United States Patent [19]

Hanson et al.

[11] **3,820,359**

[45] **June 28, 1974**

[54] **CIRCULAR KNITTING MACHINE WITH ELECTROMAGNET-OPERATED PATTERN WHEEL**

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[22] Filed: **May 11, 1971**

[21] Appl. No.: **142,129**

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

[51] **Int. Cl.** **D04b 15/76,** D04b 15/78

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

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Attorney, Agent, or Firm—Cooper, Dunham, Clark, Griffin & Moran

[57] **ABSTRACT**

A pattern wheel for a circular knitting machine of the type having a rotating needle cylinder and program means for generating program instructions directing the pattern wheel to raise selected needles from nonknitting to knitting position. The pattern wheel comprises a cylindrical array of reeds made of magnetic material and an array of radially arranged needle raising jacks, with the bottom end of each reed engaging a jack for moving the jack between a retracted and an extended jack position. A jack in the extended position engages a knitting needle to raise it to knitting position. The reeds move between an outer reed position at which they are attracted by and held against the inner face of an outer annular magnet, and an inner reed position at which they are attracted by and held against the outer face of an inner circular magnet. Selected reeds are moved to the outer reed position by an electromagnet operating under the control of the program means. The electromagnet includes a convex pole facing the outside of the cylindrical reed array, with the pole tip positioned adjacent to the reeds which are in the inner reed position. The cylindrical reed array rotates with respect to the pole tip. When the pole tip is magnetized as directed by the program means, the reed which is nearest the pole tip is attracted to and held against the pole such that it is pulled from the inner magnet toward the outer magnet as the reed array rotates, thereby moving a jack from the retracted jack position to the extended jack position to engage a knitting needle and raise it to knitting position.

17 Claims, 10 Drawing Figures

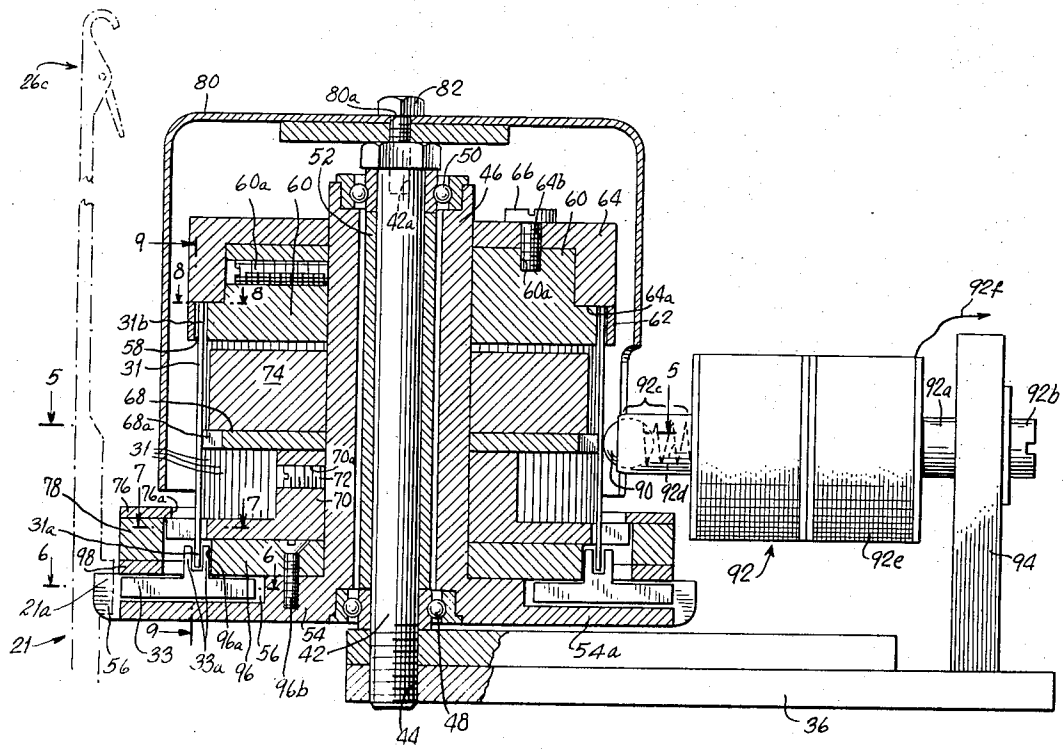
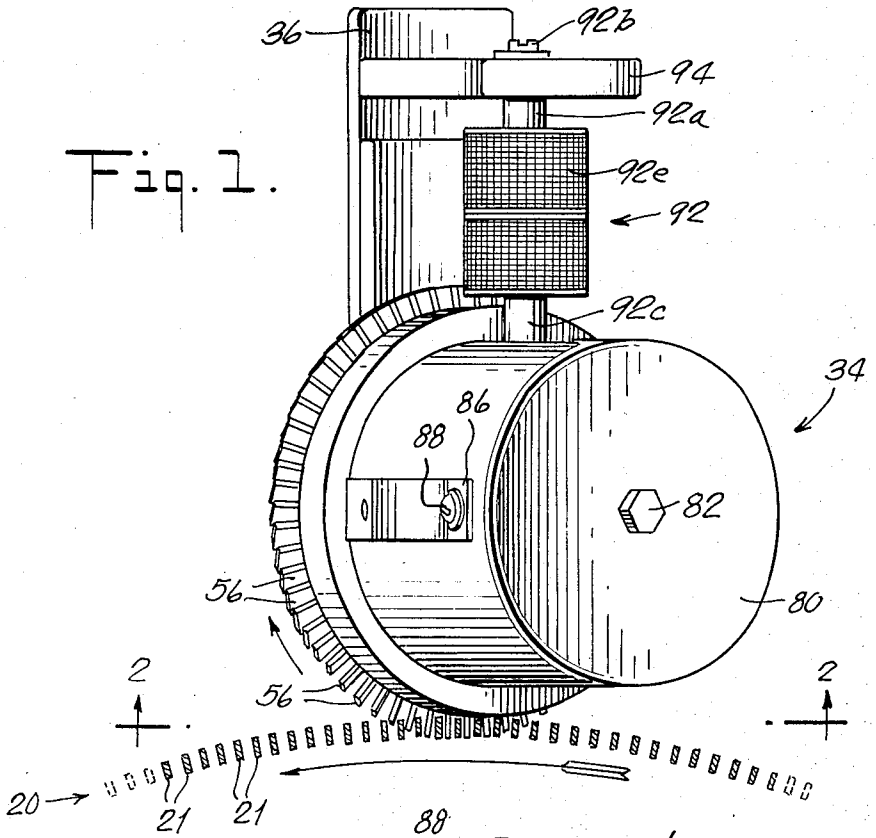


Fig. 1.



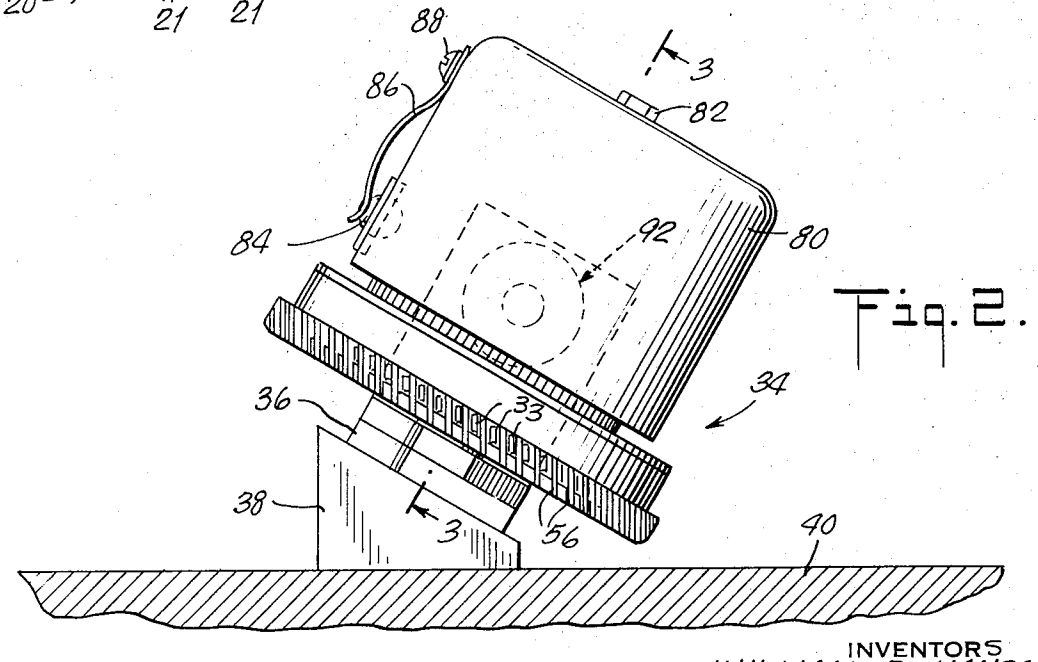


Fig. 2.

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BY Lester W. Clark
ATTORNEY

Fig. 4.

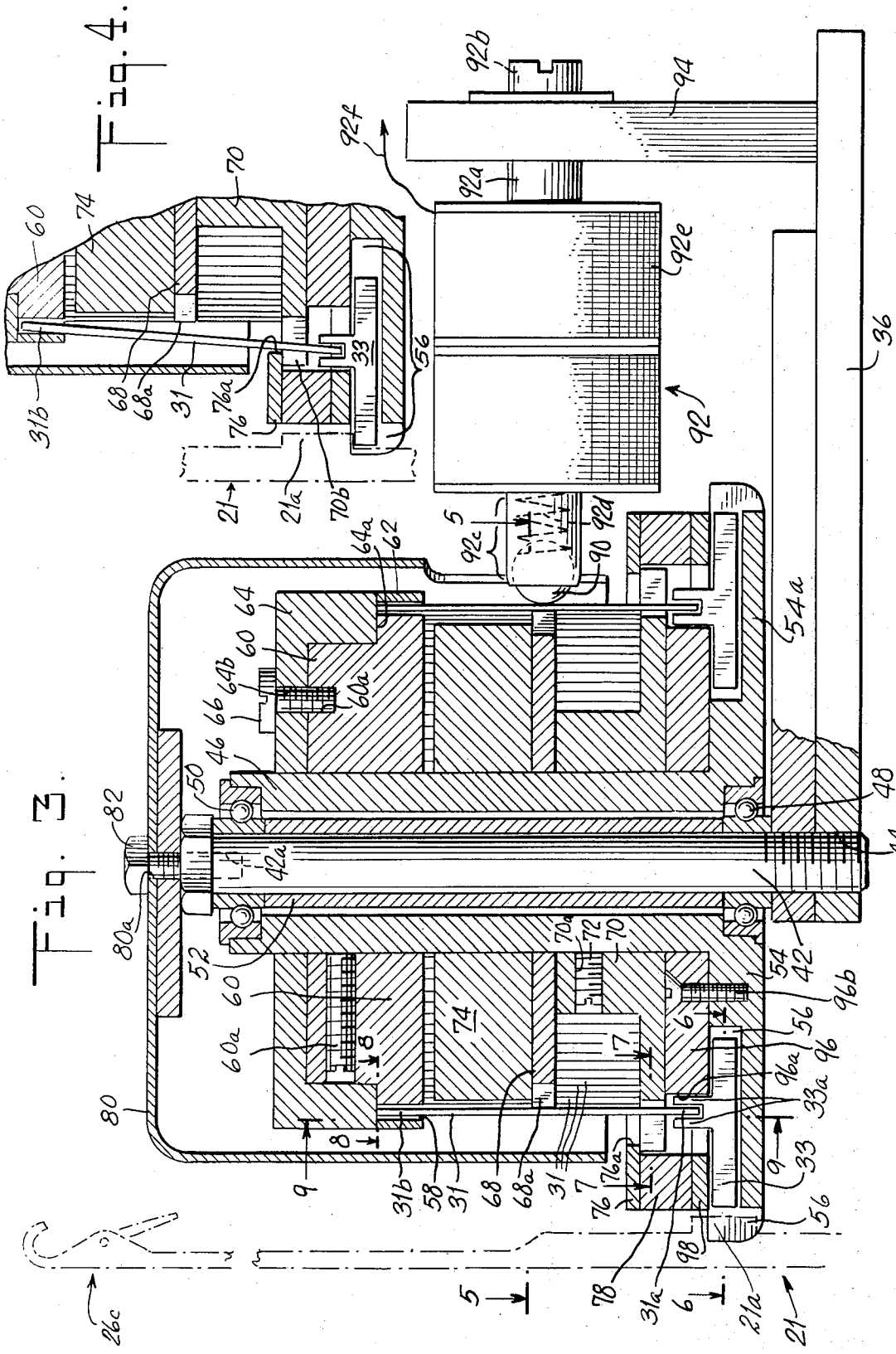
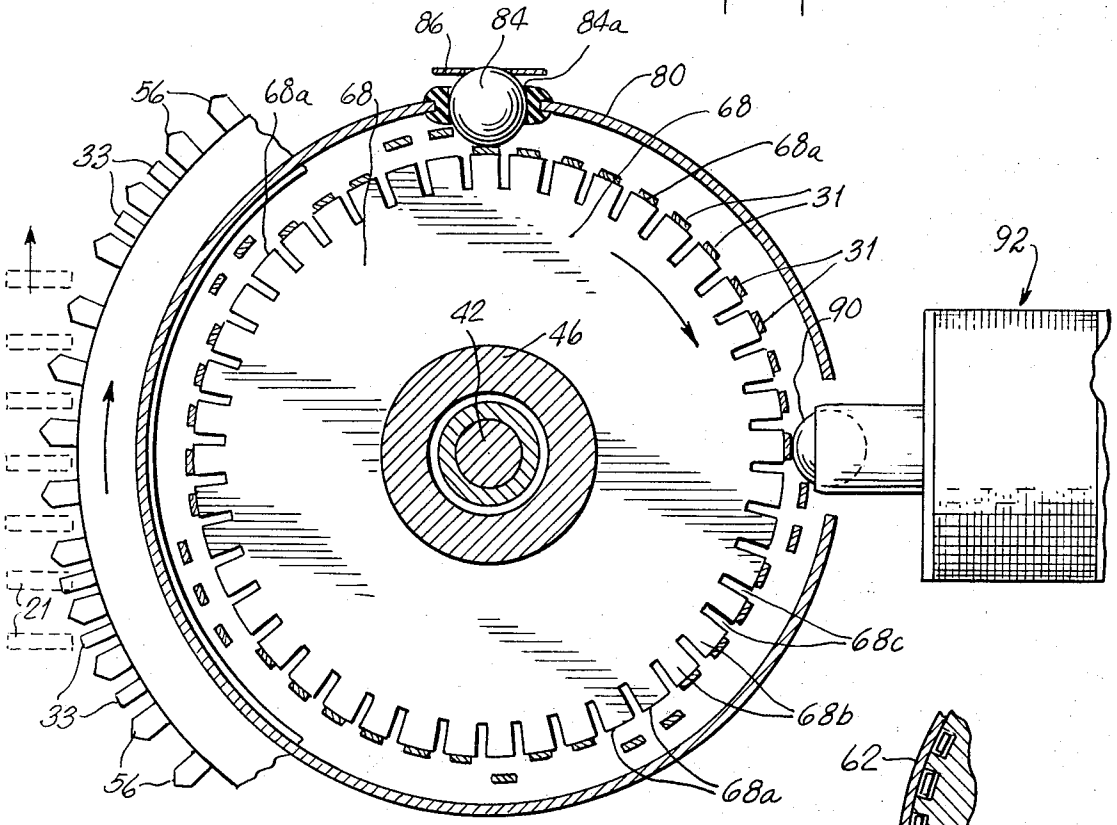

92b
94
92f
92a
92e
70
60
74
36
92
33
56
68
68a
31
76a
76
31b
21
21a
70b
5
92c
92d
90
64a
62
64
60
64b
66
60a
54a
46
50
48
44
82
42a
80a
52
42
54
70a
72
70
96b
74
56
96a
96
33a
33
80
58
68
7
78
98
31a
6
26c

Fig. 7.

Fig. 5.



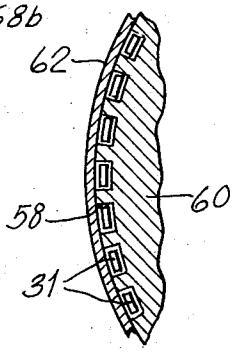


Fig. 8.

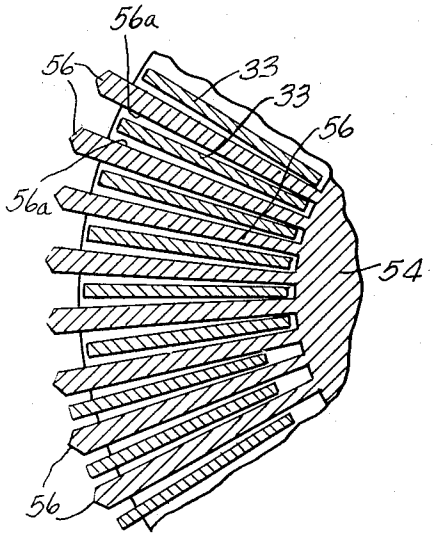


Fig. 6.

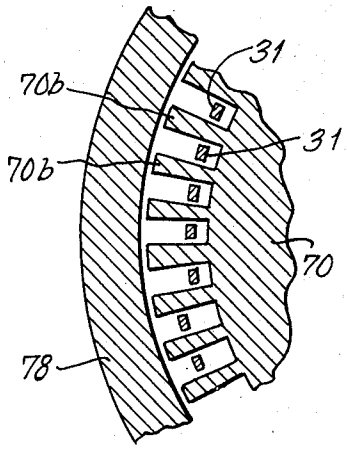


Fig. 7.

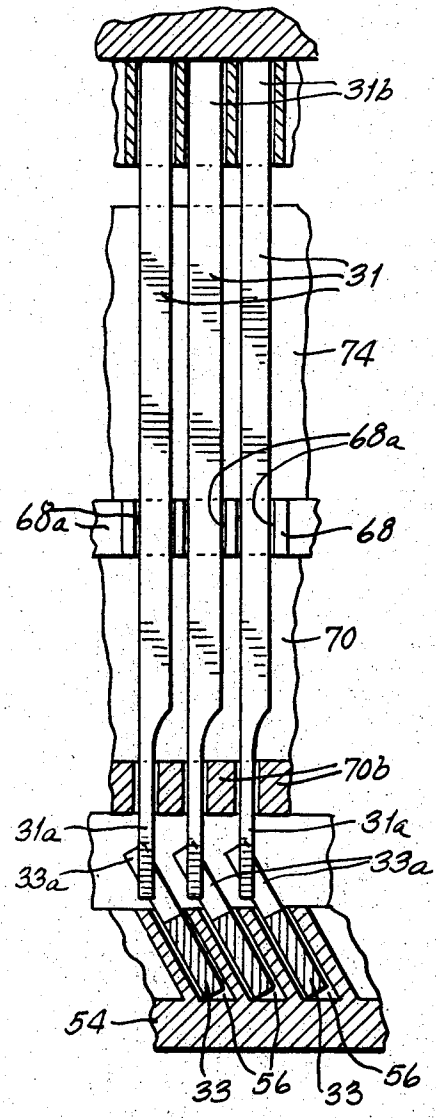

31b
31
74
68a
68a
68
70
70b
31a
31a
33a
33a
54
33
56
33
56

Fig. 9.

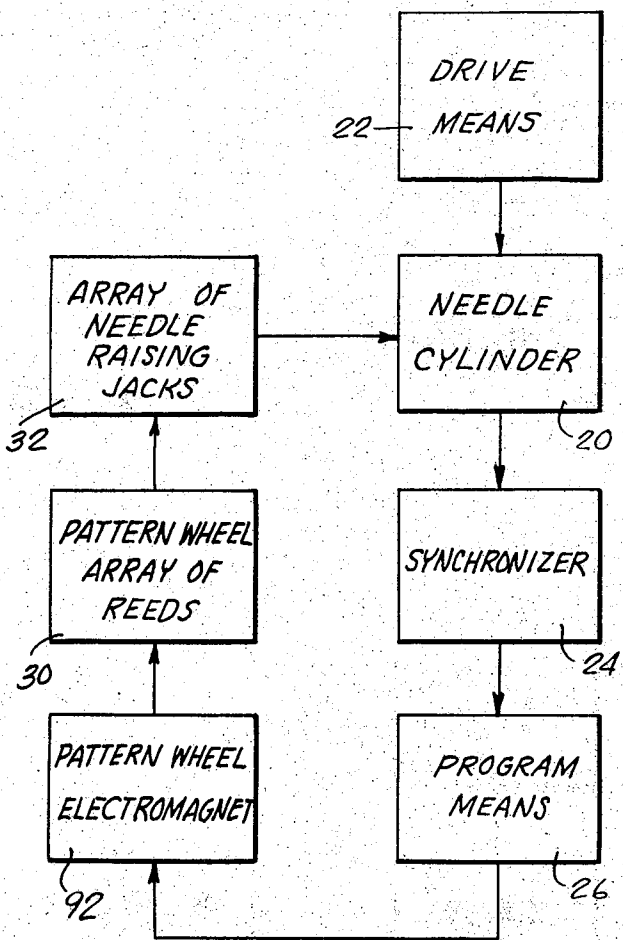

DRIVE MEANS
22
NEEDLE CYLINDER
20
ARRAY OF NEEDLE RAISING JACKS
32
PATTERN WHEEL ARRAY OF REEDS
30
SYNCHRONIZER
24
PATTERN WHEEL ELECTROMAGNET
92
PROGRAM MEANS
26

Fig. 10.

CIRCULAR KNITTING MACHINE WITH ELECTROMAGNET-OPERATED PATTERN WHEEL

BACKGROUND OF THE INVENTION

The invention relates to pattern control of knitting machines. More specifically, the invention relates to program controlled pattern wheels in which the needle raising jacks are set as indicated by instructions from a program storage means. Still more specifically, the invention relates to methods and means for moving the needle raising jacks of a pattern wheel to operating positions in response to program generated instructions.

Circular knitting machines have a number of knitting stations arranged around the needle cylinder, with a pattern wheel located at each knitting station. Each pattern wheel influences the rotating needle cylinder to cause a particular knitting pattern. Conventional pattern wheels have an annular periphery having comb teeth extending into the spaces between adjacent needle butts. The pattern wheel comb teeth mesh with the needle butts to provide synchronous rotation. The pattern wheel has, in the spaces between its comb teeth, radial guideways for needle raising jacks movable outwardly of the pattern wheel to engage with their radially outer ends the butts of knitting needles for the purpose of raising the needles into knitting positions. The raising results because of the angle between the axis of rotation of the pattern wheel and of the needle cylinder. Jacks which are extended outwardly in their guideways engage knitting needles; jacks which are retracted inwardly in the guideways do not engage needles.

One conventional type of pattern wheel has jacks which are held fixed in a particular position in their guideways by a pattern wheel cover. In order to change the arrangement of the jacks to knit a different pattern, it is necessary to remove the pattern wheel from its support, remove the pattern wheel cover, rearrange the jacks manually, and then replace the cover and the pattern wheel in their original positions.

Improved pattern wheels have jacks which are movable under the control of stored programs, as illustrated for example in Schaeder et al. U.S. Pat. No. 3,079,775, Schmidt et al. U.S. Pat. No. 3,313,128 and Stock U.S. Pat. No. 3,170,312. These patents show pattern wheels having jacks movable radially between the comb teeth of the pattern wheel under the control of cams and electromagnet operated springs. In Schaeder et al. the jacks are moved by means of spring fingers which are selected by an electromagnet to either move by their own bias to the outer surface of the cam or to pass to the inside of the cam. A similar pattern wheel arrangement is shown in Schmidt et al., while Stock shows pattern wheel jacks operated by rigid coupling members which may be connected or disconnected from the jacks by means of spring fingers which are selected by an electromagnet under program control.

While the pattern wheels mentioned above may be satisfactory in some uses, the need remains for simpler and more reliable program controlled pattern wheels.

SUMMARY OF THE INVENTION

The invention relates to a pattern wheel for a circular knitting machine having a driven needle cylinder and program means for generating a sequence of knitting pattern instructions. The pattern wheel includes a radially arranged array of needle raising jacks each movable radially between an extended jack position for engaging a needle to move it from a nonknitting position to a knitting position and a retracted jack position for not engaging any needle. The pattern wheel also includes a cylindrical array of reeds corresponding to the array of jacks, each reed having a portion movable radially between an inner position and an outer position and engaging a corresponding jack for moving it between the retracted jack position and the extended jack position respectively. Each of the reeds is made of magnetic material. The pattern wheel includes an inner magnet means positioned inside the cylindrical array of reeds for holding by magnetic action each reed which is in the inner reed position. The reeds which are in the outer reed position are held against the inner face of an outer magnetic means. As the pattern wheel rotates, the reeds are successively brought in contact with a resetting means which resets all reeds to the inner reed positions and are then brought in contact with or in the proximity of a selector means controlled by the knitting pattern instructions from the program means, where selected reeds are moved from the inner reed position to the outer reed position to move selected jacks from the retracted to the extended jack position for engaging knitting needles and thereby influencing the knitting pattern. The selector means includes an electromagnet having a convex pole facing the outside of the cylindrical reed array, with the pole tip positioned adjacent the reeds which are in the inner reed positions. The reed array rotates with respect to the electromagnet pole tip. When the electromagnet is not energized, the reeds pass by the pole tip without any radial movement. When the electromagnet is energized, the passing reed is attracted to and held against the pole tip and is pulled away from the inner magnet means to the outer magnet means, thereby moving a selected jack from the retracted jack position to the extended jack position. By energizing and deenergizing the electromagnet in accordance with the program, the reeds and hence the jacks and needles are selected in accordance with that program. This selection may be between a knitting and a non-knitting position, as defined above, or between any two desired positions of a needle, such as between a selected position corresponding to a jack in the extended position, and a non-selected position corresponding to a jack in the retracted position.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top view of a pattern wheel and of a portion of the needle cylinder of a circular knitting machine.

FIG. **2** is a view taken along line **2—2** of FIG. **1.**

FIG. **3** is a sectional view of the pattern wheel taken along line **3—3** of FIG. **2** and showing a knitting needle and a needle raising jack in the retracted jack position.

FIG. **4** is a partial view corresponding to the left-hand bottom corner of FIG. **3,** but showing a needle raising jack in the extended jack position.

FIG. **5** is a sectional view taken along line **5—5** of FIG. **3.**

FIG. **6** is a partial sectional view taken alone line **6—6** of FIG. **3.**

FIG. 7 is a partial sectional view taken along line 7—7 of FIG. 3.

FIG. 8 is a partial sectional view taken along line 8—8 of FIG. 3.

FIG. 9 is a sectional view taken along line 9—9 of FIG. 3, on an enlarged scale.

FIG. 10 is a functional block diagram of a circular knitting machine operating under the control of a program means.

DETAILED DESCRIPTION

Before proceeding to the structural and operational details shown in FIGS. 1 through 9, reference is made to FIG. 10 for a brief functional introduction into the operational environment of the invented pattern wheel. In FIG. 10, the pertinent portions of a conventional cylindrical knitting machine are a needle cylinder 20 which is a cylindrically arranged array of knitting needles, and drive means 22 such as a motor which rotates the needle cylinder 20 at suitable constant speed. As shown in the prior art (see Schmidt et al. U.S. Pat. No. 3,313,128), the needle cylinder 20 or the drive means 22 drives through a synchronizer 24 a program means 26 which may include a paper tape or other recorded program. The program means 26 issues a sequence of knitting pattern instructions which are applied to a pattern wheel electromagnet 92 after suitably synchronizing specific instructions from the program means 26 with the position of specific needles in the needle cylinder 20 with respect to the electromagnet 92. The pattern wheel electromagnet 92 selects particular reeds from a cylindrical reed array 30, and moves each selected reed from one position to another. The reeds from the array of reeds 30 in turn operate an array 32 of needle raising jacks to move selected jacks from one position to another. Depending on their position, the jacks from the array 32 act on the needles of needle cylinder 20 to move selected needles from a nonknitting position to a knitting position and thereby influence the knitting pattern.

The combination of a drive means 22, a needle cylinder 20, a synchronizer 24, and program means 26 is known in the art (see Schmidt et al., U.S. Pat. No. 3,313,128). The embodiment of the subject invention disclosed includes selective control apparatus, including the selecting electromagnet 92, the array of control elements such as reeds 30, the array of operating elements such as needle raising jacks 32 and in the cooperation between the program means 26 and the selecting electromagnet, as well as between electromagnet 92, the array 32 of needle raising jacks and the needle cylinder 20.

Referring to FIGS. 1 through 9, a pattern wheel generally indicated at 34 is carried on a support bracket 36 suitably affixed to a stand 38 on a support plate 40 which is rigid with respect to the axis of rotation of the needle cylinder 20 (shown only diagrammatically or in fragments). An upright bolt 42 (FIG. 3) is threaded at its bottom end into a suitable aperture 44 in the support bracket 36, and a sleeve 46 is journalled on the upright bolt 42 by means of antifriction bearings 48 and 50 separated by a spacer sleeve 52 fitted over the shank of the upright bolt 42. The sleeve 46 carries at its bottom end an annular flange 54 which has at its radially outward periphery a radial array of comb teeth 56. The radially outward ends of adjacent comb teeth 56 are spaced from each other so as to receive slidingly between each pair of teeth a knitting needle 21 of the needle cylinder 20. The needles 21 can move in the vertical direction. Adjacent comb teeth 56 also provide between their facing walls 56*a* (FIG. 6), guideways for needle raising jacks 33 which form a part of the array 32 of radially arranged jacks 33. Each jack 33 can slide in the radial direction between the facing walls 56*a* of the flanking pair of comb teeth 56. The jacks 33 are restrained within their guideway by means of an annular ring 98 (FIG. 3) on top of the comb teeth 56, and the continuation 54*a* of the annular flange 54, below the comb teeth 56. Each of the needle raising jacks 33 has a U-shaped extension 33*a* integral with its top surface and adapted to receive the bottom end 31*a* of a reed 31 forming a part of the array 30 of pattern wheel reeds. Each reed is of ferromagnetic material.

The upper end 31*b* of each reed 31 is received loosely in a vertically oriented groove 58 located at the radially outward periphery of an annular plate 60 which is rigidly affixed to the sleeve 46 by a set screw 60*a* (FIGS. 3 and 8). The radially outside periphery of the annular plate 60 is encircled by a locking ring 62 which keeps the reeds 31 from moving out of the grooves 58 in the radially outward direction. A top locking ring 64 is affixed to the annular plate 60 by means of a bolt 66 passing through a suitable aperture 64*b* in the top surface of the locking ring 64 and threaded into a suitable aperture 60*a* in the top surface of the annular plate 60. The ring 64 has a bottom peripheral surface 64*a* which provides a cover extending over the grooves 58 in the annular plate 60 and over the locking ring 62. The grooves 58 in the annular plate 60 and the locking rings 62 and 64 cooperate to provide for each reed 31 a vertically extending open-bottom cavity of rectangular cross-section which is slightly larger than the cross-section of the reed 31 and which receives the top end 31*b* of the reed. Each reed 31 is thus restrained against substantial movement in the vertical direction between the bottom surface 64*a* of the locking ring 64 and the bottom of the U-shaped extension 33*a* in the corresponding needle raising jack 33.

Each of the reeds 31 is movable between an inner reed position as shown in FIG. 3 and an outer reed position as shown in FIG. 4. Correspondingly, each of the jacks 33 is movable between a retracted jack position as in FIG. 3 and an extended jack position as in FIG. 4.

In the inner reed position, each of the reeds 31 is attracted to and held against a ring pole piece 68 (best seen in FIG. 5) of a ring magnet 74 (FIG. 3). The ring pole piece or inner magnet 68 is in the form of an annular plate having peripheral teeth 68*b* separated by slots 68*c*. The teeth 68*b* have end faces or other peripheral portions, which are all of equal radius. The pole piece 68 is held stationary with respect to the sleeve 46 by means of a spacer sleeve 70 fitted over the sleeve 46 and affixed thereto by means of a set screw 72 threaded into an aperture 70a in the spacer ring 70 and tightened against the radially outside surface of the sleeve 46. The ring magnet 74 is slip-fitted over the sleeve 46 above the ring pole piece 68. Together the ring magnet 74 and its ring pole piece 68 comprise an inner magnet means which has outer peripheral faces 68*a* on the ends of teeth 68*b*, which are magnetized to attract and hold reeds 31.

Each reed **31** which is in the outer reed position as in FIG. **4** is attracted to and held against the inner peripheral face **76***a* of an outer ring pole piece **76** of an outer ring magnet **78.** The face **76***a* is outside the cylindrical reed array **30** and coaxial therewith. As may be seen in FIG. **3,** the face **76***a* is of constant radius, and is therefore cylindrical. The outer ring pole **76** is positioned over the annular flange **54** and spaced therefrom by means of the interposed outer ring magnet **78.** An inverted cup-shaped housing **80** covers the upper portion of the reed array **30** and comes down to just above the outer ring pole piece **76.** The housing **80** is affixed to the bolt **44** by means of a bolt **82** passing through a suitable centrally located aperture **80***a* in the top wall of the housing **80** and threaded into a suitable aperture **42***a* into the top of the bolt **42.**

Referring to FIGS. **1** and **5,** when the reed array **30** is rotated in the clockwise direction (as viewed from the top of FIG. **5**), any reeds **31** which are in the outer reed position are returned to the inner reed position by a resetting means comprising a ball **84** held loosely in a suitable aperture **84***a* in the housing **80** and biased by a leaf spring **86** to urge the reeds **31** toward the inner reed positions. The leaf springs **86** is affixed to the cover **80** by means of a suitable screw **88.**

After being reset to the inner reed position, the reeds **31** continue rotating in the clockwise direction as viewed in FIG. **5** and approach a convex pole **90** of an electromagnet **92.** The electromagnet **92** comprises a core member **92***a* affixed by a suitable bolt **92***b* to an upright bracket **94** secured fixedly to the support plate **56.** Near its end farthest from the upright bracket **94,** the core member **92***a* has a hollow portion **92***c* which contains a coil spring **92***d* urging toward the reeds **31** a ball **90** whose exposed portion serves as a convex pole. The ball **90** is secured inside the hollow portion **92***c* of the core member **92***a* by providing a suitable inward taper at the open end of the hollow portion **92***c.* The electromagnet **92** also includes a winding **92***e* connected by means of leads **92***f* (FIG. **3**) to the adjustable synchronizer **28** and to the program means **26** (FIG. **10**) to receive therefrom pulses of current energizing the winding **92***e* to magnetize the convex pole **90.** The pole **90** is preferably tangential to the radially outward surface of the cylindrical reed array **30** and always in contact with at least one reed **31.** Since the ball **90** is not restrained against rotation, it is capable of rotation within the hollow portion **92***c* of core member **92***a.*

In operation, the array **30** of reeds **31** is driven in the clockwise direction by the cylinder **20** (as viewed in FIG. **5**) because of the mesh between the needles **21** of the needle cylinder **20** and the radially outward ends of the comb teeth **56.** Any reeds **31** which were in the outer position prior to reaching the resetting bearing ball **84** are reset thereby to the inner reed position; thus all reeds which approach the convex pole **90** are in the inner reed position.

If the convex pole **90** of the electromagnet **92** is not magnetized when a reed **31** passes by it, the reed remains in the inner reed position. If, however, the electromagnet **92** receives a pulse from the program means **26** at about the time that a particular reed **31** comes in physical contact with or in operative proximity to the convex pole **90,** the pole **90** is magnetized and attracts by magnetic action that reed **31.** The electromagnet **92** is designed such that the magnetic action of the convex pole **90** is of sufficient strength to overcome the magnetic attraction between the reed **31** and the inner ring pole piece **68,** and the reed which is attracted by the magnetized convex pole **90** separates from the outer peripheral face **68***a* of the inner ring pole piece **68** and remains in contact with the convex pole **90** while moving along its convex surface.

At the time the convex pole **90** starts acting on a reed **31,** the reed is in contact with the outer periphery **68***a* of the inner ring pole piece **68** and is held against that outer periphery **68***a* by magnetic action. Then, that reed **31** is drawn by the magnetic action of the convex pole **90,** adheres to the pole **90** and rides against its convex pole **90** to be gradually drawn away from the inner ring pole piece **68** until it is attracted to and held against the inner peripheral face **76***a* of the outer ring pole piece **76** by magnetic action. Note that while the reed **31** is being moved by the pole **90,** there is no air gap between the red and the pole.

The energy for moving the reed **31** away from the magnet **68***a* is supplied primarily by the rotation of the pattern wheel, and only partly by the electromagnet **92.** The electromagnet **92** needs to supply only enough energy to guide the reed **31.**

A reed **31** which has been moved to its outer reed position, against the inner peripheral face of the outer ring pole piece **76,** stays in that position until it reaches the resetting bearing ball **84** and is reset to the inner reed position against the outer peripheral face **68***a* of the inner ring pole piece **68.** A reed in the inner reed position is shown in FIG. **3;** a reed in the outer reed position is shown in FIG. **4.**

When a reed **31** is in the inner reed position, its jack **33** is in the retracted jack position. When a reed **31** moves to the outer reed position, it moves thereby its jack **33** to the extended jack position as in FIG. **4.** Each jack **33** moves in the guideway provided by the facing walls **56***a* of two adjacent comb teeth **56.** A backstop for a jack **33** moving toward the retracted jack position is provided by the outer peripheral face **96***a* of an annular ring **96** concentric with the array **30** of reeds **31** and affixed to the annular flange **54** by means of a screw **96***b.* A stop against excessive radially outward movement of the jacks **33** is provided by an annular ring **98** which is integral with the comb teeth **56.** The ring **98** also serves as a support for outer ring magnet **78** and its pole piece **76,** both of which may be attached to ring **98** in any suitable manner. In order to prevent undesirable lateral displacement of the reeds **31,** the spacer sleeve **70** (FIGS. **3** and **7**) is provided at its radially outward periphery with a series of uniformly spaced vertically arranged comb teeth **70***b,* with each adjacent pair of comb teeth **70***b* providing a radial movement guideway for a reed **31.**

When a jack **33** is in the retracted jack position, as in FIG. **3,** its radially outward end cannot engage the butt **21***a* of a knitting needle **21** and the radially outward ends of the comb teeth **56** which flank the needle **21** can move up with respect to the needle without raising it to a knitting position. When, however, a jack **33** is in the extended jack position, as shown in FIG. **4,** the butt **21**a of the knitting needle **21** which meshes with a pair of comb teeth **56** that provides a guideway for that jack **33** is engaged by the radially outward end of the jack **33.** When the comb teeth **56** start moving up with respect to the needle cylinder **20** because of the angle between the axis of rotation of the flange **54** and

the needle cylinder **20**, the radially outward end of the extended jack **33** engages the butt **21***a* of the needle **21** and starts raising the needle **21** from a nonknitting position to a knitting position.

A particular advantage resulting from the use of the convex pole **90** is smooth transition of reeds **31** between the inner and the outer reed position. This smooth transition allows the use of relatively thin and light reeds **31** and the jacks **33**, and help prolong the useful life of pattern wheels of the type described above.

Another specific advantage results from the use of the inner ring pole piece **68** and the outer ring pole piece **76**. These pole pieces define securely the inner and outer positions of the reeds **31**, and hence the retracted and extended position of the jacks **33**. The use of the pole pieces **68** and **76** and the magnets **74** and **78** avoids the use of cams which cause friction and early wear, and helps prolong the useful life of the invented pattern wheel.

Additionally, the use of the pole pieces **68** and **76** and the magnets **74** and **78** assures that there will be no partly retracted or partly extended jacks which may interfere with the proper operation of a knitting machine.

We claim:

1. A circular knitting machine having a driven needle cylinder and program means for generating a sequence of knitting pattern instructions, wherein the improvement is in a pattern wheel driven in synchronism with the needle cylinder and including an array of needle raising jacks each movable radially between an extended jack position for engaging a needle to move it from a non-knitting position to a knitting position and a retracted jack position for not engaging any needle, the pattern wheel comprising:

a. a cylindrical array of reeds corresponding to the array of jacks, each reed having a portion movable radially between an inner position and an outer position and continuously engaging a corresponding jack for moving the corresponding jack back and forth between the retracted jack position and the extended jack position respectively, each of said reeds including magnetic material;

b. inner magnet means having outer peripheral portions of equal radius magnetized to attract the reeds, said portions being positioned inside the cylindrical reed array coaxially therewith for holding each reed which is in the inner reed position against said portions by magnetic action;

c. outer annular magnet means having an inner peripheral cylindrical face magnetized to attract the reeds and positioned outside the cylindrical reed array coaxially therewith for holding each reed which is in the outer reed position against the inner peripheral face by magnetic action; and

d. selector means controlled by said knitting pattern instructions generated by the program means for moving only selected reeds from the inner reed position to the outer reed position while the nonselected reeds remain in the inner reed position, thereby moving the jacks corresponding to the selected reeds from the retracted jack position to the extended jack position for engaging knitting needles and influencing the knitting pattern according to the instructions generated by the program means.

2. A knitting machine as in claim **1** including support means for suspending each reed of the circular array of reeds to allow radial movement of the lower portion of each reed between the inner reed position and the outer reed position.

3. A knitting machine as in claim **1** including resetting means for restoring to the inner reed position reeds moved to the outer reed position by the selector means.

4. A knitting machine as in claim **1** including in said selector means electromagnet means having a convex pole facing the outside of the cylindrical reed array with the pole tip positioned substantially tangentially to the reeds which are in the inner reed position, and including means for maintaining synchronous rotation of the reed array with respect to the electromagnet pole to cause the reed which is nearest the pole tip when the electromagnet means is energized to be attracted and held against the pole and to be pulled away from the outer peripheral portions of the inner magnet means toward and against the inner peripheral face of the outer magnet means, thereby moving selected reeds from the inner reed position to the outer reed position as the reed array rotates with respect to the pole.

5. A circular knitting machine having a driven needle cylinder and program means for generating a sequence of knitting pattern instructions, wherein the improvement is in a pattern wheel driven in synchronism with the needle cylinder and including an array of needle raising jacks each movable between a retracted jack position in which it does not engage any needle and an extended jack position for engaging a needle to move it from a non-knitting position to a knitting position, the pattern wheel comprising:

a. a cylindrical array of reeds corresponding to the array of jacks, each reed having a portion movable radially between an inner position and an outer position and continuously engaging a corresponding jack for moving the corresponding jack between the retracted jack position and the extended jack position respectively, each of said reeds including magnetic material;

b. selector means controlled by the knitting pattern instructions generated by the program means for moving selected reeds from the inner reed position to the outer reed position, thereby moving the jacks corresponding to the selected reeds to the extended jack position for engaging knitting needles and influencing the knitting pattern according to the instructions generated by the program means, said selector means including electromagnet means having a convex pole facing the outside of the cylindrical array of reeds, with the pole tip positioned substantially tangentially to the reeds which are in the inner reed position; and

c. means for maintaining synchronous rotation of the reed array with respect to the electromagnet pole to cause the reed which is nearest the pole tip when the electromagnet means is energized to be attracted and held against the pole and to be moved from the inner reed position to the outer reed position as the reed array rotates with respect to the pole.

6. A knitting machine as in claim **5**, including at least one magnet means having a substantially cylindrical peripheral face concentric with the needle cylinder and magnetized to attract the movable portions of the reeds and positioned coaxially with the cylindrical array of

reeds for holding the reeds which are in one of said first and second reed positions against the peripheral face by magnetic action.

7. A knitting machine including a row of knitting needles and a pattern wheel having an array of needle raising jacks, each needle movable between a first needle position and a second needle position and each jack movable between a first jack position and a second jack position, means for synchronously moving the row of needles and the pattern wheel with respect to each other to cause each jack in one of said first and second jack positions to move a selected needle from the first needle position to the second needle position, and program means for generating a sequence of knitting pattern instructions in synchronism with the relative motion between the row of needles and the pattern wheel, wherein the improvement is in means for moving the jacks between said first jack position and second jack position, comprising:

a. a cylindrical array of reeds corresponding to the array of jacks, each reed having a portion movable radially between a first reed position and a second reed position and continuously engaging a corresponding jack for moving the corresponding jack between the first jack position and the second jack position respectively;

b. selector means controlled by the knitting pattern instructions for moving only selected reeds from the first reed position to the second reed position while the non-selected reeds remain in the first reed position, thereby moving the jacks corresponding to the selected reeds from the first jack position to the second jack position; and

c. at least one magnet means having a substantially cylindrical peripheral face magnetized to attract the movable portions of the reeds and positioned coaxially with the cylindrical array of reeds for holding the reeds in one of said first and second reed positions against the peripheral face by magnetic action.

8. A knitting machine including a row of knitting needles and a pattern wheel having an array of needle raising jacks, each needle movable between a first needle position and a second needle position and each jack movable between a first jack position and a second jack position, means for synchronously moving the row of needles and the pattern wheel with respect to each other to cause each jack in one of said first and second jack positions to move a selected needle from the first needle position to the second needle position, and program means for generating a sequence of knitting pattern instructions in synchronism with the relative motion between the row of needles and the pattern wheel, wherein the improvement is in means for moving the jacks between said first jack position and second jack position, comprising:

a. a cylindrical array of reeds corresponding to the array of jacks, each reed having a portion movable radially between a first reed position and a second reed position and continuously engaging a corresponding jack for moving the corresponding jack between the first jack position and the second jack position respectively;

b. selector means controlled by the knitting pattern instructions for moving selected reeds from the first reed position to the second reed position thereby moving the jacks corresponding to the selected reeds from the first jack position to the second jack position, said selector means including electromagnet means having a convex pole facing the cylindrical reed array with the pole tip positioned substantially tangentially to the reeds which are in the first reed position; and

c. means for maintaining rotation of the array of reeds with respect to the electromagnet pole to cause the reed which is nearest the pole tip when the electromagnet means is energized to be attracted and held against the pole and to be moved from the first reed position to the second reed position as the array of reeds rotates with respect to the pole.

9. Needle selecting apparatus for a circular knitting machine having a slotted needle cylinder, a circular series of needles individually disposed in and slidable lengthwise of said needle slots to a plurality of positions therein, and program means for generating a sequence of electromagnetic knitting pattern instructions for said apparatus whereby said needles are caused to be selectively moved from a first to a second of said positions thereof, said apparatus comprising:

a. a circular series of elements of ferromagnetic material operatively related to said circle of needles in such manner as to control the movement of the latter from said first to said second positions thereof, said series of elements being individually movable radially between inner and outer positions thereof;

b. inner magnet means having circularly disposed outer peripheral face portions of equal radius positioned coaxially with and inside of said circle of elements, said inner magnet means exerting magnetic attraction upon said elements of said circle thereof and by magnetic attraction holding against its said outer peripheral face portions those of said circle of elements which are placed in their said inner radial positions thereof;

c. outer magnet means having a circularly disposed inner peripheral face of constant radius positioned coaxially with and outside of said circle of elements, said outer magnet means exerting magnetic attraction upon said elements of said circle thereof and by magnetic action holding against its said inner peripheral face those of said circle of elements which are placed in their said outer radial position thereof;

d. means to move all the elements of said circle thereof to one of their said radial positions wherein said circle of elements are held by one of said magnet means; and

e. selector means controlled by said electromagnetic knitting pattern instructions to move selected ones of said circle of elements from said one magnet means holding the same to the other magnet means, in accordance with said electromagnetic knitting pattern instructions, to be held by the other magnet means, thereby to control the movement of selected ones of said circle of needles from said first to said second positions thereof.

10. Apparatus as in claim **9,** wherein said circle of elements are all moved radially inwardly where they are held by the outer peripheral face portions of said inner magnet means, and wherein selected ones of said circle of elements are moved radially outwardly from the said inner position thereof by said selector means where

they are held by the inner peripheral face of said outer magnet means.

11. Apparatus as in claim **10,** wherein said selector means includes an electromagnet having a convex faced pole tip, wherein said circle of elements rotates relative to said pole tip with the latter being positioned with its convex face tangent to said circle of elements in their said inner radial position, the relation of said pole tip and said circle of elements being such that those of said elements which are within the sphere of magnetic influence of said pole tip of said electromagnet when the latter is energized by said electromagnetic knitting pattern instructions are attracted to, are held by, and move smoothly along the convex face of said pole tip, thereby pulling the last named elements away from the outer peripheral face portions of said inner magnet means toward and against the inner peripheral face of said outer magnet means, whereby selected ones of said circle of elements are moved from their inner to their outer radial positions as rotation of said circle of elements past said pole tip continues.

12. Selective control apparatus responsive to the presence or absence of electrical pulses at predetermined intervals in a timed sequence of pulses, comprising:

a. a series of operating members to be controlled;

b. means for moving said series of members along a first closed path, including:

1. means supporting said members for individual movement between first and second positions spaced transversely of the direction of movement of said series of control elements along said closed path;

c. a series of control elements of ferromagnetic material;

d. means for moving said series of control elements synchronously with said series of operating members along a second closed path having a portion common to said first closed path at an operating station, including:

1. means supporting said elements for individual movement between first and second positions spaced transversely of the direction of movement of said series of control elements along said closed path;

2. each said element which reaches said operating station in its second position being there effective to move a corresponding member to its second position;

e. first magnet means having face portions extending longitudinally of said second closed path along one side thereof, said first magnet means exerting magnetic attraction upon said elements and holding against its face portions those elements which are placed in their first positions;

f. second magnet means having a face extending longitudinally of said second path along the opposite side thereof from said first magnet means and exerting magnetic attraction upon said elements and holding against its face those elements which are placed in their second positions;

g. restoring means at a restoring station spaced along said second path from said operating station for moving to their first positions all elements approaching said restoring station in their second positions; and

h. selector means at a selecting station between said restoring station and said operating station and controlled by a sequence of pulses synchronous with the motion of said series of members and said series of elements, said selector means being effective to move only selected ones of said elements from the face portions of the first magnet means to the face of the second magnet means, while the non-selected elements remain in their first positions, and thereby to determine which of said operating members are moved from their first positions to their second positions.

13. Selective control apparatus as in claim **12,** in which said selector means includes a stationary electromagnet having a pole tip with a convex face extending across said second path from said opposite side thereof, said face being tangent to the elements in their first positions, said pole tip being effective when said electromagnet is energized to attract and hold an adjacent passing element so that said element moves along the convex face of the pole tip and is thereby shifted from its first position to its second position, so that those elements which are passing the pole tip when the electromagnet is energized are transferred to their second positions and those elements which are passing the pole tip when the electromagnet is deenergized remain in their first positions.

14. Selective control apparatus responsive to the presence or absence of electrical pulses at predetermined intervals in a timed sequence of pulses, comprising:

a. a series of control elements of ferromagnetic material;

b. means for moving said series of control elements along a closed path through an operating station;

c. means in said moving means supporting said elements for individual movement between first and second positions spaced transversely of the direction of movement of said series of control elements along said closed path;

d. first magnet means having a face extending longitudinally of said closed path along one side thereof, said first magnet means exerting magnetic attraction upon said elements and holding against its face those elements which are placed in their first positions;

e. second magnet means having a face extending longitudinally of said path along the opposite side thereof from said first magnet means and exerting magnetic attraction upon said elements and holding against its face those elements which are placed in their second positions;

f. restoring means at a restoring station spaced along said path from said operating station for moving to their first positions all elements approaching said restoring station in their second positions; and

g. selector means at a selecting station between said restoring station and said operating station and controlled by a programmed sequence of pulses synchronous with the motion of said series of elements, said selector means being effective to move only selected ones of said elements from their first positions to their second positions while the non-selected elements remain in their first positions, wherein they abut the face of the first magnet means.

15. Selective control apparatus as in claim 14, in which said selector means includes a stationary electromagnet having a pole tip with a convex face extending across said path from said opposite side thereof, said face being tangent to the elements in their first positions, said pole tip being effective when said electromagnet is energized to attract and hold an adjacent passing element so that said element moves along the convex face of the pole tip and is thereby shifted from its first position to its second position, so that those elements which are passing the pole tip when the electromagnet is energized are transferred to their second positions and those elements which are passing the pole tip when the electromagnet is deenergized remain in their first positions.

16. Selective control apparatus as in claim 15, in which the convex face of the pole tip is spherical.

17. Selective control apparatus as in claim 15, in which:

a. said electromagnet comprises a hollow core member extending toward said path from said opposite side, said core member having an inward internal taper at its end nearest said path;

b. said pole tip comprises a ball retained within said core member by said inward taper and projecting from said core member across said path to provide said spherical convex face; and

c. spring means within said core member biasing said ball toward the inward taper, said ball being rotatably held within said core member and between said elements and said spring means.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,820,359 Dated June 28, 1974

Inventor(s) William D. Hanson; Carl H. Hanson

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

Col. 4, line 55, "other" should read -- outer --.

line 56, after the word "portions" insert -- 68a --.

Col. 5, line 7, after the word "pole" insert -- piece --.

line 24, "springs" should read -- spring --.

line 32, "56" should read -- 36 --.

Col. 6, line 19, "red" should read -- reed --.

Signed and sealed this 19th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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