United States Patent [19]

Shima

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[54] FLAT KNITTING MACHINE

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[52] **U.S. Cl.** **66/62,** 66/87

[51] **Int. Cl.** **D04b 7/00**

[58] **Field of Search** 66/75, 62, 61, 64, 66/86, 88, 87

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Primary Examiner—Ronald Feldbaum
Attorney—Dawson, Tilton, Fallon & Lungmus

[57] **ABSTRACT**

A flat knitting machine wherein, besides horizontally movable yarn feeders which are also provided in the conventional flat knitting machine, there are provided above the back or front needle bed vertically movable yarn feeders which feed weft knitting yarns to optional or desired transversely divided portions of optional distance in desired optional courses. Owing to the provisions of said vertically movable yarn feeders, there may be produced not only conventional weft knitted constructions or fabrics such as plain stitch, rib stitch, cardigan stitch or the like and RAHBEN stitch, milano rib or the like, but also various knitted constructions or fabrics having constructions similar to warp knitted ones and variously combinated constructions of such knitted constructions.

7 Claims, 20 Drawing Figures

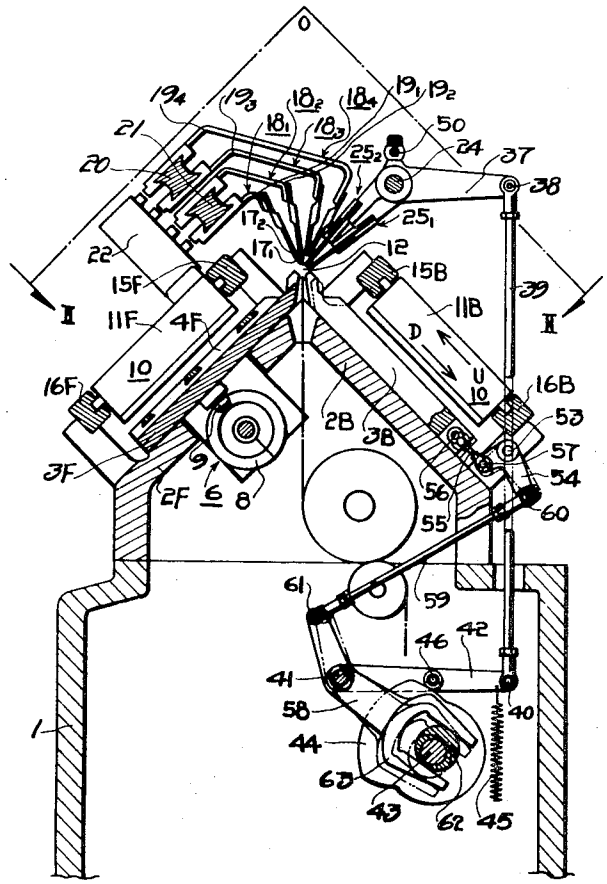
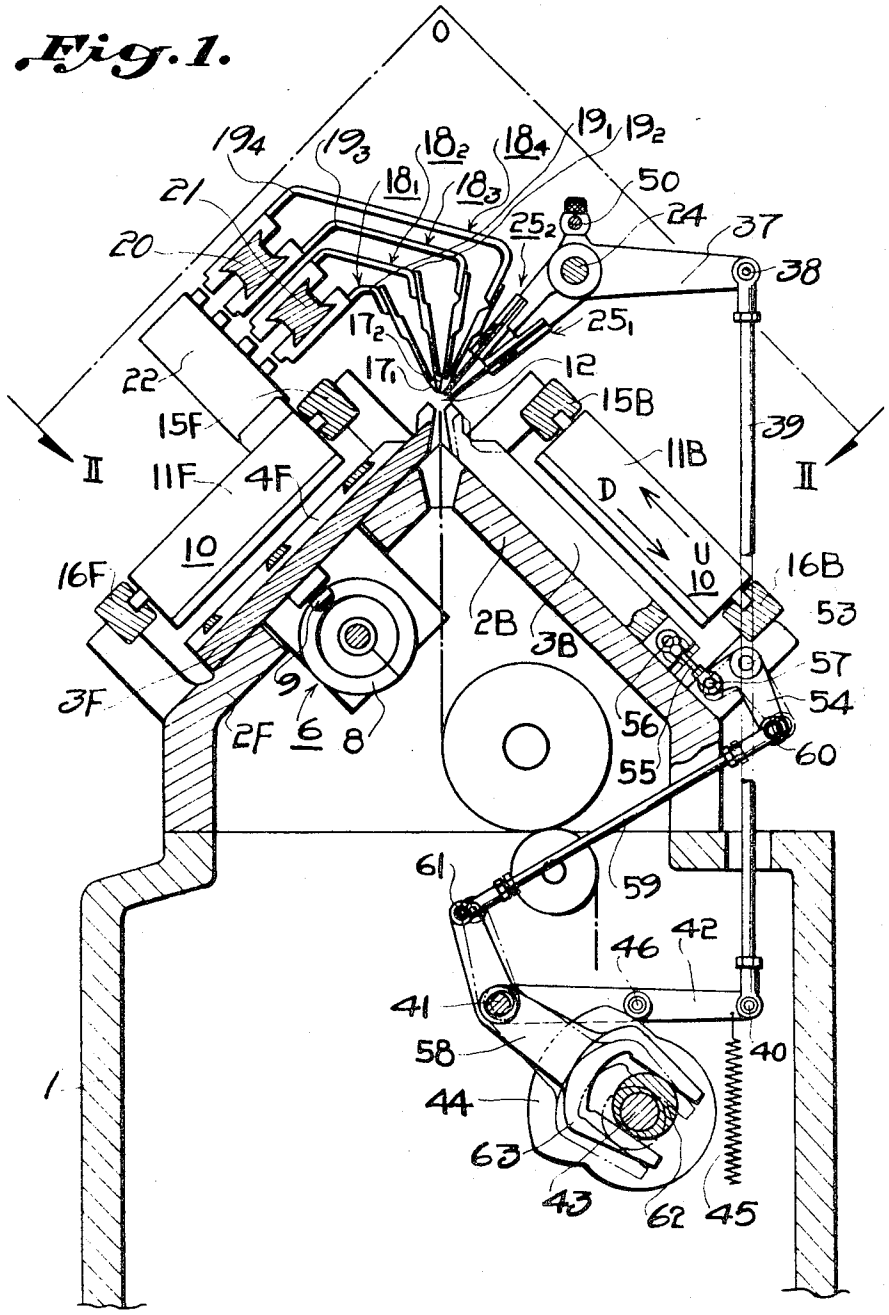


Fig. 1.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19₃
18₂
18₄
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19₂
21
18₁
18₃
50
20
25₂
24
37
38
17₂
25₁
22
17₁
12
15B
15F
39
II
11F
4F
11B
D
II
10
U
10
16F
16B
53
2B
3B
57
3F
9
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58
40
1
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63
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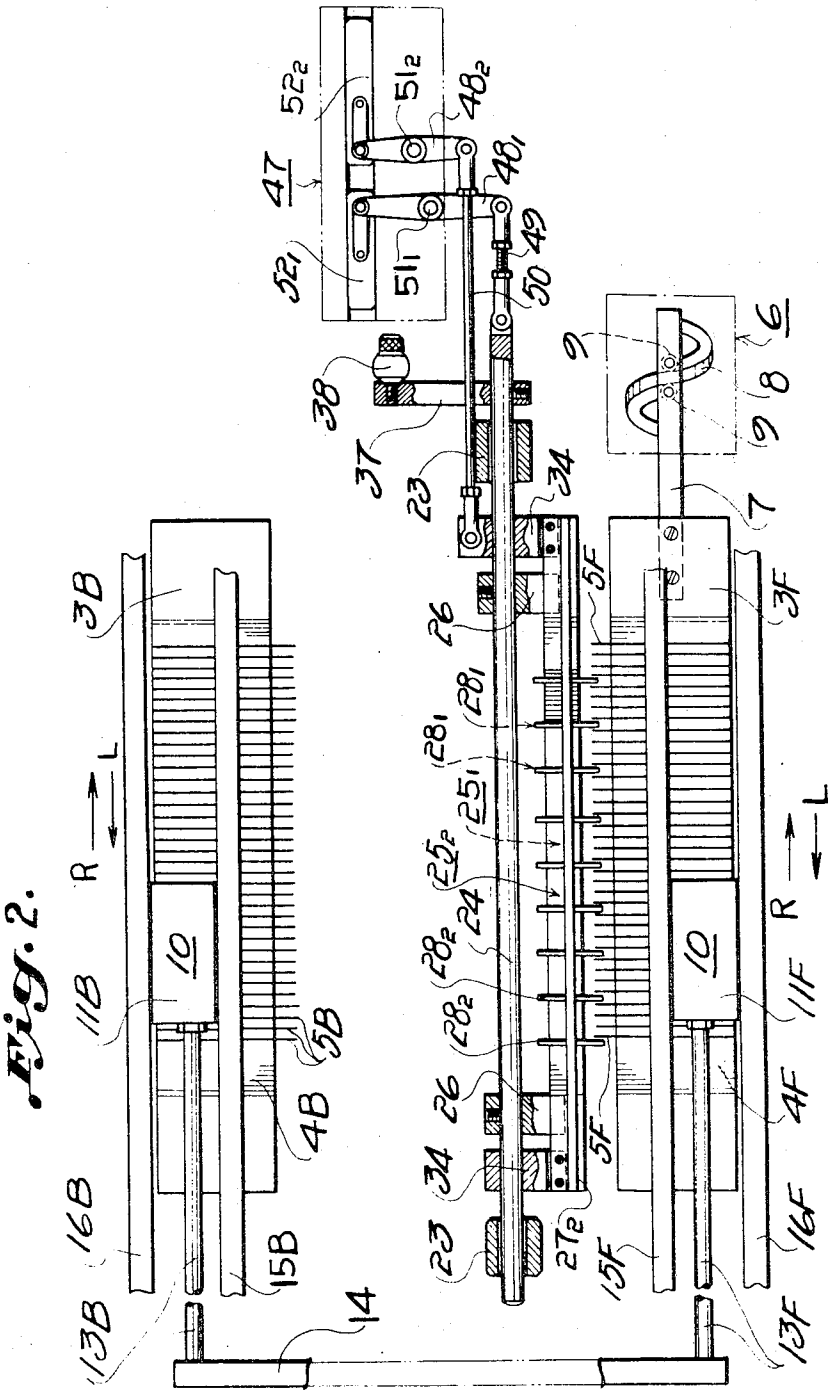
62
45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51₁
49
50
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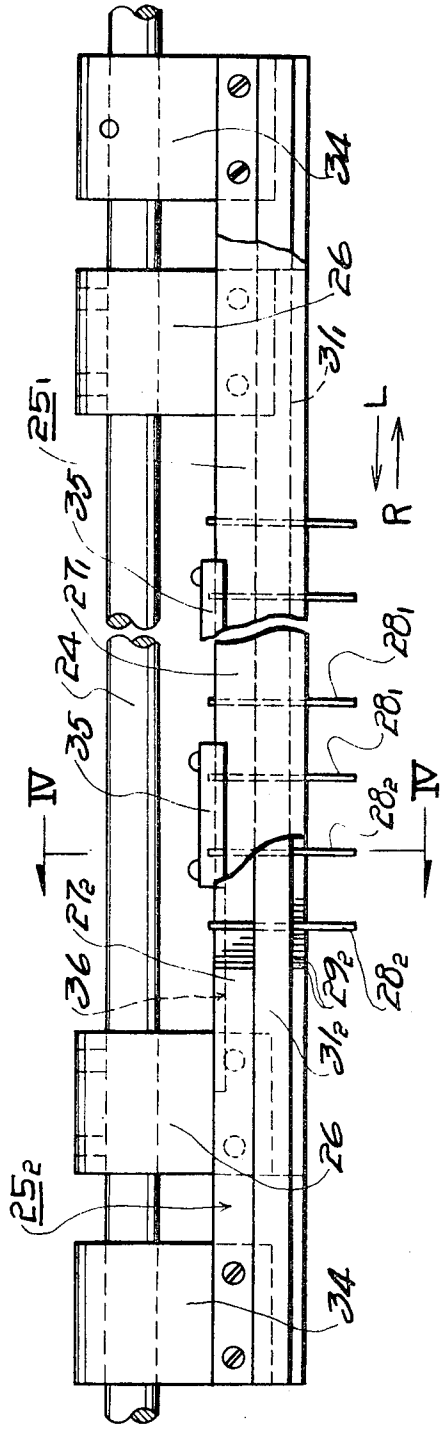
37
23
34
9
6
8
7
3B
5F
3F
26
28₁
25₁
25₂
24
28₂
11B
10
11F
5B
4B
4F
16B
15B
16F
14
13B
13F
R
L

Fig. 2.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26
31₁
25₁
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27₁
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28₁
28₁
35
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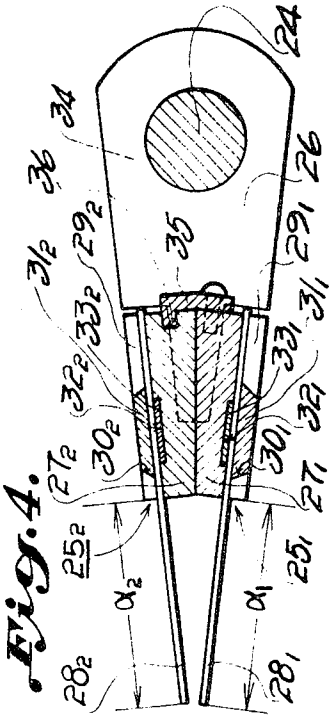
28₂
31₂
26
25₂
34
L
R

Fig. 3.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31₁
32₂
33₂
33
32
30₂
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25₂
25₁
α₂
α₁
28₂
28₁

Fig. 4.

Fig. 7.

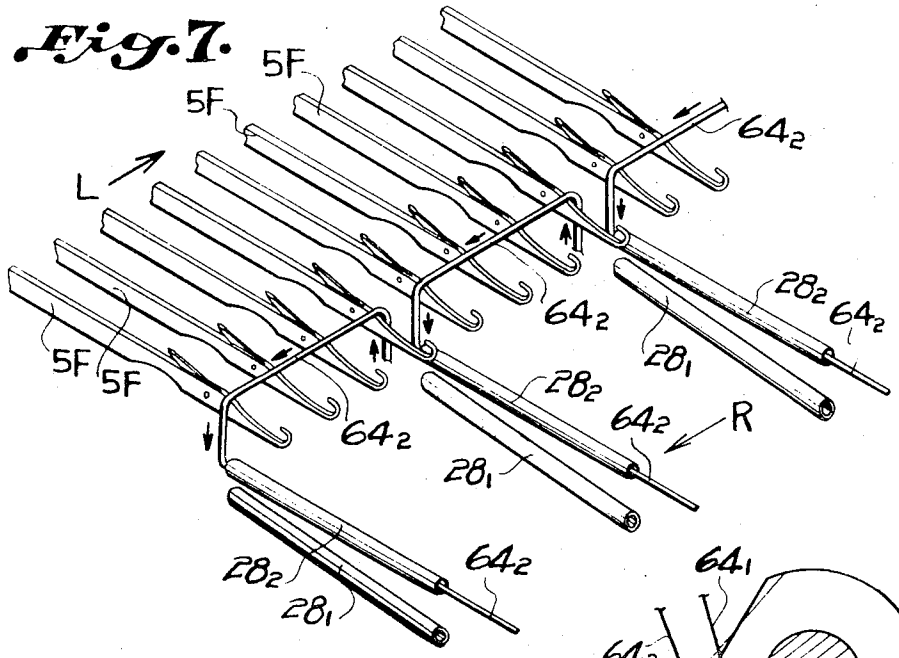
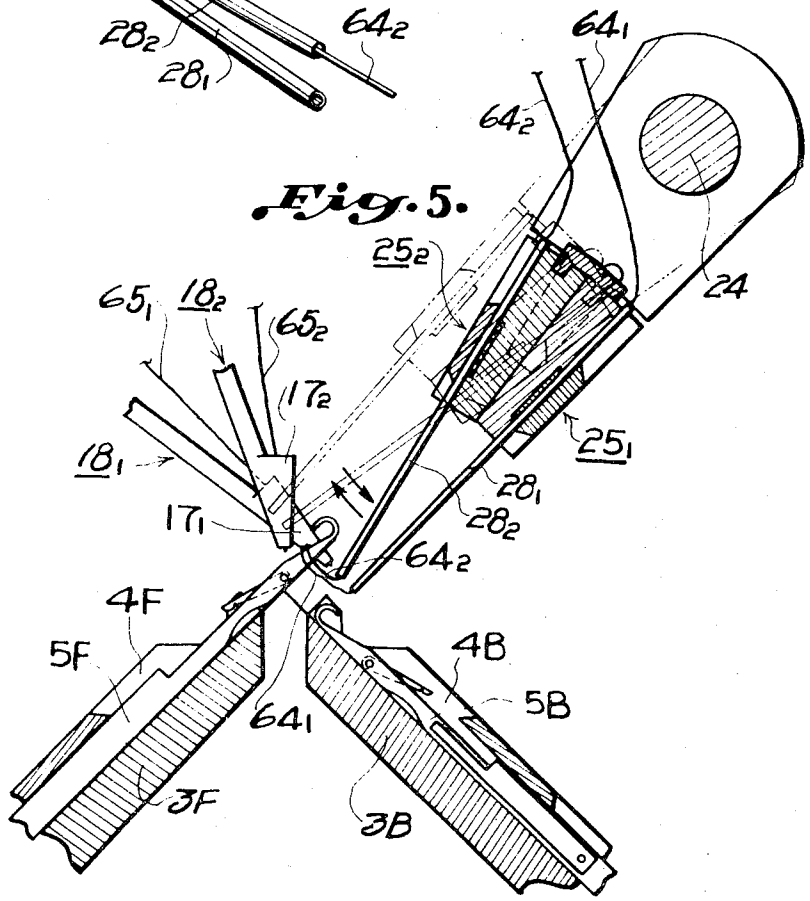

5F
5F
L
64_2
28_2 64_2
28_1
5F 5F
64_2
28_2
64_2
R
28_1
28_2
64_2
28_1

Fig. 5.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24
65_1
18_2
65_2
17_2
25_1
18_1
28_1
28_2
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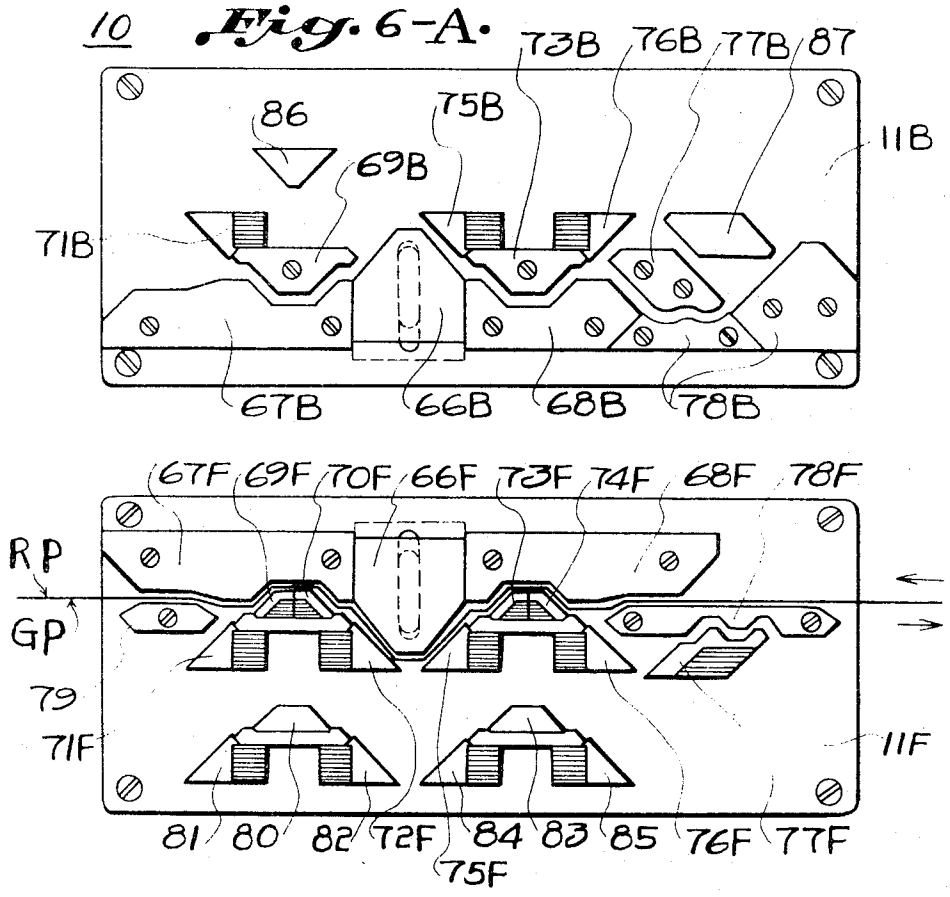
4F
5F
4B
5B
64_1
3F
3B

Fig. 6-A.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67B
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68B
78B
67F
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70F
66F
73F
74F
68F
78F
RP
GP
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71F
11F
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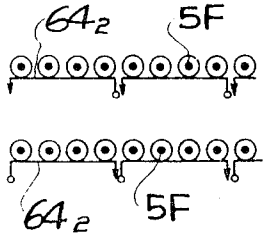
80
82
72F
84
83
85
76F
77F
75F

Fig. 6-B.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64₂
5F

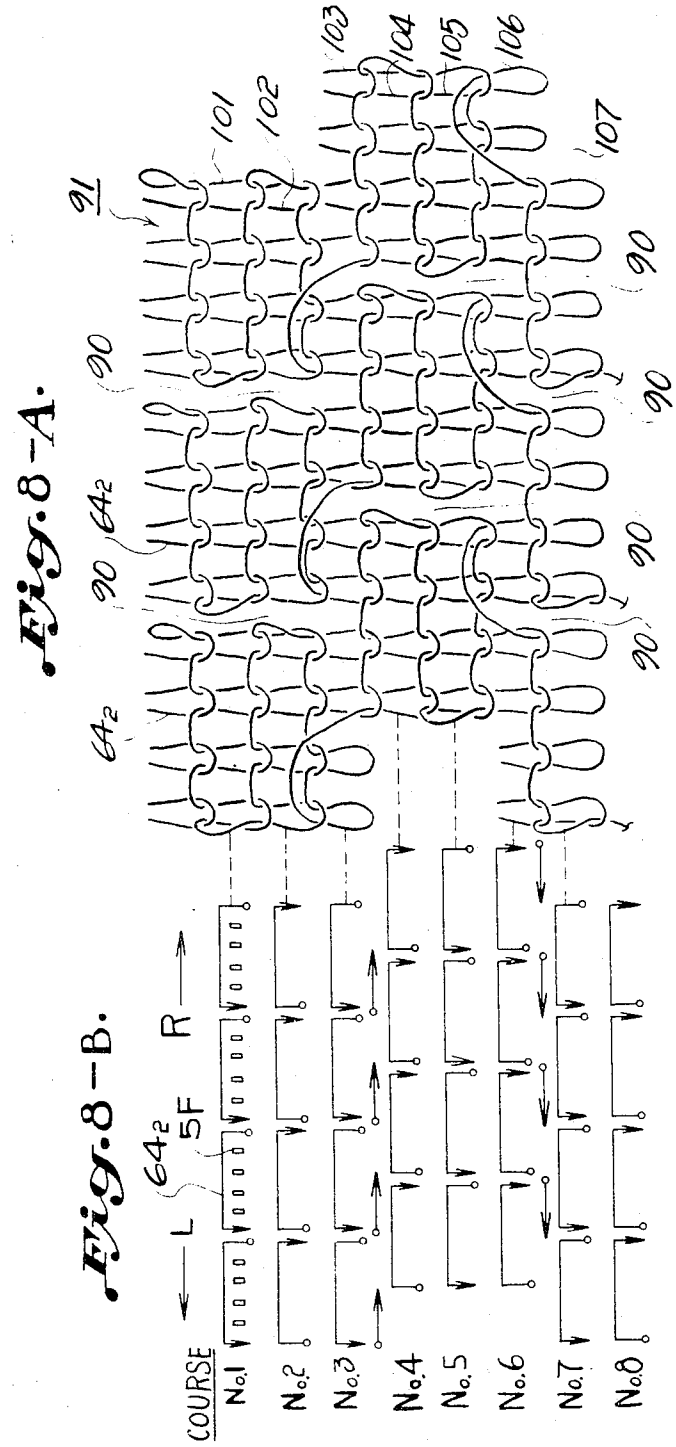


Fig. 8-A.
91
90
64₂
101
102
103
104
105
106
107
Fig. 8-B.
L
R
5F
64₂
COURSE
No.1
No.2
No.3
No.4
No.5
No.6
No.7
No.8

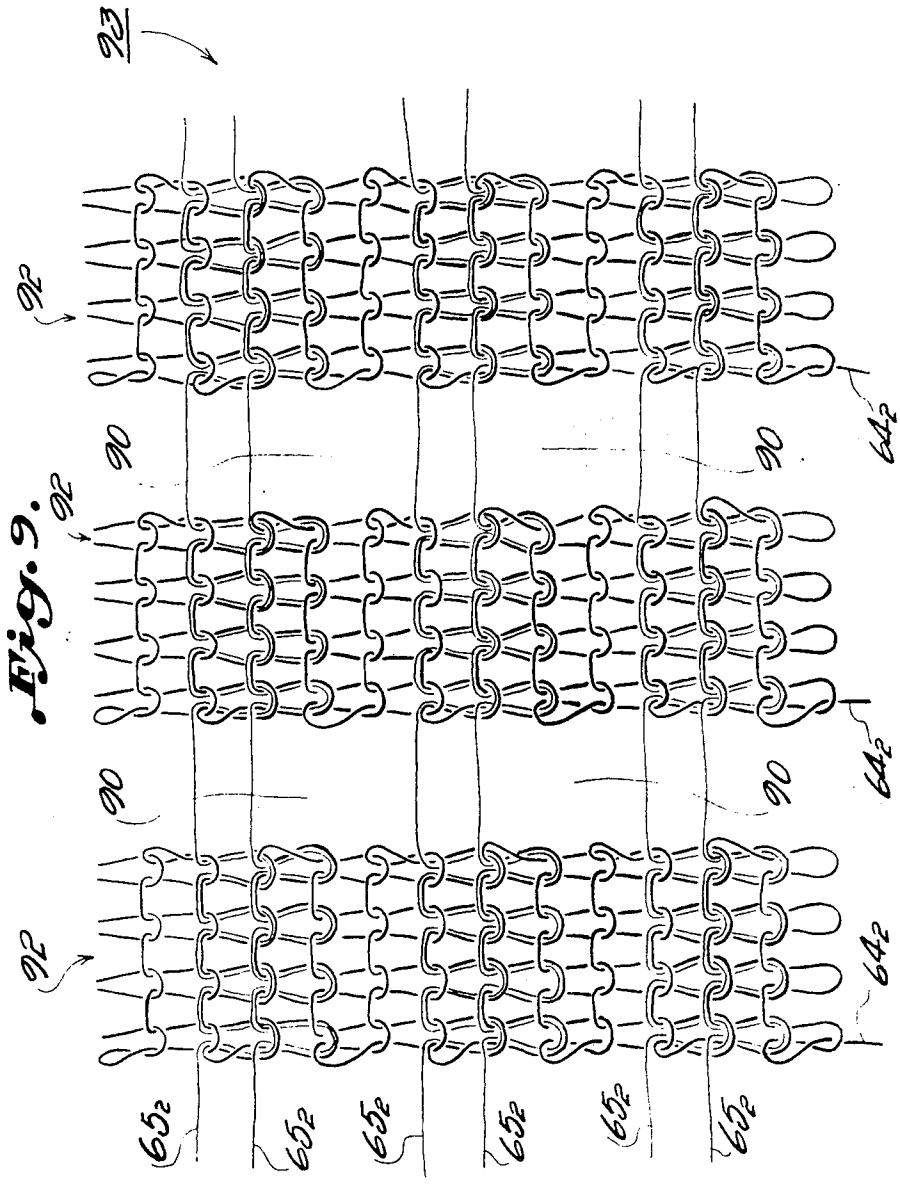


Fig. 9.

Fig. 10.

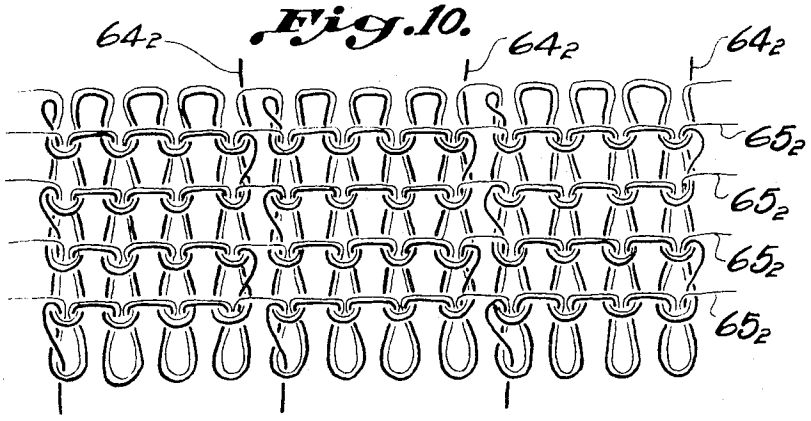


Fig. 11.

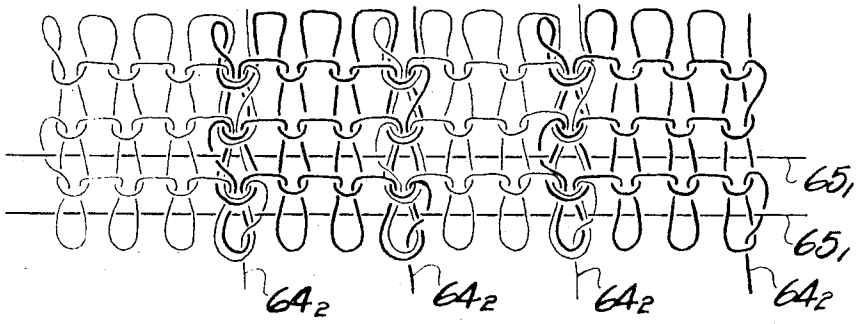


Fig. 12.

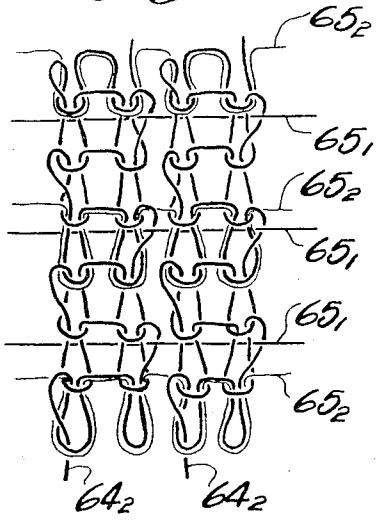


Fig. 13-A.

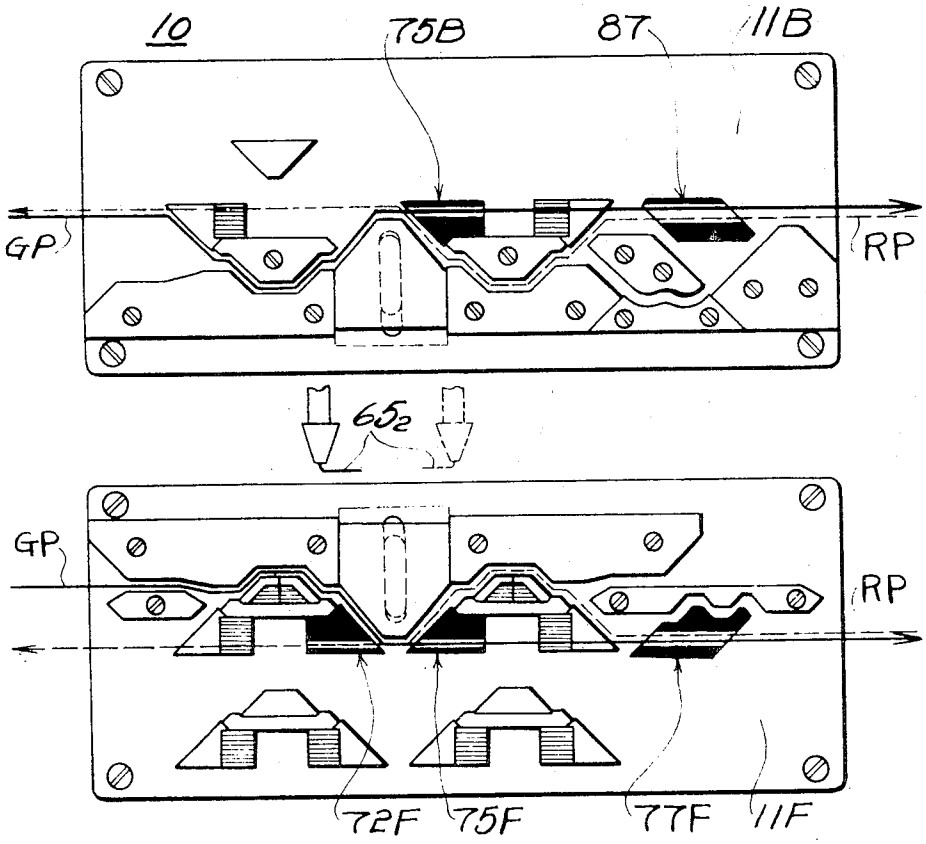


Fig. 13-B.

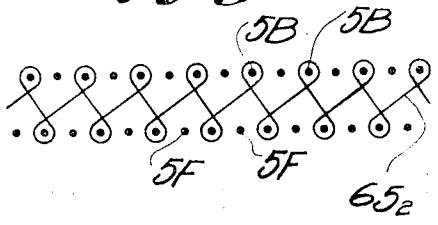


Fig. 14-A.

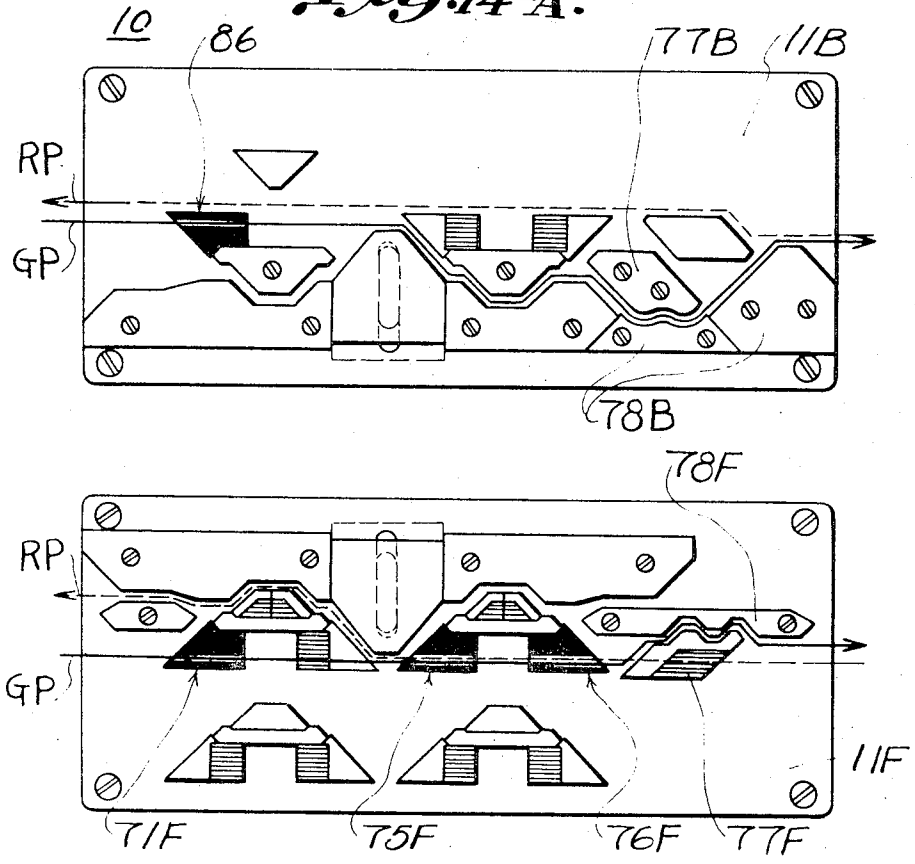


Fig. 14-B.

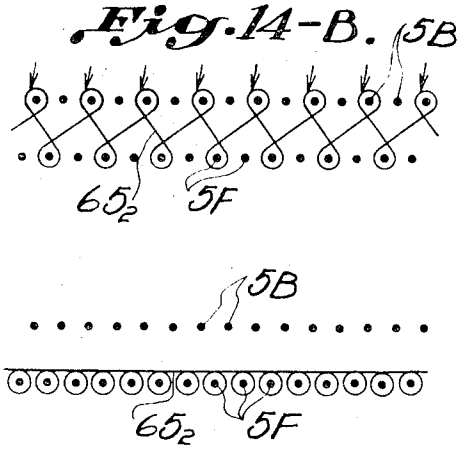


Fig. 15-A.

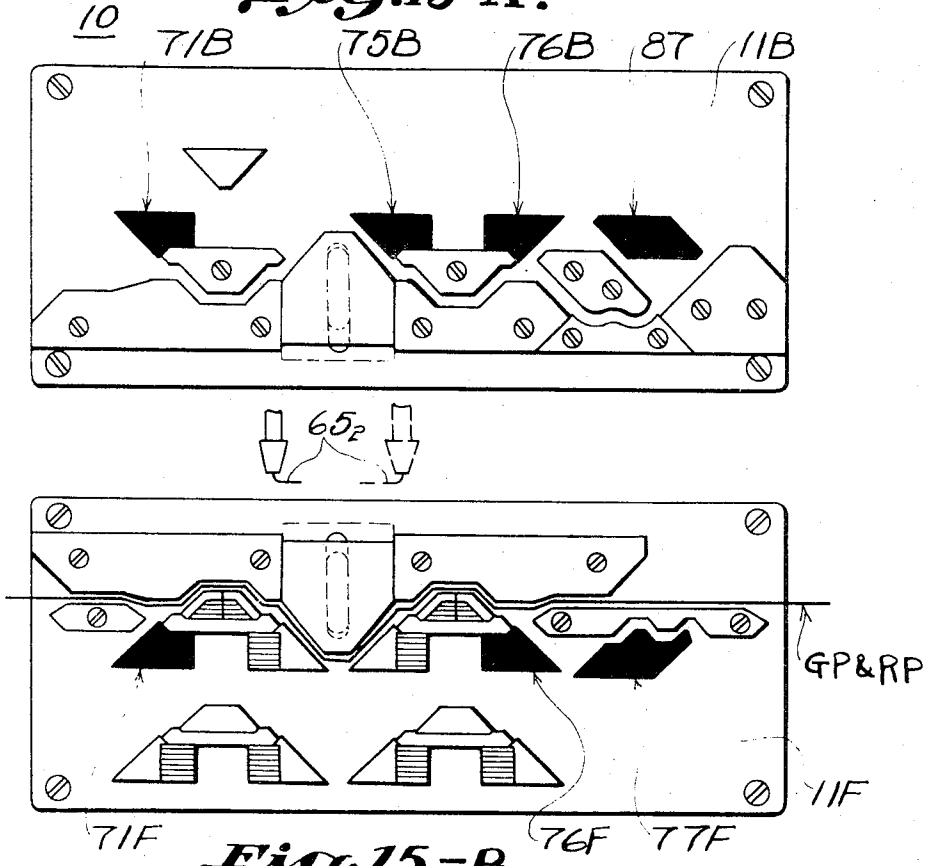
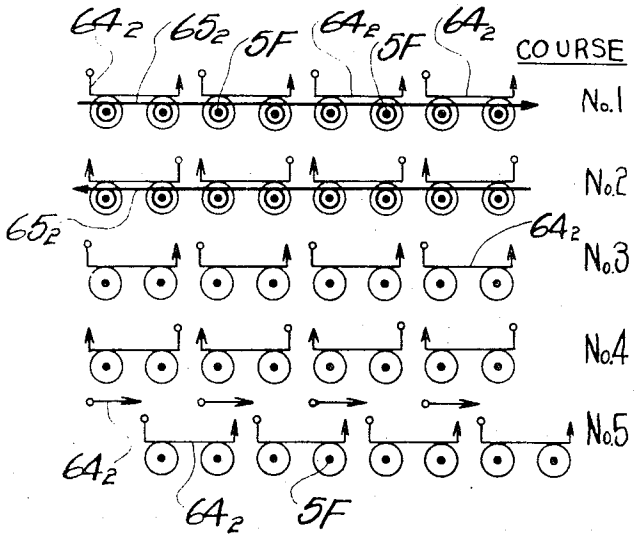


Fig. 15-B.



FLAT KNITTING MACHINE

This invention relates to a novel and improved flat knitting machine, and more particularly to a flat knitting machine by which there can be produced conventional flat or weft knitted fabrics, knitted fabrics similar to the ones obtained by warp knitting (hereinafter referred as fabrics having constructions similar to warp knitted fabrics) in which fabrics weft knitted constructions of several wales are arranged in the longitudinal direction of the fabrics in continuous manners, fabrics in which conventional weft knitted fabrics and fabrics having constructions similar to warp knitted fabrics are integrated and the like in such a manner that only one kind of knitted construction is arranged continuously or several kinds of knitted constructions are exchanged in selected courses or transverse direction of a fabric so as to arrange each of said constructions continuously or in a raw. The flat knitting machine according to the present invention may provide conventional flat or weft knitted constructions or fabrics obtained or provided by the conventional flat knitting machines such as plain stitch, plain tuber course, ribe stitch or rib knit, cardigan ribe or full cardigan, and royal rib or half cardigan owing to the provision of two needle beds, namely the front and back needle beds. The flat knitting machine according to the present invention may further provide RAHBEN stitch, milano rib and another stitches or knitted construction which can be obtained by employing a racking device for the needle beds. Furthermore, the present knitting machine may provide various kinds of fabrics having constructions similar to warp knitted fabrics by which the above mentioned weft knitted constructions are followed, exchanged or integrated.

Due to the fact that ribe stitch cannot be obtained by the conventional warp knitting machine, waist band, sleeve band or the like having been knitted previously by a flat knitting machine is connected to the warp knitted fabric produced by a warp knitting machine by means of a sewing machine or a linking machine, when such a waist band, sleeve band or the like is required to be connected to the warp knitted fabric. However, finished connection is unsightly when said connection is obtained by sewing with a sewing machine, and connecting work by a linking machine is very troublesome because stitches are looped to a raw of looping needles or points one by one.

One object of the present invention is to provide a novel flat knitting machine by which flat or weft knitted constructions including ribe stitch can be followed in a continuous manner by a fabric having construction similar to a warp knitted one without connecting the same by a sewing machine, linking machine or the like.

An another object of the present invention is to provide a novel flat knitting machine by which open works having various constructions similar to warp knitted ones can be produced with ease.

That is, though open works are produced by means of a conventional flat knitting machine by removing a part of stitches from the knitting needles and transferring the same to the adjacent knitting needles during the knitting operation whereby openings are formed at positions of said stitches, the flat knitting machine according to the present invention makes such stitch-transferring operation unnecessary and desired forms of openings are formed in weft knitted fabrics having constructions similar to warp knitted fabrics at desired

optional positions in such a simple manner that vertically movable yarn feeders peculiar to the present flat knitting machine are moved upwardly and downwardly and also in left and right direction relatively to the needle beds. The present knitting machine may, of course, produce the other various weft knitted fabrics similar to the ones obtained by a warp knitting machine.

A still another object of the present invention is to provide a novel flat knitting machine by which plating stitch is carried out by a process entirely different from the one by means of the conventional flat knitting machines whereby more various knitted constructions than those obtained by the conventional machines can be produced.

That is, in the conventional knitting machines, there are provided particular plating feeder which is moved in the transverse direction, namely left and right direction similarly to the usual yarn feeder and two yarns are fed separately to the knitting needles by said plating feeder whereby ground yarns are covered at the external side of the knitted farbic with plating yarns. In contrast with the above, by the present knitting machine, plating stitch constructions which are composed of constructions similar to the ones by a warp knitting machine and conventional weft knitted constructions can be obtained or produced, without using such a plating feeder, by using said vertically movable yarn feeders peculiar to the present knitting machine.

A further object of the present invention is to provide a novel flat knitting machine by which weft yarns can be stitched into the aforementioned constructions similar to the ones of warp knitted fabrics without forming stitches.

A still further object of the present invention is to provide a flat knitting machine in which needle beds are so constructed that the aforementioned knitting operations may be carried out in a very smooth manner.

The above objects are attained, according to the present invention by constructing a flat knitting machine in such that there are provided one or more than one vertically movable yarn feeders comprising desired numbers of feeding pipes which are arranged above the back or front needle bed with desired intervals therebetween and feeding beams which support or hold said feeding pipes and move the free ends of said pipes upwardly and downwardly toward or apartly from said front or back needle bed near the top opening between the beds, yarn-feeding device in the machine is composed of said vertically movable yarn feeders and one or more than one horizontally movable yarn feeders which are moved in left and right directions above said opening between the beds, said vertically movable yarn feeders are constructed that said feeders feed knitting yarns to the knitting needles of the front or back needle bed when the free ends of said feeding pipes of the vertically movable feeders are moved upwardly and downwardy and said vertically movable feeders are moved relatively to the front or back needle bed by desired optional pitches, and at least one of said horizontally movable yarn feeders is so constructed that said feeder feeds knitting yarns to the knitting needles of the front and back needle beds when said horizontally movable feeder is moved in left and right direction. Knitting operation with the knitting yarns fed by said vertically movable yarn feeders are carried out by the knitting cam of the carriage which is moved into the feeding direction of said vertically movable feeders after the

feeding by said feeders. For the purpose of smooth operations, the back needle bed is movable upwardly and downwardly along the sloped direction thereof.

Other and preferred features and attendant advantages of the present invention will become more readily apparent from the following description, given by way of example, in connection with the accompanying drawings in which;

FIG. 1 is a side elevational sectional view of one embodiment of the flat knitting machine according to the present invention;

FIG. 2 is an enveloped top view, partially cut away, of the front and back needle beds and the vertically movable yarn feeders employed in the knitting machine shown in FIG. 1 and seen from the direction along line II—0—II of FIG. 1;

FIG. 3 is an enlarged top view, partially cut away, of the vertically movable yarn feeders employed in the knitting machine shown in FIG. 1;

FIG. 4 is a sectional view taken along line IV—IV of FIG. 3;

FIG. 5 is a side elevational view showing the positions of yarn-feeding to the knitting needles in the front needle bed by the vertically movable yarn feeders and horizontally movable yarn feeders;

FIG. 6A is a bottom view of the cam box of the carriage employed in the knitting machine shown in FIG. 1;

FIG. 6B is an example of knitting diagrams;

FIG. 7 is a perspective view showing the yarn-feeding state corresponding to the state shown in FIG. 6B by the vertically movable yarn feeders;

FIG. 8A is an example of the knitted constructions of open works;

FIG. 8B is an illustration of yarn-feeding direction by the vertically movable yarn feeders;

FIG. 9 is another example of the knitted constructions of open works;

FIG. 10 is an example of the knitted constructions of plating stitch;

FIG. 11 is an example of the knitted constructions into which weft yarns are stitched without forming loops;

FIG. 12 is another example of such knitted constructions having weft yarns stitched in without forming loops;

FIG. 13A is a bottom view of the cam box of the carriage showing the state where ribe stitch is carried out;

FIG. 13B is a knitting diagram of ribe stitch;

FIG. 14A is a bottom view of the cam box of the carriage showing the state where transferring operation is carried out;

FIG. 14B is a knitting diagram of transfer;

FIG. 15A is a bottom view of the cam box of the carriage showing the state where plating operation to a plain stitch construction is followed by knitting of open works;

FIG. 15B is a knitting diagram of the knitting operation shown in FIG. 15A.

Referring now to the drawings, in which like numerals designate like parts throughout the several views thereof, there is shown a preferred embodiment of the flat knitting machine according to the present invention in FIGS. 1 through 6. Similarly to the well-known flat knitting machine, the upper portion of the machine frame 1 is formed into roof-like supporting members 2F and 2B for needle beds. On the front members 2F is supported or mounted a front needle bed 3F which can be slid or moved into left and right directions R and L along the member 2F, and on the back member 2B is supported or mounted a back needle bed 3B which can be displaced slightly into upward and downward directions U and D on the back member 2B so as to control the position of the back bed 3B in said directions. Therefore, the front and back needle beds 3F and 3B are placed in the form of a roof, as is the case in a usual flat knitting machine.

There are provided at the upper faces of said needle beds 3F and 3B a number of tricks or slotts 4F and 4B with equal intervals therebetween along the lengthwise direction of the beds 3F and 3B. By the tricks 4F of the front needle beds 3F are received in a suitable arrangement knitting needles 5F and jacks (not shown in the drawings) each of which needles and jacks has a high or low butt, and by the tricks 4B of the back needle bed 3B are received in a suitable arrangement knitting needles 5B having feathers or beards for loop transferring each of which needles has a high butt.

To the right end of the front needle bed 3F is connected by means of a connecting rod 7 a racking device 6 which racks the front needle bed 3F into right or left directions R and L at required points of time by required pitches (the interval between two adjacent tricks is termed as a pitch in this specification). That is, the racking device 6 comprises a helical cam 8 which can be adjustably rotated into required directions by required degrees by means of suitable driving means (not shown in the drawings) and a pair of rollers 9 which are rotatably supported with the connecting rod 7 and are engaged with said helical cam 8 at both faces thereof, so that the front needle bed 3F is racked every time when the helical cam 8 is rotated by required degrees in response to a signal.

The carriage 10 of this flat knitting machine comprises a front and back cam boxes 11F and 11B, as is the case in a usual flat knitting machine. However, being different from a usual flat machine, said cam boxes 11F and 11B are not connected to each other by means of a bridge member extending above a top opening 12 between the front and back needle beds, but the boxes 11F and 11B are connected with a connecting member 14 which is connected at both ends thereof to connecting rods 13F and 13B projected from the boxes 11F and 11B at the left ends, as shown in FIG. 2, so that the front and back cam boxes 11F and 11B are moved or travelled into a direction at the same time.

The connecting member 14 is slidably mounted on guiding rails (not shown in the drawings), and the front and back cam boxes 11F and 11B are slidably mounted respectively on guiding rails 15F, 16F and 15B, 16B which are bridged in the machine frame 1 along the lengthwise direction of the needle beds 3F and 3B, so that the boxes 11F and 11B are forwarded and returned in said lengthwise directions R and L along the rails 15F, 16F and 15B, 16B by driving means (not shown) which are operatively provided to the connecting member 14.

There are provided desired numbers of exchangeable horizontally movable yarn feeders 18_1, 18_2 and so on which can be moved into left and right directions and the yarn guides 17_1, 17_2 and so on of which are faced to the top opening 12 between the beds 3F and 3B. That is, there are provided above the opening 12 four exchangeable yarn feeders 18_1, 18_2, 18_3 and 18_4

comprising guide rods 19_1, 19_2, 19_3 and 19_4 having yarn guides 17_1, 17_2, 17_3 and 17_4, guide rails **20** and **21** which are bridged above the front needle bed **3F** and which slidably receives or supports the sliding portions at the base ends of the guide rods 19_1, 19_2, 19_3 and 19_4, and guide-taking device **22** which is provided to the front cam box **11F** for exchanging the guide rods 19_1, 19_2, 19_3 and 19_4 and taking or bringing said rods with the movement of the carriage **10** or the cam box **11F**.

Further, in the knitting machine of the present embodiment, there are particularly provided two vertically movable yarn feeders 25_1 and 25_2. The first vertically movable yarn feeder 25_1 is secured directly to a shaft **24** which is supported, above the back needle bed **3B**, rotably and slidably into the left and right directions R and L by bearing members **23** upwardly projected from the machine frame **1**. The second vertically movable yarn feeder 25_2 is supported in only slidable manner into the left and right directions R and L by said shaft **24**. Said first and second vertically movable yarn feeders 25_1 and 25_2 are positioned in an integrated manner in the vertical direction, as clearly shown in FIG. **4**.

The followings are the detailed explanations on the first vertically movable yarn feeder 25_1 which is positioned in a lower position. The lower or first feeder 25_1 comprises feeding beam 21_1 which is bridged in a parallel manner to the lengthwise direction of the needle beds between the free ends of a pair of arms **26** fixedly secured to the shaft **24** at the base ends, and a number of feeding pipes 28_1 which are attached to said feeding beam 27_1 with optional or desired intervals therebetween in such a manner that the position of each pipe 28_1 can be changed or controlled manually by forwarding or retreating the same. Each of the feeding pipes 28_1 is received by an optional one groove selected among the grooves 29_1 which are provided with equal intervals therebetween to the lower face of the feeding beam 27_1 along the pipe, is passed through a dovetail groove 30_1 which is provided to the lower face of the feeding beam 27_1 along the lengthwise direction thereof, and is locked by a locking member 31_1 which is inserted into the dovetail groove 30_1. At the faced position to the dovetail groove 30_1 beyond the feeding pipes 28_1, the feeding beam 27_1 is provided along the lengthwise direction thereof with a groove 32_1 into which a plate member 33_1 of a resilient plastic material such as rubber or synthetic resin is inserted, whereby each feeding pipe 28_1 is locked or held in the groove 29_1 owing to the resiliency of said plate member 33_1 in a desired or required position with giving an optional or desired projection α_1 from the feeding beam 27_1. The projection α_1 of each feeding pipe 28_1 can be changed or controlled only by pushing the front or base ends thereof.

Next, the second vertically movable yarn feeder 25_2 comprises a feeding beam 27_2 which is bridged between the free ends of a pair of arms **34** slidably supported by said shaft **24** and which is integrated on said feeding beam 27_1 in a parallel manner, and a number of feeding pipes 28_2 which are attached to the feeding beam 27_2 with optional or desired intervals therebetween in such a manner that the position of each pipe 28_2 can be changed or controlled by forwarding or retreating the same so as to change the projection α_2 from the beam 27_2, as is the case of the aforestated feeding pipes 28_2. That is, each of the feeding pipes 28_2 is received by an optional one groove selected among the grooves 29_2 which are provided with equal intervals therebetween to the lower face of the feeding beam 27_2 along the pipe, is passed through a dovetail groove 30_2 which is provided to the lower face of the feeding beam 27_2 along the lengthwise direction thereof, and is locked by a locking member 31_2 which is inserted into the dovetail groove 30_2. At the faced position to the dovetail groove 30_2 beyond the feeding pipes 28_2, the feeding beam 27_2 is provided along the lengthwise direction thereof with a groove 32_2 into which a plate member 33_2 of a resilient plastic material such as rubber or synthetic resin is inserted, whereby each feeding pipe 28_2 is locked or held in the groove 29_2 owing to the resiliency of said plate member 33_2 in a desired or required position with giving an optional or desired projection α_2 from the feeding beam 27_2. The projection α_2 of each feeding pipe 28_2 can be changed or controlled only by pushing the front or base ends thereof.

The first and second vertically movable devices 25_1 and 25_2 are moved at the same time. That is, a pair of key members **35** fixedly secured to the lower feeding beam 27_1 are slidably received at the projected portions thereof by a guiding groove **36** which is provided to the upper or second feeding beam 27_2, whereby the first and second yarn feeders 25_1 and 25_2 are connected by said key members **35** and the guiding groove **36** in such a manner that they can be displaced relatively by sliding only into the left and right directions R and L.

To the first and second vertically movable yarn feeders 25_1 and 25_2 is provided a mechanism which swings the feeders 25_1 and 25_2 round the shaft **24** as the fulcrum so as to move the free ends of the feeding pipes 28_1 and 28_2 upwardly and downwardly through the clearances between the knitting needles **5F** having been raised to the clearing positions thereof.

That is, an arm **37** is fixedly mounted at one end thereof on the shaft **24** to which the first vertically movable yarn feeder 25_1 is fixedly secured, and to the other end of said arm **37** is connected to the upper end of a rod **39** through a universal ball **38** (ball-and-socket joint). The lower end of the rod **39** is connected through a universal ball **40** to the free end of a lever **42** which is swung round the fulcrum **41** thereof by the following means. There is provided a cam **44** which is operatively connected through a clutch (not shown in the drawings) to a rotating shaft **43** driven by a power source (not shown in the drawings) and also a roller **46** which is rotably provided to the lever **42** and is always engaged to the periphery of said cam **44** by the force of a spring **45**, whereby the lever **42** is swung every time when the cam is rotated. The swinging of the lever **42** rotates the shaft **24** securing the first yarn feeder 25_1 by required degrees into one or the other direction through the rod **39** and the arm **37**, whereby the free ends of the feeding pipes 28_1 are moved upwardly or downwardly near the top opening **12** of the needle beds.

Owing to the fact that the feeding beam 27_2 of the second vertically movable yarn feeder 25_2 is always positioned on the upper face of the feeding beam 27_1 of the first yarn feeder 25_1, which is provided with above detailed mechanism for moving the feeding pipes 28_1 upwardly and downwardly, in such a manner that the feeding beam 27_2 can be moved relatively only into left and right directions R and L by a desired distance with keeping an intimate contact with the upper face of the

feeding beam 27_1 of the first yarn feeder 25_1, the free ends of the feeding pipes 28_2 of the second vertically movable yarn feeder 25_2 are also moved upwardly and downwardly near the opening **12** together with the upward and downward movement of the feeding pipes 28_1 of the first vertically movable yarn feeder 25_1.

The moving ranges and positions of the free ends of said feeding pipes 28_1 and 28_2 will be detailed after.

In the flat knitting machine shown in FIGS. **1** to **6**, the first and second vertically movable yarn feeders 25_1 and 25_2 are provided with a racking device **47** which moves or displaces said feeders 25_1 and 25_2 into the right and left directions R and L by each desired or required distance. That is, the shaft **24** securing the first vertically movable yarn feeder 25_1 is connected at the right end thereof through a connecting rod **49** to one end of a first lever 48_1 which is swung by said racking device **47**, and the arm **34** of the second vertically movable yarn feeder 25_2 is connected through a connecting rod **50** to one end of a second lever 48_2 which is swung by said racking device **47** independently of the first lever 48_1, so that the first and second vertically movable yarn feeders 25_1 and 25_2 may be moved or displaced independently of each other into the right and left directions R and L by each desired or required distance and the free ends of the feeding pipes 28_1 and 28_2 may be moved downwardly and upwardly near the opening **12** at the same time. The racking device **47** may be constructed in any well-known manner. In addition, the first and second levers 48_1 and 48_2 are pivoted at 51_1 and 51_2 respectively so that said levers 48_1 and 48_2 may be operated by left and right driving members 52_1 and 52_2 of the racking device **47**.

The back needle bed **3B** can be moved or displaced downwardly and upwardly along the sloped or inclined direction D and U of the same by a certain distance. The moving or displacing mechanism is detailed with reference to FIG. **1** in the followings. The lower end of said back needle bed **3B** is connected, at both sides **56** and **57**, through a link **55** to one end of a crank **54** which is pivoted at **53** to the machine frame **1**, and the other end of said crank **54** is connected to one end of a lever **58**, which is pivoted at **41**, through a connecting rod **59** at **60** and **61**. The lever **58** embraces with forked portion **63** an eccentric cam **62** which is pivotally connected to the shaft **43**, whereby the back needle bed **3B** becomes placed through the swinging of the lever **58** at a normal raised position shown with real line in FIG. **1** or at a retired position shown with imagined line in FIG. **1** every time when the eccentric cam **62** is rotated by a half cycle.

The followings are the detailed explanation with reference to FIG. **5** on the relation of positions among the yarn feeders, the front and back needle beds, the needles received with the beds near the top opening **12** between the needle beds. When the first and second vertically movable yarn feeders 25_1 and 25_2 are swung or revolved by rotating the cam **44** by a cycle after the knitting needles **5F** received by the tricks **4F** of the front needle bed **3F** have been raised to the clearing position shown with real line in FIG. **5**, the free ends of the feeding pipes 28_1 and 28_2 are moved or travelled from the lowered resting or waiting position in such a manner that the pipes 28_1 and 28_2 are once raised to the position shown with imagined line in FIG. **5** and then are lowered again to the position shown with real line in FIG. **5** with passing through the clearances between each adjacent knitting needles **5F** received by the tricks **4F** of the front needle bed **3F**. Accordingly, when one of or both of the front needle bed **3F** and the first and second vertically movable yarn feeders 25_1 and 25_2 is or are moved or displaced into the right or left direction relatively to each other at the point of time when the feeding pipes 28_1 and 28_2 of the first and second yarn feeders 25_1 and 25_2 have been raised to said raised position shown with imagined line in FIG. **5**, one of or both of the first and second vertically movable yarn feeders 25_1 and 25_2 feeds or feed one of or both of knitting yarns 64_1 and 64_2 to the knitting needles **5F** arranged in a desired or required distance or pitches (see FIG. **7**).

Further, desired numbers of the horizontally movable yarn feeders of the present knitting machine may be constructed as such movable feeders that feed weft yarns which do not form loops. The yarn feeder 18_1 is constructed as such horizontally movable yarn feeder in the present machine and the free end of the yarn guide 17_1 of said yarn feeder 18_1 is particularly passed through the following path at the following point of time. That is, the yarn feeder 18_1 is constructed in such a fashion that the yarn guide 17_1 is passed below the raised clearing position of the knitting needles **5F** and above the lowered feeding pipes 28_2 at the point of time when the knitting needles **5F** have been lowered to the knitting position, whereby the yarn feeder 18_1 enables to stitch weft yarns or fillings 65_1 into the backside of knitted fabric without forming loops.

The other horizontally movable yarn feeders 18_2, 18_3 and 18_4 are so constructed, as exemplified in relation to one feeder 18_2 of them, that said feeder 18_2 is moved into the left and right directions in such a manner that the free end of the yarn guide 17_2 feeds a knitting yarn 65_2 to the knitting needles **5F** having been raised to the clearing position, as is the case in a usual flat knitting machine.

The following are the explanation on the construction of the cam boxes **11F** and **11B** for the carriage **10**. In the front cam box **11F**, a knitting cam **66F** is provided at the center and guide cams **67F** and **68F** are succeedingly provided at the left and right hands of the cam **66F**, as shown in FIG. **6A**. At the both sides of the knitting cam **66F**, there are provided equally formed cam devices, namely one cam device comprising a pair of needle center cams **69F** and **70F** and needle raising cams **71F** and **72F** and the other cam device comprising a pair of needle center cams **73F** and **74F** and needle raising cams **75F** and **76F**. There are provided a transfer cam **77F** and a transfer guide cam **78F** at the right of the latter cam device and a guide cam **79** at the left of the former cam device.

Further, in the front cam box **11F**, there is provided below said cam devices a further cam device comprising a pair of jack center cam **80**, jack raising cams **81** and **82** and jack center cam **83**, jack raising cams **84** and **85**, which cam device makes possible to knit further various constructions or patterns in cooperation with jacks (not shown in the drawings) received by the front needle bed **3F**.

In the back cam box **11B**, a knitting cam **66B** is provided at the center and guide cams **67B** and **68B** are succeedingly provided at the left and right hands of the knitting cam **66B**. The guide cam **68B** is succeedingly followed by raising and lowering guide cams **77B** and **78B** for transfer position. Further, there are provided

a cam device comprising a needle center cam **69B** and a needle raising cam **71B** at the left side of the knitting cam **66B** and another cam device comprising a needle center cam **73B** and a pair of needle raising cam at the right side of said knitting cam **66B**. Furthermore, a pushing-up cam **86** and a resting cam **87** are provided at the left and right sides of said cam devices.

Among these cams in the front and back cam boxes **11F** and **11B**, the needle center cams **69F**, **70F**, **73F** and **74F**, the needle raising cams **71F**, **72F**, **75F**, **76F**, **71B**, **75B** and **76B**, the jack center cams **80** and **83**, the jack raising cams **81**, **82**, **84** and **85**, the transfer cam **77F**, the pushing-up cam **86** and the resting cam **87** can be projected and sunk respectively by usual cam-regulating means such as a pattern drum and pushing rods (not shown in the drawings).

As the present flat knitting machine is constructed as detailed in the above, the following knitting operations are possibly made.

First, when the back needle bed **3B** is positioned at normal raised position as shown with real line in FIG. **1** and knitting yarns are fed only by the horizontally movable yarn feeders 18_2, 18_3 and 18_4 the yarn guides 17_2, 17_3 and 17_4 of which are passed above the opening **12** through yarn-feeding position or path same as the case in a usual flat knitting machine, there can be made not only plain stitch, plain tuber course, ribe stitch or rib knit, cardigan rib or full cardigan and royal rib or half cardigan but also RAHBEN stitch, milano rib pattern and further various knitted constructions which can be obtained by the provisions of the racking mechanism to the front needle bed **3F**, the knitting needles **5B** having feathers in the back needle bed **3B**, the jacks (not shown) in the front needle bed **3F**.

Second, flat knitted constructions or fabrics which are similar to warp knitted constructions or fabrics and have never been obtained according to the prior art can be obtained by operating the present flat knitting machine as follows:

That is, the following flat knitted constructions or fabrics are obtained when all of the knitting needles **5B** received by the back needle bed **3B** becomes lowered to the rest position, the back needle bed **3B** becomes lowered to the rest position by rotating the cam **62** by half a cycle, the guide-taking device **22** on the front cam box **11F** is not operated so as to rest the horizontally movable yarn feeders 18_1, 18_2, 18_3 and 18_4, and knitting yarns are fed only to the knitting needles **5F** in the front needle bed **3F** by one of or both of the first and second vertically movable yarn feeders 25_1 and 25_2.

EXAMPLE 1

In case when knitting yarns are fed mainly by the vertically movable yarn feeders:

When the knitting needles **5F** in the front needle bed **3F** are once raised to the yarn-fed position and each of the feeding pipes 28_2 attached to the feeding beam 27_2 of the second vertically movable yarn feeder 25_2 with suitable intervals therebetween are once raised from below said knitting needles **5F** in the front needle bed **3F** through the clearances between two adjacent knitting needles **5F**, and then said second vertically movable yarn feeder 25_2 is moved into the right direction R by the racking device **47** by desired distance (four pitches in this case) or the front needle bed **3F** is moved into the reverse direction (left direction L in this case) by the racking device **6** by said distance, namely four pitches, so as to displace the feeder 25_2 and the bed **3F** horizontally relatively to each other and further each of the feeding pipes 28_2 is again lowered through the clearance between two adjacent knitting needles **5F**, knitting yarns 64_2 are fed to each knitting needle **5F** by each feeding pipe 28_2 respectively, as shown in FIG. **7**.

Therefore, when the carriage **10** is moved or travelled into the yarn-feeding direction R so as to operate the knitting cam **66F** in the front cam box **11F** upon each knitting needle **5F** after the above mentioned yarn-feeding operation of the feeding pipes 28_2, each knitting yarn 64_2 fed by each feeding pipe 28_2 is formed into a stitch of several wales.

Therefore, when such stitch of several wales is formed with each knitting yarn 64_2 and the yarn-feeding length or distance in each course by each feeding pipe 28_2, namely for example the racking distance of the second vertically movable yarn feeder 25_2, is suitably selected in the above knitting operation, an intarsia stitch construction (not shown in the drawings) can be obtained by connecting stitches of several wales to one another in the transverse direction and an open work construction **91** shown in FIG. **8A** can be obtained by forming unconnected portions of said stitches of several wales at desired or required portions of optional courses so as to make said portions openings **90**.

The following are the more detailed explanation on the knitting of said open work construction **91**. As shown in FIG. **8B**, in the first course **101**, each feeding pipe 28_2 is moved or travelled into the left direction L by four pitches so as to feed yarn and then the carriage **10** is moved into the same direction L whereby said first course **101** is knitted. Then, in the second course **102**, each feeding pipe 28_2 is moved into the right direction R and then the carriage **10** is moved into the same direction R whereby said second course **102** is knitted. In the third course **103**, each feeding pipe 28_2 and the carriage **10** are operated in the same manner as in the knitting of the first course **101**. In transferring to the fourth course **104**, the second vertically movable yarn feeder 25_2 is moved first into the right direction R by two pitches and then knitting is made in the same manner as in the second course **102**. The fifth and sixth courses **105** and **106** are knitted in the same manner as in the third and fourth courses **103** and **104**, respectively. Further, in transferring to the seventh course **107**, the second vertically movable yarn feeder 25_2 is moved first into the left direction L by two pitches, that is the reverse operation in transferring to the fourth course **104**, and further knitting is made in the same manner as in the first to sixth courses.

In the knitting operation stated in the above, the going and returning path or trace of the butts of the knitting needles **5F** (said butts are not shown in the drawings) are shown in FIG. **6A** with same line GP and RP and the knitted construction or fabric is shown in FIG. **B**. Further details will follow.

By the above knitting operation, stitches of four wales are formed with respective knitting yarns fed by respective feeding pipes 28_2 and respective openings **90** are formed in every four wales in the knitted construction. Said openings **90** are displaced in the knitting or transverse direction in the first to third courses, in the fourth to sixth courses and in the seventh to ninth courses respectively owing to the changes in the posi-

tions where knitting yarns are fed. Further, the length of each opening **90** along the wale is determined by the knitting length with yarns fed by each feeding pipe 28_2 in the same position.

In the above knitting operation for obtaining the open work fabric **91**, the feeding pipes 28_2 are moved transversely in each course by same pitches so as to feed yarns to every several (in this case four) knitting needles **5F** in each course whereby openings **90** are formed in all courses and the yarn-feeding positions are changed in every several (in this case three) courses whereby the positions of the openings **90** in the transverse directions are changed in said every several courses. Such a knitting operation for obtaining open work fabric or construction may, however, be modified variously. For example, the yarn-feeding distance or width may be changed in every optional courses so that lacks of stitch, namely openings, are formed in every optional courses and stitches are connected in the other courses. Further, as shown in FIG. **9**, knitted constructions **92** of several wales are knitted with respective yarns 64_2 fed by respective feeding pipes 28_2 in such a manner that said knitted constructions **92** are not connected to one another in the transverse direction and one of the horizontally movable yarn feeders 18_2 is taken by the carriage **10** in every optional courses so as to knit into said constructions **92** yarns 65_2 fed by the yarn guide 17_2 of the feeder 18_2, whereby there can be obtained an open work construction or fabric **93** in which knitted constructions **92** are connected to one another by means of the knitting yarns 64_2.

By the above detailed knitting operations, open work constructions or fabrics of various kinds are obtained. However, when knitting operation is made so as not to form the openings **90**, an intarsia knitted construction or fabric may be obtained. In this case, when plural numbers of the vertically movable yarn feeders are operated and the racking length or distance of said each feeder is changed in every one course respectively, there can be obtained various knitted patterns such as lozenges which are arranged continuously or intermittently in the longitudinal direction. Further, when the free ends of the feeding pipes 28_1 and 28_2 in the plural vertically movable yarn feeders are changed in positions variously and different or various colors are given to the knitting yarns 64_1 and 64_2, there can be obtained more knitted fabrics which are similar to the one obtained by warp knitting.

In the above knitting operations, the butt of each knitting needle **5F** received by the front needle bed **3F** is operated by the front cam box **11F** during the movement of the carriage **10** in such a manner as shown in FIG. **6A**. That is, said butt is passed or guided along the same path or trace GP and RP during the going and returning movement into the directions L and R, and the knitting needles **5F** are once lowered to the knitting position, when the knitting cam **66F** acts upon said needles **5F**, and then are immediately raised to the clearing position, where knitting yarns are possibly fed again by the first and second vertically movable yarn feeders 25_1 and 25_2, by the needle raising cam **72F** and needle center cam **70F** or the needle raising cam **75F** and needle center cam **73F**.

As detailed hereinbefore, the flat knitting machine according to the present invention provides open work fabrics and patterned knitted fabrics, without troublesome operations such as loop transferring by such simple operations that knitting yarns are fed by the feeding pipes of one or plural vertically movable yarn feeders positioned above the back needle bed **3B** or backwardly apart from the upper space of the front needle bed **3F** and the yarn-feeding position and yarn-feeding distance by said feeeding pipes are changed. Owing to the fact that yarn-feeding direction to the plural knitting needles by each feeding pipe and operating direction of knitting cam by the carriage are identical, the knitting operations are made in a smooth manner without troubles such as the cutting-off or breakage of yarns.

EXAMPLE 2

In case when knitting yarns are fed by the vertically movable yarn feeders and normal or conventional horizontally movable yarn feeders.

As previously explained, the vertically movable yarn feeders operate upon the knitting needles **5F** in the front needle bed **3F** in the aforementioned manners whereby various knitted fabrics which are similar to warp knitted fabrics can be obtained. Further, as shown in FIG. **9**, the knitted constructions **92** which are knitted with the knitting yarns 64_2 without interconnecting to one another are connected in every optional courses with the knitting yarns fed by the normal horizontally movable yarn feeder 18_2 whereby open work construction or fabric having openings **90** can be obtained. As can be understood from the above examples, in the use of the flat knitting machine according to the present invention, knitting yarns can be fed by the vertically movable yarn feeders to optional positions, namely optional distance and courses, of a plain stitch construction which is knitted by the normal horizontally movable yarn feeders, whereby the latter knitting yarns are plated.

FIG. **10** shows an example of such plating. Knitting yarns 64_2 which are plated to a plain work knitted with knitting yarns 65_2 can be applied or fed variously so as to obtain optional or desired plating patterns by adjustably changing or controlling the projected positions of the free ends of feeding pipes 28_1, 28_2 and so on relatively to the knitting needles **5F** previously or in every one course.

EXAMPLE 3

In case when knitting yarns are fed by the vertically movable yarn feeders and the horizontally movable yarn feeders for stitching-in weft yarns.

As previously shown in Example 1, knitted fabrics similar to the ones by warp knitting or open work fabrics are obtained when knitting yarns are fed by the vertically movable yarn feeders. In case when knitting yarns are fed by said vertically movable yarn feeders, weft yarns can be stitched into a flat knitted construction similar to the one obtained by warp knitting without forming loops particularly by feeding weft yarns into optional courses by means of the yarn feeder 18_1 which is used only for the purpose of stitching-in of weft yarns and is constructed in such a fashion that the free end of the yarn guide 17_1 thereof can be passed below the knitting needles **5F** of clearing position and above the feeding pipes of the lowered vertically movable yarn feeders. In this knitting operation, respective stitches of several wales are formed with respective knitting yarns 64_2 fed by the vertically movable yarn feeders, concerned yarn feeder 18_1 are moved or trav-

elled transversely together with the carriage **10** in optional courses in the knitting with said yarns 64_2, and weft yarn 65_1 is fed by the yarn guide 17_1 of said yarn feeder 18_1 to the position before and below the knitting needles **5F** having been lowered to the knitting position by the carriage **10** (see FIG. **5**) whereby said weft yarn is then put, during the knitting process of next course, into respective one sinker loops formed with the knitting yarns, for example yarns 64_2 fed by each feeding pipe of the vertically movable yarn feeders, so that said weft yarn 65_1 is stitched into the flat knitted construction without forming loops (see FIG. **11**).

Such stitching-in operation without forming loops can be made independently, as is the case detailed in the above, and also in combination with the aforestated plating operation (see FIG. **12**). In said stitching-in operation of weft yarn 65_1 which never forms loops, the knitting yarns 64_2 having been fed by the vertically movable yarn feeders are knocked over and then said weft yarns are fed to a position below the knitting needles **5F** having been raised to the clearing position by the raising cams and center cams **72F**, **70F** or **75F**, **73F** and above the feeding pipes 28_2.

Therefore, in the case when weft yarns which never form loops are stitched in, elasticity in the transverse direction may be given to the flat knitted fabrics by selecting weft yarns having suitable property for said purpose, and openings in an open work knitted fabric may be backed with such weft yarns.

EXAMPLE 4

In the knitting operations detailed hereinbefore, various knitting processes are carried out with resting the knitting needles **5B** in the back needle bed **3B** by using the flat knitting machine according to the present invention, and, particularly in Example 3, knitting processes are carried out by having brought the back needle bed **3B** into the lowered rest position. However, the knitting operations or processes having been described hereinbefore may be carried out with no troubles without bringing or lowering the back needle bed **3B** into the rest position.

However, when the back needle bed **3B** is so constructed that it can be brought to the lowered position, smooth yarn-feeding operations may be facilitated without any trouble even if more vertically movable yarn feeders are provided and/or feeding pipes of said feeders are projected more largely.

EXAMPLE 5

The followings are the explanations on transferring operation in case where, after the knitting needles **5B** in the back needle bed **3B** have been brought to the operative or acting position thereof, weft or flat knitted constructions or fabrics are knitted by knitting required courses of normal flat knitted construction such as ribe stitch by the horizontally movable yarn feeders first and then by knitting, with resting the knitting needles **5B** in the back needle bed **3B**, the aforementioned types of various weft or flat knitted constructions, which follow said normal flat knitted construction, by using the knitting needles **5F** in the front needle bed **3F** and the vertically movable yarn feeders or by using the vertically movable yarn feeders and the horizontally movable yarn feeders.

When the front and back knitting needles **5F** and **5B** are positioned at operative positions thereof and an optional horizontally movable yarn feeder except for the particular yarn feeder 18_1 is taken by the carriage **10**, that is the butts (not shown) of the front and back knitting needles **5F** and **5B** are operated or moved by the front and back cam boxes **11F** and **11B** along the paths GP and RP shown in FIG. **13A** respectively, a ribe stitch shown in FIG. **13B** is knitted in desired numbers of courses by the front and back knitting needles **5F** and **5B**.

Then, following to the knitting of above ribe stitch, the yarn-feeding device is rested by one going and returning course or one cycle, and then the transfer cam **77F** is put into the operative or acting position thereof and the carriage **10** is moved or travelled by one cycle whereby the butts (not shown) of the front knitting needles **5F** and the back knitting needles **5B** having the feathers are operated or travelled respectively along the paths GP and RP shown in FIG. **14A** (in this case the front needle bed **3F** is racked by half a cycle if required). In this case, as shown in FIG. **14B**, the front knitting needles **5F** are acted or operated by the transfer cam **77F** and transfer guide cam **78F** upon the back knitting needles having feathers which needles have been brought into the transfer position by the transfer raising and lowering cams **77B** and **78B**, whereby loops having been hooked or caught by the back knitting needles **5B** having feathers can be transferred to the every other knitting needles **5F** which have been rested alternately.

When the above transfer operation or process has been completed, the ribe stitch construction having already been knitted is transferred only to the knitting needles **5F** in the front needle bed **3F**. Therefore, yarn-feeding and knitting operation can be carried out thereafter by using one of or both of an optional vertically movable yarn feeder and an optional horizontally movable yarn feeder, as detailed before in relation to Examples 1 to 4 (see FIGS. **15A** and **15B**).

EXAMPLE 6

In operating the flat knitting machine according to the present invention, a flat or weft knitted construction similar to a warp knitted construction or a plating stitch construction having already been knitted is followed or exchanged again by a normal flat or weft knitted construction such as ribe stitch, full or half caridgan or RAHBEN stitch by bringing, after stopping the knitting operation according to Example **5**, the knitting needles **5B** in the back needle bed **3B** into the operative position again in an optional course and by stopping yarn-feeding by means of the vertically movable yarn feeders.

In addition, the present machine makes such exchanges of knitted constructions possible in a continuous manner, so that the machine makes needless the linking operation and the like which have been referred to at the beginning.

EXAMPLE 7

Further, the normal flat or weft knitted constructions such as ribe stitch construction, which are obtained by bringing the knitting needles **5B** in the back needle bed **3B** into the operative position, and the weft knitted constructions similar to ones by warp knitting or plating stitch construction, which are obtained by resting the knitting needles **5B** in the back needle bed **3B** can not only be exchanged among one another or be fol-

lowed by one another in the longitudinal direction of the knitted fabric but also can be distributed in the transverse direction. For example, a portion of a fabric in the transverse direction may be knitted to form into ribe stitch and the other portion of said fabric in said transverse direction may be knitted to form into plating stitch by resting the corresponding knitting needles 5B.

As can be understood from the hereinbefore detailed, the flat knitting machine according to the present invention can provide not only normal conventional flat or weft knitted constructions or fabrics which can be obtained by the use of a conventional flat knitting machine, but the aforementioned types of and another various types of flat or weft knitted constructions or fabrics which can never be obtained by the use of a conventional flat knitting machine owing to the fact that the machine according to the present invention is provided with the aforedetailed vertically movable yarn feeders as well as the conventional horizontally movable yarn feeders.

The most characteristic feature of the flat knitting machine according to the present invention consists in the facts that said vertically movable yarn feeders feed knitting weft yarns to optional or desired transversely divided portions of optional length or distance in optional or desired courses whereby flat or weft knitting similar to warp knitting may be carried out in various manners with said weft yarns and that said vertically movable yarn feeders can feed yarns in left and right directions to which direction the carriage may be moved or travelled so as to make the feeding direction by the feeders and the travelling direction of the carriage identical whereby knitting and plating operations in the above stated each transversely devided portion may be made or carried out in a very smooth manner.

In addition, the numbers of the vertically movable yarn feeders in the knitting machine according to the present invention are never limited to those, namely two, of the machine of the embodiment shown in the drawings. Further, the yarn-feeding operation of the vertically movable yarn feeders, especially the transverse movement or travel of said feeders relative to the front needle bed may be carried out or accomplished not only by moving said feeders only, as is the case in the aforedetailed embodiment, but by racking the front needle bed or by moving said feeders and the front bed into reverse directions respectively.

Furthermore, in case when the vertically movable yarn feeders are provided above the front needle bed in contrast to the case of the aforedetailed embodiment, said feeders may be constructed in such a manner that they feed knitting yarns to the knitting needles received in the back needle bed.

Having now described the invention and having exemplified the manner in which it can be carried into practise, it is apparent to those skilled in the art that innumerable variations, applications, modifications, and extensions of the basic principles may be without departing from the spirit of the present invention. The invention is, therefore, to be limited only by the appended claims.

What is claimed is:

1. A flat knitting machine comprising V-type front and back needle beds, a plurality of knitting needles slidably received by the beds, a carriage having cams which are moved horizontally into left and right directions of the machine for advancing and retreating the needles, at least one horizontally movable yarn feeder, each yarn feeder having yarn guides positioned above the top opening between the beds and which may be moved into left and right directions of the machine together with said carriage, said feeders feeding weft yarns to the needles on one or both of the needle beds when the feeders are moved into left or right direction, at least one vertically movable yarn feeder having feeding pipes which are arranged above one of the needle beds with desired intervals therebetween, cam means for moving each of the vertically movable yarn feeders so as to move the free ends of said feeding pipes downwardly and upwardly toward or away from the associated needle bed near the top opening, racking means for moving each of the vertically movable yarn feeders into left and right directions relatively to the associated needle bed by two or more desired optional pitches so that each of the feeding pipes of said vertically movable yarn feeders feeds a weft yarn to two or more needles on the associated needle bed in one course when the feeding pipes are moved vertically by said cam means and horizontally by said racking means.

2. The flat knitting machine as claimed in claim 1 wherein the cams of the carriage include a knitting cam which is movable into the feeding direction of said vertically movable yarn feeders after the feeding by the vertically movable yarn feeders whereby knitting operations with the yarns fed by the vertically movable yarn feeders are carried out.

3. The flat knitting machine as claimed in claim 1 wherein the back needle bed is movable upwardly and downwardly along the sloped direction thereof.

4. The flat knitting machine as claimed in claim 1 including a further horizontally movable yarn feeder having a yarn guide, the free end of the yarn guide of said further feeder being positioned at a lower level than the yarn guide of the other horizontally movable yarn feeders so that said free end of the yarn guide of said further feeder may be passed through a position below the clearing position of the knitting needles on the front or back needle bed and above the lowered feeding pipes of said vertically movable yarn feeders at the point of time when said knitting needles have been lowered to the knitting position during the motion of the carriage.

5. The knitting machine as claimed in claim 1 wherein the vertically movable yarn feeder includes an elongated feeder beam having a face provided with a plurality of transverse grooves therein, a longitudinally extending dovetail groove, and a second longitudinally extending groove basing the dovetail groove, the feeding pipes of said vertically movable yarn feeder being received by desired optional grooves selected from the transverse grooves of said feeder beam with equal intervals therebetween along the front and back direction, a plate member of resilient material inserted into the second longitudinal groove and a locking member inserted into the dovetail groove for pressing the feeding pipes against the plate member whereby said feeding pipes may be displaced while remaining supported within the transverse grooves to change or control the projection of the feeding pipes from the feeding beam.

6. The flat knitting machine as claimed in claim 1 wherein there are provided a plurality of vertically movable yarn feeders and each of said vertically movable feeders is connected to a racking device in such a manner that each of said vertically movable feeders is racked independently by desired pitches.

7. The flat knitting machine as claimed in claim 1 wherein the needle bed below the vertically movable yarn feeder is provided with tracks receiving knitting needles having beards whereby construction or fabric knitted by the front and back knitting needles may be transferred to the knitting needles of the other needle bed.

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