United States Patent

Sterns et al.

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[54] **POSITIONING OF MULTIPLE ELEMENTS**

[72] Inventors: **Robert B. Sterns; Robert R. Richards,** both of Great Neck, N.Y.

[73] Assignee: **Logic Systems, Inc.,** Great Neck, N.Y.

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[52] **U.S. Cl.** **318/603,** 318/4, 318/601, 83/4, 83/11, 83/549, 235/151.11

[51] **Int. Cl.** **G05b 19/28**

[58] **Field of Search** 318/603, 4, 601; 83/4, 6, 7, 83/11, 12, 549, 550, 559, 560, 576; 192/142; 235/151.11

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Primary Examiner—Benjamin Dobeck
Attorney—Ward, McElhannon, Brooks & Fitzpatrick

[57] **ABSTRACT**

Working elements such as cutters or scorers for operating at different width positions across a lengthwise moving web, such as paperboard, are positioned widthwise by according to a digitally coded program. Each element, which is provided with a position storage register, is moved along by an associated yoke which is also provided with a position storage register. The element storage registers are programmed, as from a tape etc. to a count corresponding to a desired new position. The yoke registers maintain a count corresponding to their actual position. All the yokes are driven along a common path across the web while simultaneous comparisons are made between each pair of registers. As the comparisons for each pair of registers reach zero the yoke is declutched and remains in position until all the others have been positioned. The yokes may then be disengaged from their elements for repositioning of other elements by making similar comparisons and driving the yokes to the positions of these other elements. Possible errors in position programming are detected prior to driving the yokes by making comparisons between the programmed element storage registers to ascertain the presence of improper register signals which call for a shift in the order of the elements.

28 Claims, 10 Drawing Figures

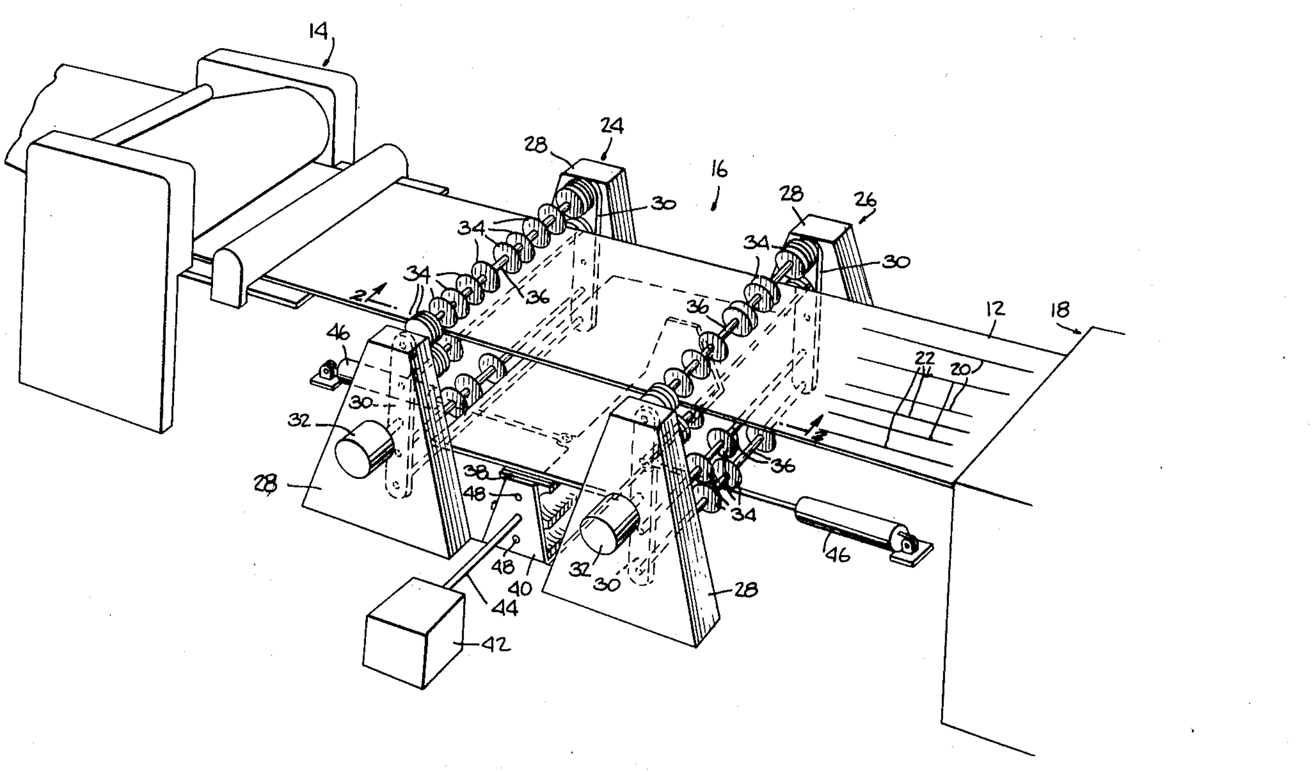
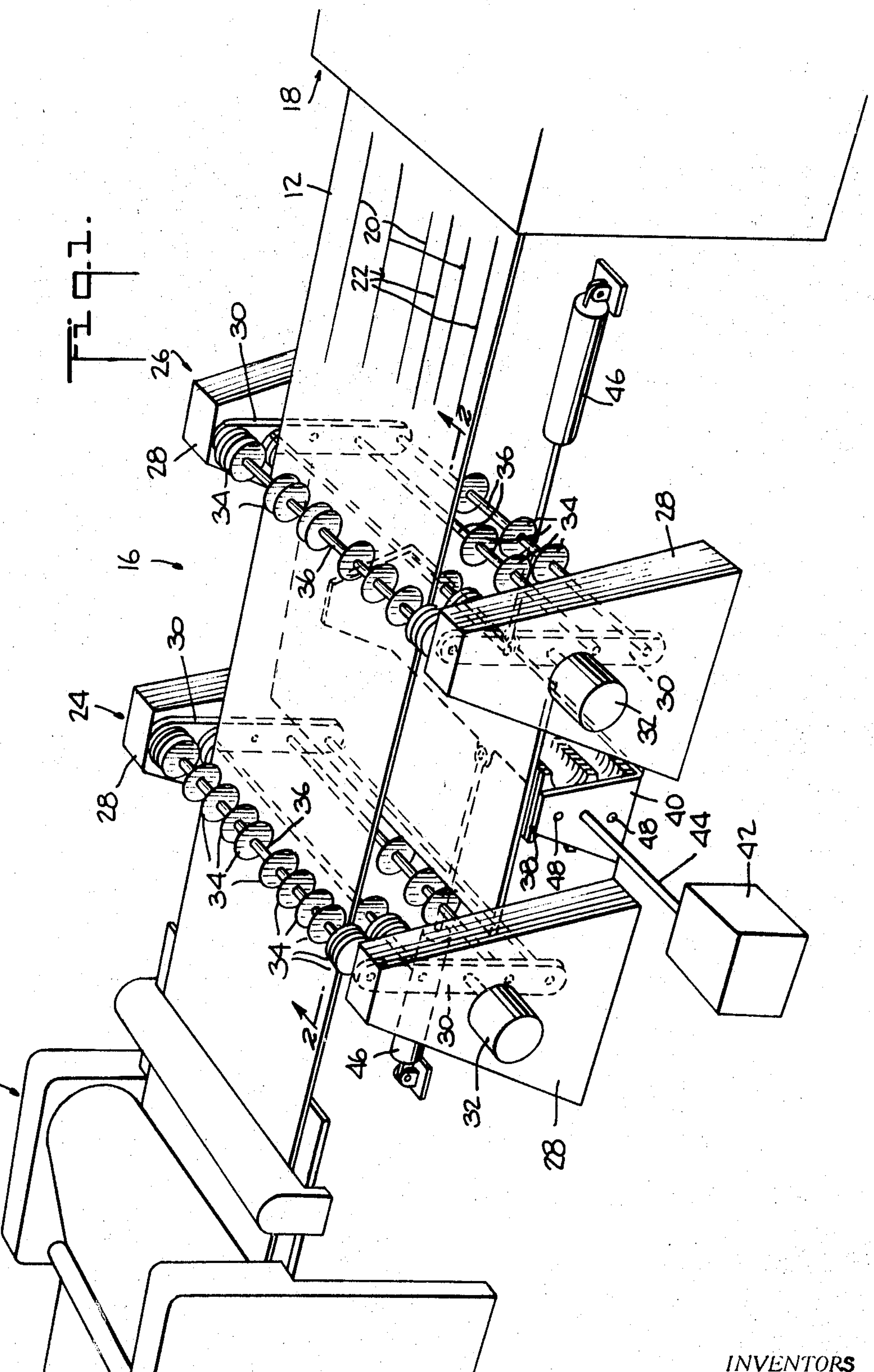


FIG. 1.



INVENTORS
ROBERT BRICKETT STERNS
BY ROBERT ROY RICHARDS

Ward, McElhannon, Brooks & Fitzpatrick
ATTORNEYS

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Fig. 2.

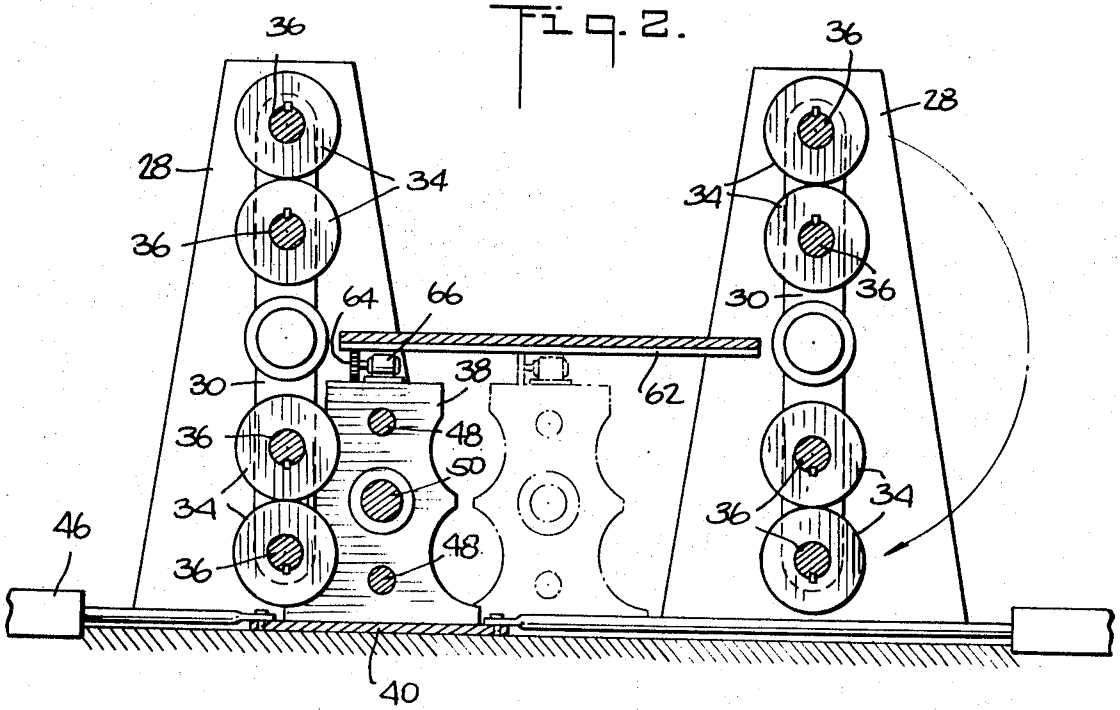
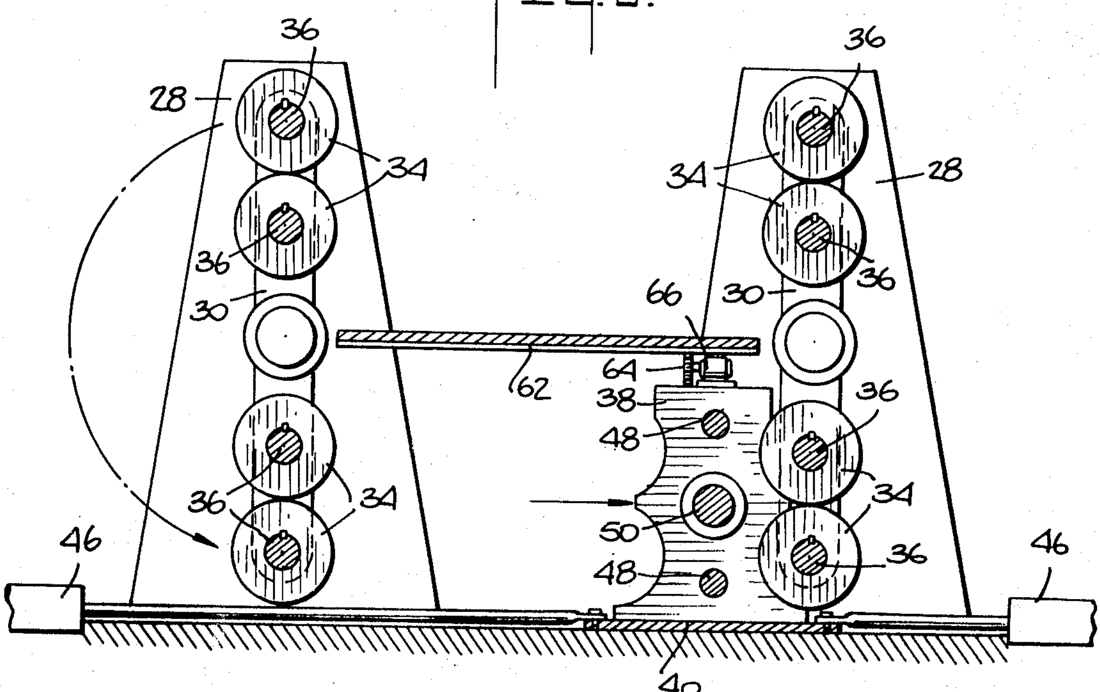


Fig. 3.



INVENTORS
ROBERT BRICKETT STEARNS
BY ROBERT ROY RICHARD

Ward McElhannon Brooks Fitzpatrick
ATTORNEYS

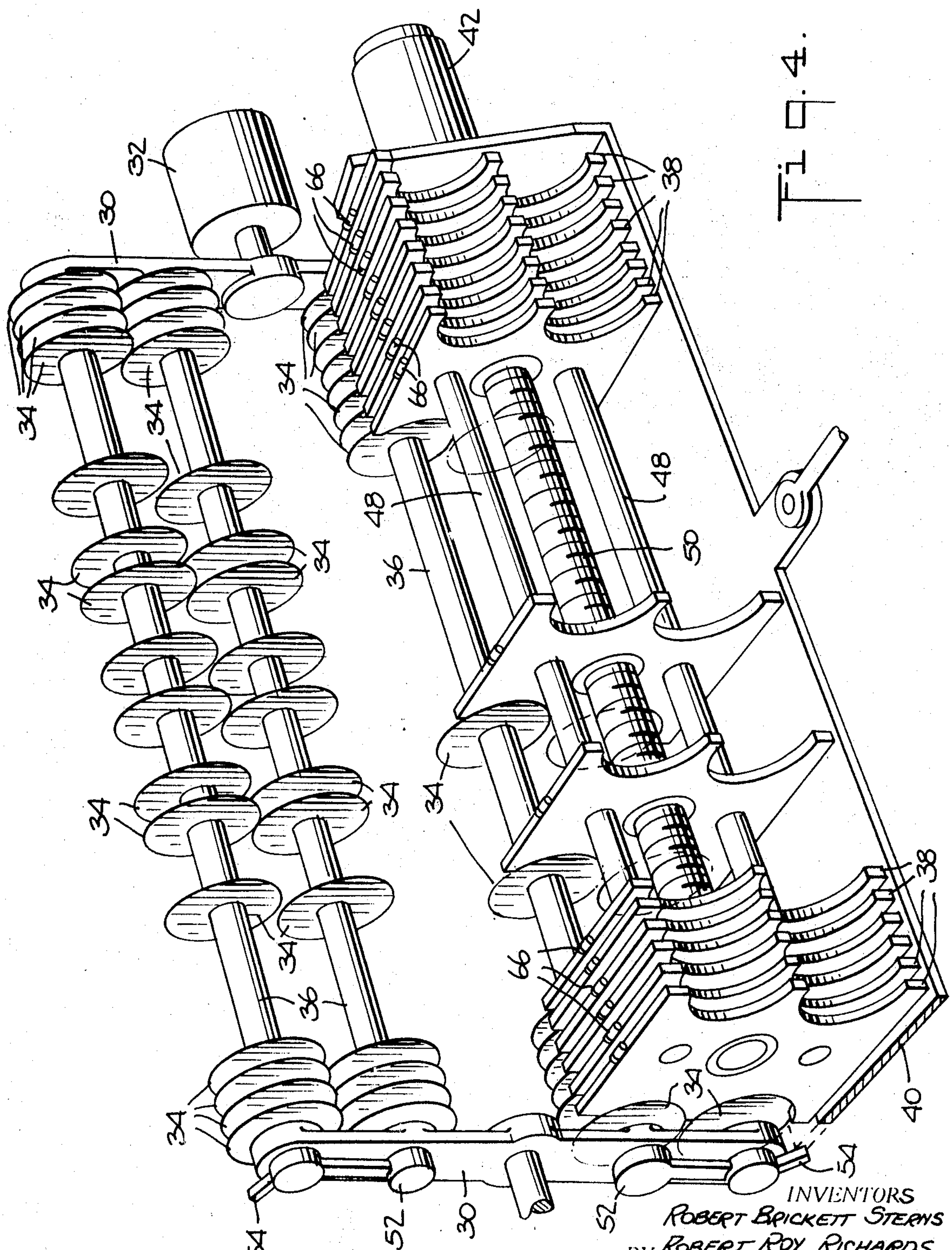


Fig. 4.

INVENTORS
ROBERT BRICKETT STERNS
BY ROBERT ROY RICHARDS

Ward McElhannon Brooks & Fitzpatrick
ATTORNEYS

Fig. 7.

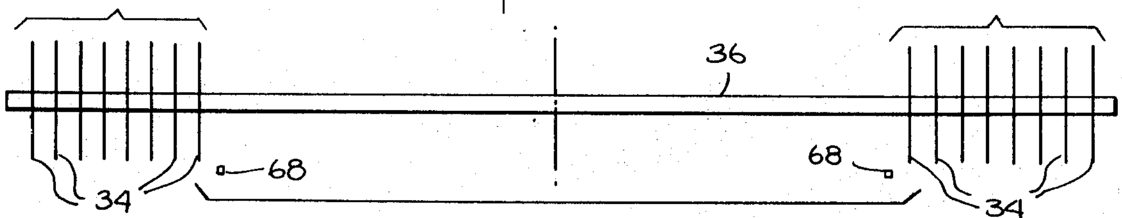
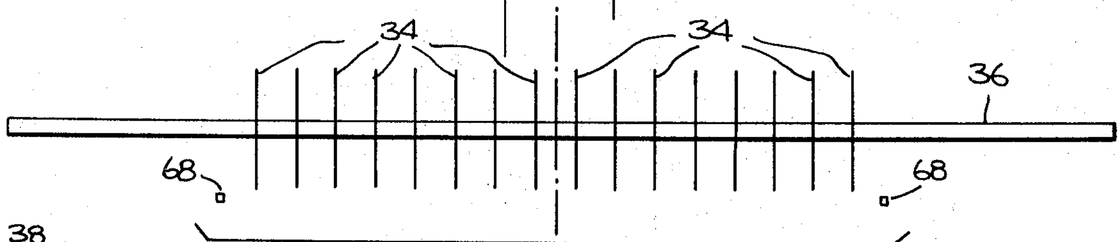


Fig. 8.



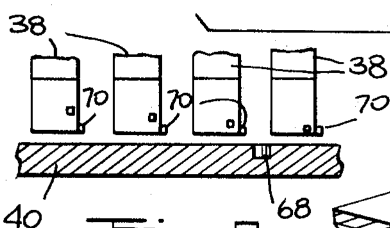


Fig. 6.

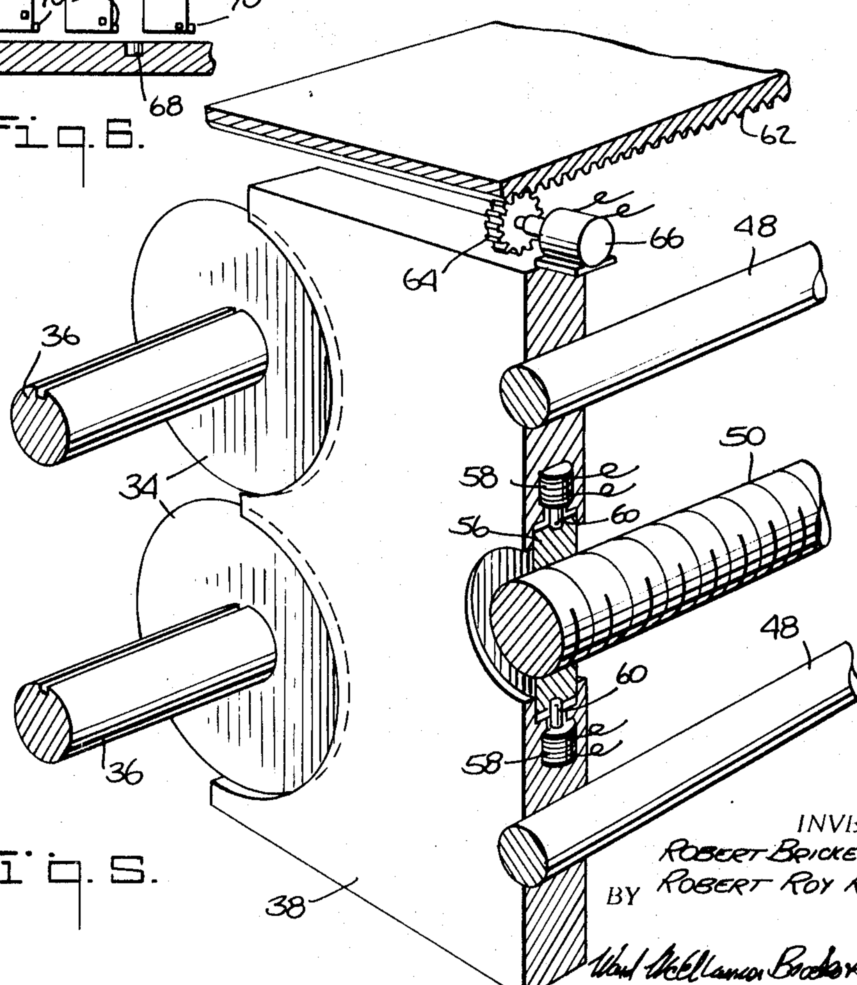


Fig. 5.

INVENTORS
ROBERT BRICKETT STERNS
BY ROBERT ROY RICHARDS

Ward, McElhannon, Brooks & Fitzpatrick
ATTORNEYS

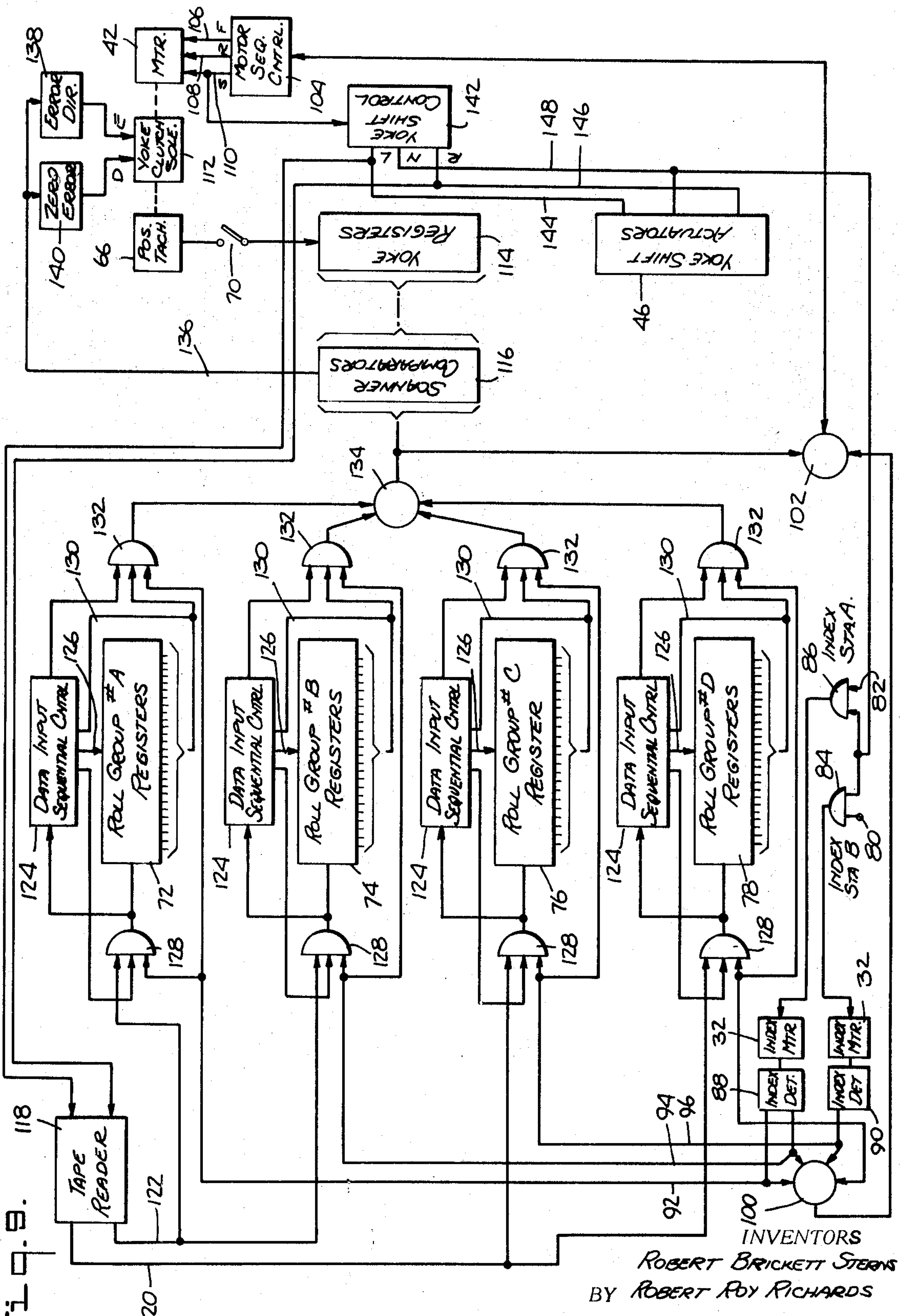


Fig. 9

INVENTORS
ROBERT BRICKETT STERNS
BY ROBERT ROY RICHARDS

Ward McElhannon Brooks Fitzpatrick
ATTORNEYS

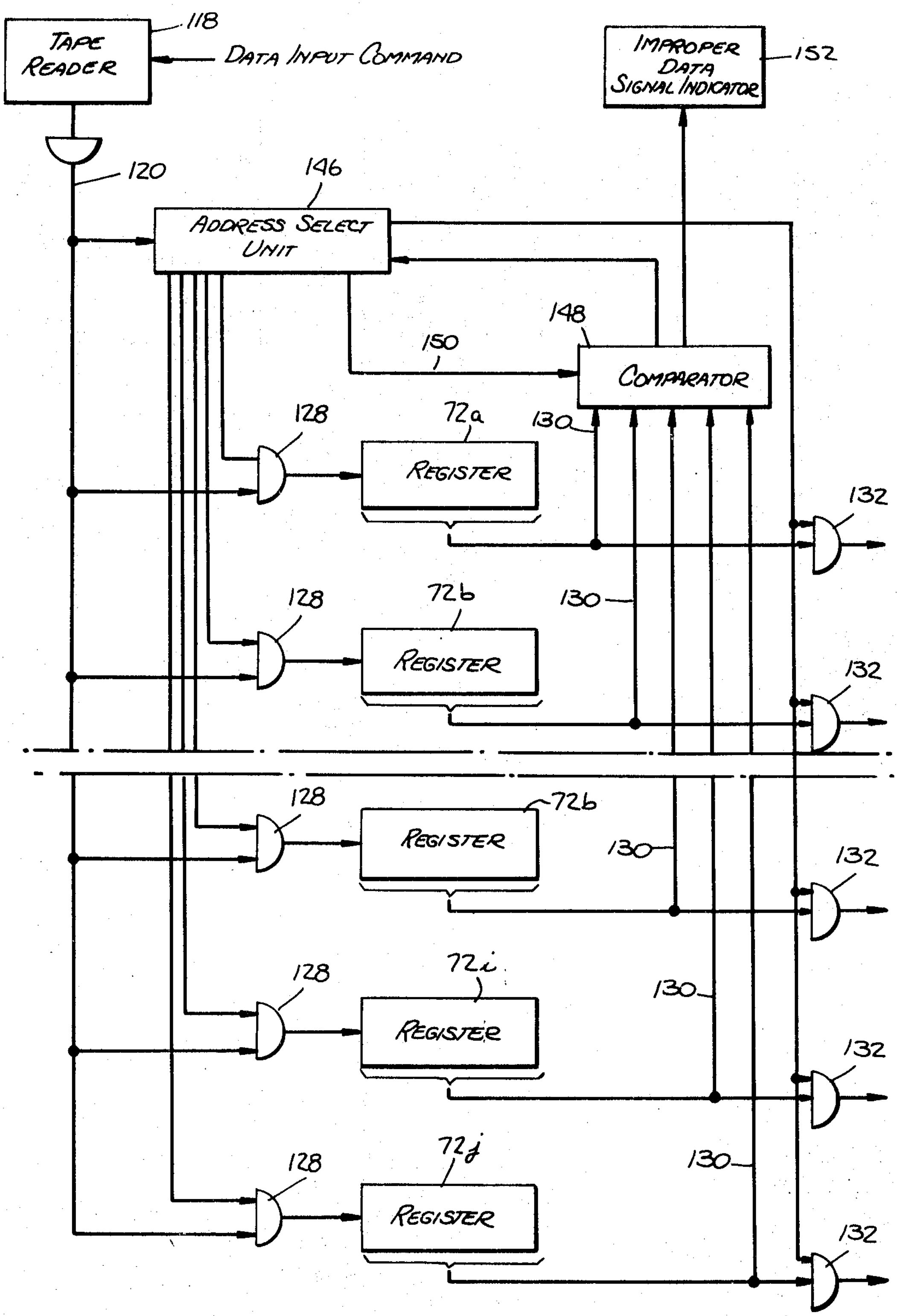


Fig.10.

INVENTORS
ROBERT BRICKETT STERNS
ROBERT ROY RICHARDS
BY
Ward McElhannon Brooks Fitzpatrick
ATTORNEYS

POSITIONING OF MULTIPLE ELEMENTS

This invention relates to positioning control systems and more particularly it concerns arrangements which permit automatic placement of moveable elements according to a preselected program.

The present invention is especially useful in those industrial processing operations where the process must be adjusted from time to time to accommodate different order specifications. For example, in the manufacture of corrugated paperboard for use in making boxes and other containers, an order may call for a particular paperboard width having a given number of longitudinal creases spaced by given amounts, while the next subsequent order may call for a different width, a different number of creases and a different crease spacing. The width control and creasing of the paperboard is provided by slitter-scorer machines which essentially comprise several pairs of slitter rolls and several pairs of scorer rolls. As the paperboard moves along longitudinally, it passes between the rolls making up each pair and these rolls cooperate to produce a longitudinal slit or crease along the paperboard according to the peripheral size and configuration of the rolls. It will be appreciated that the location of the slits and creases depends upon the transverse positioning of the various pairs of rolls.

The present invention makes possible the automatic adjustment of the location of positionable elements, such as the slitter and scorer rolls in a slitter-scorer machine. Of course, the principles of the present invention may be adapted to the adjustment of other process control elements such as machine tool cutters or even valves and the like in chemical type processing operations. For purposes of illustration, however, the present invention will be discussed in the environment of a slitter-scorer roll adjustment mechanism.

According to one aspect of the present invention, there is provided a positionable element, such as a pair of slitter-scorer rolls mounted to move along a pair of parallel shafts, a positioning element, such as a yoke, which is capable of being driven back and forth in a direction parallel to the direction of the shafts and which is arranged to engage the rolls for carrying them along and to disengage the rolls for independent movement. There are also provided register means arranged to store signals corresponding to the actual positions of the yoke and of the rolls and to store signals corresponding to their desired positions. Signal comparison means are provided to compare these stored signals and to produce driving signals. A yoke drive means is provided to drive the yoke in response to the driving signals in a direction to reduce the difference between the compared signals. Finally, a sequence control means is provided to control the signal comparison means such that when said yoke and rolls are disengaged the signals representative of their actual positions are compared, and when the yoke and rolls are engaged, the signals representative of their actual and desired positions are compared.

As illustratively embodied, the rolls are provided with a register which is arranged to have actual position and desired position data inserted at different times. That is, when the yoke and rolls are disengaged, actual position data is provided in the roll register, and when the yoke and rolls are engaged, desired position data, such as from a preprogrammed data-bearing tape, is inserted into the roll register.

The system of the present invention makes possible the use of a single positioning element to adjust the positions of several positionable elements. Thus, in the case of a slitter-scorer machine, different sets of slitter or scorer rolls from one or more stations may be indexed around to where they can be engaged by a driving yoke. The yoke will automatically move to the position of the rolls before engagement; and then upon engagement the yoke will drive the rolls to a new desired position. The rolls are then indexed back around to where they can operate on the paperboard while the yoke is repositioned to engage a different set of rolls on the same or on a different station.

In a practical situation, several yokes may be provided to adjust the positions of corresponding sets of slitter and scorer heads on different stations or on different index heads of a single station. Thus, there may be provided at a single station, two index heads each containing a pair of parallel shafts on which are mounted, for example, 16 pairs of slitter or scorer rolls. The index heads are indexed alternately to operating locations where they engage and operate on paperboard passing through the machine and to adjustment locations where they are each engaged and driven to new positions along their respective shafts by associated yokes.

According to a further aspect of the present invention, means are provided for checking data inserted into several registers to be sure that the data does not call for any roll set to overtake another roll set on the same shafts. This checking involves a comparison of the data in each of the registers for the several roll sets on each pair of shafts. The comparison is undertaken by successively comprising the data in adjacent registers and noting whether the sense, i.e., positive or negative of the successive comparisons changes.

Various further and more specific objects, features and advantages of the invention will appear from the description given below, taken in connection with the accompanying drawings, illustrating by way of example a preferred form of the invention.

In the drawings:

FIG. 1 is a perspective view of a two station, dual head slitter-scorer arrangement set up to be controlled according to the present invention;

FIG. 2 is a section view taken along line 2—2 of FIG. 1 and showing yoke and roll engagement at one station of the slitter-scorer arrangement;

FIG. 3 is a section view similar to FIG. 2 and showing yoke and roll engagement at a second station of the slitter-scorer arrangement;

FIG. 4 is an enlarged perspective view of a multiple yoke and multiple roll assembly forming a portion of the arrangement of FIG. 1;

FIG. 5 is a further enlarged fragmentary perspective view illustrating a yoke drive for the slitter-scorer arrangement of FIG. 1;

FIG. 6 is a fragmentary view taken along line 6—6 of FIG. 4 showing a referencing arrangement for obtaining common yoke and roll positioning data;

FIGS. 7 and 8 are diagrammatic representations of roll and yoke positions useful in understanding the positioning control technique of the present invention;

FIG. 9 is a block diagram of an electrical control system for positioning one roll set on each of several station heads according to the present invention; and

FIG. 10 is a further block diagram illustrating the extension of the arrangement of FIG. 9 to several roll sets on each of several station heads.

In the arrangement of FIG. 1, paperboard sheet material **12** is passed from a feed unit **14** through a two station slitter-scorer unit **16** and on to a cutoff unit **18**. The slitter-scorer unit **16** severs the material **12** lengthwise, as indicated by slit lines **20**. The unit **16** also imposes several longitudinal score lines **22** on the material **12** for enabling it to be bent into containers or other formations according to the specifications of the order being processed by the system.

The slitter-scorer unit **16** is shown in FIG. 1 as comprising two stations **24** and **26**. Each station includes a pair of supports **28** on opposite sides of the paperboard material **12**. These supports each mount a dual head indexing arm **30** at the center thereof; and the arms are arranged to be rotated by means of indexing motors **32** so that either end of the arms **30** can be brought to an uppermost or operating position while the other end is brought to a lowermost or roll adjustment position. Each end of each of the indexing arms **30** forms a portion of a different operating head.

The operating heads each comprise a plurality of pairs of rolls **34** mounted on closely spaced parallel shafts **36** which extend between corresponding arms **30** in each of the stations **24** and **26**. The paperboard material **12** passes between the rolls 34 of each pair of those operating heads which are in the uppermost or operating positions. Depending upon their peripheral configuration and edge spacing, the operating pairs of rolls will either score or slit the paperboard material longitudinally as it passes between them. The locations of these slits and scores will be controlled by the transverse positioning of the various pairs of rolls 34 along their respective shafts 36.

In the arrangement shown, while the rolls of uppermost operating heads are performing their slitting and scoring functions, those on the lowermost heads may be repositioned in accordance with the slit and score pattern of a subsequent run or order to be produced. Thereafter, when the previous run or order has been completed, the heads may be indexed around so that the subsequent run may be undertaken immediately; and while this subsequent run is taking place, the transverse positions of the roll pairs 34 of the previously operating heads may be adjusted in accordance with the specifications for a still further run.

The transverse positioning of the various roll pairs along the shafts 36 is carried out by means of a plurality of positioning yokes 38 arranged in a yoke carriage 40 located beneath and between the slitter-scorer stations 24 and 26. A yoke driving motor 42 is arranged in association with the carriage 40; and the motor 42 turns a drive shaft 44 which operates a screw drive, to be described hereinafter, for advancing and retracting the yokes 38 back and forth along a line parallel to the roll shafts 36.

Yoke shift actuators 46 are provided to position the yoke carriage 40 at an intermediate or neutral position disengaged from the slitter and scorer rolls 34, as shown in FIG. 1; and to position the yoke carriage at left and right hand positions, as shown in FIGS. 2 and 3, wherein alternately the yokes 38 each engage a pair of slitter or scorer rolls 34, of the lowermost heads of the associated stations 24 and 26.

Turning now to FIG. 4, it will be seen that the yoke carriage 40 is provided with a pair of parallel guide rods 48 which pass through each of the yokes 38 and which guide their transverse movements so that such movements are always parallel to the roll shafts 36. A drive screw 50 also passes through each of the yokes 38 and is threadedly engaged with a declutchable mechanism (to be described) on each yoke. The drive screw 50 is turned by the drive shaft 44 (FIG. 1) which in turn is driven by the yoke driving motor 42. Depending upon the direction of rotation of the screw 50, the yokes 38 will be advanced forwardly or backwardly across the yoke carriage. When the yoke carriage is in the left- or right-hand position of FIGS. 2 or 3, and the yokes 38 engage pairs of slitter or scorer rolls 34, their movements across the yoke carriage 40 will be accompanied by corresponding movements of the rolls which they engage.

Normally, the rolls 34 are locked on their shafts 36 against transverse movements, although they are permitted to rotate. However, the rolls 34 must be freed for transverse movement by the positioning yokes 38 when engaged by them. For this purpose there is provided a roll unlocking mechanism 52 attached to each end of the indexing arms 30. Each unlocking mechanism includes an actuating lever 54 which is engaged and moved by the yoke carriage 40 when the yoke carriage is moved to a position such that the yokes 38 engage the lowermost rolls 34. Movement of the actuating lever 54 releases the engaged rolls 34 allowing them to be repositioned by the yokes 38. Movement of the yoke carriage 40 back away toward its neutral position, allows the lever 54 to be released and the rolls 34 to be locked in place.

The declutchable mechanism arranged on each of the individual yokes 38 is best seen in FIG. 5. As there is shown, the drive screw 50 passes through and is threadedly engaged with a receiver element 56 in the yoke 38. Solenoids 58 are provided on the yoke and these solenoids control the projection and retraction of clutching lugs 60. When the lugs 60 are projected, they engage the receiver element 56 and prevent its rotation. Thus, when the drive screw 50 turns, it advances or retracts the yoke. On the other hand, when the clutching lugs 60 are retracted, the receiver element 56 is free to rotate with respect to the yoke 38. Accordingly, the turning of the drive screw in this situation merely results in rotative movement of the receiver element 56, and the yoke 38 will remain at rest.

As shown in FIG. 5, there is provided a gear rack 62 which extends across the yoke carriage 40 immediately above it. This gear rack is engaged by pinions 64 which are connected to position tachometers 66 mounted on the top of each yoke 38. As the yokes move back and forth transverly across the yoke carriage 40, the pinions 64 roll along the gear rack 62 and signals are produced by the tachometers 66. These signals, which represent transverse positional movements of the yokes 38, are transmitted to signal storage registers (to be described) for use in detecting and controlling the positions of the yokes.

FIGS. 6–8 serve to demonstrate the need for and manner of obtaining common position referencing for the various rolls 34 and yokes 38. As shown in FIG. 6, there is provided on the yoke carriage 40 a small magnetized reference element 68. Magnetic switches 70 are provided on each of the yokes 38. As the yokes 38 pass by the magnetized reference element 68, the switches 70 are actuated. These switches are each connected in circuit with the position tachometers 66. It will be appreciated that the position tachometers 66 can thus be arranged so that they will not produce position signals until their associated yokes are beyond the magnetized reference element 68.

Turning now to FIG. 7, it will be seen that the yokes 38 and/or the rolls 34 are kept toward the opposite ends of their respective shafts 48 and/or 36 when not in use. As shown, eight sets of rolls 34 are positioned at the left end of the shafts 36 while eight are positioned at the right end. All of the rolls as thus positioned are outside the space defined between the two magnetized reference elements 68. Paperboard material to be processed passes between the elements 68 and all dimensions for slitting and scoring are referenced to these elements. Now when the rolls are moved outwardly from their storage positions as shown in FIG. 7 to operating positions shown in FIG. 8, each roll's position will be counted from its distance to one of the magnetized reference elements 68, even through each roll is stored at a different distance from the reference elements.

Operation of the system as thus far described will now be discussed. As the paperboard material passes through the two stations 24 and 26 of the slitter-scorer unit 16, the rolls 34 of the uppermost operating heads of these two stations produce various slits and creases lengthwise of the material. At the same time, the lowermost operating heads of the two stations are in a position such that their associated rolls 34 may be adjusted.

Initially, the yoke carriage 40 is in its intermediate or neutral position, as shown in FIG. 1, with its yokes 38 disengaged from all of the rolls 34. In order to reposition the rolls 34 of the left-hand station 24, the yokes 38 must first be adjusted transversely so that they will register with associated rolls when the yoke carriage is shifted to the left, as in FIG. 2. In order to obtain this adjustment, signals representative of the position of each roll pair 34 are compared with signals representative of the position of each associated yoke 38. Driving signals are produced and the positions of the yokes are adjusted in accordance with these driving signals until the compared signals between each yoke and its associated roll pair correspond. At this point each yoke will be at the same transverse position as its associated roll in the lowermost head of the left-hand station; and it will engage that head when the yoke carriage 40 is shifted to the left. At this point, the yoke shift actuators 46 are activated to shift the yoke carriage to the left. As the yokes 38 engage the rolls 34, the yoke carriage also engages the actuating lever 54 which causes the roll unlocking mechanism 52 to release the rolls 34 for transverse movement. The signals representative of yoke and roll position are now compared to signals representative of the new desired position for each of the roll pairs. Driving signals are produced and the yokes are caused to move their associated rolls until the compared signals between the actual and desired position for each yoke and roll correspond. At this point, the rolls 34 will have been brought to their new desired position. The yoke carriage 40 is then shifted, by means of the yoke shift actuators 46, back to its intermediate or neutral position. The actuating lever 54 of the roll-unlocking mechanism is released and the rolls 34 are locked against further transverse movement. The indexing motor 32 of the left-hand station 24 may then be actuated to swing the arms 30 and the repositioned rolls 34 of the lowermost operating head around to engage the paperboard material to begin the processing of a new order.

While the yoke carriage is in its intermediate position, the yokes 38 may be repositioned so that when the yoke carriage is shifted to the right, as shown in FIG. 3, its yokes will engage associated rolls 34 of the lowermost manner of the right-hand slitter-scorer station 26. The manner of yoke and roll position adjustment at the right-hand station 26 is the same as for the left-hand station 24.

The adjustment of yoke positions, whether engaged or disengaged with the various roll pairs 34, is obtained with the single drive screw 50. This is accomplished by causing the screw to turn for a fixed length of time in one direction and then for a similar length of time in the opposite direction. Control arrangements, to be described, cause the clutching lugs 60 to engage their associated receiving elements 56 on each yoke, so that the yoke will be driven by the screw 50, only when the screw is turning in a direction which will cause the yoke to be driven in the direction of its desired new position. Moreover, the clutch will be engaged only until the yoke reaches this position. The clutch is then disengaged even though the screw 50 continues to turn, and to continue driving other yokes to their desired new positions.

The control arrangements for carrying out the above-discussed operations are shown diagrammatically in FIGS. 9 and 10. In FIG. 9, there are shown four "HEAD ROLL POSITION REGISTERS," blocks 72, 74, 76 and 78, respectively. Each of these blocks actually represents sixteen signal storage registers corresponding, respectively, to each of the 16 pairs of rolls 34 on each of the operating heads. For convenience sake, the rolls 34 shown in the uppermost position of the left-hand station 24 of FIGS. 1–3 are referred to as ROLL GROUP A, while those in the lowermost positions are referred to as ROLL GROUP B. The rolls 34 in the uppermost position of the right-hand station 26 are referred to as ROLL GROUP C, and those in the lowermost position are referred to as ROLL GROUP D.

The sequencing operation begins with the application of an index signal which commands one or the other of the stations 24 or 26 to index around and bring the rolls of its lowermost operating head into operating position and the rolls of its uppermost operating head into adjustment position. Thus, as shown in FIG. 9, there are provided two index signal input terminals 80 and 82 connected respectively to index AND-gate circuits 84 and 86. Signals from these circuits are applied to associated ones of the indexing motors 32. Index detectors 88 and 90 are arranged in association with the motors 32 to produce signals on associated index position output lines 92, 94, 96 and 98 corresponding to the particular group of rolls 34 which are in their lowermost or adjustment location. Each of the lines 92, 94, 96 and 98 is connected to a first common OR-gate circuit 100 whose output is connected to a second OR-gate circuit 102. The output of this second OR gate circuit is connected to the input of a motor sequence control circuit 104. The motor sequence control circuit is arranged to control the operation of the yoke driving motor 42 such that upon the reception of an input signal it will apply a forward drive signal on a first line 106 to the motor for a given length of time, then will apply a reverse drive signal on a second line 108 to the motor for a similar length of time and then will apply a stop signal on a third line 110 to the motor. The motor 42, as described previously, operates via the drive shaft 44 to turn the drive screw 50. The drive screw 50 operates via each of the clutching mechanisms on the 16 yokes 38 to drive the yokes. For simplification, only one clutching mechanism, indicated as 112, is represented in FIG. 9. Similarly, only one of the 16 position tachometers 66 is represented in FIG. 9. The output of each position tachometer is connected via its associated magnetic switch 70 to an associated one of 16 yoke position registers 114. Again, for purposes of simplicity, only one such yoke position register is represented.

The yoke position registers 114 and the head roll registers 72, 74, 76 and 78 are all signal storage devices capable of storing signals representative of positions across the width of the slitter-scorer unit 16. In the present situation, these registers take the form of digital or pulse-counting devices in which each counted pulse corresponds to an increment of distance from one of the reference lines defined by the magnetized reference elements 68. The yoke position registers 114 are "-forward-backward" counters, which means that they add to their stored count each impulse received from their associated position tachometers 66 when these tachometers are moving in one direction, and they subtract from their stored count each impulse received from the tachometers when moving in the opposite direction.

As indicated by brackets along each of the registers, their entire count at a given instant is taken for comparison purposes. The count comparison occurs in scanner comparators 116, of which there also are 16; but again, only one is shown for purposes of simplicity.

Each of the 16 head roll registers of each head roll register groups 72, 74, 76 and 78 are arranged to receive transverse position data for one pair of head rolls 34. It will be appreciated that there are four head roll registers for each yoke register and scanner comparator; that is, one head roll register from each of the four operating heads. Thus, the count present in the registers 114 at any time represents the transverse position of their associated yoke at that time.

Position data information for the head roll position registers 72, 74, 76 and 78 is supplied, also as pulses to be counted, from a tape reader 118 which reads this data from a preprogrammed tape. The tape reader 118 has two station output lines 120 and 122 along which desired head position information is supplied to corresponding one of the head group registers. The information on the line 120 corresponds to desired position data for the pairs of rolls 34 of the two operating heads of the left-hand slitter-scorer station 24, while the information on the line 22 corresponds to desired position data for the pairs of rolls 34 of the two operating heads of the right-hand slitter-scorer station 26.

The information on the lines 120 and 122 is first applied to a roll group select AND-gate circuits 124, 126, 128 and 130 associated with each roll register. These gate circuits are normally closed to signal passage; however, when a particular head group becomes indexed around to its adjustment position, a signal is supplied from one of the index position output lines 92, 94, 96 or 98 to an associated one of the AND-gate circuits 124, 126, 128 or 130, thereby allowing the information on one of the lines 120 or 122 to enter the associated HEAD ROLL POSITION REGISTERS.

The desired position data present on the lines 120 and 122 also includes address information which indicates to the system which of the particular head group position registers each particular item of position information is to be directed. Also, the address information provides signals which clear the registers to which they are directed of previous information so that they will be capable of accepting new data. The address information further includes signals which indicate to the system when the new desired position data has been fully inserted into a particular register.

Reading of the address information is accomplished by sequential control circuits 124 associated with each group of roll group position registers. The sequential control circuits 124 first read preliminary address information. Upon receipt of a proper address, the circuit 124 sends a "clear" signal via a register clear line **126** to react the associated roll position registers to zero count. Then a signal is produced at a data gate **128** which allows it to open and admit new position information from the tape into the register. When the data has been inserted into each of the 16 registers of a group, the associated sequential control circuits **124** sequentially compare the data to ensure that no register is set to a desired position which would require its associated pair of rolls **34** to overtake another pair of rolls in the same group. The data for this comparison is sampled via a sequence comparison line **130**. The manner in which this comparison is made will be discussed in conjunction with FIG. **10**.

Upon completion of data insertion and checking in the roll position registers of a particular group, the associated sequential control circuits **124** produce a signal which opens comparison AND-gate circuits **132** and allows the new desired position data in each of the 16 head registers of the group to be passed through a comparison OR-gate circuit **134** to associated ones of the scanner comparators **116**. In the scanner comparators, the desired new head position information in the head registers is compared to actual yoke position as represented in the corresponding yoke position registers **114**.

It will be understood that at the time this comparison is made the yoke carriage **40** is in its neutral position so that its positioning yokes **38** are free to traverse back and forth free of the roll pairs **34**.

At the time the 16 scanner comparators **116** begin operation, motor sequence start signals are applied to the associated second OR-gate circuits **102** and from there to the motor sequence control circuit **104**. As discussed above, the motor sequence control circuit **104** produces signals which cause the yoke driving motor **42** first to drive in a forward direction for a fixed duration, then to drive in a reverse direction for a similar duration, and finally to stop.

While the yoke motor drives, the scanner comparators **116** produce signals on comparison lines **136** and these signals are applied to corresponding error direction detection circuits **138** and corresponding zero error detection circuits **140**. The error direction detection circuits **138** operate to control application of signals to the clutch solenoids **58** to engage the clutching lugs **60**. The zero error detection circuits **140** operate to terminate energization of the clutch solenoids **58**. Thus, when the yoke drive motor **42** turns in a direction that would cause the discrepancy between the signals in one of the head roll position registers and its associated yoke position register to diminish, a signal is produced to energize the associated yoke clutch solenoid so that the yoke will be driven to its desired position. When the desired position is reached, the zero error detection circuit deenergizes the associated solenoid **58** and disengages the yoke from the drive screw **50** so that the motor **42** can continue its driving sequence to complete the positioning of the other yokes. Upon completion of the yoke positioning, a stop signal appears on the third line **110** of the motor sequence control circuit **104**, and this signal is applied to a yoke shift control circuit **142**. Each time this circuit receives an input signal, it sequences to produce an output signal on a different one of three yoke shift position lines **144**, **146** and **148**. These lines are connected to the yoke shift actuators **46** and serve to cause the yoke carriage **40** to move successively from a left-hand station-engaging position (FIG. **2**), to a neutral position (FIG. **1**), to a right-hand station-engaging position (FIG. **3**) back to a neutral position and back to a left-hand station-engaging position.

The line **146** of the yoke shift control circuit is also connected to the index AND-gate circuits **84** and **86**. This serves to permit indexing signals applied to the index signal input terminals **80** and **82** to produce indexing only when the yoke carriage has been shifted to a neutral position disengaged from the rolls **34**.

By way of recapitulation, the system operates as follows. Initially, one head group of slitter or scorer rolls **34** of each of the stations **24** and **26** is positioned in the uppermost or operating position, as shown in FIG. **1**, and the yoke carriage **40** is shifted to its neutral position. The stations may be operating at this time with their uppermost roll groups producing slits and scores on the paperboard sheet material **12** passing through the system.

Also, during this time, the lowermost group of rolls in each of the stations **24** and **26** may be repositioned in preparation for a subsequent order of paperboard to be produced.

This adjustment takes place first by repositioning the yokes **38** so that they can become engaged with the lowermost head rolls of one of the stations **24** and **26**. The yokes are thus positioned by allowing a comparison to be made between the data in the registers corresponding to the lowermost rolls in one of the stations **24** or **26**, and the data in corresponding yoke position registers **114**. This comparison is initiated by address information read by the tape reader. During the comparison, the yoke driving motor **42** drives through its forward-reverse-stop sequence and the clutches on the yokes are controlled by the outputs of the scanner comparators. Upon the completion of the yoke-repositioning sequence, a signal is produced on the line **110** which causes the yoke shift control circuit to shift the yoke carriage **40** into engagement with the station with whose lowermost rolls the yokes have been aligned.

Operation of the yoke shift control circuit also results in the sending of signals to the tape reader **118**, causing it to insert new desired position data into the head register group associated with the roll pairs **34** now engaged by the yokes **38**. When this new data has been inserted, a further comparison is made and the yokes are again driven by a sequencing action of the motor sequence control circuit **104**. This repositions the yokes, and the engaged roll heads to new desired positions.

Upon completion of the repositioning, a signal is applied to the yoke shift control circuit **142** causing it to shift the yoke carriage back to a neutral position. At this point, the station may be indexed, or the yokes may be used to reposition the lowermost roll pairs in the other station.

FIG. **10** illustrates the manner in which information from the tape reader is inserted into the various registers of a particular head roll group. As can be seen from FIG. **10**, signals from a data input command (not shown), or from the yoke shift control circuit **142** are applied to the tape reader **118**; and the tape reader produces address and position data information along one of the station output lines, i.e., line **120**. This data is supplied to an address select unit **146** and is also supplied to each of the several data gates **128**. In FIG. **10**, the registers for only those head rolls of one of the four groups A, B, C and D are indicated. While, as mentioned previously, in the present embodiment there are 16 roll pairs **34** in each group, for purposes of simplicity only certain ones of the registers associated with each of these roll pairs are shown. These registers are identified respectively as ***72a***, **72**,...***72h***, ***72i***, and ***72j***. The station output line **120** supplies blocks of information from the tape reader **118** to each of the data gates **128**. Each block of information, which corresponds to the new desired position of a particular one of the head rolls, is preceded by an address signal. The address signals are detected in the address select unit **146** which in turn produces an output on the appropriate one of the data gates **128**, permitting that gate to open so that the block of position data can be inserted into the associated register ***72a***, ***72b***, etc.

When each of the registers ***72a***, ***72b***, etc., have received their new position data, the data present in each register is compared with the data present in the next adjacent register. For example, the data present in the first register ***72a***, is first compared with the data present in the next register, ***72b***. Then the data present in the register ***72b*** is compared with the data present in the next subsequent register ***72c*** (not shown), and this comparison is continued until the data present in each register has been compared with the data present in the register adjacent thereto. These successive comparisons are made by sampling the individual registers and transferring the sample; data via the sequence comparison lines **130** to a sequentially operated comparator **148**. The comparator **148** is controlled to make its successive comparisons in the proper order by means of command inputs applied from the address select unit 146 along a comparator control line 150. The comparator will not produce an output signal so long as the successive comparisons show that each successive register shows a higher count than the register immediately preceding it. Should a preceding register show a higher count than a succeeding register, this would result in a command to a lower position yoke or yoke and head roll pair to overtake a higher position yoke or yoke and head roll pair. Should the comparator 148 detect a higher count in a lower position register, the comparator will produce a signal at the input terminal of an improper data signal indicator 152. This will warn the system operator that the programmed information will not function properly in the system. This signal may also be applied to stop operation of the system in order to prevent any damage from being produced.

Upon completion of the various comparisons, the comparator 148 sends a comparison completion signal to the address select unit 146; and this in turn applies a gate opening signal to each of the comparison and gates 132.

It will be appreciated that the system described herein may be modified considerably within the border concepts of the present invention. For example, it is not necessary that two stations be incorporated. Instead, one station may be used or several stations may be used with one or several yoke carriages. In addition, each station may have an indexing arrangement with more than two head groups. It is merely necessary that each head group be capable of being indexed around to the yoke carriage and that the yoke carriage be moveable to a neutral position between engagements with successive head groups. In other applications there may be provided multiple head groups in each indexing position and the head groups may be positioned simultaneously with one or several yoke carriages.

What is claimed is:

1. A position control system comprising a positionable element, a positioning element, engagement means operative to bring said positioning element and said positionable element into and out of engagement with each other so that movement of said positioning element may take place both with and independently of said positionable element, positionable element signal storage means arranged to store signals corresponding to the desired position of said positionable element and for storing signals corresponding to the actual position of said positionable element, positioning element signal storage means arranged to store signals corresponding to the actual position of said positioning element, signal comparison means arranged to compare the signals of said positionable element signal storage means and said positioning element signal storage means to produce driving signals, driving means arranged to drive said positioning element in accordance with said driving signals to reduce the difference between the compared signals, and sequence control means operative to control the comparison of signals such that when said positionable and positioning elements are disengaged, signals corresponding to the actual position of said positionable and positioning elements are compared and when said positionable and positioning elements are engaged, signals corresponding to the desired and actual positions of said positionable and positioning elements, respectively, are compared.

2. A position control system according to claim 1 further including a second positionable element arranged to be engaged with said positioning element in alternate sequence with the first-mentioned positionable element, and further including second positionable element signal storage means arranged to store signals representative of the desired position of said second positionable element, said signal comparison means being arranged to compare the signals of said positioning element signal storage means and said second positionable element signal storage means and to control said driving means in alternate sequence to its comparison of the signals of said positionable element signal storage means and said positioning element signal storage means.

3. A position control system according to claim 1 further including input signal means arranged to insert new signals representative of a new position into said positionable element signal storage means.

4. A position control system according to claim 3 further including input signal control means arranged to restrict the flow of new signals to each positionable element signal storage means to situations where said positioning element is engaged with the positionable element associated with the signal storage means to which said new signals are directed.

5. A positioning control system comprising a plurality of operating heads, each operating head being provided with a plurality of positionable elements mounted for position adjustment along a given path, a yoke carriage containing a plurality of yokes, yoke drive means for driving said yokes along paths corresponding to the given path of each operating head, shift and index means for producing relative shifting movement between said yoke carriage and said heads whereby said yokes successively engage with and become disengaged from the positionable elements of said head, first signal register means arranged to receive signals corresponding to the positions of said yokes along said corresponding paths, second signal register means arranged to receive signals corresponding to desired positions of said positionable elements, signal comparison means arranged to compare the signals present in corresponding ones of said first and second signal register means, drive means arranged to drive said yokes to bring the compared signals into conformity, desired signal input means arranged to replace the signals present in said second signal register means, and sequence means operative to control said shift and index means, said yoke drive means and said desired signal input means in a manner such that operation of said input signal means to replace signals in the second signal register means corresponding to the positionable elements of a given operating head is preceded by operation of said shift and index means to effect yoke and positionable element disengagement and operation of said drive means during disengagement to bring each yoke into position registry with corresponding positionable elements on said given operating head.

6. A position control system according to claim 5 wherein each of said yokes includes signal-transmitting means arranged to transmit signals corresponding to its movement along said corresponding paths.

7. A position control system according to claim 6 wherein each signal-transmitting means comprises a position tachometer for producing impulses, the number of which correspond to the distance of yoke movement.

8. A position control system according to claim 7 wherein said first register means comprises individual forward-backward counters, each of which accumulates an impulse count from an associated tachometer as said yoke moves in one direction and which loses counts corresponding to impulses received from said tachometer as said yoke moves in the opposite direction.

9. A position control system according to claim 8 wherein there is provided switch means between each signal transmitting means and its associated first signal register means and wherein there is provided means for closing said switch means when the associated yoke moves beyond a fixed reference.

10. A positioning control system comprising a positioning element, a positionable element, register means arranged to store signals representative of the actual position of each element and to store signals representative of the desired position of said positionable element, signal comparison means arranged to compare the stored signals to produce driving signals, driving means responsive to said driving signals to move said positioning element in a direction to reduce the difference between the compared signals, means arranged to engage and disengage the positioning and positionable elements for permitting each positioning element to be driven respectively, with and without a positionable element, and sequence means arranged to control the signal comparison such that

when said elements are disengaged, signals representative of their actual positions are compared and when said elements are engaged signals representative of their actual and desired positions are compared.

11. A position control system according to claim **10** wherein said register means comprises a first register constructed and arranged to receive signals representing programmed new position information and to retain said signals until subsequent application of further signals representing programmed new position information and wherein said register means further comprises a second register constructed and arranged to undergo changes in signal content with each movement of said positioning element thereby to maintain a signal content representative of the actual position of said element.

12. A position control system according to claim **10** wherein said driving means and said signal comparison means are both operative when said positioning and positionable elements are in engagement and when they are in disengagement.

13. In a multielement positioning system, the combination of a common drive means arranged to drive a plurality of moveable positioning elements simultaneously, individual clutch mechanisms on said elements for individually engaging and disengaging each element with said common drive means, individual position data transmitting means associated with each element for producing signals indicative of its actual position and means for individually controlling the operation of said clutch mechanisms in response to said signals, said means for individually controlling the operation of said clutch mechanism being arranged to cause each clutch mechanism to become engaged when said signals indicative of each associated element's actual position undergo changes in the direction of the element's desired position and to become disengaged upon attainment of said desired position.

14. A multielement positioning control system according to claim **17** wherein said common drive means is constructed to continue driving over a distance at least equal to the maximum displacement to be undertaken by a moveable element.

15. A multielement positioning control system according to claim **17** wherein said means for individually controlling the operation of said clutch mechanisms comprises individual means for registering signals representative of desired positions of their associated positionable elements and comparison means for comparing the registered signals with said signals indicative of the actual position of said associated elements.

16. A multielement positioning control system according to claim **17** wherein said common drive means is constructed to drive first in one direction for a given distance and thereafter to drive in the opposite direction for a similar distance.

17. A multielement positioning control system according to claim **13** wherein said elements are driven by a common drive screw.

18. A multielement positioning control system according to claim **13** wherein said moveable elements are yokes engageable with positionable elements for moving said positionable elements to desired positions.

19. In a multielement positioning control system, the combination of a plurality of positionable elements arranged for movement along different paths, yoke means arranged to drive said positionable elements, said yoke means being shiftable between said different paths for alternate engagement of the positionable elements in said different paths, first register means for registering signals corresponding to the actual position of said yoke means along said paths, individual further register means for registering signals corresponding to the desired position of corresponding ones of said positionable elements, signal comparison means arranged to compare the signals of said first register means with each of said further register means, means for driving said yoke means in accordance with the output of said comparison means in a manner so as to bring the compared signals into conformity, and means for coordinating the signal comparisons and the insertion of new signals into said further registers in a manner such that said yoke means drives to a position corresponding to the actual position of a positionable element prior to shifting into engagement with the element and prior to insertion of new desired position signals into the further register associated with said element.

20. A multielement positioning control system according to claim **19** wherein said further register means are constructed in a manner to permit retention of inserted signals corresponding to desired positions of corresponding ones of said positionable elements until subsequent signals are admitted to said further register means.

21. A multielement positioning control system according to claim **20** wherein said further register means are arranged to clear upon the application of subsequent signals whereby the subsequent signals replace previous signals.

22. A multielement positioning control system according to claim **19** wherein said positionable elements are arranged on different operating heads and wherein said operating heads are successively indexable to adjustment positions where they may be engaged by said yoke means.

23. A multielement positioning control system according to claim **22** wherein each operating head contains a number of positionable elements and wherein said yoke means includes a like number of positioning yokes.

24. A positioning control system comprising a plurality of positionable elements guided for movement along a common path, means for driving said elements along said path, a pair of signal storage registers corresponding to each of said elements and arranged to store signals representative, respectively, of the actual and the desired positions of said elements, first signal comparison means associated with each pair of elements and arranged to produce driving signals for driving each element to a position at which the signals present in its corresponding pair of registers concur, second signal comparison means arranged to compare the signals in said signal storage registers containing signals representative of the desired positions of said elements and to produce signals indicative of signal relationships representative of reversed order of relative positions of positionable elements along said path.

25. A positioning system comprising a positionable element guided for movement along a given path, a yoke moveable along a path corresponding to said given path, means for shifting said yoke for engagement and disengagement with said positionable element, position-data-transmitting means associated with said yoke for producing signals indicative of its actual position along its path, a first signal register connected to said position-data-transmitting means for maintaining a signal indicative of the yoke position a second register, means for inserting signals into said second register corresponding to a desired position of said positionable elements, signal comparison means arranged to compare the signals in said first and second registers, and yoke drive means operative to drive said yoke to a position such that the signals in said registers correspond.

26. A method for positioning a positionable element comprising the steps of storing in a first register, first signals representative of the actual position of said element, providing a positioning element, generating second signals representative of the actual position of said positioning element, maintaining said elements disengaged while comparing said first and second signals and driving said positioning element in accordance with the compared signals to bring it into registry with said positionable element, thereafter engaging said positioning and positionable elements, storing third signals representative of the desired position of said positionable element, and with said elements engaged, comparing said second and third signals and driving said positioning element until said second and third signals concurs.

27. A method for positioning several elements along a common path comprising the steps of inserting into several registers associated respectively with each of the several elements, signals representative of the desired position of each element, comparing the signals in adjacent one of said registers to ascertain the presence of improper register signals which call for a shift in the order of elements along said path, and in the absence of such improper signals following said comparing, driving said elements toward said desired positions.

28. A method according to claim **27** wherein said signals are compared by successively comparing the signals for adjacent registers in the order of their associated elements as arranged along said path.

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