United States Patent

Takano

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[45] **Feb. 1, 1972**

[54] **TIMER SWITCH APPARATUS WITH IMPROVED FLEXIBLE CHAIN WITH CODED MOVABLE PINS**

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[52] **U.S. Cl.**.....**200/33 C,** 66/156, 200/38 CA, 74/568 R, 139/334

[51] **Int. Cl.**.....**H01h 7/00,** D04b 15/66, D03c 15/02

[58] **Field of Search**.....59/5–8, 93; 66/156; 74/568; 200/33 B, 33 C, 153 L, 153 LA, 153 LB, 166 BG, 38 CA, 38 C; 139/334

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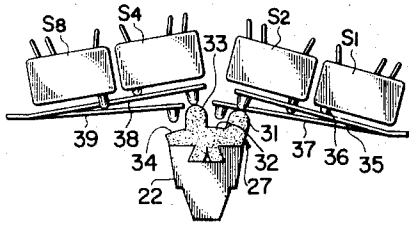
Primary Examiner—J. R. Scott

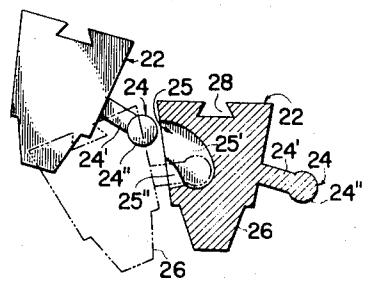
Attorney—Stevens, Davis, Miller & Mosher

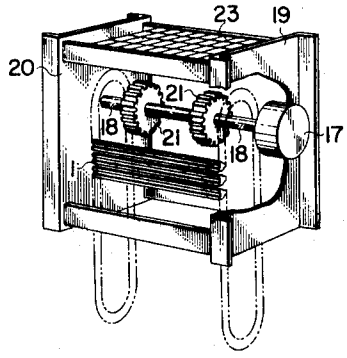
[57] **ABSTRACT**

A numerical control apparatus for use in an automation such as an automatic positioning apparatus which automatically positions the locations for boring, parts mounting or cutting. In this numerical control apparatus, a command signal for controlling the automation is generated by actuation of a multiplicity of microswitches by code pins which are sequentially moved to their microswitch actuating positions.

4 Claims, 17 Drawing Figures







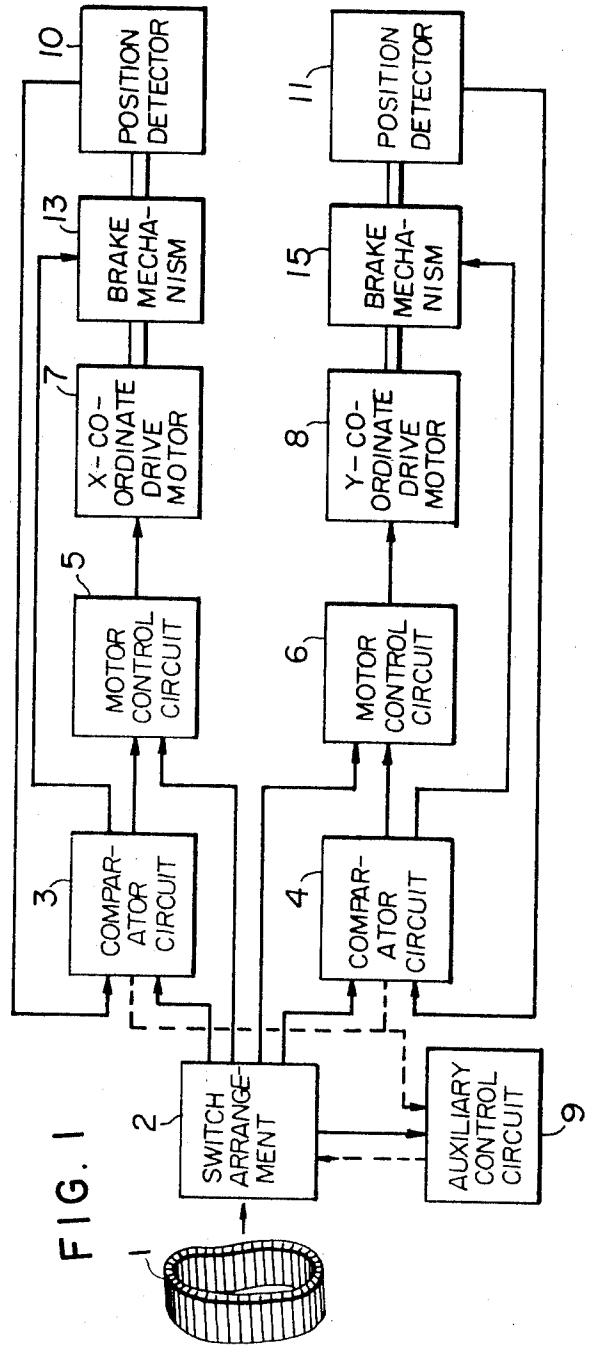


FIG. 1

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ATTORNEYS

FIG. 2

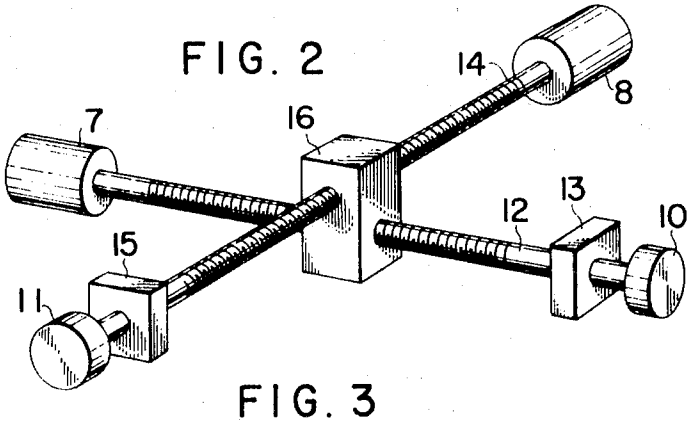


FIG. 3

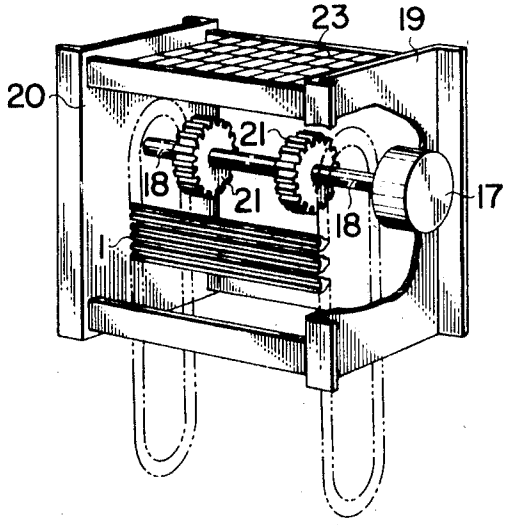


FIG. 4

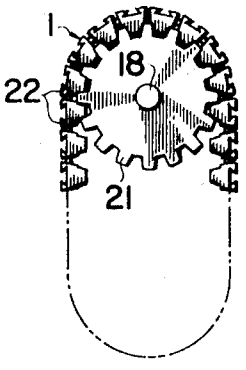


FIG. 5a

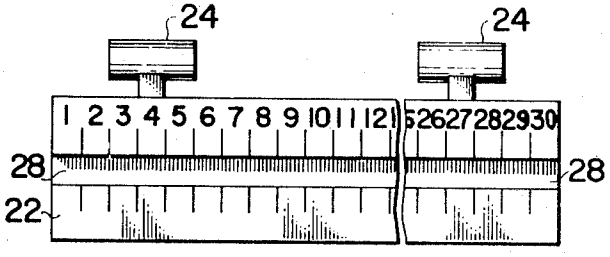


FIG. 5b

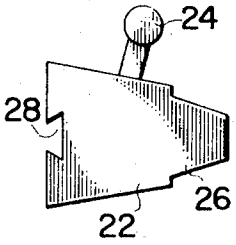


FIG. 5c

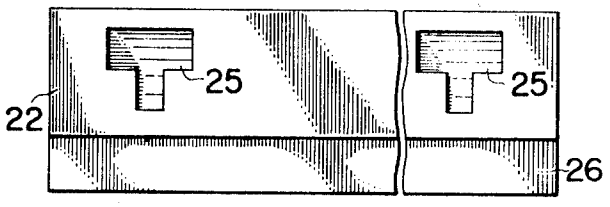


FIG. 6

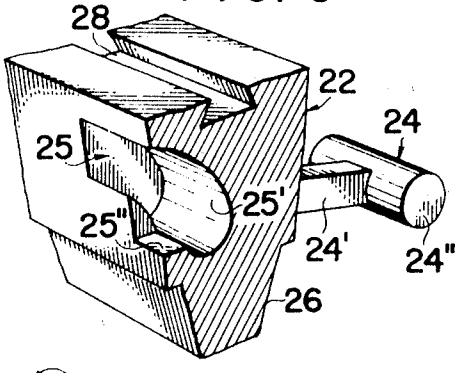


FIG. 7

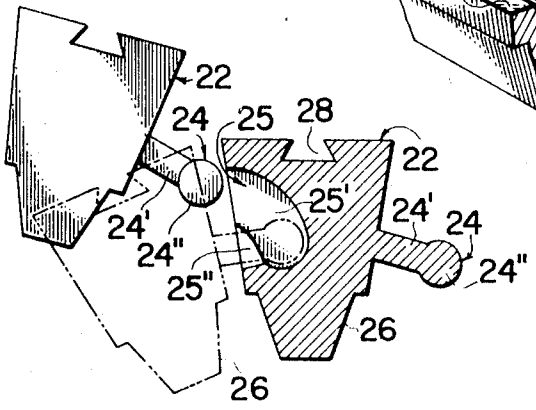


FIG. 8

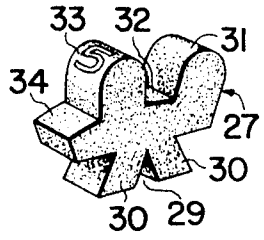


FIG. 9

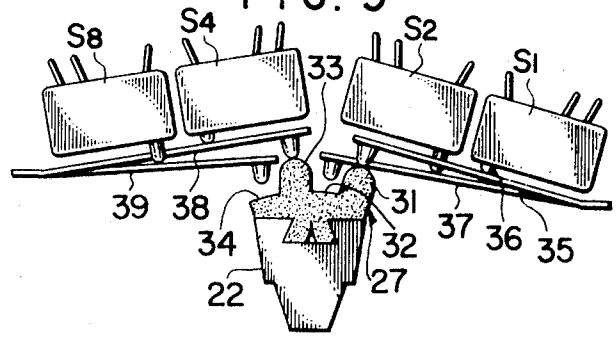


FIG. 10

DECIMAL	BINARY CODE 8 4 2 1	COLOUR CODE
0		BLACK
1		BROWN
2		RED
3		ORANGE
4		YELLOW
5		GREEN
6		BLUE
7		VIOLET
8		GREY
9		WHITE
SWITCH	S8 S4 S2 S1	

FIG. 11

LETTER		
A		GOLD
B		SILVER
C		PINK
D		LIGHT BLUE
E		YELLOWISH GREEN
F		ROUGE

FIG. 12

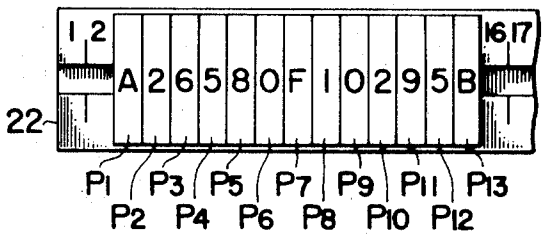

1 2
16 17
A 2 6 5 8 0 F 1 0 2 9 5 B
22
P1 P3 P5 P7 P9 P11 P13
P2 P4 P6 P8 P10 P12

FIG. 13

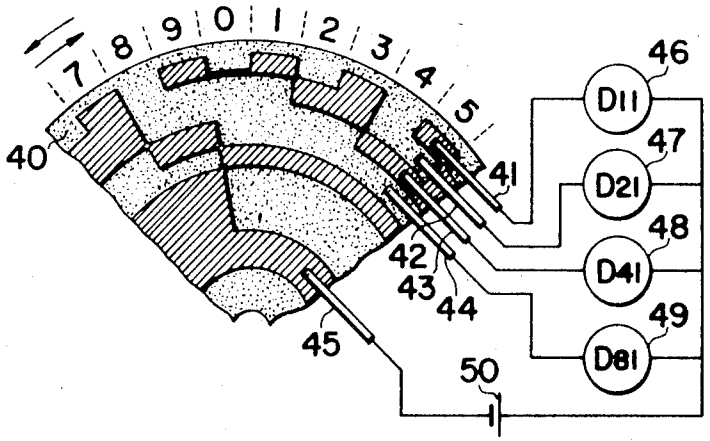

7 8 9 0 1 2 3 4 5
40
41
42
43
44
45
46
47
48
49
50
D11
D21
D41
D81

FIG. 14

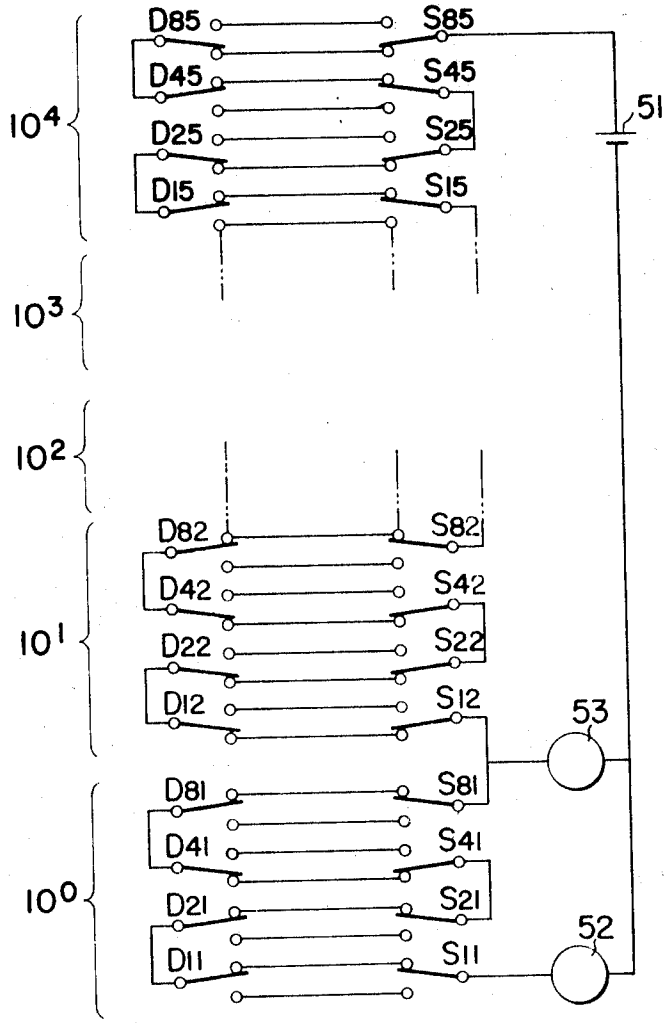
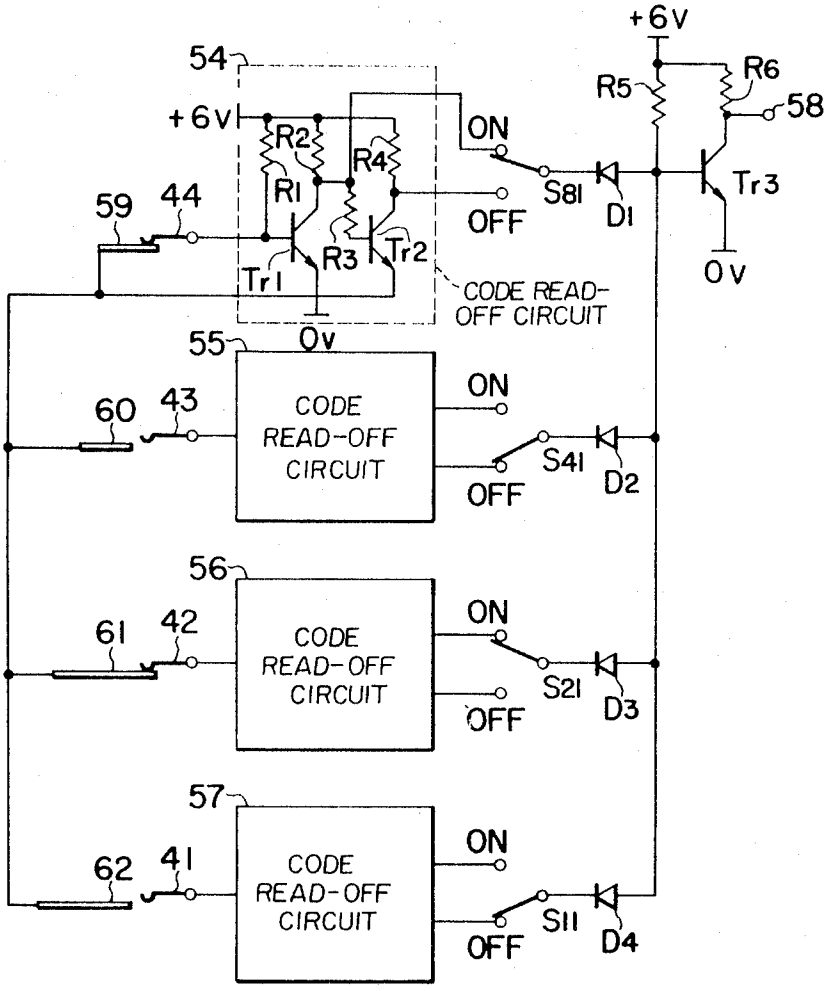

D85
S85
D45
S45
D25
S25
D15
S15
10⁴
10³
10²
D82
S82
D42
S42
D22
S22
D12
S12
10¹
D81
S81
D41
S41
D21
S21
D11
S11
10⁰
51
53
52

FIG. 15


+6V
54
+6V
R2
R4
R1
59
44
R3
Tr2
Tr1
0V
CODE READ-OFF CIRCUIT
ON
OFF
S81
D1
R5
R6
58
Tr3
0V
55
0V
60
43
CODE READ-OFF CIRCUIT
ON
OFF
S41
D2
56
61
42
CODE READ-OFF CIRCUIT
ON
OFF
S21
D3
57
62
41
CODE READ-OFF CIRCUIT
ON
OFF
S11
D4

TIMER SWITCH APPARATUS WITH IMPROVED FLEXIBLE CHAIN WITH CODED MOVABLE PINS

This invention relates to a programmed switching type numerical control apparatus.

Conventional numerical control apparatus have been a simplified form of an electronic computer comprising a number of electronic parts, mainly, transistors and IC's. These prior-art numerical control apparatus effect control of automatic positioning first by punching a paper tape with process information or recording it in a magnetic tape, second by reading out the recorded process information by the use of an optical tape reader or magnetic tape reproducing device, respectively and then by discriminating or operating the readout information to generate a command signal by a computerlike electronic device. However, these prior-art type control apparatus have a complicated construction which leads to high-production costs, and they require high-level production techniques and many maintenance engineers who must have been trained for a long time. And, the control apparatus are difficult to handle.

It is, therefore, an object of this invention to eliminate the above-said disadvantages and to provide a programmed switching type numerical control apparatus in which various process information is arbitrarily set by combinations of a plurality of code pins which are adapted to actuate some of a multiplicity of microswitches for generating a command signal, thus obviating the necessity of a paper tape, tape reader and complicated electronic devices as well as providing for a simplified structure and ease of handling.

It is another object of this invention to provide a programmed switching type numerical control apparatus in which a plurality of bars carrying thereon the information-stored code pins are detachably connected to form an endless belt which is rotated by meshing engagement with gears, whereby the stored process information can be modified by varying the number of the code pin carrying bars thus providing for the setting of a wide variety of process information.

It is another object of this invention to provide a programmed switching type numerical control apparatus in which each of the code pins carried on the plurality of bars connected in an endless form is formed with coded projections which can be easily identified as to what codes they mean, thus facilitating the setting of the process information.

It is another object of this invention to provide a programmed switching type numerical control apparatus in which each of the code pin carrying bars comprises a mounting groove formed in its top surface to detachably mount a plurality of code pins formed in their top surfaces with coded projections, a connecting portion projecting from one side surface thereof, a recess formed in the other side surface to detachably receive the connecting portion of a different code pin carrying bar, and a protuberance formed in its lower surface, whereby when the plurality of code pin carrying bars are connected to form an endless belt, with the connecting portions inserted in the recesses, the protuberances of the bars form teeth with which a gear meshes so that the endlessly connected bars are sequentially moved, providing for accurate positioning.

It is another object of this invention to provide a programmed switching type numerical control apparatus in which a plurality of code pin carrying bars each having a protuberance formed in its bottom surface, a connecting portion extending from one side surface thereof, a recess formed in the other surface and a groove formed in its top surface to detachably mount a plurality of code pins are connected to form an endless belt which is rotated by the protuberances of the bars meshing with a rotating gear, so that when the code pins mounted on the top surface of the bars are moved to predetermined positions the coded projections formed on the top surfaces of the code pins close some of the contacts of a multiplicity of microswitches mounted around the predetermined positions to generate command signals, whereby the process information can be easily set only by selectively varying the number of the code pin carrying bars and changing code pins mounted on the bars, thus obviating the necessity of conventionally employed complicated and costly electronic devices and enabling maintenance engineers to be trained in an extremely short time.

One preferred embodiment is shown by way of example in the accompanying drawings, in which:

FIG. **1** is a block diagram showing a control apparatus according to one embodiment of this invention;

FIG. **2** is a fragmentary perspective view showing one example of a table drive mechanism;

FIG. **3** is a partially broken away perspective view showing a programmed switch arrangement;

FIG. **4** is a fragmentary side view showing an endless belt carrying thereon process information and a gear which is in mesh with the belt;

FIG. **5***a*, **5***b* and **5***c* are a top plan, end and side views, respectively, showing a code pin carrying bar;

FIG. **6** is a fragmentary perspective view, partially in section, of the code pin carrying bar;

FIG. **7** is a cross-sectional view showing the connection between two identical bars;

FIG. **8** is a perspective view showing a code pin representing the numerical value "5";

FIG. **9** is a side view showing how a plurality of microswitches are actuated by the code pin;

FIG. **10** is a table showing the correspondence between numerical values and code pin configurations;

FIG. **11** is a table showing the correspondence between letters and code pin configurations;

FIG. **12** is a top plan view showing a bar having on its top surface a plurality of code pins;

FIG. **13** is a fragmentary view showing a coded disc, a plurality of brushes and corresponding relay circuits;

FIG. **14** is a circuit diagram showing one example of a comparator; and

FIG. **15** is a circuit diagram showing one example of a solid state comparator.

This invention will be explained hereinafter as to where it is applied to automatic positioning of a table simultaneously with respect to X and Y coordinates, for ease of illustration.

Referring to FIG. **1**, a numerical control apparatus is shown, in which an endless belt **1** which carries thereon numerical signals representing positions to be set and various command signals are adapted to sequentially actuate a programmed switch arrangement **2**, that is, to feed process information step by step by cooperation with the switch arrangement **2**. An X-distance control numerical signal of the readout process information is fed to a comparator **3** and a Y-distance control numerical signal to another comparator **4**. A command signal as to the direction and speed of movement is fed to an X-coordinate drive motor control circuit **5** and a Y-coordinate drive motor control circuit **6** to determine the direction and speed of rotation of an X-coordinate drive motor **7** and Y-coordinate drive motor, respectively. The remaining process information is a command signal other than location control signal, which command signal is fed to an auxiliary control circuit **9** to, for example, vary drill revolutions or control air valves. Also applied to the comparator circuits **3** and **4** are position signals generated from position detectors **10** and **11**, which position signals are compared with the X-distance and Y-distance control numerical signals. As a result of such a comparison, the difference signals obtained are fed to the X-coordinate and Y-coordinate drive motor control circuits **5** and **6**, respectively, to control the X-coordinate and Y-coordinate drive motors **7** and **8**, respectively.

As best seen in FIG. **2**, the X-coordinate drive motor **7** is operatively connected with one end of a threaded rod **12** which has a brake mechanism **13** and a position detector **10** provided at the other end thereof. The Y-coordinate drive motor **8** is also operatively connected with one end of another threaded rod **14** having a brake mechanism **15** and a position detector **11** provided at the other end thereof. The threaded rods **12** and **14** extend through a nut element mutually perpen-

dicularly so that when the threaded rods **12** and **14** are rotated axially the nut element **16** is moved simultaneously with respect to X- and Y-coordinates. Thus, a table (not shown) secured to the nut element **16** can be controlled to move simultaneously with respect to the X- and Y-coordinates. Since the position signals fed from the position detectors **10** and **11** change as the motors **7** and **8** are rotated, there should occur coincidence between the position signals and the above-mentioned numerical signals. When this coincidence takes place, the comparator circuits **3** and **4** feed coincidence signals to the motors **7** and **8** and the brake mechanisms **13** and **15** to stop the rotation of motors **7** and **8**. Automatic positioning of the table is stopped in response to the occurrence of the coincidence signals, and then other operations such as, for example, boring and parts mounting are performed in response to signals from the auxiliary control circuit **9**. In this manner, when the one-step operation is finished, the programmed switch arrangement **2** operates to read off process information stored next step and similar operations are sequentially performed at different locations.

FIG. **3** shows a programmed switch arrangement. A rotary solenoid **17** which serves to drive the endless belt **1** is operatively connected with a shaft **18** which is rotatably supported by side plates **19** and **20**. Secured to the shaft **18** are two gears **21** which are adapted to mesh with the endless belt **1**, as best shown in FIG. **4**. As previously described, the endless belt comprises a combination of a plurality of code pin carrying bars shown in FIG. **5**. A microswitch arrangement **23** comprising many groups of microswitches is placed opposite to the upper portion of the endless belt **1** which is positioned to be in mesh with the gears **21**. Each of the code pin carrying bars has a plurality of connecting pins **24** extending from one side surface thereof and a plurality of corresponding pin receiving recesses **25**, as best seen in FIG. **6**. As shown, the connecting pin comprises a shank portion **24'** extending from the bar **22** and a cylindrical head portion **24''** attached to the tip of the shank portion **24'**, and the pin receiving recess comprises a longitudinal hole **25'** extending arcuately downwardly and adapted to receive the cylindrical head portion **24''** and a transverse hole **25''** connecting the inmost depths of the longitudinal hole **25'** with the exterior in a shortest way and adapted to receive the shank portion **24'**. The connection of at least two code pin carrying bars **22** is made in such a manner that, as shown in FIG. **7**, the cylindrical head portion **24''** is inserted into the longitudinal hole **25'** obliquely from above and after the head portion **24''** reaches the bottom of the longitudinal hole **25'** the bar **22** is rotated counterclockwise to the position depicted in a phantom line whereupon the shank portion **24'** is received in the transverse hole **25''**, completing the connection of the two bars **22**. The two bars **22** can be separated by reversing the above-said procedure. In this manner, a number of code pin carrying bars **22** are sequentially connected to form an endless belt **1**. The code pin carrying bar **22** has a protuberance **26** at its bottom surface, which serves as a tooth which meshes with the gears **21** so that the endless belt **1** is rotated as the gear **21** rotate. Furthermore, the bar **22** is formed with a groove **28** for mounting a plurality of code pins **27**, one of which is best shown in FIG. **8**. The code pin **27** has downwardly extending legs **30** between which a notch **29** is formed, the legs **30** fitting in the groove **28**, as best shown in FIG. **9**. The notch **29** provides resiliency to the legs **30** which, when fitting in the groove **28** are, resiliently urged against the walls of the grooves **28** to prevent the code pin **27** from being moved from its predetermined position due to vibrations. A suitable scale is applied to the top surface of the code pin carrying bar **22** in order to facilitate positioning the code pins **27** at their predetermined locations. The code pin **27** has formed in its top surface coded projections representing numerical values and letters. The code pin **27** as shown in FIG. **8** has two projections **31** and **33** representing numerical value "5." Specifically, the projections **31** and **33** represent numerical values "1" and "4," respectively, and the numerical value "5" is the sum of those "1" and "4." The code pin **27** has two recessed portions **32** and **34** together with the projections **31** and **33**. The manner in which the numerical values are coded into arrangement of projections is shown in FIG. **10**. Conversion of these codes into corresponding electric signals is made by using, for example, an arrangement as shown in FIG. **9**. Four microswitches S_1, S_2, S_4 and S_8 are placed above the code pin **27** in the manner as shown. At this time, the projection **31** urges an actuator **35** upwardly to press up the pushbutton **36** to turn on the microswitch S_1. And, the projection **33** also urges an actuator **38** upwardly to turn on the microswitch S_4. Since actuators **37** and **39** are opposite to the recessed portions **32** and **34**, they are not urged upwardly and the microswitches S_2 and S_8 remain "off." In this manner, a numerical signal of one figure is coded by a code pin **27**. In FIG. **12**, there is shown a bar **22** carrying a plurality of code pins $P_1, P_2, \ldots P_{13}$, in which a combination of five code pins P_2, $P_3, \ldots P_6$ represent a numerical value of five figures, such as, 265.80 mm. on which the X-coordinate position is determined. The letter "A" represented by the code pin P_1 corresponds to a signal which commands the direction and speed of rotation of the X-coordinate drive motor **7**. Sixteen types of code pins shown in FIGS. **10** and **11** can be selectively mounted on the bar **22**. It is well known that with a combination of four switches 16 types of switchings are possible. Reverting to FIG. **12**, a combination of five code pins $P_8, P_9, \ldots P_{12}$ represent a Y-coordinate position, 102.95 mm. The code pin P_7 representing "F" determines the direction and speed of rotation of the Y-coordinate drive motor **8**. The code pin P_{13} has a letter as shown in FIG. **11**, which represents an auxiliary control code. When the auxiliary control code is set in this position, an auxiliary control operation such as a boring operation is commanded, and this auxiliary control has 16 variations. These code pins $P_1, P_2, \ldots P_{13}$, when mounted with reference to lines and numerals indicated on the top surface of the code pin carrying bar **22**, occupy the positions at which they face four microswitches, respectively, as shown in FIG. **9**. The microswitch arrangement **23** as shown in FIG. **3** comprises a plurality of arrays of microswitches which are laterally closely arranged, each array comprising four microswitches which are combined to represent a numeral signal of one figure. The microswitches are arranged to position between the lines indicated on the top surface of the code pin carrying bar **22**, the numerals indicated between the lines designating the lateral numbers of the switches. Thus, many code pins representing numerical values of required figures and/or letters can be easily set in the endless belt **1**. The setting of the code pins may be performed at the inoperative portion of the endless belt even if the programmed switch arrangement is in operation. The setting only requires selective replacement of the unnecessary belt portion by a preset belt portion. Furthermore, the code pin carrying bars **22** may be of one identical type, which makes it possible to mass-produce the bars at a lower cost. The code pins are manufactured by drawn-working an elongated bar and cutting the bar into identical code pins having the required size. Code pins having different codes can be made by changing the positions of projections during the drawn-working operation. The designations representing what the codes mean may be conveniently provided in the upper surface of the code pins in order to facilitate identification of the codes and to thereby expedite the setting operation as well as to check the code pins which have been already set. Moreover, colored codes as shown in the tables of FIGS. **10** and **11** also facilitate the sorting operation of the code pins and provide for an increased working efficiency of the operators.

As described above, the code pins actuate the microswitch arrangement **23** to generate electric signals which are sent to the comparator circuits **3** and **4**. The comparator circuits **3** and **4** receive other inputs from the position detectors **10** and **11** whose construction and operation will be described in detail hereinafter.

The position detectors **10** and **11** may be of any commercially available type. One of those position detectors is a

coded disc type position detector as partially shown in FIG. 13, in which the angle is coded in a binary-coded decimal system like the code pins as previously described. The disc **40** may be made of the same material as a printed circuit board. To the surface of the disc **40** there is affixed a copper plate which later is selectively etched away leaving the hatched portions. The hatched portions together are electrically connected. A plurality of brushes **41, 42, 43, 44** and **45** are placed above the coded surface of the disc **40** in sliding contact therewith. The brushes **41, 42, 43, 44** and **45** and the coded surface form an electric circuit through which many electric currents flow, and the angular position can be determined by measuring those electric currents. That is, under the conditions shown, the brush **41** contacts a numeral code "1" portion, and an electric circuit through a relay **46**, the brush **41**, the conducting portion of the coded surface, the common brush **45** and a battery **50** is completed to render the relay **46** "ON." A relay **48** also is rendered "ON" since the brush **43** connected to the relay **48** also contacts the conducting portion of the coded surface. As the remaining brushes **42** and **44** do not contact the conducting portion, relays **47** and **49** remain unactuated i.e., "OFF." The numerals indicated around the periphery of the coded disc **40** are decimals represented by the codes, and FIG. **13** shows the case where numeral "5" is read off. The coded disc **40** is adapted to rotate to produce different position signals in cooperation with the relays **46, 47, 48** and **49**.

Although a coded disc which represents a number of one figure has been described, any required number of such coded discs **40** may be practically connected at different gear ratios in order to have available electric signals representing a number of five figures ranging from 00000 to 99999. When these multicoded discs **40** are employed as the position detectors **10** and **11** as shown in FIG. **2**, they generate position signals which vary in accordance with the rotations of the threaded rods **12** and **14**. If the pitch of the threaded rods **12** and **14** and the gear ratios of the gears connected with the coded discs of the piston detectors **10** and **11** are determined such that when the nut element **16** is moved by 0.01 mm. the position signal changes in corresponding numeral by 00001, the output signals from the position detectors **10** and **11**, when they both represent a number of five figures, for example, 13576, indicate that the table has 135.76 mm. of X- and Y-distances.

The comparator circuits **3** and **4** will be described hereinafter. The comparator circuits **3** and **4** employ the switch contacts of the programmed switch arrangement **2** and the relay contacts actuated by the position detectors **10** and **11**. In FIG. **14**, four relay contacts D_{15}, D_{25}, D_{45} and D_{85} together represent the ten thousandth digit of the above-mentioned position representing number and four switch contacts S_{15}, S_{25}, S_{45} and S_{85} together represent the ten thousandth digit of the above-mentioned preset number. When these relay and switch contacts D_{15}, ... D_{85} and S_{15}, ... S_{85} are connected in series as shown, an electric circuit is completed between the switch contacts **15** and **85** by way of these relays and switch contacts. The completion of this electric circuit indicates the coincidence between the ten thousandth digits of the position representing number and the preset number. Specifically, when the contacts D_{15} and S_{15} both representing numeral "1" are rendered "ON," an electric circuit is completed between them, and when the contacts D_{25} and S_{25} both representing numeral "2" are rendered "OFF," another electric circuit is completed between them. Thus, if an electric circuit is completed between the switch contacts S_{15} and S_{85}, the pair of corresponding contacts, for example, D_{15} and S_{15}, D_{25} and S_{25}, ... D_{85} and S_{85} are urged to identical positions, "ON" or "OFF". If any of the contact pairs are not urged to the positions, the electric circuit between the switch contacts S_{15} and S_{85} is not completed that is, open. Thus, it is the time when all of the contacts representing a number of five figures are connected in series that the coincidence between the position representing numbers of five figures and the preset number of five figures occurs. When this coincidence takes place, an electric current flows from a battery **51** through the serially connected circuit to a relay **52** which in turn is rendered "ON" to control the drive motor control circuits **5** and **6** such that the drive motors **7** and **8** are simultaneously deenergized with the actuation of the brake mechanisms **13** and **15**, thus stopping the movement of the table. A relay **53** is connected to a relay circuit of the tenth digit, as shown in FIG. **14**, so that the relay **53** is rendered "ON" when the coincidence of not less than the tenth digits takes place even if the unit digit of the preset number does not coincide with that of the position representing number. Thus, when the table approaches the preset position to such extent that it must be moved by a distance of 0.09–0.00 mm. before it reaches the exact position, the relay **53** actuates the drive motor control circuit **5** or **6** to slow down the drive motor **7** or **8**. By slowing down the drive motor immediately before it stops, it is possible to prevent the table from overrunning due to the inertia of the table itself or to eliminate detection errors of the unit digit position signal which is attributed to the fact that the coded disc corresponding to the unit digit is rotated at an extremely high speed. Alternatively, the relay **53** can be connected to a relay circuit corresponding to not less than the tenth digit so that a command signal for slowing down the drive motor is produced for before the preset position is reached.

Although the position detectors comprising a plurality of relays have been described to facilitate an understanding of the operation thereof, the use of the relays presents a problem as to the service life and the like in the conditions that they are employed to continuously control the movement of the table at a high speed. In order to overcome this disadvantage, the relays are replaced by a solid state circuit such as a transistorized circuit without adding to complexity.

FIG. **15** shows a comparator circuit which is made up of solid state elements, of which a portion corresponding to the unit digit is illustrated in full detail for the clarity of illustration. The brushes **41, 42, 43** and **44** are the same as those shown in FIG. **13**. The conduction plates **59, 60, 61** and **62** are the conducting surface portions of the coded disc **40**. A code readoff circuit **54** is adapted to read off the numeral "8," a code readoff circuit **55** is adapted to read off the numeral "4," a code readoff circuit **56** the numeral "2," and a code readoff circuit **57** the numeral "1."

When the brush **44** is, as shown, positioned to contact the conducting plate **59**, the base potential of a transistor Tr_1 is kept at zero level, rendering the transistor Tr_1 nonconducting so that no collector current flows therethrough. Thus, the collector potential of the transistor Tr_1 is kept at +6 volts since the source potential +6 v. is transmitted through the resistor R_2 to the collector which in turn is connected through an output line to one terminal "ON" of a microswitch contact S_{81} (corresponding to the unit digit). When this +6 volt potential is applied to a diode D_1, it is backwardly biased to cause no current to flow therethrough. This results when the present number coincides with the position signal. When the contact of the microswitch S_{81} is positioned to contact the "OFF" terminal, the +6 volt collector potential of the transistor Tr_1 is applied through a resistor R_3 to the base of a transistor Tr_2 to render the transistor Tr_2 for conduction, so that the collector current flows through a resistor R_4 to produce a voltage drop thereacross, resulting in a collector potential of approximately zero volt. Thus, a current flows from a +6 volt potential source through a resistor R_5 and the diode D_1 to the collector of the transistor Tr_2. This occurs when the preset number does not coincide with the position signal. At this time, since the base potential of a transistor Tr_3 is kept at zero volt like the collector potential of the transistor Tr_2, the transistor Tr_3 is rendered nonconducting, so that the collector potential thereof is kept at 6 volts which in turn is fed to an output terminal **58**.

When, otherwise, the brush **44** does not contact the conducting plate **59**, the +6 volt source potential is supplied through a resistor R_1 to the base of the transistor Tr_1 to render it conductive, so that the collector potential drops down to

zero volt because of a voltage drop across the resistor R_2. Thus, no current flows through the resistor R_3, which maintains the transistor Tr_2 in a nonconducting state. This condition is opposite to those previously described, and accordingly, it is when the switch contact S_{81} is positioned to make contact with the "ON" terminal that the preset number does not coincide with the position signal and it is the time when the switch contact S_{81} is positioned to contact the "OFF" terminal that the preset number coincides with the position signal. In the code readoff circuit **55** corresponding to the numeral "4," the brush **43** does not contact the conducting plate **60**, and the switch contact S_{41} is positioned to contact the "OFF" terminal, so that no current flows through a diode D_2. In the code readoff circuit **56** of the numeral "2," the brush **42** contacts the conducting plate **61** and the switch contact S_{21} is positioned to contact the "ON" side, so that no current flows through a diode D_3. In the code readoff circuit **57** corresponding to the numeral "1," the brush **41** does not contact the conducting plate **62** and the switch contact S_{11} is positioned to contact the "OFF" side, so that no current flows through a diode D_4. Under the conditions as shown, no current flows through the four diodes D_1, D_2, D_3 and D_4, and the +6 volt source potential is applied by way of the resistor R_5 to the base of the transistor Tr_3, rendering it conductive, so that the collector potential and accordingly the output potential is kept at zero volts due to a voltage drop across the resistor R_6. This results when the preset number and the position signal coincide with each other with respect to their unit digits, and, as previously described, when any of the diodes is conducting, the output potential at **58** becomes +6 volt. The circuit of this type is provided for each of five figures to achieve the same object as in FIG. **14**.

This invention has many advantages as summarized as follows:

1. As is apparent from the detailed description of the preferred embodiment, the programmed switching-type numerical control apparatus comprises a microswitch arrangement comprising a plurality of microswitches, an endless belt comprising a plurality of code pin carrying bars and a plurality of code pins detachably mounted on a plurality of bars so as to actuate the contacts of the plurality of microswitches. With this arrangement various types of process information can be set by preforming a number of code pins having various shapes corresponding to various types of codes and then combining the code pins of various shapes in accordance with the desired process information. When these code pins are moved to actuate the desired switch contacts, an electric command signal is generated. Thus, the control apparatus according to this invention is simple in construction and inexpensive as compared with the prior-art control apparatus in which process information is stored by punching a paper tape and the information is read and converted into a corresponding command signal by the use of an electric computer. Furthermore, although the prior-art control apparatus requires such troublesome procedures as punching a paper tape or recording information on a magnetic tape, it is only necessary, in the control apparatus of this invention, to combine the code pins by using the code pin carrying bars, which provides for an increased efficiency of operation and which enables operators to be trained in a shorter time.

2. In the control apparatus of this invention, a plurality of bars each for carrying a plurality of code pins which carry various types of process information are connected to form an endless belt. This endless belt is rotated by a drive mechanism to sequentially move the code pin carrying bars towards the microswitch arrangement to actuate the desired microswitches, so that an extremely wide variety of process information can be readily set by varying the arrangement of the code pins on the bars or by varying the number of the code pin carrying bars.

3. According to this invention, the code pins detachably mounted on the bars are formed with the coded projections together with marks corresponding thereto, so that the process information can be easily set only by visually identifying the code pins.

4. According to this invention, each of the code pin carrying bars has a mounting groove formed in its top surface to detachably mount a plurality of code pins having coded projections, connecting portions extending from one side surface thereof, recessed portions formed in the other side surface to receive the connecting portions of adjacent bars and a protuberance formed in its bottom surface, which is adapted to mesh with a tooth of a drive gear. With this construction, the plurality of the code pin carrying bars can be connected to form an endless belt and the code pins can also be mounted on the bar with great ease. Furthermore, since the protuberances of the bars serve as the teeth which mesh with those of the gear, no speciality gear device is necessary in order to effect accurate position control.

5. According to this invention, each of the code pin carrying bars has a mounting groove formed in its top surface to detachably mount a plurality of code pins having coded projections, connecting portions extending from one side surface, recessed portions formed in the other side surface to receive the connecting portions of adjacent bars and a protuberance formed in its bottom surface, which is adapted to mesh with a tooth of a drive gear. And, each of said code pins has downwardly extending legs between which a notch is formed to provide resiliency to the legs so that the code pin can be easily mounted and held in position in the groove of the code pin carrying bar. Furthermore, the code pins have coded projections formed in their top surfaces to actuate a plurality of microswitches of the microswitch arrangement. With these constructions, the plurality of code pin carrying bars can be easily connected to form an endless belt and can be mass produced at a lower cost because they are of identical construction. The code pins, when mounted on the bars, cannot be moved by vibrations because of the resiliency of their legs urging themselves against the walls of the groove. Furthermore, the bars have position indicating markers on their top surface, which makes it possible to mount the code pins exactly at the required positions. Moreover, the control apparatus of this invention is simple in construction and inexpensive and the programming can be easily effected, which enables maintenance engineers to be trained more quickly.

What is claimed is:

1. A programmed switching-type numerical control apparatus comprising a microswitch arrangement having a plurality of groups of microswitches, a plurality of code pins adapted to actuate some of the microswitches and having a plurality of coded projections formed in their top surfaces, and a plurality of bars each having a mounting groove formed in its top surface to detachably mount the plurality of code pins, a connecting portion extending outwardly from one side surface thereof, a recessed portion formed in the other side surface to detachably receive the connecting portion and a protuberance formed in its bottom surface, a plurality of said bars being connected to form an endless belt which is rotated by a drive mechanism, with the protuberances of the bars in mesh with the teeth of the drive mechanism.

2. A programmed switching-type numerical control apparatus in which a plurality of bars each having a mounting groove formed in its top surface to detachably mount a plurality of code pins, a connecting portions extending outwardly from one side surface thereof, a recessed portion formed in the other side surface to detachably receive the connecting portion and a protuberance formed in its bottom surface are connected to form an endless belt, the protuberances serving as teeth which mesh with the teeth of a rotating gear, a plurality of said code pins each having two downwardly extending legs between which a notch is formed to provide resiliency to the legs so that the code pins are held in position by the resiliency of the legs, the code pins further having coded projections and corresponding markers in their top surfaces, the coded projections being adapted to actuate a plurality of microswitches arranged opposite the coded projections.

3. A programmed switching-type numerical control apparatus according to claim 1, wherein a top surface of each of said code pins is equally divided into four unit sections, each of said unit sections representing unit information with a projected section indicating the presence of information and a recessed section indicating the absence of information, a combination of said four unit sections providing said surface with a configuration representing a numeral, character of symbol whereby the microswitches are actuated according to said configuration to read out the information, and an underside of each of said code pins is further formed to engage with and slide in the mounting groove of one of said plurality of bars so that a block of unit information may be represented when a plurality of said code pins are arranged side by side, said code pins thereby facilitating setting and altering of a program.

4. A programmed switching-type numerical control apparatus according to claim 1, wherein the connecting portion of said bar comprises a shank portion extending from said one side surface of said bar and a cylindrical head portion, which is fixed to the tip end of said shank portion and extends in both longitudinal directions from said shank portion, and the recessed portion of said bar comprises a longitudinal hole having a depthwise curved cross section for receiving said cylindrical head portion of an adjacent bar and a transverse hole with which said shank portion of an adjacent bar engages.

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