United States Patent

Challenger et al.

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[54] STRAIGHT BAR KNITTING MACHINES

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[51] **Int. Cl.** **D04b 11/06**

[58] **Field of Search** 66/96, 88, 89

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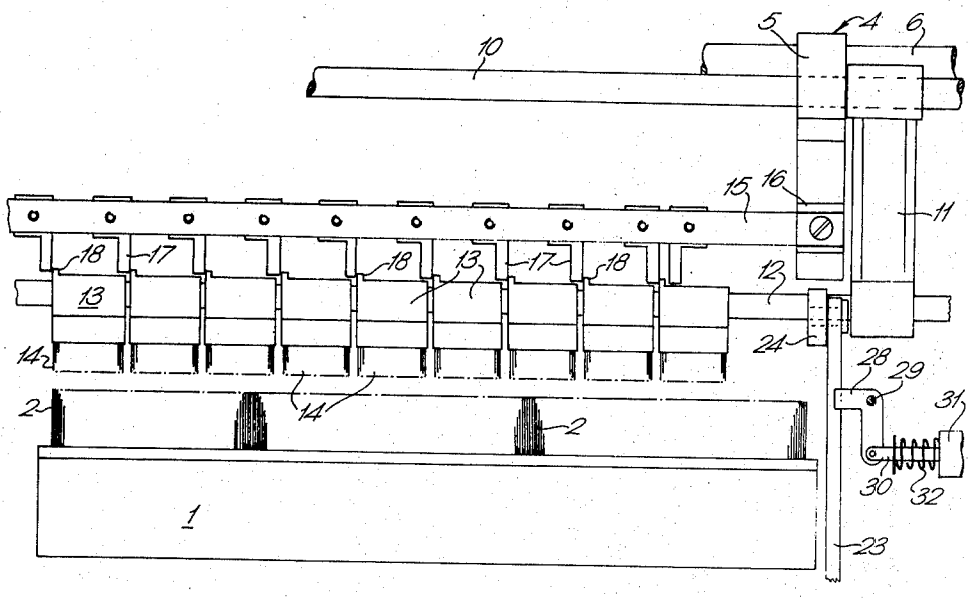
[57] **ABSTRACT**

A method and means for loop doubling in straight bar rib to plain knitting machines wherein groups of loop transfer points are movable lengthwise relative to one another to effect spaced doublings throughout the knitting width of a garment piece.

21 Claims, 12 Drawing Figures



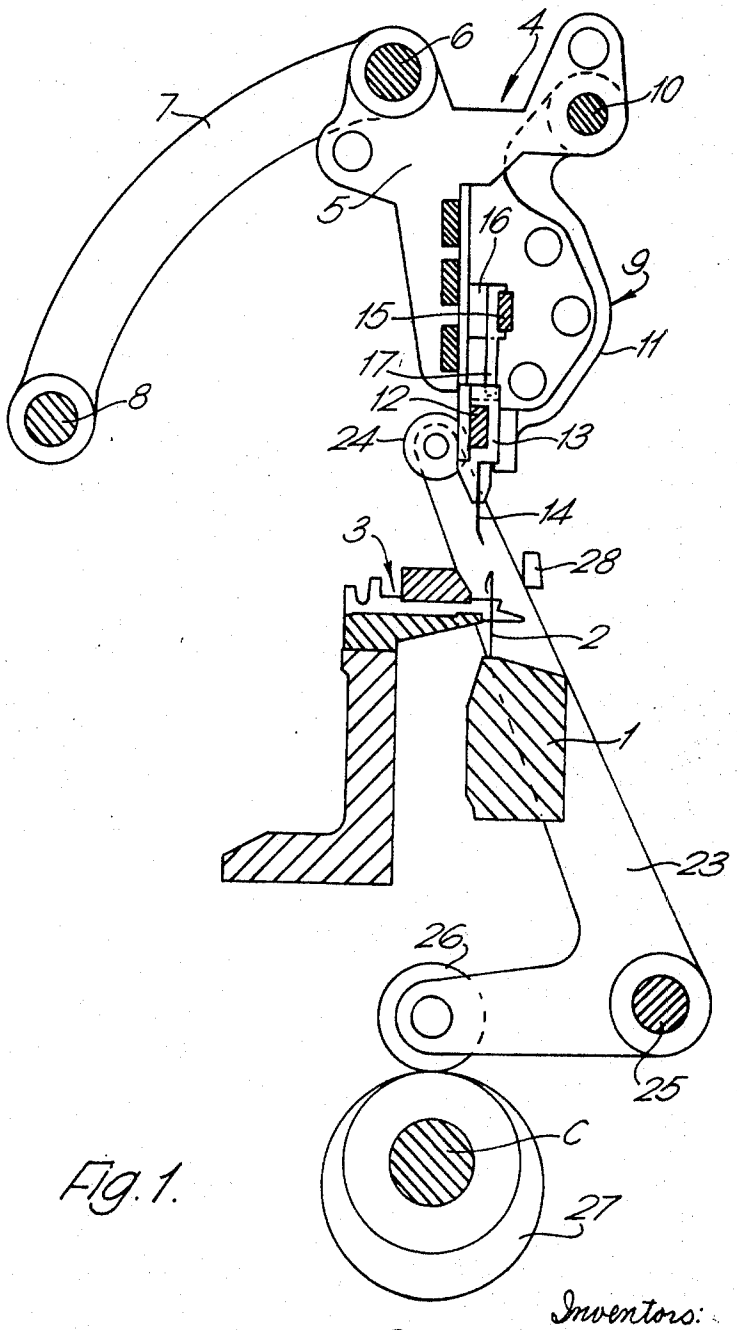


Fig. 1.

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Attorneys

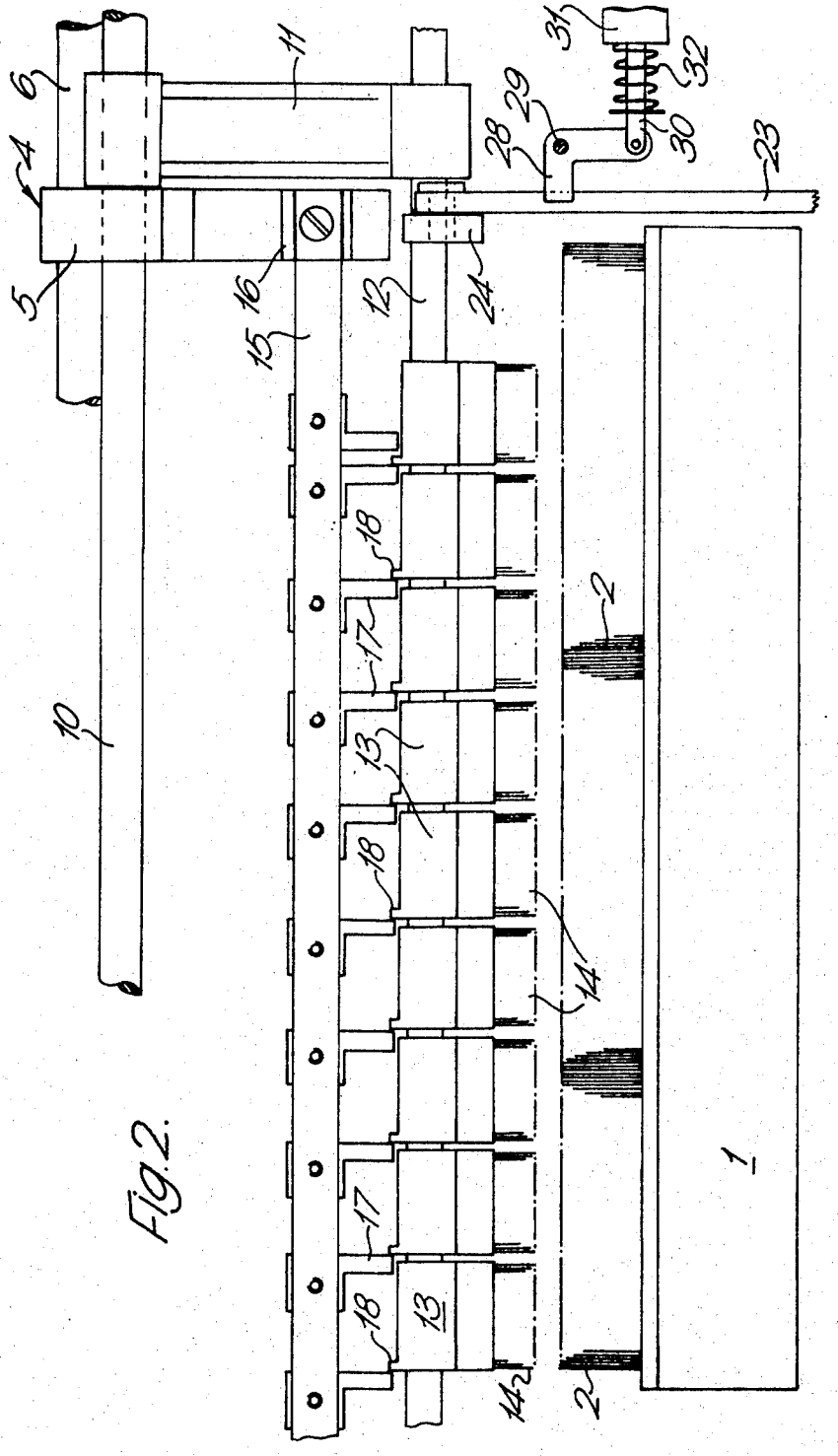

Fig. 2.

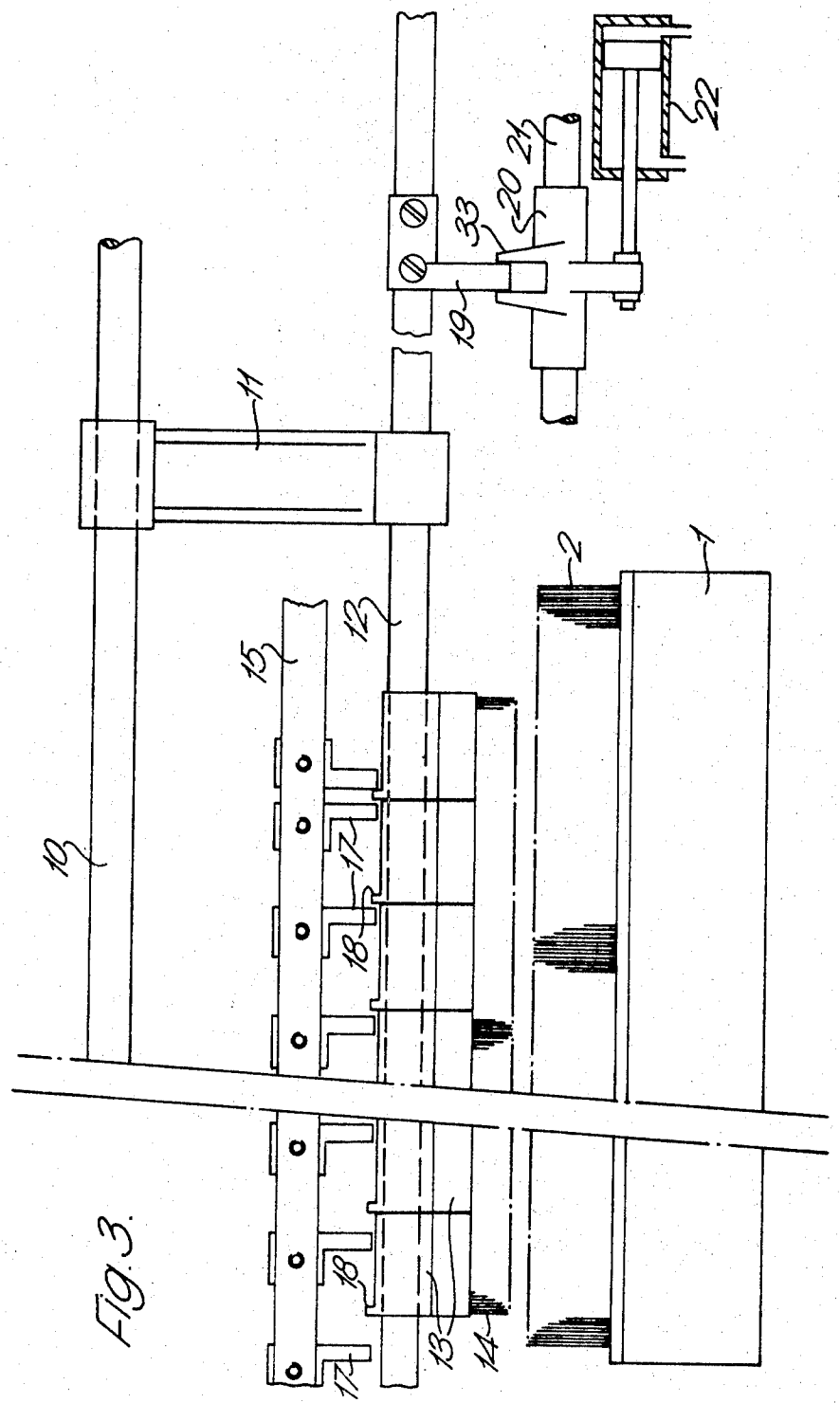

FIG. 3.

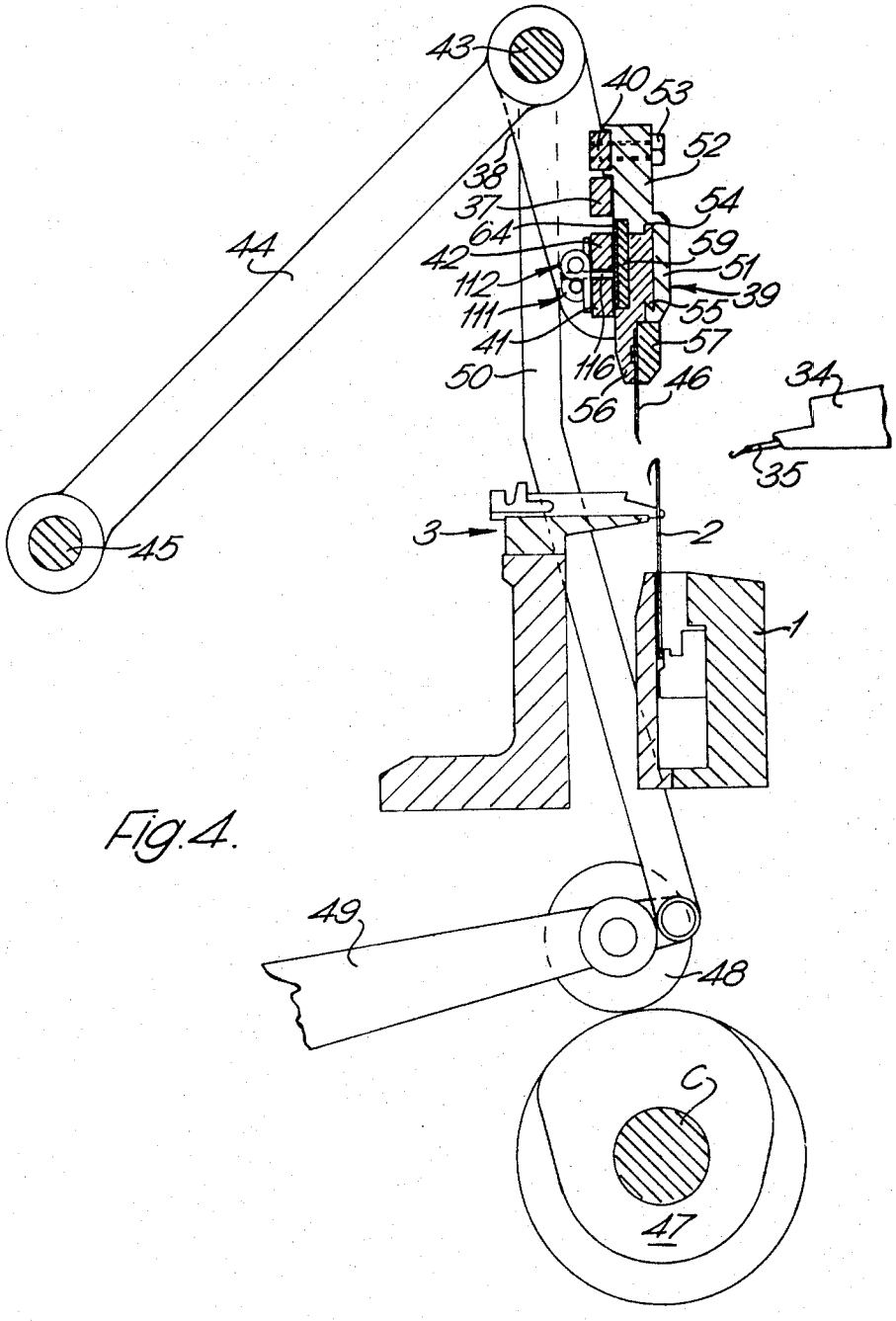
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Fig. 4.

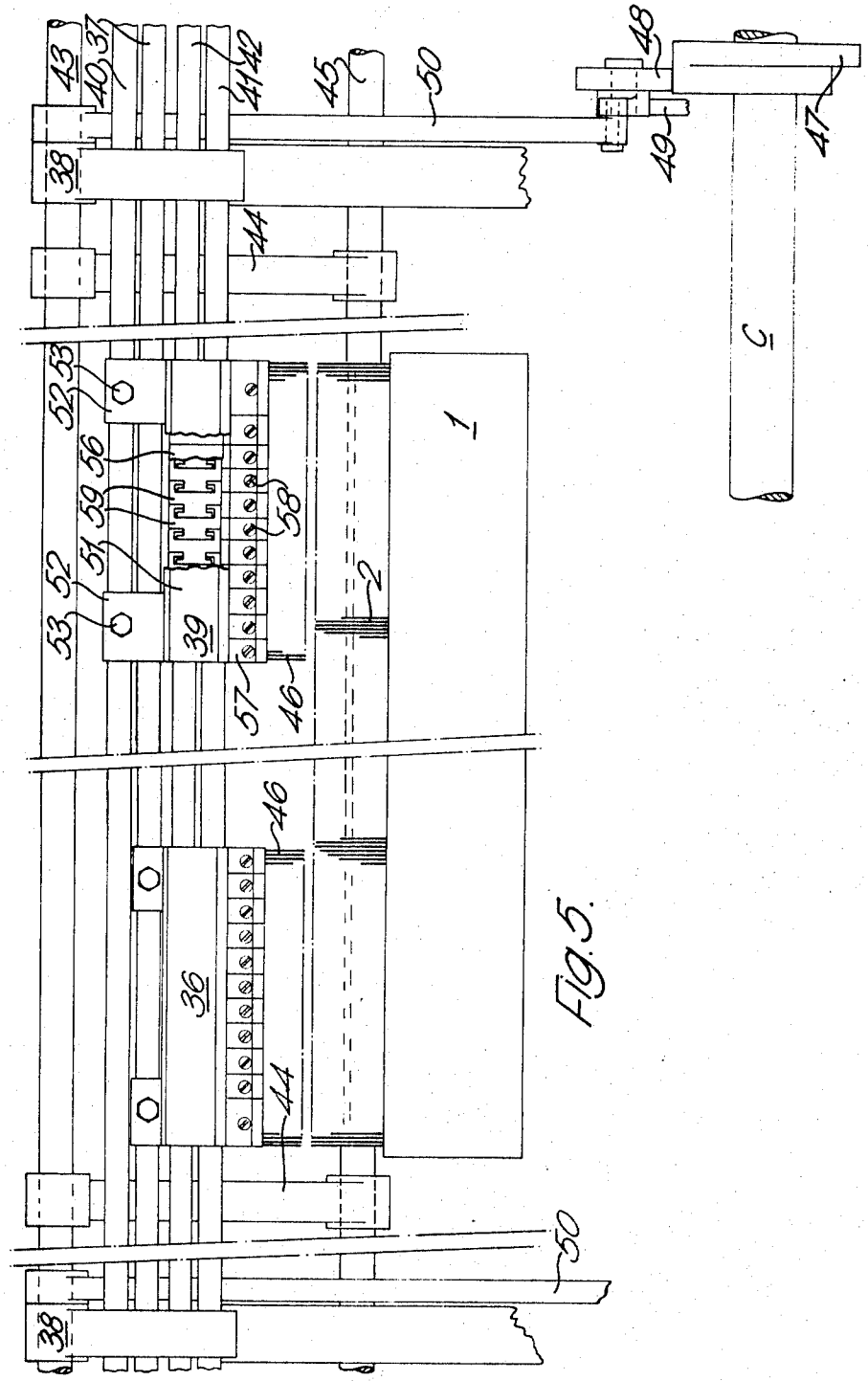
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Fig. 5.

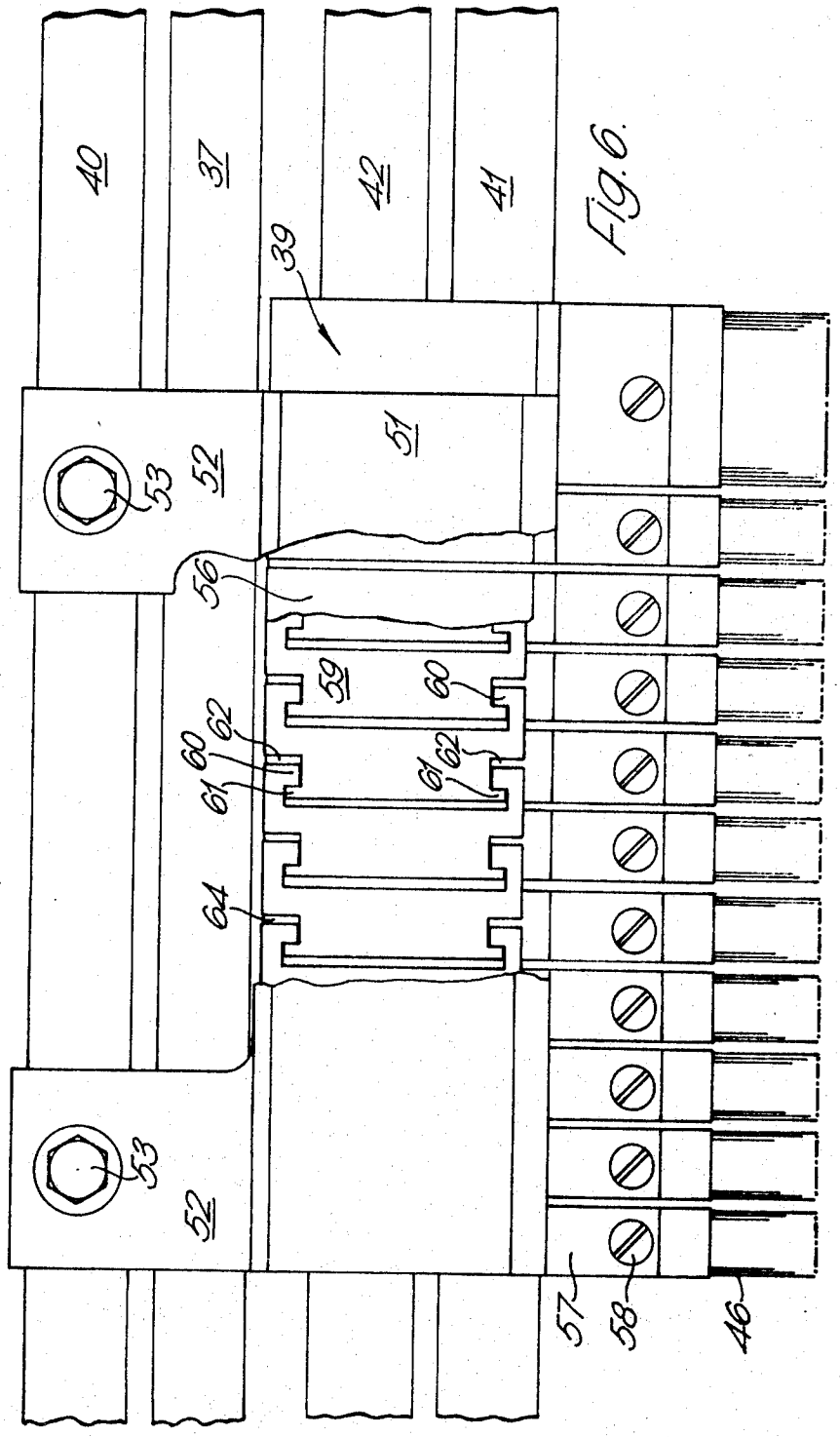

Fig. 6.

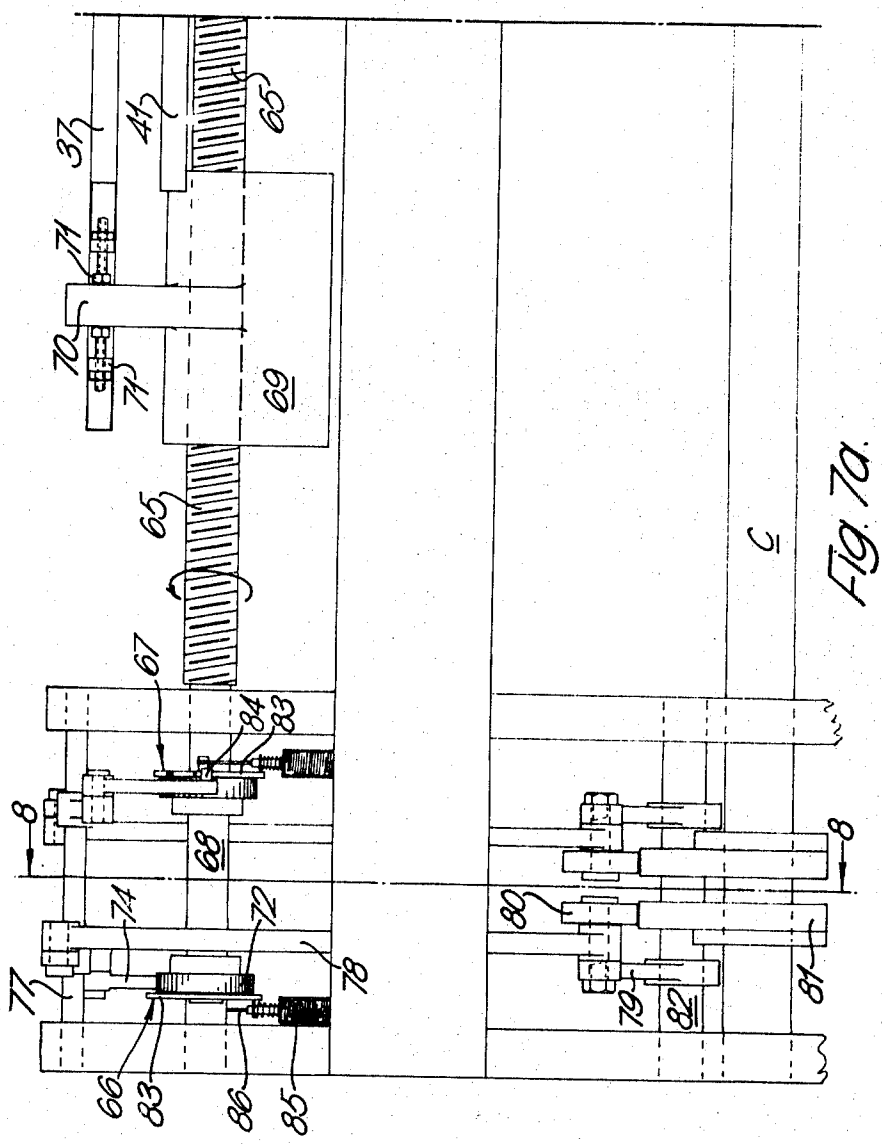
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Fig. 7a.

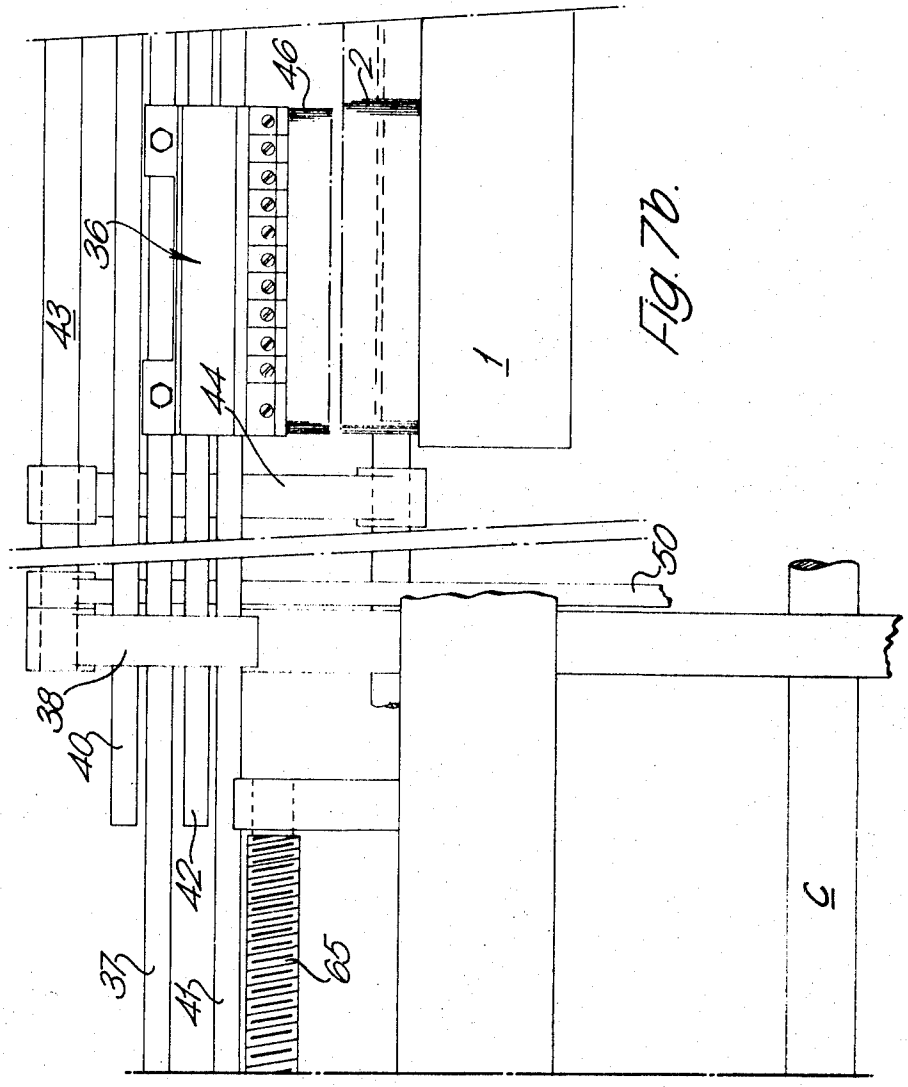

Fig. 7b.

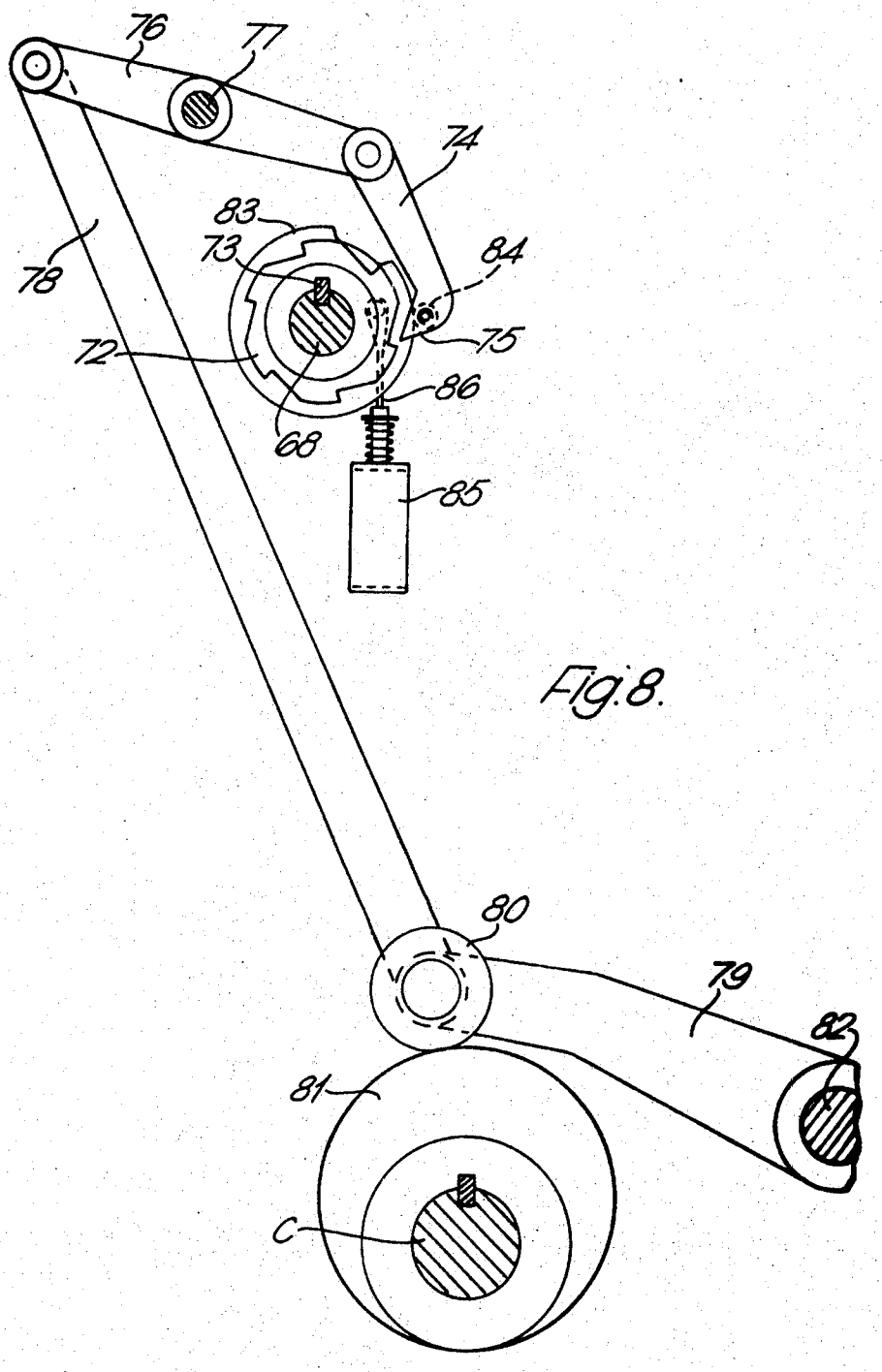

Fig.8.

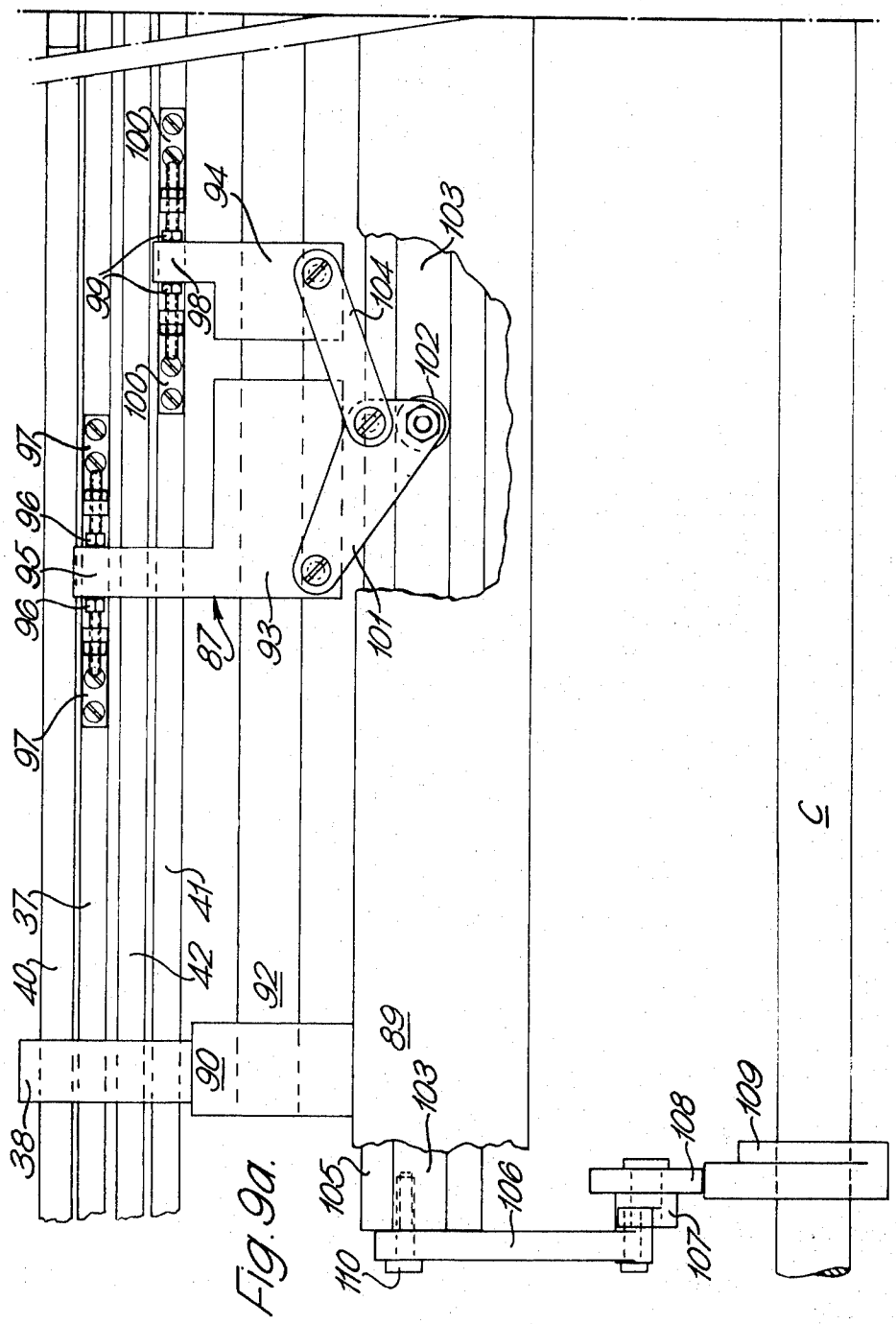
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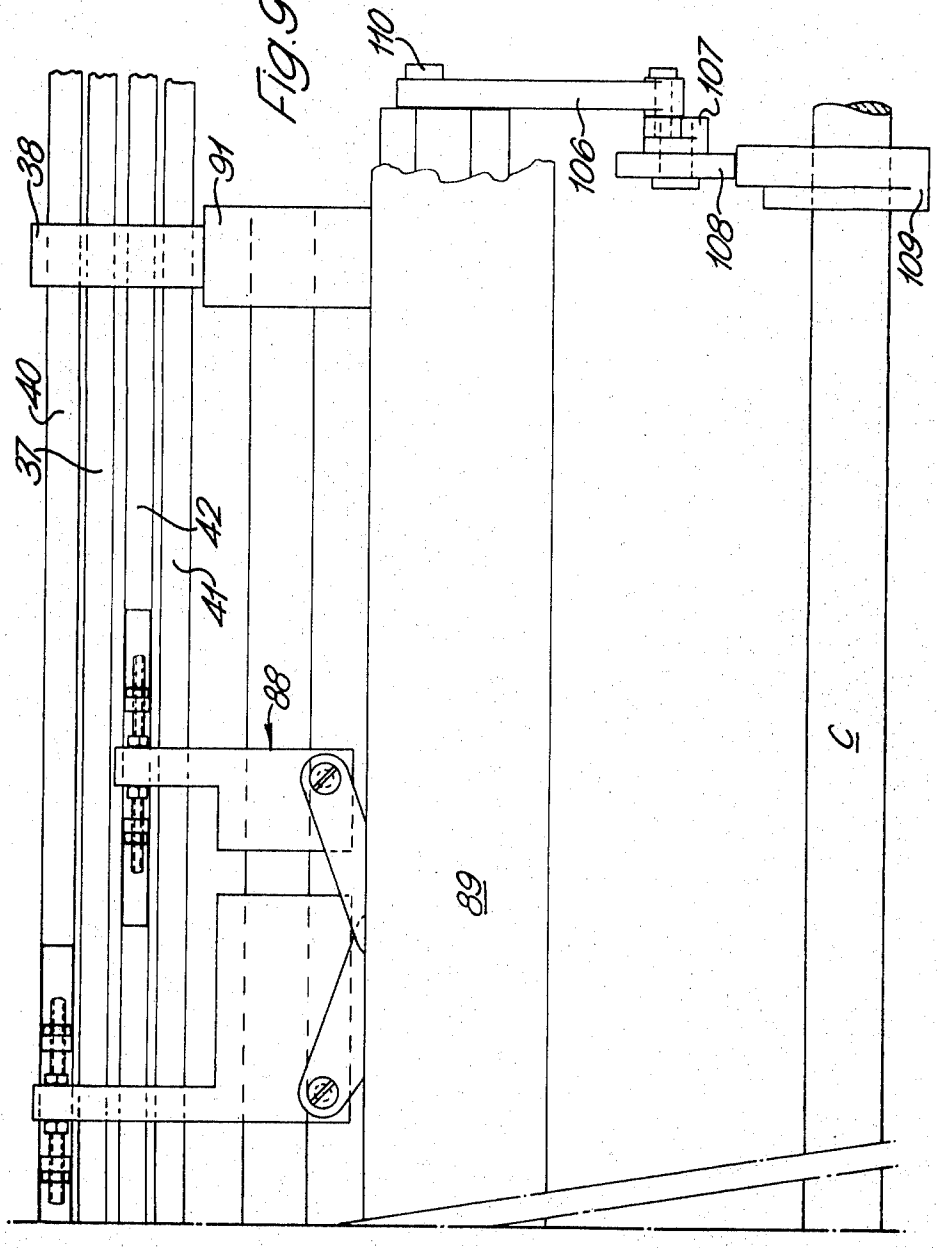
Fig. 9a.

FIG. 9b.



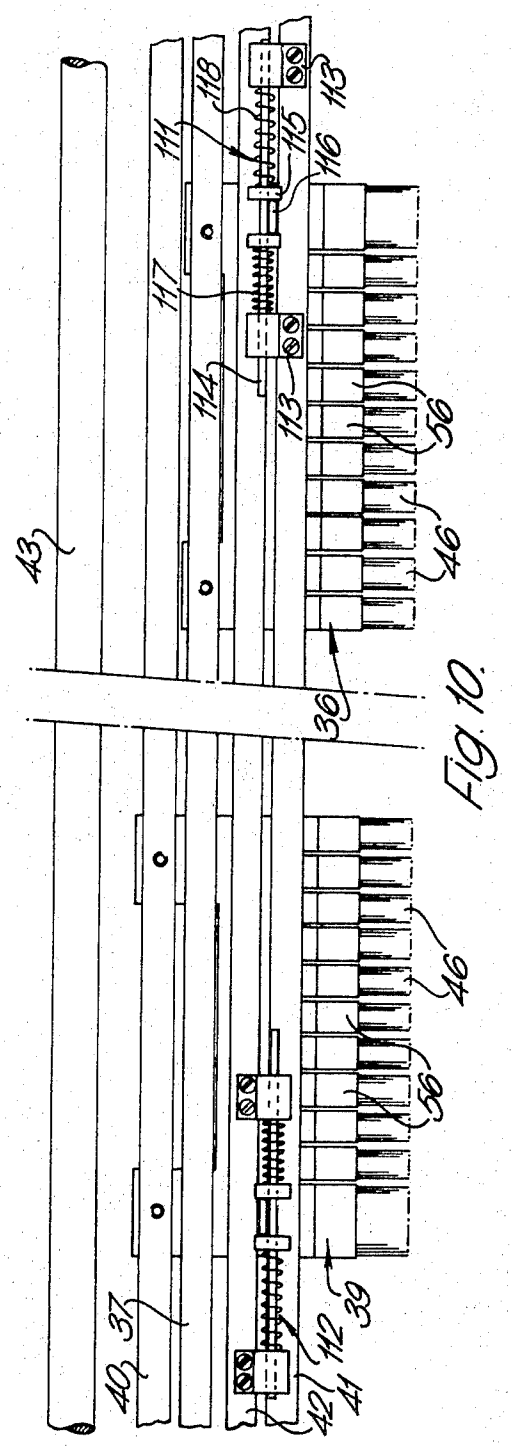


FIG. 10.

STRAIGHT BAR KNITTING MACHINES

This invention relates to straight bar knitting machines and concerns means for loop doubling in rib-welts prior to knitting plane fabric onto them.

The further development of the cotton type straight bar knitting machine has achieved a rib to plain machine capable of knitting a complete garment piece wherein several courses of rib fabric are knitted and then, by withdrawal of the rib knitting elements, the plain fabric is knitted in continuation thereof and shaped by the conventional and well known principal employed in straight bar machines.

In certain garments it is necessary to introduce doublings at the intersection of the rib fabric and the plain fabric and, since the machine automatically and continuously produces the garment piece, it is necessary that the doublings process is also automatic and that it should be accomplished in the shortest possible time.

In garment pieces where doublings are intended, the rib-welts are initially knitted to a wider fabric width and, following the knitting of the last rib course, the knitted width is reduced coursewise by the intermediate operation known as doubling.

The term "doubling" means that two knitted loops are placed on one needle and thus the fabric knitting width may be reduced by the same number of needles as there are doublings introduced. The doublings are usually equally spaced across the width of the fabric and are intended to achieve greater elasticity of a 1 × 1 rib fabric structure.

It is among the objects of the present invention to provide a method and means in a straight bar rib to plain knitting machine for effecting loop doubling automatically by means of the conventional loop transfer function of the fashioning mechanism of a Cotton type straight bar knitting machine.

According to the present invention, there is provided, in a rib to plain straight bar knitting machine, a method of loop doubling which comprises transferring spaced groups of loops from the knitting elements to a series of spaced blocks of loop transfer elements, moving the said blocks of transfer elements sideways the equivalent of one or more needle pitches, returning the said groups of loops to the knitting elements, again transferring the loops from the knitting elements to the spaced series of transfer elements, closing the blocks of transfer elements together, and again returning the loops to the knitting elements, whereby the previously spaced groups of loops are closed together on the knitting elements with spaced doublings and on fewer knitting elements than at the commencement of the operation.

According to the invention furthermore, there is provided a rib to plain straight bar knitting machine having loop doubling means mounted on the fashioning mechanism thereof, wherein the doubling means comprise a plurality of groups of loop transfer points, and means for moving the groups of points relative to one another the equivalent of at least two needle pitches.

In practice, the invention will be applicable to a straight bar knitting machine having a fashioning mechanism supporting loop transfer points which are adapted to perform loop transfer function to effect garment shaping, vee neck, fancy lace, marking, doubling, pouching and cabling operations. All of these functions are identical in principle in that the loop transfer points engage with the corresponding needles, either singly, or in groups, or en-bloc, or in fixed pattern, or in selected pattern, and pick up fabric loops of the previously knitted row of loops and transfer them sideways in either direction to the adjacent needle, or by two, or three, or four needle pitches. Obviously and necessarily a loop can be transferred from a needle leaving that needle empty thereby creating a hole in the garment or effecting narrowing of the garment, or alternatively, loops can be transferred to a needle or needles which already contain a loop or loops.

All straight bar knitting machines are provided with a fashioning mechanism which is capable of being adapted to carry out the various loop transfer functions hereinbefore set out. The fashioning mechanism has a complex array of loop transfer points and obviously, at any one time, only one loop transfer point may co-operate with one needle for the loop transfer function. It is conventional practice, and essentially so, that those loop transfer points not in use are, by either longitudinal or radial displacement, located in an inoperative position whilst the operative points are positioned relative to the needles in order to effect their particular function.

For the purpose of describing the present invention, the loop transfer elements associated with the doubling operation will be considered to be in the operative position on the fashioning mechanism whilst the main fashioning boxes associated with garment shaping will be withdrawn longitudinally to stand inoperative outside of the fabric width. Similarly, the loop transfer elements for marking and lacing will be considered to be radially displaced to an inoperative position.

Thus, during the normal and conventional dipping motions of the fashioning mechanism for the actual loop transfer function, it will only be the doubling loop transfer points which co-operate with the associated needles.

The invention is illustrated by way of example in the accompanying drawings in which,

FIG. 1 is a section through part of a rib to plain straight bar knitting machine showing only the parts thereof essential for a clear understanding of the invention,

FIG. 2 is a part plan view corresponding to FIG. 1 and showing the doubling boxes in one position,

FIG. 3 is a part plan view corresponding to FIG. 2 and showing the doubling boxes in another position,

FIG. 4 is a section through part of a rib to plain knitting machine showing an alternative doubling means and showing only those parts of the machine essential for a clear understanding of the invention,

FIG. 5 is a front elevation corresponding to FIG. 4 but on a reduced scale,

FIG. 6 is an enlarged view of the right hand doubling box shown in FIG. 5,

FIGS. 7*a* and 7*b* are together a front elevation of the left hand end control bay showing the mechanism for controlling the longitudinal movement of the doubling boxes,

FIG. 8 is a section on the line 8—8 of FIG. 7,

FIGS. 9*a* and 9*b* together are a front elevation of the centre control bay showing the mechanism for controlling the collapsing and spreading of the doubling blocks, and

FIG. 10 is a rear elevation of the left hand and right hand doubling boxes.

Referring to FIGS. 1 to 3 of the drawings, there is shown a machine needle bar 1 having needles 2 on which all the knitted loops are arranged on completion of a rib-welt, the associated known elements for carrying out a knitting operation being generally indicated at 3.

Mounted above the needle bar 1 is a conventional fashioning mechanism 4 having end frames 5 which frames are supported on a shaft 6. The shaft 6 is supported, via brackets 7, on a shaft 8 so that the mechanism can, in known manner carry out its normal dipping functions to effect sideways transfer of knitted loops.

The fashioning mechanism 4 supports a loop doubling device 9 which is hingedly mounted on a pivot shaft 10 supported between the brackets 7 so that it can be swung into an inoperative position when not required and thereby enable other transfer elements for other purposes to be moved into an operative position.

Depending from the pivot shaft 10 by means of pivot arms 11 is an actuating rod 12 which is preferably of rectangular cross-section. Slidably mounted on the actuating rod 12 is a series of doubling boxes 13 of equal width each having an equal number of loop transfer points 14. The boxes 13 are frictionally mounted on the rod 12 and are initially positioned in spaced relationship with one another as shown in FIG. 2, the spaces each corresponding to two needle pitches, i.e., one needle is left free between adjacent boxes. The series of boxes 13 is such as to extend over the entire knitting width of the needle bar 1.

Mounted above the boxes **13** is a stop bar **15** which is fixedly mounted, via fixing brackets **16**, on the end frames **5** of the fashioning mechanism **4**. The stop bar **15** has mounted thereon spaced stop members **17** which are adapted to co-operate with lugs **18** formed on their co-acting boxes **13**. The stop members **17** are positioned to close the spaces between the boxes **13** as hereinafter described.

In operation, when the last course of the rib fabric has been knitted, the main camshaft C of the machine will shog sideways and remain in this position for two complete revolutions to effect, in a conventional manner, two complete cycles of the fashioning mechanism **4**.

During the first dip or cycle of the fashioning mechanism the loop transfer points **14** of the doubling boxes **13**, initially spaced apart as hereinbefore described, engage with their corresponding spring beard needles **2** of the needle bar **1** and remove the loops from those needles in conventional manner, thus leaving loops only on those needles which correspond to the spaces between the boxes **13**. The fashioning mechanism, and thus also the doubling boxes **13**, are then moved sideways a distance equivalent to one needle pitch and the loops are returned to the adjacent needles **2** of the needle bar **1**. Thus, a series of equally spaced holes are created in the fabric and a series of equally spaced doublings are achieved. However, the fabric width remains unchanged.

During the second dip or cycle of the fashioning mechanism, the loop transfer points **14** of the doubling boxes **13**, still spaced apart as hereinbefore described, engage with the corresponding spring beard needles **2** of the needle bar **1** and remove the loops from those needles again in conventional manner. The doubling boxes **13** are then closed together and, during the completion of the second cycle, the loops are transferred back to the needles **2** but, due to the closing up of the boxes **13**, the fabric width will be reduced an amount corresponding to the number of doublings. The main camshaft C now shogs back to its normal position associated with plain knitting and the machine operates to produce plain fabric in the conventional manner, the normal loop transfer functions for fashioning purposes being accomplished via the conventional motions of the fashioning mechanism which are controlled by the main camshaft C of the machine.

Since the dipping etc. operations of the fashioning mechanism are conventional and well known, the following description will be restricted to the means for longitudinally positioning the doubling boxes **13**.

One simple arrangement for effecting the latter operation is to couple the actuating rod **12**, via a bracket **19** and a guide sleeve **20** mounted on a shaft **21**, to a pneumatic ram **22** as is shown in FIG. **3** of the drawings.

The standing position of each box **13** is determined by its co-acting stop member **18** so that all of the boxes are spaced two needle pitches apart in preparation for the first cycle of the fashioning mechanism to provide the doublings in the rib fabric as hereinbefore described. This positioning of the boxes **13** is effected by operating the ram **22** to move the rod **12** to the left to the position shown in FIG. **2**.

The next cycle of the fashioning mechanism will reduce the coursewise width of the fabric. During this cycle the entire series of spaced doubling boxes **13** are closed together at the appropriate moment by causing operation of the pneumatic ram **22** to move the rod **12** in the opposite direction i.e., to the position shown in FIG. **3**.

It will be appreciated that the above movements result from the doubling boxes **13** being frictionally mounted on the actuating rod **12**, so that any longitudinal movement of the rod simultaneously displace the doubling boxes **13** either to close them together or to space them apart.

The doubling boxes **13** may be swung outwards about the pivot shaft **10** during the rib knitting period, at which time the loop transfer point **14** remain inoperative but poised above the needles in a normal standing position until the next fashioning cycle causes them to dip and perform the normal loop transfer function in a conventional manner. In this respect, the actuating rod **12**, the doubling boxes **13** and the associated parts can be swung clear of the knitting head via a bellcrank lever **23**. A roller **24** freely mounted on the upper end of one arm of the lever **23** rests against the bar **12**. The lever **23** is pivoted about a shaft **25** and the other arm of said lever **23** has a roller **26** which rests against a cam **27** which is fixed to the main camshaft C of the machine. When the main camshaft C is shogged sideways at the commencement of the doubling operation, the lever **23** and associated roller **26** rests, as shown on FIG. **1** on the lower circular periphery of the cam **27**.

During normal knitting when the main camshaft C has been shogged sideways, the lever **23** is in a raised position caused by the eccentric periphery of cam **27**. The upper arm of lever **23** is engaged by, and is held in this position by one end of a latch **28**. Latch **28** is pivoted at **29** and its other end is connected to the armature **30** of solenoid **31**. Armature **30** is normally held in an extended position by a spring **32** but, during the raising of the lever **23**, the solenoid **31** is energised so that the lever **23** can pass freely in front of the latch **28**, after which the latch is allowed to return to its holding position and the latch **28** again engages the lever **23** and holds it in a position where it maintains the doubling boxes **13** and the bar **12** in an inoperative position.

In order to permit of angular movement of the bar **12** and the boxes **13**, the bracket **19** is in the form of a lever which is movable into and out of engagement with a bifurcated projection **33** formed on the guide sleeve **20**, thereby providing a releasable connection.

The doubling boxes **13** may be positioned in a variety of ways — for example they may be mounted on a single rod **12** and be made to slide towards one selvedge only in which case the rib fabric must be asymmetrically knitted. The rib fabric after doubling will then be symmetrical. In this case it would not be essential to remove from the needles at the standing selvedge that width of fabric which corresponds to the pitch of the doublings.

Alternatively, the doubling boxes **13** may work in opposed groups about the centre line so that each group is move progressively inwards. In this case, the initially symmetrically knitted rib fabric remains symmetrical for the continuation of plain knit fabric and it is necessary to remove all the loops from the needles and to transfer them inwards.

It will be obvious that the pitch of the doublings will correspond to the physical width of the doubling boxes **13**. Thus, for example, consider a 20 inch piece of 27 gauge rib fabric (i.e., 18 needles per inch) which is required to have nine doublings inserted to allow the fabric to be reduced in width coursewise by nine needles i.e., 9/18 or ½ inch to 19½ inches wide fabric. Then nine doubling boxes each containing 35 needles would be required to insert doublings at approximately 2 inch pitch. This would be accomplished in two dips of the fashioning mechanism as hereinbefore described. If the pitch of the doublings were to be approximately 1 inch using the same mechanism, then this could be accomplished by completing the cycle as described above and then re-siting the doubling boxes to repeat the operation. In this case, the entire doubling operation would require four dips of the fashioning mechanism. If the pitch of the doublings were to be ½ inch and eight dips of the fashioning mechanism would be required and so on.

It will be understood that timing of the operation of the loop transfer points **14** is effected by virtue of the cams on the main camshaft C, selection for operation when the machine is changed to effect a fashioning motion being effected by the shogging of the camshaft mechanism in a conventional manner.

The command signals for operating the pneumatic ram **22** will of course be timed from the main camshaft C of the machine, but the signal may be initiated from a punched tape or other conventional control means generally used in straight bar knitting machines.

Referring now to the embodiment of FIGS. **4** to **10**, there is again shown in FIG. **4** the needle bar **1** supporting the frame needles **2** on which all the knitted loops are held on comple-

tion of a rib welt, the associated known elements for carrying out a knitting operation being generally indicated at 3. Shown also in FIG. 4 in its inoperative position is the machine needle bar 34 whose needles 35 co-operate, prior to doubling, with the frame needles 2 to knit the rib welt.

Left hand doubling boxes, one of which is shown at 36, are arranged in each knitting bay of the machine and are suspended from a bar 37 which is longitudinally slidable in brackets 38 situated in each knitting bay of the machine. The bar passes continuously through all knitting bays and a centre control bay and extends into control bays arranged at each end of the machine. Similarly right hand doubling boxes, one of which is shown at 39, are suspended from a control bar 40. Two further bars 41 and 42 are provided for effecting closing together and opening out of the doubling boxes 36, 39 in the manner described hereinafter. All four bars 37, 40, 41 and 42 are guided in the brackets 38 which are supported from a shaft 43 and move in an arcuate path guided by members 44 pivoted on a shaft 45. The amount of movement of the shaft 43, and thus also of the doubling boxes 36, 39 and the loop transfer points 46 provided on the doubling boxes, is governed by a cam 47 on the main cam control shaft C of the machine. A roller 48, rotatably mounted on one end of a lever 49 which is pivoted rearwardly of the machine, follows the profile of the cam 47 when the main camshaft C is shogged sideways, as is conventional for loop transfer functions. A link 50 from the said one end of the lever 49 then transmits this movement to the shaft 43.

The left hand and right hand doubling boxes 36, 39 are essentially identical in construction and therefore only one right hand doubling box 39 will be described in detail with specific reference to FIGS. 4 and 6. Each box consists of a main bracket 51 a top part of which has projections 52 attached to the bar 40 by bolts 53, and a bottom part of which is grooved at 54 and 55 to slidingly accomodate doubling blocks 56. Each block 56 has fixed in it a number of the transfer points 46 held in position by clamp plate 57 and screws 58. Attached to each block 56 is a limiting bracket 59 which is tongued at 60 and 61 and grooved at 62 so that all the boxes can be collapsed together when required, or opened out so that adjacent points 46 on different blocks 56 can be spaced a distance of two needle pitches apart.

It will be noted that in FIGS. 5 and 6 there is one doubling block 56 of each box 39 which is wider than all the others. Attached to the limiting bracket 59 of this block is a guard plate 64 which extends across the back of all the blocks 56, when in a closed position, to keep the unit dust free. It is necessary that this block be extra wide as when the doubling boxes are opened out, a normal width doubling block would come beyond the end of the main bracket 51 and have no means of support, and for space reasons, the bracket 51 is kept to a minimum width.

In order to move the doubling boxes 36, 39 longitudinally, there is provided the usual fashioning screw 65 and associated mechanism as shown in FIG. 7*a*. To rotate the fashioning screw 65 in either direction, there are provided left hand and right hand racking mechanisms 66, 67 one of which is a mirror image of the other. By operating the left hand mechanism 66 the fashioning screw shaft 68, and thus also the fashioning screw 65, is rotated clockwise which moves a nut housing 69 to the right in FIG. 7*a* which, via a projection 70, moves the bar 37 and all the left hand doubling boxes 36 to the right. The fixed relative position of the bar 37 and the nut housing 69 is governed by adjusting screws 71. The right hand racking mechanism 67 shown in FIG. 7*a* is of course for moving the nut housing 69, and thus all the left hand doubling boxes 36, to the left.

The fashioning screw and nut housing 65, 69 and associated mechanisms 66, 67 shown in FIG. 7*a* are arranged at the left hand end of the knitting machine, and there is a further screw and nut housing and associated racking mechanisms arranged at the other end of the machine for controlling all the right hand doubling boxes 39 through bar 40.

The left hand racking mechanism 66 shown in FIGS. 7*a* and 8 comprises a racking cam 72 which is fixed to the shaft 68 by a key 73. To operate the racking cam 72, there is provided a racking pawl 74 whose nose 75 is arranged to engage with the teeth of the racking cam 72, the pawl being freely pivoted at its other end to a lever 76 which is centrally pivoted on a shaft 77. The lever 76 is rocked continuously about the shaft 77 by a connecting link 78 which is pivotally attached to its other end. Link 78 is connected to a lever 79 and has, at the same point, a freely mounted roller 80 which follows the profile of a cam 81 fixed to the main camshaft C of the machine. The lever 79 is pivoted on a shaft 82 disposed rearwardly of the main camshaft C.

Freely mounted at the side of the racking cam 72 is a bluff plate 83 which, in its position shown in FIG. 8, bears against a pin 84 attached to the pawl 74 to hold the pawl out of engagement with racking cam 72. Upon energisation of a solenoid 85, a link 86 attached to the bluff plate 72 is pulled downwards and causes the bluff plate 83 to rotate so that the cutout portion thereof comes into a position under the pin 84 allowing the racking pawl 74 to engage with the racking cam 72 and thereby turn the fashioning screw 65.

FIGS. 9*a*, 9*b* and 10 show the mechanism employed for closing and opening out the doubling boxes 36, 39. The mechanism shown in FIGS. 9*a* and 9*b* is in the centre control bay of the machine and consists of two similar mechanisms 87 and 88, the left hand mechanism 87 controlling the left hand doubling boxes 36 through bars 37 and 41, and the right hand mechanism 88 controlling the right hand doubling boxes 39 through bars 40 and 42.

The left hand and right hand doubling boxes 36 and 39 shown in FIG. 10, and their associated mechanism 87 and 88, are similarly operated and therefore only the operation with reference to the left hand doubling box 36 will be described in detail.

Fixed to the framework of the machine is a template rail 89 to which is attached supports 90 and 91 in which a fixed shaft 92 is supported. The bars 37, 40, 41 and 42 are supported as is hereinbefore described in brackets 38. Slidably located on the shaft 92 is a main block 93 and an auxiliary block 94. A projection 95 formed on the main block 93 is held between two adjusting screws 96 located in brackets 97 attached to the bar 37. Similarly, a projection 98 formed on the auxiliary block 94 is held between two adjusting screws 99 located in brackets 100 attached to the bar 41.

Pivotally supported on the lower part of the main block 93 is a link 101 having, at its free end, a freely rotatable roller 102 located in a cam track 103. A further link 104 is pivotally supported between the lower part of the auxiliary block 94 and the link 101. By suitably lowering the roller 102 from its position shown in FIG. 9*a*, the main and auxiliary blocks 93 and 94 are closed together thereby closing together the associated doubling boxes 36. This action is effected by controlling the vertical movement of a bar 105 housing the cam track 103. This operation is effected by means of a link 106 provided at either end of the bar 105, each link being connected to a rearwardly pivoted lever 107 having a roller 108 which follows the profile of a cam 109 on the main cam control shaft C of the machine. The upper end of the links 106 are pivotally attached to the bar 105 by screws 110. Thus, rotation of the cams 109 causes movements in a vertical direction, of the bar 105.

Normally, with the bar 105 held in one position, the bars 37 and 41, and likewise bars 40 and 42, are held in fixed relationship with one another and, by rotation of the fashioning screws 65, not only are bars 37 and 40 moved, but also bars 41 and 42. If it is considered that the relationship between these bars is the same in FIGS. 9*a* and 9*b* as it is in FIG. 10, then by causing bar 105 to move downwards, the main and auxiliary blocks 93 and 94 are closed together and bars 41 and 42 are moved relative to bars 37 and 40.

In FIG. 10 there is shown, attached respectively to the bars 41 and 42, mechanisms 111 and 112 which control guard

plates **64**. Since these mechanisms are the same in each case, only mechanism **111** attached to bar **41** will be fully described. The mechanism **111** comprises two brackets **113** attached to the bar **41** said brackets supporting a spindle **114**. Freely mounted on the spindle **114**, and between the brackets **113**, are a pair of collars **115** which are urged into engagement with a projection **116** by means of springs **117** and **118**. The projection **116** is fixed to the guard plate **64** which, as previously mentioned, is attached to the limiting bracket **59** of the wide doubling block **56** at the end of each of the doubling boxes **36**, **39**.

It can therefore be seen that, by sliding the bar **41** relative to the bar **37** as just described, the projection **116** with the guard plate **64** are by the action of the spring **118** caused to move to the left in FIG. **10**, which movement, due to the fact that the guard plate **64** is also fixed to the limiting bracket **59** of the wide doubling block **56**, results in closing of the doubling boxes. The relative movement between bars **41** and **37** and the tension of the springs **117** and **118** is such that, when the doubling boxes are collapsed, the spring **118** is under greater compression than the spring **117** which is the reverse of the condition shown in FIG. **10**. This is to prevent any possible unrequired movement in the doubling boxes.

In use, in order to carry out a doubling operation, the doubling boxes **36** and **39** are poised above the frames needles **2** in positions adjacent the outer quarters of the rib fabric. The doubling blocks **56** are spaced apart and the loops of the previously knitted rib fabric are positioned on the frame needles **2**.

The sequence of operations is then as follows:

First dip or cycle

The doubling boxes **36**, **39** with their blocks **56** spaced apart are lowered to pick up the loops from the needles corresponding to the points **46**. The boxes are then raised slightly leaving the needles **2** corresponding to the spaces between the blocks **56** each with a loop. The boxes **36**, **39** are then, with the blocks **56** still spaced apart, moved one needle pitch inwards and the boxes **36**, **39** are lowered to position the loops on their new needles. This results in spaced needles having two loops and the needles immediately adjacent thereto on one side having no loops. In this position, the needles having no loops correspond to the spaces between adjacent blocks **56**.

Second dip or cycle

The boxes, still in their last vertically aligned position, are lowered to pick up the loops (spaced ones of which are doubled). The boxes are then raised and their blocks **56** are closed together, after which the boxes are lowered to transfer the loops to the needles and then raised again. In this position, the outer quarters of the fabric are on a fewer number of needles with double loops at positions corresponding to the pitch of the blocks **56**.

Third dip or cycle

The boxes **36**, **39** are now kept with their blocks **56** closed together and the boxes are moved inwards the equivalent of the pitch of one block **56**. The boxes are then lowered to pick up the loops from the needles corresponding to the points **46**, raised slightly, and moved the equivalent of the one needle pitch inwards. The boxes are again lowered and subsequently raised with the result that a double loop is provided on the needle corresponding to the innermost point **46** of each box, and the needle immediately adjacent and outside the outermost point **46** of each box is left without a loop thereby presenting a hole in the fabric.

Fourth dip or cycle and any desired number of subsequent dips or cycles

These follow an identical operation to that described with reference to the third dip or cycle. This results in a series of doubled loops, at spacings corresponding to the pitch of one block **56**, being formed in the centre quarters of the fabric, and in a corresponding number of holes in the outer quarters of the fabric. In this respect, it will be appreciated that the number of said subsequent dips or cycles is determined and carried out over the centre of the fabric as required.

Last dip or cycle

Having completed the desired number of said subsequent dips or cycles, the blocks **56** are then spaced apart and the boxes **36** and **39** are moved outwards to positions where the spaces between the blocks **56** align with the needles without loops. The boxes are then lowered to pick up their corresponding loops, raised slightly, closed together and then lowered and subsequently raised to leave the loops on consecutive needles. The fabric is thus narrowed a further number of needles corresponding to the number of dips or cycles between the second and the last.

It will be appreciated that the number of dips or cycles is dependent upon the needle gauge, the width of the fabric and the amount of narrowing required and will therefore be selected accordingly. In this respect, depending on the circumstances, the required result may be achieved with the first two dips or cycles only.

The number of dips or cycles is also dependent upon the width of each block **56**, and thus also on the number of narrowing points **46**. In this respect, it has been found convenient to use blocks of one-half inch width. However, the number of doublings or dips can be reduced by increasing the width of each block but this decreases the amount of narrowing. Similarly, the amount of narrowing can be increased but this increases the number of dips or cycles necessary. The use of one-half inch blocks has been found to strike a balance between the maximum amount of narrowing required with the minimum number of dips or cycles.

What we claim is:

1. A method of loop doubling on a plain straight bar knitting machine, which comprises transferring spaced groups of loops from the frame needles to at least one series of spaced blocks of loop transfer points, moving all of the blocks of transfer points of said series sideways in one direction the equivalent of at least one needle pitch, returning the groups of loops to the knitting needles, again transferring the loops from the knitting needles to the spaced series of transfer points, closing the blocks of transfer points of said series together and again returning the loops to the knitting needles for closing together the previously spaced groups of loops on the knitting needles with spaced doublings and on fewer needles than at the commencement of the operation.

2. The method as claimed in claim **1**, and including the additional steps of moving the series of blocks of loop transfer points, in a closed condition, sideways the equivalent of the pitch of one of said blocks, transferring the loops on the corresponding needles to the transfer points, moving all of the transfer points sideways in the same direction the equivalent of one needle pitch, returning the loops to the knitting needles, and repeating said additional steps a predetermined number of times for producing on the knitting needles a plurality of spaced groups of loops.

3. The method as claimed in claim **2**, including the further steps of transferring said spaced groups of loops to the groups of loop transfer points while the group of loop transfer points are in a spaced condition, closing the spaced groups of transfer points of said one series together, and thereafter returning the loops to the knitting needles.

4. A plain straight bar knitting machine having loop doubling means mounted on fashioning mechanism thereof, and wherein the doubling means comprise at least one cooperating plurality of spaced groups of loop transfer points, and control means for selectively moving the groups of points in unison at least one needle pitch while maintaining the spaced relation and in unison while moving individual ones of said groups relative to one another the equivalent of at least two needle pitches.

5. A knitting machine as in claim **4**, wherein said control means include an actuating rod; said doubling means include a plurality of doubling boxes extending over the length of the needle bed of the machine and being slidably mounted on the actuating rod, each of said boxes supporting a group of said loop transfer points; and said control means further including means for moving the actuating rod lengthwise of the needle bed, and stop means for controlling the extent of relative movement between the actuating rod and the doubling boxes.

6. A knitting machine as in claim 5, in which the means for moving the actuating rod lengthwise comprise a fluid actuated piston and cylinder device which is releasably coupled to the actuating rod.

7. A knitting machine as in claim 6, in which the stop means comprise a series of projections arranged on a fixed stop bar, and an upstanding lug formed on each doubling box for co-acting with the projections formed on the stop bar.

8. A knitting machine as in claim 4, wherein said doubling means include left hand and right hand doubling boxes each supporting a plurality of doubling blocks each having secured thereto a group of said loop transfer points; and said control means include means for moving said doubling boxes relative to one another.

9. A knitting machine as in claim 8, including a series of limiting brackets secured to the doubling blocks to limit the extent of movement of the said blocks in an outward direction.

10. A knitting machine as in claim 9, in which the limiting brackets each comprise a flat plate element having along one edge a tongued head and along its opposite edge a grooved recess of greater depth than that of the head, the tongued head of one element being fitted into the grooved recess of the adjacent element.

11. A knitting machine as in claim 8, in which the means for moving the doubling boxes relative to one another lengthwise of the needle bed, comprise left hand and right hand fashioning screws operatively connected to each doubling box via operating bars extending lengthwise of the machine, and racking mechanisms actuated by the main camshaft of the machine for turning the fashioning screws in either direction.

12. A knitting machine as in claim 11, in which the means for effecting relative movement between the doubling blocks comprise, in respect of each doubling box, a main actuating block coupled to the operating bar of the doubling box, an auxiliary actuating block coupled to an actuating bar fixed to one of the doubling blocks, and means for moving said actuating blocks towards and away from one another.

13. A knitting machine as in claim 12, in which the means for effecting relative movement between the actuating blocks comprise a pair of interconnected links attached respectively to the actuating blocks, said links having a common roller operable in a cam track which is movable in a vertical direction.

14. A knitting machine as in claim 13, in which the cam track is movable in a vertical direction by means of linkages operable by the main camshaft of the machine.

15. A knitting machine as in any claim 8, including a guard plate operatively associated with the doubling blocks.

16. A knitting machine as in claim 15, wherein said control means include an actuating bar for each set of doubling boxes, and further including means for operating said guard plate which means comprise a spring loaded centering device mounted on the corresponding actuating bar and coupled to the guard plate.

17. A method of loop doubling on a straight bar knitting machine of the type having a needle bed supporting knitting needles, a fashioning mechanism arranged above said needle bed to carry out dipping operations towards and away from said knitting needles, a plurality, in excess of two, of doubling blocks supported by said fashioning mechanism, each of said doubling blocks having a series of loop transfer points which coact with said knitting needles, and means for moving said doubling blocks relative to one another in a direction lengthwise of said knitting needles, said method comprising transferring spaced groups of loops from said knitting needles to said loop transfer points while said doubling blocks are spaced apart, moving said doubling blocks sideways the equivalent of at least one needle pitch, returning said groups of loops to said knitting needles, again transferring said loops from said knitting needles to said loop transfer points of said spaced doubling blocks, closing said blocks together, and again returning said loops to said knitting needles, whereby the previously spaced groups of loops are closed together on said knitting needles with spaced doublings and on fewer needles than at the commencement of the operation.

18. The method as in claim 17, and including the additional steps of moving said doubling blocks, in a closed condition, sideways the equivalent of the pitch of one of said doubling blocks, transferring loops from correspondingly positioned needles to said transfer points, moving said doubling blocks sideways the equivalent of one needle pitch, returning said loops to said knitting needles, and repeating said additional steps a predetermined number of times to produce on said knitting needles a plurality of spaced groups of said loops.

19. The method as in claim 18, including the further steps of transferring said spaced groups of loops to said loop transfer points with said doubling blocks in a spaced condition, closing said doubling blocks together, and thereafter returning said loops to said knitting needles.

20. A straight bar knitting machine comprising a needle bed supporting knitting needles, a fashioning mechanism arranged above said needle bed to carry out dipping operations towards and away from said knitting needles, an actuating rod extending lengthwise over the length of said needle bed, a plurality, in excess of two, of doubling blocks slidably mounted on said actuating rod, each of said doubling blocks having a series of loop transfer points which co-act with said knitting needles, fluid actuated piston means operative to move said actuating rod relative to said doubling blocks and to move said doubling blocks relative to one another, said fluid actuated piston means being releasably coupled to said actuating rod, and stop means for controlling the extent of relative movement between said actuating rod and said doubling blocks, said stop means comprising a fixed stop bar having spaced projections, and upstanding lugs formed on said doubling blocks to co-act with said spaced projections.

21. A straight bar knitting machine comprising a needle bed supporting knitting needles, a fashioning mechanism arranged above said needle bed to carry out dipping operations towards and away from said knitting needles, left hand and right hand doubling boxes supported on said fashioning boxes, each of said doubling boxes supporting a plurality, in excess of two, of doubling blocks, said doubling blocks each having a series of loop transfer points which co-act with said knitting needles, means for moving said doubling boxes relative to each other lengthwise of said needle bed, and other means for moving said doubling blocks relative to one another a distance equivalent to at least two knitting needle pitches.

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