Nov. 24, 1959 R. C. AMIDON 2,913,888

WRAP KNITTING METHOD, MACHINE AND NEEDLE THEREFOR

Filed July 22, 1957 6 Sheets-Sheet 1

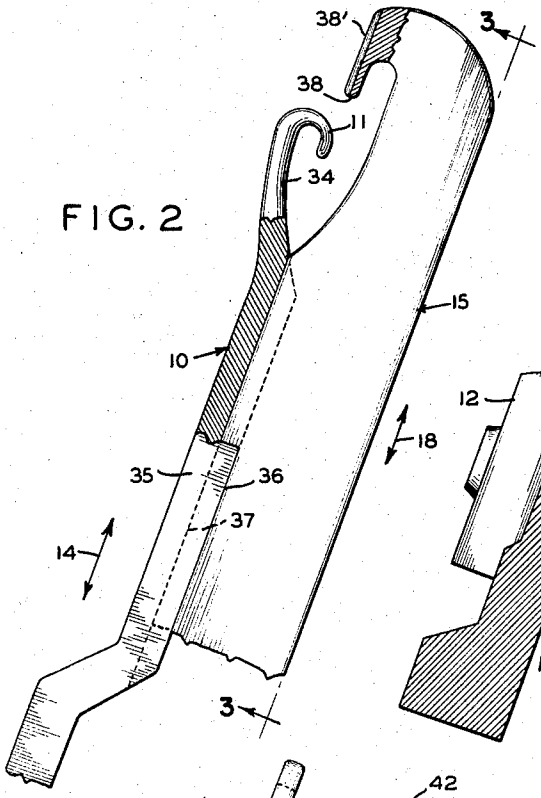


FIG. 2

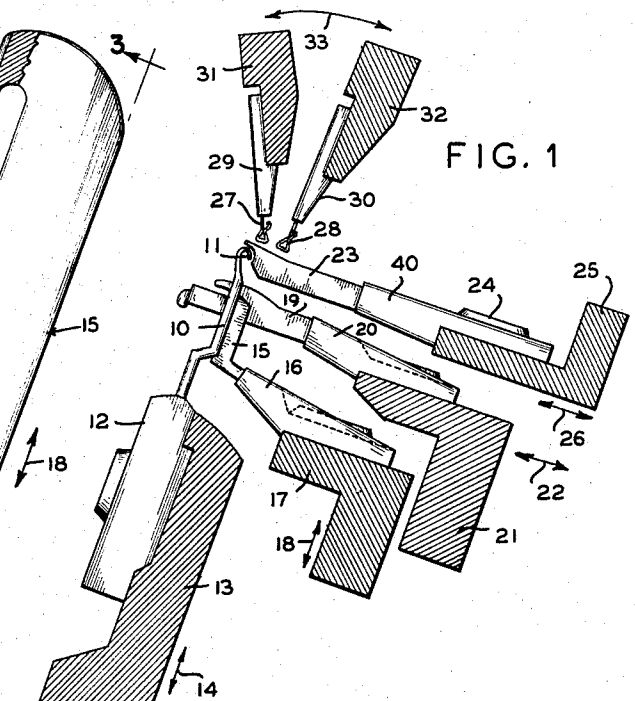


FIG. 1

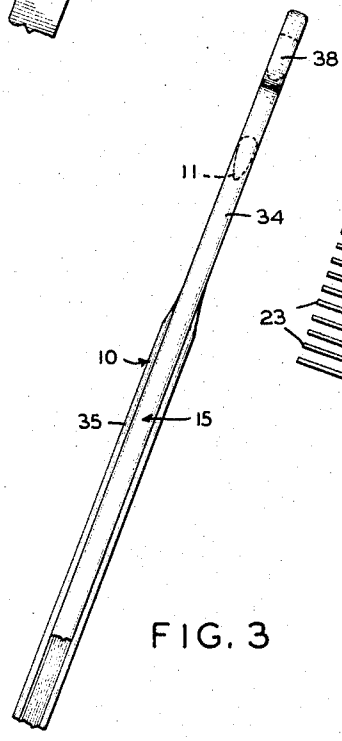


FIG. 3

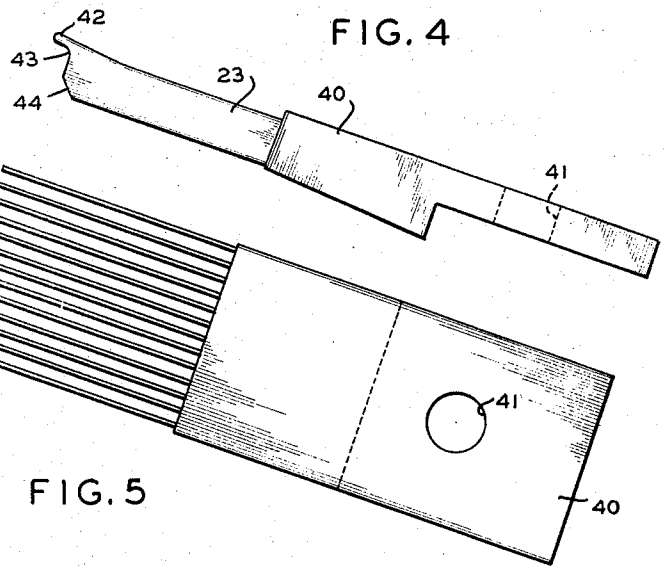


FIG. 4

FIG. 5

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Nov. 24, 1959 R. C. AMIDON 2,913,888

WRAP KNITTING METHOD, MACHINE AND NEEDLE THEREFOR

Filed July 22, 1957

6 Sheets-Sheet 2

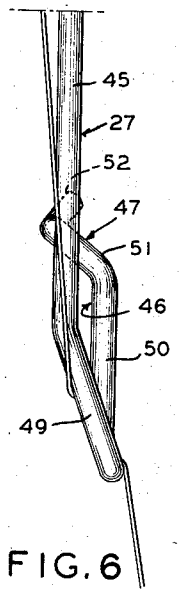


FIG. 6

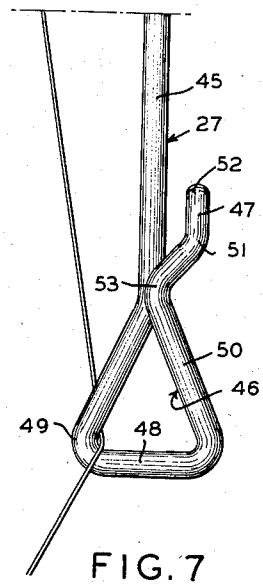


FIG. 7

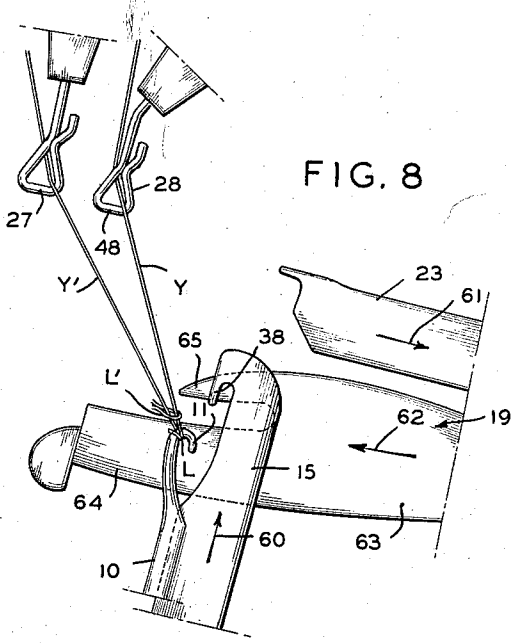


FIG. 8

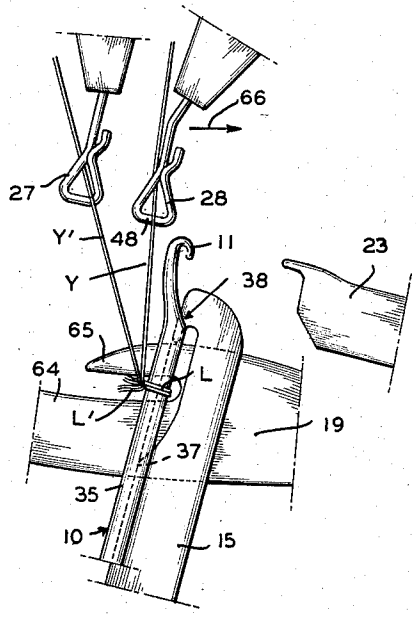


FIG. 9

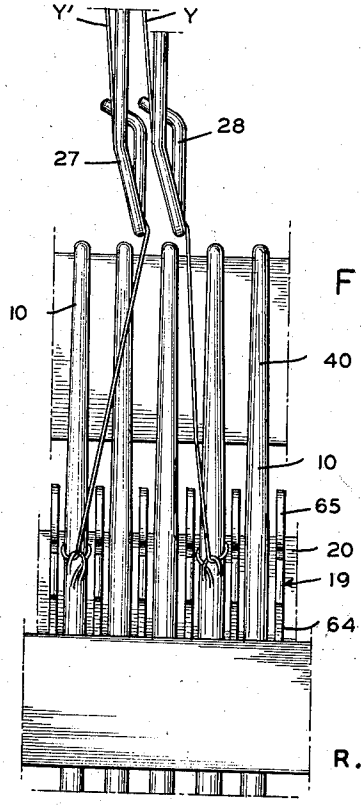


FIG. 9A

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Nov. 24, 1959 R. C. AMIDON 2,913,888

WRAP KNITTING METHOD, MACHINE AND NEEDLE THEREFOR

Filed July 22, 1957 6 Sheets-Sheet 3

FIG. 10

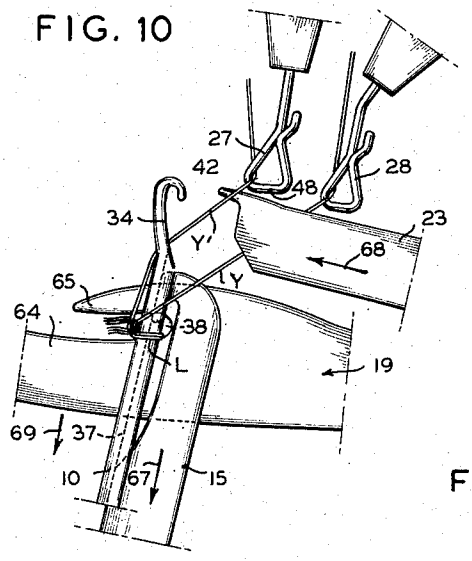
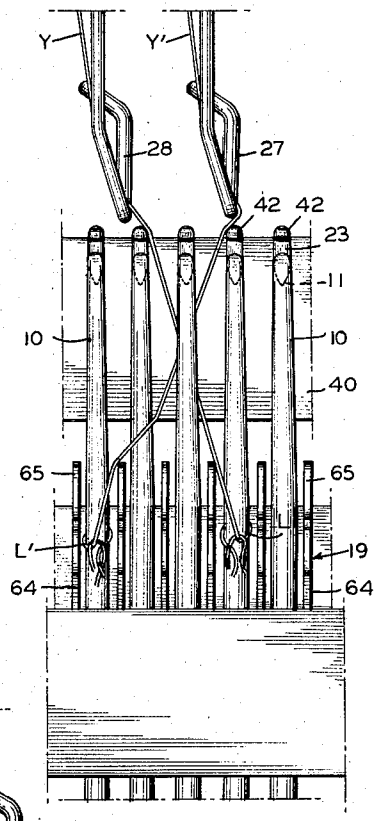


FIG. 10A



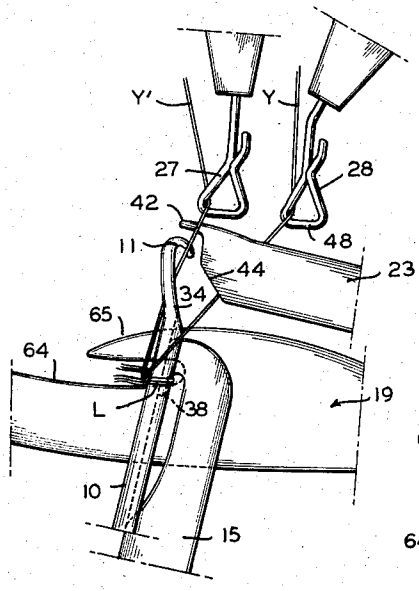


FIG. 11

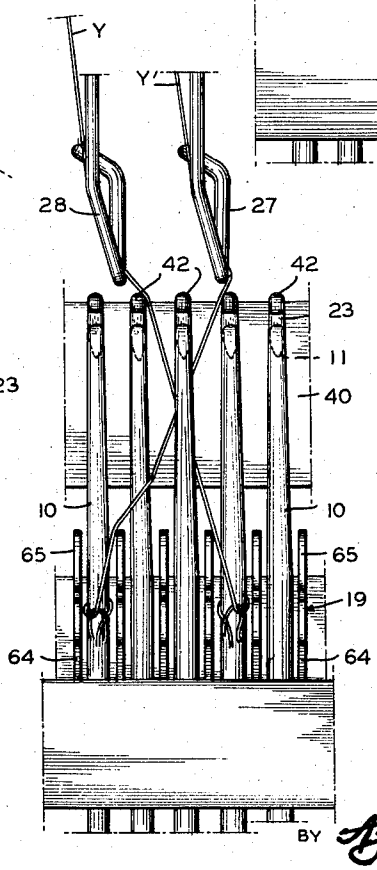


FIG. 11A

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WRAP KNITTING METHOD, MACHINE AND NEEDLE THEREFOR

Filed July 22, 1957 6 Sheets-Sheet 4

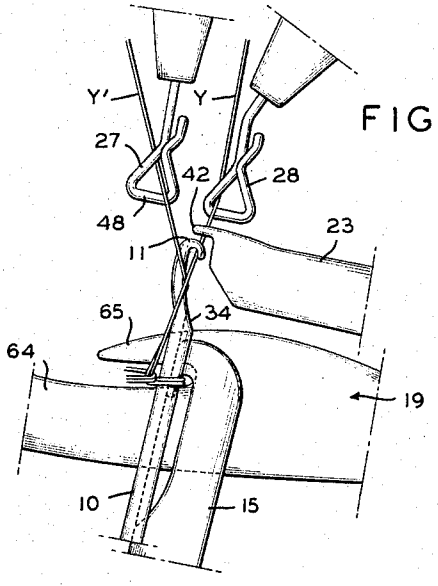


FIG. 12

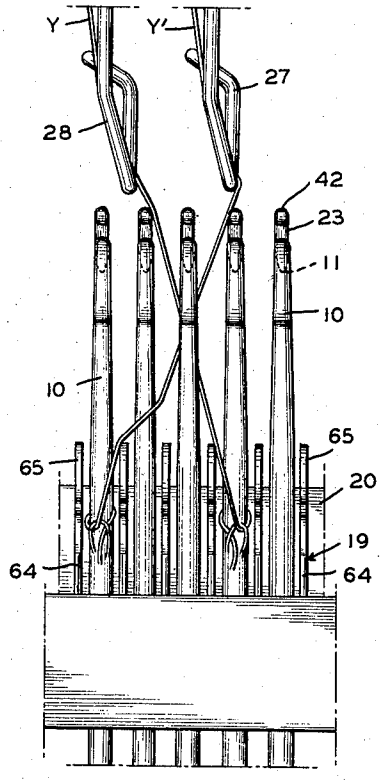


FIG. 12A

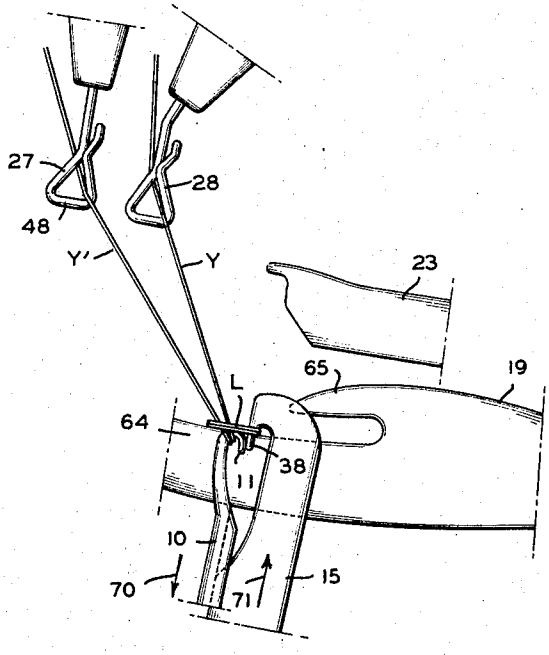


FIG. 13

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WRAP KNITTING METHOD, MACHINE AND NEEDLE THEREFOR

Filed July 22, 1957 6 Sheets-Sheet 5

FIG. 14

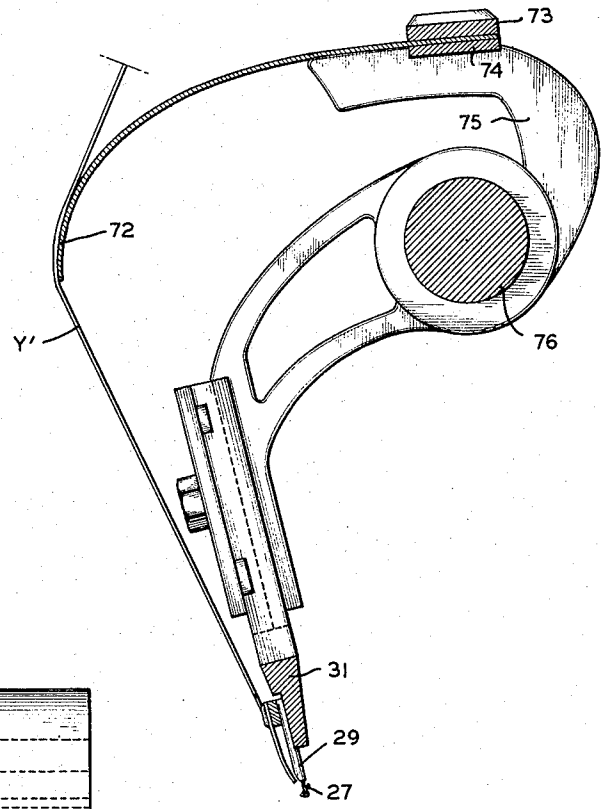
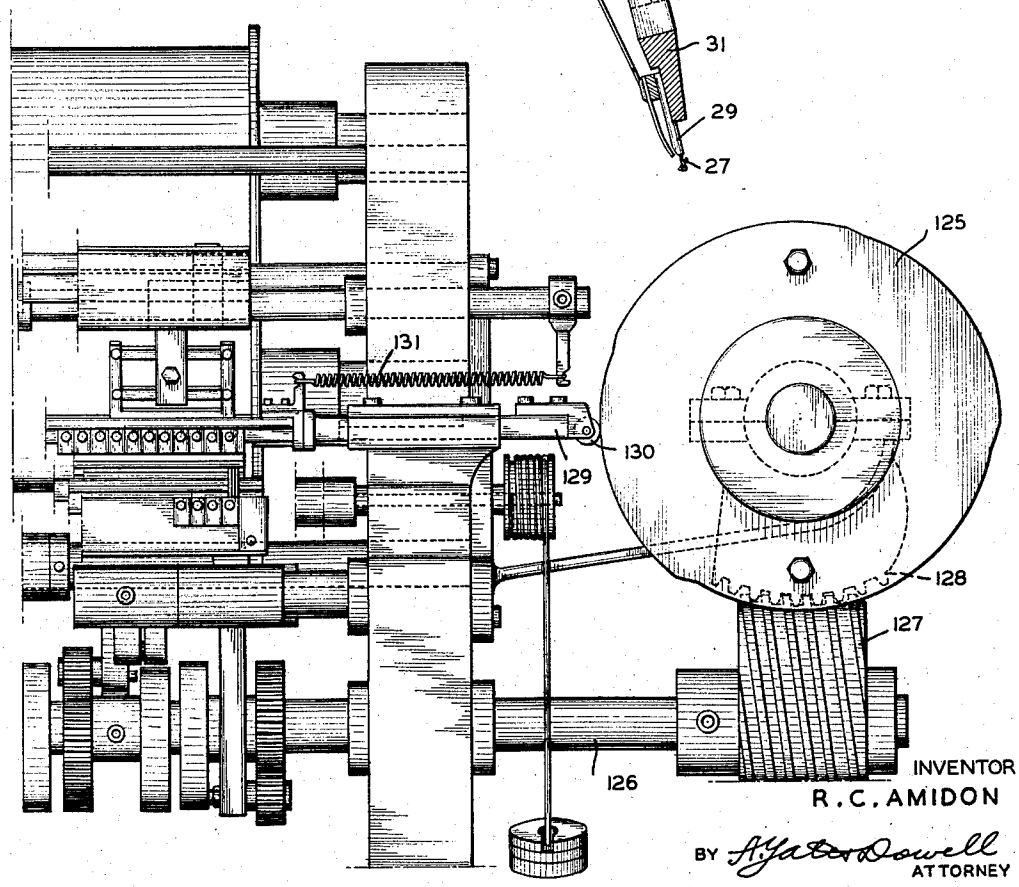


FIG. 16



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WRAP KNITTING METHOD, MACHINE AND NEEDLE THEREFOR

Filed July 22, 1957 6 Sheets-Sheet 6

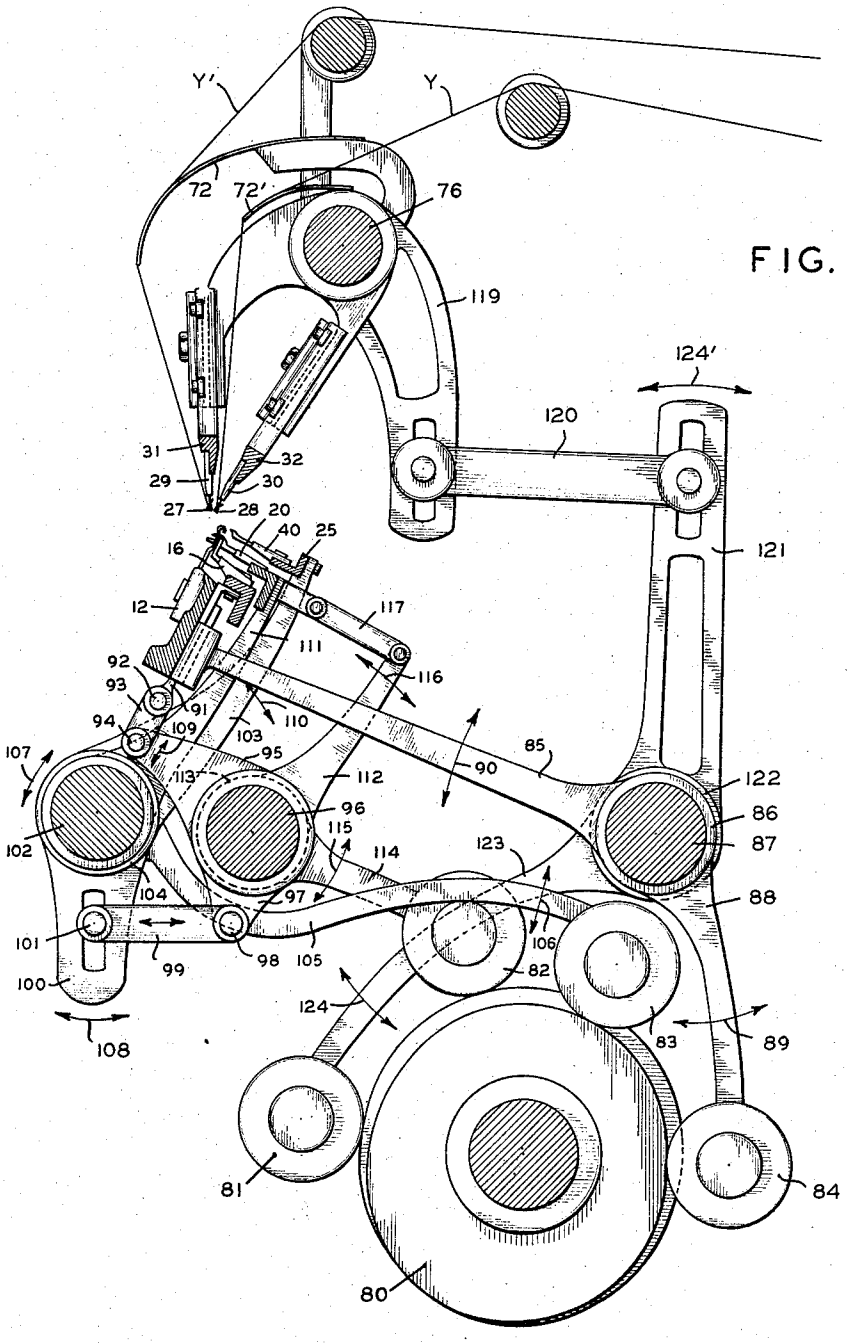


FIG. 15

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United States Patent Office 2,913,888
Patented Nov. 24, 1959

2,913,888

WARP KNITTING METHOD, MACHINE AND NEEDLE THEREFOR

Roy C. Amidon, Reading, Pa.

Application July 22, 1957, Serial No. 673,513

14 Claims. (Cl. 66—86)

The present invention relates to apparatus and method for warp knitting in which the warp yarn which is supplied is moved from a position in front of the knitting needle and is then passed between the knitting needles to a position in back of the knitting needle and is then returned to its original position in front of the knitting needle by being passed again between the knitting needles on the opposite side of the knitting needle which is coacting with the warp yarn supply.

The knitting needles are conveniently set in a line by attachment thereof to a needle bar and the warp yarns are supplied through yarn guides with the warp yarn being under tension.

In conventional warp knitting the yarn which is wrapped within the hook of the needles is made to pass through the loop of a previously formed knitted stitch by means of a trick or knockover bar, the knitted fabric being drawn away from the needles in a direction opposite to the position of the yarn guides. The knitted fabric and the stitches that are in the process of formation are held in contact with the knockover bar by the tension applied by the knitted fabric which is leaving the needles.

The casting off or knockover of the knitted stitches takes place at the top of the trick or knockover bar. The needles operate on one side of the bar and the knitted fabric is held in position and drawn away from the needles, under tension, on the opposite side of the bar.

The tension upon the knitted fabric which is produced is frequently not uniform. This is primarily true in flat or straight knitting where the tension of the fabric is more pronounced in the center of the machine. When a knockover bar is employed in the casting off of the stitches, the reduced tension between the needles and the fabric take-up roll at the sides of the knitted fabric permits the loops of the previously formed stitches to be drawn upwardly along the needle shank. Further, when the yarn has been conveyed by means of the yarn guides to a point in back of the needles and then starts forward again in the process of laying the yarn around the needles, the tension on the warp yarn which is supplied is reduced and the yarn relaxes between the yarn guides and the needles. This reduction in tension enables the yarn loops to be lifted to a still higher position upon the needle shank. This lifting of the yarn loops is a cause of distortion in the stitch formation. Further, the relaxation of the warp yarns supplied can result in an excessive impact between the warp yarn and the knitting needles.

In the downward motion of the needles which is accompanied by the retraction of the sinker nibs in timed relation, there is a termination of contact between the cross threads that connect the laterally juxtaposed stitch chains and the sinker nibs before the needles can move downward to a point where the yarn within the needle hooks can clear the sinker nibs. By reason of the above, and because of the upward tension pull upon the yarn within the needle hooks and the horizontal tension pull of the knitted fabric upon the needles, there is an unrestrained upward movement of the loops along the needle until contact is made between the yarn within the needle hooks and the loops that are around the needle. This results in an excessive impact between the yarn within the needle hooks and the loops before the loops have been drawn to their stitching position upon the sinker blades.

Further, in conventional warp knitting, the yarn is carried by a yarn guide which is not capable of accurately directing the yarn in its path to the needles, from the yarn guide. As a result, it has been necessary for the yarn guides to move in a path which is below the projected position of the needles with the yarn guides moving between the projected needles. As a consequence, the machine speeds has been limited by the danger that the yarn guides would strike the needles at excessive speeds.

An object of the presen. invention is to provide warp knitting machines capable of effective and reliable operation at faster machine speeds.

A further object of the invention is to reduce the tendency of the yarn to miss or to contact the point of the hook of the needle.

Still another object of the invention is to perform warp knitting with a minimum of yarn tension and to maintain a uniform tension upon the yarn as it is laid upon the shank of the needle in position to engage the hook thereof.

A further object of the invention is the provision of warp knitting apparatus in which the yarn is moved around the needles and placed within a hook thereof with greater accuracy than has heretofore been possible.

Another object of the invention is the provision of warp knitting apparatus in which the yarn guides are specially formed to more accurately guide the yarn and are moved through a path above the projected needles so that the yarn guides cannot strike the needles.

Still another object of the invention is the production of warp knitting fabrics having fewer imperfections therein.

Still another object of the invention is the provision of warp knitting apparatus capable of reliable operation employing a shorter needle stroke.

In accordance with the invention, the forward extremity of the knitting needle adjacent the hook thereof is arched away from the point of the needle and the rear adge of the main body or shank of the needle is formed with a longitudinally extending groove. A hook plate having a hook which faces the hook of the knitting needle is slidably mounted within the longitudinal groove of the knitting needle. The knitting needle and its associated hook plate are operated in conjunction with a sinker having a nib section for holding the yarn loop downwardly at a predetermined level so that the yarn loop will not follow the knitting needle in its upward projection. The sinker is also formed with a lower knockover section which functions to hold the yarn loop upwardly to maintain the yarn loop at predetermined level while the knitting needle is retracted to draw the fresh yarn loop through the previously knitted yarn loop which is held by the hook of the hook plate while the knitting needle retracts to draw the fresh yarn loop through the previously knitted yarn loop. The nib section of the sinker also functions to remove the previously knitted yarn loop from the hook of the hook plate when the hook plate is projected.

Further in accordance with the invention, the warp yarn is laid around and within the hook of the needles with the assistance of a slide plate. The warp yarn is laid over the slide plate which guides the yarn into the arched portion of the needle as the yarn guides move from the rear of the needles to the front of the needles. The rear of the needles is the grooved edge thereof.

Still further in accordance with the invention, the

warp yarns are tensioned by means which function as a part of the guide bar rocker shaft. More particularly, the improved tension device in accordance with the invention participates with the yarn guides in a to-and-fro movement. As the yarn guides are moved to their extreme position in back of the needles, the motion of the yarn tension device is in a downward direction toward the needles. As the yarn guides are moved forwardly to their extreme forward position in front of the needles, the tension device is moved in an upward direction away from the needles. As a result, a more uniform tension is applied to the yarn.

Also in accordance with the invention, the yarn guides are formed with a yarn guiding aperture the lower edge of which is horizontal and the yarn guide is formed so that the yarn supplied is maintained in engagement with the said horizontal lower edge and the yarn guides are moved through a path above the projected position of the needles so that the danger of having the guides strike the needles at high machine speeds is eliminated.

Fig. 1 illustrates the assemblage of operating elements which is employed in warp knitting in accordance with the invention.

Fig. 2 is a side elevation partly in section, showing the hook needle, hook plate combination of the invention.

Fig. 3 is a section taken on line 3—3 of Fig. 2.

Fig. 4 is a side elevation showing a slide plate and the block upon which the slide plate is mounted.

Fig. 5 is a plan view of the slide plate and supporting block structure shown in Fig. 4.

Fig. 6 is a partial front elevation showing a yarn guide in accordance with the invention.

Fig. 7 is a side view of the yarn guide shown in Fig. 6.

Figs. 8–13 are partial side views illustrating in step by step manner the sequence of operations employed in the warp knitting method of the invention.

Fig. 9A is a front view showing the relationship of parts at that instant of the warp knitting operation shown in Fig. 9.

Figs. 10A, 11A, and 12A are front views similar to that shown in Fig. 9A with reference to Figs. 10, 11 and 12, respectively.

Fig. 14 is a cross-section showing the yarn guide assembly and the tensioning means employed to tension the yarn which is supplied.

Fig. 15 is a diagrammatic side elevation showing an illustrative preferred structure which enables the operation of Figs. 8–13 to be performed.

Fig. 16 is a detailed view illustrating the mechanism for moving the yarn guides from side to side.

The numeral **10** designates a knitting needle having a hook **11** which is mounted in a needle bar **12** for reciprocation along the length of the needle by the needle bar reciprocating mechanism **13** which is moved back and forth as indicated by the double-ended arrow **14**.

Cooperatively disposed adjacent the needle **10** is a hook plate **15** which is mounted upon a hook plate bar **16** for reciprocation in the direction of the length of the needle by means of the hook plate bar reciprocating mechanism **17**, as indicated by the double-ended arrow **18**.

Cooperatively disposed alongside the needle **10** and the hook plate **15** is a sinker **19** which is positioned to substantially slidingly contact the sides of the needle **10** and which is mounted upon the sinker bar **20** for reciprocation in a direction transverse to the length of the needle and in the plane of the width of the needle by means of the sinker bar reciprocating mechanism **21**, as indicated by the double-ended arrow **22**.

Disposed above the sinkers **19** and substantially parallel with respect thereto is a slide plate **23** which is positioned in the plane of the needle **10**. The slide plate **23** is mounted upon the slide plate bar **40** by connecting means **24** for reciprocation in a direction transverse to the length of the needle and in the plane of the width of the needle by means of the slide plate bar reciprocating mechanism **25**, as indicated by the double-ended arrow **26**.

Disposed above the needles **10** and the slide plates **23** are pairs of yarn guides **27**, and **28** which are mounted upon the guide bars **29** and **30**. These guide bars are swung back and forth between a position in front of the needles **10** to a position in back of the needles **10**. This swinging movement is effected by the guide bar swinging mechanisms **31** and **32**, which are pivoted as is generally indicated by the double-ended arrow **33**. The guide bars **29** and **30** are also shifted from side to side by the mechanism shown in Fig. 16 so that they will traverse the path shown in Fig. 9A–12A.

Figure 2 illustrates the structure and relative disposition of the needle **10** and the hook plate **15**. As can be seen the hook **11** of the needle **10** is disposed at the upper extremity of the needle at the end of an arched portion **34** so that the hook **11** is set back from the rear edge of the main body portion or shank of the needle **35**. The rear edge **36** of the shank **35** is grooved longitudinally as indicated by the numeral **37**. The groove **37** extends to a depth such that a line projected upwardly along the bottom of the groove toward the hook **11** will just clear the hook **11**.

The upper end of the hook plate **15** is formed with a hook **38** which faces the hook **11** of the needle **10**. The front of the hook plate is mounted in the groove **37** of the shank **35** for sliding movement therein. As can be seen, the hook **38** will just miss the hook **11** as the hook plate **15** and the needle **10** are reciprocated as indicated by the arrows **14** and **18**. The hook **38** can enter the groove **37** to engage a yarn loop positioned on the shank **35** of the needle **10**. The hook **38** may be grooved as shown at **38'**.

Figure 3 is a side view of Fig. 2 and it can be seen that in the form of the invention illustrated, the needle **10** is thicker than the hook plate **15** along the shank of the needle so that the hook plate **15** can be slidably disposed within the groove **37**. As a result, the hook plate **15** is guided by the needle **10** and perfect alinement is assured. The upper end portion of the needle **10**, e.g., the arched portion **34**, and the hook **11** are conveniently of the same thickness as the hook plate.

The yarn slide plates of the invention are more clearly shown in Figs. 4 and 5. The yarn slide plates **23** are formed of a thin plate of steel or other material of similar characteristics. One end of the slide plates is free, and the opposite ends are cast in blocks forming the slide plate bar **40**, these blocks being removably mounted in line upon the reciprocating mechanism **25** (see Fig. 1). An aperture **41** is formed in the blocks to enable securement of the blocks to the reciprocating mechanism **25**.

The yarn slide plates may be of any thickness that will support the yarn without flexing. Normally, the yarn slide plates are cast in the same gauge as the needles and are moved in a to-and-fro motion with a substantial dwell at both extremities of movement.

Referring more particularly to Fig. 4, the upper surface of the plate **23**, as it extends away from the block is smooth and a forwardly extending finger portion **42** is situated at the upper portion of the plate. The surface **43** below the finger portion **42** and in back of the same is shaped to conform to the hook section of the needle. The lower end of the forward extremity of the slide plate tapers rearwardly as indicated at **44**.

The yarn guides **27** and **28** are more clearly shown in Figs. 6 and 7 where the yarn guides are identical and only the yarn guide **27** is shown. As can be seen, the guide **27** is formed of wire which is bent to provide a stem portion **45**, an opening **46** and a tail section **47**. As previously indicated, the guides **27** and **28** are mounted upon the yarn guide bars **29** and **30**.

The opening **46** is triangularly shaped and includes a

horizontal bar **48** and inclined portions **49** and **50** which are joined at their lower ends by the said horizontal bar **48**. The inclined portions **49** and **50** provide a camming action to the yarn as the yarn is moved by the movement of the guides **27** and **28**. The inclined portion **49** is also inclined with respect to the stem **45** as can be seen in Fig. 6. The yarn is inclined upon an angle greater than the angle of the wire guide so that the yarn will remain in contact with the bar **48**. This is an important feature and it assures precise lateral positioning of the yarn at all times. The opening **46** is closed by the tail portion **47** which includes an inclined portion **51** directed upwardly toward the stem **45** and a terminal portion **52** which is directed upwardly and away from the stem **45** to facilitate threading of the yarn in the opening **46**.

In threading the guides **27** and **28**, the yarn is passed between the yarn guides and is placed against the stem **45** above the tail portion **47**, and on the side of the stem **45** facing the tail portion **47**. The yarn is then passed into the opening **46** by sliding the yarn toward the bar **48** with sufficient force to cause the yarn to pass by the bend **53** (see Fig. 7).

The structure of the sinkers **19** will become apparent from the description of the operation of the warp knitting procedure of the invention which is sequentially depicted in Figs. 8, 9, 10, 11, 12 and 13 and which will now be discussed.

Referring to Fig. 8, the yarn guides **27** and **28** are positioned in front of the needle **10** which is shown in its fully retracted position. The yarns Y and Y' are caught within the hook **11** to form the loop L and the previously knitted yarn loop L' has just been cast off. Fig. 8 therefore shows the cast off position. The hook plate **15** is rising as indicated by the arrow **60**, this hook plate **15** while moving upwardly having just effected the casting off of the yarn loop L' as will be more fully described hereinafter. The hook **38** of the hook plate **15** is well above the hook **11** of the needle **10**. The yarn slide plate **23** is positioned above the needle **10** and the hook plate **15** and is being retracted as indicated by the arrow **61**. The sinker **19** is being projected as indicated by the arrow **62**.

Referring more particularly to the sinker **19**, this sinker includes a main body portion **63** at the forward extremity of which is formed a lower nib **64** which serves to prevent the yarn loop L from moving to a position lower than a predetermined level and an upper short nib **65** which serves to hold the yarn loop L down when the sinker **19** is sufficiently projected to enable the upper nib **65** to reach the loop L. The action of the nibs **64** and **65** will be more fully described later when the portions of the knitting cycle in which these nibs participate is described.

Referring to Fig. 9, the hook plate **15** has now been fully projected so that the hook **38** is above the lower surface of the upper nib **65**, the yarn slide plate **23** is fully retracted and the yarn guides **27** and **28** are moving rearwardly as indicated by the arrow **66** toward the rear of the needle **10** but are in front of the needle. It will be observed that the needle **10** has been fully projected. In this fully projected position of the needle **10**, the hook **38** of the hook plate **15** has just entered the groove **37** and the shank **35** of the needle extends across the opening between the nibs **64** and **65** of the sinker **19** which is also fully projected. The yarn loop L is positioned in the space between the nibs **64** and **65** as a result of the knitted fabric having been caught and held down by the lower surface of the upper nib **65** as the needle **10** was projected. It will be especially observed that yarn guides **27** and **28** pass above the projected needles **10** and the two cannot strike irrespective of machine speed. This is shown with particular clarity in Fig. 9A.

Referring to Fig. 10, the sinker **19** has remained in its fully projected position, the needle **10** has remained in its fully projected position and the hook plate **15** is being retracted as indicated by the arrow **67**. It will be observed that the hook **38** of the hook plate **15** has moved downwardly within the groove **37** and is about to enter the loop L, the purpose of which will become apparent later. At the same time, the yarn guides **27** and **28** have moved rearwardly to their extreme rear position in back of the needle **10** and these guides have been shifted from side to side as can be seen by comparing Figs. 9A and 10A. The slide plate **23** is being projected as indicated by the arrow **68** and the slide plate **23**, the yarn guides **27** and **28** and the needle **10** all cooperate to wrap the yarn Y around the needle. The wrapping action will be more fully described hereinafter. It will be observed at this point that the yarns Y and Y' have moved past the sides of the needle **10** and partially across the needle **10** where they have been caught by the advancing slide plate **23** (see Fig. 10A). Additionally, the needle **10** is about to be retracted a short distance as indicated by the arrow **69** for a purpose which will be evident in Fig. 11.

Referring to Fig. 11, the short retraction of the needle **10** has moved the yarn loop L to the lower portion of the space between the nibs **64** and **65** into engagement with the upper surface of the nib **64**. The purpose of this is to hold the yarn loop L to facilitate entry and retention of the yarn loop by the hook **38** of the hook plate **15**. As can be seen in Fig. 11, the hook **38** has entered the loop L. The slide plate **23** is now fully projected and the relative positions of the projected slide plate **23** and the hook **11** of the needle **10** can be clearly seen.

In Fig. 10, the yarn Y' has been laid in the arched portion **34** of the needle **10** and in Fig. 11, the finger **42** is engaging the yarn Y' to guide the yarn into the hook **11** along the arched portion **34**. At the same time, the yarn guide **28** has moved the yarn Y into engagement with the tapered portion **44** of the slide plate **23** which acts as a guide to lay the yarn Y into the arched portion **34** of the needle **10**.

In Fig. 12, the yarn guides **27** and **28** are moving forwardly and the yarn Y has been guided into the rearwardly arched portion **34** of the needle **10** to be safely trapped within the hook **11**. The needle **10** is about to be retracted and the sinker **19** is also about to be retracted.

The front views showing Figs. 9A, 10A, 11A and 12A when taken in conjunction with Figs. 8–13 will clearly show the path of the yarn guides **27** and **28**. This path is always above the needle **10** and the yarns Y and Y' are always in contact with the horizontal bar **48**.

In Fig. 13, the needle **10** is almost fully retracted as indicated by the arrows **70** and the sinker **19** is fully retracted so that the upper nib **65** is no longer in contact with the knitted fabric whereby the yarn loop L is free to rise except for the presence of the hook **38** on the hook plate **15**. The hook plate **15** is about to be projected as indicated by the arrow **71**. As will be evident, projection of the hook plate **15** will remove the hook **38** from the loop L and this loop, as a result of the retraction of the needle **10** and the presence of the lower nib **64**, is above the hook **11** on the needle **10**. Thus, projection of the hook **38** will free the loop L and cause the same to be cast off over the top of the hook **11**. The yarn guides **27** and **28** are now fully in their extreme forward position and the new loop on the needle **10** is fully formed in the hook **11**. The slide plate **23** is about to be retracted.

It will be observed that the difference between Figs. 13 and 8 is the fact that in Fig. 8, the hook plate **15** has been projected to cast off the yarn loop (now identified as L') and the sinker **19** has been projected to be in position for the start of the next knitting cycle. A further difference is the side to side shift of the yarn guides **27** and **28** which are shifted in the time period from Fig. 13 to Fig. 8 to once again resume the lateral position shown in Fig. 9A.

It will be seen from the foregoing description of the operation procedure of the warp knitting apparatus of the invention that the invention permits the use of a

short needle stroke. This stroke is shorter than is permissible with knitting machines which employ yarn guides which pass between the needles or in machines which employ latch or spring board needles in place of the hook plate **15**.

It will also be seen that when the yarn guides are moved to lay the yarn between and in front of the needle, that there is no release of yarn tension upon the yarn so that the yarn is securely and accurately placed between the needles and the yarn slide plates at high machine speeds. After the yarn has been positioned between the slide plates, the yarn guides are moved to position the yarn upon the top surface section of the plate next in line and the yarn is made to contact the tapered section of the hook needle in the same position in each knitting cycle of the machine as the yarn guides are moved to their rear position.

The yarn slide plates function from a rocker shaft position to their to-and-fro movement, and stay in line with the needles to permit the yarn to be drawn around the needle much more accurately than machines that have to depend upon the position of the guide bar exclusively to position the yarn as it is drawn in back of and around the needles.

It will also be seen that by the use of the needle hook plate to intercept and hold the previously formed loops, that the yarn loop on the shank of the needle is positively engaged and effectively released at the proper time. Moreover, the point of the needle hooks makes a sliding contact with the rounded section of the hook upon the hook plate, as compared to the possible end to end contacts between the hook and tongue elements of other types of tongue and groove needles.

It will also be noted that by the use of the previously described needle, that the hook section of the needle hook plate holds the yarn loops in position over the sinker so that the sinker nibs may be withdrawn from between the needles much more slowly and smoothly than is possible in machines that use other types of needles in a wrap knitting process.

It will also be evident that by the use of tension which is applied more uniformly to the yarn that greater machine speeds may be attained.

A feature of the invention is the provision of more uniform tension to the yarn between the warp beam and the needles than is possible in the stationary or conventional tension. An advantage of this is that when the machine is stopped and started in a knitting process, the stitches that are in the process of being formed at the stopping point, will remain in the same proportion as to length as the stitches that are formed in a continuous knitting operation. One feature of the improved yarn tensioning means is a to-and-fro movement relative to the movement of the yarn guides. More particularly, as the yarn guides are moved to the extremity of their motion in back of the needles, the yarn tensioning means is moved in a downward direction toward the needles. As the yarn guides are moved forward to their position in front of the needles, the yarn tensioning means is moved in an upward direction away from the needle, imparting a lifting effect upon the yarn by reason of the upward motion of the yarn tensioning means and the frictional contact between the flexing section of the yarn tensioning means and the yarn.

The yarn tensioning means is shown in Fig. 14 and is constructed of a springy plate **72** of steel or other material of uniform thickness to provide a flexing action. The plate **72** extends longitudinally along the length of the yarn guide bar. One lateral portion of the springy plate **72** is free and unsupported, while the opposite lateral portion is supported between two plates of metal **73** and **74** which are arranged, one upon each side of the steel plate **72**, by means of suitable rivets or bolts which join the three pieces securely together. The combined structure is rigidly supported along its length by arm member **75**. The arm member **75** is rigidly mounted upon the guide bar rocker shaft **76**. As a result, and as can be seen in Fig. 14, the springy plate **72** moves with the guide **27**. The yarn Y frictionally engages the plate **72** in its passage to the yarn guide **27**. In the same manner, the plate **72'** is engaged by yarn passing to the guide **28**.

Any suitable means may be employed to provide the necessary timed movement which is specifically shown in Figs. 8–13. Suitable means for this purpose are illustratively presented in Figs. 15 and 16.

Referring particularly to Fig. 15, the numeral **80** designates a main cam wheel having a plurality of cam tracks thereon, the followers **81**, **82**, **83** and **84** bearing against the cam tracks on the cam wheel **80**. The movement of the followers **81**, **82**, **83** and **84** regulates the time movement of the needle bar **12**, the hook plate bar **16**, the sinker bar **20**, the slide plate bar **40**, and the yarn guide bars **31** and **32**, which are all shown in their assembled relation in Fig. 1 with arrows indicating the movement which is to be effected. The description which follows of Fig. 15 will be better understood if it is taken in conjunction with the assembled relationship and movements shown in Fig. 1.

Referring first to the needle **10**, movement thereof in the direction indicated by the double-ended arrow **14** is achieved by mounting the needle bar reciprocating mechanism **13** on the end of an arm **85** which is secured to a sleeve **86** mounted for rotation on a rocker shaft **87**. The sleeve **86** is secured to an arm **88** which is connected to the follower **84**. As the follower **84** is moved toward and away from the cam wheel **80**, as indicated by the double-ended arrow **89**, the arm **85** is oscillated as indicated by the double-ended arrow **90** and the needle bar reciprocating mechanism **13** is moved back and forth as indicated by the double-ended arrow **41**.

Referring next to the hook plate **15**, the necessary movement of the hook plate bar reciprocating mechanism **17** in the direction indicated by the double-ended arrow **18** is achieved in the following manner. The hook plate bar reciprocating mechanism **17** is secured on the end of an arm **91** which is slidably disposed for longitudinal movement in an aperture in the needle bar reciprocating mechanism **13**, as diagrammatically shown in Fig. 15. In this manner the needle **10** and the hook plate **15** are independently reciprocated while they are maintained in alinement. The lower end of the bar **91** terminates in a pin **92**, to which is pivotally secured a bracket **93**. The lower end of the bracket **93** is secured to a pin **94** projecting from an arm **95** which is mounted for rotation on a shaft **96**. The arm **95** is provided with a lower projection portion **97** upon which is mounted a pin **98**, to which is pivoted a connecting rod **99**. The connecting rod **99** is pivotally mounted on a lever member **100** as indicated at **101**, the lever member **100** being fixed to a rocker shaft **102** for swinging movement as the shaft rotationally oscillates. Also fixed to the rocker shaft **102** is an arm **103** which is connected with the slide plate reciprocating mechanism **25**, the lower end of the arm **103** being constituted by a sleeve **104** which is keyed to the rocker shaft **102**. An arm **105** is fixed to the sleeve **104**, at one end, and to the follower **83**, at the other end, so that movement of the follower **83** toward and away from the cam wheel **80** as indicated by the double-ended arrow **106** will cause rotational oscillation of the rocker shaft **102**, as indicated by the double-ended arrow **107**. As a result of this movement, the arm **100** oscillates as indicated by the double-ended arrow **108** and this movement, through the connecting rod **99**, causes the arm **95** to oscillate as indicated by the double-ended arrow **109**, and this oscillation is transmitted through the bracket **93** to the slidable arm **91** to effect reciprocation of the hook plate **15** as indicated by the double-ended arrow **18**. At the same time, the movement of the arm **105** oscillates the arm **103** as indicated by the double-ended arrow **110** to effect re-

ciprocation of the slide plate reciprocating mechanism **25** as indicated by the double-ended arrow **26**.

The arm **111** is freely pivoted to the rocker shaft **102**. Thus, the arm **111** employs the shaft **102** as a center of pivotal movement so that the sinker **19** will move in a plane parallel with the plane of movement of the slide plate **23**. However, the arm **111** is not oscillated by the rocker shaft **102** since the movement of the sinker is not timed with the movement of the slide plate. Instead, the arm **111** is separately actuated in the following manner. An arm **112** having a sleeve **113** at its lower end is keyed to the rocker shaft **96** and this rocker shaft **96** is rotationally oscillated by the arm **114** which is connected at one end to the shaft **96** and at the other end to the follower **82**. As the follower **82** is moved toward and away from the cam wheel **80**, the arm **114** is caused to oscillate as indicated by the double-ended arrow **115** and this results in an oscillation of the arm **112** as indicated by the double-ended arow **116**. This movement of the arm **112** is transmitted to the arm **111** by the pivotally mounted connecting rod **117** so that there results a movement of the sinker **19** as indicated by the double-ended arrow **22**.

The yarn guide reciprocating mechanisms **31** and **32** are moved together. As can be seen, these reciprocating mechanisms **31** and **32** are mounted for swinging movement about a rocker shaft **76**. As previously indicated, the yarn guides **27** and **28** are caused to move through a path as indicated by the double-ended arrow **33**. Additionally, at each end of the swinging movement, the yarn guides are shifted from side to side (see Figs. 9A, 10A, 11A and 12A). The movement with which we are here concerned is the movement indicated by the double-ended arrow **33**, the side to side movement being discussed later.

Connected to rocker shaft **76** is a lever arm **119** at the lower end of which is pivotally mounted a connecting rod **120** and the opposite end of the connecting rod **120** is pivoted to an arm **121**, the lower end of which is formed with a sleeve **122** which is keyed to the rocker shaft **87**, the rocker shaft **87** is rotationally oscillated by the arm **123** which is connected at one end to the rocker shaft **87** and at the other end to the follower **81**. As the follower **81** moves toward and away from the cam wheel **80**, the arm **123** is oscillated as indicated by the double-ended arrow **124** and the arm **121** is oscillated as indicated by the double-ended arrow **124'** to cause the yarn guide reciprocating mechanisms **31** and **32** to carry the yarn guides **27** and **28** through the path indicated by the double-ended arrow **33**.

It will be appreciated that the showing presented in Fig. 15 is diagrammatic, there being no effort made to show precise details of construction since these are in no way material to the invention. It is important, however, to note that the construction which has been presented represents only minor structural changes from conventional warp knitting reciprocating structure and these present structures can be modified as indicated in Fig. 15 so as to permit these structures to be employed in practicing the present invention.

The mechanism for moving the yarn guide reciprocating mechanisms **31** and **32** from side to side is shown in Fig. 16 and, since it is a conventional structure, it will only be briefly discussed.

Referring to Fig. 16, a cam wheel **125** is shown which is driven by the drive shaft **126** through the gears **127** and **128**. The yarn guide reciprocating mechanisms **31** and **32** each terminate at one end in a projecting stem **129** ending in a follower **130** which is biased against a track in the cam wheel **125** by means of the spring **131**. Since each of the reciprocating bars **31** and **32** are handled in the same way, and since, in Fig. 16 these bars are one behind the other, only one of the side to side shifting structures is shown. Each of the followers **130** bears against a separate cam track in the cam wheel **125**. Since this structure for moving the yarn guides from side to side is conventional, it will not be further described.

The invention is defined in the claims which follow.

I claim:

1. In combination, a hook needle comprising a main body portion and an arched portion with a hook disposed at the upper end of said arched portion, the said hook being set back from the rear edge of said main body portion, said rear edge of said main body portion being grooved along the length of said main body portion with said groove extending to a depth such that a line projected upwardly along the bottom of said groove will just clear the front of said hook, a hook plate having a hook facing said needle at the upper extremity thereof, said hook plate being cooperatively disposed with respect to said hook needle so that the hook of the hook plate can remove a yarn loop from the main body portion of said hook needle and thereafter release said yarn loop to cast the same over the upper end of the hook of said hook needle by being slidingly mounted within the said groove of the hook needle, the hook of said hook plate being dimensioned to be received within the groove of said hook needle, and a pair of yarn guides mounted for swinging movement back and forth between a position in front of said hook needle to a position behind said hook needle through a path above the projected position of said hook needle.

2. In a warp knitting machine, a hook needle and a slide plate, said hook needle comprising a main body portion and an arched portion, with a hook disposed at the upper end of said arched portion, the said hook being set back from the rear edge of said main body portion, said slide plate being positioned in the plane of said hook needle in a direction transverse thereto, said slide plate having a forwardly projecting finger at the upper end of the forward extremity thereof, the forward surface of said slide plate immediately beneath said finger conforming with the shape of the hook of said hook needle, means to reciprocate said slide plate in a direction transverse to the length of said needle.

3. In a warp knitting machine, a hook needle, a hook plate, a slide plate and a sinker, said hook needle comprising a main body portion and an arched portion with a hook disposed at the upper end of said arched portion, said hook plate having a hook at the upper end thereof facing said needle, said needle having a longitudinal groove in the main body portion thereof facing said hook plate with said groove being dimensioned to receive the hook of said hook plate, said slide plate being positioned in the plane of said hook needle in a direction transverse thereto, said slide plate having a forwardly projecting finger at the upper end of the forward extremity thereof, the forward surface of said slide plate immediately beneath said finger conforming with the shape of the hook of said hook needle, said sinker having a main body portion, a lower nib at the forward end of said main body portion and a short upper nib at the forward end of said main body portion, means to reciprocate said needle along the length thereof, means to reciprocate said hook plate in a direction parallel with the length of said needle, means to reciprocate said slide plate in a direction transverse to the length of said needle and means to reciprocate said sinker in a plane transverse to the length of said needle, said sinker being positioned alongside said needle and said hook plate and transverse thereto.

4. In a warp knitting machine, a hook needle, a hook plate, a sinker and yarn guides, said yarn guides being mounted upon guide bars which are pivotally secured to a rocker shaft, said hook needle comprising a main body portion and an arched portion with a hook disposed at the upper end of said arched portion, said hook plate having a hook at the upper end thereof facing said needle, said needle having a longitudinal groove in the main body portion thereof facing said hook plate with said groove being dimensioned to receive the hook of said

hook plate, said hook plate being slidably mounted in the groove of said needle, said sinker having a main body portion, a lower nib at the forward end of said main body portion and a short upper nib at the forward end of said main body portion, said yarn guides being mounted above said needle for swinging movement back and forth from the front of said needle to the rear of said needle and back again to the front of said needle, means to reciprocate said needle along the length thereof, means to reciprocate said hook plate in a direction parallel with the length of said needle, means to reciprocate said sinker in a plane transverse to the length of said needle, said sinker being positioned alongside said needle and said hook plate and transverse thereto, means to swing said yarn guides to wrap the yarn carried by said yarn guides around said needles, and a flexible tension plate carried by the rocker shaft to tension the yarn as said yarn passes from a beam to said yarn guides, said tension plate being swingable with said yarn guides to place the yarn under uniform tension during the various stages of the warp knitting operation.

5. In a warp knitting machine, a hook needle, a hook plate, a sinker, yarn guides and a slide plate, said hook needle comprising a main body portion and an arched portion with a hook disposed at the upper end of said arched portion, said hook plate having a hook at the upper end thereof facing said needle, said needle having a longitudinal groove in the main body portion thereof facing said hook plate with said groove being dimensioned to receive the hook of said hook plate, said sinker having a main body portion, a lower nib at the forward end of said main body portion and a short upper nib at the forward end of said main body portion, said yarn guides being mounted above said needle for swinging movement back and forth from the front of said needle to the rear of said needle and back again to the front of said needle, said slide plate having a forwardly projecting finger at the upper end of the forward extremity thereof, the forward surface of said slide plate immediately beneath said finger conforming with the shape of the hook of said hook needle, means to reciprocate said needle along the length thereof, means to reciprocate said hook plate in a direction parallel with the length of said needle, means to reciprocate said sinker in a plane transverse to the length of said needle, said sinker being positioned alongside said needle and said hook plate and transverse thereto, means to swing said yarn guides to wrap the yarn carried by said yarn guides around said needles and means to reciprocate said slide plate in a direction transverse to the length of said needle.

6. In a warp knitting machine, a plurality of hook needles mounted in a line, a plurality of hook plates mounted in a line facing said hook needles and a plurality of pairs of yarn guides, said hook needles comprising a main body portion, a hook disposed at the upper end of said needle and an arched portion between said hook and said main body portion, means to reciprocate said hook needles to project and retract the same in unison, said hook plates being mounted for reciproation in the plane of said hook needles, said yarn guides defining a yarn guiding aperture the lower end of which is constituted by a horizontal bar, said yarn guides being mounted for swinging movement back and forth between a position in front of said hook needles to a position behind said hook needles through a path above the projected position of said hook needles and said yarn guides being shaped to cause the yarn supplied through the same to be maintained in contact with said horizontal bar as said yarn guides are moved.

7. The combination recited in claim 6 in which said yarn guides comprise a wire bent to define a triangle with a horizontal lower bar and an open upper end.

8. The combination recited in claim 7 in which said wire is bent to provide a stem portion, a triangularly shaped portion including a pair of inclined portions joined at their lower ends by a horizontal bar, one of said inclined portions being inclined with respect to said stem portion at an angle greater than the angle of said yarn guide so that the yarn remains in contact with said horizontal bar as said yarn guide is moved.

9. The combination recited in claim 7 in which tensioning bars are carried with said yarn guides to maintain uniform tension upon the yarn supplied as the yarn guides are moved.

10. The combination recited in claim 8 in which the other of said pair of inclined portions terminates in a tail portion directed upwardly toward the stem portion, said tail portion terminating in a upwardly directed terminal portion directed upwardly away from said stem portion.

11. A method of warp knitting using a hook needle, a hook plate, a sinker, and yarn guides, said hook needle comprising a main body portion and an arched portion with a hook disposed at the upper end of said arched portion, said hook plate having a hook at the upper end thereof facing said needle, said needle having a longitudinal groove in the main body portion thereof facing said hook plate with said groove being dimensioned to receive the hook of said hook plate, said hook plate being slidably mounted in the groove of said hook needle said sinker having a lower nib and a short upper nib mounted at the forward end thereof and said yarn guides being mounted above said needle for swinging movement back and forth from the front of said needle to the rear of said needle and back again to the front of said said needle comprising projecting said needle, moving said yarn guides from the front of said needle through a path over said needle to the rear of said needle, holding the old yarn loop downwardly on the main body portion of said needle with the upper nib of said sinker, retracting said hook plate with respect to said needle to cause the hook of said hook plate to move downwardly within said groove into a position within the old yarn loop on the main body portion of said needle, retracting said sinker to remove the upper nib thereof from the path of said needle and simultaneously returning said yarn guides to their initial position in front of said yarn guides to their initial position in front of said needle to wrap the yarn around said needle, then retracting said needle while supporting the old yarn loop on the lower nib of said sinker so that the old yarn loop is retained by hook of said hook plate and then projecting said hook plate to release said old yarn loop above said needle.

12. A method of warp knitting as recited in claim 11 in which a slide plate having a forwardly projecting finger at the upper end of the forward extremity thereof is employed and is projected to a position directly over the projected needle while the yarn guides are moved to a position to the rear of the needle to engage the yarn supplied by the yarn guides.

13. A method of warp knitting as recited in claim 12 in which said slide plate is formed with the forward surface thereof immediately beneath said finger conforming with the shape of the hook of said hook needle and with the lower end of the forward extremity of said slide plate is tapered to the rear of said slide plate so that the yarn supplied is guided into the arch of said needle and hence into the hook thereof.

14. A method of warp knitting as recited in claim 11 in which the yarn supplied is tensioned by means which are moved with said yarn guides so that the tension applied to the yarn which is supplied is uniform as the yarn guides move back and forth.

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