United States Patent [19]

Krylov et al.

[11] **3,859,824**

[45] **Jan. 14, 1975**

[54] **CIRCULAR KNITTING MACHINE FOR MAKING WEFT KNITTED FABRICS INCLUDING WARP YARNS AND WEFT YARNS INTERCONNECTED BY GROUND LOOPS**

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[22] Filed: **Apr. 2, 1973**

[21] Appl. No.: **346,910**

[52] **U.S. Cl.** **66/10,** 66/107, 66/136

[51] **Int. Cl.** **D04b 9/16,** D04b 9/18, D04b 15/06

[58] **Field of Search** ..... 66/10, 107, 136, 9 R

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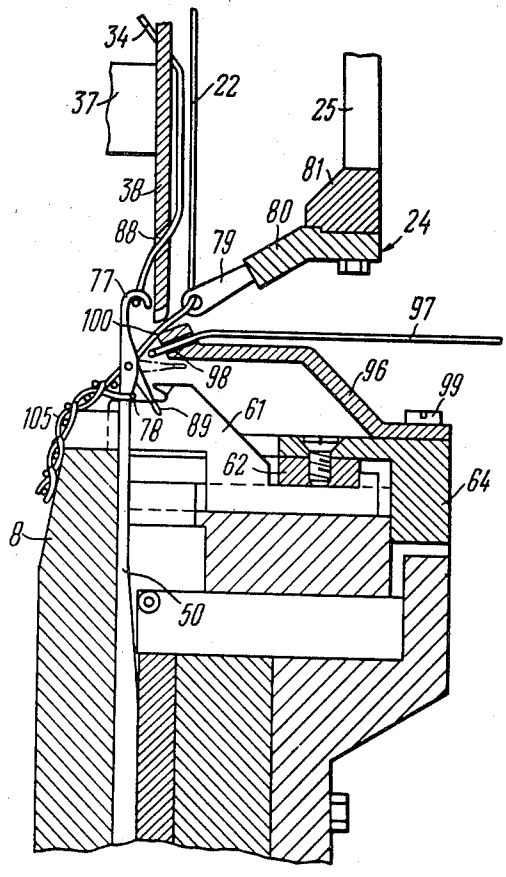
Primary Examiner—Wm. Carter Reynolds

Attorney, Agent, or Firm—Holman & Stern

[57] **ABSTRACT**

The circular knitting machine is intended for knitting weft fabrics including warp and weft yarns interconnected by loops of ground yarn. The machine includes sinkers alternating with needles and having each a hook presenting a V-shaped mouth, the hook and the body of a sinker defining therebetween a throat. The V-shaped mouth accommodates therein a warp yarn, as the sinker moves toward the axis of the machine, while the above mentioned throat accommodates therein a weft yarn, as the latter is being guided behind the backs of the needles, when the needles are being lowered; when the needles are being raised, the throat retains the weft yarns and the ground loop links. The ground, weft and warp yarn guides are so arranged that the yarns are positively retained by the needles, as well as by the V-shaped mouth and the throat of each sinker. The herein disclosed machine may further accommodate plating yarn guides, in which way plated knitted fabrics may be produced, including weft yarns and warp yarns interconnected by loops of plating and ground yarns, the warp yarns being encircled at one side by the ground yarns and at the opposite side by the plating yarns.

3 Claims, 26 Drawing Figures



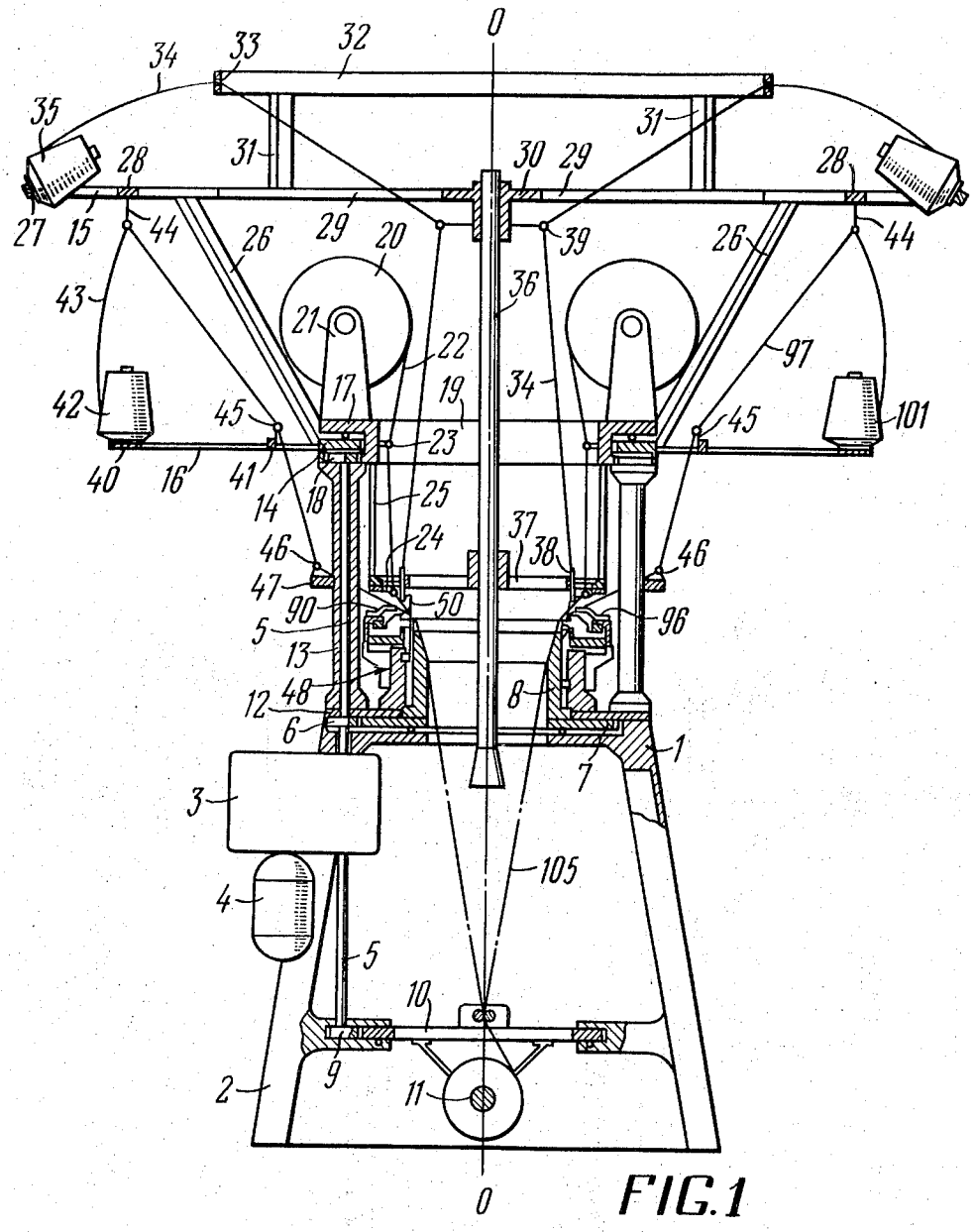

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FIG.1

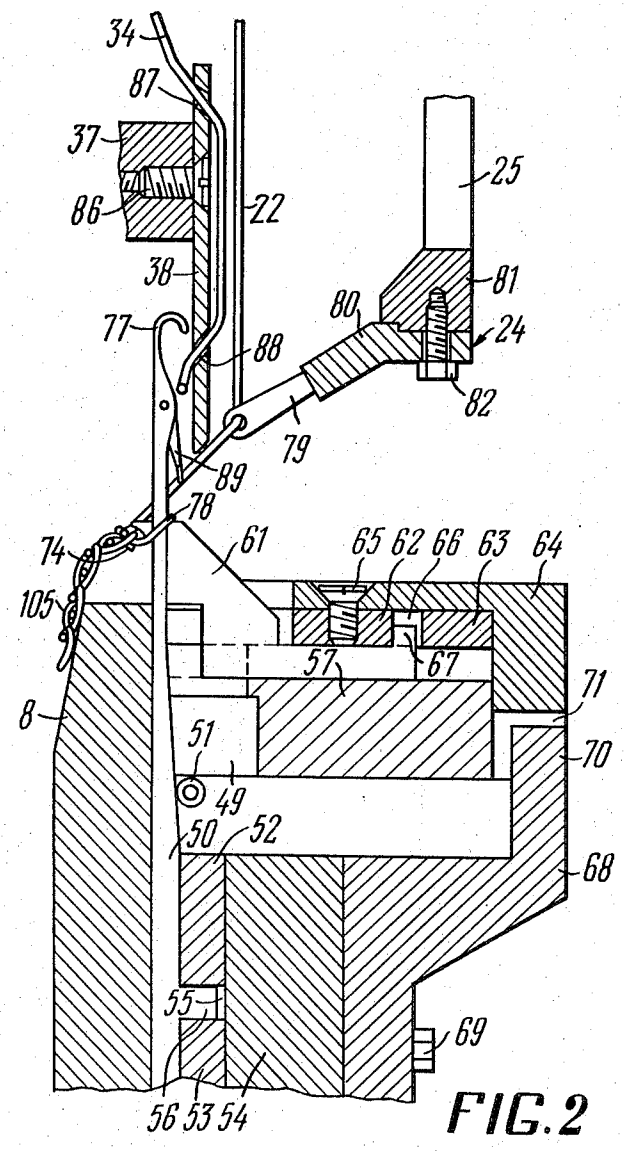
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FIG. 2

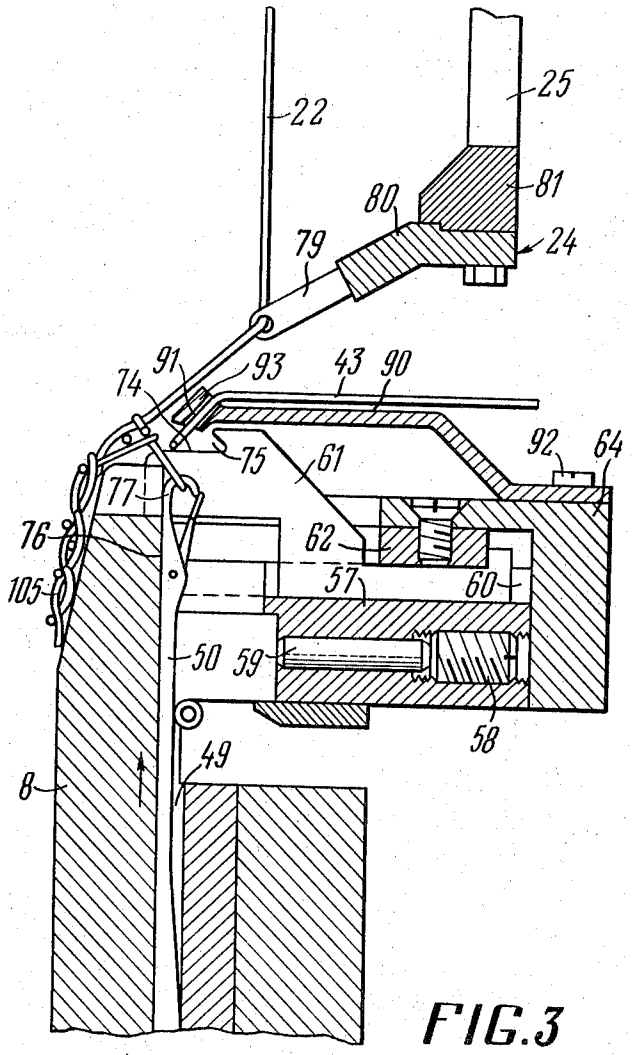
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FIG.3

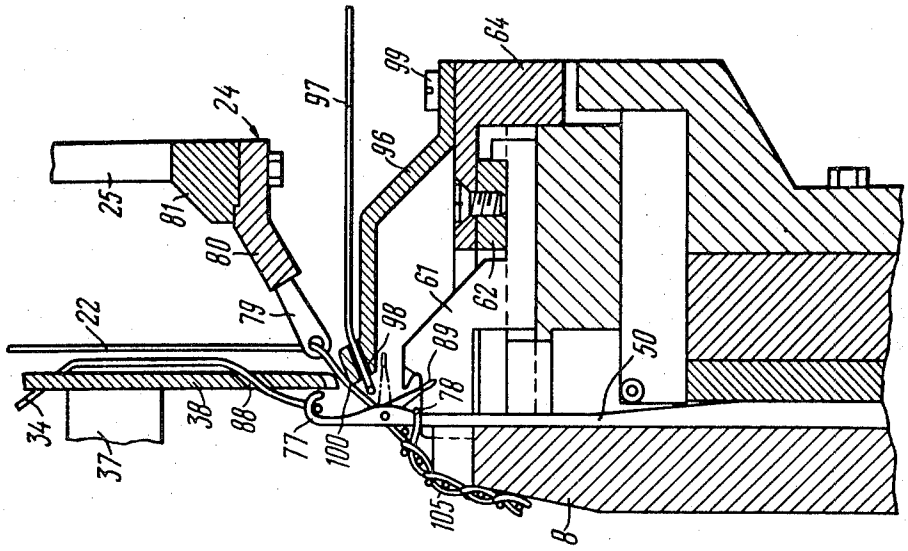

FIG. 7

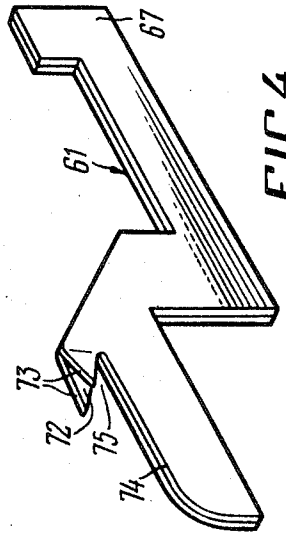

FIG. 4

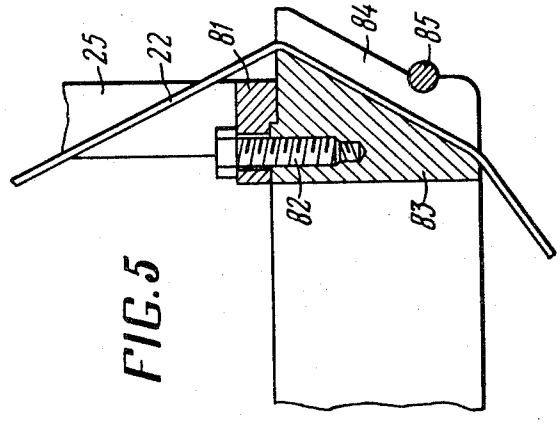

FIG. 5

FIG. 6

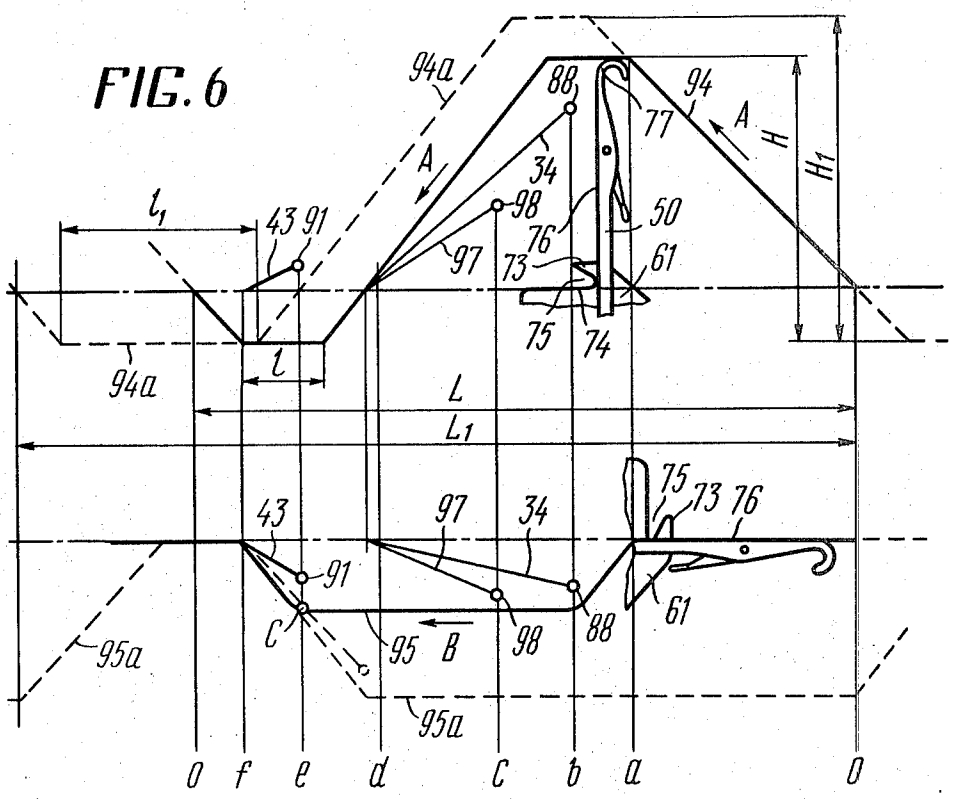
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FIG. 9a

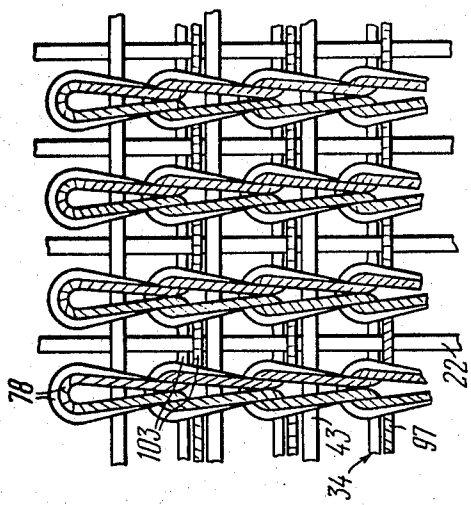


FIG. 9b

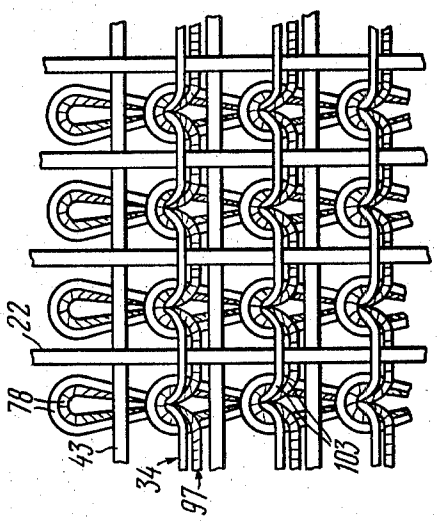


FIG. 8a

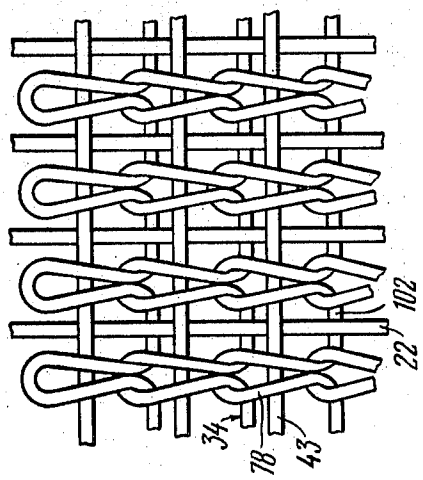
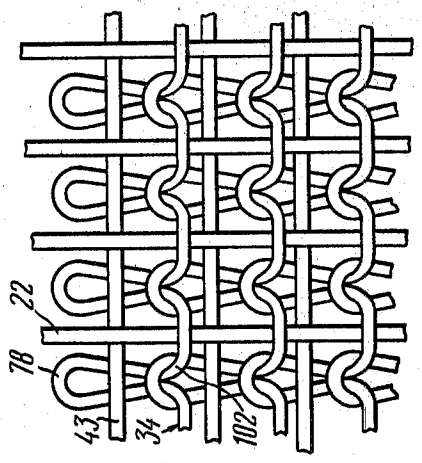


FIG. 8b



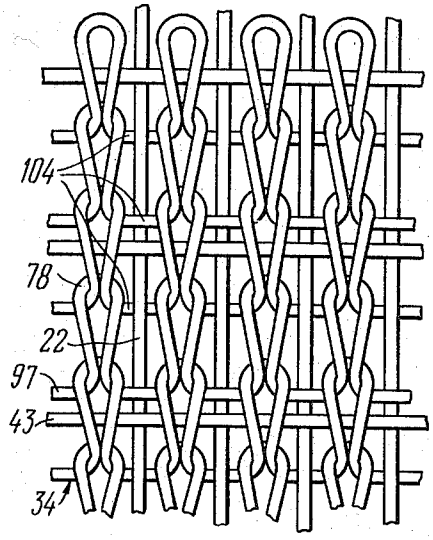


FIG. 10a

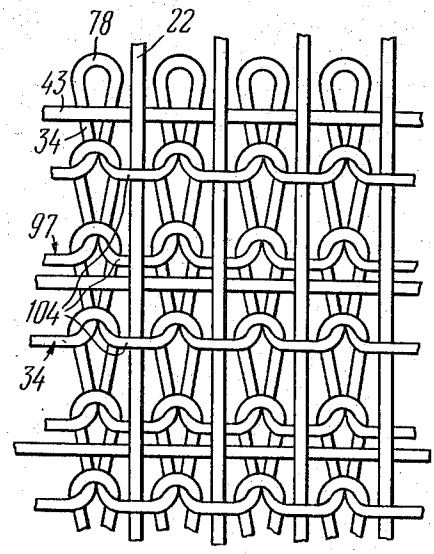


FIG. 10b

FIG. 11o

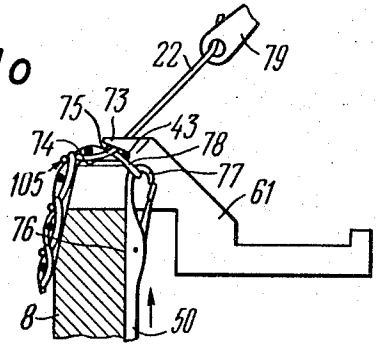


FIG. 11a

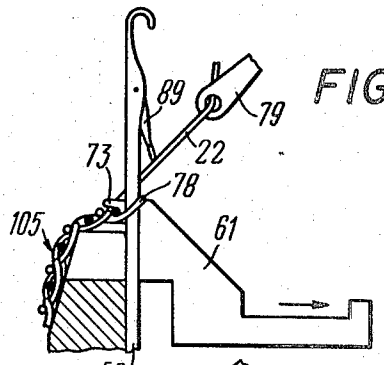


FIG. 11b

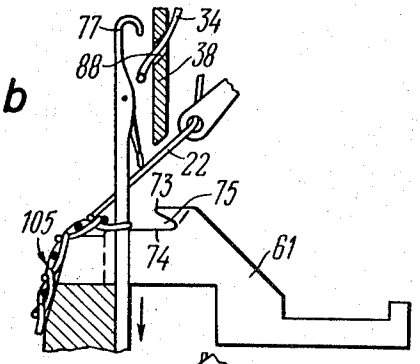


FIG. 11c

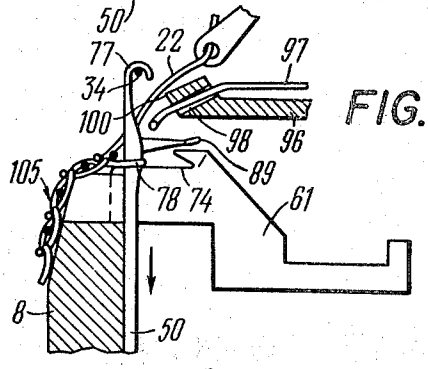


FIG. 11d

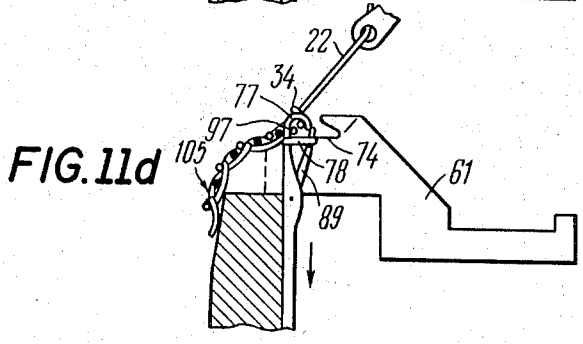
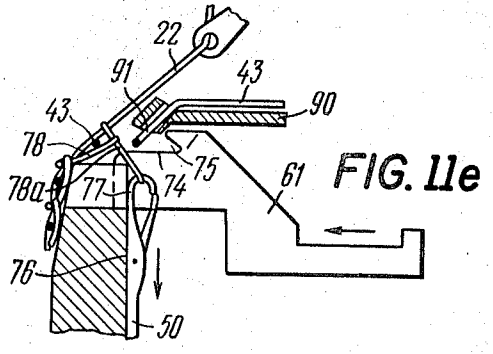


FIG. 11e



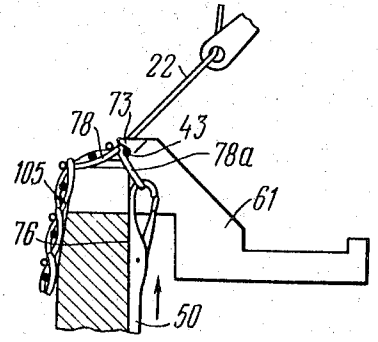


FIG. 11f

FIG. 12a

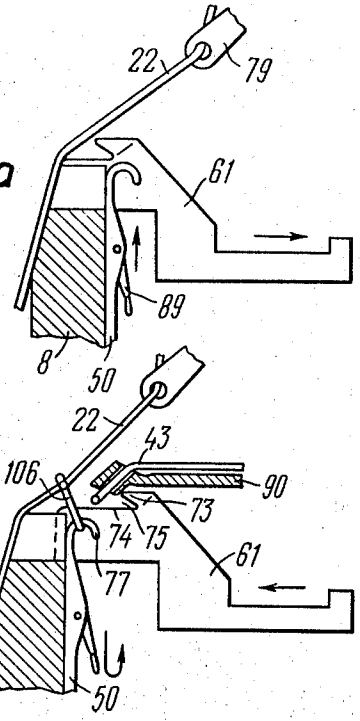


FIG. 12b

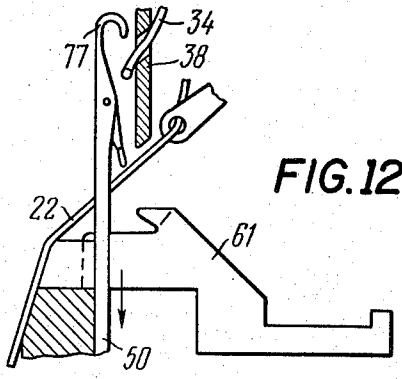
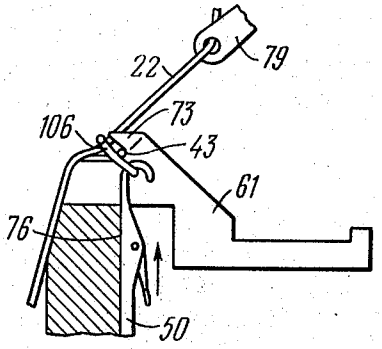


FIG. 12c

FIG. 12d



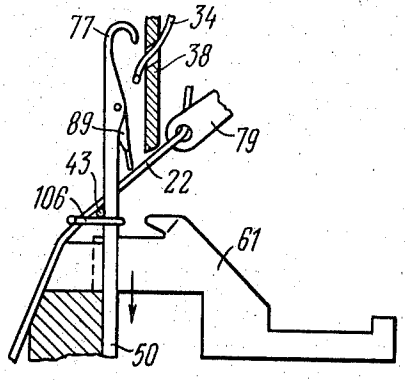


FIG. 12e

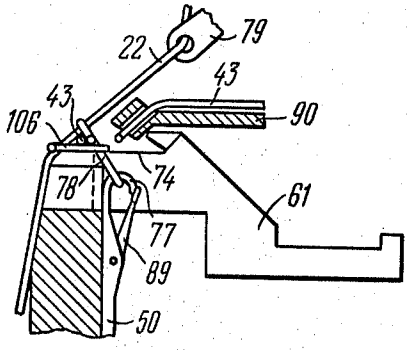


FIG. 12f

CIRCULAR KNITTING MACHINE FOR MAKING WEFT KNITTED FABRICS INCLUDING WARP YARNS AND WEFT YARNS INTERCONNECTED BY GROUND LOOPS

BACKGROUND OF THE INVENTION

The present invention relates to knitting machines for making weft knitted fabrics capable of maintaining their original shape, and, more particularly, to circular knitting machines for making weft knitted fabrics including warp yarns and weft yarns interconnected by ground loops.

There is known a circular knitting machine for making weft knitted fabrics including warp yarns and weft yarns interconnected by ground loops. The machine comprises a needle cylinder with vertically arranged latch needles and a sinker bed accommodating radially movable sinkers. The machine further comprises needle and sinker cam boxes horizontal channels, the cam boxes actuating the needles and the sinkers upon rotation of the cylinder relative to the cam boxes. The machine also comprises ground, weft and warp yarn guides, the warp yarn guides being in the form of an annular comb mounted above the cylinder. The known machine incorporates the sinkers having a rectilinear working surface, the sinkers being arranged in opposition to the needles. With the sinkers being thus arranged, they can be used exclusively for bringing the weft yarn behind the backs of the needles, as the latter are driven down (i.e., when the needles are in the loop knitting position). Therefore, each feeder or loop forming system of the known machine has a relatively great extent, which decreases the number of feeders that can be arranged about the needle cylinder; hence, the capacity of the machine is relatively low. Furthermore, the machine cannot offer a truly reliable loop forming operation, for the following reasons.

The shape of the sinkers does not provide for reliable guiding of a weft yarn behind the backs of the needles, since the rectilinear outline of the working surface of the sinker brings about unstable engagement of the yarn by this surface, and there is a tendency of the yarn to be misguided under or onto the sinker.

As the weft yarn is being brought behind the backs of the needles, the interaction of the yarn with the warp yarns results in a tendency of the weft yarn to be displaced under the sinker, the friction between the sinker and the weft yarn not counterbalancing this tendency.

The arrangement of the sinkers in opposition to the needles increases the extent of the loop forming system, since the weft yarn guide means cannot be positioned sufficiently close to the needles, as the latter are lowered into the knitting position, on account of the closing latch. Thus, it becomes necessary to increase the spacing between the needles and the weft yarn guide means, as well as the portion of the path of the needles, whereat the heads of the needles are below the knock-over comb formed by the portions of the needle cylinder between the grooves accommodating the needles. To provide for guiding of the weft yarn behind the backs of the needles, it is necessary to have a portion of the path of the sinkers equal to 2 – 3 needle pitches, disposed above the portion of the path of the needles, whereat the latter have their heads below the known-over comb. Besides, the sinkers should be retracted from the needles, as they are raised after the knitting

operation, to provide space for the latch of the needle that is being opened by the loop. This fact increases still further the portion of the path of the needles, whereat the heads of the needles are below the knock-over comb.

The sinkers arranged in opposition to the needles are incapable of retaining the weft yarns and the ground loop links, as the needles are being raised for the closing step (i.e., for displacing the loop onto the needle stem below the tip of the open latch). Consequently, the needle stroke is increased, and the extent of the loop forming system is increased, too. The weft yarn is not retained by the sinker and is subjected to the friction from the rising needle, whereby it may be displaced from the shed defined by the sides of the loops suspended from the needles and the warp yarns. This affects the loop forming process and decreases its reliability.

The known machine is devoid of means for controlling the position of the warp yarns, when the needles are raised above the knock-over comb. Thus, there is a possibility that certain of the warp yarns might be displaced into the adjacent inter-needle spaces and retained therein by the ground loops. In this way the structure of the fabric being knitted may become defective.

In the known machine the ground loops being formed are drawn-off by the tension of the fabric, which is counterbalanced to a great degree by the tension of the warp yarns. Thus, the loops suspended from the needles are but weakly tensioned and are poorly drawn-off the rising needles, which might also result in a defective structure of the fabric and affect the reliability of the performance of the machine.

And, finally, the known machine is incapable of effecting self-commencing of a fabric, on account of the absence of means that should retain the weft yarns and the loop links, as the needles are raised for the closing step, and should draw-off the fabric locally. This fact complicates operating of the machine.

SUMMARY OF THE INVENTION

It is an object of the present invention to eliminate the above mentioned disadvantages.

It is another object of the present invention to provide a highly productive, reliable and easy-to-operate circular knitting machine for making weft knitted fabrics including warp yarns and weft yarns interconnected by ground loops.

It is still another object of the present invention to provide a circular knitting machine for making knitted fabrics, wherein the sinkers should have a shape providing for reliable guiding of a weft yarn behind the backs of the needles and should be arranged so as to reduce the extent of the loop-forming system; the sinkers should be further capable of effecting control over the position of the warp yarns.

It is yet another object of the present invention to provide a circular knitting machine for making knitted fabrics, wherein the ground and weft yarn guides should be arranged so as to provide for reliable engagement by the needles and the sinkers of the ground and weft yarns, respectively.

These and other objects are attained in a circular knitting machine for making knitted fabrics including warp and weft yarns interconnected by ground loops, comprising a needle cylinder with vertically arranged

latch needles, the cylinder being mounted on a framework of the machine beneath a warp yarn beams and a weft and ground yarn creels, coaxially therewith, in which way the geometric axis of the machine is defined; a sinker bed accommodating radially movable sinkers; needle and sinker cam boxes defining horizontal channels, needle cam boxes defining channels with inclined and horizontal portions, the needle and sinker cam boxes actuating, respectively, the needles and the sinkers upon relative rotation between the cylinder and the cam boxes; ground, weft and warp yarn guide means, the warp yarn guide means being in the form of an annular comb mounted above the cylinder, in which machine in accordance with the present invention, the sinkers are arranged intermediate of the needles, alternating therewith, each sinker having a bifurcated hook presenting a V-shaped mouth, the tips of this hook accommodating therebetween a warp yarn, as the sinker is being driven toward the geometric axis of the machine, this hook defining with the body of the sinker a throat accommodating therein a weft yarn, as the latter is being guided behind the backs of the needles, when the heads of the latter are positioned below the body of the sinkers, as the needles are being raised in operation, the throat further being adapted to retain the weft yarns and the ground yarn links, when the needles are raised above the body of the sinker. In accordance with the invention, the ground yarn guide means of the machine is received internally of the annular comb, the ground yarn guides being disposed so that outlets thereof are below the level of the heads of the needles, as the needles are raised to their top position, to thread the ground yarns into the heads of the needles and to have the ground yarns encircle the warp yarns, whereas the weft yarn guides are mounted exteriorly of the annular comb and have their outlets disposed at the level of the sinker grooves, in direct proximity to the initial points of the motion of the sinkers toward the geometric axis of the machine.

The invention is further characterized in that, in order to retain the weft yarns and the ground loop links, that when the needles are brought to their top position, the sinkers are retracted from the geometric axis of the machine, and when the needles are in their bottom position, the sinkers are projected toward the geometric axis of the machine.

With the sinkers being arranged in the inter-needle spaces, they can be retracted from the geometric axis of the machine with the needles in their top position and projected toward the axis of the machine with the needles in the bottom position thereof. It should be born in mind that in the hitherto known machine where the sinkers are arranged in opposition to the needles, the sinkers can be projected toward the axis of the machine and retracted from the axis of the machine only with the needles in their bottommost position. Moreover, the sinkers arranged in the inter-needle spaces are capable of retaining the weft yarns and the loop links, when the needles are rising, in which way the stroke of the needles may be shortened.

Thus, the arrangement of the sinkers in the inter-needle spaces enables considerable reduction of the extent of the loop-forming system, whereby the productivity of the machine can be increased by increasing the number of the feeders mounted about the needle cylinder.

The employment of the sinkers having each a bifurcated hook providing a V-shaped mouth substantially increases the reliability of the process of loop formation, owing to, firstly, a throat defined between a nose and the body of the sinker reliably engaging a weft yarn and guiding it behind the back of the needle; secondly, the V-shaped mouth reliably engaging a warp thread and retaining it in the inter-needle space, as the sinker is being projected with the heads of the needles being below the bodies of the sinkers; thirdly, the throat of the sinker reliably retaining the weft yarn and the ground loop links, as the needles are raised above the bodies of the sinkers; fourthly, the throats of the sinkers ensuring local draw-off of the loops of the fabric, withdrawing them from the rising needles.

The employment of the sinkers arranged in the inter-needle spaces enables self-commencing of a fabric, which substantially facilitates operating of the machine at re-threading.

With the outlets of the ground yarn guides being disposed below the heads of the needles in the topmost position thereof, reliable engagement of the ground yarn by the needles and a dependable loop formation process are provided.

With the outlets of the weft yarn guides being positioned at the level of the grooves of the sinkers, in direct proximity to the initial point of the motion of the sinkers toward the axis of the machine, reliable engagement of the weft yarns by the hooks of the sinkers and guiding of these yarns behind the backs of the needles are also provided.

The herein disclosed circular knitting machine can be employed for utmost advantage for production of plated knitted wear, wherein the ground loops are formed by two yarns, i.e., by the ground yarn and by the plating one, and the warp yarns are secured not only between the loop links of the ground yarn and the weft yarn, but also by the loop links formed by the ground and plating yarns.

Since the arrangement of the sinkers intermediate of the needles and provision thereof with bifurcated hooks presenting V-shaped mouths, as well as the arrangement of the ground yarn guide means interiorly of the annular comb and the arrangement of the weft yarn guide means exteriorly of the comb have provided conditions for knitting plated knitted wear, the herein disclosed machine preferably includes plating yarn guides mounted exteriorly of the annular comb. The outlets of these last mentioned guides are preferably arranged in proximity to the needles and disposed below the ground yarn guides, for guiding the plating yarn simultaneously with the ground yarn into the heads of the needles and for the plating yarns to encircle the warp yarns from the side opposite to that of the encircling thereof by the ground yarns. The fabric thus knitted features greater stability of its structure, the loops formed therein not displaying a tendency of moving along the weft and warp yarns.

Therefore, the herein disclosed design of the sinkers and the arrangement thereof and of the yarn guides have made it possible to create a highly productive circular knitting machine offering reliable performance and facilitated operating.

The face of a fabric knitted by the herein disclosed machine has the appearance of a knitted fabric, while rectilinearly, the back thereof resembles a woven cloth, the fabric having the properties both of a knitted fabric

and of a woven one. The fabric is like a woven cloth in that it would not expand either longitudinally or transversely. It should be underlined that the deformability of the fabric both longitudinally and transversely is even lower than that of a woven cloth and the strength of the fabric is even greater than that of a woven cloth, since the yarns in the fabric extend rectilinerly, without bends.

A fabric knitted by the herein disclosed machine, like any other single knitted fabric displays a tendency of the sides to fold over onto the face; however, this tendency is substantially less pronounced than in ordinary knitted fabrics, since the fabric produced by the herein disclosed machine has both warp yarns and weft yarns.

The herein disclosed machine is capable of knitting fabrics of various structures, by using various kinds of yarns and threads and by varying the pattern of the threading of the yarns into the yarn guides.

Thus, by using woolen, cotton and textured yarns in high-gauge and medium-gauge machines of the herein disclosed kind, a variety of outerwear fabrics can be produced. By having coloured warp and ground yarns, it is possible to knit fabrics with horizontal or vertical stripes, as well as checkered fabrics. By employing synthetic or glass threads for the warp and weft yarns, it is possible to knit various fabrics for engineering uses, e.g., for reinforcement of plastic and glass-plastic articles, such as panels, tubes, casings. The glass threads would not be subjected to bending by the stitching members and thus will maintain in full their original strength, whereas processing of glass threads by looms and by the hitherto known knitting machines substantially affects their strength.

The herein disclosed machine is also operable with flat band-type yarns produced by splitting paper or various films, such band-type yarns excellently filling the fabric produced, without increasing its thickness.

By threading the weft yarns not into every loop-forming, or feeder system, but, let us say, into every other one, and by threading the warp yarns not into every inter-needle space, but into every second space, it is further possible to knit fabrics of various structures and stitching patterns, having various strengths and appearances.

The above description indicates the wide production capacities of the herein disclosed machine in knitting of cloth-like knitted fabrics, the machine further offering high productivity, substantially in excess of that of a loom.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described hereinbelow in connection with an embodiment thereof in a circular knitting machine, with reference being had to the accompanying drawings, wherein:

FIG. 1 shows schematically an axially sectional general view of a circular knitting machine in accordance with the invention;

FIG. 2 is a longitudinally sectional view of the ground yarn guide means of the stitching mechanism of the machine;

FIG. 3 is a longitudinally sectional view of the weft yarn guide means of the stitching mechanism of the machine;

FIG. 4 shows a sinker with a hook presenting a V-shaped mouth;

FIG. 5 is one of the embodiments of the annular comb, a cross-sectional view;

FIG. 6 is a graph illustrating combined paths of the needles and sinkers of the herein disclosed machine, against those of the hitherto known machine;

FIG. 7 is a longitudinally sectional view of the plating yarn guide means of the stitching mechanism of the machine;

FIGS. 8*a*, *b*, 9*a*, *b*, 10*a*, *b* illustrate various knitting patterns which the machine can produce, where

"*a*" is the face and

"*b*" is the back;

FIGS. 11 *o*, *a*, *b*, *c*, *d*, *e*, *f* illustrates the process of stitching, or loop formation, the respective positions *o*, *a*, *b*, *c*, *d*, *e*, *f* of the loop forming members corresponding to the similar positions of these members in the graph shown in FIG. 6;

FIGS. 12*a*, *b*, *c*, *d*, *e*, *f* illustrates the process of self-commencing of a fabric-knitting operation performed by the herein disclosed machine.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A machine in accordance with the present invention may have a stationary needle cylinder, a stationary sinker bed and a stationary warp yarn guide means in combination with rotary needle and sinker cam boxes and rotary ground and weft yarn guide means; alternatively, the needle cylinder, the sinker bed and the warp yarn guide means may be rotary, in combination with stationary needle and sinker cam boxes, ground and weft yarn guide means. The stitching process and the structure of the fabrics knitted by these two alternative versions of a machine in accordance with the invention being the same, the present invention will be described hereinbelow in connection with a machine with a rotary needle cylinder.

Referring now in particular to the appended drawings, the circular knitting machine includes a framework **1** (FIG. 1), one of the supports **2** of which carries a drive mechanism **3** associated with an electric motor **4.** An output shaft **5** of the drive mechanism **3** has mounted thereon a gear **6** meshing with a gear **7** secured to a needle cylinder **8,** to impart rotation to the latter. The bottom end of the shaft **5** carriers a gear **9** imparting motion to a draw-off mechanism **10** and to a take-up mechanism **11,** the two mechanisms being located in the bottom part of the framework **1.**

The upper part of the framework **1** is in the form of a circular table **12** supporting posts **13** carrying a ring **14** on which there are mounted a top level **15** with a ground yarn creel and a bottom level **16** with a weft yarn creel arranged one above a other; as well as the warp yarn guide means **17.**

Passing interiorly of one of the posts **13** is the above mentioned shaft **5** having mounted on the top end portion thereof a gear **18** meshing with an annular toothed rim **19** supporting a plurality of warp yarn beams **20** rotatable on brackets **21.** The number of the warp beams **20** may be two, four or six, depending on the diameter of the needle cylinder **8** and on the gauge of the machine. To guide warp yarns **22** from the beams **20** to the needle cylinder **8,** there are provided guide combs **23** mounted directly on the toothed rim **19** and the warp yarn guide means in the form of an annular comb **24** mounted above the needle cylinder **8** on posts **25** secured to the toothed rim **19.**

The top level **15** with the ground yarn creel is supported on the ring **14** by means of posts **26** and includes a series of concentric rings **27, 28** interconnected by horizontal rods **29** with a central sleeve **30.** The horizontal rods **20** support posts **31** carrying a ring **32** with a plurality of openings **33** for the passage of ground yarns **34** unwound from bobbins **35** mounted for rotation about inclined axis on the ring **27.**

A tube **36** is mounted in the opening of the central sleeve **30,** the tube rigidly supporting above the needle cylinder **8** the ground yarn guide means including a carrier **37** for ground yarn guides **38,** as well as yarn lappets **39** directing the ground yarns **34** toward the guides **38,** the lappets being mounted on the central sleeve **30.**

The bottom level **16** with the weft yarn creel is mounted on the ring **14** by means of horizontal bars (not shown in the drawing) and includes a series of concentric rings **40** and **41.** The ring **40** supports rotatable bobbins **42** with weft yarns **43.** To direct the latter toward the needle cylinder **8,** there are provided yarn lappets **44** supported on the ring **41,** yarn lappets **45** supported on bottom level **16** and yarn lappets **46** supported on a ring **47** which, in its turn, is supported on the posts **13.**

The rings **28, 32** and **47** may accommodate pickups responsive to yarn breakage or pulling-in.

A knitting, or stitching mechanism **48** of the herein disclosed machine includes the needle cylinder **8** (FIG. **2**) with a plurality of grooves **49** receiving therein latch needles **50** biased against the bottoms of the respective grooves by an annular spring **51.** The needle cylinder **8** is located beneath the beams **20** and creels **15** and **16,** coaxially therewith, so that the line passing through the centres of the annular configurations of the latter and through the axis of the needle cylinder **8** constitutes the geometric axis O — O (FIG. **1**) of the machine.

The cylinder **8** (FIG. **2**) is encircled by needle cam boxes **52** and **53** supported on a carrier **54** rigidly secured to the circular table **12** (FIG. **1**). The cam boxes **52** (FIG. **2**) and **53** define a channel **55** accommodating the butts **56** of the needles **50.** As the cylinder **8** is rotated in operation, the profile of channel **55** acts upon the butts **56** of the needles **50,** effecting reciprocation of the latter.

Fixed to the upper portion of the needle cylinder **8** is a sinker bed **57** (FIG. **3**) secured by bolts **58** and studs **59.** The sinker bed **57** has made therein a plurality of radial grooves **60** directed toward the axis O — O (FIG. **1**) of the machine, the grooves **60** (FIG. **3**) accommodating therein radially reciprocable sinkers **61.** The sinker bed **57** supports sinker cam boxes **62** and **63** (FIG. **2**) secured to an annular carrier **64** by screws **65,** to prevent rotation of the cam boxes together with the sinker bed **57** (FIG. **3**). The cam boxes **62** and **63** define a channel **66** accommodating the butts **67** of the sinkers **61,** to effect radial reciprocation of the latter with respect to the axis O — O of the machine. The annular carrier **64** is retained against rotation by a stop **68** secured to the carrier **54** of the needle cam boxes by bolts **69.** The stop **68** has an abutment **70** received in a groove **71** made in the annular holder **64.**

The sinkers **61** are arranged in the inter-needle spaces, i.e., they alternate with the needles **50,** each sinker having a shape illustrated in FIG. **4.** Each sinker **61** has a hook **73** presenting a V-shaped mouth **72** adapted to accommodate therein, as the sinker is driven toward the axis of the machine, a warp yarn **22** (FIG. **2**), the hook **73** defining with the body **74** (FIG. **4**) of the sinker a throat **75** to accommodate a weft thread **43** (FIG. **3**), as the latter is driven behind the back **76** of the needles **50,** when heads **77** of the needles are below the body **74** of the sinker **61,** as the needles are being raised; the throat **75** being further intended to retain the weft yarns **43** and loop links **78** (FIG. **2**) formed by the ground yarns **34,** when the needles **50** are raised above the body **74** of the sinker **61.**

The sinkers **61** may be made each as a combination of two separate parts (FIG. **4**) driven in synchronism or else fixed to each other, the two parts having the respective hook portions **73** thereof bent in opposite directions to present the V-shaped mouth **72;** alternatively, each sinker **61** may be an integral part (not shown) having the hook thereof split along the body, the split ends being spread apart to define therebetween the V-shaped mouth.

The annular comb **24** (FIG. **2**) mounted above the needle cylinder **8** incorporates members separating the warp yarns **22,** such as eyelets **79** secured to the base of the comb by soldering with a metal having a low melting point. The comb **24** is made of a plurality of individual sections **80** secured to an intermediate ring **81** by bolts **82.** The eyelets **79** may alternatively be secured by press-fit in corresponding grooves (not shown) cut in the base of the comb **24.**

Alternatively, the annular comb **24** may be in the form of a ring **83** (FIG. **5**) with grooves **84** adapted to accommodate therein the passing warp yarns **22,** the ring **83** being encompassed by an annular spring **85** retaining the warp yarns **22** in the grooves **84.** The ring **83** is likewise secured to the intermediate ring **81** by bolts **82.**

The guides **38** (FIG. **2**) of the ground yarns **34,** received within the annular comb **24,** are fastened to the carrier **37** with screws **86** and have inlets **87** through which the ground yarns **34** enter the guides and outlets **88** through which the yarns **34** are directed toward the needles **50.** The guides **38** are so arranged that their outlets **88** are positioned below the heads **77** of the needles **50,** when the latter are raised to their topmost position, to guide the ground yarns **34** into the heads **77** of the respective needles **50** and to make them encircle the warp yarns **22** interiorly of the machine. Each yarn guide **38** is in the form of an apertured panel positioned adjacent to the respective one of the needles **50,** tp prevent self-closing of latches **89** of the needles, when the latter are raised to their topmost position.

Mounted exteriorly of the annular comb **24** (FIG. **3**) is the guide means for weft yarn **43** including guides **90** having outlets **91** disposed at the level of the throat **75** of the respective sinker **61,** directly adjacent to the point at which the sinker starts its stroke toward the axis O — O of the machine. Each guide **90** is in the form of an apertured bent panel fastened with screws **92** to the annular carrier **64.** At the side adjacent to the respective needle, each guide **90** has a lug **93,** biasing the respective warp yarn **22** toward the axis of the machine.

The profiled channels **55** (FIG. **2**) defined by the needle cam boxes **52** and **53** have horizontal and inclined portions and the channels **66** defined by the sinker cam boxes **62** and **63** are horizontal, whereby the involute on a plane of the paths **94** (FIG. **6**) of the motion of the heads **77** of the needles **50** and of the paths **95** of the throats **75** of the reciprocable sinkers

61 is as shown in this FIG. 6. The direction of the motion of the needles 50 and of the sinkers 61 along these respective paths 94 and 95 is indicated with arrow lines A and B.

With the needles 50 raised to their top position the sinkers 61 are retracted from the central geometric axis of the machine, and with the needles 50 brought into their bottom-most position the sinkers are projected toward the axis of the machine.

FIG. 6 also illustrates the corresponding positions of the outlet 88 of the guide 38 of the ground yarn 34, which ensure reliable direction of the ground yarn beneath the heads 77 of the needles 50; as well as the successive positions of the outlet 91 of the guide 90 of the weft yarn 43, with respect to the paths 94 and 95 of the needles and sinkers, respectively. The outlet 91 is at the level of the throat 75 of the sinker 61, directly adjacent to the point C at which the sinker 61 starts its stroke toward the axis of the machine.

For the sake of comparison, FIG. 6 illustrates with dotted lines 94*a* and 95*a* the paths, respectively, of the needles and of the sinkers of the above specified hitherto known machine wherein the sinkers are arranged in opposition to the needles. The path 95*a* of the sinkers is such that the sinkers are projected toward the axis of the machine and retracted therefrom only when the needles are in their bottommost position. Consequently, in the known machine the portion 1_1 of the path 94*a* of the needles, along which the latter rest in their bottommost position is substantially longer than the corresponding horizontal portion 1 of the path 94 of the needles 50 of the herein disclosed machine. Furthermore, the stroke H_1 of the needles of the hitherto known machines is substantially longer than the stroke H of the needles of the herein disclosed machine, owing to the fact that the sinkers of the known machine would not retain the loop links, as the needles are being raised.

Consequently, the extent of the horizontal portion L of the path 94 of the needles and, correspondingly, the length of the loop-forming or stitching system of the herein disclosed machine are less than the extent of the horizontal portion L_1 of the known machine by at least 30 percent, whereby it becomes possible to arrange a greater number of the feeders about the needle cylinder 8. Thus, with a machine of a medium gauge and the cylinder diameter of 500 mm (20 inches) as many as 40 stitching systems (feeders) can be arranged about the cylinder, which provides for a high capacity of the machine.

For knitting plated weft fabrics, the machine can have mounted exteriorly of the annular comb 24 thereof guides 96 (FIG. 7) for plating yarns 97, so that outlets 98 of these guides are arranged as close as possible to the needles 50 and are positioned each above the closing latch 89 of the respective needle, as the latter is being lowered, beneath the respective outlets 88 of the guides 38 of the ground yarn 34. Each guide 96 of the plating yarn is a bent panel secured to the annular holder 64 by screws 99 and having a lug 100 facing the needle, to effect smooth biasing of the warp yarns 22 toward the axis O — O of the machine, so that the needles 50 should engage the plating yarn 97 by their heads 77 and knit it together with the ground yarn 34.

Bobbins 101 (FIG. 1) with the supply of the plating yarns 97 are mounted at the bottom level 16 of the creel, alongside of the bobbins 42 with the weft yarns 43 and are associated with lappets similar to the above described lappets 44, 45, 46.

The herein disclosed circular knitting machine produces cloth-like weft knitted fabrics of various stitching patterns, including weft and warp yarns interconnected by loops, one of such patterns being illustrated in FIGS. 8*a*, *b*, wherein the weft yarns 43 are arranged intermediate of the sides of the loops 78 of the ground yarns 34 and the warp yarns 22, the latter being retained by links 102 of the loops 78.

When the machine incorporates the guides 96 of the plating yarn 97, it is capable of knitting patterns two of which are illustrated in FIGS. 9*a*, *b* and 10*a*, *b*. In the pattern illustrated in FIGS. 9*a*, *b* the weft yarns 43 are also arranged between the warp yarns 22 and the sides of the loops 78 formed jointly by the ground yarns 34 and plating yarns 97. The plating yarn 97 encircles the warp yarn 22 at the face, while the ground yarn 34 the warp yarn 22 at the back.

Thus, the warp yarns 22 are arranged between the links 103 of the loops 78 formed jointly by the ground yarns 34 and plating yarns 97, whereby the warp yarns 22 are dependably fixed in the fabric.

In the pattern illustrated in FIGS. 10*a*, *b* the ground loops 78 are formed each by a single yarn, but the loop courses are alternatingly formed by the ground yarn 34 and the plating yarn 97. Therefore, the warp yarns 22 are arranged between the links 104 of the loops 78 of two adjacent courses. The weft yarns 43, like in the above described patterns, are arranged between the sides of the loops 78 and the warp yarns 22.

However, the above described exemplary patterns are by no means the only ones which the herein disclosed machine for production of various patterns including warp and weft yarns interconnected by the ground yarns is capable of knitting.

The herein disclosed circular knitting machine operates, as follows.

To knit a fabric 105 (FIG. 11*a*) the needle cylinder 8 is rotated by the motor 4 (FIG. 1) through the drive 3, shaft 5, gears 6 and 7. Simultaneously, the beams 20 carried by the toothed rim 19 driven by the gear 18 are also rotated about the axis O — O of the machine, the same as the draw-off mechanism 10 and the take-up mechanism 11.

In operation of the herein disclosed machine the warp yarns 22 are tensioned together with the fabric 105 by the draw-off mechanism 10 (FIG. 1); they are unwound from the beams 20 and pass through the guide combs 23 and the annular comb 24. The ground yarns 34 transformed by the needles 50 into loops are unwound from the bobbins 35 and pass through the openings 33 of the ring 32, through the lappets 39 and yarn guides 38. The weft yarns 43 and the plating yarns 97 are unwound, respectively, from the bobbins 42 and 101 and pass through the lappets 44, 45, 46 and guides 90 and 96.

As the cylinder 8 (FIG. 2) is rotated, the needles 50 extending through its grooves 49 perform a complex motion; they rotate together with the cylinder 8 about the axis O — O of the machine and reciprocate relative to the cylinder, owing to the interaction of their butts 56 with the channel 55 defined by the stationary needle cam boxes 52 and 53. The absolute motion of the needles 50 is represented by the path 94 (FIG. 6). Similarly, the sinkers 61 are reciprocated radially along the path 95, owing to the interaction of their butts 67 (FIG.

2) with the channel **66** defined by the stationary cam boxes **62** and **63.**

Owing to this motion of the needles **50** and sinkers **61** and to their joint travel relative to the stationary guides **38, 90** and **96,** respectively, of the ground, weft and plating yarns, there is effected the loop formation or stitching process, which in every stitching system associated with the corresponding feeder is performed, as follows.

In the initial position (FIG. **11** *o*) the sinkers **61** are positioned so that their throat **75** is at the level of the backs **76** of the needles **50.** Each sinker **61** retains by the V-shaped mouth **72** of its bifurcated hook **73** the respective warp yarn **22** in the inter-needle space, while its throat **75** retains the weft yarn **43** and the link of the loop **78** suspended from the needles **50,** the latter being positioned so that their heads **77** are at the level of the body **74** of the sinker **61.** The fabric **105** being knitted passes within the cylinder **8** and is drawn by the draw-off mechanism **10** (FIG. **1**).

From the above described initial position the needle **50** (FIG. **11** *o*) is raised (the direction of the raising or lowering of the needles is indicated in the respective drawings with arrow lines), the loops **78** (FIG. **11***a*) retained by the hooks **73** of the sinkers **61** opening the latches **89** of the needles **50** and sliding onto the stem of the needle **50** below the now open latch **89** thereof. The sinkers **61** are meanwhile immobile. When the needles **50** are raised to their topmost position, the sinkers **61** (FIG. **11***a*) are retracted from the axis of the machine in the direction indicated with the arrow line, making space for the ground yarn **34,** the V-shaped mouth **72** of the hook **73** of the sinker **61** disengaging the warp yarn **22.** However, this does not affect the positioning of the latter, since the warp yarns are retained by the needles **50** which rest in their topmost position.

Thereafter the needles **50** start lowering and, passing by the guide **38** (FIG. **6** and FIGS. **11***b, c*) of the ground yarn, engage the ground yarn **34** coming from the outlet **88** by their heads **77**; then, lowering still further, they bend the yarn onto the warp yarns **22** (FIG. **11***d*), biasing the latter toward the bodies **74** of the sinkers **61** which present the knock-over plane.

If the operation is that of knitting a plated fabric, then the lowering needles **50** also pass by the guide **96** (FIG. **11***c*) positioned below the guide **38** in direct proximity to the needles **50** so that the outlet **98** thereof is located above the latch **89,** as the latter is being closed by the loop **78.** The warp yarns **22,** which are rotating together with the needle cylinder **8,** slide along the lug **100** of the yarn guide **96** and are somewhat bent thereby toward the axis O — O of the machine, making space for the plating yarn **97** which latter is engaged by the head **77** of the needle **50,** simultaneously with the ground yarn **34.** The latch **89,** which is being closed by the loop **78,** as the needle **50** is being lowered, interacts with the plating yarn **97,** also promoting the direction of the latter below the needle head **77.** The plating yarn **97** is bent directly about the bodies **74** of the sinkers **61,** exteriorly of the warp yarns **22,** i.e., it encircles the warp yarn on the side opposite to that on which it is encircled by the ground yarns.

As the needle **50** lowers still further, the latch **89** becomes fully closed by the loop **78** (FIG. **11***d*), and the ground yarn **34** together with the plating yarn **97** are guided through this loop **78,** forming a new loop **78***a* (FIG. **11** *e*) onto which the loop **78** is released. The weft yarn **43** is withdrawn from the back **76** of the needle **50** and is retained between the sides of the loops **78** and the warp yarns **22.**

When the heads **77** of the needles **50** are lowered below the bodies **74** of the sinkers **61,** the latter start moving toward the axis of the machine and, while passing by the guide **90** of the weft thread **43,** of which the outlet **91** is at the level of the throat **75** of the sinker, take the weft thread **43** and direct it behind the back **76** of the needles **50** (FIG. **11** *f*) into the shed formed by the warp yarns **22** and the sides of the loops **78** *a.* While moving toward the axis O — O of the machine, the sinkers **61** engage by the V-shaped mouth **72** of their bifurcated hook **73** also the warp yarns **22,** guiding them into the inter-needle spaces; likewise, they engage the links of the loops **78***a*, thus effecting local draw-off of the fabric **105** by withdrawing the loops **78** from the rising needles **50.**

The needles **50** start rising, their heads **77** (FIG. **11***f*) being lifted to the level of the bodies **74** of the sinkers **61.** Consequently, the weft yarn **43** assumes a stable position above the sides of the loops **78** that have been formed, beneath the warp yarn **22** and behind the backs **76** of the needles **50.** Now the process of knitting of a single course is completed, and the same operation is repeated in the next loop forming system.

As a result, there is knitted a fabric of which the structure is illustrated in FIG. **8,** provided that the ground yarn guide **38** alone is operating. If the plating yarn guide **96** is operated simultaneously with the ground yarn guide **38,** there is produced a fabric of which the knitting pattern is illustrated in FIG. **9.** The machine is capable of producing other knitting patterns by operating the guides **38, 90** and **96** in different combinations and threading the warp yarns not into every inter-needle space. Thus, a fabric illustrated in FIG. **10** is produced when in every odd feeder of the machine the yarns are threaded through the guides **38** and **90,** while in the even feeders only the guide **96** has the yarn threaded therethrough.

The herein disclosed machine is a self-commencing one, i.e., it is capable of starting the first course of a fabric when the needles have no loops formed thereabout.

To commence a new fabric in the herein disclosed machine, the beams **20** (FIG. **1**) with a supply of warp yarns **22** wound thereon are mounted, and the yarns are threaded into the combs **23,** passed interiorly of the toothed rim **19** and through the eyelets **79** of the comb **24.** Then the warp yarns are guided between the needles and compressed in the nip of the draw-off mechanism **10.** Bobbins **35** with the ground yarns **34** are mounted at the top level of the creel **15,** and the yarns are threaded through the openings **33** of the ring **32,** through the lappets **39** and through the yarn guides **38,** the yarns passing interiorly of the toothed rim **19.** Bobbins **42** and **101** with the weft yarns **43** and plating yarns **97,** respectively, are mounted at the lower level of the creel **16,** and the yarns are threaded through the lappets **44, 45** and **46** and through the yarn guides **90** and **96,** respectively.

Prior to commencing the knitting operation, the heads **77** of the needles **50** (FIG. **12***a*) are put at the level of the bodies **74** of the sinkers **61,** however, the latches **89** of the needles should be open, which is attained by mounting at several points about the needle cylinder corresponding brushes or latch-openers which

are not shown in the drawings. The needles **50** are then raised to their topmost position; while passing by the guide **38** (FIG. 12*b*) of the ground yarn **34**, they engage the ground yarn by their heads **77**. The sinkers **61** are meanwhile being retracted from the axis O — O of the machine.

Then the needles are lowered, and while lowering below the bodies **74** of the sinkers **61**, they bend the ground yarn **34** about the warp yarns **22** (FIG. 12*c*), biasing the latter toward the bodies **74** of the sinkers **61** and forming half-loops **106**. When the heads **77** of the needles **50** are lowered below the bodies **74** of the sinkers **61**, the latter start moving toward the axis O — O of the machine and engage by their throat **75** (FIG. 12 *d*) the weft yarn **43**, guiding it behind the backs **76** of the needles **50** into the shed formed by the warp yarns **22** and the half-loops **106**. While moving toward the axis of the machine, the sinkers **61** engage by the V-shaped mouth **72** of their bifurcated hook **73** also the warp yarns **22** and guide them into the inter-needle spaces, while the throat **75** guides the links of the half-loops **106**. Thereafter the needles **50** are raised to their initial position, the weft yarn **43** bearing upon the half-loops **106** beneath the warp yarns **22** and behind the back **76** of the needle **50**. Owing to the tension of the warp yarns **22** and of the weft yarns **43**, the half-loops **106** are reliably biased against the stems of the needles **50**.

In the successive loop-forming system the needles **50** are again raised to their topmost position (FIG. 12 *e*) and engage by their heads **77** the ground yarn **34**. However, as the needles are lowering, the latches **89** of all the needles are already reliably closed by the half-loops **106**, owing to the tension of the latter. As the heads **77** of the needles **50** are again lowered below the bodies **74** (FIG. 12 *f*) of the sinkers **61**, the half-loop **106** is released onto the newly formed loop **78**.

Now the commencing operation is completed, and there follows the normal loop-forming operation which has been already described hereinabove.

What we claim is:

1. A circular knitting machine for making weft knitted fabrics including warp yarns and weft yarns interconnected by ground yarns, comprising: a framework; creels, respectively, with supplies of weft yarn and ground yarn mounted on said framework in the form of coaxial rings; beams with a supply of warp yarn mounted on said framework; a needle cylinder mounted on said framework beneath said beam and said creels coaxially therewith, in which way the vertical geometric axis of said machine is defined; vertical grooves made in said needle cylinder; latch needles having heads, received in said vertical grooves and also having backs facing said needle cylinder; a sinker bed arranged about said needle cylinder and secured thereto; grooves made in said sinker bed and extending radially toward said geometric axis of said machine; sinkers received in said grooves of said sinker bed intermediate of said latch needles, each said sinker having a body; needle cam boxes arranged about said needle cylinder and encircling said cylinder; sinker cam boxes arranged on said sinker bed; means for effective relative rotation of said cylinder with respect to said cam boxes; a channel defined by said needle cam boxes and having inclined portions and horizontal portions; a horizontal channel defined by said sinker cam boxes; butts provided on said latch needles and received in said channel defined by said needle cam boxes to effect reciprocation of said needles upon said relative rotation of said cylinder and said cam boxes; butts provided on said sinkers and received in said channel defined by said sinker cam boxes to effect radial reciprocation of said sinkers relative to said geometric axis of said machine upon said relative rotation of said cylinder and said cam boxes; warp yarn guiding means including an annular comb mounted above said needle cylinder; ground yarn guiding means disposed interiorly of said annular comb and including yarn guides with outlets, said yarn guides being disposed so that said outlets thereof are positioned below the level of said heads of said needles as the latter are raised in operation to their topmost position, to guide said ground yarns into said heads of said needles and to make said ground yarns encircle said warp yarns; weft yarn guiding means including weft yarn guides mounted exteriorly of said annular comb; each said sinker having a bifurcated hook presenting a V-shaped mouth, said hook being located above the body of said sinker, said mouth thereof being adapted, as said sinker is moved toward said geometric axis of said machine, to receive therein said warp yarn; a throat of each said sinker defined between said hook thereof and said body thereof, said throat being adapted to receive said weft yarn and to guide said weft yarn behind said backs of said needles, when said heads of said needles are positioned below said body of said sinkers, as said needles are being raised in operation, said throat being further adapted to retain said weft yarns and the links of the loops of said ground yarn, when said heads of said needles are raised in operation above said body of said sinker; said weft yarn guides having outlets and being arranged so that said outlets thereof are disposed at the level of said throats of said sinkers, directly adjacent to a point at which said sinkers start their stroke toward said geometric axis of said machine.

2. The circular knitting machine as claimed in claim **1**, wherein, in order to retain said weft yarns and said links of said loops of said ground yarn, that when said needles are raised in operation to their topmost position, said sinkers are retracted from said geometric axis of said machine; and when said needles are lowered to their bottommost position, said sinkers are projected toward said geometric axis of said machine.

3. The circular knitting machine as claimed in claim **1**, further comprising guides mounted about said annular comb for plating yarns having outlets that are arranged adjacent to said needles and disposed beneath said outlets of said guides of said ground yarns, to guide plating yarns together with said ground yarns into said heads of said needles, for said plating yarns to engage said warp yarns on the side thereof opposite to the side on which said ground yarns engage said warp yarns in order to knit plated weft fabrics including weft yarns and warp yarns interconnected by loops formed by said ground yarns and plating yarns.

* * * * *