# COMPUTER-AIDED TEXTILE DESIGN FOR HANDWEAVING

by

KARI ANN ARNOLD

B. F. A., The University of Kansas, 1978

---

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Clothing, Textiles, and Interior Design

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1982

Approved by:

Barbara M. Reagan
Major Professor

# TABLE OF CONTENTS

# LIST OF FIGURES

# CHAPTER I

## INTRODUCTION

The computer is coming of age in the textile industry, and with it a revolution is taking place. Computers are being used in all phases of the industry to control and assist in numerous textile processes. In the management control area, for example, computers are being used for production and inventory control, cost accounting, orders, billings, personnel data storage, sales analysis, and customer service. They are also being used to control processing systems in the area of textile development. Computer systems can control, monitor, and assist in the manufacturing and preparation of synthetic and natural fibers, in the production of woven, knitted, and printed goods, and in dyehouse operations.

The enormous capabilities of the computer have recently been adapted to the field of textile design. The computer is being used to replace traditional methods of designing woven, knitted, printed, and tufted textile products. The advantages of computer assistance in textile design are speed in designing, cost savings due to fewer mistakes and corrections, and increased design capabilities with instantaneous manipulation of pattern.

Similarly, an increase in the use of home computers has given the handweaver the advantages of speed and increased design manipulation through the use of computer programs. Computer-aided design for handweaving is a very new concept and, consequently, there are only a few programs that have been written for developing and illustrating handwoven patterns. The programs that have been written have certain disadvantages and limitations.

Some of the programs, for example, are limited to four or eight harness weaves which restricts design possibilities. A few of the programs use keypunched data cards which are fed into the computer, however, most hand-weavers do not have access to a keypunch machine or the large computer system that is required for this type of programming.

There has been little work done in developing computer programs to assist the handweaver in designing block weaves and overshot patterns. In addition, few programs are available which enable the user to manipulate color within a pattern. At the present there is only one program available that will analyze patterns for a woven design and produce the drafting information that is required to weave it. Existing computer-aided design programs for handweaving also do not provide adequate hardcopy output.

In addition, many of these programs were developed for use on the Apple II computer. Although the Apple computer is widely available, it is one of the most expensive home computers on the market. The purchase of a disc drive is also required to use the programs. The Commodore Vic 20 computer is currently the least expensive home color computer on the market and was chosen for this study because of price and capabilities.

A program design is needed that will contain the best features of the existing programs but will not have their limitations. The purpose of this study was to develope programs for the Vic 20 computer that 1) can manipulate pattern for single unit and block weaves, 2) will allow manipulation of color within a pattern, 3) will possess the ability to analyze a weave pattern and produce the drafting information required to weave it, and 4) will produce a printed hardcopy output in the form of a pattern draft that can be carried to the loom, which will provide the design and technical information needed to produce the weave.

# CHAPTER II

# REVIEW OF LITERATURE

## Use of Computers in the Textile Industry

### Computer Systems in Management and Production

The Jacquard loom, created by Joseph Jacquard in 1801 after approximately ten years of research, introduced to the physical process of weaving what would later become the basis for modern computer programming (18,45). Harnesses on the loom or individual threads of the warp could be programmed for lifting by means of holes punched in cards. The pattern is "programmed" by the hole punching. The Jacquard loom is used a great deal in the industry today for complicated designs.

The textile industry has been using modern computers since the 1950's, when the computer industry was still in its infancy. Larger textile companies were first able to take advantage of the new computer technology. As computer technology advanced, the price of computer systems dropped, and more medium sized companies were able to purchase computers. By 1967, most large and medium sized textile companies either owned or leased computer systems (9).

The early computers performed simpler tasks for the industry. Initially, computers were used primarily for financial and accounting functions. Technology has since greatly expanded the capabilities of the computer, and its applications in the industry have become varied and numerous. Computers are currently being used in all areas of the textile industry, and in all phases of textile development.

It is estimated that most textile manufacturers with available computer facilities use from 23 to 69% of their total computer time for systems management in the areas of production and inventory control, cost accounting, orders, billings, and status reports of division or departmental performance (9). The initial use of the computer for financial and accounting functions is no longer the primary function of computer based systems. Today, less than 25% of total company machine time is used for payroll and general accounting (9).

Data based systems are used for the storing and analysis of personnel information. A system such as this can include the individual's name, social security number, location, salary, position code and level, latest performance appraisal, date employed, and relocation information. By using a computerized data system, the chances of error are decreased and uniformity of the information can be increased. Some companies have established resume referral systems for hiring personnel by computer. The computer matches job applicants with career opportunities and selects candidates with the proper credentials to be interviewed for a position.

Computer time is being used for sales analysis and customer service operations. Computers can report on sample consumer textile purchases for marketing research. Computer records can be kept on production sales in order to establish market trends for fashion forecasting.

The newest area for computer applications is that of process control, which is probably the most significant area of computer systems development in the field of textiles. For example, process control systems are being used extensively in weaving production. The computer is linked to a loom for monitoring purposes. Ordinarily, a control computer maintains contact through sensing devices with an individual loom or a room full of looms. The system scans the sensors to note and log the loom's production status. This loom monitoring system can provide information such as comparative shift efficiency: the operating efficiency percentage for the current shift, previous shifts, and week-to-date for each set of looms; style efficiency: the current and week-to-date efficiency percentage of the looms running for each style, and the number of loom stops; weaver set efficiency: the total number of loom stops and efficiency percentage for each weaver's set; fixer set efficiency: the same stop total and efficiency percentage detail for each fixer's set of looms; and worst loom report: the ten most inefficient looms are flagged and reported for work planning. The computer may also print out a full, detailed history on a particular loom as an aid to keeping the loom at maximum production efficiency (9).

Process control systems are also being used in knitting production. Similar but less complicated systems are being used to monitor pickers, carders, and lapping, combing, and drawing equipment. Spinning frames may also be monitored. Other computer application areas include slashing and warping operations. Information such as yarn and lap uniformity, size, weight, machine speed, and temperature can be relayed and controlled by the computer in these operations. Computers are also being used to control many of these same factors in fiber production. Conditions can be more carefully controlled and monitored in the manufacturing of natural and man-made fibers with the assistance of computers.

Computer control in dyeing operations is a new area in the industry involving the use of the computer. Computer use in this area has been steadily increasing in the past few years. Computers in the dyehouse are used to control processes through sensing instruments. These instruments detect and signal changes in the processes to the computer. The computer then instructs controlling instruments to perform the required functions to maintain consistency in quality and rate of production.

Computer sytems are now capable of both batch and continuous dyeing operations. Dye and chemical formulas, and process variable standards such as temperature, dye bath level, pressure, and flow can be controlled by computers. The computer and associated control instruments can automatically sequence the valves or actuators necessary to fill, heat, pressurize, make chemical and dye additions, depressurize, cool, and drain dye becks. In the continuous dye range, the processing steps involving variables such as moisture, temperature, pad-bath level, pressure, and flow can be controlled by the computer. Advanced computer operations are capable of continuous monitoring of dye shades by the use of on-line color measurement instruments. All of these automatic instrument controls improve accuracy of dyehouse operations, and improve quality, production, and economy (9).

The most widely known and used application of computer assistance is that of automated color matching. This is a rapidly expanding area for computer use in the textile industry. The computer can reduce color matching time from days to a matter of minutes. Color matching by computer is more accurate than visual color matching. These benefits can result in costs savings for the manufacturer and a reduction in second quality goods. Instruments which are capable of recording the wavelengths of light reflected from dyed materials, such as colorimeters and spectrophotometers, are used. These intruments are commonly used in conjunction with computer programmed systems for fast, efficient, and accurate color matching of dyebath samples or fabrics (9).

# Computer-Aided Textile Design

## History of Computer-Aided Design

One of the newest areas for the use of the computer in the textile industry is that of computer-aided textile design. The introduction of the computer in the area of textile design has revolutionized and simplified the textile design process. Computer-aided design (CAD) was originally introduced in the field of electrical engineering in 1964 (22). Later, CAD expanded into the areas of mechanical engineering, civil engineering, the aircraft industry, and controlled systems design for military defense. Computation in these areas was directed towards the automation of large amounts of numerical calculations and technical drawings. These functions previously had to be performed by hand with limited tools.

Computer-aided design in textiles, however, is still in its exploratory stages in the industry. In the recent past, assistance by computer was not considered feasible in the area of textile design. The steps involved in the designing process were not well-defined in the industry and varied from company to company. This randomized flow of information did not lend itself to the assistance of a computer. However, with the rapid changes in textile technology, textile materials and machinery are becoming more diversified and computer assistance in textile design has become increasingly possible. New advances in computer technology have also increased the workability of computers in textile design. The speed, flexibility, and creativity offered by the computer have compelled the textile designer to take advantage of the opportunities of computer-aided design. The computer is currently being used as a design tool for textile design in weaving, knitting, and printing.

## Computer-Aided Design Methods

There are many ways in which fabric designs originate. They are recreated for the mill by a stylist or designer who may draw the original design, purchase it from an artist, or adapt the design from another source (i.e., nature or previous design work). Design considerations include the size of the design repeat, the basic fabric construction, and the weight and characteristics of the fibers and yarns. All of these factors influence the appearance of the fabric.

### CAD hardware systems

There are two forms of design input in computer design systems. The computer can be offered a fully worked-out design which is then simply "processed"; or the designer can sit at the keyboard of the computer with nothing except the ideas in his or her head and translate those ideas into computer language via the keyboard while watching the pattern form on the display screen (5).

The majority of computer design systems contain the same basic components. All systems contain a computer unit. Another basic unit the computer design system may contain is the CRT (cathode ray tube). This device resembles a television set, and displays the users graphic input on a monitor screen. A form of the original design can be fed to some systems, which then allows the design to be displayed on the monitor screen. Some systems, however, allow the designer to create directly on the blank CRT by the use of a light pen or joystick. The light pen looks like a pencil on a stick. It is photosensitive and creates an image when drawing freehand on the screen. When the pen is pointed at a display on the CRT it senses the moving beam when it passes within the field of view of the pen. The phosphor coating on the monitor screen exhibits an afterglow where the pen has passed. Other models use a joystick to draw freehand. The joystick controls a cursor, which is a lighted blip on the screen that is moved by rotating the joystick. The joystick can also be used by tracing over prepared artwork which is fixed to the work surface. The outline is traced by a telescopic wand and is transferred to the screen and computer memory (22,36,58,45). The CRT can display lines and points in any configuration, allowing freedom of design.

A teletype keyboard is attached to the CRT. This aids the user in controlling the action of the screen. The keys are used to signal the initiation of design functions on the screen through the computer. Through use of the keyboard, designs can be enlarged, contracted, repeated, rotated, mirror-imaged, erased, and subsequently changed to suit the designer. Colors can also be added or subtracted (36,58,40). There is no restriction upon the ways in which a pattern represented on the screen can be changed in shape, scale, or color. These changes can all be carried out with a speed and ease impossible by any other means, and the designer can be presented with an increased number of design possibilities in a very short time (30).

There are other information devices which serve to transfer information to or from media processed by the computer. Scanning units operate on an optical-electronic principle automatically to read an original design and separate it into different color tone weights. The images are then projected on the monitor screen. The design data is simultaneously stored in the computer's memory bank. The information may also be recorded for storage on a computer punch tape in coded form, or on microfilm or magnetic tape (36,40,27,3,24).

Other systems may include a plotter. Geospace and laser camera are two types of plotting systems. Essentially, the function of the plotter is to convert the electronic signals provided by the software into a visible image on film. A sheet of photosensitive film is held under vacuum on a drum plotter. The design display on the CRT exposes the photosensitive paper. The computer image is converted onto the film to produce a visible image. The time required for this process varies from a few minutes to an hour (36,46).

There are very elaborate CAD systems which allow the loom or knitting machine to be controlled directly by the computer. The pattern information is transferred from the computer to the loom or knitting machine for sample making. This central operating system can essentially be run by one person (28).

CAD software systems

All CAD systems involve the use of a computer. Each type of computer has its own code for description and programming of the operations that it is able to perform. Individual software programs may be written to instruct the computer to do a particular task. Many computer systems require a programming language, which provides a simpler method for expressing all the required computer operations. One language, BASIC, is used to operate many personal and home computers, as well as some CAD computers in the textile industry. BASIC is the simplest computer language to learn. The most preferable language for use in the industry at the present, however, seems to be FORTRAN. FORTRAN is the most widely known and taught language in the industry, and the programs written in it are applicable to practically all of the newer computer systems. FORTRAN or any other similar procedure-oriented language provides a good standard basis for writing all of the programs necessary in computer-aided textile design (22,45). Generally, CAD software systems consist of four phases; input, development, library, and output.

The input phase. The design is transferred, or drawn, and modified on the monitor screen in the input phase. This is done by scanning a prepared design, or by using a light pen or cursor. The CRT, keyboard, computer, and scanner all assist in the input phase. After the design has been accepted, it may be modified. When a design is composed of basic shapes that are to be duplicated in a repeat design, only one outline of each basic shape needs to be drawn. The remainder of the design can be composed with software or program functions.

The development phase. When the input phase is concluded, a completely drawn outline of the design is represented. The outline represents only part of a fabric design, however. The closed areas need to be filled in with fabric effects. The effects are textural or patterned in woven fabric. The effects for knitted and printed fabrics are composed of colors. The effects for tufted fabrics are composed of varying heights of pile. The development phase is concerned with creating these effects (36). The scanning process contributes to the labeling of closed areas of the design. For woven designs the designer selects a weave pattern for each area of closed design from a computer-stored library of weaves. Colors are selected for each closed design area for print and knit designs. Colors may also be designated for weave patterns.

The library phase. The computer memory is capable of storing a library of weaves for woven designs or a library of effects for printed designs. This allows for the display of designated weaves for woven designs or the repetition of small subpatterns for print designs. Weaves and effects may be added or deleted from the library. The computer may contain up to a thousand or more weaves or effects in its library or computer memory (36).

The output phase. In the output phase the design is prepared for direct transmission to textile machinery or for an intermediate application such as the photographic plotter or printer. This hardcopy output can illustrate design outlines or woven patterns. Hardcopy output is used to confirm the details of a design. The uses are both intermediate and final (i.e., used during design development and for keeping permanent records) (36).

## Advantages of Computer-Aided Design

Computer-aided design has many advantages over traditional methods of designing for woven, printed, or knitted textiles. Computation can 1) assist in design realization by handling the chores of conversion from the artist's sketch to the set of machine instructions; 2) assist the textile designer in the manipulation of pattern and in showing its relation to the textile structure and manufacturing constraints; and 3) assist the design engineer in evaluating the mechanical and other properties of fabrics (21). Perhaps the biggest advantage seen by the manufacturer is the amount of time saved in production, and the amount of time and money saved due to fewer mistakes and corrections. Many manufacturers feel that speed is worth the investment for a computer system.

Speed in designing allows the manufacturer to store designs electronically and sample them at short notice. It also allows designers to make their final selections from the largest possible range of real-life, industrially produced, three-dimensional fabrics. There are other advantages in terms of authority, status, and control. It is possible for a textile designer to have access to all of the information on which top management decisions are based, if there is willingness to work with a computer (5).

## Computer-Aided Design in Weaving

### Traditional textile design in weaving

Original woven textile designs are generally not uniform. The styling process corrects this by formalizing the design in ways similar to a drafter's drawing. The design emerges from the styling with uniformity of line and precision of shape. It is then passed on to a point paper designer, who transforms the styled design into a graph paper representation of the pattern to be woven (36).

The point paper designer is required to make many decisions. The designer must translate the original design onto squares of the graph or point paper. Since a curve cannot actually be woven, it must be simulated by weaving several adjacent fabric interlacings very close together. The designer must determine the placement of a weave within an area. Adjacent areas must not conflict visually, and interaction of adjacent weaves must not present problems such as surface floats. Appropriate weaves must be selected to modify or hide discontinuities.

Complicated designs are woven on Jacquard looms in which the design is controlled by punched cards. Small woven designs in which the repeat does not require more than 30 picks are woven on dobby looms where the design is controlled by punched Mylar film or cams. In setting up Jacquard looms, the completed point paper design must be manually punched into cards which control the warp yarns to be raised on the loom during weaving. The cards must be punched so that the sequence of holes corresponds to the weaving pattern. A short fabric sample, called a strike off, is then woven for evaluation and approval. Mistakes can be determined and corrected, if necessary. Although the sample may not be marketed, the costs of sampling are still incurred.

The total process of point paper designing may require up to 200 hours to complete a single design (36). The painting of weaves into areas requires the greatest amount of time. Decision making also complicates the process since original decisions may reveal the need for subsequent decisions. There may also be more complicated processes involved in designing. Double- or multi-layered fabrics would require additional time, as would designing with numerous colors.

### Textile graphics applications in weaving

Computer-aided designs for weaving are produced by using the previously described hardware and software systems. Once the outline of the design to be woven has been approved, a grid of the fabric is specified based on the number of end and picks of the desired finished fabric. The outline of the design is transformed to grid squares on the CRT screen. The grid squares correspond to the ends and picks of yarn in the fabric.

In the development phase, weaves are inserted into the areas of the design to be filled. This constitutes the weave designation process. A library of weaves is stored in computer memory to allow for the insertion of different weaves into the design areas. The library of weaves also allows building of composite weaves from basic library weaves, and the displaying of weaves in different constructions. Weaves can be added, deleted, modified, or repeated at random. Color is also added to the design areas using the same process.

Output for woven designs can be in several forms. The outline only of the design may be printed on paper, or the design with the weaves inserted may be printed. The computer may print a map giving the control information for weaving the design. The computer may produce design output in the form of punched-paper tapes which are used to prepare the Jacquard loom cards. Another type of output could be in the form of electronic impulses which directly control the loom. This direct control technique allows for instantaneous production capabilities (36). The type of output and design capabilities with computer-aided design vary with the system being used.

## Computer-Aided Design Applied to Textile Printing

### Current methods of textile printing

Roller printing and screen printing are the two most common methods used for printing textiles in the industry. Both processes require extensive photographic and manual work in preparing color separations of the design. Roller printing accounts for approximately 34% of the fabrics being printed today (48). Designs to be etched into copper rollers are transferred to the rollers in one of two ways: the pantographic process, in which the design is traced with a stylus into a coating on the roller, or the photographic process, in which a film bearing the design is wrapped around the roller. The roller is then photographically exposed and etched by photographic development (36).

Producing a copper roller by the pantographic process begins with the tracing of an artist's original sketch onto a coated zinc plate. The lines in the zinc plate are then traced with a pantographic stylus. Simultaneously, the design is being traced onto a coated copper roller. The rollers are then dipped in acid in order to etch the lines. Then they are chrome-plated. A separate roller is required for each color in the design.

Many artist's original designs cannot be conveyed by tracing, however. In this case, the artist's original drawing can be reproduced exactly in the printed textile by photographic etching. The original design is photographed once for each color in the design. One film is produced for each color. Each film is wrapped around a copper roller, then photographically exposed and etched. A combination of photographic and manual techniques may be used in preparing the rollers.

Screen printing accounts for the majority of fabrics printed today. Fabrics may be screen printed using either flat bed machines or rotary screen printers. Designs for screen printing may also be photographic or manual. The designer's sketch is transferred onto the screen from lacquer films in which the areas to be printed have been cut away. A different screen is prepared for each color that will be used in the design. When screens are made by the photographic method, the design is photographed and the negative is used to opaque areas that will not be printed (48).

## Textile graphics applications in printing

The basic tools of CAD can be applied to textile printing processes. For traceable designs, the process is greatly simplified by the computer. Hard-edged boundaries of printed designs can be traced onto the CRT very easily with the light pen or cursor. Less care and precision is required of the operator because the program smooths the freehand tracing (36). The process is greatly speeded up. A portion of the design need only be traced if the design is a repeat. The computer program will automatically expand the design. Common shapes such as squares and circles can be retrieved from computer memory and need not be traced at all. Sketching errors can easily be corrected by the light pen.

In the development phase, the designer is able to fill in design areas with color. Colors and shades can be changed instantly, and the variety is almost infinite in some CAD systems. The insertion of small repetitive subpatterns from a library of effects into the basic areas of the design may also be possible. The subpatterns are small repeats of designs that have been stored in computer memory. Time and work is saved by these computer methods since many patterns and color combinations considered to be undesirable can be eliminated before the sampling stage (18).

The color and design information fed into the computer enables the automatic production of films as computer output. A film is produced for each separate color of the design. The films may then be used as they normally would in the printing process.

## Computer-Aided Design in the Knitting Industry

### Current methods of knitted production

Knitting designs are created in a manner similar to line production. One designer creates original patterns on white paper, another transfers these designs onto graph paper, and a third person posts knitting control signals from the graph paper for use on the knitting machines (28). Each square on the knitted design graph paper becomes the control information for one knitting machine needle, which knits one stitch on the surface of the fabric. Patterning of the design is controlled by punched tape, a pattern wheel, or a pegged drum with holes, slots, or pegs indicating the selection of a particular colored yarn for a given stitch.

Textile graphics applications in knitting

A knit design in graph paper form can be constructed manually or mechanically. Manual construction is usually done by a design technologist. A mechanically constructed graph is made by a computer from an original drawing submitted to it (28). The optical scanner is the device most frequently used to replace manual graph paper painting. The scanning process is essentially an electronic gridding process, because the scanner perceives the design as tiny square elements of different colors (36). The data for each square is transmitted to a storage medium such as punched tape or magnetic tape. A hardcopy output of the design may be rendered by a plotter, which results in a gridded visual representation of the design.

The textile graphics tools used for woven and printed design are generally applicable to knitted fabrics (36). Color may be inserted into the basic design outline by use of the CRT, function keyboard, and light pen. Patterns may also be altered with these instruments. CAD is being used mainly in the production of weft knits.

## Industrial CAD Systems

Sci-Tex computer hardware is becoming well known in the textile industry for computer-aided design. Sci-Tex, an Israeli company, introduced its Response System 90 in 1973. This system is specifically designed for knit Jacquard CAD. The system consists of a Super Scanner which will accept any graphics in any medium of any color and texture. The device reads up to twelve colors at three knit courses per second and outputs to the adjoining computer with a capacity of 1.5 million stitches. Scanning the pattern requires two to three minutes. The scanner decides which color to register based on the closest match in the graphics to those calibrated. The pattern is then registered on the screen of the Color Console. Once read, colorways, or areas of color, may be altered with adjustments on the CRT. Design from may also be adjusted with the light pen/digitizer (12).

The Sci-Tex Response System 200 is being used for CAD of printed fabrics, and for carpet design by computer. The Response 200 is a specialist computer with the facility to scan and separate a design into different color tone weights precisely and automatically. The basic design is placed on a revolving drum which is scanned by a camera that stores the design characteristics in the computer memory. The image is then projected on a television monitor. At this stage, the operator can visually add or subtract colors at will, and erase or elaborate on any part of the design (40). The system's color library can store up to 999 individual color shades in the computer's memory. The designer can also develope new colors and compare a design side by side in different colorways (46).

The final output of the system is a set of screened-film negatives for use in various textile printing processes. The system has been introduced to the carpet industry where it can produce negatives which translate the basic design into standard repeats. The process of turning original designs into fabric samples is reduced from weeks to a matter of hours with the system (6,8,40,49).

The Millitron, a computer controlled dye-injection system, developed by the Deering Miliken Corporation in the United States, is one of the latest innovations in CAD for carpeting. The designer's drawing is photographed and scanned to produce a program tape for the computer. The most significant feature of the Millitron is that it allows designs to be changed over with a minimum waste of carpet (8).

Think Laboratory Company, Ltd., of Japan, has developed the DOCS (Design Organizing Computer System). The system consists of an image simulator and a design plotter. The DOCS is connected to the Think Laboratory's printing-form production system, "System '77". This is a cylindrical printing-form production system applicable to various printing processes, such as the direct gravure process, conventional gravure process, various rotary screen processes, endless offset process, resin gravure process, flexography, etc. (11).

There are many other systems in use for CAD in weaving and knitting. The Knit Pattern Information Processing System developed by Kanebo, Ltd., is aimed specifically at knit design. This system contains a knit sample making system where pattern information is transferred from the computer to the electronic pattern control knitting machine for sample making. The production system is applicable to any type of knitting (28).

Other systems for knit or woven CAD are the Fyscan computer design system, the Stibbe-Matic Scanmaster by Stibbe-Monk, Telepat by E. Dubied & Cie S. A., Instaknit by Speizman Industries, Inc., and the Patro-System by the Hell organization (3,24,27,49).

Limitations of Computer-Aided Textile Design

There are many advantages to adapting computer-aided design to current textile processes. Time is a great factor. CAD can greatly reduce the time involved in textile weaving, knitting, and printing design processes. Many laborious and time-consuming tasks, such as the painting of colorways or point paper painting, are eliminated. Since manipulation of design and color is possible, creativity in designing is greatly enhanced. Design decisions may be made prior to expensive sampling of the design and errors may be caught at an earlier stage and corrected. Both of these factors save time and money for the manufacturer.

One of the most controversial aspects of computer-aided design is the belief that designing with a computer might stifle a designer's creativity. Some feel that designers may prefer more primitive materials since these can allow one to become more deeply involved in the creation of the design. There may even be the threat of the elimination of the designer's role from the production system, since the computer is capable of producing designs on its own (14,15).

It must be stressed, however, that the computer is merely a tool for the designer. Design ideas originate in a creative mind. The computer is simply another means of executing those ideas. The designer is always in control of the computer. CAD simply offers a more diversified system to challenge the designer's creativity.

Computer-aided design is still in its early stages in the textile industry. Unfortunately, computer systems are extremely expensive when first marketed. Many smaller textile companies have not had the capital to invest in computer design systems. As is the case for all computer-oriented products, however, prices drop as the technology required to produce them becomes more feasible. Many smaller companies may soon be able to take advantage of CAD systems.

With a rise in technology in CAD systems, more trained personnel will be required in the industry. Currently, there are only a handful of universities and technical schools which offer actual experience with a CAD system in their curriculums. These needs must be met in the near future.

There are many areas in computer-aided design which need to be investigated further. There are ethics involved in the CAD process, such as man versus machine, which need to be addressed. The real nature of the process of artistic and engineering design needs to be investigated to find out the most feasible and attractive areas to be computerized (35).

## Theory of Pattern Drafting

The introduction of the computer into the home has enabled the handweaver to take advantage of computer-aided design technology for the development of handwoven patterns. In order to understand the computer design systems being used for handweaving, a thorough understanding of the process of pattern drafting is necessary. Pattern drafting is the foundation upon which fabric designing is built (31). Drafting is a system of notation used to represent graphically the appearance and mechanics of a weave (23). A complete draft illustrates the interlacings of the warp and weft yarns of the woven design to be produced. The draft also consists of the threading, tie-up, and treadling diagrams, which illustrate the necessary mechanics required to produce the weave.

There are many different ways to illustrate drafts for handweaving. Weavers in different countries, as well as in different parts of the same country and at different periods, have devised their own methods of writing and producing drafts (4). Several different notation systems for recording threading, tie-up, and treadling sequences are currently in use. Some use filled-in or darkened boxes, while others use numbers, X's, or some other notation. Some weavers read drafts from right to left. Others read from left to right. In most notation systems, however, the pattern drafts are produced on squared graph paper.

Pattern drafts are generally divided into four quadrants. A popular method for handweavers is to assign the threading draft to quadrant one, the tie-up to quadrant two, and the treadling sequence to quadrant three. Quadrant four diagrams the design created by the other three quadrants (4). Figure 1 illustrates the four quadrants.

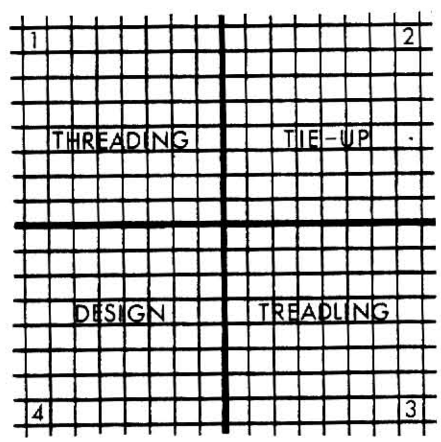


Fig. 1. Draft Quadrants

## The Threading Draft

The threading draft is the diagram which shows the order in which the individual warp threads are threaded or drawn through the heddles on the different harnesses of the loom. This draft notation is often referred to as the draw. Traditional conventions have stated that the threading draft should be read from right to left (31). However, whether read from right to left or left to right, the same fabric can be produced. The threading draft is illustrated in quadrant one of Figure 2, which shows a complete pattern draft.

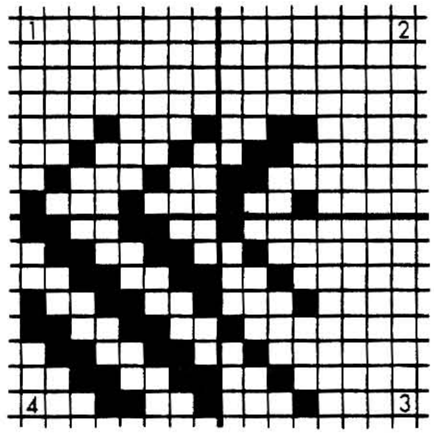


Fig. 2. Comprehensive Draft

Usually, the bottom row of squares represents the first or front harness of the loom, and the top row of squares represents the back harness. The threading sequence is usually repeated at least twice to illustrate two or more complete threading units. A threading unit is the total number of threads in one sequence.

## The Tie-Up Draft

The tie-up, illustrated in quadrant two of Figure 2, indicates which harnesses are used by depression of a single treadle on the loom. The tie-up draft is read from left to right for the treadles. The harnesses are read from bottom to top. Thus, the first vertical column of the graph paper in quadrant two refers to treadle one. The first, or bottom horizontal row refers to the first harness on the loom.

## The Treadling Draft

Quadrant three of Figure 2 illustrates the treadling draft, which shows the order in which the combinations of harnesses, as depicted in the tie-up, are depressed, or treadled. The treadling draft is read from top to bottom. The horizontal rows refer to the weft shots. The vertical rows refer to the treadles.

## The Weave Draft

The weave draft, or drawdown, is illustrated in quadrant four of Figure 2. The weave draft illustrates graphically the design to be produced in conjunction with the threading, tie-up, and treadling drafts. The design is produced by filling in squares to indicate all raised warp threads. Those squares which are not filled in indicate warp threads that have been covered by weft shots. Thus, the white squares indicate the weft threads and the black squares indicate the warp threads. The design is begun at the top row of quadrant four. This first horizontal row of squares is the first row of weaving and the first weft shot. By referring to the treadling draft, the first treadle to be depressed is noted, along with the harnesses that will be actuated with the depression of the treadle. The squares vertically under the warp threads that will be raised by depressing the treadle are then blackened. This procedure is repeated for each row of design in which a treadle is depressed. The squares that coincide with the harnesses that are lifted are filled in. The finished design will illustrate the exact design of the fabric to be woven.

By combining the threading, tie-up, treadling, and weave drafts, a comprehensive draft is created. When the treadling sequence follows the same sequence as the threading draft, the design is "woven-as-drawn-in", or "tromp-as-writ". Variations in the weave can be produced by changing one or all of the threading, tie-up, or treadling drafts.

Color can be incorporated into pattern drafts by assigning a color to each warp thread and indicating the color in the threading draft. Colors are also indicated in the treadling sequence for each weft shot. In this way, designs may be visualized in any number of color combinations (34,35).

## Theory of Block Weaves

### The Short Draft

The drafting system just described is limited to single unit drafts, where one threading pattern is repeated across the draft. A different form of weaving involves the use of block weaves. Block weaves employ multiple threading patterns across the draft, which can increase the number of design possibilities. Block weaves require a different form of drafting, referred to as the short draft. A short draft is illustrated in Figure 3.

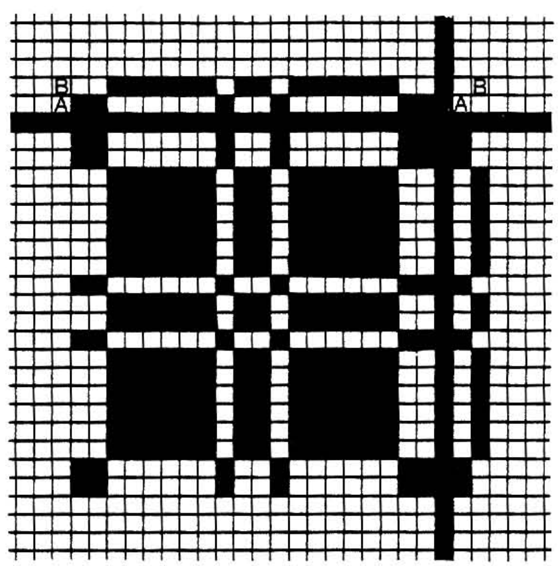


Fig. 3. The Short Draft

The weaving of block weaves involves alternating two or more units of threading and treadling. Each unit contains a set group of threaded yarns and treadlings for that unit, or block, which is repeated any number of times. The threading and treadling units can change size throughout the design of a block weave. Because these patterns are complicated to illustrate with a long draft, the short draft method is used to simplify the drafting and designing of block weaves.

The theory of block weaves is to use one filled-in square on the graph paper to represent an entire block of pattern threads. The short draft does not indicate actual threadings, treadlings, or interlacings. It only represents the overall design pattern (32). The drafts are labeled with capital letters, starting with A, to prevent confusion with the harness numbers. Each letter refers to one individual block or threading unit. Each different block is assigned a different letter. The darkened blocks are referred to as positive blocks. These blocks indicate that more warp than weft is showing. The light blocks indicate that more weft is showing, and are called negative blocks. It is the positive blocks which actually form the pattern, although both positive and negative blocks are of equal importance to the overall effect of the design. A positive block occurs when the same threaded and treadled blocks cross each other in the design quadrant of the draft. When the opposite blocks of threading and treadling cross each other in the design, a negative block appears (32).

In a block weave, a block may be threaded or treadled any number of times, creating squares or rectangles of any size. Designs can be created with the use of two-block weaves, which allows for the alternating of two different pattern blocks, or with three or more blocks, which greatly increases the design possibilities.

## The Profile Draft

An even more abbreviated form of the short draft is the profile draft, illustrated in Figure 4.

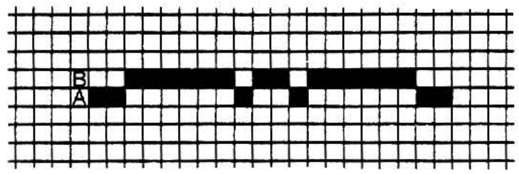


Fig. 4. The Profile Draft

The profile draft refers to the threading quadrant of the short draft. A profile draft indicates the number of times each threading unit is repeated, which also indicates the width of each block. The profile draft does not indicate the actual threading of a weave. Each darkened square in the profile draft equals one threading unit. A threading block may be repeated side by side as many times as desired. Designs can be drawn by repeating the lines of each block in the profile draft as many times as desired and in any order in the design quadrant. A complete short draft is drawn by adding the treadling sequence. The treadling sequence can follow the threading sequence exactly, or the treadling can vary to produce an unlimited number of designs.

## Overshot Drafts

Overshot weaves are well known in America from the many colonial coverlets that were woven in overshot patterns. Overshot weaves are based on the block system, but they do not lend themselves well to short draft conversion. A somewhat different drafting system is used for these weaves. An overshot draft is illustrated in Figure 5.

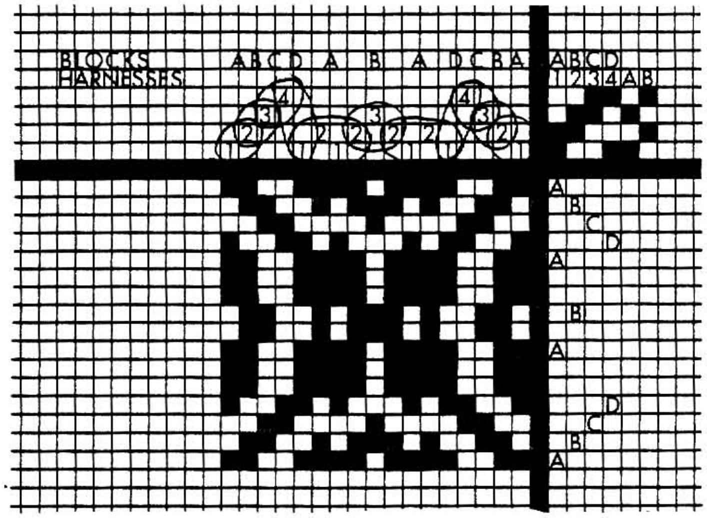


Fig. 5. The Overshot Draft

Overshot weaves are derivatives of the twill class, and are based on a repeat twill. The threads of the threading draft can be circled to form the blocks. Each block must contain at least two threads. The blocks progress in alphabetical and numerical order. All progressions are from odd to even or from even to odd numbers. Each block, made up of multiples of two different harnesses, may be any practical length. The last thread of each block becomes the first thread of the next block, so that each block overlaps the next by one thread. The draw-down is written by filling in the squares directly below the harnesses contained on the blocks to be treadled.

Overshot weaves have an underlying plain weave, or tabby, foundation. A shot of tabby follows and precedes each shot of pattern weave. The tabby foundation provides a solid fabric construction, particularly in cases where surface floats are used in a design. When weaving overshot designs, there is generally one less pattern shot woven in a treadling block than there are threads threaded in the block. A block with an even number of threads would be treadled with an uneven number of pattern shots. This is one of the rules of overshot weaving that gives the weave its characteristic designs.

## Computer-Aided Design for Handweaving

### Home Computer Programs for Computer-Aided Design

The drafting of weave patterns by the handweaver has been greatly simplified by the use of the home computer. However, because the computer is such a recent design tool, there are very few computer programs that have been written for handweavers which graphically illustrate the design and weaving details necessary for producing woven patterns.

One program written by D. N. Fordham (19) uses a Sinclair ZX80 computer connected to a television set for black and white visual displays of weaving patterns. The program allows fourteen different shaft or harness lifting variations to be combined for creating designs on four harness looms.

Margaret and Thomas Windeknecht (59), a wife and husband, fiber artist and computer scientist team, designed a computer program to display handweaving patterns using a KIM-1 processor and an Ohio Scientific 440 B video board, T.V. typewriter, and tape-cassette storage. Programs were developed in machine language for drafting handweaving patterns for up to sixteen harnesses. The program displays the graphics in black-and-white, and a 35 mm SLR camera was used to photograph the video-graphics display to provide hard copy output. The program allows the standard drafting format, consisting of the threading, tie-up, and treadling sequence, to be keyed into the computer from an ASCII keyboard, which is the processing language of the computer. Entries may be made for up to sixteen harnesses. The corresponding pattern drawdown can then be automatically displayed. The computer program is also capable of producing the harness threading, tie-up, and treadling sequence necessary to weave a particular pattern. For this, a weaving-like pattern is directly keyed into the computer, after which the drafting information can then be keyed. This system is used in analyzing and specifying the construction characteristics of existing fabrics.

The Portland Handweavers Guild computer study group has developed two computer programs that explore the processes of designing with block weaves (43,44). The programs were developed for use on the Apple II computer and require a disc drive. The Posneg program enables the user to enter a block profile draft and produces the corresponding pattern drawdown of the block design. Designing with two colors is possible upon selection of a screen color and a figure color. Each display allows a maximum viewing area of 40 spaces across and 40 spaces down. The program utilizes an editing option which allows the user to change drawdown rows during execution or after the entire drawdown has been entered. Completed patterns can be saved on diskettes and recalled by using a separate program. The Block Patterns program enables the user to assign colors to blocks according to the 16 colors available with the computer. This program contains the same features as the Posneg program.

Video Loom II, a computer weaving program released by Laurel Software, uses an Apple II+ computer and a disc drive (10). The program simulates a 32 harness loom with 64 treadles. Designs can be displayed in up to six colors. The program allows the user to vary warp and weft colors, thicknesses, and spaces between threads. Designs can be saved on diskettes, permitting the tie-up or treadling from one pattern to be combined with the threading draft from another. Hardcopy printouts of the designs are an option of the program if the computer system is equipped with a printer.

## Other CAD Programs for Handweaving

K. E. Huff (26), a former Kansas State University Computing Center employee, developed a computer program for pattern drafting using the PL1/F language. Her program uses keypunched data cards to produce pattern weaves from threading, tie-up, and treadling data for up to eight harnesses. This program does not create designs, but simply plots patterns that have been entered into the computer on data cards.

Professor W. G. Wolfgang (16) at the Philadelphia College of Textiles and Science has developed a system that enables the designer to write a description for a dobby weave. This program also uses standard keypunch cards which are punched and fed into the computer. A point paper work, or pattern draft, of the design is the printout. The software program is written in the computer's langauge, MACRO, on a magnetic tape. The program consists of variants of plain and twill weaves.

## Related Computer Use for Handweavers

Other related programs which provide useful information for the handweaver have been written. A program has been developed using the Apple II computer which determines whether or not a pattern generated by the computer will form a single, cohesive cloth, or one which separates into layers (25).

AVL looms, the only American manufacturer of dobby looms for handweavers, is currently working on a computerized dobby hookup, the AVL

Apple Dobby, using the Apple II computer. Macomber looms has also developed a microcomputer attachment for floor looms that controls the harness tie-up and treadling sequences, thus converting a standard floor loom to dobby operation. The product is called the Designer's Delight (1).

Although the programs that have been developed for designing handweaving patterns contain some very useful design functions, all of them have certain limitations or disadvantages. The Huff program cannot create designs for the weaver and is limited to designs requiring eight or fewer harnesses. The Wolfgang program is limited in the types of weaves that can be explored. Also, these programs are not practical for the handweaver since they require large computer systems utilizing keypunched data cards.

Of the programs developed for use with a home computer system, the Fordham program is the most limited. This program allows only fourteen different harness variations for four harness designs and is limited to black and white pattern displays.

The Windeknecht program is also limited to black and white visual displays. The program provides no means for a practical hardcopy output. The computer system that was used to develope the program is not a standard system and is not easily reproduceable.

The Posneg and Block Patterns programs are limited to block weave designs and are limited to a maximum viewing area of 40 x 40 spaces. The threading, tie-up, and treadling quadrants are not included in the display of the design. The programs cannot analyze weave patterns to provide information about the construction characteristics of an existing fabric. The programs were also developed for use on the Apple II computer, one of the most expensive home computers on the market.

Video Loom II also requires the use of an Apple II computer and provides no means for analyzing woven patterns in order to determine their construction characteristics. In addition to these limitations, each of the programs is limited to the entering of one treadle per treadling row, which greatly limits the number of design possibilities.

A program design was needed that contained the best features of each of these programs. The purpose of this study was to develope programs that would provide this. The programs were developed for use on the Commodore Vic-20 computer, which is currently the least expensive color computer on the market. The programs allow the visualization of designs in either black and white or color, display the drafting information on the screen for easy reference, and offer editing options to allow for input errors and design changes. The programs allow designing of any type of weave. They enable the user to enter more than one treadle per treadling row, thus greatly increasing the manipulation of designs. One program is capable of analyzing weave patterns for use in determining the construction characteristics of a pattern. Finally, hardcopy output is provided in the form of a printout which contains the design and drafting information that is required to weave it.

# CHAPTER III

# DESIGN AND IMPLEMENTATION

The purpose of this study was to develope computer programs for the designing of handwoven patterns on a widely-used, home computer. The programs enable the user to design a multitude of weaving patterns quickly and efficiently, including the drafting information necessary to produce the weave, and produce a printout of the pattern draft upon request.

## The Computer System

The progams were written using the Commodore Vic 20 personal computer. The Vic is currently the cheapest home color computer on the market, a decided advantage for those who desire to invest in a home computer system. The computer consists of a full-size typewriter keyboard with special screen editing and graphics keys. The computer has 5K RAM (Random Access Memory), and 16K ROM (Read Only Memory). Random Access Memory is used to store BASIC programs. It is volatile and can be modified or erased. When the computer's power is turned off, any stored RAM is lost. Read Only Memory cannot be erased or modified and remains in the computer when the power is off. ROM is used to store pre-programmed utilities, such as the Super Expander and Programmer's Aid cartridges, and contains the entire BASIC language used for programming. Memory expansion of the Vic to 32K RAM is possible with memory expansion cartridges available in 3K, 8K, and 16K RAM increments. There are a total of 16 possible colors that can be displayed by the computer: 16 screen colors, 8 border colors, 16 character colors, and 16 auxiliary colors.

The software programs were written in PET BASIC, the language of the computer. The computer was connected to a color television set to provide a color video display. It was necessary to expand the memory capabilities of the computer in order to develope the programs. A 16K memory expansion cartridge was added for a total of 19,831 bytes of memory. The Vic 20 Super Expander cartridge was used to add extra graphics and color capabilities including high resolution graphics, color registers for screen, border, character, and auxiliary colors, and the ability to assign color to designated areas. The Super Expander cartridge adds 3K of extra memory to the computer. However, BASIC cannot be used for programming in the 3K area when memory is expanded with the 16K cartridge. This is due to a shift in the start of the BASIC program area to the beginning of the new RAM area. Machine language programs can still be used in this area, however. The Programmer's Aid cartridge was used to help write, edit, and debug the programs. An expansion board was necessary to provide extra expansion ports for the Vic 20 cartridges that were used.

The Commodore Model C2N tape cassette was used with the Vic 20 computer. Programs written in RAM are transferred onto cassette tape to provide a permanent means of program storage. The software for using the tape cassette is built into the computer.

The Vic-1515 graphic printer was used to print outlistings of the written programs and output of weave designs and pattern drafts. The printer operates on a dot matrix print and has dot addressible graphics. It is operated through software control by the computer. The computer system is illustrated in Figure 6.

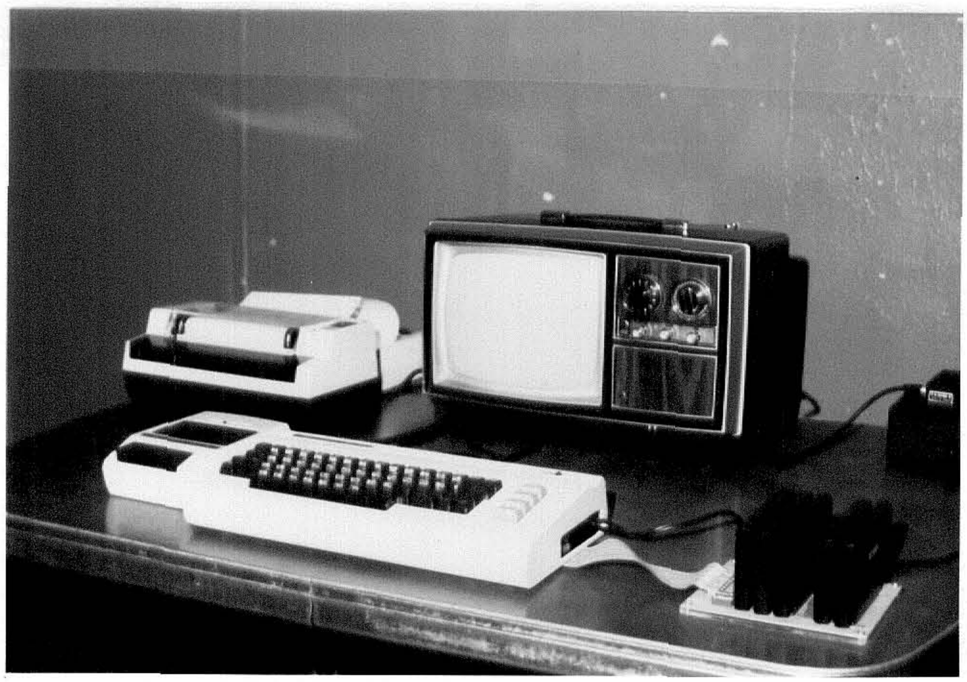

Fig. 6. The Computer System

## The Software

A total of four programs were developed in this study. These programs are 1) Weave Design, 2) Weave Design II, 3) Color Weave, and 4) Weave Analysis. Weave Design II is a variation of Weave Design. It was necessary to develope individual programs for the analysis of weaves and the manipulation of color within a pattern due to the limited amount of RAM available with the computer.

Each program is loaded separately into the computer from tape. A program is started by typing RUN and pressing the RETURN key. Each program begins with a title page containing the name of the program. The program is continued by pressing RETURN. A complete printout of each program, with functional specifications and user procedures, is listed in the appendices.

### Weave Design

The Weave Design program enables the user to enter the threading, tie-up, and treadling sequences for a weave of up to 16 harnesses and produces the pattern drawdown of the design. The program begins by requesting a harness selection of 4, 8, 12, or 16 harnesses. The user is asked to choose one of these harness selections by entering the number 1, 2, 3, or 4, based on the number of harnesses desired. After entering the harness selection the program goes to a graphics mode where the graph for the comprehensive draft is drawn by the computer. There are two different graph sizes used in the program. A graph with larger squares is used for the selection of four or eight harnesses. This size has 48 graph squares available for the threading sequence of a four harness weave. There are 44 squares available for an eight harness threading sequence. In order to provide a larger working area for more complicated designs, the graph used for the selection of 12 or 16 harnesses has smaller squares. There are 66 threading squares available for a 12 harness design and 62 squares available for a 16 harness design.

Solid division lines are painted into the graph to separate the four quadrants of the comprehensive pattern draft. The lines are one graph row or column width. The division lines are painted in by the computer by coordinates specified for the areas in the program. These lines make the two graph sizes four distinct graphs, one for each harness number selection. Each graph then has the same number of threading, tie-up, and treadling rows and columns as number of harnesses.

After the graph is drawn the threading sequence can be entered by the user. The numbered keys on the computer keyboard are used to enter the threading sequence. Each threading square is filled in by pressing the same key number as the row or harness number that is wanted. That is, to fill in a square on the bottom row, or harness number one, press key 1. To fill in a square on the second row, or harness two, press key 2. Each column will contain one filled in square. Numbers can be entered for the same number of available harnesses. That is, if the four harness graph is used, keys 1-4 can be entered. Keys 1-8 can be used with the eight harness graph. For the 12 and 16 harness graphs, two-digit numbers (10-16) are entered by holding down the SHIFT key and entering the last digit of the number. For example, 14 is entered by pressing SHIFT and key 4. Ten may be entered with or without the SHIFT key by pressing key 0 or SHIFT and key 0. The threading sequence is entered for the length of the threading draft quadrant of the graph. The threading can be entered very quickly. There is no need to worry about entering more numbers than spaces that are available since the computer will ignore any numbers after the available spaces have been filled.

Once the threading has been entered the user is ready to enter the tie-up. Before the tie-up can be entered the RETURN key must be pressed to continue the program. The tie-up is entered by pressing the numbered keys corresponding to the desired treadles. The squares in each column, or treadle on which the harnesses are tied, will continue to fill in when a different numbered key is pressed. To continue on to the next column, or treadle, RETURN must be pressed. As many numbers as harnesses can be entered for each column, although this is not usually the case in handwoven designs. There are the same number of columns for treadles as there are harnesses for each graph. That is, a 16 harness graph has 16 columns for treadles. If fewer treadles are to be used, RETURN can be pressed for each column after the last entry. The computer will jump over these columns and leave them blank. If more than the given number of treadles is needed, the graph for the next largest harness selection can be used. For example, a four harness weave can be entered on an eight harness graph to provide four more treadles. Most floor looms have only two more treadles than harnesses, but the increased treadle capacity of the program provides room for experimentation with designs and would also be useful for a table loom which has no treadles.

The RETURN key is pressed after the last tie-up entry to continue the program. The treadling sequence is now ready to be entered. The treadling sequence is entered in the same manner as the tie-up. Although only one treadle per weft shot is used in most handweaving drafts, the program allows as many treadles as harnesses to be entered per row. This greatly increases the amount of design manipulation that is possible.

In many cases, a handweaver using a floor loom will depress two treadles simultaneously. The program lets the weaver design with this in mind. A straight tie-up may also be entered, in which only one harness is tied to each treadle. This allows a great deal of freedom when experimenting with different treadling variations. As with the tie-up entries, RETURN must be pressed after each treadling row is entered to continue on to the next row.

The drawdown quadrant of the draft is automatically filled in by the computer as each row of treadling is entered. Several rows of treadling may be made at one time while waiting for the computer to execute the design. However, no more than four entries should be made ahead of the computer since entries can be lost if the computer is not given time to catch up with the last entry. The drawdown is completed when the last row of treadling is entered. Figure 7 illustrates an example of a block weave designed with the Weave Design program. Figure 8 illustrates a fabric sample woven in the design.

At any time during the threading, tie-up, or treadling executions the draft can be erased and the program started over by pressing the RUN STOP and RESTORE keys simultaneously, typing RUN, and pressing RETURN.

The threading, tie-up, and treadling routines of the program are executed with the use of arrays. An array is a sequence of related variables. Values are obtained for each threading, tie-up, and treadling entry by GET statements, which let the user input one character at a time from the keyboard. Each character is a variable that is stored in an array. The threading routine uses a one-dimensional array in which the variables are arranged in a linear list with each data item occupying a single memory location. The tie-up and treadling routines use two-

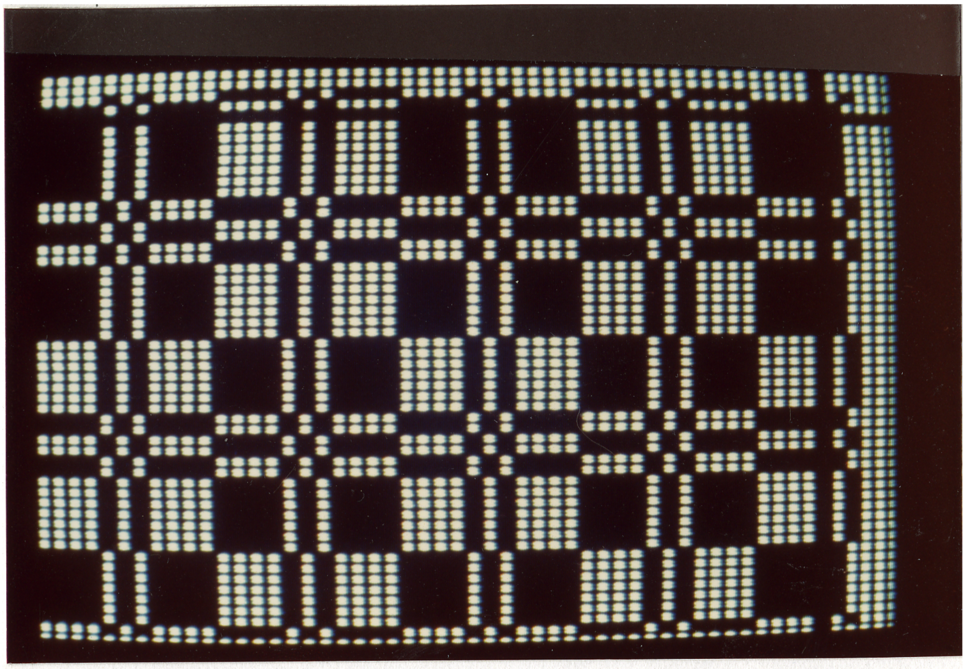

Fig. 7. Block Weave Display from Weave Design

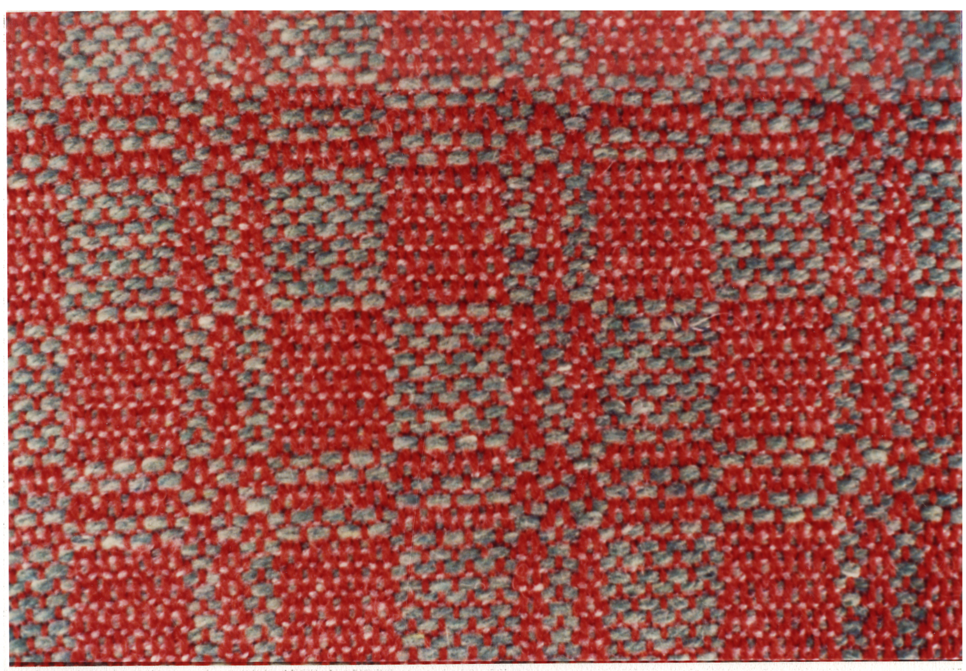

Fig. 8. Woven Sample of Block Weave Design

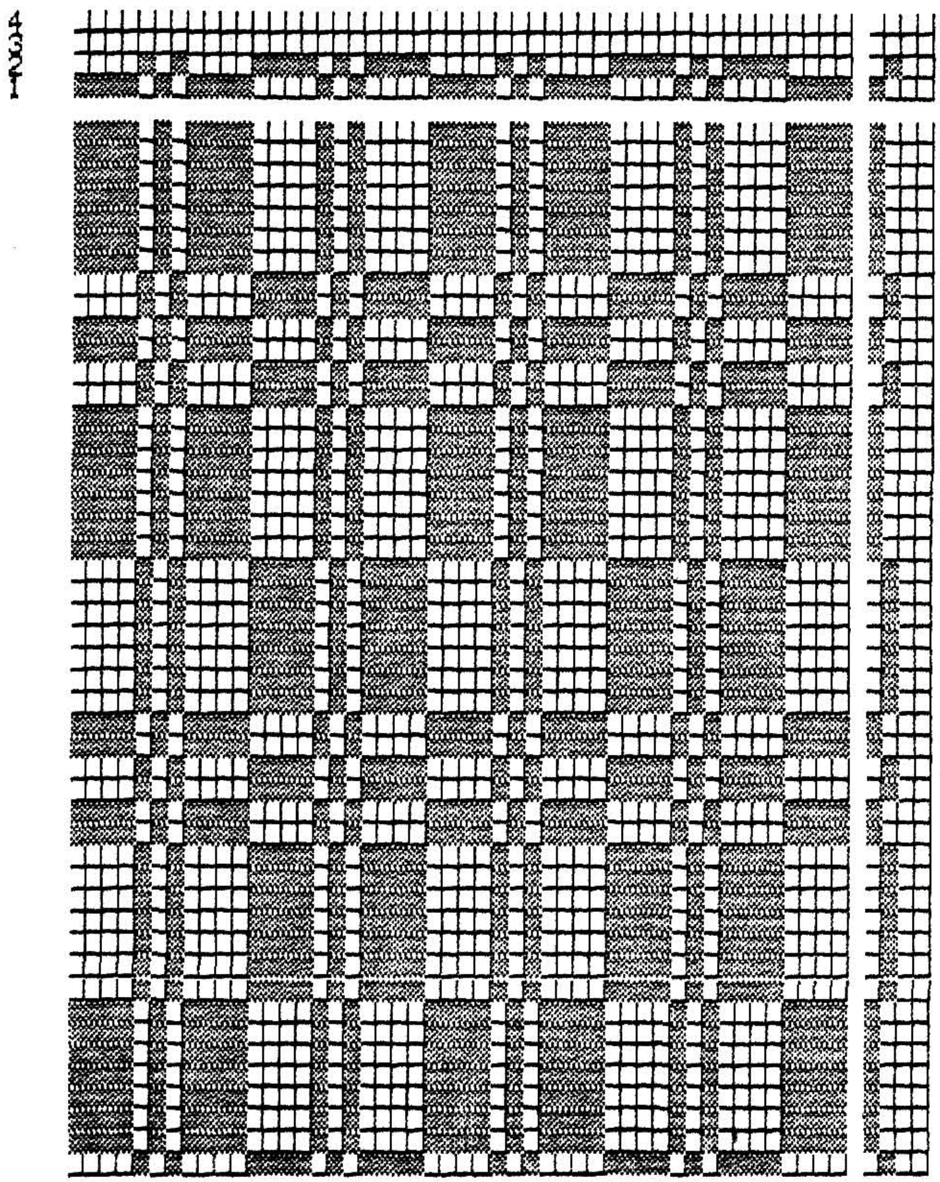


Fig. 9. Printout of Block Weave Design

dimensional arrays where the variables are arranged in rows and columns and each data item occupies a single memory location in a specific row and column. The graph squares are filled in by specifying coordinates for the variables that were entered.

As each treadling row is entered, the computer searches the tie-up array and finds the harnesses that are tied to that treadle. The threading array is then searched for threads that are attached to those harnesses and the corresponding drawdown squares are filled in.

The completed draft is printed out by pressing the P key. A printout of the draft is possible without filling in the entire treadling sequence by pressing RETURN for the remaining treadling rows after the desired treadling portion has been entered, and pressing P. The hardcopy printout is very convenient for providing a means for carrying the completed design directly to the loom. Figure 9 illustrates an example of a printout using the block weave design in Figures 7 and 8.

A two-dimensional array is used for storing the drawdown values for the print routine. Each drawdown value is stored in memory as a decimal number using a binary (base two) code. An empty square is stored as a 0 and a filled square is stored as a 1. In order to store all of the drawdown values in the completed draft, the drawdown quadrant is divided into three words, or parts, across of 22 bits each. These values are then recalled during the execution of the print routine and are printed out with the threading, tie-up, and treadling values.

## Weave Design II

Developments in the Weave Design program led to a new version of the program. This second version, entitled Weave Design II, follows essentially the same format as Weave Design but includes some important additions. The graph lines were not added to the program in order to provide a larger working area for entering the threading and treadling sequences, which in turn provides a larger drawdown area to aid in design realization. This is possible by using a different graphics mode offered by the computer. There are 80 spaces across and 80 spaces down that are available for the comprehensive draft. Each harness selection of 4, 8, 12, or 16 harnesses determines the total number of available spaces for the threading, tie-up, treadling, and drawdown quadrants of the draft. The solid division lines remain in the display. Since the screen has more display area, the array containing the drawdown values is divided into four words instead of three. Figures 10 and 11 illustrate an example of an overshot weave designed with the program and the sample fabric woven in the design. The printout of the design is illustrated in Figure 12.

Weave Design II contains some very helpful editing options. Errors made while entering the threading sequence can be corrected by using the DELETE key. Each time DELETE is pressed, the last threading square that was entered is deleted. The threading sequence can be deleted back to any desired point. This delete option works essentially by calling a subroutine in the program which returns to the last entered variable, or square that was filled in, and re-colors that point in the screen color, which is white, thus erasing the last input. The tie-up and treadling routines also have a delete option. Using DELETE in the tie-up removes an entire tie-up column. DELETE can be pressed as many times as desired to delete the tie-up back to any point. The treadling sequence is deleted in the same manner. Pressing DELETE will cancel an entire treadling row, regardless of the number of treadles entered. In this way, not only does

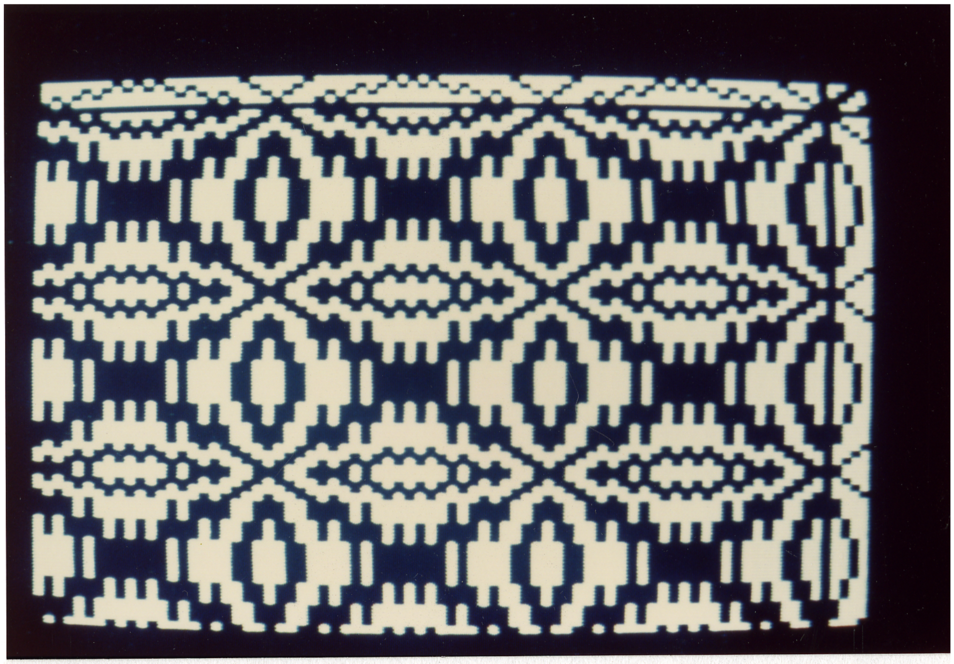

Fig. 10. Overshot Weave Display from Weave Design II

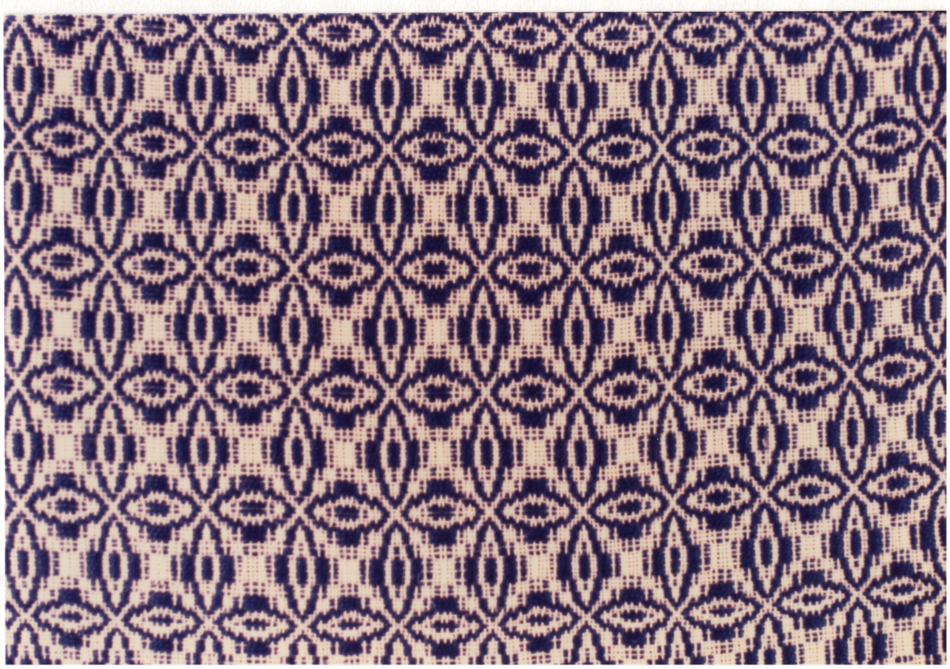

Fig. 11. Woven Sample of Overshot Weave Design

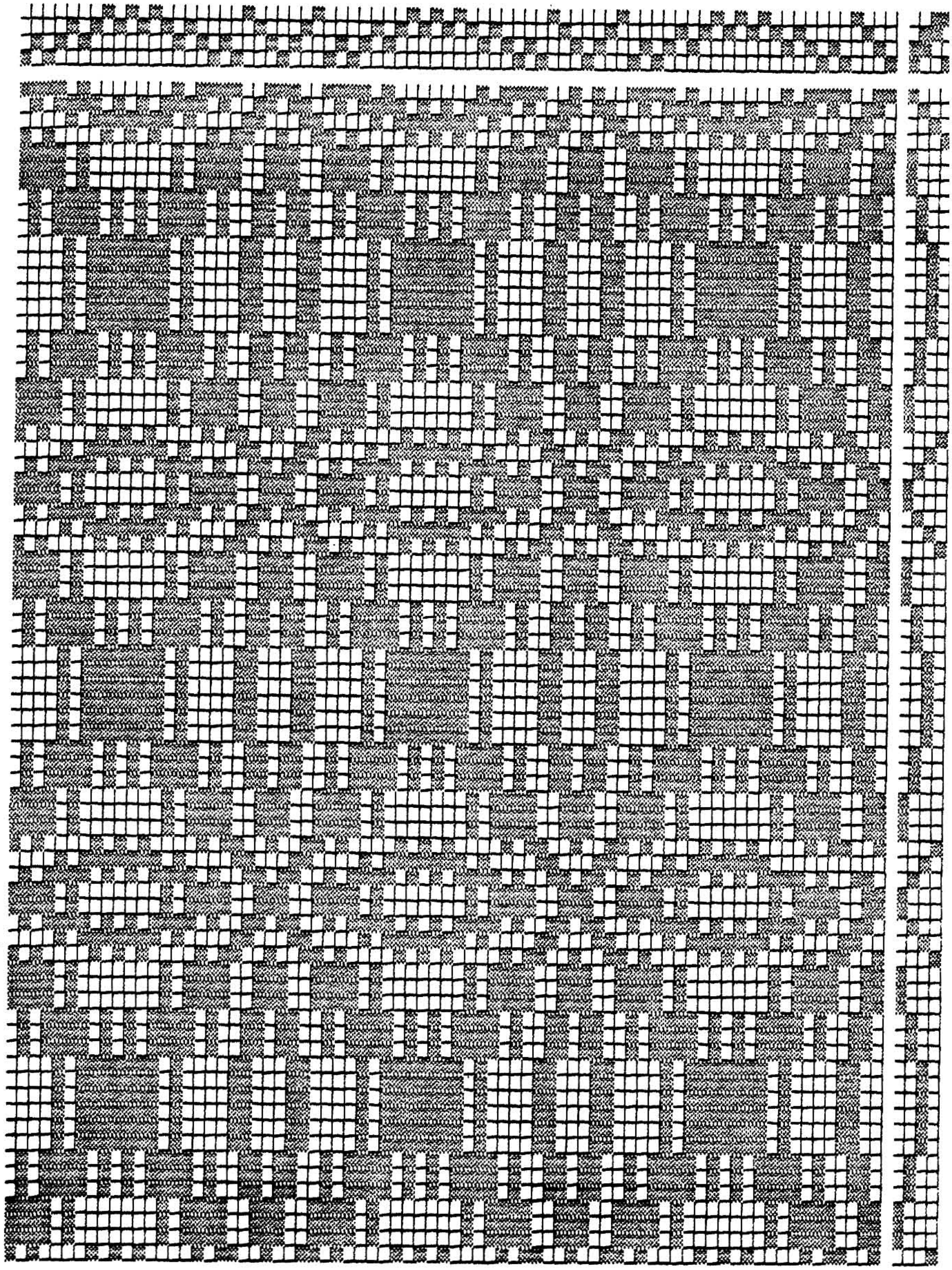

Fig. 12. Printout of Overshot Weave Design

the delete option allow for input errors, it allows greater design manipulation since design rows can be changed on command by deleting and re-entering to suit the user. When using the delete option, the last treadling row that was entered must have finished executing before the delete will work. If RETURN was pressed after the last treadling entry, the row or treadle that was last entered will be deleted. If RETURN was not pressed, the row before the last entry will be deleted. Pressing RETURN continues the program by passing over each row in succession each time RETURN is pressed.

## Color Weave

Color Weave is a modification of the Weave Design II program and follows the same format, but includes the ability to design with color. The program begins with the usual harness selection. The user is then asked to choose four colors. The choice of colors within a design is limited to four due to the graphics mode that is used in the program. These four colors represent the screen, border, character, and auxiliary colors. The screen, character, and auxiliary colors are selected from the 16 colors that are available with the Vic 20. The border color is limited to eight of these colors. The screen color should be selected in the weft color since this color will form the background of the design. Once the colors have been selected, the appropriate graphic display appears on the screen. The threading is entered with two numbers per entry. The first number indicates the color and is entered as 1, 2, 3, or 4, according to the colors that were specified for the screen, border, character, and auxiliary colors. For example, if color number 15 was entered as the character color, this color would be entered in the threading draft as a 3.

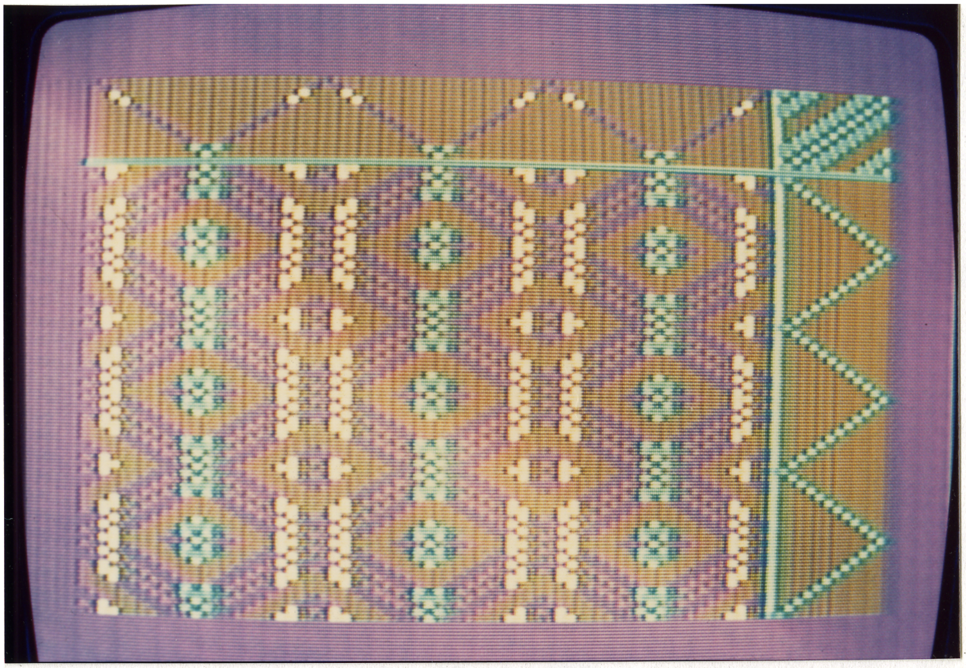

Fig. 13. 12 Harness Weave Display from Color Weave

Fig. 14. Woven Sample of 12 Harness Weave Design

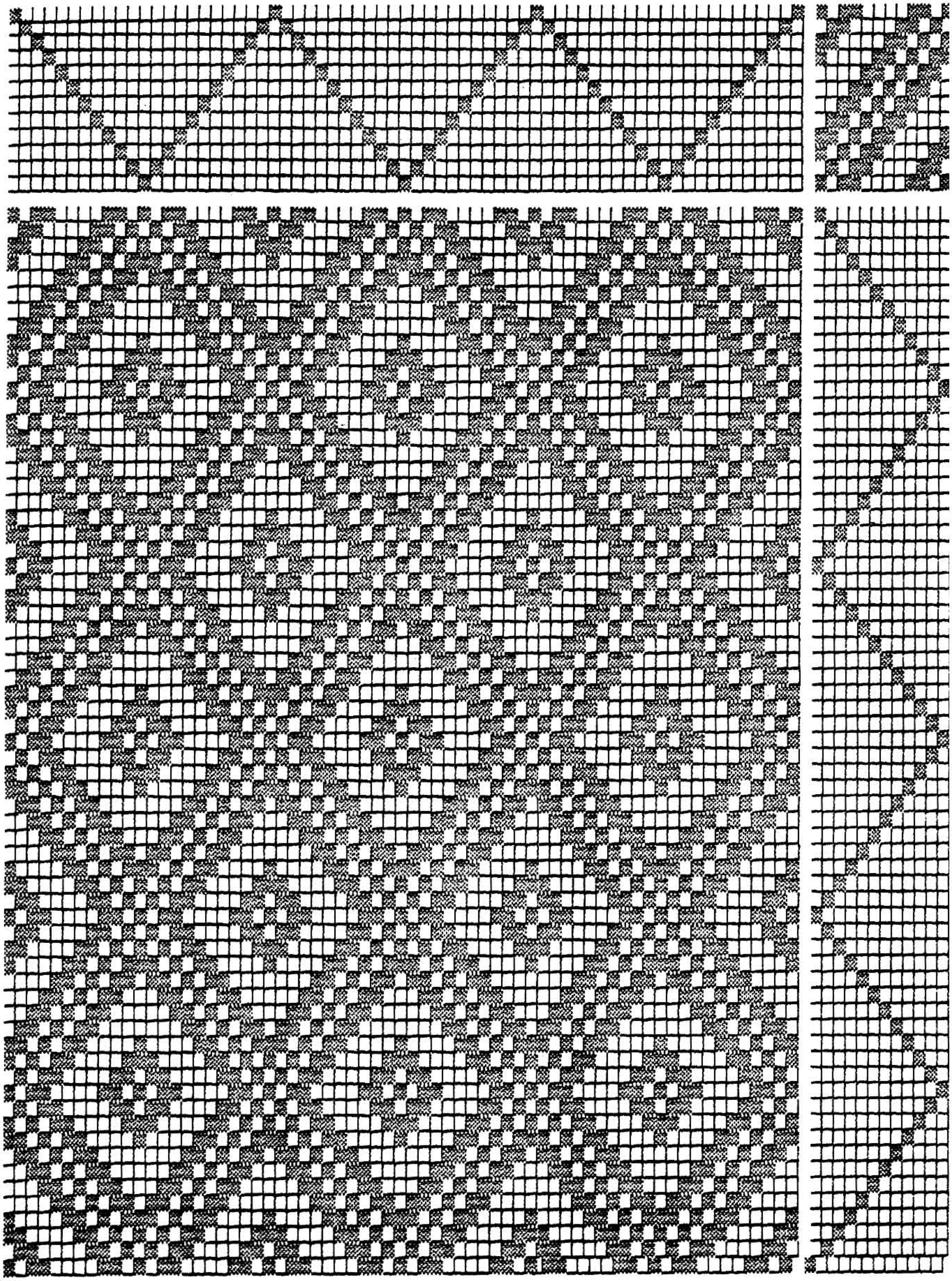

Fig. 15. Printout of 12 Harness Weave Design

The number that is entered second indicates the harness to which the color is assigned. A one-dimensional array contains values for both the color and harness numbers by combining each color and harness entry into one binary coded decimal number. This number is later recalled when the threading and tie-up arrays are searched for values to fill in the drawdown.

The tie-up and treadling are displayed in the character color when entered, although the drawdown disregards the character color and leaves any areas that are not assigned to the threading in the screen color. An example of a 12 harness design using Color Weave is shown in Figure 13. A fabric sample of the weave is shown in Figure 14.

The delete and printout options are both available in the program. A printout of the 12 harness design is shown in Figure 15.

## Weave Analysis

The Weave Analysis program enables the user to directly enter a weaving pattern in the weave draft, or drawdown, area of the pattern draft. Once the design is entered, the threading, tie-up, and treadling drafts are automatically displayed with the drafting information needed to weave the pattern, if the design can be woven on a 16 harness loom using one treadle per treadling row. This program is particularly useful for analyzing weaves for reconstruction or replication of fabrics, such as historical fabrics. It is also useful for the artist who wants to create a design directly on the screen.

The program begins by asking the user to enter a fill in size. This number indicates the maximum number of squares across and down that can be entered in the drawdown. Due to the code that is set for the variables in the entered design and the limits of the computer, the fill in size must be less than 30. The number that will be entered will depend on the amount of area that is needed to enter the design. A design using 29 spaces will take much longer to enter than one using 16 spaces. This should be taken into consideration when entering a pattern for the analysis of a woven sample, since a simple pattern would require a smaller working area and could be entered more quickly with a smaller fill in size.

After the fill in size is entered, the computer draws on the screen a gridded graph with the capability of displaying a design requiring up to 16 harnesses. To fill in a square in the drawdown, any key on the keyboard may be pressed. To pass a square and leave it blank, the space bar is pressed. A delete option enables the user to delete back to any point, thus allowing for input errors and design changes. As each square is entered, the value for that square is stored in an array as a decimal number in a binary code. An empty square is designated with a 0 and a filled square is designated with a 1. The values are stored in two arrays: one for the column (down) values and one for the row (across) values.

The entering of the design is finished when the fill in size has been completed in both directions. The computer will take no more entries at this point. The threading, tie-up, and treadling are then automatically displayed by the computer, if the design can be woven on 16 or fewer harnesses using one treadle per treadling row. If the design is not possible on a 16 harness loom, the words "CANNOT BE DONE ON A 16 HARNESS LOOM" will appear at the top of the screen.

The threading and treadling sequences are determined by the computer first. The computer searches an array containing the column values and sets the first coded column to harness one. It then searches the remaining columns and sets each identical column to harness one. The next different column is set to harness two, and so on. This is repeated for each column. The treadling sequence is assigned in the same way, with each row across, stored in a separate array, assigned to its particular treadle. The threading and treadling values are stored in their own arrays and are then searched to determine the tie-up. A printout of the finished draft is available with this program also by pressing P.

## Advantages and Limitations of the Programs

There are many advantages for using a computer and the programs that were developed in this study when designing handweaving patterns. The computer can provide reduction in time, labor, and material costs since designs can be visualized and scrutinized prior to weaving. The programs are excellent for trying out variations in tie-up and treadling sequences after a loom has been warped. The Weave Analysis program can determine the drafting information for weaving an existing fabric much faster than by hand and provides a greater guarantee of accuracy. The accuracy of weaving patterns taken from books can also be determined with the programs.

Pattern drafting is very difficult for some people to understand. These programs actually eliminate the need to understand the drafting process since the computer does the work for you. The programs would also be an excellent aid for teaching weaving students the theory of pattern drafting and the use of design techniques.

There are many advantages of the programs developed for this study. The programs were developed for use on the Commodore Vic 20 which is currently the least expensive home color computer on the market. The programs are stored on tape and do not require the purchase of an expensive disc drive.

The programs were written in BASIC which is an easy language to understand. Any type of weave, including single unit and block weaves, can be designed with the programs. The user can design in black and white for fast visualization of a pattern or in color after choosing from the 16 available colors. Designs can be visualized one row at a time when entering the treadling sequence. More than one treadle per treadling row can be entered for greater design manipulation. Design changes can be made immediately by deleting and re-entering a row. The Weave Design II, Color Weave, and Weave Analysis programs provide delete options that allow for input errors and design changes. The drafting quadrants, and drafting information, are included in the screen display of the design for easy reference and visualization. The analysis of woven patterns from existing fabrics is possible with the Weave Analysis program. Finally, the design and drafting information can be printed out by using the print option which will provide practical hardcopy output that can be carried directly to the loom.

Unfortunately, there are also limitations with the programs. Currently, only one color can be assigned to the treadling sequence of Color Weave. Although the user can choose from 16 colors, Color Weave is limited to the selection of four colors per design. The drawdown execution of the programs, particularly Color Weave, is slow due to the language in which the programs were written. Also, there is currently no way to save designs on tape for future reference. The development of these programs is not complete, however. Additions to the programs are planned that will eliminate the current limitations.

# CHAPTER IV

## SUMMARY AND CONCLUSIONS

The advantages of designing woven patterns with a computer far outweigh the disadvantages and limitations. Pattern drafting by hand is extremely slow and laborious. Any design changes in a pattern must be done from scratch with a new draft. The use of a computer for designing can reduce the amount of time involved in the drafting process from hours to minutes. The computer can also reduce material costs since designs can be visualized and scrutinized before they are woven.

In this study, four programs were developed for designing handweaving patterns with the Commodore Vic 20 color computer. Programs Weave Design, Weave Design II, and Color Weave enable the user to enter the threading, tie-up, and treadling sequences for a weave using up to 16 harnesses and produce the pattern drawdown of the design. Weave Design produces a gridded graph display of a comprehensive draft with threading, tie-up, treadling, and drawdown quadrants. Designs are displayed in black and white. Weave Design II is a variation of Weave Design. It provides a larger display area due to the elimination of the graph lines. The comprehensive draft is divided into four quadrants for entering designs in black and white. The program contains editing options which allow the user to correct input errors or change entries in the threading, tie-up, treadling, and drawdown drafts. Color Weave is a variation of Weave Design II and enables the user to design patterns in up to four colors after selecting from 16 available colors. Color Weave also contains editing options that allow for input errors and design changes.

The fourth program, Weave Analysis, enables the user to directly enter a weaving pattern in the drawdown area of the pattern draft and automatically displays the drafting information that would be required to produce the weave. The size of the pattern to be entered can vary by selecting the desired number of squares to be used in the drawdown. Weave Analysis also contains an editing option to allow for input errors or design changes while entering the pattern. All of the programs have a print option which provides a hardcopy printout of the comprehensive pattern draft.

These programs can greatly aid the handweaver and have many advantages over other computer programs for designing handweaving patterns. The programs were developed for use on the Commodore Vic 20 which is currently the least expensive color computer on the home computer market. The programs are stored on tape and do not require the purchase of an expensive disc drive. The programs were written in BASIC which is an easy language to understand.

Any type of weave, including single unit and block weaves, can be designed with the programs. Designs can be entered in black and white for quick design visualization. Chosen designs can be explored further in color from a selection of 16 possible colors.

The drafting information is displayed on the screen with the pattern. This gives the user an overall view of the weave pattern and its construction requirements, a necessity when design changes are to be made. The designs can be visualized one row at a time when entering the treadling sequence. Design changes can be made immediately by deleting and re-entering a row. The delete option also allows for input errors. Design manipulation is greatly increased with the ability to enter more than one treadle per treadling row.

Many weavers design directly on their looms by trying different tie-up and treadling variations, since these are the two design factors that can be manipulated once a loom has been set up. This is a trial-and-error system, however. Designing with the programs can be very useful in this case since different tie-up and treadling variations can be tried on the computer before they are woven thus saving time and money on wasted yarn.

The Weave Analysis program can determine the construction characteristics of a weave pattern or existing fabric much faster than by hand and provides a greater guarantee of accuracy. This program would be particularly useful for analyzing weaves for the reconstruction or replication of historical fabrics. The program is also useful for the weaver who wants to create a design directly on the screen. The accuracy of weaving patterns taken from books can also be determined with the programs.

The printout of the comprehensive draft that is provided by the programs is very convenient for the weaver to use in setting up the loom since it can be carried directly to the loom. Finally, some weavers find pattern drafting very difficult to understand. These programs eliminate the need to understand the drafting process since the computer does the work for you.

Unfortunately, there are limitations to the programs. Color Weave is limited to a selection of 16 colors due to the limits of the computer. The Color Weave program is also limited to the use of four colors within a pattern. Only one color can be assigned to the treadling sequence in Color Weave, which limits the weft of the pattern to one color. This creates a limitation on the amount of design and color manipulation within a pattern. The drawdown execution of the programs, particularly in Color

Weave, is slow due to the language in which the programs were written. Also, there is currently no way to save designs on tape for future reference.

The development of these programs is not complete, however. Although the programs are currently marketable, new developments are planned before they will be offered on the market. Developments that are planned include the ability to use more than one color in the treadling sequence of Color Weave. If possible, Color Weave will be expanded to include the ability to design with more than four colors per pattern. The program may also be revised to allow the user to change a pattern's colors after the design has been completed on the screen. Program routines that are slow in execution will be rewritten in machine language in order to speed up the execution time. The programs will also be condensed in order to reduce the amount of memory required to use them. An addition to each program that will enable the user to save designs on tape is planned. The programs may also be offered on tape or disc in the future. Changes in the programs will undoubtedly continue. Program development is a dynamic process and can continue for years as improvements and revisions are made.

The Commodore Vic 20 is quickly becoming a very popular computer for home computer systems due to its low price, availability, and capabilities. It has been estimated that there will be a computer in every home by the year 2000. The Vic 20 will very likely control a large share of this market.

Fiber art is becoming an increasingly popular medium for artistic expression. Handweaving as a hobby has always been popular and will undoubtedly remain so. Handweaving, whether for artistic expression or recreation, for pleasure or profit, will continue to be explored in many new ways. As new directions in the art are taken, the computer will very likely become an integral part of the weaving and designing process.

# BIBLIOGRAPHY


1. "Alternatives to the Jacquard." Fiberarts, March/April 1982, pp. 54-55.

2. Alvic, Philis. "Drafting: A Personal Approach." Shuttle, Spindle and Dyepot, Winter 1982, pp. 32-33.

3. "Automatic Preparation of Knitted Fabric Patterns on the Stibbematic System." British Knitting Industry 44 (July 1971):62-64.

4. Black, Mary E. New Key to Weaving. New York: Macmillan Publishing Co., Inc., 1957.

5. Brutton, Mark. "Textiles: A Suitable Case for Treatment." Design, December 1976, pp. 44-47.

6. "Color by Computer: Latest Wrinkle in Textile Printing." Graphics Art Monthly 49 (August 1977):26-28.

7. "Computer-Aided Design in Knitting." British Knitting Industry 43 (November 1970):73-74.

8. "Computers Launch Carpets into the High Street Fashion Business." Design, May 1979, p. 16.

9. Computer Technology for Textiles. A compilation of twenty-six articles from the October 1969 and March 1970 issues of Textile Industries, W. R. C. Smith Publishing Company, 1970.

10. "Computer Weaving from Laurel Software." Compute!, June 1982, pp. 178-182.

11. "Designing Programs: Think DOCS--Film Making of Original Design." Japan Textile News, May 1977, p. 91-95.

12. "Developments in Double Knit EDP." Textile Industries 138 (May 1974): 103-104.

13. Doughty, John Carr. "Design by Computer 'an Alarming Prospect'." Textile Month (August 1973):32-33.

14. Doughty, John Carr. "Design Creation and Proliferation." British Knitting Industry 46 (August 1971):34-35,74.

15. Doughty, John Carr. "The Computer in Knitwear Design." Knitting Times 42 (24 September 1973): 82-87.

16. "EDP Dobby Loom Design." Textile Industries 139 (May 1975):39,41.

17. Finkle, A.; Harris, N. Higginbottom, P.; and Tomczyk, M. Vic 20 Programmer's Reference Guide. Commodore Business Machines, Inc., 1982.

18. "First Report: New Era for Fabric Design." Textile World 122 (September 1972):82-83.

19. Fordham, D. N. "Chip Weaving." Weaver's Journal, no. 118 (Summer 1981), pp. 10-13.

20. Frey, Berta. Designing and Drafting for Handweavers. New York: The Macmillan Company, 1958.

21. Furukawa, Tsukasa. "2 Japan Firms Slate Knitting Systems for Export." Daily News Record, 15 September 1976, p. 33.

22. Hearle, J. W. S.; Konopasek, M.; and Newton, A. "Computer-Aided Textile Textile Design." New Ways to Produce Textiles; Papers of the 57th Annual Conference of the Textile Institute, 1971, pp. 133-156.

23. Held, Shirley, E. Weaving, a Handbook for Fiber Craftsmen. New York: Holt, Rinehart, and Winston, Inc., 1973.

24. Hell, Dr. Ing. R. "Computer Controlled Textile Design Processing System for Weaving and Knitting." International Textile Bulletin/Weaving, no. 2 (1980), pp. 139-140.

25. Hoskins, Janet A. "Computerized Analysis of the Drawdown." Shuttle, Spindle and Dyepot, Winter 1982, pp. 76-77.

26. Huff, Karen E. "The Computer Learns to Weave." Shuttle, Spindle and Dyepot, Fall 1975, pp. 24:19-23:21.

27. Ingus, George. "Fyscan Computer Design System Tabbed by Winston Mills." Knitting Times 42 (24 September 1973):79-81.

28. Ishizawa, Kazutomo. "Kanebo's Knit Pattern Information Processing System." Knitting Times 45 (9 February 1976):55-59.

29. Jarvis, Helen. "Computerized Weaving Calculations." Shuttle, Spindle and Dyepot, Summer 1981, pp. 46-48.

30. Jerrard, R., and Lock, R. A. "Computer-Aided Textile Design Research." Textile Manufacturer 101 (August 1974):16-17.

31. Kurtz, Carol. "Basic Drafting." Shuttle, Spindle and Dyepot, Summer 1979, pp. 18-21.

32. Kurtz, Carol. "Designing Block Weaves." Shuttle, Spindle and Dyepot, Spring 1980, pp. 5-9.

33. Kurtz, Carol. "Designing Drafts." Shuttle, Spindle and Dyepot, Fall 1979, pp. 28-33.

34. Kurtz, Carol. Designing for Weaving. New York: Hastings House, 1981.

35. Leventhal, Lance A. 6502 Assembly Language Programming. Berkeley: Osborne/McGraw-Hill, 1979.

36. Lourie, Janice R. Textile Graphics/Computer-Aided, New York: Fairchild Publications, Inc., 1973.

37. Marston, Ena. "Overshot: The Weave and the Designs." Shuttle, Spindle and Dyepot, Spring 1980, pp. 74-79.

38. Personal Computing on the Vic 20. Commodore International, Ltd., 1981.

39. Pilsk, Adele. "Computer Drafts." Fiberarts, September/October 1978, pp. 18-19.

40. Ridgway, Bernard. "Carpet Design by Computer." Textile Industries 141 (September 1977):36-37.

41. Russellkraus, J. "Computer Aid is Due for Weaving Design." Women's Wear Daily, 21 September 1981, p. 18.

42. Ryall, Pierre. Weaving Techniques for the Multiple Harness Loom. New York: Van Nostrand Reinhold Company, 1979.

43. Scorgie, Jean, and Sinclair, Ann. "The Posneg Program." Shuttle, Spindle and Dyepot, Summer 1982, pp. 26-29.

44. Scorgie, Jean, and Sinclair, Ann. "Using the Block Patterns Program." Shuttle, Spindle and Dyepot, Fall 1982, pp. 16-17.

44. Spitz, Mary. "Computers Aid Design." Residential Interiors, September/October 1979, pp. 86-86,116,118.

45. Suchecki, Stanley. "Fast Film Service." Textile Industries 140 (December 1976):104,107.

46. TerLouw, Betty. "Making a Color Draw-Up." Shuttle, Spindle and Dyepot, Spring 1982, p. 37.

47. The editors of American Fabrics and Fashions Magazine. The New Encyclopedia of Textiles. New Jersey: Prentice-Hall, Inc., 1980.

48. "The Electronically Controlled Pattern Preparation, Needle Selection and Function on the Large Size Circular Knitting Machine." International Textile Bulletin/Knitting/Hosiery/Making-Up, no. 1 (1975), pp. 13-20.

49. Tidball, Harriet. The Weaver's Book. New York: Macmillan Publishing Co., Inc., 1977.

50. Tod, Osma Gallinger. The Joy of Handweaving. New York: Dover Publications, Inc., 1977.

51. Tovey, John. Weaves and Pattern Drafting. New York: Van Nostrand Reinhold Company, 1969.

52. Unger, E. A., and Ahmed, Nasir. Computer Science Fundamentals. Columbus: Charles E. Merrill Publishing Company, 1979.

53. Van Der Beck, Stan. "New Talent-The Computer." Art in America, January/February 1970, pp. 86-91.

54. Velderman, Pat. "Computer Generated Overshot Variations." Handweaver and Craftsman, Fall 1971, pp. 10-11,42.

55. Vic-1515 Graphic Printer User's Manual. Commodore Business Machines, Inc., 1981.

56. Vic 20 Super Expander Instruction Guide. Commodore Business Machine, Inc., 1981.

57. Walker, Christine. "A Brief Encounter with Instant Knitting." Design, no. 352 (April 1978), pp. 43-47.

58. Windeknecht, Margaret B., and Thomas G. "Computer-Aided Design of Handweaving." On Computing, Winter 1980, pp. 16-21.

59. Wray, Suzanne. "Design Possibilities Broadened by Use of Electronic Equipment." Knitting Times 51 (11 January 1982):30-32.

# APPENDICES

# APPENDIX A

# WEAVE DESIGN

# WEAVE DESIGN

The Weave Design program enables the user to enter the threading, tie-up, and treadling sequences for a weave using up to 16 harnesses and produces the pattern drawdown of the weave in black and white. The user chooses from a harness selection of 4, 8, 12, or 16 harnesses. The computer then displays a graph with solid lines dividing the four draft quadrants. The user enters the threading sequence by pressing keys 1-16. Numbers 10-16 are entered by holding down the SHIFT key and entering the last digit of the number. RETURN is pressed after the last threading entry. The tie-up sequence is entered by pressing keys 1-16. RETURN is pressed to continue on to the next tie-up column. After the last tie-up entry, RETURN is pressed again. The user then enters the treadling sequence using keys 1-16. RETURN is pressed to continue on to the next treadling row. As each treadling row is entered, the subsequent drawdown row is automatically displayed by the computer. When the draft has been completed, a printout of the design and drafting information may be obtained by pressing the P key.

USER PROCEDURE

1. Turn on the machine and load the program from the tape.
2. Type RUN. Press RETURN. A title page will appear.
3 Press RETURN.
4. HARNESS SELECTION

   1. 4 HARNESS
   2. 8 HARNESS
   3. 12 HARNESS
   4. 16 HARNESS

   CHOOSE 1, 2, 3, OR 4? Press 1, 2, 3, or 4. Press RETURN.
5. A graphic display appears on the screen. Enter the threading by pressing keys 1-16, according to the harness selection.

   NOTE: To enter numbers 10-16, hold down the SHIFT key and press the last digit of the number. Ten can also be entered by just pressing 0.
6. After the threading has been entered, press RETURN.
7. Enter the tie-up by pressing keys 1-16. As many tie-up squares as harnesses can be entered per column. After each tie-up column is entered, press RETURN.
8. After the last tie-up column has been entered, press RETURN.
9. Enter the treadling by pressing keys 1-16. As many treadles as harnesses can be entered per row. After each row is entered, press RETURN.
10. Once the drawdown has been completed a printout of the pattern draft can be ontained. Press RETURN after the last treadle entry and press the P key.

    NOTE: The printer must be on to obtain a printout.

    NOTE: The drawdown does not have to be completed to obtain a printout. A printout can be obtained after only a portion of the drawdown has been executed by pressing RETURN for each remaining row of the treadling draft. Press RETURN after the last row and press P.

    NOTE: At any time during the program execution a draft can be erased and the program started over by pressing the RUN/STOP and RESTORE keys simultaneously, typing RUN, and pressing RETURN.

```
10 REM PROGRAM WEAVE DESIGN BY KARI ANN ARNOLD, SEPTEMBER, 1982.
20 REM THIS PROGRAM LETS THE USER ENTER THE THREADING, TIE-UP AND
30 REM TREADLING SEQUENCES FOR A WEAVE AND PRODUCES THE PATTERN DRAWDOWN.
40 REM DESIGNS FOR UP TO 16 HARNESSES CAN BE ENTERED.
50 REM A PRINTOUT OF THE DRAFT IS OPTIONAL.
60 REM I AND J ARE LOOP COUNTERS.
70 REM A IS THE THREADING ARRAY, B IS THE TIE-UP ARRAY, C IS THE TREADLING ARRAY
80 REM F IS THE ARRAY REPRESENTING THE DRAWDOWN FOR THE PRINT ROUTINE.
90 DIMA(66),B(16,16),C(66),F(66,3)
100 PRINT"▒▒▒   *WEAVE DESIGN*":PRINT"▒▒"
110 PRINT" BY KARI ANN ARNOLD":PRINT""
120 PRINT"  SEPTEMBER, 1982"
130 PRINT"▒▒▒";"HIT RETURN TO CONTINUE"
140 GETA$:IFA$=""THEN140
150 B=ASC(A$):IFNOT(B=13)THEN150
160 PRINT"▒ *WEAVE DESIGN*":PRINT"":PRINT""
170 PRINT"HARNESS SELECTION":PRINT""
180 PRINT" 1. 4 HARNESS"
190 PRINT" 2. 8 HARNESS"
200 PRINT" 3. 12 HARNESS"
210 PRINT" 4. 16 HARNESS"
220 PRINT""
230 INPUT"CHOOSE 1, 2, 3, OR 4";A
240 A2=6.39375
250 ONAGOTO280,350,410,470
260 GOTO170
270 REM A1 IS THE GRAPH SIZE.
280 GRAPHIC2
290 A1=19.18125
300 GOSUB540
310 REM X AND Y ARE POSITIONS FOR THE GRAPH SOLID DIVISION LINES.
320 X=INT(1023/A1)-5
330 Y=A1*4+A2
340 GOTO620
350 GRAPHIC2
360 A1=19.18125
370 GOSUB540
380 X=INT(1023/A1)-9
390 Y=A1*8+A2
400 GOTO620
410 GRAPHIC2
420 A1=12.7875
430 GOSUB540
440 X=INT(1023/A1)-13
450 Y=A1*12+A2
460 GOTO620
470 GRAPHIC2
480 A1=12.7875
490 GOSUB540
500 X=INT(1023/A1)-17
510 Y=A1*16+A2
520 GOTO620
530 REM THIS SUBROUTINE DRAWS THE GRAPH.
540 COLOR1,0,0,4
```

```
550 FORI=A1TO1023STEPA1
560 DRAW2,0,ITO1023,I
570 DRAW2,I,0TOI,1023
580 NEXT
590 RETURN
600 REM THIS LOOP PAINTS THE X AND Y SOLID DIVISION LINES.
610 REM K AND L ARE THE DIVISION LINE WIDTHS.
620 FORJ=0TO1023STEPA1
630 K=J+A2:L=X*A1+A2
640 PAINT2,K,Y
650 PAINT2,L,K
660 NEXT
670 REM THIS LOOP ENTERS THE THREADING.
680 REM ARRAY A CONTAINS THE THREADING VALUES.
690 REM A3 IS THE X COORDINATE FOR THE THREADING PAINT, A4 IS THE Y COORDINATE.
700 A=A*4
710 FORJ=0TOX-1
720 GOSUB1390
730 A(J)=Z
740 A3=J*A1+A2
750 A4=(A-A(J))*A1+A2
760 IF(A-A(J))<0ORA(J)=0THEN720
770 PAINT2,A3,A4
780 NEXT
790 GOSUB1390
800 IFNOT(Z=13)THEN790
810 REM THIS LOOP CLEARS THE TIE-UP ARRAY.
820 REM ARRAY B CONTAINS THE TIE-UP VALUES.
830 FORI=0TO16:FORJ=0TO16
840 B(I,J)=0:NEXT:NEXT
850 REM THIS LOOP ENTERS THE TIE-UP.
860 FORJ=1TOA
870 GOSUB920
880 NEXT
890 GOTO1070
900 REM TIE-UP SUBROUTINE.
910 REM B1 IS THE X COORD FOR THE TIE-UP PAINT, B2 IS THE Y COORD.
920 I=1
930 GOSUB1390
940 B(J,I)=Z
950 B1=X*A1+J*A1+A2
960 B2=(A-B(J,I))*A1+A2
970 REM 13=RETURN
980 B3=ASC(A$):IFB3=13THENRETURN
990 IF(A-B(J,I))<0ORB(J,I)=0THEN930
1000 PAINT2,B1,B2
1010 I=I+1
1020 IFI>16THENRETURN
1030 GOTO930
1040 REM THIS LOOP ENTERS THE TREADLING AND DRAWDOWN.
1050 REM ARRAY C CONTAINS THE TREADLING VALUES.
1060 REM C1 IS THE X COORD FOR THE TREADLING PAINT, C2 IS THE Y COORD.
1070 FORJ=1TOX
1080 GOSUB1140
```

```
1090 IFNOT(Z=13)THEN1080
1100 NEXT
1110 GETA$:IFA$=""THEN1110
1120 H=ASC(A$):IFH=80THEN1530
1130 GOTO1110
1140 GOSUB1390
1150 IFZ=13THENRETURN
1160 C(J)=Z
1170 C1=(X+C(J))*A1+A2
1180 C2=(A+J)*A1+A2
1190 IFC(J)=0ORC(J)>ATHEN1140
1200 PAINT2,C1,C2
1210 FORI=1TOA
1220 IFB(C(J),I)=0THEN1240
1230 GOSUB1280
1240 NEXT
1250 RETURN
1260 REM DRAWDOWN SUBROUTINE.
1270 D1 IS THE X COORDINATE FOR THE DRAWDOWN PAINT.
1280 FORC=0TOX-1
1290 D1=C*A1+A2
1300 IFA(C)=B(C(J),I)THEN1330
1310 NEXT
1320 RETURN
1330 N=INT(C/22)+1
1340 W=2↑(22-(C-(N-1)*22))
1350 F(J-1,N)=F(J-1,N)+W
1360 PAINT2,D1,C2
1370 GOTO1310
1380 REM THIS SUBROUTINE ENTERS THE THREADING, TIE-UP AND TREADLING VALUES 1-16.
1390 GETA$:IFA$=""THEN1390
1400 Z=ASC(A$)
1410 IFZ<58ANDZ>48THEN1460
1420 IFZ<39ANDZ>32THEN1480
1430 IFZ=48THEN1500
1440 IFZ=13THENRETURN
1450 GOTO1390
1460 Z=Z-48
1470 RETURN
1480 Z=Z-22
1490 RETURN
1500 Z=10
1510 RETURN
1520 REM THIS ROUTINE GIVES THE HARDCOPY PRINTOUT.
1530 OPEN4,4
1540 FORI=ATO1STEP-1
1550 M=2-INT(I/10)
1560 PRINT#4,CHR$(15)I;TAB(M);
1570 FORJ=0TOX-1
1580 IFA(J)=ITHEN1610
1590 PRINT#4,"⌋";
1600 GOTO1620
1610 PRINT#4,"▒";
1620 NEXT
```

```
1630 PRINT#4," ";
1640 FORJ=1TOA
1650 A$="┘"
1660 FORK=1TOA-1
1670 IFNOT(B(J,K)=I)THEN1690
1680 A$="▒"
1690 NEXT
1700 PRINT#4,A$;
1710 NEXT
1720 PRINT#4,CHR$(8)""
1730 NEXT
1740 PRINT#4,CHR$(8)""
1750 FORI=0TOX-1
1760 PRINT#4,CHR$(15)TAB(5);
1770 FORK=1TO3
1780 FORS=22TO1STEP-1
1790 A5=INT(F(I,K)/2↑S)
1800 IFA5=0THENA$="┘":GOTO1830
1810 A$="▒"
1820 F(I,K)=F(I,K)-2↑S
1830 PRINT#4,A$;
1840 IFX-1=K*22-STHENS=0
1850 NEXT
1860 NEXT
1870 PRINT#4," ";
1880 FORJ=1TOA
1890 IFC(I+1)=JTHENPRINT#4,"▒";:GOTO1910
1900 PRINT#4,"┘";
1910 NEXT
1920 PRINT#4,CHR$(8)""
1930 NEXT
1940 PRINT#4,""
1950 CLOSE4
1960 END
```

# APPENDIX B

# WEAVE DESIGN II

## WEAVE DESIGN II

The Weave Design II program enables the user to enter the threading, tie-up, and treadling sequences for a weave using up to 16 harnesses and produces the pattern drawdown of the weave in black and white. The user chooses from a harness selection of 4, 8, 12, or 16 harnesses. The computer than produces a graphic display with solid lines dividing the four draft quadrants. The user enters the threading sequence by pressing keys 1-16. Numbers 10-16 are entered by holding down the SHIFT key and entering the last digit of the number. When entering the threading, entry errors may be corrected or design changes may be made by pressing the DELETE key. RETURN is pressed after the last threading entry. The tie-up sequence is entered by pressing keys 1-16. RETURN is pressed to continue on to the next tie-up column. Entry errors may be corrected or design changes may be made by pressing the DELETE key. RETURN is pressed after the last tie-up entry. The user enters the treadling sequence using keys 1-16. RETURN is pressed to continue on to the next treadling row. As each treadling row is entered, the subsequent drawdown row is automatically displayed by the computer. Entry errors may be corrected or design changes may be made by pressing the DELETE key. When the draft has been completed, a printout of the design and drafting information may be obtained by pressing the P key.

USER PROCEDURE:

1. Turn on the machine and load the program from the tape.
2. Type RUN. Press RETURN. A title page will appear.
3. Press RETURN.
4. HARNESS SELECTION

   1. 4 HARNESS
   2. 8 HARNESS
   3. 12 HARNESS
   4. 16 HARNESS

   CHOOSE 1, 2, 3, OR 4? Press 1, 2, 3, or 4. Press RETURN.
5. A graphic display appears on the screen. Enter the threading by pressing keys 1-16, according to the harness selection.

   NOTE: To enter numbers 10-16, hold down the SHIFT key and press the last digit of the number. Ten can also be entered by just pressing 0.

   NOTE: If an error is made in entering the threading, the DELETE key can be pressed and the threading square re-entered. Entries will continue to delete each time the DELETE key is pressed.
6. After the threading has been entered, press RETURN.
7. Enter the tie-up by pressing keys 1-16. As many tie-up squares as harnesses can be entered per column. After each tie-up column is entered, press RETURN.

   NOTE: If an error is made in entering the tie-up, the DELETE key can be pressed and the tie-up column can be re-entered. Columns will continue to delete each time the DELETE key is pressed.
8. After the last tie-up column has been entered, press RETURN.

   NOTE: Tie-up columns can be left blank be pressing RETURN for each column to be left blank.
9. Enter the treadling by pressing keys 1-16. As many treadles as harnesses can be entered per row. After each row is entered, press RETURN.

   NOTE: If an error is made in entering the treadling, the DELETE key can be pressed and the treadling row can be re-entered. Design changes can also be made in the drawdown rows by deleting and re-entering. If RETURN was pressed after the last entry, DELETE will remove the last entry. If RETURN was not pressed, DELETE will remove the next to the last entry.
10. Once the drawdown has been completed a printout of the pattern draft can be obtained. Press RETURN after the last treadle entry and press the P key.

    NOTE: The printer must be on to obtain a printout.

NOTE: The drawdown does not have to be completed to obtain a printout. A printout can be obtained after only a portion of the drawdown has been executed by pressing RETURN for each remaining row of the treadling draft. Press RETURN after the last row and press P.

NOTE: At any time during the program execution a draft can be erased and the program started over by pressing the RUN/STOP and RESTORE keys simultaneously, typing RUN, and pressing RETURN.

```
10 REM PROGRAM WEAVE DESIGN II BY KARI ANN ARNOLD, SEPTEMBER, 1982.
20 REM THIS PROGRAM LETS THE USER ENTER THE THREADING, TIE-UP AND
30 REM TREADLING SEQUENCES FOR A WEAVE AND PRODUCES THE PATTERN DRAWDOWN.
40 REM DESIGNS FOR UP TO 16 HARNESSES CAN BE ENTERED.
50 REM A PRINTOUT OF THE DRAFT IS OPTIONAL.
60 REM I AND J ARE LOOP COUNTERS.
70 REM A IS THE THREADING ARRAY, B IS THE TIE-UP ARRAY, C IS THE TREADLING
80 REM ARRAY, F IS THE ARRAY REPRESENTING THE DRAWDOWN FOR THE PRINT ROUTINE.
90 DIMA(77),B(16,16),C(77,16),F(77,4)
100 PRINT"▒▒▒ *WEAVE DESIGN II*":PRINT"▒▒"
110 PRINT" BY KARI ANN ARNOLD":PRINT""
120 PRINT"  SEPTEMBER, 1982"
130 PRINT"▒▒▒▒";"HIT RETURN TO CONTINUE"
140 GETA$:IFA$=""THEN140
150 B=ASC(A$):IFNOT(B=13)THEN150
160 PRINT"▒*WEAVE DESIGN II*":PRINT"":PRINT""
170 PRINT"HARNESS SELECTION":PRINT""
180 PRINT" 1. 4 HARNESS"
190 PRINT" 2. 8 HARNESS"
200 PRINT" 3. 12 HARNESS"
210 PRINT" 4. 16 HARNESS"
220 PRINT""
230 INPUT"CHOOSE 1, 2, 3, OR 4";A
240 IFA<1ORA>4THEN170
250 GRAPHIC1
260 COLOR1,0,0,4
270 A=A*4
280 A1=12.7875
290 A2=6.39375
300 A3=79-A
310 X=A3*A1+A2
320 Y=A*A1+A2
330 DRAW2,0,YTO1023,Y
340 DRAW2,0,Y+A2TO1023,Y+A2
350 DRAW2,X,0TOX,1023
360 REM THIS LOOP ENTERS THE THREADING.
370 REM ARRAY A CONTAINS THE THREADING VALUES.
380 FORJ=0TOA3
390 GOSUB990
400 IFZ=20THENGOSUB1150:GOTO390
410 A(J)=Z
420 X=J*A1+A2
430 Y=(A-A(J))*A1+A2
440 IF(A-A(J))<0ORA(J)=0THEN390
450 POINT2,X,Y,X,Y+A2
460 NEXT
470 GOSUB990
480 IFNOT(Z=300)THEN470
490 REM THIS LOOP CLEARS THE TIE-UP ARRAY.
500 REM ARRAY B CONTAINS THE TIE-UP VALUES.
510 FORI=0TO16:FORJ=0TO16
520 B(I,J)=0:NEXT:NEXT
530 REM THIS LOOP ENTERS THE TIE-UP.
540 FORJ=1TOA
```

```
550 I=1
560 GOSUB990
570 IFZ=20THENGOSUB1210:GOTO560
580 IFZ=300THEN660
590 B(J,I)=Z
600 X=A1*(A3+J)+A2
610 Y=(A-B(J,I))*A1+A2
620 IF(A-B(J,I))<0ORB(J,I)=0THEN560
630 POINT2,X,Y,X,Y+A2
640 I=I+1
650 IFI<16THENGOTO560
660 NEXT
670 REM THIS LOOP ENTERS THE TREADLING AND DRAWDOWN.
680 REM ARRAY C CONTAINS THE TREADLING VALUES.
690 FORI=1TOA3
700 J=1
710 GOSUB990
720 IFZ=20THENGOSUB1300:GOTO710
730 IFZ=300THEN930
740 IFZ<1ORZ>ATHEN710
750 C(I,J)=Z
760 X=(A3+Z)*A1+A2
770 Y=(A+I)*A1+A2
780 IFC(I,J)=0ORC(I,J)>ATHEN710
790 POINT2,X,Y,X,Y+A2
800 FORK=1TOA
810 IFB(C(I,J),K)=0THENK=A+1:GOTO900
820 FORC=0TOA3
830 X1=C*A1+A2
840 IFNOT(A(C)=B(C(I,J),K))THEN890
850 N=INT(C/22)+1
860 W=2↑(22-(C-(N-1)*22))
870 F(I-1,N)=F(I-1,N)+W
880 POINT2,X1,Y,X1,Y+A2
890 NEXTC
900 NEXTK
910 J=J+1
920 GOTO710
930 NEXTI
940 GETA$:IFA$=""THEN940
950 Z=ASC(A$):IFZ=80THEN1430
960 GOTO940
970 END
980 REM THIS SUBROUTINE ENTERS THE THREADING, TIE-UP AND TREADLING VALUES 1-16.
990 GETA$:IFA$=""THEN990
1000 Z=ASC(A$)
1010 IFZ<58ANDZ>48THEN1070
1020 IFZ<39ANDZ>32THEN1090
1030 IFZ=48THEN1110
1040 IFZ=20THENRETURN
1050 IFZ=13THENZ=300:RETURN
1060 GOTO990
1070 Z=Z-48
1080 RETURN
```

```
1090 Z=Z-22
1100 RETURN
1110 Z=10
1120 RETURN
1130 REM DELETE SUBROUTINE.
1140 REM THREADING DELETE.
1150 J=J-1:IFJ<0THENJ=1:RETURN
1160 X=J*A1+A2
1170 Y=(A-A(J))*A1+A2
1180 POINT0,X,Y,X,Y+A2
1190 RETURN
1200 REM TIE-UP DELETE.
1210 I=I-1
1220 IFI<1THENI=1:J=J-1
1230 IFJ<1THENJ=1:I=1:GOTO1280
1240 FORI=ATO1STEP-1
1250 B(J,I)=0:NEXT
1260 X=A1*(A3+J)+A2
1270 DRAW0,X,0TOX,A1*A
1280 I=I+1
1290 REM TREADLING DELETE.
1300 I=I-1
1310 IFI<1THENI=1:GOTO1410
1320 FORJ=ATO1STEP-1
1330 C(I,J)=0:NEXT
1340 X1=A3*A1
1350 X2=(A3+2)*A1
1360 Y=A1*(A+I)+A2
1370 DRAW0,0,YTOX1,Y
1380 DRAW0,X2,YTO1023,Y
1390 DRAW0,0,Y+A2TOX1,Y+A2
1400 DRAW0,X2,Y+A2TO1023,Y+A2
1410 RETURN
1420 REM THIS ROUTINE GIVES THE HARDCOPY PRINTOUT.
1430 OPEN4,4
1440 FORI=ATO1STEP-1
1450 FORJ=0TOA3-1
1460 IFA(J)=ITHEN1490
1470 PRINT#4,CHR$(15)"┘";
1480 GOTO1500
1490 PRINT#4,CHR$(15)"▒";
1500 NEXTJ
1510 PRINT#4," ";
1520 FORJ=1TOA
1530 A$="┘"
1540 FORK=1TOA-1
1550 IFNOT(B(J,K)=I)THEN1570
1560 A$="▒"
1570 NEXTK
1580 PRINT#4,A$;
1590 NEXTJ
1600 PRINT#4,CHR$(8)""
1610 NEXTI
1620 PRINT#4,CHR$(8)""
```

```
1630 FORI=0TOA3-1
1640 FORK=1TO4
1650 FORS=22TO1STEP-1
1660 A4=INT(F(I,K)/2↑S)
1670 IFA4=0THENA$="┘":GOTO1700
1680 A$="▒"
1690 F(I,K)=F(I,K)-2↑S
1700 PRINT#4,CHR$(15)A$;
1710 IFA3-1=K*22-STHENS=0
1720 NEXTS
1730 NEXTK
1740 PRINT#4," ";
1750 FORK=1TOA
1760 A$="┘"
1770 FORL=1TOA
1780 IFC(I+1,L)=KTHENA$="▒"
1790 NEXTL
1800 PRINT#4,A$;
1810 NEXTK
1820 PRINT#4,CHR$(8)""
1830 NEXTI
1840 PRINT#4,""
1850 CLOSE4
1860 END
```

# APPENDIX C

# COLOR WEAVE

# COLOR WEAVE

The Color Weave program enables the user to enter the threading, tie-up, and treadling sequences in color for a weave using up to 16 harnesses and produces the pattern drawdown of the weave in color. The user chooses from a harness selection of 4, 8, 12, or 16 harnesses. The user then chooses four colors to be used in the weave design from a selection of 16 possible colors. The computer produces a graphic display according to the harness and color selections with solid lines dividing the four draft quadrants. The user enters the threading sequence with two numbers per entry. The first number indicates the color and is entered as a 1, 2, 3, or 4. The second number indicates the harness and is entered using numbers 1-16. Numbers 10-16 are entered by holding down the SHIFT key and entering the last digit of the number. When entering the threading, entry errors may be corrected or design changes may be made by pressing the DELETE key. RETURN is pressed after the last threading entry. The tie-up sequence is entered by pressing keys 1-16. RETURN is pressed to continue on to the next tie-up column. Entry errors may be corrected or design changes may be made by pressing the DELETE key. RETURN is pressed after the last tie-up entry. The user enters the treadling sequence using keys 1-16. RETURN is pressed to continue on to the next treadling row. As each treadling row is entered, the subsequent drawdown row is automatically displayed in the colors assigned to the threading and treadling. Entry errors may be corrected or design changes may be made by pressing the DELETE key. When the draft has been completed, a printout of the design and drafting information may be obtained by pressing the P key.

USER PROCEDURE:

1. Turn on the machine and load the program from the tape.
2. Type RUN. Press RETURN. A title page will appear.
3. Press RETURN.
4. HARNESS SELECTION
   1. 4 HARNESS
   2. 8 HARNESS
   3. 12 HARNESS
   4. 16 HARNESS

   CHOOSE 1, 2, 3, OR 4? Press 1, 2, 3, or 4. Press RETURN.
5. CHOOSE 4 COLORS
   1. SCREEN: 0-15? Choose a number from 0-15 to designate the screen color. Press RETURN.
   2. BORDER: 0-7? Choose a number from 0-7 to designate the border color. Press RETURN.
   3. CHARACTER: 0-15? Choose a color from 0-15 to designate the character color. Press RETURN.
   4. AUXILIARY: 0-15? Choose a color from 0-15 to designate the auxiliary color. Press RETURN.
6. A graphic display appears on the screen in the designated colors. Enter the threading with two numbers per entry. The first number indicates the color and is entered as a 1, 2, 3, or 4, according to the assigned screen, border, character, and auxiliary colors. The next number is entered with keys 1-16 according to the harness selection.

   NOTE: To enter numbers 10-16, hold down the SHIFT key and press the last digit of the number. Ten can also be entered by just pressing 0.

   NOTE: If an error is made in entering the threading, the DELETE key can be pressed and the threading square re-entered. Entries will continue to delete each time the DELETE key is pressed.
7. After the threading has been entered, press RETURN.
8. Enter the tie-up by pressing keys 1-16. As many tie-up squares as harnesses can be entered per column. After each tie-up column is entered, press RETURN.

   NOTE: If an error is made in entering the tie-up, the DELETE key can be pressed and the tie-up column can be re-entered. Columns will continue to delete each time the DELETE key is pressed.
9. After the last tie-up column has been entered, press RETURN.

   NOTE: Tie-up columns can be left blank by pressing RETURN for each column to be left blank.
10. Enter the treadling by pressing keys 1-16. As many treadles as harnesses can be entered per row. After each row is entered, press RETURN.

NOTE: If an error is made in entering the treadling, the DELETE key can be pressed and the treadling row can be re-entered. Design changes can also be made in the drawdown rows by deleting and re-entering. If RETURN was pressed after the last entry, DELETE will remove the last entry. If RETURN was not pressed, DELETE will remove the next to the last entry.

11. Once the drawdown has been completed a printout of the pattern draft can be obtained. Press RETURN after the last treadle entry and press the P key.

    NOTE: The printer must be on to obtain a printout.

    NOTE: The drawdown does not have to be completed to obtain a printout. A printout can be obtained after only a portion of the drawdown has been executed by pressing RETURN for each remaining row of the treadling draft. Press RETURN after the last row and press P.

    NOTE: At any time during the program execution a draft can be erased and the program started over by pressing the RUN/STOP and RESTORE keys simultaneously, typing RUN, and pressing RETURN.

```
10 REM PROGRAM COLOR WEAVE BY KARI ANN ARNOLD, SEPTEMBER, 1982.
20 REM THIS PROGRAM LETS THE USER DESIGN WEAVING PATTERNS IN COLOR
30 REM BY ENTERING THE THREADING, TIE-UP, AND TREADLING SEQUENCES AND
40 REM PRODUCES THE PATTERN DRAWDOWN IN COLOR.
50 REM DESIGNS USING UP TO FOUR COLORS AND SIXTEEN HARNESSES CAN BE ENTERED.
60 REM A IS THE THREADING ARRAY, B IS THE TIE-UP ARRAY, C IS THE TREADLING
70 REM ARRAY, F IS THE ARRAY REPRESENTING THE DRAWDOWN FOR THE PRINT ROUTINE.
80 DIMA(77),B(16,16),C(77,16),F(77,4)
90 PRINT"]QQ   *COLOR WEAVE*":PRINT"QQ"
100 PRINT" BY KARI ANN ARNOLD":PRINT""
110 PRINT"  SEPTEMBER, 1982"
120 PRINT"QQQQ";"HIT RETURN TO CONTINUE"
130 GETA$:IFA$=""THEN130
140 B=ASC(A$):IFNOT(B=13)THEN140
150 PRINT"]  *COLOR WEAVE*":PRINT"":PRINT""
160 PRINT"HARNESS SELECTION":PRINT""
170 PRINT" 1. 4 HARNESS"
180 PRINT" 2. 8 HARNESS"
190 PRINT" 3. 12 HARNESS"
200 PRINT" 4. 16 HARNESS"
210 PRINT""
220 INPUT"CHOOSE 1, 2, 3, OR 4";A
230 IFA<1ORA>4THEN160
240 PRINT"]CHOOSE 4 COLORS":PRINT""
250 INPUT"1.SCREEN:0-15";C1
260 INPUT"2.BORDER:0-7";C2
270 INPUT"3.CHARACTER:0-15";C3
280 INPUT"4.AUXILIARY:0-15";C4
290 GRAPHIC1
300 COLORC1,C2,C3,C4
310 A=A*4
320 A1=12.7875
330 A2=6.39375
340 A3=79-A
350 X=(79-A)*A1+A2
360 Y=A*A1+A2
370 DRAW2,0,YTO1023,Y
380 DRAW2,0,Y+A2TO1023,Y+A2
390 DRAW2,X,0TOX,1023
400 COLORC1,C2,C3,C4
410 REM THIS LOOP ENTERS THE COLOR AND THREADING.
420 REM ARRAY A CONTAINS THE COLOR AND THREADING VALUES.
430 REM Z IS THE THREADING VALUE, C IS THE COLOR VALUE.
440 FORJ=1TOA3
450 GOSUB1150
460 IFZ=20THENGOSUB1310:GOTO450
470 IFZ<1ORZ>4THEN450
480 C=Z-1
490 GOSUB1150
500 IFZ<1ORZ>ATHEN490
510 REM A(J) PUTS COLOR AND HARNESS NUMBERS INTO BINARY CODE.
520 A(J)=Z+C*32
530 X=J*A1
540 Y=(A-Z)*A1+A2
```

```
550 POINTC,X,Y,X,Y+A2
560 NEXT
570 GOSUB1150
580 IFNOT(Z=300)THEN570
590 REM THIS LOOP CLEARS THE TIE-UP`ARRAY.
600 FORI=0TOA:FORJ=0TOA
610 B(I,J)=0:NEXT:NEXT
620 REM THIS LOOP ENTERS THE TIE-UP.
630 REM ARRAY B CONTAINS THE TIE-UP VALUES.
640 FORJ=1TOA
650 I=1
660 GOSUB1150
670 IFZ=20THENGOSUB1380:GOTO660
680 IFZ=300THEN760
690 B(J,I)=Z
700 X=A1*(A3+J)+A2
710 Y=(A-B(J,I))*A1+A2
720 IF(A-B(J,I))<0ORB(J,I)=0THEN660
730 POINT2,X,Y,X,Y+A2
740 I=I+1
750 IFI<16THENGOTO660
760 NEXT
770 REM THIS LOOP ENTERS THE TREADLING AND DRAWDOWN.
780 REM ARRAY C CONTAINS THE TREADLING VALUES.
790 REM ENTERS THE TREADLING.
800 FORI=1TOA3
810 J=1
820 GOSUB1150
830 IFZ=20THENGOSUB1470:GOTO820
840 IFZ=300THEN1090
850 IFZ<1ORZ>ATHEN820
860 C(I,J)=Z
870 X=(A3+Z)*A1+A2
880 Y=(A+I)*A1+A2
890 POINT2,X,Y,X,Y+A2
900 REM ENTERS THE DRAWDOWN.
910 REM D REVALUES THE THREADING IN BINARY.
920 REM E REVALUES THE COLOR.
930 FORK=1TOA
940 IFB(C(I,J),K)=0THENK=A+1:GOTO1060
950 FORL=1TOA3
960 C=L-1
970 D=(A(L)AND224)/32
980 E=31ANDA(L)
990 X1=L*A1-A2
1000 IFNOT(E=B(C(I,J),K))THEN1050
1010 N=INT(C/22)+1
1020 W=2↑(22-(C-(N-1)*22))
1030 F(I-1,N)=F(I-1,N)+W
1040 POINTD,X1,Y,X1,Y+A2
1050 NEXTL
1060 NEXTK
1070 J=J+1
1080 GOTO820
```

```
1090 NEXTI
1100 GETA$:IFA$=""THEN1100
1110 Z=ASC(A$):IFZ=80THEN1600
1120 GOTO1100
1130 END
1140 REM THIS SUBROUTINE ENTERS THE THREADING, TIE-UP AND TREADLING VALUES 1-1
1150 GETA$:IFA$=""THEN1150
1160 Z=ASC(A$)
1170 IFZ<58ANDZ>48THEN1230
1180 IFZ<39ANDZ>32THEN1250
1190 IFZ=48THEN1270
1200 IFZ=20THENRETURN
1210 IFZ=13THENZ=300:RETURN
1220 GOTO1150
1230 Z=Z-48
1240 RETURN
1250 Z=Z-22
1260 RETURN
1270 Z=10
1280 RETURN
1290 REM DELETE SUBROUTINE.
1300 REM THREADING DELETE.
1310 J=J-1:IFJ<1THENJ=1:RETURN
1320 X=J*A1
1330 B=A(J)AND31
1340 Y=(A-B)*A1+A2
1350 POINT0,X,Y,X,Y+A2
1360 RETURN
1370 REM TIE-UP DELETE.
1380 I=I-1
1390 IFI<1THENI=1:J=J-1
1400 IFJ<1THENJ=1:I=1:GOTO1450
1410 FORI=ATO1STEP-1
1420 B(J,I)=0:NEXT
1430 X=A1*(A3+J)+A2
1440 DRAW0,X,0TOX,A1*A
1450 RETURN
1460 REM TREADLING DELETE.
1470 I=I-1
1480 IFI<1THENI=1:GOTO1580
1490 FORJ=ATO1STEP-1
1500 C(I,J)=0:NEXT
1510 X1=A3*A1
1520 X2=(A3+2)*A1
1530 Y=A1*(A+I)+A2
1540 DRAW0,0,YTOX1,Y
1550 DRAW0,X2,YTO1023,Y
1560 DRAW8,0,Y+A2TOX1,Y+A2
1570 DRAW0,X2,Y+A2TO1023,Y+A2
1580 RETURN
1590 REM THIS ROUTINE GIVES THE HARDCOPY PRINTOUJ.
1600 OPEN4,4
1610 FORI=ATO1STEP-1
1620 FORJ=1TOA3-1
```

```
1630 E=A(J)AND31
1640 IFE=ITHEN1670
1650 PRINT#4,CHR$(15)"┘";
1660 GOTO1680
1670 PRINT#4,CHR$(15)"▒";
1680 NEXTJ
1690 PRINT#4," ";
1700 FORJ=1TOA
1710 A$="┘"
1720 FORK=1TOA
1730 IFNOT(B(J,K)=I)THEN1750
1740 A$="▒"
1750 NEXTK
1760 PRINT#4,A$;
1770 NEXTJ
1780 PRINT#4,CHR$(8)""
1790 NEXTI
1800 PRINT#4,CHR$(8)""
1810 FORI=0TOA3-1
1820 FORK=1TO4
1830 FORS=22TO1STEP-1
1840 A4=INT(F(I,K)/2↑S)
1850 IFA4=0THENA$="┘":GOTO1880
1860 A$="▒"
1870 F(I,K)=F(I,K)-2↑S
1880 PRINT#4,CHR$(15)A$;
1890 IFA3-2=K*22-STHENS=0
1900 NEXTS
1910 NEXTK
1920 PRINT#4," ";
1930 FORK=1TOA
1940 A$="┘"
1950 FORL=1TOA
1960 IFC(I+1,L)=KTHENA$="▒"
1970 NEXTL
1980 PRINT#4,A$;
1990 NEXTK
2000 PRINT#4,CHR$(8)""
2010 NEXTI
2020 PRINT#4,""
2030 CLOSE4
2040 END
```

# APPENDIX D

## WEAVE ANALYSIS

## WEAVE ANALYSIS

The Weave Analysis program enables the user to enter a weaving pattern in the drawdown area of the pattern draft and automatically displays the drafting information required to produce the weave. The user selects a fill in size to indicate the maximum number of squares across and down that will be used in the drawdown. The computer then displays a graph with solid lines in positions for draft quadrants using up to 16 harnesses. The user enters a design by pressing any key on the keyboard to fill in a square, and by pressing the space bar to leave a square blank. Entry errors may be corrected or design changes may be made by pressing the DELETE key. When the design has been entered, the computer automatically displays the threading, tie-up, and treadling sequences that would be required to produce the weave. A printout of the design and drafting information may be obtained by pressing the P key.

USER PROCEDURE:

1. Turn on the machine and load the program from the tape.
2. Type RUN. Press RETURN. A title page will appear.
3. Press RETURN.
4. ENTER FILL IN SIZE

   MUST BE < 30? Enter a number less than 30 to indicate the maximum number of squares across and down for the design to be entered. Press RETURN.
5. A graphic display will appear on the screen. Enter the design by using any key on the keyboard to fill in a square. Pressing the space bar will leave the square blank. The computer will stop taking entries when the fill in size has been completed in both directions. The computer will then automatically display the threading, tie-up, and treadling sequences.

   NOTE: If the design that was entered cannot be woven on a 16 harness loom, the words "CANNOT BE WOVEN ON A 16 HARNESS LOOM" will appear at the top of the screen.
6. A printout of the draft can be obtained by pressing the P key.

   NOTE: The printer must be turned on to obtain a printout.

   NOTE: At any time during the program execution a draft can be erased and the program started over by pressing the RUN/STOP and RESTORE keys simultaneously, typing RUN, and pressing RETURN.

```
10 REM PROGRAM WEAVE ANALYSIS BY KARI ANN ARNOLD, SEPTEMBER, 1982.
20 REM THIS PROGRAM LETS THE USER ENTER A WEAVE PATTERN DIRECTLY
30 REM ONTO THE SCREEN AND PRODUCES THE DRAFTING INFORMATION
40 REM NECESSARY TO WEAVE IT.
50 REM A PRINTOUT OF THE DRAFT AND DESIGN IS OPTIONAL.
60 REM I AND J ARE LOOP COUNTERS.
70 REM A IS THE THREADING ARRAY, B IS THE TIE-UP ARRAY,
80 REM C IS THE TREADLING ARRAY.
90 REM ARRAY D CONTAINS THE VALUES FOR THE ARRANGEMENT OF COLUMNS.
100 REM ARRAY E CONTAINS THE VALUES FOR THE ARRANGEMENT OF ROWS.
110 DIMA(30),B(16,16),C(30),D(30),E(30),F(30)
120 PRINT"⌉⌧⌧  *WEAVE ANALYSIS*":PRINT"⌧⌧⌧"
130 PRINT" BY KARI ANN ARNOLD":PRINT""
140 PRINT"  SEPTEMBER, 1982"
150 PRINT"⌧⌧⌧⌧";"HIT RETURN TO CONTINUE"
160 GETA$:IFA$=""THEN160
170 B=ASC(A$):IFNOT(B=13)THEN170
180 PRINT"⌉ *WEAVE ANALYSIS*":PRINT"":PRINT""
190 PRINT"ENTER FILL IN SIZE."
200 INPUT"MUST BE < 30";Q
210 Q=Q-1
220 IFQ>29THEN190
230 GRAPHIC2
240 FORJ=0TOQ
250 E(J)=0:D(J)=0
260 A(J)=0:C(J)=0
270 NEXT
280 REM A1 IS THE GRAPH SIZE.
290 A1=19.18125
300 A2=6.39375
310 REM THIS LOOP DRAWS THE GRAPH.
320 COLOR1,0,0,4
330 FORI=A1TO1023STEPA1
340 DRAW2,0,ITO1023,I
350 DRAW2,I,0TOI,1023
360 NEXT
370 REM THIS LOOP PAINTS THE GRAPH SOLID DIVISION LINES.
380 X=INT(1023/A1)-17
390 Y=A1*16+A2
400 FORJ=0TO1023STEPA1
410 K=J+7:L=X*A1+A2
420 PAINT2,K,Y
430 PAINT2,L,K
440 NEXT
450 REM THIS LOOP CLEARS THE TIE-UP ARRAY.
460 FORI=0TO16
470 FORJ=0TO16
480 B(I,J)=0
490 NEXT:NEXT
500 REM THIS LOOP ENTERS THE DESIGN. K AND L ARE LOOP COUNTERS.
510 FORI=0TOQ
520 K=0
530 FORJ=0TOQ
540 GETA$:IFA$=""THEN540
```

```
550 Z=ASC(A$)
560 IFZ=20THENGOSUB1470:GOTO540
570 B1=J*A1+A2
580 B2=17*A1+I*A1+A2
590 REM 32=SPACE.
600 IFZ=32THEN650
610 PAINT2,B1,B2
620 REM ARRAYS D AND E DESIGNATE VALUES FOR THE FILLED IN SQUARES.
630 E(I)=E(I)+2↑J
640 D(J)=D(J)+2↑I
650 NEXTJ
660 F(I)=E(I)
670 NEXTI
680 REM THIS LOOP READS THE DESIGNATED VALUES AND SETS A CODE.
690 K=1
700 L=1
710 FORI=0TOQ
720 D=0
730 FORJ=0TOQ
740 IFD(J)=0THEN760
750 D=D(J):J=30
760 NEXT
770 E=0
780 FORJ=0TOQ
790 IFE(J)=0THEN810
800 E=E(J):J=30
810 NEXT
820 IFD=0THEN870
830 REM SETS CODE FOR HARNESSES.
840 FORJ=0TOQ
850 IFD(J)=DTHENA(J)=K:D(J)=0
860 NEXT:K=K+1
870 IFE=0THEN920
880 REM SETS CODE FOR TREADLES.
890 FORM=0TOQ
900 IFE(M)=ETHENC(M)=L:E(M)=0
910 NEXTM:L=L+1
920 IFL>16ORK>16THEN1440
930 NEXTI
940 REM THIS LOOP PAINTS THE THREADING.
950 FORJ=0TOQ
960 X=J*A1+A2
970 Y=(16-A(J))*A1+A2
980 PAINT2,X,Y
990 NEXTJ
1000 REM THIS LOOP PAINTS THE TREADLING.
1010 FORJ=0TOQ
1020 X=(36+C(J))*A1+A2
1030 Y=(17+J)*A1+A2
1040 PAINT2,X,Y
1050 NEXTJ
1060 REM THIS LOOP SETS VALUES FOR THE TIE-UP.
1070 FORI=0TOQ
1080 L=0
```

```
1090 N=0:D=F(I)
1100 FORM=QTO0STEP-1
1110 A3=INT(F(I)/2↑M)
1120 IFA3=0THENGOTO1150
1130 F(I)=F(I)-2↑M
1140 E(N)=M+1:N=N+1
1150 NEXT
1160 F(I)=D
1170 FORJ=0TOQ
1190 IFE(J)=0THEN1290
1200 FORK=0TO15
1210 IFB(C(I),K)=A(E(J)-1)THEN1260
1220 NEXT
1230 B(C(I),L)=A(E(J)-1)
1240 L=L+1
1250 GOTO1280
1260 K=17
1270 NEXTK
1280 E(J)=0
1290 NEXTJ
1300 NEXTI
1310 REM THIS LOOP PAINTS THE TIE-UP.
1320 FORJ=0TO15
1330 FORI=0TO15
1340 IFB(I,J)=0THEN1380
1350 X=(36+I)*A1+A2
1360 Y=(16-B(I,J))*A1+A2
1370 PAINT2,X,Y
1380 NEXT
1390 NEXT
1400 GETA$:IFA$=""THEN1400
1410 H=ASC(A$)
1420 IFH=80THEN1620
1430 GOTO1400
1440 CHAR0,0,"CANNOT BE DONE ON A 16 HARNESS LOOM"
1450 END
1460 REM DELETE SUBROUTINE.
1470 J=J-1
1480 IFJ<0THENJ=Q:I=I-1
1490 IFI<0THENJ=0:I=0
1500 A5=INT(E(I)/2↑J)
1510 IF(A5=0)THEN1600
1520 E(I)=E(I)-2↑J
1530 D(J)=D(J)-2↑I
1540 X=J*A1+A2
1550 Y=17*A1+I*A1+A2
1560 POINT0,X,Y
1570 POINT0,X+A2,Y
1580 POINT0,X,Y+A2
1590 POINT0,X+A2,Y+A2
1600 RETURN
1610 REM THIS ROUTINE GIVES THE HARDCOPY OUTPUT.
1620 OPEN4,4
1630 FORI=16TO1STEP-1
```

```
1640 M=2-INT(I/10)
1650 PRINT#4,CHR$(15)I;TAB(M);
1660 FORJ=0TO29
1670 IFA(J)=ITHEN1700
1680 PRINT#4,"┘";
1690 GOTO1710
1700 PRINT#4,"▒";
1710 NEXT
1720 PRINT#4," ";
1730 FORJ=1TO16
1740 A$="┘"
1750 FORK=0TO15
1760 IFNOT(B(J,K)=I)THEN1780
1770 A$="▒"
1780 NEXT
1790 PRINT#4,A$;
1800 NEXT
1810 PRINT#4,CHR$(8)""
1820 NEXT
1830 PRINT#4,CHR$(8)""
1840 FORI=0TO29
1850 PRINT#4,CHR$(15)TAB(5);
1860 FORS=0TOQ
1870 A4=2↑SANDF(I)
1880 IFA4=0THENA$="┘":GOTO1910
1890 A$="▒"
1900 F(I)=F(I)-2↑S
1910 PRINT#4,A$;
1920 NEXT
1930 A$="┘"
1940 FORS=QTO29
1950 PRINT#4,A$;
1960 NEXT
1970 PRINT#4," ";
1980 FORJ=1TO16
1990 IFC(I)=JTHEN2020
2000 PRINT#4,"┘";
2010 GOTO2030
2020 PRINT#4,"▒";
2030 NEXT
2040 PRINT#4,CHR$(8)""
2050 NEXT
2060 PRINT#4,""
2070 CLOSE4
2080 END
```

COMPUTER-AIDED TEXTILE DESIGN FOR HANDWEAVING

by

KARI ANN ARNOLD

B. F. A., The University of Kansas, 1978

---

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Clothing, Textiles, and Interior Design

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1982

ABSTRACT

A total of four computer programs were developed for designing handweaving patterns using the Commodore Vic 20 color computer, Vic-1515 graphic printer, Model C2N tape cassette, a color television set, and the Super Expander and Programmer's Aid cartridges. A 16K memory expansion cartridge was also used to increase the amount of RAM available in the computer.

Program Weave Design enables the user to enter the threading, tie-up, and treadling sequences for a weave using up to 16 harnesses and produces a pattern drawdown of the design in black and white. The program produces a gridded graph upon selection of the number of harnesses for a weave: 4, 8, 12, or 16. The threading sequence for the weave is entered first. The tie-up is entered next and the treadling sequence is entered last. As many treadles as available number of harnesses may be entered in each treadling row. As the treadling sequence is entered, the drawdown portion of the graph is automatically displayed row by row. A printout of the design may be obtained by pressing the P key.

Program Weave Design II follows the same format as Weave Design, however, the graph is omitted in order to provide a larger area for entering designs. Weave Design II has the ability to delete points or areas that have been entered in the threading, tie-up, treadling, or drawdown drafts in order to correct input errors and to aid in the manipulation of pattern. Any point on the screen may be deleted. The printout option also is available with this program.

Program Color Weave follows the same format as Weave Design II but includes the ability to design in color. A total of four colors may be selected from the 16 colors available with the Vic 20. These colors form the basis for the design. Three colors may be assigned to the threading,

while the treadling color forms the background, or screen color. The delete and printout options are available in this program.

Program Weave Analysis enables the user to directly enter a weaving pattern in the drawdown area of the pattern draft and automatically displays the drafting information required to produce the weave. The program produces a gridded graph which is capable of displaying designs requiring up to 16 harnesses. This program is just the opposite of the others in that the design is entered first in the drawdown quadrant of the draft. A delete option is available for input errors or design changes. After the design has been entered, the threading, tie-up, and treadling drafts are automatically displayed with the drafting information that would be required to weave the pattern. The completed draft may then be printed out by pressing the P key.

The advantages of the programs are numerous. The programs were developed for use on the Commodore Vic 20 which is currently the least expensive color computer on the home computer market. The programs are stored on tape and do not require the purchase of a disc drive. The language in which the programs were written is one of the easiest languages to understand.

Any type of weave, including single unit and block weaves, can be designed with the programs. Designs can be entered in black and white for quick design visualization or explored further in color. The drafting information is displayed on the screen with the pattern, giving the user an overall view of the weave pattern and its construction requirements. The designs can be visualized one row at a time when entering the treadling sequence and design changes can be made immediately by using the delete option. The delete option also allows for input errors. The user can enter as many treadles per treadling row as available harnesses, which greatly increases the amount of design manipulation that is possible. The analysis of woven patterns from existing fabrics is possible. The programs provide hardcopy output of the design and drafting information in the form of a printout which is extremely convenient for carrying directly to the loom.

There are limitations with the programs, however. The Color Weave program is limited to the use of four colors within a pattern. Only one color can be assigned to the treadling sequence in Color Weave, limiting the weft of the pattern to one color. The drawdown execution of the programs is slow due to the langauge in which the programs were written. Also, there is currently no way to save designs on tape for future reference.