United States Patent [19]

Brandt et al.

[11] **3,709,002**

[45] **Jan. 9, 1973**

[54] **APPARATUS FOR PRODUCING PATTERNED DEEP PILE CIRCULAR KNITTED FABRICS**

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[22] Filed: **Aug. 20, 1970**

[21] Appl. No.: **65,413**

[52] **U.S. Cl.** ....66/9 B

[51] **Int. Cl.** **D04b 9/14**

[58] **Field of Search** ....66/9 B

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Primary Examiner—Robert R. Mackey
Attorney—Frederick M. Arbuckle

[57] **ABSTRACT**

Each head of a multiple feed sliver knitting machine includes a plurality of fiber feeding zones and the knitting needles are selectively raised to take fibers from one or more of such zones. Clutching devices control the quantities of fibers of different colors delivered to each of the zones. Tape controlled patterning means coordinate needle selection and fiber feed to assure the presence in each knitted stitch of the correct amount of pile fibers of the desired color.

10 Claims, 8 Drawing Figures

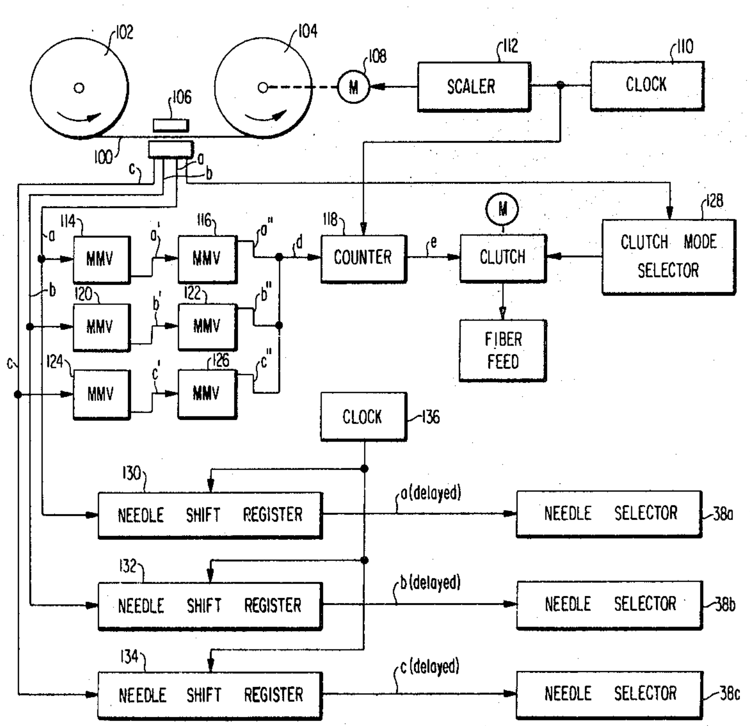


FIG. 1

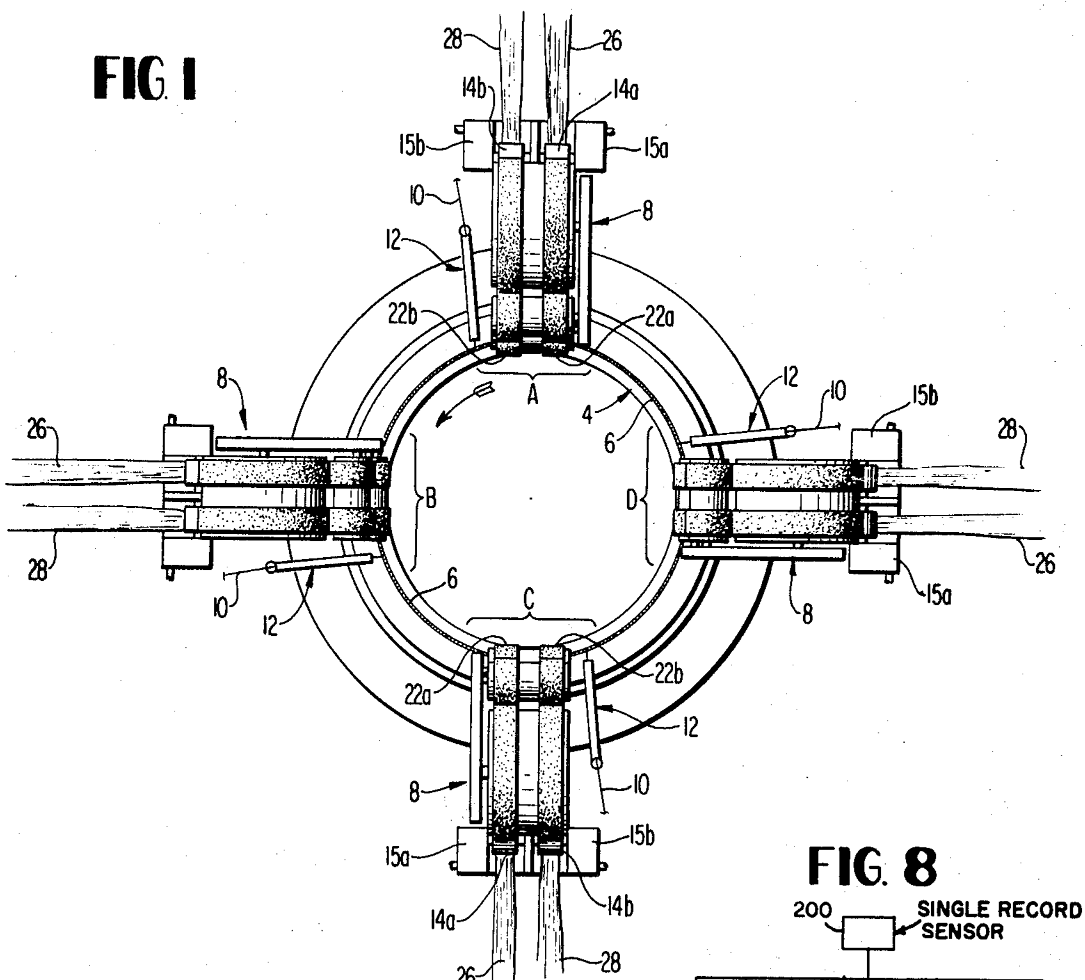


FIG. 8

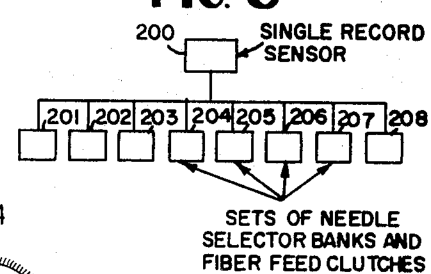
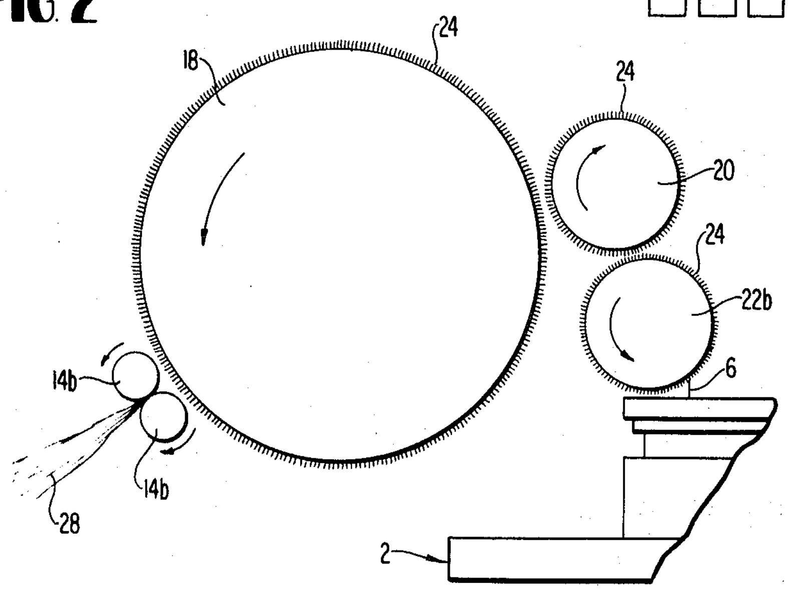
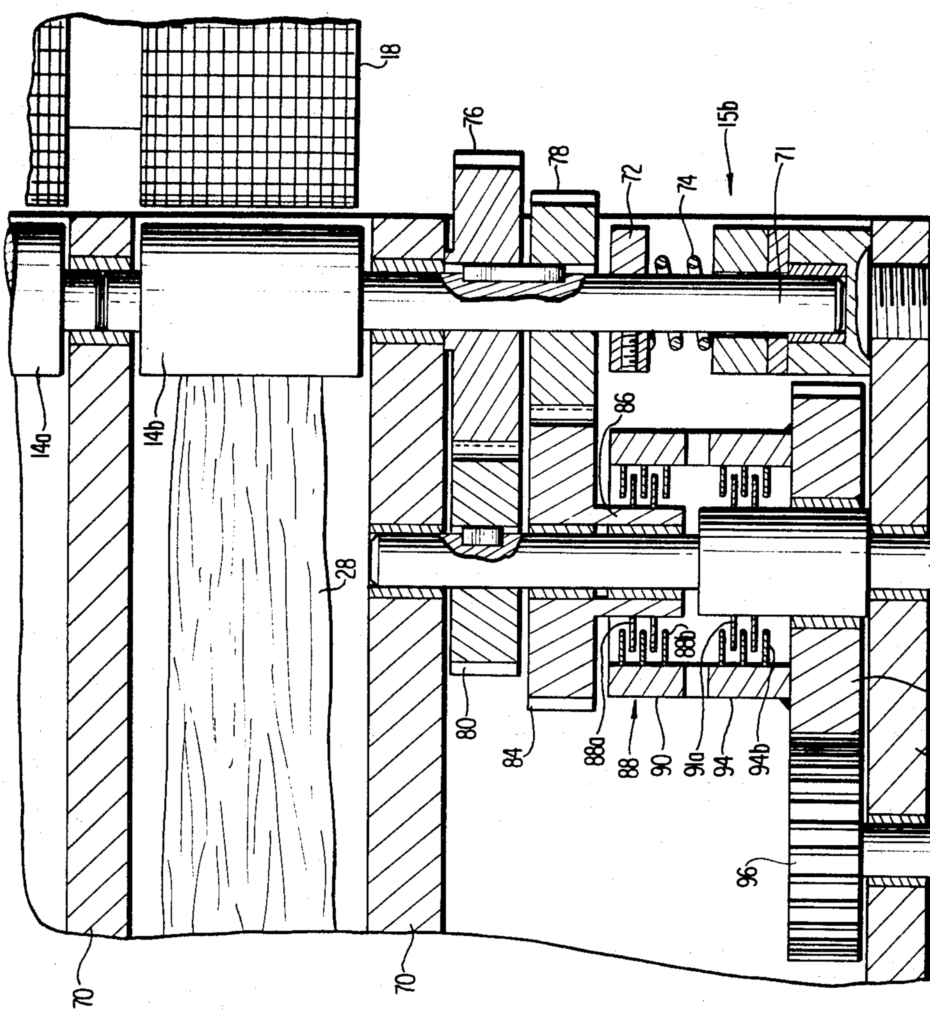


FIG. 2

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76
78
72
74
15b
71
14a
14b
86
28
82
80
84
88a
88
90
91a
88b
94
94b
92
70
96
98

FIG 5

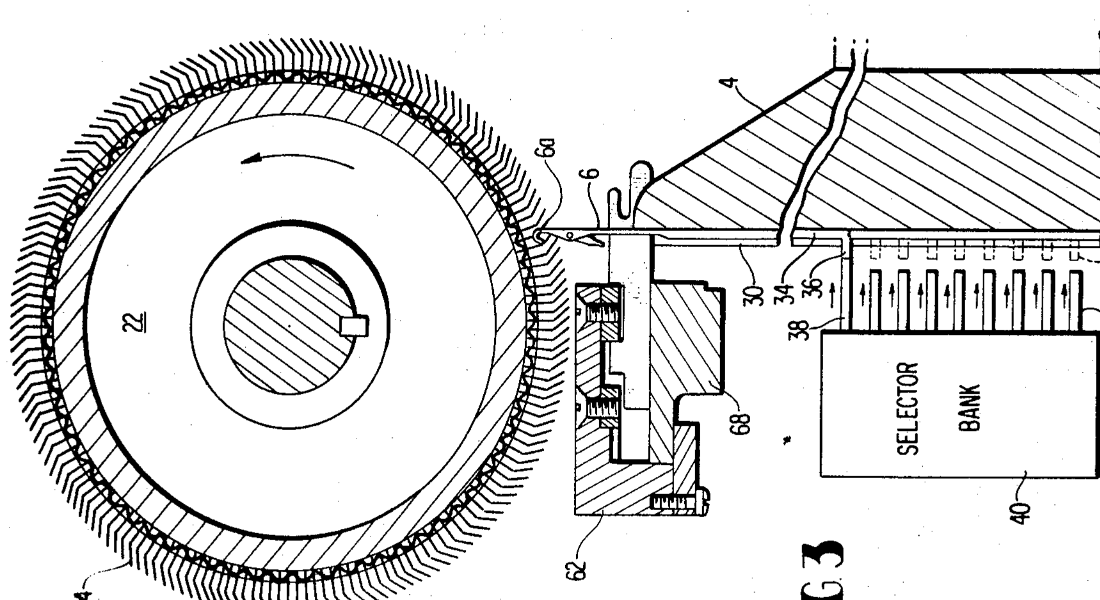

24
22
62
68
6a
6
4
30
34
36
38
SELECTOR
BANK
40

FIG 3

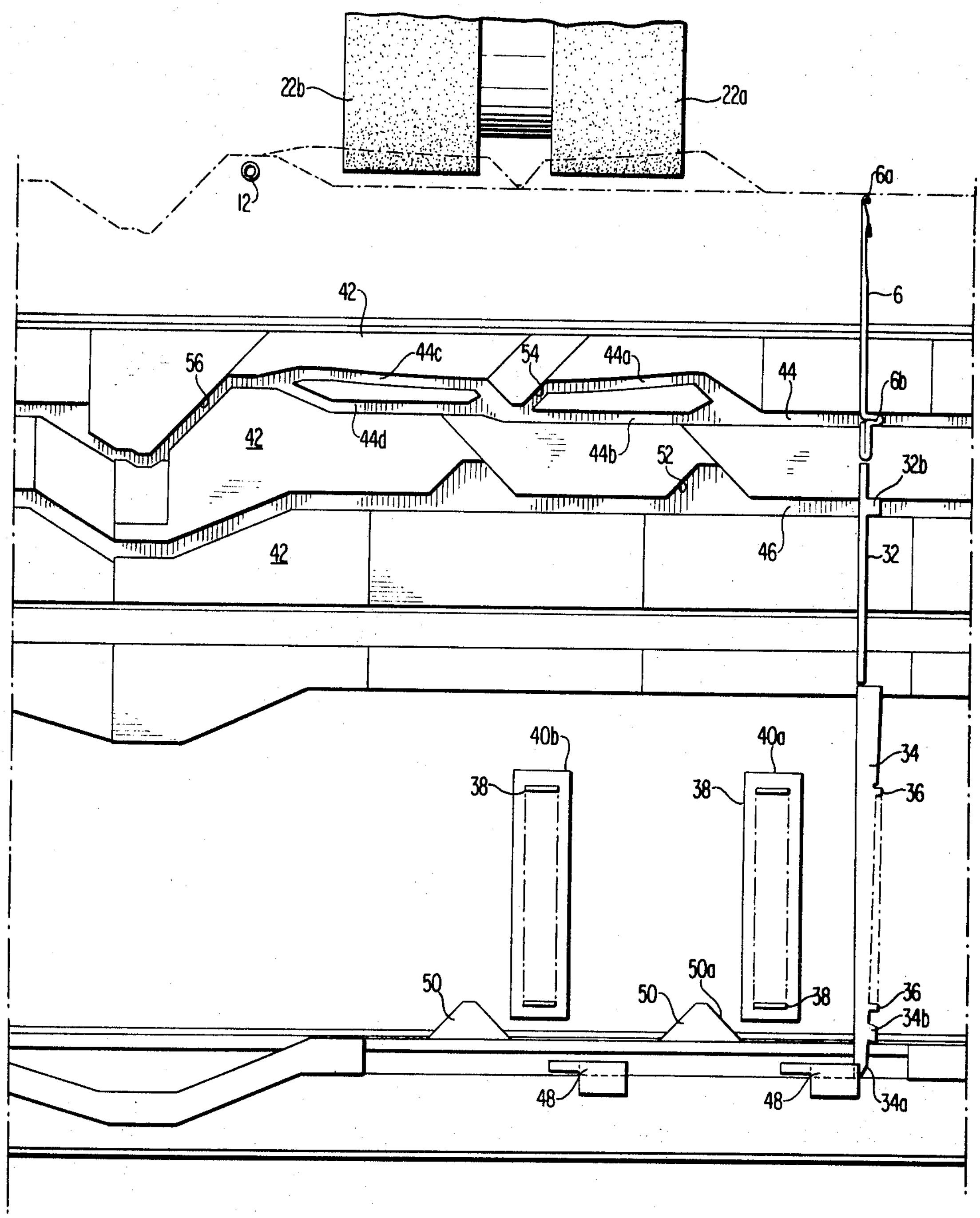
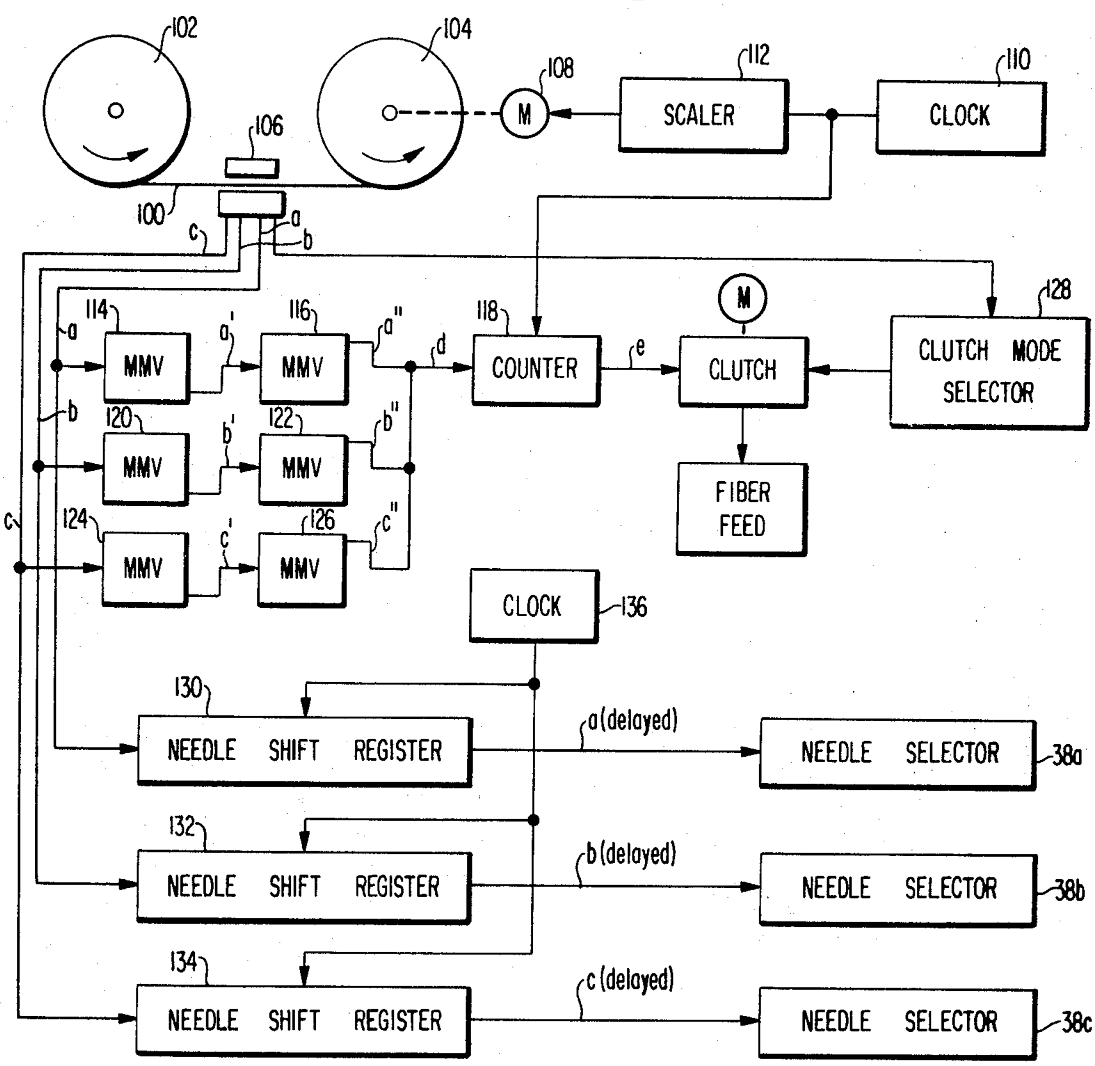

22b
22a
12
6a
6
42
56
44c
54
44a
44
6b
42
44d
44b
52
32b
42
46
32
40b
40a
34
38
38
36
50
50a
50
38
36
34b
48
48
34a

FIG 4

FIG. 6


102
104
108
M
112
SCALER
110
CLOCK
106
100
c
a
b
114
MMV
116
MMV
a'
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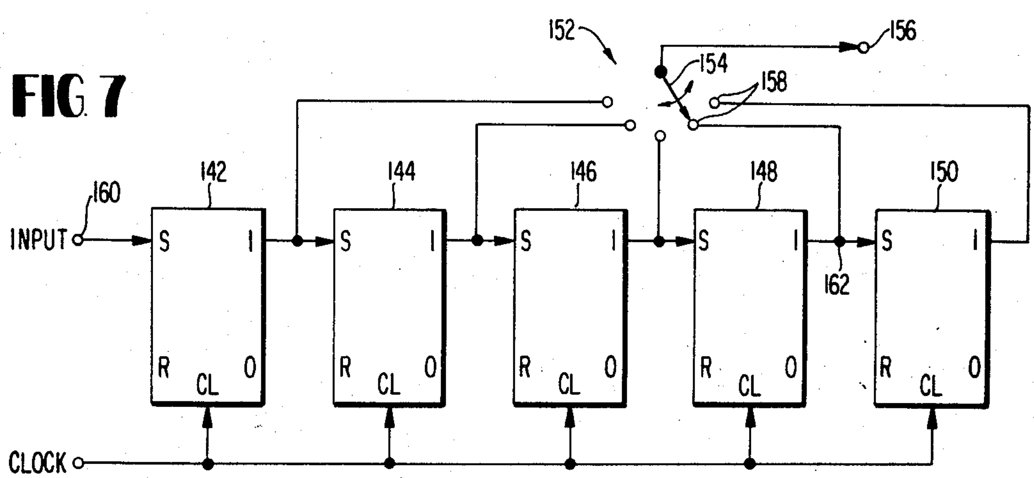
d
118
COUNTER
e
M
CLUTCH
128
CLUTCH MODE SELECTOR
120
MMV
122
MMV
b'
b"
FIBER FEED
124
MMV
126
MMV
c'
c"
CLOCK
136
130
NEEDLE SHIFT REGISTER
a (delayed)
NEEDLE SELECTOR
38a
132
NEEDLE SHIFT REGISTER
b (delayed)
NEEDLE SELECTOR
38b
134
NEEDLE SHIFT REGISTER
c (delayed)
NEEDLE SELECTOR
38c

FIG. 7


152
156
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158
142
144
146
148
150
160
INPUT
S
I
R
CL
O
162
CLOCK

APPARATUS FOR PRODUCING PATTERNED DEEP PILE CIRCULAR KNITTED FABRICS

BACKGROUND OF THE INVENTION

This invention relates to silver knitting machines and more particularly to the production of intricate pattern effects in circular knit deep pile fabrics.

In a typical commercial installation, deep pile fabrics are manufactured on circular knitting machines equipped with carding means that take fibers from slivers, or other loosely bound fiber assemblies, and supply these fibers to the hook portions of the knitting needles. Body yarns also are supplied to the hook portions of the knitting needles, and as the needles are manipulated to draw the body yarns into interlocked loops, the pile fibers supplied by the carding means are bound in with the body yarn loops. The end portions of the fibers project from the body yarn loops to form a pile surface on the knitted fabric. Ordinarily, air jets are directed toward the hook portions of the needles so as to dispose the pile fibers on the inside surface of the circular knit fabric. After the knitting operation, the tubular fabric is slit longitudinally and subjected to suitable finishing treatments such as shearing and the like.

Various techniques for achieving pattern effects in these knitted pile fabrics have been used heretofore. Of particular interest is the technique disclosed in U.S. Pat. No. 3,413,823 to Beucus et al., wherein pile fibers of different characteristics are delivered to axially spaced surface portions of the doffer element of the fiber feeding and carding head at each feed station, and the knitting needles are selectively raised into contact with one or more of the doffer surface portions to pick up fibers of the characteristics required for achieving the desired pattern effect.

Although such apparatus is quite satisfactory for the production of many patterns, it is less than ideally suited to the production of patterns wherein there are long intervals between stitches incorporating fibers of a given color. In these instances, such problems as undesired fiber buildup in the fiber feeding and carding lines may develop due to a lack of correlation between fiber input and fiber utilization. Additionally, the cam system of needle selection specifically disclosed in the Beucus et al., U.S. Pat. No. 3,413,823 is best suited to the production of short "repeats" or pattern sections, rather than the more intricate, long "repeat," pattern effects such as pictorial representations and the like.

SUMMARY OF THE INVENTION

It is an object of this invention to overcome the disadvantages noted above. More particularly, it is an object of the invention to provide a needle selection system having the great flexibility required for the production of extremely intricate patterns in deep pile knitted fabrics and to provide means for coordinating needle selection with the various fiber supplies so that the quantities of different fibers supplied to the machine will correspond with the quantities used there.

In a preferred embodiment, needle selection is effected under the control of one or more indicia bearing tapes of whatever length may be required to produce the desired pattern. With this system, the indicia on the tape determine which, if any, fiber is picked up by each needle on any given pass of that needle by a fiber feed station. The fiber supplies to the various feed lines are

similarly controlled by the tape system. Clutches or the like, actuated from the tape, control the fiber input quantities to correlate them with the needle selections and therefore the fiber utilization quantities.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention will be gained from a consideration of the following detailed description of an embodiment illustrated in the accompanying drawings, in which:

FIG. **1** is a somewhat diagrammatic plan view illustrating a circular knitting machine in accordance with the invention;

FIG. **2** is a diagrammatic elevational view depicting one of the pile fiber carding and feeding units of the apparatus shown in FIG. **1**;

FIG. **3** is an enlarged vertical cross-sectional view through a portion of the needle cylinder of the apparatus of FIG. **1**, illustrating the operative relationship between a knitting needle and the doffer of one of the pile fiber carding and feeding units and illustrating diagrammatically a needle selection arrangement;

FIG. **4** is an elevational layout of the means for controlling the positions of the knitting needles relative to the fiber supplying doffer at one of the feed stations;

FIG. **5** is a cross-sectional view showing pile fiber feed rolls for one of the carding and feeding units and a clutching system for controlling the operation of such feed rolls;

FIG. **6** is a diagram of a control system for the apparatus of FIGS. **1–5**;

FIG. **7** is a diagram illustrating one of the components of the control system of FIG. **6**; and

FIG. **8** is a diagram showing the use of a single control for a plurality of pile fiber supplies.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

The general organization of the machine elements will be evident from FIGS. **1** and **2**. Stationary frame means suggested at **2** serves to support a rotating needle cylinder **4** carrying vertically reciprocable knitting needles **6** in slots or grooves on its periphery. As the needle cylinder **4** rotates past a feed station A, selected knitting needles **6** are moved upwardly in sequence to receive in their hook portions pile fibers from a carding and feeding unit **8** and a body yarn **10** from supply means indicated at **12**. Then each needle is moved downwardly to draw a loop of the body yarn **10** through a previously formed body yarn loop, to cast off such previously formed loop, and to cause the pile fibers to become interlocked with the body yarn loops. This sequence is repeated at each of the remaining stations B, C and D, so that four courses of body yarn stitches are formed during each revolution of the cylinder. Air jets, not shown, are directed toward the needles **6** in the customary manner to orient the pile fibers so that they protrude from the body yarn loops toward the interior of the knitted tube.

The number of the stations A, B, etc., should be as great as is permitted by space limitations and the like, because the rate of fabric production is a function of the number of feeds and economy is important in the manufacture of deep pile knitted fabrics. Four feed stations have been illustrated in FIG. **1** as exemplary of suitable high production equipment. The invention may be applied in machines having five or more feeds and operated to produce a like number of courses of knitted stitches during each revolution of the cylinder.

Each of the pile fiber carding and feeding units **8** includes two pairs of silver feed rollers **14***a* and **14***b* controlled respectively by clutch units **15***a* and **15***b*, a main drum **18**, a transfer roll **20**, and a doffer **22**. These components are rotated in the directions indicated by the arrows in FIG. **2**, and all of them except the silver feed rollers **14***a* and **14***b* bear conventional card clothing **24** on their peripheries. However, as indicated in FIG. **1**, there is a centrally located gap in the card clothing on each of the components **18**, **20**, and **22**. By reason of these gaps in the card clothing, the unit **8** is divided into two axially spaced apart fiber paths or lines.

Ordinarily, slivers of different types are supplied to each of the units **8**. In FIG. **1**, the numerals **26** and **28** have been applied to two slivers that differ from one another in color and/or in some other characteristic. For purposes of explanation, it will be convenient to assume that the fibers of the slivers **26** are white and that the fibers in the slivers **28** are red. The white fibers are delivered to the feed rolls **14***a* and the red fibers are delivered to the feed rolls **14***b*. The gaps in the card clothing served to keep the fibers from the respective slivers in spaced paths as they move through the unit **8**. Hence, the card clothing at one end portion **22***a* of the doffer **22** will be supplied with white fibers from the silver **26** and the card clothing at the other end portion **22***b* of the doffer will be supplied with red fibers from the sliver **28**.

The manner in which the knitting needles **6** are caused to cooperate with the doffers **22** of the various fiber carding and feeding units **8** will now be explained in connection with FIGS. 3 and 4. These views illustrate the structures located at one of the feed stations, and it will be understood that the other stations are similar.

In the illustrated embodiment three elements are disposed within each of the vertical slots **30** at the periphery of the needle cylinder **4**. The uppermost element is a latch needle **6** having a hook portion **6***a* at its upper end and an outwardly extending butt portion **6b** located above its lower end. An intermediate positioning jack **32** is located beneath each knitting needle **6** and is movable vertically in its slot **30** with its upper end bearing against the lower end of the needle **6**. The lowermost element in each of the cylinder slots **30** is a pattern jack **34** the upper end of which bears against the lower end of the positioning jack **32**. The pattern jack **34** is movable vertically in its slot **30**, and the lower end portion of the pattern jack **34** also is movable radially in its slot **30**.

As manufactured, each pattern jack **34** has a plurality of outwardly projecting tabs **36** on its outer edge. Two of these tabs are depicted diagrammatically in FIG. **4**, but it will be understood that similar tabs are located in the zone between those illustrated. These tabs are so fabricated that individual ones of them may be removed from the pattern jack **34** by the machine mechanic, and ordinarily all but one of them will be broken off prior to installation of the pattern jack in its slot **30** in the outer cylindrical wall of the needle cylinder **4**. The tabs cooperate with selectors **38** movably mounted in selector banks **40** containing means for moving the selectors **38** individually toward the needle cylinder **4** or permitting retraction thereof away from the needle cylinder **4**. When a pattern jack **34** having a tab **36** at a given level moves past an extended selector **38** at the same level, the pattern jack is moved radially inwardly in its slot **30**. These mechanisms are well known in the art and need not be described in greater detail here.

Stationary cam means **42** (FIG. **4**) extend circumferentially of the needle cylinder **4** in spaced relation thereto for cooperation with the needle butts **6***b* and with butts **32***b* on the positioning jacks **32**. The cam means **42** are arranged to provide cam slots **44** and **46** through which the needle butts **6***b* and the jack butts **32***b* move as the needle cylinder **4** rotates past the stationary cam means.

Additional stationary camming devices **48** and **50** are provided adjacent the needle cylinder opposite the lower end portions of the pattern jacks **34**. The cams **48** bear outwardly against the inner edges of the protruding lower end portions **34***a* of all the pattern jacks **34**, so that all of the lower end portions of the pattern jacks will be moved outwardly in their slots **30** as the pattern jacks move past a cam **48**. In this connection, it will be understood by those skilled in the art that the pattern jacks **34** are bent slightly so as to frictionally engage the walls of their slots **30** and thereby maintain whatever positions are given them. That is to say, a pattern jack **34** will remain stationary in its slot **30** until some affirmative action is taken to positively change such position.

The cams **50** have upwardly facing cam surfaces **50***a* spaced outwardly from the periphery of the needle cylinder **4**. These are intended for cooperation with cam follower tabs **34***b* near the lower ends of the pattern jacks **34**, the spatial relationship being such that each jack **34** may either move passively by a cam **50** or be acted upon by the cam **50** depending upon whether the lower end portion of the jack **34** is disposed inwardly or outwardly in its slot **30**. When the lower end portion of a pattern jack **34** is disposed outwardly in its slot **30**, its cam follower tab **34***b* will contact the cam surface **50***a* of a cam **50**, and as the cylinder **4** rotates, the pattern jack **34** will be raised vertically in its slot **30**.

The various camming and selector components referred to above cooperate to control the vertical movements of the knitting needle **6** as the needles move past the various feed stations A, B, etc. of the machine. The sequence of effects produced on a given needle **6** as it moves past a feed station can best be explained with reference to FIG. **4** of the drawings. In considering this view, it will be assumed that the needle cylinder slot bearing the diagrammatically illustrated needle **6**, positioning jack **32** and pattern jack **34** is moving from right to left.

As the illustrated pattern jack **34** moves to the left from the illustrated position, its downwardly protruding lower end **34***a* will be urged outwardly in its cylinder slot by the first cam **48**. This has no immediate effect on the vertical position of the selector jack **34**.

Continued rotation of the needle cylinder will bring the pattern jack **34** into a position adjacent a first bank **40***a* of pattern controlled selectors **38**. It is within the patterning capacity of the equipment to project toward the needle cylinder any or none of the selectors **38** in the bank **40***a*. One of these selectors **38** will be at a level corresponding to the level of a tab **36** on the pattern jack **34**. If that particular selector is in its extended position, the pattern jack **34** will be shifted, upon passage by the selector, to an inward position in its slot **30**. Otherwise the pattern jack **34** will move past the selector bank **40***a* without having its outward position in the slot **30** disturbed in any way.

If the pattern jack **34** remains in its outer position, the cam follower tab **34***b* will upon continued rotation of the needle cylinder **4**, ride up on the inclined cam surface **50***a* and the jack will be moved upwardly in its slot **30**. As the jack moves upwardly in its slot, it presses against the positioning jack **32** to lift it, and the positioning jack in turn presses against the lower end of the needle **6** to raise the needle.

On the other hand, if the pattern jack **34** has been moved inwardly in its slot **30** by the action of a selector **38** in the selector bank **40***a*, the cam follower tab **34***b* thereof will be disposed radially inwardly of the cam **50** and the jack will pass the cam **50** while remaining in its lowered position.

Referring now to the cam means **42**, it will be observed that the cam slot **44** for the needle butt **6***b* branches in the zone above the cam **50**. A needle butt **6**b which has not been raised by the action of the cam **50** on its pattern jack **34** will move along the lower of the two branch paths **44***a* and **44***b* upon continued rotation of the needle cylinder. However, the butt **6***b* of a needle which has been raised by the action of the cam **50** on its pattern jack **34** will be moved upwardly into a position to contact a cam surface leading into an upper branch path **44***a*.

After the needle butt **6**b has entered the upper branch path **44***a*, the butt **32***b* of the positioning jack **32** contacts the downwardly inclined surface **52** of the cam means, and both the positioning jack **32** and the pattern jack **34** are returned to their lowered positions.

These branch paths **44***a* and **44***b* are disposed in the zone of doffer section **22***a* of the pile fiber feeding and carding head. The hook portion **6***a* of a needle whose butt follows the lower branch path **44***b* will pass beneath the doffer section **22***a* and will not take pile fibers therefrom. On the other hand, the hook portion **6***a* of a needle whose butt **6***b* follows the upper branch path **44***a* will be projected into the card clothing on the doffer section **22***a* and will take fibers for incorporation into the fabric being knitted.

While the needle butt **6***b* is moving along one or the other of the branch paths **44***a* or **44***b* of the cam slot **44**, another pattern jack selection sequence begins. Another cam **48** is provided for acting upon the lower end portion of the pattern jack **34** to assure that the jack will be disposed outwardly in its slot **30** prior to movement of the jack past another selector bank **40***b*. Again, the positions of the selectors **38** determine whether the pattern jack **34** will be allowed to remain in its outward position or be pressed inwardly in its slot **30**.

At about this time, the branch paths **44***a* and **44***b* are merged again. A needle butt which has been following the upper branch path **44***a* will be lowered as it is moved along a downwardly inclined cam surface **54**. Hence, as each needle reaches this point, it is in its lower position and is in contact with the upper end of the lowered positioning jack **32**.

As rotation of the needle cylinder continues, a new selective lifting sequence is carried out by another cam **50** and there is another branch in the needle butt cam slot **44**. If the needle is raised by the action of the second cam **50**, its butt **6***b* will follow an upper branch path **44***c* and its hook portion **6***a* will be projected into the card clothing on the doffer section **22***b* to take pile fibers therefrom. On the other hand, if the pattern jack **34** passes behind the second cam **50**, the needle butt **6***b* will pass along a lower branch path **44***d* and the hook of the needle will not take pile fiber from the doffer section **22***b*.

The branch paths **44***c* and **44***d* of the cam slot **44** merge to the left in FIG. **4** in such a manner as to assure that the needle **6** will be in an elevated position as it is moved past the body yarn supply **12**. Having picked up a body yarn **10** in its hook portion **6**a at this point, the needle then is moved downwardly by a conventional stitch cam **56**.

As the needle **6** is moved downwardly by the stitch cam **56**, its hook portion **6***a* passes between adjacent ones of the sinkers (FIG. **3**) carried by a sinker ring so that a loop portion of the newly supplied body yarn **10** will be drawn through a previously formed loop which rides up over the needle latch and is cast off. A sinker cap **62** and the other components associated with the sinkers are conventional and they need not be described here in detail.

From the description given above, it will be evident that the needle selection system has virtually unlimited capacity for achieving pattern effect variations. In passing a given feed station A, B, etc., a needle **6** may pick up no pile fiber at all or it may pick up pile fiber from either or both of the slivers **26** and **28**. Moreover, the pile fiber load acquired by a needle during any given pass by a feed station may be different from the pile fiber load acquired thereby during any other pass by that station. Pattern controlled actuation of the selectors **38** gives individual control over each needle raising operation, and even the most intricate of patterns are readily obtainable.

The invention also provides for regulation of sliver inputs to the various feed heads so that the fiber quantities supplied may be correlated with the fiber quantities required for the production of a desired pattern. In the illustrated embodiment, the sliver feed roll sets **14***a* and **14***b* of the various heads A B, etc., are controlled by clutch systems shown in FIG. **5**. This view shows the clutch drive system **15***b* for one of the sliver feed rolls **14***b*, and it will be understood that similar clutch drive systems are provided for at least one of the rolls of each of the feed roll pairs **14***a* and **14***b* in the machine. The other roll of each pair may be geared to the clutch driven roll or it may be weighted against the clutch driven roll so as to rotate therewith.

As shown in FIG. **5**, the rolls **14***a* and **14***b* at a given head A, B, etc. are journalled for independent rotation in frame means **70**. An outwardly projecting shaft portion **71** of the roll **14***b* has a collar **72** fixed thereto, and a compression spring **74** bears against the collar **72** to impose a frictional drag on the shaft portion **71** inwardly to prevent slivers engaged by the wire clothing from moving feed roll **14***b*.

Also fixed to the outwardly projecting shaft portion **71** are a pair of gears **76** and **78** of different diameters. The gear **76** meshes with a gear **80** keyed to a parallel shaft **82**, while the gear **78** meshes with a gear **84** mounted for free rotation on the shaft **82**. This latter gear **84** has a sleeve **86** integral therewith which carries at **88***a* elements of a first electromagnetic clutch indicated diagrammatically at **88**. Cooperating elements **88***b* of the clutch **88** are carried by a sleeve **90** fixed to a drive gear **92** journalled on an enlarged section of the shaft **82**. A second electromagnetic clutch **94** includes elements **91***a* carried by the shaft **82** and elements **94***b* carried by the sleeve **90**.

The gear **92** is driven continuously by a gear **96** fixed on a drive shaft **98** coupled to a power source (not shown). The rotational speed of the drive shaft **98** is coordinated with the rotational speed of the needle cylinder **4** and ordinarily it will be found convenient to provide a mechanical coupling system between these components. However, it will be understood that separate drives may be provided if desired.

Each of the clutches **88** and **94** is of a known type requiring electrical energization in order to achieve coupling effect. In the absence of energization for the clutches, the sleeve **90** will rotate freely without exerting substantial drive effects on either the gear sleeve **86** or the shaft **82**. When energizing current is supplied to the clutch **88**, however, the sleeve **90** will be rotationally coupled to the gear sleeve **86** to drive the roll shaft **71** through the meshing gears **84** and **78**. Energization of the clutch **94**, on the other hand, couples the clutch sleeve **90** to the shaft **82** so as to activate the drive train which includes the gears **80** and **76**.

The relative sizes of the gears of the two sets **76–80** and **78–84** are chosen to provide two distinctly different speed ratios between the roll shaft **71** and the drive shaft **98**. Hence it will be seen that the arrangement depicted in FIG. **5** provides a capability for electrically selecting three different feed conditions for the pile fiber sliver **28** being handled by the feed rolls **14***b*. When neither clutch **88** nor clutch **94** is energized, the feed rolls **14***b* will be stationary, so that no fiber input will be provided to this particular feed line. Energization of the clutch **94**, however, provides a relatively slow drive for the feed rolls **14***b*, so that modest amounts of fiber from the sliver **28** will be introduced into the feed line. Maximum input of fiber from the sliver **28** is achieved by energization of the clutch **88** which brings into play the high speed drive train. As will be apparent, one should not energize both of the clutches **88** and **94** simultaneously. If desired, the electrical circuits for the clutches may be so arranged as to positively prevent the inadvertent occurrence of such an event.

Coordinated control over needle selection and feed clutch actuation may be provided by a system of the type illustrated in FIG. **6**. In this view a pattern bearing tape **100** is shown extending from a supply reel **102** to a takeup reel **104**. This tape may be a transparent tape having darkened areas selectively located in rows extending transversely of the tape, but other indicia such as holes may be employed if desired. Moreover, magnetic tapes bearing suitable pattern codings are well known and may be used if desired. A scanner **106** is located intermediate the supply **102** and the takeup **104** to read the transversely extending rows of indicia as these rows move into position in the scanner. The tape is advanced incremently by a motor **108** which operates at intervals related to the rotational speed of the needle cylinder **4** of the machine.

In the illustrated system, control over the timing of the motor **108** is derived from a clock pulse generator **110**. The basic time interval for the pulse generator **110** is equal to the time required for rotation of the needle cylinder **4** through an angle corresponding to the spacing of successive knitting needle slots **30** at the periphery of the needle cylinder. These pulses are fed to a scaler **112** which provides no output signal to the motor **108** until the accumulation of a predetermined number of pulses. Ordinarily it will be desirable to accumulate in the scaler **112** a number of pulses corresponding to the number of selectors **38** in each of the selector banks **40**. With this arrangement the indicia bearing tape **100** will be indexed one unit for each time interval corresponding to the time required for movement past a given point of that number of needles which can be controlled by a single selector bank. In cases where the number of needles employed by the knitting machine is not a whole multiple of the pattern width (expressed in number of needles) it will, of course, be necessary to either program the tape accordingly or index the tape position to a reference point at the completion of needle cylinder revolution.

In the interest of simplicity of illustration, the showing in FIG. **6** deals with the control system for the needle selectors in a single selector bank and for a single fiber feed clutch. It will be understood, however, that all the other clutches and selectors may be similarly controlled from the tape **100** and that ordinarily this will be done in order to minimize the probability of problems arising through lack of coordination between the control signals on separately operated tapes. Such an arrangement is shown in FIG. **8**, where the block **200** indicates a sensor apparatus operating on a single record bearing medium such as a tape and where the blocks **201**, **202**, **203**, **204**, **205**, **206**, **207** and **208** indicate the respective sets of needle selector banks and fiber feed clutches disposed about the periphery of the machine.

The scanner **106** provides separate output channels for each of the needle selectors being controlled thereby. In FIG. **6** only three of these have been shown in the interest of simplicity. When a needle is to be selected for elevation into contact with a particular doffer element of a pile fiber feeding line, the appropriate signal channel *a*, *b*, *c*, receives a signal from the scanner **106** to this effect. Such signal also is utilized to condition the clutch for the feed rolls of that particular pile fiber line so as to cause one increment of pile fiber input to that line. The system also includes means for adjusting the time interval between clutch actuation and needle selection so that the fiber feed may be initiated somewhat in advance of the fiber utilization if desired.

These various relationships may best be explained by way of an example. In this instance, it will be assumed that a given index operation of the tape **100** has placed in the scanner **106** a tape portion which signals to channel *a* that needle selector **38***a* is to be extended, which signals to channel *b* that needle selector **38***b* is to remain in its retracted position, and which signals to channel *c* that needle selector **38***c* is to be extended.

Referring to channel *a*, it will be seen that the signal there is coupled to a monostable or one-shot multivibrator **114**. The leading edge of the pulse from the scanner **106** sets the multivibrator **114** to produce a square wave having a predetermined duration. An output signal at one terminal of the multivibrator **114** is produced concurrently with the trailing edge of this square wave, and such signal triggers a second similar monostable multivibrator **116**. An output signal from the multivibrator **116** serves to advance a counter **118** by one unit.

Similar monostable multivibrator pairs **120–122** and **124–126** are provided for channels *b* and *c*. However, the multivibrators **114**, **120** and **124** have different time constants and this produces square waves of different durations. Since the trailing edges of the square wave output signals from these units effectively activate the second multivibrators in the various channels, the pulses from these second multivibrators **116**, **122** and **126** will arrive at the counter **118** as separate signals so that they may be accumulated there as discrete units. In the stated example, there will be no output from the multivibrator pair in channel *b* but there will be a second output from the multivibrator in channel *c*. Hence, the counter **118** will receive two units of advance on the occasion of this particular reading by the scanner **106**.

The clock pulse generator **110** also is coupled to the counter **118**. This coupling serves to count down whatever signal is delivered to the counter in regularly timed increments. The output signal from the counter **118** is connected to the fiber feed clutch in such a fashion that one or the other of the two clutch coils will be energized as long as there is any signal in the counter. Hence, in the example, the clutch will operated for two units of time and will advance into the fiber feed line a corresponding quantity of pile fibers.

Another channel from the scanner **106** controls a clutch mode selector **128** that determines which one of the two clutch coils on the clutch will be activated during this cycle.

Returning to channels *a*, *b* and *c*, it will be observed that these also lead to shift registers **130**, **132** and **134**. The shift registers are clocked by a clock pulse generator **136** and may be adjusted to provide a variable delay between the appearance of a signal at the input terminal of a shift register and the appearance of a corresponding output signal therefrom. Frequently it will be found desirable to utilize such a delay in order that an increment of fiber input may be correlated more closely with an increment of fiber utilization. That is to say, there is a real time interval between the supply of pile fibers to the feed rolls of a fiber feeding and carding unit and the utilization of that particular increment of pile fibers by the knitting needles, and this interval may be taken into account by appropriate regulation of the shift registers **130**, **132**, and **134**.

FIG. 7 shows one form of shift register unit which may be employed, if desired. In this view, a plurality of binary elements or flip-flops **142–150** are shown serially connected in a manner such that a high level signal applied to the set input terminal S of any one of the flip-flops, upon receipt of a clock signal applied to the clock input terminal CL, will provide a high signal level on the binary "1" output terminal thereof. This high level signal is applied to the set input terminal S of the immediately subsequent flip-flop which, when clocked, will be operative to provide a high level signal on the set input terminal S of the next flip-flop. In this fashion, a binary "1," introduced into the first flip-flop **142**, will be successively walked through the chain of binary elements in the shift register by the application of clock pulses.

The number of binary elements in the shift register may be varied as desired. Since the time interval between successive clock pulses has been predetermined, the length of time for an input signal to walk through the register is a function of the number of binary elements in the register.

For ease in varying the effective number of binary elements in the register, and thus the time interval, a switch **152** is provided having a rotary arm **154** connected at one end to an output terminal **156** and selectively rotatable into contact with one of a plurality of terminals **158**. Each of these terminals **158** may be connected to receive the output signal from the binary "1" output terminal of one of the binary elements in the register. In the switch position illustrated in FIG. 7, the time delay between the application of a pulse to the input terminal **160** and the appearance thereof at the output terminal **156** is a function of the time required to walk the signal through the binary elements **142-148** to the terminal **162**, a time interval of four clock pulses.

The output signals from the several shift registers **130**, **132** and **134** are individually coupled to needle selector means **38*a***, **38*b*** and **38*c*** to control the reciprocation of selected needles into contact with the doffer section of the fiber feed line controlled by the signal channels *a*, *b*, and *c*. In this example, selector means **38*a*** and **38*c*** will be conditioned to cause needles to reciprocate and selector **38*b*** will be conditioned to allow a needle to move passively by the fiber feed line without taking pile fiber therefrom.

Thus, it will be seen that the illustrated system provides close correlation between fiber input and fiber utilization. Unless needles are to be raised into contact with the doffer surface of a particular fiber feed line, the feed rolls for that line do not continue to supply fiber. Yet, the fiber input is ample to accommodate the requirements of whatever needles are to be raised.

This close correlation between fiber input and fiber utilization is particularly significant in connection with the production of patterns in which there are substantial variations in the intervals between needles which must take fiber from a particular feed line. In such instances the use of a constant fiber input rate tends to produce undesired accumulation of fiber in the feeding and carding line during the intervals when no needles are removing fiber and/or to supply inadequate quantities of fibers to groups of closely spaced needles. Such difficulties are entirely obviated through use of the present invention which makes possible the production of even the most intricate of patterns.

The tape control system also is ideally suited to the production of intricate patterns. Although in many instances the desired pattern may be coded into a tape short enough to permit of its being handled mechanically as a single endless band containing a pattern "repeat," more complex patterns can be obtained through the use of supply and wind-up reels as illustrated.

Still other modifications and variations will be evident to persons skilled in the art. Accordingly, it is intended that the foregoing detailed description be considered as exemplary only, and that the scope of the invention be ascertained from the following claims.

We claim:

1. In a pile fabric knitting apparatus of the type in which a rotatable needle cylinder carries an endless succession of reciprocable knitting needles and in which pile fiber feeding means deliver pile fibers from separate supplied to spaced apart zones adjacent the needle cylinder to be picked up by such of the knitting needles as are reciprocated into the respective zones, the combination which comprises:

needle selector means spaced about the needle cylinder for selecting the individual needles which are to take pile fiber from individual ones of said zones;

means for reciprocating the individual knitting needles selected by said needle selector means into individual ones of said zones to cause removal of pile fiber therefrom;

controllable means for regulating the quantities of pile fibers delivered to the respective ones of said zones; and

pattern means for controlling both said needle selector means and said controllable means for regulating the quantities of pile fibers delivered to the respective ones of said zones to correlate the quantities of pile fibers delivered to any of said zones with the number of knitting needles reciprocated into such zone.

2. Apparatus according to claim 1 wherein said pile fiber feeding means includes a plurality of feeding and carding heads spaced about the circumference of the needle cylinder; each of said heads comprising a rotatable doffer having card clothing on axially spaced apart surface zones thereof adjacent the circumference of the needle cylinder for separately making available to the knitting needles the pile fibers supplied to the respective doffer surface zones, and means including independently controllable feed roll pairs for separately feeding controlled quantities of pile fibers to the respective ones of said doffer surface zones.

3. Apparatus according to claim 1 wherein said controllable means includes multiple speed transmission means for regulating the quantity of pile fibers delivered to one of said zones, and wherein said pattern means is operative selectively to cause no fiber delivery to such zone, slow fiber delivery to such zone or fast fiber delivery to such zone.

4. In a pile fabric knitting apparatus of the type in which a rotatable needle cylinder carries an endless succession of reciprocable knitting needles and in which pile fiber feeding means deliver pile fibers from separate supplies to spaced apart zones adjacent the needle cylinder to be picked up by such of the knitting needles as are reciprocated into the respective zones, the combination which comprises:

means for reciprocating selected knitting needles into individual ones of said zones to cause removal of pile fiber therefrom;

controllable means for regulating the quantities of pile fibers delivered to the respective ones of said zones; and

pattern means for controlling said controllable means to correlate the quantities of pile fibers delivered to any of said zones with the number of knitting needles reciprocated into such zone, said pattern means including a record bearing medium having indicia corresponding to the pattern produced and means responsive to said indicia for both selecting the individual needles reciprocated into one of said zones and controlling the means for regulating the quantities of pile fibers delivered to such zone.

5. Apparatus according to claim 4 wherein said pattern means includes means for initiating the delivery of an increment of fiber to such zone prior to reciprocation of a selected needle into said zone to assure the presence in said zone at the time of passage of the needle of the quantity of fiber intended for such needle.

6. In a pile fabric knitting apparatus of the type in which a rotatable needle cylinder carries an endless succession of reciprocable knitting needles and in which pile fiber feeding means deliver pile fibers from separate supplies to spaced apart zones adjacent the needle cylinder to be picked up by such of the knitting needles as are reciprocated into the respective zones, the combination which comprises:

means for reciprocating selected knitting needles into individual ones of said zones to cause removal of pile fiber therefrom;

controllable means for regulating the quantities of pile fibers delivered to the respective ones of said zones; and

pattern means for controlling said controllable means to correlate the quantities of pile fibers delivered to any of said zones with the number of knitting needles reciprocated into such zone;

said means for reciprocating selected needles into a particular one of said zones including individual needle selectors controlled by said pattern means, and said pattern means being operative to control said regulating means so as to cause an increment of fiber delivery to such zone for each needle reciprocated into that zone.

7. Apparatus according to claim 6 wherein a plurality of said needle selectors are arranged in a bank disposed adjacent the periphery of the needle cylinder in the vicinity of one of said zones; and wherein said pattern means includes a movable record bearing medium having in areas spaced along the direction of movement sets of indicia the individual ones of which are related to the control effects desired for each of the needle selectors in the bank, means for moving said medium in timed relation to the rotation of said needle cylinder, indicia reading means adjacent said medium for sequentially reading the indicia of the different sets of indicia spaced along the medium and for developing during each such reading operation a separate signal for each indication that a needle is to be reciprocated into such zone, and means for adding up the number of needle reciprocation operations signalled during a given reading operation and causing fiber delivery to such zone for a time interval corresponding to the sum of the signalled needle reciprocation operations.

8. Apparatus according to claim 7 including a number of needle selector banks corresponding in number to the number of said zones and wherein a sin-

gle record bearing medium controls all of said selector banks.

9. Apparatus of the circular high pile knitting machine type for producing a pile fabric having a backing material during the formation of which pile fibers of different selected colors have been applied for retention thereby to produce a desired color pattern in the pile fabric, said apparatus comprising in combination:

controllable pile fiber feeding means for conditionally dispensing fibers of predetermined selected colors for retention by the backing material;

a record bearing medium bearing indicia depicting the relative positions on the backing material being formed where pile fibers of predetermined colors are to be retained thereby to produce a desired color pattern in the pile fabric;

means responsive to said record bearing medium for effecting the retention by the backing material of different color fibers conditionally dispensed by said fiber feeding means in accordance with the indicia borne by said record bearing medium; and

means responsive to said record bearing medium and being coupled to said fiber feeding means for controlling the quantities of each different color fiber at any time dispensed thereby in accordance with the amounts thereof to be retained by said backing material as defined by the indicia borne by said record bearing medium.

10. In a pile fabric knitting apparatus of the type in which a rotatable needle cylinder carries an endless succession of reciprocable knitting needles and in which pile fiber feeding means deliver pile fibers from separate supplies to spaced apart zones adjacent the needle cylinder to be picked up by such of the knitting needles as are reciprocated into the respective zones, the combination which comprises:

means for reciprocating selected knitting needles into individual ones of said zones to cause removal of pile fiber therefrom;

controllable means for regulating the quantities of pile fibers delivered to the respective ones of said zones, said controllable means including multiple speed transmission means for regulating the quantity of pile fibers delivered to one of said zones, said transmission means including an electromagnetic clutch unit having low speed and high speed outputs; and

pattern means for delivering electrical control signals to said clutch unit and being operative selectively to cause no fiber delivery to such zone, slow fiber delivery to such zone or fast fiber delivery to such zone, said pattern means additionally controlling said controllable means to correlate the quantities of pile fibers delivered to any of said zones with the number of knitting needles reciprocated into such zone.

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