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Nishikawa et al.

[11] **3,786,987**

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[54] **METHOD OF AUTOMATICALLY MAKING PATTERN CARDS FOR JACQUARD LOOMS**

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[51] **Int. Cl.** **G06k 1/02**

[58] **Field of Search** 234/1-3, 131, 89, 234/59, 51-57, 67-73

[56] **References Cited**

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Primary Examiner—J. M. Meister

Attorney, Agent, or Firm—William J. Daniel

[57] **ABSTRACT**

A method of automatically making pattern cards for Jacquard looms or for controlling the operation of the loom directly in which the pattern or design to be woven is scanned directly and signals corresponding to location and color of changes in such pattern or design are fed to a computer for controlling a card punching machine or the operation of the loom directly.

2 Claims, 7 Drawing Figures

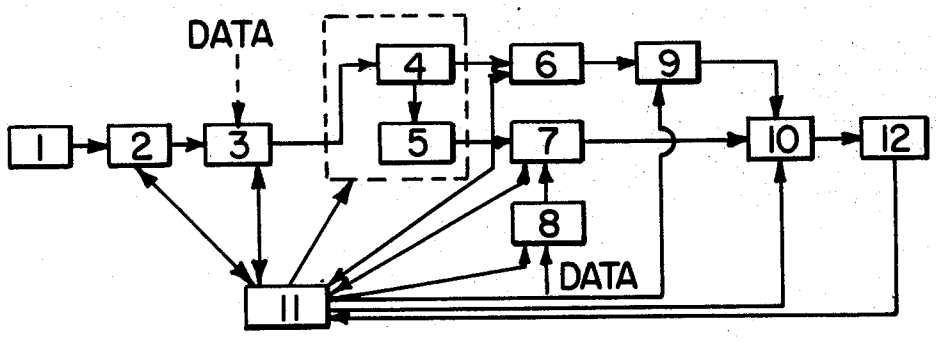


FIG. 1.

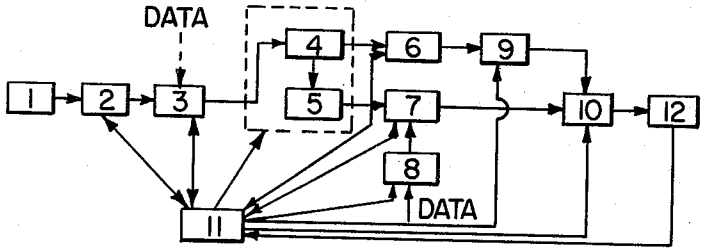


FIG. 2a.

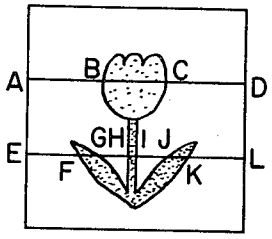


FIG. 2b.

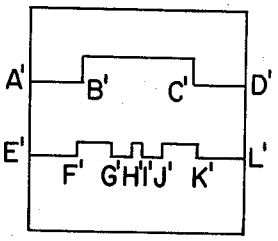


FIG. 3a.

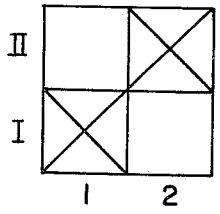


FIG. 3b.

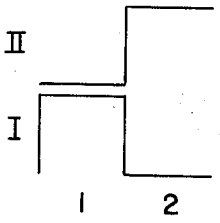


FIG. 4a.

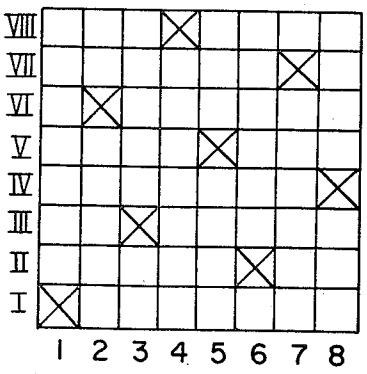
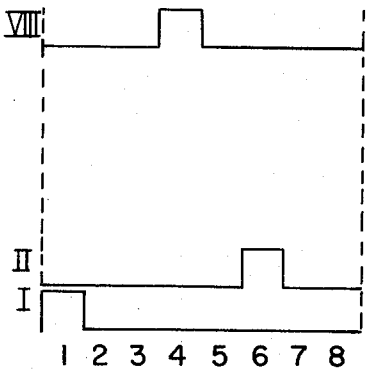


FIG. 4b.



METHOD OF AUTOMATICALLY MAKING PATTERN CARDS FOR JACQUARD LOOMS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method of automatically making pattern cards for Jacquard weaving machines.

The Jacquard weaving machine is used for pattern weave wherein the machine gives suitable shedding motion to the warp and controls color and pattern warp by warp, thus weaving a piece of cloth with a complicated pattern. This weaving machine requires many numbers of pattern cards for the control of color and pattern.

2. Description of the Prior Art

In the prior art, the pattern card is made in such a manner that a design paper is drawn based on an original plan and weave texture, and a card is punched manually to figure the desired pattern on the card by the use of pattern card punching machine. This work requires highly specialized skill and thus it has been impossible to efficiently produce the pattern cards or to produce the pattern cards on an industrial basis. Furthermore, a considerable length of time is needed for change or modification of pattern because pattern change or modification must be made card by card. Recently, the textile industry has been extremely short of men skilled in the pattern card making and the supply of pattern cards has become limited. Under the circumstances, realization of an easily operable, automatic pattern card making apparatus is an urgent requirement in the field of textile industry.

Several automatic pattern card making apparatus have been proposed in the prior art (reference: Japanese Pat. No. 88461 and Japanese Publication No. 504/1966, for example).

These apparatus are not practical enough or made only poor automatic control available. They require considerable time and labor for various treatments incidental to the automatic operation and are applicable only to very simple weave products such as blankets and floor mats. Nevertheless, industrially practical, highly efficient automatic pattern card making apparatus have never been proposed in the prior art.

As a result of research on fully automatic operations for making pattern cards, we have derived a fully automated mechanism utilizing an electronic computer to produce the desired pattern card directly from the original plan and textile design without using a design paper. This invention was accomplished on the basis of the above devisal.

An object of this invention is to provide a method of automatically making the pattern cards for the Jacquard weaving machine based on the predetermined pattern and textile design.

Other objects of this invention will be apparent from the following detailed description. The objects of this invention can be readily attained by using the method of this invention.

GENERAL DESCRIPTION OF THE INVENTION

Briefly, the automatic pattern card making method of this invention is a fully automated method in which the desired pattern card is produced directly according to the initially drawn design and textile design.

More particularly, the method of this invention is characterized by storing in an information medium pattern signals read directly from the original design by an optical means; identifying the stored pattern signals according to colors while selecting, among signals converted from a plurality of textile designs which have been stored previously in the information medium, the desired signals according to the identified colors; replacing the pattern signals by the signals selected as above to form figure signals; and punching a pattern card according to the figure signals or storing the figure signals in the information medium and then making a pattern card by sequentially retrieving the stored figure signals.

According to this invention, therefore, pattern cards can be manufactured automatically, without making a design paper in the process of making pattern cards in the prior art or without making a secondary design drawn on manual procedure by rewriting the original design with a special ink, by using the initial design drawn with commercially available paints and the like without being strictly limited to the size of the design. Furthermore, multiple colors can be discriminated from one another according to this invention and, hence, pattern cards specifically adapted for weaving textiles with extra thin, multicolor weft to form a pattern in vignette style on fabric can automatically be punched. The efficiency of pattern card making can be markedly increased by the use of an optical device in combination with an electronic computer for judging the color component of the pattern signal.

DETAILED DESCRIPTION

This invention will more specifically be described by referring to the appended drawings illustrating one embodiment of apparatus for practicing the method of this invention.

Referring to FIG. **1**, there is shown a system embodying this invention wherein the reference numeral **1** denotes a design reading device, **2** a pattern signal reading device, **3** a design paper calculating device, **4** and **5** pattern signal registers, **6** and **7** color decision registers, **8** a textile register, **9** a shuttle change register, **10** a figure register, **11** a control device, and **12** a card punching machine.

FIGS. **2***a* and **2***b* show in comparison an example of colored design and the pattern signal provided from the design reading device of this invention. FIGS. **3***a* and **3***b* show in comparison a textile design and its signal train. FIGS. **4***a* and **4***b* also show in comparison a textile design and its signal train.

In FIG. **1**, the design reading device **1** is operated in such a manner that a pattern signal is formed from a given design by an optical means and is stored in a memory medium such as perforation tape or magnetic tape. The pattern signal reading device **2** connected to the design reading device is synchronized with the punching machine at each scanning line of the design, reads said pattern signal, and gives this pattern signal to the design paper calculating device **3** where the pattern signal is calculated according to the ratio between the warp and weft based on the textile design specification, the result of calculation being stored in the first pattern signal register **4**. This pattern signal register consists of a certain number of words equal to the number of needles of Jacquard. One word has a sufficient number of bits for coding the necessary number of col-

ors. The second pattern signal register 5 and the second color decision register 6 are connected in parallel to the first pattern signal register 4. The first color decision register 7 is connected to the second pattern register 5. The content of the first pattern signal register 4 is supplied to the second pattern signal register 5 by the next synchronous signal, and is shifted sequentially at the first color decision register 7, which consists of a color decision circuit and a certain number of words or bits equal to the number of needles of Jacquard. The first color decision register 7 is operated in such a manner that color decision on the information shifted from the second pattern signal register 5 is made on each specific color designated by the control device according to AND logic, the contents of the second pattern signal register 5 are selectively stored according to the specific colors, the stored data is combined with the design information supplied from the textile register 8, a necessary number of AND operations is done on the combined data, and all the given data are converted into pattern signals. The textile register 8 previously stores the desired textile design as an information and supplies it to the first color decision register 7 in response to the specific color to be determined therein. The figure signal register 10 is connected to said first color decision register 7 and receives said converted pattern signal synchronously with the motion of the knife of the pattern card punching machine according to the format determined by the arrangement of the knives of the pattern card punching machine. The figure signal register 10 then sends out the signal as selection signal of the knife of the pattern card punching machine. In the above manner, the pattern card punching operation is performed for each color of the pattern signal register and thus it is possible to punch the card for all the colors by combining the operations of individual colors.

The signal regarding the shuttle change necessary for the selection of the weft must be treated as a signal of one pick before a given signal for punching the pattern card. This operation is performed in the system branched from the first pattern signal register 4. The pattern signal of the first pattern signal register 4 is selectively stored in the second color decision register 6 according to specific colors as in the case of the first color decision register 7. This second color decision register 6 has a color decision circuit and consists of a certain number of words corresponding to the necessary number of colors. One word has the same number of bits as that of the first pattern signal register 4. The second color decision register 6 is connected to a shuttle change register 9 where the pattern signal is converted into a shuttle change signal corresponding to the result of the color decision and is supplied to the figure signal register 10. The figure signal register 10 is connected to a pattern card punching machine 12 where the pattern card is punched by the knife operated by the selection signal given from the figure signal register 10.

The apparatus further includes a control device 11 in which the signal sent from the pattern card punching machine 12 and indicating that the punching operation is available is confirmed, and transmission of the figure signal to the pattern card punching machine from the figure signal register 10 are controlled. Also, control on the selection of color contained in the pattern signal sent from the second pattern signal register 5 to the first decision register 7, control on the selection of the signals converted from the textile design which correspond to the color signal stored in the first color decision register 7, and control on conversion of the contents of the register 7 are done by control signal of the control device 11. Signal exchange and necessary timing are controlled for the first pattern signal register 4 and for the second color decision register 6 by the control device 11. After the data on selection of shuttles is given to the design paper calculation device 3, the control signal is formed in the control device 11 based on that data and sampling of the pattern signal is controlled in the design paper calculation device 3 according to the control signal. In relation to the pattern signal reading device 2, the control device 11 confirms the pattern signal corresponding to one pick and controls the reading device 2. In relation to the second color decision register 6, the control device 11 controls selection of the color of the signal given to the second color decision register 6 from the first pattern signal register 4 and also controls selection of the color to be sent to the shuttle change register 9. In relation to the shuttle change register 9, the control device 11 controls selection of the shuttle change register 9 according to the color selected by the second color decision register 6. Thus, based on the signal from the pattern card punching machine 12 indicating that punching operation is available, the control device 11 performs the control function necessary to operate the control system as a whole for the purpose aimed at.

The apparatus arranged as above is operated in the following manner. When a pattern signal corresponding to the first shuttle is supplied to the first pattern signal register 4 by way of the design reading device 1, pattern signal reading device 2 and design paper calculation device 3, no pattern signal is given to the second pattern signal register 5, and the register 5 is not initiated. Therefore, the content of the second pattern signal register 5 is used as a dummy for waste punch on the card. When the color signal obtained by the second color decision register 6 is selected in the order of the decision or in an arbitrary order and sent to the shuttle change register 9 for punching on the card, the one pick previous color signal will be punched out on the card. By repeating this operation, the registers 4, 5, 6 and 7 are given subsequently the succeeding signals via the control device 11 at the time the necessary operation is over.

For example, in the relation between the pattern signal registers 4 and 5, the pattern signal is read repeatedly as many times as the number of colors of the second pattern signal register 5 and the read signals are sent to the first color decision register 7. The register 5 is given a new signal from the first pattern signal register 4 at the time the repeating operation is finished. Similarly, in the relation between the first pattern signal register 4 and the second color decision register 6, the latter receives a new signal from the former upon completion of the operation where the signals corresponding to the number of colors are sent to the shuttle change register 9.

The signal passing through the second pattern signal register 5 and the first color decision register 7 is supplied to the figure signal register 10, always one pick behind the signal passing through the second color decision register 6 and shuttle change register 9. In the figure signal register 10, the two signals are combined

together and converted into a selection signal for pattern card punching.

In the apparatus described above, the information at the figure signal register **10** is temporarily stored and collated to the pattern card provided by the pattern card punching machine to make it possible to check whether the necessary pattern is correctly punched on the card. If necessary, the signal obtained by the figure signal register **10** is stored in an arbitrary memory medium such as perforation tape or magnetic tape, and the stored data is read for card punching when desired.

A concrete example of the method of this invention will be described below.

A design is formed by combining lines, groups of lines and colors. In this example, seven to twelve colors are used and a multicolor design reading device is employed. FIGS. **2***a* and **2***b* show in comparison a multicolor design of plant consisting of three colors, red, green and white, and the pattern signal provided by the multicolor design reading device. In FIG. **2***a*, the red part indicates a flower, green a leaf and white a cloth. When this design is set in the multicolor design reading device, the device divides the design longitudinally by a certain number of scanning lines at certain definite intervals and moves the design and scans the design in succession from one end (left) to the other (right) along the scanning lines.

This scanning is made in such a manner that a light beam from a fixed point is irradiated on the design and the color difference is indicated in terms of a pulse according to the quantity ratio of the reflected light (or transmission light). In FIG. **2***a*, the uppermost line indicates the first scanning line: the line ABCD, the i^{th} scanning line, and the line EFGHIJKL, the n^{th} scanning line. The whole of the first line represents white without a pulse. In the i^{th} line, AB is white without a pulse, BC is red with a pulse corresponding to red, and CD is white at the height of AB. In the n^{th} line, EF is white without a pulse, FG is green with a pulse corresponding to green, GH is white at the height of EF, HI is green with a pulse corresponding to green, IJ is white at the height of EF, JK is green with a pulse at the height of FG, and KL is white at the height of EF. By this scanning, a pattern signal as shown in FIG. **2**b is obtained. Since the quantity ratio of the reflected light differs according to color, the change in color is indicated in terms of change in the height of the pulse and the combination of signal trains formed by the individual pulses and the duration of the pulses make up a pattern signal corresponding to the design.

The scanning density of one complete design can be adjusted by mechanically changing the feed speed of the machine. Thus, it becomes possible to obtain a pattern signal by scanning the design as the mesh corresponding to the cross point of the threads of fabric.

It is also possible to correspond the pattern signal to the quantized code provided by an electronic computer. For example, the pattern signal is transferred to a paper tape and supplied as an input signal to the computer.

The textile design to be supplied to the computer is drawn previously corresponding to the design. As in the case of the pattern signal, the shuttle of the weft against the warp is converted into a design signal corresponding to one scanning line. This design signal can be supplied in the form of a code to the computer.

FIGS. **3***a'* and **3***b'* show figure diagrams of the design shown in comparison to that in FIG. **2***a* in comparison with a design signal concisting of signal trails obtained according to the figure diagram. It is assumed that the cloth (white) of the plant design shown in FIG. **2***a* is of plain weave, the flower (red) is of sateen weave, and the leaf (green) is of twill weave. FIGS. **3***a'* and **3***b'* show in comparison the figure diagram of the plain weave (cloth, white) and the signal trains obtained from this textile design. FIG. **3***a'* is a typical representation of plain weave and FIG. **3***b'* shows the signal corresponding to the plain weave. The signal as in FIG. **3***b'* is continuously repeated so long as the plain weave portion continues. FIGS. **4***a''* and **4***b''* show in comparison the textile design of the sateen weave (flower, red) and the signal trains obtained therefrom. The 7 × 7 matrix shown in FIG. **4***a''* is determined so as to indicate one complete, and the individual rows correspond to wefts. The symbol X in FIG. **4**a'' represents the part appearing on the surface of the warp. FIG. **4**b'' shows that a pulse comes out each time the X part appears.

It is apparent that a similar indication as above is obtained for the twill weave.

The textile design of the portions such as the plain weave, the sateen weave and the twill weave as shown in FIGS. **3**a' and **4**a'' make up the signal trains in the corresponding positions as in FIGS. **3**b' and **4**b''. Thus, a texture signal indicating one complete textile design as a whole is organized. This signal converted from textile design is set into the information medium corresponding to the quantized code of the computer or the like and combined with the pattern signal and supplied to the computer.

In the computer, these signals are combined to form the so-called weave design diagram by the memory device, and the resultant signal is used as the figure signal. Namely, the pattern signal is discriminated with respect to color according to the information medium, the necessary signal is selected according to the discriminated color from the signals converted from the textile design and the pattern signal is replaced with the selected signal (converted from the textile design) and used as the figure signal. The pattern card punching machine is controlled directly by the output command from the computer whereby the pattern card is produced.

The output command has the function to convert the matrix signal into a series signal and to store it temporarily in a memory medium such as paper tape. The stored data is applied at need to a pattern card punching machine to manufacture a pattern card having a definite textile design.

An example of operation for making pattern cards by the use of the present method will be described below.

In this example, Hitachi Hitac 10 made by Hitachi Manufacturing Works is used for the signal formation, signal conversion and the signal reading device, and the piano machine made by Yamakawa Kikai is used for the pattern card punching machine, with suitable modifications adapted to the purpose of this invention. The pattern analyzer made by Chuo Denshi is used for the design reader.

In this example, the flower pattern as in FIG. **2***a* is used. This pattern is treated by the design reading device **1** where the design is scanned laterally at certain definite intervals and the color variation on the scanning line is obtained in terms of a pulse as shown in FIG. **2**b.

In the same manner as above, the pulses A'B'B'D' and E'F'G'H' I'J'K'L' as in FIG. 2*b* are obtained corresponding to the scanning lines ABCD and EFGHIJKL as in FIG. 2*a*. Thus, by the combination of signal trains formed by the pulses and their duration time, a pattern signal corresponding to the specific design is formed. The density of scanning of the design as a whole, namely, the interval of the scanning lines, can be adjusted by mechanically changing the feed speed. The pattern signal formed in the manner as above is transferred to a memory medium such as perforation tape and magnetic tape and then is supplied to the subsequent pattern signal reading device **2** at each scanning of the design via the control device, being synchrous with the operation of the pattern card punching machine.

The pattern signal passing through the pattern reading device is sampled according to the data obtained from the result of the shuttle selection given previously by a design paper calculation device **3** and then stored in the first pattern signal register.

In the beginning the registers **4, 6** and **7** are in the cleared state. The registers **4, 5, 6, 7** and **10** are cleared via the control device **11** after the necessary signals have been taken out from these registers. Then the next signals are stored in these registers.

The signals converted from the textile design which correspond to the initial value (related not to the colors, red, green and white, of the specific design but to such a color as blue) of the register **5** and those which correspond to the colors red, green and white are stored in the register **8.** The signal of the register **9** corresponding to the clear state of the register **6** is not stored in the register **8.**

By the command from the control device **11,** the pattern signal such as A'B'C'D' corresponding to the first scanning line of the patterned fabric is stored as A'B' (white...white), B'C' (red . . . red) and C'D' (white . . . white) in the register **4** by way of the devices **1, 2** and **3.**

When the pattern signal is stored in the register **4,** the register **6** is in the cleared state to be ready to accept a color signal from the register **4.** Therefore, the colors (white and red) of the first pattern signal for which the color decision has been made in the register **4** are stored in the register **6.**

When the first color (white) of the first pattern signal is stored in the register **4,** the initial value such as blue is stored in the register **5.** This content of register **5** is stored in the register **7** after color decision and then is collated with the content of the register **8.** Since the signal converted from the textile design which corresponds to the initial value (such as blue) of the register **5** is stored in the register **8,** the initial value of the register **5** is combined with the signal corresponding to the contents of the register **8,** thereby forming a figure signal. This figure signal is stored as a dummy in the register **10.**

On the other hand, the first color, namely white (A'B') of the pattern signal (A'B'C'D') is supplied as a shuttle change signal to the register **10** via the registers **6** and **9.** Upon ending this operation, the colors stored in the register **6** are cleared in sequence.

When a figure signal is supplied to the register **10,** the first one (white, A'B') of the colors sent to the register **7** from the register **5** is cleared, and the next color, namely red (B'C') is supplied thereto. In this case, when the pattern signal stored in the register **5** as initial value is of one color, the register **7** is also cleared. When the contents of the register **7** are perfectly cleared in the above manner, the register **5** is cleared via the control device **11.** As a result, the pattern signals (white, red and white) of the register **4** are stored in the register **5** and the register **4** is cleared.

Thus, by the command from the control device **11,** the pattern signals (E'F'G'H'I'J'K'L') corresponding to the second scanning line are supplied in sequence to the register **4,** and the storage and clearance operation is repeated.

The data (for example, white is plain weave, red is sateen weave) regarding the figure selected previously corresponding to the colors are supplied from the register **8** to the register **7** where the figure signal corresponding to the first color, namely white, is punched out. This operation continues for the period (A'B') the white signal is being sent out. When the white signal is changed to the red signal (B'C'), the collation is not coincident and, therefore, no figure signal is delivered. When it come to the white (C'D'), the operation is resumed. In this way, the data regarding white (A'B' and C'D') among the pattern signal A'B'C'D' corresponding to the scanning line ABCD is first formed as a figure signal. After completion of the treatment on white, the same treatment is done on red. In this case, the collation between color and figure is not coincident for the period (A'B') of the first white signal is being sent out. Therefore, no figure signal is delivered. When it comes to red (B'C'), a figure signal is delivered because B'C' is coincident with the predetermined combination of red and sateen weave. Thus, a figure signal regarding red is formed.

The figure signal formed in the above manner is supplied as the selection signal of the knife of the pattern card punching machine by way of the register **10** whereby the pattern card is punched according to the corresponding colors.

As a result, the first punched card is given as a dummy. The second et seq. cards, regular pattern cards containing all the information such as box motion can continuously be obtained.

This invention is capable of providing quickly and directly from the original design various pattern cards applicable to such simple weaves as floor mats, as well as to complicated multicolor weaves such as "Nishijin" textiles (highly complicated silk weaves). Thus, this invention can be said to be an epoch-making invention in the point that pattern card making is perfectly automatic and the need of specialized skill is eliminated.

In this invention, the pattern signal train read at a reasonable accuracy is sampled according to the design paper calculation and, hence, a design with an arbitrary size can be used. Either an analog or digital input signal can be used for this purpose. In addition, a mechanism for punching the holes for connecting the pattern cards or peg (of Jacquard cylinder) of the pattern card, or automatic cutting mechanism can be controlled by this invention. This makes it possible to automate the auxiliary procedures necessary for the card punching operation.

The invention makes other various modifications available. For example, the figure signal formed in the figure signal register **10** is supplied to the needle selection device (for example, an actuator comprising a solenoid valve, solenoid valve drive power source, memo-

ries corresponding to the number of needles of Jacquard, etc.) being synchronous with the needle of the Jacquard weaving machine under the control of the control device, and the needle of Jacquard machine is selected directly by the use of the figure signal. By this arrangement, it becomes possible to weave a pattern textile without using pattern cards.

We claim:

1. A method of making pattern cards for operating a Jacquard weaving machine to weave a selected textile design comprising the steps of:

a. optically scanning the selected textile design linewise to produce a sequential series of pattern signals varying according to the coloration occurring in the design along the line thereof being scanned,

b. delivering said series of pattern signals in sequence to an information storage medium having stored therein a multiplicity of comparison signals previously derived from a plurality of colored textile designs and discriminated by color in said medium,

c. comparing each pattern signal in turn with said stored multiplicity of comparison signals to identify the color thereof and generate a figure signal corresponding to the thus identified color, and

d. controlling the punching of said pattern cards in accordance with the sequential series of figure signals thus obtained.

2. The method according to claim 1 wherein said figure signals from step c) are stored in series in an information medium and are subsequently read out to control the punching of said cards.

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