Computer design in the handweaving process

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Computer design in the handweaving process

by

Susan Aileen Poague

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF ARTS

Department: Art and Design
Major: Craft Design

Signatures have been redacted for privacy

Iowa State University
Ames, Iowa
1987

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INTRODUCTION

Over the past twenty years computers have played an increasing role in the textile industry and in the work of handweavers. Computers and weaving are uniquely compatible; such compatibility is not seen with any of the other crafts. Computers and looms process information in similar ways, sharing characteristics that inspired new inventions in each discipline. The first chapter of this thesis will explore the invention of the Jacquard loom attachment, its inspirations, and the repercussions it caused in the evolution of the computer industry. The differences and similarities between Jacquard looms and computers will be explored, the first attempts to interface with and thus control looms described, and the role of computers in today’s textile industry summarized.

Today computers are being used in all aspects of the handweaving design process, including drafting weaves and analyzing fabrics, functions for which computers are especially suited since these tasks involve tedious, repetitive steps and are subject to human error. A further computer function available to handweavers now is the computers’ ability to interface with handlooms; the result of this is that the computer—programmed with all of the
needed design information—actually runs the loom. The second chapter will survey the extensive literature available on the subject of computers and weaving for the handweaver: magazine articles, program listings, design articles, books, software, and software reviews.

While there are a number of software packages on the market for weavers, there are only a few written for the loom control function as well as for drafting and designing. Two of these are Weave Master, written for the Atari line of computers, and Pattern Master IV, with versions written for the Apple and IBM lines of computers. The major part of the research for this thesis was conducted by working with both of these weaving softwares at the theoretical design level, and at the practical level while using them to design pieces for the creative aspect of the thesis. The third chapter will be a concentrated review of the functions of these two software packages that formed the focus of thesis research. The strengths and weaknesses of the two programs will be discussed in terms of how they performed on basic drafting tasks.

Chapter Four will describe the series of author-designed and woven fiber works. These works entail the exploration of block weaves in weave design. The structures used will be described in reporting the development of the woven pieces. Complete print-outs and
technical specifications will be included.

My thanks are due to my major professor, Shirley E. Held, and to the Iowa State University College of Design for making available to me an Atari 800 XL computer, color monitor, Weave Master software and a complete computer-loom interface system, without which the research for this thesis would have lacked depth. Thanks are due also to the Graduate College and the College of Design Research Institute for awarding me a Research Minigrant during the summer of 1986.
CHAPTER 1

THE JACQUARD EVOLUTION—FROM LOOM TO COMPUTER
AND BACK

J. M. Jacquard and His Loom

Joseph Marie Jacquard (1752-1834) is generally given credit for the invention of the attachment to the handloom which virtually eliminated widespread use of the drawloom and made figured woven cloth economical. He can, in a different perspective, be seen as someone who saw an opportunity and took advantage of it. Some considered Jacquard to be a mere "workman," though a very good one, who took the best parts of a series of other persons' attempts after 1725 to make such a loom feasible. He fused these ideas and produced a loom which would virtually weave any design "programmed" into it with sets of punched cards (3, p. 141). There followed other men who incorporated Jacquard's solutions into their creative efforts.

Charles Babbage (1791-1871) was inspired by Jacquard's system of punched cards for determining the shedding sequences of patterned cloths and he incorporated that idea into his invention. He used the best part of the Jacquard attachment, the means of storing and transmitting information, as the basis for his planned computing machine,
the Analytical Engine. The engine was never completed, but Babbage’s concept was impeccable. Later, at the turn of the century, Herman Hollerith saw merit in the efforts of Babbage (inspired by Jacquard), and successfully proved the usefulness of the Jacquard-Baggage punched card theory with his census tabulation system. Thus, while each man in his own way and in his own time was successful in advancing the technologies in his field, each was taking and building on successful procedures of earlier inventors. These men’s inventions were instrumental in the establishment of computers in textile formation.

The evolution of Jacquard’s loom attachment originated with an invention in 1725 by Basile Bouchon for improving the efficiency of a standard drawloom. Drawlooms had been used for many centuries by the Chinese. These looms were eventually brought to Europe, when, after the introduction of silk cultivation, weavers were producing intricately figured brocades and velvets. However, weaving on a drawloom was a two-person operation, cumbersome and slow. While the weaver sat at the front of the loom and threw the shuttles, a drawboy or girl was required to stand at the side of the loom and pull groups of cords in the correct order and in rhythm with the movements of the weaver according to the requirements of the pattern of the cloth. In order to make drawloom fabrics less costly and more
error-free, men such as Bouchon tried to develop ways to aid the drawboy or girl's work.

Bouchon proposed that a band of perforated paper be used as part of the system which determined the patterning sequence. The paper, perforated with a line of holes, would carry the same information as the group of cords tied together i.e., which warps to raise at a certain time. Bouchon designed a system whereby each simple cord on the side of the loom was looped around a tail cord above the drawboy's head, then passed vertically through the eye of a horizontal needle which was encased in a box and extended out in front of the box through a needle-board. A continuous band of perforated paper passed around a roller which pressed against the needle-board. Wherever a hole in the paper occurred, the needle passed through and remained stationary; wherever a blank space occurred, the needle was rejected, a knot in the simple cord was caught in a comb-like device and the drawboy might then depress the comb with a foot pedal, pulling down a tail cord and thus raising a group of warps (1b, p. 367 and 3, p. 142).

In 1728 Bouchon's idea was modified by M. Falcon by replacing the perforated paper mounted on cylinders with a chain of perforated cards on a square beam (3, p. 141). His intent, like Bouchon, was to improve the drawloom.

In 1745 Jacques de Vaucanson continued these efforts by
removing the simple cords and tail cords, and mounting his new shedding mechanism on top of the loom. He did not use punched cards, but went back to Bouchon's continuous paper system. He added a metal bar, the griffe, which raised the wires left stationary by the perforations in the pierced paper. He eliminated the drawboy by placing the pierced paper over a large cylinder which could be moved backward or forward. With the aid of a ratchet the cylinder could move the short distance required between each pattern row on the program paper (3, p. 141). None of these inventions seemed to have been employable on a large scale.

Jacquard had originally gained recognition in England for his invention of a machine to make nets. Napoleon learned of this work and requested that he apply his expertise to correct the faults of Vaucanson's loom. Napoleon's aim was to revitalize the French silk industry, which was losing trade and being replaced with textiles from England's factories. Jacquard had already worked on an invention to improve the drawloom and he exhibited that machine at the Paris Industrial Exhibition of 1801 (88b, p. 63). After he studied the looms of Falcon, Bouchon and Vaucanson (60, p. 7), Jacquard returned to Lyons in 1804 where he completed his invention. He became the first to succeed in making practical the punched card driven weaving machine. Napoleon awarded Jacquard a pension for his work,
but he received violent reactions from the weaving industry of Lyons. The workers received it as a threat to their jobs and three times made attempts on Jacquard's life. It took approximately ten years before the French textile industry recognized the value of the Jacquard attachment. Its introduction allowed France to become competitive once again in the world textile market (3, p. 145).

Upon combining the best parts of the inventions of Bouchon, Falcon and Vaucanson, Jacquard had perfected the idea of a completely automatic machine with a free imaging mechanism for weaving cloth. In fact, says Leslie J. Clarke, "So perfect was Jacquard's solution...apart from purely mechanical improvements, this machine is used all over the world just as he invented it over a century and a half ago" (21, p. 54).

Description of Jacquard's Invention

The Jacquard machine, in strict mechanical terms, is "simply a frame containing a number of wire hooks, which are connected direct [sic] to the healds of the loom. These hooks are raised according to the pattern to be woven--the pattern being first transferred from the design paper to the cards, which operate upon the hooks through the medium of needles" (3, p. 148).

The first Jacquard attachments were made for handlooms.
This device made intricate cloth structuring and imaging possible by carrying the designs programmed in a series of punched cards strung together in an endless chain. Each warp could be lifted separately without need for harness frames. Each card was acted on by a series of independent wire needles sufficient to represent a single shed, or the opening for a pass of the shuttle. The card moved beyond the reach of the wire needles until its turn came again in the next repeat of the pattern. To change the design of the cloth one had only to change the set of punched cards. A single warp of hundreds of yards could be used for any design simply by changing the weft colors or replacing the cards.

The major working parts of the apparatus consisted of a vertical wire hook, curved at the top so that it might be caught and raised by a straight metal bar called a griffe. The wire hook passed through the eye of a horizontal wire, and connected to one or many leash cords which passed through the holes of the comberboard. Each heddle (or "heald") containing a warp thread under tension was attached to the leash cord. The leash was weighted by lingoes below the warp, which were heavy enough to bring the warp back into rest position after the shuttle was thrown. In order for a warp thread to be raised it had to be acted on by the horizontal wire mentioned above. Each wire had a spring on
one end which pushed into a spring box. The opposite end passed through a hole in the needle board and extended to the other side. When a punched card came in contact with the needle board and was pressed against it, the needles in line with holes remained in the same position. All other needles were pushed back. When the griffe bar was raised the wire hooks which stayed in place would rise, while the ones which had been pushed back would not. In turn, the particular heddles attached to the leash cords connected to these wire hooks would be raised. The punched holes on each card determined the individual rising warp threads for each shed. (See figure next page, after Jirousek.)
A - Springbox  B - Griffes
C - Needleboard  D - Needles
E - Hooks  F - Leashes
F1 - Leashes  G - Comberboard
H - Warp  I - Lingoes
J - Cards and Square Cylinder

Figure 1. Parts of the Jacquard mechanism
The cards revolved around a square beam which made a one-quarter turn for each shed. Each of the four surfaces had sufficient holes to accommodate all of the needles in the machine.

The size of the Jacquard attachments varied according to the needs of the woven goods. Narrow labels required many fewer warps than wide fabrics. The sizes were determined by the number of hooks and needles, and ranged from 200 to 1200. The greater the number of hooks available, the more detailed the fabric that could be woven.

Designing fabrics for the Jacquard loom necessitated new and different jobs in preparation for the weaving of the cloth. The artist's rendering had to be translated onto squared paper called point paper. Every interlacement in the cloth had to be established here. All the color decisions would be made, such as the shadings, the transitions from background to foreground, and the modelling of figures. Next the point paper design had to be rendered onto the punched cards so that it would be "read" correctly through the complicated maze of needles and hooks and leash cords and translated into woven cloth. If there were many colors of weft in one shed, each color had a separate card. For brocades with long floats on the back, a "ground" card was used to provide a base structure in satin or twill weave (21, p. 55).
The machine which traditionally is used to punch the cards for the Jacquard loom is called a piano machine. It is so called because the operator sits before it with the point paper design to be read like music on a piano stand, and presses keys which correspond to the positions of the holes to be punched. The keys resemble piano keys. When all keys for a section to be punched are correctly pressed, the operator pushes a foot pedal which activates the hole punching mechanism. The operator then moves to the next section of the design line. The point paper must be read section by section within each line because the cards are divided into short rows with a total capacity of 1200 holes. A design line meant for a 1200 hook machine would be divided into a hundred short rows of twelve punches each. The process is long and tedious. It can take hundreds of hours to punch and string together the cards for very elaborate patterns (48b, p. 52-53).

Over the years many attempts were made to improve on the basic design of Jacquard's invention, particularly as it was applied to power looms. These improvements usually ran into problems and were abandoned shortly after being patented. Different tricks were used to get as much design interest as possible from the amount of hooks available. These tricks included repeating a figure as many times as needed, reversing a figure, using a compound harness as with
drawlooms, or using a modified compound harness or "split harness" (3, p. 160).

Industrial modifications of the original single lift Jacquard machine included the double lift single cylinder machine, which, by allowing two hooks for every needle and alternating griffe bars, lifted warp threads in rapid succession. The shed was never closed completely, so caused less friction for the warp and doubled production rates. The double lift double cylinder machine was a combination of two Jacquard machines mounted on top of the loom. Each leash was connected to a hook from both machines. By operating the machines alternately, a weaver could greatly increase the speed of production (60, pp. 67-69).

The methods of hanging the cards were different for handlooms and power looms. On handlooms the cards were generally hung over the side of the loom, whereas with power looms the cards were hung above the warp. The two methods for hanging the cards required different means for connecting the leashes with the hooks. Sometimes this was a vertical tie-up, sometimes horizontal. With a reversed design the leashes had to be reversed. These were complicated but often exquisitely designed tie-ups. They were ingenious, but it was still Jacquard's basic idea which carried through (3, pp. 160-64).

At various times people attempted to improve various
parts of the loom attachment. Some such attempts were: replacing cords with wires, substituting paper, canvas or wire cloth, or finally, foreshadowing our 20th century computerized control, using electricity in lieu of perforated cards (3, p. 274).

Documentation of the modifications of 19th century Jacquard machines can be long, technical and tedious. My purpose here is to crystallize what Jacquard did and remember that, though modifications occurred, those modifications were for the benefit of the textile industry. The ideas of the Englishman, Charles Babbage, were gleaned from Jacquard's concept of punched cards to carry the information necessary to perform a task; those ideas were never improved upon. They go back to Bouchon and his perforated paper and come all the way forward to our IBM cards of today. They are a binary method of coding information, a basic mode of communication. We will see how the modifications continued through to the 1960s when Janice Lourie of IBM saw that computers could improve the use of Jacquard looms, both by aiding in the card punching stage and by actually taking the place of the punched cards and running the loom.
Charles Babbage and Herman Hollerith: The First "Computers"

One of his principal backers, Augusta Ada Byron, Countess of Lovelace, said of Charles Babbage’s Analytical Engine, "It will weave algebraic equations the way a Jacquard loom weaves flowers" (48b, p. 21). Inspired by the way a Jacquard loom translated binary information into mechanical motion (indeed, Babbage was even the owner of a silk portrait of Jacquard, woven on his loom with a sequence of 10,000 cards!), Babbage developed his first idea for a computing machine between 1820-21. Called a Difference Engine, it could calculate mathematical tables by the method of constant differences, print the tables, and was run by steam. He set about building the engine in 1823. Although the intricacies required by this engine vastly improved England’s machine tool industry, it proved to be an incredibly costly and time-consuming project. A small part of the engine was finally completed in 1832 and it worked perfectly (2, pp. 47-50). His next plan was to build the Analytical Engine, thus making the Difference Engine obsolete. His grand scheme was for a machine that would solve any mathematical problem, not just those problems based on constant differences and numerical progressions. Starting in 1836, he worked with the plans until his death in 1871.
Babbage modified Joseph Jacquard’s concept of punched cards for programming the machine by providing three types of cards. His operation cards bore instructions for the engine; the variable cards carried symbols and values of variables in equations as well as constants; and his number cards supplied numbers for tables and logs. Like a modern day computer, the Analytical Engine could make decisions based on its own calculated results; it could do branching, loops or subroutines (2, pp. 63-64). Were it not for his lack of financial backing and for the lack of adequate technology in the 19th century, Babbage might have succeeded in building the precursor of our modern day computer.

In the late 1800s Herman Hollerith, faced with the prospect of manipulating large quantities of numbers in his job with the national census, developed a punched card system, much like Jacquard weaving cards, for facilitating the first "number crunching" operation. These cards were actually the original IBM cards (48b, p. 21). Hollerith proved that, not only could a punched card contain information to be tabulated, but that machines could be devised to sort cards according to different kinds of data which could then be analyzed by machine (2, p. 70). Run by electricity, Hollerith’s first tabulation system used punched tape to activate a counter to show a numerical readout. This was time-consuming, however, when the tapes
had to be searched repeatedly to obtain all of the needed
information. To gain easier access to the same information,
Hollerith switched to punched cards, literally by cutting up
his punched tape. In modern day terms, this is the
difference between serial and random access. His cards were
read by an electric card reader and were used for the first
time in the 1890 census (2, pp. 72-77).

While these two inventions by Babbage and Hollerith
were pivotal in turning the world's attention to the
possibilities of automatic calculations and to the power
inherent therein, they were not true computers. Augarten
calls the Analytical Engine a "program-controlled
calculator" (p. 66). It could not retain programmed
instructions, since its instructions were always carried on
the punched cards, an external program.

What Is a Computer?

Augarten defines a computer as "an
information-processing machine [that] can store
data—numbers, letters, pictures or symbols—and manipulate
that data according to programs that also have been stored
in the machine." Computers have certain basic parts: a
central processing unit, a central control, memory, input
unit(s) and output unit(s) (p. 65). The central processing
unit, or CPU, is the heart of the computer, containing
permanent memory such as arithmetic or logic, a control unit and an internal clock. The programs which contain this permanent memory are activated when the computer is turned on; they are always there. Input devices provide information to the computer and come in many forms: punched cards, telephone modem, keyboard, mouse, digitizer, graphics tablet and light pen. Output contains the information which comes from the computer. Output can be carried in many forms: computer screen images (cathode ray tube or CRT), printer or plotter paper, floppy disks, magnetic tapes, modems, or punched cards.

Was Jacquard’s loom attachment a computer? Certainly, it did not contain all the components necessary to make up a modern day computer; in fact, even Babbage’s "calculator" was more of a computer than the Jacquard loom. For the last ten years or so the connection has been made between the Jacquard punched cards and IBM cards of today. People viewing very old Jacquard looms in museums are told that the cards used to run those looms were the first IBM cards. Suddenly the logical jump was made: Jacquard looms were the first computers (55). Not necessarily. There are certain characteristics of computers that are also characteristic of Jacquard looms, and while it is true that the punched card mechanism became the inspiration for today's punched cards, their beginnings were very small indeed.
The punched cards can be considered input. They are coded in a binary language which says that there are two ways of communicating data: by a hole or a non-hole. A set of cards is an external program for weaving a certain design into a length of cloth. It is also its own means of storage. The data on those cards cannot be stored anywhere else except on those cards or on other sets just like them. When a set of cards is mounted on the loom and the process of weaving is set in motion, the program can run only from the first card to the last card in a straight linear progression. If there are any variations in the design to be woven, intervention must come from the person operating the loom. The loom cannot make those decisions on its own. The mechanism which is set is motion by the punched cards, and, by extension, the cloth woven by that mechanism, is the output. The cloth can be considered a form of hard copy.

Although the loom is not a computer per se, the analogy between looms and computers is very strong. Janet Lourie in her book *Textile Graphics* makes this point in a compelling comparison. Briefly, computers and looms process data in similar ways. When we speak of representing data in weaving in 1s and 0s, or in binary terms, we are basically speaking of the interlacements which occur when a warp is raised or not raised, and thus covered or not covered by a particular weft thread. All of the warp
threads which are covered by a weft on graph paper or point paper would be represented by a black square; in a binary representation, by a 1. All of the warp threads not covered by wefts would be white squares, or 0s. If we were not using graph paper at all, we could write a row of a weave draft using the number 1 in place of a black square, and the number 0 in place of a white square. A very simple harness to treadle tie-up might be written like this:

<table>
<thead>
<tr>
<th>Binary Form</th>
<th>Graph Paper Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>H 1 0 0 1</td>
<td>H 1001</td>
</tr>
<tr>
<td>H 0 0 1 1</td>
<td>H 1100</td>
</tr>
<tr>
<td>H 0 1 1 0</td>
<td></td>
</tr>
<tr>
<td>H 1 1 0 0</td>
<td></td>
</tr>
<tr>
<td>T T T T</td>
<td>T T T T</td>
</tr>
</tbody>
</table>

Figure 2. Tie-up draft

The first column represents a treadling instruction to depress treadles 1 and 4, reading bottom to top; column two, treadles 1 and 2; column three, treadles 2 and 3; column 4, treadles 3 and 4. A binary representation of a harness threading for a four harness loom (each horizontal row corresponds to one harness) might appear this way:
and would be read 1,2,3,4,1,4,3,2,1. Thus, a draft which called for lifting harnesses 1 and 2 in Figure 3, when being interpreted by a computer, would be the equivalent of adding columns one and two as shown in Figure 4:

If a loom were tied up to raise harnesses 1 and 2, a similar combination would also occur.

This binary representation of data is the reason that weaving and computers work so well together, and the reason computers can be invaluable as an aid to design for weaving. They have the ability to manipulate the weaver's data quickly and accurately—something the weaver can never quite claim. When a computer "weaves" it outputs a weave diagram to the screen and/or to the printer, and as it does so for
each row, a set of drafts is read, the numbers are added, and the resulting row is printed using a means of representation determined by the program.

Bringing the Jacquard Loom to Computer Control

In 1966 Janice R. Lourie of IBM, herself a handweaver, began to take inspiration from her knowledge of the craft and its similarities to computers, and to be interested in the possibilities of computerizing aspects of the workings of the Jacquard loom. Lourie came up with a system called Textile Graphics, which was a method of computer fabric designing for the Jacquard loom.

Textile Graphics involved using a light pen and a CRT to design a Jacquard fabric quickly and easily. The designer could draw directly on the CRT screen. When satisfied with the sketch, the designer would then choose a specific weave structure from a library of structures in memory for the different areas of the design, press a button, and the choices would appear on the screen in all the indicated areas. Again using the light pen, the designer would make any alterations of thread interlacements between adjacent areas for either aesthetic or structural reasons. A computer print-out of the finished design would be used to guide the cutting of the cards needed to operate
the loom.

Previous attempts by the textile industry to computerize the making of Jacquard punched cards had failed because they had involved one-pass scanning of the completed point paper without the artist's or designer's manual intervention. This was a costly mistake. An interactive system in which the designer could work with the design even as the computer was processing it was more feasible. This new system had the potential to save the textile industry many hundreds of hours in designing each new pattern. Textile Graphics was intended to give the designer almost limitless freedom to create patterns in many varieties; to change patterns as they progressed; and to facilitate the making of the punched cards so that many sample fabrics might be woven before a decision was made to go ahead with a specific design (48c, p. 19). This was a significant breakthrough.

But the ultimate application for Textile Graphics came in 1968 when Ms. Lourie was asked to integrate the Jacquard loom and the computer. Her task was to interface the loom and computer and in doing so eliminate the need for punched cards. The punched cards were replaced by a mechanism which would receive its impulse from electronic signals sent to it by computer. Lourie experimented with a Jacquard loom used for weaving labels. She coupled it with an IBM computer,
and the CRT and light pen employed in the earlier version of Textile Graphics. This system was "showcased" in the IBM exhibit at Hemisfair in San Antonio, Texas in 1968. Fairgoers were encouraged to draw original designs on the CRT with the light pen. Once all the design specifications were made, the fabric could be woven on the loom with all operations controlled by the computer (88a, pp. 11-12). In addition, the completed design could be stored on a disk so that it could be recalled and woven again. Through a combination of hardware and programming, "the loom became an input/output device over which interruptive control from the programmed function keyboard was retained" (48b, p. 239-44). The designing function on the computer was overlapped with the weaving function by the computer and a real-time weaving operation was achieved.

Inspired by the origins of the computer, Janice Lourie had brought Jacquard full circle: the computers which were inspired by the workings of a loom were being used to design for and run that same loom. Applications for Textile Graphics were soon found for textile printing processes and for Jacquard knitting. It only remained to be seen whether the technology could be improved enough to make it economically feasible. At the time that Textile Graphics was being developed, computers were relatively few and very expensive. Ways had to be explored to make it possible to
control many looms simultaneously by one computer. At first with the loom-computer interface weaving time was actually increased because there was a lag time between impulses from one shed to the next.

A survey of the textile trade journals since the late 1960s has shown that the actual use of computers to run looms such as the Jacquard was not common for a time. A variety of reasons can be suggested to account for this. The biggest strike against loom/computer interfacing was economics. The costs were too great to implement such systems and the technology was too expensive. In addition, printed fabrics were the preferred mode of patterning textiles; the fashions of the 1960s and 70s did not call for quantities of Jacquard brocades. Most Jacquard fabrics were manufactured for upholstery textiles, neckties, and damasks for table linens (54, p. 106).

However, the electronic reading of Jacquard designs and subsequent transferrence of that information onto continuous punched cards was well-received by the textile industry. Problems of card storage were solved by storing patterns in long-term computer memory such as magnetic tape, and electronic card readers could transfer a pattern from tape to punched cards in a fraction of the time that a piano machine operator had been capable of doing the same task (54, p. 105).
Since Lourie's Textile Graphics system, which was limited to a small label loom output, others have posited systems for electronically controlled Jacquard weaving of tufted carpets both for the Axminster Carpet Loom and also for broadloom weaving. Interface logistics has been the major drawback. Repeatedly, the cost of interfacing loom and computer has proved to be cumbersome and costly (30, pp. 59-62). It was not until 1985 that the first electronically controlled Jacquard looms began to be used in industry, nearly twenty years after the idea for it was developed (18a).

Electronics in the textile industry with respect to fabric formation (including woven and non-woven textile processes) has seen its biggest success in monitoring routine operations. In an industry where efficiency, cost-, price-, and time-reduction, and quality control are of utmost importance, computer monitoring of every aspect of machine operations, at all times, has proved to be indispensable. Data processing has been of use to the textile industry and was implemented at a relatively small cost in comparison with the boosts in productivity that came with it.
CHAPTER 2
REVIEW OF LITERATURE ON COMPUTERS
AND WEAVING

General

The first computer applications in the area of handweaving were in generating patterns from weave drafts. Through the early 1970s most of the work was confined to university research projects by private individuals, usually computer scientists who had side interests in weaving. Microcomputers, at that time, were not available to the general public. As early as 1971, research was conducted by Pat Velderman, a student at Michigan State University, on a computer-generated overshot pattern sampling program. His findings were published in an article in Handweaver and Craftsman. His purpose was to generate new patterns quickly and easily from existing threading and treadling sequences published in weavers' pattern books. By exploring many combinations, he hoped to find all the patterns possible within the genre of overshot designs (87). In 1975, Karen E. Huff, a computer programmer working at Kansas State University, experimented with "teaching the computer to weave." Working not only with overshot patterns, but with woven structure in general, Huff and her computer
simulated weaving with a line plotter. The lines drawn by
the computer underscored the under-and-over relationships of
warp and weft, and aided in Huff's understanding of
structure as crucial in developing a woven design (38).

Another 1975 project documented in Shuttle Spindle &
Dyepot in the following year was put forth by Magdelena
Muller and her associates at Carnegie-Mellon University.
Muller probably produced the first complete system of
software for weavers and textile designers who had no
previous experience with computers. The emphasis was on
interaction and flexibility, changing design areas when
needed, and trying new combinations of patterns in designs.
This system was not available for the general public, but
was a big step toward the kinds of software that would
eventually be available to handweavers (51).

In 1978 an article appeared in Fiberarts describing
Margaret and Tom Windeknecht's computer drafting system.
Margaret Windeknecht is a weaver, while Tom Windeknecht was
at the time a computer scientist at Memphis State
University. He had worked with students in 1976-77 to
devising programs to generate weaving patterns. In fact, his
interest in woven structures took two directions: one, in
generating patterns from known drafts; the other, in
generating drafts from known patterns. With a home-built
computer, Windeknecht wrote a program for his wife Margaret.
He wanted to save her much of the time she spent drafting patterns. From the first, the idea was to maximize flexibility in the design process in order to avoid costly and time-consuming warping and rewarping of the loom (59).

Before describing the tasks that computers do for handweavers, it is necessary to relate the work handweavers have had to do.

In handweaving the convention for representing the design of a weave structure is called drafting. This is essentially weaving on graph paper. There are three basic drafting elements in any harness-controlled loom woven design. They are the threading draft (the order in which the warps are threaded); the tie-up draft (the combinations of harnesses tied to the treadles); and the treadling draft (the sequence of treadling). Together, these drafts determine the woven pattern. The three elements are represented on graph paper as black and white squares. Because the squares are usually larger than the threads, the design resembles on a coarse scale how the fabric will appear. It is an aid to the weaver in deciding how to proceed.

To set up a four harness loom for weaving using a simple design, first a threading order for the arrangement of the warp yarns would be chosen, perhaps a repeat of the sequence 1, 2, 3, 4. Another possible threading draft might be
1, 2, 3, 4, 3, 2, 1, 4. No matter what the sequence is, all of the warps threaded to harness 1 will move when that harness is treadled. Likewise the warps threaded to harnesses 2, 3, and 4 will react in the same manner.

Each foot treadle is tied to a harness either singly or in one of several possible combinations, such as: harnesses 1 and 2, 2 and 3, 3 and 4, 4 and 1. The tie-up draft indicates the particular combinations of harnesses which will be used for the chosen design. The treadling draft organizes the sequence of the tie-up draft information. The weaver might treadle a sequence of 1, 2, 3, 4; or perhaps, 1, 2, 3, 4, 3, 2, 1, 4. Each treadling draft for one threading and tie-up draft will yield a new weave draft, or more commonly, drawdown. In fact, changing any part of any of the three drafting elements will alter the drawdown in some way.

As mentioned before, in the area of handweaving, the first computer applications were for generating patterns from weave drafts. Since "weaving" on graph paper can be tedious, time-consuming, and subject to error, and since computers perform that type of task very quickly and easily, it was a natural application. Before 1980 virtually no programs were available to the general public, most being privately produced for computer research. By 1980, however, software and articles describing weaving software on the market (that is, mostly available by mail order through
weaving journals and magazines) began to appear. The Apple computer line was now gaining popularity, as were many other brands of limited memory capacity (i.e., 16K - 48K) computers. These computers were meant specifically for home use. Although a large part of their target market was for games, and most people were bewildered and hesitant about using these new electronic marvels, it was generally accepted that computers were to become an integral part of the future, and that anyone who tried to ignore them would be left far behind. In addition to the games function, the public was being sold on computers' word and number processing, and record-keeping capabilities.

The Weaver program by Bruce Bohannan and Video Loom by Howard Harawitz are examples of programs which were written for the Apple II computer and were the subject of an article by Clotilde Barrett in the January 1980 issue of The Weaver's Journal. (The majority of weaving software on the market at the time was written for the Apple II, II+, or IIe computers, although TRS, Atari and IBM computers were soon included. Later on, programs such as Weft-Writer by Carol and Stewart Strickler, the Pattern Master series by Janet Hoskins, and Weave Master by Broos Information Systems appeared.) Each of these programs was able to simulate the drafting process, that is, when a threading order, tie-up, and treadling sequence were entered, a pattern "wove itself"
on the screen, row by row. The programs had a color capability, Bohannan's with a palette of 6 colors (high resolution graphics), Harawitz's with a palette of 15 (low resolution graphics). They also differed in the number of warps that they were able to accept for a given pattern. Once a pattern was produced on the screen, and modified if desired, it could be saved on disk (4a).

Compared to the first programs written in the 1970s, these programs were much more sophisticated in their graphic display capabilities. Before, input was limited to alpha-numeric characters and output limited to either the same characters or line plotters; now, output was closer to the graph paper pictures resembling the actual woven cloth.

Program Listings

In addition to the growing body of commercially available weaving simulation software on the market, various periodicals, both computer- and weaver-oriented, began publishing program listings with various applications in weaving. These are, in essence, free computer programs written in the BASIC language. The potential user of these programs needs only to type them into a computer, save them on a disk or tape, and they will be available to run whenever needed.

The first of these free listings was published in
November 1980 in a computer enthusiasts' magazine, *Nibble Express*, and was titled Super Weaver. Most weavers were probably unaware of its existence. A drawdown program, Super Weaver was probably too early for its potential audience, and it was written for only one brand of printer with no clues as to how to rewrite the program for other printers. In 1980 there were not many weavers who knew how to adapt programs readily or even had the equipment to do so.

By 1981-82, weaving magazines such as *The Weaver's Journal* and *Shuttle Spindle & Dyepot* were publishing small programs, mainly for use with Apple computers, sometimes for use with Timex-Sinclair or TRS computers. (I must admit I found these articles puzzling. Even after reading through the authors' explanations it was difficult to visualize how these programs were supposed to work.) Some of these programs did jobs other than simple drawdowns. Two program listings were published in *Shuttle Spindle & Dyepot* in 1982 which dealt with designing block weaves. The concept of block weaves and block substitution took the weaver a step further in drafting knowledge. Rather than being concerned with thread-by-thread interlacements, the weaver could work with design units, or blocks, which varied in proportion. Design areas are much larger in scale. Once a block or profile draft has been determined, the weaver may
choose a structure from potential weaves conforming to this type of designing and featuring alternating textures to define the blocks (66). These program listings, written in Applesoft Basic, are called Posneg (or, positive/negative) and Block Patterns. Posneg is meant for use with a two-color pattern, and Block Patterns may be used for more than two colors. Again, the advantage in using these programs lies in the flexibility of the design process, the ability to compile a block pattern file or library on a floppy disk and the ability to see the designs displayed in color. The limitation lies in the viewing area, which is 40 spaces across and 40 rows down, the maximum allowed in low resolution graphics. This is usually less than what can be represented on the average piece of graph paper. The inability to print low resolution graphics except with specialized software was another drawback.

Thus far, I have described the possibilities of pattern generation with the aid of computers. Weavers do not always start with spools of yarn, pattern books and graph paper to determine a set of weave drafts and ultimately a length of fabric. Sometimes, a weaver has a piece of fabric, which may be a contemporary factory produced piece or a historical piece, and wishes to know how that fabric was woven. A useful application for computers is for fabric analysis. By this process a woven structure is examined row by row to
produce a graphic representation of the thread-by-thread
interlacements. When the weave draft is known, the other
three drafts (threading, treadling, and tie-up) can be
deduced. However, this hand process is also tedious,
time-consuming and subject to error; it is also a job the
computer does well and quickly.

In 1982, Janet A. Hoskins published an article in
Shuttle Spindle & Dyepot titled "Computerized Fabric
Analysis." This was a program listing, again in Applesoft
Basic, which when run does an excellent job of generating
all the drafting information needed by the weaver. Starting
with the draw-down, or cloth, each row of interlacements is
fed into the computer in a series of 1s and 0s. The 1s
stand for any spot in the row of weaving where a warp thread
is under a weft. The 0s fill in the spots in the row of
weaving where a warp thread is over weft (35c).

Another program listing published by Ms. Hoskins
actually tests a weave design still in graphic form to
determine whether the warp and weft will make all the proper
interlacements and hang together, or whether they will
separate into layers and not make cloth at all. The impetus
behind this program is, ironically, computer-generated weave
drafts. Because the possibilities are endless once set in
motion, it is possible to generate thousands of weave drafts
and in the process generate a few which would weave as
layers of threads, rather than interlacements necessary for actual cloth. Again, this program was designed so that the data is entered in a series of Is and Os, a binary grid (35b).

The helter-skelter manner in which program listings were published for a predominantly unknowledgeable audience must have been sensed at some point. But it was not until 1983 that Handwoven magazine’s co-contributor to the “Interface” column, Stewart Strickler, attempted to help beginning computer users and wrote a step-by-step explanation of how a BASIC computer program is put together and illustrated his explanation with a rudimentary drawdown program (85).

Other useful programs which have appeared in the weaver’s magazines include a database program titled Weavcat I (86a); a couple of programs intended for name drafts, a type of drafting and drawdown system using letters to create a kind of coded design—one intended to produce a thread-by-thread result, the other a block design result (52, 42); a portion of a sophisticated drawdown program (also commercially available in its complete form) for Commodore Vic 20 computer users (1b); another fabric analysis program—less rudimentary than Hoskins’, but still primitive (75); and calculations programs.

Calculating warp and weft requirements for projects is
one of the most trying aspects of weaving for many people. Warp yardage must be calculated before yarn is measured and mounted on the loom. The calculations must account for the shrinkage that occurs both during the weaving and when the project is washed. Likewise, weft yardage must be calculated in a similar fashion. Purchasing adequate materials to complete the proposed project is essential. Weavers' calculations are also made complex because of the variety of forms in which yarn is marketed. Yarn from each type of fiber (i.e., cotton, wool, silk, etc.) is spun according to a different ratio of yards per pound. In addition, each yarn type may be available in several different diameters, making it thicker and heavier with less yards in a pound, or thinner and lighter with more yards in a pound. But, with a computer program designed to work out all these calculations, taking cost, as well as all of the variables mentioned above into account, the weaver can plan a project more easily with the knowledge that she has purchased enough supplies to complete it.

In 1981 Shuttle Spindle & Dyepot (40) published a program which would perform the functions just described. Two listings were given, one for an HP41C calculator, the other for a TR800 or Apple II computer. Further convenience was afforded to the HP41C user, in that, once programmed, the calculator could be used right in the weaving supplies
store. In 1984 another program, the Warp/Weft Calculator, was published in Handwoven (84) for the Apple II. Again, this program was accompanied by some helpful comments about the components of the program language. Commercial calculations software has also been available for some time.

Informational Articles

An effort to make weavers comfortable with using computers did not occur until 1982-83. Articles began to appear explaining the benefits of computers for fiber people. The emphasis in these articles was on the ease of working with computers, how the prices for them were coming down, and how much easier life was going to be with computers doing all their tedious jobs. The hardware was explained again and again: the methods of saving information, the various input and output devices, as well as the graphics capabilities of the various computers. The word-processing functions and record-keeping capabilities of computers were carefully explained, with particular attention being paid to yarn inventories and customer lists (45).

In a series of articles in The Weaver’s Journal (12a; 12b; 12c), Earl W. Barrett did a knowledgeable job of explaining the inner workings of microcomputers. The first article was a description of all the components that go into
a home computer system. His aim was to make computer language understandable. He started with the keyboard, disks, disk drives, carefully explaining how the information is stored on and accessed from the disks. From there he went to the types of peripherals that could be used for graphics input essential to weavers. Barrett explained the graphics capabilities of the kinds of printers available and noted why some are better than others for weavers. He also described the types of video displays available. In the next two articles Barrett probably got more technical than most weavers want to get. He touched on the binary storing of information, memory locations, power supplies, and types of memory. (Mr. Barrett unfortunately died soon after writing the third installment in this series of articles. Although still supportive of computer applications in handweaving, The Weaver's Journal has not published as many articles on the subject as it did when he was a regular contributor.)

The "Interface" column in Handwoven magazine also has served the same type of function over the past few years. Generally targeted at those just getting started with computers, the authors offer information on what is available—brands of computers, graphics capabilities, printers, and software. They have started a network for persons writing their own weaving-related programs to share
those programs. As a result of this network program listings have been published by the magazine.

Design Articles

The number of published articles which describe creative or research projects in weaving using computer technologies has been relatively small. The first published projects were accomplished by weavers who were either computer programmers or who had family members with that particular expertise. They did not use commercially available software.

For example, Nate Salsbury, in his article "My Computer Designs a Bedspread," described how he programmed his computer to generate possible drawdowns for a bedspread project. He was inspired by an interesting old woven bedspread, the structure of which he used as a springboard for many new designs. He provided a series of sample drawdowns and print-outs from his program in the article (63). Another article by Paul O'Connor, "Twill Color & Weave Effects--From the Computer," in Interweave magazine (56), describes how his son programmed a computer to generate 8-harness twill patterns. Wanting a quick way of reviewing all the possible twill patterns which could be threaded on a straight draw (that is, repeating the consecutive threading sequence 1,2,3,4,5,6,7,8), and not
wanting to do all the drawdowns by hand, O'Connor's computer program was efficient. He explored twill with different tie-ups, treadling sequences, and warp and weft color sequences (commonly known as color-and-weave). Although the article itself was confined to generating twill effects on four harnesses, O'Connor published a book in 1981 titled A Twill of Your Choice which widened the scope of the study to eight harnesses.

That same year, Margaret and Tom Windeknecht published Color and Weave, a book resulting from their computer program experimentations. Their program generated thousands of examples of plain and twill weave sequences using a design technique which separates surface design and structure in woven pieces by alternating dark and light in both warp and weft. The Windeknechts later made their program, also titled Color and Weave, available for purchase.

Works by weavers who have been inspired by computer imagery have been documented in articles. One such piece by Joyce Marquess Carey appeared in Fiberarts magazine (19a). Her inspiration was a fusion of the graph paper images so commonly used by weavers, and computer-generated images based on gradations of dark and light and printed in little squares. Carey does series pieces in which the imagery evolves. For the piece spotlighted in this
particular article she took an image from an old German weaver's pattern book, broke it down and let it evolve into a computerized self-portrait. The whole series is superimposed on "graph paper," that is, a white ground weave broken up into squares in the same manner as graph paper.

In another example, Ronnine Bohannon wrote about a piece she wove, designed by computer, which also echoes computer imagery (17). Her piece, titled "Five Minutes in February," is actually a warp-faced replication of three digital clock read-outs. This piece shows the affinity that computer and woven imagery have for each other. The same blocks that build images in low-resolution graphics on the computer screen work well when building woven images. Each medium is working on a strict horizontal-vertical grid.

A designer for the textile industry, Patrice George, designs and weaves prototypes of fabrics on handlooms. She documented her adoption of computer technology in an article for Handwoven magazine (26). Using drawdown software, Generation II and Pattern Master IV, plus a special computer/dobby loom interface which makes weaving automatic, she increased enormously her speed in planning and her sample-weaving capabilities.

Another article about weaver Barbara Pickett of Eugene, Oregon reported on her use of computer-loom software and interfacing in order to re-create Renaissance European silk
velvet weaving. The intricately woven pieces which she laboriously creates with many fine silk threads per inch are facilitated by her computer which affords unlimited tie-ups of harnesses (23).

Books

With the exception of the two books previously mentioned, Paul O'Connor's A Twill of Your Choice and the Windeknecht's Color and Weave, there has been little else published which deals with computer-aided design for handweaving. The most recent book length project was a thoroughly annotated list of available software, Software for Weavers...a Resource by Lois Larson. This is a helpful listing of all the available programs for weavers with complete descriptions and, when possible, sample print-outs of their results.

Software Reviews

Software reviews began appearing in The Weaver's Journal around 1980-81. This magazine was the first to actively support computers as viable tools for handweaving. Earl Barrett began reviewing the programs being offered through the weaver's magazines as an aid to potential customers, just as others reviewed yarns, equipment and books. The various functions of each program were
described, indicating how many harnesses and treadles could be accommodated, and assessing their strengths and weaknesses. Sample print-outs were included. Later, the other weaving magazines started performing the same service, often comparing a few programs at a time on various key points.

The practice of knowledgeable weavers reviewing software has been helpful to the weaving public. Oftentimes updated programs have been reviewed as their newer versions come out, so that potential customers can be aware of improvements. Also, this service has been an aid to non-Apple computer users. As software has appeared for Macintosh, IBM, Commodore and TRS computers, reviews have followed quickly.
CHAPTER 3
SOFTWARE APPLICATIONS IN HANDLOOM WEAVING

Software Packages

Pattern Master IV

There are many weaving-related programs on the market, but only a few of them offer more than the traditional drawdown function. A goal of this study was to gain experience with programs which perform a variety of different tasks. One of the most comprehensive software packages available for weaving is the Pattern Master IV series written by Janet A. Hoskins. A major portion of the research for this thesis was done using this software on an Apple IIe computer.

Pattern Master IV consists of a series of programs on a total of ten disks. At first, I used only the Master Disk and Filer Disk. Later, as work progressed, I included the Archivist Disk, Picture Filer Disk and Extended Analysis disk in my research. Pattern Master IV is a menu-driven set of programs, which means that the user needs only to choose an item on the screen to run a particular program. This aspect makes the software easy to use, but also makes it slow: sometimes one must go through two or three menus to reach the desired one. The Master Disk is the starting
point for the complete set. With it and the Filer Disk, which is used to store patterns and designs, all of the major design work the weaver needs can be done: drawdowns, fabric (or design) analysis, color display, editing functions, printing capabilities and cross-sectional views.

A drawdown, which may represent from 4 to 16 harnesses and from 6 to 18 treadles, begins in the Display Menu. First, the parameters of the design must be established. The program must be told the number of harnesses and treadles to be used. A threading grid must be chosen from a number of possible available sizes. This is comparable to the different scales of graph paper that would be used if the pattern were being graphed by hand. The program asks for this information using the term "pixels" on a scale of from 1 to 9; the smaller the number the smaller the scale grid. Next the program needs to be told the total number of warps and wefts (columns and rows) which will be required for the design. These can be increased or decreased later as needed. The user may establish a "design window" if the pattern is very large, enabling her to work with sections of the threading and treadling, thereby avoiding errors in entering information. When all decisions have been made the empty threading grid must be displayed. For example:
This may be the grid for the whole design; or, if a smaller "window" was established, it will represent the design window. Later, when the drawdown is complete the window may be removed, revealing the entire pattern.

To begin entering the design the user moves from the Display Menu to the Design Entry Menu, and chooses the Threading, Tie-up, Treadling Entry option there. Four keys are used to move the cursor to the desired locations on the grid: I = up, J = left, K = right, and M = down. Pressing the backspace key once blackens the square that the cursor is on; pressing it again erases that square. After the three elements of the draft have been filled in, the user presses the Return key, the screen goes blank, and the computer presents the drawdown. Editing (in the Design Edit Menu, accessible from the Design Entry Menu) may be done before or after viewing the drawdown in the Display Menu.
This is an example of a finished drawdown:

Figure 6. Drawdown

The user may exit from the Display Menu, return to the Design Entry Menu, and from there exit to the Structure Menu. A choice of structural cross-sections for four types of cloth—single layer, double, triple or quadruple—is given here. The design in memory is visible to the weaver as the weft travels over and under the warps.

For example:
The weaver may access the Structure Sub-Menu from the Structure Menu, and put the drawdown through further analysis. The design may be tested for "Reducibility"—that is, whether it will hang together sufficiently to "make cloth" (see Chapter 2). The design may also be checked to find the longest warp or weft float. This option would be important when considering possible uses and durability of the fabric. Long floats which might snag or pull out should be modified in the design.

The Design function on the Master Disk takes a possible drawdown as given and lets the computer calculate how to weave it (see Chapter 2). This is called "fabric or design analysis." The drawdown may be an original design, an adaptation of a commercial piece of fabric, or it may be a thread-by-thread reading of a historical textile. The design option begins in the Display Menu. The weaver chooses the appropriate scale design grid, again based on 1 - 9 pixels. The threading, tie-up and treadling elements
will not be used. The grid appears like this on the screen:

![Design grid](image)

**Figure 8. Design grid**

The weaver exits to the Design Entry Menu where, with the Design Entry option, she fills in the squares as described above. The I, J, K and M keys move the cursor across the design grid, while the backspace key is used to fill in or erase each square. After completion of the design it may be necessary to go to the Design Edit Menu to delete any unused rows or columns. When the design is finished it might look like this:

![Completed design](image)

**Figure 9. Completed design**
The user may return to the Display Menu, and, with the Analyze the Design in Memory option, the computer will calculate the threading, tie-up and treadling instructions to weave the design. The weaver selects the yarns and colors for the project.

Figure 10 is the final computer generated drawdown:

![Figure 10. Drawdown](image)

The Print Menu is another useful option on the Master Disk. The program will print the complete current design or any portion of it in memory, depending upon which form last appeared on the screen. It is possible to enlarge, rotate, and emphasize (darken by printing twice) the image.

The weaver accesses the Filer Menu and Disk from the Designer Command Menu on the Master Disk. This program is
used to save, delete, and load patterns. The Filer Disk may be copied, making it possible for the weaver to maintain an extensive library of designs.

A Color Display Menu can be accessed from the Master Disk. The weaver may choose a background and a pattern color from the six available in Apple computer's high resolution graphics. (I do not own a color monitor, however, so did not make use of this option in my design work. It was really not necessary.)

The Filer Menu on the Master Disk contains the Make a Design a Picture option. This may be used if the Picture Filer Disk is available for use. Once the design is converted to a picture it may be saved, and loaded from or deleted on the Picture Filer Disk just as on the Filer Disk. The Picture Filer Disk has other functions for editing and manipulating the picture graphically on the screen.

The Archivist Disk is accessed on the Master Disk from the Designer Command Menu. This disk contains a database of twills and their derivatives. The three elements of weaving design, threading, tie-up and treadling, are established in separate files and the weaver may call them up independently to generate thousands of combinations in drawdowns. For example, if a threading and treadling had been chosen and the weaver wanted to experiment with different tie-ups to see how the structure might be varied, she could try the
tie-ups in the database successively until finding a suitable one.

The Archivist Disk also contains a block structured weave database. Block weaves are based on threading units which result in textural contrasts that can be combined and used effectively for designing. There are many different types of weaves—for example, Summer and Winter, Beiderwand, double weave and damask—available in block designing. Many of these are stored on this disk in a block weave database. The weaver may also add new ones to the database. Each generic weave structure can be employed with the Block Substitution program. Below is an example of the previous design translated to 5-shaft damask weave when substituted for the blocks of the profile draft:

![Figure 11. Block substitution--damask](image.png)

Forty-five harnesses would be required to weave this nine block design in 5-shaft damask with 5 harnesses per block.
Weave Master

Weave Master was written for the Atari personal computers in the 400, 600XL, 800 and 800XL, and 1200XL lines. Atari computers were chosen for this software because of their excellent color capability, an unusual trait for small computers in 1982-83. Unfortunately this line of Atari computers is no longer being manufactured even though the Macomber company is still marketing them in 1987. Macomber Company is promising that Weave Master will be compatible with IBM and Commodore computers at a later date.

This software package contrasts in many ways with Pattern Master IV. Whereas Pattern Master IV is comprehensive, Weave Master is limited primarily to a program for generating drawdowns. Its strengths lie in its ease of use, flexibility, speed, color and interactive aspects. The basic program is carried on a cartridge which is loaded into a slot above the fingerboard on the computer's CPU. Various expansion programs are carried on a series of floppy disks. These include Weave Master Plus, Weave Master Pattern Libraries, Color Plotter Drivers, and Peg Plan Reports.

The research for this thesis was limited to the use of an Atari 800XL computer, a color monitor, and a disk drive (which was unreliable). The Weave Master Plus disk was acquired at a later time, but, because of the unreliability
of the disk drive, it was not used as anticipated. No printer or color plotter was available.

Weave Master is a mixture of menu-driven and command-driven programs. Having chosen a menu, the user presses a key, the first letter of a command, and the program immediately moves to that command. The process is very fast. (There is only one menu on the basic Weave Master cartridge. However, when using the cartridge with the supplemental disk Weave Master Plus, the number of menus increases to five.)

When executing a drawdown the user begins with the command menu on the screen. The parameters of the design are defined first. By pressing H, the user tells the computer how many harnesses (up to 32) are needed. By pressing P, the number of pedals (treadles) up to 64 is established. The program is now ready for operation. (With Weave Master no threading grid has to be displayed, as was the case with Pattern Master IV, nor is it necessary to estimate the total warps and wefts.) The weaver presses D, and the "loom" is ready to be dressed. The threading information may be displayed numerically on the screen with a table which includes a listing of thread number, harness number, thread color, size or width, and spacing. The user may fill in this table one column at a time, moving from top to bottom, or one line at a time, moving from left to right.
This is a non-traditional method for displaying the information that weavers employ for designing, so requires adjustment and time to get acquainted with it. There is another way to dress the loom by using a split screen. The top area viewed is the traditional quadrant with the threading area at top left, tie-up at top right, treadling area at bottom right and drawdown at bottom left. At the beginning, only the lines dividing the space will be visible. For example:

<table>
<thead>
<tr>
<th>threading</th>
<th>tie-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>drawdown</td>
<td>treadling</td>
</tr>
</tbody>
</table>

Figure 12. Drawdown quadrant

The bottom area of the screen will be the same Dress command table, but with only a few lines of it visible. As the user fills in the table at the bottom of the screen, the design elements will appear simultaneously at the top, in the graphic area of the screen.
This method of working is accessed if the user, before pressing D, presses V for View level. There are eight view levels possible, but levels 1 – 4 are appropriate at this stage of designing. Level 1, closest to the viewer, is the largest scale with respect to thread by thread viewing. It is the fastest with which to work. Levels 2, 3 and 4 progress farther and farther from the viewer, are smaller in scale and slower. A good view level for inputting a drawdown is level 3. It is fine enough that a large part of the design is visible on the screen, yet it is not so slow that the viewer becomes impatient.

When the threading is finished, the user presses the Escape key, and selects the key for the Tie-up command (T). A table will appear at the bottom on the split screen. At the left side of the table are pedal numbers. Across from left to right are spaces for numbers, to indicate which harnesses will be tied to each pedal. Again, this is a non-traditional method of manipulating drafting information. Use of the split screen permits easier visualization. As the weaver matches the harness numbers with the pedal numbers, the tie-up forms on the screen. When the tie-up is complete, the user presses the Escape key once more.

The third drafting element is the treadling sequence. Weave Master calls this command Weave. When the weaver
presses \texttt{W}, the table for inputting this information appears. The user supplies the pedal number, weft color, yarn width or size, and spacing. When the information for each weft is complete, the design "weaves" itself as the graphic "shuttle" moves from left to right. This is a fascinating and uncannily close simulation of the actual weaving process.

The weaver may enlist other commands for viewing or editing the complete drawdown. The pattern may be scrolled up, down, right or left using the arrow keys, if the total pattern is too large to be seen on screen at one time. The drafting elements may be switched off or on for viewing, without distractions, using more of the screen. The back of the pattern may be seen by pressing \texttt{B}; the front may be seen by pressing \texttt{F}. Each view level may be invoked by pressing \texttt{V} and the numbers from 1 to 7. View level 1 displays the pattern at its highest level of magnification, 40 columns and 20 rows. View levels 2, 5, 6 and 7 display 80 columns and 40 rows. View level 3 displays 160 columns and 80 rows. View level 4 displays 320 columns and 160 rows.

The view levels interpret color in different ways. View levels 1, 2 and 3 can display a maximum of 4 colors from a palette of 128. Because of the fineness of the resolution of view level 4, only one color can be displayed,
but in two shades. View level 5 can display 9 colors from a palette of 128; level 6, 16 colors with 1 shade per color; level 7, 1 color out of 16, but in 16 shades. The Color Editor Command, invoked by pressing C, allows the user to modify a specific color number (chosen when the drafting configurations were made). The color number may be in the warp, weft or both. After specifying the color number, the user presses the up and down arrow keys to display the drawdown in eight different shades of light and dark. The right and left arrow keys allow the visualization in turn of the 16 colors used by Atari. There are some limitations on the color numbers to be modified, depending on the view level, as was stated above. It is unfortunate that the maximum flexibility in color is available on view levels which show magnified versions of the design. This makes it difficult to realize the full impact of color changes and juxtapositions with respect to the total design. The best view for color and design is level 4; however, its fine resolution makes only the design visible without color.

Within the Dress and Weave commands, the weaver may invoke sub-commands for editing the pattern. The I key may be pressed to Insert a thread at a specific location, and E is pressed to Erase a thread. The Repeat sub-command, invoked with R, is useful after the design has been entered once. To save time the program will repeat
the design unit as often as the user specifies.

When the weaver is using a storage device to save patterns on floppy disks, the command for Save is S, and the command for retrieving a pattern is G, or Get. There are sub-commands under Get and Save. The user may opt for Save within the Dress, Tie-up or Weave commands to store just those parts of patterns. When creating new patterns, the user may invoke Get within the Dress, Tie-up and Weave commands in order to use already established drafting elements no matter whether they were saved as partial patterns or as parts of whole patterns.

The Electronic Dobby Loom

The dobb y is similar to the Jacquard attachment. It is another mechanism intended for making sheds in the warp, but it is attached to looms with harness frames. This is in contrast to the Jacquard attachment which eliminated harness frames in favor of independently manipulated warps. The dobb y or "witch-dobby" (24a, p. 7) is used on looms with more harnesses than can be manipulated easily with traditional treadles. A handloom is usually equipped with from 2 - 16 harnesses and from 2 - 20 treadles. Depending on the loom's construction the shed is accomplished by depressing a treadle, and activating the harness or harnesses tied to it. The weight of more than 16 harnesses
tied to treadles in various combinations is heavy and cumbersome. Changing those tie-ups is awkward. The dobbyst which operates on the same principle as the Jacquard, although on a much smaller scale, can solve these problems.

Instead of a series of hundreds or perhaps thousands of punched cards, the dobbyst loom uses as many 50 narrow wooden strips called lags. The lags are strung together in the sequence needed to weave a unit of a pattern. Together this group of lags is called the dobbyst lag chain. Each lag has holes drilled into it along its length equal to the number of harnesses on the loom. Pegs fill the holes not being used for a particular shed. The lag chain is mounted on the side of the loom, just as the first Jacquard mechanisms were mounted to the sides of handlooms. However, instead of substituting different sets of cards for each new sequence of sheds, dobbies need only to be re-pegged, using the same wooden strips over and over. The pegged lags are the tie-up for the loom. Only two treadles are needed—one to open the shed, the other to close the shed and advance the lag into position for the next combination of harnesses.

Often, weavers who use these looms weave prototypes of cloth for the textile industry, or they are cottage industry (production) weavers working at home or in small studios. They may keep the same warp and threading, making changes only in the weft or in the tie-up. The dobbyst tie-up is easy
to change, even in complicated sequences. A variety of complex weaves may be woven in a relatively short period of time on this type of loom.

In 1981 the dobby and the computer were introduced in what was to become the first non-industrial computer-loom interface application. Ahrens and Violette, a dobby loom manufacturer in Chico, California, began distribution of a system for interfacing its production dobby loom with either Apple or IBM computers. Pattern Master IV with its Dobby Control disk was one of the computer programs used to replace the lag chain; the tie-up became electronic and stored in the computer’s memory. The pattern in memory is woven automatically, as the computer selects the harness lifts in sequence. The lag chain is no longer limited to 50 lags and repegging is eliminated. The software is able to simulate a loom with up to 600 treadles, although the harness numbers will always be limited to the number available on the loom. The computer can monitor the weft number, displaying the weaver’s progress. In addition, the weaver can exercise the option to design as the weaving progresses, one shed at a time, entering treadling directions as the loom responds to each last command.

Macomber Looms of York, Maine began marketing their own version of an electronic "dobby" at about the same time as the AVL loom was converted. Macomber targeted their
Computer Assisted Textile Design and Production Series for the non-industry weaver. This was a much more accessible system than the AVL compu-dobby because it could be added to any Macomber Type B handloom built since 1936. The convenience of an electronic dobby was available for Macomber looms of any size having any number of harness frames. There was a choice in the type of computer to be used to interface with this loom. A small microprocessor could be attached to the shuttle box at the top of the loom. This was a computer with a limited capacity and only a digital readout, without a screen for graphics. It was able to perform the same Autoweave functions as the Atari computer system, the other alternative for interfacing. Although the addition of computers will never increase the harness capability of a loom, they do add flexibility in the basic loom set-up. Treadle numbers increase dramatically, as do tie-up combinations. Aside from no longer having to crawl under the loom to tie treadles to harnesses, the weaver is free to do much of the designing in the tie-up, a very Jacquard-like way of working. Instead of the two-pedal system used by the AVL compu-dobby, the Macomber system uses a single pedal to replace the center four treadles on the conventional loom. This pedal contains a bank of solenoids, one solenoid for each harness connection, having the odd numbered ones on the left and the even numbered ones on the
right. Each solenoid connects to special vertical hooks attached to the lam m bars connected to the treadles. It is the lam m bars which push the harnesses up after the treadles are depressed. When the electronic signal from the computer reaches a solenoid, it pushes a small rod out through the middle of the special hook. In order to lift the selected harnesses to make the shed in the warp, the weaver presses the pedal down. While not a true dobby loom in the traditional sense, the Macomber electronic dobby works as one with the aid of computer memory and sequencing.

**Autoweave on the Atari**

The Autoweave command is available on the basic Weave Master cartridge. It may be invoked by pressing A if the Macomber loom in use is equipped with a master pedal and a power supply connected to the Atari computer. The operation of the loom becomes electronic at this point, which means that the treadling (Weave) sequence in memory will be performed, one shed at a time. The Autoweave command can be used in any view level; the levels with greatest magnification are fastest, while levels 3 and 4 are the slowest. When the first shed is selected the solenoids, corresponding to the harnesses to be raised, are activated. The weaver presses the master pedal down; the harnesses are lifted; the weaver throws the shuttle. The master pedal is
allowed to return to the "up" position. The cursor on the screen moves to the next point on the Weave draft, activating the solenoids for the next shed. The process continues until the Weave sequence is complete. The split screen is used in this mode with the graphic image at the top and the Autoweave table at the bottom so the weaver can keep track of the weft number and the harnesses to be raised. This is an efficient method for weaving complicated pattern sequences. Errors are virtually eliminated. The weaver may begin at any point in the pattern by choosing the weft number which will be the starting point. It is possible to reverse the design by pressing the down arrow key for each shed that is to be woven in the opposite direction.

The Designer's Delight

The Designer's Delight computer system is the alternative to the Atari computer and Weave Master software in the Autoweave mode. The sole use of the Designer's Delight, together with a power supply and the electronic master pedal, is to run the Macomber loom. This computer is not used for designing drawdowns because there is no graphic display available, but only an LED readout. It is used only after the weaver has configured a design in terms of tie-up and treadling, and after the loom is dressed, ready to
weave. The weaver may enter these design elements into the computer's memory and save them on design keys. These keys (actually key-shaped) are microchips which can store information much like a floppy disk or magnetic tape.

The Designer's Delight may be operated in three different modes to run the loom. The first possible choice is the Manual mode. In this mode all that is needed is a tie-up, which the weaver may enter before work begins or read from a memory key. The weaver then presses a pedal number on the keyboard for each shed. The indicated solenoids are activated, and when the weaver depresses the electronic master pedal the needed harnesses will rise. No part of the treadling sequence remains in memory. This mode of working is beneficial if the weaver is designing on the loom, if she needs interaction with the actual textile before making final design decisions. The weaving for the projects in the creative component of this thesis were woven in this mode when using the Designer's Delight computer.

The second weaving mode is the Design Mode. The weaver starts in the same manner as with Manual. Again, only a tie-up is needed to begin. The difference here is that the computer stores the treadling sequence in memory as each pick is executed. The user may edit the sequence for a final design configuration. The treadling may then be executed automatically in Auto Design mode or it may be
saved for later use with a design key.

The third weaving mode is Automatic Mode. In this mode a tie-up and a treadling sequence are needed. When the weaver enters all the information for these elements, the computer will run the loom in the predetermined order of sheds. The weaver may edit the sequence by inserting or deleting lines (or picks) or by unweaving a section when sequences are reversed.

These two types of computer-looms are the accomplishment on a small scale of the idea that Janet Lourie developed with Textile/Graphics for the textile industry. Although the Jacquard/loom interfacing system was not feasible for factory use for many years, the problems faced there would not be faced by the handloom weaver. High speed for the handloom weaver is seldom a factor. Even with a computer-interfaced loom, one would not expect nor want to weave hundreds of sheds per minute. The quantities of solenoids are limited: only one is needed per harness, in comparison with the hundreds needed for the hooks of Jacquard looms. For the most complex Macomber loom a maximum of 30 solenoids would be necessary. A changeover to the use of a solenoid bank and its upkeep is not a prohibitive expense, if the weaver considers it to be a real enhancement of design possibilities.
Conclusion

When I was considering which weaving software to buy in 1984 there were several features I knew I wanted. I was looking for software with functions which went beyond just the drawdown, and with the potential for loom control, an application to be added at a later date. I was also conscious of the types of computers for which weaving software was being written. The computer market was in a state of flux. There were many varieties; few were compatible. The overwhelming majority of commercial and non-commercial software written for weaving was for Apple computers. This was the primary reason I chose Apple for thesis research. The Pattern Master IV software was the most comprehensive system package at the time and still is, although it is clearly not the fastest. It could be compared to an encyclopedia of design and structure.

The Atari computer used with Weave Master software and the Designer's Delight compu-dobby system, which were purchased for the Weaving Studio in the Art and Design Department at Iowa State University, were marketed aggressively by the Macomber loom company. Weave Master's speed and ease of use made it competitive with other software on the market. However, the Macomber company focused on Atari's use of color, which went far beyond the
capabilities of Apple computers, in order to make it a definite alternative. High resolution color display on the Apple IIe with Pattern Master IV is limited. From a total of six available colors, only two colors may be invoked at the same time for a design, one color for background and one color for foreground. In comparison, Atari's palette of 128 colors provides much more variety to those weavers working with multi-colored patterns.

Weave Master was the only weaving program written for Atari, showing a lack of support for this computer system on the part of programmers. Further, the system was not supported by its own manufacturing company. If new versions of Weave Master for other computer systems become available, the market for it will probably improve. As it stands now, the Atari line of computers for which it was originally written is virtually non-existent. Software written for Apple, IBM, Commodore and Tandy computers remain the most viable choices. Modern microcomputer history has evolved so quickly that these trends could not have been foreseen in 1982.

Pattern Master IV and Weave Master are so different that I found that they actually complemented, rather than excluded, each other in use. I used Pattern Master IV to develop profile drafts. By nature these are short and do not include long and complicated repeats of units. Pattern
Master IV operates fastest with this kind of draft. Variables can be changed quickly and results printed in a fairly short period of time. The design analysis function always analyzes a pattern to be woven in the most direct manner. One can be sure that patterns will be presented with an efficient use of harnesses and treadles.

I used Weave Master to develop structural drafts. These drafts were long and intricate, examinations of structure, or sometimes original drafts combining different structures. Inputting drafting information for these patterns would take a long time on Pattern Master IV, but was relatively fast on Weave Master. The view levels made it possible to examine both sides of the designs easily, and adjust threadings for smooth transitions. In addition, the high resolution screen made viewing large patterns possible.

Designer’s Delight, by itself, without drawdown software and a graphics screen, seems inadequate. Although Designer’s Delight is a good system for efficient weaving, I believe Autoweave on the Atari is far more complete and answers every weaver’s needs in terms of computer-loom interfacing, with the added benefit of drawdown designing in color.
CHAPTER 4

CREATIVE ASPECT OF THE THESIS

Block Weaves

The creative aspect of this thesis comprises a series of works based on block weave design. I became interested in designing with block weaves on the computer when I started working with Scorgie and Sinclair's Block Patterns and Posneg programs (66; 67). The Posneg program generates 2-block designs while the Block Patterns program generates designs of up to 6 blocks. Their methods of output on the computer screen are rudimentary, displaying a maximum of 40 rows and 40 columns in low resolution graphics. The programs provide commands for saving designs and auxiliary programs for retrieving them. Though printing low resolution graphics is not automatic with my graphics card -- Grappler+ -- it can be accomplished with additional software. A program, titled Triple Dump, allows low resolution graphics to be printed with some rewriting of the Block Patterns program, though the Triple Dump disk must be run with the Block Patterns program disk. Given their limitations, these programs proved to be less useful as design tools and more useful as inspiration for working with the particular class of weaves called Block Weaves and
traditional drawdown programs.

As was stated in Chapter 2, block weaves are characterized by their variety of structure and texture, and the fact that they can be designed by combining and interchanging separate threading, tieup and treadling units in any order for the complete design. Block weave designs are manifested by the juxtaposition of textures between background and foreground. They may be used to create abstract geometric as well as realistic designs. Block weaves used for the creative component for this thesis are Summer and Winter in several variations, Damask, Tied Lithuanian, Biederwand, and Double Two-Tie Twill.

**Summer and Winter**

Summer and Winter is a tied unit weave with a supplemental pattern weft alternating with a tabby weft. The threading is divided into alternating pattern and ground (or tie-down) warps. By convention the ground warps are threaded on harnesses 1 and 2, the minimum number of harnesses needed to make a tabby or plain weave. The pattern threads are distributed on the remaining harnesses. For example, on an eight harness loom, the first two are tie-down harnesses, and the other six are pattern harnesses, one for each block. The basic threading unit is four threads long, containing both tie-down threads alternated
with two pattern threads on one harness. The potential
design units for an 8-harness loom are: 1,3,2,3; 1,4,2,4; 1,5,2,5;
1,6,2,6; 1,7,2,7; and 1,8,2,8. The individual
units may be repeated any number of times and combined in
any way in order to satisfy design needs. Often the draft
is expressed in a condensed form called a profile. When the
weaver uses a profile draft with Summer and Winter, each
filled-in square in the threading draft is equal to one
four-thread unit.

I have used Summer and Winter in different ways for my
designs, because it is a very versatile block weave. Not
only can its threading units be varied, but the methods of
weaving it are also quite diverse. In traditional Summer
and Winter the pattern weft floats over a maximum of 3
threads before it is tied down. In some designs I extended
the threading unit to increase the float length. For
instance, in one threading sequence I used 1,3,1,3,2,3,2,3;
1,4,1,4,2,4,2,4, etc. to achieve a five-thread float. In
another design I used the threading sequence 3,1,3; 4,2,4;
5,1,5; 6,2,6; 7,1,7; 8,2,8 etc., augmented to 3,1,3,1,3,1,3;
4,2,4,2,4,2,4; 5,1,5,1,5,1,5 etc. and achieved a float of
nine threads. I have treadled Summer and Winter in its
traditional texture with the back of the fabric a negative
image of the front. I have also used it to achieve a
tapestry-like texture with the weft completely covering the
warp, and the background and foreground defined solely by color.

Another reason for my frequent use of Summer and Winter was because it offered the greatest number of blocks for designing. Six blocks was the maximum used on my 8-harness loom. Eight blocks were used on the 10-harness computer-loom in the design studio.

**Damask**

Damask and its variations were the only 2-block weaves I worked with on the computer. (It is also possible to produce 2-block double weave on eight harnesses. I did work with 2-block double weave, but not as thesis research.) A true damask actually requires 5 harnesses per block. A "mock" or "false" damask is possible with but 4 harnesses per block. The resulting structure is a broken twill with a texture that closely resembles true damask. The two blocks that alternate in damask are satin weave, in which there is a warp emphasis allowing small dots of weft to show through; and sateen, in which there is a weft emphasis allowing dots of warp to show through. Damask is typically a dense fabric. The tie-up creates warp or weft floats. If the warp and weft threads are tightly spun, and have a hard finish with no short fiber ends protruding, the weaving will possess a light-reflective quality that is always associated
with this structure. Silk and linen are often the long staple fibers appropriate for this purpose. One striking aspect of damask is the effect created by weaving with the same color in warp and weft. The satin (warp emphasis) blocks appear to be a different color than the sateen (weft emphasis) blocks. This phenomenon is due to the light reflective qualities of the weave.

Damask is threaded to a straight twill. Each block repeats its threading in the same order, either 1,2,3,4 or 5,6,7,8. The blocks may be repeated or alternated as many times as desired. True damask has floats of 4 threads tied down by 1 thread in each 5-thread sequence. These are treadled purposely to create a random order of tie-downs, drawing attention away from a regular twill diagonal. False damask on 8 harnesses is treadled with floats of 3 threads tied down by 1 thread in each 4-thread sequence. With a closely spaced warp and a broken twill treadling order of 1,3,2,4, the false damask blocks are very similar in appearance to true damask.

**Tied Lithuanian**

Tied Lithuanian is another block weave. Harnesses 1 and 2 provide the ground weave and are threaded as a pair alternately with paired pattern harnesses. Blocks are threaded 1,2,3,4,3,4,3,4,3,4 or 1,2,5,6,5,6,5,6,5,6.
The pattern harnesses are paired for two reasons. First, they can provide longer floats than, for example, the 3-thread float limit in Summer and Winter. These pattern harnesses can be threaded for floats of any desired length. Secondly, odd/even pairs are needed to provide a plain weave shed treadled after every pattern float shed to "lock" the float in place. Since the pattern harnesses must be paired, only three pattern blocks are possible on an eight harness loom. This limits design potential, though three blocks provide more opportunities than damask.

The lack of tie-down "dots" in the plain weave areas is the visual advantage of this weave structure. In Summer and Winter these unavoidable dots are a prominent part of the design in both back- and foreground. Their effect can be minimized to some extent with various weaving "tricks." The Tied Lithuanian background is "cleaner" with the tie-down appearing as a vertical line between each pattern row.

**Beiderwand**

Beiderwand is another member of the "family" of tied block weaves. Tie-down threads are again on harnesses 1 and 2. With Beiderwand each block unit has but one tie-down and two alternating adjacent pattern harnesses. The threading blocks follow a sequence of 1,3,4,3,4,3,4, or 2,5,6,5,6,5,6, or 1,7,8,7,8,7,8,7,8.
The tie-down threads are independent of the background or tabby areas, making sharp color distinctions possible. The tie-downs appear only in the pattern float areas allowing the weaver to keep background and pattern colors completely separate. Again, since the pattern harnesses are threaded in pairs, only three blocks are possible on an eight harness loom. A true plain weave cannot be produced because adjacent harnesses do not always follow an odd/even sequence.

**Double Two-Tie Twill**

The double two-tie is a system of threading the loom which gives rise to many different structures by changing only the tie-up. It is not a block weave per se, but it may be treated as such since the individual threading units may be used as blocks. It is *double two-tie*, as opposed to Summer and Winter, which is a *single two-tie* unit weave. The difference is obvious when one studies the individual threading units. A Summer and Winter unit, 1,3,2,3, has two tie threads, but with identical pattern harnesses. With double two-tie, a threading unit may be 1,3,2,4. The tie threads remain the same, but there are two different—thus double instead of single—pattern harnesses.

The system is flexible. Each threading block, depending on how it is tied up, acts independently of all
others. Many structures may be woven on this threading; structures may be mixed in the same tie-up. Balanced (2/2) and unbalanced (3/1) twills, double weave, huck textures, basket weave, and Summer and Winter may be woven on the same threading. The major limitation is the small number of block variations that exist. As with Tied Lithuanian and Belderwand, only 3-block designs are possible on an eight harness loom, compared with six potential units in Summer and Winter.

Double two-tie twill is a method of designing twills that enables the weaver to change the direction of the twill from the right diagonal to the left independently for each block. For example, a fabric may be woven with blocks A, B, and C all moving first in right diagonals. Then the weaver may wish blocks A and C to remain at right diagonals, but reverse Block B to a left diagonal. The change is made in the tie-up; no change takes place in threading or treadling sequences. The tie-ups require a thorough understanding of drafting, but offer a great deal of freedom once the designing conventions for the system are understood.
Since the creative aspect of the thesis was to be a study of block weaves, I felt the most systematic way to proceed was from the smallest number to the largest number of blocks possible on eight or ten harness looms. As the number of blocks increased from two to eight, the more complex the design became. Two-block designs were limited to variations on damask. Three blocks were used with Tied Lithuanian, Beiderwand and Double Two-Tie Twill. There are block weaves limited to four or five blocks, but they are really variations of Summer and Winter. I preferred to use Summer and Winter to its full potential of up to six blocks on an eight harness loom or up to eight blocks on a ten harness loom.

Two Blocks: Damask

"Gridsatin: Hardcopy"

"Gridsatin: Hardcopy" was one of several designs in which I used the computer program called--by my own term--BPP, a modified version of Blockpatterns (66). Modifications had to be made to allow printing of low-resolution graphics. This was a 2-block design with two colors, red and black, used in both warp and weft. Patterns
having only two blocks rely heavily on the play of proportions and repeats of units. This was a formal study of grids that alternated between remaining constant or varying in size. The grids that were constant were woven with red weft; the grids that varied were woven with black weft. The black weft area grids became elongated up to a point a little more than halfway from the top. They then became shorter, until the last two were smaller than the red areas. There were four repeats of the color/threading units with two of each type: black background with red squares, or red background with black squares. Below is a profile draft of the basic design:

![Profile draft of the basic design](image)

**Figure 13. "Gridsatin: Hardcopy" profile draft**

The draft showed four blocks in the threading area, which was the computer's way of compensating for color changes in the warp. The proportions of the blocks and their order were the same for the units on lines 3 and 4 as for the units on lines 1 and 2. The design was treated in warping and weaving as two blocks. The color order in the
warp, corresponding to the blocks in the profile draft, was: B, RR, B, RR, B, RR, B, R, BB, R, BB, R, BB, R, B.

The structure used was "false" damask, having two blocks of four harnesses each for a total of eight harnesses. The "B" block was threaded on harnesses 1, 2, 3, and 4, and the "R" block on harnesses 5, 6, 7, and 8, before the proportional arrangement was reversed. More contrast was visible in the finished piece than appears in the computer drawdown. In addition to the use of two contrasting weft colors, there is a further textural differentiation within each color area creating texture grids of warp satin and weft sateen.

The following print-out of a block substitution of damask weave in the profile draft shows the texture difference between satin and sateen weaves. Again, the computer cannot show color, so the boundaries of the grid do not appear "filled in."

Figure 14. "Gridsatin: Hardcopy" drawdown
Project Specifications:

Warp: 20/2 polyester
Weft: 20/2 polyester
Ends per inch: 45
Width on the loom: 25"
Total warp ends: 1125
Dimensions off loom: 73" x 23"

"T. Satin: Hardcopy"

The final design for "T. Satin: Hardcopy" was developed from two computer programs. I started with BPP to arrange figures and background into suitable groupings. The actual draft for the structure, which combined plain weave and 5-shaft satin weave, was developed on Weave Master. Below are, (a) the profile draft of the basic block arrangement and, (b) a print-out of the BPP configuration:
Figure 15. "T.Satin: Hardcopy" profile draft
As with "Gridsatin: Hardcopy," this is an examination of formal design possibilities. There are nine distinct groups of rectangles which divide the visual space horizontally and vertically. The variety and similarity in the proportions of the rectangles is only one aspect of the
total design. Color also plays an important role. The squares of pattern are defined by colors of differing and mixed hues. The warp for these areas was made by winding several colors simultaneously. After the required number for a group was wound, one color was dropped and another added. In this way the transition from brown/magenta/burgundy on the left became gold/orange/peach/dusty pink in the center, and finally brown/lavender/gold-brown on the right side. The colors were threaded in random order on the pattern harnesses (damask threading). The satin treadling order with harnesses lifted to cover warps in order on harnesses 1, 4, 2, 5, 3 created a pattern that recalls card-woven textiles.

The two blocks were a combination of two structures: the background block using plain weave, and for the pattern areas, 5-shaft satin. A total of seven harnesses was needed for this weave structure. The background areas consisted of one set of warps with the plain weave areas threaded on harnesses 6 and 7. Two sets of warps appeared in the pattern areas; one for ground and one for the pattern. These were independent structures joined by a common weft yarn. The pattern warp was threaded on harnesses 1 through 5, alternating with 6 and 7. In the background areas, only harnesses 6 and 7 were activated, but in pattern areas,
satin weave and plain weave were activated together. The plain weave was made invisible because it was covered by the pattern warp's satin structure. Wherever the satin warp was not included in the design, it floated on the back. The dense satin weave created a sculptural relief against the flat plain weave.

Figure 17 is the threading draft and tie-up draft used:

![Weave Draft](image1)

Figure 17. "T.Satin: Harcoopy"

The weave structure was developed from Weave Master. I was seeking a 2-block damask with background areas which would have no evidence of color from the pattern blocks. The only way to accomplish two distinct color and background areas was to use two sets of warps which could either act independently or interact, depending upon the treadling, although only one weft was used.
Project Specifications:

Warp: 5/2 cotton
Weft: 5/2 cotton

Ends per inch: 
plain weave—20  
satin weave—30  
combined areas—50  

Width on the loom: 22 3/4"

Total warps: 
plain weave—455  
satin weave—450  
combined—905  

Dimensions off the loom: 32" x 21"

Three Blocks: Tied Lithuanian

"Drawdown Series 1, 2, 3, 4"  

This drawdown series originated with an idea to bring the drafting elements used by weavers when designing on graph paper directly to the weaving. The drawdown became the woven piece. I was working with Pattern Master IV during the summer of 1985 when I became aware of the interrelatedness of the elements of drafting, as well as the grids used in computer programs for weavers. I felt that an appropriate application of the software would be to create a series of pieces which changed the design by varying one element of the draft, the tie-up. The series comprises a transition with four separate parts. To intensify the idea of drawdown as fabric, I "superimposed"
lines of black in both warp and weft to give the feeling that the pattern was filling in squares on a page of graph paper.

An additional challenge was the incorporation of a 3-block weave, Tied Lithuanian. The strong verticals of the tie-down areas and the clean spaces of the background and pattern areas made this an appropriate weave for the graph paper idea. However, I had to design a pattern with sufficient interest to create a series in transition, yet simple enough for three blocks. A cropped four harness "blooming leaf" type pattern, generic in origin, generally intended as a four-block design, was converted to three blocks. I edited this new design and cropped it further until I was satisfied with the block arrangement. To complete the transition idea I varied the tie-up by systematically adding a harness block for each successive piece. The diagrams below illustrate the development of the transition in both the tie-ups and in the profile drafts:

Figure 18. Tie-up transitions
Figure 19. "Drawdown Series 1, 2, 3, 4" profile drafts
Color was an important aspect of the transition study. I blended the colors of the warps starting with dark rose then working through pink to lavender and finally light blue. I chose very fine cotton and gradually added or subtracted colors so no colors would appear to form stripes. The fineness of the warp helped the eye to blend the colors.

I used different background and pattern weft colors in each. The interaction of background weft and pattern weft added a dimension in a background/foreground interchange from #1 to #4. Light pink background weft and dark purple pattern weft were chosen for the first unit: the figure was dominant over the background. For the second the tabby weft was light blue against a bright pink pattern weft. With the addition of an extra block in the tie-up the design lost most of its "curve." The blue background receded, but the bright pink of the pattern weft blended into the background because it was not strong enough to stand out. The figure/ground relationship became more ambiguous. With the third I used light violet background and dark mauve pattern weft. The pattern areas continued to fill a greater portion of the space. Again the light purple background and mauve figure were ambiguous. The last in the series had a burgundy tabby weft and light blue pattern weft. The pattern areas receded for two reasons. First, due to the color placement in the warp, the pink background areas
tended to come forward; two, because of the static nature of the blue pattern weft which made it less interesting than the light warm color of the background. These factors caused the pattern and background to switch roles.

Project Specifications:

Warp: 40/3 cotton

Background weft: 40/3 cotton
Pattern weft: 5/2 cotton

Ends per inch: 50

Width on the loom: 9"

Total number warp: 450

Dimensions off the loom (each piece): 9" x 11"

Three Blocks: Belderwand

"Transitions: Hardcopy"

I continued my investigation of transition in this piece. Although less complex than "Drawdown Series 1, 2, 3, 4," it demonstrates the possibilities of designs using just three blocks. I wanted to use Belderwand in a piece that required a clean break between back- and foreground. I wanted to avoid color distractions and eliminate tie-down yarns because I had chosen lurex for the background weft.

The profile design selected was similar to the one used for the drawdown series. I began with a tie-up and again added blocks each time for three other versions of the
design. The tie-up sequences were as follows:

<table>
<thead>
<tr>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Tie-up #1" /></td>
<td><img src="image2.png" alt="Tie-up #2" /></td>
<td><img src="image3.png" alt="Tie-up #3" /></td>
<td><img src="image4.png" alt="Tie-up #4" /></td>
</tr>
</tbody>
</table>

Figure 20. Tie-ups

The sequence, as shown in the profile draft print-out, maintains the curves and the "sense" of the design, even as the figure/ground emphasis slowly reverses itself. The negative version of the top image becomes a positive image at the bottom.

Figure 21. "Transitions: Hardcopy" profile draft
The warp was made by blending colors as was done for the drawdown series, but with a series of five colors ranging from beige, to copper, to light browns. I used copper colored lurex for the tabby weft throughout. This seemed to unify the warp, blending to give a subtle effect. The impact of color change and "shimmer" often depended upon the angle of viewing. I used the same pattern weft, deep burgundy, to unify the four images of the transition.

The profile draft is an expanded version of the drawdown series' cropped "blooming leaf."

**Project Specifications:**

Warp: 20/2 cotton  
Background Weft: lurex  
Pattern Weft: 5/2 cotton  
Ends per Inch: 45  
Width on the loom: 18"  
Total warp ends: 810  
Dimensions off the loom: 27 1/2" x 17 1/2"  

Three Blocks: Double Two-Tie Twill

Wool Yardage

The purpose of this project was to use computer-block designing to weave a textile suitable for a garment when completed. I chose to weave a plaid fabric with twill variations in double two-tie twill. The process of
designing with these twills involved making a small schematic grid to show the twill direction for each treadling block. The following diagram illustrates the grid developed for this fabric. It is also a condensed method for representing the tie-up.

![Diagram](image)

Figure 22. Wool yardage twill diagram

The capital letters indicate the order for the three treadling blocks. Each block consists of four treadles. The small letters denote the harnesses, 3 and 4, 5 and 6, 7 and 8, and the direction of the twill for each set. Thus for treadling block A which will be woven on treadles 1 - 4, the twill be a right diagonal on harnesses 3 and 4, left diagonal on harnesses 5 and 6, and left diagonal on harnesses 7 and 8. Harnesses 1 and 2 function as a "base" and are always tied in the same way. The following illustrations represent the tie-up; the profile draft used for the wool yardage; and the translation of that draft into double two-tie twill:
Figure 23. Tie-up draft  

Figure 24. Profile draft  

Figure 25. Wool yardage drawdown
The color order of the plaid, in black, grey, taupe and white, corresponds to the blocks of the profile draft. The color blocks are also repeated in the same order in the treadling sequence.

**Project Specifications:**

Warp: 18/2 wool worsted  
Weft: 18/2 wool worsted  
Ends per inch: 24  
Width: 37"  
Total warps: 876  

**Five Blocks: Summer and Winter**  

"Untitled Rug #1"

At the time my design interests were focusing on block weaves, the weaving pattern book of a 19th century German-American weaver, Jacob Angstadt, came to my attention (33c). Published in 1976 by Ruth Holroyd and Ulrike Beck, Angstadt’s book of patterns was mostly block drafts to be used with double weave, twill diaper, or damask, on a loom requiring up to 32 harnesses. His profile drafts work well with a smaller number of harnesses because they can be modified with any of the block weaves. This rug began with a portion of a draft in Angstadt’s book. It quickly metamorphosed, however, and the finished draft bears little
resemblance to the original. Pattern Master IV made design changes happen quickly. I rearranged parts of the threading as well as parts of the treadling. Below is draft information resulting from the computer designing:

Figure 26. Preliminary profile draft
The draft was rotated 90 degrees, analyzed, and the following data were used for the actual woven rug:

The design initially required six blocks, but after altering and analyzing it was reduced to five blocks.

The pattern that emerged was a symmetrical arrangement of rectangular shapes. There was a strong sense of the
horizontal broken only by a few vertical lines, placed on the right and left sides and at the center. I used natural white rug wool for the background with rust, orange, brown and grey wools for the figured areas. The colors were combined and grouped to heighten the idea of a horizontal and vertical within the rectangles. Vertical striping developed when two weft colors were alternated with each shed; horizontal striping was possible if two shots of the weft colors were thrown in adjacent sheds followed with two shots of the second color.

In this piece I used the Summer and Winter structure in a technique called "boundweave." This term refers to weaving in which the warp was completely covered by the weft. Plain weave was not used to lock the pattern weft into place. Instead, the pattern blocks were kept in place by the next weft woven on the opposite blocks. For example, if blocks on harnesses 3, 5 and 7 were used for the pattern area, blocks on harnesses 4 and 6 would be used for the background area. Each pattern combination had to be woven first with the first tie-down harness followed then by the second. The following is a tie-up for Summer and Winter with boundweave showing the tie-down harnesses required for each pattern block:
Tie-ups for this technique typically required many more combinations of harnesses than there were treadles on the loom. This necessitated re-tieing the treadles after a set of pattern blocks was woven, or working out a system forcing use of both feet to press on more than one treadle.

**Project Specifications:**

Warp: 10/4 linen used double  
Weft: rug wool  
Ends per inch: 5 (10)  
Width on the loom: 36"  
Total warp ends: 180 (360)  
Dimensions off the loom: 48" x 34"

"Untitled Rug #2"

This rug also began in the pattern book of Jacob Angstadt. I used one of his designs but again the profile draft was no longer recognizable. With Pattern Master IV it
was possible to manipulate the threading elements, changing block positions and proportions. When a draft was finished I exited to the Design Entry Menu and rearranged the drawdown. The new design was analyzed, and the new draft information was developed. Eventually I selected the 5-block design to be woven with Summer and Winter in the boundweave technique.

Figure 29. "Untitled Rug #2" profile draft
Like the previous rug, this was a horizontally and vertically symmetrical design. Two groupings on the right and left were mirror images facing the center. The center motif was a series of rectangles connected by short, alternating stripes of positive and negative space. The design was less complex than the previous rug, both in the design and in the number of colors used. There were two pattern colors, turquoise and red violet, on a grey background. Visual interest was heightened by the addition of small areas of striping to break up the area of the large rectangles.

**Project Specifications:**

Warp: 10/4 linen doubled  
Weft: Rug wool  
Ends per inch: 5 (10)  
Width: 34 1/2"  
Total warp ends: 172 (344)  
Dimensions: 48" x 32 1/2"

Six Blocks: Summer and Winter

"MacKintosh Variation #1"

The "MacKintosh Variations" pieces were inspired by patterns in the Jacob Angstadt book. I had noticed a portion of a design that reminded me of the design work of
Charles Rennie MacKintosh. MacKintosh was a Scottish architect who worked at the turn of the 20th century. He also designed furniture and textile prints. MacKintosh used grids as design motifs in his furniture, often combining organic abstract floral forms with geometric lines. I focused on that detail in the Angstadt book and decided to work with it on the computer. The resulting design retained much of the original MacKintosh feeling.

Figure 30. "MacKintosh Variation #1" profile draft
The design area was divided into three nearly equal spaces with grids at each of the four corners. However, with changes in threading and treadling each grid was different from the all others and they were connected on all four sides by three stripes. The four corner motifs were common to all pieces in this series. The middle motif was a stepped figure with a modified grid at the center. The middle grouping was elongated vertically so that the vertical space division was unequal. The appearance of symmetry was misleading: the image was balanced, but not symmetrical.

The colors used for the warp in this piece were wound in stripes with blues and purples corresponding with each side block, and pinks and lavender corresponding with each center block. I wove the background weft in color stripes so that the "windows" of the grids would change color. The pattern weft chosen was a heavy weight cotton in pale grey. I wanted an ambiguous statement of figure/ground relationships from this color. The figure stood out because of its texture. The background asserted itself with subtle color variations.

I wove this Summer and Winter structure in a technique somewhat like Tied Lithuanian, in that I used only one tie-down harness instead of the two typical of Summer and Winter. This produced a vertical effect that was less
cluttered than the traditional Summer and Winter, as seen in the following print-out of the tie-up:

![Figure 31. Tie-up draft](image_url)

**Project Specifications:**

- **Warp:** 40/3 cotton
- **Background weft:** 40/3 cotton
- **Pattern weft:** 5/2 cotton
- **Ends per inch:** 45
- **Width:** 15 4/5”
- **Total warp ends:** 704
- **Dimensions:** 20” x 15”

**"MacKintosh Variation #2"**

This piece in the MacKintosh series was woven with the rug format, Summer and Winter in boundweave, for a tapestry effect. (In a sense, all of the rugs were loom-controlled tapestries. The weft was continuous from selvedge to selvedge, there was no hand manipulation of the warps, but the warp was completely covered by the weft and the design was defined by the colors of the weft. Although
seemingly contradictory, I think the term loom-controlled tapestry applied here.)

The corner motifs appeared again, though they account for proportionately less of the total space. The stepped figure in the center of the previous piece had given way to a grid within another larger grid. The stripes and small

Figure 32. "MacKintosh Variation #2" profile draft
squares seen in the border areas were echoed in the center motif. I worked with the ambiguity of background and foreground once more, using dark grey for the background and a series of bright colors, greens, turquoise, rust, gold and orange, for the figure areas. The colors played against each other, repeating, moving the viewer's eye around the piece.

**Project Specifications:**

Warp: 10/4 linen (double)

Weft: rug wool

Ends per inch: 5 (10)

Width: 32 4/5"

Total warps: 164 (328)

Dimensions: 44" x 31 3/4"

"MacKintosh Variation #3"

The third piece in this series again used the corner motifs, reduced to occupy only about 2/9 of the total horizontal design space. As with "Untitled Rug #2," only two pattern colors were used, muted red and coral pink, woven against a light grey background. The center motif was simplified to a grid superimposed on a square, bordered by large rectangles and squares. The red areas formed a border around the whole piece. The pink figures "weave" behind and
In front of the red figures. This color effect was achieved by changing the blocks which carry either red or pink in the tie-up. I used the boundweave technique with Summer and Winter threading once again.

The following is the print-out:

**Figure 33. "MacKintosh Variation #3" profile draft**

**Project Specifications:**

Warp: 10/4 linen (double)

Weft: rug wool

Ends per inch: 5 (10)
Width on the loom: 37"
Total warps: 185 (370)
Dimensions off the loom: 50 1/2" x 34 1/2"

Eight Blocks: Summer and Winter

"Little Schoolhouse Runner"

I used two computer systems to produce this piece, Pattern Master IV for the design and Autoweave In Weave Master to weave it. I began with an image. I wanted to see if the folk-art motif of a "little schoolhouse" could be analyzed for weaving within the 10-harness limit of the Macomber computer-loom in the Design College weaving studio. Because of the limited number of harnesses I had to make the design "fit the loom." However, since I was planning to weave it with the electronic dobby attachment, the amount of treadles required could be unlimited.

The initial design was a straight-on view. I entered it on the design grid screen of Pattern Master IV, knowing I had to keep the design to a minimum number of blocks. I knew that Pattern Master IV would yield the simplest solution possible in drawdown form. However, even the simplest drawdown still required 13 harness blocks and 8 treadling blocks. See print-out:
Thirteen harness blocks would have required a 15 harness loom in the Summer and Winter structure. But, since there were just eight treadling blocks I decided to exchange the threading and treadling sequences. (This is called "turning" a draft, that is, rotating it clockwise 90 degrees.) Pattern Master IV provided that option on the Design Edit menu. When the rotated design was re-analyzed, the new drawdown presented required 8 harness blocks and 13 treadling blocks. I was well within the loom's harness
capabilities for Summer and Winter since 10 harnesses were necessary for 8 pattern blocks. The following is the finished design print-out:

Figure 35. "Little Schoolhouse" profile draft

I chose a traditional Summer and Winter treadling technique that required two treadles per harness combination—one with the first tie-down harness, then with the second tie-down harness—plus two plain weave treadles
for a total of 28 treadles. On a traditional handloom this would have meant re-tying treadles frequently, but with the compu-dobby system, all the tie-up combinations plus the treadling sequence, were stored in the computer's memory. Weaving this runner was a simple matter of mentally monitoring the progress of the sequence, watching the computer screen, moving the master pedal up and down and throwing the shuttle.

The runner is symmetrical, with rows of paired houses on each side for the length of the piece. Typical colors of

Figure 36. "Little Schoolhouse Runner"
blue and white were used to strengthen the traditional feeling of motif and structure.

Project Specifications:
Warp: 12/2 cotton
Background weft: 12/2 cotton
Pattern weft: 5/2 verel
Ends per inch: 24
Width: 14 1/3"
Total warp ends: 344
Dimensions: 13 3/4" x 36"

"Shimmer #2"

The concept for this piece was to design in the tie-up. Accepting the harness limits on the compu-dobby loom, but knowing that treadle numbers were virtually unlimited, I proposed to try a complete design within the confines of the tie-up. It would be just eight blocks high, but it could be as wide as needed. I worked out an undulating pattern with 8 harness blocks and 18 treadling blocks.
The initial experiments with threading and treadling sequences proved to be uninteresting. I wanted a design that was appropriate to computer weaving both in production and appearance, making use of traditional elements for design structure with an end product that was non-traditional. I was using Weave Master on the Atari computer at this stage of the design. The drafting elements required many repeats and Weave Master assimilated them quickly. I changed sequences many times before I decided to fragment the threading. Instead of the straight sequence of 1,2,3,4,5,6,7,8, I tried 1,2,3,4; 2,3,4,5; 3,4,5,6; 4,5,6,7; 5,6,7,8; 6,7,8,1; 7,8,1,2; 8,1,2,3. The same grouped fragmentation was introduced in the treadling. The resulting draft looked like this:
I retained the undulating aspect of the design with the addition of computer imagery.
This design took a long time to weave successfully because of many technical problems which had to be solved. I tried traditional Summer and Winter technique with fine cottons, but the design was "buried" in tie-downs. I made color errors: figure and ground were too similar. I wanted to use fine cottons, set closely together, but that meant I needed longer floats than traditional Summer and

Figure 39. "Shimmer #2" drawdown
Winter would allow. I finally used a variation of the Summer and Winter threading published by Carey (19b). This threading draft yielded a Summer and Winter-like structure with the same number of pattern harnesses. The float increased to three times the traditional float length of three threads for a greater visual impact.

I wove the design with one tie-down to minimize the effect of the background, and created a fabric similar to the Tied Lithuanian. In addition, by using a pattern weft that was a bundle of several colors, the tie-down effect was further minimized by dispersing it in colors that blended well with the neutral grey warp. I used silver lurex for background weft which unified the background and provided a new dimension to the title "Shimmer." "Shimmer" occurred also in the design because of the fragmented undulation of the figure; in color, in the bundled peacock colors of the pattern weft; as well as in the metallic sheen of the background weft.

I wove this piece with Autoweave on the Atari. The sequences went very quickly, so quickly that the whole piece took little more than two hours to complete.
Project Specifications:

Warp: 40/3 cotton

Background weft: silver lurex
Pattern weft: 5 strands of 40/3 cotton wound together: turquoise, purple, green, blue, and red-violet

Ends per inch: 50
Width on the loom: 11"
Total ends: 550
Dimensions off the loom: 10 3/8" x 10 3/4"

Six Blocks: Summer and Winter

"Undulation"

This project is a 6-block interpretation of the undulating draft used for "Shimmer #2". It was woven on an eight harness loom with a tie-up of 17 treadles. This piece allowed further exploration of the concept of imagery which is appropriate to both computers and weaving.

I used the fragmented threading order and treadling sequence once more, this time breaking the units into groups of three.
My design for the piece was intended to invoke digitized images seen on video screens. Generalized into color value areas, these images are typical of computer technology used in television. The already fragmented undulating pattern was broken further into color blocks of
two shades of grey and black, with a white background. The color blocks alternated in random order by changing the shuttle order as the blocks were treadled.

The tie-up for this piece utilized one tie-down. I wove the pattern areas and the background areas both with a pattern weft, locking them in with plain weave. The pattern and background developed the same texture, defined by color like the rug pieces. It was not woven with boundweave since only one tie-down was used. Boundweave requires two tie-downs.

My use of shiny cottons provided a light-reflective sheen, also appropriate to the design.

**Project Specifications:**

Warp: 10/2 cotton

Background weft: 40/3 cotton
Pattern weft: 5/2 cotton

Width: 14.4" 

Ends per inch: 20

Total warp ends: 288

Dimensions: 17" x 13 1/2"
Conclusion

A question that arises in the study of weaving and computers is whether computers are necessary as design tools. Could this study have been done, these pieces woven, without the aid of weaving software? How integral to the design process were Weave Master and Pattern Master IV?

Certainly, speed is one advantage of weaving software. The simpler 2- and 3-block pieces in this study could easily have been blocked out by hand, albeit at a much slower pace. The simplicity of those pieces was augmented by design complexities for which the computer was not responsible, but which were conceptual on my part—i.e., color transitions or texture grids. However, as the complexities of the designs grew, the usefulness of the computer became more and more apparent. The ease of design modification made pieces possible which had to go through at least ten or twelve revisions before a final design was chosen. The time factor would have been a much bigger determinant in the amount of work that could have been done had there been no weaving software with which to work. Also, without a computer, the spontaneity of designing would have been lost. Because more ideas can be tried more quickly, the number of ideas multiplies. The process is self-perpetuating. Yet, at the same time, speed is not always necessary. We go through phases in our work when it is easy to work quickly, when
ideas just flow. We also go through phases when it is best to slow down and think about our work. Computers in the design studio accommodate to our work habits; they are ready to help whenever we need them, and ready to sit idle, when needed, too.

The computer is a tool that can be used for all levels of weavers, from beginning to advanced. Beginning students can visualize with computers, in a dramatic way not possible with pencil and paper, how a simple design will look and how it will change. The Weave Master program probably provides the closest possible visual simulation of woven structure, much closer than provided by graph paper and colored pencils. The intermediate weaver can gain practice using the weaving software as a drawdown maker, especially if pattern weaves are a favorite mode of work. The advanced weaver can go beyond drawdowns when solving technical problems of structure, in combining structures, or deciding on appropriate structures; here designing becomes a truly intellectual exercise.

I brought to my woven pieces more than just a computerized drawdown. This software is just a part of the process. The rest of the process must come from the weaver. The pieces, in order to be effective on a variety of levels, require more than can be supplied by the computer. My creative works are complex in color, texture, structure,
visual appeal. I added those aspects of design to the computer print-outs and made the print-outs work.

I have always had an affinity for the geometry of harness loom images, the combinations of blocks which could be made to form stars, diamonds and leaf shapes. The fact that these same shapes could be produced easily in low- or high-resolution graphics on computer screens was an exciting prospect for me. I found, as I worked, that focusing on block weaves was a very appropriate way to combine computers and weave design. I felt, also, at first, that using computers as design tools would be sufficient for my aesthetic requirements. I soon saw that the compatibility of computers and weaving points more and more to imagery that is appropriate to both media. My goal in computer-weaving is to produce images that are computer-inspired. The "Shimmer 2" and "Undulation" designs were a start in this direction. I believe that computer and weaving imagery are complementary. Computer graphics seem to have a "textile" look with their pixels of color which echo the dots of color formed by over/under woven structure. I intend to produce computer textiles which reflect computer imagery.

Computer weaving, obviously, is not for everyone. Some would claim that computers and a nine-thousand-year-old craft like handweaving are not meant for each other at all,
and would ask whether the product of the two is really handweaving. Many weavers find satisfaction in throwing the shuttle, and watching the "magic" of the pattern appear, one weft at a time. These weavers are not looking for speed or efficiency. They do not want a million pattern possibilities. They would probably use closer to 100 patterns in a lifetime of weaving and would no doubt be satisfied with the design potential of a simple four harness loom. Yet, computer-weaving enthusiasts also feel the magic of creating new cloth in the form of more and more complex weaves. At this stage of design, exploration of complex weaves becomes not only an intellectual exercise, but also an integral part of the creative process. The danger lies in letting such an easily used tool do too much of the designing. Computers will never understand the fabric structure. They will not weave the cloth; they will only describe it. From there on it is up to the weaver. Thus, the use of computer-aided design, especially for those interested in complex weaving, is of inestimable value. A loom interface is not absolutely necessary, but a real-time, interactive computer-loom system does represent a giant step forward both in the creative and in the production process.
SUMMARY OF FINDINGS

The purpose of this study was to explore computer applications in all aspects of weaving with a particular focus on handweaving. Chapter one described the evolution of the Jacquard loom beginning with the first efforts by Bouchon, Falcon, and Vaucanson to make the drawloom more efficient for weaving patterned cloth. The Jacquard attachment was described in detail and compared with the first efforts of Basile Bouchon. While Jacquard's loom revitalized the French silk industry, its punched card mechanism also inspired Charles Babbage in his quest to build an automatic computing machine. The first chapter described how Jacquard's invention provided the conceptual impetus for the evolution of the computer. The contributions of Charles Babbage and Herman Hollerith, with his punched card census tabulation system, to their fields and their influences on the computer industry were discussed. The information in this chapter brought the evolution of the computer and loom full circle by describing how Janet Lourie, an IBM computer applications specialist, made the conceptual connection necessary for bringing computer control to the weaving process, specifically to the Jacquard loom of today. In this context the differences and similarities between Jacquard looms and computers were
explored. The first attempts to interface computers with weaving in order to control looms were described and the role of computers in today's textile industry was summarized.

Computers used by handweavers in their design work dates from the early 1970s, but it was not until the early 1980s that commercial software for weave design on microcomputers became widely available for use in the home or office. The second chapter described the extensive body of literature in the area of computer applications for handweavers. The different types of software were discussed in the contexts of their various functions. Weave drafting was summarized and it was shown how drawdown programs aid the handweaver in doing this job more efficiently and much faster. The types of "free" software, i.e., program listings, were discussed, and reference was made to informational articles of all types, design articles, books and software reviews.

The third chapter focused on two major software programs with multiple handweaving applications, Weave Master for Atari computers, and Pattern Master IV for Apple computers. The author described the steps involved in doing a drawdown with both programs. Extra functions for each of the programs were described: for example, the structural analysis capabilities of Pattern Master IV, and the color
capabilities of Weave Master. The strengths and weaknesses of each software program were discussed. Both of these programs are capable of interfacing with and running dobbý looms. The workings of the dobbý loom and each type of interface were described. The author's assessment of these "state of the art" looms was also given.

The fourth chapter was an analysis of the creative pieces used for the investigation of computers and handweaving, including the structures used for each piece, descriptions of the designs, print-outs, and technical specifications for each weaving. The author's assessment of the usefulness of computers in handweaving design was offered, as well as a statement of how computers will figure in her future work.
GLOSSARY OF TERMS

basket weave a variation of plain weave in which adjacent paired warps are interlaced with paired wefts.

binary a numbering system based on the numbers 0 and 1. Used by computers because of the two ways they respond to electricity, on or off, making the binary numbering system a convenient means for encoding information to be processed.

block or profile draft a shortened version of a weave draft, where the units in the threading draft represent groups of, rather than individual, warps. Used for designing with block weaves.

block weaves weaves with a variety of structures and textures which have the common characteristic of being combined in the threading and tie-up drafts in any order to create a motif. Blocks are defined by the juxtaposition of textures of background and foreground, as well as by possible contrast of colors. Also called "unit weaves."

bound weave a method of weaving some pattern weave structures such as overshot and Summer and Winter, in which weft floats produced by one set of harnesses are locked in place, or bound, by floats made by harnesses which are complements of the first set. No plain weave is used to lock weft floats in place. Used to produce weft-faced textiles.

comberboard equipment on a loom with a Jacquard attachment. A board with rows of holes through which the leash cords pass, to separate the warps and determine the density of the warp in terms of ends per inch.

command-driven program a computer program which is run by typing commands directly into the computer without referring to a menu.

compu-dobby loom a dobby loom equipped with a computer to provide an electronic means for powering it.

database computer software which stores information as a record-keeping function and has the ability to manipulate that information in a variety of ways.
**design in memory** when using Pattern Master IV weaving software, this is the stage of a design as it last appeared on the screen.

**dobby loom** a hand loom equipped with harness frames to carry the heddles, which uses sets of pegged wooden strips (lags) in a chain, much like a Jacquard attachment, for selecting and raising combinations of harnesses.

**drafting** the process of designing a woven pattern or structure, usually using graph paper scaled to any size grid.

**drawdown** the graphic result of combining the three elements of drafting, the threading, tie-up and treadling drafts. Also known as a "weave draft."

**drawloom** a hand loom used for weaving patterned textiles, and equipped with a set of harnesses for controlling the ground weave and a figure harness for controlling the individual warp threads which make patterns.

**fabric analysis** the act of documenting the interlacements of the warp and weft of a textile in order to determine the drawdown.

**griffe** on a Jacquard attachment, a metal bar over which the hooks attached to the lease cords are suspended, and which rise and fall with each turn of the square "cylinder" carrying the punched cards.

**ground weave** a weave which forms the background and anchor for textiles with patterning formed by supplemental warps or wefts. May be plain, twill, or satin weave.

**hand loom** any loom which is operated by a person rather than by machine power. Includes simple harness looms, dobby looms and looms with Jacquard attachments.

**harness** a frame on the loom which supports a number of heddles. Raising or lowering designated harnesses creates openings in the warp called sheds. Looms are equipped with a minimum of two harnesses, but most looms have four or more.

**heddle** a wire, flat metal strip, or cord with an eye or hold in the middle through which warps are threaded.
huck weave a loom-controlled lace weave which forms patterns with small motifs defined by warp floats on the face and weft floats on the reverse of the textile.

lag on a dobby loom, strips of wood with holes drilled lengthwise which may be filled with pegs. When several lags are strung together, they form a "lag chain," the dobby loom tie-up, much like the punched cards of Jacquard looms.

lamm on rising shed or jack loom, metal or wood bars which are tied to the treadles and which push the harnesses up when the treadles are pushed down.

leash cord on a drawloom or loom with a Jacquard attachment, cord with a small hole or eye in the middle through which the warp is threaded. Functions as a heddle does in harness looms.

lingo a weight attached to each leash cord on a drawloom or loom with a Jacquard attachment, which causes the warp to return to the closed or neutral position after a shed has been woven.

menu-driven program a computer program which is run by making choices from a list of commands displayed on the screen.

overshot a weave characterized by its patterns created by supplementary weft floats of varying lengths anchored in a ground weave of plain weave.

pattern thread a warp or weft yarn or group of yarns used to form a design or pattern to ornament the ground weave of a patterned textile.

plain weave the most basic weave structure, characterized by alternate warps and wefts passing over and under each other. The simplest weave. Also called "tabby" weave.

point paper paper divided into squares or rectangles like graph paper, and used for designing for the drawloom or Jacquard loom. Serves as a guide for cutting the punched cards for Jacquard looms.

power loom a loom powered mechanically, rather than manually.
random access in computers, memory or information which can be accessed at any location from any location instantly.

real-time in computers, output which is almost simultaneous with input.

reed on the beater of a loom, that part which acts to keep the warp yarns horizontally spaced, and to push each new weft into place.

serial access in computers, memory or information which can only be accessed in sequential order starting from a specific location.

shaft the group of heddles suspended on one harness frame.

shed openings or separations in the warp through which the weft yarn is passed in the weaving process.

shuttle a tool used in weaving, which comes in many shapes and sizes, and is used to carry the weft through the open shed of the warp. Holds a quantity of weft.

simple cord on a drawloom, the cords connected to the tail cords, which hang vertically, and which are tied in groups and pulled in sequence by the drawboy.

solenoid a cylinder containing a wire coil which acts as a magnet when an electrical current passes through it. On the Macomber compu-dobby loom electronic master pedal, each solenoid has a rod which is pushed from one side to the other side when an electric current passes through the solenoid and which connects with special hooks, making the treadle to harness connection.

split screen when using Weave Master software, sometimes the screen displays part graphic and part alpha-numeric information displays.

straight draw the convention of threading warp yarns through the heddles in consecutive order, i.e., 1, 2, 3, 4. This threading order may be used for plain weave, twill weave and satin weave.

tail cord on a drawloom, the cords which extend horizontally from the top of the loom, are anchored to the
side of the loom, and from which the simple cords are suspended.

**tapestry** a textile characterized by discontinuous weft which covers the warp completely and defines design areas by the colors and textures used in the weft yarns.

**threading draft** one of the three essential elements of a weave draft which indicates, in graphic form, the sequence of threads as they are assigned to harnesses on a loom.

**tie-down thread** the warps in tied unit or block weaves which bind pattern weft floats to make woven structures. In pattern areas these appear at regular intervals. In background areas these warps form plain weave with some texture from the pattern area tie-down points on the reverse side.

**tie-up** on the loom: the tying of treadles and harnesses into combinations which control the structure of the textile to be woven.

**tie-up draft** one of the elements of a weave draft which indicates in graphic form the combinations of harnesses to be used for a particular weave.

**tied unit weave** a unit or block weave characterized by supplemental pattern floats of weft which are anchored at regular intervals by tie-down warps.

**treadle** a pedal or lever, pressed by the foot, which activates the harnesses on a floor loom.

**treadling draft** one of the elements of a weave draft which indicates in graphic form the sequence of treadles to be pressed by the weaver.

**turned draft** method of weaving where the draft is rotated 90 degrees. The treadling draft becomes the threading draft and the threading draft becomes the treadling draft.

**twill** one of the basic weave structures, characterized by diagonal lines caused by the progression of the binding point of the warp or the float of the weft by an increment of one to the right or left.
warp a thread or group of threads held under tension on a loom which, when woven, forms the lengthwise element of a textile. Used with the word "ends", as in "warp ends," or simply "ends."

warping the loom the actions involved in preparing a warp for weaving: measuring, winding onto the warp beam, pulling the warp through the heddles and the reed, and tying the warp to the cloth beam rod under even tension. Also known as "dressing the loom."

weave draft see drawdown

weft a thread or group of threads which forms the crosswise interlacement of a woven textile.
EXHIBITIONS

"T.Satin: Hardcopy."


"Drawdown Series 1,2,3,4."


"Untitled Rug #1."


"MacKintosh Variation #1"


"Shimmer #2"

SLIDE LIST

1. "Gridsatin: Hardcopy." Polyester. 73" x 23"
2. "T. Satin: Hardcopy." Cotton. 32" x 21"
3a. "Drawdown Series 1,2,3,4." Cotton. Each: 9" x 11"
3b. "Drawdown Series 1,2,3,4." Detail.
4a. "Transitions: Hardcopy." Cotton, lurex. 27 1/2" x 17 1/2"
6. "Untitled Rug #1." Wool, linen. 48" x 34"
7. "Untitled Rug #2." Wool, linen. 48" x 32 1/2"
8a. "MacKintosh Variation #1." Cotton. 20" x 15"
8b. "MacKintosh Variation #1." Detail.
9. "MacKintosh Variation #2." Wool, linen. 44" x 31 3/4"
10. "MacKintosh Variation #3." Wool, linen. 50 1/2" x 34 5/8"
11. "Little Schoolhouse Runner." Cotton, velvet. 13 3/4" x 36"
12. "Shimmer #2." Cotton, lurex. 10 3/8" x 10 3/4"
13a. "Undulation." Cotton. 17" x 13 1/2"
13b. "Undulation." Detail.
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