April 9, 1963 M. PHILIP 3,084,528

METHOD AND APPARATUS FOR KNITTING

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FIG. 1

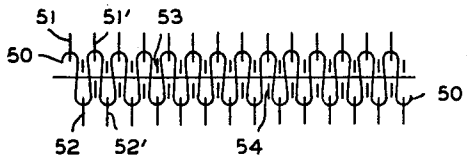


FIG. 2

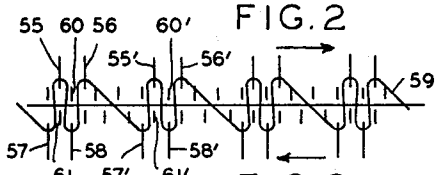


FIG. 3

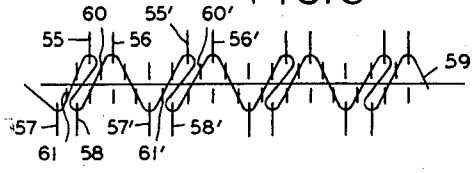


FIG. 4

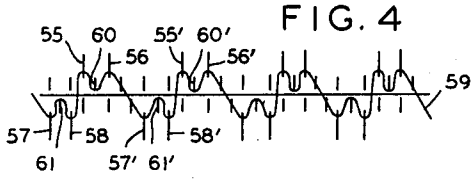


FIG. 5

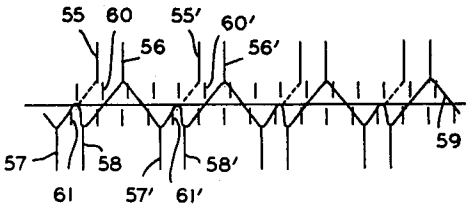
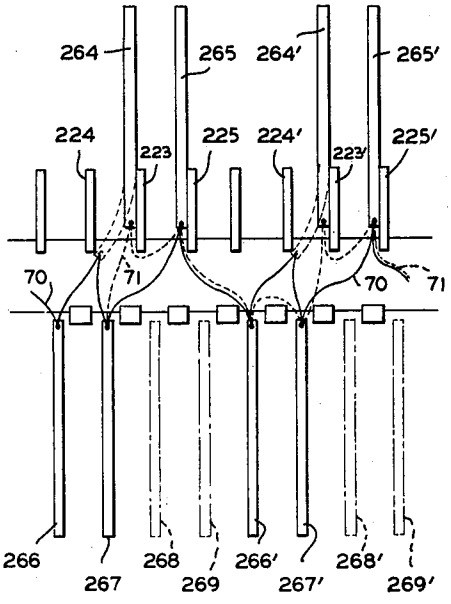


FIG. 6



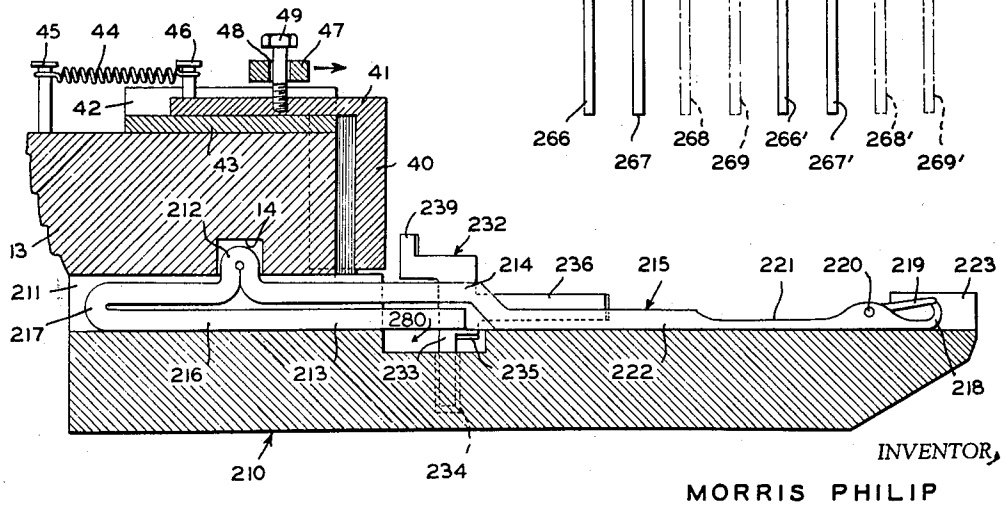


FIG. 7

INVENTOR,
MORRIS PHILIP

BY Tarlof & Ackerhoff

ATTORNEYS

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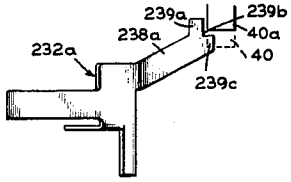


FIG. 8A

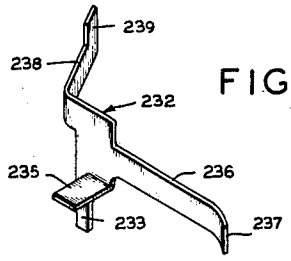


FIG. 8

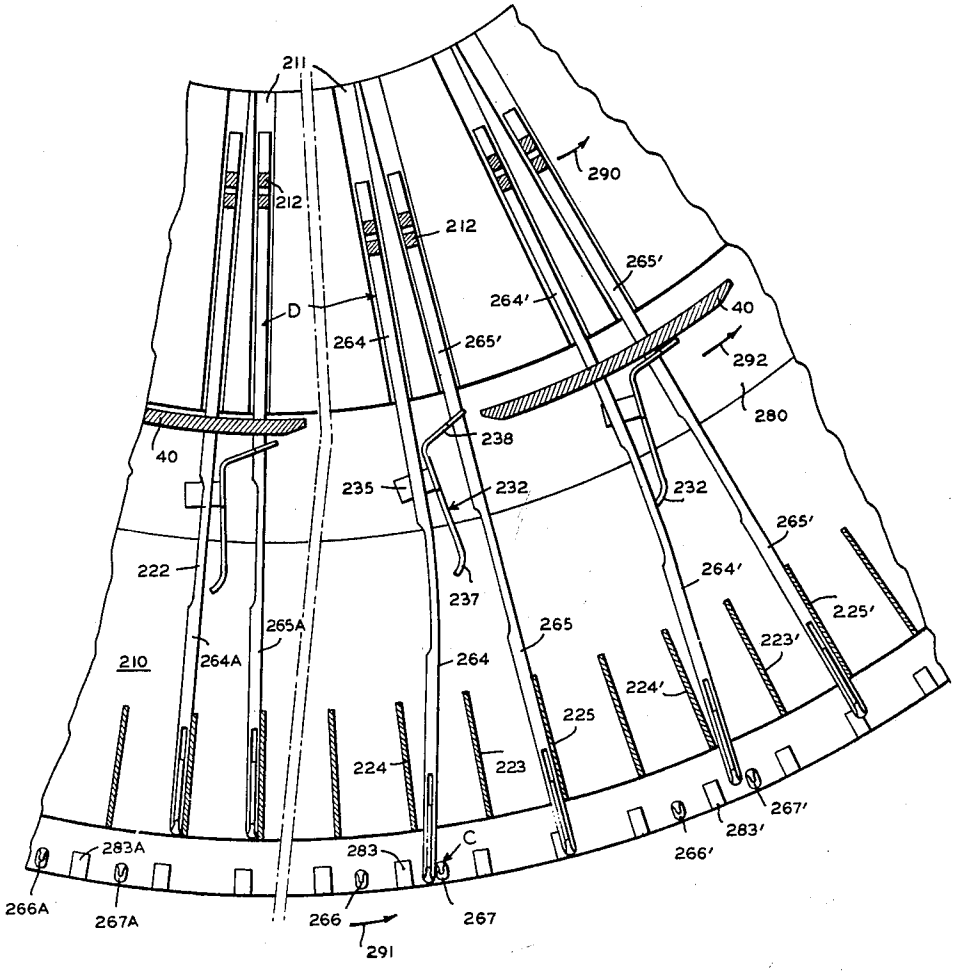


FIG. 9

INVENTOR,

MORRIS PHILIP

BY Tinkf & Ackerff

ATTORNEYS

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FIG. 10

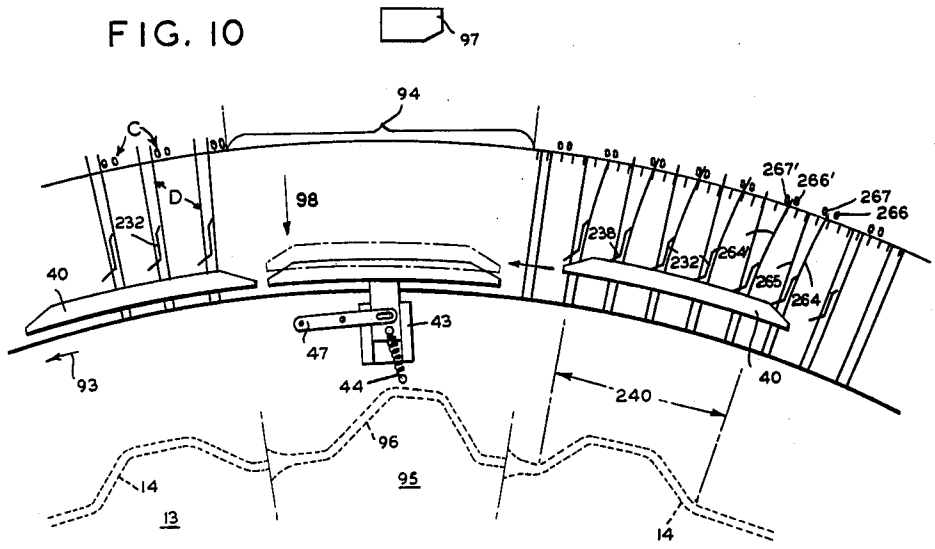
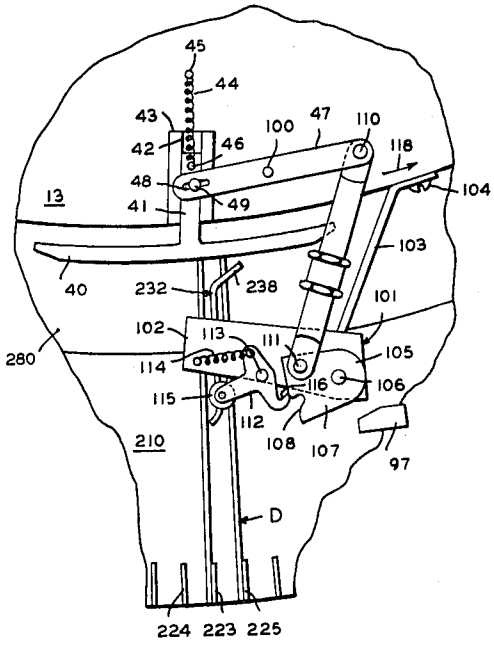


FIG. 12



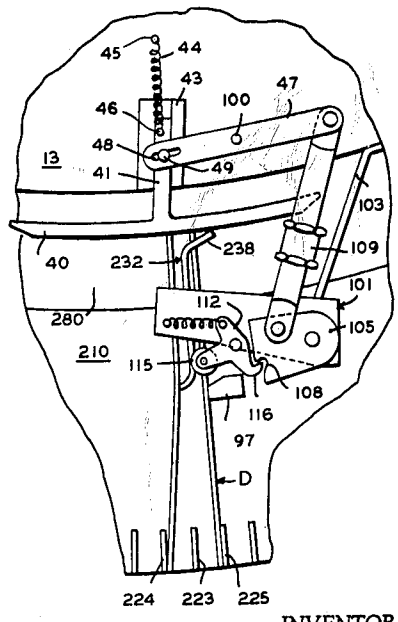


FIG. 11

INVENTOR,

MORRIS PHILIP

BY Tarlf & Ackerhoff

ATTORNEYS

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FIG. 13

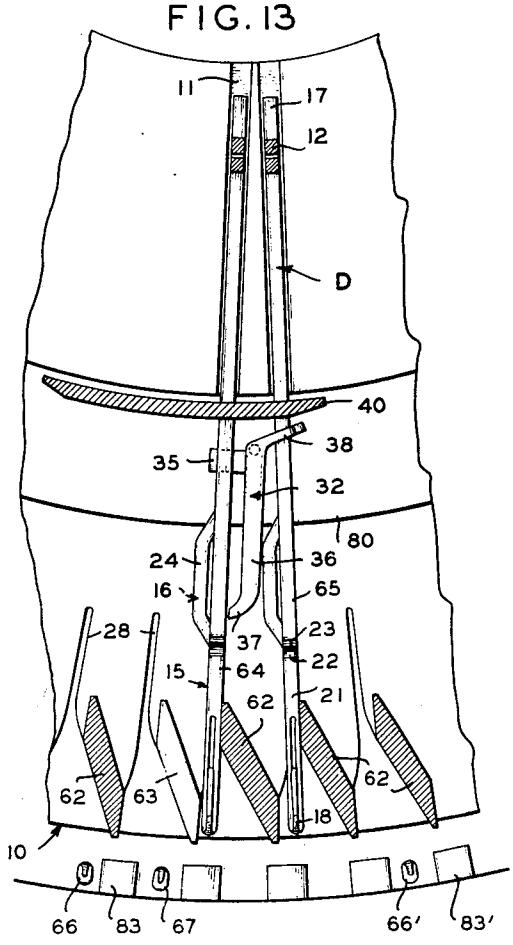


FIG. 14

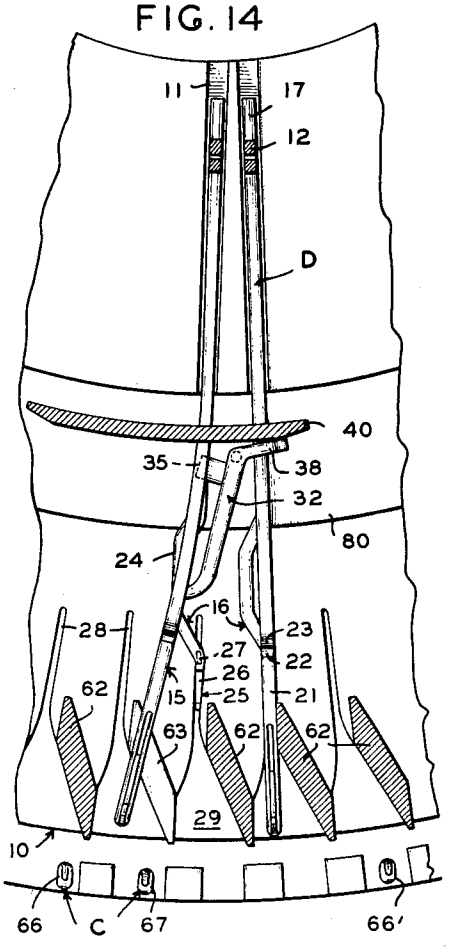


FIG. 14A

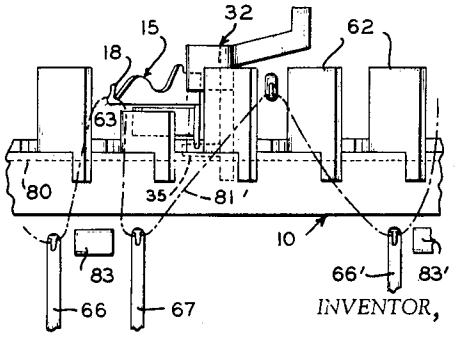
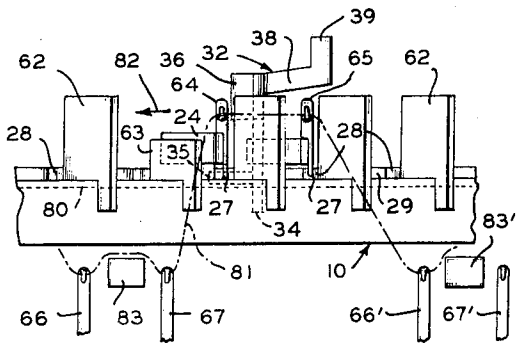


FIG. 13A



INVENTOR,
MORRIS PHILIP

BY Taskof & Ackerhoff

ATTORNEYS

April 9, 1963 M. PHILIP 3,084,528

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FIG. 24

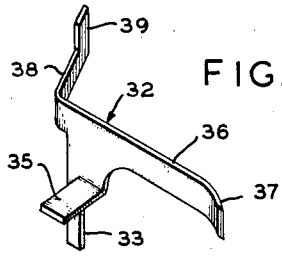
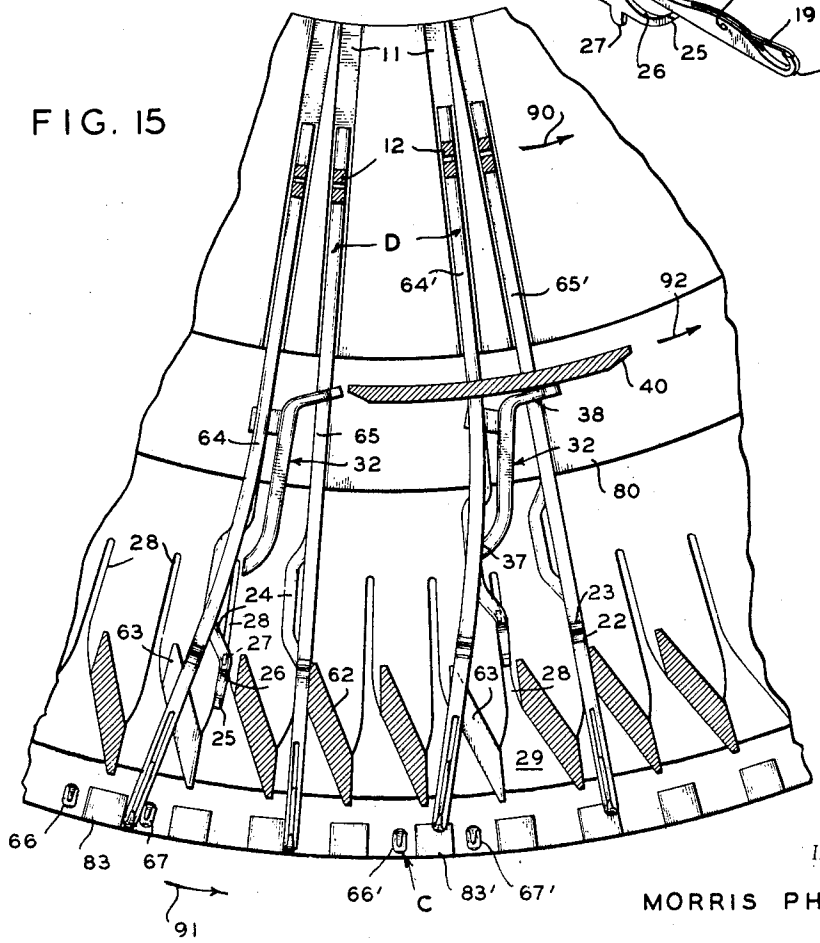


FIG. 25

FIG. 15



INVENTOR,
MORRIS PHILIP

BY Tarshof & Ashcroff

ATTORNEYS

April 9, 1963 M. PHILIP 3,084,528

METHOD AND APPARATUS FOR KNITTING

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FIG. 16

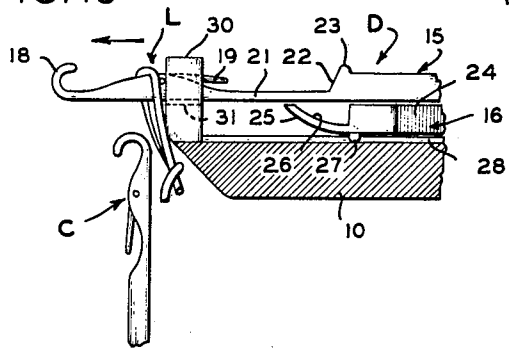


FIG. 16A

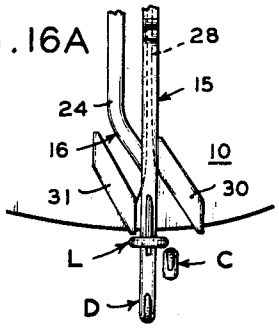
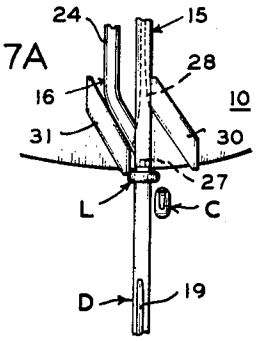


FIG. 17A



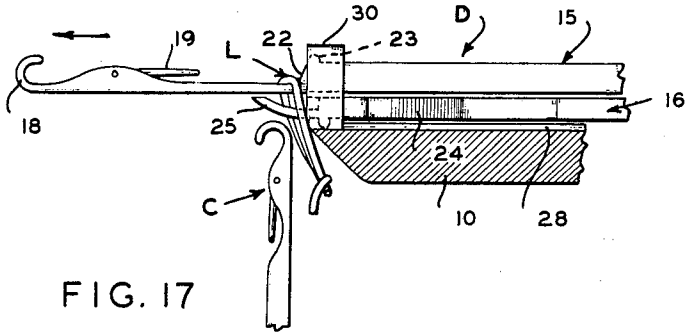
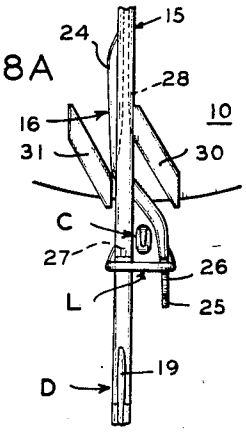


FIG. 17

FIG. 18A



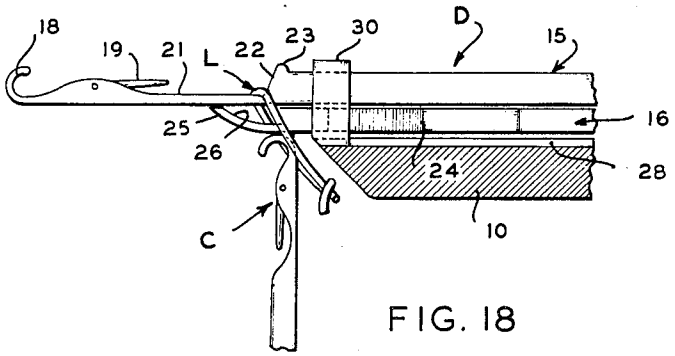


FIG. 18

INVENTOR,

MORRIS PHILIP

BY Townsend & Townsend

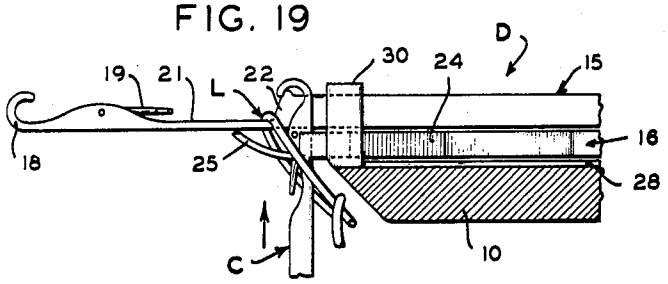
ATTORNEYS

April 9, 1963 M. PHILIP 3,084,528

METHOD AND APPARATUS FOR KNITTING

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FIG. 19



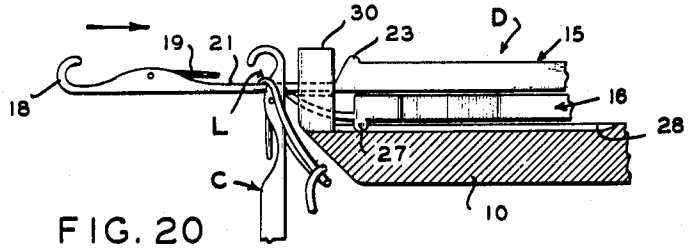


FIG. 20

FIG. 23

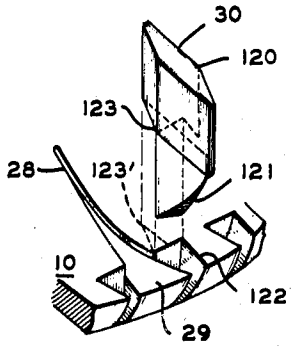
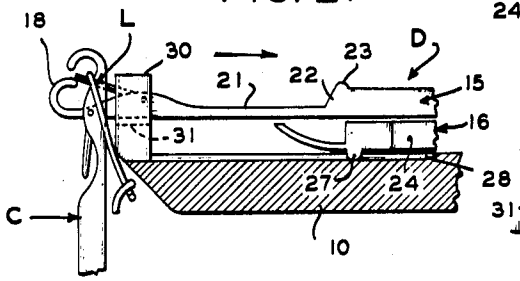


FIG. 21



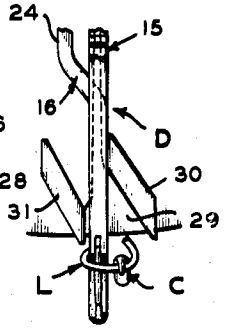


FIG. 21A

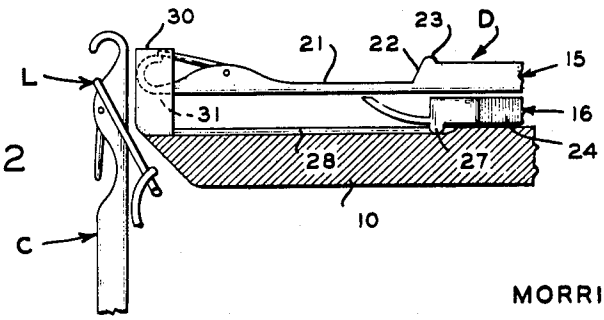


FIG. 22

INVENTOR,
MORRIS PHILIP

BY Tackf & Ackerhoff

ATTORNEYS

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METHOD AND APPARATUS FOR KNITTING

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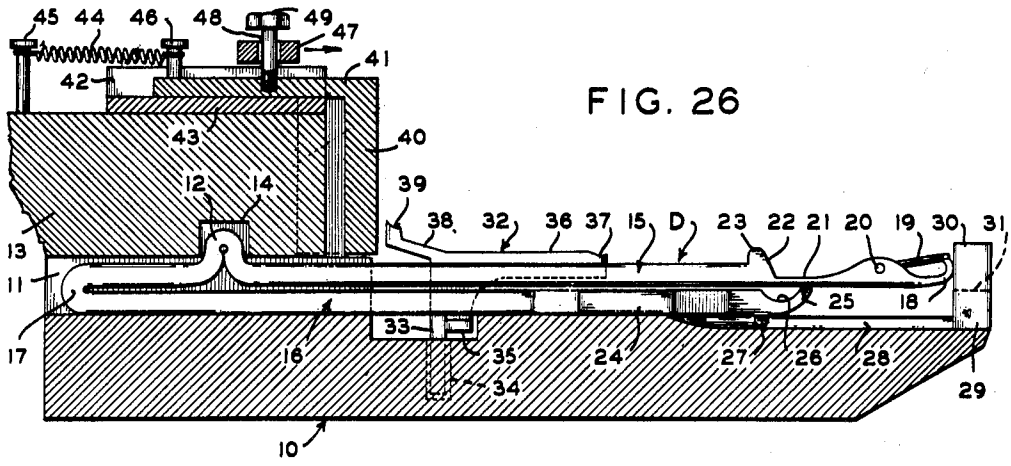


FIG. 26

INVENTOR,

MORRIS PHILIP

BY Tarlof & Ackerhoff

ATTORNEYS

April 9, 1963 M. PHILIP 3,084,528

METHOD AND APPARATUS FOR KNITTING

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Fig. 27.

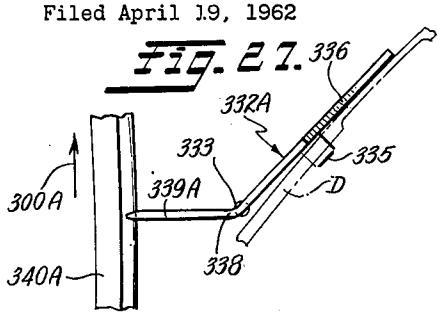
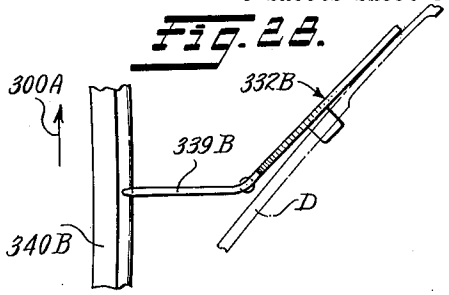


Fig. 28.



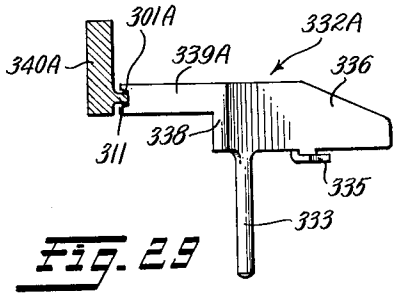


Fig. 29

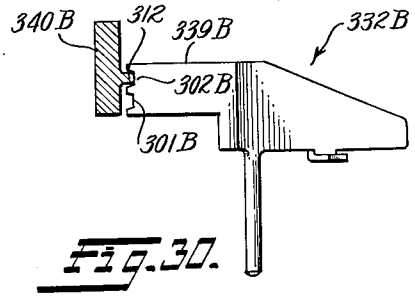


Fig. 30.

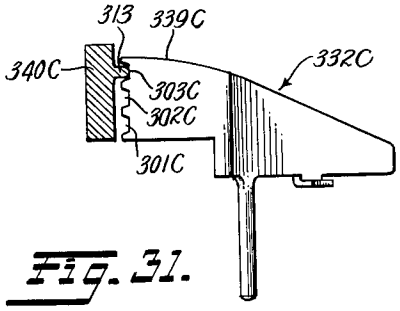


Fig. 31.

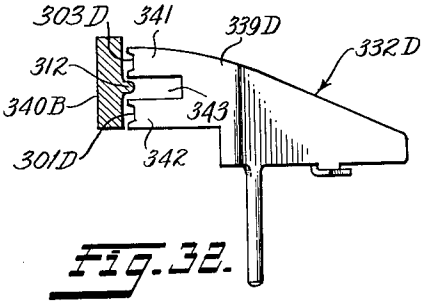


Fig. 32.

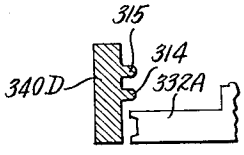


Fig. 33.

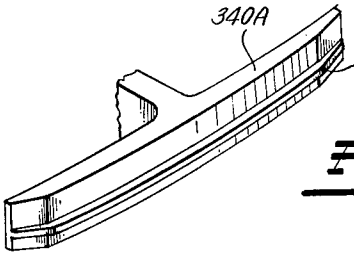


Fig. 34.

INVENTOR,
Morris Philip

BY Tarhof & Asheroff

ATTORNEYS

United States Patent Office

3,084,528

Patented Apr. 9, 1963

3,084,528

METHOD AND APPARATUS FOR KNITTING

Morris Philip, 2519 Grand Ave., Bronx, N.Y.

Filed Apr. 19, 1962, Ser. No. 188,761
56 Claims. (Cl. 66—24)

The present invention relates to knitting and in particular, to method and apparatus for changing the knitting pattern of a knitting machine. More particularly, the invention is concerned with independent needle, multiple needle bank knitting, and is especially concerned with changing the relative position of the needles in the respective needle banks to thereby change the knitting pattern, and also with the transfer of loops from the needles of one of the needle banks to needles of another needle bank to produce a further change in the character of the product which is needed.

This application is a continuation-in-part of my copending application Ser. No. 840,880, filed September 18, 1959, now abandoned, which is a continuation-in-part of my application Ser. No. 596,724, filed July 9, 1956 now abandoned.

The present invention is especially concerned with the automatic production of sweaters having a rib bottom with a selvage. As is known, and as will be more fully explained hereinafter, this normally requires that the sweater be started with a 1 x 1 rib knitted course and that the pattern of knitting be changed, for example, to a 2 x 2 rib knit to produce the rib bottom. The remainder of the sweater is then knitted using any type of stitch. In the described embodiment, the remainder is plain knitted to produce a jersey body.

In order to change the knitting pattern from 1 x 1 rib knitting to a 2 x 2 rib knitting in the prior art machines, one needle bank has to be racked or shogged, that is, moved laterally relative to the other needle bank in order to change the positions of the needles of one needle bank relative to the needles of the other needle bank. According to the prior art machines, this racking is generally achieved while none of the needles are knitting and by moving one entire bank of needles laterally relative to the other bank.

According to one aspect of the present invention, as it will be hereinafter readily apparent, each needle can be independently racked and this may be done while all the needles of the machine including those being racked, are going through a knitting cycle. More particularly, according to the preferred aspect of the invention each needle which is to be racked is laterally flexed or bent so that its knitting portion is moved laterally relative to the needles of the opposed bank.

After the 2 x 2 rib bottom has been knit, if the sweater is to have a jersey body, it is necessary to transfer loops of the yarn from the needles of one of the needle banks to needles of another needle bank to enable the machine to plain or jersey knit. To accomplish this result according to another aspect of the invention the knitting needles are formed to include a knitting portion and an adjacent laterally displacable loop-spreading portion. The knitting needles are guided on a plate or bed and cooperate with combining teeth which are set at an angle to the direction of movement of the needles. A section of the loop-spreading portion of the needle is bent out of the plane of the needle and is cam-acted upon by the combing teeth after the needles are projected forwardly to an extent sufficient to cause the forward extremity of the loop-spreading portion to enter the loop. This cam action forces the loop-spreading portion to spread the loop while the loop is stationary with respect to the needle which supports the same. In addition, certain of the combing teeth are of reduced height to permit the knitting portion of an adjacent needle to be laterally shifted or racked to provide for the racking operation described above to change the knitting pattern from 1 x 1 rib knit to 2 x 2 rib knit.

In order to flex the needles to effect racking of the knitting portion, means are provided to apply a lateral force to the side of the knitting portion of the needles to produce flexing. The flexing means are preferably constituted by means which slidably engage the side of the knitting portion of the needles so that the needles will retain their laterally shifted position while they are longitudinally reciprocated to perform the knitting operation. More particularly, the lateral shifting is simply effected by means of a pivotally mounted member having an arm engaging the side of the knitting portion of the needles and having a projecting heel portion which is cam actuated to thereby accurately position the needles and to perform this function in a manner which does not abrade and thereby damage the operating portions of the knitting needles.

The invention may be employed in straight knitting or for the production of tubular knitted fabrics in a continuous manner, as for example, using a circular knitting machine. The present invention will be described in connection with a circular knitting machine wherein the value of the invention is not limited to continuous knitting or to circular type knitting machines.

An object of the invention is the provision of a method of knitting and automatic knitting apparatus, preferably of the circular type, capable of high-speed operation enabling individual needles to be racked while all the needles, including those being racked, go through their knitting cycle.

Another object of the invention is the provision of a method and apparatus for changing the relative positions of the needles in cooperating needle banks without altering the relative positions of the respective needle supports.

Another object of the invention is the provision of an apparatus and method for individually racking selected needles of a knitting machine without interrupting the knitting cycle of any of the needles.

Another object of the invention is the provision of an apparatus and method for individually racking selected needles, preferably by flexing the needles, to change the relative position of the knitting portions of the needles in cooperating needle banks.

Another object of the invention is the provision of a method and apparatus for transferring loops or stitches from the needles of one bank to the needles of another bank without forcing the yarn along the length of the needle while the loop is being spread or opened to thereby enable the formation of a smaller loop while still enabling the efficient formation of a loop having an adequate opening and to reduce the danger of damaging the yarn.

Other and further objects of the invention will become apparent from the description of the invention which follows, taken in conjunction with the accompanying drawings in which the invention is illustrated by reference to a conventional circular knitting machine having a bank of dial needles and a cooperating bank of cylinder needles, the dial needles and the parts cooperating therewith being modified in accordance with the invention.

FIG. 1 is a schematic view illustrating the production of a 1 x 1 rib knit using all of the needles in both the cylinder and the dial.

FIG. 2 is a schematic view illustrating the production of a 1 x 1 rib knit using spaced pairs of needles in each of the needle banks.

FIG. 3 is a schematic view illustrating the result of laterally shifting one of the needle banks in FIG. 2.

FIG. 4 is a schematic view illustrating the production

of a 2 x 2 rib knit by knitting with the laterally displaced needles of FIG. 3.

FIG. 5 is a schematic view illustrating the production of a 1 x 1 rib knit using spaced pairs of needles mounted in needle banks and positioned in the same manner as in FIG. 3 by flexing some of the needles.

FIG. 6 is a schematic view similar to FIG. 5, and on an enlarged scale, both a 1 x 1 rib knit and a 2 x 2 rib knit being shown.

FIG. 7 is a partial side elevation, in section, and showing the invention illustratively incorporated in a circular, independent needle, knitting machine having cooperating banks of dial and cylinder needles, the section being taken through the center of a radial needle-guiding groove in the dial plate and the knitting needle being shown in elevation, the cylinder needle bank not being shown.

FIG. 8 is a perspective view of a flexing member constructed in accordance with the invention.

FIG. 8A is an elevation of a modified form of the flexing member showing its cooperation with the cam bar.

FIG. 9 is a top plan view of a portion of the dial plate and showing the dial needles in flexed and unflexed positions.

FIG. 10 is a diagrammatic plan view of the portion of the dial and overlying turntable and illustrating the manner in which the cam bar 40 is projected and retracted when it overlies a blank section on the dial.

FIG. 11 is a plan view of a portion of the dial and turntable and shows illustrative cam means for projecting and retracting the cam bar, which actuates the needle-flexing member, the cam bar being shown in retracted or inoperative position.

FIG. 12 is a plan view similar to FIG. 11 but showing the cam bar in projected or operative position.

FIG. 13 is a top plan view of a portion of the dial plate in a modification of the invention and above the dial needles retracted in unflexed position.

FIG. 13A is a front elevation of the structure shown in FIG. 13.

FIG. 14 is a top plan view similar to that of FIG. 13 and shows the dial needles retracted in flexed position.

FIG. 14A is a front elevation of the structure shown in FIG. 14.

FIG. 15 is a top plan view similar to FIG. 14 and showing the dial needle projected in flexed position.

FIG. 16 is a partial side elevation with the dial plate being shown in section and showing a first step in the transfer of a yarn loop from a needle of the dial to an adjacent needle on the cylinder.

FIG. 16A is a partial plan view of the needle position shown in FIG. 16.

FIG. 17 is a partial side elevation similar to FIG. 16 and showing the dial needle in partially projected position.

FIG. 17A is a partial plan view of the needle position shown in FIG. 17.

FIG. 18 is a partial side elevation similar to FIG. 16 and showing the dial needle in fully projected position.

FIG. 18A is a partial plan view of the needle position shown in FIG. 18.

FIG. 19 is a partial side elevation similar to FIG. 16 and showing the cylinder needle after projection thereof.

FIG. 20 is a partial side elevation similar to FIG. 16 and showing the dial needle in a partially retracted position.

FIG. 21 is a partial side elevation similar to FIG. 16 and showing the dial needle in a further retracted position.

FIG. 21A is a partial plan view of the needle position shown in FIG. 21.

FIG. 22 is a partial side elevation showing the dial needle in fully retracted position with the yarn loop having been transferred to the cylinder needle.

FIG. 23 is a partial exploded perspective view of a combing tooth and the forward extremity of the dial plate of the modification shown in FIGS. 13 and 26.

FIG. 24 is a perspective view of a flexing member for use in the modification of FIGS. 13 and 26.

FIG. 25 is a perspective view of an illustrative needle for use in racking and transferring the modification of FIGS. 13 and 26.

FIG. 26 is a partial side elevation in section of the modification of FIG. 13, illustratively showing the invention in a circular, independent needle knitting machine having cooperating banks of dial and cylinder needles, the section being taken through the center of a radial needle dialing groove in the dial plate, and the knitting needle being shown in elevation, the cylinder needle bank not being shown.

FIG. 27 is a top plan view of a third embodiment of the flexing member showing its cooperation with the cam bar. In this figure, the flexing member is also shown in cooperation with a dial needle, the latter being shown in phantom;

FIG. 28 is a top plan view similar to that of FIG. 27 of a fourth embodiment of the flexing member showing its cooperation with the cam bar;

FIGS. 29, 30, 31, and 32 are elevations showing, respectively, the third, the fourth, a fifth and a sixth embodiment of the flexing member showing the cooperation of the flexing members with the cam bar;

FIG. 33 is a fragmentary elevation showing a modified form of cam bar in cooperation with the flexing member of FIG. 29;

FIG. 34 is a perspective view of the cam bar of FIGS. 27 and 29.

Before proceeding with a detailed explanation of the invention, it is thought desirable to briefly set forth the problem to which the invention is directed. The problem will be explained in schematic form, including an explanation of 1 x 1 rib knitting, 2 x 2 rib knitting and the relationship therebetween which is utilized in accordance with the invention to produce a change from one to the other.

FIG. 1 schematically shows a 1 x 1 rib knit produced using all of the needles in both the cylinder and the dial. It will be seen that the yarn 50 extends from a needle 51 on the dial to needle 52 on the cylinder to the next needle 51' on the dial to the next needle 52' on the cylinder, and so on. It will be seen that the dial combing teeth 53 and the cylinder combing teeth 54 do not participate in the knitting action and each needle draws against and is positioned between a pair of oppositely disposed needles. The loops of the knitted product are not shown to simplify the drawing.

As will later more fully appear, it is not necessary to a 1 x 1 rib knit that all the needles be present, or, if present, be operated. So long as each needle which is operated is positioned between and draws against a pair of oppositely disposed operating needles, a 1 x 1 rib knit will be produced. The spacing between the needles is also immaterial to the production of a 1 x 1 rib knit.

FIG. 2 schematically shows a 1 x 1 rib knit produced using spaced pairs of needles in each of the needle banks. Thus, the dial is provided with needles 55 and 56 and the cylinder is provided with needles 57 and 58. Yarn 59 extends from lefthand cylinder needle 57, to lefthand dial needle 55, to righthand cylinder needle 58, to righthand dial needle 56, to lefthand cylinder needle 57', etc. The combing teeth 60 and 61 do not participate in the knitting action and the relative spacing of the operating dial and cylinder needles has not prevented the production of a 1 x 1 rib knit.

Conventionally, the 1 x 1 rib knit shown in FIG. 2 is converted into a 2 x 2 rib knit by "racking," e.g., laterally shifting one of the needle banks as shown by the arrows in FIG. 2. Either one of the banks can be shifted and the lateral shift produced is shown in FIG. 3. FIG. 3 is self-explanatory and simply represents the appearance of FIG. 2, after lateral shifting, and prior to further knitting.

FIG. 4 schematically shows a 2 x 2 rib knit produced using spaced pairs of needles in each of the needle banks.

Thus, the dial is provided with needles 55 and 56 and the cylinder is provided with needles 57 and 58. Yarn 59 extends from lefthand cylinder needle 57 to cylinder combing tooth 61, to righthand cylinder needle 58, to lefthand dial needle 55, to dial combing tooth 60, to righthand dial needle 56, to lefthand cylinder needle 57', to cylinder combing tooth 61', to righthand cylinder needle 58', to lefthand dial needle 55', to dial combing tooth 60', to righthand dial needle 56', etc. If FIG. 4 is compared with FIG. 3, it will be seen that FIG. 4 simply pictures the result of knitting with the "racked" or laterally shifted needle position shown in FIG. 3.

It will be noted that spaces are provided between the pairs of needles which can accommodate additional needles. It is not material to a 2 x 2 rib knit whether additional needles are present or not so long as these needles, if present, are not operated. It will be here pointed out that a 2 x 2 rib knit is not a limitation of the invention but is only illustrative of a rib knit in which at least some of the combing teeth on the cooperating needle banks cooperate with at least some of the needles on that bank in the knitting operation. In other words, a feature of this type of knitting is the fact that the combing teeth participate in the knitting operation and the knitting pattern is such that it can be converted to a 1 x 1 rib knit by conventional "racking."

FIG. 5 schematically illustrates the manner in which the 1 x 1 rib knit of FIG. 2 can be converted into the 2 x 2 rib knit of FIG. 4, and vice versa, by flexing some of the needles. The numbering used in FIGS. 2 and 4 is retained in FIG. 5. In FIG. 5 the needles are shown in the flexed position in phantom, and in the flexed position the needles knit 1 x 1 rib. When the needles are unflexed or returned to their normal position, the knitting pattern is a 2 x 2 rib knit identical with that shown in FIG. 4, and is not reproduced in FIG. 5. The knitting pattern produced with the needles in the flexed position is effectively the same as that shown in FIG. 2 and this pattern is presented in FIG. 5, the flexed needles, for the purpose of clarity, being shown in the projected position. Thus, the flexing illustrated in FIG. 5 has produced the identical pattern change formerly achieved by racking.

It will be noted from FIG. 5 that the flexed needles are needles 55, 55', etc. As will be obvious, the same result will be achieved by flexing only needles 58, 58', etc., or by flexing needles 55, 55', etc. and 58, 58', etc.

The action of FIG. 5 schematically represents the method of racking of the present invention. This action of FIG. 5 is shown on an enlarged scale in FIG. 6.

Referring more particularly to FIG. 6, the dial needles are numbered 264, 265, 264', 265', etc., and the cylinder needles are numbered 266, 267, 268 and 269, etc., from left to right. Cylinder needles 268 and 269 are shown in phantom, since these needles are present but not operated during the rib knitting operations.

In the knitting of a sweater having a rib bottom with a selvage, the first course which constitutes the selvage is knit with the needles positioned so that there is a dial needle between adjacent operating cylinder needles and vice versa to produce what can be broadly referred to as a 1 x 1 rib knit. This is schematically indicated by the yarn 70 shown by a solid line. After the first course of 1 x 1 rib knit, a few courses of a welt can be knit by holding the needles of either of the needle banks inoperative while the needles of the other bank work. This welt forms no part of the invention and is not essential, although it serves to provide a clearer edge when knitting a 2 x 2 rib. Thereafter, the pattern of knitting is changed so that both banks of needles operate and the combing teeth participate in the knitting as for example by the production of a 2 x 2 rib knit which forms the rib bottom of the sweater.

The change in rib knitting pattern is illustrated in FIG. 6 by the flexing of dial needles 264 and 264' to laterally shift the knitting or operating ends thereof. The flexed position is shown by dotted lines, and it will be seen that the needle 264 is flexed between combing teeth 223 and 224, that is, in the unflexed position needle 264 is adjacent combing teeth 223 and in the flexed position needle 264 is adjacent combing tooth 224. Similarly, needle 264' flexes between combing teeth 223' and 224'. The needles are preferably arranged so that the 1 x 1 rib is effective with the needles in flexed position. It is desired to state that the combing teeth 223 and 223' guide the respective needles in the unflexed position. In addition, the yarn draws against these combing teeth when the needles are in the unflexed position. Combing teeth 225 and 225' are positioned adjacent needles 265 and 265'.

To continue with the preparation of the sweater, knitting with the needles 264 and 264' in the flexed or laterally shifted position enables the production of a course of 1 x 1 rib knitting. When the flexing force is released, the flexed needles return to their normal position and further knitting with the needles of both banks produces a 2 x 2 rib knit indicated by yarn 71, which is shown in FIG. 6 by dotted lines. The 2 x 2 rib knit is then continued until the rib bottom of the sweater has been completed.

The body of the sweater may be completed utilizing any stitch, for example, rib knit, Jacquard or any other fancy stitch, plain knit or any other type of knitting. When the body of the sweater is to be jersey knit, it is necessary to transfer the yarn loops from the needles of one of the cooperating banks to the nedles of the other bank which then knits independently to produce the jersey body of the sweater. Transferring may not be necessary for other types of knitting. In the illustration of FIG. 6, the loops are transferred to the cylinder needles. Specifically, the loop on needle 264 is transferred to the cylinder needle 268, the loop on needle 265 is transferred to cylinder needle 269, the loop on needle 264' is transferred to cylinder needle 268', and the loop on needle 265' is transferred to cylinder needle 269' This transfer of the loops can be accomplished by methods and devices well known in the art, and these methods and devices need not be described herein. However, according to another aspect of the present invention, there is provided a particular modification for effecting this transfer, and this modification will be described hereinafter.

When the body has been knitted, the body is completed in conventional manner to enable separation between the sweaters which are knitted continuously, one after the other. This can be done by starting the dial needles and knitting one or two courses with both banks of needles in operation. The dial needles are then stopped and two or three courses of welt stitch can be made using one bank of needles while the other bank is held inoperative and holds the loops. The cylinder needles can then be operated in conventional manner to cast off the loops thereon so that the entire fabric is held on the dial needles. A separating pull thread is then fed to the dial needles to facilitate separation and a sweater is now completed. The next sweater is then begun by operating the spaced pairs of cylinder needles 266, 267, 266', 267', etc., and by flexing the dial needles 264, 264', etc. to knit a course of 1 x 1 rib knitting.

Bearing in mind the above-discussed principles of the invention, there will now be described in detail an illustrative embodiment thereof. Referring to FIG. 7, the numeral 210 generically designates a dial plate having a plurality of dial needles mounted in needle-guiding grooves 211 formed in said dial. One such needle 215 is shown in FIG. 7. It will be noted that the grooves 211 are formed in the rear or inner portion of the dial plate to leave the forward or outer portion, namely, the knitting portion of the needles free for lateral movement. The rear or inner portion of the needles ride in the grooves 211 and each needle is formed with an upwardly

projecting needle butt 212, this being conventional, and a turntable 13 having a cam track 14 is mounted immediately above the dial plate 210 with the needle butt 212 projecting into the cam track 14, so that relative rotation of the turntable 13 with respect to the dial plate 210 will cause the needles to be reciprocated.

It is desired to here point out that the turntable 13 with its cam track 14 is entirely conventional and will not be shown in detail. Further, as is also well known, it is desired from time to time to vary the timing or the extent of projection of the needles and, for this purpose, sections of the turntable may be made movable into and out of engagement with the needle butts 212 or the same result achieved in other ways. Suitable structure for this purpose is old and well known and will not be specifically shown. It is desired to here state that the reciprocation of the needles to control the extent of projection and retraction and to properly time the needles of the respective banks so that knitting, casting off, transferring, etc. may be effected, forms no part of the present invention.

The needle 215 is constituted by a forward knitting portion 221 and a rear portion 216. The rear portion 216 is formed of a lower member 213 and an upper member 214 interconnected at the rear of the needle 217. The knitting portion 221 is continuous with member 214, but is aligned with member 213 so that the knitting portion 221 and member 213 are slidingly supported by the dial plate. The member 214 has an upwardly directed bend therein which defines needle butt 212. The forward or outer extremity of the knitting portion 221 is formed to provide a hook 218 and a latch 219 is pivotally secured at 220 in a conventional fashion. The forward or outer extremity of the dial plate 210 is provided with upstanding combing teeth 223.

Means are provided to slidingly engage the side of the knitting portion of at least certain of the dial needles to cause these knitting portions to flex and the forward extremities thereof to be laterally displaced as will later be described at length. In the form illustrated, the sliding flexing action is provided by a flexer 232 (see also FIG. 8), which is pivotally mounted by means of a pin 233 in a bore 234 in a dial plate 210. Preferably, to prevent the flexer 232 from inadvertently becoming disengaged from the bore 234, the flexer 232 is provided with a lateral lug 235 which underlies the needle 215. The upper portion of flexer 232 is formed with a forwardly or outwardly projecting arm 236, the forward extremity of which engages the side of knitting portion 221 and a heel portion 238, which is preferably provided with an enlarged tail piece 239. Heel 238 extends above the needles so as not to interfere therewith and is angled to the side and to the rear for engagement by the cam bar 40 which is carried by the turntable 13. As can be seen, cam bar 40 is mounted for radial reciprocation by means of arm 41 which rides in track 42 formed in a guide member 43. Arm 41, and hence cam bar 40, is urged inwardly of the dial (away from heel 238) by spring 44 which extends in tension between pin 45 on the turntable 13 and pin 46 on arm 41. As will later more fully appear, cam bar 40 is forced against heel 238 of flexer 232 by suitable means, these means causing displacement of arm 41 against the tension of spring 44 by moving lever 47 in the direction shown by the arrow. To this end, lever 47 is slotted at 48 and pin 49 extends through the slot 48 and is fixed to the arm 41. To render the needles more flexible, the needles may have a portion of reduced thickness 222 (see also FIG. 9).

The change in knitting pattern illustrated in FIG. 6 will now be described more specifically utilizing as the dial needles the specific needle construction shown in FIG. 7. In connection with this description, reference is particularly made to FIG. 9, which shows a top plan view of a portion of the dial plate and shows the dial needles in flexed and unflexed positions. C generically designates the cylinder needles, and D generically designates the dial needles. This figure shows three pairs of dial needles, the first pair being 264A and 265A, the second pair being needles 264 and 265 and the third pair being 264′ and 265′. Cooperating with these pairs of dial needles are three pairs of cylinder needles, the first pair being needles 266A and 267A, the second pair being needles 266 and 267, and the third pair being needles 266′ and 267′. The dial needles 264A and 265A are shown in their normal unflexed position. As will be recalled from the description of FIG. 6 when the needles are in this position, a 2 x 2 rib will be produced. In this position the cylinder needles draw against cylinder combing teeth 283A, 283, and 283′. When these needles 264A and 265A knit in their normal unflexed position, the cam bar 40 is in the retracted position as shown in the lefthand portion of FIG. 9.

When it is desired to knit 1 x 1 rib, the cam bar 40 is moved forwardly or outwardly of the dial plate, that is, toward the cylinder. This position of cam bar 40 is shown in the righthand portion of FIG. 9. When the cam bar is in this position, it acts upon the tail piece or heel 238 and particularly the enlarged portion 239 thereof to pivot the flexer 232 to cause the arm 236 to bear against the side of the knitting portion 221 of the adjacent dial needle 264′ to cause the knitting portion thereof to be flexed and, therefore, the forward extremity of the knitting portion to be laterally displaced. The movement of cam bar 40 as shown by arrow 292 is so timed that tail piece 238 is contacted to cause flexing of needle 264′ while the needle is in the retracted position. As the cam bar and the turntable continue rotation in the direction of arrow 292, the cam track 14 causes outward movement of needle 264′. In the righthand portion of FIG. 9, needle 264′ is shown partially projected. The cam bar 40 may be of such a length that the needle is maintained in flexed position throughout its knitting cycle, that is, throughout its projection and withdrawal. It is apparent that the flexing action moves the knitting portion of needle 264′ from its normal position on the righthand side of cylinder needle 267′ to a displaced or racked position wherein dial needle 264′ is to the left of cylinder needle 267′, or between cylinder needles 266′ and 267′. In the preferred form of the invention, the cam bar is of such a length that it no longer engages the tail piece 238 once the flexed needle has been projected past the opposed cylinder needle. This preferred form is illustrated in FIG. 9 and is shown in connection with needle 264. The cam bar 40, as is evident from FIG. 9, during its rotation in the direction of arrow 292, no longer contacts tail piece 238 of the flexer 232 associated with the needle 264. However, needle 264 has been displaced to the left of cylinder needle 267 and has been projected beyond needle 267. Therefore, the needle 264 is maintained in its flexed position during the remainder of its knitting cycle by sliding engagement against the lefthand side of cylinder needle 267.

In FIG. 9 the dial needles are shown in cooperation with the cylinder needles and the needles are in the act of being projected by means of conventional cam tracks which are not shown. The direction of rotation of respective cam tracks is indicated by the arrows 290 and 291, and the cam bar 40 is rotated with the dial turntable as indicated by the arrow 292. It is emphasized that the initial contact between the cam bar 40 and the flexer 232 occurs while the dial needles are fully retracted and out of engagement with the cylinder needles, so that there is no danger of either having the lateral shifting of the dial needles prevented by interengagement with the cylinder needles or of having coacting needles collide during projection. More particularly, the side of needle 264 slides against the forward extremity 237 of the flexer 232, so that the flexed position is retained during projection thereof at least until the forward extremities of the

coacting cylinder and dial needles pass each other. Thereafter, the flexed needles may be released and the coacting needles permitted to slide one against the other, as above described. In FIG. 9, the cam bar 40 is shown of minimum length, so that the trailing end of the cam bar 40 passes the flexer 232 adjacent the needle 264 as soon as this needle has been projected sufficiently to interengage with the coacting needle 267.

The cam bar 40 may be longer than illustrated in FIG. 9, so as to maintain the needles in their flexed position over a greater portion or even the entirety of a single knitting projection and retraction. However, it is essential that the cam bar 40 extend from a point in advance of the knitting area where the needles are retracted to at least a point of the knitting area where the coacting cylinder and dial needles are sufficiently projected for interengagement. It is apparent that in any case means are provided to flex or to laterally shift selected needles from one side of opposing needles to the other side thereof and to maintain this flexed or laterally shifted position through a knitting cycle.

It is evident that the above-described operation results in individually racking selected needles while all the needles of the machine, including those that are being racked, continue in their knitting cycle. In other words, the racking operation does not change or interrupt the knitting cycle of any of the needles, since all the needles of the machine go through their usual reciprocating movements as the yarn is being fed to the needles.

In the conventional racking operation the needle bed itself is moved. Normally at the time a needle bed is to be moved for racking some of the needles of this bed are projected at every instant of time, and lateral shifting of the bed is impossible until all the needles have been retracted. Customarily, in conventional machines one complete rotation of the machine is employed for the specific purpose of retracting all of the needles in at least one of the needle banks so that lateral shifting of the needle bed will not be resisted by interengagement of the projected needles of the respective needle banks or accompanied by collision of needles being projected. This interrupts the knitting cycle of the needles. Normally it is necessary to discontinue the yarn feeds to the respective knitting areas, since the cylinder and dial cannot work together while racking is being effected. To this end, the yarn being fed is striped out of position with a striping knife. In a multi-feed machine in which each individual yarn is fed by a two-finger striper, one of the striper fingers on each of the stripers carries no thread and is reserved for the racking operation. This means that the striping action of one striping finger on each striper is sacrificed to permit the automatic change of pattern effected by the racking operation. The other finger is needed to knit the cloth, and it, therefore, cannot stripe.

However, in accordance with the present invention the initial positioning of the dial and cylinder is maintained during the racking operation, and there is no need to employ a needle retracting rotation or to discontinue any of the yarn feeds since all the needles may continue through their knitting cycle during racking. This is possible because racking takes place by successively laterally shifting individual needles, and these needles are racked without disturbing their normal knitting cycle or the knitting cycle of the other needles. This is true irrespective of the sequence of knitting operations which is performed or the number of yarn feeds employed.

In FIG. 10, there is shown the modification wherein the cam bar 40 is sufficiently long to maintain the needles flexed during the entire knitting cycle. In this figure, it will be seen that the cam bar 40 in the righthand portion of the figure is projected to engage the tail or heel 238 of each flexer 232 to cause the dial needles 264, 264', etc. to be flexed into the laterally shifted position between adjacent operative cylinder needles 266, 267, 266', 267', etc., whereby a 1 x 1 rib knit pattern will be produced.

It will be observed that the knitting area 240 is defined by the cam track 14 on the turntable 13 and that the cam bar 40 is fixed with respect to the turntable 13 and hence with respect to the cam track 14. It will further be seen that the cam bar 40 extends over the entire circumferential length in which the dial knitting needles are projected to an extent sufficient to cause engagement with the cylinder needles in at least one particular knitting area. As a result, the dial needles are flexed when they are retracted and prior to that portion of the knitting operation where the needle is projected sufficiently to prevent lateral shifting. Further, the laterally shifted position is maintained until the knitting action has been completed and the needle retracted to an extent sufficient to prevent engagement with the cooperating cylinder needle.

The turntable 13 in FIG. 10 is rotated in the direction indicated by the arrow 93, and the cam bar 40 is maintained in projected position until it assumes a position overlying a portion of the dial 210, in which the needles are missing, this portion being designated by the numeral 94 and being normally present in conventional circular knitting machines to enable the knitting pattern defined by the cam track 14 to be altered. Thus, when the dial needles are to be projected a distance greater than is employed for the normal knitting operation to enable loops thereon to be transferred to neeedles of another needle bank, a section 95 of the turntable 13 is lowered to cause a different cam track 96 to engage the needle butts 212. This is done by moving the cam section 95 into butt-engaging position when the section 95 overlies the blank section 94 on the dial, and this expedient is conventionally employed to insure proper engagement between the transfer track 96 and the needle butt 212.

In accordance with the present invention, the blank section 94 of the dial is preferably longer than the length of the cam bar 40 and the cam bar 40 is projected and retracted when the turntable 13 is rotated to a position where the cam bar 40 overlies the blank section 94 of the dial 210. Accordingly, projection and retraction of the cam bar 40 is effected without danger of collision between the needles of the respective coacting banks. This is shown in FIG. 10 by illustrating the projected position of the cam bar 40 in phantom where the cam bar 40 overlies the blank section 94 and by showing a stationary cam 97 adjacent the blank section 94.

As will later be explained, the projection and retraction of the cam bar 40 is effected by the stationary cam 97 and accordingly radial movement of the cam bar 40 is confined within the circumferential zone defined by blank section 94 of the dial 210. Thus, in FIG. 10 the righthand position of the cam bar 40 illustrates the completion of a single course of 1 x 1 rib knit and the cam bar 40 then moves with the turntable 13 in the direction indicated by the arrow 93 to a position overlying the blank section 94 where it is retracted as indicated by the arrow 98 and further rotation of the turntable 13 causes the cam bar 40 to continue to move in retracted position where it does not engage the flexers 232 so that the dial needles are not laterally shifted and this results in the production of a 2 x 2 rib knit as indicated by the unflexed dial needles in the lefthand portion of FIG. 10.

In FIG. 10 there are shown three cam bars 40. It is evident that in a multi-feed machine there would be one cam bar associated with each feed. It is therefore apparent that FIG. 10 shows the cam bar 40 associated with each successive feed. However, FIG. 10 equally illustrates the successive positions of a single cam bar associated with a single feed as the feed rotates in the direction of the arrow 93. In other words, as the turntable rotates in the direction of arrow 93, a single cam bar 40 associated with one yarn feed successively moves throughout the positions shown in the righthand portion

of FIG. 10, the middle portion of FIG. 10 and the left-hand portion of FIG. 10.

It is desired to point out that movement of the cam bar 40 between its projected and retracted positions should not be effected while any of the needles which will be flexed by the projection of the cam bar 40 are in the act of being projected since, if this is done, there is a danger that the projecting needles will collide leading to possible needle breakage and costly delays and repairs. For this purpose, it is preferred to effect projection and retraction of the cam bar 40 while this cam bar overlies a section of the needle bed on which there are no needles. This represents no problem whatever in straight knitting where projection and retraction of the cam bar may be effected while the yarn feeding and needle actuating carriage is at rest at one of the lateral margins of the straight knitting machine.

In circular knitting, use is made of the blank section which is normally present as previously indicated. Naturally, and ignoring other factors, the shorter the cam bar 40, the shorter is the length of the necessary blank space on the needle bed. As indicated in FIG. 10, the cam 97 is stationary with respect to the needle beds and this cam 97 may be raised or lowered to actuate mechanism which will project or retract the cam bar 40 while the same is in proper rotational position with respect to the needle beds.

Cam 97 is a conventional cam used to shift needle-engaging cam tracks in and out of position. Cam 97 is mounted on the frame of the machine and moved up and down into and out of actuating position by means of the chain controlling the cycle of the machine.

Illustrative mechanism for effecting the desired projection and retraction of the cam bar 40 is shown in FIGS. 11 and 12 where the cam bar 40 is mounted upon the arm 41 which is slidably mounted on the track 42 of guide member 43 which is mounted for rotation with the turntable 13. The arm 41 is biased inwardly into retracted position by the spring 44 which extends between pins 45 and 46 as is more clearly shown in FIG. 7. The tension of spring 44 is overcome by operation of the lever arm 47 which is provided with a slot 48 bearing upon the pin 49 which is secured to the arm 41, as is also more clearly shown in FIG. 7. Arm 47 is pivotally mounted at 100 upon the turntable 13 and the end of the arm 47 remote from the slot 48 is secured to a projecting and retracting mechanism indicated generically by the numeral 101.

The projecting and retracting mechanism 101 may be constituted by any suitable means. In the form of the invention illustrated, the projecting and retracting mechanism 101 is supported upon a platform 102 which is carried by an arm 103 fixed to the turntable 13 by any suitable means such as the screws 104.

The projecting and retracting mechanism 101 more specifically includes a pivotally mounted cam member 105 which is pivotally mounted at 106 on the platform 102 and is provided with a cam surface 107 and a notch 108. A turnbuckle 109 provides an adjustable securement between the pivot 110 on the lever 47 and a pivot 111 on the cam member 105. A second pivotally mounted cam member 112 is pivotally mounted at 113 upon the platform 102 and is spring biased as shown by the spring 114. The cam member 112 carries a cam roller 115 and a latch 116.

FIG. 11 illustrates the retracted position of the cam bar 40 in which the latch 116 is out of engagement with the notch 108 so that the spring 44 is free to withdraw the cam bar 40 away from the heel portion 238 of the flexer 232. As will be appreciated, when the turntable 13 is rotated as indicated by the arrow 118, the cam 97 can engage the cam surface 107 of the cam member 105 to pivot the cam member 105 and permit the spring 114 to pivot the cam member 112 so that the latch 116 can engage the notch 108.

Therefore, the cam bar 40 is positively forced into projected position and retained in this position by the tension of spring 114. After a complete rotation of the turntable 13, during which time a course of 1 x 1 rib knit will be produced, the projecting and retracting mechanism 101 is once again opposite the cam 97 which is now lowered for engagement with the cam roller 115 of the cam member 112. As will be clear from FIG. 12, engagement of the cam 97 with the roller 115 will pivot the cam member 112 to free the latch 116 from the notch 108 and the spring 44 will then return the cam bar 40 to its retracted position where it will remain until the cam 97 is raised again.

Referring again to FIG. 9, for the sake of clarity the yarn has not been illustrated. However, the yarn is engaged by the needles as shown in FIG. 6. In order to permit the laterally projecting lug 235 on the flexer 232 to underlie the needles the dial plate 210 is formed with a circumferential depression 280. As is apparent in FIGS. 6 and 9, the combing teeth on the dial are so spaced that needles 264 and 264' can flex from one side of needles 267 and 267', respectively, to the other side thereof during the racking operation. Combing teeth 223 and 223' guide the needles when in the unflexed position and are also used for the needles to draw against when there is no opposing needles, that is, during the production of a 2 x 2 rib knit, as shown in FIG. 6.

Although in the illustrated embodiment the dial needles are shown in spaced pairs wherein alternate needles of said pairs are flexed when converting from 2 x 2 rib knit to 1 x 1 rib knit, it is apparent that the present invention comprehends within its scope a knitting machine wherein the dial is provided with a continuous or substantially continuous bank of dial needles and wherein all or selected needles may be racked as desired. For example, if all the needles are to be racked, it is merely necessary to position a flexer 232 adjacent each needle. On the other hand, if only selected needles are to be racked, the flexer 232 can be positioned adjacent those needles which are to be racked.

Furthermore, the present invention comprehends within its scope a structure wherein different needles or selected groups of needles are racked at different times during the knitting operation to produce special designs. This is not possible with prior art machines. For example, in addition to one or more flexers 232 illustrated in FIG. 8, there may be supplied one or more flexers 232*a*, as in FIG. 8A. The flexer 232*a* is similar to that of flexer 232, except that the free end of heel portion 238*a* is modified. At the end of heel portion 238*a* is an upstanding tail piece 239*a* which is set back to provide a notch 239*b*.

In addition, the machine is provided with one or more cam bars 40 and one or more cam bars 40*a*, the two cam bars being identical in structure, except that cam bar 40*a* is somewhat shorter in height than cam bar 40 so that it terminates a greater distance above the dial plate 210. In FIG. 8A, cam bar 40*a* is shown in solid lines and cam bar 40 is shown in dotted lines. It is, therefore, apparent that as each cam bar 40 rotates, it will engage all flexers 232 at tail piece 239 and also engage all flexers 232*a* at the extremity 239*c* of heel portion 238*a*.

Therefore, each cam bar 40 will cause flexing of each needle adjacent to a flexer 232 or 232*a*. On the other hand, cam bar 40*a*, because of its reduced height, will not engage flexers 232*a* as shown in FIG. 8A because the lowest extremity of cam bar 40 will pass through notch 239*b*. However, cam bar 40*a* will engage tail piece 239 of each flexer 232. It is thus apparent that during operation of the machine, each cam bar 40 will engage each flexer 232*a* and 232 whereas cam bar 40*a* will only engage flexers 232.

Other methods of selectively flexing selected needles will be readily apparent to workers skilled in the art. For example, instead of providing two cam bars 40 and 40*a*

means (not shown) can be used to raise or lower the cam bars 40 to engage selected flexers.

FIGS. 27 through 34 are directed to modified constructions of the flexing member and the cam bar to provide greater versatility to the machine. Briefly, in these modifications, the heel portion of the flexing member is so constructed that each flexer may be provided with one or more cam-contacting areas, the position of these areas varying on each flexer, so that each flexer will cooperate with a predetermined rib or camming surface on the cam bar to provide for selective flexing of the flexers.

Referring to FIGS. 27 and 29, flexer 332A is provided with a pin 333 for mounting the flexer in the bore 234 of the dial plate 210. The flexer is provided with a lateral lug 335, which underlies the needle in the same manner as do the lateral lugs of the previously described embodiments. The upper portion of flexer 332A is formed with a forwardly or outwardly projecting arm 336, the forward extremity of which engages the side of a knitting portion of a dial needle D. Flexer 332A is provided with a heel portion 338, which extends above the needles so as not to interfere therewith and is angled to the side and to the rear for engagement by the cam bar 340A, which is carried by the turntable 13 in the same manner as cam bar 40, previously described.

A tail piece 339A extends rearwardly from heel portion 338, the rear extremity of the tail piece being notched at 301A to provide a cam-contacting area. It is noted that the vertical height of the tail piece adjacent the notch is slightly greater than the height of the notch. Cam bar 340A is provided with a forwardly extending horizontal rib 311, the rib 311 being located on the cam bar 340A at such a height that, when the cam bar 340A moves in the direction of arrow 300A, the rib 311 will engage flexer 332A at notch or cam-contacting area 301A to rotate the flexer and thereby cause flexing of needle D.

Referring to FIGS. 28 and 30, flexer 332B is similar to flexer 332A, except that tail piece 339B is approximately double the height of tail piece 339A, and tail piece 339B is provided with two notches 301B and 302B, the latter being above the former. The cam bar 340B has a rib 312 at a height that it will engage flexer 332B at notch or cam-contacting area 302B.

FIG. 31 shows a flexer 332C similar to flexers 332A and 332B, except that tail piece 339C is approximately three times the height of tail piece 339A and is provided with three notches or cam-contacting areas 301C, 302C and 303C. Cam bar 340C has its rib 313 at a height where it will engage flexer 332C at notch 303C.

FIG. 32 again shows a similar flexer 332D, the difference being that the tail piece 339D has two rearwardly extending, vertically spaced-apart branches, the upper one being 341 and the lower one being 342. The upper and lower branches 341 and 342, respectively, are each about the same height as tail piece 339A of FIG. 29, and the space 343 between the branches is about the same as, or slightly less than, the height of tail piece 339A. Branch 341 has a notch or cam-contacting area 303D, and branch 342 has a notch or cam-contacting area 301D. Cam bar 340B, that is, the same cam bar as shown in FIG. 30, is shown with the rib 312 at a height wherein it will pass through space 343 when the cam bar passes flexer 332D and, therefore, during such passage cam bar 340B will not effect any movement of flexer 332D.

The flexers shown in FIGS. 29 through 32 have been shown with particular cam bars. However, it is emphasized that these flexers may be used with other cam bars to provide selective action, as will be hereinafter described.

When the flexers are in the dial plate, notches 301A, 301B, 301C and 301D will all be at the same height, so that, if all four flexers are used at the same time, a cam having the configuration of cam 340A will actuate each one of the flexers, since rib 311 is at the same height as notches 301A, 301B, etc. On the other hand, if a cam bar is used having the configuration shown in FIG. 30, with the rib 312 at the height of notches 302B, 302C and space 343, the cam bar would not act on flexer 332A or 332D, and only act on flexers 332B and 332C.

If the same four flexers 332A–332D are in the machine and cam bar 340C is utilized, the rib 313 would not act upon flexers 332A or 332B, but would act on flexers 332C and 332D. It will be appreciated, therefore, that many combinations of flexers and cam bars can be used to produce variations in the knitting pattern. The ones that have been described, particularly flexers 332A–332D, merely show four variations in flexers, and it is apparent that more or less flexers having the illustrated combinations or other combinations of notches (not shown) may be used. Furthermore, the described flexers only have three positions for the cam-contacting areas. More or less positions (not shown) may be used, depending upon the effects to be achieved.

A selection of flexers for producing a zigzag pattern will now be described. In the particular area of the dial plate where it is desired to produce the zigzag pattern, flexers 332B and 332D are positioned adjacent their respective needles, with flexer 332B being adjacent one needle, flexer 332D being adjacent the next needle, another flexer 332B being adjacent the next needle, and so on, so that the flexers 332B and 332D alternate. If the zigzag pattern is to be fifteen wales wide, the flexers would be placed adjacent fifteen successive needles.

This pattern is, for example, to be knit with a machine having twenty knitting cams, i.e., twenty yarn-feeds Nos. 1 through 20, and an appropriate cam bar 340B or 340C would be provided for each yarn-feed, either alternating individually or alternating in groups. When the cam bars are to alternate in groups of five, for example, feeds one through five and eleven through fifteen would each be provided with a cam bar 340B, and feeds six through ten and sixteen through twenty would each be provided with a cam bar 340C. When cam bar 340B passes each flexer 332B, the adjacent needle will be flexed because rib 312 is at the height of notch 302B. On the other hand, when cam bar 340B passes each flexer 332D, the adjacent needle will not be flexed because rib 312 will pass through space 343 and not actuate flexer 332D. When cam bar 340C passes flexers 332B, the latter will not be flexed because rib 313 is positioned above the highest notch on flexer 332B. On the other hand, cam bar 340C will flex flexers 332D because rib 313 is at the proper height to engage notch 303D. In this description, it will be assumed that, during the operation of the machine, all the cam bars are in the inner position, so that they could engage the flexers.

When the dial plate rotates, in the course of one revolution, the first five yarn-feeds will flex all flexers 332B, but will not flex any flexers 332D. Yarn-feeds six through ten will cause flexing of all flexers 332D, but will permit flexers 332B to return to their normal unflexed position. Of course, during this revolution, all needles having no flexers adjacent thereto will not flex at all. Durthis operation, it is apparent, therefore, that in one revolution of the machine one group of needles never flex. A second group of needles flex during certain courses and return to the unflexed position during other courses; while a third group of needles return to the unflexed position during said certain courses and flex during the other courses.

Furthermore, during a single revolution of the machine, during the knitting of a single course some needles do not flex, and some needles flex and other needles return to the unflexed position after having been flexed in a previous course.

In a single revolution of the machine, one or more particular needles may knit one course in the normal unflexed position, may knit the next course in the flexed position, and may return to the unflexed position in a subsequent course.

In the above example, one or more needles, other than those having adjacent thereto flexers 332B and 332D, may be provided with a flexer 332C, and these needles will flex every time a yarn-feed having a cam bar passes these needles.

The pattern can be further varied, for example, by having one or more of the yarn-feeds provided with a cam bar 340A, and this yarn-feed will cause flexing of all needles having a flexer adjacent thereto. Lastly, a still further pattern can be produced if adjacent to one or more needles there is placed a flexer 332A, which will only flex when cam bar 340A passes thereby. If, in using the above combinations of flexers, it is further desired to produce one or more courses where no flexing takes place, the yarn-feeds knitting such courses would either be provided with no cam bar or would have the cam bar in the inactive position.

Other combinations will be readily apparent and need not be specifically described. By proper selection of flexers and cam bars, many variations in knitting patterns can be made. In a dial and cylinder machine, needles may flex in either the dial or cylinder or in both the dial and cylinder. For example, in a multifeed circular knotting machine having a cylinder bank of needles and a dial bank of needles where only dial needles are flexed, the following effects can be obtained:

(1) During a single revolution of the machine, no needle flexes in any course.

(2) During a single revolution of the machine, all needles flex in each course.

(3) During a single revolution of the machine, all of a combination of some of the following may take place:

(*a*) During each of one or more courses, no needles flex.

(*b*) During each of one or more courses, all needles flex.

(*c*) During each of one or more courses, some needles flex and some do not flex.

(*d*) During each of one or more of certain courses, some needles flex and others do not flex; but in one or more other courses, at least some needles which flexed in said certain courses do not flex (i.e., they return from the flexed position to the unflexed position) and at least some needles flex which did not flex in said certain courses.

(4) The same as itemized under 3, but, instead of (*a*), certain needles flex in each course and certain other needles flex in one or more courses but not in others.

(5) The same as itemized under 3, but instead of (*b*), certain needles do not flex in any course and certain other needles flex in one or more courses but not in others.

FIG. 33 shows a cam bar 340D having two ribs 314 and 315, both of said ribs being higher than the notch 301 in cam bar 332A, so that this cam bar cannot engage flexer 332A but can engage flexers 332B, 332C and 332D. This illustrates a method of producing variations by varying the number of ribs on the cam bar. Such variation can be used together with, or instead of, some of the variations of the described flexers. It will be apparent that, instead of providing three cam bars 340A, 340B and 340C, one cam bar can be used and the machine provided with means (not shown) to lower or raise the cam bar to place the rib at the appropriate position.

It is apparent from the above description that each time a needle flexes, it returns to its unflexed position before the next course. Stated differently, the flexed needles are unflexed between courses, that is, between the time the needle is in one position as the knitting cam or knitting station passes thereby and the time it is in the same position when the next knitting cam passes thereby. It is apparent that a needle should not be flexed when it is crossing a needle of the opposed bank because relative movement would break the needles. Therefore, the needle is flexed at any time in its cycle between the time when it is sufficiently withdrawn into its bed so that it will not contact a needle of the opposing bank during flexing and the time when the needle is being projected but before it crosses a needle of the opposing bank.

According to this invention, the needles are individually flexed independently of the other needles being flexed. This occurs even though, as shown in the righthand portion of FIG. 10, a single cam bar may simultaneously contact a plurality of flexers and, therefore, simultaneously affect a plurality of needles because, at any particular moment, if two needles are flexing, each is at a different stage of movement from the other. For example, when the cam bar affects the first needle of a group of needles, that needle will start its movement, and then, when the cam bar affects the next needle, said next needle will start its movement, and, at the same time, the first needle will be continuing its movement or will have completed its movement. Stated differently, although a single cam bar may, at the same time, cause movement of a plurality of needles, each needle is moving at different points of its cycle of movement.

It will also be appreciated that, in a multifeed machine having a cam bar for each feed, such as shown in FIG. 10, these cam bars may be so timed that, at the same moment, each cam bar flexes its needles identically with other cam bars so as to provide simultaneous, identical flexing of a plurality of needles. However, any such simultaneous flexing may be considered merely fortuitous, and these needles are still considered as being moved individually and independently because they are actuated by different cam bars.

As has been previously pointed out in connection with FIG. 6, after the 2 x 2 rib bottom has been knit when making a jersey body, it is necessary to transfer the yarn loops from the needles of one of the cooperating banks to needles of the other bank which then knit independently to produce the jersey body of the sweater. Although this transfer of the loops can be accomplished by various methods and devices well known in the art, according to another aspect of the present invention, there is provided a particular modification perfecting this transfer. This modification is particularly illustrated in FIGS. 13, 13A, 14, 14A, 15–26. Referring more particularly to FIGS. 25 and 26, according to this modification, the dial plate and dial needles are modified, the remaining construction being the same as previously described. The dial plate has dial needle D mounted in needle-guiding grooves 11 formed therein, the grooves 11 being formed in the rear or inner portion of the dial plate to leave the forward or outer portion of the needles free for lateral movement. The rear or inner portion of the needles D are formed with an upwardly projecting needle butt 12, this being conventional, and a turntable 13 having a cam track 14 is mounted immediately above the dial plate 10 with the needle butts 12 projecting into the cam track 14, so that relative rotation of the turntable 13 with respect to the dial plate 10 will cause the needles D to be reciprocated.

The turntable 13 with its cam track 14 and cam 40 together with the mechanism for moving cam 40 are the same as described in connection with FIGS. 7, 10, 11 and 12.

The needles D are formed in two portions, the forward sections of which are laterally displaceable with respect to one another. Thus, needle D is formed with an upper knitting portion 15 and a lower loop-spreading portion 16. The rear or inner extremities of the portions 15 and 16 are interconnected at 17, so that both of the portions 15 and 16 can be reciprocated together.

The forward or outer extremity of the knitting portion 15 is formed to provide a hook 18 and the conventional latch 19 is pivotably secured at 20 in normal fashion. Knitting portion 15 extends rearwardly of the pivot 20 with a section 21 of reduced height and the section 21

terminates in an upstanding shoulder 22 which is preferably accentuated by the upwardly projecting lug 23.

The loop-spreading portion 16 underlies the knitting portion 15 with the exception of a section 24 which is laterally bent out of the plane of the knitting portion. This will later be more fully discussed. The forward extremity of the loop-spreading portion 16 terminates in an edge 25 which directly underlies the section 21 of knitting portion 15 in advance of the shoulder 22. Immediately beneath the shoulder 22, the loop-spreading portion 16 is preferably recessed at 26 for a purpose to be later explained.

Means are provided to maintain the edge of the loop-spreading portion 16 in a position directly underlying the normal position of knitting portion 15 while permitting lateral displacement of the knitting portion 15 in at least one direction and lateral displacement of the loop-spreading portion in the opposite direction at least when the edge 25 extends beyond the forward or outer extremity of the dial plate 10. Preferred means for achieving the desired alignment are shown in FIG. 26 where the loop-spreading portion 16 is formed with a downwardly extending portion 27 at a point which is approximately in line with the shoulder 22. The portion 27 rides in a narrow groove 28 and this maintains the edge 25 in the normal path of the knitting portion 15 until needle D has been projected sufficiently to place the portion 27 beyond the forward or outer extremity of the groove 28, so that loop-spreading portion 16 can be laterally deflected by the camming action of the combing teeth upon the bent section 24. It will be mentioned that the forward or outer extremity of groove 28 is preferably flared at 29 for a purpose to be later discussed.

The forward or outer extremity of the dial plate 10 is provided with upstanding combing teeth 30 and 31 which, in accordance with the invention, serve a multiplicity of functions. First, combing teeth 30 guide the needles D and the yarn is drawn against combing teeth 30 when there is no opposing needle against which the yarn can be drawn. This function is conventional. Additionally, the combing teeth 30 and 31 act as cams upon the bent portion 24 of the loop-spreading portion 16. Still further, combing teeth 31 is of reduced height, so that knitting portion 15 is not influenced thereby and can pass thereover, as will later be more fully set forth.

The means for flexing the needle comprises flexer 32 comprising pin 33, lug 35, arm 36, forward extremity 37, heel 38 and tail piece 39 which are equivalent to the corresponding elements of flexer 232 previously described. The essential difference between flexer 32 and flexer 232 is that the arm 36 together with extremity 37 are spaced further above lateral lug 35 than the corresponding parts of flexer 232.

The structure shown in FIGS. 24, 25 and 26 may be utilized for independently racking needles in a manner similar to the previously described modification. The functioning of the modification of FIGS. 24–26 will now be described in connection with FIGS. 13, 13A, 14 and 14A.

FIGS. 13 and 13A are respectively a plan view of the dial plate and a front elevation thereof for showing the dial needles in their normal unflexed position wherein they will produce a 2 x 2 rib.

More specifically, it will be seen that the dial plate 10 is formed with a circumferential depression 80, so that a space is provided for the laterally projecting lug 35 on the flexer 32 to underlie the loop-spreading portion 16 of the needles D. As previously indicated, the flexer 32 is provided with a pin 33 which fits within the bore 34 and at the upper portion of the flexer 32 is a forwardly or outwardly projecting arm 36 which bears against the side of the knitting portion 15 of the needle D. This will be particularly apparent from the plan view shown in FIG. 13. As will be evident, it is necessary that the forwardly projecting arm 36 be moved accurately so that the knitting portion 15 of the needle D will be flexed to a carefully controlled degree so that the hooks 18 of the dial needles which are flexed will be accurately positioned with respect to the cylinder needles with which a knitting coaction is established. This positioning is obtained in accordance with the invention by providing the flexer 32 with a rearwardly and sidewardly projecting tail piece or heel 38 which is preferably provided with an upwardly directed enlargement 39. As will be particularly clear in FIG. 13A, the tail piece or heel 38 is positioned above the dial needles, so that the longitudinal reciprocation of these needles is not interfered with.

Referring again to FIG. 26, the tail piece or heel 38 and particularly the enlarged portion 39 thereof is acted upon by the bam bar 40 to pivot the flexer 32 to cause the arm 36 to bear against the side of the knitting portion 15 to be flexed and, therefore, the forward extremity of the knitting portion 15 to be laterally displaced. This lateral displacement can be seen with particular clarity in the plan view shown in FIGS. 14 and 15 and the manner in which the hooks 18 of the knitting portions 15 ride over the short combing teeth 63 will be particularly apparent from the front elevation shown in FIG. 14A. FIGS. 13A and 14A further show the spaced pairs of operative cylinder needles 66, 67, 66′ and 67′ and the 2 x 2 rib knit which is produced when the dial needles 64 and 65 are in their normal and unflexed position is schematically indicated in FIG. 13A by the numeral 81. Arrows 82 in FIG. 13A indicate the direction in which the needles 64 and 64′ are flexed to produce the 1 x 1 rib knit pattern shown in FIG. 14A and the numerals 83 and 83′ designate the cylinder combing teeth against which cylinder needles 66 and 67 and 66′ and 67′ respectively draw.

As can be seen in FIG. 14A, the cylinder combing teeth and 83 and 83′ are not involved in the 1 x 1 rib knit operation, this pattern being schematically indicated in FIG. 14A by numeral 81′.

Referring more particularly to FIGS. 13 and 14, it will be seen that the lateral shifting of some of the needles is effected while these needles are in their retracted position and that the lateral shifting is attained through a flexing force applied to the side of the knitting portion of the needles. When a needle is then projected, as for knitting, the knitting portion of the needle slides against the forward extremity 37 of the projecting arm 36, so that the laterally displaced position of the knitting portion 15 is maintained throughout the knitting operation. As in the first modification, the knitting portion may be maintained laterally displaced by the flexer or by a sliding engagement with a coacting needle.

FIG. 15 illustrates a modification where the cam bar 40 is of such a length that the flexer is released prior to the completion of the knitting action and after the flexed needles have been projected beyond the coacting needles of the cooperating bank. In this figure, the direction of rotation of the respective cam tracks is indicated by arrows 90 and 91 and a cam bar 40 is rotated with the dial turntable as indicated by the arrow 92. This figure shows the successive action of the cam bar 40 as it passes dial needles 64, 65, 64′ and 65′. The action of cam bar 40 and the flexer 32 is identical with the action illustrated and described in connection with FIG. 9 and will not be further described.

It is apparent that insofar as the racking operation is concerned, the operation is identical whether the dial and needles are constructed in accordance with the modification of FIG. 7 or in accordance with the modification of FIG. 26. For example, a longer cam bar 40 can also be used in connection with the modification of FIG. 26 in the same manner as illustrated in FIG. 10 with reference

to the modification of FIG. 7. The mechanism for actuating the cam bar as described above in connection with FIGS. 11 and 12 is identical in both modifications.

The modification described in connection with FIG. 26 and related figures permits a novel loop transfer action enabling efficient and rapid loop transfer which is particularly adapted for closely positioned needles. The new transfer action of the invention will become apparent from the description which follows taken in conjunction with FIGS. 16–22 which illustrates the transfer sequence in a step-by-step fashion.

Briefly stated, the novel transfer action of the invention involves the lateral displacement of the lower loop-spreading portions **16** of the knitting needles after the forward extremities thereof, e.g., the edges **25**, have the yarn loops which are supported on the knitting portions **15** and which are thrust forwardly beyond the plane of the cylinder needles by the excessive projection of the dial needles and by engagement of the yarn loops with the shoulders **22** or the projections **23**. As a result, the yarn loop is spread while it is stationary with respect to the needle supporting the same.

Referring to FIGS. 16 and 16A, the dial needle D is shown at an early stage in its projection and the yarn loop L moves rearwardly along the knitting portion **15** as the same is projected. The loop-spreading portion **16** underlies the knitting portion **15** and is accurately positioned by the lug **27** which rides in the narrow groove **28** in the forward portion of the dial plate **10**. Combing teeth **30** guide the knitting portion **15** and the bent portion **24** of the loop-spreading portion **16** has not yet reached the cam-acting combing teeth **30** and **31**.

The cooperating cylinder needle C is closely adjacent the forward extremity of the dial plate **10** and projection of the cylinder needle is delayed, as is conventional, until the dial needle D has been projected to its extreme forward position.

FIGS. 17 and 17A illustrate further projection of the dial needle D and the loop L has been forced rearwardly with respect to the knitting portion **15** until the loop L is engaged by the shoulder **22**. The edge **25** now projects through the loop L and the bent portion **24** of the loop-spreading portion **16** has just reached a position where it engages the combing tooth **31**. Thus, the yarn loop L is now fixed with respect to the knitting portion **15**; the edge **25** of the loop-spreading portion **16** is in position to spread the loop L but such spreading has not yet commenced.

The fully projected position of the dial needle D is shown in FIGS. 18 and 18A where it can be seen that the upper portion of the loop L has been moved forwardly or outwardly by engagement between the loop and the shoulder **22** to project the forward portion of the loop beyond the plane of the cylinder needle C. At the same time, the combing tooth **31** has engaged the bent portion **24** of the loop-spreading portion **16** and the edge **25** has been thrust sidewardly as shown in FIG. 18A to spread the loop. The recess **26** now functions to keep the portion of the loop L which is engaged by the edge **25** in a forward position. Also, recess **26** provides a space for the yarn of the loop L when the edge **25** of one needle is laterally displaced to a position beneath or beyond a closely adjacent needle, so that transferring of yarn loops may be efficiently achieved with closely positioned needles.

As can be seen in FIGS. 18 and 18A, the cylinder needle C has not yet been projected but is in position where projection thereof will cause the needle C to enter the opening formed by the spread loop L.

At this point it is desired to state that the combing teeth are positioned close together to accurately guide the knitting portion **15**. Accordingly, the combing teeth are set up at an angle to the direction of movement of the needles so that adequate space is provided for the lateral deflection of the bent portion **24** of the loop-spreading portion **16**.

In FIG. 19 the cylinder needle C is projected as indicated by the arrow and retraction of the dial needle D can now be effected. The start of this retracting operation is shown in FIG. 20 where it can be seen that the loop L is now engaged by the cylinder needle C and is being slid forwardly of the needle D along the reduced portion **21** thereof.

FIG. 21 and FIG. 21A illustrate further retraction of the dial needle D and the latch **19** has now been closed and the yarn loop L is riding thereover. The completion of the loop transfer operation is shown in FIG. 22 where the dial needle D is completely retracted and the loop L has been transferred to the cylinder needle C.

Referring to FIG. 23, a partial exploded perspective view is presented to illustrate some of the details of construction of the combing teeth and the manner in which these teeth are mounted in the forward extremity of the needle bed, e.g., the dial plate **10**. While it is possible to form the combing teeth integral with the needle bed, as a practical matter it is preferable to form the combing teeth individually and set these in grooves in the forward extremity of the needle bed. As can be seen in FIG. 23, the combing tooth **30** is formed with an upper tooth portion **120** and the lower portion is formed as a depending wedge-shaped member **121**.

The wedge-shaped lower portion **121** fits within the triangular grooves **122** and is forced therein by a downward motion as indicated by the phantom lines. The lower wedge-shaped portion **121** is shorter in the radial direction than the tooth portion **120** to provide an overhanging ledge or shoulder **123** which acts as a stop against the upper surface of the needle bed as indicated by the numeral **123'**. When the combing teeth are mounted as aforesaid, these teeth may be machined individually from high-strength alloy steels whereas the dial plate itself may be cold rolled steel.

FIG. 23 shows with particular clarity the narrow grooves **28** and the flared portion **29** at the outer ends of the grooves **28**. As will be evident, when the dial needle D is retracted as shown in FIGS. 19 and 20, the flared portion **29** insures that the lug **27** will return smoothly to its proper position within the groove **28**.

The combing teeth have three functions: (1) to guide the needles; (2) the lower halves of the combing teeth act as cams to flex the bent portions **24** of the loop-spreading portions **16** in the transfer operation; and (3) the upper half of the combing teeth are only necessary for the needles to draw against when there are no opposing needles, e.g., in the production of a 2 x 2 rib knit.

It is desired to point out that the procedure for changing the rib-knitting pattern, as has been herein described, is particularly adapted for the attainment of high-operating speeds in multi-feed knitting machines. This is because needle actuation before, during and after the change in a rib-knitting pattern remains constant and there is no need to change the speed of the machine as was necessary in the prior-art machines where racking was accomplished by moving an entire needle bed relative to the other bed. Further, striping can be eliminated and pattern effects can be achieved using the multi-feed procedure and structure disclosed in my previous application Ser. No. 575,267, filed March 30, 1956, now Patent No. 2,775,880. In other words, the present invention may be used with interlock knitting. Still further, as previously indicated, striping mechanisms can be employed to feed the yarn. In this event, all the stripers can retain their primary striping function.

It is desired to stress that the present invention is simply adapted to conventional knitting equipment while simultaneously permitting substantial simplification in the existing equipment. Thus, the conventional equipment for reciprocating the needles may be retained while mechanism for shifting the needle banks, holding the

banks in shifted position, changing the speed, and striping the yarn may be eliminated.

The transfer action is also a rapid one. It will be appreciated that the invention permits the yarn loop to be sufficiently stretched with a minimum stretching of the yarn loop and with a greatly reduced danger of the yarn being damaged. It will also be observed that the transfer action can be conducted with very closely spaced needles and, as a result, automatic knitting with an unusually high number of operating needles per linear distance of knit product becomes feasible.

The conventional machines concerned with production of jersey sweaters having a rib bottom with a selvage are unusually complex, and maximum speeds are inadequate and the number of needles per inch is limited to about 12, the use of 13 being dangerous and the use of 14 being presently out of the question for a 2 x 2 rib, so that the finer knit products having a 2 x 2 rib bottom cannot be produced. The invention provides knitting apparatus of simplified construction capable of automatically knitting jersey sweaters having a rib bottom with a selvage, of accomplishing the same at substantially increased speed and of employing an increased number of needles per inch. As a result, jersey sweaters, as aforesaid, are produced more rapidly and efficiently, and, if desired, the knit product can be finer, e.g., be constituted by smaller and more closely positioned stitches.

The present invention has been particularly described in connection with a cylinder machine of the cam-rotating, stationary needle type. It is apparent that the invention is equally applicable to machines of the stationary cam, rotating-needle type.

In one illustrated form of the invention, knitting is performed utilizing cooperating needles disposed on opposed banks wherein the knitting portion of each operating needle on one bank is disposed between the knitting portions of a pair of operating needles on the other bank, then individually laterally shifting at least the knitting portions, each independently of the others, of some of the operating needles on at least the first bank, so that at least the knitting portions of two adjacent operating needles of one of said banks do not have between them the needles of the other needle bank, and then knitting a second knitting pattern. The invention, however, is broader than this embodiment, in that, if desired all or selected needles can be laterally shifted in various combinations to produce various patterns during the same or during different revolutions of the machine.

In the preceding description, reference has been made to the flexed position and to the unflexed position of the needles. It is apparent that these are relative terms. In other words, if the needle is originally straight and the flexing force is applied thereto, the needle is flexed from the straight position to the bent position. When the flexing force is released, the needle returns to the straight position, and this may be considered as flexing the needle from a bent position to a straight position. To state it another way, flexing as herein used includes flexing by the application of a lateral force or by removal of a lateral force.

Broadly, the present invention is directed to a method and machine, wherein at least knitting portions of at least some of the needles are individually laterally shifted, each independently from the others, from a first knitting position to a second knitting position (including return to the first position) with the needles knitting in both positions. In the illustrated embodiments, the knitting portions are laterally shifted by flexing the needles. It is apparent that this invention is not limited to the exemplary embodiments disclosed, and the description is to be interpreted in an illustrative, and not in a limiting, sense.

I claim:

1. A method of knitting utilizing cooperating needles disposed on opposed needle banks which comprises knitting a first pattern, individually laterally shifting at least the knitting portion of at least some of the needles on one needle bank relative to the needles of the other needle bank, each knitting portion being shifted independently of the other knitting portions being shifted, and with said knitting portions in the shifted position knitting a second knitting pattern.

2. A method of knitting utilizing cooperating needles disposed on opposed needle banks which comprises knitting a first pattern, individually laterally shifting at least the knitting portion of at least some of the needles on one needle bank relative to the needles of the other needle bank, each knitting portion being shifted independently of the other knitting portions being shifted, while continuing the knitting cycle of said needles, and with said knitting portions in the shifted position knitting a second pattern.

3. A method of knitting utilizing cooperating needles disposed on opposed needle banks which comprises knitting a first pattern in which each operating needle on one of said needle banks is disposed on one side of an adjacent operating needle on the other bank, individually laterally shifting at least the knitting portion of at least some of the needles on one needle bank relative to the needles of the other needle bank, each knitting portion being shifted independently of the other knitting portions being shifted, so that each shifted knitting portion is positioned on the opposite side of said adjacent needle of the other needle bank and with the knitting portions in said shifted position knitting a second knitting pattern.

4. A method of knitting utilizing cooperating needles disposed on opposed needle banks which comprises knitting a first pattern, individually laterally flexing at least some of the needles on one needle bank, so that the knitting portions thereof are laterally shifted relative to the needles of the other needle bank, each needle being flexed independently of the other needles being flexed, and with said knitting portions in a shiftd position knitting a second pattern.

5. A method of knitting utilizing cooperating needles disposed on opposed needle banks which comprises knitting a first pattern, individually laterally flexing at least some of the needles on one handle bank, so that the knitting portions thereof are laterally shifted relative to the needles of the other needle bank, each needle being flexed independently of the other needles being flexed, while continuing the knitting cycle of said needles, and with said knitting portions in the shifted position knitting a second pattern.

6. A method as recited in claim 1, wherein one pattern is a 1 x 1 rib and wherein the other pattern is a 2 x 2 rib.

7. A method of knitting utilizing cooperating needles disposed on opposed needle banks which comprises knitting a first pattern in which the knitting portion of each operating needle on a first needle bank is disposed between a pair of operating needles on the opposed needle bank, individually laterally flexing at least some of said operating needles on at least said first needle bank, so that at least two adjacent operating needles of one of said needle banks do not have between them the knitting portion of a needle of said other bank, each needle being flexed independently of the other needles being flexed, and with said needles in said flexed position knitting a second pattern.

8. A method of knitting utilizing cooperating needles disposed on opposed needle banks which comprises knitting a first pattern in which the knitting portion of each operating needle on one of said needle banks is disposed on one side of an adjacent operating needle on the other bank, individually laterally flexing at least some of the operating needles of at least one of said banks, so that the knitting portion of each flexed needle is positioned on the opposite side of said adjacent needle of the other needle bank, each needle being flexed independently of the other needles being flexed, and with

the needles in said flexed position knitting a second pattern.

9. A method as recited in claim 8, wherein each flexing needle is individually flexed in sequence.

10. A method of knitting utilizing a circular knitting machine having two opposed needle banks which comprises knitting a first pattern in which the knitting portion of each operating needle on one of said needle banks is disposed between a pair of operating needles on the opposed needle bank, individually and sequentially laterally shifting at least the knitting portion of at least some of said operating needles on at least one of said needle banks, so that at least two adjacent operating needles do not have between them the knitting portion of a needle of said other bank, each knitting portion being shifted independently of the other knitting portions being shifted, and with the needles in said shifted position knitting a second pattern.

11. A method as recited in claim 8, in which non-adjacent operating needles of one of said banks are laterally flexed in sequence.

12. A method of racking utilizing a knitting machine having two cooperating needle banks which comprises individually and sequentially laterally displacing to a racked position at least the knitting portions of at least some of the needles of one of said needle banks, each knitting portion being shifted independently of the other knitting portions being shifted.

13. In a knitting machine, a needle bank comprising a needle bed having a plurality of independently reciprocable needles slidingly mounted thereon, at least the knitting portion of at least some of said needles being individually laterally shiftable from a first knitting position to a second knitting position, means for knitting with said needles in each of said positions, and means for individually laterally shifting said shiftable knitting portions, each independently of the other, from said first position to said second position.

14. In an independent needle, multiple needle bank knitting machine, a first needle bank, a second needle bank opposed thereto, at least the knitting portion of at least some of the needles of one of said banks being individually laterally shiftable from a first knitting position to a second knitting position, means for knitting with the knitting portions in each of said positions, and means for individually laterally shifting said knitting portions, each independently of the other, from said first position to said second position.

15. In a knitting machine, a needle bank comprising a needle bed having a plurality of independently reciprocable needles slidably mounted thereon, at least some of said needles being laterally flexible so that at least the knitting portions thereof can be laterally shifted from a first knitting position to a second knitting position, means for knitting with the knitting portions in each of said positions, and flexing means for applying a flexing force individually to the side of each of said flexing needles, each independently of the other, to force said needles from the first position to the second position.

16. A knitting machine as recited in claim 15 in which said needle flexing means are mounted in said bed adjacent each flexing needle, each flexing means including an arm engaging the side of the adjacent flexing needle intermediate the length thereof.

17. A knitting machine as recited in claim 15 in which said needle flexing means are mounted in said bed adjacent each flexing needle for pivotal movement about an axis transverse to the plane of said bed and each needle flexing means includes a forwardly projecting arm engaging the side of the adjacent flexing needle and a heel portion extending above the level of said needles and directed sidewardly thereof, and means for moving said heel portion to pivot said needle flexing means to flex said knitting portion.

18. In an independent needle, multiple needle bank knitting machine, a first needle bank, a second needle bank opposed thereto, means for individually laterally flexing at least some of the needles of one of said banks from a first knitting position to a second knitting position, in the first position the knitting portion of each flexing needle being on one side of an adjacent needle of the opposed bank and in the second position the knitting portion of each flexing needle being on the other side of said adjacent needle of the opposed bank, and means for knitting with the needles in said first position and means for knitting with the needles in said second position.

19. A machine as recited in claim 18, wherein the means for laterally flexing said needles individually flexes each of said flexing needles in sequence.

20. In an independent needle, multiple needle bank knitting machine, a first needle bank, a second needle bank opposed thereto, each needle bank comprising a needle bed having a plurality of independently reciprocable needles slidably mounted thereon, at least some of the needles of one of said banks laterally flexing from a first knitting position to a second knitting position, in the first position the knitting portion of each flexing needle being on one side of an adjacent needle of the opposed bank and in the second position the knitting portion of each flexing needle being on the other side of said adjacent needle of the opposed bank, means for applying a flexing force individual to the side of each of said flexing needles, each independently of the other, to flex said needles from the first position to the second position, and means for knitting with the needles in each of said positions.

21. A knitting machine as recited in claim 20 in which said needle flexing means are mounted in said bed adjacent each flexing needle, each flexing means including an arm engaging the side of the adjacent flexing needle intermediate the length thereof.

22. A knitting machine as recited in claim 20 in which said needle flexing means are mounted in said bed adjacent each flexing needle for pivotal movement about an axis transverse to the plane of said bed and each needle flexing means includes a forwardly projecting arm engaging the side of the adjacent flexing needle and a heel portion extending above the level of said needles and directed sidewardly thereof, and means for moving said heel portion to pivot said needle flexing means to flex said knitting portion.

23. A knitting machine as recited in claim 22 where each said flexing means includes a laterally projecting lug positioned beneath its adjacent flexing needle.

24. A knitting machine as recited in claim 22 in which a cam bar is employed to move said heel portion, said cam bar extending from a point in advance of a knitting area to at least a point in said knitting area where the needles are projected sufficiently to extend beyond the line of needles of the cooperating needle bank.

25. A machine as recited in claim 20, wherein in one of said positions each operating needle of one needle bank is disposed between a pair of operating needles of the opposed needle bank and wherein in the other of said positions at least two adjacent operating needles of one of said needle banks do not have between them an operating needle of said opposed needle bank.

26. A machine as recited in claim 20, wherein the machine is a circular knitting machine.

27. A knitting needle comprising a knitting portion and an intermediate underlying loop-spreading portion, said loop-spreading portion having forward, intermediate and rear sections, the knitting portion and the rear section of the loop-spreading portion being interconnected at the rear of said needle, the knitting portion and the loop-spreading portion to be unconnected at the forward portion of the needle to permit lateral displacement of each of the forward portions of said knitting portion and loop-

spreading portion with respect to one another, the forward section of the loop-spreading portion normally lying in the plane defined by the knitting portion, yarn stop means on said knitting portion at a point intermediate the length of said knitting portion, the forward extremity of the forward section of said loop-spreading portion extending forwardly of said stop means, the intermediate section of said loop-spreading portion being laterally bent out of the plane defined by said knitting portion, the forward section of said loop-spreading portion being positioned below the lowest edge of the forward extremity of said knitting portions.

28. A knitting needle as recited in claim 27 in which said knitting portion includes a yarn hook and latch, and a section of reduced height relative to the latch, said section of reduced height extending rearwardly of said latch and terminating in a shoulder constituting said yarn stop means.

29. A knitting needle as recited in claim 27 in which said loop-spreading portion includes a yarn receiving recess facing said knitting portion and aligned with said stop means.

30. A needle bed comprising a plate formed with an upstanding rear portion defining a plurality of knitting needle receiving and guiding grooves, said plate including a forward generally planar portion for slidingly supporting the needles which are received and guided within said grooves, and a forward extremity provided with a plurality of spaced upstanding combing teeth, some non-adjacent combing teeth being of lesser height than other of said combing teeth.

31. A needle bed as recited in claim 30 in which said combing teeth are positioned with their major horizontal axis at an angle with respect to said grooves.

32. A needle bed as recited in claim 30 in which said plate is formed with a recessed portion between said rear portion and said forward portion and said recessed portion is provided with a plurality of bores for pivotally supporting needle flexing members.

33. A needle bed as recited in claim 30 in which said forward portion of said plate is formed with a plurality of narrow grooves aligned with said needle receiving and guiding grooves, said narrow grooves extending to the forward extremity of said plate between said combing teeth.

34. A needle bed as recited in claim 33 in which said narrow grooves flare laterally between said combing teeth and terminate in the outer extremity of said plate in a channel substantially wider than said narrow grooves.

35. In an independent needle, multiple needle bank knitting machine, the improvement which comprises at least one needle bank including a needle bed comprising a plate formed with an upstanding rear portion defining a plurality of knitting needle receiving and guiding grooves, a plurality of knitting needles comprising an upper knitting portion and an underlying loop-spreading portion, the forward section of said loop-spreading portion lying in the plane defined by said knitting portion and laterally shiftable with respect thereto, said needles being mounted in said grooves, said plate including a forward portion for slidably supporting said needles and a forward extremity provided with a plurality of spaced upstanding combing teeth, some of said combing teeth being of sufficient height to engage said knitting portion and other of said combing teeth being of lesser height to engage said loop-spreading portion but not said knitting portion.

36. The combination recited in claim 35 in which said loop-spreading portion includes an intermediate section laterally bent out of the plane defined by said knitting portion, said combing teeth of lesser height engaging said bent sections when said needles are projected beyond a knitting position to laterally shift said loop-spreading portion with respect to said knitting portion.

37. The combination recited in claim 36 in which said combing teeth are positioned with their major horizontal axes at an oblique angle with respect to said needles to function as cams for engaging said bent sections and laterally shifting said loop-spreading portion.

38. The combination recited in claim 35 including needle flexing means for laterally flexing the knitting portion of said needles.

39. The combination recited in claim 38 in which said needle flexing means are mounted in said plate between said needles, said flexing means including an arm engaging the side of only the knitting portion of an adjacent needle.

40. The combination recited in claim 35 in which said forward portion of said plate is formed with a plurality of grooves narrower than the width of said loop-spreading portion aligned with said needle receiving and guiding grooves, said narrow grooves extending to the forward extremity of said plate between said combing teeth, and each of said loop-spreading portions has a forward extremity formed with a narrow downwardly depending lug riding in each of said narrow grooves.

41. The combination recited in claim 35 including needle flexing means for laterally flexing the knitting portion of said needles pivotably mounted in said plate adjacent each needle to be flexed, said needle flexing means including a heel portion extending above the level of said needles and directed sidewardly thereof, and a cam bar for moving said heel portion, said cam bar extending from a point in advance of a knitting area to at least a point in the knitting area where the needles are projected sufficiently to extend beyond the plane of needles of a cooperating needle bank.

42. In an independent needle, multiple bank knitting machine, the improvement which comprises at least one needle bank including a needle bed comprising a plate formed with an upstanding rear portion defining a plurality of knitting needle receiving and guiding grooves, a plurality of knitting needles comprising a knitting portion and an intermediate underlying loop-spreading portion, said loop-spreading portion having forward, intermediate and rear sections, the knitting portion and the rear section of the loop-spreading portion being interconnected at the rear of said needle, the knitting portion and the loop-spreading portion being unconnected at the forward portion of the needle to permit lateral displacement of each of the forward portions of said knitting portion and loop-spreading portion with respect to one another, the forward section of the loop-spreading portion lying in the plane defined by the knitting portion, yarn stop means on said knitting portion at a point intermediate the length of said knitting portion, the forward extremity of the forward section of said loop-spreading portion extending forwardly of said stop means, the intermediate section of said loop-spreading portion being laterally bent out of the plane defined by said knitting portion, the forward section of said loop-spreading portion being positioned below the lowest edge of the forward extremity of said knitting portion, said knitting needles being mounted in said grooves, said plate including a forward portion for slidably supporting said portions and a forward extremity provided with a plurality of spaced upstanding combing teeth, some of said combing teeth being of sufficient height to engage said knitting portion and other of said combing teeth being of lesser height to engage said loop-spreading portion but not said knitting portion.

43. The combination recited in claim 42 including needle flexing means for laterally flexing the knitting portion of said needles, each flexing means being pivotally mounted in said plate adjacent each needle to be flexed, each needle flexing means including an arm engaging the side of only the knitting portion of said adjacent needle and a heel portion extending above the level of said needles and directed sidewardly thereof.

44. In a knitting machine, a needle bank comprising a

needle bed having a plurality of independently reciprocable needles slidably mounted thereon, at least some of said needles being laterally flexible so that at least the knitting portions thereof can be laterally shifted from a first knitting position to a second knitting position, means for knitting with the knitting portions in each of said positions, and flexing means for applying a flexing force individually to the side of each of said flexing needles, each independently of the other, to force said needles from the first position to the second position without interrupting the knitting cycle of any of the needles.

45. A method of knitting, utilizing a knitting machine having cooperating needles disposed on opposed needle banks, the knitting portions of the needles of one needle bank normally being in one lateral position relative to the needles of the other needle bank to provide a first knitting pattern, said method comprising individually laterally shifting at least the knitting portions of at least some of the needles of said one needle bank relative to the needles of the other needle bank, and, with the knitting portions so disposed, knitting another knitting pattern, each knitting portion being shifted independently of the other knitting portions being shifted.

46. A method of knitting, utilizing a knitting machine having cooperating needles disposed on opposed needle banks, the knitting portions of the needles of one needle bank normally being in one lateral position relative to the needles of the other needle bank to provide a first knitting pattern, said method comprising individually laterally shifting at least the knitting portions of only some of the needles of said one needle bank relative to the needles of the other needle bank and maintaining the knitting portions of the other needles of said one needle bank in their normal lateral position and knitting at least one course with the knitting portions so disposed to provide another pattern, each knitting portions being shifted independently of the other knitting portions being shifted.

47. A method of knitting utilizing a circular knitting machine having cooperating needles disposed on opposed needle banks, the knitting portions of the needles of one needle bank being normally in one lateral position relative to the needles of the other needle bank to provide a first knitting pattern, said method comprising knitting at least two courses, one of the courses being knitted with the knitting portions of only some of the needles of said one bank in said normal lateral position and the knitting portions of other of the needles of said one bank being laterally shifted, another of said courses being knitted with the knitting portions of other of said needles of said one bank being laterally shifted, said knitting portions being laterally shifted by individually laterally shifting at least the knitting portions of the needles of said one bank relative to the needles of the other needle bank to provide a different knitting pattern, each knitting portion being shifted independently of the other knitting portions being shifted.

48. A method of knitting according to claim 47, wherein both of said courses are knitting during one revolution of the machine.

49. In an independent needle, plural yarn-feed, multiple needle bank circular knitting machine, a first needle bank, a second needle bank opposed thereto, at least the knitting portion of at least some of the needles of one of said banks being individually laterally shiftable from a first knitting position to a second knitting position, means for knitting with the knitting portions in each of said positions, and means for individually laterally shifting said knitting portions, each independently of the other, from said first position to said second position, said last-named means including means for laterally shifting some of said knitting portions during one knitting course, and means for laterally shifting other of said knitting portions during another course in the same revolution of the machine.

50. A knitting machine as recited in claim 14, wherein said means for shifting said knitting portions shifts them while continuing the knitting cycle of the needles.

51. A method of knitting as recited in claim 1, wherein the knitting is performed on a circular knitting machine, a plurality of successive courses are knitted during one revolution of the machine with knitting portions in the shifted position and the shifted portions are returned to the unshifted position between sad courses.

52. A method of knitting as recited in claim 1, wherein the knitting portions which are shifted are returned to their unshifted position before the course immediately following a course in which the knitting portions were in the shifted position.

53. A method of knitting utilizing a circular knitting machine having cooperating needles disposed on opposed needle banks, the knitting portions of the needles of one needle bank being normally in one lateral position relative to the needles of the other needle bank to provide a first knitting pattern, said method comprising knitting at least a course and a subsequent course, said one course being knitted with the knitting portions of only some of the needles of said one bank in said normal lateral position and the knitting portions of other of the needles of said one bank being laterally shifted, said subsequent course being knitted with the knitting portions of other of said needles of said one bank being laterally shifted and with at least some of the knitting portions which were shifted in said one course being in their normal position, said knitting portions being laterally shifted by individually laterally shifting at least the knitting portions of the needles of said one bank relative to the needles of the other needle bank to provide a different knitting pattern, each knitting portion being shifted independently of the other knitting portions being shifted.

54. A method of knitting as recited in claim 53, wherein both said course and said subsequent course are knitted during the same revolution of the machine.

55. In an independent needle, plural yarn-feed, multiple needle bank circular knitting machine, a first needle bank, a second needle bank opposed thereto, at least the knitting portion of at least some of the needles of one of said banks being individually laterally shiftable from a first knitting position to a second knitting position, means for knitting with the knitting portion in each of said positions, and means for individually laterally shifting said knitting portions, each independently of the other, from said first position to said second position; said last-named means including means for laterally shifting some of said knitting portions during one knitting course, means for laterally shifting other of said knitting portions during a subsequent course in the same revolution of the machine, and means for returning, to the first position during said subsequent course, at least some of the knitting portions shifted during said one knitting course.

56. In an independent needle, plural yarn-feed, multiple needle bank circular knitting machine, a first needle bank, a second needle bank opposed thereto, at least the knitting portion of at least some of the needles of one of said banks being individually laterally shiftable from a first knitting position to a second knitting position, means for knitting with the knitting portions in each of said positions, and means for individually laterally shifting at pendently of the other, from said first portions, each independently of the other, from said first position to said second position for knitting therewith in one course and for returning said shifting portions to said first position prior to knitting the next course in the same revolution of the machine.

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