July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

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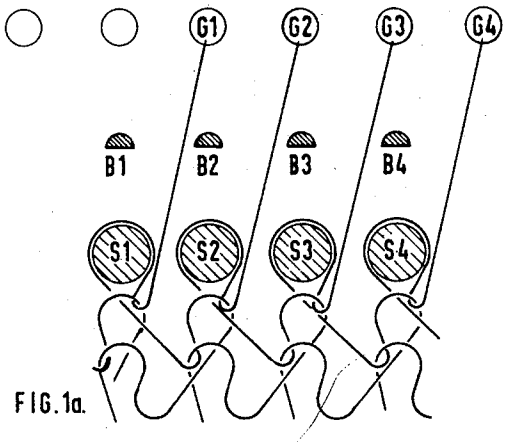


FIG.1a.

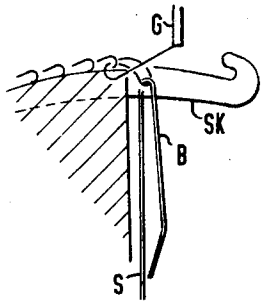


FIG.1aa.

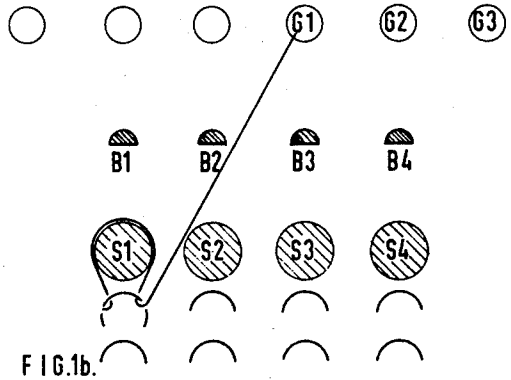


FIG.1b.

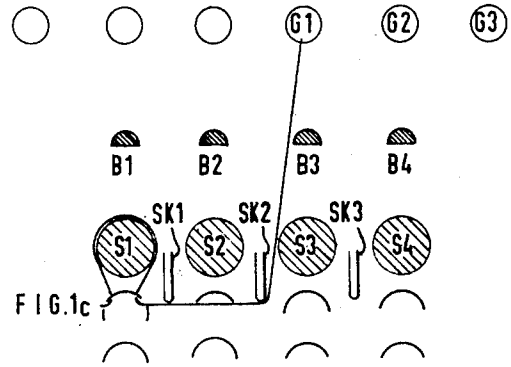


FIG.1c

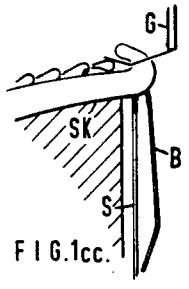


FIG.1cc.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

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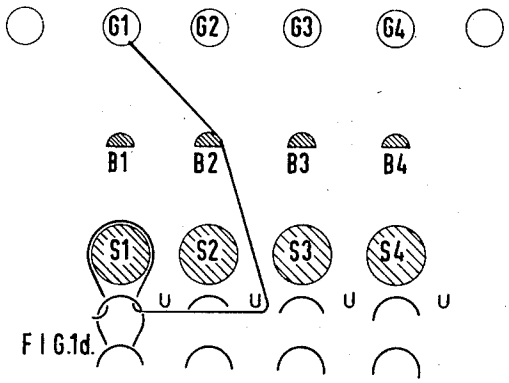


FIG.1d.

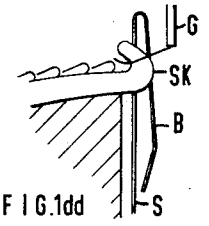


FIG.1dd

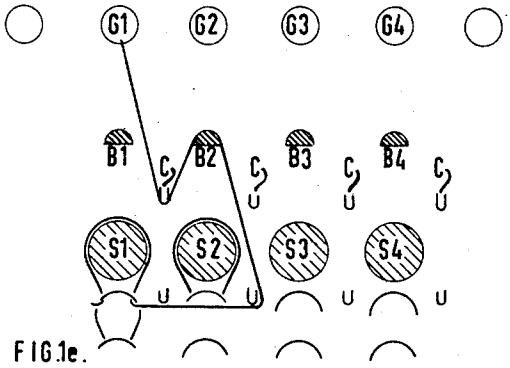


FIG.1e.

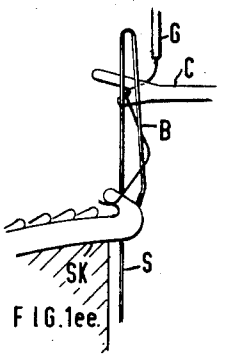


FIG.1ee.

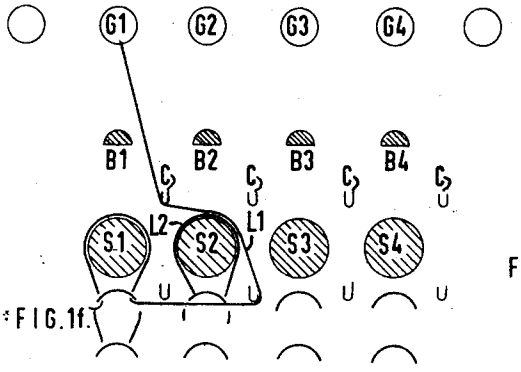


FIG.1f.

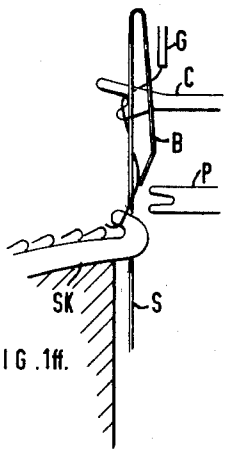


FIG.1ff.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Greitenfeld
ATTORNEY

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

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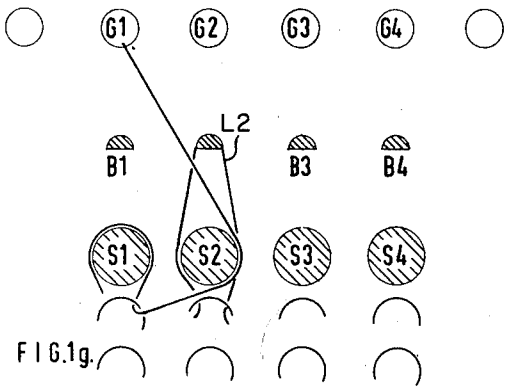


FIG.1g.

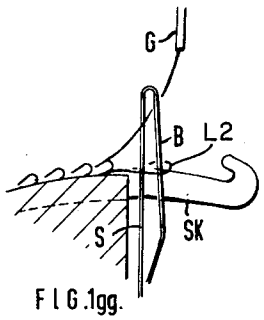


FIG.1gg.

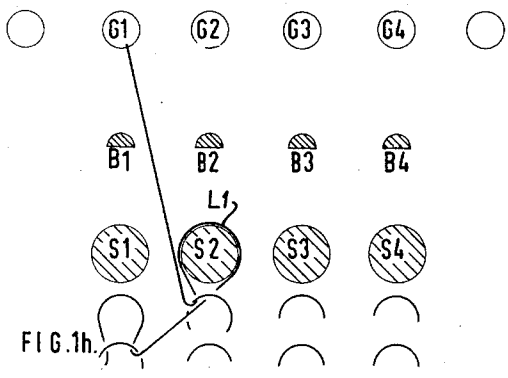


FIG.1h.

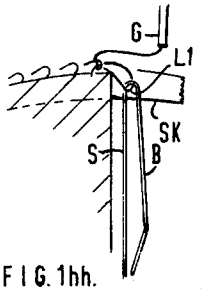


FIG.1hh.

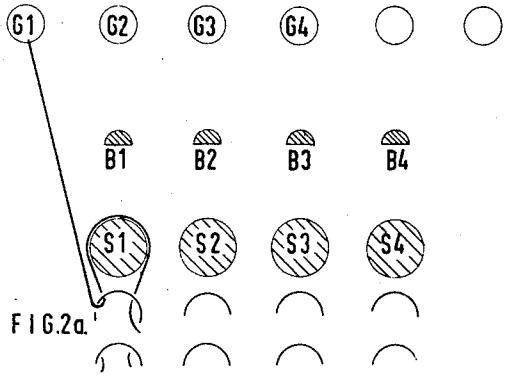


FIG.2a.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

Filed Oct. 4, 1960 20 Sheets-Sheet 4

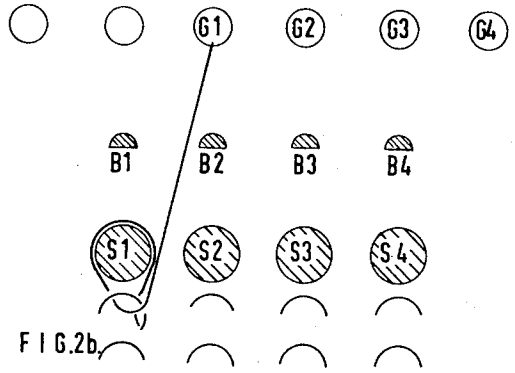


FIG.2b.

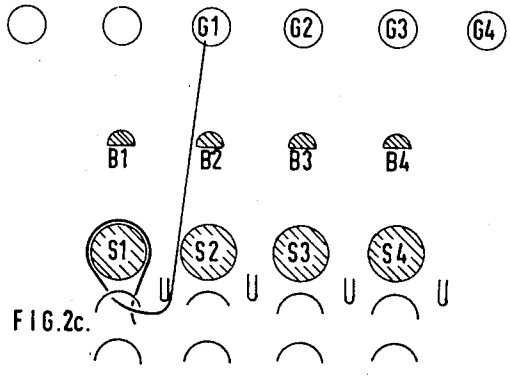


FIG.2c.

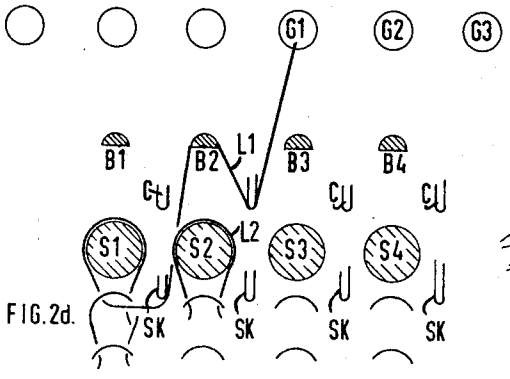


FIG.2d.

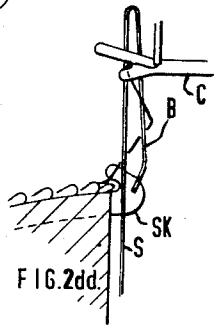


FIG.2dd.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Greitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

Filed Oct. 4, 1960 20 Sheets-Sheet 5

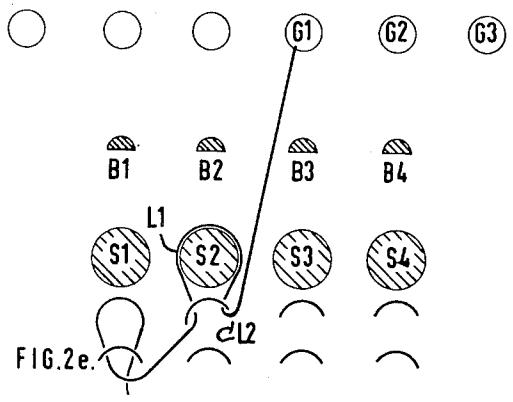


FIG.2e.

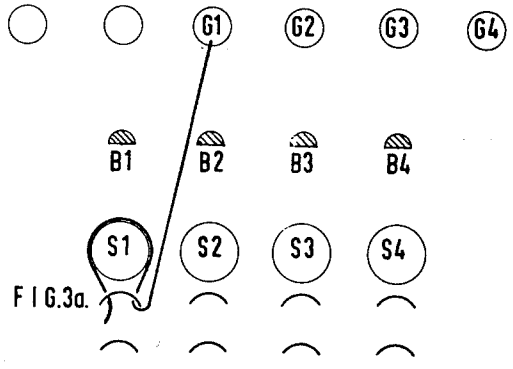


FIG.3a.

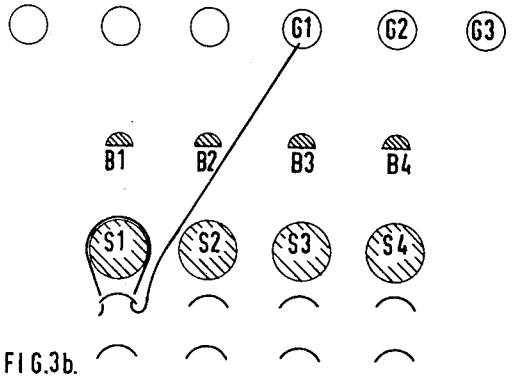


FIG.3b.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

WARP KNITTING MACHINE AND METHOD

Filed Oct. 4, 1960 20 Sheets-Sheet 6

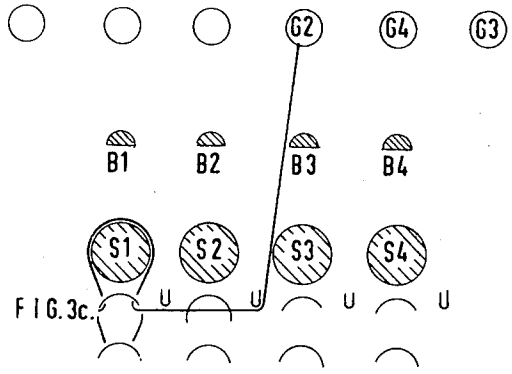


FIG. 3c.

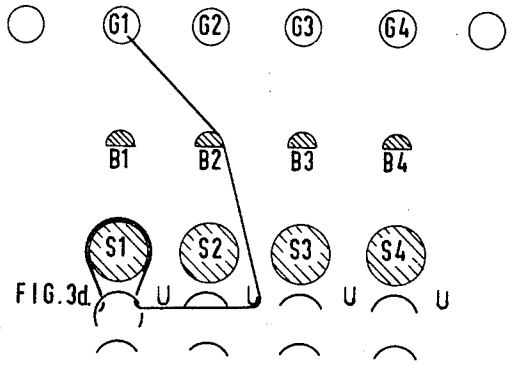


FIG. 3d.

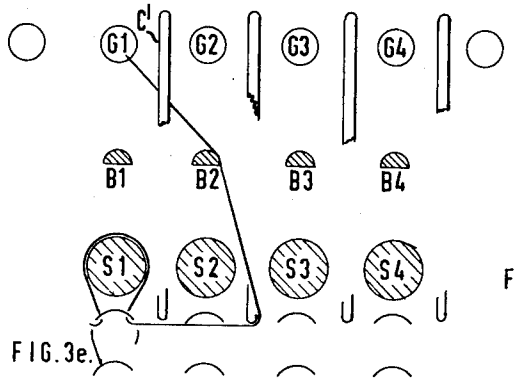


FIG. 3e.

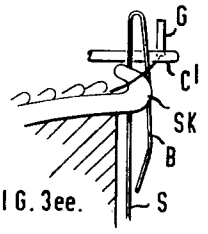


FIG. 3ee.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

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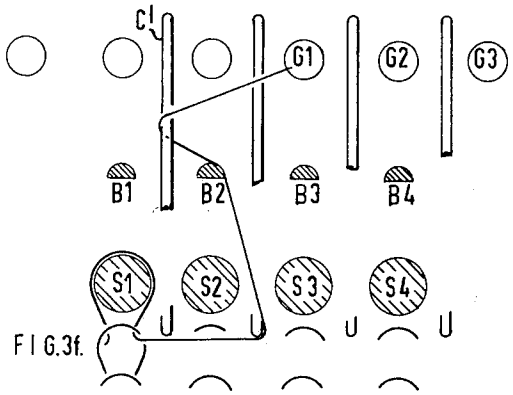


FIG.3f.

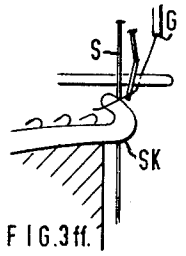


FIG.3ff.

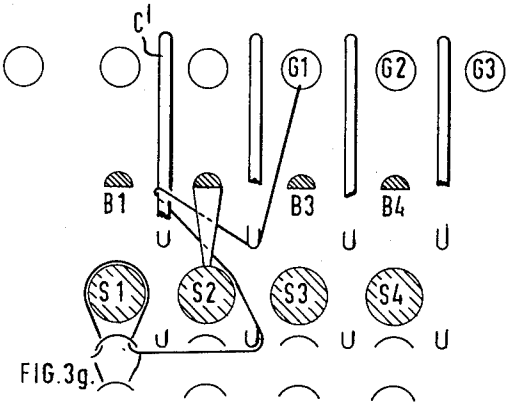


FIG.3g.

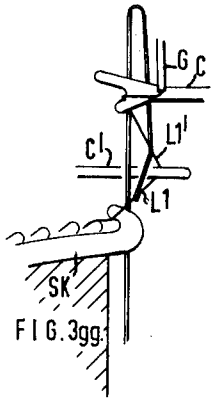


FIG.3gg.

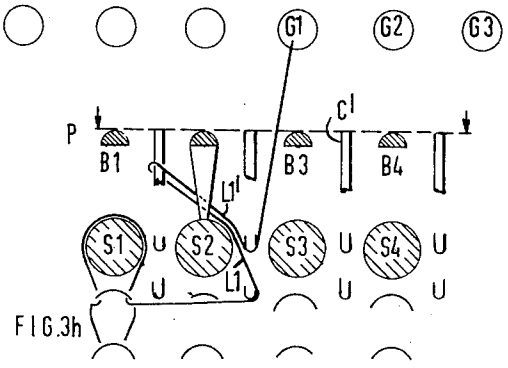


FIG.3h

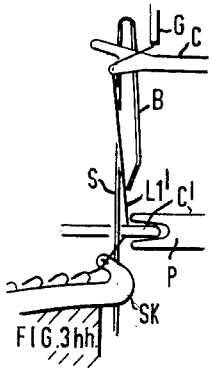


FIG.3hh.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Braitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

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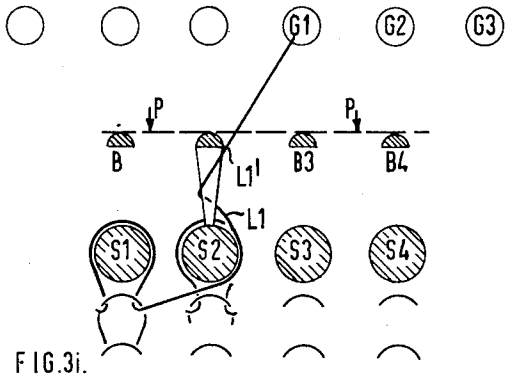


FIG.3i.

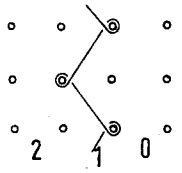


FIG.4.
PRIOR ART

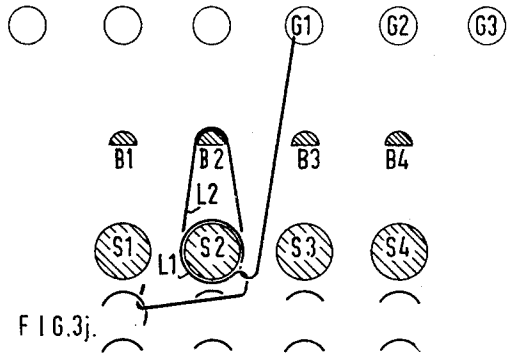


FIG.3j.

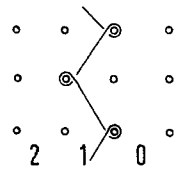


FIG.5.

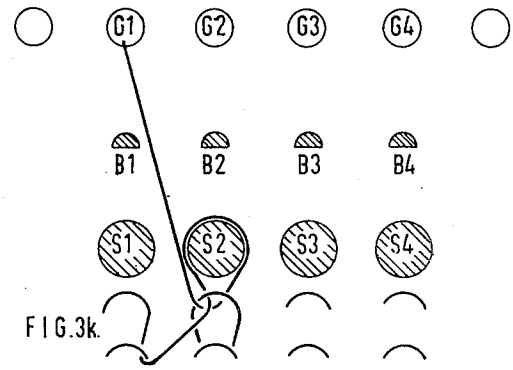


FIG.3k.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

Filed Oct. 4, 1960

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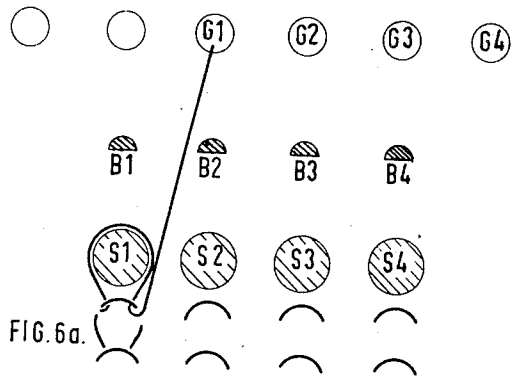


FIG. 6a.

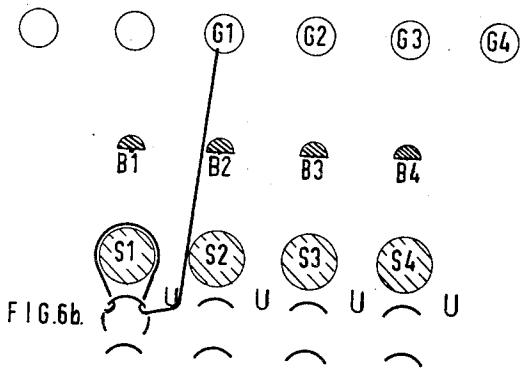


FIG. 6b.

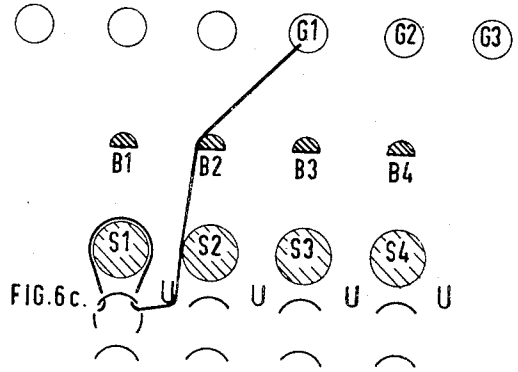


FIG. 6c.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Kreitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

Filed Oct. 4, 1960 20 Sheets-Sheet 10

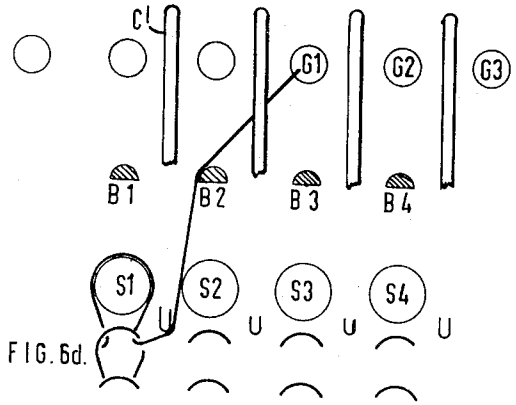


FIG.6d.

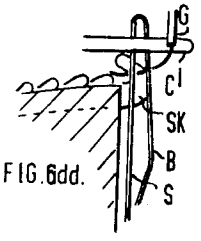


FIG.6dd.

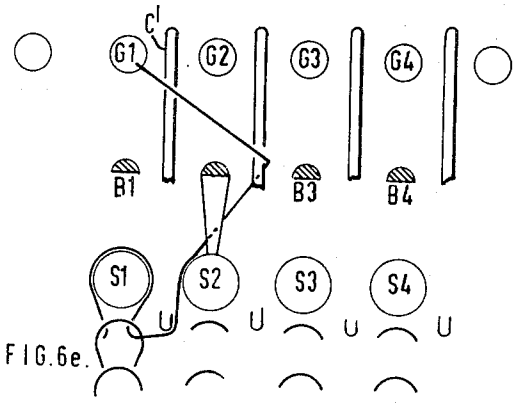


FIG.6e.

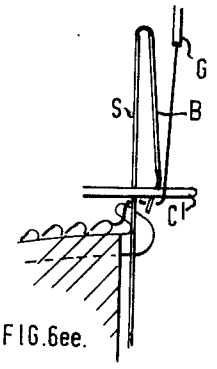


FIG.6ee.

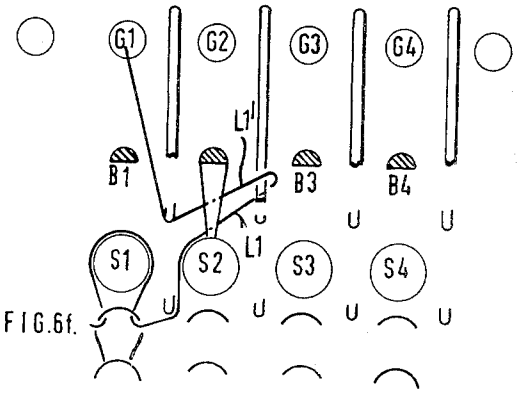


FIG.6f.

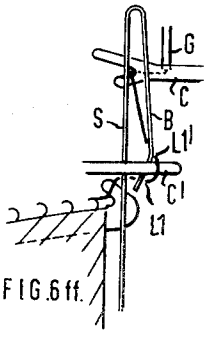


FIG.6ff.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

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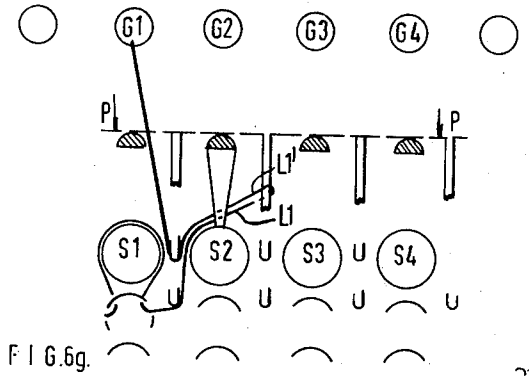


FIG.6g.

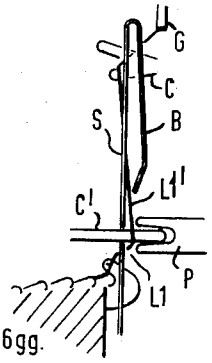


FIG.6gg.

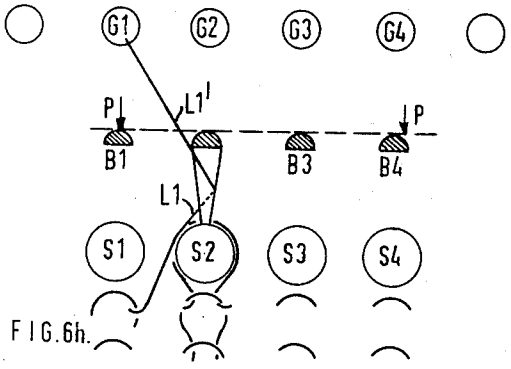


FIG.6h.

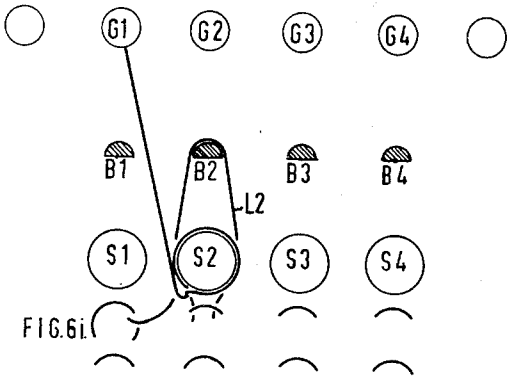


FIG.6i.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

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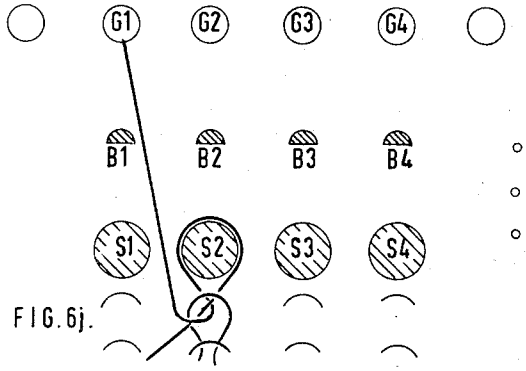


FIG. 6j.

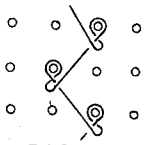


FIG. 7.

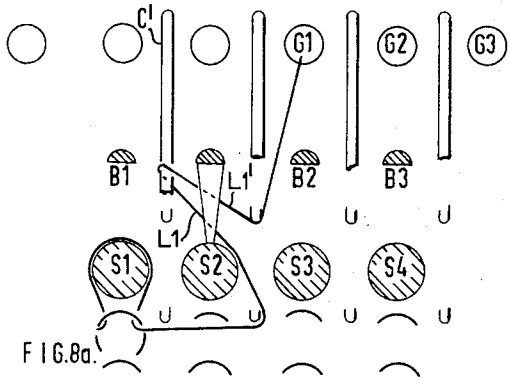


FIG. 8a.

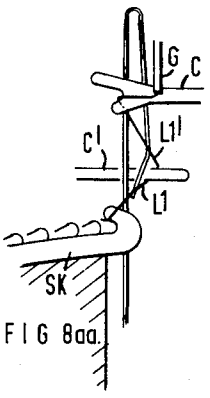


FIG 8aa.

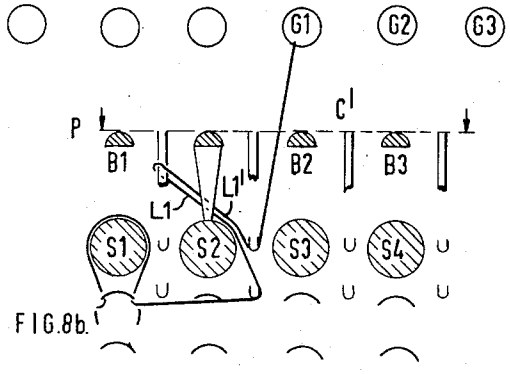


FIG. 8b.

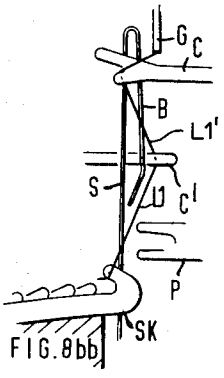


FIG. 8bb.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld Attorney

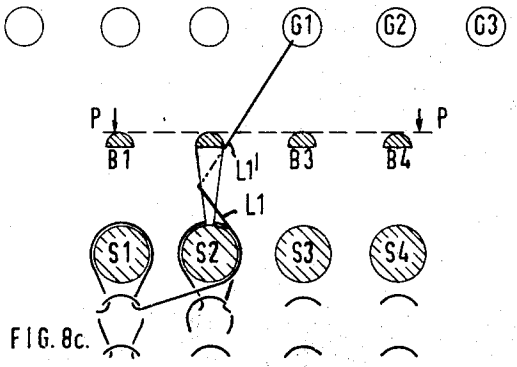


FIG. 8c.

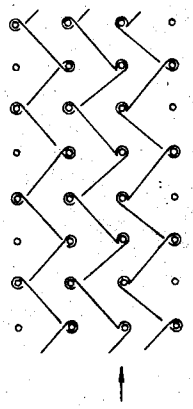


FIG. 16.

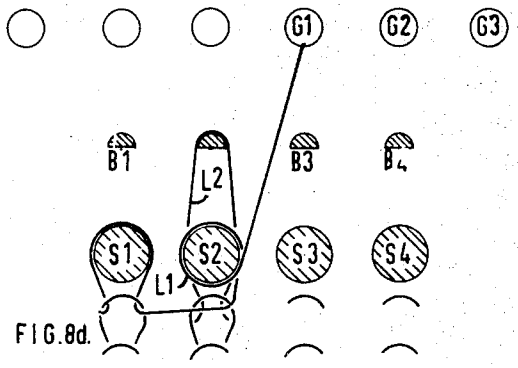


FIG. 8d.

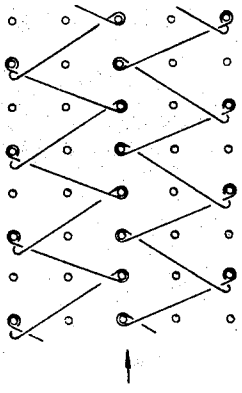


FIG. 17.

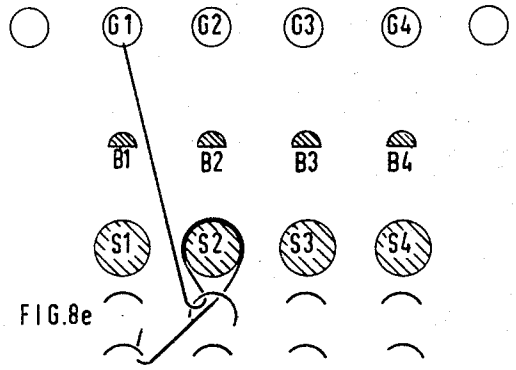


FIG. 8e

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Gaitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

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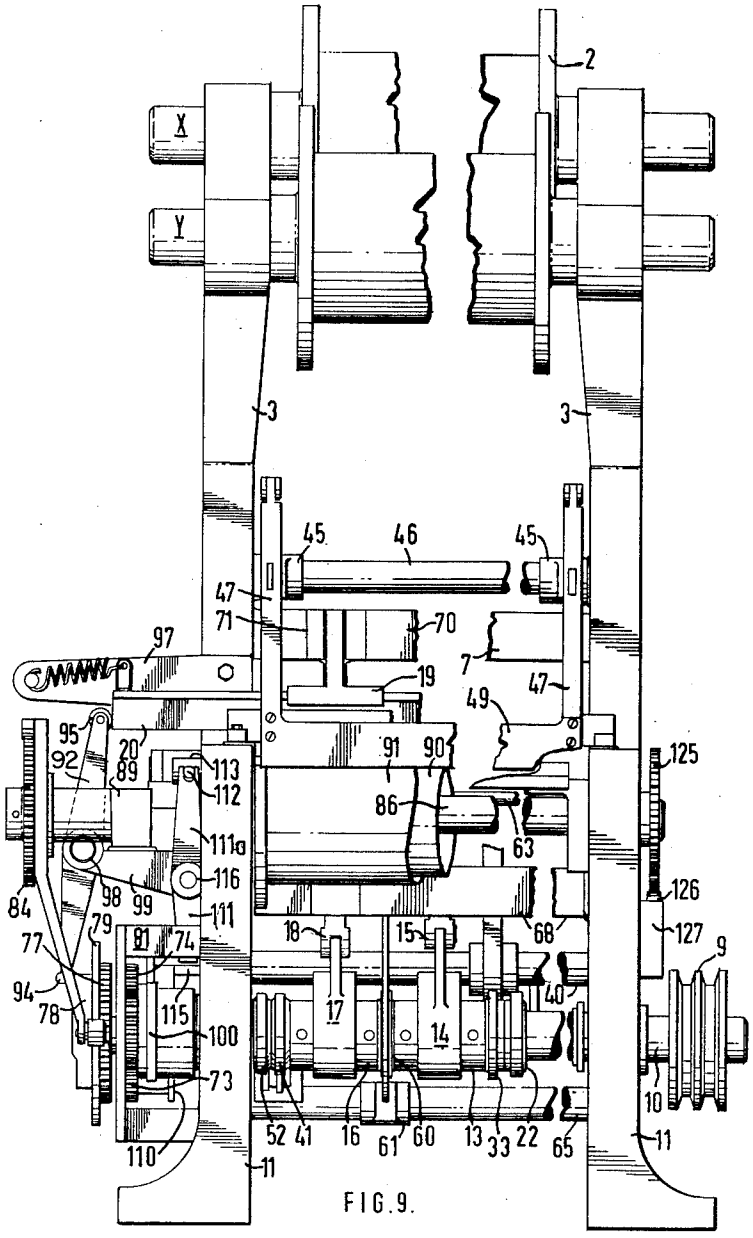


FIG. 9.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

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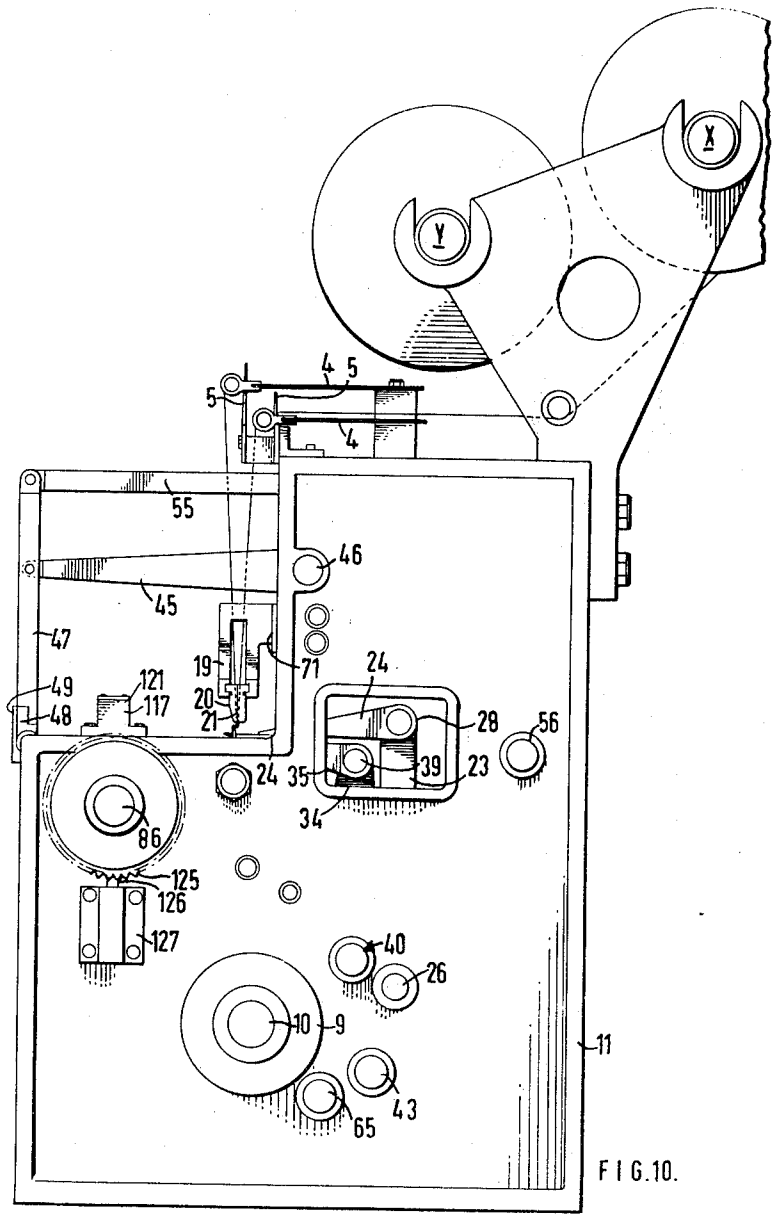


FIG.10.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

Filed Oct. 4, 1960 20 Sheets-Sheet 16

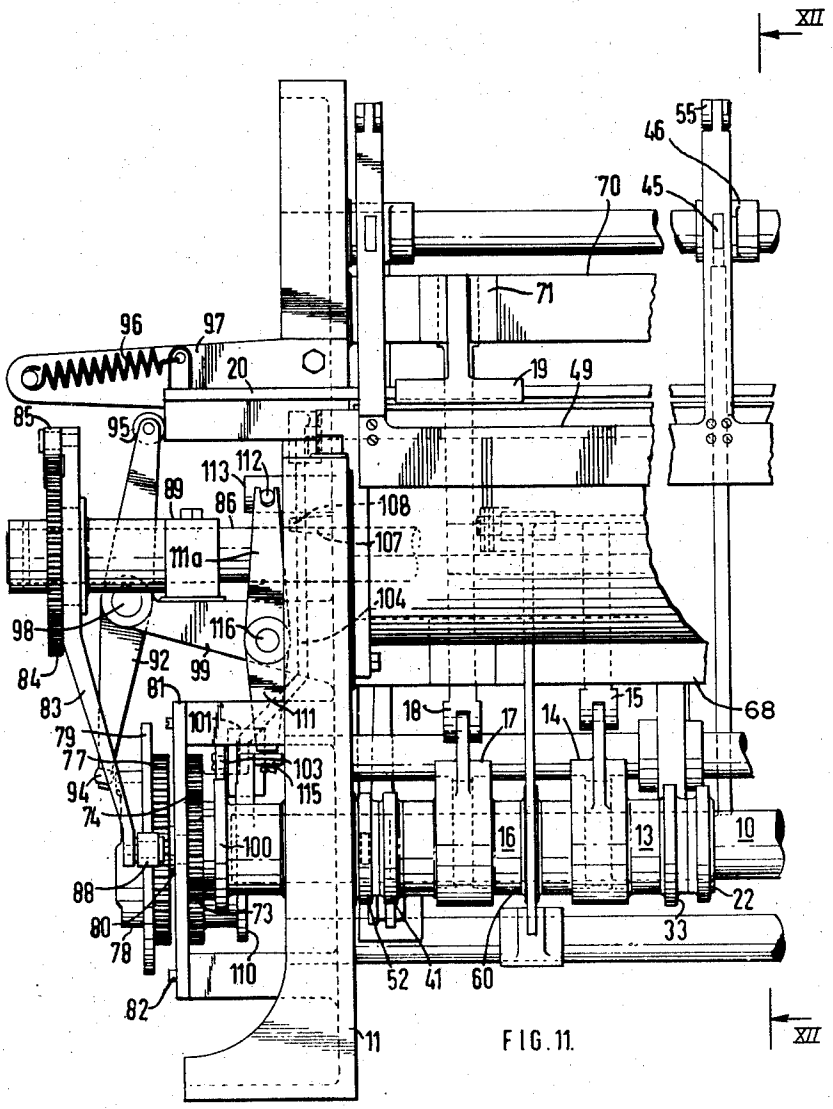


FIG. 11.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

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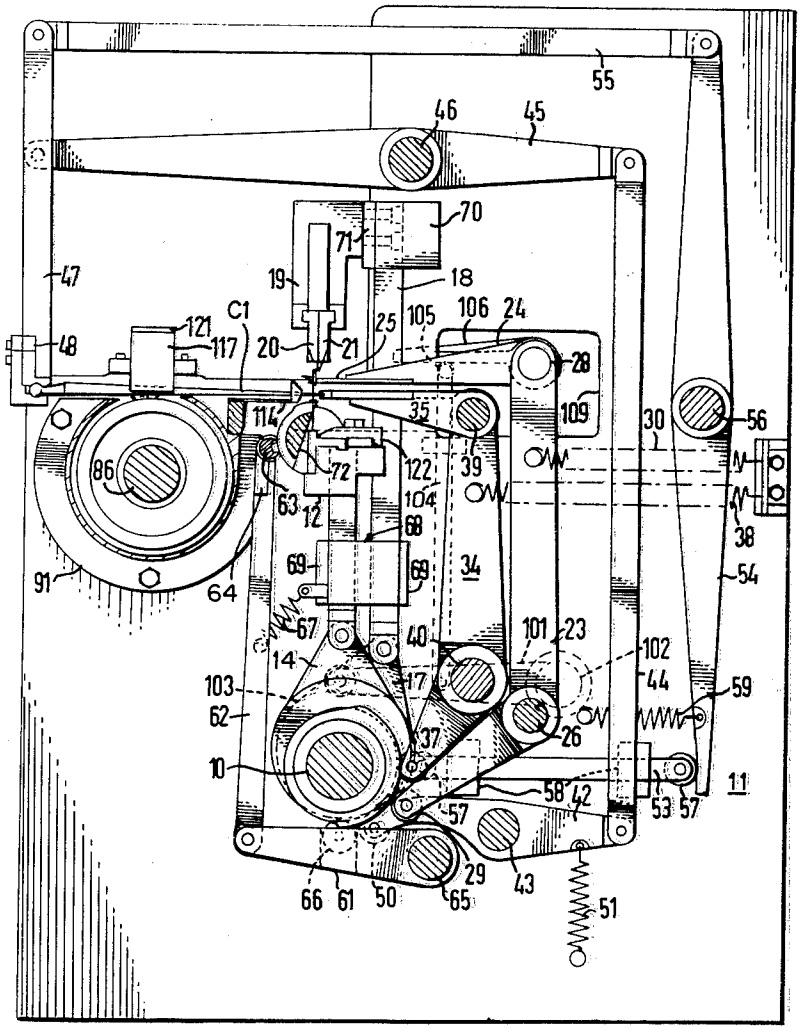


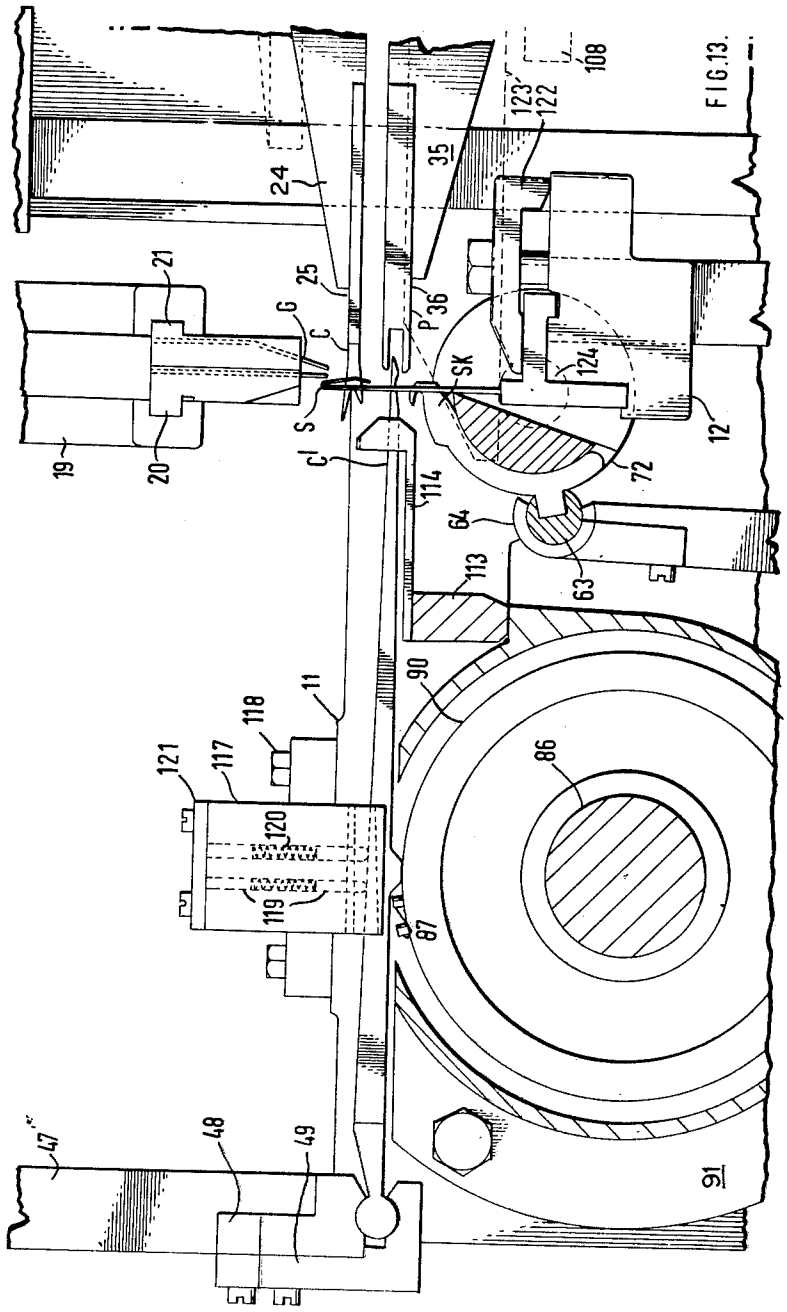
FIG.12.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

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INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

July 21, 1964 H. N. SMITH 3,141,315

WARP KNITTING MACHINE AND METHOD

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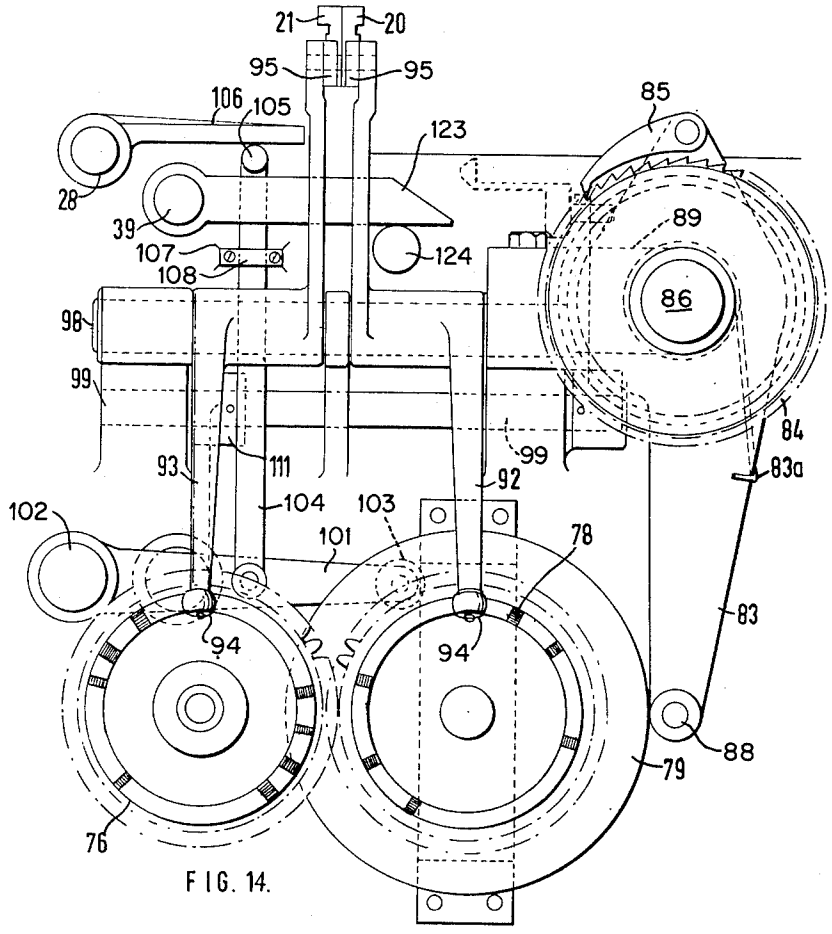


FIG. 14.

INVENTOR:
HERBERT NOEL SMITH
BY
Frederick Breitenfeld
Attorney

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WARP KNITTING MACHINE AND METHOD

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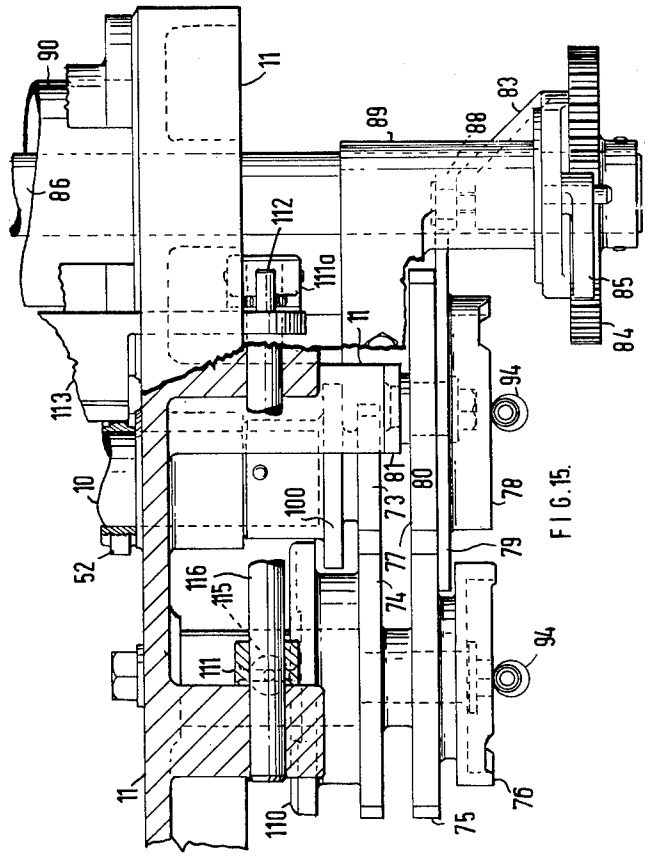


FIG. 15.

INVENTOR:
HERBERT N. SMITH
BY:
Frederick Brectenfeld
ATTORNEY

United States Patent Office 3,141,315 Patented July 21, 1964

3,141,315

WARP KNITTING MACHINE AND METHOD

Herbert Noel Smith, Handforth, England, assignor, by mesne assignments, to The Cotton Silk and Man-Made Fibres Research Association, Shirley Institute, Didsbury, Manchester, England

Filed Oct. 4, 1960, Ser. No. 60,380
Claims priority, application Great Britain Oct. 7, 1959
15 Claims. (Cl. 66—86)

This invention concerns automatic warp-knitting.

Conventional warp-knitting methods and machines are capable of producing varied patterns and fabric effects. In conventional warp-knitting machines however, only two basic types of stitches are possible, namely an open-loop and a closed, or crossed, loop in which the yarn end from the supply overlies the other leg of the loop. This, in itself, limits the range of fabric constructions, which can be obtained on such machines.

The present invention is based on the appreciation of the fact that if the overlap and underlap of the yarn could be achieved without the use of yarn guiding instrumentalities which move both longitudinally of the machine bed, and transversely between the needles (as do the conventional guides) other types of stitches could be produced, and therefore an increase in the range of fabric constructions facilitated.

According to the present invention, a method of automatic warp knitting comprises the cyclical course-forming steps of guiding yarn ends passing from the supply to the last course of the fabric, each at a point at the opposite side of the needles to the fabric, substantially longitudinally of the needle bed, to a position corresponding to the desired lay of the yarn ends at the fabric side of the needles, thereafter guiding the yarn ends adjacent the last course of the fabric substantially at right angles to the needle bed to assume the desired lay, all whilst the needles are retracted so as not to interfere with the guided yarn ends, thereafter moving the needles into a position for engagement with said guided yarn ends, thereafter guiding the yarn ends, at a point at the opposite side of the needles to the fabric, substantially longitudinally of the needle bed to a position corresponding to the desired lay of the yarn ends at the opposite side of the needles to the fabric, thereafter guiding the yarn ends substantially at right angles to the needle bed to assume said desired lay, for engagement with the needle hook, thereafter operating the needles to engage the yarn so laid, in the hooks thereof, and carry same through the loops of the previously knitted course.

The yarn ends may, when being guided to said position corresponding with the desired lay at the opposite side of the needles to the fabric, be moved first in one direction longitudinally of the needle bed and then in the other direction longitudinally of the needle bed, the ends being restrained at the point of reversal of movement to form open loops lying across the needles whereby one or other leg of said loops may be engaged by the needle hooks and passed over said hooks into the needle stem.

The invention also includes an automatic warp knitting machine, having cyclicly operable course forming instrumentalities, comprising means adapted to guide yarn ends passing from the supply to the last course of the fabric, each at a point on the opposite side of the needles to the fabric, substantially longitudinally of the needle bed, to a position corresponding to the desired lay of the yarn ends at the fabric side of the needles, other means adapted thereafter to guide the yarn ends adjacent the last course of the fabric substantially at right angles to the needle bed to assume the desired lay, means for holding the needles retracted meanwhile to prevent interference with the yarn ends so guided, and adapted thereafter to move

the needles into a position for engagement with the guided yarn ends, means adapted thereafter to guide the yarn ends, at a point at the opposite side of the needles to the fabric, substantially longitudinally of the needle bed to a position corresponding to the desired lay of the yarn ends at the opposite side of the needles to the fabric, other means thereafter adapted to guide the yarn ends, at the opposite side of the needles to the fabric, substantially at right angles to said needle bed to assume the desired lay, for engagement with the needle hook, and means thereafter adapted to operate the needles to engage the yarn so laid, in the hooks thereof, and to carry same through the loops of the previously knitted course.

Preferably said means adapted to guide the yarn ends to a position corresponding to the desired lay at the opposite side of the needles to the fabric can be arranged to be operative so as to move said yarn ends first in one direction longitudinally of the needle bed and then in the other direction longitudinally of the needle bed for this purpose, and further comprising means, about which by these movements, the yarn ends are each wrapped to form open loops lying across the needles, and means for causing one leg or the other of each such loop to be engaged by the respective needle hook, prior to passing thereover onto the needle stem.

The invention will now be described further, by way of example, with reference to the accompanying diagrams and drawings.

In the diagrams, and in accordance with the invention:

FIGURES 1*a*, 1*aa*, 1*b*, 1*c*, 1*cc*, 1*d*, 1*dd*, 1*e*, 1*ee*, 1*f*, 1*ff*, 1*g*, 1*gg*, 1*h* and 1*hh* illustrate the knitting of a conventional open-loop fabric;

FIGURES 2*a*, 2*b*, 2*c*, 2*d*, 2*dd* and 2*e*, illustrate the knitting of a conventional crossed loop fabric;

FIGURES 3*a*, 3*b*, 3*c*, 3*d*, 3*e*, 3*ee*, 3*f*, 3*ff*, 3*g*, 3*gg*, 3*h*, 3*hh*, 3*i*, 3*j* and 3*k* illustrate the knitting of another type of crossed loop fabric;

FIGURES 4 and 5 show the knitted structure of FIGURES 2*a* to 2*e* and FIGURES 3*a* to 3*k* according to the point paper convention;

FIGURES 6*a*, 6*b*, 6*c*, 6*d*, 6*dd*, 6*e*, 6*ee*, 6*f*, 6*ff*, 6*g*, 6*gg*, 6*h*, 6*i* and 6*j* illustrate the knitting of yet another type of crossed loop fabric;

FIGURE 7 shows the knitted structure of FIGURES 6*a* to 6*j* according to the point paper convention; and

FIGURES 8*a*, 8*aa*, 8*b*, 8*bb*, 8*c*, 8*d* and 8*e* illustrate a variation of the knitting illustrated in FIGURES 3*a* to 3*k*.

These diagrams are intended to illustrate, in a simple yet adequate manner the range of stitches which can be knitted according to the present invention. The mechanisms whereby the knitting instrumentalities of a machine would perform their necessary various movements are not illustrated at all in the diagrams but one embodiment of a machine including such mechanisms is described later with reference to the drawings in which:

FIGURE 9 is a front elevation of the machine, with much of the central portion omitted to reduce the view to convenient dimensions;

FIGURE 10 is an end elevation from the right of FIGURE 9;

FIGURE 11 is a more detailed front view of the lower part of the left-hand end of the machine shown in FIGURES 9 and 10;

FIGURE 12 is a sectional view on the line XII—XII of FIGURE 11;

FIGURE 13 is a detail view to a larger scale of the knitting instrumentalities shown in FIGURE 12;

FIGURE 14 is a detail end view from the left of FIGURE 11;

FIGURE 15 is a detail plan view corresponding to FIGURE 14; and

FIGURES 16 and 17 are each point paper illustrations

of different stitches which can be produced by the machine in the same course.

Referring first to FIGURES 1*a* to 1*g*, FIGURE 1*a* illustrates diagrammatically a short section of a warp knitting machine at the end of a cycle. FIGURE 1*aa* is an end view corresponding to FIGURE 1*a*, and these two figures together indicate the positions of the basic instrumentalities used in practising the present invention, such positions being somewhat different from those of conventional warp knitting machines. G1, G2, G3 etc. indicate guides mounted on a common guide bar (the guide elements are so arranged that other elements, e.g. sinkers and combs, can pass freely between them); B1, B2, B3 etc. the needle beards in section; S1, S2, S3 etc. the needle stems in section; and SK1, SK2, SK3 etc. the sinkers, all mounted in a sinker block (only the end views e.g. FIGURE 1*aa* show both the sinkers and sinker block).

The knitting of an open loop fabric (0–1/2–1) will be described (with reference to FIGURES 1*a*, 1*aa* to FIGURES 1*h*, 1*hh*).

As stated, FIGURE 1*a* shows the situation (in plan) at the end of a cycle, with the needles below the level of the sinker block (omitted from FIGURE 1*a* for clarity, but see FIGURE 1*aa*). The guides, by a suitable movement of the guide bar, now displaced one needle space to the right as shown in FIGURE 1*b* (i.e. G1 moves to the position previously occupied by G2, G2 to G3 etc. in FIGURE 1*a*) and the threads pass over the tops of the needles as in FIGURE 1*b*. The sinkers SK1 etc. are now withdrawn into their block catching the threads in the manner of FIGURES 1*c* and 1*cc*. The needles start to rise and the guide bar shifts two spaces to the left taking the threads around the outsides of the beards as in FIGURES 1*d* and 1*dd*. To ensure that the threads enter the beards later in the cycle, a comb C (FIGURES 1*e* and 1*ee*) pushes the threads against the needle beards. As the needles continue to rise the threads fall off the beards onto the stems (see FIGURES 1*f* and 1*ff*). It will be noted that the guides and comb rise with the needles. The needles now fall and the threads L^1 enter the beards. The latter are then closed by a presser, P (FIGURES 1*f* and 1*ff*), so that as the needles fall further the loops L_2 (see FIGURE 1*g*) of the previous course (shown in only some of the figures in the interests of clarity) ride over the beards. A special bifurcated presser (see later) is used which ensures that the beards remain closed for a sufficiently long period, to enable the loops L_2 to pass onto the beards. The comb C is withdrawn as soon as the beards are closed; the presser is withdrawn when the loops L_2 have been penetrated (FIGURES 1*g* and 1*gg*). Finally, at the knock-over position (see FIGURES 1*h* and 1*hh*) the loop L_2 is cast off the needle leaving the new loop L_1 on the needles as shown in FIGURES 1*h* and 1*hh*. Meanwhile, the guides have fallen to the position shown in FIGURE 1*hh* ready for the start of the next cycle. In the next cycle the guides move to the left so that the next loop from thread L_1 is knitted on needle S_1 etc.

It will be seen that the major difference between this method and the conventional method is that the underlap operation (FIGURES 1*b* and 1*cc*) is carried out by a combination of guide and sinker movement. As a result, there is no need for the guides to pass between the needles.

The knitting of a crossed loop fabric is shown in FIGURES 2*a* to 2*e*; the construction is 1–0/1–2 (see FIGURE 4) and is theoretically identical with such a crossed loop fabric knitted by the conventional methods. The only material differences between the embodiment of FIGURES 1*a* to 1*h* and FIGURES 2*a* to 2*e* is that in the case of the latter embodiment the overlap movement is in the same direction as the underlap movement; and that, when knitting multifilament yarn an extra guide bar movement of one pitch to the left occurs between the positions of FIGURES 2*c* and 2*d* to prevent accidental picking up of filaments by the needles as they rise.

By using a second comb it is possible to knit two further loops which are outside the range of normal warp knitting machines. This arises from the fact that in the method of knitting according to the present invention it is possible to wrap the thread in the form of a loop round the needle beard, as will shortly be described.

In a crossed loop knitted on a conventional machine the thread from the supply always lies above the other leg of the loop. Such a loop can therefore be uncrossed by a suitable subsequent movement of the guide bar. With the method of knitting according to the invention it is possible to knit crossed loops in which the supply thread lies *below* the other leg. Such a loop cannot be uncrossed. Its formation will now be described with reference to FIGURES 3*a* to 3*k*. The initial guide movements, which are similar to those in the knitting operations already described are illustrated in FIGURES 3*a* to 3*d*, and are not described in detail. The situation shown in FIGURE 3*d* having been reached an additional comb C^1 moves in transversely of the needle bed (and from the front of the machine) passing over the threads to the guides (FIGURES 3*e* and 3*ee*). The guide bar is then displaced two needle spaces to the right so that the thread passes round the comb C^1 (FIGURES 3*f* and 3*ff*). FIGURES 3*g* and 3*gg* and FIGURES 3*h* and 3*hh* show the thread disposition just before the thread enters the beard. The part of the beard below the section is shown in these figures on needle S_2 to make this clear. It will be seen that the additional comb C^1 in combination with the comb C is used to create an open loop or fold in the thread under the beard. This means that it is possible to enter the top part L_1^1 of the thread under the beard into the needle hook via the comb C. When the beard is closed, as in FIGURE 3*i* it is completely wrapped by the loop formed by the thread $L_1—L_1^1$. When the loop of the last course is in the process of being cast-off, the loop on the beard is pushed up the beard, over the top part of the needle, until it lies on the stem. In thus being turned through 180° it becomes crossed as in FIGURE 3*j*. Finally, as the guides start the next cycle (after the knock-over) the loop takes up the disposition shown in FIGURE 3*k*. The difference between such a loop and a normal crossed loop can be illustrated on point paper in the manner shown in FIGURE 4 (conventional crossed loop) and FIGURE 5 (crossed loop just described).

The reason for the bifurcation of the presser P will be apparent from the preceding description and FIGURE 3*hh* from which it is seen that the additional comb C^1 has to operate in the plane of the presser P and in overlapping motion with it. The recess in the end of presser P provided by virtue of the bifurcation enables this movement of the additional comb C^1 to take place.

By a slight modification to the guide bar movement it is possible to produce loops with a double crossing. The stitch formation is illustrated in FIGURES 6*a* to 6*j* and is described now. The representation on point paper is shown in FIGURE 7. FIGURE 6*a* shows the situation at the end of a knitting cycle just after the knock-over operation. The needles and guides are in their lowest positions. Thus when the sinkers are withdrawn into their block (FIGURE 6*b*) the threads to the guides are picked up and held at the fronts of the needles. When knitting multifilament yarn, the guides now move one pitch to the left (not shown) to avoid filaments being caught by the needle as it rises. The guides then move one or two pitches to the right as the case may be, as they and the needles rise, such that the threads lie round the beards as shown in FIGURE 6*c*. At this point the comb C^1 enters and passes over the threads to the guides as shown in FIGURES 6*d* and 6*dd*. The needles and guides continue to rise, the guides meanwhile moving two pitches to the left in order to wrap the threads round the comb C^1 (see FIGURES 6*e* and 6*ee*). The entry of

the comb C now ensures that the threads are held against the needle beards as shown in FIGURES 6*f* and 6*ff*. As a result of the upward motion of needles, guides and comb C (comb C^1 remaining stationary), the threads fall off the beards to give the situation shown in FIGURES 6*g* and 6*gg*. The upper portion of the thread to the guides L_1^1 is now in a position to enter into the beard as the needle falls. Once this has taken place, the beard is closed by the action of the presser P so that the lower portion of the thread L_1, cannot enter into the beard. The combs C and C^1 are now withdrawn, but the presser remains in position until the previously knitted loop L_2 has started to ride up the outside of the beard (as a result of the downward motion of the needles); the situation is illustrated by FIGURES 6*h* and 6*i*. In FIGURE 6*i* the presser has been withdrawn and the loop L_2 is riding up the outside of the beard. The knock-over occurs when the needles reach their lowest positions; the resulting loops are doubly crossed as shown in FIGURE 6*j*.

It will be appreciated that the position of the additional comb C^1 is critical in the formation of the two crossed stitches just described. The nature of the crossing depends entirely upon whether the leg L_1^1 or the leg L_1 enters the beard. This can be turned to good advantage in the following manner. Referring to FIGURES 8*a* and 8*aa* (c.f. FIGURES 3*g* and 3*gg*) it will be seen that by raising the additional comb C^1 such that it maintains the same position relative to C it is possible to enter L_1 into the beard instead of L_1^1 (FIGURES 8*b* and 8*bb*); the loop now produced (FIGURES 8*c* to 8*e*) will be uncrossed instead of crossed as before. If a similar modification is carried out in the cycle of FIGURES 6*a* to 6*i* a conventional crossed instead of a doubly crossed loop is formed. By having the teeth of the comb C^1 arranged for individual control, it is possible to knit certain combinations of different types of stitches *in the same course*, i.e. the new singly crossed stitches can be knitted with plain (open loop) stitches, and conventional singly crossed stitches can be knitted with the new doubly crossed stitches. Thus, true "Jacquard" (i.e. individual warp thread) control is possible.

With regard to the diagrams, it is to be noted that the loops of the previous course have been shown, for simplicity, as open or uncrossed loops, and that, in all but the first example described the new loops of the next course are of a different nature. Furthermore in the plan views, the combs have been shown in simplified form as will be appreciated from the end views.

The needles shown in the diagrams are bearded needles, but it will be appreciated that the operation and design of the necessary instrumentalities could, without substantial difficulty, be modified in such manner as to enable tongue needles to be used.

In certain cases the patterning may require a different rate of thread supply to different needles over an extended period. In this event it is likely therefore, that it will be necessary to regulate the feed of yarn to the respective guides accordingly. One method would be to have separate suppliers of yarn, and another, in the case of a common supply beam, would be to provide suitable compensating means.

It will readily be appreciated that the invention has been described with reference to one guide bar only of the machine. In practice it would be usual to use at least two guide bars.

It will also be appreciated that the stitch formations described hereinbefore are limited to single needle displacements for the sake of simplicity.

A machine constructed to perform new stitch-forming operations described hereinbefore, and with a "Jacquard" control, could also perform the usual techniques of conventional warp-knitting machines involving, for example, multi-needle displacements of the guides to give geometric patterning, laying-in, part set threading of the guides to give special effects, and so on.

The following important advantages are indicated in connection with the present invention by the work which has been carried out up to the present time.

(1) The range of basic stitches is greater than in conventional mechanical warp-knitting. This may be used for example, to improve the quality or modify the characteristics of the fabric and to increase the patterning scope. For example, we have found that a fabric knitted wholly from the new crossed stitches has little or no tendency to curl at the edges; and that an increased cover factor is obtained when using these stitches.

(2) True "Jacquard" control is possible. Where there is sufficient differentiation between the different types of stitches, unlimited patterns are possible particularly across the width of the fabric by knitting different types of stitches in the same course. The invention may, of course, be used in conjunction with the conventional guide bar patterning mechanism or its equivalent, or not. For example, the guide bars may be controlled as described in U.S. Patent No. 3,089,322.

Reference will now be made to FIGURES 9–15 which illustrate an experimental machine capable of knitting according to the invention, and provided with a Jacquard mechanism. The machine is designed to carry out a knitting operation of a limited nature, in that the guide bar actuating mechanism, as will later be described provides for a two-course cycle only. Clearly the machine could be modified to enable conventional or other guide bar actuating mechanisms to be used, whereby a lengthy cycle could be obtained. Arrangements for mechanical let-off of the threads from beams, and mechanical take-up of the knitted fabrics, have not been shown in the figures, but such arrangements are well-known, and their design would be within the capabilities of a person skilled in the art.

The machine has main side frame members **11** suitably connected together, which serve to support the various elements, and in particularly to support bearings for the ends of the various shafts referred to hereinafter which extend across the machine.

A main driving shaft **10** supported by bearings in the side frames **11** runs longitudinally of the machine, and carries a pulley **9** outside the right-hand side frame **11** whereby the drive from an electric motor having suitable control gear (not shown) may be transmitted by belts (not shown) to the shaft **10**.

The knitting instrumentalities are as follows (see FIGURE 13):

(*a*) Bearded needles S supported in a needle bed **12** by clamps **122**.

(*b*) Guides G. There are two sets of guides, front and back, each set being carried in a guide bar **20, 21** respectively. Each individual guide is in the form of a metal tube, through which the threads pass, this facilitating the passage of other instrumentalities therebetween.

(*c*) Sinkers SK which are of the arcuate type, slidably and rotatably mounted in a sinker bed **72.**

(*d*) A presser P mounted in a plate **36.**

(*e*) A back comb C mounted in a plate **25.**

(*f*) A front or additional assembly of combs C^1 mounted in steady bar **117.**

The means for moving appropriately these instrumentalities in appropriate manner will now be described.

The Needles S

Shaft **10** carries two or more eccentrics **13,** (FIGURE 11) according to the length of the machine (there being at least one at each end) each operating a connecting rod **14** which in turn operates a push rod **15** which transmits a vertical reciprocating motion to the needle bed **12.** Each push rod is supported in a slot, in a slide bar **68** (FIGURE 12) fitted with a cover plate **69.**

The Guides G

Referring to FIGURES 11 and 12 it will be seen that shaft **10** carries two or more eccentrics **16** each operat-

ing a connecting rod **17**, which in turn operates a push rod **18** which transmits vertical reciprocating movement to the guide bars **20, 21**, by virtue of its attachment to a guide bar bearing **19**. Each push rod **18** is supported in a slot in a slide bar **68** and a slot in a slide bar **70** fitted with cover plates **69, 71** respectively.

Shaft **10** (see FIGURES 9, 11 and 15 especially) has a pinion **73** fixed to its left-hand end outside the machine frame **11**. Pinion **73** drives spur wheel **74** twice its pitch diameter. Spur wheel **74** is integral with coaxial spur wheel **75** (behind spur wheel **74** in FIGURES 9 and 11, and therefore not shown; see FIGURE 15) of like size, which carries a face cam **76**. Spur wheel **75** drives a like spur wheel **77** having a face cam **78** and an edge cam **79** integral therewith. The spur wheel-cam assembly **77, 78, 79** is mounted for rotation on a stud **80** riveted onto a bridge plate **81** fixed to the side frame **11** by screws **82**.

The edge cam **79** causes rotation of a pin drum or Jacquard drum **90** described in more detail hereinafter.

Face cams **76, 78** control the endwise movements of the guide bars **20, 21** (FIGURES 9, 11 and 14). The movement is transmitted by means of rocker levers **92** (for front guide bar **20**) and **93** (for back guide bar **21**). The levers **92, 93** have roller followers **94** at their lower ends and **95** at their upper ends. The ends of the guide bars **20, 21** are kept in abutment with the rollers **95** by means of tension springs **96** secured to the left hand side frame **11** by plate **97** (FIGURES 9 and 11). Clearly the spring action will also ensure that rollers **94** maintain contact with the respective face cams **76, 78**. The levers **92, 93** are supported for rotation on a shaft **98** carried in bearing brackets **99** integral with side frame **11**.

The face cams **76, 78** (FIGURE 14) are contoured to provide a two course movement cycle for the guide bars. As follows from the preceding description these cams perform one complete revolution for every two revolutions of the shaft **10**, which controls the movement cycles of the remaining instrumentalities.

The Sinkers

The shaft **10** carries a series of cams **60** (FIGURES 9 and 11) spaced therealong which impart the necessary arcuate reciprocating movement to the sinkers SK through the agency of levers **61** and lifters **62** (FIGURE 12). Each lifter **62** has fixed to its upper end a part-annular cap **64** to provide a supporting station for a rod **63**, (see also FIGURE 13), extending across the machine, which rod **63** is slotted to receive the sinker butts, and is free to rotate in the caps **64**. A torque shaft **65** (FIGURE 12) extends across the machine and is associated with several such assemblies. Each lever **61** has a roller follower **66**, held to face of its cam **60** (FIGURE 9) by a tension spring **67** (FIGURE 12).

The Presser

Shaft **10** carries a series of cams **33** (FIGURES 9 and 11) spaced therealong which control the horizontal reciprocating motion of the presser P. Each cam **33** operates a lever **34** (FIGURE 12) which in turn transmits movement to lever **35** fixed to the beard presser plate P. Lever **34** has a roller follower **37** which is maintained in contact with the face of cam **33** (FIGURES 9 and 11) by the action of tension spring **38** (FIGURE 12). The levers **34, 35** are mounted on common torque shafts **40, 39**. A lever **123** (FIGURE 13) is pinned to shaft **39** outside the side frame **11** and is urged into contact with a pin **124** (FIGURE 14) (formed as an extension to the fixed sinker bed **72**) by a spring (not shown). This lever **123** serves to keep the presser P substantially horizontal, and is necessary because the lever **35** moves in an arcuate manner.

The Back Comb

Shaft **10** carries two or more cams **22** (FIGURES 9 and 11), each of which operates lever **23** (FIGURE 12), which in turn causes movement of lever **24** attached to the plate **25** (FIGURE 13) of comb C in which the individual comb members are held. This controls the horizontal reciprocating movement of the comb C. The levers **23, 24** (FIGURE 12) are mounted on common torque shafts **26, 28** respectively, and to the end of shaft **28** outside the side frame **11** is pinned lever **106**, (also FIGURE 14), which performs a function shortly to be described The lower end of each lever **23** carries a cam follower **29** (FIGURE 12), which is maintained in contact with its cam **22** (FIGURES 9 and 11) by means of the action of a tension spring **30** (FIGURE 12).

The comb C has to perform an up-and-down motion as well as a back-and-forth motion and the means by which this is achieved is now described.

Shaft **10** carries a pinion **73** (FIGURE 15) at its left-hand end. The pinion **73** has an integral edge cam **100**. A rocker lever **101** (FIGURE 14), pivotally mounted on a stud **102**, attached to the side frame **11** moves cyclicly under the influence of cam **100** (FIGURE 15), by the engagement with the latter of roller **103** (FIGURE 14) at the end of lever **101**. This movement is transmitted to a push rod **104**, which carries a roller **105** at its upper end. The roller **105** bears against the undersurface of lever **106**, which, being pinned to shaft **28**, moves the plate **25** (FIGURE 13), and thus the comb members C, up-and-down, in synchronism with their back-and-forth movement. A spring, not shown, holds lever **106** against roller **105** and also keeps roller **103** against the face of cam **100**. Push rod **104** is guided at its upper end by a guide lug **107** retained by cap **108** (FIGURE 14), integral with the side frame **11**.

The Front or Additional Combs C¹

These consist of a series of flat blades, shaped in end elevation as shown in FIGURES 12 and 13, their left-hand key-hole shaped ends being of somewhat greater width than the remainder thereof.

The combs C¹ are slidable in locating slots in a steady bar **117** (FIGURE 13) above the Jacquard drum **90**. The steady bar **117** is fixed by bolts **118** at its extremities to side frames **11**, and has staggered holes in it which accommodate pins **119** urged resiliently downwards by springs **120**. The spring **120** are retained by a plate **121**. The steady bar assembly serves to urge the combs C¹ towards pins **87** in the drum **90**, the combs C¹ having lugs for engagement by the pins **87**.

The shaft **10** carries a series of cams **41** spaced therealong. Each cam operates a rocker **42** (FIGURES 9 and 11) supported on a rocker shaft **43** (FIGURE 12) extending across the machine. Each rocker **42** transmits motion to a push rod **44** which turns lever **45** and rocker shaft **46** (which extends across the machine), thereby imparting a raising and lowering motion to lever **47**. A bar **48** and cap bar **49** are fixed to the ends of levers **47**. These bars have curved grooves to engage the outer ends of combs C¹. A roller **50**, freely mounted at the end of rocker **42**, is held against the cams **41** (FIGURES 9 and 11) by virtue of the action of tension spring **51** (FIGURE 12). This arrangement enables the front combs C¹ to be lifted at the outer ends to clear the pins **87** (FIGURE 13) when the drum **90** is racked round as will be described.

The edge cam **79** (FIGURE 14) previously referred to imparts an intermittent motion to a lever **83**, thereby turning a rack wheel **84** by means of pawl **85**. Rack wheel **84** thus turns the shaft **86** (FIGURES 9 and 13) of drum **90**, causing successive rows of pattern pins **87** (FIGURE 13) to come into operative position beneath the combs C¹. Lever **83** (FIGURE 14) has a roller follower **88** and turns on a spigot portion of a bearing bracket **89** mounted on an extension **99** of the side frame **11**. A torsion spring **83***a* ensures that follower **88** maintains contact with the cam **79**. At the right hand end of the machine (FIGURE 10) shaft **86** carries a check wheel **125**.

A plunger **126** supported in a bracket **127** is spring loaded against the teeth of the check wheel **125**.

The drum **90** (FIGURES 9 and 13) is a hollow metal cylinder with rows of peripheral holes spaced to correspond with the combs C^1, and having an angular pitch equal to the rack movement. Pins **87** are a push fit in the holes, and a flanged tube **91** fastened to side frames **11**, guards against the pins **87** falling out of the drum **90**.

A cam **52** (FIGURES 9 and 11) at each end of shaft **10** acts on a push rod **53** (FIGURE 12) and thus moves lever **54** pinned to shaft **56**. The shaft **56** in turn moves link **55** which imparts angular motion to lever **47** about the end of lever **45**. In this way the combs C^1 are reciprocated horizontally and pass between the needles during part of their motion. The push rods **53** each carry a roller **57** at one end which contacts the cam **52** and a roller **57** at the other in contact with which the lever **54** is urged by tension spring **59**. The push rods move in bearings **58**.

Spur wheel **74** (FIGURE 15) carries a face cam **110**, which actuates a lever **111** (FIGURE 11). Lever **111** is pinned on shaft **116**. The shaft **116** carries a second lever **111***a* which transmits a corresponding translatory movement to pin **112** located in a bifurcation at the end of lever **111***a*. Pin **112** is fixed in a bar **113** (FIGURE 13) slidably mounted across the machine beneath the forward ends of the combs C^1. Bar **113** carries a further transverse member **114** having an enlarged head, which is slotted to accommodate the combs C^1. Lever **111** has a roller follower **115** (see FIGURES 9 and 11), which is held against the cam **110** by a spring (not shown) acting on bar **113** at the left hand side frame **11**. This arrangement causes a shogging motion of one needle pitch of the combs C^1 by virtue of sideways flexing thereof between the formation of successive stitches so that the control of the individual combs C^1 over the stitch formation is effective at the same needle. This ensures, in spite of the fact that in the machine being described the pattern effect of a given row of pins in the drum **90** is maintained for two courses, that a well-defined pattern effect is obtained.

To summarise the motions of Comb C^1, it can be said that between the knitting of successive courses the outer ends of the combs C^1 are raised, whilst the combs are retracted. During knitting of a course (as will be appreciated from the earlier diagrams) the combs C^1 enter between the needles and, if they are required to cause the lower leg instead of the upper leg of a loop formed therearound to enter the beard their inner ends must also execute an upward movement. If a pin **87** is beneath a given comb C^1 then the downward movement of its outer end which takes place during knitting will cause the required upward movement of the inner end by virtue of the fact that the comb C^1 pivots about the pin **87**. On the other hand, if no pin **87** is present beneath the comb C^1 the inner end does not make any material movement.

Operation

The machine described is set up to operate as will now be described.

First, the eccentrics and cams are arranged to cause the needles S, sinkers SK, presser P and back comb C to perform in synchronism the basic knitting movements described with reference to the earlier diagrams. The manner in which this is achieved, involving the provision of cams and eccentrics of appropriate shape, and their setting relative to each other is a matter within the province and abilities of a person skilled in the art, and will not be described in detail. The threads from beams X, Y are fed respectively to guide bars **20**, **21** (one thread per guide) and a thread from a guide of each guide bar is then passed to each needle.

Second, guide bar cams **76**, **78** are contoured to give both front and back guide bars suitable endwise movements. In the case of cam **76**, this is contoured and set

to give the back guide bar **21** cyclic endwise movements appropriate in direction, extent, and timing, to the formation of two successive courses of the new doubly crossed stitches with a two needle displacement (see FIGURES 3*a* to 3*k*). In the case of cam **78**, this is contoured and set to give the front guide bar **20**, cyclic endwise movements appropriate in direction, extent, and timing, to the formation of two successive rows of the new singly crossed stitches with a single needle displacement.

Third, the pins **87** in the drum **90** are arranged to provide a predetermined pattern. Thus, where it is desired to obtain, anywhere across the width of the fabric, a different visual effect, pins are arranged to be present under the appropriate front combs C^1 during knitting of the courses concerned. Thereby the front combs C^1 are raised and instead of singly crossed loops being knitted by the front bar open loops are knitted (FIGURES 8*a* to 8*e*); instead of doubly crossed loops by the back bar, conventional singly crossed loops are knitted.

FIGURES 16 and 17 illustrate in the point paper convention the two types of stitches which can be knitted by the front and back guide bars respectively with only one front comb element coming into operation at every course. To achieve this only one circumferential line of pins is inserted into the drum **90**.

The machine described is provided with a Jacquard control but where width-wise patterning is not required this control is unnecessary. In this event the pins are removed or a machine with no Jacquard control is used. In either case the full range of stitches described with reference to the earlier diagrams can be knitted, it merely being necessary to provide appropriate cams for the required endwise movements of the guide bars. In some cases the combs C^1 although operative, will perform no function (as in the case of the stitches illustrated in FIGURES 1*a* to 1*h* and FIGURES 2*a* to 2*e*). It is pointed out that although the direction and extent of the guide bar movements are the same when forming open loops (FIGURES 1*a* to 1*h*) and doubly crossed loops (FIGURES 6*a* to 6*j*) their timing is not, and the difference is such as to allow the front combs C^1 to take a loop of thread in the latter case but not in the former. When knitting such unpatterned fabrics different types of stitches may be formed by different guide bars, and of course, the amount of needle displacements is not limited to those shown in the earlier diagrams which illustrate the minimum displacements. Nor, as has been pointed out, need the cycle be limited to a two course cycle.

Patterning may be obtained by the alternative production of either the two types of stitches previously referred to by any guide bar (i.e. new singly crossed loops and open loops) or of doubly crossed loops and conventional crossed loops.

I claim:

1. A method of automatic warp knitting using needles with hooks, comprising the cyclical course-forming steps of guiding yarn ends passing from the supply to the last course of the fabric, each at a point at the opposite side of the needles to the fabric, substantially longitudinally of the needle bed, to a position corresponding to the desired lay of the yarn ends at the fabric side of the needles, thereafter guiding the yarn ends adjacent the last course of the fabric substantially at right angles to the needle bed to assume the desired lay, all whilst the needles are retracted so as not to interfere with the guided yarn ends, thereafter moving the needles into a position for engagement with said guided yarn ends, thereafter guiding the yarn ends, at a point at the opposite side of the needles to the fabric, substantially longitudinally of the needle bed to a position corresponding to the desired lay of the yarn ends at the opposite side of the needles to the fabric, thereafter guiding the yarn ends, at the opposite side of the needles to the fabric substantially at right angles to the needle bed to assume said desired lay, for engagement with the needle hooks, thereafter operating the needles to engage

the yarn so laid, in the hooks thereof, and carry same through the loops of the previously knitted course.

2. A method of automatic warp knitting as claimed in claim 1 in which the yarn ends when being guided to said position corresponding with the desired lay at the opposite side of the needles to the fabric, are moved first in one direction longitudinally of the needle bed and then in the other direction longitudinally of the needle bed, the ends being restrained at the point of reversal of movement to form open loops lying across the needles whereby one or other leg of said loops may be engaged by the needle hooks and passed over said hooks onto the needle stem.

3. A method as claimed in claim 2 using bearded needles in which one or more of said open loops are so disposed, in relation to the respective needles, that on the yarn engaging operation of the needles the second formed legs of these loops are first engaged beneath the needle beards which are then closed to prevent the first formed leg from subsequent engagement therebeneath.

4. A method as claimed in claim 2 using bearded needles in which one or more of said open loops are so disposed, in relation to the respective needles, that on the yarn engaging operation of the needles the second formed legs of these loops are located over the needle beards to prevent their engagement therebeneath, and the first formed legs over the needle stems to allow their subsequent engagement beneath the needle beards.

5. An automatic warp knitting machine having cyclicly operable course forming instrumentalities, including needles with hooks comprising means adapted to guide yarn ends passing from the supply to the last course of the fabric, each at a point on the opposite side of the needles to the fabric, substantially longitudinally of the needle bed, to a position corresponding to the desired lay of the yarn ends at the fabric side of the needles, other means adapted thereafter to guide the yarn ends adjacent the last course of the fabric substantially at right angles to the needle bed to assume the desired lay, means for holding the needles retracted meanwhile to prevent interference with the yarn ends so guided, and adapted thereafter to move the needles into a position for engagement with the guided yarn ends, said first-named means being adapted thereafter to guide the yarn ends, at a point at the opposite side of the needles to the fabric, substantially longitudinally of the needle bed to a position corresponding to the desired lay of the yarn ends at the opposite side of the needles to the fabric, other means thereafter adapted to guide the yarn ends, at the opposite side of the needles to the fabric, substantially at right angles to said needle bed to assume the desired lay, for engagement with the needle hooks, and means thereafter adapted to operate the needles to engage the yarn so laid, in the hooks thereof, and to carry same through the loops of the previously knitted course.

6. An automatic warp knitting machine as claimed in claim 5 wherein said means adapted to guide the yarn ends to a position corresponding to the desired lay at the opposite side of the needles to the fabric can be arranged to be operative so as to move said yarn ends first in one direction longitudinally of the needle bed and then in the other direction longitudinally of the needle bed for this purpose, and further comprising means, about which, by these movements, the yarn ends are each wrapped to form open loops lying across the needles, said further means causing one leg or the other of each such loop to be engaged by the respective needle hook prior to passing thereover onto the needle stem.

7. An automatic warp knitting machine as claimed in claim 6, and having bearded needles, further comprising means for so synchronising the movements of the instrumentalities and for so controlling the position and configuration of one or more of said open loops that the second formed legs of the latter are first engaged beneath the needle beards, and means adapted then to close said beards to prevent the first formed leg from being subsequently engaged therebeneath.

8. An automatic warp knitting machine as claimed in claim 6, and having bearded needles, further comprising means for so synchronising the movement of the instrumentalities and for so controlling the position and configuration of one or more of said open loops that the second formed legs of said open loops are located over the needle beards to prevent their engagement therebeneath, and the first formed legs over the needle stems to allow their subsequent engagement beneath the needle beards.

9. An automatic warp knitting machine as claimed in claim 6 in which said means about which the yarn ends are each wrapped to form open loops lying across the needles, and for causing one leg or the other of each such loop to be engaged by the respective needle hook prior to passing thereover onto the needle stem consist of a plurality of comb members, one corresponding to each needle, and further comprising means capable of being pre-set as described, associated with each said comb member, and adapted, depending upon its pre-set condition, to cause its associated comb member to act in one or other of its alternative ways.

10. An automatic warp knitting machine as claimed in claim 7 in which the means for controlling the position and configuration of said open loops is the means about which the respective yarn ends and wrapped and form said open loops.

11. An automatic warp knitting machine as claimed in claim 8 in which the means for controlling the position and configuration of said open loops is the means about which the respective yarn ends are wrapped to form said open loops.

12. An automatic warp knitting machine as claimed in claim 9, further comprising a drum intermittently rotatable in synchronism with the machine operation and having holes for accommodating circumferential rows of removable pins, each row corresponding with one said comb member, and means whereby the absence or presence of a pin will cause the appropriate comb member to act in one or other of its alternative ways.

13. An automatic warp knitting machine as claimed in claim 5 in which said means adapted to guide the yarn ends to a position corresponding to the desired lay of the threads at the fabric side of the needles and at the opposite side of the needles to the fabric comprises tubular guides through which the threads pass, supported in guide bars associated with means for imparting the necessary movements thereto, endwise, and in the same directions as the needle.

14. An automatic warp knitting machine as claimed in claim 5 in which said means adapted to guide the yarn ends to assume the desired lay at the fabric side of the needles comprises a plurality of sinkers disposed in a sinker bed at the fabric side of the needles and in staggered relationship with the needles, associated with means for imparting thereto reciprocating motions so that they move at the appropriate part of the operating cycle of the machine to engage the yarn ends between the needles and convey them to their desired positions.

15. An automatic warp knitting machine as claimed in claim 5 in which said means adapted to guide the yarn ends to assume the desired lay at the opposite side of the needles to the fabric comprises a comb, associated with means for imparting thereto reciprocating motion so that its teeth move, at the appropriate part of the operating cycle of the machine, between the needles to engage the yarn ends and convey them to their desired positions.

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