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Schuman

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[54] **KNITTING MACHINE ENCODER**

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[73] Assignee: **The Warner and Swasey Company,** Cuyahoga County, Ohio

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[52] **U.S. Cl.** .... **66/50 R,** 250/210, 250/233

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

[58] **Field of Search** .... 66/50 R, 50 A, 50 B, 154 A, 66/25; 250/210, 233

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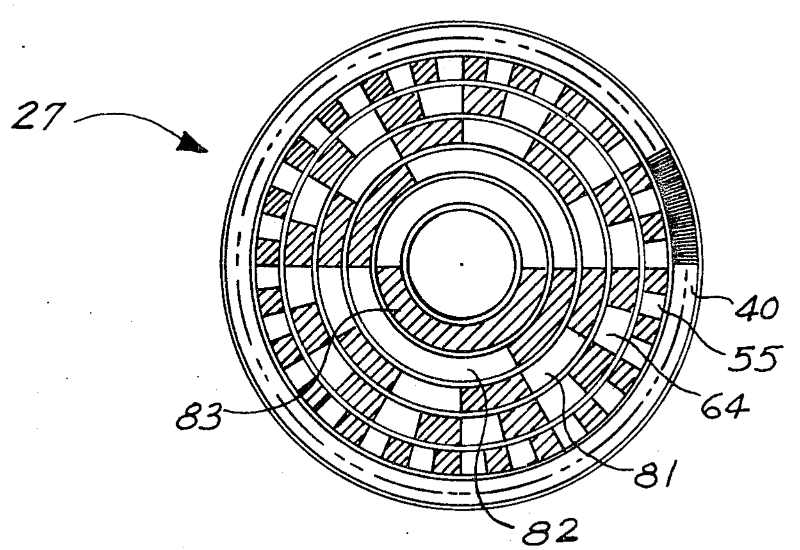
Primary Examiner—Wm. Carter Reynolds

[57] **ABSTRACT**

An improved knitting machine includes an encoder which provides signals which vary with variations in the relative position of a needle cylinder and associated feeders. The encoder includes code tracks for providing binary coded needle count signals, feeder count signals, and revolution count signals. A control system receives these binary coded signals and effects the knitting of a selected one of a plurality of patterns. A pattern selector switch is operable to vary the selected pattern.

5 Claims, 7 Drawing Figures



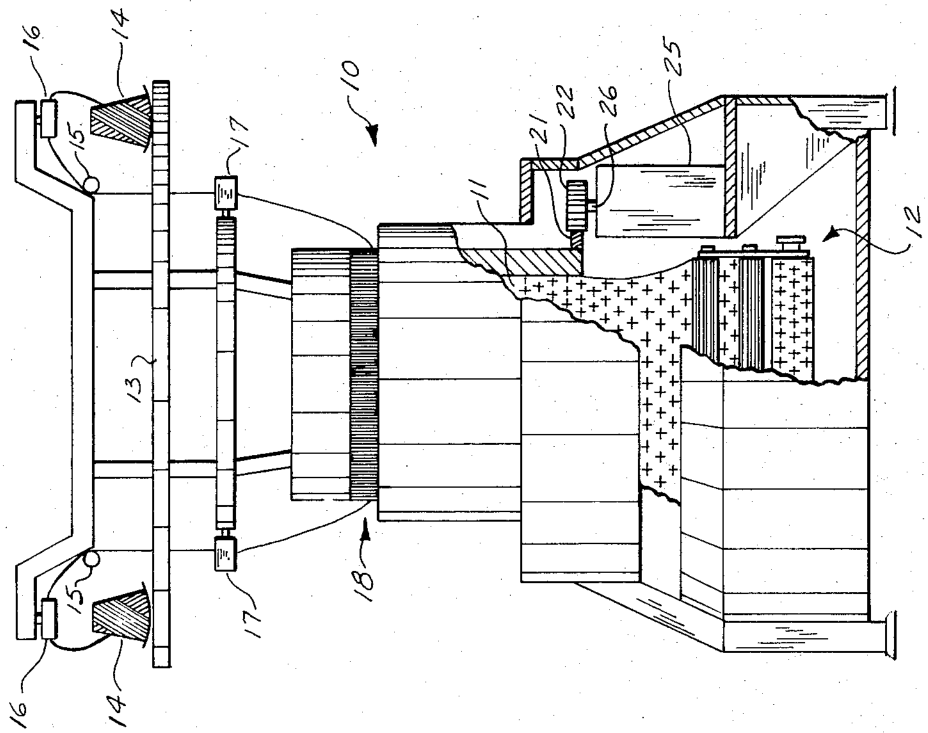


FIG. 1

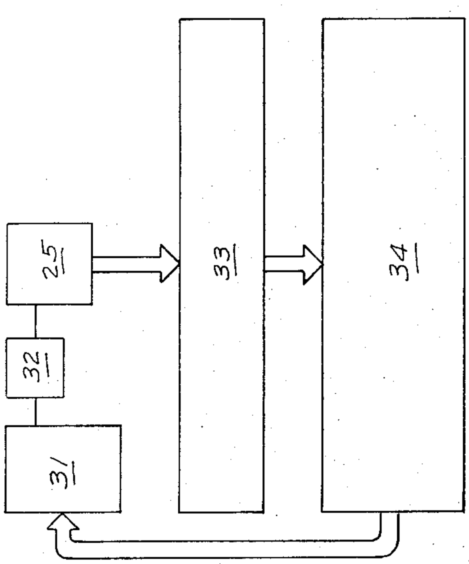


FIG 2

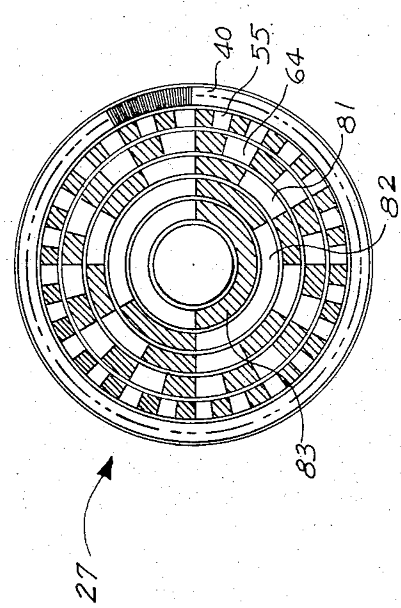


FIG 3

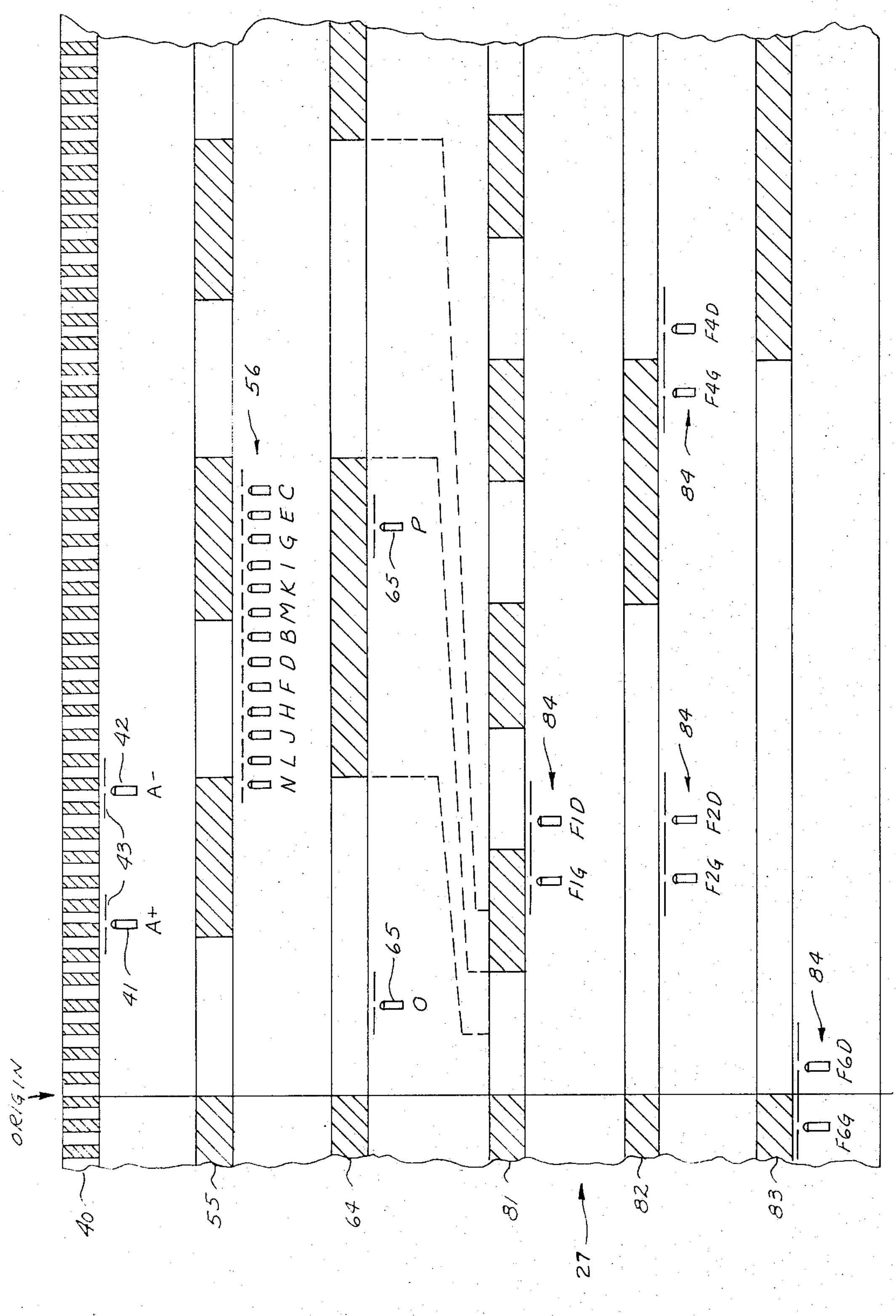

ORIGIN
40
55
64
81
82
83
27
41
43
42
A+
A-
56
N L J H F D B M K I G E C
65
P
O
84
F1G
F1D
F2G
F2D
F4G
F4D
F6G
F6D

FIG. 4

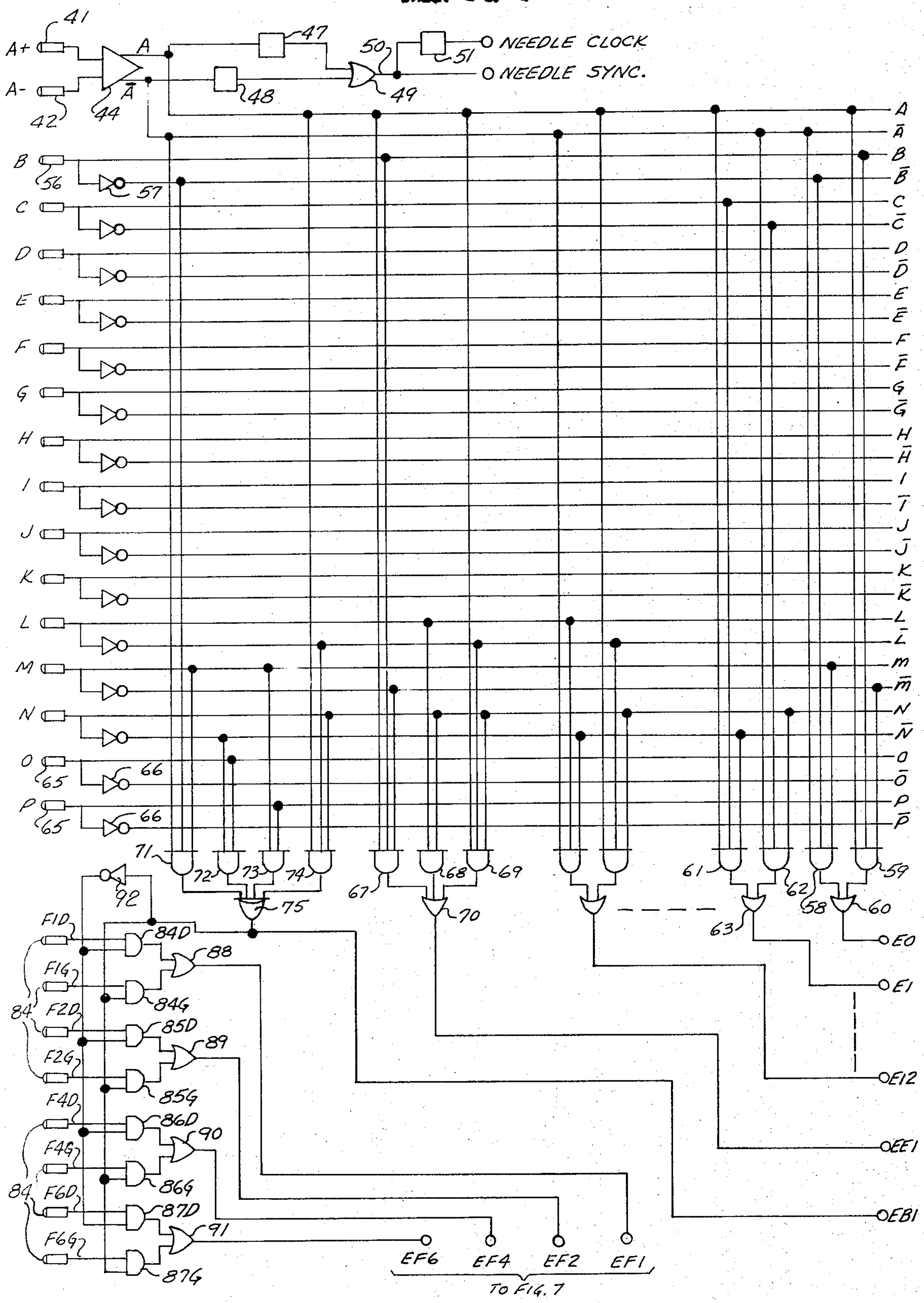

NEEDLE CLOCK
NEEDLE SYNC.
A+
A-
EO
E1
E12
EE1
EB1
EF6
EF4
EF2
EF1
TO FIG. 7

FIG. 5

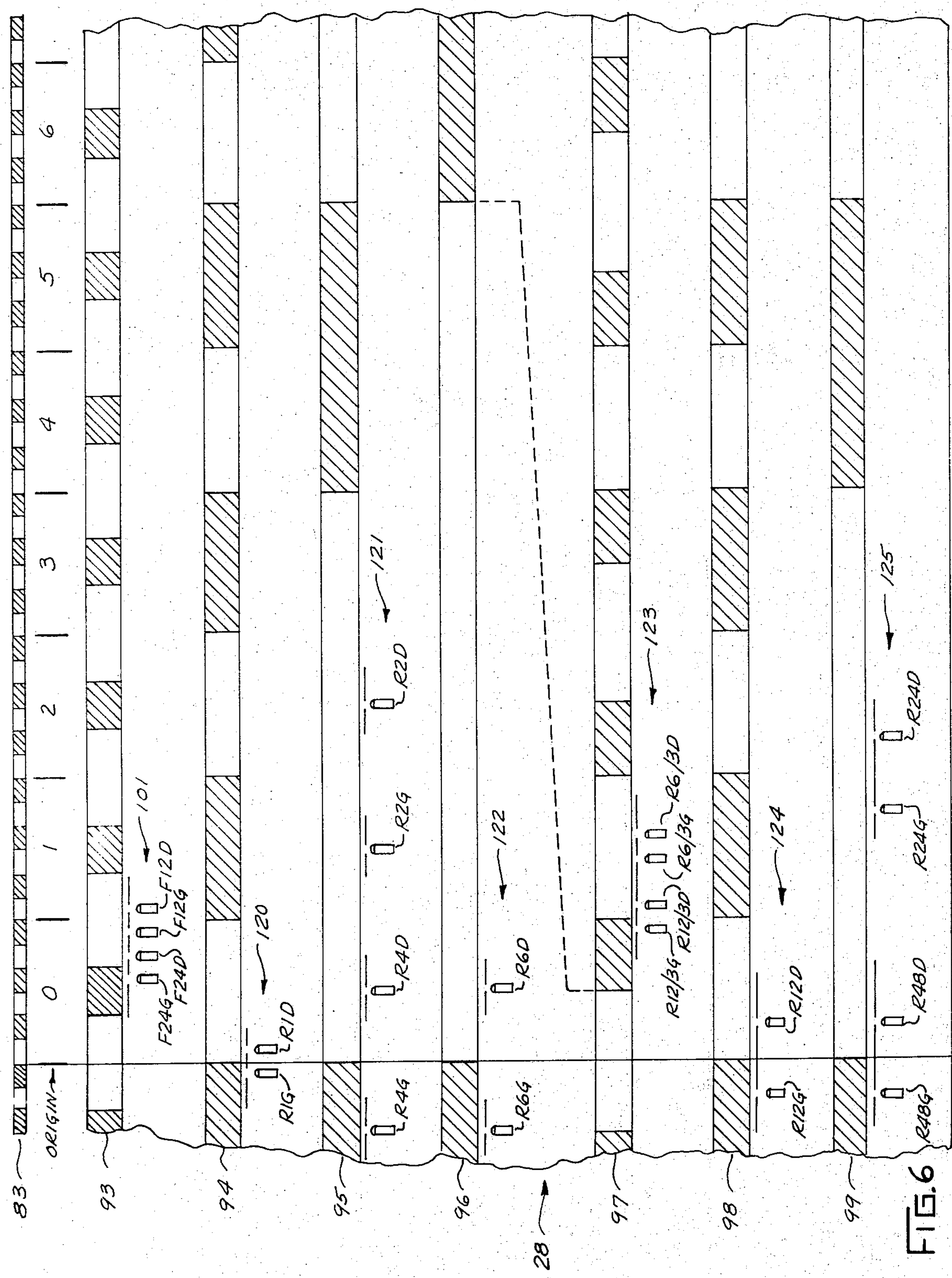

83
ORIGIN
0
1
2
3
4
5
6
93
94
95
96
97
98
99
28
101
F24G
F24D
F12G
F12D
120
R1G
R1D
121
R4G
R4D
R2G
R2D
122
R6G
R6D
123
R12/3G
R12/3D
R6/3G
R6/3D
124
R12G
R12D
125
R48G
R48D
R24G
R24D

FIG. 6

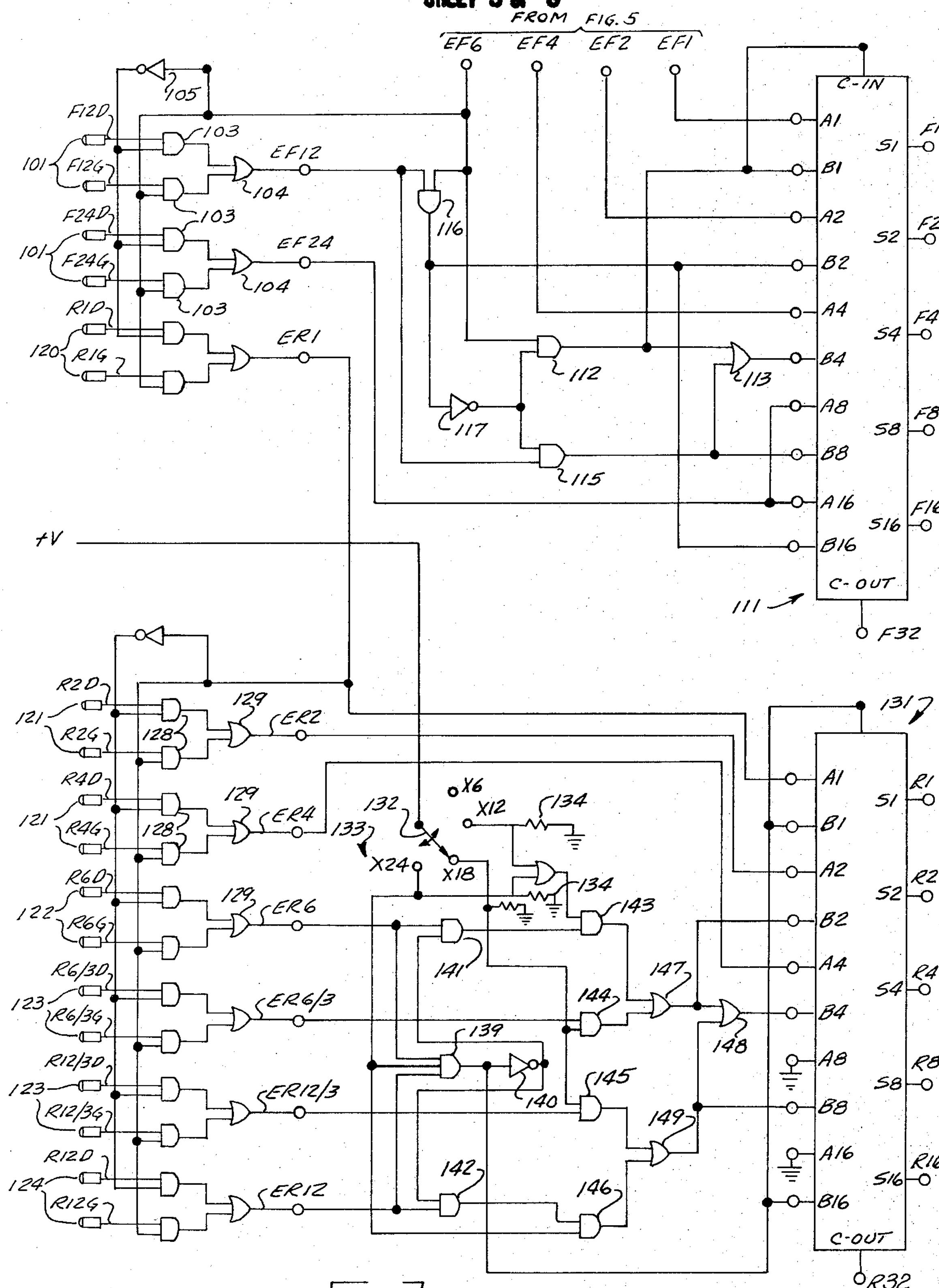

FROM FIG. 5
EF6
EF4
EF2
EF1
105
F12D
F12G
101
103
104
EF12
116
F24D
F24G
EF24
R1D
R1G
120
ER1
112
113
117
115
C-IN
A1
B1
A2
B2
A4
B4
A8
B8
A16
B16
S1
S2
S4
S8
S16
F1
F2
F4
F8
F16
C-OUT
111
F32
+V
R2D
R2G
121
128
129
ER2
R4D
R4G
ER4
R6D
R6G
122
ER6
R6/3D
R6/3G
123
ER6/3
R12/3D
R12/3G
ER12/3
R12D
R12G
124
ER12
X6
X12
X18
X24
132
133
134
139
140
141
142
143
144
145
146
147
148
149
131
R1
R2
R4
R8
R16
R32

FIG. 7

KNITTING MACHINE ENCODER

BACKGROUND OF THE INVENTION

The present invention pertains generally to code converters, and more particularly to optical shaft encoders.

Optical shaft encoders have been known and used in a variety of applications for several years. The most common use of optical shaft encoders is to provide digital position feedback signals for servomechanism positioning systems, or to provide digital position signals for a digital position readout and display system.

Most optical shaft encoders generate binary arithmetic outputs or Gray code outputs. There are also encoders that generate output signals that represent some mathematical function of the input shaft rotation, e.g. the sine of the angle of rotation. None of the known encoders, however, were suitable for providing the required positional signals for an electronically controlled circular knitting machine.

The knitting machine control system with which the present encoder is intended to operate is described in application Ser. No. 193,047 filed Oct. 27, 1971 in the name of Paul Christiansen entitled Knitting Machine Controls and assigned to the assignee of the present application. Briefly, the control provides means for assembling pattern data in a memory device, such as a magnetic disc, means for retrieving the stored information from memory, and means for directing it to the proper electromagnetic acutators at the several feeders to cause the proper needles to knit or non-knit as required to knit the pattern represented by the stored pattern data. The encoder of the present invention provides the knitting machine control with position signals to enable the control to retrieve the proper portion of pattern data from memory at the proper time and direct it to the proper feeders and actuators. These signals represent the rotational position of the knitting machine with respect to a reference position in terms of needle distances, and a plurality of multiple needle distances including an echelon, a byte, and a feeder distance. Knitting machine revolutions are also represented, and the number of revolutions uniquely represented between appearances of reference position is selectable to accommodate a plurality of pattern types and heights.

Therefore, it is an object of the present invention to provide an improved optical shaft encoder for use with circular knitting machines.

It is a further object of the present invention to provide an encoder to generate signals representative of knitting machine position in terms of needle distances and multiple needle distances.

It is a still further object of the present invention to provide an encoder to generate signals representative of knitting machine revolutions, and to provide means for selecting the number of revolutions uniquely represented between appearances of the reference position.

These and other objects and advantages of the present invention will become apparent as the detailed description proceeds, reference being made to the attached drawings and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a simplified elevation view of a circular knitting machine, partially cut away to reveal the knitted hose and take-down mechanism.

FIG. 2 is a generalized block diagram showing how the encoder of the present invention fits into the control system.

FIG. 3 is an illustration of a code disc having a plurality of concentric code tracks comprising transparent and opaque code zones.

FIG. 4 is a developed view of a portion of the fine code disc showing its origin.

FIG. 5 is a logic circuit diagram illustrating how signals from the photocells reading the fine disc are operated upon logically to produce the desired binary code.

FIG. 6 is a developed view of a portion of the coarse code disc showing its origin.

FIG. 7 is a logic circuit diagram illustrating how the signals from the photocells reading the coarse code disc and some of the signals from photocells reading the coarse code disc are operated upon logically to produce the desired binary code.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The general relationships between the positional signals required by the control described in application Ser. No. 19,047 filed Oct. 27, 1971 by Paul Christiansen and entitled Knitting Machine Controls and the relationships with other circular knitting machines are somewhat similar, but will differ in detail according to the specific geometry of each knitting machine and other factors. For example, the knitting machine controls of the Christiansen application require an indication of actuator or needle count, feeder count and revolution count as knitting progresses. However, one knitting machine may have 48 feeders and 2,400 needles, while another may have 36 feeders and 1,728 needles. One may knit 12 repeats of a pattern while the other knits nine repeats of the same size pattern. Because of these differences, no standard binary arithmetic or Gray code encoder can readily be used to generate the required signals. Nor, may an encoder made according to the present invention for one knitting machine generally be usable with another knitting machine having a different number of needles and feeders. Another encoder, however, embodying the subject matter of the present invention could be constructed to accommodate the specific geometry of the other knitting machine.

To illustrate the encoder of the present invention, one specific embodiment will be shown and described for use with a circular knitting machine having 1,872 needles and 36 feeders. As the knitting machine cylinder turns, each of the needles is sequentially brought into operative relationship with each of the feeders. At each feeder, each needle must knit or non-knit. That is, it must move up to the knit position and take a new loop or stay below the knit position and not create a new loop. The term "knit" as used herein will include "tuck" wherein a new loop is created without throwing off the old loop.

At each feeder there are cam tracks that cooperate with projecting cam butts on needle jacks and selector jacks to lift the needles to the required height. Needles are selected to knit or non-knit by electromagnetic actuators that either interfere with a selector butt on a selector jack, causing its cam butt to enter the non-knit cam track, or do not interfere with the selector butt so that the cam butt enters the knit cam track. Thus, because there are 1,872 needles and 36 feeders in the illustrative knitting machine, 36 × 1872 or 67,392 knit and non-knit commands must be supplied to the actuators each revolution of the knitting machine. If the illustrative knitting machine were operated at 24 revolutions per minute, then the actuators would require about 27,000 knit and non-knit commands per second. Although this is not a high data transmission rate for electronic digital computers, it is quite a high data transmission rate to interface to a mechanical apparatus such as a knitting machine. The encoder of the present invention permits handling the necessary knit and non-knit information at the required data transmission rates with considerably fewer electronic manipulations, and therefore greater economy, than could otherwise be achieved.

As described in more detail in application Ser. No. 193,047 referred to above, pattern data is stored on nine tracks of a magnetic disc. Each track is divided into four zones. One zone stores all the pattern data for one feeder for a complete pattern. An arbitrary pattern size of 208 stitches wide by 216 stitch rows high was selected for use on the illustrative knitting machine. Thus, because there are 1,872 needles around the cylinder, the pattern will be knitted nine times around the circumference of the finished knitted tube. The number of revolutions required to knit the 216 stitch rows of pattern height, however, will depend upon the type of pattern being knitted. For example, three-color plain pattern requires three feeders per stitch row. Therefore, the illustrative machine will knit 12 stitch rows per revolution and require 18 revolutions to knit 216 stitch rows. For a pattern requiring only two feeders per stitch row, the illustrative machine will knit 18 stitch rows per revolution and would require only 12 revolutions to knit 216 stitch rows.

In both the examples given above, the pattern would be knitted nine times during the required number of revolutions. This is true for all patterns 208 stitches wide knitted on the illustrative machine. Or, stated in another way, the stored pattern data will be used nine times during the required number of revolutions to knit 216 stitch rows.

The four zones of each data track on the magnetic disc are divided into sectors such that a sector contains all the knitting data required for one feeder for one full stitch row of the pattern. Since a pattern width of 208 stitches has been selected, each sector must contain 208 bits of data. Because a feeder knits on the same stitch row of the pattern for one full revolution of the knitting machine, which is nine repeats of the pattern in the present embodiment, a new sector address is required only once per revolution. The information from the sector, however, will be used nine times during the revolution. Revolution count and sector address are provided by the encoder and its associated translator circuitry.

Because of operating speed limitations of the electromechanical actuators, the task of steering the needles at each feeder is divided among 13 actuators. In this manner, each actuator steers only every 13th needle. Thus, signals are required for directing the knit and non-knit information to the proper actuator at each feeder. These signals are also provided by the present encoder and its associated translator circuitry.

Because a continuous flow of knit and non-knit information is required by each feeder and because information is retrieved from the disc in a discontinuous manner, an interface is required between the disc and each feeder. This interface, in the present embodiment, may include two 26 bit shift registers per feeder. While the information is being read out of one of the shift registers, information is located on the disc and loaded into the other shift register. Therefore, by switching back and forth between its two associated shift registers, a feeder receives a continuous flow of patterning information. In an alternative system, a single 208 bit shift register is provided for each feeder and a 208 bit buffer shift register provides the time interface between the disc and all the feeder shift registers. In the first system the 26 bits required to load each shift register are taken from the 26-bit bytes of information on the disc. In order to retrieve these bytes, a byte address is required in addition to the sector address. The byte addresses are provided by the present encoder and its associated translator circuitry. In the second system, byte addresses are not required. Instead, the 208 bits in each feeder shift register are recirculated for a full knitting machine revolution.

Two-color plain patterns, and one-color tuck patterns, require two feeders per stitch row. Three-color plain patterns, and one- and two-color blister patterns require three feeders per stitch row. Four-color plain patterns and three-color blister patterns require four feeders per stitch row. An arbitrary pattern height of 216 stitch rows then requires twelve revolutions, 18 revolutions, and 24 revolutions for two, three, and four feeder-per-stitch row patterns, respectively. In order to selectively knit two, three, or four feeder-per-stitch row patterns, the encoder signals must recycle to the beginning after 12, 18 or 24 machine revolutions. To knit a two-feeder-per-stitch row pattern **108** stitch rows high, the encoder signals must recycle after six revolutions. Other combinations may also be desired. To avoid prolixity of description, the controls of the above identified Christenson application Ser. No. 193,047 will not be set forth in detail herein. However, it should be understood that the disclosure of this application is fully incorporated herein by this and other references thereto.

FIG. **1** is a diagrammatic illustration of a circular knitting machine **10** partially cut away to show the finished knitted tube **11** and the take-down mechanism **12.** A creel structure **13** supports spools of yarn **14** to be knitted. The yarn passes through tensioning means **15** and stop motions **16** and **17** to feeder blocks located circumferentially around the knitting machine at **18.** A large ring gear **21** mounted to the lower portion of the knitting machine or needle cylinder drives a pinion gear **22** mounted on the input shaft of optical shaft encoder **25** which is affixed to the frame of knitting machine **10** in any suitable manner. As the knitting machine cylinder rotates, ring gear **21** drives pinion gear **22** to rotate the input shaft of encoder **25.**

Within encoder **25** are two code discs, a fine code disc **27** (FIGS. **3** and **4**) and a coarse code disc **28** (FIG. **6**). Fine code disc **27** is mounted for rotation on a shaft that is gear coupled to input shaft **26** such that fine code disc **27** rotates three full revolutions for each rotation of the knitting machine needle cylinder. Coarse code disc **28** is mounted for rotation on a shaft that is gear coupled to the fine code disc shaft such that coarse code disc **28** rotates one full revolution for each **216** fine code disc revolution, which is one full revolution for each **72** knitting machine cylinder revolutions.

Each of the encoder discs **27, 28** have a plurality of code tracks with which a plurality of photocells cooperate to provide a plurality of binary coded electrical signals. These signals may be used directly, or be operated upon logically to provide further binary coded signals, to provide the necessary synchronizing and position indicating information for the knitting machine control. It is not necessary to describe in detail here the relationship between encoder discs, light sources, and photocells, because these details are well known in the art. For example, see U.S. Pat. No. 3,218,626 issued Nov. **16, 1965** to Ralph H. Schuman and assigned to the assignee of the present invention.

FIG. **2** is included to illustrate generally where and how encoder **25** fits into and cooperates with the overall knitting machine and control. The circular knitting machine, including its drive, feeders, cylinders, etc., is represented by the block **31.** The mechanical coupling between the knitting machine cylinder and encoder **25,** including gears **21** and **22,** is represented by block **32.** Many of the binary electrical signals generated by encoder **25** are operated upon logically by translator circuitry **33** to provide derived signals. Both the derived signals and signals from encoder **25** are used by a plurality of feeder controls **34** to retrieve the proper knitting data from memory means, such as a magnetic disc, and provide the proper knit and non-knit signals to the feeder actuators in block **31.** It will be recognized that the immediately foregoing description of how the encoder of the present invention fits into the overall control is very abbreviated. The overall control is fully described in Paul Christiansen's Application Ser. No. 193,047 filed Oct. 24, 1971, entitled Knitting Machine Controls and referred to above.

FIGS. **3** and **4** show the arrangement of the code tracks and photocells of the first or fine disc **27.** The presence of crosshatching indicates an area of a transparent characteristic that will permit light to pass and illuminate a photocell to generate a logic one signal. The absence of crosshatching represents an area of an opaque characteristic that will prevent light from illuminating a photocell to thereby generate a logic zero. Because the fine disc **27** makes one revolution for each one-third revolution of the knitting machine, it must resolve 1,872 ÷ 3 or 624 parts per revolution to provide a change in signal each time the needles are advanced one needle position during a revolution of the needle cylinder. This is achieved by dividing the finest code track **40** into 312 opaque and 312 transparent zones of equal size and alternately located around the code track with each of the opaque and transparent zones corresponding to a needle position. The code track **40** is utilized to provide needle signals which vary in response to relative movement between the needle cylinder and feeders by an extent corresponding to the spacing of adjacent needles.

A pair of photocells **41, 42** are connected in a push-pull relationship and positioned 180° of a needle position out of phase with respect to fine code track **40** to read the fine code track through mask slits **43** which have a width that is approximately one-third the tangential dimension of either an opaque or transparent code zone. This provides a signal which, after amplification, is considerably more precise than one-tenth of a code zone, or, related to the knitting machine, one-tenth of a needle distance. The fine code track photocell outputs are labeled A+ and A−. These outputs are fed in push-pull to an amplifier **44** (FIG. **5**) to produce a signal A which is at logic one when photocell **41** is illuminated. Amplifier **44** also produces a signal $\overline{A}$, the complement of signal A. Signals A and $\overline{A}$ are connected respectively to monostable multivibrators **47** and **48.** Monostable multivibrator **47** produces a short pulse output each time signal A changes from logic one to logic zero and monostable multivibrator **48** produces a short pulse output each time signal A changes from logic one to logic zero. The outputs of monostable multivibrator **47** and **48** are combined by or gate **49** to produce on line **50** one pulse each time the knitting machine has moved one needle position. These pulses may be used to transfer patterning data from feeder control storage to the actuators. An additional monostable multivibrator **51** which generates a short pulse output each time the signal on line **50** changes from one to zero may be used to shift feeder control shift registers in timed relationship with rotation of the needle cylinder in a manner more fully described in the aforementioned Christiansen application Ser. No. 193,047. In order to provide an enabling signal to each of the thirteen actuators at each feeder, it is necessary to provide an actuator or needle count number to indicate which of the thirteen needles in each echelon is to be steered next. To produce this indication, a second code track **55** is provided on the fine disc **27.** This code track **55** is divided into **24** transparent and **24** opaque code zones, each having a tangential length substantially equal to **13** finest code track **40** code zones (48 × 13 = 624). Thirteen photocells **56** are arranged to read the second code track in a staggered or phase displaced manner to provide **13** outputs that are labeled B, C, D, E, F, G, H, I, J, K, L, M, and N in FIGS. **4** and **5.**

The signals from the thirteen photocells **56** are combined logically according to the Boolean Algebra equations of Table I to provide the actuator enabling signals **E0** – **E12** corresponding to the number of an actuator to be enabled for activation in accordance with a pattern signal from a suitable memory device (not shown but fully described in the aforementioned Christiansen application). Since each opaque and transparent zone of the code track **55** corresponds to 13 needles and associated actuators, any one of which may require activation to knit a selected pattern, thirteen enabling signals **E0** – **E12** are provided for each of the opaque and transparent zones of the code track **55.** The actual decoding circuitry is illustrated in FIG. **5** wherein each of the photocells **56** is connected to an inverter **57** to produce the signals $\overline{B}$, $\overline{C}$, $\overline{D}$, $\overline{E}$, $\overline{F}$, $\overline{G}$, $\overline{H}$, $\overline{I}$, $\overline{J}$, $\overline{K}$, $\overline{L}$, $\overline{M}$, and $\overline{N}$ as well as B, C, D, E, F, G, H, I, J, K, L, M, and N.

To produce each of the enabling signals **E0** – **E12** for each transparent and opaque zone of the code track **55,** the photocells **56** are paired by the logic circuitry of FIG. **5.** When the leading photocell of a pair is adjacent an opaque zone and the trailing cell is adjacent a transparent zone an enabling signal is produced. In addition, when the leading photocell of a pair is adjacent a transparent zone and the trailing cell is adjacent an opaque zone another enabling signal is produced. Thus, for the pair of cells B and M, an enable signal E0 is produced by combining $\overline{A}$, $\overline{B}$, and M in an and gate **58**, combining A, B, and $\overline{M}$ in an and gate **59**, and combining the outputs of and gates **58** and **59** in or gate **60**. This produced E0 in accordance with the Boolean equation $E0 = \overline{A}\,\overline{B}\,M + A\,B\,\overline{M}$. Similarly A, C, $\overline{N}$, $\overline{A}$, $\overline{C}$, and N are combined in and gates **61** and **62** and or gate **63** to produce E1 according to the Boolean equation $E1 = A\,C\,\overline{N} + \overline{A}\,\overline{C}\,N$. Each of the remaining enable signals E2 – E12 are produced similarly in accordance with the Boolean equations of Table **1**, the circuitry for producing E2 – E11 being omitted to avoid unnecessary prolixity.

TABLE 1

$E0 = \overline{A}\,\overline{B}\,M + A\,B\,\overline{M}$
$E1 = A\,C\,\overline{N} + \overline{A}\,\overline{C}\,N$
$E2 = \overline{A}\,B\,\overline{D} + A\,\overline{B}\,D$
$E3 = A\,\overline{C}\,E + \overline{A}\,C\,\overline{E}$
$E2 = \overline{A}\,D\,F + A\,\overline{D}\,F$
$E5 = A\,\overline{E}\,G + \overline{A}\,E\,\overline{G}$
$E6 = \overline{A}\,F\,\overline{H} + A\,\overline{F}\,H$
$E7 = A\,\overline{G}\,I + \overline{A}\,G\,I$
$E8 = \overline{A}\,H\,\overline{J} + A\,\overline{H}\,J$
$E9 = A\,\overline{I}\,K + \overline{A}\,I\,\overline{K}$
$E10 = \overline{A}\,J\,\overline{L} + A\,\overline{J}\,L$
$E11 = A\,\overline{K}\,M + \overline{A}\,K\,\overline{M}$
$E12 = \overline{A}\,L\,\overline{N} + A\,\overline{L}\,N$

Because in the aforementioned Christiansen application there are **26** bits in a byte in the selected pattern data format, it is necessary to provide **26** discrete steering signals to transfer each pattern data bit from a **26** bit shift register to one of thirteen actuators. One manner of accomplishing this is to provide an additional signal that is at logic one during alternate echelons of needles. For this reason, a third code track **64** is provided on fine disc **27** having alternate transparent and opaque areas each having a tangential length substantially equal to **26** finest code track **40** code zones. Photocells **65** are positioned 90°, or **6 1/2** fine code track zones out of phase to read code track **64** to provide outputs that are labeled O and P. Inverters **66** produce the signals $\overline{O}$ and $\overline{P}$.

Should it be desired to keep track of echelons of needles, e.g. whether the echelon is even or odd, such a signal may be provided by associating even echelons with opaque zones of the code track **55** and odd echelons with transparent zones of the code track **55**. This may be accomplished by logically combining signals A, B, L, M, and N according to the Boolean equation, $EE1 = A\,B\,\overline{M} + L\,N + A\,\overline{L}\,N$ with and gates **67, 68, 69**, and or gate **70**. This produces a logic one when the echelon is odd and a logic zero when the echelon is even. Similarly, a byte signal may be produced by the logical combination $EB1 = \overline{A}\,\overline{B}\,M + \overline{N}\,O + M\,P + A\,\overline{L}\,N$ with and gates **71 – 74** and or gate **75**. Signal EB1 will be at logic zero when the byte number is even and at logic one when the byte number is odd, and may be used to steer bytes read from the disc to the proper one of two feeder shift registers. The byte signal is also used in determining the feeder number as will be described below.

During operation of the knitting machine **10**, pattern data for at least a portion of a particular stitch row is transmitted from a memory disc to controls for a feeder of a feeder group which is knitting this particular stitch row. The pattern data for any one feeder of a feeder group may be different than the pattern data for any other feeder in the feeder group. Since different stitch rows of a pattern are knitted by each feeder group on consecutive revolutions of the needle cylinder, the pattern data for any one feeder may be different on different revolutions of the needle cylinder. In addition, during any one revolution of the needle cylinder from feeder **0** to feeder **35**, the feeder groups ahead of a first needle on the cylinder and the pattern change point will be completing the knitting of a stitch row corresponding to the preceeding revolution of the needle cylinder while the feeder groups behind the first needle and after the pattern change point will be knitting a stitch row corresponding to the present revolution of the needle cylinder. It should be understood that the beginning and ending points of a stitch row are displaced longitudinally along a generally cylinderical tube of knitted material by a number of stitch rows corresponding to the number of feeder groups. Therefore, the pattern change point extends linearly along the tube of knitted material.

A feeder count number which is indicative of the feeder in which the first needle on the needle cylinder and pattern change point are located is transmitted from the translator **33** to the feeder controls **34**. To provide a feeder number which changes with movement of the pattern change point and of the first needle on the needle cylinder from feeder **0** through feeder **35** with each revolution of the needle cylinder, the fine code disc has three additional code tracks **81, 82,** and **83.** Note the change of scale in FIG. **4** between code tracks **64** and **81.** Code track **81** is equally divided into six opaque and six transparent code zones. Because the fine code disc rotates one revolution for each one-third revolution of the knitting machine, and since there are **36** feeders and **52** needles per feeder on the knitting machine, one code zone on code track **81** corresponds to one feeder on the knitting machine and **52** zones of code track **40.** Code track **82** is divided into two transparent and two opaque code zones, the opaque zones being twice as long as the transparent zones and alternately located with the transparent zones as shown in FIG. **4.** Thus, an opaque zone of code track **82** corresponds to four feeders and a transparent zone corresponds to two feeders. Code track **83** is divided into two equal code zones, one transparent and one opaque. Each of the zones of code track **83** corresponds to six feeders. Lead and lag photocells **84** are positioned as shown in FIG. **4** and cooperate with code tracks **81, 82,** and **83** to provide binary code signals F1D, F1G, F2D, F2G, F4D, F4G, F6D, and F6G.

The lead photocell (D) of each photocell pair is located so that it reads ahead of the actual transition point and each lag photocell (G) is located so that it reads behind the actual transition point. The byte signal (EB1) is utilized to switch between lead and lag photocells **84.** Lead-lag switching is accomplished by and gates **84D, 84G, 85D, 85G, 86D, 86G,** and **87D, 87G,** and or gates **88, 89, 90,** and **91,** connected as shown in FIG. **5.** Signal EB1 is directly connected to one input of each and gate **84G, 85G, 86G,** and **87G,** to enable those gates when EB1 is at the logic one level during odd bytes. Signal EB1 is connected to one input of each and gate **84D, 85D, 86D,** and **87D,** through an inverter **92** to enable those gates when EB1 is at the logic zero level during even bytes. Because the byte signal depends on the A signal for its accuracy, and because the

A signal is accurate to approximately one-tenth needle position, use of the byte signal to control the lead-lag switching on photocells **84** provides binary code signals EF1, EF2, EF4, and EF6, weighted **1, 2, 4,** and **6,** and indicating feeder numbers from **0** thru **11** with an accuracy of one-tenth needle position.

In order to provide feeder numbers **0 – 35** on each needle cylinder revolution, feeder numbers **0 – 11** are generated three times. That is, during a first revolution of the fine code disc **27**, code tracks **81, 82,** and **83** are decoded to indicate feeders **0 – 11.** The next revolution they are decoded to indicate feeders **12 – 23.** During the third revolution they are decoded to indicate feeders **24 – 35.** The coarse code disc **28** is associated with the fine code disc **27** to provide the necessary information as to which series of feeder numbers is being provided at any given time. Thus, the code tracks **81, 82** and **83** are utilized to provide coded feeder signals which vary in response to relative movement between the needle cylinder and feeders by an extent which is a function of the spacing of adjacent feeders. These coded signals are indicative of the feeder with which the first needle is associated.

Whether code tracks **81, 82,** and **83** should be decoded as feeders **0 – 11, 12 – 23,** or **24 – 35,** is determined by signals generated by code tracks on the coarse code disc **28** that is coupled to the fine code disc **27** by gear means giving a **216:1** gear ratio such that coarse code disc **28** rotates one time for each **216** revolutions of the fine code disc. This means that the coarse code disc will rotate once for each **72** revolutions of the knitting machine. The coarse code disc **28** has seven code tracks concentrically arranged similarly to the code tracks of fine code disc **27** shown in FIG. **3.** These are identified in order of decreasing diameter by reference numerals **93 – 99** and are illustrated in a developed view in FIG. **6.** Code track **83** of fine disc **27** is shown at the top of FIG. **6** to illustrate the relationship between code discs **27** and **28.** As was previously mentioned, each of the zones of code track **83** corresponds to six feeders. The numerals immediately below code track **83** in FIG. **6** indicate revolutions of the needle cylinder, each of which corresponds to three revolutions of the fine disc **27.** Note the scale change between code tracks **96** and **97.**

Signals indicative of which of the three revolutions is being made by the fine code disc **27** are provided by four photocells **101** arranged in two lead-lag pairs to read code track **93** and provide signals F12D, F12G, F24D, and F24G. As shown in FIG. **7,** lead-lag switching is accomplished by and gates **103** and or gates **104.** And gates **103** are alternately enabled to select either the lead or lag signals by means of signal EF6 being directly connected with the lag gates and connected to the lead gates through an inverter **105.** Thus, when transparent zones (crosshatched) on code track **93** are being read and signal EF6 is at the logic one level, signals F12G and F24G are enabled. When opaque zones (not cross-hatched) on code track **93** are being read and signal EF6 is at the logic zero level and signals F12D and F24D are enabled.

When code tracks **81, 82** and **83** are to be decoded as feeders **0 – 11** the gated photocells **101** are reading opaque zones of code track **93** and the enabled signals EF12 and EF24 are at logic level zero. During continued rotation of the needle cylinder certain of the photocells **101** read transparent zones of code track **93** and the code tracks **81, 82** and **83** are decoded as feeders **12 – 23.** During this time signal EF**12** is at logic level one while EF**24** remains at logic level zero. Upon still further rotation of the needle cylinder, code tracks **81, 82** and **83** are decoded as feeders **24 – 35** and signal EF**12** returns to logic level zero while signal EF**24** is at logic level one. Thus both signals EF**12** and EF**24** remain at logic level zero for **24** consecutive feeder numbers and are at logic level one for **12** consecutive feeder numbers.

To enable signal EF**12** to remain at logic level zero for feeder numbers **24 – 35** during one revolution of the needle cylinder and for the immediately succeeding feeder numbers **0 – 11** on the next revolution of the needle cylinder, code track **93** has **72** opaque zones which are read by photocells F**12**D and F**12**G during feeder numbers **24 – 35** of one needle cylinder revolution and feeder numbers **0 – 11** of the next needle cylinder revolution. However, signal EF**12** is at logic one level during feeder numbers **12 – 23** of each needle cylinder revolution. Accordingly, code track **93** has **72** transparent zones (shown crosshatched in FIG. **6**) which are read by the photocells F**12**D and F**12**G during feeder numbers **12 – 23.** The transparent zones of code track **93** are one half as long as the opaque zones.

The signal EF**24** remains at logic level zero during feeder numbers **0 – 23** and is at logic level one during feeder numbers **24 – 35.** Thus, signal EF**24** switches to logic level one as signal EF**12** switches from logic level one to logic level zero. Accordingly, photocells F**24**D and F**24**G read a transparent zone of code track **93** immediately after it is read by the photocells F**12**D and F**12**G.

The signals produced by photocells **101** may be considered as adder signals for combining with the EF1, EF2, EF4, and EF6 signals to produce a binary code weighted **1, 2, 4, 6, 12, 24.** The truth table for the feeder numbers is as follows:

	COARSE DISC			FINE DISC		
Feeder No.	EF24	EF12	EF6	EF4	EF2	EF1
0	0	0	0	0	0	0
1	0	0	0	0	0	1
2	0	0	0	0	1	0
3	0	0	0	0	1	1
4	0	0	0	1	0	0
5	0	0	0	1	0	1
6	0	0	1	0	0	0
7	0	0	1	0	0	1
8	0	0	1	0	1	0
9	0	0	1	0	1	1
10	0	0	1	1	0	0
11	0	0	1	1	0	1
12	0	1	0	0	0	0
13	0	1	0	0	0	1
14	0	1	0	0	1	0
15	0	1	0	0	1	1
16	0	1	0	1	0	0
17	0	1	0	1	0	1
18	0	1	1	0	0	0
19	0	1	1	0	0	1
20	0	1	1	0	1	0
21	0	1	1	0	1	1
22	0	1	1	1	0	0
23	0	1	1	1	0	1
24	1	0	0	0	0	0
25	1	0	0	0	0	1
26	1	0	0	0	1	0
27	1	0	0	0	1	1
28	1	0	0	1	0	0
29	1	0	0	1	0	1
30	1	0	1	0	0	0
31	1	0	1	0	0	1
32	1	0	1	0	1	0
33	1	0	1	0	1	1

-Continued

	COARSE DISC				FINE DISC	
Feeder No.	EF24	EF12	EF6	EF4	EF2	EF1
34	1	0	1	1	0	0
35	1	0	1	1	0	1

By proper digital arithmetic techniques, these signals may be translated to feeder count numbers in any desired code, e. g. normal binary weighted **1, 2, 4, 8, 16,** etc. FIG. **7** shows how signals EF1 – EF24 may be translated to normal binary by the use of a **5**-stage full binary adder or register means **111** having carry-in and carry-out capacity. Adder **111** is arranged to add two normal binary numbers, A and B, plus a carry-in bit at C-in, and produce their sum S. The electrical signals representing number A are connected to terminals A1 – **A16** and those representing number B to terminals B1 – **B16,** the terminal reference numerals also indicating the numerical weight of their digit signals. The signals representing the sum appear at terminals S1 – **S16** and at carry-out terminal C-out. EF1, EF2, and EF4 are directly connected to A1, A2, and A4, respectively. EF6, weighted **6,** is connected to C-in and B1 via an and gate **112,** and thence to B4 via one input of or gate **113.**

When and gate **112** is enabled, a logic one on EF6 will cause logic ones to appear at C-in, B1, and B4 contributing six toward the sum S. EF12, weighted **12,** is connected to B8 via an and gate **115,** and thence to B4 via the other input of or gate **113.** Thus, when and gate **115** is enabled, a logic one on EF12 will cause logic ones to appear at B4 and B8, contributing twelve toward the sum S. EF6 and EF12 are also connected to an and gate **116,** the output of which is connected to B2 and B16. Thus, when EF6 and EF12 are both at logic one, logic ones appear at B2 and B16, contributing 18 toward the sum S. The output of and gate **116** is also inverted by an inverter **117,** the output of which provides the enabling signal for and gates **112** and **115.** Thus, when EF6 and EF12 are both at logic one, and gates **112** and **115** prevent logic ones from appearing at C-in, B1, B4, and B8. EF24, weighted **24,** is directly connected to A8 and A16, and therefore, a logic one on EF24 contributes **24** to the sum S. The sum appearing at terminals S1 – S16 and C-out indicates the knitting machine feeder count number in normal binary arithmetic. The feeder count number digit signals are designated F1, F2, F4, F8, F16, and F32, the numerical portion of the designation indicating the numerical weighting of the digit signal.

The feeder count number is transmitted from the translator **33** to the feeder controls **34** and is utilized to provide a feeder offset number which shifts from logic level zero to logic level one immediately before the pattern change point enters a feeder. The operation of the feeder controls **34** is not, per se, a part of the present invention and therefore has not been fully described. However, the operation of the feeder controls is fully set forth in the aforementioned Christiansen application.

It is contemplated that the knitting machine **10** will be utilized to knit many different types of patterns, such as two, three or four color plain patterns or one, two or three color blister patterns. In order to enable the machine **10** to knit these different patterns, the **36** feeders are associated in a known manner in groups of either two, three or four feeders, depending upon the pattern to be knitted. Assuming a constant pattern of 216 stitch rows, the number of revolutions required to knit a pattern will vary depending upon the number of feeders in each feeder group. Thus, for a pattern having one feeder in each feeder group, six revolutions of the needle cylinder are required to knit the pattern. For a pattern having two feeders in each of eighteen feeder groups, 12 revolutions of the needle cylinder are required to knit the pattern. Similarly, a three feeder group pattern is knitted in 18 cylinder revolutions and a four feeder group pattern is knitted in 24 cylinder revolutions.

Once a pattern has been knitted during the requisite number of needle cylinder revolutions, the pattern is repeated as the needle cylinder continues to rotate. To facilitate for this repetitive knitting of the pattern, the signals from the encoder **25** are repeated each time the needle cylinder rotates through the requisite number of revolutions. Thus, the signals from the encoder **25** are repeated after every six revolutions when one feeder is used in each feeder group to knit a 216 stitch row pattern. Similarly, the signals from the encoder **25** are repeated after twelve revolutions for a pattern requiring two feeders per group, after 18 revolutions for a pattern requiring three feeders per group, and after 24 revolutions for a pattern requiring four feeders per group.

To enable the signals from the encoder to be repeated in the number of revolutions corresponding to the selected pattern, photocells **120, 121, 122, 123, 124,** and **125** cooperate with code tracks **94, 95, 96, 97, 98,** and **99** to provide revolution count signals which repeat after either six, 12, 18 or 24 cylinder revolutions. A selector switch **133** (FIG. **7**) is provided to enable the cycling of the revolution count to be matched with a selected pattern.

To provide repetitive revolution count signals, code track **94** is equally divided into **36** transparent and **36** opaque code zones of equal tangential length alternately located about the code track. Lead and lag photocells **120** reading this code track are switched by the EF6 signal in the same manner as the signals from photocells **101** to produce one change of a signal ER1 for each revolution of the knitting machine. Thus, the ER1 signal functions as the units digit signal for a binary coded set of signals indicating revolution number. The additional binary coded digit signals for indicating revolution number are generated by code tracks **95 – 99** and photocells **121 – 125** as shown in FIGS. **6** and **7.** Each of the photocells **121 – 125** are arranged in lead-lag pairs to produce signals R2D, R2G, R4D, R6D, R6G, R6/3D, R6/3G, R12/3D, R12/3G, R12D, R12G, R24D, R24G. These signals are connected to and gates **128** that are switched by the ER1 signal in the same manner that the EF6 signal switches the signals from photocells **101** and **120.** Or gates **129** combine the signals from and gate pairs. Since the ER1 signal is switched by the EF6 signal, which in turn is switched by the A signal, one-tenth needle position accuracy is maintained in resulting revolution number signals ER1, ER2, ER6, ER6/3, ER12/3, and ER12. The truth table for these signals is as follows:

Needle Cylinder Rev.	Lead-Lag ER48	Switched by ER6			Lead Lag	Switched by ER1			
		ER24	ER12	ER12/3	ER6/3	ER6	ER4	ER2	ER1
0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	0	1	0
3	0	0	0	0	0	0	0	1	1
4	0	0	0	0	0	0	1	0	0
5	0	0	0	0	0	0	1	0	1
6	0	0	0	0	1	1	0	0	0
7	0	0	0	0	1	1	0	0	1
8	0	0	0	0	1	1	0	1	0
9	0	0	0	0	1	1	0	1	1
10	0	0	0	0	1	1	1	0	0
11	0	0	0	0	1	1	1	0	1
12	0	0	1	1	0	0	0	0	0
13	0	0	1	1	0	0	0	0	1
14	0	0	1	1	0	0	0	1	0
15	0	0	1	1	0	0	0	1	1
16	0	0	1	1	0	0	1	0	0
17	0	0	1	1	0	0	1	0	1
18	0	0	1	0	0	1	0	0	0
19	0	0	1	0	0	1	0	0	1
20	0	0	1	0	0	1	0	1	0
21	0	0	1	0	0	1	0	1	1
22	0	0	1	0	0	1	1	0	0
23	0	0	1	0	0	1	1	0	1
24	0	1	0	0	1	0	0	0	0
25	0	1	0	0	1	0	0	0	1
26	0	1	0	0	1	0	0	1	0
27	0	1	0	0	1	0	0	1	1
28	0	1	0	0	1	0	1	0	0
29	0	1	0	0	1	0	1	0	1
30	0	1	0	1	0	1	0	0	0
31	0	1	0	1	0	1	0	0	1
32	0	1	0	1	0	1	0	1	0
33	0	1	0	1	0	1	0	1	1
34	0	1	0	1	0	1	1	0	0
35	0	1	0	1	0	1	1	0	1
36	0	1	1	0	0	0	0	0	0
37	0	1	1	0	0	0	0	0	1
38	0	1	1	0	0	0	0	1	0
39	0	1	1	0	0	0	0	1	1
40	0	1	1	0	0	0	1	0	0
41	0	1	1	0	0	0	1	0	1
42	0	1	1	0	1	1	0	0	0
43	0	1	1	0	1	1	0	0	1
44	0	1	1	0	1	1	0	1	0
45	0	1	1	0	1	1	0	1	1
46	0	1	1	0	1	1	1	0	0
47	0	1	1	0	1	1	1	0	1
48	1	0	0	1	0	0	0	0	0
49	1	0	0	1	0	0	0	0	1
50	1	0	0	1	0	0	0	1	0
51	1	0	0	1	0	0	0	1	1
52	1	0	0	1	0	0	1	0	0
53	1	0	0	1	0	0	1	0	1
54	1	0	0	0	0	1	0	0	0
55	1	0	0	0	0	1	0	0	1
56	1	0	0	0	0	1	0	1	0
57	1	0	0	0	0	1	0	1	1
58	1	0	0	0	0	1	1	0	0
59	1	0	0	0	0	1	1	0	1
60	1	0	1	0	1	0	0	0	0
61	1	0	1	0	1	0	0	0	1
62	1	0	1	0	1	0	0	1	0
63	1	0	1	0	1	0	0	1	1
64	1	0	1	0	1	0	1	0	0
65	1	0	1	0	1	0	1	0	1
66	1	0	1	1	0	1	0	0	0
67	1	0	1	1	0	1	0	0	1
68	1	0	1	1	0	1	0	1	0
69	1	0	1	1	0	1	0	1	1
70	1	0	1	1	0	1	1	0	0
71	1	0	1	1	0	1	1	0	1

To provide a revolution count which is cyclic in six revolutions to knit a 216 stitch row pattern requiring only one feeder per group, the selector switch **133** (FIG. **7**) is set to position X6. When the selector switch is in this position, only signals ER1, ER2 and ER4 are utilized to repetitively count from zero to five. Thus, on the sixth, 12th, 18th, etc., needle cylinder revolutions the signals ER1, ER2 and ER4 are logically combined to indicate revolution zero when the selector switch **133** is set to position X6.

A revolution count which is cyclic in 12 revolutions is necessary to knit a **216** stitch row pattern requiring two feeders per group. To accomplish this the selector switch **133** is set to position X12 and signals ER1, ER2, ER4 and ER6 are utilized to repetitively count from zero to eleven.

When the selected pattern requires three feeders per group, the selector switch 133 is set to position 18X to enable signals ER1, ER2, ER4, ER6/3 and ER12/3 to be combined to provide a revolution count which is cyclic in eighteen revolutions. It should be noted that the ER6/3 signal was utilized rather than the ER6 signal. This is because repetitive counting to eighteen requires that the signal given a weight of six must be at logic level zero for cylinder revolutions 12 – 17 during one counting cycle and remain at level zero for revolutions 0 – 5 of the next following counting cycle. Since the ER6 signal must change logic levels every six revolutions to enable this signal to be used for a revolution count which is cyclic in 12 revolutions, this signal is unsatisfactory for use in providing a revolution count which is cyclic in 18 revolutions. It should likewise be noted that the ER12/3 signal was utilized rather than the ER12 signal. This is because repetitive counting to 18 requires that a signal given the weight of 12 must be at a logic one for cylinder revolutions 12–17 during each counting cycle, and the ER12 signal is at a logic zero during a needed portion of the entire 0–71 cylinder revolution counting capacity of the coarse disc, i.e., the ER12 signal is at a logic level zero during needle cylinder revolutions 30–35 and 48–53 as can be seen from the truth table.

Finally, when a 216 stitch row pattern requiring four feeders per group is to be knitted, the selector switch is set to position X24. This setting of the selector switch results in signals ER1, ER2, ER4, ER6 and ER12 being utilized to provide a revolution count which is cyclic in 24 revolutions.

Referring to FIG. 7, it will be seen that signals ER1, ER2, and ER4 are connected to the A1, A2, and A4 terminals of a full binary adder or register means 131 which is identical to and has terminals identified the same as adder 111. A multi-position selector switch 133 has a wiper contact 132 connected to a source of voltage +V which represents a logic one. Each of the terminals of switch 133 may be connected to ground (logic zero) by a resistor 134 to insure that a logic zero appears thereon whenever the wiper contact 132 is turned to another position. The terminals are designated X6, X12, X18 and X24, the numerical portion of the designation indicating the number of revolutions per pattern cycle.

The logic circuitry for gating revolution number signals ER1 – ER24 is fully described by the circuit diagram of FIG. 7 and therefore need not be described verbally. Turning switch 133 to its various positions operates to enable different combinations of and gates to pair selected ones of signals ER6, ER6/3, ER12/3, and ER12 to adder 131. Selective translator circuitry for utilizing ER24 and ER48 is not shown in FIG. 7, however, the translator circuitry illustrated may be readily extended to encompass those signals. For example, ER24 would, via appropriate gating, enabled by an additional terminal on switch 133, be selectively connected to A8 and A16 of adder 131, thereby contributing 24 toward the sum at the proper time. Thus, the code tracks 93–99 cooperate with the associated readers to provide coded revolution signals which vary in response to relative movement between the needle cylinder and feeders by an extent which is a function of one complete revolution of relative movement. These coded revolution signals are indicative of the number of revolutions of relative movement which have occurred.

By way of illustration, two translator configurations will be described in detail. First, with switch 133 in the X6 position, only and gates 141 and 142 will be enabled by the output of inverter 140 being at logic one because the output of and gate 139 is at logic zero. The output of and gate 139 can be at logic one only when switch 133 is in the X24 position. However, because and gates 143, 144, 145, and 146 are disabled, no signals other than ER1, ER2, and ER4 will reach adder 131. Therfore, the output of adder 131 will be normal binary that counts 0 – 5 and repeats. These revolution signals are associated with the feeder controls 34 in the manner fully described in the aforementioned Christiansen application to repeat a selected pattern after every six revolutions of the needle cylinder.

With switch 133 in the X18 position, as shown in FIG. 7, and gates 144 and 145 are enabled to pass the ER6/3 and ER12/3 signals to adder 131. Disabled and gates 143 and 146 prevent the passage of signals ER6 and ER12. Signal ER6/3 is connected via and gate 144 and or gate 147 to B2, and thence via or gate 148 to B4. Thus, when ER6/3 is at logic one, B2 and B4 are at logic one, contributing six to the adder output. Similarly, signal ER12/3 is connected via and gate 145 and or gate 149 to B8, and thence via or gate 148 to B4. Thus, when signal ER12/3 is at logic one, twelve will be contributed to adder 131 output. Because ER6/3 and ER12/3 are never both at logic one at the same time, both signals may share the B4 terminal of adder 131.

The output of adder 131 is the revolution number in normal binary arithmetic. The revolution number digit signals are designated R1, R2, R4, R8, R16, and R32, the numerical portion of the designation indicating the numerical weighting of the digit signal.

Description of how the signals generated by the encoder of the present invention are utilized by the knitting machine control in the manner fully described in Paul Christiansen application Ser. No. 193,047 filed Oct. 27, 1971, and entitled Knitting Machine Controls. Suffice it to be said here that the encoder of the present invention provides electrical signals necessary for generating data addresses for retrieving patterning information from a memory, and provides signals for insuring that the right data reaches the right actuator at the right time. Those who are interested in the manner in which the signals from the encoder 25 may be utilized to effect operation of a knitting machine are referred to the aforementioned Christiansen application.

It will be appreciated that the arithmetic base of the encoder of the present invention may be altered to suit the requirements of any particular circular knitting machine without departure from the spirit or scope of the claims. It should also be understood that although the present invention has been described herein in association with a knitting machine of the type in which the needle cylinder rotates relative to stationary feeders, the present invention could be utilized in association with a known type of knitting machine in which the feeders rotate relative to a stationary needle cylinder. It should also be understood that although it is contemplated that the present invention can advantageously be used with the knitting machine controls of the aforementioned Christiansen application, the present invention can also be used in conjunction with other knitting machine control systems.

Having described a specific preferred embodiment of the invention, the following is claimed:

1. Apparatus for use in a knitting machine having a needle cylinder holding a plurality of needles to which strands of material are fed from feeders during relative rotation between the needle cylinder and feeders to knit a predetermined one of a plurality of different patterns the knitting of each of which requires different numbers of revolutions of relative rotation between the needle cylinder and feeders with the feeders associated with each other in groups of any one of a plurality of different sizes, wherein said apparatus comprises encoder means for providing signals which vary with variations in the relative position of the needle cylinder and feeders and for providing revolution signals which vary with revolutions of relative rotation between the needle cylinder and the feeders, said encoder means includes a first code track having a plurality of zones of a first characteristic and a plurality of zones of a second characteristic, each of said zones of said first code track being of the same longitudinal extent, a second code track having a plurality of zones of the first characteristic and a plurality of zones of a second characteristic, each of said zones of a first characteristic of said second code track being of the same longitudinal extent as one of said zones of a first characteristic of said first code track and each of said zones of a second characteristic of said second code track being of a longitudinal extent which is at least twice as great as the longitudinal extent of one of said zones of a second characteristic of said first code track, first reader means for cooperating with each of said zones of the first characteristic of said first code track in turn to provide a signal of a first level during relative rotation between the needle cylinder and feeders for a first predetermined number of revolutions and for cooperating with each of said zones of the second characteristic of said first code track in turn to provide a signal of a second level during relative rotation between the needle cylinder and feeders for the first predetermined number of revolutions, and second reader means for cooperating with each of said zones of a first characteristic of said second code track in turn to provide a signal of a first level during relative rotation between the needle cylinder and feeders for the first predetermined number of revolutions and for cooperating with each of said zones of the second characteristic of said second code track in turn to provide a signal of a second level during relative rotation between the needle cylinder and feeders for a second predetermined number of revolutions which is at least twice as great as said first predetermined number of revolutions, control means for receiving signals from said encoder means and for effecting activation of the needles during relative rotation between the needle cylinder and feeders, said control means including revolution register means activated in response to revolution signals from said encoder means for providing a series of coded revolution count signals each of which is indicative of a revolution of relative movement between the needle cylinder and feeders and for sequentially repeating said series of coded revolution count signals each time a predetermined number of revolutions of relative rotation occurs between the needle cylinder and feeders during operation of the knitting machine, means for effecting a knitting of a selected one of the plurality of patterns each time said series of coded revolution count signals is repeated by said revolution register means, and selector means for varying the predetermined number of revolutions required to effect a repetition of said series of coded revolution count signals by said revolution register means to enable the knitting machine to knit patterns requiring different numbers of revolutions of relative rotation between the needle cylinder and feeders, said selector means including switching means for effecting a transmittal of signals from said first reader means to said revolution register means during the knitting of a pattern requiring a first predetermined number of revolutions of relative movement between the needle cylinder and feeders and for effecting transmittal of signals from said second reader means to said revolution register means during the knitting of a pattern requiring a second predetermined number of revolutions of relative movement between the needle cylinder and feeders.

2. Apparatus as set forth in claim **1** wherein said encoder means further includes means for providing feeder signals which vary as a function of relative movement between the needle cylinder and feeders, said control means further including feeder register means activated in response to feeder signals from said encoder means for providing a series of coded feeder count signals which are indicative of the feeder in which a predetermined needle on the needle cylinder is located during a revolution of relative movement between the needle cylinder and feeders.

3. A knitting machine for use in knitting a selected one of a plurality of patterns, said machine comprising a needle cylinder, a plurality of needles disposed on said needle cylinder in a circular array which begins with a first needle and ends with a last needle, a plurality of feeders disposed about said needle cylinder for feeding strands of material to said needles, actuator means in each of said feeders for effecting operation of said needles to knit the strands of material into a pattern, drive means for effecting relative rotation between said feeders and said needle cylinder and for effecting sequential cooperation between each of said feeders and each of said needles in turn such that each of said feeders is associated in turn with each of said needles on said needle cylinder, encoder means for providing signals which vary with variations in the relative position of said needle cylinder and feeders, said encoder means including first circular code track means, first reader means cooperating with said first circular code track means to provide binary coded feeder signals which vary with relative movement between said feeders and needle cylinder, second circular code track means distinct from said first circular code track means, and second reader means distinct from said first reader means cooperating with second circular code track means to provide binary coded revolution signals which vary with relative movement between said feeders and needle cylinder, control means for receiving signals from said encoder means and for effecting activation of said actuator means to knit a pattern during relative movement between said needle cylinder and feeders, said control means including feeder register means activated in response to feeder signals from said first reader means means for arithmetically operating on said binary coded feeder signals to provide a series of binary coded feeder count signals indicative of the particular feeder with which said first needle is associated during relative rotation between said needle cylinder and feeders and which binary coded feeder count signals vary in response to a change in the feeder with which said first needle is associated, said control means including revolution register means activated in response to said binary coded revolution signals from said second reader means for providing a series of coded revolution count signals each of which is indicative of a revolution of relative movement between the needle cylinder and feeders.

4. A knitting machine as set forth in claim **3** wherein said revolution register means includes means for sequentially repeating said series of coded revolution count signals each time a predetermined number of revolutions of relative rotation occurs between the needle cylinder and feeders during operation of the knitting machine and a plurality of circuit means which are selectively activatable to conduct signals from said plurality of reader means to said revolution register means, for effecting a knitting of a selected one of the plurality of patterns each time said series of coded revolution count signals is repeated by said revolution register means, and selector means for varying the predetermined number of revolutions required to effect a repetition of said series of coded revolution count signals by said revolution counter means to enable the knitting machine to knit patterns requiring different numbers of revolutions of relative rotation between the needle cylinder and feeders, said selector means including switching means for activating predetermined combinations of said circuit means to effect a repetition of said series of revolution count signals by said revolution register means in a number of revolutions corresponding to a selected one of the plurality of patterns.

5. A knitting machine for knitting any one of a plurality of different patterns, said machine comprising a needle cylinder, a plurality of spaced apart needles disposed on said needle cylinder and arranged in a circular array extending between a first needle and a last needle, a plurality of feeders disposed about said needle cylinder for feeding strands of material to said needles, said feeders being associated with each other in feeder groups comprised of a number of feeders which is variable to correspond to a selected pattern, drive means for providing relative movement between said needle cylinder and feeders to enable said first needle to be associated with each of said feeders in turn, encoder means for providing signals which vary with relative movement between said needle cylinder and feeders, said encoder means including first code track and reader means for providing needle signals which vary in response to relative movement between said needle cylinder and feeders by an extent corresponding to the spacing of adjacent needles, second code track and reader means for providing coded feeder signals which vary in response to relative movement between said needle cylinder and feeders by an extent which is a function of the spacing of adjacent feeders, said coded feeder signals being indicative of the feeder with which said first needle is associated, and third code track and reader means for providing coded revolution signals which vary in response to relative movement between said needle cylinder and feeders by an extent which is a function of one complete revolution of relative movement, said coded revolution signals being indicative of the number of revolutions of relative movement which have occurred between said needle cylinder and feeders during the knitting of a pattern, and control means for receiving said needle signals, coded feeder signals, and coded revolution signals from said encoder means and for effecting activation of said needles during relative rotation between said needle cylinder and feeders, said third code track and reader means including one code track having a plurality of zones of a first characteristic and a plurality of zones of a second characteristic, each of said zones of said one code track being of the same longitudinal extent, another code track having a plurality of zones of a first characteristic and a plurality of zones of a second characteristic, each of said zones of a first characteristic of said other code track being of the same longitudinal extent as one of said zones of said one code track and each of said zones of a second characteristic of said other code track having a longitudinal extent which is greater than the longitudinal extent of one of said zones of a first characteristic of said other code track, a first reader for cooperating with each of said zones of the first characteristic of said one code track in turn to provide a signal of a first level during relative rotation between said needle cylinder and feeders for a first predetermined number of revolutions and for cooperating with each of said zones of the second characteristic of said one code track in turn to provide a signal of a second level during relative rotation between the needle cylinder and feeders for said first predetermined number of revolutions, and a second reader for cooperating with each of said zones of a first characteristic of said other code track in turn to provide a signal of a first level during relative rotation between said needle cylinder and feeders for said first predetermined number of revolutions and for cooperating with each of said zones of the second characteristic of said other code track in turn to provide a signal of a second level during relative rotation between the needle cylinder and feeders for a second predetermined number of revolutions which is greater than said first predetermined number of revolutions, said control means including switching means for enabling said control means to utilize signals from said first reader during the knitting of a pattern requiring a first predetermined number of revolutions of relative movement between the needle cylinder and feeders and for enabling said control means to utilize signals from said second reader during the knitting of a pattern requiring a second predetermined number of revolutions of relative movement between the needle cylinder and feeders.

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