AN INTERACTIVE PC COMPUTER PROGRAM BASED ON
CRAFT AND IIE PLANT LAYOUT SOFTWARE FOR USE IN
FACILITIES DESIGN,

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ABSTRACT

The purpose of this thesis is to continue with the development of the CRAFT based IBM PC Plant Layout/IIE Microsoftware as developed by Dr. Gary Whitehouse and his associates at the University of Central Florida. The software was loaned to Ohio University in 1986 by the Institute of Industrial Engineers and under Associate Professor E. Ralph Sims Jr. PE, CMC, the continual development and modifications to the original software by graduate students at Ohio University has attempted to overcome several deficiencies inherent in the original software as well as enhancing the capabilities of the original software.

The focus of the thesis is to describe the design and development of the continuing effort in developing a commercially usable desk-top plant layout package for use by facility designers. One of the main objectives is the development of a user interactive design approach that was taken by this thesis. The software is now capable of permitting the facility designer to experiment with different layouts through manual changes made to the physical plant parameters that were entered into the software. The effects are displayed in both a graphic output of the new layout and corresponding CRAFT calculated move costs. The facility designer has a choice of keeping the new experimental layout or returning to the original CRAFT generated layout for further experimentation. New features and capabilities have also been added to the software as well as a redesign in the program architecture to aid in the program's operation.

The resulting software, now called "OUPLANT", is extremely flexible and versatile in that experienced facility designers realize that a CRAFT generated layout is not always practical or usable and that some compromise must be reached. One of the main capabilities of OUPLANT is that it will allow the facility designer to manually change/vary each or all of the physical plant parameters to fit the required specifications of each facility designing task and see its effect on the CRAFT move cost. This allows the facility designers to determine which plant parameter compromises are acceptable with regard to the move cost.
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CHAPTER 1
INTRODUCTION

1.1 Introduction

The objective of this thesis is to develop a comprehensive user interactive computer program for use by facility designers and executives in the process of facilities planning, and more specifically, as an aid in plant layout. The software will be based on CRAFT techniques as used in the Institute of Industrial Engineer's IBM PC Plant Layout Package. The software is designed for use on systems such as IBM's PC XT/AT desk-top microcomputers and compatibles.

In 1986 the Institute of Industrial Engineer loaned their IBM PC Plant Layout Microsoftware package to Ohio University for use as a basis for developing a more refined package. The package was originally developed by Dr. Gary E. Whitehouse, Chairman/Professor of the Industrial Engineering Department, Dr. Yasser A. Hosni, Associate Professor of the Industrial Engineering Department, and Timothy S. Atkins. All were from the University of Central Florida. At that stage, the software contained four separate programs written in BASIC and was capable of producing an alphanumerical plant layout based on information generated from its from-to chart generator. The package was also capable of determining the optimum
location for a new facility/machine with respect to a number of existing facilities/machines. In addition, the package could also evaluate a number of alternative layout designs without generating a new layout.

This initial research work in the development of the plant layout software will be the basis for expansion of the capabilities of the existing software. Under the guidance of Associate Professor E. Ralph Sims Jr. P.E., CMC., a registered professional engineer and Chairman of the Sims Consulting Group, a succession of graduate students at Ohio University that consisted of Ilango Sankaralingam, Wittawat Smuthranond and Ekachai Heamavattanachai began work in 1986 in the development of a more user interactive program.

The objective was to develop the software into a commercially usable desk-top plant layout package for use by facility designers so that he/she could experiment with layouts at his/her desk through a desk top computer. The final goal that the researchers had hoped to accomplish were three fold. First, the aim was to develop the basic algorithm and research techniques for the microcomputer generation of optimum and alternative plant layouts for use in future research and industrial applications through a user-friendly/interactive software. Second, to develop the plant layout algorithm which will respond to building configuration economics and manufacturing policy parameters. Third, to develop an advanced microcomputer algorithm to incorporate
group technology and computer integrated manufacturing approaches into plant layout processes.

The software developed at Ohio University had attempted to overcome some of the deficiencies inherent in the original program and has now reached the stage where user interactive graphics enhancement has been added through the use of a color graphics monitor. The program has been designed with the goal of being very user-friendly and user-interactive and so that the high graphics content of the displays play an important role in achieving the design goals. Also, the ability to introduce and incorporate aisles into the layout has been added.

1.2 Problem and Objective

The original plant layout software package developed by Dr. Whitehouse had several drawbacks and limitations. Some major drawbacks and limitations are that the package lacked the graphics capabilities that would allow it to be a truly user-friendly and usable desk-top package. The deficiencies of a mono-chrome alphanumeric layout became very obvious as eye fatigue and hard-to-interpret layouts were presented after prolonged use of the package. Figure 1.1 illustrates the alphanumeric layout.

In addition, the package also lacked the capability to allow the facility designer to change parameters such as building size, building length, building width, bay size, bay
Figure 1.1 Original alphanumeric layout from IIE Plant Layout Package.
length, bay width etc. The package lacked the capability to allow the facility designer to change plant parameters after the CRAFT algorithm generated a layout to see its effects on the layout. It also was unable to calculate the move cost during the operation of the program without having to re-start the program from the beginning. These drawbacks were obvious in that a facility designer presented with fairly elaborate plant parameters would not want to re-enter the time consuming data each time a single parameter was changed.

Also, the original package did not incorporate capabilities to manually adjust the final layout to compensate for odd-shaped departments in the layout.

The main objective of this thesis is concerned with the development and refinement of the Institute of Industrial Engineers' IBM PC Plant Layout package as developed by Dr. Whitehouse and his associates. More specifically, this research represents the continuation of the work initiated by graduate students at Ohio University since 1986 under the guidance of Associate Professor E. Ralph Sims Jr. PE. that will eventually lead to a commercially usable desk-top package for plant layout.

This thesis will focus on five main objectives. These objectives are:

1. To correct several major programming structural errors as a result of the last program modification that was performed to the original
plant layout software.

2. To correct the move cost algorithm for calculating both the euclidean and rectilinear moves that was incorrectly incorporated into the graphics output portion of the final CRAFT generated layout.

3. To incorporate the capabilities that will allow the user to change plant parameters while the program is running prior to the graphics output.

4. To incorporate the capabilities that will allow the user to change plant parameters while the program is running in the graphics mode.

5. To enhance the operation of the software through changes in program architecture to increase operating efficiency and to add additional output features such as a product summary/from-to chart to aid in plant layout.

The achievement of these objectives will permit the proper operation of the plant layout software and allow the user to change plant parameters such as building length or width, number of bays, fixing departments in a certain sequence, change initial sequence or type of move cost calculation etc., while the program is running without having to re-enter all of the data such as the from-to chart, the move cost chart, and plant parameters, from the beginning of
the program. The user will also be able to make the same plant parameter changes while in the graphics mode without having to re-start and re-enter the data from the beginning of the program. This allows the user to directly see the changes graphically on the screen as plant parameters are changed with the corresponding changes in plant layout configuration. The user will also be able to experiment with different plant parameters and see their effects in both the graphic layout and the CRAFT calculated cost. Also, changes in the program architecture will allow the program to operate more efficiently (increase in operating speed between modes of operation). Additional features such as enhanced outputs that contain a product summary and accompanying from-to chart will greatly aid the user in the process of facilities layout.

This thesis research will correct and integrate the previous work initiated since 1986 by graduate students at Ohio University. The graphics capabilities and the ability to change plant parameters that was developed previously will be corrected and modified so that they will function correctly. The separate sections will then be incorporated into the layout software to form a comprehensive plant layout software package. The research work in this thesis will then add the capability to permit the "experimentation" of the various plant parameters to see their effects on the layout and the transportation cost.
CHAPTER 2
APPROACH AND DEVELOPMENT

2.1 Literature Review

This section discusses the different approaches to software development that have been used for facilities layout. Facilities layout, most often called plant layout is the portion of facilities design that involves the arrangement and coordination of physical facilities, an example being departments within the plant.

*Systematic Layout Planning* by Richard Muther (6), first printed in 1961, is probably the book most widely read by facilities designers on the topic of facilities layout. Mr. Muther attempted to provide procedures to solve problems systematically. Today, much of Mr. Muther's systematic approach and variations of it have been incorporated into computer program/software to aid facilities designers in the plant layout processes.

A questionnaire seeking information on the usefulness of computers and software in facilities layout appeared in the April 1975 issue of the Newsletter of Facilities Planning and Design Division of the American Institute of Industrial Engineers. Seventy-eight members answered the questionnaire and it was found that roughly one out of three have had some
experience with software that aided in layout work. Fifty-seven percent of the respondents that have had experience with layout software were practicing Industrial Engineers. One of the questions that was also asked in the questionnaire was "What assistance have the computer software offered in the design of the facilities?". Eighty-three percent responded that the software packages were being used either to generate alternative layouts or to evaluate alternative layouts. Most of the available plant layout algorithms were based on adaptations of Richard Muther's original "Systematic Plant Layout" principles. These layout algorithms (i.e. CRAFT, CORELAP, ALDEP, etc.) are usually limited to block type layouts with little or no ability to incorporate layouts containing system design details or variations in production processes or building shape parameters.

Facilities design projects usually fall into four categories. These categories as identified by Tompkins and Moore (11) are:

1. New facility construction.
2. New design in an existing facility.
3. Redesign of a restricted or limited area.
4. Adding a machine in an existing facility.

In general, the new facility construction project does not occur very often and the other three categories occur more frequently. A major portion of facilities design projects involve the redesigning of existing facilities which range
from the installation of a new machine/department to completely revising and redesigning an exiting facility. This has led to two approaches to plant layout softwares. The two approaches to computer routines to aid in plant layout are either the construction type routine or the improvement type routine.

The plant layout softwares incorporating a construction algorithm construct a solution in an open floor area from raw data. The algorithm basically takes relationships between activity-areas and generates a block layout. Their basic approach is to find a starting point or initial activity placement and then add the remaining activity-areas according to certain rules. In some algorithm, the rules are similar to Muther's vowel-letter sequencing (A,E,I,O,U,X) that designates letters for closeness relationships. Figures 2.1 and 2.2 illustrate the relationship chart using the vowel-letter sequencing procedure. Other algorithms combine Muther's rules with an improvement-like distance minimization. Three well known examples of construction algorithms are CORELAP, PLANET, and ALDEP.

Plant layout softwares incorporating improvement algorithms require a feasible or an initial solution as part of the input. The program works on this feasible solution and improves on it until no further improvements can be found. The basic approach of improvement algorithms is to minimize
Figure 2.1 Relationship Chart.
Figure 2.2 Relationship Chart.
transportation cost or movement cost by reducing the distance on the most traveled routes. Two well-known examples of improvement algorithms are COFAD, and CRAFT.

A brief discussion on the operating characteristics of each of the five popular algorithms will help in the understanding of the different approaches to plant layout problems. The five algorithms are the previously mentioned: CORELAP, ALDEP, PLANET, COFAD, and CRAFT. Also, a brief discussion of Richard Muther's contribution to the field of computer-aided facilities layout in his facilities layout software called RMA Comp I will be included in this section.

The last part of this section will introduce and discuss an existing IBM PC department location software called BLOCPLAN.

CORELAP

CORELAP, which is an acronym for "Computerized Relationship Layout Planning" is a construction algorithm and was developed by Robert C. Lee and James Moore and published in 1967. It is summarized by Tompkins and Moore (11) under "Computer Aided Layout: A User's Guide" in Facilities Planning and Design Division, publication no. 1. CORELAP is the oldest construction algorithm and is based on Richard Muther's manual procedure of converting the Relationship Chart into a layout. Muther's procedure of manually converting interdepartmental relationships becomes extremely tedious for large problems.
that may contain over 1000 pairs of interdepartmental relationships. CORELAP was designed to reduce the effort required to convert a relationship chart to a layout. The basic inputs required by CORELAP are the relationship chart and the area requirements of each department. CORELAP begins by calculating the "total closeness rating" (TCR) for each department where TCR is the sum of the numerical values assigned to the closeness relationships (A=6, E=5, I=4 etc.).

CORELAP then constructs the first layout routine by selecting the most critical department (department with the highest TCR) and places it in the center of the layout. Ties are broken with departments having the larger area. Then CORELAP selects departments having the highest relationship with the already placed departments and places it as close to the already placed department as possible. The placement method is based on assigning "placing ratings" which is the sum of the weighted closeness ratings between the entering departments and departments already placed. Layouts constructed by CORELAP grow outward like a crystal from the center.

A disadvantage of CORELAP is that it has problems when an attempt is made to fix departments in a certain location. CORELAP does not take into account the building and is dependent on the layout arrangement. CORELAP is useful for new plants where the layout is to determine the building design and not for buildings already in existence.
ALDEP

ALDEP, an acronym for "Automated Layout Design Program" was developed within IBM and presented by Jerrold Seehof and Wayne Evans and was published in 1967. It is also summarized by Tompkins and Moore (11). ALDEP has the same basic data input requirements as CORELAP. However, ALDEP differs from CORELAP in that instead of using the Total Closeness Rating for placement of departments, ALDEP selects and places departments randomly. CORELAP attempts to construct the one best layout while ALDEP constructs many layouts and rates each layout and thus leaves the final decision of selecting the appropriate layout to the facility designer.

There are four variables that effect the ALDEP layout algorithm. The first variable is the variable that specifies the number of layouts to be generated; the second variable is the variable that specifies the degree of closeness by which departments are selected to be placed in the layout; the third variable is the variable that specifies the sweep (the left-to-right sweeping motion to fill the plant area) width of the departments that are placed in the layout; lastly, the fourth variable is the variable that specifies the minimum rating by which a layout may be accepted. As stated earlier, the first department selected by ALDEP to be placed in the layout is chosen randomly. Then, the relationship chart is scanned to determine all the departments that have a relationship rating that is equal to or more important than the initially
specified degree of closeness. If more than one exists, one is chosen randomly to be placed in the layout. If none exists, another department is chosen randomly to be entered into the layout. This process is continued until all the departments are placed in the layout.

ALDEP places the initial department in the upper left corner of the layout and adds departments to it in a downward direction. The width of the downward movement of the departments being placed in the layout is initially specified by the sweep width. The placement configuration is by a convoluting up and down placement of departments within the layout at a width equal to the sweep width until the specified area of the department is used-up. Succeeding departments are added to the layout where the last department ended in the same configuration.

After all the departments are placed in the layout, ALDEP then rates the layout by assigning values to the relationships among adjacent departments. For example, if a department is adjacent to a department with an "A" relationship, a value of sixty-four is added to the rating of the layout. A relationship of E, I an O adds sixteen, four and one respectively. A relationship with a U has no effect while a relationship with an X causes a subtraction of 1024 from the layout. The rating of the layout is then compared to the minimum layout rating that was initially specified by the facility designer. If the rating is less than the specified
Figure 2.3  ALDEP Layout Sweep sequence
minimum layout rating, the layout is not considered; otherwise the layout is printed. Also, if the number of specified layouts requested by the facility designer is not reached, ALDEP will restart the entire layout procedure again by randomly selecting a department to be initiated by the next layout. If the number of generated layouts equals the number of required layouts, the layout algorithm is stopped. Figure 2.3 illustrates how ALDEP arranges the department layout.

An advantage of ALDEP is that it generates layouts that are usually rectangular or square in shape. ALDEP is capable of handling facilities with up to three floors and provides the capability to fix departments in a certain location and to include docks, elevators and stairwells. The disadvantage with ALDEP is that it randomly picks departments for consideration in the layout process so that ALDEP should be run several times to assure that the layouts generated are the "best" layouts. The "best" layout will eventually be generated. However due to the randomness by which ALDEP chooses departments to be laid out, "Run Time" will be a consideration factor.

PLANET

PLANET, is an acronym for "Plant Layout Analysis and Evaluation Technique" and is a construction type algorithm. PLANET is discussed by Deisenroth and Apple in "A Computerized Plant Layout Analysis and Evaluation Technique" in the
Technical Papers of the AIIE 1972 Annual Conference and is summarized by Tompkins and Moore (11). PLANET uses the same input requirements as CRAFT. PLANET is flexible in that it will accept material flow data in three formats and that there are three different layout construction phases available. The three phases that are available to generate a layout are as follows. The first phase involves the translation of the input data so that it is useful to the algorithm in PLANET. The second phase involves the selection of the order in which the departments are to be considered in the layout. The third phase involves the determination of the placement of the departments when they are considered for the layout (placement priority from the highest to the lowest 1 to 9).

PLANET requires inputs that describe the departments and the materials flow. Information about the departments should contain the department name, identifier, area and placement priority. Information about the materials flow can be entered in either the extended parts list, directly input from a from-to chart or to input a chart similar to a from-to chart, but containing values indicating the desirability of locating departments close to one another. The extended parts list includes the frequency, sequence and cost per move per 100 ft. for each part. PLANET then compacts the data into a from-to cost chart using the previous information. The second method of directly entering a from-to chart can be used directly by the algorithm in PLANET. The third method of entering a
modified from-to chart but containing values indicating the desirability of locating departments close to one another is converted by PLANET into a penalty chart. Penalty values range between negative nine to ninety-nine (-9 means departments should not be close together while 99 means departments should be close together).

PLANET converts the materials flow information from either a from-to cost chart, a from-to chart or a penalty chart to a flow-between cost chart. This is done by adding the values in both directions between departments and then entering the sum for the flow in each direction. The basis for the PLANET selection algorithms are the flow-between cost chart and placement priorities. As stated earlier, there are three methods in the algorithm for the layout processes. The first method selects a pair of departments which is in the highest priority group and has the highest flow-between cost for consideration in the layout. The next department to be considered is also in the highest priority group of unselected departments but has the highest flow-between cost with one of the already selected departments. This process is continued until all the departments have been considered in the layout.

The second method selects the first pair of departments to be considered in the layout in the same procedure as the first method but the next department to be considered in the layout is in the highest priority group of unselected departments and has the highest sum of flow-between costs with
all the other selected departments. The process is continued until all the departments have been considered in the layout.

The third method selects the first department to be considered in the layout by selecting departments in the highest priority group which has the highest sum of flow-between cost with all of the other departments. The next department to be considered in the layout is selected in the same procedure. The process is continued until all the departments have been considered in the layout.

PLANET's algorithm for the layout places the first two departments considered for the layout adjacent to each other at the center of the layout. Additional departments that are considered in the layout are positioned so as to minimize the increase in handling cost. This is done by rotating the added department about the perimeter of the departments already in the layout and the handling cost is calculated for each point about the perimeter. The point having the lowest additional handling cost is selected for the placement of the additional department. The department is placed in this location and the perimeter of the expanded layout is then circumscribed so as to determine the location which will add the least handling cost for the next department to be added to the layout. The process is repeated until all the departments are placed in the layout.

The advantages of using PLANET are that it is very flexible in allowing inputs such as materials flow data to be
entered in three formats and having three methods in constructing a layout. The disadvantages with PLANET are that in its conversion of inputs to a flow-between cost chart, PLANET considers the closeness relationships between departments but conceals the direction of flow among departments. This may result in layouts that have a considerable amount of backtracking among the departments. Also, PLANET does not restrict the departments to a predetermined building shape so some layouts may not be useable due to unusual shapes.

COFAD

COFAD, is an acronym for "Computerized Facilities Design" and is a modification of CRAFT. COFAD is discussed by Tompkins and Reed in "Computerized Facilities Design" in the Technical Papers of the AIIE 1973 Annual Conference and is summarized by Tompkins and Moore (11). Like CRAFT, COFAD is an improvement algorithm. It allows the inclusion of move costs for all the materials handling equipment alternatives so that both the materials handling system and the layout are taken into account in the layout processes. The inputs required by COFAD are alternative materials handling system capable of performing specific moves, the costs of these alternatives, from-to charts for each equipment alternative and an initial layout. COFAD attempts to construct a layout with a minimal materials handling cost through four steps.
These four steps are: determine a layout, select a materials handling system, relate the costs of the handling system to the individual moves and re-iterate step one again until a steady-state layout is reached.

COFAD's algorithm first tries to improve the initially inputted layout by a procedure that is similar to CRAFT except that COFAD is capable of considering straight line as well as rectilinear distances between departments being considered for interchange. This is useful for materials handling systems that use conveyors that do not have to follow aisles in a rectilinear fashion. COFAD then determines the cost of performing each move using the feasible materials handling system alternatives available. This is dependent on the type of materials handling system chosen (ie. fixed path equipment such as conveyors or mobile equipment such as tote carts). COFAD's next function is to use the above move costs to determine a minimal cost materials handling system.

The algorithm tries to select the materials handling system alternative that has the lowest move cost for a certain move. The algorithm's first improvement attempt is to try to utilize all the alternative types of materials handling system. It does this by summing the utilization for each assigned materials handling equipment type and rounding up this figure to determine how many pieces of each equipment type are required. The rounded figures are known as the design equipment requirements for each equipment type. The
differences between the design equipment requirements and the sums of the equipment utilizations are then calculated and called the deviations for each of the materials handling equipment types. The materials handling equipment type having the greatest deviation will give up some of its assignment to equipment types which have a smaller deviations for the moves where it had the second least expensive move cost. This process is continued until all deviations are minimized. This procedure is essentially exchanging assignments from poorly utilized equipment to equipment with good utilization thereby improving utilization of the materials handling systems available.

The second improvement is through the comparison of the initially determined move cost for each move with the allocated cost for the best existing solution. For all the moves where the allocated cost is greater than the original move cost, all the feasible equipment types are temporarily assigned and the total cost recalculated. If a reduction in the total cost is realized, the temporary assignment is made permanent. This process is continued until the entire move set with allocated cost that is greater than the initial move cost is "looked at" without a new assignment being made. When no further reduction is possible, the layout is generated. COFAD then compares the generated layout with prior layouts generated to see if the cost of the materials handling system and the number of changes in materials handling system
assignments varies by less than an initially inputted steady state percentage. If so, the algorithm stops. If not, the flow volumes within the from-to charts are varied by an initially inputted percentage and the entire algorithm process is repeated. This is to check for steady state and if it is not found, COFAD restarts by apportioning the costs of the materials handling system to individual moves by dividing the annual cost of each equipment by the quotient of the annual total number of moves for that equipment type and the annual total distances traveled by that equipment. This starts the CRAFT-like procedure for the next improvement iteration and continues until a steady state is reached.

The advantages of using COFAD are that it allows a realistic determination of a jointly selected layout and materials handling system. COFAD allows the user to fix locations of departments as well as the option to assign or negate certain materials handling system from being considered in the layout process. The disadvantages of using COFAD are that the sensitivity analysis within COFAD only considers variations in the total flow volume for a predefined product mix and does not evaluate changes in product mix.

CRAFT

CRAFT, is an acronym for "Computerized Relative Allocation of Facilities Technique" which appeared in 1963. It was the first improvement algorithm for use in computerized
facilities design and was originally presented by Armour and Buffa and is summarized by Tompkins and Moore (11). CRAFT has grown to become the most used and written about computerized facilities design technique due to its computational efficiency in providing heuristic solutions to quadratic assignment problems and the capability of considering multiple materials handling systems.

CRAFT's algorithm is the underlying algorithm for many improvement routines. The basic approach to CRAFT's improvement algorithm is to minimize transportation or movement cost by reducing the distances on the most heavily traveled routes. CRAFT's inputs are a from-to chart, a move-cost chart and an initial layout. The from-to chart contains information of the number of movements between departments, as illustrated in Figure 2.4. The move-cost chart contains information of the cost of handling a unit load per unit distance.

The initial layout contains information of the spatial requirements of the departments to be located in the layout. CRAFT initially begins by determining the centroids of the departments in the initial layout. Then, the rectilinear distances between department centroids are stored in a distance chart, for each iteration. The transportation cost for the initial layout is then determined by calculating the product of the initially inputted from-to chart, move-cost chart and distance chart. Next, CRAFT proceeds with the
Figure 2.4 Prom-to Chart.
departmental interchanges for departments which are of equal area or have a common border. CRAFT looks at five possible interchanges. These are; pair-wise, three-way, pair-wise followed by three-way, three-way followed by pair-wise and the best of the pair-wise or three-way interchanges. The transportational cost is then approximated for each of the proposed interchanges by exchanging the centroids of the interchanged departments. The interchange with the greatest reduction in move cost is kept and the actual department centroids of the improved layout are then calculated.

A new distance chart is then calculated from the new centroid locations and the transportational cost for the improved layout is calculated. The algorithm continues by taking into consideration the departmental interchanges, approximating the transportation costs of the proposed interchanges and selecting the interchange with the greatest reduction in transportation cost. The algorithm stops when no interchanges in the layout will reduce the transportation cost.

CRAFT is used when the flow of materials is a significant factor to be considered in the layout design as opposed to ALDEP or CORELAP which is based on activity relationship instead of flow relationship. Thus, CRAFT is often referred to as a quantitative layout algorithm whereas ALDEP and CORELAP are referred to as qualitative layout algorithms. Although CRAFT was developed for use in designing layouts with
a consideration to materials handling costs, CRAFT can also be applied to nonmanufacturing activities. In fact, modifications to CRAFT resulted in software such as LAYOUT for office layout designs. CRAFT can also be used to evaluate individual layouts without searching for an improved layout. CRAFT can handle up to forty departments with the option of fixing certain departments in a certain location.

There are several assumptions within CRAFT that facility designers should be aware of:

1. The move costs that are inputted as the cost per unit moved per unit distance require the following criteria:
   a. The materials handling system is determined before the facility is laid out.
   b. The move costs are known with confidence and they are independent of the utilization of the equipment.
   c. The move costs are linearly related to the length of the moves.
2. All the flows between the departments originate and terminate at the centroids of the departments and they follow a rectilinear path.
3. If the move costs (transportational costs) are reduced by the proposed interchanging of the centroids of the departments, then there will be a corresponding reduction in costs when the
departments are actually interchanged. CRAFT users should also be aware that CRAFT will generally give a different layout solution if the initially inputted layout is changed each time CRAFT is run. To overcome this inconvenience, the facility designer should try different initial layouts and then fix the departments that appear to be placed in the same location for each new layout generated. Also, when using CRAFT the facility designer can incorporate fixed dummy departments that have no materials flow with other departments but only to use up space. This serves to fill building irregularities, to mark stairways and obstructions and to aid in the evaluation of aisle locations in the final layout. Dummy departments also allow the facility designer to mold layouts into rectangular or square shapes so that the final layout is practical and feasible.

These descriptions of the operating characteristics of the six well known and most popular plant layout algorithms illustrates the different approaches taken to help facility designers in the plant layout process. There are of course many more approaches to plant layout problems taken by different developers. However, most are variations of the approaches taken by the previously mentioned algorithms. The current and planned continuing research aims to overcome the limitations of existing plant layout algorithms/software packages and to respond to the proliferation of management and engineers' use of computerized plant layout packages in the
analysis and planning of a facility.

In general, there are basically four computer-aided facilities layout programs available today that print out the preliminary or adjusted layout plans. Three of these programs have already been discussed and are very well known. The three are: CRAFT, CORELAP, and ALDEP. The fourth program is less known and is called RMA Comp I.

RMA Comp I

RMA Comp I is an acronym for Richard Muther & Associates. RMA Comp I was developed by Richard Muther & Associates and was designed to do by computer what the Systematic Layout Planning (SLP) does manually (6). The inputs required by RMA Comp I are essentially the same as the data developed during the mental-manual analysis. Like the other algorithms discussed in this section, RMA Comp I also requires inputs such as relationships and space requirements as illustrated in Figure 2.5. RMA Comp I uses the Relationship Chart of assigned closeness ratings, like ALDEP and CORELAP, and selects the activity with the largest total closeness rating (TCR) to be placed first in the center of the layout. The area size of the activity is not considered (RMA Comp I differs from CORELAP in that RMA Comp I develops a schematic pattern of relative locations first, then assigns the required space). Each subsequent activity is then placed so that all its relationships are considered before it is actually placed.
Figure 2.5 Space/Relationship Chart.
Room is left for related activities which will be placed later and at the same time, a check is made to assure that relationships with an X rating are satisfied. Then, relationships with an A rating, an E rating, an I rating and so on are selected and placed. From this, a relationship diagram is formed, still exclusive of the space requirements. The relationship diagram is then exploded and the required amount of space are assigned to each activity in the diagram. The print-out will be in the form of a space relationship diagram as shown in Figure 2.6. Figure 2.7 shows the output from RMA Comp I. Each activity is rectangular in shape and the block of space is to scale. The space requirement for each activity is indicated in the output. For example, an activity requiring 2000 square feet will have the number 2000 repeated over and over to signify the particular block. In the center of the block, the activity number and the code number for the type of space are indicated. Further manual adjustment of the layout will be necessary to develop a practical workable layout.

Basically, RMA Comp I develops a theoretical best activity relationship diagram according to the assigned closeness rating desired and then explodes the diagram and adds the space, and then prints out a space relationship diagram.

Limitations to RMA Comp I are that it cannot effectively honor a shape or configuration requirement for any activity.
Figure 2.6  Space Relationship Diagram developed by RMA Comp I. The lines outlining the area have been added to show the area boundary.
Figure 2.7  RMA Comp I output.
It cannot fix the location of any activities or score or evaluate numerically the constructed output of its layout.

BLOCPLAN

BLOCPLAN, is an acronym for "Block Layout Overview with Computer Planning" and was developed by Dr. Charles E. Donaghey, Chairman of the Industrial Engineering Department at the University of Houston (2). BLOCPLAN is a departmental location system that includes random, construction and improvement type algorithms for developing layouts and can be used on an IBM PC microcomputer. The creation of BLOCPLAN was due to the fact that there have been several computer programs that have been developed in the past twenty years for generating block plans for facilities layout. A large number of software packages have been introduced in the market to help the facility designers in the layout task. However, most of these software packages are Computer Aided Design and Drafting Systems (CADD) that allow the user to prepare very detailed layouts but do not actually assist the facility designer in determining how and where each of the departments in the layout should be located/placed. Also, the majority of the software packages can not be used on off-the-shelf microcomputers.

BLOCPLAN basically displays the layout graphically on the screen, as opposed to printer plots that were commonn, and scores the layout by its scoring algorithm. The inputs that
are required are: the number of departments (max. 18), the names of the departments, their corresponding areas, and a relationship chart. The relationship chart format is the same as suggested by Muther (6) in his Systematic Layout Planning procedures. Once the relationship chart has been entered, BLOCPLAN then displays a default vector of "Code Equivalent Scores" (CES). The purpose of this is to allow the facility designer to indicate the importance attached to the ratings in the relationship chart. BLOCPLAN needs to use some quantifiable factor to make decisions when it generates and scores layouts. It uses the CES vector to assign a numeric value to the relationship chart. The default CES vector values are 10, 5, 3, 2, 1, 0, -10. This means that an "A" rating is worth 10, an "E" rating is worth 5 and so on. An "X" rating is worth -10. The facility designer can also set his/her own values if desired.

The procedure that BLOCPLAN uses to generate layouts is that it first determines an Importance Rating (IR) for each department in the layout. The rating is the sum of all the relationship scores for each department, using the CES vector values. Second, a menu for the facility designer is displayed. The options are:

1. Random Layout.
2. Layout Algorithm.
3. Improvement Algorithm.
4. Adjust Relationship Information.
5. Manually Insert Departments.


7. Stop.

8. Save Problem Data.

Selecting option one, Random Layout, will cause a layout to be developed without regard to the relationship chart. The departments will be located randomly in one of the eighteen zones that the software has generated. BLOCPLAN divides the building layout into three tiers, with three zones per tier. Each zone can be further divided into its left and right side giving the possible eighteen zones. Figure 2.8 illustrates the tier/zone arrangement for BLOCPLAN. BLOCPLAN randomly selects one of the eighteen locations for each department and assigns it to a particular location.

After all the departments have been assigned a location, the software proceeds to draw the layout. It looks at the departments that are located in Tier 1, up to six departments can be located in Tier 1. The total required area of a tier is the sum of all the areas for the departments located in that particular tier. Each department is drawn in proportion to its area and the departments are rectangular in shape. If a department with a small area is the only one located in a tier, it will be drawn as a long narrow department stretching across the entire layout. BLOCPLAN continues with this procedure for all the tiers.

The layout generated is scored by the scoring algorithm
Figure 2.8 BLOCPLAN Three tiers with three zones per tier. Each zone is divided into a left and right side for a total of eighteen locations to place a department.
based on an adjacency criterion. The CES scores for departments that share a common boundary in the layout are summed and then divided by the sum of all the positive CES scores from the relationship chart. A score of 1.0 indicates that all "good" relationships in the relationship chart have been satisfied in the layout.

Selecting option two, Layout Algorithm, will cause the software to make available to the facility designer a layout algorithm. The algorithm places departments that have high IR scores in the center of the layout and then surrounds them with departments with high relationships. Departments with an "X" relationship are separated as much as possible. This method of locating the departments produces layouts that are "better" than the random process.

Selecting option three, Improvement Algorithm, will cause the software to try to improve on a layout that has been saved in memory. The improvement algorithm interchanges each pair of departments in the layout and then displays its score before moving to the next interchange when the facility designer hits the "Return Key". The number of interchanges is the combination of the number of departments taken two at a time. For example, for ten departments there will be forty-five interchanges. The optimum layout can be obtained by using option two, Layout Algorithm, and then using this option, Improvement Algorithm, to improve on the previous saved layout.
Selecting option four, Adjust Relationship Info, allows the relationship information to be changed. The facility designer can change the relationship information and the CES scores that were originally entered. This allows the effects of changes in the relationship chart to be evaluated.

Selecting option five, Manually Insert Departments, will allow the manual placement of departments in the layout. Each department can be manually placed in the desired tier and zone. This is the same as fixing a department in a layout.

The advantages of BLOCPLAN are that it is a useful tool to facility designers in that layouts can be generated or evaluated, the effects of changing the values in a relationship chart can be analyzed, and it only requires a microcomputer as opposed to a mainframe to operate. Although the processing time varies with the number of departments that have to be located, the limitation of BLOCPLAN being able to only handle eighteen departments limits the processing time to a reasonable amount. The disadvantages of BLOCPLAN are:

1. BLOCPLAN can only handle layouts with eighteen departments or less.
2. BLOCPLAN can only store twenty layouts in memory.
3. All the layouts are displayed on the screen within a rectangular drawing that has a horizontal length of 6.75 inches and a vertical height of 4.75 inches regardless of the number of departments in the layout or their placement in the layout.
CHAPTER 3
SYSTEMS ANALYSIS AND DEVELOPMENT

3.1 SYSTEMS ANALYSIS

This section discusses the present state of the plant layout software. The present plant layout software based on the IIE Plant layout package which was written in an open ended architecture in BASIC language and using the CRAFT approach to plant layout was last modified by a graduate student at Ohio University in 1988. The present software has the capability to produce a graphical plant layout as opposed to a numerical layout. The graphics capabilities also include the ability to display the materials flow in both euclidean (straight line between departments) flow or in rectilinear (right-angle lines between departments) flow, Figure 3.1. The package is also capable of crudely adjusting the final layout manually. The package also has the capability of graphically displaying aisle(s) in the final layout, further discussions on the manual adjustment and aisle application will be presented in Chapter 6.

An analysis of the modified software indicated several problems which are a result of the last modification that was performed on the software. The major problems that were found were:
Rectilinear costs are determined by movements that are orthogonal to each other (at right angles) from one centroid to another centroid of the departments.

Euclidean costs are determined by movements in a straight line from one centroid to another centroid of the departments.

Figure 3.1 Calculation types available.
1. The calculated cost displayed in the graphics portion during the layout was incorrect. Both methods of calculation, euclidean or rectilinear, were incorrect. Also, the printed hard copy of the layout displayed an incorrectly calculated cost.

2. The program did not flow smoothly from one module to another and execution of certain modules took an unreasonable length of time. Also, the user could not return to certain modules while the program was operating.

3. There were many programming errors in the form of syntactical structures that needed to be corrected. Many bugs were found in the structure of the program that caused the program to halt execution as it performed certain functions.

4. The previous modification attempted to incorporate the capability of changing plant parameters while the program was running. However, the new calculated cost after certain plant parameters were changed was incorrect and did not reflect the actual changes made and in some cases, the software did not recalculate the move cost at all but only made graphical changes to the layout while retaining the original move cost.

5. The software forced the facility designer to
manually adjust the final layouts for all the departments in the layout, even for departments that did not require any adjustments.

6. The aisle application module was not operating as it was designed. It randomly scattered the departments around as it inserted aisle(s) into the layout. As a result, the final layout was not what CRAFT had generated prior to the insertion of the aisle(s).

It was obvious from the analysis of the present software that before any further modifications or additions to the software could be initiated, there was an urgent need to extensively overhaul and correct some very major structural faults in the programming of the software. The indication of an incorrectly calculated move cost in both euclidean and rectilinear distances hinted that the calculation algorithm was incorrect.

The inability to transfer control to certain modules of the program in a reasonable amount of time/or the inability to transfer control at all indicated that the architecture in the programming structure that performs the transfer function was inefficiently written or that the program lacked the program transfer function entirely.

The halting of program execution during certain operations indicated that syntactical or architectural programming errors existed within the program and that time
consuming debugging procedures would have to be initiated to isolate and correct the errors.

The incorrectly calculated move cost after plant parameters were changed during the program operation indicated an incorrect cost calculation algorithm. This is a similar problem to the incorrectly displayed move cost in the graphics output portion of the final CRAFT generated layout. Again, the cost algorithm would have to be corrected.

The fact that the software forces the facility designer to manually adjust all the departments in the layout even when certain departments did not need any adjustments would have to be corrected.

Finally, the aisle application module will have to be analyzed to determine the cause of the departments being scattered when the aisle(s) are inserted. This problem will be discussed later on in Chapter 6.

Once the major errors were corrected in the program along with other programming errors, the modifications to the program proceeded so that the initial objectives could be met.

3.2 SYSTEMS DEVELOPMENT

This section discusses the development decisions of the original plant layout software. The original IIE Plant Layout Software was written as an open ended program in BASIC and designed for use on any desk-top computer such as the IBM PC XT/AT type. The reason for using an open ended architecture
was for the ease of modifications that any facility designer could make to modify the software to suit specific applications and to be compatible with computers with different computing power and memory capabilities.

The software is operated under DOS and was written in BASIC because the original designers believed that BASIC is the most common language that is easily available to any facility designer and that BASIC, being a high level programming language, does not require an extensive knowledge or require the facility designer to be a highly skilled programmer.

The plant layout software was designed so that it could be used on a microcomputer because there are already many plant layout packages available on the main frame and that the original designers believed that in reviewing the computerized plant layout field, there is a growing availability of microcomputers with large data capacities and graphics capabilities that would support a flexible, powerful user-friendly plant layout software for desk-top microcomputers. There is also a growing trend in corporations to provide desk-top microcomputers to almost every office workstation and the ease of the availability of desk-top microcomputers due to decreasing costs as opposed to a very expensive and hard to obtain main-frame computer makes a very logical factor in the effort to provide plant layout softwares on the desk-top microcomputers.
CRAFT was used as the basis for the plant layout algorithm in IIE's Plant Layout Software because CRAFT, being the oldest improvement algorithm method is the most widely known and used. Also, an improvement algorithm was chosen over a construction algorithm was a result of a survey that indicated that the construction of a new facility occurs less frequently than the redesigning of an existing facility. CRAFT is also able to take into consideration the flow of materials as well as being able to fix dummy departments to force a layout that is feasible. CRAFT can also evaluate existing layouts without generating a new layout.

In keeping with the original design goals, the software was designed for use on desk-top microcomputers. The open ended architecture will be kept along with the BASIC programming language and the CRAFT approach to plant layout. Although BASIC is not a very structured or efficient programming language, the decision to continue using BASIC is based on the compatibility with the existing program without the need to convert the entire software to a totally different programming language. However, throughout the development of the modifications and additions that will be added to the software, certain modules of the existing software were converted to QUICKBASIC for ease of debugging.

3.3 SYSTEMS DESIGN

This section addresses the design of the modifications
and additions that will be incorporated into the plant layout software. As stated earlier, several structural errors and bugs had to be corrected before any further additions to the program could be initiated. Two categories of programming were initiated. The two categories were modifications and additions. Modification programming refers to the modification of certain programming codes that already existed but were incorrectly applied. The modification programming was designed to correct any structural programming errors that existed as well as to increase the efficiency in which the software operates. Addition programming refers to the addition of programming codes that did not exist previously so that new capabilities could be incorporated into the software.

Several modifications were performed on the program to remove the bugs which prevented the program from running correctly and without terminating at various points. Most of the errors were found to be syntactical. Some of these syntactical errors ranged from misspelled key command terminologies such as GOT instead of GOTO to misspelled variable names that have been used repeatedly elsewhere in the program.

There were also several GOTO statements that instructed the program to branch to a certain line number. However, the line number that the program was supposed to branch to did not exist so the program would "hang" and give an error message.
This indicated that the program may have had the line numbers renumbered by a RENUM command in BASIC. The RENUM command in BASIC is used for renumbering line numbers in a BASIC or GWBASIC program. However, in some cases the RENUM command does not do a thorough job of renumbering every single line number in the program.

Also, several FOR/NEXT loops did not have the NEXT statement along with several GOSUB/RETURN subroutine loops that did not have the RETURN statement. This also caused the program to "hang" or to terminate execution because the program did not know how to complete the loop.

A major error that was corrected was the way the main program transferred control to other program modules. The previous modification to the program used CHAIN commands to transfer control to other program modules. However, the modification was performed incorrectly in that the CHAIN command must specify which variables will be passed to the chain-to program by either specifying ALL or through the use of the COMMON command. Since this was not done, the program did not know which variables were to be passed to the chain-to program and in most cases, the program either halted execution or executed the chain-to program module incorrectly. Also, once the chain-to program transfers control back to the calling program that initiated the CHAIN command, the calling program did not recognize the data generated by the chain-to program module. This problem was corrected by having each
module that uses a CHAIN command to transfer control to a
different program module by writing to a disk file on the hard
drive and then having the chain-to program module read from
that disk file. This procedure serves four purposes, the
first being to completely make each separate program module
independent in that it would write any output generated within
the module to a file that could be read by another module.
The second is to save memory space by writing to a disk file
instead of storing the data in memory. The third is to be
able to reaccess the disk file to retrieve the original data
should no changes be desired after modifications have been
performed to the data by other program modules. The fourth
is to increase the speed in which the program can access
individual program modules.

Other syntactical errors that had to be corrected were;
restructuring the way the program read files and wrote files,
redimensioning arrays and setting flags.

After the structure of the program was corrected and
the program was operating properly, the transportation cost
calculation algorithm had to be corrected. As stated earlier,
the cost calculation for both the euclidean and rectilinear
moves were calculated incorrectly in the graphics output
portion of the final CRAFT plant layout. It was found that
the last modification incorporated an incorrect cost
calculation algorithm for the transportation move cost for
both the euclidean and rectilinear moves. This was corrected
by referring to the original cost calculation algorithm in the IIE Plant Layout Software and making the necessary changes to correct the algorithm.

At this stage, the modifications to the program allowed the program to operate correctly. The next stage was to incorporate the additions that will be added to the program to increase the capabilities of the software. As stated in the objective, the main capability that will be added is to incorporate into the software the option which will allow the facility designer to make changes to the plant parameters while the program was running without having to restart the entire program. This option consists of two parts.

The first part is the option of changing plant parameters prior to the CRAFT generated graphics output. This condition occurs when the facility designer instructs the software to read from a disk file the data storage of a certain case that contains a specific plant parameter and the designer wishes to change the plant parameter, the initial sequence, fix certain departments or change the calculation method to see its effects on the move cost.

The second part is the option of changing plant parameters in the graphics output portion of the final CRAFT generated layout to see its effects on the move cost as well as to graphically see its effects on the layout.

To be able to incorporate both of these capabilities, internal loops will be required to allow the plant parameters
to be changed without having to restart the entire program. The addition of this capability for the first part requires a loop for changing plant parameters to be placed prior to the CRAFT calculation algorithm. The previous modification incorporated a loop to perform the change in plant parameters. However, the CRAFT calculation algorithm did not properly recognize the changes made in the plant parameter so the resulting cost calculation was incorrect. The previous modifications did not include the algorithm that calculated the parameters for the area boundary/reference point of each department. This is one of the major calculation requirements when using the CRAFT approach to plant layout since CRAFT uses centroids of departments for its transportation move cost calculation. This problem was corrected by adding the required algorithm.

To be able to add the same capability to the second part required a more extensive program modification and addition. The addition of the capability for the software to allow the user to change plant parameters while in the graphics mode as the CRAFT generated layout is being displayed was more extensive since the module of the software that produced the graphics was after the CRAFT algorithm module. The problem that existed was that once the user made the plant parameter changes in the graphics module, the new layout will be displayed with the parameter changes. However, since the graphics and the change modules (CGRAPH and CHANGE) were after
the CRAFT algorithm module, the move cost was not changed and did not reflect the actual move cost according to the parameter changes. Also, one of the requirements that was part of the capabilities of being able to change plant parameters, was to allow the user to recall the original CRAFT generated layout should the changes in plant parameters produce unacceptable move costs.

The solution that was arrived at to resolve these problems was to add a separate CRAFT algorithm to calculate the move cost in the "CHANGE" module to handle the recalculation after plant parameter changes so that a new move cost could be displayed in the GRAPH module that displays the layout with the new changes as well as the move cost that truly reflected the new changes.

Two data files called CDATA and XDATA were created to store the specifications of the final CRAFT generated layout and move costs in the CRAFT module. The main data file called CDATA, is used in the CGRAPH module to generate the graphics layout while the XDATA data file is used in the CHANGE module for changing plant parameters. The back-up data file called XDATA, is used as a back-up in case the user wishes to recall the original CRAFT generated layout. Data from the CDATA file is used in the CHANGE module as the user made plant parameter changes to see the effects on the move costs. The data file is manipulated as the user experiments with different layouts by changing the plant parameters and it stores the data for
these transitional layouts for use by CGRAPH. If the user decides that he/she wishes to go back to the original CRAFT generated layout, the program recalls the data stored in the XDATA back-up data file and loads its contents to the main CDATA data file. However, if the user decides to keep a certain layout after the plant parameters have been changed, the program makes the data that was manipulated in the CDATA data file permanent.
4.1 Discussion On Program Operation

This section discusses the operation of the programs in this modified plant layout software package. The four main programs or modules consist of:

1. FROMTO
2. CRAFT
3. LOCAT
4. EVAL

There are two BASIC programs called HELLO and STARTUP that precede the four main modules. The BASIC program called STARTUP.BAS contains the introductory screen and title that is called by the AUTOEXEC.BAT file when the plant layout software package is first accessed. The STARTUP.BAS program then calls the first module, HELLO, in the software package.

Within the CRAFT module there are three subprograms. These three subprograms are:

1. CGRAPH
2. CHANGE
3. AISLE
The modifications to the plant layout software package at Ohio University concentrated mainly on the four modules. However, a discussion on the operation of the two modules, EVAL and LOCAT will be included in the discussion.

HELLO

The HELLO module is the first module in the plant layout software package. This module is automatically called by the STARTUP.BAS program in the AUTOEXEC.BAT file when the computer is first turned on and the word "OUPLANT" is entered on the keyboard. The HELLO module consists of the screen color setting, the background color setting and the four options that the user can enter. The four options allow the user to go directly to the FROMTO, the CRAFT, the LOCAT or the EVAL modules. The user enters the number corresponding to the option desired. The program uses the ON GOTO statement to route the program branching to the specific option requested. A string variable that contains the names of the four options is activated by the RUN (string variable) statement. Control is then transferred to the program module that the user had requested.

FROMTO

The FROMTO module contains the algorithm to generate a from-to chart that shows the number of trips made between departments. This module is called from the HELLO module by
the user. The FROMTO module uses arrays of size thirty-five to store data for up to 35 departments. The module allows the user to recall previous data files that contain past runs of the FROMTO module or to enter new information for a new product/facility. If the user decides to enter information on a new product, the required inputs are:

1. The number of departments (max. 35).
2. The unit load (pieces, pallets etc.).
3. The part number (max. 10 digits).
4. The batch size (max. 35).
5. The quantity (max. 35).
6. The operation sequence.

After all the required inputs are entered, the program displays a summary of what the user has inputted and allows the user to make changes if desired. If no changes are required, the program calculates the number of trips exchanged between departments and generates a from-to chart. The algorithm for calculating the number of trips exchanged between departments uses the six required inputs and determines the number of trips exchanged between each pair of departments given the quantity of the products and the batch size that is moved each time with respect to the sequence of the departments between which the move is being made.

Once the from-to chart calculations are completed, the program gives the user six options. The six options are:
1. Save the generated from-to chart to a disk file.
2. Display and modify the existing data.
3. Restart the FROMTO module for a new product.
4. Print a hard copy of the department trip summary.
5. Display or print a hard copy of the product summary and from-to chart.
6. Exit the module to the HELLO module.

The user enters the number corresponding to the option desired and the program will branch accordingly. The FROMTO module is independent of the other three modules so the user must exit the FROMTO module to the HELLO module to be able to continue with the software.

CRAFT

The CRAFT module contains algorithms to calculate the move cost and to generate a layout using CRAFT techniques. The module can also perform functions similar to the FROMTO module except that it requests the number of trips exchanged between departments to be entered (this information is obtained from the from-to chart). However, in the CRAFT module the user also enters the cost of making a trip between certain departments and the module calculates a move cost chart for moving between each pair of departments. The CRAFT module is called from the HELLO module by the user. Like the
FROMTO module, the CRAFT module uses arrays to store data and has the capacity to store data for 35 departments. The module allows the user to recall previous runs from either or both of the data generated by the FROMTO module or the CRAFT module. There is also a "help" section in the CRAFT module that contains instructions/information on how to use the module if the user requests it. The required inputs for the CRAFT module are:

1. The number of departments (max. 35).
2. The minimum area required for the plant.
3. The width of plant (length is automatically calculated).
4. The number of longitudinal bays or the bay width.
5. The number of lateral bays or the bay length.
6. The area for each department.
7. The number of trips between departments.
8. The cost of making the trips between departments.
9. The initial sequence of a layout.
10. The option to fix certain departments in a sequence.
11. The method of calculation (euclidean or rectilinear).

After the required data are entered, the CRAFT module uses the required information as explained in the literature.
review in Chapter 2, Section 2.1 regarding the CRAFT method of generating a layout based on the least materials handling cost. However, some changes had to be made to the CRAFT application so that it could be applicable to the desk-top microcomputers. The CRAFT algorithm as used in this plant layout software package made several assumptions. These assumptions are:

1. The layout will be based on the number of longitudinal bays. This means that the number of longitudinal bays will govern how the layout will be generated, Figure 4.1.

2. The departments in the layout are arranged in bays of fixed width, Figure 4.1.

3. The CRAFT algorithm considers pairwise exchanges.

Basically, the algorithm performs a series of iterations that exchanges departments within the initial starting sequence until a least cost with regards to the move cost is found. Then, the final sequence is displayed with the corresponding cost.

Once the CRAFT module completes its calculations, the user has six options. The six options are:

1. Graphically display the final layout.
2. Input a new starting initial sequence.
3. Change the plant parameters.
4. Save the CRAFT output to a disk file.
Figure 4.1 Longitudinal bay layout.

(six bays in this example).
5. Restart the CRAFT module for a new facility.

6. Exit the CRAFT module to the HELLO module.

Options two through five cause the program to run within the CRAFT module environment. If the user chose option six, this instructs the program to transfer control back to the HELLO module so that the EVAL or the LOCAT modules could be accessed. If the user chose option one, this instructs the program to transfer control to the CGRAPH module where a graphical representation of the final CRAFT generated layout could be displayed. Also, this option allows the user to access either the CHANGE module to make changes while in the CGRAPH module or to access the AISLE module to insert aisle(s) into the final layout. The CRAFT module is an independent module and must be exited to be able to access the other three modules (FROMTO, EVAL or LOCAT).

CGRAPH

The CGRAPH module contains the algorithm that produces the graphical displays that illustrate the final CRAFT generated layout. The module also displays the materials flow, either euclidean or rectilinear, depending on what the user chose as the method for the CRAFT calculation. The CGRAPH module is called by the CRAFT module. The required inputs for this module are obtained from the data file called CDATA that was generated by the CRAFT module. The data file contains data that consists of:
1. The type of calculation (euclidian or rectilinear).
2. The number of departments (inputted by the user).
3. The number of departmental blocks (calculated by the CRAFT algorithm).
4. The number of longitudinal and lateral bays.
5. The plant length and width.
6. The length and width of bays.
7. The length of the departments.
8. The area of the departments.
9. The sequence of the departments.
10. The department numbers that were fixed in the sequence.
11. The cost per trip between departments.
12. The number of trips exchanged between departments.
13. The x and y coordinate of the dummy centroid for a department.
14. The subarea of a department.

* Note. Not all the data in the data file are used by the CGRAPH module.

After the CDATA file has been read into the CGRAPH module, the module then performs a series of calculations that determines the coordinate points for the program to draw the graphical representation of the CRAFT generated layout. The
calculated data are stored in a string and BASIC commands such as the DRAW command are used to draw from the string and thus a layout is created graphically.

Once the layout is graphically displayed on the screen, the user has eight options. The eight options are:

1. Print a hard copy of the plant summary.
2. Restart the CRAFT module.
3. Access the CHANGE module to change plant parameters.
4. Adjust the final layout.
5. Save the CRAFT output to a disk file.
6. Display a previously adjusted final layout.
7. Access the AISLE module to insert aisle(s).
8. Exit the CGRAPH module to the HELLO module.

The CGRAPH module is dependent on the CRAFT module and can only be accessed through the CRAFT module. Once inside the CGRAPH module, the user has the eight options mentioned above. If the user chose options one, four, or six, the program continues to operate within the CGRAPH environment. If the user chose option two, the program transfers control back to the CRAFT module for entering new data. If the user chose option three, the program transfers control to the CHANGE module for making plant parameter changes. If the user chose option seven, the program transfers control to the AISLE module for adding aisle(s) to the layout. Finally if the user chose option eight, the program exits the CGRAPH module and
transfers control back to the HELLO module so that the user can access the other remaining three modules (FROMTO, EVAL or LOCAT).

If the user chose option four, which is the option to adjust the final CRAFT generated layout, the program allows the user the option of placing a grid onto the layout. The user can enter a numerical number that is not larger than the length or width of the plant. A grid spacing with dimensions in feet that is equivalent to the number entered will then be placed on the layout. The program then asks the user if any adjustments are required for each of the departments in the layout. If the user chose "no", the program moves on to the next department in the layout and asks the same question again. If the user chose "yes", the program then asks the user to enter the number of feet from a reference point to a department wall. For example, the program may prompt the user to enter the number of feet distance from the north wall of the plant to the north wall of the department. This section also displays summaries of departments with respect to points of references as mentioned above. Once all the necessary adjustments are made the user has five options. The five options are:

1. Print a summary of the adjusted layout.
2. Print a summary of the department location.
3. Return to the CGRAP module.
4. Return to the HELLO module.
This section of the CGRAPh module, option four, is still under development and future modifications will be required for it to function properly. A detailed discussion concerning its limitations is provided in Chapter 6, Section 6.2.

CHANGE

The CHANGE module consists of the algorithm that permits the user to change various plant parameters as well as the CRAFT algorithm to calculate the move cost with respect to the changes made to the plant parameters. The CHANGE module is called by the CGRAPh module and is dependent on the CGRAPh module. The CHANGE module receives its inputs from the XDATA data file generated by the CGRAPh module. The XDATA data file is almost identical to the CDATA data file received by the CGRAPh module from the CRAFT module mentioned earlier. The XDATA data file is used by the CHANGE module as inputs so that users can experiment by making plant parameter changes and see their effects on the layout and the move cost. If the user decides to recall the original CRAFT generated layout, the XDATA data file is retrieved. However, if the user decides to keep the new layout with the parameter changes, the data generated in the CHANGE module is loaded to the CDATA data file for permanent storage. In the CHANGE module, the user has nine options. The nine options are:

1. Change the plant area.
2. Change the width of the plant.
3. Change the length of the plant.
4. Change the bay width.
5. Change the number of longitudinal bays.
6. Change the number of lateral bays.
7. Change the bay length.
8. Display the changes made.
9. No change, retrieve the original CRAFT generated layout.

The user chooses the number corresponding to the option desired. Once the desired plant parameter changes have been made, the user can then choose option eight. Option eight stores the generated data and changes from the CHANGE module into the CGRAPH data file and transfers control back to the CGRAPH module so that the new layout can be graphically displayed. If the user decides that the old CRAFT generated layout was more acceptable, the user should choose option three in the CGRAPH module for accessing the CHANGE module. When the user is inside the CHANGE module, the user should choose option nine for no change. If this is the case, the CHANGE module will recall the unchanged data from the XDATA data file and load it into the CDATA data file for display in the CGRAPH module. Control is then transferred to the CGRAPH module where the data for the original CRAFT generated layout will now be stored permanently.

If the user chose options one through eight, the program will operate within the CHANGE environment. If the user chose
option nine, control is transferred to the CGRAPH module.

AISLE

The AISLE module contains the algorithm to insert the desired aisle into the CRAFT generated layout. The AISLE module was developed by previous graduate students as a stand alone module. At the present, the module does not function correctly and that the CRAFT algorithm does not consider the AISLE module in its CRAFT calculation. The AISLE module is called by the CGRAPH module and is dependent on the CGRAPH module. The aisle module receives its inputs from the CDATA data file in a similar form as the CGRAPH module. The user has four options of aisles to choose from. The four options are:

1. Insert a single aisle.
2. Insert a multiple aisle.
3. Insert a U-shape aisle.

If the user chose option one, the program will prompt the user to enter the following information:

1. Insert the aisle along the length or the width of the plant (vertically or horizontally).
2. The aisle width.
3. The distance of the north wall or the west wall to the aisle, depending on the option chosen.
The program allows the user to make changes if a mistake was made. The layout is displayed with the aisle inserted.

If the user chose option two, the program will prompt the user to enter the following information:

1. Insert the aisles along the length or the width of the plant (vertically or horizontally).
2. The number of aisles required.
3. The width of each aisle.
4. The distance of the north wall or west wall to the first aisle, depending on the option chosen in 1.
5. The distance of the north wall or west wall to the succeeding aisle etc., depending on the option chosen in 1.

The program allows the user to make changes if a mistake was made. The layout is displayed with the aisles inserted.

If the user chose option three, the program will prompt the user to enter the following information:

1. Insert the u-shape aisle along the length or the width of the plant (vertically or horizontally).
2. The aisle width.
3. The distance of the north wall or west wall to the aisle, depending on the option chosen in 1.
4. The width of the u-shape aisle (width between the "U").

5. The distance of the south or east wall to the aisle, depending on the option chosen in 1.

The program allows the user to make changes if a mistake was made. The layout is displayed with the u-shape aisle inserted.

This module needs further development for it to operate correctly. A detailed discussion is presented in Chapter 6, Section 6.3 concerning its limitations.

LOCAT

The LOCAT module contains the algorithm that determines the optimum location for a new machine/facility with respect to existing machines/facilities. The algorithm is based on the optimality with respect to the cost of the number of material handling trips that are exchanged between the existing machine/facility and the new machine/facility. The algorithm in this module calculates the optimum location based on an exhaustive search and thus takes a considerable amount of run time. This module is called by the HELLO module and is independent of the other three modules and was designed for use in a manufacturing environment where a new machine is to be added or located in a department where several other machines already exist. Certain requirements may have to be met such as aisles restrictions. Several assumptions were
made in this module. These assumptions were:

1. The existing facility as well as the new facility are considered to be square and the same in size.

2. The program can handle the addition of ten new facilities that are to be added to up to fifteen existing facilities. The new facilities are dealt with one at a time.

3. The program will consider aisles, however, the material flow is not restricted to those aisles.

The required inputs are:

1. The option to retrieve files from a past run.

2. The number of existing machines.

3. The number of new machines to be added.

4. The length of the south and west wall.

5. The length of each square/block machine.

6. The number of aisles.

* if aisles are inputted, the program will ask:

1. The distance from either the south to the north center of the aisle or the distance from the east to the west center of the aisle.

7. The existing machine locations.

8. The material flow between the new and the existing machines.
The program allows changes to be made if a mistake was made as well as providing an information screen if the user requests it. Once the required inputs are entered, the program calculates the preferred location in coordinate point format for placing the new machine. The user then has eight options to choose from. The eight options are:

1. Change the machine area size.
2. Change the existing machine locations.
3. Enter new materials flow.
4. Execute a case study.
5. Print a hard copy of the results.
6. Save the generated data on a disk file.
7. Restart the LOCAT module.
8. Exit the LOCAT module to the HELLO module.

If the user chose options one through seven, the program will operate in the LOCAT environment. If the user chose option eight, the program would transfer the control to the HELLO module for accessing the other three modules (FROMTO, CRAFT or EVAL).

EVAL

The EVAL module contains the algorithm to evaluate different layout designs to see which design should be looked into for further analysis. The evaluation process in this module that evaluates alternative block plans considers the proximity between departments as the criterion in the
evaluation process. This module is usually used to eliminate some designs from several available designs for consideration. This module could also be used for evaluating existing layouts to see the effectiveness of the layout. The EVAL module is called by the HELLO module and is independent of the other three modules. The required inputs are:

1. The option to recall past evaluation runs from a disk file.
2. The number of departments.
3. The relationship chart between departments.
4. The destination department to change.
5. The adjacent departments for each department.

The program allows changes to be made if mistakes were made as well as providing an information screen if the user requests it. Once the required inputs have been entered, the program then computes and reports the first largest equivalent relationship chart, followed by a score for meeting the requirements of the layout to the desired relationship chart. The program also makes suggestions concerning the repositioning of departments to increase the score of a layout. The algorithm of this module is based on comparing an existing layout of the departments to a desired relationship chart constructed by the user based on the standards of closeness factors such as:
The user enters the arrangement of existing departments by telling the module the departments that are adjacent to each other in the layout. The algorithm then constructs an equivalent relationship chart. The algorithm uses the rules listed below to construct the relationship chart:

1. If two departments are adjacent, it is a relationship of degree one and is given a value of six.

2. If two departments are separated by one department, it is a relationship of degree two and is given a value of five.

3. If two departments are separated by two departments, it is a relationship of degree three and is given a value of four and so forth.

Then, the two relationship charts are compared and scores are calculated. The algorithm checks for any "absolutely necessary" ratings and "undesirable" ratings and compares them to the entries in the equivalent layout relationship chart.
If the above ratings are not met, the layout is rejected. The algorithm then compares each element in the relationship chart. Scores are assigned to equivalent layout relationship charts that have higher values than the product relationship chart. Comparisons are done by subtracting the values in the equivalent layout relationship chart from the desired product relationship chart.

The unmatched entries are reported and suggestions are made to increase the score. The algorithm places high priorities on the "absolutely necessary" and the "undesirable" relationships and attempts to fulfill these factors. Basically, the algorithm uses the criterion of the proximity between the different departments in the layout and the degree in which the layout satisfies the desired relationship chart.

After the EVAL module makes its evaluation report, the user has five options to choose from. The five options are:

1. Print a hard copy of the evaluation.
2. Change the entered data.
3. Restart the EVAL module for a new run.
4. Save the generated data to a disk file.
5. Exit the EVAL module to the HELLO module.

If the user chose option one through four, the program will operate in the EVAL module. If the user chose option five, the program would transfer control to the HELLO module for accessing the other three modules (FROMTO, CRAFT and LOCAT).
CHAPTER 5
OPERATING MANUAL

5.1 Operating Manual and Sample Cases

This section discusses the operation of the OUPLANT plant layout software in manual form. The format of this section is structured as an operating manual to the OUPLANT plant layout software package. The section will provide a step-by-step instruction on how to perform a facility design layout problem by providing a sample case for the user. The instructions include:

1. Guiding the user through the steps required to enter the necessary data into the software.
2. Make corrections to inputted data, if necessary.
3. Save data to a disk file.
4. Obtain a from-to chart output.
5. Obtain a CRAFT calculated move cost.
6. Obtain a graphical layout of the facility.
7. Experiment with the layout by changing various plant parameters.
8. Adjust the final layout.
9. Insert aisle(s).
10. Obtain hard copy print outs.

The instruction will also provide some insight to the features that the OUPLANT software is capable of performing.

Also, as an aid to the operating instructions this section will provide sample screen outputs so that the user would know what to expect to see as the software responds to various commands. Sample printed outputs from the printer
when the hard copy option is selected will also be included. A desk-top microcomputer such as an IBM PC AT with a color monitor and printer operating on DOS 3.2 or higher and running GWBASIC should be available. A hard drive is not necessary but would aid in operating efficiency and be convenient to the user.

Getting started

* Always hit the "ENTER" key after each entry if the software does not give specific instructions as to what key to hit.

You need to activate the "GRAPHICS" command in DOS by entering the DOS directory and type GRAPHICS so that you can print the graphic layout using the "SHIFT" and "PrtSc" keys.

To initiate the OUPLANT plant layout software, the facility designer should perform the following steps:
Assuming that the OUPLANT software is in drive a, the procedure to start the package is:

1. Type a:
2. Type OUPLANT

The introduction screen as shown in Figure 5.1 should appear on the screen. The user should then:

1. Hit ENTER

The main menu screen as shown in Figure 5.2 should appear on the screen. The main menu contains the four main options that the facility designer can select from. The options that are
IBM PC PLANT LAYOUT
IIE/ISE OU OUPLANT
Press Any Key When Ready

Figure 5.1 Introduction Screen.

<<<< IIE MICROSOFTWARE >>>>

THIS DISK CONTAINS PROGRAMS FOR PLANT LAYOUT DESIGN
------------------------------------------
1. FROM/TO CHART GENERATOR (O.U)
2. MICRO-CRAFT (O.U)
3. OPTIMUM FACILITY LOCATION
4. LAYOUT EVALUATION

5. EXIT THE PACKAGE

ENTER YOUR SELECTION:

Figure 5.2 Main Menu in HELLO.
available are:

1. **FROM/TO CHART GENERATOR (O.U)**

   This option will allow the facility designer to enter in production information, Table 5.1, so that a from-to chart can be generated for use in the CRAFT module.

2. **MICRO-CRAFT (O.U)**

   This option will allow the facility designer to enter in plant and department specifications so that a layout can be generated based on CRAFT approach.

3. **OPTIMUM FACILITY LOCATION**

   This option will allow the facility designer to enter information for determining the optimum location for a new facility or machine to be located with respect to existing facilities or machines.

4. **LAYOUT EVALUATION**

   This option will allow the facility designer to enter information for evaluating a layout using a relationship chart as the evaluating criterion.

From/to

Suppose a facility designer was given the task of designing a facility with the information given in Table 5.1 and that the OUPLANT plant layout software was available to the facility designer. The user would want to choose option 1 since CRAFT uses a from-to chart in its layout analysis.

1. **Select 1**
2. **Hit ENTER**

The user should now be in the FROMTO module and the credit screen should appear. The next step is to enter the product characteristic into the FROMTO module. The user should hit ENTER to get to the next screen after the credit screen.
Table 5.1 Data for the From-to Chart.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Quantity</th>
<th>Batch Size</th>
<th>Operation Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>300</td>
<td>5</td>
<td>1, 9, 5, 2, 9</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>2</td>
<td>1, 4, 9</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>2</td>
<td>1, 5, 6, 7, 9,</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>2</td>
<td>1, 7, 4, 7, 2, 9</td>
</tr>
<tr>
<td>5</td>
<td>400</td>
<td>1</td>
<td>1, 7, 5, 3, 9, 8, 9</td>
</tr>
</tbody>
</table>
The first prompt asks if the user wants to retrieve a previous file generated by the FROMTO module. If the user enters Y for yes, the software will ask for the file name and the drive that it is located in. Suppose that a new file needs to be created, the user would enter N for no. The software would then require the user to enter information about the product characteristic:

1. Enter 9 for nine departments.

The facility designer has the option to choose the different types of unit loads available. The options are illustrated in Figure 5.3. For this case, the option for "pieces" should be selected.

2. Enter 1 for unit load in "pieces".

Information about the data entering procedure are displayed on the screen for the user to read as illustrated in Figure 5.4. Hit ENTER when the user is done reading the information.

3. Enter 1 for part number one.
4. Enter 300 for a quantity of three hundred pieces.
5. Enter 5 for batch size of five.

Enter the sequence one at a time, hit ENTER after each entry. Enter " 0" to end a sequence for a given part and "/" to end the product characteristic input mode.

6. 1, ENTER, 9, ENTER, 5, ENTER, 2, ENTER, 0, ENTER

Repeat the same procedure for the rest of the parts (2 to 5).

After part number 5 has been entered, do the following:

7. Enter / for the part number prompt, to end the product characteristic input mode.
8. Hit ENTER
ENTER YOUR SELECTION OF UNIT LOAD THAT YOU USE FOR BATCH SIZE

1) PIECES
2) TOTEBOXES
3) PALLETS
4) OTHERS

ENTER YOUR SELECTION?

Figure 5.3 From-to Unit load option menu.
INFORMATION:
FOR EACH PART IN PRODUCTION THE USER HAS TO ENTER THE FOLLOWING:

1) PART NUMBER & QUANTITY OF EACH PRODUCT
2) BATCH SIZE:
3) DEPARTMENT SEQUENCE

NOTE:
1) THE USER USES THE DEPT. NUMBER AS OPERATION SEQUENCE NUMBER.
2) DEPT. NUMBER MUST BE BETWEEN 1 AND 3
3) THE USER MUST ENTER ' 0 ' TO SIGNAL ENDING OF OPERATIONAL SEQUENCE
4) NUMBER OF OPERATIONS CANNOT EXCEED 35 PER PRODUCT
   (INCLUDING REPEAT TRIPS TO PRIOR DEPARTMENT)
5) THE USER CAN USE A PRODUCT CODE AS THE PART # (MAX. 10 DIGITS)
   PRESS ' ENTER ' TO CONTINUE

Figure 5.4 Information screen for entering data into FROMTO
After information for each part has been entered, the software will display a summary such as Figure 5.5 and ask the user if changes are required. If the user entered N for no, the software would go back to step 3 and ask for the next part number. If the user entered Y for yes, the software would go to the "Change Menu" such as Figure 5.6 and ask the user to enter the number corresponding to the change required.

The Change Menu has six options. The six options are:

1. **PART NUMBER**

   This option will allow the facility designer to enter a new part number or a production code for the given part. This option is mainly used when a production code is used to identify a part instead of sequential number a part starting from 1, 2, 3, ....... and so on.

2. **NUMBER OF PIECES**

   This option will allow the facility designer to enter a new quantity for a given part.

3. **BATCH SIZE**

   This option will allow the facility designer to enter a new batch size for a given part.

4. **DEPARTMENT SEQUENCE**

   This option will allow the facility designer to enter a new department sequence for a given part.

5. **RE-ENTER DATA FOR THIS PRODUCT**

   This option will allow the facility designer to re-enter all the information for a given part (options one through four).

6. **EXIT TO MAIN MENU**

   This option will allow the facility designer to exit the FROMTO module and return to the main menu in the HELLO module.
SUMMARY OF INPUT DATA

PART NUMBER 1
QUANTITY 10 PIECES
BATCH SIZE 2 PIECES or UNITS / LOT
DEPARTMENT SEQUENCE
1 9 5 2

DO YOU WANT TO MAKE CHANGES (Y/N) ?

Figure 5.5 Summary screen for product information.

ENTER YOUR SELECTION

1) PART NUMBER (1)
2) NUMBER OF PIECES (10)
3) BATCH SIZE (2)
4) DEPARTMENT SEQUENCE
5) RE-ENTER DATA FOR THIS PRODUCT
6) EXIT TO MAIN MENU

ENTER YOUR SELECTION?

Figure 5.6 Change Menu in FROMTO.
FROM/TO CHART
UNIT: NO. OF TRIPS

| FROM DEPT. 1 | TO DEPT. 1 | NO. OF TRIPS = 0 |
| TO DEPT. 2 | NO. OF TRIPS = 0 |
| TO DEPT. 3 | NO. OF TRIPS = 0 |
| TO DEPT. 4 | NO. OF TRIPS = 7 |
| TO DEPT. 5 | NO. OF TRIPS = 21 |
| TO DEPT. 6 | NO. OF TRIPS = 0 |
| TO DEPT. 7 | NO. OF TRIPS = 435 |
| TO DEPT. 8 | NO. OF TRIPS = 0 |
| TO DEPT. 9 | NO. OF TRIPS = 60 |

PRESS ' ENTER ' TO CONTINUE

FROM/TO CHART
UNIT: NO. OF TRIPS

| FROM DEPT. 2 | TO DEPT. 1 | NO. OF TRIPS = 0 |
| TO DEPT. 2 | NO. OF TRIPS = 0 |
| TO DEPT. 3 | NO. OF TRIPS = 0 |
| TO DEPT. 4 | NO. OF TRIPS = 0 |
| TO DEPT. 5 | NO. OF TRIPS = 0 |
| TO DEPT. 6 | NO. OF TRIPS = 0 |
| TO DEPT. 7 | NO. OF TRIPS = 0 |
| TO DEPT. 8 | NO. OF TRIPS = 0 |
| TO DEPT. 9 | NO. OF TRIPS = 95 |

PRESS ' ENTER ' TO CONTINUE

Figure 5.7 Screen display of the trip interchange.
After step eight has been completed, the software will calculate the number of trips between departments and display it on the screen as illustrated in Figure 5.7. The facility designer should hit ENTER to proceed from screen to screen to view all the trips for each department. Once all the trips for each department has been displayed, a menu such as the one in Figure 5.8 will be displayed. The menu allows the facility designer six options. The six options are:

1. **SAVE OUTPUT ON DISK**
   This option will allow the facility designer to save the information generated from the FROMTO module to a disk file.

2. **DISPLAY & MODIFY EXISTING DATA**
   This option will allow the facility designer to change the information for a product characteristic. The Change Menu, Figure 5.6 will reappear.

3. **INPUT NEW DATA (RE-RUN FROM/TO)**
   This option restarts the FROMTO module again.

4. **PRINTED OUTPUT OF FROM/TO**
   This option will print a hard copy of the summary of the number of trips for each department on the printer.

5. **DISPLAY SUMMARY AND FROMTO CHART**
   This option will display a summary of the product and from-to chart on the screen as illustrated in Figure 5.9 and Figure 5.10. The facility designer also has the option of obtaining a hard copy on the printer.

6. **EXIT PROGRAM TO MAIN MENU**
   This option will allow the facility designer to exit the FROMTO module and return to the main menu in the HELLO module.
ENTER YOUR SELECTION:

1) SAVE OUTPUT ON DISK
2) DISPLAY & MODIFY EXISTING DATA
3) INPUT NEW DATA (RE-RUN FROM/TO)
4) PRINTED OUTPUT OF FROM/TO
5) DISPLAY SUMMARY AND FROMTO CHART
6) EXIT PROGRAM TO MAIN MENU

ENTER YOUR SELECTION?

Figure 5.8 Option menu in FROMTO.

SUMMARY OF PRODUCT.

<table>
<thead>
<tr>
<th>PART</th>
<th>QUANTITY</th>
<th>BATCH</th>
<th>DEPARTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE</td>
<td>SIZE</td>
<td>SEQUENCE</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>300</td>
<td>5</td>
<td>1 9 5 2 9</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>2</td>
<td>1 4 9</td>
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<tr>
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<td>42</td>
<td>2</td>
<td>1 5 6 7 9</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>2</td>
<td>1 7 4 7 2 9</td>
</tr>
<tr>
<td>5</td>
<td>400</td>
<td>1</td>
<td>1 7 5 3 9 8 9</td>
</tr>
</tbody>
</table>

PRESS <ENTER> TO CONTINUE.

Figure 5.9 Screen display of Summary Product in FROMTO.
FROMTO CHART FOR DEPARTMENTS.

<table>
<thead>
<tr>
<th>FROM</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>21</td>
<td>0</td>
<td>435</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>95</td>
</tr>
<tr>
<td>3</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>400</td>
</tr>
<tr>
<td>4</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>21</td>
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</tr>
<tr>
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<td>0</td>
<td>400</td>
</tr>
<tr>
<td>9</td>
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<td>0</td>
<td>0</td>
<td>60</td>
<td>0</td>
<td>0</td>
<td>400</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

PRESS <ENTER> TO CONTINUE.

Figure 5.10 Screen display of From-to Chart in FROMTO.
Craft

Suppose a facility designer was given the task of designing a facility with the information given in Table 5.2, 5.3, and that the OUPLANT plant layout software was available to the facility designer. The user would want to select the CRAFT module by choosing Option 2 in the main HELLO module.

1. Select 2 and hit ENTER
2. Hit ENTER to proceed after the credit screen.
3. Hit Y if instructions are desired. The instruction screen is illustrated in figure 5.11, 5.12, 5.13.

The software will ask if the user wants to recall a previous run of CRAFT. If "Y" is entered, a prompt for the file name and drive location will be displayed. Since this is a new case, the facility designer should select N and hit ENTER. The software will then ask if the user wants to recall a previous run of FROM/TO. For this new case select N and hit ENTER. The software will then ask for the plant characteristic. Follow the steps below to enter information for the sample case in Table 5.2 and Table 5.3, based on the IIE Plant Layout manual by Dr. Whitehouse (5). Remember to hit ENTER after each entry.

1. Enter 9 for the number of departments.
2. Enter 27300 for the plant area.
3. Enter 210 for the plant width.

The plant length will be calculated automatically. The screen will look like Figure 5.14. An information screen as illustrated in Figure 5.15 will be displayed. The user will have two options of either entering the number of longitudinal
Table 5.2 Plant information for CRAFT input.

<table>
<thead>
<tr>
<th>Plant Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant area</td>
</tr>
<tr>
<td>Plant length</td>
</tr>
<tr>
<td>Plant width</td>
</tr>
<tr>
<td>Departments</td>
</tr>
<tr>
<td>Number of longitudinal bays</td>
</tr>
<tr>
<td>Number of lateral bays</td>
</tr>
<tr>
<td>Length of bay</td>
</tr>
<tr>
<td>Width of bay</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Department Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department 1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
</tbody>
</table>

Initial Sequence of Department

1, 2, 4, 5, 3, 8, 9, 7, 6  No fixing of departments.
### Table 5.3 Data needed for CRAFT input.

<table>
<thead>
<tr>
<th>Departments</th>
<th>To 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
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<tbody>
<tr>
<td>From</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>15</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
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<td>2</td>
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<tr>
<td>2</td>
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<td>6</td>
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<tr>
<td>4</td>
<td>4</td>
<td>8</td>
<td>25</td>
<td>0</td>
<td>10</td>
<td>5</td>
<td>15</td>
<td>7</td>
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<td>20</td>
<td>0</td>
<td>1</td>
<td>20</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>40</td>
<td>1</td>
<td>3</td>
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<tr>
<td>7</td>
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<td>8</td>
<td>4</td>
<td>25</td>
<td>15</td>
<td>4</td>
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<td>0</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>30</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>30</td>
<td>5</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>9</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*From-to Chart for the number of trips between departments.*

<table>
<thead>
<tr>
<th>Departments</th>
<th>To 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>5</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
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<td>3</td>
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<td>2</td>
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<td>2</td>
</tr>
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<td>0</td>
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<td>2</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
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<tr>
<td>9</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*From-to Chart for the cost per movement between departments.*
PROGRAM PERFORMS PAIRWISE EXCHANGE BETWEEN DEPARTMENTS IN A PRODUCTION PLANT. IT DETERMINES A SUB-OPTIMAL ARRANGEMENT WITH RESPECT TO MINIMIZING TOTAL COST OF MATERIAL HANDLING (M.H.) IN THE PLANT.

ASSUMPTIONS:
------------
1. PLANT AREA IS RECTANGULAR OR SQUARE IN SHAPE
2. DEPARTMENTS ARE ARRANGED IN BAYS
3. THE COST OF MATERIAL HANDLING IS A FUNCTION OF EITHER RECTILINEAR OR EUCLIDEAN DISTANCE BETWEEN DEPARTMENT CENTROIDS.
4. MAXIMUM NO. OF DEPARTMENTS IS 35

THE PROGRAM ACCEPTS DATA PERTINENT TO DEPARTMENT AREAS, AN INITIAL ARRANGEMENT, NUMBER OF TRIPS BETWEEN DEPARTMENTS, AND COST PER TRIP ($/TRIP/UNIT DISTANCE).

IT PROVIDES A GRAPHICAL REPRESENTATION OF A SUB-OPTIMAL ARRANGEMENT.

PRESS 'ENTER' TO CONTINUE

Figure 5.11 Information Screen in CRAFT.

INITIAL ARRANGEMENT

FOR THE INITIAL ARRANGEMENT, ENTER THE SEQUENCE OF DEPARTMENTS WHICH CORRESPONDS TO THE INITIAL ARRANGEMENT FOLLOWING THE DIRECTION OF THE ARROWS

PRESS 'ENTER' TO CONTINUE

Figure 5.12 Information Screen in CRAFT.
THE PROGRAM PROVIDES THE USER AN OPPORTUNITY TO STOP CALCULATIONS WHENEVER A MORE COST EFFECTIVE LAYOUT HAS BEEN OBTAINED. THE USER SIMPLY PRESSES ANY KEY WHILE THE THE COMPUTER IS CALCULATING. AS SOON AS A NEW SOLUTION IS GENERATED THE USER CAN DECIDE TO TERMINATE SEARCHING OR TO CONTINUE WITH THE CRAFT ALGORITHM. THIS OPTION IS PROVIDED SO THAT IF THE USER DOES NOT WANT HAVE TO WAIT FOR A BETTER LAYOUT, HE CAN TERMINATE THE CRAFT CALCULATION AND ANALYZE THE LAYOUT GIVEN AT THAT TIME. HE CAN CONTINUE OR THIS IS ESPECIALLY USEFUL FOR LARGE PROBLEMS FOR WHICH THE EXECUTION TIME CAN BE A FEW HOURS LONG. IF YOU SAVE THE INTERMEDIATE ANSWER ON A DISK FILE, CALCULATION CAN BE CONTINUED AT A LATER TIME.

PRESS 'ENTER' TO CONTINUE

Figure 5.13 Information Screen in CRAFT.

ENTER THE NUMBER OF DEPARTMENTS: ? 9
ENTER MINIMUM REQUIRED AREA FOR PLANT ? 27300
ENTER WIDTH OF PLANT ? 210
LENGTH OF PLANT 130

PRESS 'ENTER' TO CONTINUE

Figure 5.14 Screen display for entering plant data.
SELECT YOUR OPTION.

FIRST OPTION: ENTER THE NUMBER OF LATERAL BAYS. IF YOU SELECT THIS OPTION LENGTH OF BAY WILL BE CALCULATED FROM THE FOLLOWING FORMULA:

\[ \text{LENGTH OF BAY} = \frac{\text{LENGTH OF PLANT}}{\text{NUMBER OF LATERAL BAYS}} \]

SECOND OPTION: YOU CAN INPUT LENGTH OF BAY. THE NUMBER OF LATERAL BAYS WILL BE CALCULATED FROM THE FOLLOWING FORMULA:

\[ \text{NUMBER OF LATERAL BAYS} = \frac{\text{LENGTH OF PLANT}}{\text{LENGTH OF BAY}} \]

PRESS 'ENTER' TO CONTINUE

Figure 4.15 Option information in CRAFT.

SELECT YOUR OPTION.

FIRST OPTION: ENTER THE NUMBER OF LONGITUDINAL BAYS. IF YOU SELECT THIS OPTION WIDTH OF BAY WILL BE CALCULATED FROM THE FOLLOWING FORMULA:

\[ \text{WIDTH OF BAY} = \frac{\text{WIDTH OF PLANT}}{\text{NUMBER OF LONGITUDINAL BAYS}} \]

SECOND OPTION: YOU CAN INPUT WIDTH OF BAY. THE NUMBER OF LONGITUDINAL BAYS WILL BE CALCULATED FROM THE FOLLOWING FORMULA:

\[ \text{NUMBER OF LONGITUDINAL BAYS} = \frac{\text{WIDTH OF PLANT}}{\text{WIDTH OF BAY}} \]

PRESS 'ENTER' TO CONTINUE

Figure 4.16 Option information in CRAFT.
bays or the bay width. For this case select 1.

4. Enter 6 for the number of longitudinal bays.

Another information screen will be displayed as illustrated in Figure 5.16. The user will have two more options of either entering the number of lateral bays or the bay length. For this case select 1.

5. Enter 5 for the number of lateral bays.

A summary of the plant will be displayed on the screen as illustrated in Figure 5.17. The software will also ask the facility designer if any changes are desired. If "Y" is selected, a Change Menu will be displayed as shown in Figure 5.18. The facility designer has nine options to choose from. The nine options are:

1. **CHANGE NO. OF DEPTS**

   This option will allow the facility designer to change the number departments in the plant.

2. **CHANGE PLANT AREA**

   This option will allow the facility designer to change the plant area of the plant.

3. **CHANGE WIDTH OF PLANT**

   This option will allow the facility designer to change the width of the plant.

4. **CHANGE LENGTH OF PLANT**

   This option will allow the facility designer to change the length of the plant.

5. **CHANGE WIDTH OF BAYS**

   This option will allow the facility designer to change the width of the bays.
NUMBER OF DEPARTMENTS = 9
PLANT AREA = 27300
LENGTH = 130
WIDTH = 210
NUMBER OF LATERAL BAYS = 5
LENGTH OF BAY = 26
WIDTH OF BAY = 35
DO YOU WANT TO MAKE ANY CHANGES (Y/N) ?

Figure 5.17 Plant Summary screen in CRAFT.

PLEASE SELECT YOUR OPTION:
1) CHANGE NO. OF DEPTS ( 9 )
2) CHANGE PLANT AREA ( 27300 )
3) CHANGE WIDTH OF PLANT ( 210 )
4) CHANGE LENGTH OF PLANT ( 130 )
5) CHANGE WIDTH OF BAYS (WBAY = 35 )
6) CHANGE NUMBER OF LATERAL BAYS ( 6 )
7) CHANGE LENGTH OF BAY (LBAY = 26 )
8) CHANGE NUMBER OF LATERAL BAYS ( 5 )
9) NO CHANGES.
   ENTER YOUR SELECTION?

Figure 5.18 Change Menu in CRAFT.
6. CHANGE NUMBER OF LONGITUDINAL BAYS

This option will allow the facility designer to change the number of longitudinal bays in the plant. The number of longitudinal bays are the main factor that decides how the layout will be generated.

7. CHANGE LENGTH OF BAYS

This option will allow the facility designer to change the length of the bays.

8. CHANGE NUMBER OF LATERAL BAYS

This option will allow the facility designer to change the number of lateral bays in the plant.

9. NO CHANGES

This option does not make any changes to the inputted plant information and returns to the plant summary screen in Figure 5.17.

If the facility designer decides to choose any of the eight change options, the software will provide instructions and prompts to guide the facility designer through the "change process". For example, suppose the facility designer wishes to change the number of longitudinal bays from six to four. The facility designer should do the following:

1. Select Y to request a change.
2. Select 6 to change the number of longitudinal bays.
3. Select 4 for four longitudinal bays.

The facility designer now has two options as illustrated in Figure 5.19. Suppose the facility designer wishes to fix the width of the bay. The facility designer should then select 1. The software will then return to the plant summary screen in Figure 5.17.

If the facility designer does not want any changes made
Figure 5.19 Option menu in CRAFT.

ENTER NUMBER OF LONGITUDINAL BAYS : ? 4

ENTER YOUR SELECTION.
1) FIXED WIDTH OF BAY (WBAY = 35 )
2) FIXED WIDTH OF PLANT ( 210 )

ENTER YOUR SELECTION :?

Figure 5.20 Prompt to enter areas.

FOR EACH DEPT. ENTER AREA

<table>
<thead>
<tr>
<th>DEPT.#</th>
<th>AREA</th>
<th>DEPT.#</th>
<th>AREA</th>
<th>DEPT.#</th>
<th>AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.21 Area summary display.

SUMMARY OF DEPARTMENT AREA

<table>
<thead>
<tr>
<th>DEPT.#</th>
<th>AREA</th>
<th>DEPT.#</th>
<th>AREA</th>
<th>DEPT.#</th>
<th>AREA</th>
<th>DEPT.#</th>
<th>AREA</th>
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<tbody>
<tr>
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<td>6300</td>
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<td>2100</td>
<td>4</td>
<td>5600</td>
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<td>5</td>
<td>1400</td>
<td>6</td>
<td>2800</td>
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<td>8</td>
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<td>9</td>
<td>1540</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TOTAL PLANT AREA = 27300    TOTAL INPUT AREA = 27300
UNOCCUPIED SPACE = 0

DO YOU WANT TO MAKE ANY CHANGES (Y/N)?
after the plant summary screen, an N should be selected. The software will now request the areas of each department to be entered as illustrated in Figure 5.20. For this case, enter the area as shown in Figure 5.3 by doing the following:

1. Enter 2800 for the area for the first department.
2. Enter 6300 for the area for the second department.

Repeat the same procedure for the rest of the departments.

Once all the areas for the departments have been entered, a summary of the department areas will be displayed as shown in Figure 5.21. The facility designer will also have the option of changing the department area information by selecting "Y" at the change prompt. If a "Y" is selected, the software will prompt the user to enter the department number to be changed and the new department area. If an "N" is selected, the software will proceed to prompt the user to enter the number of trips and cost per trip between departments as illustrated in Figure 5.22. For this case, enter the number of trips and the cost per trip for each department from Figure 5.3 by:

1. Enter 15 for the number of trips from department one to department two.
2. Enter 5 for the cost per trip from department one to department two.
3. Enter 3 for the number of trips from department one to department three.
4. Enter 5 for the cost per trip from department one to department three.

Repeat the above steps for all the departments in Figure 5.3.

The software also allows changes to be made if a mistake was made while entering the data. This can be accomplished by selecting "Y" at the change prompt. Once all the number of
FOR EACH DEPARTMENT INPUT: (NO. OF TRIPS) AND (COST($)/TRIP UNIT DISTANCE)

FROM DEPARTMENT 1 TO:

<table>
<thead>
<tr>
<th>DEPT NO.</th>
<th>TRIPS</th>
<th>$/UNIT</th>
<th>DEPT NO.</th>
<th>TRIPS</th>
<th>$/UNIT</th>
<th>DEPT NO.</th>
<th>TRIPS</th>
<th>$/UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2 ?

Figure 5.22 Prompt to enter number of trips.

INPUT INITIAL SEQUENCE OF DEPARTMENTS
FROM RECEIVING TO SHIPPING

(EX: SEQ.1 = 3, SEQ.2 = 11, ETC)

DEPARTMENT NO. DEPARTMENT NO. DEPARTMENT NO.
SEQ. 1 = ?

Figure 5.23 Prompt to enter initial sequence.

INPUT INITIAL SEQUENCE OF DEPARTMENTS
FROM RECEIVING TO SHIPPING

(EX: SEQ.1 = 3, SEQ.2 = 11, ETC)

DEPARTMENT NO. DEPARTMENT NO. DEPARTMENT NO.
SEQ. 1 = ? 2  SEQ. 2 = ? 8  SEQ. 3 = ? 1
SEQ. 4 = ? 6  SEQ. 5 = ? 9  SEQ. 6 = ? 3
SEQ. 7 = ? 7  SEQ. 8 = ? 5  SEQ. 9 = ? 4

WOULD YOU LIKE TO FIX THE LOCATION OF ANY DEPARTMENT (Y/N) ?

Cont.
<table>
<thead>
<tr>
<th>DEPT SEQUENCE</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>2, 8, 1, 6, 9, 3, 7, 5, 4</td>
<td>137858.6</td>
</tr>
<tr>
<td>2, 1, 8, 6, 9, 3, 7, 5, 4</td>
<td>136296.9</td>
</tr>
<tr>
<td>1, 2, 8, 6, 9, 3, 7, 5, 4</td>
<td>136196.1</td>
</tr>
<tr>
<td>6, 2, 8, 1, 9, 3, 7, 5, 4</td>
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<td>2, 6, 8, 1, 9, 3, 7, 5, 4</td>
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</tr>
<tr>
<td>2, 6, 8, 1, 7, 9, 3, 5, 4</td>
<td>115925.6</td>
</tr>
</tbody>
</table>

*THE MICRO-CRAFT GENERATED ARRANGEMENT HAS BEEN REACHED*

PRESS 'ENTER' TO CONTINUE
Figure 5.25 Craft Menu after the cost calculation.
trips and the cost per trip for each department have been entered, the software will prompt the user to enter the initial sequence for the layout so that an improvement can be made. This is illustrated in Figure 5.23. The software will also ask if any departments should be fixed in a specific sequence. For this case, do the following:

1. Select 1, hit ENTER
2. Select 2, hit ENTER

Repeat the above procedure and enter the sequence: 1, 2, 4, 5, 3, 8, 9, 7, 6.

3. Select N to avoid fixing any department in a certain location.
4. Select N to avoid making any changes.
5. Select E to choose the move cost to be calculated by euclidean distance.

The software will then calculate the sequence and move cost and display the results on the screen as illustrated in Figure 5.24. Follow the prompts to get to the next menu. The menu will give the facility designer six options as illustrated in Figure 5.25. The six options are:

1. **GRAPHICAL REPRESENTATION OF LAYOUT AND PRINTED OUTPUT**
   This option will transfer control to the CGRAPH module so that the generated layout can be graphically displayed.

2. **INPUT NEW INITIAL SEQUENCE**
   This option will allow the facility designer to input a new initial sequence for the software to improve on.

3. **MODIFY LAYOUT DATA**
   This option will allow the facility designer to modify the layout data by returning to the plant
summary screen in Figure 5.17.

4. SAVE THE INPUT FILE TO DISK

This option will allow the facility designer to save the plant specification information inputted into the CRAFT module to a disk file.

5. RE-START CRAFT FOR ENTERING DATA

This option will re-start the CRAFT module from the beginning.

6. EXIT THE PROGRAM TO MAIN MENU

This option will allow the facility designer to exit the CRAFT module and return to the main menu in the HELLO module.

Before proceeding, the data should be saved to a disk file by selecting option four and following the prompts.

For this case, a graphical display of the generated layout is desired so the facility designer should select option one.

6. Select 1 for a graphic display of the generated layout. (Use SHIFT and PrtSc keys together to get a print out of the layout shown on the screen on to the printer.)

The first graphic display is the flow of material between departments as illustrated in Figure 5.26. For this case, the flow is displayed in a euclidean format. The second display is the CRAFT generated layout with the department numbers as illustrated in Figure 5.27. The third display is the same display as the second display but with the CRAFT calculated cost as illustrated in Figure 5.28. The fourth display is the menu display with eight options as illustrated in Figure 5.29.
Figure 5.26 Screen display of the material flow.
Figure 5.27 Screen display of the departments.
TOTAL HANDLING COST <E>: $115925.6
PRESS < ENTER > TO CONTINUE

Figure 5.28 Screen display of the move cost.
Figure 5.29 Screen display of the Graphics Menu in CGRAPH.
The eight options are:

1. PRINT

This option will allow the facility designer to obtain a printed output of the plant summary.

2. RERUN

This option will re-start the CRAFT module again.

3. CHANGE SPEC

This option will allow the facility designer to change the plant parameter specifications through a "Change Menu". This option is used when the facility designer wishes to experiment with different changes to the plant parameter to see their effect on the layout and the move cost.

4. ADJUST

This option will allow the facility designer to make adjustments to the final CRAFT generated layout.

5. SAVE

This option will allow the facility designer to save the plant specification information inputted into the CRAFT module to a disk file.

6. DISPLAY

This option will allow the facility designer to retrieve a saved data file of an adjusted layout.

7. AISLE

This option will allow the facility designer to insert different types of aisles into the generated layout.

8. EXIT

This option will allow the facility designer to exit the CRAFT module and return to the main menu in the HELLO module.

This part of the manual will now discuss option three, four and seven in more detail. The manual will assume that
the facility designer is at the graphics menu, Figure 5.29, for each case.

Change Spec

Option three is used when the facility designer wishes to experiment with different plant parameters such as plant length, plant width, number of longitudinal bays.....etc, to see their effects on the layout and move cost. To select this option, the facility designer should select 3 and hit ENTER in the graphics menu in Figure 5.29. A "Change Menu" will then be displayed as in Figure 5.30 with nine options. The nine options are:

1. **AREA**
   
   This option will allow the facility designer to change the plant area.

2. **WIDTH**
   
   This option will allow the facility designer to change the plant width.

3. **LENGTH**
   
   This option will allow the facility designer to change the plant length.

4. **BAY WIDTH**
   
   This option will allow the facility designer to change the bay width.

5. **#.LONG BAY**
   
   This option will allow the facility designer to change the number of longitudinal bays.

6. **#.LAT BAY**
   
   This option will allow the facility designer to
Figure 5.30 Screen display of the Change Menu in CHANGE.
change the number of lateral bays.

7. **BAY LENGTH**

This option will allow the facility designer to change the bay length.

8. **DISPLAY CHANGE**

This option will allow the facility designer to see the effects of the changes to the plant parameters on the layout and the move cost.

9. **NO CHANGE**

This option will allow the facility designer to retrieve the original CRAFT generated layout and corresponding move cost if the changes made to the plant parameters were determined to be unacceptable. Selecting this option will return the software to the graphics menu in Figure 5.29.

For example, suppose the facility designer wishes to see the effect if the number of longitudinal bays were changed from six to five. The facility designer should do the following:

1. Select 5 for "#.Long Bay" in the graphics menu in Figure 5.29.
2. Enter 5 for the new number of longitudinal bays.

The facility designer will then have two options as illustrated in Figure 5.31. For this case, let's fix the width of the plant to 210 feet by selecting 2.

3. Select 8 to display the resulting change to the layout and the move cost as a result of changing the number of longitudinal bays from six to five.

The software will display a "Please Wait...." message while it is recalculating the changes. Once the changes have been calculated, the result will be displayed on the screen. The first display will be the flow of material through the departments as illustrated in Figure 5.32. The second display...
Figure 5.31 Screen display of option in CHANGE.
Figure 5.32 New material flow after changes.
Figure 5.33 New layout after change.
Figure 5.34 New cost after changes.
will be the labelling of the departments as illustrated in Figure 5.33. The third display will be the move cost as illustrated in Figure 5.34. As a result of changing the number of longitudinal bays from six to five, we can see the new layout and the relocated departments. Also, the move cost has increased to $122,404 from $115,925.60. This indicates that the changes made has increased the move cost for the layout which is unacceptable. Now suppose the facility designer wishes to retrieve the original CRAFT generated layout. By following the prompts, the software will return to the graphics menu as illustrated in Figure 5.29. From the graphics menu, the facility designer should do the following:

1. Select 3 for "Change Spec".
2. Select 9 for "No Change".

The software will ask the user to wait while it is retrieving the original CRAFT generated layout. By following the prompts, the original layout will be displayed and the graphics menu as illustrated in Figure 5.29 will reappear.

Adjust

Option four is used when the facility designer wishes to make a final adjustment on the CRAFT generated layout to correct odd or irregular shaped departments. To select this option, the facility designer should select 4 and hit ENTER. The software will ask the facility designer to enter the size of the grid as illustrated in Figure 5.35. For this case,
Figure 5.35 Screen display of the grid size prompt.
select 10 and hit ENTER. This means that a grid with ten foot spacing will be used to adjust the layout. The facility designer will also have the option of displaying the grid on the layout or not. Select Y and hit ENTER. A grid will now be overlaid on the layout, Figure 5.36, with ten foot spacing. Follow the prompt on the screen and select N for making no changes to the grid size. The software will now ask for information to adjust each of the departments. The software will ask for the distances from a selected reference point so that adjustments could be made to the department, Figure 5.37. From this point, the facility designer would follow the prompts on the screen and adjust the departments according to whatever criteria the facility designer chooses. The software will give several options pertaining to the adjustment of the departments. An example of one of the options is illustrated in Figure 5.38. Once the departments have been adjusted, a screen menu will appear, Figure 5.39 giving the facility designer five options. The five options are:

1. PRINT SUMMARY
   This option will print the summary of the plant.

2. PRINT DETAILS OF DEPT
   This option will print the summary of the location of the adjusted departments in the layout.

3. SAVE GRAPHICS
   This option will save the adjusted layout to a disk file for later use.
Figure 5.36 Grid overlay on the layout.
Figure 5.37 Adjustment prompt.
Figure 5.38 Adjustment option.
1-Print Summary 2-Print Details of Dept
3-Save graphics
4-GRAPHICS MENU 5-MAIN MENU

Figure 5.39 Final adjustment menu.
4. **GRAPHICS MENU**

This option will return control to the Graphics Menu in Figure 5.29.

5. **MAIN MENU**

This option will return control to the Main Menu in the HELLO module.

As stated in Chapter 6, there are still some problems with the "adjustment" section of the software and that further refinements will be necessary to make this capability truly operational.

**Aisle**

Option seven is used when the facility designer wishes to insert aisles into the layout. To select this option, the facility designer should select 7 and hit **ENTER** in the graphics menu in Figure 5.29. The software will then display the Aisle Type Menu, Figure 5.40 with four options. The four options are:

1. **SINGLE AISLE**

   This option will allow the facility designer insert a single aisle into the layout.

2. **MULTIPLE AISLES**

   This option will allow the facility designer to insert multiple aisles into the layout.
Figure 5.40 Screen display of the aisle menu in the AISLE module.
3. **U-SHAPE**

This option will allow the facility designer to insert a U-shape aisle into the layout.

4. **EXIT**

This option will return control to the graphics menu in the CGRAPh module, Figure 5.29.

The facility designer would choose the aisle type that he/she wishes to insert into the layout. The software would then ask for the aisle orientation (place the aisle vertically or horizontally into the layout), the dimensions and location placement information for the aisle. Suppose for this case the facility designer wishes to place a U-shape aisle into the layout. The steps are:

1. Select 3 for U-shape aisle.
2. Select 2 for "Along with width", which means a vertical aisle placement. Figure 5.41.
3. Enter 8 for an eight feet aisle width.
4. Enter 20 to place the aisle twenty feet from the west wall of the plant. Figure 5.42.
5. Enter 45 for a forty-five feet U-Shape spacing.
6. Enter 25 for placing the aisle twenty-five feet from the south wall of the plant.

The software would then display the placement of the U-Shape aisle in the layout, Figure 5.43, and ask if any changes are necessary. By following the prompts, the software will return to the aisle type menu, Figure 5.40. The facility designer should then select 4 and hit ENTER to return to the graphics menu, Figure 5.29.

The aisle module is a stand-alone program at the moment. This module does not function correctly and the CRAFT
Aisle Pattern.........OPTION >> 2
1-ALONG WITH LENGTH
2-ALONG WITH WIDTH

Figure 5.41 Screen display of the aisle placement menu.
Figure 5.42 Screen display of the aisle location prompt.
Figure 5.43 Screen display of the aisle placement in the layout.
algorithm does not take into account the presence of aisles when it performs the CRAFT calculation for the layout. An attempt was made in this research to look into the problem with this module. However, due to the time limitations no significant progress has been made to the Aisle Module. Further research and development will be required to correct and integrate the Aisle Module to this plant layout package.

The last two modules, LOCAT and EVAL are selected from the Main Menu in the HELLO module, Figure 4.2. Since this thesis did not modify or alter the two modules, the operating instructions are not included. However, the screen prompts for the two modules are sufficient to guide the user through the operations of the two modules. For an indepth operating instruction to the LOCAT and EVAL modules, the user can refer to the IBM PC Plant Layout IIE Microsoftware manual by Dr. Whitehouse (5, Manuals Section).
6.1 Discussion on Software Requirements.

This section discusses the requirements of the software as modified at Ohio University. The OUPLANT plant layout software was designed for use on any desk-top microcomputer with at least 640K RAM internal memory operating GWBASIC under the 3.2 DOS (or higher) operating system. The software was modified on an IBM PC AT with an 8088 microprocessor, 640K RAM operating at 8 MHZ and then eventually on an IBM PC with a 386 microprocessor upgrade, 1MB RAM operating at 16 MHZ when the equipment became available.

The microcomputer used for running the OUPLANT plant layout software must have a 5 1/4 inch disk drive and should have a hard drive for faster operation, but that is not a necessity. The microcomputer should operate with a clock speed of at least 8 MHZ or else the software will take a considerable amount of operating time for layouts with more than ten departments. The microcomputer should also have a color monitor and a color graphics card as well as a printer for displaying the layout on the screen and for obtaining a printed hard copy.

The OUPLANT plant layout software is capable of handling
up to thirty-five departments, however the arrays in the
program code could be re-dimensioned for more than thirty-five
departments if the user's computer has the capability to do so.

6.2 Discussion on Software Capabilities.

This section discusses the capabilities of the OUPLANT
plant layout software. At the present, the modified IIE plant
layout software now called OUPLANT plant layout software is
capable of accepting inputs for thirty-five departments for
the from-to chart as well as inputs for thirty-five
departments for CRAFT in which the software would produce a
from-to chart and product summary. The software would also
produce a graphical representation of the CRAFT generated
optimum layout in the form of a drawing of the layout of the
plant and departments using straight lines as opposed to
previously using alphanumeric characters. The graphic output
also draws the material flow between departments in either
euclidean or rectilinear flow, depending on the user, and will
number each department in the layout for ease of
identification as well as indicating the length and width of
the plant. Screen outputs are supplemented by printer outputs
if the user requests a hard copy print-out.

In addition, the software is capable of allowing the user
to experiment with different plant layouts by varying any of
the plant parameters in the software and obtaining a new
calculated move cost and new CRAFT generated layout without having to restart the entire software for each change in the plant parameters.

Also, the final CRAFT generated layout could be adjusted to handle odd or irregular shaped layouts. A grid with dimensions in feet could be inserted on top of the layout so that the user would have points of reference in adjusting the final layout. Some limitations exist in the "adjustment" part of the software that will be discussed further in Section 6.3.

Different types of aisles could be inserted by the user into the final adjusted layout. However, some problems still exist in the aisle application module and will be discussed further in Section 6.3.

6.3 Discussion on Software Limitations.

This section discusses the limitations of the OUPLANT plant layout software. Although the program has been corrected and debugged as much as possible, two known problems still exist due to limitations in time and equipment availability. The two problems that exist are in the final CRAFT adjusted portion of the software and the aisle application portion of the software.

The problems that exist in the final adjustment portion of the software are three fold:

1. The insertion of the grid for the final adjustment of the layout causes the layout to be distorted and
unclear. The grid is drawn on top of the layout and thus overwrite some parts of the layout which makes adjustment difficult, but not impossible. This is a result of the method that the GWBASIC language uses create graphic displays. The graphics capability of GWBASIC is not detailed enough to permit overlaying of drawings on top of each other, such as the grid on top of the layout.

2. The display of the final adjustment algorithm needs refinement. In some cases, it is possible to place a department outside of the plant and departments are displayed one at a time which makes it hard to visualize what the final adjusted layout will eventually look like. An algorithm is needed to check for plant boundaries to prevent departments from being located outside the plant walls. Also, the present algorithm should be reconfigured so that it does not display an adjusted department one at a time.

3. The methodology for the recalling previously adjusted layouts from the disk drive and the printing of the final adjusted plant summary needs to be improved. The retrieval algorithm is incorrect.

The problems that exist in the aisle application portion of the software are two fold:
1. The insertion of the aisle(s) causes the CRAFT generated layout to be rearranged randomly to allow the aisle(s) to fit into the layout. Some aisle(s) may cut through a department which splits a single department into two. The aisle insertion algorithm should be checked.

2. CRAFT does not recognize the presence of the aisle(s) and does not consider them in the calculation so the inserting and displaying of the aisle(s) are only for graphic visualization purposes.

The problems stated in the two portions of the software are methodology problems, other problems that exist in the software are the result of using GWBASIC as the programming language. As stated earlier, the decision to use GWBASIC as the programming language instead of other programming languages was to follow the objectives set by Dr. Whitehouse when the original plant layout software was developed.

As a result of using GWBASIC as the programming language, the software is not efficient in using memory space in the microcomputer and operates much slower than if another programming language was used. Since GWBASIC operates under the DOS operating system, another limitation to the expansion and operation of the software is that DOS itself is limited to 640K of memory. This means that future additions to the software may cause it to use more memory space when it is
operating than available. An example being the re-
dimensioning of the arrays to handle more than thirty-five
departments. This may or may not cause a memory related
problem depending on how efficiently memory space is used in
the microcomputer.

Also, the graphics capabilities of the software is barely
adequate at best and the only way to get a printed hard copy
of the layout is to use the "SHIFT" and "PRINT SCREEN" keys.
This method is somewhat clumsy and primitive. However,
consultations with Dr. Patrick McCuistion, an Assistant
Professor in the Industrial Technology Department at Ohio
University and an expert on AUTOCAD in incorporating AUTOCAD
with the software to produce the layout drawing indicated that
GWBASIC and AUTOCAD graphic display approaches are not
compatible and that very extensive modifications would be
required.

6.4 Recommendations.

This section discusses the recommendations that should
be performed on the OUPLANT plant layout software to make it
a commercially marketable plant layout package. Throughout
the development and after the final modifications/additions
to the OUPLANT plant layout software were completed, several
recommendations were generated. These recommendations are:

1. Correct the final CRAFT layout adjustment portion
   of the software.
a. Modify the graphic display so that the presentation of the grid overlay of the layout is better presented. This can be done by switching to a different programming language or limit the grid spacing from being too small so that it distorts the layout underneath it.

b. Solve the methodology problems so that departments are confined within the plant and that all the departments are shown simultaneously to ease in the adjustment processes.

c. Modify the methodology in the recalling of previously adjusted layout from the disk file and the printing of the final adjusted plant summary.

2. Correct the aisle application portion of the software.

a. Solve the algorithm in which the aisle(s) are inserted so that departments are not randomly rearranged and that they don't cut through a department.

b. Incorporate the aisle application program into the CRAFT algorithm so that CRAFT will take into account the presence of aisle(s) in its calculations.

3. Refine or modify the way the final CRAFT generated
layout is printed. Software such as AUTOCAD and CADKEY could be considered.

4. Rewriting the software in a different language to improve operating efficiency and to conserve memory space.

5. Incorporating the capabilities of the "mouse" as an aid in handling menu functions etc.
CHAPTER 7
SUMMARY AND CONCLUSIONS

7.1 Summary

This section summarizes the accomplishments pertaining to the development of the modified IIE plant layout software, now known as OUPLANT, in the direction towards producing a commercially marketable desk-top microcomputer operated plant layout software package. The IIE plant layout software developed by Dr. Whitehouse at the University of Central Florida had been at Ohio University since 1986. The software refinement and development program at Ohio University was under the direction of professor E. Ralph Sims Jr. PE, of the Industrial and Systems Engineering Department. Under his direction and guidance several graduate students began the process of refining the software package. In 1989, the work for this thesis began with further refinements and corrections to the previous modifications performed on the plant layout software package. At this point, the plant layout software package has the following capabilities:

1. The capability to produce a graphical representation of the CRAFT generated layout using straight lines instead of using alphanumeric characters.
2. The capability to produce a graphical representation of the materials flow through the departments in either rectilinear or euclidean flow.

3. The capability to allow the user to experiment with different layouts through the manipulation of plant parameters, to see its effects on the layout and the CRAFT calculated move cost without the need to restart the entire package and to recall the original CRAFT generated layout if no changes were desired.

4. The capability to produce a product summary chart and from-to chart.

5. The capability to fix departments in a certain location.

6. The capability to produce enhanced color graphics in both the menu displays as well as the CRAFT output displays.

The OUPLANT plant layout software package is now ready for future modifications to enable it to incorporate group technology and materials flow analysis so that the package could be a truly comprehensive plant layout software package.
7.2 Conclusions

The OUPLANT plant layout software package is a versatile user-friendly interactive plant layout software based on CRAFT techniques. Its graphic enhanced outputs greatly aid in visual displays of the generated layouts as opposed to the previous eye-straining alphanumeric characters used in many layout software. The capability to allow the facility designer to experiment and "play around" with different plant layouts through the manipulation of the various plant parameters and obtaining an instant change in both the graphic display of the new layout with the new recalculated move cost makes the package very versatile and dynamic to the facility designer.

Even though the capability to adjust the final layout has not been perfected yet, the ability to somewhat adjust the final layout makes the package more practical in real world applications to plant layout problems since it is capable of correcting odd or irregular shaped layouts that the software may produce. Also, the inclusion of the stand-alone aisle application program module makes the package a viable basis for future expansion so that aisle consideration could be taken into account without the need to use fixed dummy departments to represent aisles.
REFERENCES

Facilities Planning


Computer Applications


Manuals


2. *DOS, Disk Operating System*, Property of IBM 1985

3. *BASIC 3.0*, Property of IBM 1984


1 REM HELLO MODULE
2 REM ******************************************************
3 REM ASSIGN COLOR, BACKGROUND AND CONDITIONS.
4 REM ******************************************************
5 SCREEN 0,1:COLOR 3,0:KEY OFF
10 CLS:SCREEN 0,1:COLOR 3,0:WIDTH 80
11 REM ******************************************************
20 OPEN "O",1,"CFLAG"
30 PRINT #1,0
40 CLOSE #1
50 GOSUB 260
60 LOCATE 5,27:PRINT "<<< IIE MICRO-SOFTWARE >>>"
70 LOCATE 8,27:PRINT "THIS DISK CONTAINS PROGRAMS";
80 LOCATE 9,27:PRINT " FOR PLANT LAYOUT DESIGN"
90 LOCATE 10,27:PRINT "---------------------------I1-
100 LOCATE 12,27:PRINT "1. FROM/TO CHART GENERATOR (O.U)"
110 LOCATE 13,27:PRINT "2. MICRO-CRAFT (O.U)"
120 LOCATE 14,27:PRINT "3. OPTIMUM FACILITY LOCATION"
130 LOCATE 15,27:PRINT "4. LAYOUT EVALUATION"
140 LOCATE 17,27:PRINT "5. EXIT THE PACKAGE"
150 LOCATE 19,27:INPUT"ENTER YOUR SELECTION : ",V
160 IF V<1 OR V>5 THEN PRINT CHR$(7):LOCATE 21,27:COLOR 4,0:PRINT "*** ERROR ***":LOCATE 21,27:PRINT "RE-ENTER THE SELECTION BETWEEN 1 AND 5 :":COLOR 3,0:GOTO 150
170 ON V GOTO 180,190,200,210,230
180 AS="FROMTO": GOTO 220
190 AS="CRAFT": GOTO 220
200 AS="LOCAT": GOTO 220
210 AS="EVAL": GOTO 220
220 RUN AS:GOTO 10
230 CLS:SYSTEM
240 '
250 '
251 REM PRINTING OF BORDER.
252 REM ******************************************************
260 COLOR 10,0
270 LOCATE 2,1:PRINT CHR$(213)+STRING$(77,205)+CHR$(184)
280 FOR I=3 TO 22
290 LOCATE I,1:PRINT CHR$(179):LOCATE I,79:PRINT CHR$(179)
300 NEXT I
310 LOCATE 23,1:PRINT CHR$(212)+STRING$(77,205)+CHR$(190)
311 REM ******************************************************
320 RETURN
VARIABLE LISTING FOR HELLO

V  Variable for assigning user options (5).

AS  String variable for assigning the program names of the four main modules.
HELLO MODULE

START

INITIALIZE VARIABLES

HELLO MAIN MENU
1. FROM/TO CHART GENERATOR
2. MICRO-CRAFT
3. OPTIMUM FACILITY LAYOUT
4. LAYOUT EVALUATION
5. EXIT THE PACKAGE

1. RUN FROM/TO MODULE
2. RUN MICRO-CRAFT MODULE
3. RUN OPTIMUM LOCATED MODULE
4. RUN LAYOUT EVALUATION MODULE
5. EXIT TO SYSTEM
10  '*****************************************************************************
20  ' PLANT LAYOUT-FROM/TO CHART
30  '*****************************************************************************
40  ' INITIALIZE AND DIMENSION VARIABLES
50  '*****************************************************************************
60  DIM P(35,35),Q(35),B(35),TP(35),N(35),JU$(35)
70  DIM DD(35,35)
80  SCREEN 0,1:COLOR 3,0
90  ON ERROR GOTO 3610
100  TZ=0
110  GOSUB 1690
120  '*****************************************************************************
130  ' INPUT DATA
140  '*****************************************************************************
141  REM * ASK FOR INPUT MODE FOR FROMTO CHART (DISK OR MANUAL). *
142  REM ************************************************************=
150  CLS:LOCATE 5,1:PRINT TAB(10):INPUT"DO YOU WANT TO USE PREVIOUS RUN OF FROMTO CHART (Y/N)";AS
160  IF AS = "Y" OR AS = "y" THEN GOSUB 3530:GOTO 3320
170  IF AS = "N" OR AS = "n" THEN 190
181  REM *** MANUALLY ENTERING DATA FOR FROMTO CHART. *****
190  CLS:LOCATE 5,1:PRINT:PRINT TAB(10):INPUT"ENTER NUMBER OF PRODUCTION DEPARTMENTS (MAX. 35)";ND
191  REM *** MANUALLY ENTERING DATA FOR FROMTO CHART.*****
200  IF ND > 35 OR ND < 2 THEN PRINT CHR$(7):COLOR 4,0:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10):INPUT"RE-ENTER THE DATA (BETWEEN 2 TO 35 DEPT. ) ":,ND:COLOR 3,0:GOTO 200
210  CLS:LOCATE 3,1:PRINT:PRINT TAB(10)" ENTER YOUR SELECTION OF UNIT LOAD THAT YOU USE FOR BATCH SIZE"
220  PRINT:PRINT TAB(12)" 1) PIECES 
230  PRINT:PRINT TAB(12)" 2) TOTEBOXES 
240  PRINT:PRINT TAB(12)" 3) PALLETS 
250  PRINT:PRINT TAB(12)" 4) OTHERS 
260  PRINT:PRINT TAB(10):INPUT"ENTER YOUR SELECTION";UN%
270  IF UN% = 1 THEN AUS="PIECES":GOTO 350
280  IF UN% = 2 THEN AUS="TOTEBOXES":GOTO 350
290  IF UN% = 3 THEN AUS="PALLETS":GOTO 350
300  IF UN% = 4 THEN GOTO 320
310  PRINT CHR$(7):PRINT:COLOR 4,0:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10):INPUT"RE-ENTER THE DATA ":,UN%:COLOR 3,0:GOTO 270
320  PRINT:PRINT TAB(10):INPUT"ENTER YOUR UNIT LOAD";AUS
330  '*****************************************************************************
340  ' INFORMATION
350  '*****************************************************************************
360  CLS:PRINT TAB(10)"INFORMATION :
370  PRINT TAB(10)"FOR EACH PART IN PRODUCTION THE USER HAS TO
ENTER THE FOLLOWING:

380 PRINT: PRINT TAB(12) "1) PART NUMBER & QUANTITY OF EACH PRODUCT": PRINT: PRINT TAB(12) "2) BATCH SIZE": PRINT: PRINT TAB(12) "3) DEPARTMENT SEQUENCE"

390 PRINT: PRINT TAB(10) "NOTE:"

400 PRINT: PRINT TAB(12) "1) THE USER USES THE DEPT. NUMBER AS OPERATION SEQUENCE NUMBER."

410 PRINT: PRINT TAB(12) "2) DEPT. NUMBER MUST BE BETWEEN 1 AND"; ND

420 PRINT: PRINT TAB(12) "3) THE USER MUST ENTER ' 0 ' TO SIGNAL ENDING OF OPERATIONAL SEQUENCE"

430 PRINT: PRINT TAB(12) "4) NUMBER OF OPERATIONS CANNOT EXCEED 35 PER PRODUCT": PRINT: PRINT TAB(12) "(INCLUDING REPEAT TRIPS TO PRIOR DEPARTMENT)"

440 PRINT: PRINT TAB(12) "5) THE USER CAN USE A PRODUCT CODE AS THE PART # (MAX. 10 DIGITS)"

450 PRINT: PRINT TAB(20): INPUT WPRESS ' ENTER ' TO CONTINUE, Y$

460 CLS

470 J = 1

480 NP = 0

490 GOSUB 540

500 J = J + 1

510 IF J > 90 THEN PRINT CHR$(7): COLOR 4, 0: PRINT TAB(10) "WARNING! THE COMPUTER WILL ACCEPT ONLY "; 101-J; " MORE INPUTS!": COLOR 3, 0: PRINT

520 IF J = 101 THEN 1100

530 GOTO 490

540 N(J) = 0

541 REM ****** ENTERS PART NUMBER (PRODUCT CODE). *******

550 '******************************************************************************************

560 ' FOR EACH PRODUCT INPUT THIS DATA

570 ' 1) PART NO.  2) QUANTITY OF PRODUCT

580 ' 3) BATCH SIZE 4) OPERATION SEQUENCE

590 '******************************************************************************************

600 CLS: LOCATE 5, 1: PRINT TAB(10) "ENTER PART NUMBER (USE PRODUCT CODE, MAX. 10 DIGITS)": PRINT: PRINT TAB(10): INPUT"( ENTER ' / ' SIGNALS END OF INPUT)"; JUS(J)

610 IF JUS(J) = "/" THEN 1100

620 FOR K = 1 TO J-1

630 IF JUS(J) = JUS(K) THEN PRINT CHR$(7): COLOR 4, 0: PRINT TAB(10) " THIS PART NUMBER HAS BEEN USED": COLOR 3, 0: GOTO 650

640 GOTO 690

650 PRINT: PRINT TAB(10): INPUT "DO YOU WANT TO CHANGE THE DATA OF THIS PRODUCT (Y/N)"; AS

660 IF AS = "Y" OR AS = "y" THEN PRINT: PRINT TAB(10): INPUT"ENTER PART NUMBER"; JUS(J): GOTO 700

670 IF AS = "N" OR AS = "n" THEN GOTO 660


690 NEXT K

700 CLS: LOCATE 5, 1: PRINT TAB(10) "ENTER NUMBER OF
";AU$:PRINT:PRINT TAB(10):INPUT"(NEGATIVE ` QUANTITY ` SIGNALS
END OF INPUT)" ; Q(J)
701 REM .................................
710 IF Q(J) < 0 THEN 1100
720 CLS:LOCATE 5,1:PRINT TAB(10)"ENTER BATCH SIZE ( ";AU$:"
or UNITS / LOT )" ; INPUT B (J)
730 NP=NP+1
740 IF B(J) <= 0 THEN PRINT CHR$(7):PRINT:COLOR 4,0:PRINT
TAB(10)"*** ERROR ***" : PRINT:PRINT TAB(10):INPUT"ENTER BATCH
SIZE GREATER THAN ZERO : ",B(J):COLOR 3,0:GOTO 740
750 CLS:LOCATE 1,1:PRINT TAB(10)"ENTER ' 0 ' TO END OF
DEPARTMENT SEQUENCE."
760 FOR I = 1 TO 35
770 PRINT:PRINT TAB(10)"ENTER DEPARTMENT NO. FOR OPERATION
" ; I;
780 INPUT " ; P(J,I)
790 IF P(J,I) > ND OR ND < 0 THEN PRINT CHR$(7):PRINT:COLOR
4,0:PRINT TAB(10)"*** ERROR ***" : PRINT:PRINT TAB(10)"RE-ENTER
THE DEPT. NUMBER (BETWEEN ZERO AND ";ND;")" ; PRINT
TAB(10):INPUT ";,P(J,I):COLOR 3,0:GOTO 790
800 IF I>1 THEN I1=I-1 ELSE 820
810 IF P(J,I) = P(J,II) THEN PRINT CHR$(7):PRINT:COLOR
4,0:PRINT TAB(10)"*** ERROR ***" : PRINT:PRINT
TAB(10):INPUT"RE-ENTER THE DEPT. NUMBER (TRIPS CANNOT BE
INSIDE SAME DEPARTMENT) :");P(J,I):COLOR 3,0:GOTO 800
820 IF P(J,I) = 0 THEN 870
830 N(J) = N(J) + 1
840 NEXT I
850 PRINT CHR$(7):PRINT:COLOR 4,0:PRINT TAB(10)"*** ERROR ***
" : PRINT:PRINT TAB(10)"RE-ENTER THE DATA (THE NUMBER OF
OPERATIONS CANNOT EXCEED 35! ");COLOR 3,0
860 PRINT:PRINT TAB(10)"PRESS ` ENTER ` TO CONTINUE" ; INPUT
AS
870 IF TZ=1 THEN TZ=0:GOTO 1070
871 REM * SCREEN OUTPUT SUMMARY FOR EACH PRODUCT. *
872 ' **********************************************
873 ' SUMMARY INPUT DATA FOR EACH PRODUCT
874 ' **********************************************
875 CLS:LOCATE 5,1:PRINT TAB(15)"SUMMARY OF INPUT DATA"
876 JUS$(J)=LEFT$(JUS$(J),10)
877 PRINT:PRINT TAB(10)"PART NUMBER ";JUS$(J)
878 PRINT:PRINT TAB(10)"QUANTITY";Q(J);AU$ 
879 PRINT:PRINT TAB(10)"BATCH SIZE";B(J); AU$ " or UNITS / 
LOT"
880 PRINT:PRINT TAB(10)"DEPARTMENT SEQUENCE"
881 IC=0:PRINT:PRINT TAB(15)
882 FOR IJ=1 TO N(J)
883 PRINT P(J,IJ):IC=IC+1:IF IC>10 THEN PRINT:PRINT
TAB(15) #:IC=0
890 NEXT IJ:PRINT:PRINT
900 PRINT:PRINT:PRINT TAB(15):INPUT "DO YOU WANT TO MAKE
CHANGES (Y/N) " ; B$
1020 IF $B$ = "N" OR $B$ = "n" THEN GOTO 1070
1030 IF $B$ = "Y" OR $B$ = "y" THEN GOSUB 1050: GOTO 870
1050 GOSUB 1840
1060 RETURN
1070 CLS
1080 RETURN
1090 '******************************************************************************
1100 '   CALCULATE NUMBER OF TRIPS BETWEEN DEPARTMENTS.
1110 '******************************************************************************
1120 CLS: LOCATE 5, 1
1130 PRINT TAB(25) "PLEASE WAIT................"
1140 PRINT: PRINT TAB(25) "COMPUTER IS CALCULATING"
1150 FOR J1 = 1 TO ND: FOR J2 = 1 TO ND: DD(J1, J2) = 0: NEXT J2: NEXT J1
1160 FOR J = 1 TO NP
1170 T = Q(J) / B(J)
1180 TT = INT(T)
1190 IF TT < T THEN TT = TT + 1
1200 TP(J) = TT
1210 NEXT J
1220 FOR J = 1 TO NP
1230 M = N(J) - 1
1240 FOR I = 1 TO M
1250 I1 = I + 1
1260 J1 = P(J, I): J2 = P(J, I1)
1270 DD(J1, J2) = DD(J1, J2) + TP(J)
1280 NEXT I
1290 NEXT J
1300 CLS: GOSUB 1310: GOTO 1580
1310 IC = 0
1320 FOR I = 1 TO ND
1321 REM * OUTPUT TO SCREEN # TRIPS BETWEEN DEPT. FOR EACH DEPT. *
1330 LOCATE 3, 1: PRINT TAB(20) "FROM/TO CHART": PRINT TAB(20) "UNIT: NO. OF TRIPS"
1340 TAB(15) "---------------------------------------": PRINT
1350 PRINT TAB(10): "FROM DEPT. "; I
1360 FOR J = 1 TO ND
1370 PRINT TAB(10): " TO DEPT. "; J; " NO. OF TRIPS= "; DD(I, J)
1380 IC = IC + 1
1390 IF IC < 15 THEN 1480
1400 PRINT: PRINT TAB(10): "PRESS 'ENTER' TO CONTINUE"
1410 IF INKEY$ = "" THEN 1410
1420 IC = 0
1430 IF J = ND THEN CLS: GOTO 1480
1440 CLS: LOCATE 3, 1
1450 PRINT TAB(20) "FROM/TO CHART": PRINT: PRINT TAB(20) "UNIT:
NO. OF TRIPS"
1460 PRINT TAB(15)"---------------------------------------":

PRINT
1470 PRINT TAB(10);"FROM DEPT. ";I
1480 NEXT J
1490 IF IC=0 THEN 1520
1500 PRINT:PRINT TAB(10);"PRESS ' ENTER ' TO CONTINUE"
1510 IF INKEY$="" THEN 1510 ELSE IC=0:CLS
1520 NEXT I
1530 REM
1540 RETURN
1550 '***********************************X**
1560 'FROM/TO CHART OPTION MENU1
1570 '***********************************
1580 CLS:LOCATE 5,1
1590 PRINT TAB(10)"ENTER YOUR SELECTION :"
1600 PRINT:PRINT TAB(12)"1) SAVE OUTPUT ON DISK 
1610 PRINT:PRINT TAB(12)"2) DISPLAY & MODIFY EXISTING DATA"
1620 PRINT:PRINT TAB(12)"3) INPUT NEW DATA (RE-RUN FROM/TO)"
1630 PRINT:PRINT TAB(12)"4) PRINTED OUTPUT OF FROM/TO"
1640 PRINT:PRINT TAB(12)"5) DISPLAY SUMMARY AND FROM/TO CHART"
1650 PRINT:PRINT TAB(12)"6) EXIT PROGRAM TO MAIN MENU"
1660 IF AA<1 OR AA>6 THEN PRINT CHRS(7):PRINT:COLOR 4,0:PRINT
TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10):INPUT"RE-ENTER BETWEEN 1 AND 6 ":,AA:COLOR 3,0:GOTO 1660
1670 ON AA GOTO 2630,2330,110,2440,3750,1680
1680 RUN "HELLO"
1681 REM ******* INTRODUCTION CREDITS. ***************
1690 CLS:PRINT
1700 PRINT TAB(25)"PLANT LAYOUT & MATERIALS FLOW"
1710 PRINT TAB(33)"FROM/TO CHART"
1720 PRINT TAB(35)"I.I.E."
1730 PRINT:PRINT TAB(27)"RE-WRITTEN AND MODIFIED"
1740 PRINT TAB(36)" BY ":
1750 PRINT:PRINT TAB(18)"E. RALPH SIMS Jr. P.E. ASSOCIATE PROFESSOR"
1760 PRINT:PRINT TAB(18)"WITTAWAT SMUTHRANOND GRADUATE STUDENT"
1770 PRINT TAB(18)"ILANGO SANKARALINGAM GRADUATE STUDENT"
1775 PRINT TAB(18)"EKACHAI HEAMAVATTANACHAI GRADUATE STUDENT"
1776 PRINT TAB(18)"VIC KICHODHAN GRADUATE STUDENT"
1780 PRINT:PRINT TAB(18)"DEPT. OF INDUSTRIAL & SYSTEMS ENGINEERING"
1790 PRINT:PRINT TAB(32)"OHIO UNIVERSITY"
1800 PRINT:PRINT TAB(34)"COPYRIGHTED"
1810 LOCATE 24,1 :PRINT TAB(25):INPUT "PRESS ' ENTER ' TO CONTINUE",AS
1820 RETURN
1830 STOP
1840 REM
1850 '******************************************************************************
1860 FROM TO CHANGING DATA MENU 1
1870 '******************************************************************************
1880 CLS: LOCATE 5, 1: PRINT TAB(10) "ENTER YOUR SELECTION"
1890 PRINT: PRINT TAB(12) " 1) PART NUMBER ("; JUS(J); ")"
1900 PRINT: PRINT TAB(12) " 2) NUMBER OF "; AU$; ("; Q(J); ")"
1910 PRINT: PRINT TAB(12) " 3) BATCH SIZE ("; B(J); ")"
1920 PRINT: PRINT TAB(12) " 4) DEPARTMENT SEQUENCE "
1930 PRINT: PRINT TAB(12) " 5) RE-ENTER DATA FOR THIS PRODUCT"
1940 PRINT: PRINT TAB(12) " 6) EXIT TO MAIN MENU"
1950 PRINT: PRINT TAB(10): INPUT "ENTER YOUR SELECTION"; X
1960 IF X = 1 THEN 2130
1970 IF X = 2 THEN 2160
1980 IF X = 3 THEN 2190
1990 IF X = 4 THEN 2220
2000 IF X = 5 THEN 2030
2010 IF X = 6 THEN RUN "HELLO"
2020 PRINT CHR$(7): PRINT: COLOR 4, 0: PRINT TAB(10) "*** ERROR ***": PRINT: PRINT TAB(10) "RE-ENTER YOUR SELECTION BETWEEN 1 AND 6: "; X: COLOR 3, 0: GOTO 1960
2030 REM ********* RE-ENTER DATA FOR PRODUCT. ************
2040 CLS
2050 CG = 1
2120 '******************************************************************************
2130 ' ENTER NEW INPUT DATA
2140 '******************************************************************************
2150 PRINT: PRINT TAB(10): INPUT "ENTER PART NUMBER (PRODUCTION CODE, MAX. 10 DIGITS)"; JUS(J)
2151 IF CG <> 1 THEN GOTO 2320
2155 REM * NEW NUMBER OF PARTS *
2160 PRINT: PRINT TAB(10) "ENTER NEW VALUE FOR NUMBER OF "; AU$: INPUT Q(J)
2170 IF Q(J) <= 0 THEN PRINT CHR$(7): PRINT: COLOR 4, 0: PRINT TAB(10) "*** ERROR ***": PRINT: PRINT TAB(10) :INPUT "RE-ENTER THE DATA GREATER THAN ZERO "; Q(J): COLOR 3, 0: GOTO 2170
2180 CLS: IF CG <> 1 THEN 2320
2181 REM ********* NEW BATCH SIZE ************
2190 PRINT: PRINT TAB(10): INPUT "ENTER NEW VALUE FOR BATCH SIZE "; B(J)
2200 IF B(J) <= 0 THEN PRINT CHR$(7): PRINT: COLOR 4, 0: PRINT TAB(10) "*** ERROR ***": PRINT: PRINT TAB(10): INPUT "RE-ENTER THE DATA GREATER THAN ZERO "; B(J): COLOR 3, 0: GOTO 2200
2210 CLS: IF CG <> 1 THEN 2320
2211 REM ********* NEW DEPT. SEQUENCE ************
2220 N(J) = 0
2230 FOR I = 1 TO 35
2240 PRINT: PRINT TAB(10) "ENTER NEW DEPT. # OF OPERATION "; I;
2250 INPUT " ": "; P(J, I)
2260 IF P(J, I) > ND OR P(J, I) < 0 THEN PRINT CHR$(7): PRINT: COLOR 4, 0: PRINT TAB(10) "*** ERROR
***":PRINT:PRINT TAB(10)"RE-ENTER THE DEPT.#. (BETWEEN 0 AND ";ND")":INPUT;P(J,I):COLOR 3,0:GOTO 2260
2270 IF I>1 THEN I1=I-1 ELSE 2290
2290 IF P(J,I) = 0 THEN RETURN
2300 N(J) = N(J) + 1
2310 NEXT I
2320 RETURN
2321 REM ******* DISPLAY & MODIFY EXISTING DATA ********
2330 J=1
2340 GOSUB 870
2350 J=J+1
2360 IF J<=NP THEN 2340
2370 ' ****************************************************
2380 ' ADD NUMBER OF PRODUCT
2390 ' ****************************************************
2400 CLS:LOCATE 5,1:PRINT TAB(10):INPUT "DO YOU WANT TO ADD MORE PRODUCTS (Y/N)";AS
2410 IF AS="Y"OR AS="y" THEN CLS:GOTO 490
2420 IF AS="N" OR AS="n" THEN 1120
2430 PRINT CHR$(7):PRINT:COLOR 4,0:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10):INPUT"RE-ENTER THE DATA ";,AS:COLOR 3,0:GOTO 2410
2440 GOSUB 2890:GOTO 1580:REM PRINTER OUTPUT OF FROMTO ****
2450 ' ****************************************************
2460 ' OUTPUT SUMMARY OF EACH DEPARTMENT
2470 ' ****************************************************
2480 CLS:LOCATE 5,1:PRINT TAB(15)"SUMMARY OF INPUT DATA 
2490 PRINT ": # OF PARTS TO BE PRODUCED ";NP
2500 PRINT ": # OF PRODUCTION DEPARTMENTS: ";ND
2510 FOR J = 1 TO NP
2520 PRINT:PRINT TAB(10)"PART NUMBER ";JUS$(J)
2530 PRINT:PRINT TAB(10)"QUANTITY";Q(J);AU$
2540 PRINT:PRINT TAB(10)"BATCH SIZE";B(J); AU$ "/ LOAD"
2550 PRINT:PRINT TAB(10)"OPERATIONAL SEQUENCE"
2560 IC=0:PRINT:PRINT TAB(15);
2570 FOR IJ=1 TO N(J)
2580 PRINT P(J,IJ);:IC=IC+1:IF IC>10 THEN PRINT:PRINT TAB(15);:IC=0
2590 NEXT IJ:PRINT:PRINT
2600 PRINT : PRINT : PRINT : PRINT
2610 NEXT J
2620 RETURN
2630 GOSUB 2640: GOTO 1580:REM * SAVE ON DISK AND RETURN TO MENU *
2631 REM ******* SAVE OUTPUT ON DISK ***************
2640 REM DISK STORE
2650 GOSUB 3530
2660 OPEN "O",1,F$
2670 PRINT #1,"FROM"
2680 PRINT #1,ND
2690 PRINT #1,NP:PRINT #1,AUS
2700 FOR I = 1 TO ND
2710 FOR J = 1 TO ND
2720 PRINT #1,DD(I,J)
2730 NEXT J
2740 NEXT I
2750 FOR I = 1 TO NP
2760 PRINT #1,Q(I)
2770 PRINT #1,B(I)
2780 PRINT #1,TP(I)
2790 PRINT #1,N(I):PRINT #1,JU$(I)
2800 FOR J=1 TO N(I)
2810 PRINT #1,P(I,J)
2820 NEXT J
2830 NEXT I
2840 CLOSE #1
2850 RETURN
2860 '*************************************************************************************
2870 'PRINTER OUTPUT OF # TRIPS BETWEEN DEPT. FOR EACH DEPT. *
2880 '*************************************************************************************
2881 REM * PRINTER OUTPUT OF # TRIPS BETWEEN DEPT. FOR EACH DEPT. *
2890 CLS:LPRINT:LPRINT:LPRINT:LOCATE 10,1
2900 LPRINT: LPRINT: LPRINT:TAB(25)"PLANT LAYOUT & MATERIALS FLOW"
2910 LPRINT: LPRINT: TAB(33)"FROM/TO CHART"
2920 LPRINT: LPRINT: TAB(35)"I.I.E."
2930 LPRINT: LPRINT: TAB(27)"RE-WRITTEN AND MODIFIED"
2940 LPRINT: LPRINT: TAB(36)"BY"
2950 LPRINT: LPRINT: TAB(18)"E. RALPH SIMS Jr. P.E. ASSOCIATE PROFESSOR"
2960 LPRINT: LPRINT: TAB(18)"WITTAWAT SMUTHRANOND GRADUATE STUDENT"
2970 LPRINT: TAB(18)"ILLANGO SANKARALINGAM GRADUATE STUDENT"
2975 LPRINT: TAB(18)"EKACHAI HEAMAVATTANACHAI GRADUATE STUDENT"
2976 LPRINT: TAB(18)"VIC KICHODHAN GRADUATE STUDENT"
2980 LPRINT: LPRINT: TAB(18)"DEPT. OF INDUSTRIAL & SYSTEMS ENGINEERING"
2990 LPRINT: LPRINT: TAB(30)"OHIO UNIVERSITY"
3000 LPRINT: LPRINT: TAB(31)"COPYRIGHTED"
3010 LPRINT CHR$(12)
3020 CLS:LOCATE 5,1:LPRINT TAB(15)"SUMMARY OF INPUT DATA"
3030 LPRINT: LPRINT
3040 LPRINT: LPRINT: TAB(10)" NO. OF PARTS TO BE PRODUCED : ";NP
3050 LPRINT: LPRINT: TAB(10)" NO. OF PRODUCTION DEPARTMENTS: ";ND
3060 LPRINT: LPRINT
3070  K=1
3080  FOR J= 1 TO NP
3090  K=K+1: LPRINT: LPRINT TAB(10) "PART NUMBER "; JUS(J)
3100  LPRINT: LPRINT TAB(10) "QUANTITY"; Q(J); AUS
3110  LPRINT: LPRINT TAB(10) "BATCH SIZE"; B(J); AUS " or UNIT / LOT"
3120  LPRINT: LPRINT TAB(10) "OPERATIONAL SEQUENCE"
3130  IC=0: LPRINT: LPRINT TAB(15);:
3140  FOR IJ=1 TO N(J)
3150  LPRINT P(J, IJ);: IC=IC+1: IF IC>10 THEN LPRINT: LPRINT
3160  TAB(15);: IC=0
3170  NEXT IJ: LPRINT: LPRINT
3180  LPRINT: LPRINT: LPRINT
3190  IF K > 3 THEN K=1: LPRINT Chr$(12)
3200  NEXT J
3210  LPRINT"
3220  LPRINT: LPRINT TAB(20) "FROM/TO CHART": LPRINT
3230  TAB(18) "UNITS: NO. OF TRIPS"
3240  LPRINT TAB(18) "-------------------": LPRINT"
3250  FOR I = 1 TO ND
3260  LPRINT: LPRINT: LPRINT TAB(10) "FROM DEPT. "; I: LPRINT
3270  FOR J = 1 TO ND
3280  LPRINT TAB(15) "TO DEPT."; J; " NO. OF TRIPS= "; DD(I, J)
3290  NEXT J
3300  K=K+1
3310  IF K > 2 THEN K=1: LPRINT Chr$(12)
3320  NEXT I
3330  RETURN
3340  REM GETTING FILENAME FROM DISK FOR PREVIOUS FROMTO RUN
3350  ON ERROR GOTO 3611
3360  OPEN "I", 1, FS
3370  INPUT #1, TT$ 3380  IF TT$ <> "FROM" THEN CLOSE #1: PRINT: PRINT Chr$(7): COLOR 4, 0: PRINT TAB(10) "DISK FILE SELECTED WAS NOT GENERATED BY THE 'FROMTO' PROGRAM" : PRINT: COLOR 3, 0: PRINT TAB(10): INPUT "PRESS 'ENTER' TO CONTINUE", XX$: GOTO 140
3390  REM **** LOADING FILE FROM DISK TO COMPUTER ****
3400  INPUT #1, ND
3410  INPUT #1, NP: INPUT #1, AUS
3420  FOR I = 1 TO ND
3430  FOR J = 1 TO ND
3440  INPUT #1, DD(I, J)
3450  NEXT J
3460  NEXT I
3470  FOR I = 1 TO NP
3480  INPUT #1, Q(I)
3490  INPUT #1, B(I)
3500  INPUT #1, TP(I)
3510  INPUT #1, N(I): INPUT #1, JUS(I)
3520  FOR J=1 TO N(I)
3530  FOR J=1 TO NP
3540  FOR J=1 TO NP
3500 NEXT I
3510 CLOSE #1
3520 OLD=1:GOTO 1580
3521 REM ***** GETTING PREVIOUS FILENAME & DISK DESIG. FROM USER *****
3530 CLS:FOR RT = 1 TO 7:PRINT:NEXT RT
3540 INPUT " INPUT THE FILE NAME: " ;G$
3550 PRINT
3560 INPUT " INPUT THE DISK DRIVE I.D. (A, B, OR C): ";FS
3570 FS=FS + ":" + G$
3580 RETURN
3590 ' ERROR MESSAGE
3600 ' ERROR MESSAGE
3601 ' ERROR MESSAGE
3610 IF ERL=2890 THEN 3660
3611 IF ERR=53 THEN 3711
3630 IF ERL=2660 THEN 3700
3640 IF ERL=3320 THEN 3699
3641 IF ERL=2900 THEN 3660
3642 ON ERROR GOTO 0
3660 CLS:FOR RT = 1 TO 10:PRINT:NEXT RT
3670 PRINT CHR$(7):COLOR 4,0:PRINT TAB(10);"THE PROGRAM IS HAVING DIFFICULTY PRINTING ."
3680 PRINT:PRINT TAB(10);"CHECK TO SEE IF THE PRINTER IS READY!":COLOR 3,0
3690 GOTO 3720
3699 JMP=1
3700 CLS:FOR RT = 1 TO 10:PRINT:NEXT RT
3710 PRINT CHR$(7):COLOR 4,0:PRINT TAB(10);"THE PROGRAM IS HAVING DIFFICULTY WITH YOUR DISK FILE!":COLOR 3,0:GOTO 3720
3711 JMP=1:PRINT CHR$(7):COLOR 4,0:PRINT "FILE NOT FOUND!":RESET:COLOR 3,0
3720 FOR RT= 1 TO 5:PRINT:NEXT RT
3730 PRINT TAB(10);"PRESS ' ENTER ' TO CONTINUE";:INPUT AS
3731 IF JMP=1 THEN JMP=0:RESUME 150
3740 RESUME 1580
3741 REM ***** SCREEN DISPLAY OF SUMMARY OF PRODUCT *****
3750 CLS:PRINT:PRINT "SUMMARY OF PRODUCT.":PRINT:PRINT
3760 PRINT "PART QUANTITY BATCH DEPARTMENT"
3761 PRINT " SIZE SIZE SEQUENCE "
3762 PRINT ""
3780 FOR D=1 TO NP
3790 PRINT JUS$(D) TAB(6) Q(D) TAB(16) B(D) TAB(22);
3800 FOR IJ=1 TO N(D)
3801 PRINT USING "###";P(D,IJ);
3805 NEXT IJ
3806 PRINT
3810 NEXT D
3820 PRINT:PRINT:PRINT TAB(5):INPUT "PRESS <ENTER> TO CONTINUE.",AS
3821 REM** SCREEN DISPLAY OF FROMTO CHART FOR PRODUCT ***
CLS:PRINT:PRINT "FROM TO CHART FOR DEPARTMENTS.";PRINT:PRINT
CLS:PRINT:PRINT "FROM TO " ; FOR DA=1 TO ND:PRINT USING "###";DA;:NEXT DA
PRINT:PRINT:PRINT:PRINT
3880 FOR DB=1 TO ND
3890 FOR DC=1 TO ND
3900 PRINT USING "###";DD(DB,DC);
3910 NEXT DC
3920 PRINT:PRINT:PRINT:PRINT TAB(5):INPUT "PRESS <ENTER> TO CONTINUE.",A$
3941 IF D$="YH OR D$="yW THEN 4000
3950 IF D$="NU OR D$="n" THEN GOTO 1580
3970 GOTO 3940
4000 LPRINT:LPRINT "SUMMARY OF PRODUCT.";LPRINT:LPRINT
4010 LPRINT "PART QUANTITY BATCH DEPARTMENT"
4020 LPRINT "SIZE SEQUENCE "
4030 LPRINT 
4040 FOR D=1 TO NP
4050 LPRINT JUS(D) TAB(6) Q(D) TAB(16) B(D) TAB(22);
4060 FOR IJ=1 TO N(D)
4070 LPRINT USING "###";P(D,IJ);
4080 NEXT IJ
4090 LPRINT
5000 NEXT D
5010 LPRINT:LPRINT:LPRINT
5020 LPRINT "FROM TO CHART FOR DEPARTMENTS.";LPRINT:LPRINT:LPRINT
5030 LPRINT "FROM TO " ; FOR DA=1 TO ND:LPRINT USING "###";DA;:NEXT DA
5040 LPRINT:LPRINT 
5050 FOR DB=1 TO ND
5060 LPRINT DB TAB(10);
5070 FOR DC=1 TO ND
5080 LPRINT USING "###";DD(DB,DC);
5090 NEXT DC
6000 LPRINT
6010 NEXT DB
6020 GOTO 1580
VARIABLE LISTING FOR FRMTO

AUS Variable for unit load for batch size.

B(I) Variable for array for batch size.

BD(I,J) Variable for array for the number of trips from department I to department J.

I Integer index variable for department X.

J Integer index variable for department X+1.

JUS(I) Variable for array for the part number.

N(I) Variable for array for number of operations in a part. Counter for number of sequences per part.

ND Variable for number of production departments.

NP Variable for counter for the number of parts in a product.

P(I,J) Variable for array for the sequence of the department number for each product.

Q(I) Variable for array for the number of pieces, quantity, in a part.

TP(I) Variable for array for the number of trips to transport all of the parts, given a batch size.
FROMTO MODULE

START

INIT. VARIABLE

INTRO. CREDIT

INPUT FROM DISK FILE?

Y

RETRIEVE DATA FROM DISK FILE

N

INPUT # OF DEPT

INPUT UNIT LOAD

SCREEN INFO.

INPUT PRODUCT INFORMATION

FROMTO CHANGE MENU
1. PART NUMBER.
2. QUANTITY SIZE.
3. BATCH SIZE.
4. DEP. SEQUENCE.
5. RE-ENTER DATA.
6. EXIT.

MAKE CHANGE?

A

FROMTO CHANGE DATA MODULE

CALCULATE NUMBER OF TRIPS EXCHANGED

SCREEN DISPLAY OF THE EXCHANGED # OF TRIPS

SS

AA

SCREEN SUMMARY

CD

N

FM1

FM1
FROMTO MENU 1
1. SAVE.
2. DISPLAY/MOD.
3. RE-RUN.
4. PRINT.
5. DISPLAY.
6. EXIT.

1. SAVE TO DISK FILE
2. SS
3. CD
4. PRINTER OUTPUT
5. SCREEN DISPLAY OF PRODUCT SUMMARY
6. HELLO MODULE

PRINTED COPY?

Y
N

PRINTER OUTPUT
10 ' **************************************************************
20 ' CRAFT PROGRAM
30 ' **************************************************************
40 ' INITIALIZE AND DIMENSION VARIABLES
50 ' **************************************************************
60 SCREEN 0,1:COLOR 3,0:WIDTH 80
70 DIM NT(35,35),CST(35,35),Q(35)
80 0 D M
90 K1%=24:A=1:Z=0:TN%=10:CENT%=100
100 ZQ%=0:B=2:C=3:T1%=30:P5=.5:XZZ=0
110 GOSUB 190
120 130 ON ERROR GOTO 170
140 OPEN "1",1,"CFLAG":INPUT #1,FF%:CLOSE #1
150 OPEN "O",1,"CFLAG":PRINT #1,0:CLOSE #1
160 ON (FF%+1) GOTO 310,510,3690,3690
170 'ON ERROR GOTO 0:RESUME
180 GOTO 310
190 CLS:PRINT:PRINT TAB(25)"PLANT LAYOUT & MATERIALS FLOW"
200 PRINT TAB(33)"MICRO-CRAFT"
210 PRINT TAB(35)" I.I.E "
220 PRINT:PRINT TAB(27)"RE-WRITTEN AND MODIFIED"
230 PRINT TAB(36)" BY "
240 PRINT:PRINT TAB(18)"E. RALPH SIMS Jr. P.E. ASSOCIATE
250 PRINT:PRINT TAB(18)"WITTAWAT SMUTHRANOND GRADUATE
260 PRINT TAB(18)"ILANGO SANKARALINGAM GRADUATE
270 PRINT TAB(18)"EKACHAI HEAMAVATTANACHAI GRADUATE
280 PRINT TAB(18)"VIC KICHODHAN GRADUATE
290 PRINT:PRINT TAB(18)"DEPT. OF INDUSTIAL & SYSTEMS
300 PRINT:PRINT TAB(18)"OHIO UNIVERSITY"
310 PRINT:PRINT TAB(34)"COPYRIGHTED"
320 PRINT:PRINT:PRINT TAB(25):INPUT"PRESS ' ENTER ' TO
330 ' CONTINUE ",A$
340 CLS
350 ' ****************************************************
360 ' INPUT DATA FORM PREVIOUS RUN
370 ' ****************************************************
380 CLS:LOCATE 10,1:PRINT:PRINT TAB(10):INPUT "DO YOU WANT TO
390 ' DISPLAY INSTRUCTIONS (Y/N) ":YN$
400 IF YN$="N" OR YN$="n" THEN YN$="N":GOTO 440
410 IF YN$="Y" OR YN$="y" THEN YN$="Y" :GOSUB 4720:GOTO 440
420 PRINT CHR$(7)
430 PRINT:COLOR 4,0:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT
440 TAB(10):INPUT" RE-ENTER THE ANSWER TO THE QUESTION :

";YN$:COLOR 3,0
410 IF YNS="N" OR YNS="n" THEN YNS="N":GOTO 440
420 IF YNS="y" OR YNS="Y" THEN YNS="Y" :GOSUB 4720:GOTO 440
430 GOTO 390
440 CLS:LOCATE 8,1:PRINT:PRINT TAB(10)"PROGRAM MAY ACCEPT DATA FROM A PREVIOUS RUN OF THE CRAFT ":PRINT:PRINT TAB(10)"PROGRAM FROM A DISK FILE":PRINT:PRINT:PRINT TAB(15):INPUT "DO YOU WANT TO SELECT THIS OPTION (Y/N) ";YN$
450 IF YNS="N" OR YNS="n" THEN YNS="N":GOTO 520
460 IF YNS="y" OR YNS="Y" THEN YNS="Y" :PREV%=1:GOTO 4420
470 PRINT CHR$(7)
480 PRINT:COLOR 4,0:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10):INPUT" RE-ANSWER THE QUESTION : ",YN$:COLOR 3,0
490 IF YNS="N" OR YNS="n" THEN YNS="N":GOTO 520
500 IF YNS="Y" OR YNS="Y" THEN YNS="Y" :PREV%=1:GOTO 4420
510 GOTO 440
520 CLS:LOCATE 10,1
530 PRINT:PRINT TAB(10)"PROGRAM MAY ACCEPT DATA FROM THE FROM/TO PROGRAM USING A DISK FILE":PRINT:PRINT TAB(15): INPUT "DO YOU WANT TO USE THIS OPTION (Y/N) ";YN$
540 IF YNS="N" OR YNS="n" THEN YNS="N":GOTO 580
550 IF YNS="Y" OR YNS="Y" THEN YNS="Y" :GOSUB 3860:DSK=1:CLS:GOSUB 690:SL%=0:GOTO 1380
570 GOTO 540
580 GOSUB 590:GOTO 1380
590 CLS
591 REM ***************** MANUAL ENTERING OF PLANT DATA **********
600 '***************************************************************************
610 ' INPUT DATA OF PLANT
620 '***************************************************************************
630 REM **************** NUMBER OF DEPARTMENTS *******************
650 IF I%>2 AND I%<36 THEN 690
660 PRINT CHR$(7)
670 PRINT:COLOR 4,0:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10)"THE NUMBER OF DEPTS. MUST BE BETWEEN 3 AND 35":COLOR 3,0
690 GOTO 640
700 REM **************** AREA OF PLANT ********************
710 PRINT:PRINT TAB(10):INPUT"ENTER MINIMUM REQUIRED AREA FOR PLANT ":AREA
720 IF AREA > 0 THEN 720
740 REM **************** WIDTH OF PLANT ******************
720 PRINT:PRINT TAB(10):INPUT"ENTER WIDTH OF PLANT ";W
730 IF W < 0 THEN 750
740 PRINT CHR$(7):PRINT:COLOR 4,0:PRINT "*** ERROR ***":PRINT:PRINT "WIDTH OF PLANT MUST BE GREATER THAN ZERO! RE-ENTER THE WIDTH ";,W:COLOR 3,0:GOTO 730
750 L=AREA/W:PRINT:PRINT TAB(10)"LENGTH OF PLANT ";L
760 PRINT:PRINT:PRINT TAB(15)"PRESS ' ENTER ' TO CONTINUE"
770 AS=INPUT$(1)
771 REM ******************** OPTION 1 FOR BAYS ********************
790 PRINT:PRINT TAB(5)" WIDTH OF BAY = WIDTH OF PLANT / NUMBER OF LONGITUDINAL BAYS"
800 PRINT TAB(5)"SECOND OPTION: YOU CAN INPUT WIDTH OF BAY. THE NUMBER OF LONGITUDINAL BAYS WILL BE CALCULATED FROM THE FOLLOWING FORMULA : ":PRINT:PRINT TAB(5)"NUMBER OF LONGITUDINAL BAYS = WIDTH OF PLANT / WIDTH OF BAY"
810 PRINT:PRINT:PRINT TAB(5)"PRESS ' ENTER ' TO CONTINUE"
820 AS=INPUT$(1)
830 CLS:PRINT:PRINT:PRINT:PRINT TAB(5)"ENTER YOUR SELECTION. ";INPUT:PRINT:PRINT TAB(5)" 1) INPUT NUMBER OF LONGITUDINAL BAYS"
840 PRINT:PRINT TAB(5)" 2) INPUT WIDTH OF BAY"
850 PRINT:PRINT TAB(5):INPUT"ENTER YOUR SELECTION ";WS$ 
860 IF WS$="2" THEN 970
870 IF WS$="1" THEN 910
880 IF WS$="1" THEN 910
890 PRINT CHR$(7)
900 PRINT:COLOR 4,0:PRINT TAB(5)"*** ERROR ***":PRINT:PRINT TAB(5):INPUT "RE-ENTER YOUR SELECTION (1 OR 2): ";WS$:COLOR 3,0:GOTO 870
901 REM ******************** ENTER # OF BAYS ********************
910 PRINT:PRINT TAB(5):INPUT"ENTER NUMBER OF LONGITUDINAL BAYS ";NB
920 IF NB > 0 THEN 940
930 PRINT CHR$(7):PRINT:COLOR 4,0:PRINT "*** ERROR ***":PRINT:PRINT:INPUT"RE-ENTER THE DATA (NO.OF BAYS MUST BE GREATER THAN ZERO) ";,NB:COLOR 3,0:GOTO 920
940 IF WS1=1 THEN W=NB*BW:AREA=W*L:GOTO 1290
950 BW=W/NB:NA%=NB+I%-A
960 GOTO 1030
961 REM ******************** ENTER WIDTH OF BAYS ********************
970 PRINT:PRINT TAB(10):INPUT"ENTER WIDTH OF BAY ";BW
980 IF BW < 0 THEN 1000
990 PRINT CHR$(7):PRINT:COLOR 4,0:PRINT "*** ERROR ***":PRINT:PRINT:INPUT"RE-ENTER THE DATA (WIDTH OF BAY MUST BE GREATER THAN ZERO) ";,BW:COLOR 3,0:GOTO 980
1000 WI=W/BW:WI1=INT(W/BW):WI2=INT((W/BW)+1)
1010 IF WI = WI1 THEN NB=WI:GOTO 1030
1020 NB=W/BW
1021 REM ******************** OPTION 2 FOR BAYS ********************
1030 CLS:PRINT:PRINT TAB(5)"SELECT YOUR OPTION. ";PRINT:PRINT...
FIRST OPTION: ENTER THE NUMBER OF LATERAL BAYS. IF YOU SELECT THIS OPTION, LENGTH OF BAY WILL BE CALCULATED FROM THE FOLLOWING FORMULA:

LENGTH OF BAY = LENGTH OF PLANT / NUMBER OF LATERAL BAYS

SECOND OPTION: YOU CAN INPUT LENGTH OF BAY AND THE NUMBER OF LATERAL BAYS WILL BE CALCULATED FROM THE FOLLOWING FORMULA:

NUMBER OF LATERAL BAYS = LENGTH OF PLANT / LENGTH OF BAY

PRINT: PRINT TAB(15) "PRESS \ ENTER \ TO CONTINUE" A$=INPUT$(1)
CLS: PRINT: PRINT: PRINT: PRINT: PRINT TAB(5) "ENTER YOUR SELECTION.") 1) INPUT NUMBER OF LATERAL BAYS"
PRINT: PRINT TAB(5) "2) INPUT LENGTH OF BAY"
PRINT: PRINT TAB(5): INPUT "ENTER YOUR SELECTION "; WSS
IF WSS = "2" THEN 1220
IF WSS = "1" THEN 1160
PRINT CHR$(7)
PRINT: COLOR 4,0: PRINT TAB(10) "*** ERROR ***": PRINT: PRINT TAB(10): INPUT "RE-ENTER YOUR SELECTION (1 OR 2) "; WSS: COLOR 3,0: GOTO 1120
REM "\ ENTER # OF LATERAL BAYS "***************
PRINT: PRINT TAB(5): INPUT "ENTER NUMBER OF LATERAL BAYS "; NCOL
IF NCOL > 0 THEN 1190
PRINT CHR$(7): PRINT: COLOR 4,0: PRINT "*** ERROR ***": PRINT: PRINT: INPUT "RE-ENTER THE DATA (NO. OF LATERAL BAYS MUST BE GREATER THAN ZERO) "; NCOL: COLOR 3,0: GOTO 1170
IF WSS = 1 THEN L = NCOL*BCOL: AREA = W*L: GOTO 1230
BCOL = L/NCOL
GOTO 1290
REM "\ ENTER LENGTH OF BAYS "***************
PRINT: PRINT TAB(10): INPUT "ENTER LENGTH OF BAY "; BCOL
IF BCOL > 0 THEN 1250
PRINT CHR$(7): PRINT: COLOR 4,0: PRINT "*** ERROR ***": PRINT: PRINT: INPUT "RE-ENTER THE DATA (LENGTH OF BAY MUST BE GREATER THAN ZERO) "; BCOL: COLOR 3,0: GOTO 1230
NCOL = L/BCOL
REM "\ DISPLAY AND CHANGE PLANT DATA "********
CLS: PRINT: PRINT TAB(5); "NUMBER OF DEPARTMENTS = "; I%: PRINT: PRINT TAB(5); "PLANT AREA = "; L*W: AREA = L*W: PRINT TAB(5); "LENGTH = "; L: PRINT TAB(5); "WIDTH = "; W: PRINT: PRINT TAB(5); "NUMBER OF LATERAL BAYS = "; NCOL
PRINT TAB(5) "LENGTH OF BAY = "; BCOL: PRINT TAB(5) "WIDTH OF BAY = "; BW: PRINT: PRINT TAB(5): INPUT "DO YOU WANT TO MAKE ANY CHANGES (Y/N) "; A$
IF A$ = "Y" OR A$ = "y" THEN MA% = 1: FIR% = 1: GOSUB 5280: GOTO 1290
1320 IF A$="N" OR A$="n" THEN 1340  
1340 NA%=N+B+I%-A  
1341 I=1  
1342 LD(I)=Q(I)/BW  
1343 I=I+1  
1344 IF I<=I% THEN 1342  
1345 RETURN  
1349 REM  ***************  INPUT AREA OF EACH DEPT.  ***************  
1350 '*  INPUT AREA OF EACH DEPT.  
1370 '*  ***************  
1380 OVR%=O:SLZ%=O:SZ%=O:CLS:II = A: PRINT:PRINT TAB(10):"FOR EACH DEPT. ENTER AREA": GOSUB 1390: IF DSK=1 THEN 2030 ELSE 1640  
1390 PRINT:SUM=0:PRINT,"DEPT.## AREA","DEPT.## AREA","DEPT.## AREA","DEPT.## AREA","DEPT.## AREA":PRINT,"DEPT.## AREA":PRINT,"*********"  
1400 I=1  
1410 PRINT,:PRINT USING "###";I;:IF SL%=0 AND SZ%=0 THEN PRINT":":INPUT; Q(I) :LD(I)=Q(I)/BW:GOTO 1430  
1420 LD(I)=Q(I)/BW: PRINT USING"###":Q(I) ;  
1430 IF I/4 = INT(I/4) THEN PRINT  
1440 I=I+1  
1450 IF I<=I% THEN 1410  
1460 IF SZ%=0 THEN SZ%=1:CLS:PRINT:PRINT TAB(10)"SUMMARY OF DEPARTMENT AREA":GOTO 1390  
1470 IF SLZ%=1 THEN SLZ%=0  
1480 SUM = Z: FOR J = A TO I%:SUM = SUM + Q(J): NEXT J  
1490 PRINT:PRINT:PRINT TAB(10)"TOTAL PLANT AREA =";L*W:"TOTAL INPUT AREA =";SUM:PRINT TAB(40)"UNOCCUPIED SPACE =";L*W-SUM  
1500 IF SUM > L*W+.5 THEN PRINT CHRS(7):COLOR 4,0:PRINT:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10)"RE-ENTER THE AREA FOR DEPT.##":IX%=PRINT TAB(10):"INPUT AREA EXCEEDS THE TOTAL PLANT AREA BY ";ABS(L*W-SUM);" SQ.FT":SLZ%=1:OVR%=1:COLOR 3,0:GOTO 1580  
1501 REM  ***************  DISPLAY AND CHANGE DEPT. AREA  ***************  
1510 '  ***************  
1520 '  DISPLAY AND CHANGE AREA OF DEPT.  
1530 '  ***************  
1540 PRINT:PRINT TAB(10):INPUT"DO YOU WANT TO MAKE ANY CHANGES (Y/N)";A$  
1550 IF A$="Y" OR A$="y" THEN 1580  
1560 IF A$="N" OR A$="n" THEN RETURN  
1580 PRINT:PRINT:PRINT TAB(10):INPUT"ENTER ` DEPT. # . ` TO
CHANGE  : ".IX%
1590 IF IX% < Z OR IX% > I% THEN PRINT CHR$(7):PRINT:COLOR 4.0:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10)"RE-ENTER
THE DATA ":;COLOR 3.0:GOTO 1580
1600 IF IX% = Z AND OVR% = 1 THEN 1480
1610 IF IX% = Z THEN RETURN
1620 OVR%=0
1630 PRINT: PRINT " ENTER NEW AREA FOR DEPARTMENT NO:
";IX%;" ": INPUT Q(IX%):LD(IX%) = Q(IX%)
1640 BW:CLS:PRINT:SZ%=0:GOTO 1460
1650 I=1
1660 OPT% = TRV%
1670 REM ***** ENTER HANDLING COST PER TRIP PER DEPT. *****
1680 ' INPUT HANDLING COST PER TRIP PER UNIT DISTANCE
1690 '******************************************************************************
1700 IF OPT%=1 THEN CLS:PRINT: PRINT "FOR EACH DEPARTMENT
1710 IF OPT%=2 THEN CLS:PRINT: PRINT "FOR EACH DEPARTMENT
1720 IF OPT%=3 THEN CLS:PRINT:PRINT:PRINT TAB(10)"SUMMARY OF
1730 PRINT:PRINT TAB(10)"FROM DEPARTMENT":;I;" TO:
1740 PRINT
1750 FOR KJ=1 TO 3:PRINT " DEP'T NO. OF S/UNIT ";:NEXT
1760 FOR KJ=1 TO 3:PRINT " NO. TRIPS DISTANCE ";:NEXT
1770 FOR KJ=1 TO 3:PRINT " ----- -------- --------- ";:NEXT
1780 J=1
1790 CC=0
1800 IF J=I THEN 1850
1810 PRINT TAB(CC*26);:PRINT USING "### ";J;
1820 IF OPT%=1 THEN PRINT" ";INPUT; NT(I,J) ELSE PRINT USING
"####### ";NT(I,J);
1830 IF OPT%=1 OR OPT%=2 THEN PRINT" ";INPUT; CST(I,J) ELSE
1840 CC=CC+1:IF CC = 3 THEN CC=0:PRINT:
1850 J=J+1:IF J= I% THEN 1800
1860 REM ******** DISPLAY AND CHANGE HANDLING COSTS ********
1870 '******************************************************************************
1880 IF OPT%=3 THEN 1900 ELSE OPT%=3:CLS:PRINT:PRINT
1890 PRINT TAB(10)"SUMMARY OF THE DATA OF HANDLING COST PER UNIT
1900 PRINT:PRINT:PRINT TAB(10):INPUT"DO YOU WANT TO MAKE ANY
1910 IF A$="Y" OR A$="y" THEN MA%=1:GOTO 1940
1920 IF A$="N" OR A$="n" THEN 1990
1940 PRINT:PRINT TAB(10):INPUT "ENTER ' DEPT. #. ' TO CHANGE, ENTER ' 0 ' TO CONTINUE ";JJ%:IF JJ% = Z THEN PRINT : GOTO 1990
1950 IF JJ% < A OR JJ% > I% THEN PRINT CHR$(7):PRINT:COLOR 4,0:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10):INPUT"RE-ENTER THE DATA ( 0 < DEPT. #. <=";I%;")":PRINT:PRINT TAB(10):INPUT"",JJ%:COLOR 3,0:GOTO 1950
1970 PRINT:PRINT TAB(10)"FROM ";I;" TO ";JJ%;" ": INPUT; "ENTER NO. OF TRIPS ";:NT(I,JJ%):PRINT TAB(7):INPUT" ENTER $ / UNIT DISTANCE";CST(I,JJ%)
1980 GOTO 1700
1990 I=I + 1
2000 IF I <=I% THEN 1660
2010 FOR I=1 TO I%;FOR J=1 TO I%;C(I,J)=NT(I,J)*CST(I,J):NEXT J:NEXT I
2020 RETURN
2030 GOSUB 2060:GOTO 2440
2040 CLS:PRINT:PRINT TAB(15):"INPUT INITIAL SEQUENCE OF DEPARTMENTS *****
2070 Q = A: IF J = Q THEN 2120
2080 FOR I = A TO J - A: IF SQ%(I,A) = SQ%(J,A) THEN PRINT CHR$(7):PRINT "*** ERROR *** DEPT. NO. ":SQ%(J,A);"IS ALREADY ASSIGNED TO SEQ. NO. ";I; "RE-ENTER THE DATA.";COLOR 3,0:GOTO 2080
2090 NEXT I
2100 CC=CC+1
2110 IF CC=3 THEN PRINT:CC=0
2120 GOTO 2140
2130 IF QZ%=1 THEN 2300
2140 REM ****** FIXING A LOCATION OF A DEPARTMENT ******
2150 '***************antwort auf die Frage
2160 '***************antwort auf die Frage
2170 '***************antwort auf die Frage
2180 '***************antwort auf die Frage
2190 PRINT:PRINT TAB(10):INPUT "WOULD YOU LIKE TO FIX THE LOCATION OF ANY DEPARTMENT (Y/N) ";A$
2200 IF A$="N" OR A$="n" THEN 2300
2210 IF A$="y" OR A$="y" THEN 2230
2230 PRINT : FOR I = A TO 1%
2240 PRINT TAB(10)"FIX DEPT. NO. ";I;" (Y/N) ?";:INPUTVRE-ANSWER
2241 THE QUESTION:",A$:COLOR 3,0:GOTO 2250
2243 FX%(I)=A:
2244 GOTO 2250
2245
2250 IF FX%(I)=Z
2251 NEXT I: PRINT
2252 CLS:PRINT TAB(20);"INITIAL SEQUENCE OF DEPARTMENTS":PRINT TAB(15);" FROM RECEIVING TO SHIPPING":ZX%=0
2253 PRINT : PRINT " (EX: SEQ.1 = 3 , SEQ.2 = 11,...ETC) ": PRINT : PRINT TAB(10);"DEPARTMENT NO.":TAB(33);"DEPARTMENT NO.":TAB(58);"DEPARTMENT NO.":CC=0:FOR J = A TO I%
2256 PRINT TAB(CC*25+10);"SEQ.":J;" = ";: PRINT SQ%(J,A)::
2257 IF FX%(SQ%(J,A))=A THEN PRINT**:":ZX%=1:
2258 CC=CC+1
2259 IF CC=3 THEN PRINT:CC=0
2260 REM ****** DISPLAY AND CHANGE DEPT. SEQUENCE *****
2261 ' ****** Display and change sequence of dept.
2262 NEXT J: PRINT
2263 IF ZX%=1 THEN PRINT TAB(10)"** DESIGNATES DEPARTMENTS WITH FIXED SEQUENCE"
2264 PRINT :PRINT TAB(10):INPUT "DO YOU WANT TO MAKE ANY CHANGES (Y/N) ";AS
2265 IF AS="Y" OR AS="y" THEN MA%=1:GOTO 2060
2266 IF AS="N" OR AS="n" THEN RETURN
2267 PRINT CHRS(7):PRINT:COLOR 4,0:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10):INPUT"RE-ANSWER THE QUESTION:",AS:COLOR 3,0:GOTO 2410
2269 IF PREV%=1 THEN 2460
2270 GOTO 2640
2271 IF MA%=1 THEN MA%=0:GOTO 2640
2272 CLS:LOCATE 5,1:PRINT:PRINT TAB(10):INPUT"DO YOU WANT TO DISPLAY THE PREVIOUS CALCULATION (Y/N) ";AS
2273 IF AS="Y" OR AS="y" THEN 2510
2274 IF AS="N" OR AS="n" THEN 2750
2275 PRINT CHRS(7):PRINT:COLOR 4,0:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10):INPUT"RE-ANSWER THE QUESTION:",AS:COLOR 3,0:GOTO 2480
2277 PRINT:PRINT:PRINT "DEPT. SEQUENCE":CT=0:PRINT;
2278 FOR IK= 1 TO I%:PRINT SQ%(IK,1);
2279 IF IK <> I% THEN PRINT ":-";
2280 CT=CT+1:IF CT= 40 AND I% <> IK THEN CT=0
2281 NEXT IK
2282 PRINT:PRINT"COST <";CS; "> = $ ";LO
THE NEXT IMPROVED SEQUENCE
THEN PRINT THEN KK%
---...---
CENT%: RETURN
IF SUM=O:IS%=O:GO TO 2750
2780:IS%=I:
TOTAL COST": PRINT
"DEPT.SEQUENCE
---
2720 IF ZQ%=1 THEN 2740
2730 PRINT"(PRESS 'ANY KEY' TO STOP CALCULATION AT THE END OF
THE NEXT IMPROVED SEQUENCE")
2740 SUM=0:IS%=B:IT%=A:GOSUB 2790:GOSUB 2950:GOSUB
2750:IS%=A:IT%=B:IF ZQ%=1 THEN XZZ=1:ZQ%=O:GO TO 3230 ELSE 3130
2750 KC%=Z:LO=SUM:FOR KE=A TO I%:IF SQ%(KE,A)<TN%
THEN KC%=KC%+B:GO TO 2770
2760 KC%=KC%+C
2770 SQ%(KE,IS%)=SQ%(KE,IT%):PRINT SQ%(KE,A):;IF KE<I%
THEN PRINT ","__;IF KC%>KI% THEN KC%=Z:PRINT;PRINT;
2780 NEXT KE:PRINT TAB(65);INT(CENT%*LO+F5)/
CENT%:RETURN
SUM+LD:IF SUM>L AND AN%<NA% THEN 2860
2800 LA(AN%)=LD:IF DIR%=R THEN 2820
2810 XC=(LN+(LD/B))):LN=LN+LD:GOTO 2830
2820 XC=(LN-(LD/B)):LN=LN-LD
2830 IF SUM<L THEN 2920
2840 SUM=Z:Q=Z:GOTO 2890
2850 L2=SUM-L:L=L2:LA(AN%)=L1:LA(AN%+A)=L2:
IF DIR%=R THEN 2870
2860 X(AN%)=(L-(L1/B)):Y(AN%)=(YC):DP%(AN%)=J%:AN%
= AN% + A:XC = (L - (L2 / B)): GOTO 283C
2870 X(AN%) = (L1 / B):Y(AN%) = YC:DP%(AN%) = J%:AN% = AN% + A:XC = (L2 / B)
2830 SUM = L2:Q = L2:YC = YC + B * YB
2890 IF DIR% = R THEN LN = L - Q: GOTO 2910
2900 LN = Q
2910 DIR% = ( - A) * DIR%
2920 X(AN%) = XC:Y(AN%) = YC:DP%(AN%) = J%:AN% = AN% + A: IF SUM = Z THEN YC = YC + B * YB
2930 NEXT I: IF AN% > NA% THEN RETURN
2940 FOR I = AN% TO NA%:DP%(I) = Z: NEXT I: RETURN
2950 SUM = Z: FOR I = A TO NA%: FOR J = A TO I%: IF DP%(I) <> J THEN
2960 IF DP%(I) = Z THEN 3040
2970 IF I = NA% THEN 3000
2990 IF DP%(I + A) <> J THEN 3090
3000 XC = X(I):YC = Y(I)
3010 FOR K = A TO NA%:D% = DP%(K): IF D% = J THEN 3100
3020 IF D% = Z THEN 3120
3030 IF K = NA% THEN 3060
3040 IF DP%(K + A) <> D% THEN 3060
3050 JJ% = K + A:XC = (LA(I) * X(I) + LA(JJ%) * X(JJ%)) / (LA(I) + LA(JJ%)):YC = (LA(I) * Y(I) + LA(JJ%) * Y(JJ%)) / (LA(I) + LA(JJ%)):K = JJ%: GOTO 3070
3060 X2 = X(K):Y2 = Y(K):X = (ABS (XC - X2)):Y = (ABS (YC - Y2)): IF CS = "E" THEN 3090
3070 SUM = SUM + (ABS (XC - X2) + ABS (YC - Y2)) * C(J,D%)
3080 GOTO 3100
3090 SUM=SUM+SQR((XC-X2)^2+(YC-Y2)^2)*C(J,D%)
3100 NEXT K
3110 NEXT J
3120 NEXT I: RETURN
3130 FOR IE = A TO I% - A: IF FX%(SQ%(IE,B)) = R THEN 3220
3140 FOR JE = IE + A TO I%: IF FX%(SQ%(JE,B)) = R THEN 3210
3150 T% = SQ%(IE,B):SQ%(IE,B) = SQ%(JE,B):SQ%(JE,B) = T%: GOSUB 2790: GOSUB 2950: IF SUM + .05 > = LO THEN 3200
3160 GOSUB 2750: TS=INKEYS: IF TS=""THEN 3130
3170 PRINT TAB(10): INPUT "DO YOU WANT TO TERMINATE CALCULATION (Y/N)";YS
3180 IF YS="Y" OR YS = "Y" THEN XZZ=1:GOTO 3230
3190 IF YS="N" OR YS = "n" THEN 3130 ELSE 3170
3200 SQ%(JE,B) = SQ%(IE,B):SQ%(IE,B) = T%
3210 NEXT JE
3220 NEXT IE
3230 IT%=A: GOSUB 2790
3240 IF XZZ=1 THEN XZZ=0:GOTO 3270
3250 PRINT:PRINT TAB(10): < THE MICRO-CRAFT GENERATED ARRANGEMENT HAS BEEN REACHED >"
3260 PRINT:PRINT TAB(10): INPUT "PRESS ' ENTER ' TO CONTINUE"
CLS : PRINT "INPUT DESIRED SEQUENCE OF DEPARTMENTS": PRINT "FROM SHIPPING TO RECEIVING": SL% = 5: GOTO 2070
LOCATE 10,5: PRINT TAB(10): "PLEASE WAIT....."
IT% = A: GOSUB 2790: GOSUB 2950: LO = SUM: PRINT : PRINT "COST = "; INT (CENT% * LO + P5) / CENT%: GOTO 3350
REM ********************** CRAFT MENU **********************
CLS

' *********************** CRAFT OPTION MENU1
CLS: LOCATE 8,25: COLOR 4,0: PRINT "*** IMPORTANT NOTE ***": PRINT: PRINT TAB(10) "SAVE YOUR SIMULATION OUTPUT & INPUT DATA BY USING THE FOLLOWING MENU": PRINT: PRINT TAB(10) "OTHERWISE, YOU MAY LOOSE THEM!
LOCATE 23,1: PRINT TAB(20): INPUT "PRESS ' ENTER ' TO CONTINUE ", AS
CLS: FF% = 0: SUM = 0: SCREEN 0, 1: COLOR 3,0: PRINT: PRINT: PRINT TAB(10) "ENTER YOUR SELECTION ": PRINT: PRINT TAB(12) "1) GRAPHICAL REPRESENTATION OF LAYOUT AND PRINTED OUTPUT": PRINT: PRINT TAB(12) "2) INPUT NEW INITIAL SEQUENCE"
PRINT: PRINT TAB(12) "3) MODIFY LAYOUT DATA": PRINT: PRINT TAB(12) "4) SAVE THE INPUT FILE TO DISK ": PRINT: PRINT TAB(12) "5) RE-START CRAFT FOR ENTERING THE DATA"
PRINT: PRINT TAB(12) "6) EXIT THE PROGRAM TO MAIN MENU"
PRINT: PRINT: PRINT TAB(10): INPUT "ENTER YOUR SELECTION "; SL%
IF SL%=1 THEN 3490
IF SL%=2 THEN MA%=1: GOTO 2030
IF SL%=3 THEN 4130
IF SL%=4 THEN 4520
IF SL%=5 THEN 310
IF SL%=6 THEN 3850
PRINT CHR$(7): PRINT: COLOR 4,0: PRINT TAB(10) "*** ERROR ***": PRINT: PRINT TAB(10): INPUT "RE-ENTER THE NUMBER BETWEEN 1 AND 6 "; SL%: COLOR 3,0: GOTO 3410
CLS: LOCATE 8,5: PRINT "PLEASE WAIT............"
REM *********************** GRAPHICAL REPRESENTATION ************
OPEN CRAFT FILE FOR OUTPUT
' OPEN CRAFT FILE FOR OUTPUT
OPEN "0",1,"CDATA"
GOSUB 3550: GOTO 3650
PRINT #1,CS: PRINT #1,I%=PRINT #1,NA%: PRINT #1,NB: PRINT #1,L: PRINT #1,W: PRINT #1,BW: PRINT #1,LO: PRINT #1,NCOL: PRINT #1,BCOL
FOR I=A TO NA%: IF I>I% THEN 3590
PRINT #1,LD(I): PRINT #1,Q(I): PRINT #1,SQ%(I,A): PRINT #1,FX%(I)
FOR J=A TO I%: PRINT #1,C(I,J): PRINT #1,NT(I,J): PRINT
#1.CST(I,J): NEXT J
3590 PRINT #1,X(I):PRINT #1,Y(I):PRINT #1,DP%(I):PRINT
#1,LA(I): NEXT I
3600 CLOSE #1
3610 'OPEN "O",#1,"JDATA"
3620 'PRINT #1,AREA:PRINT #1,SUM
3630 'CLOSE #1
3640 RETURN
3641 REM RUN CGRAPH FOR GRAPHICAL REPRESENTATION OF LAYOUT
3650 OPEN "O",1,"XDATA":GOSUB 3550:RUN "CGRAPH"
3660 '********************A***************
3670 'OPEN CRAFT FILE FOR INPUT
3680 '********************A***************
3690 OPEN "I",1,"CDATA"
3700 GOSUB 3710:GOTO 3810
3710 REM * LOADING DATA FROM PREVIOUS CRAFT RUN INTO COMPUTER
FROM DISK *
3720 FOR I=A TO NA%: IF I>I% THEN 3750
3730 INPUT #1,LD(I),Q(I),SQ%(I,A),FX%(I)
3740 FOR J=A TO 1%: INPUT #1,C(I,J),NT(I,J),CST(I,J):
NEXT J
3750 INPUT #1,X(I),Y(I),DP%(I),LA(I): NEXT I
3760 CLOSE #1
3770 'OPEN "I",1,"JDATA"
3780 'INPUT #1,AREA,SUM
3790 'CLOSE #1
3800 RETURN
3801 REM ***
3810 NB=NA%-I%+A: CLS
3820 PRINT P$:IF FF%=B THEN 3310 ELSE 2710
3830 OPEN "O",1,"CFLAG"
3840 PRINT #1,0: CLOSE #1
3841 REM * EXITING CRAFT FROM CRAFT MENU 1 TO MAIN MENU *
3850 CLS:RUN "HELLO"
3851 REM **** GETTING PREVIOUS FROMTO RUN FROM DISK ****
3860 REM GETTING PREVIOUS FROMTO RUN FROM DISK FILE.
3870 GOSUB 3880:GOTO 3940
3880 CLS:FOR RT=1 TO 7:PRINT:NEXT RT
3890 INPUT " :GS:PRINT:PRINT
3900 INPUT " :GS:PRINT:PRINT
3910 FS=FS+"":"+GS
3920 RETURN
3930 RETURN
3940 REM ********* READ FROM DISK FOR FROMTO FILES ******
3950 OPEN "I",1,FS
3960 ' OPEN FROMTO FILE FOR INPUT
3970 '**************
3980 INPUT #1,TESTS
3990 IF TESTS="FROM" THEN 4000 ELSE 4490
4000 INPUT #1, ND  
4010 I% = ND  
4020 INPUT #1, NP  
4025 INPUT #1, EQPTS  
4030 II = 0  
4040 JJ = 0  
4050 IF II = II + 1: IF II = ND + 1 THEN 4090  
4060 JJ = JJ + 1: IF JJ = ND + 1 THEN JJ = 0: GOTO 4050  
4070 INPUT #1, NT(I, JJ)  
4080 GOTO 4060  
4090 CLOSE #1  
4100 TRV% = 2  
4110 GOSUB 1730  
4120 RETURN  
4121 REM ***** MODIFY LAYOUT DATA, CHANGE CRAFT RUN *****  
4130 DSK = 1: CLS: GOSUB 1290  
4140 OVR% = 0: SZ% = 0: SLZ% = 0  
4150 '*************************************************************  
4160 ' DISPLAY AND CHANGE PREVIOUS CRAFT RUN  
4170 '*************************************************************  
4180 CLS: LOCATE 5, 1: PRINT: PRINT: PRINT TAB(10): INPUT"DO YOU WANT TO DISPLAY THE DEPARTMENT AREA (Y/N)"; AS  
4190 IF AS = "Y" OR AS = "y" THEN GOTO 4220  
4200 IF AS = "N" OR AS = "n" THEN GOTO 4340  
4220 IF SZ% = 0 THEN SZ% = 1: CLS: PRINT: PRINT: PRINT TAB(10); "SUMMARY OF DEPARTMENT AREA"  
4230 PRINT: SUM = 0: PRINT, "DEPT. # AREA", "DEPT. # AREA", "DEPT. # AREA": PRINT, "----------------", "----------------", "----------------", "-----------"  
4240 I = 1: SAM = 0  
4250 PRINT: PRINT USING "###"; I; IF SL% = 0 AND SZ% = 0 THEN PRINT" ";: INPUT; Q(I): LD(I) = Q(I) / BW: GOTO 4270  
4260 LD(I) = Q(I) / BW: PRINT USING"########"; Q(I)  
4270 IF I / 4 = INT(I / 4) THEN PRINT  
4275 SAM = SAM + Q(I)  
4280 I = I + 1  
4290 IF I <= I% THEN 4250  
4292 PRINT: PRINT TAB(10)"TOTAL PLANT AREA ="; L*W; "  
4294 PRINT TAB(40)"UNOCCUPIED SPACE ="; L*W - SAM  
4300 PRINT: PRINT TAB(15): INPUT"DO YOU WANT TO MAKE ANY CHANGES (Y/N)"; SMS  
4310 IF SMS = "Y" OR SMS = "y" THEN MA% = 1: GOSUB 1580: GOTO 4340  
4320 IF SMS = "N" OR SMS = "n" THEN 4340  
4330 PRINT CHR$(7): PRINT: COLOR 4, 0: PRINT TAB(10)"*** ERROR ***": PRINT: PRINT TAB(10): INPUT"RE-ANSWER THE QUESTION : ", SMS; COLOR 3, 0: GOTO 4310  
4340 CLS: LOCATE 5, 1: PRINT: PRINT TAB(10): INPUT"DO YOU WANT TO
DISPLAY THE HANDLING COST PER UNIT DISTANCE (Y/N)";AS
4350 IF AS="Y" OR AS="y" THEN TRV%=3:GOSUB 1650:GOTO 4380
4360 IF AS="N" OR AS="n" THEN TRV%=3:GOSUB 4380
4380 CLS:LOCATE 5,1 :PRINT:PRINT TAB(10):INPUT"DO YOU WANT TO DISPLAY THE SEQUENCE OF DEPARTMENT (Y/N)";SMS
4390 IF SMS="Y" OR SMS="y" THEN GOSUB 2300:GOTO 2460
4400 IF SMS="N" OR SMS="n" THEN GOTO 2460
4420 GOSUB 3880
4430 "************************************************************
4440 ' ERROR MESSAGE
4450 '************************************************************
4460 OPEN ",1,FS
4470 INPUT #1,TESTS
4480 IF TESTS ="CRAFT" THEN GOSUB 3710 :GOTO 4130
4490 PRINT:PRINT CHR$(7):COLOR 4,0:PRINT TAB(10)"THE DISK FILE WAS NOT GENERATED BY THE APPROPRIATE PROGRAM":COLOR 3,0:RESET
4500 PRINT:PRINT TAB(10):INPUT"PRESS ' ENTER ' TO CONTINUE";AA$;
4510 GOTO 310
4511 REM ******** SAVE INPUT FILE OF CRAFT TO DISK *****
4520 GOSUB 3880
4530 OPEN ",1,FS
4540 PRINT #1,"CRAFT"
4550 GOSUB 3550
4551 REM ******** ERROR MESSAGES ************
4560 GOTO 3370
4570 IF ERL=3530 THEN 4640
4580 IF ERL=3690 THEN 4640
4590 IF ERL=3830 THEN 4640
4600 IF ERL=3940 THEN 4639
4610 IF ERL=4460 THEN 4639
4620 IF ERL=4530 THEN 4640
4630 ON ERROR GOTO 0
4639 JXP=1
4640 CLS:FOR RT=1 TO 10:PRINT:NEXT RT
4650 PRINT CHR$(7):COLOR 4,0:PRINT "COMPUTER IS HAVING DIFFICULTY READING FROM OR WRITING TO A DISK FILE OR THE FILE DOES NOT EXIST!":COLOR 3,0
4660 FOR RT=1 TO 8:PRINT:NEXT RT
4670 PRINT TAB(10):INPUT "PRESS ' ENTER ' TO CONTINUE";AA$;
4671 IF JXP=1 THEN JXP=0:RESET:RESUME 310
4679 JXP=0
4680 RESUME 3370
4681 REM ****************** CRAFT INSTRUCTIONS ************
4690 "************************************************************
INFORMATION

IMPLEMENTED THE PROGRAM PERFORMS PAIRWISE EXCHANGE BETWEEN DEPARTMENTS

IN A PRODUCTION PLANT. IT DETERMINES A SUB-OPTIMAL

ARRANGEMENT WITH RESPECT TO MINIMIZING TOTAL COST OF

MATERIAL HANDLING (M.H.) IN THE PLANT.

ASSUMPTIONS:

1. PLANT AREA IS RECTANGULAR OR SQUARE IN SHAPE

2. DEPARTMENTS ARE ARRANGED IN BAYS

3. THE COST OF MATERIAL HANDLING IS A FUNCTION OF EITHER

RECTILINEAR OR EUCLIDEAN DISTANCE BETWEEN

DEPARTMENT CENTROIDS.

MAXIMUM NO. OF DEPARTMENTS IS 35:

THE PROGRAM ACCEPTS DATA PERTINENT TO DEPARTMENT AREAS,

AN INITIAL ARRANGEMENT, NUMBER OF TRIPS BETWEEN DEPARTMENTS,

AND COST PER TRIP ($/TRIP/UNIT DISTANCE).

IT PROVIDES A GRAPHICAL REPRESENTATION OF A SUB-OPTIMAL

ARRANGEMENT.

PRESS 'ENTER' TO CONTINUE

INITIAL ARRANGEMENT

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5010 PRINT"->-:->-:->-:->-:->-:->-:->-:->-:->-:->-:->-:->-;->- 5020 PRINT"->;" 5030 PRINT"->-:->-:->-:->-:->-:->-:->-:->-:->-:->-:->-:->- 5040 PRINT:PRINT 5050 PRINT TAB(10);"FOR THE INITIAL ARRANGEMENT, ENTER THE SEQUENCE OF" 5060 PRINT TAB(10);"DEPARTMENTS WHICH CORRESPONDS TO THE INITIAL ARRANGEMENT" 5070 PRINT TAB(10);"FOLLOWING THE DIRECTION OF THE ARROWS":PRINT 5080 PRINT TAB(20);"PRESS 'ENTER' TO CONTINUE";:INPUT "",A$ 5090 CLS:PRINT:PRINT 5100 PRINT TAB(10);"THE PROGRAM PROVIDES THE USER AN OPPORTUNITY TO STOP" 5110 PRINT TAB(10);"CALCULATIONS WHENEVER A MORE COST EFFECTIVE LAYOUT HAS" 5120 PRINT TAB(10);"BEEN OBTAINED. THE USER SIMPLY PRESSES ANY KEY WHILE THE" 5130 PRINT TAB(10);"THE COMPUTER IS CALCULATING. AS SOON AS A NEW SOLUTION" 5140 PRINT TAB(10);"IS GENERATED THE USER CAN DECIDE TO TERMINATE SEARCHING" 5150 PRINT TAB(10);"OR TO CONTINUE WITH THE CRAFT ALGORITHM. THIS OPTION" 5160 PRINT TAB(10);"IS PROVIDED SO THAT IF THE USER DOES NOT WANT HAVE TO WAIT" 5170 PRINT TAB(10);"FOR A BETTER LAYOUT, HE CAN TERMINATE THE CRAFT CALCULATION" 5180 PRINT TAB(10);"AND ANALYZE THE LAYOUT GIVEN AT THAT TIME. HE CAN CONTINUE OR QUIT" 5190 PRINT TAB(10);"THIS IS ESPECIALLY USEFUL FOR LARGE PROBLEMS FOR WHICH THE" 5200 PRINT TAB(10);"EXECUTION TIME CAN BE A FEW HOURS LONG. IF YOU SAVE" 5210 PRINT TAB(10);"THE INTERMEDIATE ANSWER ON A DISK FILE, CALCULATION CAN" 5220 PRINT TAB(10);"BE BE CONTINUED AT A LATER TIME.":PRINT:PRINT:PRINT 5230 PRINT TAB(10);"PRESS 'ENTER' TO CONTINUE";:INPUT"", AS 5240 RETURN 5241 REM *************** CHANGE PLANT DATA *************** 5250 '**************************** 5260 ' CRAFT CHANGING DATA MENU 1 5270 '**************************** 5280 CLS:PRINT:PRINT TAB(5);"PLEASE SELECT YOUR OPTION : " 5290 PRINT:PRINT TAB(5);"1) CHANGE NO. OF DEPTS" 5290 PRINT:PRINT TAB(5);"2) CHANGE PLANT AREA" 5290 PRINT:PRINT TAB(5);"3) CHANGE WIDTH OF PLANT
1-";W;"")
5300 PRINT:PRINT TAB(5)"4) CHANGE LENGTH OF PLANT
(";L;")";PRINT:PRINT TAB(5)"5) CHANGE WIDTH OF BAYS (WBAY
=";"BW;")"
5310 PRINT:PRINT TAB(5)"6) CHANGE NUMBER OF LONGITUDINAL BAYS
(";NB;")";PRINT:PRINT TAB(5)"7) CHANGE LENGTH OF BAY (LBAY
=";"LBAY;")";PRINT:PRINT TAB(5)"8) CHANGE NUMBER OF LATERAL
BAYS (";NCOL;")";PRINT:PRINT TAB(5)"9) NO CHANGES."
5311 SUM=0:FOR CT=1 TO I%:SUM=SUM+Q(CT):NEXT
5320 PRINT:PRINT TAB(14):INPUT"ENTER YOUR
SELECTION";WH%
5330 IF WH%=1 THEN 5420
5340 IF WH%=2 THEN 5530
5350 IF WH%=3 THEN 5630
5360 IF WH%=4 THEN 5870
5370 IF WH%=5 THEN 6120
5380 IF WH%=6 THEN 6220
5390 IF WH%=7 THEN 6320
5400 IF WH%=8 THEN 6420
5401 IF WH%=9 THEN MA%=0:IF%=0:RETURN
5410 PRINT CHR$(7):PRINT:COLOR 4,0:PRINT "*** ERROR ***
";PRINT:PRINT:INPUT"RE-ENTER YOUR OPTION BETWEEN 1 AND 9 :
",WH%:COLOR 3,0:GOTO 5330
5411 REM ************ CHANGE # OF DEPARTMENTS ************
5420 CLS:LOCATE 5,1:PRINT:PRINT TAB(5):INPUT"ENTER NUMBER OF
DEPARTMENT : ";I%
5430 IF I% > 2 AND I% <36 THEN 5460
5440 PRINT CHR$(7):PRINT:COLOR 4,0:PRINT "*** ERROR ***
";PRINT:PRINT TAB(5)" THE NUMBER OF DEPARTMENT MUST BE
BETWEEN 3 AND 35":COLOR 3,0
5450 PRINT:PRINT TAB(5):INPUT"RE-ENTER THE NUMBER OF
DEPARTMENT : ",I%:GOTO 5430
5460 PRINT:PRINT TAB(10):INPUT"DO YOU WANT TO CHANGE PLANT
AREA (Y/N) ";AS
5470 IF AS="Y" OR AS="y" THEN 5530
5480 IF AS="N" OR AS="n" THEN RETURN
5490 PRINT CHR$(7):PRINT:COLOR 4,0:PRINT "*** ERROR ***
3,0
5500 IF AS="Y" OR AS="y" THEN 5530
5510 IF AS="N" OR AS="n" THEN RETURN
5520 GOTO 5490
5521 REM ******************* CHANGE PLANT AREA **************
5530 CLS:LOCATE 5,1:PRINT:PRINT TAB(5):INPUT"ENTER MINIMUM
REQUIRED AREA FOR PLANT : ";AREA
5540 IF AREA > 0 THEN 5560
5550 PRINT CHR$(7):PRINT:COLOR 4,0:PRINT "*** ERROR
***":PRINT:PRINT:INPUT"PLANT AREA MUST BE > 0 , RE-ENTER THE
AREA : ",AREA:COLOR 3,0:GOTO 5540
5560 IF AREA < SUM THEN PRINT:PRINT CHR$(7):COLOR 4,0:PRINT
"PLANT WILL BE TOO SMALL FOR THE DEPARTMENTS! ":COLOR 3,0:GOSUB
7000:GOTO 5530
5565 PRINT:PRINT TAB(5)"ENTER YOUR SELECTION."
5570 PRINT:PRINT TAB(5)"1) FIXED WIDTH OF PLANT (";W;")"
5580 PRINT:PRINT TAB(5)"2) FIXED LENGTH OF PLANT (";L;")"
5590 PRINT:PRINT TAB(5):INPUT"ENTER YOUR SELECTION :";AH%
5600 IF AH%=1 THEN L=AREA/W:GOTO 5810
5610 IF AH%=2 THEN W=AREA/L:WIT%=1:GOTO 5730
5620 PRINT Chr$(7):PRINT:COLOR 4,0:PRINT TAB(5)"*** ERROR ***":PRINT:PRINT TAB(5):INPUT"RE-ENTER YOUR SELECTION :";AH%:COLOR 3,0:GOTO 5600
5630 CLS:LOCATE 5,1:PRINT:PRINT TAB(5):INPUT"ENTER WIDTH OF PLANT :";W
5640 IF W > 0 THEN 5660
5650 PRINT Chr$(7):PRINT:COLOR 4,0:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10):INPUT"PLANT'S WIDTH MUST BE > 0 , RE-ENTER THE WIDTH :";W:COLOR 3,0:GOTO 5640
5660 PRINT:PRINT TAB(5)"ENTER YOUR SELECTION."
5670 PRINT:PRINT TAB(5)"1) FIXED PLANT AREA (";AREA;")"
5680 PRINT:PRINT TAB(5)"2) FIXED LENGTH OF PLANT (";L;")"
5690 PRINT:PRINT TAB(5):INPUT"ENTER YOUR SELECTION :";AH%
5700 IF AH%=1 THEN L=AREA/W:GOTO 5730
5705 IF AH%=2 AND W*L < SUM THEN PRINT:PRINT Chr$(7):COLOR 4,0:PRINT "PLANT WILL BE TOO SMALL FOR THE DEPARTMENTS!":COLOR 3,0:GOSUB 7000:GOTO 5630
5710 IF AH%=2 THEN AREA=W*L :WIT%=1:GOTO 5730
5720 PRINT Chr$(7):PRINT:COLOR 4,0:PRINT TAB(5)"*** ERROR ***":PRINT:PRINT TAB(5):INPUT"RE-ENTER YOUR SELECTION :";AH%:COLOR 3,0:GOTO 5700
5730 PRINT:PRINT TAB(5)"ENTER YOUR SELECTION."
5740 PRINT:PRINT TAB(5)"1) FIXED NUMBER OF LONGITUDINAL BAYS (";NB;")"
5750 PRINT:PRINT TAB(5)"2) FIXED WIDTH OF BAY (WBAY =";BW;")"
5760 PRINT:PRINT TAB(5):INPUT"ENTER YOUR SELECTION :";AH%
5770 IF AH%=1 THEN BW=W/NB :GOTO 5800
5780 IF AH%=2 THEN NB=W/BW:GOTO 5800
5790 PRINT Chr$(7):PRINT:COLOR 4,0:PRINT TAB(10)"*** ERROR ***":PRINT:PRINT TAB(10):INPUT"RE-ENTER YOUR SELECTION :";AH%:COLOR 3,0:GOTO 5770
5800 IF WIT%=1 THEN WIT%=0 :RETURN
5810 PRINT:PRINT TAB(5)"1) FIXED NUMBER OF LATERAL BAYS (";NCOL;")"
5820 PRINT:PRINT TAB(5)"2) FIXED LENGTH OF BAY (LBAY =";BCOL;")"
5830 PRINT:PRINT TAB(5):INPUT"ENTER YOUR SELECTION :";AH%
5840 IF AH%=1 THEN BCOL=L/NCOL:RETURN
5850 IF AH%=2 THEN NCOL=L/BCOL:RETURN
5860 PRINT Chr$(7):PRINT:COLOR 4,0:PRINT TAB(5)"*** ERROR ***":PRINT:PRINT TAB(5):INPUT"RE-ENTER YOUR SELECTION :";AH%:COLOR 3,0:GOTO 5840
5861 REM ************* CHANGE LENGTH OF PLANT *************
5870 CLS:LOCATE 5,1:PRINT:PRINT TAB(5):INPUT"ENTER LENGTH OF PLANT :";L
5880 IF L > 0 THEN 5900
5890 PRINT CHRS(7):PRINT:COLOR 4,0:PRINT TAB(5)"*** ERROR ***":PRINT:PRINT TAB(5):INPUT"PLANT'S LENGTH MUST BE > 0",L:COLOR 3,0:GOTO 5880
5900 PRINT:PRINT TAB(5)"ENTER YOUR SELECTION."
5910 PRINT:PRINT TAB(5)"1) FIXED PLANT AREA (";AREA:""
5920 PRINT:PRINT TAB(5)"2) FIXED WIDTH OF PLANT (";W;")"
5930 PRINT:PRINT TAB(5):INPUT"ENTER YOUR SELECTION :";AH%
5940 IF AH%=1 THEN W=AREA/L:GOTO 5970
5945 IF AH%=2 AND W*L < SUM THEN PRINT:PRINT CHRS(7):COLOR 4,0:PRINT "PLANT WILL BE TOO SMALL FOR THE DEPARTMENTS!":COLOR 3,0:GOSUB 7000:GOTO 5870
5950 IF AH%=2 THEN AREA=W*L:WIT%=1:GOTO 5970
5970 PRINT:PRINT TAB(5)"ENTER YOUR SELECTION."
5980 PRINT:PRINT TAB(5)"1) FIXED NUMBER OF LATERAL BAYS (";NCOL;"
5990 PRINT:PRINT TAB(5)"2) FIXED LENGTH OF BAYS (LBAY =";BCOL;"
6000 PRINT:PRINT TAB(10):INPUT"ENTER YOUR SELECTION :";AH%
6010 IF AH%=1 THEN BCOL=L/NCOL:GOTO 6040
6020 IF AH%=2 THEN NCOL=L/BCOL:GOTO 6040
6030 PRINT CHRS(7):PRINT:COLOR 4,0:PRINT TAB(5)"*** ERROR ***":PRINT:PRINT TAB(5):INPUT"RE-ENTER YOUR SELECTION :";AH%:COLOR 3,0:GOTO 6010
6040 IF WIT%=1 THEN WIT%=0:RETURN
6050 PRINT:PRINT TAB(5)"ENTER YOUR SELECTION."
6060 PRINT:PRINT TAB(5)"1) FIXED NUMBER OF LONGITUDINAL BAYS (";NB;"
6070 PRINT:PRINT TAB(5)"2) FIXED WIDTH OF BAY (WBAY =";BW;"
6080 PRINT:PRINT TAB(5):INPUT"ENTER YOUR SELECTION :";AH%
6090 IF AH%=1 THEN BW=W/NB :RETURN
6100 IF AH%=2 THEN NB=W/BW:RETURN
6110 PRINT CHRS(7):PRINT:COLOR 4,0:PRINT TAB(5)"*** ERROR ***":PRINT:PRINT TAB(5):INPUT"RE-ENTER YOUR SELECTION :";AH%:COLOR 3,0:GOTO 6090
6111 REM *********** CHANGE WIDTH OF BAY ***************
6130 IF BW > 0 THEN 6150
6140 PRINT CHRS(7):PRINT:COLOR 4,0:PRINT "*** ERROR ***":PRINT:PRINT:INPUT"WIDTH OF BAY MUST BE > 0",RE-ENTER THE DATA : ";BW:COLOR 3,0:GOTO 6130
6150 PRINT:PRINT TAB(5)"ENTER YOUR SELECTION."
6160 PRINT:PRINT TAB(5)"1) FIXED NUMBER OF LONGITUDINAL BAYS (";NB;"
6170 PRINT:PRINT TAB(5)"2) FIXED WIDTH OF PLANT (";W;")"
6180 PRINT:PRINT TAB(5):INPUT"ENTER YOUR SELECTION :";AH%
6185 IF AH%=1 AND NB*BW*L < SUM THEN PRINT:PRINT CHRS(7):COLOR 4,0:PRINT "PLANT WILL BE TOO SMALL FOR THE DEPARTMENTS!":COLOR 3,0:GOSUB 7000:GOTO 6120
6190 IF AH%=1 THEN W=NB*BW : AREA=W*L: RETURN
6200 IF AH%=2 THEN NB=W/BW: RETURN
6211 REM ***** CHANGE # OF LONGITUDINAL BAYS *************
6220 CLS: LOCATE 5,1: PRINT TAB(5): INPUT "ENTER NUMBER OF LONGITUDINAL BAYS : ", NB
6230 IF NB > 0 THEN 6250
6240 PRINT CHR$(7): PRINT: COLOR 4,0: PRINT "*** ERROR ***": PRINT: PRINT: INPUT "NUMBER OF BAYS MUST BE > 0, RE-ENTER THE DATA : ": , NB: COLOR 3,0: GOTO 6230
6250 PRINT PRINT TAB(5): "ENTER YOUR SELECTION."
6260 PRINT PRINT TAB(5): "1) FIXED WIDTH OF BAY (WBAY ="; BW; ")"
6270 PRINT PRINT TAB(5): "2) FIXED WIDTH OF PLANT ("; W; ")"
6280 PRINT PRINT TAB(5): INPUT "ENTER YOUR SELECTION : ": AH%
6285 IF AH%=1 AND NB*BW*L < SUM THEN PRINT PRINT CHR$(7): COLOR 4,0: PRINT "PLANT WILL BE TOO SMALL FOR THE DEPARTMENTS!": COLOR 3,0: GOSUB 7000: GOTO 6220
6290 IF AH%=1 THEN W=NB*BW: AREA=W*L: RETURN
6300 IF AH%=2 THEN BW=W/NB: RETURN
6310 PRINT CHR$(7): PRINT: COLOR 4,0: PRINT "*** ERROR ***": PRINT: PRINT: INPUT "WIDTH OF COLUMN MUST BE > 0, RE-ENTER THE DATA : ": , BCOL: COLOR 3,0: GOTO 6300
6311 REM ******** CHANGE WIDTH OF COLUMN *************
6320 CLS: LOCATE 5,1: PRINT TAB(5): INPUT "ENTER LENGTH OF BAY : ", BCOL
6330 IF BCOL > 0 THEN 6350
6340 PRINT CHR$(7): PRINT: COLOR 4,0: PRINT "*** ERROR ***": PRINT: PRINT: INPUT "WIDTH OF COLUMN MUST BE > 0, RE-ENTER THE DATA : ": , BCOL: COLOR 3,0: GOTO 6330
6350 PRINT PRINT TAB(5): "ENTER YOUR SELECTION."
6360 PRINT PRINT TAB(5): "1) FIXED NUMBER OF LATERAL BAYS ("; NCOL; ")"
6370 PRINT PRINT TAB(5): "2) FIXED LENGTH OF PLANT ("; L; ")"
6380 PRINT PRINT TAB(5): INPUT "ENTER YOUR SELECTION : ": AH%
6385 IF AH%=1 AND W*NCOL*BCOL < SUM THEN PRINT PRINT CHR$(7): COLOR 4,0: PRINT "PLANT WILL BE TOO SMALL FOR THE DEPARTMENTS!": COLOR 3,0: GOSUB 7000: GOTO 6320
6390 IF AH%=1 THEN L=NCOL*BCOL: AREA=W*L: RETURN
6400 IF AH%=2 THEN NCOL=L/BCOL: RETURN
6410 PRINT CHR$(7): PRINT: COLOR 4,0: PRINT "*** ERROR ***": PRINT: PRINT: INPUT "RE-ENTER YOUR SELECTION : ": , AH%; COLOR 3,0: GOTO 6390
6411 REM ******** CHANGE NUMBER OF COLUMNS *************
6420 CLS: LOCATE 5,1: PRINT TAB(5): INPUT "ENTER NUMBER OF LATERAL BAYS : ": NCOL
6430 IF NCOL > 0 THEN 6450
6440 PRINT CHR$(7): PRINT: COLOR 4,0: PRINT "*** ERROR ***": PRINT: PRINT: INPUT "NUMBER OF COLUMNS MUST BE > 0, RE-ENTER THE DATA : ": , NCOL: COLOR 3,0: GOTO 6430
6450 PRINT PRINT TAB(5): "ENTER YOUR SELECTION."
6460 PRINT:PRINT TAB(5)"1) FIXED LENGTH OF BAY (LBAY =";BCOL;")"
6470 PRINT:PRINT TAB(5)"2) FIXED LENGTH OF PLANT (";L;")"
6480 PRINT:PRINT TAB(5):INPUT"ENTER YOUR SELECTION :";AH%
6485 IF AH%=1 AND W*NCOL*BCOL < SUM THEN PRINT:PRINT CHRS(7):COLOR 4,0:PRINT "PLANT WILL BE TOO SMALL FOR THE DEPARTMENTS!":COLOR 3,0:GOSUB 7000:GOTO 6420
6490 IF AH%=1 THEN L=NCOL*BCOL:AREA=W*L:RETURN
6500 IF AH%=2 THEN NCOL=L/BCOL:RETURN
6510 PRINT CHRS(7):PRINT:COLOR 4,0:PRINT TAB(5)"*** ERROR ***":PRINT:PRINT TAB(5):INPUT"RE-ENTER YOUR SELECTION :";AH%:COLOR 3,0:GOTO 6490
7000 PRINT:PRINT "YOU HAVE TO RE-ENTER YOUR INPUT !":PRINT:PRINT
7010 INPUT "PRESS <ENTER> TO CONTINUE.";AS
7020 RETURN
### VARIABLE LISTING FOR CRAFT

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AREA</td>
<td>Variable for area of plant.</td>
</tr>
<tr>
<td>BCOL</td>
<td>Variable for length of bay.</td>
</tr>
<tr>
<td>BW</td>
<td>Variable for width of bay.</td>
</tr>
<tr>
<td>C(J,I)</td>
<td>Variable for array for the handling cost from department J to department I.</td>
</tr>
<tr>
<td>CS</td>
<td>String Variable for storing the type of calculation (euclidean or rectilinear) for the material handling cost.</td>
</tr>
<tr>
<td>CST(J,I)</td>
<td>Variable for array for the cost per trip from department J to department I.</td>
</tr>
<tr>
<td>DP%</td>
<td>Variable for array for storing the department sequence.</td>
</tr>
<tr>
<td>FX%(I)</td>
<td>Variable for array for storing the fixed location for department I.</td>
</tr>
<tr>
<td>I%</td>
<td>Variable for storing the number of departments.</td>
</tr>
<tr>
<td>IX%</td>
<td>Variable for storing the department number for change.</td>
</tr>
<tr>
<td>JJ%</td>
<td>Variable for storing the department number for change.</td>
</tr>
<tr>
<td>L</td>
<td>Variable for storing the length of the plant.</td>
</tr>
<tr>
<td>LA(I)</td>
<td>Variable for array for storing the sub-area of department area I.</td>
</tr>
<tr>
<td>LD(I)</td>
<td>Variable for array for storing the length of department I.</td>
</tr>
<tr>
<td>LO</td>
<td>Variable for storing the final CRAFT calculated move cost.</td>
</tr>
<tr>
<td>MA%</td>
<td>Variable for indicating changes being made.</td>
</tr>
<tr>
<td>N%</td>
<td>Variable for storing the number of departments.</td>
</tr>
</tbody>
</table>
NB Variable for storing the number of longitudinal bays.
NCOL Variable for storing the number of lateral bays.
NT(J,I) Variable for array for storing the number of trips from department J to department I.
PREV% Variable for indicating a request for a previous CRAFT run.
Q(I) Variable for array for storing the area of department I.
SQ(J,I) Variable for array for storing the sequences of the departments.
SUM Variable for storing the summation of all the department areas.
X(I) Variable for array for storing the X co-ordinate of the dummy centroid.
XC Variable for storing the X co-ordinate of the centroid.
Y(I) Variable for array for storing the Y co-ordinate of the dummy centroid.
YC Variable for storing the Y co-ordinate of the centroid.
ZZ% Variable for indicating fixed departments.

**DATA FILES**

CDATA Data file to store the CRAFT output for use by other modules.

XDATA Data file to store the CRAFT output for use by the CHANGE module.
AREAS
SEQUENCE
FIX DEPTS.
ENTERED
DISPLAY PREVIOUS CALCULATION
USE PREV CALC IN LAYOUT ?
CM1

INPUT DEPT. AREAS

INPUT INITIAL SEQUENCE

FIX A DEPT.? \( Y \)

PREV RETRIEVE FILE ? \( N \)

DISP. PREV. CALCULATION ? \( Y \)

DISPLAY PREVIOUS CALCULATION

R/E

CALCUL. MENU
1. RECTILINEAR
2 EUCLIDEAN

CRAFT CALCULATED COST.

DISPLAY SEQ. AND COST.
1. GRAPHIC LAYOUT
2. NEW INIT. SEQ.
3. MODIFY LAYOUT
4. SAVE TO DISK
5. RE-START CRFT
6. EXIT

Craft Menu 1

1. CDATA
   - SAVE CALCULATION DATA TO DISK

2. INS

3. CM

4. SAVE TO DISK

5. RS

6. HELLO MODULE

XDATA
   - SAVE CALCULATION DATA TO DISK

CGRAPH MODULE
OPTION FOR FIXING DEPENDENT PARAMETERS.

A

- FIX PLANT WIDTH
  - FIX NO. LAT. BAY
  - FIX BAY LENGTH
  - FIX NO. LONG. BAY
  - FIX BAY WIDTH

B

- FIX PLANT LENGTH
  - FIX NO. LAT. BAY
  - FIX BAY LENGTH
  - FIX NO. LONG. BAY
  - FIX BAY WIDTH

C

- FIX PLANT AREA
  - FIX NO. LAT. BAY
  - FIX BAY LENGTH

D

- FIX PLANT WIDTH
  - FIX NO. LAT. BAY
  - FIX BAY WIDTH
  - FIX NO. LONG. BAY
OPTION FOR FIXING DEPENDENT PARAMETERS.
10 '******************************************************************************
20 ' SUBPROGRAM "CGRAPH"
30 '******************************************************************************
40 ' INITIALIZE AND DIMENSION VARIABLES
50 '******************************************************************************
60 SCREEN 1: KEY OFF
70 DIM
80 LL (35), SEQ(35), DP(35), A(35), XC(35), YC(35), B(35), C(35, 35), W
90 I(35), LG(35), EA(35), NN(35), X(35), Y(35), LA(35)
30 ON ERROR GOTO 2480
90 KI%= 30: Z= 0: A= 1: BI= 2
: P5=. 5
100 DEVC= 1: IADJ%= 0
110 DIM
120 PIC(50, 70), Q(35), FX(35), NT(35, 35), CST(35, 35), GRIDX(35), GRIDY(35), WW(35), EW(35), NW(35), SW(35), XCEN(35), YCEN(35), IA(35), IB(35), IC(35)
130 GOSUB 690: GOTO 800
140 'CLS: FOR RT = 1 TO 2: PRINT: NEXT RT
150 '******************************************************************************
160 'SUMMARY OF LAYOUT BY COMPUTER
170 '******************************************************************************
180 'GOSUB 9160: CLS: KEY OFF
190 'PRINT: PRINT "PLANT AREA: "; L*D
200 'PRINT "PLANT LENGTH: "; L
210 'PRINT "PLANT WIDTH : "; D: PRINT
220 'PRINT "NUMBER OF LONGITUDINAL BAYS: "; NB
230 'PRINT "NUMBER OF LATERAL BAYS: "; NCOL
240 'PRINT "LENGTH OF BAY: "; BCOL
250 'PRINT "WIDTH OF BAY: "; BW
260 'PRINT "NUMBER OF DEPARTMENTS: "; N%: PRINT
270 'PRINT "DEPT. SEQUENCE (DEPT. AREA): "; CT= 0: PRINT;
280 'PRINT: Print "": IF ZX% = 1 THEN : PRINT "** DESIGNATES DEPARTMENTS
290 WITH FIXED SEQUENCE": PRINT "": ELSE PRINT ""
300 IF C$= "R" THEN 441
LOCATE 2,2:PRINT "TOTAL HANDLING COST <E>: ":CO
GOTO 460
PRINT "BASED UPON ";
LOCATE 2,2:PRINT "TOTAL HANDLING COST <R>: ":CO
IF CS="E" THEN PRINT "EUCLIDEAN DISTANCE" ELSE PRINT "RECTILINEAR DISTANCE"
LOCATE 3,2:PRINT "PRESS < ENTER > TO CONTINUE"
A$=INPUTS(1)
REM ****** SCREEN OUTPUT OF MENU FOR LAYOUT ************
'*****************
MENU
SCREEN 1:GOSUB 9140:GOSUB 9160:CLS
LOCATE 2,1:PRINT "1-Print 2-Rerun 3-Change Spec.
4-Adjust"
LOCATE 3,1:PRINT "5-Save Craft 6-Display 7-Aisle 8-EXIT: ":GO
GOSUB 9160
LOCATE 3,39:INPUT "",S%
IF S% > 8 OR S%< 1 GOTO 550
IF S%=7 THEN RUN "AISLE"
IF S%=3 THEN 650
IF S%=6 THEN GOSUB 9220:GOSUB 8560:GOSUB 8780:GOTO 510
IF S%=1 THEN 1830
IF S%=2 THEN 750
IF S%=5 THEN GOSUB 9210:GOTO 510
IF S%=4 THEN GOSUB 5140:KUS="1":GOSUB 7250:GOSUB 7250:GOTO 510
IF S%=3 THEN RUN "CHANGE"
GOSUB 800
GOTO 130
W=D
IF ND>35 THEN PRINT "THE LAYOUT DATA EXCEEDS THE
GRAPHICS":PRINT "PROGRAM CAPACITY":CLOSE #I:GOTO 510
FOR I=A TO N%:INPUT #I,LL(I),Q(I),SEQ%(I),FX%(I)
FOR J=1 TO N%:INPUT #I,C(I,J),NT(I,J),CST(I,J):NEXT J
INPUT #I,X(I),Y(I),DP%(I),LA(I):NEXT I:CLOSE #1:RETURN
REM ****************** RE-RUN CRAFT ***************
FF% = Z:GOTO 760
OPEN DATA FILE
'*******************
OPEN "I",1,"CDATA": INPUT
#1,CS,N%,X%,NB,L,D,BW,CO,NCOL,BCOL
W=D
IF N%>35 THEN PRINT "THE LAYOUT DATA EXCEEDS THE
GRAPHICS":PRINT "PROGRAM CAPACITY":CLOSE #I:GOTO 510
FOR I=A TO N%:INPUT #I,LL(I),Q(I),SEQ%(I),FX%(I)
FOR J=1 TO N%:INPUT #I,C(I,J),NT(I,J),CST(I,J):NEXT J
INPUT #I,X(I),Y(I),DP%(I),LA(I):NEXT I:CLOSE #1:RETURN
REM ****************** RE-RUN CRAFT ***************
FF% = B1
OPEN "O",1,"CFLAG"
PRINT #I,FF%
CLOSE #1
IF S%=8 THEN RUN "HELLO" ELSE RUN "CRAFT"
B=D/BW:FACT =INT(22/B)
GOSUB 9160:CLS:LOCATE 2,10:PRINT " <<< PLEASE WAIT ">>:LOCATE 3,2:PRINT "LAYOUT CAN BE PRINTED BY
REM ******************** CALCULATE NUMERIC LAYOUT *************
' ********************
CALCULATE FOR ALPHANUMERIC LAYOUT
' ********************
WID=FACT*B
RA=40/19
LE= INT(RA * L/D * WID + .5)
IF LE<70 THEN 930
FACT=FACT -1
IF FACT>=1 THEN 850
LE = 69
FACT = 1
SUM = 0
FOR I=1 TO N%:NN(I)=Q(I)/BW:NEXT I
FOR I = 1 TO N%
LL(I)=INT((NN(I)*LE/L)+.5)
NEXT I
FOR I = 1 TO N%:SUM=SUM+LL(I):NEXT I
OP=INT(LE*WID /FACT-SUM+.5)
IF OP<O THEN OP=O
FOX I=1 TO 22
FOR J = 1 TO 70
PIC%(I,J)=32
NEXT J
NEXT I
SQ = INT((70- LE)/2+1)
LN=INT((22-WID)/2 +.5)+1
SP= SQ -1+LE
FLAG = 0
II=O:CT=O:TEST=O
B2=1
I=LN
IF FLAG=1 THEN J=SP
IF FLAG=0 THEN J=SQ
GOTO 1280
II = II + 1
CT=0
IF II>N% THEN 1410
TEST =LL(SEQ%(II))
BB=48+SEQ%(II)
IF BB>57 THEN BB=BB+7
IF I>= LN+WID-.5 THEN 1470
PIC%(I,J)=BB
J=J+1-FLAG*2
CT=CT+1
IF FLAG=1 AND J<SQ THEN 1300
IF J>SP THEN 1300
IF CT=TEST THEN 1160
GOTO 1200
I=I+1
IF B2=FACT THEN B2=1:GOTO 1370
B2=B2+1
FOR K = 1 TO 70
PIC%(I,K)=PIC%(I-1,K)
NEXT K
GOTO 1300
IF I>= LN+WID THEN 1470
IF FLAG=0 THEN FLAG=1:GOTO 1130
IF FLAG=1 THEN FLAG=0
GOTO 1130
IF OP=0 THEN 1470
TEST=OP:BB=48:CT=0
GOTO 1220
REM *** DISPLAY LAYOUT IN NUMBERS (OLD OPTION) ****
' ***********************************************
'DISPLAY ALPHANUMERIC LAYOUT
' ***********************************************
CLS:SCREEN 1,0:WIDTH 80
FOR I=LN TO LN+WID
PRINT TAB(5);I
FOR J=1 TO 69
PRINT CHR$(PIC%(I,J))
NEXT
PRINT
NEXT I
PRINT TAB(20):INPUT VPRESS 'ENTER TO CONTINUE W,A$
CLS
' ***********************************************
' DISPLAY GRAPHIC LAYOUT
' ***********************************************
SCREEN 1:GOSUB 9140:GOSUB 9190:CLS:GOSUB 2580
GOSUB 4040
WX=INT((ST/8+(EN-ST)/16)):WY=INT(BWI/8)
LOCATE WY,WX:PRINT L
LX=INT(EN/8+2):LY=INT((NB*FECT)/16+BWI/8)
LOCATE LX,LX:PRINT D
GOSUB 9160:CLS
LOCATE 2,7:PRINT "PRESS < ENTER > TO CONTINUE"
A$=INPUT$(1)
SCREEN 1:GOSUB 9190:CLS:GOSUB 2580
GOSUB 5010
WX=INT(ST/8+(EN-ST)/16):WY=INT(BWI/8)
GOSUB 9190
LOCATE WY,WX:PRINT L
LX=INT(EN/8+2):LY=INT((NB*FECT)/16+BWI/8)
LOCATE LX,LX:PRINT D
LOCATE 2,7:PRINT "PRESS < ENTER > TO CONTINUE"
A$=INPUT$(1)
'SCREEN 1:WIDTH 40:
'IF CS="E" THEN CO=CSUB1 ELSE CO=CSUB2
GOTO 130
1821 REM ***** SEND OUTPUT TO PRINTER ************
1830 LPRINT:LPRINT
1840 LPRINT TAB(25):"PLANT LAYOUT & MATERIALS FLOW"
1850 LPRINT TAB(33):"MICRO-CRAFT"
1860 LPRINT TAB(35):"I.I.E."
1870 LPRINT:LPRINT TAB(27):"RE-WRITTEN AND MODIFIED"
1880 LPRINT TAB(36)" BY "
1890 LPRINT:LPRINT TAB(18):"E. RALPH SIMS Jr. P.E.
ASSOCIATE PROFESSOR"
1900 LPRINT:LPRINT TAB(18):"WITTAWAT SMUTHRANOND
GRADUATE STUDENT"
1910 LPRINT:LPRINT TAB(18):"ILANGO SANKARALINGAM
GRADUATE STUDENT"
1915 LPRINT:LPRINT TAB(18):"EKACHAI HEAMAVATTANACHAI
GRADUATE STUDENT"
1916 LPRINT:LPRINT TAB(18):"VIC KICHODHAN
GRADUATE STUDENT"
1920 LPRINT:LPRINT TAB(18):"DEPT. OF INDUSTRIAL & SYSTEMS
ENGINEERING"
1930 LPRINT:LPRINT TAB(32):"OHIO UNIVERSITY"
1940 LPRINT:LPRINT TAB(34):"COPYRIGHTED"
1950 LPRINT:LPRINT:LPRINT
1960 FOR I=LN TO LN+WID
1970 FOR J= 1 TO 69
1980 LPRINT CHR$(PIC%(I,J));
1990 NEXT J
2000 LPRINT"
2010 NEXT I
2020 LPRINT:LPRINT CHR$(12)
2030 LPRINT:LPRINT TAB(15):"SUMMARY OF LAYOUT GENERATED BY
COMPUTER"
2040 LPRINT:LPRINT:LPRINT "PLANT AREA: ";L*D
2050 LPRINT "PLANT LENGTH: ";L
2060 LPRINT "PLANT WIDTH : ";D:LPRINT"
2070 LPRINT "NUMBER OF LONGITUDINAL BAYS: ";NB
2080 LPRINT "NUMBER OF LATERAL BAYS: ";NCOL
2090 LPRINT "LENGTH OF BAYS : ";BCOL
2100 LPRINT "WIDTH OF BAYS : ";BW
2110 LPRINT "NUMBER OF DEPARTMENTS : ";N%:LPRINT"
2120 LPRINT "DEPT. SEQUENCE (DEPT. AREA): ";CT=0:LPRINT;
2130 ZX%=0
2140 IF (N%/5) = INT(N%/5) THEN KK=N%/5:GOTO 2160
2150 KK=INT(N%/5)+1
2160 FOR I= 1 TO KK
2170 IF N%-(5*I) >= 0 THEN II=5:GOTO 2190
2180 II=N%-(5*(I-1))
2190 FOR NM=1 TO II
2200 NU=5*(I-1)+NM
2210 LPRINT SEQ%(NU);
2220 LPRINT "(";INT(NN(SEQ%(NU))*BW+.5);")");
2230 IF FX%(SEQ%(NU))=1 THEN LPRINT"** ";:ZX%=1
2240 IF NU < N% THEN LPRINT "-";
2250 NEXT NM
2260 LPRINT
2270 NEXT I
2280 LPRINT"":IF ZX% =1 THEN :LPRINT"** DESIGNATES DEPARTMENTS
WITH FIXED SEQUENCE":LPRINT"" ELSE LPRINT"
2290 LPRINT "TOTAL HANDLING COST : $":CO
2300 LPRINT "BASED UPON ";
2310 IF CS="E" THEN LPRINT "EUCLIDEAN DISTANCE" ELSE LPRINT
"RECTILINEAR DISTANCE"
2320 LPRINT:LPRINT CHRS(12):K=1
2330 LPRINT TAB(19);"SUMMARY OF MOVEMENT BETWEEN DEPARTMENTS"
2340 FOR I=1 TO N%
2350 LPRINT
2360 LPRINT TAB(15);"FROM TO NO. OF
$/UNIT"
2370 LPRINT TAB(15);"DEPT DEPT TRIPS
DISTANCE"
2380 LPRINT TAB(15);"---- ---- ----- ----
---------"
2390 CCC$="#### #### ####### #
2400 FOR J=1 TO N%
2410 IF I=J THEN 2430
2420 LPRINT USING CCC$;I,J,NT(I,J),CST(I,J)
2430 NEXT J
2440 K=K+1
2450 IF K > 3 THEN K=1:LPRINT CHRS(12)
2460 NEXT I
2470 FOR RT= 1 TO 10:LPRINT"" :NEXT RT:GOTO 510
2471 REM "******** ERROR MESSAGES ***********
2480 IF ERL = 1830 THEN 2500
2481 IF ERL=7900 GOTO 10000
2482 IF ERL=8210 GOTO 10000
2483 IF ERL=8400 THEN 8719
2484 IF ERL=8560 THEN 8720
2490 ON ERROR GOTO 0
2500 CLS
2510 PRINT CHRS(7):CLS:LOCATE 1,1:PRINT "COMPUTER IS HAVING
DIFFICULTY PRINTING, CHECK YOUR PRINTER!"
2520 FOR RT = 1 TO 8:PRINT:NEXT RT
2530 LOCATE 3,1:INPUT "PRESS <ENTER> TO CONTINUE.",AS
2540 RESUME 510
2541 REM "******** CALCULATION FOR GRAPHICS LAYOUT *******
2550 '***********************************************
2560 'CALCULATE FOR GRAPHIC LAYOUT
2570 '***********************************************
2580 SCREEN 1,0
2590 COLOR 1,4:KEY OFF:RB=7/5
2600 FECT=INT(144/B)
2610 WOD=TECT*B
2620 LO=INT((RB*L/D*WOD)+.5)
2630 IF LO<280 THEN 2680
2540 FECT = FECT - 8
2550 IF FECT >= 8 THEN 2610
2560 LOC = 276
2570 FECT = 8
2580 'FOR I = 1 TO N%: NU(I) = NN(I): NEXT I
2590 ST = INT((280 - LOC) / 2 + 1): EN = ST - 1 - LOC: BWI = 20 * LN
2600 FOR I = 1 TO N%
2610 LL(I) = INT((NN(SEQ(I)) * LO / L))
2620 NEXT I
2630 J = 1: A(1) = ST
2640 BWI = 40
2650 DRAW "BM = ST; = BWI;"
2660 FOR NN = 2 TO NN% + 1
2670 '********************************************************************************
2680 ' ODD BAY
2690 '********************************************************************************
2700 A(NN) = A(NN - 1) + LL((NN - 1))
2710 IF A(NN) <= EN THEN 3280
2720 J = J + 1
2730 SW1 = LL(NN - 1) - (EN - A(NN - 1)): M = 1
2740 IF SW1 <= M * (EN - ST) THEN 2870
2750 J = J + 1
2760 M = M + 1: GOTO 2840
2770 IF M = 1 THEN 3140
2780 IF J > NB THEN SW1 = 0 : MO = 0: DD6 = (M - MO - 1) * FECT: GOTO 2930
2790 '********************************************************************************
2800 ' # OF BAY > 2
2810 '********************************************************************************
2820 SW1 = SW1 - (M - 1) * (EN - ST): MO = 0
2830 DR = EN - A(NN - 1): DD1 = FECT: DD = (M - MO) * FECT: DL = A(NN - 1) - ST: DD2 = (M - 1)
2840 IF J = J/2 = INT(J/2) THEN 3010
2850 DL1 = EN - ST - SW1: DR1 = SW1
2860 DRAW "R = DR; D = DD; L = DL1;"
2870 DRAW "BR = DL1; BU = DD; BL = DR;"
2880 IF J > NB THEN DRAW "D = DD1; L = DL; D = DD6;": GOTO 3000
2890 DRAW "D = DD1; L = DL; D = DD; R = DR1; U = DD1;"
2900 A(NN) = ST + SW1: GOTO 3860
2910 DR1 = EN - ST - SW1: DL1 = SW1
2920 IF J <= NB THEN 3070
2930 DD5 = (M - 1) * FECT
2940 DRAW "R = DR; D = DD5;"
2950 DRAW "BU = DD5; BL = DR;"
2960 GOTO 3090
2970 DRAW "R = DR; D = DD3; L = DL1; U = DD1;"
2980 DRAW "BD = DD1; BR = DL1; BU = DD3; BL = DR;"
2990 DRAW "D = DD1; L = DL; D = DD2; R = DR1;"
3000 A(NN) = EN - SW1: GOTO 3860
3010 '********************************************************************************
3020 ' # OF BAYS = 2
3130 '******************************************************************************
3140 IF J>NB THEN A(11N)=EN:GOTO 3280
3150 DR=EN-A(NN-1):DD=2*FECT:DL=SW1:DB=FECT
3160 DRAW"R=DR;D=DD;L=DL;U=DB;"
3170 DRAW"BD=DB;BR=DL;BU=DD;BL=DR;"
3180 IF DL>DR THEN 3210
3190 AD=DL-DR.
3200 DRAW"D=DB;L=AD;" :GOTO 3230
3210 AD=DL-DR
3220 DRAW"D=DB;L=AD;"
3230 A(1NN)=EN-DL
3240 GOTO 3860
3250 '******************************************************************************
3260 ' # OF BAY = 1
3270 '******************************************************************************
3280 DD=FECT:DR=A(1NN)-A(1NN-1):DA=A(1NN)-A(1NN-1)
3290 DRAW"R=DR;D=DD;L=DR;U=DD;R=DA;"
3300 GOTO 3860
3310 '******************************************************************************
3320 ' EVEN BAY
3330 '******************************************************************************
3340 A(1NN)=A(1NN-1)-LL(1NN-1)
3350 IF A(1NN)>ST THEN 3840
3360 J=J+1
3370 SW2=LL(1NN-1)-(A(1NN-1)-ST)
3380 MM=1
3390 IF SW2 <= MM*(EN-ST) THEN 3420
3400 J=J+1
3410 MM=MM+1:GOTO 3390
3420 IF MM=1 THEN 3660
3430 IF J > NB THEN SW2=0 :MO=0 :DD4=(M-MO-1)*FECT:GOTO 3480
3440 '******************************************************************************
3450 ' # OF BAYS > 2
3460 '******************************************************************************
3470 SW2=SW2-(MM-1)*(EN-ST):MO=0
3480 DL=A(1NN-1)-ST:DD=(M-MO)*FECT:DD1=FECT:DR1=EN-A(1NN-1):DD2=(M-M1)*FECT:DD3=(MM-MO+1)*FECT
3490 IF J/2 = INT(J/2) THEN 3600
3500 DR=SW2:DL1=EN-SW2-ST
3510 IF J <= NB THEN 3560
3520 DD5=(M-1)*FECT
3530 DRAW"L=DL;D=DD5;"
3540 DRAW"BU=DD5;BR=DL;"
3550 GOTO 3580
3560 DRAW"L=DL;D=DD3;R=DR;U=DD1;"
3570 DRAW"BD=DD1;BL=DR;BU=DD3;BR=DL;"
3580 DRAW"D=DD1;R=DR1;D=DD2;L=DL1;"
3590 A(1NN)=ST+SW2:GOTO 3860
3600 DR=EN-SW2-ST:DL1=SW2
3610 DRAW"L=DL;D=DD;R=DR;"
3620 DRAW"BL=DR;BU=DD;DR=DL;"
3630 IF J > NB THEN DRAW"D=DD1;R=DR1;D=DD4:" : GOTO 3650
3640 DRAW"D=DD1;R=DR1;D=DD;L=DL1;U=DD1;"  : GOTO 3660
3650 A(NN)=EN-SW2: GOTO 3680
3660 IF J > NB THEN A(NN)=ST: GOTO 3640
3670 '************************************************************************
3680 ' # OF BAYS = 2
3690 '************************************************************************
3700 WL=A(NN-1)-ST; WD=2*FECT; WR=SW2; WU=FECT
3710 DRAW"L=WL;D=WD;R=WR;U=WU;"  : GOTO 3720
3720 DRAW"BD=WU;BL=WR;BU=WD;BR=WL;"  : GOTO 3730
3730 IF WL > WR THEN 3770
3740 ADD=WL-WR
3750 DRAW"WU;L=ADD;"  : GOTO 3790
3760 ADD=WL-WR
3770 DRAW"WU;L=ADD;"  : GOTO 3790
3780 A(NN)=ST+WR
3790 GOTO 3860
3800 '************************************************************************
3810 ' # OF BAY = 1
3820 '************************************************************************
3830 WD=FECT; WL=A(NN-1)-A(NN); WA=A(NN-1)-A(NN)
3840 DRAW"L=WL;D=WD;R=WL;U=WD;L=WA;"  : GOTO 3860
3850 NEXT NN
3860 REM ***** UNUSED AREA IN PLANT *****
3870 '************************************************************************
3880 ' PAINT EMPTY AREA IN PLANT
3890 '************************************************************************
3900 'YO=BWI+NB*FECT
3910 'LINE (ST-1,BWI-1)-(EN+1,YO+1), ,B
3920 A1=ST-1
3930 B1=BWI-1
3940 YO=BWI+NB*FECT
3950 DRAW"BM=A1;=B1;"
3960 CC=EN-ST+2
3970 TT=YO-BWI+2
3980 DRAW"R=CC;D=TT;L=CC;U=TT;"
3990 'PAINT (EN-.5,YO-.5): PAINT (ST+.5,YO+.5)
4000 RETURN
4010 REM ***** DRAWS FLOW LINE BETWEEN DEPARTMENTS *****
4020 '************************************************************************
4030 '************************************************************************
4040 JC=1; B(1)=ST
4050 STARS="C2S8UNDNENFNGNH"
4060 COL=2: DRAW"C=COL;"
4070 '************************************************************************
4080 ' CALCULATE AND DRAWS FLOW LINE BETWEEN CENTROID OF EACH DEPARTMENT
4090 '************************************************************************
4100 FOR N=2 TO N%+1
4110 IF JC/2 = INT(JC/2) THEN 4490
B(N) = B(N-1) + LL(N-1)

IF B(N) <= ST THEN 4450

Y1 = BWI + (JC - .5) * FECT

JC = JC + 1

SW1 = LL(N-1) - (B(N) - ST) : MM = 1

IF SW1 <= MM*(EN-ST) THEN 4200

JC = JC + 1

M = M + 1 : GOTO 4170

IF M = 1 THEN 4360

SW1 = SW1 - (M-1)*(EN-ST)

AR1 = (EN-B(N-1)) * FECT

X1 = B(N-1) + (EN-B(N-1))/2

AR2 = (EN-ST)*(M-1) * FECT

X2 = ST + (EN-ST)/2

Y2 = Y1 + (M/2)*FEcat

AR3 = SW1*FEcat

IF JC/2 = INT(JC/2) THEN 4310

X3 = ST + SW1/2: B(N) = ST + SW1

GOTO 4320

X3 = EN - SW1/2: B(N) = EN - SW1

Y3 = Y2 + (M/2)*FEcat

XC(N) = (X1*AR1 + X2*AR2 + X3*AR3) / (AR1 + AR2 + AR3)

YC(N) = (Y1*AR1 + Y2*AR2 + Y3*AR3) / (AR1 + AR2 + AR3)

GOTO 4840

AR1 = (EN-B(N-1)) * FECT

X1 = B(N-1) + (EN-B(N-1))/2

AR2 = SW1*FEcat

X2 = EN - SW1/2

Y2 = Y1 + FECT

XC(N) = (X1*AR1 + X2*AR2) / (AR1 + AR2)

YC(N) = (Y1*AR1 + Y2*AR2) / (AR1 + AR2)

B(N) = EN - SW1

GOTO 4840

XC(N) = B(N-1) + LL(N-1)/2

YC(N) = BWI + (JC - .5) * FECT

B(N) = B(N-1) + LL(N-1)

GOTO 4840

B(N) = B(N-1) - LL(N-1)

IF B(N) >= ST THEN 4810

Y1 = BWI + (JC - .5) * FECT

JC = JC + 1

SW2 = LL(N-1) - (B(N-1) - ST) : MM = 1

IF SW2 <= MM*(EN-ST) THEN 4570

JC = JC + 1

MM = MM + 1 : GOTO 4540

IF MM = 1 THEN 4720

SW2 = SW2 - (MM-1)*(EN-ST)

AR1 = (B(N-1) - ST) * FECT

X1 = B(N-1) - (B(N-1) - ST)/2

X2 = ST + (EN-ST)/2

Y2 = Y1 + (MM/2)*FEcat

AR3 = SW2*FEcat
4640 IF JC/2=INT(JC/2) THEN 4670
4650 X3=ST+SW2/2: B(N)=ST+SW2
4660 GOTO 4680
4670 X3=EN-SW2/2: B(N)=EN-SW2
4680 Y3=Y2+(MM/2)*FECT
4690 XC(N)=(X1*AR1+X2*AR2+X3*AR3)/(AR1+AR2+AR3)
4700 YC(N)=(Y1*AR1+Y2*AR2+Y3*AR3)/(AR1+AR2+AR3)
4710 XC(N)=B(N-1)-LL(N-1)/2
4720 AR1=(B(N-1)-ST)*FECT
4730 X1=ST+(B(N-1)-ST)/2
4740 AR2=SW2*FECT
4750 X2=ST+SW2/2
4760 Y2=Y1+FECT
4770 XC(N)=(X1*AR1+X2*AR2)/(AR1+AR2)
4780 YC(N)=(Y1*AR1+Y2*AR2)/(AR1+AR2)
4790 B(N)=ST+SW2
4800 GOTO 4840
4810 XC(N)=B(N-1)-LL(N-1)/2
4820 YC(N)=BWI+(JC-.5)*FECT
4830 B(N)=B(N-1)-LL(N-1)
4840 XCEN(N)=XC(N): YCEN(N)=(YC(N)-BWI)*W/144+BWI
4842 NEXT N
4845 IF IADJ%=1 THEN IADJ%=0:RETURN
4850 DRAW"BM=XC(2),=YC(2):"; DRAW STARS
4860 IF CS="R" THEN 4920
4870 FOR JJ=3 TO N%+1
4880 CX=XC(JJ): CY=YC(JJ)
4890 DRAW"M=CX,),=CY:"; DRAW STARS
4900 NEXT JJ
4910 GOTO 4970
4920 FOR II=3 TO N%+1
4930 CX=XC(II): CY=YC(II): CX1=XC(II-1)
4940 DRAW"M=CX1,),=CY:"; DRAW STARS
4950 DRAW STARS
4960 NEXT II
4970 RETURN
4971 REM *******PRINT SEQUENCE NUMBER *******
4980 ' *********************************************************
4990 '  PRINT SEQ. NO.
5000 '  *********************************************************
5010 FOR N=2 TO N%+1
5020 XC(N)=INT(5/7*(XC(N)/6+.5)): YC(N)=INT(YC(N)/7.5)
5030 MX=XC(N): MY=YC(N)
5040 LOCATE MY,MX
5050 PRINT SEQ%(N-1)
5060 NEXT N
5070 RETURN
5080 '  *********************************************************
5090 '  RE-ARRANGE
5100 '  *********************************************************
5110 '  *********************************************************
5120 '  DRAW GRID
5130 '*******************************************************************************
5131 REM * INSERT GRID TO ADJUST CRAFT LAYOUT OUTPUT *
5140 GOSUB 9160:CLS:LOCATE 2,2:INPUT"ENTER SIZE OF THE SQUARE GRID =",GRID
5150 IF GRID <= 0 THEN 5170
5160 IF GRID <= L AND GRID <= D THEN 5180
5170 PRINT CHR$(7):CLS:LOCATE 2,7:PRINT"**** ERROR IN INPUT ****":GOSUB 9380:GOSUB 5140
5180 CLS:LOCATE 2,1:INPUT"DISPLAY FINAL LAYOUT WITH GRID? (Y/N)",AS
5190 IF AS="Y" OR AS="y" THEN NUK%=1:ADJ%=1:GOSUB 6090:GOSUB 2580:GOSUB 4010:GOSUB 5010:GOTO 5220
5200 IF AS="N" OR AS="n" THEN 5270
5210 PRINT CHR$(7):GOTO 5180
5220 GOSUB 9160:CLS:LOCATE 2,2:INPUT"PRESS <ENTER> TO CONTINUE",AS
5230 CLS:LOCATE 2,2:INPUT"CHANGE SIZE OF SQUARE GRID? (Y/N)",AS
5240 IF AS="Y" OR AS="y" THEN 5140
5250 IF AS="N" OR AS="n" THEN 5270
5260 PRINT CHR$(7):GOTO 5230
5270 K=1
5280 IF K > N% THEN RETURN
5290 '*******************************************************************************
5300 ' INPUT NEW DATA
5310 '*******************************************************************************
5320 I= SEQ%(K)
5330 GOSUB 9160:CLS:LOCATE 1,15:PRINT"DEPT.#";I
5331 'LOCATE 2,1:INPUT "MAKE ANY ADJUSTMENTS? (Y/N) : ",AS
5332 'IF AS="Y" OR AS="y" THEN CLS:GOTO 5340
5333 'IF AS="N" OR AS="n" THEN 5930
5334 'GOTO 5330
5340 LOCATE 2,1:PRINT"DIST. N.WALL(PLANT)-N.WALL(DEPT) ="
5350 LOCATE 2,35:INPUT IA(I)
5360 IF IA(I) >= 0 AND IA(I) < D THEN 5380
5370 PRINT CHR$(7):GOTO 5350
5380 IF R=1 THEN R=0:GOTO 5610
5390 LOCATE 3,1:PRINT"DIST. W.WALL(PLANT)-W.WALL(DEPT) ="
5400 LOCATE 3,35:INPUT IC(I)
5410 IF IC(I) >= 0 AND IC(I) <= L THEN 5430
5420 PRINT CHR$(7):GOTO 5400
5430 IF R= 1 THEN R= 0:GOTO 5610
5440 CLS:LOCATE 1,2:PRINT"1) DIST. N.WALL(PLANT)-S.WALL(DEPT)"
5450 LOCATE 2,2:PRINT"2) DIST. W.WALL(PLANT)-E.WALL(DEPT)"
5460 LOCATE 3,2:PRINT "ENTER YOUR SELECTION =>"
5470 LOCATE 3,27:INPUT "",NU%
5480 IF NU% = 1 THEN 5560
5490 IF NU% = 2 THEN 5510
5500 PRINT CHR$(7):GOTO 5470
5510 CLS:LOCATE 2,1:PRINT"DIST. W.WALL(PLANT)-E.WALL(DEPT) ="
5520 LOCATE 2,35:INPUT EA(I)
5530 IF EA(I) > IC(I) AND EA(I) <=L THEN 5600
5540 PRINT CHR$(7):GOTC 5520
5550 IF R=1 THEN R=0 :GOTO 5610
5560 CLS:LOCATE 2,1:PRINT"DIST. N.WALL(PLANT)-S.WALL(DEPT) = "
5570 LOCATE 2,3:INPUT IB(I)
5580 IF IB(I) <= D AND IB(I) > IA(I) THEN 5600
5590 PRINT CHR$(7):GOTO 5570
5600 IF R=1 THEN R=0 :GOTO 5610
5610 IF NU% = 1 THEN 5650
5620 LG(I)=EA(I)-IC(I):WI(I)=Q(I)/LG(I)
5630 IB(I)=IA(I)+WI(I)
5640 GOTO 5670
5650 IF R=1 THEN R=0 :GOTO 5610
5660 IF NU%=1 THEN 5750
5670 LG(I)=EA(I)-IC(I):WI(I)=Q(I)/LG(I)
5680 IB(I)=IA(I)+WI(I)
5690 GOTO 5670
5700 CLS:LOCATE 2,1:INPUT "DO YOU WANT TO MAKE ANY CHANGES? (Y/N) ", ZS
5710 IF ZS= "N" OR ZS= "n" THEN 5850
5720 IF ZS= "Y" OR ZS= "y" THEN 5710
5730 PRINT CHR$(7):GOSUB 9400:GOTO 5670
5740 LOCATE 2,1:PRINT "CHANGE DISTANCE MENU (Plant-Dept)"
5750 IF NU%=1 THEN 5750
5760 LOCATE 2,23:PRINT "1)N.WALL-N.WALL(";IA(I);")"
5770 LOCATE 3,35:INPUT ",CH%
5780 IF CH% =1 THEN R=1:GOTO 5340
5790 IF CH% = 2 THEN R=10:GOTO 5510
5800 IF CH% =2 THEN R=1:GOTO 5560
5810 IF CH% =3 THEN R=1:GOTO 5390
5820 IF CH% =3 THEN R=1:GOTO 5390
5830 PRINT CHR$(7):GOSUB 9400:GOTO 5780
5840 'CLS:LOCATE 2,1:INPUT "CONTINUE ADJUSTMENT ? (Y/N) ":,AS
5850 'IF AS="Y" OR AS="n" THEN 5854
5860 'IF AS="Y" OR AS="y" THEN RETURN
5870 GOTO 5850
5880 IF IB(I) > D THEN 5940
5890 IF DEP=1 THEN DEP=0:GOTO 5910
5900 JM=JM+1
5910 GOSUB 6090
5920 IF K=K+1:GOTO 5280
5930 CLS:PRINT CHR$(7):LOCATE 2,2:PRINT "DEPT. AREA CANNOT FIT IN PLANT AREA":GOSUB 9380
5950 IF NU% = 1 THEN 6000
5960 IF IA(I)=0 THEN 5990
5970 CLS:LOCATE 1,2:PRINT "SUGGESTION :INCREASE LENGTH OF DEPT."
5980 LOCATE 2,2:PRINT "OR CHANGE LOCATION OF NORTH WALL":GOTO 6040
CLS:LOCATE 1,2:PRINT "SUGGESTION :INCREASE LENGTH OF DEPT." : GOTO 6040
6000 IF IC(I)=0 THEN 6020
6010 CLS:LOCATE 1,2:PRINT "SUGGESTION :INCREASE WIDTH OF DEPT." : GOTO 6040
6020 CLS:LOCATE 1,2:PRINT "SUGGESTION :INCREASE WIDTH OF DEPT." : GOTO 6040
6030 LOCATE 2,2:PRINT "OR CHANGE LOCATION OF WEST WALL" : GOTO 6040
6040 LOCATE 3,2:INPUT "PRESS <ENTER> TO CONTINUE ",A$
6050 GOTO 5330
6051 REM ********* DRAW PLANT LAYOUT WITH GRID **********
6060 '~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
6070 ' DRAW NEW PLANT WITH GRID
6080 '~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
6090 GOSUB 9190:CLS:SCREEN 1:COLOR 1,4:KEY OFF:XSP=GRID
6100 SGRID=XSP*(FECT*NB)/D
6110 NGRID=INT((FECT*NB)/SGRID)
6120 XI=ST;YF=BWI;XF=EN;JJ=1
6130 GRIDX(1)=-_WI
6140 LAS=BWI+FECT*NB
6150 A1=EN-ST:B1=LAS-BWI
6160 DRAW "BM=ST;,,=BWI;"
6170 DRAW "C3;R=A1;D=B1;L=A1;U=B1;"
6180 'LINE (ST,BWI)-(EN,LAS),,B
6190 FOR J=2 TO NGRID
6200 GRIDX(J)=GRIDX(J-1)+SGRID
6210 DRAW "BM=XI;,=GRIDX(J);"
6220 DRAW "C2;R=A1;"
6230 'LINE (XI,GRIDX(J))-(XF,GRIDX(J)),,1
6240 NEXT J
6250 YSP=GRID:YCOL=BCOL
6260 PCOL=YCOL*(EN-ST)/L
6270 PGRID=YPSP*(EN-ST)/L
6280 MGRID=INT((EN-ST)/PGRID)
6290 YI=BWI:YFI=BWI+(FECT*NB)
6300 GRIDY(1)=ST
6310 FOR J=2 TO MGRID
6320 GRIDY(J)=GRIDY(J-1)+PGRID
6330 'LINE (GRIDY(J),YI)-(GRIDY(J),YF1),,1
6340 DRAW "BM=GRIDY(J);,,=YI;"
6350 DRAW "C2;D=B1;"
6360 NEXT J
6370 XCOL=ST
6380 FOR JK = 2 TO NCOL
6390 XCOL=XCOL+PCOL
6400 DRAW "BM=XCOL;,=YF;"
6410 DRAW "C1;D=B1;"
6420 'LINE (XCOL,YF)-(XCOL,YF1),,,&HFOF
6430 NEXT JK
6440 FOR J=2 TO NB
6450 YF=FECT+YF
DRAW "BM=XI;,,=YF;"
DRAW "C3;R=A1;"
'LINE (XI,YF)-(XF,YF),,,,&HFOF
NEXT J
WX=INT((ST/8+(EN-ST)/16)):WY=INT(BWI/8)
LOCATE WX,WX:PRINT L
LX=INT(EN/3+2):LY=INT((NB*FECT)/16+BWI/8)
LOCATE LY,LX:PRINT D
IF NUK%=1 THEN NUK%=0:RETURN

REM ********** CALCULATE LOCATION OF DEPARTMENT **********
'CAL. LOCATION OF DEPT.
.......................................
CAL. LOCATION OF DEPT.
.......................................
RAT = LO/L
FOR II= 1 TO JM
KK = SEQ%(II)
NW(II)=BWI+(IA(KK))*FECT/BW)
SW(II)=BWI+(IB(KK))*FECT/BW
WW(II)=ST+(IC(KK))*LO/L
EW(II)=ST+(EA(KK))*LO/L
Al=EW(II)-WW(II);Bl=SW(II)-NW(II)
DRAW "BM=WW(II);,=NW(II);"
DRAW "C3;R=Al;D=Bl;L=Al;U=Bl;"
'LINE (WW(II),NW(II)1-(EW(II),SW(II))2,B
NEXT II

REM ********** CALCULATE NEW CENTROID **********
'CAL. NEW CENTROID
.......................................
CAL. NEW CENTRIOD
.......................................
FOR M= 1 TO JM
XCEN(M)=WW(M)+(EW(M)-WW(M))/2
YCEN(M)=NW(M)+(SW(M)-NW(M))/2
XEN=INT(5.2/7*(XCEN(M)/6+.5))
YEN=INT((YCEN(M)/7.5)+.5)
LOCATE YEN,XEN
PRINT SEQ%(M)
NEXT M

REM ******************* CHANGE LAYOUT *******************
'CHANGE LAYOUT
.......................................
CHANGE LAYOUT
.......................................
GOSUB 9160:CLS:LOCATE 2,2:INPUT"DO YOU WANT TO CHANGE
LAYOUT? (Y/N) ",ZS
IF ZS="n"OR ZS="N" THEN JOE%=1:GOTO 6850
IF ZS="y"OR ZS="y" THEN 6850
PRINT CHR$(7):GOTO 6810
REM ********** DISPLAY DEPT. INFORMATION **********
'DISPLAY DEPT. INFO.
.......................................
DISPLAY DEPT. INFO.
.......................................
CLS:LOCATE 2,1:INPUT"DO YOU WANT DETAILS ABOUT
DEPT. (Y/N)"; ZS
6900 IF ZS="N" OR ZS="n" THEN GOSUB 9160: GOTO 6930
6910 IF ZS="Y" OR ZS="y" THEN 6950
6920 PRINT CHR$(7): GOTO 6890
6930 IF JOE%=1 THEN JOE%=0: GOTO 7210
6940 GOTO 7160
6950 CLS: LOCATE 2, 2: PRINT "ENTER DEPARTMENT NUMBER =>"
6960 LOCATE 2, 27: INPUT INF%
6970 IF INF% <= N% AND 0 < INF% THEN 6990
6980 PRINT CHR$(7): GOTO 6960
6990 CLS: LOCATE 1, 15: PRINT "DEPT. #" ; INF%
7000 O=INF%
7010 LOCATE 2, 1: PRINT "AREA =" ; Q(O)
7020 LOCATE 2, 15: PRINT "WIDTH =" ; WI(O)
7030 LOCATE 2, 28: PRINT "LENGTH =" ; LG(O)
7040 LOCATE 3, 7: INPUT "PRESS <ENTER> TO CONTINUE", ANSS
7050 CLS: LOCATE 1, 2: PRINT "N.WALL-N.WALL(" ; IA(I) ; ")"
7060 LOCATE 1, 21: PRINT "W.WALL-E.WALL(" ; EA(I) ; ")"
7070 LOCATE 2, 2: PRINT "N.WALL-S.WALL(" ; IB(I) ; ")"
7080 LOCATE 2, 21: PRINT "W.WALL-W.WALL(" ; IC(I) ; ")"
7090 LOCATE 3, 7: INPUT "PRESS <ENTER> TO CONTINUE", ANSS
7100 CLS: LOCATE 2, 2: INPUT "DETAILS OF OTHER DEPTS. (Y/N)" ; ZS
7110 IF ZS="N" OR ZS="n" THEN 7140
7120 IF ZS="Y" OR ZS="y" THEN 6950
7130 PRINT CHR$(7): GOTO 7100
7140 IF JOE%=1 THEN JOE%=0: GOTO 7210
7150 GOTO 7160
7160 CLS: LOCATE 2, 2: PRINT "ENTER DEPT. NUMBER TO CHANGE =>"
7170 LOCATE 2, 34: INPUT "" ; DE%
7180 IF DE% <= N% AND 0 < DE% THEN 7200
7190 PRINT CHR$(7): GOTO 7170
7200 I=DE%: DEP=1: GOTO 5330
7210 RETURN
7220 '**************************************************************************
7230 ' DRAW STAR AND LINE
7240 '**************************************************************************
7250 CLS: SCREEN 1, 0: COLOR 1, 4: KEY OFF
7260 'LINE (ST, BWI)-(EN, LAS), , , B
7270 YF=BWI: XI=ST: XF=EN: PCOL=BCOL* (EN-ST) / L
7280 FOR LL = 2 TO NB
7290 YF=YF+FCET
7300 'LINE (ST, YF)-(EN, YF), , , &HFOF
7310 NEXT LL
7320 FOR JK = 2 TO NCOL
7330 XI=XI+PCOL
7340 'LINE (XI, BWI)-(XI, LAS), , , &HFOF
7350 NEXT JK
7360 WX=INT((ST/8+(EN-ST)/16)): WY=INT(BWI/8)
7370 LOCATE WX, WY: PRINT L
7380 LX=INT(EN/8+2): LY=INT((NB*FCET)/16+BWI/8)
7390 LOCATE LY, LX: PRINT D
7400 FOR LA = 1 TO N%
7410 'LINE (WW(LA),NW(LA))-(EW(LA),SW(LA)),2,B
7420 NEXT LA
7430 STARS$="CIS8NUNDNENFNGNH"
7440 'DRAW STARS
7450 FOR LB =2 TO N%
7460 PX=XCENT(LB-1):PX1=XCENT(LB):PY=YCENT(LB-1):PY1=YCENT(LB)
7470 IF KUS="1"THEN GOTO 7490
7480 'DRAW"M=PX1,=PY1:";DRAW"M=PX1,=PY1;":GOTO 7500
7490 'DRAW"M=PX1,=PY1;":DRAW"M=PX1,=PY1;"
7500 'DRAW STARS
7510 NEXT LB
7520 GOSUB 9160:CLS:LOCATE 2,2:PRINT "PRESS <ENTER> TO CONTINUE"
7530 AS=INPUTS(1)
7540 IF KUS ="1" THEN KUS="2":RETURN
7550 '************************************************************************
7560 'CAL. COST
7570 '************************************************************************
7571 GOTO 7690
7580 CSUB1=0:CSUB2=0
7590 FOR N=1 TO N%
7600 FOR M=1 TO N%
7610 XSUB=ABS(XCENT(M)-XCENT(N))
7620 YSUB=ABS(YCENT(M)-YCENT(N))
7630 SSUB1=XSUB+YSUB
7640 SSUB2=SQR(XSUB^2+YSUB^2)
7650 CSUB1=CSUB1+(SSUB1*C(N,M))
7660 CSUB2=CSUB2+(SSUB2*C(N,M))
7670 NEXT M
7680 NEXT N
7690 '************************************************************************
7700 'SUMMARY OF MODIFIED LAYOUT
7710 '************************************************************************
7720 IF CS="R" OR CS="r" THEN 7740
7730 CLS:LOCATE 2,2:PRINT "HANDLING COST (EUCLIDEAN):";CO:GOTO 7750
7740 LOCATE 2,2:PRINT "HANDLING COST (RECTILINEAR):";CO
7750 LOCATE 3,7:PRINT "PRESS < ENTER > TO CONTINUE"
7760 AS=INPUTS(1)
7770 CLS:LOCATE 1,1:PRINT "1-Print Summary 2-Print Details of Dept"
7780 LOCATE 2,1:PRINT "3-Save graphics"
7790 LOCATE 3,1:PRINT "4-Graphics Menu 5-Main Menu :	"
7800 LOCATE 3,31:INPUT "",MO%
7810 IF MO% = 1 THEN GOSUB 7900:GOTO 7770
7820 IF MO% = 2 THEN GOSUB 8190:GOTO 7770
7830 IF MO% = 3 THEN GOSUB 9160:GOSUB 9220:GOSUB 8400:GOTO 7770
7840 IF MO%=4 THEN GOTO 510
7850 IF MO%=5 THEN RUN "HELLO"
7860 PRINT CHR$(7):GOTO 7800
7861 REM ********** SEND OUTPUT TO PRINTER **********
7870 '***********PRINTER HARD COPY
7880 '***********
7890 LPRINT: LPRINT TAB(15)"SUMMARY OF LAYOUT AFTER
7900 ARRAGEMENT."
7910 LPRINT: LPRINT "PLANT AREA: ";L*D
7920 LPRINT "PLANT LENGTH: ";L
7930 LPRINT "PLANT WIDTH : ";D: LPRINT
7940 LPRINT "NUMBER OF LONGITUDINAL BAYS: ";NB
7950 LPRINT "NUMBER OF LATERAL BAYS: ";NCOL
7960 LPRINT "LENGTH OF BAYS: ";BCOL
7970 LPRINT "WIDTH OF BAYS : ";BW
7980 LPRINT "NUMBER OF DEPARTMENTS: ";N%: LPRINT
7990 LPRINT "DEPT. SEQUENCE (DEPT. AREA): ";CT=0: LPRINT;
8000 ZX%=0
8010 IF (N%/5) = INT(N%/5) THEN KK=N%/5: GOTO 8030
8020 KK=INT(N%/5)+1
8030 FOR I= 1 TO KK
8040 IF N%-(5*I) >= 0 THEN II=5: GOTO 8060
8050 II=N%-(5*(I-1))
8060 FOR NM=1 TO II
8070 NU=5*(I-1)+NM
8080 LPRINT SEQ%(NU);
8090 LPRINT "( ";INT(NN(SEQ%(NU))*BW+.5); ");"
8100 IF FX%(SEQ%(NU))=1 THEN LPRINT"** ";ZX%=1
8110 IF NU < N% THEN LPRINT "-";
8120 NEXT NM
8130 LPRINT
8140 NEXT I
8150 LPRINT": IF ZX%=1 THEN : LPRINT"** DESIGNATES DEPARTMENTS
8160 WITH FIXED SEQUENCE": LPRINT"" ELSE LPRINT""
8170 IF CS="R" OR CS="r" THEN 8170
8180 LPRINT: LPRINT "TOTAL HANDLING COST : ";CO;" BASED
8190 UPON EUCLIDEAN DISTANCE": GOTO 8180
8200 LPRINT: LPRINT "TOTAL HANDLING COST : ";CO;" BASED
8210 UPON RECTILINEAR DISTANCE"
8220 RETURN
8230 N=1: IF ERL=8210 THEN GOTO 10000
8240 FOR JU = 1 TO N%
8260 TAB(10)"DEPT. NO.": JU
8270 LPRINT: LPRINT TAB(10)"AREA OF DEPT. = ";Q(JU)
8280 LPRINT: LPRINT TAB(10)"WIDTH OF DEPT. = ";WI(JU)
8290 LPRINT: LPRINT TAB(10)"LENGTH OF DEPT. = ";LG(JU)
8300 LPRINT: LPRINT TAB(10)"DISTANCE FROM NORTH WALL OF PLANT
8310 TO NORTH WALL OF DEPT. = ";IA(JU)
8320 LPRINT: LPRINT TAB(10)"DISTANCE FROM NORTH WALL OF PLANT
8330 TO SOUTH WALL OF DEPT. = ";IB(JU)
8340 LPRINT: LPRINT TAB(10)"DISTANCE FROM WEST WALL OF PLANT
8350 TO WEST WALL OF DEPT. = ";IC(JU)
8360 LPRINT: LPRINT TAB(10)"DISTANCE FROM WEST WALL OF PLANT
8370 TO WEST WALL OF DEPT. = ";IC(JU)
TO EAST WALL OF DEPT. =";EA(JU)
8290 K=K+1
8300 IF K > 2 THEN K=1 :LPRINT:LPRINT CHR$(12)
8310 NEXT JU
8320 RETURN
8330 REM ********** GET FILENAME AND DRIVE **********
8330 CLS:LOCATE 2,2:INPUT"ENTER THE FILE NAME";GS
8340 LOCATE 3,2:INPUT"ENTER THE DISK DRIVE I.D. (A, B, OR C):";FS
8350 ON ERROR GOTO 8690
8360 '*******************************************************************
8370 ' OPEN CGRAPH FILE FOR OUTPUT
8380 '*******************************************************************
8390 'FS=FS+"";+GS
8400 OPEN "O",1,FS
8410 PRINT #1,"MGGRAPH"
8420 PRINT #1,N%:PRINT #1,CSUB1:PRINT #1,CSUB2:PRINT
8430 #1,GRID:PRINT #1,ST:PRINT #1,BWI:PRINT #1,EN:PRINT
8440 #1,LAS:PRINT #1,RECT:PRINT #1,NB:PRINT #1,RAT:PRINT
8450 FOR I = 1 TO N%
8460 INPUT #1,NW(I),SW(I),WW(I),BW(I),EI(I),EI(I),EA(I),IC(I),Y(I)
8470 NEXT I
8480 RETURN
8490 CLS:LOCATE 5,1:PRINT TAB(10):INPUT"ENTER THE FILE NAME";GS
8500 PRINT:PRINT TAB(10):INPUT"ENTER THE DISK DRIVE I.D. (A, B, OR C):";FS
8510 ON ERROR GOTO 8690
8520 FS=FS+"";+GS
8530 '*******************************************************************
8540 ' OPEN CGRAPH FILE FOR INPUT
8550 '*******************************************************************
8560 OPEN "I",#1,FS
8570 INPUT #1,TESTS
8580 IF TESTS="MGGRAPH" THEN 8590 ELSE 8750
8590 INPUT #1,N%:INPUT #1,CSUB1:INPUT #1,CSUB2:INPUT
8600 #1,GRID:INPUT #1,ST:INPUT #1,BWI:INPUT #1,EN:INPUT
8610 #1,LAS:INPUT #1,RECT:INPUT #1,NB:INPUT #1,RAT:INPUT
8620 FOR I = 1 TO N%
8630 INPUT #1,NW(I),SW(I),WW(I),EI(I),EI(I),EA(I),IC(I),Y(I)
8640 NEXT I
8650 RETURN
8660 '**************************************************************************
8670 ' ERROR MESSAGE
8680 '**************************************************************************
8690 IF ERL=8400 THEN 8719
8700 IF ERL=8560 THEN 8720
8710 'ON ERROR GOTO 0
8719 CLS:LOCATE 2,2:PRINT "***** ERROR WRITING TO DISK FILE  
8720 CLS:LOCATE 2,2:PRINT "***** ERROR READING DISK FILE *****"
8730 LOCATE 3,7:INPUT "PRESS < ENTER > TO CONTINUE", AS
8740 RESUME 7770
8750 GOSUB 9160:CLS:LOCATE 2,7:PRINT "****:GOTO 8730
8760 LOCATE 3,7:INPUT "PRESS < ENTER > TO CONTINUE "; A$
8770 RESUME 510
8780 GOSUB 9190:CLS:SCREEN 1:COLOR 1,4:KEY OFF
8790 XI=ST:XF=EN:YF=BWI:YF1=LAS:PCOL=BCOL*(EN-ST)/L
8795 A1=EN-ST:B1=LAS-BWI
8796 DRAW "BM=XI;=BWI;"
8797 DRAW "C1;R=A1;D=B1;L=A1;U=B1;"
8800 'LINE(ST,BWI)-(EN,LAS),,,B
8810 FOR JK = 2 TO NCOL
8820 XI=XI+PCOL
8830 DRAW "BM=XI;=BWI;"
8835 DRAW "C2;D=B1;"
8840 NEXT JK
8850 FOR J=2 TO NB
8860 YF=PECT+YF
8865 DRAW "BM=ST;=YF;"
8866 DRAW "C3;R=A1;"
8870 'LINE (ST,YF)-(EN,YF),,,&HFOF
8880 NEXT J
8890 FOR NM = 1 TO N%
8895 A2=EW(NM)-WW(NM):B2=SW(NM)-NW(NM)
8896 DRAW "BM=WW(NM);=NW(NM);"
8897 DRAW "C3;R=A2;D=B2;L=A2;U=B2;"
8900 'LINE (WW(NM),NW(NM))-(EW(NM),SW(NM)),2,B
8910 XEN = INT(5.2/7*(XCEN(NM)/6+.5))
8920 YEN = INT(YCEN(NM)/7.5)
8930 LOCATE YEN,XEN:PRINT SEQ%(NM)
8940 NEXT NM
8950 RETURN
8990 '**************************************************************************
9000 ' CALCULATE COST
9010 '**************************************************************************
9020 CSUB1=0:CSUB2=0
9030 FOR N= 2 TO N%+1
9040 FOR M= 2 TO N%+1
9050 XSUB=ABS(XCEN(M)-XCEN(N))
9060 YSUB=ABS(YCEN(M)-YCEN(N))
9070 SSUB1=XSUB+YSUB
9080 SSUB2=SQRT(XSUB^2+YSUB^2)
9090 CSUB1=CSUB1+(SSUB1*C(N,M))
9100 CSUB2=CSUB2+(SSUB2*C(N,M))
9110 NEXT M
9120 NEXT N
9130 RETURN
9140 'WINDOW (0,0)-(L*1.5,L*1.5)
9150 RETURN
9160 WIDTH 40
9170 SCREEN 1:VIEW (1,1)-(315,25),,2
9180 RETURN
9190 VIEW (1,26)-(315,195),,1
9200 RETURN
9210 GOSUB 9160:GOSUB 9220:GOSUB 9270:RETURN
9220 CLS:LOCATE 2,2:INPUT "FILE NAME ":,GS
9230 LOCATE 3,2:INPUT "DISK DRIVE I.D. (A, B OR C) ":,FS
9240 'IF FS = "A" OR FS = "B" OR FS = "C" GOTO 9260
9250 'IF FS <> "a" OR FS <> "b" OR FS <> "c" THEN GOSUB
9260:CLS:LOCATE 2,6:PRINT "ERROR IN DISK DRIVE I.D ":GOSUB
9280:CLS:GOTO 9220
9290 FS=FS+" ":+GS:RETURN
9300 REM ***** OPEN CRAFT FILE FOR OUTPUT **********
9310 OPEN "O",1,FS
9320 PRINT ",CRAFT"
9330 PRINT #1,CS:PRINT #1,N%:PRINT #1,X%:PRINT #1,NB:PRINT
9340 PRINT #1,L:PRINT #1,W:PRINT #1,BW:PRINT #1,CO:PRINT #1,NCOL:PRINT
9350 PRINT #1,BCOL
9360 FOR I=A TO X%:IF I>N% THEN 9330
9370 PRINT #1,LL(I):PRINT #1,Q(I):PRINT #1,SEQ%(I):PRINT
9380 PRINT #1,FX%(I)
9390 FOR J=1 TO N%:PRINT #1,C(I,J):PRINT #1,NT(I,J):PRINT
9400 PRINT #1,CST(I,J):NEXT J
9410 PRINT #1,X(I):PRINT #1,Y(I):PRINT #1,DP%(I):PRINT
9420 PRINT #1,LA(I):NEXT I
9430 CLOSE #1:RETURN
9440 PRINT CHRS(7):FOR IO=1 TO 1000:NEXT IO
9450 PRINT CHRS(7):RETURN
9460 ' 
9470 PRINT:INPUT "PRESS <ENTER> TO CONTINUE.",AS:RETURN
9480 ' 
9490 PRINT CHRS(7):CLS:LOCATE 2,7:COLOR 4,0:PRINT "** ERROR IN INPUT **":COLOR 3,0:GOSUB 9380:RETURN
10000 CLS:PRINT CHRS(7):LOCATE 1,1:PRINT "CHECK YOUR PRINTER!"
10010 PRINT:LOCATE 2,1:INPUT "PRESS <ENTER> TO CONTINUE.",AS
10020 RESUME 7770
VARIABLE LISTING FOR CGRAPH

A(I) Variable for array for storing the last reference point of department I.

AR1,2,3 Variable for storing the sub-area of department I.

B Variable for storing the number of longitudinal bays.

B(I) Variable for array for storing the last reference point of department I.

BW Variable for storing the width of bays.

BWI Variable for storing the Y co-ordinate of the origin of the plant's area.

C(J,I) Variable for array for storing the handling cost from department J to department I.

CO Variable for storing the CRAFT calculated material handling cost.

CST(J,I) Variable for array for storing the handling cost per trip per distance from department J to I.

CS String variable for the type of calculation cost (euclidean or rectilinear).

CT Variable for the counter for the number of departments.

CX Variable for the X co-ordinate of the department centroid.

CY Variable for the Y co-ordinate of the department centroid.

D Variable for the width of the plant.

EA(I) Variable for array for the distance from the west wall of the plant to the east wall of department I.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW(I)</td>
<td>Variable for array for the distance from the west wall of the plant to the east wall of department I.</td>
</tr>
<tr>
<td>EN</td>
<td>Variable for the X co-ordinate of the ending point of the plant’s area.</td>
</tr>
<tr>
<td>FACT.LECT</td>
<td>Variable for the width of bay in the layout.</td>
</tr>
<tr>
<td>FX%(I)</td>
<td>Variable for array for fixing the location of department I.</td>
</tr>
<tr>
<td>GRID</td>
<td>Variable for the grid size.</td>
</tr>
<tr>
<td>IA(I)</td>
<td>Variable for the array for the distance from the north wall of the plant to the north wall of department I.</td>
</tr>
<tr>
<td>IB(I)</td>
<td>Variable for the array for the distance from the north wall of the plant to the south wall of department I.</td>
</tr>
<tr>
<td>IC(I)</td>
<td>Variable for the array for the distance from the west wall of the plant to the west wall of department I.</td>
</tr>
<tr>
<td>L</td>
<td>Variable for the length of the plant.</td>
</tr>
<tr>
<td>LN</td>
<td>Variable for the Y co-ordinate of the origin point of the plant area.</td>
</tr>
<tr>
<td>LAS</td>
<td>Variable for the Y co-ordinate of the ending point of the plant area.</td>
</tr>
<tr>
<td>LE,LO</td>
<td>Variable for the length of the plant in the layout.</td>
</tr>
<tr>
<td>LG(I)</td>
<td>Variable for the array for the distance from the west wall of department I to the east wall of department I.</td>
</tr>
<tr>
<td>LL(I)</td>
<td>Variable for the array for storing the length of department I.</td>
</tr>
<tr>
<td>MGRID</td>
<td>Number of grid spacing along the Y axis.</td>
</tr>
<tr>
<td>MX</td>
<td>The X co-ordinate of the centroid of the department.</td>
</tr>
<tr>
<td>MY</td>
<td>The Y co-ordinate of the centroid of the department.</td>
</tr>
<tr>
<td>Variable</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>N%</td>
<td>The number of departments.</td>
</tr>
<tr>
<td>NGRID</td>
<td>Number of grid spacing along the X axis.</td>
</tr>
<tr>
<td>N1(I)</td>
<td>Variable for the array for the length of department I.</td>
</tr>
<tr>
<td>NT(J,I)</td>
<td>Variable for the array for the number of trips from department J to I.</td>
</tr>
<tr>
<td>NU(I)</td>
<td>Length of department I.</td>
</tr>
<tr>
<td>NW(I)</td>
<td>Variable for the array for the distance from the north wall of the plant to the north wall of department I.</td>
</tr>
<tr>
<td>PGRID</td>
<td>Length of grid along the Y axis.</td>
</tr>
<tr>
<td>PIC%(I,J)</td>
<td>Variable for array for storing the alphanumeric layout pattern in the previous CRAFT software.</td>
</tr>
<tr>
<td>SEQ%(I)</td>
<td>Variable for array for storing the sequence of the departments.</td>
</tr>
<tr>
<td>SGRID</td>
<td>Length of grid along the X axis.</td>
</tr>
<tr>
<td>SP</td>
<td>The X co-ordinate of the ending point of the plant's area.</td>
</tr>
<tr>
<td>SQ,ST</td>
<td>The X co-ordinate of the origin point of the plant's area.</td>
</tr>
<tr>
<td>STARS</td>
<td>Centroid marker.</td>
</tr>
<tr>
<td>SW,WI(I)</td>
<td>Variable for array for the distance from the north wall of the plant to the south wall of department I.</td>
</tr>
<tr>
<td>WID,WOD</td>
<td>Variable for the width of the plant in the layout.</td>
</tr>
<tr>
<td>WW(I)</td>
<td>Variable for array for the distance from the west wall of the plant to the west wall of department I.</td>
</tr>
<tr>
<td>XC(I)</td>
<td>Variable for array for the X co-ordinate of centroid of department I.</td>
</tr>
<tr>
<td>XCEN(I)</td>
<td>The X co-ordinate of the centroid of department I in the layout.</td>
</tr>
<tr>
<td>XEN(I)</td>
<td>The X co-ordinate of the centroid of department I in the layout.</td>
</tr>
<tr>
<td>XSP</td>
<td>The length of the grid along the X axis.</td>
</tr>
<tr>
<td>Variable</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>YC(I)</td>
<td>Variable for array for the Y co-ordinate of centroid of department I.</td>
</tr>
<tr>
<td>YCEN/I</td>
<td>The length of the grid along the Y axis.</td>
</tr>
<tr>
<td>YSP</td>
<td>The Y co-ordinate of the ending point of the plant's area.</td>
</tr>
</tbody>
</table>
CGRAPH MODULE

- INITIALIZE VARIABLE
- READ DATA FILE FROM CRAFT
- CALCULATE FOR GRAPHIC OUTPUT
- DRAW GRAPHIC OF PLANT LAYOUT

**GRAPHICS MENU**
1. PRINT
2. RERUN CRAFT
3. CHANGE SPEC.
4. ADJUST
5. SAVE
6. DISPLAY
7. AISLE
8. EXIT

**Flowchart**
- A
  - 1. PRINTER OUTPUT
  - 2. CRAFT MODULE
  - 3. CHANGE SPEC. MODULE
  - 4. ADJ
  - 5. SAVE TO DISK FILE
  - 6. RETRIEVE ADJUSTED LAYOUT FROM DISK
  - 7. AISLE MODULE
  - 8. HELLO MODULE
GRID
DRAW
GRID
CALCULATE AND
DRAW LAYOUT.
ADJ.

ENTER SIZE OF
GRID

DISPLAY
GRID ?

DRAW GRID

CALCULATE AND
DRAW LAYOUT.

CHG.
GRID SIZE ?

ADJ. INFO. INPUT
FOR EACH DEPT.

CHECK FOR FIT

DAD

DAD

DRAW ADJUSTED
DEPARTMENT

CHANGE
LAYOUT ?

DEPT.
DETAILS ?

IDENTIFY
DEPT. FOR
DETAILS

DISPLAY
IDENT.
DEPT.
DETAIL

MORE
DETAIL ?

ADJUST

Y/N

Y/N

Y

Y

N

B

C

A

A

B

N

N

N

Y

Y

Y

N
SUMMARY MENU
1. PRT SUMMARY
2. PRT DEPT.
3. DETAIL
4. SAYE
5. GRAPHIC MENU
6. HELLO MENU

1. PRINTER OUTPUT

2. PRINTER OUTPUT

3. SAYE TO DISK

4. CGRAPH MODULE

5. HELLO MODULE
APPENDIX A5


10 ' DISPLAY AND CHANGE INPUT DATA OF PLANT
20 ' *******************************************
30 CLEAR
40 A=1:B=2:C=3:KI%=24:Z=0:TN%=10:CENT%=100:ZQ%=0:T1%=30:P5=.5:X ZZ=0
50 GOSUB 1440
60 AREA=L*W:KEY OFF

70 REM ******** Graphic Display of Menu ********
80 SCREEN 1:GOSUB 1570:CLS
90 LOCATE 1,2:PRINT "1-Area 2-Width 3-Length 4-Bay Width"
100 LOCATE 2,2:PRINT "5-#.Long Bay 6-#.Lat Bay 7-Bay Length"
110 MA%=1:FI%=1:GOSUB 160:GOTO 70
120 GOSUB 2100:GOSUB 1630:GOSUB 1570:RUN "CGRAPH"
130 ' *******************************************
140 ' CRAFT CHANGING DATA MENU 1
150 ' *******************************************
160 LOCATE 3,38:INPUT ",",W%
170 IF W%=1 THEN GOSUB 260:RETURN
180 IF W%=2 THEN GOSUB 390:RETURN
190 IF W%=3 THEN GOSUB 650:RETURN
200 IF W%=4 THEN GOSUB 920:RETURN
210 IF W%=5 THEN GOSUB 1040:RETURN
220 IF W%=6 THEN GOSUB 1280:RETURN
230 IF W%=7 THEN GOSUB 1160:RETURN
240 IF W%=8 THEN GOTO 120
241 IF W%=9 THEN GOSUB 2060:RUN "CGRAPH"
250 GOTO 160
251 REM ********* Change Module *********
260 REM ********** Change Plant Area *********
270 CLS:GOSUB 1570:LOCATE 2,2:PRINT "ENTER NEW AREA (";CINT(L*W);" )"
271 LOCATE 2,30:INPUT ": ",AREA
280 IF AREA > 0 THEN 300
290 CLS:LOCATE 2,2:PRINT "PLANT AREA MUST BE > 0. ":GOSUB 2010:GOTO 270
300 IF AREA < SUMX THEN CLS:LOCATE 2,2:PRINT "PLANT WILL BE TOO SMALL FOR THE DEPTS. ":GOSUB 2010:GOTO 270
310 CLS:GOSUB 1570
320 LOCATE 1,2:PRINT "1) Fixed Width of Plant (";CINT(W);")"
330 LOCATE 2,2:PRINT "2) Fixed Length of Plant (";CINT(L);")"
340 LOCATE 3,2:INPUT " ENTER YOUR SELECTION : ",AH%
350 IF AH%=1 THEN L=AREA/W :GOTO 580
360 IF AH%=2 THEN W=AREA/L:WI%=1:GOTO 500
370 GOTO 310
380 REM ******** Change Width of Plant ********
390 CLS:GOSUB 1570:LOCATE 2,2:PRINT "ENTER NEW WIDTH
391 LOCATE 2,30:INPUT ":" ,W
400 IF W > 0 THEN 420
410 CLS:LOCATE 2,2:PRINT "PLANT'S WIDTH MUST BE > 0.":GOSUB 2010:GOTO 390
420 CLS:GOSUB 1570
430 LOCATE 2,1:PRINT "1) FIXED PLANT AREA (";AREA;")"
440 LOCATE 2,2:PRINT "2) FIXED LENGTH OF PLANT (";CINT(L);")"
450 LOCATE 3,2:INPUT "ENTER YOUR SELECTION : ";AH%
460 IF AH%=1 THEN L=AREA/W :GOTO 500
480 IF AH%=2 THEN AREA=W*L :WIT%=1:GOTO 500
490 GOTO 420
500 CLS:GOSUB 1570
510 LOCATE 1,2:PRINT "1) FIXED NUMBER OF LONG BAY (";CINT(NB);")"
520 LOCATE 2,2:PRINT "2) FIXED WIDTH OF BAY (";CINT(BW);")"
530 LOCATE 3,2:INPUT "ENTER YOUR SELECTION : ";AH%
540 IF AH%=1 THEN BW=W/NB :GOTO 570
550 IF AH%=2 THEN NB=W/BW :GOTO 570
560 GOTO 500
570 IF WIT%=1 THEN WIT%=0 :RETURN
580 CLS:GOSUB 1570:LOCATE 1,2:PRINT "1) FIXED NUMBER OF LAT BAY (";CINT(NCOL);")"
590 LOCATE 2,2:PRINT "2) FIXED LENGTH OF BAY (";CINT(BCOL);")"
600 LOCATE 3,2:INPUT "ENTER YOUR SELECTION : ";AH%
610 IF AH%=1 THEN BCOL=L/NCOL :RETURN
620 IF AH%=2 THEN NCOL=L/BCOL :RETURN
630 GOTO 580
640 REM ***** CHANGE LENGTH OF PLANT ***************
650 CLS:GOSUB 1570:LOCATE 2,2:PRINT "ENTER NEW LENGTH (";CINT(L);")"
651 LOCATE 2,30:INPUT ":" ,L
660 IF L > 0 THEN 680
670 CLS:LOCATE 2,2:PRINT "PLANT'S LENGTH MUST BE > 0.":GOSUB 2010:GOTO 650
680 CLS:GOSUB 1570
690 LOCATE 1,2:PRINT "1) FIXED PLANT AREA (";AREA;")"
700 LOCATE 2,2:PRINT "2) FIXED WIDTH OF PLANT (";CINT(W);")"
710 LOCATE 3,2:INPUT "ENTER YOUR SELECTION : ";AH%
720 IF AH%=1 THEN W=AREA/L :GOTO 760
730 IF AH%=2 AND W*L < SUMX THEN CLS:LOCATE 2,2:PRINT "PLANT WILL BE TOO SMALL FOR THE DEPTS." :GOSUB 2010:GOTO 650
740 IF AH%=2 THEN AREA=W*L :WIT%=1:GOTO 760
750 GOTO 680
760 CLS:GOSUB 1570
770 LOCATE 1,2:PRINT "1) FIXED NUMBER OF LAT BAYS (";CINT(NCOL);")"
780 LOCATE 2,2:PRINT "2) FIXED LENGTH OF BAY (";CINT(BCOL);")"
790 LOCATE 3,2:INPUT "ENTER YOUR SELECTION : ";AH%
800 IF AH%=1 THEN BCOL=L/NCOL :GOTO 830
810 IF AH%=2 THEN NCOL=L/BCOL:GOTO 830
820 GOTO 760
830 IF WIT%=1 THEN WIT%=0:RETURN
840 CLS:GOSUB 1570
850 LOCATE 1,2:PRINT "1) FIXED NUMBER OF LONG BAY (";CINT(NB);")"
860 LOCATE 2,2:PRINT "2) FIXED WIDTH OF BAY (";CINT(BW);")"
870 LOCATE 3,2:INPUT " ENTER YOUR SELECTION : ";AH%
880 IF AH%=1 THEN BW=W/NB :RETURN
890 IF AH%=2 THEN NB=W/BW:RETURN
900 GOTO 840
910 REM *************** CHANGE WIDTH OF BAY *****************
920 CLS:GOSUB 1570:LOCATE 2,2:PRINT "ENTER NEW BAY WIDTH (";CINT(BW);")"
930 LOCATE 2,30:INPUT ":",BW
940 IF BW > 0 THEN 950
950 CLS:LOCATE 2,2:PRINT "LENGTH OF BAY MUST BE > 0. ":GOSUB 2010:GOTO 920
960 CLS:GOSUB 1570
970 LOCATE 1,2:PRINT "1) FIXED NUMBER OF LONG BAYS (";CINT(NB);")"
980 LOCATE 2,2:PRINT "2) FIXED WIDTH OF PLANT (";CINT(W);")"
990 LOCATE 3,3:INPUT " ENTER YOUR SELECTION : ";AH%
1000 IF AH%=1 AND NB*BW*L < SUMX THEN CLS:LOCATE 2,2:PRINT "PLANT WILL BE TOO SMALL FOR THE DEPTS. ":GOSUB 2010:GOTO 920
1010 IF AH%=1 THEN W=NB*BW :AREA=W*L:RETURN
1020 IF AH%=2 THEN NB=W/BW:RETURN
1030 GOTO 950
1040 REM ********** CHANGE # OF LONGITUDINAL BAYS ************
1050 CLS:GOSUB 1570:LOCATE 2,2:PRINT "ENTER NUMBER OF LONG BAYS (";CINT(NB);")"
1060 LOCATE 2,35:INPUT ":",NB
1070 IF NB > 0 THEN 1070
1080 CLS:LOCATE 2,2:PRINT "NUMBER OF BAYS MUST BE > 0 >":GOSUB 2010:GOTO 1040
1090 CLS:GOSUB 1570
1100 LOCATE 1,2:PRINT "1) FIXED WIDTH OF BAY (";CINT(BW);")"
1110 LOCATE 2,2:PRINT "2) FIXED WIDTH OF PLANT (";CINT(W);")"
1120 LOCATE 3,2:INPUT " ENTER YOUR SELECTION : ";AH%
1130 IF AH%=1 AND NB*BW*L < SUMX THEN CLS:LOCATE 2,2:PRINT "PLANT WILL BE TOO SMALL FOR THE DEPTS. ":GOSUB 2010:GOTO 1040
1140 IF AH%=1 THEN W=NB*BW:AREA=W*L:RETURN
1150 IF AH%=2 THEN NB=W/BW:RETURN
1160 GOTO 1070
1170 REM ************ CHANGE LENGTH OF BAY ******************
1180 CLS:GOSUB 1570:LOCATE 2,2:PRINT "ENTER LENGTH OF BAY (";CINT(BCOL);")"
1190 LOCATE 2,30:INPUT ":",BCOL
1200 IF BCOL > 0 THEN 1190
1210 LOCATE 1,2:PRINT "LENGTH OF BAY MUST BE > 0. ":GOSUB 2010:GOTO 1160
1220 CLS:GOSUB 1570
1200 LOCATE 1,2:PRINT "1) FIXED NUMBER OF LAT BAYS"
(";CINT(NCOL):")"
1210 LOCATE 2,2:PRINT "2) FIXED LENGTH OF PLANT (";CINT(L):")"
1220 LOCATE 3,2:PRINT "ENTER YOUR SELECTION : ";AH%
1230 IF AH%=1 AND W*NCOL*BCOL < SUMX THEN CLS:LOCATE 2,2:PRINT
"PLANT WILL BE TOO SMALL FOR THE DEPTS.":GOSUB 2010:GOTO 1160
1240 IF AH%=1 THEN L=NCOL*BCOL:AREA=W*L:RETURN
1250 IF AH%=2 THEN NCOL=L/BCOL:RETURN
1260 GOTO 1190
1270 REM ******** CHANGE NUMBER OF LATERAL BAYS *********
1280 CLS:GOSUB 1570:LOCATE 2,2:PRINT "ENTER NUMBER OF LAT BAYS"
(";CINT(NCOL):")"
1290 IF NCOL > 0 THEN 1310
1300 CLS:LOCATE 2,2:PRINT "NUMBER OF LAT BAYS MUST BE > 0.":GOSUB 2010:GOTO 1280
1310 CLS:GOSUB 1570
1320 LOCATE 1,2:PRINT "1) FIXED LENGTH OF BAY"
(";CINT(BCOL):")"
1330 LOCATE 2,2:PRINT "2) FIXED LENGTH OF PLANT (";CINT(L):")"
1340 LOCATE 3,2:PRINT "ENTER YOUR SELECTION : ";AH%
1350 IF AH%=1 AND W*NCOL*BCOL < SUMX THEN CLS:LOCATE 2,2:PRINT
"PLANT WILL BE TOO SMALL FOR THE DEPTS.":GOSUB 2010:GOTO 123:
1360 IF AH%=1 THEN L=NCOL*BCOL:AREA=W*L:RETURN
1370 IF AH%=2 THEN NCOL=L/BCOL:RETURN
1380 GOTO 1310
1390 ' ** CRAFT FILE FOR INPUT **
1400 OPEN "I",1,"XDATA"
1410 SUMX=0
1420 INPUT #1,C$,I%,NA%,NB,L,W,BW,LO,NCOL,BCOL
1430 FOR I=A TO NA%:IF I>I% THEN 1540
1440 INPUT #1,LD(I),Q(I),SQ%(I,A),FX%(I)
1450 SUMX=SUMX+Q(I)
1460 FOR J=A TO I%:INPUT #1,C(I,J),NT(I,J),CST(I,J):NEXT J
1470 FOR I=A TO NA%:IF I>I% THEN 1510
1480 PRINT #1,LD(I),Q(I),SQ%(I,A),FX%(I)
1490 CLOSE #1
1500 RETURN
1510 WIDTH 40
1520 VIEW (1,1)-(315,25),,2
1530 RETURN
1540 ' ** CRAFT FILE FOR OUTPUT **
1550 OPEN "O",1,"CDATA"
1560 PRINT #1,CS:PRINT #1,I%,NA%,NB,L,W,BW,LO,NCOL,BCOL
1570 FOR I=A TO NA%:IF I>I% THEN 1710
1580 PRINT #1,LD(I),Q(I),SQ%(I,A),FX%(I)
1590 FOR I=A TO NA%:IF I>I% THEN 1710
1600 PRINT #1,LD(I):PRINT #1,Q(I):PRINT #1,FX%(I)
1700 FOR J=A TO I%:PRINT #1,C(I,J):PRINT #1,NT(I,J):PRINT #1,LX(I):NEXT J
1710 PRINT #1,LY(I):PRINT #1,DP%(I):PRINT #1,PA;T #1:LA(1):EXIT
1720 CLOSE #1
1730 RETURN
2000 REM ********** PAUSE AFTER AN ERROR IN INPUT **********
2010 LOCATE 3,2:INPUT "PRESS <ENTER> TO CONTINUE.";AS
2020 GOSUB 1570:RETURN
2080 OPEN "I",1, "XDATA"
2090 GOSUB 148C
2100 "RE-ADJUST DEPT. AREA AFTER CHANGE
2100 "*************************************
2100 NA%=NB+I%-A
2150 I=1
2200 LS(I)=Q(I)/BW
2250 I=I+1
2300 IF I<=I% THEN 2600
2300 "************************************************************************
2310 'CALULATE HANDLING COST
2310 "****************************************************************************
2310 CLS:GOSUB 1570:LOCATE 2,2:PRINT "PLEASE WAIT....";
2320 IF ZQ%=1 THEN 3060
2330 LOCATE 3,2:PRINT "PRESS ANY KEY TO STOP."
2340 SUM=0:IS%=B:IT%=A:GOSUB 3110:GOSUB 3270:GOSUB 1100:B=GOTO 3090
2350 KC%=Z:LO=SUM:FOR KE=A TO I%:IF SQ%(KE,A) THEN KC%=KC%+B:GOTO 3090
2360 KC%=KC%+C
2370 SQ%(KE,IS%) = SQ%(KE,IT%):'PRINT SQ%(KE,A);IF KE < I% THEN PRINT ";":IF KC% > = K1% THEN KC% = Z:'PRINT ':PRINT;
2380 NEXT KE:'PRINT TAB( 65 ); INT (CENT% * LO + P5) / CENT%: RETURN
2390 R = A: SUM = Z;YB = W / (B * NB): LN = Z:DIR% = A:AN% = A:YC = YB: FOR I = A TO I%: J% = SQ%(I,IT%): LD = LD(J%):SUM = SUM + LD: IF SUM > L AND AN% < NA% THEN 3170
2400 LA(AN%) = LD: IF DIR% = - R THEN 3140
2410 XC = (LN + (LD / B)): LN = LN + LD: GOTO 3150
2420 XC = (LN - (LD / B)): LN = LN - LD
2430 IF SUM < L THEN 3240
2440 SUM = Z;Q = Z: GOTO 3210
2450 L2 = SUM - L:L1 = LD - L2: LA(AN%) = L1:LA(AN% + A) = L2: IF DIR% = - R THEN 3190
2460 X(AN%) = (L - (L1 / B)) * Y(AN%) = (YC):DP%(AN%) = J%:AN% = AN% + A:XC = (L2 - L2 / B): GOTO 3200
2470 X(AN%) = (L1 / B): Y(AN%) = YC:DP%(AN%) = J%:AN% = AN% + A:XC = (L2 / B)
2480 SUM = L2;Q = L2: YC = YC + B * YB
2490 IF DIR% = R THEN LN = L - Q: GOTO 3230
3220 LN = Q
3230 DIR% = ( - A ) * DIR%
3240 X(AN%) = XC; Y(AN%) = YC; DP%(AN%) = J%; AN% = AN% + A: IF
3250 SUM = Z THEN YC = YC + B * YB
3250 NEXT I: IF AN% > NA% THEN RETURN
3260 FOR I = AN% TO NA%: DP%(I) = Z: NEXT I: RETURN
3270 SUM = Z: FOR I = A TO NA%: FOR J = A TO I%: IF DP%(I) < > J THEN 3430
3280 IF DP%(I) = Z THEN 3360
3290 IF I = NA% THEN 3320
3300 IF DP%(I + A) < > J THEN 3320
3310 IX% = I + A; XC = ((LA(I) * X(I) + LA(IX%) * X(IX%)) / (LA(I) + LA(IX%))): YC = ((LA(I) * Y(I) + LA(IX%) * Y(IX%)) / (LA(I) + LA(IX%))): I = IX%: GOTO 3330
3320 XC = X(I): YC = Y(I)
3330 FOR K = A TO NA%: D% = DP%(K): IF D% = J THEN 3420
3340 IF D% = Z THEN 3380
3350 IF K = NA% THEN 3380
3360 IF DP%(K + A) < > D% THEN 3380
3370 JJ% = K + A; X2 = (LA(K) * X(K) + LA(JJ%) * X(JJ%)) / (LA(K) + LA(JJ%)): Y2 = (LA(K) * Y(K) + LA(JJ%) * Y(JJ%)) / (LA(K) + LA(JJ%)): K = JJ%: GOTO 3390
3380 X2 = X(K): Y2 = Y(K): X = (ABS (XC - X2)): Y = (ABS (YC - Y2)): IF CS = "E" THEN 3410
3390 SUM = SUM + (ABS (XC - X2) + ABS (YC - Y2)) * C(J, D%)
3400 GOTO 3420
3410 SUM = SUM + SQR ((XC-X2)^2 + (YC-Y2)^2) * C(J, D%)
3420 NEXT K
3430 NEXT J
3440 NEXT I: RETURN
3450 FOR IE = A TO I% - A: IF FX%(SQ%(IE, B)) = R THEN 3540
3460 FOR JE = IE + A TO I%: IF FX%(SQ%(JE, B)) = R THEN 3530
3470 T% = SQ%(IE, B): SQ%(IE, B) = SQ%(JE, B): SQ%(IE, B) = T%: GOSUB 3110: GOSUB 3270: IF SUM + .05 > = LO THEN 3520
3480 GOSUB 3070: TS = INKEY$: IF TS = "" THEN 3450
3490 CLS: GOSUB 1570: LOCATE 2, 2: PRINT "DO YOU WANT TO STOP? (Y/N)"
3491 LOCATE 2,30: INPUT ": ", YS
3500 IF YS="Y" OR YS = "y" THEN XZZ=1: GOTO 3550
3510 IF YS="N" OR YS = "n" THEN 3450 ELSE 3490
3520 SQ%(JE, B) = SQ%(IE, B): SQ%(IE, B) = T%
3530 NEXT JE
3540 NEXT IE
3550 IT% = A: GOSUB 3110
3560 IF XZZ=1 THEN XZZ=0: GOTO 3590
3570 REM * THE CRAFT GENERATED ARRANGEMENT HAS BEEN REACHED *
3580 REM * RETURNS CONTROL TO CALLING COMMAND FOR LAYOUT *
3590 RETURN
### VARIABLE LISTING FOR CHANGE

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AREA</td>
<td>Variable for area of the plant.</td>
</tr>
<tr>
<td>NCOL</td>
<td>Variable for the number of lateral bays.</td>
</tr>
<tr>
<td>BW</td>
<td>Variable for the width of bay.</td>
</tr>
<tr>
<td>C(J,I)</td>
<td>Variable for array for the material handling cost from department J to I.</td>
</tr>
<tr>
<td>CST(J,I)</td>
<td>Variable for array for the cost per trip between department J and I.</td>
</tr>
<tr>
<td>CS</td>
<td>String variable for storing the type of calculation (euclidean or rectilinear).</td>
</tr>
<tr>
<td>DP%(I)</td>
<td>Variable for array for the department sequence I.</td>
</tr>
<tr>
<td>I%</td>
<td>Variable for the number of departments.</td>
</tr>
<tr>
<td>L</td>
<td>Variable for the plant length.</td>
</tr>
<tr>
<td>LA(I)</td>
<td>Variable for array for the sub-area of department I.</td>
</tr>
<tr>
<td>LD(I)</td>
<td>Variable for array for the department length.</td>
</tr>
<tr>
<td>LO</td>
<td>Variable for the CRAFT calculated move cost.</td>
</tr>
<tr>
<td>NA%</td>
<td>Variable for the number of departments.</td>
</tr>
<tr>
<td>NB</td>
<td>Variable for the number of longitudinal bays.</td>
</tr>
<tr>
<td>NCOL</td>
<td>Variable for the number of lateral bays.</td>
</tr>
<tr>
<td>Q(I)</td>
<td>Variable for array for the department area.</td>
</tr>
<tr>
<td>SQ%</td>
<td>Variable for the sequence of the departments.</td>
</tr>
<tr>
<td>SUMX</td>
<td>Variable for the summation of the department areas.</td>
</tr>
<tr>
<td>W</td>
<td>Variable for the plant width.</td>
</tr>
</tbody>
</table>
Variable for the X co-ordinate of the dummy centroid.

Variable for the Y co-ordinate of the dummy centroid.

DATA FILES

CDATA Data file used by changed and generated by CRAFT.

XDATA Data file used in transitional modes during plant parameters changes.
CHANGE SPEC. MODULE

READ DATA FILE FROM DISK (FROM CRAFT)

CHANGE SPEC. MENU
1. AREA
2. PLANT WIDTH
3. PLANT LENGTH
4. BAY WIDTH
5. NO. LONG BAY
6. NO. LATERAL BAY
7. BAY LENGTH
8. DISPLAY CHANGE
9. NO CHANGE

OPTIONS TO FIX DEPENDENT PARAMETERS
A
B
C
D
E
F
G

CHANGE SPEC. MODULE

CHANGE LAT. BAY

CHANGE BAY LENGTH

DISPLAY CHANGES

NO CHANGES

CSM
CHANGE SPEC MODULE CONTINUE

CGRAPH MODULE  ↬  SAVE TO DISK FILE  ↬  CRAFT CALCU.

SAVE RETREIVE DATA AS CURRENT DATA IN FILE  ↬  RETREIVE ORIGINAL CRAFT GENERATED LAYOUT FROM DISK FILE

9

8
OPTION FOR FIXING DEPENDENT PARAMETERS.

A

- Fix plant width
- Fix plant length
  - Fix no.* lat. bay
  - Fix bay length
  - Fix no.* long. bay
  - Fix bay width

B

- Fix plant area
- Fix plant length
  - Fix no.* long. bay
  - Fix bay width
  - Fix no.* long. bay
  - Fix bay width

C

- Fix plant area
- Fix plant width
  - Fix no.* lat. bay
  - Fix bay length
  - Fix no.* lat. bay
  - Fix bay length
  - Fix no.* long. bay
  - Fix bay width

D

- Fix plant area
- Fix plant width
  - Fix no.* long. bay
  - Fix bay width
OPTION FOR FIXING DEPENDENT PARAMETERS.

Diagram:

- **E**
  - FIX BAY WIDTH
  - FIX PLANT WIDTH

- **F**
  - FIX BAY LENGTH
  - FIX PLANT LENGTH

- **G**
  - FIX NUMBER LATERAL BAY
  - FIX PLANT LENGTH
' PUT AISLES IN THE LAYOUT
A=1
DIM DP%(50),LA(50),LL(40),A(40)
DIM LD(40),Q(40),SEQ%(40),FX%(40),C(40,40),NT(40,40),CST(40,40),X(50),Y(50)
DIM NPA(10),FECT(10),WOD(10),WA(10)
GOSUB 1160
KEY OFF
REM Aisle Menu
SCREEN 1:GOSUB 1290:CLS
LOCATE 2,2:PRINT "1-Single Aisle 2-Multiple Aisles"
LOCATE 3,2:PRINT "3-U-Shaped 4-Exit ==OPTION==>"
MA%=1:FIR%=1:GOTO 190
GOSUB 1290 : CLS : GOSUB 1320 : GOTO 80
END
REM *k~*k**************************~*********
SINGLE AISLE (HORIZONTAL)
GOSUB 1290
CLS : LOCATE 2,2 : PRINT "ENTER AISLE WIDTH ="
LOCATE 2,22 : INPUT "",WA
IF WA < 0 THEN GOTO 300
IF AP$ = "2" THEN 3030
W1=W
W1=W1+WA
BW=W1/NB
IF WA > BW THEN GOTO 290
CLS : LOCATE 2,2 : PRINT "ENTER DIST. OF N. WALL - AISLE ="
LOCATE 2,35 : INPUT "",NPA
FOR BB=1 TO NB
IF (NPA <= (BB*BW)) AND (NPA+WA > (BB*BW)) THEN GOTO 420
NEXT BB
GOSUB 1350 : GOSUB 1320 : CLS : GOTO 350
GOSUB 8940
RB=7/5 : CP=144
FECT1 = INT(CP*NPA/W1)
FECT2 = INT(CP*(W1-NPA-WA)/W1)
WOD1 = FECT1+FECT2+INT(CP*WA/W1)
LO1 = INT((RB*L/W1*WOD1)+.5)
490 IF LO1 < 240 THEN GOTO 530
500 CP=CP-8
510 IF CP >= 8 THEN GOTO 450
520 LO1=2815 : FECT1=8 : FECT2=INT((CP*(W1-NPA-WA)/W1)-3)
530 ST=INT((280-LO1)/2+1) : EN=ST-1+LO1
540 A(I)=ST : J=1 : BWI=40
550 DRAW "BM=ST; , =BWI;"
560 FOR I=1 TO NA
570 IF J > 1 THEN
580 LL(I)=INT(Q(SEQ%(I)) / (W1-NPA-WA)*LO1/L) : GOTO 680
590 LL(I) = INT(Q(SEQ%(I)) / NPA*LO1/L)
600 A(I+1)=A(I) + LL(I)
610 IF A(I+1) <= EN THEN GOTO 650
620 SW=(LL(I)-(EN-A(I)))*FECT1/FECT2
630 DR=EN-A(I) : DD=WOD1 : DL=SW1 : DB=FECT2
640 DRAW "R=DR; D=DD; L=DL; U=DB;"
650 J=J+1 : GOTO 700
660 DD=FECT1 : DR=A(I+1)-A(I)
670 DRAW "R=DR; D=DD; L=DR; U=DD; R=DR;"
680 GOTO 700
690 DRAW "D=DD; L=DR; U=DD;"
700 NEXT I
710 DRAW "BM=ST; , =BWI;"
720 DR=LO1 : DD=WOD1 : DA=FECT1 : DB=FECT2
730 DRAW "R=DR; D=DD; L=DR; U=DD;"
740 DRAW "D=DA; R=DR; U=DD; L=DR;"
750 DRAW "D=DD; U=DB; R=DR;"
760 '*****************************************************************************
770 ' CHANGE OPTION FOR SINGLE AISLE (HORIZONTAL)
780 '*****************************************************************************
790 SCREEN 1 : GOSUB 1290 : CLS
800 LOCATE 2,6 : PRINT "MAKE ANY CHANGE (Y/N)?"
810 LOCATE 2,29: INPUT "",CHS
820 IF CHS="Y" OR CHS="yw" THEN 850
830 IF CHS="N" OR CHS="n" THEN 1040
840 GOTO 810
841 AEN ****** CHANGING AISLE DATA ******
850 CLS : LOCATE 1,2 : PRINT "1.AISLE WIDTH = ";WA
860 LOCATE 2,2 : PRINT "2.DIST OF N. WALL-AISLE = ";NPA
870 LOCATE 3,2 : PRINT "3.BOTH 1&2 ==ENTER CHANGED OPTION=>";
880 GOSUB 1290
890 LOCATE 3,38 : INPUT "",OPTS
900 IF OPTS="1" THEN GOSUB 1290 : GOTO 940
910 IF OPTS="2" THEN GOSUB 1290 : GOTO 1000
920 IF OPTS="3" THEN GOSUB 1290 : GOTO 290
930 GOTO 890
940 CLS : LOCATE 2,2:PRINT "ENTER A NEW AISLE WIDTH"
950 LOCATE 3,2 : PRINT "NEW AISLE WIDTH(1);WA;") = "
960 LOCATE 3,26 : INPUT "",WA
970 W1=W : W1=W1+WA : BW=W1/NB
380 IF WA > BW THEN GOSUB 1430 : GOSUB 1320 : GOTO 290
990 GOTO 380
1000 CLS : LOCATE 2, 2 : PRINT "ENTER A NEW DISTANCE"
1010 LOCATE 3, 2 : PRINT "NEW N. WALL- AISLE(" ; NPA ; ") = "
1020 LOCATE 3, 27 : INPUT "", NPA
1030 GOTO 380
1040 GOTO 140
1050 '******************************************************************************
1060 ' OPEN CRAFT FILE FOR OUTPUT
1070 '******************************************************************************
1080 OPEN "O", 1, "CDATA"
1090 PRINT #1, CS : PRINT #1, I% : PRINT #1, NA% : PRINT #1, NB : PRINT
1100 PRINT #1, L : PRINT #1, W : PRINT #1, BW : PRINT #1, LO : PRINT #1, NCOL : PRINT #1, BCOL
1110 FOR I = A TO NA% : IF I > I% THEN 1130
1120 PRINT #1, LD(I) : PRINT #1, Q(I) : PRINT #1, SEQ%(I) : PRINT
1130 NEXT J
1140 FOR J = A TO I% : PRINT #1, C(I, J) : PRINT #1, NT(I, J) : PRINT
1150 NEXT J
1160 FOR I = A TO NA% : IF I > I% THEN 1260
1170 PRINT #1, X(I), Y(I), DP%(I), LA(I) : NEXT I
1180 CLOSE #1
1190 RETURN
1200 SUM = 0
1210 INPUT #1, CS, I%, NA%, NB, L, W, BW, LO, NCOL, BCOL
1220 FOR I = A TO NA% : IF I > I% THEN 1260
1230 INPUT #1, LD(I), Q(I), SEQ%(I), FX%(I)
1240 SUM = SUM + Q(I)
1250 FOR J = A TO I% : INPUT #1, C(I, J), NT(I, J), CST(I, J) : NEXT J
1260 INPUT #1, X(I), Y(I), DP%(I), LA(I) : NEXT I
1270 CLOSE #1
1280 RETURN
1290 WIDTH 40
1300 VIEW (1, 1) - (315, 25), 2
1310 RETURN
1320 LOCATE 3, 5 : INPUT "PRESS < ENTER > TO CONTINUE", WS
1330 GOSUB 1290
1340 RETURN
1350 REM ****** WARNING ABOUT AISLE CONDITIONS **********
1350 CLS : LOCATE 1, 2 : PRINT "AISLE SHOULD NOT LOCATE IN THE"
1360 LOCATE 2, 2 : PRINT "INTERSECTION AREA BET. BAY & COLUMN"
1370 GOSUB 1290 : RETURN
1380 VIEW (1, 26) - (315, 195), 1
1390 RETURN
1400 CLS : LOCATE 1, 2 : PRINT "AISLE SHOULD NOT LOCATE IN
THIS
1410 LOCATE 2,2 : PRINT "AREA (NO SPACE LEFT FOR OTHER
AISLES)"
1420 GOSUB 1290 :RETURN
1430 CLS: LOCATE 1,10 : PRINT "AISLE IS BIGGER THAN "
1440 LOCATE 2,7 : PRINT "THE WIDTH OF BAY OR COLUMN"
1450 GOSUB 1290 : GOSUB 1320 : RETURN
1460 '******************************************************************************
1470 'MULTIPLE HORIZONTAL AISLES
1480 '******************************************************************************
1490 GOSUB 1290
1500 CLS : LOCATE 2,2 : PRINT "ENTER NUMBERS OF AISLES = "
1510 LOCATE 2,27 : INPUT "",C
1520 FOR I=1 TO C
1530 CLS:LOCATE 2,2:PRINT "ENTER THE ";I;"'S AISLE WIDTH = "
1540 LOCATE 2,32 : INPUT "",WA(I)
1550 IF APS="1" THEN 1580
1560 IF WA(I)<BCOL THEN 1600
1570 GOSUB 1430 : GOTO 1530
1580 IF WA(I)<BW THEN 1600
1590 GOSUB 1430 : GOTO 1530
1600 NEXT I
1610 IF APS="2" THEN 3780
1620 WW=W : W1=W
1630 FOR K=1 TO C : W1=W1+WA(K) : NEXT K
1640 BW=W1/NB
1650 CLS:LOCATE 2,2: PRINT "ENTER DIST.OF N.WALL-1 TH AISLE = "
1660 LOCATE 2,37 : INPUT "",NPA(1)
1670 FOR T=1 TO NB
1680 IF NPA(1) <= 0 THEN 1650
1690 IF NPA(1) > WW THEN 1750
1700 IF (NPA(1) < T*BW) AND ((NPA(1)+WA(1)) <= T*BW) THEN
1710 IF NPA(1) >= T*BW THEN 1730
1720 GOTO 1760
1730 NEXT T
1740 GOTO 1770
1750 GOSUB 1400 : GOSUB 1320 : GOTO 1650
1760 GOSUB 1350 : GOSUB 1320 : GOTO 1650
1770 FOR J=2 TO C
1780 CLS : LOCATE 2,2: PRINT "ENTER DIST.OF
THE";J-1;"'S-";J;"'S AISLE="
1790 LOCATE 2,37 : INPUT "",NPA(J)
1800 IF NPA(J) <= 0 THEN 1790
1810 SUMW=0 : WW1=0
1820 FOR R=1 TO J
1830 SUMW=SUMW+NPA(R)+WA(R)
1840 WW1=WW1+WA(R)
1850 NEXT R
1860 IF SUMW < WW+WW1 THEN 1880
1870 GOSUB 1400 : GOSUB 1320 : GOTO 1780
1880 TEST=SUMW - WA(J)
1890 FOR RR=1 TO NB
1900 IF (TEST < RR*BW) AND (SUMW <= RR*BW) THEN 1930
1910 IF TEST >= RR*BW THEN 1930
1920 GOSUB 1350 : GOSUB 1320 : GOTO 1780
1930 NEXT RR
1940 NEXT J
1950 AAA=0
1960 FOR H=1 TO C : AAA=AAA+NPA(H)+WA(H) : NEXT H
1970 NPA(C+1) = W1 - AAA : WA(C+1)=0
1980 GOSUB 8940
1990 RB=7/5 : CP=144
2000 FOR CC=1 TO C+1
2010 FECT(CC) = INT(CP*NPA(CC)/W1)
2020 WOD(CC) = INT(CP*WA(CC)/W1)
2030 NEXT CC
2040 WOD1=0
2050 FOR II=1 TO C+1
2060 WOD1=WOD1 + WOD(II) + FECT(II)
2070 NEXT II
2080 LO1 = INT((RB*L/W1*WOD1)+.5)
2090 IF (LO1 < 240) AND (WOD1 < 150) THEN 2160
2100 CP=CP-8
2110 IF CP >= 8 THEN 2000
2120 LO1 = 210 : WOD1=150
2130 FOR E=1 TO C+1
2140 FECT(E) = INT(150*NPA(E)/W1) : WOD(E)=INT(150*WA(E)/W1)
2150 NEXT E
2160 ST = INT((-310-LO1)/2)+1
2170 A(1)=ST : Q=1 : BWI=40
2180 DRAW "BM=ST;=BWI;"
2190 FOR NN=2 TO NA%+1
2200 PP=Q
2210 LL(NN-1)=INT(Q(SEQ%(NN-1))/NPA(Q)*LO1/L)
2220 IF Q/2=INT(Q/2) THEN 2440
2230 REM************** ODD AISLE ****************
2240 A(NN)=A(NN-1)+LL(NN-1)
2250 IF A(NN) <= EN THEN DR=LL(NN-1) : GOTO 2500
2260 Q=Q+1
2270 SW1 = LL(NN-1) - (EN - A(NN-1))
2280 CONV1=SW1*FECT(Q-1) - (EN-ST)*FECT(Q)
2290 IF CONV1 <= 0 THEN 2320
2300 SW1=CONV1/FECT(Q)
2310 Q=Q+1 : GOTO 2280
2320 ALEFT=INT(SW1*FECT(Q-1)/FECT(Q))
2330 SUM1 = 0
2340 FOR KK=PP TO Q-1
2350 SUM1 = SUM1+FECT(KK) + WOD(KK)
2360 NEXT KK
2370 IF Q/2 = INT(Q/2) THEN 2410
2380 DB=A(NN-1)-ST : DD1=SUM1
2390  DRAW "L=DB ; D=DD1;"
2400  DR = ALEF1 : A(NN)=ALEF1+ST : GOTO 2500
2410  DB=EN-A(NN-1) : DD1=SUM1
2420  DRAW "R=DB ; D=DD1;"
2430  A(NN)=EN-ALEF1 : DL=ALEF1 : GOTO 2560
2440  REM ***************** EVEN AISLE ***************
2450  A(NN)=A(NN-1)-LL(NN-1)
2460  IF A(NN) >= ST THEN DL=LL(NN-1) : GOTO 2560
2470  Q=Q+1
2480  SW1 = LL(NN-1) - (A(NN-1)-ST)
2490  GOTO 2280
2500  '**********************************************************************
2510  '                     ODD PLOT                                    
2520  '**********************************************************************
2530  DD=FECT(Q)
2540  DRAW "D=DD;R=DR;U=DD;"
2550  GOTO 2610
2560  '**********************************************************************
2570  '                     EVEN PLOT                                  
2580  '**********************************************************************
2590  DD=FECT(Q)
2600  DRAW "D=DD;L=DL;U=DD;"
2610  NEXT NN
2620  DRAW "BM=ST;,=BWI;"
2630  DR=LO1 : DD=WOD1
2640  DRAW "R=DR ; D=DD ; L=DR ; U=DD;"
2650  SFECT = 0
2660  FOR S=1 TO C
2670  SFECT=SFECT+FECT(S)
2680  DD=SFECT : DR=LO1
2690  DRAW "R=DR ; D=DD ; L=DR ; U=DD;"
2700  DD=SFECT+WOD(S)
2710  DRAW "R=DR ; D=DD ; L=DR ; U=DD;"
2720  SFECT=DD
2730  NEXT S
2740  '**********************************************************************
2750  ' CHANGE OPTION FOR MULTIPLE AISLES (HORIZONTAL)
2760  '**********************************************************************
2770  SCREEN 1 : GOSUB 1290: CLS
2780  LOCATE 2,6 : PRINT "MAKE ANY CHANGE (Y/N)?"
2790  LOCATE 2,29:INPUT ",CH$ 
2800  IF CH$="Y" OR CH$="y" THEN 2830
2810  IF CH$="N" OR CH$="n" THEN 2920
2820  GOTO 2790
2830  CLS : LOCATE 1,2 : PRINT "1.NUMBERS OF AISLES
2840  2.AISLES' WIDTH" 
2850  LOCATE 2,2 : PRINT "3.DISTANCE BETWEEN AISLES"
2860  LOCATE 3,2 : PRINT "==ENTER CHANGED OPTION=>>"
2870  GOSUB 1290
2880  LOCATE 3,28 : INPUT ",OPT$ 
2890  IF OPT$="1" THEN GOTO 1500
2890  IF OPT$="2" THEN GOTO 1520
2900 IF OPT$="3" THEN GOTO 1650
2910 GOTO 2870
2920 GOTO 140
2930 '******************************************************************************
2940 ' AISLE PATTERN OPTIONS
2950 '******************************************************************************
2960 CLS: LOCATE 1,2:PRINT "Aisle Pattern...........OPTION >>"
2970 LOCATE 2,2:PRINT "1-ALONG WITH LENGTH"
2980 LOCATE 3,2:PRINT "2-ALONG WITH WIDTH "
2990 GOSUB 1290
3000 LOCATE 1,33:INPUT ",AP$"
3010 IF (APS <> "1") AND (APS <> "2") THEN 2930
3020 RETURN
3030 '******************************************************************************
3040 ' SINGLE AISLE (VERTICAL)
3050 '******************************************************************************
3060 L1=L : L1=L1+WA : BCOL=L1/NCOL
3070 IF WA > BCOL THEN GOSUB 1430 : GOTO 290
3080 CLS : LOCATE 2,2 : PRINT "ENTER DIST. OF W. WALL - AISLE = "
3090 LOCATE 2,35 : INPUT "",WPA
3100 IF WPA < 0 THEN GOTO 3030
3110 FOR BB=1 TO NCOL
3120 IF (WPA < (BB*BCOL)) AND (WPA+WA > (BB*BCOL)) THEN GOTO 3150
3130 NEXT BB
3140 GOTO 3160
3150 GOSUB 1350 : GOSUB 1320 : GOTO 3080
3160 GOSUB 8940
3170 RB=5/7 : CP=250
3180 FECT1 = INT(CP*WPA/L1)
3190 FECT2 = INT(CP*(L1-WPA-WA)/L1)
3200 LO1 = FECT1+FECT2+INT(CP*WA/L1)
3210 WOD1 = INT((RB*W/L1*LO1)+.5)
3220 IF WOD1 < 150 THEN GOTO 3260
3230 CP=CP-8
3240 IF CP >= 8 THEN GOTO 3180
3250 WOD1=136 : FECT1=8 : FECT2=INT((CP*(L1-WPA-WA)/L1)-8)
3260 ST=INT((280-LO1)/2+1) : EN=ST-1+WOD1
3270 A(1)=ST : J=1 : BWI=40
3280 DRAW "BM=ST;R=DD;U=DL;L=DB;"
3290 FOR I=1 TO NA%
3300 IF J > 1 THEN
3310 LL(I)=INT(Q(SEQ%(I))/(L1-WPA-WA)*WOD1/W):GOTO 3410
3320 A(I+1)=A(I)+LL(I)
3330 IF A(I+1) <= EN THEN GOTO 3380
3340 SW1=(LL(I)-(EN-A(I)))*FECT1/FECT2
3350 DR=EN-A(I) : DD=LO1 : DL=SW1 : DB=FECT2
3360 DRAW "D=DR;R=DD;U=DL;L=DB;"
3370 J=J+1 : GOTO 3430
3380 DR=FECT1 : DD=A(I+1)-A(I)
CHANGE OPTION FOR SINGLE AISLE (VERTICAL)  

SCREEN 1:gosub 1290: cls
locate 2,6: print "make any change (y/n)?"
locate 2,29: input "", ch$
if ch$="y" or ch$="y" then 3580
if ch$="n" or ch$="n" then 3770
goto 3540
cls: locate 1,2: print "1.aisle width = "; wa
locate 2,2: print "2. dist of w. wall-aisle = "; wpa
locate 3,2: print "3. both 1&2 ==enter changed option==>"
gosub 1290
locate 3,38: input "", opt$
if opt$="1" then gosub 1290: goto 3670
if opt$="2" then gosub 1290: goto 3730
if opt$="3" then gosub 1290: goto 290
goto 3110
cls: locate 2,2: print "enter a new aisle width"
locate 3,2: print "new aisle width("; wa; ") = "
locate 3,26: input "", wa
l1=l: l1=l1+wa: bcol=l1/ncol
if wa > bcol then gosub 1430: gosub 1320: goto 290
goto 3110
cls: locate 2,2: print "enter a new distance"
locate 3,2: print "new w. wall-aisle("; wpa; ") = "
locate 3,27: input "", wpa
goto 3110
goto 140
' ********************
MULTIPLE VERTICAL AISLES

ww=l: l1=l
for k=1 to c : l1=l1+wa(k) : next k
bcol=l1/ncol
cls: locate 2,2: print "enter dist.of w. wall-1 th aisle = "
locate 2,37: input "", wpa(1)
for t=1 to ncol
if wpa(1) <= 0 then 3840
if wpa(1) > ww then 3840
3890 IF (WPA(1) < T*BCOL) AND ((WPA(1) + WA(1)) <= T*BCOL) THEN 3920
3900 IF WPA(1) >= T*BCOL THEN 3920
3910 GOTO 3950
3920 NEXT T
3930 GOTO 3960
3940 GOSUB 1400 : GOSUB 1320 : GOTO 3840
3950 GOSUB 1350 : GOSUB 1320 : GOTO 3840
3960 FOR J = 2 TO C
3970 CLS : LOCATE 2, 2 : PRINT "ENTER DIST. OF THE"; J-1; "S"; J; "S AISLE=
3980 LOCATE 2, 37 : INPUT "", WPA(J)
3990 IF WPA(J) = 0 THEN 3980
4000 SUMW = 0 : WW1 = 0
4010 FOR R = 1 TO J
4020 SUMW = SUMW + WPA(R) + WA(R)
4030 WW1 = WW1 + WA(R)
4040 NEXT R
4050 IF SUMW < WW+WW1 THEN 4070
4060 GOSUB 1400 : GOSUB 1320 : GOTO 3840
4070 TEST = SUMW - WA(J)
4080 FOR RR = 1 TO NCOL
4090 IF (TEST < RR*BCOL) AND (SUMW <= RR*BCOL) THEN 4120
4100 IF TEST >= RR*BCOL THEN 4120
4110 GOSUB 1350 : GOSUB 1320 : GOTO 3840
4120 NEXT RR
4130 NEXT J
4140 AAA = 0
4150 FOR H = 1 TO C : AAA = AAA + WPA(H) + WA(H) : NEXT H
4160 WPA(C+1) = L1 - AAA : WA(C+1) = 0
4170 GOSUB 8940
4180 RB = 5/7 : CP = 270
4190 FOR CC = 1 TO C+1
4200 FECT(CC) = INT(CP*WPA(CC)/L1)
4210 WOD(CC) = INT(CP*WA(CC)/L1)
4220 NEXT CC
4230 LO1 = 0
4240 FOR II = 1 TO C+1
4250 LO1 = LO1 + WOD(II) + FECT(II)
4260 NEXT II
4270 WOD1 = INT((RB*W/L1*LO1) + .5)
4280 IF (LO1 < 240) AND (WOD1 < 150) THEN 4350
4290 CP = CP - 8
4300 IF CP >= 8 THEN 4190
4310 LO1 = 210 : WOD1 = 150
4320 FOR E = 1 TO C+1
4330 FECT(E) = INT(210*WPA(E)/L1) : WOD(E) = INT(210*WA(E)/L1)
4340 NEXT E
4350 ST = INT((310-LO1)/2+1) : EN = ST-1+WOD1
4360 A(1) = ST : Q = 1 : BWI = 40
4370 DRAW "BM=ST;" BWI;" 
4380 FOR NN = 2 TO NA%+1
4390  PP=Q
4400  LL(NN-1)=INT(Q(SEQ%(NN-1))/WPA(Q)*WOD1/W)
4410  IF Q/2=INT(Q/2) THEN 4630
4420  REM ******************** ODD AISLE ********************
4430  A(NN)=A(NN-1)+LL(NN-1)
4440  IF A(NN) <= EN THEN DD=LL(NN-1) : GOTO 4690
4450  Q=Q+1
4460  SW1=LL(NN-1)-(EN-A(NN-1))
4470  CONV1=SW1*FECT(Q-1)-(EN-ST)*FECT(Q)
4480  IF CONV1 <= 0 THEN 4510
4490  SW1=CONV1/FECT(Q)
4500  Q=Q+1 : GOTO 4470
4510  ALEFT=INT(SW1*FECT(Q-1)/FECT(Q))
4520  SUM1=0
4530  FOR KK=PP TO Q-1
4540    SUM1=SUM1+FECT(KK)+WOD(KK)
4550  NEXT KK
4560  IF Q/2 = INT(Q/2) THEN 4600
4570  DB=A(NN-1)-ST : DD1=SUM1
4580  DRAW "U=DB ; R-DD1;"
4590  DD=ALEFT : A(NN)=ALEFT+ST : GOTO 4690
4600  DB=EN-A(NN-1) : DD1=SUM1
4610  DRAW "D=DB ; R-DD1;"
4620  A(NN)=EN-ALEFT : DU=ALEFT : GOTO 4750
4630  REM ******************** EVEN AISLE ********************
4640  A(NN)=A(NN-1)-LL(NN-1)
4650  IF A(NN) >= ST THEN DU=LL(NN-1) : GOTO 4750
4660  Q=Q+1
4670  SW1=LL(NN-1)-(A(NN-1)-ST)
4680  GOTO 4470
4690  '******************************************************************************
4700  ' ODD PLOT
4710  '******************************************************************************
4720  DR=FECT(Q)
4730  DRAW "R=DR;D=DD;L=DR;"
4740  GOTO 4800
4750  '******************************************************************************
4760  ' EVEN PLOT
4770  '******************************************************************************
4780  DR=FECT(Q)
4790  DRAW "R=DR;U=DU;L=DR;"
4800  NEXT NN
4810  DRAW "BM=ST; ,=BWI;"
4820  DR=LO1 : DD=WOD1
4830  DRAW "R=DR ; D=DD ; L=DR ; U=DD;"
4840  SFECT = 0
4850  FOR S=1 TO C
4860  SFECT=SFECT+FECT(S)
4870  DD=SFECT : DR=WOD1
4880  DRAW "D=DR ; R=DD ; U=DR ; L=DD;"
4890  DD=SFECT+WOD(S)
4900  DRAW "D=DR ; R=DD ; U=DR ; L=DD;"
SFECT=DD
NEXT S

CHANGE OPTION FOR MULTIPLE AISLES (VERTICAL)

SCREEN 1: GOSUB 1290: CLS
LOCATE 2.6: PRINT "MAKE ANY CHANGE (Y/N)?"
LOCATE 2.29: INPUT "",CHS
IF CHS="Y" OR CHS="y" THEN 5020
IF CHS="N" OR CHS="n" THEN 5110
GOTO 4980
CLS : LOCATE 1.2 : PRINT "1.NUMBERS OF AISLES"
2.AISLES' WIDTH"
LOCATE 2.2 : PRINT "3.DISTANCE BETWEEN AISLES"
LOCATE 3.2 : PRINT "==ENTER CHANGED OPTION=>>
GOSUB 1290
LOCATE 3.28 : INPUT "",OPTS
IF OPTS="1" THEN GOTO 1500
IF OPTS="2" THEN GOTO 1520
IF OPTS="3" THEN GOTO 3840
GOTO 5060
GOTO 140
U-SHAPE HORIZONTAL AISLE

GOSUB 1290 :CLS : LOCATE 2.2 : PRINT "ENTER AISLE WIDTH ="
LOCATE 2.22 : INPUT "",WA
IF WA < 0 THEN 5160
W1=W : L1=L
IF APS = "2" THEN 7050
W1=W1+2*WA : L1=L1+WA : BW=W1/NB : BCOL=L1/NCOL
IF WA > BW OR WA > BCOL THEN GOSUB 1430 : GOTO 5150
CLS:LOCATE 2.2 : PRINT "ENTER DIST. OF N. WALL - AISLE ="
LOCATE 2.35 : INPUT "",NPA(1)
IF NPA(1) <= 0 OR NPA(1) >= W1 THEN 5220
FOR BB=1 TO NB
IF (NPA(1) < BB*BW) AND ((NPA(1)+WA) > (BB*BW)) THEN 5290
NEXT BB
GOTO 5300
GOSUB 1350 : GOSUB 1320 : GOTO 5220
CLS:LOCATE 2.2 : PRINT "ENTER WIDTH OF U-SHAPE = "
LOCATE 2.27 : INPUT "",NPA(2)
IF NPA(2) <= 0 THEN 5310
SUMW = NPA(1)+NPA(2)+WA
FOR BB=1 TO NB
IF (SUMW < BB*BW) AND (SUMW+WA > BB*BW) THEN 5380
NEXT BB
GOTO 5390
GOSUB 1350 : GOSUB 1320 : GOTO 5300
CLS:LOCATE 2,2 : PRINT "ENTER DIST. OF E. WALL - AISLE ="
LOCATE 2,35 : INPUT "",EPA(1)
IF EPA(1) < 0 OR EPA(1) >= L1 THEN 5390
EPA(2)=L1-EPA(1)-WA
FOR BB=1 TO NCOL
IF (EPA(2) < BB*BCOL) AND (EPA(2)+WA > BB*BCOL) THEN
NEXT BB
GOTO 5480
GOSUB 1350 : GOSUB 1320 : GOTO 5390
NPA(3)=W1-NPA(1)-NPA(2)-(2*WA) : EPA(2)=L1-EPA(1)-WA
GOSUB 8940
RB=7/5 : CP=144
FOR I=1 TO 3 : FECT(I)=INT(CP*NPA(I)/W1) : NEXT I
WWA=INT(CP*WA/W1)
WCD1=TECT(1)+TECT(2)+TECT(3)+2*WWA
FOR I=1 TO 2 : FECT(I)=INT(EPA(I)*LO1/L1) : NEXT I
LO1=INT((RB*LL/W1*W1)+.5)
LWX=INT(WA*LO1/L1)
FOR I=1 TO 2 : FECT(I)=INT(EPA(I)*LO1/L1) : NEXT I
WWA=INT(150*WA/W1)
LWA=INT(210*WA/L1)
ST=INT((310-LO1)/2+1)
A(1)=ST : BWI=40 : EN=ST+LO1
EN1=EN-LWA-TECT1(1) : EN2=EN1+LWA
DRAW "BM=ST;.:=BWI;"
LL(1)=INT(Q(SEQ%(1))/(NPA(1)+NPA(2)/2+WA)*LO1/L1)
LL(NA%)=INT(Q(SEQ%(NA%))/(NPA(1)+NPA(2)/2+WA)*LO1/L1)
IF LL(NA%)<0 THEN NA%=NA%-1 : GOTO 5690
DR=LL(1) : DR=LL(NA%) : FECT2=INT(TECT(2)/2)
DD1=TECT(1)+TECT2+WWA
DD2=TECT(3)+TECT2+WWA
DD=DD1+DD2
DRAW "R=DR1;D=DD1:L=DR1;"
DRAW "R=DR2;D=DD2:L=DR2;U=DD;R=DR1;"
A(2)=A(1)+LL(1) : Q=0
FOR NN=2 TO NA%-1
IF Q <> 0 THEN 6070
LL(NN)=INT(Q(SEQ%(NN))/(NPA(1)+NPA(2)/2)*LO1/L1)
A(NN+1)=A(NN)+LL(NN)
IF A(NN+1) <= EN1 THEN 6510
DR=EN1-A(NN) : A(NN)=EN1
DRAW "R=DR;"
SW1=LL(NN)-(DR)
CONV1=SW1*(TECT(1)+TECT2) - (EN2-EN1)*TECT(1)
IF CONV1 < 0 THEN 6300
DR=EN2-A(NN) : A(NN)=EN2
5890  DRAW "R=DR;"
5900  CONV2=CONV1-(EN-EN2)*(FECT(1)+FECT2+WWA)
5910  IF CONV2 < 0 THEN 6350
5920  DR=EN-A(AN); A(AN)=EN
5930  DRAW "R=DR; D=WOD1;"
5940  CONV3=CONV2-(EN-EN2)*(FECT(3)+FECT2+WWA)
5950  IF CONV3 < 0 THEN 6400
5960  DL=A(AN)-EN2: A(AN)=EN2
5970  DRAW "L=DL;"
5980  CONV4=CONV3-(EN-EN2)*FECT(3)
5990  IF CONV4 < 0 THEN 6460
6000  DL=A(AN)-EN1: A(AN)=EN1
6010  DRAW "L=DL;"
6020  CONV5=CONV4-DL*FECT(3)
6030  DL=CONV5/(FECT2+FECT(3)) : Q=5: A(AN+1)=A(AN)-DL
6040  DU=FECT(3): DU1=WWA: DU2=FECT2
6050  DRAW "L=DL; U=DU; BU=DU1; U=DU2; D=DU2; BD=DU1; D=DU;"
6060  GOTO 6530
6070  IF Q <> 1 THEN 6120
6080  LL(AN)=INT(Q(SEQ%(NN)/NPA(1)*LO1/L1)
6090  SW1=LL(AN)
6100  CONV1=(LL(AN)-(EN2-A(AN)))*FECT(1)
6110  GOTO 5870
6120  IF Q <> 2 THEN 6170
6130  LL(AN)=INT(Q(SEQ%(NN))/NPA(1)+NPA(2)/2+W)*LO1/L1)
6140  CONV2=LL(AN)*FECT(1)+FECT2+WWA)
6150  CONV3=(LL(AN)-(A(AN)-EN2))*(FECT(1)+FECT2+WWA)
6160  GOTO 5910
6170  IF Q <> 3 THEN 6220
6180  LL(AN)=INT(Q(SEQ%(NN))/NPA(3)+NPA(2)/2+W)*LO1/L1)
6190  CONV2=LL(AN)*FECT(3)+FECT2+WWA)
6200  CONV3=(LL(AN)-(A(AN)-EN2))*(FECT(3)+FECT2+WWA)
6210  GOTO 5950
6220  IF Q <> 4 THEN 6270
6230  LL(AN)=INT(Q(SEQ%(NN))/NPA(3)*LO1/L1)
6240  CONV3=LL(AN)*FECT(3)
6250  CONV4=(LL(AN)-(A(AN)-EN1))*FECT(3)
6260  GOTO 5990
6270  LL(AN)=INT(Q(SEQ%(NN))/NPA(3)*LO1/L1)
6280  DL=LL(NN) : A(AN+1)=A(AN)-LL(AN)
6290  GOTO 6040
6300  ALEFT=INT(SW1*(FECT(1)+FECT2)/FECT(1))
6310  A(AN+1)=A(AN)+ALEFT
6320  DR=ALEFT : DD=FECT(1) : Q=1
6330  DRAW "R=DR; D=DD; U=DD;"
6340  GOTO 6530
6350  ALEFT=INT(CONV1/(FECT(1)+FECT2+WWA))
6360  A(AN+1)=A(AN)+ALEFT
6370  DR=ALEFT : DD=FECT(1)+FECT2+WWA : Q=2
6380  DRAW "R=DR; D=DD; L=DR; R=DR; U=DD;"
6390  GOTO 6530
ALEFT=INT(CONV2/(FECT(3)+FECT2+WWA))

A(NN+1)=A(NN)-ALEFT

DL=ALEFT : DD=FECT(3)+FECT2+WWA : Q=3

DL1=A(NN+1)-EN2

DRAW "L=DL; U=DD; L=DL1; R=DL1; D=DD;"

GOTO 6530

ALEFT=INT(CONV3/FECT(3))

A(NN+1)=A(NN)-ALEFT

DL=ALEFT : DD=FECT(3) : Q=4

DRAW "L=DL; U=DD; D=DD;"

GOTO 6530

DR=L(L(NN) : DD=FECT(1) : DD1=WWA : DD2=FECT2

DRAW "R=DR; D=DD; BD=DD1; D=DD2; U=DD2; BU=DD1; U=DD;"

NEXT NN

'**************************************************************************

DRAW FRAME

'**************************************************************************

DRAW "BM=ST; =BWI;"

DR=LO1 : DD=WOD1

DRAW "D=DD; R=DR; U=DD; L=DR;"

DR1=L(1) : DR2=LO1-LL(1)-FECT1(1)

DD1=FECT(1) : DD2=FECT(2)+2*WWA

DL1=LO1-LL(NA%)-FECT1(1)

DRAW "R=DR1; D=DD1; R=DR2; D=DD2; L=DL1;"

DRAW "BM=ST; =BWI;"

DR3=DR2-LWA : DD3=DD1+WWA

DD4=FECT(2) : DL2=DL1-LWA

DRAW "R=DR1; D=DD3; R=DR3; D=DD4; L=DL2;"

DRAW "BM=ST; =BWI;"

DD5=DD1+WWA+FECT2

DRAW "R=DR1; D=DD5; R=DR3;"

'**************************************************************************

CHANGE OPTION FOR U-SHAPE AISLE (HORIZONTAL)

'**************************************************************************

SCREEN 1 : GOSUB 1290: CLS

LOCATE 2,6 : PRINT "MAKE ANY CHANGE (Y/N)?"

LOCATE 2,29:INPUT "",CHS

IF CHS="Y" OR CHS="y" THEN 6790

IF CHS="N" OR CHS="n" THEN 7040

GOTO 6790

CLS : LOCATE 1,6 : PRINT "==ENTER CHANGED OPTION==> "

LOCATE 2,3:PRINT "1.AISLE WIDTH 3.DIST E.WALL-AISLE"

LOCATE 3,3 : PRINT "2.U-SHAPE WIDTH 4.DIST N.WALL-AISLE"

LOCATE 1,31 : INPUT "," ,OPTS

IF OPTS="1" THEN GOSUB 1290 : GOTO 6880

IF OPTS="3" THEN GOSUB 1290 : GOTO 6920

IF OPTS="4" THEN GOSUB 1290 : GOTO 6960

IF OPTS="2" THEN GOSUB 1290 : GOTO 7000

GOTO 6870

GOTO 6820
CLS: LOCATE 2, 2: PRINT "ENTER A NEW AISLE WIDTH"
LOCATE 3, 2: PRINT "NEW AISLE WIDTH("; WA;") = "
LOCATE 3, 26: INPUT "", WA
LOCATE 3, 2: PRINT "NEW AISLE WIDTH; WA = "
LOCATE 3, 27: INPUT "", WA
CLS: LOCATE 2, 2: PRINT "ENTER A NEW DISTANCE"
LOCATE 3, 2: PRINT "NEW E.WALL-AISLE("; EPA(1);") = "
LOCATE 3, 27: INPUT "", EPA(1)
LOCATE 2, 2: PRINT "ENTER A NEW AISLE DISTANCE"
LOCATE 3, 2: PRINT "NEW N.WALL-AISLE("; NPA(1);") = "
LOCATE 3, 27: INPUT "", NPA(1)
LOCATE 5410
CLS: LOCATE 2, 2: PRINT "ENTER A NEW U-WIDTH"
LOCATE 3, 2: PRINT "NEW U-WIDTH; WA = "
LOCATE 3, 27: INPUT "", WA
CLS: LOCATE 2, 2: PRINT "ENTER U-SHAPE VERTICAL AISLE"
W1=W : L1=L
L1=L1+2*WA : W1=W1+WA : BW=W1/NB : BCOL=L1/NCOL
IF WA > BW OR WA > BCOL THEN GOSUB 1430 : GOTO 5150
CLS: LOCATE 2, 2: PRINT "ENTER DIST. OF W. WALL - AISLE ="
LOCATE 2, 35: INPUT "", NPA(1)
IF NPA(1) <= 0 OR NPA(1) >= L1 THEN 7120
FOR BB=1 TO NCOL
IF (NPA(1) < BB*BCOL) AND ((NPA(1)+WA) > (BB*BCOL)) THEN 7180
NEXT BB
GOSUB 1350: GOSUB 1320 : CLS: GOTO 7110
CLS: LOCATE 2, 2: PRINT "ENTER WIDTH OF U-SHAPE = "
LOCATE 2, 27: INPUT "", NPA(2)
IF NPA(2) <= 0 THEN 7200
SUMW = NPA(1)+NPA(2)+WA
FOR BB=1 TO NCOL
IF (SUMW < BB*BCOL) AND (SUMW+WA > BB*BCOL) THEN 7270
NEXT BB
GOTO 7280
GOSUB 1350 : GOSUB 1320 : GOTO 7190
CLS: LOCATE 2, 2: PRINT "ENTER DIST. OF S. WALL - AISLE ="
LOCATE 2, 35: INPUT "", EPA(1)
IF EPA(1) < 0 OR EPA(1) >= W1 THEN 7290
EPA(2)=W1-EPA(1)-WA
FOR BB=1 TO NB
IF (EPA(2) < BB*BW) AND (EPA(2)+WA > BB*BW) THEN 7360
NEXT BB
GOTO 7370
GOSUB 1350 : GOSUB 1320 : GOTO 7290
NPA(3) = L1 - NPA(1) - NPA(2) - (2 * WA) : EPA(2) = W1 - EPA(1) - WA

GOSUB 8940

RB = 5/7 : CP = 270

FOR I = 1 TO 3 : FECT(I) = INT(CP * NPA(I) / L1) : NEXT I

LWA = INT(CP * WA / L1)

LOC1 = FECT(1) + FECT(2) + FECT(3) + 2 * LWA

WOD1 = INT((RB * W1 / L1 / LOC1) + .5)

W1A = INT(WA * WOD1 / W1)

FOR I = 1 TO 2 : FECT1(I) = INT(EPA(I) * WOD1 / W1)

IF (L01 < 240) AND (WOD1 < 150) THEN 7530

CP = CP - 8

IF CP >= 8 THEN 7400

L01 = 210 : WOD1 = 150

FOR I = 1 TO 3 : FECT(I) = INT(NPA(I) * LO1 / L1) : NEXT I

FOR I = 1 TO 2 : FECT1(I) = INT(EPA(I) * WOD1 / W1)

ST = INT((310 - LO1) / 2 + 1)

A(1) = ST : BWI = 40 : EN = ST + WOD1

EN1 = EN - WWA - FECT1(1) : EN2 = EN1 + WWA

DRAW "BM = ST ; ; BWI ;"

LL(1) = INT(Q(SEQ%(1)) / (NPA(1) + NPA(2) / 2 + WA) * WOD1 / W1)

LL(NA%) = INT(Q(SEQ%(NA%)) / (NPA(3) + NPA(2) / 2 + WA) * WOD1 / W1)

IF LL(NA%) <= 0 THEN NA% = NA% - 1 : GOTO 7580

DD1 = LL(1) : DD2 = LL(NA%) : FECT2 = INT(TECT(2) / 2)

DR1 = FECT(1) + FECT2 + LWA

DR2 = FECT(3) + FECT2 + LWA

DR = DR1 + DR2

DD = DD1 : R = DR1 : U = DD1 ;"

DRAW "D = DD2 ; R = DR2 ; U = DD2 ; L = DR ; D = DD1 ;"

A(2) = A(1) + LL(1) : Q = 0

FOR NN = 2 TO NA% - 1

IF Q <> 0 THEN 7960

LL(NN) = INT(Q(SEQ%(NN)) / (NPA(1) + NPA(2) / 2) * WOD1 / W1)

A(NN+1) = A(NN) + LL(NN)

IF A(NN+1) <= EN1 THEN 8400

DD = EN1 - A(NN) : A(NN) = EN1

DRAW "D = DD ;"

SW1 = LL(NN) - (DD)

CONV1 = SW1 * (TECT(1) + FECT2) - (EN2 - EN1) * FECT(1)

IF CONV1 < 0 THEN 8190

DD = EN2 - A(NN) : A(NN) = EN2

DRAW "D = DD ;"

CONV2 = CONV1 - (EN - EN2) * (TECT(1) + FECT2 + LWA)

IF CONV2 < 0 THEN 8240

DD = EN - A(NN) : A(NN) = EN

DRAW "D = DD ; R = LO1 ;"

CONV3 = CONV2 - (EN - EN2) * (TECT(3) + FECT2 + LWA)

IF CONV3 < 0 THEN 8290

DU = A(NN) - EN2 : A(NN) = EN2

DRAW "U = DU ;"

CONV4 = CONV3 - (EN2 - EN1) * FECT(3)

IF CONV4 < 0 THEN 8350
7890   DU=A(\text{NN}) - EN1 : A(\text{NN}) = EN1
7900   DRAW "U=DU;"
7910   CONV5=CONV4 - DU*FECT(3)
7920   DU=CONV5/(FECT2+\text{FECT}(3)) : Q=5 : A(\text{NN}+1) = A(\text{NN}) - DU
7930   DL=FECT(3) : DL1=LWA : DL2=FECT2
7940   DRAW "U=DU; L=DL; BL=DL1; L=DL2; R=DL2; BR=DL1; R=DL;"
7950   GOTO 8420
7960   IF Q <> 1 THEN 8010
7970   LL(\text{NN}) = INT(Q(\text{SEQ}\%(\text{NN})) / NPA(1) * WOD1/W1
7980   SW1=LL(\text{NN})
7990   CONV1=(LL(\text{NN}) - (EN2 - A(\text{NN}))) * FECT(1)
8000   GOTO 7760
8010   IF Q <> 2 THEN 8060
8020   LL(\text{NN}) = INT(Q(\text{SEQ}\%(\text{NN})) / (NPA(1) + NPA(2)/2 + WA) * WOD1/W1)
8030   CONV1=LL(\text{NN}) * (FECT(1)+FECT2+LWA)
8040   CONV2=(LL(\text{NN}) - (EN-A(\text{NN}))) * (FECT(1)+FECT2+LWA)
8050   GOTO 7800
8060   IF Q <> 3 THEN 8110
8070   LL(\text{NN}) = INT(Q(\text{SEQ}\%(\text{NN})) / (NPA(3) + NPA(2)/2 + WA) * WOD1/W1)
8080   CONV2=LL(\text{NN}) * (FECT(3)+FECT2+LWA)
8090   CONV3=(LL(\text{NN}) - (A(\text{NN}-EN2)) * (FECT(3)+FECT2+LWA)
8100   GOTO 7840
8110   IF Q <> 4 THEN 8160
8120   LL(\text{NN}) = INT(Q(\text{SEQ}\%(\text{NN})) / (NPA(3) + NPA(2)/2 + WA) * WOD1/W1)
8130   CONV3=LL(\text{NN}) * FECT(3)
8140   CONV4=(LL(\text{NN}) - (A(\text{NN}-EN1)) * FECT(3)
8150   GOTO 7880
8160   LL(\text{NN}) = INT(Q(\text{SEQ}\%(\text{NN})) / (NPA(3) + NPA(2)/2 + WA) * WOD1/W1)
8170   DU=LL(\text{NN}) : A(\text{NN}+1) = A(\text{NN}) - LL(\text{NN})
8180   GOTO 7930
8190   ALEFT=INT(SW1 * (FECT(1)+FECT2)/FECT(1))
8200   A(\text{NN}+1) = A(\text{NN}) + ALEFT
8210   DD=ALEFT : DR=FECT(1) : Q=1
8220   DRAW "D=DD; R=DR; L=DR;"
8230   GOTO 8420
8240   ALEFT=INT(CONV1/(FECT(1)+FECT2+LWA))
8250   A(\text{NN}+1) = A(\text{NN}) + ALEFT
8260   DD=ALEFT : DR=FECT(1)+FECT2+LWA : Q=2
8270   DRAW "D=DD; R=DR; U=DD; D=DD; L=DR;"
8280   GOTO 8420
8290   ALEFT=INT(CONV2/(FECT(3)+FECT2+LWA))
8300   A(\text{NN}+1) = A(\text{NN}) - ALEFT
8310   DU=ALEFT : DR=FECT(3)+FECT2+LWA : Q=3
8320   DU1=A(\text{NN}+1) - EN2
8330   DRAW "U=DU; L=DR; U=DU1; D=DU1; R=DR;"
8340   GOTO 8420
8350   ALEFT=INT(CONV3/FECT(3))
8360   A(\text{NN}+1) = A(\text{NN}) - ALEFT
8370   DU=ALEFT : DR=FECT(3) : Q=4
8380   DRAW "U=DU; L=DR; R=DR;"
3400 DD=LL(N1) ; DR=FECT(1) ; DR1=LWA ; DR2=FECT2
3410 DRAW "D=DD; R=DR; BP=DR1; R=DR2; L=DR2; BL=DR1;
L=DR:"
3420 NEXT N1
3430 '**********************************************************************
3440 ' DRAW FRAME
3450 '**********************************************************************
3460 DRAW "BM=ST:, =BWI;"
3470 DR=LC1 ; DD=WOD1
3480 DRAW "D=DD; R=DR; U=DD; L=DR;"
3490 DD1=LL(1) : DD2=WOD1-LL(1)-FECT1(1)
3500 DR1=FECT(1) : DR2=FECT(2)+2*LWA :
DU1=WOD1-LL(NA%-)-FECT1(1)
3510 DRAW "D=DD1; R=DR1; D=DD2; R=DR2; U=DU1;"
3520 DRAW "BM=ST:, =BWI;"
3530 DD3=DD2-WWA : DR3=DR1+LWA
3540 DR4=FECT(2) : DU2=DU1-WWA
3550 DRAW "D=DD1; R=DR3; D=DD3; R=DR4; U=DU2;"
3560 DRAW "BM=ST:, =BWI;"
3570 DR5=DR1+LWA+FECT2
3580 DRAW "D=DD1; R=DR5; D=DD3;"
3590 '**********************************************************************
3600 ' CHANGE OPTION FOR U-SHAPE AISLE (VERTICAL)
3610 '**********************************************************************
3620 SCREEN 1 : GOSUB 1290 : CLS
3630 LOCATE 2,6 : PRINT "MAKE ANY CHANGE (Y/N)?"  
3640 LOCATE 2,29:INPUT "",CHS
3650 IF CHS="Y" OR CHS="y" THEN 3680
3660 IF CHS="N" OR CHS="n" THEN 8930
3670 GOTO 8640
3680 CLS : LOCATE 1,6 : PRINT "==ENTER CHANGED OPTION==> "
3690 LOCATE 2,3 : PRINT "1.AISLE WIDTH 3.DIST  
S.WALL-AISLE"
3700 LOCATE 3,3 : PRINT "2.U-SHAPE WIDTH 4.DIST 
W.WALL-AISLE"
3710 LOCATE 1,31 : INPUT "",OPT$  
3720 IF OPTS="1" THEN GOSUB 1290 : GOTO 8770
3730 IF OPTS="3" THEN GOSUB 1290 : GOTO 8810
3740 IF OPTS="4" THEN GOSUB 1290 : GOTO 8850
3750 IF OPTS="2" THEN GOSUB 1290 : GOTO 8890
3760 GOTO 8710
3770 CLS : LOCATE 2,2:PRINT "ENTER A NEW AISLE WIDTH"  
3780 LOCATE 3,2 : PRINT "NEW AISLE WIDTH(";WA;") = "
3790 LOCATE 3,26 : INPUT "",WA
3800 GOTO 5170
3810 CLS : LOCATE 2,2 : PRINT "ENTER A NEW DISTANCE"  
3820 LOCATE 3,2 : PRINT "NEW S.WALL-AISLE(";EPA(1);") = "
3830 LOCATE 3,27: INPUT "",EPA(1)
3840 GOTO 7300
3850 CLS : LOCATE 2,2 : PRINT "ENTER A NEW DISTANCE"  
3860 LOCATE 3,2 : PRINT "NEW W.WALL-AISLE(";NPA(1);") = "
3870 LOCATE 3,27: INPUT "",NPA(1)
3880 GOTO 7130
3890 CLS : LOCATE 2,2 : PRINT "ENTER A NEW U-WIDTH "
3900 LOCATE 3,2 : PRINT "NEW U-WIDTH ('';NPA(2);') = "
3910 LOCATE 3,27: INPUT "";NPA(2)
3920 GOTO 7210
3930 GOTO 140
3940 '*********************************************************************************************
3950 '<<<< PLEASE WAIT >>> MESSAGE IS DISPLAYED ON THE SCREEN
3960 '*********************************************************************************************
3970 GOSUB 1290:CLS:LOCATE 2,10:PRINT "<<<< PLEASE WAIT >>>"
3980 LOCATE 3,2:PRINT "LAYOUT CAN BE PRINTED BY <SHIFT+PRTSC>"
3990 SCREEN 1:GOSUB 1380:CLS
4000 SCREEN 1,0 : COLOR 1,4 : KEY OFF
4010 RETURN
VARIABLE LISTING FOR AISLE

A(I) Variable for array for the last reference point of department I.

AAA Variable for the sum of the distance of the north (or west) wall to the last aisle.

ALEFT Variable for the length of the department that has not been drawn.

APS String variable for storing the type of aisle orientation (horizontal or vertical).

BCOL Variable for the length of the bay.

BW Variable for the width of the bay.

CONVX Department area that has not been drawn under condition X (X=1,2,3,4,5).

EPA(I) Variable array for the distance from the east (or south) wall of the plant to the aisle in horizontal (or vertical) U-Shape aisle pattern.

FECT(I) Variable array for the distance between aisles.

FECT1 Variable array for the distance from the north (or west) wall of the plant to the aisle in horizontal (or vertical) multiple aisle pattern.

FECT2 Variable array for the distance from the south (or west) wall of the plant to the aisle in horizontal (or vertical) multiple aisle pattern.

L Variable for the length of plant.

LA Sub-area of department area.

LL(I) Variable array for the length of department I.

LO1 Variable for the length of the plant in the layout.

L1 Variable for the dummy plant length.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAD</td>
<td>Variable for the number of departments.</td>
</tr>
<tr>
<td>NBD</td>
<td>Variable for the number of longitudinal bays.</td>
</tr>
<tr>
<td>NCCL</td>
<td>Variable for the number of lateral bays.</td>
</tr>
<tr>
<td>NPA</td>
<td>Variable for the distance from the north (or east) wall of the plant to the aisle in horizontal (or vertical) single aisle pattern.</td>
</tr>
<tr>
<td>NPA(I)</td>
<td>Variable array for the distance between aisles.</td>
</tr>
<tr>
<td>Q(I)</td>
<td>Variable array for of department I.</td>
</tr>
<tr>
<td>SEQ(I)</td>
<td>Variable array for the sequence of departments.</td>
</tr>
<tr>
<td>SPECT</td>
<td>Variable for the summation of PECT(I).</td>
</tr>
<tr>
<td>SUMW</td>
<td>Variable for the sum of width from the north wall of the plant to the aisle in horizontal (or vertical) multiple aisle pattern.</td>
</tr>
<tr>
<td>SUM1</td>
<td>Variable for the department area that has not been drawn in the layout.</td>
</tr>
<tr>
<td>W</td>
<td>Variable for the width of the plant.</td>
</tr>
<tr>
<td>WA(I)</td>
<td>Variable array for the width of the aisles in I.</td>
</tr>
<tr>
<td>WOD(I)</td>
<td>Variable array for the width of the aisles in I layout.</td>
</tr>
<tr>
<td>WP(A)</td>
<td>Variable for the distance from the west wall of the plant to the aisle in the single vertical aisle pattern.</td>
</tr>
<tr>
<td>WW1</td>
<td>Variable for the width of the dummy plant.</td>
</tr>
<tr>
<td>W1</td>
<td>Variable for the length of the dummy plant.</td>
</tr>
<tr>
<td>X</td>
<td>Variable for the X co-ordinate of the dummy centroid.</td>
</tr>
<tr>
<td>Y</td>
<td>Variable for the Y co-ordinate of the dummy centroid.</td>
</tr>
</tbody>
</table>
AISLE MODULE

READ DATA FILE

INITIALIZE YAR.

AISLE MENU
1. SINGLE AISLE
2. MULT. AISLE
3. U-SHAPE AISLE
4. EXIT

AISLE ORIENTATION MENU
1. ALONG LENGTH (HORIZ.)
2. ALONG WIDTH (VERT.)

ENTER AISLE INFO. FOR HORIZ. AISLE
ENTER AISLE INFO. FOR VERT. AISLE

CHECK FOR FIT

Y

WARNING MESSAGE FOR FITTING AISLE
RE-ENTER AISLE DATA

N

CALCULATION FOR AISLE AND LAYOUT
DRAW AISLE INSERTED IN LAYOUT
SAVE TO DISK FILE

A
10 REM SUBPROGRAM "LOCAT"
20 DIM X(25), Y(25), W%(25, 10)
30 DIM S%(100, 100), AI(20, 4), AC(20, 5)
40 LW = 35: LS = 35
50 SCREEN 0, 1: COLOR 3, 0: KEY OFF
60 GOSUB 80
70 ON ERROR GOTO 4070
80 GOTO 160
90 CLS: FOR RT = 1 TO 9: PRINT: NEXT RT
100 PRINT TAB(30); "OPTIMUM LOCATION"
110 PRINT: PRINT: PRINT
120 PRINT TAB(35); "I.I.E."
130 PRINT TAB(31); "MICRO-SOFTWARE"
140 PRINT TAB(32); "COPYRIGHTED"
150 RETURN
160 FOR I = 1 TO LS: FOR J = 1 TO LW: S%(I, J) = 0: NEXT J: NEXT I
170 CLS: FOR RT = 1 TO 9: PRINT: NEXT RT
180 PRINT: PRINT TAB(15); "DO YOU WANT INSTRUCTIONS (Y/N)"
190 IF AS = "Y" OR AS = "y" THEN GOSUB 2710: GOTO 210
200 IF AS = "N" OR AS = "n" THEN 210 ELSE 180
210 CLS: FOR RT = 1 TO 9: PRINT: NEXT RT
220 PRINT "DO YOU WISH TO INPUT FROM A DISKFILE (Y OR N)"; AS
230 IF AS = "Y" OR AS = "y" THEN GOSUB 4010: GOSUB 3310: GOTO 2350
240 IF AS = "N" OR AS = "n" THEN 250 ELSE 220
250 CLS: PRINT
260 PRINT: INPUT "ENTER THE # OF EXISTING MACHINES: ": NM
270 IF NM > 15 THEN PRINT TAB(15); "# OF EXISTING MACHINES IS LIMITED TO 15!"; GOTO 260
280 PRINT
290 INPUT "ENTER THE # OF NEW MACHINES: ": NA
300 IF NA > 10 THEN PRINT TAB(15); "# OF NEW MACHINES IS LIMITED TO 10!"; GOTO 280
310 PRINT: INPUT "ENTER THE LENGTH OF THE SOUTH WALL": LS
320 IF LS > INT (LS) THEN PRINT TAB(15); "THE WALL LENGTH IS LIMITED TO 100!"; PRINT TAB(17); "YOU MAY WISH TO SCALE YOUR DISTANCES! ": GOTO 310
330 PRINT
340 INPUT "ENTER THE LENGTH OF THE WEST WALL": LW
350 IF LW > INT (LW) THEN PRINT TAB(15); "THE WALL LENGTH IS LIMITED TO 100!"; PRINT TAB(17); "YOU MAY WISH TO SCALE YOUR DISTANCES! ": GOTO 310
360 PRINT: PRINT "ENTER THE DESIRED LENGTH OF EACH SQUARE": INPUT "MACHINE AREA "; DM
370 PRINT: INPUT "ENTER THE NUMBER OF AISLES ": A%
460 IF A%>10 THEN PRINT TAB(15);"THE NUMBER OF AISLES IS LIMITED TO 10!":GOTO 390
470 GO TO 460
480 IF LF = INT (L)
490 DF = L - LF
500 LF = INT(L+.1)
510 RETURN
520 PRINT:PRINT:INPUT" ANY CHANGES (Y,N) ";AS
530 IF AS = "Y" OR AS="y" THEN 250
540 IF AS = "N" OR AS="n" THEN 500
550 GO TO 460
560 REM ** PLANT GRID **
570 K1 = 1
580 NT = NH + NA
590 IF A% = 0 THEN 360
600 L% = 1
610 CLS:PRINT TAB(7);"** AISLES **"
620 FOR I = 1 TO A%
630 PRINT : PRINT TAB(10);" AISLE NO. ";I:PRINT
640 PRINT TAB(10);" 1. SOUTH->NORTH AISLE"
650 PRINT TAB(10);" OR 2. EAST->WEST AISLE ?"
660 INPUT " ENTER SELECTION NUMBER ":;SL:AZ(I,1)=SL
670 IF SL = 1 THEN WS = "WEST":LS = "SOUTH":US = "NORTH":GOTO 650
680 IF SL = 2 THEN WS = "SOUTH":LS = "WEST":US = "EAST":GOTO 650
690 GOTO 610
700 PRINT:INPUT " AISLE WIDTH ":;W:PRINT:AZ(I,2)=W:W=W+.02
710 PRINT TAB(10);" DISTANCE TO CENTER OF AISLE FROM ":;WS;" WALL ";: INPUT DC:AZ(I,3)=DC
720 PRINT :PRINT TAB(10);" DISTANCE TO ";LS;" END OF AISLE FROM ";WS;" WALL ";: INPUT DL:AZ(I,4)=DL
730 PRINT:PRINT TAB(10);" DISTANCE TO ";US;" END OF AISLE FROM ";LS;" WALL ";: INPUT DU:AZ(I,5)=DU
740 PRINT :PRINT " ANY CHANGES (Y/N) ":AS
750 IF AS = "Y" THEN CLS:GOTO 580
760 IF AS = "N" THEN 730
770 GOTO 690
780 IF SL = 2 THEN 750
790 YL=DL:XL=DC-W/2:YU=DU:XU=DC+W/2:GOTO 760
800 YL=DC-W/2:XL=DL:YU=DC+W/2:XU=DU
810 GOSUB 1250
820 IF SL = 1 AND DL = 0 THEN YL = 0
830 IF SL = 2 AND DL = 0 THEN XL = 0
840 IF XL > .01 THEN XL = XL + DM / 2
850 IF XU < LS THEN XU = XU - DM / 2
860 IF YL > .01 THEN YL = YL + DM / 2
870 IF YU < LW THEN YU = YU - DM / 2
1000 PRINT TAB(10);" ENTER MC. # AND CORRECT DISTANCES"
1010 PRINT TAB(10);" (ENTER MC.#=0 TO CONTINUE)"
1020 GOSUB 1150
1030 PRINT TAB(15);:INPUT;J
1040 IF J < 0 OR J > NM THEN PRINT TAB(10);"MUST BE BETWEEN 0 AND ";HM: GOTO 1030
1050 IF J = 0 THEN RETURN
1060 PRINT TAB(30);:INPUT Y(J),X(J);: IF Y(I) > LW OR Y(I) < 0 THEN PRINT TAB( 32);"" MUST BE BETWEEN ";:PRINT TAB( 35);"0 AND ";:LW;" -REDO": GOTO 1060
1070 IF X(I) > LS OR X(I) < 0 THEN PRINT TAB( 35);"" BETWEEN 0 AND": PRINT TAB( 37);LS;" -REDO": GOTO 1060
1080 GOTO 1030
1090 CLS: GOSUB 1150:K = K + KK
1100 NEXT I: IF NM = K - KK THEN 1210
1110 PRINT : INPUT " ANY CHANGES (Y/N) ";AS
1120 IF AS = "Y" THEN GOSUB 1000: GOTO 1190
1130 IF AS = "N" THEN 1190
1140 GOTO 1110
1150 PRINT TAB(10);" MC.NO. DISTANCE FROM:
1160 PRINT TAB(23);"SOUTH WALL, WEST WALL"
1170 RETURN
1180 REM
1190 L%= 1
1200 PRINT : PRINT TAB(10);" PLEASE WAIT"
1210 FOR I = 1 TO NM
1220 GOSUB 1230: GOTO 1370
1230 XL = X(I) - DM / 2: XU = X(I) + DM / 2
1240 YL = Y(I) - DM / 2: YU = Y(I) + DM / 2
1250 IF XL < = 0 THEN XL = .01
1260 IF XU > LS THEN XU = LS
1270 IF YL < = 0 THEN YL = .01
1280 IF YU > LW THEN YU = LW
1290 L = XL: GOSUB 420: XL = LF
1300 L = YL: GOSUB 420: YL = LF
1310 L = XU: GOSUB 420: XU = LF
1320 L = YU: GOSUB 420: YU = LF
1330 FOR J = XL TO XU: FOR K = YL TO YU
1340 S%(J,K) = L%
1350 NEXT K: NEXT J
1360 RETURN
1370 NEXT I
1380 RETURN
1390 GOSUB 1400: GOTO 1970
1400 CLS: PRINT : PRINT TAB(10);" " 'MATERIAL
FLOW": PRINT
1410 ENS = "EXISTING": GOSUB 1430
1420 GOTO 1470
1430 PRINT TAB(10);" FLOW BETWEEN:" NUMBER MAT'L"
1440 PRINT TAB(12); ENS: TAB(22); "NEW
OF
HDLC.COST"
1450 PRINT TAB(10);" MC.# MC.# TRIPS
(S/TRIP/DIST)
1460 PRINT
TAB(10);"-----------------------------------------------": RETURN
1470 KC = 12: KK = KC: PRINT TAB(10); "INPUT EXAMPLE =>
4,0.15 (ENTER)
1480 FOR I = 1 TO NM
1490 FOR J = 1 TO NA
1500 K = (I-1)*NA + J
1510 PRINT TAB(13); I; TAB(23); J; TAB(30);
1520 INPUT T,C
1530 W%(I,J) = T * C
1540 IF K < KC THEN 1670
1550 INPUT " ANY CHANGES (Y/N) ": AS
1560 IF AS = "Y" OR AS = "y" THEN GOSUB 1590: GOTO 1660
1570 IF AS = "N" OR AS = "n" THEN 1660
1580 GOTO 1550
1590 PRINT TAB(10);" ENTER CORRECT INFORMATION": PRINT
TAB(10);" (ENTER MC.#=0 TO CONTINUE)": PRINT:
GOSUB 1430
1600 PRINT TAB(12): INPUT; JI: IF JI > NM OR JI < 0 THEN
PRINT TAB(10); "MUST BE BETWEEN 0 AND "; NM: GOTO 1600
1610 IF JI = 0 THEN RETURN
1620 PRINT TAB(21): INPUT; JJ: IF JJ > NA OR JJ < 0 THEN
PRINT TAB(10); "MUST BE BETWEEN 0 AND "; NA: GOTO 1610
1630 PRINT TAB(30): INPUT T,C
1640 W%(JI + NW, JJ) = T * C
1650 GOTO 1600
1660 CLS: GOSUB 1430: KC = KC + KK
1670 NEXT J
1680 NEXT I
1690 IF NM * NA = KC - KK THEN 1740
1700 PRINT : INPUT " ANY CHANGES (Y/N) ":AS
1710 IF AS = "Y" OR AS="y" THEN GOSUB 1590: GOTO 1740
1720 IF AS = "N" OR AS="n" THEN 1740
1730 GOTO 1700
1740 CLS
1750 IF NA = 1 THEN 1960
1760 EMS = "NEW": GOSUB 1430
1770 KC = 12: KK = 12: K = 0
1780 FOR I = 1 TO NA - 1: FOR J = 1 TO NA
1790 IF I = J THEN 1930
1800 K = K + 1
1810 PRINT TAB(13);I; TAB( 23);J: TAB(32);
1820 INPUT T,C
1830 WH(I - NM.J) = T * C
1840 IF K < KC THEN 1930
1850 GOSUB 1860: GOTO 1920
1860 PRINT
1870 INPUT " ANY CHANGES (Y/N) ":AS
1880 IF AS = "Y" OR AS="y" THEN NW = NM: NW = NA: GOSUB
1890 NM = NW: NW = 0: GOTO 1910
1900 IF AS = "N" OR AS="n" THEN 1910
1910 GOTO 1870
1920 RETURN
1930 CLS: GOSUB 1430: KC = KC + KK
1940 NEXT J: NEXT I
1950 GOSUB 1860
1960 REM ** CALCULATIONS **
1970 GOTO 1920
1980 RETURN
1990 L = DM: GOSUB 420
2000 L1 = LF
2010 TH% = .00022 * NA * LS * LW * (4 * NM + 3 * L1 ^ 2 + 12) + 1
2020 CLS: PRINT TAB(20);" PLEASE WAIT !"
2030 GOSUB 2020: GOTO 2060
2040 PRINT : PRINT TAB(10);"NEW DISTANCE FROM:"
2050 PRINT TAB(10);"MC# SOUTH WALL WEST WALL"
2060 PRINT TAB(10);"--------------------------------------"
2070 PRINT TAB(10);"-----------------------------"
2080 RETURN
2090 FOR I = 1 TO NA
2100 PRINT TAB(12);I;
2110 NP = 0
2120 REM ** MC. AREA **
2130 STP=1
2140 FOR I1 = 1 TO LS - L1 + 1 STEP STP
2150 FOR J1 = 1 TO LW - L1 + 1 STEP STP
2160 FOR J2 = J1 + L1 - 1
2170 IF I1 = J1 THEN J2 = J2 + 1
2180 IF J2 = J1 + L1 - 1
2190 IF J1 = LW - L1 + 1
2200 REM * ALREADY OCCUPIED ? *
2210 IF NP = 0 THEN 2250
2220 IF NP = 0 THEN 2250
FOR X = I1 TO I2: FOR Y = J1 TO J2
IF S%(X,Y) = 1 THEN 2270: REM ** OCCUPIED **
NEXT Y: NEXT X
REM ** POSSIBLE LOC **
X = (I2 + I1 - 1) / 2: Y = (J2 + J1 - 1) / 2
NP = NP + 1
REM ** SCORE **
SUM = 0: FOR J = 1 TO NM + I - 1
SUM = SUM + (W%(J,1) * SQRT ((X - X(J)) ^ 2 + (Y - Y(J)) ^ 2))
NEXT J
IF NP = 1 OR SUM < MI THEN MI = SUM: XM% = X / K1: YM% = Y / K1
NEXT J1: NEXT I
GOSUB 2300: GOTO 2290
PRINT TAB(31): YM%: IF K1 < 1 THEN PRINT " + - "; K1;
PRINT TAB(43): XM%: IF K1 = 1 THEN PRINT: GOTO 2330
PRINT " + - "; K1
RETURN
X(NM + I) = XM%: Y(NM + I) = YM%
IQ = I: I = NM + I: GOSUB 1230: I = IQ
NEXT I
PRINT
INPUT " HIT 'ENTER' TO CONTINUE "; AS
CLS: PRINT: PRINT: PRINT
PRINT TAB(10): " SELECT YOUR NEXT ACTION : "
PRINT
PRINT TAB(10): " <1> CHANGE MACHINE AREA"
PRINT TAB(10): " TO A SMALLER SIZE"
PRINT TAB(10): " <2> CHANGE EXISTING MC. "
PRINT TAB(10): " LOCATIONS"
PRINT TAB(10): " <3> ENTER NEW MATERIAL FLOWS"
PRINT TAB(10): " <4> EXECUTE THE CASE STUDY"
PRINT TAB(10): " <5> HARD COPY OF RESULTS"
PRINT TAB(10): " <6> SAVE DATA ON A DISK FILE"
PRINT TAB(10): " <7> ANOTHER RUN"
PRINT TAB(10): " <8> EXIT PROGRAM"
PRINT
INPUT " ENTER SELECTION # "; SL
IF SL < 1 OR SL > 8 THEN PRINT " INPUT MUST BE BETWEEN 1 AND 7 "; GOTO 2520
GOTO 2540
ON SL GOTO 2580, 2630, 2640, 2650, 2670, 2560, 50, 2680
GOSUB 4010: GOSUB 3660: GOTO 2390
GOTO 2570
PRINT: PRINT TAB(10): " ENTER THE DESIRED LENGTH OF EACH SQUARE"
INPUT " MACHINE AREA (FT) "; FT
IF FT < 0 OR FT > DM + .5 THEN PRINT: PRINT TAB(10): " MUST BE BETWEEN 0 AND "; DM: GOTO 2580
L% = 0: GOSUB 1200
THE PROGRAM REFERS TO A 'SOUTH WALL' AS LINES OF "TOTAL COST OF MATERIAL FLOW. FOR"锰 PRINT TAB(15);"MORE THAN ONE NEW MACHINE, SOLUTION": PRINT TAB(15);"IS SUB-OPTIMAL."
2750 PRINT : PRINT TAB(15);"THE PROGRAM ACCEPTS DATA PERTINENT": PRINT TAB(15);"TO THE FLOW OF MATERIAL BETWEEN MACHINES": PRINT TAB(15);"INEX AND REPORTS THE OPTIMAL/SUBOPTIMAL": PRINT TAB(15);"LOCATIONS."
2760 GOSUB 2960:CLS
2770 FOR RT = 1 TO 7:PRINT :NEXT RT: PRINT TAB(15);"THE PROGRAM REFERS TO A 'SOUTH WALL' AS LINES OF "
2780 PRINT TAB(15);"REFERENCE FOR THE LOCATIONS OF THE MACHINES": PRINT TAB(15);"CHINES. ALTHOUGH THE 'WALLS' USED TO "
2790 PRINT TAB(15);"GATHER THE INPUT DATA DO NOT NEED TO BE": PRINT TAB(15);"ACTUALLY ORIENTED TOWARD THE SOUTH AND" 
2800 PRINT TAB(15);"WEST, THEY MUST BE PERPENDICULAR, AND," PRINT TAB(15);"WITH YOUR BACK TOWARD THE 'SOUTH WALL',": PRINT TAB(15);"THE 'WEST WALL' MUST BE TO THE LEFT."
2810 GOSUB 2960:CLS
2820 FOR RT = 1 TO 5:PRINT :NEXT RT: PRINT TAB(15);"THE SPACE OCCUPIED BY THE MACHINES": PRINT TAB(15);"ARE CONSIDERED TO BE SQUARE, WITH THE": PRINT TAB(15);"MACHINE LOCATION AT THE CENTER. THE" 
2830 PRINT TAB(15);"USER WILL INPUT THE DESIRED LENGTH OF " 
2840 PRINT TAB(15);"THE SIDE OF THE SQUARE."
2850 PRINT TAB(15);"IT IS IMPORTANT TO INCLUDE": PRINT TAB(15);"INFORMATION ABOUT THE FOLLOWING AREAS :
2860 PRINT TAB(15);"1. DOORWAYS": PRINT TAB(15);"
2. DESIRED AISLE SPACE": PRINT TAB(15);"
3. OTHER EQUIPMENT": PRINT TAB(15);"
4. STORAGE FACILITIES"
2870 GOSUB 2960:CLS
2880 FOR RT = 1 TO 7:PRINT:NEXT RT: PRINT TAB(15);"
ASSIGNING A MACHINE AREA TO A "": PRINT TAB(15);"DOORWAY OR
OTHER USED AREA WILL PREVENT": PRINT TAB(15);"A NEW MACHINE
FROM BEING PLACED THERE."
2890 PRINT TAB(15);"WHEN MATERIAL FLOW FROM OR TO THESE ":
PRINT TAB(15);"AREAS IS REQUESTED, SIMPLY ENTER 0.0": PRINT
TAB(15);"UNLESS THE AREA IS A DOORWAY THROUGH"
2900 PRINT TAB(15);"WHICH MATERIAL DOES FLOW": PRINT
2910 GOSUB 2960
2920 FOR RT = 1 TO 7:PRINT:NEXT RT:PRINT TAB(15);"ANY
AISLES WILL BE TREATED SEPARATELY": PRINT TAB(15);"ATELY FROM
THE MACHINES WITHIN THE PRODUCTION": PRINT TAB(15);"GRANITES": PRINT
TAB(15);"IF THE MACHINES ARE LONG AND"
2930 PRINT TAB(15);"NARROW, THEY SHOULD BE SUBDIVIDED
INTO": PRINT TAB(15);"SMALLER EQUAL AREAS SO THAT THE MOST":
PRINT TAB(15);"POSSIBLE SPACE WILL BE USED."
2940 GOSUB 2960
2950 RETURN
2960 FOR RT = 1 TO 5:PRINT:NEXT RT:PRINT TAB(15);"HIT
'ENTER' TO CONTINUE"
2970 INPUT AAS: RETURN
2980 CLS:FOR RT = 1 TO 10:PRINT:NEXT RT:INPUT "TURN ON YOUR
PRINTER AND PRESS ENTER":AS
2990 FOR RT = 1 TO 7:LPRTN"":NEXT RT
3000 LPRTN TAB(30);"OPTIMUM LOCATION"
3010 LPRTN TAB(30);"FOR NEW MACHINES"
3020 LPRTN"":LPRTN"":LPRTN""
3030 LPRTN TAB(35);"I.I.E.""
3040 LPRTN TAB(31);"MICRO-SOFTWARE"
3050 LPRTN TAB(32);"COPYRIGHTED"
3060 LPRTN"":LPRTN"":LPRTN"
3070 LPRTN"":LPRTN TAB(10);"DISTANCE FROM WEST TO EAST
":;LW
3080 LPRTN"":LPRTN TAB(10);"FROM SOUTH TO NORTH
":;LS
3090 LPRTN"":LPRTN TAB(10);"LENGTH OF SQUARE MACHINE
AREA":;DM
3100 LPRTN"":LPRTN"":LPRTN TAB(10);"EXISTING MACHINES:
FROM (SOUTH,WEST)"
3110 FOR I = 1 TO NM
3120 LPRTN"":LPRTN TAB(10);"MACHINE ";I;" : ";Y(I);":X(I)
3130 NEXT I
3140 LPRTN"":LPRTN"":LPRTN TAB(10);"NEW MACHINES: FROM
(SOUTH,WEST)"
3150 FOR I = NM + 1 TO NM + NA
3160 LPRTN"":LPRTN TAB(10);"MACHINE ";I-NM;" :
";Y(I);", X(I)
3170 NEXT I
3180 IF A%<1 THEN 3290
3190 LPRINT"";LPRINT"";LPRINT TAB(10);"AISLES"
1000 FOR I=1 TO A%
2220 SL=AZ(I,1);LPRINT"";LPRINT"";LPRINT TAB(13);"AISLE "+I
3220 IF SL = 1 THEN WS = "WEST";LS = "SOUTH";US = "NORTH";
GOTO 324;
3230 IF SL = 2 THEN WS = "SOUTH";LS = "WEST";US = "EAST";
GOTO 3240
3240 LPRINT:LPRINT " AISLE WIDTH ";AZ(I,2)
3250 LPRINT:LPRINT TAB(10);" DISTANCE TO CENTER OF AISLE 
FROM ";WS;" WALL ";AZ(I,3)
3260 LPRINT :LPRINT TAB(10);" DISTANCE TO ";LS;" END OF 
AISLE FROM ";LS;" WALL ";AZ(I,4)
3270 LPRINT:LPRINT TAB(10) " DISTANCE TO ";US;" END OF 
AISLE FROM ";LS;" WALL ";AZ(I,5)
3280 NEXT I
3290 FOR RT= 1 TO 8:LPRINT"";NEXT RT
3300 GOTO 2390
3310 OPEN "I",1,FS
3320 INPUT #1,K1
3330 INPUT #1,NM
3340 INPUT #1,NA
3350 INPUT #1,NW
3360 INPUT #1,LS
3370 INPUT #1,LW
3380 INPUT #1,DM
3390 INPUT #1,A%
3400 INPUT #1,LF
3410 INPUT #1,DF
3420 INPUT #1,NL
3430 INPUT #1,NT
3440 IF A%=0 THEN 3520
3450 FOR I = 1 TO A%
3460 FOR J = 1 TO 4
3470 INPUT #1,AZ(I,J)
3480 INPUT #1,AI(I,J)
3490 NEXT J
3500 INPUT #1,AZ(I,5)
3510 NEXT I
3520 FOR I = 1 TO LS
3530 FOR J = 1 TO LW
3540 INPUT #1, S%(I,J)
3550 NEXT J
3560 NEXT I
3570 FOR I = 1 TO NT
3580 INPUT #1, X(I)
3590 INPUT #1, Y(I)
3600 FOR J = 1 TO 10
3610 INPUT #1,W%(I,J)
3620 NEXT J
CLS: FOR RT = 1 TO 8: PRINT: NEXT RT
INPUT "INPUT THE FILE NAME: "; GS
PRINT
INPUT "INPUT THE DISK DRIVE I.D. (A, B, OR C): "; FS
FS = FS + ": " + GS
RETURN
IF ERL = 2990 THEN 4110
IF ERL = 3310 THEN 4150
IF ERL = 3660 THEN 4150
ON ERROR GOTO 0
CLS: FOR RT = 1 TO 10: PRINT: NEXT RT
PRINT TAB(10); "THE PROGRAM IS HAVING DIFFICULTY PRINTING"
4130 PRINT: PRINT TAB(10); "CHECK TO SEE IF THE PRINTER IS TURNED ON"
4140 GOTO 4170
4150 CLS: FOR RT = 1 TO 10: PRINT: NEXT RT
4160 PRINT TAB(10); "THE PROGRAM IS HAVING DIFFICULTY WITH YOUR DISK FILE"
4170 FOR RT = 1 TO 5: PRINT: NEXT RT
4180 PRINT TAB(10); "HIT 'ENTER' TO CONTINUE": INPUT AS
4190 RESUME 2390
APPENDIX A8
REM SUBPROGRAM "EVAL"
DIM D(30, 30), DD(30, 30), E(30, 21), LSS(30, 30)
DIM JX(5), ME(5, 435, 2)
PP = 0
COLOR 3, 0
GOSUB 2150
CLS: FOR RT = 1 TO 10: PRINT: NEXT RT
PRINT TAB(15): "DO YOU NEED INSTRUCTIONS (Y, N) ": INPUT YS
ON ERROR GOTO 3960
IF YS = "Y" OR YS = "y" THEN GOSUB 170: GOTO 120
IF YS = "N" OR YS = "n" THEN 120
PRINT: GOTO 70
CLS: FOR RT = 1 TO 10: PRINT: NEXT RT
PRINT TAB(15): "DO YOU WISH TO INPUT FROM A DISKFILE (Y OR N) ": INPUT YS
IF YS = "Y" OR YS = "y" THEN GOSUB 3760: GOSUB 3820: GOTO 2510
IF YS = "N" OR YS = "n" THEN 330
PRINT: GOTO 120
CLS
PRINT TAB(15): "THIS PROGRAM IS DESIGNED TO EVALUATE"
PRINT TAB(15): "A DEPARTMENTAL ARRANGEMENT (LAYOUT)"
PRINT TAB(15): "WITH RESPECT TO SATISFYING A" RELATIONSHIP CHART TO BE SUPPLIED ": PRINT TAB(15): "BY THE USER. EVALUATION CRITERIA IS": PRINT TAB(15): "THE PROXIMITY BETWEEN DEPARTMENTS."
PRINT TAB(15): "PROGRAM ACCEPTS A RELATIONSHIP CHART": PRINT TAB(15): "USING THE FOLLOWING 'RELVAL'S :":
PRINT TAB(15): "RELVAL KEY"
PRINT TAB(15): "6: ABSOLUTELY CLOSE 3: ORDINARY CLOSE"
PRINT TAB(15): "5: ESPECIALLY CLOSE 2: UNIMPORTANT"
PRINT TAB(15): "4: IMPORTANT 1: UNDESIRABLE"
PRINT: INPUT "HIT 'ENTER' TO CONTINUE": AS
RETURN
CLS: FOR RT = 1 TO 8: PRINT: NEXT RT
INPUT "ENTER THE # OF DEPARTMENTS ": ND
IF ND > 30 THEN PRINT: PRINT TAB(18): "THE NUMBER OF DEPARTMENTS IS LIMITED TO 30": GOTO 340
N1 = ((ND * ND) - ND) / 2
CLS: PRINT TAB(20): "DESIRED RELATIONSHIP CHART": PRINT TAB(20): "---------------------": PRINT
FOR I = 1 TO ND-1
J1 = I + 1
PRINT TAB(15): "ENTER RELVAL BETWEEN DEPT. ": I
410 FOR J = J1 TO ND
420 PRINT TAB(15);" AND DEPT. ";J;" = ";;
430 IF DD(I,J) > 6 OR DD(I,J) < 1 THEN PRINT TAB(20);"RELVAL SHOULD BE BETWEEN 1 & 6! PLEASE REENTER!": GOTO 420
440 NEXT J
450 GOSUB 2600
460 CLS: PRINT TAB(20);"DESIRED RELATIONSHIP CHART": PRINT TAB(20);"-----------------------------": PRINT
470 NEXT I
480 CLS:PRINT:PRINT:PRINT:PRINT
490 REM ** RELATIONSHIP CHART W.R.T. ADJACENT DEPTS.
500 PRINT TAB(15);"< INPUT DATA FOR LAYOUT TO BE EVALUATED >"
510 PRINT
520 PRINT TAB(15);" FOR EACH DEPARTMENT,"
530 PRINT TAB(15);" ENTER THE # OF CORRESPONDING ADJACENT DEPTS."
540 PRINT
550 PRINT TAB(15);"NOTE: 1. NO. OF ADJACENT DEPTS. NOT TO EXCEED 20"
560 PRINT TAB(15);" 2. INPUT ZERO TO END SEQUENCE OF ADJACENT DEPTS."
570 PRINT:PRINT TAB(15);"HIT 'ENTER' TO CONTINUE"::INPUT AS
580 FOR I = 1 TO ND
590 GOSUB 600:GOTO 740
600 CLS
610 PRINT TAB(15);"FOR DEPT. ";I
620 FOR J=1 TO 20:E(I,J)=0:NEXT J
630 FOR J = 1 TO 20
640 PRINT TAB(15);" ADJACENT DEPT. ";J;" IS ";: INPUT E(I,J)
650 IF E(I,J) > ND THEN PRINT TAB(15);" DEPT.# CANNOT EXCEED ";ND;"! REENTER!": GOTO 640
660 IF E(I,J) = I THEN PRINT TAB(15);"DEPT. CANNOT BE ADJACENT TO ITSELF! REENTER!": GOTO 640
670 IF J=1 THEN 710
680 FOR RT = 1 TO J-1
690 IF E(I,RT)=E(I,J) THEN PRINT TAB(15);"DEPT. # HAS ALREADY BEEN STATED FOR THIS DEPT.! REENTER!":GOTO 640
700 NEXT RT
710 IF E(I,J) = 0 THEN RETURN
720 NEXT J
730 RETURN
740 PRINT : PRINT
750 PRINT : INPUT " DO YOU WANT TO MAKE CHANGES(Y OR N) ";BS: IF BS = "Y" OR BS="y" THEN GOTO 590
760 CLS
770 NEXT I
780 CLS:FOR RT=1 TO 10:PRINT :NEXT RT:PRINT TAB(15);"YOUR
COMPUTER IS CALCULATING"
790 FOR I = 1 TO ND
800 FOR J = 1 TO ND
810 D(I,J) = 0
820 NEXT J
830 NEXT I
840 FOR I = 1 TO ND
850 FOR J = 1 TO 21
860 J1 = E(I,J)
870 IF J1 = I GOTO 1190
880 IF J1 = 0 GOTO 1200
890 IF D(I,J1) > 6 GOTO 910
900 D(I,J1) = 6
910 FOR K = 1 TO 21
920 K1 = E(J1,K)
930 IF K1 = 0 GOTO 1190
940 IF K1 = I GOTO 1180
950 IF D(I,K1) > 5 GOTO 970
960 D(I,K1) = 5
970 FOR L = 1 TO 21
980 L1 = E(K1,L)
990 IF L1 = 0 GOTO 1180
1000 IF L1 = I GOTO 1170
1010 IF D(I,L1) > 4 GOTO 1030
1020 D(I,L1) = 4
1030 FOR M = 1 TO 21
1040 M1 = E(L1,M)
1050 IF M1 = 0 GOTO 1170
1060 IF M1 = I GOTO 1160
1070 IF D(I,M1) > 3 GOTO 1090
1080 D(I,M1) = 3
1090 FOR T = 1 TO 21
1100 T1 = E(M1,T)
1110 IF T1 = 0 GOTO 1160
1120 IF T1 = I GOTO 1150
1130 IF D(I,T1) > 2 GOTO 1150
1140 D(I,T1) = 2
1150 NEXT T
1160 NEXT M
1170 NEXT L
1180 NEXT K
1190 NEXT J
1200 NEXT I
1210 FOR I = 1 TO ND
1220 FOR J = 1 TO ND
1230 IF I = J THEN 1250
1240 IF D(I,J) = 0 THEN D(I,J) = 2
1250 NEXT J
1260 NEXT I
1270 REM ** SYMMETRY**
1280 FOR I = 1 TO ND
1290 FOR J = 1 TO ND
1300 IF D(I,J) > D(J,I) THEN D(J,I) = D(I,J)
1310 IF D(J,I) > D(I,J) THEN D(I,J) = D(J,I)
1320 NEXT J
1330 NEXT I
1340 GOSUB 1350: GOTO 1380
1350 CLS
1360 PRINT TAB(15);" LAYOUT EQUIVALENT": PRINT
TAB(15);" RELATIONSHIP CHART": PRINT TAB(15);" -------------------": PRINT
1370 RETURN
1380 IC = 0
1390 FOR I = 1 TO ND
1400 PRINT TAB(15);"BETWEEN DEPT. # "; I
1410 FOR J = 1 TO ND
1420 IF I = J THEN 1500
1430 PRINT TAB(15);" AND DEPT. # "; J:" LAYREL=";D(I,J)
1440 IC = IC + 1
1450 IF IC<12 AND J<ND THEN 1500
1460 PRINT:PRINT TAB(15);"HIT 'ENTER' TO CONTINUE"::INPUT AS
1470 CLS:GOSUB 1350
1480 IF IC=12 THEN PRINT TAB(15);"BETWEEN DEPT. # "; I
1490 IC=0
1500 NEXT J
1510 NEXT I
1520 PRINT :PRINT TAB(15);"HIT 'ENTER' TO CONTINUE"::INPUT AS
1530 CLS:FOR RT = 1 TO 10:PRINT:NEXT RT:PRINT
TAB(15);"COMPUTER IS CALCULATING"
1540 REM ** RELATIONSHIP CHART EVALUATION PROCESS
1550 REM **SUBTRACT REL. CHART W.R.T. PRODUCT - REL. CHART
W.R.T. ADJACENT DEPTS.
1560 FOR I = 1 TO ND - 1
1570 FOR J = I + 1 TO ND
1580 IF DD(I,J) = 6 AND D(I,J) < > 6 THEN GOSUB 2410:
GOTO 2080
1590 IF DD(I,J) = 1 AND D(I,J) = 6 THEN GOSUB 2460: GOTO 2080
1600 NEXT J
1610 NEXT I
1620 CLS: PRINT : PRINT : PRINT TAB(15);" EVALUATION
SCORING": PRINT TAB(15);" -------------------": PRINT
1630 L = 0:LT = 0
1640 IC = 0
1650 FOR I1 = 1 TO 5:JX(I1) = 0: NEXT I1
1660 FOR I = 1 TO ND - 1
1670 FOR J = I + 1 TO ND
1680 X = DD(I,J) - D(I,J)
1690 L = L + 1
1700 LS = 0
1710 IF X < 0 THEN LS = 5: GOTO 1750
FOR I1 = 1 TO 4
IF X = I1 THEN GOSUB 1340: GOTO 1750
NEXT I1
PRINT TAB(15);"FROM DEPT ";I1;" TO DEPT ";J;" EVAL
SCORE= ";LS
LSS(I,J)=LS
IC = IC + 1
IF IC<12 THEN 1800
PRINT:INPUT "HIT 'ENTER' TO
CONTINUE";YS:IC=0:CLS: PRINT : PRINT : PRINT TAB(15);"EVALUATION SCORING": PRINT TAB(15);
--------------------------": PRINT
LT = LT + LS
NEXT J
GOTO 1890
REM **SUBROUTINE EFFICIENCY**
IF X = I1 THEN LS = (5 - I1):JD = LS + 1:JX(JD) = JX(JD) + 1
J1 = JX(JD)
ME(JD,J1,1) = I:ME(JD,J1,2) = J
RETURN
L = 5 ^ L
PRINT:PRINT TAB(15):"A TOTAL EVALUATION SCORE OF ";LT:
PRINT TAB(20);" OUT OF"
PRINT TAB(15);"A MAXIMUM OF ";L;" WAS COMPUTED."
PRINT: INPUT ";HIT 'ENTER' TO
CONTINUE";YS: CLS
REM ** DISPLAY OF DATA ** RETURN
FOR I = 1 TO 5
Z = 0:R = 0:IC=0
IF JX(I) = 0 THEN 2070
CLS: PRINT : PRINT TAB(15);"IF THE FOLLOWING DEPTS. ";PRINT TAB(15);"BECAME CLOSER ";PRINT
FOR J = 1 TO JX(I)
PRINT TAB(15);" DEPT. ";ME(I,J,1);" & DEPT.
";ME(I,J,2)
IC=IC+1:IF IC = 12 THEN PRINT:PRINT TAB(15);"HIT
'ENTER' TO CONTINUE";INPUT AS:IC = -4:CLS
NEXT J
Z = 6 - I:R = R + Z
PRINT : PRINT TAB(15);"THIS WOULD INCREASE THE TOTAL":PRINT TAB(15);"EVALUATION SCORE TO ";LT + (R * JX(I))
PRINT TAB(15);"OUT OF A POSSIBLE MAXIMUM OF ";L: PRINT
PRINT TAB(15);"NEXT STEP TO BE PERFORMED ";PRINT TAB(19);"1. PRINTED OUTPUT":
PRINT TAB(19);"2. CHANGE DATA": PRINT TAB(19);"3. NEW
RUN: PRINT TAB(19); "4. Save data on disk": PRINT TAB(19); "5. Exit".
2090 PRINT: PRINT: INPUT "ENTER"
2100 SELECTION ": W: IF W < 0 OR W > 5 THEN 2080
2110 ON W GOTO 2880, 2110, 2120, 2130, 2130
2110 GOTO 2510
2120 CLS: GOTO 40
2130 RETURN BACK TO MAIN PROGRAM
2140 RUN: "HELLO"
2150 CLS: FOR RT = 1 TO 8: PRINT: NEXT RT
2160 PRINT TAB(32): "Plant Design"
2170 PRINT TAB(30): "Layout Evaluation"
2180 PRINT: PRINT: PRINT
2190 PRINT TAB(35): "I.I.E.
2200 PRINT TAB(31): "Micro-Software"
2210 PRINT TAB(33): "Copyrighted"
2220 FOR I = 1 TO 30; FOR J = 1 TO 21: E(I, J) = 0: :"EXT J: NEXT I
2230 RETURN
2240 FOR I = 1 TO ND: :CLS
2250 PRINT TAB(15): "For Dept. #": I
2260 FOR J = 1 TO 20
2270 INPUT "NEW ADJACENT DEPT. = " : E(I, J)
2280 IF E(I, J) = I OR E(I, J) > ND THEN PRINT TAB(15): "DEPT. # INCORRECT, RE-ENTER": GOTO 2270
2290 IF E(I, J) = 0 THEN RETURN
2300 N%(I) = N%(I) + 1
2310 NEXT J
2320 RETURN
2330 PRINT: INPUT " ANY CHANGES (Y/N) " ; YS
2340 IF YS = "N" OR YS = "n" THEN 2400
2350 IF YS = "Y" OR YS = "Y" THEN 2360 ELSE 2330
2360 INPUT "CHANGE RELVAL BET. DEPT. "; I
2370 INPUT " AND DEPT. "; J
2380 IF I > ND OR J > ND THEN PRINT TAB(15): "DEPT. # SHOULD BE LESS THAN "; ND; ": PLEASE RE-ENTER": GOTO 2360
2390 INPUT "REL. VALUE ": DD(I, J)
2400 RETURN
2410 CLS
2420 FOR T = 1 TO 8: PRINT: NEXT T
2430 PRINT TAB(15): " DEPT. "; I; " AND DEPT. "; J: PRINT TAB(15): "SHOULD BE ADJACENT IN ANY": PRINT TAB(15):
2440 PRINT " LAYOUT ARRANGEMENT. ": PRINT TAB(15): " THE LAYOUT IN HAND
2450 PRINT " DOES NOT": PRINT TAB(15): " FULFILL THIS REQUIREMENT."
2460 PRINT: PRINT: PRINT TAB(15): "HIT 'ENTER' TO
2470 RETURN
2480 FOR T = 1 TO 8: PRINT: NEXT T
2490 PRINT TAB(15): " DEPT. "; I; " AND DEPT. "; J: PRINT TAB(15): "CANNOT BE ADJACENT IN ANY": PRINT TAB(15): "}
LAYCUT ARRANGEMENT.

THE LAYOUT IN

HAND DOES NOT:

FULFILL THIS

REQUIREMENT.

2490 PRINT ; PRINT : PRINT TAB(15); "HIT 'ENTER' TO

CONTINUE" ; : INPUT AS

2500 RETURN

2510 REM CHANGE DATA ROUTINE

2520 GOSUB 2530; GOSUB 2720; GOTO 780

2530 CLS

2540 FOR I = 1 TO ND-1

2550 J1 = I + 1

2560 GOSUB 2600

2570 CLS

2580 NEXT I

2590 RETURN

2600 CLS:PRINT TAB(16); "SUMMARY OF THE RELVALS FROM

DEPARTMENT" ; I; PRINT; OBS=0

2610 FOR J = J1 TO ND

2620 PRINT TAB(5+OBS*40); "TO

DEPARTMENT" ; J; TAB(23+OBS*40); DD(I, J); IF OBS=1 THEN PRINT; OBS=0 ELSE OBS=1

2640 NEXT J

2650 PRINT

2660 PRINT:PRINT TAB(10); "INPUT DESTINATION DEPARTMENT TO

CHANGE (0 TO CONTINUE)" ; : INPUT IZ

2670 IF IZ=0 THEN RETURN

2680 IF IZ>ND OR IZ<J1 THEN PRINT TAB(12); "INPUT MUST BE

BETWEEN" ; J1 ; " AND" ; ND; GOTO 2660

2690 PRINT TAB(15); "INPUT RELVAL FROM DEPT." ; I ; " TO

DEPT." ; IZ ; : INPUT DD(I, IZ)

2700 DD(IZ, I)=DD(I, IZ)

2710 GOTO 2600

2720 REM LAYOUT INFO.

2730 CLS

2740 PRINT TAB(15); "DEPT.#" ; TAB( 25) ; "ADJACENT DEPTS. " : PRINT

2750 FOR I = 1 TO ND

2760 ID=0:PRINT TAB(17); I ; TAB(23); IF ID=1: IF ID>12 THEN PRINT:PRINT TAB(23); ID=0

2780 IF E(I, J)=0 THEN 2800 ELSE PRINT E(I, J);" "; NEXT J

2800 NEXT I

2810 IF I=10 THEN PRINT :PRINT TAB(15); "HIT 'ENTER' TO

CONTINUE" ; : INPUT AS; CLS

2820 NEXT I

2830 PRINT ; PRINT TAB(15); "INPUT DEPARTMENT # TO CHANGE (0

TO CONTINUE)" ; : INPUT II

2840 IF II = 0 THEN 2870

2850 IF II < 1 OR II > ND THEN PRINT TAB(15); "DEPT.# OUT

OF RANGE" ; GOTO 2830

2860 I = II; GOSUB 600; GOTO 2730

2870 RETURN
FOR RT=1 TO 3: LPRINT":" ; NEXT RT
LPRINT TAB(32); "PLANT DESIGN"
LPRINT TAB(30); "LAYOUT EVALUATION"
LPRINT"
LPRINT TAB(35); "I.I.E."
LPRINT TAB(31); "MICRO-SOFTWARE"
LPRINT TAB(33); "COPYRIGHTED"
FOR RT=1 TO 4: LPRINT":" ; NEXT RT
LPRINT TAB(15); "INPUT DATA": LPRINT
TAB(15); "-----------": LPRINT"
LPRINT TAB(15); "NO. OF DEPTS. INVOLVED": LPRINT";
LPRINT TAB(17); "DESIGNED RELATIONSHIPS": LPRINT
TAB(17); "------------------": LPRINT"
FOR I = 1 TO ND
J1 = I + 1
IF J1 > ND AND I = ND THEN 3070
LPRINT TAB(15); "RELVAL BETWEEN DEPARTMENT ": I
FOR J = J1 TO ND
LPRINT TAB(23); "AND DEPARTMENT ": J; " = "; DD(I,J)
NEXT J
NEXT I
LPRINT"": LPRINT"": LPRINT TAB(17); "LAYOUT
DESCRIPTION": LPRINT TAB(17); "------------------": LPRINT"": LPRINT TAB(15); "DEPT.": TAB(22); "ADJACENT
DEPARTMENTS": LPRINT"
FOR I = 1 TO ND
LPRINT TAB(17); I; TAB(23);
FOR J = 1 TO 20
IF E(I,J)=0 THEN 3120 ELSE LPRINT E(I,J); ";
NEXT J
NEXT I
LPRINT"": LPRINT"
NEXT I
LPRINT"": LPRINT"": LPRINT TAB(15); "PROGRAM
RESULTS": LPRINT TAB(15); "------------------": LPRINT"": LPRINT"
LPRINT TAB(15); "LAYOUT EQUIVALENT": LPRINT
TAB(15); "RELATIONSHIP CHART": LPRINT TAB(15); ";
------------------": LPRINT"
FOR I = 1 TO ND
LPRINT TAB(15); "BETWEEN DEPT. ": I
FOR J = 1 TO ND
IF I = J THEN 3220
LPRINT TAB(15); "AND DEPT. ": J; " LAYREL=
":D(I,J)
NEXT J
NEXT I
FOR I = 1 TO ND - 1
FOR J = I + 1 TO ND
IF DD(I,J) = 6 AND D(I,J) < > 6 THEN GOSUB 3530:
GOTO 2080
IF DD(I,J) = 1 AND D(I,J) = 6 THEN GOSUB 3570: GOTO
2080 NEXT J
2090 NEXT I
2100 LPRINT"" :LPRINT"" :LPRINT TAB(15);" EVALUATION
SCORING" :LPRINT TAB(15);" -------------------------------" :LPRINT"
2110 LT = 0
2120 FOR I = 1 TO ND - 1
2130 FOR J = I + 1 TO ND
2140 LPRINT TAB(15);" DEPT." :I;" TO DEPT." :J;" EVAL
SCORE=" :LSS(I, J)
2150 LT = LT + LSS(I, J)
2160 NEXT J
2170 NEXT I
2180 LPRINT"" :LPRINT TAB(15);" A TOTAL EVALUATION SCORE OF ";LT;
2190 LPRINT TAB(20);" OUT OF"
2200 LPRINT TAB(15);" A MAXIMUM OF" ;L;" WAS COMPUTED."
2210 FOR I = 1 TO 5
2220 Z = 0 : R = 0
2230 IF JX(I) = 0 THEN 3510
2240 LPRINT"" :LPRINT TAB(15);" IF THE FOLLOWING
DEPTS.;" :LPRINT TAB(15);" BECAME CLOSER ---" :LPRINT"
2250 FOR J = 1 TO JX(I)
2260 LPRINT TAB(15);" DEPT." ;ME(I, J, 1);" & DEPT.
" ;ME(I, J, 2)
2270 NEXT J
2280 Z = 6 - I : R = R + Z
2290 LPRINT"" :LPRINT TAB(15);" THIS WOULD INCREASE THE 
TOTAL" :LPRINT TAB(15);" EVALUATION SCORE TO ";LT + (R * 
JX(I))
2300 LPRINT TAB(15);" OUT OF A POSSIBLE MAXIMUM OF 
" ;L;LPRINT"" :LPRINT"
2310 NEXT I
2320 FOR RT = 1 TO 8: LPRINT"" :NEXT RT: GOTO 2080
2330 FOR T = 1 TO 8: LPRINT"" : NEXT T
2340 LPRINT TAB(15);" DEPT." ;I;" AND DEPT." ;J: LPRINT
TAB(15);" SHOULD BE ADJACENT IN ANY" :LPRINT TAB(15);"
LAYOUT ARRANGEMENT." :LPRINT TAB(15);" THE LAYOUT IN HAND
DOES NOT" :LPRINT TAB(15);" FULFILL THIS REQUIREMENT."
2350 FOR T = 1 TO 8:LPRINT"" : NEXT T
2360 RETURN
2370 FOR T = 1 TO 8: LPRINT"" : NEXT T
2380 LPRINT TAB(15);" DEPT." ;I;" AND DEPT." ;J: LPRINT
TAB(15);" CANNOT BE ADJACENT IN ANY" :LPRINT TAB(15);"
LAYOUT ARRANGEMENT." :LPRINT TAB(15);" THE LAYOUT IN
HAND DOES NOT" :LPRINT TAB(15);" FULFILL THIS
REQUIREMENT." 2390 FOR T = 1 TO 8:LPRINT"" : NEXT T
2400 RETURN
2410 GOSUB 3760
2420 OPEN "O", 1, FS
2430 PRINT #1, ND
5640 FOR I = 1 TO ND
5650 FOR J = 1 TO ND
5660 PRINT #1, DD(I, J)
5670 NEXT J
5680 NEXT I
5690 FOR I = 1 TO ND
5700 FOR J = 1 TO 20
5710 PRINT #1, E(I, J)
5720 NEXT J
5730 NEXT I
5740 CLOSE #1
5750 GOTO 2080
5760 CLS: FOR RT = 1 TO 7: PRINT: NEXT RT
5770 INPUT " INPUT THE FILE NAME: "; GS
5780 PRINT
5790 INPUT " INPUT THE DISK DRIVE I.D. (A, B, OR C): "; FS
5800 FS = FS + ":" + GS
5810 RETURN
5820 OPEN "I", 1, FS
5830 INPUT #1, ND
5840 FOR I = 1 TO ND
5850 FOR J = 1 TO ND
5860 PRINT #1, DD(I, J)
5870 NEXT J
5880 NEXT I
5890 FOR I = 1 TO ND
5900 FOR J = 1 TO 20
5910 PRINT #1, E(I, J)
5920 NEXT J
5930 NEXT I
5940 CLOSE #1
5950 RETURN
5960 IF ERL = 2880 THEN 4000
5970 IF ERL = 3620 THEN 4040
5980 IF ERL = 3820 THEN 4040
5990 ON ERROR GOTO 0
6000 CLS: FOR RT = 1 TO 10: PRINT: NEXT RT
6010 PRINT TAB(10); "THE PROGRAM IS HAVING DIFFICULTY PRINTING"
6020 PRINT: PRINT TAB(10); "CHECK TO SEE IF THE PRINTER IS TURNED ON"
6030 GOTO 4060
6040 CLS: FOR RT = 1 TO 10: PRINT: NEXT RT
6050 PRINT TAB(10); "THE PROGRAM IS HAVING DIFFICULTY WITH YOU DISK FILE"
6060 FOR RT = 1 TO 5: PRINT: NEXT RT
6070 PRINT TAB(10); "HIT 'ENTER' TO CONTINUE"; : INPUT AS
6080 RESUME 2080