are also shown, the first pair representing closed laps from left to right and right to left, and the second pair represent open laps from left to right and right to left.

Finally, two identical icons, labelled "Free Underlap" represent a misslapping effect, (these have been duplicated in the display purely for the convenience of the user).

The operator is now required to select the required lapping arrangements from the menu of icons by positioning a cursor on the required icon, and then repositioning it onto the point paper displayed on the screen relative to a threaded guide, in a course by course sequence until one basic repeat of the structure has been completed. The corresponding underlaps are automatically developed during this process, the maximum length of underlap permissible on an individual course being no greater than twelve needle spaces.

(iv) By a simple command, the lapping sequence previously defined is now automatically drawn out on the screen relative to the threading order and colours selected.

(v) The sequence of events described at (ii)-(iv) is then repeated for each guide bar in turn, until a composite simulation is shown on the screen.

(vi) Details of the pattern chain construction can then be displayed for each guide bar employed, together with the threading arrangements used.

(vii) The composite simulation can now be scaled to match a predefined stitch density, and is displayed on screen for appraisal, and subsequent alteration if so desired.

(viii) Finally, pattern data can be filed and loaded onto disk, and/or hard copies of the design can be printed out in colour if required.

7. Conclusions

Through this work it has been shown that it is possible to develop a computer aided design system that uses relatively inexpensive hardware. Being menu-driven, it is user friendly and simple to operate, and can rapidly simulate many types of warp knitted fabric, without the need to go through the time consuming and laborious process of drafting-out patterns by conventional means.

Further work will involve interfacing the system with a warp knitting machine for sample fabric manufacture, and the improvement of the software to give a more accurate simulation of designs processed.

References

1. Smith, J.A., Textile Horizons, June 1989, p.58.
2. Home, I., Knitting International, June 1989, p. 96.
3. Latifi, M., Ph.D. Research, The University of Leeds.

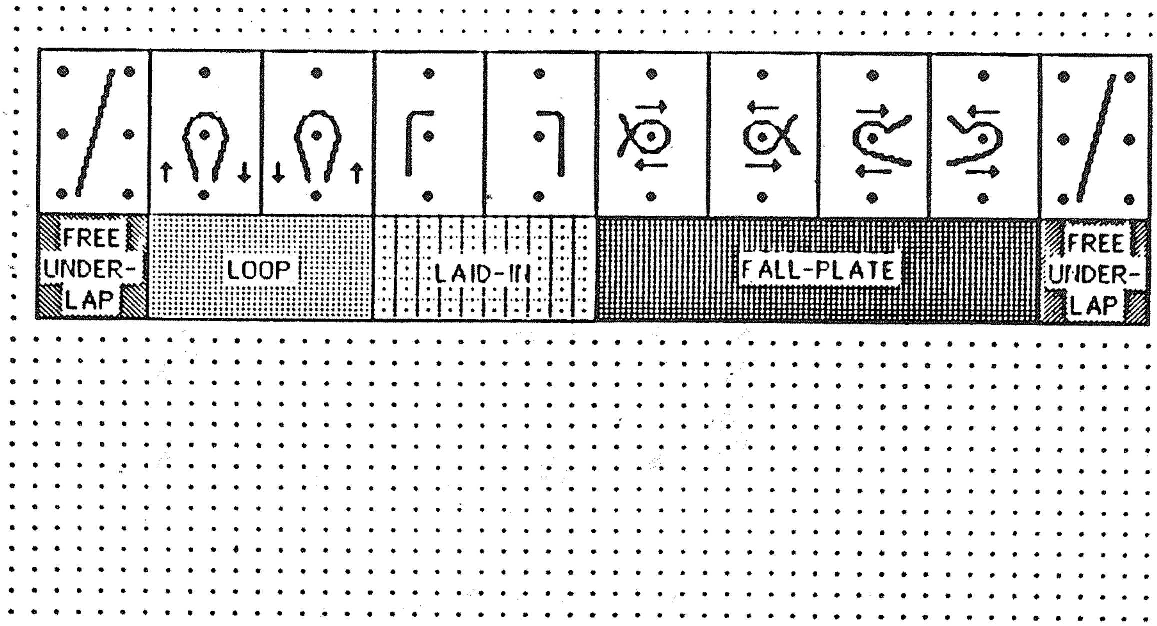

Figure 8

a simple set of procedures which are briefly described below.

(i) The operator is first of all requested to specify the number of guide bars he/she wishes to use for the intended design. A maximum number of six guide bars are available for use.

(ii) The next event involves defining the necessary guide bar threading sequence for the first guide bar. A display of sixteen blocks of colour is presented on the screen and the operator is then required to position a cursor onto appropriate blocks to initiate the desired colour sequence. A diagram of the threading arrangement is then displayed, where a threaded guide is represented by a 'I' symbol in the chosen colours, and where an unthreaded guide is required this is shown as a 'O' in the threading diagram, the latter being achieved by selecting the black coloured block from the palett.

(iii) Upon completion of the threading arrangement for the first guide bar, the screen now displays the threading arrangement below the first row of point paper, and a series of icons, that show nine lapping sequences is shown at the top of the screen.

Figure 8 shows the appearance of these icons, which are labelled, "Loop"; "Laid-in"; "Fall Plate" and "Free Underlap".

The two "Loop" icons represent an overlap (open or closed lap) moving from needle spaces left to right, and right to left respectively.

A pair of icons described as "Laid-in" represent laid-in laps either moving to a needle space on the right or alternatively to the left.

Four icons relating to "Fall Plate" laps

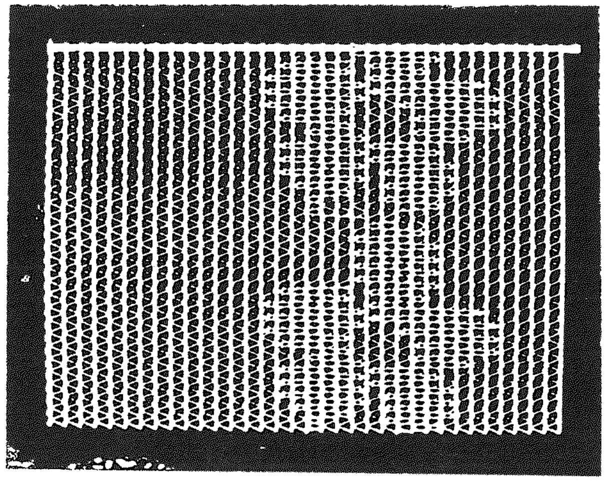

Figure 5

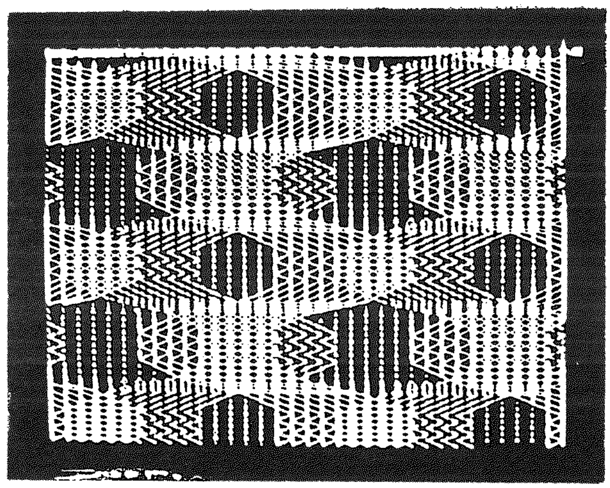

Figure 6

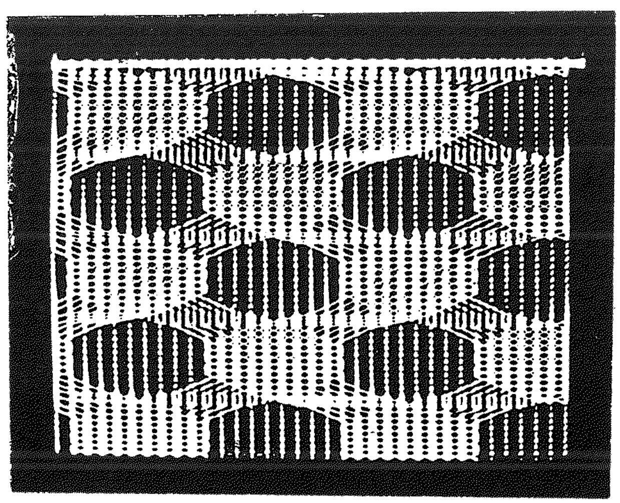

Figure 7

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The chain notation of guide bar 1 is : 1 - 0 / 1 / 2  3 / 2 /
The chain notation of guide bar 2 is : 0 - 0 / 1 / 2  2 / 1 /

The threading order of guide bar 1 is : 1 1 1 1 1 1 1 1 1 1 1 1 1
The threading order of guide bar 2 is : 1 1 1 0 0 1 1 0 1 1 0 0 1
```

Figure 3

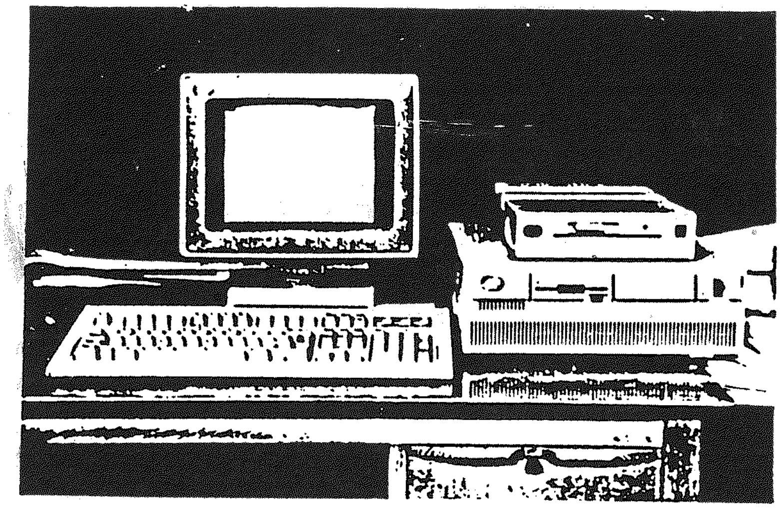

Figure 4

set, with any combination of designated colours. With the exception of cut-presser constructions, any fabric design intended for knitting on any gauge of single needle bar machine can be executed, providing the maximum design repeat does not exceed thirty five needles in width by fifty nine courses in depth, and the repeat of the guide bar threading sequence is no greater than thirty five guides. Any alterations or modifications to a design can be made quickly and easily, with respect to lapping movements, guide bar threading and colour arrangements, at any stage in processing, furthermore, a completed design can be displayed on screen to a specified stitch density, thereby giving a realistic representation of its appearance in fabric form on the knitting machine.

The software also includes an automatic checking facility that will confirm the technical validity of a design for subsequent knitting, and will then generate pattern chain construction details together with guide bar threading information. Hard copies of a design may be printed out in colour if required, and all data can be stored on either 5¼" or 3¼" floppy disks.

Figures 5, 6 and 7, show the screen displays of typical designs processed on the system.

6. System Operation

When embarking on the design of a fabric on the current system, the operator is required to follow

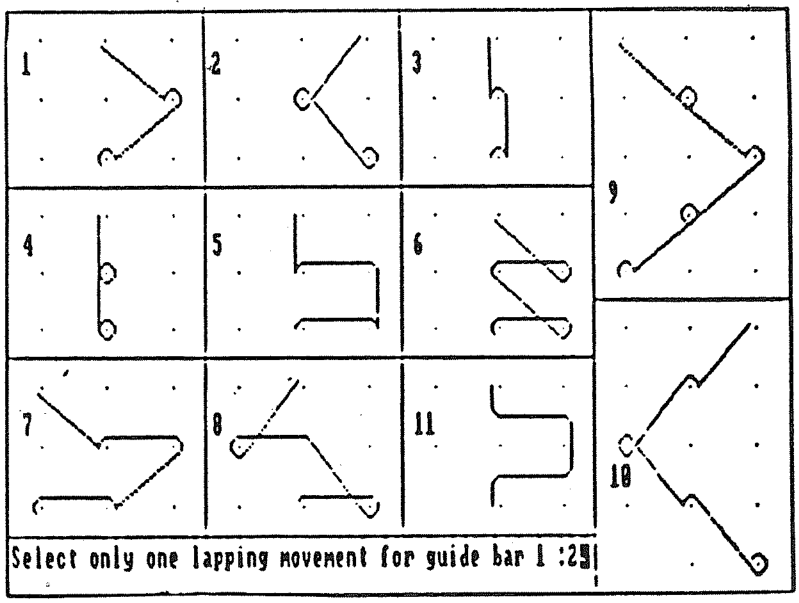

Figure 1

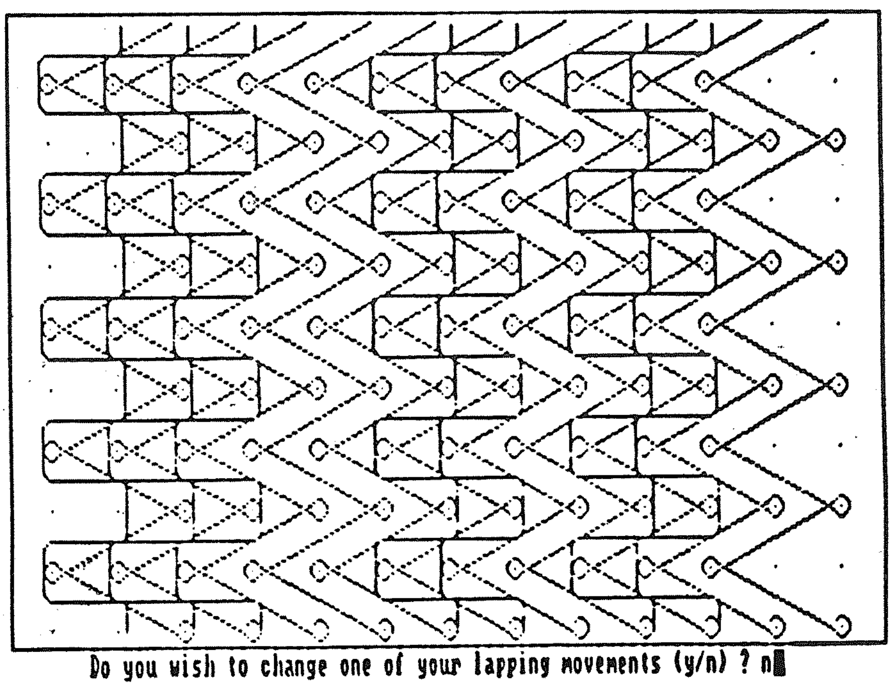

Figure 2

(iv) A completed design, displayed on the monitor screen should show a reasonably accurate simulation of the appearance of the technical back of the fabric.

(v) A simulated design should be capable of being manipulated, by, for example, increasing or reducing its scale to a preselected course and wale density so as to imitate the general fabric appearance if actually knitted to those parameters.

(vi) Full specifications relating to the pattern chain construction for each guide bar used, and the respective guide bar threading orders should be made readily accessible.

4. Initial Software Development

For purposes of simplicity, the initial software was written in Basica Language, and designed to operate on an IBM PC with a 256k memory. Although the software program provided the opportunity to represent guide bar lapping movements without having to draw these out manually, the maximum screen resolution of 640 x 200 pixels was considered to be rather inferior, giving poor graphics definition of structures displayed. In addition, it was observed that the maximum size of pattern repeat that could be processed was limited to ten courses deep by thirteen needles wide, with a maximum underlap length of five needle spaces, and only two colours, (black and white) could be used to designate lapping diagrams, and although the program was menu-driven, it was felt to be rather slow and cumbersome in operation.

Despite the aforementioned disadvantages of this initial work, one significant achievement had been established, in that the program had been devised in such a way to dispense with the necessity to manually draw out any guide bar lapping movements. This was made possible whereby a graphic menu of eleven standard lapping sequences was held in memory and the operator could select any of these to use in a design, and modify any underlap lengths if so desired. The next stage was where the lapping diagram was automatically constructed on the screen which displayed a series of dots representing warp knitting point paper, and the laps for a particular guide bar were superimposed over the dots. The lapping movements displayed on the screen corresponded to the pre-determined threading order for a particular guide bar. The program also provided information for the pattern chain construction for each individual guide bar utilised. Figure 1 shows the graphic menu of standard lapping sequences; Figure 2 illustrates the representation of a two bar structure on screen, and the corresponding pattern chain notations together with the guide bar threading orders are shown at Figure 3.

5. Further Refinements and Developments

In order to improve the system, it was necessary to upgrade the type of hardware used, and employ a more advanced programming language in order to enhance the screen resolution, increase the maximum structure repeat dimensions, widen the colour facilities and provide a more responsive and automated operation.

In its present form the system uses an IBM PS2 (Model 50) shown at Figure 4. The new software program was written in Pascal, and being menu-driven it has been simplified as far as is technically possible, and the time therefore required to develop a design has been substantially reduced. With a now much improved screen resolution of 640 x 480 pixels the simulation of patterns is much more realistic than before. Typically, a design may now contain up to fifteen colours, which are selected from a standard palette and utilize from one to six guide bars, that may be fully-set, half-set or part-that can arise when using very sophisticated computerised design methods, and these can be attributed to their complexity of operation, requiring on the user's part extensive training and in addition the software employed on many systems is over sophisticated.

In an attempt to try and resolve some of the problems associated with the design and development of warp knitted textiles, a programme of research was initiated at Leeds University which has concentrated on the development of a novel software program to provide a computer aided design system that is user-friendly and simple to operate, and will quickly simulate designs on a colour monitor screen, and provide necessary fabric production specifications.(3)

2. Warp Knitted Design Methodology

Prior to the commencement of the development of a prototype software program, it was necessary to first of all define the usual processes encountered when undertaking the design of a warp knitted fabric by conventional non-computer aided methods. From the design methodology employed in this context, it was established that ideally the stages for which a computer aided design system would be of benefit related primarily to the following activities:-

(i) Defining the threading order for each guide bar used.

(ii) Drawing out of the individual guide bar lapping movements on point paper.

(iii) Representation of the composite lapping movements relative to the threading order used.

(iv) Determination of the pattern chain contruction for each guide bar employed.

3. Considerations Relating to Hardware and Software Requirements and System Performance

Careful consideration was exercised in order to establish the necessary pre-requisites needed for both hardware and software requirements and towards the overall system performance.

Hardware

The computer hardware employed should be a relatively inexpensive standard personal computer package, such as an IBM PC, which, from a commercial standpoint, when not being used for fabric design purposes, could be employed for other functions such as word processing, production control etc. Peripheral equipment should include either a thermal, ink-jet or video printer to generate colour hard copies of any fabric designs processed.

Software

It was established that the architecture of the software program should provide for the following applications and features:-

(i) The user of the system should find it simple and logical to operate, requiring a minimal number of input commands via a keyboard and/or "mouse".

(ii) The process of designing a fabric should take a minimum amount of time and the software program should avoid the necessity to draw out any lapping diagrams and guide bar threading arrangements of a structure by hand.

(iii) A wide variety of single needle bar warp knitted constructions and design types should be capable of being processed, using initially up to a maximum of six guide bars, and the software should allow for any modifications to be made to a design being developed.

Overcoming Some of the Problems Associated with the Design of Warp Knitted Fabrics by the Use of a Computer Aided Design

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1. Introduction

Computer aided design systems are now being effectively utilized across a wide range of both industrial and commercial applications. Within the fabric manufacturing sectors of the textile industry, there are a wide variety of computer aided design systems avilable for use in the design and development processes of woven, knitted and printed textiles, and by their employment a fabric producer can gain significant benefits. Notably such benefits relate to the ability to target new fabric collections more accurately, resulting in reduced sample-making costs, the provision of a wider product choice to the customer, the reduction of lead times, and a much quicker response to customers' specific design requirements.

Although computer aided design applications are today considered to be very necessary implements for the designer of fabrics, there are very few systems commercially available that are specifically produced to suit the requirements and particular creative and technical needs of the designer of warp knitted textiles. Those systems that do exist for the warp knitter are not by definition really true computer aided design systems but are in fact computerised pattern preparation methods where, typically, a pattern is initiated and processed on the computer and then the appropriate patterning information is then relayed to a numerically controlled warp knitting machine for subsequent fabric manufacture. These available systems, although undoubtedly useful to the warp knitter, are rather limited in their application and flexibility when compared to the high-level of equipment one can readily acquire for other fabric manufacturing areas. Leading-edge computer technology now allows for the simulation of fabric designs on a high resolution colour monitor screen that have an amazing realism of the true fabric. Weft knitted, woven and printed designs can be electronically presented in this format to, for example, a customer who, working alongside the fabric designer, can make any aesthetic alterations, be it to colour, texture or pattern on the computer to suit and satisfy the customer's precise requirements. This concept of so-called "electronic design presentation" increases the overall efficiency of the design process, improves communication channels between the producer and customer and avoids the unnecessary manufacture of unsatisfactory sample material.[1,2] There are, however, problems