United States Patent [19]

Levin et al.

[11] **3,710,020**

[45] **Jan. 9, 1973**

[54] **TEXTILE PATTERN TRANSLATOR**

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[22] Filed: **Dec. 15, 1969**

[21] Appl. No.: **884,802**

[30] **Foreign Application Priority Data**

Dec. 20, 1968 France 68179558

[52] **U.S. Cl.** ....**178/5.2 R,** 234/55, 234/89

[51] **Int. Cl.** **H04n 9/02**

[58] **Field of Search**..............178/5.2, 5.2 A, 6.7, 7.6

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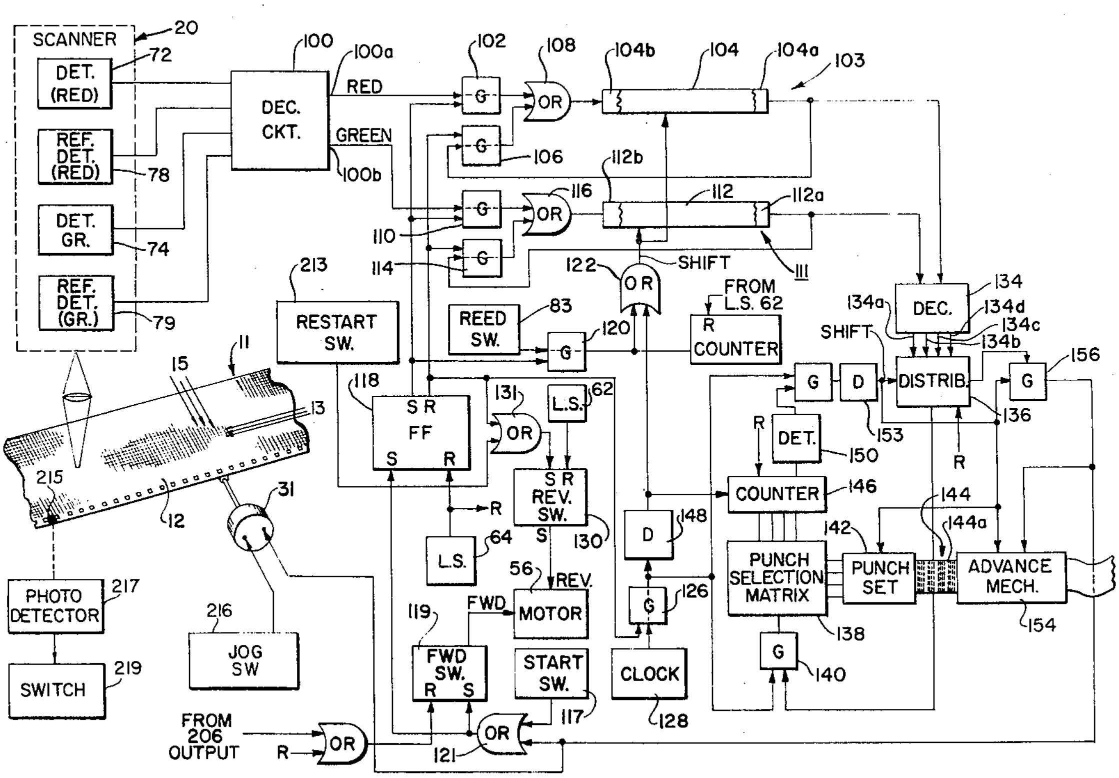
[57] **ABSTRACT**

A machine for translating a graticulated textile design pattern to a format readable by a textile machine incorporates color-sensitive photodetectors mounted in a scanner head. The scanner head automatically scans successive columns of the design pattern so that the photodetectors sense the colors of successive cells in each column. The photodetector outputs are stored each time an individual cell is traversed and after an entire column has been scanned, the stored information is decoded to the format necessary to control a card punching machine. Additionally, the output from the decoding machine may be used to control a pattern verifier which utilizes decoded information to reproduce the design pattern being scanned.

24 Claims, 7 Drawing Figures



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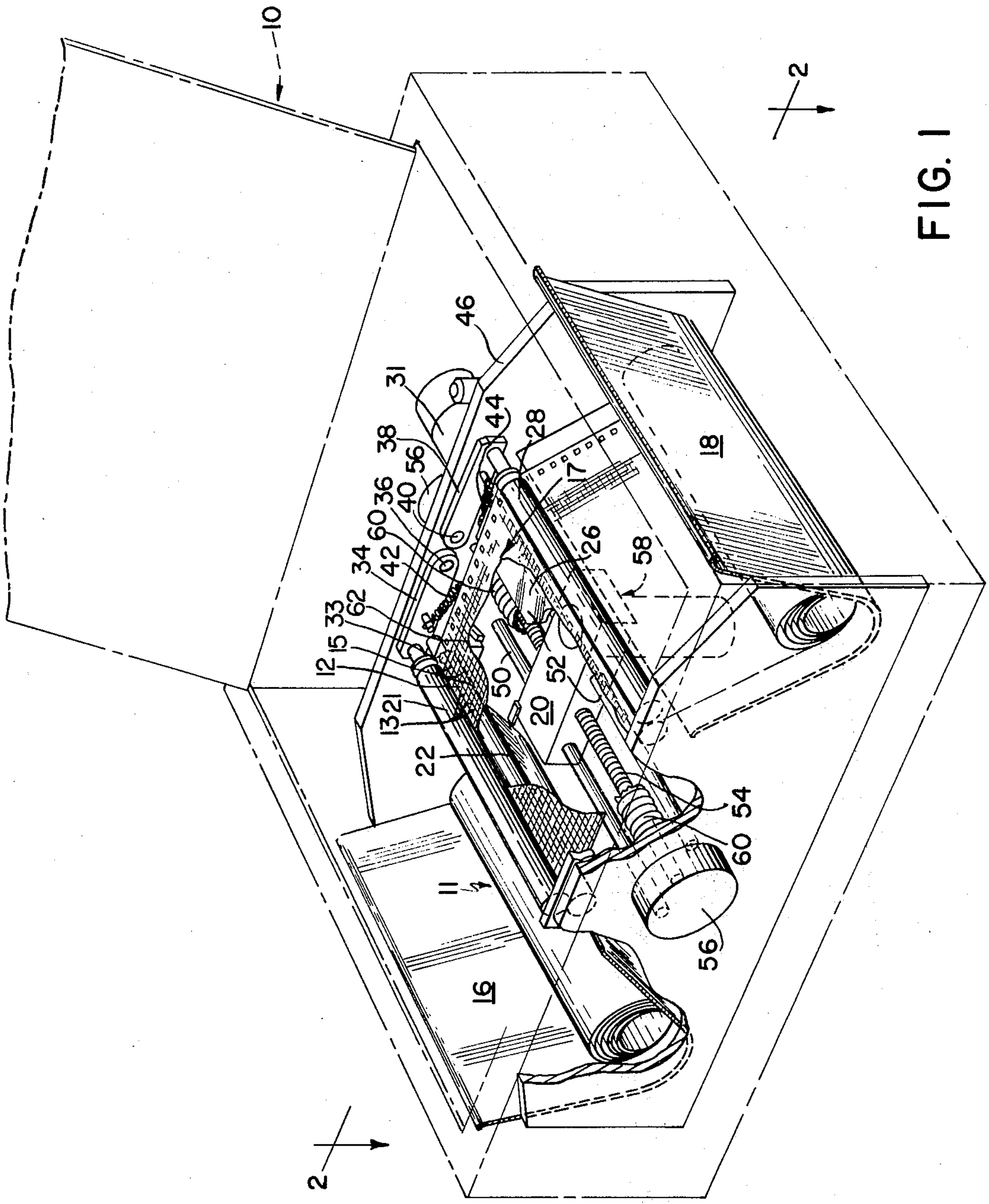

FIG. 1

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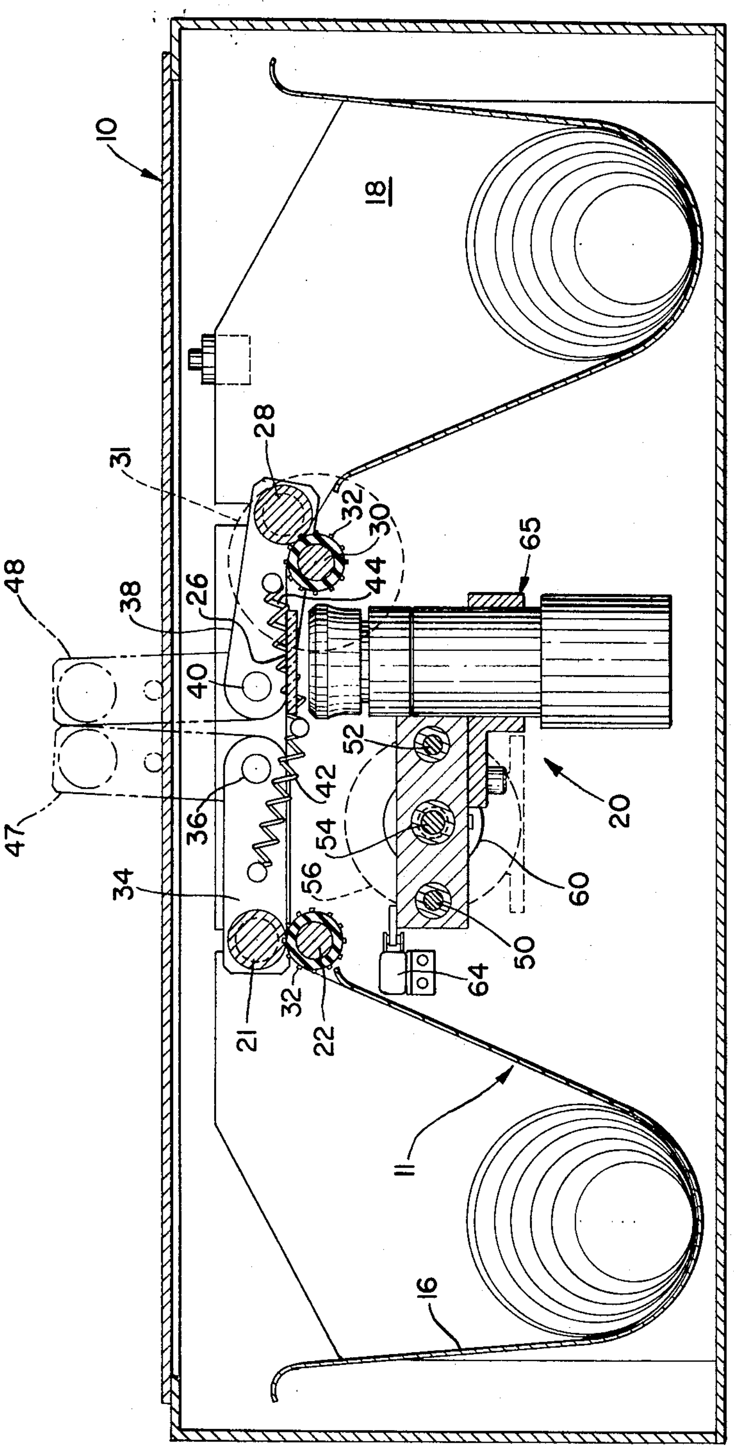

FIG. 2

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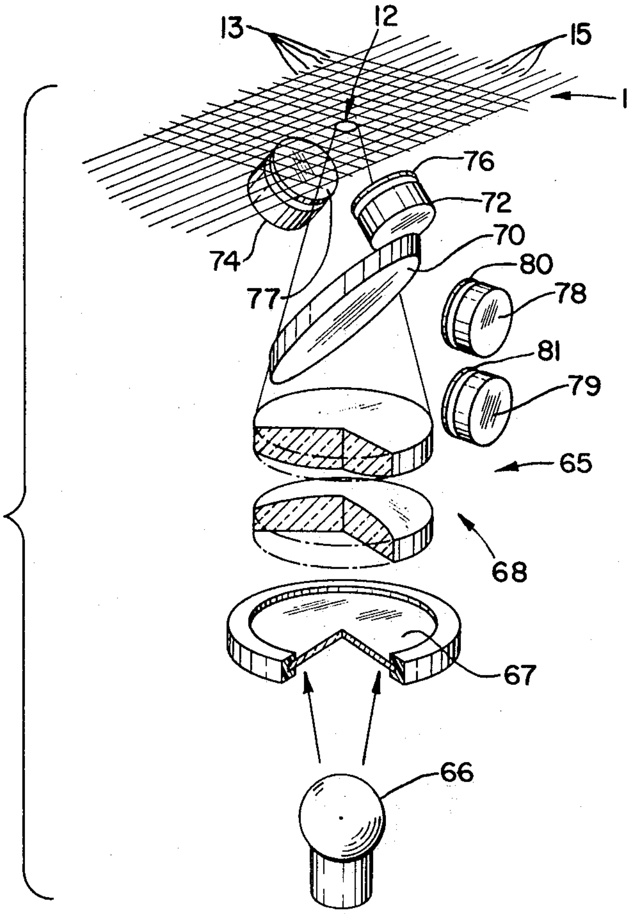

FIG. 3

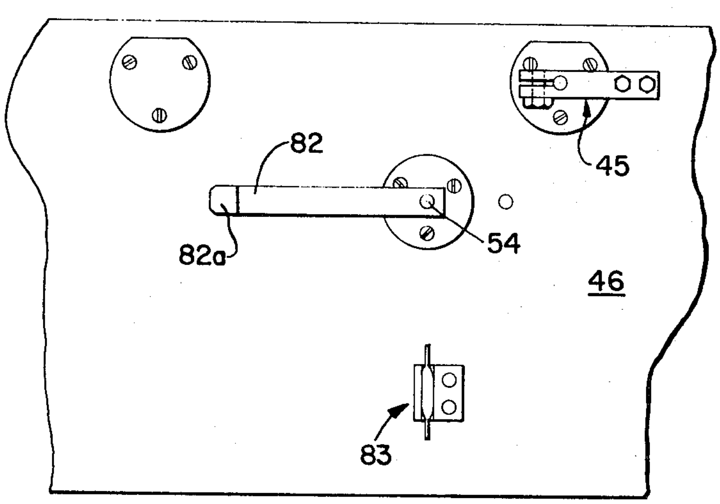

FIG. 4

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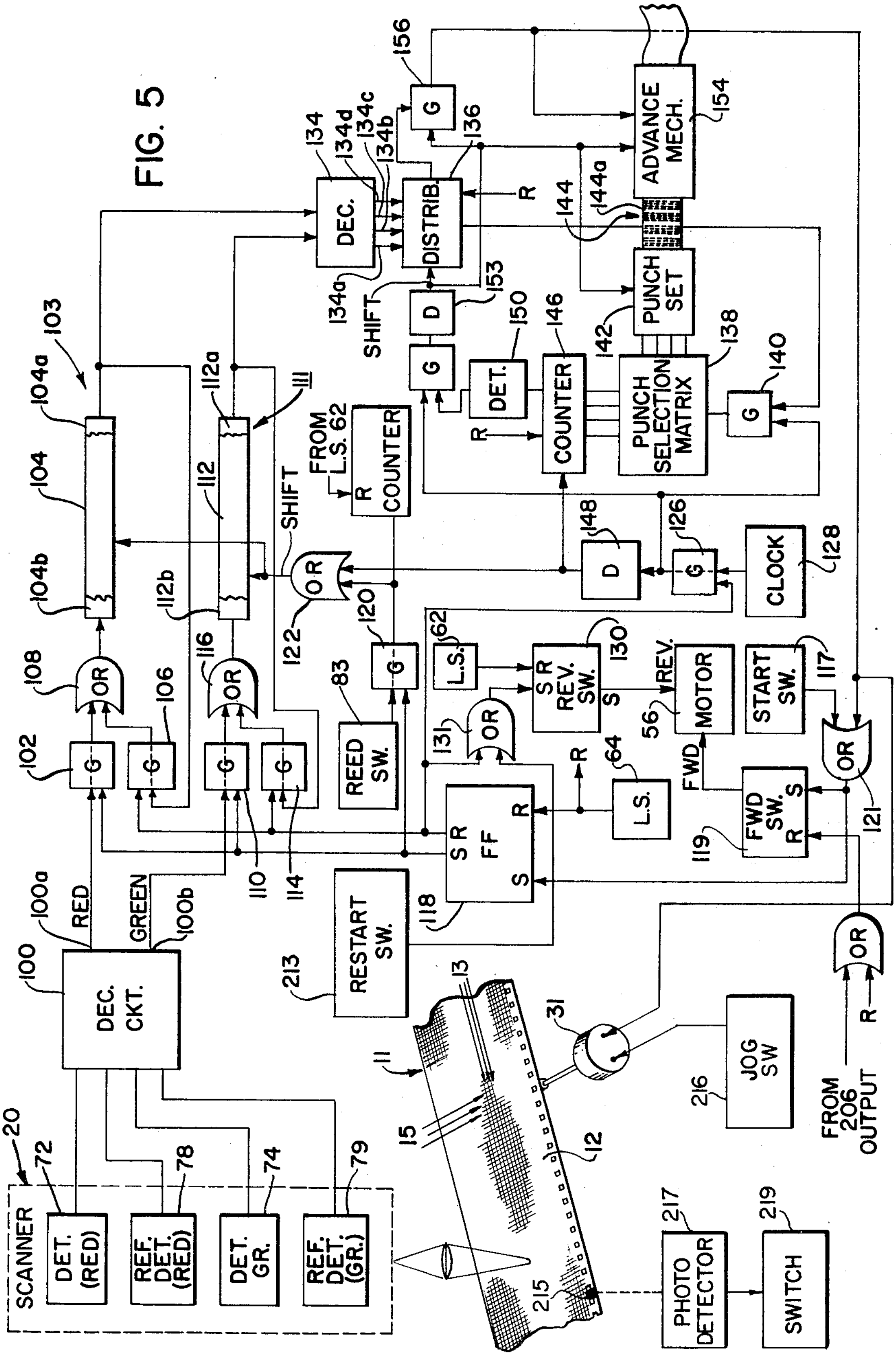
FIG. 5


SCANNER
DET. (RED)
REF. DET. (RED)
DET. GR.
REF. DET. (GR.)
DEC. CKT.
RED
GREEN
OR
G
SHIFT
DEC.
DISTRIB.
ADVANCE MECH.
PUNCH SET
PUNCH SELECTION MATRIX
COUNTER
DET.
D
FROM L.S. 62
R
REED SW.
L.S.
S R REV. SW.
REV.
MOTOR
FWD
START SW.
FWD SW.
CLOCK
S R FF
RESTART SW.
JOG SW
FROM 206 OUTPUT
PHOTO DETECTOR
SWITCH

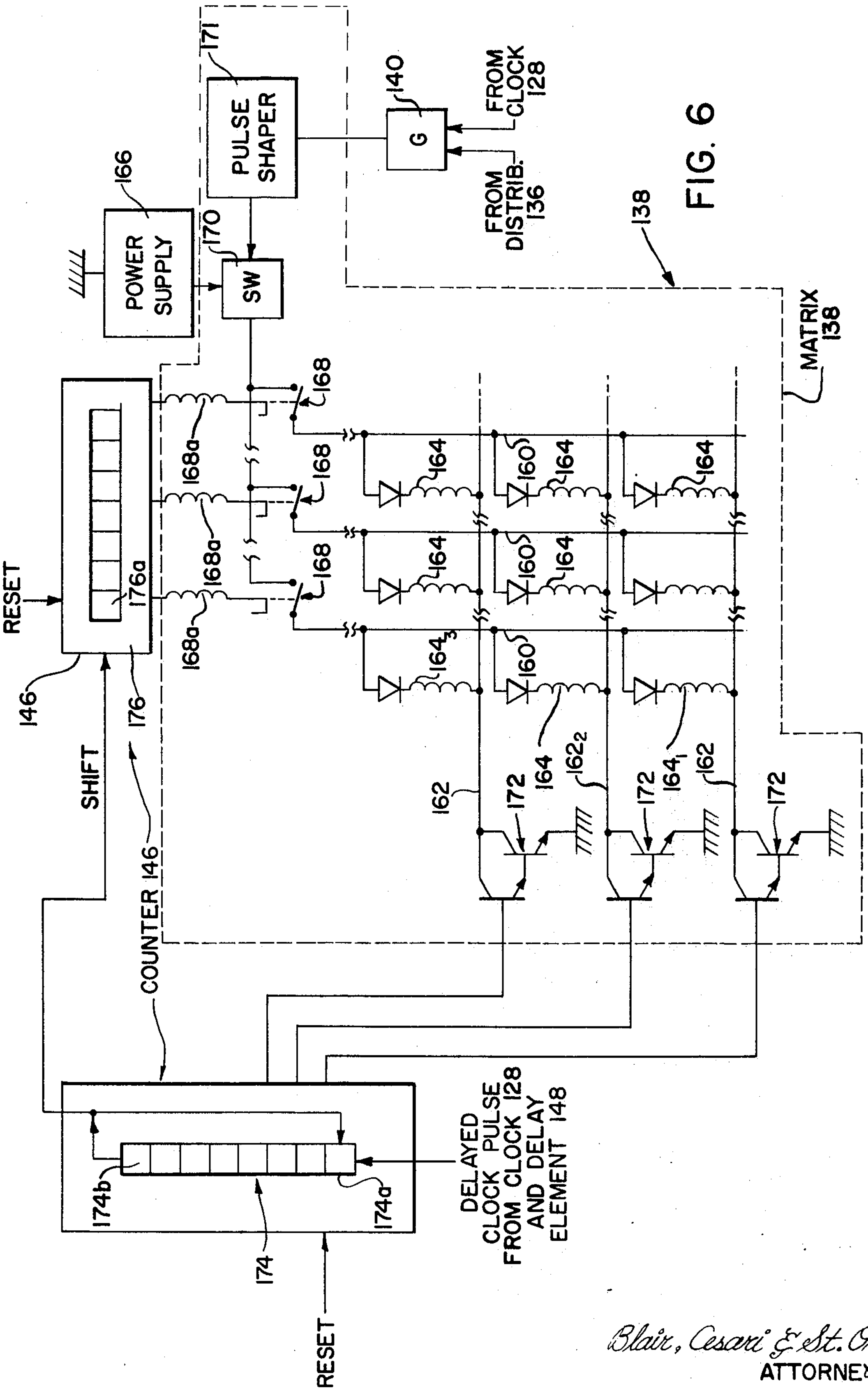


FIG. 6

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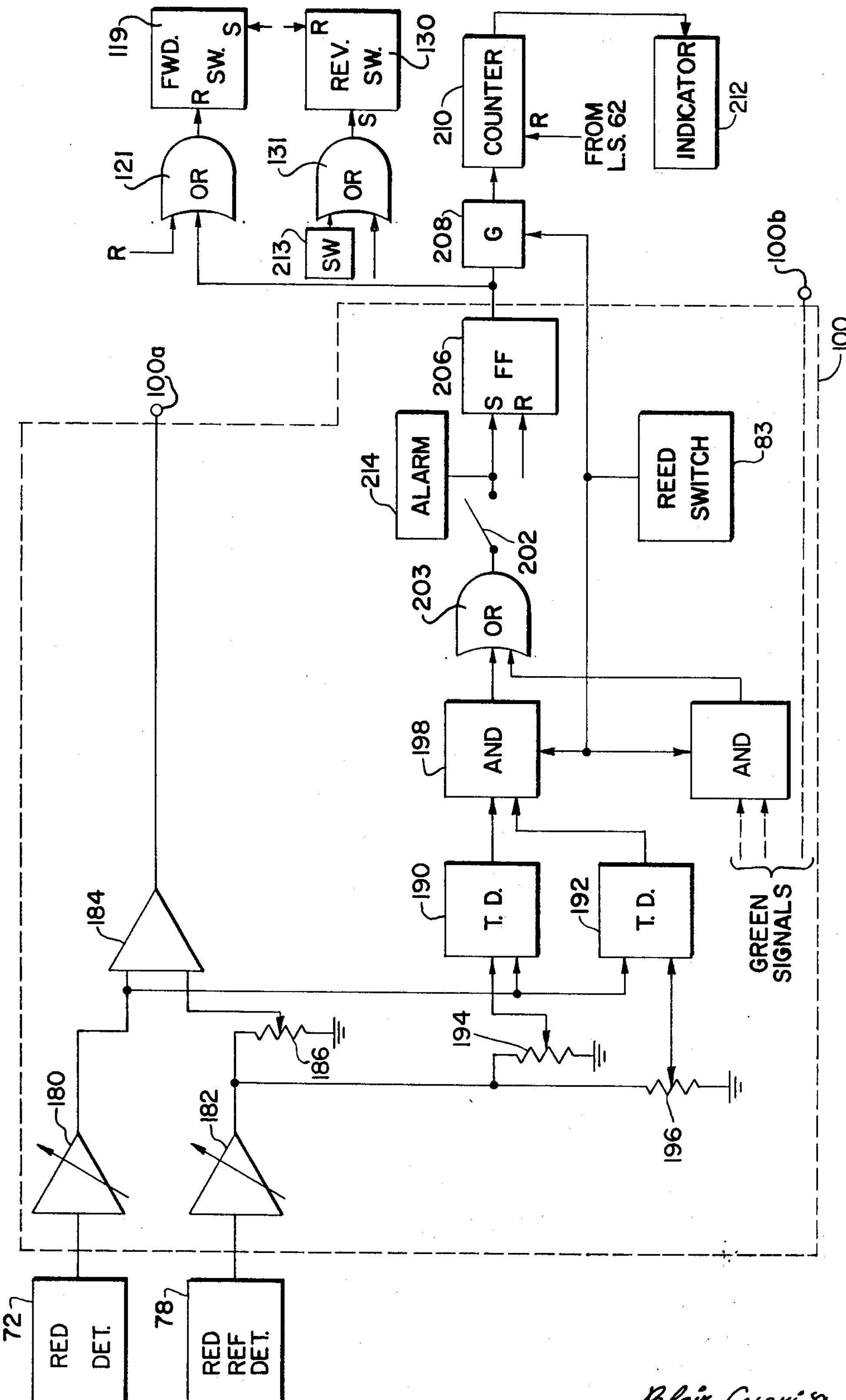

FIG. 7

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TEXTILE PATTERN TRANSLATOR

BACKGROUND OF THE INVENTION

A. Field of the Invention

This invention relates to the reproduction of textile pattern instructions in a form readable by programmable textile machines. Specifically, the invention relates to the translation of textile patterns from a multi-colored, graticulated pattern format utilized by the textile designer to a punched card or tape format readable by a textile knitting or weaving machine.

The textile designer normally lays out a design pattern on a strip of drawing material which we shall call the scanner art medium. A graticulated pattern is overlayed on the art medium, with each individual element of the resultant grid being a cell of the design pattern. A "row" of the art medium is a sequence of cells traversing the width of the medium while a "column" is a sequence of cells extending lengthwise of the medium.

The designer has two or more colors at his disposal with which to mark the cells of the art medium. Each cell corresponds to a particular location on the final textile fabric. Each color, according to the code being used, may represent a particular variable in the textile design pattern. For example, the color in the cell may represent a particular thread color, type of stitch, or size of thread in the corresponding location of the textile fabric.

The art medium with its color-coded pattern, must be translated into a format which is meaningful to the textile machine. The following discussion will center on the well-known Wildman-Jacquard machine; however, the invention is fully applicable to other textile machines controlled by a coded input.

The Wildman-Jacquard machine responds to instructions punched on cards or tapes utilizing a one-out-of-four color code. Information is fed into the machine on punched cards or tapes. Since the textile machine senses the presence or absence of a hole on a punched tape for each of four variables, it is necessary to have a field of four rows on the tape for each row on the art medium. Each of these four rows corresponds to one of the four colors at the artist's disposal. That is, each column of four cells in a field on the tape corresponds with a single cell in the art medium and a single location in the textile fabric. One of the four cells in the tape column is punched, in accordance with the color in the corresponding art medium cell, to designate the desired feature in the textile location. Since each field of the punched tape has **56** columns, each row of the art medium is **56** cells in length.

B. Prior Art

Ordinarily, the translation from the color-coded art medium to the punched tape is done manually. The operation requires two people; one operator scans the cells of the art medium while the other operates the tape-punch machine. The tape-punch machine advances the tape one column at a time; hence, all cells in a given field of the tape which are to be punched with the same color information are punched before the tape is advanced to the next row.

Therefore, the scanner must look at every cell in a particular row of the art medium for one color, calling out the location (row) of that color every time it is encountered. While the scanner moves along a row of the art medium, the punch machine operator moves along a row of the punched tape. When a cell location is called out by the scanner, the machine operator must position the punch machine to punch the tape in the row called out by the scanner. The scanner then scans the same row of the art medium a second time for the second color, while the punch operator moves down the second row in the same field of the punched tape. The sequence is repeated until the row in the art medium has been scanned for each color in the code. This arrangement is a time-consuming one which occupies the full attention of both operators.

Inherent in the two-operator, manual translation method are several problems which tend to cause errors in translation. The scanner may improperly identify the cell location; the punch operator may misunderstand the cell location identified by the scanner; or the punch operator may position the punch mechanism over the incorrect row of the punched tape, even though he properly hears the scanner.

A further problem arises when there is a cell which contains two colors. In order to avoid an ambiguous instruction to the textile machine, or alternately, the absence of an instruction, the scanner must decide which of the two colors should be punched on the machine control tape. Accordingly, when he first perceives a cell partly containing a color for which he is scanning at that time, he must decide whether or not that color predominates. On a later scan of the same row, he will encounter the other color in the cell. He must remember his initial decision as to whether the first color in the cell dominates. The failure to remember his initial decision can cause either the lack of a machine instruction pertaining to that cell or instructions ordering the textile machine to do two different operations in that cell.

Moreover, the manual translation process is quite tedious, and this increases the probability of error.

When considering the undesirability of the laborious manual translation process described above, with its high possibility of error, it must be remembered that the Wildman-Jacquard machine is a relatively unsophisticated textile knitting machine. A more complex machine may utilize a color code with more colors. This increases the time required for manual translation and it also increases the probability of error.

Several systems have been proposed to perform the scanning operation either automatically or semi-automatically. The systems of interest here basically use a scanning head that moves along each row of the art medium, focuses light on successive cells of the row, and senses the color located in each cell. Simultaneously with the scanning operation, a tape-punching machine is actuated to punch the translated information into a machine-readable format.

In a typical system, the scanner head contains one photodetector with color filters located on a disc between the art medium and the photodetector. The disc rotates so that all the filters are successively interposed between the art medium and the photodetector every time a cell of the art medium is sensed. In this manner, each cell is sensed for all possible colors during the scanning operation.

These systems have failed to gain widespread commercial acceptance, apparently for several reasons. For example, in a system to be used in connection with a Wildman-Jacquard machine, punching the tape simultaneously with the scanning operation complicates the machine decoding process by requiring that the punching commands control motion in two dimensions, so that any of the four colors of the code may be punched on the machine-readable tape. Specifically, the tape punch controller must allow translation of the punch mechanism over a 4 × 56 matrix; which is the size of the punched tape field corresponding to each row of the art medium.

Moreover it appears to us that the systems previously proposed are less mechanically reliable than one would desire. For example, they require that the sensing and punching operations be properly synchronized. Improper time synchronization results in improper punching.

Additionally, one must remember that textile machines are used throughout the world, frequently in countries or areas of relatively unsophisticated technological capabilities. Any complexity in an automatic translating machine which increases operating or servicing problems greatly decreases the usefulness of the machine. It is desirable that a machine be operable with a minimum of technological understanding and be easily serviced.

Accordingly, it is an object of this invention to provide an accurate and reliable machine for translating a color-coded art medium to a format readable by a textile machine.

It is a further object of this invention that the machine be capable of use by workers with a minimal amount of mechanical aptitude or training.

It is also an object of this invention that the machine operate accurately and rapidly.

It is a further object of this invention to provide a machine with a minimal need for service or repair.

It is also an object of this invention to provide a translating machine which is easily serviceable by people with relatively little knowledge about the basic operation of the machine.

A further object of this invention is to provide a machine that is easily adaptable to a broad variety of textile weaving or knitting machines and to other processes which require translation of a visually encoded pattern to a machine-control punched card or tape.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

SUMMARY OF THE INVENTION

Our translation machine comprises an indexing mechanism which moves the art medium through a scanner row-by-row. Each time the medium is indexed, a scanner head moves a set of photodetectors along a row of the medium to develop outputs corresponding to the colors of successive cells in the row.

Each time the color of an individual cell has been sensed, the information is electronically stored in a memory, if the translative is for a Wildman-Jacquard machine or other textile machine that uses a similar punched tape format. Then, after an entire row of the art medium has been scanned, the contents of the memory are decoded, control signals for a tape-punching machine are properly developed, and a machine control tape is accordingly punched. The art medium is then indexed and another row thereon is scanned.

The scanner head contains a light source which is focused on a single cell of the design pattern. Thus, as the head moves along a row of the art medium, the light beam successively illuminates each cell in the row. Diffusely reflected light from each illuminated cell is simultaneously sensed by a pair of photodetectors mounted in the scanner head.

The photodetectors are color-sensitive and, by a proper selection of their characteristics, it is possible to have the two detectors jointly sense the presence of any of four colors. More specifically, one photodetector may be selectively responsive to green light incident upon it, while the other may be selectively responsive to red light. Therefore, if a cell is colored green or red, only one photodetector or the other will have an output; if a cell is colored white, which contains both green and red light, both photodetectors will have an output; if a cell is colored black, neither detector will have an output. As a result, the photodetector outputs comprise a two-bit binary code representative of the color in the art medium cell.

If, during a scan, there is more than one color in any cell, the machine can always decide which of the colors predominates and correspondingly store that color in the memory. As an alternative, the machine can be programmed to stop if the color-indicating signals are within a predetermined "indecision range" and indicate the presence and location of the multi-colored cell. In this event, the operator may erase the contents of the cell in question and color the cell as he chooses. He then resets the machine which rescans the same row. This time the cell which previously caused the indecision is now colored with only one color, so that the machine may properly decide how the textile machine control card should be punched.

The punching machine advances the punched tape through a bank or set of punches one row at a time. Accordingly, the contents of the memory are searched four times, once for each color row of the tape. Specifically, the contents of the memory are decoded in order for a particular color, and the machine control tape is correspondingly punched. The tape is then advanced in the punching machine and the memory contents are decoded for another color. This is repeated until the punched tape rows for all four colors have been punched.

The fact that the punching operation does not take place until a complete art medium row has been scanned allows simplification of the punching machine and its control circuitry when a Wildman-Jacquard machine is involved. Only one row of punches need be used and they can be restricted to one punched tape row at a time.

The invention also facilitates verification of the information sensed from the art medium. The output of the translation described above is applied to a verifier which reproduces the pattern of the original art medium. The verifier advances a second, or facsimile, art medium past a printing head row-by-row. The printing head contains four inking pens which ink the individual cells of the facsimile in response to the same commands from the translation machine that control the punching operation. This enables the operator to check the validity of the translation by comparing the verifier output with the original art medium.

The art medium we prefer to use is a plastic tape colored by means of color pencils. An ideal plastic is transparent polyethyleneterephthalate slightly roughened or textured on one side to facilitate marking by the textile designer. If one of the colors used is white, the white cells can be left blank. The tape is then viewed by the scanner against a white background which projects white through the uncolored cells. Alternatively, the plastic itself can be loaded with a white pigment and thereby provide its own white background. However, the art medium must then be positioned with the pattern facing the scanner and this will make it difficult to erase portions of the pattern when required by the translator as described herein.

The pencils, whose colors are matched by filters in the scanner, are inexpensive, they are easier to store and use than conventional inking supplies and their markings are readily erased to correct mistakes in coloring the art medium. A plastic colored in this manner can easily be washed to remove the textile pattern recorded on it, while leaving the grid, row numbers, etc. which are indelibly pre-printed. The art medium can thus be used again and again for different textile patterns.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a pictorial view, partly broken away, of a textile pattern translator embodying the invention;

FIG. 2 is a section along the line 2—2 of FIG. 1;

FIG. 3 is a simplified pictorial view of the scanner head;

FIG. 4 is a fragmentary plan view of an interior back plate of the translator;

FIG. 5 is a block diagram of the electric circuitry of the translator;

FIG. 6 is a diagram of the punch selection matrix and associated counter; and

FIG. 7 is a diagram of the decision circuit.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 depicts the textile pattern translator with its cover **10** raised, exposing the internal mechanism of the translator. The art medium, in the form of a basically transparent tape **11**, carrying a graticulated pattern with cells **12** arranged in columns **13** and rows **15**, is loaded into a feed bin **16** and advanced row-by-row, across a scanning area **17** into a spill bin **18**. Each tape advance brings a new row **15** into the scanning area **17**, where a scanner **20** below the tape transverses the tape **11** to sense the colors of the cells **12** in the row. The sensed data is electronically stored and later used to control a card-punching machine.

More specifically, as shown in FIG. 2, the tape **12** passes from the bin **16** between a top roller **21** and a bottom roller **22**, and over an erase support plate **26** in the scanning area **17**. The tape then passes between a top roller **28** and a bottom roller **30** and finally into the spill bin **18**.

The tape **11** is advanced by a stepping motor **31** which is coupled to the bottom roller **30**.

The resulting rotation of the bottom roller **30** pulls the tape **11** across the scanning area **17** by means of cogs **32** that mesh with sprocket holes **33** (FIG. 1) along both edges of the tape. These cogs **32**, and similar cogs on the bottom rollers **22** also serve to position the tape **11** in both the longitudinal and transverse directions, thereby assuring that each tape advance brings a new tape row **15** (FIG. 1) into the correct location in the scanning area **17**.

With further reference to FIGS. 1 and 2, top roller **21** is supported by an arm **34** which rotates on a pivot **36**. The top roller **28** is similarly supported by an arm **38** on a pivot **40**. Tension springs **42** and **44**, connected to the arms **34** and **36**, maintain pressure between the top rollers and their corresponding bottom rollers. As shown in FIG. 4, an adjustable friction brake **45**, mounted on a back plate **46** (FIGS. 1 and 4), restrains rotation of the bottom roller **22**, thereby applying tension to the tape **12** to keep it taut between the rollers **22** and **30**.

To load the tape **11**, the arms **34** and **36** are rotated to loading positions **47** and **48**, depicted in dashed lines in FIG. 2, lifting the top rollers **20** and **28**, and thereby enabling the operator to thread the tape over the bottom rollers **22** and **30**.

Referring again to FIG. 1, the scanner **20** is mounted on guide rods **50** and **52** and is coupled to a lead screw **54**. A drive motor **56** rotates the lead screw **54** to advance the scanner **20** across the tape **11**, i.e. along a row **15**. A boot **60** protects the lead screw **54** from dirt or other damaging substances.

The colors of the tape cells **12** are sensed in a scanner head **65** as the scanner **20** advances. When the scanner has traversed a tape row **15**, it is automatically returned to its starting position where it awaits a signal to scan the next row **15**. A limit switch **62** is engaged when the scanner **16** is at its starting position, and a second limit switch **64** (FIG. 2) is engaged when the scanner **20** has traversed to the opposite end of a tape row **15**.

Referring to FIG. 3, the scanner head **65** carries a lamp **66** which projects light through an infrared filter **67**, a focusing lens system **68** and a partially reflecting mirror **70** onto a tape cell **12** on the optical axis of the lens system. Photodetectors **72** and **74** receive light diffusely reflected from the tape cell **12**.

The textile pattern is on the top surface of the tape, so that color indicating reflections come from that surface. A white background provided by the bottom surface of the cover **10** when the latter is closed, or by a plate (not shown) resting on the tape **11**, causes white light to be reflected back through enclosed cells **12**. Alternatively a white pencil can be used on these cells to cause them to reflect white.

A color filter **76**, interposed between the tape **11** and the photodetector **72**, selectively passes a band of red light and a filter **77** between the tape **11** and the photodetector **74** selectively passes green light. Thus, the photodetector **72** generates an output in response to red or white light, while the photodetector **74** generates an output in response to green or white light.

Table I shows the outputs of the photodetectors **72** and **74** as a function of the color reflected from a cell **12**.

TABLE I

Color of Cell	Photodetector 72 output	Photodetector 74 output

Red	yes	no
Green	no	yes
White	yes	yes
Black	no	no

Any one of four colors may be detected by simultaneously sensing the outputs of both photodetectors. Specifically, an output from photodetector **72**, with no output from photodetector **74**, indicates that the cell color is red; an output from photodetector **74** with the absence of an output from photodetector **72** indicates that the cell color is green. An output from both photodetectors indicates that the cell color is white; and an output from neither photodetector indicates that the cell color is black.

As also shown in FIG. **3**, a pair of reference photodetectors **78** and **79** receive light reflected from the mirror **70**. A red-transmitting filter **80**, similar to the filter **76** is positioned in front of the detector **78**; and in like manner, a green-transmitting filter **81** having the characteristics of the filter **77** is positioned in front of the detector **79**. With this arrangement, the outputs of the detectors **78** and **79** vary in the same manner as the respective outputs of the detectors **72** and **74** in response to changes in the light from the lamp **66**. As described below, the reference detectors **78** and **79** are used to eliminate the effects of such changes.

As shown in FIG. **4**, an arm **82** is attached to lead screw **54**. During each revolution of the lead screw **54**, arm **82** moves past a magnetic reed switch **83** mounted on the back plate **46**, and a small magnet **82**a on the tip of the arm causes the switch to close momentarily. The pitch of the lead screw **54** is equal to the distance between centers of consecutive cells **12** on the tape **11** (FIG. 1) and the parts are positioned so that the switch **83** closes whenever the light from lamp **66** (FIG. **3**) is focused on a single tape cell **12**. The switch closure actuates photodetector readout circuitry to be described, thereby assuring that the information sensed corresponds to an individual cell.

FIG. **5** depicts in block form the electric circuits associated with the translator. The outputs of the detectors **72** and **74** are applied to a decision circuit **100** along with the outputs of the reference detectors **78** and **79**. At an output terminal **100**a the decision circuit provides a signal indicating whether or not the color red has been detected by the red-detector **72** and at an output terminal **100*b*** it provides a signal indicating whether or not the color green has been detected by the detector **74**. Thus the signals on the terminals **100*a*** and **100*b*** together indicate which of the four art medium colors is being sensed in accordance with the logic arrangement shown in Table I.

The red signal from the terminal **100*a*** is fed through a gate **102** to a recirculating memory **103**. The memory **103** comprises a shift register **104** whose last stage **104*a*** is connected back to the first stage **104*b*** by way of a gate **106** and an OR circuit **108** that also receives the output of the gate **102**. Similarly, the green signal from the terminal **100*b*** is applied through a gate **110** to a recirculating memory **111**. The memory **111** includes a shift register **112** whose contents can be returned from an output stage **112*a*** to an input stage **112*b*** by way of a gate **114** and an OR circuit **116**.

To begin operation a START switch **117** is momentarily actuated to turn on a latching forward motor switch **119** by way of an OR circuit **121**. This starts the motor **56** in the forward direction and the scanner **20** (FIGS. **1** and **5**) thereby begins to scan a row **15** on the tape **11**. The output of the OR circuit **121** also sets a flip-flop **118**, thereby enabling the gates **102** and **110** and disabling the gates **106** and **114**. This couples the red and green signals into the shift registers **104** and **112** while at the same time preventing recirculation of the contents of the registers. The set condition of the flip-flop **118** also enables a gate **120** to pass pulses from the reed switch **83** to an OR circuit **122** from which they are applied to the shift registers **104** and **112** as shift pulses. Thus each time the switch **83** closes, the contents of the registers **104** and **112** are shifted and the signals from the decision circuit terminals **100*a*** and **100*b*** are loaded into the register stages **104*b*** and **112*b***.

More specifically, as pointed out above the switch **83** emits a pulse each time the scanner **16** is properly positioned to sense the color of a cell **12** on the tape **11** (FIG. **1**), at which times the signals at the decision circuit terminals **100*a*** and **100*b*** accurately reflect the color of a cell. Therefore, the first pulse from the switch **83** causes the color of the first cell in the row being scanned to be recorded in the input stages **104*b*** and **112*b*** of the shift registers, the colors being recorded in a binary form code corresponding to the logical arrangement of Table I. The second pulse from the switch **83** causes the color indication of the first cell to be shifted to the second stages of the shift registers **104** and **112**, with the color of the second cell on the tape column being loaded into the input stages **104*b*** and **112*b***.

In this manner the colors of all of the cells in the row being scanned are recorded in the two shift registers. The number of stages in each shift register preferably equals the number of cells in an art medium row (**56** in the example) so that, at the end of the row the color of the first cell is recorded in the stages **104*a*** and **112*a*** and the color of the last cell in stages **104*b*** and **112*b***.

When the scanner **16** reaches the end of the row it engages the limit switch **64** (FIGS. **2** and **5**) and the output of the switch **64** resets the flip-flop **118**, as well as the motor switch **119** and other resettable elements, as indicated by the signal R. The output of flip-flop **118** now disables the gates **102** and **110** and enables the gates **106** and **114** to connect the shift registers **104** and **112** for a recirculating mode of operation. At the same time, the output of the flip-flop disables the gate **120** to cut off the switch **83** pulses from the shift registers **104** and **112** and enables a gate **126** to pass shift pulses from a clock **128** to the OR circuit **122**.

When the flip-flop **118** is reset it also actuates a latching reverse switch **130** for the scanner motor **56** by way of an OR circuit **131**. The motor **56** thereupon returns the scanner **20** to its initial position at which point the limit switch **62** (FIGS. **1** and **5**) resets the switch **130** to cut off the motor **56**.

The circuit is now ready to control the punching of a punched tape used by the textile machine.

The signals for this operation are provided by a decoder **134** to which the contents of the shift register output stages **104*a*** and **112*a*** are applied. The decoder **134** has output terminals **134*a*–134*d***, each of which is associated with one of the four colors used in the system described herein. One of these terminals is energized at any given time, depending on the color whose code is contained in the stages **104***a* and **112***a*. The outputs at the respective decoder terminals are selected by means of a distributor **136** which passes the selected output to a punch selection matrix **138** by way of a gate **140**. The matrix **138**, in turn, applies these signals to punches in a punch set **142**.

The punch set **142** punches holes in a tape **144** that is to control a textile machine in accordance with the colors in the respective cells **12** of the scanner art medium. As noted above, the tape **144** has a series of fields, each of which consists of four transversely extending rows **144***a*. Each field corresponds to a given row **15** on the art medium tape **11**; and each row **144***a* corresponds to one color. The punches in the set **142** are disposed along a column **144***a* of the tape **144**, each punch corresponding to row **13** on the art medium tape **11**. The punches are actuated in unison so as to simultaneously punch a series of holes. Each of these holes corresponds to an art medium cell **12** that contains the color to which the column **144***a* corresponds.

More specifically, the individual punches in the set **142** are unlocked by means of solenoids (not shown in FIG. 5). The solenoids are energized according to where the various holes in the tape **144** row are to be punched; and after the requisite punches are unlocked, a further solenoid (not shown) is energized to actuate them. The punches are selected one-by-one by the matrix **138** in response to the output of a counter **146**. Each punch selected in this manner is unlocked or not depending on whether the corresponding art medium cell has the color associated with the row **144***a* being punched.

For example, assume that the first row **144***a* in each field on the tape **144** corresponds to the color red and that the decoder **134** energizes the terminal **134***a* whenever it detects the code for red in the shift register stages **104***a* and **112***a*. At the beginning of the punching operation, the distributor **136** is positioned by the reset signal from the switch **124** to pass the signal at the terminal **134***a* to the gate **140**. Similarly the counter **146** has been reset so as to cause the matrix **138** to select the first punch in the set **142**.

The matrix thus passes the output of the gate **140** to the solenoid associated with the first punch. If the color in the first cell on the art medium tape **11** is red, the corresponding output at the terminal **134***a* will enable the gate **140** to pass the first pulse from the clock **128** through to the matrix **138** and on to the first punch solenoid, thereby unlocking the first punch. On the other hand if the first cell color is other than red, the gate **140** will not be enabled and the first solenoid will not be energized.

Next, following a short delay, provided by a delay element **148**, e.g., a one shot multivibrator, the clock pulse is applied to the shift registers **104** and **114** to shift the color code for the next cell **12** into the output stages **104***a* and **112***a*. At the same time, the delayed clock pulse advances the counter **146** so that the matrix **138** selects the second punch in the punch set **142**. The gate **140** is now enabled or inhibited depending on whether the color of the second cell is red and this determines whether or not the next pulse from the clock **128** will be passed to the second solenoid in the punch set **142**.

This cycle is repeated until the entire contents of the shift registers **104** and **112** have been searched for the red code and correspondingly, the matrix **138** has selected in turn all of the punches in the set **142**. At this point the counter **146** has reached its maximum count corresponding to the number of cells in the row **144a** being punched. This condition is detected by a detector **150** which enables a gate **152**. The next pulse from the clock **128** is thus passed by the gate **152** to a delay element **153** and on to the distributor **136**, thereby stepping the distributor to the decoder output terminal **134***b*.

The output of the delay element **153** also actuates the punches in the set **142** and indexes the mechanism **154** that advances the tape **144** to bring the next row on the tape into alignment with punch set **142**.

The output of the delay element **148** following the same pulse returns the counter **146** to its initial state so that the matrix **138** once again selects the first punch in the punch set **142**. The contents of the registers **104** and **112** have now undergone one complete circulation so that the color of the first cell recorded in the registers is again contained in the output stages **104***a* and **112***a*. If the decoder terminal **134***b* provides an output when the decoder senses the color green, for example, the presence of green in the first cell will result in the enabling of gate **140**, as described above, so that the next pulse from the clock **128** will energize the solenoids associated with the first punch in the set **142**.

Operation continues in the foregoing manner, with the matrix **138** selecting in turn the success of punches in the set **142** and the decoder **134** unlocking the punches which correspond to the green cells **12** in the art medium column **15** whose colors are stored in the memories **103** and **111**. When the contents of the memories have been searched for green, the punches are actuated and the tape **144** advanced as described above, and the distributor **136** is indexed to select the decoder output terminal **134***c*.

This format continues until the memories have been searched for the color that provides an output from the decoder terminal **134***d* and the corresponding holes have been punched in the tape **144**. The next distributor-shifting pulse from the delay element **153** is passed by a gate **156** which is enabled by an output from the distributor **136** when the distributor is in its fourth state, i.e., selecting the decoder terminal **134***d*. This pulse causes the card advance mechanism **154** to advance the tape **144** an additional increment to provide the requisite separation between fields on the tape. The same pulse sets the flip-flop **118** to return operation to the scanning mode as described above and it energizes the stepping motor **31** to advance the next tape row **15** into position for scanning.

FIG. 6 illustrates the preferred embodiments of the matrix **138** and counter **146**. The matrix **138** comprises a set of vertical conductors **160** and a set of horizontal conductors **162**. The punch-selecting solenoids **164** of the punch set **142** (FIG. 5) interconnect the conductors **160** and **162** at the respective crossovers thereof. The vertical conductors **160** are selectively connected to a power supply **166** by means of relays **168** and an intervening switch **170**. The horizon conductors **162** are selectively grounded by switches **172**.

Thus by energizing a relay coil **168a** in one of the relays **168** and at the same time closing one of the switches **172**, the system can select the solenoid **164** connected to a particular pair of vertical and horizontal conductors **160** and **162**. If the selected solenoid **164** is to be energized to unlock a punch and ultimately punch a corresponding hole in the tape **144** (FIG. **5**), the gate **140** will be enabled by the output of the distributor **136** to pass a pulse from the clock **128**, as described above, thereby closing the switch **170** momentarily by way of a pulse shaper **171**. This briefly passes current from the power supply **166** to the selected solenoid.

The counter **146** comprises a pair of recirculating shift registers **174** and **176**. Each stage of the shift register **174** is coupled to one of the switches **172** and similarly the contents of the stages in the shift register **172** are applied to the relay solenoids **168a**. Whenever a stage in the register **174** contains a a ONE the switch **172** associated therewith is closed; otherwise the switch is open. Likewise, whenever a stage in register **176** contains a ONE, the relay solenoid **168a** associated therewith is energized and if the stage contains a ZERO, the solenoid is not energized.

The initial resetting of the counter **146** inserts a ONE in the first stage **174a** of the register **174**, and also in the first stage **176a** of the register **176**. The other stages of both registers contain ZEROES. Thus, the lower left hand punch solenoid 164_1 is initially selected by the matrix **138**. The next delayed pulse from the clock **128** shifts the ONE in the register **174** to the second stage thereof so as to select the punch solenoid 164_2. This sequence continues until the ONE reaches the last stage **174b** of the register **174**. The next clock pulse transfers it back to the first stage **174a** and the change from a ONE to a ZERO in the stage **174b** causes a shift in the register **176** to move the ONE in that register from the first stage **176a** to the second stage of that register. The counter **146** and matrix **138** then sequence through the punch solenoids connected to the second vertical conductor **160**, and this operation continues until all of the solenoids **164** have been selected. As described above, whenever the output of the distributor **136** indicates that a cell in the art medium contains the color then being searched for, the corresponding solenoid **164** is energized to unlock the punch associated therewith. The unlocked punch later makes a hole in the tape **144**.

The makeup of the decision circuit **100** is illustrated in FIG. **7**. Since the circuit contains identical sections for the detection of red and green, only one of these need be shown in detail, e.g., the section that detects the color red. This section includes amplifiers **180** and **182** that receive the outputs of the red detector **72** and red reference detector **78**. The red signal from the amplifier **180** is applied directly as one input of a differential amplifier **184**. The other input of the amplifier **184** is derived from the output of the amplifier **182** by way of a potentiometer **186**. The amplifier **184** has a sufficiently high gain to serve as a threshold detector indicating which of its input signals is greater.

The output of the amplifier **180** is at a maximum level V_h when the red detector **72** senses a red or white cell on the art medium tape **11**, and it is at a minimum level V_l when the cell is green or black. The potentiometer **186** is set to provide a reference voltage from the reference detector **78** half way between V_l and V_h, i.e., $(V_l + V_h)/2$. Thus when the output of the amplifier **180** is above this half-way point, indicating that the detector **74** has detected the red color of a red or white art medium cell **12** (FIG. **5**), the amplifier **184** will saturate in one direction, providing a red or white-indicating voltage at the terminal **100a**. Conversely, when the output of the amplifier **180** is less than $(V_l + V_h)/2$cell, the output of the amplifier **184** will saturate in the opposite direction and there will be no red signal at the terminal **100a**.

The decision circuit **100** also includes an indecision detector comprising a pair of threshold detectors **190** and **192** responding to the differences between the output of the amplifier **180** on the one hand, and the voltages provided by potentiometers **194** and **196**, respectively. The input voltage for these potentiometers is the output of the amplifier **182**. The potentiometers **194** and **196** are set to provide an indecision band defined by a pair of reference voltages above and below the level V_r provided by the potentiometer **186**. For example, the potentiometer **194** may be set to provide a voltage $(V_r + \delta)$, with the potentiometer **196** providing a voltage $(V_r - \delta)$.

The threshold detector **190** provides an output to an AND circuit **198** when the red-indicating signal from amplifier **180** is less than $(V_r + \delta)$, while the threshold detector **192** provides an output to the AND circuit when the output of amplifier **180** exceeds $(V_r - \delta)$. The AND circuit **198** is thus enabled to pass a pulse from the reed switch **83** whenever the output of the amplifier **180** is in a band having the width 2δ and centered between the voltages V_l and V_h. This is the indecision band and when the red detector **74** provides a signal within this band, the system terminates the scanning operation if it is operating in the "indecision mode."

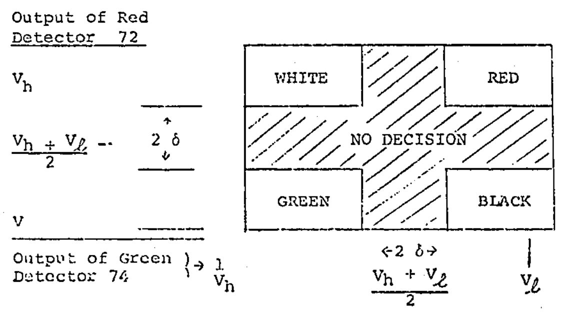
More specifically, the indecision mode is selected by closing a switch **202** that applies the output of AND circuit **198** from an OR circuit **203** to a flip-flop **206**, thereby setting the flip-flop. The resulting output of flip-flop **206** resets the motor switch **119**.

At the same time the flip-flop **206** output inhibits a gate **208** that passes the reed switch pulses to a counter **210**. The counter **210** begins counting with the beginning of each scanning cycle. Thus, at any given time, its content indicates the number of the art medium column **13** containing the cell **11** whose color is being sensed.

Since the counter stops counting in response to an indecision signal from the AND circuit **198**, it holds the column number of the cell in which the indecision occurred. This number is transmitted to the operator by means of an indicator **212**. Referring briefly to FIG. **1**, the operator can thus immediately identify the cell on the tape **11**, erase the contents of the cell, and then recolor it, all without moving the tape. A transparent plate **215** underlying the tape **11** supports the tape for erasure and recoloring. He then actuates a push button restart switch **213** (FIG. **5**) to reverse the motor **56** and return the scanner to its initial position at the beginning of the same column on the tape **11**. The scanner then rescans the entire column and the translator continues operation in the manner described above.

Table II is a logic diagram illustrating operation of the system in the indecision mode.

TABLE II



The outputs of the red and green detectors **72** and **74** are registered as long as the output of each detector is greater or less than an intermediate band of outputs (the indecision band) having a width of 2δ. In such cases the color indications as shown in Table II correspond to those of Table I. On the other hand, if the output of either detector falls within the indecision band, the system makes no decision, but rather stops for corrective action by the operator.

To facilitate operation of the translator without close attention we prefer to include a visible or audible alarm **214** actuated by the output of the switch **202** when operation is interrupted by an indecision.

The translator can also be arranged to shut itself off automatically after the entire pattern on the art medium tape **11** has been scanned. As shown in FIG. **5**, the pattern designer applies a black mark **215** on the margin of the tape, which is otherwise transparent or white. The mark **215** is opposite the row **15** following the last row of the textile pattern. When the mark moves into the scanning area, it is sensed by a photodetector **217**. The output of the photodetector is applied to a switch **219** that turns off the translator or otherwise inhibits further operation.

From the point of view of the operator, the translator is an exceedingly simple device. He merely loads the art medium tape **11** as described above and then repeatedly actuates a jog switch **216** (FIG. **5**) to step the motor **31** and advance the first column **15** of the tape **11** into position over the scanner **20** (FIG. **1**). Finally, he actuates the start switch **117** (FIG. **5**) and automatic translation commences.

Moreover, the translator is relatively small in size and weight, facilitating its use in almost any desired location; and it is characterized by high reliability, a particularly advantageous feature when use in remote installations is contemplated in remote locations particularly those having uncontrolled environments, is also facilitated by the use of a dimensionally stable, reusable plastic art medium colored by pencils as described above.

What is claimed is:

1. A translator for translating an encoded multi-colored graticulated design pattern for the control of a textile machine in which a sequence of cells traversing one dimension of said design pattern is a column of the pattern and a sequence of cells traversing the other dimension of said pattern is a row of the pattern, said translator comprising

A. a scanner for scanning successive cells in the design pattern to sense the colors thereof and thereby detect the encoded design, said scanner including
   1. a scanner head,
   2. means for moving said scanner head along a row of design pattern cells, and
   3. a plurality of photodetectors mounted on said head for movement therewith and arranged to simultaneously detect light reflected from the same location of said design pattern and thereby collectively sense the color in that location, each photodetector being responsive to a particular color range whereby the outputs of the photodetectors when taken together provide a multi-bit representation of the colors of said cells,

B. means responsive to the position of said scanner head by emitting a sensing signal each time said head is positioned for sensing the color of a single design pattern cell,

C. electronic storage means connected to store in digital form the colors of successive sets of cells, said storage means comprising
   1. a plurality of shift registers, each having an input stage, and
   2. means for applying the signal at a decision circuit output terminal to a separate shift register input stage, said shift registers responding to said sensing signal by integrally shifting and by accepting the decision circuit signals into their input stages,

D. means for generating signals indicating completion of the scanning of a set of cells, and

E. output means responsive to said signals for reading out the information in said storage means in a form suitable for control of a machine.

2. The translator defined in claim **1** wherein said output means provides signals suitable for control of a card or tape punching machine.

3. The translator defined in claim **1** wherein

A. said encoded design pattern is a graticulated pattern in which
   1. a sequence of cells traversing one dimension of said design pattern is a column of the pattern, and
   2. a sequence of cells traversing the other dimension of said pattern is a row of the pattern, and

B. said sets of cells successively scanned by said scanner are rows of said pattern.

4. The translator defined in claim **3** wherein said scanner includes

A. a scanner head,

B. means for moving said scanner head along a row of design pattern cells,

C. a plurality of photodetectors
   1. mounted on said head for movement therewith, and
   2. arranged to simultaneously detect light reflected from the same location of said design pattern and thereby collectively sense the color in that location, and

D. wherein each photodetector is responsive to a particular color range, whereby the outputs of said photodetectors, when taken together, provide a multi-signal representation of the colors of said cells.

5. The translator defined in claim **4**

A. including a decision circuit associated with said photodetectors, said decision circuit

1. having an output terminal corresponding to each photodetector, and
2. providing at each output terminal a signal indicating whether or not the intensity of the light sensed by the corresponding photodetector exceeds a reference level, an intensity exceeding the reference level indicating that the color range to which the photodetector responds is present in the design pattern location whose color is being sened at that time.

6. The translator defined in claim 4 wherein there are two photodetectors in said scanner for use with a four-color design code, one photodetector being selectively responsive to light of a first color range and the other to light of a second color range.

7. The translator defined in claim 1 including
A. a decoder for decoding the combined contents of a corresponding stage of each of said shift registers to provide a decoded color signal indicating the color stored in said corresponding stages,
B. means for emitting a punch signal after each design pattern row has been scanned,
C. mode control means responsive to said punch signal by connecting said shift registers for a recirculating mode of operation, whereby the entire contents of said storage means are decoded in succession by said decoder.

8. The translator defined in claim 7
A. including a color-selecting distributor for selecting a single output of said decoder indicating one of the colors of said design pattern,
B. including punch-selecting means for selecting a succession of punches for punching or not punching, according to the decoder output selected by said distributor,
C. said mode control means causing said shift registers to shift and causing said punch-selecting means to select said punches in step with the shifting of said registers.

9. The translator defined in claim 8 including means causing said distributor to select a further decoder output each time said decoder has decoded the contents of said storage means.

10. A translation system for translating an encoded, multicolored, design pattern for the control of textile machine, said system comprising
A. a transparent plastic art medium
1. having a grid imprinted thereon and
2. having a textile design recorded on a first surface thereof in the form of various removable colors in the cells of said grid, and
B. a scanner
1. for sensing the colors in said cells and providing electrical signals indicative of said colors, and
2. disposed on the opposite side of said medium from said first surface so as to view the colors through the medium, thereby to facilitate changing colors on said medium when said medium is in position for scanning by the scanner.

11. The system defined in claim 10 in which said medium is receptive to the deposition of colors from color pencils.

12. The system defined in claim 10 in which said grid is imprinted on the medium in a form that permits eradication of said colors from the medium without eradicating the grid.

13. A translator for translating a coded multi-colored design pattern for the control of a textile machine, said translator comprising
A. a scanner for scanning successive cells in the design pattern to sense the colors thereof and thereby detect the encoded design, said scanner developing a set of signals each of which is indicative of the presence of a particular color in the area whose color is being sensed,
B. means for developing a reference signal whose level is intermediate to the level of one of said color signals when the color to which the color signal corresponds is absent and the level when the color is present and,
C. a decision circuit comprising means for ascertaining, for each of said color signals, whether its level is above or below the reference level, thereby to indicate whether the color to which the color signal corresponds is present or absent.

14. The translator defined in claim 13
A. including means for developing an indecision band of reference levels intermediate to the maximum and minimum levels of each of said color signals, said band being a function of said reference level, a color signal level outside of said band at one end thereof indicating the presence of the color to which the color signal corresponds and a level outside the band at the other end thereof indicating the absence of that color, and
B. means for generating an indecision signal in response to a color signal within said reference band.

15. A translator for translating an encoded multicolored graticulated design pattern for the control of the textile machine in which a sequence of cells traversing one dimension of said design pattern is a column of the pattern and a sequence of cells traversing the other dimension of said pattern is a row of said pattern, said translator comprising
A. a scanner for scanning successive cells in the design pattern to sense the colors thereof and thereby detect the encoded design, said scanner including
1. a scanner head,
2. means for moving said scanner head along a row of design pattern cells,
3. a plurality of photodetectors mounted on said head for movement therewith and arranged to simultaneously detect light reflected from the same location of said design pattern and thereby collectively sense the color in that location, each photodetector being responsive to a particular color range, whereby the outputs of said photodetectors when taken together provide a multi-bit representation of the colors of said cells, and
4. a light source for illuminating the location of said pattern whose color is being sensed by said photodetectors,
B. a reference detector arranged to sense light emanating directly from said source,
C. means for deriving a reference level for at least one of said photodetectors from the output of said reference detector,

D. a decision circuit associated with said photodetectors, said decision circuit
   1. having an output terminal corresponding to each photodetector, and
   2. providing at each output terminal a signal indicating whether or not the intensity of the light sensed by the corresponding photodetector exceeds a reference level, and intensity exceeding the reference level indicating that the color range to which the photodetector responds is present in the design pattern location whose color is being sensed at that time,
E. electronic storage means connected to store in digital form the colors of successive sets of cells in response to the signals at said output terminals,
F. means for generating signals indicating completion of the scanning of a set of cells, and
G. output means responsive to said completion signals for reading out the information in said storage means in a form suitable for control of a machine.

16. A translator for translating an encoded multi-colored graticulated design pattern for the control of a textile machine in which a sequence of cells traversing one dimension of said design pattern is a column of the pattern and a sequence of cells traversing the other dimension of said pattern is a row of the pattern, said translator comprising
A. a scanner for scanning successive cells in the design pattern to sense the colors thereof and thereby detect the encoded design, said scanner comprising
   1. a scanner head,
   2. means for moving said scanner head along a row of design pattern cells,
   3. a plurality of photodetectors mounted on said head for movement therewith and arranged to simultaneously detect light reflected from the same location of said design pattern and thereby collectively sense the color in that location, each photodetector being responsive to a particular color range whereby the outputs of said photodetectors when taken together provide a multi-bit representation of the colors of said cells, and
   4. a light source for illuminating the location on said pattern whose color is being sensed by said photodetectors,
C. a plurality of reference detectors, each reference detector
   1. being arranged to sense light directly emanating from said light source,
   2. being associated with one of said photodetectors, and
   3. having essentially the same spectral response as the photodetector associated therewith,
D. means for deriving from each of said reference detectors the reference level for the photodetector associated therewith,
E. a decision circuit associated with said photodetectors, said decision circuit
   1. having an output terminal corresponding to each photodetector, and
   2. providing at each output terminal a signal indicating whether or not the intensity of the light sensed by the corresponding photodetector exceeds the reference level, an intensity exceeding the reference level indicating that the color range to which the photodetector responds is present in the design pattern location whose color is being sensed at that time,
F. electronic storage means connected to store in digital form the colors of successive sets of cells,
G. means for generating signals indicating completion of the scanning of a set of cells, and
H. output means responsive to said completion signals for reading out the information in the storage means in a form suitable for control of a machine.

17. A translator for translating an encoded multi-colored graticulated design pattern for the control of a textile machine in which a sequence of cells traversing one dimension of said design pattern is a column of the pattern and a sequence of cells traversing the other dimension of said pattern is a row of the pattern, said translator comprising
A. a scanner for scanning successive cells in the design pattern to sense the colors thereof and thereby detect the encoded design, said scanner comprising
   1. a scanner head,
   2. means for moving said scanner head along a row of design pattern cells,
   3. a plurality of photodetectors mounted on said head for movement therewith and arranged to simultaneously detect light reflected from the same location of said design pattern and thereby collectively sense the color in that location, each photodetector being responsive to a particular color range whereby the outputs of said photodetectors when taken together provide a multi-bit representation of the colors of said cells,
B. a decision circuit associated with said photodetectors said decision circuit
   1. having an output terminal corresponding to each photodetector,
   2. providing at each output terminal a signal indicating whether or not the intensity of the light sensed by the corresponding photodetector exceeds a reference level, an intensity exceeding the reference level indicating that the color range to which the photodetector responds is present in the design pattern location whose color is being sensed at the time,
   3. including means for defining an indecision band within the range of photodetector output levels, said band being a function of said reference level, a photodetector level outside said band on one end thereof indicating the presence of a color in the design pattern location whose colors are being sensed and an output level outside said band on the other end thereof indicating the absence of said color, and
   4. including means for generating an indecision signal in response to a photodetector output level within said band,
C. electronic storage means connected to store in digital form the colors of successive sets of cells,
D. means for generating signals indicating completion of a scanning of a set of cells, and

F. output means responsive to such signals for reading out the information in said storage means in a form suitable for control of a machine.

18. A translator for translating an encoded multicolored graticulated design pattern for the control of a textile machine in which a sequence of cells traversing one dimension of said design pattern is a column of the pattern and a sequence of cells traversing the other dimension of said pattern is a row of the pattern, said translator comprising

A. a scanner for scanning successive cells in a single column or row of the design pattern to sense the colors thereof,

B. electronic storage means connected to store in digital form the colors of successive cells in that single column or row,

C. means for generating signals indicating completion of the scanning of the single column or row of cells, and

D. output means responsive to said signals for causing the scanner to scan the successive cells in a second single column or row in the design pattern.

19. The translator defined in claim 18 and further including output means responsive to said signals for reading out the information in said storage means in a form suitable for control of a machine.

20. A translator for translating a coded color design into a digital signal, said translator comprising

A. a sensor for sensing the color of the light reflected from said design, said sensor developing a set of signals, each of which is indicative of the presence of and corresponds to a particular color or color component in the design,

B. means for developing a reference signal whose level is intermediate to the level of one of said color signals when the color or color component to which the color signal corresponds is absent and the level when the color or color component is present, and

C. a decision circuit comprising means for ascertaining as to each of said color signals whether its level is above or below the reference level, thereby to indicate whether the color or color component to which the color signal corresponds is present or absent.

21. The translator defined in claim 20 and further including

A. means for developing an indecision band of reference levels intermediate to the maximum and minimum levels of each of said color signals, said band being a function of said reference level, a color signal level outside of said band at one end thereof indicating the presence of the color or color component to which the color signal corresponds and a level outside the band at the other end thereof indicating the absence of that color or color component, and

B. means for generating an indecision signal in response to a color signal within said reference band.

22. The translator defined in claim 20 and further including

A. electronic storage means responsive to the output of the decision circuit for storing in the form of digital signals the colors or color components in the design, and

B. output means responsive to said digital signals in the storage means to further process the color information.

23. The translator defined in claim 20 wherein the scanner includes

A. a scanner head,

B. means for moving said scanner head over the design,

C. a plurality of photodetectors

1. mounted on said head for movement therewith, and
2. arranged to simultaneously detect light reflected from the same location on said design and thereby collectively sense the color at that location, and

D. wherein each photodetector is responsive to a particular color range whereby the outputs of the photodetectors when taken together provide a multisignal representation of the colors of said design.

24. The translator defined in claim 20 wherein the scanner includes

A. a scanner head,

B. means for moving the scanner head over the design,

C. a photodetector assembly mounted on said head for movement therewith, said assembly including

1. a photodetector arranged to detect light detected from the portion of the design being scanned, and
2. means for sequentially making said photodetector responsive to particular color ranges,

D. wherein the decision circuit

1. has a plurality of reference levels, each corresponding to one of said color ranges,
2. is switchable between said reference levels in synchronism with said responsivity to particular color ranges, and
3. provides at its output terminal a signal indicating whether or not the intensity of the light sensed by the photodetector exceeds the reference level, intensity exceeding the reference level indicating that the color range to which the photodetector responds is present in the cell being scanned at the time, and

E. means for storing the sequential output signals of the decision circuit, said stored signals obtained from the decision circuit when the scanner scans a particular portion of the design providing a multisignal representation of the color of said design portion.

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