Computer Modeling of Continuous Miner Cutting Systems for Dust Generation

By B. D. Hanson and W. W. Roepke
Mission: As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.
Computer Modeling of Continuous Miner Cutting Systems for Dust Generation

By B. D. Hanson and W. W. Roepke
Hanson, Bruce D.
Computer modeling of continuous miner cutting systems for dust generation.

(Report of investigations; 9245)
Includes bibliographical references.
Supt. of Docs. no.: I 28.23:9245.


**UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>hp</td>
<td>horsepower</td>
<td>mg/m³</td>
<td>milligram per cubic meter</td>
</tr>
<tr>
<td>in</td>
<td>inch</td>
<td>mg/st</td>
<td>milligram per short ton</td>
</tr>
<tr>
<td>in/r</td>
<td>inch per revolution</td>
<td>pct</td>
<td>percent</td>
</tr>
<tr>
<td>in/s</td>
<td>inch per second</td>
<td>rpm</td>
<td>revolution per minute</td>
</tr>
<tr>
<td>lbf</td>
<td>pound (force)</td>
<td>st</td>
<td>short ton</td>
</tr>
<tr>
<td>lbf/ft</td>
<td>pound (force) per foot</td>
<td>yr</td>
<td>year</td>
</tr>
<tr>
<td>m³</td>
<td>cubic meter</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
COMPUTER MODELING OF CONTINUOUS MINER CUTTING SYSTEMS FOR DUST GENERATION

By B. D. Hanson and W. W. Roepke

ABSTRACT

The U.S. Bureau of Mines has developed an interactive computer program which enables the user to identify the effect of cutting system changes on relative dust generation and forces for continuous miner drums. The program simultaneously evaluates machine and coal seam parameters, and those parameters which the user can control. One or more of these parameters may be changed to determine their individual or collective effect on relative dust generation and cutting forces. The program is written in the BASIC programming language. A complete program listing is included along with user instructions and sample outputs.

1Physical scientist
2Supervisory physical scientist.

Twin Cities Research Center, U.S. Bureau of Mines, Minneapolis, MN.
INTRODUCTION

Since the enactment of the Federal Coal Mine Health and Safety Act of 1969, the U.S. Bureau of Mines has conducted an extensive research program on the control and reduction of respirable coal dust. Over the past 15 yr, research has been conducted in small-scale laboratory tests, in intermediate-sized prototype tests, and in full-scale in-mine demonstrations. The main objective of the work at the Bureau's Twin Cities (MN) Research Center has been the determination of the effect of controllable machine parameters on respirable dust generation. These controllable parameters include depth of cut, bit spacing, bit geometry, and operating conditions.

The body of data collected during this research provides a broad base of knowledge on the coal cutting phenomenon. The results are available to the industry in the form of a multitude of Bureau publications. There is so much information in so many places that individuals interested in reducing respirable dust generation at a specific mining operation will have difficulty finding their way through the available data to extract the specific information they need. The advent of the microcomputer and its universal availability provides a means of alleviating this problem.

This report presents a version of the cutting system model (CSM) specifically structured for the analysis of continuous mining machines (CM-CSM).

PROGRAM DESCRIPTION

The CM-CSM program was developed to analyze the relative dust generated by a continuous mining machine cutting in a coal seam containing rock band or middle man. The program is menu driven, allowing the user to make parametric changes with a minimum of steps. It is written in BASIC and will run on an IBM Personal Computer or equivalent. The menus through which the program operates allow the user to change parameter values, calculate dust values, save modified data files, obtain printer copies of summary reports, lists of modifications, and a listing of the entire data file. Also, a "Help" menu provides online assistance to the user. A program listing is given in appendix A. The parameters used are defined in appendix B.

The logical flow of the program is shown in figure 1. The program first determines the angle of contact between the drum and the coal face. At the start of sump this angle will be 90° and will increase as the sump cut is made. An average cut depth will be calculated based on either the user specified maximum sump rate or shear rate for each vertical strata (coal, rock, coal) through which the drum is cutting. This average cut depth is calculated based on the analysis of rotary cutting performed by Roepke.

The equation used is

$$\text{average depth} = \frac{\int_{\phi_1}^{\phi_2} D(\phi) \, d\phi}{\phi_2 - \phi_1},$$

where

- $\phi_1 =$ angle at entry,
- $\phi_2 =$ angle at exit,
- $D(\phi) = R + A \cos(\phi) - (R^2 - A^2 \sin^2(\phi))^\frac{1}{2}$
  unless $D(\phi) > D_{max}$, in which case
- $D(\phi) = D_{max}$
- $R =$ drum radius,
- $A =$ advance per revolution,
- $D_{max} =$ maximum cut depth due to bit interaction,

and $\phi =$ rotation angle about drum center.

Once the average cut depth is calculated, the cutting and normal forces will be computed. Both the cutting and normal forces are assumed to be linear functions of depth. The force equations are defined by a slope and intercept, which can be obtained from either laboratory cutting tests or from in situ measurements with the in-seam tester. The effect of bit wear is incorporated by the application of multipliers to both the cutting and normal forces. For new bits (e.g., wear equal to 0 pct), the multiplier is 1. A maximum of three different wear stages can be used by the user.
Compute angle of contact

Compute depth of cut for coal and rock layers

Drum dimensions bit spacing seam conditions

Reduce advance rate

Computer horsepower and thrust requirements

Force parameters, wear conditions

Are thrust and horsepower available?

Y

Are sump and shear complete?

N

Update status variables and sum dust

Y

Compute dust production and costs; print report

Figure 1.-Program flowchart.
program. The required torque is calculated from the cutting force, drum diameter, and number of bits. If this torque exceeds the available torque, the sump or shear rate is reduced by 5% of the original value and the calculation procedure is repeated. In a similar manner, the thrust required to advance the drum is calculated from the normal force and the number of bits. This iterative process is continued until the required torque or thrust is equal to or less than the available torque or thrust. Relative airborne dust, production, and cost values are calculated for a summary report. The program then returns the user to the main menu.

**OPERATION**

The program is menu driven. The main menu, which controls all the program functions, is shown in figure 2. Selecting item 1 on this menu causes the program to recalculate the relative dust value using the procedures described in the previous section. Figure 3 shows an example of the summary report that is generated by the analysis. At this point the user is given the option of printing a hard copy of the report. The user will be returned to the main menu regardless of the choice made.

Changes in parameter values are accomplished by selecting items 2 through 5 on the main menu. Figure 4 shows a change being made in the drum revolutions from 60 to 51 rpm. This menu was reached by selecting item 2 from the main menu. Appendix B gives a list of parameter definitions and identifies the category in which the parameter appears. Item 6 sets the wear condition of the bits. The value is entered as a percent of total bit life. Item 7 provides a data file utility that allows saving the current data file, inputting a new data file, or obtaining a hard copy of the entire data file. Item 8 provides online help messages to assist the user. Selecting this item causes

```
1 - RECALCULATE DUST VALUE
2 - MODIFY MACHINE PARAMETERS
3 - MODIFY SEAM PARAMETERS
4 - MODIFY OPERATOR-CONTROLLABLE PARAMETERS
5 - MODIFY BIT PARAMETERS
6 - CHANGE WEAR CONDITION
7 - DATA FILE UTILITY
8 - HELP MENU
9 - TERMINATE THIS RUN
```

**Figure 2.-Main menu.**

```plaintext
*** DUST ANALYSIS SUMMARY ***

<table>
<thead>
<tr>
<th></th>
<th>SUMP</th>
<th></th>
<th>SHEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVG. CUT DEPTH (IN)</td>
<td>2.00</td>
<td>AVG. CUT DEPTH (IN)</td>
<td>2.00</td>
</tr>
<tr>
<td>AVERAGE SUMP RATE (IN/SEC)</td>
<td>2.00</td>
<td>AVERAGE SHEAR RATE (IN/SEC)</td>
<td>2.00</td>
</tr>
<tr>
<td>BIT SPACING (IN)</td>
<td>1.50</td>
<td>BIT WEAR CONDITION (PCT)</td>
<td>0.0</td>
</tr>
</tbody>
</table>

| SUMP       | 33000 | AVAILABLE DRUM TORQUE(FT-LB) | 40000 |
| UTILIZED THRUST(LB) | 4847  | UTILIZED DRUM TORQUE(FT-LB)  | 19383 |

| SHEAR      | 74999 | AVAILABLE DRUM TORQUE(FT-LB) | 40000 |
| UTILIZED THRUST(LB) | 2261  | UTILIZED DRUM TORQUE(FT-LB)  | 14484 |

| TONS/MINUTE | 7.60  | TONS/SHIFT               | 730   |
| COST/TON - BITS AND POWER | 0.33  | COST/SHIFT - BITS AND POWER | 241   |
| PCT TOTAL DUST - SUMP     | 28.8  | PCT TOTAL DUST - SHEAR   | 71.2  |

<table>
<thead>
<tr>
<th></th>
<th>SUMP</th>
<th></th>
<th>SHEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>28.8</td>
<td>PCT TOTAL DUST - SUMP</td>
<td>71.2</td>
</tr>
</tbody>
</table>

* FULL SHIFT RELATIVE DUST - 1569.50 PER TON 8.42 PER CU. M. *
```

**Figure 3.-Sample summary report.**
another menu, shown in figure 5, to be printed. The first seven items of the help index menu are identical to their counterparts on the main menu. Selecting the appropriate item from this menu will cause a help message covering the subject to be printed.

The program performs internal checks on the data as the calculations are being made. The user is informed if the bit spacing is less than 1 in and given the option to change the data before proceeding with the analysis. The value for the wear condition is checked to ensure it is within the ranges specified by the input data. If the values for drum revolution per minute and sump rate result in a depth of cut greater than the drum radius, the user is so informed and returned to the main menu. Likewise, a similar check is made on the drum revolution per minute and the shear rate. These two checks are necessary to prevent an error condition which causes the program to terminate.

Most of the data required by the program is self-explanatory. Certain data elements need more explanation than is provided in appendix B. Data elements 3 through 5 are used to calculate the available downward force in the shear portion of the cut. The program assumes the hydraulic cylinders on the boom can exert enough force to raise the front end of the miner. If this is not the case, then the force they can exert must be calculated and entered as data element 3 and both data elements 4 and 5 must be set to 1.

The advancing thrust (data element 9) should be limited to the force available to advance the drum into the face. The force necessary to move the mass of the miner forward should not be included.

**INPUT DATA**

ENTER THE NUMBER OF THE VARIABLE YOU WISH TO CHANGE, USE ZERO(0) TO TERMINATE - 7
ENTER NEW DRUM REVOLUTIONS (RPM) - 51

ENTER THE NUMBER OF THE VARIABLE YOU WISH TO CHANGE, USE ZERO(0) TO TERMINATE - 0

---

**Figure 4.—Parameter modification example.**

---

**Figure 5.—Help index menu.**
Since the CM-CSM provides the user with a relative dust value it should not be necessary to vary the two dust parameters (data elements 16 and 17). The values found in appendix C should be adequate for most analysis. The maximum sump and shear rates should be set reasonably close (within 20 pct of the actual rates). As explained in the "Program Operation" section, the program will reduce these rates by 5 pct of the original value until calculations indicate the miner has sufficient thrust or torque to cut at that rate. If the initial value is very high compared with the actual value the program execution time is greatly increased and the final sump or shear rate could be significantly lower than the maximum possible.

The end ring parameters (data elements 25-27) are for one end of the drum only. The program assumes the drum has two ends in the computations.

The center chain section parameters (data elements 28-30) should be used for the chain mat on chain driven drums or for the strut sections for gear driven drums. The number of bits entered for a chain driven drum should be equal to that number that are found on a chain length equal to the drum circumference. The program assumes only one center section, so if a drum with two struts is being analyzed the data must include the number of bits on both struts even though there is a drum section between the struts.

The user must bear in mind the influence of production time per shift (data element 33) on the relative dust per cubic meter value. Generally, any parameter change that lowers production will lower relative dust per cubic meter if the production time per shift is unchanged. An example of this behavior is shown in table 1. The table shows an analysis of the effect of bit wear condition. In Case A, the production time per shift was fixed at 20 pct. Under these conditions the relative dust per short ton value increases with an increase in bit wear while relative dust per cubic meter begins decreasing after bit wear has reached 40 pct. In Case B, the production time was adjusted to produce a constant tonnage per shift. Dust per cubic meter, in this case, increases with increasing bit wear.

**VERIFICATION**

The in-mine results from the Bureau contract "Deep Cutting Continuous Miner" were compared with relative values calculated by the CM-CSM. The miner specifications are shown in table 2. The underground tests were run with 3 rpm (9, 18, and 51) and 3 depth of cuts (1, 2, and 3.5 in/r). The average sump and shear rates for each of the nine combinations of drum revolution per minute and depth of cut (advance per revolution) that were run are shown in table 3. These rates were input to the CM-CSM to calculate the relative dust value for each combination. The results are shown in table 4 and graphically in figure 6. The in-mine results showed a much larger amount of scatter than did the CM-CSM results. The in-mine data has a worst case coefficient of variation of 40 pct, but the nominal range is between 20 and 26 pct. This should be expected since the CM-CSM uses average values and is not subject to in-mine variations in ventilation, coal properties, and so forth. The in-mine data show a reduction of 63 pct between 51 rpm at 1-in depth and 9 rpm at 3.5 in depth while the CSM shows a 62 pct reduction for the same conditions. In the worst case, 51 rpm at 1-in depth for both in-mine and CSM the difference is only 25 pct. In spite of the in-mine scatter this is very good agreement.

**TABLE 1.—Effect of bit wear and production time on relative dust per cubic meter**

| Bit wear, Dust, St per Dust, Case A Case B | Production time, Dust, mm/day |
|----------|------------------|------------------|
| Bit wear | Dust, mg/st | St per shift | mg/m³ | Dust, mg/m³ |
| 0        | 598             | 900             | 9.88  | 20           | 9.88 |
| 10       | 628             | 865             | 10.00 | 20.8         | 10.39 |
| 20       | 729             | 754             | 10.10 | 23.8         | 12.02 |
| 30       | 796             | 667             | 10.06 | 26.2         | 13.17 |
| 40       | 866             | 631             | 10.06 | 28.5         | 14.34 |
| 50       | 931             | 570             | 9.76  | 31.5         | 15.37 |
| 60       | 1012            | 519             | 9.66  | 34.6         | 16.72 |
| 70       | 1101            | 467             | 9.52  | 36.2         | 17.23 |
| 80       | 1101            | 457             | 9.46  | 38.5         | 18.20 |
| 90       | 1121            | 449             | 9.27  | 40.0         | 18.53 |

Production time per shift percent for Case A was 20. Short ton per shift for Case B was 900.

**TABLE 2.—Miner specifications**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drum diameter</td>
<td>44.5 in</td>
</tr>
<tr>
<td>Number of scrolls</td>
<td>1</td>
</tr>
<tr>
<td>Drum revolutions</td>
<td>9, 18, 51 rpm</td>
</tr>
<tr>
<td>Seam height</td>
<td>79 in</td>
</tr>
<tr>
<td>Sump distance</td>
<td>18 in</td>
</tr>
<tr>
<td>Bits per scroll</td>
<td>20</td>
</tr>
<tr>
<td>Number of kerf lines-end</td>
<td>3</td>
</tr>
<tr>
<td>Number of kerf bits-end</td>
<td>9</td>
</tr>
<tr>
<td>End kerf section width</td>
<td>12 in</td>
</tr>
<tr>
<td>Number of bit lines-chain</td>
<td>12</td>
</tr>
<tr>
<td>Total number of bits-chain</td>
<td>12</td>
</tr>
<tr>
<td>Chain kerf section width</td>
<td>24 in</td>
</tr>
</tbody>
</table>
An interactive computer program has been developed which allows the user to evaluate, on a relative basis, the effect of cutting system changes on primary dust generation for continuous mining machines. The program is written in BASIC for use on IBM compatible microcomputers using MS-DOS. The program is menu driven and allows the user to systematically vary cutting system parameters either individually or collectively to determine their effect on dust generation.

The program can be used to determine the range of cutting parameters that produces the minimum relative dust value, thereby reducing or eliminating the need for extensive and costly underground testing. Those parameters, which have the greatest effect on dust, can be identified by using the program and given priority in any underground tests.
APPENDIX A.-PROGRAM LISTING

10 PRINT: PRINT: PRINT TAB(30); "CUTTING SYSTEM MODEL": PRINT TAB(26); "Continuous Miner Version 2.0"
20 PRINT TAB(34); "July 7, 1988"
30 PRINT: PRINT TAB(20); "by Bruce D. Hanson and Wallace W. Roepke": PRINT TAB(17); "US Department of the Interior, Bureau of Mines"
40 PRINT: PRINT TAB(10); "For technical assistance contact the authors at the Twin Cities"
50 PRINT TAB(10); "Research Center, 5629 Minnehaha Avenue So., Minneapolis, MN 55417"
60 PRINT TAB(20); "or phone (612) 725-4782 or 725-4780"
70 PRINT: PRINT" THIS PROGRAM CALCULATES RELATIVE RESPIRABLE DUST GENERATED BY A ROTARY DRUM"
80 PRINT"BASED ON THE DRUM DIMENSIONS, COAL PARAMETERS AND OPERATING CONDITIONS OF THE"
90 PRINT"MINER. SECONDARY DUST, THAT IS, DUST GENERATED BY THE GRINDING ACTION OF THE"
100 PRINT"DRUM AND FALLING COAL IS INCLUDED IN THE CALCULATIONS. THE EFFECT OF COLLECTION"
110 PRINT"AND/OR SUPPRESSION SYSTEMS ARE INCORPORATED IN THE PROGRAM. THE PROGRAM ALSO"
120 PRINT"CALCULATES BIT AND POWER COSTS FOR NEW AND WORN BITS. SITUATIONS WITH A ROCK"
130 PRINT"MIDDLEMAN CAN BE ANALYZED. THE USER CAN MODIFY ALL OF THE DRUM DIMENSIONS, COAL"
140 PRINT"PARAMETERS AND OPERATING CONDITIONS EITHER COLLECTIVELY OR INDIVIDUALLY TO"
150 PRINT"DETERMINE THE EFFECT ON DUST GENERATION."
160 PRINT: PRINT "....HIT ANY RETURN TO CONTINUE.....": INPU{ A$
180 PRINT: PRINT: PRINT: PRINT" The Bureau of Mines expressly declares that there are no warranties"
190 PRINT"express or implied which apply to the software contained herein. By acceptance"
200 PRINT"and use of said software, which is conveyed to the user without consideration"
210 PRINT"by the Bureau of Mines, the user hereof expressly waives any and all claims for"
220 PRINT"damage and/or suits for or by reason of personal injury, or property damage,"
230 PRINT"including special, consequential or similar damages arising out of or in any"
240 PRINT"way connected with the use of the software contained herein."
250 PRINT: PRINT: PRINT: PRINT
260 DIM NAM$(62), IV(62), PC(10), F$(1)
270 PI=3.1415926#: F$(0)="SCRN:": F$(1)="LPT1:"
280 DEF FN DC(Z)=R+A*COS(Z)-SQR(R*R-A*A*SIN(Z)^2)
290 PRINT: PRINT: PRINT TAB(10) "ENTER DATA FILE NAME": INPUT FI$
300 OPEN "I", #1, FI$
FOR I=1 TO 62: INPUT #1,NAM$(I),IV(I): NEXT I
CLOSE: GOTO 880
K=38: GOSUB 1310: MN=MF
K=51: GOSUB 1310
IF WC>IV(47) THEN PRINT: PRINT: PRINT: PRINT "You have specified a wear condition greater than" IV(47) " percent": PRINT: GOTO 1050
OS=(IV(2)-IV(30)-2*IV(27))/IV(24)
B$=" Your bit spacing is less than 1 inch, this will lead to excessive dust levels. Do you still want the number of bits you have specified"
IF OS<1 THEN PRINT: PRINT: PRINT: PRINT B$; INPUT A$: IF A$="N" THEN 880
A=60*IV(20)/IV(6)/IV(7): IF A<IV(1)/2 THEN 420
IV(20)=IV(1)*IV(6)*IV(7)/120
PRINT: PRINT: PRINT: PRINT "The depth of cut is greater than the drum radius, this causes the program to crash, please reduce the sump rate": GOTO 880
DSU=0: DSH=0: R=IV(1)/2: MA=IV(20): CA=IV(20)/20: HPSU=0: PRINT: PRINT: NR=0: GOSUB 1510
A=60*IV(21)/IV(6)/IV(7): IF A<IV(1)/2 THEN 460
IV(21)=IV(1)*IV(6)*IV(7)/120
PRINT: PRINT: PRINT: PRINT "The depth of cut is greater than the drum radius, this causes the program to crash, please reduce the shear rate": GOTO 880
SS=TA/NS: CA=IV(21)/20: NS=0: SH=0: SHHP=0: PRINT: PRINT: GOSUB 1800
TP=IV(22)*IV(10)*IV(2)*IV(7)/43200/(NS+NR)
DSU=DSU*IV(19)/10*IV(1)/12*PI: DSH=DSH*IV(19)/10*IV(1)/12*PI
K=0
OPEN F$(K) FOR OUTPUT AS #1
PRINT#1,"": PRINT#1,TAB(21)"*** DUST ANALYSIS SUMMARY ***": PRINT#1,"": A$="AVG__CUT__DEPTH_(IN)_SUMP_####.##": PRINT#1,USING A$; SS
A$="AVG__CUT__DEPTH_(IN)_SHARP_####.##": PRINT#1,USING A$; SH*IV(7)/60
A$="AVG__CUT__DEPTH_(IN)_SHARP_####.##": PRINT#1,USING A$; SH*IV(7)/60
A$="BITE__spacing_(IN)_####.##": PRINT#1,USING A$; OS
A$="BITE__wear__condition_(PCNT)_####.##": PRINT#1,USING A$; WC: PRINT#1,"": PRINT#1,"SUMP"
A$="AVAILABLE__THRUSS_T(LB)_####.##": PRINT#1,USING A$; AST
A$="AVAILABLE__DUM__TORQUE_CFT_LB)_####.##": PRINT#1,USING A$; AST
A$="UTILIZED__THRUSS_T(LB)_####.##": PRINT#1,USING A$; UST
**A$=" UTILITY D R U M T O R Q U E (F T - L B )__ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ ____
PRINT:PRINT TAB(9)"ENTER THE NUMBER FOR THE ACTION YOU WISH TO DO NEXT ";:INPUT WT
950 IF WT<1 OR WT>9 THEN 890
960 ON WT GOTO 330,970,980,1040,990,1050,1060,1070,1080
970 N1=1:N2=9:GOSUB 1160:GOTO 890
980 N1=10:N2=19:GOSUB 1160:GOTO 890
990 N1=37:N2=49:PRINT:PRINT TAB(9)"DO YOU WISH TO MODIFY NORMAL (N) OR CUTTING (C) FORCE PARAMETERS ";:INPUT A$:IF A$="N" THEN 1030
1010 IF A$="C" THEN A=13:GOTO 1030
1020 GOTO 990
1030 N1=N1+A:N2=N2+A:GOSUB 1160:GOTO 890
1040 N1=20:N2=36:GOSUB 1160:GOTO 890
1050 PRINT:PRINT TAB(18)"ENTER WEAR CONDITION (%) - ";:INPUT WC:GOTO 890
1060 GOSUB 2440:GOTO 890
1070 GOSUB 2610:GOTO 890
1080 PRINT:PRINT TAB(9)"ARE YOU SURE YOU WISH TO TERMINATE THE PROGRAM (Y/N) ";:INPUT A$:IF A$="N" THEN 890
1100 IF A$="Y" THEN END
1110 GOTO 890
1120 END
1130 REM
1140 REM VARIABLE CHANGE ROUTINE
1150 REM
1160 N=0:PRINT:PRINT
1170 FOR I=N1 TO N2:X=35-LEN(NAM$(I))–INT(I/10):PRINT TAB(18)I;" - ";NAM$(I);SPC(X);IV(I):NEXT I
1180 PRINT:PRINT TAB(18)"ENTER THE NUMBER OF THE VARIABLE YOU WISH TO CHANGE, USE ZERO(0) TO TERMINATE ";:INPUT "+":;INPUT A$:IF A$="N" THEN 1210
1200 IF A$="Y" THEN END
1210 IF N=0 THEN RETURN
1220 PRINT:PRINT TAB(18)"DO YOU WISH A HARD COPY OF THESE CHANGES (Y/N) ";:INPUT A$:IF A$="Y" THEN 1250
1230 IF A$="N" THEN RETURN
1240 GOTO 1220
1250 OPEN F$(1) FOR OUTPUT AS #1
1260 PRINT#,""
1270 FOR K=1 TO N:L=PC(K):PRINT#,TAB(9)"******** ";NAM$(L);" - ";IV(L):NEXT K:PRINT#,"":CLOSE:RETURN
1280 REM
1290 REM WEAR MULTIPLIER ROUTINE
1300 REM
1310 FOR I=1 TO 3:K=K+3:IF WC<=IV(K) THEN 1330
1320 NEXT I
1330 MF=IV(K+1)+WC*IV(K+2):RETURN
1340 REM
1350 REM CUT DEPTH ROUTINE
1360 REM
1370 SM=FN DC(P1):IF SM>DX THEN SM=DX
1380 IF F=1 THEN SM=SM*COS(P1)
1390 DL=FN DC(P2):IF DL>DX THEN DL=DX
1400 IF F=1 THEN DL=DL*COS(P2)
1410 SM=SM+DL:DL=(P2-P1)/10
1420 FOR I=2 TO 8 STEP 2:X=FN DC(I*DL+P1):IF X>DX THEN X=DX
1430 IF F=1 THEN X=X*COS(I*DL+P1)
1440 SM=SM+2*X:NEXT I
1450 FOR I=1 TO 9 STEP 2:X=FN DC(I*DL+P1):IF X>DX THEN X=DX
1460 IF F=1 THEN X=X*COS(I*DL+P1)
1470 SM=SM+4*X:NEXT I:SM=SM/30:RETURN
1480 REM
1490 REM SUMP ROUTINE
1500 REM
1510 TA=0
1520 OS=(IV(2)-IV(30)-2*IV(27))/IV(24):A=60*MA/IV(7)/IV(6):
   DX=OS*TAN((90-IV(14)/2)*PI/180)
1530 P2=ATN(A/2/SQR(R*R-A*A/4))+PI/2:P3=-P2:
   IF TA<R THEN P3=-ATN(SQR(2*R*TA-TA*TA)/(R-TA))
   NB=IV(6)*IV(24):GOSUB 2190
1550 TN=NF:TC=FC:TD=D
1560 REM
1570 REM END RING
1580 REM
1590 A=A*IV(25)/IV(26):P2=ATN(A/2/SQR(R*R-A*A/4))+PI/2:P3=-P2:
   IF TA<R THEN P3=-ATN(SQR(2*R*TA-TA*TA)/(R-TA))
1600 P1=P3:OS=IV(27)/IV(25):DX=OS*TAN((90-IV(14)/2)*PI/180):
   NB=2*IV(26):GOSUB 2190
1610 TN=TN+NF:TC=TC+FC:TD=TD+D
1620 REM
1630 REM CENTER SECTION
1640 REM
1650 A=A*IV(26)/IV(25)*IV(28)/IV(29):
   P2=ATN(A/2/SQR(R*R-A*A/4))+PI/2:P3=-P2:
   IF TA<R THEN P3=-ATN(SQR(2*R*TA-TA*TA)/(R-TA))
1660 P1=P3:OS=IV(30)/IV(25):DX=OS*TAN((90-IV(14)/2)*PI/180):
   NB=IV(29):GOSUB 2190
1670 TN=TN+NF:TC=TC+FC:TD=TD+D
1680 IF IV(9)>TN THEN UST=TN:GOTO 1700
1690 MA=MA-CA:GOTO 1520
1700 AC=IV(1)*TC/12
1710 IF IV(8)>AC THEN 1730
1720 MA=MA-CA:GOTO 1520
1730 TA=TA+60*MA/IV(7)/IV(6):NR=NR+1:DSU=DSU+TD:SUHP=AC:
   HPSU=HPSU+IV(7)/2*5260*AC+5*MA*TN/33000!
1740 LOCATE 23,1:PRINT USING "_M_I_N_E_R_H_A_S__C_O_M_P_L_E_T_E_D###.##_I_N_C_H_E_S__O_F_S_U_M_P";TA
1750 IF TA<IV(22) THEN 1520
1760 LSU=A:RETURN
1770 REM
1780 REM SHEAR ROUTINE
1790 REM
1800 TS=IV(1):CH=IV(22)
1810 MA=IV(21):IF TS<IV(11) THEN XYZ=1:GOTO 1880
1820 IF TS>IV(12) THEN 1850
1830 IF (TS-R)<IV(11) THEN XYZ=2:
   MT=R-SQR(R^2-(R+IV(11)-TS)^2); MB=CH; GOTO 1880
1840 XYZ=3; MB=CH; GOTO 1880
1850 IF (TS-R)<IV(11) THEN XYZ=4: MT=R-SQR(R^2-(R+IV(11)-TS)^2):
   MB=R-SQR((R^2)-(R+IV(12)-TS)^2); GOTO 1880
1860 IF (TS-R)<IV(12) THEN XYZ=5:
   MB=R-SQR((R^2)-(R+IV(12)-TS)^2); GOTO 1880
1870 XYZ=1
1880 OS=(IV(2)-IV(30)-2*IV(27)/IV(24); NB=IV(6)*IV(24):
   A=60*MA/IV(7)/IV(6); DX=OS*TAN((90-IV(14)/2)*PI/180)
1890 NF=0; FC=0; D=0; P1=ATN((R-CH)/SQR(CH*(2*R-CH))):
   P2=ATN(A/2/SQR(R*R-A*A/4))+PI/2; P3=P1
1900 ON XYZ GOSUB 2400,2190,2320,2190,2310
1910 TN=NF; TC=FC; TD=D
1920 REM
1930 REM END RING
1940 REM
1950 OS=IV(27)/IV(25); DX=OS*TAN((90-IV(14)/2)*PI/180):
   A=A*IV(25)/IV(26); NB=2*IV(26); NF=0; FC=0; D=0
1960 P1=ATN((R-CH)/SQR(CH*(2*R-CH))):
   P2=ATN(A/2/SQR(R*R-A*A/4))+PI/2; P3=P1
1970 ON XYZ GOSUB 2400,2190,2320,2190,2310
1980 TN=TN+NF; TC=TC+FC; TD=TD+D
1990 REM
2000 REM CENTER SECTION
2010 REM
2020 OS=IV(30)/IV(28); DX=OS*TAN((90-IV(14)/2)*PI/180):
   A=A*IV(26)/IV(25)*IV(28)/IV(29); NB=IV(29); NF=0; FC=0; D=0
2030 P1=ATN((R-CH)/SQR(CH*(2*R-CH))):
   P2=ATN(A/2/SQR(R*R-A*A/4))+PI/2; P3=P1
2040 ON XYZ GOSUB 2400,2190,2320,2190,2310
2050 TN=TN+NF; TC=TC+FC; TD=TD+D
2060 AN=IV(3)*IV(5)/IV(4); IF AN>TN THEN 2080
2070 MA=MA-CA: GOTO 1880
2080 AC=IV(1)*TC/12: IF IV(8)>AC THEN 2100
2090 MA=MA-CA: GOTO 1880
2100 TS=TS+60*MA/IV(7)/IV(6); NS=NS+1; DSH=DSH+TD:
   HPSH=HPSH+AC*IV(7)/2/5260
2110 IF USH<TN THEN USH=TN
2120 IF SHHP<AC THEN SHHP=AC
2130 LOCATE 23,1; PRINT USING "__________ T H E _________
   _M I N E R_ _H A S###.####_N C H E S_ O F_ S H E A R_
   _R EM A I N-r-N-G"; IV(10)-TS;
2140 IF TS<IV(10) THEN 1810
2150 RETURN
2160 REM
2170 REM DUST/FORCE ROUTINE
2180 REM
2190 NF=0; FC=0; D=0; IF MT=MB OR MT=>CH THEN 2400
2200 REM
2210 REM CALCULATE DUST & FORCES FOR TOP COAL
2220 REM
2230 X=(IV(1)-2*MT)/IV(1); P1=ATN(X/SQR(1-X*X)); F=1: GOSUB 1370
2240 NF=MN*(IV(37)*(SIN(P2)-SIN(P1))/(P2-P1)+IV(38)*SM)*((P2-P1)/PI/2*NB
2250 F=0:GOSUB 1370:D=(IV(16)+SM*IV(17))*NB*(P2-P1)/PI/2
2260 FC=MF*(IV(50)+SM*IV(51))*(P2-P1)/PI/2*NB
2270 REM
2280 REM CALCULATE DUST & FORCES FOR MIDDLEMAN
2290 REM
2300 P2=P1:P1=P3:IF MB=>CH THEN 2320
2310 X=(IV(1)-2*MB)/IV(1):Pl=ATN(X/SQR(1-X*X))
2320 F=1:GOSUB 1370:NF=NF+MN*(IV(39)*(SIN(P2)-SIN(P1))/(P2-P1)+IV(40)*SM)*(P2-P1)/PI/2*NB
2330 F=0:GOSUB 1370:FC=FC+MF*(IV(52)+IV(53)*SM)*(P2-P1)/PI/2*NB
2340 D=D+(IV(16)+SM*IV(17))*NB*((P2-P1)/PI/2)*(5^IV(13)*.01)*2
2350 IF MB=>CH THEN RETURN
2360 REM
2370 REM CALCULATE BOTTOM COAL DUST & FORCES
2380 REM
2390 P2=P1:P1=P3
2400 F=1:GOSUB 1370:NF=N+F+MN*(IV(37)*(SIN(P2)-SIN(P1))/(P2-P1)+IV(38)*SM)*((P2-P1)/PI/2*NB
2410 F=0:GOSUB 1370:D=+(IV(16)+SM*IV(17))*NB*((P2-P1)/PI/2)*(5^IV(13)*.01)*2
2420 FC=FC+MF*(IV(50)+SM*IV(51))*(P2-P1)/PI/2*NB
2430 RETURN
2440 PRINT:PRINT:PRINT"########################################################################### DATA FILE
UTILITY###########################################################################"
2450 PRINT:PRINT"1 - SAVE CURRENT DATA FILE";PRINT TAB(40)"2 - PRINT CURRENT DATA FILE"
2460 PRINT"3 - READ NEW DATA FILE";PRINT TAB(40)"4 - RETURN TO MAIN MENU"
2470 PRINT:PRINT TAB(9)"ENTER THE NUMBER FOR THE ACTION YOU WISH TO DO NEXT ":INPUT WT
2480 ON WT GOTO 2490,2530,2510,2550
2490 PRINT:PRINT:"ENTER SAVE DATA FILE NAME ";FI$:PRINT:OPEN "O", #2, FI$;
2500 FOR I=1 TO 62:PRINT #2, NAM$(I);","IV(I):NEXT I:
2510 CLOSE 2:GOTO 2440
2520 PRINT:PRINT TAB(9)"ENTER NEW DATA FILE NAME ";:INPUT FI$:OPEN "I", #1, FI$
2530 FOR I=1 TO 62:INPUT #1, NAM$(I), IV(I):NEXT I:CLOSE:
2540 GOTO 2440
2550 OPEN "O", #1, "LPT1":A$="##### \\
2560 FOR I=1 TO 62:PRINT#1,USING A$;I,NAM$(I);:PRINT#1,IV(I):
2570 NEXT I:CLOSE 1:GOTO 2440
2580 RETURN
2590 KW=.746*(HPSU/NR+HPSH/NS):KH=KW*IV(33)*8/100:BL=IV(36)
2600 IF IV(12)-IV(11)=0 THEN 2600
2610 FOR I=1 TO 62:PRINT#1,USING A$;I,NAM$(I);:PRINT#1,IV(I):
2620 NEXT I:CLOSE 1:GOTO 2440
2630 RETURN
2640 PRINT:PRINT:PRINT"########################################################################### HELP INDEX FOR MAIN MENU###########################################################################"
2630 PRINT:PRINT"1 - RECALCULATE DUST VALUE"; :PRINT TAB(35) "2 - MODIFY MACHINE PARAMETERS"
2640 PRINT"3 - MODIFY SEAM PARAMETERS"; :PRINT TAB(35) "4 - MODIFY OPERATOR-CONTROLLABLE PARAMETERS"
2650 PRINT"5 - MODIFY BIT PARAMETERS"; :PRINT TAB(35) "6 - CHANGE WEAR CONDITION"
2660 PRINT"7 - DATA FILE UTILITY"; :PRINT TAB(35) "8 - RETURN TO MAIN MENU"
2670 PRINT:PRINT TAB(9) "ENTER THE NUMBER FOR THE ITEM FOR WHICH YOU DESIRE HELP "; :INPUT HT
2680 IF HT<1 OR HT>8 THEN 2620
2690 ON HT GOTO 2700, 2790, 2840, 2910, 2960, 3010, 3070, 3110
2700 PRINT:PRINT:PRINT"******************* MENU ITEM 1 - RECALCULATE RELATIVE DUST VALUE *******************"
2710 PRINT"THE USER MAY PRINT A HARD COPY OF THE SUMMARY REPORT WHEN THE CALCULATIONS ARE COMPLETE. THE PROGRESS OF THE DRUM IN THE SUMP AND SHEAR CUTS IS SHOWN ON THE SCREEN. IF THE AVAILABLE HORSEPOWER OR THRUST IS INSUFFICIENT TO ADVANCE THE MACHINE AT THE SPECIFIED RATE THE PROGRAM WILL DECREASE THE SUMP OR SHEAR RATE UNTIL THE REQUIRED HORSEPOWER OR THRUST IS LESS THAN THE AVAILABLE."
2780 PRINT"*****************************************:GOTO 2600" :GOTO 2620
2790 PRINT:PRINT:PRINT"******************* MENU ITEM 2 - MODIFY MACHINE PARAMETERS *******************"
2800 PRINT"THE USER CAN CHANGE ANY OF THE 9 VARIABLES WHICH DESCRIBE THE CONTINUOUS MINER. THE PROGRAM HAS NO INTERNAL ERROR CHECKING ROUTINES TO INSURE THAT THE DRUM DIMENSIONS ARE CONSISTENT WITH EACH OTHER."
2830 PRINT"*****************************************:GOTO 2600" :GOTO 2620
2840 PRINT:PRINT:PRINT"******************* MENU ITEM 3 - MODIFY SEAM PARAMETERS *******************"
2850 PRINT"THE USER CAN CHANGE ANY OF 10 SEAM AND/OR COAL PROPERTY VARIABLES. THE ROCK BAND VALUES (TOP AND BOTTOM) ARE MEASURED FROM THE TOP OF THE MINING HORIZON.
2870 PRINT"ONE ASPECT OF PROGRAM FLOW IS CONTROLLED BY VARIABLES IN THIS MENU. SETTING THE ROCK BAND TOP EQUAL TO THE ROCK BOTTOM WILL CAUSE THE PROGRAM TO CONSIDER CUTTING ONLY COAL."
2890 PRINT:PRINT:PRINT"*****************************************:GOTO 2600" :GOTO 2620
2910 PRINT:PRINT:PRINT"******************* MENU ITEM 4 - MODIFY OPERATOR - CONTROLLABLE PARAMETERS *******************"
I·

PRINT"THIS MENU ALLOWS THE USER TO CHANGE 17 'CONTROLLABLE' PARAMETERS SUCH AS AIR"
PRINT"FLOW, PRODUCTION TIME PER SHIFT, NUMBER OF BITS, BIT LIFE, COST OF BITS, COST OF"
PRINT"POWER, AND DUST SUPPRESSION ETC."
PRINT
PRINT"*************** MENU ITEM 5 - MODIFY BIT PARAMETERS ********************
PRINT"THE USER CAN CHANGE ANY OF 26 FORCE AND WEAR CHARACTERISTICS OF THE BITS"
PRINT"BEING USED IN THE ANALYSIS. THE VALUES FOR FORCE AND WEAR PARAMETERS MUST BE"
PRINT"OBTAINED FROM IN SITU FORCE MEASUREMENTS AND FROM LAB WEAR TESTS."
PRINT
PRINT"*************** MENU ITEM 6 - CHANGE WEAR CONDITION ********************
PRINT"THE USER CAN CHANGE THE WEAR CONDITION OF BITS THROUGH THIS MENU ITEM. THE"
PRINT"WEAR CONDITION IS EXPRESSED IN A PERCENTAGE, ZERO (0) BEING A NEW BIT, AND 100"
PRINT"REPRESENTING A TOTALLY WORN BIT. THE WEAR CONDITION IS USED TO DETERMINE A FORCE"
PRINT"MULTIPLIER FOR THE BITS."
PRINT
PRINT"*************** MENU ITEM 7 - DATA FILE UTILITY ********************
PRINT"THIS OPTION ALLOWS THE USER TO SAVE THE CURRENT DATA FILE, READ A NEW DATA"
PRINT"OR OBTAIN A PRINTER LISTING OF DATA FILE VALUES."
PRINT
PRINT"***************":GOTO 2620
PRINT"RETURN"
# APPENDIX B.-PARAMETER DEFINITION

<table>
<thead>
<tr>
<th>Element Number</th>
<th>Name - Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>MACHINE PARAMETERS</strong></td>
</tr>
<tr>
<td>1</td>
<td>DRUM DIAMETER (IN) - Bit tip to bit tip diameter</td>
</tr>
<tr>
<td>2</td>
<td>DRUM WIDTH (IN) - Cutting width of the drum</td>
</tr>
<tr>
<td>3</td>
<td>MACHINE WEIGHT (LB) - Weight of the mining machine. If the hydraulic cylinders on the boom cannot lift the front end of the machine off the floor then the maximum force the cylinders can exert should be used</td>
</tr>
<tr>
<td>4</td>
<td>DRUM CENTER DISTANCE (IN) - The distance from stabilizing jack (rear sprocket of tracks, if miner has no stabilizing jack) to the center of drum at the midpoint of the shear cut</td>
</tr>
<tr>
<td>5</td>
<td>CENTER GRAVITY DISTANCE (IN) - The distance from the stabilizing jack to the center of gravity of the miner</td>
</tr>
<tr>
<td>6</td>
<td>NUMBER OF SCROLLS - number of scrolls on the main portion of the drum</td>
</tr>
<tr>
<td>7</td>
<td>DRUM REVOLUTIONS (RPM) - Drum speed as measured in RPM</td>
</tr>
<tr>
<td>8</td>
<td>AVAIL. CUTTING TORQUE - Torque available to turn the drum</td>
</tr>
<tr>
<td>9</td>
<td>AVAIL. ADVANCING THRUST - Thrust available to sump the miner into the face</td>
</tr>
<tr>
<td></td>
<td><strong>SEAM PARAMETERS</strong></td>
</tr>
<tr>
<td>10</td>
<td>SEAM HEIGHT (IN) - Height of coal and rock being removed</td>
</tr>
<tr>
<td>11</td>
<td>ROCK BAND TOP (IN) - Distance from the top of the seam to the top of the rock band</td>
</tr>
<tr>
<td>12</td>
<td>ROCK BAND BOTTOM (IN) - Distance from the top of the seam to the bottom of the rock band, if set equal to the ROCK BAND TOP the program assumes there is no rock band</td>
</tr>
<tr>
<td>13</td>
<td>PCT SILICA IN ROCK BAND - Percent silica in the rock band</td>
</tr>
<tr>
<td>14</td>
<td>BREAKOUT ANGLE (°) - A measure of the bit interaction, the included angle of the trench left by the bit. This angle will vary for different coal type, and bedding plane direction.</td>
</tr>
<tr>
<td>15</td>
<td>SWELL FACTOR - Ratio of mined volume to insitu volume</td>
</tr>
<tr>
<td>16</td>
<td>FIRST DUST PARAMETER - Intercept of the linear dust versus cut depth equation</td>
</tr>
<tr>
<td>17</td>
<td>SECOND DUST PARAMETER - Slope of the linear dust versus cut depth equation</td>
</tr>
<tr>
<td>18</td>
<td>COMPRRESSIVE STRENGTH - Compressive strength measured in pounds per square inch. (Not currently used, reserved for future modifications)</td>
</tr>
<tr>
<td>19</td>
<td>GRINDABILITY INDEX - Hardgrove Grindability Index</td>
</tr>
</tbody>
</table>
OPERATOR CONTROLLABLE PARAMETERS

20 MAX. SUMP RATE (IN/S) - The maximum rate at which the miner will attempt to sump into the face
21 MAX. SHEAR RATE (IN/S) - The maximum rate at which the miner will attempt to shear down
22 SUMP DISTANCE (IN) - The distance the miner sumps into the face during the sump portion of the cycle
23 ENTRY WIDTH (IN) - Width of the entry being mined
24 BITS PER SCROLL - The number of bits on one scroll of the main portion of the drum
25 NUMBER OF KERF LINES--END - Number of kerf lines on the drum end
26 NUMBER OF KERF BITS--END - Number of kerf bits on the drum end
27 END KERF SECTION WIDTH - Width of the kerf cutter section on the end of the drum
28 NUMBER OF KERF LINES--CHAIN - Total number of kerf lines on the chain or strut sections of the drum
29 NUMBER OF KERF BITS--CHAIN - Total number of kerf bits on the chain or strut sections of the drum
30 CENTER CHAIN SECTION WIDTH (IN) - Width of the center chain or strut section(s) on the drum
31 AIRFLOW (CFM) - Average airflow at the middle of the face, measured in cubic feet per minute
32 DUST SUPPRESSION (PCT) - Percent reduction in the total dust value due to suppression system
33 PRODUCTION TIME PER SHIFT (PCT) - Percent of shift spent cutting coal, based on an 8-hour shift
34 COST PER KILOWATT-HOUR - Cost per kilowatt-hour at the face
35 COST PER BIT - Cost of bit installed on drum
36 BIT LIFE (ST) - Average bit life, expressed in tons

BIT NORMAL FORCE PARAMETERS *

37 NORMAL FORCE INTERCEPT - Intercept for the normal force versus cut depth equation, cutting in coal
38 NORMAL FORCE SLOPE - Slope for the normal force versus cut depth equation, cutting in coal
39 RB NORMAL FORCE INTERCEPT - Intercept for the normal force versus cut depth equation, cutting in rock
40 RB NORMAL FORCE SLOPE - Slope for the normal force versus cut depth equation, cutting in rock
41 FIRST STAGE END POINT (PCT) - Defines the end of the first straight line segment of the wear function for normal force
42 FIRST STAGE INTERCEPT - Intercept of the first straight line segment
43 FIRST STAGE SLOPE - Slope of the first straight line segment
44 SECOND STAGE END POINT (PCT) - Defines the end of the second straight line segment of the wear function for normal force
45 SECOND STAGE INTERCEPT - Intercept of the second straight line segment
SECOND STAGE SLOPE - Slope of the second straight line segment
THIRD STAGE END POINT (PCT) Defines the end of the third straight line segment of the wear function for normal force
THIRD STAGE INTERCEPT - Intercept of the third straight line segment
THIRD STAGE SLOPE - Slope of the third straight line segment

-----------------------------
BIT CUTTING FORCE PARAMETERS *
-----------------------------
CUTTING FORCE INTERCEPT - Intercept for the cutting force versus cut depth equation, cutting in coal
CUTTING FORCE SLOPE - Slope for the cutting force versus cut depth equation, cutting in coal
RB CUTTING FORCE INTERCEPT - Intercept for the cutting force versus cut depth equation, cutting in rock
RB CUTTING FORCE SLOPE - Slope for the cutting force versus cut depth equation, cutting in rock
FIRST STAGE END POINT (PCT) - Defines the end of the first straight line segment of the wear function for cutting force
FIRST STAGE INTERCEPT - Intercept of the first straight line segment
FIRST STAGE SLOPE - Slope of the first straight line segment
SECOND STAGE END POINT (PCT) - Defines the end of the second straight line segment of the wear function for cutting force
SECOND STAGE INTERCEPT - Intercept of the second straight line segment
SECOND STAGE SLOPE - Slope of the second straight line segment
THIRD STAGE END POINT (PCT) - Defines the end of the third straight line segment of the wear function for cutting force
THIRD STAGE INTERCEPT - Intercept of the third straight line segment
THIRD STAGE SLOPE - Slope of the third straight line segment

* from laboratory and/or In-Seam Tester data
### APPENDIX C—SAMPLE DATA

<table>
<thead>
<tr>
<th>Element Number</th>
<th>Data Element Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DRUM DIAMETER (IN)</td>
<td>44.5</td>
</tr>
<tr>
<td>2</td>
<td>DRUM WIDTH (IN)</td>
<td>124</td>
</tr>
<tr>
<td>3</td>
<td>DRUM WEIGHT (LBF)</td>
<td>40000</td>
</tr>
<tr>
<td>4</td>
<td>DRUM CENTER DISTANCE (IN)</td>
<td>144</td>
</tr>
<tr>
<td>5</td>
<td>CENTER GRAVITY DISTANCE (IN)</td>
<td>108</td>
</tr>
<tr>
<td>6</td>
<td>NUMBER OF SCROLLS</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>DRUM REVOLUTIONS (RPM)</td>
<td>51</td>
</tr>
<tr>
<td>8</td>
<td>AVAILABLE DRUM TORQUE (FT-LBF)</td>
<td>40000</td>
</tr>
<tr>
<td>9</td>
<td>AVAILABLE THRUST (LBF)</td>
<td>33000</td>
</tr>
<tr>
<td>10</td>
<td>SEAM HEIGHT (IN)</td>
<td>79</td>
</tr>
<tr>
<td>11</td>
<td>ROCK BAND TOP</td>
<td>95</td>
</tr>
<tr>
<td>12</td>
<td>ROCK BAND BOTTOM</td>
<td>95</td>
</tr>
<tr>
<td>13</td>
<td>PCT SILICA - ROCK BAND</td>
<td>75</td>
</tr>
<tr>
<td>14</td>
<td>BREAKOUT ANGLE</td>
<td>115</td>
</tr>
<tr>
<td>15</td>
<td>SWELL FACTOR</td>
<td>1.5</td>
</tr>
<tr>
<td>16</td>
<td>FIRST DUST PARAMETER</td>
<td>5.0E+07</td>
</tr>
<tr>
<td>17</td>
<td>SECOND DUST PARAMETER</td>
<td>2.5E+07</td>
</tr>
<tr>
<td>18</td>
<td>COMPRESSION STRENGTH (PSI)</td>
<td>4000</td>
</tr>
<tr>
<td>19</td>
<td>GRINDABILITY INDEX</td>
<td>90</td>
</tr>
<tr>
<td>20</td>
<td>MAX. SUMP RATE (IN/S)</td>
<td>2.75</td>
</tr>
<tr>
<td>21</td>
<td>MAX. SHEAR RATE (IN/S)</td>
<td>3.23</td>
</tr>
<tr>
<td>22</td>
<td>SUMP DISTANCE</td>
<td>18</td>
</tr>
<tr>
<td>23</td>
<td>ENTRY WIDTH (IN)</td>
<td>144</td>
</tr>
<tr>
<td>24</td>
<td>BITS PER SCROLL</td>
<td>20</td>
</tr>
<tr>
<td>25</td>
<td>NUMBER OF KERF LINES--END</td>
<td>3</td>
</tr>
<tr>
<td>26</td>
<td>NUMBER OF KERF BITS--END</td>
<td>9</td>
</tr>
<tr>
<td>27</td>
<td>END KERF SECTION WIDTH (IN)</td>
<td>9</td>
</tr>
<tr>
<td>28</td>
<td>NUMBER OF KERF LINES--CHAIN</td>
<td>12</td>
</tr>
<tr>
<td>29</td>
<td>NUMBER OF KERF BITS--CHAIN</td>
<td>12</td>
</tr>
<tr>
<td>30</td>
<td>CENTER CHAIN SECTION WIDTH (IN)</td>
<td>24</td>
</tr>
<tr>
<td>31</td>
<td>AIRFLOW (CFM)</td>
<td>4000</td>
</tr>
<tr>
<td>32</td>
<td>DUST SUPPRESSION (PCT)</td>
<td>33</td>
</tr>
<tr>
<td>33</td>
<td>PRODUCTION TIME PER SHIFT (PCT)</td>
<td>20</td>
</tr>
<tr>
<td>34</td>
<td>COST PER BIT ($)</td>
<td>2.5</td>
</tr>
<tr>
<td>35</td>
<td>COST PER KILOWATT-HR ($)</td>
<td>.06</td>
</tr>
<tr>
<td>36</td>
<td>BIT LIFE (ST)</td>
<td>130</td>
</tr>
<tr>
<td>37</td>
<td>NORMAL FORCE INTERCEPT</td>
<td>0</td>
</tr>
<tr>
<td>38</td>
<td>NORMAL FORCE SLOPE</td>
<td>260</td>
</tr>
<tr>
<td>39</td>
<td>NORMAL FORCE INTERCEPT (RB)</td>
<td>0</td>
</tr>
<tr>
<td>40</td>
<td>NORMAL FORCE SLOPE (RB)</td>
<td>500</td>
</tr>
<tr>
<td>41</td>
<td>FIRST STAGE END POINT (PCT)</td>
<td>25</td>
</tr>
<tr>
<td>42</td>
<td>FIRST STAGE INTERCEPT</td>
<td>1</td>
</tr>
<tr>
<td>43</td>
<td>FIRST STAGE SLOPE</td>
<td>.12</td>
</tr>
<tr>
<td>44</td>
<td>SECOND STAGE END POINT (PCT)</td>
<td>50</td>
</tr>
<tr>
<td>45</td>
<td>SECOND STAGE INTERCEPT</td>
<td>2</td>
</tr>
<tr>
<td>46</td>
<td>SECOND STAGE SLOPE</td>
<td>.08</td>
</tr>
<tr>
<td>47</td>
<td>THIRD STAGE END POINT (PCT)</td>
<td>100</td>
</tr>
<tr>
<td>48</td>
<td>THIRD STAGE INTERCEPT</td>
<td>6</td>
</tr>
</tbody>
</table>
49  THIRD STAGE SLOPE  
50  CUTTING FORCE INTERCEPT  
51  CUTTING FORCE SLOPE  
52  CUTTING FORCE INTERCEPT (RB)  
53  CUTTING FORCE SLOPE (RB)  
54  FIRST STAGE END POINT (PCT)  
55  FIRST STAGE INTERCEPT  
56  FIRST STAGE SLOPE  
57  SECOND STAGE END POINT (PCT)  
58  SECOND STAGE INTERCEPT  
59  SECOND STAGE SLOPE  
60  THIRD STAGE END POINT (PCT)  
61  THIRD STAGE INTERCEPT  
62  THIRD STAGE SLOPE  

.06
.04
.02