United States Patent [19]

Bliss-Hill et al.

[11] **3,733,855**

[45] **May 22, 1973**

[54] **ELECTRONICALLY CONTROLLED NEEDLE SELECTION SYSTEM FOR KNITTING MACHINES**

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[73] Assignee: **Stibbe Machinery Limited**, Leicester, England

[22] Filed: **Dec. 2, 1970**

[21] Appl. No.: **94,427**

[52] **U.S. Cl.** ..... **66/50 R**

[51] **Int. Cl.** **D04b 15/78**

[58] **Field of Search** ..... 66/50 R, 50 B, 25, 66/75, 154 A

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Primary Examiner—Wm. Carter Reynolds
Attorney—Larson, Taylor and Hinds

[57] **ABSTRACT**

A knitting machine having individually operable needles, pattern information carrier means movable in sympathy with the machine and an electronically controlled needle selection system which, at the dictates of the pattern information and via butts associated with the needles, selectively controls the latter. Each needle has its own magnetic actuator unit. Each such unit includes a light responsive detector responsive to light signals transmitted to it by the pattern information carrier means. A light level detector circuit provides a step voltage output when the level of signal received by the detector exceeds a threshold value. When triggered by this output a monostable circuit produces an output pulse. This pulse energizes an opposing winding associated with a permanent magnet included in the unit to re-direct the attractive force of the magnet. Associated with each unit is an armature normally retained by the magnet but releasable therefrom, to change the path of flux, to exercise selective control over corresponding needle.

9 Claims, 9 Drawing Figures

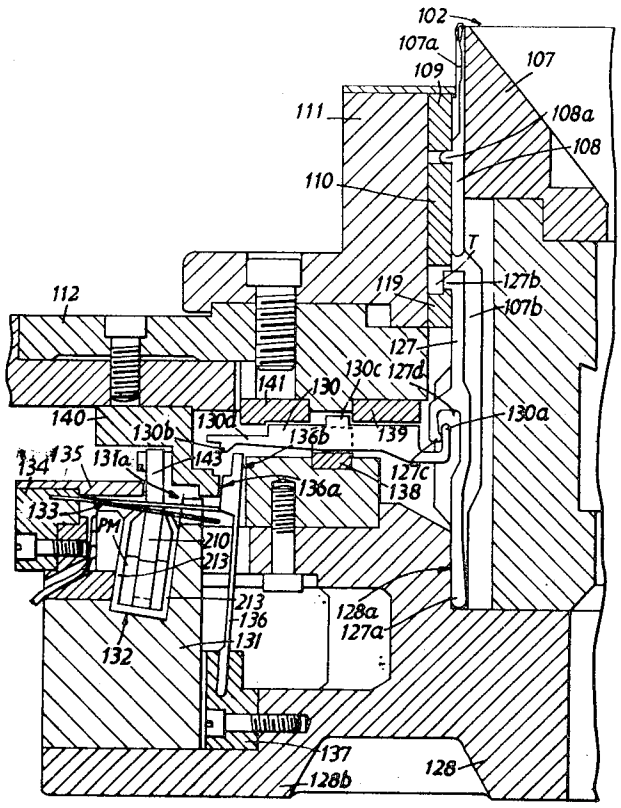


FIG. 1.

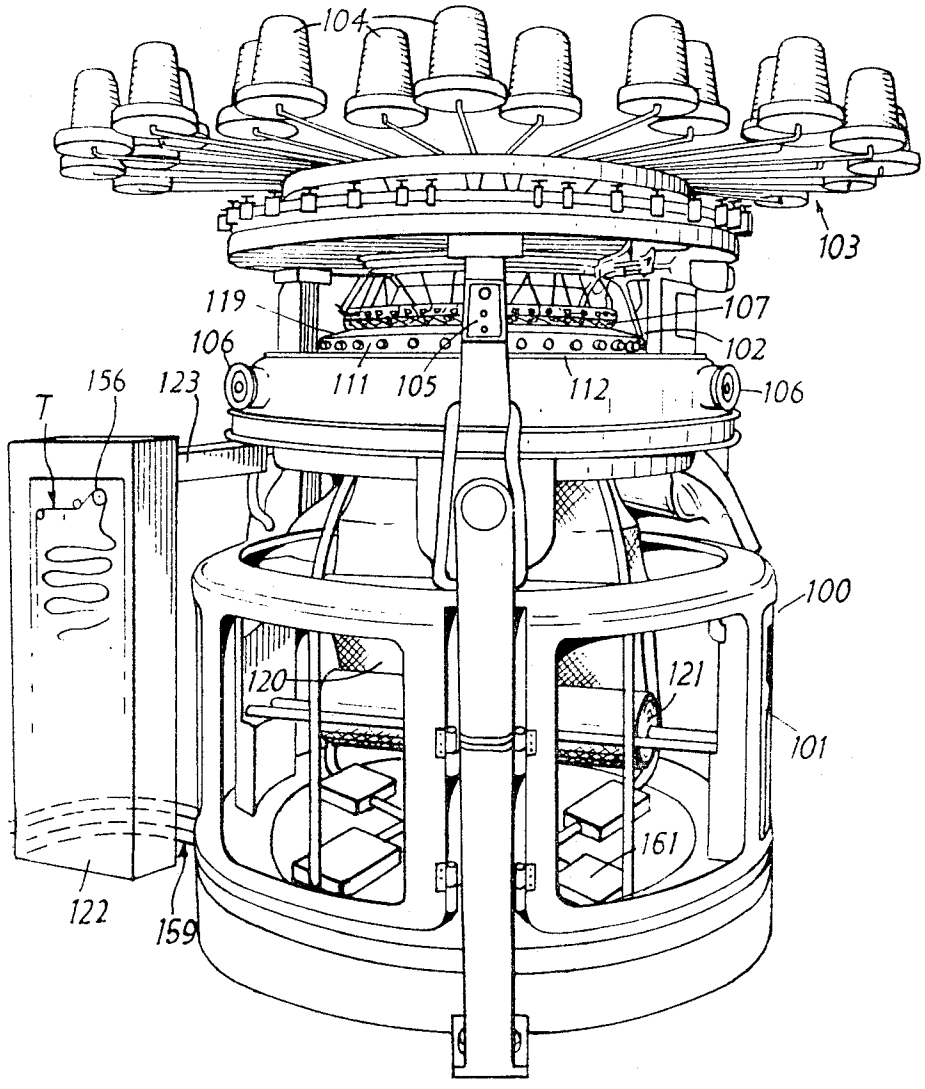
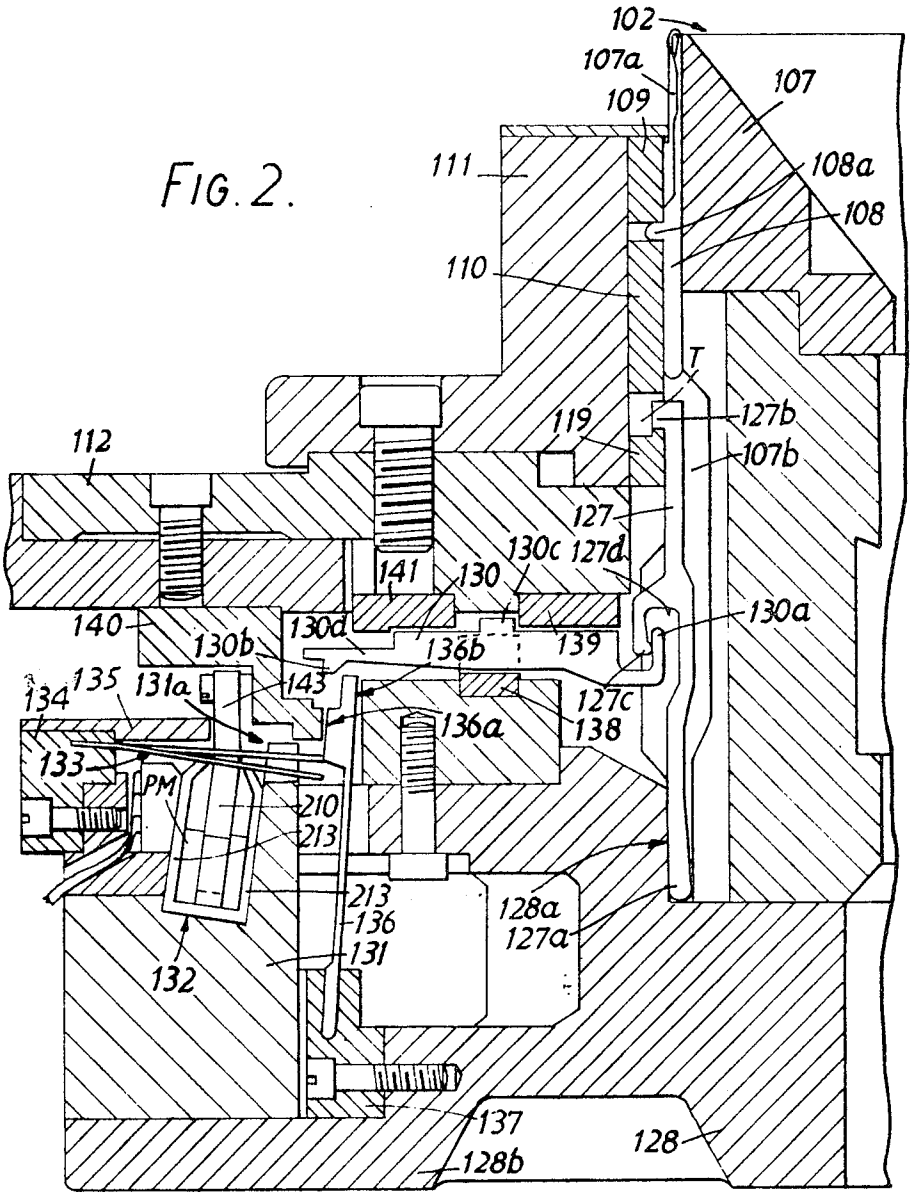

104
103
119
107
106
102
111
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112
106
156
123
T
100
120
121
101
161
122
159

FIG. 2.


102
107a
109
107
111
108a
108
110
T
119
127b
107b
112
127
130c
127d
141
130
130a
140
130d
136b
139
130b
143
135
131a
134
127c
138
136a
133
PM
210
213
213
136
131
128a
127a
132
137
128
128b

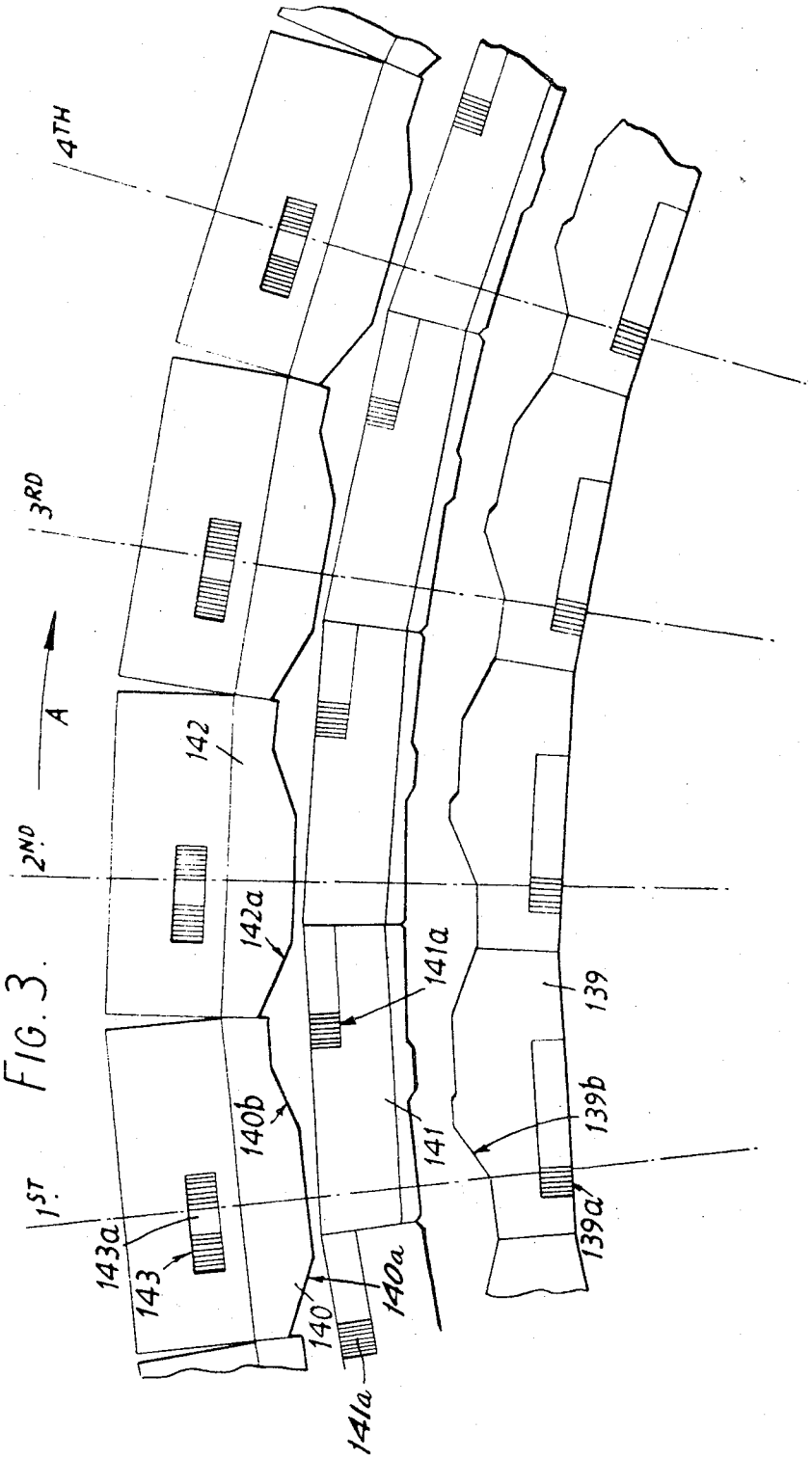

4TH
3RD
2ND
1ST
A
142
142a
141a
139
139b
141
140b
143a
143
140
140a
141a
139a

FIG. 3.

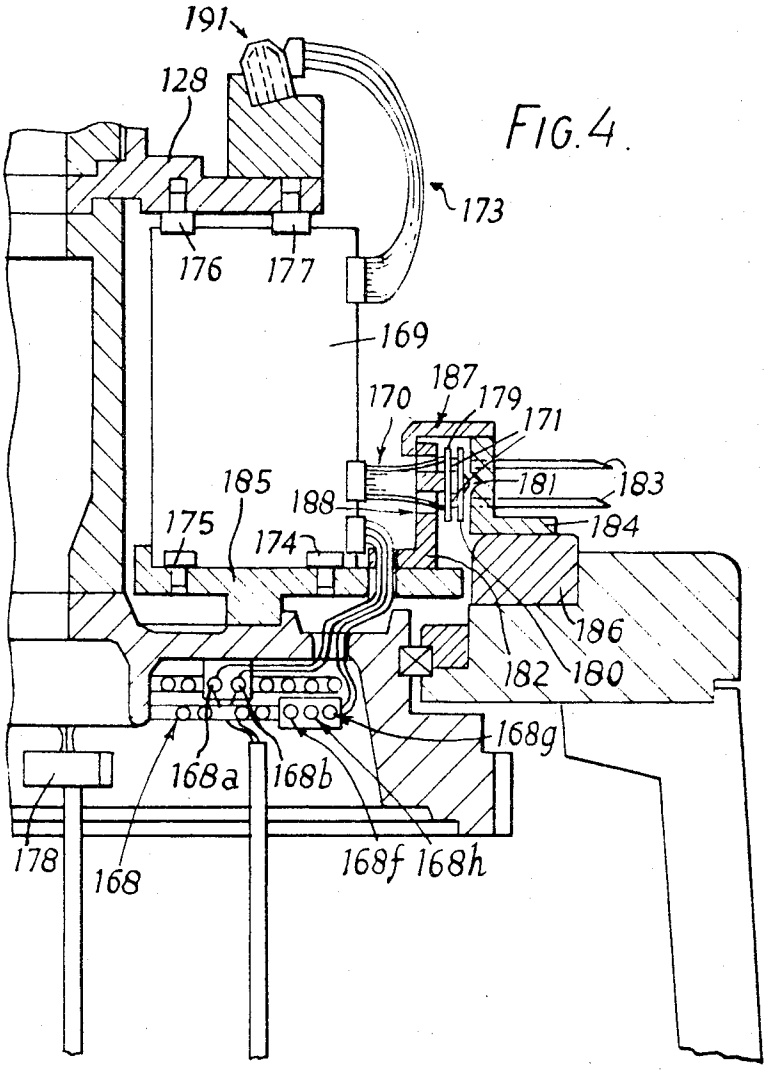

191
128
173
176
177
169
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187
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171
181
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168g
168a
168b
178
168
168f
168h

FIG. 4.

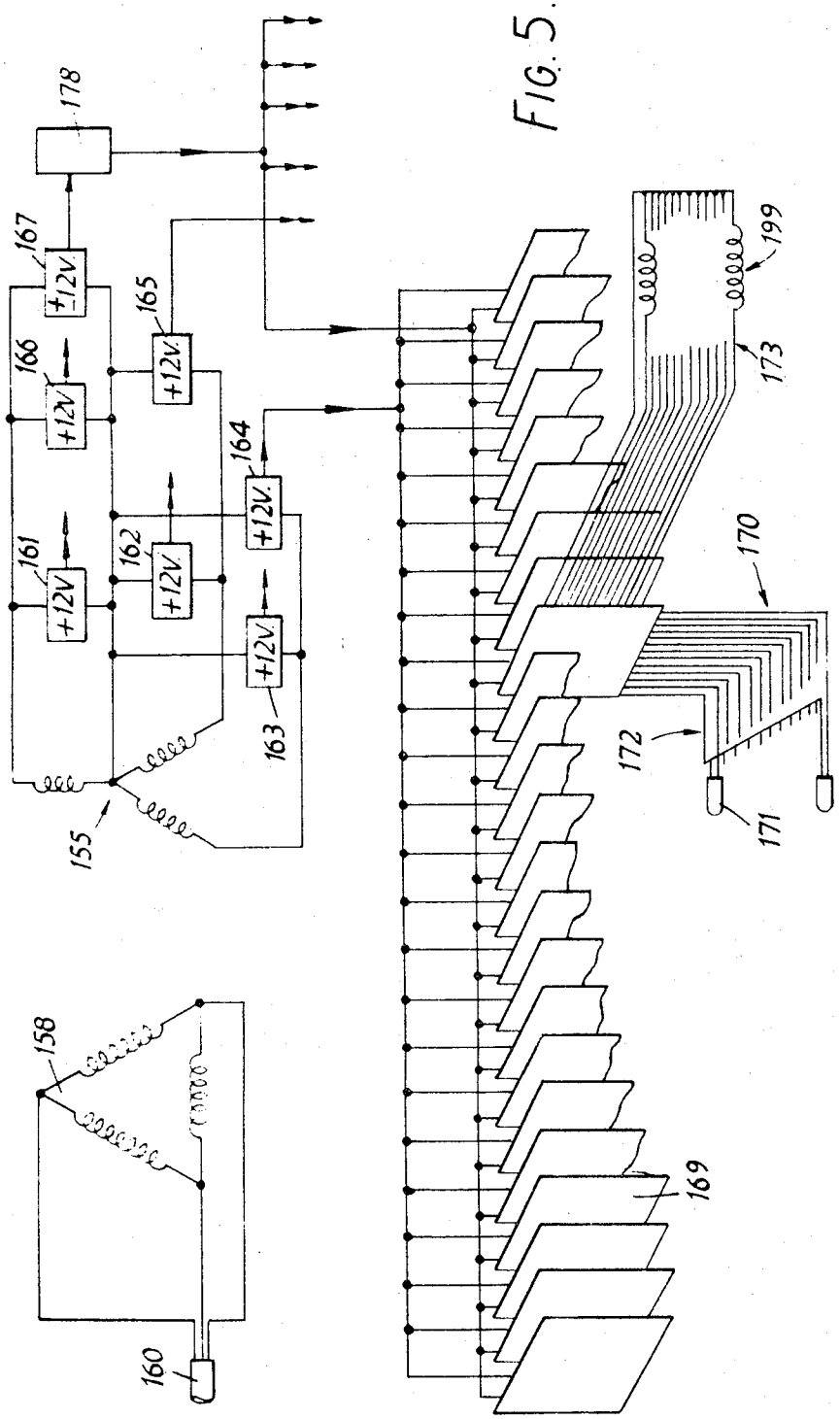

178
167
+12V
165
+12V
166
+12V
164
+12V
161
+12V
162
+12V
+12V
163
155
158
160
199
173
170
172
171
169

FIG. 5.

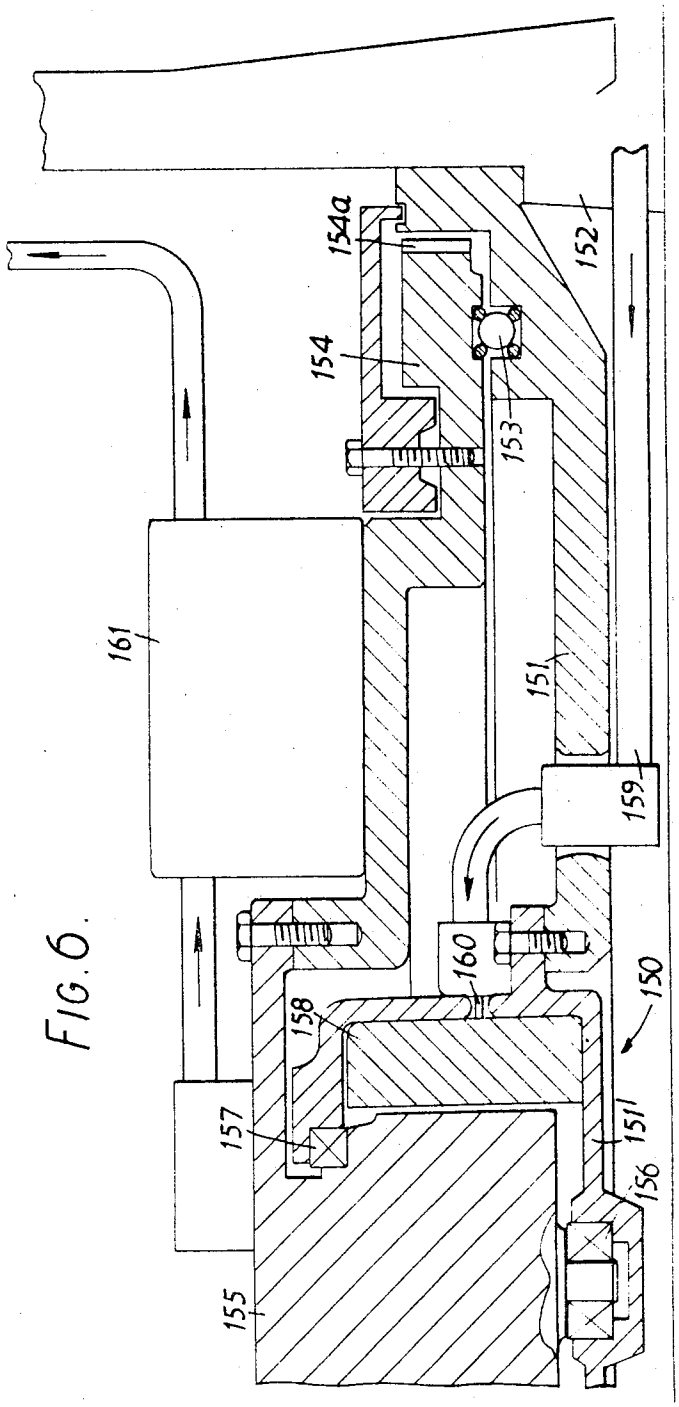


FIG. 6.

FIG. 7.

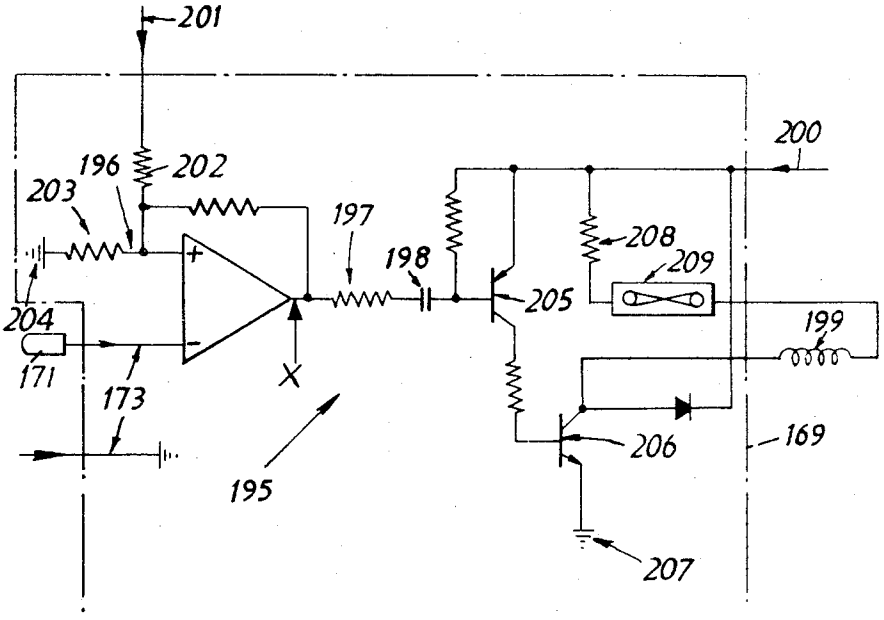
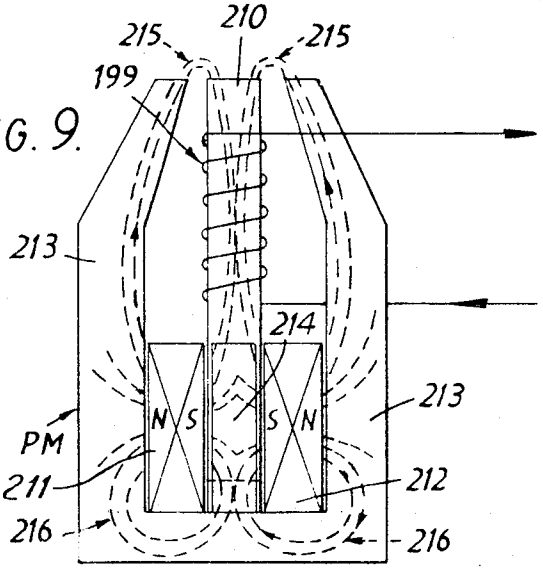

201
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196
202
203
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198
208
209
205
204
199
171
173
X
206
169
195
207

FIG. 9.


210
215
215
199
213
214
213
N
S
S
N
PM
211
212
216
216

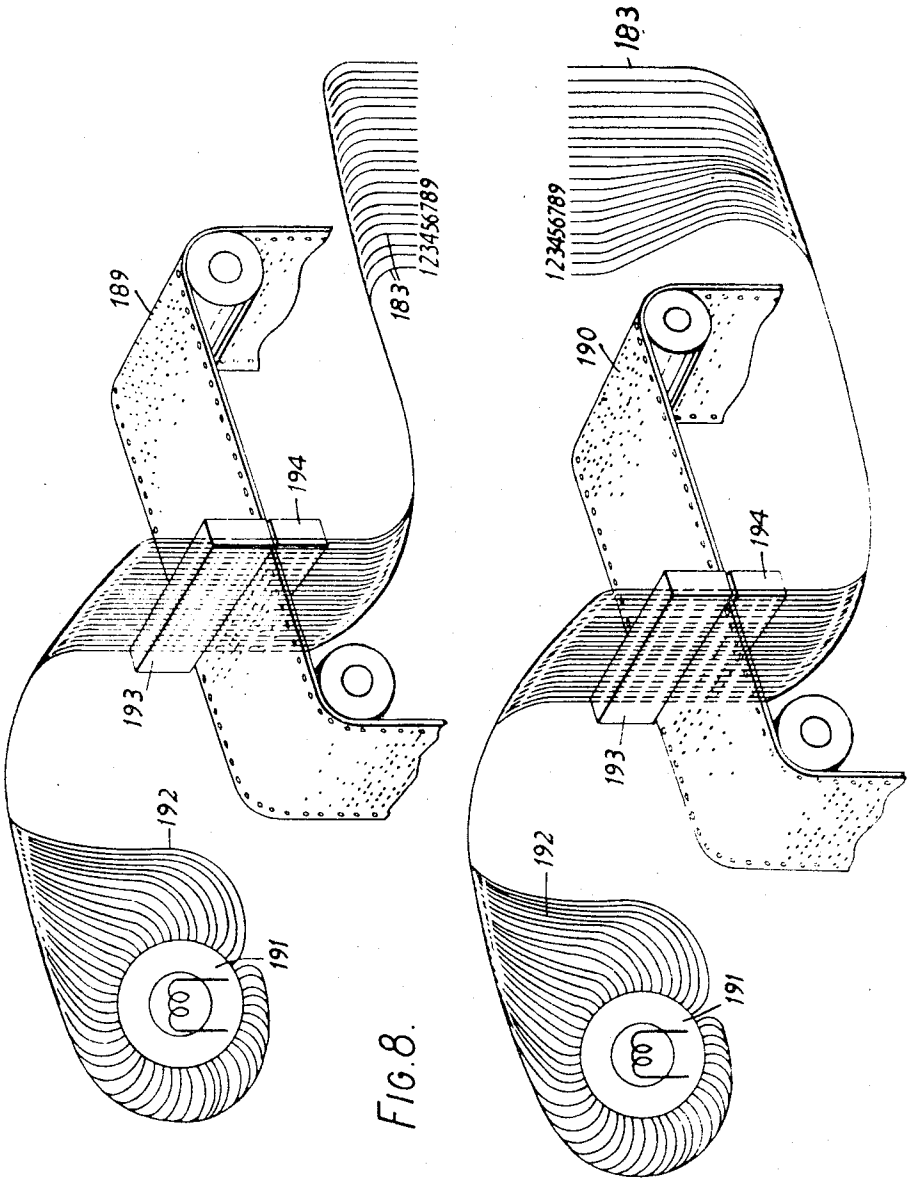

183
123456789
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123456789
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191
191

FIG. 8.

ELECTRONICALLY CONTROLLED NEEDLE SELECTION SYSTEM FOR KNITTING MACHINES

This invention relates to knitting machines of the general class equipped with individually operable knitting needles, and means, including one or more pattern information carriers movable in sympathy with the machine, for exercising selective and individual control over these needles, through the medium of associated butts which, according to predetermined patterning requirements, are either left undisturbed or are acted upon in any desired manner to influence the corresponding needles in different ways according to the nature of the patterned knitted fabric to be produced.

The term "associated butts", is used herein in a generic sense and is intended to be sufficiently broad to cover not only the more usual case in which the butts are provided on jacks, sliders or like instruments separate from the needles, but also a case in which the butts are on the needles themselves.

Although principally intended for application to multi-feed circular jacquard knitting machines of the rotary needle cylinder type, there is no limitation in this respect since the invention may be applied to any other appropriate types of circular knitting machines, as well as to flat knitting machines having either a single needle bed or two opposed needle beds.

For convenience and simplicity in the following further description, it will be assumed, without any limitation of the broad scope of the invention, that the butts associated with the needles are selectively acted upon suchwise as to cause some needles to knit and others to non-knit.

In particular, the invention has reference to an electronically controlled needle selection system for a knitting machine of the general class referred to.

It has previously been proposed to apply such a needle selection system to a knitting machine wherein the aforementioned associated butts are all disposed at the same level by employing magnetic means for effecting the single level selections. It is also known, on such a machine, to adopt electro-mechanical transducers which are arranged for action upon needle-actuating jacks, either directly or through the medium of individual spring selector wires, for effecting the single level selections.

It has also been proposed to apply an electronically controlled needle selection system to a multi-feed circular jacquard knitting machine in which the associated butts are so disposed in a multiplicity of planes as to enable the butts in any one plane to be well spaced apart with time intervals between them. In such a case, both magnetic means and also electro-mechanical transducers have been used to effect the necessary multi-level selections. For example, according to one particular prior proposal, selectively operable transducer-actuated butt displacing devices are arranged in the several butt planes, the system including pattern control means bearing information adapted to influence actuation of the said butt displacing devices, an electronic pattern scanning means for systematically scanning the information borne by the pattern control means and for converting it into electrical signals, and means for thereupon routing such signals to desired ones of the transducer-actuated butt displacing devices.

The various previously proposed electronically controlled needle selection systems mentioned above are subject to disadvantages. Thus, for instance, in a single-level selection system there is an extremely short time available (approximately 1 ms) between any two butts in which to effect an electronic selection. As regards a multi-level selection system, the electronics required to provide the many levels or information are prohibitively expensive.

Moreover, when using electro-mechanical transducers in either system the pivot bearings, end stops etc. have a very limited life, necessitating frequent renewals of components.

The object of the present invention is to provide, in a knitting machine of the class concerned, a generally improved electronically controlled needle selection system which combines the advantage and has none of the disadvantages of both of the previously proposed systems. That is to say, the aim is to provide a system which will make possible single level magnetic selections and yet at the same time provide a sufficiently long period of time in which to satisfactorily effect each selection.

According to this invention, each individually operable knitting needle in the machine has its own magnetic actuator unit comprising, in combination, a detector responsive to signals transmitted thereto at the dictates of movable pattern information carrier means; a level detector circuit adapted to provide a step voltage output when the level of signal received by the detector exceeds a predetermined threshold value; a monostable circuit capable of producing an output pulse when triggered by the output from the said level detector circuit; and a permanent magnet having in association with it an opposing winding for flux re-direction, the said winding being energizable in response to an output pulse produced by the monostable circuit suchwise as to re-direct the attractive force of the magnet.

Each magnetic actuator unit has in association therewith an armature which is arranged to be normally attracted to and retained by the permanent magnet but releasible therefrom upon re-direction of flux to initiate selective actuation of the knitting needle, e.g. to knit or miss-knit, as the case may be.

Preferably, the armature associated with each permanent magnet consists of a relatively thin spring wire which, whenever released for movement away from the said magnet, is either acted upon mechanically or functions mechanically to influence the relevant needle — either directly or, more usually, through the medium of a jack housed in the same groove or trick in the needle bed, or the relevant needle bed, as that accommodating the said needle. An advantage of employing spring wires as armatures is that their inherent springiness can be relied on to assist in moving them away from the permanent magnets at such times as the magnetic retaining forces of the latter are re-directed. Conversely, a spring wire can be readily cammed against the spring action from a normal position in which the wire is in a relaxed condition into a position in which the said wire is in contact with the corresponding permanent magnet and is retained thereby against the reaction of the spring bias.

The knitting machine essentially includes a cam, in advance of the or each needle selecting station, for forcibly moving all of the armatures seriatim into contact with their respective permanent magnets — prepa-

ratory to selected ones of these magnets having their flux re-directed to release the corresponding armatures, whereas the remaining magnets are unaffected and retain their associated armatures, all at the dictates of the moving pattern information carrier means.

In accordance with an essential feature of the present invention, the said cam or cams is or are so arranged that there is a maximum possible distance between the point at which a signal is transmitted to the level detector of each magnetic actuator unit and the point at which the corresponding armature, if selected, is released to initiate mechanical selection of the relevant knitting needle. This time-extending distance may be of the order of from, say, ten to twelve needle pitches in the case of a circular 48-feed knitting machine. Thus, this substantial extension of the time available in which an electronic selection can be effected represents one of the main advantages of the improved system. The potential frequency of the signals determined by the moving pattern information carrier or carriers, must, of course, be the same as the frequency of the relative movement of needle tricks or grooves past the means employed to transmit such signals to the level detectors: but since each trick or groove has its own magnetic actuator unit, the latter has, in fact, a time equivalent to a plurality (e.g. ten to twelve) needle pitches in which to operate.

In the principal application of the invention to a multi-feed circular knitting machine of the rotary needle cylinder type there is at each feed a control station at which is provided means for transmitting signals to predetermined ones of the level detectors passing by the same as the needle cylinder rotates.

But in a flat knitting machine in which the or each needle bed is stationary, the means for transmitting signals to selected level detectors would be mounted on the traversible cam carriage so that in this case the said means pass by the stationary detectors at each traverse of the carriage in either direction. A flat knitting machine may be provided with only one feed.

Preferably, the level detectors are in the form of light-responsive devices so that each detector provides a step voltage output when the level of light received by it exceeds a predetermined threshold value.

Advantageously, the means at the or each feed for transmitting light signals to the light-responsive detectors may consist of a fiber-optic light guide. Such a light guide consists of a flexible tube containing a bundle of light-transmitting fibers and is now well known and commercially available.

The or each pattern information carrier may conveniently be in the form of a programmed control tape adapted to be driven synchronously with the knitting machine. Such a tape would have one row of information per feed, one end of a corresponding tubular fiber-optic light guide terminating adjacent to the row whilst the other end of the said guide is so arranged at the feed as to be passed by, or to pass, the light-responsive detectors.

In order that the invention may be more clearly understood and readily carried into practical effect, a specific form of the improved electronically controlled needle selection system as applied to a multi-feed double jersey jacquard machine of the rotary needle cylinder and dial type will now be described with reference to the accompanying drawings, wherein,

FIG. **1** is a general perspective view of the said machine,

FIG. **2** is a detail sectional view taken through the knitting head of the machine showing the needle cylinder, the associated cam box, one of the magnetic actuator units and the corresponding spring wire armature which is releasable from the permanent magnet to initiate selective actuation of the relevant needle,

FIG. **3** is a diagrammatic underside plan view of cams employed at selecting stations for controlling and moving spring wire armatures seriatim into contact with their respective permanent magnets and also cams for rocking selector members engaged with patterning jacks in the manner and for the purpose hereinafter to be described,

FIG. **4** is a detail vertical sectional view through the cylinder carriage and associated parts beneath those shown in FIG. **2**,

FIG. **5** illustrates the general electrical circuit layout used for needle selection purposes,

FIG. **6** is a detail vertical sectional view taken through the base of the knitting machine and shows a rotary transformer through which electrical power is fed to the needle actuator units,

FIG. **7** is a diagrammatic representation of the electrical circuitry, including the monostable circuit associated with each of a multiplicity of circuit boards such as that shown in and hereinafter to be described with reference to FIG. **4**,

FIG. **8** is an artist's impression diagrammatically illustrating a particular arrangement of control tapes, light sources, illuminating heads, reading heads and fiber optic light guides for carrying the invention into effect, and

FIG. **9** is a side view of the permanent magnet and the associated opposing winding for flux re-direction included in one of the needle actuator units.

Referring to FIG. **1** of the drawings, the machine to which the illustrated example of the invention is applied is generally designated by the reference numeral **100.** This machine is a double jersey jacquard machine of the rotary needle cylinder and dial type. The hollow base **101** supports the rotary knitting head **102** of the machine, and a conventionally mounted superstructure **103** carries the yarn packages in the form of cones **104** of variously colored yarns. At **105** are indicated main switches for starting, stopping and inching the machine, whereas at **106** are shown ventilating fans.

The rotary needle cylinder of the machine — shown very generally in FIG. **1** and in more detail in FIG. **2** — is designated by the numeral **107.** This cylinder is cut with tricks **107***a* to accommodate independent latch needles such as **108** (FIG. **2**) each having thereon an operating butt **108***a* arranged to be acted upon by cams, such as **109, 110,** housed in a stationary annular cam box or shell **111.** This cylinder cam box is mounted upon a fixed bed ring **112** shown both in FIGS. **1** and **2.**

In FIG. **1,** moreover, the patterned fabric **120** produced on the machine is shown being drawn down by a rotary draw-down mechanism and finally rolled up upon a driven reel **121** housed within the hollow base **101.**

At **122** in FIG. **1** is depicted a punched tape control unit which is mechanically connected at **123** to, and driven from, the knitting machine. The tape T is shown passing over a sprocket-like pulley **156.**

Referring again to FIG. 2, it will be seen that there is provided beneath each cylinder needle **108**, in the same trick **107***a*, a patterning jack **127**. Each jack is pivotally located at its lower end **127***a* in the bottom of the cylinder trick **107***a* and held there between the back of the cylinder trick and a fixed projection **128***a* on the cylinder carriage **128**. The vertical movement of the patterning jack **127** is governed by cams **119** and **110** acting on a butt **127***b* at the top of the said jack. The jack is capable of being swung inwardly more deeply into its cylinder trick in order to disengage its top butt **127***b* from its controlling cams. To permit of such an inward swinging movement of the jack **127**, the cylinder trick **107***a* is made deeper at the location **107***b*. In this example, the butt **127***b* is one of the "associated butts" previously referred to herein.

At a point disposed approximately midway between its ends, each patterning jack **127** is furnished with a hook **127***c* and recess **127***d* arranged to co-operate with a hook **130***a* on the inner end of a horizontal selector member **130**. The arrangement is such that normally each patterning jack **127** is held in its forwardly tilted position by virtue of the hook **130***a* pulling on hook **127***c* to maintain the butt **127***b* engaged with its controlling cams so that the corresponding needle **108** will knit. By pushing a selector member **130** inwardly the hook **130***a* thereon will contact and push against the back of the recess **127***d* in the corresponding patterning jack **127** with the result that this jack will be tilted inwardly to withdraw its butt **127***b* from the track T between the cams **110** and **119** so that the corresponding needle will not knit.

In an annular part of the machine rotating together with but in the outside of the needle cylinder **107** are mounted '*n*' needle actuator units **132** where '*n*' equals the number of needles **108** in the needle cylinder. These actuator units **132**, hereinafter to be more fully described, are mounted on a ring **131** which is in turn supported on an outwardly directed flange **128***b* of the cylinder carriage **128**. Each actuator unit includes a spring wire armature **133** held at its outer end substantially horizontally in blocks such as **134**, supported on the ring **131**. An inner portion of each spring wire armature is freely supported in comb type portions **131***a* of a ring **131**. A cover ring **135** is fitted onto the blocks **134** to cover and thereby protect the wires **133** from outside influence. The inner extremity of each spring wire armature **133** co-operates with the upper end of a further spring member **136** mounted substantially vertically and held at its lower end in blocks, such as **137**, supported on the cylinder carriage **128**. The upper end of each spring member **136** is of stepped configuration having two working edges **136***a* and **136***b*.

The selector members **130** are mounted freely in comb members **138**. By "freely mounted" it is to be understood that the selector members **130** are not fixed but held by friction to the extent that they are able to pivot and slide as dictated by operating cams. At its outer end each of these selector members is provided with a butt **130***b* for co-operation with edge **136***b* of the corresponding spring member **136**. A further butt **130***c* disposed mid-way along the top edge of the selector member **130** is operated on by cams **139**, **141**.

There is a selector member **130**, a spring wire armature **133** and a spring member **136** all as just described to each needle **108** and associated patterning jack **127** in the needle cylinder, and these parts co-operate in the following manner to cause the needles to knit or non-knit.

Reference will now be made to FIG. 3 in which the rotational direction of movement of the needles and associated elements is shown by the arrow designated A. At the commencement of selection at the first selecting station shown in FIG. 3, the cam face **140***a* of cam **140** pushes on operating edges **136***a* of spring members **136** which are not already held in the radial inward position by armatures **133** as a result of selection at the previous station to push the latter clear of the ends of spring wire armatures **133**. Immediately prior to action on edges **136***a* by face **140***a* a cam **141***a* lowers butts **130***b* of selectors **130**. Thus, the jacks are selectively rocked. Immediately this is accomplished the spring wire armatures **133** are cammed down by cam **143** onto their respective actuator units **132** where they are held by magnetic attraction after having passed holding-down land **143***a* on cam **143**. The actuator units **132** are then influenced to release selected spring wire armatures **133** as will be hereinafter described.

At the same time as selection takes place, a cam face **139***a* of a cam **139** rocks all the selector members **130** so that the butt **130***b* of each such member is clear of the upper end of the corresponding spring member **136**, immediately following which a cam face **139***b* on said cam **139** acts on butts **130***c* to push radially outwards those selector members **130** which were not already radially outward as a result of non-selection at the last station, whereby all the butts **127***b* of the patterning jack **127** are in the lifting jack track T. Selected spring members **136** are then allowed to move outwards under their own inherent spring tension to follow a cam face **140***b* at the selecting station. It is only selected ones of these members **136** which will operate in this way, as the non-selected ones will be held inwards due to their operating edges **136***a* being engaged with the inner extremities of those spring wire armatures **133** which were previously released from their actuator units **132**.

This selective operation accordingly now leaves some of the spring members **136** in front of and others behind the positions of butts **130***b* of those selector members **130** which are tilted upwardly to position the said butts clear of the upper ends of the spring members **136**. A cam face **141***a* of a cam **141** at the selecting station is now engaged by the outer end portions **130***d* of relevant selector members **130** which as a consequence are tilted downwardly in order that corresponding butts **130***b* shall now be lowered to a position where some spring members **136** are in front of, and some behind, the butts **130***b*.

A cam **142**, identical to cam **140**, is provided at the second selecting station shown in FIG. 3 but its leading cam face **142***a* in fact performs the relevant selecting operation of the first selecting station. This particular operation is performed by virtue of the cam face **142***a* pushing on the front operating edges **136***a* of selected spring members **136** whose rear operating edges **136***b* push on butts **130***b* of corresponding selector members **130**. As previously described herein this action results in the hooks **130***a* of the rearwardly pushed selector members **130** pushing on the corresponding patterning jacks **127** to disengage their butts **127***b* from the jack lifting track T causing the relevant needles not to knit.

This entire operation as just described for the first selecting station is then repeated for each subsequent selecting station around the machine.

To enable such a needle selection system to operate it is necessary that electrical power is fed to the needle actuator units **132** and, since the latter rotate together with the needle cylinder **107** it is necessary to provide either slip rings or, as in the specific illustrated example, a rotating transformer.

Such a rotating transformer, generally designated **150,** is illustrated in FIG. **6.** The transformer is located in a suitable housing within the base of the knitting machine below the conventional fabric take-down rollers. In this specific example the rotary transformer is mounted in a main housing **151** supported just clear of the floor by the legs **152.** Mounted on a bearing **153** within the housing **151** is a driving bracket **154** for the rotating part, i.e. rotor, **155** carrying the secondary windings of the rotary transformer. This driving bracket **154** is in turn driven in unison with the needle cylinder **107** through the medium of gear teeth **154***a*. The rotor **155** is also supported by bearings **156** and **157.**

The stator **158** carrying the stationary or primary windings of the rotary transformer **150** is housed within a subsidiary casing **151**[1] which also houses the rotor bearings **156** and **157** and is supported by the main housing **151.** Three phase AC power is supplied to the stator **158** within conduits **159** by stator leads **160.** This electrical power is induced into the rotor **155** and passed on to power supply packs **161** to **167** spaced circumferentially around the base of the machine as shown in FIGS. **1** and **6.** The power supply packs are used for converting the AC supply into DC for operating the opposing windings **199** associated with the permanent magnets PM of the needle cylinder units **132.** In particular the packs **161** to **166** are used to supply the + 12 volts power for the windings **199** of the actuator units and supply pack **167** to supply ± 12 volts stabilized power for operating the selection of that power as will be described later.

The DC power is now passed from the supply packs **161** to **167** to a number of bus-bars **168***a* to **168***p* which are in turn connected to a number of electronic circuit boards such as **169** (see FIGS. **4** and **5**). Each circuit board in this specific example carries the electronic circuitry for twelve actuator units **132** one of which circuits is shown in FIG. **7.** The power supply to each board **169** is taken from several bus bars **168** in order to ensure an even distribution of the power load. Thus, in FIG. **4** the two bus bars **168***a* and **168***b*, supplied from the power pack **161,** are connected to a series of the circuit boards. The poser supply from pack **167** is connected to a voltage stabilizer **178** and then to three bus bars **168***g*, **168***h*, **168***f* which are in turn connected to all the circuit boards around the machine.

Further connections to each circuit board **169** are shown in FIGS. **4** and **5** these including one connection **170** for each individual one of a set of twelve P.E. (i.e. photoelectric) cells **171,** and one common connection **172** for each such set. As stated before, each circuit board **169** is a common carrier for twelve circuits connected to their respective P.E. cells and needle actuator units **132.** The connections to the needle actuator units are designated by the numeral **173.**

Each circuit board **169** is mounted radially below the needle cam box as shown in FIG. **4.** The said boards are slotted in between pin heads **174, 175, 176** and **177** and are therefore easily removable by first removing brackets **182** and **184** which are distributed around the machine in a complete circle.

The photo-electric cells **171** are mounted in the required sets on boards **179** and **180** which are fixed by screws, such as **181,** to the brackets **182.** The latter are secured upon a main rotating member **185** of the frame of the machine.

Fiber optic light guides **183** are fitted into the brackets **184** which are mounted on a main stationary member **186** of the machine frame, these light guides being in close proximity to, and in heightwise alignment with, the P.E. cells **171.** Cover plates **187** are attached to the tops of the brackets **184** in order to keep the spaces occupied by the P.E. cells free from dust and outside interference. An additional seal **188** is also placed at the back of the P.E. cells **171** allowing only the respective connectors **170** and **172** through to the circuit boards **169.**

In FIG. **4,** the P.E. cells **171** and the fiber optic light guides **183** are shown at two heights; thus, in the illustrated example, there are two fiber optic light guides at each feed station arranged one above the other. There is one P.E. cell **171** to each needle **108** in the machine, these cells being arranged in two horizontal rows around the machine in a staggered relation such that alternate P.E. cells are actuated by light guides at the higher level whilst intermediate P.E. cells are actuated by light guides at the lower level. In this particular arrangement, quoted merely by way of example, the higher level light guides and the lower level light guides are respectively connected to reading heads arranged to scan respective punched control tapes running in synchronism with the machine.

Other appropriate arrangements of P.E. cells **171** and fiber optic light guides **183** may, however, be applied to the herein described needle selection system. For instance, in one such alternative arrangement there may be one row of P.E. cells and light guides connected to one reading head arranged to scan a single punched tape. Or two rows of P.E. cells and light guides as described above may be connected to one reading head scanning one punched tape. Yet again, a multiplicity of heightwise spaced rows of P.E. cells and light guides may be controlled from one or a multiplicity of reading heads scanning one or a multiplicity of punched tapes.

One specific arrangement of control tapes and reading heads will now be described with reference to FIG. **8.** In this arrangement, two punched control tapes **189** and **190** are set out with the necessary information for controlling respectively alternate and intervening needle actuator units **132** at each feed.

A multiplicity of fiber optic light guides **192** (48 to each control tape in this example) are used to transmit light from either a common light source **191** or a plurality of such light sources to an illuminating head **193.** Each illuminating head is arranged at one side of the relevant tape in such a way that each light guide **192** is directed onto one longitudinal row of information on the said tape. A reading head **194** is so located at the opposite side of each control tape that one fiber optic light guide **183** is directly over a corresponding longitudinal row of information and in line with one of the light guides **192,** there being, of course, forty eight light guides **183** to each reading head, that is to say one for each feed of the knitting machine. With such an ar-

rangement there is a minimum amount of light dissipation outside of its intended paths through the control tapes.

In FIG. 7 is represented one of a number of identical circuits, including the monostable circuitry on each circuit board **169**, the chain dotted line in this figure defining the area of that board. Each such circuit includes a level detector in the form of a photo-voltaic cell **171** the volt output from which is fed into a differential amplifier **195** with a feed back circuit **196**. This cell **171** is, of course, one of the P.E. cells shown in FIG. **5**. When, as light starts to pass through a hole in a control tape and along a relevant light guide **183** to the photo-voltaic cell **171**, the illumination intensity reaches a pre-determined level the Schmitt trigger action of the circuit causes a fast transition in output voltage from a positive to a negative value at point X. The light intensity continues to rise to a maximum as the hole in the tape passes between the relevant aligned light guides **192** and **183** and as the photo-voltaic cell **171** passes the end of the light guide **183**, after which the intensity will start to fall-off until a next predetermined level of intensity is reached which is higher than the first illumination intensity. At this point a fast voltage transition in the opposite direction takes place at point X. The difference between the two levels of illumination intensity determines the hysteresis of the circuit so that unrequired voltage oscillations do not occur in the amplifier **195**. The hysteresis action normally associated with a Schmidt trigger is contained up to the point X in FIG. **7**. Such oscillations might otherwise occur due to vibration effects on a knitting machine which has been stopped causing slight backward, i.e. reverse, movement of the needle cylinder **107**. The switching levels of the Schmitt trigger circuit are set to values of maximum sensitivity compatible with 'cross talk' of light at the reading head **194** and between the photo-cells **171** and light guides.

Although the above description refers specifically to a photo-voltaic cell it could equally well apply to any other appropriate type of P.E. cell such as a photo-resistive cell or a photo-transistor, which in turn feeds a Schmitt trigger circuit with input hysteresis.

The output from X further consists of a network of two transistor stages **205** and **206**, a resistor **197** and a capacitor **198** in series on the input side. This network receives a step voltage transition in the negative direction from the Schmitt trigger circuit as just described when the illumination intensity reaches the lower predetermined level. This causes a capacitor **198** to charge through the transistor **205** so that current is passed through a selector via transistor **206** for a period of time determined by the time constant of the input network capacitor-resistor **197, 198**. The amplifier may, however, be switched-off earlier than this by the positive voltage transition, that is transition in the opposite direction as previously described; such a condition may occur at speeds higher than that at which a knitting machine is at present expected to run.

Current from one of the power supply packs **161** to **166** is supplied through respective bus bars **168** to current input line **200**, and current from the power supply pack **167** is supplied through the voltage stabilizer **178** to a current input line **201**. The current to the last mentioned line is normally routed through resistors **202** and **203** to earth at **204**, but upon the operation of the Schmitt trigger circuit it is routed through the resistor **197** and capacitor **198** to switch on transistor **205**. When transistor **205** is switched on, a current from input line **200** is routed through it to switch on transistor **206**. Upon switching on of the latter, current is caused to pass along the input line **200** to earth at **207** and in so doing energizes the coil **199** of the permanent magnet PM of the needle actuator unit **132**.

In order that the current passing to the coil **199** shall be strictly regulated it is first passed both through resistance **208** and current limiter **209** which ensure that the coil **199** does not overheat and damage in the event of the circuit to earth **207** remaining closed.

The actual needle actuator included in each needle actuator unit **132** accordingly comprises a permanent magnet PM and an opposing winding, (viz. the coil **199**) for flux re-direction. Such a needle actuator is shown in detail in FIG. **9**: as will be seen it consists of a center pole piece **210** made of a soft magnetic material around an upper part of which is wound the coil **199**. At opposite sides of the root of the center pole piece **210** are magnets **211** and **212**, and surrounding the whole are outer limbs **213** made of a ferrous material. Due to the accuracy requirement with this type of needle selection on a knitting machine it is advantageous that a pair of magnets **211** and **212**, common to several of the magnetic actuator units, shall be arranged to span all of the latter. In this case, spacer pieces **214** made of non-ferrous material are placed between adjacent center pole pieces **210**.

Normally, the magnetic flux flows in the path and direction shown by dotted lines **215**, thereby attracting the relevant spring wire armature **133** towards the free end of the center pole piece **210**, but upon energization of the coil **199**, as previously described, the magnetic flux is re-directed to flow in the path and direction shown by dotted lines **216** thereby releasing the spring wire armature **133**.

As will be appreciated from the foregoing description, depending on the type of machine to which the invention is applied, the light-responsive detector of each magnetic actuator unit passes across, or is passed transversely by, the relevant fiber-optic light guide provided at the or each feed control station thereby receiving or not receiving a light signal or pulse as determined by the programmed tape of the appropriate tape, as the case may be. Each light signal or pulse received from a fiber-optic light guide by a light-responsive detector will, as previously mentioned, vary in intensity, rising from a low level to a peak and subsiding again to the low level, as a consequence of which the voltage output from the said detector will vary commensurately: this is why it is necessary to combine with each light-responsive detector a level detector circuit designed to provide a step voltage output only when the level of light received by the light-responsive detector rises above a predetermined threshold value.

We claim:

1. A circular knitting machine which includes a rotating tricked needle cylinder bed; individually operable knitting needles in said needle cylinder; pattern information carrier means movable synchronously with the machine but not rotatable with the needle cylinder; and an electronically controlled needle selection system which, at the dictates of the said pattern information carrier means, and through the butts associated with the needles, exercises selective and individual control over the latter so that some are influenced in one way

and others in another way according to the nature of the patterned knitted fabric to be produced; said machine being characterized in that each individually operable knitting needle therein has its own magnetic actuator unit, all said magnetic actuator units being movable in rotation with the needle cylinder, each magnetic actuator unit comprising, in combination, a detector responsive to signals transmitted thereto at the dictates of the movable pattern information carrier means; a level detector circuit for each needle, each circuit being movable in rotation with the needle cylinder, said circuits including means for providing a step voltage output when the level of signal received by the detector exceeds a predetermined threshold value; a means for supplying electrical power to the rotating needle cylinder bed; a monostable circuit for each needle capable of receiving said electrical power and producing an output pulse when triggered by the output from the said level detector circuit; and said magnetic actuator units having a permanent magnet having in association therewith an opposing winding for flux re-direction, the said winding being energizable in response to an output pulse produced by the monostable circuit suchwise as to re-direct the flux of the magnet; and in that in association with each magnetic actuator unit there is an armature rotatable with the magnetic actuator units, said armature being arranged to be normally attracted to and retained by the permanent magnet but releasable therefrom, upon said re-direction of flux in response to the output pulse of the monostable circuit, for exercising selective control over the corresponding knitting needle; the armature associated with each magnetic needle actuator unit comprising a spring wire rotatable with the needle cylinder bed which is adapted, when released from the permanent magnet of that unit, to initiate selective actuation of the corresponding needle, and wherein each knitting needle is actuated through the medium of a patterning jack housed in the same groove in the needle bed as that accomodating the said needle, the jack being adapted to be mechanically influenced to initiate desired behavior of the needle whenever the corresponding spring wire armature is released for movement away from its respective permanent magnet.

2. A circular knitting machine which includes a rotating tricked needle cylinder bed; individually operable knitting needles in said needle cylinder; pattern information carrier means movable synchronously with the machine but not rotatable with the needle cylinder; and an electronically controlled needle selection system which, at the dictates of the said pattern information carrier means, and through the butts associated with the needles, exercises selective and individual control over the latter so that some are influenced in one way and others in another way according to the nature of the patterned knitted fabric to be produced; said machine being characterized in that each individually operable knitting needle therein has its own magnetic actuator unit, all said magnetic actuator units being movable in rotation with the needle cylinder, each magnetic actuator unit comprising, in combination, a detector responsive to signals transmitted thereto at the dictates of the movable pattern information carrier means; a level detector circuit for each needle, each circuit being movable in rotation with the needle cylinder, said circuits including means for providing a step voltage output when the level of signal received by the detector exceeds a predetermined threshold value; a means for supplying electrical power to the rotating needle cylinder bed; a monostable circuit for each needle capable of receiving said electrical power and producing an output pulse when triggered by the output from the said level detector circuit; and said magnetic actuator units having a permanent magnet having in association therewith an opposing winding for flux re-direction, the said winding being energizable in response to an output pulse produced by the monostable circuit suchwise as to re-direct the flux of the magnet; and in that in association with each magnetic actuator unit there is an armature rotatable with the magnetic actuator units, said armature being arranged to be normally attracted to and retained by the permanent magnet but releaseable therefrom, upon said re-direction of flux in response to the output pulse of the monostable circuit, for exercising selective control over the corresponding knitting needle; the armature associated with each magnetic needle actuator unit comprising a spring wire rotatable with the needle cylinder bed which is adapted, when released from the permanent magnet of that unit, to initiate selective actuation of the corresponding needle, and further including a cam, in advance of each needle selecting station for forcibly urging all the armatures seriatim from their relaxed condition into contact with their respective permanent magnets, preparatory to selected ones of these magnets having their flux paths changed to release the corresponding armatures, whereas the non-selected magnets are unaffected and retain their associated armatures all at the dictates of the moving pattern information carrier means.

3. A knitting machine according to claim **2,** wherein the camming is so arranged that there is a maximum possible distance between the point at which a signal is transmitted to the level detector of each magnetic actuator unit and the point at which the corresponding armature, if selected, is released to initiate mechanical selection of the relevant needle, and the potential frequency of the signals determined by the moving pattern information carrier means is the same as the frequency of the relative movement of needle grooves past the means employed to transmit such signals to the level detectors whereby there is a substantial extension of the time available in which an electronic selection can be effected.

4. A circular knitting machine which includes a rotating tricked needle cylinder bed; individually operable knitting needles in said needle cylinder; pattern information carrier means movable synchronously with the machine but not rotatable with the needle cylinder; and an electronically controlled needle selection system which, at the dictates of the said pattern information carrier means, and through the butts associated with the needles, exercises selective and individual control over the latter so that some are influenced in one way and others in another way according to the nature of the patterned knitted fabric to be produced; said machine being characterized in that each individually operable knitting needle therein has its own magnetic actuator unit, all said magnetic actuator units being movable in rotation with the needle cylinder, each magnetic actuator unit comprising, in combination, a detector responsive to signals transmitted thereto at the dictates of the movable pattern information carrier means; a level detector circuit for each needle, each circuit being movable in rotation with the needle cylinder, said

circuits including means for providing a step voltage output when the level of signal received by the detector exceeds a predetermined threshold value; a means for supplying electrical power to the rotating needle cylinder bed; a monostable circuit for each needle capable of receiving said electrical power and producing an output pulse when triggered by the output from the said level detector circuit; and said magnetic actuator units having a permanent magnet having in association therewith an opposing winding for flux re-direction, the said winding being energizable in response to an output pulse produced by the monostable circuit suchwise as to re-direct the flux of the magnet; and in that in association with each magnetic actuator unit there is an armature rotatable with the magnetic actuator units, said armature being arranged to be normally attracted to and retained by the permanent magnet but releaseable therefrom, upon said re-direction of flux in response to the output pulse of the monostable circuit, for exercising selective control over the corresponding knitting needle; the armature associated with each magnetic needle actuator unit comprising a spring wire rotatable with the needle cylinder bed which is adapted, when released from the permanent magnet of that unit, to initiate selective actuation of the corresponding needle, and wherein the permanent magnet of each magnetic needle actuator unit comprises a center pole piece of magnetic material around which is wound the opposing winding for flux re-direction, a pair of magnets at respectively opposite sides of the said center pole piece and, surrounding the whole, outer limbs of a ferrous material.

5. A circular knitting machine which includes a rotating tricked needle cylinder bed; individually operable knitting needles in said needle cylinder; pattern information carrier means movable synchronously with the machine but not rotatable with the needle cylinder; and an electronically controlled needle selection system which, at the dictates of the said pattern information carrier means, and through the butts associated with the needles, exercises selective and individual control over the latter so that some are influenced in one way and others in another way according to the nature of the patterned knitted fabric to be produced; said machine being characterized in that each individually operable knitting needle therein has its own magnetic actuator unit, all said magnetic actuator units being movable in rotation with the needle cylinder, each magnetic actuator unit comprising, in combination, a detector responsive to signals transmitted thereto at the dictates of the movable pattern information carrier means; a level detector circuit for each needle, each circuit being movable in rotation with the needle cylinder, said circuits including means for providing a step voltage output when the level of signal received by the detector exceeds a predetermined threshold value; a means for supplying electrical power to the rotating needle cylinder bed; a monostable circuit for each needle capable of receiving said electrical power and producing an output pulse when triggered by the output from the said level detector circuit; and said magnetic actuator units having a permanent magnet having in association therewith an opposing winding for flux re-direction, the said winding being energizable in response to an output pulse produced by the monostable circuit suchwise as to re-direct the flux of the magnet; and in that in association with each magnetic actuator unit there is an armature rotatable with the magnetic actuator units, said armature being arranged to be normally attracted to and retained by the permanent magnet but releaseable therefrom, upon said re-direction of flux in response to the output pulse of the monostable circuit, for exercising selective control over the corresponding knitting needle; the armature associated with each magnetic needle actuator unit comprising a spring wire rotatable with the needle cylinder bed which is adapted, when released from the permanent magnet of that unit, to initiate selective actuation of the corresponding needle, and wherein the level detectors in the needle actuator units include means responsive to light for providing a step voltage output when the level of light received by it exceeds a predetermined threshold value.

6. A knitting machine according to claim **5**, including means for transmitting light signals to each said detector comprising a fiber-optic light guide comprising a flexible tube containing a bundle of light-transmitting fibers, and said pattern information carrier means includes a programmed control tape which is adapted to be driven synchronously with the machine and has one row of information per feed, one end of a corresponding fiber-optic light guide terminating in a reading head adjacent to the row while the other end of the said guide is so arranged as to be passed by, or to pass, the said detectors.

7. A knitting machine according to claim **6**, wherein further fiber-optic light guides are provided at the side of the tape remote from the light-responsive detectors to pass light from at least one light source to the rows of information on the tape, via an illuminating head, the said light guides which extend between the light source and the illuminating head being in alignment with corresponding light guides extending between the reading head and the light-responsive detectors whereby whenever the tape permits of the passage of light therethrough the light will travel through the relevant light guide for a period of time determined by the speed of the tape, the resulting light signal being transmitted to the corresponding light-responsive detector.

8. A circular knitting machine which includes a rotating tricked needle cylinder bed; individually operable knitting needles in said needle cylinder; pattern information carrier means movable synchronously with the machine but not rotatable with the needle cylinder; and an electronically controlled needle selection system which, at the dictates of the said pattern information carrier means, and through the butts associated with the needles, exercises selective and individual control over the latter so that some are influenced in one way and others in another way according to the nature of the patterned knitted fabric to be produced; said machine being characterized in that each individually operable knitting needle therein has its own magnetic actuator unit, all said magnetic actuator units being movable in rotation with the needle cylinder, each magnetic actuator unit comprising, in combination, a detector responsive to signals transmitted thereto at the dictates of the movable pattern information carrier means; a level detector circuit for each needle, each circuit being movable in rotation with the needle cylinder, said circuits including means for providing a step voltage output when the level of signal received by the detector exceeds a predetermined threshold value; a means for supplying electrical power to the rotating needle cylinder bed; a monostable circuit for each needle capable

of receiving said electrical power and producing an output pulse when triggered by the output from the said level detector circuit; and said magnetic actuator units having an permanent magnet having in association therewith an opposing winding for flux re-direction, the said winding being energizable in response to an output pulse produced by the monostable circuit suchwise as to re-direct the flux of the magnet; and in that in association with each magnetic actuator unit there is an armature rotatable with the magnetic actuator units, said armature being arranged to be normally attracted to and retained by the permanent magnet but releasable therefrom, upon said re-direction of flux in response to the output pulse of the monostable circuit, for exercising selective control over the corresponding knitting needle; the armature associated with each magnetic needle actuator unit comprising a spring wire rotatable with the needle cylinder bed which is adapted, when released from the permanent magnet of that unit, to initiate selective actuation of the corresponding needle, wherein said means for supplying electrical power to the cylinder bed comprises means for passing AC electrical power to rotating windings of a transformer and converter means for converting the power to D.C. electrical power, and means for passing the D.C. electrical power to the magnetic needle actuator units.

9. A knitting machine according to claim **8**, in which said converter means includes supply packs for converting AC to DC current for operating the magnetic needle actuator units, and the DC power is passed to bus bar means which are in turn connected to electronic circuit boards each carrying the electronic circuitry for a group of the needle actuator units.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,733,855 Dated May 22, 1973

Inventor(s) Herbert Brian Bliss-Hill and Eric William Tewsley

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Please correct the heading of the above identified patent by adding the following priority information:

--[30] Foreign Application Priority Data

December 17, 1969 Great Britain.....62077/69--.

Signed and sealed this 20th day of November 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.