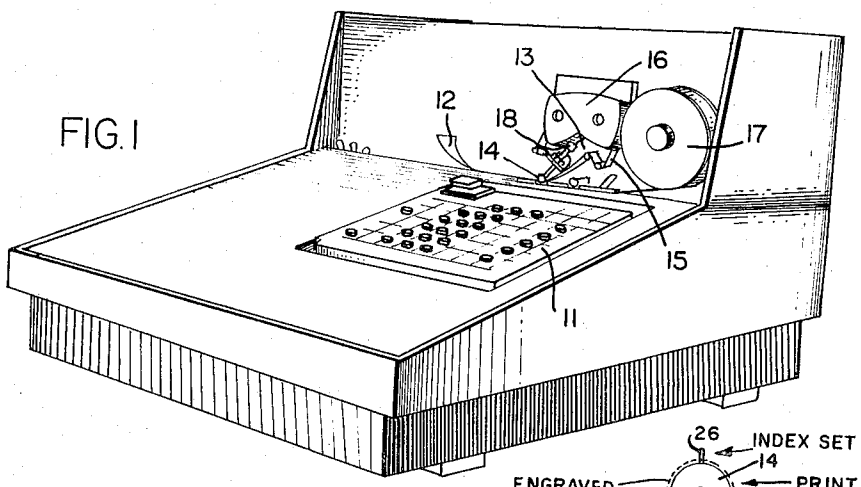
Feb. 21, 1967 R. W. REACH ET AL 3,304,858

ELECTROMECHANICAL PRINTING SYSTEM FOR DIGITAL SYSTEMS

Filed Dec. 23, 1963

2 Sheets-Sheet 1

FIG. 1



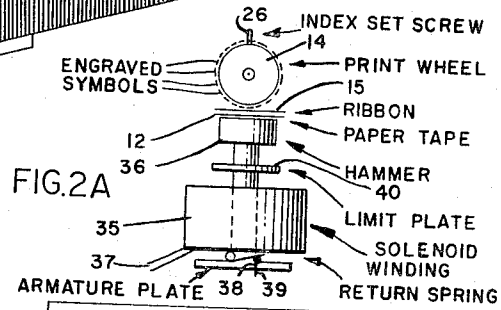


FIG. 2A

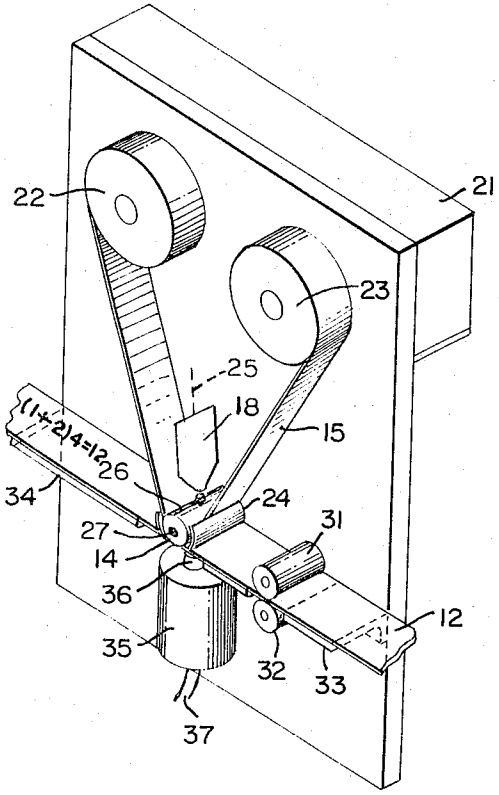


FIG. 2

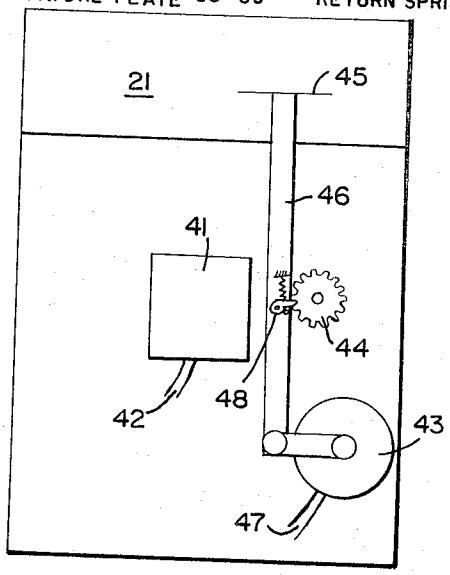


FIG. 3

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ELECTROMECHANICAL PRINTING SYSTEM FOR DIGITAL SYSTEMS

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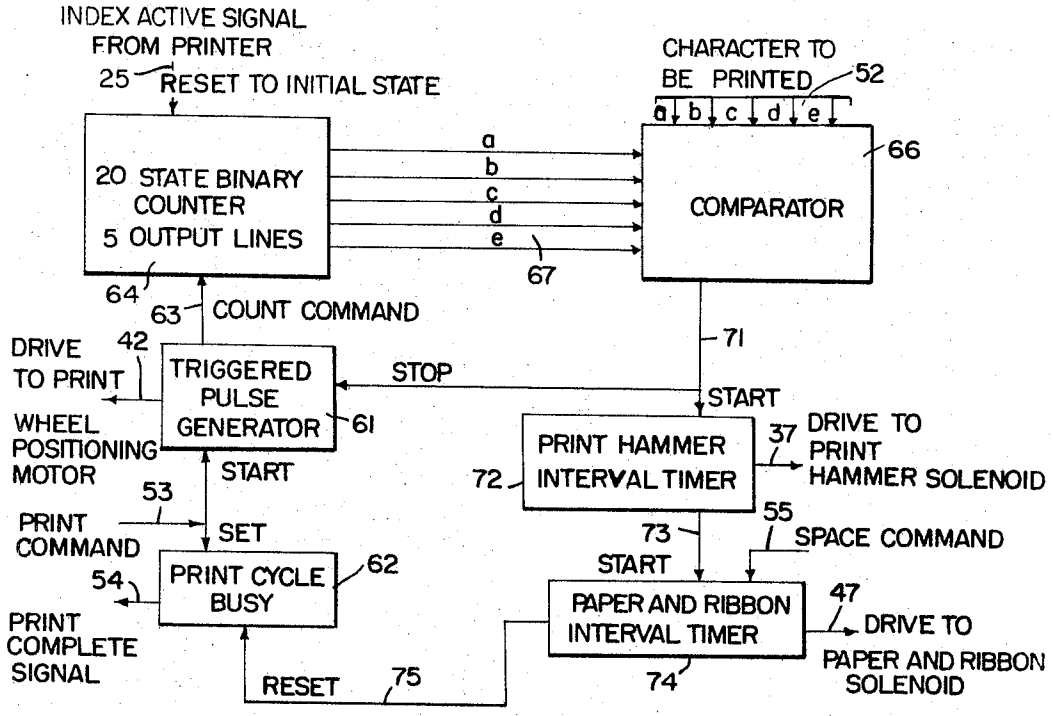


FIG. 5

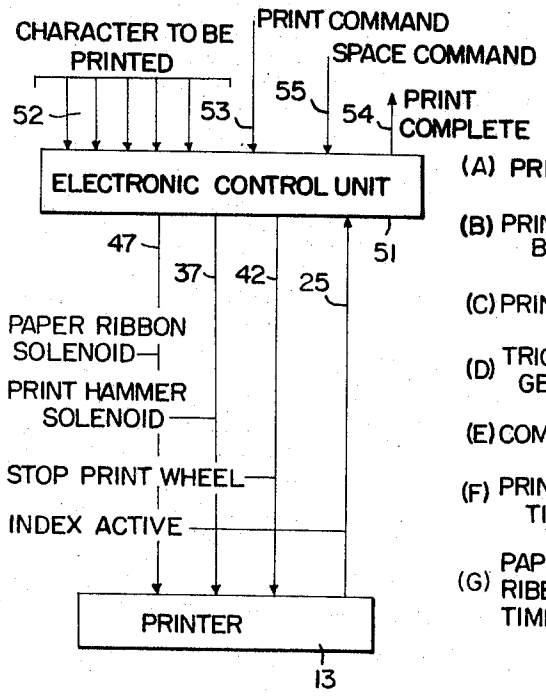
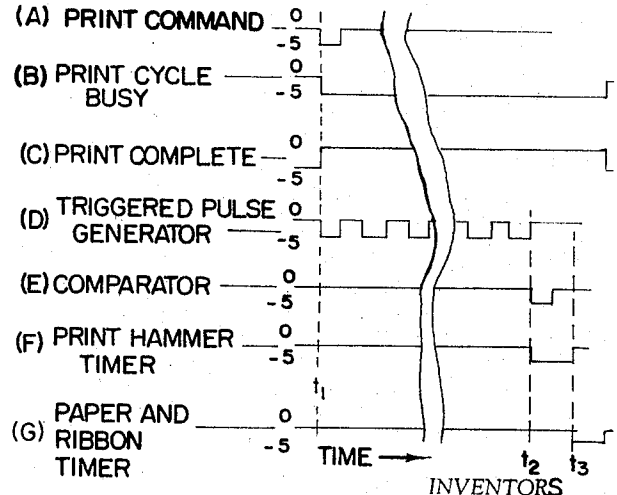


FIG. 4

FIG. 6



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ELECTROMECHANICAL PRINTING SYSTEM FOR DIGITAL SYSTEMS

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13 Claims. (Cl. 101—93)

The present invention relates in general to symbol selection and more particularly concerns a novel electromechanical printing system especially useful in connection with digital control systems. A particular form of the invention creates a printed record on a narrow paper tape to display the results of actions that have been either created electronically or have been converted into electronic form for manipulation purposes prior to being printed. Printing occurs at a relatively rapid rate with high reliability in a system composed of relatively few components.

One type of conventional strip printer produces a printed record upon the activation of a large number of mechanically coupled parts arranged in a system powered by an electric motor. Mechanical selection of the character to be printed, either by linkage from a keyboard or by the electronic activation of a solenoid or solenoids, usually initiates printing action. This mechanical selection typically engages the motor to drive interconnected mechanical parts through a cycle causing the desired characters to be printed. This cycle ends with the release of the motor from the mechanical coupling.

In another prior art electronically controlled printer, a continuously rotating drum carries impressions of the various symbols for printing around each of a series of axially spaced circumferential tracks with the drum axis generally parallel to a line to be printed. By activating a bank of "print hammers," either electrically or mechanically, at suitable times, the paper receives a line of printing upon each drum revolution as each hammer urges paper and drum together at the precise instant the character selected for printing is opposite a respective printing hammer.

These prior art printers have a number of disadvantages. The former printer is primarily a mechanical device with a large number of complex moving parts. As a result, this printer is expensive, complicated to construct, relatively large in size and difficult to maintain in good working order. Furthermore, when this type of printer is used in conjunction with electronic systems which designate symbols for printing by electronic signals rather than mechanical signals, the interconnecting electronics required are frequently complex and expensive.

The second type of printer described above is basically designed for use with electronic systems, but it too has a number of serious disadvantages. The extremely precise timing required to synchronize the rotating print drum with the time when the print hammers must be activated is both complicated and difficult to maintain over a long period of time without adjustment. Furthermore, the finite movement of the drum during the finite interval in which the print hammer urges paper and drum together results in a tendency to smear the characters and produce irregular lines of print. The requirement for precise synchronization between instantaneous drum position and actuation of a print hammer results in complex mechanisms for the print hammer system and the electromechanical sensing system for providing continuous information on the drum position to the electronic controls.

It is an important object of this invention to provide an efficient electronically controlled printer that is relatively inexpensive to build and maintain, compact, reliable and relatively fast in operation.

It is a further object of this invention to achieve the preceding object with relatively few interconnected mechanical parts.

It is still another object of the invention to achieve the preceding objects with relatively little driving power and a driving unit that is relatively compact and low in cost.

It is still a further object of the invention to achieve the preceding objects with a system where symbol selection is normally accomplished without using feedback.

It is still another object of the invention to achieve the preceding objects with a system free from critical timing relationships among a number of mechanical parts, yet capable of producing high quality impressions.

It is still another object of the invention to achieve the preceding objects in a strip printer.

According to the invention, means define a continuous surface having a succession of symbols each located in respective contiguous symbol cells thereon identifiable by a consecutive series of order numbers. Means define a symbol selection area. Means support the continuous surface defining means relatively movable with respect to the symbol selection area so that any one of the symbols may be selectively positioned opposite the symbol selection area. Pulsating motive means move the continuous surface to position successively each of the symbols opposite the symbol selection area in stepwise increments each corresponding substantially to the length of a symbol cell along the continuous surface by one of such increments for each pulse that pulsates the motive means. Means pulse the pulsating motive means to advance the next of the symbols opposite the symbol selection area on each pulsation. Means provide an indexing signal indicative of the first of the symbols being opposite the symbol selection area. Means provide a count signal representative of one of the symbols selected for retention opposite the symbol selection area. Means responsive to each pulsation of the pulsating motive means provide a position signal referenced to the index signal representative of which of the symbols is then opposite the symbol selection area. Means responsive to correspondence of that position signal with the count signal interrupt the pulsation of the motive means with the symbol selected for retention positioned opposite the symbol selection area.

Numerous other features, objects and advantages of the invention will become apparent from the following specification when read in connection with the accompanying drawing in which:

FIG. 1 shows a view of the novel printing mechanism above the keyboard of a compact flexible digital computer incorporating electronic logic;

FIG. 2 is a perspective view of basic elements of an embodiment of the printing mechanism;

FIG. 2A is a front view in greater detail of the print wheel and print hammer of FIG. 2;

FIG. 3 is a rear view of the apparatus shown in FIG. 2;

FIG. 4 is a block diagram illustrating the logical arrangement of a printing system according to the invention;

FIG. 5 is a more detailed block diagram illustrating the logical arrangement of a specific system according to the invention; and

FIG. 6 is a graphical representation of electrical control signals plotted to a common time scale helpful in understanding the operation of the system of FIGS. 5 and 6.

With reference now to the drawing and more particularly FIG. 1 thereof, there is shown a perspective view of the novel printer positioned above the keyboard of a compact digital computer incorporating electronic logic.

Where appropriate, the same reference symbols identify corresponding elements throughout the drawing. Results of computations initiated under operator control through the keyboard **11** are printed out on paper tape **12** through means including the novel printing mechanism **13**. The printing mechanism includes a rotatable cylindrical element **14** separated from the paper strip **12** by an inked ribbon **15** carried on spools inside the replaceable case **16**. This ribbon may be similar to the ribbon assembly used on typewriters. A reel **17** stores the paper strip **12**. A sensing element **18**, which may be a magnetic pickup, provides an indexing signal to indicate when the first of the array of symbols on the cylinder **14** is opposite the printing area on the tape.

Referring to FIG. 2, there is shown a more detailed view of certain elements of the printing mechanism **13** diagrammatically illustrating the relationship of the different elements. The ribbon control mechanism **21** selectively advances the ribbon **15** as it moves between left reel **22** and right reel **23**. The ribbon **15** rides along ribbon guide **24** between the cylindrical print wheel **14**, typically having twenty symbols engraved thereon in this specific embodiment, and the paper strip **12**. The magnetic position sensor **18** provides an impulse on line **25** when the print wheel indexing set screw **26** passes close to magnetic sensor **18**. The print wheel mounting shaft **27** carries the print wheel **14**.

A paper driver roller **31** presses the paper tape **12** against the paper idler roller **32** to selectively advance the paper tape **12**. The paper tape rides along right paper guide **33** and left paper guide **34**.

A print hammer solenoid **35** drives print hammer **36** upward against paper tape **12** to define a symbol selection area on the paper tape where it urges the paper tape against the ribbon **15**. This action produces an impression on the tape of the symbol selected for printing. This symbol is opposite the symbol selection area on the face of print wheel **14** when solenoid **35** is energized through solenoid leads **37**.

Referring to FIG. 2A, there is shown a front view of the print wheel **14** and the solenoid operated print hammer in greater detail. The solenoid actuated hammer is of conventional type and includes the print hammer **36** at the upper end of the solenoid plunger which carries at its lower end an armature plate **38** urged downward by a return spring **39** when solenoid **35** is de-energized to a position corresponding to limit plate **40** contacting the top of the solenoid winding. The outline of the array of engraved symbols in relief is represented on the periphery of print wheel **14**. Portions of ribbon **15** and paper tape strip **12** are also shown so that the relationship of the mechanical elements that produce the visible impression is clear.

Referring to FIG. 3, there is shown a rear view of the assembly of FIG. 2. The print wheel positioning motor **41** advances the print wheel so that each symbol moves in succession to a position opposite the symbol selection area defined by print hammer **36** upon receipt of a corresponding succession of electrical impulses on print wheel motor leads **42**.

A paper and ribbon drive rotary solenoid **43** advances a paper drive gear **44** and the ribbon drive connection **45** through means including a push rod **46** when the rotary solenoid leads **47** are energized.

The printer operates as follows. Electrical impulses in a driving train of pulses applied to leads **42** advance print wheel positioning motor **41** until the desired one of twenty possible symbols to be printed is opposite the symbol selection area defined by the print hammer **36**. Each impulse advances the wheel $\frac{1}{20}$ of a revolution, or 18 degrees. An electrical impulse applied through leads **37** then activates print hammer solenoid **35** to push print hammer **19** upward to contact paper tape **12** and ribbon **15**. As print hammer **36** advances further upward, print wheel **14** and paper tape **12** sandwich ribbon **15** and impress the selected character then sitting stationary at the point of impact with print wheel **14** in the position previously selected.

After print hammer **36** is withdrawn following impression of the selected symbol on the paper tape **12**, an energy pulse is applied to leads **47** of paper and ribbon feed solenoid **43** to activate that solenoid. This causes the push rod **46** to move upward engaging both paper drive gear **44** via ratchet **48**, and the ribbon control mechanism **21** through the ribbon and drive connection **45**. Paper drive gear **44** rotates to cause paper drive roller **31** to move the paper strip **12** to the left one symbol position, thereby exposing the symbol just printed at the left of print wheel **14**. Push rod **46** also causes the ribbon control mechanism **21** to displace the ribbon **15** by substantially at least one symbol position in preparation for printing the next symbol. Upon de-energizing paper and ribbon rotary solenoid **43**, this solenoid returns to its original rest position allowing ratchet **48** to assume a position preparatory to pushing the paper drive gear **44** again in the next cycle. This completes the print cycle.

Whenever print wheel positioning motor **41** advances print wheel **14** to a position where steel set screw **26** is immediately adjacent to magnetic position sensor **18**, index signal output line **25** provides a signal indicating an index position of the wheel **14** with the first of the symbols available for selection then being opposite the symbol selection area defined by print hammer **36**. This signal may be used in association with an electronic control unit for subsequent control of the printer.

As a practical matter, the indexing signal provided on line **25** when the print wheel indexing set screw **26** passes close to magnetic sensor **18** is normally required only when power is first applied to the apparatus. This initial indexing may be effected by providing twenty pulses on line **42** when the apparatus is first energized to insure at least one revolution of the print wheel and the generation of an indexing pulse. Thereafter, the indexing pulse is really not needed and only serves as insurance that the position counter **64** will always be in step with the position of the print wheel. Since the pulse trains that drive the print wheel **14** and advance the position counter **64** start and stop together, only this starting and stopping of the pulse trains need be controlled.

Referring now to FIG. 4, there is shown a block diagram generally illustrating the logical arrangement of a printing system incorporating the printer **13** just described in association with an electronic control unit **51**. The electronic control unit **51** receives a position count signal comprising an electrical code representation of a symbol selected for printing in parallel binary form on input lines **52**, receives the index signal from line **25** and provides appropriate control signals on lines **37**, **42** and **47** to effect printing of the symbol represented by the code on lines **52**.

The five lines **52** can specify one of 32 possible combinations in binary code, but in the exemplary embodiment described herein with only 20 symbols on a single track, only 20 of the 32 possible identifying codes are used. The electronic control unit **51** also receives a PRINT COMMAND signal on line **53** which initiates a print cycle for printing the symbol specified by the coded signal then applied to lines **52**. At the completion of such a cycle, the electronic control unit **51** provides a PRINT COMPLETE signal on line **54**.

If it is desired to establish a blank space on paper strip **12**, a SPACE COMMAND signal is applied to line **55**. This signal causes paper strip **12** to space and renders the electronic control unit **51** insensitive to the state of lines **52**.

Operation of an exemplary electronic control unit will be better understood by considering the more detailed block diagram of FIG. 5 along with the signal waveforms of FIG. 6 plotted to a common time scale. A

PRINT COMMAND signal (FIG. 6A) applied to line **53** is coupled to the start input of triggered pulse generator **61** and to the set input of the PRINT CYCLE BUSY control unit **62** at time t_1. Triggered pulse generator **61** produces a sequence of relatively high power driving pulses (FIG. 6D) on line **42** for stepping the print wheel positioning motor synchronized with counting pulses at lower power level on line **63** for advancing the twenty state binary counter **64**. Each pulse from the triggered pulse generator **61** both causes print wheel **14** to advance one angular step (18°) and causes the twenty state binary counter **64** to advance one state or count. The twenty state binary counter is reset to an initial state upon receipt of an indexing signal on line **25** from the magnetic pickup **18**. Thus, the binary count in counter **64** corresponds to the position of print wheel **14** and identifies which symbol would then be printed if print hammer **36** was then actuated.

A comparator compares the binary number stored in counter **64** represented in parallel binary notation on the five output lines **67** with the signals applied on lines **52** designating the binary number identifying the symbol for printing. When the binary number represented by the signals on lines **67** corresponds to the binary number represented by the signals on lines **52**, comparator **66** provides an output compare signal (FIG. 6E) on line **71** which at time t_2 is applied to the stop input of trigger pulse generator **61** and the start input of print hammer interval timer **72**. This comparator output signal stops triggered pulse generator **61** from providing any more output pulses, thereby keeping print wheel **14** stationary and the count in counter **64** indicative of that stationary position. This comparator signal also starts print hammer interval timer **72** to provide a signal (FIG. 6F) on line **37** for actuating the print hammer to effect printing.

Upon de-energizing output line **37** to withdraw print hammer **36**, print hammer interval timer **72** provides a signal on output line **73** that energizes the start input of paper and ribbon interval timer **74** to produce a signal (FIG. 6G) on output line **47** at time t_3. This signal energizes paper and ribbon rotary solenoid **43** to move paper and ribbon one space in the manner described above. A signal applied to the space command input line **55** will also operate paper and ribbon interval timer **74** to produce a signal on line **47** for energizing the paper and ribbon rotary solenoid **43**. Upon operation of paper and ribbon interval timer **74** a signal transmitted on line **75** resets the print cycle busy flip-flop **62** to provide a PRINT COMPLETE resume signal on line **54** indicating the apparatus is ready to receive another PRINT SYMBOL or SPACE COMMAND signal from external equipment.

A preferred embodiment of this invention operates at a maximum speed of 25 characters per second and an average speed of 18 characters per second. The triggered pulse generator **61** provides pulses at a 400 c.p.s. rate, thereby advancing the print wheel **14** 1/20 of a revolution or 18° every 2.5 milliseconds. The print hammer timer provides a 15 millisecond pulse and the paper and ribbon feed timer provides a 25 millisecond pulse for driving the paper. This allows a maximum speed of 25 steps per second if the print wheel is not moved and a minimum speed of 11.4 characters per second if the wheel must be stepped 19 positions—the worst case—per character.

It is evident that the specific sequence of moving the print wheel, activating the print hammer and moving the paper and ribbon could be effected in various sequences. It is also possible to provide a print wheel with a number of circumferential tracks together with means for displacing the print wheel axially to select a track within the principles of the invention, thereby multiplying the number of possible symbols that can be selected from a single print wheel. Numerous other modifications and uses of and departures from the specific embodiment described herein may be practiced by those skilled in the arts without departing from the inventive concepts. Consequently, the invention is to be construed as limited solely by the spirit and scope of the appended claims.

What is claimed is:

1. Symbol selection apparatus comprising,
means defining a continuous surface having a succession of symbols thereon identifiable by a consecutive series of order numbers,
means defining a symbol selection area,
means for supporting said continuous surface defining means relatively movable with respect to said symbol selection area so that any one of said symbols may be selectively positioned opposite said symbol selection area,
pulsating motive means for moving said continuous surface in pulses to position successively in step-wise increments each of said symbols opposite and relatively stationary to said symbol selection area for at least a first duration less than the time interval between successive ones of said pulses,
means for pulsing said pulsating motive means to advance the next of said symbols opposite said symbol selection area on each pulsation,
means for providing an indexing signal indicative of the first of said symbols being opposite said symbol selection area,
means for providing a count signal representative of one of said symbols selected for retention opposite said symbol selection area,
means responsive to each pulsation of said pulsating motive means for providing a position signal referenced to said index signal representative of which of said symbols is then opposite said symbol selection area,
and means responsive to correspondence of said position signal with said count signal for interrupting the pulsation of said motive means with said symbol selected for retention then opposite said symbol selection area and for maintaining said continuous surface and said symbol selection area relatively stationary for a second duration greater than the time interval between successive ones of said pulses.

2. Symbol selection apparatus in accordance with claim **1** wherein said means providing an indexing signal comprises means attached to said continuous surface defining means.

3. Symbol selection apparatus in accordance with claim **1** and further comprising,
means for receiving an impression of each symbol selected for retention opposite said symbol selection area,
means for relatively moving said impression receiving means and the symbol opposite said symbol selection area together upon each interruption of pulsation to reproduce each selected symbol upon said impression receiving means during said duration,
and means for successively advancing said impression receiving means relative to said symbol selection area to reproduce a selected train of said symbols upon said impression receiving means.

4. Symbol selection apparatus in accordance with claim **1** wherein said means for providing a position signal comprises a counter indexed in response to each pulsation and reset to a predetermined count when said first symbol is opposite said symbol selection area,
and the means responsive to correspondence of said position signal with said count signal comprises comparator means providing an output signal for interrupting the pulsation of said motive means when the count in said counter corresponds to a digital number represented by said position signal.

5. Symbol selection apparatus comprising,
means defining a surface with a succession of symbols

each identifiable by a unique order number,
means defining a symbol selection area,
means for supporting said surface defining means relatively movable with respect to said symbol selection area so that any one of said symbols may be positioned opposite said symbol selection area,
means for relatively displacing said surface defining means and said symbol selection area in stepwise increments to sequentially position each of said symbols opposite and relatively stationary to said symbol selection area for at least a first relatively short time duration,
means for providing a position signal representative of which of said symbols is then opposite said symbol selection area,
means for providing a selection signal representative of the order number associated with one of said symbols,
means responsive to said position and selection signals for providing a compare signal when said position signal represents the symbol associated with the latter order number,
and means responsive to said compare signal for interrupting the relative displacement between said surface defining means and said symbol selection area with the latter symbol then opposite said symbol selection area and for maintaining said continuous surface and said symbol selection area relatively stationary for a second duration that is longer than said first duration.

6. Signal selection apparatus in accordance with claim 5 wherein said means for providing a position signal comprises a counter stepped in synchronism with the relative displacement between said surface defining means and said symbol selection area to store a digital number corresponding to the order number associated with the symbol then opposite said symbol selection area,
said means for providing a selection signal representative of the order number associated with one of said symbols includes means for providing a digital signal corresponding to the said latter order number,
and said means for providing a compare signal includes means for providing said compare signal when the latter digital signal corresponds to the count in said counter.

7. Signal selection apparatus in accordance with claim 5 wherein said surface defining means comprises a cylinder rotatable about its axis,
and said means for relatively displacing comprises means for angularly displacing said cylinder in regular angular increments about said axis.

8. Signal selection apparatus in accordance with claim 6 wherein said surface defining means comprises a cylinder rotatable about its axis,
and said means for relatively displacing comprises means for angularly displacing said cylinder in regular angular increments about said axis.

9. Signal selection apparatus in accordance with claim 8 and further comprising a source of pulses,
means for applying pulses from said source to said means for angularly displacing to displace said cylinder one of said angular increments for each applied pulse,
means for applying pulses from said source to said counter to advance the count stored therein by one for each applied pulse,
and means responsive to said compare signal for interrupting the application of pulses from said source to said means for angularly displacing and to said counter.

10. Signal selection apparatus in accordance with claim 9 and further comprising,
means for receiving an impression of the symbol selected for retention opposite said symbol selection area,
means responsive to said compare signal for relatively moving said impression receiving means and the symbol opposite said symbol selection area together for a prescribed time interval sufficient to then impress the latter symbol on said impression receiving means during said second duration,
means for relatively displacing said impression receiving means and said symbol selection area by a prescribed space length following impression of a symbol on said impression receiving means,
a source of a command signal for initiating the delivery of pulses from said source of pulses to said means for angularly displacing and to said counter, and
means responsive to said command signal for providing a busy signal and responsive to said displacement by said prescribed space length for providing a completion signal indicating that said apparatus is ready to receive another position signal.

11. Symbol selection apparatus comprising,
means defining a continuous surface having a succession of symbols each located in respective contiguous symbol cells thereon and each identifiable by a respective order number in a consecutive series of order numbers,
means defining a symbol selection area,
means for supporting said continuous surface defining means relatively movable with respect to said symbol selection area so that any one of said symbols may be selectively positioned opposite said symbol selection area,
a source of pulses,
pulsatable motive means for relatively displacing said continuous surface with respect to said symbol selection area in stepwise increments with each of said increments corresponding substantially to the length of a said symbol cell along said continuous surface,
means for coupling a driving train of pulses from said source of pulses to said pulsatable motive means to position successively in said stepwise increments by one of said stepwise increments for each of said pulses each of said symbols opposite and relatively stationary to said symbol selection area for a first duration less than the time interval between successive pulses in said train,
means for providing an indexing signal indicative of the first of said symbols being opposite said symbol selection area,
position counter means for providing a position count signal,
means for coupling said indexing signal and a counting train of pulses syncronized with said driving train of pulses from said source of pulses to said position counter means to establish said position count signal representative of which of said symbols is then opposite said symbol selection area,
a source of a symbol selection count signal representative of an order number corresponding to that one of said symbols selected for retention opposite said symbol selection area,
comparing means responsive to correspondence between said position count signal and said symbol selection count signal for providing a compare signal,
and means responsive to said compare signal for terminating the coupling of said driving train of pulses to said pulsatable motive means and said counting train of pulses to said position counter means for at least a second duration greater than the time interval between successive ones of said pulses in said trains and thereby maintaining said continuous surface and said symbol selection area relatively stationary during said second duration.

12. Symbol selection apparatus in accordance with claim 11 and further comprising,
a source of a resume signal indicative of the end of said duration,
and means responsive to said resume signal for restor-

ing the coupling of said driving train of pulses to said pulsatable motive means and said counting train of pulses to said position counter means.

13. Symbol selection apparatus in accordance with claim 12 and further comprising,

a medium for receiving a sequence of impressions of selected ones of said symbols,

and means responsive to each compare signal for placing an impression of the then selected symbol upon said medium during each second duration beside the impression of the immediately preceding impression.

References Cited by the Examiner

UNITED STATES PATENTS

2,658,942	11/1953	Durkee	101—93 X
2,668,870	2/1954	Ridler	101—93 X
2,692,551	10/1954	Potter	101—93
2,776,618	1/1957	Hartley	101—93
2,805,620	9/1957	Rosen et al.	101—93
2,910,935	11/1959	Cignetti	101—93
3,015,265	1/1962	Gmeiner	101—93
3,024,723	3/1962	Wasserman	101—93

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