

[54] METHOD AND APPARATUS FOR
PRODUCING JACQUARD CARDS

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[51] Int. Cl. D03d 149/00, G06d 17/00
[58] Field of Search 340/172.5; 139/319, 59

[56] References Cited

UNITED STATES PATENTS			
2,083,960	6/1937	Nakanishi	139/319
2,714,901	8/1955	Casper	139/59
3,026,913	3/1962	Horak	139/319
3,117,598	1/1964	Burkhalter	139/319

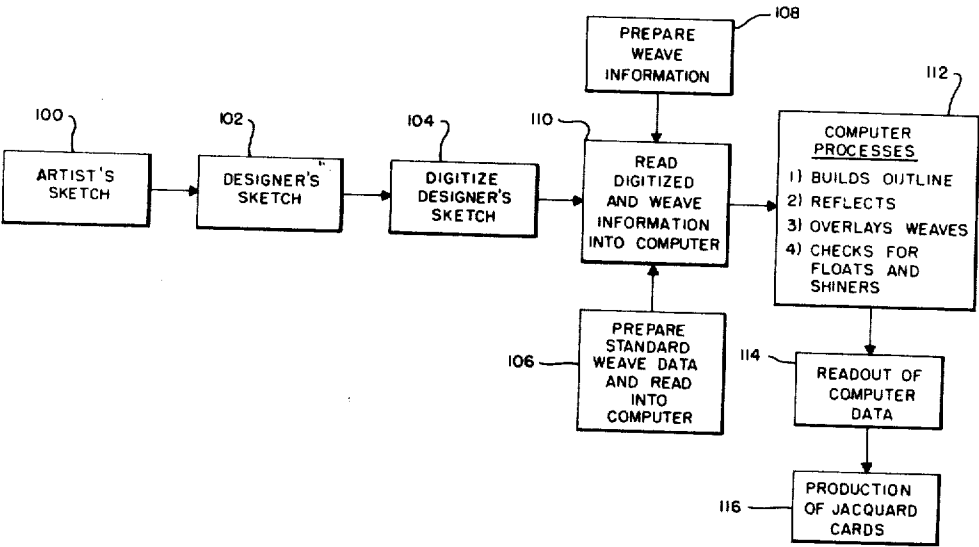
3,247,815 4/1966 Polevitzky 139/319
3,529,298 9/1970 Lourie 340/172.5

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[57] ABSTRACT

A method and apparatus for producing Jacquard cards in which the pattern of the artist's sketch is digitized into numerical coordinates corresponding to pattern change on a pick by pick basis and a data carrying medium having this coordinate information thereon is produced. The data carrying medium is supplied to a computer which builds an outline of the pattern in its memory and overlays the outline with the appropriate weaves which are also stored in the computer memory. The finished pattern with overlaid weaves is read out of computer memory in a data format which can be readily converted into the finished Jacquard cards.

12 Claims, 6 Drawing Figures



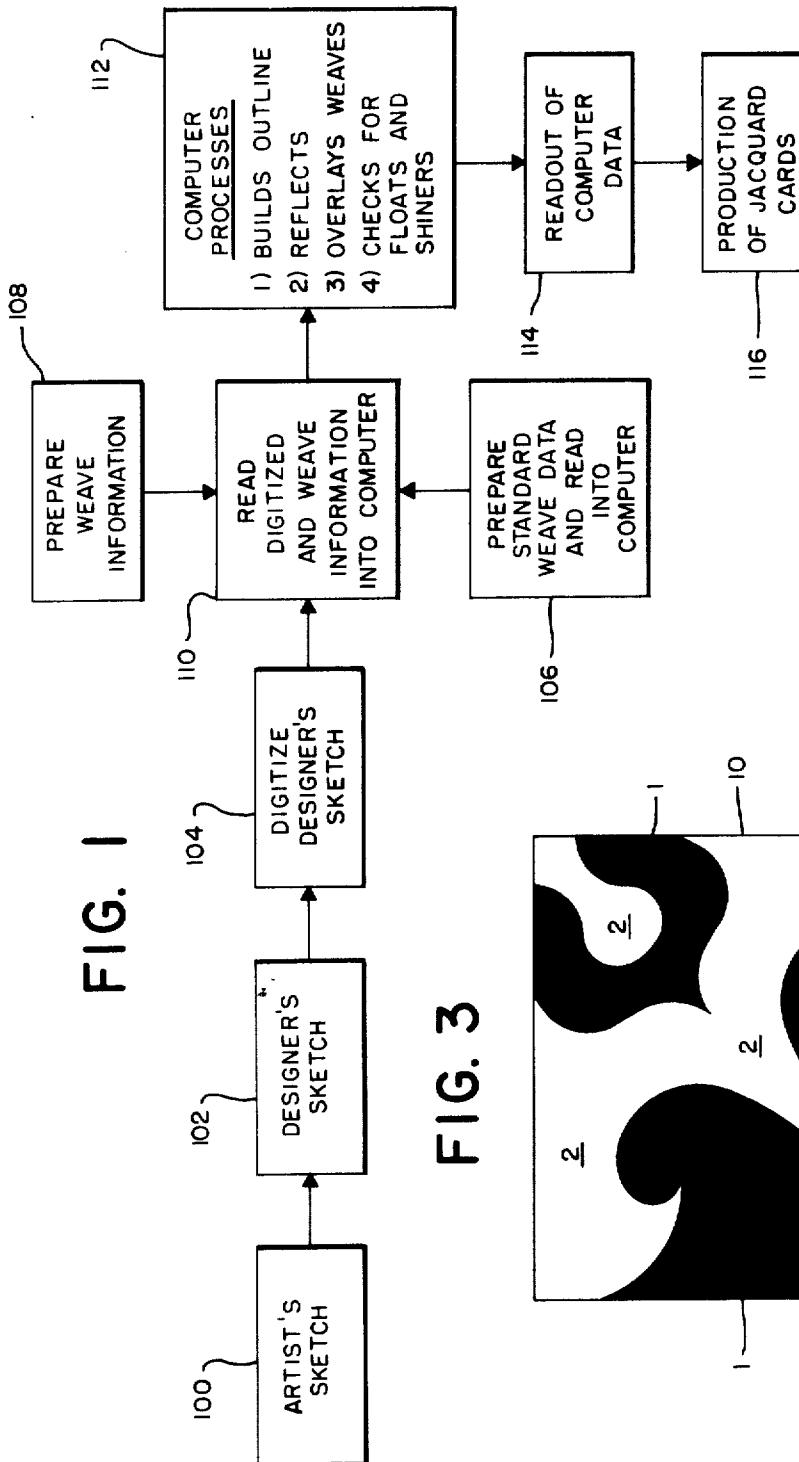
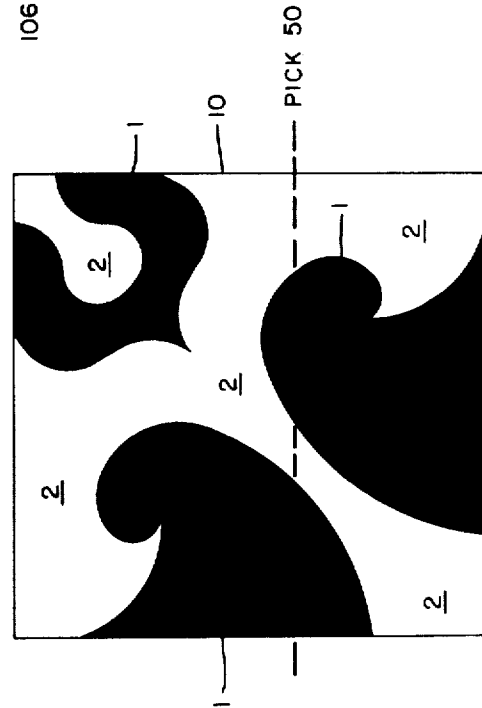


FIG. 3



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FIG. 2

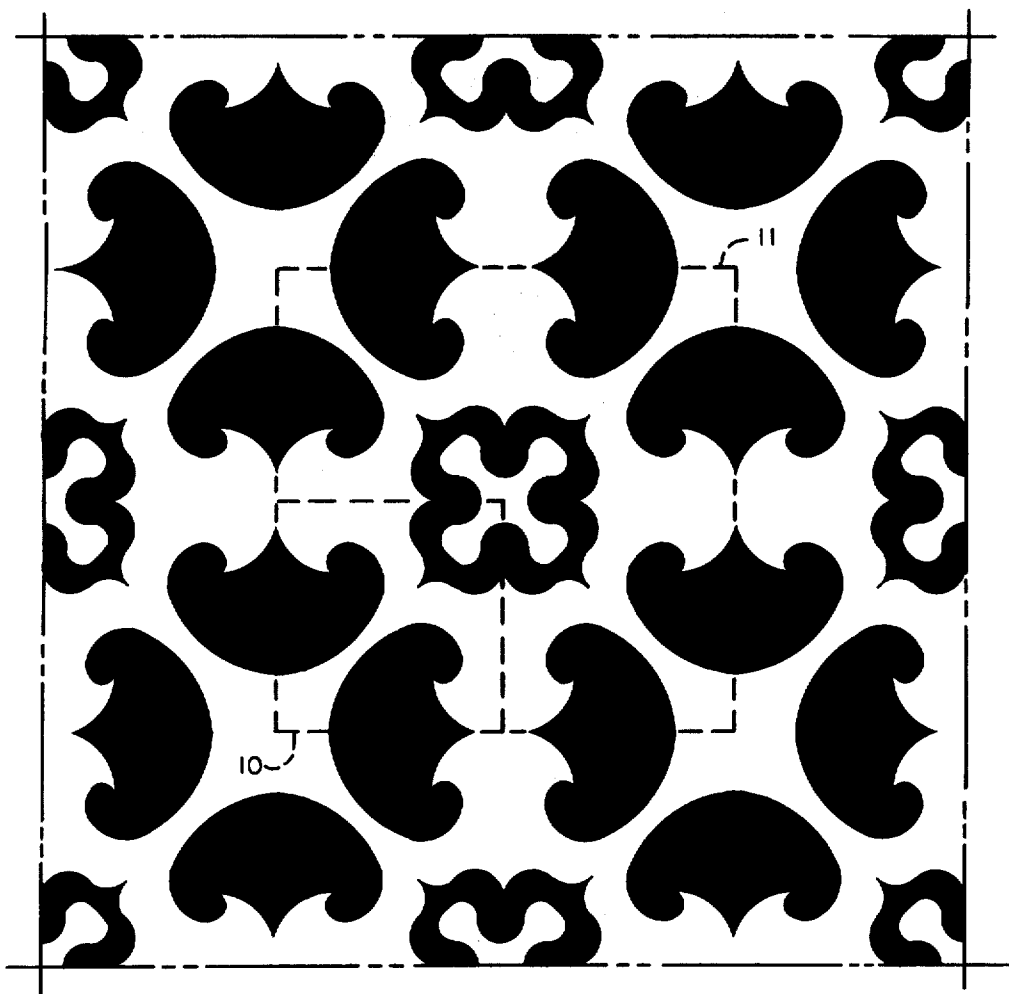


FIG. 4

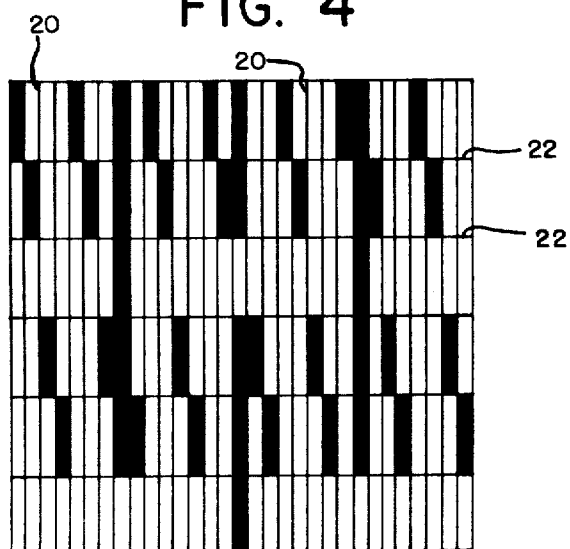
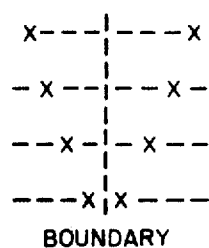


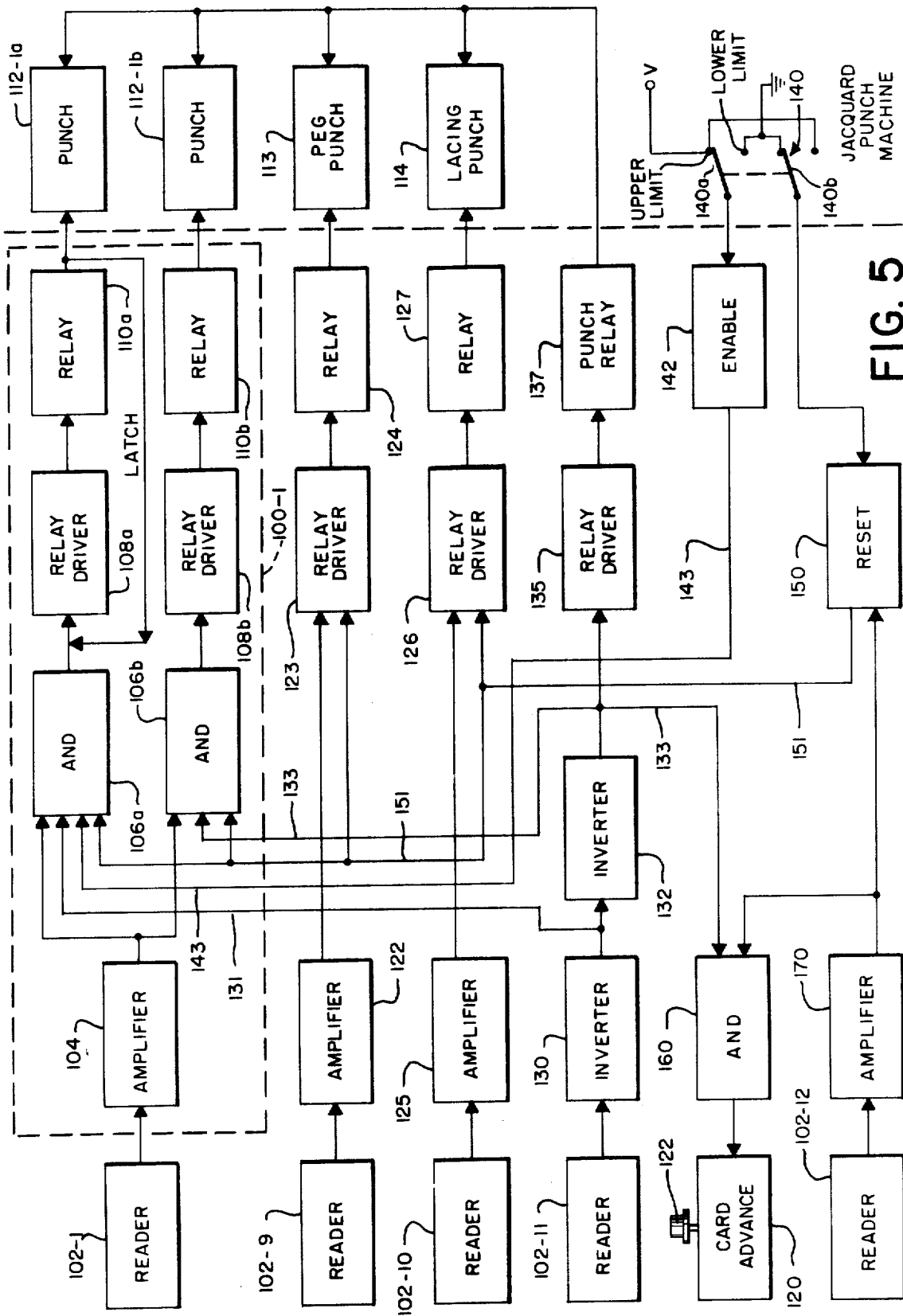
FIG. 6



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METHOD AND APPARATUS FOR PRODUCING JACQUARD CARDS

This invention relates to weaving and more particularly to a novel process and system for producing Jacquard cards to control a weaving loom.

The conventional process for making Jacquard cards for controlling the operation of a weaving loom is a long and laborious one. In this process, the artist first makes a hand sketch of the fabric to be woven. This sketch usually has the weave information, such as for example, twill, herringbone, satin, etc., designated thereon. Each weave is produced by a predetermined crossing arrangement of the vertical and horizontal threads of the fabric. The artist's sketch next goes to a designer who redraws the artist's design onto "point," or rectangular X-Y coordinate paper, which is used to simulate the design. The point paper has vertical lines, corresponding to the "weave" or "end" lines of the finished fabric, and horizontal lines corresponding to the fabric weave lines.

In working with the point paper the designer next meticulously and painstakingly paints in where the pick lines cross the end lines and the manner in which they cross, that is, over or under to produce the desired color and weave patterns. Since every crossing of a pick and a weave line must be designated, the designer must often contend with making representations of hundreds and sometimes thousands of such crossings on a single piece of point paper for a single design thereon. Since these crossings are vital in determining the finished product, the designer is usually a responsible worker who must spend a considerable amount of time working with a design.

After the point paper is finished, another skilled worker working from the finished point paper weave operates a machine which cuts the Jacquard cards. The operation of this machine is on a purely visual basis in which the operator must also take into consideration every crossing of a weave and a pick line. The Jacquard cards are thus usually cut on a line-by-line basis and requires a highly skilled operator.

Because in any given design the crossing of every pick with every end, or weave line, must be accounted for by the artist, the designer and the card cutter operator the entire process of going from the original artist's sketch into the Jacquard cards for ultimately controlling the loom is an exacting and time-consuming one which can, in many cases, take weeks. The process is also relatively expensive.

The present invention is directed to a process for making Jacquard cards which, as compared to the prior art process: is considerably simpler and easier to perform; takes less time to go from artist sketch to Jacquard cards; is more economical; and can be performed by relatively unskilled workers after the sketch of the design is made by the artist. The invention also relates to a novel system for performing this process.

In accordance with the system and process of the present invention, the pattern made by the artist is first converted by a digitizer on a pick-by-pick basis into X-Y numerical coordinate data which is supplied into a computer. This data is representative of color change from one area to another on the artist's sketch. From the data supplied to it the computer builds an outline of the pattern in its memory. From memory and in accordance with instructions previously supplied, the computer then overlays the outline with the appropriate weaves to form a composite memory pattern of the complete pattern - pattern outline and weave information. The information stored in the computer's memory, which corresponds to the point paper of the prior art process, is then read out in another data medium, such as tape or cards. This data medium is used to control a machine for producing the Jacquard cards. The cards produced by the machine are used on a loom in the conventional way.

It is therefore an object of the present invention to provide a novel system and process for producing Jacquard cards which eliminates the manual process of plotting point paper.

A further object is to provide a novel system and process for producing Jacquard cards in which only the boundary conditions of a pattern need be determined by an operator.

Another object is to provide a system and process for producing Jacquard cards in which the sketch of a pattern provided by an artist has its outline digitized into X-Y coordinate numerical data and the data is supplied to a computer to build the outline of the pattern in the computer memory.

An additional object is to provide a novel system and process for producing Jacquard cards in which weaves are overlaid onto the outline of a pattern stored in the memory of a computer by the computer.

Still a further object is to provide a system and process for producing Jacquard cards in which the sketch of an artist's pattern is digitized and supplied to a computer memory to build the outline of a pattern in the computer, the pattern in the memory is overlaid with weaves, and the composite pattern of the memory is read out in a data format which is used to operate a Jacquard card cutting machine.

Other objects and advantages of the present invention will become more apparent upon reference to the following specifications and annexed drawings in which:

FIG. 1 is a schematic block diagram illustrating the system and process of the present invention;

FIG. 2 shows a typical artist's sketch;

FIG. 3 is an enlarged drawing of a portion of the original artist's sketch as used by the designer;

FIG. 4 is an illustration of a weave slip;

FIG. 5 is a schematic diagram of a card-to-card converter for use with the system of the present invention; and FIG. 6 is a schematic diagram of a weave pattern.

System Diagram

FIG. 1 shows a block diagram of the process and system of the present invention. In accordance with the invention, a sketch of the pattern to be embodied on the completed textile fabric is made by the artist as is designated in block 100. The artist's sketch is then converted by the designer into a sketch suitable for his purposes. This is shown in block 102. The designer's sketch need only show the outline of the pattern made on the artist's sketch and does not have to have any designations for weave patterns at each crossing of the vertical (weave) and pick (horizontal) lines. Usually, since the pattern is repetitive, only a portion of it need be reproduced by the designer. The designer's sketch is then digitized, as shown at 104, into X-Y numerical coordinate information in a data format suitable for input to and use by a digital computer. The computer already has in its memory data of standard weave patterns. The preparation of this data and the reading into the computer is shown at block 106. Information on any special weaves which are to be used in the finished product are prepared as data suitable for feeding into a computer at block 108. Both the digitized data of the designer's sketch and the special weave information are read into a computer, as shown at block 110.

The computer is a conventional digital type computer which performs several functions as shown at 112. The first of these is to build an outline of the original pattern of the artist's sketch in its memory. Utilizing instructions in its memory, the digitized information of the designer's sketch is reflected to produce the complete pattern. The standard and special weaves are then overlaid on the outline at the appropriate places and the computer next checks the completed pattern for "floats" and "shiners."

The information stored in the computer's memory is then readout as shown at 114. A data format is preferably used in the readout which can be supplied to a machine for cutting the Jacquard cards. This data is used by the machine, as shown at 116, to produce the finished cards. The cards are then used on a loom in the conventional manner.

Artist's and Designer's Sketches

FIG. 2 shows a typical sketch of a pattern which is made by an artist in designing textile material. Predetermined portions of the pattern can be of any desired color and this is taken into account in the finished fabric by using the appropriate color threads. The artist in many cases also designates the particular type of weave to be used at a given area of his design. The pat-

tern is a repetitive one and the basic pattern is shown within the outlined area 11. The basic pattern is also symmetrical about both the X and Y axes as shown by the outlined area 10 within the larger area 11. The area 10 is one quadrant, or one quarter of the basic design. It should be understood that most textile designs are of the repetitive, symmetrical type.

Working from the artist's sketch of FIG. 2, the designer next prepares his sketch, which is shown in FIG. 3. The sketch of FIG. 3 can be done in pencil and need provide only the outline of the pattern. The sketch is made on point type (rectangular coordinate) paper in which the vertical lines represent the weave (or end) lines and the horizontal lines the pick lines. Only one pick line is shown. Because the computer program used, as described below, overlays the weave information, the designer does not have to put in the weave information. Further, since the computer reflects the pattern or any portion of it, the designer need draw repetitive portions of the pattern only once. Therefore, in the example of the pattern shown in FIG. 2, the designer need draw only that portion of the pattern shown within the blocked area 10. This can be relatively simply done since no detailed weave information need be supplied to the drawing.

It should be understood that it is also possible to work directly from the artist's sketch of FIG. 2 since it is only necessary to have the artist draw the sketch on the proper type of paper initially or to reproduce, by photographic or other techniques, the pertinent portion of the artist's sketch. Also, due to the reflection properties of the computer program, the artist can in the proper case draw only one quadrant of a repetitive, symmetrical design.

Weave Slips

In the enlarged view of the single quadrant of the pattern shown in FIG. 3, those outlined areas designated by reference numerals 1 and 2 of the blocked area 10 indicate different weaves which are to be made on the finished fabric. For example, the areas designated 1 indicate a standard weave, such as a twill, satin or taffeta, and the areas designated 2 also indicate one of the standard types of weaves, which are the same or different from the areas designated 1, or a special weave. By "weave" is meant the particular pattern in which the pick line crosses over or under an end line.

The instructions for the standard weaves are contained in the computer memory. If a standard weave is used in both of the area portions 1 and 2, nothing further need be done by the artist or designer. If a special weave is desired for any particular area or portion of the design this weave would be entered onto a special weave slip. Thus, for example, if the areas designated by the numeral 2 were to have a special weave, then the necessary information concerning this weave would be put into the proper data format to be supplied to the computer, as in block 108 of FIG. 1.

FIG. 4 shows in greatly enlarged form a special weave slip. The weave slip shown in FIG. 4 does not correspond to the complete quadrant of the pattern shown in FIG. 3 but only to a very small portion thereof indicated by the number of ends 20 and picks 22. As shown in FIG. 4, the ends are indicated by area between the vertical lines 20 and the picks by the areas between the horizontal lines 22. Where there is a dark area, it means that the pick crosses under an end, and where there is a light area it means that the pick crosses over an end.

The information on the special weave slip is then converted into a format which can be read into computer memory. This can be done on punched cards, magnetic tape, or any other medium compatible with the computer input. In a typical situation using punched cards, the key punch operator follows a pick (horizontal line) and at each change in the crossing pattern of the pick, that is a change from under to over or over to under, records the change. Consider, for example, that a cross-over is represented by a 1 and a cross-under by a 0. A typical data card or cards, depending upon the quantity of data, operating on the top pick line of FIG. 4 would be punched out to read as follows:

0001	0001 0	0002 1	0005
0006 1	0008 0	0009 1	0010 0
0011 1	0014 0	0015 1	0016 0
0017 1	0019 0	0020 1	0023 0
0025 1	0028 0	0029 1	

The end and pick lines of the numerical data set forth above refers only to the special weave information itself and not the pattern pick and end lines. The special weave data is overlaid onto the pattern in the computer.

The first number 0001 of the data set above represents the pick line number, called number 1 of the special weave. The first four digits of each succeeding number is the number of the end line of the special weave that pick line 1 of the special weave crosses and the last digit is the type of crossing over or under. The end lines of the special weave are illustratively numbered sequentially from left to right. The actual end number of the pattern where the special weave commences is computed in the computer based on the value, in inches, of the distance that the new weave is located from the origin. The operator only keys in the weave number. This is explained below in Section IV.

The information of each pick line crossing pattern is converted into computer input format in a similar manner and stored in the computer memory. It should be understood that only the basic portion of the special weave need be stored in memory since this can be reflected, or repeated, in the computer. Each weave is assigned a number in computer memory for retrieval purposes.

Information on standard weaves is produced and stored in the computer in the same manner. A weave slip is prepared and converted into data for input to the computer. Since the standard weaves are used on many jobs, they need only be converted into computer data format once. In fact, the data on standard weaves can be supplied as part of the main computer program.

Digitizing the Pattern

The designer's sketch of FIG. 3 is now digitized. By this it is meant that the numerical X-Y coordinates of the outline of the sketch of FIG. 3 are derived and put into computer format. The digitizing may be performed by any conventional digitizer device or machine. A typical example of one such machine is the Auto-Trol Corporation Model 3939X-Y Coordinator-graph which is manufactured by the Auto-Trol Corporation of 6621 West 56th Ave., Arvada, Col., 80002, and has a punched card output. Since a curve tracer is not required in the present invention, a simple X-Y plotter is all that is needed. Another suitable machine is the LARR-V manufactured by the Benson-Lahner Corporation, which is a subsidiary of University Computing Company, of Van Nuys, Cal.

In general, the digitizer is composed of a large stationary board, a vertical arm which moves sideways (in the X direction) across the board, and an index member which moves transversely (horizontally) with respect to the arm. Any point on the board as measured by the index, can be expressed in terms of the horizontal distance of the arm from the left-hand side of the board (X coordinate), or other fixed reference such as the lower left-hand corner of a piece of point paper onto which the sketch of FIG. 3 is drawn and the vertical position of the index with respect to the arm (Y coordinate). The digitizer produces a continuous readout and a continuous indication of this point in terms of the X-Y coordinate.

The digitizer operator attaches the sketch of FIG. 3 to the digitizer board. Starting at the lower left-hand corner of the sketch, which is the reference point, the digitizer index is moved so that it is on the lowest pick line, called pick 1, and the necessary information relating to this pick at this point is produced in the digitizer console. The operator keys into the digitizer the number of the pick line and a number representing the weave at that point in the pattern. Referring to FIG. 3 at the lower left-hand corner point, the pattern number is 2.

As indicated above, the digitizer automatically has this position in X-Y coordinates in terms of a high degree of accuracy.

The operator then presses a suitable control on the digitizer to

produce a readout, here in terms of a punched card which has on it the pick number and weave pattern at a given point, the left-hand corner. The punched card is described below.

Continuing the digitizing, the operator moves the arm across the board to the right. The pick 1 designation is still maintained in the digitizer and every time the weave changes, for example from weave 1 to weave 2, the operator keys in the new weave number and operates the digitizer to obtain a punched card readout. When the digitizer is operated, it automatically records the distance of the arm in inches from the left-hand reference, or starting position. This is continued until the operator reaches the end of pick line 1.

The operator continues the digitizing operation on a pick-by-pick basis going upwards from pick 1. FIG. 3 shows how pick 50 is digitized. The operator moves the digitizer index to the left-hand side of the pick, keys in the number 50 into the digitizer and the weave number 1. The record key of the digitizer is operated and a card is punched which has this information plus the coordinate location produced by the digitizer. The arm of the digitizer is then moved to the right until pattern number 2 is encountered and the new weave number is keyed into the digitizer and the card punched. This is continued until the right side of the sketch is reached.

The data which is printed out on the punch card for pick 50 of FIG. 3 is set forth below:

0050 0000 1 0150 2 0230 1 0310 2

The punch card corresponding to this printed data is not shown since the punching pattern is conventional, for example, a standard ten line fifty row IBM card.

The first group of numbers 0050 corresponds to the pick number, in this case pick 50. The second group of numbers 0000 1 corresponds to the weave pattern 1 at the left-hand edge of the pick. The next group of numbers 0150 2 corresponds to weave pattern number 2 which occurs 1.50 inches from the left-hand edge of pick 50. The next group of numbers 0230 1 corresponds to weave pattern number 1 of pick 50 which occurs 2.30 inches from the left side of the pattern and the last group 0310 2 corresponds to weave pattern 2 which appears at 3.10 inches from the left-hand side of the weave pattern.

In this manner, the entire pattern of FIG. 3 is digitized to produce a series of cards, one or more cards for each pick, depending upon how many weave changes occur along a particular pick. In a typical case, each punch card can handle approximately eight weave changes. As discussed above, the particular weave patterns are stored in the computer. These weave patterns will be made to occur at the designated coordinate from the origin as keyed out on the digitizer.

A relatively unskilled operator can perform the digitizing process since all it requires is movement of the index marker of the digitizer along a pick line and the punching in of a weave pattern every time a change occurs. This is a relatively simple operation. It should be noted that the operator has to record only changes in the weave. Between changes, the computer will fill in the appropriate weave needed for punching out the final Jacquard cards.

The designer can also instruct the digitizer operator to digitize only every other or every third line of the pattern. The computer can be programmed to fill in the intervening information.

Further, if the pattern is very regular, such as a simple diagonal produced by two different weaves, the operator can digitize just the first and last lines and the computer can be programmed to supply the inbetween information.

As shown particularly with respect to FIG. 3, patterns containing symmetries need not be digitized entirely. Only half of each mirror image is digitized and the reflected half is computed.

Data Input to Computer

The data corresponding to the pattern outline or the basic element of the pattern, as produced by the digitizer, is next read into computer memory. The basic element is considered

to be the smallest portion of the pattern which has to be digitized in order to provide sufficient information for the complete pattern to be constructed in the computer. In the case of the pattern of FIG. 2, only one quadrant of the pattern as shown by numeral 10 in FIG. 3 need be digitized and read into the computer. The computer has the capability of operating on this basic element, due to its symmetry, to construct the complete pattern. Since this data is all in binary form, and illustratively is on punched cards, a standard card-reading device can be used for the computer input. Also, any standard digital computer can be utilized in the system and process of the present invention, one such computer being the Control Data Corporation Model 3600.

In addition to reading the pattern outline into the computer memory, which can have core, tape disc, or other type of storage, the special weave information, which also is illustratively in the form of punched cards, is also read into the computer and is stored in memory. Information on standard weaves, which is prepared in the same manner as the special weave information, are also produced as described above and read into memory. Thus, the computer has stored in its memory three sets of data which are: (1) the pattern outline information, containing the weave numbers and coordinate information; (2) the standard weave information; and (3) the special weave information. These three sets of data are stored at separate places in computer memory for ease of access.

In addition to these three sets of data, a set of instructions are prepared. These instructions, which can also be on punched cards called instruction control cards, control the operation of the computer on the three sets of data. Any standard computer language consistent with the capability of the computer can be used for the instructions.

From the data read into computer memory, an outline of the basic unit of the pattern is built within the memory. A basic pattern unit would be, for example, the complete pattern shown by the area 11 of FIG. 2. This basic pattern unit is to be repeated, both horizontally and vertically on the finished fabric. If the pattern requires reflection of the basic element 10 to form the complete pattern, a special instruction is included with the control cards and the computer reflects the basic element the number of times and in the proper direction necessary to produce the pattern unit 11. Thus, for example, with the sketch of the basic element 10 of the pattern of FIG. 3 which is only one quadrant of the total pattern unit, the outline must first be reflected to the right to form half of the basic pattern unit. This half is then reflected down to produce a complete pattern unit.

Following establishment of the outline of the pattern unit in the computer memory, all standard weaves are operated upon by the instructions and are overlaid on the appropriate areas of the now complete pattern unit. It should be understood that this can be readily done since the computer contains the standard weave information and the positional coordinate information as to where these weaves should be placed. The positional coordinate information for the other three quarters of the pattern unit outline formed by reflection are also available by symmetry from the positional coordinates of the basic element. After this is done, the instructions overlay the special weaves, if present, onto the pattern outline in the same way as the standard weaves.

As a last step, after the basic pattern unit and the weaves have been formed in computer memory, the computer checks its overall plan of the fabric to insure automatic weave-locking and the absence of floats and shiners.

Computer Operation

As indicated above, the computer, after it has been supplied with the necessary information, performs four functions: These are: (1) reflect the basic element of the pattern outline the predetermined number of times and in the direction needed to produce the complete pattern unit (this need not be done if the pattern is such, such as non-symmetrical about a given axis, that a complete basic pattern unit has to be digitized); (2) overlay the standard weaves in the appropriate

areas of the pattern unit outline; (3) overlay the special weaves in the appropriate areas of the pattern unit outline; and (4) make an automatic lock to check for floats and shiners.

The operation of the computer is described below in terms of the computer program. The computer program itself is described in terms of the instructions and sub-routines. The sub-routines are not described in detail since they can be written in any desired notation, format, or sequence depending upon the particular type of computer being utilized, computer language, etc.

Program - General

The control of the general purpose digital computer is accomplished through the instructions. The instructions are written in terms of the particular job being processed. In the system of the present invention, the central instructions are written on punched cards which are read into the computer on command. The computer memory already has stored therein a number of special sub-routines which, in the case of the present invention, actually operate the computer in the desired manner.

The program is described below, first in terms of the instruction flow and then where necessary and applicable the individual sub-routines are described. As indicated previously, the description is of a general nature and any desired technique can be used to make the sub-routines.

Program - Main

All controls initiate and return to and from the main program depending upon the requirements of the job being processed. The flow of instructions or program statements, is as follows:

1. START
2. Read control cards
3. Write heading pages
4. Change weave numbers (optional)
5. Read in standard weaves, if any
6. Call RDMATR to read in special weaves, if any
7. Call READIN to read in digitized data cards
8. Call INTERP to print abbreviated printout (optional) of digitized data
9. Call BINDEND if weave is a binder weave
10. Call NTAFF if weave is a generalized taffeta
11. Call NTW if weave is a generalized twill
12. Call WVMAT if weave is a special weave
13. Call MLASSE if pattern is a matelasse
14. Call HALFDP if pattern is a halfdrop
15. Call VASTUF if stuffer pick routine desired (optional)
16. Call SHINER if shiners are to be eliminated
17. Call FINISH
18. Call UNFLOAT if floats are to be eliminated
19. Call STORE if simulated weave printout is desired
20. Call CONSTR if special loom construction desired
21. Call PRINT if Jacquard card image printout desired
22. Call PCARDS if IBM cards to be converted to Jacquard cards are desired
23. Call GROSSE if IBM cards to be converted to verdol paper on the GROSSE machine are desired
24. Call DACTY if IBM cards to be converted to verdol paper on the DACTYLISEUSE machine are desired
25. Go to statement 2 if a new job is in the queue
26. STOP

As should be apparent the instruction statements for any particular job are written by the computer operator and serve to control the computer.

Program - Sub-Routines

Before discussing the sub-routines in detail, it should be understood that the computer operates on a pick-by-pick basis. To state it another way, once the program statements are written, the same statements apply to each pick of the original pattern. Thus, statements 9 through 24 given above are repeated for each pick automatically in the computer until the last pick is reached. At that time the computer automatically sequences to step 25. In a similar manner statements 9 through 12 are re-

peated for each weave, that is, each type of weave, along a pick.

The instruction statements and sub-routines are described in the same numerical sequence presented above.

1. START — The computer reads this instruction statement and starts its processing operation.
2. READ CONTROL CARDS — The control cards containing the instruction statements which were prepared by the computer operator are read and stored in computer memory.
3. WRITE HEADING PAGES — The instructions which were written are printed out for a visual check. The computer is preferably placed on a hold cycle after the heading pages are written to permit the check and allow changes to be made in the instructions, if needed.
4. CHANGE WEAVE NUMBERS — An instruction can be written so that the weave numbers are changed automatically as they are read in. This is a simple shift operation in the computer, for example, all weave numbers 1 on the data output cards of the digitizer can automatically be changed to some other weave number whose pattern is stored in the computer. This gives the designer the flexibility of experimenting with different types of weaves for the same overall pattern. This is an option which is not necessary to the overall operation of the system.
5. READ IN STANDARD WEAVES — If additional standard weaves are to be stored in computer memory, they are read in at this stage. As explained above, the data cards for the standard weaves are obtained in the manner described with respect to FIG. 4. The standard weaves are stored in computer memory and are called for overlay on the correct portion of the pattern, as the program is operated on the pick-by-pick basis.
6. RDMATR — Sub-routine RDMATR reads in the data cards into the computer which describe a special weave. These are produced as described with respect to FIG. 4, and are stored in computer memory for call-up by a weave number or a data card produced by the digitizer at the appropriate portion of the weave pattern.
7. READIN — Sub-routine READIN reads in the digitized data cards which describe the geometry of the pattern and the weave number distribution on the numerical coordinate basis. These data cards are produced in the manner described above with respect to FIGS. 2 and 3. This data is stored in computer memory as the pattern outline of the basic pattern unit, such as the unit 10 of FIG. 3, or as the complete pattern. This depends upon the type of pattern being processed as the quantity of data digitized.
8. INTERP — All of the necessary data is now stored in the computer memory and the computer can now operate, in accordance with its instructions, to perform a variety of tasks. The first of these tasks can be, for example, to build a complete pattern from the basic pattern unit read into the computer in step 7 and reflect the pattern unit in the appropriate way, or ways, to produce the complete pattern.

At this point, the complete pattern built in the computer memory from the basic pattern unit can be read out, that is displayed on a printout sheet. This printout is in an abbreviated form which indicates the weave code number for every pick at every tenth end. If the complete pattern is digitized and read into the computer in step 7 (READIN) then the computer does not have to process the basic pattern unit information to obtain the complete printout. Instead, the printout can be made directly from the digitized data read into the computer. The INTERP sub-routine is described in greater detail below. At this point it should be considered that the computer is processing on a pick-by-pick basis working on the information stored in its memory. Thus, the computer automatically steps on a pick-by-pick basis in accordance with instructions previously supplied.

Sub-routine INTERP determines the weave distribution, that is the weave code numbers, for each pick along its complete length. If the pick being processed has been completely described during digitizing (including all symmetries) then INTERP returns the digitized information which can be printed out. Otherwise INTERP performs simple arithmetic operations on the stored digitized information to produce a complete description of the pick in this manner:

1. If pattern is a generalized matelasse do either A or B; otherwise skip to step (2). A matelasse is a raised floral or geometric design with a puckered or quilted appearance which is achieved by interlacing threads during weaving. A If the previous step has been completed, determine the pick whose weave distribution should be used for the next step.
- B. If the previous step has not been completed, determine the pick whose weave distribution is being used for the present step.
2. If the pattern is symmetrical about the horizontal axis, and the previously determined pick is greater than the number of picks digitized, determine the pick among those that were digitized which is the mirror image about the horizontal axis. It should be understood that the complete pattern will contain a certain number of picks and the basic pattern unit only half that number. The computer is programmed to process the number of picks for the complete pattern. Thus, once it sequences to a pick number greater than that digitized, if the pattern is symmetrical it need only find the pick which is the mirror image of the one being processed. The mirror image pick is that one which is located the same number of picks above the horizontal axis, if the basic pattern unit is an upper quadrant or half of the complete pattern. If the basic pattern unit is a lower quadrant or half then the mirror image pick would occur the same number of picks below the horizontal axis. The mirror image pick is obtained in the computer by a simple numerical subtraction (or addition) and the data corresponding to it is printed out.
3. If a particular pick being processed has not been digitized (not every pick need be digitized within a cross section of the pattern which consists only of linear segments) find the digitized picks that bracket this pick. This information is available in computer memory by a search which determines the numbers of the picks which were digitized which bracket, above and below, the pick being operated on.
4. Determine the weave distribution for this pick which was not originally digitized, by linearly interpolating between the bracketed picks. This step involves a straight linear interpolation. For example if picks 10 and 20 are the bracketing picks which were digitized and pick 15 is the pick being operated upon, the computer searches the weave numbers at adjacent coordinate locations and interpolates an answer for pick 15. Thus, for example, if both picks 10 and 20 have weave code 1 at 1 inch from the origin and weave code 2 at 2 inches the computer will compute the same weave code numbers at the same coordinates for pick 15.
5. If the pattern is symmetrical about the vertical axis, duplicate the weave distribution accordingly. This again is a simple operation since it means only that the computer read out the stored digitized data inversely starting at the vertical axis. To state it another way, starting at the vertical axis and going from left to right, the digitized information of the same pick line is read right to left.
6. If desired, shift the pattern to the right by a specified number of ends. This permits the entire pattern to be shifted in computer memory and printed out accordingly, thereby giving another degree of freedom to the designer without the laborious task of plotting a new point paper diagram.

7. If the pattern is a wheeler and the required pick is in the wheeled section, rearrange the weave distribution for that pick to create the wheeler. Furthermore, if the pattern is a wheeler from the middle, shift the distribution halfway to the right.

8. If the weaves which are overlaid must start and end on odd ends, call sub-routine ODDEND. The ODDEND sub-routine is described below.

9. BINDED — As indicated previously sub-routines 9 through 24 are repeated for each pick and sub-routines 9 through 12 are repeated for each weave along a pick. Sub-routines 9 through 12 are actually weave patterns which are stored in the computer memory and thus are referenced by the weave numbers. When a weave number is read out from computer memory along a pick, the weave number having been previously stored in computer memory at a coordinate location by the readout of the cards produced by the digitizer, the weave number calls one of the sub-routines 9 through 12. As has also been described previously, the actual weave information for each weave has already been stored in computer memory, in sub-routines or instruction steps 5 and 6. For each weave number readout of memory along a pick the appropriate sub-routine is operated upon in memory, this sub-routine containing the necessary weave information.

As each pick is being operated upon, the weave information provided by the sub-routines is stored in memory for subsequent readout. thus, in essence, what the program does is to build in computer memory a detailed pattern of weave information (cuts and misses) in rectangular coordinates corresponding to point paper. The building of this detailed pattern is controlled by the instructions which direct the sub-routine to fill in the weave information along each pick at the proper rectangular coordinate dictated by the digitized data read into the computer. One such weave, the binding weave is described below as sub-routine 9.

Sub-routine BINDEND allows the insertion of short segments of a special binder weave, such as a selvage, with only the starting position of the binder weave digitized. If the binder weave is to start at the same end number for each pick, then the binder weave number need only be digitized at one coordinate location along the first and last picks and the computer programmed to repeat the binder weave at the same end number along each pick. The details of the special binder weave, that is the manner in which the picks cross the ends, and the width of the binder weave, in ends, are also stored in computer memory.

The computer is instructed to BINDEND at the beginning of the binder weave. The end number of the beginning of the binder weave and the width, in ends, of the binder weave are set into the computer by the instructions. Thus, for each pick, the following steps are performed in the sub-routine.

1. Determine the "end" number which begins the binder weave.
2. Determine the "end" number which terminates the binder weave.
3. Call WVMAT (see sub-routine 12). For purposes of illustration, this sub-routine is assumed to have the binder weave information.
4. Set weave number in the computer to the weave number preceding the special binder weave.
10. NTAF — For purposes of illustration, one of the standard weaves stored in memory is considered to be a generalized taffeta. When called by the appropriate sub-routine instruction, on terms of a weave number, along a pick, sub-routine NTAF weaves a generalized taffeta. A taffeta is defined in the system of the present invention as any weave which consists only of a rectangular array of cuts and misses. A cut is the stitch produced when the vertical thread, the end, goes over the horizontal thread, the pick or filling. A miss is the opposite. Each weave, taffeta and any other type, is formed by a predetermined sequence of cuts and misses. Two variables define any taffeta weave:

1. The number of consecutive cuts per one repeat of the weave.
2. The number of consecutive identical picks. The taffeta weave is automatically initialized in NTAF (the origin occurs at pick number 1 and end number 1) by generating the cuts first (variable 1) and repeating this N times (variable 2). The repeat is accomplished as the next successive picks are operated upon. For certain effects, the initialization may be defined by two additional variables:
 - a. If, along a pick, one repeat of the taffeta does not divide integrally into the number of ends for a repeat of the complete pattern, then this variable determines if the taffeta starts at the first end or stops at the last end. If the pattern is reflected about the vertical axis, this variable tells whether the weave should be continuous across the center and break across the first and last ends, or whether the weave should be continuous across the first and last ends.
 - b. The starting pick, which determines at which pick the taffeta weave begins.

11. NTW — Subroutine NTW, which is another standard weave, weaves a generalized twill. This is defined in the system of the subject invention, as any weave which consists of a diagonal array of cuts and misses.

Three variables define any twill weave:

1. The number of ends per one repeat of the weave cycle.
2. The number of consecutive cuts per one repeat of the weave cycle.
3. The number of ends shifted to the right for each consecutive pick. The first two variables define one pick of the twill weave. The third variable defines the diagonal effect by stating how many ends the weave shifts to the right for each consecutive pick. All of this data is stored in the computer memory. Refer to subroutine NTAF for the two additional variables (designated (a) and (b)) which also apply to subroutine NTW.

12. WVMAT — Subroutine WVMAT weaves with one of the special weaves which have been read in by subroutine RDMATR. There can be several special weaves used for a given pattern; all of these special weaves are stored in the computer memory at step 6. Each special weave is designated by its own weave number and the data corresponding to a special weave called out by its number is read out into the appropriate section of computer memory where the detailed pattern is being constructed.

The program is flexible enough to construct its own special weaves. Thus, for example, if two or more special weaves have the same pattern of stitches, yet differ in orientation, it is necessary to read in only one of the special weaves and use the following four variables to describe the orientation which should be done on the read-in weave to create the other weaves. The following variables may also refer to the read-in weave if certain properties of that weave are desired.

1. The weave may reverse direction (goes backwards).
2. The cuts and misses may be interchanged. Refer to subroutine NTAF for the two additional variables (a) and (b) which apply to subroutine WVMAT as well. Using these four variables, special weaves can be constructed in computer memory for call up upon command.

As should be clear, what has been described so far is the overlaying of the weave information onto the digitized pattern. To recapitulate, the digitized coordinate information is read in and stored as well as the weave information. The computer operates on a pick-by-pick basis to construct the detailed pattern corresponding to point paper, in a designated portion of the computer memory for subsequent readout to produce the Jacquard cards. As each pick is operated upon, each time a different weave number is encountered at a different coordinate location, the appropriate sub-routine, described as sub-routines 9 through 12, is enacted to fill in the detailed weave information. Each weave sub-routine is initialized to a starting point, which is the beginning of the particular

weave at a point on the pattern, and the sub-routine operates to overlay the weave in the portion of the memory where the pattern is being constructed on a pick-by-pick basis. The weave sub-routine also steps pick-by-pick corresponding to successive picks of the overall pattern. During the construction of the detailed pattern information, the pattern can be reflected about a horizontal or vertical axis in the manner previously described for sub-routine INTERP. This is also programmed into the computer by the instructions. For example, if a reflection about the vertical axis is desired, the computer is instructed to make the reflection by reading the digitized coordinate data from right to left once the axis is reached.

13. MLASSE — In addition to overlaying the weaves and making the reflections of the basic pattern unit, the computer program also operates on each pick to perform a number of special functions, if desired. These are described below with reference to sub-routines 13 through 18.

The first special function is called sub-routine MLASSE. This sub-routine inserts a special binder weave around the edges of the pattern between different weaves. The binding is done between fillings, along fillings, and if desired (for special effects) not done between odd numbered picks. The MLASSE sub-routine is also stored in the computer and if used, is called up at the time when there is a transition on a pick from one weave number to another.

14. HALFDP — Subroutine HALFDP produces a halfdrop effect on the pattern by shifting the pattern halfway to the right and dropping it halfway down. This is done by the computer memory on the detailed constructed pattern as a simple shift operation. The constructed pattern can be shifted in memory by any desired amount and in any desired direction.

15. VASTUF — This is another special subroutine which inserts stuffer picks throughout the pattern. The stuffer picks are arranged in a special manner.

16. SHINER — Subroutine SHINER eliminates shiners. A shiner occurs at the boundary of a figure within the pattern. Since these boundaries are simply the boundaries of weaves (i.e., the weaves change at a boundary thus creating the figure), the interlocking of the two weaves is often irregular. One irregularity is the appearance of one end going over two picks or one pick going under two ends with the double end shining along the border.

At each boundary the computer makes a check to see if there is a shiner formed, for example, in the manner described above. This is a search of the constructed detailed pattern in the computer memory which can be done during the construction of a pattern or once the detailed information of cuts and misses for the complete pattern has been formed. The latter is preferable. Those shiners found are eliminated by shifting a stitch to the left (along a pick or filling) or down (along an end). If a new shiner arises after the shift, the stitch is shifted in the other direction until no shiners exist. The shifting is done on the higher numbered weave.

Shiners may correspond to cuts or misses and may be eliminated along fillings and/or between fillings.

17. FINISH — Subroutine FINISH repeats the pattern if the pattern contains less ends than the loom provides. For instance, if the loom provides for 1,200 hooks (ends) and one repeat of the pattern has 400 ends, subroutine FINISH duplicates the first 400 ends in ends 401 to 800 and also in ends 801 to 1200.

18. UNFLOAT — Subroutine UNFLOAT eliminates floats. A float occurs at the boundary of a figure within the pattern. Since these boundaries are simply the boundaries of weaves (i.e., the weaves change of a boundary, thus creating the figure), the interlocking of the two weaves is often irregular. One irregularity is when the two weaves join (either along a filling or an end) to produce a string of cuts or misses longer than desired. For example, the two weaves shown in FIG. 6, each have a repeat of four ends on each side of the boundary. The cuts are shown by the

X and the misses by the - . As seen, at the uppermost pick, the two weaves produce a float of six ends. If the longest float desired is five ends, a subroutine UNFLOAT will change one of the two ends of the boundary.

In general, the float is eliminated by changing the stitch in the middle of the float to its opposite, thus halving the float. Floats may be eliminated along fillings and/or ends. This is again a computer search operation with the computer analyzing the detailed constructed pattern for a given number of stitches on each side of the boundary. If the number of the same type of stitch exceeds a predetermined number, then the change is made.

19. STORE — Subroutine STORE transfers and stores the weave distribution from an unpacked linear array into a packed (40 bits to the word) array for use in the output subroutine, WEAVE.

20. CONSTR — Subroutine CONSTR formats each pick according to a special layout. This special layout is requested by the customer.

21. PRINT

All of the data necessary for the complete design is now stored in the computer memory available for printout in any of a number of desired formats. Some of these formats are discussed below.

Subroutine PRINT prints an image of the completed Jacquard card. Two formats are permitted: one is for fine index cards which, illustratively, have 80 columns and 16 rows, the other is for coarse index cards which have 52 columns and 12 rows. The printed card image uses a suitable indicia, such as a zero (0) to represent cuts and a period (.) to represent misses.

22. PCARDS — Subroutine PCARDS writes punched cards to be converted to Jacquard cards on a standard Jacquard card cutting machine. The apparatus for converting the output cards of the machine onto Jacquard format is described in detail below. In a preferred embodiment of the invention three punched cards of 80 column, nine row capacity (excluding three rows for control signals) are needed for each Jacquard card. The punched cards are in standard card format with the top two rows (unnumbered) and rows 0 and 9 used for the control of the electronics of the card cutting machine. Numbered rows 1 through 8 contain the data used for the Jacquard punching information, there being an alternation between two columns on a punched card to obtain the 16 bits of data needed for one column of the Jacquard card. The subroutine operates to punch the data on the cards as well as punch the electronic control signals. To state it another way, the computer is programmed to read out eight data bits for each byte. At the time of the punch out, four control bits are inserted. The purpose of these control bits is described below with respect to the converter.

23. GROSSE — Subroutine GROSSE writes three punched cards in a manner similar to that described with respect to subroutine PCARDS to be converted to verdol paper for use with a GROSSE type punching machine, such as the model CJEMr-2 manufactured by Grosse Webereimaschinen GmbH of Neu-Ulm-Donau, West Germany. The format of this punch out is different from subroutine 22.

24. DACTY — Subroutine DACTY writes three punched cards to be converted to verdol paper for the Dactyliseuse card cutting machine. This operation is also similar to subroutine PCARDS with a different format.

25. Miscellaneous Subroutines

a. ODDEND — Subroutine ODDEND forces even numbered picks to start and end on odd numbered ends. This is a designer's tool which is sometimes desired.

b. Subroutine SHIFT shifts the pattern to the right by a specified number of ends, and repeats this a specific number of times.

c. WEAVE — As explained previously, the computer has within its memory a complete plan of the fabric which

is equivalent (except for color) to the point paper that the designer normally would prepare in the prior art process. If the user wishes to see this plan exactly as it is stored, then it can be printed out from the computer memory. Such a printout is called a "weave printout" and is accomplished by operating subroutine WEAVE. In general, this printout is in the format of a number of rows corresponding to the pick lines. Each row has information corresponding to where the pick passed over or under a weave. The printout is made, for example, to have a dash printed out where the pick passes under an end and an "I" printed out where the pick passes over and end.

Production of Jacquard Cards

As indicated above, one of the outputs of the computer in subroutine PCARDS is a set of punch cards from which Jacquard cards can be made on a suitable conventional punching machine. The punch card output of the computer is described illustratively in a standard format of a 12-row card with eighty columns. The number of columns on a card is of no real significance but if standard eighty-column cards are used, then it takes approximately three punch cards to provide the data necessary for one Jacquard card.

In a typical Jacquard card, provision must be made to punch up to 16 Jacquard loom control holes in a given column plus additional peg and lacing control holes. The peg and lacing holes are offset from the column containing the loom control holes which are used for conventional purposes of orienting and stringing the Jacquard cards end-to-end. As should be apparent, a converter must be provided to convert the computer output data, which has only up to 12 bits of information per column on the punch cards being described, into the 16 bits of information required for the Jacquard loom control signals plus the additional bits needed for peg and lacing punch signals. This is accomplished in the present invention by a converter which uses the information in the computer output cards as follows: eight rows for the Jacquard weaving information, two rows for peg and lacing information, and the other two rows for control of the electronics of the converter. The converter is shown in schematic block diagram form in FIG. 5.

For purposes of describing the converter with respect to a practical embodiment of a punch card, the top two unnumbered rows of the punch card are designated rows 12 and 11 (from top to bottom); numbered row 0 as row 10; and numbered rows 1 through 9 as their corresponding numbers. There is a respective reader or sensor 102-1 through 102-12 for each row with the suffix number corresponding to the row number. Actually, only one reader is provided which has the necessary number of sensors for the twelve rows of information. The sensors, are of any conventional construction, such as photocells in which light passes through the holes on the punch cards; contacts which extend through the holes, etc., as is the card reader machine itself and its advance mechanism. Many types of commercially available card reader machines are suitable, for example those which have been made by IBM for many years.

The converter of FIG. 5 has eight modules 100, each module corresponding to a numbered row 1 through 8 of the punch card. Since these modules are identical, only one of them, 100-1, the one receiving the signal from reader 102-1, will be described in detail, it being understood that each of the other modules connected to the respective readers 102-2 through 102-8 is of the same construction and receives the same type of signals from its respective reader 102. Each of the modules receives an input; from a respective reader 102 of the card reader into which the punch cards of the computer are placed. The output of each reader 102 is connected to the input of an amplifier 104. Each amplifier serves to amplify the output from the respective channel of the reader. Any suitable semiconductor or vacuum tube amplifier can be used, the former being preferred. See, for example, the amplifiers described in the "The Digital Logic Handbook" published by Digital Equipment Corporation of Maynard, Mass.

1966-1967 Edition, Copyright 1966, pages 11 and 132. ; output of the amplifier 104 feeds one input of each of an upper and a lower AND circuit 106a, 106b. The output of each of the AND circuits 106a and 106b is connected to a respective relay driver 108a and 108b which are conventional amplifiers. The AND circuits are conventional logic circuits, preferably of the transistor type. The relay drivers also can be of any suitable type. It is the function of the relay drivers 108 to take a relatively low level logic signal from the respective AND circuits and produce a signal of a larger voltage or current to control a relay. The latter is a device which upon receipt of a signal operates to open or close a contact or set of contacts. In the preferred embodiment of the invention, each relay when energized operates a respective punch mechanism by supplying operating current to the punch. ; The output of these drivers are in turn connected to the respective relays 110a and 110b.

Each of the relays 110 controls a respective punch 112 in the Jacquard card punching machine which itself is of a conventional construction. The punches 112 are any suitable devices for making a hole in the medium of the Jacquard card. Typically a Jacquard card is a card of stiff paper or cardboard. The punch merely has to be able to penetrate the medium to make a hole. These are preferably electromagnetically operated devices so that when a respectively connected relay 110 is operated, the corresponding punch is energized to make a hole in the card medium. The two punches shown are labelled 112-1a and 112-1b corresponding to the first module 100-1 upper and lower punches. The Jacquard card machine has a total of sixteen punches for the loom control signals, which are controlled by the modules 100-1 through 100-8, plus additional punches for the peg and lace holes. The punches 113 and 114 for making the peg and lace holes are the same as punches 112 previously described. The terms "peg" and "lace" merely designate specific information. In general, the AND gates 106a and 106b of each module are energized alternately and if a signal is read by the reader 102 of a module from the computer output punch card that signal will energize the respectively connected relay 110a or 110b. The relays 110a of the eight modules 100 control the upper eight rows of a column of the loom information of the Jacquard card and the relays 110b of the eight modules 100 control the lower eight rows of a column. Thus, the sixteen rows of information can be produced for each column of the Jacquard card using only eight rows of loom information from each of two columns of computer punch card sensed in two successive bytes.

In operation, the punch cards from the output of the computer are placed in the card reader in a stack. The card reader is of conventional construction and contains a card advance mechanism 120. To start the conversion sequence a push-button 122 of the card mechanism is actuated and the first card is fed into the reader and advanced one column at a time. For purposes of description consider that the even numbered columns of the computer punch cards are to be used to control the upper set of relays 110a of each of the modules 100 and the odd numbered columns the lower set of relays 110b. This sequence can be reversed, if desired. Consider, for purposes of illustration, that the first punch card of a set of three corresponding to one Jacquard card, is located to read the first even numbered column containing loom information. A signal, in the form of the presence of a hole in the punch card, is sensed by a respective reader 102 and applied to its connected amplifier 104. This signal is passed to the upper input of each of the two AND gates 106a and 106b. The output of the computer is such that punch cards are produced with no hole at each even numbered column on the row corresponding to row 11, which, as being described, is the second unnumbered row at the top of the card. The absence of a hole is picked up by the reader 102-11 inverted in an inverter 130 and applied over line 131 to the second input of AND 106a as an enabling signal. The signal at the output of inverter 130 is supplied to another inverter 132 which produces a signal

which is applied over line 133 to the second input of AND 106b to act as a blocking signal during the time the even numbered column is being read. Because of the blocking signal on line 133 the relays 110b in each of the modules 100 cannot be set up during the time that an even column is being read.

The AND 106a of each of the modules 100 also receives another enabling signal which is produced by a limit switch 140 with two sections 140a and 140b located in the Jacquard card punching machine. The limit switch 140 indicates the physical position of the punches in the Jacquard card machine so that the relays 110 of the modules 100 will be set up only when the punches are in a cleared, or upper, position. Thus, with the limit switches cleared, or in the upper position, an enabling circuit 142 receives a signal from the V input via limit switch section 140a and in turn produces a signal which is applied to a third input of the AND 106a. As shown in FIG. 5, circuit 142 would be of the OR type.

The remaining input to AND 106a of each module 100 is from a reset circuit 150. Reset circuit 150 is in a condition to produce an AND enabling signal on line 151 for AND 106a during the time that both the limit switch 140 is in the upper limit, or cleared, position and there is no signal from the reader 102-12. To state it another way, the reset circuit 150 operates to produce a reset signal when either switch 140 is in the lower limit position, meaning that a column of the Jacquard card has been punched, or there is a signal (hole) on row 12. The latter is present at the end of a three card set of punch cards and is placed there by the computer. Reset circuit 150 can be of the two input NOR type to produce a blocking signal at AND 106a either upon the sensing of a hole by reader 102-12 or switch section 140b being the lower limit (V) position. In the absence of a hole being sensed by reader 102-12 and switch section 140b being at the upper limit (ground) position, circuit 150 provides an enabling signal to AND 106a.

With the reader on an even numbered row and the three lower inputs to the AND 106a of each of the modules 100-1 to 100-8 enabled by the respective signals from: (1) the inverter 130; (2) the upper limit switch through enable gate 142 and (3) the absence of a reset (blocking) signal from either the lower limit switch 140 or reader 102-12, all of the readers 102-1 through 102-8 which sense a hole in the punch card, have their AND gates 106a enabled and they pass an output signal. The output signal from each AND gate enabled, passes through a respective relay driver 108a and energizes a relay 110a. Each relay 110a has a separate set of contacts which form a latching circuit to produce a signal which is fed back to the input of relay driver 108a to hold a relay 110a energized, if it was originally energized, during the time when the next column of the punch card is being read and relays 110b of the modules 100 are being set. It should be understood that when a relay 110 is set that this closes a circuit of the respectively connected punch 112 in the Jacquard card machine which punch in turn will be energized on a suitable command. Thus, all relays 110 are set, or left unset, depending upon the punch card data and a punch command signal operates to energize those punches of the Jacquard card cutter whose punches 112 have been set.

The card advance mechanism 120 operates at a slow enough speed which permits setting of the relays 110. The card advance mechanism 120 is part of a conventional punch card reader in which the card is advanced past the sensors one row at a time. Considering now that the even numbered column of the card has been read and the advance mechanism has stepped the card one column so that an odd numbered column is being read, the upper AND gate 106a of each module is now blocked and the lower AND 106b is enabled to pass a signal from the respectively connected reader. This is accomplished by punching out the cards in a manner so that row 11 has a hole in the odd column. If reader 102-11 senses the hole, the inverter 130 produces a signal on line 131 which blocks all of the AND gates 106a but inverter 132 produces a signal on line 133 of a type to enable the AND gates 106b. The lower input of AND 106b is still held enabled by the enabling

output signal of the circuit 150 on line 151 since the limit switch of the Jacquard punching machine is still at the upper position and there is no hole in row 12 of the card.

If a reader 102 connected to an AND gate 106b senses a signal, then the connected relay 110b sets the corresponding punch 112b in the Jacquard card machine through the respective relay driver 108b.

With the odd numbered column of a punch card being read, the hole sensed in row 11 goes through a double inversion in circuits 130 and 132 and is applied to a relay driver 135. The output of the relay driver is connected to a punch relay 137. The punch relay is connected in circuit with all of the punches 112 of the Jacquard card cutting machine, as well as peg and lacing punches 113 and 114 which are controlled by respective relays 124 and 127 in the converter. The actuation of these latter two punches is described below. The punch relay 137 when actuated causes the actuation of all the punches of the Jacquard card machine whose corresponding relays in the converter have been set up by signals read from the computer punch cards. Considering the 16 loom information punches 112, those punches whose corresponding relays 110 were set up during the reading of the two columns of the punch card, are actuated to punch the corresponding holes in the Jacquard card. If desired, relay 137 can be made somewhat slower acting than the other relays 110 to provide sufficient delay for relays 110b and the peg and lacing relays 124 and 127 to be set up before relay 137 is actuated. The hole in the eleventh row which actuates relay 137 occurs in the same column as the holes which control the relays 110b. When relay 137 is actuated during the reading of an odd numbered column, one column of loom control information is punched out on the Jacquard card.

Considering now the peg and the lacing punches 113 and 114, these are controlled by readers 102-9 and 102-10 which read from the ninth and tenth rows of the punch cards. Holes in the ninth and tenth rows to control the peg and/or lacing punches can occur in the same odd numbered columns as the loom control data or in separate columns. In the latter case, there also must be a hole in the eleventh row of the punch card since there is no storage arrangement for the peg and lacing signals such as for relays 110a of the modules 100. A hole sensed by reader 102-9 is amplified by the connected amplifier 122 and relay driver 123 to energize the relay 124. Similarly, a hole sensed by reader 102-10 is amplified by amplifier 125, relay driver 126 and sets relay 127. When either of the relays 124 and 127 is set, the respectively connected punch 113 or 114 in the card cutting machine is actuated upon energization of the punch relay 137.

Upon actuation of the punch relay 137 all of the punches in the card cutting machine move down and move the limit switch 140 from the upper limit toward the lower limit position. When this occurs, a signal is applied from the upper contact 140a, now moved to ground, to change the state of the enable circuit 142. The enable circuit now produces a blocking signal on line 143 which is applied to the third input of the AND 106a of each of the modules 100. This prevents any signal from passing through the AND circuits 106a to change the state of the corresponding connected relays 110a.

The lower section 140b of the limit switch 140 applies a signal from the voltage source V to the reset circuit 150 when the punches reach the lower limit position. It is preferred that this signal be produced only after the punches have gone fully through the Jacquard cards so that, in essence, the upper section 140a of the limit switch operates to change the state of the enable circuit 142 as soon as the punches start to move down and the lower section 140b of the limit switch operates to change the state of reset circuit 150 after the punches have gone completely through the card. When the reset circuit 150 is actuated, a signal is produced on line 151 which is applied to the relay drivers 123 and 126 of the peg and lacing punches. This signal, which is in the nature of a blocking signal insofar as AND circuits 106 are concerned, are applied as well as to the third input of each of the AND circuits 106a and 106b of

the modules 100. This resets, or clears all of the relays and makes them ready to be set up again.

After the punchthrough of one column of the Jacquard card is completed, the punches of the machine automatically move up and carry the limit contacts of the switch 140 from the lower to the upper position as shown in FIG. 5. This changes the state of both circuits 142 and 150 so that the next successive column of the computer punch card readout can be used to set up the relays 110 through the AND circuits 106. The next column is advanced by the card reader drive mechanism under the readers 102, the advance being sufficiently slow to permit proper operation of the punches and the limit switch 140.

The operation continues in sequence on a column-by-column basis of the punch cards until the three cards in a set corresponding to one Jacquard card are read. At the end of a three-card set, or at the beginning of another three-card set depending upon the choice for a particular operation, a hole is punched in row 12. This hole is produced by the computer at a designated place together with a hole in the eleventh row. The two holes in the eleventh and twelfth rows, when they occur in the same column, enable an AND gate 160, whose output signal is applied to the card advance mechanism 120. The production of a signal by AND 160 causes the card mechanism to pause. This permits the insertion of a new Jacquard card into the card cutting machine. Once the cutting machine has been loaded with a new card, the pushbutton 122 on the card advance mechanism 120 is energized and the reading continues on a column-by-column basis for a new set of three cards. If peg and/or lacing signals occur in the same column with the signals in the eleventh and twelfth rows then the corresponding punches will be actuated. The same holds true if the two signals in the eleventh and twelfth rows occur in an odd numbered column with loom control signals and/or peg and lacing signals.

Although the operation of the converter has been described with respect to a punch card output of the computer, it should be understood that this is not necessary since it can operate in response to any type of stored data upon suitable selection of the input readers or sensors. For example, the converter can operate from magnetic tape, in which case the computer output would be magnetic tape and the readers 102 would be tape heads. Further, if also desired, the intermediate storage medium between the computer and converter can be eliminated and a direct transfer be made of the stored computer data into the converter. In this case, the stored data would be read out directly from computer memory in groups of bits and applied directly to the inputs of the amplifiers 104, 122, 125, 130 and 170 of the converter. The latter system lends itself particularly well to relatively small capacity special purpose digital computers which can be wired, or programmed, to perform only the specific functions described above with respect to the various subroutines instead of using a general purpose digital computer.

What is claimed is

1. A method for producing information to produce Jacquard cards comprising the steps of forming a design on a record medium, analyzing the design along selected coordinate lines and producing machine readable information of the types of weave patterns along said coordinate lines and the boundary locations of each type of pattern, overlaying by machine within the boundaries of each type of weave pattern located along said analyzed coordinate lines machine stored detailed weave information of the corresponding weave pattern determined during the analyzing step, producing by machine data corresponding to the overlaid detailed weave information, reading out said stored pattern in groups of bits of a number less than that needed to produce a complete group of Jacquard card loom control data, storing at least one of said readout groups of bits, and providing signals for the controls of a Jacquard card punching apparatus in response to said stored group of bits and at least one other group of bits for the production of a complete group of Jacquard loom control data on a Jacquard card.

2. The method of claim 1 wherein two groups of bits are read out to provide the signals needed for controlling the Jacquard card punching apparatus to produce a complete group of loom control data.

3. A converter responsive to groups of bits of a first type, each group of said first type having a number of bits less than a predetermined number, means for receiving the groups of bits of said first type, means responsive to the first received group of bits of said first type for producing a first group of control signals of a second type, means responsive to the second received group of bits of said first type for producing a second group of control signals of said second type, the total number of control signals in said first and second groups of control signals of said second type being equal to said predetermined number, and means for reading out said first and second groups of control signals of said second type at the same time.

4. A converter as in claim 3 wherein said receiving means receives a group of bits of said first type in parallel and said receiving means comprises one first receiving means for each bit of a group of said first type, first and second gating means connected to each of said first receiving means, first and second storage means respectively connected to the output of each of said first and second gating means, means responsive to the first received group of bits of said first type for enabling each of said first gating means to pass said first group of bits of said first type to the respectively connected first storage means, and means responsive to the second received group of bits of said second type for enabling each of said second gating means to pass said second received group of bits of said first type to the respectively connected second storage means, and means for simultaneously reading out the data stored in said first and second storage means as said control signals of said second type.

5. A converter as in claim 4 in combination with a card cutting machine, said card cutting machine having a plurality of punches, means for connecting a respective punch in circuit with each of said first and second storage means of said converter, said means for reading out the data stored in said first and second storage means energizing selected ones of said punches in accordance with the data stored.

6. Apparatus as in claim 5 wherein each of said first and second storage means is a relay which is in circuit with a respective punch.

7. A converter as in claim 4 wherein each of said first storage means includes means for holding it in a predetermined condition upon receipt of a signal from the first received group of bits of said first type during the receipt of the second group of bits of said first type.

8. A method to be practiced on a data processor for producing Jacquard card data comprising the steps of:

1. representing discrete areas of a design in the form of coordinate data for the boundary lines thereof,

2. identifying selected ones of a plurality of prestored weave patterns for individual ones of said discrete areas, each of said pre-stored weave patterns being represented by crossing data for orthogonal pick and weave lines having a fixed orientation relative to the orientation of said design,

3. generating pick and weave crossing data for discrete areas of said design in accordance with the weave patterns identified in step (2),

4. selecting at least one sub-routine stored in said data processor which when executed controls the generation of pick and weave crossing data for discrete areas of said design in accordance with respective generalized rules which are independent of particular weave pattern crossing data and the shapes of said discrete areas, and

5. executing the sub-routine selected in step (4) to generate at least some new pick and weave crossing data to be utilized as Jacquard card data for said design.

9. A method in accordance with claim 8 wherein the generalized rules for at least one sub-routine pertain to the elimination of floats in the Jacquard card data for said design, and the execution of said sub-routine in step (5) is operative to change pick and weave crossing data generated in step (3) for said design in the immediate vicinity of boundary lines thereof.

10. A method in accordance with claim 8 wherein the generalized rules for at least one sub-routine pertain to the elimination of shiners in the Jacquard card data for said design, and the execution of said sub-routine in step (5) is operative to change pick and weave crossing data generated in step (3) for said design in the immediate vicinity of boundary lines thereof.

11. A method in accordance with claim 8 wherein the generalized rules for at least one sub-routine pertain to the insertion of special weaves for matelasse designs, and the execution of said sub-routine in step (5) is operative to change pick and weave crossing data generated in step (3) for said design in the immediate vicinity of boundary lines thereof.

12. A method in accordance with claim 8 wherein the generalized rules for at least one sub-routine pertain to the re-orientation of said discrete areas, and the execution of said sub-routine in step (5) is operative to generate pick and weave crossing data for said design for at least one re-oriented discrete area thereof.

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