Eye, or recessed place, into which the Point 5 of the Spring Beard 2 enters, *i. e.*, is pushed into, during one stage of the process of knitting. The Shank of the needle is shown at 6. Fig. 5 shows a spring needle known as the "Trick" needle. The shape of the Shank 6 is changed, (to form what is called the "trick") as will be readily seen by comparing diagrams Figs. 4 and 5 with each other; the other parts of the needle are not changed.

The Principle of Latch Needle Knitting. As previously referred to, the Latch needle is used for Plain and Rib Knitting. Having given a description of the needle itself, we now will take up the two kinds of knitting and describe their operations in detail.

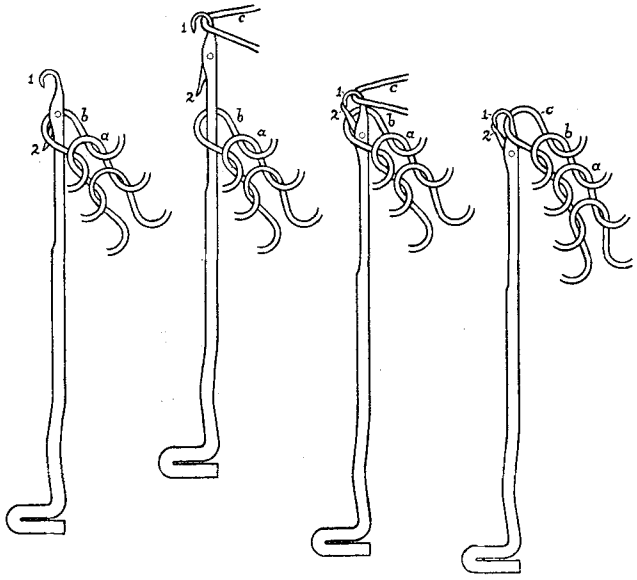


FIG. 6. FIG. 7. FIG. 8. FIG. 9.

Plain Stitch. The principles of knitting, or making a stitch on the latch needle, can be best explained by means of the accompanying illustrations, Figs. 6 to 9, which show a single needle, (for clearness) also showing the successive positions of the yarn and the needle during the operation of making a stitch. In these illustrations, only one needle has been used and the stitches are shown as made by that needle alone. It must be understood, however, that each needle on the machine makes, in turn, a similar stitch from the same thread, and that the different loops or stitches, shown in these illustrations as different threads, are really only different portions of the same continuous thread, the stitches shown being made, one at a time, until a complete circular course of the fabric has been completed by one revolution of the cylinder, or of the yarn carrier, according to the type of machine in question, and then the same operation is repeated for each succeeding course of the fabric. It is here understood, that, for clearness, the yarn carrier is not shown, since the same has nothing to do with the knitting operation any more than to feed the thread, in rotation to the hooks of the needles.

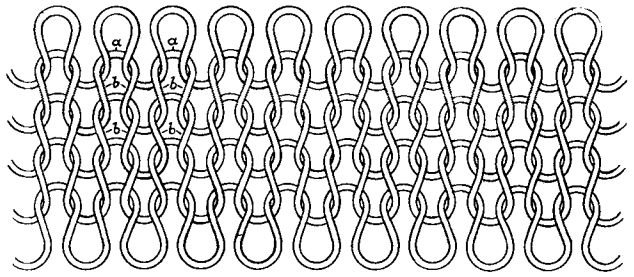


FIG. 10.

Fig. 6 is a diagram, showing the position of the needle and a loop of yarn *b* resting on it, when said needle is in its normal or resting position, the stitch *a* having been made previously by this needle. It will be noticed that the loop *b* is resting on the latch 2, which is turned back at this particular stage of the operation, thus leaving the hook open.

Fig. 7 shows the needle as it would be when raised to its highest position, in which it is seen that the loop *b* is resting on the neck of the needle, below the latch, and that the yarn *c*, for forming the next loop, has been deposited in the hook 1 of the needle. The needle is now given a downward movement, and the latch 2 and the loop *b* now take the position shown in Fig. 8, the loop *b* practically remaining stationary while the needle moves, thus causing said loop to push up the latch 2 and close the hook, as the needle slides in the loop. The loop *b* is now free to slide over the end of the closed hook, while the newly deposited yarn *c*, which now also is formed into a loop, rests in the closed hook. The needle descends further until the loop *b* finally slides over the end of the hook, or is, what is technically termed, *cast off*, as shown in Fig. 9. After casting off the loop, which we now call a *stitch*, the needle returns to its normal position, shown in Fig. 6, and the loop *c* takes the same position as was held by loop *b* in that diagram.

By using a set of needles, as is done in a knitting machine, a series of loops are formed at every course, and on the next course new loops are drawn through these, thus interlocking them and making a uniform web.

This system of knitting with one set of needles will produce a "plain stitch" web, a diagram of a portion

of which is shown in Fig. 10. It will be noticed that all of the loops *a* of the stitches are on the back of the web; in a knitted fabric, however, the loops are longer than they are wide, as shown in the diagram, hence they produce a smooth and even surface. The sides, or converging portions *b*, of the stitches are all on the face of the web, and being close together in the

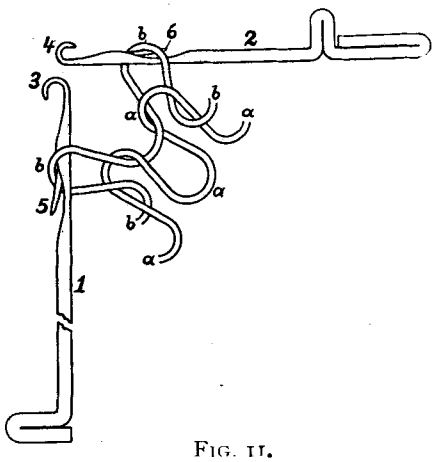


FIG. 11.

fabric, will form a rib or raised line for every vertical row of stitches, said raised lines being close to each other.

Owing to the smooth inside surface of the web produced, this style of stitch is used almost exclusively on fabrics worn next to the body, such as underwear, stockings, etc.

The Rib Stitch. The operation of knitting by means of two separate sets of needles is best shown in connection with Figs. 11, 12, 13, and 14, which are diagrams representing the four principal positions which the needles occupy during the making of the

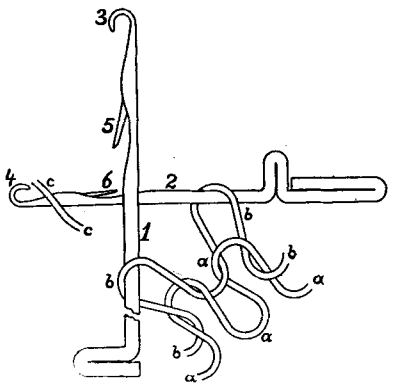


FIG. 12.

stitch. The action of the needles is similar to the action of the single needle already explained, and the two sets work in conjunction with each other. Only one needle from each set is shown, and the web produced is shown twisted out of line in order to see the stitches to better advantage. In the illustrations, 1 and 2 indicate the body of the vertical and horizontal needles, respectively, 3 and 4 are their respective hooks, and 5 and 6 their latches. Each needle makes a stitch from the same yarn, as shown by the loops on both needles made from the yarn *b*, stitch *a* having been previously deposited on them and the stitches formed from it. Fig. 11 is the normal position of the needles and loops, in which it is seen that the loops *b-b* of the yarn rest on the latches of the respective needles, which are turned back at this stage of the operation. These needles are, at the proper time, moved, respectively, upwardly and outwardly, and the loops then rest behind the needles, as shown in Fig. 12 at *b-b*. At the same time, the yarn carrier, not shown here, deposits the course of yarn *c*, which rests on the projecting end of the horizontal needle 2, just below the hook. Then the vertical needle 1 starts downward, as shown in Fig. 13, and its hook 3 catches the yarn *c*, as deposited on the horizontal needle, and begins to draw it into a loop. Just after this, the horizontal needle 2 is drawn inward, and catches the same yarn in its hook, and as the two needles continue

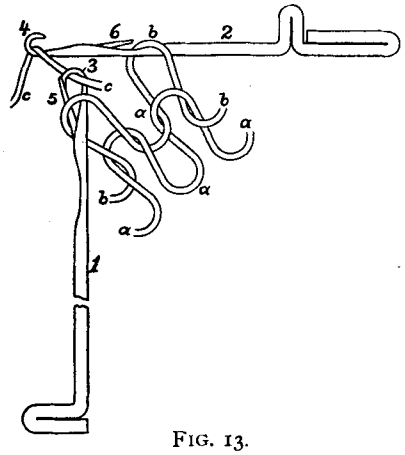


FIG. 13.

to move away from each other, the respective loops *c-c*, which were resting behind the latches, now close said latches by coming under their back-turned ends, thus enclosing the new loops of yarn *c-c* in their hooks.

The loops *b-b* which were resting on the needles are now free to be cast over their hooks, when the needles have moved sufficiently far inwardly and down-

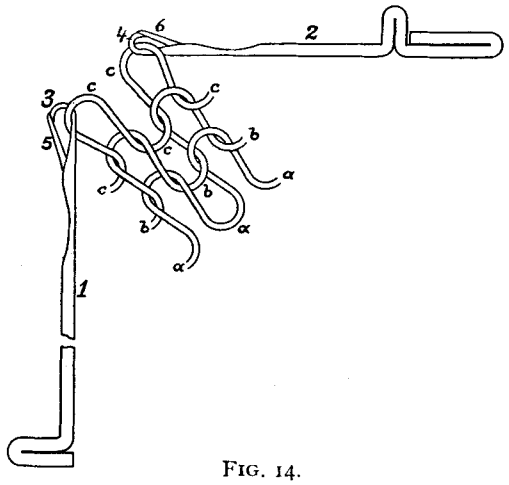


FIG. 14.

wardly. This last position is shown in Fig. 14, in which the needles have moved downwardly and inwardly, respectively, as far as possible, thus casting off the loops of the yarn *b-b* and making stitches of

them. The needles then assume again the positions shown in Fig. 11, the loops of the yarn *c-c*, of course, taking the place of the loops of yarn *b-b*, and the procedure is repeated.

The appearance of the web made with two sets of needles is different from that made with one set, and this fabric is known as "rib stitch." A rib fabric is characterized by the fact that each side presents a similar appearance, that is, each side contains rib lines with a small space between each of these lines. The

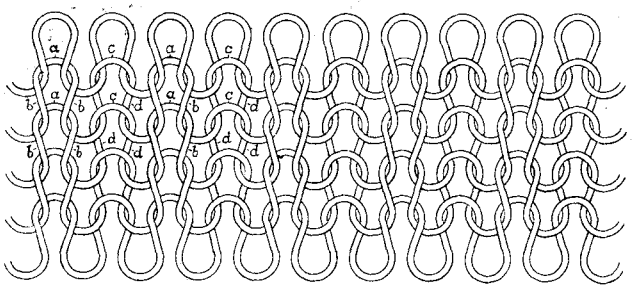


FIG. 15.

rib lines on one side of the fabric come opposite to the spaces on the other side, which can be readily understood by referring to diagram Fig. 15, which represents a portion of the web. It will be noticed that every alternate horizontal part of the loops *a* is on the back of the web, and therefore the converging parts *b* of the stitch will be on the face of the web, and will make vertical rib lines with the successive stitches drawn through them. The loops *c* of the stitches, between those just referred to, are on the face of the web, and consequently the converging parts *d* of the stitches will be on the back and form rib lines there. As the loops on both sides of the web form smooth places, it will be readily seen, that, by the stitch thus explained, these smooth places occur just opposite to the rib lines on the other side of the web, and also come between the rib lines on the same side of the fabric. Owing to the elasticity of this style of web, it is used for making tops for half hose, wrists of undershirts, etc.

The stitch thus explained is known as 1 : 1 rib stitch. Other varieties of this stitch are derived by combining the action of the two sets of needles either 2 : 2, 3 : 1, 4 : 1, etc., by which we mean, that, for instance, with the 2 : 2 rib stitch, 2 rib lines alternate with 2 smooth spaces on each side of the fabric, the rib lines on one side of the fabric being directly opposite the smooth spaces on the other side of the fabric. It will be readily understood that in order to produce this stitch, two needles from one set must be placed side by side to alternate with two needles of the other set.

In order to produce a 3 : 1 stitch, three needles of one set must be placed side by side to alternate with one needle of the other set. The fabric produced will, of course, show a predominance of rib on one side, and smooth portion on the other. It thus will be seen that the varieties in rib stitches may be obtained by simply arranging the two sets of needles according to the stitch desired.

The Tuck Stitch. This stitch is derived from the rib stitch, by a modification of the action of the needles. The tuck stitch is made from two sets of needles, and on the same machine as used for the rib stitch, by a certain cam action that will be explained when describing a typical machine. With the rib stitch, each loop on each needle is cast off after every course of yarn has been deposited in the hooks, as was explained, while with the tuck stitch, the loops on the vertical needles are cast off after every course of yarn has been deposited, but the loops on the horizontal needles are only cast off after every other course, thus making two loops to be cast off at the same time instead of separately, this operation, in turn, resulting in half the number of stitches being made by the horizontal needles as are made by the vertical needles.

Since both loops are always cast off the needle with only one loop remaining in the hook of the needle, only one loop forms a stitch, the other simply being bound in with the stitch. A diagram of a portion of a web made with the tuck stitch is shown in Fig. 16, from which the method of interlocking the loops is easily seen.

In the diagram Fig. 16, the stitches *a* are made by the vertical needles, therefore the loops are on the back of the web as in the rib stitch. The stitches *b* are the tuck portion and contain two loops cast over one stitch, said loops being on the front side of the web, indicating that the stitches were made by the horizontal needles. This style of stitch gives a wider fabric than the rib stitch, and is used a great deal for making ladies' underwear, together with the rib stitch, the latter being used when knitting the waist portion of the garment and also for knitting the wrists or ankles of the same or other garments.

The stitches thus explained comprise what are

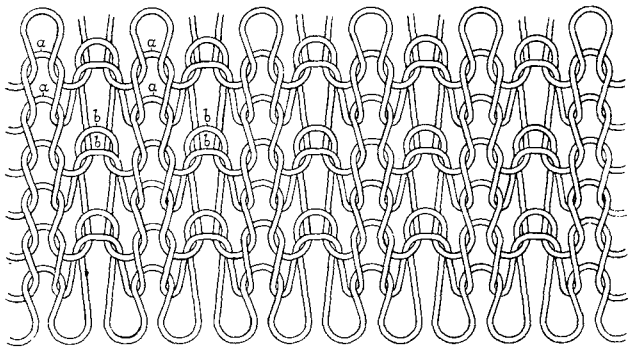


FIG. 16.

termed the foundation knitting stitches, and are found, separately or combined, in all knitted fabrics, either in the original form or in a modification thereof. Different combinations of stitches produce varied effects in the fabric.

(*To be continued*)