Oct. 26, 1971 J. RADIN 3,614,877

COMPOUND STITCH CAM FORK KNITTING MACHINES

Filed March 14, 1969 3 Sheets-Sheet 1

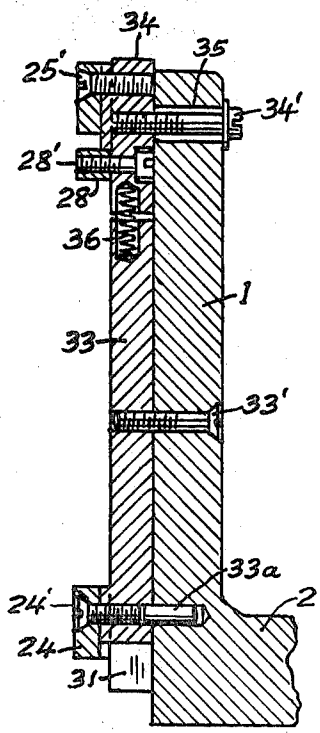

Fig. 5.

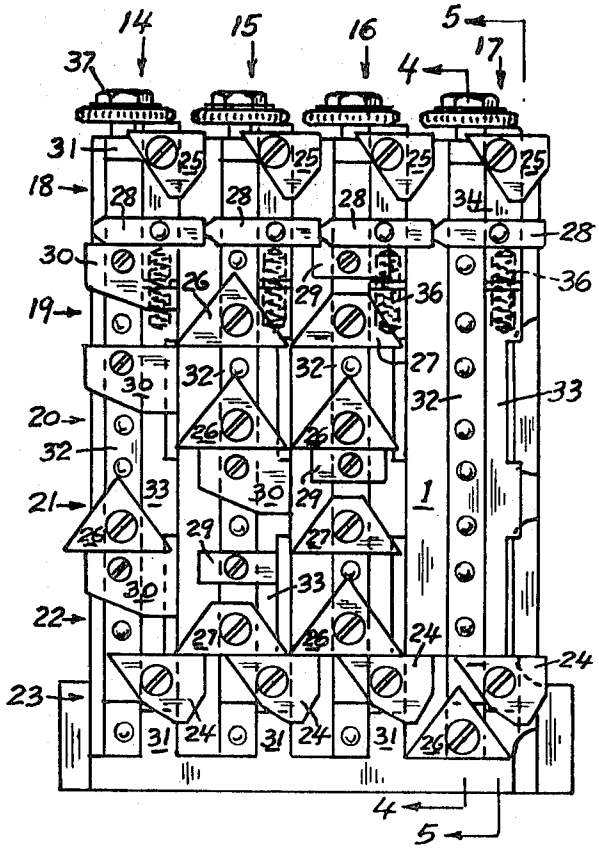

Fig. 1.

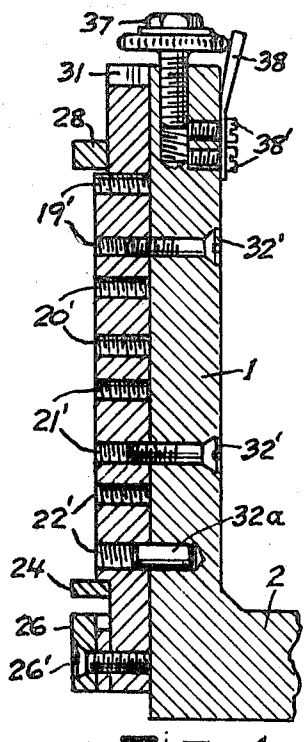

Fig. 4.

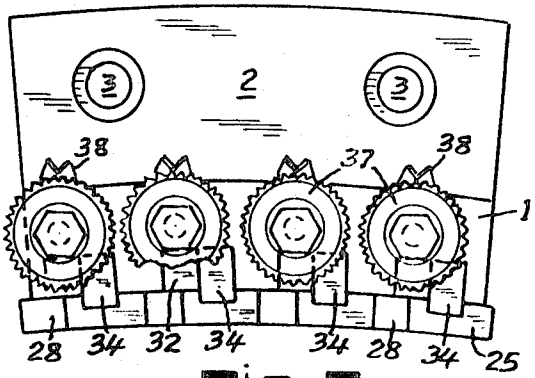

Fig. 2.

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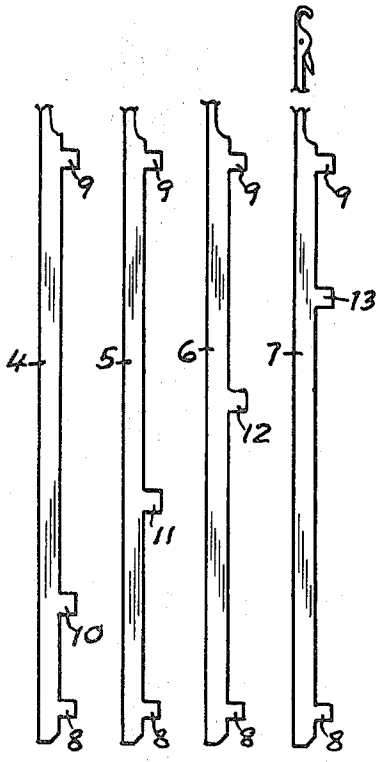


Fig. 5.

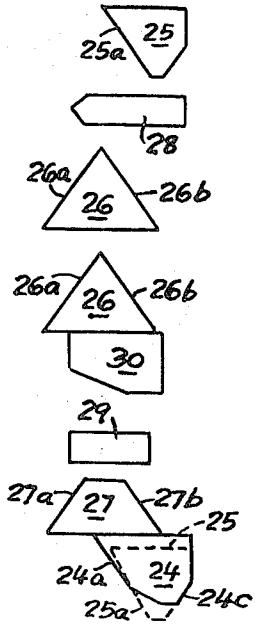
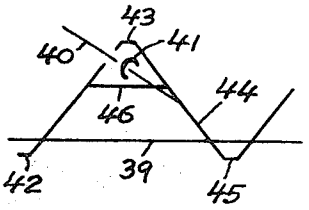
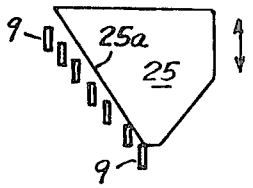


Fig. 8.





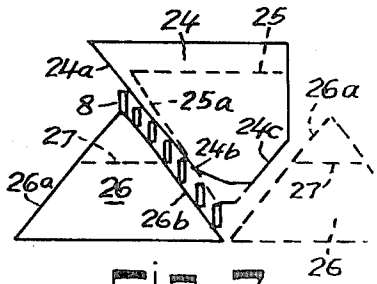


Fig. 7.

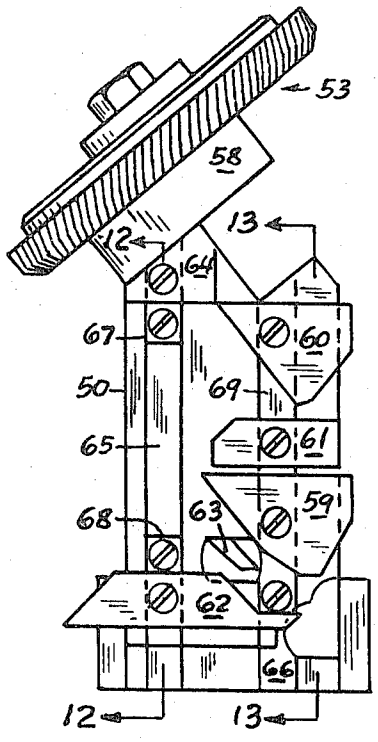


Fig. 9.

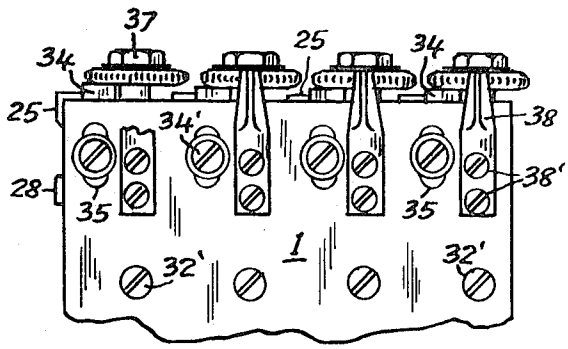


Fig. 3.

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COMPOUND STITCH CAM FORK KNITTING MACHINES

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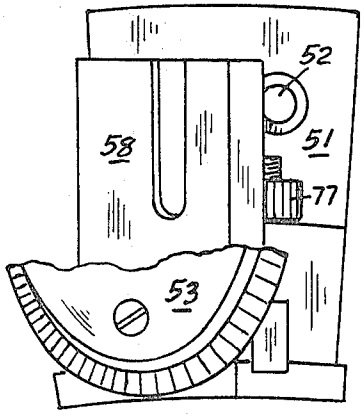


Fig. 10.

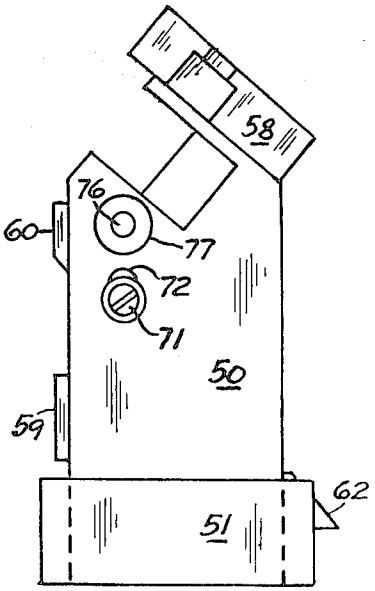


Fig. 11.

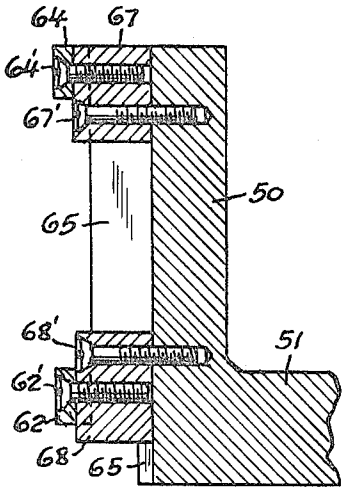


Fig. 12.

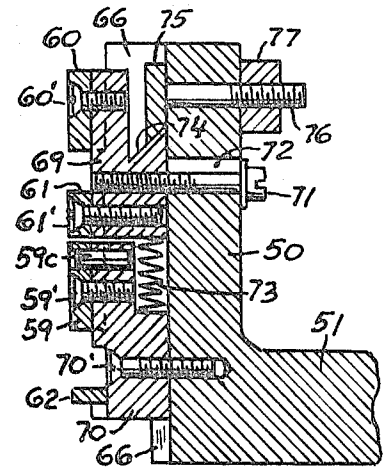
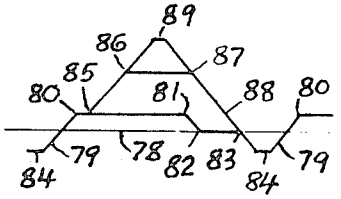
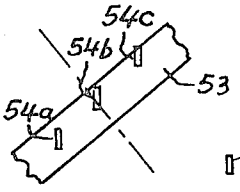


Fig. 13.





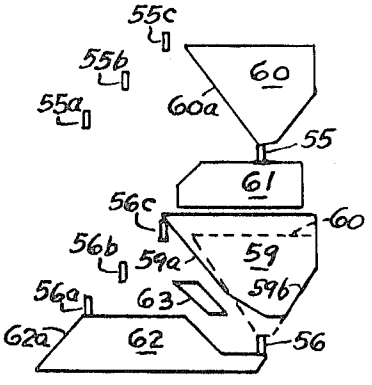


Fig. 15.

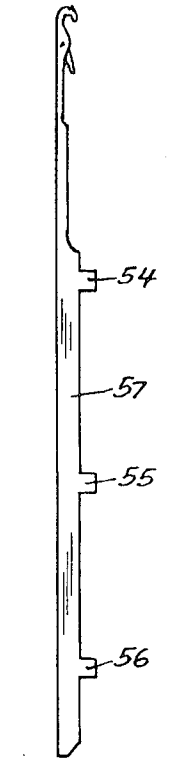


Fig. 14.

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3,614,877

COMPOUND STITCH CAM FOR KNITTING MACHINES

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Int. Cl. D04b 9/38, 15/76
U.S. Cl. 66—42 13 Claims

ABSTRACT OF THE DISCLOSURE

A compound stitch cam, particularly for use at each feed of a multi-feed latch needle circular knitting machine, comprising a fixed main and an adjustable auxiliary stitch cam to act upon a pair of vertically spaced butts on the shanks of the latch needles in the machine, the said stitch cams also being vertically spaced with the main stitch cam acting upon the lower ones of said butts to lower the needles to less than their stitch forming level and with the auxiliary stitch cam thereafter acting upon the upper ones of said butts to lower the needles to their stitch forming level. The said compound stitch cam and the latch needles being arranged in combination with needle selecting pattern means on the said machines for three level selection of the needles to welt, tuck and knit positions.

The present invention relates generally to the art of knitting and more particularly to latch needle knitting machines wherein the needles are independently movable to and from their stitch forming position. The invention provides a novel compound stitch cam means to move the latch needles to their stitch forming position, the said means comprising a main stitch cam which moves the needles to less than their stitch forming position and an auxiliary stitch cam which thereafter moves the needles to their stitch forming position. The compound stitch cam means provides for fixed pathways for the needles and for the combination therewith of needle selecting means.

In present day multi-feed latch needle circular knitting machines, due to the desire to place the maximum number of feeds thereon, the needle operating cams are sharply angled to aid in the reduction of space required for each of the feeds. Such sharply angled cams often cause some of the needles to be overthrown, even though they have been initially self frictioned in their slots, with the result that such overthrown needles no longer follow their proper paths of travel and thus cause imperfections in the fabric being knitted. It is also desirable to have the needle latches as short as possible in order to reduce the amount of needle travel which in turn reduces the required size of the needle operating cams. It is further desirable to have the needles move in fixed confined pathways as much as possible to prevent overthrow of the needles by the sharply angled cams, particularly during the time yarns are fed to the needle hooks to insure proper feeding and to prevent drop stitches. Heretofore with the use of the single adjustable stitch cam at a feed of the machine, the pathway of the needles necessarily changed with each stitch cam adjustment and it was often found necessary to accordingly adjust the position of the yarn feeding guides at the same time that the stitch cams were adjusted in order to properly feed the yarns to the needle hooks.

It is the principal object of the present invention to provide a novel compound stitch cam means comprising a relatively fixed main stitch cam to move the needles to less than their stitch forming position and a relatively adjustable auxiliary stitch cam to thereafter move the needles to their stitch forming position, the said compound stitch cam means providing for the formation of

an increased number of fixed pathways for the needles, whereby adjustment of the yarn feeding guides is eliminated, whereby overthrowing of the needles is substantially eliminated, whereby shorter latch needles may be used, whereby smaller sizes of needle operating cams may be employed and whereby a greater number of feeds may be placed upon a machine of a given diameter.

It is also an object of the present invention to provide a novel compound stitch cam means which can be used in combination with a variety of needle selecting means on the machine whereby patterning may be provided in the fabric being knitted and whereby the stitches of such fabric are drawn by the said compound stitch cam means.

The above and other objects and advantages of the invention will be fully apparent hereinafter, it being understood that the present invention is primarily concerned with a novel two-piece compound stitch cam for use upon latch needles and with which the needles may be selected to provide patterning in the fabric knit thereby, all as will be described in detail hereinafter, as shown in the accompanying drawings which are illustrative of two preferred embodiments of the invention and as set forth in the appended claims.

In the drawings:

FIG. 1 is a front elevational view of the cam side of one arc-shaped cam section of the circular cam ring of a multi-feed latch needle circular knitting machine showing the cam arrangement at four adjacent feeds of the machine including the novel main and auxiliary stitch cams of the present invention at each of the feeds and also the cam means used for the needle selection.

FIG. 2 is a plan view of the cam section shown in FIG. 1.

FIG. 3 is a rear elevational view, partly in section, of the upper part of the cam section shown in FIG. 1.

FIG. 4 is a vertical sectional view of the cam section as taken on lines 4—4 of FIG. 1

FIG. 5 is a vertical sectional view of the cam section as taken on lines 5—5 of FIG. 1.

FIG. 6 is a view showing a series of latch needles with butts at six levels as used in the needle cylinder of the present machine and which are acted upon by the cams shown in FIG. 1.

FIG. 7 is an enlarged schematic view illustrating the action of the two-piece compound stitch cam of the present invention in relation to certain of the needle butts, the stitch forming level and the yarn feeding position, other of the cams and the needle selecting butts being omitted.

FIG. 8 is a schematic view showing the outline of the cams at one of the feeds shown in FIG. 1 with the outline of the auxiliary stitch cam superimposed upon the outline of the main stitch cam.

FIG. 9 is a front elevational view of the cam side of one arc-shaped cam section of the circular cam ring of another multifeed latch needle circular knitting machine showing the cam arrangement at one feed of the machine including the novel main and auxiliary stitch cams of the present invention and an inclined design wheel used in conjunction therewith for needle selection.

FIG. 10 is a plan view of the cam section shown in FIG. 9.

FIG. 11 is a rear elevational view of the cam section shown in FIG. 9 with the design wheel removed.

FIG. 12 is a vertical sectional view of the cam section as taken on lines 12—12 of FIG. 9.

FIG. 13 is a vertical sectional view of the cam section as taken on lines 13—13 of FIG. 9.

FIG. 14 is a view showing the type of latch needles used in the machine and which are acted upon by the cams and the design wheel shown in FIG. 9, and

FIG. 15 is a schematic view illustrating the action of the cams and of the design wheel of FIG. 9 in relation to the butts of the latch needles shown in FIG. 14 and in relation to their stitch forming level.

Each of the cam sections of a circular cam ring of a multifeed latch needle circular knitting machine is arc-shaped in outline, as shown in FIGS. 1, 2 and 3, and is L-shaped in cross-section with its upright portion indicated at **1** and its base portion at **2**, the latter being provided with a pair of spaced holes **3** through which screws (not shown) extend to secure each cam section in place on the machine frame. It is understood that a plurality of like circularly arranged cam sections together form the circular cam ring surrounding the needle cylinder of the machine. The radius of each cam section is obviously dependent upon the diameter of the machine's needle cylinder and its circumferential extent is sufficient to encompass the minimum length required for a plurality (here shown as four) of feeds of the machine, the machine itself being of the multi-feed type with the maximum number of feeds for the diameter thereof. In this type of machine, the needle moving cams have relatively steep slopes in order that each of the feeds may take up a minimum of circumferential extent of the machine's cam ring or, in other words, that a maximum number of feeds can be placed on the machine. Also, in order to increase the number of feeds, the needle latches are made shorter so that less needle travel is required to form stitches. It is also desirable that the needles follow confined pathways as much as possible, particularly during the stitch forming operation.

The present compound stitch cam is of general application to all types of knitting machines including both plain and rib circular machines and to machines having needle selecting means therein. The invention is shown in connection with one type of needle selection (cams and needle butts at several levels) in the FIGS. 1 through 8 and with another type of needle selection (inclined design wheel) in the FIGS. 9 through 15.

In the apparatus of FIGS. 1 through 8, there are needle selecting cams at four levels of each feed of the cam sections to act upon the needle butts at four corresponding levels of the needles, the latter also having a pair of butts, one above and one below the said four butt levels, upon which the main and the auxiliary stitch cams of the present invention act to lower the needles. The needles are shown in FIG. 6 at **4**, **5**, **6** and **7**, being of normal construction at their hook and latch ends and having butts at six levels on their shanks. There are common level butts **8** and **9** at the lower and at the upper levels of all of the needle shanks with a butt **10** at the second level on needle **4**, a butt **11** at the third level on needle **5**, a butt **12** at the fourth level on needle **6** and a butt **13** at the fifth level on needle **7**.

In FIG. 1, the four feeds are indicated at **14**, **15**, **16** and **17** while the six needle actuating cam levels at each of the feeds are indicated at **18**, **19**, **20**, **21**, **22** and **23**. The four intermediate levels, **19** through **22**, are the needle selecting levels at which there are selectively placed needle actuating cams to act upon the butts **10** through **13** while upper and lower levels, **18** and **23**, have the main and the auxiliary switch cams to act upon the needle butts **8** and **9**, and additionally, raise cams may be placed at the level **23** at one or more of the feeds to act upon the butts **8** when it is desired to provide uniform raising action on all of the needles at such feed or feeds. Like characters are placed upon the several like cams even though such cams are at different levels and/or at different feeds, for example, each of the main switch cams at level **23** of feeds **14** through **17** is indicated at **24** while each of the auxiliary stitch cams at level **18** of the same feeds is indicated at **25**. Similarly, knit raise cams, which elevate the needles to full latch clearing level, are shown at **26** in level **21** of feed **14**, in levels **19** and **20** of feed **15**, in levels **20** and **22** of feed **16** and in level **23** of feed **17**. The tuck raise cams, which elevate the needles to tuck level (with the old loops still on their latches), are shown at **27** in level **22** of feed **15** and in levels **19** and **21** of feed **16**. Shown at **28** in level **18** of all four feeds are guard cams **28** which are associated with the auxiliary stitch cams **25** in fixed spaced relation thereto and which serve to prevent overthrow of the needle butts **9** (and of the needles) when the latter are lowered by the auxiliary stitch cams **25**. Shown at **29**, in association with each of the tuck raise cams **27**, is a guard cam **29** which serves to prevent overthrow of the needle butts when the latter are raised by the tuck raise cams **27**. Shown also, at **30** in levels **19**, **20** and **22** of feed **14** and in level **21** of feed **15** are welt guard cams which act upon the needle butts of needles which are not to be raised by cams and which serve to keep these needles (if accidentally raised) at a welt level wherein their hooks will not take yarn nor interfere with the feeding thereof to the hooks of raised needles.

The above set forth needle actuating cams are affixed to the wall **1** of the cam sections at each feed in novel manner which includes the formation of a double width vertical keyway milled in the inner side of the cam section at each feed, with a pair of side-by-side keys of rectangular cross section secured to the cam section in each keyway thereof and the several needle cams secured to the keys themselves. Each of the double width keyways is shown at **31** with a pair of side-by-side keys **32** and **33** therein, the former each being secured in place by a pair of spaced screws **32'** passing through suitable apertures in wall **1** of the cam section and threaded part way into suitable tapped apertures in the key itself while each of the latter is similarly secured to the cam section by a screw **33'**. The said keys **32** and **33** are additionally positioned by means of suitable pins **32*a*** and **33*a*** set in the wall **1** and in the keys themselves.

In the keyway **31**, above the key **33** (which is shorter than the key **32**), there is a relatively short section of a separate key **34** which is vertically adjustable within the keyway. This key is secured in position by means of a screw **34'** extending through a suitable vertically elongated slot **35**, in the wall **1** and into threaded engagement with the key **34**, a suitable washer being placed between the head of screw **34'** and the outer face of the wall **1** whereby the screw **34'**, after being loosened, may be moved vertically within the limits of the slot **35** (as key **34** is adjusted) and then tightened to position the key **34**. A compression spring **36**, set in suitable apertures in the upper end of key **33** and in the lower end of key **34**, serves to urge key **34** upwardly and is of assistance in the adjustment of the latter key. To also assist in the adjustment of key **34** (and the cams carried thereon), a large headed screw **37** is provided which is threadedly engaged vertically into the top of wall **1** in such disposition that the underside of its head (the outer edge of which is serrated) overlies the key **34**. Thus, when screw **34'** is loosened, the position of key **34** may be adjusted by appropriately turning the screw **37** against which the spring **36** forces the key. The screw **37** is spring retained in adjusted position by a V-shaped flat spring **38** pressed into the serrations of the head of screw **37**, the spring itself being retained in active position on the outer face of wall **1** by a pair of screws **38'**, **38'** passing through the spring into threaded engagement with the wall.

The several cams **24** through **30** are each secured to one or the other of the keys **32** and **33** by means of screws passing through the cams into threaded engagement with the keys (the reverse being the situation as regards the cams **28**), the latter having slots formed in their rear sides to fit over the keys. Thus, screw **24'** passes through a suitable aperture in cam **24** into threaded engagement with the key **33** to secure the cam thereto. Similarly, screw **26'** secures the cam **26** to key **32**, screw **25'** secures the cam **25** to key **34** and screw **28'** passes through key **34** into threaded engagement with cam **28** to secure the latter to the key. The other cams

are similarly secured to their respective keys and, at each of the needle selecting levels **19** to **22**, the keys **32** are provided with suitably tapped holes **19'**, **20'**, **21'** and **22'**, FIG. 4, whereby any desired ones of the cams **26**, **27**, **29** and **30** may be secured thereto. The particular choice of a selecting cam at each level of each feed, whether it be a knit raise cam **26**, a tuck raise cam **27** and guard cam **29** or a welt guard cam **30**, will depend upon the action desired of each of the needles at each of the feeds and also upon the sequential arrangement of the needles **4** through **7** in the cylinder. If it is desired that all the needles are to knit at a feed, this may be accomplished by locating a knit raise cam **26** on a key **32** at level **23** to act on butts **8**, as in feed **17**.

The compound action of the main stitch cam **24** on butts **8** and of the auxiliary stitch cam **25** on butts **9** of needles **4** through **7** is graphically shown in FIG. 7 wherein **39** represents the level of the surface over which the stitches are drawn (sinkers or the edge of a cylinder or dial), wherein **40** indicates a knitting yarn being fed to the needles through a yarn guide aperture **41** and wherein the path of the needle hooks during plain knitting at a feed is indicated by the path lines **42**, **43**, **44** and **45**, when all the needles are raised by the action of a cam **26** at level **23** on the butts **8**, as at feed **17** of FIG. 1. However, the stitch forming action itself is the same on selected needles raised by the cams **26** at the levels **19** through **22**. The needle hooks move up as they follow the path lines **42** to **43** as their butts **8** move up the cam face **26***a* of cam **26** and then move down to follow the common path line **43** to **44** as their butts **8** move down the face **24***a* of cam **24** to its point **24***b*. At this time the action of cam face **25***a* of cam **25** takes over on butts **9** (the cam **24** being cut back below its point **24***b* to no longer act on the butts **8** beyond this point) and the needle hooks follow the common path line **44** to **45**, the latter point being at the stitch forming level as the butts **9** pass under the point of cam **25**. The outline of cam **25** has been superimposed in dotted lines over that of cam **24** so that the action of butts **8** on cam face **24***a* of cam **24** and that of butts **9** on cam face **25***a* of cam **25** may be clearly seen. It will be noted that portions of cams **24** and **25** are common to an arc of the cam ring. Since the cam **24** is fixed it follows that the pathway **43** to **44** is likewise fixed and since the cam **25** is adjustable (as indicated by the arrow in FIG. 7) it follows that the pathway **44** to **45** will vary in accordance with the degree of adjustment. The fixed pathway **43** to **44** is determined by the action of the cam face **26***b* of cam **26** and that of cam face **24***a* of cam **24** up to its point **24***b* on the butts **8** of the needles while the variable pathway **44** to **45** is determined by the action of the lower end of the cam face **26***b* of cam **26** on the butts **8** of the needles and by the action of the lower end of the cam face **25***a* of cam **25** on the butts **9** of the needles. Once the needles have passed cam **25** at a feed, they begin to rise for the next feed if they have a butt at a level where there is a cam **26** or **27** and, as shown in FIG. 7, such upward movement is also in a confined pathway between the cam surface **24***c* of cam **24** on butts **8** and the cam surface **26***a* of a cam **26** (or **27***a* of a cam **27**, see FIG. 8) on the butts at the level at which such cam **26** (or **27**) is located. It may be noted here that the confined pathways for the needles may be determined either by the action of a pair of cam faces at one level acting upon common level butts on the needles or by the action of a pair of cam faces at separate levels acting upon spaced butts positioned at the said separate levels. As to needles which are raised to tuck level by cam face **27***a* of cam **27**, FIG. 8, their butts also follow a confined pathway in their upward movement as determined by the action of cam face **27***a* on the needle butts at the level of cam **27** and by the action of the cam face **24***c* of the cam **24** on the needle butts **8**. The butts then move across the top of cam **27** between it and guard cam **29** until butts **8** are moved down by cam face **24***a* of cam **24** in a pathway determined by the action of cam face **24***a* on butts **8** and cam face **27***b*, FIG. 8, of cam **27** on the butts at the level at which cam **27** is located. Once point **24***b* has been reached, the cam **25** takes over to complete the tuck stitch movement to stitch forming level. Naturally, the pathway of the hooks of the tuck level needles does not extend up to the point **43** (the full latch clearing level) but stops short thereof with the old loops still on the latches and then moves across along the line **46** to join the pathway **43** to **44** and then moves downwardly to the stitch forming level at **45**.

It will be seen that the needle hook pathways, except for the line **44** to **45**, are fixed by the action of fixed needle moving cams and that the pathway **44** to **45** will vary with the position of cam **25**. The point **44** at which the cam **25** starts to move the needles is after the needles, in both knit and tuck position, take the yarn **40** and therefore the position of the yarn feeding guide (of which its aperture is shown at **41**) may remain fixed and need not be changed when the stitch length is changed by adjusting the stitch cam **25**. It will also be seen that since the needles follow fixed or confined pathways, their needle hooks do likewise so there is no possibility of overthrown needle hooks interfering with the yarn feeding. This is a distinct improvement over the action in machines wherein a single adjustable stitch cam is employed because in such machines when the stitch cam is moved to a new position the pathway of all the needle hooks is changed and this often requires a change in the position of the yarn guides to avoid drop stitches. Also, in such machines, confined pathways for the needles, as shown in the present invention, are not possible since room must be left available for movement of the entire stitch cam and as a result the needles are often overthrown upwardly or downwardly in such manner as to interfere with the yarn feeding which results in undesirable drop stitches being formed. The extent to which the cam **24** acts before the cam **25** takes over may be varied and while it is shown that the cam **25** takes over just prior to the needle hooks passing the stitch forming line **39**, the invention is not so limited, however, in all cases the action of both cams **24** and **25** is required for the machine to be able to knit conventional fabrics and the basic changes in stitch length to be made in the machine and in the fabrics are made by adjusting the stitch cams **25**.

The cam layout in FIG. 8 is that of the cams at feed **15** of FIG. 1 with the outline of cam **25** superimposed in dotted lines over the outline of cam **24**. All needles **6** and **7** passing this feed will be raised to full latch clearing level by the cams **26** at levels **19** and **20** acting on their butts **12** and **13**, all needles **5** passing this feed will not be raised at all since no raise cam is present at level **21** but the cam **30** at this level acting on butts **11** of any needles accidentally raised will lower these needles sufficiently so that their hooks will not take yarn or interfere with the feeding thereof to other raised needles, and all needles **4** passing this feed will be raised by cam **27** at level **22** acting on their butts **10**. Fixed pathways for the needles **6** and **7** are provided by the cam face **24***c* (of the cam **24** at the preceding feed **14**) and the cam faces **26***a* of cam **26** and by the cam faces **26***b* of cams **26** and the cam face **24***a* of cam **24**. A fixed pathway for needles **4** is provided by the cam face **24***c* (of the cam **24** at the preceding feed **14**) and the cam face **27***a* of cam **27** and by the cam face **27***b* of cam **27** and the cam face **24***a* of cam **24**.

A modification of the invention is shown in FIGS. 9 through 15 wherein at each feed of a multi-feed latch needle circular knitting machine the main and the auxiliary stitch cams act upon the lower two of three spaced butts on the shanks of the latch needles used in the machine while an inclined design wheel acts upon the third butts of the needles to selectively place them in welt, tuck or knit positions. Each of the cam sections of the machine

is arc-shaped in outline, as shown in FIGS. 9 through 11, and is L-shaped in cross section with its upright portion indicated at **50** and its base portion at **51**, the latter being provided with one or more suitable apertures **52** through which screws extend to secure each cam section in place on the machine frame. The needle selection is provided by an inclined design wheel **53** which acts upon the upper one, **54**, of three spaced butts **54**, **55** and **56** on the shanks of latch needles shown at **57**, FIG. 14, to cause certain of the said needles to pass through the wheel at a low tuck level, others are raised to the regular tuck level and still others of the needles are raised to the full latch clearing level. The wheel is mounted in customary manner upon an inclined forked member **58** extending radially outwardly from the upper portion of the wall **50** of the cam section. The cams acting upon the butts **55** and **56** of the needles, FIGS. 9 and 15, includes the main stitch cam **59** acting on butts **56** to partially lower the needles, the auxiliary stitch cam **60** acting on butts **55** to lower the needles to stitch forming level, the guard cam **61** in fixed spaced relation to the cam **60** (and serving the same function as cam **28** in the first modification of the invention), the leveling cam **62** acting on butts **56** to raise the needles from their stitch forming level to which they were lowered by an auxiliary stitch cam (not shown) at the preceding feed and to bring them up to a common low tuck level for presentation of their butts **54** to the design wheel **53** at such low tuck level, the cam **63** which is a retractable wing cam and which acts upon the butts **56** of those needles remaining at the low tuck level (after passing through the wheel **53** without being raised) to lower them to welt level so that they do not take yarn in their hooks and the cam **64** which is a conventional fixed stationary guard cam adapted to act upon the butts **54** of the needles to prevent the overthrow thereof.

The several cams (other than the wing cam **63** which is positioned at the forward end of a member inserted into a milled opening formed in the wall **50**) are secured to keys set in keyways in the inner side of the wall **50** in a manner similar to that described in connection with the apparatus of FIGS. 1 through 8. Set into the spaced vertically extending keyways **65** and **66** milled in the inner side of wall **50** is a pair of keys **67** and **68** in keyway **65** and a pair of keys **69** and **70** in keyways **66**, FIGS. 9, 12 and 13. The cam **64** is secured to the key **67** by means of a screw **64'** extending through the cam into threaded engagement with the key while the latter is secured to the wall **50** by means of a screw **67'** extending through the key into threaded engagement with the wall **50**. The cam **62** is similarly secured to the key **68** by screw **62'** and the key **68** is similarly secured to the wall **50** by means of a screw **68'**. Also, the cam **59** is similarly secured to key **70** by screw **59'** and additionally by a pin **59***c* extending through cam and key while the latter is similarly secured to the wall **50** by a screw **70'**. The cams **60** and **61** are likewise secured to the key **69** by screws **60'** and **61'** while the key is secured to the wall **50** in such manner as to permit vertical adjustment thereof. A screw **71** extends through a vertically elongated slot **72** in wall **50** into threaded engagement with the key **69** with a washer placed between the underside of the head of screw **71** and the outer face of the wall. A compression spring **73** disposed in a suitable aperture in the upper end of key **70** acts upon the lower end of key **69** to urge the latter upwardly, the key **69** in FIG. 13 being shown in its lowermost position. The rear upper portion of key **69** is cut away to provide the angled surface **74** which is in contact with a similarly angled face of an elongated adjusting hammer **75** set in the keyway **66**, the member **75** being provided with a screw extension **76** passing through the wall **50** and upon the free end of which is placed a knurled head adjusting nut **77**. Normally, when the screw **71** is tightened the key **69** and its cams **60** and **61** are held fast in adjusted position. When adjustment of these cams is desired, the screw **71** is loosened and the adjusting nut **77** is turned on screw **76** to move the head **77** radially as required during which time the spring **73** keeps inclined surface **74** of key **69** in contact with the head **77** whereby the key **69** is adjustably moved and thereafter the screw **71** is again tightened to hold the parts in position. A flat spring, similar to the spring **38** of the first embodiment, may be provided to act upon the knurled portion of the nut **77** to yieldingly maintain the same in position.

In FIG. 15, the outline of the auxiliary stitch cam **60** has been superimposed over that of the main stitch cam **59** in order to show where the action of cam face **59***a* of the cam **59** on the butts **56** stops and the action of cam face **60***a* of the cam **60** takes over on the butts **55** to lower the needles to stitch forming level. The level over which the stitches are drawn is shown at **78** and the several paths of travel of the needle hooks are also indicated in FIG. 15. As the needle butts come (from stitch forming level at a preceding feed) up cam face **62***a* of cam **62** to the top thereof, their needle hooks follow the line **79** to point **80** which is the low tuck level of the needles at which level the butts **54** of the needles move toward the pattern wheel **53**, the needles at this level being represented by the position of their butts at **54***a*, **55***a* and **56***a*. As to those needles whose butts **54** pass through wheel **53** without being raised thereby, their butts **56** pass along the top of cam **62**, are lowered by wing cam **63** and are further lowered by the action of cam face **60***a* of cam **60** on their butts **55** to stitch forming level, while their needle hooks follow the pathway from point **80** to **81**, **81** to **82**, **82** to **83** and **83** to **84**, the latter being at the stitch forming level. The action of wing cam **63** is to lower the nonselected needles from their low tuck level to welt level wherein they do not take yarn. The action of the wheel **53** on butts **54** to raise selected ones thereof to tuck level is indicated by the level of such tucked needles of which their butts are shown at **54***b*, **55***b* and **56***b*. These tucked needles continue on, with their butts **56** passing over cam **63** and into contact with cam face **59***a* of cam **59** which first lowers them part way after which they are lowered to stitch forming level by the action of cam face **60***a* of cam **60** on their butts **55**. The hooks of these tucked needles take yarn, following the needle path from point **85** (where they were raised by the wheel **53**) to **86**, **86** to **87** over the cam **63**, **87** to **88** on the cam face **59***a* and **88** to **84** on the cam face **60***a*. As to those needles whose butts **54** are raised to latch clearing or knit level by the wheel **53**, the level thereof is indicated by the position of their butts at **54***c*, **55***c* and **56***c*. These needles continue on (with their butts **56** well above cam **63**) until their butts **56** contact cam face **59***a* which first lowers them part way after which they are lowered to stitch forming level by the action of cam face **60***a* on their butts **55**. The hooks of these knit needles take yarn, following the needle path from point **85** (where they were raised by the wheel **53**) to **89**, **89** to **88** on the cam face **59***a* and **88** to **84** on the cam face **60***a*.

It should be noted that the needle butts are in a fixed and confined pathway as they are lowered from tuck level with their butts **56** between the cams **63** and **59** at which time the needles are taking yarn so that the position of the yarn feeding guides need not be changed when adjustments are made to the cam **60**, as indicated by the arrow, to change the stitch length of the fabric being knitted. The needle butts are also in a fixed and confined pathway as they are raised by the cam **62** with their butts **56** between the cam face **62***a* of cam **62** and cam face **59***b* of a main stitch cam **59** (not shown) at the preceding feed of the machine. By reason of the cam arrangement shown, it is possible to use shorter latch needles and accordingly the design wheels will be more effective in that they will now be required to raise the needles a shorter distance to latch clearing level. Furthermore, by the use of separate spaced butts on the needle shanks for selective action by the design wheel and for movement by the needle operating cams, less

distance is required per feed so that more feed may be placed upon a machine of given diameter.

While the compound stitch cam of the present invention has been shown as comprising a pair of spaced stitch cams acting upon a pair of spaced needle butts, the principle of the invention is not so limited and includes other arrangements of the main and the auxiliary stitch cams and of the needle butts, including the arrangement wherein the two stitch cams are at substantially a common level in overlying relation with both cams acting in sequence upon a common level butt of the needles. Additionally, one of the two stitch cams may be placed at a plurality of levels to act upon needle butts at said plurality of levels while the other stitch cam is placed at a single level to act upon a common level butt of the needles at said single level. It should also be understood that while the design wheel **53** has been shown acting upon the separate level butt **54** with the stitch cams acting upon the butts **55** and **56** at other levels, the invention is not so limited and it is within the scope of the invention for the design wheel to act upon the same butt upon which one of the stitch cams act in which case the needles will have only a pair of spaced butts thereon.

What is claimed is:

1. A multi-feed circular knitting machine having a circularly shaped slotted needle bed, a full complement of latch needles for said machine individually disposed in and movable lengthwise of the slots in said needle bed between latch clearing, tuck and stitch forming positions and having a circularly shaped sectional cam ring with means thereon to move said needles lengthwise of said slots, yarns fed to said needles at each of said feeds, said needles each having a pair of spaced butts extending from shanks thereof and said cam ring having a compound stitch cam disposed thereon at individual ones of the feeds of said machine, each said compound stitch cam comprising a relatively fixed main stitch cam and a relatively adjustable auxiliary stitch cam, each said pair of main and auxiliary stitch cams being spaced in the direction extending lengthwise of said slots and having a corresponding pair of cam surfaces to engage said pair of needle butts to move said needles from their latch clearing and tuck positions toward and to their stitch forming position, said pair of cam surfaces having portions thereof common to an arc of said cam ring, said cam surface of said main stitch cam at each of said weeds being of a length to act upon all the needle butts of one of said pair thereof to commonly move said full complement of needles toward their stitch forming position only to and not past a common position the location of which is short of said stitch forming position and said cam surface of said auxiliary stitch cam at each of said feeds being adapted to act upon all of the butts of the other of said pair thereof to thereafter commonly move said full complement of needles a common distance from their said common position to their stitch forming position, said stitch forming position being adjustable and being determined by adjustments of said auxiliary stitch cam, the hooks of said full complement of needles passing along a first common path during their movement by said main stitch cam and thereafter passing along a continuing second common path during their movement by said auxiliary stitch cam, said main and said auxiliary stitch cams being continuously operative to act upon said full complement of needles and their said combined actions upon said needle butts being required to move said needles from their latch clearing and tuck positions to their stitch forming position in the normal operation of said machine.

2. A knitting machine as in claim **1** wherein said needle moving means on said cam ring includes pattern selecting apparatus thereon in combination with the said stitch cams, said apparatus being operatively related to the said needles to move selected ones thereof to their tuck and latch clearing positions.

3. A knitting machine as in claim **1** wherein the location of said common position of said needles is between their tuck and their stitch forming positions.

4. A knitting machine as in claim **1** wherein said needle bed is a cylinder, wherein said needles are vertically disposed and have said butts disposed at a pair of levels on their shanks, wherein said sectional cam ring is cylindrically shaped and wherein said main and auxiliary stitch cams are disposed at a plurality of levels on said cam ring.

5. A knitting machine as in claim **4** wherein said needle moving means on said cam ring includes pattern selecting apparatus thereon in combination with said main and auxiliary stitch cams, said apparatus being operatively related to the said needles to raise selected ones thereof to tuck and to latch clearing levels.

6. A knitting machine as in claim **5** wherein the shanks of said needles are each additionally provided with a butt disposed thereon at a level other than said pair of butt levels upon which said main and auxiliary stitch cams act and wherein said pattern means includes an inclined design wheel operatively related to said additional butt of said needles to raise selected ones thereof.

7. A knitting machine as in claim **5** wherein the butts on said needles are disposed at three levels thereof, wherein said pattern means includes inclined design wheels operatively related to the upper level of butts of said needles to raise selected ones thereof, wherein said main stitch cams act upon the lower level of butts of said needles and wherein said auxiliary stitch cams act upon the middle level of butts of said needles.

8. A knitting machine as in claim **5** wherein the shanks of said needles are additionally provided with individual butts disposed thereon at a plural number of levels other than the said pair of butt levels upon which said main and auxiliary stitch cams act, and wherein said pattern selecting apparatus includes needle raising cams placed at selected ones of a like plural number of levels in operative relation to said additional individual butts of said needles to raise selected ones thereof.

9. A knitting machine as in claim **5** wherein the butts on said needles are disposed at six levels of which level six is closest to the hooks of the needles, said needles having commonly disposed butts at levels one and six thereof and having individual butts disposed thereon at levels two through five thereof, wherein said pattern selecting apparatus includes needle raising cams placed at selected ones of four levels in operative relation to the butts of said needles at said levels two through five thereof to raise selected ones of said needles, wherein said main stitch cams act upon the butts of said needles at said level six thereof and wherein said auxiliary stitch cams act upon the butts of said needles at level one thereof.

10. A knitting machine as in claim **9** including raising cams placed in operative relation to the butts of said needles at said level six theerof to raise all of said needles.

11. A knitting machine as in claim **8** wherein said raise cams are so disposed relative to said main and auxiliary stitch cams as to cause the butts of said needles to follow a confined pathway during their downward movement by said stitch cams, the said confined pathway being provided by the action of said stitch cams on the needle butts being lowered thereby and by the action of the said raise cams on the needle butts passing thereby.

12. A knitting machine as in claim **8** wherein said raise cams are so disposed relative to said main and auxiliary stitch cams as to cause the butts of said needles to follow a confined pathway during their upward movement by said raise cams, the said confined pathway being provided by the action of said raise cams on the needle butts being raised thereby and by the action of the said stitch cams on the needle butts passing thereby.

13. A knitting machine as in claim **8** wherein at each feed of the machine said cam ring is provided with a pair of vertically positioned side-by-side keys and is provided with a common keyway within which said pair of keys is

disposed, said raise cams being attached to one of said pair of keys and said stitch cams being attached to the other thereof.

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