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[54] **DIGITAL PATTERN CONTROL APPARATUS FOR TEXTILE MACHINERY**

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[21] Appl. No.: **118,030**

[52] **U.S. Cl.** .....**112/79 A**, 139/319, 178/5.2 R, 250/227, 340/172.5

[51] **Int. Cl.**.....**D05c 15/26**

[58] **Field of Search** ....112/79 R, 79 A, 80, 266, 410; 139/319; 156/299; 234/55, 58, 67, 68, 69, 89; 178/5.2 R, 5.2 A; 250/226, 227; 340/172.5

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[57] **ABSTRACT**

Apparatus for developing a pattern in textile goods formed by a tufting operation employs an array of optical fibers to optically scan a replica of the desired pattern. The continuous output scan signal is digitally quantized, and sampled by scan-synchronized strobe circuitry to provide a series of binary information bits descriptive of the scanned pattern with accurate resolution. The serial bits are converted to parallel form, and preserved in a storage medium together with control information as plural bit frames of predetermined format.

Pattern implementing control circuitry operates asynchronously under control of the tufting machine to automatically receive present stitch (row) and next stitch information in corresponding holding registers from the pattern storage medium. Pattern controllers are responsive to the binary digital information stored in the present stitch register for determining the pattern-defining operations effected by tufting stations disposed across the width of the tufting machine.

14 Claims, 5 Drawing Figures

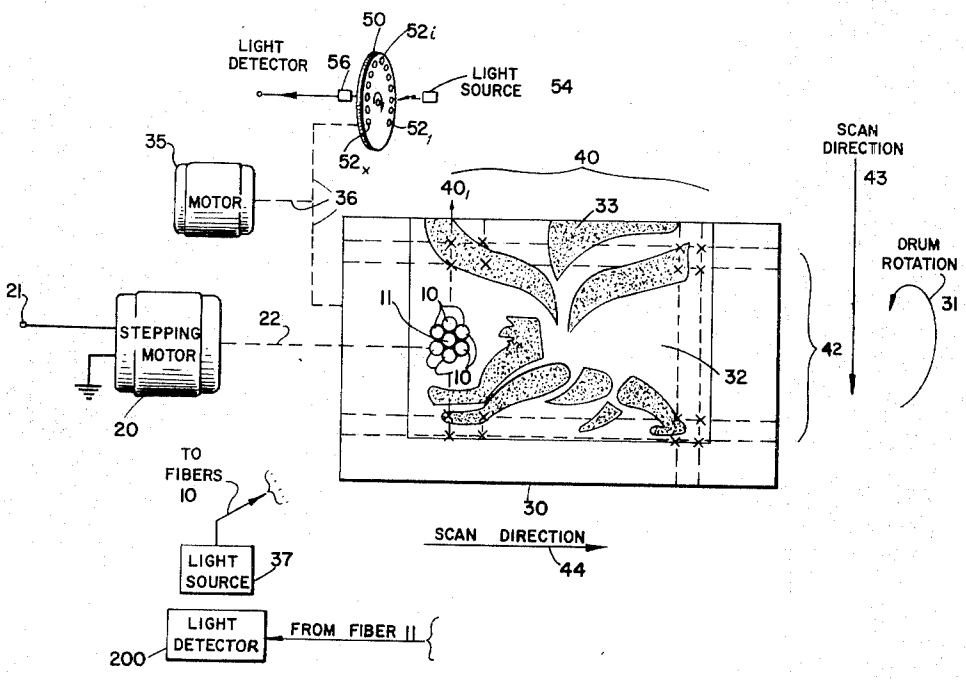
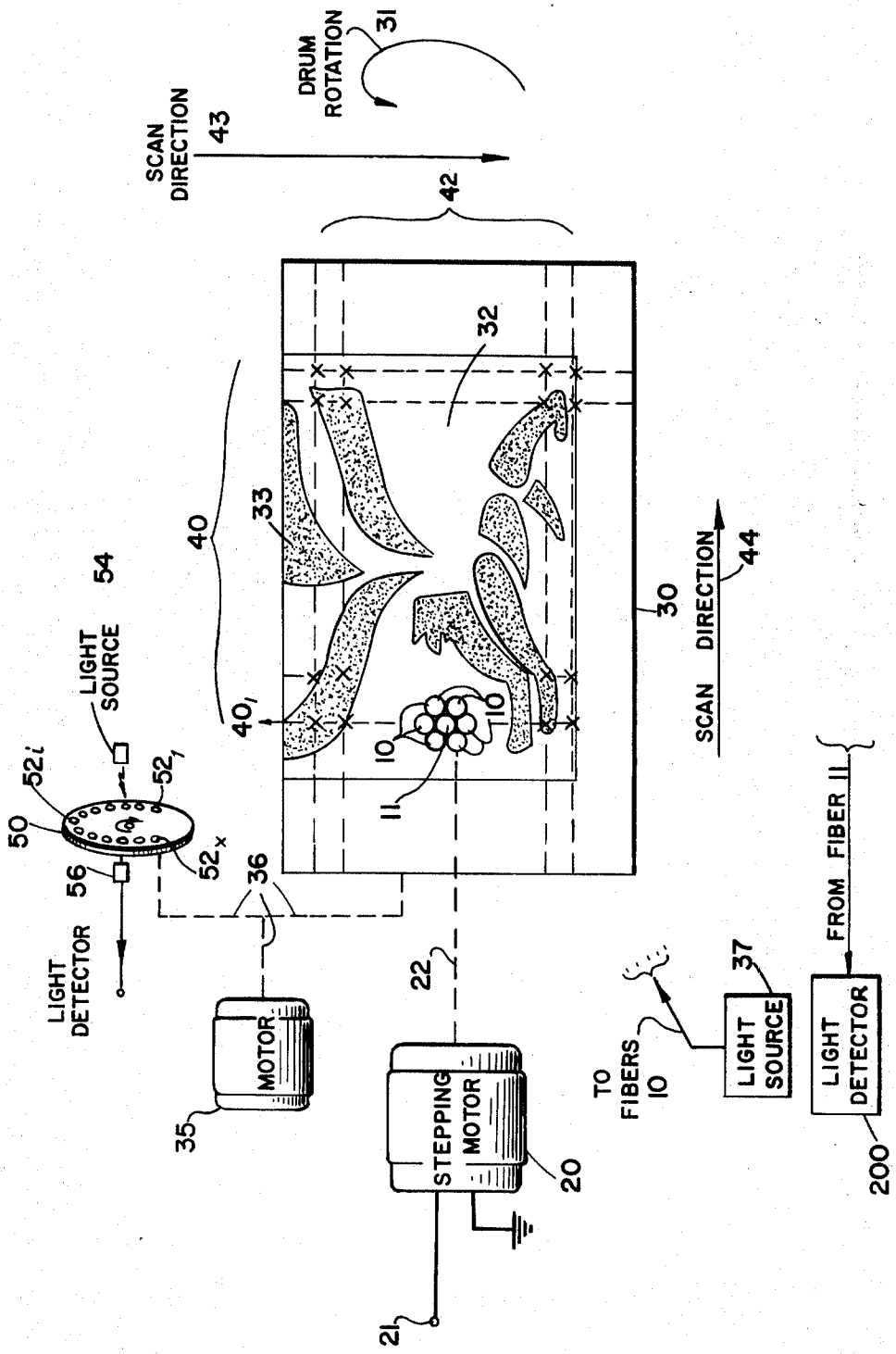


FIG. 1



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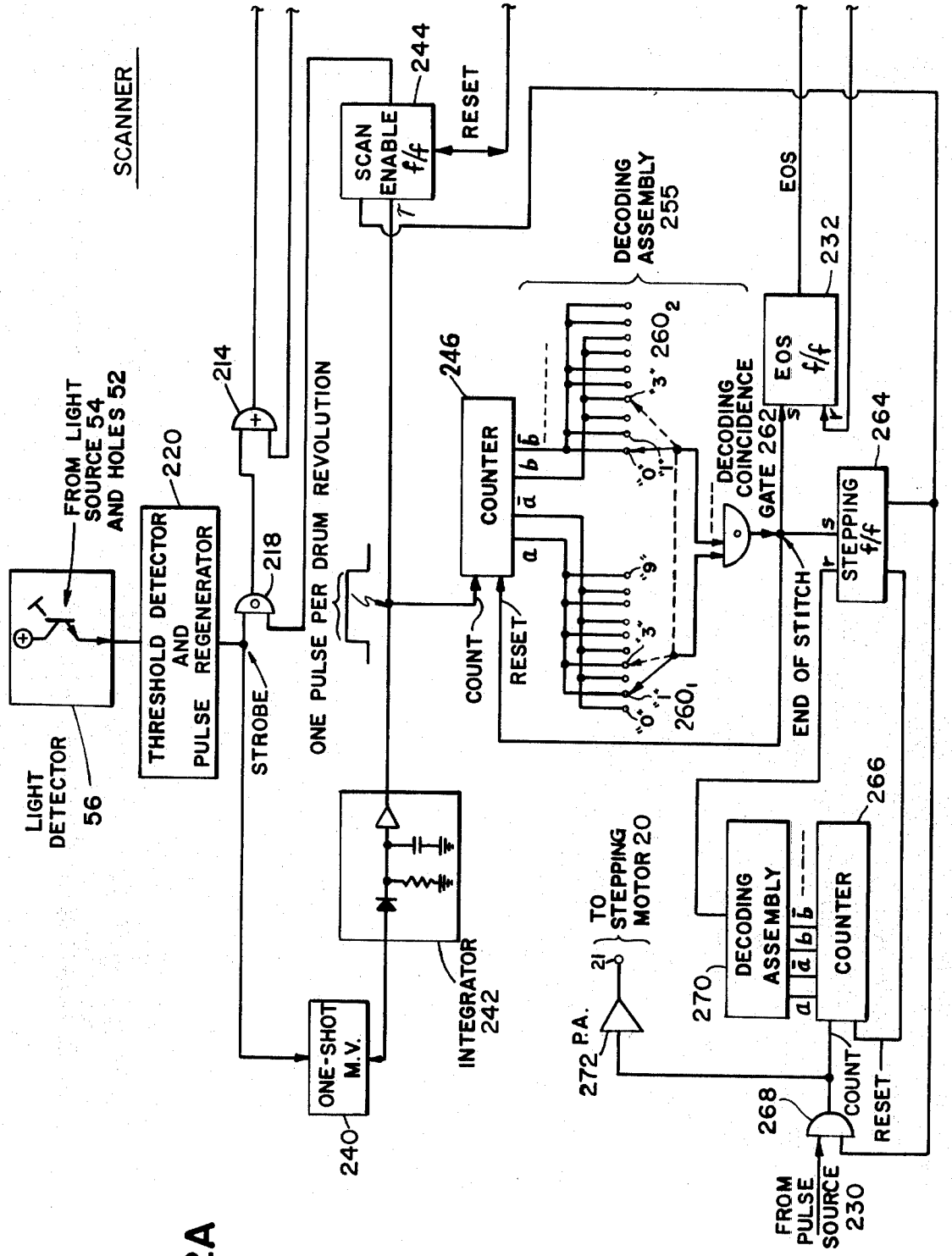


FIG. 2A

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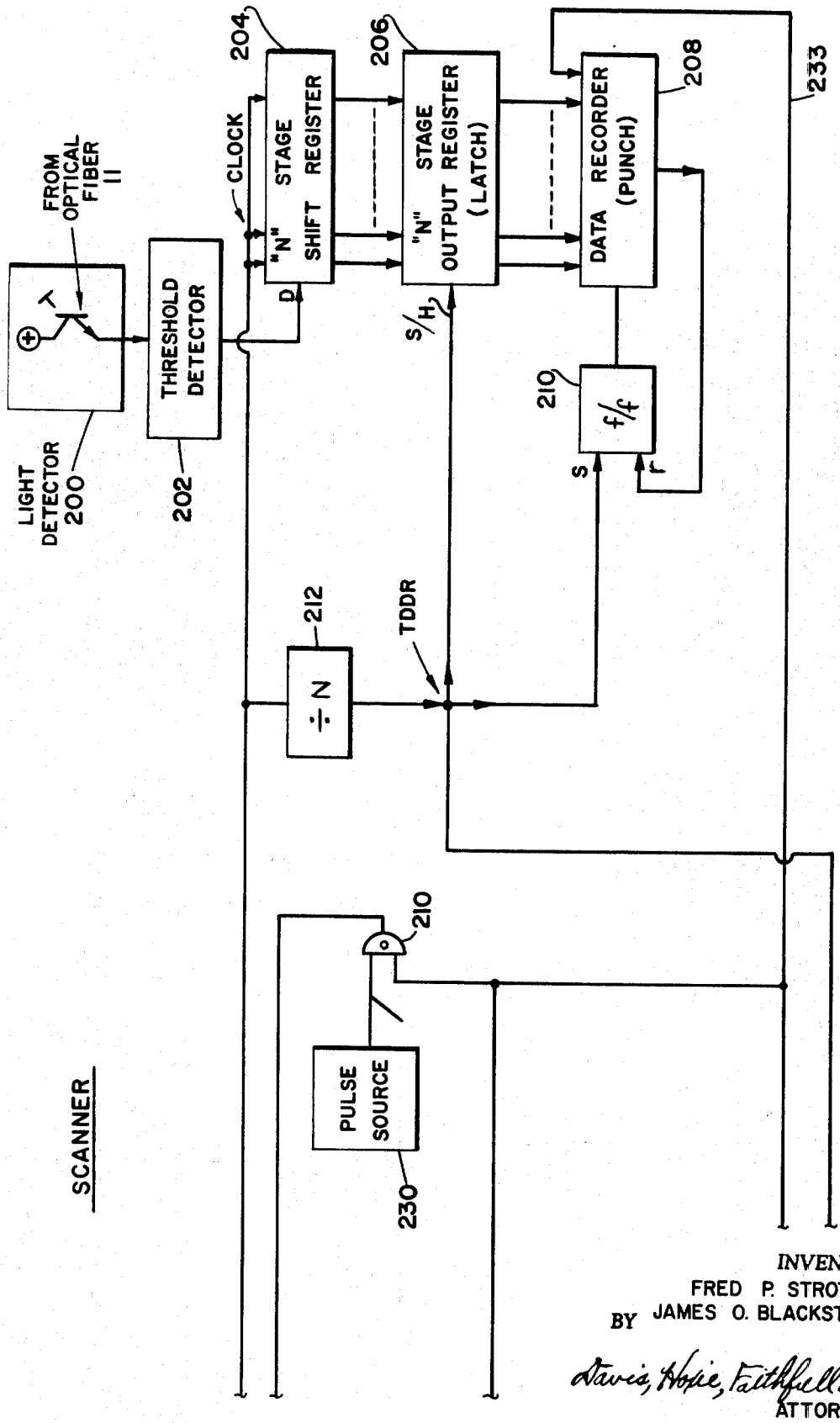


FIG. 2B

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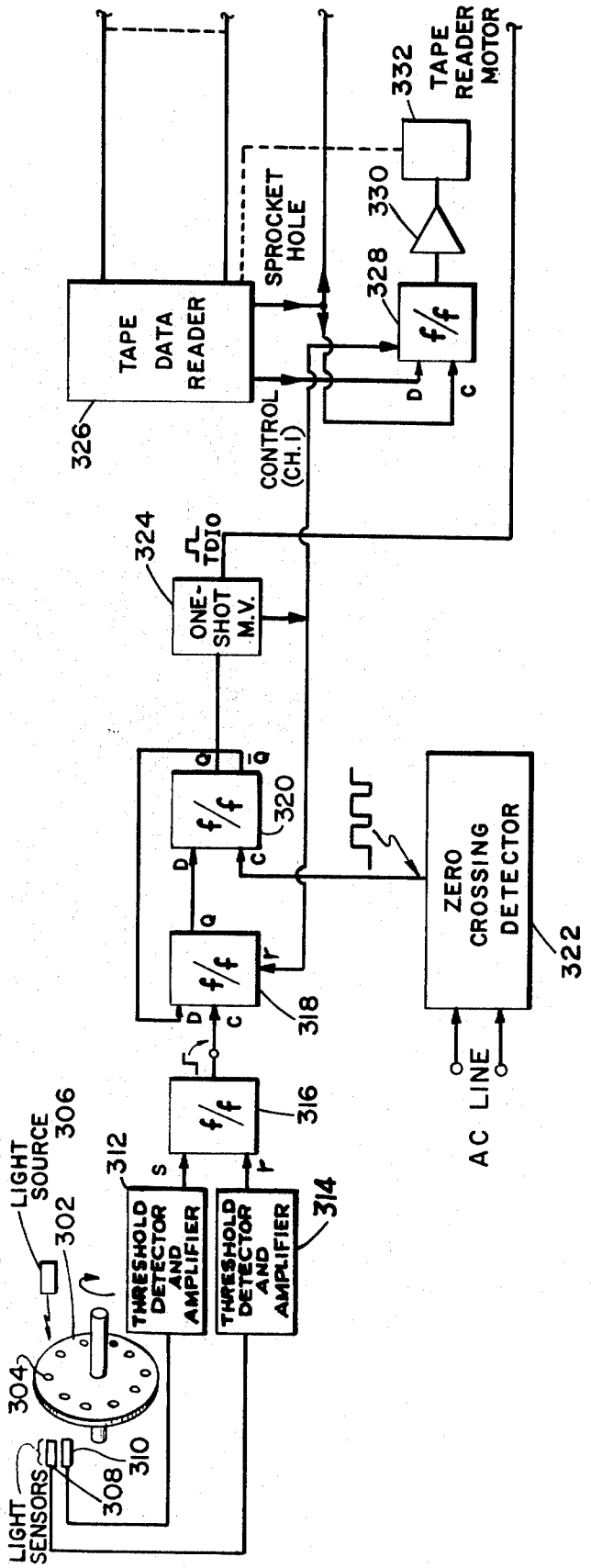


FIG. 3A

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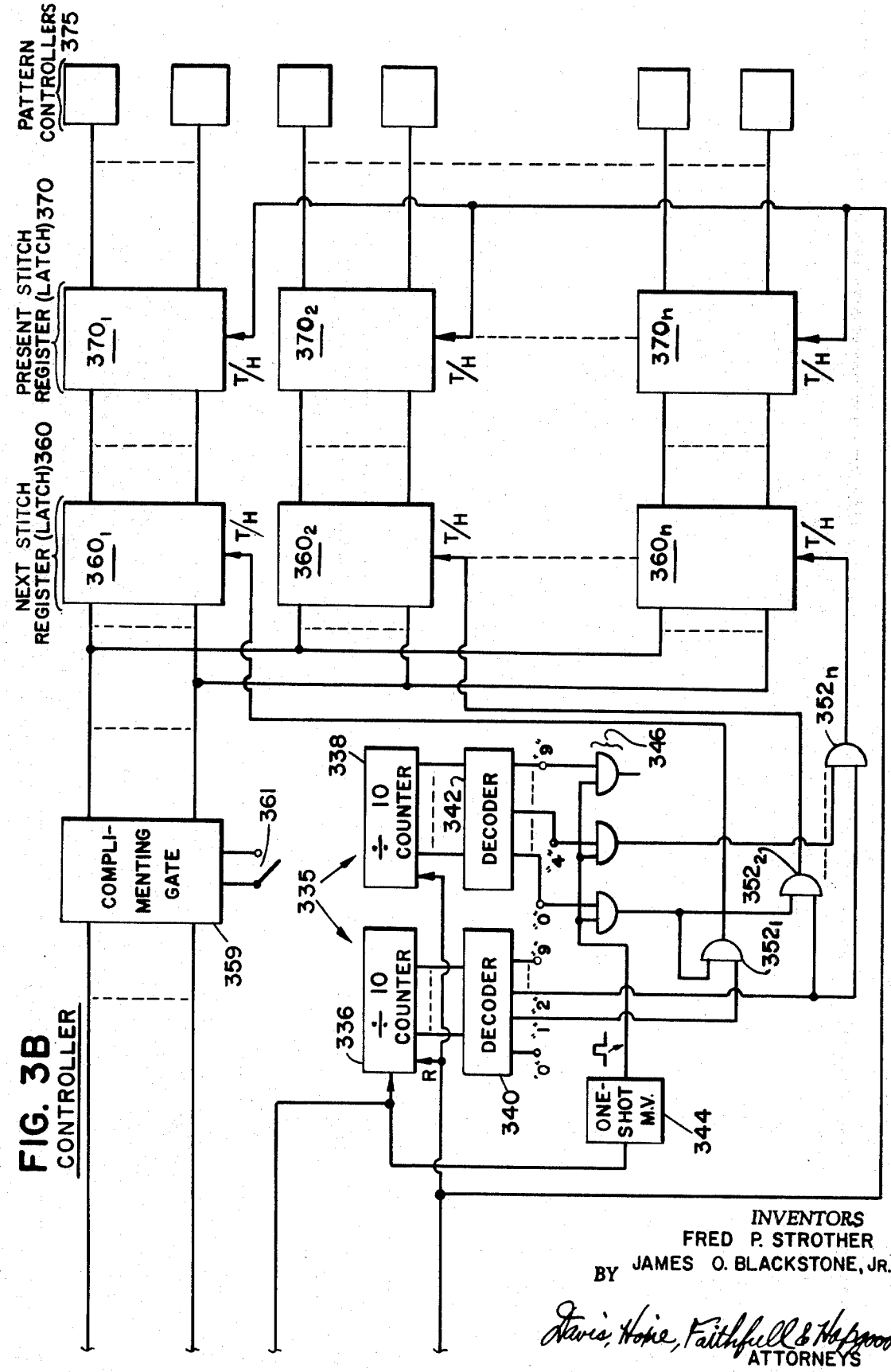


FIG. 3B
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DIGITAL PATTERN CONTROL APPARATUS FOR TEXTILE MACHINERY

This invention relates to textile fabrication and, more specifically, to digital electronic apparatus for reproducing a graphic pattern in tufted carpet and other textile materials.

Tufting equipment is widely employed to produce carpet and other soft goods products, and typically employs a linear array of tufting stations spaced across the width of the equipment. Each tufting station illustratively includes a threaded needle, hook, and, in the case of cut loop carpet, a knife for shearing the loop thread ("end"). A carpet base, or web substrate, is drawn lengthwise transverse to the array of tufting stations, and individual carpet pile loops are formed in the carpet substrate by the reciprocating needles and hooks. Each end thread progresses lengthwise down the length of the carpet under the action of an associated tufting station. The loop packing density in each carpet dimension is made sufficiently great such that the tufted loops appear continuously disposed about the carpet surface, the specific loop density in relation to the material forming the end thread bears on the quality of the carpet.

Several physical mechanisms have heretofore been employed to form an ornamental pattern in tufted carpet and other like textiles. For example, a difference in appearance (to define pattern detail) results between carpet areas having cut as compared with non-cut loops; long vis-a-vis short loops; or a selection between several needles at each tufting station to form loops of a different color. The pattern detail has been implemented by various electronic actuating controllers such as electromagnetic relays or clutches or electrically controlled pneumatic valves associated with each tufting station. Thus, for example, the carpet loops formed during a stitch (a pattern row across the carpet width) may or may not be cut during an operative tufting cycle by selectively actuating controllers with a pattern of control potentials. The energized controllers respond to the applied potential by moving an actuating member which is mechanically coupled to the loop severing knife. Also, such controllers may selectively vary the tension in the end thread as by controlling tension in a feed roller, to implement a pattern by the loop-robbing technique (long or short resulting loops).

Prior art pattern controlling arrangements for tufting machines have been of several forms. The desired carpet pattern may be effected by placing a replica of the pattern, formed of electrically conductive and non-conductive areas, on a drum which rotates in synchronism with the tufting machine. An array of mechanically biased conducting sensors slide across the pattern to actuate pattern effecting controllers when conductive pattern areas are encountered. The pattern impress in the carpet will then correspond to that mounted on the rotating drum. The pattern for such prior art apparatus is self-repeating along the length of the carpet, one full pattern being formed for each complete drum rotation. The pattern may be repeated across the carpet width by simply wiring in parallel two or more control ports for the pattern implementing controls, spaced across the carpet width.

The above-described pattern control function has also been implemented by forming the pattern of transparent and opaque areas, and employing a light source inside a rotating transparent drum together with a plurality of light sensors mounted outside the drum.

Another common manner of forming patterns is to machine an array of pattern control bars, or "slats" which mechanically rotate in synchronization with tufting machine operation. The slats directly control the carpet pattern by metering the yarn which, in turn, varies the loop length.

The above and other pattern control arrangements suffer several deficiencies. First, the conducting-non-conducting drum pattern, and the array of slats, are difficult and expensive to prepare, a slat pattern costing several thousands of dollars. Also, the resolution and/or repeatability of the selectively conducting or light transmitting drum patterns is limited, thus also limiting the pattern detail which can be accommodated. Moreover, the pattern fidelity for a conductive pattern deteriorates over long drum service as state transition errors are developed by the sliding sense wipers.

Further, it is tedious and time consuming to change patterns with prior art apparatus. For each pattern change, the drum pattern or array of slats must be completely replaced.

As still another disadvantage, prior art pattern controllers are not amenable to pattern design or pattern modification. It is expensive and time consuming to make a drum overlay or slat pattern for a new design which may prove worthless should the resulting pattern be aesthetically unappealing, or otherwise unsatisfactory. Also, it is very difficult to make modifications in a pattern, or to combine several patterns or portions of patterns.

It is thus an object of the present invention to provide improved pattern control apparatus for textile fabricating.

More specifically, an object of the present invention is the provision of pattern control apparatus for textile fabrication which is readily amenable to pattern design and rapid pattern implementation; wherein pattern changes may be conveniently performed; which provides accurate, repeatable pattern control of detail limited only by the controlled tufting machine; and wherein pattern implementation may be affected without expensive or time-consuming mechanical construction.

The above and other objects of the present invention are realized in an illustrative pattern control system for tufting apparatus wherein a desired pattern is formed as a graphic display, e.g., a black and white artistic conception or photograph. The display is optically scanned across a stitch (a pattern row in the direction of the carpet width), and quantized into a time varying electrical wave form which is subdivided (sampled) by a synchronized electronic strobe into an array of binary information bits representing pattern information across the stitch. The digital bits are grouped into parallel frames (substitch size bytes) by a series-to-parallel conversion, and registered on a storage medium such as a punched paper tape. Also recorded on the medium is synchronizing information sufficient to identify each bit within a frame, each frame within a composite stitch, and each stitch.

To effect the desired carpet pattern, the prepared tape is loaded into a tape reader which responds to

recurring synchronizing signals from the tufting machine. When such a signal is received, stored data frames corresponding to exactly one pattern stitch are read into a "next stitch" register (latch). Upon completion of a stitch by the tufting machine, data is transferred from the "next stitch" register to the "present stitch" register, while new information is gated from the tape reader into the "next stitch" register.

An array of output interfacing drivers in one-to-one correspondence with the tufting stations across the pattern width selectively activate the carpet pattern implementing switching elements in accordance with the digital pattern stored in the present stitch output register. After each stitch has been executed, tape reader actuation and storage register updating is automatically performed on an asynchronous basis responsive to timing signals generated by the tufting machine.

The above and other objects, features and advantages of the present invention are realized in a specific, illustrative pattern controlling arrangement, described in detail below in conjunction with the accompanying drawing, in which:

FIG. **1** depicts pattern scanning and scan-synchronized strobe signal generating apparatus embodying the principles of the present invention;

FIGS. **2A** and **2B** respectively comprise the left and right portions of a diagram illustrating digital scanner circuitry for processing the pattern information and for preparing a record thereof; and

FIGS. **3A** and **3B** respectively comprise the left and right portions of tufting machine controller circuitry which embodies the principles of the present invention.

Referring now to FIG. **1**, there is shown scanning apparatus operative in conjunction with the circuitry of FIGS. **2A–2B** for generating a stored digital record of a pattern **33** desired for a textile application, e.g., to be formed in a tufted carpet. The pattern **33**, formed on a backer sheet **32**, may comprise, for example, an artist's conception, lettering, photograph, or the like. The graphic depiction **32-33** may then be mounted on a cylindrical drum **30**, for example, which is rotated by motor **35** via any suitable coupling **36** such as gears, a belt, or the like. For purposes of quantizing the pattern into digital information, it is required that the pattern **33** and the blank sheet **32** surface exhibit contrasting light reflecting properties. Accordingly the pattern **33** shown in FIG. **1** may comprise nonreflecting black areas, while the remainder of the substrate **32** is either reflective per se or transparent to permit light reflection from a polished outer surface of the drum **30**. Alternatively, the graphic depiction may be mounted on a flat surface which is reciprocated by motor **35** and a suitable cam coupling.

Pattern scanning is performed by a plurality of optical fibers **10**, **11**, which scan the pattern across its width, i.e., along a plurality of discretely spaced circumferential scan travels, indicated by the dashed lines **40**. Other optical systems of light generation and reception may also be used for scanning. The pattern sensed along one scan line **40** is eventually implemented to form one carpet stitch (row) across the width of a tufted carpet. The relative scan travels **40** effectively proceed in the direction of a vector **43**, each complete scan line being accomplished when the drum rotates once past the stationary optical fiber bundle **10–11** (any number of rotations may be employed where the pattern is repeated across the carpet width as discussed below). After each complete scan, i.e., after each complete drum **30** rotation (or series of rotations for pattern width repeating), the optical system is shifted one position to the right (down the carpet pattern length) under the action of a stepping motor **20** acting through a coupling **22**, e.g., a threaded shaft and next follower. For purposes of clarity, the distance between successive scan travels **40** (and also the distance between the intervals **42** discussed below) is shown relatively large in the drawing. However, in practice the distance is small in relation to the detail of the pattern, and is directly proportional to the distance between successive tufting stitches in the formed carpet.

The optical fiber array includes a plurality of peripheral fibers or fiber bundles **10** each of which is supplied with light from a light source **37** at the end remote from the pattern **33**. The incident light is coupled by the fibers **10** from the light source and emanates from the fiber ends nearest the pattern **32–33** to illuminate a small area of the pattern, the illuminated area being very much smaller than the relative scale shown in FIG. **1** for illustration. A light receiving optical fiber **11** has its light input end centrally disposed among the fibers **10**, and selectively couples a measure of the light reflected by the illuminated pattern area to the control node of a light sensitive element **200** such as the junction of a silicon phototransistor or the like. More specifically, if the illuminated pattern area corresponds to a predominantly black portion of the pattern, relatively little light is reflected from the output ends of the fibers **10** to the receiving end of the fibers **11** such that the light responsive element produces a relatively small output. Correspondingly, if the sampling light from the fibers **10** falls upon a predominantly reflecting portion of the pattern, the optical fiber **11** couples a relatively large amount of light to the light detector which provides a relatively large output. The pattern may then be digitally quantized by examining the amount of light reflected by the pattern (a continuous function) at particular sampling time intervals corresponding to spaced points across the pattern width. If the value of the reflected light at the strobed point exceeds a selectable level, a binary signal of one form results; if the reflected light at that point is below the selectable level, a binary signal of the other form results.

To provide the timing, or electronic strobe signals for sampling a continuously scanned pattern, an opaque plate **50** is driven by the motor **35** and coupling **36** in synchronization with rotation of the drum **30**. The plate **50** includes a plurality of angularly spaced holes **52** therein, with a light source **54** and a light detector **56** being disposed on opposite sides of the plate **50**. The light detector **56** supplies an output corresponding to a first binary state when the opaque plate isolates the source **54** and detector **56**. Conversely, when one of the holes **52** is oriented between the members **54** and **56**, light impinges on the detector **56** which supplies a relatively narrow output pulse of the alternate binary state.

As more fully discussed below in conjunction with the electronic circuitry of FIGS. **2A** and **2B**, each of the typically periodic sequential pulses generated by the

light detector **56** gives rise to a pattern sampling interval for the scanned pattern **33**. Thus, as the scanning optical fiber bundle **10-11** proceeds across the pattern width along one of the dashed scanning paths **40**, e.g., the first path 40_1, the output of the photo-sensing element **200** coupled to the optical fiber **11** is interrogated at the spaced points noted by the crosses "*x*" shown therealong.

Each such information point corresponds to the interval when a different one of the holes **52** in the plate **50** provides a light propagating path between the light source **54** and the light detector **56**. Since the drum **30** and disc **50** rotate in synchronization, the pattern interrogating "*x*" points will be the same for each of the scans **40**. The locus of these points across the scan paths **40** is shown by the lines **42** which have a time direction shown by the vector **44**, and which correspond to the length direction of the pattern and the tufted carpet. It will thus be appreciated that the array of scan lines **40** and **42** define a pattern interrogating grid at their intersections, and that a pattern of fine detail may be scanned with accurate resolution and fidelity by merely employing a scanning grid having interline spacings which are small in relation to the pattern definition.

The holes **52** are disposed in an arc about a significant portion of a circular radius of the disc **50**, but do not proceed about a complete circle. Correspondingly, the pattern sheet **32** does not occupy the full circumference of the drum **30**, there being some blank drum portion along the length of the drum. The pattern is mounted on the drum such that the scan line **42** corresponding to the first aperture 52_1 in the disc **50** occurs at the beginning of the pattern, i.e., and at its right edge for the specific arrangement of the drawing. Sufficient holes **52** are provided such that the scanned lines **42** will cover the largest (i.e., widest) of all patterns desired.

As discussed more fully below, circuitry is provided to recognize the relatively long time interval which occurs between the times when the last hole 52_x and the first strobe hole 52_1 optically couple the elements **54** and **56** vis-a-vis the relatively short time interval between other consecutive aperture pairs. This long interval recognition signals the end of one scan line **40** and is used for various control purposes, one of these being to gate pulses to an input terminal **21** of the stepping motor **20** to advance the optical fiber array to the next scan position.

As noted above, each scan path **40** generates digital information for reproducing one tufting stitch across the width of the pattern. This pattern may correspond to the entire width of the carpet, or may be repeated across the width of the carpet. The successive binary bits generated by the quantized and sampled output of the fiber **11** are collected and employed to selectively actuate the pattern controlling switching elements at the plural tufting stations of a tufting machine, i.e., the loop-robbing elements, color selecting solenoids, loop - cutting knife, or the like. Thus, the individual tufting loops in a stitch correspond to the sequence of digitized pattern signals produced during the pattern scanning procedure thereby reproducing the desired pattern in the carpet.

Turning now to FIGS. **2A** and **2B**, hereinafter referred to as composite FIG. **2**, there is shown circuitry for preparing a stored digital record of the pattern information sensed by the optical fiber bundle **10–11** of FIG. **1**. For purposes of concreteness, it will be assumed that the record medium is punched paper tape, e.g., of the common eight track class. Other storage structures for preserving digital information, for example, any of the well known magnetic storage embodiments, may be employed as well.

The light detector **200** provides a continuous analog output signal descriptive of the relative reflective properties of that portion of the desired pattern then being illuminated by the light fibers **10**. This analog signal is passed to a threshold detector **202** such as a Schmitt trigger which quantizes the information as predominantly black or white (i.e., as reflective or non-reflective), and supplies this time varying binary information to the data input terminal of a shift register **204**.

As a data format, the eight track tape is divided into a single control track and seven information (tufting station pattern controlling) channels. The control bit and the seven information bits across one tape width are a data word frame, or byte. The number of tape frames required to control one full carpet stitch thus comprises the number of seven bit words or parts thereof required to furnish one bit for each tufting station to define the state of each station as the stitch is executed. For this seven information bits per frame data format, the shift register **204** includes seven binary stages, the shift register and its ancillary apparatus performing a series-to-parallel conversion.

To develop the strobe signals for circulating data through the shift register **204** (and thereby also for defining the effective pattern interrogating sampling intervals) the light detector **56** associated with the strobe timing wheel **50** of FIG. **1** periodically supplies pulses to a threshold detector and pulse regenerator **220**, e.g., a Schmitt trigger. The digital strobe pulses pass through a normally partially enabled coincidence gate **218** and a disjunctive logic gate **214** to the clock, or data shifting inputs of the shift register **204** stages. As used herein, coincidence gates will alternately and nominally be referred to a "AND" logic gates, and disjunctive logic will be considered "OR" logic, but it is to be understood that any other corresponding logic forms such as NAND gates for coincidence logic and NOR gates for disjunctive logic may be employed in accordance with well known principles. The choice of negative true or positive true logic; the choice of the many flip-flop and logic gate forms commercially available; and the selective use of inverters to interface the several gates and flip-flop ports will be readily apparent to those skilled in the art in view of the discussion herein.

The binary pattern signal value present at the output of the threshold detector **202** is entered into the first shift register stage during each strobe pulse impressed on the clock inputs of the shift register **204**. Thus, the strobe signal functions to digitally sample the scanned and quantized pattern. Further, all information already contained in the shift register is shifted by one stage with each strobe pulse.

Conventional non-optical strobing means alternatively may be used to generate the strobe signals. Light

source **37** also can be pulsed at the desired strobe rate, rather than providing a continuous output.

A scaler or counter **212** count the strobe pulses which pass through the OR gate **214**. Each time a full data frame (seven information bits for the assumed data format) is determined by the scaler **212** counting the last of a set of seven strobe pulses, the counter output undergoes a voltage transition which defines a TDDR (transfer data to data register) signal. The TDDR signal converts a data output register **206**, e.g., a seven bit latch register, from a sample to data hold mode of operation. While operating in the sampling mode, the seven bit latch register **206** tracks the corresponding digital outputs from the shift register **204**. When converted to its hold mode during the TDDR signal, the latch register **206** retains at its outputs the binary bits from the shift register **204** which were present when the latch was last tracking the shift register. Accordingly, since the hold TDDR signal begins at the end of a complete data frame when a full frame of seven pattern information bits were contained in the register, the TDDR signal locks a full frame of seven pattern bits into the latch **206**.

The end of frame TDDR signal is also employed to set a flip-flop **210** which signals the data recorder **208**, in this case a paper tape punch, to record the data then residing at the output terminals of the latch **206**. Accordingly, the data punch **208** makes a record on paper tape of the seven binary bits which were stored in the shift register **204** at the end of the last processed information frame. The paper tape punch may advantageously include internal structure for resetting the flip-flop **210** after punching is completed. Such a signal has heretofore been generated, for example, by actuating a pair of contacts at a particular point in the travel of the punch head. Alternatively, the punch **208** may be activated by the TDDR signal directly or by a differentiated replica or one-shot output signal produced responsive to each TDDR signal. Since the latch **206** typically operates at electronic speeds, e.g., a nanosecond rate, while the punch operates at mechanical speed, there is no race condition between the elements **206** and **208**.

In addition to recording the information bits in the seven information tracks of the paper tape, the punch **208** also records a single information synchronizing control bit supplied thereto by way of a lead **233** from an "end of stitch" flip-flop **232** during each frame. For example, the control bit in the eighth control tape track is not punched (e.g., a binary zero) unless the frame then being punched corresponded to the last frame in a complete stitch.

By way of timing and control signal processing, the regenerated strobe pulses from pulse circuit **220** trigger a one-shot multivibrator **240** which supplies an output pulse of a timed duration to an integrator **242**. The integrator **242** is operative in conjunction with the one-shot multi-vibrator **240** for supplying a signal of one binary value (a relatively high output potential) when the strobe pulses occur relatively frequently, i.e., when the closely spaced holes **52** in the plate **50** of FIG. **1** periodically unblock the light source **50** and the light detector **56**. Conversely, following the last aperture 52_x passing between the elements **54** and **56**, a relatively long time interval elapses before the first aperture 52_1 is again encountered. Accordingly, in the beginning portion of this relatively long interval, the integrator **242** times out (e.g., an output capacitor becomes fully discharged) and its output voltage reverts to the alternate binary state. Integrating circuits are well known per se, a simple and adequate one being shown in the drawing wherein the output of the one-shot multivibrator charges a capacitor through a series diode, the capacitor becoming fully discharged through a shunt resistor when the one-shot circuit **240** ceases supplying charging pulses following the last aperture 52_x. The output of the integrator **242**, as indicated by the waveform in the drawing, comprises a single voltage pulse for each complete revolution of the opaque wheel **50**, and thereby also for each single complete revolution of the pattern-bearing drum **30** corresponding to one pattern scanning line **40**.

The output from the integrator **242** is supplied to a digital counter **246** which develops an output binary state at its several stages which is descriptive of the number of drum revolutions undergone since the counter was last reset. Where one drum revolution always corresponds to the complete width of one full carpet stitch, i.e., where no pattern repetition is desired across the carpet width, the output pulse from the integrator **242** includes information sufficient to identify the end of a stitch, and this may be connected to the control channel of the punch **208**. However, it is often desired to repeat a pattern across the width of a complete carpet stitch and, to this end, the counter **246** and adjustable decoding assembly **255** are employed to permit the user to specify the number of horizontal repeats desired across the carpet.

As noted above, the digital state of the counter **246** identifies the number of drum **30** revolutions occurring since the counter **246** was last cleared. For decoding purposes, each counter stage is adapted to present both its true and inverted output values, i.e., $\underline{a}$ and $\overline{a}$ for the least significant counter stage, $\underline{b}$ and $\overline{b}$ for the next more significant digit, and so forth, $\underline{n}$ counter stages and output variables being required to provide a maximum of 2^n pattern repeats across the carpet width.

The decoding assembly **255** includes a plurality of switch subassemblies 260_i in one-to-one correspondence with the number of counter stages. The switch subassemblies 260_i each have an output terminal selectively connecting a different input of a coincidence gate **262** with one of a number of input terminals, the transfer members of the switches **260** being operative in synchronism. Each counter **246** output variable and its inverted replica is connected to selected ones of the input switch terminals in accordance with the desired binary decoding. To decode a straight binary counter such that the switches 260_1, 260_2 . . . directly correspond to decimal units, tens . . . digits (as shown in the drawing), the least significant or $\underline{a}$ variables $\underline{a}$ and $\overline{a}$ are connected to alternate contacts of the switch 260_1; the second stage variables $\underline{b}$ and $\overline{b}$ are connected in alternate groups of two; the next significant stage connected in alternate groups of four; and so fourth in accordance with the binary-decimal numerical pattern.

The coincidence detecting gate **262** is fully enabled and switches only when all of the input signals supplied thereto are in the same, predetermined binary state. For any setting of the transfer contacts of the switches

260_i, this will occur for one and only one particular count state for the counter **246**. For example, for the transfer contact position shown by the solid line in FIG. **2** (corresponding to one pattern across the full carpet width without repeats), the gate **262** is fully enabled when the least significant bit is a one (the variable *a* equals one), and when the variable *b* and all other variables are zero (b-not and the inverted outputs of the more significant digits being one). By way of further illustration, an original and two pattern repeats will be formed (corresponding to three revolutions of the drum **30** to define a single carpet stitch) when the switches **260** are in the dashed position shown in the drawing. For this latter case, three output pulses from the integrator **242** are required for this switch setting before the counter **246** attains the binary stage . . . *ba* = . . . 011 at which point all inputs to the gate **262** are a digital one and the gate **262** switches state.

The "end of stitch" (EOS) signal generated when the decoding coincidence gate **262** switches state at the end of stitch scanning sets an "end of stitch" flip-flop **232**. The set flip-flop **232** supplies a binary one to the control channel of the recording punch **208** such that the requisite binary one is punched in the control channel during the next frame to identify that frame as the last of a complete stitch frame sequence. The end of stitch flip-flop **232** is subsequently reset by the next following TDDR pulse. The EOS signal also resets the counter **246** such that the counter again begins counting drum revolutions starting from zero to measure the next following stitch.

The end of stitch pulse is also employed to set a stepping motor actuating flip-flop **264**. The set flip-flop **264** partially enables a coincidence gate **268**, allowing the gate **268** to pass periodically generated pulses from a pulse source **230** to a power amplifier **272**. The amplified pulses, occurring at the end of a stitch, are applied to the input port **21** of the stepper motor **20** of FIG. **1**. The pulses cause the stepper motor **20** to advance the pattern scanning light fibers toward the next scanning position in discrete steps.

The number of pulses passed by the gate **268** from the source **230** to the amplifier **272** and stepper motor **20** defines the interstitch spacing for the pattern, and for the resulting carpet as far as pattern detail is concerned. This spacing is varied depending upon the pattern detail and concomitant requirement for pattern resolution, type of end material, and the like. Accordingly, the counter **266** and a decoding assembly **270** are employed to reset the stepping motor flip-flop **264** after a preselected number of stepping pulses has been counted and passed through to the motor **20**. The counter **266** and decoding assembly **270** may be structurally and functionally identical to the counter-decoding assembly **246–255** discussed above. After the desired number of stepping motor pulses have been sensed by the apparatus **266–270**, the flip-flop **264** is reset, thereby clearing the counter **266** and blocking the coincidence gate **268** such that pulses from the source **230** can no longer reach the power amplifier **272**.

A new stitch scanning cycle may not begin while the stepping motor **20** is still moving the optical fiber **10–11** laterally along the pattern towards a new scanning position. Accordingly, a scan enabled flip-flop **244**, reset at the end of each stitch, is employed to disable the gate **218** while the flip-flop **264** remains set, thereby isolating the strobe pulses preventing these pulses from clocking pattern information into the shift register **204** when the stepping motor **20** is still operative. When the output of the integrator **242** first changes to a high voltage state after flip-flop **264** has been reset as is the usual case, the flip-flop **244** is set to enable pattern scanning along a new scan line **40**. The flip-flop **244** may thus comprise an edge trigger or D-flip flop. When set, the flip-flop **244** partially enables the coincidence gate **218**, such that the FIG. **2** structure resides in a condition to sample the pattern along the next scan path in the manner discussed above. Pattern scanning thus always begins at the edge of the pattern independent of the travel of the scanning apparatus between scan positions.

Finally, as noted above, sufficient punched data frames must be employed for each stitch to provide control data for all tufting stations during the stitch. Unless the number of tufting stations in an integral multiple of the number of information bits in each tape frame, the last frame in each stitch will have less than a full complement of data bits, i.e., less than seven for the assumed data format. Accordingly, a coincidence gate **210** is partially enabled by the end of stitch signal from the set flip-flop **232** to pass pseudo strobe pulses from the pulse source **230** through the OR gate **214** to step the shift register **204** and the counter **212**. If the end of stitch flip-flop **232** is not reset by the scaler **212** responding to actual strobe pulses (indicative of the presence of the exact number of bits required, i.e., a multiple of seven for the assumed case), the pseudo strobe pulses advance the counter **212** until the seventh state is reached to generate the required end of frame TDDR signal. These end of stitch make-up pulses are automatically stopped after the proper number have been developed in the modulo seven counter **212** at which time the flip-flop **232** is reset, thereby blocking the gate **210**.

Thus the apparatus of FIG. **2** has been shown to respond to the continuous (in time) quantized pattern information from the light detector **200** and pulse circuit **220**, and to the timing strobe signals from the light detector **56** for generating stored digital pattern and control signals, as on a punched paper tape.

Referring now to FIGS. **3A** and **3B**, hereinafter referred to as composite FIG. **3**, there is shown circuitry for automatically controlling the pattern formed in a carpet by a tufting machine in accordance with stored pattern and control information such as that produced by the FIG. **2** arrangement. The apparatus of FIG. **3** depends for timing information upon the operative state of the tufting machine, and runs asynchronously with the progress of the tufting machine thereby assuring that slowdown or shutdown of the tufting machine will not affect pattern fabrication. In overall effect, the FIG. **3** structure regulates a plurality of pattern determining control elements **375** associated with the several tufting stations in accordance with the digital information stored in a digital record, e.g., on punched paper tape corresponding to the output of the punch **208** of FIG. **2**. The pattern control elements **375** may comprise pneumatic or electromechanical elements for controlling loop-shearing

knives, loop-length robbing apparatus, or the like as discussed above.

To provide the requisite timing signals for the circuitry of FIG. 3, an opaque disc **302** is rotated in synchronization with the driving apparatus for the tufting machine, as by direct mounting on the tufting machine drive shaft or by any mechanical coupling thereto. A light source **306** is disposed on one side of the disc **302**, and two light sensors **308** and **310**, e.g., photo transistors, are mounted on the opposite side of the disc. A plurality of equidistant holes **304** are disposed at a like radius about the disc **302**, the angular spacing between successive holes **304** being larger than that between the light sensors **308** and **310** and the diameter of the holes small enough to prevent overlapping signals. At most only one sensor **308** or **310** is optically coupled to the source **306** via aperture **304**.

The apertures **304** are aligned relative to the tufting cycle such that an aperture **304** will couple the source **306** and the sensor **310** after a stitch has been implemented by the tufting machine. Accordingly, a "tufting completed" signal is generated at such time by the sensor **310** and threshold detector and amplifier **312**, thereby setting a flip-flop **316**. Similarly, some time later, less than the interstitch time interval, the aperture which previously activated the sensor **310** passes light from the source **306** to the sensor **308** which resets the flip-flop **316** acting through the threshold detector and amplifier **314**. Passage of each hole **304** in the disc **302** past the sensor **310** thus signals completion of a new tufting stitch and, accordingly, a like polarity voltage transient is generated at such times at the output of the flip-flop **316**, each output from sensor **308** resetting the completion of stitch determining circuitry.

By way of overall functional operation for the controller of FIG. 3, an array of digital bits for actuating the control elements **375** in accordance with a desired pattern during a single stitch presently being executed are stored in a present stitch register, or latch **370** formed of a number of latch modules 370_1–370_n. The latch **370** contains as many bits of information as there are tufting stations, such that each output bit of latch **370** acts through an associated control element **375** for defining the pattern formed at a single tufting station when the present stitch is mechanically executed.

In addition, data for the next complete tufting stitch is stored in a plurality of register or latch modules 360_1–360_n of a next stitch latch **360**. After execution of a stitch has been completed by the tufting machine, as signaled by the sensor **310**, the next stitch information in the next stitch latch **360** is transferred to the present stitch latch **370**. Moreover, a data input device **326**, e.g., a punched paper tape reader for the assumed data storage medium, is activated to read the number of frames yielding one complete stitch into the next stitch register **360**. The controller of FIG. 3 then maintains this status, with the tape reader **326** dormant, until the end of the next stitch.

By way of more explicit detailed controller functioning, and returning again to the timing portion of the circuitry of FIG. 3, a TDIO (transfer data from input to output latch) signal is generated after each complete tufting stitch. The leading edge of the TDIO signal, which results in data being gated into the present stitch latch **370**, is advantageously delayed until the A.C. power line voltage goes through zero. This is preferred since the inductive transient signals generated by the control solenoids **375** or the like will be greatly reduced if the drivers change state when the solenoids have no voltage applied thereacross. To this end, a zero crossing detector **322** of any known configuration, e.g., full wave rectified line voltage applied to a Schmitt trigger, supplies a plurality of positive going voltage transients to the clock input of an edged triggered D-type flip-flop **320**. The D, or data input of the flip-flop **320** is connected to the output of a flip-flop **318** which, in turn, is connected with the output of the flip-flop **316**.

The flip-flop **318** normally resides in a reset condition such that the positive going voltage transitions at the output of the zero crossing detector **322** near zero line voltage initially do not change the state of the flip-flop **320** which, therefore, does not activate a following one shot multivibrator **324**. At the end of a stitch, the flip-flop **316** becomes set and its output voltage transition sets the flip-flop **318**. Accordingly, the next following positive voltage transition output from the detector **322** sets the flip-flop **320** which thus energizes the one shot multivibrator **324**. The multivibrator **324** provides a timed data transferring TDIO signal, the leading edge of which thus occurs at a zero line voltage value. The one shot multivibrator also resets the flip-flop **318**, and the flip-flop **320** becomes reset at the next line voltage transition output of detector **322**. The flip-flop **316** is reset when the aperture **304** signaling the end of stitch unblocks the sensor **308**. The timing circuitry thus returns to its initial status following the output from the sensor **308** to await the next end of stitch signal for producing a new TDIO signal.

The transfer data TDIO signal is directly coupled to control input terminals of the present state latch modules 370_i. Accordingly, for the duration of the TDIO pulse, the latches operate in their track mode to accept the next stitch information then residing in the next stitch latch register **360**. Following the end of the TDIO signal, the present stitch latches **370** revert to their hold mode wherein they are unresponsive to the information, or change of information, in the next stitch latch **360**. The pattern implementing elements **375** then selectively change state depending upon the new "present stitch" data. Since the data transfer mode was effected at the zero line voltage transition, the state of the pattern controllers **375** (typically inductive) is varied while little energy is stored in the reactive controller coils, thus maintaining any reactive switching transient at manageable or negligible levels. This is significant where, as in a typical installation, several hundred controllers may be employed and consume hundreds of amperes at their peak point in the A.C. line voltage cycle.

Following the end of stitch and updating of the present stitch register **370**, the next tufting stitch pattern information is read frame by frame from the paper tape and loaded into the next stitch register **360**. To actuate the tape reader, the TDIO output signal from the one shot multivibrator **324** is employed to preset a flip-flop **328**. The output from the flip-flop **328** then acts through a power amplifier or a switch **330** to activate the tape reader motor **332**.

Once actuated, the tape reader **326** progressively reads the punched paper tape, frame by frame. The seven pattern information bits read in parallel from the tape during each frame are supplied to a complementing gate **359** for purposes discussed below; the output from the control track for the frame is supplied to the data input of the flip-flop **328**; and the output from sprocket hole sensor is supplied to the clock input of the flip-flop **328** (any other frame sensor may replace the sprocket hole sensor to detect the incidence of each frame).

The tape reader reads the frames on the tape at its cyclic speed as long as the flip-flop **328** remains set. The flip-flop **328**, in turn, stays set as long as a relatively high voltage (i.e., binary one) is present at the data input (corresponding to no end of stitch signal in the control track) each time a positive going voltage, indicative of a sprocket hole and, therefore, also indicative of a new tape frame, is supplied to the flip-flop clock input. When the last frame of a stitch is encountered, the control track impresses a binary zero at the data input of the flip-flop **328** which thus becomes reset thereby deactivating the tape reader motor **322**. The tape reader **326** thus automatically reads tape frames seriatim until one complete stitch has been read from the tape responsive of each pulse generated by the one shot multivibrator **324**. The tape reader **326** then automatically reverts to its dormant step until the next pulse is generated by the multivibrator **324** following the end of the next tufting machine stitch.

The seven information bits read for each frame by the tape reader **326** are supplied to the complementing gate **359** where they are inverted or not inverted depending upon the setting of a switch **361**. It is sometimes desirable to make a carpet pattern with the pattern detail inverted from that stored on the tape, e.g., reversing the high and low tufts, sheared and non-sheared loops, or the like.

This selective inversion is automatically performed by the completing gate **359**, embodiments of which are well known and readily available.

The bits for each frame are supplied by the complementing gate **359** to the several inputs of each of the next stitch latch modules 360_1 in a parallel manner. A plurality of coincidence gates **352** are operable, one at a time, to register the data at the output terminals of the complementing gate **359** in only one selected latch module 360_1 during each frame read by the tape reader **326**. In particular, the module 360_1 is switched to the data accepting track mode of operation during the first tape frame of a composite stitch by an enabled gate 352_1. Thereafter, latch 360_1 operates in a hold mode to preserve this data since the latch controlling gate 352_1 will not be fully enabled again during data processing for the stitch. Similarly, the latch 360_2 is operable to store the information present during the second frame of a stitch under control of the coincidence gate 352_2, and so forth. After all the stitch describing information is registered in the latch modules **360**, a process completed shortly after the end of the previous stitch since the tape reader **326** is operative more rapidly than the tufting machine, next stitch data is fully available for transfer into the present stitch register **370** responsive to the next following TDIO command.

To energize the control nodes of the appropriate next stitch latches 360_1, the sprocket hole pulse detected in each tape frame is supplied to the input of a counter **335** of capacity larger than the largest number of frames for any stitch for any pattern. The counter **335**, illustratively formed of two decade counting modules **336** and **338**, starts from a reset position at the end of each stitch (the TDIO signal effects such a state) and counts the number of frames encountered in the reading of the next stitch information. The digital count state of the counter modules **336** and **338** is separately decoded in two decoding modules **340** and **342**, respectively, each decoder containing sufficient coincidence logic and inverting gates to fully decode unique states of the counters **336** and **338**. Accordingly, each decoder includes a plurality of output terminals each of which is enabled when the corresponding count is present at the output of the associated counter, i.e., the "0" terminal is energized when the state of the associated counter is 0000; the "1" is enabled when the counter state is 0001; . . . ; and the "9" output terminal enabled when the counter state is 1001. The output signals from the decoder **342** are passed through a plurality of coincidence gates **346** which are strobed with a delayed replica of the sprocket pulse, generated by one shot multivibrator **344**, to avoid any race condition between count rippling in the counter **335** and the selection of one of the gates **352**.

Each gate **352** has two input terminals each connected to a particular tens and units digit from the decoder outputs **342** and **340**, respectively, in accordance with the numbered frame in a stitch sequence associated with the latch module **360** controlled by that gate **352**. Thus the gate 352_1 associated with the first (binary 01) latch 360_1 which stores the first frame in a stitch sequence has its inputs connected to the units and tens digits "01." Accordingly, when the tape reader supplies the first seven information bits during the first frame to the complementing gate **359**, and therefrom to the inputs of each of the latch modules 360_1, the state of the counters **336–338** will correspond to 0001 and 0000 since only one sprocket hole has been encountered during the stitch. Accordingly, the decoders **340** and **342** will decode "1" and "0" such that the coincidence gate 352_1 is fully enabled and selects the latch 360_1 for operation in the data accepting track mode for the duration of the pulse supplied by the multivibrator **344**. Following this pulse, the gates **346** are all inhibited, thus inhibiting the gate 352_1 (as well as all others) and restoring latch 360_1 to its hold mode to retain the first frame information.

Correspondingly, during reading of the second frame, only the gate 352_2 is selected during the pulse supplied by the multivibrator **344**, the output state of counter **336** now being 0010. Thus, the latch modules 360_2 has the second frame information registered therein during the one shot pulse, this data being retained therein for the remainder of stitch processing. Illustratively also, the last gate 352_n — assumed associated with the last or forty-second frame of a stitch for a tufting machine with about two hundred ninety tufting stations — has its inputs connected to the units and tens digits two and four respectively for registering data in the associated latch 360_{42} during the forty-second and final frame of a stitch sequence.

Following execution of the present stitch information stored in latch **370** by the tufting machine, the next TDIO pulse transfers the information then contained in the next stitch latch **360** into the present stitch latch **370** for implementation as discussed above.

Thus the apparatus of FIG. **3** has been shown by the above to update the digital pattern information in the present stitch register **370** after each tufting cycle to control individual tufting station pattern control elements **375**. The apparatus derives its timing signals from the tufting machine, and thus cannot lose synchronization with the machine independent of any tufting speed variations or stoppages. After each stitch has been executed, next stitch data is transferred to the present stitch output register **370**, and the tape reader **326** is signaled to read the next series of frames corresponding to data for one tufting stitch into the next stitch register **360**. The reader **326** automatically stops after the requisite number of frames has been read. The bits generated during a frame are gated by the counter **335**, decoding and coincidence logic **340, 342, 344, 346, 352** into a particular module of the next stitch register **360** and are available for control purposes after execution of the present stitch has been completed. The above apparatus may continuously function in the above manner until all stitches on the tape have been formed as a completed pattern in the carpet. Alternatively, the tape may be connected end to end to form a recurring information loop to generate pattern repeats along the length of a carpet which may thus be continuously formed into a roll of length limited only by external physical constraints.

Variation in the carpet pattern may be effected by splicing tape sections, and corrections or modifications in carpet pattern made in a similar manner. As noted above, the stored information may be contained in a magnetic, optical or other storage media and read by any conventional memory interrogation technique. The information storage media may be gated to the control apparatus by computer via any suitable transmission link. Further, the computer may itself generate a carpet pattern, or change the carpet pattern, by a programed transformation of an initial pattern.

In addition a pattern tape may be checked and verified by causing an electronically controlled typewriter to type out a replica of the stored pattern in the form of marks and blank spaces. This requires a reconversion of the stored data from parallel to series form.

The arrangement of FIG. **2** has thus been shown to be an accurate and convenient structure for providing a digital record of an optically scanned pattern. Similarly, the asynchronous apparatus of FIG. **3** provides ready means for implementing the carpet pattern in accordance with stored digital pattern information.

The above-described apparatus is merely illustrative of the principles of the present invention.

Many modifications within the scope of the invention will be apparent to those skilled in the art. Therefore the invention is not limited to the specific form illustrated and described, but is applicable to other textile fabricating operations such as weaving, for example. The information on the paper tape may be used to directly control stations of a loom, or may be converted by conventional means to the data format of a Jacquard card, which card can then be used to control a Jacquard loom.

What is claimed is:

1. In combination in apparatus for providing a digital record of pattern information characterizing a pattern to be formed in textile goods by the selective actuation of plural pattern forming stations during a single textile forming stitch, scanning means for scanning patterns in the direction of the desired textile stitch and for providing an output characterizing said pattern along the scanning direction, digital quantizing means for quantizing the output of said scanning means, strobe means operative in synchronization with said scanning means for sampling the output of said quantizing means at a plurality of spaced locations along said scanning direction, series-to-parallel converter means for converting subsets of said sampled output digits from said scanning and quantizing means into parallel form, said series-to-parallel converter means including a shift register supplied with said quantized scanned data, said strobe means including means for supplying data clocking shift control pulses to said shift register, a latch register connected to said shift register, and a counter connected to said strobe means for periodically transferring data from said shift register into said latch register, scan line timing means associated with said strobe means for providing a signal at a predetermined point during the relative travel of said scanning means along said scan direction, stitch signaling means connected to said scan line timing means for generating a control signal at a predetermined point during data processing for each stitch, and data storing means for storing the output of said series-to-parallel converter means and said control signal supplied by said stitch signaling means.

2. In combination in apparatus for providing a digital record of pattern information characterizing a pattern to be formed in textile goods by the selective actuation of plural pattern forming stations during a single textile forming stitch, scanning means for scanning patterns in the direction of the desired textile stitch and for providing an output characterizing said pattern along the scanning direction, digital quantizing means for quantizing the output of said scanning means, strobe means operative in synchronization with said scanning means for sampling the output of said quantizing means at a plurality of spaced locations along said scanning direction, said strobe means including light occluding means having a plurality of apertures therein, with a relatively large light occluding area between particular ones of said apertures, means for rotating said light occluding means in synchronization with movement of said scanning means relative to the pattern, a light source and a light detector disposed on opposite sides of said light occluding means, and threshold detector means connected to said light detector, series-to-parallel converter means for converting subsets of said sampled output digits from said scanning and quantizing means into parallel form, scan line timing means associated with said strobe means for providing a signal at a predetermined point during the relative travel of said scanning means along said scan direction, said scan line timing means including means for integrating the pulses produced by said light detector, stitch signaling means connected to said scan line timing means for generating

a control signal at a predetermined point during data processing for each stitch, and data storing means for storing the output of said series-to-parallel converter means and said control signal supplied by said stitch signaling means.

3. In combination in apparatus for providing a digital record of pattern information characterizing a pattern to be formed in textile goods by the selective actuation of plural pattern forming stations during a single textile forming stitch, scanning means for scanning patterns in the direction of the desired textile stitch and for providing an output characterizing said pattern along the scanning direction, digital quantizing means for quantizing the output of said scanning means, strobe means operative in synchronization with said scanning means for sampling the output of said quantizing means at a plurality of spaced locations along said scanning direction, series-to-parallel converter means for converting subsets of said sampled output digits from said scanning and quantizing means into parallel form, means for generating pseudo strobe signals responsive to the number of strobe pulses in a stitch being less than an integral multiple of the number of strobe pulses required for a subset of said sampled data signals, scan line timing means associated with said strobe means for providing a signal at a predetermined point during the relative travel of said scanning means along said scan direction, stitch signaling means connected to said scan line timing means for generating a control signal at a predetermined point during data processing for each stitch, and data storing means for storing the output of said series-to-parallel converter means and said control signal supplied by said stitch signaling means.

4. In combination in apparatus for providing a digital record of pattern information characterizing a pattern to be formed in textile goods by the selective actuating of plural pattern forming stations during a single textile forming stitch, scanning means for scanning patterns in the direction of the desired textile stitch and for providing an output characterizing said pattern along the scanning direction, digital quantizing means for quantizing the output of said scanning means, strobe means operative in synchronization with said scanning means for sampling the output of said quantizing means at a plurality of spaced locations along said scanning direction, series-to-parallel converter means for converting subsets of said sampled output digits from said scanning and quantizing means into parallel form, scan line timing means associated with said strobe means for providing a signal at a predetermined point during the relative travel of said scanning means along said scan direction, stitch signaling means connected to said scan line timing means for generating a control signal at a predetermined point during data processing for each stitch, data storing means for storing the output of said series-to-parallel converter means and said control signal supplied by said stitch signaling means, a tufting machine controller including data reading means for reading the data recorded by said data storing means, a present stitch register, a next stitch register, timing means adapted to be driven by the tufting machine for supplying a signal indicative of the completion of a stitch by the tufting machine, said timing means including an opaque plate having a plurality of apertures therein, a light source disposed on one side of the said plate and two spaced light sensors disposed on the other side of the said plate, first bistable means alternatively switched between its stable states by said light sensors, means responsive to a particular voltage transition for said first bistable means for generating said completion of stitch signal, control means responsive to said end of stitch signal for transferring data from said next stitch register to said present stitch register and for activating said data reading means for entering information descriptive of the next stitch into said next stitch register, means for normally inhibiting said completion of stitch signal, and means for determining the next zero power line voltage transition following said particular voltage transition for said first bistable means for enabling said completion of stitch signal.

5. In combination in apparatus for providing a digital record of pattern information characterizing a pattern to be formed in textile goods by the selective actuation of plural pattern forming stations during a single textile forming stitch, scanning means for scanning patterns in the direction of the desired textile stitch and for providing an output characterizing said pattern along the scanning direction, digital quantizing means for quantizing the output of said scanning means, strobe means operative in synchronization with said scanning means for sampling the output of said quantizing means at a plurality of spaced locations along said scanning direction, series-to-parallel converter means for converting subsets of said sampled output digits from said scanning and quantizing means into parallel form, scan line timing means associated with said strobe means for providing a signal at a predetermined point during the relative travel of said scanning means along said scan direction, stitch signaling means connected to said scan line timing means for generating a control signal at a predetermined point during data processing for each stitch, data storing means for storing the output of said series-to-parallel converter means and said control signal supplied by said stitch signaling means, a tufting machine controller including data reading means for reading the data recorded by said data storing means, a present stitch register, a next stitch register, timing means adapted to be driven by the tufting machine for supplying a signal indicative of the completion of a stitch by the tufting machine, control means responsive to said end of stitch signal for transferring data from said next stitch register to said present stitch register and for activating said data reading means for entering information descriptive of the next stitch into said next stitch register, said next stitch register controlling means including means for counting said data subsets read by said data reading means, means for decoding the output of said counter means, said next stitch register being formed of a plurality of register modules, additional decoding means selectively connected to said subset counter decoding means for sequentially enabling said next stitch register modules, and means for supplying data from said reading means in parallel to said next stitch register modules.

6. In combination in pattern control apparatus for providing digital output signals for controlling a plural station textile fabricating machine for effecting a pattern in a formed textile during a textile forming stitch in accordance with pattern information stored in a digital pattern record, a present stitch register for supplying

output signals for controlling the textile machine stations, a next stitch register having outputs thereof connected to inputs of said present stitch register, timing means adapted to be driven in synchronization with the textile machine for providing a digital signal indicative of completion of a stitch by the machine, said means including an opaque plate having a plurality of apertures therein, a light source disposed on one side of the said plate and two spaced light sensors disposed on the other side of the said plate, first bistable means alternatively switched between its stable states by said light sensors, and means responsive to a particular voltage transition for said first bistable means for generating said completion of stitch signal, means for reading said stored digital pattern information, control means responsive to said completion of stitch signal for activating said data reading means for registering information corresponding to a single stitch in said next stitch register, means for deactivating said data reading means after information descriptive of a complete stitch has been read thereby, and means responsive to said completion of stitch signal for transferring data from said next stitch register to said present stitch register.

7. In combination in pattern control apparatus for providing digital output signals for controlling a plural station textile fabricating machine for effecting a pattern in a formed textile during a textile forming stitch in accordance with pattern information stored in a digital pattern record, a present stitch register for supplying output signals for controlling the textile machine stations, a next stitch register having outputs thereof connected to inputs of said present stitch register, timing means adapted to be driven in synchronization with the textile machine for providing a digital signal indicative of completion of a stitch by the machine, means for reading said stored digital pattern information, control means responsive to said completion of stitch signal for activating said data reading means for registering information corresponding to a single stitch in said next stitch register, said next stitch register controlling means comprising means for counting said data subsets read by said data reading means, means for decoding the output of said subset counter means, said next stitch register being formed of a plurality of register modules, additional decoding means selectively connected to said subset counter decoding means for sequentially enabling said next stitch register modules, and means for supplying data from said reading means in parallel to said next stitch register modules, means for deactivating said data reading means after information descriptive of a complete stitch has been read thereby, and means responsive to said completion of stitch signal for transferring data from said next stitch register to said present stitch register.

8. In combination in apparatus for providing a digital record of pattern information characterizing a pattern to be formed in textile goods by the selective actuation of plural pattern forming stations during a single textile forming stitch, said pattern being formed of light reflecting and light non-reflecting portions, scanning means for scanning patterns in the direction of the desired textile stitch and for providing an output characterizing said pattern along the scanning direction, said scanning means including a plurality of optical fibers which are movable in the direction of the desired textile stitch, at least one of said optical fibers transmitting light to a local area of said pattern and at least one of said optical fibers transmitting the light reflected by said pattern, digital quantizing means for quantizing the output of said scanning means, strobe means operative in synchronization with said scanning means for sampling the output of said quantizing means at a plurality of spaced locations along said scanning direction, series-to-parallel converter means for converting subsets of said sampled output digits from said scanning and quantizing means into parallel form, scan line timing means associated with said strobe means for providing a signal at a predetermined point during the relative travel of said scanning means along said scan direction, stitch signaling means connected to said scan line timing means for generating a control signal at a predetermined point during data processing for each stitch, and data storing means for storing the output of said series-to-parallel converter means and said control signal supplied by said stitch signaling means.

9. A combination as in claim **8** wherein:

said plurality of optical fibers is arranged in a bundle having peripheral optical fibers for transmitting light to a local area of said pattern and a central optical fiber for transmitting light reflected by said pattern.

10. In combination in apparatus for providing a digital record of pattern information characterizing a pattern to be formed in textile goods by the selective actuation of plural pattern forming stations during a single textile forming stitch, scanning means for scanning patterns in the direction of the desired textile stitch and for providing an output characterizing said pattern along the scanning direction, digital quantizing means for quantizing the output of said scanning means, strobe means operative in synchronization with said scanning means for sampling the output of said quantizing means at a plurality of spaced locations along said scanning direction, series-to-parallel converter means for converting subsets of said sampled output digits from said scanning and quantizing means into parallel form, scan line timing means associated with said strobe means for providing a signal at a predetermined point during the relative travel of said scanning means along said scan direction, stitch signaling means connected to said scan line timing means for generating a control signal at a predetermined point during data processing for each stitch, data storing means for storing the output of said series-to-parallel converter means and said control signal supplied by said stitch signaling means, means for generating repeated pattern information across the width of the textile goods including a scan counter for counting the signals generated by said scan line timing means, and adjustable decoding means for enabling said stitch signaling means in response to a preselected state of said scan counter.

11. A combination as in claim **10** wherein:

said means for generating repeated pattern information includes a plurality of scan counters and said adjustable decoding means includes a plurality of switch subassemblies in one-to-one correspondence with the number of said scan counters to receive true and inverted output values from said scan counters.

12. A combination as in claim 11 including:

a coincident gate electrically coupled to the output terminals of said switch subassemblies.

13. In combination in pattern control apparatus for providing digital output signals for controlling a plural station textile fabricating machine for effecting a pattern in a formed textile during a textile forming stitch in accordance with pattern information stored in a digital pattern record, a present stitch register for supplying output signals for controlling the textile machine stations, a next stitch register having outputs thereof connected to inputs of said present stitch register, timing apparatus adapted to be driven in synchronization with the textile machine for providing a digital signal indicative of completion of a stitch by the machine, means for reading said stored digital pattern information, control means responsive to said completion of stitch signal for activating said data reading means for registering information corresponding to a single stitch in said next stitch register, complementing means for selectively inverting the digital pattern information supplied by said data reading means to said next stitch register, means for deactivating said data reading means after information descriptive of a complete stitch has been read thereby, and means responsive to said completion of stitch signal for transferring data from said next stitch register to said present stitch register.

14. A combination as in claim 6 further comprising means for normally inhibiting said completion of stitch signal, and means for determining the next zero power line voltage transition following said particular voltage transition for said first bistable means for enabling said completion of stitch signal.

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