# United States Patent [19]

**Hamano**

[11] **3,727,433**

[45] **Apr. 17, 1973**


[54] **METHOD AND APPARATUS FOR WARP KNITTING HOOK AND LOOP FASTENERS**


[75] Inventor: **Hisashi Hamano,** Soka, Japan

[73] Assignee: **International Knitlok Corporation,** New York, N.Y.



[22] Filed: **Nov. 17, 1970**

[21] Appl. No.: **90,415**

[52] **U.S. Cl.** .....**66/84,** 66/86, 66/147

[51] **Int. Cl.** .....**D04b 23/06**

[58] **Field of Search**.....66/86, 125 A, 149, 66/147; 28/74, 76



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*Primary Examiner*—Ronald Feldbaum

*Attorney*—Pennie, Edmonds, Morton, Taylor & Adams



[57] **ABSTRACT**

Novel warp knitting apparatus is disclosed for producing a knitted pile fabric suitable for use in a hook and loop fastener. In conjunction therewith, means are disclosed for heat setting the pile and for cutting pile loops to form hooks.


**12 Claims, 43 Drawing Figures**

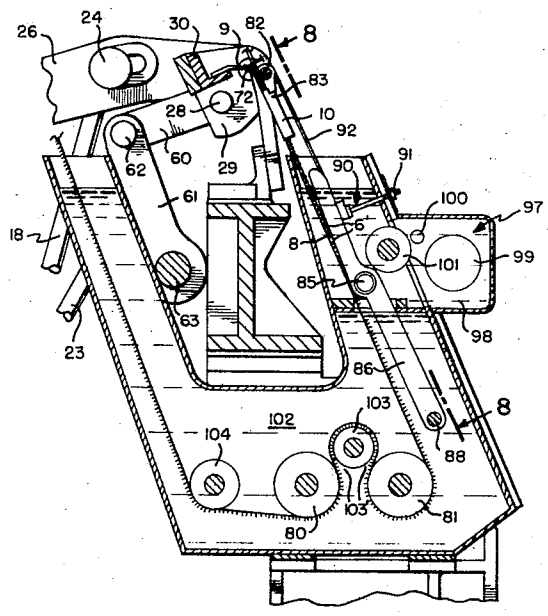
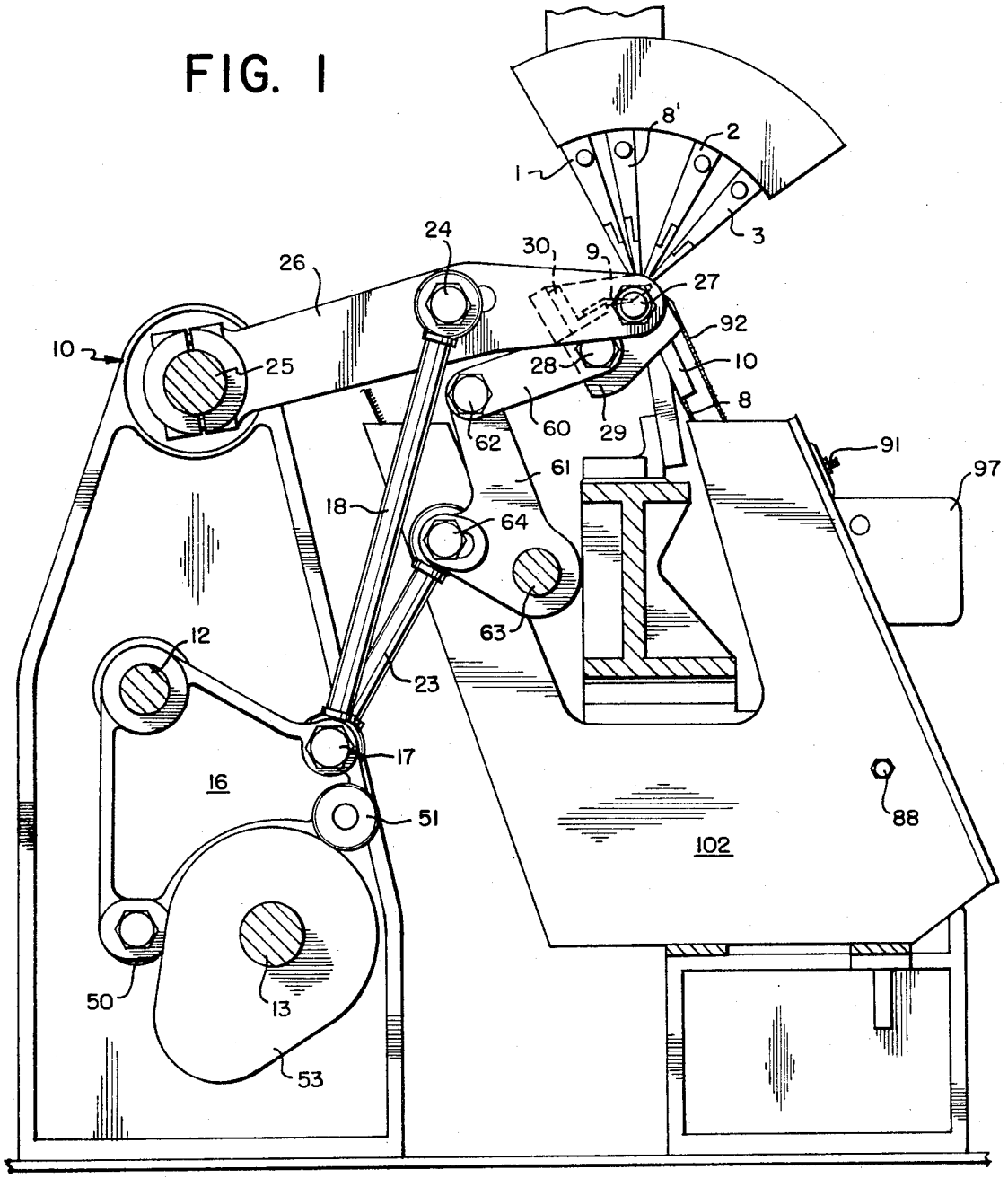


FIG. 1




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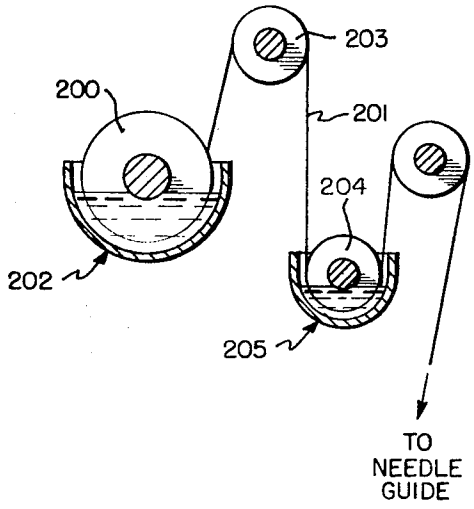



FIG. 2

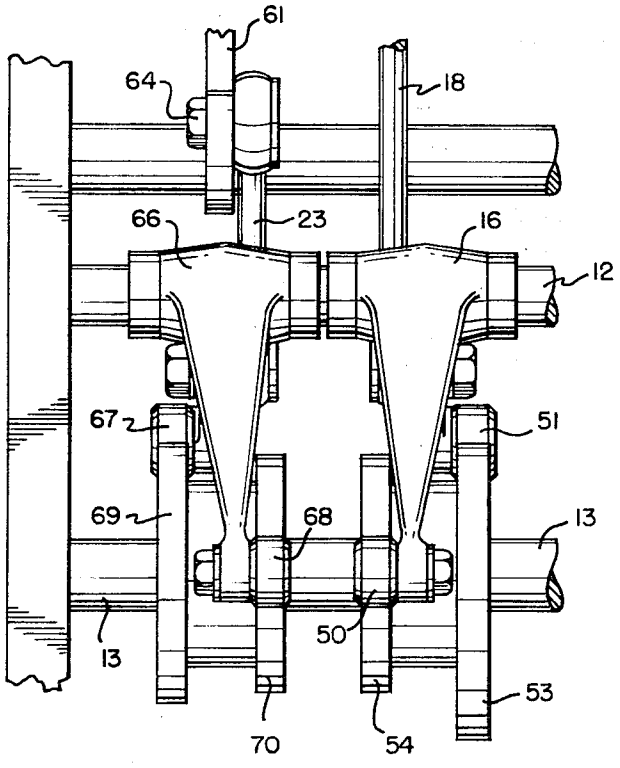



FIG. 3

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FIG. 2A

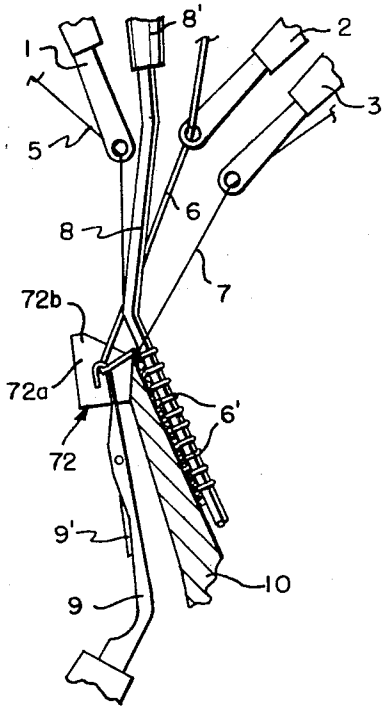



FIG. 2B

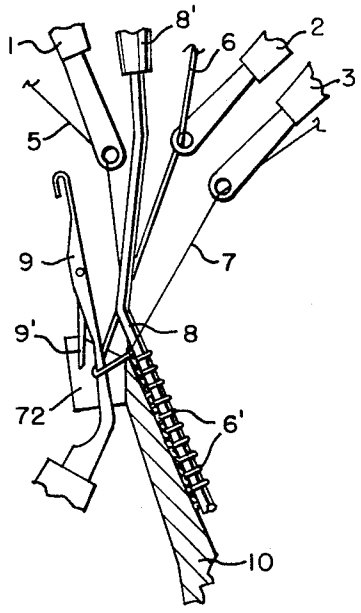



FIG. 2C

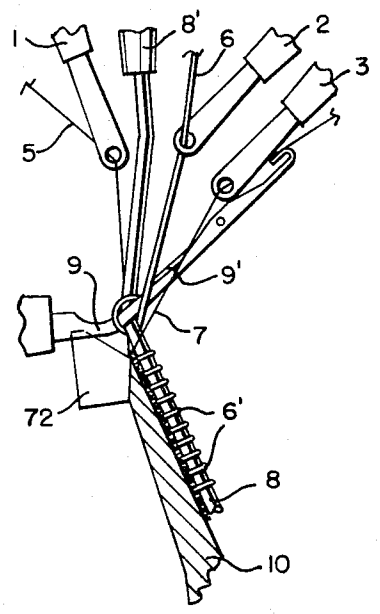



FIG. 2D

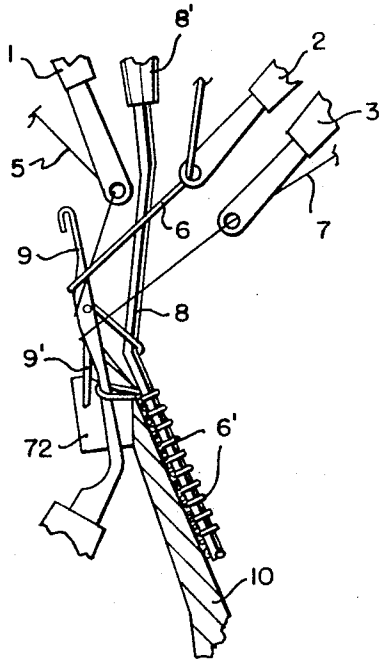



FIG. 2E

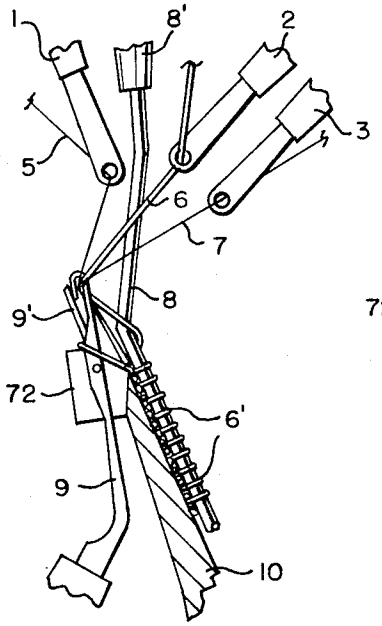
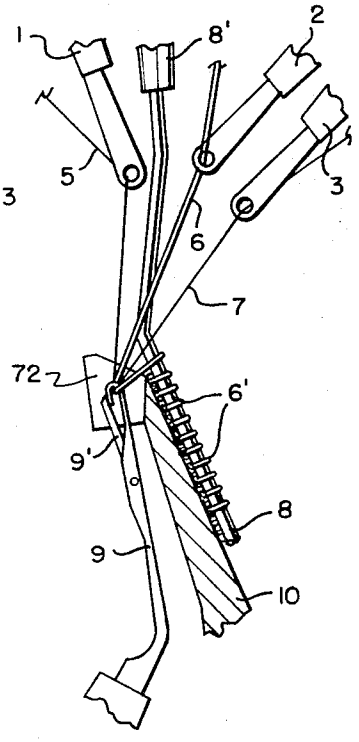



FIG. 2F




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FIG. 4

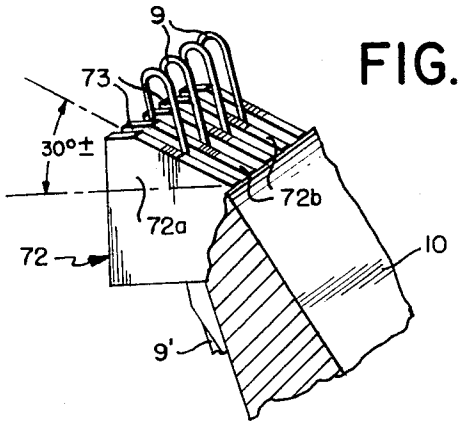
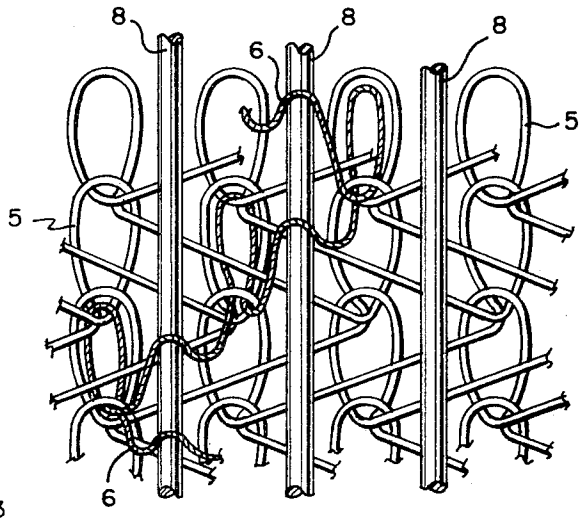



FIG. 5



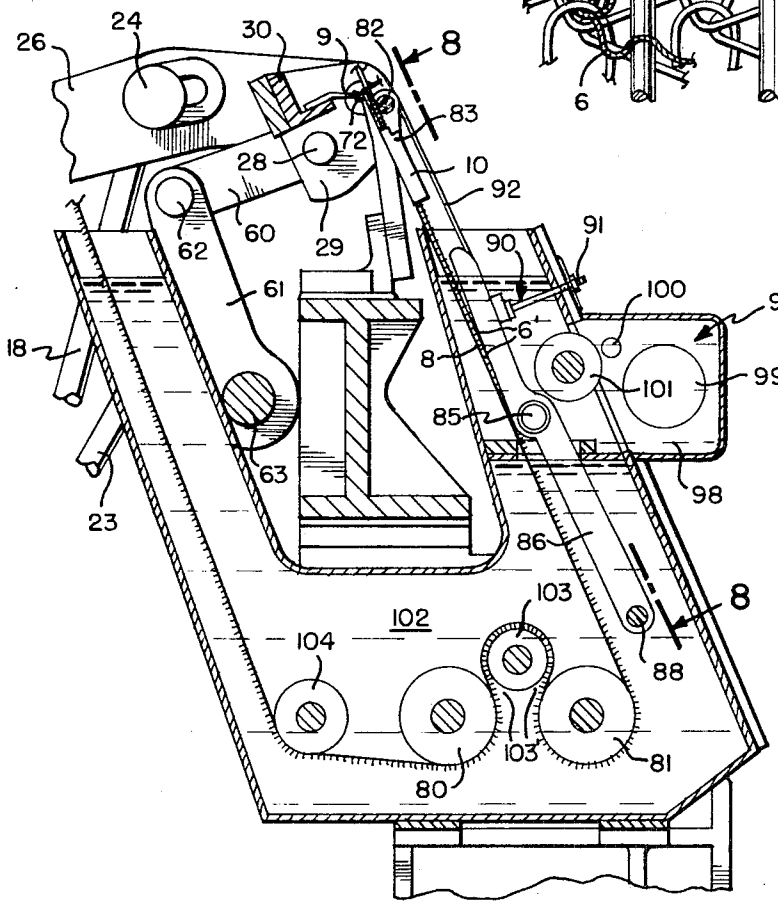




FIG. 7

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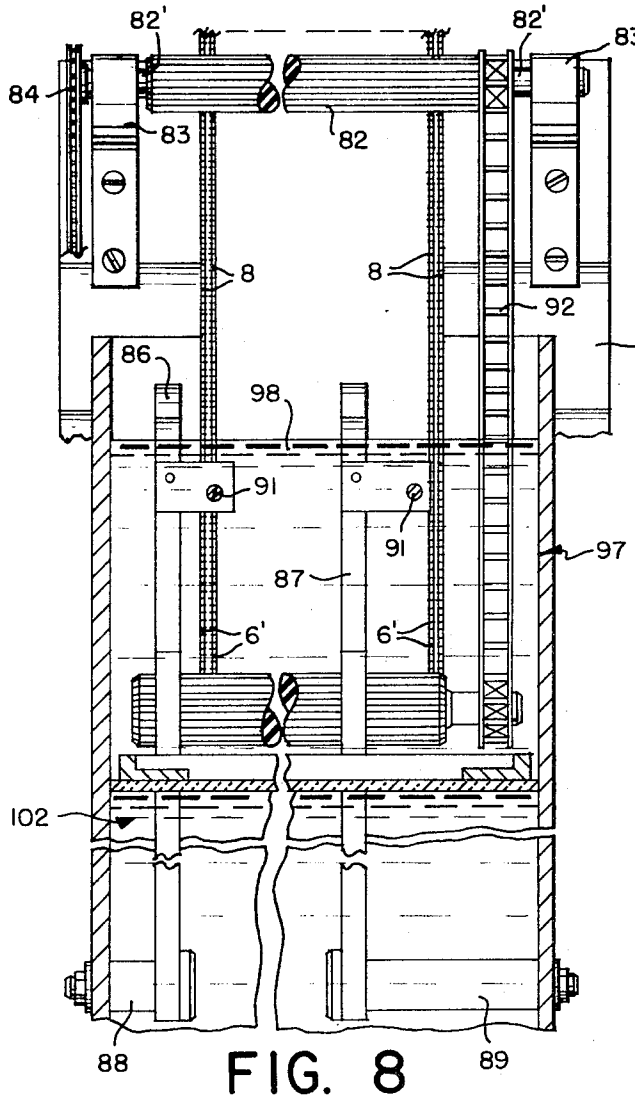



FIG. 8

FIG. 9

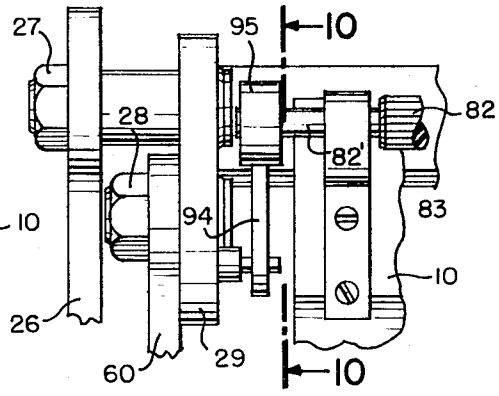
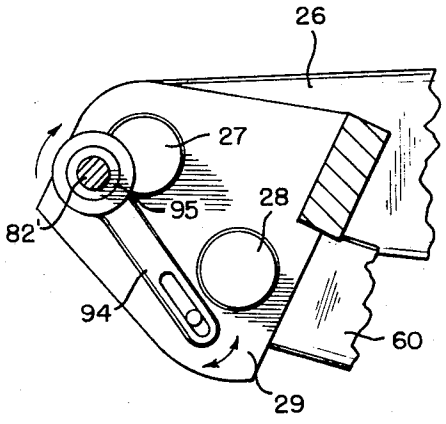



FIG. 10



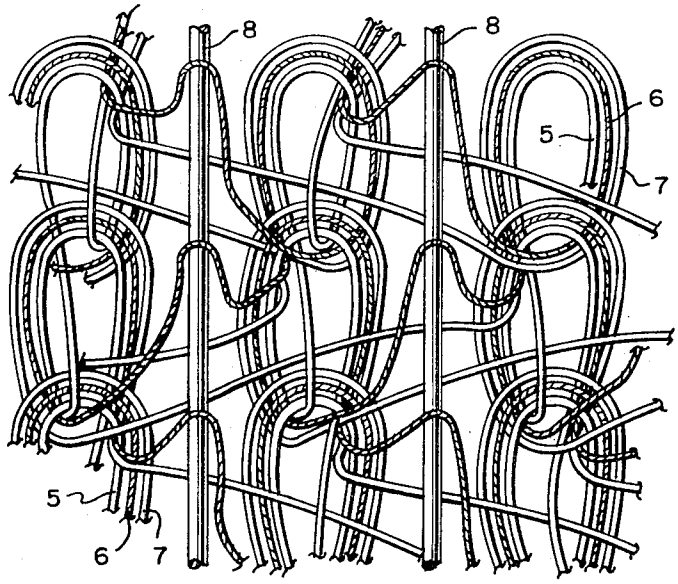




FIG. 6

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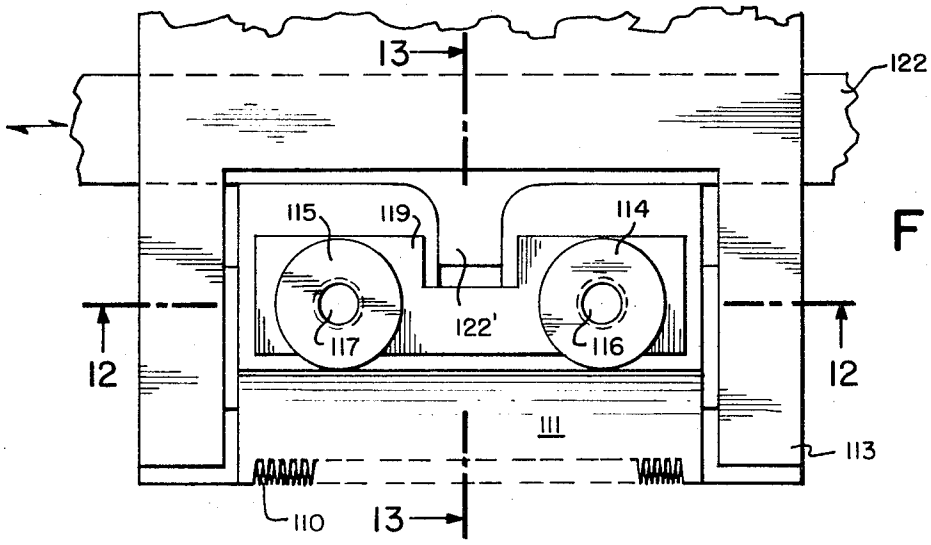



FIG. 11

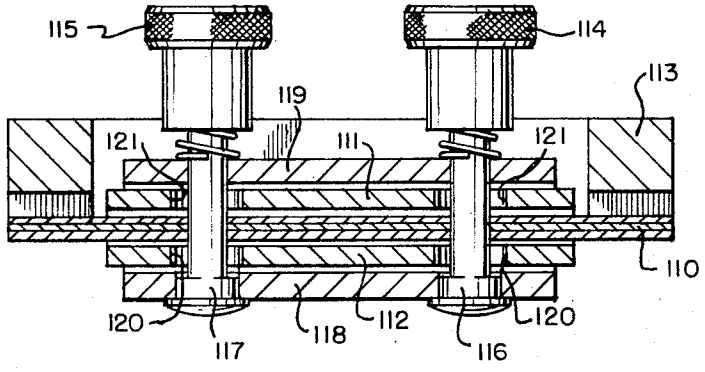



FIG. 12

FIG. 13

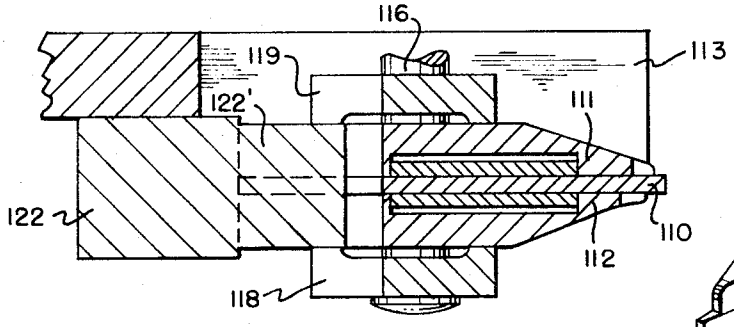
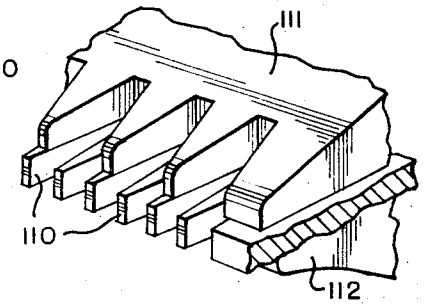



FIG. 14



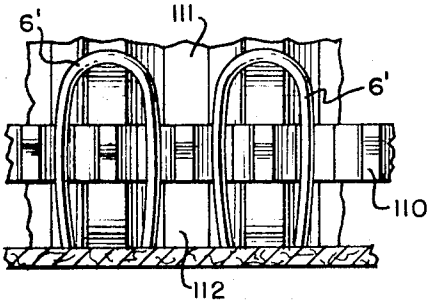




FIG. 15

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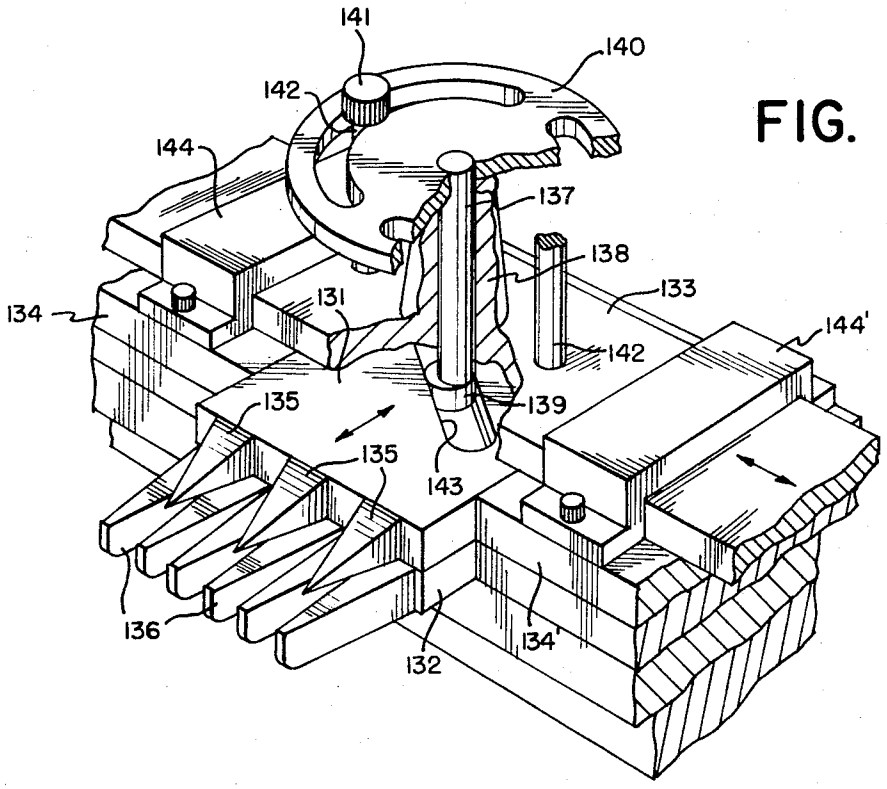
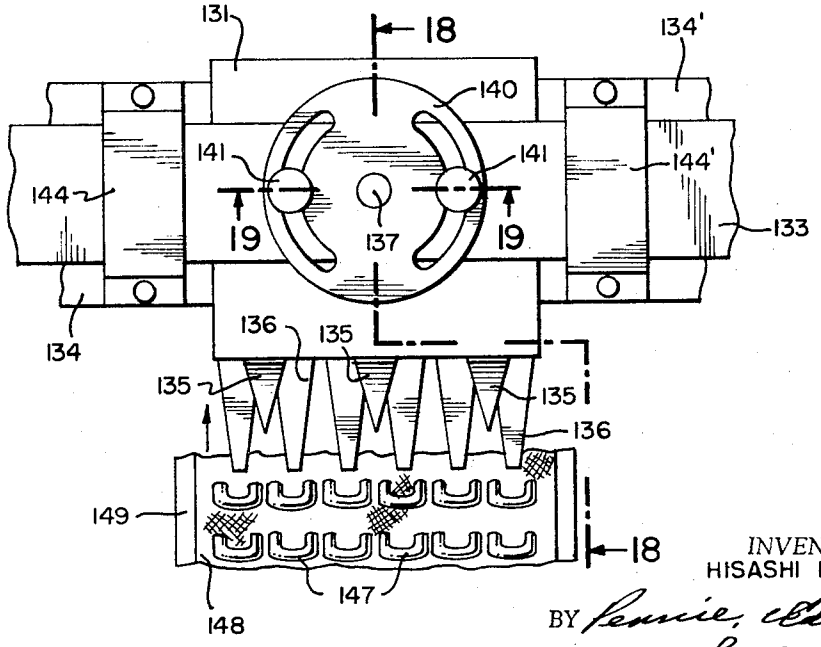



FIG. 16

FIG. 17




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FIG. 18

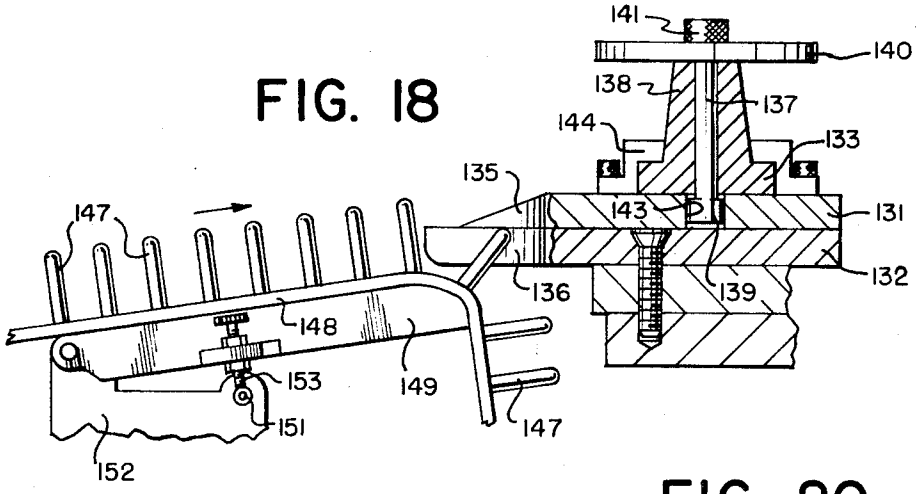



FIG. 19

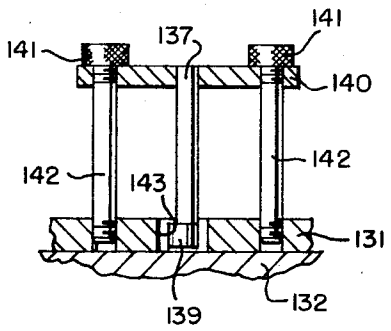



FIG. 20

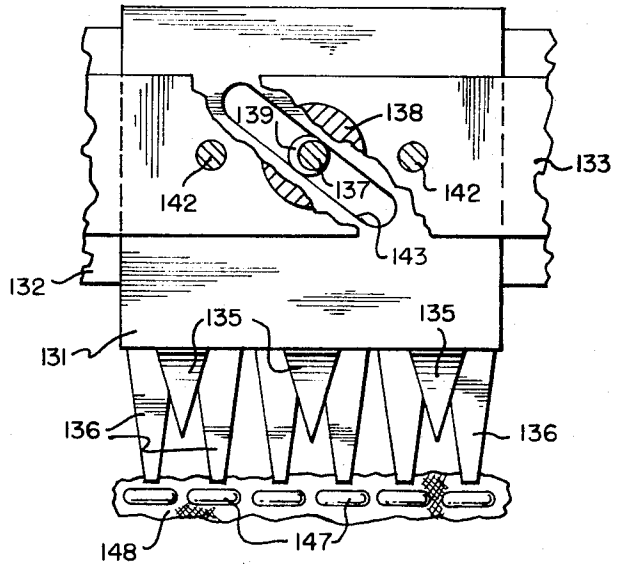



FIG. 22

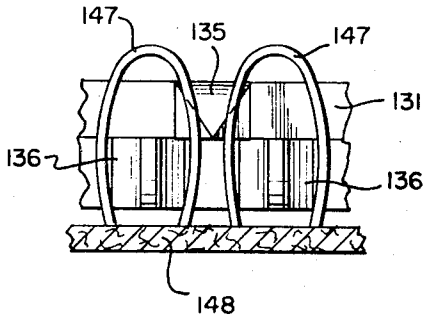
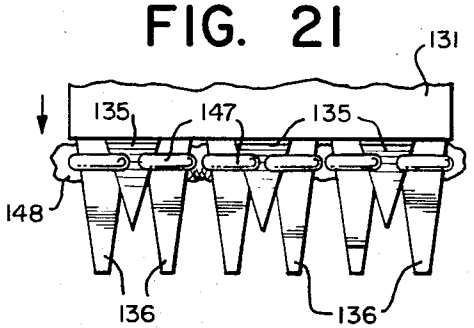



FIG. 21




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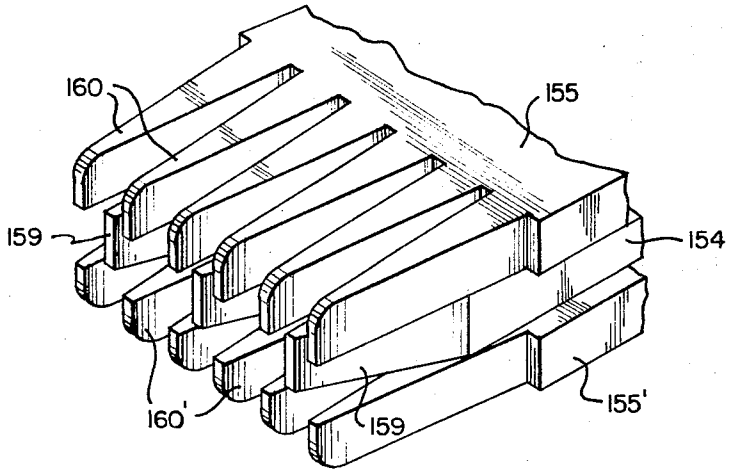



FIG. 23

FIG. 24

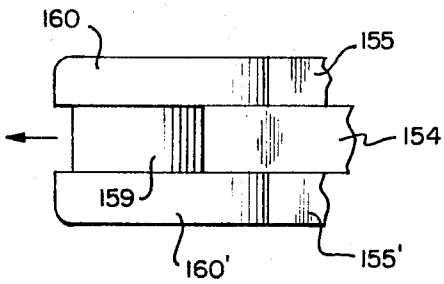
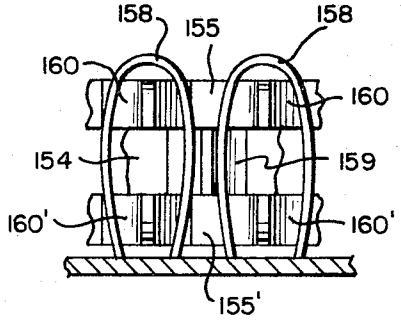



FIG. 25



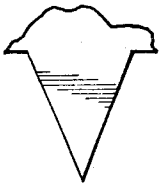



FIG. 26

FIG. 28

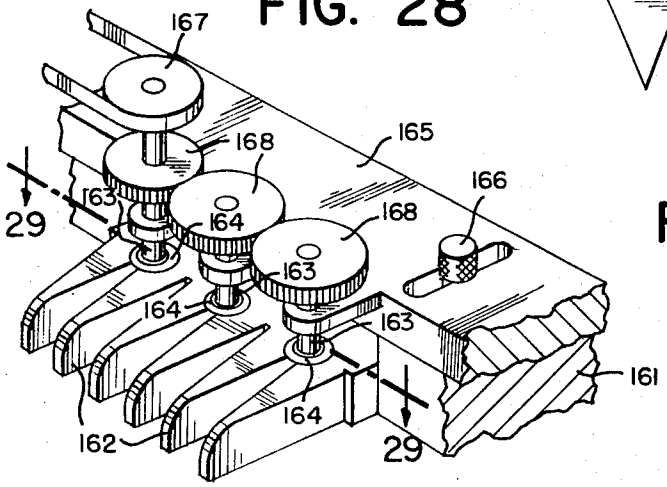
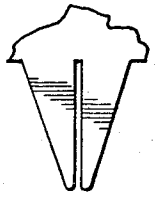



FIG. 27



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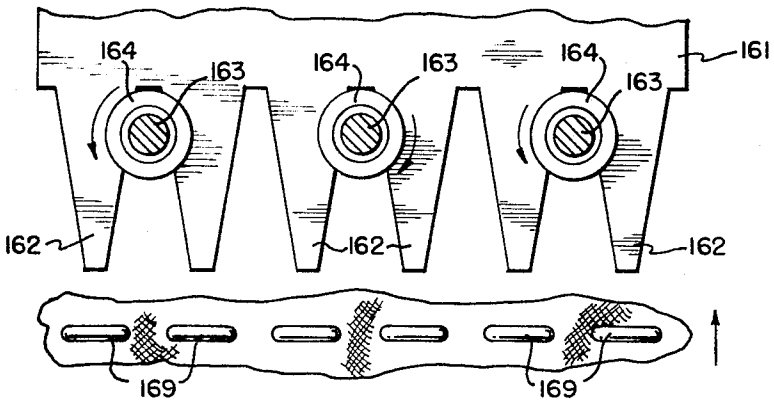



FIG. 29

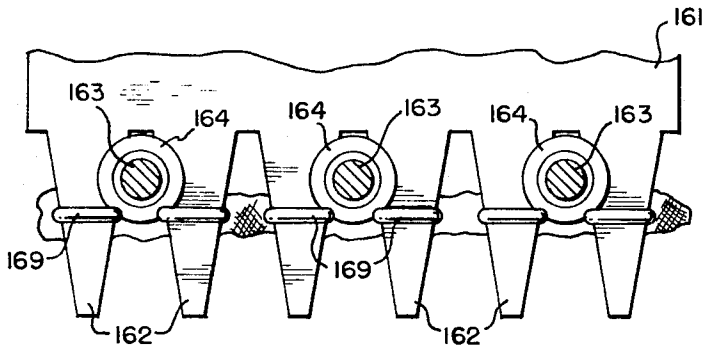



FIG. 30

FIG. 31

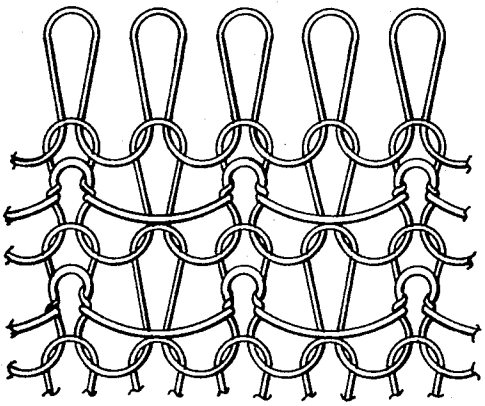


FIG. 32

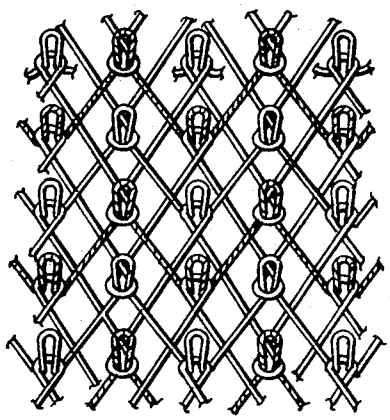
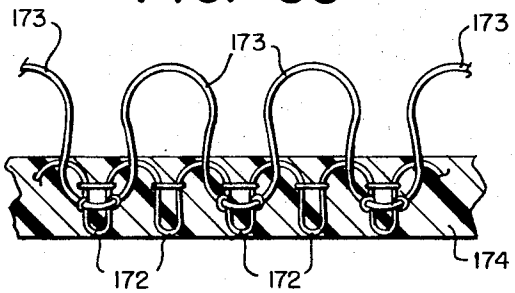


FIG. 33




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FIG. 34

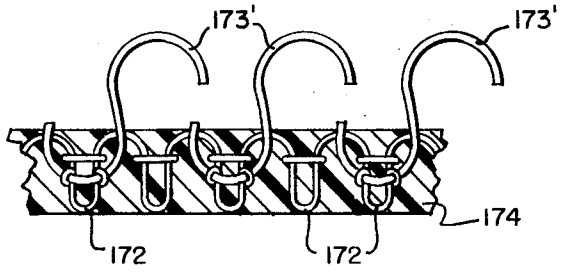



FIG. 35

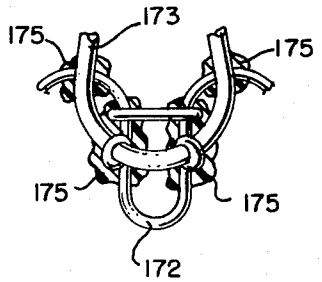



FIG. 36

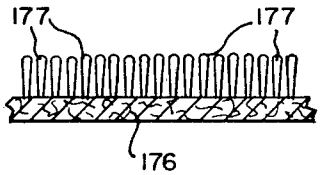
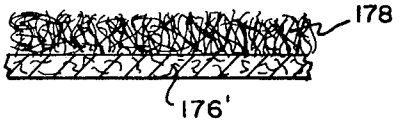



FIG. 37




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# METHOD AND APPARATUS FOR WARP KNITTING HOOK AND LOOP FASTENERS

## BACKGROUND OF THE INVENTION

Conventional methods for knitting a pile fabric include adding a special sinker to a round knitting machine or employing a Raschelle machine equipped with straight needles arranged against a row of knitting needles. When a warp knit is required as the knitted base fabric, the latter method has been conventionally employed, i.e., the thread to be formed into the piles is applied to the straight needles and then it is knitted into the basic pattern. Immediately after the completion the knitting-in action, the straight needles are drawn away from the pile. If these two sequences of operation could be completed in one action, it is estimated that the efficiency of the production would be doubled. Also, as stated above, as the piles are drawn away from the needles immediately after the completion of the knitting action, this type of operation has the shortcoming that the shape of the piles cannot be securely maintained when the knitting operation is completed. This adverse tendency is especially conspicuous when a high rigidity thread of the piles is employed. It is one purpose of the present invention to rectify these shortcomings so that fabric material can be warp knitted efficiently with stable and orderly piles. It is furthermore a purpose of the invention to disclose methods and means for producing a pile fabric suitable for use in strip form as either the hook or loop portion of a hook and loop fastener.

## SUMMARY OF THE INVENTION

In accordance with the present invention, warp knitting apparatus comprises means for warp knitting a pile fabric having a series of upstanding loops joined to a knitted base fabric and means for maintaining the loops as they are knitted thereafter in an orderly series. The material used may be, for example, a heat settable nylon and in the case where it is desired to convert the loop pile into a series of hooks, the invention provides novel means for heat setting the pile fabric while the loops are maintained in a uniform upstanding position. Thereafter, the invention furthermore provides means for fixing the fabric so that it cannot unravel when loops are cut into hooks, various cutting means further being disclosed for this later purpose.

These and other aspects of the invention will be readily apparent upon a detailed examination of the following specification and of the accompanying drawing.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevation of a warp knitting machine incorporating novel means for warp knitting pile fabric in accordance with the principles of the present invention;

FIG. 2 is a diagrammatic illustration of means for applying water and oil to a yarn prior to knitting;

FIGS. 2A–2F illustrate the knitting sequence showing needles and yarn guides to form the pile fabric of the invention;

FIG. 3 is a fragmentary view of portions of the machine shown in FIG. 1;

FIG. 4 is a fragmentary perspective view of needle guides;



FIG. 5 illustrates the loop pile sequence and the interengagement therewith of a base knitted fabric employing one yarn for the base fabric;

FIG. 6 is shown similar to FIG. 5 wherein two yarns are used to form the base fabric;

FIG. 7 is a side elevation section showing novel means of the invention for heat setting for the pile fabric;

FIG. 8 is a view taken in the direction of FIG. 8—8 of FIG. 7;

FIGS. 9 and 10 are fragmentary details of an alternate drive means for the roller apparatus of FIG. 8;

FIGS. 11–15 illustrate one form of cutting apparatus used to convert loops into hooks;

FIG. 16 is a perspective illustration of an alternate form of cutter for converting a series of loops into hooks;

FIG. 17 is a plan view of the cutter shown in FIG. 16;

FIG. 18 is a view taken in the direction of arrows 18—18 of FIG. 17;

FIG. 19 is a view taken in the direction of arrows 19—19 of FIG. 17;

FIG. 20 illustrates the interrelationship of the cutter plate and cam actuation mechanism shown in FIG. 16;

FIGS. 21 and 22 are details illustrating the position of the cutters in relation to loops during the cutting operation;

FIG. 23 is an alternate cutting apparatus as shown in perspective;

FIG. 24 is a fragmentary side elevation of the apparatus of FIG. 23;

FIG. 25 shows the relationship of the apparatus of FIG. 23 to two adjacent loops during cutting thereof;

FIGS. 26 and 27 illustrate alternate cutting heads suitable for use in the apparatus of FIG. 23;

FIG. 28 is another form of cutting apparatus;

FIGS. 29 and 30 are sequential illustrations of the apparatus of FIG. 28 cutting rows of loops; and taken on line 29—29 of FIG. 28;

FIGS. 31 and 32 are schematic illustrations of knitted pile fabric which can be produced according to the present invention;

FIGS. 33 and 34 illustrate the anchoring of loops and of hooks in a fabric base by means of plastic fully impregnating said base;

FIG. 35 illustrates another manner in which pile is anchored to the base fabric without impregnating said fabric and;

FIGS. 36 and 37 illustrate the looped portion of a hook and loop fastener.

## DESCRIPTION OF PREFERRED EMBODIMENT

Referring initially to FIGS. 1 and 2A of the drawings, a knitting machine modified in accordance with the present invention has been illustrated. The machine has yarn guide bars consisting of warp guides 1, 2 and 3. Bars 1 and 3 are threaded with base threads 5 and 7. Guide bar 2 is threaded with a yarn 6 which will become a looped pile in the form of series loops 6′ as indicated in FIG. 2*a*. The aforementioned guide bars do not make any movement to the left or right and make forward and backward movements only (i.e., toward and away from the plane of the paper).

Between the battens is mounted a metallic lancette 8 whose upper part 8′ is attached fixedly to the machine

base. The lower end of the lancette 8 is free and the lancette extends throughout its length parallel to a guide plate 10.

As best seen in FIGS. 2A–2F, a row of needles 9 of the latched or flapped type is aligned on a needle base 30 to the left of the guide plate 10. The needles have a combined vertical and sideways flipping or pivotal action which is imparted by an articulated lever and camming system.

The knitting sequence according to FIGS. 2A–2F will be described as follows: At the start of the sequence FIG. 2A the needle 9 begins to rise. FIG. 2B shows the needle 9 fully risen with the yarns 5, 6 and 7 having cleared the latch 9'. In FIG. 2C the needle 9 has moved to a somewhat horizontal position in front of the lancette 8, that is on the side thereof where it engages pile yarn 6 and the base fabric yarn 7. In FIG. 2D the needle has moved beyond the lancette 8 drawing with it yarns 5 and 7 which are base fabric yarns and the pile yarn 6. By so doing, the pile yarn 6 is pulled around the lancette 8 to form a loop 6'. FIG. 2E shows the movement of needle 9 in a downward direction with the latch 9' being closed by the preceding stitch so that all three yarns 5, 6 and 7 are within the hook of the needle. In FIG. 2F the needle continues its downward direction to pull the yarns through the preceding stitch thereby forming a new stitch and completing the knitting sequence.

An example of the knitting pattern formed by the above process is shown in FIGS. 5 and 6. In FIG. 6, the base thread 5 is the weft and the base 7 is the warp, the two together forming the base knitted fabric pattern. The pile thread 6 forms the pile after being formed over the lancettes 8. The relative positions of the pile thread guide bars 2 and the lancette 8 as shown in the drawings 2A and 2F are so arranged that the guide bar 3 shifts by one gradation so that the pile thread 6 goes over the lancette 8. That is, the latched needle knits the piles into the base pattern and then the pile thread alone goes over the lancette so that the pile thread continues to be formed to the adjacent row together with the base thread. In the drawings so far described base yarns 5 and 7 have been used. However, if the base warp 7 is not employed, the pattern can be knitted as a pile knitted fabric as shown in FIG. 5. It is of course possible to obtain other patterns by altering the lancette spacing and by varying the range of action or the number of yarn guide.

The portion of the knitting apparatus which causes the vertical and sideways flipping action of the needles 9 will now be described. The row of flapped needles 9 are installed in a needle base 30 supported by a pivotable mount 29. At the approximate top of mount 29 a pin 27 is provided, attached thereto in such a manner as to permit free rotation of mount 29. Also attached to the pin 27 is the lever 26 whose opposite end is rotatably attached to a shaft 25. At the approximate center of the lever 26 is a rotatable pin connection 24 connecting lever 18 thereto. The lower end of lever 18 is connected by pin 17 to cam follower support 16. The latter is rotatably connected to shaft 12 and has two cam followers 50, 51 which traverse cams 53 and 54 (FIG. 3). Cams 53 and 54 are affixed to drive shaft 13. The purpose of having the two cams 53, 54 is to provide a positive engagement of followers 50, 51 therewith at all times, resulting in a vertical actuation of lever 18.

To one end of the mount 29 which supports needle base 30, is a pin connection 28. An arm 60 is rotatably connected to mount 29 by means of the pin 28 at one end and at the other end thereof is rotatably connected to a bell crank 61 by a pin 62. Bell crank 61 is pivoted by pin 63 which is affixed to the machine structure. The end of the bell crank opposite the pin connection 62 is rotatably connected to a pin connection 64 which joins the bell crank and a lever 23 whose opposite end is pivotedly connected to a second cam follower support 66. The latter has cam followers 67, 68 which positively engage cams 69, 70. The cam follower support 16 is pivoted about shaft 12 and cams 69, 70 are driven by shaft 13 (see FIG. 3). The purpose of cams 69, 70, cam follower support 66 and the connections 23, 61, 60 linking with the needle mount 29 is to provide a generally sideways motion to the mount 29 in concert with the generally vertical motion imparted to mount 29 by cam follower support 16 and connecting linkage 18 and 26. Thus the needle mount support 29 is capable of imparting to the row of needles 9 the combined vertical and sideways or flipping action as has been heretofore described in FIGS. 2A–2F.

The invention further includes novel means of guiding needles 9 during the above described sideways flipping action. With respect particularly to FIG. 4, it will be seen that the guide plate 10 has attached thereto a series of plates 72 which define grooves 73 therebetween. The plates 72 have generally triangular sections 72*a* wherein, the top surface 72*b* forms an angle of approximately 30° with respect to a horizontal line drawn from the top edge of the guide plate 10. The provision of the triangular section 72*a* prevents the needles 9 from being displaced from the guide plates 72 during the sideways flipping action. Furthermore, the fact that the section 72a slants back from the guide 10 at the angle indicated provides a surface against which the knitting action takes place that is, as each new stitch is formed by the needles 9 as shown in FIG. 2F, the old stitch will tend to be held against the top edges 72*b* of the plate 72 as the needles 9 pull the yarns through the preceding stitch. It has been found that by employing the guide plate 72 an optimum effect will be obtained in minimizing distance between the top of the needle 9 and the top of the guide plate 72 when utilizing a thick fiber, for example a mono-filament fiber for the piles 61, thereby increasing the density of the knitted fabric when utilizing thick fibers. As explained above, the use of the plate 72 will assure accuracy of the needles, thereby making it possible to operate at high efficiency and also making it possible to obtain a high density pile knitted fabric sheet utilizing thick fibers.

Referring to FIG. 2, a beam 200 containing yarn 201 is shown partially immersed in a water bath 202. After passing over guide roller 203 the yarn passes under a second guide roller 204 which causes the yarn to pass through an oil bath 205. The yarn thereafter passes to the needles. The purpose of the apparatus of FIG. 2 is to provide greater flexibility of yarns such as nylon for example by impregnating them first with water. Then, by coating them subsequently with oil the yarns are lubricated before passing to the needles which will

prevent wear of the needles and will offset the harmful effects of water impregnated yarn upon the needles.

Referring now to FIGS. 7 and 8, there has been illustrated further portions of the knitting apparatus of the present invention which are utilized to heat set fibers so that during a subsequent operation, the loops 6' may be cut to form resilient hooks. Accordingly, as the knitting action proceeds, a series of loops 6' will progress downwardly along each lancette 8 together with the backing or base fabric. As the pile loops 6' proceed down the plate 10, the knitted sheet consisting of both loops and base fabric, is pulled out by pullout rollers 80, 81 provided at the lower part of the machine. Since the knitted sheet becomes free of the lancette 8, the sheet would ordinarily become relatively distorted especially since considerable force is necessary to withdraw from the lancette. The effect of the withdrawing force would also be felt upon the needles if transmitted thereto and would affect the knitting action. Consequently the present invention provides a fluted guide roller 82 at the upper end of the guide plate 10 which engages the knitted pile 6' and which will stabilize the movement of the newly knitted sheet. At the same time the roller 82 performs the auxiliary function of feeding the newly knitted sheet in a downward direction along the lancettes 8.

As can best be seen with respect to FIG. 8, the roller 82 is supported by a shaft 82' supported by end bearings 83. The end of shaft 82' is driven by a chain 84 connected to a suitable source of power such as an electrical motor for example (not shown) which will be geared appropriately. A second roller 85 is located below the roller 82 and is journalled and supported within arms 86, 87 which are mounted to fixed pivot shafts 88, 89. At their upper ends, the arms 86, 87 are attached to an adjusting mechanism which includes a pair of adjusting screws 91 for moving the arms 86, 87 toward or away from the knitted sheet. The function of the roller 85 is to contact the newly released pile loops as they pass from the lancette 8 and to cause the loops to be in an upstanding position. The roller 85 is driven by means of a chain link belt 92 which receives power from shaft 82' of roller 82.

FIGS. 9 and 10 disclose an alternate mechanism for driving the rollers 82 and 85. In the embodiment of FIGS. 9 and 10, the needle mount 29 is connected to an arm 94 which has at its upper end a one-way clutch mechanism 95 interconnecting the arm 94 and shafts 82' of roller 82. The arrangement is such that as needle mount 29 moves, it will impart a one-way movement to the roller 82 through the agency of the arm 94 and clutch 95. The lower roller 85 is connected to the roller 82 by a chain link belt 92 and will therefore be driven at the same time.

Referring again to FIG. 7, the apparatus of the present invention includes an oil bath chamber 97 containing a quantity of oil 98 which is kept at an elevated temperature suitable for heat setting the particular fiber for instance nylon. The oil 98 is heated by a heater element 99 controlled by a thermostat 100. Oil is circulated by means of a screw type impellor 101 to maintain the oil at an even temperature throughout the chamber 97. After being heat set, the knitted sheet will pass into a lower chamber 102 which contains a quantity of oil maintained at a cooled temperature by a suitable means. The knitted sheet is picked up by rollers 81, 103, 80 and 104 and then passes out of the cooling oil as seen at the upper left of FIG. 7.

Since the heated oil in chamber 97 is positioned above the cool oil chamber 102, there will be very little tendency for the heat within chamber 97 to migrate downward. Both the heat chamber 97 and the cooling chamber 102 below are designed in accordance with the processing speed of the knitted sheet to effect a complete heat treatment of the sheet. It will be noted that the lancette 8 extends a considerable distance into the heated oil bath and this is done so that the fiber of the loops will have their shape heat set prior to their removal from the lancette. Rollers 80, 81 will be driven by suitable motors. Roller 103 has protruding needles 103' so arranged as to allow the looped pile to penetrate into the needles which protects the pile from being pressed or crushed.

After being heat treated the sheet is ready for further processing to convert the loops of the pile into resilient hooks. It will be understood that this is done when it is desired to produce the hooked portion of a hook and loop fastener. To produce the loop portion of such a fastener, it is not necessary to heat treat the knitted sheet after it is produced by the described knitted action. Rather, the pile yarn 6 would most likely consist of a multi-filament instead of a single mono-filament and the looped pile would be processed by being napped or brushed to cause optimum disorientation of the pile. However, where it is desired to produce the hooked portion of the hook and loop fastener the pile thread will generally consist of a single mono-filament such as nylon fiber which must be heat treated prior to cutting to form hooks. The heat treating procedure has just been described. We shall now describe several embodiments of cutting apparatus for converting looped pile produced in accordance with the present invention into hooks.

One form of cutting apparatus is shown in FIGS. 11–15. The apparatus comprises a central stationary toothed guide 110 sandwiched between the upper and lower cutters 111, 112. The guide 110 is anchored to the cutter frame 113. Spring biased nuts 114, 115 secure the cutter plates 111, 112 by attachment to bolts 116, 117 and by being held between upper and lower plates 118, 119. Oversize openings 120, 121 in plates 112, 111 permit sideways movement of the cutter plates. Such movement is caused by a drive bar 122 whose tongue 122' engages within grooves of a similar shape in the cutters 111, 112. As best seen in FIG. 15, each of the loops 6' will first be picked up by the toothed ends of the guide 110 which will hold the loops while the sideways action shears through one leg only of each upstanding loop.

With respect to the apparatus of FIGS. 16–20 the stationary guide support 132 supports the guides 136 which are projected parallel to one another at one end thereof, and the tip ends of the guides 136 are aligned on one straight line. The guides 136 are inserted into the loops when the cutting operation of the said loops is effected in order to firmly support the loops in a vertically erected position. The support 131 of the movable cutting blades is positioned on top of the surface of the stationary guide 132 so that the support 131 of the movable cutting blades slide upon the surface of the

stationary guide support **132** in a perpendicular direction to the straight line formed by the tip ends of the guide **136**. The arrow shows the direction in the drawing which shall hereinafter be referred to as the forward direction.

The support **131** for the movable cutting blades further supports the cutting blades **135** which are projected in the forward direction and arranged parallel to one another on one end thereof. The relationship between the cutting blades **135** and the guides **136** is, as shown in FIG. **17**, such that the cutting blades **135** are projected into every other valley between the guides **136**. Also, on both sides of the support **131** for the movable cutting blades, the wall guides **134**, **134'** are fixed so as to regulate the sliding direction of the support **131**. A sliding body **133** is installed upon the surface of the support **131** and wall guides **134**, **134'**, and the sliding body **133** is actuated reciprocally in a parallel direction to the straight line formed by the tip ends of the guides **136** shown by arrow in the drawing which direction shall hereinafter be referred to as the sidewise direction. Further, the wall guides **144**, **144'** are fixed to the wall guides **134**, **134'** of the support **131** of the movable blades in such a manner that the wall guides **144**, **144'** directly cover the surface of the sliding body **133** in order to regulate the reciprocal action of the sliding body.

The cam shaft **137** projects into contact with sliding body **133** through the journal **138**. The bottom end of the cam shaft **137** is shaped as an eccentric cam **139** so that the cam is fitted into a cam channel **143** provided in such a manner that the cam channel is a pre-determined angle in a forward direction to the support **131** for the movable blades. A wheel **140** is installed at the top end of the cam shaft **137**, and the wheel **140** is screwed to the setting bolts **142**, which are fixed to the sliding body **133**, by set screws **141**. In FIG. **18** a support base **149** is positioned so as to confront the cutting device, and the backing **148**, which supports the loops **147** on a flat surface, is shifted in the direction of the arrow upon the support base **149** by suitable means. The support base **149** is borne by a base **152** through an adjusting screw **153**. The inclination of the base **149** can be adjusted through screw **153**, which centers on the end of the bearing **151**.

FIG. **20** shows the mechanism for actuating in a sliding motion the support **131** for the movable blades in the forward direction. As mentioned above, when the sliding body **133** is reciprocally actuated in the sidewise direction, the eccentric cam **139** which is incorporated into the sliding body **133** through the cam shaft **137** will also tend to move reciprocally in the sidewise direction. However, as the eccentric cam **139** is fitted into the cam channel **143** in order to effect the reciprocal sidewise action of the eccentric cam **139**, the support **131** for the movable cutting blades which contains the cam channel **133** is forced to move reciprocally in a forward direction so as to synchronize with the reciprocal action in a sidewise direction of the eccentric cam **139**. As a result, the reciprocal action of the sliding body **133** in the sidewise direction will be synchronized, i.e., the reciprocal movement of the said sliding body **133** will be converted into the reciprocal action in the forward direction effected by the support **131** of the movable cutting blades. Further, by rotating the wheel **140**, the eccentricity of the cam **139** can be arbitrarily selected so as to adjust the extent of insertion of the cutting blades **135** as and when required.

The cutting action of the device is shown move particularly in FIGS. **20–22**. If the backing **148** shifts in the direction of the arrow in the drawing, the loops **137** on the surface thereof will also approach the said cutting device. At this stage, the cutting blades **135** are at their most recessed position (FIG. **20**). The loop **137** then approaches nearer to the cutting device. The guides **136** corresponding to the loops **137** of each row will be inserted into the loops **137** so that the guides **136** will support the loops **137** in a vertically erected position. At the same time, due to the shifting of the support for the movable cutting blades, the cutting blades **135** proceed in the direction of the arrow, and the movable cutting blades **135** come into contact with the loops **137** which are already held in a vertically erected position by the guides **136**, in such a way that the cutting blades **135** cut one side of the side portions of the loops in a manner similar to a sawing action (FIGS. **21** and **22**). In this manner the cutting blades **135** complete their cutting action on reaching their most advanced position, and then the cutting blades **135** return themselves to their previous position by withdrawing.

A further alternate embodiment of cutting device relating to this invention is shown in FIGS. **23–25**. In this example, the support **154** for the movable cutting blades is positioned between a pair of supports **155** and **155'** for the stationary guides installed on the upper and lower parts with a pre-determined clearance between them. By reciprocal action in the sidewise direction of the sliding body **133**, and by the same mechanism as in the cases of the cutting device described in the example of FIGS. **16–20**, the support **154** for the movable cutting blades is actuated reciprocally in a forward direction (shown by the arrow in the drawing), and, as shown in FIG. **25** removes a portion of one of the two sides of the loop **158**. The relationship between the cutting blades **159** and the guides **160**, **160'**, etc., of the cutting device in this example, is the same as that in the case of the cutting device in the example of FIGS. **16–20**. In the cutting device of FIGS. **23–25**, it is possible to remove whatever length is desired of the portion of one of the two sides of the loop **158** by arbitrarily selecting cutting blades **159** of a thickness corresponding to the distance between **160** and **160'** which have been installed as a pair, thereby making it easy to produce various forms of hook shaped objects simply by adjusting the distance between **160** and **160'** and the thickness of the cutting blades **159**. FIGS. **26** and **27** show the different shapes of cutting blades which may be employed in the cutting device. An arbitrary selection can be made as to the thickness and the shape of the blades according to the material, the density and the shape of the loops to be cut.

A final embodiment of a cutting device in conjunction with this invention is shown in FIGS. **28–30**. In this embodiment, the support **161** for the stationary guides supports the guides **162** projected and aligned on one end thereof, the tip ends of these guides **162** being aligned on one straight line. These guides **162** are inserted into the loops during the cutting operation in order to support the loops firmly in a vertically erected

position. At every other valley of these guides **162**, a number of rotating shafts **163** are provided parallel to one another, and a number of rotating cutting blades **164** are affixed to the lowest end of each one of the rotating shafts **163** close to the top surface of the said guides **162**. These rotating shafts **163** are supported by a supporting board **165** which is located at the upper part of the said support **161** for the stationary guides. In the case of a cutting device in this actual example, the said rotating cutting blades **164** are rotated by transmitting a rotating motion from a suitable motivating power through a pulley **167** to a row of gears **168** installed at the top end of each of the rotating shafts **163**. By shifting the supporting board **167** in a forward direction after releasing the setting screw **166**, it is possible to adjust the position of the rotating cutting blades **164**. FIGS. **28** and **29** show the cutting mechanism progressively with respect to loops being cut. When the backing shifts in the direction shown by arrow in the drawing, the loops **169** on the surface thereof will also approach the cutting device. When the loops **169** further approach the cutting device, the guides **162** corresponding to each row of the loops **169** are inserted into the loops **169** in such a way that the guides **162** firmly maintain the loops **169** in a vertically erected position. When the loops **169** further approach the cutting device, the loops **169** finally come into contact with the rotating cutting blades **164** which rotate in the direction shown by the arrow in such a way that a side portion of the loops **169** is cut off.

Referring to FIGS. **31** and **32** there have been illustrated different views of loop knitted fabric which may be produced in accordance with the knitting techniques of the present invention. As mentioned previously, it is possible to utilize such loop knitted fabric as the raw material for the hooked portion of a hook and loop fastener. However, if the loops of this raw material are cut in such a procedure, the loops will be released causing the knitted fabric to disintegrate. Therefore, it is necessary to ensure procedure so that the knitted fabric will not disintegrate when the loops are cut. One method to ensure such a procedure is to differentiate the material of the threads forming the pile from those materials of the threads forming the knitted fabric. Therefore, FIG. **32**, shows a fabric employing multi-filament thread **172**, for instance, and FIG. **31** shows a fabric employing mono-filament thread **172'**, for instance. By increasing the density of the multi-filament thread, the adherence of the piles to the base fabric which consists of the multi-filament thread is enhanced. However, there still is a possibility that the piles which are cut will be detached from the knitted base fabric consisting of the multi-filament threads. Therefore, as shown in FIG. **33**, the base sheet of the knitted fabric consisting of the multi-filament threads **172** is immersed in a suitable resin material **174** in order to ensure a procedure whereby the piles **173** are permanently mingled into the multi-filament thread.

Thus the knitted base fabric knitted as shown in FIG. **33** is immersed in a resin solution. The resin applied to the knitted fabric is then hardened by a suitable heat treatment applied thereafter.

When a knitted fabric such as shown in FIG. **31** is used, there are loops on both front and rear sides. Therefore, the loops on the rear side must be pre-flattened onto the knitted fabric base sheet by a suitable method, e.g., by heat rollers, at first, then must be treated by immersion into a suitable resin as described above.

Thus, the loops of the rear side are firmly attached to the base fabric sheet in order to form a fastener base, and the front side loops are firmly attached to this fastener base.

Naturally, the pile which serves to construct the loops and the multi-filament thread are affected by thermal shrinkage at the time of the heat treatment. Therefore, according to the extent of the shrinkage, the density of the knitted fabric of multi-filament thread and the size of the loops of the piles must be designed so as to take this heat shrinkage possibility into consideration.

The loops suitably fixed by the above mentioned procedure are each cut at the top by a suitable cutting method so as to become fastener pieces as shown in FIG. **34**. As these hooks **173'** are, by means of the resin, fixed to the base fabric sheet which has been knitted with the multi-filament thread, the hooks will not be detached from the base sheet even with repeated use as a fastener.

An alternative method which may be employed and which possesses certain advantages is illustrated in FIG. **35**. Here resin globules **175** secure the interstices of the fabric, the resin having been deposited at these points by using limited amounts of resin and depending upon capillary action to draw resin to the interstices. This method has the advantage of using less resin and permits the fabric to retain greater flexibility.

Aside from the above-mentioned method of fixing the loops to the base sheet by means of resin, another method is to employ a fiber which shrinks when exposed to high temperature as the material for constructing the base sheet, and further, to inter-knit the pile thread into the knitted fabric made of the fiber which shrinks when exposed to high temperature. By treating the pile knitted fabric under high temperature, the base sheet assumes a very dense form so that the piles adhere firmly to the base sheet and therefore, as mentioned above regarding resin treatment of the base sheet, the hooks will not be detached from the base sheet even with repeated use as fasteners.

The looped portion of the two confronting pieces forming the hook and loop fastener has the form shown in FIGS. **36** and **37** which shows the base sheet made of a knitted fabric. The base sheet **176** made of a knitted fabric has a number of loops **177**. The higher the density of the loops, the greater will be the fastening effect so that it is desirable to employ loops made of multi-filament thread. FIG. **36** shows the looped piece with raised hair on the surface

What is claimed is:

**1.** An apparatus for warp knitting loop pile fabric suitable for use as part of a hook and loop type fastener comprising a warp knitting machine having a plurality of knitting needles, a plurality of stationary lancettes mounted in a fixed position adjacent to said needles, means for moving said needles in a knitting cycle about said lancettes to knit a base fabric and a series of loops as a pile connected to said base fabric, said lancettes extending beyond the point of knitting for a distance to

maintain said loops in uniformity with respect to each other and said base fabric, a chamber means positioned beneath said needles and surrounding at least a portion of the lancettes beyond the point of knitting, a heating medium in said chamber means in the form of heated oil surrounding extended portions of said lancettes, roller means for drawing said base fabric and pile along said lancettes and through said heating zone, and drive means for driving said roller means.

2. The apparatus according to claim 1 wherein said roller means comprises two rollers wherein a first roller is positioned immediately adjacent to and below said needles for receiving newly formed fabric, and the second roller is positioned in said oil bath for drawing said fabric and loops from said lancettes, and drive means for coordinating the rotary movement of said rollers.

3. The apparatus according to claim 2 wherein a cooling medium is provided immediately below said heated oil for cooling said fabric, and means for moving said fabric therethrough.

4. The apparatus according to claim 3 wherein said means for coordinating said movement of the roller comprises a linked belt drive.

5. The apparatus according to claim 4 wherein said means for moving said roller comprises a one-way clutch actuated by movement of actuating linkage for said needles.

6. The apparatus according to claim 1 in combination with cutting means for cutting one upstanding leg of each said loops to form hooks.

7. The apparatus according to claim 6 wherein said cutting means comprises a toothed comb for receiving said loops movement of said fabric toward said cutting means, a flat cutter blade slidably in contact with said comb and means for reciprocating said cutter blade with respect to said comb to cut the legs of said loops.

8. The apparatus of claim 7 wherein said comb and cutter blade are held in slidable contact by spring mounted pins, and said reciprocating means comprises a plate and means connecting said plate and cutter blade.

9. The apparatus of claim 8 wherein additional means are provided for adjusting said cutter in blade directions perpendicular to said reciprocal cutting movement.

10. The apparatus according to claim 6 wherein said cutting means include a comb for receiving the loops of said loop pile prior to cutting and a plurality of rotary knives are provided for cutting an upstanding leg of each of said loops.

11. An apparatus for warp knitting loop pile fabric suitable for use as part of a hook and loop type fastener comprising a warp knitting machine having a plurality of knitting needles, a plurality of stationary lancettes mounted in a fixed position adjacent to said needles, means for an actuating linkage connected to said needles, cam means for driving said linkage and said needles firstly in a general vertical direction, secondly in a general sideways direction wherein yarn is formed about said lancettes and finally in a vertical direction to complete each stitch, said base fabric being supported in part by a guide plate, a guide plate extension mounted to the upper end thereof, said guide plate extension having an upper surface portion which is sloped with respect to a horizontal plane, said guide plate extension further defining grooves between which each of said needles reciprocates vertically and further defining an angular grooved top section for guiding said needles when each reciprocates in a sideways direction, thereby providing clearance and support adjacent to said lancettes for the formation of new stitches thereupon when said needles complete said sideways motion and pull each new stitch through a previous stitch, said guide plate extension further minimizing the distance between the top of the needle and the top of the guide plate such that relatively thick monofilament fibers will result in increased tightness of the fabric due to increased tightness in the stitches.

12. An apparatus for warp knitting loop pile fabric suitable for use as part of a hook and loop type fastener comprising a warp knitting machine having a plurality of knitting needles, a plurality of stationary lancettes mounted in a fixed position adjacent to said needles, means for actuating linkage connected to said needles, cam means for driving said linkage and said needles firstly in a generally vertical direction, secondly for pivoting said needles in a generally sideways and horizontal direction wherein yarn is formed about said lancettes and finally in a vertical direction to complete each stitch, said lancettes extending beyond the point of knitting for a distance to maintain said loops in uniformity with respect to each other and said base fabric, a chamber means positioned beneath said needles and surrounding at least a portion of the lancettes beyond the point of knitting, a heating medium in said chamber means in the form of heated oil surrounding extended portions of said lancettes, and roller means for drawing said base fabric and pile along said lancettes and through said knitting zone, and drive means for driving said roller means.

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