July 22, 1969 J. C. DOUGHTY 3,456,459

KNITTING MACHINE

Filed Jan. 13, 1967 6 Sheets-Sheet 1

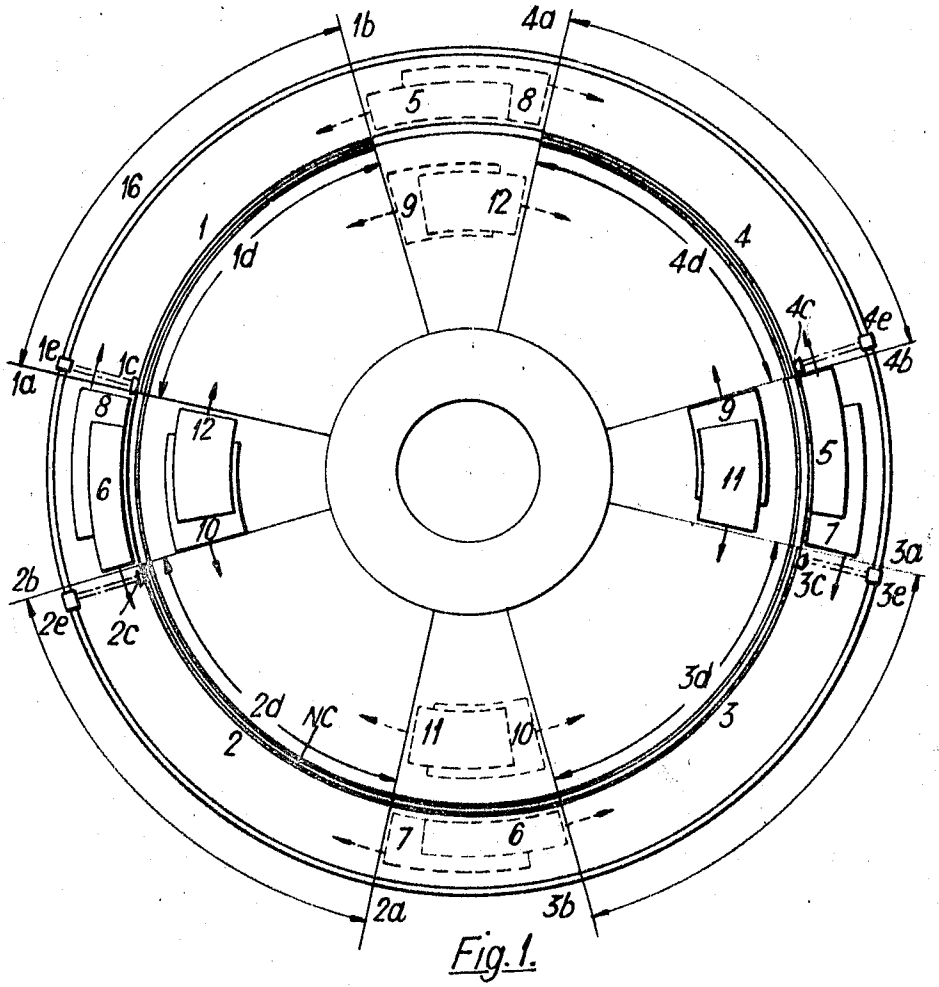


Fig. 1.

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KNITTING MACHINE

Filed Jan. 13, 1967 6 Sheets-Sheet 2

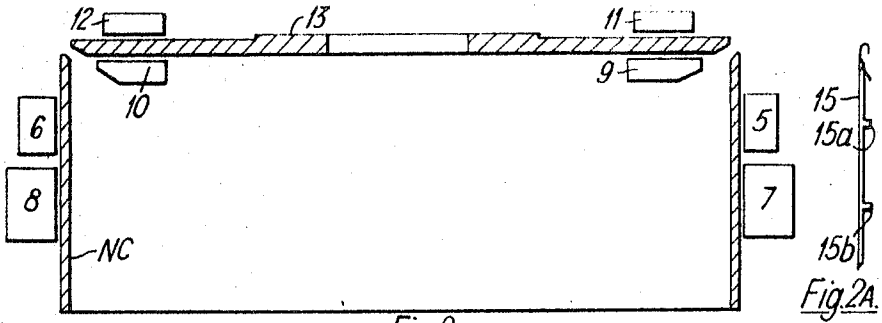


Fig. 2.

Fig. 2A.

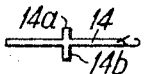


Fig. 2b.

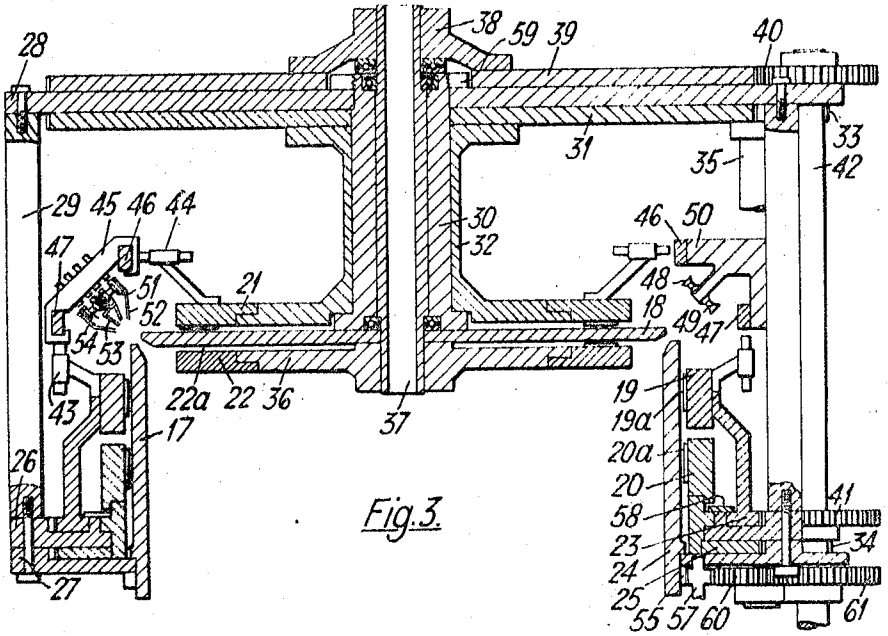


Fig. 3.

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KNITTING MACHINE

Filed Jan. 13, 1967 6 Sheets-Sheet 3

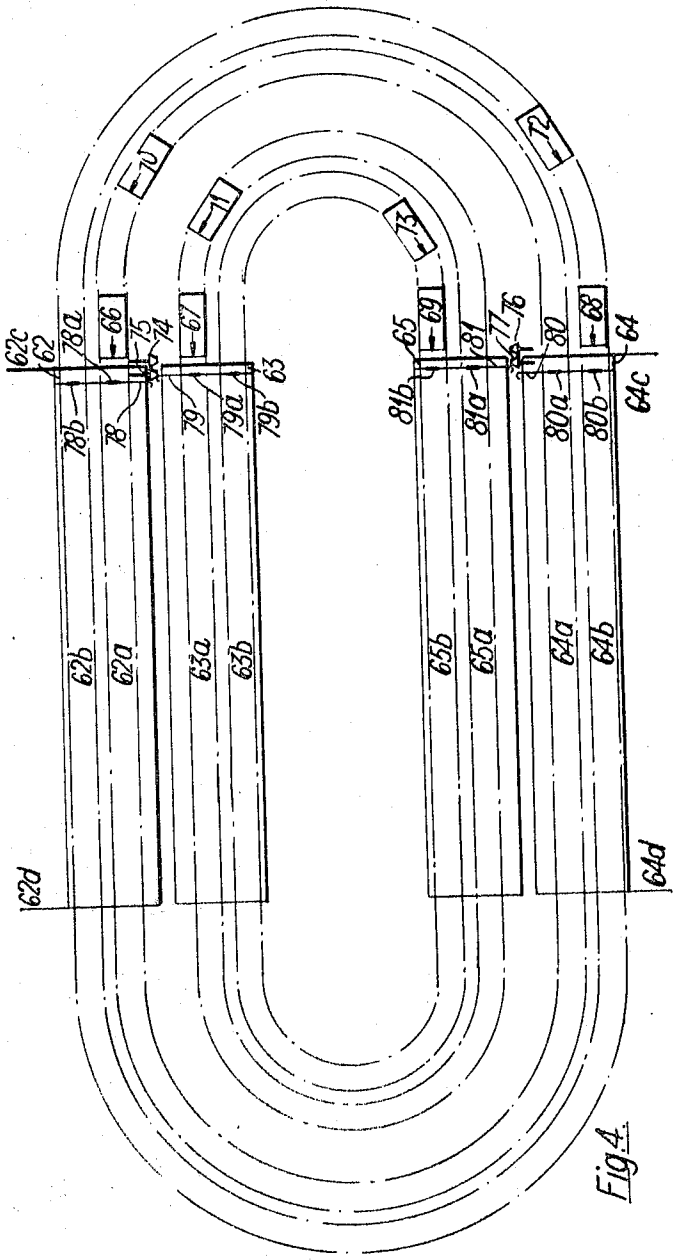


Fig. 4.

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KNITTING MACHINE

Filed Jan. 13, 1967 6 Sheets-Sheet 4

Fig. 5.

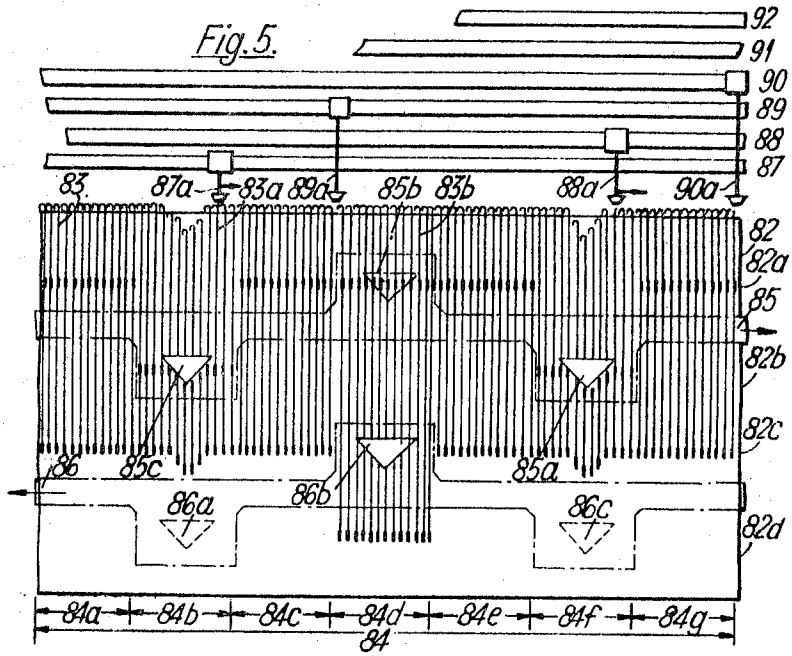
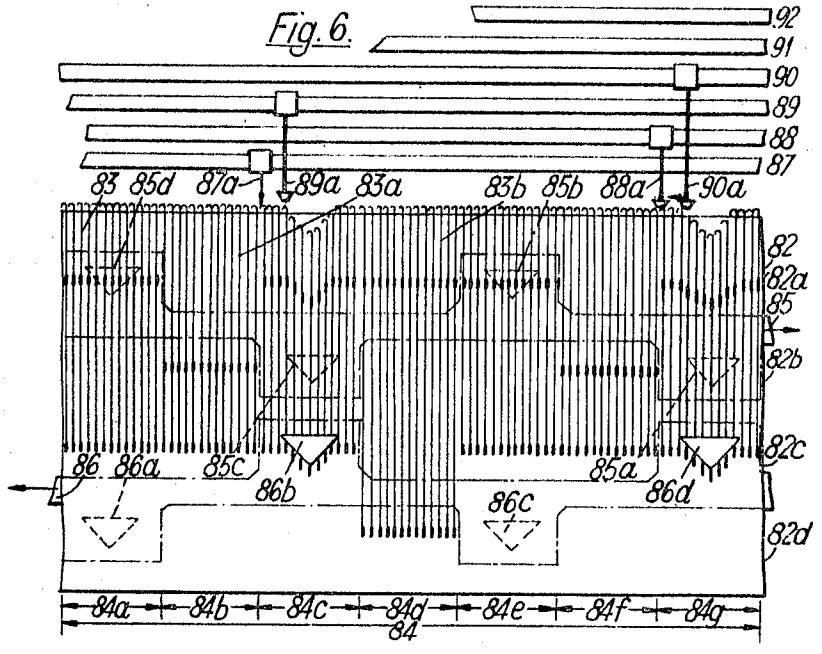


Fig. 6.



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KNITTING MACHINE

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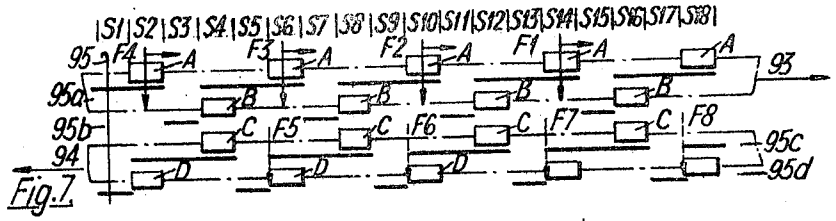


Fig. 7.

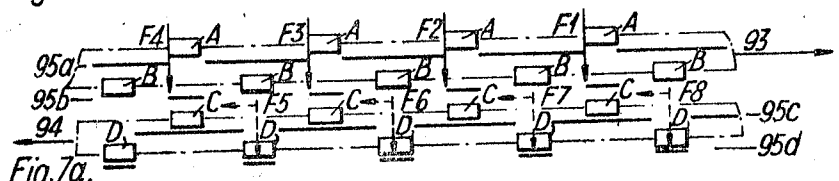


Fig. 7a.

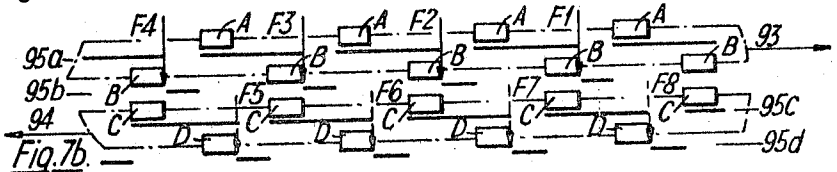


Fig. 7b.

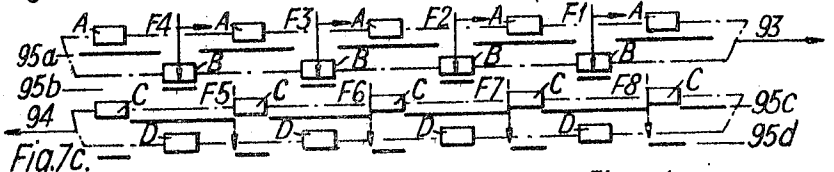


Fig. 7c.

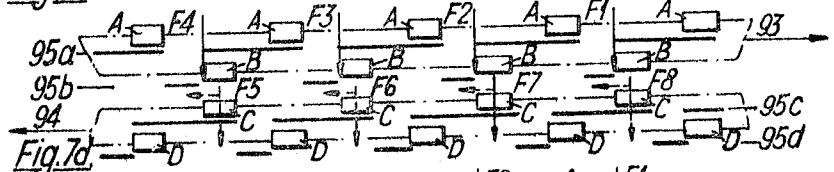


Fig. 7d.

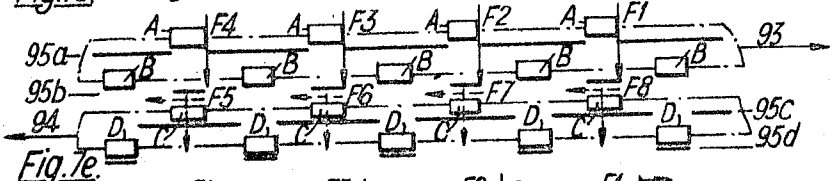


Fig. 7e.

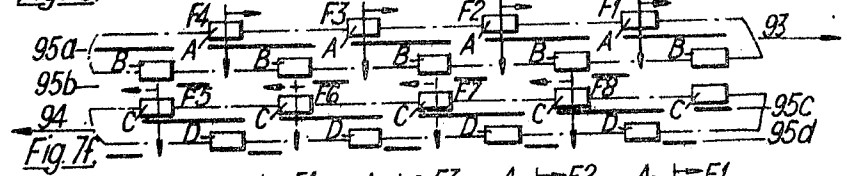


Fig. 7f.

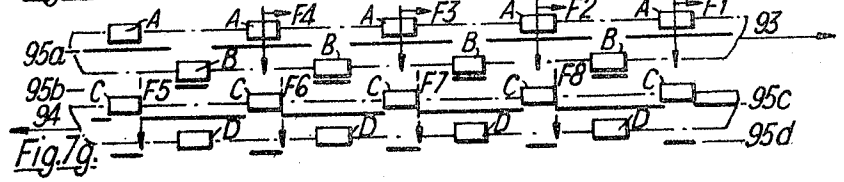


Fig. 7g.

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KNITTING MACHINE

Filed Jan. 13, 1967 6 Sheets-Sheet 6

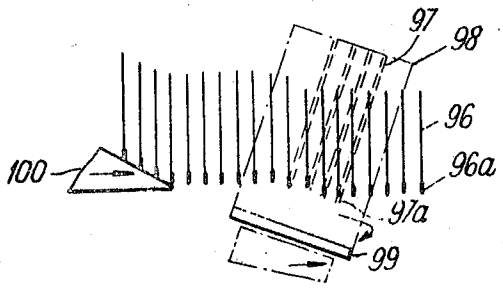


Fig. 8.

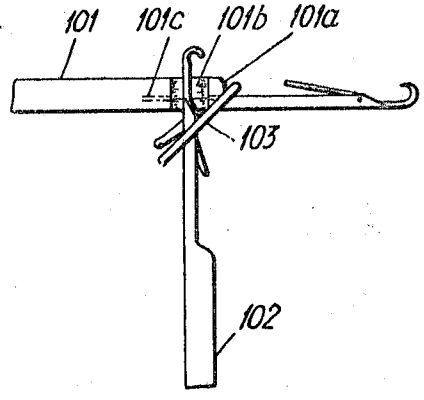


Fig. 9.

United States Patent Office

3,456,459
Patented July 22, 1969

3,456,459

KNITTING MACHINE

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Claims priority, application Great Britain, Feb. 1, 1966, 4,304/66
Int. Cl. D04b 9/14, 9/44, 15/58
U.S. Cl. 66—13 19 Claims

ABSTRACT OF THE DISCLOSURE

A two-bed knitting machine with needles in both beds co-operable to draw loops in respectively opposite directions has first and second sets of cams for action upon needle-actuating butts, there being provision for relative uni-directional movements in respectively opposite directions between the beds and the first and second sets of cams. At least one yarn feeder is arranged to be reciprocated along a path relative to the co-operable needles in both beds. These co-operable needles are actuated in reverse sequences by the first and second sets of cams to produce rows of knitted loops in both directions.

At the present date there are three main kinds of weft knitting machines, namely, straight-bar knitting machines, circular knitting machines and flat knitting machines. All of these can produce single or double fabric and may be equipped with means whereby the machines can knit welts, ribs, fabric patterned by yarn colour jacquard or varying types of stitch formations. Some knitting machines are capable of knitting purl stitch formations.

The expression "double fabric" wherever used in this specification means a fabric which is knitted on two opposed groups or sets of knitting needles arranged to draw loops in respectively opposite directions.

A straight-bar knitting machine is capable of producing fully-fashioned pieces of knitted fabric suitable for use as parts of garments, the parts being fashioned by narrowing or widening on the machine and having selvedged edges.

A circular kniting machine may be capable of producing either plain or double knitted fabrics or purl knitted fabrics, depending upon the construction of the machine, the fabrics being either tubularly formed or of constant width and being knitted at a high speed. Such fabric may be used as garment parts, the fabrics being shaped by cutting. Circular knitting machines may also be used to produce shaped fabrics or articles such, for example, as a hose or half hose, a portion of which, for instance the heel, is produced by reciprocatory knitting, viz. relative oscillation between the needle bed or beds and the cam system(s) of the machine. Usually, however, there is no provision, in a circular knitting machine, for adding to or reducing the number of needles in operation in order to produce fully-fashioned fabrics, i.e. fabrics which are shaped by widening and narrowing to produce suitably contoured selvedged edges.

An object of the present invention is to provide a novel knitting machine capable of knitting fabric of either constant width or fabric which is fully-fashioned.

A particular aim of the invention is the provision of a knitting machine which occupies a minimum of floor space and which combines some of the high speed capabilities of circular knitting machines with the ability of flat and straight-bar machines to produce fully-fashioned fabric parts suitable for use as the component parts of high quality knitted garments whereby such fabrics can be produced at a fast rate.

Another object is to enable two or more such fully-fashioned fabrics of identical forms to be simultaneously knitted upon a circular knitting machine.

Broadly considered, the knitting machine in accordance with the present invention comprises, in combination, opposed needle beds each formed with tricks; at least one group of knitting instruments in the tricks of each needle bed, said groups of instruments being co-operable to knit double fabric and such instruments having butts associated therewith; first sets of cams in association with the opposed needle beds for action upon actuating butts associated with the instruments in those beds respectively, there being provision for relative uni-directional movement in one direction between the beds and said first sets of cams; second sets of cams in association with the needle beds for action upon actuating butts associated with the instruments in the opposed beds respectively, there being provision for relative uni-directional movement in the opposite direction between the beds and the second sets of cams; and at least one yarn feeder arranged to be reciprocated along a suitable path relative to the co-operable groups of instruments in both beds, the arrangement being such that the said opposed groups of instruments will be actuated in one sequence by the uni-directional action upon actuating butts by the first sets of cams to produce a row of knitted loops in one direction, and the said groups of instruments will be actuated in the reverse sequence by the uni-directional action upon actuating butts by the second sets of cams to produce a second row of knitted loops in the opposite direction, the yarn feeder being movable first in one direction and then in the opposite direction in timed relation with the execution of the said knitting sequences.

Advantageously, each of the said knitting instruments may have associated therewith separate first and second actuating butts, in which instance the first and second sets of cams would be provided respectively for action upon these first and second actuating butts. The first and the second sets of cams are thus so arranged in association with the needle beds that of each of the first and the second sets there is at least one in association with one bed which lines up and works in timed relationship with at least one other in association with the opposed bed.

It is primarily the intention that the opposed needle beds shall be stationary, and that the various sets of cams shall move relatively thereto; however, it would be possible for both the needle beds and the sets of cams to move, providing there is such relative movement between the said beds and cams as to enable the results described to be achieved.

However, for convenience it will be assumed in the following further description that the needle beds are stationary and that the relevant sets of cams are movable contra-directionally relatively thereto. But in the case, say, of a circular knitting machine the cylinder and the dial or the two cylinders, as the case may be, may rotate, the first sets of cams being stationary and the second sets of cams (or vice versa) being rotatable in the same direction as the rotary beds but at a higher speed (preferably twice the speed of the beds), In such a case the yarn feeders would be arranged accordingly.

In any event there is preferably provision in the improved knitting machine for relative shogging movements between the opposed beds. In this regard one of the said opposed beds is preferably shogged relatively to the other.

The said first and second butts may be provided either directly upon knitting needles or upon intermediate sliders or jacks, and this will be assumed hereinafter.

For simplicity it will also be assumed in the following further description of the invention that action upon the butts causes the associated needles to knit, although it will be appreciated that actuation of the butts could produce

any desired selective actuation of the associated needles for patterning purposes or for effecting widening and narrowing of the fabrics in addition to causing the needles to knit. If desired, and in accordance with conventional practice, actuating butts of different lengths may be used in conjunction with cams adjustable towards and away from the needle beds.

In accordance with an important but optional feature of the invention there may be provided in the improved knitting machine, in association with opposed needle beds capable of being relatively shogged as aforesaid, means of any suitable character for controlling the end needles of a section of needles relatively to transfer means suchwise as to effect stitch transfers from predetermined needles to other needles whereby fully-fashioned fabric, i.e. narrowed or/and widened fabric with selvedged edges can be produced on the machine. The stitch transfers may be from needles of one bed to needles in the other bed, or vice versa, or simply from needles in one bed to adjacent needles in the same bed.

These means may advantageously be of the type conventionally provided in flat knitting machines. In the case of the cylinder and the dial, or the two cylinders, of a circular knitting machine these would be capable of being shogged relatively to one another when the cams of the opposed cam systems are withdrawn from contact with the needle actuating butts or are otherwise not in contact with such butts.

Where, as will usually be the case, there is a plurality of yarn feeders in the improved machine, each of such feeders may simply be reciprocated over a section of needles of a limited width—circumferentially or lengthwise of the opposed needle beds depending on whether the machine is of a circular or a flat type—without the feeder crossing over any other feeder. But in other cases yarn feeders may arranged to cross over one another, as will be hereinafter described.

In the application of the invention to a circular knitting machine of the superimposed needle cylinder type the two cylinders may each be equipped with a set of needles or there may be a single set of double-ended needles selectively located in the cylinders and capable of producing rib or purl stitch formations. As will be appreciated from the foregoing description, where the machine comprises a needle cylinder and a dial or superimposed needle cylinders, the cylinder and the dial, or the two cylinders, as the case may be, each has associated therewith contra-rotating cam systems.

A flat knitting machine or plant in accordance with the invention and for knitting a plurality of separate fabrics with selvedged edges and which can be narrowed and widened as required, may comprise a plurality of opposed pairs of beds, the beds of each pair being respectively equipped with co-operable groups of needles having associated therewith sets of butts arranged to be actuated successively by a first set or sets of cams movable in one direction along a continuous circulating path and a second set or sets of cams movable in the opposite direction along another continuous circulating path.

Manifestly, a knitting machine capable of simultaneously knitting a plurality of separate fabrics, each produced with the assistance of a yarn feeder reciprocating as in a flat knitting machine, may be employed to produce a wide variety of fabrics. For example, a single machine in accordance with the invention may be arranged to produce twelve or more separate knitted strappings with the advantage of undirectional rotary action, and such strappings my be narrowed and widened if required.

A knitting machine in accordance with the invention may be relatively simple in that the contra-directional cams can be arranged to pass one another at times when they are not transversing actuating butts.

However, in accordance with a further important feature of the invention a knitting machine of any of the forms described above may be so arranged that the cam systems travelling in the opposite directions are arranged to pass one another adjacent a group or groups of needles. Thus, the needles of a group may be caused to be actuated in opposite sequences i.e. in opposite directions each from the relevant end needle(s) to the opposite end needle(s) of the group. In this way, the needles of a group are simultaneously actuated by the contra-directional cam systems which pass one another whilst traversing in opposite directions needles of the same group which is knitting.

To accomplish such knitting sequences, cams moving in one direction may traverse opposed needle beds in a plurality of separate paths whilst cams moving in the opposite direction traverse the said beds in a plurality of other separate paths, the knitting instruments being arranged with associated actuating butts in predetermined ones of these paths. The dispositions of these butts in the various paths may vary as between one section or group of needles and an adjacent section or group.

In applying this feature to a circular knitting machine there may be a plurality of sets of cams rotating in one direction and arranged in a plurality of tiers, that is to say at different levels, around the or each needle cylinder and a plurality of sets of cams rotating in the opposite direction and similarly arranged about the same cylinder in a plurality of tiers or at different levels. Moreover, in the case of a machine having a cylinder and a dial, there may be a plurality of cams, arranged, e.g. on a dial cam plate, to rotate in one direction in annular paths of different diameters arranged concentrically with respect to the dial, and a plurality of cams arranged to rotate in the opposite direction and again in annular paths of different diameters arranged concentrically with respect to the dial. Such annular paths of different diameters may accordingly be adjacent both to the upper and the underneath surfaces of the dial. As will be appreciated, contra-rotating cam systems rotating at constant speed create knitting in differential interrupted manner in conjunction with stop/go feeders, i.e. feeders which oscillate in clockwise and counterclockwise manner across the total width of the fabric being knitted.

In most flat knitting machines during the passage of the carriage over the needle beds relatively few needles, i.e. only those directly under the actual cam systems, are actuated at a particular time and the remainder of the needles, usually the majority of them, are idle at this time and are merely holding loops. However, in accordance with this invention and by the use of multi-path cam systems and suitable needles hereinafter to be described, simultaneously with the traverse of cam systems in one direction, other cam systems traverse in the opposite direction, and without any actual increase in the speed of operation of the needles, the speed of production of fabrics is increased because needles which would have been idle knit more frequently.

A flat knitting machine or plant may comprise simply a plurality of opposed pairs of beds, which lie back to back, and two sets of contra-directional cams successively operating needles in the pairs of beds. A more sophisticated version of such a machine, however, would be one which includes a plurality of sets of cams arranged to travel along different paths in the same direction.

In order that the invention may be more clearly understood and readily carried into practical effect, specific examples thereof will now be described with reference to the accompanying drawings, wherein:

FIGURE 1 is a purely diagrammatic plan view of a knitting machine of the cylinder and dial type having applied thereto contra-rotational cam systems,

FIGURE 2 is a vertical sectional view of the cylinder and dial of this machine shown in relation to the various cam boxes.

FIGURES 2*a* and 2*b* respectively illustrate cylinder

and dial needles as used in the machine shown in FIGURES 1 and 2.

FIGURE 3 is a more developed vertical sectional view of a cylinder and dial knitting machine (similar to that shown in FIGURES 1 and 2) illustrating cam systems lying adjacent to non-tricked portions of the cylinder and the dial, as will be hereinafter described,

FIGURE 4 is a diagrammatic plan view illustrating the application of contra-rotating cam systems to a flat knitting machine of the "back to back" type,

FIGURE 5 is a developed layout of contra-rotating cam systems and feeders applied to a circular knitting machine having a needle cylinder only,

FIGURE 6 is a view similar to FIGURE 5 but with the cam box rings having rotated further in their respective anti-clockwise and clockwise directions,

FIGURES 7 and 7*a*–7*g* together constitute a chart representing, in purely schematic fashion, various conditions of the cam boxes, feeders and needle butts in a circular knitting machine functioning with contra-rotating cam systems and interrupted yarn feed,

FIGURE 8 shows diagrammatically one method of needle selection applicable to a circular knitting machine constructed in accordance with this invention, and

FIGURE 9 depicts the method of stitch transfer from a cylinder needle to a dial needle or vice versa.

Turning to FIGURE 1, it will be seen that the needle cylinder NC is formed with four separate groups of tricks **1**, **2**, **3** and **4**, and the dial with four corresponding sets of tricks **1***d*, **2***d*, **3***d* and **4***d*. The sections of the cylinder and the dial between **1***a* and **2***b*, **2***a* and **3***b*, **3***a* and **4***b* and **4***a* and **1***b* are "gapped" in that they have no tricks formed in them.

The cylinder needles are of the form shown at **15** in FIGURE 2*a* and each such needle being equipped with two separate knitting butts **15***a* and **15***b* so that when the needles lie in position in the cylinder tricks the butts **15***a* are disposed in a tier around the upper portion of the cylinder whereas the butts **15***b* are disposed in another tier around the lower portion of the cylinder.

The dial needles are of the form shown at **14** in FIGURE 2*b*, each such needle being equipped with a knitting butt **14***a* and an oppositely directed knitting butt **14***b*. Thus, when these dial needles lie in position in the tricks formed in the upper surface of the dial, butts **14***a* are disposed in an annular path concentric with the dial and project above the upper surface of the latter. The butts **14***b*, however, pass down through slots of limited radial length which are formed from the bottoms of the tricks downwardly, through the thickness of the dial and of the same width as the tricks. In this way the butts **14***b* are enabled to project below the under surface of the dial and thereby lie in an annular path concentric with the dial. The diameter of the annular path of the butts **14***b* in the same as the diameter of the annular path of the butts **14***a*.

The machine cylinder is stationary, and the dial, except for a limited degree of circumferential shogging movement relatively to the cylinder, controlled from the main control source of the machine, is also stationary. Alternatively, the dial may be fixed and the cylinder arranged to shog.

The cam box **7** and the cam box **8** are secured diametrically opposite to one another to a common cam box ring. These two cam boxes rotate about the lower portion of the cylinder in a clockwise direction at constant speed, and their cam systems act upon the butts **15***b* to actuate to the cylinder needles **15**. The cam boxes **5** and **6** are secured, again at diametrically opposite locations, to another common cam box ring and they are arranged to rotate about the upper portion of the machine cylinder in an anti-clockwise direction at a constant speed, their cam systems acting upon the butts **15***a* to actuate the same needles **15**.

In this particular example, however, cam systems rotating clockwise must never act upon a butt **15***b* at the same time as an anti-clockwise rotating cam system is acting upon the butt **15***a* of the same needle **15**. Thus, the cam systems **7** and **8** are arranged to rotate in a clockwise direction at the same constant speed as the cam systems **5** and **6** rotate in the anti-clockwise direction. Moreover, the systems **7** and **8** rotate in timed relationship with the systems **5** and **6** such that cam box **5** coincides in position above cam box **7** when both boxes are between points **3***a* and **4***b* of the surface of the cylinder, and cam box **6** coincides in position above cam box **8** when both boxes are between points **1***a* and **2***b* of the surface of the cylinder. Accordingly, after a quarter of a revolution of each system, the cam box **5** coincides in position above box **8** between positions **4***a* and **1***b* and cam box **6** coincides above cam box **7** between positions **2***a* and **3***b* as shown in dotted lines in FIGURE 1. Consequently, no cam systems of an anti-clockwise rotation ever pass over a cam system of clockwise rotation whilst such systems are traversing knitting butts.

The upper dial cam systems **11** and **12** traverse the upper surface of dial **13** (see FIGURE 2) and are suitably lined up with cam systems **7** and **8** of the cylinder with which they rotate in the same direction and with which they maintain a constant station. The lower dial cam systems **9** and **10** traverse the lower surface of the dial and are suitably lined up with cam systems **5** and **6** of the cylinder with which they rotate in the same direction and with which they maintain a constant station.

A feeder ring **16** is fixed to a stationary part of the machine and is concentric with the cylinder NC.

Feeders **1***c*, **2***c*, **3***c* and **4***c* are secured to feeder blocks **1***e*, **2***e*, **3***e* and **4***e* respectively which are adapted to oscillate on ring **16** between limits **1***a* and **1***b*, **2***b* and **2***a*, **3***a* and **3***b* and **4***b* and **4***a* respectively and are provided in conventional manner for engagement with and disengagement from cam systems of either rotation in a manner known in respect of flat frame knitting machines.

The operation of the described arrangement is as follows:

Cam systems **8** and **12** collect feeder **1***c* and knit from **1***a* to **1***b*;
Cam systems **7** and **11** collect feeder **3***c* and knit from **3***a* to **3***b*;
Cam systems **6** and **10** collect feeder **2***c* and knit from **2***b* to **2***a*; and
Cam systems **5** and **9** collect feeder **4***c* and knit from **4***b* to **4***a*.

As a consequence one row of knitting has been formed on each of the four knitting sections of the machine. At this stage,

feeder **1***c* is dropped at position **1***b*;
feeder **2***c* is dropped at position **2***a*;
feeder **3***c* at position **3***b*, and
feeder **4***c* at position **4***a*.

Thus, after the first quarter of a revolution of each rotation of the cam boxes, the latter lie in the position shown dotted in FIGURE 1. That is to say, boxes **5**, **8**, **9** and **12** lie in the gap between **1***b* and **4***a* whilst the boxes **6**, **7**, **10** and **11** similarly lie in the gap between **2***a* and **3***b*.

On further rotation of the cam boxes:

Cam systems **5** and **9** collect feeder **1***c* and knit from from **1***b* to **1***a*;
Cam systems **6** and **10** collect feeder **3***c* and knit from **3***b* to **3***a*;
Cam systems **7** and **11** collect feeder **2***c* and knit from **2***a* to **2***b*,
And cam systems **8** and **12** collect feeder **4***c* and knit from **4***a* to **4***b*.

Simultaneously, feeders **1***c*, **2***c*, **3***c* and **4***c* are then dropped at positions **1***a*, **2***b*, **3***a* and **4***b* respectively.

Thus, by this time each of the four groups of needles has knitted two rows of loops in a "to and fro" manner similar to the knitting operation of a flat frame machine. Moreover, at this stage, cam boxes **5** and **7**, and **9** and **11** occupy positions between **1***a* and **2***b* whilst cam boxes **6** and **8** and **10** and **12** occupy positions between **3***a* and **4***b*. As will be appreciated, further rotation of the cam systems enables further knitting to be produced on each of the four groups of needles in a similar manner to that already described.

Thus, by operation of the clockwise and anti-clockwise rotating cam systems at constant speed, oscillatory knitting sequences result to produce separate fabrics with selvedged edges in a similar way to fabrics produced by reciprocatory action on a flat frame machine. Narrowing and widening of fabrics produced on the described circular knitting machine can be accomplished by conventional needle selection and by known needle to needle stitch transfer combined with controlled relative shogging between the dial **13** and the cylinder NC. In this regard, either the dial may be shogged relatively to a stationary needle cylinder, or vice versa. The sectional elevation of FIGURE 2 is taken through the centre of the machine and shows the vertical dispositions of cam boxes **5**, **6**, **7**, **8**, **9**, **10**, **11** and **12**.

The needle cylinder **17** illustrated in FIGURE 3 is stationary, except for a limited degree of shogging movement thereof relatively to the dial **18** which is also stationary. The cylinder has four groups of axially extending tricks formed in its outer surface, these groups being equally spaced apart. The radial tricks formed in the dial **18** correspond with those in the cylinder. That is to say, the layout is similar to that shown diagrammatically in FIGURE 1. The cylinder needles are of the form shown in FIGURE 2*a*. The upper butts **15***a* of these needles are acted upon by clockwise rotating cam systems **19***a* in cam boxes **19** which rotate about the cylinder **17**. The lower butts **15***b* of the cylinder needles **15** are acted upon by anti-clockwise rotating cam systems **20***a* in cam boxes **20** also arranged to rotate about the cylinder.

The dial needles are of the form depicted in FIGURE 2*b* and when lying in the tricks formed in the upper surface of the dial **18** the upper butts **14***a* are acted upon by anti-clockwise rotating cams **21***a* in dial cam boxes **21** which rotate about the upper surface of the dial. On the other hand, the lower butts **14***b* of the dial needles **14** pass through the dial **18** and project below its lower surface so that they can be acted upon by clockwise rotating cams **22***a* in dial cam boxes **22** which rotate below the dial.

The cam boxes **19** are secured to a common carrier ring **23** which rotates clockwise about the cylinder **17**. The ring **23** lies in an annular channel formed in the upper portion **26** of the composite base ring, and gear teeth formed in the outer periphery of the said ring engage teeth of a drive gear **41** mounted on vertical shaft **42**. Similarly, the cam boxes **20** are secured to a common carrier ring **24** which rotates about the cylinder in an anti-clockwise direction. The last mentioned ring is formed with a flange which is accommodated within a recess in the base ring **26**. Under the upper portion of the base ring **26** is a gear ring **25** which is secured to the carrier ring **24**. Gear teeth on the ring **25** engage the teeth of drive gear **34** which is secured to a second vertical layshaft **35**. The lower portion **27** of the said composite base ring provides both bearer surfaces to rings **24** and **25** and also bearing housings for the lower end portions of the shafts **42** and **35**. A segmental security ring **58** presents at its underside a bearer surface adapted to act upon the rings **23** and **24** to prevent them lifting.

Columns such as **29**, located midway between the ends of adjacent untricked portions of the cylinder and the dial, are secured at their lower ends to the composite base ring **26**, **27** and provide supports for a top plate **28**.

As will be seen, this top plate is secured upon the upper ends of the columns **29** which latter also provide supports for brackets **50**. These brackets are secured one to each column **29** and in turn support not only upper and lower plunger block rings **46** and **47** but also upper and lower feeder rings **48** and **49**. The rings **46**, **47**, **48** and **49** are also secured to the brackets **50**. For the sake of clarity in FIGURE 3, a bracket **50** is not shown on the left hand column.

At **30** is indicated a sleeve the upper end of which is keyed into a bore formed centrally in the top plate **28** and is locked by a collar **59**. This collar is threaded internally and screws on to threads formed externally on the said upper end of the fixed sleeve **30**. At its lower end the sleeve is flanged and has the dial **18** secured thereto.

Above the top plate **28** is provided an upper gear **39** which is arranged to rotate in a clockwise direction in mesh with a gear **40** secured to the shaft **42**. A flanged boss **38** secured to the upper surface of the gear **39** has extending through it the upper end of a tubular spindle **37**. The latter in turn extends through the bore of the sleeve **30** with slight clearance, and is mounted for rotation in suitable bearings within the said sleeve. Secured upon the lower end of the tubular spindle **37** is a lower dial cam box carrier disc **36** serving to carry the cam boxes **22**. A lower gear **31** is arranged to rotate beneath the top plate **28** in an anti-clockwise direction and in mesh with a gear **33** secured to the aforementioned layshaft **35**.

An outer sleeve **32** having an internal bearing surface is rotatable about the outer surface of the fixed inner sleeve **30**. A flange at the upper end of this outer sleeve **32** carries the lower gear **31** to which it is secured. The lower end of the outer sleeve **32** is also flanged to form an upper dial cam box carrier disc to which the cam boxes **21** are secured.

Thus, when the main drive shaft **42** is driven anti-clockwise, a gear **61** secured thereto drives another similar gear **60** secured to the layshaft **35**. Consequently the shaft **35** rotates clockwise at the same speed as the shaft **42** rotates anti-clockwise. Accordingly, when a constant anti-clockwise drive is applied to the main drive shaft **42**, the lower cylinder cam boxes **20** and the upper dial cam boxes **21** will rotate in an anti-clockwise direction, these cam boxes lining up to provide sequential knitting action to the cylinder and dial needles in such a manner that the cylinder needles can co-operate with opposing dial needles to knit rib, purl or similar fabric.

Simultaneously, the cam boxes **19** and **22** are caused to rotate in a clockwise direction, the cam boxes **19** lining up with the cam boxes **22** to provide sequential knitting action to the cylinder and dial needles in such manner that the cylinder needles can cooperate with opposing dial needles to knit rib, purl or similar fabric. Furthermore, the cam systems **21** and **20** can, by the suitable meshing of the gears, be arranged in such relationship with the cam boxes **19** and **22** that a cam box **21** is directly above a cam box **22** and a cam box **19** is directly over a cam box **20** whilst such cam boxes are adjacent a gapped blank (i.e. untricked) portion of the cylinder **17** and the corresponding gapped (or untricked) portion of the dial **18**. Consequently, no cam systems rotating anti-clockwise can actuate a needle or needles at the same time as such needle or needles is or are being acted upon by cam systems rotating clockwise. Although the application of the invention illustrated in FIGURES 1 and 2 is simpler than that just described with reference to FIGURE 3, it does not permit oppositely rotating cam boxes to pass one over another adjacent to a group of needles. On the other hand, FIGURE 3 basically illustrates the main elements and the method of operation of a circular knitting machine in which cam boxes rotating in one direction may pass over cam boxes rotating in the opposite direction whilst such boxes are traversing a group of needles. To this end, the cylinder **17** is of substantial

depth and the cam boxes **19** occupy two separate tiers as also do the cam boxes **20**, the cylinder needles **15** each having two knitting butts **15***a* and **15***b* which are disposable in any of the four tiers or paths as hereinafter described in more detail. Likewise, both the dial cam boxes **21** and the cam boxes **22** each occupy two separate annular paths of different diameters, and the dial needles **14** are arranged each with a butt **14***a* projecting above the dial **18** in either of the two top paths, and also with a butt **14***b* which passes downwards through the said dial and projects below the lower surface thereof in either of the two annular paths traversed by the cam systems beneath the dial also as hereinafter described in greater detail.

The feeder system shown in FIGURE 3 is of a simple form which although quite adequate for types of machines wherein the cam boxes pass one over another adjacent to gapped or non-tricked sections of the needle beds, is also suitable for use in double cam system and other appropriate multi-cam system machines. In the particular case illustrated a selecting plunger block **45** has four spring-loaded plunger units respectively engageable with dogs formed in feeder blocks lying in the relevant paths. Each cam box **19** has a spring-loaded plunger unit **43** adapted to engage dogs formed in the plunger block **45**; similarly, each cam box **21** has a spring-loaded plunger unit **44** adapted to engage such dogs.

The plunger units rely upon the springs controlling them to effect their engagement with and disengagement from the dogs. Thus each plunger unit automatically engages one of the dogs formed either in the plunger block **45** or in the relevant feeder block lying in its path, and is disengaged from this dog by virtue of being acted upon and thereby lifted against spring action by means of a cam-shaped element combined with a stop block. The said stop blocks are adjustably mounted upon bars to enable the distance through which a plunger block or a feeder block is oscillatable to be varied, as occasion demands according to the width of fabric being knitted. The feeder system is not described in any detail as it is basically akin to a conventional feeder mechanism of a flat frame machine.

Thus, the plunger block **45** is first oscillated about guide rings **46** and **47** by a cam box rotating in one direction and, after traversing a group of needles, is reversely oscillated by a cam box rotating in the opposite direction. Feeder blocks of the form indicated at **51** and **52** are oscillatable along a feeder ring **48**, and feeder blocks of the form indicated at **53** and **54** are oscillatable about a feeder ring **49**.

In the case of multi-system cam boxes (e.g. double systems), the plungers in the block **45** may be repeated at a circumferential distance about the said block to suit the spacing of the systems of cams in the cam box and any appropriate linkages and interlocks may be employed to ensure that a feeder leading during one stroke of an oscillation will maintain its lead during the reverse stroke thereof. In fact, conventional flat frame feeder control means may be used.

In the arrangement shown in FIGURE 3, the cam boxes, besides housing the clearing, stitch drawing and tucking cams, are also equipped, as required, with stitch transfer cams adapted to operate in conjunction with the needle cylinder shogging mechanisms operated from the main control unit of the machine. Such shogging of the cylinder is effected as a consequence of the action of a shogging pinion **57** on gear teeth formed over a limited portion of the periphery of a ring **55** secured to the cylinder **17**.

Wherever, in FIGURE 3, plain bearing surfaces or ball bearings are shown between various components, no limit is implied in this respect as any other suitable bearings or bearing surfaces may be used according to the particular constructional materials used and dependent on the size of a particular machine and the relative surface speed between the relevant components.

The "back to back" flat frame machine shown diagrammatically in FIGURE 4 is operated by sets of cam systems constantly circulating in respectively opposite directions.

One unit included in this machine comprises opposed needle beds **62** and **63** equipped with full complements of needles **78** and **79** respectively and yarn feeders **74** and **75** capable of reciprocating over the length of such beds. A second unit included in the machine comprises opposed needle beds **64** and **65** equipped with full complements of needles **80** and **81** respectively and yarn feeders **76** and **77** capable of reciprocating along these beds.

Each needle is furnished with two knitting butts one of which lies in the path of cam systems rotating in one direction and in so doing, traversing adjacent to the knitting verge of the bed in which the needle is accommodated, and the other butt lying in the path of cam systems rotating in the opposite direction and traversing another path which is remote from the verge of the said bed.

The operation of the machine illustrated in FIGURE 4 is as follows:

Cam systems **66** and **67** (of constant anti-clockwise rotation) engage a feeder **75** through the medium of conventional flat frame feeder operating mechanism and traverse paths **62***a* and **63***a* over beds **62** and **63** respectively, thereby causing needles such as **78** and **79** to knit, by action of cams, on their butts **78***a* and **79***a* respectively, from position **62***c* to **62***d*; at point **62***d* the feeder **75** is disengaged from the cam system. During this operation, the following cam systems **70** and **71**, by engaging a feeder **74** and operating on butts **78***a* and **79***a* cause the formation of a second row of knitting—again from point **62***c* towards **62***d* whereupon the said feeder **74** is also released from engagement with such cam systems **70** and **71**.

Simultaneously with above described operation, cam systems **68** and **69** (of constant clockwise rotation) engage a feeder **77** and traverse paths **64***b* and **65***b* over beds **64** and **65** respectively, thus causing needles **80** and **81** to knit, by action of cams upon their butts **80***b* and **81***b* respectively, from position **64***c* to **64***d*; at point **64***d* the feeder **77** is disengaged from the cam systems. During the last mentioned operation the following cam systems **72** and **73**, by engaging a feeder **76** and operating upon butts **80***b* and **81***b*, create a second row of knitting from point **64***c* towards point **64***d* and feeder **76** is later released from engagement with cam systems **72** and **73**.

On further rotation of the contra rotating-cam systems, cam systems **68** and **69** engage the feeder **75** and slightly later cam systems **72** and **73** engage the feeder **74** and, by acting upon butts **78***b* and **79***b* cause the formation of two rows of knitting on needles **78** and **79** from point **62***d* to point **62***c* at which point the feeders **75** and **74** are disengaged from the cam systems. Simultaneously, cam systems **66** and **67** engage the feeder **77** and slightly later systems **70** and **71** engage the feeder **76** and, by acting upon butts **80***a* and **81***a* cause two rows of knitting to be created on needles **80** and **81** from point **64***d* to point **64***c* at which point the feeders **77** and **76** are disengaged from the cam systems. In this way a sequence of operation has been established which enables both of the flat frame units to produce knitting in a reciprocating manner with selvedged edges by the action of one train of cams of constant clockwise rotation and a second train of cams of constant anti-clockwise rotation, and by the use of conventional stitch transfer needles and cams and of bed shogging, the knitting can be narrowed and widened in a similar manner to that practised on flat frame machines.

A machine of the type illustrated in FIGURE 4 may have more than two feeders per unit, and more than two sets of cam systems in the train of cams, but no

needle may be acted on simultaneously by cam systems rotating in opposite directions.

To increase the productivity of the machine it is possible to arrange for feeders and cam systems to traverse the needle beds in opposite directions simultaneously so that the knitting process on each unit proceeds simultaneously from the opposite ends of the unit and the knitting from one direction pauses whilst knitting from the opposite end proceeds uninterruptedly. This can be achieved by the provision of four separate paths per bed (instead of the two shown in FIGURE 4), and by the employment of leading and lagging cam systems each traversing a separate path over a bed and the use of needles each formed with two knitting butts. In such a case, the needles may be arranged in groups, and the two knitting butts of each needle can be disposed in different operating paths in one group with respect to those of an adjacent group. Such an arrangement of butt layouts and leading and lagging cam systems operating in clockwise and anti-clockwise directions, with interrupted feeds, is more fully described hereinafter.

Turning now to FIGURE 5, the reference numeral **84** indicates a portion of a tricked needle cylinder **82** furnished with an arrangement of needles accommodated in cylinder sections **84***a*, **84***b*, **84***c*, **84***d*, **84***e*, **84***f* and **84***g*. In this figure are also shown the positions, heightwise of the cylinder normally occupied by the knitting butts whilst at rest. That is to say, each knitting butt is shown disposed in one of the vertically spaced paths **82***a*, **82***b*, **82***c*, or **82***d*.

Each needle has two knitting butts, viz. an upper butt disposed either in path **82***a* or path **82***b* and capable of being respectively acted upon by upper or lower cam systems attached to a cam ring **85** arranged for constant rotation anti-clockwise, and a lower butt disposed either in path **82***c* or path **82***d* and capable of being respectively acted upon by upper or lower cam systems attached to a cam ring **86** arranged for constant rotation clockwise. Thus, every needle in the machine has one butt which is capable of being actuated by one tier of cam systems of anti-clockwise rotation and also a second knitting butt which is capable of being actuated by another tier of cam systems of clockwise rotation.

The cam box ring **85** rotates constantly in an anti-clockwise direction and to it are attached upper cam boxes such as **85***b* which traverse path **82***a* around the cylinder **82** and lower cam boxes such as **85***a* and **85***c* which traverse the path **82***b* around the cylinder. The cam box ring **86** rotates at the same constant speed as the ring **85** but in a clockwise direction and to it are attached upper cam boxes such as **86***b* which traverse the path **82***c* around the cylinder and lower cam boxes such as **86***a* and **86***c* which traverse the path **82***d* around the cylinder. The rings **85** and **86** are geared so that they rotate in timed relationship one with the other but in opposite directions.

Three forms of needle are used in the machine cylinder. The first form **83** has one butt in path **82***a* and the other in path **82***c*. The second form **83***a* has one butt in path **82***b* and the other in path **82***c*; and the third form **83***b* has one butt in the path **82***a* and the other in the path **82***d*. Sections **84***a*, **84***b*, **84***c*, **84***d*, **84***e*, **84***f* and **84***g* of the illustrated portion **84** of the needle cylinder are respectively equipped with needles of forms **83**, **83***a*, **83**, **83***b*, **83**, **83***a* and **83**, and each section is approximately one cam box length in extent circumferentially.

The cam boxes in any one path are arranged around the relevant cam box ring so that the distance circumferentially between one box and the next is three cam box lengths, and the lower cam boxes of each cam box ring are located midway circumferentially between the upper cam boxes of that ring.

The reference numerals **87**, **88**, **89**, **90**, **91** and **92** indicate some of the feeder rings of the machine, i.e. only those relevant to the portion **84** of the cylinder shown in FIGURE 5. Thus, the feeder rings **87**, **88**, **89** and **90** which are only the ones concerned in this description, are equipped with oscillatory feeder blocks and feeders **87***a*, **88***a*, **89***a* and **90***a* respectively. Thus, each of these feeders is capable of being oscillated circumferentially of the cylinder in timed relationship with a cam system of the machine and of being disengaged from that system and oscillated in timed relationship with another cam system according to a predetermined programme.

As shown in FIGURE 5, the needles in cylinder sections **84***b* and **84***f* are being acted upon by the cam systems **85***c* and **85***a* respectively rotating in an anti-clockwise direction, and feeders **87***a* and **88***a* are being oscillated in timed relationship with these two cam systems. Cam system **85***b* was retracted when it previously passed over section **84***b* having no butts in its path. Cam system **86***b* is being reintroduced in section **84***d* but is inoperative as no butts are disposed in its path over this section. Cam systems **86***a* and **86***c* were retracted over sections **84***c* and **84***g* respectively and are still retracted. Feeders **89***a* and **90***a* have been disengaged from relevant cam systems and are stationary, awaiting the arrival of cam box **86***b* and **86***d* (shown in FIGURE 6) respectively.

FIGURE 6 is similar to FIGURE 5, but shows the positions and operating conditions of the cam systems and the feeders after the cam box ring **85** has been rotated a further cam box length circumferentially of the cylinder in an anti-clockwise direction and the cam box ring **86** has been rotated a further cam box length circumferentially of the cylinder in a clockwise direction. The situation now is that the feeders **87***a* and **88***a* have completed their anti-clockwise oscillation over cylinder sections **84***b* and **84***f* respectively, and have been respectively disengaged from cam systems **85***c* and **85***a*. Moreover, these same two feeders have been arrested in their anti-clockwise progression and the cam systems **85***c* and **85***a* have been automatically retracted at cylinder sections **84***c* and **84***g* respectively where no butts lie in their path. On the other hand, the feeders **89***a* and **90***a* which were arrested in their clockwise progress in FIGURE 5 have now become engaged in timed relationship with the clockwise rotating cam systems **86***b* and **86***d* respectively and caused to oscillate about the cylinder in a clockwise direction across the cylinder sections **84***c* and **84***g* respectively to feed yarn to the needles in these sections. The needles in the said two sections are acted upon and caused to knit by the cam systems **86***b* and **86***d* respectively. The cam systems **86***a* and **86***c* are still retracted.

Thus, FIGURES 5 and 6 illustrate how feeders **89***a* and **90***a* proceeding in a clockwise oscillation about the cylinder needles are able to pass feeders **87***a* and **88***a* proceeding in an anti-clockwise oscillation about the cylinder needles by the disengagement of feeders **87***a* and **88***a* from cam systems for a short period of time whilst the feeders **89***a* and **90***a* pass them. The knitting action of a group of needles likewise stops when the relevant feeder stops, and knitting by relevant needles takes place when a feeder is in motion.

All of the cam systems in a path being traversed thereby are automatically retracted when passing over a gap in the butts in that particular path and are re-introduced into action when passing over the next gap in the butts in the same path, and this sequence, continuous during normal knitting conditions, is applicable to each of the four paths traversed by cam systems at the different levels. The reason for the successive retraction and reintroduction of the cams is to prevent needles from being acted upon by such cams in advance of an arrested feeder which would cause a press off of the loops held by said needles.

Any feeder which has oscillated in one direction in association with a cam system rotating in that direction, to a point just beyond the edge of fabric being knitted, is caused to oscillate in the opposite direction in association with a cam system rotating in the last mentioned direction. Thus, knitting can proceed from both edges of the fabric

towards the opposite edges thereof simultaneously but in an interrupted manner with first the knitting in one direction being interrupted whilst the knitting in the opposite direction proceeds, and then vice versa.

Accordingly, FIGURES 5 and 6 show in detail the principles of knitting with contra-rotating cam systems by showing knitting conditions before and after cam systems have moved circumferentially in opposite directions to the extent of one cam box length. FIGURES 7 and 7*a*–7*g*, however, now to be described, together constitute a chart from which much of this detail has been omitted but which illustrates in a broader way the movements of cam systems and feeders over a considerable degree of cam system rotation.

Thus, in this chart needles **95** accommodated in vertical tricks in a needle cylinder are each provided with two knitting butts. **S1** to **S18** are sections, i.e. groups, of needles in succeeding portions of the cylinder, and the positioning of the knitting butts upon the needles varies from one section to the next. Each knitting butt is disposed in one of four paths or tiers vertically spaced apart heightwise of the cylinder. That is to say in the top path there are knitting butts **95***a*, in the next lower path knitting butts **95***b*, in the bottom but one path butts **95***c* and in the bottom path butts **95***d*. In the various sections **S1** to **S18** heavy horizontal lines denote the positions of the knitting butts at the two heights on all needles in that particular section. For example, one of the two knitting butts on every needle in section **S1** lies in the path **95***a* and the other butt on every such needle in path **95***d*. In section **S2** one butt on every needle lies in path **95***a* and the other butt in path **95***c*. In section **S3** one butt of every needle lies in path **95***b* and the other butt in path **95***c*. The positions of the butts at the two heights in sections **S5**, **S9**, **S13** and **S17** are similar to those in section **S1**. On the other hand, the positions of the butts in sections **S4**, **S6**, **S8**, **S10**, **S12**, **S14**, **S16** and **S18** are similar to those in section **S2**, and the positions of the butts in sections **S7**, **S11**, **S15** are similar to those in section **S3**. A pattern of butt layouts is thus established and every needle has one butt lying in a path traversed by upper or lower anti-clockwise rotating cam systems and another butt lying in the path of upper or lower clockwise rotating cam systems.

An upper cam box ring **93** shown in chain dotted lines rotates in an anti-clockwise direction about the machine cylinder and cam boxes A (which traverse butts **95***a*) are secured to the said ring as are also cam boxes B (which traverse butts **95***b*). A lower cam box ring **94** also indicated in chain dotted lines rotates in a clockwise direction about the machine cylinder and cam boxes C and D (which traverse butts **95***c* and **95***d* respectively) are secured to this ring. The sections of needles **S1**, **S2**, **S3**, etc. are each of a cam box length circumferentially. The cam boxes traversing any one path are positioned on the relevant cam box ring so that the circumferential distance between any two of them is equal to three cam box lengths, i.e. equivalent to the width of three adjoining needle sections.

The lower cam boxes B are spaced midway between the cam boxes A on the rings **93**, and the lower cam boxes D are similarly spaced midway between the cam boxes C on the ring **94**. Cam box rings **93** and **94** rotate at the same speed and in timed relationship one with the other but in respectively opposite directions.

In FIGURE 7 four yarn feeders **F1**, **F2**, **F3** and **F4**, are being oscillated in an anti-clockwise rotation in temporary association with cam boxes A, whereas the four yarn feeders **F5**, **F6**, **F7** and **F8** have been previously disengaged from cam boxes rotating clockwise and are awaiting the arrival of clockwise rotation cam box D before they are able to proceed in their further clockwise oscillation. Each feeder is slidable along a separate feeder ring or upon a separate section of feeder ring so that any feeder, upon moving to a point beyond the edge of the fabric being knitted, can be oscillated in the opposite direction by engagement with cam boxes rotating in such direction. Thus, the feeder action comprises intermittent oscillation in an anti-clockwise direction until it passes the edge of the fabric after which it is caused to oscillate intermittently in the clockwise direction until it passes the other edge of the fabric; thereafter, it intermittently oscillates again in an anti-clockwise direction, and so on. In short, each feeder oscillates to and fro across the width of the relevant fabric or garment part being knitted, in a manner akin to that of a feeder in a flat frame machine.

FIGURES 7*a*, 7*b*, 7*c*, 7*d*, 7*e*, 7*f* and 7*g* show the positions of the cam boxes and of the feeders relative to groups of needles (which are assumed to be in a stationary cylinder) after successive movements of the cam box systems each to a circumferential extent equivalent to the length of the cam box. Hence, FIGURES 7 and 7*a*–7*g* show the progression of feeders **F1**, **F2**, **F3** and **F4** (and consequently also the progression of knitting) in an anti-clockwise direction; that is to say, while in FIGURE 7 needle sections **S2**, **S6**, **S10** and **S14** are knitting in FIGURE 7*g* sections **S5**, **S9**, **S13**, and **S17** are knitting.

Also in this set of figures is shown the progression of feeders **F5**, **F6**, **F7** and **F8** (and hence also the progression of knitting in a clockwise direction). Thus, in FIGURE 7, feeders **F5**, **F6**, **F7** and **F8** are stationary at the beginning of needle sections **S5**, **S9**, **S13** and **S17** whereas in FIGURE 7*g* these feeders have progressed in a clockwise direction to the beginning points of needle sections **S1**, **S5**, **S9** and **S13**.

On a further circumferential movement of each cam system to a circumferential extent equivalent to one cam box length beyond the position it occupies in FIGURE 7*g*, conditions are created similar to those shown in FIGURE 7 as cam boxes lagging behind those shown in FIGURE 7 by eight cam box lengths have now occupied the positions of the cam boxes shown in FIGURE 7, and the feeders have progressed four cam box lengths in their respective oscillations. Accordingly, feeders **F4** and **F8** now occupy positions shown for **F3** and **F7** respectively in FIGURE 7. In this way a pattern of operation has been shown.

To clarify the description, the progress of feeders **F4** and **F5** will now be described. In FIGURE 7 feeder **F4** is supplying yarn to the needle section **S2** in association with an anti-clockwise rotating cam box A, and feeder **F5** is arrested awaiting engagement with a clockwise rotating cam box D. In FIGURE 7*a* the cams of anti-clockwise rotating cam boxes A are retracted to prevent them from acting on butts **95***a* of sections **S4**, **S5** and **S6** in advance of the feeder **F4** which is arrested. Feeder **F5** has been engaged by a clockwise rotating cam box D and supplies yarn across needle section **S5**. In FIGURE 7*b* feeder **F4** remains stationary. Feeder **F5** is stationary at the beginning of section **S4** and clockwise rotating cam boxes D may now have their cams retracted.

In FIGURE 7*c* feeder **F4** has been engaged by anti-clockwise cam box B and knits across section **S3**. Feeder **F5** remains stationary. Cams of clockwise rotating cam box C are rendered operative whilst over section **S5**. In FIGURE 7*d* feeder **F4** is stationary and has been disengaged from anti-clockwise rotating cam boxes B whose cams can now be retracted. Feeder **F5** has been engaged by clockwise rotating cam box C and supplies yarn across section **S4**. In FIGURE 7*e* the feeder **F4** is stationary but the cam systems of anti-clockwise rotating cam boxes A are rendered operative whilst over section **S3**. Feeder **F5** is still engaged to clockwise rotating cam box C and supplies yarn across section **S3**. In FIGURE 7*f* feeder **F4** is engaged by an anti-clockwise rotating cam box A and supplies yarn across needle section **S4**. Feeder **F5**, still engaged by clockwise rotating cam box C supplies yarn across section **S2**. In FIGURE 7*g* feeder **F4**, still engaged to anti-clockwise rotating cam box A, supplies yarn across section **S5**. Feeder **F5** is disengaged from clockwise rotating cam box C at the beginning of section **S1** and the cams

of clockwise rotating cam boxes C are retracted whilst over section S1.

When a feeder is disengaged from association with a cam box and arrested, it can withdraw from the normal point of feed to avoid its yarn being collected into the heads of needles then knitting in the opposite direction and which receive yarn from another feeder travelling in such a direction. Before knitting proceeds, the feeder can be returned to its normal feed position. Any automatic means, e.g. pickers, can be used as necessary to provide such slight manipulation of yarn feed.

The retraction and reintroduction of cams in the cam boxes A is always performed whilst such cams traverse the cylinder over needle sections in which no butts **95***a* are present, and every relevant cam of the whole of cam systems A can be automatically retracted and reintroduced simultaneously. Likewise, the relevant cams of the whole of the cam boxes B, or C or D, can be retracted or reintroduced simultaneously.

For clarity in FIGURES 7 and 7*a*–7*g* only the cam systems appertaining to the cylinder of a machine have been shown; it is, however, to be clearly understood that the cams associated with a superimposed cylinder or a dial, as the case may be are also arranged to provide similar actions to the respective cylinder or dial needles to enable them to co-operate with opposing needles of the cylinder in the production of double, e.g. rib, fabric.

Moreover, FIGURES 7 and 7*a*–7*g*, show the method of contra-rotating cam systems with interrupted feed as applied more especially to circular knitting machines. However, a modified form of this method, operating with reciprocatory straight line action, is applicable to all types of flat frame knitting machines. Each needle bed of such a machine is arranged so that a knitting butt may lie in one of four paths of the bed (similar to **95***a*, **95***b*, **95***c* and **95***d* in FIGURE 7), and leading and lagging cam systems (such as A and B of FIGURE 7) starting from one end of the bed can traverse two such paths (e.g. **95***a*, and **95***b* in FIGURE 7). Similarly, in timed relationship with such cam systems, other leading and lagging cam systems (such as C and D of FIGURE 7) starting from the opposite end of the bed can traverse the other two paths (e.g. **95***c* and **95***d* in FIGURE 7), and by the use of groups of needles) each needle having two knitting butts) suitably positioned contra-directional knitting with interrupted feeds is practicable, thereby enabling the production of a flat frame machine to be substantially increased. A practical limit is, however, imposed to the number of leading and lagging cam systems which can be employed as the adoption of additional cam systems naturally adds to the length of the machine.

In a less complicated version of any of the forms of machine capable of working on the principles illustrated in FIGURES 7 to 7*g*, the numbers of cam systems, feeders and cross-over points of knitting may be reduced. For example, there may only be one position at which the knitting from opposite directions crosses in the full width of the fabric or garment part and the layout of the needle sectional can be greatly simplified as compared with the layout of sections S1 to S18 in FIGURES 7 to 7*g*.

In FIGURE 8, which shows diagrammatically a method of needle selection applicable to a cylinder and, in modified form, to the dial of a contra-rotating cam machine, the numeral **96***a* indicates butts which are formed upon elements **96**. These elements may be needles (or jacks or clavettes which act upon needles) and the lie in the tricks of the relevant bed in the machine. Selectors **97** are formed with projections **97***a* in such a manner as to enable the latter to lift butts **96***a* when the said projections are allowed to stand outwards from their tricks in a pattern drum **98**. This drum is rotated about an axle by means of a gear **99** when the pattern drum assembly, mounted onto a cam ring, is rotated about the cylinder of the machine. The gearing is such, and the pattern drum **98** is so tricked, that projections **97***a* coincide under respective butts **96***a* during such rotation, and the inclination of the patterning drum axle provides the selectors **97** with the necessary raising action. A cam **100** is arranged to act upon those of the particular butts **96***a* which have been lifted to give them greater lift to enable a butt of a relevant needle to pass into the knitting or other required track of a cam system. Butts **96***a* which are not thus selected pass under the cam **100** as a consequence of which the corresponding needles remain inoperative. Selectors **97** which are normally cammed outwardly to enable projections **97***a* to engage butts **96***a* can each be selectively depressed by a conventional method, e.g. mechanically, electrically or hydraulically or selectors could be normally cammed into their tricks and selectively caused to project outwardly. Control of the said selectors may be provided by any means such, for example, as a card, tape or drum.

FIGURE 9 shows a method of stitch transfer from a cylinder needle to a dial needle, or vice versa.

The dial needle **101** has formed on its shank a shoulder **101***a* which, when the needle is cammed outwards from the dial, causes the loop **103** it holds to be in position for penetration by the head of a receiving cylinder needle **102** (when the dial and cylinder are relatively shogged slightly). The cylinder needle head thereupon slides further upwards in a channel **101***b* formed in part of the thickness of the shank of the dial needle **101**. The head of the cylinder needle **102** remains above the shank of the dial needle **101** until the latter is drawn back into the dial trick. On withdrawal of the dial needle **101** the latch thereof is automatically closed by contact with the loop **103** and the said needle casts off the loop which is then left on the cylinder needle **102**. The latter can then be withdrawn into its trick in the cylinder.

Needles **101** and **102** may be of similar construction at their hook ends, i.e. formed with shoulder and channel and when suitably acted upon by stitch transfer cam systems a loop held by the needle **102** can be transferred to the needle **101**.

Such types of needle are known and some are furnished with a bowed spring **101***c* which is open at the end towards the needle head and is fixed to the needle shank to form a bow which passes over the channel **101***b* so that the head of the cylinder needle **102** can pass through channel **101***b* and inside of the bow **101***c*. Upon withdrawal of the dial needle **101** and bow **101***c* is sprung open. Accordingly, stitch transfer direct from one needle to another can be effected by this method. Or any other suitable method may be used. For example, in a circular knitting machine, a cam which causes needle heads to flex towards opposite needles may be used to facilitate the transfer of loops. Although in the examples described above, reference has been made to a particular and preferred arrangement of needle butts enabling contra-rotating cam systems to pass one another, it is to be understood that any other appropriate method of causing cam systems to miss the actuating butts of certain needle sections as required may be adopted. For example, there may be used for this purpose any of the following techniques: Pattern wheels, retraction of butts into tricks, displacement of cam systems from contact with butts, different lengths of butts in various groups, and various methods of mechanical, electrical or hydraulic needle selection, or combinations of any such methods.

In the various foregoing examples where the number of tiers or vertical heights of needle butts or the number of annular paths of dial needle butts or the number of tiers or annularly displaced cam boxes or the number of different cam box paths and displaced cam boxes of a flat machine have been stated this does not imply a limit to the number which may be used which may be many. On the other hand, various economies in the number of butt and cam box paths may be made. Although little has been stated regarding patterning and control facilities of these machines, these facilities would be of the normal character usually provided in conventional flat frame and circular machines.

Instead of feeders or feeder plunger blocks being arranged to oscillate on fixed rings, such feeders or blocks may alternatively be secured to rings which are themselves capable of being oscillated. Feeder systems can in simple cases follow flat frame practice and be either semi-automatic with stop blocks set by hand, or fully automatic, being controlled from a control source and automatically adjustable to vary the degree of oscillation for widening and narrowing of fabrics or garment parts. In all cases, a plurality of selectively operated feeders for feeding selected yarns may be employed.

Also in the foregoing examples where the number of yarn feeders or feeder bars or rings have been stated this does not imply any limitation as to the actual number which may be used. Also where an example is applied to a double bed flat machine or a double bed purl machine or a multi-bed flat frame machine of any type this invention is applicable to all such types. Likewise, where the reference is made to a cylinder and dial machine, a machine with two opposed needle cylinders each with a set of needles or a two opposed cylinder machine with one set of double-ended needles, it is to be understood that the invention is applicable to all types of circular knitting machines. Again, where the number of fabrics or garment pieces is stated in the foregoing examples the invention caters for one or more or many such fabrics or pieces. On a machine which can produce a number of separate fabrics or garment parts, each of the latter could be fashioned and also jacquard or patterned by stitch formation differently to the adjacent fabric or part. All of the machines of this invention are capable of widening and narrowing fabric using the stitch transfer and needle bed shogging method. In the sophisticated interrupted feed types, cam systems can retract in "gaps" in the needle butts successively before shogging and be re-engaged in the timed sequence after shogging.

Although in all of the illustrated machines, the sets of cams are shown as being adjacent to the needle beds, these cams could alternatively be separate and spaced from the beds. For example, the sets of cams may be embodied in a remote control unit, the butts actuated by the cams being provided upon parts coupled to the needles suchwise as to actuate the latter from the remote location.

Although latch needles are shown in the drawings, it would alternatively be possible to employ any suitable type of compound needles having separate hook and latch-operating butts.

Machines to which the invention may be applied include those having additional needle beds or needle blocks containing auxiliary knitting needles.

The auxiliary needles can be operated either by contra-directional cam systems traversing separate paths as required or from a remote control unit. Indeed, such auxiliary needles can be operated by or from any appropriate form of self-contained unit adjacent or attached to the needle block and timed in its operation with the relevant knitting action of opposing needles of the machine. Moreover, auxiliary needles may be caused to knit patterns similar to or contrasting with patterns produced on the opposed main needles in the machine.

The came systems of the cam boxes may be multiple systems; hence, any relevant cam box may sweep several lines of actuating butts. Such additional lines of butts need not necessarily be formed on needles, jacks or sliders but also on clavettes as in flat frame jacquard machines.

Cam boxes secured to a cam box ring or disc may be of a size only just sufficiently to house the relevant cams, or alternatively they may be continuous about the machine and incorporate, where practicable, further cams located between adjacent stitch forming cams and designed to assist in the general guidance and control of needles.

Cylinders may, if desired, be cone-shaped and dials dish-shaped, with associated sets of cams shaped to suit. Also, where appropriate, security springs and needle or other instrument damping means may be employed to facilitate control and prevent over-action.

Relative shogging of needle beds can be either to an extent of one or more tricks, or even to an extent of less than one trick, e.g. to enable a needle after being raised from its out of action position in a widening process to pass through a loop held on an auxiliary needle and thus share such loop to avoid the formation at this point of an unsightly hole in the fabric.

I claim:

1. A knitting machine including opposed needle beds each formed with tricks; at least one group of knitting instruments in the tricks of each needle bed for co-operating to knit fabric by drawing loops in respectively opposite directions; the instruments having actuating butts associated therewith; and sets of cams in association with the opposed needle beds for action upon said actuating butts: wherein the improvement resides in the provision in the machine of the combination of first sets of cams for acting upon actuating butts associated with the knitting instruments in the opposed needle beds respectively; common carrier means for said first sets of cams; main drive means; first subsidiary drive means operable from said main drive means for effecting relative uni-directional movement in one direction between the opposed needle beds and said first sets of cams; second sets of cams in association with the needle beds for acting upon actuating butts associated with the instruments in the opposed needle beds respectively; further common carrier means for said second sets of cams; second subsidiary drive means operable from said main drive means for effecting relative uni-directional movement in the opposite direction between said beds and the second sets of cams; yarn feeders; means associated with the respective common carrier means for the first and second sets of cams for collecting said yarn feeders, for moving said sets of cams to predetermined positions and for thereupon leaving said sets of cams at such positions so that each yarn feeder is reciprocated along a path relative to the co-operable groups of instruments in both beds; the combination constituting means for enabling the opposed groups of instruments to be actuated in one sequence by the uni-directional action upon actuating butts by the first sets of cams to produce a row of knitted loops in one direction, and in the reverse sequence by the uni-directional action upon actuating butts by the second sets of cams to produce a second row of knitted loops in the opposite direction, each yarn feeder being movable by the means associated with the cam carrier means first in one direction and then in the opposite direction in timed relation with the execution of the sad knitting sequences.

2. A knitting machine according to claim **1** wherein each of the said knitting instruments has associated therewith separate first and second actuating butts, and the first and seconds sets of cams act respectively upon the said first and second butts.

3. A knitting machine according to claim **1**, wherein the opposed needle beds are stationary, and the respective sets of cams move contra-directionally relatively thereto.

4. A knitting machine according to claim **1**, further comprising means for effecting relative shogging movements between the opposed needle beds.

5. A knitting machine according to claim **1**, wherein said knitting instruments comprise needles and wherein said actuating butts are located upon said needles.

6. A knitting machine according to claim **4**, further comprising means in association with the opposed needle beds capable of being relatively shogged for controlling the end needles of a section of needles relatively to transfer means suchwise as to effect stitch transfers from predetermined needles to other needles whereby there can

be produced on the machine fully-fashioned fabric with selvedged edges.

7. A knitting machine according to claim 1, further comprising means, on parts associated with cam boxes rotating in opposite directions, for engaging and disengaging the yarn feeders to enable each such feeder to be moved back and forth over a section of needles of limited width without crossing over any other feeder.

8. A knitting machine according to claim 1, further comprising at least two reciprocable yarn feeders capable of crossing over one another.

9. A circular knitting machine in accordance with claim 1, further comprising a cylinder and a dial each having contra-rotating sets of cams associated therewith.

10. A flat knitting machine in accordance with claim 1, further comprising a plurality of opposed pairs of needle beds, the beds of each pair being respectively equipped with co-operable groups of needles having associated therewith two series of butts; at least one first set of cams; said first subsidiary drive means being operable from the main drive means for moving said first set of cams in one direction along a continuous circulating path for action upon one of the series of butts; at least one second set of cams; said second subsidiary drive means being operable from the main drive means for moving said second set of cams in the opposite direction along another continuous circulating path for action upon the other series of butts.

11. A circular knitting machine according to claim 9, wherein the cylinder and dial are equipped with a plurality of needle groups, the cylinder and dial needles of each group having associated butts and being co-operable, said machine including clockwise rotating and anti-clockwise rotating cam system for acting on said associated butts; cam boxes accommodating said cam systems; means driving said cam boxes respectively in these contra-rotating directions; at least one yarn feeder for each co-operable needle group; and means for engaging said feeders with and effecting their disengagement from parts associated with the contra-rotating cam boxes thus enabling each yarn feeder to reciprocate over a needle group as in a flat machine.

12. A knitting machine according to claim 1, wherein cam systems driven in one direction by the first subsidiary drive means and cam systems driven in the opposite direction by the second subsidiary drive means both act upon butts associated with knitting instruments mounted in the opposed needle beds, said machine further comprising a section of the opposed needle beds devoid of knitting instruments, and the said first and second subsidiary drive means being so timed as to enable the contra-rotating cam systems to pass one another adjacent to said section of the beds.

13. A knitting machine according to claim 1, wherein cam systems travelling in opposite directions pass one another adjacent to a section of needles.

14. A knitting machine according to claim 13, wherein cams driven in opposite directions act simultaneously upon butts associated with a group of needles mounted in the opposed needle beds, the said first and second subsidiary drive means being so timed that cams moving in the one direction pass the cams moving in the opposite direction while traversing the said butts.

15. A knitting machine according to claim 14, wherein needles in the opposed tricked needle beds each has associated therewith a plurality of actuating butts disposed in predetermined paths spaced longitudinally along the tricks, the dispositions of the butts in the said paths varying as between different sections of such needles, and wherein cams movable by the first subsidiary drive means in one direction are staggered for movement along certain of these paths while cams movable by the second subsidiary drive means in the opposite direction are staggered for movement along other of said paths to enable butts in any particular path to be acted upon by the cams traversing such paths.

16. A circular knitting machine in accordance with claim 5, wherein cam systems rotating in respectively opposite directions are arranged in a plurality of vertical tiers around a needle cylinder.

17. A circular knitting machine according to claim 16, further comprising a needle cylinder and a needle dial; first bearing means above said dial; a plurality of cam systems rotatable about said first bearing means and arranged in annular paths of different diameters concentric with respect to said dial, the first subsidiary drive means rotating these cam systems in one direction; second bearing means below the dial; a further plurality of cam systems rotatable about said second bearing means and arranged in further annular paths of different diameters concentric with respect to the dial, the second subsidiary drive means rotating the further cam systems in the opposite direction.

18. A circular knitting machine comprising a normally stationary cylinder formed with tricks; needles in the tricks of said cylinder having knitting butts thereon; a normally stationary dial which is disposed above said cylinder and has tricks formed therein; dial needles in the tricks in the dial having knitting butts thereon, the cylinder needles and the dial needles being co-operable to produce double fabric as herein defined and the said cylinder and the dial being relatively shoggable; cylinder cam boxes having cams for action on the knitting butts of the cylinder needles and dial cam systems for action on the knitting butts of the dial needles; the improvements in the said machine comprising, in combination, a needle cylinder having a plurality of spaced arcuate sections tricked to receive needles and intervening non-tricked sections; needles in the cylinder tricks having two separate knitting butts spaced heightwise; a dial having corresponding tricked and non-tricked sections; needles in the dial tricks each having an upwardly directed knitting butt which projects above the dial and a downwardly directed knitting butt which extends through and projects below said dial; two cam boxes having cams for action on the lower butts of the cylinder needles, said cam boxes being secured to diametrically opposite portions of a common ring rotatable in one direction at constant speed around the cylinder; two further cam boxes having cams for action on the upper butts of the cylinder needles, said further cam boxes being secured to diametrically opposite portions of a common ring rotatable in the opposite direction at constant speed around the cylinder; two diametrically opposite upper dial cam systems for action on the upwardly directed dial needle butts and arranged to traverse the upper surface of the dial, said upper dial cam systems being lined up with the lower cylinder cam boxes; two diametrically opposite lower cam systems for action on the downwardly directed dial needle butts and arranged to traverse the lower surface of the dial, said lower dial systems being lined up with the upper cylinder cam boxes, and the contra-rotating cams being arranged to pass one another at the non-tricked sections of the cylinder and dial; and a plurality of yarn feeders one to each section of cylinder and dial needles, each of such feeders being arranged to oscillate to and fro between the opposite ends of the relevant section of needles, and provision being made whereby the feeders are oscillated by the cam boxes and cam systems by virtue of being engaged thereby and disengaged therefrom in a desired sequence.

19. A circular knitting machine comprising a normally stationary needle cylinder formed with tricks; needles in the tricks of said cylinder having knitting butts thereon; a normally stationary dial which is disposed above said cylinder and has tricks formed therein; dial needles in the tricks in the dial having knitting butts thereon, the cylinder needles and the dial needles being co-operable to produce double fabric as herein defined and the said cylinder and the dial being relatively shoggable; cylinder cam boxes having cams for action on the knitting butts of the cylinder needles and dial cam systems for action on the knitting

butts of the dial needles; the improvements in the said machine comprising, in combination, a needle cylinder having a plurality of spaced arcuate sections tricked to receive needles and intervening non-tricked sections; needles in the cylinder tricks having two separate knitting butts spaced heightwise; a dial having corresponding tricked and non-tricked sections; needles in the dial tricks each having an upwardly directed knitting butt which projects above the dial and a downwardly directed knitting butt which extends through and projects below said dial; a plurality of first cam boxes occupying two separate tiers around the cylinder; a first carrier ring to which said first cylinder cam boxes are secured; means rotating said first carrier ring clockwise about the cylinder; a plurality of second cam boxes occupying a further two separate tiers around the cylinder; a second carrier ring to which said second cam boxes are secured; means rotating said second carrier ring anticlockwise about the cylinder, the two separate knitting butts on the cylinder needles being disposable to be acted upon by cams in relevant ones of the four tiers; upper dial cam boxes arranged to traverse the upper surface of the dial in two separate annular paths of different diameters, the upwardly directed butts on the dial needles being disposable in either of said two upper annular paths; lower cam boxes arranged to traverse the lower surface of the dial in two separate annular paths of different diameters, the downwardly directed butts on the dial needles being disposable in either of said two lower

annular paths; gearing through the medium of which the upper dial cam boxes are rotated anticlockwise together with the second cylinder cam boxes with which they are lined up; further gearing through the medium of which the lower dial cam boxes are rotated clockwise together with the first cylinder cam boxes with which they are lined up, the arrangement enabling contra-rotating cam boxes to pass over one another whilst traversing needle butts; yarn feeders arranged to oscillate between the opposite ends of relevant sections of needles; and spring-loaded plunger means combined with the sets of cam boxes and operable for causing yarn feeders to be engaged with and disengaged from relevant cam boxes whereby the necessary movements of the said feeders are achieved.

References Cited

UNITED STATES PATENTS

1,923,949	8/1933	Nobst	66—13
2,911,807	11/1959	Lombardi	66—50
2,988,905	6/1961	Mishcon	66—19
3,192,741	7/1965	Hanel	66—49

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