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A micro computer based approach to machine tool selection.

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A MICRO COMPUTER BASED APPROACH
TO MACHINE TOOL SELECTION

BY

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ABSTRACT

This thesis is the result of research carried out in the area of computer aided process planning (CAPP). The research focused on the use of a micro computer to aid the process engineer in the development of process plans. The use of a micro computer was an important consideration since it allows for a more wide spread use by todays industries. A procedure to adequately describe the component in terms of shapes to be removed was developed which would allow the system to optimize the machine tool selection procedure. The research focused on the selection of machines and the generation of cutting parameters to aid the process engineer by speeding up the arithematic and heuristic procedures required for the generation of process plans. The procedure allows the system to select machines based on the operations determined by the system, generate the cutting parameters and rank each alternative for selection by the process engineer. The alternatives were ranked according to minimum cost or maximum production rate. As a result of this research, it has been determined that micro-computers can be effectively used to aid the process engineer in the development of process plans in smaller machine shop environments.

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This thesis is dedicated to my wife Debbie, who for the past two years gave me the encouragement and support needed to complete this report.

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1.0 INTRODUCTION

The selection of machine tools can no longer be left to the judgement of individuals. Markets today have forced industry to streamline production techniques to reduce costs in all areas of manufacturing. This need to reduce costs has resulted in the use of computers to aid in the selection of optimal machine tools for the purpose of process plan generation.

Process planning is the determination of the sequence of cutting tools and the cutting parameters to manufacture a particular component. Computerized process planning will form the link between computer aided design and computer aided manufacturing systems. This thesis discusses a computer based approach that can be used to aid the in this function by selecting suitable machine tools and generating the cutting parameters.

1.1 Goals of Computer Aided Process Planning (CAPP)

In recent years, with the advancements which have been made in manufacturing technology, there has been an increased need to utilize machines to their fullest potential. It has become necessary to ensure that not only is the proper machine selected for a job, but that the machining parameters are selected such that the part characteristics are achieved at a minimum cost. A problem that has been brought about by more sophisticated machines is that often the individuals developing the plans do not have the experience required to allow them to develop process plans for the new style of modern machines. Younger machinist may never achieve this same level of experience, since the new machines do not require the same level of machining skill to operate as the older manual machines once required.

Today, the task of machine selection is often performed manually by a machinist who selects, in his judgement, the best choice of machine tools available in the shop. The machinist then attempts to determine the optimal machining parameters for the job based on his judgement and past experiences. It has been reported that in most cases the machinist will choose the machine which he is most familiar with (2), which may not be the best alternative available. The ideal solution would be to consider all possible tool combinations available in the shop, and determine the most cost effective plan for the part to be manufactured. Until all combinations of tools can be explored the development of optimal process plans is very unlikely to occur.

A computer based system can be a useful aid to the process planner by considering the potential alternatives for manufacturing in order to ensure the best possible process plan can be generated. For small firms, a micro-computer may be all that is required to aid in this function, since the number of alternative machines would be considerably less than in larger firms. The use of a micro-computer could be advantageous for smaller industries since they are less expensive and well within their financial capabilities. Moreover memory requirements need not inhibit their use, since the alternative machines available would normally be less when compared to larger industries.

1.2 Potential Benefits of A CAPP System

Benefits other than the selection of machine-tools which are brought about by computer aided process planning include;

1. The ability to produce plans more rapidly. The use of a computer allows more rapid generation of process plans. Plans that may have taken days to develop may only take hours with the aid of a computer. As a result there would be a savings in the cost of generating the plans.

2. Reduction in cost by increasing productivity. By selecting the proper machines and the machining parameters to manufacture the part a higher level of

productivity can be achieved since the machines are utilized to their highest potential.

3. Faster implementation of new technologies. By allowing the computer to select machines the installation of new machines will be incorporated into the system immediately and not require the complete learning of the machine's capabilities by the operator.

4. Lower level of machine knowledge. Since the computer is responsible for the selection of machine tools the operator does not require complete knowledge of all machining methods available. Therefore, the higher paid machinist are not required to operate the system and can be used in more important functions on the shop floor.

These and other potential benefits will result in more wide spread use of computers to aid in the generation of process plans. Computer aided process planning systems will be incorporated in industries both large and small. With this increased demand, there is a need to develop a micro computer based system which can be used to aid in the development of process plans.

2.0 GOALS AND OBJECTIVES OF RESEARCH

The goal of the research was to determine if a generative process planning system could be developed in a manner requiring the use of only a micro-computer; if such a system were possible, develop a methodology to allow for optimal process plan generation within a reasonable time period. A computer with 512K of operating memory and with a hard disk capability of 2 megabytes was selected for the study, since this would conform to standard micro computer systems normally used by small industry.

Based on studies and tests of the system it was decided that the optimal generation of process plans could be left to the operator of the system, the operator then uses the computer as an aid in the selection of tools and to provide the recommended cutting parameters. The final selection and sequencing of machine tools would be left to the operator of the system.

The thesis proposes two separate methodologies to develop "optimum" process plans based on component description and capabilities of existing machines on the shop floor as follows:

1. Allow for optimal generation of process plans using a micro-computer.

2. Use a micro-computer to aid in the selection of appropriate machine tools and cutting parameters.

The two systems have been developed and compared based on various parameter characteristics and operating conditions.

3.0 LITERATURE SURVEY

Several papers were reviewed covering many different topics related to tool selection, process plan generation as well as papers dealing with machining processes. The wide variety of topics reviewed indicate the difficulty in developing a tool selection procedure especially using only a micro-computer. Many papers dealt with specific areas in the field, with none providing a procedure which can be applied to a micro-based system. The papers were grouped into different categories as listed below;

1. Machine and Tool selection.
2. Cutting Parameter Estimation
3. Process planning Systems
   a. Variant
   b. Generative
   c. Expert

3.1 Machine and Tool Selection

A few papers dealt with procedures which can be followed in the selection of machine-tools (2,8,18,19,22). The selection of appropriate machine tools is one of the most vital steps in the process planning function. It is important to relate the machine tool capabilities to those required by the component to be manufactured, and also to determine if simultaneous machining of the component is possible by having more than a single cutting tool in contact with the component at any point in time. The selection usually involves an estimate of the machining cost for a particular machining operation specified by the operator. The specification of the machining operation however, assumes that the machining operation is known. For a truly generative system the machining process required should be generated by the system. This would allow for different alternative operation combinations resulting in the same finished part.

3.2 Cutting Parameter Estimation

Once the machine has been selected for a particular operation a number of cutting parameters must be determined to ensure that the specifications of the component are met. These parameters will include machine speeds, tool feeds, etc. In all the papers some form of an assumption is made to simplify the determination of the cutting parameters. In some cases only a single pass was made, or the feed rate was fixed. Based on these assumptions, the remaining parameters were calculated using the tool life equations. Several papers dealt with the generation of cutting parameters, these include (3,4,5,6,9,13,14,16,24,25).

3.3 Process Plan Generation

Several papers dealing with process plan generation were reviewed. Process planning involves both of the previous steps of machine-tool selection and cutting parameter estimation as well as the sequencing of machines to perform the required operation. The overall plan should result in the generation of a process plan that meets the requirements of the part at the Iowest cost.

3.3.1 Types of Process Planning Systems

The traditional approach to process planning has been the manual manipulation of information by a skilled machinist to develop a process plan based on an engineering drawing. This approach is quickly being replaced in many industries by computerized approaches to the problem.

There are two computer based approaches;

1. Variant
2. Generative

Each of these approaches is unique in terms of their method of process plan generation. Each will be described in detail as to how they are used to generate or aid in the generation of process plans.

3.3.1.1 Variant Approach

A few of the papers dealt with the variant approach of process plan generation. The list of papers include (11, 19,23). In these papers the main objective was to determine an appropriate coding scheme to be used to store and retrieve existing process plans from storage. The adjustments to machine selection, sequencing, and cutting parameters due to differences in the components was not discussed in detail and was often left to the individual operator of the system.

The Variant approach involves the codification of the component based on predetermined component characteristics. Common coding systems include the Opitz and Miclass coding methods (19). Based on the code devloped by the above methods, an existing process plan is retrieved from storage and manual alterations are made to the plan to allow the component to be manufactured to the new specifications. This procedure requires the manual manipulation of the plan which could be subject to error or prejudices based on the operator's experience. It is the potential error and prejudices which have to be eliminated in order to ensure the generation of optimal process plans. The Generative approach brings us closer to truly independent and non-prejudicial development of a process plan.

3.3.1.2 Generative Approach

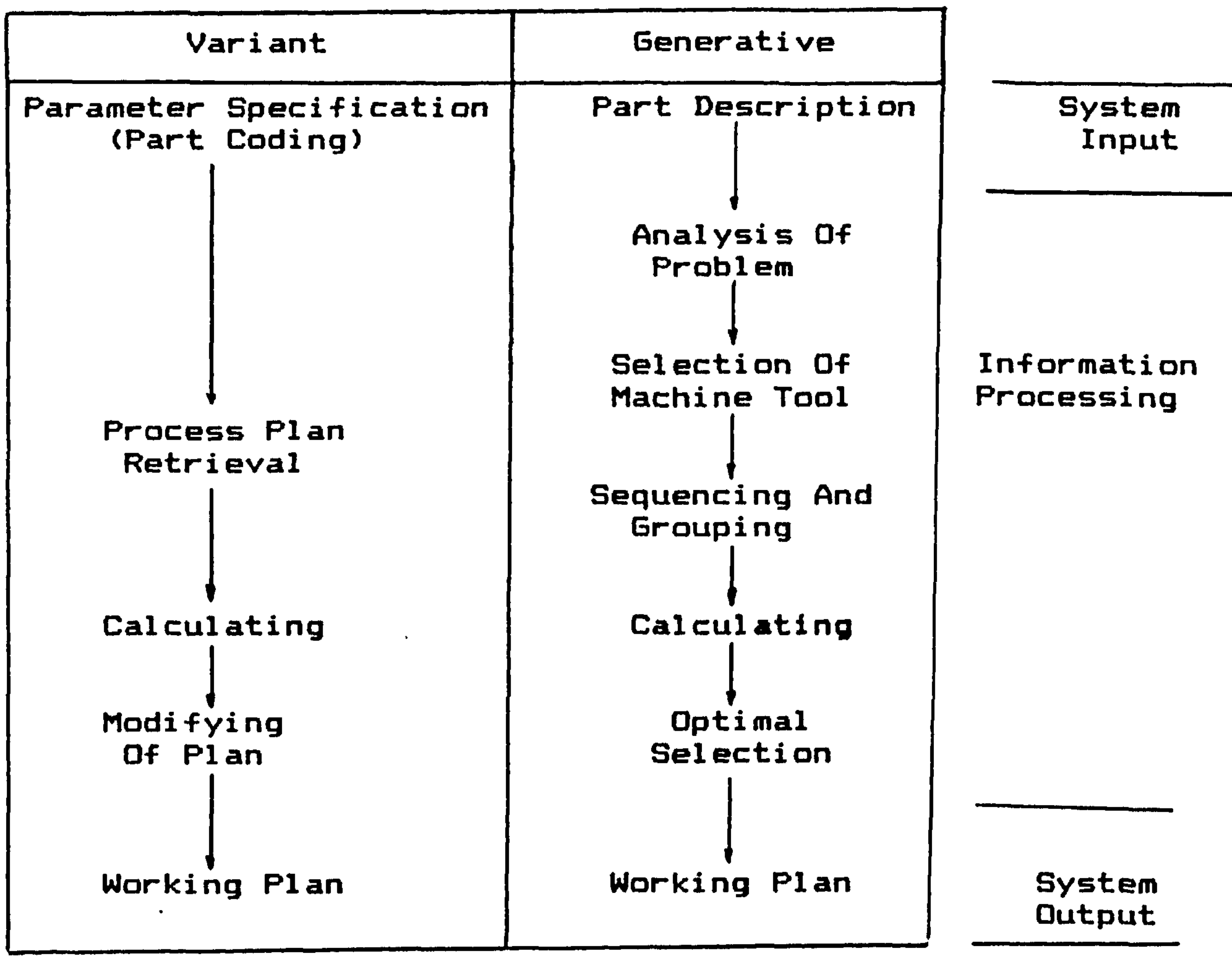
Here also, several papers dealt with the components which go into the development of a Generative process planning system. These papers included (9,10,15,19,21,23). The difficulty with these papers seemed to be the inflexibility of the designed systems and the size of computer which was often required to run the system. The papers dealt with systems which were often designed to suit the needs of one particular user. Often the design took many man years to develop and required a large computer system to operate. None of the papers dealt with a universal system which could be applicable to a wide number of users through its implementation on a micro-computer.

The Generative approach involves generating new process plans from the beginning each time a part is to be manufactured. The system not only considers the part features and specifications, but also the number of components which are to be manufactured, as well as the current machines available. In Generative process planning the component must be uniquely defined by the operator to the system in terms of features to be removed, the tolerance and the surface finish of each feature. This entirely new plan generation allows the system to consider every possible machine tool combination each time to ensure that an optimal plan is generated. This approach requires a complete description of all machines and tools to be kept in a machine database. This database is used to compare the requirements of the component with the tools available and their capabilities.

3.3.2 Expert System

Expert systems have been designed for both the Variant and Generative approaches to process planning. The recent trend towards an intelligent system has prompted much research in this area, but, it is still in its infancy. Through the development of more powerful computers and new programming languages such as Prolog, these system may eventually be used to develop complete process plans with very little interaction by the operator. A few papers were found which did describe systems which utilize this new found knowledge. These include (7,10,15,17).

A comparison of the Variant and Generative approaches is illustrated in Figure 3.1. Under the Variant approach the operator of the system must carry out what is called a "modifying" operation. The operator must take the existing process plan and modify it to suit the characteristics of the current problem. It is in this modification phase that the prejudices of the operator may affect his selection of



Comparison Of The Variant

& Generative Approaches To

Process Planning

Figure 3.1

alternative choices. The generative approach requires no modification to the process plan, but the complexity of the problem is greatly increased due to the enormous number of calculations required and the number of comparisons to be made between the machine capabilities and the component requirements.

3.4 Comparison Of Existing Process Planning Systems

There have been numerous attempts to develop computer aided process planning systems with several successes in both the Variant and Generative approaches. A third approach which is receiving considerable attention is the Expert system of process planning. Each of the first two have been developed in most cases by industry to suit the particular needs of a given company. The Expert systems which are being developed are designed to be applicable to more then a single user. The Expert systems have the capability of learning from their past decisions, so that mistakes in the past will not occur in the future. These systems are capable of making decisions in a similar manner to the human decision process and therefore are capable of learning as the system is utilized. The Expert system is not a new method of process or tool selection, but, is a new approach in system design using advanced computer languages such as Prolog and Lisp.

Table 3.1 contains a listing of systems which have been developed or are currently in the process of being developed by industry or in research facilities. Each system has been broken down to allow for comparison based on certain definitions such as; system name, type (variant, generative,expert), component type and reference papers where information on the various systems can be found. None of the current systems reviewed have been developed to specifically run on a micro computer, and a great number of these systems have been developed with a particular user in mind.

An indepth review of these systems has indicated a diversity of approaches to the problem of generating process plans. However, the goal of each system is to develop a cost effective plan for the user of the system. Using cost effectiveness as a basis, the system to be used in industry should also be affordable for the user in terms of the initial capital investment. In many of the cases shown in Table 3.1 the system could not be used by a smaller industry, or any other user since it was designed for the particular needs of a specific company. For this reason it is necessary to develop a method to aid in the process planning function which can be used by a number of different companies and which can be run on a

SYSTEMS IN INDUSTRY

SYSTEM NAME	TYPE	ROT/PRIS.	REFERENCE
APLAN	N/A	ROT	15
AUTAP	N/A	ROT	15,23
CADSY	N/A	ROT	15,23
DREKAL	N/A	ROT	15
SISPA	N/A	ROT	15
DISAP	GENERATIVE	PRIS	15,23
EXCAP	EXPERT/GENER	N/A	15
COATS	EXPERT	ROT	12
ACAPS	SEMI-GENERATIVE	N/A	9,19
XPLANE	EXPERT/GENER	ROT/NRIS	10
CUTTECH	OP. PLANNING	N/A	2
ICAPP	VAR/GEN	PRIS	11
ROUND	GENERATIVE	ROT	21
XPS-E	EXPERT	ROT/PRIS	17
MIPLAN	VARIANT	N/A	19,23
CAPP	VARIANT	N/A	19,23
APPAS	GENERATIVE	PRIS	19
GENPLAN	GENERATIVE	ASSEMBLY	19
CMPP	GENERATIVE	ROT	19
GARI	N/A	N/A	23
XPS-1	EXPERT	N/A	7
CAPSY	N/A	ROT	11
MITURN	N/A	ROT	11
AUTOPLAN	N/A	ROT	11
SIB	N/A	SHEET	23

The Above Is A List Of

Systems Which Can Be Found

In Industry Or Research

Institutions

Table 3.1

micro-computer. This report focuses on the specific approach to develop optimum process plans using process characteristics based on existing machining capabilities, and to do so solely within the limitations of a standard micro-computer system.

3.5 Summary of Literature Survey

From the review of these papers it was decided that a micro-computer based system can have a large number of benefits to a great many users, provided the system can be designed for more then one user. Through a review of various papers (14,16,24,25) it was decided that the use of "tool life equation" techniques for cutting parameter estimation would not be used due to the limited applications and the size of optimization procedure which results when solving for the process parameters using tool life equations. Instead, standard cutting equations and heuristics can be applied to determine the individual parameters and still be able to provide near optimal solutions.

Various papers will be referred to throughout this report as the information from these papers is related to the development of the micro-computer based system.

4.0 DEVELOPING A FRAMEWORK FOR SYSTEM DESIGN

The remainder of this thesis will develop a possible design for a micro-computer based machine selection procedure. Before the details of the system can be developed, it is necessary to propose a framework within which the system will operate.

Under no circumstances can any model be developed to consider all possible situations. There are limitations to all systems no matter how complete they may be. To develop a micro computer based system it was necessary to restrict the size of the problem. Therefore, it was necessary to restrict the number of processes considered, and the type of components which can be handled by the system. The system which will be described in the subsequent chapters uses the tool oriented approach of matching the features to be removed with the tool capabilities of different machines.

4.1 Micro Computer Tool Oriented Machine Selection

The model is able to select machine tools based on the description of the component in terms of identifiable features by the system. The system is currently restricted to known features which are listed in Table 4.1. A detailed description of the classification system for component

LIST OF SHAPES WHICH ARE INCLUDED IN THE SYSTEM

Prismatic shapes;	-Rectangles
	-Triangles
	-Trapezoid
	-Rhomboid
	-Internal Keyway
	-External Keyway
Rotational shapes;	-External cylinder
	-Internal cylinder
	-Portion of a cylinder
	-Tapered surfaces.

The Above List Of Features Are The Only Features Which Are Recognized By the System

Table 4.1.

identification is given in section 5.1.2. The number of features can be expanded to include others, but, for the initial problem the features in Table 4.1 were considered sufficient for fairly complex components. The system was written in "Better Basic" which allowed the computer to use all the available memory in the computer. The system was designed to be run on a IBM AT with a memory of 512K with hard disk capabilities on which the machine tool records were stored for faster retrieval. The system output was printed using a 132 column Epson printer.

It is important to note that the program was written for interactive use. The system has been designed to be as user friendly as possible in order that it accommodate non expert operators on the shop floor. In Appendix A a users guide is provided to aid the user with any difficulties which may occur. There should be little trouble in allowing the system to be operated by an individual who has little knowledge of computers or the machine selection function.

The initial system considers a limited number of processes for rotational and prismatic components. Although the number of processes is limited, the complexity of the component can be such that the optimal selection of the machine tools by manual methods would prove to be very time consuming.

4.2 Processes Considered

The processes were divided among the two types of parts considered (rotational/prismatic). The machine files were designed to group the processes separately to reduce the size of the files, and speed up the machine selection function. The grouping procedure is described in section 5.1.2.

4.2.1 Rotational components

Processes included are;
- -Ext. Turning
- -Ext. Grinding
- -Int. Drilling
- -Boring
- -Int. Grinding
- -Ext. Drilling, Reaming
- -Ext/Int Keyways

4.2.2 Prismatic Components

Processes included are:
- -End milling
- -Peripheral milling
- -Face milling
- -Ext. surface Grinding
- -Drilling, Reaming
- -Boring
- -Int. Grinding

As can be seen by the above list, fairly complex parts can be created since the number and type of processes considered is capable of creating a large number of varied features.

4.3 Assumptions

There were a number of assumptions made throughout the research for purposes of model development. These assumptions were necessary to allow the system to be operated on a micro-computer and provide selections in a reasonable amount of CPU time. The assumptions made are listed below with a brief description of each:

1. Only consider rotational internal features for both rotational and prismatic components. (exclude sharp corners as found in pockets.) [Figure 4.1a.] By making this assumption the type of operations were restricted. This assumption however, does not restrict the use of internal keyways.

2. All features must run parallel to one of the major axis of the component. (exclude angular cuts) [Figure 4.1b.] This assumption restricts simultaneous movement in two different directions by the tool.

3. Only consider one representation of shapes: those provided by the user of the system. Do not consider other shapes which can be derived from combinations of shapes [Figure 4.1c.] The same features can be created by combining other shapes. To restrict considering different combinations of features only the one provided by the operator is used.

ILLUSTRATION OF ASSUMPTIONS

VALID INVALID

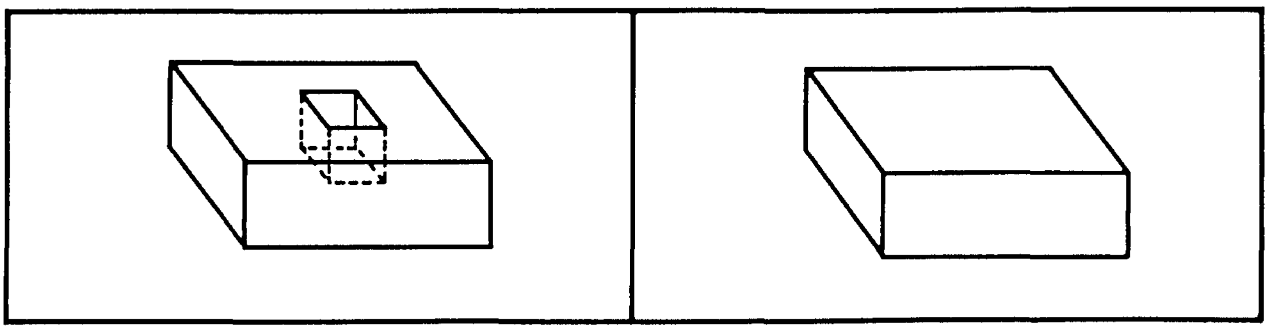


FIGURE 4.1a

VALID INVALID

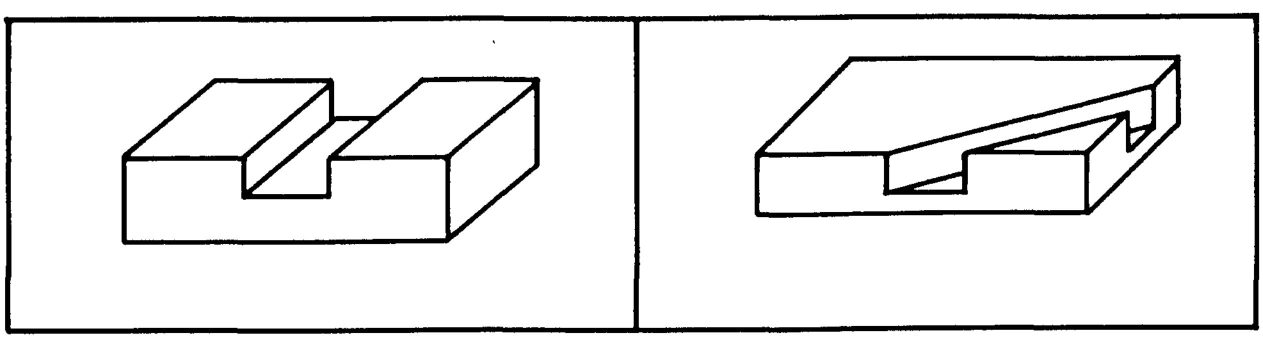


FIGURE 4.1b

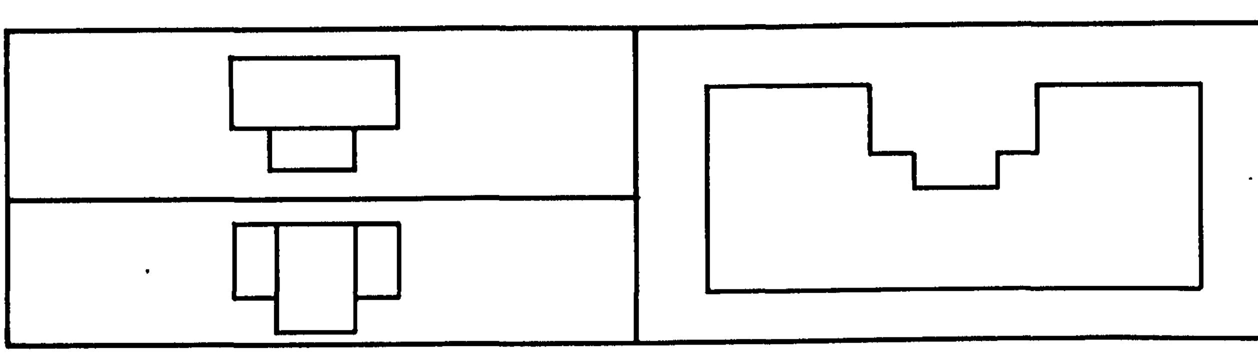


FIGURE 4.1c

4. There are no special tools such as form tools. Special form tools can create a number of defined features simultaneously. The system is restricted to creating a single feature with a tool.

5. All tools are either HSS or Carbide. The metal removal rate of these tools will be considered to be constant (no allowance for tool wear). In estimating the tool costs of machining, the tool will operate as if it were a new tool.

6. Only one tool can be in contact with the component at any one time. There can be no simultaneous machining operations.

The remaining assumptions will be outlined as used throughout this thesis.

5.0 SYSTEM DESIGN AND DEVELOPMENT

This chapter discusses the specific sections (modules) for the machine tool selection procedure. The first step in the development of a machine selection procedure is the transformation of component features into alternative processing methods. Once this relationship has been established available machining capabilities are examined to correlate the alternative processes to the machine tools available on the shop floor. The last step is to use a cost justification approach to derive a combination of machine tools to generate various combinations of components. A unique feature of this approach has been the incorporation of batch sizing of the components into the cost justification system.

Figures 5.1 and 5.2 contain a flow diagram of the two approaches taken to aid in the generation of process plans. For the remainder of this report the two approaches will be called ALT1 and ALT2 respectively. The difference between the two systems is that in ALT1 a sequencing of operations is carried out to determine the optimal sequence of machine tools, whereas ALT2 does not sequence the operations, but leaves the sequencing to the operator of the system. In both cases the procedure ranks the alternative outputs based on minimum cost, ALT2 also ranks the output by

FLOW CHART FOR ALT1 PROGRAM

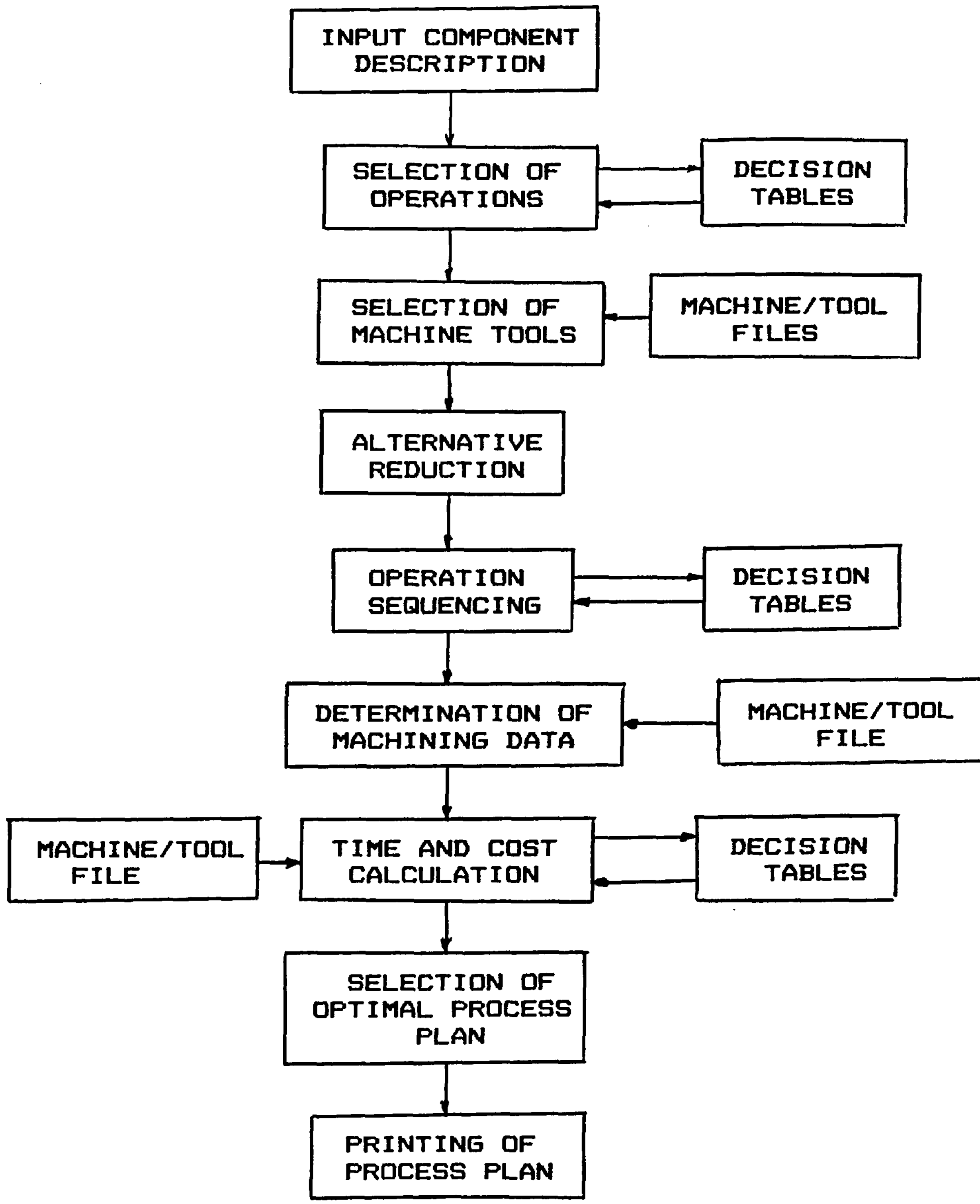


FIGURE 5.1

FLOW CHART FOR ALT2 PROGRAM

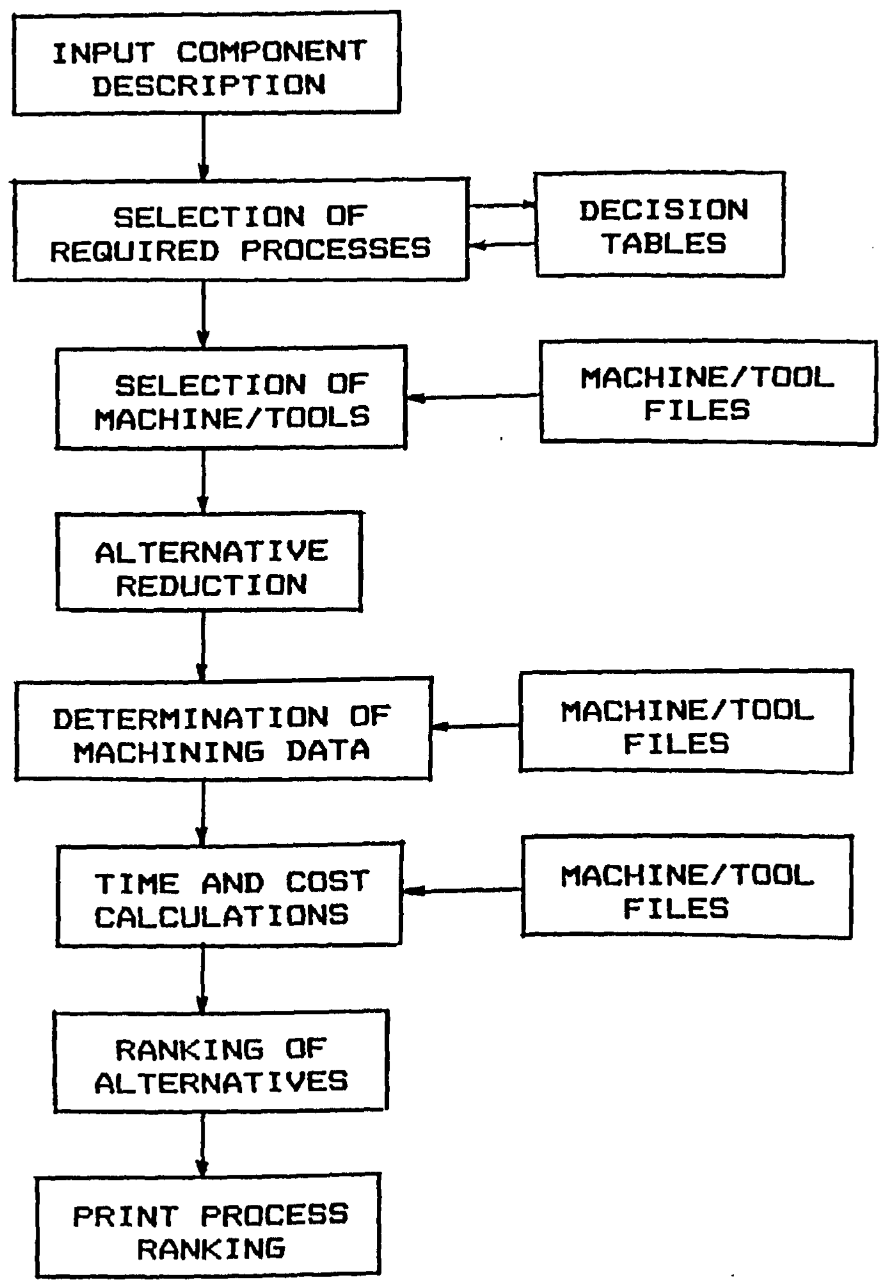


FIGURE 5.2

maximum production rate.

Figure 5.1 lists the modules developed to include the sequencing of the operations to determine the overall optimal process plan for ALT1. For ALT2 as shown in Figure 5.2 there is no sequencing of operations; instead the system generates and ranks the alternative machine tools for each required operation. The ranking is based on either minimum cost or maximum production rate. Each module in Figures 5.1 and 5.2 will be described as to its contents and the function it performs in the program. Several of the modules of Figures 5.1 and 5.2 are identical in design and function; in these instances only a single description will be provided. However, when differences between the two procedures exist, the module will be discussed separately.

Unlike some systems which require the user to input information using a card deck or in the form of a data file, this system is designed to be user interactive. The system prompts the operator to describe the part in terms of the raw dimensions and features to be machined.

Upon start up of the system, the user has a number of alternative choices in the form of a menu from which to choose. Upon selection of an operation to be performed the system will transfer to the appropriate program and begin execution. The main menu of the system is shown in Figure 5.3. The purpose of this menu is to send control to the

```
************************************************
*                                              *
*  SELECT THE OPTION THAT YOU WISH TO USE IN   *
*      THE PROCESS PLAN GENERATION PACKAGE     *
*                                              *
*          CREATED BY DAVID MELOCHE            *
*                 FALL 1986                    *
*                                              *
*          1. Edit Machine Records             *
*          2. Create Machine Record File       *
*          3. Determine Tool Selection (ALT1)  *
*          4. Determine Tool Selection (ALT2)  *
*          5. Return to DOS                    *
*                                              *
*               ___ Selection                  *
*                                              *
*       (Press Return After Selection)         *
************************************************
```

Illustration of main menu of program

Figure 5.3

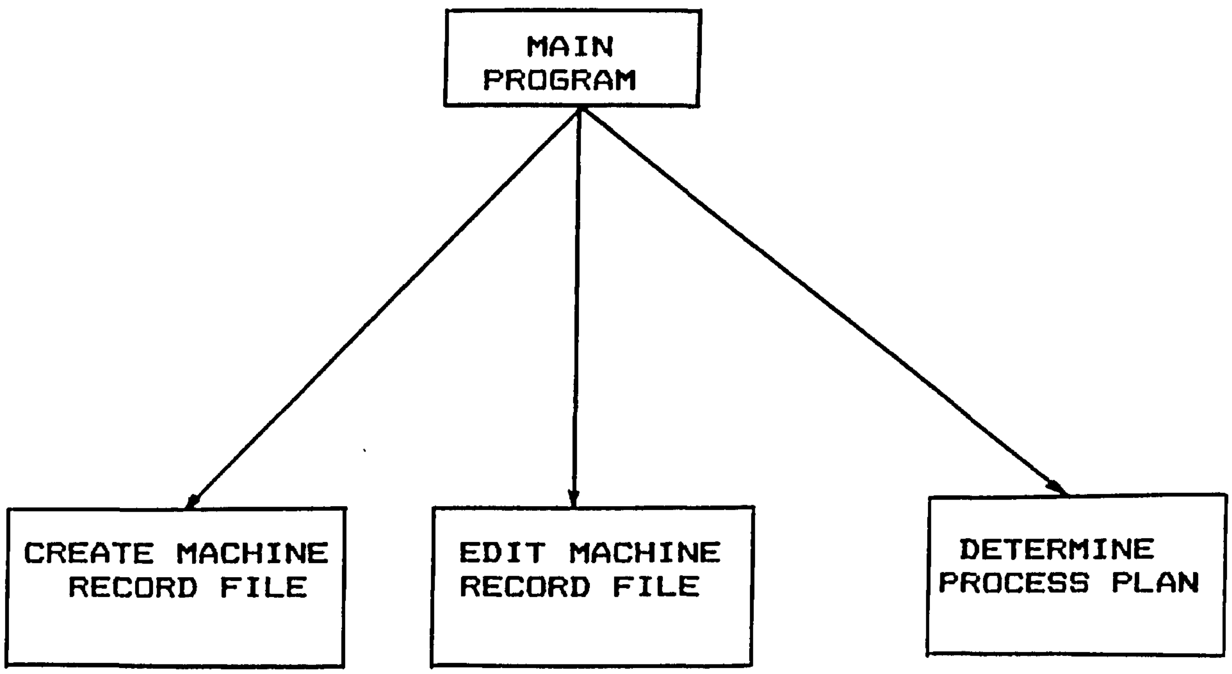
desired program which the operator selected. By selecting the program to be loaded, the amount of memory required to store the program is reduced thus making memory available for other applications in the system. A micro-computer based system requires effective use of available memory in order to handle the complicated analysis and the storage capacity required to develop a process planning system. Figure 5.4 illustrates the procedure of branching to different programs by the system in order to "free up" available memory by not having all the programs loaded simultaneously.

The modular design and branching techniques were followed throughout the development of the system. In subsequent sections, the breakup of the machine files and the component description into modules were necessary to make the entire system more efficient.

5.1 Development of System Modules

As shown in Figures 5.1 and 5.2 the task of process planning can be divided into several modules as listed below;

1. Machine description
2. Component description
3. Selection of operations



<u>BREAK-UP OF PROGRAM INTO</u>

<u>SPECIFIC FUNCTIONS</u>

FIGURE 5.4

4. Selection of machine tools
5. Operation sequencing
6. Grouping of operations
7. Determination of machining characteristics
8. Time and cost calculations
9. Selection of best process plan
10. Printing of process sheet.

Based on these modules, it is feasible that an optimal process plan can be generated as outlined in Figure 5.1. It will be shown however, that the generation of the optimal process plan may not provide the most useful information to the operator. The generation and ranking of alternatives for each required operation would provide more information to the operator of the system. The system would allow the operator to select which machine to use for an operation from the machines which are currently available. In the case of a rush job, where the machine in the optimal process plan may not be available, the operator can select an alternative machine. Also, there will be increased flexibility in scheduling, by avoiding the over scheduling of a particular machine based on set optimal process plans as determined by ALT1.

Before the program can run, a complete description of the available machines must first be stored as an accessible database. Therefore, before describing the machine tool selection procedure the logical order would be to develop the machine tool database since this serves as the cornerstone for deriving the procedure for process planning.

5.1.1 Machine Data File

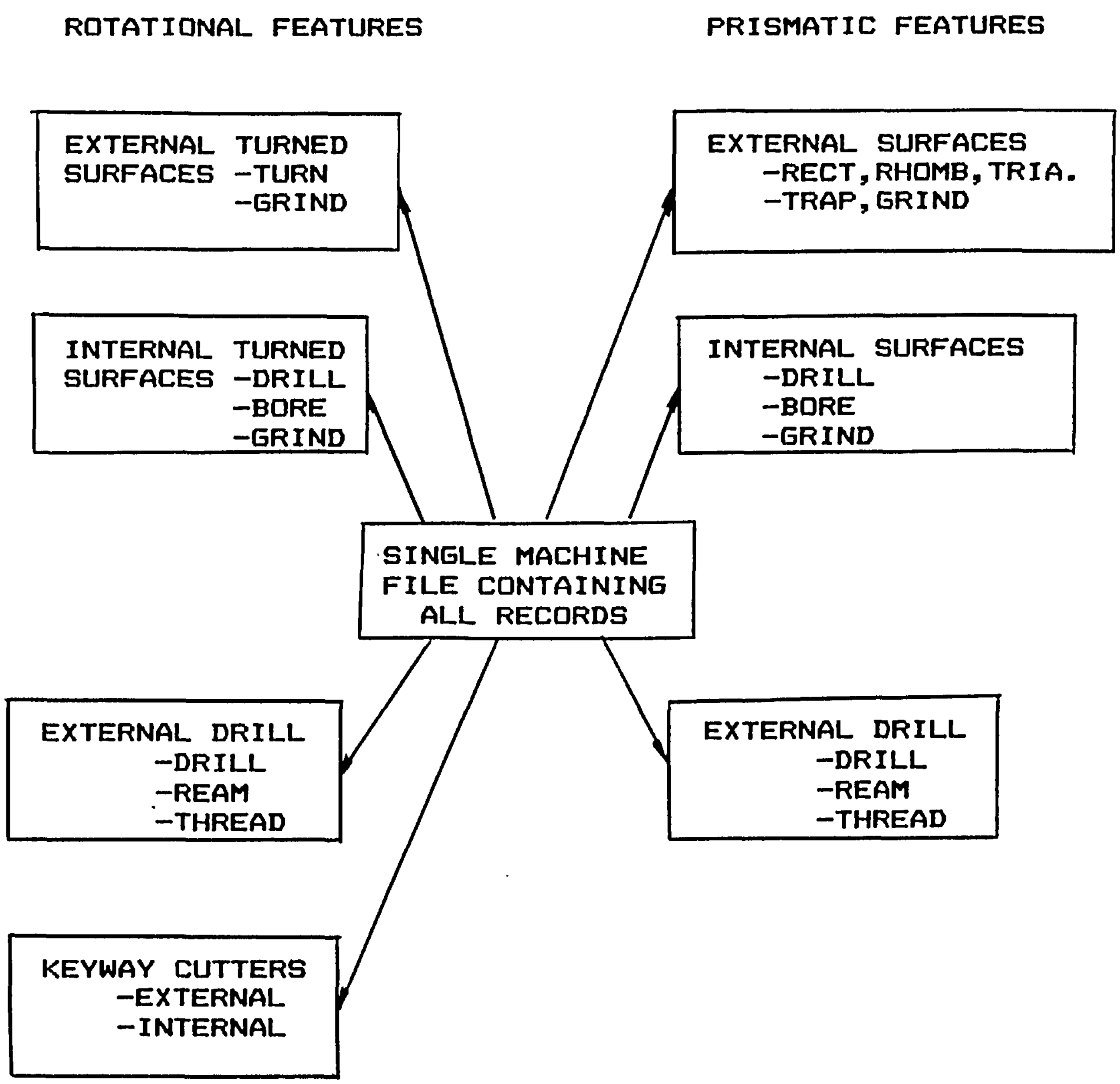
Before machine tool selection can take place, a complete listing of machines and tools must exist in a database. The database must contain the specific information on the available machines and tools in the shop to allow for the selection of not only the machines, but also the generation of cutting parameters for each of the required operations.

For a micro-computer based system, the procedure of machine selection and cutting parameter generation requires the same information as larger systems. However, for a micro-computer based system the organization of the information must allow for more rapid searching and selection of machines and calculation of cutting parameters. The machine database developed allows the operator of the system to input specific machine characteristics which the system will utilize in its selection of the appropriate machine tool and cutting parameters. For large computer systems, a single database may be developed to contain all the information on the available machines. This procedure was initially followed for the micro-based system, but when the system was tested the time taken to run the program often took 5-6 hours depending on the size of the problem. As a result, the single database was divided into a number of operation specific databases as illustrated in Figure 5.5.

The machine files were divided in such a manner that the class of operations in each of the files was specific to a particular class of features to be generated. By separating the files, the search time was drastically reduced and only relevant records were searched for each required operation. Since a micro-computer based system is considerably slower than a larger system the task of searching records can be several times longer than in larger computer system. Also a micro-based system may take a considerable amount of time to compute the same amount of information as a mini or mainframe, thus making the system non-economical.

Considering the speed at which the information should be provided by the system to the operator it was necessary to make certain assumptions (as outlined in Section 4.3) to reduce the number of calculations performed. If many of the assumptions were not made, the operator may at times be

BREAK-UP OF MACHINE FILES



The Above Break Up Of The Machine Files Allows

For More Rapid Retrieval Of Information

FIGURE 5.5

better off to develop process plans manually without the aid of a micro-computer. Throughout the design, care was taken to minimize the computing and searching time required in order to make a micro-based system justified for use in smaller machine shops. The file structure used allowed for rapid searching and locating of specific information and contained the necessary information for machine tool selection. A method which sped up the search process was to create random access machine database files. By creating random access files, specific information can be read for a particular machine tool without a sequential search of all records.

The specific description of the machine file is divided into three categories;

1. Machine Characteristics
2. Process Characteristics
3. Tool Characteristics.

Each of these categories are used to create an individual machine record. A flowchart and listing of the program is contained in Appendix B. The program was developed so the information on a particular machine would not have to be inputted repeatedly for each record. The information would be inputted once and all records for that machine will have access to the information. A similar procedure occurs when an operation can be performed by a number of tools on the same machine. The specific information on each of these sections will be outlined in the following sections.

5.1.1.1 Machine Characteristics

The first task is to input the general machine characteristics in the program. The information to be inputted includes;

1. Machine number
2. Machine horse power and
3. Number of operations which can be performed on the machine.

A complete listing of operations which are included in the system are listed in Table 5.1. Along with each of the operations in the table, is the operation code which will be inputted in the next portion of the machine description program. Once the above information has been inputted the operator must input the process characteristics.

5.1.1.2 Process Characteristics

In this section, a more specific description of the machines and the operations they can perform is required.

Features And Codes For Alterative Operations

	Feature/operation	Code
1.	External Turn	1
2.	External Cylindrical Grind	2
3.	Rotational Axis Drill	3
4.	Rotational Axis Bore	5
5.	Rotational Axis Grind	6
6.	External Drill	8
7.	Rotational Axis Ream	4
8.	External Ream	9
9.	Rotational Axis Thread	7
10.	External Thread	10
11.	Internal Keyway cutter	13
12.	External Keyway cutter	14
13.	External Rectangle	15
14.	External Triangle	16
15.	External Trapezoid	17
16.	External Rhomboid	18
17.	External Portion of Cylinder	19
18.	Internal Bore	11
19.	Internal Grind	12
20.	External Surface Grind	20

The Above List Contains The Operations

And The Codes To Be Inputted Into

The Machine Records

Table 5.1

Here, the particular operation characteristics are defined for each of the machines.

The inputs required are;

1. Operation code
2. Set-up cost ($)
3. Operator cost ($/min)
4. Time to load and unload a part (min)
5. Expected % down time
6. Maximum length of part (mm)
7. Maximum diameter of part (mm)
8. Maximum width of part (mm)
9. Maximum height of part (mm)
10. Number of tools available to perform the machining operation.

Each of the inputs is specific to the operation to be performed and the machine which the operation is to be carried out on. Once the above information has been inputted by the operator, the system begins the description of each of the available tools to perform the operation on the machine.

5.1.1.3 Tool Characteristics

In this section, the specific characteristics of each of the tools which are available to perform the specified operation on the machine are inputted. In this case the input gets more specific as to the capabilities of the tool. Here the input includes;

1. Tool number
2. Tool cost of machining ($/min)
3. Tool material
4. Number of teeth on the tool
5. Tool diameter, (mm) if applicable
6. Tool width, (mm) if applicable
7. Tool nose radius (mm)
8. Maximum metal removal rate (cu.mm/min)
9. Maximum depth of cut
10. Tolerance attainable (mm) and
11. Surface finish attainable (RMS).

Under different conditions, certain questions may play a dual role. For instance, in the case of a boring operation the value of the tool diameter will indicate the minimum size of a hole required before this tool can be used. Maximum depth of cut for boring may indicate the maximum depth for each pass, but in the case of a drilling operation it indicates the length of the tool. These dual roles of different tools depend on the tools themselves and will be clearly explained in the users instructions in Appendix A.

Using the above procedure all the available machine tools can be described and stored on file to be used later to select the required alternative combinations of tools to meet the specific requirements of the component. Once the machine tools available in the shop have been inputted to the system they never need to be re-inputted. In Figure 5.3 the main menu indicates the option of editing the machine files. This is only necessary when new machines or tools are introduced onto the shop floor, or machines are to be removed.

In subsequent sections, the machine files will be used to select the tool required and estimate the costs of machining with a specific tool. Appendix I contains the data which was inputted into the machine files from which the examples in this report were generated.

5.1.2 Component Description

Once a machine database exists the next step is to input the description of the component to be manufactured. This involves the description of the component to be manufactured by the operator of the system. Two types of information is required to be inputted;

1. General information and
2. Specific component information.

For the specific component description, the system divides the problem into two systems;

a. Specific Rotational Information

b. Specific Prismatic Information.

The breakup between Rotational/Prismatic components allows the procedure to consider the two problems as separate systems since there is little similarity between the two types of parts. For the purpose of speeding up the process plan generation phase an internal disk drive was created. This drive is accessable like other disk drives, but greatly speeds up the process of reading and writing to files, since the information is contained in the computer memory itself, rather than on disk. The component description will be stored on this disk drive since a permanent record of the component description is not required once the task of machine selection has been completed.

5.1.2.1 General Information

The information inputted at the start of the system contains the general information about the part to be manufactured.

The information includes;

Date

Operators name
Part number
Part name
Number of parts per lot
Part material
Maximum production rate or Minimum production cost and
Part type (rotational/prismatic).

Once this information has been inputted, the system enters the appropriate portion of the program based on whether the part is rotational or prismatic. Upon entering the proper program, the system begins to prompt the operator for the specific feature description of the part to be manufactured. Depending on whether the part is a rotational component or a prismatic component, different yes/no questions are asked along with the specific part characteristics. An answer of "no" to any of the questions will result in the system omitting the appropriate portion of the component description program and the subsequent machine selection phases. A listing of the yes/no questions which are asked is contained in Table 5.2 for the rotational components and in Table 5.3, for the prismatic components.

These yes/no questions are used to initiate the different sections of the program only as required, there-by speeding up the interrogation process, and later reducing the required calculation time by eliminating

Yes/no Questions For Rotational Parts

1. Are there external turned features?
2. Are there internal features along the axis?
3. Are the features through the entire part?
4. Do the features originate at the reference end?
5. Do the features originate at the opposite end?
6. Are there any drill holes parallel to the axis?
7. Do the drill holes start at the reference end?
8. Do the drill holes start at the opposite end?
9. Are there any external drill holes?
10. For each drill hole, is it threaded?
11. Are there any internal keyways?
12. Are there any external keyways?

These questions are used to aid in the selection of required operations as well as to determine which portions of the program must be run.

Table 5.2

Yes/no Questions For Prismatic Parts

1. Are there any surfaces to be machined?
2. Are there any external features to be machined?
3. Does the feature run along an edge?
4. Does the feature run the length of a surface?
5. Are there any internal features to be machined?
6. Are there any external drill holes?
7. Are there any drill holes in positive x direction?
8. Are there any drill holes in negative x direction?
9. Are there any drill holes in positive y direction?
10. Are there any drill holes in negative y direction?
11. Are there any drill holes in positive z direction?
12. Are there any drill holes in negative z direction?
13. For each hole, is the hole threaded.?

These questions are used to aid in the selection of required operations as well as to determine which portions of the program must be run.

Table 5.3

certain portions of the program. The yes/no questions are also used to aid in the selection of the processes which are required to manufacture the component as described by the operator. The selection of operations required is generated by arranging the yes/no answers in the form of decision tables.

5.1.2.2 Rotational Part Description

Here, along with the questions in Table 5.2, specific information is required such as the dimensions of all the features to be created, along with their tolerances and surface finishes. The descriptions, along with the yes/no questions asked, are then compared to the capabilities of the available machines. The procedure first compares the raw dimensions and, then compares the specific requirements of the component.

The yes/no questions allow the system to break up the component into its individual feature classes, which can be compared to the machine file breakup described in the machine file section of this report. This break-up allows the different component description files to be matched with machining files which are capable of creating the features in the particular class.

The feature description for rotational components is divided into six classes;

a. External Turned Features

b. Internal Turned Features

c. Drill Holes Parallel To Axis

d. Drill Holes Perpendicular To Axis

e. Internal Keyways and

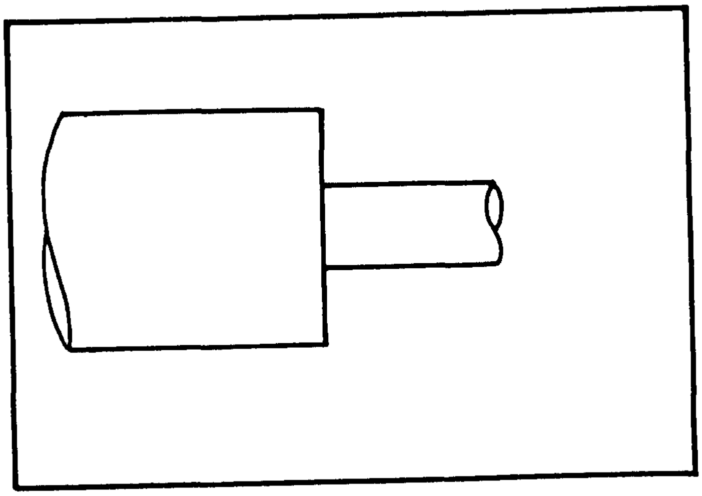
f. External Keyways.

The external and internal turned surfaces are described in terms of steps and tapers. An illustration of the meaning of a step and taper is shown in Figure 5.6. Depending on the type of feature present, different information is prompted by the system to be inputted by the operator. The information required for steps and tapers is listed with the illustrations in Figure 5.6.

For each of the yes/no questions of Table 5.2, similar inputs are required to define the features which are to be created. Only when a yes/no question is answered with a "yes" will the system prompt for specific information. If a "no" is entered by the operator for one of the above questions the system assumes that no feature of this type exists, and immediately goes on to the next class of features. A complete list of the descriptions for the rotational components is contained in Appendix C.

ILLUSTRATION OF TURNED FEATURES

STEPPED FEATURE



INPUT

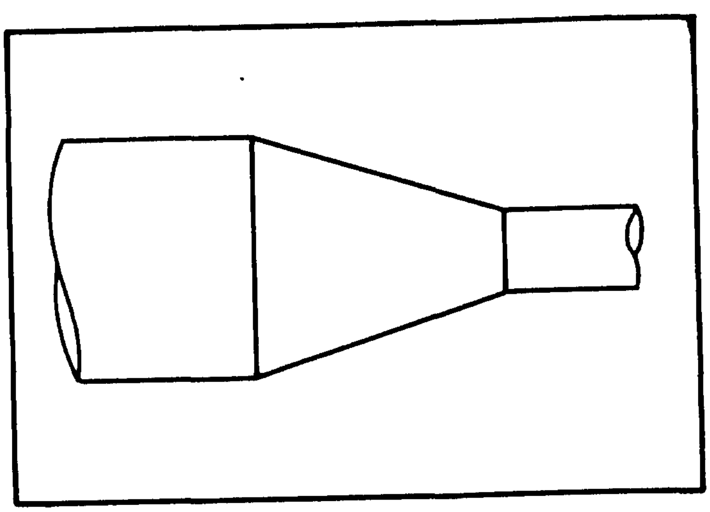
LENGTH, TOLERANCE

DIAMETER, TOLERANCE

SURFACE FINISH

FIGURE 5.6a

TAPERED FEATURE



INPUT

LENGTH, TOLERANCE

START DIAMETER, TOLERANCE

FINISH DIAMETER, TOLERANCE

SURFACE FINISH

FIGURE 5.6b

5.1.2.3 Prismatic Part Description

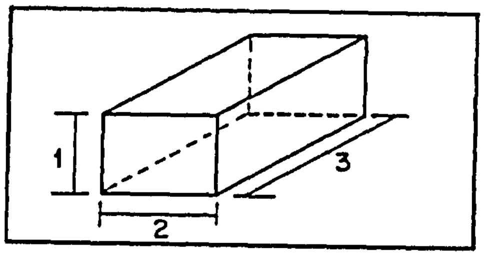
For prismatic components the yes/no questions in Table 5.3 perform the same function as for the rotational components. They allow the system to break the component description into distinct classes of features. During later stages, these files can be matched with the machine record files capable of creating the features for each of the classes in the system.

The initial starting shape of the raw material must be described in terms of its shape as well its dimensions. Here, the system is limited, since the initial raw material must also be one of the pre-defined shapes. Referring to Table 5.1 we can see the prismatic feature and their codes which are acceptable inputs to the system, as described earlier. Figure 5.7 contains the illustrations of the prismatic features which can be created along with their required dimensions. In this case, additional information has to be inputted by the operator to ensure proper selection of tools. This additional information is how the feature to be removed relates to the initial raw material. Through the use of yes/no questions during this phase the system can determine the relative relationship between the raw material and the feature to be removed.

Here, as in the case of rotational components, the

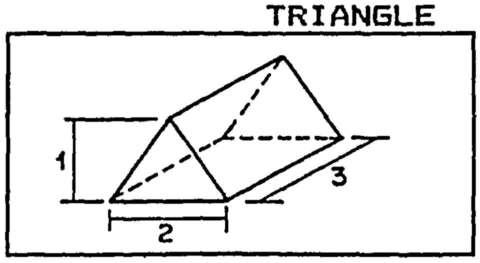
TABLE OF PRISMATIC FEATURES

RECTANGLE



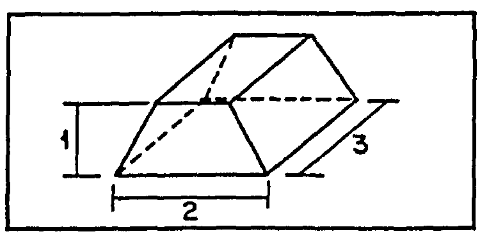
WHERE,
1. HEIGHT
2. WIDTH
3. LENGTH

TRIANGLE



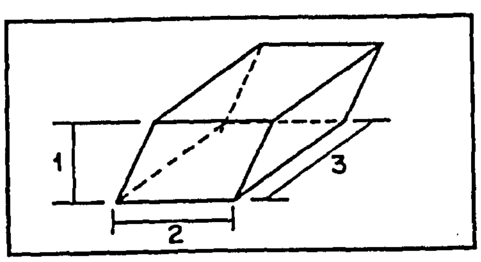
1. HEIGHT
2. WIDTH
3. LENGTH

TRAPEZOID



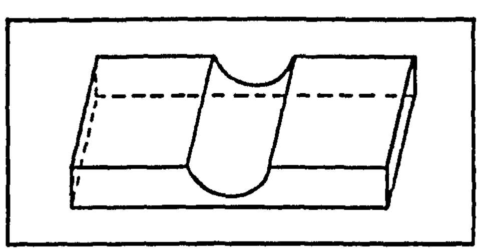
1. HEIGHT
2. BOTTOM WIDTH
3. LENGTH
4. TOP WIDTH

RHOMBOID



1. HEIGHT
2. WIDTH
3. LENGTH
4. ANGLE

PORTION OF CYLINDER



1. LENGTH
2. RADIUS
3. DEPTH
4. WIDTH

FIGURE 5.7

features are divided into a number of classes, which can be matched to a given file of machine records which are capable of creating each of the classes of features. The individual classes of features for the prismatic component description include;

a. Surfaces to be machined

b. External features

c. Internal turned surfaces

d. Drill holes parallel to an axis.

Here again, each feature must be described in terms of dimensions, tolerances and surface finishes. Refer to Appendix D. for a complete listing of all the information which must be supplied by the user to completely describe a prismatic component.

Once the component description phase has been completed the system can begin to determine which of the machine records are required to create the different features of the component for either a rotational or prismatic component.

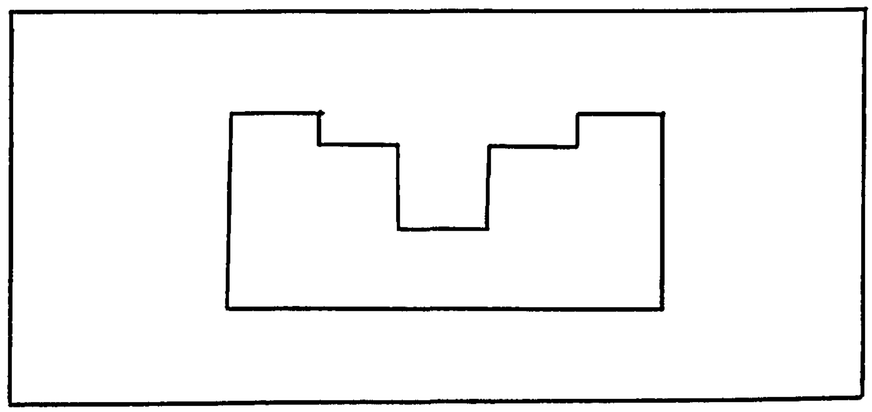
5.1.3 Selection of Alternative Processes

This section determines the alternative machine selections based on the component description of the part.

In this phase of process plan generation the variant and generative approaches of process planning differ the most. For generative process planning, the basic goal is to determine all feasible process alternatives in order to ensure that the optimal plan is among the ones generated. Thus, for each feature of each class as defined in the component description phase every alternative means of manufacture must be considered. This approach is the method which will be followed by this micro-based system. As would be expected, as the complexity of the part increases, the number of alternative processes increase, and quickly the problem becomes too large for a micro-based system to solve. To simplify one aspect of the problem, an assumption was made that states that the shapes to be removed are considered to exist only as described by the operator of the system. This assumption was necessary to reduce the number of alternatives generated. If this assumption was not made, the component could be considered to be created by other combinations of alternative shapes as illustrated in Figure 5.8. Therfore, the number of potential operations would be multiplied by every feasible combination of alternative features. This would result since the system could not assume that the description provided by the operator was the only possible description. This illustrates the need for this assumption considering the

ILLUSTRATION OF ALTERNATIVE FEATURES WHICH CAN BE USED TO DESCRIBE THE SAME COMPONENT

PART TO BE DESCRIBED



DESCRIPTION OF FEATURES

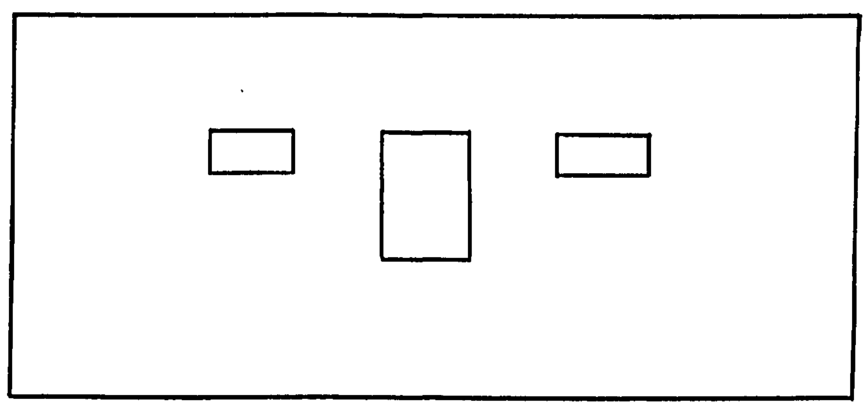


FIGURE 5.8a

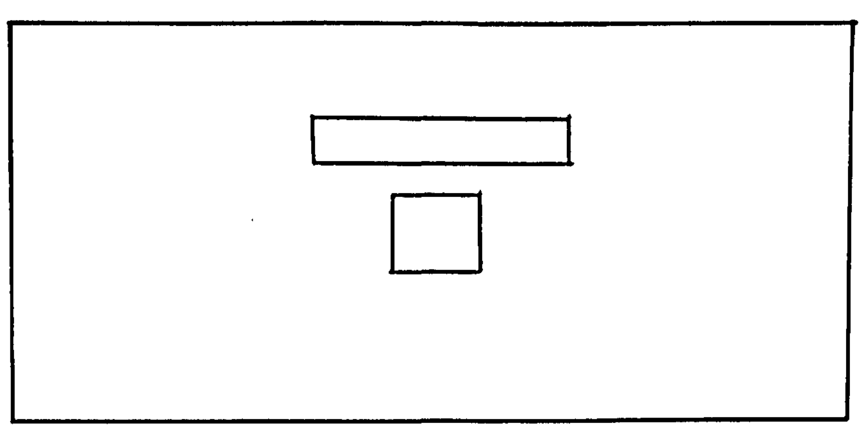


FIGURE 5.8b

limited capabilities of a micro-computer based system.

The procedure determines all feasible tool combinations to create the features to the specifications as described in the previous section. No attempt has been made to consider different combinations of shapes which will result in the same component. This next section utilizes the yes/no answers of the description phase to determine the type of processes which are required. The yes/no answers are not the only restriction when selecting different processes. Also considered, is the dimension of the feature itself and the required tolerances and surface finishes.

Based on the yes/no answers provided in the component description phase, and the raw material, the system determines which processes are required to create the rough features. In order to determine if a finishing operation is required, the system must compare the capabilities of the initial process selected with the specifications of the features. One assumption made is that if a tool selected for the initial process can achieve the parameters of the feature (tolerance, surface finish), the same tool will be used for both the rough and finishing cuts. For example, in the case of internal features, the system determines that at least two operations are required. First, the system must create a drill hole of appropriate diameter, and select the boring process to create the features. The system cannot, however, determine if internal grinding is required since it has not yet compared the capabilities of the tool to perform the boring operations with the specifications of the component. The system has only selected the initial processes required to create the features. The procedure has not yet determined if the machine tool capabilities exceeds those required by the component. For each class of features, the system will determine the initial operations required based on the "yes/no" answers for the component. The procedure is illustrated in Table 5.4 for a rotational component based on the questions in Table 5.2.

5.1.4 Selection of Machine Tools

Once the appropriate processes have been selected based on the features to be removed, machine tools are selected from the machine files to perform each of the required processes. Each tool selected must satisfy certain preliminary conditions;

1. The machine tool can perform the desired operation and
2. The machine can handle the part in terms of its shape and raw dimensions.

Decision Table for Rotational Components Based On Questions In Table 5.2

Question 1	(Y/N)	Y										
Question 2	(Y/N)		Y	Y	Y	Y						
Question 3	(Y/N)		Y	N	N	N						
Question 4	(Y/N)		N	Y	N	Y						
Question 5	(Y/N)		N	N	Y	Y						
Question 6	(Y/N)						Y	Y	Y			
Question 7	(Y/N)						Y	N	Y			
Question 8	(Y/N)						N	Y	Y			
Question 9	(Y/N)									Y		
Question 10	(Y/N)											
Question 11	(Y/N)										Y	
Question 12	(Y/N)											Y
ACTION		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11

Where A1= External Turn
A2= Internal Bore Through Entire Part
A3= Internal Bore From Reference End Of Part
A4= Internal Bore From Opposite End Of Part
A5= Internal Bore From Both Ends Of Part
A6= Drill Parallel To Axis From Reference End
A7= Drill Parallel To Axis From Opposite End
A8= Drill Parallel To Axis From Both Ends
A9= External Drilling Required
A10= Internal Keyway Cutting Required
A11= External Keyway Cutting Required

The above procedure will determine the initial processes required based on the Yes/No questions answered during the component description portion of the program.

Table 5.4

The system begins by selecting each class of features described by the operator and reads the individual records for the features in the class which are stored on the internal disk. The system searches the appropriate machine file based on the feature class and the raw material to select a possible alternative machine tool record. Only if the tool cannot meet the specifications of the component, in terms of its tolerance and surface finish will the system generate a finishing operation. If a finishing operation is required the system will determine the alternative machine records available to perform the operation. If a tool is capable of creating the desired feature to the specifications described by the operator no finishing operation will be generated.

The system maximizes the number of possible alternatives by considering for each feature(J) of each class and each potential machine record(I,K,L) required to meet the specifications of the component. I,K,L are a combination of machine records which are required to meet the specifications of feature J. The potential tool combinations allow for, at most, three operations to be performed to create a single feature. Considering the case of an internal feature, the operations required are;

Drill,

Bore,

and possibly Internal grind.

Similarly for other feature classes the maximum number of operations required is three.

5.1.5 Maximization of Alternatives

In the machine selection procedure, it is important to consider all feasible alternatives. Only by considering all possible combinations can the procedure guarantee that the optimal alternative will be generated. This maximization of tool combinations considers each tool combination (I,K,L) for each feature J. The following equation illustrates how the system considers each tool combination.

$$MAX\sum^{I}\sum^{J}\sum^{K}\sum^{L} P(I,J,K,L) \qquad (1)$$

Where
P(I,J,K,L)=1 If machine records I,K,L are feasible and required to create feature J.
ELSE P(I,J,K,L)=0

Note that the variables K and L may take on a value of 0 if the operations associated with them are not required, but, P(I,J,K,L) can still take on the value of 1. This maximization is carried out over all features in a particular class. The resulting (I,K,L) values are stored as feasible alternatives to create the feature (J). Since this information will not be required once the procedure has been completed, the data is stored on the internal disk. By storing the data on this disk, it speeds up later reading operations performed by the system to select the optimal combination of tools. The above system creates all the feasible tool combinations there-by ensuring that the optimal one is among the ones generated.

Equation (1) simplifies the procedure which is performed by the program at this stage. Many other calculations are required to ensure the proper selection of machine records at this stage. For example, consider the case where there are internal features along the axis of a rotational component. The first requirement is to determine the minimum diameter of all internal features in order to determine the maximum diameter for the drilling tool. This can be illustrated by the following equation;

$$\text{Let diameter}=100000$$
$$\forall_j \quad \text{if (diameter} > Diam_j\text{) then diameter} = Diam_j \qquad (2)$$

Where

$Diam_j$ is the diameter of feature j

Using equation (2),the system determines the minimum diameter of all internal features. Knowing this value, the drill diameter can be selected accordingly. Incorporated in the system is the fact that the final drill diameter is usually only 3-5 (mm) less then the smallest feature diameter, provided the smallest diameter is not greater then 50 mm. Based on this diameter all feasible drilling tool records are compared to this value to see if they meet this requirement along with the other requirements for an acceptable alternative. Once the maximum drill diameter has been selected the boring tools are selected by comparing their required diameter restriction with the hole diameter to see which tools can be considered for the boring operation. By comparing the capabilities of the boring tools in terms of tolerance and surface finish the system determines if an internal grinding operation is required. If grinding is required, the system selects an appropriate tool based on the previous restrictions. The system not only compares the tools, but also the machines to ensure that the selection is feasible based on the raw material dimensions of the part.

The above procedure will result in determining the maximum number of feasible tool combinations to create the features as defined by the operator. Comparisons are made for each class of features, this will result in generating the maximum number of feasible machine tool combinations, thus ensuring that the optimal machine tool combination is among the ones generated.

Once all feasible combinations have been generated for each class of features, the system must sequence the machine tools in order to achieve the final component features.

5.1.6 Machine Tool Sequencing

The sequencing of machine tools within each class of features is determined prior to the selection of alternative machines. This sequencing has been built into the system itself. For a given class of features, there exists a single sequence in which the operations must be performed. Although the machine chosen varies, the operation it will perform is the same. For example, in the case of an internal feature, drilling must be the first operation performed followed by boring which must precede internal grinding if grinding is required. Therefore, within a class there exists a predetermined sequence of operations which will result in a predefined sequence of machine tools. However, the sequencing of operations between classes of features cannot be determined in the same manner since the sequence of operations between classes are basically independent of each other. Operations from different classes can be performed together if the preceding operation restrictions within the class have been satisfied. As an example, the sequencing of operations for the overall component must satisfy the individual sequencing of the feature classes. Therefore, operations from two classes of features can be machined one after the other by the same tool or on the same machine, provided the features of the two classes are at the stage where the tool/machine is required for both the classes of features.

In a truly generative process planning system, the user would input rules to provide a rough framework for the ordering of operations between classes. These rules would apply to classes of features or operational sequences. However, even with these rules there would be a large number of alternative sequences to consider in order to determine the optimal sequence. Consider the simple example where there are two classes of features to be machined and where each class requires only two operations and a limited number of ten alternative machines for each operation. There could be as many as 60,000 possible sequence combinations to consider. Considering the limited problem size defined above, the difficulty in managing a larger more realistic problem on a micro computer becomes apparent. As a result of the large number of combinations it was decided to rank the alternatives for each required operation, rather than the overall sequenced alternatives that would have resulted in the generation of the optimal process plan. Instead the operations between classes were not intertwined but each class of features was considered separately.

5.1.7 Consolidation of Alternative Processes

Once the system has generated the alternatives it finds itself with too large a group of possible alternatives for a micro-based system even with the restrictions previously defined. In the previous phase, the system generated all tool combinations for each of the individual features in a particular class. At this point a reduction in the amount of available information is required. A likely reduction is to group the stored information to determine which combinations of machine tools are capable of creating all or the majority of features in a particular class of features. In the selection of machine tool portion of the program, each feature, within each class, generated its own set of alternative machine tool combinations. During this section a single machine tool combination is determined which can generate all the features within a particular class of features. For ALT1 and ALT2 the individual class sequences are searched, each time a tool is found to perform a given operation the system notes the tool and the operation and stores it in memory. If the same tool is found to be performing the same operation but with different tools performing the other operations in the class it is noted, but, not restored. Therefore, the end result is a complete listing of all tools which are used to machine all the features for a given sequence of operations for each class of features.

In the case of an internal feature as described before, there should exist a combination of drilling, boring, and grinding tools which can create all the features in the class. For the case of internal grinding some features may not require the finishing operation, but for all the features there may exist at least one feature which does. Therefore, the combination will meet all the requirements of the features and reduce the number of alternatives by generating only alternatives which can create all the features in the class. Using this procedure any machine tool combination which can create only a single feature in a class is eliminated and only tools which are common to all features in a class are considered further. This procedure can be illustrated by the following equation:

$$\forall_{alternatives} \; S_{max}=(P_{i,j}+P_{k,j}+P_{l,j}) \qquad (3)$$

Where

$$P_{i,j}=1 \text{ if } I_{j+1}=I_j$$
$$P_{k,j}=1 \text{ if } K_{j+1}=K_j$$
$$P_{l,j}=1 \text{ if } L_{j+1}=L_j$$
$$\text{ELSE } P_{i,j}=P_{k,j}=P_{l,k}=0$$

I_j=Process I for feature j
K_j=Process K for feature j
L_j=Process L for feature j

Since no more then three operations are required to generate a class of features if S_{max}=3*J (where J=number of features in the class) the combination spans all the features and the combination is stored as a feasible alternative. This procedure can be applied only in certain classes of features where one tool combination can create all the features, such as the classes of external turning or internal feature generation. In other classes it may not always be possible to determine a single tool combination and hence no alternative reduction can be carried out in this manner. In such a case, all features within a class which are machined by a common machine tool are determined. This allows the system to determine the minimum number of tools required to complete the feature class.

5.1.8 Determination of Machining Characteristics

For optimal machine selection it is not only important to determine the minimum cost or maximum production rate alternative; it is also necessary to determine the cutting parameters of the operations in order to meet the projected cost estimation and still meet the specifications of the part in terms of tolerance and surface finish.

For the micro-based system it was felt that the determination of optimum speeds and feeds should not be generated from "tool life equations", but, instead to use an approximation based on common machining practices. From the study of different machining handbooks (26,27) and speaking with machinists in industries in Windsor it was determined that adjustments to speed and feed are made for different part material and tool material combinations. Finish cutting adjustments are also made to ensure that the finish characteristics are achieved as well. For example, when machining a part if the tool material is changed, the optimum speed at which the operation is performed will change. For rough machining a fixed approximation was made as to the speed change for different part materials. Based on this the speed and feed can be determined for each of the roughing operations required.

In the tool description phase of the system, one input was the tool nose radius. Based on the tool nose radius, the system can determine the feed rate for both the roughing and finishing operations. Another input was the metal removal rate of the tool. This information will be used along with the maximum depth of cut allowed, to determine the speed at which the machine will operate. The procedure is explained below. The equations used are found in Figure 5.9.

Based on the nose radius of the tool, the system determines the feed rate for the tool in terms of mm/rpm. For example, for rough turning and boring, the feed rate is

CALCULATION OF CUTTING PARAMETERS

MRR -METAL REMOVAL RATE OF TOOL FOR 1020 STEEL PART MATERIAL

TNR -TOOL NOSE RADIUS

Z -CORRECTION FACTOR FOR ACTUAL PART MATERIAL

Z=1 IF MATERIAL=1020 STEEL
Z=.7 IF MATERIAL=4140 STEEL
Z=1 IF MATERIAL=CAST IRON
Z=1.4 IF MATERIAL=BRASS/BRONZE

THEREFORE; MMR=MMR*Z (mm^3/min)

FEED RATE FOR -ROUGHING OPERATION = TNR
(mm/rev) -FINISHING OPERATION =.25*TNR

DEPTH -ROUGHING MAXIMUM SPECIFIED IN TOOL FILE
-FININSHING = 1mm

SPEED CALCULATION;

SPEED=(MMR)/(TNR*DEPTH) (mm/min)

SPEED=SPEED/1000 (m/min)

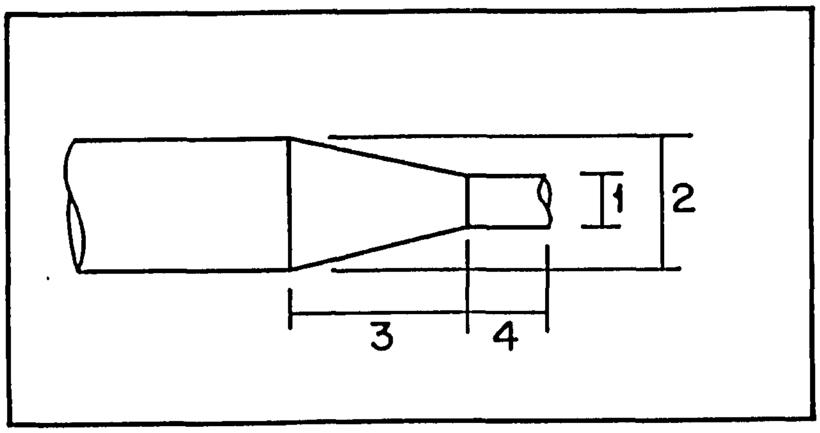
This example illustrates the method by which the system is able to determine the various cutting parameters for each of the alternative machine records available.

FIGURE 5.9

equal to the tool nose radius of the tool which was inputted in the machine record files. For finish turning the feed rate should be adjusted to account for the surface finish required. Here a value of (1/4*tool nose radius) is used as an approximation. Based on the predetermined approximations for the metal removal rate found in the machine record file, an adjusted metal removal rate can be determined based on the part material. Using this new metal removal value along with the feed rate and the maximum depth of cut allowed, the system determines the recommended surface speed (mm/min) for the operation. For the finish cut, the final depth of cut would be equal to 1 mm and the feed is equal to ".25*tool nose radius". Based on industry standards the speed is adjusted to ten percent above the roughing speed. One assumption made is that the machine is capable of an infinite settings of speed and feed rates.

Based on the metal removal rate of the system, an approximate time for machining is calculated. This is done by determining the amount of material to be removed by the operation and dividing this value by the metal removal rate capacity of the tool. An example of the procedure is illustrated in Figure 5.10, for turned features.

ESTIMATION OF TIME BASED ON THE AMOUNT OF MATERIAL REMOVED DURING A TURNING OPERATION



WHERE,
1 = 30mm
2 = 75mm
3 = 100mm
4 = 50mm

MATERIAL= MAT1 + MAT2

MAT1 = $(3.1415*(75/2)^2-3.1415*(30/2)^2)*50$
=185550.3

MAT2= $((3.1415*(75/2)^2-3.1415*(30/2)^2)$
$+.5*(3.1415*(75/2)^2-3.1415(30/2)^2))*100$
=185550.3

MATERIAL =185550+185550
=371101 (mm^3)

ASSUME A VALUE FOR MRR =65000 mm^3/min

MACHINING TIME =MAT/MRR
=371101/65000
=5.7 min.

FIGURE 5.10

5.1.9 Cost Estimation of Operations

Once the determination of speeds and feeds have been completed, the system determines the time and cost for each class of features for each tool performing each of the operations to complete the components.

Information in this section was derived from various sources (5,11) as well as experience in this area.

The system must calculate;

1. Machining time per piece
2. Total time on machine per lot
3. Total cost per lot
4. Average cost per part.

5.1.9.1 Machining Time Per Piece

As described earlier the time taken for a given operation can be approximated based on the tool part combination and the metal removal rate for the operation using a particular tool. Based on this, a machining time per piece can be determined using the following equation.

$$Time = Tm/Mrr \qquad (4)$$

where;

Tm=total metal to be removed by the tool
Mrr=the adjusted metal removal rate of the tool based on the part material

The determination of the amount of material to be removed is derived from the shape description provided at the start of the program. For external turning refer to Figure 5.10 for a sample calculation.

5.1.9.2 Total Time Machine Is In Use

In order to determine the effective cost of the procedure chosen, the system determines the total time which a machine is being used. This value can be divided into two terms;

1. Machining time.
2. Load/unload time

The machining time was determined in the previous section, and the load/unload time was one of the inputs to the machine file. It is, however, important to keep the two separate since the tool cost of machining will only relate to the actual machining time. The total time calculation must be determined for the entire lot size. Therefore, the following equation can be used to determine the total time a machine will be in use.

$$\text{Total time} = (Mt + LUT) \times lots \qquad (5)$$

Where Mt= machine time per part.
Lut= load/unload time per part
lots= lot size of job

Based on this estimate of the total time required the system can determine the overall cost of production for the particular method for each feasible alternative.

5.1.9.3 Cost Of Each Operation

Of importance in any machine selection system is the ability to accurately estimate the cost of production for each of the features to be created as well as the total cost for the part. The total cost is divided into three areas, labour cost, machine cost, handling cost
The total cost can be expressed by the following equation.

$$\text{Min } LC+MC+HC \qquad (6)$$

where LC= labour cost
MC= machine cost
HC= handling cost

5.1.9.3.1 Total Labour Cost

Here each cost can be further broken down. Included in the labour cost are;

i. Handling time

ii. Machining time

$$LC=(Lut+Mt)\times(L\$)\times(lots) \qquad (7)$$

where Lut= Handling time (min)
Mt= Machining time (min)
L$= Labour cost/min

Here the labour cost is based on a per part basis.

Looking at the above equation, it would appear that the machine that requires the minimum time and handling would result in the minimum cost. This in some cases will be true but, not in all cases since one of the inputs to the machine files was the labour cost for the particular operation on a particular machine. Therefore, the labour cost can vary from one machine to another and the faster may have a higher operator charge rate resulting in a higher overall cost for the operation.

5.1.9.3.2 Total Machine Cost

The total machine cost can be broken into two factors which are; a. Tool cost

b. Set up cost

These will be outlined in the following equation.

$$MC = (Mt) \times (Tc) \times (lots) + St \qquad (8)$$

where Mt= machining time (min)
Tc= tool cost ($/min)
St= set up cost ($)

For the purpose of this problem the machine time was based on a per lot basis. Based on the above example, it would appear that the machine with the fastest machining time would be the best. One input to the machine database was the cost to set up the machine for a particular job, therefore the faster machine may have a higher set-up cost making the slower machine more cost justified. Another input to the machine file was the tooling cost, a machine with a slower machining rate may have a lower tooling cost and make it more cost justified than a faster machine.

5.1.9.3.3 Handling Cost

The handling cost can be considered to be the cost of transporting the material from one machine to the next, the cost of having the raw material in storage, etc. In this model these costs were not included and the total cost was based only on the labour and machining costs of the component.

5.1.10 Total Cost

Based on the cost calculations of the previous sections the total cost to machine a feature on a particular machine using a certain tool is;

$$\text{Total cost} = LC + MC \qquad (9)$$

Where LC= total labour cost($)
MC= total machine cost($)

The average cost is determined by dividing the total cost by the lot size to be produced.

$$\text{Average cost} = \text{Total cost} / \text{lots} \qquad (10)$$

5.2 System Optimization

Until this point, ALT1 and ALT2 (sequencing vs. ranking) are identical to each other in terms of component description, machine tool selection, operation grouping and cost estimation. It is the optimization of the machine selection phase where alternatives from different classes of features are to be combined to determine the overall optimal solution that the differences between ALT1 and ALT2 occur. The procedure used is not an optimization procedure in the strictest sense, the procedure involves enumerating the possible alternatives for each process and determining a ranking for the alternatives. There are no constraint equations since each alternative must be considered in order to determine the optimal alternatives. ALT1 has been validated for two classes of a rotational component the results of this approach will be reviewed. ALT2 has been validated for the same two classes of operations as well as two additional classes of features. In ALT2 there was no attempt to combine the operations between the different classes, the optimization is carried out on each of the operations within the individual classes. For this reason there is no need for the formulation of large matrices to contain the different alternatives required to determine the optimal sequencing of operations. This resulted in a great savings of computer memory. The size of the matrix required by ALT1 to allow for sequencing would have to be a NxJx10 matrix where J is the number of classes, N is the maximum number of alternative machine files in a class and 10 is the number of different types of information required from each machine record.

The two systems will be discussed separately as to the method of optimization which was carried out.

5.2.1 Optimization Of ALT1

At this stage ALT1 combines the operation classes to determine the combination of machine tools which will result in the minimum overall cost per lot. There was no attempt to generate the maximum production rate alternative since it would be for only a two stage example and since this system was eventually modified to the new system. Since no sequencing rules were incorporated into the system, the sequence of operations was predetermined prior to running the system. The procedure was able to generate optimal process plans for all combinations of machine tools for each of the operations in a predefined sequence.

For the optimization, the system considered all feasible remaining tool alternatives for each process in order to ensure the best alternative was generated. Only tools which were able to create all the features within a class were considered. In the case of external turning and internal boring there is a total of five different operations, These are;

1. Turning
2. External grinding
3. Drilling
4. Boring and
5. Internal grinding.

In order to determine all feasible combinations, the system considered each alternative for an operation in combination with each alternative for all the other operations. For example, assume there are only ten alternatives for each operation; the system would make 10x10x10x10x10=100,000 comparisons. Even for a micro-system the amount of time taken may be fairly small when compared to manual methods. However, consider that before a comparison can be made the system must first read each record from the appropriate file, calculate the total cost, and then compare it with the other alternatives. The end result could easily approach several hours of computer time.

If ALT1 were allowed to consider the alternative operation sequences between the classes of features, considerably longer run times would have resulted, since for this two stage example there would have been "nine" additional sequences resulting in ten times the number of calculations and comparisons. It can be shown that for additional classes to be considered, the number of alternative sequencing combinations will increase and the time taken will increase significantly, making prompt results unattainable. In order for the system to provide information to the operator quickly, ALT2 was developed. For ALT1 the cost formula took the form of equation (11) as shown below.

$$\text{Rank Minimum} \quad T_i+EG_j+D_k+B_l+IG_m-P_{i,j}-P_{j,k}-P_{k,l}-P_{l,m} \qquad (11)$$

where T_i = alternative machine record i for turning
EG_j = alternative machine record j for external grinding
D_k = alternative machine record k for drilling
B_l = alternative machine record l for boring
IG_m = alternative machine record m for internal grinding
$P_{i,j}$ = reduction due to alternative i being on same machine as operation j
$P_{j,k}$ = same as $P_{i,j}$
$P_{k,l}$ = same as $P_{i,j}$
$P_{l,m}$ = same as $P_{i,j}$

For example purposes, the value of $P_{i,j}$ was taken to be .5*(set up cost)/(lot size). This value was used only as an approximation. In order for the system to determine the optimal process plan, the system would determine if two operations should be performed on a part before the next part is loaded onto the machine. This would have to be based on the load/unload times as well as the additional cost to set up two operations on the same machine. This problem is beyond the capabilities of the system and would result in even further expansion of the time taken to determine an optimal process plan.

From initial studies of ALT1, it was found that the system is capable of generating simplified process plans the output from the procedure will be examined in section 5.3. The time taken for this two stage problem was found, however, to be considerable. For this reason ALT2 was developed as an aid to the process planner, not as a process planning system. The alternative system considers all operations as being independent of the other operations.

5.2.2 Optimization Of ALT2

For the optimization of ALT2 the task was simplified since there was no need to sequence the operations. There was no need to consider the possibility of operation interaction between different operations within a class or between classes. Each operation was considered to be independent of the others and the optimization was carried out on each single operation within each class of features. Because of this the system did not need to determine the total cost for all operations or the reduction in cost due to sequential operations being performed on the same machine. The simplified optimization equation is shown below:

For each i Rank the Minimum= $TC_{i,j}$ (12)

where $TC_{i,j}$ = cost of operation i on each alternative tool j

In addition to the minimization of cost for each operation ALT2 can also determine the optimal machine selection for maximum production rate. The procedure is based on the amount of material to be removed and the metal removal rate of the alternative machine selected. The equation is outlined below:

For each i Rank the Minimum= Mat/Mrr_j (13)

where Mat= amount of material to be removed during the operation.
Mrr_j = rate at which alternative tool j can remove material.

Since there is no comparison between operations and no summing over all the possible combinations, the system was able to operate much faster and provide the information to the operator in a fraction of the time taken by ALT1. By not generating an optimized alternative for the entire process plan there was no need to create the large arrays to store the combined optimized operation sequence alternatives. Simpler arrays were constructed to manipulate the data for each operation and subsequent optimization. Upon completion of an operation the arrays were re-intialized and used for the next required operation, there-by greatly reducing the amount of memory required.

As a result, it was found that for the ALT1 system, the two stage example of external turned surfaces, and internal surfaces could use virtually all the available memory when the system is expanded for a more realistic size problem, even when there was no allowance for inter-sequencing of operations between classes of features. As a result, this preliminary system is only able to consider a two stage process of external turning and internal turning. As the size of the machine file grows and becomes more realistic the number of alternative machine records would increase for each alternative operation and the size of the required matrix would increase. Therefore, for each loop of the program the system will have to perform several extra calculations and comparisons. For example, in the two stage case where there was 10 feasible alternatives for each of the required operations it was shown that a total of

100,000 calculations were required, a increase of just one alternative for one operation will result in an additional 10,000 calculations and comparisons. As a result, for such a small number of machine tools it was decided that this procedure should be altered to make the system faster and more of an aid to the process planner rather than a process plan generator.

From preliminary comparisons of the output from ALT1 it was found that the difference between two sets of ranked alternatives was only a single operation. This is illustrated in Appendix E which contains sample output for ALT1. Therefore, ALT2 which provides individual rankings of all the alternatives for each operation in a given class may provide more vital information to the user of the system rather than just outputting the optimal plan.

As an example, if the machine selected as part of the optimal plan by ALT1 were not available, the operator would have to generate a plan manually, but through ranking, the revised system would allow the user to select from one of the other ranked alternatives which is currently available.

5.3 System Output

The output from the two systems consisted of machines, speeds, feeds, costs and other information required to machine the component. ALT1 outputted information relative to the individual operations as well as the combined operations. This section compares the two outputs from ALT1 and ALT2.

5.3.1 ALT1 System Output

The output from ALT1 provided the first twenty ranked alternative process plans to create the part as described by the operator. The ranking was based on the minimum cost plan. The output from ALT1 includes information for each operation and the order in which the operations are to be performed; since the order was fixed only a single sequence was generated.

The output for each required operation included:

-Machine number

-Tool number

-Machining time for the operation

-Average cost per part for the operation

-Suggested speeds (mm/min)

-Suggested feeds (mm/rev)

The information provided by this system could be taken directly to the machine shop floor and used to set-up the machine and manufacture the component. Additionally, for each process plan generated, the total average cost per part using the above tools was provided. Looking at the examples in Appendix E the total cost for each plan may not be the same as the sum of the individual cost elements. The difference occurs since the cost is reduced when a machine can perform two operations in a row on the same part as outlined in the optimization phase of this problem. One additional bit of information is the time taken by the computer to generate the output. A sample output is contained in Table 5.5. A number of sample outputs for different parts can be seen in Appendix E.

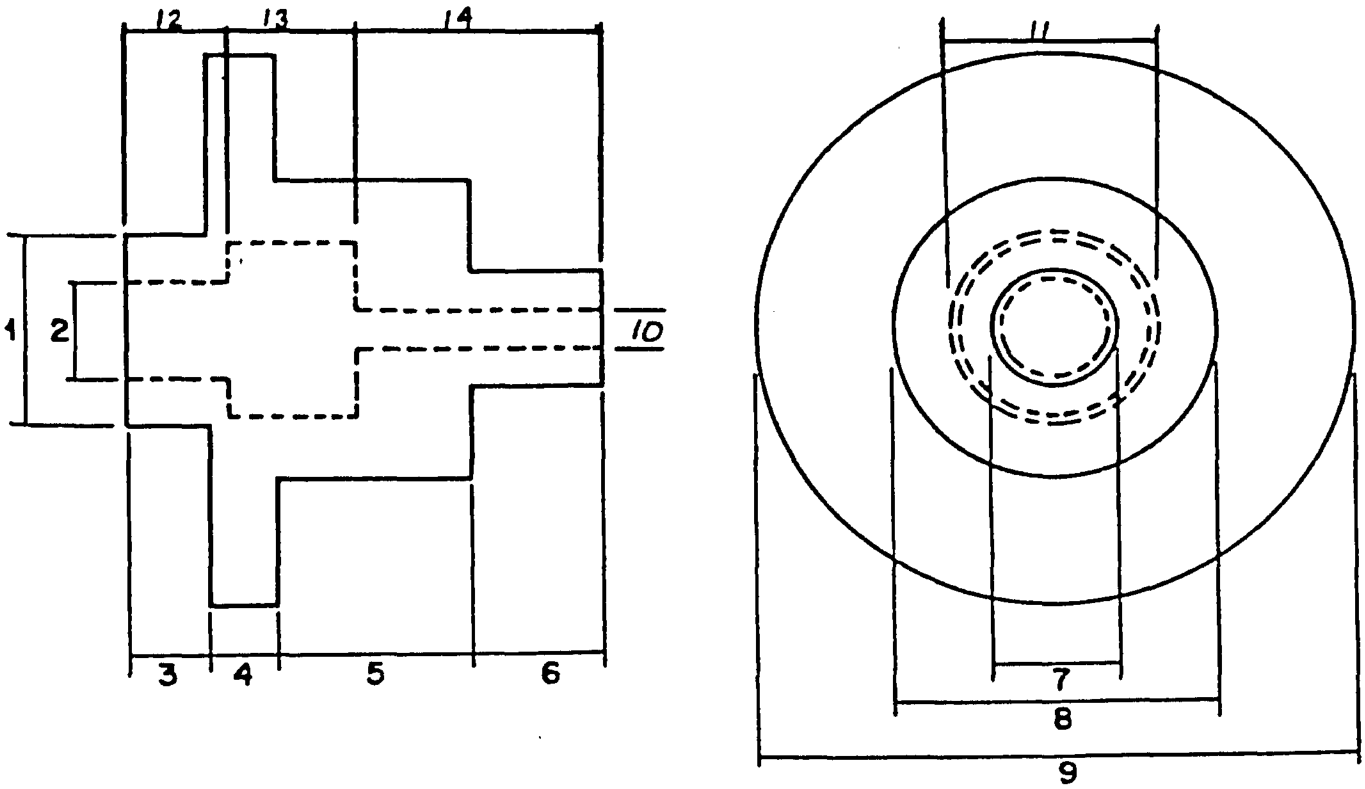
5.3.2 ALT2 System Output.

Unlike ALT1, the output from this program does not include the sequenced operations to produce the component. The sequencing is left to the Process Engineer and as a result he/she will be able to select the sequence of operations which will result in a more efficient process plan generation. In this case each operation is ranked according to either minimum cost or maximum production rate which is chosen by the operator. The information provided along with the rankings include;

-Machine number

-Tool number

Example Problem



COMPONENT DESCRIPTION,

Part Name = Pully
Part Number = 9138
Start Diameter = 200 mm
Start Length = 400 mm
Material = 1020 steel
Lot size = 120

Feature,		
	1. =75mm	2. =40mm
	3. =67mm	4. =67mm
	5. =133mm	6. =133mm
	7. =60mm	8. =120mm
	9. =180mm	10. =20mm
	11. =70mm	12. =100mm
	13. =100mm	14. =200mm

Surface Finish = 75 Rms
Tolerence =.02mm

Table 5.5

****

TODAYS DATE APRIL 16/87 LOT SIZE= 120

PART NAME= PULLY PART NUMBER= 9138

****

MACHINE #	TOOL #	MACHINE TIME (min)	TOTAL COST/LOT ($)	AVE COST/PART ($)	ROUGH CUT PART FEED (mm/RPM)	ROUGH CUT PART SPEED (mm/min)	FINISH CUT PART FEED (mm/RPM)	FINISH CUT PART SPEED (mm/min
C-1802	TUC-B15	38.0918	1344.152	11.20127	.26	97435.9	6.5E-02	107179.5
I-11	DRH-D35	3.333333E-03	65.31046	.5442539	.26	1627.885		
F-37	BOC-C19	2.529174	172.5974	1.438311	.28	105357.1	.07	115892.9
COST FOR THIS PLAN IS= 13.18383								
C-1802	TUC-B15	38.0918	1344.152	11.20127	.26	97435.9	6.5E-02	107179.5
I-11	DRH-D35	3.333333E-03	65.31046	.5442539	.26	1627.885		
C-1500	BOH-A11	2.925907	173.162	1.443016	.22	99350.65	5.5E-02	109285.7
COST FOR THIS PLAN IS= 13.18854								
C-1802	TUC-B15	38.0918	1344.152	11.20127	.26	97435.9	6.5E-02	107179.5
I-11	DRH-D35	3.333333E-03	65.31046	.5442539	.26	1627.885		
F-37	BOH-B46	2.57278	173.9479	1.449566	.26	167307.7	6.5E-02	184038.5
COST FOR THIS PLAN IS= 13.19509								
C-1802	TUC-B15	38.0918	1344.152	11.20127	.26	97435.9	6.5E-02	107179.5
I-11	DRH-D35	3.333333E-03	65.31046	.5442539	.26	1627.885		
F-37	BOH-B13	2.869639	183.8303	1.531919	.14	557142.9	.035	612857.2
COST FOR THIS PLAN IS= 13.27744								
C-1802	TUC-B15	38.0918	1344.152	11.20127	.26	97435.9	6.5E-02	107179.5
I-11	DRH-D35	3.333333E-03	65.31046	.5442539	.26	1627.885		
C-1802	BOH-C1	2.925907	186.9327	1.557773	.18	212500	4.5E-02	233750
COST FOR THIS PLAN IS= 13.3033								
C-1802	TUC-B11	39.1213	1378.384	11.48653	.16	231250	4.0E-02	254375
I-11	DRH-D35	3.333333E-03	65.31046	.5442539	.26	1627.885		
F-37	BOC-C19	2.529174	172.5974	1.438311	.28	105357.1	.07	115892.9
COST FOR THIS PLAN IS= 13.4691								

C-1802	TUC-B11	39.1213	1378.384	11.48653	.16	231250	4.0E-02	254375
I-11	DRH-D35	3.333333E-03	65.31046	.5442539	.26	1627.885		
C-1500	BOH-A11	2.925907	173.162	1.443016	.22	99350.65	5.5E-02	109285.7

COST FOR THIS PLAN IS= 13.4738

C-1802	TUC-B11	39.1213	1378.384	11.48653	.16	231250	4.0E-02	254375
I-11	DRH-D35	3.333333E-03	65.31046	.5442539	.26	1627.885		
F-37	BOH-B46	2.57278	173.9479	1.449566	.26	167307.7	6.5E-02	184038.5

COST FOR THIS PLAN IS= 13.48035

C-1802	TUC-B11	39.1213	1378.384	11.48653	.16	231250	4.0E-02	254375
I-11	DRH-D35	3.333333E-03	65.31046	.5442539	.26	1627.885		
F-37	BOH-B13	2.869639	183.8303	1.531919	.14	557142.9	.035	612857.2

COST FOR THIS PLAN IS= 13.5627

C-1802	TUC-B11	39.1213	1378.384	11.48653	.16	231250	4.0E-02	254375
I-11	DRH-D35	3.333333E-03	65.31046	.5442539	.26	1627.885		
C-1802	BOH-C1	2.925907	186.9327	1.557773	.18	212500	4.5E-02	233750

COST FOR THIS PLAN IS= 13.58856

TIME TAKEN TO RUN PROGRAM= 5.155682 (MIN)

-Machine time/part

-Total Time/Lot

-Total Cost/Lot

-Average cost/part

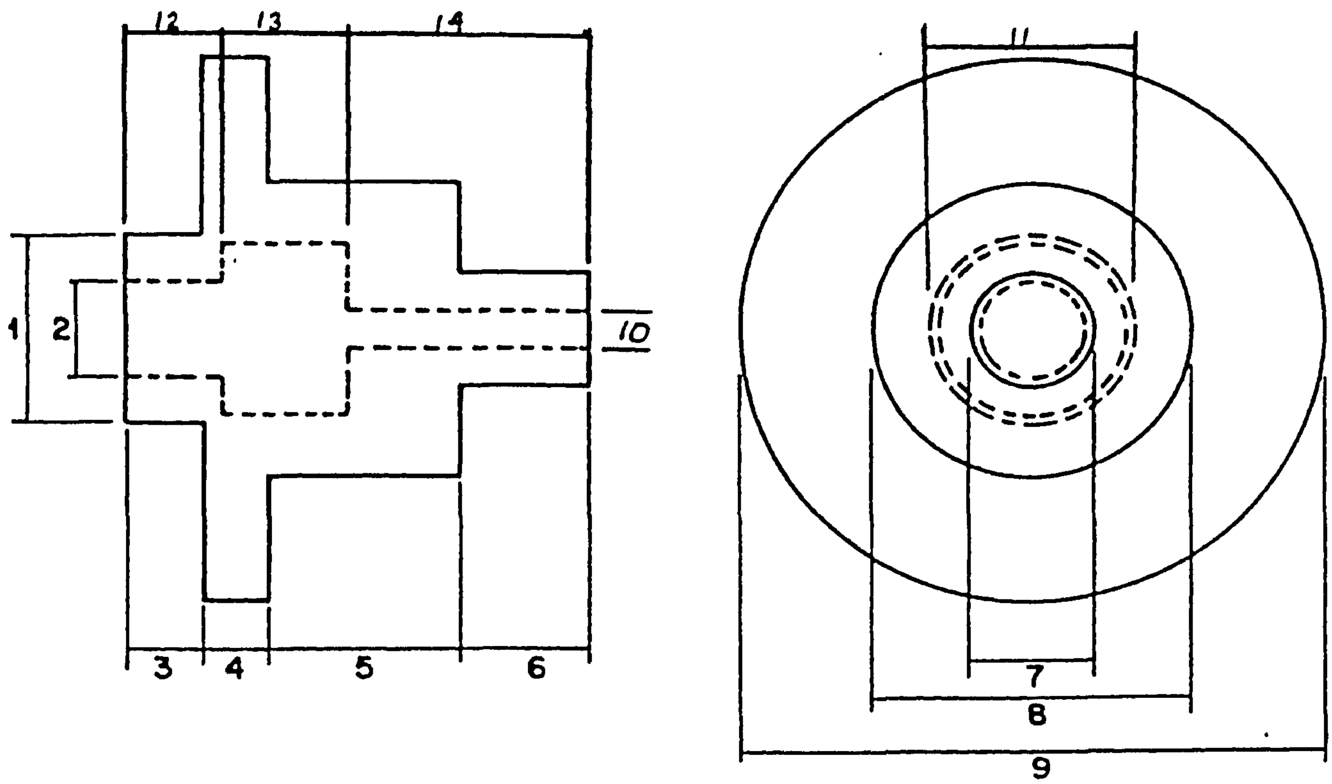
-Suggested speeds (mm/min)

-Suggested feeds (mm/rev)

-Suggested depth (mm)

and when necessary -If a finishing operation is required

The output is arranged according to the required operation. The operator has the choice as to which machine he/she wishes to use and in which order to arrange the operations. The system tells the operator the ranked order, and as a result if the highest rank alternative machine is not available he/she can select from any of the other alternatives. The operator also has the choice of selecting alternatives which allow for more then one operation to be performed on a machine. The final cost for production must be calculated by the process planner, by taking into consideration the sequencing interactions of the operations. A sample output for the system is shown in Table 5.6, several outputs from the system are contained in Appendix F.



COMPONENT DESCRIPTION,

Part Name	= Pully
Part Number	= 9138
Start Diameter	= 200 mm
Start Length	= 400 mm
Material	= 1020 steel
Lots Size	= 120

Features,

1. =75mm	2. =40mm
3. =67mm	4. =67mm
5. =133mm	6. =133mm
7. =60mm	8. =120mm
9. =180mm	10. =20mm
11. =70mm	12. =100mm
13. =100mm	14. =200mm

Surface finish = 75 Rms
Tolerence =.02mm

Table 5.6

****

PART NAME: PULLY

OPERATOR: D. MELOCHE DATE: APRIL 16/87

LOT SIZE: 120

****

****
OPERATION REQUIRED TO GENERATE
THE EXTERNAL FEATURES
****

TOOLS AVAILABLE FOR TURNING

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	DEPTH (mm)	Rough cut FEED (mm/RPM)	Rough cut SPEED (mm/min)	Finish cut FEED (mm/RPM)	Finish cut SPEED (mm/min)	GRINDING REQUIRED
C-1802	TUC-B23	36.98751	4678.501	1307.235	10.89362	15	.48	33333.33	.12	36666.67	Y
C-1802	TUC-B21	37.9154	4789.848	1338.087	11.15072	11	.34	62566.84	.085	68823.53	Y
F-37	TUH-C41	37.9154	4801.848	1349.687	11.24739	11	.5	42545.45	.125	46800	Y
C-1802	TUC-B15	38.89212	4907.054	1370.563	11.42136	9	.26	97435.9	6.5E-02	107179.5	N
C-1802	TUH-A23	39.40001	4968.001	1385.906	11.54922	13	.48	36057.69	.12	39663.46	Y
F-37	TUC-B12	39.40001	4980.001	1401.367	11.67805	9	.26	96153.85	6.5E-02	105769.2	Y
C-1802	TUH-A21	39.92163	5030.596	1403.229	11.69358	9	.34	72549.02	.085	79803.93	Y
C-1802	TUC-B11	39.92163	5030.596	1404.794	11.70662	6	.16	231250	4.0E-02	254375	N
J-19	TUC-B11	39.92163	4982.596	1412.724	11.7727	16	.42	33035.71	.105	36339.29	Y
F-37	TUH-C11	39.92163	5042.596	1416.394	11.80329	9	.34	72549.02	.085	79803.93	Y
C-1802	TUH-A11	40.45755	5094.906	1421.027	11.84189	7	.26	120329.7	6.5E-02	132362.6	N
C-1802	TUH-A7	41.00835	5161.001	1439.319	11.99433	4	.16	337500	4.0E-02	371250	N
J-19	TUC-B17	42.15716	5250.859	1487.234	12.39362	13	.28	57692.3	.07	63461.54	Y
J-19	TUH-C21	42.75653	5322.784	1504.694	12.53911	13	.36	44230.77	9.0E-02	48653.85	Y
B-30	TUC-H11	44.00897	5521.076	1551.49	12.92909	12	.26	64423.08	6.5E-02	70865.39	N
J-19	TUH-C17	44.66365	5551.638	1568.144	13.06786	11	.26	69230.77	6.5E-02	76153.85	N
H-91	TUC-C45	44.66365	5575.638	1570.821	13.09018	5	.14	282857.2	.035	311142.9	N
H-91	TUH-C13	46.7524	5826.288	1639.436	13.66197	2	.1	945000	.025	1039500	N
B-30	TUC-H16	46.7524	5850.288	1642.874	13.69062	7	.18	150000	4.5E-02	165000	N
J-19	TUH-C1	48.25903	5983.084	1687.762	14.06468	5	.18	203333.3	4.5E-02	223666.7	N
B-30	TUH-H14	49.86781	6224.138	1744.686	14.53905	5	.18	196666.7	4.5E-02	216333.3	N

GRINDING TOOLS AVAILABLE

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	DEPTH (mm)	FEED (mm/RPM)	SPEED (RPM)
EG-40	ERG-E21	.8	504	215.4	1.795	2.26661	8.75	4418.937
EG-40	ERG-E33	.8	504	215.4	1.795	2.26661	8.75	4418.937
EG-40	ERG-E16	.8	504	215.4	1.795	2.26661	8.75	4418.937

****
OPERATIONS REQUIRED TO
GENERATE INTERNAL FEATURES
WHICH PASS THROUGH THE PART
****

DRILLING RECORDS AVAILABLE

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	FEED (mm/RPM)	SPEED (mm/min)
K-21	DRH-A28	1.074017	296.882	97.37144	.8114287	.2	1862.168
I-11	DRH-D35	1.047167	305.66	99.9031	.8325259	.26	1469.166

BORING RECORDS AVAIABLE

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	TOOL DEPTH	ROUGH CUT FEED (mm/Rpm)	ROUGH CUT SPEED (mm/min)	FINISH CUT FEED (mm/Rpm)	FINISH CUT SPEED (mm/min)	GRINDING REQUIRED
F-37	BOC-C19	3.129174	603.3009	192.3974	1.603311	6	.28	105357.1	.07	115892.9	N
C-1500	BOH-A11	3.525907	651.1088	192.962	1.608016	7	.22	99350.65	5.5E-02	109285.7	N
F-37	BOH-B46	3.17278	608.7336	193.7479	1.614565	4	.26	167307.7	6.5E-02	184038.5	N
F-37	BOH-B13	3.469639	644.3368	203.6303	1.696919	2	.14	557142.9	.035	612857.2	N
C-1802	BOH-C1	3.525907	651.1088	206.7327	1.722773	4	.18	212500	4.5E-02	233750	N

NO TOOLS AVAILABLE TO PERFORM GRINDING
TIME TAKEN TO RUN PROGRAM= 3.461509 (MIN)

5.4 Comparison of ALT1 AND ALT2

Alt1 was developed to perform all aspects of process plan generation, such as determining which machines the operations should be carried out on, which will result in the minimum cost. As well the system calculated the machining parameters required to meet the specifications of the part and considered the cost reduction due to the operation sequence to be followed.

ALT1, however, is limited in many ways when one thinks of a truly generative system.

These limitations include;

- The system does not consider alternative descriptions of the component, since alternative descriptions would result in a greater number of alternatives to consider further increasing the memory required,
- The system only considers one order of operations, due to the complexity and size when allowing the system to generate alternative sequencing,
- The system does not allow for one machine to perform simultaneous machining operations and
- The system does not consider the non-availability of a machine.

Although, ALT2 does not provide the sequence of operations, it does provide the user with very important information, which includes;

- -The ranking of alternatives for a particular operation based on minimum cost or maximum production rate,
- -All relevant information for machining, including speeds, feeds and depths of cut,
- -Allows the operator to sequence operations to the best alternatives,
- -In ALT1 if a machine is not available the process plan is no longer acceptable, but, by using ALT2 the operator can select the next alternative from the list,
- -The system can be expanded to generate information for all classes of features and
- -The system gives the user the final say in the process plan which will give the operator the satisfaction of making the final decision.

It is felt that ALT2 would give the process planner more flexibility when developing process plans. The process engineer will be able to generate more reliable process plans than the manual approach and the system will provide other useful information other than just a process plan. A flow chart for ALT1 and ALT2 is listed in Appendix G. A complete listing of the program for ALT1 is contained in Appendix H along with the portion of the modified program for ALT2.

6.0 CONCLUDING REMARKS

6.1 Discussion

The system described in this thesis is able to generate process plans faster and more accurately then manual procedures. It does not however eliminate the need for process planners since decision based on the output must still be made. Compared to other systems its ability to determine required processes based on part description and consider more then a single operation makes it more advantageous then other systems. The major point is its ability to perform the steps outlined in this report only utilizing a micro-computer.

Of the two systems described in this report it is felt that ALT2 would provide more information and more flexibility to the Procees Engineer. Because of the complexity of the first system and the time taken to select an optimal sequence of machine tools only a sample solution was considered, and no further extension of the system would be possible.

For ALT2 where the system ranks the individual operations, the program has been completed for four classes of features and expansion of the system is possible. In ALT2 the operator can select from the ranked alternatives to select machines which are best suited under the current situation. By allowing the operator the final sequencing of machines the overall optimal sequence may not be generated. The trade off is that when a particular machine in not available when required the operator can select from the alternatives. Also, this procedure would provide better scheduling of machines by not overloading a particular machine that could be used by a number of parts.

Although ALT1 does not meet the initial expectations, it does provide a method through which a micro-based system can be effectively used to aid the operator in the generation of process plans. The user of the system should have a working knowledge of machining practices, but, does not have to be an expert on the tools which are available on the shop floor. The system will generate the ranking of all operations to be performed and using cost formulas and intuition the operator can determine the best selection from each of the operations to be performed. The final generation of the sequenced operations in the development of process plans has been left to the operator of the system. The system as designed will allow the operator to generate more feasible process plans than are currently being developed manually. The micro-computer will save the process engineer time by performing the calculations required to generate detailed process plans. This system would be applicable where there are 10-50 machine tools in the shop resulting in 100-500 machine records. For a smaller number manual methods would likely prove to be better, and for systems larger than this a larger computer would be required to manipulate the information.

As a result of the research a procedure was developed which can effectively be used to describe a component to the computer for the purpose of machine tool selection. The modular development of both the machine description and the subsequent machine tool selection provides the ability for a micro-computer to aid the process planner in process plan generation. Although ALT1 does not measure up to the initial expectations, the modified version can be used in the future by the Process Engineer to aid in process plan generation. The development of this micro-based system provides a system which can be applied to a wide number of companies, since the system was not designed for a particular user. The machine database individualizes each system to the needs of each user, since users create their own unique machine files. The system is capable of running on a micro-computer and as a result can be applied to a much larger group of users than most other systems which often require the use of a mainframe system. From the literature survey, no micro-based system before now has been developed which would allow the selection of operations and generation of cutting parameters based only on the description of the component.

6.2 Scope for Further Work

During the development of the two systems there was no attempt to determine the type or form of jig and or fixture required to accurately machine the part. The selection was left to the operator of the system. A possible extension would be to have the system search a jig/fixture file to determine which jig/fixture is required for the machine selected to manufacture the component.

Additional research may include the use of the computer to generate optimal cutting parameters based on tool life equations and using geometric programming as outlined by Sundaram and Cheng.

Another, possible extension of the work can be the generation of alternative shapes to describe the component. This procedure would not assume that the description provided by the operator is the only possible description, and as a result the system would generate alternative descriptions of the component, then select machine tools based on alternative systems.

A fourth extension would be to consider alternative process sequencing between operations from different classes of features. This would allow for the optimal generation of plans considering alternative operation sequencing and consider simultaneous machining of the component.

A fifth area which could be incorporated into future research would be the inclusion of the quality level for each machine and an overall acceptance level for the product to be manufactured.

Also not included in this report was the problem of machine chattering which would affect the quality of the part. A method of using stability charts could be included to further extend the research described in this report.

A final possible extension would be to link the system to a CAD database so information can be taken directly from the CAD system and a machine tool selection will be outputted automatically.

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RESULT OF LITERATURE SURVEY AND BIBLIOGRAPHY

The list of papers found in this section will be of use to students interested in continueing the reseach topics proposed in this report. Also the information can be useful to individuals doing research in related topics.

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Appendix A

USERS GUIDE

APPENDIX A

The users guide contained in this appendix is not designed to take the operator step by step through the program. The intent of the guide is to provide a reference manual which can be used by the operator when difficulties or ambiguities occur. Since the entire system is menu driven and user interactive there should be few problems in running the system. Once the operator becomes familiar with terms used in the system he should have no troubles with the system.

There are only two times that the operator must interact with the system, once when the operator is creating the machine files, and the other when the operator describes the component. The creation of the machine files is performed only at the initialization of the system. It is important however, that the creation of these files is performed correctly since these files form the basis from which the system selects the alternatives.

Each area will be discussed separately on the following pages, beginning with the machine description files.

MACHINE DESCRIPTION

It is important that each of the question prompted during the machine description phase be answered, since any omission may result in sub-optimal selection of machine tools and there cutting parameters at later stages. The purpose of the stage is to describe all machining alternatives available to the system. The system begins by prompting the operator for three types of information; a. Machine data

b. Process information for the machine

c. Tool information for each machine/process combination.

a. Machine Data

1. Machine number -the operator can input any alphanumeric 6 digit code which identifies the particular machine.

2. Horse power -the operator inputs the rated horse power of the particular machine

3. Number of operations -the operator must input the number of operations which can be performed on a particular machine. Ex. A lathe may be able to turn, axial drill, and bore therefore the operator would input "3" for the number of operations.

Once the operator has inputted the above information the system begins to prompt the operator for information on each process the machine can perform.

b. Process Information

1. Operation code -the operator must input the operation code (Table 5.1) for each operation the machine can perform.

2. Set-Up Cost -the operator inputs the cost to set-up the machine for the particular operation. ($)

3. Operator cost -the operator must input a dollar value for the cost of the machinist operating the process on the particular machine. ($/minute)

4. Load/Unload time -for a particular operation the operator must input the estimated loading and unloading time on a per part basis. (minute)

5. Expected Down Time -each machine will have a history of down times vs. up time a percent value is inputted to give a better estimate of the time taken to machine the components. (%)

The next section determines the maximum part dimensions the particular operation on the machine can handle.

6. Maximum length of part -maximum length allowed on the machine. (mm)

7. Maximum diameter -the maximum diameter of part which can be machined. (mm) If no rotational parts can be machined enter "0".

8. Maximum width -the maximum width of part which can be handled. (mm)

9. Maximum Height -the maximum height of part which can be handled. (mm)

10. Number of tools -the operator must input the number of tools which are available to perform the operation on the particular machine.

Ex. Turning on a lathe -there may be "5" different tools available each with it's own characteristics.

The next section looks into the details of each of the tools to perform the operation on the particular machine.

c. Tool Characteristics

1. Tool Number -the operator can input any six digit alphanumeric code to identify the particular tool.

2. Tool cost -in order for the system to generate

costs it must consider the tool cost. The operator must input this cost based on tool replacement. Dollars/min of machining time, since the tool cost only occurs during contact with the part.

3. Tool material -Based on the tool material and the part material combination there will be changes in the cutting parameters. Tool material can be either;

HSS -high speed steel

CAR -carbide tool

4. Number of teeth -the operator must input the number of teeth on the tool in order to aid in the cutting parameter estimations.

5. Tool diameter -in certain cases a tool will have a certain diameter ex. drills, end mills, etc. In other circumstances the tool diameter will indicate the hole diameter required prior to using the tool.

Ex. Boring operation -prior to a boring operation a hole must exist of a least a certain value to allow clearance of the tool during operation. Other operations would include; Internal keyways and Tapping.

6. Tool Width -the width of the tool to perform the operation. (mm)

7. Tool nose radius -most machining operations have individual cutters that come in contact with the part, each of these cutters has a radius associated the it's tip this radius must be inputted to aid in generating

feeds for the operation (mm).

8. Maximum metal removal rate -For a particular operation using a certain tool on a machine there will be a maximum amount of metal which can be removed in a minute based on the part material being 1020 steel. This metal removal rate must be inputted to allow for an estimated machine time for the machine/operation/ tool combination. (mm^3/minute)

9. Maximum depth of cut -the maximum depth of cut which can be made in a single pass where the part material is 1020 steel is inputted (mm). For some operations such as drilling, reaming, and tapping the maximum depth of cut refers to the length of the tool.

10. Tolerance attainable -in order for the system to select appropriate tools the system must know the tolerance which the tool can achieve for the process on the particular machine. (mm)

11. Surface Finish -the system must also know the surface finish which the machine/process/tool combination can achieve. (Rms)

COMPONENT DESCRIPTION

As indicated in the report a modular approach to machine description was taken that allows the matching of operations required for a particular class of operations to particular machine files. This process greatly speeds up the generation and selection phase of the program. The individual modules will be described for the system which have been completed.

The system has been designed for the description of both rotational components as well as prismatic components.

Rotational components are components which require external turning operations on a lathe to create there external features. They may include internal rotational features to be machined by a boring operation. Also included are drilling operations and both internal and external keyway cutting. Other features cannot be described by the system, nor can machine tool selection take place for other features on a rotational component. Prismatic components are components which require mostly none rotational machining. The majority of features are a block type. The system also includes drilling operations which may be performed on any surface of the component.

General Information

Upon entering the system the operator must input certain general information which includes;

1. Date -the current date
2. Name -the name of the operator running the system
3. Part number -the number of the part which the operator will be describing.
4. Part name -the name given to the part.
5. Part material -the material the component is made of will affect the estimation of cutting time and machining parameters so the material must be inputted. The materials which the operator has a choice of inputting are;

    a. Cast Iron

    b. 1020 Carbon steel

    c. 4140 Steel

    d. Brass

6. Maximum production rate or minimum cost

    -the operator indicates the ranking of the machine selected for each of the processes, based on either minimum cost or maximum production rate.

7. Type of part (Rotational/Prismatic) -based on this input the system will begin to prompt the operator for the appropriate information on the features of the part.

Rotational Component Description

Along with the Yes/No questions asked by the system as shown in Table 5.2 the operator must input certain specific information for the description of the individual features in a class.

First Class -External Turned Surfaces

In this class of there can be two forms of features, stepped, and tapered as illustrated in Figure 5.6. The information required from each feature is given below.

Stepped Features -a step feature consists of a cylinder of uniform diameter along the axis of the part, the required inputs are;

-Length, and Tolerance

-Diameter, and Tolerance

-Surface Finish

Tapered Features -a tapered feature unlike a stepped feature has a diameter which changes as you travel the length of the feature. The change is uniform along the length of the part.

The inputs required are;

-Length, and Tolerance

-Start Diameter, and Tolerance

-Finish Diameter, and Tolerance

-Surface Finish

As can be seen there is no need to input the location of the feature since the description starts at one end of the part and the features across the part are inputted as they appear on the part.

Once the operator has finished the description of the external features the system prompts for the description of the internal features.

Second Class -Internal Turned Features

In this class of features there are three sub classes;

Features that extend the length of the part

Features that originate from the reference end

Features that originate from the none reference end

Where the reference end is determined by the operator prior to describing the component and must remain the same throughout the description.

Each class of internal shapes are described using the same features as the External Turned Feature class.

Third Class -Parallel Drill Holes

In this class of features the operator inputs the description of drill holes which are parallel to the axis of the part. Here as above the drill holes can originate from the reference end or the opposite end. The additional information required is listed below.

Distance From end

On/Off the axis

Diameter, and Tolerance

Depth, and Tolerance

If the Drill Hole is Threaded

Fourth Class -External Drill Holes

In this class the information required is the same as above, except the question of being On/Off the axis is not asked.

Fifth And Sixth Classes -Internal/External Keyways

In these two classes of features the operator must indicate if there are any internal/external keyways to be machined. If there were no internal features (class two) the system will skip the internal keyway portion. The information required to describe the features are;

Width of Keyway

Length of Keyway

Depth of Cut

Distance From Reference/Opposite End.

The above describes the input required from the operator to describe the features of a rotational component

Prismatic Component Description

This next section takes you through the possible information for the description of a prismatic component and the features to be removed to create the desired finished product.

First Class -External Surfaces

The operator must input the surfaces of the component which require machining. The operator inputs a rectangular box to indicate the area to be machined, although the actual material may not be a rectangle. The input includes;

-Length

-Width

-Depth, and Tolerance

-Surface Finish.

No tolerance is required for the length and width since it is assumed that the rectangle travels the length and width of the surface.

Second Class -External Features

The operator inputs the features other then surfaces to be machined. Here the operator must first select the feature to be machined from one of the following; Rectangle, Triangle, Trapezoid, Rhomboid, and Portion of a Cylinder. Upon selection the operator must input the Description of the feature. A complete listing of the required input is found in Appendix D.

Third class -Internal Turned Features

In this class of features the operator uses the same terms as in the internal features for rotational components. The system asks the operator to indicate the axis which the feature is parallel to so the system can determine the orientation of the features.

Fourth Class -Drill Holes

The last description is of the individual drill holes to be machined on the component. The features are divided into six sub-classes, two for each of the three axis of the part, since they can be either in the positive or negative direction relative to the axis.
The information required for each hole includes;

-Drill Diameter, and Tolerance

-Drill Depth, and Tolerance

-Surface Finish

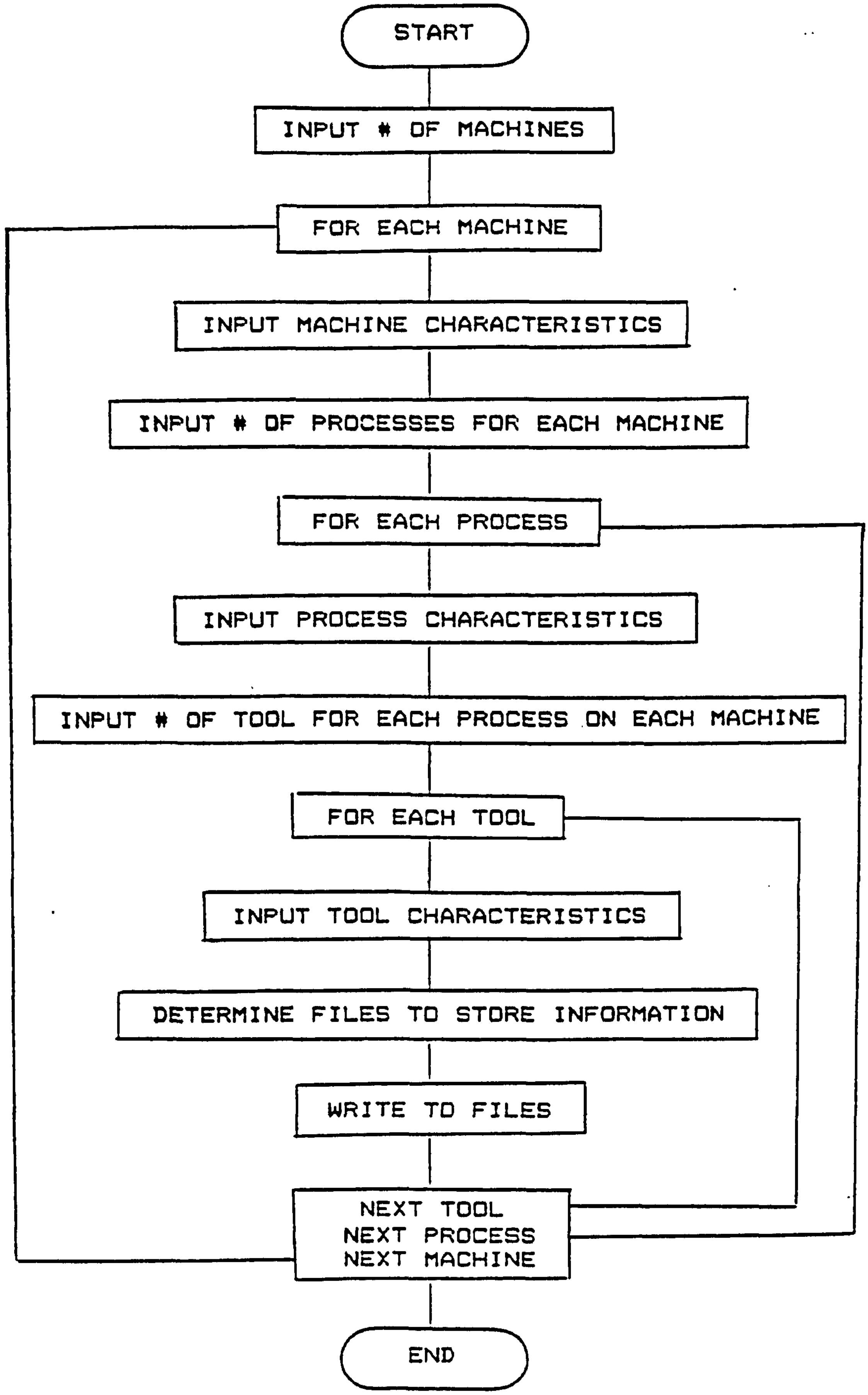
-If the drill hole is threaded.

As shown above the entire component can be easily described in terms of the above features to the system. The input is easy to follow and understand and the operator should have no trouble using the system to aid in the selection of appropriate machine tools.

APPENDIX B

FLOW CHART AND LISTING OF

MACHINE DESCRIPTION PROGRAM


START
INPUT # OF MACHINES
FOR EACH MACHINE
INPUT MACHINE CHARACTERISTICS
INPUT # OF PROCESSES FOR EACH MACHINE
FOR EACH PROCESS
INPUT PROCESS CHARACTERISTICS
INPUT # OF TOOL FOR EACH PROCESS ON EACH MACHINE
FOR EACH TOOL
INPUT TOOL CHARACTERISTICS
DETERMINE FILES TO STORE INFORMATION
WRITE TO FILES
NEXT TOOL
NEXT PROCESS
NEXT MACHINE
END

```
SOURCE
PRECISION= 7
AUTODEF=OFF
OPTION BASE=0
ERL=OFF
ERRORMODE=LOCAL
RESUME=LINE
FORMODE=BB
SCOPE=ON
PROCS=0
STRUCTURE: MMMM
   INTEGER: JJ,NT
   REAL: LLL,DDD,WD,HGT,TOL,SuF,TC
   REAL: TM,TTD,TW,TNR,EFF,OC,SC,TAA
   STRING: COMB[16],SIM[16],RULE[16],MN$[16],TN$[16]
   REAL: HP,LUT,EBDM,MRR
END STRUCTURE

MMMM: P31
INTEGER: M,F,I,PPA,J,PPP,TJ,K
STRING: MM$[16],TTT$[16]
REAL: AA,BB,CC,DD,EE,FF,GG
REAL: HH,II,JA,KK,LL,MM,NN,OO
REAL: PP,QQ,MMR,DA
INTEGER: TT,F1,F2,F3,F4
INTEGER: F5,F6,F7,F8
STRING: YY[16],Ccc[16]


'MAIN Program:


   10 'THIS PROGRAM MUST BE DIVIDED UP TO CREATE SEPERATE FILES FOR DIFFERENT
   20 'TYPES OF MACHINING OPERATIONS SINCE IT WAS FOUND THAT FOR LARGE
   30 'DATABASES THE TIME TO SEARCH ALL THE RECORDS WITH A MICRO-COMPUTER
   40 'WOULD TAKE TO MUCH TIME
   50 CLS
   60 CLOSE
   70 PRINT "NUMBER OF MACHINES IN THE SHOP"
   80 LOCATE 1,32:INPUT " ";M
   90 OPEN "C:AAA" AS #1 LEN=SIZE(P31)
  100 READ RECORD #1 1 P31
  110 LET F1=P31.NT+1
  120 CLOSE
  130 OPEN "C:BBB" AS #1 LEN=SIZE(P31)
  140 READ RECORD #1 1 P31
  150 LET F2=P31.NT+1
  160 CLOSE
  170 OPEN "C:CCC" AS #1 LEN=SIZE(P31)
  180 READ RECORD #1 1 P31
  190 LET F3=P31.NT+1
```

```
200 CLOSE
210 OPEN "C:DDD" AS #1 LEN=SIZE(P31)
220 READ RECORD #1 1 P31
230 LET F4=P31.NT+1
240 CLOSE
250 OPEN "C:EEE" AS #1 LEN=SIZE(P31)
260 READ RECORD #1 1 P31
270 LET F5=P31.NT+1
280 CLOSE
290 OPEN "C:FFF" AS #1 LEN=SIZE(P31)
300 READ RECORD #1 1 P31
310 LET F6=P31.NT+1
320 CLOSE
330 OPEN "C:GGG" AS #1 LEN=SIZE(P31)
340 READ RECORD #1 1 P31
350 LET F7=P31.NT+1
360 CLOSE
370 CLS
380 F1=2:F2=2:F3=2:F4=2:F5=2:F6=2:F7=2
390 FOR I=1 TO M
400   CLS
410   PRINT "MACHINE NUMBER="
420   PRINT "HORSE POWER OF MACHINE"
430   LOCATE 1,17:INPUT " ",MM$
440   LOCATE 2,24:INPUT " ",AA
450   PRINT "NUMBER OF PROCESSES WHICH CAN BE PERFORMED ON MACHINE";MM$
460   PRINT "IS"
470   LOCATE 4,4:INPUT " ",PPA
480   PRINT:PRINT
490   INPUT "IS ABOVE CORRECT (Y/N)",YY
500   IF YY="N" THEN GOTO 400
510   CLS
520   FOR J=1 TO PPA
530     CLS
540     PRINT "PROCESS NUMBER"
550     PRINT "CLAMPING DEVICE"
560     PRINT "SET UP COST ($)"
570     PRINT "OPERATOR COST ($/HR)"
580     PRINT "TIME TO LOAD AND UNLOAD PART (MIN)"
590     PRINT "EXPECTED BREAK DOWN MULTIPLE"
600     PRINT "EFFIENCY AT THE SPINDLE (%)"
610     PRINT "MAX LENGTH OF PART (mm)"
620     PRINT "MAX DIAMETER OF PART (mm) IF APPLICABLE ELSE 0)"
630     PRINT "MAX WIDTH OF PART (mm) IF APPLICABLE ELSE 0)"
640     PRINT "MAX HEIGHT OF PART (mm) IF APPLICABLE ELSE 0)"
650     LOCATE 1,16:INPUT " ",PPP
660     LOCATE 2,17:INPUT " ",Ccc
670     LOCATE 3,17:INPUT " ",BB
680     LOCATE 4,22:INPUT " ",CC
690     LOCATE 5,36:INPUT " ",DD
700     LOCATE 6,30:INPUT " ",DA
```

```
710     LOCATE 7,29:INPUT " ",EE
720     LOCATE 8,25:INPUT " ",FF
730     LOCATE 9,49:INPUT " ",GG
740     LOCATE 10,46:INPUT " ",HH
750     LOCATE 11,47:INPUT " ",II
760     PRINT "NUMBER OF TOOLS WHICH ARE AVAILABLE TO PERFORM PROCESS";J
770     PRINT "IS"
780     LOCATE 13,4:INPUT " ",TJ
790     INPUT "IS ABOVE CORRECT (Y/N)",YY
800     IF YY="N" THEN GOTO 530
810     FOR K=1 TO TJ
820       CLS
830       PRINT "TOOL NUMBER"
840       PRINT "TOOL COST OF MACHINING ($/HR)"
850       PRINT "TOOL MATERIAL"
860       PRINT "NUMBER OF TEETH ON TOOL"
870       PRINT "TOOL DIAMETER (mm) IF APPLICABLE ELSE 0"
880       PRINT "TOOL WIDTH (mm) IF APPLICABLE ELSE 0"
890       PRINT "TOOL NOSE RADIUS (mm) IF APPLICABLE ELSE 0"
900       PRINT "MAXIMUM METAL REMOVAL RATE (cu.mm/min.)"
910       PRINT "MAXIMUM DEPTH OF CUT (mm)"
920       PRINT "TOLERENCE ATTAINABLE (mm)"
930       PRINT "SURFACE FINISH ATTAINABLE (RMS)"
940       LOCATE 1,13:INPUT" ",TTT$
950       LOCATE 2,31:INPUT " ",JA
960       LOCATE 3,15:INPUT " ",KK
970       LOCATE 4,25:INPUT " ",TT
980       LOCATE 5,41:INPUT " ",LL
990       LOCATE 6,38:INPUT " ",MM
1000      LOCATE 7,44:INPUT " ",NN
1010      LOCATE 8,41:INPUT " ",MMR
1020      LOCATE 9,27:INPUT " ",OO
1030      LOCATE 10,27:INPUT " ",PP
1040      LOCATE 11,33:INPUT " ",QQ
1050      PRINT:PRINT
1060      INPUT "IS ABOVE CORRECT (Y/N)",YY
1070      IF YY="N" THEN GOTO 820
1080      P31.JJ=PPP:P31.TOL=PP:P31.SuF=QQ:P31.LLL=FF:P31.DDD=GG:P31.WD=HH
1090      P31.HGT=II:P31.TC=JA:P31.TM=KK:P31.TTD=LL:P31.TW=MM:P31.TNR=NN
1100      P31.TAA=OO:P31.EFF=EE:P31.OC=CC:P31.SC=BB:P31.HP=AA:P31.LUT=DD
1110      P31.MN$=TTT$:P31.TN$=MM$:P31.MRR=MMR:P31.EBDM=DA:P31.NT=TT
1120      P31.COMB=Ccc
1130      IF PPP=1 OR PPP=2 THEN GOSUB 1460
1140      IF PPP=3 OR PPP=5 OR PPP=6 THEN GOSUB 1510
1150      IF PPP=3 OR PPP=8 OR PPP=4 OR PPP=9 OR PPP=7 OR PPP=10 THEN GOSUB 1560
1160      IF PPP=8 OR PPP=9 OR PPP=10 THEN GOSUB 1610
1170      IF PPP=13 OR PPP=16 THEN GOSUB 1660
1180      IF PPP=15 OR PPP=16 OR PPP=17 OR PPP=18 OR PPP=19 OR PPP=20 OR PPP=21 THEN GOSUB 1710
1190      IF PPP=8 OR PPP=11 OR PPP=12 THEN GOSUB 1760
1200      CLS
1210    NEXT K
```

```
1220   NEXT J
1230 NEXT I
1240 P31.NT=F1
1250 F1=1
1260 GOSUB 1460
1270 P31.NT=F2
1280 F2=1
1290 GOSUB 1510
1300 P31.NT=F3
1310 F3=1
1320 GOSUB 1560
1330 P31.NT=F4
1340 F4=1
1350 GOSUB 1610
1360 P31.NT=F5
1370 F5=1
1380 GOSUB 1660
1390 P31.NT=F6
1400 F6=1
1410 GOSUB 1710
1420 P31.NT=F7
1430 F7=1
1440 GOSUB 1760
1450 STOP:END
1460 OPEN "C:AAA" AS #1 LEN=SIZE(P31)
1470 WRITE RECORD #1 F1 P31
1480 F1=F1+1
1490 CLOSE
1500 RETURN
1510 OPEN "C:BBB" AS #1 LEN=SIZE(P31)
1520 WRITE RECORD #1 F2 P31
1530 F2=F2+1
1540 CLOSE
1550 RETURN
1560 OPEN "C:CCC" AS #1 LEN=SIZE(P31)
1570 WRITE RECORD #1 F3 P31
1580 F3=F3+1
1590 CLOSE
1600 RETURN
1610 OPEN "C:DDD" AS #1 LEN=SIZE(P31)
1620 WRITE RECORD #1 F4 P31
1630 F4=F4+1
1640 CLOSE
1650 RETURN
1660 OPEN "C:EEE" AS #1 LEN=SIZE(P31)
1670 WRITE RECORD #1 F5 P31
1680 F5=F5+1
1690 CLOSE
1700 RETURN
1710 OPEN "C:FFF" AS #1 LEN=SIZE(P31)
1720 WRITE RECORD #1 F6 P31
```

```
1730 F6=F6+1
1740 CLOSE
1750 RETURN
1760 OPEN "C:666" AS #1 LEN=SIZE(P31)
1770 WRITE RECORD #1 F7 P31
1780 F7=F7+1
1790 CLOSE
1800 RETURN
```

ENDFILE

APPENDIX C

DESCRIPTION FOR ROTATIONAL COMPONENT

DESCRIPTION FOR A ROTATIONAL COMPONENT

1. Are there any external turned features (y/n)

If no go to question 2.

Starting from one end of the part describe each feature.

1a. Is feature stepped/tapered (s/t)

If t goto 1b.

Input; Length of step, Tolerance

Diameter, Tolerance

Surface Finish

1b. Input; Length of taper, Tolerance

Start diameter, Tolerance

Finish diameter, Tolerance

Surface Finish

2. Are there any internal turned features (y/n)

If no goto question 3.

2.1 Does the feature pass through the part (y/n)

If no goto question 2.2

Starting from one end of the part describe each feature.

2.1a Is feature stepped/tapered (s/t)

If t goto 2.1b

Input; Length of step, Tolerance

Diameter, Tolerance

Surface Finish

2.1b Input; Length of taper, Tolerance

Start diameter, Tolerance

Finish diameter, Tolerance

Surface Finish

2.2 Does feature originate from reference end (y/n)

If no goto question 2.3

Starting from one end of the part describe each feature.

2.2a Is feature stepped/tapered (s/t)

If t goto 2.2b

Input; Length of step, Tolerance

Diameter, Tolerance

Surface Finish

2.2b Input; Length of taper, Tolerance

Start diameter, Tolerance

Finish diameter, Tolerance

Surface Finish

2.3 Does feature originate from reference end (y/n)

If no goto question 3

Starting from one end of the part describe each feature.

2.3a Is feature stepped/tapered (s/t)

If t goto 2.3b

Input; Length of step, Tolerance

Diameter, Tolerance

Surface Finish

2.3b Input; Length of taper, Tolerance

Start diameter, Tolerance

Finish diameter, Tolerance

Surface Finish

3. Are there any drill holes parallel to axis (y/n)

If no goto question 4

3.1 Do they originate in the direction of the reference end (y/n)

If no goto question 3.2

Input; Number of Drill holes

For each drill hole Input; Length, Tolerance
Diameter, Tolerance
Threaded (y/n)
Surface Finish
Distance from center axis
Distance from reference end

3.2 Do they originate in the direction of the opposite end (y/n)

If no goto question 4

Input; Number of Drill holes

For each drill hole Input; Length, Tolerance
Diameter, Tolerance
Threaded (y/n)
Surface Finish
Distance from center axis
Distance from opposite end

4. Are there any external drill holes (y/n)

If no goto question 5.

Input; Number of Drill holes

For each drill hole Input; Length, Tolerance
Diameter, Tolerance
Threaded (y/n)
Surface Finish

Distance from reference end

5. Are there any internal keyways (y/n)

   If no goto question 6.

   Input; Number of internal keyways

For each internal keyway Input;

Start distance from Reference end

Length, Tolerance

Depth, Tolerance

Width, Tolerance

6. Are there any external keyways (y/n)

   If no stop

   Input; Number of internal keyways

For each internal keyway Input;

Start distance from Reference end

Length, Tolerance

Depth, Tolerance

Width, Tolerance

APPENDIX D

DESCRIPTION OF PRISMATIC COMPONENTS

DESCRIPTION OF PRISMATIC FEATURE CLASSES

1. Input the description of the raw material

   Rectangle

   Triangle

   Trapezoid

   Rhomboid

   Input the dimensions for each raw material form.

2. Are there any external surfaces to machine (y/n)

   If no then goto question 3.

   Input number of surfaces

   For each surface Input; Length

   Width

   Depth, Tolerance

   Surface Finish

3. Are there any external features to machine (y/n)

   If no then goto question 4.

   Input number of features

   For each feature Input;

Feature (rectangle, triangle, trapezoid, rhomboid, portion of cylinder)

Based on feature Input; Dimensions, Tolerances

Surface Finish

X, Y, Z coordinates of end of feature.

Direction of travel (X, Y, Z)

4. Are there any internal features to machine (y/n)

If no goto question 5.

Input number of groups

For each group

Input number of features in the group

4.1 Starting from the external surface is the feature stepped or tapered (s/t)

If t then goto 4.2

Input; Length, Tolerance

Diameter, Tolerance

Surface Finish

4.2 Input; Length, Tolerance

Start Diameter, Tolerance

Finish Diameter, Tolerance

Surface Finish

5. Are there any external drill holes (y/n)

If no then stop

5.1 Are there any in positive x direction (y/n)

If no goto question 5.2

Input; Number in direction

For each drill hole Input; Length, Tolerance

Diameter, Tolerance

Threaded (y/n)

Surface Finish

5.2 Are there any in negative x direction (y/n)

If no goto question 5.3

Input; Number in direction

For each drill hole Input; Length, Tolerance

Diameter, Tolerance

Threaded (y/n)

Surface Finish

5.3 Are there any in positive y direction (y/n)

If no goto question 5.4

Input; Number in direction

For each drill hole Input; Length, Tolerance

Diameter, Tolerance

Threaded (y/n)

Surface Finish

5.4 Are there any in negative y direction (y/n)

If no goto question 5.5

Input; Number in direction

For each drill hole Input; Length, Tolerance
Diameter, Tolerance
Threaded (y/n)
Surface Finish

5.5 Are there any in positive z direction (y/n)

If no goto question 5.6

Input; Number in direction

For each drill hole Input; Length, Tolerance
Diameter, Tolerance
Threaded (y/n)
Surface Finish

5.4 Are there any in negative z direction (y/n)

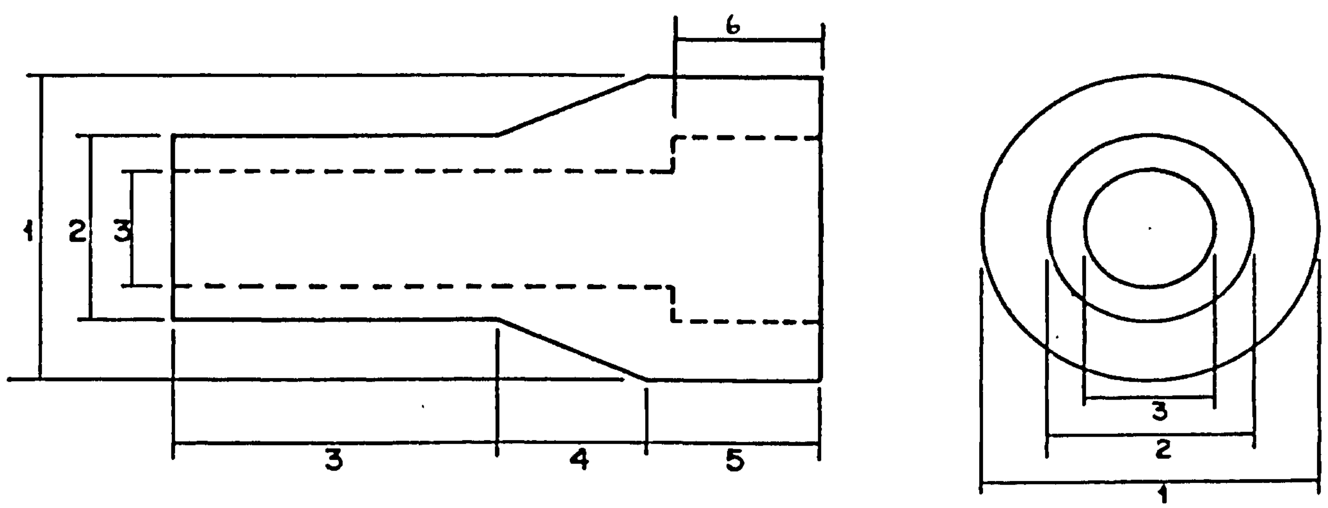
If no then stop

Input; Number in direction

For each drill hole Input; Length, Tolerance
Diameter, Tolerance
Threaded (y/n)
Surface Finish

APPENDIX E

EXAMPLES FROM ALT1 SYSTEM



PART # 9871 PART NAME – SPINDLE

COMPONENT INFORMATION,

Part Name = SHAFT
Part Number = 124
Start Diameter = 110 mm
Start Length = 400 mm
lot size = 200
material = cast iron

Features, 1 = 100 mm
2 = 50 mm
3 = 40 mm
3a = 200 mm
4 = 100 mm
5 = 100 mm
6 = 90 mm

Surface Finish = 60 Rms
Tolerance = .02 mm

TODAYS DATE APRIL 16/87 LOT SIZE= 100

PART NAME= CENTER PART NUMBER= 1427

					Rough Cut		Finish Cut	
MACHINE #	TOOL #	MACHINE TIME (min)	TOTAL COST/LOT ($)	AVE COST/PART ($)	PART FEED (mm/RPM)	PART SPEED (mm/min)	PART FEED (mm/RPM)	PART SPEED (mm/min
H-91	TUC-C45	10.59066	368.6144	3.686144	.14	282857.1	.035	311142.8
K-21	DRH-A28	2.197802E-03	54.1607	.541607	.2	1804.176		
F-37	BOH-B13	.3161996	86.63719	.8663719	.14	390000	.035	429000
COST FOR THIS PLAN IS= 5.094123								
H-91	TUC-C45	10.59066	368.6144	3.686144	.14	282857.1	.035	311142.8
C-1801	DRH-H11	1.993356E-03	64.25504	.6425503	.18	2210.244		
F-37	BOH-B13	.3161996	86.63719	.8663719	.14	390000	.035	429000
COST FOR THIS PLAN IS= 5.195066								
H-91	TUH-C13	11.09498	382.4075	3.824075	.1	945000	.025	1039500
K-21	DRH-A28	2.197802E-03	54.1607	.541607	.2	1804.176		
F-37	BOH-B13	.3161996	86.63719	.8663719	.14	390000	.035	429000
COST FOR THIS PLAN IS= 5.232054								
H-91	TUC-C45	10.59066	368.6144	3.686144	.14	282857.1	.035	311142.8
M-24	DRH-D21	2.197802E-03	68.31068	.6831068	.18	2004.64		
F-37	BOH-B13	.3161996	86.63719	.8663719	.14	390000	.035	429000
COST FOR THIS PLAN IS= 5.235623								
B-30	TUC-H16	11.09478	383.3513	3.833513	.18	150000	4.5E-02	165000
K-21	DRH-A28	2.197802E-03	54.1607	.541607	.2	1804.176		
F-37	BOH-B13	.3161996	86.63719	.8663719	.14	390000	.035	429000
COST FOR THIS PLAN IS= 5.241492								
H-91	TUC-C45	10.59066	368.6144	3.686144	.14	282857.1	.035	311142.8
A-90	DRH-H11	1.948052E-03	72.1469	.721469	.22	1850.437		
F-37	BOH-B13	.3161996	86.63719	.8663719	.14	390000	.035	429000
COST FOR THIS PLAN IS= 5.275985								
H-91	TUH-C13	11.09498	382.4075	3.824075	.1	945000	.025	1039500
C-1801	DRH-H11	1.993356E-03	64.25504	.6425503	.18	2210.244		
F-37	BOH-B13	.3161996	86.63719	.8663719	.14	390000	.035	429000
COST FOR THIS PLAN IS= 5.332997								
B-30	TUC-H16	11.09498	383.3513	3.833513	.18	150000	4.5E-02	165000
C-1801	DRH-H11	1.993356E-03	64.25504	.6425503	.18	2210.244		
F-37	BOH-B13	.3161996	96.63719	.8663719	.14	390000	.035	429000
COST FOR THIS PLAN IS= 5.342435								

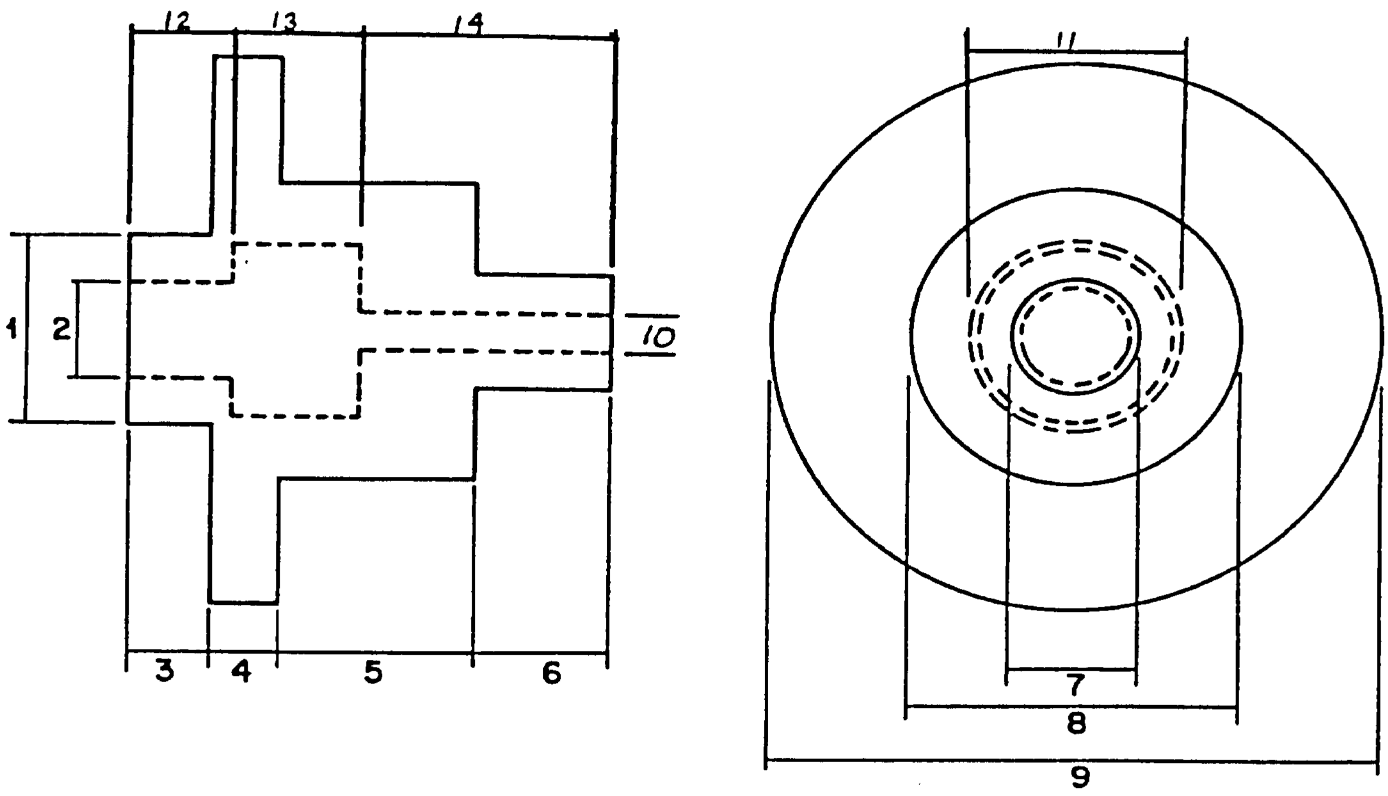
H-91	TUH-C13	11.09498	382.4075	3.824075	.1	945000	.025	1039500
M-24	DRH-D21	2.197802E-03	68.31068	.6831068	.18	2004.64		
F-37	BOH-B13	.3161996	86.63719	.8663719	.14	390000	.035	429000

COST FOR THIS PLAN IS= 5.373554

B-30	TUC-H16	11.09498	383.3513	3.833513	.18	150000	4.5E-02	165000
M-24	DRH-D21	2.197802E-03	68.31068	.6831068	.18	2004.64		
F-37	BOH-B13	.3161996	86.63719	.8663719	.14	390000	.035	429000

COST FOR THIS PLAN IS= 5.382992

TIME TAKEN TO RUN PROGRAM= 61.89009 (MIN)



COMPONENT INFORMATION,

Part Name = Center
Part Number = 1427
Start Diameter = 120 mm
Start Length = 180 mm
Material = 4140 steel
Lot Size = 100

Features, 1 = 40 mm
3 = 30 mm
5 = 60 mm
7 = 25 mm
9 = 100 mm
11 = 35 mm
13 = 45 mm

2 = 20 mm
4 = 30 mm
6 = 60 mm
8 = 75 mm
10 = 18 mm
12 = 45 mm
14 = 90 mm

Surface Finish = 50 Rms
Tolerance = .02

TODAYS DATE APRIL 16/87 LOT SIZE= 200

PART NAME= SPINDLE PART NUMBER= 9871

MACHINE #	TOOL #	MACHINE TIME (min)	TOTAL COST/LOT ($)	AVE COST/PART ($)	ROUGH CUT PART FEED (mm/RPM)	ROUGH CUT PART SPEED (mm/min)	FINISH CUT PART FEED (mm/RPM)	FINISH CUT PART SPEED (mm/min
C-1802	TUC-B11	19.50944	1199.496	5.997482	.16	231250	4.0E-02	254375
K-21	DRH-A45	.0040004	92.82058	.4641029	.4	220.4208		
F-37	BOH-B13	3.005108E-07	130.1	.6505001	.14	371391.4	.035	408530.6
		COST FOR THIS PLAN IS= 7.112085						
C-1802	TUC-B11	19.50944	1199.496	5.997482	.16	231250	4.0E-02	254375
K-21	DRH-A45	.0040004	92.82058	.4641029	.4	220.4208		
C-1802	BOC-C3	2.790458E-07	131.3	.6565	.18	103693.3	4.5E-02	114062.7
		COST FOR THIS PLAN IS= 7.118085						
C-1802	TUC-B11	19.50944	1199.496	5.997482	.16	231250	4.0E-02	254375
K-21	DRH-A45	.0040004	92.82058	.4641029	.4	220.4208		
A-90	BOC-D9	2.790458E-07	134.82	.6741	.16	116655	4.0E-02	128320.5
		COST FOR THIS PLAN IS= 7.135685						
C-1802	TUC-B11	19.50944	1199.496	5.997482	.16	231250	4.0E-02	254375
K-21	DRH-A45	.0040004	92.82058	.4641029	.4	220.4208		
A-90	BOH-D3	3.005108E-07	134.82	.6741	.12	433290	.03	476619
		COST FOR THIS PLAN IS= 7.135685						
C-1802	TUC-B11	19.50944	1199.496	5.997482	.16	231250	4.0E-02	254375
C-1802	DRH-C33	4.082041E-03	121.525	.6076252	.4	205.0768		
C-1802	BOC-C3	2.790458E-07	131.3	.6565	.18	103693.3	4.5E-02	114062.7
		COST FOR THIS PLAN IS= 7.138858						
C-1802	TUC-B11	19.50944	1199.496	5.997482	.16	231250	4.0E-02	254375
C-1802	DRH-C33	4.082041E-03	121.525	.6076252	.4	205.0768		
F-37	BOH-B13	3.005108E-07	130.1	.6505001	.14	371391.4	.035	408530.6
		COST FOR THIS PLAN IS= 7.199858						
C-1802	TUC-B11	19.50944	1199.496	5.997482	.16	231250	4.0E-02	254375
C-1802	DRH-C33	4.082041E-03	121.525	.6076252	.4	205.0768		
A-90	BOC-D9	2.790458E-07	134.82	.6741	.16	116655	4.0E-02	128320.5
		COST FOR THIS PLAN IS= 7.223458						
C-1802	TUC-B11	19.50944	1199.496	5.997482	.16	231250	4.0E-02	254375
C-1802	DRH-C33	4.082041E-03	121.525	.6076252	.4	205.0768		
A-90	BOH-D3	3.005108E-07	134.82	.6741	.12	433290	.03	476619
		COST FOR THIS PLAN IS= 7.223458						

C-1802	TUH-A7	20.05137	1228.636	6.14318	.16	337500	4.0E-02	371250
K-21	DRH-A45	.0040004	92.82058	.4641029	.4	220.4208		
F-37	BOH-B13	3.005108E-07	130.1	.6505001	.14	371391.4	.035	408530.6

COST FOR THIS PLAN IS= 7.257783

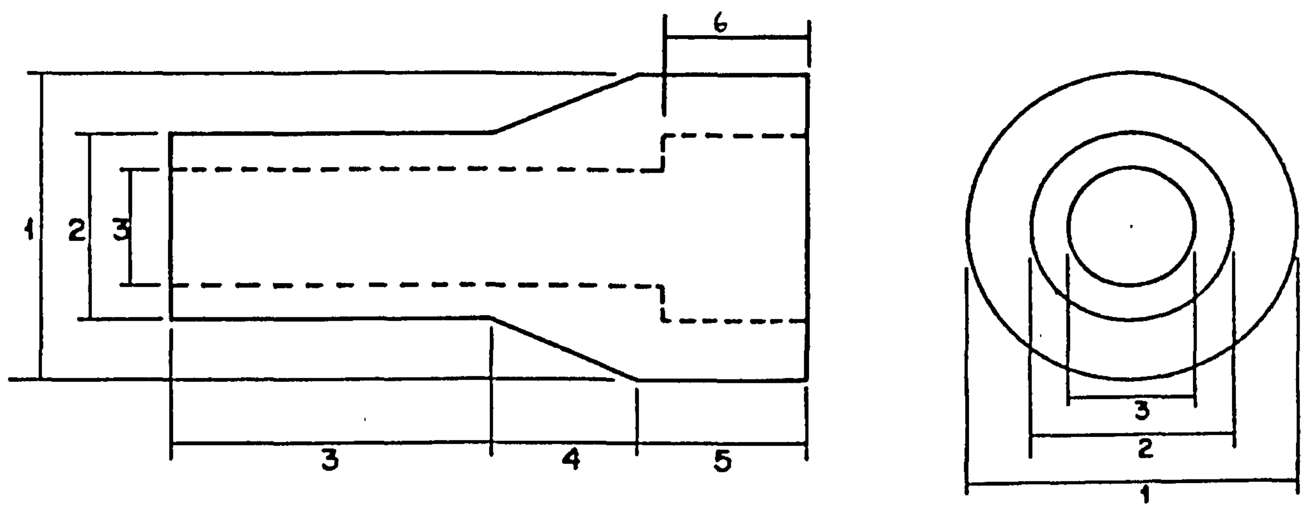
C-1802	TUH-A7	20.05137	1228.636	6.14318	.16	337500	4.0E-02	371250
K-21	DRH-A45	.0040004	92.82058	.4641029	.4	220.4208		
C-1802	BOC-C3	2.790458E-07	131.3	.6565	.18	103693.3	4.5E-02	114062.7

COST FOR THIS PLAN IS= 7.263783

TIME TAKEN TO RUN PROGRAM= 128.379 (MIN)

APPENDIX F

EXAMPLES FROM ALT2 SYSTEM



COMPONENT INFORMATION,

Part Name = Shaft
Part Number = 9871
Start Diameter = 110 mm
Start Length = 400 mm
lot size = 200
material = cast iron

Features, 1 = 100 mm
2 = 50 mm
3 = 40 mm
3a = 200 mm
4 = 100 mm
5 = 100 mm
6 = 90 mm

Surface Finish = 60 Rms
Tolerance = .02 mm

****

PART NAME: SPINDLE

OPERATOR: D. MELOCHE DATE: APRIL 11/87

LOT SIZE: 200

****

****
OPERATION REQUIRED TO GENERATE
THE EXTERNAL FEATURES
****

TOOLS AVAILABLE FOR TURNING

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	DEPTH (mm)	Rough cut FEED (mm/RPM)	Rough cut SPEED (mm/min)	Finish cut FEED (mm/RPM)	Finish cut SPEED (mm/min)	GRINDING REQUIRED
C-1802	TUC-B23	6.522495	1704.499	481.8179	2.409089	9.999	.48	33333.33	.12	36666.67	Y
C-1802	TUC-B21	6.674354	1734.87	490.208	2.45104	7.3326	.34	62566.84	.085	68823.53	Y
C-1802	TUC-B15	6.834205	1766.841	499.0399	2.4952	5.9994	.26	97435.89	6.5E-02	107179.5	Y
C-1802	TUH-A23	6.917328	1783.466	503.3797	2.516898	8.6658	.48	36057.69	.12	39663.46	Y
M-24	TUC-C19	7.090405	1758.081	503.5141	2.51757	11.9988	.26	46794.87	6.5E-02	51474.36	Y
F-37	TUH-C41	6.674354	1754.87	504.008	2.52004	7.3326	.5	42545.45	.125	46800	Y
J-19	TUC-B11	7.002697	1720.539	504.8612	2.524306	10.6656	.42	33035.71	.105	36339.29	Y
C-1802	TUH-A21	7.002697	1800.54	508.093	2.540465	5.9994	.34	72549.02	.085	79803.92	Y
C-1802	TUC-B11	7.002697	1800.54	508.349	2.541745	3.9996	.16	231250	4.0E-02	254375	N
C-1802	TUH-A11	7.090405	1818.081	512.9352	2.564676	4.6662	.26	120329.7	6.5E-02	132362.6	Y
F-37	TUC-B12	6.917328	1803.466	517.8115	2.589057	5.9994	.26	96153.84	6.5E-02	105769.2	Y
C-1802	TUH-A7	7.18055	1836.11	517.9122	2.589561	2.6664	.16	337500	4.0E-02	371250	N
F-37	TUH-C11	7.002697	1820.539	522.149	2.610745	5.9994	.34	72549.02	.085	79803.92	Y
J-19	TUC-B17	7.368566	1793.713	525.1047	2.625524	8.6658	.28	57692.3	.07	63461.54	Y
C-1801	TUC-C17	7.273233	1854.647	528.6964	2.643482	7.9992	.34	52205.88	.085	57426.47	Y
M-24	TUH-B17	7.56764	1853.528	529.3622	2.646811	10.6656	.28	45535.71	.07	50089.28	Y
M-24	TUC-D17	7.56764	1853.528	529.9196	2.649598	10.6656	.18	70833.33	4.5E-02	77916.66	Y
J-19	TUH-C21	7.46666	1813.332	530.1204	2.650602	8.6658	.36	44230.77	9.0E-02	48653.85	Y
C-1801	TUC-C7	7.368566	1873.713	533.9663	2.669832	5.3328	.26	100961.5	6.5E-02	111057.7	Y
C-1801	TUH-H6	7.56764	1913.528	544.8318	2.724159	5.3328	.3	84999.99	.075	93499.99	Y
C-1801	TUC-C9	7.56764	1913.528	544.9712	2.724856	3.333	.18	226666.7	4.5E-02	249333.3	N
M-24	TUH-D11	7.889225	1917.845	547.1297	2.735648	5.3328	.2	121875	.05	134062.5	Y
J-19	TUH-C17	7.778782	1875.756	547.3713	2.736857	7.3326	.26	69230.77	6.5E-02	76153.85	Y
H-91	TUC-C45	7.778782	1915.756	553.7149	2.768574	3.333	.14	282857.1	.035	311142.8	N
B-30	TUC-H11	7.671636	1934.327	553.9322	2.76966	7.9992	.26	64423.08	6.5E-02	70865.39	Y
C-1801	TUH-H3	7.889225	1977.845	562.6025	2.813013	2.6664	.2	243750	.05	268125	N
C-1800	TUC-B2	7.56764	2013.528	569.2409	2.846205	7.9992	.26	65384.62	6.5E-02	71923.08	Y
H-91	TUH-C13	8.120628	1984.126	572.4651	2.862326	1.3332	.1	944999.9	.025	1039500	N
C-1800	TUH-A3	7.671636	2034.327	574.7079	2.873539	5.9994	.32	69791.66	8.0E-02	76770.84	Y
B-30	TUC-H16	8.120628	2024.126	578.766	2.89383	4.6662	.18	150000	4.5E-02	165000	N
J-19	TUH-C1	8.367207	1993.441	579.8936	2.899468	3.333	.18	203333.3	4.5E-02	223666.7	Y
C-1800	TUC-B1	7.889225	2077.845	587.0212	2.935106	3.333	.16	243750	4.0E-02	268125	Y
C-1800	TUH-A2	8.120628	2124.126	599.5147	2.997574	3.9996	.24	131250	.06	144375	Y
B-30	TUH-H14	8.630503	2126.1	606.6459	3.033229	3.333	.18	196666.7	4.5E-02	216333.3	N
C-1800	TUH-A1	8.49666	2199.332	620.2905	3.101453	1.9998	.158	379746.8	.0395	417721.5	N
A-45	TUC-A21	8.912274	2182.455	640.5453	3.202726	6.666	.24	71250	.06	78375	Y
A-45	TUH-A19	9.214539	2242.908	657.3965	3.286983	3.333	.24	137500	.06	151250	N

GRINDING TOOLS AVAILABLE

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	DEPTH (mm)	FEED (mm/RPM)	SPEED (RPM)
EG-40	ERG-E21	.6	800	319	1.595	1.13322	8.75	2209.303
EG-40	ERG-E33	.6	800	319	1.595	1.13322	8.75	2209.303
EG-40	ERG-E16	.6	800	319	1.595	1.13322	8.75	2209.303

****
OPERATIONS REQUIRED TO
GENERATE INTERNAL FEATURES
WHICH PASS THROUGH THE PART
****

DRILLING RECORDS AVAILABLE

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	FEED (mm/RPM)	SPEED (mm/min)
C-1500	DRH-D45	2.107294	741.4589	214.654	1.07327	.26664	316.3298
K-21	DRH-A45	2.233732	726.7464	215.768	1.07884	.26664	298.4243
C-1802	DRH-C33	2.279318	815.8657	246.9588	1.234794	.26664	292.4558
B-30	DRH-E11	2.326804	865.3608	261.8	1.309	.26664	286.4873

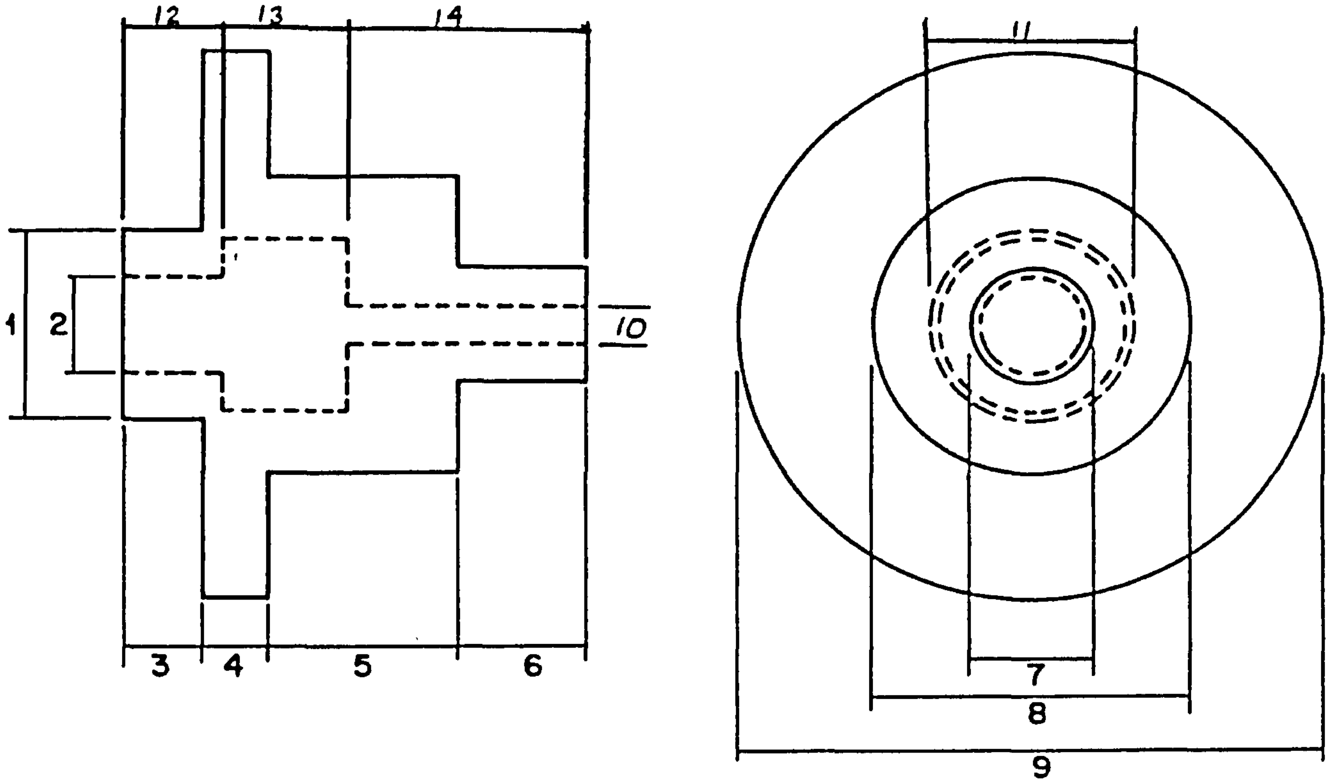
BORING RECORDS AVAIABLE

							ROUGH CUT		FINISH CUT		
MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	TOOL DEPTH	FEED (mm/Rpm)	SPEED (mm/min)	FEED (mm/Rpm)	SPEED (mm/min)	GRINDING REQUIRED
C-1500	BOC-A45	.4000001	460	139.5	.6975	5.99994	.24	73611.1	.06	80972.22	Y
C-1500	BOC-A13	.4000002	460	139.5	.6975	4.66662	.18	121428.6	4.5E-02	133571.4	Y
C-1500	BOH-A11	.4000002	460	139.5	.6975	4.66662	.22	99350.64	5.5E-02	109285.7	Y
B-30	BOC-B3	.4000001	440	146.5	.7325	9.9999	.24	52500	.06	57750	Y
B-30	BOH-A3	.4000001	440	146.5	.7325	7.33326	.24	65909.09	.06	72500	Y
F-37	BOC-C33	.4000001	460	152.1	.7605	5.99994	.34	60784.31	.085	66862.74	Y
F-37	BOC-C19	.4000001	460	152.1	.7605	3.99996	.28	105357.1	.07	115892.9	Y
F-37	BOH-C21	.4000001	460	152.1	.7605	3.3333	.3	120000	.075	132000	Y
F-37	BOH-B46	.4000001	460	152.1	.7605	2.66664	.26	167307.7	6.5E-02	184038.5	Y
F-37	BOH-B13	.4000001	460	152.1	.7605	1.33332	.14	557142.9	.035	612857.2	N
C-1802	BOC-C3	.4000001	460	153.3	.7665	3.99996	.18	155555.6	4.5E-02	171111.1	N
C-1802	BOH-C1	.4000002	460	153.3	.7665	2.66664	.18	212500	4.5E-02	233750	Y
A-90	BOH-D3	.4000001	500	158.1	.7905	1.33332	.12	650000	.03	715000	N
A-90	BOH-D6	.4000001	500	158.1	.7905	2.66664	.16	253125	4.0E-02	278437.5	Y
A-90	BOC-D9	.4000001	500	158.1	.7905	3.99996	.16	175000	4.0E-02	192500	N
A-90	BOC-D11	.4000001	500	158.1	.7905	5.33328	.2	108750	.05	119625	Y

GRINDING TOOLS AVAILABLE

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	TOOL DEPTH	TOOL FEED	TOOL SPEED
IG-50	IRG-133	32.4	7040	2397.08	11.9854	1.3	6.25	3569.23
IG-50	IRG-123	40.4	8640	2931.72	14.6586	1.1	5	4545.455
IG-50	IRG-119	80.4	16640	5608.92	28.0446	.8	2.5	10500

TIME TAKEN TO RUN PROGRAM= 13.17584 (MIN)



COMPONENT INFORMATION,

Part Name = Center
Part Number = 1427
Start Diameter = 120 mm
Start Length = 180 mm
Material = 4140 steel
Lot size = 100

Features,

1 = 40 mm	2 = 20 mm
3 = 30 mm	4 = 30 mm
5 = 60 mm	6 = 60 mm
7 = 25 mm	8 = 75 mm
9 = 100 mm	10 = 18 mm
11 = 35 mm	12 = 45 mm
13 = 45 mm	14 = 90 mm

Surface Finish = 50 Rms
Tolerance = .02 mm

****

PART NAME: CENTER

OPERATOR: D. MELOCHE DATE: APRIL 16/87

LOT SIZE: 100

****

****
OPERATION REQUIRED TO GENERATE
THE EXTERNAL FEATURES
****

TOOLS AVAILABLE FOR TURNING

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	DEPTH (mm)	Rough cut FEED (mm/RPM)	Rough cut SPEED (mm/min)	Finish cut FEED (mm/RPM)	Finish cut SPEED (mm/min)	GRINDING REQUIRED
C-1802	TUC-B23	5.08131	708.131	207.4064	2.074064	10.5	.48	33333.33	.12	36666.67	Y
C-1802	TUC-B21	5.191087	719.1087	210.4527	2.104527	7.7	.34	62566.84	.085	68823.53	Y
C-1802	TUC-B15	5.306643	730.6642	213.6593	2.136594	6.3	.26	97433.9	6.5E-02	107179.5	Y
C-1802	TUH-A23	5.36673	736.673	215.1441	2.151441	9.099999	.48	36057.69	.12	39663.46	Y
C-1802	TUH-A21	5.428443	742.8444	216.8542	2.168542	6.3	.34	72549.02	.085	79803.93	Y
C-1802	TUC-B11	5.428443	742.8444	217.0393	2.170393	4.2	.16	231250	4.0E-02	254375	Y
M-24	TUC-C19	5.491847	719.1848	217.2241	2.172241	12.6	.26	46794.88	6.5E-02	51474.36	Y
C-1802	TUH-A11	5.491847	749.1847	218.611	2.18611	4.9	.26	120329.7	6.5E-02	132362.7	Y
C-1802	TUH-A7	5.557011	755.7011	220.4168	2.204168	2.8	.16	337500	4.0E-02	371250	Y
F-37	TUH-C41	5.191087	727.1087	221.5027	2.215027	7.7	.3	42545.46	.125	46800	Y
J-19	TUC-B11	5.428443	702.8444	224.4096	2.244096	11.2	.42	33033.71	.105	36339.29	Y
M-24	TUH-B17	5.836836	753.6836	226.4222	2.264222	11.2	.28	45535.71	.07	50089.29	Y
F-37	TUC-B12	5.36673	746.673	226.6508	2.266508	6.3	.26	96153.85	6.5E-02	105769.2	Y
M-24	TUC-D17	5.836836	753.6836	226.8251	2.268251	11.2	.18	70833.34	4.5E-02	77916.68	Y
C-1801	TUC-C17	5.624012	762.4011	227.811	2.27811	8.4	.34	52205.88	.085	57426.47	Y
F-37	TUH-C11	5.428443	752.8444	228.0893	2.280893	6.3	.34	72549.02	.085	79803.93	Y
C-1801	TUC-C7	5.692926	769.2926	229.7255	2.297255	5.6	.26	100961.5	6.5E-02	111057.7	Y
H-47	TUC-D13	5.692926	749.2926	231.1723	2.311723	10.5	.24	58333.33	.06	64166.66	Y
J-19	TUC-B17	5.692926	729.2926	231.7701	2.317701	9.099999	.28	57692.31	.07	63461.55	Y
M-24	TUH-D11	6.069305	776.9305	232.8732	2.328732	5.6	.2	121875	.05	134062.5	Y
J-19	TUH-C21	5.763838	736.3838	233.4458	2.334458	9.099999	.36	44230.77	9.0E-02	48653.85	Y
C-1801	TUH-H6	5.836836	783.6836	233.6226	2.336226	5.6	.3	85000	.075	93500	Y
C-1801	TUC-C9	5.836836	783.6836	233.7233	2.337233	3.5	.18	226666.7	4.5E-02	249333.3	Y
B-30	TUC-H11	5.912012	791.2012	238.965	2.38965	8.4	.26	64423.08	6.5E-02	70865.39	Y
H-47	TUC-C11	5.989467	778.9467	239.419	2.394191	7.7	.16	112500	4.0E-02	123750	Y
J-19	TUH-C17	5.989467	758.9467	239.7115	2.397115	7.7	.26	69230.77	6.5E-02	76153.85	Y
C-1801	TUH-H3	6.069305	806.9305	240.0759	2.400759	2.8	.2	243750	.05	268125	Y
H-91	TUC-C45	5.989467	778.9467	240.5153	2.405153	3.5	.14	282857.1	.035	311142.8	N
C-1800	TUC-B2	5.836836	833.6836	244.2237	2.442237	8.4	.26	65384.62	6.5E-02	71923.09	Y
C-1800	TUH-A3	5.912012	841.2012	246.1083	2.461083	6.3	.32	69791.67	8.0E-02	76770.84	Y
H-91	TUH-C13	6.236585	803.6585	247.274	2.47274	1.4	.1	945000	.025	1039500	N
B-30	TUC-H16	6.236585	823.6584	247.9914	2.479914	4.9	.18	150000	4.5E-02	165000	N
H-47	TUH-C10	6.324271	812.4271	248.4538	2.484538	2.1	.14	442857.2	.035	487142.9	Y
C-1800	TUC-B1	6.069305	856.9305	250.684	2.50684	3.5	.16	243750	4.0E-02	268125	Y
J-19	TUH-C1	6.414833	801.4833	251.5237	2.515237	3.5	.18	203333.3	4.5E-02	223666.7	Y
C-1800	TUH-A2	6.236585	873.6584	255.1152	2.551152	4.2	.24	131250	.06	144375	Y
B-30	TUH-H14	6.605166	860.5167	258.0095	2.580095	3.5	.18	196666.7	4.5E-02	216333.3	N
C-1800	TUH-A1	6.508414	900.8414	262.6585	2.626585	2.1	.159	379746.3	.0395	417721.5	Y
A-45	TUC-A21	6.809856	880.9857	271.5332	2.715332	7	.24	71250	.06	78375	Y
A-45	TUH-A19	7.[illegible]2736	[illegible]	277.3312	2.[illegible]3311	3.5	.24	137500	.06	151250	Y

GRINDING TOOLS AVAILABLE

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	DEPTH (mm)	FEED (mm/RPM)	SPEED (RPM)
EG-40	ERG-E33	5.428443	742.8444	216.8542	2.168542	6.3	.34	72549.02
EG-40	ERG-E21	5.36673	736.673	215.1441	2.151441	9.099999	.48	36057.69
EG-40	ERG-E16	5.306643	730.6642	213.6593	2.136594	6.3	.26	97435.9
EG-25	ERG-E17	5.191087	719.1087	210.4527	2.104527	7.7	.34	62566.84
EG-25	ERG-E14	5.08131	708.131	207.4064	2.074064	10.5	.48	33333.33

****
OPERATIONS REQUIRED TO
GENERATE INTERNAL FEATURES
WHICH PASS THROUGH THE PART
****

DRILLING RECORDS AVAILABLE

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	FEED (mm/RPM)	SPEED (mm/min)
K-21	DRH-A28	.2740355	167.4035	61.66886	.6166886	.14	2298.972
I-11	DRH-D31	.2740355	177.4036	64.51886	.6451886	.154	2089.975
H-47	DRH-A15	.2671846	196.7185	71.02429	.7102429	9.8E-02	3368.457
C-1801	DRH-H11	.2485439	204.8544	71.0623	.710623	.126	2816.405
M-24	DRH-D21	.2740355	217.4035	75.81612	.7581612	.126	2554.413
A-90	DRH-H11	.2428951	214.2895	79.18497	.7918497	.154	2357.92

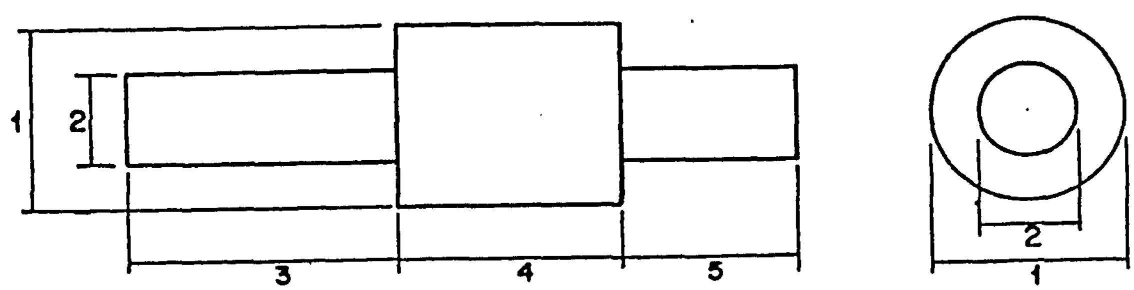
BORING RECORDS AVAIABLE

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	TOOL DEPTH	ROUGH CUT FEED (mm/Rpm)	ROUGH CUT SPEED (mm/min)	FINISH CUT FEED (mm/Rpm)	FINISH CUT *SPEED (mm/min)	GRINDING REQUIRED
A-90	BOH-D3	.7549379	285.4938	95.71432	.9571432	1.4	.12	650000	.03	715000	Y
F-37	BOC-C19	.7365554	263.6555	98.15034	.9815034	4.2	.28	105357.1	.07	115892.9	Y
F-37	BOH-B13	.7549379	265.4938	98.65572	.9865572	1.4	.14	557142.9	.035	612857.2	N
C-1802	BOH-C1	.7579759	265.7976	99.94173	.9994174	2.8	.18	212500	4.5E-02	233750	Y

GRINDING TOOLS AVAILABLE

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	TOOL DEPTH	TOOL FEED	TOOL SPEED
IG-10	IRG-I5	36.6	3760	1338.24	13.3824	1	2.5	9200
IG-10	IRG-I3	72.6	7560	2523	25.23	.5	1.25	35200

TIME TAKEN TO RUN PROGRAM= 12.37637 (MIN)



COMPONENT INFORMATION,

Part Name = Spindle
Part Number = 124
Start Diameter = 125 mm
Start Length = 350 mm
Material = Brass
Lot size = 300

Feature, 1 = 100 mm
2 = 50 mm
3 = 150 mm
4 = 100 mm
5 = 100 mm

Surface Finish = 30 Rms
Tolerance = .02 mm

****

PART NAME: SHAFT

OPERATOR: D. MELOCHE DATE: APRIL 16/87

LOT SIZE: 300

****

****
OPERATION REQUIRED TO GENERATE
THE EXTERNAL FEATURES
****

TOOLS AVAILABLE FOR TURNING

MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	DEPTH (mm)	Rough cut FEED (mm/RPM)	Rough cut SPEED (mm/min)	Finish cut FEED (mm/RPM)	Finish cut SPEED (mm/min)	GRINDING REQUIRED
C-1802	TUC-B23	13.17839	4553.516	1266.962	4.223205	15	.48	33333.33	.12	36666.67	Y
C-1802	TUC-B21	13.5009	4650.273	1293.65	4.312168	11	.34	62566.84	.085	68823.53	Y
F-37	TUH-C41	13.5009	4680.273	1310.2	4.367334	11	.5	42545.45	.125	46800	Y
C-1802	TUC-B15	13.8404	4752.122	1321.744	4.405812	9	.26	97435.9	6.5E-02	107179.5	Y
C-1802	TUH-A23	14.01695	4805.084	1335.816	4.452719	13	.48	36057.69	.12	39663.46	Y
J-19	TUC-B11	14.19826	4739.477	1337.443	4.458145	16	.42	33035.71	.105	36339.29	Y
M-24	TUC-C19	14.38453	4825.36	1349.423	4.498077	18	.26	46794.88	6.5E-02	51474.36	Y
C-1802	TUH-A21	14.19826	4859.477	1350.812	4.502706	9	.34	72549.02	.085	79803.93	Y
C-1802	TUC-B11	14.19826	4859.477	1351.356	4.504519	6	.16	231250	4.0E-02	254375	Y
F-37	TUC-B12	14.01695	4835.083	1353.707	4.512358	9	.26	96153.85	6.5E-02	105769.2	Y
C-1802	TUH-A11	14.38453	4915.36	1366.219	4.554063	7	.26	120329.7	6.5E-02	132362.6	Y
F-37	TUH-C11	14.19826	4889.477	1367.906	4.559685	9	.34	72549.02	.085	79803.93	Y
C-1802	TUH-A7	14.57598	4972.795	1382.054	4.606846	4	.16	337500	4.0E-02	371250	Y
J-19	TUC-B17	14.9753	4972.589	1401.806	4.672687	13	.28	57692.3	.07	63461.54	Y
C-1801	TUC-C17	14.77283	5031.849	1404.527	4.681756	12	.34	52205.88	.085	57426.47	Y
J-19	TUH-C21	15.18364	5035.09	1418.188	4.727292	13	.36	44230.77	9.0E-02	48653.85	Y
C-1801	TUC-C7	14.9753	5092.59	1421.287	4.737625	8	.26	100961.5	6.5E-02	111057.7	Y
M-24	TUH-B17	15.3981	5129.43	1432.193	4.773977	16	.28	45535.71	.07	50089.29	Y
M-24	TUC-D17	15.3981	5129.43	1433.377	4.777923	16	.18	70833.34	4.5E-02	77916.67	Y
C-1801	TUH-H6	15.3981	5219.43	1455.991	4.853303	8	.3	85000	.075	93500	Y
C-1801	TUC-C9	15.3981	5219.43	1456.287	4.85429	5	.18	226666.7	4.5E-02	249333.3	Y
J-19	TUH-C17	15.84653	5233.959	1473.055	4.910184	11	.26	69230.77	6.5E-02	76153.85	Y
B-30	TUC-H11	15.61897	5285.69	1478.02	4.926737	12	.26	64423.08	6.5E-02	70865.39	Y
H-91	TUC-C45	15.84653	5293.958	1485.06	4.9502	5	.14	282857.2	.035	311142.9	Y
M-24	TUH-D11	16.08109	5334.328	1488.71	4.962368	8	.2	121875	.05	134062.5	Y
C-1800	TUC-B2	15.3981	5369.43	1494.385	4.981283	12	.26	65384.62	6.5E-02	71923.08	Y
C-1800	TUH-A3	15.61897	5435.69	1512.07	5.040233	9	.32	69791.67	8.0E-02	76770.84	Y
C-1801	TUH-H3	16.08109	5424.327	1512.515	5.041717	4	.2	243750	.05	268125	Y
H-91	TUH-C13	16.57255	5511.766	1544.848	5.149494	2	.1	945000	.025	1039500	Y
C-1800	TUC-B1	16.08109	5574.327	1550.929	5.169765	5	.16	243750	4.0E-02	268125	Y
B-30	TUC-H16	16.57255	5571.766	1556.987	5.189958	7	.18	150000	4.5E-02	165000	Y
J-19	TUH-C1	17.09624	5608.874	1576.494	5.254981	5	.18	203333.3	4.5E-02	223666.7	Y
C-1800	TUH-A2	16.57255	5721.766	1590.979	5.303263	6	.24	131250	.06	144375	Y
B-30	TUH-H14	17.65544	5896.632	1645.979	5.486596	5	.18	196666.7	4.5E-02	216333.3	Y
C-1800	TUH-A1	17.37118	5961.354	1657.065	5.52355	3	.158	379746.8	.0395	417721.5	Y
A-45	TUC-A21	18.25388	6076.163	1745.174	5.817245	10	.24	71250	.06	78375	Y
A-45	TUH-A19	18.89584	6268.75	1799.13	5.997102	5	.24	137500	.06	151250	Y

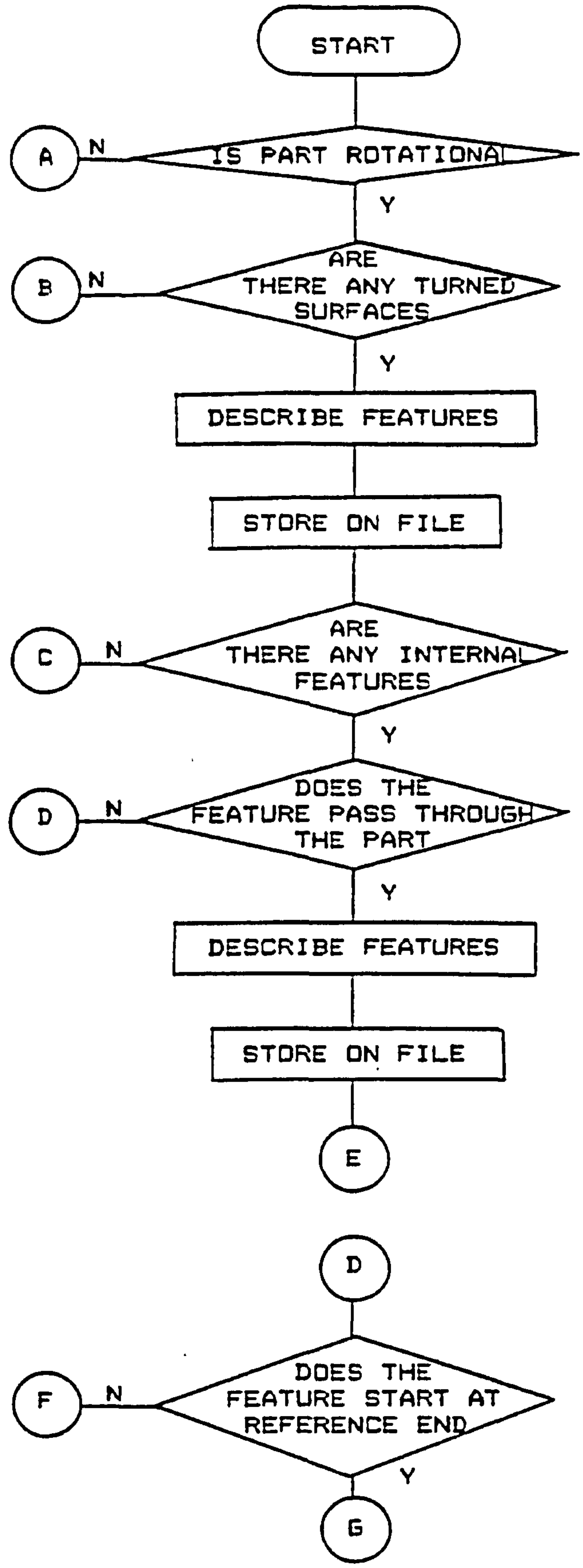
GRINDING TOOLS AVAILABLE

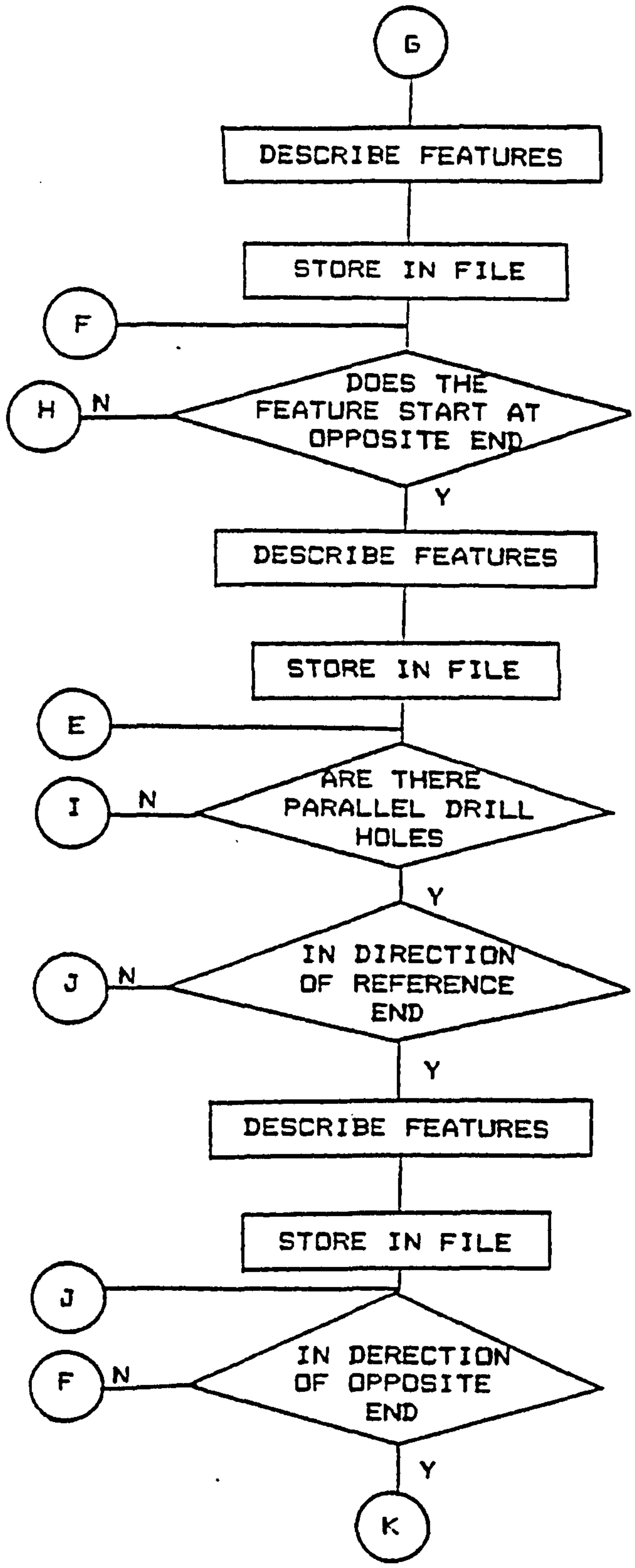
MACHINE #	TOOL #	TIME PER PART	TOTAL TIME	TOTAL COST	AVE COST	DEPTH (mm)	FEED (mm/RPM)	SPEED (RPM)
EG-40	ERG-E33	.6	1200	459	1.53	3.4	8.75	6628.571
EG-40	ERG-E16	.6	1200	459	1.53	3.4	8.75	6628.571
EG-40	ERG-E21	.6	1200	459	1.53	3.4	8.75	6628.571

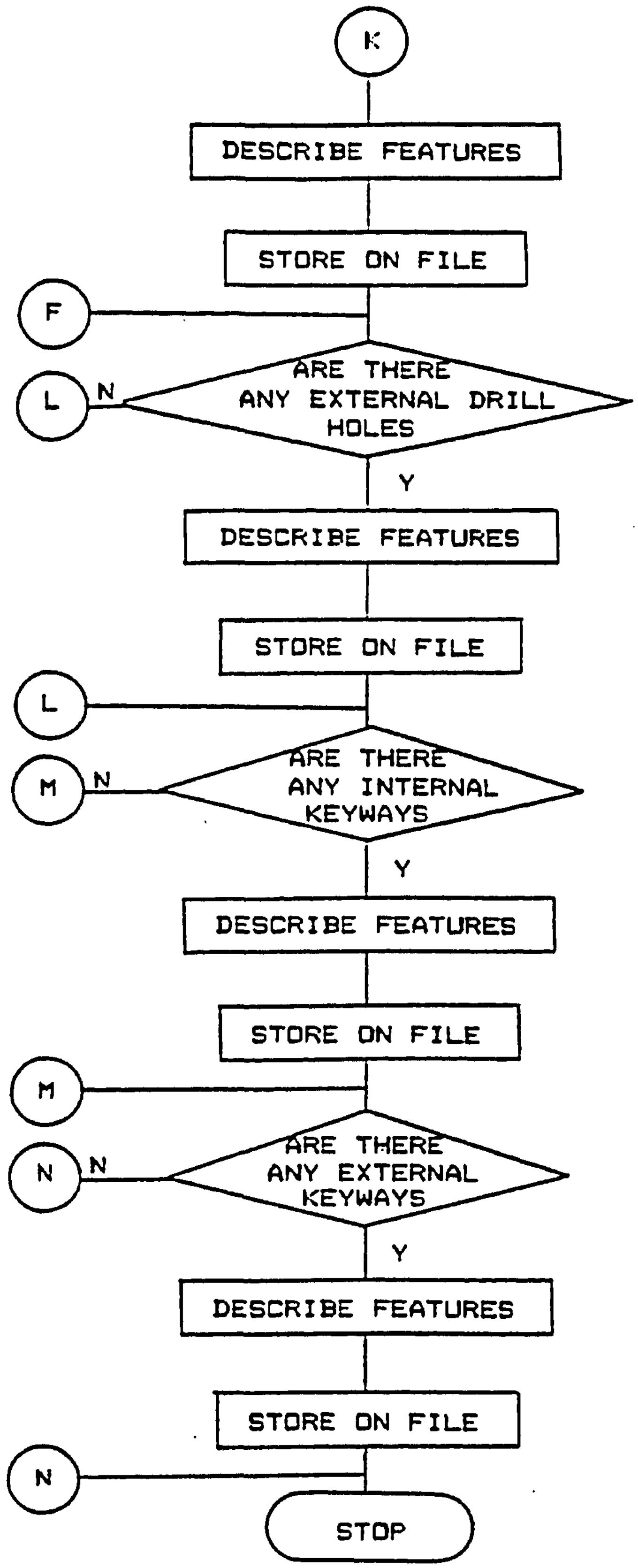
TIME TAKEN TO RUN PROGRAM= 5.622694 (MIN)

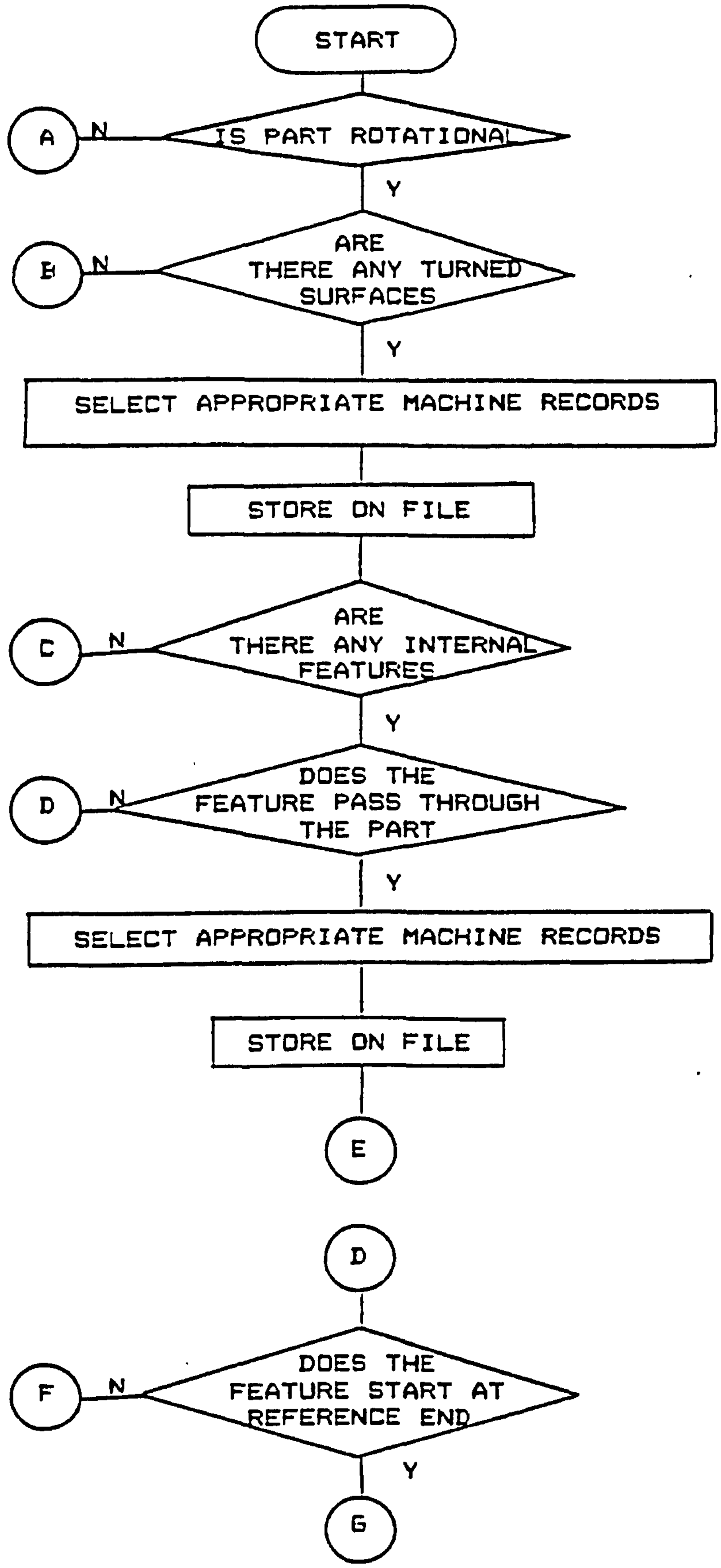
APPENDIX G

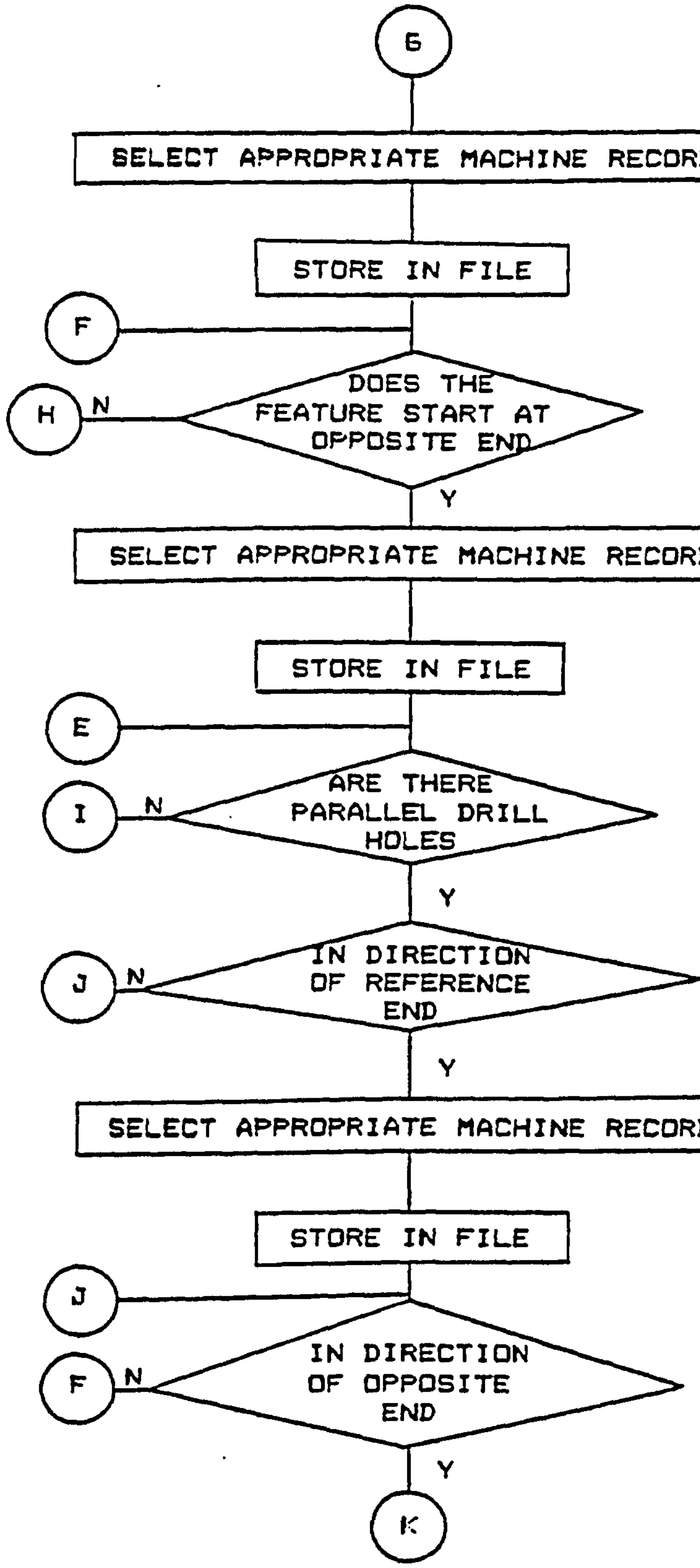
FLOW CHART OF SYSTEM

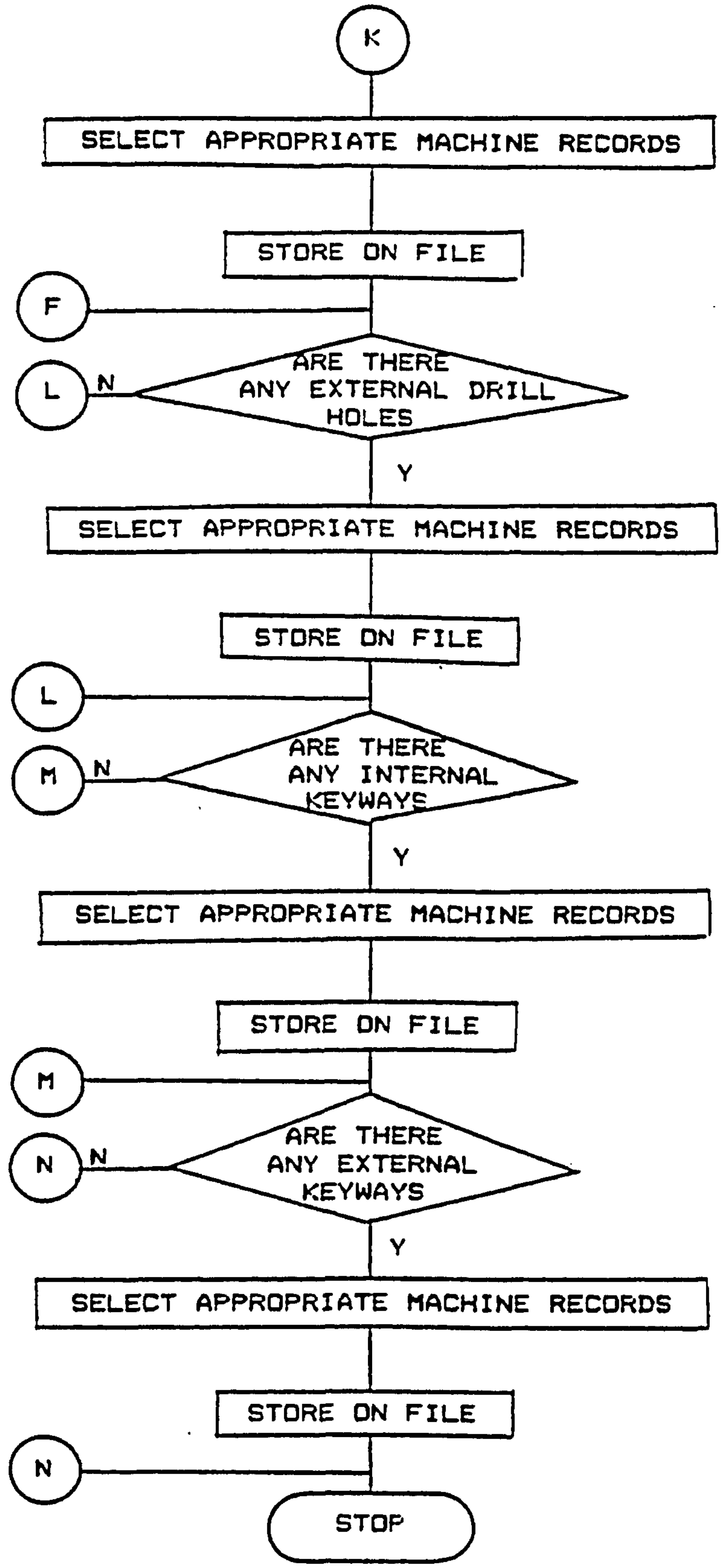

START
IS PART ROTATIONAL
A
N
Y
ARE THERE ANY TURNED SURFACES
B
N
Y
DESCRIBE FEATURES
STORE ON FILE
ARE THERE ANY INTERNAL FEATURES
C
N
Y
DOES THE FEATURE PASS THROUGH THE PART
D
N
Y
DESCRIBE FEATURES
STORE ON FILE
E
D
DOES THE FEATURE START AT REFERENCE END
F
N
Y
G

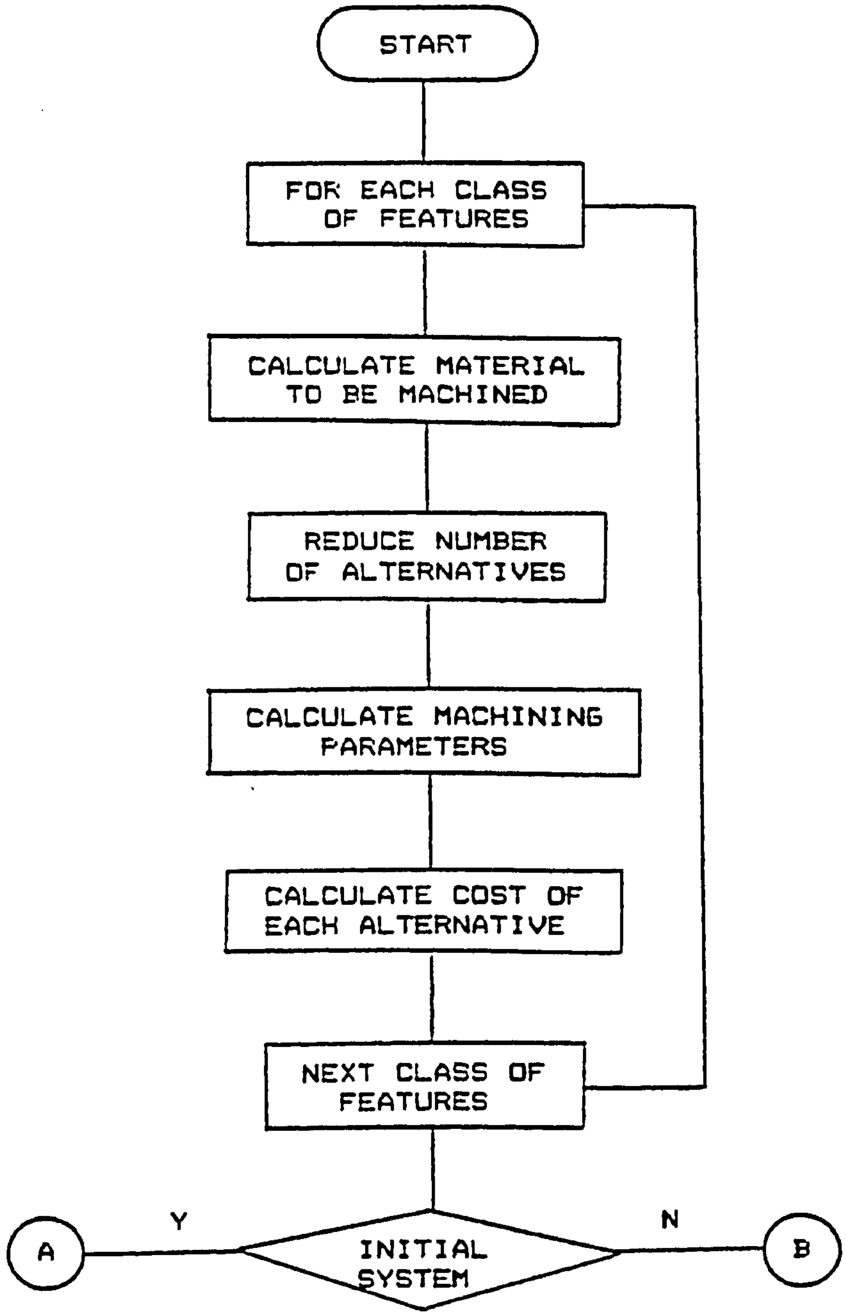

G
DESCRIBE FEATURES
STORE IN FILE
F
DOES THE FEATURE START AT OPPOSITE END
H
N
Y
DESCRIBE FEATURES
STORE IN FILE
E
ARE THERE PARALLEL DRILL HOLES
I
N
Y
IN DIRECTION OF REFERENCE END
J
N
Y
DESCRIBE FEATURES
STORE IN FILE
J
IN DERECTION OF OPPOSITE END
F
N
Y
K

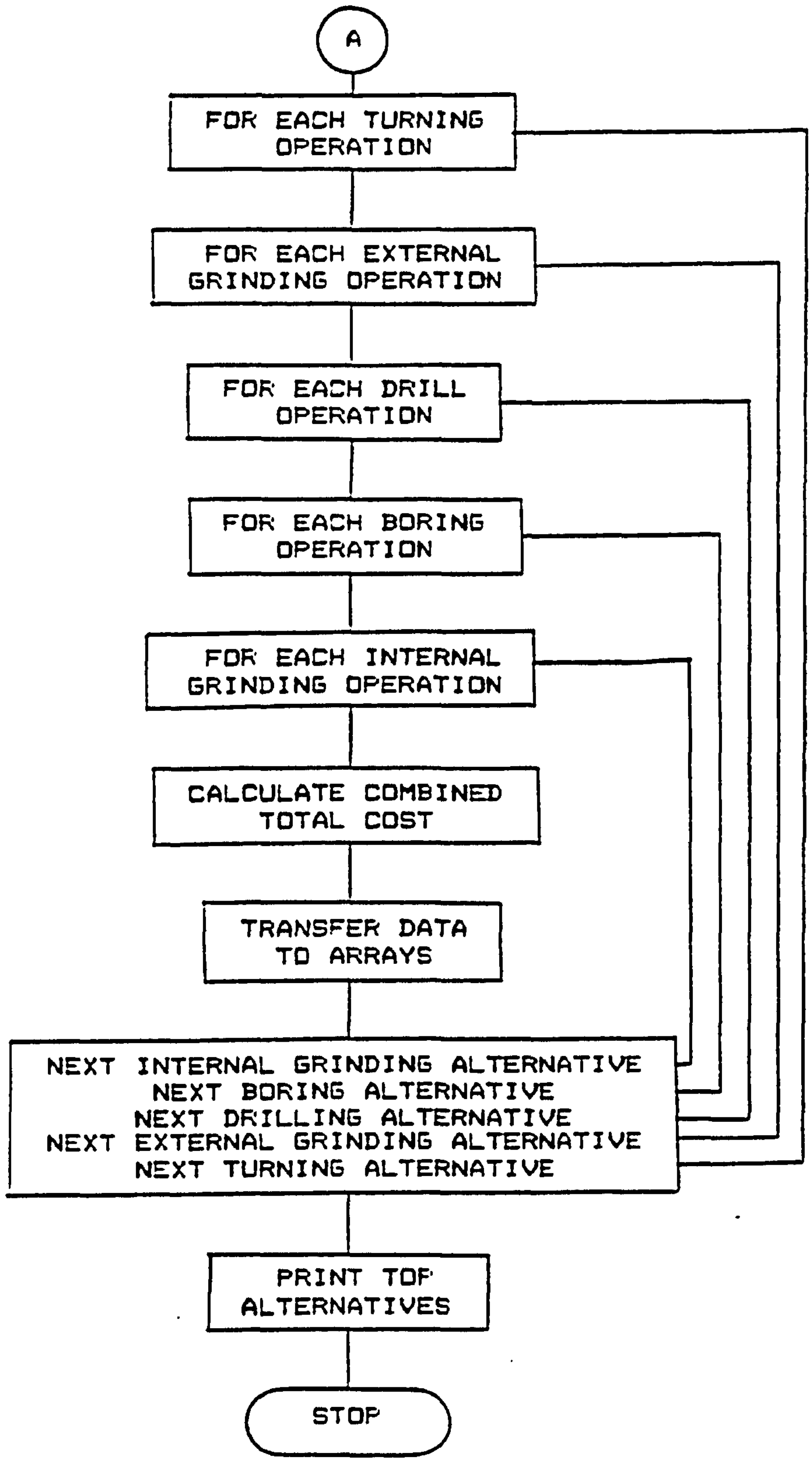

K
DESCRIBE FEATURES
STORE ON FILE
F
ARE THERE ANY EXTERNAL DRILL HOLES
L
N
Y
DESCRIBE FEATURES
STORE ON FILE
L
ARE THERE ANY INTERNAL KEYWAYS
M
N
Y
DESCRIBE FEATURES
STORE ON FILE
M
ARE THERE ANY EXTERNAL KEYWAYS
N
N
Y
DESCRIBE FEATURES
STORE ON FILE
N
STOP

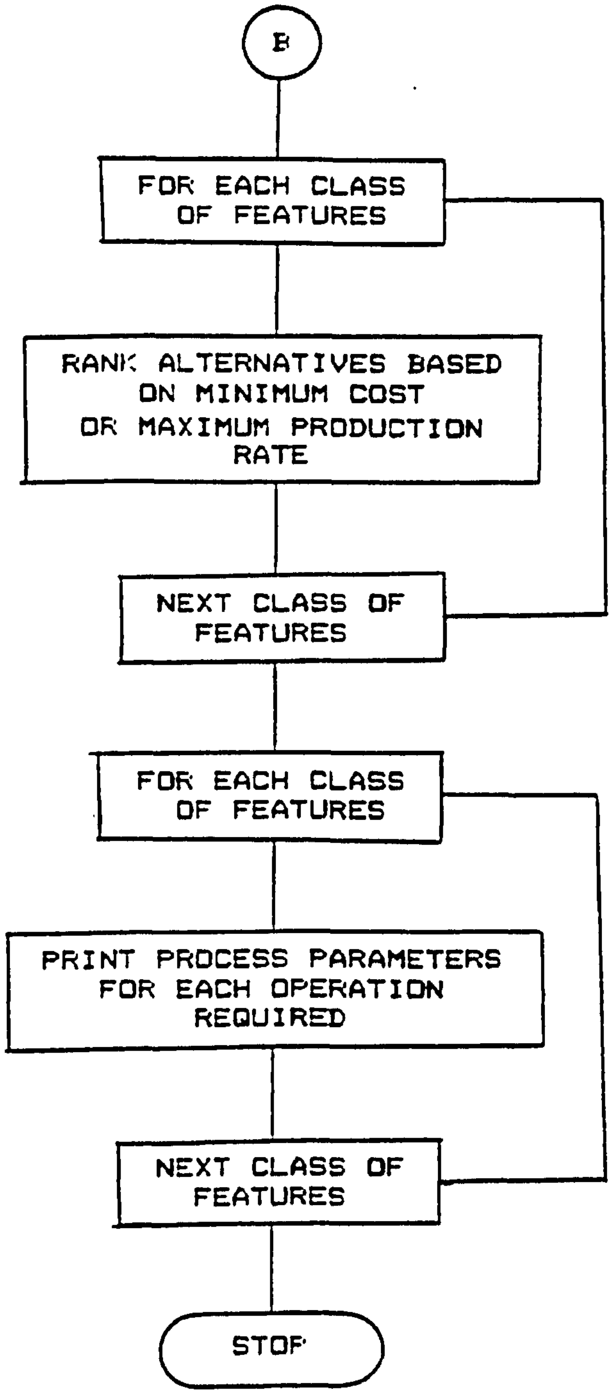

START
IS PART ROTATIONAL
N
A
Y
ARE THERE ANY TURNED SURFACES
N
B
Y
SELECT APPROPRIATE MACHINE RECORDS
STORE ON FILE
ARE THERE ANY INTERNAL FEATURES
N
C
Y
DOES THE FEATURE PASS THROUGH THE PART
N
D
Y
SELECT APPROPRIATE MACHINE RECORDS
STORE ON FILE
E
D
DOES THE FEATURE START AT REFERENCE END
N
F
Y
G


G
SELECT APPROPRIATE MACHINE RECORDS
STORE IN FILE
F
DOES THE FEATURE START AT OPPOSITE END
H
N
Y
SELECT APPROPRIATE MACHINE RECORDS
STORE IN FILE
E
ARE THERE PARALLEL DRILL HOLES
I
N
Y
IN DIRECTION OF REFERENCE END
J
N
Y
SELECT APPROPRIATE MACHINE RECORDS
STORE IN FILE
J
IN DIRECTION OF OPPOSITE END
F
N
Y
K


K
SELECT APPROPRIATE MACHINE RECORDS
STORE ON FILE
F
ARE THERE ANY EXTERNAL DRILL HOLES
L
N
Y
SELECT APPROPRIATE MACHINE RECORDS
STORE ON FILE
L
ARE THERE ANY INTERNAL KEYWAYS
M
N
Y
SELECT APPROPRIATE MACHINE RECORDS
STORE ON FILE
M
ARE THERE ANY EXTERNAL KEYWAYS
N
N
Y
SELECT APPROPRIATE MACHINE RECORDS
STORE ON FILE
N
STOP


START
FOR EACH CLASS OF FEATURES
CALCULATE MATERIAL TO BE MACHINED
REDUCE NUMBER OF ALTERNATIVES
CALCULATE MACHINING PARAMETERS
CALCULATE COST OF EACH ALTERNATIVE
NEXT CLASS OF FEATURES
INITIAL SYSTEM
Y
N
A
B


A
FOR EACH TURNING OPERATION
FOR EACH EXTERNAL GRINDING OPERATION
FOR EACH DRILL OPERATION
FOR EACH BORING OPERATION
FOR EACH INTERNAL GRINDING OPERATION
CALCULATE COMBINED TOTAL COST
TRANSFER DATA TO ARRAYS
NEXT INTERNAL GRINDING ALTERNATIVE
NEXT BORING ALTERNATIVE
NEXT DRILLING ALTERNATIVE
NEXT EXTERNAL GRINDING ALTERNATIVE
NEXT TURNING ALTERNATIVE
PRINT TOP ALTERNATIVES
STOP


B
FOR EACH CLASS OF FEATURES
RANK ALTERNATIVES BASED ON MINIMUM COST OR MAXIMUM PRODUCTION RATE
NEXT CLASS OF FEATURES
FOR EACH CLASS OF FEATURES
PRINT PROCESS PARAMETERS FOR EACH OPERATION REQUIRED
NEXT CLASS OF FEATURES
STOP

APPENDIX H

LISTING OF PROGRAMS

```
SOURCE
   10 CLS
   20 PRINT TAB(12) "*****************************************************"
   30 PRINT TAB(12) "*                                                   *"
   40 PRINT TAB(12) "*   SELECT THE OPTION THAT YOU WISH TO USE IN       *"
   50 PRINT TAB(12) "*       THE PROCESS PLAN GENERATION PACKAGE         *"
   60 PRINT TAB(12) "*                                                   *"
   70 PRINT TAB(12) "*           CREATED BY DAVID MELOCHE                *"
   80 PRINT TAB(12) "*                  FALL 1986                        *"
  110 PRINT TAB(12) "*                                                   *"
  120 PRINT TAB(12) "*        1.    EDIT MACHINE RECORDS               *"
  130 PRINT TAB(12) "*        2.    CREATE MACHINE RECORD FILE           *"
  140 PRINT TAB(12) "*        3.    DETERMINE TOOL SELECTION (ALT2)      *"
  150 PRINT TAB(12) "*        4.    DETERMINE TOOL SELECTION (ALT1)      *"
  160 PRINT TAB(12) "*        5.    RETURN TO DOS                        *"
  190 PRINT TAB(12) "*                                                   *"
  200 PRINT TAB(12) "*                                                   *"
  210 PRINT TAB(12) "*                      SELECTION                    *"
  220 PRINT TAB(12) "*                                                   *"
  230 PRINT TAB(12) "*         (PRESS RETURN AFTER SELECTION)            *"
  250 PRINT TAB(12) "*****************************************************"
  260 LOCATE 16,30
  270 INPUT "";Ab$
  275 AB=VAL(Ab$)
  280 IF AB=1 CHAIN "EMACH"
  290 IF AB=2 CHAIN "MACH"
  300 IF AB=3 CHAIN "SEPERATE"
  310 IF AB=4 CHAIN "EOTH"
  320 IF AB=5 SYSTEM
  330 GOTO 10
  340 STOP:END
ENDFILE
```

```
SOURCE
PRECISION= 7
AUTODEF=OFF
OPTION BASE=0
ERL=OFF
ERRORMODE=LOCAL
RESUME=LINE
FORMODE=BB
SCOPE=ON
PROCS=0
STRUCTURE: MMMM
   INTEGER: JJ,NT
   REAL: LLL,DDI,WD,HGT,TOL,SUF,TC
   REAL: TM,TTC,TW,TNR,EFF,DC,SC,TAA
   STRING: COMB[16],SIM[16],RULE[16],MN$[16],TN$[16]
   REAL: HP,LUT,EBDM,MRR
END STRUCTURE

MMMM: P31
INTEGER: M,F,I,PPA,J,PPP,TJ,K
STRING: MM$[16],TTT$[16]
REAL: AA,BB,CC,DD,EE,FF,GG
REAL: HH,II,JA,KK,LL,MM,NN,OO
REAL: PP,QQ,MMR,DA
INTEGER: TT,F1,F2,F3,F4
INTEGER: F5,F6,F7,F8
STRING: YY[16],Ccc[16]


'MAIN Program:


   10 'THIS PROGRAM MUST BE DIVIDED UP TO CREATE SEPERATE FILES FOR DIFFERENT
   20 'TYPES OF MACHINING OPERATIONS SINCE IT WAS FOUND THAT FOR LARGE
   30 'DATABASES THE TIME TO SEARCH ALL THE RECORDS WITH A MICRO-COMPUTER
   40 'WOULD TAKE TO MUCH TIME
   50 CLS
   60 CLOSE
   70 PRINT "NUMBER OF MACHINES IN THE SHOP"
   80 LOCATE 1,32:INPUT " ";M
   90 OPEN "C:AAA" AS #1 LEN=SIZE(P31)
  100 READ RECORD #1 1 P31
  110 LET F1=P31.NT+1
  120 CLOSE
  130 OPEN "C:BBB" AS #1 LEN=SIZE(P31)
  140 READ RECORD #1 1 P31
  150 LET F2=P31.NT+1
  160 CLOSE
  170 OPEN "C:CCC" AS #1 LEN=SIZE(P31)
  180 READ RECORD #1 1 P31
  190 LET F3=P31.NT+1
```

```
200 CLOSE
210 OPEN "C:DDD" AS #1 LEN=SIZE(P31)
220 READ RECORD #1 1 P31
230 LET F4=P31.NT+1
240 CLOSE
250 OPEN "C:EEE" AS #1 LEN=SIZE(P31)
260 READ RECORD #1 1 P31
270 LET F5=P31.NT+1
280 CLOSE
290 OPEN "C:FFF" AS #1 LEN=SIZE(P31)
300 READ RECORD #1 1 P31
310 LET F6=P31.NT+1
320 CLOSE
330 OPEN "C:GGG" AS #1 LEN=SIZE(P31)
340 READ RECORD #1 1 P31
350 LET F7=P31.NT+1
360 CLOSE
370 CLS
380 F1=2:F2=2:F3=2:F4=2:F5=2:F6=2:F7=2
390 FOR I=1 TO M
400   CLS
410   PRINT "MACHINE NUMBER="
420   PRINT "HORSE POWER OF MACHINE"
430   LOCATE 1,17:INPUT " ",MM$
440   LOCATE 2,24:INPUT " ",AA
450   PRINT "NUMBER OF PROCESSES WHICH CAN BE PERFORMED ON MACHINE";MM$
460   PRINT "IS"
470   LOCATE 4,4:INPUT " ",PPA
480   PRINT:PRINT
490   INPUT "IS ABOVE CORRECT (Y/N)",YY
500   IF YY="N" THEN GOTO 400
510   CLS
520   FOR J=1 TO PPA
530     CLS
540     PRINT "PROCESS NUMBER"
550     PRINT "CLAMPING DEVICE"
560     PRINT "SET UP COST ($)"
570     PRINT "OPERATOR COST ($/HR)"
580     PRINT "TIME TO LOAD AND UNLOAD PART (MIN)"
590     PRINT "EXPECTED BREAK DOWN MULTIPLE"
600     PRINT "EFFIENCY AT THE SPINDLE (%)"
610     PRINT "MAX LENGTH OF PART (mm)"
620     PRINT "MAX DIAMETER OF PART (mm) IF APPLICABLE ELSE 0)"
630     PRINT "MAX WIDTH OF PART (mm) IF APPLICABLE ELSE 0)"
640     PRINT "MAX HEIGHT OF PART (mm) IF APPLICABLE ELSE 0)"
650     LOCATE 1,16:INPUT " ",PPP
660     LOCATE 2,17:INPUT " ",Ccc
670     LOCATE 3,17:INPUT " ",BB
680     LOCATE 4,22:INPUT " ",CC
690     LOCATE 5,36:INPUT " ",DD
700     LOCATE 6,30:INPUT " ",DA
```

```
710     LOCATE 7,29:INPUT " ",EE
720     LOCATE 8,25:INPUT " ",FF
730     LOCATE 9,49:INPUT " ",GG
740     LOCATE 10,46:INPUT " ",HH
750     LOCATE 11,47:INPUT " ",II
760     PRINT "NUMBER OF TOOLS WHICH ARE AVAILABLE TO PERFORM PROCESS";J
770     PRINT "IS"
780     LOCATE 12,4:INPUT " ",TJ
790     INPUT "IS ABOVE CORRECT (Y/N)",YY
800     IF YY="N" THEN GOTO 530
810     FOR K=1 TO TJ
820       CLS
830       PRINT "TOOL NUMBER"
840       PRINT "TOOL COST OF MACHINING ($/HR)"
850       PRINT "TOOL MATERIAL"
860       PRINT "NUMBER OF TEETH ON TOOL"
870       PRINT "TOOL DIAMETER (mm) IF APPLICABLE ELSE 0"
880       PRINT "TOOL WIDTH (mm) IF APPLICABLE ELSE 0"
890       PRINT "TOOL NOSE RADIUS (mm) IF APPLICABLE ELSE 0"
900       PRINT "MAXIMUM METAL REMOVAL RATE (cu.mm/min.)"
910       PRINT "MAXIMUM DEPTH OF CUT (mm)"
920       PRINT "TOLERENCE ATTAINABLE (mm)"
930       PRINT "SURFACE FINISH ATTAINABLE (RMS)"
940       LOCATE 1,13:INPUT" ",TTT$
950       LOCATE 2,31:INPUT " ",JA
960       LOCATE 3,15:INPUT " ",KK
970       LOCATE 4,25:INPUT " ",TT
980       LOCATE 5,41:INPUT " ",LL
990       LOCATE 6,38:INPUT " ",MM
1000      LOCATE 7,44:INPUT " ",NN
1010      LOCATE 8,41:INPUT " ",MMR
1020      LOCATE 9,27:INPUT " ",OO
1030      LOCATE 10,27:INPUT " ",PP
1040      LOCATE 11,33:INPUT " ",QQ
1050      PRINT:PRINT
1060      INPUT "IS ABOVE CORRECT (Y/N)",YY
1070      IF YY="N" THEN GOTO 820
1080      P31.JJ=PPP:P31.TOL=PP:P31.SuF=QQ:P31.LLL=FF:P31.DDD=GG:P31.WD=HH
1090      P31.HGT=II:P31.TC=JA:P31.TM=KK:P31.TTD=LL:P31.TW=MM:P31.TNR=NN
1100      P31.TAA=OO:P31.EFF=EE:P31.OC=CC:P31.SC=BB:P31.HP=AA:P31.LUT=DD
1110      P31.MN$=TTT$:P31.TN$=MM$:P31.MRR=MMR:P31.EBDM=DA:P31.NT=TT
1120      P31.COMB=Ccc
1130      IF PPP=1 OR PPP=2 THEN GOSUB 1460
1140      IF PPP=3 OR PPP=5 OR PPP=6 THEN GOSUB 1510
1150      IF PPP=3 OR PPP=8 OR PPP=4 OR PPP=9 OR PPP=7 OR PPP=10 THEN GOSUB 1560
1160      IF PPP=8 OR PPP=9 OR PPP=10 THEN GOSUB 1610
1170      IF PPP=13 OR PPP=16 THEN GOSUB 1660
1180      IF PPP=15 OR PPP=16 OR PPP=17 OR PPP=18 OR PPP=19 OR PPP=20 OR PPP=21 THEN GOSUB 1710
1190      IF PPP=8 OR PPP=11 OR PPP=12 THEN GOSUB 1760
1200      CLS
1210    NEXT K
```

```
1220   NEXT J
1230 NEXT I
1240 P31.NT=F1
1250 F1=1
1260 GOSUB 1460
1270 P31.NT=F2
1280 F2=1
1290 GOSUB 1510
1300 P31.NT=F3
1310 F3=1
1320 GOSUB 1560
1330 P31.NT=F4
1340 F4=1
1350 GOSUB 1610
1360 P31.NT=F5
1370 F5=1
1380 GOSUB 1660
1390 P31.NT=F6
1400 F6=1
1410 GOSUB 1710
1420 P31.NT=F7
1430 F7=1
1440 GOSUB 1760
1450 STOP:END
1460 OPEN "C:AAA" AS #1 LEN=SIZE(P31)
1470 WRITE RECORD #1 F1 P31
1480 F1=F1+1
1490 CLOSE
1500 RETURN
1510 OPEN "C:BBB" AS #1 LEN=SIZE(P31)
1520 WRITE RECORD #1 F2 P31
1530 F2=F2+1
1540 CLOSE
1550 RETURN
1560 OPEN "C:CCC" AS #1 LEN=SIZE(P31)
1570 WRITE RECORD #1 F3 P31
1580 F3=F3+1
1590 CLOSE
1600 RETURN
1610 OPEN "C:DDD" AS #1 LEN=SIZE(P31)
1620 WRITE RECORD #1 F4 P31
1630 F4=F4+1
1640 CLOSE
1650 RETURN
1660 OPEN "C:EEE" AS #1 LEN=SIZE(P31)
1670 WRITE RECORD #1 F5 P31
1680 F5=F5+1
1690 CLOSE
1700 RETURN
1710 OPEN "C:FFF" AS #1 LEN=SIZE(P31)
1720 WRITE RECORD #1 F6 P31
```

```
1730 F6=F6+1
1740 CLOSE
1750 RETURN
1760 OPEN "C:666" AS #1 LEN=SIZE(P31)
1770 WRITE RECORD #1 F7 P31
1780 F7=F7+1
1790 CLOSE
1800 RETURN
```

ENDFILE

```
SOURCE
PRECISION= 7
AUTODEF=OFF
OPTION BASE=0
ERL=OFF
ERRORMODE=LOCAL
RESUME=LINE
FORMODE=BB
SCOPE=ON
PROCS=0
STRUCTURE: MMMM
   INTEGER: JJ,NT
   REAL: LLL,DDD,WD,HET,TOL,SuF,TC
   REAL: TM,TTB,TW,TNR,EFF,OC,SC,TAA
   STRING: COMB[16],SIM[16],RULE[16],MN$[16],TN$[16]
   REAL: HP,LUT,EBDM,MRR
 END STRUCTURE

 MMMM: P31
 INTEGER: M,F,I,PPA,J,PPP,TJ,K
 STRING: MM$[16],TTT$[16]
 REAL: AA,BB,CC,DD,EE,FF,GG
 REAL: HH,II,JA,KK,LL,MM,NN,OO
 REAL: PP,QQ,MMR,DA
 INTEGER: TT,F1,F2,F3,F4
 INTEGER: F5,F6,F7,F8
 STRING: YY[16],Ccc[16]


 'MAIN Program:


   10 CLS
   20 PRINT:PRINT
   30 PRINT "      ##################################################"
   40 PRINT "      #    PROGRAM TO EDIT THE MACHINE RECORDS         #"
   50 PRINT "      #                                                #"
   60 PRINT "      #   1. ADD AN ADDITIONAL MACHINE                 #"
   70 PRINT "      #   2. ELIMINATE A MACHINE                       #"
   80 PRINT "      #   3. RETURN TO MAIN MENU                       #"
   90 PRINT "      #                                                #"
  100 PRINT "      ##################################################"
  110 LOCATE 12,20:INPUT "SELECTION   ",M
  120 CLS
  130 IF M=3 CHAIN "MENU"           'CHAIN TO MAIN MENU
  140 OPEN "C:AAA" AS #1 LEN=SIZE(P31)
  150 READ RECORD #1 1 P31
  160 F1=P31.NT
  170 CLOSE 1
  180 OPEN "C:BBB" AS #1 LEN=SIZE(P31)
  190 READ RECORD #1 1 P31
```

```
200 F2=P31.NT
210 CLOSE
220 OPEN "C:CCC" AS #1 LEN=SIZE(P31)
230 READ RECORD #1 1 P31
240 F3=P31.NT
250 CLOSE
260 OPEN "C:DDD" AS #1 LEN=SIZE(P31)
270 READ RECORD #1 1 P31
280 F4=P31.NT
290 CLOSE
300 OPEN "C:EEE" AS #1 LEN=SIZE(P31)
310 READ RECORD #1 1 P31
320 F5=P31.NT
330 CLOSE
340 OPEN "C:FFF" AS #1 LEN=SIZE(P31)
350 READ RECORD #1 1 P31
360 F6=P31.NT
370 CLOSE
380 OPEN "C:GGG" AS #1 LEN=SIZE(P31)
390 READ RECORD #1 1 P31
400 F7=P31.NT
410 CLOSE
420 IF M=1 GOSUB 450
430 IF M=2 GOSUB 1920
440 GOTO 10
450 CLS
460 F1=F1+1:F2=F2+1:F3=F3+1:F4=F4+1
470 F5=F5+1:F6=F6+1:F7=F7+1
480 PRINT "NUMBER OF MACHINES TO BE ADDED TO THE SHOP"
490 LOCATE 1,32:INPUT " ";M
500 FOR I=1 TO M
510   CLS
520   PRINT "MACHINE NUMBER="
530   PRINT "HORSE POWER OF MACHINE"
540   LOCATE 1,17:INPUT " ",MM$
550   LOCATE 2,24:INPUT " ",AA
560   PRINT "NUMBER OF PROCESSES WHICH CAN BE PERFORMED ON MACHINE";MM$
570   PRINT "IS"
580   LOCATE 4,4:INPUT " ",PPA
590   PRINT:PRINT
600   INPUT "IS ABOVE CORRECT (Y/N)",YY
610   IF YY="N" THEN GOTO 510
620   CLS
630   FOR J=1 TO PPA
640     CLS
650     PRINT "PROCESS NUMBER"
660     PRINT "CLAMPING DEVICE"
670     PRINT "SET UP COST ($)"
680     PRINT "OPERATOR COST ($/HR)"
690     PRINT "TIME TO LOAD AND UNLOAD PART (MIN)"
700     PRINT "EXPECTED BREAK DOWN MULTIPLE"
```

```
710     PRINT "EFFIENCY AT THE SPINDLE (%)"
720     PRINT "MAX LENGTH OF PART (mm)"
730     PRINT "MAX DIAMETER OF PART (mm) IF APPLICABLE ELSE 0)"
740     PRINT "MAX WIDTH OF PART (mm) IF APPLICABLE ELSE 0)"
750     PRINT "MAX HEIGHT OF PART (mm) IF APPLICABLE ELSE 0)"
760     LOCATE 1,16:INPUT " ",PPP
770     LOCATE 2,17:INPUT " ",Ccc
780     LOCATE 3,17:INPUT " ",BB
790     LOCATE 4,22:INPUT " ",CC
800     LOCATE 5,36:INPUT " ",DD
810     LOCATE 6,30:INPUT " ",DA
820     LOCATE 7,29:INPUT " ",EE
830     LOCATE 8,25:INPUT " ",FF
840     LOCATE 9,49:INPUT " ",GG
850     LOCATE 10,46:INPUT " ",HH
860     LOCATE 11,47:INPUT " ",II
870     PRINT "NUMBER OF TOOLS WHICH ARE AVAILABLE TO PERFORM PROCESS";J
880     PRINT "IS"
890     LOCATE 12,4:INPUT " ",TJ
900     INPUT "IS ABOVE CORRECT (Y/N)",YY
910     IF YY="N" THEN GOTO 640
920     FOR K=1 TO TJ
930       CLS
940       PRINT "TOOL NUMBER"
950       PRINT "TOOL COST OF MACHININE ($/HR)"
960       PRINT "TOOL MATERIAL"
970       PRINT "NUMBER OF TEETH ON TOOL"
980       PRINT "TOOL DIAMETER (mm) IF APPLICABLE ELSE 0"
990       PRINT "TOOL WIDTH (mm) IF APPLICABLE ELSE 0"
1000      PRINT "TOOL NOSE RADIUS (mm) IF APPLICABLE ELSE 0"
1010      PRINT "MAXIMUM METAL REMOVAL RATE (cu.mm/min.)"
1020      PRINT "MAXIMUM DEPTH OF CUT (mm)"
1030      PRINT "TOLERENCE ATTAINABLE (mm)"
1040      PRINT "SURFACE FINISH ATTAINABLE (RMS)"
1050      LOCATE 1,13:INPUT" ",TTT$
1060      LOCATE 2,31:INPUT " ",JA
1070      LOCATE 3,15:INPUT " ",KK
1080      LOCATE 4,25:INPUT " ",TT
1090      LOCATE 5,41:INPUT " ",LL
1100      LOCATE 6,38:INPUT " ",MM
1110      LOCATE 7,44:INPUT " ",NN
1120      LOCATE 8,41:INPUT " ",MMR
1130      LOCATE 9,27:INPUT " ",OO
1140      LOCATE 10,27:INPUT " ",PP
1150      LOCATE 11,33:INPUT " ",QQ
1160      PRINT:PRINT
1170      INPUT "IS ABOVE CORRECT (Y/N)",YY
1180      IF YY="N" THEN GOTO 930
1190      P31.JJ=PPP:P31.TOL=PP:P31.SuF=QQ:P31.LLL=FF:P31.DDD=GG:P31.WD=HH
1200      P31.HGT=II:P31.TC=JA:P31.TM=KK:P31.TTD=LL:P31.TW=MM:P31.TNR=NN
1210      P31.TAA=DD:P31.EFF=EE:P31.OC=CC:P31.SC=BB:P31.HP=AA:P31.LUT=DD
```

```
1220        P31.MN$=TTT$:P31.TN$=MM$:P31.MRP=MMP:P31.EBDM=DA:P31.NT=TT
1230        P31.COMB=Ccc
1240        IF PPP=1 OR PPP=2 THEN GOSUB 1570
1250        IF PPP=3 OR PPP=5 OR PPP=6 THEN GOSUB 1620
1260        IF PPP=3 OR PPP=8 OR PPP=4 OR PPP=9 OR PPP=7 OR PPP=10 THEN GOSUB 1670
1270        IF PPP=8 OR PPP=9 OR PPP=10 THEN GOSUB 1720
1280        IF PPP=13 OR PPP=16 THEN GOSUB 1770
1290        IF PPP=15 OR PPP=16 OR PPP=17 OR PPP=18 OR PPP=19 OR PPP=20 OR PPP=21 THEN GOSUB 1820
1300        IF PPP=8 OR PPP=11 OR PPP=12 THEN GOSUB 1870
1310        CLS
1320      NEXT K
1330    NEXT J
1340 NEXT I
1350 P31.NT=F1
1360 F1=1
1370 GOSUB 1570
1380 P31.NT=F2
1390 F2=1
1400 GOSUB 1620
1410 P31.NT=F3
1420 F3=1
1430 GOSUB 1670
1440 P31.NT=F4
1450 F4=1
1460 GOSUB 1720
1470 P31.NT=F5
1480 F5=1
1490 GOSUB 1770
1500 P31.NT=F6
1510 F6=1
1520 GOSUB 1820
1530 P31.NT=F7
1540 F7=1
1550 GOSUB 1870
1560 RETURN
1570 OPEN "C:AAA" AS #1 LEN=SIZE(P31)
1580 WRITE RECORD #1 F1 P31
1590 F1=F1+1
1600 CLOSE
1610 RETURN
1620 OPEN "C:BBB" AS #1 LEN=SIZE(P31)
1630 WRITE RECORD #1 F2 P31
1640 F2=F2+1
1650 CLOSE
1660 RETURN
1670 OPEN "C:CCC" AS #1 LEN=SIZE(P31)
1680 WRITE RECORD #1 F3 F31
1690 F3=F3+1
1700 CLOSE
1710 RETURN
1720 OPEN "C:DDD" AS #1 LEN=SIZE(P31)
```

```
1730 WRITE RECORD #1 F4 P31
1740 F4=F4+1
1750 CLOSE
1760 RETURN
1770 OPEN "C:EEE" AS #1 LEN=SIZE(P31)
1780 WRITE RECORD #1 F5 P31
1790 F5=F5+1
1800 CLOSE
1810 RETURN
1820 OPEN "C:FFF" AS #1 LEN=SIZE(P31)
1830 WRITE RECORD #1 F6 P31
1840 F6=F6+1
1850 CLOSE
1860 RETURN
1870 OPEN "C:GGG" AS #1 LEN=SIZE(P31)
1880 WRITE RECORD #1 F7 P31
1890 F7=F7+1
1900 CLOSE
1910 RETURN
1920 CLS
1930 INPUT"         MACHINE TO BE ELIMINATED   ",MM$
1940 M=2
1950 OPEN "C:AAA" AS #1 LEN=SIZE(P31)
1960 FOR I=2 TO F1
1970   READ RECORD #1 I P31
1980   IF P31.TN$=MM$ THEN GOTO 2010
1990   WRITE RECORD #1 M P31
2000   M=M+1
2010 NEXT I
2020 P31.NT=M
2030 WRITE RECORD #1 1 P31
2040 CLOSE
2050 LET F1=M
2060 M=2
2070 OPEN "C:BBB" AS #1 LEN=SIZE(P31)
2080 FOR I=2 TO F2
2090   READ RECORD #1 I P31
2100   IF P31.TN$=MM$ THEN GOTO 2130
2110   WRITE RECORD #1 M P31
2120   M=M+1
2130 NEXT I
2140 P31.NT=M
2150 WRITE RECORD #1 1 P31
2160 CLOSE
2170 LET F2=M
2180 M=2
2190 OPEN "C:CCC" AS #1 LEN=SIZE(P31)
2200 FOR I=2 TO F3
2210   READ RECORD #1 I P31
2220   IF P31.TN$=MM$ THEN GOTO 2250
2230   WRITE RECORD #1 M P31
```

```
2240   M=M+1
2250 NEXT I
2260 P31.NT=M
2270 WRITE RECORD #1 1 P31
2280 CLOSE
2290 LET F3=M
2300 M=2
2310 OPEN "C:DDD" AS #1 LEN=SIZE(P31)
2320 FOR I=2 TO F4
2330   READ RECORD #1 I P31
2340   IF P31.TN$=MM$ THEN GOTO 2370
2350   WRITE RECORD #1 M P31
2360   M=M+1
2370 NEXT I
2380 P31.NT=M
2390 WRITE RECORD #1 1 P31
2400 CLOSE
2410 LET F4=M
2420 M=2
2430 OPEN "C:EEE" AS #1 LEN=SIZE(P31)
2440 FOR I=2 TO F5
2450   READ RECORD #1 I P31
2460   IF P31.TN$=MM$ THEN GOTO 2490
2470   WRITE RECORD #1 M P31
2480   M=M+1
2490 NEXT I
2500 P31.NT=M
2510 WRITE RECORD #1 1 P31
2520 CLOSE
2530 LET F5=M
2540 M=2
2550 OPEN "C:FFF" AS #1 LEN=SIZE(P31)
2560 FOR I=2 TO F6
2570   READ RECORD #1 I P31
2580   IF P31.TN$=MM$ THEN GOTO 2610
2590   WRITE RECORD #1 M P31
2600   M=M+1
2610 NEXT I
2620 P31.NT=M
2630 WRITE RECORD #1 1 P31
2640 CLOSE
2650 LET F6=M
2660 M=2
2670 OPEN "C:GGG" AS #1 LEN=SIZE(P31)
2680 FOR I=2 TO F7
2690   READ RECORD #1 I P31
2700   IF P31.TN$=MM$ THEN GOTO 2730
2710   WRITE RECORD #1 M P31
2720   M=M+1
2730 NEXT I
2740 P31.NT=M
```

```
2750 WRITE RECORD #1: 1 P3:
2760 CLOSE
2770 LET F7=M
2780 RETURN

ENDFILE
```

```
SOURCE
PRECISION= 7
AUTODEF=OFF
OPTION BASE=0
ERL=OFF
ERRORMODE=LOCAL
RESUME=LINE
FORMODE=BB
SCOPE=ON
PROCS=2
REAL: X,II
STRING: NAME$[?],DDDD$[?]
REAL: PNU
STRING: PN$[?],MAT$[?]
STRUCTURE: EXTF
   STRING: EF$[2],TH$[2]
   REAL: L,TL,D,TD
   REAL: SF,SD,TSD,FD,TFD
END STRUCTURE

STRING: PR$[2]
REAL: LP,DP
STRING: A$[2],B$[2],C$[2],D$[2],E$[2]
INTEGER: NEF,I,Nif
INTEGER: Nifr,Nifo,DHR,DHO,EDH,INK,EXK
EXTF: P10
STRUCTURE: INTF
   REAL: LA,TLA
   REAL: DA,TDA,SFA,SDA,TSDA,FDA,TFDA
   STRING: IFA$[2],THA$[2]
END STRUCTURE

INTF: P11
STRUCTURE: INTFR
   REAL: LB,TLB,DB,TDB,SFB,SDB,TSDB,FDB
   REAL: TFDB
   STRING: IFRB$[2],THB$[2]
END STRUCTURE

INTFR: P12
STRUCTURE: INTFO
   REAL: LC,TLC,DC,TDC,SFC,SDC,TSDC,FDC
   REAL: TFDC
   STRING: IFOc$[2],THC$[2]
END STRUCTURE

INTFO: P13
STRUCTURE: DRILLR
   REAL: DPD,TDPD,DD,TDD,DISD
   STRING: THD$[2]
END STRUCTURE
```

```
DRILLR: P14
STRUCTURE: DRILLO
   REAL: DPE,TDPE,DE,TDE,DISE
   STRING: THE$[2]
END STRUCTURE

DRILLO: P15
STRUCTURE: EXDRILL
   REAL: EDRF,DPF,TDPF,DF,TDF
   STRING: THF$[2]
END STRUCTURE

EXDRILL: P16
STRUCTURE: INTKEY
   REAL: STDG.FNDG,IWDG,TIWDG,IDPG,TIDPG,IKSFG
END STRUCTURE

INTKEY: P17
STRUCTURE: EXTKEY
   REAL: STDH,FNDH,EWDH,TEWDH,EDPH,TEDPH,EKSFH
END STRUCTURE

EXTKEY: P18
INTEGER: J
REAL: AA.AAA,BB,BBB,CC,EE,EEE,FF
REAL: FFF,GG,GGG,HH
STRING: DD$[2],F$[2],G$[2],H$[2],I$[2]
STRING: J$[2],K$[2]
STRUCTURE: DRILLX
   REAL: DPN,TDPN,DN,TDN,XN,YN,SFN
   REAL: ZN
   STRING: THN$[2]
END STRUCTURE

DRILLX: P23
INTEGER: NS,NEFR,NSS,DHX,DHNX,DHY,DHNY,DHZ
INTEGER: DHNZ
STRUCTURE: DRILLNX
   REAL: DPO,TDPO,DOO,TDO,SFO,XO,YO,ZO
   STRING: THO$[2]
END STRUCTURE

DRILLNX: P24
STRUCTURE: DRILLY
   REAL: DPP,TDPP,DDP,TDDP,SFP,XP,YP,ZP
   STRING: THP$[2]
END STRUCTURE

DRILLY: P25
STRUCTURE: DRILLNY
```

```
   REAL: DPQ,TDPQ,DQ,TDQ,SFQ,XQ,YQ,ZQ
   STRING: THQ$[2]
END STRUCTURE

DRILLNY: P26
STRUCTURE: DRILLZ
   REAL: DPR,TDPR,DR,TDR,SFR,XR,YR,ZR
   STRING: THR$[2]
END STRUCTURE

DRILLZ: P27
STRUCTURE: DRILLNZ
   REAL: DPS,TDPS,DDS,TDDS,SFS,XS,YS,ZS
   STRING: THS$[2]
END STRUCTURE

DRILLNZ: P28
STRUCTURE: INTFEA
   REAL: LM,TLM,DM,TDM,SFM,SDM,TSDM,FDM
   REAL: TFDM,XM,YM,ZM,NSG
   STRING: INFM$[2],THM$[2],NAM$[2],NBM$[2]
   STRING: NCM$[2]
END STRUCTURE

INTFEA: P22
STRUCTURE: EXTS
   REAL: LK,TLK,BK,TBK,HK,THK,AK,UBK
   REAL: TUBK,LSK,TLSK,SFK,XAK,XBK,XCK,YAK
   REAL: YBK,YCK,ZAK,ZBK,ZCK
   STRING: DIRK$[2],EXSK$[16]
END STRUCTURE

EXTS: P20
STRUCTURE: EXTFE
   REAL: LL,TLL,BL,TBL,HL,THL,AL,UBL
   REAL: TUBL,LSL,TLSL,SFL,XAL,XBL,XCL,YAL
   REAL: YBL,YCL,ZAL,ZBL,ZCL
   STRING: DIRL$[2],EXFL$[16],RSLL$[2],RAE$[2]
END STRUCTURE

EXTFE: P21
STRING: SHAP$[10],L$[2],M$[2],N$[2],O$[2],P$[2],Q$[2]
REAL: XXA,XXB
REAL: XXC,YYA,YYB,YYC,ZZA,ZZB,ZZC
STRING: R$[2],S$[2]
STRING: T$[2],U$[2]
REAL: CCC
STRUCTURE: Pris
   REAL: LT,TLT,BT,TBT,HT,THT,AT
   REAL: UBT,TUBT,LSTT,TLST,XAT,XBT,XCT,YAT
   REAL: YBT,YCT,ZAT,ZBT,ZCT
```

```
   STRING: DIRT$[2],PRIST$[16]
END STRUCTURE

Pris: P30
STRUCTURE: Alt1
   INTEGER: A1,A2,A3,A4
END STRUCTURE

Alt1: P40
STRUCTURE: Alt2
   INTEGER: B1,B2,B3,B4
END STRUCTURE

Alt2: P41
STRUCTURE: Alt3
   INTEGER: C1,C2,C3,C4
END STRUCTURE

Alt3: P42
STRUCTURE: Alt4
   INTEGER: D1,D2,D3,D4
END STRUCTURE

Alt4: P43
STRUCTURE: Alt5
   INTEGER: E1,E2,E3,E4
END STRUCTURE

Alt5: P44
STRUCTURE: Alt6
   INTEGER: F1,F2,F3,F4
END STRUCTURE

Alt6: P45
STRUCTURE: Alt7
   INTEGER: G1,G2,G3,G4
END STRUCTURE

Alt7: P46
STRUCTURE: Alt8
   INTEGER: H1,H2,H3,H4
END STRUCTURE

Alt8: P47
STRUCTURE: Alt9
   INTEGER: I1,I2,I3,I4
END STRUCTURE

Alt9: P48
STRUCTURE: Alt10
   INTEGER: J1,J2,J3,J4
```

```
END STRUCTURE

Alt10: P50
STRUCTURE: Alt11
   INTEGER: Hh1,Hh2,Hh3,Hh4
END STRUCTURE

Alt11: P51
STRUCTURE: Alt12
   INTEGER: L1,L2,L3,L4,L5
END STRUCTURE

Alt12: P52
STRUCTURE: Alt13
   INTEGER: M1,M2,M3,M4
END STRUCTURE

Alt13: P53
STRUCTURE: Alt14
   INTEGER: N1,N2,N3,N4
END STRUCTURE

Alt14: P54
STRUCTURE: Alt15
   INTEGER: O1,O2,O3,O4
END STRUCTURE

Alt15: P55
STRUCTURE: Alt16
   INTEGER: P1,P2,P3,P4
END STRUCTURE

Alt16: P56
STRUCTURE: Alt17
   INTEGER: Q1,Q2,Q3,Q4
END STRUCTURE

Alt17: P57
STRUCTURE: Alt18
   INTEGER: R1,R2,R3,R4
END STRUCTURE

Alt18: P58
STRUCTURE: Mmmm
   INTEGER: Jj,NT
   REAL: L11,Ddd,Wd,Hgt,Tol,Suf,TC
   REAL: TM,TTD,TW,TNR,EFF,OC,SC,TAA
   STRING: Comb[16],Sim[16],Rule[16],MN$[16],TN$[16]
   REAL: HP,LUT,EBDM,MRR
END STRUCTURE
```

```
Name: P31
STRING: AA$[16]
INTEGER: AA1,BB1,CC1,DD1,EE1,FF1,GG1,H11
INTEGER: II1,JJ1,HH11,LL1,MM1,NN1,OO1,PP1
INTEGER: QQ1,RR1,MFA,MFB,MFC,MFD,MFE,MFF
INTEGER: MFG,Lots
STRING: Choice$[16]

PROCEDURE: Mach
END PROCEDURE

PROCEDURE: Both
END PROCEDURE


PROCEDURE: Mach
   EXTERNAL: P30,P20,P21,P22,P23,P24,P25,P26
   EXTERNAL: P27,P28,P10,P11,L1,Dp,P12,P13
   EXTERNAL: P14,P15,P16,P17,P18,P40,P41,P42
   EXTERNAL: P43,P44,P45,P46,P47,P48,P50,P51
   EXTERNAL: P52,P53,P54,P55,P56,P57,P58
   INTEGER: A
   EXTERNAL: P31
   INTEGER: Z,I
   INTEGER: J,K,L
   EXTERNAL: PR$,A$,NEF,B$,C$,NIF
   EXTERNAL: D$,NIFR,E$,NIFO,F$,G$,DHR,H$
   EXTERNAL: DHO,I$,EDH,J$,INK,K$,EXK,L$
   EXTERNAL: NS,M$,NEFR,N$,NSS,O$,P$,DHX
   EXTERNAL: Q$,DHNX,R$,DHY,S$,DHNY,T$,DHZ
   EXTERNAL: U$,DHNZ,LP
   INTEGER: ZZ,KK
   REAL: F,DIAM,DIA
   EXTERNAL: AA1,BB1,CC1
   EXTERNAL: DD1,EE1,FF1,GG1,H11,II1,JJ1,HH11
   EXTERNAL: LL1,MM1,NN1,OO1,PP1,QQ1,RR1,MFA
   EXTERNAL: MFB,MFC,MFD,MFE,MFF,MFG
     10 GOTO 40
     20 IF PR$="N" GOTO 5960
     30 IF A$="N" GOTO 540
     40 OPEN "c:AAA" AS #1 LEN=SIZE(P31)
     50 A=1
     60 READ RECORD #1 A P31
     70 LET A=P31.NT-1
     80 MFA=A
     90 OPEN "D:EXTF.DAT" AS #2 LEN=SIZE(P10)
    100 OPEN "D:ALT1" AS #3 LEN=SIZE(P40)
    110 Z=1
    120 FOR I=2 TO A
    130   READ RECORD #1 I P31
    140   IF P31.JJ=1 AND P31.LLL>LP AND P31.DDD>DP THEN GOTO 160
```

```
150   GOTO 490'NEXT I
160   FOR J=1 TO NEF
170     READ RECORD #2 J P10
180     K=0:L=0
190     IF P10.EF$="T" GOTO 340
200     IF P31.TOL<P10.TD AND P31.SUF<P10.SF THEN GOTO 300
210     FOR K=2 TO A
220       READ RECORD #1 K P31
230       IF P31.JJ=2 AND P31.LLL>LP AND P31.DDD>DP THEN GOTO 250
240       GOTO 280     'NEXT K
250       P40.A1=I:P40.A2=J:P40.A3=K:P40.A4=L
260       WRITE RECORD #3 Z P40
270       Z=Z+1
280     NEXT K
290     GOTO 470  'NEXT J
300     P40.A1=I:P40.A2=J:P40.A3=K:P40.A4=L
310     WRITE RECORD #3 Z P40
320     Z=Z+1
330     GOTO 470  'NEXT J
340     IF P31.TOL<P10.TSD AND P31.TOL<P10.TFD AND P31.SUF<P10.SF THEN GOTO 440
350     FOR K=2 TO A
360       READ RECORD #1 K P31
370       IF P31.JJ=2 AND P31.LLL>LP AND P31.DDD>DP THEN GOTO 390
380       GOTO 420    'NEXT K
390       P40.A1=I:P40.A2=J:P40.A3=K:P40.A4=L
400       WRITE RECORD #3 Z P40
410       Z=Z+1
420     NEXT K
430     GOTO 470'NEXT J
440     P40.A1=I:P40.A2=J:P40.A3=K:P40.A4=L
450     WRITE RECORD 3 Z P40
460     Z=Z+1
470     READ RECORD #1 I P31
480   NEXT J
490 NEXT I
500 AA1=Z
510 P40.A1=0
520 WRITE RECORD #3 Z P40
530 CLOSE:GOTO 560
540 IF B$="N" GOTO 2620
550 IF C$="N" GOTO 1220
560 OPEN "C:BBB" AS #1 LEN=SIZE(P31)
570 A=1
580 READ RECORD #1 A P31
590 LET A=P31.NT
600 MFB=A
610 OPEN "D:INTF.DAT" AS #2 LEN=SIZE(P11)
620 OPEN "D:ALT2" AS #3 LEN=SIZE(P41)
630 Z=1
640 DIAM=1000000
650 FOR J=1 TO NIF
```

```
 660   READ RECORD #2 J P11
 670   IF P11.IFA$= "T" GOTO 700
 680   IF DIAM>P11.DA THEN DIAM=P11.DA
 690   GOTO 720
 700   IF DIAM>P11.SDA THEN DIAM=P11.SDA
 710   IF DIAM>P11.FDA THEN DIAM=P11.FDA
 720 NEXT J
 730 FOR I=2 TO A
 740   READ RECORD #1 I P31
 750   IF (P31.JJ=3 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD<DIAM AND P31.TTD>(DIAM-3)) THEN
GOTO 770
 760   GOTO 1160   'NEXT I
 770   DIA=P31.TTD
 780   FOR K=2 TO A
 790     READ RECORD #1 K P31
 800     IF P31.JJ=5 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD<DIA THEN GOTO 820
 810     GOTO 1150 'NEXT K
 820     FOR J=1 TO NIF
 830       L=0
 840       READ RECORD #2 J P11
 850       IF P11.IFA$="T" THEN GOTO 1000
 860       IF P31.TOL<P11.TDA AND P31.SUF<P11.SFA THEN GOTO 960
 870       FOR L=2 TO A
 880         READ RECORD #1 L P31
 890         IF P31.JJ=6 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD<DIAM THEN GOTO 910
 900         GOTO 940'NEXT L
 910         P41.B1=I:P41.B2=J:P41.B3=K:P41.B4=L
 920         WRITE RECORD #3 Z P41
 930         Z=Z+1
 940       NEXT L
 950       GOTO 1130     'NEXT J
 960       P41.B1=I:P41.B2=J:P41.B3=K:P41.B4=L
 970       WRITE RECORD #3 Z P41
 980       Z=Z+1
 990       GOTO 1130     'NEXT J
1000       IF P31.TOL<P11.TSDA AND P31.TOL<P11.TFDA AND P31.SUF<P11.SFA THEN GOTO 1100
1010       FOR L=2 TO A
1020         READ RECORD #1 L P31
1030         IF P31.JJ=6 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD<DIAM THEN GOTO 1050
1040         GOTO 1080     'NEXT L
1050         P41.B1=I:P41.B2=J:P41.B3=K:P41.B4=L
1060         WRITE RECORD #3 Z P41
1070         Z=Z+1
1080       NEXT L
1090       GOTO 1130     'NEXT J
1100       P41.B1=I:P41.B2=J:P41.B3=K:P41.B4=L
1110       WRITE RECORD #3 Z P41
1120       Z=Z+1
1130       READ RECORD #1 K P31
1140     NEXT J
1150   NEXT K
```

```
1160 NEXT I
1170 BB1=Z-1
1180 P41.B1=0
1190 WRITE RECORD #3 Z P41
1200 CLOSE:GOTO 10900
1210 GOTO 2620'SKIP TO DRILL HOLE SECTION
1220 IF D$="N" GOTO 1910
1230 OPEN "C:BBB" AS #1 LEN=SIZE(P31)
1240 A=1
1250 READ RECORD #1 A P31
1260 IF P31.TN$="LAST" THEN GOTO 1290
1270 A=A+1
1280 GOTO 1250
1290 A=A-1
1300 MFB=A
1310 OPEN "INTFR" AS #2 LEN =SIZE(P12)
1320 OPEN "ALT3" AS #3 LEN=SIZE(P42)
1330 Z=1
1340 DIAM=1000000
1350 FOR J=1 TO NIFR
1360   READ RECORD #2 J P12
1370   IF P12.IFRB$="T" THEN GOTO 1400
1380   IF DIAM>P12.DB THEN DIAM=P12.DB
1390   GOTO 1420
1400   IF DIAM>P12.SDB THEN DIAM=P12.SDB
1410   IF DIAM>P12.FDB THEN DIAM=P12.FDB
1420 NEXT J
1430 FOR I=1 TO A
1440   READ RECORD #1 I P31
1450   IF P31.JJ=3 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD<DIAM THEN GOTO 1470
1460   GOTO 1860   'NEXT I
1470   DIA=P31.TTD
1480   GOTO 1860   'NEXT I
1490   FOR K=1 TO A
1500     READ RECORD #1 K P31
1510     IF P31.JJ=5 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD<DIA THEN GOTO 1530
1520     GOTO 1850'NEXT K
1530     FOR J=1 TO NIFR
1540       L=0
1550       READ RECORD #2 J P12
1560       IF P12.IFRB$="T" THEN GOTO 1710
1570       IF P31.TOL<P12.TDB AND P31.SUF<P12.SFB THEN GOTO 1670
1580       FOR L=1 TO A
1590         READ RECORD #1 L P31
1600         IF P31.JJ=6 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD<DIAM THEN GOTO 1620
1610         GOTO 1650'NEXT L
1620         P42.C1=I:P42.C2=J:P42.C3=K:P42.C4=L
1630         WRITE RECORD #3 Z P42
1640         Z=Z+1
1650       NEXT L
1660       GOTO 1840      'NEXT J
```

```
1670        P42.C1=I:P42.C2=J:P42.C3=K:P42.C4=L
1680        WRITE RECORD #3 Z P42
1690        Z=Z+1
1700        GOTO 1840       'NEXT J
1710        IF P31.TOL<P12.TSDB AND P31.TOL<P12.TFDB AND P31.SUF<P12.SFB THEN GOTO 1810
1720        FOR L=1 TO A
1730          READ RECORD #1 L P31
1740          IF P31.JJ=6 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD<DIAM THEN GOTO 1760
1750          GOTO 1790    'NEXT L
1760          P42.C1=I:P42.C2=J:P42.C3=K:P42.C4=L
1770          WRITE RECORD #3 Z P42
1780          Z=Z+1
1790        NEXT L
1800        GOTO 1840      'NEXT J
1810        P42.C1=I:P42.C2=J:P42.C3=K:P42.C4=L
1820        WRITE RECORD #3 Z P42
1830        Z=Z+1
1840      NEXT J
1850    NEXT K
1860 NEXT I
1870 CC1=Z
1880 P42.C1=0
1890 WRITE RECORD #3 Z P42
1900 CLOSE
1910 IF E$="N" GOTO 2620
1920 Z=1
1930 OPEN "C:BBB" AS #1 LEN=SIZE(P31)
1940 IF MFB>0 THEN GOTO 2020
1950 A=1
1960 READ RECORD #1 A P31
1970 IF P31.TN$="LAST" THEN GOTO 2000
1980 A=A+1
1990 GOTO 1960
2000 A=A-1
2010 MFB=A
2020 A=MFB
2030 OPEN "INTFO" AS #2 LEN=SIZE(P13)
2040 OPEN "ALT4" AS #3 LEN=SIZE(P43)
2050 DIAM=1000000
2060 FOR J=1 TO NIFO
2070   READ RECORD #2 J P13
2080   IF P13.IFDC$="T" THEN GOTO 2110
2090   IF DIAM>P13.DC THEN DIAM=P13.DC
2100   GOTO 2130
2110   IF DIAM>P13.SDC THEN DIAM=P13.SDC
2120   IF DIAM>P13.FDC THEN DIAM=P13.FDC
2130 NEXT J
2140 FOR I=1 TO A
2150   READ RECORD #1 I P31
2160   IF P31.JJ=3 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD<DIAM THEN GOTO 2180
2170   GOTO 2570  'NEXT I
```

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2180   DIA=P31.TTD
2190   GOTO 2570  'NEXT I
2200   FOR K=1 TO A
2210     READ RECORD #1 K P31
2220     IF P31.JJ=5 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD<DIA THEN GOTO 2240
2230     GOTO 2560 'NEXT K
2240     FOR J=1 TO NIFO
2250       L=0
2260       READ RECORD #2 J P13
2270       IF P13.IFOC$="T" GOTO 2420
2280       IF P31.TOL<P13.TDC AND P31.SUF<P13.SFC THEN GOTO 2380
2290       FOR L=1 TO A
2300         READ RECORD #1 L P31
2310         IF P31.JJ=6 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD<DIAM THEN GOTO 2330
2320         GOTO 2360     'NEXT L
2330         P43.D1=I:P43.D2=J:P43.D3=K:P43.D4=L
2340         WRITE RECORD #3 Z P43
2350         Z=Z+1
2360       NEXT L
2370       GOTO 2550    'NEXT J
2380       P43.D1=I:P43.D2=J:P43.D3=K:P43.D4=L
2390       WRITE RECORD #3 Z P43
2400       Z=Z+1
2410       GOTO 2550    'NEXT J
2420       IF P31.TOL<P13.TSDC AND P31.TOL<P13.TFDC AND P31.SUF<P13.SFC THEN GOTO 2520
2430       FOR L=1 TO A
2440         READ RECORD #1 L P31
2450         IF P31.JJ=6 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD<DIAM THEN GOTO 2470
2460         GOTO 2500    'NEXT L
2470         P43.D1=I:P43.D2=J:P43.D3=K:P43.D4=L
2480         WRITE RECORD #3 Z P43
2490         Z=Z+1
2500       NEXT L
2510       GOTO 2550       'NEXT J
2520       P43.D1=I:P43.D2=J:P43.D3=K:P43.D4=L
2530       WRITE RECORD #3 Z P43
2540       Z=Z+1
2550     NEXT J
2560   NEXT K
2570 NEXT I
2580 DD1=0
2590 P43.D1=0
2600 WRITE RECORD #3 Z P43
2610 CLOSE
2620 IF F$="N" GOTO 4700
2630 IF G$="N" GOTO 3660
2640 OPEN "C:CCC" AS #1 LEN=SIZE(P31)
2650 A=1
2660 READ RECORD #1 A P31
2670 IF P31.TN$="LAST" THEN GOTO 2700
2680 A=A+1
```

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2690 GOTO 2660
2700 A=A-1
2710 MFC=A
2720 OPEN "DRILLR" AS #2 LEN=SIZE(P14)
2730 OPEN "ALT5" AS #3 LEN=SIZE(P44)
2740 Z=1
2750 FOR I=1 TO A
2760   READ RECORD #1 I P31
2770   IF P31.JJ=3 OR P31.JJ=8 THEN GOTO 2790
2780   GOTO 3610'NEXT I
2790   FOR J=1 TO DHR
2800     READ RECORD #2 J P14
2810     K=L=0
2820     IF (P31.JJ=3 OR P31.JJ=8) AND P14.DISD=0 AND P31.TTD=P14.DD THEN GOTO 2860
2830     IF P31.JJ=3 AND P14.DISD>0 THEN GOTO 3600   'NEXT J
2840     IF P31.JJ=8 AND P14.DISD>0 AND P31.TTD=P14.DD THEN GOTO 3240
2850     GOTO 3600 'NEXT J
2860     IF P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P14.DD THEN GOTO 2880
2870     GOTO 3600 'NEXT J
2880     IF P31.TOL<P14.TDD THEN GOTO 3090
2890     FOR K=1 TO A
2900       READ RECORD #1 K P31
2910       L=0
2920       IF (P31.JJ=4 OR P31.JJ=9) AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P14.DD THEN GO
TO 2940
2930       GOTO 3070     'NEXT K
2940       IF P14.THD$="N" THEN GOTO 3040
2950       FOR L=1 TO A
2960         READ RECORD #1 L P31
2970         IF (P31.JJ=7 OR P31.JJ=10) AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P14.DD THEN
 GOTO 2990
2980         GOTO 3020     'NEXT L
2990         P44.E1=I:P44.E2=J:P44.E3=K:P44.E4=L
3000         WRITE RECORD #3 Z P44
3010         Z=Z+1
3020       NEXT L
3030       GOTO 3070      'NEXT K
3040       P44.E1=I:P44.E2=J:P44.E3=K:P44.E4=L
3050       WRITE RECORD #3 Z P44
3060       Z=Z+1
3070     NEXT K
3080     GOTO 3600'NEXT J
3090     K=0
3100     IF P14.THD$="N" THEN GOTO 3200
3110     FOR L=1 TO A
3120       READ RECORD #1 L P31
3130       IF (P31.JJ=7 OR P31.JJ=10) AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P14.DD THEN G
OTO 3150
3140       GOTO 3180   'NEXT L
3150       P44.E1=I:P44.E2=J:P44.E3=K:P44.E4=L
3160       WRITE RECORD #3 Z P44
```

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3170      Z=Z+1
3180     NEXT L
3190     GOTO 3600 'NEXT J
3200     P44.E1=I:P44.E2=J:P44.E3=K:P44.E4=L
3210     WRITE RECORD #3 Z P44
3220     Z=Z+1
3230     GOTO 3600 'NEXT J
3240     IF P31.LLL>LP AND P31.DDD>DP THEN GOTO 3260
3250     GOTO 3600  'NEXT J
3260     IF P31.TOL<P14.TDD AND P14.THD$="N" THEN GOTO 3470
3270     IF P31.TOL<P14.TDD THEN GOTO 3510
3280     FOR K=1 TO A
3290       L=0
3300       READ RECORD #1 K P31
3310       IF P31.JJ=8 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P14.DD THEN GOTO 3330
3320       GOTO 3460      'NEXT K
3330       IF P14.THD$="N" THEN GOTO 3430
3340       FOR L=1 TO A
3350         READ RECORD #1 L P31
3360         IF P31.JJ=10 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P14.DD THEN GOTO 3380
3370         GOTO 3410'NEXT L
3380         P44.E1=I:P44.E2=J:P44.E3=K:P44.E4=L
3390         WRITE RECORD #3 Z P44
3400         Z=Z+1
3410       NEXT L
3420       GOTO 3460'NEXT K
3430       P44.E1=I:P44.E2=J:P44.E3=K:P44.E4=L
3440       WRITE RECORD #3 Z P44
3450       Z=Z+1
3460     NEXT K
3470     P44.E1=I:P44.E2=J:P44.E3=K:P44.E4=L
3480     WRITE RECORD #3 Z P44
3490     Z=Z+1
3500     GOTO 3600   'NEXT J
3510     K=0
3520     FOR L=1 TO A
3530       READ RECORD #1 L P31
3540       IF P31.JJ=10 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P14.DD THEN GOTO 3560
3550       GOTO 3590      'NEXT L
3560       P44.E1=I:P44.E2=J:P44.E3=K:P44.E4=L
3570       WRITE RECORD #3 Z P44
3580       Z=Z+1
3590     NEXT L
3600   NEXT J
3610 NEXT I
3620 EE1=Z
3630 P44.E1=0
3640 WRITE RECORD #3 Z P44
3650 CLOSE
3660 IF H$="N" THEN GOTO 4700
3670 OPEN "C:CCC" AS #1 LEN=SIZE(P31)
```

```
3680 IF MFC>0 THEN GOTO 3760
3690 A=1
3700 READ RECORD #1 A P31
3710 IF P31.TN$="LAST" THEN GOTO 3740
3720 A=A+1
3730 GOTO 3700
3740 A=A-1
3750 MFC=A
3760 A=MFC
3770 OPEN"DRILLO" AS #2 LEN=SIZE(P15)
3780 OPEN "ALT6" AS #3 LEN =SIZE(P45)
3790 Z=1
3800 FOR I=1 TO A
3810   READ RECORD #1 I P31
3820   IF P31.JJ=3 OR P31.JJ=8 THEN GOTO 3840
3830   GOTO 4650  'NEXT I
3840   FOR J=1 TO DHO
3850     READ RECORD #2 J P15
3860     K=L=0
3870     IF (P31.JJ=3 OR P31.JJ=8) AND P15.DISE=0 AND P31.TTD=P15.DE THEN GOTO 3910
3880     IF P31.JJ=3 AND P15.DISE>0 THEN GOTO 4640   'NEXT J
3890     IF P31.JJ=8 AND P15.DISE>0 THEN GOTO 4280
3900     GOTO 4640    'NEXT J
3910     IF P31.LLL<LP OR P31.DDD<DP THEN GOTO 4640  'NEXT J
3920     IF P31.TOL<P15.TDE AND P15.THE$="N" THEN GOTO 4240
3930     IF P31.TOL<P15.TDE THEN GOTO 4140
3940     FOR K=1 TO A
3950       L=0
3960       READ RECORD #1 K P31
3970       IF (P31.JJ=4 OR P31.JJ=9) AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P15.DE THEN GO
TO 3990
3980       GOTO 4120      'NEXT K
3990       IF P15.THE$="N" THEN GOTO 4090
4000       FOR L=1 TO A
4010         READ RECORD #1 L P31
4020         IF (P31.JJ=7 OR P31.JJ=10) AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P15.DE THEN
 GOTO 4040
4030         GOTO 4070'NEXT L
4040         P45.F1=I:P45.F2=J:P45.F3=K:P45.F4=L
4050         WRITE RECORD #3 Z P45
4060         Z=Z+1
4070       NEXT L
4080       GOTO 4120
4090       P45.F1=I:P45.F2=J:P45.F3=K:P45.F4=L
4100       WRITE RECORD #3 Z P45
4110       Z=Z+1
4120     NEXT K
4130     GOTO 4640 'NEXT J
4140     K=0
4150     FOR L=1 TO A
4160       READ RECORD #1 L P31
```

```
4170      IF (P31.JJ=7 OR P31.JJ=10) AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P15.DE THEN G
OTO 4190
4180      GOTO 4220'NEXT L
4190      P45.F1=I:P45.F2=J:P45.F3=K:P45.F4=L
4200      WRITE RECORD #3 Z P45
4210      Z=Z+1
4220    NEXT L
4230    GOTO 4640   'NEXT J
4240    P45.F1=I:P45.F2=J:P45.F3=K:P45.F4=L
4250    WRITE RECORD #3 Z P45
4260    Z=Z+1
4270    GOTO 4640    'NEXT J
4280    IF P31.LLL<LP OR P31.DDD<DP THEN GOTO 4640       'NEXT J
4290    IF P31.TOL<P15.TDE AND P15.THE$="N" THEN GOTO 4610
4300    IF P31.TOL<P15.TDE THEN GOTO 4510
4310    FOR K=1 TO A
4320      L=0
4330      READ RECORD #1 K P31
4340      IF P31.JJ=9 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P15.DE THEN GOTO 4360
4350      GOTO 4490      'NEXT K
4360      IF P15.THE$="N" THEN GOTO 4460
4370      FOR L=1 TO A
4380        READ RECORD #1 L P31
4390        IF P31.JJ=10 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P15.DE THEN GOTO 4410
4400        GOTO 4440   'NEXT L
4410        P45.F1=I:P45.F2=J:P45.F3=K:P45.F4=L
4420        WRITE RECORD #3 Z P45
4430        Z=Z+1
4440      NEXT L
4450      GOTO 4490     'NEXT K
4460      P45.F1=I:P45.F2=J:P45.F3=K:P45.F4=L
4470      WRITE RECORD #3 Z P45
4480      Z=Z+1
4490    NEXT K
4500    GOTO 4640 'NEXT J
4510    K=0
4520    FOR L=1 TO A
4530      READ RECORD #1 L P31
4540      IF P31.JJ=10 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P15.DE THEN GOTO 4560
4550      GOTO 4590   'NEXT L
4560      P45.F1=I:P45.F2=J:P45.F3=K:P45.F4=L
4570      WRITE RECORD #3 Z P45
4580      Z=Z+1
4590    NEXT L
4600    GOTO 4640    'NEXT J
4610    P45.F1=I:P45.F2=J:P45.F3=K:P45.F4=L
4620    WRITE RECORD #3 Z P45
4630    Z=Z+1
4640  NEXT J
4650 NEXT I
4660 CLOSE
```

```
4670 FF1=Z
4680 P45.F1=0
4690 WRITE RECORD #3 Z P45
4700 IF I$="N" GOTO 5320
4710 OPEN "C:DDD" AS #1 LEN=SIZE(P31)
4720 A=1
4730 READ RECORD #1 A P31
4740 IF P31.TN$="LAST" THEN GOTO 4770
4750 A=A+1
4760 GOTO 4730
4770 A=A-1
4780 MFD=A
4790 OPEN "EXDRILL" AS #2 LEN=SIZE(P16)
4800 OPEN "ALT7" AS #3 LEN=SIZE(P46)
4810 Z=1
4820 FOR I=1 TO A
4830   READ RECORD #1 I P31
4840   IF P31.JJ=8 AND P31.LLL>LP AND P31.DDD>DP THEN GOTO 4860
4850   GOTO 5270'NEXT I
4860   FOR J=1 TO EDH
4870     READ RECORD #2 J P16
4880     K=L=0
4890     IF P31.TTD=P16.DF THEN GOTO 4910
4900     GOTO 5260 'NEXT J
4910     IF P31.TOL<P16.TDF AND P16.THF$="N" THEN GOTO 5230
4920     IF P31.TOL<P16.TDF THEN GOTO 5130
4930     FOR K=1 TO A
4940       L=0
4950       READ RECORD #1 K P31
4960       IF P31.JJ=9 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P16.DF THEN GOTO 4980
4970       GOTO 5110     'NEXT K
4980       IF P16.THF$="N" THEN GOTO 5080
4990       FOR L=1 TO A
5000         READ RECORD #1 L P31
5010         IF P31.JJ=10 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P16.DF THEN GOTO 5030
5020         GOTO 5060 'NEXT L
5030         P46.G1=I:P46.G2=J:P46.G3=K:P46.G4=L
5040         WRITE RECORD #3 Z P46
5050         Z=Z+1
5060       NEXT L
5070       GOTO 5110 'NEXT K
5080       P46.G1=I:P46.G2=J:P46.G3=K:P46.G4=L
5090       WRITE RECORD #3 Z P46
5100       Z=Z+1
5110     NEXT K
5120     GOTO 5260
5130     K=0
5140     FOR L=1 TO A
5150       READ RECORD #1 L P31
5160       IF P31.JJ=10 AND P31.LLL>LP AND P31.DDD>DP AND P31.TTD=P16.DF THEN GOTO 5180
5170       GOTO 5210 'NEXT L
```

```
5180        P46.G1=I:P46.G2=J:P46.G3=K:P46.G4=L
5190        WRITE RECORD #3 Z P46
5200        Z=Z+1
5210      NEXT L
5220      GOTO 5260 'NEXT J
5230      P46.G1=I:P46.G2=J:P46.G3=K:P46.G4=L
5240      WRITE RECORD #3 Z P46
5250      Z=Z+1
5260    NEXT J
5270 NEXT I
5280 GG1=Z
5290 P46.G1=0
5300 WRITE RECORD #3 Z P46
5310 CLOSE
5320 IF J$="N" THEN GOTO 5600
5330 Z=1
5340 OPEN "C:EEE" AS #1 LEN=SIZE(P31)
5350 A=1
5360 READ RECORD #1 A P31
5370 IF P31.TN$="LAST" THEN GOTO 5400
5380 A=A+1
5390 GOTO 5360
5400 A=A-1
5410 MFE=A
5420 OPEN "INTKEY" AS #2 LEN=SIZE(P17)
5430 OPEN "ALT8" AS #3 LEN=SIZE(P47)
5440 FOR I=1 TO A
5450    READ RECORD #1 I P31
5460    FOR J=1 TO INK
5470      READ RECORD #2 J P17
5480      K=L=0
5490      IF P31.JJ=13 AND P31.LLL>LP AND P31.DDD>DP THEN GOTO 5510
5500      GOTO 5540  'NEXT J
5510      P47.H1=I:P47.H2=J:P47.H3=K:P47.H4=L
5520      WRITE RECORD #3 Z P47
5530      Z=Z+1
5540    NEXT J
5550 NEXT I
5560 H11=Z
5570 P47.H1=0
5580 WRITE RECORD #3 Z P47
5590 CLOSE
5600 IF K$="N" GOTO 5920
5610 OPEN "C:EEE" AS #1 LEN=SIZE(P31)
5620 IF MFE>0 THEN GOTO 5700
5630 A=1
5640 READ RECORD #1 A P31
5650 IF P31.TN$="LAST" THEN GOTO 5680
5660 A=A+1
5670 GOTO 5640
5680 A=A-1
```

```
5690 MFE=A
5700 A=MFE
5710 OPEN "EXTKEY" AS #2 LEN=SIZE(P18)
5720 OPEN "ALT9" AS #3 LEN=SIZE(P48)
5730 Z=1
5740 FOR I=1 TO A
5750   READ RECORD #1 I P31
5760   FOR J=1 TO EXK
5770     READ RECORD #2 J P18
5780     K=L=0
5790     IF P31.JJ=16 AND (LEFT$(P31.MN$,3)="EMC" OR LEFT$(P31.MN$,3)="EMH") AND P31.LLL>LP A
ND P31.DDD>DP THEN GOTO 5810
5800     GOTO 5860'NEXT J
5810     IF P31.TOL<P18.TEWDH AND P31.TOL<P18.TEDPH AND P31.SUF<P18.EKSFH THEN GOTO 5830
5820     GOTO 5860
5830     P48.I1=I:P48.I2=J:P48.I3=K:P48.I4=L
5840     WRITE RECORD #3 Z P48
5850     Z=Z+1
5860   NEXT J
5870 NEXT I
5880 II1=Z
5890 P48.I1=0
5900 WRITE RECORD #3 Z P48
5910 CLOSE
5920 'THIS COMPLETES THE SECTION FOR THE SELECTION OF ALL POSSIBLE MACHINE
5930 'TOOLS TO GENERATE THE INDIVIDUAL FEATURES FOR ROTATIONAL COMPONENTS.
5940 'THIS NEXT SECTION WILL PERFORM THE SAME RESULTS FOR PRISMATIC COMPONENTS
5950 GOTO 10900
5960 OPEN "PRIS" AS #1 LEN=SIZE(P30)
5970 READ RECORD #1 1 P30
5980 CLOSE
5990 IF L$="N" GOTO 6370
6000 OPEN "C:FFF" AS #1 LEN=SIZE(P31)
6010 A=1
6020 READ RECORD #1 A P31
6030 IF P31.TN$="LAST" THEN GOTO 6060
6040 A=A+1
6050 GOTO 6020
6060 A=A-1
6070 MFF=A
6080 OPEN "ALT10" AS #3 LEN=SIZE(P50)
6090 OPEN "EXTS" AS  #2 LEN=SIZE(P20)
6100 Z=1
6110 FOR I=1 TO A
6120   READ RECORD #1 I P31
6130   IF (P31.JJ=15 OR P31.JJ=21) AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT TH
EN GOTO 6150
6140   GOTO 6320'NEXT I
6150   FOR J=1 TO NS
6160     READ RECORD #2 J P20
6170     K=L=0
```

```
6180     IF P31.TOL>P20.THK OR P31.SUF>P20.SFK THEN GOTO 6230
6190     P50.J1=I:P50.J2=J:P50.J3=K:P50.J4=L
6200     WRITE RECORD #3 Z P50
6210     Z=Z+1
6220     GOTO 6310    'NEXT J
6230     FOR K=1 TO A
6240       READ RECORD #1 K P31
6250       IF P31.JJ=15 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TOL<P
20.THK AND P31.SUF<P20.SFK THEN GOT
O 6270
6260       GOTO 6300      'NEXT K
6270       P50.J1=I:P50.J2=J:P50.J3=K:P50.J4=L
6280       WRITE RECORD #3 Z P50
6290       Z=Z+1
6300     NEXT K
6310   NEXT J
6320 NEXT I
6330 JJ1=Z
6340 P50.J1=0
6350 WRITE RECORD #3 Z P50
6360 CLOSE
6370 IF M$="N" GOTO 6880
6380 OPEN "C:FFF" AS #1 LEN=SIZE(P31)
6390 IF MFF>0 THEN GOTO 6470
6400 A=1
6410 READ RECORD #1 A P31
6420 IF P31.TN$="LAST" THEN GOTO 6450
6430 A=A+1
6440 GOTO 6410
6450 A=A-1
6460 MFF=A
6470 A=MFF
6480 OPEN "EXTFE" AS #2 LEN=SIZE(P21)
6490 OPEN "ALT11" AS #3 LEN=SIZE(P51)
6500 Z=1
6510 FOR I=1 TO A
6520   READ RECORD #1 I P31
6530   IF (P31.JJ=16 OR P31.JJ=17 OR P31.JJ=18 OR P31.JJ=19 OR P31.JJ=20) AND P31.LLL>P30.LT
AND P31.WD>P30.BT AND P31.HGT>P30.H
T THEN GOTO 6550
6540   GOTO 6830 'NEXT I
6550   FOR J=1 TO NEFR
6560     READ RECORD #2 J P21
6570     L=K=0
6580     IF P21.EXFL$="RECT" THEN ZZ=16
6590     IF P21.EXFL$="TRIA" THEN ZZ=17
6600     IF P21.EXFL$="TRAP" THEN ZZ=18
6610     IF P21.EXFL$="ROMB" THEN ZZ=19
6620     IF P21.EXFL$="PCYL" THEN ZZ=20
6630     IF P31.JJ=ZZ THEN GOTO 6650
6640     GOTO 6820    'NEXT J
```

```
6650      IF P21.RSLL$="Y" AND P21.RAE$="N" AND (LEFT$(P31.MN$,3)="EMC" OR LEFT$(P31.MN$,3)="E
MH" OR LEFT$(P31.MN$,3)="PMC" OR LE
FT$(P31.MN$,3)="PMH") AND P31.TW<P21.BL THEN GOTO 6690
6660      IF (P21.RSLL$="Y" OR P21.RSLL$="N") AND P21.RAE$="Y" THEN GOTO 6690
6670      IF P21.RAE$="N" AND P21.RSLL$="N" AND (LEFT$(P31.MN$,3)="EMC" OR LEFT$(P31.MN$,3)="E
MH") THEN GOTO 6690
6680      GOTO 6820   'NEXT J
6690      IF P31.TOL>P21.TLL OR P31.TOL>P21.TBL OR P31.TOL>P21.THL OR P31.SUF>P21.SFL THEN GOT
O 6740
6700      P51.HH1=I:P51.HH2=J:P51.HH3=K:P51.HH4=L
6710      WRITE RECORD #3 Z P51
6720      Z=Z+1
6730      GOTO 6820'NEXT J
6740      FOR K=1 TO A
6750        READ RECORD #1 K P31
6760        IF P31.JJ=21 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT THEN GOTO 678
0
6770        GOTO 6810   'NEXT K
6780        P51.HH1=I:P51.HH2=J:P51.HH3=K:P51.HH4=L
6790        WRITE RECORD #3 Z P51
6800        Z=Z+1
6810      NEXT K
6820    NEXT J
6830 NEXT I
6840 HH11=Z
6850 P51.HH1=0
6860 WRITE RECORD #3 Z P51
6870 CLOSE
6880 IF N$="N" GOTO 7580
6890 OPEN "C:666" AS #1 LEN=SIZE(P31)
6900 A=1
6910 READ RECORD #1 A P31
6920 IF P31.TN$="LAST" THEN GOTO 6950
6930 A=A+1
6940 GOTO 6910
6950 A=A-1
6960 MFG=A
6970 OPEN "INTFEA" AS #2 LEN=SIZE(P22)
6980 OPEN "ALT12" AS #3 LEN=SIZE(P52)
6990 Z=1
7000 FOR KK=1 TO NSS
7010   DIAM=1000000
7020   FOR J=1 TO P22.NSG
7030     READ RECORD #2 J P22
7040     IF P22.INFM$="T" GOTO 7070
7050     IF DIAM>P22.DM THEN DIAM=P22.DM
7060     GOTO 7090
7070     IF DIAM>P22.SDM THEN DIAM=P22.SDM
7080     IF DIAM>P22.FDM THEN DIAM=P22.FDM
7090   NEXT J
7100   FOR I=1 TO A
```

```
7110    READ RECORD #1 I P31
7120    IF P31.JJ=8 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD<DIAM
 THEN GOTO 7140
7130    GOTO 7520'NEXT I
7140    DIA=P31.TTD
7150    FOR K=1 TO A
7160      READ RECORD #1 K P31
7170      IF P31.JJ=11 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD<D
IA THEN GOTO 7190
7180      GOTO 7510   'NEXT K
7190      FOR J=1 TO P22.NSG
7200        READ RECORD #2 J P22
7210        GOTO 7500   'NEXT J
7220        IF P22.INFM$="T" THEN GOTO 7370
7230        IF P31.TOL<P22.TDM AND P31.SUF<P22.SFM THEN GOTO 7330
7240        FOR L=1 TO A
7250          READ RECORD #1 L P31
7260          IF P31.JJ=12 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.T
TD<DIAM THEN GOTO 7280
7270          GOTO 7310'NEXT L
7280          P52.L1=I:P52.L2=J:P52.L3=K:P52.L4=L
7290          WRITE RECORD #3 Z P52
7300          Z=Z+1
7310        NEXT L
7320        GOTO 7500 'next J
7330        P52.L1=I:P52.L2=J:P52.L3=K:P52.L4=L
7340        WRITE RECORD #3 Z P52
7350        Z=Z+1
7360        GOTO 7500  'NEXT J
7370        IF P31.TOL<P22.TSDM AND P31.TOL<P22.TFDM AND P31.SUF<P22.SFM THEN GOTO 7470
7380        FOR L=1 TO A
7390          READ RECORD #1 L P31
7400          IF P31.JJ=12 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.T
TD<DIAM THEN GOTO 7420
7410          GOTO 7450  'NEXT L
7420          P52.L1=I:P52.L2=J:P52.L3=K:P52.L4=L
7430          WRITE RECORD #3 Z P52
7440          Z=Z+1
7450        NEXT L
7460        GOTO 7500'NEXT K
7470        P52.L1=I:P52.L2=J:P52.L3=K:P52.L4=L:P52.L5=KK
7480        WRITE RECORD #3 Z P52
7490        Z=Z+1
7500      NEXT J
7510    NEXT K
7520  NEXT I
7530 NEXT KK
7540 LL1=Z
7550 P52.L1=0
7560 WRITE RECORD #3 Z P52
7570 CLOSE
```

```
7580 IF O$="N" GOTO 10900
7590 OPEN "C:DDD" AS #1 LEN=SIZE(P31)
7600 A=1
7610 READ RECORD #1 A P31
7620 IF P31.TN$="LAST" THEN GOTO 7650
7630 A=A+1
7640 GOTO 7610
7650 A=A-1
7660 MFD=A
7670 IF P$="N" THEN GOTO 8210
7680 OPEN "DRILLX"AS #2 LEN=SIZE(P23)
7690 OPEN "ALT13" AS #3 LEN=SIZE(P53)
7700 Z=1
7710 FOR I=1 TO A
7720   READ RECORD #1 I P31
7730   IF P31.JJ=8 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT       THEN GOTO 77
50
7740   GOTO 8160   'NEXT I
7750   FOR J=1 TO DHX
7760     READ RECORD #2 J P23
7770     K=L=0
7780     IF P31.TTD=P23.DN THEN GOTO 7800
7790     GOTO 8150   'NEXT J
7800     IF P31.TOL<P23.TDN AND P31.SUF<P23.SFN AND P23.THN$="N" THEN GOTO 8020
7810     IF P31.TOL<P23.TDN AND P31.SUF<P23.SFN THEN GOTO 8060
7820     FOR K=1 TO A
7830       READ RECORD #1 K P31
7840       L=0
7850       IF P31.JJ=9 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD=P2
3.DN THEN GOTO 7870
7860       GOTO 8000   'NEXT K
7870       IF P23.THN$="N" THEN GOTO 7970
7880       FOR L=1 TO A
7890         READ RECORD #1 L P31
7900         IF P31.JJ=10 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD
=P23.DN THEN GOTO 7920
7910         GOTO 7950'NEXT L
7920         P53.M1=I:P53.M2=J:P53.M3=K:P53.M4=L
7930         WRITE RECORD #3 Z P53
7940         Z=Z+1
7950       NEXT L
7960       GOTO 8000    'NEXT K
7970       P53.M1=I:P53.M2=J:P53.M3=K:P53.M4=L
7980       WRITE RECORD #3 Z P53
7990       Z=Z+1
8000     NEXT K
8010     GOTO 8150 'NEXT J
8020     P53.M1=I:P53.M2=J:P53.M3=K:P53.M4=L
8030     WRITE RECORD #3 Z P53
8040     Z=Z+1
8050     GOTO 8150  'NEXT J
```

```
8060     K=0
8070     FOR L=1 TO A
8080       READ RECORD #1 L P31
8090       IF P31.JJ=10 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD=P
23.DN THEN GOTO 8110
8100       GOTO 8140   'NEXT L
8110       P53.M1=I:P53.M2=J:P53.M3=K:P53.M4=L
8120       WRITE RECORD #3 Z P53
8130       Z=Z+1
8140     NEXT L
8150   NEXT J
8160 NEXT I
8170 MM1=Z
8180 P53.M1=0
8190 WRITE RECORD #3 Z P53
8200 CLOSE 2,3
8210 IF Q$="N" THEN GOTO 8740
8220 OPEN "DRILLNX" AS #2 LEN=SIZE(P24)
8230 OPEN "ALT14" AS #3 LEN=SIZE(P54)
8240 Z=1
8250 FOR I=1 TO A
8260   READ RECORD #1 I P31
8270   IF P31.JJ=8 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT THEN GOTO 8290
8280   GOTO 8690 'NEXT I
8290   FOR J=1 TO DHNX
8300     READ RECORD #2 J P24
8310     K=L=0
8320     IF P31.TTD=P24.DOO THEN GOTO 8340
8330     GOTO 8680 'NEXT J
8340     IF P31.TOL<P24.TDO AND P31.SUF<P24.SFO AND P24.THO$="N" THEN GOTO 8550
8350     IF P31.TOL<P24.TDO AND P31.SUF<P24.SFO THEN GOTO 8590
8360     FOR K=1 TO A
8370       READ RECORD #1 K P31
8380       L=0
8390       IF P31.JJ=9 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD=P2
4.DOO THEN GOTO 8410
8400       GOTO 8540    'NEXT K
8410       IF P24.THO$="N" THEN GOTO 8510
8420       FOR L=1 TO A
8430         READ RECORD #1 L P31
8440         IF P31.JJ=10 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD
=P24.DOO THEN GOTO 8460
8450         GOTO 8490'NEXT L
8460         P54.N1=I:P54.N2=J:P54.N3=K:P54.N4=L
8470         WRITE RECORD #3 Z P54
8480         Z=Z+1
8490       NEXT L
8500       GOTO 8540'NEXT K
8510       P54.N1=I:P54.N2=J:P54.N3=K:P54.N4=L
8520       WRITE RECORD #3 Z P54
8530       Z=Z+1
```

```
8540      NEXT K
8550      P54.N1=I:P54.N2=J:P54.N3=K:P54.N4=L
8560      WRITE RECORD #3 Z P54
8570      Z=Z+1
8580      GOTO 8680 'NEXT J
8590      K=0
8600      FOR L=1 TO A
8610        READ RECORD #1 L P31
8620        IF P31.JJ=10 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD=P
24.DDP THEN GOTO 8640
8630        GOTO 8670   'NEXT L
8640        P54.N1=I:P54.N2=J:P54.N3=K:P54.N4=L
8650        WRITE RECORD #3 Z P54
8660        Z=Z+1
8670      NEXT L
8680    NEXT J
8690 NEXT I
8700 NN1=Z
8710 P54.N1=0
8720 WRITE RECORD #3 Z P54
8730 CLOSE 2,3
8740 IF R$="N" GOTO 9280
8750 OPEN "DRILLY" AS #2 LEN=SIZE(P25)
8760 OPEN "ALT15" AS #3 LEN=SIZE(P55)
8770 Z=1
8780 FOR I =1 TO A
8790   READ RECORD #1 I P31
8800   IF P31.JJ=8 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT THEN GOTO 8820
8810   GOTO 9230   'NEXT I
8820   FOR J=1 TO DHY
8830     READ RECORD #2 J P25
8840     K=L=0
8850     IF P31.TTD=P25.DDP THEN GOTO 8870
8860     GOTO 9220 'NEXT J
8870     IF P31.TOL<P25.TDDP AND P31.SUF<P25.SFF AND P25.THP$="N" THEN GOTO 9090
8880     IF P31.TOL<P25.TDDP AND P31.SUF<P25.SFP THEN GOTO 9130
8890     FOR K=1 TO A
8900       L=0
8910       READ RECORD #1 K P31
8920       IF P31.JJ=9 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD=P2
5.DDP THEN GOTO 8940
8930       GOTO 9070    'NEXT K
8940       IF P25.THP$="N" THEN GOTO 9040
8950       FOR L=1 TO A
8960         READ RECORD #1 L P31
8970         IF P31.JJ=10 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD
=P25.DDP THEN GOTO 8990
8980         GOTO 9020    'NEXT L
8990         P55.D1=I:P55.D2=J:P55.D3=K:P55.D4=L
9000         WRITE RECORD #3 Z P55
9010         Z=Z+1
```

```
9020        NEXT L
9030        GOTO 9070    'NEXT K
9040        P55.01=I:P55.02=J:P55.03=K:P55.04=L
9050        WRITE RECORD #3 Z P55
9060        Z=Z+1
9070      NEXT K
9080      GOTO 9220 'NEXT J
9090      P55.01=I:P55.02=J:P55.03=K:P55.04=L
9100      WRITE RECORD #3 Z P55
9110      Z=Z+1
9120      GOTO 9220 'NEXT J
9130      K=0
9140      FOR L=1 TO A
9150        READ RECORD #1 L P31
9160        IF P31.JJ=10 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD=P
25.DDP THEN GOTO 9180
9170        GOTO 9210    'NEXT L
9180        P55.01=I:P55.02=J:P55.03=K:P55.04=L
9190        WRITE RECORD #3 Z P55
9200        Z=Z+1
9210      NEXT L
9220    NEXT J
9230 NEXT I
9240 DD1=Z
9250 P55.01=0
9260 WRITE RECORD #3 Z P55
9270 CLOSE 2,3
9280 IF S$="N" GOTO 9820
9290 OPEN "DRILLNY" AS #2 LEN=SIZE(P26)
9300 OPEN "ALT16" AS #3 LEN=SIZE(P56)
9310 Z=1
9320 FOR I=1 TO A
9330    READ RECORD #1 I P31
9340    IF P31.JJ=8 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT THEN GOTO 9360
9350    GOTO 9770 'NEXT I
9360    FOR J=1 TO DHNY
9370      READ RECORD #2 J P31
9380      K=L=0
9390      IF P31.TTD=P26.DQ THEN GOTO 9410
9400      GOTO 9760 'NEXT J
9410      IF P31.TOL<P26.TDQ AND P31.SUF<P26.SFQ AND P26.THQ$="N" THEN GOTO 9630
9420      IF P31.TOL<P26.TDQ AND P31.SUF<P26.SFQ THEN GOTO 9670
9430      FOR K=1 TO A
9440        READ RECORD #1 K P31
9450        L=0
9460        IF P31.JJ=9 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD=P2
6.DQ THEN GOTO 9480
9470        GOTO 9610'NEXT K
9480        IF P26.THQ$="N" THEN GOTO 9580
9490        FOR L=1 TO A
9500          READ RECORD #1 L P31
```

```
9510        IF P31.JJ=10 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD
=P26.DB THEN GOTO 9530
9520        GOTO 9560'NEXT L
9530        P56.P1=I:P56.P2=J:P56.P3=K:P56.P4=L
9540        WRITE RECORD #3 Z P56
9550        Z=Z+1
9560      NEXT L
9570      GOTO 9610'NEXT K
9580      P56.P1=I:P56.P2=J:P56.P3=K:P56.P4=L
9590      WRITE RECORD #3 Z P56
9600      Z=Z+1
9610    NEXT K
9620    GOTO 9760'NEXT J
9630    P56.P1=I:P56.P2=J:P56.P3=K:P56.P4=L
9640    WRITE RECORD #3 Z P56
9650    Z=Z+1
9660    GOTO 9760   'NEXT J
9670    K=0
9680    FOR L=1 TO A
9690      READ RECORD #1 L P31
9700      IF P31.JJ=10 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD=P
26.DB THEN GOTO 9720
9710      GOTO 9750     'NEXT L
9720      P56.P1=I:P56.P2=J:P56.P3=K:P56.P4=L
9730      WRITE RECORD #3 Z P56
9740      Z=Z+1
9750    NEXT L
9760  NEXT J
9770 NEXT I
9780 PP1=Z
9790 P56.P1=0
9800 WRITE RECORD #3 Z P56
9810 CLOSE 2,3
9820 IF T$="N" GOTO 10360
9830 OPEN "DRILLZ" AS #2 LEN=SIZE(P27)
9840 OPEN "ALT17"AS #3 LEN=SIZE(P57)
9850 Z=1
9860 FOR I=1 TO A
9870  READ RECORD #1 I P31
9880  IF P31.JJ=8 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT THEN GOTO 9900
9890  GOTO 10310'NEXT I
9900  FOR J=1 TO DHZ
9910    READ RECORD #2 J P27
9920    K=L=0
9930    IF P31.TTD=P27.DR THEN GOTO 9950
9940    GOTO 10300'NEXT J
9950    IF P31.TOL<P27.TDR AND P31.SUF<P27.SFR AND P27.THR$="N" THEN GOTO 10170
9960    IF P31.TOL<P27.TDR AND P31.SUF<P27.SFR THEN GOTO 10210
9970    FOR K=1 TO A
9980      READ RECORD #1 K P31
9990      L=0
```

```
10000       IF P31.JJ=9 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD=P2
7.DR THEN GOTO 10020
10010       GOTO 10150    'NEXT K
10020       IF P27.THR$="N" THEN GOTO 10120
10030       FOR L=1 TO A
10040         READ RECORD #1 L P31
10050         IF P31.JJ=10 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD
=P27.DR THEN GOTO 10070
10060         GOTO 10100    'NEXT L
10070         P57.Q1=I:P57.Q2=J:P57.Q3=K:P57.Q4=L
10080         WRITE RECORD #3 Z P57
10090         Z=Z+1
10100       NEXT L
10110       GOTO 10150   'NEXT K
10120       P57.Q1=I:P57.Q2=J:P57.Q3=K:P57.Q4=L
10130       WRITE RECORD #3 Z P57
10140       Z=Z+1
10150     NEXT K
10160     GOTO 10300  'NEXT J
10170     P57.Q1=I:P57.Q2=J:P57.Q3=K:P57.Q4=L
10180     WRITE RECORD #3 Z P57
10190     Z=Z+1
10200     GOTO 10300  'NEXT J
10210     K=0
10220     FOR L=1 TO A
10230       READ RECORD #1 L P31
10240       IF P31.JJ=10 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD=P
27.DR THEN GOTO 10250
10250       GOTO 10290    'NEXT L
10260       P57.Q1=I:P57.Q2=J:P57.Q3=K:P57.Q4=L
10270       WRITE RECORD #3 Z P57
10280       Z=Z+1
10290     NEXT L
10300   NEXT J
10310 NEXT I
10320 QQ1=Z
10330 P57.Q1=0
10340 WRITE RECORD #3 Z P57
10350 CLOSE 2,3
10360 IF U$="N" GOTO 10900
10370 OPEN "DRILLNZ" AS #2 LEN=SIZE(P28)
10380 OPEN "ALT18" AS #3 LEN=SIZE(P58)
10390 Z=1
10400 FOR I=1 TO A
10410   READ RECORD #1 I P31
10420   IF P31.JJ=8 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT THEN GOTO 10440
10430   GOTO 10850  'NEXT I
10440   FOR J=1 TO DHNZ
10450     READ RECORD #2 J P28
10460     K=L=0
10470     IF P31.TTD=P28.DDS THEN GOTO 10490
```

```
   10480      GOTO 10840  'NEXT J
   10490      IF P31.TOL<P28.TDDS AND P31.SUF<P28.SFS AND P28.THS$="N" THEN GOTO 10710
   10500      IF P31.TOL<P28.TDDS AND P31.SUF<P28.SFS THEN GOTO 10750
   10510      FOR K=1 TO A
   10520        L=0
   10530        READ RECORD #1 K P31
   10540        IF P31.JJ=9 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD=P2
8.DDS THEN GOTO 10560
   10550        GOTO 10690   'NEXT K
   10560        IF P28.THS$="N" THEN GOTO 10660
   10570        FOR L=1 TO A
   10580          READ RECORD #1 L P31
   10590          IF P31.JJ=10 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD
=P28.DDS THEN GOTO 10610
   10600          GOTO 10640     'NEXT L
   10610          P58.R1=I:P58.R2=J:P58.R3=K:P58.R4=L
   10620          WRITE RECORD #3 Z P58
   10630          Z=Z+1
   10640        NEXT L
   10650        GOTO 10690      'NEXT K
   10660        P58.R1=I:P58.R2=J:P58.R3=K:P58.R4=L
   10670        WRITE RECORD #3 Z P58
   10680        Z=Z+1
   10690      NEXT K
   10700      GOTO 10840'NEXT J
   10710      P58.R1=I:P58.R2=J:P58.R3=K:P58.R4=L
   10720      WRITE RECORD #3 Z P58
   10730      Z=Z+1
   10740      GOTO 10840'NEXT J
   10750      K=0
   10760      FOR L=1 TO A
   10770        READ RECORD #1 L P31
   10780        IF P31.JJ=10 AND P31.LLL>P30.LT AND P31.WD>P30.BT AND P31.HGT>P30.HT AND P31.TTD=P
28.DDS THEN GOTO 10800
   10790        GOTO 10830    'NEXT L
   10800        P58.R1=I:P58.R2=J:P58.R3=K:P58.R4=L
   10810        WRITE RECORD #3 Z P58
   10820        Z=Z+1
   10830      NEXT L
   10840    NEXT J
   10850 NEXT I
   10860 RR1=Z
   10870 P58.R1=0
   10880 WRITE RECORD #3 Z P58
   10890 CLOSE 2,3
   10900 CLOSE
END PROCEDURE

PROCEDURE: Both
   EXTERNAL: P10,P11,P31,P40,P41,Ni$,Ne$,Aa1
   EXTERNAL: Bb1,Mat$,Lots,Choice$
```

```
SOURCE
  10 OPEN "D:EXTF.DAT" AS #1 LEN=SIZE(P10)
  20 Mat1=0:Mat2=0:LENGTH=0
  30 FOR I=1 TO Nef
  40   READ RECORD #1 I P10
  50   IF P10.EF$="T" THEN GOTO 80
  60   Mat1=Mat1+(P10.L*(3.1415*(DP)^2/4-3.1415*(P10.D)^2/4))
  70   GOTO 90
  80   Mat1=Mat1+P10.L*((3.1415*(DP)^2/4-3.1415*(P10.FD)^2/4)+.5*(3.1415*(P10.FD)^2/4-3.11415*(P
10.SD)^2/4))
  90 NEXT I
 100 CLOSE
 110 OPEN "D:INTF.DAT" AS #1 LEN=SIZE(P11)
 120 Diam=10000000
 130 FOR I=1 TO Nif
 140   READ RECORD #1 I P11
 150   LENGTH=LENGTH+P11.LA
 160   IF P11.IFA$="T" THEN GOTO 200
 170   Mat2=Mat2+(P11.LA*(3.1415*(P11.DA)^2/4))
 180   IF Diam>P11.DA THEN Diam=P11.DA
 190   GOTO 230
 200   Mat2=Mat2+(P11.LA*((3.1415*(P11.SDA)^2/4)+(.5*(3.1415*(P11.FDA)^2/4)-3.1415*(P11.SDA)^2/4
)))
 210   IF Diam>P11.SDA THEN Diam=P11.SDA
 220   IF Diam>P11.FDA THEN Diam=P11.FDA
 230 NEXT I
 240 Mat2=Mat2-(3.1415*(Diam)^2/4)*LENGTH
 250 CLOSE
 260 P=1:Q=1:R=1:S=1:T=1
 270 OPEN "D:ALT1" AS #1 LEN=SIZE(P40)
 280 OPEN "C:AAA" AS #2 LEN=SIZE(P31)
 290 OPEN "D:EXTF.DAT" AS #3 LEN=SIZE(P10)
 300 Aa1=Aa1-1
 310 FOR I=1 TO Aa1
 320   READ RECORD #1 I P40
 330   READ RECORD #2 P40.A1 P31
 340   Tol1=P31.TOL:Sf1=P31.SUF
 350   IF P40.A3=0 THEN GOTO 390
 360   READ RECORD #2 P40.A3 P31
 370   Tol2=P31.TOL:Sf2=P31.SUF
 380   GOTO 400
 390   Tol2=100:Sf2=100
 400   IF Tol1>Tol2 THEN Tol1=Tol2
 410   IF Sf1>Sf2 THEN Sf1=Sf2
 420   FOR J=1 TO Nef
 430     READ RECORD #3 J P10
 440     IF P10.EF$="T" THEN GOTO 470
 450     IF Tol1<P10.TD AND Sf1<P10.SF THEN GOTO 490
 460     EXIT TO,640
 470     IF Tol1<P10.TSD AND Tol1<P10.TFD AND Sf1<P10.SF THEN GOTO 490
 480     EXIT TO,640
```

```
490   NEXT J
500   LET Alt11(P)=P40.A1
510   IF P40.A3=0 THEN GR1(P)="N" ELSE GR1(P)="Y"
520   IF P<2 THEN GOTO 560
530   FOR J=1 TO P-1
540     IF Alt11(J)=Alt11(P) THEN EXIT TO,570
550   NEXT J
560   P=P+1
570   LET Alt13(R)=P40.A3
580   IF P40.A3=0 THEN GOTO 640
590   IF R<2 THEN GOTO 630
600   FOR J=1 TO R-1
610     IF Alt13(J)=Alt13(R) THEN EXIT TO,640
620   NEXT J
630   R=R+1
640 NEXT I
650 CLOSE
660 OPEN "D:ALT2" AS #1 LEN=SIZE(P41)
670 OPEN "C:BBB" AS #2 LEN=SIZE(P31)
680 OPEN "D:INTF.DAT" AS #3 LEN=SIZE(P11)
690 FOR I=1 TO Bb1
700   READ RECORD #1 I P41
710   READ RECORD #2 P41.B3 P31
720   Tol1=P31.TOL:Sf1=P31.SUF
730   IF P41.B4=0 THEN GOTO 760
740   READ RECORD #2 P41.B4 P31
750   Tol2=P31.TOL:Sf2=P31.SUF:GOTO 770
760   Tol2=100:Sf2=100
770   IF Tol1>Tol2 THEN Tol1=Tol2
780   IF Sf1>Sf2 THEN Sf1=Sf2
790   FOR J=1 TO Nif
800     READ RECORD #3 J P11
810     IF P11.IFA$="T" THEN GOTO 840
820     IF Tol1<P11.TDA AND Sf1<P11.SFA THEN GOTO 860
830     EXIT TO,1070
840     IF Tol1<P11.TSDA AND Tol1<P11.TFDA AND Sf1<P11.SFA THEN GOTO 860
850     EXIT TO,1070
860   NEXT J
870   LET Alt21(Q)=P41.B1
880   IF Q<2 THEN GOTO 920
890   FOR J=1 TO Q-1
900     IF Alt21(J)=Alt21(Q) THEN EXIT TO,930
910   NEXT J
920   Q=Q+1
930   LET Alt23(S)=P41.B3
940   IF P41.B4=0 THEN GR2(S)="N" ELSE GR2(S)="Y"
950   IF S<2 THEN GOTO 990
960   FOR J=1 TO S-1
970     IF Alt23(J)=Alt23(S) THEN EXIT TO,1000
980   NEXT J
990   S=S+1
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1000   IF P41.B4=0 THEN GOTO 1070
1010   LET Alt24(T)=P41.B4
1020   IF T<2 THEN GOTO 1060
1030   FOR J=1 TO T-1
1040     IF Alt24(J)=Alt24(T) THEN EXIT TO,1070
1050   NEXT J
1060   T=T+1
1070 NEXT I
1080 CLOSE
1090 P=P-1:R=R-1:Q=Q-1:S=S-1
1100 T=T-1
1110 OPEN "C:AAA" AS #1 LEN=SIZE(P31)
1120 FOR I=1 TO P
1130   READ RECORD #1 Alt11(I) P31
1140   IF Mat$="1" THEN ZZ=.6666
1150   IF Mat$="2" THEN ZZ=1
1160   IF Mat$="3" THEN ZZ=.70
1170   IF Mat$="4" THEN ZZ=1
1180   A1(I)=Mat1/(P31.MRR*ZZ)                          'MACHINING TIME
1190   B1(I)=Lots*(A1(I)+P31.LUT)                            'TIME PART ON MACHINE
1200   C1(I)=B1(I)*(P31.OC)+(P31.TC)*(A1(I))+P31.SC   'TOTAL COST/LOT
1210   D1(I)=C1(I)/Lots                                      'AVE. COST PER PART
1220   E1(I)=P31.TNR              '24=SPEED FOR 1020 STEEL AND CARBIDE TOLL
1230   F1(I)=P31.MRR*ZZ/(E1(I)*(P31.TAA*ZZ))         'N MRR/SPEED
1240   G1(I)=P31.TNR*.25                     'FINISH FEED
1250   H1(I)=F1(I)*1.1              'FINISH SPEED
1260 NEXT I
1270 FOR I=1 TO R
1280   READ RECORD #1 Alt13(I) P31
1290   IF Mat$="1" THEN ZZ=1
1300   IF Mat$="2" THEN ZZ=1
1310   IF Mat$="3" THEN ZZ=1
1320   IF Mat$="4" THEN ZZ=1
1330   A2(I)=.2*Nef+LENGTH/1000          '+LENGTH/FEED*ZZ 1000=1M/MIN
1340   B2(I)=(A2(I)+P31.LUT)*Lots          'TIME ON MACHINE ENTIRE LOT
1350   C2(I)=B2(I)*(P31.OC)+(P31.TC)*(A2(I)-.2*Nef)+P31.SC
1360   D2(I)=C2(I)/Lots                    'AVERAGE COST PER PART
1370   E2(I)=.25*P31.TW
1380   F2(I)=P31.MRR*ZZ/E2(I)
1390 NEXT I
1400 CLOSE
1410 OPEN "C:BBB" AS #1 LEN=SIZE(P31)
1420 FOR I=1 TO Q
1430   READ RECORD #1 Alt21(I) P31
1440   IF Mat$="1" THEN ZZ=.6666
1450   IF Mat$="2" THEN ZZ=1
1460   IF Mat$="3" THEN ZZ=.70
1470   IF Mat$="4" THEN ZZ=1
1480   IF P31.MRR=0 THEN P31.MRR=15000
1490   A3(I)=LENGTH/(P31.MRR*ZZ)
1500   B3(I)=Lots*(A3(I)+P31.LUT)            'TOTAL TIME ON MACHINE
```

```
1510   C3(I)=B3(I)*(P31.OC)+(P31.TC)*A3(I)+P31.SC 'TOTAL COST PER LOT
1520   D3(I)=C3(I)/Lots
1530   E3(I)=P31.TNR                  'CALCULATE TOOL FEED
1540   F3(I)=P31.MRR*ZZ/(E3(I)*(3.1415*(P31.TTD)^2/4))  'CALCULATE TOOL SPEED
1550 NEXT I
1560 FOR I=1 TO S
1570   READ RECORD #1 Alt23(I) P31
1580   IF Mat$="1" THEN ZZ=.6666
1590   IF Mat$="2" THEN ZZ=1
1600   IF Mat$="3" THEN ZZ=.7
1610   IF Mat$="4" THEN ZZ=1
1620   A4(I)=Mat2/(P31.MRR*ZZ)
1630   B4(I)=Lots*(A4(I)+P31.LUT)                  'TOTAL TIME ON MACH.
1640   C4(I)=B4(I)*(P31.OC)+(P31.TC)*(A4(I))+P31.SC  'TOTAL COST
1650   D4(I)=C4(I)/Lots
1660   E4(I)=P31.TNR          'TOOL FEED
1670   F4(I)=P31.MRR*ZZ/(P31.TAA*E4(I))       'TOOL SPEED  mm/min
1680   G4(I)=P31.TNR*.25
1690   H4(I)=F4(I)*1.1
1700 NEXT I
1710 FOR I=1 TO T
1720   READ RECORD #1 Alt24(I) P31
1730   IF Mat$="1" THEN ZZ=1
1740   IF Mat$="2" THEN ZZ=1
1750   IF Mat$="3" THEN ZZ=1
1760   IF Mat$="4" THEN ZZ=1
1770   A5(I)=.2*Nif*ZZ+LENGTH/1000     ' LENGTH/1000=1M/MIN
1780   B5(I)=Lots*(A5(I)+P31.LUT)     'TOTAL TIME OF PART HADLING+MACHINING
1790   C5(I)=B5(I)*(P31.OC)+(P31.TC)*(A5(I)-.2*Nif)+P31.SC
1800   D5(I)=C5(I)/Lots
1810   IF P31.TW=0 THEN P31.TW=25
1820   E5(I)=.25*P31.TW
1830   F5(I)=P31.MRR*ZZ/(E5(I))
1840 NEXT I
1850 CLOSE
1860 OPEN "C:AAA" AS #1 LEN=SIZE(P31)
1870 OPEN "C:BBB" AS #2 LEN=SIZE(P31)
1880 Z=1
1890 FOR I=1 TO P
1900   FOR J=1 TO R
1910     FOR K=1 TO Q
1920       FOR L=1 TO S
1930         FOR M=1 TO T
1940           AC=D1(I)+D3(K)+D4(L)
1950           IF GR1(I)="Y" THEN AC=AC+D2(J)
1960           IF GR2(L)="Y" THEN AC=AC+D5(M)
1970           READ RECORD #1 Alt11(I) P31
1980           MM=P31.TN$
1990           IF GR1(I)="N" THEN GOTO 2030
2000           READ RECORD #1 Alt13(J) P31
2010           IF MM=P31.TN$ THEN AC=AC-.5*P31.SC/Lots
```

```
2020          MM=P31.TN$
2030          READ RECORD #2 Alt21(K) P31
2040          IF MM=P31.TN$ THEN AC=AC-.5*P31.SC/Lots
2050          MM=P31.TN$
2060          READ RECORD #2 Alt23(L) P31
2070          IF MM=P31.TN$ THEN AC=AC-.5*P31.SC/Lots
2080          MM=P31.TN$
2090          IF GR2(L)="N" THEN GOTO 2120
2100          READ RECORD #2 Alt24(M) P31
2110          IF MM=P31.TN$ THEN AC=AC-.5*P31.SC/Lots
2120          V1(Z)=I:X1(Z)=K:Y1(Z)=L
2130          IF GR1(I)="N" THEN W1(Z)=0 ELSE W1(Z)=J
2140          IF GR2(L)="N" THEN Z1(Z)=0 ELSE Z1(Z)=M
2150          IF Z<2 THEN GOTO 2190
2160          FOR A=1 TO Z-1
2170            IF V1(Z)=V1(A) AND W1(Z)=W1(A) AND X1(Z)=X1(A) AND Y1(Z)=Y1(A) AND Z1(Z)=Z1(A)
THEN EXIT TO,2270
2180          NEXT A
2190          Acc(Z)=AC
2200          IF Z<2 THEN GOTO 2260
2210          FOR A=1 TO Z-1
2220            IF Acc(A)<Acc(Z) THEN GOTO 2250
2230            SWAP Acc(A),Acc(Z):SWAP V1(A),V1(Z):SWAP W1(A),W1(Z):SWAP X1(A),X1(Z)
2240            SWAP Y1(A),Y1(Z):SWAP Z1(A),Z1(Z)
2250          NEXT A
2260          IF Z<25 THEN Z=Z+1
2270        NEXT M
2280      NEXT L
2290    NEXT K
2300  NEXT J
2310 NEXT I
2320 CLOSE
2330 LPRINT "****************************************************************************************
****************************"
2340 LPRINT:LPRINT TAB(6) "TODAYS DATE ",DDDD$;TAB(60) "LOT SIZE= ",Lots
2350 LPRINT:LPRINT TAB(6) "PART NAME= ",PN$, TAB(60) "PART NUMBER= ",PNU
2360 LPRINT:LPRINT "****************************************************************************************
**********************************"
2370 LPRINT
2380 OPEN "C:AAA" AS #1 LEN=SIZE(P31)
2390 OPEN "C:BBB" AS #2 LEN=SIZE(P31)
2400 LPRINT "                                                                    ROUGH CUT
     FINISH CUT"
2410 LPRINT "MACHINE      TOOL      MACHINE       TOTAL       AVE          PART        PART
  PART       PART"
2420 LPRINT "  #           #          TIME        COST/LOT    COST/PART     FEED        SPEED
  FEED       SPEED"
2430 LPRINT "                         (min)         ($)         ($)        (mm/RPM)    (mm/min)
(mm/RPM)   (mm/min"
2440 LPRINT "****************************************************************************************
**************************"
```

```
 2450 LPRINT
 2460 FOR I=1 TO 10
 2470   READ RECORD #1 Alt11(V1(I)) P31
 2480   LPRINT TAB(1) P31.TN$;TAB(12) P31.MN$;TAB(22) A1(V1(I));TAB(37) C1(V1(I));TAB(50) D1(V1(I
));TAB(65) E1(V1(I));TAB(75) F1(V1(
I));TAB(85) G1(V1(I));TAB(95) H1(V1(I))
 2490   IF W1(I)=0 THEN GOTO 2520
 2500   READ RECORD #1 Alt13(W1(I)) P31
 2510   LPRINT TAB(1) P31.TN$;TAB(12) P31.MN$;TAB(22) A2(W1(I));TAB(37) C2(W1(I));TAB(50) D2(W1(I
));TAB(85) E2(W1(I));TAB(95) F2(W1(
I))
 2520   READ RECORD #2 Alt21(X1(I)) P31
 2530   LPRINT TAB(1) P31.TN$;TAB(12) P31.MN$;TAB(22) A3(X1(I));TAB(37) C3(X1(I));TAB(50) D3(X1(I
));TAB(65) E3(X1(I));TAB(75) F3(X1(
I))
 2540   READ RECORD #2 Alt23(Y1(I)) P31
 2550   LPRINT TAB(1) P31.TN$;TAB(12) P31.MN$;TAB(22) A4(Y1(I));TAB(37) C4(Y1(I));TAB(50) D4(Y1(I
));TAB(65) E4(Y1(I));TAB(75) F4(Y1(
I));TAB(85) G4(Y1(I));TAB(95) H4(Y1(I))
 2560   IF Z1(I)=0 THEN GOTO 2590
 2570   READ RECORD #2 Alt24(Z1(I)) P31
 2580   LPRINT TAB(1) P31.TN$;TAB(12) P31.MN$;TAB(22) A5(Z1(I));TAB(37) C5(Z1(I));TAB(50) D5(Z1(I
));TAB(85) E5(Z1(I));TAB(95) F5(Z1(
I))
 2590   LPRINT
 2600   LPRINT TAB(20) "COST FOR THIS PLAN IS=" Acc(I)
 2610   LPRINT
 2620 NEXT I
 2630 CLOSE
ENDFILE
```

```
    2310 OPEN "C:AAA" AS #1 LEN=SIZE(P31)
    2320 OPEN "C:BBB" AS #2 LEN=SIZE(P31)
    2330 LPRINT "                                                                    ROUGH CUT
 FINISH CUT"
    2340 LPRINT "MACHINE      TOOL      MACHINE       TOTAL        AVE        PART      PART
PART   PART"
    2350 LPRINT "   #          #          TIME        COST/LOT    COST/PART   FEED      SPEED
FEED   SPEED"
    2360 LPRINT "################################################################################
#############"
    2370 LPRINT
    2380 FOR I=1 TO 20
    2390   READ RECORD #1 A1t11(V1(I)) P31
    2400   LPRINT TAB(1) P31.TN$;TAB(15) P31.MN$;TAB(22) A1(V1(I));TAB(35) C1(V1(I));TAB(50) D1(V
1(I));TAB(65) E1(V1(I));TAB(75) F1(
V1(I));TAB(85) G1(V1(I));TAB(95) H1(V1(I))
    2410   IF W1(I)=0 THEN GOTO 2440
    2420   READ RECORD #1 A1t13(W1(I)) P31
    2430   LPRINT TAB(1) P31.TN$;TAB(15) P31.MN$;TAB(22) A2(W1(I));TAB(35) C2(W1(I));TAB(50) D2(W
1(I));TAB(85) E2(W1(I));TAB(95) F2(
W1(I))
    2440   READ RECORD #2 A1t21(X1(I)) P31
    2450   LPRINT TAB(1) P31.TN$;TAB(15) P31.MN$;TAB(22) A3(X1(I));TAB(35) C3(X1(I));TAB(50) D3(X
1(I));TAB(65) E3(X1(I));TAB(75) F3(
X1(I))
    2460   READ RECORD #2 A1t23(Y1(I)) P31
    2470   LPRINT TAB(1) P31.TN$;TAB(15) P31.MN$;TAB(22) A4(Y1(I));TAB(35) C4(Y1(I));TAB(50) D4(Y
1(I));TAB(65) E4(Y1(I));TAB(75) F3(
Y1(I));TAB(85) G3(Y1(I));TAB(95) H4(Y1(I))
    2480   IF Z1(I)=0 THEN GOTO 2510
    2490   READ RECORD #2 A1t24(Z1(I)) P31
    2500   LPRINT TAB(1) P31.TN$;TAB(15) P31.MN$;TAB(22) A5(Z1(I));TAB(35) C5(Z1(I));TAB(50) D5(Z
1(I));TAB(85) E5(Z1(I));TAB(95) F5(
Z1(I))
    2510   LPRINT TAB(20) "COST FOR THIS METHOD IS=" Acc(I)
    2520   LPRINT
    2530 NEXT I
END PROCEDURE

'MAIN Program:


   10 WIDTH "LPT1:",132
   20 DP=140:LP=550
   30 Nif=2:NEF=2:MAT$="2":GOTO 5600
   40 'PROGRAM TO DISPLAY THE OBJECTIVE OF THE PROGRAM
   50 CLS
   60 PRINT TAB(8)"#############################################################"
   70 PRINT TAB(8)"#                                                           #"
   80 PRINT TAB(8)"# PROGRAM TO AID IN THE DEVELOPMENT OF A MICRO-BASED #"
   90 PRINT TAB(8)"#                                                           #"
```

```
100 PRINT TAB(8)"*              PROCESS PLANNINS SYSTEM              *"
110 PRINT TAB(8)"*                                                   *"
120 PRINT TAB(8)"**            WRITTEN BY DAVID MELOCHE             **"
130 PRINT TAB(8)"*                                                   *"
140 PRINT TAB(8)"*                   FALL OF 1986                    *"
150 PRINT TAB(8)"*                                                   *"
160 PRINT TAB(8)"******************************************************"
170 GOSUB 5640
180 INPUT "PRESS <ENTER> TO CONTINUE";X
190 CLS
200 'PROGRAM TO FEATURES OF PART TO BE MANUFACTURED
210 PRINT TAB(8)"THIS PORTION OF THE PROGRAM WILL INTERROGATE YOU TO"
220 PRINT TAB(8)"DESCRIBE THE INDIVIDUAL FEATURES OF THE COMPONENT."
230 PRINT TAB(8)"YOU WILL REQUIRE SPECIFIC INFORMATION SUCH AS THE SHAPE"
240 PRINT TAB(8)"TO BE CREATED, ITS DIMENSIONS, LOCATION, TOLERENCE AND"
250 PRINT TAB(8)"SURFACE FINISH, AS WELL YOU ARE REQUIRED TO ANSWER "
260 PRINT TAB(8)"SPECIFIC YES/NO QUESTIONS CONCERNING THE COMPONENT"
270 GOSUB 5640
280 INPUT "PRESS <ENTER> TO CONTINUE";X
290 CLS
300 'PORTION TO INDICATE THE GENERAL INFORMATION
310 PRINT "GENERAL INFORMATION"
320 GOSUB 5680
330 INPUT "NAME OF OPERATOR";NAME$
340 INPUT "TODAYS DATE";DDDD$
350 INPUT "PART NUMBER";PNU
360 INPUT "PART NAME  ";PN$
370 GOSUB 5680
380 INPUT "PRESS <ENTER> TO CONTINUE";X
390 CLS
400 PRINT "SPECIFIC PART INFORMATION"
410 GOSUB 5680
420 PRINT TAB(8)" TYPES OF MATERIAL THE SYSTEM CAN CONSIDER"
430 PRINT " "
440 PRINT TAB(12)"FOR CAST IRON INPUT........(1)"
450 PRINT TAB(12)"FOR 1020 STEEL INPUT.......(2)"
460 PRINT TAB(12)"FOR 4140 STEEL INPUT.......(3)"
470 PRINT TAB(12)"FOR BRASS INPUT............(4)"
480 GOSUB 5680
490 INPUT "PART MATERIAL IS";MAT$
500 CLS
510 INPUT "IS PART ROTATIONAL Y/N";PR$
520 IF PR$="N" GOTO 2790
530 PRINT "INPUT THE DIMENSIONS OF THE RAW MATERIAL"
540 PRINT " "
550 INPUT "LENGTH OF PART  ";LP
560 INPUT "DIAMETER OF PART";DP
570 GOSUB 5680
580 INPUT "PRESS <ENTER> TO CONTINUE";X
590 CLS
600 PRINT "SPECIFIC FEATURE DESCRIPTION"
```

```
610 PRINT "DESCRIPTION OF EXTERNAL FEATURES"
620 GOSUB 5680
630 INPUT "ARE THERE ANY EXTERNAL TURNED FEATURES Y/N";A$
640 IF A$="N" GOTO 880
650 INPUT "NUMBER OF FEATURES";NEF
660 'SECTION TO DESRIBE THE EXTERNAL FEATURES
670 PRINT "STARTING FROM REFERENCE END USE S FOR STEPPED"
680 PRINT "AND T FOR TAPER TO DESCRIBE FEATURES OF THE PART"
690 OPEN "D:EXTF.DAT" AS #1 LEN=SIZE(P10)
700 GOSUB 5680
710 INPUT "PRESS <RETURN> TO CONTINUE";X
720 FOR I=1 TO NEF
730   CLS
740   PRINT "FEATURE";I:PRINT " "
750   INPUT "S OR T";P10.EF$
760   IF P10.EF$="T" GOTO 810
770   GOSUB 5720
780   P10.L=AA :P10.TL=AAA :P10.D=BB :P10.TD=BBB :P10.SF=CCC :P10.TH$=DD$
790   WRITE RECORD #1,I,P10
800   GOTO 840
810   GOSUB 5830
820   P10.L=EE:P10.TL=EEE:P10.SD=FF:P10.TSD=FFF:P10.FD=GG:P10.TFD=GGG:P10.SF=HH
830   WRITE RECORD #1,I,P10
840 NEXT I
850 CLOSE 1
860 GOSUB 5680
870 INPUT "PRESS <ENTER> TO CONTINUE";X
880 CLS
890 PRINT "DESCRIPTION OF INTERNAL FEATURES"
900 PRINT " "
910 INPUT "ARE THERE ANY INTERNAL FEATURES ALONG THE AXIS OF THE PART (Y/N)";B$
920 IF B$="N" GOTO 1700
930 INPUT "DO THE FEATURES PASS THROUGH THE ENTIRE PART (Y/N)";C$
940 IF C$="N" GOTO 1230
950 INPUT "NUMBER OF INTERNAL FEATURES";Nif
960 'SECTION TO DESCRIBE THE INTERNAL FEATURES
970 CLS
980 PRINT "STARTING FROM REFERENCE END USE S FOR STEPPED "
990 PRINT "AND T FOR TAPERED TO DESCRIBE THE FEATURES"
1000 PRINT "OF THE FINISHED PART"
1010 OPEN "D:INTF.DAT" AS #1 LEN=SIZE(P11)
1020 GOSUB 5680
1030 INPUT "PRESS <ENTER> TO CONTINUE";X
1040 FOR I=1 TO Nif
1050   CLS
1060   PRINT "FEATURE";I:PRINT " "
1070   INPUT "S OR T";P11.IFA$
1080   IF P11.IFA$="T" GOTO 1130
1090   GOSUB 5720
1100   P11.LA=AA:P11.TLA=AAA:P11.DA=BB:P11.TDA=BBB:P11.SFA=CCC:P11.THA$=DD$
1110   WRITE RECORD #1,I,P11
```

```
1120   GOTO 1170
1130   GOSUB 5830
1140   P11.LA=EE:P11.TLA=EEE:P11.SDA=FF:P11.TSDA=FFF:P11.FDA=GG:P11.TFDA=GGG
1150   P11.SFA=HH
1160   WRITE RECORD #1,I,P11
1170 NEXT I
1180 CLOSE
1190 GOSUB 5680
1200 INPUT "PRESS <ENTER> TO CONTINUE";X
1210 CLS
1220 GOTO 1700
1230 INPUT "ARE THERE ANY INTERNAL FEATURES AT REFERENCE END Y/N";D$
1240 IF D$="N" GOTO 1470
1250 INPUT "NUMBER OF FEATURES AT REFERENCE END";Nifr
1260 PRINT " "
1270 PRINT "STARTING FROM REFERENCE END USE S FOR STEPPED AND T"
1280 PRINT "FOR TAPERED TO DESCRIBE FINISHED COMPONENT"
1290 OPEN "D:INTFR" AS #1 LEN=SIZE(P12)
1300 GOSUB 5680
1310 INPUT "PRESS <ENTER> TO CONTINUE";X
1320 FOR I=1 TO Nifr
1330   CLS
1340   PRINT "FEATURE";I:PRINT " "
1350   INPUT "S OR T";P12.IFRB$
1360   IF P12.IFRB$="T" GOTO 1400
1370   GOSUB 5720
1380   P12.LB=AA:P12.TLB=AAA:P12.DB=BB:P12.TDB=BBB:P12.SFB=CC:P12.THB$=DD$
1390   GOTO 1430
1400   GOSUB 5830
1410   P12.LB=EE:P12.TLB=EEE:P12.SDB=FF:P12.TSDB=FFF
1420   P12.FDB=GG:P12.TFDB=GGG:P12.SFB=HH
1430   WRITE RECORD #1,I,P12
1440 NEXT I
1450 CLOSE
1460 CLS
1470 INPUT "ARE THERE ANY INTERNAL FEATURES AT OPPOSITE END Y/N";E$
1480 IF E$="N" GOTO 1700
1490 INPUT "NUMBER OF FEATURES AT OPPOSITE END";Nifo
1500 PRINT " "
1510 PRINT "STARTING FROM OPPOSITE END USE S FOR STEPPED AND T"
1520 PRINT "FOR TAPERED TO DESCRIBE FINISHED FEATURES"
1530 OPEN "D:INTFO" AS #1 LEN=SIZE(P13)
1540 GOSUB 5680
1550 INPUT "PRESS <ENTER> TO CONTINUE";X
1560 FOR I=1 TO Nifo
1570   CLS
1580   PRINT "FEATURE";I:PRINT " "
1590   INPUT "S OR T";P13.IFOc$
1600   IF P13.IFOc$="T" GOTO 1640
1610   GOSUB 5720
1620   P13.LC=AA:P13.TLC=AAA:P13.DC=BB:P13.TDC=BBB:P13.SFC=CC:P13.THC$=DD$
```

```
1630   GOTO 1670
1640   GOSUB 5830
1650   P13.LC=EE:P13.TLC=EEE:P13.SDC=FF:P13.TSDC=FFF
1660   P13.FDC=GG:P13.TFDC=GGG:P13.SFC=HH
1670   WRITE RECORD #1,I,P13
1680 NEXT I
1690 CLOSE
1700 CLS
1710 INPUT "ARE THERE ANY DRILL HOLES PARALLEL TO AXIS Y/N";F$
1720 IF F$="N" GOTO 2140
1730 INPUT "ARE THERE ANY IN DIRECTION OF REFERENCE PLANE (Y/N)";G$
1740 IF G$="N" GOTO 1940
1750 INPUT "NUMBER IN DIRECTION OF REFERENCE PLANE";DHR
1760 OPEN "D:DRILLR" AS #1 LEN=SIZE(P14)
1770 FOR I=1 TO DHR
1780   CLS
1790   PRINT "DRILL HOLE";I:PRINT " "
1800   PRINT "DISTANCE FROM END ="
1810   PRINT "DEPTH =          TOL ="
1820   PRINT "DIAMETER=        TOL ="
1830   PRINT "THREADED Y/N"
1840   LOCATE 3,20:INPUT " ",AA$:P14.DISD=VAL(AA$)
1850   LOCATE 4,8:INPUT " ",AA$:P14.DPD=VAL(AA$)
1860   LOCATE 4,22:INPUT " ",AA$:P14.TDPD=VAL(AA$)
1870   LOCATE 5,10:INPUT " ",AA$:P14.DD=VAL(AA$)
1880   LOCATE 5,22:INPUT " ",AA$:P14.TDD=VAL(AA$)
1890   LOCATE 6,14:INPUT " ",P14.THD$
1900   WRITE RECORD #1,I,P14
1910 NEXT I
1920 CLOSE
1930 CLS
1940 INPUT "ARE THERE ANY DRILL HOLES IN OPPOSITE DIRECTION Y/N";H$
1950 IF H$="N" GOTO 2140
1960 INPUT "NUMBER IN OPPOSITE DIRECTION";DHO
1970 OPEN "D:DRILLO" AS #1 LEN =SIZE(P15)
1980 FOR I=1 TO DHO
1990   CLS
2000   PRINT "DRILL HOLE";I:PRINT " "
2010   PRINT "DISTANCE FROM OPPOSITE END="
2020   PRINT "DEPTH=           TOL="
2030   PRINT "DIAMETER=        TOL="
2040   PRINT "THREAD Y/N"
2050   LOCATE 3,28:INPUT " ",P15.DISE
2060   LOCATE 4,7:INPUT " ",AA$:P15.DPE=VAL(AA$)
2070   LOCATE 4,21:INPUT " ",AA$:P15.TDPE=VAL(AA$)
2080   LOCATE 5,10:INPUT " ",AA$:P15.DE=VAL(AA$)
2090   LOCATE 5,21:INPUT " ",AA$:P15.TDE=VAL(AA$)
2100   LOCATE 6,12:INPUT " ",P15.THe$
2110   WRITE RECORD #1,I,P15
2120 NEXT I
2130 CLOSE
```

```
2140 CLS
2150 INPUT "ARE THERE ANY DRILL HOLES ON THE EXTERNAL SURFACE Y/N";I$
2160 IF I$="N" GOTO 2340
2170 INPUT "NUMBER OF DRILL HOLES ON EXTERNAL SURFACE";EDH
2180 OPEN "D:EXDRILL" AS #1 LEN =SIZE(P16)
2190 FOR I=1 TO EDH
2200   CLS:PRINT "DRILL HOLE";I:PRINT " "
2210   PRINT "DISTANCE FROM REFERENCE END="
2220   PRINT "DEPTH=        TOL="
2230   PRINT "DIAMETER=     TOL="
2240   PRINT "THREADED Y/N"
2250   LOCATE 3,28:INPUT " ",P16.EDRF
2260   LOCATE 4,7:INPUT " ",AA$:P16.DPF=VAL(AA$)
2270   LOCATE 4,19:INPUT " ",P16.TDPF
2280   LOCATE 5,10:INPUT " ",AA$:P16.DF=VAL(AA$)
2290   LOCATE 5,19:INPUT " ",P16.TDF
2300   LOCATE 6,14:INPUT " ",P16.THF$
2310   WRITE RECORD #1,I,P16
2320 NEXT I
2330 CLOSE
2340 CLS
2350 INPUT "ARE THERE ANY INTERNAL KEYWAYS Y/N";J$
2360 IF J$="N" GOTO 2560
2370 INPUT "NUMBER OF INTERNAL KEYWAYS";INK
2380 OPEN "D:INTKEY" AS #1 LEN=SIZE(P17)
2390 FOR I=1 TO INK
2400   CLS:PRINT "INTERNAL KEYWAY";I:PRINT " "
2410   PRINT "STARTING DISTANCE FROM REFERENCE END="
2420   PRINT "FINISHING DISTANCE FROM REFERENCE END="
2430   PRINT "WIDTH=        TOL="
2440   PRINT "DEPTH=        TOL="
2450   PRINT "SURFACE FINISH="
2460   LOCATE 3,39:INPUT " ",P17.STDG
2470   LOCATE 4,39:INPUT " ",P17.FNDG
2480   LOCATE 5,7:INPUT " ",AA$:P17.IWDG=VAL(AA$)
2490   LOCATE 5,19:INPUT " ",P17.TIWDG
2500   LOCATE 6,7:INPUT " ",AA$:P17.IDPG=VAL(AA$)
2510   LOCATE 6,19:INPUT " ",P17.TIDPG
2520   LOCATE 7,16:INPUT " ",P17.IKSFG
2530   WRITE RECORD #1,I,P17
2540 NEXT I
2550 CLOSE
2560 CLS
2570 INPUT "ARE THERE ANY EXTERNAL KEYWAYS Y/N";K$
2580 IF K$="N" GOTO 2770
2590 INPUT "NUMBER OF EXTERNAL KEYWAYS";EXK
2600 OPEN "D:EXTKEY" AS #1 LEN=SIZE(P18)
2610 FOR I=1 TO EXK
2620   CLS:PRINT "EXTERNAL KEYWAY";I:PRINT " "
2630   PRINT "STARTING DISTANCE FROM REFERENCE END="
2640   PRINT "FINISHING DISTANCE FROM REFERENCE END="
```

```
2650   PRINT "WIDTH=        TOL="
2660   PRINT "DEPTH=        TOL="
2670   PRINT "SURFACE FINISH="
2680   LOCATE 3,38:INPUT " ",P18.STDH
2690   LOCATE 4,39:INPUT " ",P18.FNDH
2700   LOCATE 5,7:INPUT " ",AA$:P18.EWDH=VAL(AA$)
2710   LOCATE 5,20:INPUT " ",P18.TEWDH
2720   LOCATE 6,7:INPUT " ",AA$:P18.EDPH=VAL(AA$)
2730   LOCATE 6,20:INPUT " ",P18.TEDPH
2740   LOCATE 7,16:INPUT " ",P18.EKSFH
2750   WRITE RECORD #1,I,P18
2760 NEXT I
2770 CLOSE
2780 GOTO 5510
2790 CLS
2800 PRINT "THIS SECTION WILL INTERROGATE YOU TO DESCRIBE"
2810 PRINT "THE FEATURES TO BE REMOVED TO MAKE THE FINISHED"
2820 PRINT "COMPONENT. THE INITIAL SHAPE MUST BE ONE OF THE "
2830 PRINT "FOLLOWING RECTANGLE, TRIANGLE, TRAPIZOID OR ROMBOID"
2840 PRINT "TO DESCRIBE PRISMATIC COMPONENTS YOU MUST SET UP A"
2850 PRINT "GLOBAL FRAME OF REFERENCE IN WHICH NO PART OF THE"
2860 PRINT "COMPONENT HAS A NEGATIVE COORDINATE POINT"
2870 GOSUB 5680
2880 INPUT "PRESS <ENTER> TO CONTINUE";X
2890 CLS
2900 OPEN "PRIS" AS #1 LEN=SIZE(P30)
2910 PRINT "$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$"
2920 PRINT "$                                                $"
2930 PRINT "$ STARTING SHAPE OF RAW MATERIAL IS              $"
2940 PRINT "$                                                $"
2950 PRINT "$    RECTANGLE          INPUT <RECT>             $"
2960 PRINT "$    TRIANGLE           INPUT <TRIA>             $"
2970 PRINT "$    TRAPEZOID          INPUT <TRAP>             $"
2980 PRINT "$    ROMBOID            INPUT <ROMB>             $"
2990 PRINT "$                                                $"
3000 PRINT "$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$"
3010 GOSUB 5680
3020 INPUT "SHAPE OF INITIAL RAW MATERIAL IS";P30.PRIST$
3030 CLS
3040 IF P30.PRIST$="RECT" THEN GOTO 3050 ELSE GOTO 3120
3050 PRINT "LENGTH OF RECTANGLE="
3060 PRINT "WIDTH OF RECTANGLE="
3070 PRINT "HEIGHT OF RECTANGLE="
3080 LOCATE 1,21:INPUT " ",AA
3090 LOCATE 2,20:INPUT " ",BB
3100 LOCATE 3,21:INPUT " ",CC
3110 GOTO 3400
3120 IF P30.PRIST$="TRIA" THEN GOTO 3130 ELSE GOTO 3220
3130 PRINT "LENGTH OF TRIANGLE="
3140 PRINT "BASE WIDTH OF TRIANGLE="
3150 PRINT "HEIGHT OF TRIANGLE="
```

```
3160 PRINT "ANGLE AT CORNER (0,0,0)="
3170 LOCATE 1,21:INPUT " ",AA
3180 LOCATE 2,25:INPUT " ",BB
3190 LOCATE 3,21:INPUT " ",CC
3200 LOCATE 4,26:INPUT " ",EE
3210 GOTO 3400
3220 IF P30.PRIST$="TRAP" THEN GOTO 3230 ELSE GOTO 3320
3230 PRINT "LENGTH OF TRAPEZOID="
3240 PRINT "BOTTOM WIDTH="
3250 PRINT "TOP WIDTH="
3260 PRINT "HEIGHT="
3270 LOCATE 1,22:INPUT " ",AA
3280 LOCATE 2,15:INPUT " ",BB
3290 LOCATE 3,12:INPUT " ",FF
3300 LOCATE 4,9:INPUT " ",CC
3310 GOTO 3400
3320 PRINT "LENGTH OF ROMBOID="
3330 PRINT "WIDTH OF ROMBOID="
3340 PRINT "HEIGHT OF ROMBOID="
3350 PRINT "ANGLE AT CORNER (0,0,0)="
3360 LOCATE 1,20:INPUT " ",AA
3370 LOCATE 2,19:INPUT " ",BB
3380 LOCATE 3,20:INPUT " ",CC
3390 LOCATE 4,26:INPUT " ",EE
3400 P30.LT=AA:P30.TLT=AAA:P30.BT=BB:P30.TBT=BBB:P30.HT=CC:P30.THT=CCC
3410 P30.XAT=XXA:P30.XBT=XXB:P30.XCT=XXC:P30.YAT=YYA:P30.YBT=YYB
3420 P30.YCT=YYC:P30.ZAT=ZZA:P30.ZBT=ZZB:P30.ZCT=ZZC
3430 WRITE RECORD #1,,P30
3440 CLOSE
3450 CLS
3460 PRINT "DESCRIPTION OF EXTERNAL SURFACES TO BE MACHINED"
3470 PRINT " "
3480 INPUT "ARE THERE EXTERNAL SURFACES TO BE MACHINED (Y/N)";L$
3490 IF L$="N" GOTO 3830
3500 INPUT "NUMBER OF SURFACES";NS
3510 OPEN "EXTS" AS #1 LEN=SIZE(P20)
3520 FOR I=1 TO NS
3530   CLS
3540   PRINT "************************************************"
3550   PRINT "*  SHAPE TO BE REMOVED IS                      *"
3560   PRINT "*                                              *"
3570   PRINT "*   RECTANGLE     INPUT <RECT>                 *"
3580   PRINT "*   TRIANGLE      INPUT <TRIA>                 *"
3590   PRINT "*   TRAPEZOID     INPUT <TRAP>                 *"
3600   PRINT "*   ROMBOID       INPUT <ROMB>                 *"
3610   PRINT "*                                              *"
3620   PRINT "************************************************"
3630   GOSUB 5680
3640   INPUT "SHAPE TO BE REMOVED";P20.EXSK$
3650   IF P20.EXSK$="RECT" THEN GOSUB 5950 ELSE GOTO 3680
3660   P20.DIRK$=DD$
```

```
3670   GOTO 3760
3680   IF P20.EXSK$="TRIA" THEN GOSUB 6260 ELSE GOTO 3710
3690   P20.AK=EE:P20.DIRK$=DD$
3700   GOTO 3760
3710   IF P20.EXSK$="TRAP" THEN GOSUB 6610 ELSE GOTO 3740
3720   P20.UBK=FF:P20.TUBK=FFF:P20.DIRK$=DD$
3730   GOTO 3760
3740   IF P20.EXSK$="ROMB" THEN GOSUB 6970
3750   P20.AK=EE:P20.DIRK$=DD$
3760   P20.LK=AA:P20.TLK=AAA:P20.BK=BB:P20.TBK=BBB:P20.HK=CC:P20.THK=CCC
3770   P20.SFK=GG:P20.XAK=XXA:P20.XBK=XXB:P20.XCK=XXC:P20.YAK=YYA
3780   P20.YBK=YYB:P20.YCK=YYC:P20.ZAK=ZZA:P20.ZBK=ZZB:P20.ZCK=ZZC
3790   WRITE RECORD #1,I,P20
3800 NEXT I
3810 CLOSE
3820 GOSUB 5680
3830 INPUT "PRESS <ENTER> TO CONTINUE";X
3840 CLS
3850 PRINT "ARE THERE ANY EXTERNAL FEATURES OTHER THEN SURFACES"
3860 INPUT "TO BE REMOVED Y/N";M$
3870 IF M$="N" GOTO 4280
3880 INPUT "NUMBER OF FEATURES TO BE REMOVED";NEFR
3890 OPEN "EXTFE" AS #1 LEN=SIZE(P21)
3900 FOR I=1 TO NEFR
3910   CLS
3920   PRINT "***********************************************"
3930   PRINT "*                                             *"
3940   PRINT "* SHAPE TO BE REMOVED IS                      *"
3950   PRINT "*                                             *"
3960   PRINT "*  RECTANGLE            INPUT <RECT>          *"
3970   PRINT "*  TRIANGLE             INPUT <TRIA>          *"
3980   PRINT "*  TRAPEZOID            INPUT <TRAP>          *"
3990   PRINT "*  ROMBOID              INPUT <ROMB>          *"
4000   PRINT "*  PORTION OF CYLR.     INPUT <PCYL>          *"
4010   PRINT "*                                             *"
4020   PRINT "***********************************************"
4030   GOSUB 5680
4040   INPUT "SHAPE TO BE REMOVED";P21.EXFL$
4050   INPUT "DOES FEATURE RUN FROM SURFACE TO SURFACE (Y/N)",P21.RSLL$
4060   INPUT "DOES FEATURE RUN ALONG A EDGE (Y/N)",P21.RAE$
4070   IF P21.EXFL$="RECT" GOSUB 5950 ELSE GOTO 4100
4080   P21.DIRL$=DD$
4090   GOTO 4210
4100   IF P21.EXFL$="TRIA" GOSUB 6260 ELSE GOTO 4130
4110   P21.AL=EE:P21.DIRL$=DD$
4120   GOTO 4210
4130   IF P21.EXFL$="TRAP" GOSUB 6610 ELSE GOTO 4160
4140   P21.UBL=FF:P21.TUBL=FFF:P21.DIRL$=DD$
4150   GOTO 4210
4160   IF P21.EXFL$="ROMB" GOSUB 6970 ELSE GOTO 4190
4170   P21.AL=EE:P21.DIRL$=DD$
```

```
4180   GOTO 4210
4190   IF P21.EXFL$="PCYL" GOSUB 7320
4200   P21.AL=HH
4210   P21.LL=AA:P21.TLL=AAA:P21.BL=BB:P21.TBL=BBB:P21.HL=CC:P21.THL=CCC
4220   P21.SFL=GG:P21.XAL=XXA:P21.XBL=XXB:P21.XCL=XXC:P21.YAL=YYA
4230   P21.YBL=YYB:P21.YCL=YYC:P21.ZAL=ZZA:P21.ZBL=ZZB:P21.ZCL=ZZC
4240   WRITE RECORD #1,I,P21
4250 NEXT I
4260 CLOSE
4270 GOSUB 5680
4280 INPUT "PRESS <ENTER> TO CONTINUE";X
4290 CLS
4300 INPUT "ARE THERE ANY MAJOR INTERNAL FEATURES Y/N";N$
4310 IF N$="N" GOTO 4670
4320 INPUT "NUMBER OF SEPERATE INTERNAL GROUPS OF FEATURES";NSS
4330 OPEN "INTFEA" AS #1 LEN =SIZE(P22)
4340 PRINT "FOR EACH SEPERATE GROUP DESCRIBE THE SHAPES"
4350 GOSUB 5680
4360 INPUT "PRESS <ENTER> TO CONTINUE";X
4370 FOR I=1 TO NSS
4380   CLS
4390   PRINT "NUMBER OF SHAPES IN THE GROUP="
4400   PRINT "DOES FEATURE PASS THROUGH THE PART="
4410   PRINT "ARE THE SHAPES ROTATIONAL Y/N"
4420   PRINT "PARALLEL TO WHICH AXIS X/Y/Z"
4430   LOCATE 1,32:INPUT " ",P22.NSG
4440   LOCATE 2,37:INPUT " ",P22.NAM$
4450   LOCATE 3,32:INPUT " ",P22.NBM$
4460   LOCATE 4,32:INPUT " ",P22.NCM$
4470   CLS
4480   PRINT "STARTING FROM MAJOR SURFACE USE S FOR STEPPED"
4490   PRINT "AND T FOR TAPERED TO DESCRIBE THE FEATURES OF"
4500   PRINT "THE FINISHED PART"
4510   GOSUB 5680
4520   INPUT "PRESS <ENTER> TO CONTINUE";X
4530   FOR J=1 TO P22.NSG
4540     CLS:PRINT "FEATURE";I:PRINT " "
4550     INPUT "S OR T";P22.INFM$
4560     IF P22.INFM$="T" GOTO 4600
4570     GOSUB 5720
4580     P22.LM=AA:P22.TLM=AAA:P22.DM=BB:P22.TDM=BBB:P22.SFM=CC:P22.THM$=DD$
4590     GOTO 4630
4600     GOSUB 5830
4610     P22.LM=EE:P22.TLM=EEE:P22.SDM=FF:P22.TSDM=FFF
4620     P22.FDM=GG:P22.TFDM=GGG:P22.SFM=HH
4630     WRITE RECORD #1,I,P22
4640   NEXT J
4650 NEXT I
4660 CLOSE
4670 CLS
4680 PRINT "SECTION TO DESCRIBE THE EXTERNAL DRILL HOLES"
```

```
4690 PRINT " "
4700 INPUT "ARE THERE ANY EXTERNAL DRILL HOLES Y/N";O$
4710 IF O$="N" GOTO 5510
4720 GOSUB 5680
4730 INPUT "IN THE POSITIVE X DIRECTION Y/N";P$
4740 IF P$="N" GOTO 4850
4750 OPEN "DRILLX" AS #1 LEN=SIZE(P23)
4760 INPUT "NUMBER IN THE X DIRECTION";DHX
4770 FOR I=1 TO DHX
4780   CLS:PRINT "DRILL HOLE ";I:PRINT " "
4790   GOSUB 7670
4800   P23.DPN=AA:P23.TDPN=AAA:P23.DN=BB:P23.TDN=BBB:P23.SFN=CC
4810   P23.XN=XXA:P23.YN=YYA:P23.ZN=ZZA:P23.THN$=DD$
4820   WRITE RECORD #1,I,P23
4830 NEXT I
4840 CLOSE
4850 CLS
4860 INPUT "ARE THERE ANY IN THE NEGATIVE X DIRECTION";Q$
4870 IF Q$="N" GOTO 4990
4880 OPEN "DRILLNX" AS #1 LEN=SIZE(P24)
4890 INPUT "NUMBER IN NEGATIVE X DIRECTION";DHNX
4900 FOR I=1 TO DHNX
4910   CLS:PRINT "DRILL HOLE";I:PRINT " "
4920   GOSUB 7670
4930   P24.DPO=AA:P24.TDPO=AAA:P24.DOO=BB:P24.TDO=BBB:P24.SFO=CC
4940   P24.XO=XXA:P24.YO=YYA:P24.ZO=ZZA:P24.THO$=DD$
4950   WRITE RECORD #1,I,P24
4960 NEXT I
4970 CLOSE
4980 CLS
4990 INPUT "ARE THERE ANY IN THE POSITIVE Y DIRECTION";R$
5000 IF R$="N" GOTO 5110
5010 OPEN "DRILLY" AS #1 LEN=SIZE (P25)
5020 INPUT "NUMBER IN POSITIVE Y DIRECTION";DHY
5030 FOR I=1 TO DHY
5040   CLS:PRINT "DRILL HOLE";I:PRINT " "
5050   GOSUB 7670
5060   P25.DPP=AA:P25.TDPP=AAA:P25.DDP=BB:P25.TDDP=BBB:P25.SFP=CC
5070   P25.XP=XXA:P25.YP=YYA:P25.ZP=ZZA:P25.THP$=DD$
5080   WRITE RECORD #1,I,P25
5090 NEXT I
5100 CLOSE
5110 CLS
5120 INPUT "ARE THERE ANY DRILL HOLES IN THE NEGATIVE Y DIRECTION";S$
5130 IF S$="N" GOTO 5240
5140 INPUT "NUMBER IN NEGATIVE Y DIRECTION";DHNY
5150 OPEN "DRILLNY" AS #1 LEN=SIZE(P26)
5160 FOR I=1 TO DHNY
5170   CLS:PRINT "DRILL HOLE";I:PRINT " "
5180   GOSUB 7670
5190   P26.DPQ=AA:P26.TDPQ=AAA:P26.DQ=BB:P26.TDQ=BBB:P26.SFQ=CC
```

```
5200   P26.X0=XXA:P26.Y0=YYA:P26.Z0=ZZA:P26.THO$=DD$
5210   WRITE RECORD #1,I,P26
5220 NEXT I
5230 CLOSE
5240 CLS
5250 INPUT "ARE THERE ANY DRILL HOLES IN THE POSITIVE Z DIRECTION";T$
5260 IF T$="N" GOTO 5370
5270 INPUT "NUMBER IN POSITIVE Z DIRECTION";DHZ
5280 OPEN "DRILLZ" AS #1 LEN=SIZE(P27)
5290 FOR I=1 TO DHZ
5300   CLS:PRINT "DRILL HOLE";I:PRINT " "
5310   GOSUB 7670
5320   P27.DPR=AA:P27.TDPR=AAA:P27.DR=BB:P27.TDR=BBB:P27.SFR=CC
5330   P27.XR=XXA:P27.YR=YYA:P27.ZR=ZZA:P27.THR$=DD$
5340   WRITE RECORD #1,I,P27
5350 NEXT I
5360 CLOSE
5370 CLS
5380 INPUT "ARE THERE ANY IN THE NEGATIVE Z DIRECTION";U$
5390 IF U$="N" GOTO 5510
5400 INPUT "NUMBER IN NEGATIVE Z DIRECTION";DHNZ
5410 OPEN "DRILLNZ" AS #1 LEN=SIZE(P28)
5420 FOR I=1 TO DHNZ
5430   CLS:PRINT "DRILL HOLE";I:PRINT " "
5440   GOSUB 7670
5450   P28.DPS=AA:P28.TDPS=AAA:P28.DDS=BB:P28.TDDS=BBB:P28.SFS=CC
5460   P28.XS=XXA:P28.YS=YYA:P28.ZS=ZZA:P28.THS$=DD$
5470   WRITE RECORD #1,I,P28
5480   GOSUB 5680
5490 NEXT I
5500 CLOSE
5510 CLS
5520 PRINT "$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$"
5530 PRINT "$                                                      $"
5540 PRINT "$ THIS COMPLETES THE SECTION OF PART DESCRIPTION       $"
5550 PRINT "$ THE SYSTEM WILL KNOW DETERMINE THE OPTIMUM PROCESS $"
5560 PRINT "$ PLAN BASED ON THE DESCRIPTION YOU PROVIDED AND THE $"
5570 PRINT "$ MACHINES YOU HAVE AVAILABLE IN YOUR SHOP            $"
5580 PRINT "$                                                      $"
5590 PRINT "$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$"
5600 Mach
5610 INPUT "THE NUMBER OF PARTS IN THE LOT=";Lots
5620 Both
5630 STOP:END
5640 FOR II=1 TO 10
5650   PRINT " "
5660 NEXT II
5670 RETURN
5680 FOR II=1 TO 5
5690   PRINT " "
5700 NEXT II
```

```
5710 RETURN
5720 PRINT "LENGTH=          TOL="
5730 PRINT "DIAMETER=        TOL="
5740 PRINT "SURFACE FINISH="
5750 PRINT "THREADED Y/N"
5760 LOCATE 4,8:INPUT " ",AA$:AA=VAL(AA$)
5770 LOCATE 4,23:INPUT " ",AAA
5780 LOCATE 5,10:INPUT " ",AA$:BB=VAL(AA$)
5790 LOCATE 5,23:INPUT " ",BBB
5800 LOCATE 6,16 :INPUT " ",CCC
5810 LOCATE 7,13:INPUT " ",DD$
5820 RETURN
5830 PRINT "LENGTH=          TOL="
5840 PRINT "START.DIA.=      TOL="
5850 PRINT "FINISH DIA.=     TOL="
5860 PRINT "SURFACE FINISH="
5870 LOCATE 4,8:INPUT " ",AA$:EE=VAL(AA$)
5880 LOCATE 4,23:INPUT " ",EEE
5890 LOCATE 5,12:INPUT " ",AA$:FF=VAL(AA$)
5900 LOCATE 5,23:INPUT " ",FFF
5910 LOCATE 6,13:INPUT " ",AA$:GG=VAL(AA$)
5920 LOCATE 6,23:INPUT " ",GGG
5930 LOCATE 7,16:INPUT " ",HH
5940 RETURN
5950 CLS
5960 PRINT "LENGTH OF RECTANGLE=          TOL="
5970 PRINT "WIDTH OF RECTANGLE=           TOL="
5980 PRINT "HEIGHT OF RECTANGLE=          TOL="
5990 PRINT "SURFACE FINISH OF FEATURE="
6000 PRINT "  "
6010 PRINT "LOCATE THREE CORNER PTS ON ONE FACE OF RECTANGLE"
6020 PRINT "FIRST CORNER PT;  X=     Y=      Z="
6030 PRINT " "
6040 PRINT "SECOND CORNER PT; X=     Y=      Z="
6050 PRINT " "
6060 PRINT "THIRD CORNER PT;  X=     Y=      Z="
6070 PRINT " ":PRINT "DIRECTION OF TRAVEL OF RECTANGLE IS <X OR Y OR Z>"
6080 LOCATE 1,21:INPUT " ",AA$:AA=VAL(AA$)
6090 LOCATE 1,36:INPUT " ",AAA
6100 LOCATE 2,20:INPUT " ",AA$:BB=VAL(AA$)
6110 LOCATE 2,36:INPUT " ",BBB
6120 LOCATE 3,21:INPUT " ",AA$:CC=VAL(AA$)
6130 LOCATE 3,36:INPUT " ",CCC
6140 LOCATE 4,27:INPUT " ",GG
6150 LOCATE 7,21:INPUT " ",AA$:XXA=VAL(AA$)
6160 LOCATE 7,28:INPUT " ",AA$:YYA=VAL(AA$)
6170 LOCATE 7,36:INPUT " ",ZZA
6180 LOCATE 9,21:INPUT " ",AA$:XXB=VAL(AA$)
6190 LOCATE 9,28:INPUT " ",AA$:YYB=VAL(AA$)
6200 LOCATE 9,36:INPUT " ",ZZB
6210 LOCATE 11,21:INPUT " ",AA$:XXC=VAL(AA$)
```

```
6220 LOCATE 11,28:INPUT " ",AA$:YYC=VAL(AA$)
6230 LOCATE 11,36:INPUT " ",ZZC
6240 LOCATE 13,51:INPUT " ",DD$
6250 RETURN
6260 CLS
6270 PRINT "SECTION TO DESCRIBE THE TRIANGLE TO BE REMOVED"
6280 PRINT " "
6290 PRINT "LENGTH OF TRIANGLE=          TOL="
6300 PRINT "WIDTH OF TRIANGLE=           TOL="
6310 PRINT "             HIEGHT=         TOL="
6320 PRINT "SURFACE FINISH OF FEATURE="
6330 PRINT "ANGLE AT LEFT BASE="
6340 PRINT " "
6350 PRINT "LOCATE THREE CORNER PTS ON ONE FACE"
6360 PRINT " "
6370 PRINT "FIRST CORNER PT;  X=     Y=     Z="
6380 PRINT "SECOND CORNER PT; X=     Y=     Z="
6390 PRINT "THIRD CORNER PT;  X=     Y=     Z="
6400 PRINT " "
6410 PRINT "DIRECTION OF TRAVEL IS (X OR Y OR Z)";DD$
6420 LOCATE 3,20:INPUT " ",AA$:AA=VAL(AA$)
6430 LOCATE 3,36:INPUT " ",AAA
6440 LOCATE 4,20:INPUT " ",AA$:BB=VAL(AA$)
6450 LOCATE 4,36:INPUT " ",BBB
6460 LOCATE 5,20:INPUT " ",AA$:CC=VAL(AA$)
6470 LOCATE 5,36:INPUT " ",CCC
6480 LOCATE 6,27:INPUT " ",GG
6490 LOCATE 7,19:INPUT " ",EE
6500 LOCATE 11,20:INPUT " ",AA$:XXA=VAL(AA$)
6510 LOCATE 11,27:INPUT " ",AA$:YYA=VAL(AA$)
6520 LOCATE 11,35:INPUT " ",ZZA
6530 LOCATE 12,20:INPUT " ",AA$:XXB=VAL(AA$)
6540 LOCATE 12,27:INPUT " ",AA$:YYB=VAL(AA$)
6550 LOCATE 12,35:INPUT " ",ZZB
6560 LOCATE 13,20:INPUT " ",AA$:XXC=VAL(AA$)
6570 LOCATE 13,27:INPUT " ",AA$:YYC=VAL(AA$)
6580 LOCATE 13,35:INPUT " ",ZZC
6590 LOCATE 15,38:INPUT " ",DD$
6600 RETURN
6610 CLS
6620 PRINT "SECTION TO DESCRIBE THE TRAPEZOID TO BE REMOVED"
6630 PRINT " "
6640 PRINT "LENGTH OF TRAPEZOID=          TOL="
6650 PRINT "       BOTTOM WIDTH=          TOL="
6660 PRINT "             HIEGHT=          TOL="
6670 PRINT "          TOP WIDTH=          TOL="
6680 PRINT "SURFACE FINISH OF FEATURES="
6690 PRINT " "
6700 PRINT "LOCATE THREE CORNER PTS ON ONE FACE"
6710 PRINT " "
6720 PRINT "FIRST CORNER PT; X=     Y=     Z="
```

```
6730 PRINT "SECOND CORNER PT X=     Y=     Z="
6740 PRINT "THIRD CORNER PT; X=     Y=     Z="
6750 PRINT " "
6760 PRINT "DIRECTION OF TRAVEL IS <X OR Y OR Z>"
6770 LOCATE 3,21:INPUT " ",AA$:AA=VAL(AA$)
6780 LOCATE 3,36:INPUT " ",AAA
6790 LOCATE 4,21:INPUT " ",AA$:BB=VAL(AA$)
6800 LOCATE 4,36:INPUT " ",BBB
6810 LOCATE 5,21:INPUT " ",AA$:CC=VAL(AA$)
6820 LOCATE 5,36:INPUT " ",CCC
6830 LOCATE 6,21:INPUT " ",AA$:FF=VAL(AA$)
6840 LOCATE 6,36:INPUT " ",FFF
6850 LOCATE 7,28:INPUT " ",GG
6860 LOCATE 11,20:INPUT " ",AA$:XXA=VAL(AA$)
6870 LOCATE 11,26:INPUT " ",AA$:YYA=VAL(AA$)
6880 LOCATE 11,33:INPUT " ",ZZA
6890 LOCATE 12,20:INPUT " ",AA$:XXB=VAL(AA$)
6900 LOCATE 12,26:INPUT " ",AA$:YYB=VAL(AA$)
6910 LOCATE 12,33:INPUT " ",ZZB
6920 LOCATE 13,20:INPUT " ",AA$:XXC=VAL(AA$)
6930 LOCATE 13,26:INPUT " ",AA$:YYC=VAL(AA$)
6940 LOCATE 13,33:INPUT " ",ZZC
6950 LOCATE 15,38:INPUT " ",DD$
6960 RETURN
6970 CLS
6980 PRINT "SECTION TO DESCRIBE THE ROMBOID TO BE REMOVED"
6990 PRINT " "
7000 PRINT "LENETH OF FEATURE=            TOL="
7010 PRINT "    FEATURE WIDTH=            TOL="
7020 PRINT "   FEATURE HEIGHT=            TOL="
7030 PRINT "ANGLE OF FEATURE="
7040 PRINT "SURFACE FINISH OF FEATURE="
7050 PRINT " "
7060 PRINT "LOCATE THREE CORNER PTS ON ONE FACE"
7070 PRINT " "
7080 PRINT "FIRST CORNER PT;  X=     Y=     Z="
7090 PRINT "SECOND CORNER PT; X=     Y=     Z="
7100 PRINT "THIRD CORNER PT;  X=     Y=     Z="
7110 PRINT " "
7120 PRINT "DIRECTION OF TRAVEL IS <X OR Y OR Z>"
7130 LOCATE 3,19:INPUT " ",AA$:AA=VAL(AA$)
7140 LOCATE 3,34:INPUT " ",AAA
7150 LOCATE 4,19:INPUT " ",AA$:BB=VAL(AA$)
7160 LOCATE 4,34:INPUT " ",BBB
7170 LOCATE 5,19:INPUT " ",AA$:CC=VAL(AA$)
7180 LOCATE 5,34:INPUT " ",CCC
7190 LOCATE 6,19:INPUT " ",EE
7200 LOCATE 7,27:INPUT " ",GG
7210 LOCATE 11,21:INPUT " ",AA$:XXA=VAL(AA$)
7220 LOCATE 11,28:INPUT " ",AA$:YYA=VAL(AA$)
7230 LOCATE 11,35:INPUT " ",ZZA
```

```
7240 LOCATE 12,21:INPUT " ",AA$:XXB=VAL(AA$)
7250 LOCATE 12,28:INPUT " ",AA$:YYB=VAL(AA$)
7260 LOCATE 12,35:INPUT " ",ZZB
7270 LOCATE 13,21:INPUT " ",AA$:XXC=VAL(AA$)
7280 LOCATE 13,28:INPUT " ",AA$:YYC=VAL(AA$)
7290 LOCATE 13,35:INPUT " ",ZZC
7300 LOCATE 15,38:INPUT " ",DD$
7310 RETURN
7320 CLS
7330 PRINT "SECTION TO DESCRIBE THE PORTION OF A CYLINDER TO BE REMOVED"
7340 PRINT " "
7350 PRINT "LENGTH OF FEATURE=           TOL="
7360 PRINT "    WIDTH OF BASE=           TOL="
7370 PRINT "    HEIGHT OF ARC=           TOL="
7380 PRINT "RADIUS OF ARC="
7390 PRINT "SURFACE FINISH OF FEATURE="
7400 PRINT " "
7410 PRINT "LOCATION OF CENTER OF ONE BASE"
7420 PRINT "X=            Y=             Z="
7430 PRINT " "
7440 PRINT "LOCATION OF TOP OF ARC"
7450 PRINT "X=            Y=             Z="
7460 PRINT " "
7470 PRINT "LOCATION OF OPPOSITE END OF BASE"
7480 PRINT "X=            Y=             Z="
7490 LOCATE 3,19:INPUT " ",AA$:AA=VAL(AA$)
7500 LOCATE 3,34:INPUT " ",AAA
7510 LOCATE 4,19:INPUT " ",AA$:BB=VAL(AA$)
7520 LOCATE 4,34:INPUT " ",BBB
7530 LOCATE 5,19:INPUT " ",AA$:CC=VAL(AA$)
7540 LOCATE 5,34:INPUT " ",CCC
7550 LOCATE 6,19:INPUT " ",HH
7560 LOCATE 7,27:INPUT " ",GG
7570 LOCATE 10,3:INPUT " ",AA$:XXA=VAL(AA$)
7580 LOCATE 10,17:INPUT " ",AA$:YYA=VAL(AA$)
7590 LOCATE 10,32:INPUT " ",ZZA
7600 LOCATE 13,3:INPUT " ",AA$:XXB=VAL(AA$)
7610 LOCATE 13,17:INPUT " ",AA$:YYB=VAL(AA$)
7620 LOCATE 13,32:INPUT " ",ZZB
7630 LOCATE 16,3:INPUT " ",AA$:XXC=VAL(AA$)
7640 LOCATE 16,17:INPUT " ",AA$:YYC=VAL(AA$)
7650 LOCATE 16,32:INPUT " ",ZZC
7660 RETURN
7670 PRINT "   DEPTH=          TOL="
7680 PRINT "DIAMETER=          TOL="
7690 PRINT "SURFACE FINISH="
7700 PRINT "THREADED Y/N"
7710 PRINT " "
7720 PRINT "LOCATION OF DRILL HOLE"
7730 PRINT "X-COORDINATE="
7740 PRINT "Y-COORDINATE="
```

```
7750 PRINT "Z-COORDINATE="
7760 LOCATE 3,10:INPUT " ",AA$:AA=VAL(AA$)
7770 LOCATE 3,25:INPUT " ",AAA
7780 LOCATE 4,10:INPUT " ",AA$:BB=VAL(AA$)
7790 LOCATE 4,25:INPUT " ",BBB
7800 LOCATE 5,16:INPUT " ",CC
7810 LOCATE 6,14:INPUT " ",DD$
7820 LOCATE 9,14:INPUT " ",XXA
7830 LOCATE 10,14:INPUT " ",YYA
7840 LOCATE 11,14:INPUT " ",ZZA
7850 RETURN

ENDFILE
```

```
SOURCE
  10 LPRINT "********************************"
  20 LPRINT " OPERATION REQUIRED TO GENERATE "
  30 LPRINT " THE EXTERNAL FEATURES          "
  40 LPRINT "********************************"
  50 LPRINT:LPRINT
  60 OPEN "D:EXTF.DAT" AS #1 LEN=SIZE(P10)
  70 A=3.1415265:MATT=0
  80 FOR I=1 TO NEF
  90   READ RECORD #1 I P10
 100   IF P10.EF$="T" THEN GOTO 130
 110   MATT=MATT+(P10.L*(A*(DP)^2/4-A*(P10.D)^2/4))
 120   GOTO 140
 130   MATT=MATT+P10.L*((A*(DP)^2/4-A*(P10.FD)^2/4)+.5*(A*(P10.FD)^2/4-A*(P10.SD)^2/4))
 140 NEXT I
 150 CLOSE
 160 OPEN "D:ALT1" AS #1 LEN=SIZE(P40)
 170 OPEN "C:AAA" AS #2 LEN=SIZE(P31)
 180 OPEN "D:EXTF.DAT" AS #3 LEN=SIZE(P10)
 190 P=1:R=1
 200 AA1=AA1-1
 210 FOR I=1 TO AA1
 220   READ RECORD #1 I P40
 230   READ RECORD #2 P40.A1 P31
 240   TOL1=P31.TOL:SF1=P31.SUF
 250   IF P40.A3<0 THEN P40.A3=0
 260   IF P40.A3=0 THEN GOTO 300
 270   READ RECORD #2 P40.A3 P31
 280   TOL2=P31.TOL:SF2=P31.SUF
 290   GOTO 310
 300   TOL2=100:SF2=100
 310   IF TOL1>TOL2 THEN TOL1=TOL2
 320   IF SF1>SF2 THEN SF1=SF2
 330   FOR J=1 TO NEF
 340     READ RECORD #3 J P10
 350     IF P10.EF$="T" THEN GOTO 380
 360     IF TOL1<P10.TD AND SF1<P10.SF THEN GOTO 400
 370     EXIT TO,540
 380     IF TOL1<P10.TSD AND TOL1<P10.TFD AND SF1<P10.SF THEN GOTO 400
 390     EXIT TO,540
 400   NEXT J
 410   LET ALT11(P)=P40.A1
 420   IF P<2 THEN GOTO 460
 430   FOR J=1 TO P-1
 440     IF ALT11(J)=ALT11(P) THEN EXIT TO,480
 450   NEXT J
 460   IF P40.A3=0 THEN HH(P)="N" ELSE HH(P)="Y"
 470   P=P+1
 480   LET ALT13(R)=P40.A3
 490   IF R<2 THEN GOTO 530
 500   FOR J=1 TO R-1
```

```
510     IF ALT13(J)=ALT13(R) THEN EXIT TO,540
520   NEXT J
530   R=R+1
540 NEXT I
550 P=P-1:R=R-1
560 IF P>0 THEN GOTO 590
570 LPRINT "NO TURNING TOOLS AVAILABLE TO PERFORM THE OPERATIONS"
580 GOTO 1210
590 LPRINT "TOOLS AVAILABLE FOR TURNING":LPRINT:LPRINT
600 LPRINT "                                                              Rough
 cut          Finish cut"
610 LPRINT "MACHINE    TOOL     TIME PER      TOTAL        TOTAL      AVE     DEPTH    FEED
 SPEED      FEED     SPEED     GRI
NDING"
620 LPRINT "  #         #        PART         TIME         COST       COST    (mm)    (mm/RPM)
(mm/min)   (mm/RPM)  (mm/min)   REQ
UIRED"
630 FOR J=1 TO P
640   READ RECORD #2 ALT11(J) P31
650   IF MAT$="1" THEN ZZ=.6666
660   IF MAT$="2" THEN ZZ=1
670   IF MAT$="3" THEN ZZ=.70
680   IF MAT$="4" THEN ZZ=1
690   MTP=MATT/P31.MRR*ZZ+.2*NEF
700   TT=LOTS*(MTP+P31.LUT)             '
710   TC=TT*P31.OC+P31.TC*(MTP-.2*NEF)+P31.SC
720   ACP=TC/LOTS
730   DEP=P31.TNR                 'FEED RATE
740   LET AA(J)=MTP
750   LET BB(J)=TT
760   LET CC(J)=TC
770   LET DD(J)=ACP
780   LET FF(J)=DEP
790   DEP=P31.TAA*ZZ
800   LET EE(J)=DEP
810   DEP=(P31.MRR*ZZ)/(EE(J)*FF(J))
820   LET GG(J)=DEP
830 NEXT J
840 IF CHOICE$="PRR" THEN GOTO 1000
850 FOR I=1 TO P
860   FOR J=1 TO P
870     IF DD(I)>DD(J) THEN GOTO 970
880     SWAP ALT11(I),ALT11(J)
890     SWAP AA(I),AA(J)
900     SWAP BB(I),BB(J)
910     SWAP CC(I),CC(J)
920     SWAP DD(I),DD(J)
930     SWAP EE(I),EE(J)
940     SWAP FF(I),FF(J)
950     SWAP GG(I),GG(J)
960     SWAP HH(I),HH(J)
```

```
 970   NEXT J
 980 NEXT I
 990 GOTO 1140
1000 FOR I=1 TO P
1010   FOR J=1 TO P
1020     IF AA(I)>AA(J) THEN GOTO 1120
1030     SWAP ALT11(I),ALT11(J)
1040     SWAP AA(I),AA(J)
1050     SWAP BB(I),BB(J)
1060     SWAP CC(I),CC(J)
1070     SWAP DD(I),DD(J)
1080     SWAP EE(I),EE(J)
1090     SWAP FF(I),FF(J)
1100     SWAP GG(I),GG(J)
1110     SWAP HH(I),HH(J)
1120   NEXT J
1130 NEXT I
1140 FOR I=1 TO P
1150   READ RECORD #2 ALT11(I) P31
1160   DEP=P31.TNR*.25
1170   ACP=GG(I)*1.1
1180   LPRINT TAB(1) P31.TN$;TAB(11) P31.MN$;TAB(20) AA(I);TAB(33) BB(I);TAB(46) CC(I);TAB(57) D
D(I);TAB(68) EE(I);TAB (76) FF(I);T
AB(82) GG(I);TAB(95) DEP;TAB(104) ACP;TAB(119) HH(I)
1190 NEXT I
1200 LPRINT:LPRINT
1210 IF R>0 THEN GOTO 1240
1220 LPRINT "NO GRINDING TOOLS AVAILABLE TO PERFORM THE OPERATION"
1230 GOTO 1820
1240 LPRINT "GRINDING TOOLS AVAILABLE":LPRINT:LPRINT
1250 LPRINT "MACHINE     TOOL     TIME PER       TOTAL       TOTAL        AVE     DEPTH       FEED
      SPEED"
1260 LPRINT "   #           #         PART           TIME        COST        COST     (mm)       (mm/R
PM)    (RPM)"
1270 FOR J=1 TO R
1280   IF ALT13(R)=0 THEN GOTO 1480           'NEXT R
1290   READ RECORD #2 ALT13(R) P31
1300   IF MAT$="1" THEN ZZ=.6666
1310   IF MAT$="2" THEN ZZ=1.3333
1320   IF MAT$="3" THEN ZZ=1
1330   IF MAT$="4" THEN ZZ=2
1340   MTP=.2*NEF   '(+LENGTH/FEED)*ZZ
1350   TT=(MTP+P31.LUT)*LOTS
1360   TC=TT*P31.OC+P31.TC*(MTP-.2*NEF)+P31.SC
1370   ACP=TC/LOTS
1380   DEP=P31.TAA*ZZ
1390   LET AA(J)=MTP
1400   LET BB(J)=TT
1410   LET CC(J)=TC
1420   LET DD(J)=ACP
1430   LET EE(J)=DEP
```

```
1440   DEP=P31.TW*.25
1450   LET FF(J)=DEP
1460   DEP=P31.MRR*ZZ/(FF(J))
1470   LET GG(J)=DEP
1480 NEXT J
1490 IF CHOICE$="PRR" THEN GOTO 1640
1500 FOR I=1 TO R
1510   FOR J=1 TO R
1520     IF DD(I)<DD(J) THEN GOTO 1610
1530     SWAP ALT13(I),ALT13(J)
1540     SWAP AA(I),AA(J)
1550     SWAP BB(I),BB(J)
1560     SWAP CC(I),CC(J)
1570     SWAP DD(I),DD(J)
1580     SWAP EE(I),EE(J)
1590     SWAP FF(I),FF(J)
1600     SWAP GG(I),GG(J)
1610   NEXT J
1620 NEXT I
1630 GOTO 1770
1640 FOR I=1 TO R
1650   FOR J=1 TO R
1660     IF AA(I)<AA(J) THEN GOTO 1750
1670     SWAP ALT13(I),ALT13(J)
1680     SWAP AA(I),AA(J)
1690     SWAP BB(I),BB(J)
1700     SWAP CC(I),CC(J)
1710     SWAP DD(I),DD(J)
1720     SWAP EE(I),EE(J)
1730     SWAP FF(I),FF(J)
1740     SWAP GG(I),GG(J)
1750   NEXT J
1760 NEXT I
1770 FOR I=1 TO R
1780   IF ALT13(I)=0 THEN GOTO 1810             'NEXT I
1790   READ RECORD #2 ALT13(I) P31
1800   LPRINT TAB(1) P31.TN$;TAB(12) P31.MN$;TAB(23) AA(I);TAB(38) BB(I);TAB(49) CC(I);TAB(59) D
D(I);TAB(66) EE(I);TAB(79) FF(I);TA
B(89) GG(I)
1810 NEXT I
1820 CLOSE
1830 LPRINT:LPRINT
ENDFILE
SOURCE
  10 LPRINT "******************************"
  20 LPRINT "   OPERATIONS REQUIRED TO   "
  30 LPRINT "  GENERATE INTERNAL FEATURES "
  40 LPRINT " WHICH PASS THROUGH THE PART "
  50 LPRINT "******************************"
  60 LPRINT:LPRINT
  70 OPEN "D:INTF.DAT" AS #1 LEN=SIZE(P11)
```

```
 80 Matt=0:LENGTH=0
 90 Diam=1000000
100 FOR I=1 TO Nif
110   READ RECORD #1 I P11
120   LENGTH=LENGTH+P11.LA
130   IF P11.IFA$="T" THEN GOTO 170
140   Matt=Matt+(P11.LA*(3.1415*(P11.DA)^2/4))
150   IF Diam>P11.DA THEN Diam=P11.DA
160   GOTO 200
170   Matt=Matt+(P11.LA*((3.1415*(P11.SDA)^2/4)+(.5*(3.1415*(P11.FDA)^2/4)-3.1415*(P11.SDA)^2/4
)))
180   IF Diam>P11.SDA THEN Diam=P11.SDA
190   IF Diam>P11.FDA THEN Diam=P11.FDA
200 NEXT I
210 CLOSE
220 Matt=Matt-3.1415*LENGTH*(Diam)^2/4
230 OPEN "D:ALT2" AS #1 LEN=SIZE(P41)
240 OPEN "C:BBB" AS #2 LEN=SIZE(P31)
250 OPEN "D:INTF.DAT" AS #3 LEN=SIZE(P11)
260 P=1:R=1:Q=1
270 FOR I=1 TO Bb1
280   READ RECORD #1 I P41
290   READ RECORD #2 P41.B3 P31
300   Tol1=P31.TOL:Sf1=P31.SUF
310   IF P41.B4=0 THEN GOTO 340
320   READ RECORD #2 P41.B4 P31
330   Tol2=P31.TOL:Sf2=P31.SUF:GOTO 350
340   Tol2=100:Sf2=500
350   IF Tol1>Tol2 THEN Tol1=Tol2
360   IF Sf1>Sf2 THEN Sf1=Sf2
370   FOR J=1 TO Nif
380     READ RECORD #3 J P11
390     IF P11.IFA$="T" THEN GOTO 420
400     IF Tol1<P11.TDA AND Sf1<P11.SFA THEN GOTO 440          'NEXT J
410     EXIT TO,650                                            'NEXT I
420     IF Tol1<P11.TSDA AND Tol1<P11.TFDA AND Sf1<P11.SFA THEN GOTO 440
430     EXIT TO,650                                            'NEXT I
440   NEXT J
450   LET Alt21(P)=P41.B1
460   IF P<2 THEN GOTO 500
470   FOR A=1 TO P-1
480     IF Alt21(A)=Alt21(P) THEN EXIT TO,510
490   NEXT A
500   P=P+1
510   LET Alt23(R)=P41.B3
520   IF P41.B4=0 THEN GR$(R)="N" ELSE GR$(R)="Y"
530   IF R<2 THEN GOTO 570
540   FOR A=1 TO R-1
550     IF Alt23(A)=Alt23(R) THEN EXIT TO,580
560   NEXT A
570   R=R+1
```

```
580  IF P41.B4=0 THEN GOTO 650
590  LET Alt24(Q)=P41.B4
600  IF Q<2 THEN GOTO 640
610  FOR A=1 TO Q-1
620    IF Alt24(A)=Alt24(Q) THEN EXIT TO,650            'NEXT I
630  NEXT A
640  Q=Q+1
650 NEXT I
660 P=P-1:R=R-1:Q=Q-1
670 IF P>0 THEN GOTO 700
680 LPRINT " NO RECORDS AVAILABLE TO PERFORM THE DRILLING OPERATION"
690 GOTO 1180
700 LPRINT "DRILLING RECORDS AVAILABLE":LPRINT:LPRINT
710 LPRINT "MACHINE       TOOL       TIME PER       TOTAL       TOTAL       AVE        FE
ED      SPEED"
720 LPRINT "  #            #            PART            TIME         COST        COST       (mm/
RPM)    (mm/min)"
730 FOR I=1 TO P
740  READ RECORD #2 Alt21(I) P31
750  IF MAT$="1" THEN ZZ=.6666
760  IF MAT$="2" THEN ZZ=1
770  IF MAT$="3" THEN ZZ=.70
780  IF MAT$="4" THEN ZZ=1
790  AAA(I)=(LENGTH*3.1415*(Diam)^2/4)/P31.MRR*ZZ     'LENGTH/FEED RATE
800  BBB(I)=LOTS*(AAA(I)+P31.LUT)               'TOTAL TIME ON MACHINE
810  CCC(I)=BBB(I)*P31.OC+P31.TC*AAA(I)+P31.SC  'TOTAL COST PER LOT
820  DDD(I)=CCC(I)/LOTS                         'AVERAGE COST PER PART
830  IF P31.TNR=0 THEN P31.TNR=2
840  EEE(I)=P31.TNR*ZZ                          'CALCULATE TOOL FEED
850  FFF(I)=P31.MRR*ZZ/(EEE(I)*3.1415*(Diam)^2/4) 'CALCULATE TOOL SPEED
860 NEXT I
870 IF CHOICE$="PRR" THEN GOTO 1010
880 FOR I=1 TO P
890  FOR J=1 TO P
900    IF DDD(I)>DDD(J) THEN GOTO 980        'NEXT J
910    SWAP AAA(I),AAA(J)
920    SWAP BBB(I),BBB(J)
930    SWAP CCC(I),CCC(J)
940    SWAP DDD(I),DDD(J)
950    SWAP EEE(I),EEE(J)
960    SWAP FFF(I),FFF(J)
970    SWAP Alt21(I),Alt21(J)
980  NEXT J
990 NEXT I
1000 GOTO 1130
1010 FOR I=1 TO P
1020  FOR J=1 TO P
1030    IF AAA(I)>AAA(J) THEN GOTO 1110       'NEXT J
1040    SWAP AAA(I),AAA(J)
1050    SWAP BBB(I),BBB(J)
1060    SWAP CCC(I),CCC(J)
```

```
1070      SWAP DDD(I),DDD(J)
1080      SWAP EEE(I),EEE(J)
1090      SWAP FFF(I),FFF(J)
1100      SWAP Alt21(I),Alt21(J)
1110    NEXT J
1120 NEXT I
1130 FOR I=1 TO P
1140   READ RECORD #2 Alt21(I) P31
1150   LPRINT TAB(1) P31.TN$;TAB(13) P31.MN$;TAB(27) AAA(I);TAB(42) BBB(I);TAB(56) CCC(I);TAB(67
) DDD(I);TAB(81) EEE(I);TAB(92) FFF
(I)
1160 NEXT I
1170 LPRINT:LPRINT
1180 IF R>0 THEN GOTO 1200
1190 GOTO 1750
1200 LPRINT "BORING RECORDS AVAIABLE":LPRINT:LPRINT
1210 LPRINT "                                                                        ROUGH CUT
        FINISH CUT"
1220 LPRINT "MACHINE   TOOL   TIME PER    TOTAL      TOTAL       AVE     TOOL      FEED        SP
EED     FEED        SPEED        G
RINDING"
1230 LPRINT "    #       #       PART       TIME       COST       COST    DEPTH   (mm/Rpm)    (mm/
min)   (mm/Rpm)     (mm/min)      R
EQUIRED"
1240 FOR I=1 TO R
1250   READ RECORD #2 Alt23(I) P31
1260   IF MAT$="1" THEN ZZ=.66666
1270   IF MAT$="2" THEN ZZ=1
1280   IF MAT$="3" THEN ZZ=.70
1290   IF MAT$="4" THEN ZZ=1
1300   AAA(I)=Matt/P31.MRR*ZZ+.2*Nif                       'TIME TO MACHINE
1310   BBB(I)=LOTS*(AAA(I)+P31.LUT)                         'TOTAL MACHINE TIME
1320   CCC(I)=BBB(I)*P31.OC+P31.TC*(AAA(I)-.2*Nif)+P31.SC 'TOTAL COST
1330   DDD(I)=CCC(I)/LOTS                                   'AVERAGE COST
1340   EEE(I)=P31.TAA*ZZ                                   'DEPTH OF CUT
1350   IF P31.TNR=<0 THEN P31.TNR=1
1360   FFF(I)=P31.TNR
1370   GGG(I)=(P31.MRR*ZZ)/(FFF(I)*EEE(I))
1380 NEXT I
1390 IF CHOICE$="PRR" THEN GOTO 1540
1400 FOR I=1 TO R
1410   FOR J=1 TO R
1420      IF DDD(I)>DDD(J) THEN GOTO 1520
1430      SWAP Alt23(I),Alt23(J)
1440      SWAP AAA(I),AAA(J)
1450      SWAP BBB(I),BBB(J)
1460      SWAP CCC(I),CCC(J)
1470      SWAP DDD(I),DDD(J)
1480      SWAP EEE(I),EEE(J)
1490      SWAP FFF(I),FFF(J)
1500      SWAP GGG(I),GGG(J)
```

```
1510      SWAP GR$(I),GR$(J)
1520    NEXT J
1530 NEXT I:GOTO 1680
1540 FOR I=1 TO R
1550    FOR J=1 TO R
1560      IF AAA(I)>AAA(J) THEN GOTO 1660
1570      SWAP Alt23(I),Alt23(J)
1580      SWAP AAA(I),AAA(J)
1590      SWAP BBB(I),BBB(J)
1600      SWAP CCC(I),CCC(J)
1610      SWAP DDD(I),DDD(J)
1620      SWAP EEE(I),EEE(J)
1630      SWAP FFF(I),FFF(J)
1640      SWAP GGG(I),GGG(J)
1650      SWAP GR$(I),GR$(J)
1660    NEXT J
1670 NEXT I
1680 FOR I=1 TO R
1690    READ RECORD #2 Alt23(I) P31
1700    DEP=GGG(I)*1.1
1710    ACP=P31.TNR*.25
1720    LPRINT TAB(1) P31.TN$;TAB(9) P31.MN$;TAB(19) AAA(I);TAB(28) BBB(I);TAB(39) CCC(I);TAB(50)
DDD(I);TAB(61) EEE(I);TAB(70) P31.
TNR;TAB(80) GGG(I);TAB(92) ACP;TAB(103) DEP;TAB(122) GR$(I)
1730 NEXT I
1740 LPRINT:LPRINT
1750 IF Q>0 THEN GOTO 1780
1760 LPRINT "NO TOOLS AVAILABLE TO PERFORM GRINDING"
1770 GOTO 2290
1780 LPRINT "GRINDING TOOLS AVAILABLE":LPRINT:LPRINT
1790 LPRINT "MACHINE     TOOL       TIME PER        TOTAL          TOTAL        AVE          TOOL
  TOOL        TOOL"
1800 LPRINT "   #          #           PART           TIME           COST         COST         DEPTH
  FEED       SPEED"
1810 FOR I=1 TO Q
1820    READ RECORD #2 Alt24(I) P31
1830    IF MAT$="1" THEN ZZ=1
1840    IF MAT$="2" THEN ZZ=1
1850    IF MAT$="3" THEN ZZ=1
1860    IF MAT$="4" THEN ZZ=1
1870    IF P31.TW<=0 THEN P31.TW=25
1880    AAA(I)=.2*Nif*ZZ+LENGTH/(.5*P31.TW) 'MACHINE TIME PER PART
1890    BBB(I)=LOTS*(AAA(I)+P31.LUT)
1900    CCC(I)=BBB(I)*P31.OC+P31.TC*(AAA(I)-.2*Nif)+P31.SC   'TOTAL COST
1910    DDD(I)=CCC(I)/LOTS                    'AVERAGE COST PER PART
1920    EEE(I)=P31.TAA*ZZ
1930    FFF(I)=P31.TW*.25
1940    GGG(I)=P31.MRR*ZZ/(EEE(I)*FFF(I))
1950 NEXT I
1960 IF CHOICE$="PRR" THEN GOTO 2110
1970 FOR I=1 TO Q
```

```
1980   FOR J=1 TO Q
1990     IF DDD(I)>DDD(J) THEN GOTO 2080
2000     SWAP Alt24(I),Alt24(J)
2010     SWAP AAA(I),AAA(J)
2020     SWAP BBB(I),BBB(J)
2030     SWAP CCC(I),CCC(J)
2040     SWAP DDD(I),DDD(J)
2050     SWAP EEE(I),EEE(J)
2060     SWAP FFF(I),FFF(J)
2070     SWAP GGG(I),GGG(J)
2080   NEXT J
2090 NEXT I
2100 GOTO 2240
2110 FOR I=1 TO Q
2120   FOR J=1 TO Q
2130     IF AAA(I)>AAA(J) THEN GOTO 2220
2140     SWAP Alt24(I),Alt24(J)
2150     SWAP AAA(I),AAA(J)
2160     SWAP BBB(I),BBB(J)
2170     SWAP CCC(I),CCC(J)
2180     SWAP DDD(I),DDD(J)
2190     SWAP EEE(I),EEE(J)
2200     SWAP FFF(I),FFF(J)
2210     SWAP GGG(I),GGG(J)
2220   NEXT J
2230 NEXT I
2240 FOR I=1 TO Q
2250   READ RECORD #2 Alt24(I) P31
2260   LPRINT TAB(1) P31.TN$;TAB(11) P31.MN$;TAB(24) AAA(I);TAB(38) BBB(I);TAB(49) CCC(I);TAB(62
) DDD(I);TAB(75) EEE(I);TAB(86) FFF
(I);TAB(95) GGG(I)
2270 NEXT I
2280 LPRINT:LPRINT
2290 CLOSE
ENDFILE
SOURCE
   10 LPRINT "******************************"
   20 LPRINT "   OPERATIONS REQUIRED TO"
   30 LPRINT " GENERATE INTERNAL FEATURES"
   40 LPRINT "  WHICH ORIGINATE FROM THE "
   50 LPRINT "      REFERENCE END            "
   60 LPRINT "******************************"
   70 LPRINT:LPRINT
   80 OPEN "D:INTFR" AS #1 LEN=SIZE(P12)
   90 Diam=1000000
  100 Matt=0:Length=0
  110 FOR I=1 TO NIFRR
  120   READ RECORD #1 I P12
  130   Length=Length+P12.LB
  140   IF P12.IFRB$="T" THEN GOTO 180
  150   Matt=Matt+(P12.LB*(3.1415*(P12.DB)^2/4))
```

```
160   IF Diam>P12.DB THEN Diam=P12.DB
170   GOTO 210
180   Matt=Matt+(P12.LB*((3.1415*(P12.SDB)^2/4)+(.5*(3.1415*(P12.FDB)^2/4)-3.1415*(P12.SDB)^2/4
)))
190   IF Diam>P12.FDB THEN Diam=P12.FDB
200   IF Diam>P12.SDB THEN Diam=P12.SDB
210 NEXT I
220 CLOSE
230 Matt=Matt-3.1415*Length*(Diam)^2/4
240 OPEN "D:ALT3" AS #1 LEN=SIZE(P42)
250 OPEN "C:BBB" AS #2 LEN=SIZE(P31)
260 OPEN "D:INTFR" AS #3 LEN=SIZE(P12)
270 P=1:R=1:Q=1
280 FOR I=1 TO Cc1
290   READ RECORD #1 I P42
300   READ RECORD #2 P42.C3 P31
310   Tol1=P31.TOL:Sf1=P31.SUF
320   IF P42.C4=<0 THEN GOTO 350
330   READ RECORD #2 P42.C4 P31
340   Tol2=P31.TOL:Sf2=P31.SUF:GOTO 360
350   Tol2=100:Sf2=500
360   IF Tol1>Tol2 THEN Tol1=Tol2
370   IF Sf1>Sf2 THEN Sf1=Sf2
380   FOR J=1 TO Nifr
390     READ RECORD #3 J P12
400     IF P12.IFRB$="T" THEN GOTO 430
410     IF Tol1<P12.TDB AND Sf1<P12.SFB THEN GOTO 450        'NEXT J
420     EXIT TO,660                                           'NEXT I
430     IF Tol1<P12.TFDB AND Tol1<P12.TSDB AND Sf1<P12.SFB THEN GOTO 450
440     EXIT TO,660
450   NEXT J
460   LET Alt31(P)=P42.C1
470   IF P<2 THEN GOTO 510
480   FOR A=1 TO P-1
490     IF Alt31(A)=Alt31(P) THEN EXIT TO,520
500   NEXT A
510   P=P+1
520   LET Alt33(R)=P42.C3
530   IF P42.C4=0 THEN Gr$(R)="N" ELSE Gr$(R)="Y"
540   IF R<2 THEN GOTO 580
550   FOR A=1 TO R-1
560     IF Alt33(A)=Alt33(R) THEN EXIT TO,590
570   NEXT A
580   R=R+1
590   IF P42.C4=0 THEN GOTO 660
600   LET Alt34(Q)=P42.C4
610   IF Q<2 THEN GOTO 650
620   FOR A=1 TO Q-1
630     IF Alt34(A)=Alt34(Q) THEN EXIT TO,660
640   NEXT A
650   Q=Q+1
```

```
660 NEXT I
670 P=P-1:R=R-1:Q=Q-1
680 IF P>0 THEN GOTO 710
690 LPRINT "NO DRILLING TOOLS AVAILABLE"
700 GOTO 1190
710 LPRINT "DRILLING TOOLS AVAILABLE":LPRINT:LPRINT
720 LPRINT "MACHINE      TOOL      TIME PER        TOTAL          TOTAL        AVE
FEED       SPEED"
730 LPRINT "  #             #          PART             TIME           COST         COST         (
mm/RPM)     (mm/min)"
740 FOR I=1 TO P
750   READ RECORD #2 Alt31(I) P31
760   IF Mat$="1" THEN ZZ=.6666
770   IF Mat$="2" THEN ZZ=1
780   IF Mat$="3" THEN ZZ=.70
790   IF Mat$="4" THEN ZZ=1
800   AA(I)=(Length*3.1415*(Diam)^2/4)/P31.MRR    'LENGTH/FEED RATE
810   BB(I)=Lots*(AA(I)+P31.LUT)                   'TOTAL TIME ON MACHINE
820   CC(I)=BB(I)*P31.OC+P31.TC*AA(I)+P31.SC       'TOTAL COST
830   DD(I)=CC(I)/Lots                             'AVERAGE COST
840   IF P31.TNR<=0 THEN P31.TNR=2
850   EE(I)=P31.TNR*.25                     'FEED RATE
860   FF(I)=P31.MRR*ZZ/(EE(I)*(3.1415*(Diam)^2/4))    'SPEED
870 NEXT I
880 IF Choice$="PRR" THEN GOTO 1020
890 FOR I=1 TO P
900   FOR J=1 TO P
910     IF DD(I)>DD(J) THEN GOTO 990              'NEXT J
920     SWAP AA(I),AA(J)
930     SWAP BB(I),BB(J)
940     SWAP CC(I),CC(J)
950     SWAP DD(I),DD(J)
960     SWAP EE(I),EE(J)
970     SWAP FF(I),FF(J)
980     SWAP Alt31(I),Alt31(J)
990   NEXT J
1000 NEXT I
1010 GOTO 1140
1020 FOR I=1 TO P
1030   FOR J=1 TO P
1040     IF AA(I)>AA(J) THEN GOTO 1120
1050     SWAP AA(I),AA(J)
1060     SWAP BB(I),BB(J)
1070     SWAP CC(I),CC(J)
1080     SWAP DD(I),DD(J)
1090     SWAP EE(I),EE(J)
1100     SWAP FF(I),FF(J)
1110     SWAP Alt31(I),Alt31(J)
1120   NEXT J
1130 NEXT I
1140 FOR I=1 TO P
```

```
 1150   READ RECORD #2 Alt31(P) P31
 1160   LPRINT TAB(1) P31.TN$;TAB(13) P31.MN$;TAB(26) AA(I);TAB(42) BB(I);TAB(56) CC(I);TAB(69) D
D(I);TAB(84) EE(I);TAB(95) FF(I)
 1170 NEXT I
 1180 LPRINT:LPRINT
 1190 IF R>0 THEN GOTO 1220
 1200 LPRINT "NO BORING TOOLS AVAILABLE"
 1210 GOTO 1760
 1220 LPRINT "BORING TOOLS AVAILABLE":LPRINT:LPRINT
 1230 LPRINT "                                                                          ROUGH CUT
          FINISH CUT"
 1240 LPRINT "MACHINE   TOOL    TIME PER     TOTAL     TOTAL     AVE       TOOL      FEED      SP
EED        FEED     SPEED    GRIND
ING"
 1250 LPRINT "   #        #          PART        TIME      COST      COST      DEPTH    (mm/Rpm)   (mm/
min)      (mm/Rpm)  (mm/min)  REQUI
RED"
 1260 FOR I=1 TO R
 1270   READ RECORD #2 Alt33(I) P31
 1280   IF Mat$="1" THEN ZZ=.66666
 1290   IF Mat$="2" THEN ZZ=1
 1300   IF Mat$="3" THEN ZZ=.70
 1310   IF Mat$="4" THEN ZZ=1
 1320   AA(I)=Matt/P31.MRR*ZZ+.2*Nifr
 1330   BB(I)=Lots*(AA(I)+P31.LUT)
 1340   CC(I)=BB(I)*P31.DC+P31.TC*(AA(I)-.2*Nifr)+P31.SC
 1350   DD(I)=CC(I)/Lots
 1360   EE(I)=P31.TAA*ZZ                           'DEPTH OF CUT
 1370   FF(I)=P31.TNR
 1380   GG(I)=P31.MRR*ZZ/(FF(I)*EE(I))
.1390 NEXT I
 1400 IF Choice$="PRR" THEN GOTO 1550
 1410 FOR I=1 TO R
 1420   FOR J=1 TO R
 1430     IF DD(I)>DD(J) THEN GOTO 1530
 1440     SWAP Alt33(I),Alt33(J)
 1450     SWAP AA(I),AA(J)
 1460     SWAP BB(I),BB(J)
 1470     SWAP CC(I),CC(J)
 1480     SWAP DD(I),DD(J)
 1490     SWAP EE(I),EE(J)
 1500     SWAP FF(I),FF(J)
 1510     SWAP GG(I),GG(J)
 1520     SWAP Gr$(I),Gr$(J)
 1530   NEXT J
 1540 NEXT I:GOTO 1690
 1550 FOR I=1 TO R
 1560   FOR J=1 TO R
 1570     IF AA(I)>AA(J) THEN GOTO 1670
 1580     SWAP Alt33(I),Alt33(J)
 1590     SWAP AA(I),AA(J)
```

```
1600      SWAP BB(I),BB(J)
1610      SWAP CC(I),CC(J)
1620      SWAP DD(I),DD(J)
1630      SWAP EE(I),EE(J)
1640      SWAP FF(I),FF(J)
1650      SWAP GG(I),GG(J)
1660      SWAP Gr$(I),Gr$(J)
1670    NEXT J
1680 NEXT I
1690 FOR I=1 TO R
1700   READ RECORD #2 Alt33(I) P31
1710   DEP=GG(I)*1.1
1720   ACP=P31.TNR*.25
1730   LPRINT TAB(1) P31.TN$;TAB(9) P31.MN$;TAB(18) AA(I);TAB(29) BB(I);TAB(40) CC(I);TAB(50) DD
(I);TAB(62) EE(I);TAB(72) P31.TNR;T
AB(79) GG(I);TAB(93) ACP;TAB(103) DEP;TAB(117) Gr$(I)
1740 NEXT I
1750 LPRINT:LPRINT
1760 IF Q>0 THEN GOTO 1790
1770 LPRINT "NO GRINDING TOOLS AVAILABLE"
1780 GOTO 2300
1790 LPRINT "AVAILABLE GRINDING RECORDS":LPRINT:LPRINT
1800 LPRINT "MACHINE     TOOL       TIME PER      TOTAL       TOTAL          AVE        TOOL        T
OOL      TOOL"
1810 LPRINT "  #           #              PART          TIME        COST        COST       DEPTH        F
EED      SPEED"
1820 FOR I=1 TO Q
1830   READ RECORD #2 Alt34(I) P31
1840   IF Mat$="1" THEN ZZ=1
1850   IF Mat$="2" THEN ZZ=1
1860   IF Mat$="3" THEN ZZ=1
1870   IF Mat$="4" THEN ZZ=1
1880   IF P31.TW=0 THEN P31.TW=25
1890   AA(I)=.2*Nifr +Length/(.5*P31.TW)
1900   BB(I)=Lots*(AA(I)+P31.LUT)
1910   CC(I)=BB(I)*P31.OC+P31.TC*(AA(I)-.2*Nifr)+P31.SC
1920   DD(I)=CC(I)/Lots
1930   EE(I)=P31.TAA*ZZ
1940   FF(I)=P31.TW*.25
1950   GG(I)=P31.MRR*ZZ/(EE(I)*FF(I))
1960 NEXT I
1970 IF Choice$="PRR" THEN GOTO 2120
1980 FOR I=1 TO Q
1990   FOR J=1 TO Q
2000     IF DD(I)>DD(J) THEN GOTO 2090
2010     SWAP Alt34(I),Alt34(J)
2020     SWAP AA(I),AA(J)
2030     SWAP BB(I),BB(J)
2040     SWAP CC(I),CC(J)
2050     SWAP DD(I),DD(J)
2060     SWAP EE(I),EE(J)
```

```
2070     SWAP FF(I),FF(J)
2080     SWAP GG(I),GG(J)
2090   NEXT J
2100 NEXT I
2110 GOTO 2250
2120 FOR I=1 TO Q
2130   FOR J=1 TO Q
2140     IF AA(I)>AA(J) THEN GOTO 2230
2150     SWAP Alt34(I),Alt34(J)
2160     SWAP AA(I),AA(J)
2170     SWAP BB(I),BB(J)
2180     SWAP CC(I),CC(J)
2190     SWAP DD(I),DD(J)
2200     SWAP EE(I),EE(J)
2210     SWAP FF(I),FF(J)
2220     SWAP GG(I),GG(J)
2230   NEXT J
2240 NEXT I
2250 FOR I=1 TO Q
2260   READ RECORD #2 Alt34(I) P31
2270   LPRINT TAB(1) P31.TN$;TAB(11) P31.MN$;TAB(25) AA(I);TAB(38) BB(I);TAB(48) CC(I);TAB(60) D
D(I);TAB(72) EE(I);TAB(82) FF(I);TA
B(92) GG(I)
2280 NEXT I
2290 LPRINT:LPRINT
2300 CLOSE
ENDFILE
SOURCE
   10 LPRINT "**********************************"
   20 LPRINT " OPERATIONS TO GENERATE FEATURES  "
   30 LPRINT " AT OPPOSITE END OF FEATURE       "
   40 LPRINT "**********************************"
   50 LPRINT:LPRINT
   60 CLOSE
   70 OPEN "D:INTFO" AS #1 LEN=SIZE(P13)
   80 DIAM=1000000
   90 FOR I=1 TO NIFO
  100   READ RECORD #1 I P13
  110   LENGTH=LENGTH+P13.LC
  120   IF P13.IFOC$="T" THEN GOTO 160
  130   MATT=MATT+(P13.LC*(3.1415*(P13.DC)^2/4))
  140   IF DIAM>P13.DC THEN DIAM=P13.DC
  150   GOTO 190
  160   MATT=MATT+(P13.LC*((3.1415*(P13.SDC)^2/4)+(.5*(3.1415*(P13.FDC)^2/4)-3.1415*(P13.SDC)^2/4
)))
  170   IF DIAM>P13.FDC THEN DIAM=P13.FDC
  180   IF DIAM>P13.SDC THEN DIAM=P13.SDC
  190 NEXT I
  200 CLOSE
  210 MATT=MATT-((DIAM)^2/4)*3.1415*LENGTH
  220 OPEN "D:ALT4" AS #1 LEN=SIZE(P43)
```

```
230 OPEN "C:BBB" AS #2 LEN=SIZE(P31)
240 OPEN "D:INTFO" AS #3 LEN=SIZE(P13)
250 P=1:R=1:Q=1
260 FOR I=1 TO DD1
270   READ RECORD #1 I P43
280   READ RECORD #2 P43.D3 P31
290   TOL1=P31.TOL:SF1=P31.SUF
300   IF P43.D4=<0 THEN GOTO 330
310   READ RECORD #2 P43.D4 P31
320   TOL2=P31.TOL:SF2=P31.SUF:GOTO 340
330   TOL2=100:SF2=100
340   IF TOL1>TOL2 THEN TOL1=TOL2
350   IF SF1>SF2 THEN SF1=SF2
360   FOR J=1 TO NIFO
370     READ RECORD #3 J P13
380     IF P13.IFOC$="T" THEN GOTO 410
390     IF TOL1<P13.TOC AND SF1<P13.SFC THEN GOTO 430          'NEXT J
400     EXIT TO,640
410     IF TOL1<P13.TSOC AND TOL1<P13.TFOC AND SF1<P13.SFC THEN GOTO 430
420     EXIT TO,640
430   NEXT J
440   LET ALT41(P)=P43.D1
450   IF P<2 THEN GOTO 490
460   FOR A=1 TO P-1
470     IF ALT41(A)=ALT41(P) THEN EXIT TO,500
480   NEXT A
490   P=P+1
500   LET ALT43(R)=P43.D3
510   IF P43.D4=0 THEN GR$(R)="N" ELSE GR$(R)="Y"
520   IF R<2 THEN GOTO 560
530   FOR A=1 TO R-1
540     IF ALT43(A)=ALT43(R) THEN EXIT TO,570
550   NEXT A
560   R=R+1
570   IF P43.D4=0 THEN GOTO 640
580   LET ALT44(Q)=P43.D4
590   IF Q<2 THEN GOTO 630
600   FOR A=1 TO Q-1
610     IF ALT44(A)=ALT44(Q) THEN EXIT TO,640
620   NEXT A
630   Q=Q+1
640 NEXT I
650 P=P-1:R=R-1:Q=Q-1
660 IF P>0 THEN GOTO 690
670 LPRINT "NO DRILLING TOOLS AVAILABLE TO PERFORM THE OPERATION"
680 GOTO 1180
690 LPRINT "DRILLING RECORDS AVAILABLE"
700 LPRINT:LPRINT:LPRINT
710 LPRINT "MACHINE     TOOL     TIME PER      TOTAL      TOTAL              AVE          F
EED           SPEED"
720 LPRINT "  #           #        PART          TIME       COST               COST         (■■
```

```
/RPM)         (mm/min)"
 730 FOR I=1 TO P
 740   READ RECORD #2 ALT41(I) P31
 750   IF MAT$="1" THEN ZZ=.66666
 760   IF MAT$="2" THEN ZZ=1
 770   IF MAT$="3" THEN ZZ=.70
 780   IF MAT$="4" THEN ZZ=1
 790   AA(I)=(LENGTH*3.1415*(DIAM)^2/4)/P31.MRR
 800   BB(I)=LOTS*(AA(I)+P31.LUT)
 810   CC(I)=BB(I)*P31.OC+P31.TC*AA(I)+P31.SC
 820   DD(I)=CC(I)/LOTS
 830   IF P31.TNR=0 THEN P31.TNR=2
 840   EE(I)=P31.TNR*.25
 850   FF(I)=P31.MRR/(EE(I)*(3.1415*(DIAM)^2/4))
 860 NEXT I
 870 IF CHOICE$="PRR" THEN GOTO 1010
 880 FOR I=1 TO P
 890   FOR J=1 TO P
 900     IF DD(I)>DD(J) THEN GOTO 980
 910     SWAP AA(I),AA(J)
 920     SWAP BB(I),BB(J)
 930     SWAP CC(I),CC(J)
 940     SWAP DD(I),DD(J)
 950     SWAP EE(I),EE(J)
 960     SWAP FF(I),FF(J)
 970     SWAP ALT41(I),ALT41(J)
 980   NEXT J
 990 NEXT I
1000 GOTO 1130
1010 FOR I=1 TO P
1020   FOR J=1 TO P
1030     IF AA(I)>AA(J) THEN GOTO 1110
1040     SWAP AA(I),AA(J)
1050     SWAP BB(I),BB(J)
1060     SWAP CC(I),CC(J)
1070     SWAP DD(I),DD(J)
1080     SWAP EE(I),EE(J)
1090     SWAP FF(I),FF(J)
1100     SWAP ALT41(I),ALT41(J)
1110   NEXT J
1120 NEXT I
1130 FOR I=1 TO P
1140   READ RECORD #2 ALT41(I) P31
1150   LPRINT TAB(1) P31.TN$;TAB(12) P31.TN$;TAB(22) AA(I);TAB(35) BB(I);TAB(48) CC(I);TAB(65) D
D(I);TAB(82) EE(I);TAB(97) FF(I)
1160 NEXT I
1170 LPRINT:LPRINT
1180 IF R>0 THEN GOTO 1210
1190 LPRINT "NO BORING TOOLS AVAILABLE TO PERFORM THE OPERATION"
1200 GOTO 1750
1210 LPRINT"AVAILABLE BORING RECORDS":LPRINT:LPRINT
```

```
 1220 LPRINT "                                                                                          ROUG
H CUT          FINISH CUT      "
 1230 LPRINT "MACHINE     TOOL     TIME PER      TOTAL      TOTAL      AVE       TOOL      FEED
  SPEED      FEED     SPEED    GRIN
DING"
 1240 LPRINT "  #            #        PART         TIME       COST       COST      DEPTH   (mm/Rpm)
 (mm/min)  (mm/Rpm)  (mm/min)  REQU
IRED"
 1250 FOR I=1 TO R
 1260   READ RECORD #2 ALT43(I) P31
 1270   IF MAT$="1" THEN ZZ=.6666
 1280   IF MAT$="2" THEN ZZ=1
 1290   IF MAT$="3" THEN ZZ=.70
 1300   IF MAT$="4" THEN ZZ=1
 1310   AA(I)=MATT/P31.MRR*ZZ+.2*NIFD
 1320   BB(I)=LOTS*(AA(I)+P31.LUT)
 1330   CC(I)=BB(I)*P31.DC+P31.TC*(AA(I)-.2*NIFD)+P31.SC
 1340   DD(I)=CC(I)/LOTS
 1350   EE(I)=P31.TAA*ZZ
 1360   FF(I)=P31.TNR
 1370   GG(I)=P31.MRR*ZZ/(FF(I)*EE(I))
 1380 NEXT I
 1390 IF CHOICE$="PRR" THEN GOTO 1540
 1400 FOR I=1 TO R
 1410   FOR J=1 TO R
 1420     IF DD(I)>DD(J) THEN GOTO 1520
 1430     SWAP ALT43(I),ALT43(J)
 1440     SWAP AA(I),AA(J)
 1450     SWAP BB(I),BB(J)
 1460     SWAP CC(I),CC(J)
 1470     SWAP DD(I),DD(J)
 1480     SWAP EE(I),EE(J)
 1490     SWAP FF(I),FF(J)
 1500     SWAP GG(I),GG(J)
 1510     SWAP GR$(I),GR$(J)
 1520   NEXT J
 1530 NEXT I:GOTO 1680
 1540 FOR I=1 TO R
 1550   FOR J=1 TO R
 1560     IF AA(I)>AA(J) THEN GOTO 1660
 1570     SWAP ALT43(I),ALT43(J)
 1580     SWAP AA(I),AA(J)
 1590     SWAP BB(I),BB(J)
 1600     SWAP CC(I),CC(J)
 1610     SWAP DD(I),DD(J)
 1620     SWAP EE(I),EE(J)
 1630     SWAP FF(I),FF(J)
 1640     SWAP GG(I),GG(J)
 1650     SWAP GR$(I),GR$(J)
 1660   NEXT J
 1670 NEXT I
```

```
1680 FOR I=1 TO R
1690   READ RECORD #2 ALT43(I) P31
1700   DEP=GG(I)*1.1
1710   ACP=P31.TNR*.25
1720   LPRINT TAB(1) P31.TN$;TAB(12) P31.MN$;TAB(21) AA(I);TAB(33) BB(I);TAB(45) CC(I);TAB(55) D
D(I);TAB(67) EE(I);TAB(76) P31.TNR;
TAB(84) GG(I);TAB(97) FF(I);TAB(104) DEP;TAB(118) GR$(I)
1730 NEXT I
1740 LPRINT:LPRINT
1750 IF Q>0 THEN GOTO 1780
1760 LPRINT "NO GRINDING TOOLS AVAILABLE TO PERFORM THE OPERATION"
1770 GOTO 2270
1780 LPRINT " AVAILABLE GRINDING RECORDS":LPRINT:LPRINT
1790 LPRINT "MACHINE     TOOL      TIME PER       TOTAL        TOTAL        AVE          TOOL
TOOL       TOOL"
1800 LPRINT "  #           #            PART          TIME        COST        COST         DEPTH
FEED       SPEED"
1810 FOR I=1 TO Q
1820   READ RECORD #2 ALT44(I) P31
1830   IF MAT$="1" THEN ZZ=1
1840   IF MAT$="2" THEN ZZ=1
1850   IF MAT$="3" THEN ZZ=1
1860   IF MAT$="4" THEN ZZ=1
1870   AA(I)=.2*NIFO+LENGTH/(.5*P31.TW)
1880   BB(I)=LOTS*(AA(I)+P31.LUT)
1890   CC(I)=BB(I)*P31.OC+P31.TC*(AA(I)-.2*NIFO)+P31.SC
1900   DD(I)=CC(I)/LOTS
1910   EE(I)=P31.TAA*ZZ
1920   FF(I)=P31.TW*.25
1930   GG(I)=P31.MRR*ZZ/(EE(I)*FF(I))
1940 NEXT I:IF CHOICE$="PRR" THEN GOTO 2090
1950 FOR I=1 TO Q
1960   FOR J=1 TO Q
1970     IF DD(I)>DD(J) THEN GOTO 2060
1980     SWAP ALT44(I),ALT44(J)
1990     SWAP AA(I),AA(J)
2000     SWAP BB(I),BB(J)
2010     SWAP CC(I),CC(J)
2020     SWAP DD(I),DD(J)
2030     SWAP EE(I),EE(J)
2040     SWAP FF(I),FF(J)
2050     SWAP GG(I),GG(J)
2060   NEXT J
2070 NEXT I
2080 GOTO 2220
2090 FOR I=1 TO Q
2100   FOR J=1 TO Q
2110     IF AA(I)>AA(J) THEN GOTO 2200
2120     SWAP ALT44(I),ALT44(J)
2130     SWAP AA(I),AA(J)
2140     SWAP BB(I),BB(J)
```

```
2150     SWAP CC(I),CC(J)
2160     SWAP DD(I),DD(J)
2170     SWAP EE(I),EE(J)
2180     SWAP FF(I),FF(J)
2190     SWAP GG(I),GG(J)
2200   NEXT J
2210 NEXT I
2220 FOR I=1 TO Q
2230   READ RECORD #2 ALT44(I) P31
2240   LPRINT TAB(1) P31.TN$;TAB(12) P31.MN$;TAB(23) AA(I);TAB(37) BB(I);TAB(49) CC(I);TAB(61) D
D(I);TAB(74) EE(I);TAB(84) FF(I);TA
B(94) GG(I)
2250 NEXT I
2260 LPRINT:LPRINT
2270 CLOSE
ENDFILE
```

APPENDIX I

DESCRIPTION OF MACHINE RECORDS

Abbriviations For Tables Of Machine Files

A. Machine Number
B. Horse Power
C. # of operations which can be performed
D. Code for each operation
E. Set-up cost of operation on the machine
F. Operator Cost ($/min)
G. Load/Unload time (min)
H. % Down Time for machine
I. Effeciency of spindle
J. Maximum Length of part which can be machined (mm)
K. Maximum Diameter of part which can be machined (mm)
L. Maximum Width of part which can be machined (mm)
M. Maximum Height of part which can be machined (mm)
N. # of tools available to perform the operation
O. Tool Number
P. Tool Cost ($/min)
Q. Tool material (HSS=1, Carbide=2)
R. # of teeth on tool
S. Tool Diameter (mm)
T. Tool Width (mm)
U. Tool Nose Radius (mm)
V. Metal Removal Rate (mm^3/min)
W. Maximum Depth of cut (mm)
X. Tolerence Achievable
Y. Surface Finish Achievable

Note all information is considering the part material to be 1020 steel. The information which was inputted for the examples shown in the report are listed in the following tables.

TABLE OF MACHINE RECORDS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
C-1800	15	3	1	13.5	.275	2.5	5	95	500	150	0	0	5	TUH-A1	.25	1	1	0	0	.16	180,000	3	.002	50
														TUH-A2	.25	1	1	0	0	.24	189,000	6	.006	75
														TUH-A3	.25	1	1	0	0	.32	201,000	9	.008	90
														TUC-B1	.29	2	1	0	0	.16	195,000	5	.004	70
														TUC-B2	.29	2	1	0	0	.26	204,000	12	.006	80
			3	27.8	.275	2.0	5	95	300	100	0	0	5	DRH-D1	.1	1	2	13	0	.16	126,000	180	.009	100
														DRH-D2	.1	1	2	17	0	.26	138,000	250	.01	130
														DRH-D3	.1	1	2	25	0	.32	153,000	300	.017	150
														DRH-D4	.1	1	2	29	0	.4	159,000	300	.02	180
														DRH-D5	.13	1	2	31	0	.4	158,000	300	.04	200
			5	13.3	.275	2.5	5	90	300	120	0	0	5	BOH-B1	.27	1	1	15	0	.2	150,000	4	.003	60
														BOH-B2	.27	1	1	18	0	.2	159,000	10	.005	75
														BOC-B3	.31	2	1	15	0	.12	156,000	4	.002	55
														BOC-B4	.31	2	1	18	0	.18	168,000	9	.004	65
														BOC-B5	.31	2	1	21	0	.24	174,000	15	.007	75
C-1801	18	3	1	16.8	.275	2.0	9	90	750	200	0	0	5	TUH-H3	.26	1	1	0	0	.2	195,000	4	.003	50
														TUH-H6	.26	1	1	0	0	.3	204,000	8	.005	70
														TUC-C9	.28	2	1	0	0	.3	204,000	5	.002	50
														TUC-C7	.28	2	1	0	0	.26	210,000	8	.003	60
														TUC-C17	.28	2	1	0	0	.34	213,000	12	.005	70
			3	14.7	.275	1.8	9	95	400	175	0	0	4	DRH-H11	.11	1	2	17	0	.18	129,000	170	.01	100
														DRH-H14	.12	1	2	23	0	.3	147,000	250	.03	150
														DRH-H17	.12	1	2	29	0	.4	159,000	300	.07	200
														DRH-H21	.12	1	2	35	0	.4	171,000	400	.1	300
			5	23.6	.275	2.3	9	90	400	200	0	0	3	BOH-B7	.27	1	1	18	0	.22	159,000	6	.006	75
														BOC-B9	.27	2	1	23	0	.2	162,000	9	.005	70
														BOC-B13	.29	2	1	26	0	.35	174,000	11	.007	80
C-1802	21	3	1	11.6	.275	2.0	10	90	1000	250	0	0	8	TUH-A7	.21	1	1	0	0	.16	206,000	4	.004	55
														TUH-A11	.21	1	1	0	0	.26	209,000	7	.006	70
														TUH-A21	.21	1	1	0	0	.34	222,000	9	.01	100
														TUH-A23	.21	1	1	0	0	.48	225,000	13	.015	120
														TUC-B11	.25	2	1	0	0	.16	219,000	6	.003	55
														TUC-B15	.25	2	1	0	0	.26	228,000	9	.004	65
														TUC-21	.25	2	1	0	0	.34	234,000	11	.007	75
														TUC-B23	.25	2	1	0	0	.48	240,000	15	.01	100
			3	22.3	.275	1.8	10	85	500	250	0	0	8	DRH-C11	.12	1	2	21	0	.26	129,000	200	.007	80
														DRH-C14	.13	1	2	27	0	.38	135,000	300	.01	100
														DRH-C19	.13	1	2	33	0	.4	141,000	400	.017	130
														DRH-C33	.13	1	2	39	0	.4	147,000	450	.023	170
														DRH-C45	.13	1	2	45	0	.4	153,000	500	.04	220
														DRH-C13	.14	1	2	51	0	.4	159,000	500	.06	240
														DRH-C12	.14	1	2	55	0	.4	165,000	500	.09	260

													DRH-C18	.14	1	2	60	0	.4	171,000	500	.11	300
			5	26.8	.275	1.9	10	80	500	250	0	0	2	BOH-C1	.3	1	1	15	0	.18	153,000	4	.003	60
													BOC-C3	.33	2	1	21	0	.18	168,000	6	.002	50
A-45	11	1	1	20.5	.283	2	5	90	600	175	0	0	2	TUH-A19	.25	1	1	0	0	.24	165,000	5	.003	50
													TUC-21	.29	2	1	0	0	.24	171,000	10	.005	65
A-90	13	2	3	16.8	.291	1.9	15	85	550	190	0	0	4	DRH-H11	.11	1	2	17	0	.22	132,000	190	.009	90
													DRH-C13	.13	1	2	23	0	.35	138,000	350	.011	110
													DRH-H21	.13	1	2	29	0	.4	144,000	350	.014	140
													DRH-C45	.13	1	2	31	0	.4	150,000	350	.02	170
			5	12.6	.291	2.1	5	90	550	190	0	0	4	BOH-D3	.23	1	1	16	0	.12	156,000	2	.003	50
													BOH-D6	.23	1	1	21	0	.16	162,000	4	.005	65
													BOC-D9	.29	2	1	20	0	.16	168,000	6	.002	50
													BOC-D11	.29	2	1	26	0	.2	174,000	8	.007	70
B-30	21	3	1	19.8	.275	2.0	15	80	700	220	0	0	3	TUH-H14	.27	1	1	0	0	.18	177,000	5	.005	40
													TUC-H16	.31	2	1	0	0	.18	189,000	7	.005	45
													TUC-H11	.31	2	1	0	0	.26	201,000	12	.008	65
			3	23.5	.275	2.0	15	80	600	200	0	0	8	DRH-E1	.12	1	2	19	0	.24	117,000	200	.007	80
													DRH-E4	.12	1	2	24	0	.3	129,000	350	.009	90
													DRH-E7	.14	1	2	32	0	.38	135,000	450	.012	110
													DRH-E11	.14	1	2	38	0	.4	144,000	600	.017	130
													DRH-E19	.14	1	2	43	0	.4	150,000	600	.02	150
													DRH-E21	.13	1	2	49	0	.4	153,000	600	.025	160
													DRH-E14	.14	1	2	53	0	.4	159,000	600	.03	165
													DRH-E17	.14	1	2	57	0	.4	165,000	600	.04	170
			5	25.5	.275	1.8	15	75	600	200	0	0	2	BOH-A3	.31	1	1	29	0	.24	176,000	11	.007	80
													BOC-B3	.35	2	1	32	0	.24	189,000	15	.007	80
B-31	24	2	3	17.4	.283	1.5	12	78	500	100	0	0	4	DRH-A11	.15	1	2	15	0	.18	120,000	300	.006	75
													DRH-A13	.15	1	2	26	0	.3	135,000	350	.009	100
													DRH-A19	.15	1	2	37	0	.4	138,000	450	.011	120
													DRH-A23	.17	1	2	42	0	.4	147,000	500	.02	160
			5	26.6	.283	1.9	12	80	500	100	0	0	3	BOH-A7	.31	1	1	19	0	.2	156,000	6	.003	70
													BOH-A5	.31	1	1	23	0	.26	162,000	11	.007	90
													BOC-B4	.35	2	1	20	0	.24	162,000	11	.006	80
IG-10	17	1	6	33.6	.325	3.0	15	70	300	200	0	0	3	IGR-I3	.45	0	0	14	5	0	22,000	.5	.0001	10
													IGR-I5	.49	0	0	17	10	0	23,000	1	.0003	16
													IGR-I7	.53	0	0	21	15	0	25,000	1.2	.0005	21
IG-50	19	1	6	35.8	.383	2.8	10	78	1000	300	0	0	4	IGR-I19	.4	0	0	24	10	0	21,000	.8	.0002	16
													IGR-I23	.47	0	0	26	20	0	25,000	1.1	.0004	19
													IGR-I33	.53	0	0	29	25	0	29,000	1.3	.0005	23
													IGR-I45	.6	0	0	40	30	0	32,000	1.7	.0007	27
EG-25	8	1	2	39.8	.341	3.3	13	80	300	175	0	0	2	ERG-E14	.3	0	0	43	10	0	20,000	1	.0002	10
													ERG-E17	.5	0	0	48	20	0	22,000	1.3	.0004	16
EG-40	12	1	2	39.0	.35	3.4	15	85	1000	250	0	0	3	ERG-E16	.35	0	0	24	15	0	17,000	1.1	.0003	16
													ERG-E21	.47	0	0	29	25	0	23,000	1.4	.0007	19
													ERG-E33	.53	0	0	33	35	0	29,000	1.7	.0009	25
F-37	21	2	1	19.9	.275	2.1	15	90	1000	300	0	0	3	TUH-C11	.25	1	1	0	0	.34	222,000	9	.006	80
													TUH-C41	.25	1	1	0	0	.5	234,000	11	.009	100
													TUC-B12	.31	2	1	0	0	.26	225,000	9	.007	85

			5	25.6	.275	1.9	15	85	500	300	0	0	5	BOH-B13	.29	1	1	11	0	.14	156,000	2	.002	45
														BOH-B46	.29	1	1	17	0	.26	174,000	4	.004	60
														BOH-C21	.29	1	1	23	0	.3	180,000	5	.008	85
														BOC-C19	.33	2	1	16	0	.28	177,000	6	.006	70
														BOC-C33	.33	2	1	25	0	.34	186,000	9	.009	100
H-91	17	1	1	24.8	.275	1.8	20	80	1000	270	0	0	2	TUH-C13	.27	1	1	0	0	.1	189,000	2	.002	40
														TUC-C45	.29	2	1	0	0	.14	198,000	5	.003	40
H-24	14	3	1	17.9	.275	1.7	15	90	700	200	0	0	4	TUH-D11	.25	1	1	0	0	.2	195,000	8	.006	80
														TUH-B17	.25	1	1	0	0	.28	204,000	16	.009	80
														TUC-D17	.33	2	1	0	0	.18	204,000	16	.005	75
														TUC-C19	.33	2	1	0	0	.26	219,000	18	.008	100
			3	16.0	.275	1.9	10	80	400	200	0	0	8	DRH-D21	.11	1	2	17	0	.18	117,000	200	.009	80
														DRH-D30	.13	1	2	23	0	.26	129,000	350	.01	95
														DRH-D31	.13	1	2	29	0	.32	138,000	400	.013	110
														DRH-D32	.13	1	2	32	0	.4	144,000	400	.017	125
														DRH-D40	.13	1	2	36	0	.4	150,000	400	.019	135
														DRH-D45	.14	1	2	39	0	.4	153,000	400	.021	150
														DRH-D47	.14	1	2	42	0	.4	159,000	400	.023	165
														DRH-D52	.14	1	2	47	0	.4	165,000	400	.027	180
			5	22.5	.275	1.7	15	88	400	200	0	0	2	BOH-C17	.31	1	1	17	0	.22	159,000	8	.005	70
														BOC-C21	.35	2	1	27	0	.22	171,000	14	.005	60
H-47	19	2	1	23.6	.275	1.8	15	90	400	125	0	0	3	TUH-C10	.26	1	1	0	0	.14	166,000	3	.003	55
														TUC-C11	.31	2	1	0	0	.16	198,000	11	.004	70
														TUC-D13	.31	2	1	0	0	.24	210,000	15	.007	95
			3	16.9	.275	1.7	15	90	400	125	0	0	6	DRH-A15	.1	1	2	15	0	.14	120,000	175	.008	90
														DRH-A19	.11	1	2	21	0	.22	126,000	350	.01	105
														DRH-A21	.11	1	2	27	0	.34	135,000	400	.014	120
														DRH-A27	.11	1	2	33	0	.4	141,000	400	.017	130
														DRH-A30	.13	1	2	37	0	.4	147,000	400	.019	145
														DRH-A34	.13	1	2	41	0	.4	153,000	400	.022	160
I-11	15	1	3	15.7	.275	1.5	10	85	675	320	0	0	8	DRH-D27	.12	1	2	13	0	.12	111,000	150	.007	75
														DRH-D31	.12	1	2	15	0	.22	117,000	200	.009	90
														DRH-D35	.14	1	2	19	0	.26	120,000	250	.011	110
														DRH-D38	.14	1	2	22	0	.34	126,000	450	.014	120
														DRH-D42	.14	1	2	25	0	.38	132,000	550	.017	135
														DRH-D47	.14	1	2	29	0	.4	141,000	675	.019	160
														DRH-D51	.14	1	2	31	0	.4	144,000	675	.021	160
														DRH-D53	.14	1	2	33	0	.4	150,000	675	.024	175
J-19	21	3	1	29.6	.275	1.6	17	85	700	300	0	0	5	TUH-C1	.27	1	1	0	0	.18	183,000	5	.002	60
														TUH-C17	.27	1	1	0	0	.26	198,000	11	.004	70
														TUH-C21	.27	1	1	0	0	.36	207,000	13	.009	90
														TUC-B17	.33	2	1	0	0	.28	210,000	13	.005	75
														TUC-B11	.33	2	1	0	0	.42	212,000	16	.008	85
			3	24.6	.275	1.1	20	85	350	300	0	0	4	DRH-C17	.12	1	2	33	0	.4	141,000	250	.013	120
														DRH-C27	.12	1	2	39	0	.4	147,000	350	.018	130
														DRH-C37	.12	1	2	42	0	.4	156,000	350	.025	150
														DRH-C41	.12	1	2	47	0	.4	165,000	350	.025	170
			5	27	.275	1.6	10	90	350	300	0	0	1	BOH-B11	.31	1	1	23	0	.28	153,000	11	.003	60

K-21	16	1	3	15.6	.275	1.4	15	80	600	250	0	0	7	DRH-A21	.12	1	2	12	0	.16	108,000	200	.007	75
														DRH-A28	.12	1	2	17	0	.2	117,000	300	.009	90
														DRH-A33	.12	1	2	24	0	.3	126,000	450	.013	120
														DRH-A37	.12	1	2	29	0	.38	135,000	600	.017	135
														DRH-A40	.14	1	2	35	0	.4	144,000	600	.019	145
														DRH-A45	.14	1	2	38	0	.4	150,000	600	.023	160
														DRH-A51	.14	1	2	41	0	.4	156,000	600	.027	175
C-1500	15	2	3	10.5	.275	1.6	15	90	750	250	0	0	7	DRH-D11	.11	1	2	23	0	.34	123,000	300	.009	95
														DRH-D17	.11	1	2	25	0	.38	129,000	450	.013	100
														DRH-D23	.11	1	2	27	0	.4	135,000	600	.015	115
														DRH-D27	.11	1	2	29	0	.4	141,000	700	.017	130
														DRH-D33	.12	1	2	31	0	.4	147,000	750	.019	135
														DRH-D41	.12	1	2	33	0	.4	153,000	750	.023	145
														DRH-D45	.12	1	2	37	0	.4	159,000	750	.027	155
			5	13.0	.275	1.9	10	85	750	250	0	0	3	BOH-A11	.31	1	1	17	0	.22	153,000	7	.004	60
														BOC-A13	.37	2	1	23	0	.18	153,000	7	.003	60
														BOC-A45	.37	2	1	31	0	.24	159,000	9	.005	75
D-100	10	1	3	23.4	.266	1.7	20	90	600	200	0	0	5	DRH-C19	.11	1	2	11	0	.14	99,000	400	.006	70
														DRH-C27	.13	1	2	13	0	.16	111,000	500	.008	85
														DRH-C31	.14	1	2	19	0	.26	117,000	600	.01	100
														DRH-C41	.16	1	2	21	0	.28	123,000	600	.012	115
														DRH-C50	.16	1	2	23	0	.3	129,000	600	.014	120

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The author was born February 27 1962 in Windsor, Ontario. In September 1981 he attended the University Of Windsor and joined the department of Industrial Engineering. In June 1985 he graduated from the department with a Bachelor's degree in Industrial Engineering. Thereupon he enrolled as a graduate student in the department of Industrial Engineering.