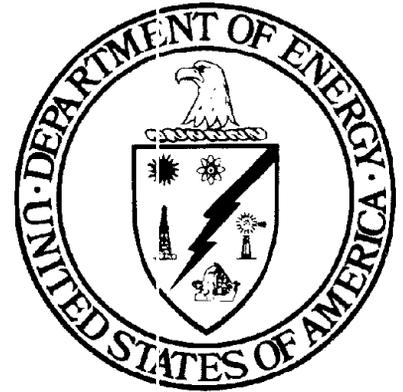


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**Development of Operational Aids for  
Improved Dragline Utilization**

**Volume 3**

**System Manual for the Dragline Simulation Model**

**Final Report**

**Contractor--McDonnell Douglas Electronics Company**

**June 1978**

**Contract No. U.S.D.O.E.ET-76-C-01-8922**



**U. S. Department of Energy**  
**Assistant Secretary for Energy Technology**  
**Division of Fossil Fuel Extraction**  
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# DEVELOPMENT OF OPERATIONAL AIDS FOR IMPROVED DRAGLINE UTILIZATION

## VOLUME 3

### SYSTEM MANUAL FOR THE DRAGLINE SIMULATION MODEL

Prepared for

UNITED STATES DEPARTMENT OF ENERGY

June 1978

**MCDONNELL DOUGLAS ELECTRONICS COMPANY**

*P.O. Box 426, Saint Charles, Missouri 63301*

A DIVISION OF

**MCDONNELL DOUGLAS**  
CORPORATION



Final Report  
on:

Contract No. ET-76-C-01-8922  
Development of Operational  
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16. ABSTRACT An on-board dragline display and recording system was developed and installed on a dragline. This system monitors the dragline operation and displays essential parameters such as cycle time, bucket fill, and load time to the operator. A computer simulation model of a dragline was developed. This model was used to evaluate the effect of various dragline operating parameters and procedures on productivity. Volume I of this report contains the results of field tests for both the display system and the simulation model. Volume II is a system manual for the display system. Volume III is a system manual for the simulation model.			
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## 1. INTRODUCTION

The purpose of this manual is to document the design and development of the computer programs that comprise MDEC's Dragline Computer Simulation Model.

### 1.1 SCOPE

Simulation is the technique of representing by a set of equations a real world system of interest which, for technical or economical reasons, is not suitable for direct manipulation. The set of equations is known as the simulation model, and it ideally represents the essential characteristics and behavior of the actual system under study. A simulation model may be deterministic or stochastic. A deterministic model is an algorithmic representation of an actual situation, with single valued solutions determined for each given set of input parameters. A stochastic model is one in which the mathematical or logical relationships are represented by chance or statistical parameters; the results for a given set of input parameters can be predicted only in terms of probabilities and statistical spreads.

The MDEC dragline simulation is a deterministic model programmed in FORTRAN on a PDP 11/45 digital computer. The dragline simulation model includes all pertinent parameters of the dragline, its geometric usage and mine conditions. The program provides a realistic assessment of dragline behavior in terms of output parameter variation directly related to changes in input parameters. Any given dragline can be modelled in the simulation by changing input parameters such as boom length, bucket dimensions, swing rate, hoist cable length, etc. Its geometric usage can be varied by changing the location from which it operates, the angle through which it swings, the height at which it dumps, etc. Actual mine conditions can be varied by changing such parameters as the depth of the overburden, the depth of the topsoil, the angle of repose of the spoil, etc.

### 1.2 SCHEMATIC DRAWING INDEX

There are no hardware drawings or schematics associated with the dragline simulation model.

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1.3 RELATED DOCUMENTS

This section lists design notes related to the development of the Dragline Computer Simulation Model.

1.3.1 Design Notes

1450-7305, 03-16-73, Dragline Operation - Determination of Distance Between Spoil Peak and Edge of High Wall.

1450-7306, 03-16-73, Dragline Operation - Spoils Rehandling.

1450-7307, 03-16-73, Dragline Operation - Point Mass Analysis.

1450-7308, 06-16-73, Potential Improvement Areas in Operation of Draglines.

1450-7309, 07-11-73, Dragline Operation - New Spoiling Procedure.

1450-7312, 10-11-73, Dragline Operation Improvements.

1450-7607, 02-23-76, Computer-Aided Analysis Program Parameters.

1450-7608, 02-23-76, Computer-Aided Analysis Simulation Displays.

1420-7602, 11-23-76, Dragline Computer Simulation Model.

1420-7703, 02-15-77, Computer-Aided Analysis Optimization Routine.

1420-7709, 05-11-77, Computer-Aided Analysis Validation Plan.

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#### 1.4 ABBREVIATIONS AND TERMINOLOGY

Abbreviations and common terms that are used throughout this manual are defined below.

CRT - Cathode Ray Tube

DINP - Data Input Program

DRAG - Dragline Simulation Program

GETD - Result Processing Program

MDEC - McDonnell Douglas Electronics  
Company

TMPR - Temporary

#### 1.5 REFERENCES

The following reference documents were utilized during the program development.

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## 2. SIMULATION DEVELOPMENT

The objective of the dragline computer simulation model was to develop a program that could be used to study the effects of mine dimensions, dragline parameters, dragline positions, dig procedures and spoil techniques for simple sidecast and advance benching methods of strip mining. A secondary development goal of the simulation model was the capability to be utilized by mine personnel to increase the efficiency of their draglines in their particular mine conditions. The program is oriented to investigating conditions for a single cut, with inputs and outputs simplified as much as possible.

In mid 1972, MDEC, at the invitation of Old Ben Coal Company, visited a surface mine to observe the operation of a Bucyrus-Erie 2570W walking dragline. The purpose of the visit was to determine the feasibility of a dragline simulator to train the operators to attain a higher level of machine usage efficiency. As a result of that visit, MDEC then initiated a company funded study of surface coal mining. This study was conducted with the cooperation of Old Ben Coal Company and Peabody Coal Company. While the initial effort was directed to training equipment, it soon broadened to include other aspects of surface mining, including a systems study of improving dragline efficiency. During 1973, the results of these studies began to be documented in Engineering Design Notes.

In September 1974, as a result of this work, MDEC elected to answer a Commerce Business Daily request for letter proposals on "Innovative Surface Coal Mining Concepts." MDEC proposed a feasibility study of various training equipment, a dragline simulation model and of a dragline on-board display device. This led to a directed RFQ to MDEC.

In June 1975, the U.S. Bureau of Mines awarded MDEC a contract to perform a "Concept Feasibility Study for Training Equipment to Improve Coal Productivity". This contract addressed three specific areas:

- a. Establish the technical and economical feasibility of training equipment/training aids for haulage trucks, front-end loaders, and shovels.

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- b. Establish the feasibility of using a computer simulation model to improve dragline utilization.
- c. Establish the feasibility of a dragline display system to improve dragline operator performance.

The equipment study involved the analysis of both the individual pieces of mining equipment and their interrelationships within the overall mining system. A detailed computer simulation model of a dragline and its immediate mine conditions was developed and demonstrated. Conceptual designs for dragline operator display systems were developed. The study concluded that both the dragline computer simulation model and the dragline display system were both technically and economically feasible and recommended continued development.

In April 1976, MDEC received a contract modification to use the dragline computer simulation model to support a U.S. Bureau of Mines program that was investigating/evaluating four cross-pit conveyor system designs. This contract modification necessitated additions and changes to the simulation model to simulate four different cross-pit conveyor systems. The model was used to evaluate draglines dumping into the hopper portions of the cross-pit conveyor systems and how stripping rates could be maximized by the related positions of the dragline and the hopper. This Computer-Aided Analysis of Cross-Pit Conveyor Systems study was to be used in conjunction with existing draglines and mine conditions to improve the efficiency of spoiling overburden and parting waste at western mines. The results obtained show that stripping rate increases varied between 3% to 22% and was affected by factors such as length and width of the cut, location of the hopper and continuous digging across the face (as opposed to a "keycut" operation).

In September 1976, MDEC received a contract from the U.S. Bureau of Mines (H0262056) for the completion and validation of the dragline simulation model and of the dragline display device. The contract is entitled, "Development of Operational Aids for Improved Dragline Utilization". The dragline simulation model has been

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expanded to include bench fill procedures and to automate portions of the procedure so as to obtain optimal parameter values. Optimum overburden removal procedures have been proposed. The simulation and the results obtained were evaluated and validated at two mine sites.

The work described above has been one of analyzing mining systems and developing evaluation techniques for improving productivity through more efficient use of mining equipment. The dragline computer simulation model can be used as a primary tool for the development of dragline operating guidelines.

The simulation model solves all of the equations necessary to simulate a dragline walking and performing overburden removal, bench removal and bench fill operations. In addition, printouts and graphic displays were developed to aid in the evaluation of the simulation results.

The model simulates the dragline overburden removal procedure by making a pass through the program for each bucket-fill-swing-dump cycle. The model determines where to position the bucket to remove the required volume, swings the bucket over the position, lowers it to the grade level, fills and raises the bucket, swings to the dump position, dumps the bucket, and swings to the next dig position. While performing these functions, the model calculates the hoist, drag and swing dynamics, cycle time, energy consumption and updates the overburden and spoil pile data arrays. The input data has been formulated to maximize the freedom allowed to set-up and execute any simple sidecast or advance benching procedure.

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### 3. SIMULATION DESCRIPTION

The simulation model is composed of three main computer programs DINP, DRAG and GETD. The DINP program allows the entry of 'mine language' inputs which are processed to generate the data files necessary to simulate the prescribed removal procedures. The program DRAG does the simulation of the dragline and mine environment. Data files specifying the characteristics of the mine and dragline and the removal procedure are entered in the DRAG program at run time. This data can be entered manually via the CRT or read in from a prepared file. The prepared file could have been manually entered earlier through the CRT or generated by the DINP program. If the data files have been created by DINP the simulation of the removal procedures will be sequenced automatically and the results stored. After the simulation run has been completed the results are collated by the GETD program. If the data files have not been generated by DINP the simulation results are stored in a file under the prescribed name. In this case it is not necessary to run GETD. The difference here is that only one removal procedure can be simulated per run unless the DINP program is used. The DINP program accepts multiple inputs which generate a number of different removal procedures. In this way the affect of various parameters can be more conveniently studied. In the sections that follow a description is given of what each of the three main programs do and what is considered in the simulation model.

#### 3.1 DRAGLINE COMPUTER SIMULATION MODEL

This discussion provides an overview of the dragline simulation model:

- o What is Simulated.
- o How it is Simulated.
- o Required Input Data.
- o Simulation Results.

The programs were developed on a Digital Equipment Corporation PDP 11/45 Computer. The dragline routines were written in standard FORTRAN IV. Peripheral devices required by the program are CRT terminals, disc and a printer plotter.

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The dragline computer simulation programs can be subdivided into four main program groups:

<u>Program Groups</u>	<u>Computer Words</u>
Dragline Simulation	91,449
Dragline Input Data	42,527
Result Output Routine	10,124
Plot Routines	10,009

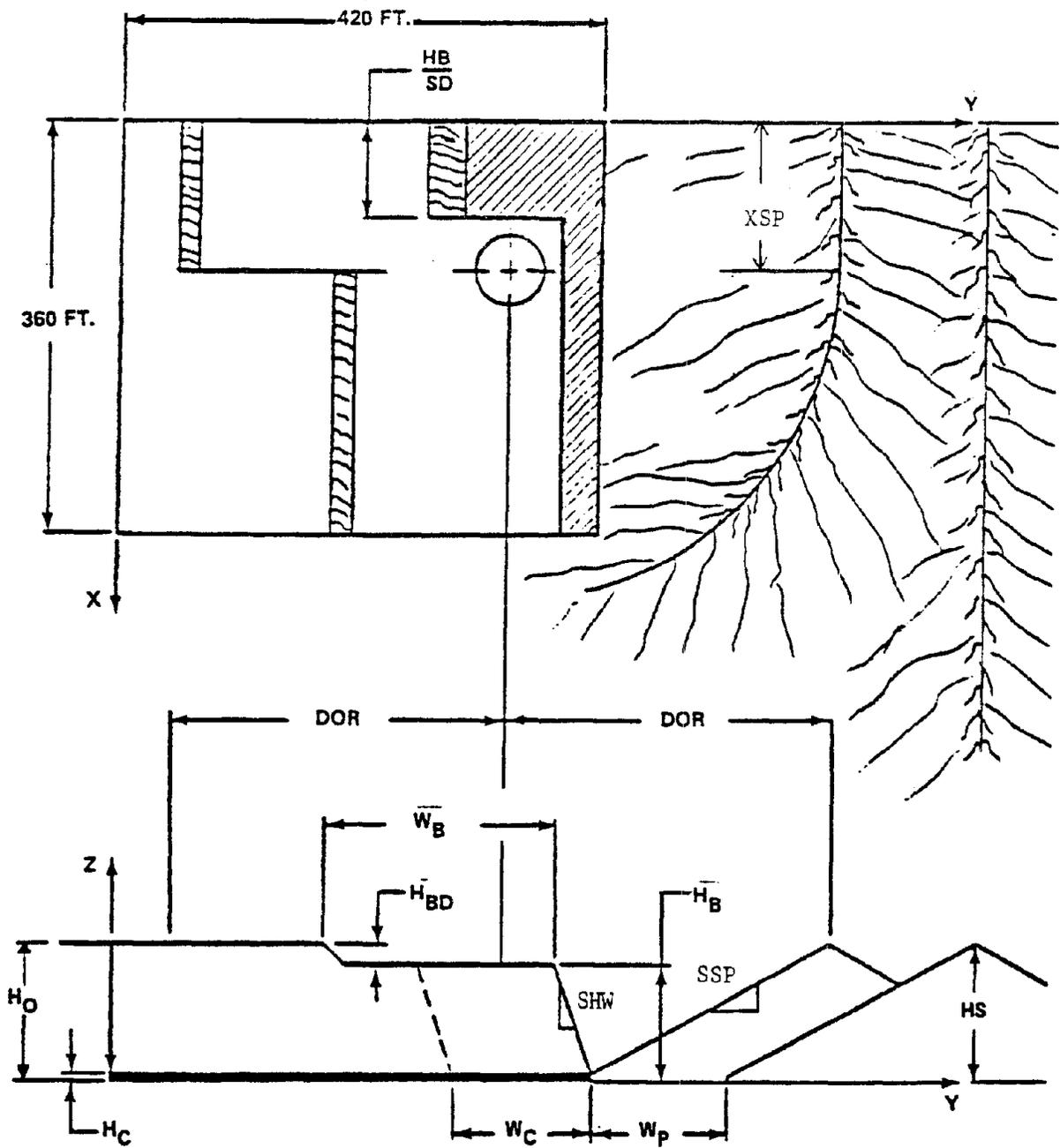
The maximum size program that can be loaded in the PDP 11/45 at any one time is 32,000 words. To overcome this restriction, the programs are subdivided into sub-routines and stored on the system disc. The subroutines are overlaid during program execution. This means the individual routines are loaded from the disc when required, executed and the memory space relinquished to the next routine.

### 3.1.1 Mine Simulation

A surface mine covers a vast area. Overburden conditions and pit configurations can vary considerably from one area of a mine to another. To simulate an entire mine, maintaining the resolution necessary to obtain meaningful results would require an enormous amount of computer memory. In addition, it would unnecessarily complicate the collection of data and increase the setup time. To alleviate these problems and since a dragline works in a relatively small section of a surface mine, only the immediate dragline working area is simulated. The simulated area encompasses a 360 by 420 foot overburden area and an adjacent, variable width spoil pile. (See Figure 3-1.) Dimension Terminology is defined in Table 3-1. This area is sufficient to permit the simulation of one complete sequence of overburden removal. The mine parameters defining the working area can be easily changed to simulate different mine conditions.

The terms 'cycle', 'case', 'block' and 'operation' are used frequently throughout this report and are defined here. A cycle includes the total sequence of events necessary to remove a bucket full of overburden, dump it in a given position and

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NOTE: Dimension Terminology Defined in Table 3-1.

Figure 3-1. Mine Area

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return to the next dig position. A case is the removal of a block of overburden. A block is roughly a parallelepiped, defined by the cut width, cut length and thickness. An operation can be a move, or the removal of a specified volume of overburden from a specified position. Several operations may be required to remove a block of overburden.

Table 3-1. Dimension Terminology

<u>Symbol</u>	<u>Description</u>
DOR	Operating Radius
HB	Height of Bench
HBD	Bench Depth
HC	Height of Coal
HO	Height of Overburden
HP	Height of Parallelogram
HTP	Height of Triangle Peak
HS	Spoil Height
PWSEG	Width of Spoil Segment
SD	Slope of Dig Face
SHW	Slope of Highwall
SSP	Slope of Spoil Pile
WB	Width of Bench
WC	Width of Cut
WP	Width of Pit
XSP	X Spoil Peak Location

### 3.1.1.1 Overburden

A rectangular coordinate system was selected to facilitate keeping track of the overburden and dragline position. (See Figure 3-1.) The axis of the coordinate system was positioned such that the dragline always works in the same quadrant. The positive X direction points in the stripping direction. The positive Y direction points to the spoil pile. The positive Z direction corresponds to an increasing overburden height. The X-Y plane is located just below the coal seam.

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The overburden area is stored in a two-dimensional (X,Y) array of heights. The displacement between adjacent array elements is one yard. To store this array as real values (two words/element) would require 33,600 words of memory. Since this alone exceeds the maximum program size of 32,000 words, the array is stored in eight-bit bytes (two bytes/word) reducing the memory requirements to 8,400. The maximum allowable overburden plus coal height is 255 feet.

A maximum of five layers of overburden material can be simulated. Each layer is defined by its height, density, swell factor, angle of repose and cutting force. Since the area of the block of overburden to be removed is small (typically 120 x 90 feet), the coal seam and overburden layers are assumed to be flat and parallel.

#### 3.1.1.2 Spoil Pile

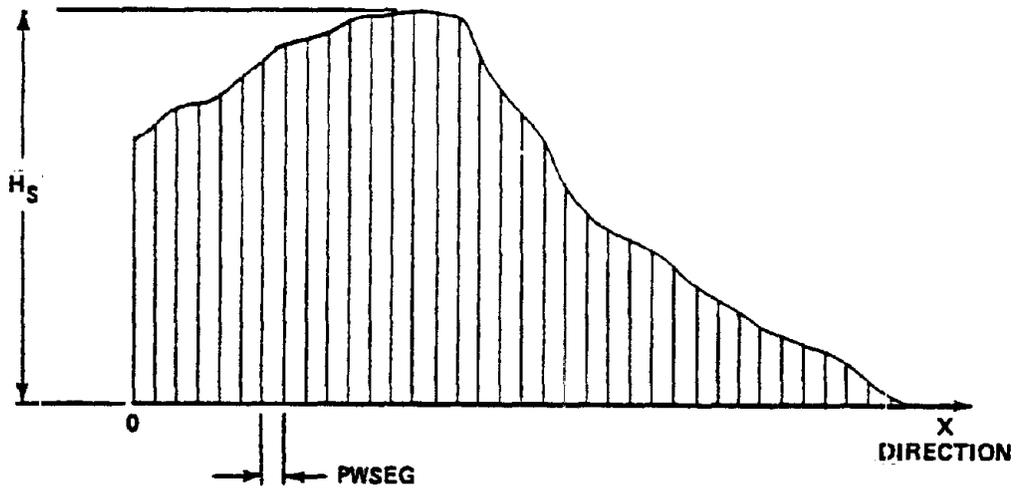
The shape of the spoil pile is not as critical as the shape of the overburden area. The buildup of the spoil pile occurs over a long period of time with the dragline dumping several bucket loads, essentially in the same position. The spoil pile is assumed to build along a ridge. The ridge location is a function of the current dragline position and its operating radius. The spoil pile is sliced in six-foot increments along the X axis and stored in a two-dimensional array of heights and volumes. (See Figure 3-2.) The width of the spoil pile (pit width) is variable. The assumptions eliminate the calculations necessary to keep track of the spoil pile in terms of cones.

A spoil road parallel to the highwall and adjacent to the coal seam can be simulated by displacing the spoil pile to the width of the spoil road. (See Figure 3-3.) The road allows hoppers located on the pit floor to be moved out of the way should the cross-pit conveyor system be inoperable for an extended period of time. Conventional side cast spoiling procedures can then be used.

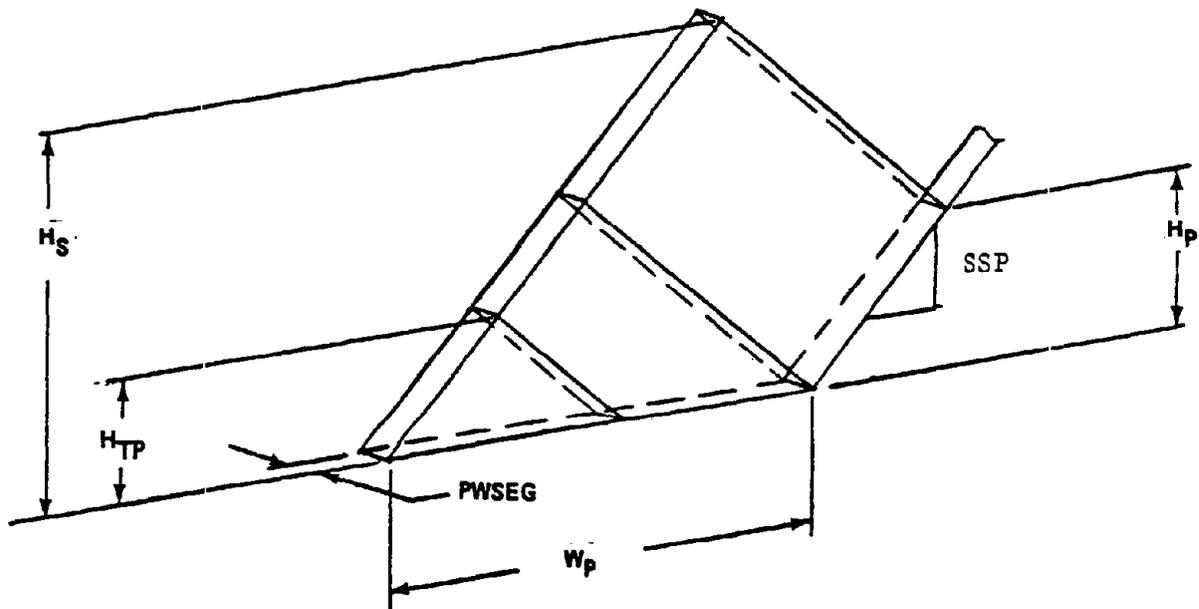
#### 3.1.2 Dragline Simulation

The dragline simulation model mimics the operation of a dragline in a mine environment. Overburden material is removed on a cycle by cycle basis according to the

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SIDE VIEW



SEGMENT SPOIL PILE

NOTE: DIMENSION TERMINOLOGY DEFINED IN TABLE 3-1.

Figure 3-2. Spoil Pile

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PITHR. DAT  
OPERATION NO. 4  
O. B TO SPOIL

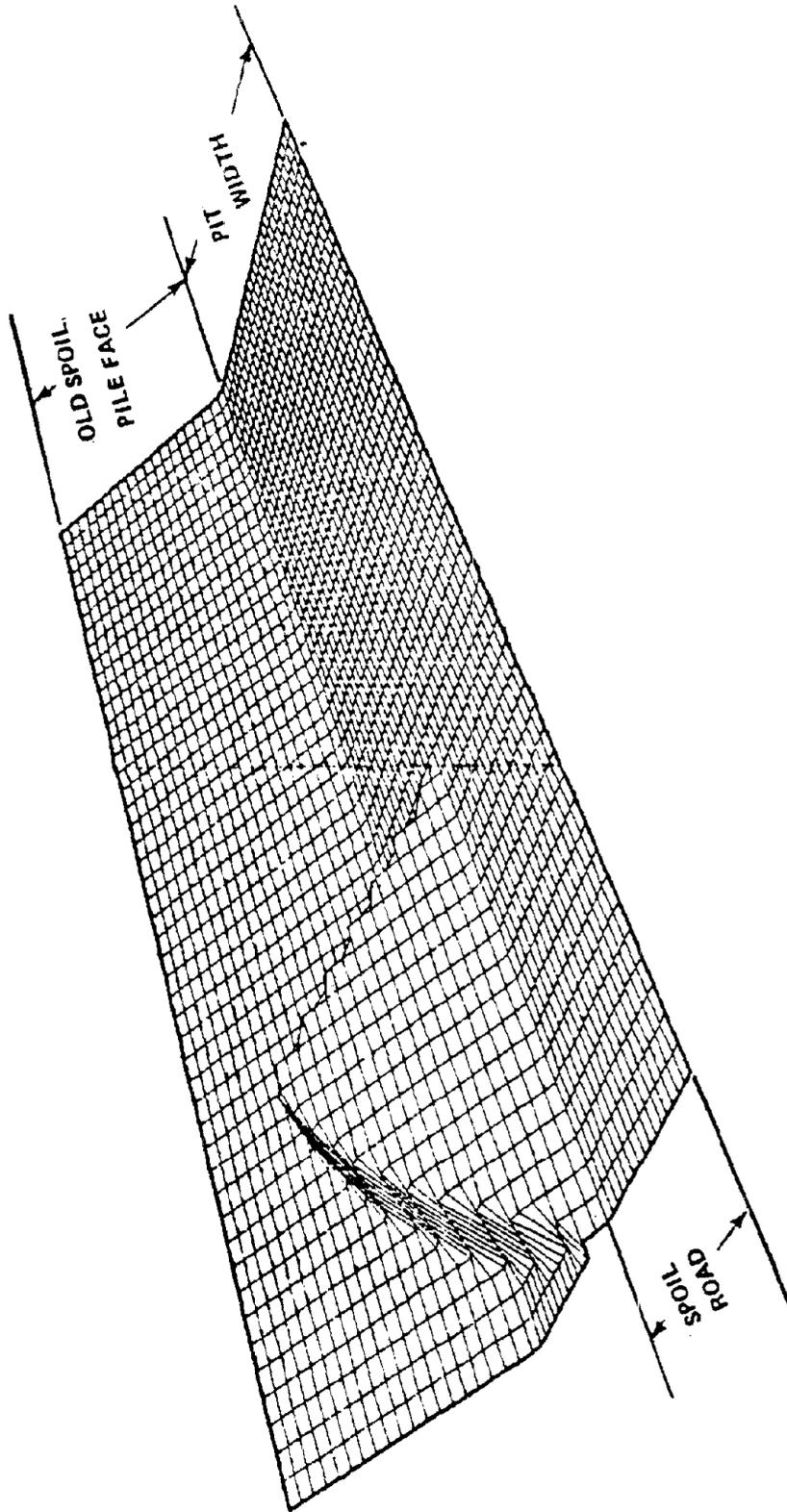


Figure 3-3. Pit Floor

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dig-spoil procedure which can be specified. The bucket trajectory and mass dynamics required to move the bucket along the trajectory are calculated for each cycle. Hoist and drag rope forces, torque required to rotate the machine, time, power and energy consumption are calculated.

A series of bucket path coordinates are generated to move the bucket from the dig to spoil position and vice versa. The bucket path is a smooth trajectory, selected so the hoist, drag and swing motions arrive at the end coordinate simultaneously. When obstructions are encountered, the bucket path is modified to avoid bucket and cable contact. The hoist, drag and swing forces required to move the bucket between adjacent coordinates are calculated. The time required to complete each motion is calculated from the dragline performance data. The maximum time for the three motions is determined and used to recalculate the forces, slowing down the other motions. To insure a smooth trajectory, the dynamics of the past and future increments are used in the calculations. This is necessary to accurately model the plugging and stopping motions.

### 3.1.2.1 Bucket Loading

The dragline is a radial machine. The simulated volume of overburden to be excavated is intended to be a 'natural' dig for the dragline. The model attempts to remove the overburden in layers, each layer thickness being equal to the cutting height of the bucket being simulated. A number of bucket passes may be required to remove a layer. Each bucket loading path extends radially from the center of dragline rotation and is a bucket width wide. The bucket paths are overlapped to ensure that all of the overburden is removed. The overlapping is greatest near the fairlead because of the smaller radius. Each bucket path is searched to determine if there is enough overburden to load the bucket. There can be three outcomes: (1) a reject; (2) a stop; or (3) a full bucket.

A reject occurs when the available overburden along the bucket path is less than a specified percentage of the bucket capacity. The result of a reject is to search the

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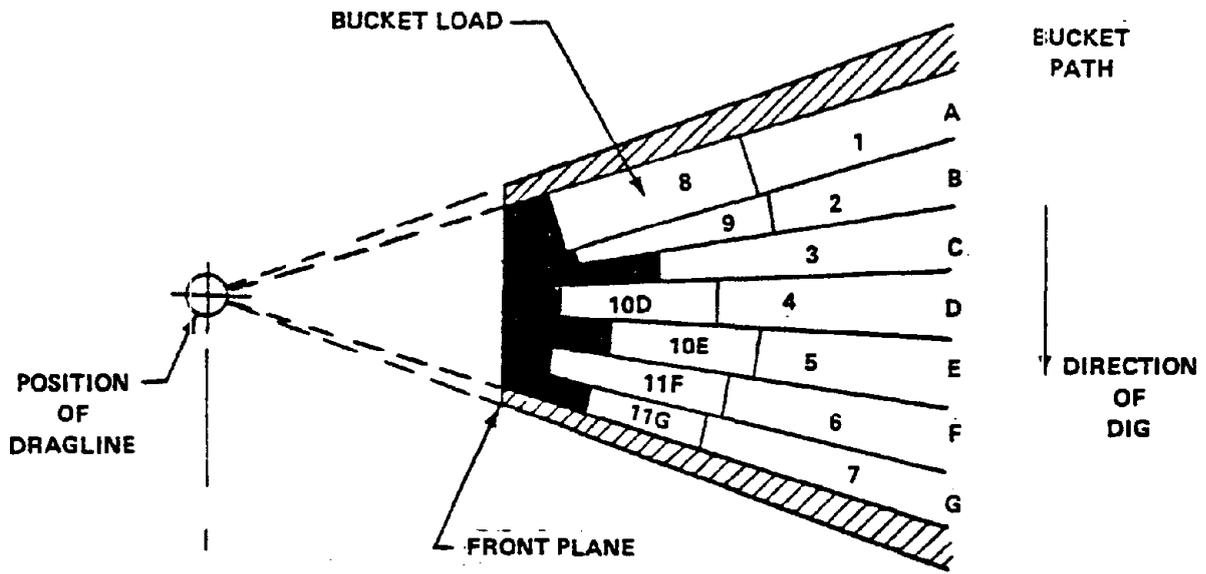
next bucket path. When the entire layer of overburden has been removed, the dig height is decreased by the cutting height of the bucket and the next layer of overburden is removed.

A stop occurs when there is an acceptable load, but a restriction prevents a full load. Possible restrictions are drag cables being drug through the overburden or the drag stop limit (short drag). The result of a stop is to either accept less than a full bucket load or to make a second bucket loading pass along the next path. The decision to make a second pass is based on the amount of material in the bucket and the average time required to make a second pass. Generally, a second pass is made when 20 to 40% of the bucket capacity can be loaded. It is worthwhile to load this additional volume. The bucket must be at least 80% full to be considered a full bucket.

Figure 3-4 shows a typical bucket loading sequence required to remove a layer of overburden, when the dragline is making a long cut length. In the example, eleven bucket loads were required to remove the layer of overburden. Bucket paths A through G were sequentially searched and bucket loads 1 through 7 were removed. The bucket paths were searched a second time. Bucket load 8 was removed and spoiled. Bucket load 9 in path B was not a full load. The drag stop limit was encountered before a full load could be achieved. Sufficient volume existed so the overburden was loaded and spoiled. Path C was rejected, the volume was not worth loading. A partial load was removed from path D (10D) and a second loading pass was made along path E (10E). Bucket load 11 is removed from paths F and G. The bucket paths were searched a third time. No bucket loads were achieved, so the dig height was decreased and the next layer removed. The overburden that could not be removed (shaded areas) may be removed later. The vertical bucket path will follow the contour of the overburden.

As previously stated, the simulation model attempts to remove the overburden in layers. However, this is not always possible. The cut length may be so short that an acceptable load cannot be found in any single layer. (See Figure 3-5.) In this example, an acceptable bucket load was not achieved until the third layer was searched.

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**BUCKET LOADING SEQUENCE**

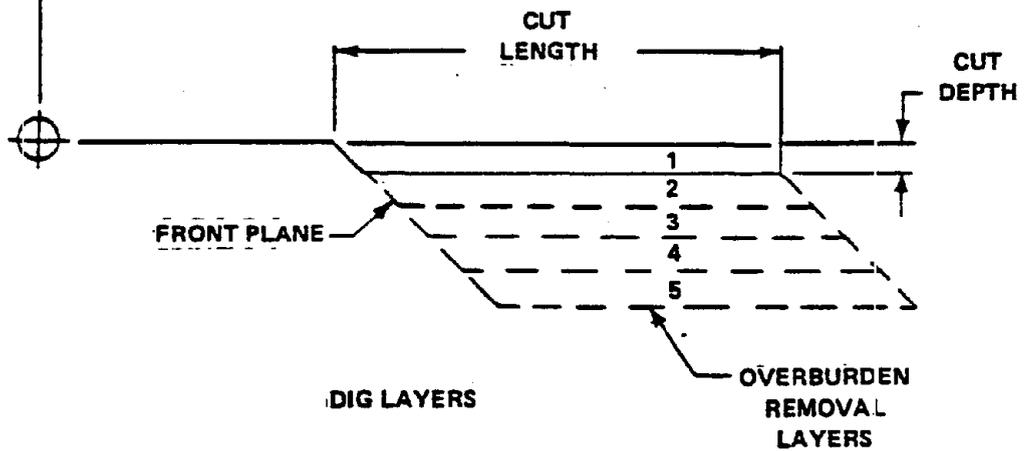


Figure 3-4. Long Cut Length Bucket Loading Sequence

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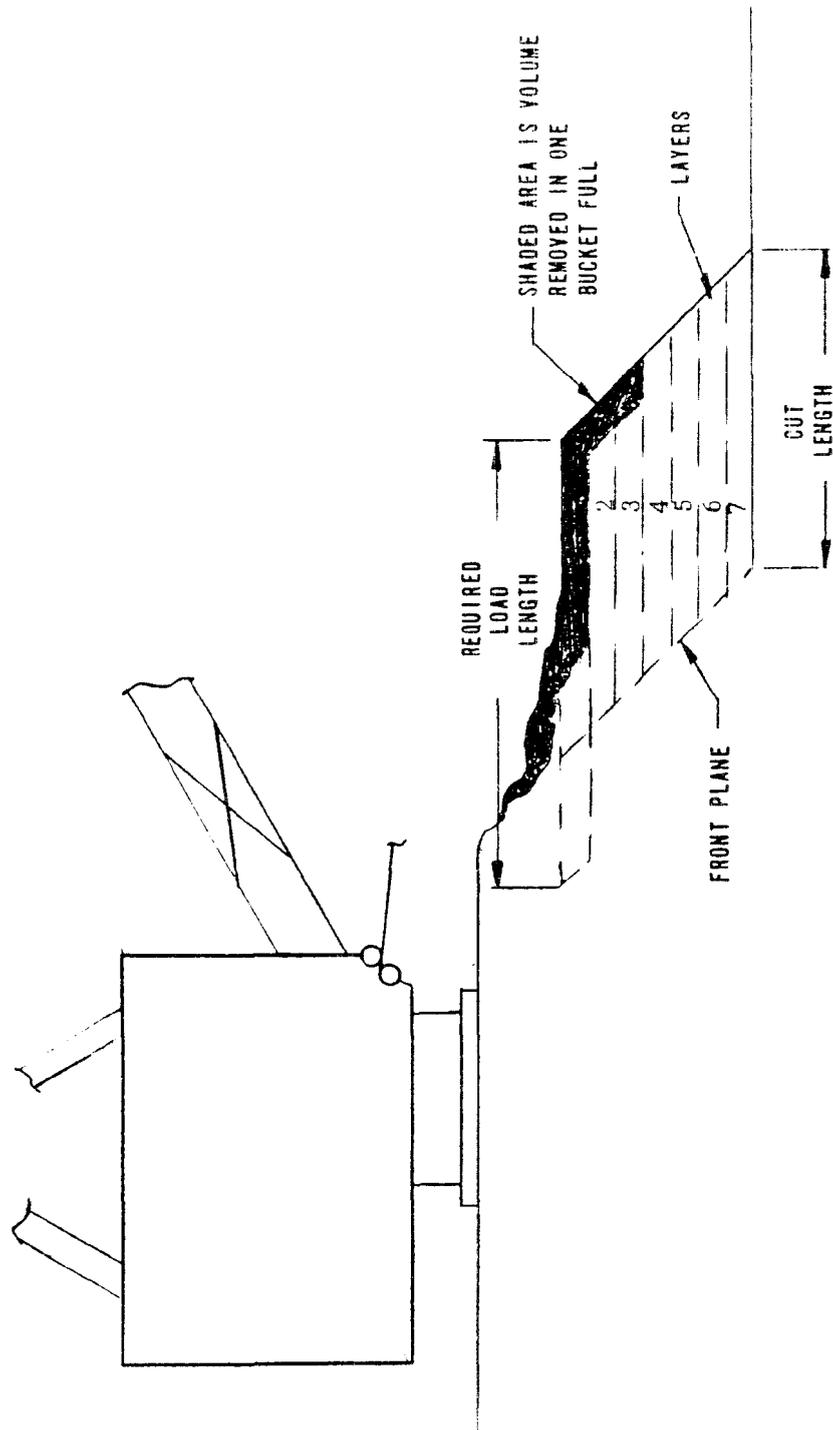


Figure 3-5. Short Cut Length Bucket Loading Path

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Since the bucket path followed the contour of the overburden, the bucket load consisted of overburden removed from all three layers. As the digging depth increases, the bucket path approaches the slope of the front plane angle.

After a bucket path is located the bucket is loaded. Hoist motion is not used during bucket loading unless the path is inclined or a stall condition is encountered. It was assumed that any stall condition can be overcome by 'shaking' the bucket with a nominal amount of hoist motion.

The time, power and energy required to pull the bucket through the overburden are calculated from the speed versus pull characteristics of the dragline. The forces modeled on the bucket are: gravitational force, frictional force, shear force and packing force. Frictional force is due to dragging the bucket over the overburden. It is proportional to the gross weight of the bucket and its contents.

Shear force is the force necessary to cut through the overburden. It is proportional to the surface area cut per unit length. Packing force is the force required to push the overburden through the mouth of the bucket. It is proportional to the volume of overburden entering the bucket mouth per unit length.

The overburden data array is updated by subtracting the cut height along the bucket loading path. The load time includes a pause to simulate bucket spotting or positioning prior to digging.

### 3.1.2.2 Dump

The dump simulation determines the dump coordinates and accounts for the radial and lateral distribution of the overburden material during dumping. Three dump procedures are simulated: sidecast, bench fill and dumping into a hopper.

#### 3.1.2.2.1 Sidecast

When normal sidecast procedures are used, the dragline dumps bucket load after bucket load of overburden material onto the spoil pile. The spoil pile height is calculated

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by equating the swelled cross-sectional area of the overburden to be removed to the cross-sectional area of available spoil space. The location of the spoil peak along the X-axis is an input computed by the DINP program.

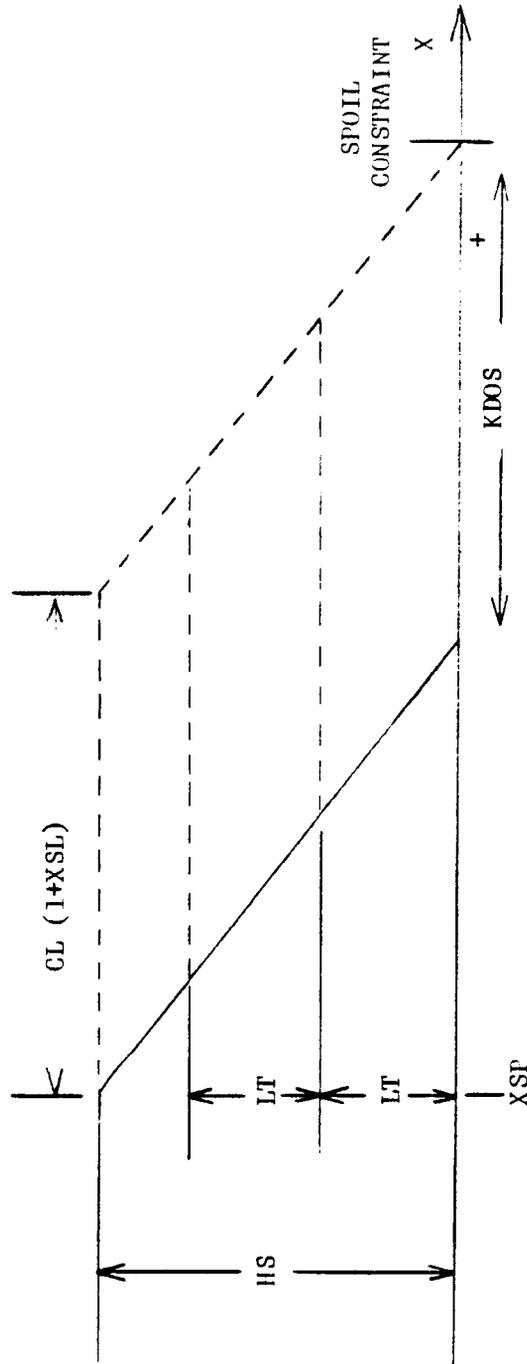
For each bucket load, the spoil pile is searched in either the positive or negative X direction for a spoil location that is within reach of the dragline. The direction of the search is determined by the spoil direction flag KDOS. (See Figure 3-6.) When KDOS is positive or zero, the direction of spoil is in the positive X direction. When KDOS is negative, the direction of spoil is in the negative X direction. In this case, the spoiling begins a cut length in front of the spoil peak and proceeds toward the spoil peak.

The spoil pile is built up in layers. The thickness of these layers is specified as a percentage of the spoil pile height. In Figure 3-6 the percentage is SM. Hence, the layer thickness is  $LT = (SM) \times (HS)/100$ . If  $SM = 100$ , the spoil pile filled as one layer. The DUMP routine searches the spoil pile in the direction specified by KDOS and at the specified layer height. The material is dumped at the first coordinate where the spoil pile height is less than the search height and is within the reach of the dragline. The material is spread to maintain the angle of repose. If a spoil location within reach cannot be found, the search height is incremented by LT and the search is repeated. If the search height equals the height of the spoil, HS, the dragline swings perpendicular to the spoil pile and dumps. The volume of overburden dumped in this manner is considered rehandle and is identified as such in the simulation results.

#### 3.1.2.2.2 Bench Fill

The area to be filled is determined by the two angles BFLA and BFRA. BFLA is the left angle limit and BFRA is the right angle limit. These angles are generated by DINP but can also be input in DRAG. The dump coordinates are generated as the region is filled. The bench fill takes place from outside inward and in an angular direction corresponding to the value of KDOS. If KDOS is positive or zero, the fill is from right to left and if KDOS is negative, the direction of fill is from left to

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CL - CUT LENGTH OF THE BLOCK OF OVERBURDEN  
 HS - SPOIL PEAK HEIGHT  
 KDOS - DIRECTION OF SPOIL FLAG  
 LT - LAYER THICKNESS LT = HS (SM/100)  
 SM - LAYER HEIGHT AS A PERCENTAGE OF THE SPOIL PEAK HEIGHT  
 XSL - PERCENTAGE OF SPOIL LENGTH INCREASE/DECREASE  
 XSP - INITIAL SPOIL PEAK LOCATION

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Figure 3-6. Spoil Buildup

right. The material is dumped into a region about the dump coordinate until the average height equals the fill height FLHT. The material falling from the bucket is spread to maintain the angle of repose. For dump coordinates inside the carry radius, the bucket is accelerated toward the dragline and then the drag is stopped and paid out as the material is dumped.

If FLHT is input as a negative number, this indicates the material should be smoothed by bucket heeling. After a region is filled to the specified height (FLHT) the bucket is drawn in ahead of the dump coordinate. The heel of the bucket then smooths the terrain as the hoist ropes pull the bucket outward. The material being carried by the bucket load is displaced according to the terrain and angle of repose of the material.

### 3.1.2.2.3 Hopper

Two different hopper procedures are simulated. In one, the swing motion is stopped with the boom positioned over the hopper before initiating drag payout to dump the bucket. The other procedure allows dumping during swing direction change, similar to dumping onto a spoil pile.

When a hopper is simulated, the spoil pile is removed by initializing an empty pit. The bucket dump height is limited by the minimum and maximum hopper dump heights. The minimum hopper dump height prevents the bucket and drag chains from striking the hopper. During the swing to the dump position, the bucket is not allowed to go beyond the carry radius until the appropriate dump conditions occur. Beyond the carry radius the bucket will begin to dump. The carry radius is a function of the dumping height and is located approximately 15 degrees from a vertical line passing through the boom point. All overburden material dumped into a hopper is assumed to be conveyed away.

The stop swing before dump procedure does not initiate drag payout to dump the bucket until the very end of the swing. The cycle time includes the additional time required

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to move the bucket from the carry radius to the operating radius. An adjustable dump pause can be added to allow time for the bucket to empty.

The dump during swing direction change procedure is a function of hopper dimensions and orientation. Drag payout to initiate bucket dumping begins when carry radius intersects the hopper opening. (See Figure 3-7.) This corresponds to point B for clockwise (CW) and point D for counter clockwise (CCW) approach angles. The dump is complete when the dragline operating radius intersects the center of the hopper opening, point F. When using this procedure, the hopper is usually oriented with its length perpendicular to the operating radius when the dragline boom is positioned over the center of the hopper opening. This provides the maximum dumping area.

### 3.1.2.3 Move

The move simulation controls the sequence of events necessary to move the dragline and/or the hopper from its current position to a new position.

The dragline moves in a rectangular pattern, stepping parallel to the X and Y axis. The order in which the steps are taken is established by determining whether the dragline is stepping toward or away from the spoil pile. The Y steps are taken first when the dragline is stepping away from the spoil pile. Once the step direction has been determined, the dragline swings to the proper direction positioning the bucket at the midpoint of its operating radius and 15 feet above the bench height. The number of steps to be taken are calculated and rounded to the nearest whole step. The step time is calculated by multiplying the number of steps by the step time constant. The grounds-man preparation time is simulated as a linear function of the number of steps taken. It is specified as a percentage of the step time. The dragline move time is the sum of the step time and grounds-man preparation time.

The step energy is calculated by assuming the dragline lifts 80% of its weight and drags the other 20%. The dragline move energy is the sum of the step energy and the energy required to swing to the walk angle.

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The hopper portion of cross-pit conveyor systems are propelled by either walkers or crawlers. The propelling systems can be rotated, allowing movement in any direction. The simulation model moves the hopper along a straight line, directly to the desired position. The hopper move time accounts for:

- a. The removal of Stabilizing Jacks
- b. Walker or Crawler Rate
- c. Hopper Position Check
- d. Placement of Stabilizing Jacks
- e. Hopper and Belt Startup Times if required

The total move time is the larger of the dragline or hopper move times.

### 3.1.3 Input Parameters

The dragline computer simulation model requires four different types of input data:

- o Dragline/Mine Characteristics
- o Case Parameters
- o Operation Parameters
- o Program Control Flags

#### 3.1.3.1 Dragline/Mine Characteristics

The dragline characteristics and mine conditions that are to be simulated are specified by a set of input parameters. (See Figure 3-8.) The parameters are grouped in six general areas:

- o Mine and Hopper
- o Dragline Specifications
- o Dragline Performance
- o Bucket
- o Overburden
- o Curves

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SAMPLE.DMT

MINE & HOPPER		DRAGLINE-SPEC		DRAGLINE-PERF		BUCKET		OVERBURDEN		CURVES	
NAME	ID	VALUE	NAME	ID	VALUE	NAME	ID	VALUE	NAME	ID	VALUE
SP	1	1.20	DOP	1	292.00	UTIL	1	1.00	LEVEL 1		
SHW	2	2.75	DBL	2	325.00	EFH	2	0.85	HGHT	1	20.00
HC	3	12.00	DBA	3	35.00	EFB	3	0.85	REPS	2	3375.00
IBD	4	10.00	DBAS	4	62.00	EFTH	4	0.85	SMALL	3	1.24
HBFL	5	0.00	DFLH	5	15.00	DHMC	5	15.00	REPS	4	0.78
HSRD	6	0.00	DFLR	6	40.00	HCLR	6	25.00	CUTF	5	50000.00
HPSL	7	60.00	CRD	7	68.00	CA	7	15.00	LEVEL 2		
HF SW	8	45.00	TUFD	8	3081.00	DPAH	8	10.00	HGHT	6	15.00
HPH	9	70.00	BRAD	9	23.25	DPTH	9	1.00	DENS	7	3200.00
HDL1	10	19.00	GRAD	10	19.88	TPS1	10	1.50	SMALL	8	1.24
HDL2	11	0.00	PIEL	11	360000.00	TPS2	11	3.00	REPS	9	0.78
HCSP	12	13.00	HSLD	12	850.00	BUMP	12	0.40	CUTF	10	25000.00
HPC	13	0.00	APPC	13	937.00	HCH	13	0.85	LEVEL 3		
HPJ	14	0.00	SHT	14	100.00	SCT1	14	39.80	HGHT	11	90.00
HPJ	15	0.00	SHT	15	1.00	SCT2	15	0.60	DENS	12	3250.00
HPDX	16	163.00	SHT	16	1.00	CHRF	16	100000.00	REPS	14	1.24
HPD1	17	143.00				RHS	17	40.00	CUTF	15	75000.00
									LEVEL 4		
									HGHT	16	0.00
									DENS	17	0.00
									SMALL	18	0.00
									REPS	19	0.00
									CUTF	20	0.00
									LEVEL 5		
									HGHT	21	0.00
									DENS	22	0.00
									SMALL	23	0.00
									REPS	24	0.00
									CUTF	25	0.00
									DRAG		
									FORCE	19	0.00
									FORCE	20	460000.00
									FORCE	21	750000.00
									SPEED	22	5.48.00
									SPEED	23	475.00
									SPEED	24	0.00
									SPEED	25	0.00

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Figure 3-8. Dragline/Mine Characteristics

### 3.1.3.1.1 Mine and Hopper

These parameters define the overburden slopes, overburden depth and hopper specifications (if applicable).

- SD - Dig face slope, dig face rise for a unit horizontal run.
- SHW - Highwall slope, highwall rise per unit run.
- HC - Feet; coal height.
- HBD - Feet; bench depth.
- HBFL - Feet; bench fill height.
- HSRD - Feet; spoil road width.
- HPSL - Feet; hopper opening length.
- HPSW - Feet; hopper opening width.
- HPH - Feet; hopper opening height.
- HDL1 - Feet; radial distance between the carry radius and the center of the hopper opening.
- HDL2 - Feet; radial distance between the operating radius and the center of the hopper opening.
- HCSP - Feet/minute; hopper move speed.
- HPC - Seconds; position check time, accounts for the time spent positioning the bucket above the hopper and minor position adjustments.
- HPJ - Seconds; stabilizing jack insert time.
- HRJ - Seconds; stabilizing jack removal time.
- HPDX - Feet; maximum hopper dump height.
- HPDM - Feet; minimum hopper dump height.

### 3.1.3.1.2 Dragline Specifications

These parameters define the physical characteristics of the dragline.

- DOR - Feet; dragline operating radius.
- DBL - Feet; boom length from the fairlead to the hoist sheave.

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- DBA - Degrees; angle between the boom and the horizontal.
- DBAS - Feet; diameter of the dragline base.
- DFLH - Feet; fairlead height above the bench.
- DFLR - Feet; radial distance from the center of rotation to the drag fairlead.
- CRD - Feet; radius required to clear the dragline house.
- TWTD - Tons; total dragline revolving weight, including the bucket.
- BRAD - Feet; roller circle radius.
- GRAD - Feet; pitch radius of the swing rack.
- RMSL - Pounds; maximum suspended load.
- HSLD - Feet/minute; maximum hoist lowering speed.
- DSLO - Feet/minute; maximum drag payout speed.
- ADPC - The ratio of swing deceleration to acceleration.
- SAM - Dragline acceleration adjustment
- SIM - Dragline inertia adjustment

### 3.1.3.1.3 Dragline Performance

These parameters define the performance characteristics of the dragline.

- UTIL - %; machine utilization.
- EFH - %, hoist efficiency.
- EFD - %, drag efficiency.
- EFTH - %, swing efficiency.
- DHWC - Feet; minimum tub to highwall crest distance.
- HCLR - Feet; minimum height required to clear obstacles.
- CA - Degrees; carry angle, the minimum angle between vertical and the hoist rope required to keep the bucket from dumping.
- DPAN - Degrees; dump angle, when the swing angle to the dump location is less than this angle, bucket dumping will be initiated.

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- DPTM - Seconds; dump pause, the time required to empty the bucket prior to starting the return swing.
- TPS1 - Seconds; spotting or positioning time prior to bucket loading.
- TPS2 - Seconds; spotting or positioning time when within ten feet of coal.
- BWMP - %, buckwall material percentage. If the bucket contains more than this percentage of buckwall material, then it must be deposited at a point below the buckwall height (HBW).
- STEP - Feet; length of a step.
- STIM - Seconds; time required to take a step.
- SPTM - %; ground preparation time as a percentage of the direct move time.

#### 3.1.3.1.4 Bucket

These parameters define bucket and chain dimensions and the bucket performance characteristics such as bucket fill, cutting height and bucket loading characteristics.

- BC - Bank cubic yards; bucket capacity.
- BFIL - %, average percentage of bucket fill.
- BWT - Pounds, empty bucket weight.
- BW - Feet; bucket width.
- BTL - Feet; bucket length.
- BCL - Feet; horizontal distance between the bucket drag and hoist connectors.
- BCHC - Feet; vertical distance between the bucket bottom and the hoist connector.
- BCHT - Feet; vertical distance between bucket drag and hoist connectors.
- HCL - Feet; hoist chain length.
- DCL - Feet; drag chain length.
- DPCL - Feet; dump cable length.
- HCH - Feet; bucket cutting height.

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BFL2 - %; full bucket percentage, additional loading passes are not required.

SCL1 - Cable drag ratio.

ALT - Seconds; average bucket loading time.

CARF - Foot pounds/cubic yard; bucket loading resistance pressure.

RMLS - Feet/minute; minimum loading speed for drag.

#### 3.1.3.1.5 Overburden

These parameters define the characteristics of the overburden material. Five layers of overburden can be simulated. The layers are numbered from the pit floor up (increasing height). Each layer is specified by five parameters.

HGHT - Feet; overburden layer thickness.

DENS - Pounds/cubic yard; expanded overburden density.

SWLL - Swell factor.

REPS - Angle of repose, rise per unit run of the material when spoiled.

CUTF - Foot-pounds/square yard; cutting force required to separate the material from the bank.

#### 3.1.3.1.6 Curves

These parameters define the swing, hoist and drag performance of the dragline. The swing performance of the dragline is defined by the six points shown in Figure 3-9. The hoist and drag performance are defined by the three points shown in Figure 3-10.

#### 3.1.3.2 Case Parameters

The case parameters define the pit conditions and the initial dragline location and orientation. (See Figure 3-11.)

CL - Feet; cut length, length of the block of overburden.

WC - Feet; cut width, the perpendicular distance from the crest of the new highwall to the crest of the old highwall.

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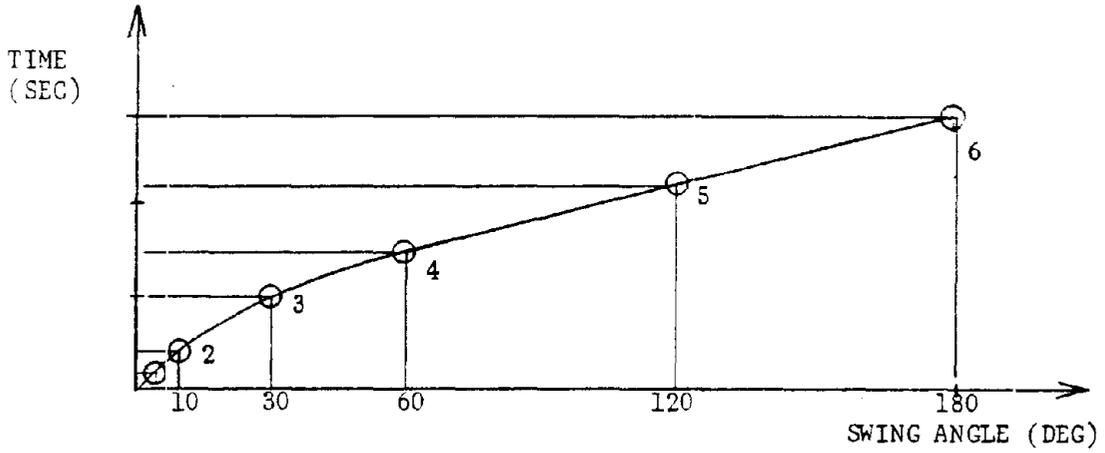


Figure 3-9. Swing Performance

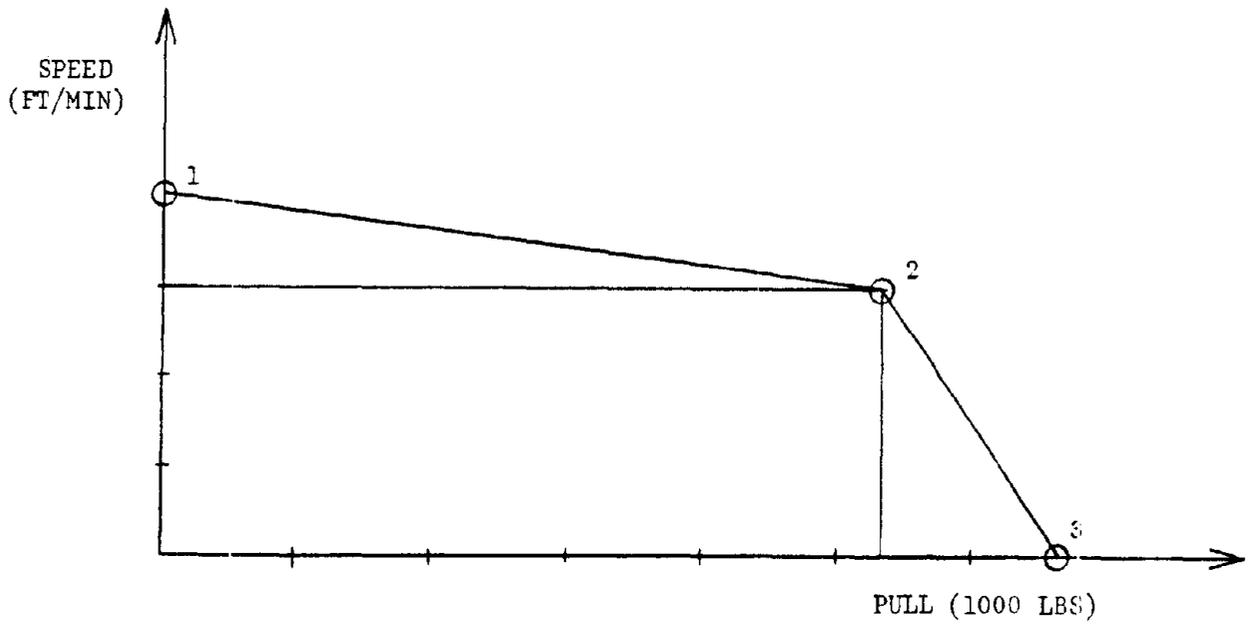


Figure 3-10. Hoist/Drag Performance

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- WP - Feet; pit width, the perpendicular distance from the toe of the old highwall to the toe of the old spoil pile.
- XSP - Feet; X spoil peak location.
- XSL - %, percentage of increase or decrease in the spoil length. The length of available spoil space is normally equal to the cut length (CL).
- SHRP - %, allowable percentage of spoil rehandle.
- DX - Feet; X dragline position.
- DY - Feet; Y dragline position.
- DZ - Feet; dragline height.
- BT - Degrees; dragline swing angle.
- BR - Feet; bucket radius.
- BZ - Feet; bucket hoist hitch height.
- NHSM - Hopper Simulation Flag
- HPCX - Feet; X hopper position
- HPCY - Feet; Y hopper position
- HPA - Degrees; Hopper Angle with X-Axis

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----- CASE PARAMETERS -----			
NAME	ID	VALUE	DESCRIPTION
CL	1	65.00	CUT LENGTH
WC	2	110.00	CUT WIDTH
WP	3	110.00	PIT WIDTH
XSP	4	0.00	X SPOIL COORDINATE
XSL	5	65.00	X SPOIL ADVANCE
SRHP	6	0.00	SPOIL REHANDLE %
DX	7	129.00	DRAGLINE X LOCATION
DY	8	330.00	DRAGLINE Y LOCATION
DZ	9	127.00	DRAGLINE Z LOCATION
BT	10	180.00	BUCKET ANGLE
BR	11	195.00	BUCKET RADIUS
BZ	12	147.00	BUCKET HEIGHT
NHSM	13	-161.00	HOPPER FLAG
HPCX	14	0.00	HOPPER X COORD
HPCY	15	380.00	HOPPER Y COORD
HPA	16	80.00	HOPPER ANGLE

Figure 3-11. Case Parameters

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### 3.1.3.3 Operation Parameters

The dragline move and overburden removal procedures that are to be simulated are specified by a series of operation parameters. (See Figure 3-12.) The move operation parameters specify the next dragline and hopper positions.

- NXTX - Feet; next dragline X coordinate.
- NXTY - Feet; next dragline Y coordinate.
- HPNX - Feet; next hopper opening X coordinate.
- HPNY - Feet; next hopper opening Y coordinate. Either HPNX or HPNY must be negative. The negative parameter is calculated from the opposite parameter and the dragline position.
- HPNA - Degrees; desired hopper orientation. The angle is measured counter-clockwise from the positive X direction to the centerline of the hopper length. If negative, the hopper length is oriented perpendicular to the operating radius.
- HACT - A control flag that controls whether the hopper is active or inactive (0 = inactive).

The dig volume or the volume of overburden to be removed by the dragline is specified by the dragline position and 13 operation parameters. (See Figure 3-13.) The volume is bounded by (1) the dig face or front plane boundary, (2) the bottom plane, (3) the range limit and (4) the left and right sidewall planes. The sidewall planes are formed by passing a plane through the dragline position and the respective left and right volume coordinates. The range limits are determined by R1 and R2. When  $R1 > 0$  and  $R2 = 0$ , the outer boundary of the dig volume is a cylinder of radius R1. The range is not allowed to exceed the operating radius of the dragline.

The dig/spoil procedure to be simulated is specified by the following six parameters.

- SM - %, spoil method, percentage of the total spoil height that the spoil pile layers will be built up to.
- KDOS - A control flag that controls the direction of the spoil pile buildup (positive = spoil advance direction, negative = from spoil advance limit back towards the spoil pile).

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OPERATION * 1			OPERATION * 2			OPERATION * 3			OPERATION * 4			OPERATION * 5			OPERATION * 6		
DRAGLINE			OVERBURDEN REMOVAL			MOVE			BENCH REMOVAL			BENCH FILL			OVERBURDEN REMOVAL		
NAME	ID	VALUE	NAME	ID	VALUE	NAME	ID	VALUE	NAME	ID	VALUE	NAME	ID	VALUE	NAME	ID	VALUE
HNTX	1	194.00	SPIX	1	94.00	HNTX	1	194.00	SPIX	1	231.00	SPIX	1	94.00	SPIX	1	94.00
HNTY	2	295.00	SPIY	2	290.00	HNTY	2	330.00	SPIY	2	162.00	SPIY	2	290.00	SPIY	2	290.00
HOPR	3	47.00	SPIZ	3	47.00	HOPR	3	47.00	SPIZ	3	121.00	SPIZ	3	47.00	SPIZ	3	47.00
HPIK	4	360.00	R1	4	292.00	HPIK	4	-1.00	R1	4	292.00	R1	4	292.00	R1	4	292.00
HPIA	5	-1.00	SPLA	5	20.00	HPIA	5	380.00	SPLA	5	0.00	SPLA	5	20.00	SPLA	5	20.00
HACT	6	1.00	SP2X	6	94.00	HACT	6	-1.00	SP2X	6	162.00	SP2X	6	94.00	SP2X	6	94.00
			SP2Y	7	330.00				SP2Y	7	162.00	SP2Y	7	410.91	SP2Y	7	410.91
			SP2Z	8	47.00				SP2Z	8	121.00	SP2Z	8	47.00	SP2Z	8	47.00
			R2	9	0.00				R2	9	0.00	R2	9	0.00	R2	9	0.00
			SPRA	10	30.00				SPRA	10	0.00	SPRA	10	20.00	SPRA	10	20.00
			SBFA	11	40.00				SBFA	11	40.00	SBFA	11	40.00	SBFA	11	40.00
			SBPA	12	0.00				SBPA	12	0.00	SBPA	12	0.00	SBPA	12	0.00
			PROCEDURE						PROCEDURE						PROCEDURE		
			SH	13	0.00				SH	13	0.00	SH	13	0.00	SH	13	0.00
			K105	14	0.00				K105	14	0.00	K105	14	0.00	K105	14	0.00
			K10P	15	-1.00				K10P	15	1.00	K10P	15	-1.00	K10P	15	-1.00
			K360	16	0.00				K360	16	0.00	K360	16	0.00	K360	16	0.00
			KSH1	17	0.00				KSH1	17	0.00	KSH1	17	0.00	KSH1	17	0.00
			K0VF	18	0.00				K0VF	18	0.00	K0VF	18	0.00	K0VF	18	0.00
			FILL LIMITS						FILL LIMITS						FILL LIMITS		
			BFA	19	255.60				BFA	19	255.60	BFA	19	255.60	BFA	19	255.60
			BFA	20	276.31				BFA	20	276.31	BFA	20	276.31	BFA	20	276.31
			FLHT	21	-130.00				FLHT	21	-130.00	FLHT	21	-130.00	FLHT	21	-130.00

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Figure 3-12. Operation Parameters

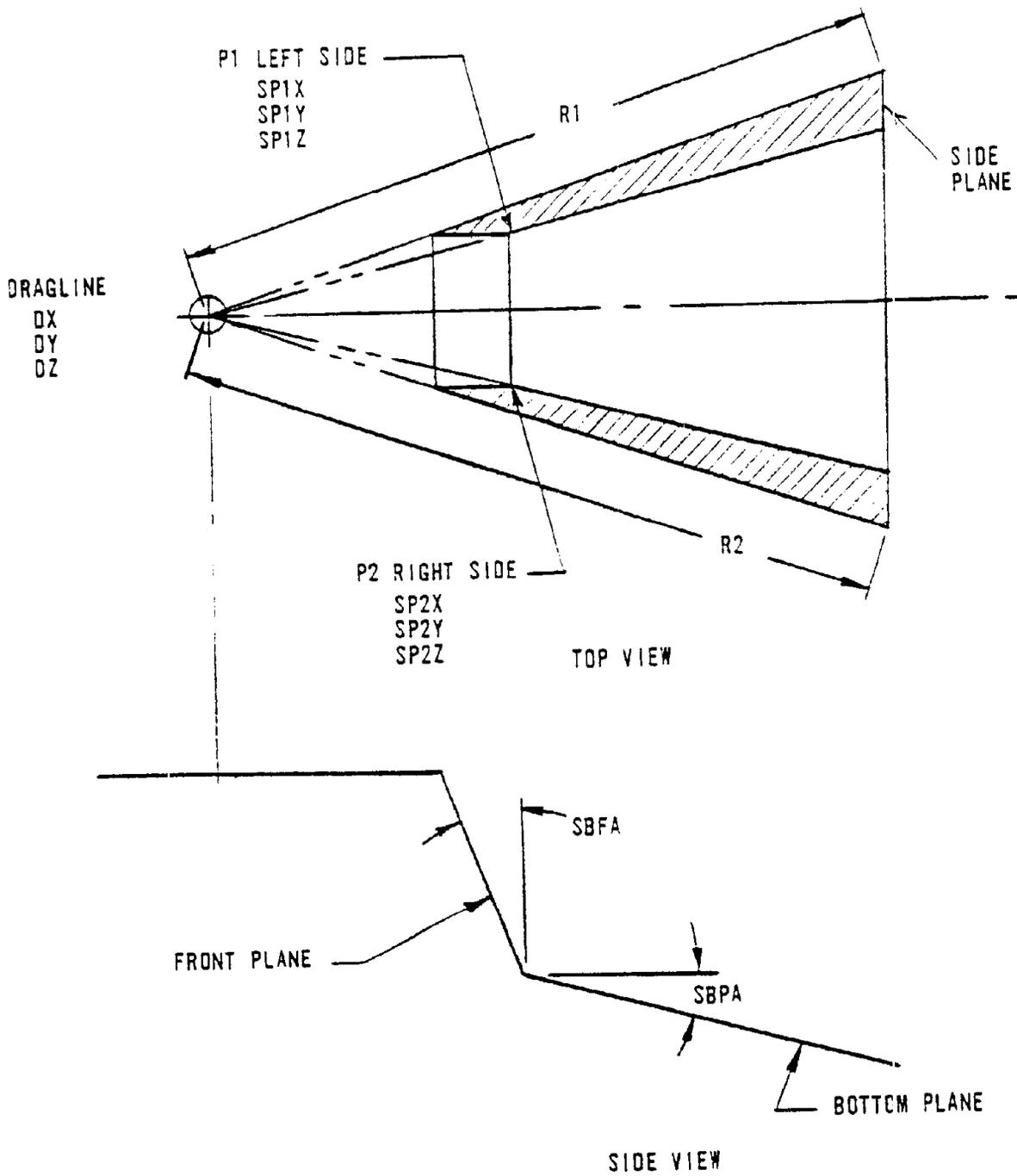


Figure 3-13. Dig Volume

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- KDGD - A control flag that controls the direction that the overburden layers are removed (positive = counter clockwise, negative = clockwise).
- K360 - A control flag that will allow 360 degree swings (>0 = allow 360). A 360 degree swing will be made if it will reduce the cycle time.
- KSHT - A control flag that will allow the dragline to take the shortest swing angle (>0 = shortest swing angle). The normal swing directions are clockwise to the spoil location and counter clockwise to the dig location.
- KOVR - A control flag that specifies that any spoil pile obstructions will be hoisted over (>0 = hoist over). If not selected, the bucket will be held closer to the dragline to avoid hitting the spoil pile.

Bench fill limits are specified by the following three parameters.

- BFRA - Degrees; bench fill right angle limit.
- BFLA - Degrees; bench fill left angle limit.
- FLHT - Feet; bench fill height. Bucket heeling can be specified by entering the bench fill height as a negative number.

#### 3.1.3.4 Program Control Flags

This section provides a central location for program logic control flags. (See Figure 3-14.) Most of the flags control diagnostic printouts that provide detailed information about the individual routines (0 = off or no printout).

- KEND - A control flag used to terminate the dragline simulation.
- KB01 - Control flags used to control diagnostic printouts for the specified routines.  
to  
KB08
- KB09 - A control flag that will create a data file containing hoist, drag and swing positions and power consumption as a function of time. The data is accumulated in the file until the flag is reset to zero.
- KB10 - Spares.  
to  
KB13

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PROGRAM FLAGS			
NAME	ID	VALUE	DESCRIPTION
KEND	1	0	TERMINATE
KB01	2	0	DIAG-DUMP.SPILE
KB02	3	0	DIAG-BCORD
KB03	4	0	DIAG-INITIALIZATION
KB04	5	0	DIAG-TPUR
KB05	6	0	DIAG-DIG
KB06	7	0	DIAG-BUCKET
KB07	8	0	DIAG-BPUR
KB08	9	0	DIAG-MOVE
KB09	10	0	DIAG-DATA FILE
KB10	11	0	DIAG-SWG HISTOGRAM
KB11	12	0	DIAG-CYCLE PERF
KB12	13	0	DIAG-
KB13	14	0	DIAG-

Figure 3-14. Control Flags

### 3.1.4 Simulation Outputs

Printouts and graphic displays have been developed to aid in the documentation and evaluation of the simulation results. Sample printout formats and plots, that can be obtained, will be described in this section. The results described are for a 70 cubic yard dragline removing a block of overburden 90 feet high, 65 feet long, 110 feet wide; and the overburden is dumped into the hopper portion of a cross-pit conveyor system. The input parameters for this case are shown in the following figures.

Figure	Description
3-8	Dragline/Mine Characteristics
3-11	Case Parameters
3-12	Operation Parameters

The hopper printouts only appear when a hopper is simulated.

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3.1.4.1 Printouts

The simulation results printout consists of the following items:

- o Quick Reference Cover Sheet
- o Individual Operation Results
- o Total Results for Similar Operations
- o Total Sequence Results

The quick reference cover sheet displays pertinent information describing the overburden dimensions, spoil height, dragline dimensions and dragline performance characteristics. (See Figure 3-15.) The individual operation results are listed next, in the order that they were performed.

Figure 3-12 defined six dragline operations; they were:

- a. Move
- b. Overburden Removal (Keycut)
- c. Move
- d. Bench Removal
- e. Bench Fill
- f. Overburden Removal (Plug)

A typical move operation printout is shown in Figure 3-16. The printout shows the starting and ending coordinates, the number of steps, the move time and the energy required to move the dragline from one location to another. In addition, when the hopper is active, the printout will show the hopper start and end coordinates, orientation, status, move distance and move time.

- X Start - X coordinate of the dragline prior to the move.
- X End - X coordinate of the dragline after move.
- X Steps - Total number of steps parallel to X axis.

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PARAMETER LIST

OVERBURDEN:

HEIGHT OF OVERBURDEN = 137.00 FEET  
 HEIGHT OF BENCH = 127.00 FEET  
 HEIGHT OF COAL = 12.00 FEET  
 SLOPE OF HIGHWALL = 2.75  
 SLOPE OF DIG FACE = 1.20

SPOIL:

HEIGHT OF SPOIL PILE = 159.12 FEET  
 HEIGHT OF BUCKWALL = 0.00 FEET  
 SLOPE OF SPOIL PILE = 0.78

DRAGLINE:

UTILIZATION = 1.00 PERCENT/100.  
 OPERATING RADIUS = 292.00 FEET  
 BOOM LENGTH = 325.00 FEET  
 BOOM ANGLE = 35.00 DEGREES  
 DIAMETER OF BASE = 62.00 FEET  
 DISTANCE TO HIGHWALL = 15.00 FEET  
 LENGTH OF STEP = 7.00 FEET  
 TIME OF STEP = 39.80 SECONDS  
 POSITIONING TIME = 0.60 SECONDS  
 BUCKET SPOTTING TIME = 1.50 SECONDS  
 BUCKET SPOTTING TIME  
 NEAR COAL = 3.00 SECONDS  
 BUCKET CAPACITY = 70.00 BCU-YDS  
 BUCKET FILL = 0.80 PERCENT/100.  
 BUCKET WIDTH = 15.75 FEET  
 BUCKET CUT HEIGHT = 3.00 FEET  
 SWING ACCELERATION = 0.01959 RADIAN/SEC\*\*2  
 INERTIA = 21539786752. LBS\*FT\*\*2

MAXIMUM PIT WIDTH WITHOUT REHANDLE = 97.70 FEET  
 CRITICAL ANGLE FOR A 360 DEGREE SWING = 152.00 DEGREES

Figure 3-15. Quick Reference Cover Sheet

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- Y Start - Y coordinate of the dragline prior to the move.
- Y End - Y coordinate of the dragline after move.
- Y Steps - Total number of steps parallel to Y axis.
- Total Time - Total move time, greater of the dragline or hopper move times. The dragline move time is the sum of the Drag Move Time and the Position Time.
- Total Energy - Total dragline move energy.
- Position Time - Dragline position and ground preparation time.
- Drag Move Time - Minimum walk time.
- Hopper Printouts
  - X - X coordinate of the hopper opening.
  - Y - Y coordinate of the hopper opening.
  - Angle - The hopper orientation angle is measured from the positive X direction to the centerline of the hopper length.
  - Active - Control flag indicating that the hopper is active or inactive (0 = inactive).
  - Move Distance - Distance between the hopper start and end coordinates in feet.
  - Move Time - Hopper move time in minutes.

OPERATION # 1 MOVE

X START	= 129.00 FEET	Y START	= 330.00 FEET
X END	= 192.00 FEET	Y END	= 295.00 FEET
X STEPS	= 9.00	Y STEPS	= -5.00
TOTAL TIME	= 15.86 MINUTES		
TOTAL ENERGY	= 79.21 KW-HR		
POSITION TIME	= 5.95 MINUTES		
DRAG MOVE TIME	= 15.86 MINUTES		

HOPPER START		HOPPER END	
X	= 0.00 FEET	X	= -87.35 FEET
Y	= 380.00 FEET	Y	= 380.00 FEET
ANGLE	= 80.00 DEGREES	ANGLE	= 73.08 DEGREES
ACTIVE	= 0.00 0-OFF	ACTIVE	= 1.00 0-OFF

MOVE DISTANCE = 87.35  
 MOVE TIME = 6.72

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Figure 3-16. Move Operation Printout

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A typical overburden removal operation printout is shown in Figure 3-17. The TOTALS column shows the number of cycles removed, the overburden volume removed, intra cycle times and energies. The AVERAGES column displays the same information on a cycle basis. Details of the printout are described below.

TOTALS

- Cycles - The number of completed dig-dump cycles.
- Volume - Total volume removed in this operation.
- Time-Position - Time required to swing to the first dig position.
- Time-Swing - Total time spent swinging.
- Time-Load - Total time spent spotting and loading the bucket.
- Time-Dump - Total time spent waiting for the bucket to empty.
- Time-Heel - Total time spent bucket heeling.
- Time - Total time required to remove the volume defined by the operation parameters.
- Energy-Position - Energy consumed when swinging to the first dig position.
- Energy-Loading - Total bucket loading energy.
- Energy-Transit - Total swing, hoist and drag energy consumed during swing motions.
- Energy - Total energy required to remove the volume defined by the operation parameters.
- Number of Heels - The number of times the bucket is used to heel or blade the overburden.
- Second Loading Passes - The number of second bucket loading passes that were made.
- Second Loading Time - The total second bucket loading pass time.
- Full Load - The bucket is considered full when it contains this yardage.

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OPERATION # 5 BENCH FILL

TOTALS		AVERAGES	
CYCLES	= 57.00	STRIP RATE	= 1883.86 YDS/HR
VOLUME	= 3035.33 BCU.YDS	STRIP RATE	= 26.91 YDS/HR/YDS
TIME - POSITION	= 0.71 MINUTES	BUCKET FILL	= 53.35 BCU.YDS
TIME - SWING	= 61.01 MINUTES	SWING ANGLE	= 111.70 DEGREES
TIME - LOAD	= 22.21 MINUTES	TIME - SWING	= 32.11 SECONDS
TIME - DUMP	= 0.95 MINUTES	TIME - LOAD	= 23.38 SECONDS
TIME - HEEL	= 11.79 MINUTES	TIME - DUMP	= 1.00 SECONDS
TIME	= 96.67 MINUTES	TIME - HEEL	= 12.41 SECONDS
ENERGY - POSITION	= 5.30 KW-HR	CYCLE TIME	= 101.01 SECONDS
ENERGY - LOADING	= 673.65 KW-HR	ENERGY - LOADING	= 11.82 KW-HR
ENERGY - TRANSIT	= 1153.87 KW-HR	ENERGY - TRANSIT	= 20.24 KW-HR
ENERGY	= 1832.82 KW-HR	ENERGY/CYCLE	= 32.05 KW-HR
NUMBER OF HEELS	= 34.00	HEEL TIME	= 20.81 SECONDS
2ND LOADING PASSES	= 1.00	2ND LOADING TIME	= 23.96 SECONDS
2ND LOADING TIME	= 0.38 MINUTES		
FULL LOAD	= 45.63 BCU.YDS		
REHANDLE VOLUME	= 3763.81 BCU.YDS		

\*\*\* SWING ANALYSIS \*\*\*

NUMBER OF SWINGS = 114.00  
AVERAGE SWING ANGLE = 111.70 DEGREES  
AVERAGE SWING TIME = 32.11 SECONDS

SWING RANGE	*----- NUMBER	TOTALS ANGLE (DEG)	-----* TIME (MIN)	*-- AVERAGE --* ANGLE (DEG)	TIME (SEC)
0 - 30	0	0.00	0.00	0.00	0.00
30 - 60	0	0.00	0.00	0.00	0.00
60 - 90	1	77.86	0.41	77.86	24.44
90 - 100	14	1307.15	7.36	93.37	31.52
100 - 120	76	8491.86	40.03	111.74	31.60
120 - 150	23	2857.32	13.22	124.23	34.48
150 - 180	0	0.00	0.00	0.00	0.00
180 - 360	0	0.00	0.00	0.00	0.00
MINIMUM SWING ANGLE		= 77.86 DEGREES		24.44 SECONDS	
MAXIMUM SWING ANGLE		= 129.80 DEGREES		23.89 SECONDS	

Figure 3-17. Overburden Removal Printout

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	52

AVERAGES

- Strip Rate - Total Volume/Total Time.
- Total Volume/Total Time/Bucket Capacity.
- Bucket Fill - Total Volume/Cycles.
- Swing Angle - Total Swing Angle/2 x Cycles.
- Cycle Time - Total Time/Cycles.
- Energy/Cycle - Total Energy/Cycles.

3.1.4.2 Swing Analysis

The swing analysis provides a histogram of the dragline swing angles. The swing angle to the dump position and the return swing angle to the next dig position are classified according to swing angle ranges.

3.1.5 Plots

Graphic plots of the overburden area and spoil pile can be obtained on a Tektronix graphic terminal or on a line printer. Four types of plots can be obtained:

- o Entire Overburden Area
- o Selected 50 x 50 Yard Position of the Overburden Area
- o Spoil Pile Area
- o Spoil Pile Profile

A plot of the entire overburden area is shown in Figure 3-18. The plot shows the appearance of the overburden area following the simulation case described in the preceding section. The date, time, file name and the last operation completed are listed on the plot for identification. The dragline position coordinates are listed and the position is indicated by the triangular peak on the overburden plot.

The eye-point or viewing position is also listed on the plot. The azimuth is the angle, in radians, about the Z axis of the overburden coordinate system. The azimuth is measured from the -X direction. (See Figure 3-19.) The elevation is the angle,

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	53

09-NOV-77  
 05:27:15  
 SAMPLE: DAT  
 OPERATION# 6  
 O.B. TO SPOIL  
  
 DRAGLINE POSITION  
 DX 192  
 DY 330  
  
 EYE POSITION 2.9  
 AZIMUTH 6.3  
 ELEVATION 300.0  
 DISTANCE  
 GRID SIZE 9 FT

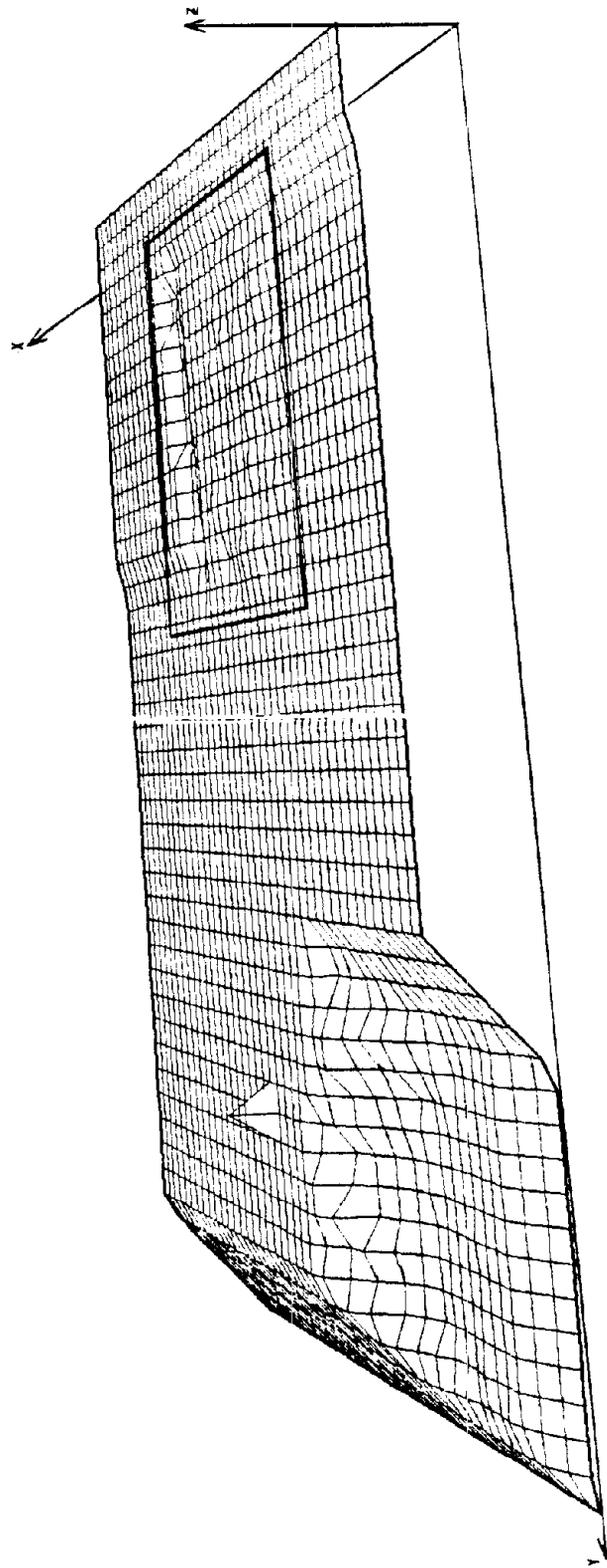


Figure 3-18. Entire Overburden Area

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	54

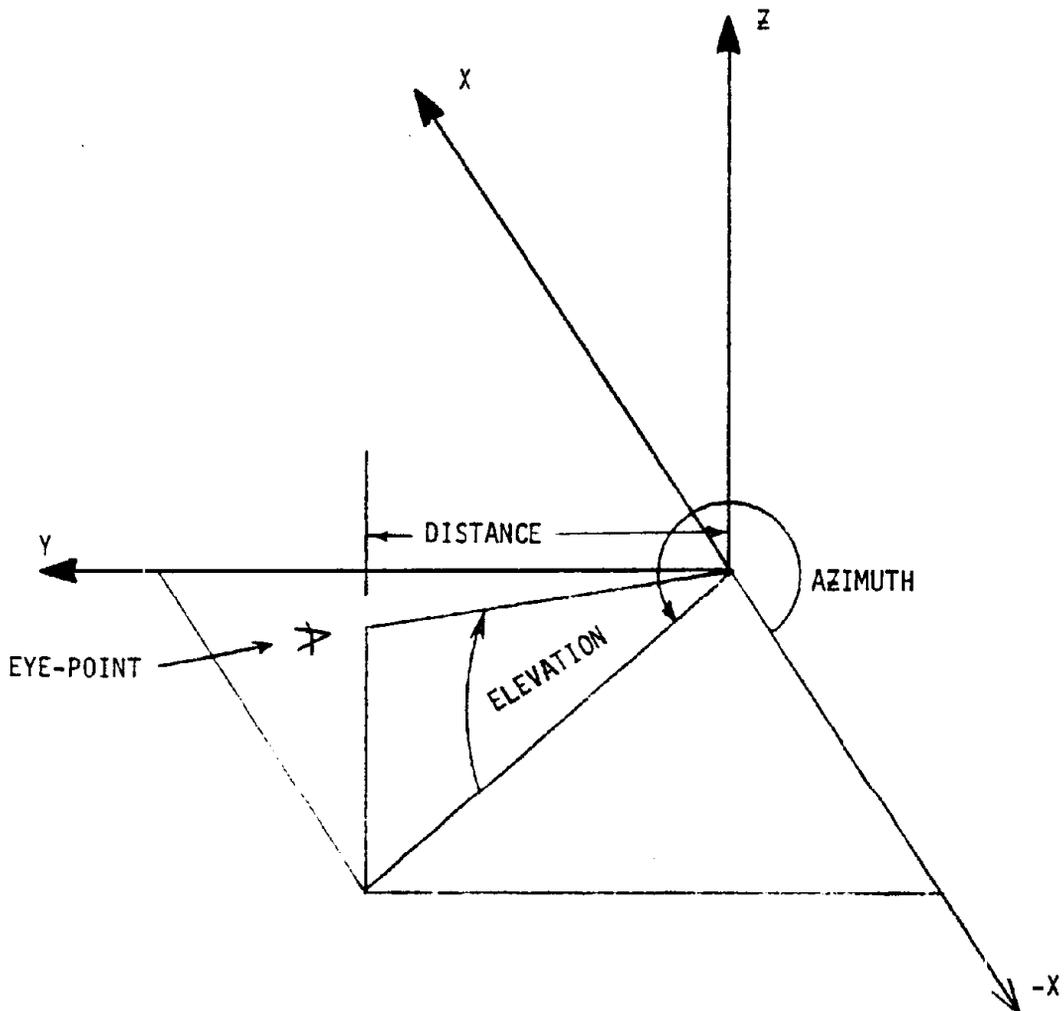


Figure 3-19. Eye-Point Position

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	55



Reproduced from  
best available copy.

in radians, from the intersection of the X-Y plane and the Z axis. The distance is the eye-point distance to the origin of the coordinate system.

The grid size of the "entire overburden plot" was nine feet. This size was selected to reduce the program size and processing time. This grid size is adequate for displaying the general shape of the overburden; but occasionally, a finer resolution is desirable. To facilitate these occasions, a close-up of any 50 x 50 yard portion of the overburden area can be plotted with a grid size of 3 feet. Figure 3-20 shows a 50 x 50 yard plot of the bench fill area outlined on Figure 3-18. In addition to the identification and eye-point information, the plot coordinates are listed.

```

4-11-77
C:\D\119
SAMPLE.DAT
VELOCITY#A
DIR TO SPOIL

EYE POSITION
AZIMUTH      21.0
ELEVATION    21.0
DISTANCE     200.0

PLOT AREA (YARDS)
YMIN      85.
YMAX      87.
XMIN      8.
XMAX      18.

```

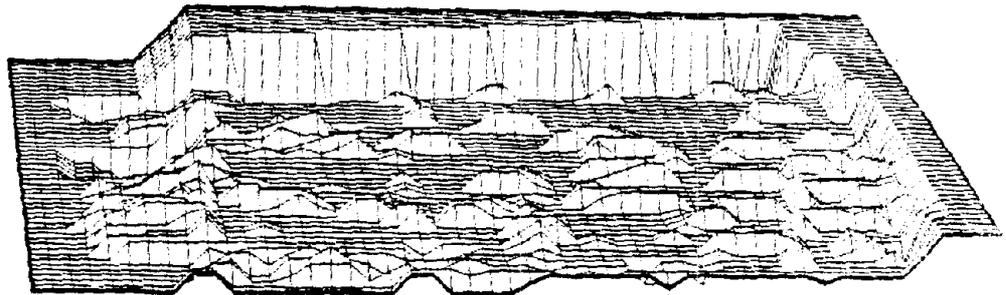


Figure 3-20. 50 x 50 Yard Plot

Figure 3-21 shows a typical spoil pile plot, and Figure 3-22 shows a profile of the same spoil pile.

### 3.2 DINP PROCESSING ROUTINE

The Dragline Simulation program provides a means to evaluate different removal procedures for a given mine and dragline. By simulating various configurations a best or optimal removal procedure can be found. How optimal this procedure is depends on how extensive a search can be made. The DINP program was written to structure and expedite the search for the optimal procedure.

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	56

11-JUN-76  
 09:10:21  
 PITHR. DAT  
 OPERATION NO. 4  
 O. B TO SPOIL

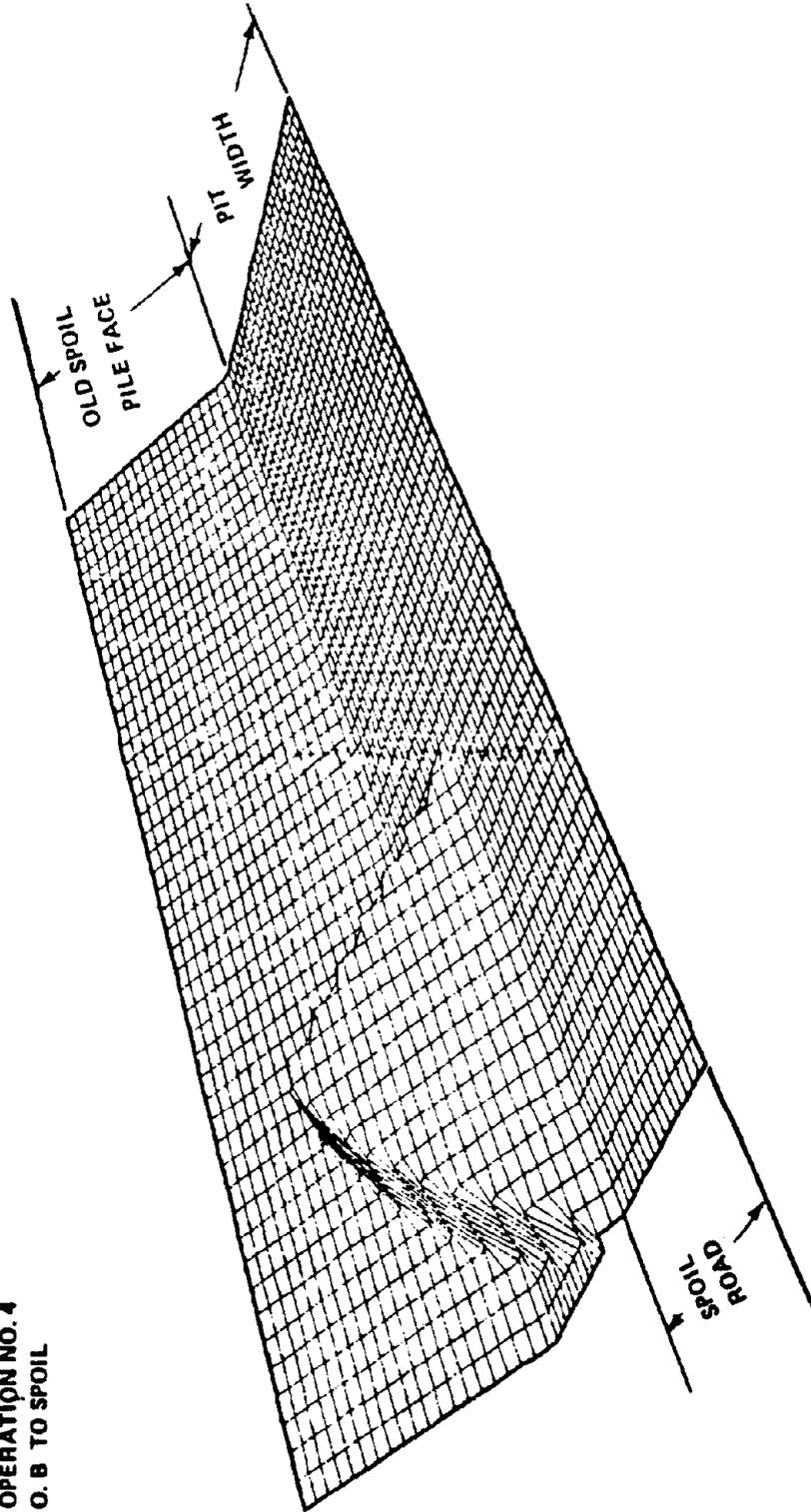


Figure 3-21. Spoil Pile Plot

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	57

09-NOV-77  
16:10:38  
BMX1.DAT  
OPERATION#10  
O.B. TO SPOIL

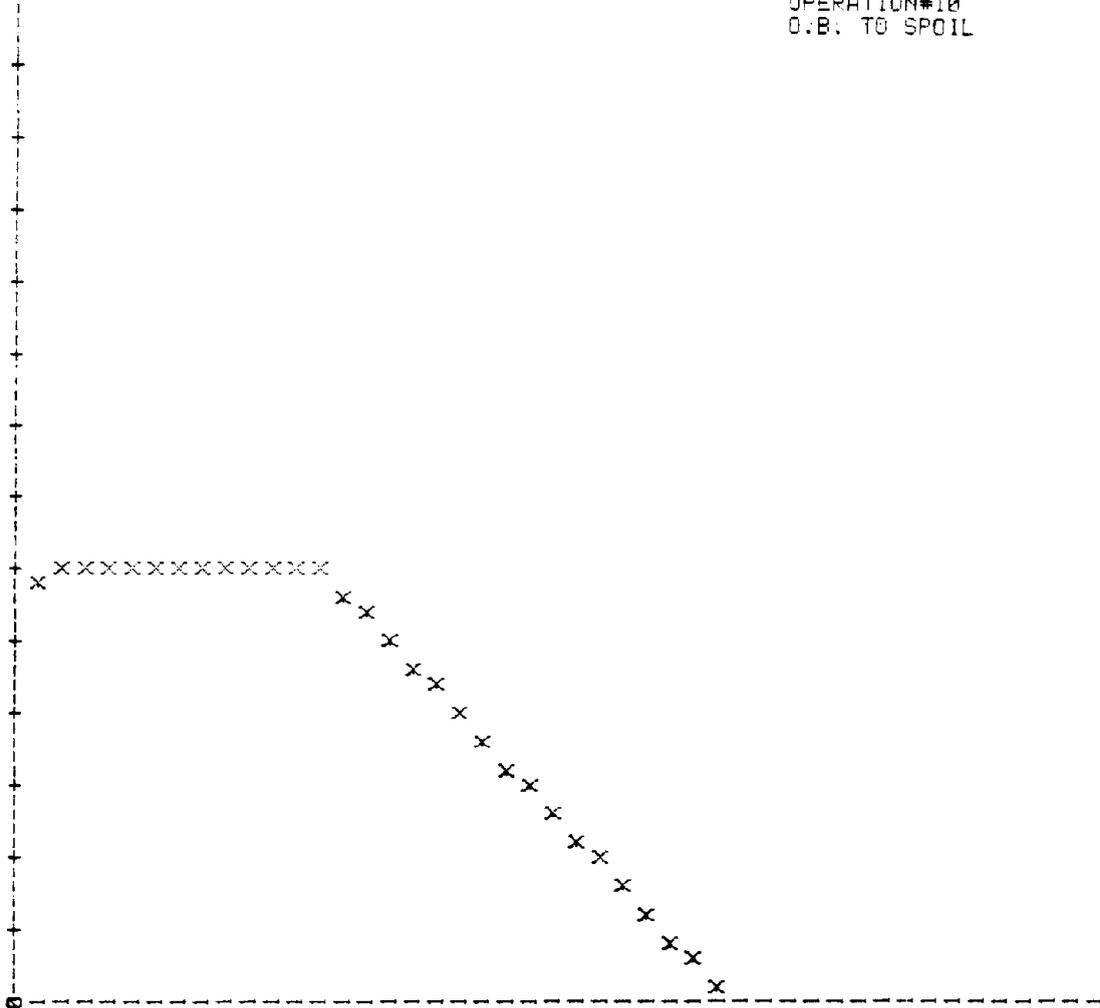


Figure 3-22. Spoil Pile Profile

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	58

A removal procedure is the manner in which a case block of overburden is removed. Removal procedures are specified by a case file and a series of operation files. These files contain a geometric description of the dig and spoil areas in the coordinate system of the simulation model. The DINP program is designed to generate this geometric data from more general 'mine language' inputs such as cut width, pit width and type of cut. This eliminates manual calculations of this data from mine layouts. Also variations of a basic removal procedure can be investigated by entering several values of an input parameter. For instance several keycut widths may be entered to investigate the effect of this on the strip rate. The program creates the case and operation files corresponding to each distinct series of inputs. These files are then labelled according to a specified nomenclature. This nomenclature not only distinguishes the files but also structures the simulation of the removal procedures to reduce the computer time required. The idea is to apply the principles of dynamic programming in simulating the removal procedures.

### 3.2.1 Data Inputs

This section describes the data inputs to the DINP program and their significance to the determination of a removal procedure. The inputs are all answers to questions which appear on a CRT terminal. The possible responses are also displayed. The inputs are discussed in the same order as they appear in the program. A printout of a sample run is given in Figure 3-23.

#### 3.2.1.1 Set Number

The set number is a classification number that identifies the mine, dragline and removal strategy to be simulated. The input is a number from 1 to 26. The numbers do not have to be used consecutively.

#### 3.2.1.2 Parameter File Input

The parameter file contains the dragline and mine specifications. This information can be entered from a prepared file or input through the CRT. The input procedure is the same as in the DRAG program.

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WEO2M001	
SCALE	REVISION	SHEET	59

```

INPUT SET NUMBER
1
DATA ACTIVITY
ID DESCRIPTION
1 DISPLAY/UPDATE SOURCE DATA
2 DISPLAY/UPDATE PARAMETER DATA
3 DISPLAY/UPDATE CASE DATA
4 DISPLAY/UPDATE OPERATION DATA
5 DISPLAY/UPDATE PROGRAM FLAG DATA
INPUT ACTIVITY
0 NONE
ID-ACTIVITY
1

DATA SOURCE ACTIVITY
ID DESCRIPTION
1 UPDATE PROGRAM CMD TERMINAL
2 UPDATE PARAMETER TERMINAL
3 UPDATE CASE TERMINAL
4 UPDATE OPERATION TERMINAL
5 UPDATE PROGRAM FLAG TERMINAL
INPUT ACTIVITY
0 NONE
ID-ACTIVITY
1

INPUT SOURCE FOR PARAMETER DATA
1-NEW FILE
2-ACTIVE FILE
PARAMETER DATA FILE NAME?
NAME1

DATA SOURCE ACTIVITY
ID DESCRIPTION
1 UPDATE PROGRAM CMD TERMINAL
2 UPDATE PARAMETER TERMINAL
3 UPDATE CASE TERMINAL
4 UPDATE OPERATION TERMINAL
5 UPDATE PROGRAM FLAG TERMINAL
INPUT ACTIVITY
0 NONE
ID-ACTIVITY
1

DATA ACTIVITY
ID DESCRIPTION
1 DISPLAY/UPDATE SOURCE DATA
2 DISPLAY/UPDATE PARAMETER DATA
3 DISPLAY/UPDATE CASE DATA
4 DISPLAY/UPDATE OPERATION DATA
5 DISPLAY/UPDATE PROGRAM FLAG DATA
INPUT ACTIVITY
0 NONE
ID-ACTIVITY
2

FROM THIS POINT ON, ALL INPUTS ARE REAL NUMBERS
AND MUST BE FOLLOWED BY A COMMA.
MULTIPLE INPUTS MAY BE ENTERED BY SIMPLY REPEATING
THE QUESTION RESPONSES. THE NUMBER IN BRACKETS ( )
IS THE NUMBER OF MULTIPLE INPUTS.
(1) HOOPER SIMULATION (0/0)
>0 = YES
0 = NO
100.00, 120., 135.,
120.00
(1) INPUT REMOVAL STRATEGY
NUMBER, BR - BLANCH REMOVAL, KC - BEG CUT
CM - COMPLETE WIDTH, MC - NORMAL CUT
PS - HIGHWALL SIDE, SS - HIGHWALL SIDE
REPEATING A POSITION NUMBER WILL FORCE THE DRAGLINE
TO REMAIN STATIONARY.
A CARRIAGE RETURN WILL TERMINATE THE STRATEGY INPUTS
1.0M,4C,5
THE BUCKET CUTS 4.0 FEET DEEP
(3) INPUT CUT DEPTH (SHOULD BE A MULTIPLE OF 4.0)
24.00
28.00
(3) INPUT CUT WIDTH
150.00
150.00
(3) INPUT RIGHT SIDEWALL ANGLE
15.00
15.00
(3) INPUT LEFT SIDEWALL ANGLE
15.00
15.00
(2) INPUT DIRECTION (r/-)
1 = COUNTER-CLOCKWISE
2 = CLOCKWISE
(2) INPUT SPOIL LAYER THICKNESS AS A % OF THE TOTAL SPOIL HEIGHT
100.00
100.00
(2) INPUT SPOIL DIRECTION (r/-)
1 = DIRECTION OF SPOIL ADVANCE
1.00

```

```

(2) INPUT HOIST SWING (0/0)
0 = NO
>0 = YES
(2) INPUT SHORTEST SWING (0/0)
0 = NO
>0 = YES
(2) INPUT HOIST OVER (0/0)
0 = NO
>0 = YES
0.00
ANY MISTAKES? 1-GO BACK, 0-GO ON
(1) INPUT REMOVAL STRATEGY
NUMBER, BR - BLANCH REMOVAL, KC - BEG CUT
CM - COMPLETE WIDTH, MC - NORMAL CUT
PS - HIGHWALL SIDE, SS - HIGHWALL SIDE
REPEATING A POSITION NUMBER WILL FORCE THE DRAGLINE
TO REMAIN STATIONARY.
A CARRIAGE RETURN WILL TERMINATE THE STRATEGY INPUTS
(1) INPUT ALLOWABLE SPOIL RETURN % (0/0)
0 = NONE
0.00
(1) INPUT % OF SPOIL LENGTH CHANGE (0/0)
0 = INCREASE SPOIL AREA
0 = SPOIL LENGTH = CUT LENGTH
-5. = DECREASE SPOIL AREA

```

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	60

Figure 3-23. DIMP - Sample Run

### 3.2.1.3 Hopper Simulation

If a hopper is to be simulated, this input is greater than zero. This will permit entry of the hopper data later in the program. If there is to be no hopper simulated in this set input a zero or carriage return. In this case no hopper data can be input for this set.

### 3.2.1.4 Enter Cut Length, Cut Width and Pit Width

The cut length, cut width and pit width give the dimensions of the case block and spoil area. For a given removal strategy it may be desirable to simulate several cut lengths, cut widths and pit widths. This can be done by repeating the ordered triple (cut length, cut width, pit width) as indicated on the CRT display. Five such triples can be entered.

### 3.2.1.5 Input Removal Strategy

The removal strategy is determined by a series of lines. Each line is input in a mnemonic language. There are four entries to each line; position number, volume location, cut type and spoil area.

#### 3.2.1.5.1 Position Number

A number from one to ten can be entered here. Usually the position numbers are consecutive and correspond to each line entered. However, if it is not desirable for the dragline to move from its previous location to make the present cut the line number can be repeated. This serves as a cue to the DINP program to not move the dragline from its past position. In general, the dragline is located at the most advantageous position for each cut.

#### 3.2.1.5.2 Volume Location

This input is used to give a general location of the dig volume that will be further specified by the inputs that follow. Inputs are:

- o BR - Bench Removal
- o CW - Complete Width
- o HS - Highwall Side
- o SS - Spoil Side

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	61

The response BR indicates the volume is to be removed from the bench. CW indicates a layer will be removed from the entire width of the cut. HS indicates a cut will be made from the new highwall to desired width toward the old highwall. The cut width is input after the line is entered. The SS input indicates a cut be made from the old highwall to a desired width toward the new highwall.

### 3.2.1.5.3 Type of Cut

There are two possible inputs:

- o KC - Keycut
- o NC - Normal Cut

The KC response indicates the cut is to be made so a highwall is maintained along the side farthest from the spoil pile. This response is usually used with the HS or the CW cut location. In this case the dragline is positioned to advance the new highwall. When used with the SS response the result is the same except the highwall is located on the left side of the cut. This situation is not usual.

The NC response used with a CW or HS entry will position the dragline in the middle of the cut. The dragline is not positioned to maintain a highwall.

The NC response with a SS response causes the dragline to be located as close to the old highwall as possible. This is to maximize the reach of the dragline. Neither the NC or KC response has any affect when used with a BR - Removal. The BR response is sufficient to determine the position of the cut.

### 3.2.1.5.4 Spoil Area

The fourth entry of the removal strategy specifies the spoil area.

- o B - Overburden to Bench
- o S - Overburden to Spoil Pile

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	62

A three position procedure can be specified by three lines. The line entry for the top cut could be

1, CW, KC, S.

This could be followed by a keycut

2, HS, KC, S

and the removal of the plug by

3, SS, NC, S.

After each line is entered, a carriage return will advance the program to input more detailed data for that line. The inputs for each line are as follows.

#### 3.2.1.5.4.1 Cut Depth

This input specifies the depth of this cut measured from the bench level down. In case the second entry is a BR this input is not used. The depth of the bench cut is given by HBD and HBFL which occur in the parameter file. Also, if the second entry is a SS, HS or CW and the fourth entry is a B the cut depth need not be entered. In this case the depth is computed from the cut width and the bench fill volume.

#### 3.2.1.5.4.2 Cut Width

This input specifies the cut width of the line. This input is used only for lines with second entry HS or SS. In the case of an HS entry the cut width is measured from the new highwall. For an SS entry it is the cut width measured from the old highwall.

The CW input implies the cut width equal to the width of the case block. In this case the cut width inputs are ignored. If the second entry of the line is a BR the cut width is calculated from the pit dimensions. The cut width input is not used. There can be three cut widths entered for each line.

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	63

3.2.1.5.4.3 Right Side Wall Angle

Input the angle of the right dig wall. This angle is measured from the vertical in degrees. At most three numbers can be entered here.

3.2.1.5.4.4 Left Side Wall Angle

Input the angle of the left dig wall. This angle is measured from the vertical in degrees. There can be as many as three inputs.

3.2.1.5.4.5 Dig Direction

This input determines the direction the dragline will dig. Inputting a positive real number corresponds to digging in the clockwise direction (swing angle). Inputting a negative number corresponds to digging in the counterclockwise direction. At most two inputs are permitted.

3.2.1.5.4.6 Hopper Active

This input is to set the Hopper Active Flag for this line. A positive input sets the Hopper Active Flag and a negative input resets this flag indicating no hopper is to be simulated in this line. This input does not appear if the Hopper Simulation Flag has not been set. Only one entry is permitted.

3.2.1.5.4.7 X-Coordinate of the Hopper Location

This input appears only if the Hopper Simulation Flag is set. The X coordinate of the hopper location is entered. As in the DRAG program, one of the hopper coordinates either the X or Y must be negative. This serves as a cue to calculate the negative coordinate using the positive coordinate and the location of the dragline. Then the hopper is located at the proper distance from the dragline on the X or Y coordinate that is positive. Only one entry is permitted.

3.2.1.5.4.8 Y-Coordinate of the Hopper Location

This input appears only if the Hopper Simulation Flag is set. The entry of the Y coordinate is the same as the X coordinate described above.

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	64

3.2.1.5.4.9 Spoil Layer Thickness

This input is a percentage from 0 to 100 and specifies how the spoil pile is to evolve. For example an input of 50 will cause the spoil pile to evolve in two layers. The thickness of each layer will be half of the total height of the spoil pile. The first layer is filled to half the spoil pile height as much as allowed by the reach of the dragline. Then the material is deposited above this height.

This input applies for this line only. The next line may employ another spoil strategy. This input is not used when doing a bench fill. At most two inputs are allowed.

3.2.1.5.4.10 Spoil Direction

This input determines the direction of the spoiling both to the spoil pile and to the bench. A positive entry corresponds to spoiling in the counterclockwise direction. A negative entry corresponds to spoiling in a clockwise direction. Two inputs are permitted.

3.2.1.5.4.11 Input a 360° Swing

This input is a flag that enables the dragline to do a 360° swing if it will reduce the swing time. If the flag is not set the dragline will not do any 360° swings. The entry of a positive number sets the flag. A negative or zero entry resets the flag and disables the 360° swing. There can be two entries.

3.2.1.5.4.12 Input Shortest Swing

This flag permits the dragline to swing in the direction of the smallest swing angle. If the flag is not set, a zero or negative number is entered, the dragline will swing to the bench area in the clockwise direction and to the spoil area in the counterclockwise direction regardless of possible shorter paths. For instance in a bench removal if the angle exceeds 180° the dragline will not take the shorter swing if the Shortest Swing flag is not set. If this flag is set by entering a positive number the dragline will always seek the shortest swing regardless of direction. Two inputs are permitted.

SIZE	CODE IDENT NO.		
A	12464	WE02M001	
SCALE	REVISION	SHEET	65

3.2.1.5.4.13 Hoist Over

On the swing to the spoil pile to dump the material the bucket can be hoisted over the existing spoil peak or held in toward the dragline cab to miss this obstruction. If the Hoist Over Flag is set the bucket is hoisted over the obstruction. If it is not set the bucket is held in to miss the obstruction. The entry of a positive number sets the flag. The entry of a negative number or zero disables the flag. Two entries are permitted.

3.2.1.5.4.14 Any Mistakes: 1 - Go Back, 0 - Go On

If a mistake has been made on a line or the data entered after the line, this allows one to go back and re-enter the line and the data that follows.

After this last input the program returns to input another line of the removal strategy. A total of 10 lines can be entered. However, the total number of operations resulting from these 10 lines is limited to 12. Overburden to spoil, bench fill and moves generate one operation. Bench removals generate two operations. So depending on whether the dragline moves, a line generates from 1 to 3 operations. After the last line of the removal strategy is entered a carriage return will terminate the entry of the removal strategy.

3.2.1.5.4.15 Input Allowable Spoil Room

The DINP program computes the volume of each dig area and determines the spoil room available from the dragline positions and the spoil method. From these computations it locates the spoil peak relative to the dig face, determines the height of the spoil, and indicates how much if any material must be rehandled.

If material has to be rehandled, the algorithm tries to minimize the amount of rehandle. In doing so the spoil peak is located nearer the dig face so the reach of the dragline is maximized and the rehandle kept to a minimum. Occasionally it may be desirable to allow some rehandle or restrict the spoil room without affecting the position of the spoil peak. This can be done by entering the desired percentage of the spoil room available.

- + % - Percentage of rehandle allowed.
- % - Percentage of spoil room reduction.

Only one entry is permitted.

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
SCALE		REVISION	SHEET 66

3.2.1.5.4.16 Input Change in Spoil Length in Percent

To simulate an approach to a spoil road or other irregular condition, the length of the spoil pile can be altered. This is done by entering a percentage of the original spoil length which is equal to the cut length. A negative percentage will shorten the spoil pile. A positive percentage will lengthen the spoil pile. For example, an entry of 33 will increase the length of the spoil area 33% of the cut length. This is the last entry of the set. One entry is permitted. A carriage return will complete the data inputs for this set. The DINP program does the necessary computations and returns to display the results via the DATA program. The DINP program displays the removal procedure of each case of the set in the order they were created. The operation and case files can be printed out at this time. The data in these files can also be edited but operations can not be added or deleted. After the last removal procedure has been examined the program asks for the next set number. Another set can be entered and the process repeated or a carriage return entered to halt the inputs and terminate the program.

3.2.2 File Nomenclature and Optimization Sequencing

After the data for each set has been entered DINP calls a number of subroutines to process the input data and create the corresponding parameter, case and operation files. Each set has only one parameter file containing the mine and dragline specifications and one removal strategy specified by the series of "lines" entered. The details of the removal procedure are specified by the remaining inputs. Each distinct series of inputs will generate a distinct removal procedure. Again a removal procedure refers to the manner in which the overburden is removed and is specified by the operation files and the case file. The DINP program creates and labels the operation and case files for each removal procedure. This labelling is a series of numbers that identifies that operation as belonging to its appropriate set and case. It also structures the manner in which the operations are simulated in order to reduce the computer run time. For instance, two removal procedures of the same set may differ only in the last of four operations. So the results of the first three operations would be identical for both case blocks. Then it is necessary to simulate the first three operations once and the two different fourth operations. The case results

SIZE	CODE IDENT NO.		
A	12464	WEO2M001	
SCALE		REVISION	SHEET 67

for both removal procedures can then be reconstructed from these five operations rather than simulating the eight operations for both case blocks. Also suppose two removal procedures containing four operations differ only in the second operation. In this second operation the difference is one has the 360° Swing Enable set and the other does not. When simulated this difference does not affect the geometry of the pit. It is possible to simulate the first operation, the second operation for both 360° Swing Enable set and not set, and the remaining two operations to produce the case results for both procedures. The crucial factor here is that the 360° Swing Enable does not affect the pit geometry. So the initial and final pits produced by the simulation of both second operations are identical. Other inputs which do not affect the pit geometry are Hoist Over and Shortest Path. The nomenclature used to store the removal procedure data identifies to the DRAG simulation program the initial pit to use, the name of the pit produced by the operation and the sequence in which to simulate the operations. In order to store and manipulate the data and results there are several file types using the same name. Files are of the form: "Name. Type; Version". The name is a nine character word beginning with a letter of the alphabet. The type is a three character word beginning with a letter of the alphabet. The version is a number of at most two characters. File types of the form "DV1" are used to store the input data to be processed by the subroutines of the DINP program. These files have the form:

A(ISET) LJKLM. DV1;\*

where ISET denotes the set number and A(ISET) is the letter corresponding to the number ISET (i.e., A(1)=A, etc.) I is a single digit number. The range of I is between 1 and NC. NC is the number of ordered triples, (cut length, cut width, pit width), entered in DINP. J is a single digit number. The range of J is  $1 \leq J \leq NL$  where NL is the number of lines in the removal strategy. K is a two digit number which denotes the previous pit of the case to which this operation is a member. L is a two digit number which denotes the operation's number among the pits generated for this line number of the removal strategy. M is a two digit number which denotes the

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE		REVISION	SHEET 68

path or procedure used in operations that begin and finish with identical pit geometries. If two file names differ only in this digit the two operations will have the same initial and final pit geometry. For example the file name A11010101. DV1; 1 locates the operation as being generated from set number 1, from the first order triple entered, from line 1 of the removal strategy, it is the first operation of the case, it is the first operation of this line number, and it is the first procedure input. A more extensive example is given in Figure 3-24.

The input data is written out in DV1 files in the program DINP. These files are used to generate the operation data files of type DV2. The same name is used for these files as for DV1 type files. The DV2 files are inputs to the DRAG program which executes the defined operation and writes the results in unformatted fashion in files of type DV3. The same nomenclature is used here. The pit file resulting from these runs are stored under file type DVT with the same first name as the DV3 file. File type COM is used to store the dragline and mine parameters associated with each input set. It also is used to store index pointers (number of lines, number of operations, etc.) associated with that set number. The name of the COM file is of the form A(ISET).COM; where ISET is the set number and A(ISET) is the corresponding letter of the alphabet. In addition to these data files there is also a file named ACT.FIL. This file is used by DRAG to store the index pointers that sequence the simulation of the various operations. The first line of ACT.FIL contains the IXF flag. The second line contains the set numbers to be run. The third line contains a pointer to which set number is presently being simulated. The fourth line contains the name of the pit being simulated. The fifth line contains the index pointers of the "DO" loop that sequences the DRAG program through the operations of the set. The ACT.FIL must be initialized at the beginning of each simulation run. The DRAG program then updates ACT.FIL file at the completion of each operation. If DRAG aborts for any reason the simulation can be restarted in sequence with a RUN command. Upon entry DRAG reads ACT.FIL to determine its place in the simulation run. The files used by DINP, DRAG and GETD are summarized in the following list. The file names, A11010101 and A01,

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
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INPUTS:

ISET = 2

One Triple: (Cut Length, Cut Width, Pit Width)

Removal Strategy:

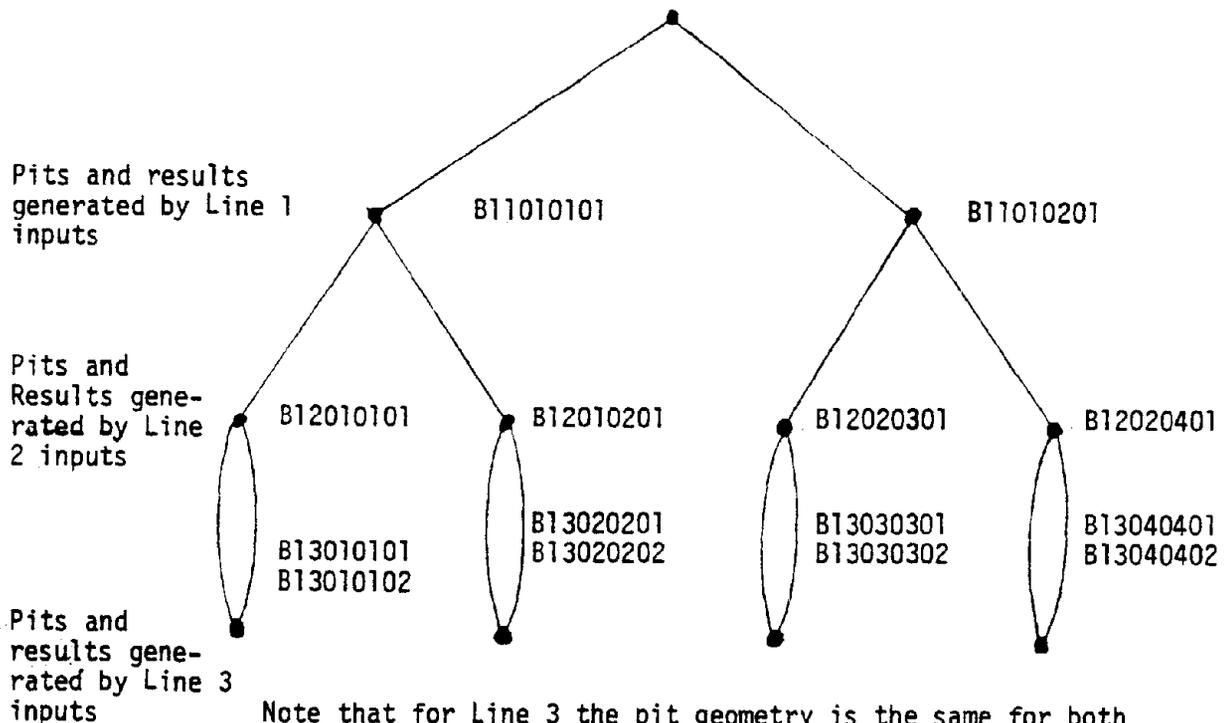
Line 1: 1, CW, KC, S - Two Cut Depth Inputs

Line 2: 2, HS, KC, S - Three Cut Width Inputs

Line 3: 3, SS, NC, S - Two Hoist Over Inputs

These inputs would result in the following file structure:

Initial pit generated from  
input parameters



Note that for Line 3 the pit geometry is the same for both Hoist Over inputs. The results are different and are stored under the appropriate names.

Figure 3-24. Example of File Nomenclature

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are used to indicate the form of the name. The name of these file types vary with set number, line number and other input parameters.

- ACT.FIL; - A file used to store the index pointers for the DRAG program.
- All010101.DV1; - Files of type DV1 are created in the DINP program to store input data.
- All010101.DV2; - Files of type DV2 are created in the DINP program to store the operation data generated from the corresponding DV1 type file.
- All010101.DV3; - Files of type DV3 are created in the DRAG program to store in unformatted form the results of the operations described in the corresponding DV2 type file.
- All010101.DVT; - Files of type DVT are created in the DRAG program to store the pit corresponding to the operations described in the DV2 type file.
- A01.DV4; - Files of type DV4 are created in GETD to store the case results as they are generated from the operation results stored in the DV3 type files.
- All010101.DV6; - Files of this type are created by DRAG to store the results of each operation simulated. The results are stored in a formatted form rather than unformatted as in the DV3 type files. The DV6 file corresponding to the first operation of each case is used by GETD to obtain the parameter header for the DV4 type file which contains the case results.
- A01.COM; - Files of this type are used to store the index pointers and machine parameters of the set.

### 3.3 GETD

When the DRAG program simulates the removal procedures generated by the DINP program the results of each operation are stored in DV3 type files. The name of these DV3 type files corresponds to the nomenclature used for the input data (DV2 type files) and for the pit files (DVT type files). The GETD program generates the total and averages for each case from the operation data. The input to the GETD program is the

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<b>A</b>	<b>12464</b>		
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set number. GETD generates the results for each case of the set and stores these results in a file. The names of the case files are of the form:

AI. DV4; 1

where A is a letter of the alphabet corresponding to the set number. I is a two digit number corresponding to the number of the case in this set. DV4 is the file type and 1 is the version number. For example, the results of the fourth case in the third set would be written in the file C04.DV4;1. The number of cases in the set corresponds to the number of different inputs entered in DINP. If there are a number of different pit widths or entries on each line of the removal strategy the number of cases grows rapidly. However, the printout of the operation data and case data produced by the DINP program for each case is titled by the same first name. Thus the input and output data for each case can be associated by the title appearing on the top of the page with the time and the date of the simulation run.

### 3.4 SAMPLE RUN

This section contains an example of a simulation run using the DINP, DRAG and GETD programs. The purpose of the run was to study the effect of cut length on the strip rate for a given removal procedure. The process went as follows:

Step 1: A parameter data file was prepared on the mine environment and dragline. The parameters considered and the format of the file is given in Display/Edit Section 4.

Step 2: The DINP program was run and the following data input:

- a. Set Number - Enter a number from one to twenty-six. In this instance the set number was three.
- b. Name of Parameter File - The parameter file prepared in Step 1 was read by the DATA subroutine thus entering the mine and dragline data.

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<b>A</b>	<b>12464</b>	WE02M001	
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- c. Hopper in Simulation - A zero, implying no hopper is to be simulated, was entered.
- d. Input cut length, cut width, pit width - 120., 152., 200., 100., 152., 200., 80., 152., 200.
- e. Input Removal Strategy:

```

Line 1: 1, CW, KC, S
Line 2: 2, HS, KC, S
Line 3: 3, SS, NC, S
Line 4: 3, BR, NC, S
Line 5: 3, SS, NC, B
Line 6: 3, SS, NC, S

```

The entries for the respective lines are given in Table 3-2.

- f. Allowable Spoil Rehandle - 0
- g. Spoil Length Change - 0

Step 3: The DINP program processed the input data and produced the case and operation files for three cases with cut lengths equal to 120, 100 and 80 feet. These files were then displayed and printed out for each of the three cases. The time, date and case name were printed at the top of the first page of each file. The case names were C01, C02 and C03 respectively.

Step 4: The file ACT.FIL was edited to the following form:

```

Line 1: 1
Line 2: 3 0 0 0 0 0 0 0 0
Line 3: 1
Line 4: C11010101. DVT
Line 5: 1 1 1 1 1

```

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	73

Step 5: The program DRAG was run. No inputs were necessary. The data was prepared and stored by the DINP program.

Step 6: After the DRAG program had finished the program GETD was run. The request for set number was answered by inputting a 3. GETD then generated the simulation results for each of the three cases and stored the same in files C01.DV4, C02.DV4 and C03.DV4.

Step 7: The files, C01.DV4, C02.DV4 and C03.DV4 were printed out.

Table 3-2. Data Line Entries

Data Entry	1	2	3	4	5	6
Cut Depth	28	66	56	-	-	66
Cut Width	-	27	150	-	150	150
Right Side Wall Angle	15	15	15	15	15	15
Left Side Wall Angle	15	15	15	15	15	15
Dig Direction	1	-1	1	1	-1	1
Spoil Layer	100	100	100	100	100	100
Spoil Direction	1	1	1	1	1	1
360° Swing	0	0	0	0	0	0
Shortest Swing	0	0	0	0	0	0
Hoist Over	0	0	0	0	0	0

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
SCALE		REVISION	SHEET 74

#### 4. SIMULATION DATA INPUT PROGRAMS

This section describes the simulation data input routines. The function of these routines is to input and/or edit, display and print the simulation input data.

The input data has been classified into five different categories. The main routines associated with each category are listed below:

<u>Data Type</u>	<u>Routine</u>
Source	DSRCE
Parameter	UPSET
Case	UPCASE
Operation	OPSEQ
Program Flags	UPFLG

DATA is the executor routine that controls which type of data is being manipulated. Figure 4-1 describes the data input process.

##### 4.1 BLANK

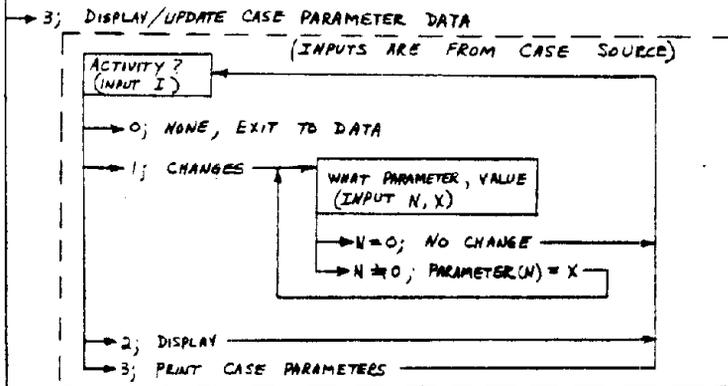
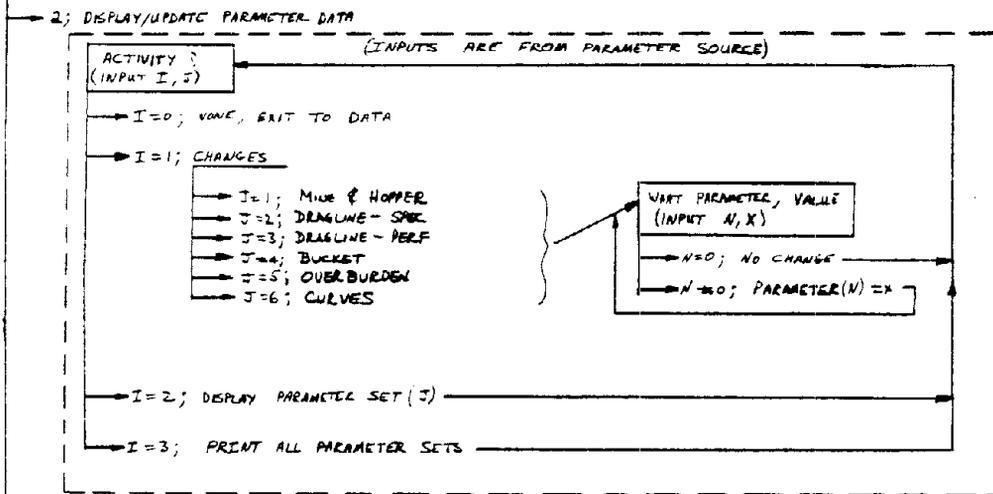
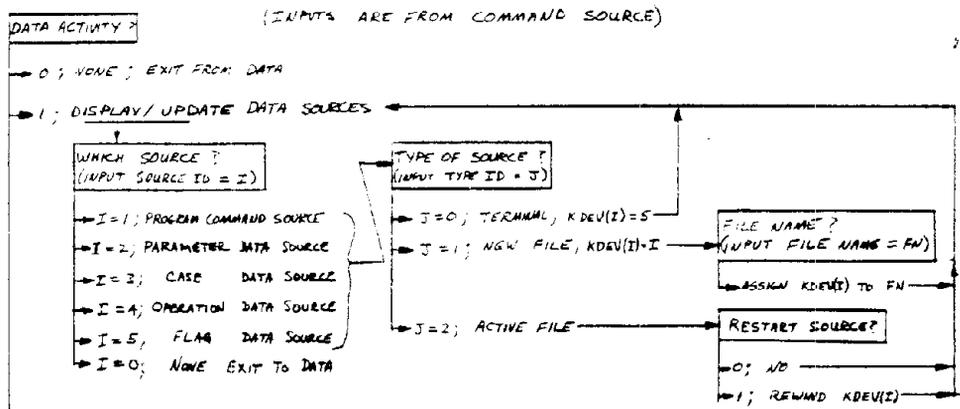
This routine blanks the CRT display. It is called prior to displaying a new page of information. (See Figure 4-2.)

##### 4.2 DATA

This routine is the main or executor routine that controls what type of simulation data is being input/edited, displayed or printed. If the CRT terminal is active, a message identifying the types of simulation data is displayed followed by a request for which type of data is to be manipulated. When the type has been specified, the appropriate routine is executed.

If the CRT terminal is inactive, the type of data to be manipulated is read from a data file. (See Figure 4-3.)

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A	12464	WE02M001	
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4 AND 5 ON NEXT PAGE

Figure 4-1. Data Input Routine Flow Chart (Sheet 1 of 2)

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	76

DATA ACTIVITY FROM PREVIOUS PAGE

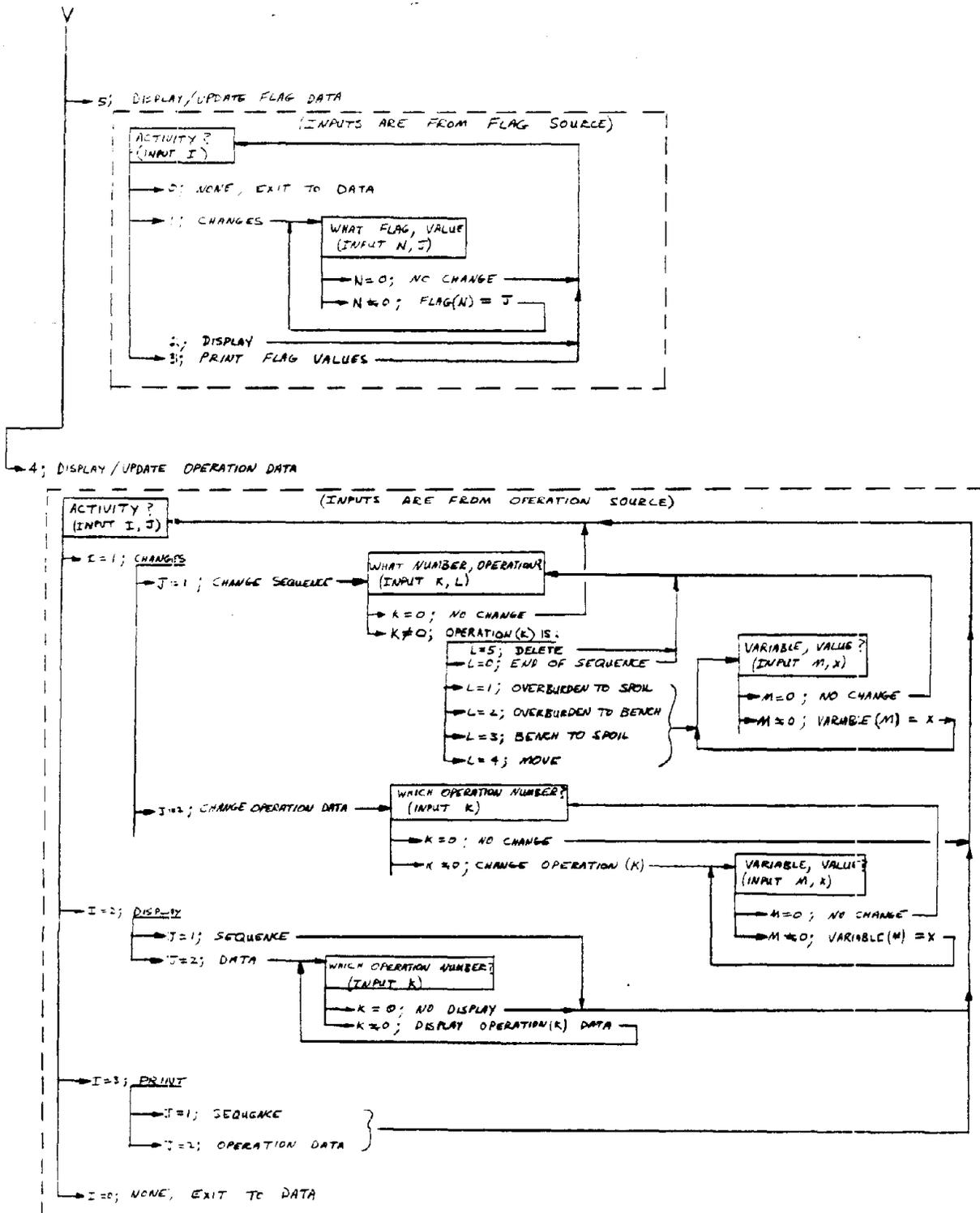


Figure 4-1. Data Input Routine Flow Chart (Sheet 2)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	77

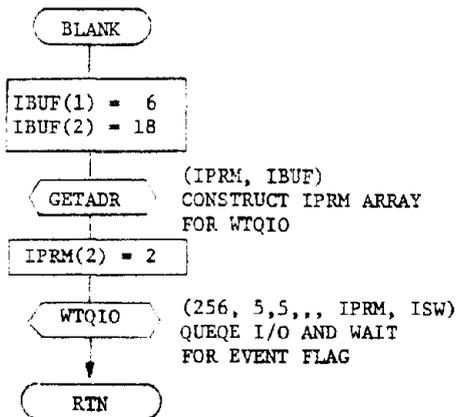


FIGURE 4-2. Blank Routine Flow Chart

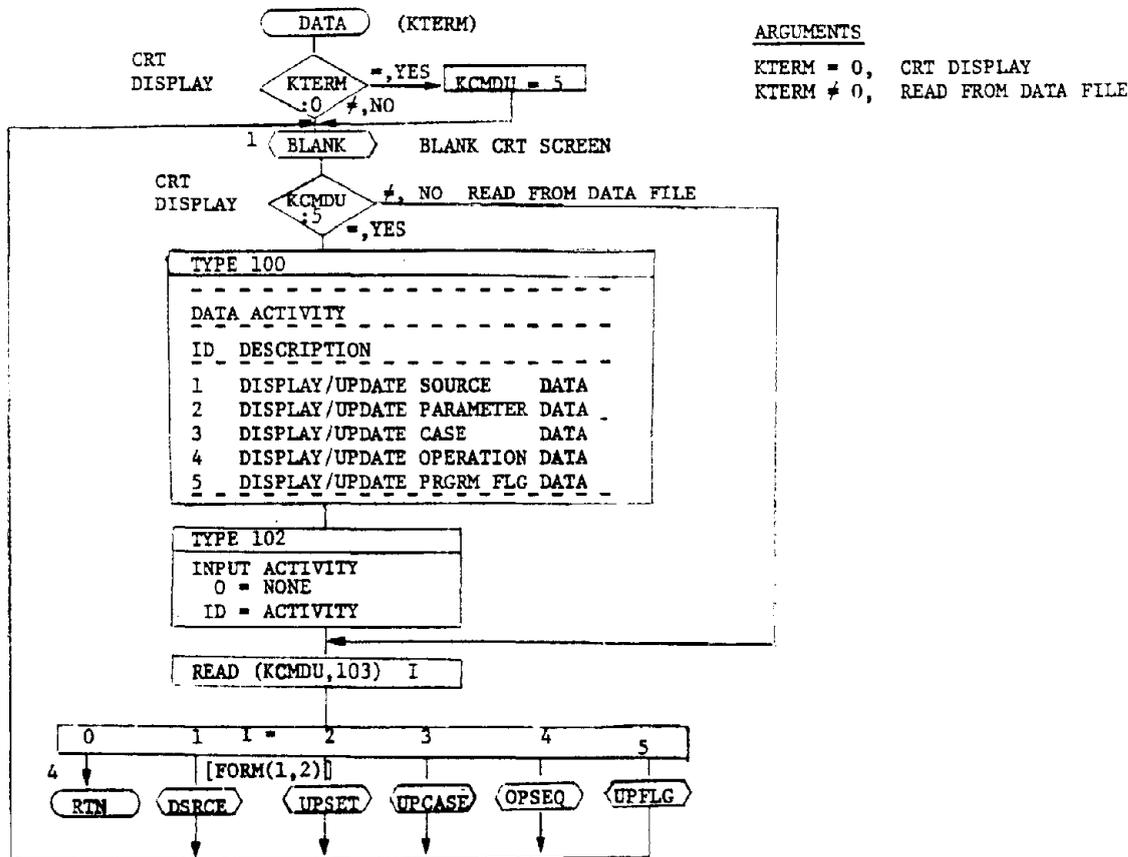


Figure 4-3. Data Routine Flow Chart

SIZE	CODE IDENT NO.	
<b>A</b>	<b>12464</b>	WEO2MO01
SCALE	REVISION	SHEET 78

### 4.3 DSPAC

This routine is associated with the manipulation of parameter data. It is called by the UPSET routine only when the CRT terminal is active. It displays the different types of parameters and allowable activities. (See Figure 4-4.)

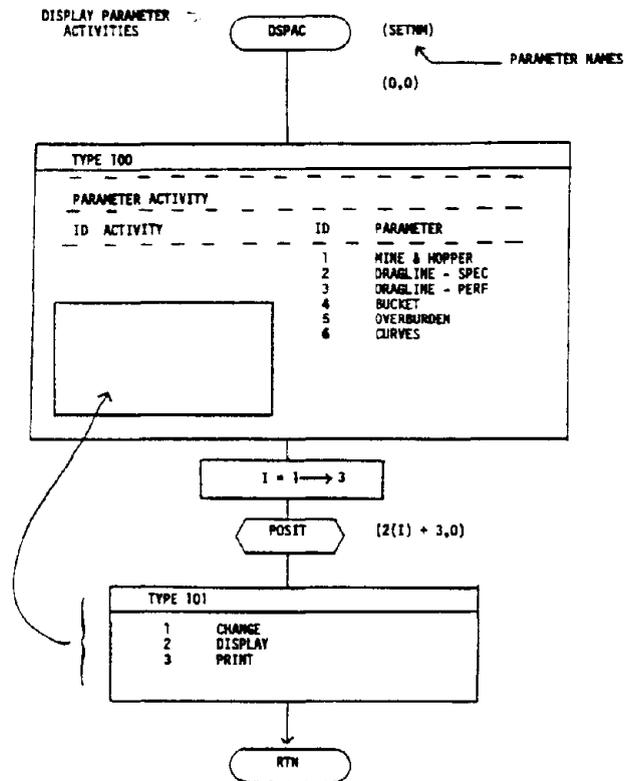


Figure 4-4. DSPAC Routine Flow Chart

### 4.4 DSPDS

This routine is associated with the control of the data sources. It is called by the DSRCE routine only when the CRT terminal is active. It displays the types of input data and the source of the input commands. The command information can either be

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	79

input from the CRT terminal or read from a previously prepared data file. A typical display format is shown on the flow chart. (See Figure 4-5.)

#### 4.5 DSPOD

This routine is associated with the manipulation of the dragline operation data. It displays the elements of an individual operation. The operation to be displayed is selected by the OPSEQ routine and passed to DSPOD via the calling arguments. (See Figure 4-6.)

#### 4.6 DSPPD

This routine displays the mine and dragline parameters on the CRT display to facilitate editing from the terminal. It is called by the UPSET routine. (See Figure 4-7.)

#### 4.7 DSPSQ

This routine is associated with the manipulation of the dragline operation data. It displays and prints the sequence of operations. It is called by the OPSEQ routine. The argument IDP specifies whether the operation sequence is to be printed or displayed on the CRT. The argument KTAB specifies the location of the display on the CRT. (See Figure 4-8.)

#### 4.8 DSRC

This is the main routine for controlling the source of the simulation input data types. It displays the data types and requests the source of input data. Data can be input from either the CRT terminal, a new data file or an active data file. (See Figure 4-9.)

#### 4.9 DSSAC

This routine is associated with the manipulation of the dragline operation data. It displays the allowable operation activities. It is called by the OPSEQ routine only when the CRT terminal is active. (See Figure 4-10.)

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	80

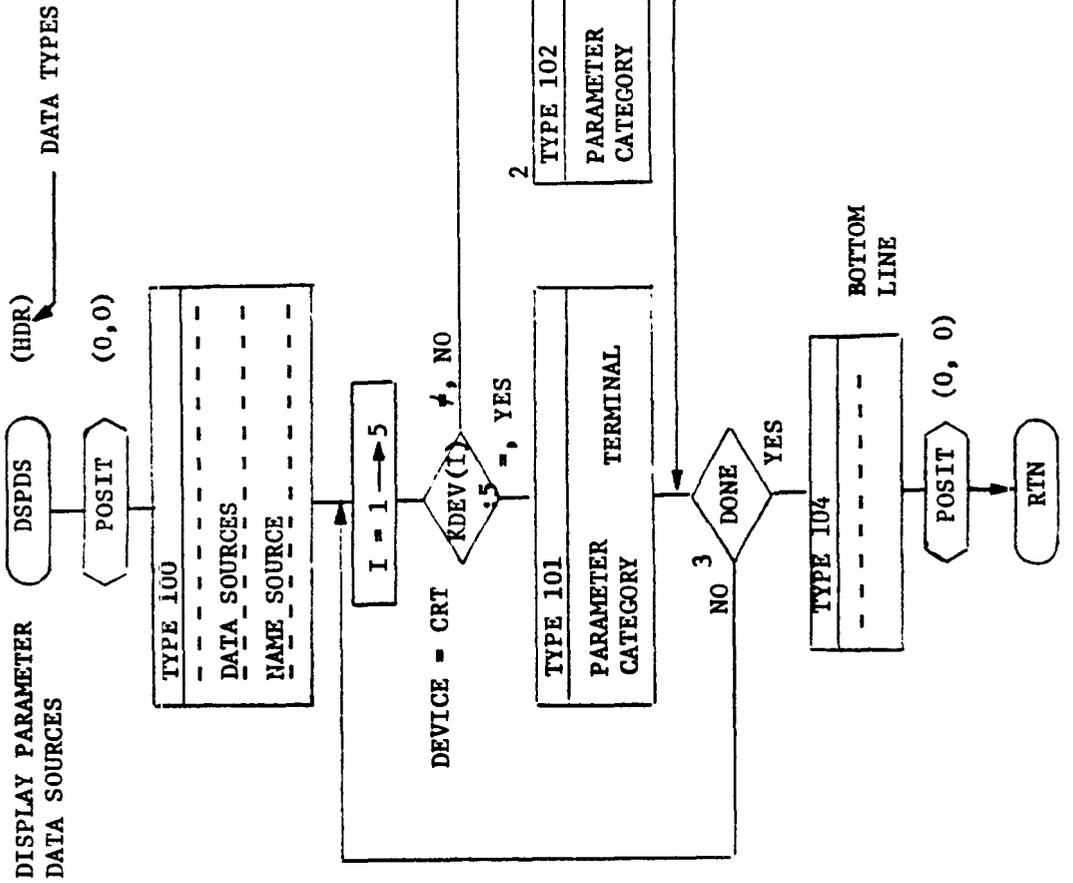


Figure 4-5. DSPDS Routine Flow Chart

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	81



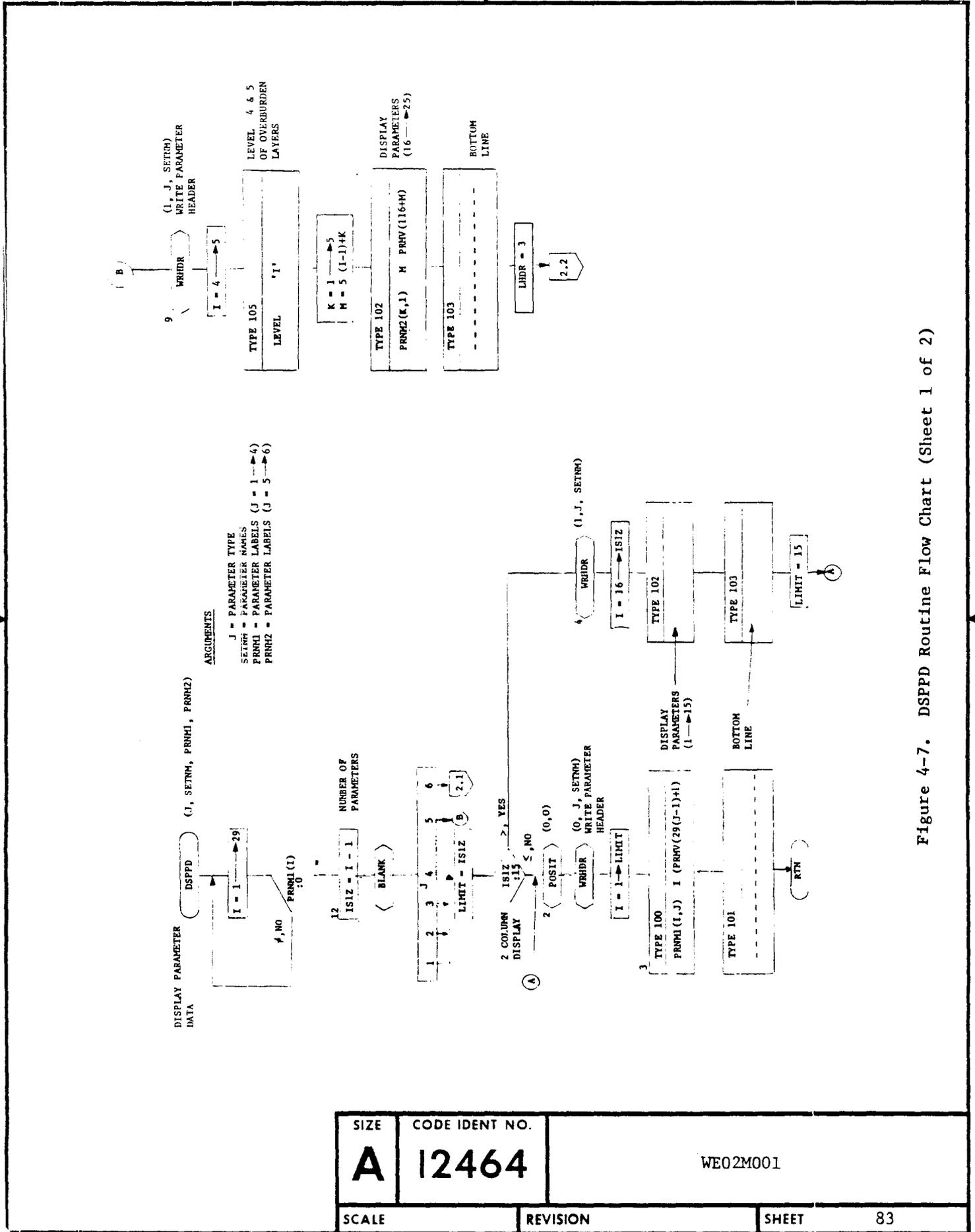


Figure 4-7. DSPPD Routine Flow Chart (Sheet 1 of 2)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WEO2M001	
SCALE	REVISION	SHEET	83

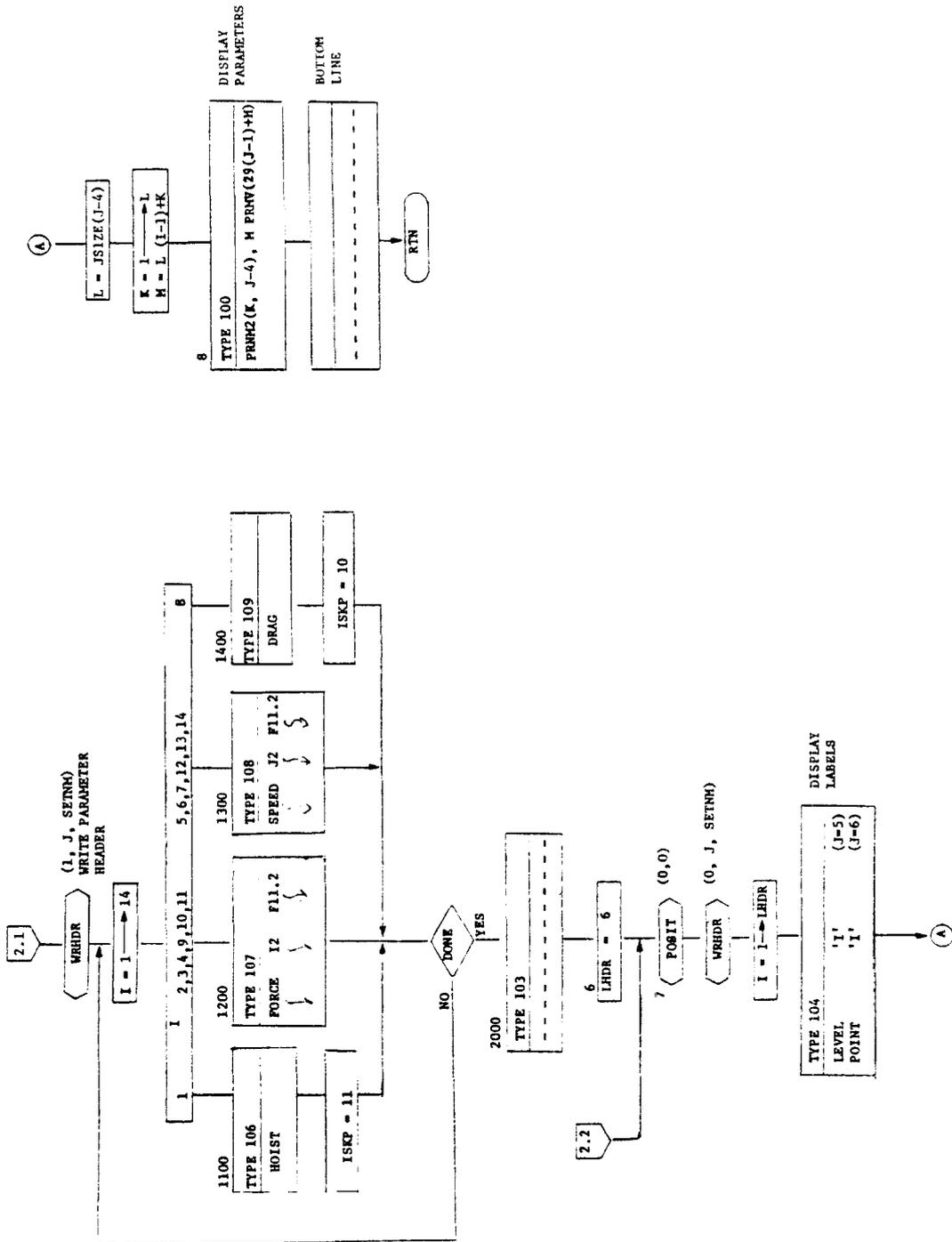


Figure 4-7. DSPPD Routine Flow Chart (Sheet 2)

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	84

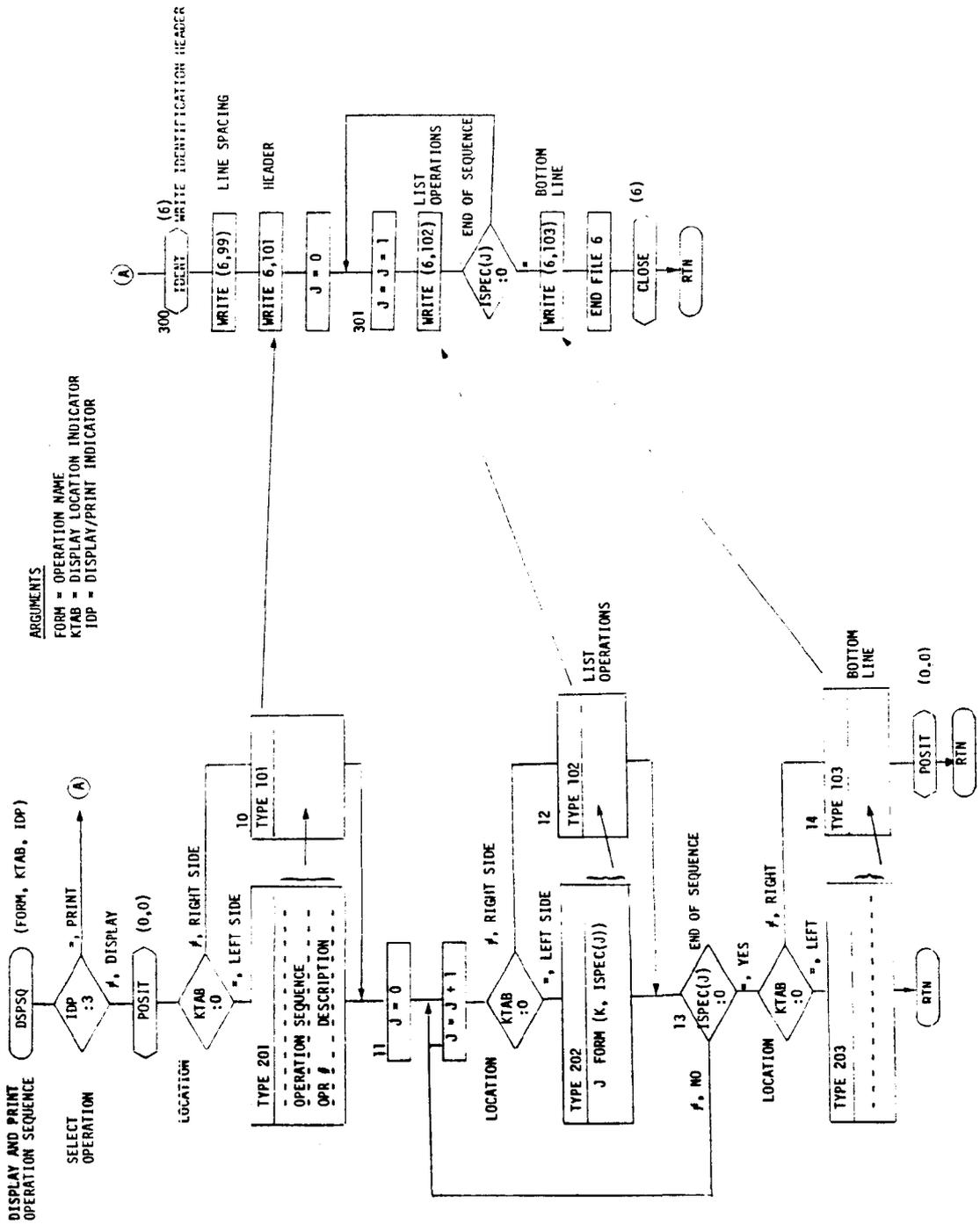


Figure 4-8. DSFSQ Routine Flow Chart

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	85

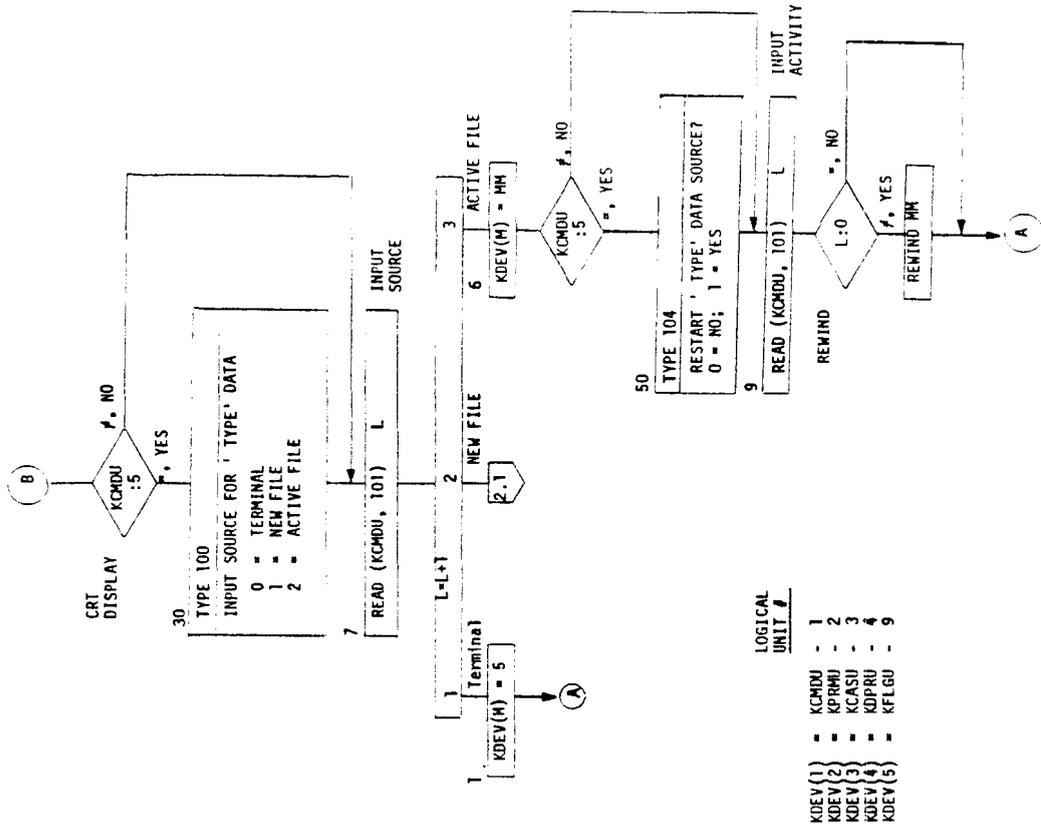
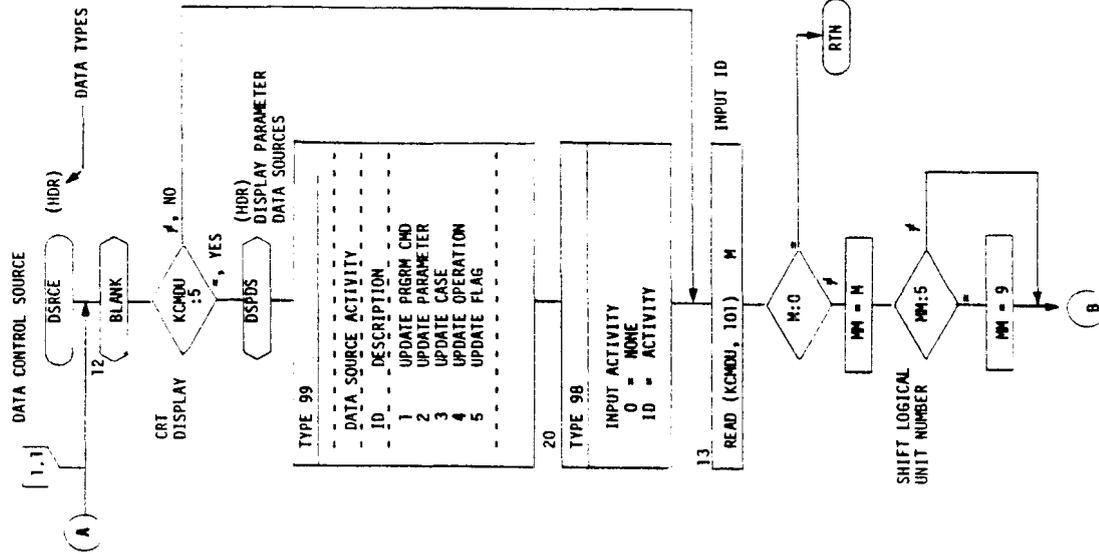


Figure 4-9. DSRCE Routine Flow Chart (Sheet 1 of 2)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	86

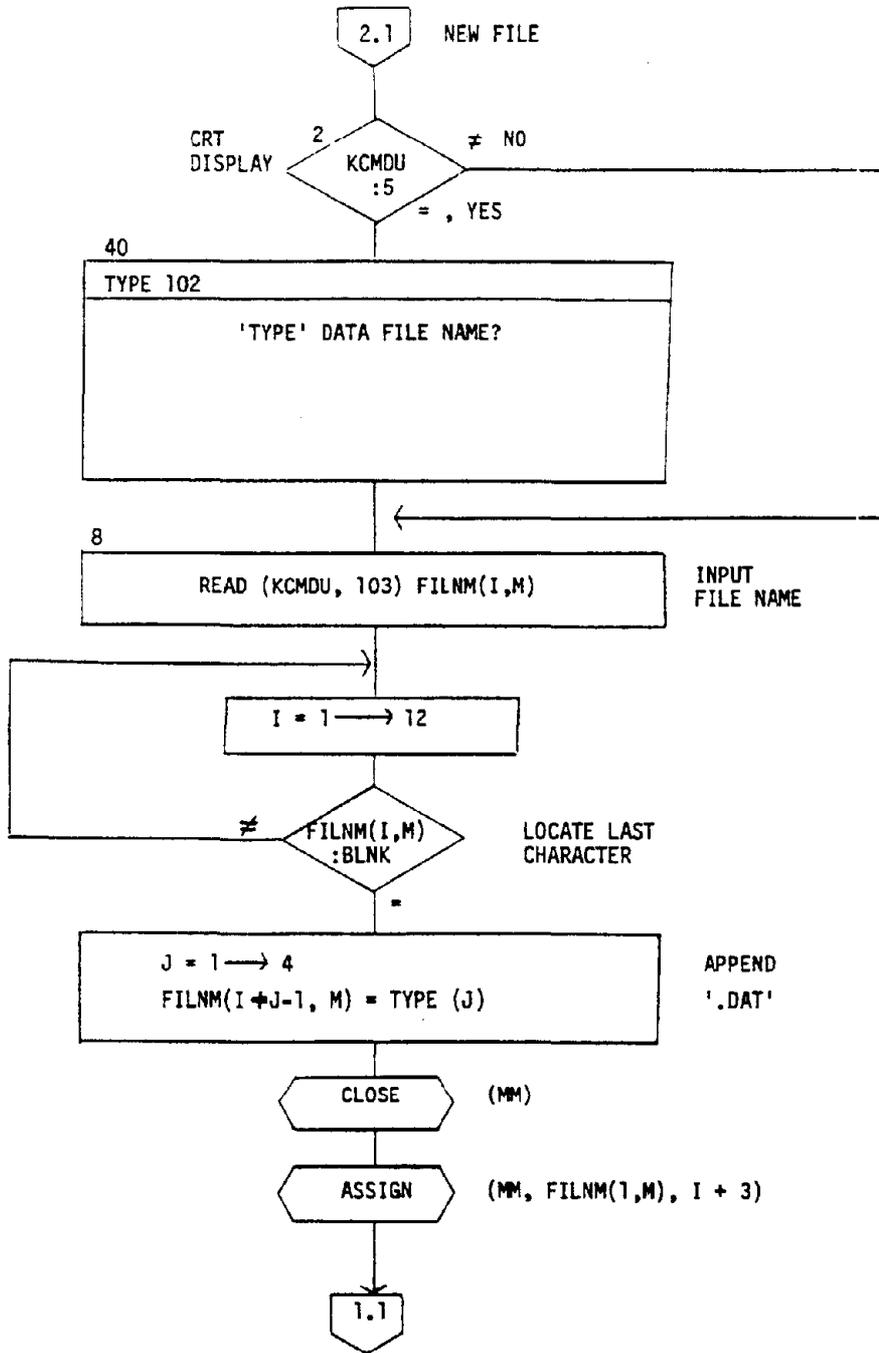


Figure 4-9. DSRCE Routine Flow Chart (Sheet 2)

SIZE	CODE IDENT NO.	WEO2M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	87

DISPLAY OPERATION  
SEQUENCE ACTIVITY

DSSAC

```

TYPE 100
-----
OPERATION SEQUENCE ACTIVITY
ID_ ACTIVITY_ID_ OBJECT
1 SEQUENCE
2 OPR DATA
  
```

POSIT (5,0)

```

TYPE 101
1 CHANGE
2 DISPLAY
3 PRINT
  
```

RTN

Figure 4-10. DSSAC Routine Flow Chart

#### 4.10 IDENT

This routine writes the simulation run identification header in the upper right hand corner of the CRT display and/or page of the listing. The header consists of Date, Time and Name of the simulation run. (See Figure 4-11.)

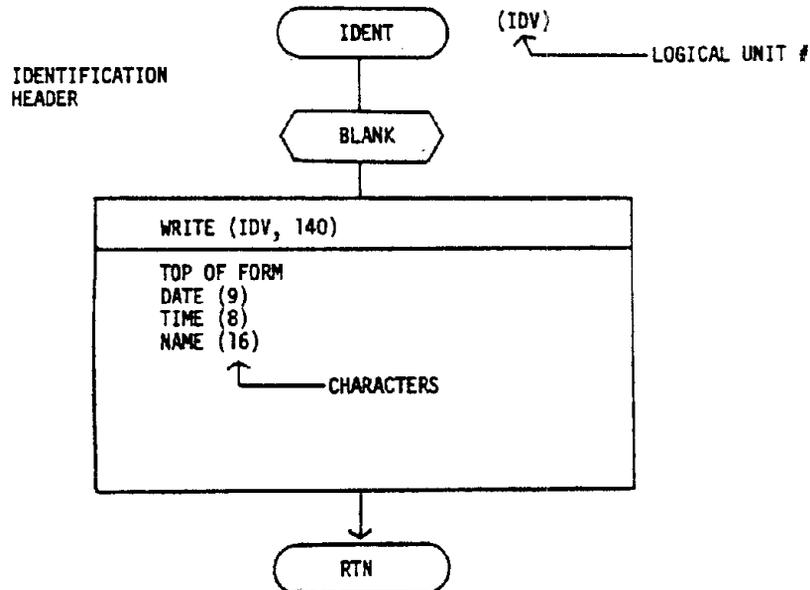


Figure 4-11. IDENT Routine Flow Chart

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	88

4.11 OPDFM

This routine is associated with the manipulation of the dragline operation data. It performs page formatting to list the operation data on the line printer. It is called by the PROPD routine. It formats one line of operation data (20 characters) each time it is called. (See Figure 4-12.)

4.12 OPDUP

This routine is associated with the manipulation of the dragline operation data. It controls the input and/or editing of operation data. It is called by the OPSEQ routine. (See Figure 4-13.)

4.13. OPSEQ

This is the main routine for controlling the manipulation of the dragline operation sequences and data. It requests what type of activity (Change, Display or Print) is to be performed and at what level (Sequence or Operation). It then calls the appropriate routines.

Data can be input from either the CRT terminal or a previously prepared data file. (See Figure 4-14.)

4.14 POSIT

This routine positions the cursor of the CRT display. It controls the location of the information displayed on the CRT. (See Figure 4-15.)

4.15 PRNPD

This routine is associated with the manipulation of parameter data. It prints the mine and dragline parameters on the line printer. Each line of parameter data is formatted and placed in the A(5,6) array for printing. It is called by the UPSET routine. (See Figure 4-16.)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE		REVISION	SHEET 89



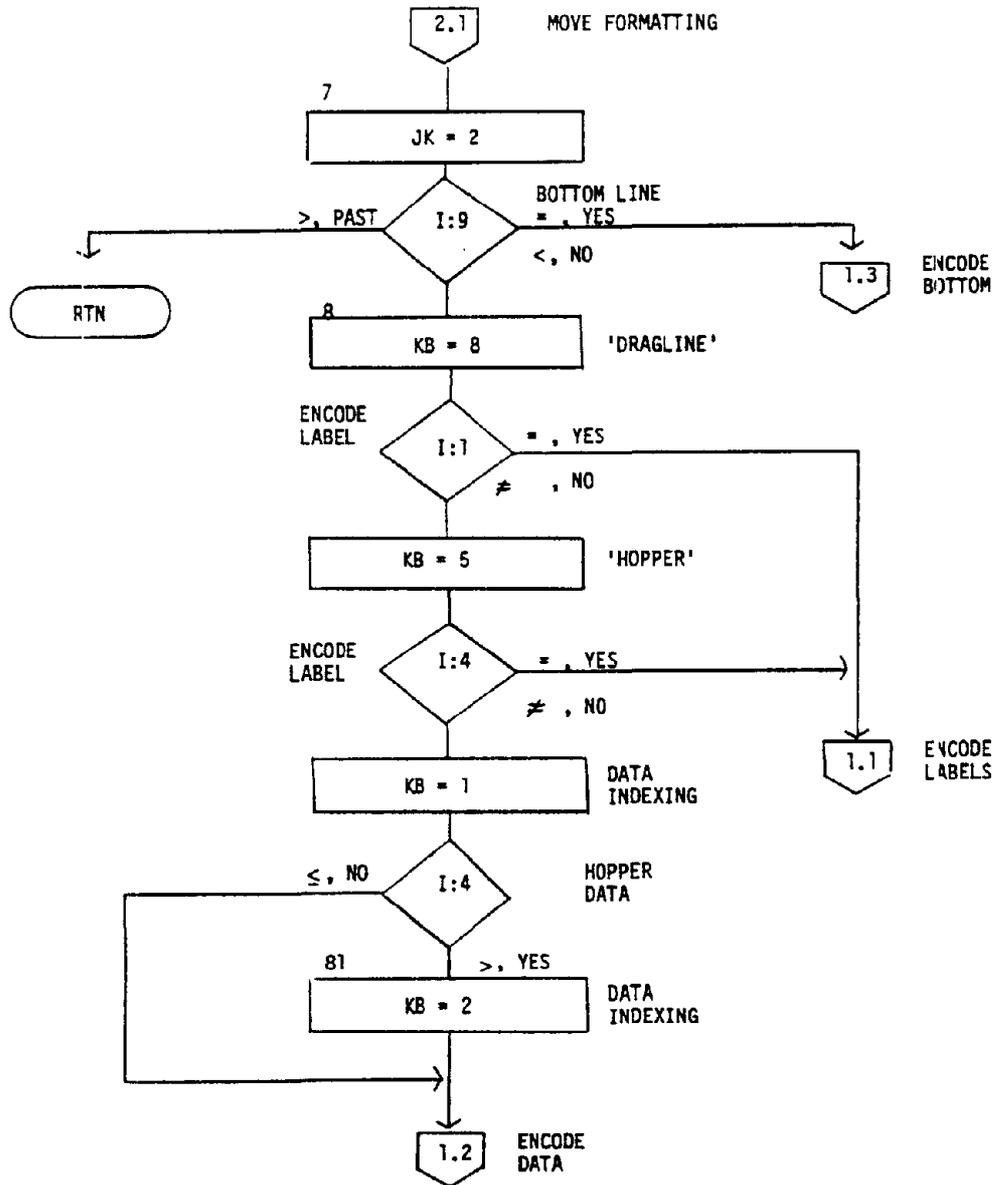


Figure 4-12. OPDFM Routine Flow Chart (Sheet 2)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	91

ARGUMENTS  
 K = OPERATION NUMBER  
 FORM = OPERATION NAMES  
 DPRNM = OPERATION ELEMENT NAMES

OPERATION DATA UPDATE (K, FORM, DPRNM)

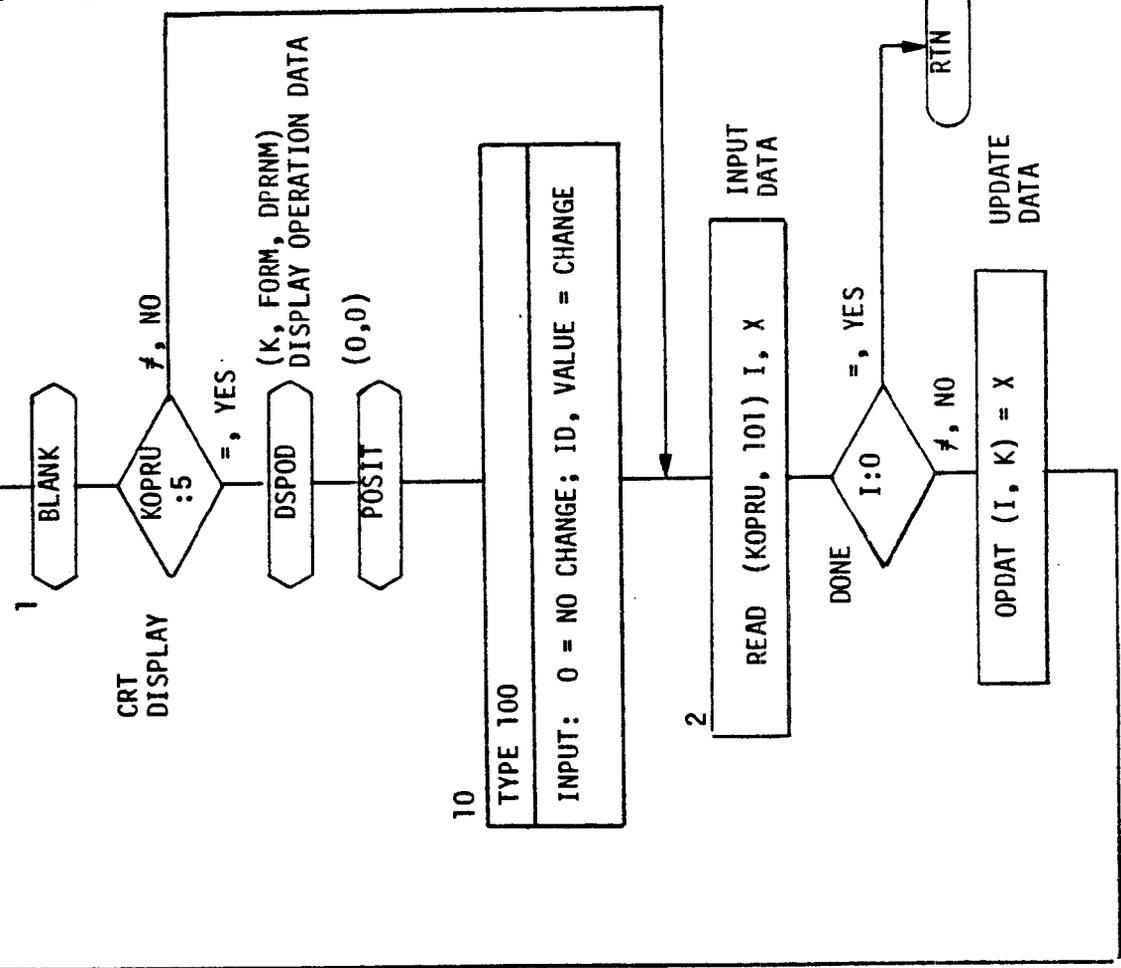


Figure 4-13. OPDUP Routine Flow Chart

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	92

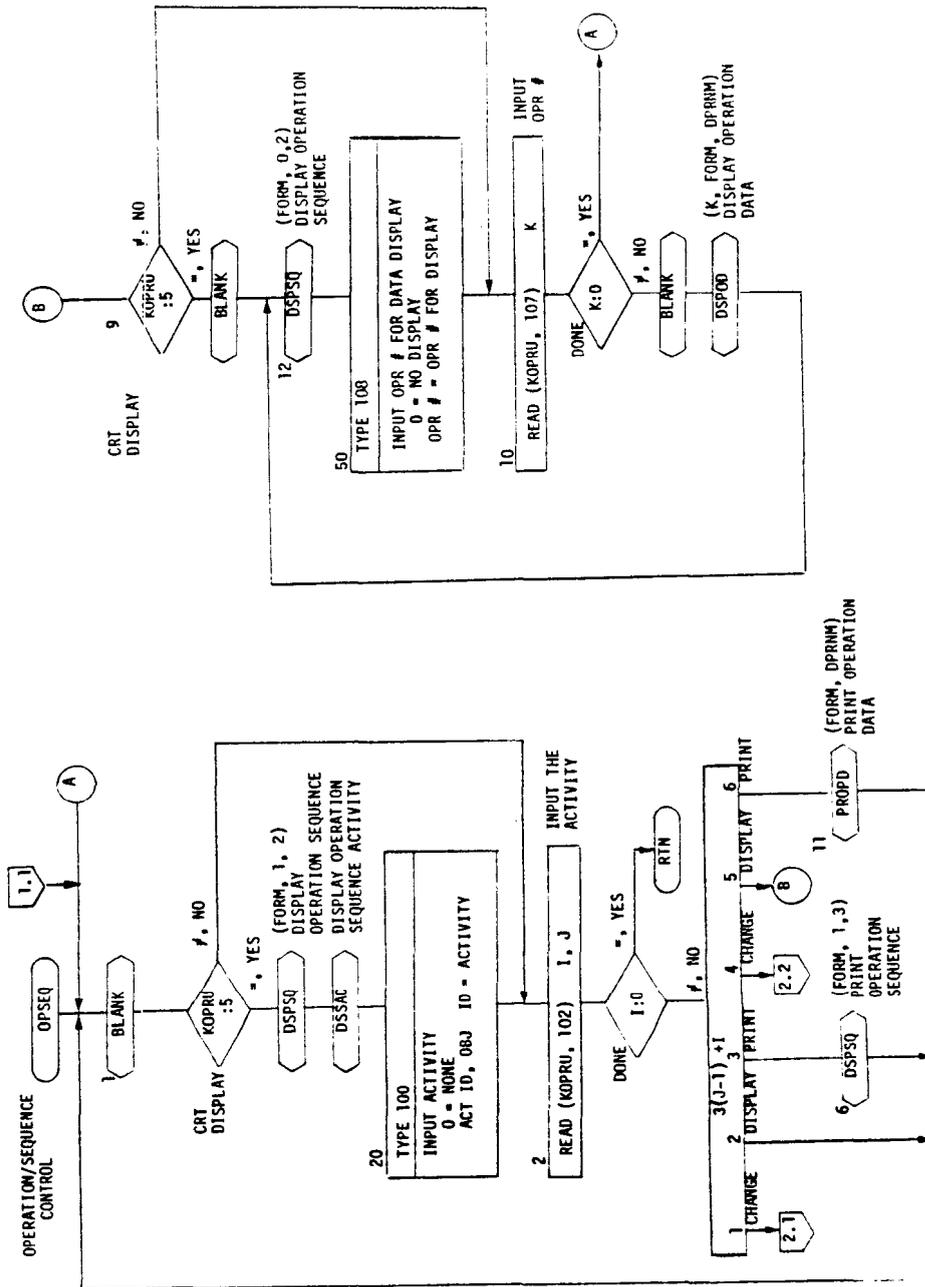


Figure 4-14. OPSEQ Routine Flow Chart (Sheet 1 of 2)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	93

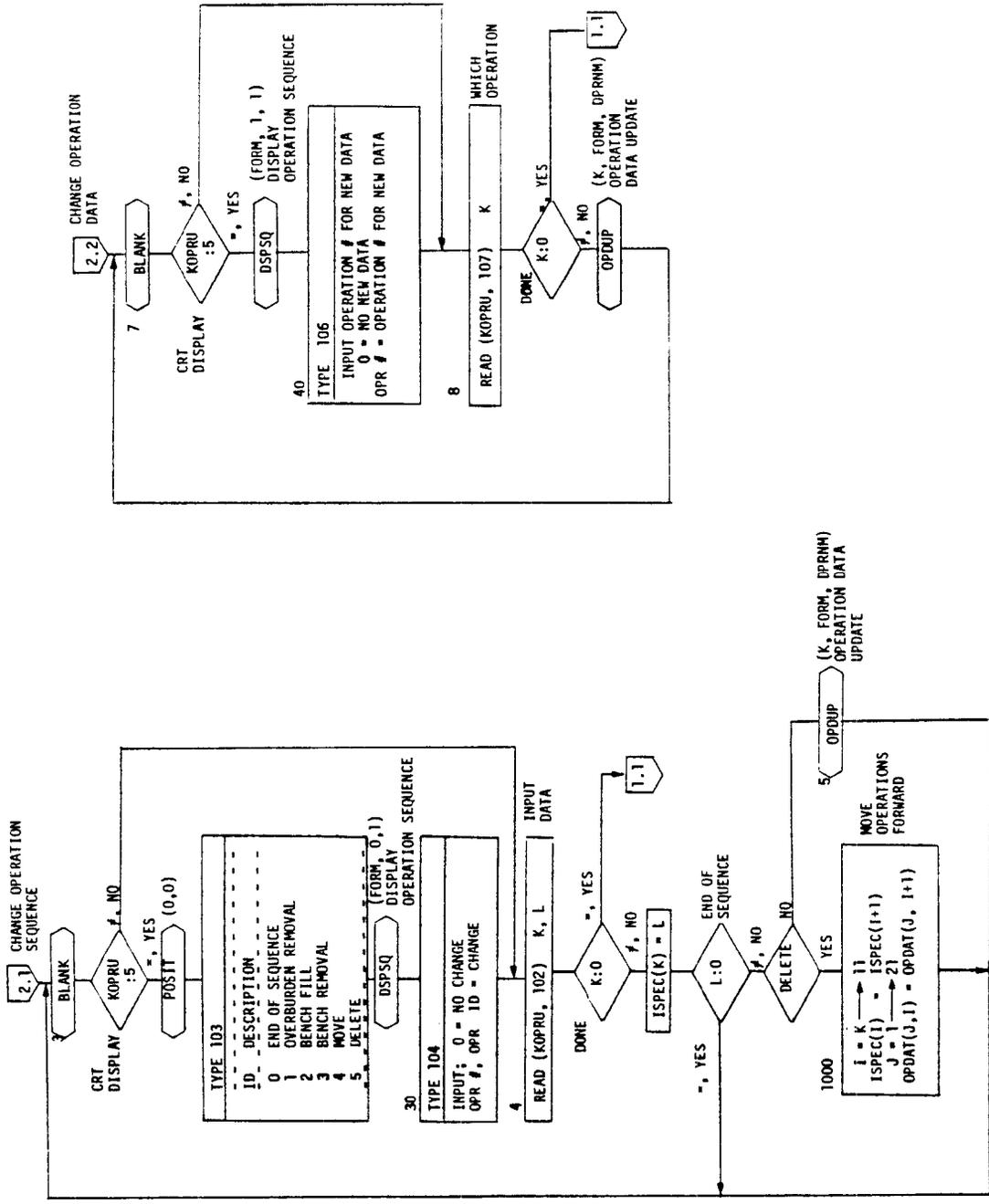


Figure 4-14. OPSEQ Routine Flow Chart (Sheet 2)

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001
SCALE	REVISION	SHEET 94

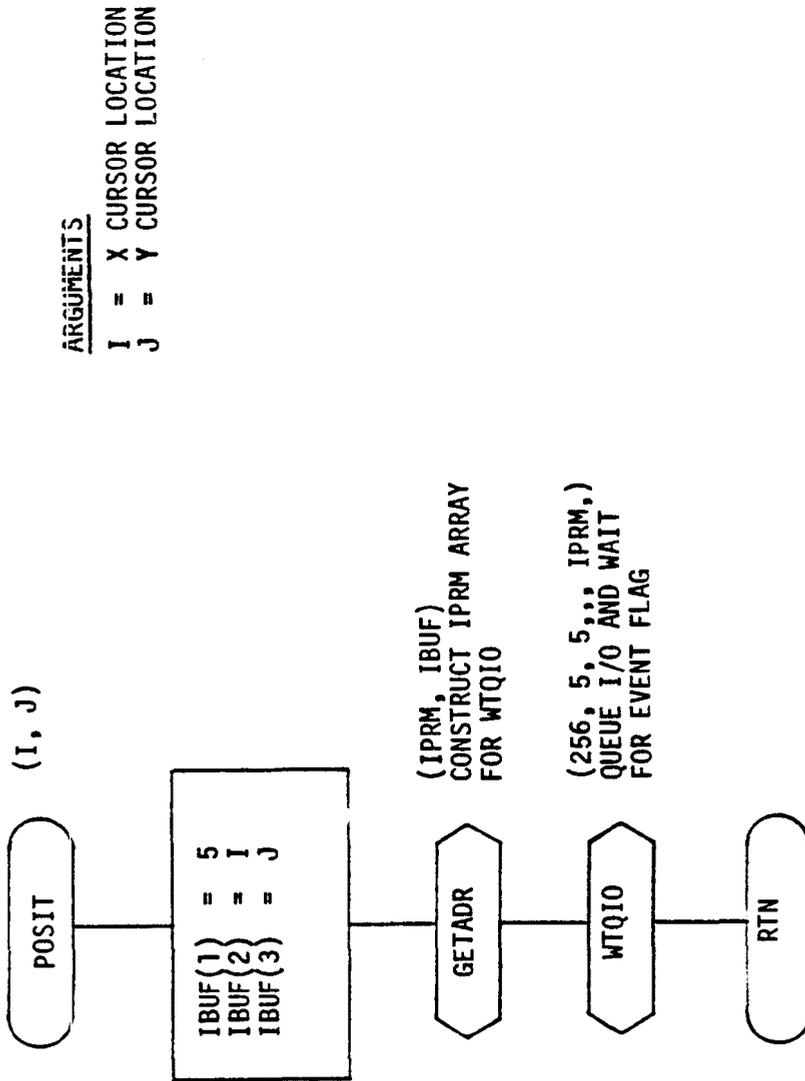


Figure 4-15. POSIT Routine Flow Chart

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	95



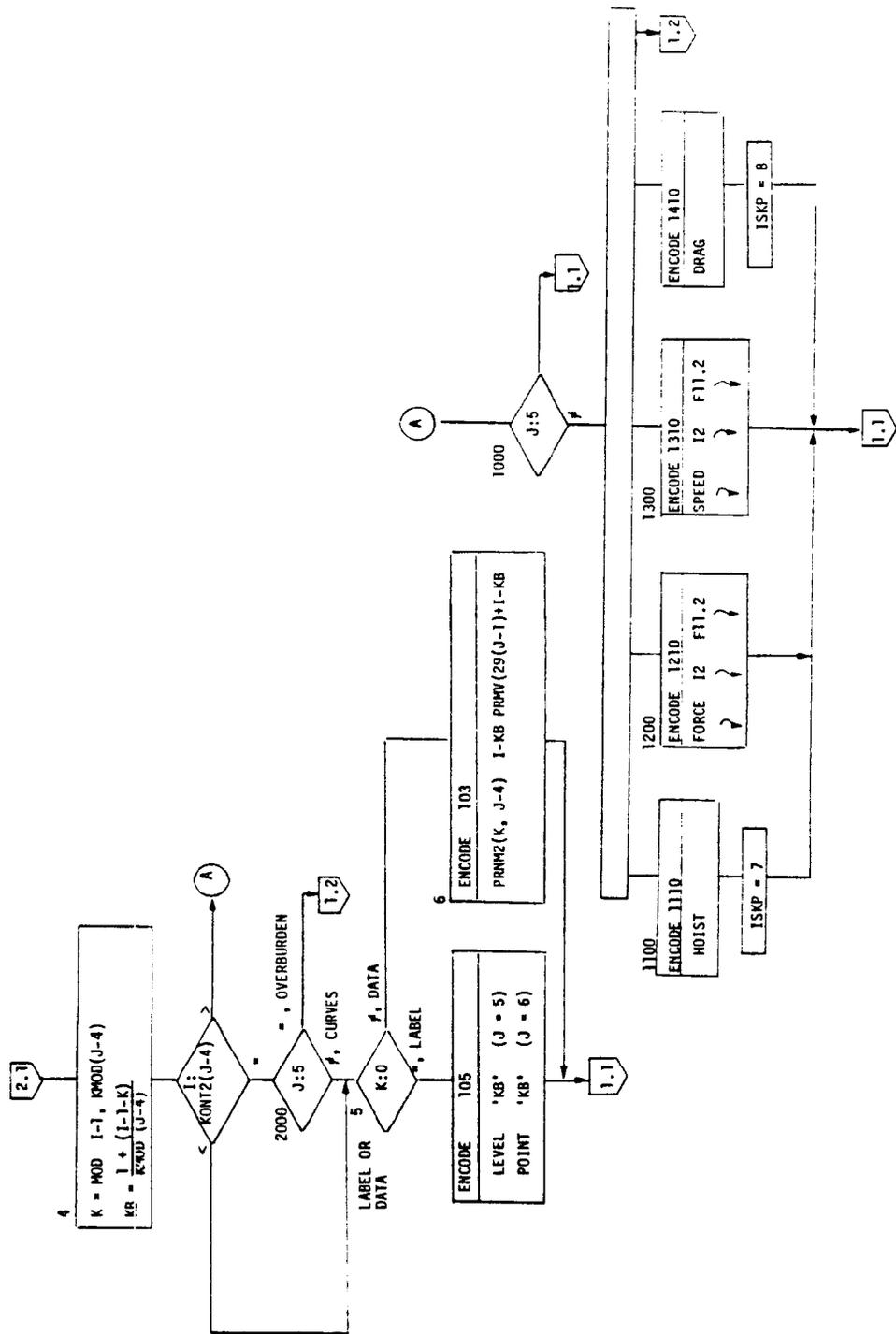


Figure 4-16. PRNPD Routine Flow Chart (Sheet 2)

SIZE	CODE IDENT NO.	WE02M001
<b>A</b>	<b>12464</b>	
SCALE	REVISION	SHEET 97

4.16 PROPD

This routine is associated with the manipulation of the dragline operation data. It prints the operation data on the line printer. A maximum of six operations can be printed on a page. Each line of the page is formatted, stored in the A (5,6) array and printed. It is called by the OPSEQ routine. (See Figure 4-17.)

4.17 UPCASE

This is the main routine for controlling the manipulation of the case parameters. It requests the type of activity (Change, Display or Print) that is to be performed and then performs the activity.

Data can be input from either the CRT terminal or a previously prepared data file. (See Figure 4-18.)

4.18 UPFLG

This is the main routine for controlling the manipulation of the program flags. It requests what type of activity (Change, Display or Print) that is to be performed and then performs the activity.

Data can be input from either the CRT terminal or a previously prepared data file. (See Figure 4-19.)

4.19 UPSET

This is the main routine for controlling the manipulation of the mine and dragline parameters. It requests what type of activity (Change, Display or Print) is to be performed and which parameter category is to be manipulated. The parameter categories are:

- o Mine and Hopper
- o Dragline Specification
- o Dragline Performance
- o Bucket
- o Overburden
- o Curves

Data can be input from either the CRT terminal or a previously prepared data file. (See Figure 4-20.)

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
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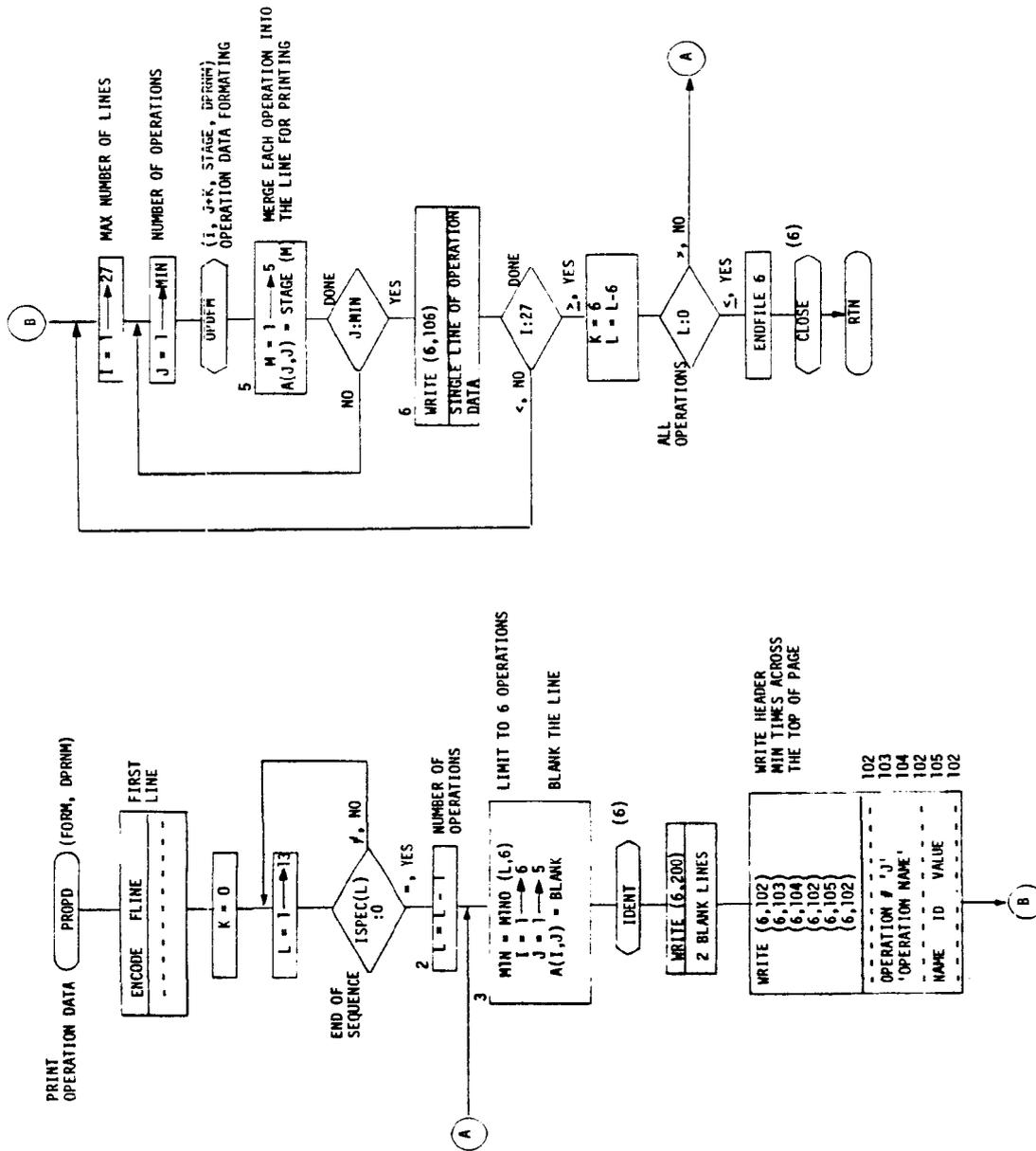


Figure 4-17. PROPD Routine Flow Chart

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	99

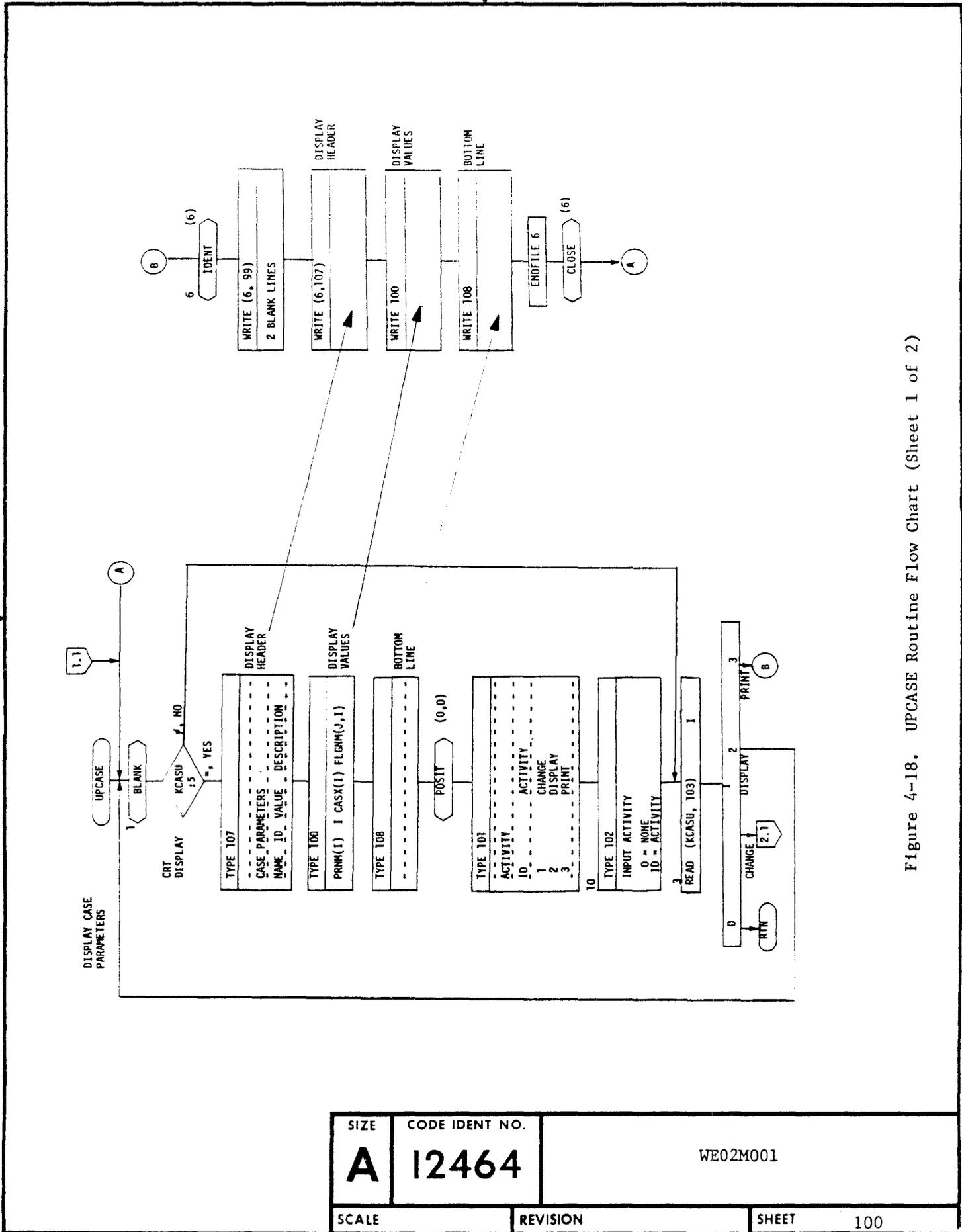


Figure 4-18. UPCASE Routine Flow Chart (Sheet 1 of 2)

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	100

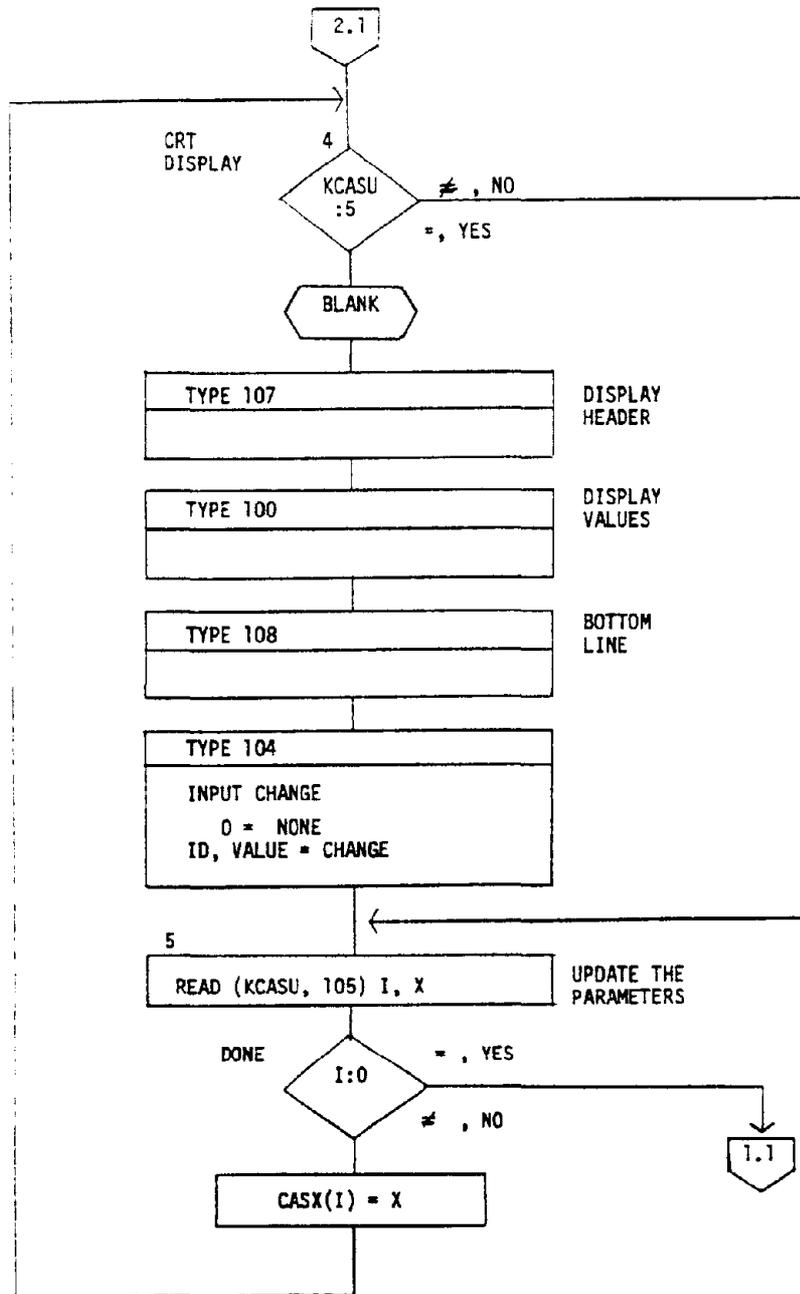
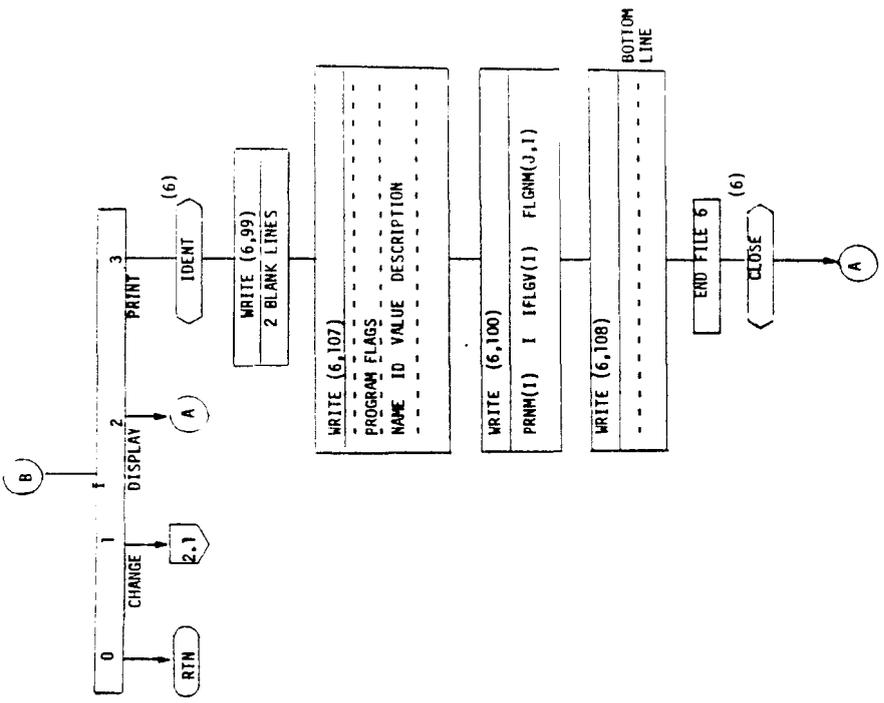
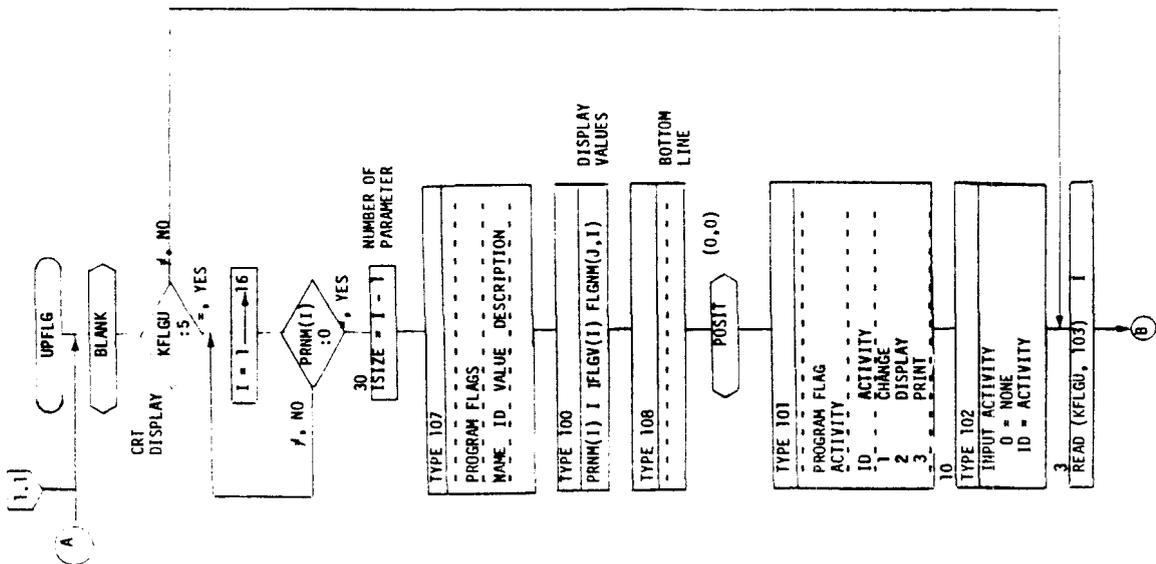


Figure 4-18. UPCASE Routine Flow Chart (Sheet 2)

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	101



SIZE	CODE IDENT NO.	WE02M001
<b>A</b>	<b>12464</b>	
SCALE	REVISION	SHEET 102

Figure 4-19. UPFLG Routine Flow Chart (Sheet 1 of 2)

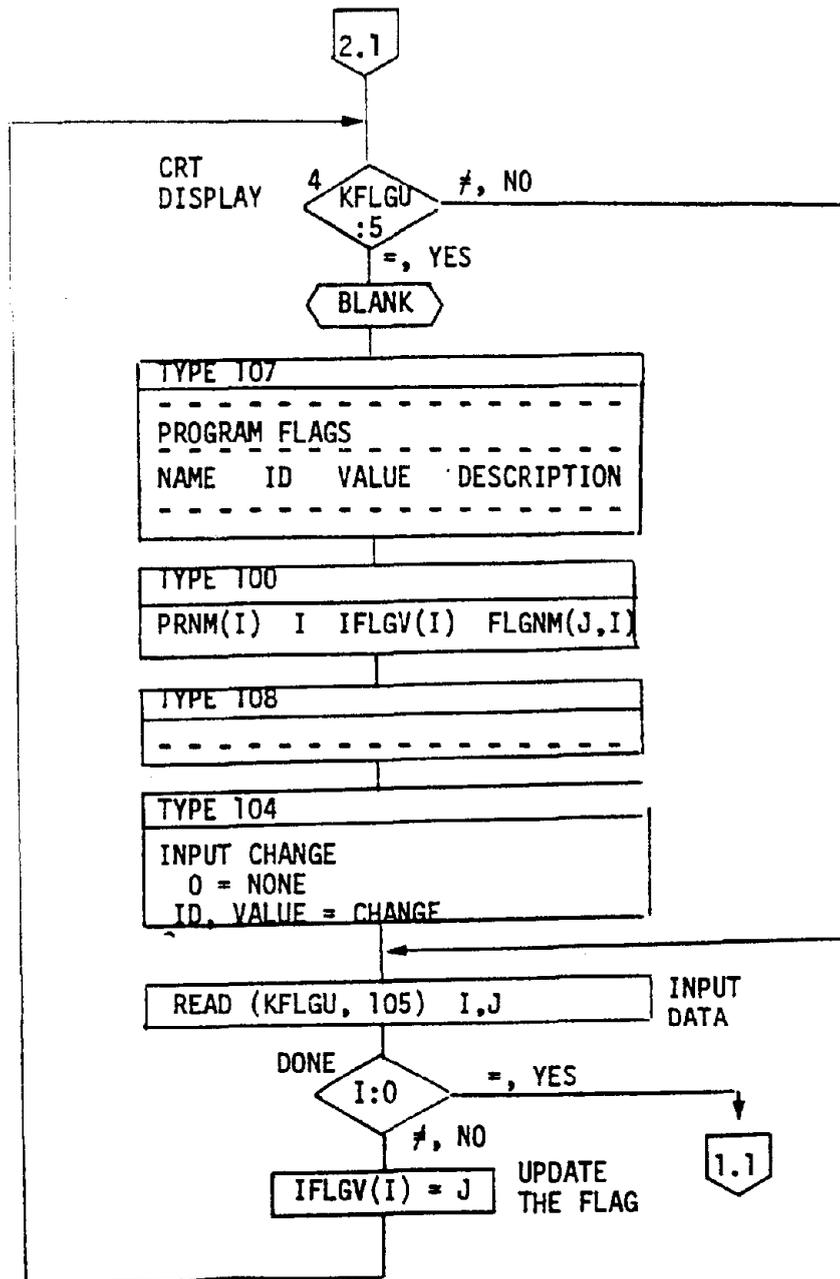


FIGURE 4-19 . UPFLG ROUTINE FLOW CHART (Sheet 2)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>		
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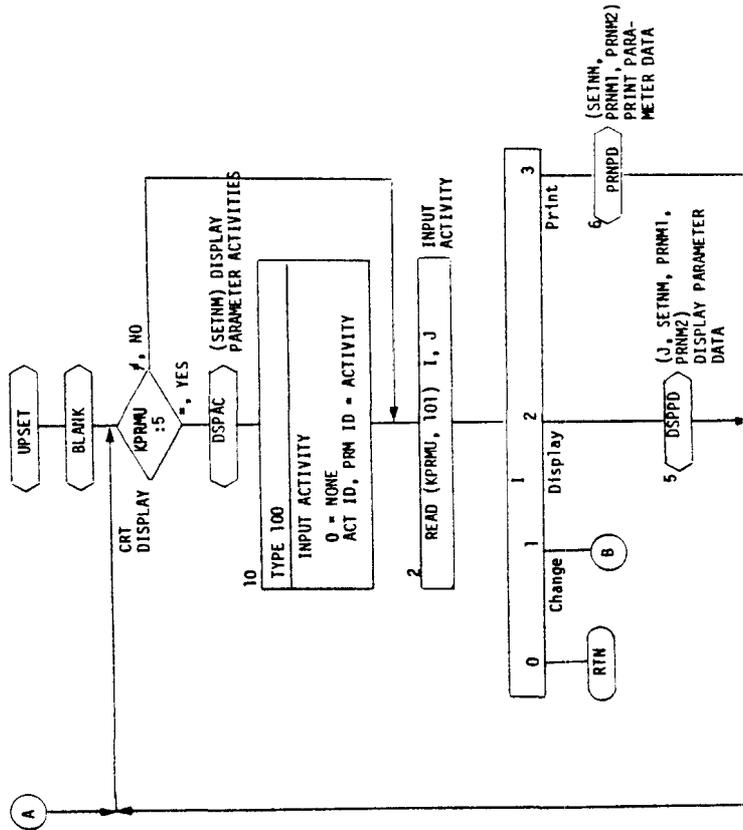
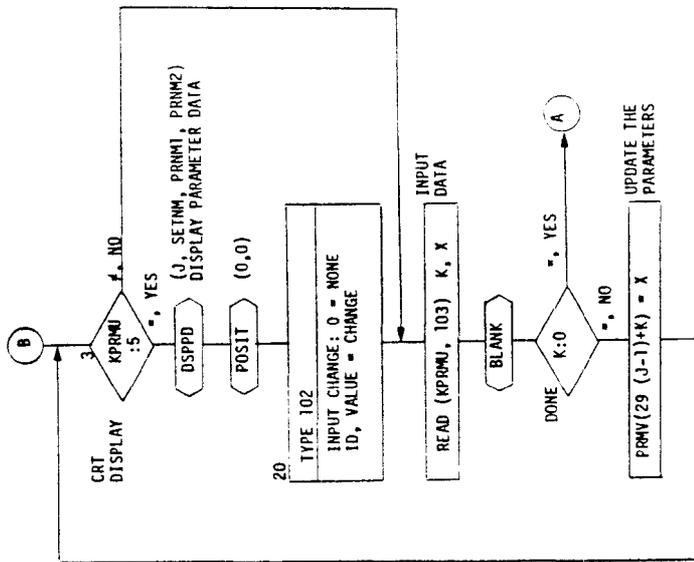


Figure 4-20. UPSET Routine Flow Chart

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	104

4.20 WRHDR

This routine is associated with the changing and displaying of the mine and dragline parameters. It displays the parameter identification header above the column of parameter data. It is called by the PSPPD routine. (See Figure 4-21.)

ARGUMENTS

I = LOCATION CONTROL  
 J = PARAMETER TYPE  
 SETNM = PARAMETER NAMES

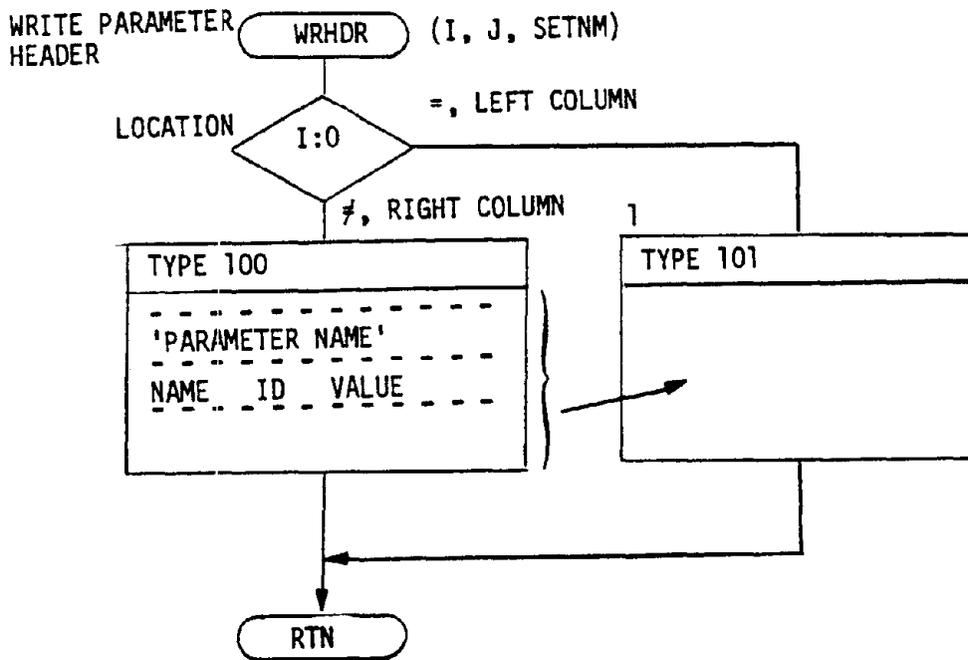


Figure 4-21. WRHDR Routine Flow Chart

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	105



## 5. DRAGLINE PROGRAMS

This section describes the individual dragline simulation routines. Written descriptions, flow charts and lists of internal symbols may be used to describe each routine.

Common block symbols used by the routines are identified in Appendix B.

### 5.1 AHOP

The AHOP routine is called if a hopper is to be simulated in the current operation. AHOP calculates the center coordinates of the hopper, the angle the hopper length makes with the X-axis and the angle limits that determine where the bucket is to be positioned for dumping into the hopper. The flow chart and symbol table are given in Figures 5-1 and 5-2.

The hopper center coordinates (HPCX and HPCY) are inputs. One of these coordinates is input as a negative number and the other as a positive number. The negative coordinate serves as a cue for AHOP to compute that coordinate using the positive input, the dragline position and the dragline's reach. The angle the hopper length makes with the X-axis is also an input. If this input is positive, the hopper is placed at this position. If the angle input is negative, the AHOP routine computes that angle which positions the hopper length perpendicular to the dragline boom.

The coordinates of the hopper's corners are also computed by the AHOP routine. This information is used to define the physical limits of the hopper to avoid hitting it with the bucket and to compute the angle limits that determine the hopper opening. The angle at which the dump can be initiated is determined by intersecting the circle centered at the dragline position with radius equal to the carry radius and the hopper sides. There will actually be two angles; one for a left-handed approach and one for a right-handed approach. Similarly, two angles are computed to determine by when the dump should be completed. The radius used to compute these angles is the operating radius rather than the carry radius. Thus, the initial angle indicates when the

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SYMBOL	UNITS	DESCRIPTION
A	FT <sup>2</sup>	Variable Used in Calculation of Dump Angles
AL	RAD	Variable Used in Calculation of Dump Angles
AR	RAD	Variable Used in Calculation of Dump Angles
B	FT <sup>2</sup>	Variable Used in Calculation of Dump Angles
BA	FEET	Variable Used in Calculation of Hopper Corners
C	FT <sup>2</sup>	Variable Used in Calculation of Dump Angles
D1		Dummy Variable Used in a Subroutine Call
D2		Dummy Variable Used in a Subroutine Call
HANG	RAD	Hopper Angle to Center of Hopper
HANGL	RAD	Left Hopper Angle
HANGR	RAD	Right Hopper Angle
HAR	RAD	Right Dump Angle
HRAD	RAD	Variable Used in Calculation of Minimum Distance Between Hopper and Dragline
HXI		Variable Used in Calculation of Hopper Dump Angles
HYI		Variable Used in Calculation of Hopper Dump Angles
KFLG		Flag Used in Triggering Diagnostic Printout
NHIN		Flag Used in Calculation of Hopper Dump Angle
R	FEET	Variable Used in Calculation of Hopper Angle
RANG	RAD	The Angle the Hopper Center Makes with the Dragline Boom
RR	FEET	Variable Used in Calculation of Dragline Position
S		Variable Used in Calculation of Hopper Dump Angle
U		Variable Used in Calculation of Hopper Dump Angle
V		Variable Used in Calculation of Hopper Dump Angle
W		Variable Used in Calculation of Hopper Dump Angle
HT		Array Used in Calculation of Hopper Dump Angle
X		Array Used in Calculation of Hopper Dump Angle

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Figure 5-2. AHOP Symbol Table (Sheet 1 of 2)



drag should begin to pay out and the final angle indicates the limit pass which the bucket should not be swung while dumping.

### 5.2 AOBR

This routine displays and prints the totals and averages for each stripping operation. At the completion of a simulation run it displays the sequence or case totals and averages. If no cycles were taken, the routine exits without displaying anything.

The averages are calculated first and then the totals and averages are displayed. A swing angle histogram is displayed when the results of an individual operation are being displayed. (See Figures 5-3 and 5-4.)

### 5.3 BCORD

This routine generates a bucket path from the current bucket position to the end coordinate specified by the calling arguments. It searches the overburden area and spoil pile for possible obstructions and modifies the bucket path to clear any obstructions. A series of bucket path coordinates are generated to move the bucket from the dig to spoil positions and vice versa. The bucket path is a smooth trajectory, selected so the hoist, drag and swing motions arrive at the end coordinate simultaneously. For the following discussions, refer to the flow charts in Figures 5-5 and 5-6.

During normal overburden removal cycles, the dragline will swing clockwise to the dump position and counterclockwise back to the dig position. There are several simulation options that can modify this normal procedure:

- o Take the shortest swing angle.
- o Make a 360 degree swing.
- o Hoist above all obstructions.

When the shortest swing angle option (KSHT#0) is selected, the dragline swing angle is compared to 180 degrees. If it is greater than 180 degrees, the dragline will swing in the opposite direction, taking the shortest swing angle.

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AOBR (TT, A)

DIMENSION COMMON EQUIVALENCE

T(1) = 20  
T(2) = T(2)

ANY CYCLES TAKEN  
CYCLES = 10  
# YES

CALCULATE AVERAGES

SEC = CO./CYCN  
A(1) = VOBR/TOBR\*60.  
A(2) = A(1)/BC  
A(3) = VOBR/CYCN  
A(4) = SOBR/SWGN  
A(5) = TSWT/WSGN\*60  
A(6) = TLOT\*SEC  
A(7) = TPT\*SEC  
A(8) = TMLT\*SEC  
A(9) = (TOBR - PT)\*SEC  
A(10) = TLP/CYCN  
A(11) = TPC/CYCN  
A(12) = (EOBR - ME)/CYCN  
A(13) = 0.  
A(14) = 0.

ANY 2ND LOADING PASSES  
SPCT = 10  
# YES

A(15) = TPT/SPCT\*60

A(16) = A(9)\*EBC/(A(9)+A(15))

DISPLAY TOTALS AND AVERAGES

WRITE (8) A(1), CYCN, A(1), VOBR  
A(2), PT, A(3), TSWT, A(4), TLOT, A(5)  
TPT, A(6), TMLT, A(7), TOBR, A(8)  
PE, TLP, A(10), TPC, A(11), EOBR, A(12)  
MELN, A(13), SPCT, TPT, A(14), A(15)

ANY REMAINDER VOLUME  
VOLR = 0.0, WH  
# YES

WRITE (3) VOLR

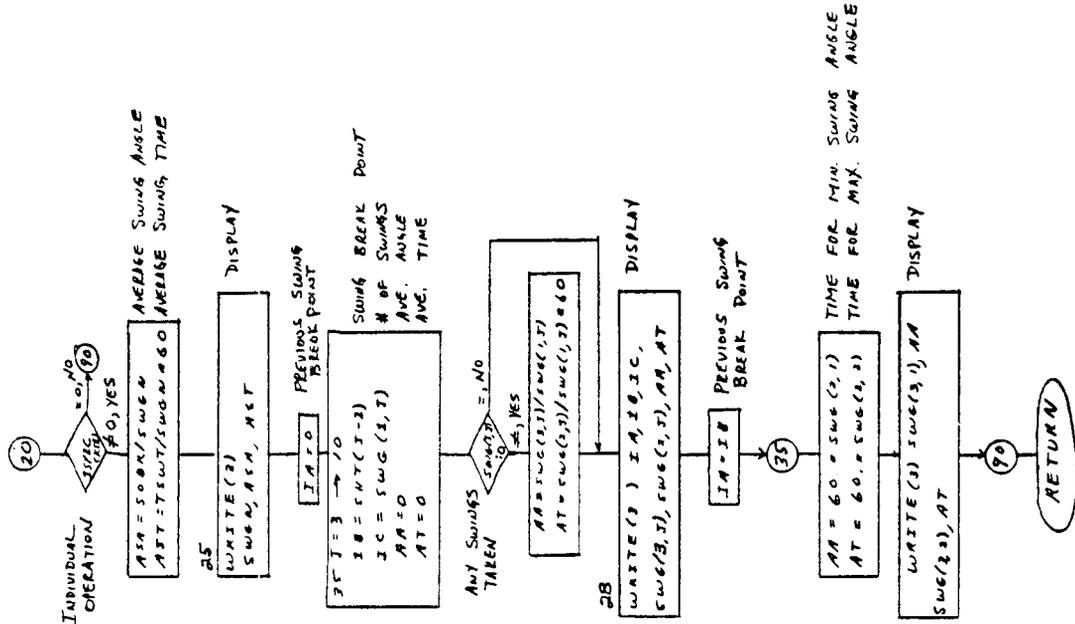


Figure 5-3. AOBR Routine Flow Chart

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	111

SYMBOL	UNITS	DESCRIPTION
AA	DEG	Average Swing Angle for Histogram
ASA	DEG	Total Average Swing Angle
AST	SEC	Total Average Swing Time
AT	SEC	Average Swing Time for Histogram
CYCN		Number of Cycles
EOBR	KW-HR	Total Energy
HELN		Total Number of Heels
IA	DEG	Previous Swing Angle Breakpoint
IB	DEG	Swing Angle Breakpoint
IC		Number of Swings
PE	KW-HR	Initial Positioning Energy
PT	MIN	Initial Positioning Time
SHT(8)	DEG	Swing Angle Histogram Breakpoints
SOBR	DEG	Total Swing Angle
SPCT		Total Number of Second Bucket Loading Passes
SMGN		Total Number of Swings
T(20)		Dummy Array for Equivalences
TDPT	MIN	Total Dump Time
THLT	MIN	Total Heel Time
TLDT	MIN	Total Loading Time
TLP	KW-HR	Total Loading Energy
TOBR	MIN	Total Time
TPC	KW-HR	Total Transit Energy
TSPT	MIN	Total Second Bucket Loading Pass Time
TSWT	MIN	Total Swing Time
VOBR	BYDS	Total Overburden Moved
VOLR	EYDS	Total Rehandle Yards Moved

Figure 5-4. AOBR Symbol Table

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	112



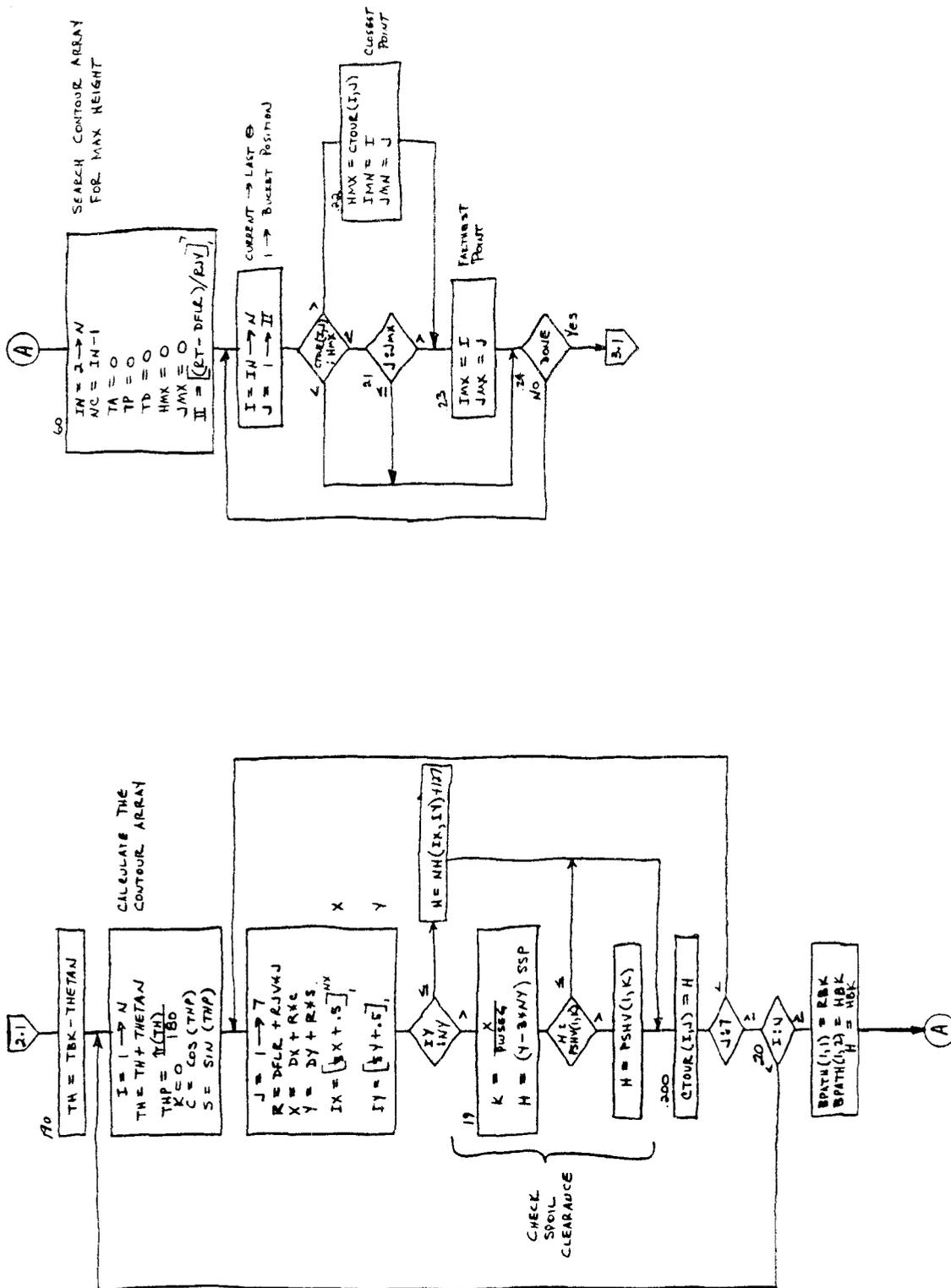
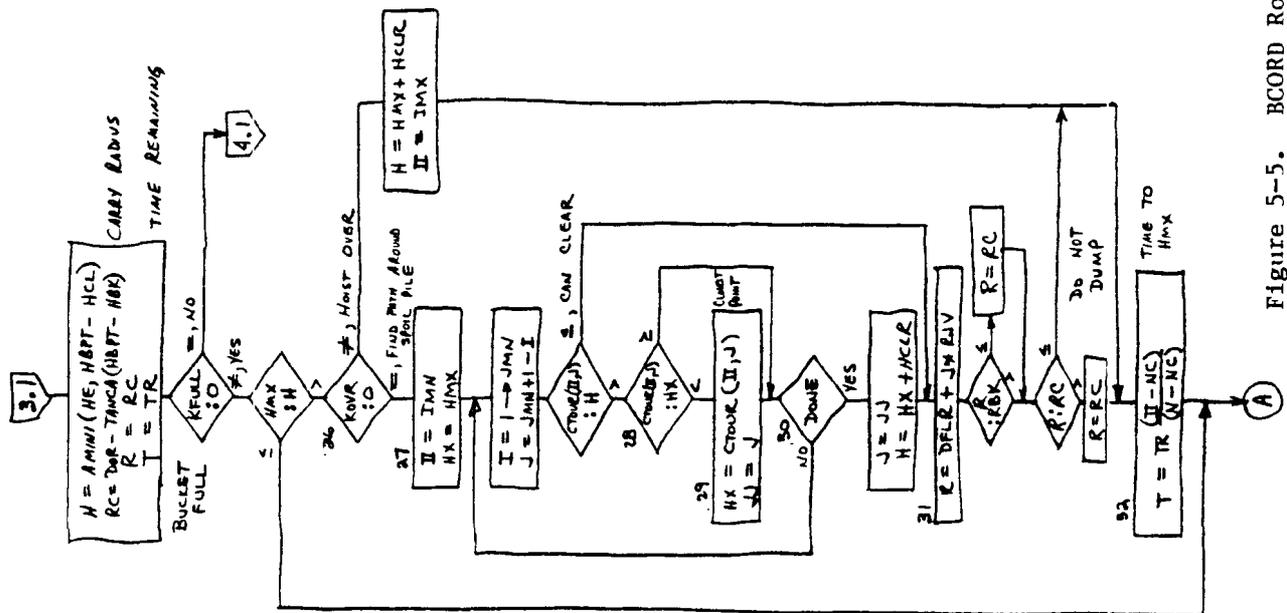
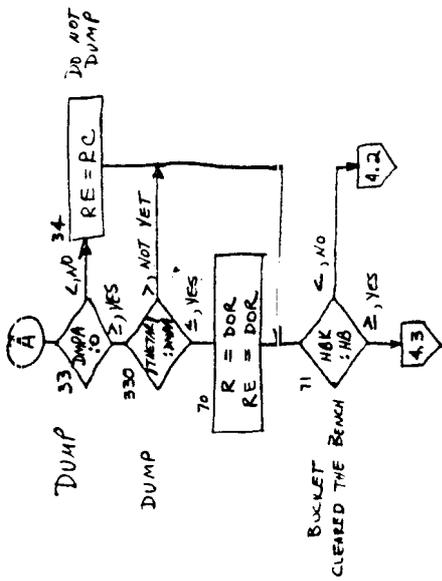
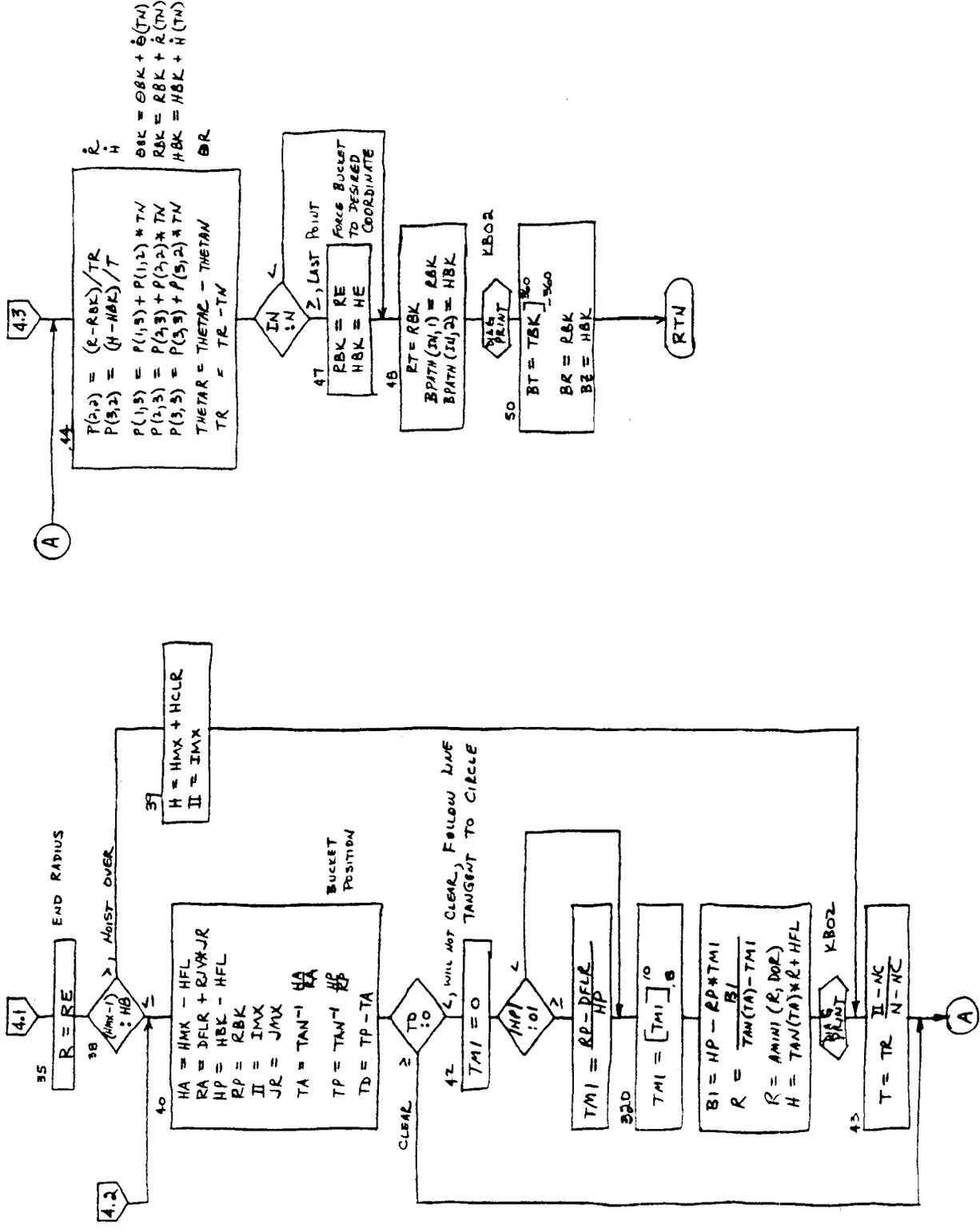


Figure 5-5. BCORD Routine Flow Chart (Sheet 2)

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	114





SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	116

Figure 5-5. BCORD Routine Flow Chart (Sheet 4)

SYMBOL	UNITS	DESCRIPTION
C		Cosine of Contour Array Angle
CTOUR (36,7)		Contour Array CTOUR (N,J) N = Number of Radial Spoke J = Radial Distance Along Spoke
DMPA	DEG	DUMP Angle -1 = Do not Dump, Bucket Limited to Carry Radius 0 = Fast Payout to Dump (Bench Fill) $\theta$ = Begin Dump when remaining Angle < $\theta$
H	FEET	TMPR Height Variable
HA	FEET	Obstruction Height Relative to the Fairlead + = Obstruction Higher than Fairlead
HBK	FEET	Bucket Height
HBPT	FEET	Height of Boom Point
HE	FEET	Height of End Point
IMX	FEET	Maximum Height to be Cleared
HP	FEET	Bucket Height Relative to the Fairlead + = Bucket above Fairlead
HX	FEET	TMPR Height Variable
II		Index for Radial Distance
IMN		Index for Closest Radial Spoke Obstruction
IMX		Index for Furthest Radial Spoke Obstruction
IN		Index for Contour Array Search
IX	YARDS	X Index for Height Array
IY	YARDS	Y Index for Height Array
JJ		TMPR Variable
JMN		Index for Closest Radial Distance Obstruction
JMX		Index for Furthest Radial Distance Obstruction

Figure 5-6. BCORD Symbol Table (Sheet 1 of 3)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WEO2M001	
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SYMBOL	UNITS	DESCRIPTION
JR		Index for Radial Distance Obstruction
K		Index for Spoil Segment
KDGD		Direction of Dig Flag, + = CCW
KDOS		Direction of Spoil Flag, + = Advancing Spoil Pile
KOVR		Hoist Over all Obstructions Flag
KSHT		Take the Shortest Swing Angle Flag
K360		Make a 360° Swing when $\theta > SX360$
N		Number of Radial Spokes
NC		Number of Radial Spokes Remaining
P (3,3)		Position Array, P (I,J)
		I = 1, Swing Angle
		I = 2, Bucket Radius
		I = 3, Bucket Height
		J = 1, Desired Position
		J = 2, Velocity
		J = 3, Current Position
R	FEET	TMPR Radius Variable
RA	FEET	Obstruction Radius
RBK	FEET	Bucket Radius
RC	FEET	Carry Radius
RE	FEET	Bucket Radius of End Point
RONE		Sign Multiplier
RP	FEET	Bucket Radius
RT	FEET	Initial Bucket Radius
S		Sine of Contour Array Angle
SGNTD		Sign of Swing Angle
T	SEC	Time to End Point

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	118

Figure 5-6. BCORD Symbol Table (Sheet 2)



When the 360 degree swing option (K360#0) is selected, the dragline will swing 360 degrees if it will reduce the cycle time. A critical swing angle (SX360) is calculated from the dragline swing performance. When the swing angle to the dump position exceeds this critical angle a 360 degree swing will be made with the dragline dumping on the fly.

When the hoist over all obstructions option (KOV#0) is selected the bucket will be hoisted above all obstructions. When the dragline is positioned close to the spoil pile, as in the bench removal position, the spoil pile may interfere with the normal bucket path. The hoist over option will raise the bucket higher to clear the spoil pile. If not selected, the bucket will be held closer to the dragline to miss the spoil pile. When returning to the dig position, the bucket must hoist over all obstructions.

Once the swing direction has been determined, the swing angle is calculated and the theoretical swing time is calculated from the dragline swing performance data. The area between the initial and final bucket positions is searched and an array of heights (contour array) is created. The contour array is searched to find the highest obstruction.

The dragline bucket must be carried inside the operating radius to prevent the overburden from falling out. This radial distance is calculated and will be referred to as the carry radius (RC). Beyond this radius the bucket is assumed to dump. When swinging to the dump position the bucket is not allowed to exceed the carry radius until the remaining swing angle is less than the dump angle (DMPA).

The bucket path coordinates (BPATH) generated by BCORD will be passed to the TPWR routine which will calculate the mass dynamics required to move the bucket along the path.

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<b>A</b>	<b>12464</b>	WE02M001	
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#### 5.4 BFILL

The BFILL routine calculates the dump coordinates for bench fill operations and processes the overburden array to insure proper distribution of the dumped material.

On the reset pass, the BFILL routine sets up the sequencing of the fill operation. The inputs from the operation file are the angle limits BFLA and BFRA, the fill height FLHT, and the direction of fill DOF. The routine sets up a loop that increments the dump coordinates from the outer radius to the inner dumping radius and in the direction prescribed by the DOF flag. This means the outer rim would be filled first and would progress inward toward the dragline. The increment in the radial direction is one bucket length. The angular increment is that angle corresponding to one bucket width of arc length at the given radius.

The routine computes the average height of the material in a square centered about the proposed dump coordinates. The dimensions of the square are equal to the average of the length and width of the bucket. It then compares this with the desired fill height. Material is dumped at this coordinate until the proper average height is attained. The routine will function the same regardless of whether the material is smoothed by bucket heeling. Slightly more material will be dumped into a region if bucket heeling is done.

The material is distributed over a set region as it is dumped. One third of the material is dumped a half of a bucket length before (along the bucket radius) the dump coordinate. One-half of the material is dumped at the dump coordinate. One sixth of the material is dumped one-half bucket length behind the dump coordinate. The actual spreading of the material is done by the subroutine SPREAD.

Note that if the BHEEL flag is set (FLET is negative), the routine BFILL will trigger the bucket heeling by setting the flag ICS = -1 if the average height is equal to or greater than the fill limit. The flow chart and symbol table are contained in Figures 5-7 and 5-8.

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
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SYMBOL	UNITS	DESCRIPTION
A	FEET	Average Height of Overburden
D		Dummy Variable for Subroutine RHTA
DAL	Radians	Left Angle Limit for Fill
DAR	Radians	Right Angle Limit for Fill
DT		Parameter Increment for Spreading Dumped Material
DTH	Radians	Angle Increment for Fill
DTHC	Radians	Angle of Fill
H	FEET	Fill Height Passed to Subroutine Spread
I		Index
ICC		X - Grid Point for Dumping Material
ICX		X - Grid Point for Center of Fill
IR		X - Fill Coordinate
J		Index
JCC		Y - Grid Point for Dumping Material
JCY		Y - Grid Point for Center of Fill
M		Integer for determining Average Height
MI		X - Grid Point Limit for Height Calculation
MJ		Y - Grid Point Limit for Height Calculation
PIX		X - Coordinate Start Dump
P2X		X - Coordinate Finish Dump
PIY		Y - Coordinate Start Dump
P2Y		Y - Coordinate Finish Dump
R	FEET	Radius of Final Bucket Position
RCD	FEET	Radius of Dump Coordinate
RRTA	FEET	Height of Overburden
T		Parameter used in Spread Calculations
UI		X - Component along Bucket Radius

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	123

Figure 5-8. BFILL Symbol Table (Sheet 1 of 2)



### 5.5 BFL

This routine controls the bench fill procedure, removing the overburden and dumping it on the bench. For the following discussions, refer to the flow chart in Figure 5-9.

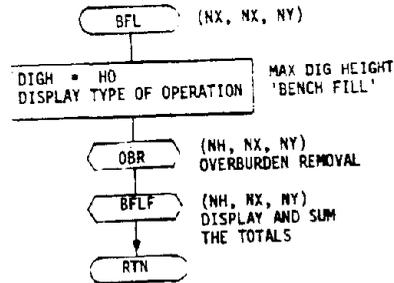


Figure 5-9. BFL Routine Flow Chart

The maximum dig height (DIGH) is limited to the total overburden height and the overburden removal routine (OBR) is called. OBR terminates when the bench area defined by the bench fill operation parameters has been filled to the specified height. The BFLF routine is then called to display the operation totals for this bench fill operation and to sum this operation with the total bench fill operations.

### 5.6 BFLF

This routine writes the current bench fill operation totals on the line printer and on the CRT terminal, when controlling the number of cycles to be removed. For the following discussions, refer to the flow chart in Figure 5-10.

The IDENT routine issues a top of form command and writes the identification header (date, time and file name). The operation number and type of operation are then written.

The current bench fill totals (OBRX) are passed to the AOBR routine where they are averaged and displayed.

The current operation totals are then summed with the total bench fill figures (TBFL).

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
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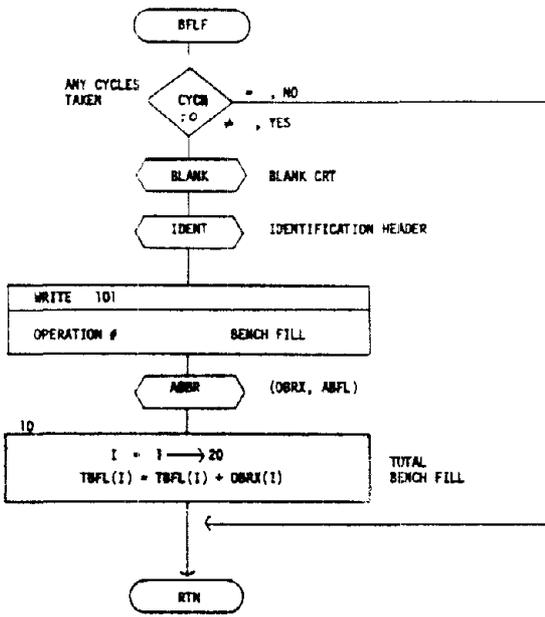


Figure 5-10. BFLF Routine Flow Chart

5.7 BHEEL

The routine BHEEL calculates the bucket path coordinates and distributes the material for bucket heeling during bench fill operations. (See Figures 5-11 and 5-12.)

Bucket heeling is triggered by BFILL. After dumping the bucket, if the average height in a neighborhood of the dump coordinate is equal to or greater than the desired fill height, a flag, ICS, is set as an indication to call BHEEL. In BHEEL, the initial coordinates (one bucket length toward the dragline cab from the dump coordinates) are computed. An iterative process is then set up that sweeps at the fill height from that point out toward the end of the boom. The width of this sweep is the width of the bucket rounded up to the nearest yard. The purpose of this sweep is to simulate the advance of the bucket heel. Each array coordinate encountered is compared to the fill height. If the material height is greater than the fill height, the material is removed (subtracted from the grid) and added to the carry volume that simulates the

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<b>A</b>	<b>12464</b>	WE02M001
SCALE	REVISION	SHEET 126

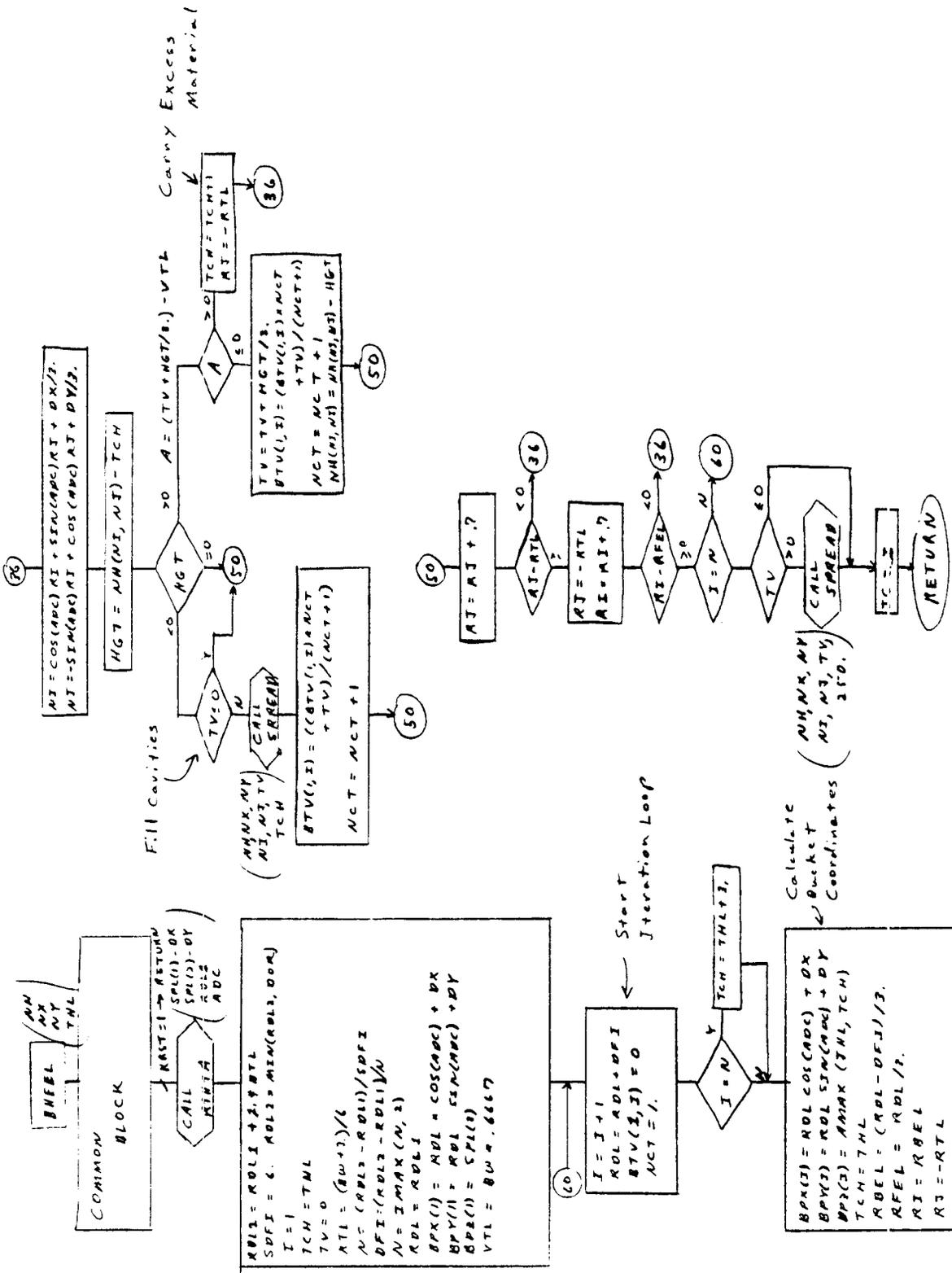


Figure 5-11. BHEEL Routine Flow Chart

SIZE	CODE IDENT NO.	WE02M001
<b>A</b>	<b>12464</b>	
SCALE	REVISION	SHEET
		127



material being pushed by the bucket heel. If the material height is less than the fill height, some material from the carry volume is used to fill this area. This is done by calling the subroutine SPREAD. If the carry volume is zero or insufficient to fill the "hole" it remains being filled by what volume was available. Similarly, if the material height is greater than the cut height but the carry volume is already at its maximum value, the height of the sweep is incremented by one foot. The process is then continued. At the completion of this iteration, the sweep height is reset to the fill height. The maximum carry volume is taken to be 2/3 times the bucket width in cubic yards.

The sweep continues for two bucket lengths from the initial coordinate. If the carry volume is zero at this time, the sweep is halted. If not, the sweep continues out the radius until the carry volume is zero or the bucket is under the boom sheeve. In the latter case, the carry volume is dispersed in the last iteration step.

As the sweep is done, the coordinates of the bucket path are computed. This is usually done every six feet modulo roundoff. These coordinates and the carry volume at each coordinate are then passed to BPWR for power computations.

### 5.8 BNR

This routine controls the normal bench removal procedure, removing the overburden and dumping either on the spoil pile or into a hopper. For the following discussions, refer to the flow chart in Figure 5-13.

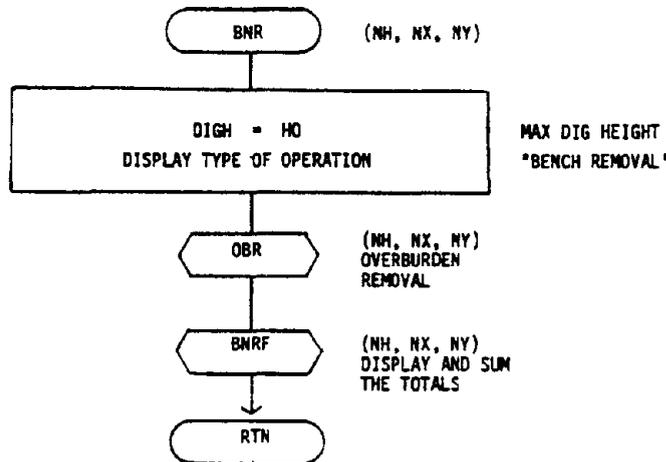


Figure 5-13. BNR Routines Flow Chart

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	129

The maximum dig height (DIGH) is limited to the total overburden height and the overburden removal routine (OBR) is called. When the bench has been removed, the BNRF routine is called to display the operation totals for this bench removal procedure and to sum this operation with the total bench removal operations.

### 5.9 BNRF

This routine writes the current bench removal operation totals on the line printer and on the CRT terminal, when controlling the number of cycles to be removed. For the following discussions, refer to the flow chart in Figure 5-14.

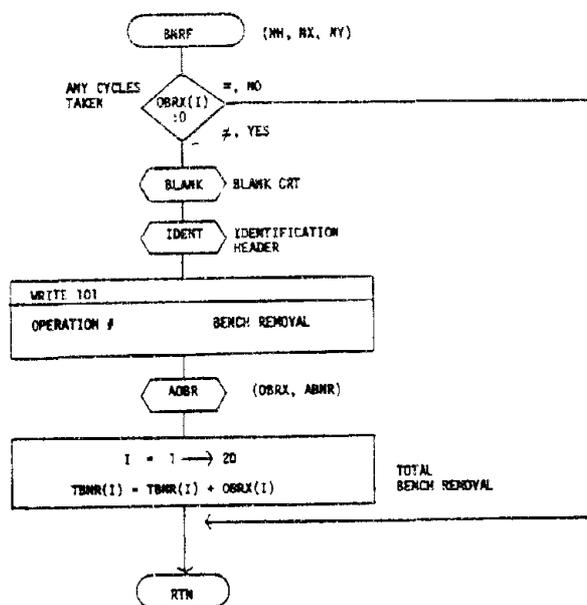


Figure 5-14. BNRF Routine Flow Chart

The IDENT routine issues a top of form command and writes the identification header (date, time and file name). The operation number and type of operation are then written.

The current bench removal totals (OBRX) are passed to the AOBR routine where they are averaged and displayed.

The current operation totals are then summed with the total bench removal figures (TBNR).

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WEO2M001	
SCALE		REVISION	SHEET 130

### 5.10 BPWR

The BPWR routine computes the power used in loading the bucket and in smoothing the terrain by heeling during bench fill operations. These two operations require motion in the opposite direction. In loading the bucket, the motion is toward the dragline cab. In bucket heeling, the motion of the bucket is away from the dragline cab. The flag, ICS, is used to indicate to the BPWR routine which of these motions to perform. We first discuss bucket loading.

The coordinates of the bucket loading path are generated by the routine BUCKET. BUCKET generates these coordinates which are stored in the arrays BPX, BPY and BPZ. It also records the volume of material removed along this path and the surface area of the material cut by the bucket edge. The volume information is stored in the array BTV (I,J). The Index I is on the material layers. The Index J is on the increment of the bucket path. The length of this increment is approximately 10 feet (see description of BUCKET routine). For each increment of the bucket path, the BPWR routine calculates the force required to move the bucket and the subsequent power used. There are three factors considered in the force calculations. The frictional force, the cutting force and the force required to pack the material in the bucket. (See Figure 5-15.) The bucket weight is the empty bucket weight plus the material loaded into the bucket at that time in the loading process. This is needed to compute the frictional force of sliding the bucket along the path. The coefficient of friction is taken to be one. The cutting force is proportional to the surface area of the material being loaded. The constant of proportionality is a function of the material and is stored in the array HBANK(5,I) where I is the index on the layers of overburden material. This force simulates the cutting or shearing of the bucket edge through the material. The packing force is proportional to the amount of material entering the mouth of the bucket. The constant of proportionality is denoted by CARF and this number is independent of the material. It is an input parameter.

It is assumed the force applied to the bucket will be through the drag motion. Only in instances where a stall condition is reached or the bucket path is steep will the

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	131

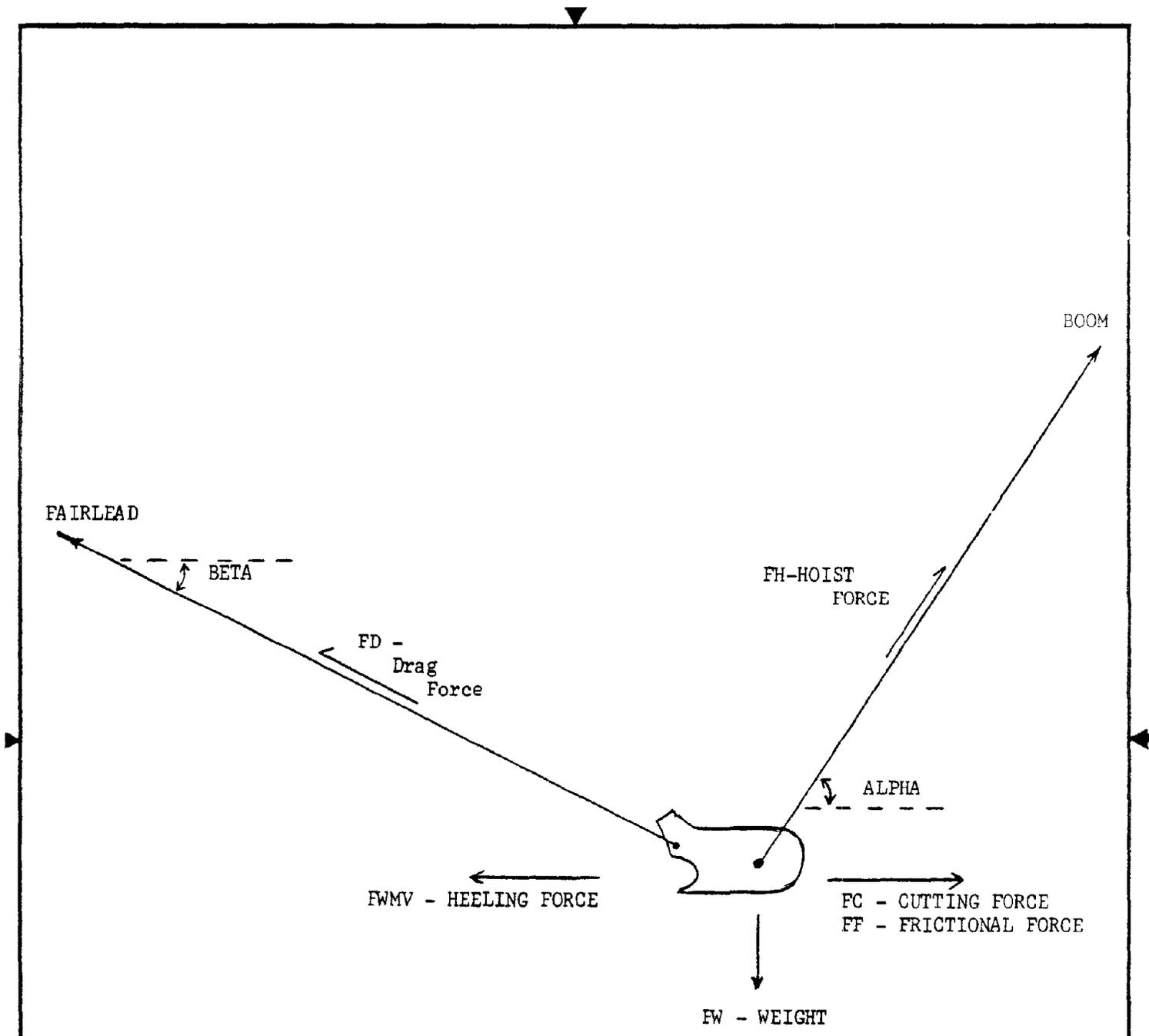


Figure 5-15. Bucket Forces for Digging and Heeling

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hoist motion be used to help. If the hoist motion is used, the frictional force drops out and is replaced by the horizontal component of the hoist force in the computation of the total drag force. The force calculations for hoist and drag are done for each increment. The average bucket weight and the average angular displacement are used in the force calculations for each increment. After the drag and hoist forces are completed, the time required to perform these motions is determined. This is done by doing an interpolation of the dragline's performance tables. There is also a drag speed limit which is considered in the calculations. This speed limit is computed from the performance parameters; ALT - loading time, and RNTL - loading length. It is assumed that the operator never exceeds this speed when loading the bucket. Stall conditions are determined by the input stall speed. If the drag speed falls below this, it is assumed that the hoist force will be used to "loosen" the bucket. The force is then multiplied by the average velocity to determine the average power usage. The raw power is multiplied by the reciprocal of the drag efficiency to determine the power required by the drag motors. The efficiency is determined as a function of force. The efficiency is equal to the input parameter EFD unless the force exceeds the knee of the performance curve. In which case the efficiency drops linearly from EFD to EFD - 0.10 as the force increases from the knee to the stall load.

The modelling of the bucket heeling is done after the same fashion only the motion is in the opposite direction. The hoist motion is used to pull the bucket toward a point under the boom sheave. The bucket path coordinates are generated by the routines BFILL and BHEEL and are stored in the arrays BPX, BPY and BPZ. Also, the amount of material carried by the bucket heel is stored in the array BTV (1,I) where I is the index on the bucket path increments. These are the same arrays used for the loading motion. The horizontal component of the hoist force is proportional to the carry volume and the frictional force of the empty bucket. This constant of proportionality is taken to be one as in the coefficient of friction. The drag force is used to support the bucket at the fill height if the carry volume is zero. This assumes if the carry volume is zero, there is not sufficient material under or being moved by the bucket to be of any consequence. The time and power calculations are then made

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by interpolating the performance tables. The flow charts and symbol table are given in Figures 5-16 and 5-17.

### 5.11 BUCKET

The BUCKET and DIG subroutines determine where the bucket is to be loaded each cycle. The DIG subroutine sets up a search pattern to increment through possible bucket paths in the dig area. In the BUCKET subroutine, each bucket path is processed to determine if a load can be obtained along this path. A bucket path is a rectangular area extending from the initial point generated by the DIG subroutine to a point in front of the dragline fairlead determined by the length of the drag chains and cable. The width is equal to the bucket width. The BUCKET subroutine defines this rectangular area in terms of the line segments that form its border. The overburden grid is interrogated from rear to front and the volume of material above the cut height is accumulated. If this volume eventually equals EBC, the effective bucket capacity, the bucket can be filled along this path. Once this has been determined, the process is repeated and the material is loaded. The bucket path is segmented into increments of approximately 10 feet. The volume of material removed from the grid each increment is stored in an array corresponding to that increment. Also, the surface area the bucket cuts through to remove the material and a series of coordinates that define the trajectory of the bucket is stored. The bucket is initially at the cut height determined by the DIG subroutine. As it is loaded, the bucket follows the terrain of the grid minus the cut depth. If the front or lower plane is encountered, the bucket follows the plane. The coordinates, the volume removed, and the cutting surface area are used by the subroutine BPWR to compute the loading energy and time.

Not all bucket paths produce a full load. There may not be much, if any, material above the cut height set by the DIG routine. So the digging may have to stop before a full load is obtained. The loading must be stopped if the drag ropes are pulled in as far as possible or the drag ropes are rubbing on the overburden. When a restriction is reached, the bucket loading stops and a decision is made whether to accept the load, reject the load or return for a second pass. The volume accumulated in the

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SYMBOL	UNITS	DESCRIPTION
ABPL	FEET	Bucket Fill Length
ACCM1	FEET	Dummy Variable - Hoist Length for Printout
ACCM2	FEET	Dummy Variable - Drag Length for Printout
ALPH	radians	Average Hoist Angle
ALPH1	radians	Hoist Angle - Initial Point of Increment
ALPH2	radians	Hoist Angle - Final Point of Increment
ARXC	FEET	X - Component Bucket to Fairlead (Boom)
ARYC	FEET	Y - Component Bucket to Fairlead (Boom)
BETA	radians	Average Drag Angle
BETA1	radians	Drag Angle - Initial Point of Increment
BETA2	radians	Drag Angle - Final Point of Increment
BPL	FEET	Length of Bucket Path for Increment
D		Dummy Variable in Call to Subroutine RHTA
DD	FEET	Drag Length per Increment
DEN	LBS/YD <sup>2</sup>	Average Density of Material for Heeling Motion
DH	FEET	Hoist Length per Increment
DT	MIN	Drag Time
DV	FEET/MIN	Drag Rope Velocity
FC	LBS	Cutting Force
FD	LBS	Drag Force
FF	LBS	Frictional Force
FH	LBS	Hoist Force
FW	LBS	Weight of Material and Bucket
FWMV	LBS	Force Due to Heeling - Smoothing Material
HT	MIN	Hoist Time
HV	FT/MIN	Hoist Rope Velocity
I		Index

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Figure 5-17. BPWR Symbol Table (Sheet 1 of 2)

SYMBOL	UNITS	DESCRIPTION
II		Index on Bucket Path
K		Index
KI		Index
NNOPTS		Counter for Number of Increments (KB09)
NOPTS		Counter for Number of Increments (KB09)
PDL D	KW-HR	Drag Energy per Increment
PHL D	KW-HR	Hoist Energy per Increment
PWLD	KW	Total Drag Power
PWLH	KW	Total Hoist Power
TBW	SEC	Total Time to Load Bucket
TH	radians	Incline of Bucket Path
TL	MIN	Time per Increment
TPOS		Position Time for Initial Dig
U1		X - Component of Bucket Radius - Unit
U2		Y - Component of Bucket Radius - Unit
V1		X - Component of Bucket Radius
V2		Y - Component of Bucket Radius
W1		Used in Function SLV Definition
W2		Used in Function SLV Definition
W3		Used in Function SLV Definition
XB		X - Component of Boom Position
XF		X - Component of Fairlead Position
YB		Y - Component of Boom Position
YF		Y - Component of Fairlead Position
ZB		Z - Component of Boom Position
ZF		Z - Component of Fairlead Position

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Figure 5-17. BPWR Symbol Table (Sheet 2)

search along the bucket path is compared to BPLF1. BPLF1 is a test volume computed in the OBR subroutine. If the accumulated volume is greater than BPLF1, it would not be profitable to make a second pass to get a fuller load and the load is accepted. The value of BPLF1 is usually about 80% of the effective bucket capacity, depending on the characteristics of the dragline. That is how fast it could make a second pass. If the accumulated volume is less than BPLF1 it is compared to BPLF2. BPLF2 is a test volume that is percentage of the effective bucket capacity. The percentage is entered as the parameter BFL2 in the parameter input file. If the accumulated volume is less than BPLF2, the load is rejected and another path is searched. If the accumulated volume is greater than BPLF2, a second pass will be made to fill the bucket above the BPLF1 limit. In this case, the BUCKET routine accepts the load. The load is then removed and the BUCKET subroutine searches for a suitable path to get the load above the BPLF1 limit. In no case will the dragline make 3 passes to get a load. The value of BFL2 is usually set at 60 to 70 percent. The parameter controls how many second passes are taken and how 'clean' the dig area will be upon completion of the operation.

A bucket path may also be rejected if the ratio of volume accumulated to the length is too low. This ratio is the parameter entry SCL1. The length is measured from the start of the dig to the present position. The start of the dig is the increment before that increment of the bucket path where material was first encountered. If this load length exceeds one half of the operating radius, the volume vs. length test is made. This prevents taking unnecessarily long loads.

The cut height is determined by the DIG subroutine. If the lower plane is parallel to the X-Y plane, the cut height is never below this lower plane. If the lower plane slopes toward the toe of the dig, then the bucket path can intersect the lower plane. When this happens, the bucket follows the contour of the lower plane, taking all the overburden material above it.

The cut depth of the bucket is input by the parameter HCH. However, if the material has a cut force coefficient (CUTF) greater than or equal to 50,000 the cut height

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is reduced by one if the angle drag ropes make with the horizontal is greater than 29 degrees. The value, 29 degrees, is an approximation based on field data. Figures 5-18 and 5-19 contain the flow chart and symbol table.

### 5.12 DIG

Each dig volume is defined by an operation file. The boundaries of the volume are defined by the front plane, the lower plane, the dig range, and the left and right dig wall angles. The DIG subroutine sets up the procedure to remove the dig volume. The material is removed in layers from the top down. The thickness of the layers is given by, HCH, the bucket cut depth. Each layer is partitioned into bucket paths. A bucket path is a rectangular area a bucket width wide extending from the front plane to the specified dig range given by R1 and R2 in the operation file. All bucket paths are centered on a line passing through the dragline center of rotation. The bucket paths overlap slightly near the operating radius and more so nearer to the fairlead. Then all the material of the layer is included in the series of bucket paths. The DIG subroutine calls the BUCKET subroutine to search each bucket path for a load. Figure 5-20 shows a typical bucket loading sequence required to remove a layer of overburden. In the example, eleven bucket loads were required to remove the layer of overburden. Bucket paths A through G were sequentially searched and bucket loads 1 through 7 removed. The order of removal is determined by the direction of dig, KDGD, which appears in the operation file. The bucket paths were searched a second time. Bucket load 9 in path B was not a full load. The front plane boundary and/or the drag stop limit was encountered before a full load could be achieved. Sufficient volume existed so the overburden was loaded and spoiled. Path C was rejected, the volume was not worth loading. A partial load was removed from path D (10D) and a second loading pass was made along path E (10E). Bucket load 11 is removed from paths F and G. The bucket paths were searched a third time. No bucket loads were achieved, so the dig height was decreased and the next layer removed. The overburden that could not be removed (shaded areas) may be removed later. As the layers are removed, the side dig wall angles are maintained by decreasing the width of the layer. A vertical cross-section of the side walls would look like a stair step descending to the bottom of the cut.

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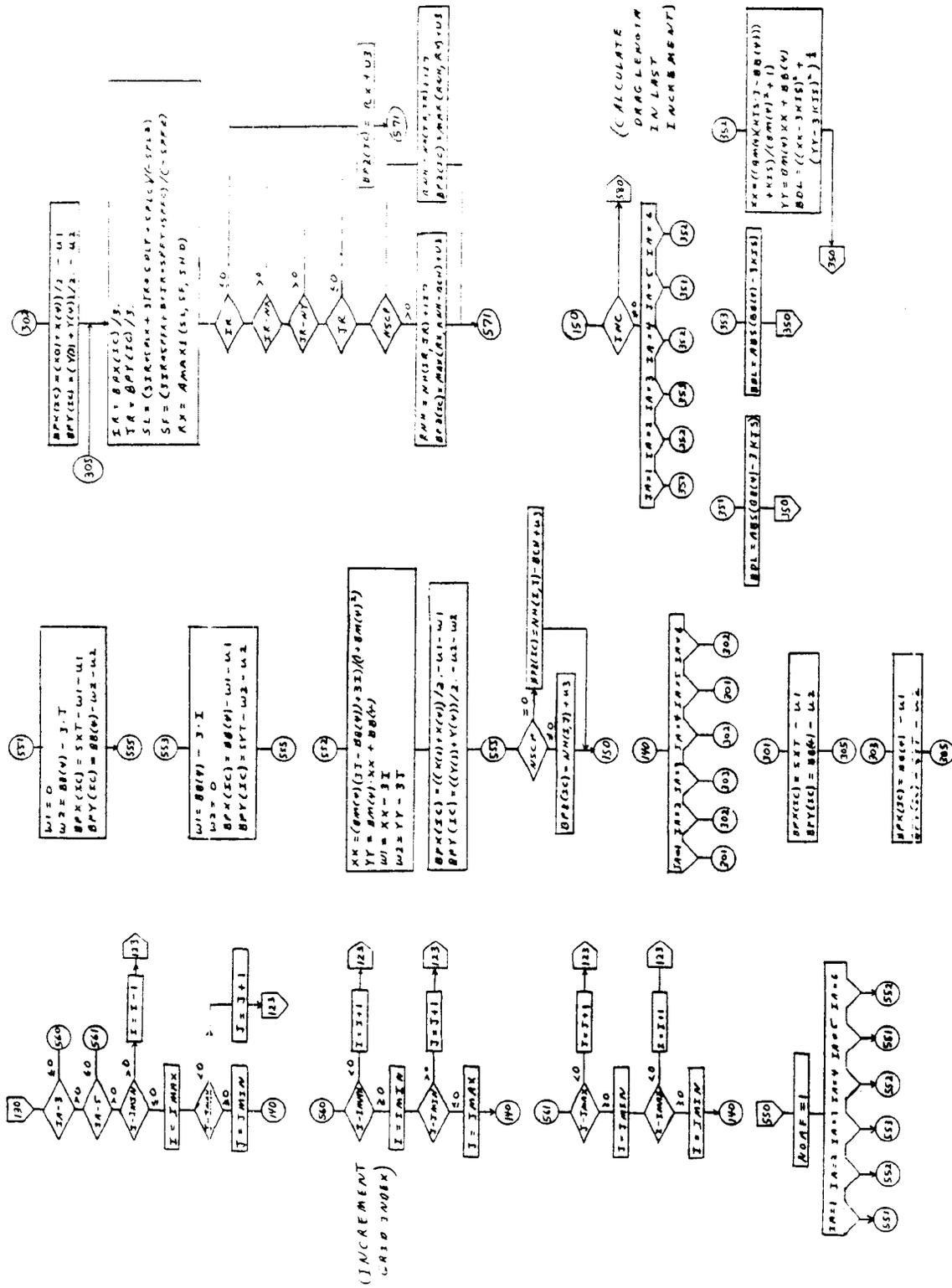


Figure 5-18. BUCKET Routine Flow Chart (Sheet 3)

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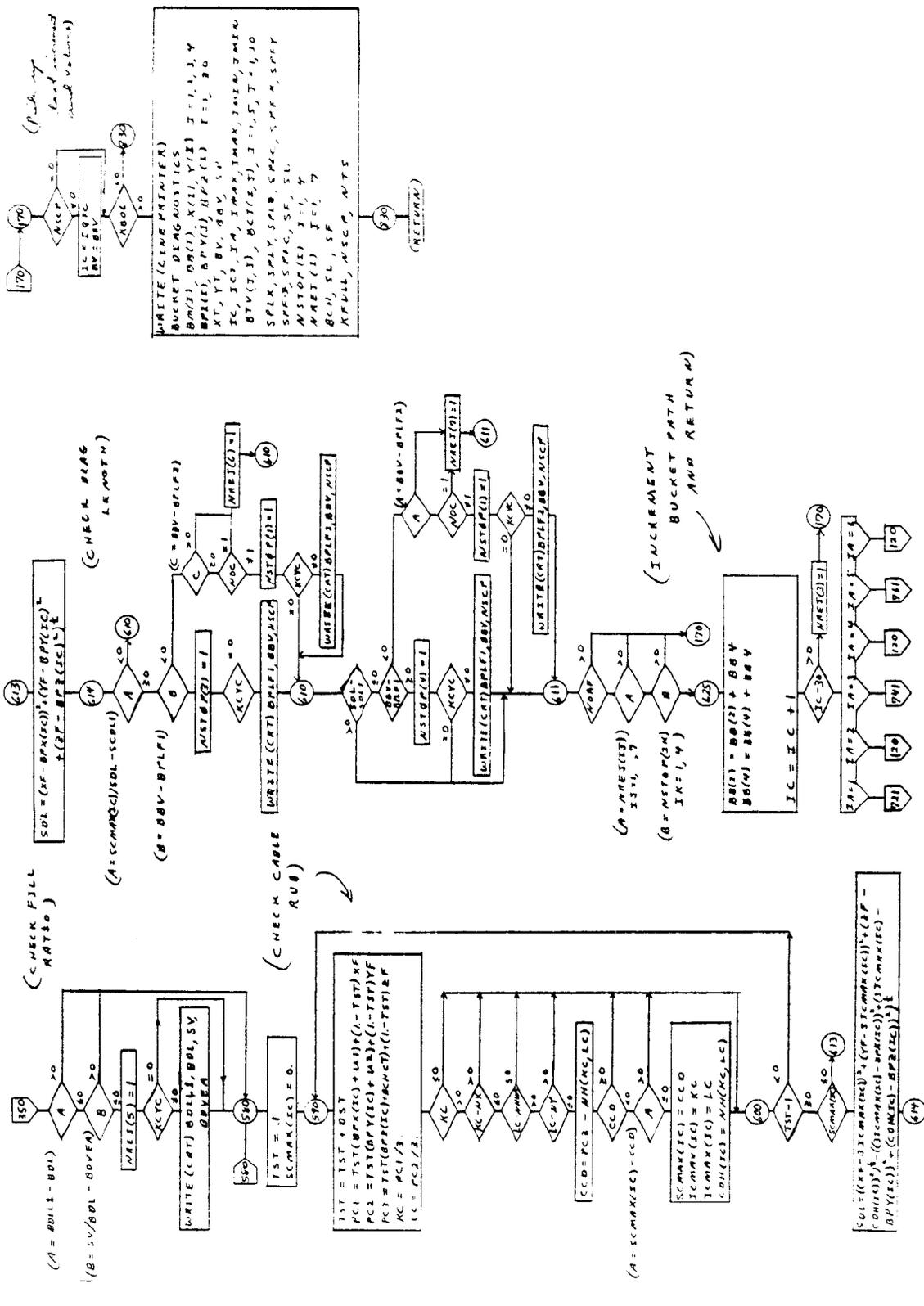


Figure 5-18. BUCKET ROUTINE Flow Chart (Sheet 4)

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SYMBOL	UNITS	DESCRIPTION
BB		Array used in Bucket Path Increment
BBV	YD <sup>3</sup>	Volume of Material Along Bucket Path
BB1		Y - Intercept of Line Defining Bucket Path
BB2		Y - Intercept of Line Defining Bucket Path
BB3		Y - Intercept of Line Defining Bucket Path
BB4		Y - Intercept of Line Defining Bucket Path
BCH	FEET	The Bucket Cut Height for a Given Grid Point
BDL	FEET	Length of Bucket Path From First Dig
BM		Array Used in Bucket Path Increment
CCD	FEET	Height of Cable Over Dig Face Crest
IA		Index on Quadrant of Dig Angle
IMAX		Maximum X Coordinate in Bucket Increment
IMIN		Minimum X Coordinate in Bucket Increment
INC		Flag to Indicate First Dig Grid Point
IR		X Coordinate of Last Dig Grid Point
JMAX		Maximum Y Coordinate in Bucket Increment
JMIN		Minimum Y Coordinate in Bucket Increment
JR		Y Coordinate of Last Dig Grid Point
KC		Integer Used in Cable Rub Test
KIS		X Coordinate of First Dig Grid Point
KJS		Y Coordinate of First Dig Grid Point
LC		Integer Used in Cable Rub Test
NHWS		Y Coordinate of High Wall
NRSAP		360° - 0° Singular Point Flag
PC1		X Coordinate Used in Check for Cable Rub
PC2		Y Coordinate Used in Check for Cable Rub
PC3	FEET	Height of Cable in Test for Cable Rub

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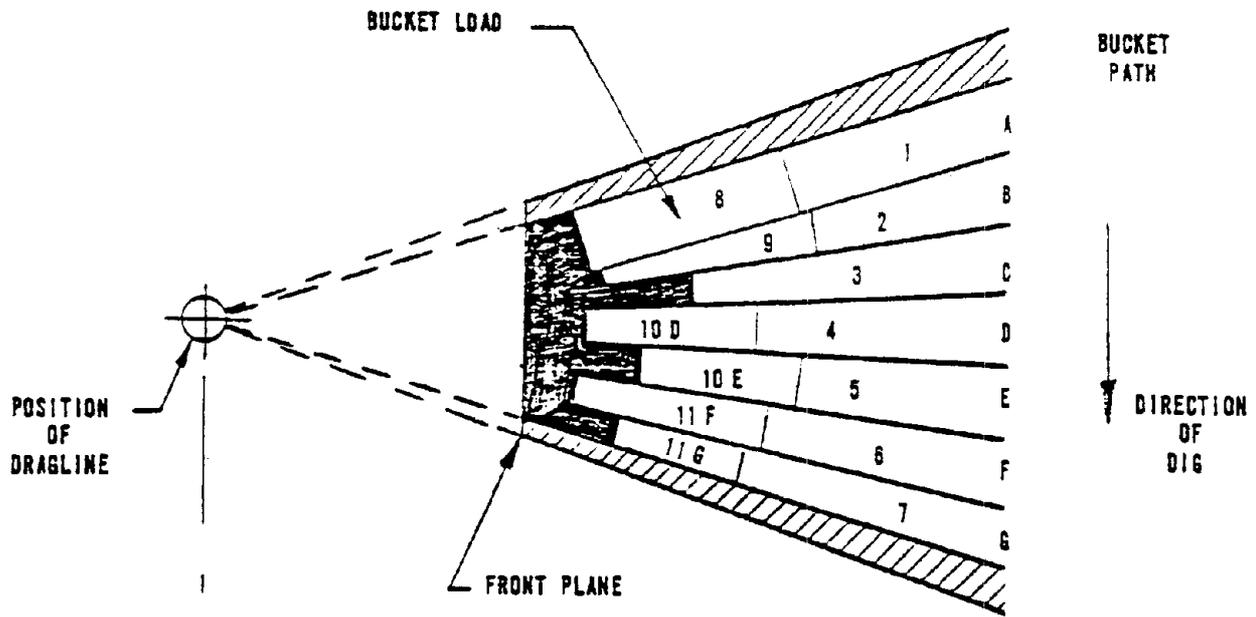
Figure 5-19. BUCKET Symbol Table (Sheet 1 of 3)

SYMBOL	UNITS	DESCRIPTION
RNH	FEET	Used to Convert Logical to Real for Use in a Subroutine Call
RRNH	FEET	Used to Convert Logical to Real for Use in a Subroutine Call
SCMAX	FEET	Variable Used in Cable Rub Test
SDL	FEET	Length Used in Volume/Length Ratio Test
SF		Variable Used in Front Plane Test
SCN		Variable Used in Locating Grid Points Inside Bucket Increment
SH	FEET	Height of First Dig Point
SL	FEET	Lower Plane Value at Dig Coordinate
SV	YD <sup>3</sup>	Volume Accumulated in Search
TLA	FEET	Variable Used in Calculation of Cut Height
TLX	FEET	Variable Used in Calculation of Cut Height
TLY		Variable Used in Calculation of Cut Height
TST		Variable Used in Calculation of Cable Rub
U1		Vector Used to Locate Bucket Initial Position
U2		Vector Used to Locate Bucket Initial Position
U3		Vector Used to Locate Bucket Initial Position
V1		Vector Used to Locate Bucket Initial Position
V2		Vector Used to Locate Bucket Initial Position
XF		X Coordinate of Fairlead
X		Array for Bucket Path
XMAX		Maximum X Value of Bucket Path Increment
XMIN		Minimum X Value of Bucket Path Increment
XT		X - Test Coordinate Used in Locating Grid Points
XX		Variable Used in Final Increment Calculation
Y		Array for Bucket Path
YF		Y Coordinate of Fairlead
YMAX		Maximum Y Coordinate in Bucket Path Increment

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Figure 5-19. BUCKET Symbol Table (Sheet 2)





BUCKET LOADING SEQUENCE

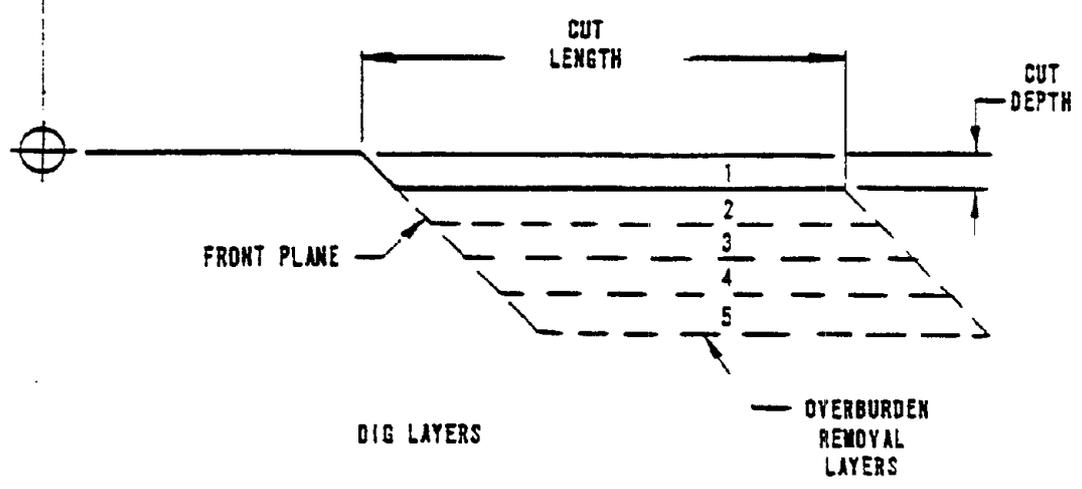


Figure 5-20. Overburden Removal

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The DIG routine calls the BUCKET routine twice each cycle. Once to load the bucket and then to search for the next load. The first search is done in the reset mode at the start of each operation. DIG also calls subroutine BPWR after each bucket load. BPWR calculates the energy and time to load the bucket from the data stored by the BUCKET subroutine. If a second pass is required to load the bucket, the DIG subroutine treats it as another cycle although it is recorded by the higher level program OBR as a second pass. The flow chart and symbol table are contained in Figures 5-21 and 5-22.

5-13. DRAG

The DRAG subroutine is called by EXDRG. DRAG in turn calls subroutine INAM to name the case and record the time and date. If the IXF flag is zero, DRAG calls subroutine DATA to enter the parameter, operation and case data. If the IXF flag is not zero, this information has already been entered in subroutine WRDG which is called from EXDRG. In this case, DATA is not called but the device unit number is set to 8 indicating there will be no inputs from the CRT. DRAG then checks the end flag KEND which can be set in DATA. If DRAG is not to end, it calls subroutine INT. INT initializes the pit and spoil pile either by creating a new pit and spoil pile or reading a prepared file. It also initializes the values of variables and constants used in the simulation. After initializing, DRAG sequences through the series of operations to be simulated. The type of operation is stored in the array ISPEC. The operation number is KSE. ISPEC (KSE) equal to one corresponds to an overburden removal, a two to a bench fill, a three to a bench removal and a four to a move. DRAG calls either OBS, BFL, BNR or MOVE depending on the value of ISPEC (KSE). After each operation is simulated, the resulting pit is written into a file. DRAG calls subroutine PFILE to do this. After all the operations of the series have been run, DRAG calls WTOT to compute and record the totals and averages of the operations simulated. DRAG also calls subroutines DATE and TIME to determine when the run was completed. DRAG then closes devices 5, 6 and 7 and returns to EXDRG. (See Figures 5-23 and 5-24.)

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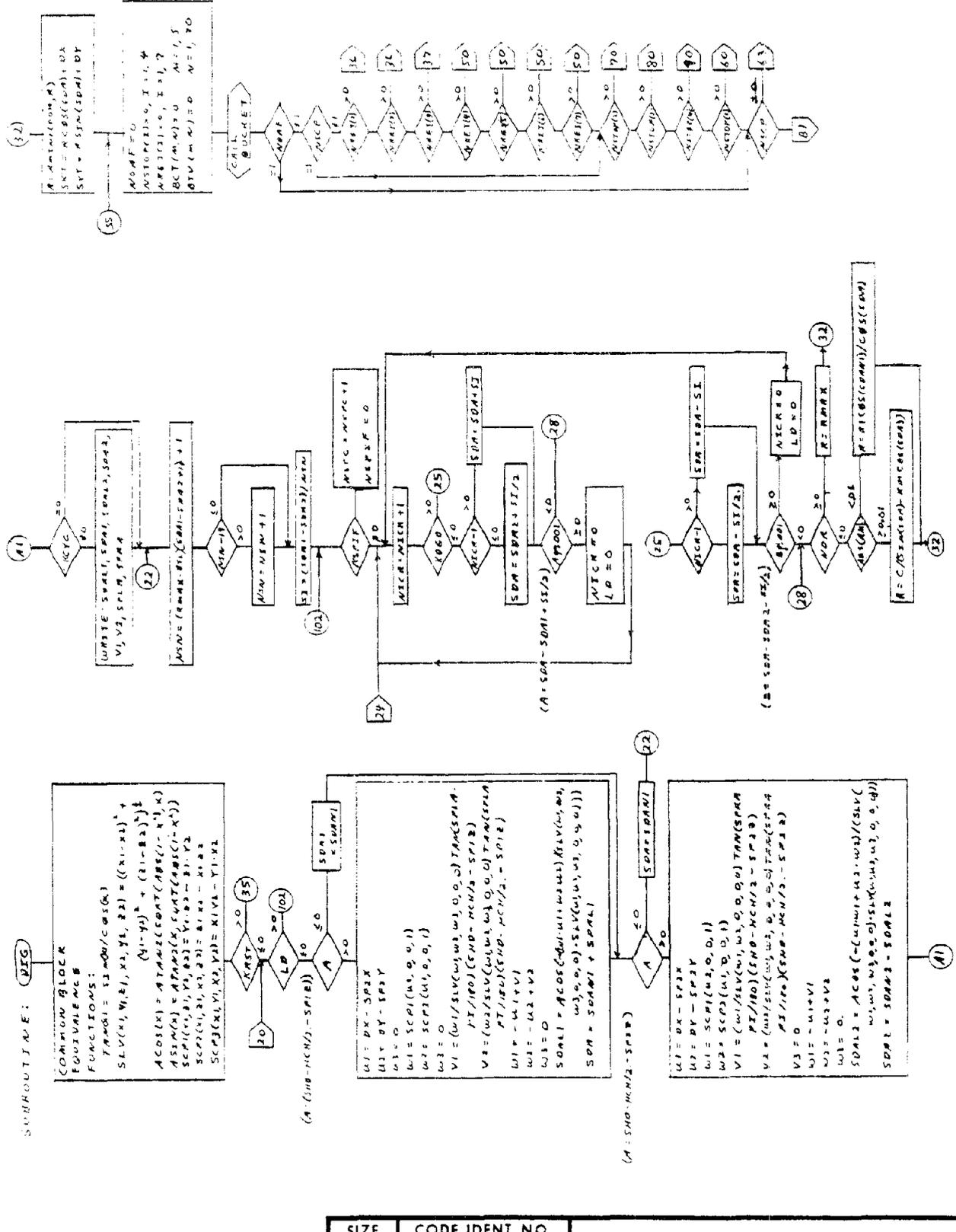


Figure 5-21. DIG Routine Flow Chart (Sheet 1 of 2)

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#### 5.14 DTOT

This routine displays and prints the totals and averages for each type of simulated operation and the total simulation results. Only operations that were actually performed will be displayed. For each operation a:

- o New Page is Started
- o Simulation Identification Header is Printed
- o Type of Operation is Printed
- o AOBR Routine Prints the Totals and Averages

Figure 5-25 contains the flow chart for this routine.

#### 5.15 DUMP

This routine searches the spoil pile for a dump location that can be reached by the dragline. When a dump location is located the swing angle and the X, Y coordinates of the dump location are calculated.

If dumping into a hopper, the swing angle is set equal to the angle through the center of the hopper and the dump height is limited to the minimum and maximum hopper dump heights.

There are numerous considerations and constraints that must be resolved when dumping on the spoil pile. (See Figure 5-26.) These include:

- a. Allowable Spoil Advance (XSL)
- b. Direction of Spoil Advance Buildup (KDOS)
- c. Dump Height (H)
  - 1. Layers (HTS)
  - 2. Maximum Spoil Height that can be Reached from the Current Dragline Position (THR)
  - 3. Buckwall Height (HBW)
  - 4. Spoil Peak (HS)
  - 5. Maximum Spoil Height that could be Reached by the Dragline (HMX)

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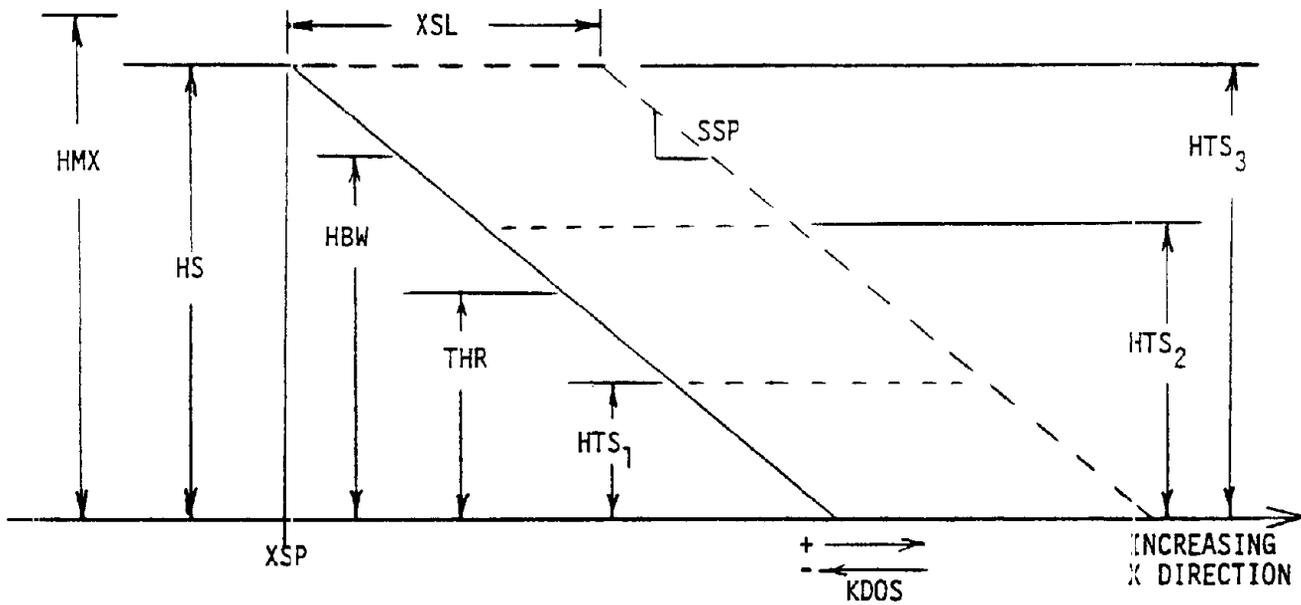


Figure 5-26. Spoil Pile Dump Area Diagram

The dump area of the spoil pile is defined by the parallelogram defined by the spoil peak location (XSP), the allowable spoil advance (XSL) and the angle of repose (SSP). This parallelogram is searched for a spoil height that is below the desired dump height. The direction of search is specified by the direction of spoil flag (KDOS).

The parallelogram will be filled in layers. The layers can be specified as a percentage (SM) of the spoil peak height (HS). These layers are shown in Figure 5-26 as  $HTS_1$ ,  $HTS_2$  and  $HTS_3$ . When a layer is filled, the dump height is incremented to the next layer height. If the parallelogram is to be filled as a single layer (SM = 100%), the dump height will be either the spoil peak height (HS) or the buckwall height (HBW) depending upon the type of overburden in the bucket. If the dragline has sufficient reach to stack the overburden higher (HMX) than the spoil height, it will do so when the parallelogram is full.

No matter what dump height is desired, the dragline will not stack the overburden any higher than can be reached from its current position (THR). If a spoil position within

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reach cannot be located, the dragline will swing perpendicular to the spoil pile and dump. The volume of overburden dumped in this manner is considered rehandle and is listed as such in the operation results. Figures 5-27 and 5-28 contain the flow chart and symbol table.

#### 5.16 EXDRG

EXDRG is the main program of the simulation. It calls the DRAG subroutine which sequences the simulation through the operations entered. EXDRG exists only to sequence DRAG through the files prepared by the DINF program. EXDRG calls WRDG to read the ACT.FIL file. This file contains the index pointers as to what files to read and simulate. The set number and file names are contained in the ACT.FIL. EXDRG then calls WRDG again but with the flag IT set to zero rather than -1 as on the first call. If IT is set to zero, WRDG reads the case file \*.COM which contains the case data and index pointers for this set. EXDRG then enters a nest of DO's. For each pass, it calls WRDG with the IT flag set to one to read the operation data stored in the DV2 type file for that operation. Subroutine DRAG is called to simulate the operation. EXDRG executes this DO loop until all operations have been simulated.

If the IXF flag read in by WRDG from the ACT.FIL is a zero, this indicates no files of DV2 type are to be read. EXDRG jumps directly to the DRAG subroutine. (See Figures 5-29 and 5-30.)

#### 5.17 INAM

The subroutine INAM is called by DRAG. If the IXF flag is set to one, INAM calls subroutine DATE and TIME to establish the data and time and then exists. If IXF is set to zero, INAM asks for the file name to store the results and asks if the cycles are to be controlled as well as establishing the time and date. (See Figures 5-31 and 5-32.)

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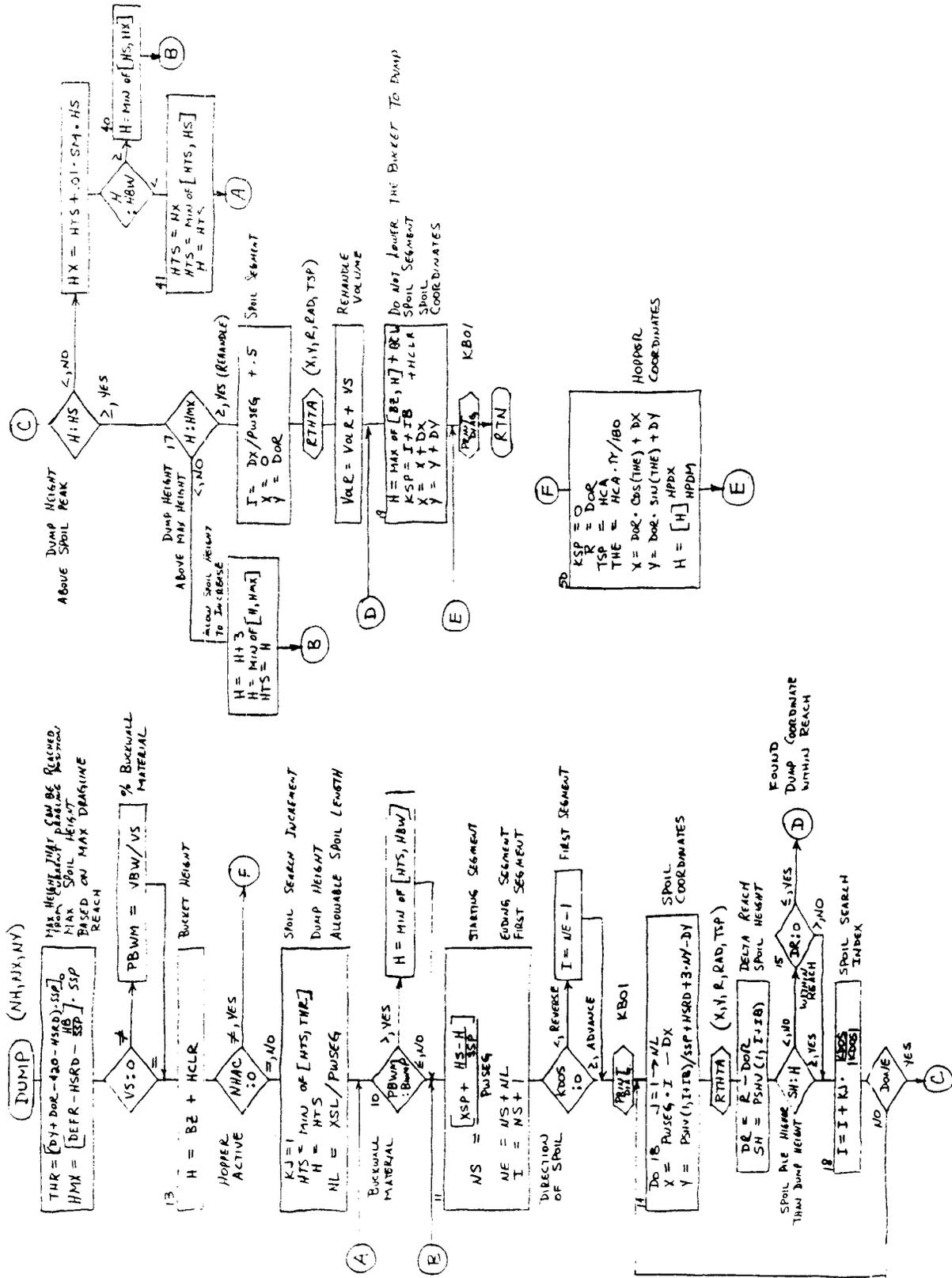
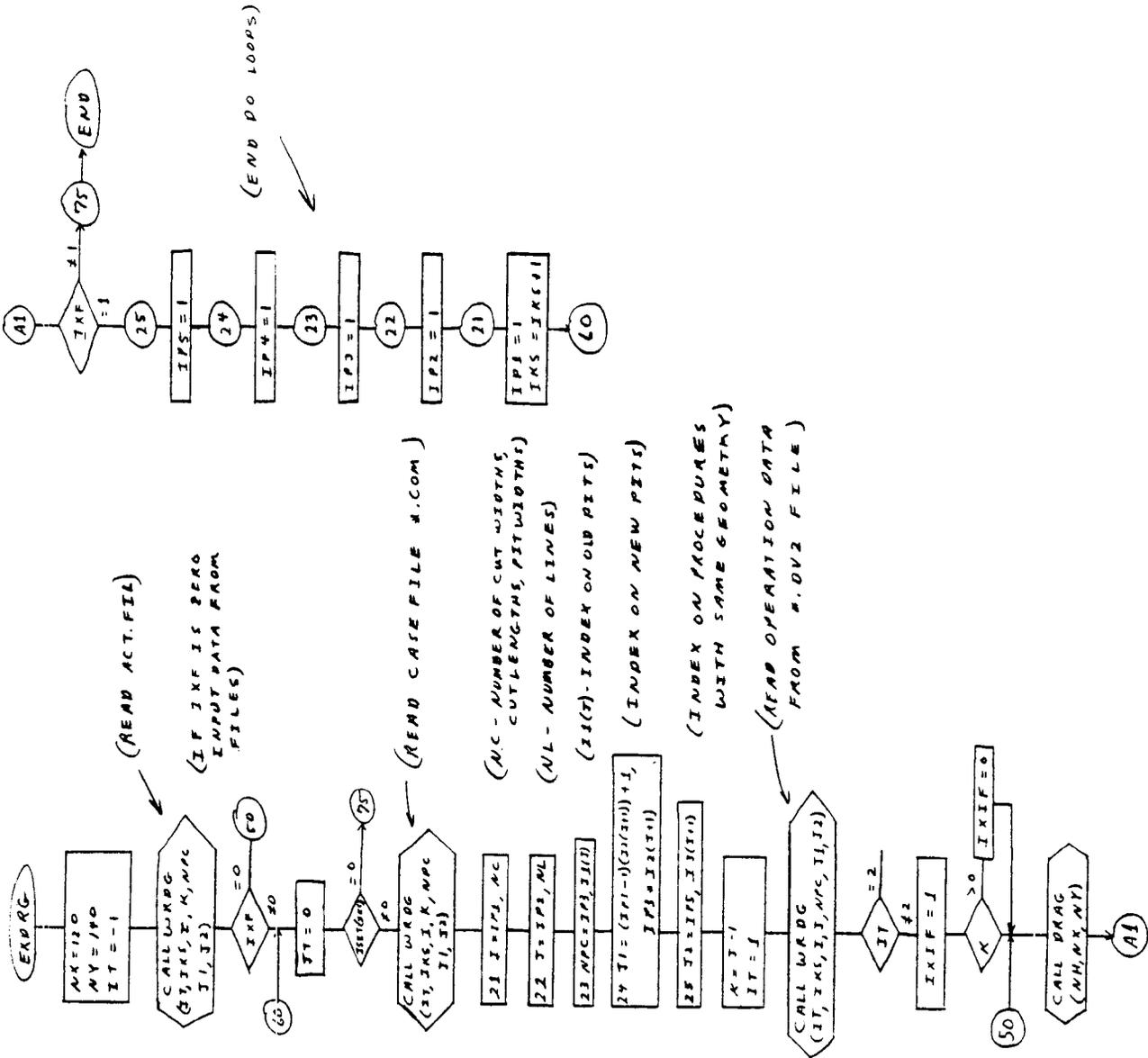


Figure 5-27. DUMP ROUTINE Flow Chart

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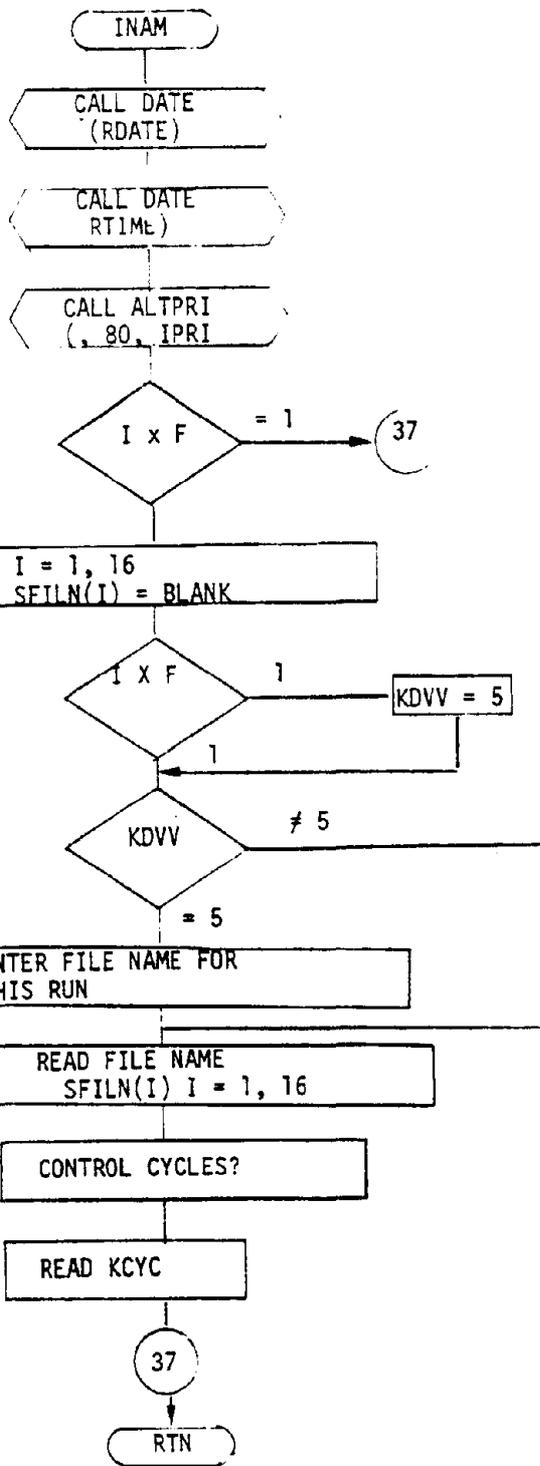


Figure 5-31. INAM Routine Flow Chart

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<b>A</b>	<b>12464</b>	WE02M001	
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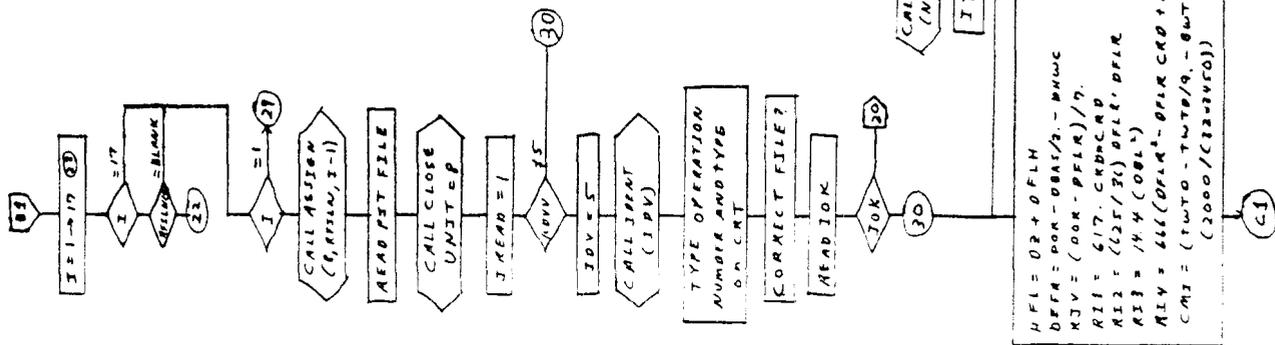
### 5.18 INT

The subroutine INT is called by DRAG before the first operation of each case file. INT performs the following functions:

- o INT assigns the proper file names to store the simulation results. The results are written into DV5 and DV6 file types if the cycle control flag KCYC is not set. If the KCYC flag is set, only the DV6 file is saved. The first name of the DV5 and DV6 type files is input in subroutine INAM if the IXF flag is set to zero in the file ACT.FIL. If the IXF is set to one, the first name is taken to be the same as the first name of the DV2 data file.
- o INT initializes the overburden grid and the spoil pile. The grid and spoil pile can be read in from an existing file or built up from the data given in the parameter and case files. To read in a file, the name is entered through the CRT unless the IXF is set to one. Then the file name is determined in subroutine WRDG and passed to INT in the RFILN array. The spoil pile and overburden grid can be created by INT as specified by pit width, spoil peak location, overburden height and other parameters. INT calls the subroutine PINIT to build up the overburden grid. The spoil pile is created by INT with help from subroutines SHGT and SVOL. Even if a file is read to initialize the overburden grid, it is possible to create a new spoil pile which will overlay the spoil pile read from the file. This option appears as a question on the CRT.
- o INT calculates the values of constants and initial values of many variables used in the simulation model. The inertia of the dragline, the acceleration and deceleration rates, the total overburden height are a few of the items calculated.
- o INT writes out some of the more essential constants and input parameters into the DV5 and DV6 type files. This provides a header for the simulation results which are to be written in the same files.

See Figures 5-33 and 5-34 for the flowchart and symbol table of this routine.

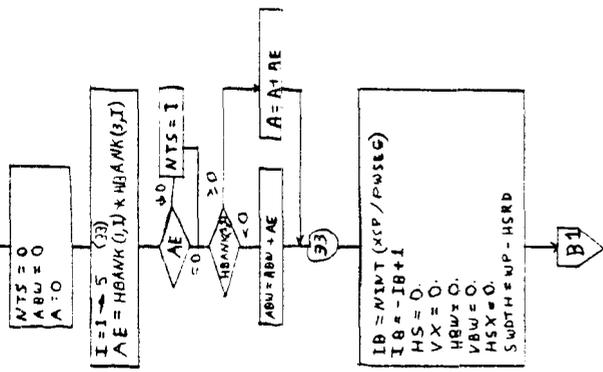
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(31)
ALND = CMI(A11 + A12 + A13 + A14)
HDDDD = (.8 * (AMSL - 847)32) / BWT
SVLB = DPC3 - ((DPC3) - DPC2) * (MLS) / DS(2)
PI = AMAXI(0.7L/2, (0.0R - 0.01L) / 3.4)
THDL = ((ST(1,6) - ST(1,7)) / (ST(2,6) - ST(2,5))) * (PI / 180)
THDDA = (4 * ST(1,2) / ST(2,2)) * (PI / 180)
HDL0 = ASLD / 60.
DDLO = DSLO / 60.
SLNT = .95 * AP(3)
SLOT = .95 * DP(3)
THDD = .01 * ADPC * THDDA
SOLI = DCL + SQRT(BCNCT + BCL) + 0.0F1
EBC = BC * BFL
PSL = 60 * ANTL - BTL / ALT
BOLLI = DOR * .5
BDVEA = BDFL * EBC / BPLLI
SERG = TWT0 * (.8 + .2 * ST(2,4)) * 1.0007533
ATIMD = .01 * ADPC * ST(2,4)
SK36D = PI - THDL * ST(2,4) / 4
SK360 = SK360 - 180 / PI

```



INITIALIZE THESE VARIABLES

INITIALIZE PIT

Figure 5-33. INT Routine Flow Chart (Sheet 3)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	166

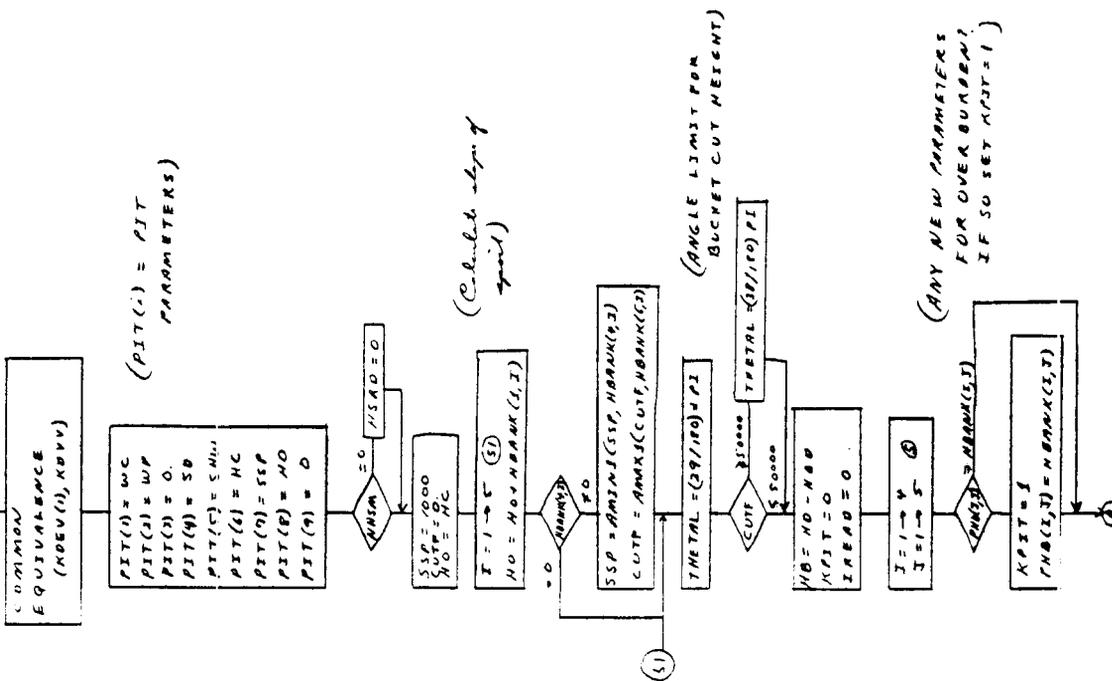
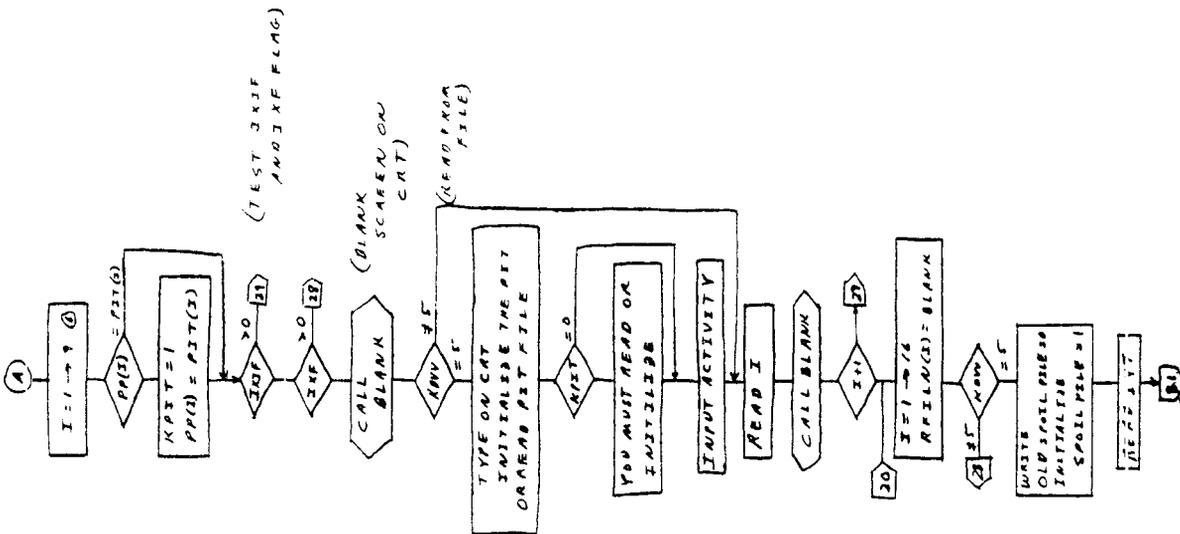


Figure 5-33. INT Routine Flow Chart (Sheet 1 of 4)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	167



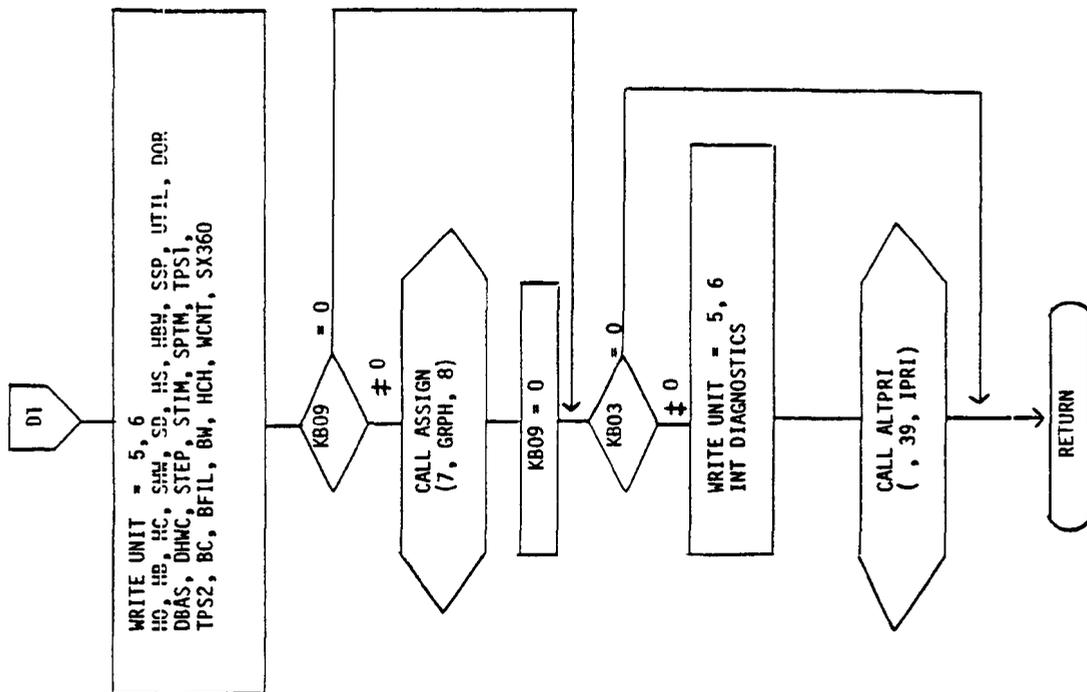


Figure 5-33. INT Routine Flow Chart (Sheet 4)

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	169

SYMBOL	UNITS	DESCRIPTION
A	SQUARE FEET	Variable Used in Calculation of Spoil Pile Height
ABW	SQUARE FEET	Variable Used in Calculation of Spoil Pile Height
AL	SQUARE FEET	Variable Used in Calculation of Spoil Pile Height
AREA1	SQUARE FEET	Variable Used in Calculation of Spoil Pile Height
CMI		Variable Used in Calculation of Dragline Inertia
DOT		Constant Equal to '.'
HSX		Variable Used in Calculation of Spoil Pile Height
I		Index
IDV		Index
IOK		Flag Used in Reading Old Pit File
IPRI		Variable in Call to ALTPRI
IREAD		Flat Indicating a Pit File is to be Read
K		Index
KH		Index
KOP		Operation Number
KPIT		Flag to Indicate Entry of New Data
L2		Integer Used in Calculation of Maximum Cut Width
N		Index
RI1		Variable Used in Calculation of Dragline Inertia
RI2		Variable Used in Calculation of Dragline Inertia
RI3		Variable Used in Calculation of Dragline Inertia
RI4		Variable Used in Calculation of Dragline Inertia
SWDTH		Variable Used in Calculation of Spoil Pit Height
VBW		Variable Used in Calculation of Spoil Pit Height
VX	YD <sup>3</sup>	Volume Used in Calculation of Spoil Pile Height
WCUT	FEET	Maximum Cut Width Without Rehandle
XTIND	SEC	Time for Swing to Reach Maximum Angular Velocity

SIZE	CODE IDENT NO.	WE02M001
<b>A</b>	<b>12464</b>	
SCALE	REVISION	SHEET 170

Figure 5-34. INT Symbol Table (Sheet 1 of 2)



5.19 MOVE

This routine controls the sequence of events necessary to move the dragline and/or a hopper from its current position to a new position. (See Figure 5-35.)

The dragline moves in a rectangular pattern, stepping parallel to the X and Y axis. The order in which the steps are taken is established by determining whether the dragline is stepping toward or away from the spoil pile. The Y steps are taken first when the dragline is stepping away from the spoil pile. Once the step direction has been determined, the dragline swings to the proper direction, positioning the bucket at the midpoint of its operating radius and 15 feet above the bench height. The number of steps to be taken are calculated and rounded to the nearest whole step. Step time and energy are obtained by multiplying the number of steps by the appropriate time or energy constant.

Ground preparation and positioning or alignment time is specified as a percentage (SPTM) of the minimum walking time. The alignment or positioning time increases in direct proportion to the number of steps taken.

The hopper portion of cross-pit conveyor systems are propelled by either walkers or crawlers. The propelling systems can be rotated, allowing movement in any direction. The simulation model moves the hopper along a straight line, directly to the desired position. The hopper move time accounts for the

- a. Removal of Stabilizing Jacks
- b. Walker or Crawler Rate
- c. Hopper Position Check
- d. Placement of Stabilizing Jacks
- e. Hopper and Belt Startup Times if Required

The dragline and hopper move performance are displayed on the CRT and printed on the line printer. The current move operation totals are then summed with the total move figures.

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	172



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Figure 5-35. MOVE Routine Flow Chart (Sheet 1 of 2)

SIZE	CODE IDENT NO.	
<b>A</b>	<b>12464</b>	WE02M001
SCALE	REVISION	SHEET 173

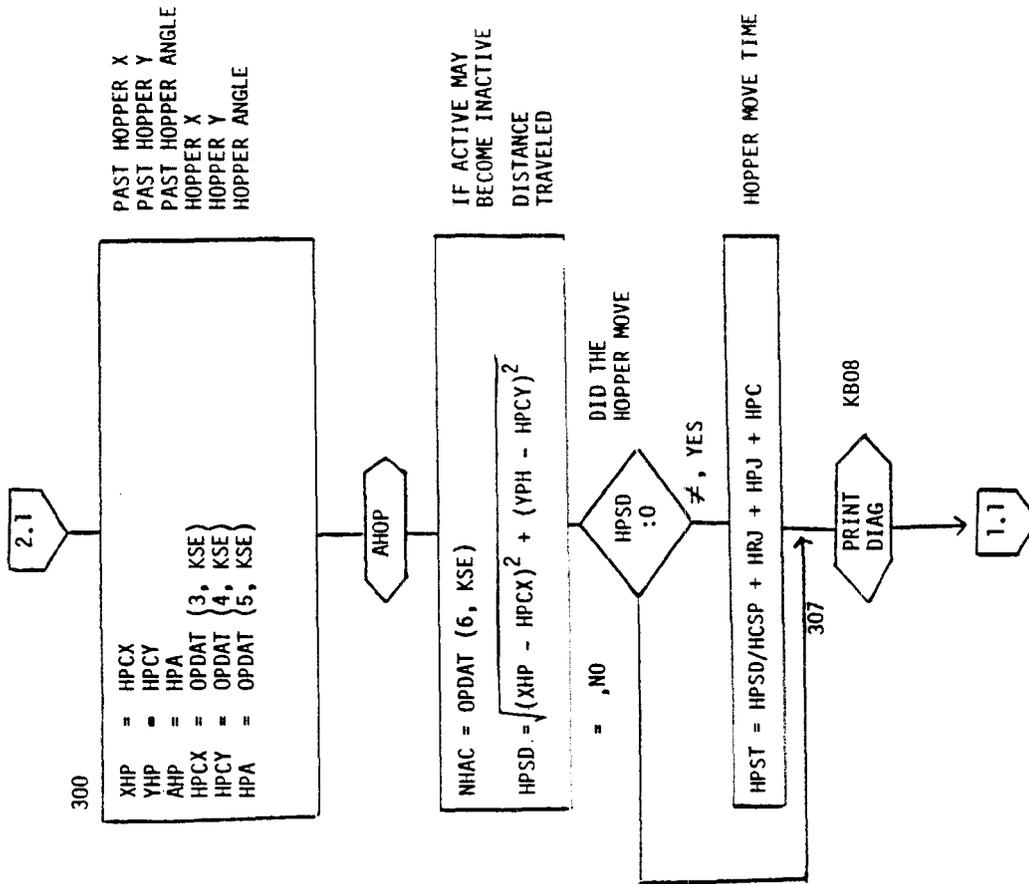


Figure 5-35. MOVE Routine Flow Chart (Sheet 2)

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	174

5.20 MVSG

This routine is called by the MOVE routine. It handles the common move functions for taking both X and Y direction steps. (See Figure 5-36.)

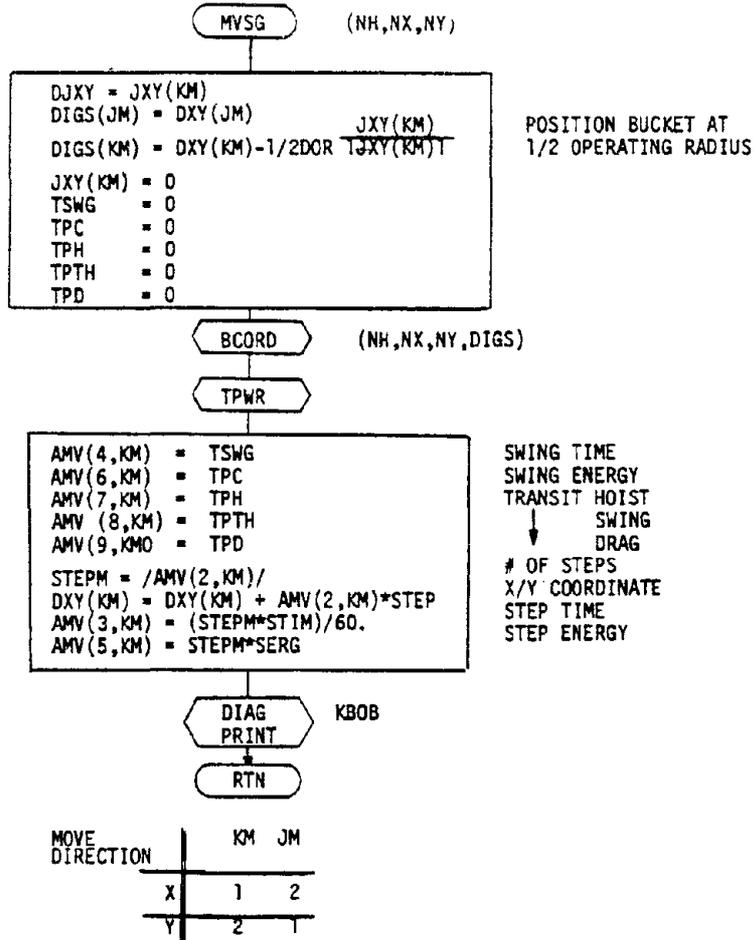


Figure 5-36. MVSG Routine Flow Chart

This routine positions the bucket at the midpoint of the operating radius and calculates the X, Y coordinates (DIGS array) of the bucket position prior to the dragline walking. The bucket is moved to that position by calling the BCORD and TPWR routines.

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	175

5.21 OBR

This routine controls the sequence of events necessary to perform overburden-to-spoil, bench removal and bench fill operations. The routines that simulate the dig-spoil cycle are sequentially executed until the volume defined by the current operation has been removed. For the following discussions, refer to the flow charts in Figures 5-37 and 5-38.

To reduce the size of this routine, the major portion of the initialization functions were grouped together and placed in the OBRI routine.

If the number of dig-spoil cycles are being controlled via the terminal, the number of cycles will be requested. There are three possible responses:

- a. XXX - This number of cycles will be made, the results displayed and the request repeated. When the dig volume specified by the operation parameters has been removed, the routine exits.
- b. 0 - The number of cycles will be set to a maximum and the dragline will dig until the dig volume has been removed.
- c. -XX - A negative number signals the routine to exit.

The diagnostic print flags can be changed each time the number of cycles are entered.

The bucket is loaded by the DIG routine. If the bucket is not fully loaded (KFULL=0), the bucket is repositioned by the BCORD and TPWR routines and another bucket loading pass is made.

When the bucket is loaded, the overburden material in the bucket is expanded and the dump location is determined (i.e., spoil pile or bench). To dump on the spoil pile, the dump angle is specified and the DUMP, SWGA and SPILE routines are called. DUMP

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WEO2M001	
SCALE		REVISION	SHEET 176

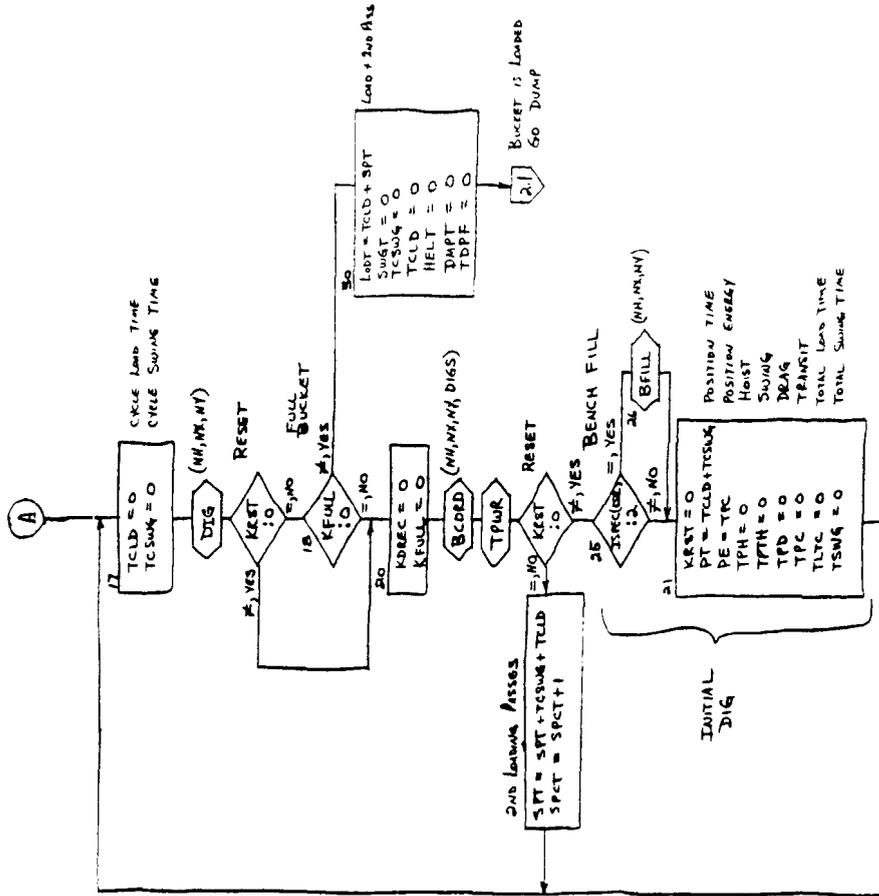
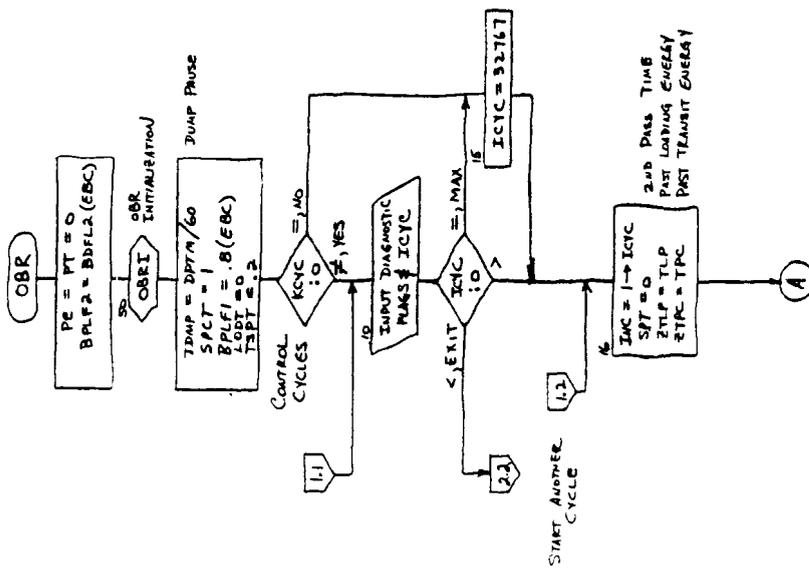


Figure 5-37. OBR Routine Flow Chart (Sheet 1 of 3)

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	177

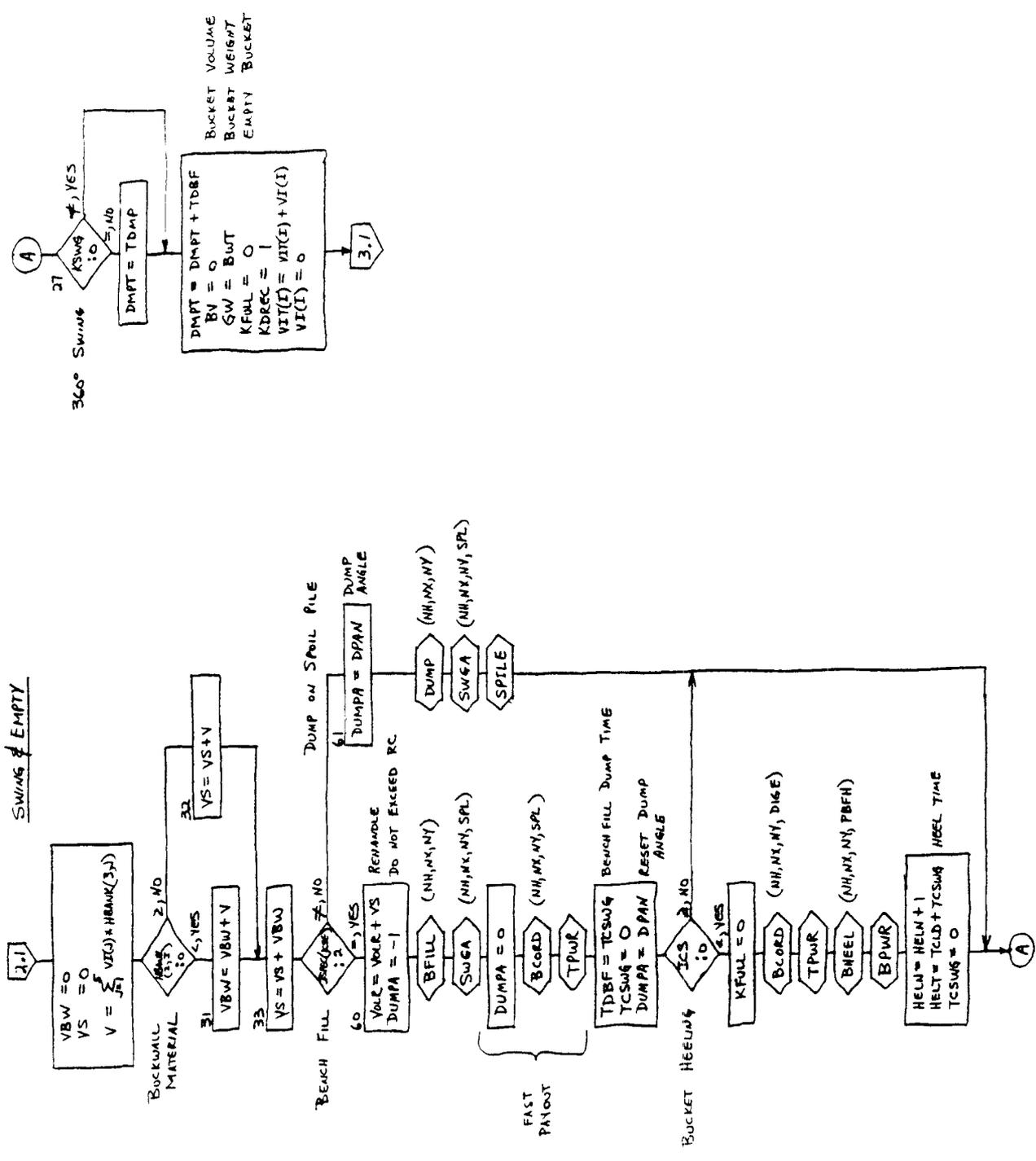
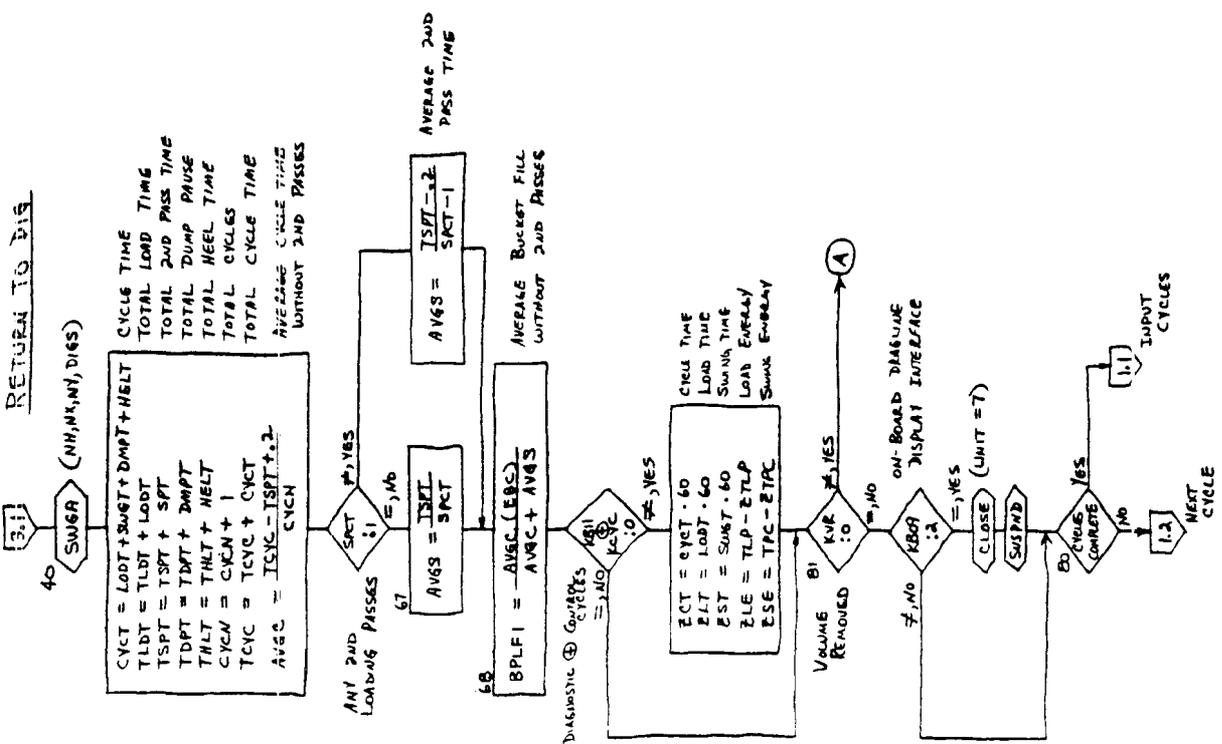


Figure 5-37. OBR Routine Flow Chart (Sheet 2)

SIZE	CODE IDENT NO.	
<b>A</b>	<b>12464</b>	WE02M001
SCALE	REVISION	SHEET 178

RETURN TO DIG



90

$S_{OBR} = \sum_{j=1}^N SWGR = TSWT = 0$   
 $S_{OBR} = \sum_{j=1}^N SWGR(1,j)$   
 $TSWT = \sum_{j=1}^N SWGR(3,j)$   
 $TOBR = (TLDT + TSWT + TDPT + THLT + FT) / UT/L$   
 $V_{OBR} = \sum_{j=1}^N VIT(j)$   
 $E_{OBR} = TPC + TLP + PE$   
 $SPCT = SPCT - 1$   
 $TSPT = TSPT - 0.2$

TOTAL SWINES  
 TOTAL SWIN ANGLE  
 TOTAL SWIN TIME  
 TOTAL TIME  
 TOTAL VOLUME  
 TOTAL ENERGY  
 TOTAL 2ND PASSES  
 TOTAL 2ND PASS TIME

Figure 5-37. OBR Routine Flow Chart (Sheet 3)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	179



locates the spoil position. SWGA calculates the trajectory, moves the bucket and keeps track of the swing angle histogram data. SPILE updates the spoil pile shape.

When performing bench fill, the total volume of overburden placed on the bench is considered as rehandle material. The BFILL routine determines where to dump the overburden and when the area to be filled is full. The bucket cannot exceed the carry radius until the dragline swings to the dump angle and stops. The bucket is then payed out at a fast rate to allow maximum radial distribution of the overburden.

If bucket heeling is to be performed, the bucket is pulled in by BCORD and TPWR and payed out by BHEEL and BPWR.

When the bucket dumps, a dump pause is added to the cycle time to allow time for the overburden to fall out of the bucket. SWGA returns the bucket to the dig area.

When the dig volume has been removed (KVR≠0), the total time, volume and energy for the current operation is calculated.

#### 5.22 OBRF

This routine writes the current overburden removal operation totals on the line printer and on the CRT terminal, when controlling the number of cycles to be removed. For the following discussions, refer to the flow chart in Figure 5-39.

The IDENT routine issues a top of form command and writes the identification header (date, time and file name). The operation number and type of operation are then written.

The current overburden removal totals (OBRX) are passed to the AOBR routine where they are averaged and displayed.

The current operation totals are then summed with the total overburden removal figures (TOBS).

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02MOC1	
SCALE	REVISION	SHEET	181

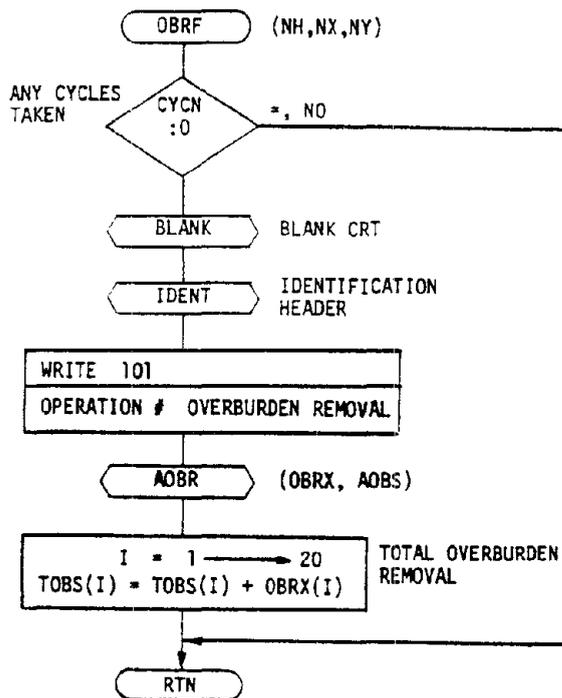


Figure 5-39. OBRF Routine Flow Chart

### 5.23 OBRI

The subroutine OBRI is called by OBS. It determines the attitude numbers of the front and lower planes from the data in the operation file. It also determines the angular limits that will contain the dig volume, the maximum dig depth, and the dragline's reach. Each operation OBRI initializes variables such as the starting spoil height, the bench fill heeling flag, the cycle time and the swing time. (See Figures 5-40 and 5-41.)

### 5.24 OBS

This routine controls the normal overburden removal procedures, removing overburden and dumping either on the spoil pile or into a hopper. For the following discussions, refer to the flow chart in Figure 5-42.

The maximum dig height (DIGH) is limited to the bench height and the overburden removal routine (OBR) is called. When the overburden has been removed, the OBRF routine is called to display the operation totals for this overburden removal procedure and to sum this operation with the total overburden removal operations.

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	182





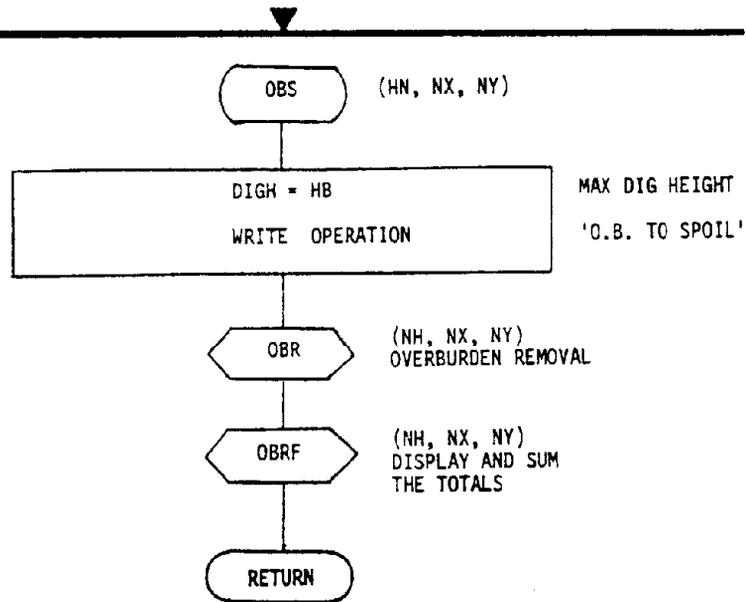


Figure 5-42. OBS Routine Flow Chart

#### 5.25 PFILE

The subroutine PFILE is called by DRAG after each operation to write the date, time, overburden grid and the spoil pile array into a file. The name of this file is the same as that entered in INAM unless the IXF is set to one. This indicates the operation data was prepared by DINP. In this case, the file name will be the same as the DV2 data file but the file type name will be DVT. (See Figure 5-43.)

#### 5.26 PINIT

The subroutine PINIT is called by INT to initialize the overburden grid. The boundaries of the highwall, dig face, bench and other pit features are determined by PINIT. The grid is then built up by several calls to SFILL. SFILL uses the information passed by PINIT to create the properly shaped pit. (See Figures 5-44 and 5-45.)

#### 5.27 RTHTA

This routine calculates the radial distance and angle to a desired point. The X and Y distances to the desired point are input via the calling arguments. The radial distance and angle to the desired point are calculated. The angle is expressed in both radians and degrees. Only positive angles are permitted. (See Figures 5-46.)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	185

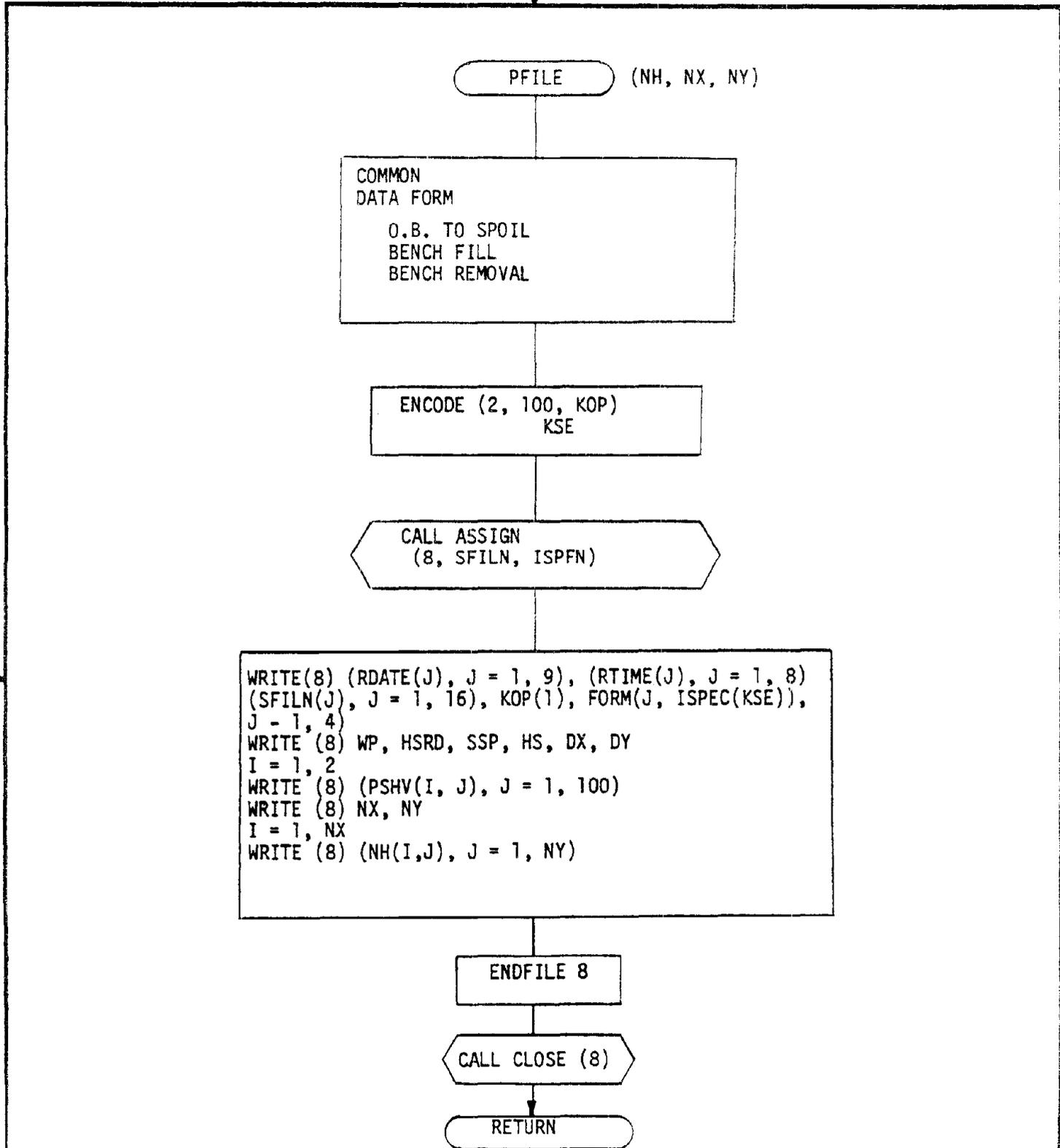


Figure 5-43. PFILE Routine Flow Chart

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	186

INITIAL BENCH

CALL SFILL  
(-1, 2, 0, N, M, A, I, A - LOKH, HC - SH,  
SH, A, N, M)

ALPHA = ATAN2(CL/2, DOR)  
ICX = (FDX + BW/2)/3.  
ICY = FDY/3.  
NYLC = (FDX - CL/2)/3.  
NXUC = (FDX + CL/2)/3.  
NYUC = IBY + (HO - HD)/5.  
NYLC = INBY - IO.

I = NXLC, NXUC  
J = NYLC, NYUC

SY = IABS(J - ICY)  
SX = IABS(I - ICX)  
THA = ATAN2(SX, SY)

THA > ALPHA

R = SQRT((2 \* SX)<sup>2</sup> + (3 \* SY)<sup>2</sup>)  
AD = 0

R > DOR

AD = (R - DOR \* HBD / SHW) \* SHW

A(I, J) = HB + AD - 127

RETURN

(INITIAL BENCH)

A = (DOR - HBD / SHW)

PINIT (A, N, M)

COMMON  
A(N, N) ~ NH(NX, NY)

I = 1, N  
J = 1, M  
A(I, J) = -127  
HBT = HB - HC  
SDX = 3 \* SD  
SH = 3 \* SHW  
TBD = HBD / SDX + .5  
IXC = HBT / SDX + .5  
IBKH = HBT / SH + .5  
IYC = M - IBKH - WC / 3. + .5  
IURE = (DOR) / 3. + .5  
Y = SQRT((DOR \* 2 - (CL/2) \* A) \* 2)  
INBY = (3 \* M - HB / SHW - DORAS / 2 - DHWC - Y) / 3.  
IBY = INBY + WC / 3.  
FCY = 3 \* M - HB / SHW - DORAS / 2 - DHWC  
FDX = HB / SD + DORAS / 1 + BW / 4.  
IYDL = FDX / 2.  
IYDL = M - IBKH - (DORAS / 1. + IO) / 3. + .5

CALL SFILL  
(1, 0, 0, N, 0, M, HB, 0, A, N, M)

CALL SFILL  
(1, 0, 0, IYOL, 0, INBY, HO, 0, A, N, M)

CALL SFILL  
(1, 2, 0, IYOL, INBY, IYBY + IOD, HO,  
-SDX, A, N, M)

CALL SFILL  
(1, 0, IYDL, 0, IY, HO, 0, A, N, M)

CALL SFILL  
(1, 2, IYDL, 0, IY, IY + IOD, HO, -SDX,  
A, N, M)

CALLSFILL  
(-1, 1, 0, IXC, IYC, IYC, IYC, M, HC  
SDX, A, N, M)

CALL SFILL  
(1, 2, 0, IYC, IYC, IYC + IBKH, HB,  
-SH, A, N, M)

(A)

(INITIALIZE PIT)

(CALCULATE LIMITS)

Figure 5-44. PINIT Routine Flow Chart

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	187

SYMBOL	UNITS	DESCRIPTION
AD	FEET	Reach Limit for Bench Initialization
ALPH	RAD	Angle Limit for Bench Initialization
FDX		Dragline Position X - Coordinate
FDY		Dragline Position Y - Coordinate
HBT	FEET	Height of Overburden Minus Height of Coal
I		Index
IBD		Width of Bench Grade
IBKH		Width of Highwall Grade
ICX	YARD	X Coordinate of Dragline for Bench Removal
ICY	YARD	Y Coordinate of Dragline for Bench Removal
IDOR	YARD	Operating Radius in Yards
J		Index
NXLC		Lower Limit for Bench Initialization - X Coordinate
NXUC		Upper Limit for Bench Initialization - X Coordinate
NYLC		Lower Limit for Bench Initialization - Y Coordinate
NYUC		Upper Limit for Bench Initialization - Y Coordinate
R	FEET	Radial Limit for Bench Initialization
SDX		Slope of Dig Face Times Three
SH		Slope of Highwall Times Three
SX		Variable Used in Initialization of the Bench
SY		Variable Used in Initialization of the Bench
THA		Variable Used in Initialization of the Bench
X		Variable Used in Initialization of the Bench

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	<b>WE02MG01</b>
SCALE	REVISION	SHEET <b>188</b>

Figure 5-45. PINIT Symbol Table

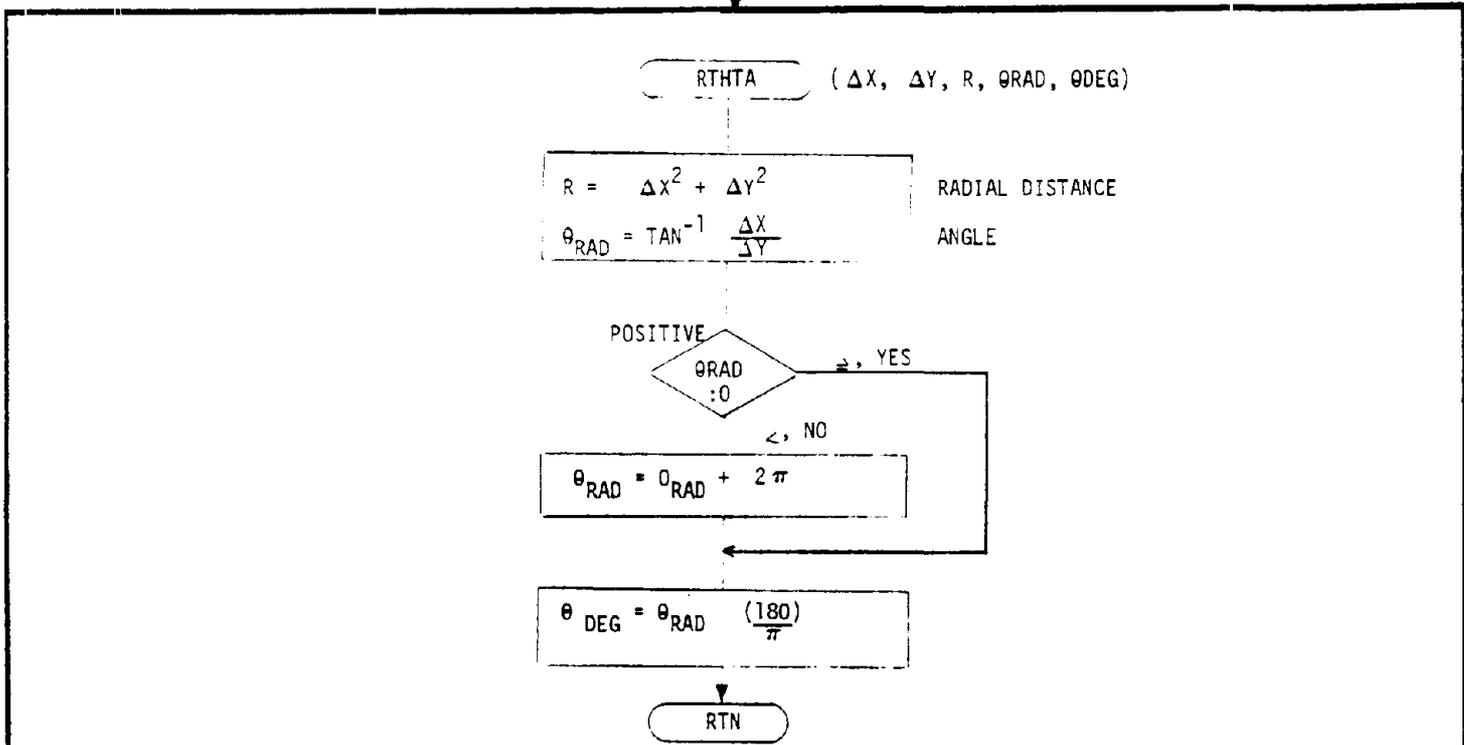


Figure 5-46. RHTTA Routine Flow Chart

5.28 SFILL

SFILL is called by PINIT to initialize an overburden grid. PINIT passes X and Y limits, X and Y starting points and a slope to SFILL. SFILL creates the shape defined by these values. SFILL is called seven times. Each time it shapes a part of the grid. (See Figures 5-47 and 5-48.)

5.29 SHGT

This routine calculates the height of a spoil pile segment. It calculates the height from the volume contained in the spoil segment and the pit dimensions. (See Figure 5-49.)

There are two sets of spoil segment height equations. (See Figure 5-50.) One set of equations for AREAL and another set for heights greater than PHAL.

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	189

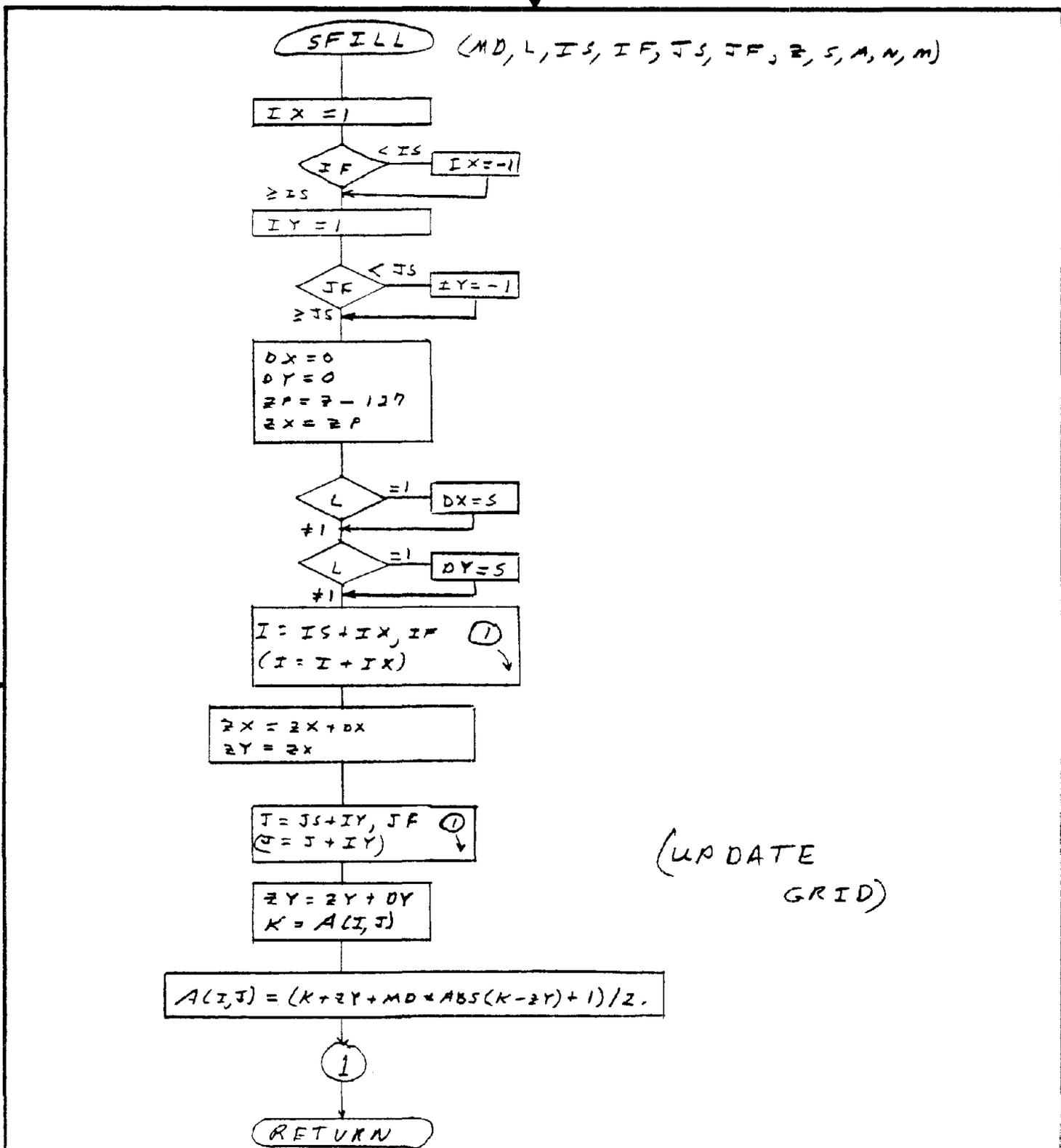


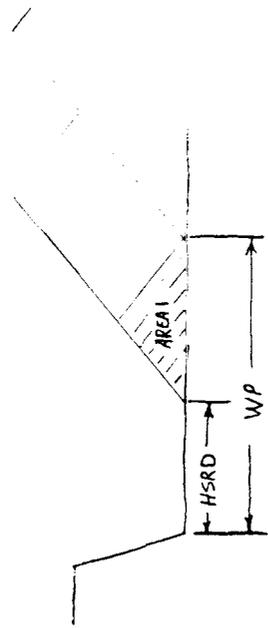
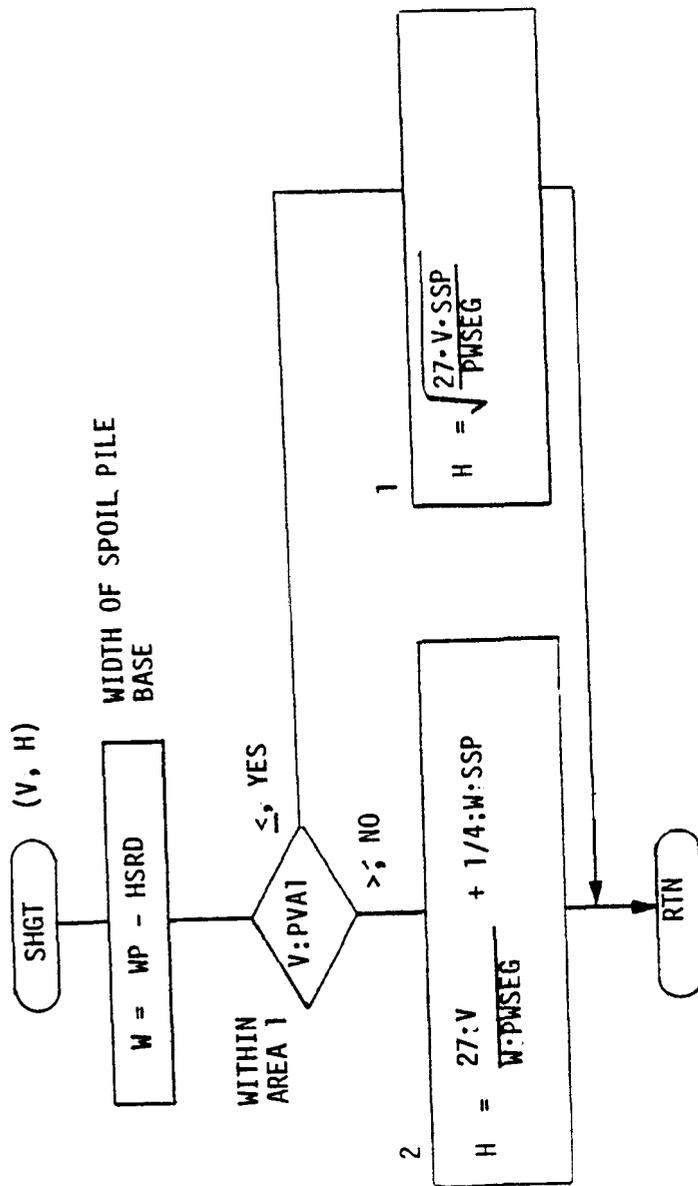
Figure 5-47. SFILL Routine Flow Chart

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	190

SYMBOL	UNITS	DESCRIPTION
DX		X Increment on Overburden Grid
DY		Y Increment on Overburden Grid
I		Index
IX		X DO Loop Increment
IY		Y DO Loop Increment
J		Index
K	FEET	Grid Height
ZP	FEET	Grid Height
ZX	FEET	Grid Height
ZY	FEET	Grid Height

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001
SCALE	REVISION	SHEET 191

Figure 5-48. SFILL Symbol Table



SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	192

Figure 5-49. SHGT Routine Flow Chart

BENCH

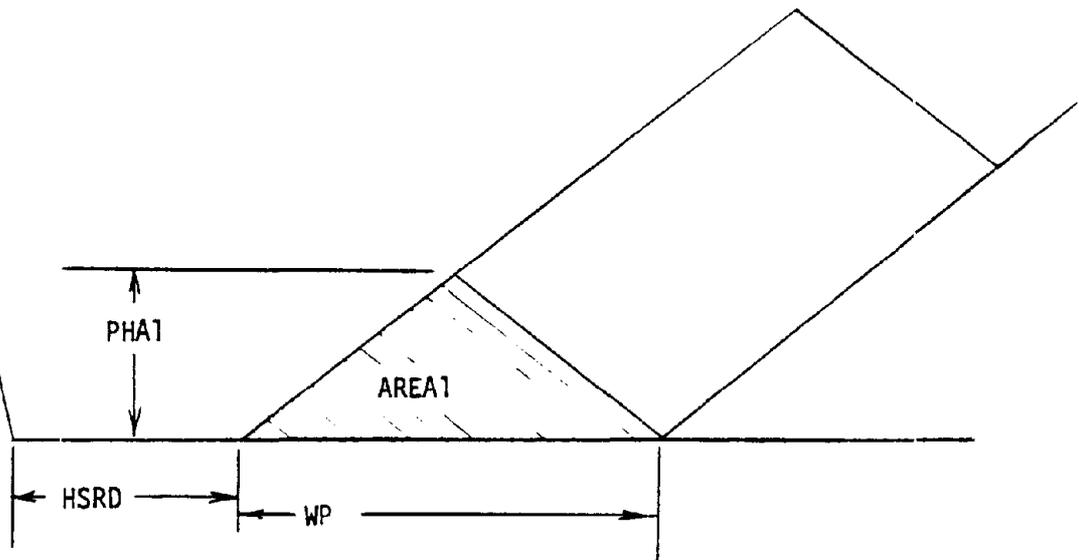


Figure 5-50. Spoil Segment Height Equations

### 5.30 SPEED

The SPEED subroutine is called by TPWR to calculate the time required for the hoist, drag or swing motions of a given increment of the bucket trajectory. For each increment SPEED is called three times for the three different motions. The inputs to SPEED are: the total number of increments, the number of the present increment, the maximum acceleration of the motion, the maximum deceleration of the motion, the velocity limit of the motion, an array indicating increments where the motion is stopped or changes direction, the 360° swing flag, the initial velocity of the increment, a flag indicating the motion (either hoist, drag or swing) and an array containing the displacement of the motion for each increment. The SPEED subroutine examines the trajectory and determines the maximum velocity allowed at the end of the increment. This

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	193



is a function of the velocity limit of the motion, the displacement of the increment and the displacement to the next stop or direction change of the motion. SPEED either speeds up, slows down or continues the present velocity through this increment. Because of the processing of the displacement to the next stop, the motion is not called upon to decelerate more than is possible. If the motion accelerates, the velocity cannot exceed the prescribed velocity limit. From these calculations, the time of the motion is determined. It can be the case that for a given increment a motion has a small initial velocity, rather large displacement and a zero terminal velocity due to a stop or change in direction. The trajectory grid is not fine enough to allow the motion to accelerate then decelerate. The acceleration must be constant for a given increment. This situation can lead to an excessive time to perform the motion. To avoid this situation, the time for each increment is checked against an average time calculated assuming the motion can be accelerated and decelerated in the same increment. The smaller time is taken for the increment. The power taken to do this accelerating and decelerating is lost and not included in the total power figures. If the 360° Swing Flag is set, the past velocity of the bucket is saved so no momentum is lost from the dig to return swing. (See Figures 5-51 and 5-52.)

### 5.31 SPILE

This routine controls the buildup of the spoil pile. The position where the overburden material is to be dumped (KSP) was determined by the DUMP routine. This routine places the overburden in that spoil segment, PSHV(2,KSP) and then calculates the height of the spoil segment. The overburden is then spread in both X directions to maintain the spoil pile angle of repose. It is spread first in the direction that the dragline approached the spoil segment. This simulates the bucket swinging past the dump position when the swing direction is reversed.

There are two sets of spoil segment equations for height and volume calculations. (See Figure 5-50.) One set of equations for AREAL and another set for heights greater than PHAL. (See Figures 5-53 and 5-54.)

SIZE	CODE IDENT NO.	
<b>A</b>	<b>12464</b>	WE02M001
SCALE	REVISION	SHEET 194







SYMBOL	UNITS	DESCRIPTION
ADEL		Direction of Spoil Distribution - = Advancing X Direction + = Decreasing X Direction
F1	YD <sup>3</sup> /FT <sup>2</sup>	Constant for Volume Calculations
F2	YD <sup>3</sup> /FT	Constant for Volume Calculations
FLAG		Check Spoil Slope of Adjacent Segments Flag 0 = Slopes OK - Finished 1 = Check Slopes
HX	FEET	Allowable Height Difference (Angle of Repose) Between Adjacent Spoil Segments
HXT	FEET	Maximum Allowable Height Difference
IA		Spoil Segment Index
IBX		Spoil Segment Index
KI		Spoil Search Index
SF	YD <sup>3</sup> /FT <sup>2</sup>	Constant for Volume Calculations
T1	FT <sup>2</sup>	Constant for Volume Calculations
VT	YD <sup>3</sup>	Total Volume of Two Adjacent Spoil Segments
VT0	YD <sup>3</sup>	Volume Difference Breakpoint
VX	YD <sup>3</sup>	TMPR Volume Variable
VX0	YD <sup>3</sup>	Allowable Volume Difference (Angle of Repose) Between Adjacent Spoil Segments in Linear Region

SIZE	CODE IDENT NO	
<b>A</b>	<b>12464</b>	WE02M001
SCALE	REVISION	SHEET 198

Figure 5-54. SPILE Symbol Table

5.32 SPREAD

The routine SPREAD distributes material that has been dumped in a bench fill operation or graded while bucket heeling. (See Figures 5-55 and 5-56.)

The inputs to the routine are spread coordinates, the volume of material and the fill height. The coordinates mark the starting point for the spreading procedure. The routine adds one foot (one third of a yard of volume) to the grid array at the given coordinate. The derivative of the grid height or gradient is computed in eight directions along the coordinate axis and the diagonals. If any of these gradients are less than (more negative) than the angle of repose, the material moves in that direction one step. The step size is either 1 or 1.414 yards. The direction chosen is always that of the steepest descent. Ties are broken by a random number generator. After the initial test, the gradient is computed only in the five directions that are less than or equal to 90 degrees from the direction of the last motion. If the gradient is less than the angle of repose, the process stops. The array height is incremented by one foot at this coordinate. The routine then returns to the original coordinate and repeats this process. This iteration loop is completed when either all the material has been distributed or the material has piled up and equalled the height limit. In the first case, the subroutine returns the volume equal to zero. In the latter case, the volume will be returned non-zero. The height limit is used in BHEEL to fill up the terrain as the material is graded by the bucket's heel.

5.33 SVOL

This routine calculates the volume contained in a spoil pile segment. It calculates the volume from the height of the spoil segment and the pit dimensions.

There are two sets of spoil segment volume equations. (See Figure 5-50.) One set of equations for AREAL and another set for heights greater than PHAL. (See Figure 5-57.)

5.34 SWGA

This routine moves the bucket from the bucket loading position to the dump location and vice versa. It also updates the swing angle histogram.

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A	12464	WE02M001	
SCALE	REVISION	SHEET	199



SYMBOL	UNITS	DESCRIPTION
GS		Gradient of Fill Material in Ith Direction
GM		Maximum Gradient
HD	FEET	Height of Material Spread
HGT	FEET	Maximum Fill Height at Grid Point ICC, JCC
I		Index
ICC		X - Grid Point
II		Index
J		Index
JCC		Y - Grid Point
JD		Index
JJ		Index
K		Integer Array to Store Direction
KJK		Random Integer
KKK		Index
M		Index
NICC		New Fill Point X - Component
NJCC		New Fill Point Y - Component
NRL		Check Stop if Close to Grid Limits
PHD	FEET	Proposed Additional Fill Height
R		Step Size of Gradient Procedure
TH		Constant
VR		Volume to be Spread
XR		Direction of Step Arrays X - Component
YR		Direction of Step Arrays Y - Component

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	201

Figure 5-56. SPREAD Symbol Table

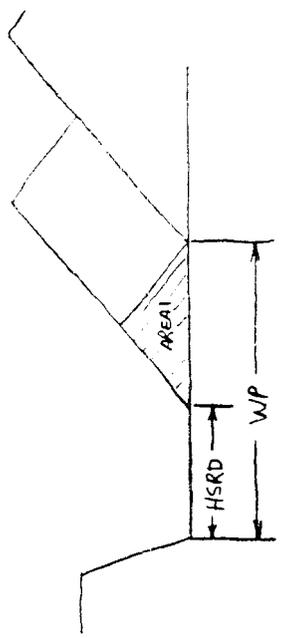
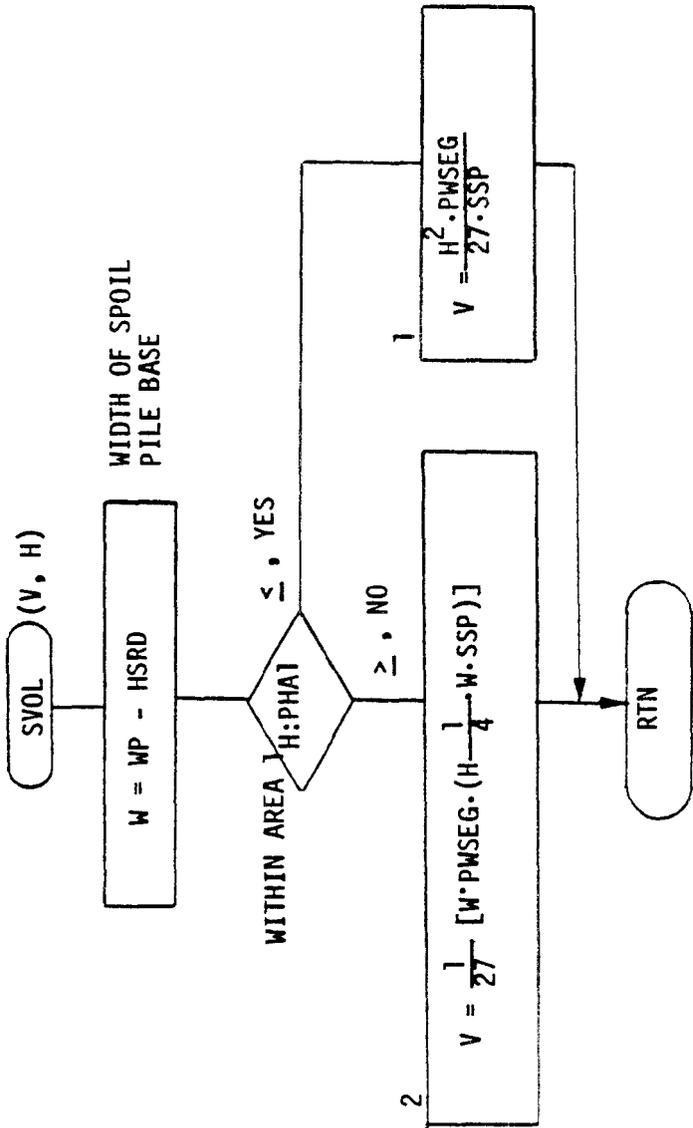
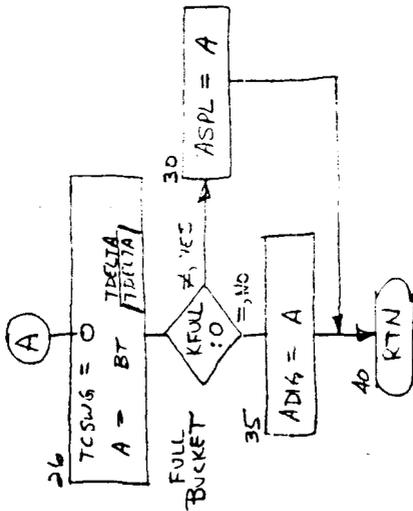


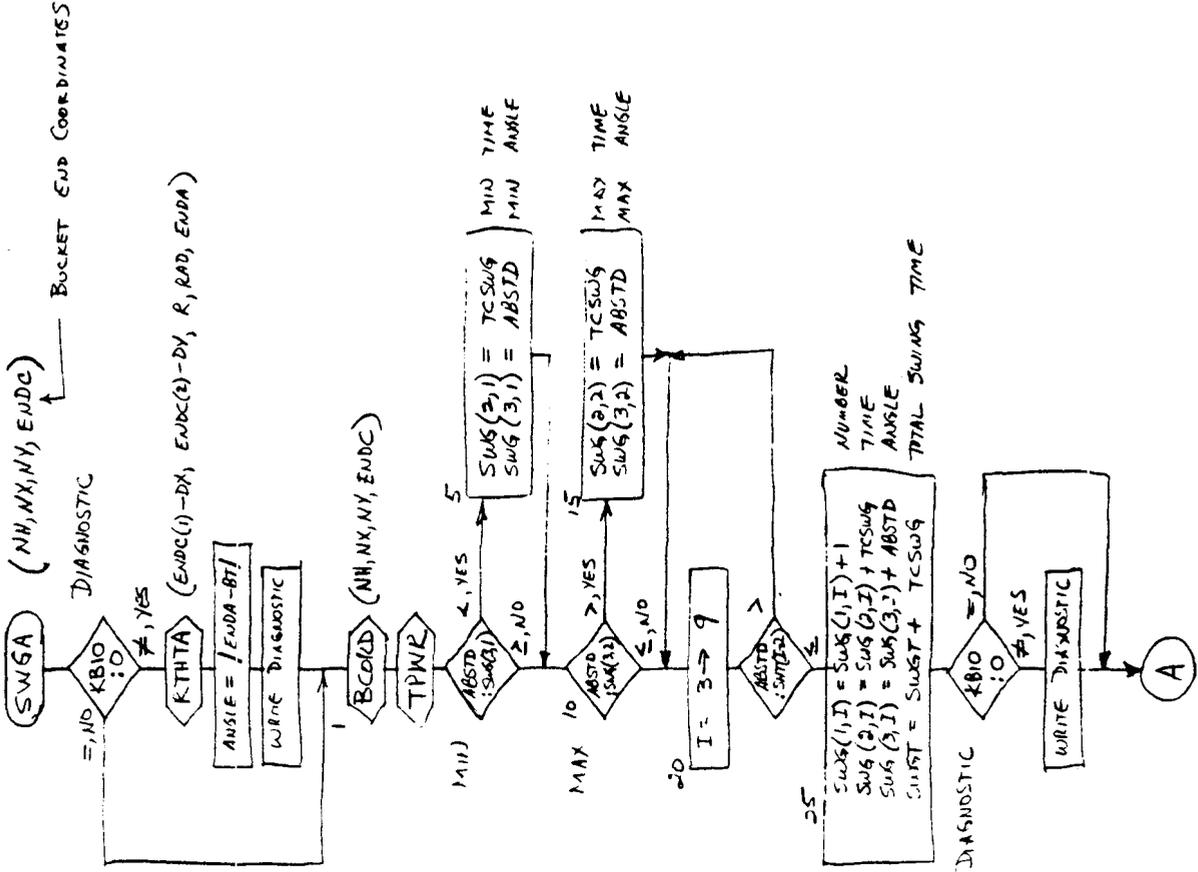
Figure 5-57. SVOL Routine Flow Chart

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001
SCALE	REVISION	SHEET 202



SWGS (X,I)	MINIMUM	MAXIMUM
(X,1)	0	30
(X,2)	30	60
(X,3)	60	80
(X,4)	80	100
(X,5)	100	120
(X,6)	120	150
(X,7)	150	180
(X,8)	180	360
(X,9)		
(X,10)		

WHERE  
 X = 1, NUMBER  
 X = 2, TIME  
 X = 3, ANGLE



SIZE	CODE IDENT NO.	WE02M001
<b>A</b>	<b>12464</b>	
SCALE	REVISION	SHEET
		203

Figure 5-58. SWGA Routine Flow Chart

The desired bucket ending coordinates are specified by the array ENDC (3). The bucket is removed to that position by calling the BCORD and TPWR routines.

The minimum and maximum swing angle values are updated if necessary. Then the swing angle traversed and swing time required are stored in the appropriate swing angle histogram category. (See Figures 5-58 and 5-59.)

### 5.35 TPWR

For each cycle the BCORD subroutine generates the bucket trajectory from the end of the dig to the spoil point and from the spoil point to the start of the next dig. This bucket trajectory consists of a series of coordinates  $(r_i, \theta_i, z_i)$  that define the path of the bucket. BCORD produces a set of these coordinates for the swing to spoil and a set for the return swing. For each half cycle or swing these coordinates are passed to the subroutine TPWR. TPWR calculates the time and energy required to move the bucket through the trajectory specified by BCORD. The flow charts for this routine are contained in Figures 5-60 and 5-61.

The TPWR calculates the hoist and drag lengths for each point of the bucket trajectory. The drag length is the distance from the drag socket to the fairlead. The hoist length is the distance from the hoist hitch to the boom point. The drag socket and the hoist hitch can be located from the trajectory point. The difference between successive hoist and drag lengths is calculated. If this difference exceeds five feet the trajectory is refined by linear interpolation. This refined trajectory is then processed to detect any stops or changes in direction of the hoist and drag motions. It is assumed that the swing motion will always be in one direction. So there is only one stop for the swing motion and that is the end coordinate. TPWR uses this information plus the performance parameters to calculate the time required for each increment of the bucket trajectory. This is done by calculating the time required for each motion (hoist, drag and swing) and taking the maximum as the time for this increment. The calculations for each motion are done by the SPEED subroutine. The time for this increment and the

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<b>A</b>	<b>12464</b>	WE02M001	
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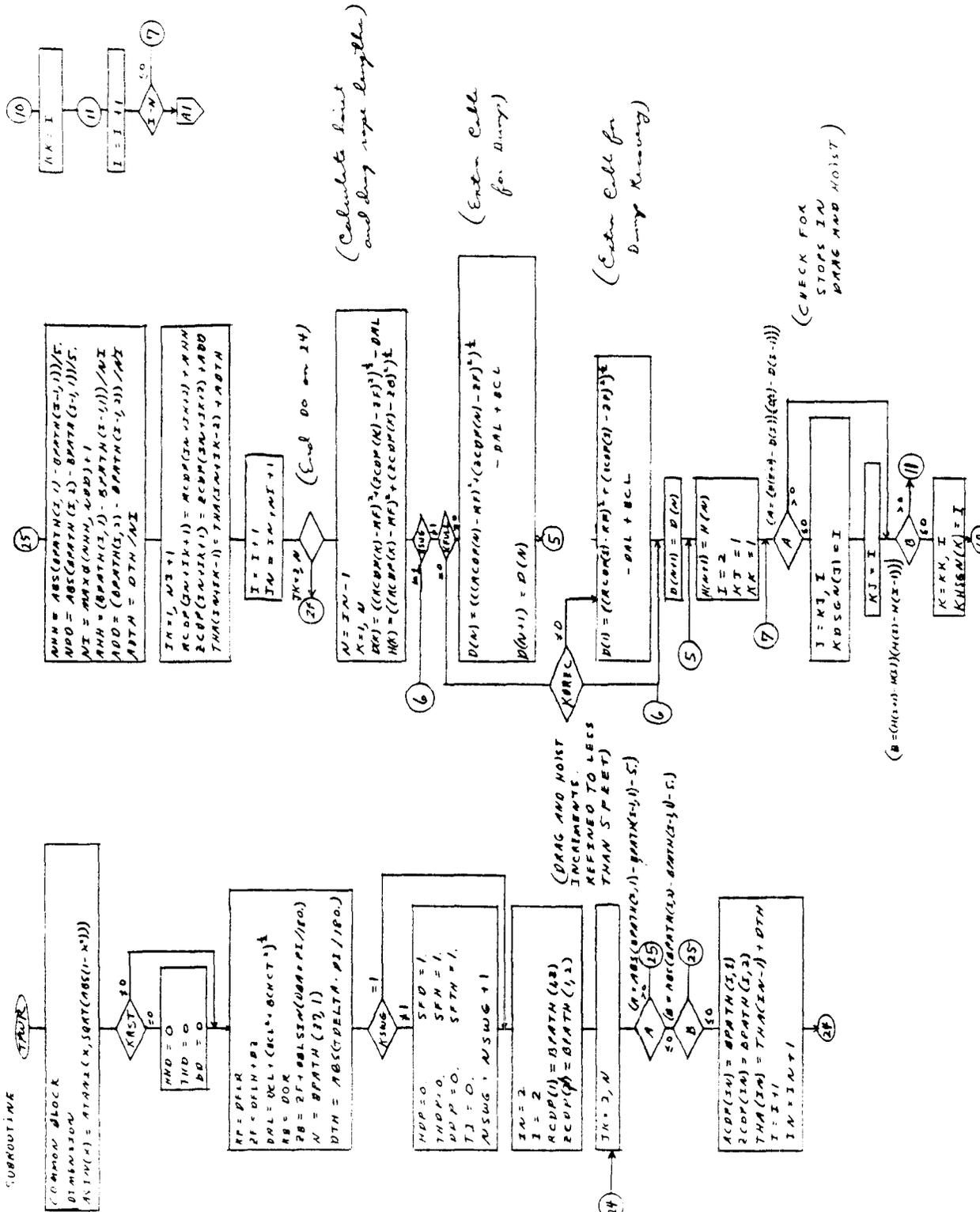


Figure 5-60. TPWR Routine Flow Chart (Sheet 1 of 3)

SIZE	CODE IDENT NO.	
<b>A</b>	<b>12464</b>	WE02M001
SCALE	REVISION	SHEET 206

SCALE	REVISION	SHEET	207
SIZE <b>A</b>		CODE IDENT NO. <b>12464</b>	
		WEO2M001	

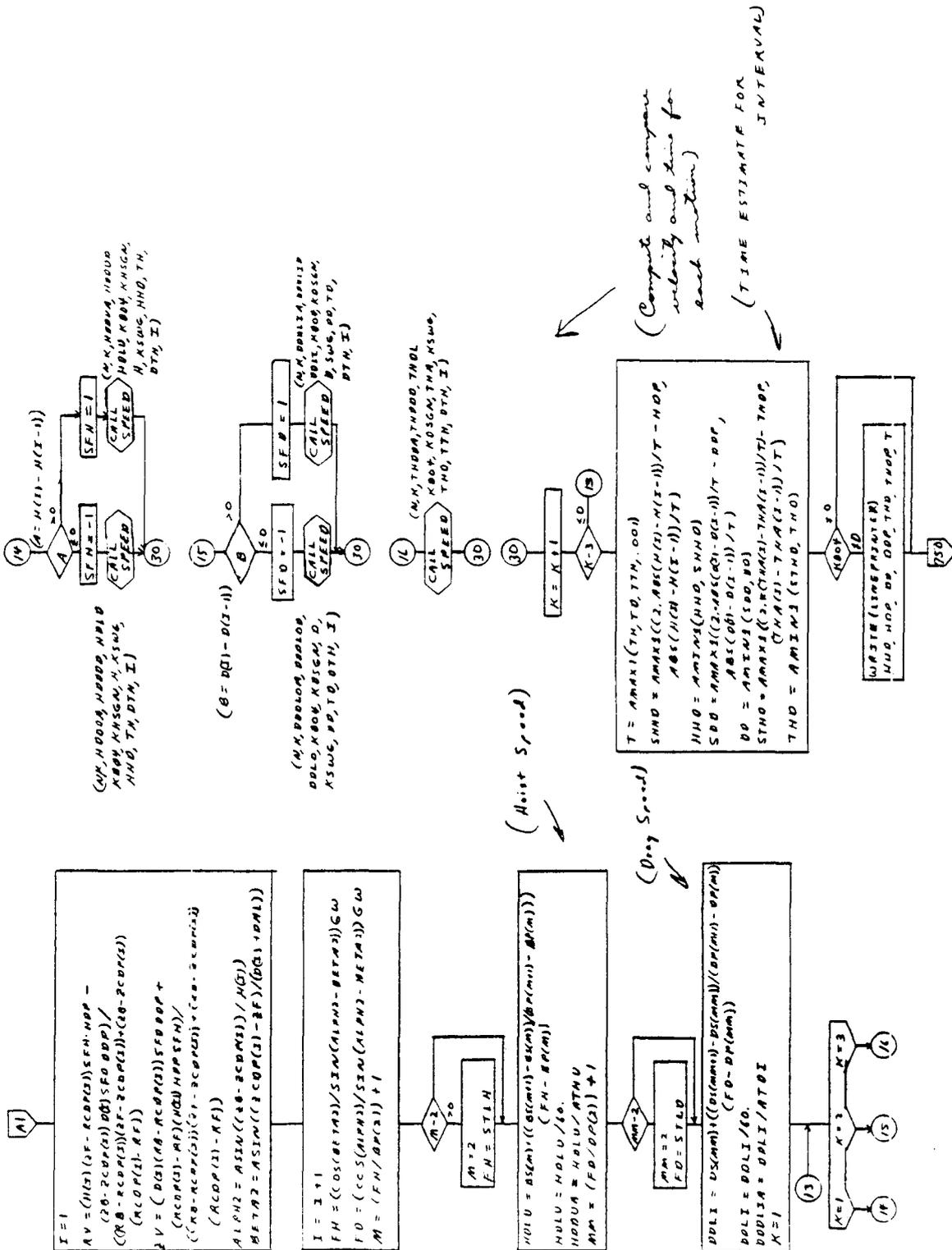


Figure 5-60. TPWR Routine Flow Chart (Sheet 2)



SYMBOL	UNITS	DESCRIPTION
ADD		Variable Used in Refinement of Trajectory
ADTH		Variable Used in Refinement of Trajectory
AHH		Variable Used in Refinement of Trajectory
ALPH	RAD	Average Angle the Hoist Rope Makes with the Vertical
ALPH1	RAD	Angle Hoist Rope Makes with the Vertical
ALPH2	RAD	Angle hoist Rope Makes with the Vertical
BETA	RAD	Average Angle the Drag Rope Makes with the Horizontal
BETA1	RAD	Angle the Drag Rope Makes with the Horizontal
BETA2	RAD	Angle the Drag Rope Makes with the Horizontal
D		Array Used to Store Drag Cable Lengths
DAL	FEET	Distance from Drag Socket to Hoist Hitch
DD	FEET/SEC	Drag Velocity
DDDLIA	FEET/SEC <sup>2</sup>	Drag Acceleration Limit Inward
DDLI	FEET/SEC	Drag Speed Limit Inward
DR		Dummy Variable Used in Print Diagnostic
DTH	RAD	Theta Increment of Swing
FAD	LBS	Force Due to Acceleration on Drag Ropes
FAH	LBS	Force Due to Acceleration on Hoist Ropes
FD	LBS	Force Drag
FH	LBS	Force Hoist
H		Array Used to Store Hoist Cable Lengths
HDDUA	FEET/SEC <sup>2</sup>	Hoist Acceleration Limit Upward
HDLU	FEET/SEC	Hoist Velocity Limit Upward
I		Variable Used in Refinement of Trajectory
IB		Index
IK		Index

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<b>A</b>	<b>12464</b>	WE02M001	
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Figure 5-61. TPR Symbol Table (Sheet 1 of 3)

SYMBOL	UNITS	DESCRIPTION
IN		Index
J		Index
JK		Index
KDSGN		Array Used to Record Stops in Drag
KHSGN		Array Used to Record Stops in Hoist
K		Index
KJ		Index
KK		Index
M		Index
MM		Index
N		Index
NDD		Number of Divisions in Trajectory Refinement - Drag
NHHH		Number of Divisions in Trajectory Refinement - Hoist
NI		Index
NSWG		Swing Counter Incremented in Reset
PD	KW	Drag Power this Increment
PH	KW	Hoist Power this Increment
PTH	KW	Swing Power this Increment
PW	KW	Total Power for this Increment
RA	FEET/SEC <sup>2</sup>	Acceleration in Radial Direction
RB	FEET	Radius of Boom
RF	FEET	Fairlead Radius
RV	FEET/SEC	Radial Velocity
RVP	FEET/SEC	Past Radial Velocity
SDD	FEET/SEC	Drag Velocity
SHHD	FEET/SEC	Hoist Velocity
STHD	RAD/SEC	Theta Velocity

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
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Figure 5-61. TPWR Symbol Table (Sheet 2)



initial velocities are used to compute the final velocities for all three motions. The initial velocities are saved from the previous increment in the variables DDP (drag), HDP (hoist) and THDP (swing). The hoist and drag rope velocities are then converted to velocities in the (r,z) plane. The average accelerations for hoist, drag and swing are calculated from the initial and final velocities. From this and from the bucket weight the average hoist and drag force applied for this increment are determined. For the swing motion the torque is calculated from the bearing friction, the angular acceleration and the inertia. The power and energy for the increment are then calculated from the average force and efficiency of the motion. If the acceleration of any of the motions is opposite the direction of motion that motion is plugging and power will be generated. This situation is detected in the time and velocity calculations and a flag is set. This flag reverses the sign of the power calculations and a flag is set. This flag reverses the sign of the power calculations. As power is generated by a motion the efficiency of that motion is reversed. The power generated is a percentage of the power applied to that motion's gearing. The energy for each motion and for the combined motions are totaled for each increment. If the sum of the energies for each motion is negative this negative value is not summed in the total. Thus the total energy figure represents the energy used by the dragline. If regenerated power is not used as it is generated it is lost.

### 5.36 WDAT

The subroutine WDAT writes out the results (totals and averages) of an operation in a file with type name DV3. The first name corresponds to the name of the pit file for that operation and is stored in the array WFILN. WDAT is called by OBR or MOVE. It is not called unless the IXF flag is set to one which means the simulation is using DV2 type data files prepared by DINP. (See Figures 5-62 and 5-63.)

### 5.37 WRDG

The Subroutine WRDG is called by EXDRG. WRDG performs one of three functions depending on the value of the variable IT which is passed to WRDG. If IT is equal to minus

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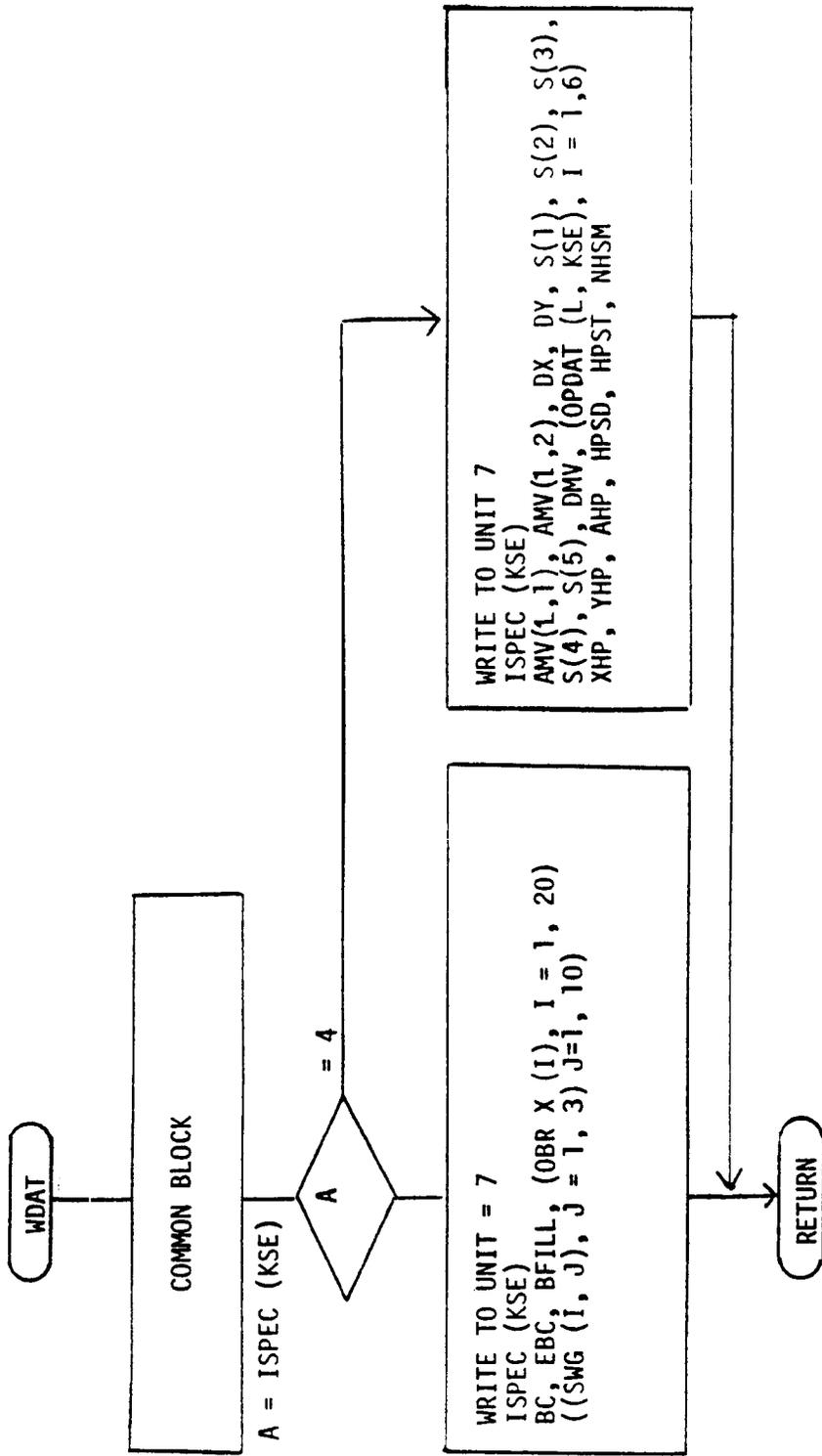


Figure 5-62. WDAT Routine Flow Chart

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	213



one, WRDG reads the file ACT.FIL to obtain the index pointers for EXDRG. If the IXF flag is set to zero, EXDRG does not call WRDG again. If the IXF flag is set to one, EXDRG calls WRDG with IT=0. In this case, WRDG reads the proper parameter file for the simulation of this Set. The type name of this parameter file is COM and the first name is that letter of the alphabet corresponding to the Set number. EXDRG then calls WRDG with IT=1. On this call, WRDG reads the DV2 file to get the operation data. WRDG also determines whether to initialize a pit or read in a pit file. If a pit file is to be read in, WRDG determines the name of the pit. This name is stored in the array RFILN for the INT subroutine which reads the pit file. (See Figures 5-64 and 5-65.)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	215





## 6. DATA INPUT AND OPTIMIZATION PROGRAMS

### 6.1 DINP

The DINP program is the main program of the data input and optimization scheme. It provides a means to specify removal procedures by a series of "mine language" inputs. From these "mine language" inputs it creates the proper operation and case data files for the DRAG program to simulate the removal procedures. The program also determines the sequence in which the operations are to be simulated by DRAG in order to decrease the computer run time and avoid repetition in simulating the operations. DINP is a conversational program. Data is entered by responding to statements as they appear on the CRT screen. The first input is the set number which is used to identify the mine and dragline characteristics and the basic removal strategy specifying the type and order of the operations in the case. Within this basic removal strategy multiple inputs are accepted. For example, one can enter several pit widths or keycut widths. DINP stores the input data for each set in data files. After all the data has been entered DINP calls the subroutine OPRP to process these inputs and create the proper operation and case data for the DRAG program. DINP also determines which operations must be simulated in order to produce the results for each case of the set. For instance if two cases differ in the last of four operations it suffices to simulate only five operations to produce the results for both cases. The operation and case data for each case are displayed by the subroutine DATA. The data can be edited at this time if any changes are desirable. However, operations can not be deleted from or added to any case. After the editing is complete DINP writes the case and operation data into a DV2 type file. Then it branches back to accept data for the next set. (See Figures 6-1 and 6-2.)

### 6.2 GDATA

GDATA is a subroutine called by DINP to convert ASCII input characters to numbers. GDATA is passed the input line in the array B and returns the numerical values of the inputs in the array P. If an error is detected in the conversion an error flag is set. This error flag is tested in DINP. If it is set the DINP program asks for the input entry to be repeated. (See Figures 6-3 and 6-4.)

SIZE	CODE IDENT NO.		
A	12464	WE02M001	
SCALE	REVISION	SHEET	218

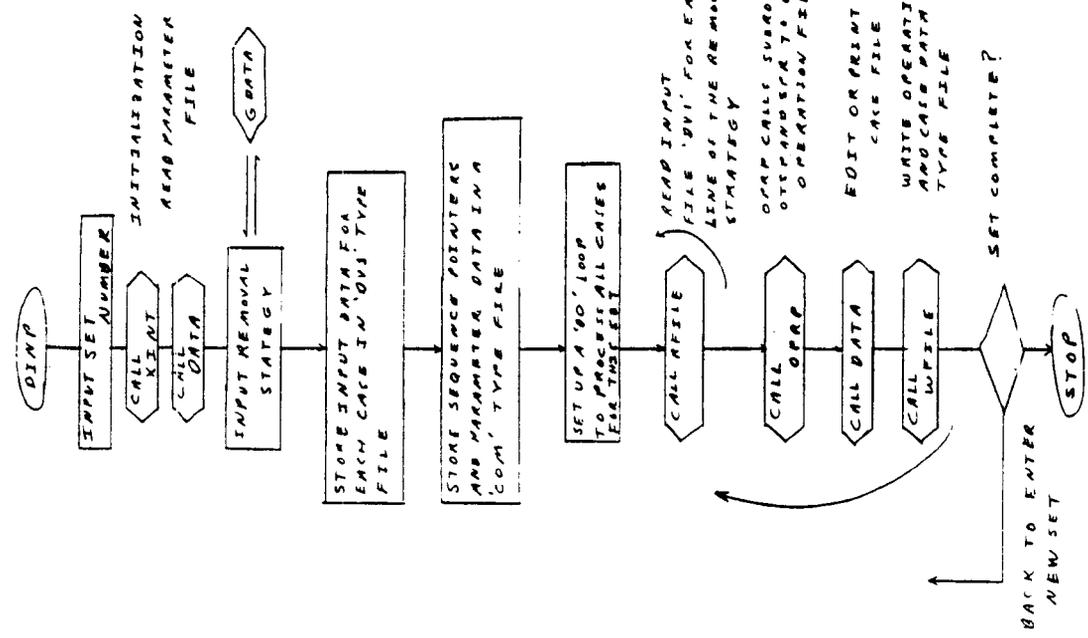
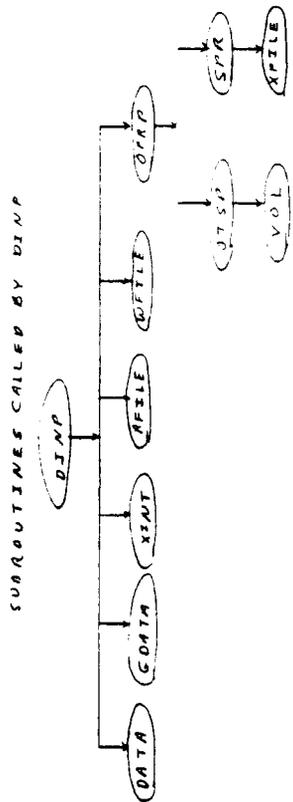
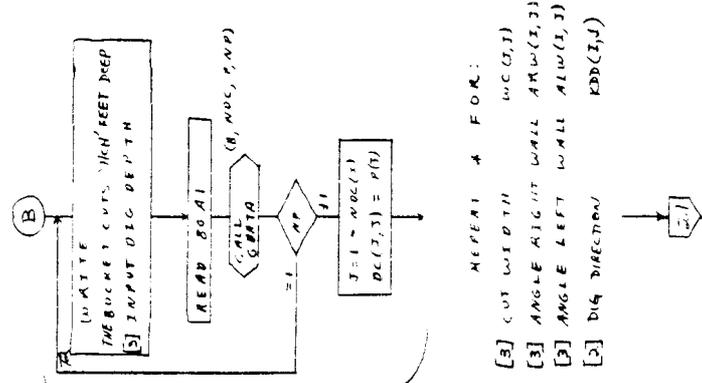
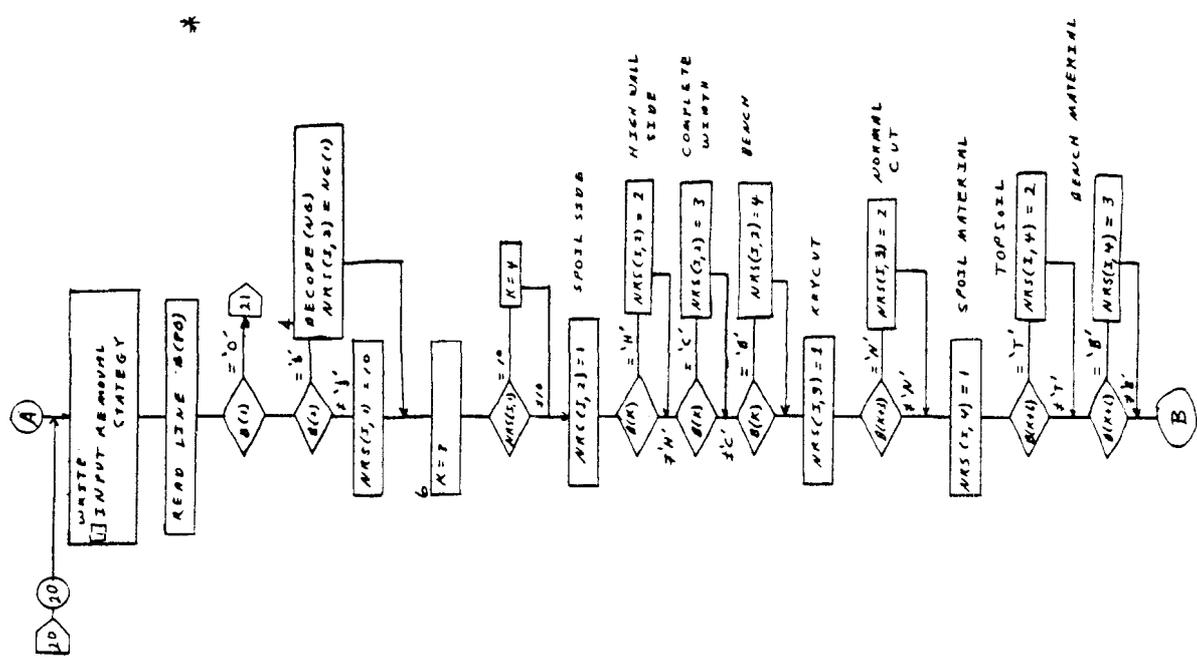
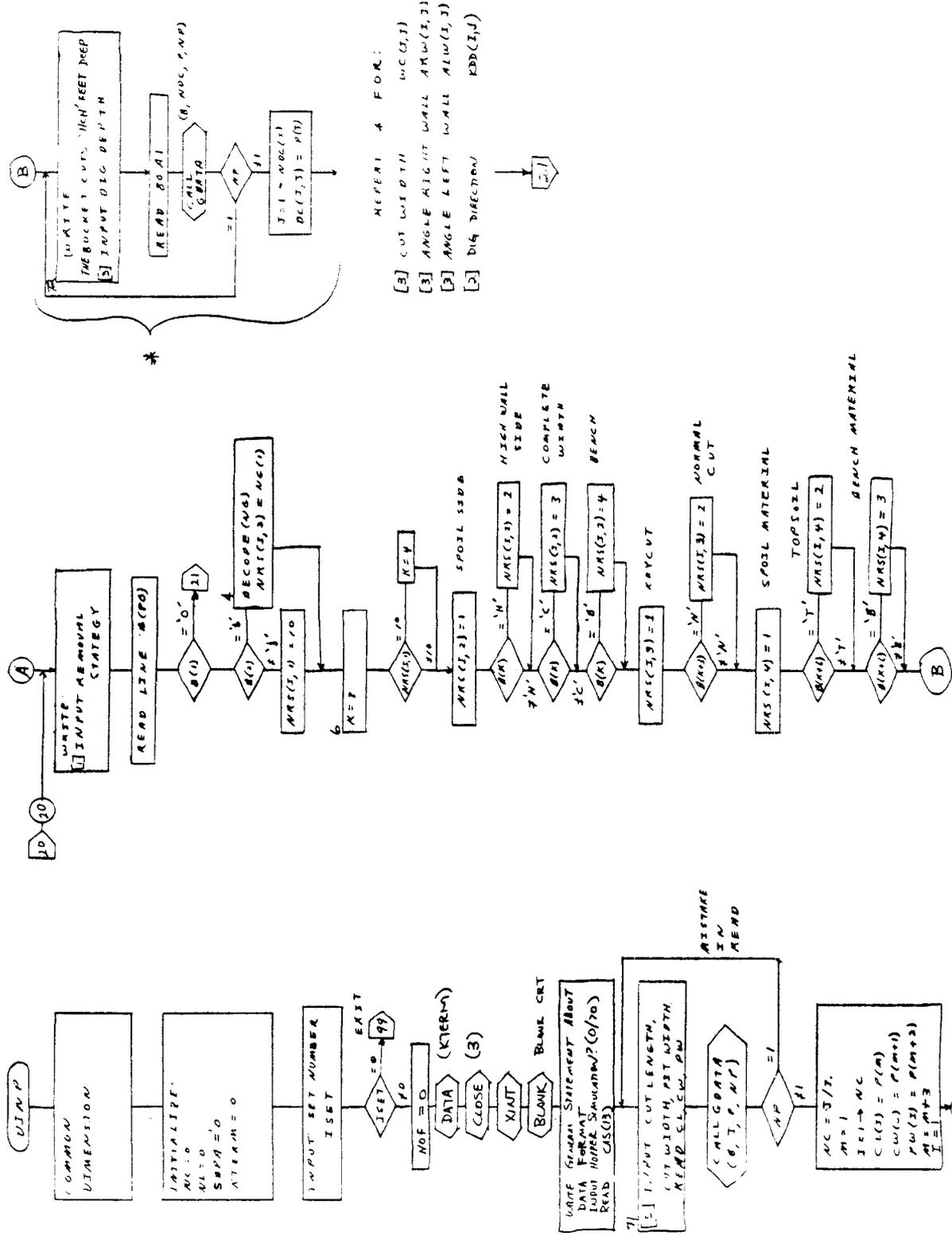


Figure 6-1. DIMP Routine Flow Chart (Sheet 1 of 5)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	219



SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	220

Figure 6-1. DIMP Routine Flow Chart (Sheet 2)

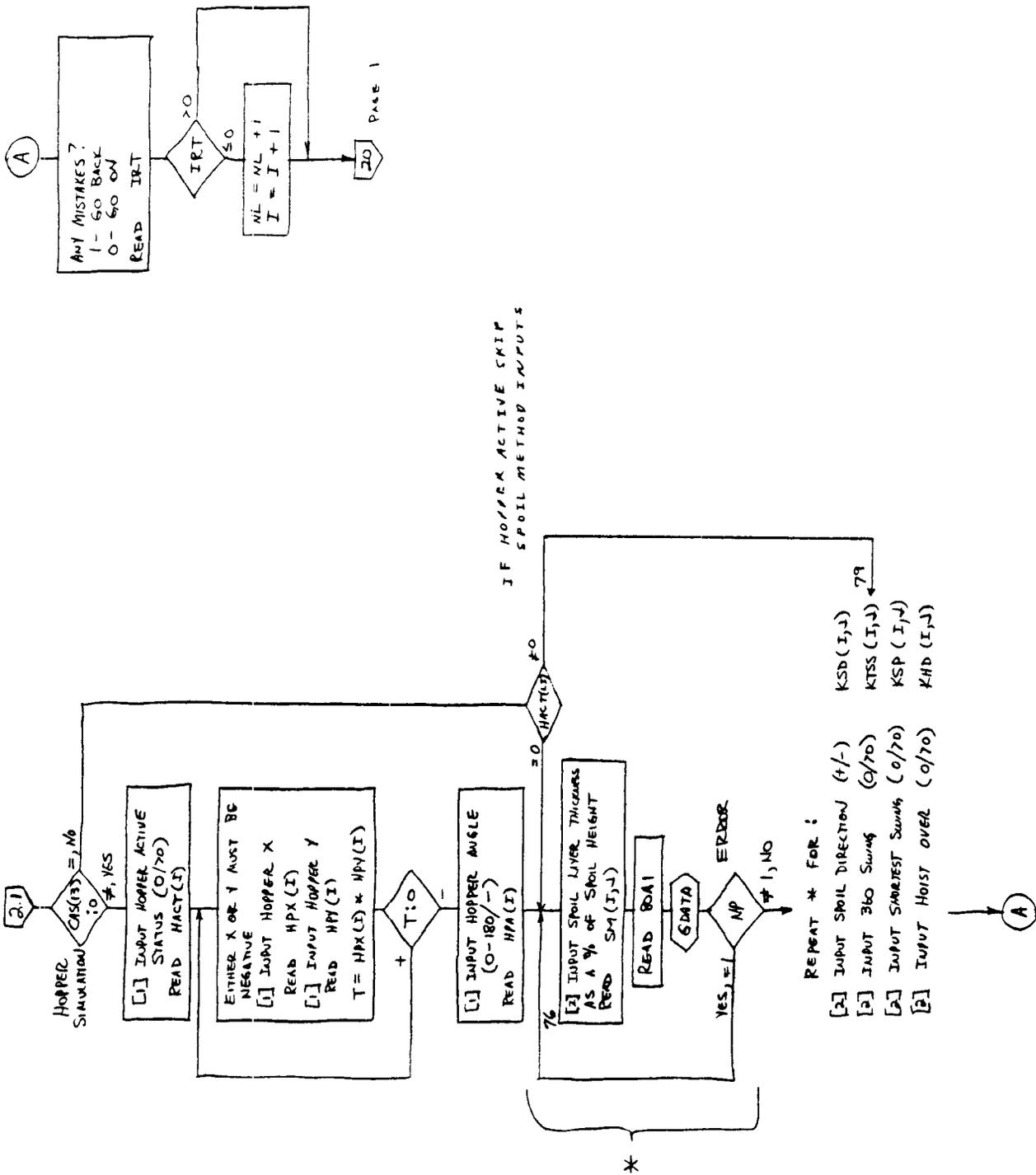
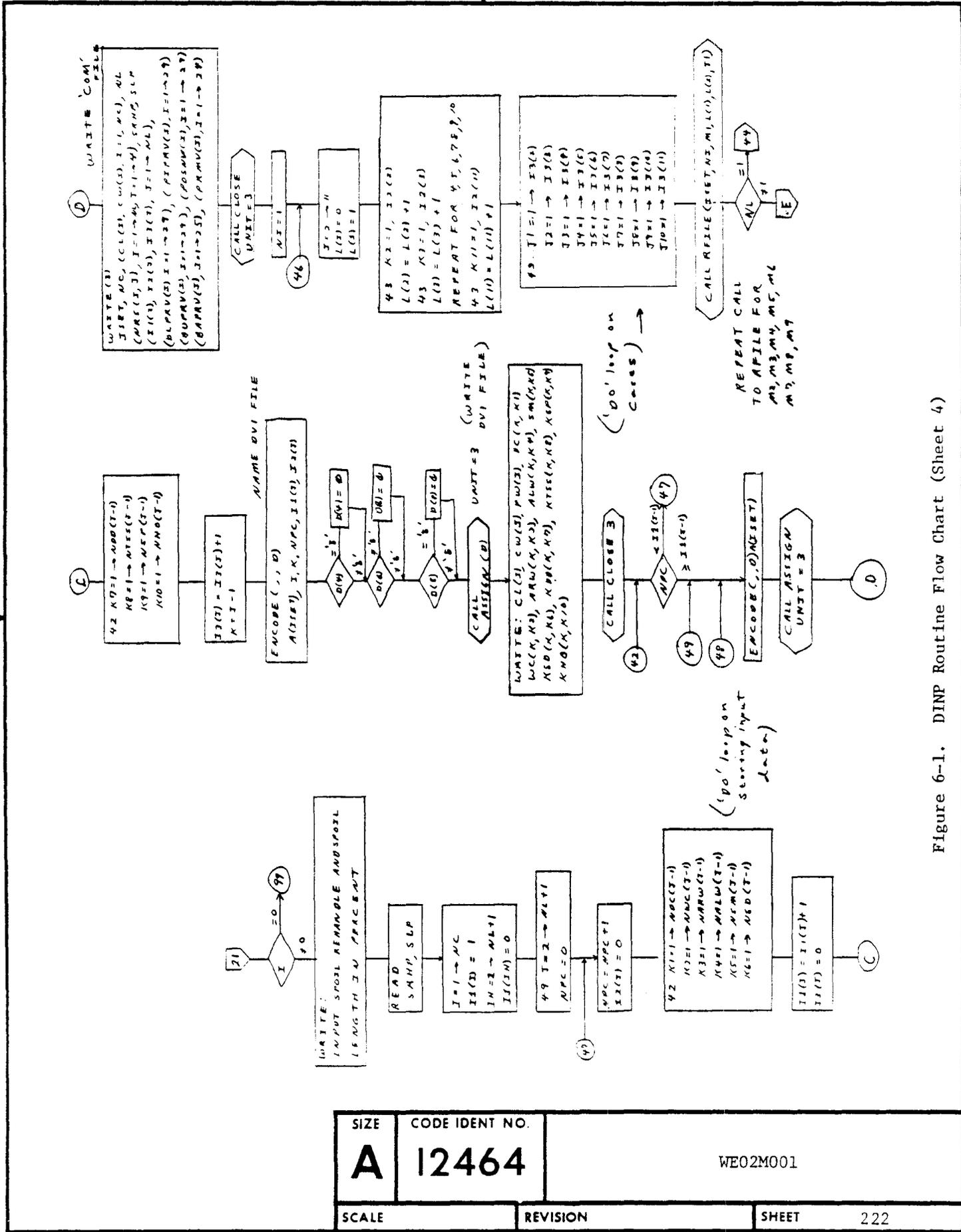


Figure 6-1. DIMP Routine Flow Chart (Sheet 3)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	221



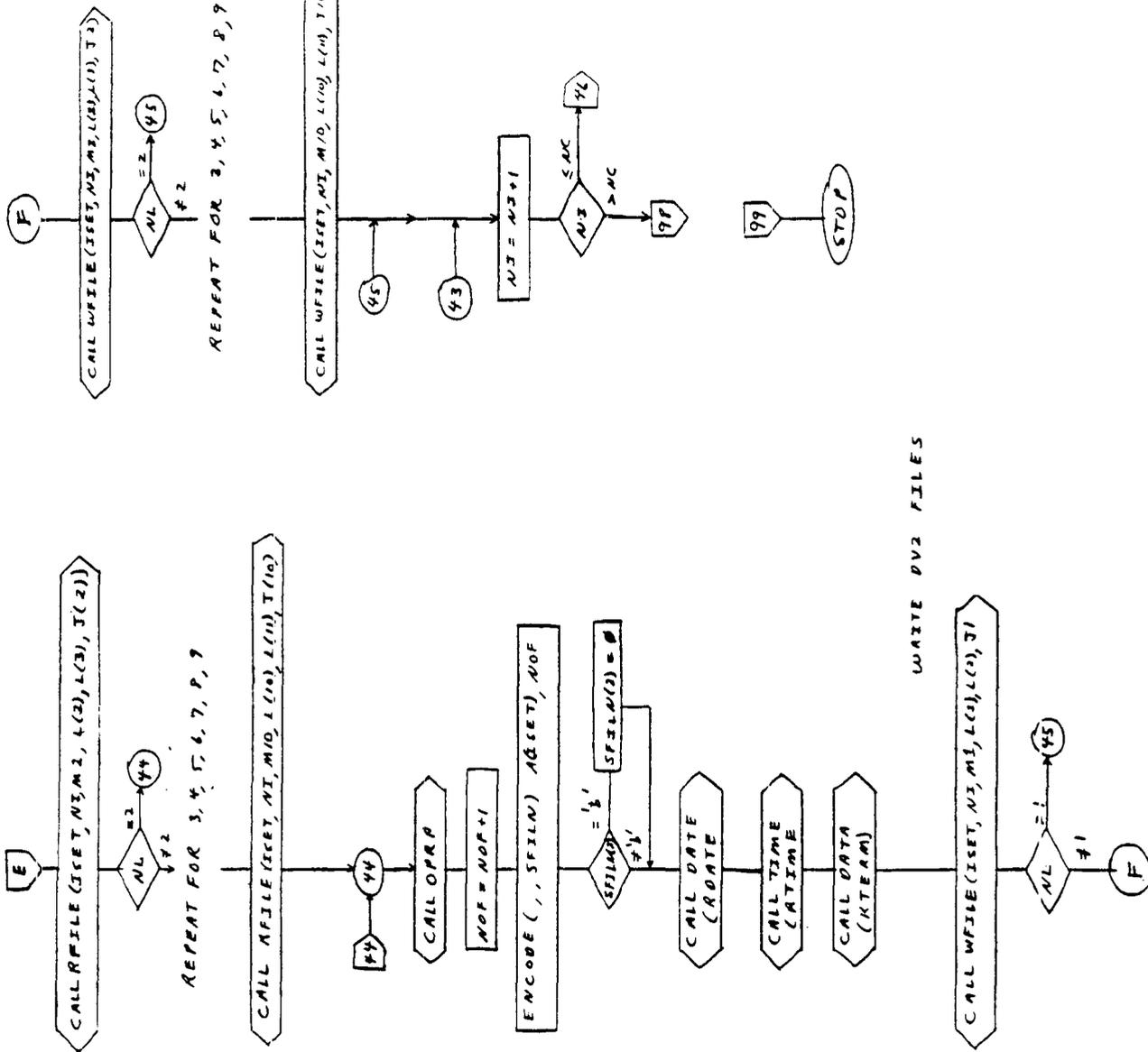


Figure 6-1. DINP Routine Flow Chart (Sheet 5)

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	223

SYMBOL	UNITS	DESCRIPTION
I		Index
IH		Index
IRT		Mistake Flag for Repeating a Line of Strategy
ISET		Set Number
J		Index
J1		Index on 'D0' Loop to Read and Process Data
J10		Index on 'D0' Loop to Read and Process Data
J2		Index on 'D0' Loop to Read and Process Data
J3		Index on 'D0' Loop to Read and Process Data
J4		Index on 'D0' Loop to Read and Process Data
J5		Index on 'D0' Loop to Read and Process Data
J6		Index on 'D0' Loop to Read and Process Data
J7		Index on 'D0' Loop to Read and Process Data
J8		Index on 'D0' Loop to Read and Process Data
J9		Index on 'D0' Loop to Read and Process Data
K		Index
KTERM		Input Flag to Subroutine DATA
K1		Index on 'D0' Loop to Read and Process Data
K10		Index on 'D0' Loop to Read and Process Data
K11		Index on 'D0' Loop to Read and Process Data
K2		Index on 'D0' Loop to Read and Process Data
K3		Index on 'D0' Loop to Read and Process Data
K4		Index on 'D0' Loop to Read and Process Data
K5		Index on 'D0' Loop to Read and Process Data
K6		Index on 'D0' Loop to Read and Process Data
K7		Index on 'D0' Loop to Read and Process Data
K8		Index on 'D0' Loop to Read and Process Data

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	224

Figure 6-2. DIMP Symbol Table (Sheet 1 of 2)

SYMBOL	UNITS	DESCRIPTION
K9		Index on 'DO' Loop to Read and Process Data
M		Index
M1		Number Equal to 1 Used as an Input to RFILE
M10		Number Equal to 10 Used as an Input to RFILE
M2		Number Equal to 2 Used as an Input to RFILE
M3		Number Equal to 3 Used as an Input to RFILE
M4		Number Equal to 4 Used as an Input to RFILE
M5		Number Equal to 5 Used as an Input to RFILE
M6		Number Equal to 6 Used as an Input to RFILE
M7		Number Equal to 7 Used as an Input to RFILE
M8		Number Equal to 8 Used as an Input to RFILE
M9		Number Equal to 9 Used as an Input to RFILE
NC		Number of Inputs of (Cut Length, Cut Width, Pit Width)
NI		Index on Line Number
NOF		Counter on Number of Cases in a Set
NP		Error Flag Passed to Subroutine GDATA
NPC		Index on Past Pit
T		Test for Negative Hopper Coordinate
B		Array Passed to GDATA
D		Array Containing the Input Line Passed to GDATA
L		Array Used to Store Number of Initial and Final Pit
NG		Integer Used in Decode Statement
P		Array Containing Input Value Passed to GDATA

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001
SCALE	REVISION	

Figure 6-2. DINP Symbol Table (Sheet 2)

GDATA (B, J, P, N)

ARGUMENTS

B - INPUT DATA LINE  
 J - NUMBER OF INPUT FIELDS  
 P - ARRAY OF INPUT DATA  
 N - ERROR FLAG

DIMENSION P(10)  
 DATA A(1) = 'BLANK'  
 A(2) = ','

J = 0  
 N = 0  
 K = 0  
 I = 1 → 10  
 P(I) = 0

B(I) = A(1) → 11

B(I) ≠ A(1)

B(I) = A(2)

B(I) ≠

K = K + 1  
 C(K) = B(I)

8  
 J = J + L  
 DECODE (K, C, ERROR = 10) P(J)  
 K = 0

KK = 1 → 10  
 C(KK) = A(1)

10  
 ERROR

NO

YES

N = 1

11  
 RTN

Figure 6-3. GDATA Routine Flow Chart

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	226



### 6.3 GETD

The DINP program prepares the operation and case files to be simulated by the dragline simulation program DRAG. DRAG simulates the individual operations as prescribed by DINP. DRAG stores the results of each operation in DV3 type files. The program GETD processes these DV3 type files and produces the case results. These case results are written in DV4 type files. The first name of the DV4 type file corresponds to its case number for that set. The form is:

A(ISET) I. DV4;

where A(ISET) is that letter of the alphabet corresponding to the number ISET. I is a two digit integer representing the number of the case in that set. The DV4 files contain the totals and averages of each operation of the case and the overall totals and averages for that case. The only input to GETD is the set number. After the set number is input GETD creates the DV4 files for all cases in this set. It then asks for the next set number. Functionally, GETD first reads the case file A(ISET) I. COM; to obtain the index pointers for this set. It then uses these pointers in a "DO" loop. In the "DO" loop the index pointers are passed to the subroutine GETR which reads the proper operation file of type DV3. When all the operation files of the case are read GETD calls subroutine WTOT to total the case results. The program then proceeds to the next case of the set. The flow chart and symbol table are contained in Figures 6-5 and 6-6.

### 6.4 GETR

The GETR subroutine is called by GETD to read the operation data files of type DV3 and write these results in the case file of type DV4. GETD passes GETR the index pointers that specify the DV3 operation file. GETR reads the DV3 file, checks the type of operation (move, bench fill, bench removal or overburden to spoil), writes the appropriate operation header and calls subroutine WOBR which writes the operation results in formatted form into the DV4 type case file. GETR is called once for each operation of the case. (See Figures 6-7 and 6-8.)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	228



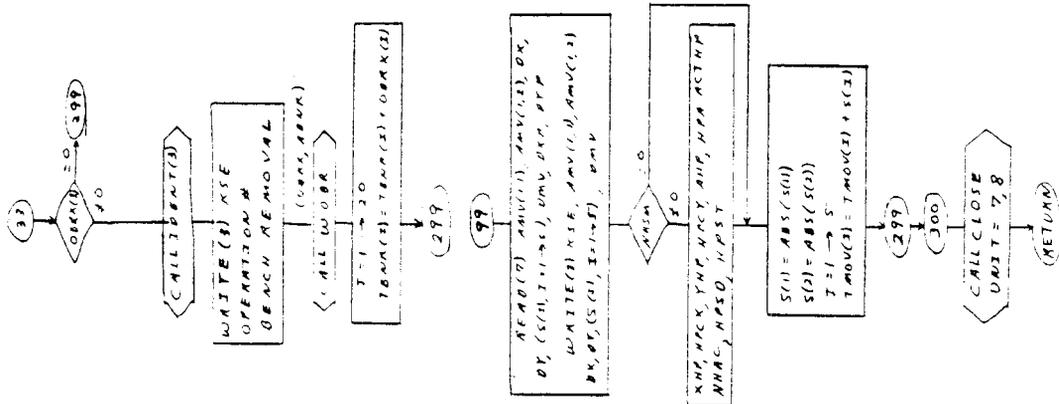
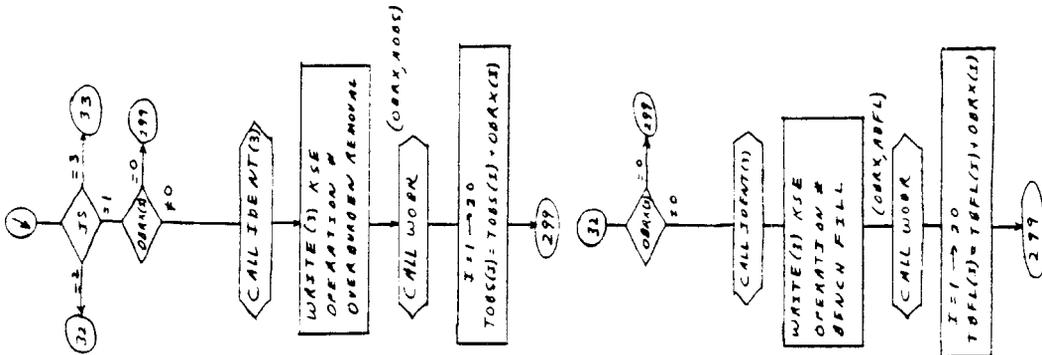
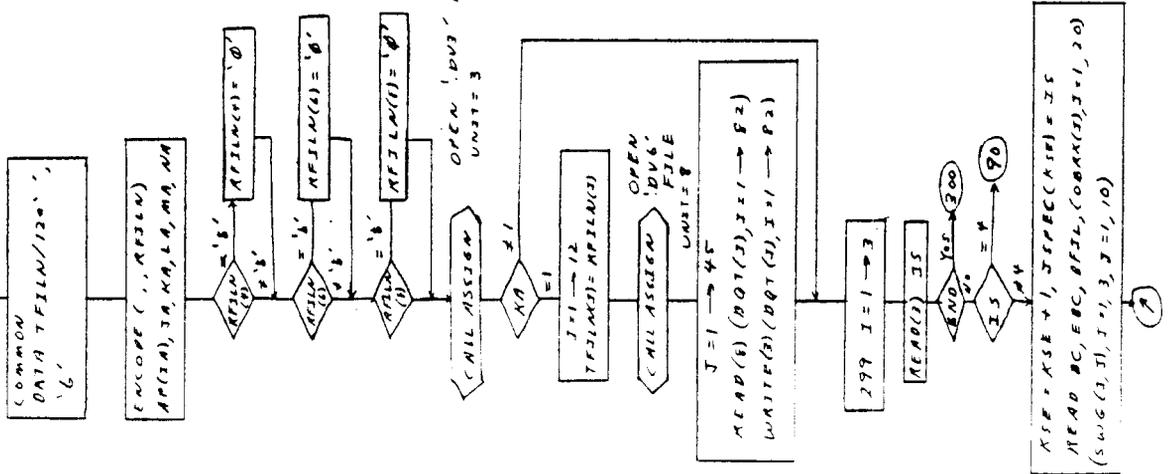
SYMBOL	UNITS	DESCRIPTION
D1		Dummy Variable Used in Read of COM File
D2		Dummy Variable Used in Read of COM File
I		Index
ISET		Set Number
J		Index
K10		Index Pointer in 'D0' Loop
K11		Index Pointer in 'D0' Loop
K2		Index Pointer in 'D0' Loop
K3		Index Pointer in 'D0' Loop
K4		Index Pointer in 'D0' Loop
K5		Index Pointer in 'D0' Loop
K6		Index Pointer in 'D0' Loop
K7		Index Pointer in 'D0' Loop
K8		Index Pointer in 'D0' Loop
K9		Index Pointer in 'D0' Loop
L		Array to store the Number of the Past and Present Pits
M1		Index Pointer in 'D0' Loop
M10		Index Pointer in 'D0' Loop
M2		Index Pointer in 'D0' Loop
M3		Index Pointer in 'D0' Loop
M4		Index Pointer in 'D0' Loop
M5		Index Pointer in 'D0' Loop
M6		Index Pointer in 'D0' Loop
M7		Index Pointer in 'D0' Loop
M8		Index Pointer in 'D0' Loop
M9		Index Pointer in 'D0' Loop
NC		Number of Cut Lengths, Cut Widths, Pit Widths of Case

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001
SCALE	REVISION	

Figure 6-6. GETD Symbol Table (Sheet 1 of 2)



GETR (NOF, IA, TA, KA, LA, MA, NA)



(READ DV2 FILE)

Figure 6-7. GETR Routine Flow Chart

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET 232	



### 6.5 OPRP

The subroutine OPRP is called by DINP to compute the operation and case files specified by the inputs to DINP. OPRP initializes several parameters then calls a subprogram OTSP for each line of the removal strategy. OTSP calculates the dragline positions and dig coordinates. OPRP also calls the subprogram SPR to calculate the spoil height and check for rehandle. Before returning to GETD, OPRP transfers the case information to the CAS array. (See Figures 6-9 and 6-10.)

### 6.6 OTSP

The subprogram OTSP is called by OPRP to calculate the dragline position and dig coordinates for each line of the removal strategy. After the calculations are made the data is stored in the OPDAT array corresponding to the operations generated by that line of the removal strategy. OTSP also calls subroutine VOL which calculates the volume of material removed for each operation. (See Figures 6-11 and 6-12.)

### 6.7 RFILE

The subroutine RFILE is called by DINP to read the DVI type data files. The DVI files contain the "mine language" input data stored by DINP. (See Figure 6-13.)

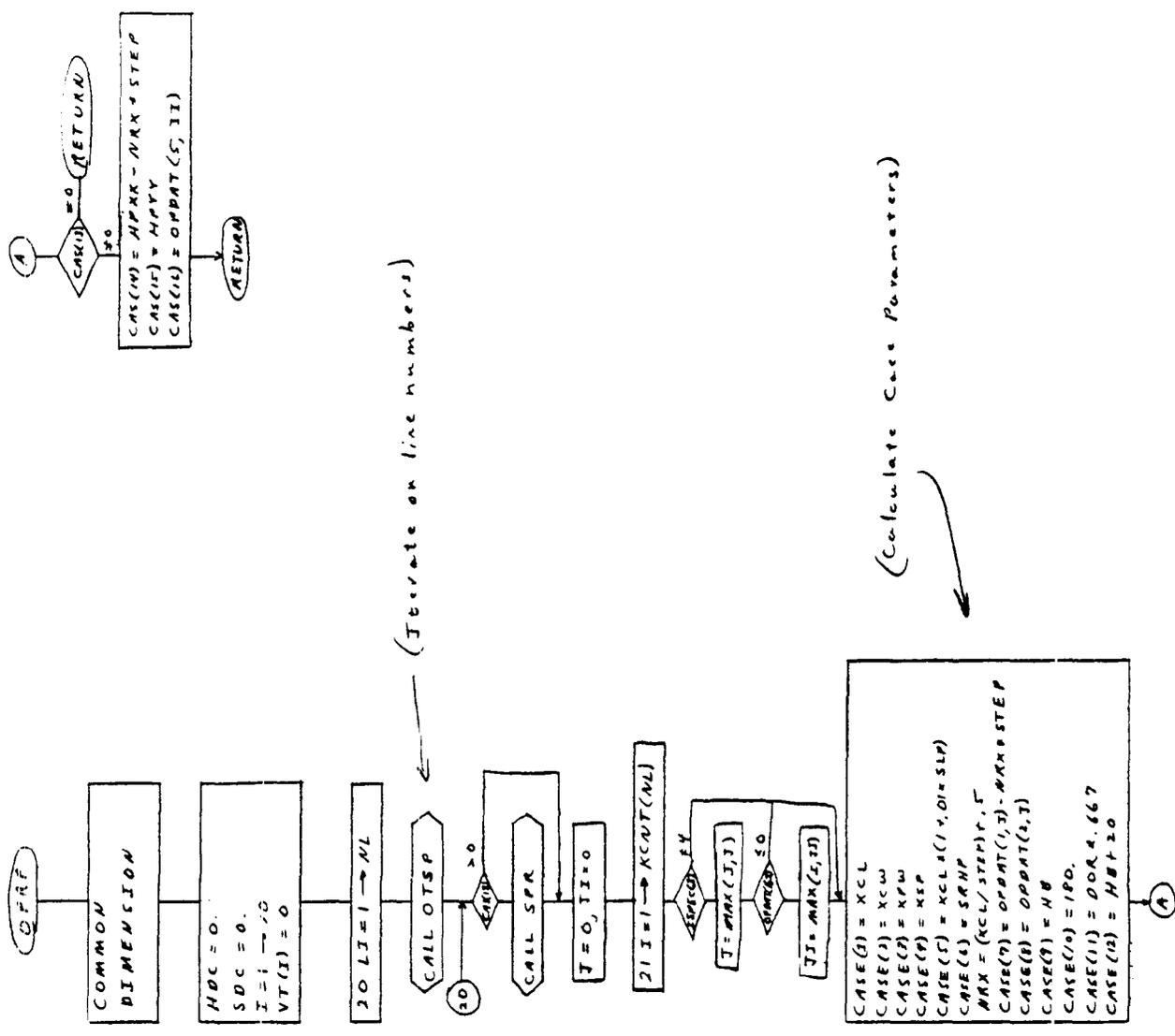
### 6.8 SPR

The subroutine SPR is called by OPRP to calculate the spoil height, the spoil peak and the percentage of rehandle. The percentage of rehandle is computed by placing the spoil material on the spoil pile from the dragline position of each operation. The spoil material is spread on the spoil pile by the subroutine XPILE which is called by SPR. The dragline reach, material swell and angle of repose are considered in the calculations. Before returning to OPRP the volume of material moved in each operation is written on the CRT. (See Figures 6-14 and 6-15.)

### 6.9 VOL

The subroutine VOL is called by OTSP to calculate the volume of material removed in a given operation. VOL is passed two cut depths that define the thickness of the cut

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	234



(Iterate on line numbers)

(Calculate Case Parameters)

Figure 6-9. OPRP Subroutine Flow Chart

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	235



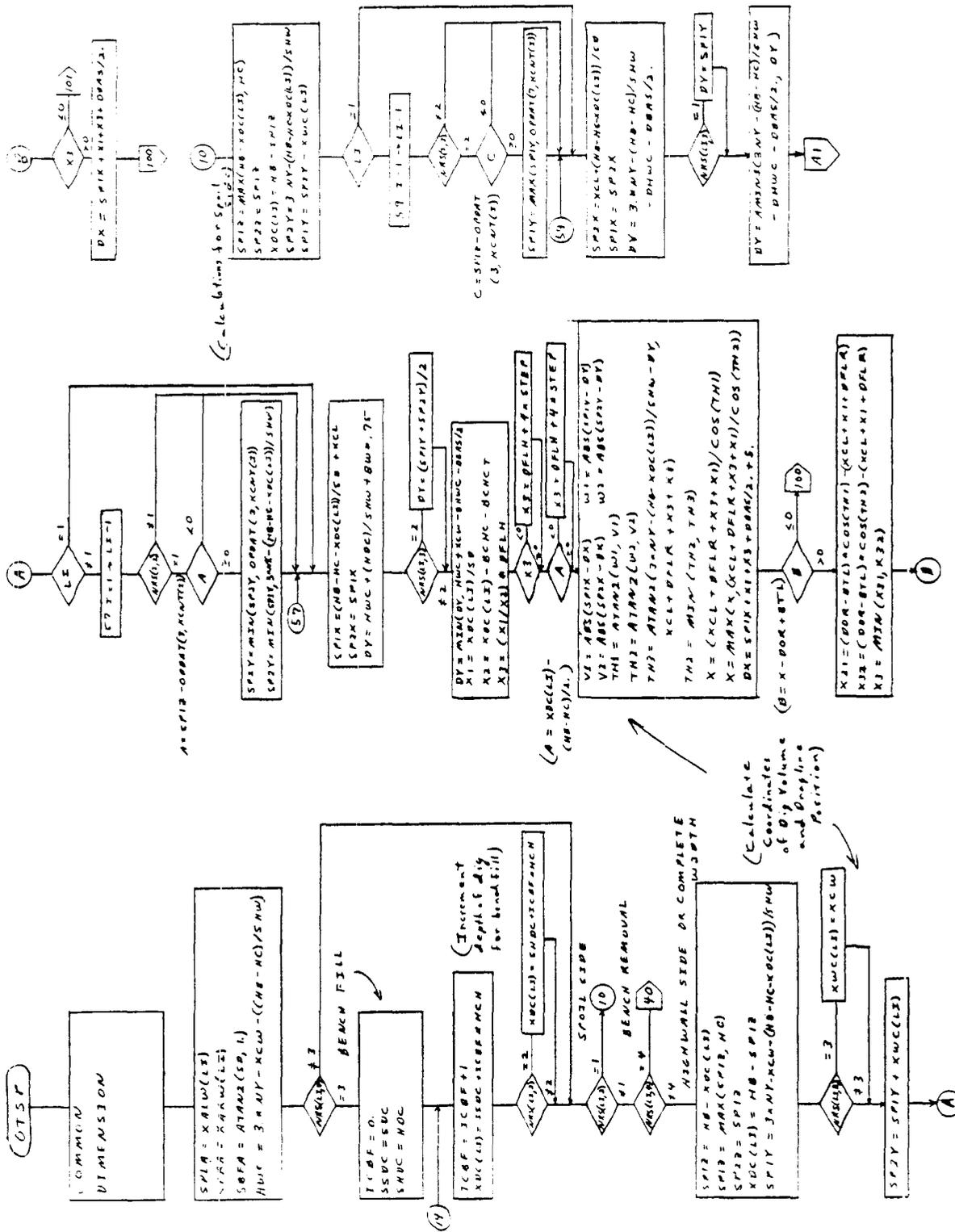
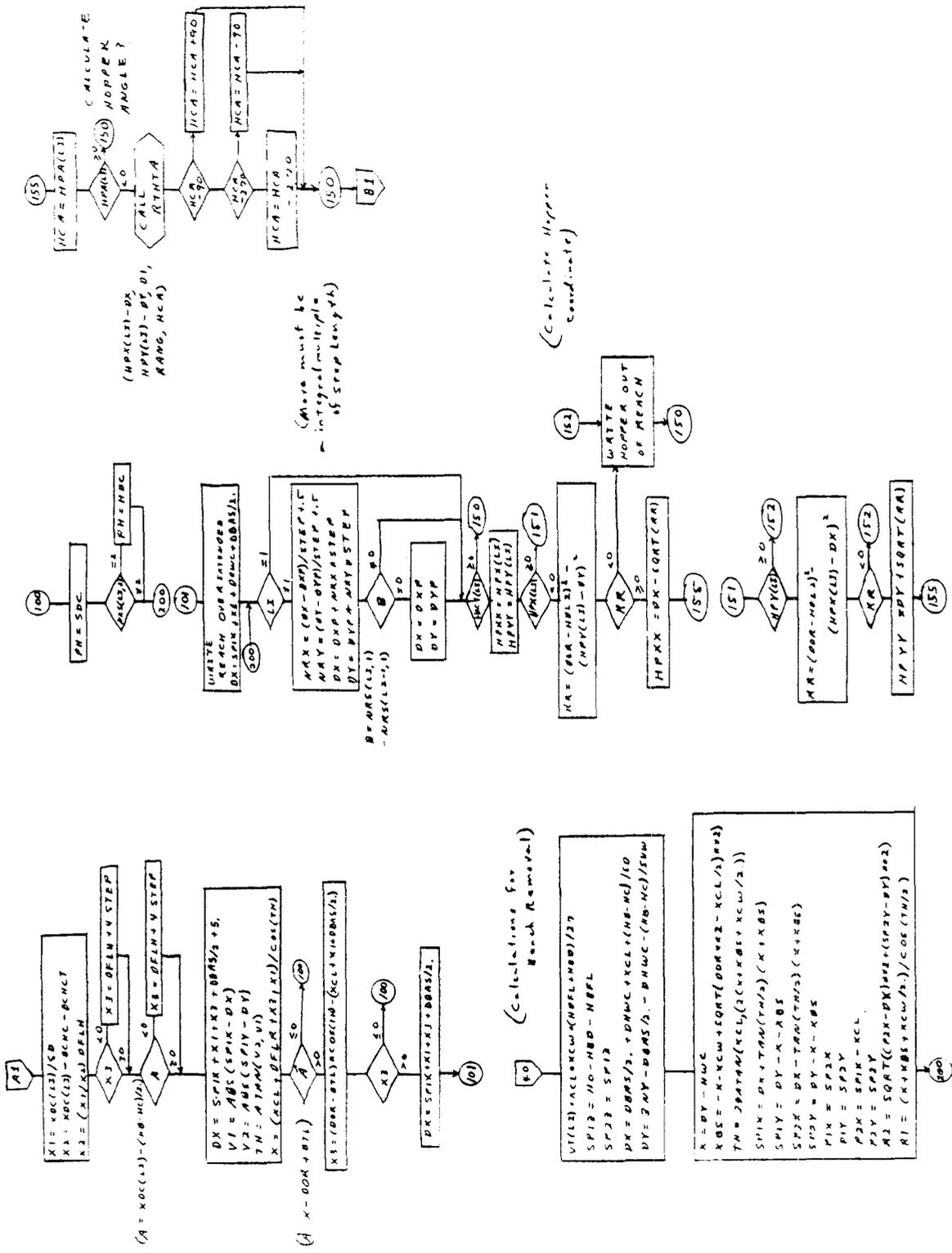


Figure 6-11. OTSP Subroutine Flow Chart (Sheet 1 of 5)

SIZE	CODE IDENT NO.	
<b>A</b>	<b>12464</b>	WE02M001
SCALE	REVISION	SHEET
		237



(Calculate Hyper-coordinate)

(Calculations for Branch Removal)

(Must be integer multiple of step length)

Figure 6-11. OTSP Subroutine Flow Chart (Sheet 2)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	238



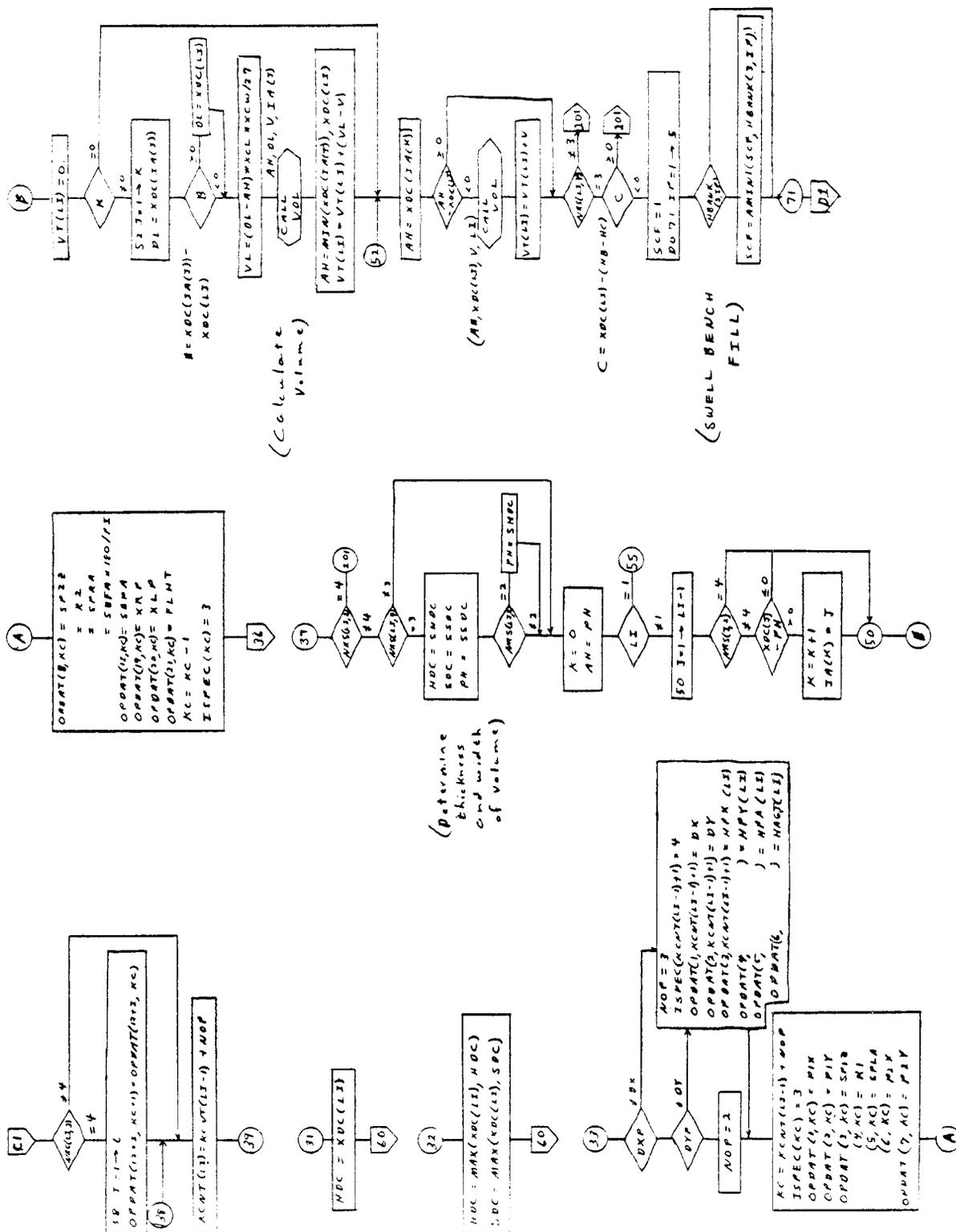


Figure 6-11. OTSP Subroutine Flow Chart (Sheet 4)

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	240

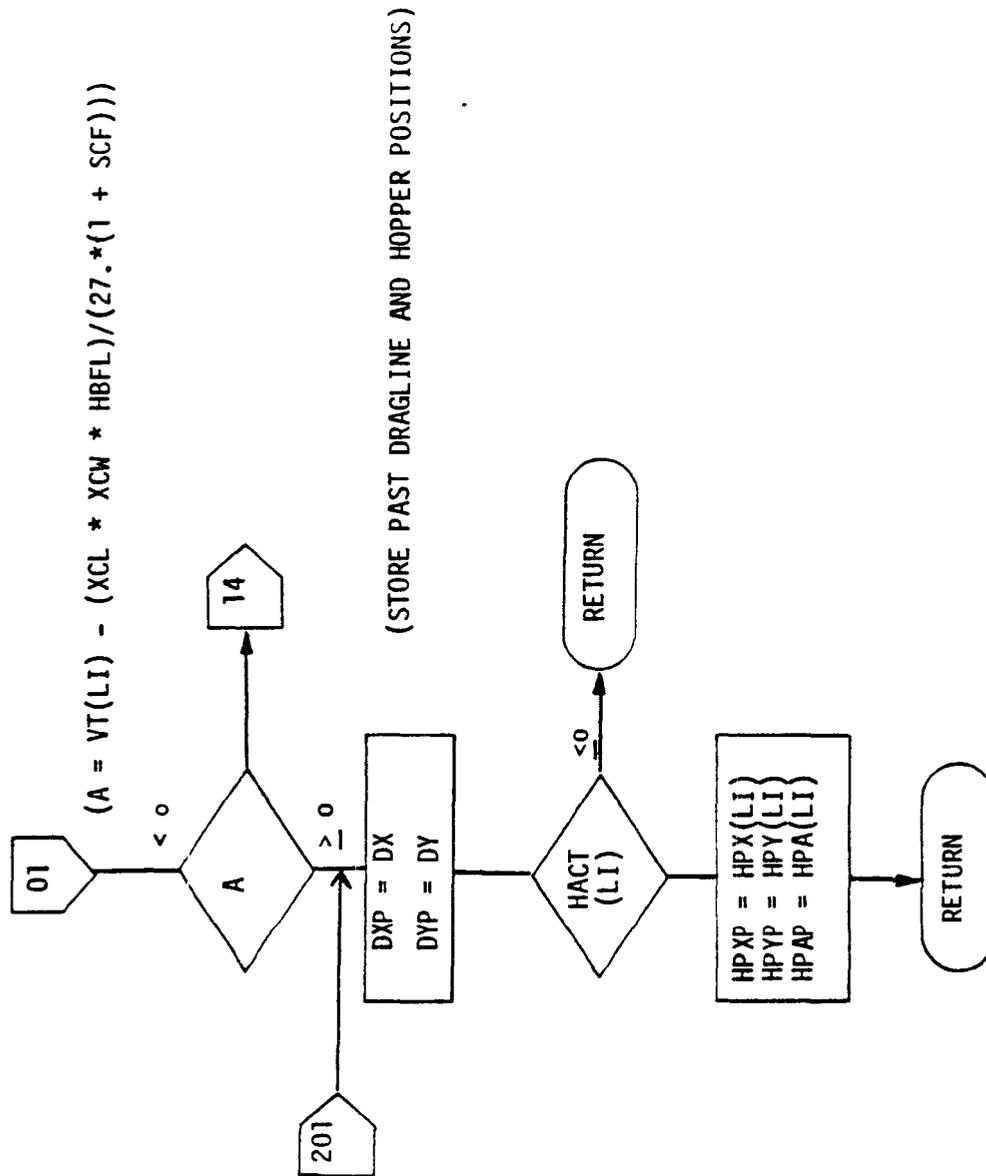


Figure 6-11. OTSP Subroutine Flow Chart (Sheet 5)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	241

SYMBOL	UNITS	DESCRIPTION
A	Degrees	Variable Used in Calculation of Bench Fill Angle
AH	FEET	Variable Used in Calculation of Volume of Dig
B	Degrees	Variable Used in Calculation of Bench Fill Angle
DL	FEET	Depth of Cut
D1		Dummy Parameter in Call to RHTA
D2		Dummy Parameter in Call to RHTA
HWC		Y - Coordinate of Highwall Crest
I		Index
IA		Array used in Calculation of Dig Volume
ICBF		Index to Increment Cut Depth on a Bench Fill
IE		Index
J		Index
K		Index
KC		Index
NOP		Integer Used to Increment Operation Counter
NRX		Number of Steps in X Direction
NRX		Number of Steps in X Direction
NRX		Number of Steps in Y Direction
PH	FEET	Cut Depth
PLX		Variable Used in Calculation of Bench Removal Coordinates
PLY		Variable Used in Calculation of Bench Removal Coordinates
P2X		Variable Used in Calculation of Bench Removal Coordinates
P2Y		Variable Used in Calculation of Bench Removal Coordinates
RANG		Angle of Hopper with X Axis
RR		Variable Used in Hopper Coordinate Calculation
R1		Variable Used in Calculation of Dragline Range
R2		Variable Used in Calculation of Dragline Range
SBFA	Degrees	Front Plane Angle

SIZE	CODE IDENT NO.	
<b>A</b>	<b>12464</b>	WE02M001
SCALE	REVISION	SHEET 242

Figure 6-12. OTSP Symbol Table (Sheet 1 of 3)

SYMBOL	UNITS	DESCRIPTION
SBPA	Degrees	Bottom Plane Angle
SCF		Expansion of Bench Fill Material
SHDC	FEET	Cut Depth
SPLA	Degrees	Left Dig Wall Angle
SPRA	Degrees	Right Dig Wall Angle
SPIX		Dig Coordinate for Left Side
SPIY		Dig Coordinate for Left Side
SPIZ		Dig Coordinate for Left Side
SP2X		Dig Coordinate for Right Side
SP2Y		Dig Coordinate for Right Side
SP2Z		Dig Coordinate for Right Side
SSDC	FEET	Cut Depth
TH	Degrees	Angle Used in Calculation of Dragline Position
TH1		Angle Used in Calculation of Dragline Position
TH2		Angle Used in Calculation of Dragline Position
TH3		Angle Used in Calculation of Dragline Position
V	YD <sup>3</sup>	Volume Passed to Subroutine VOL
V1		Variable Used in Calculation of Dragline Position
V2		Variable Used in Calculation of Dragline Position
W1		Variable Used in Calculation of Dragline Position
W2		Variable Used in Calculation of Dragline Position
X		Variable Used in Calculation of Dragline Position
XBS		Variable Used in Calculation of Dragline Position
XLP	Degrees	Left Bench Fill Angle
XRP	Degrees	Right Bench Fill Angle
X1		Variable Used in Calculation of Dragline Position
X2		Variable Used in Calculation of Dragline Position

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	243

Figure 6-12. OTSP Symbol Table (Sheet 2)



Arguments:

- ID - Set Number
- J - Cut Number
- K - Line Number
- L - Old Pit Number
- M - New Pit Number
- N - Procedure Number

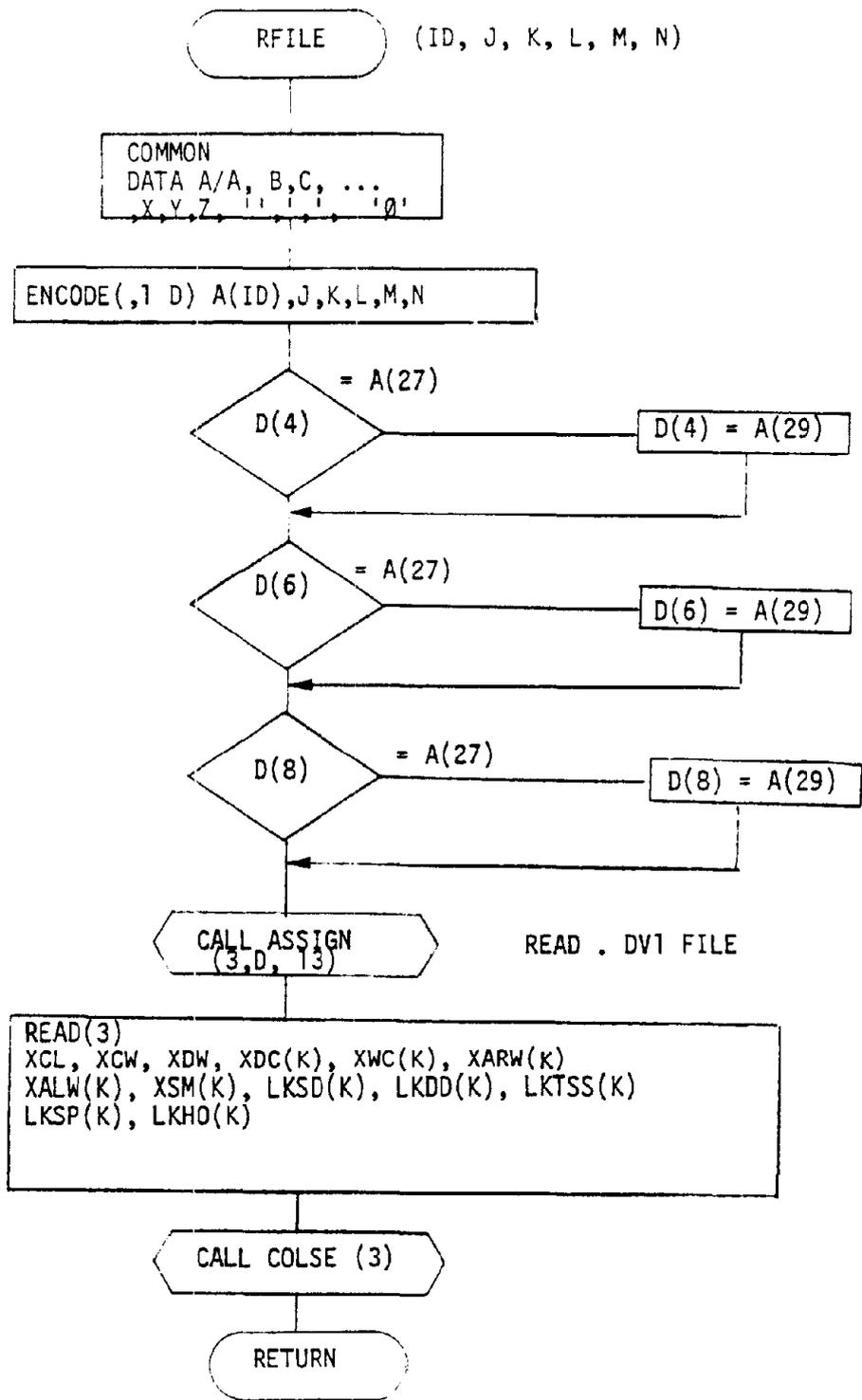


Figure 6-13. RFILE Subroutine Flow Chart

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	245





SYMBOL	UNITS	DESCRIPTION
AV	YD <sup>2</sup>	Cross-Sectional Area of Overburden
CV	YD <sup>3</sup>	Difference in Volume in Spoil Segment and Volume Reached
EAV	YD <sup>3</sup>	Rehandle Volume
HMAX	FEET	Maximum Spoil Height for Dragline Reached
HPTX	FEET	Spoil Height Passed to XPILE
HT	FEET	Spoil Height Determined From Spoil Method Input
I		Index
IB		Segment Bias of Spoil Pile
IQ		Index
ISTOP		Input to Stop Program to Display Dig Volumes
J		Index on Line Number
JB		Spoil Segment Passed to XPILE
JJ		Index
K		Segment of Spoil Pile Where Peak is Located
KF		Final Segment of Spoil Pile
KI		Increment of Iteration Loop to Spread Volume
KS		Starting Segment of Spoil Pile
L		Length of Spoil Slope From Peak to Toe
LP		Used in Calculation of Spoil Point
M		Used to Locate Spoil Peak
MN		Used in Calculation of Spoil Point
N		Lengths of Spoil Pile in 6 Foot Segments
NFS		Number of Layers of Overburden
PR		Percentage Rehandle Volume
PRV		Rehandle Volume
PX		Used in Determining Spoil Peak
PY		Used in Determining Spoil Peak

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	248

Figure 6-15. SPR Symbol Table (Sheet 1 of 2)



and the number of the operation. The operation dig coordinates are used to define the front and side planes. This region is intersected with the left and right high-wall planes. The program iterates over all grid points in the contained region and sums these volumes to produce the total volume. VOL may be called several times by OTSP to calculate the volume of an operation that is irregularly shaped. If an operation follows an operation that has been taken on the same side (either highwall side or spoil side) and the cut width of that operation was less than the present operation the volume of the overlapped region will not be computed. For instance, if a keycut is made and then widened by a later operation to the same depth the volume for this last operation would be computed as zero. Operations on the same side should be nested with decreasing cut widths. This is true in the real world also. The bucket tends to work out of the cut and slide down the dig wall. The flow chart and symbol table are given in Figures 6-16 and 6-17.

#### 6.10 WFILE

The subroutine WFILE is called by DINP to write the operation and case data into the proper DV2 type file. WFILE is passed the index pointers that define the correct first name of the file. The program then writes the case and operation data into this file. (See Figures 6-18 and 6-19.)

#### 6.11 WOBR

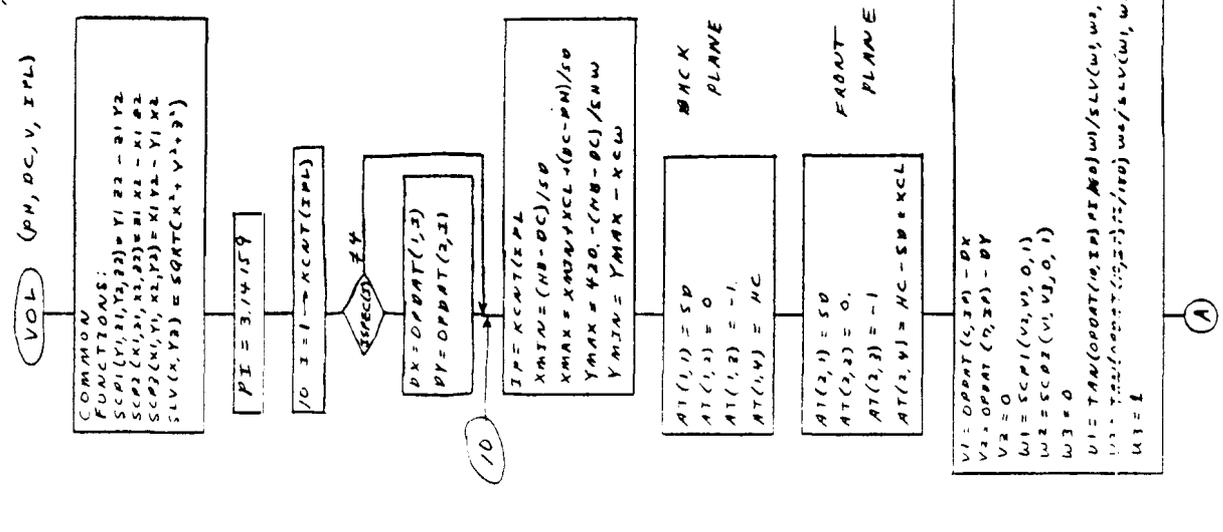
The program WOBR is called by GETR to compute the totals and averages resulting from an operation and write this data in a formatted form into a file of type DV4. The name of the file corresponds to the set and case number. (See Figures 6-20 and 6-21.)

#### 6.12 WTOT

The subroutine WTOT is called by GETD to calculate the totals and averages of the case being processed. After the calculations are complete the subroutine writes this data into the DV4 type file. (See Figures 6-22 and 6-23.)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	250

Arguments: PH - Position of Graph  
 DC - Cut Depth  
 V - Volume  
 IPL - Operation Number



RIGHT PLANE  
 $AT(2,1) = SCPI(V2, V3, V3)$   
 $AT(2,2) = SCPI(V1, V3, V3)$   
 $AT(2,3) = SCPI(V1, V2, V3)$   
 $AT(2,4) = -AT(2,1) * OPBNT(6, IPL)$   
 $-AT(2,2) * OPBNT(7, IPL) - OPBNT(8, IPL)$   
 $AT(2,5)$

LEFT PLANE  
 $V1 = OPBNT(1, IPL) - DX$   
 $V2 = OPBNT(2, IPL) - DY$   
 $V3 = 0$   
 $W1 = SCPI(V2, V3, 0, 1)$   
 $W2 = SCPI(V1, V3, 0, 1)$   
 $W3 = 0$   
 $W4 = TAN(OPBNT(9, IPL) * PI/180) * W1 / SLV(W1, W2, W3)$   
 $W5 = TAN(OPBNT(10, IPL) * PI/180) * W2 / SLV(W1, W2, W3)$   
 $W6 = 1$

BACK PLANE  
 $AT(1,1) = 50$   
 $AT(1,2) = 0$   
 $AT(1,3) = -1$   
 $AT(1,4) = HC$

FRONT PLANE  
 $AT(2,1) = 50$   
 $AT(2,2) = 0$   
 $AT(2,3) = -1$   
 $AT(2,4) = HC - SB + XCL$

HIGHWAIL PLANE  
 $AT(6,1) = 0$   
 $AT(6,2) = 50$   
 $AT(6,3) = 1$   
 $AT(6,4) = -420.5 * HW - HC$   
 $AT(5,1) = 0$   
 $AT(5,2) = 50$   
 $AT(5,3) = 1$   
 $AT(5,4) = -(420 - XCW) * HW - HC$

Loop to Compute Volume  
 $V = 0$   
 $XMAX = XMAX / 3$   
 $YMAX = YMAX / 3$   
 $ZMAX = ZMAX / 3$   
 $ZI = JMIN -> JMAX$   
 $XI = 3 * J$   
 $YI = JMIN -> JMAX$   
 $VI = I * 3$

Iteration  
 $ALC = -AT(4,1) * XI + AT(4,3) * YI$   
 $+ AT(4,4) / AT(4,2)$   
 $ALB = MAX(ALB, ALC(1), NB - NC)$   
 $ZI = -AT(4,2) * AT(4,3) * YI$   
 $+ AT(4,4) / AT(4,2)$   
 $ZJ = -AT(4,1) * XI + AT(4,3) * YI$   
 $+ AT(4,4) / AT(4,2)$   
 $UB = MIN(NB - PH, ZI, ZJ)$   
 $V = V + (UB - ALB) / 3$   
 $UK = ALB$   
 $UK > ALB$   
 $UK < ALB$   
 $XI = 0$   
 $YI = 0$   
 $ZI = 0$   
 RETURN

Figure 6-16. VOL Subroutine Flow Chart

SIZE	CODE IDENT NO.	WEO2M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	
		251	

SYMBOL	UNITS	DESCRIPTION
AT		Array containing Attitude Numbers of the Boundary Planes
DX		Dragline Position X - Coordinate
DY		Dragline Position Y - Coordinate
IMAX		Maximum X Grid Point of Iteration
IMIN		Minimum X Grid Point of Iteration
IP		Operation Number
JMAX		Maximum Y Grid Point
JMIN		Minimum Y Grid Point
RL		Array Containing Height of the Boundary Plane
RLB		Lower Boundary of Dig Volume
UB		Upper Boundary of Dig Volume
U1		Vector Used in Calculation of Boundary Planes
U2		Vector Used in Calculation of Boundary Planes
U3		Vector Used in Calculation of Boundary Planes
V1		Vector Used in Calculation of Boundary Planes
V2		Vector Used in Calculation of Boundary Planes
V3		Vector Used in Calculation of Boundary Planes
W1		Vector Used in Calculation of Boundary Planes
W2		Vector Used in Calculation of Boundary Planes
W3		Vector Used in Calculation of Boundary Planes
XI		X Coordinate of Grid Point
XMAX		Maximum X Coordinate
XMIN		Minimum X Coordinate
YI		Y Coordinate of Grid Point
YMAX		Maximum Y Coordinate
YMIN		Minimum Y Coordinate
ZI		Height of Front Plane at Test Coordinate

SIZE	CODE IDENT NO.	
<b>A</b>	<b>12464</b>	WE02M001
SCALE	REVISION	SHEET
		252

Figure 6-17. VOL Symbol Table (Sheet 1 of 2)





SYMBOL	UNITS	DESCRIPTION
NFN		Integer Used as a Pointer to the First Operation to be Written to the DVI File
NST		Integer Used as a Pointer to the Last Operation to be Written to the DVI File
PS1		Variable Used to Determine Correct Initial Position for Dragline and Hopper
PS2		Variable Used to Determine Correct Initial Position for Dragline and Hopper
PS4		Variable Used to Determine Correct Initial Position for Dragline and Hopper
PS5		Variable Used to Determine Correct Initial Position for Dragline and Hopper
PS6		Variable Used to Determine Correct Initial Position for Dragline and Hopper

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001
SCALE	REVISION	

Figure 6-19. WFILE Symbol Table

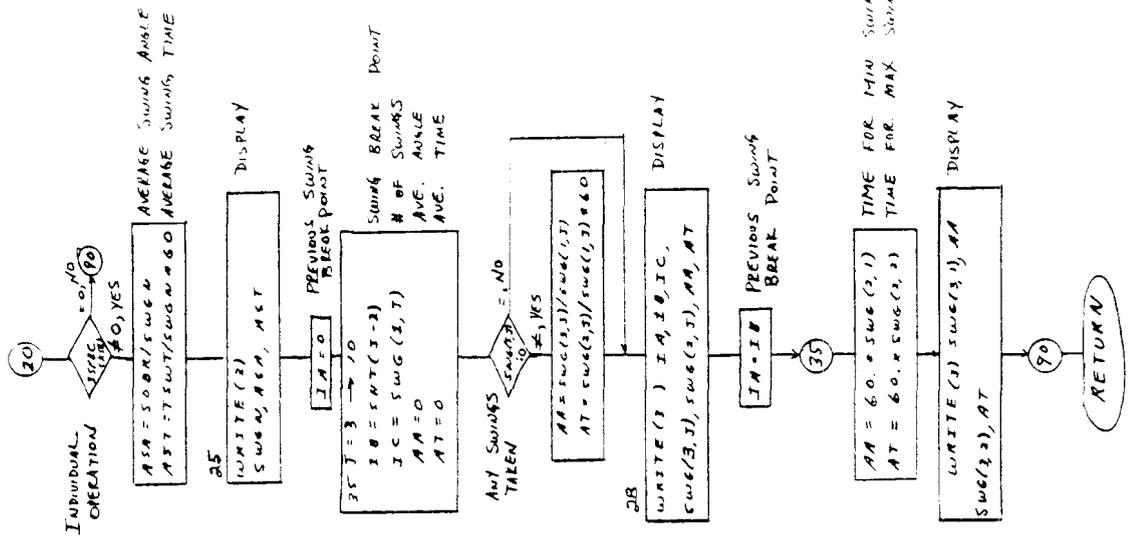
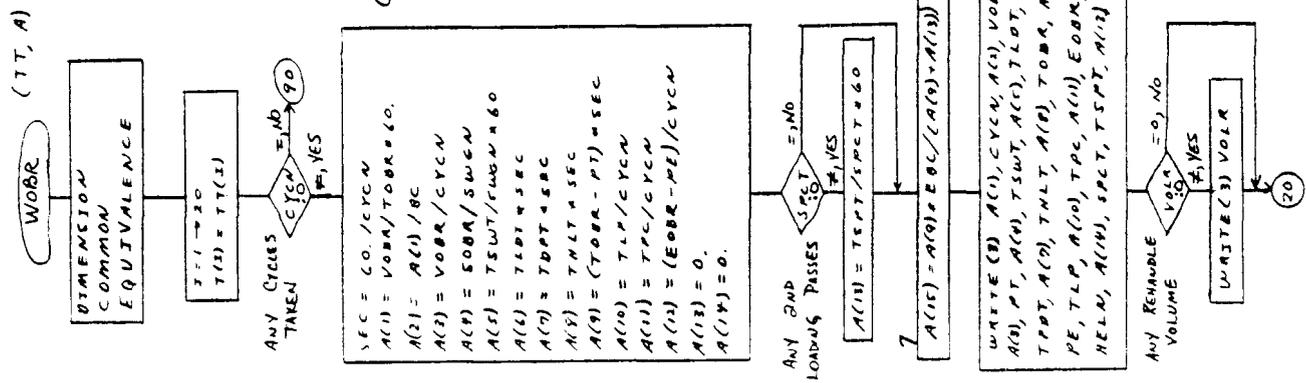


Figure 6-20. WOBRC Subroutine Flow Chart

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	256

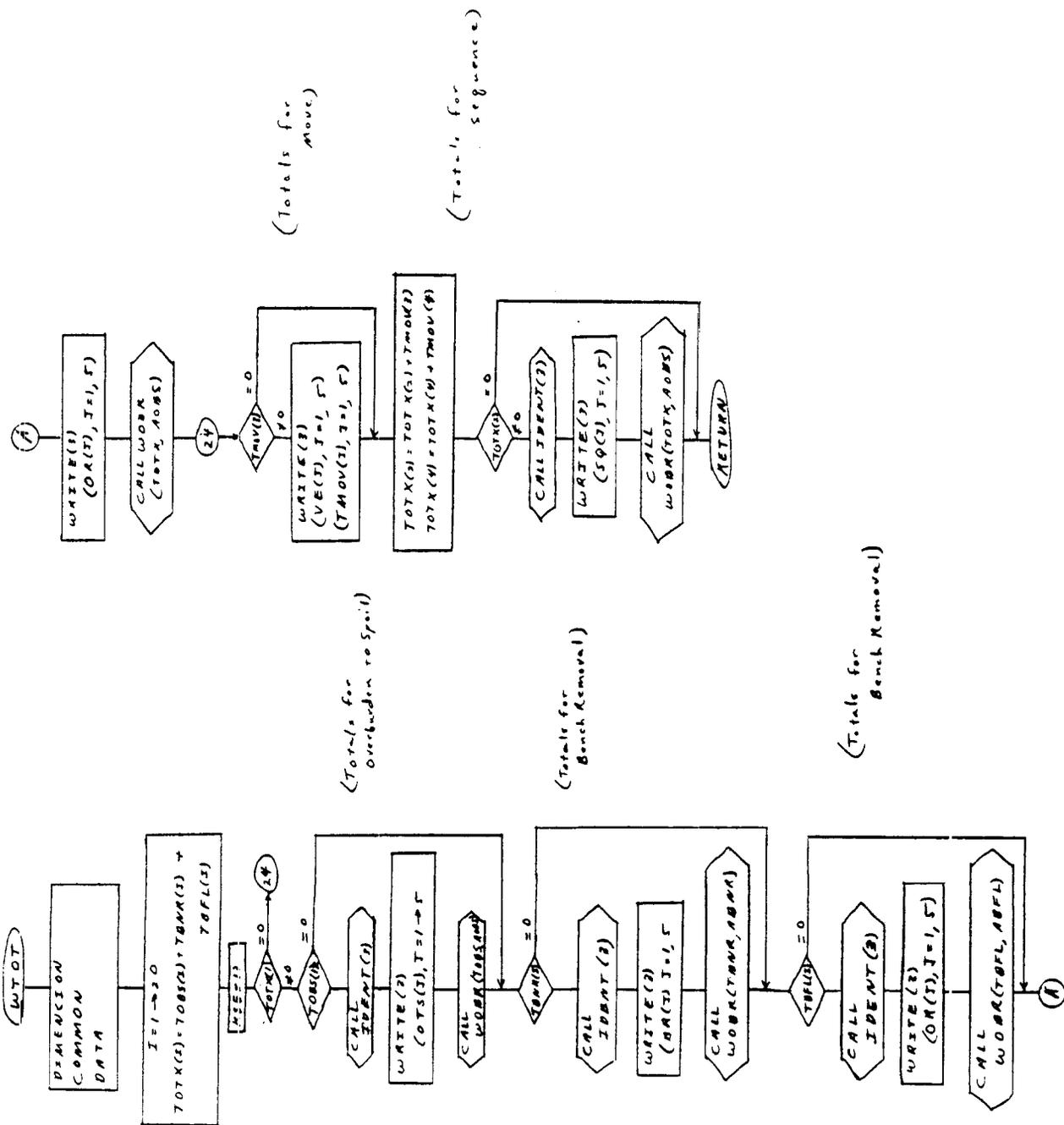
SYMBOL	UNITS	DESCRIPTION
AA	SEC	Total Swing Time
ASA	Degree	Average Swing Angle
AST	SEC	Average Swing Time
AT	SEC	Average Swing Time
CYCN		Number of Cycles
EOBR	KW-HR	Total Energy for Operation
HELN		Number of Heels
I		Index
IA		Minimum Swing Angle for this Increment
IB		Maximum Swing Angle for this Increment
IC		Number of Swings in this Increment
PE		Position Energy
PT		Position Time
SEC	SEC	Equal to 60 Divided by CYCN
SHF		Array Used in Swing Time Histogram
SOBR		Total Swing Angle
SPT		Second Pass Time
SWCN		Number of Swings
T		Array Used to Manipulate Totals and Averages
TDPT		Total Dump Time
THLT		Total Heeling Time
TLDT		Total Loading Time
TLP		Total Loading Energy
TOBR		Total Time
TPC		Total Transit Energy
TRAD		
TSPT		Total Second

SIZE	CODE IDENT NO.	WE02M001
<b>A</b>	<b>12464</b>	
SCALE	REVISION	SHEET
		257

Figure 6-21. WOBR Symbol Table (Sheet 1 of 2)



Figure 6-22. WTOT Subroutine Flow Chart

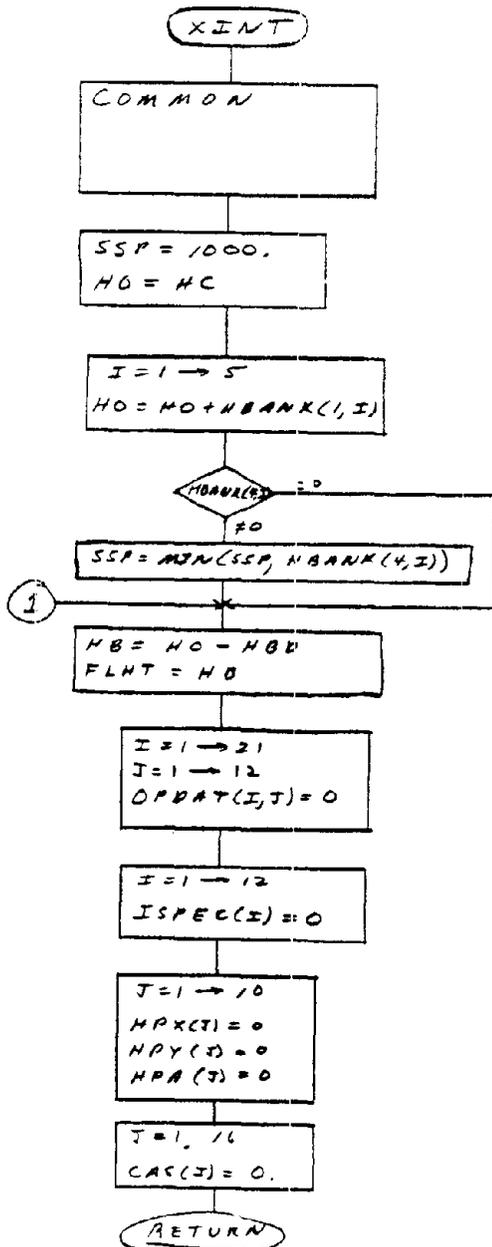


SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	259



### 6.13 XINT

The subroutine XINT is called by DIMP for each set number to initialize several machine and mine parameters and set other variables to zero. (See Figure 6-24.)



Initialize and Calculate Parameters

Figure 6-24. XINT Subroutine Flow Chart

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	261

6.14 XPILE

The subroutine XPILE is called by SPR to distribute material on the spoil pile. XPILE is passed the spoil segment number, the volume of material to be spread and the maximum height at that segment number. The material is distributed in 10 cubic yard increments by an iterative algorithm. The algorithm computes the gradient of the material and adds volume to the spoil segment until the input volume is exhausted or the maximum height is reached. (See Figures 6-25 and 6-26.)

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	262

Arguments: (IO, VINF, HMAX)

ID - Segment Number  
 VIMP - Volume  
 HMAX - Maximum Height

XPILE

COMMON  
 VL, V(I), H(I), WP, WB

INITIALIZE

XXW = XPW - HSRB  
 VL = (XW \* HSRB) / (PWSEG \* AB) SSP  
 VA = IO.  
 I = IB

1

G1 = (PSNV(I, I) - PSNV(I, I+1)) / PWSEG  
 G2 = (PSNV(I, I) - PSNV(I, I-1)) / PWSEG

(Calculate gradient and compare with angle of repose)

G1 > 0  
 -SSP  
 I = I + 1  
 1

G2 < 0  
 -SSP  
 I = I - 1  
 1

PSNV(I, I) = PSNV(I, I) + VA  
 XSW = XPW - HSRB  
 PSNV(I, I) = (XSW \* SSP) / (XNW \* PWSEG) + PSNV(I, I) (1.01 SNAP)

(Add volume and calculate height)

A = PSNV(I, I) - VL

A < 0  
 PSNV(I, I) = (PSNV(I, I) \* 54) / (PWSEG \* XNW)

I = ID

VIMP < VA  
 VA = VIMP

(Decrease total volume)

VIMP = VIMP - VA

(B = PSNV(I, I) - HMAX)

B > 0  
 RETURN

B < 0  
 VIMP >= 0  
 RETURN

1

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	263

Figure 6-25. XPILE Subroutine Flow Chart



## 7. PLOT PROGRAMS

This section contains the flow charts and descriptions of the programs used in conjunction with the simulation model to plot such items as the overburden grid, the spoil pile and the bucket trajectory and power usage of the dragline.

### 7.1 FLIMTS

The subroutine FLIMTS is called by PLOTF to subdivide the overburden grid into 3 yard increments. (See Figure 7-1.)

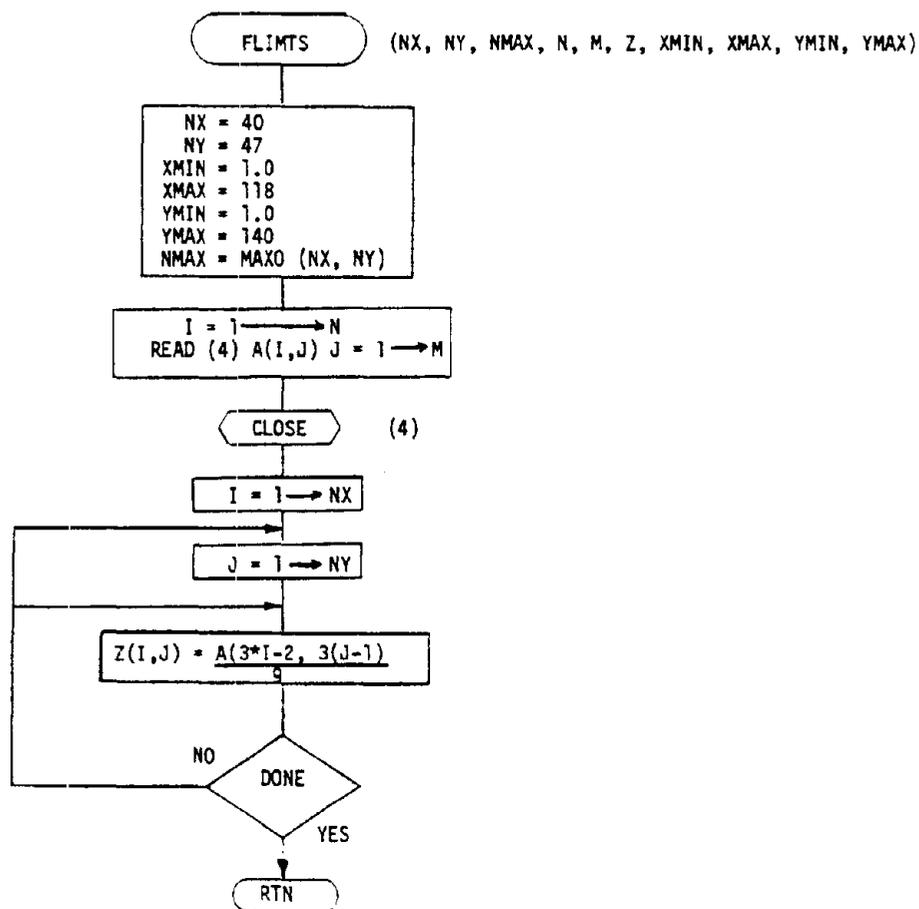


Figure 7-1. FLIMTS Subroutine Flow Chart

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	265

## 7.2 GRAPH

The program GRAPH plots a profile of the spoil pile. The plot produced is two dimensional and shows the spoil pile height in yards vs. the spoil pile length in six foot segments. The only input to GRAPH is the name of the pit. (See Figure 7-2.)

## 7.3 PDATA

The program PDATA will plot either the hoist power, drag power, swing power and total power as a function of time or the drag length, hoist length and swing angle as a function of time. The data to be plotted is obtained from the DRAG program by setting the KB09 diagnostic flag. Only one cycle can be plotted at a time. PDATA calls subroutines CRAYON and COLOR. These subroutines are included in the flow charts contained in Figure 7-3.

## 7.4 PLOTF

The program PLOTF is used to plot the overburden grid in increments of 9 feet. The name of the pit, the angle of elevation, the angle of rotation and the distance to the eyepoint must be input to PLOTF. PLOTF calls the subroutine FLIMTS and several system subroutines. (See Figure 7-4.)

## 7.5 PLOTS

The program PLOTS is used to plot segments of the overburden grid. A segment of the grid is specified by upper and lower bounds on the X and Y coordinates. The program generates a plot of this area in increments of one yard. The overburden area plotted can be no larger than 50 yards by 50 yards. The name of the pit, angle of elevation, angle of rotation and the distance to the eyepoint must be input through the CRT. PLOTS calls subroutine SLIMTS and several other system subroutines. (See Figure 7-5.)

## 7.6 PLOTSUBS

PLOTSUBS is a library of system subroutines used by the plot programs. It contains subroutines BLANK, DRAW, MODE, NOTE and PLOT3D.

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12454</b>	WE02M001	
SCALE	REVISION	SHEET	266

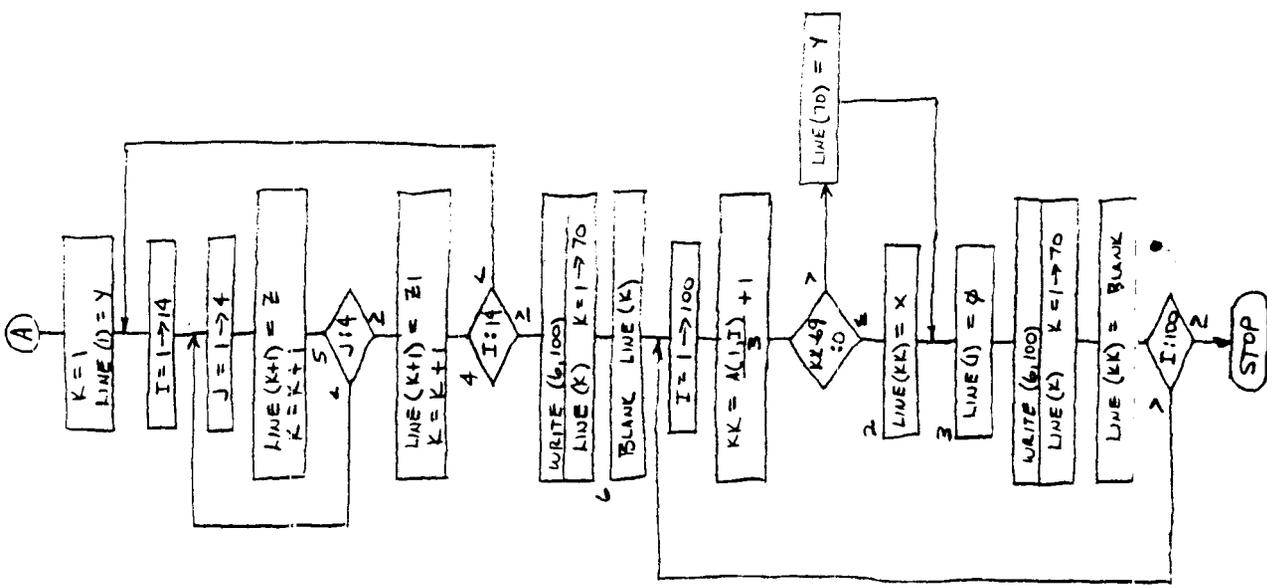
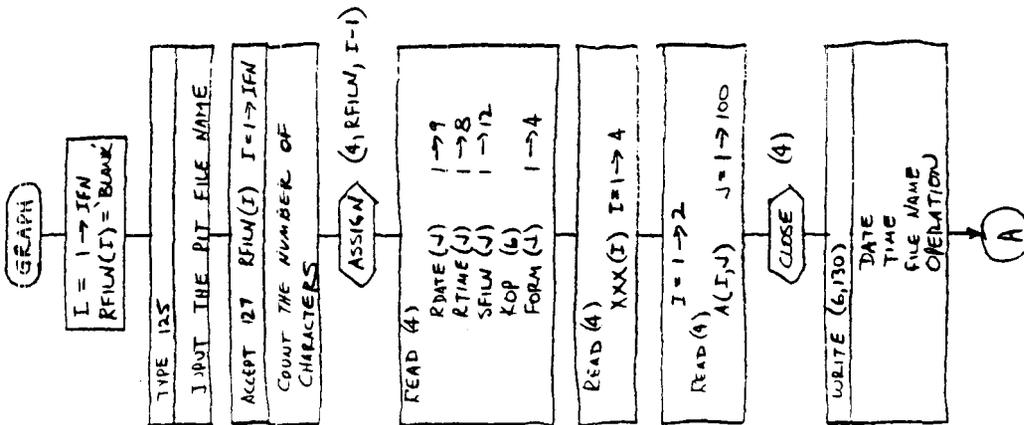


Figure 7-2. GRAPH Subroutine Flow Chart

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>		WE02M001
SCALE	REVISION	SHEET	267



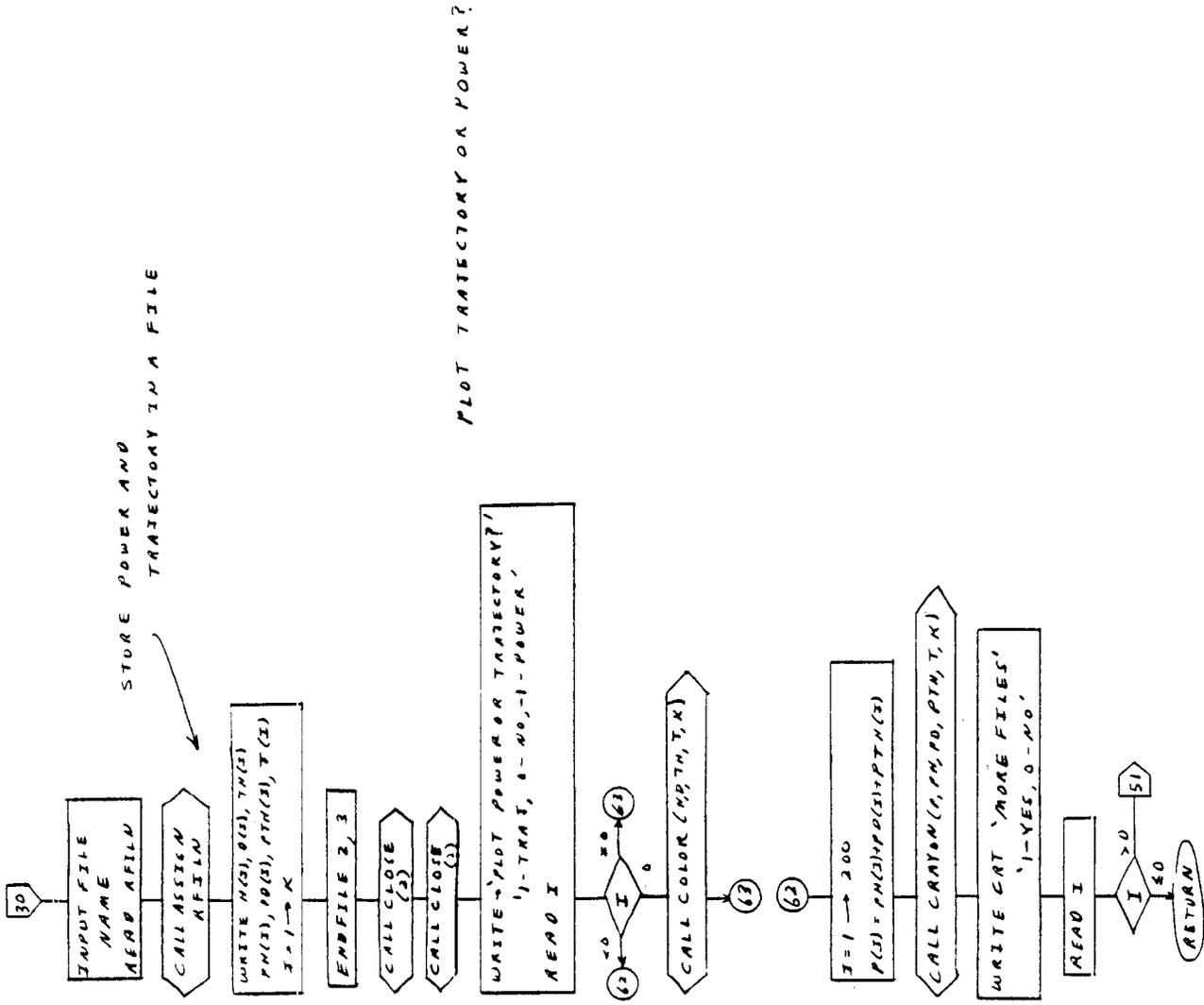


Figure 7-3. PDATA Subroutine Flow Chart (Sheet 2)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	269

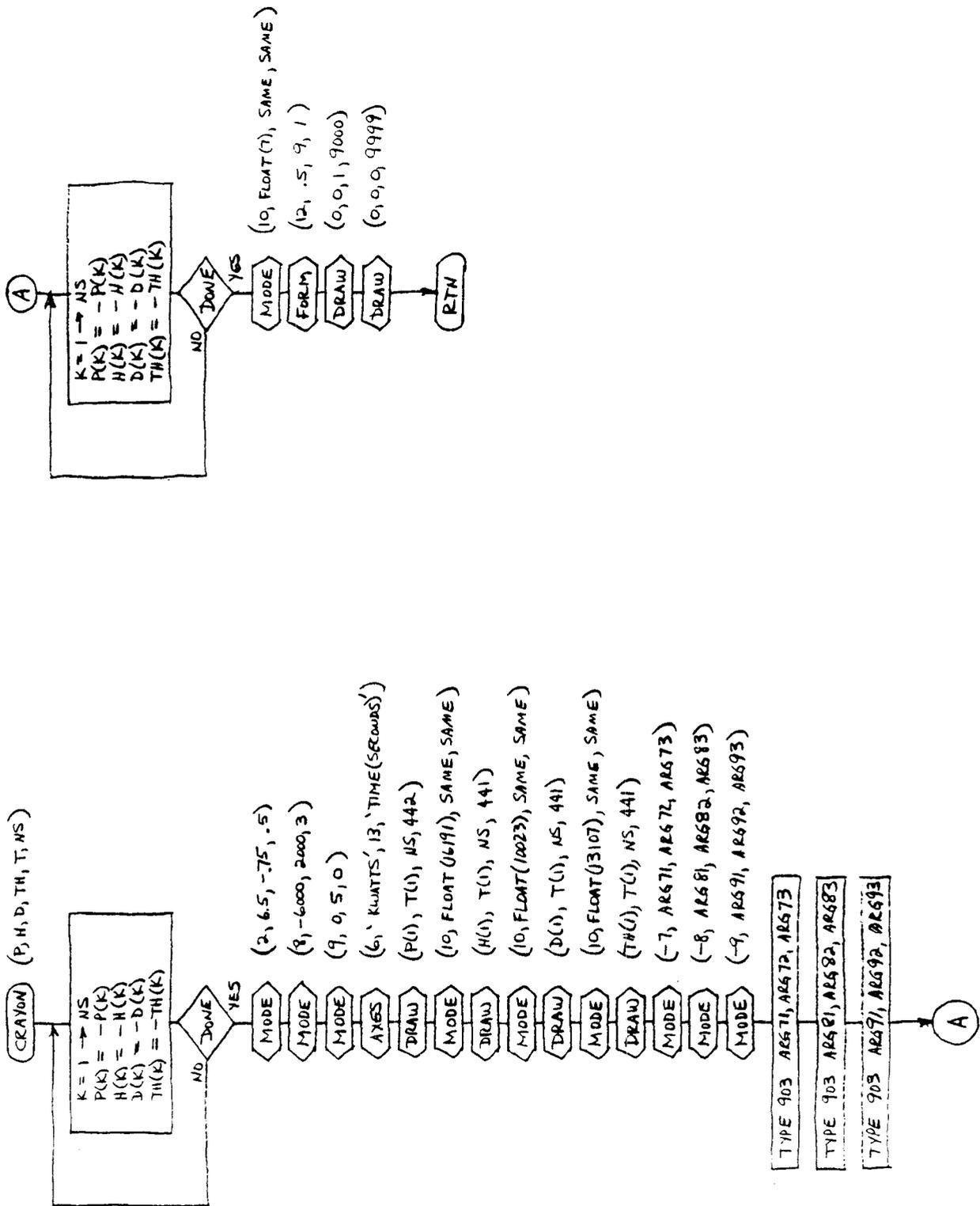


Figure 7-3. PDATA Subroutine Flow Chart (Sheet 3)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	270

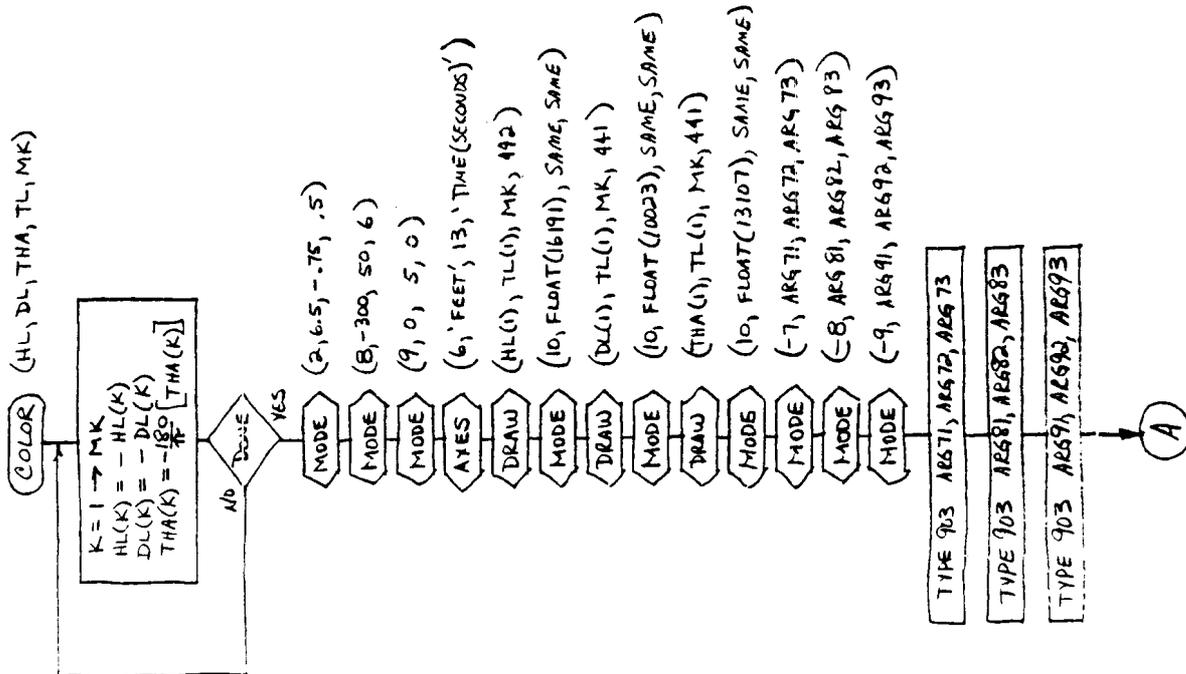
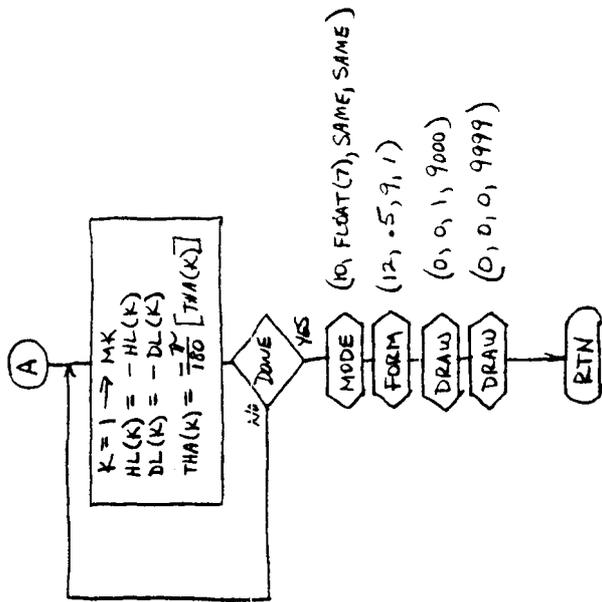


Figure 7-3. PDATA Subroutine Flow Chart (Sheet 4)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	271

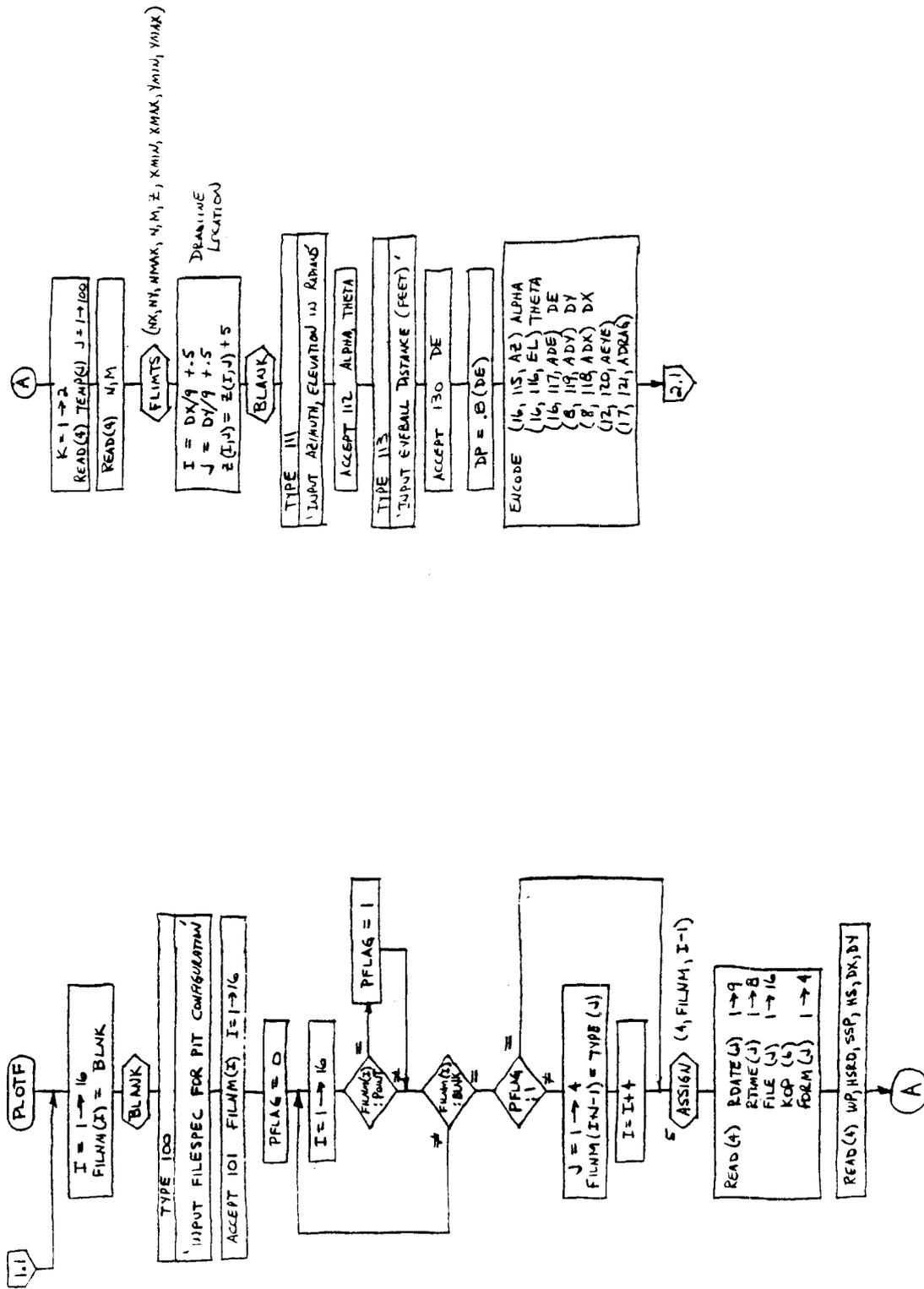


Figure 7-4. PLOTF Subroutine Flow Chart (Sheet 1 of 2)

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	272

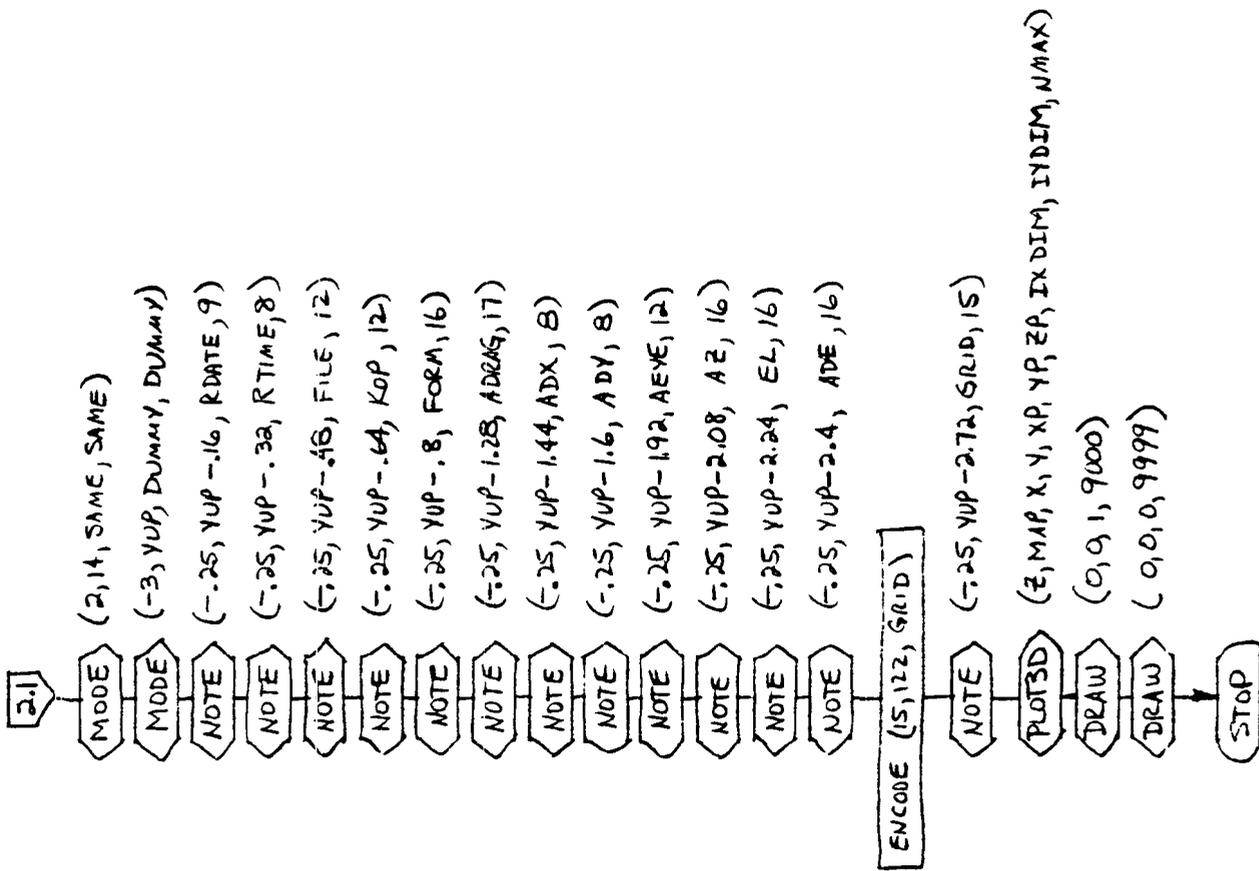


Figure 7-4. PLOTF Subroutine Flow Chart (Sheet 2)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	273

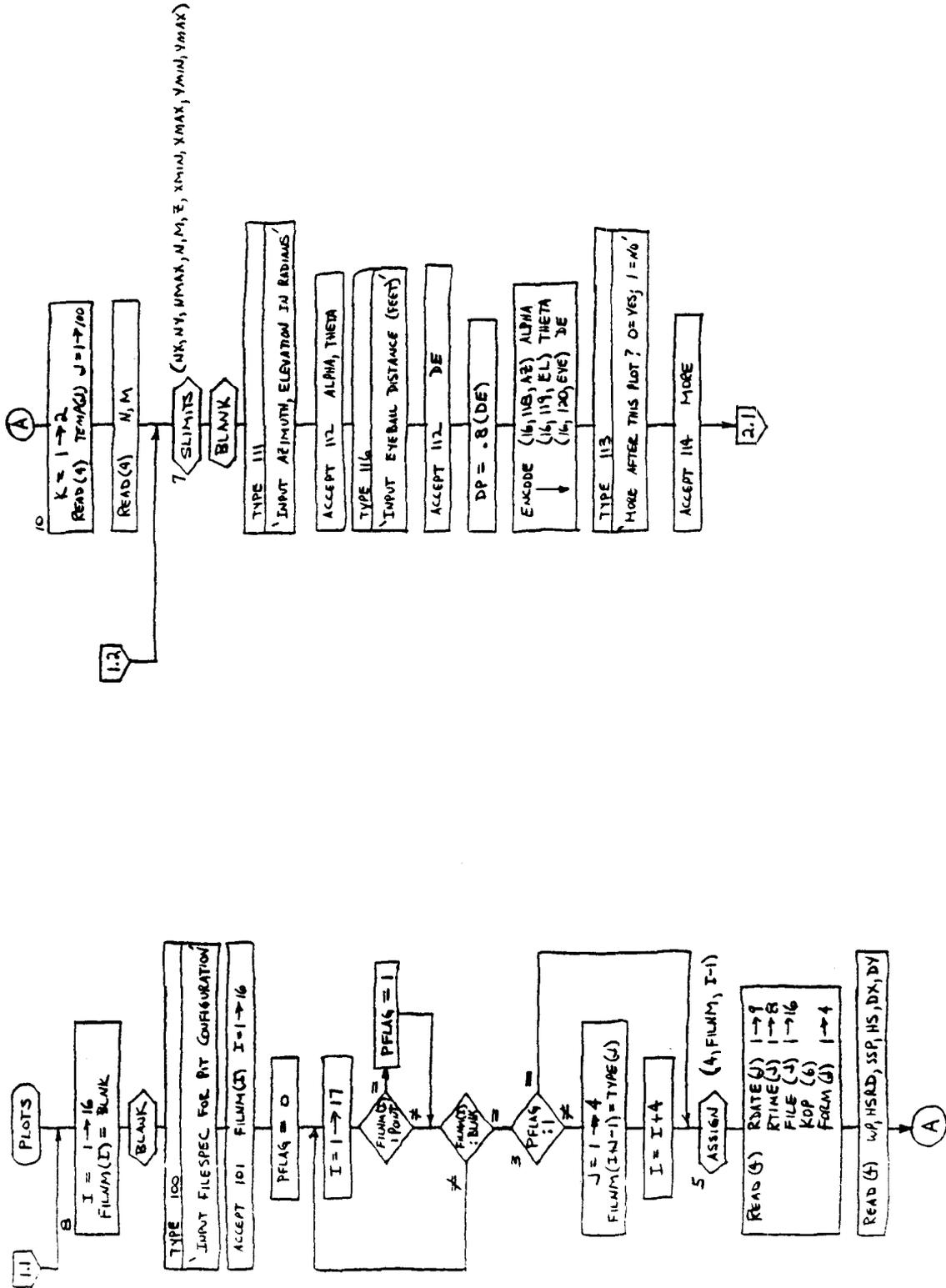
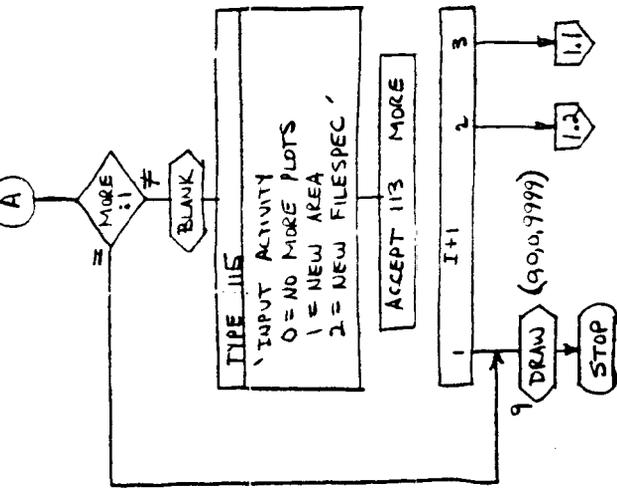
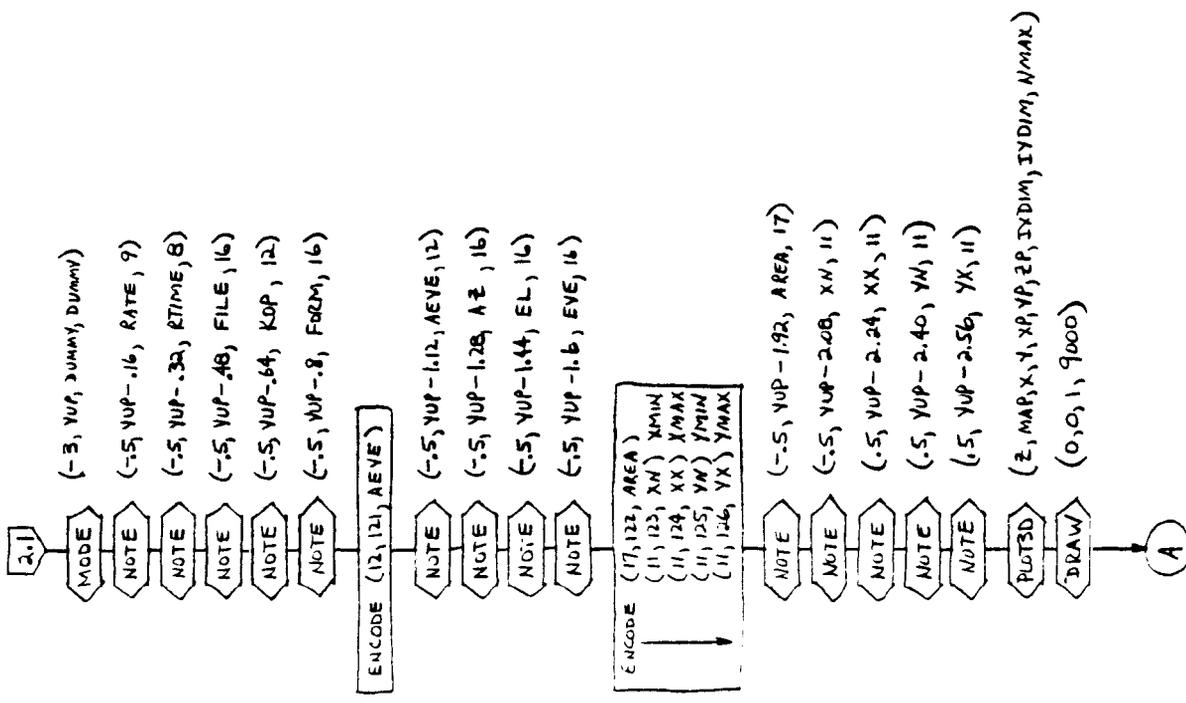


Figure 7-5. PLOTS Subroutine Flow Chart (Sheet 1 of 2)

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	274



SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	275

Figure 7-5. PLOTS Subroutine Flow Chart (Sheet 2)

7.7 SLIMITS

The subroutine SLIMITS is called by PLOTS to properly space the grid points between the X and Y coordinate limits and transfer these grid points to the plotting array. (See Figure 7-6.)

7.8 SPLIM

The subroutine SPLIM is called by SPLOT to read in the spoil pile height array and from this determine the grid points. (See Figure 7-7.)

7.9 SPLOT

The program SPLOT is used to plot the spoil pile in 3 dimensions with increment size equal to one yard. The name of the pit, angle of elevation, angle of rotation and distance to the eyepoint must be entered. SPLOT calls subroutine SPLIM and several system subroutines. The flow chart is given in Figure 7-8.

SIZE	CODE IDENT NO.	WE02M001	
<b>A</b>	<b>12464</b>		
SCALE	REVISION	SHEET	276



ARGUMENTS: NX, NY, NMAX, M, R,  
XMIN, XMAX, YMIN, YMAX

READ PIT FILE

INITIALIZE LIMITS

READ SPOIL HEIGHTS  
FROM PIT FILE

CALCULATE HEIGHT AT  
EACH GRID POINT

SPLIM

READ WP, NPM, SSP, HS,  
DX, DY

NX = 50  
NY = 50  
XMIN = 1.  
XMAX = 600.  
YMIN = 1.  
YMAX = WP + HS / SSP  
NMAX = MAX (NX, NY)

READ (H(I) I=1, 100)

CALL CLOSE(N)

I = 1 → 50

YP = NPM \* H(I) / SSP  
K1 = NPM \* SO / YMAX  
K2 = YP \* SO / YMAX

J = 1 → K1  
P(I, J) = 0

J = K1 + 1 → K2  
XT = J  
P(I, J) = SSP \* (XT + YMAX / SO. - NPM)

J = K2 + 1 → 50  
KJ = J  
P(I, J) = AMAX (N(2, J) - (XT - YMAX / SO. - YP) SSP, (XT + YMAX / SO. - WP) \* SSP)  
P(I, J) = AMAX (P(I, J), 0)

END  
LOOP ON I

RETURN

SIZE	CODE IDENT NO.		
A	12464	WE02M001	
SCALE	REVISION	SHEET	278

Figure 7-7. SPLIM Subroutine Flow Chart

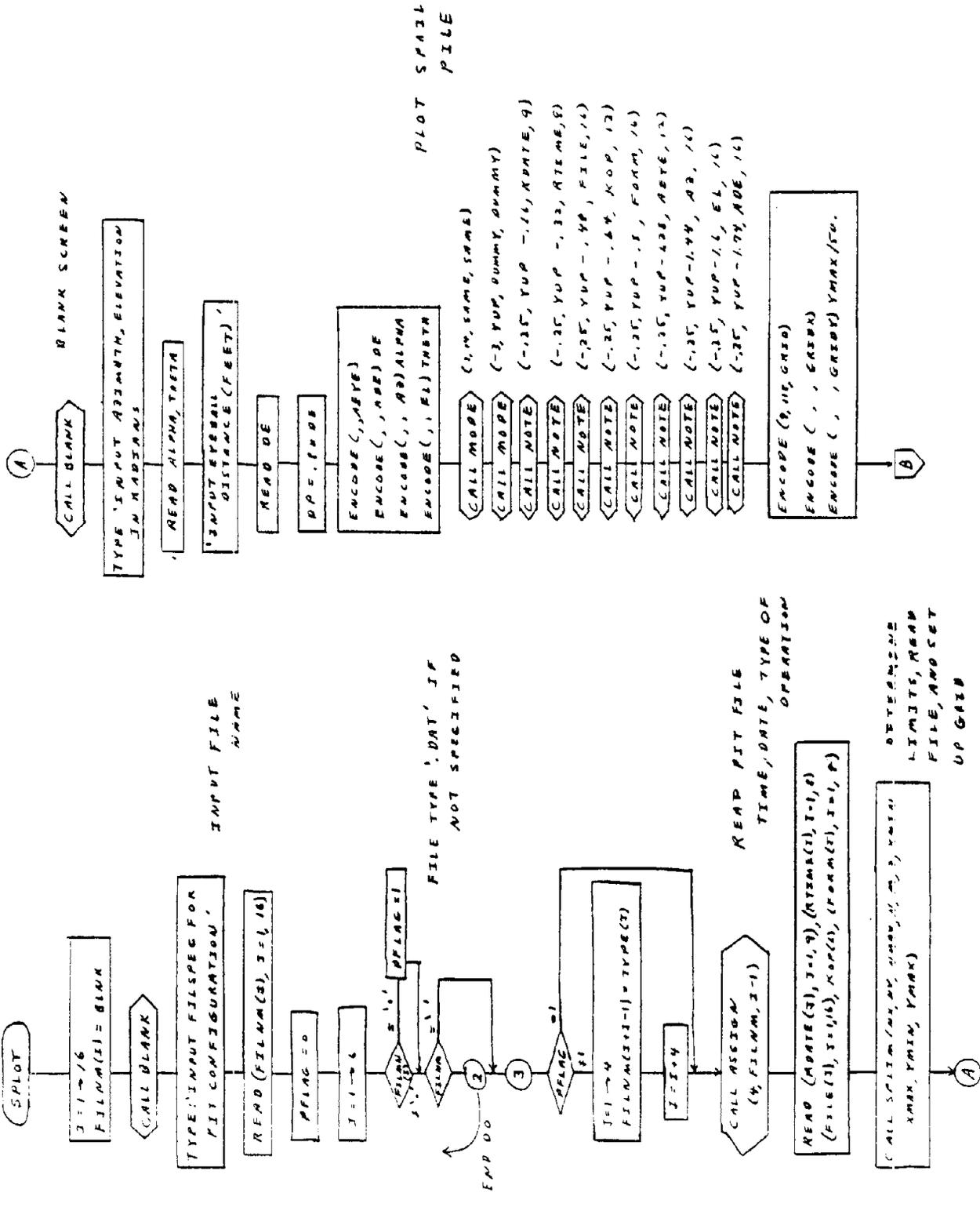
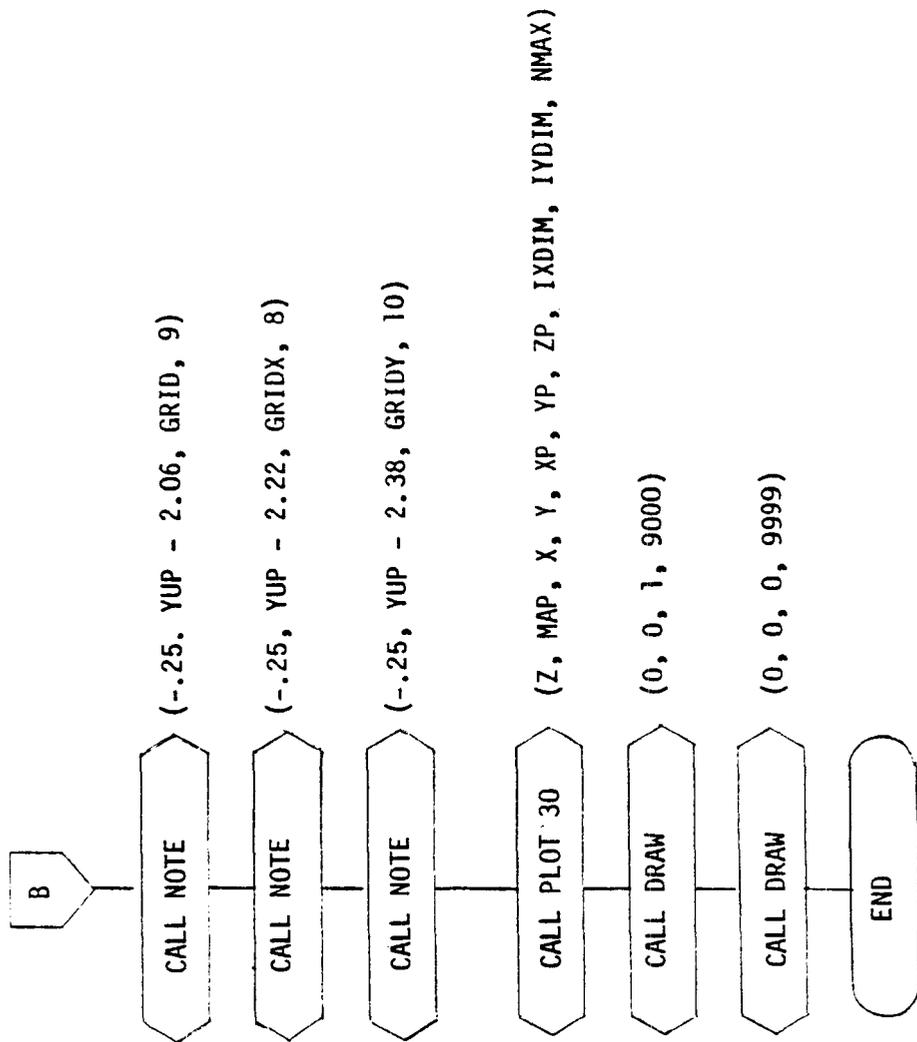


Figure 7-8. SPLIT Subroutine Flow Chart (Sheet 1 of 2)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	279



SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE		REVISION	SHEET 280

Figure 7-8. SPLOT Subroutine Flow Chart (Sheet 2)

APPENDIX A  
REQUIRED SIMULATION DATA  
(WE02M001)

COMPUTER-AIDED DRAGLINE ANALYSIS  
REQUIRED SIMULATION DATA

### 1.0 PURPOSE

The following pages document the information required to define the dragline and mine conditions that are to be simulated.

### 2.0 DISCUSSION

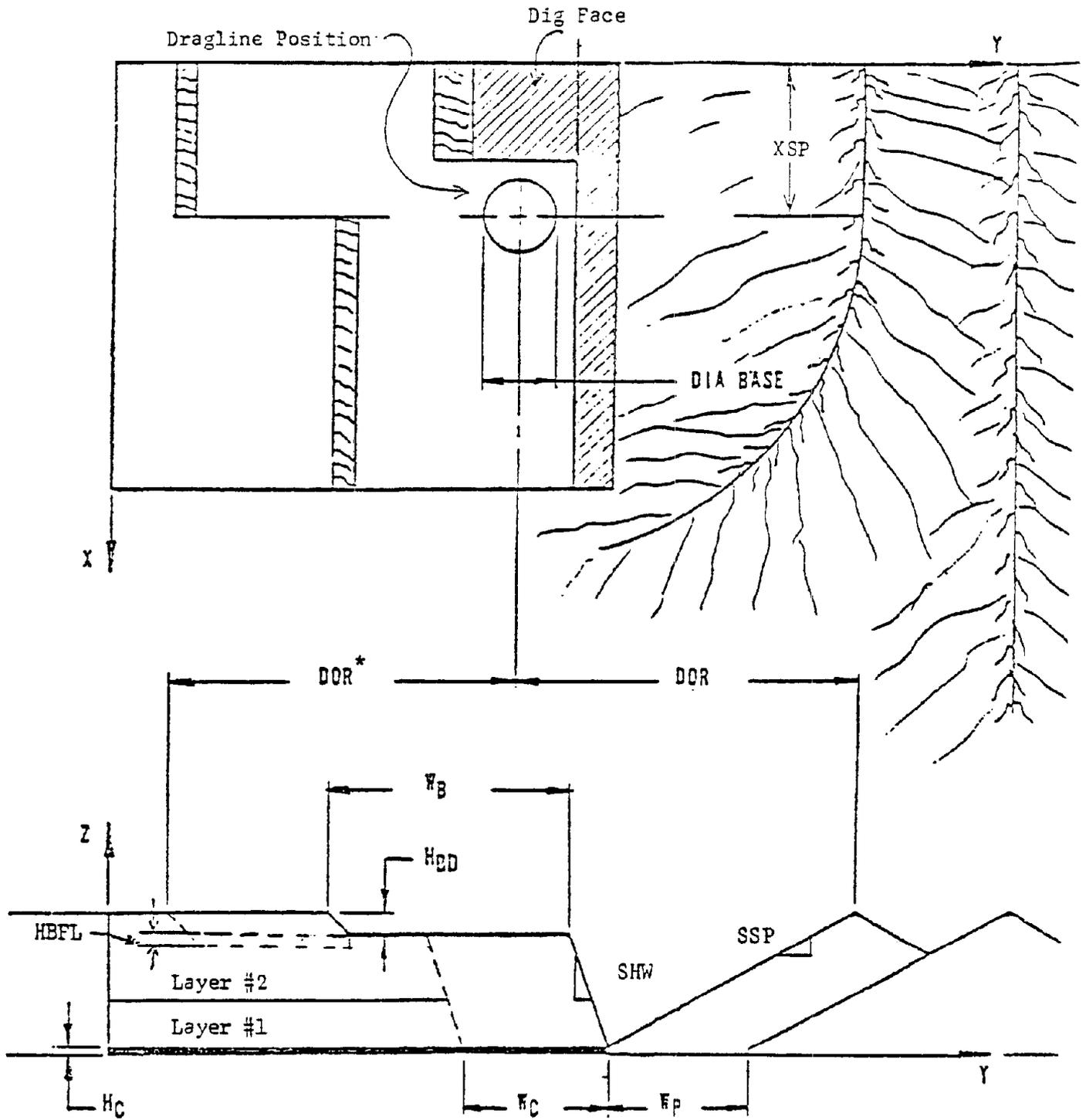
The simulation model requires a considerable amount of data to define a specific dragline working in specific mine conditions. An attempt has been made to keep the amount of required data to a minimum and in terms that are easily understood.

The data requested in the following pages may not be readily available in the specific formats shown. The data formats are not binding. The pages are intended to define what is required. Specification sheets, drawings, etc., can be attached. If an item is not understood, place a question mark by it and skip it.

### 3.0 MINE AREA

The following information is required to define the dragline working area, reference Figure 1.

- A. Width of Cut (WC) = \_\_\_\_\_ FT.
- B. Width of Pit (WP) = \_\_\_\_\_ Ft.
- C. Width of Bench (WB) = \_\_\_\_\_ Ft.
- D. Slope of Dig Face (SD), Rise/Run = \_\_\_\_\_
- E. Slope of Highwall (SHW), Rise/Run = \_\_\_\_\_
- F. Slope of Spoil Pile (SSP), Rise/Run = \_\_\_\_\_
- G. Height of Coal (HC) = \_\_\_\_\_ FT.
- H. Bench Depth (HBD) = \_\_\_\_\_ FT.
- I. Bench Fill Height (HBFL) = \_\_\_\_\_ FT.
- J. The overburden area can usually be considered to be composed of several layers of different types of material (i.e., clay, sand, rock or shale) that have different physical characteristics. The layer description and thickness is the minimum information required. The additional data will be obtained from a materials handbook if it is not supplied.

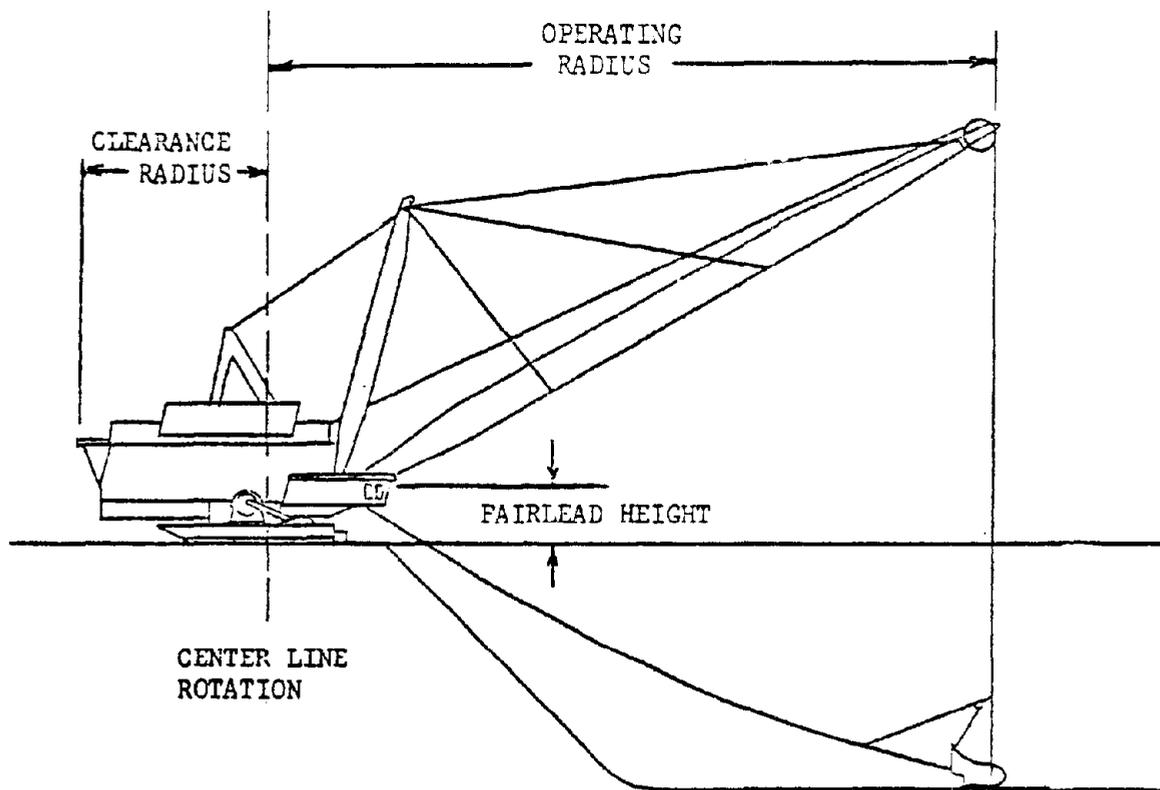


\* DOR - Operating Radius of the Dragline

PLAN VIEW OF MINE

FIGURE 1





DRAGLINE DIMENSIONS

FIGURE 2

5.0 HOIST

The following information is required to define the hoist performance of the dragline.

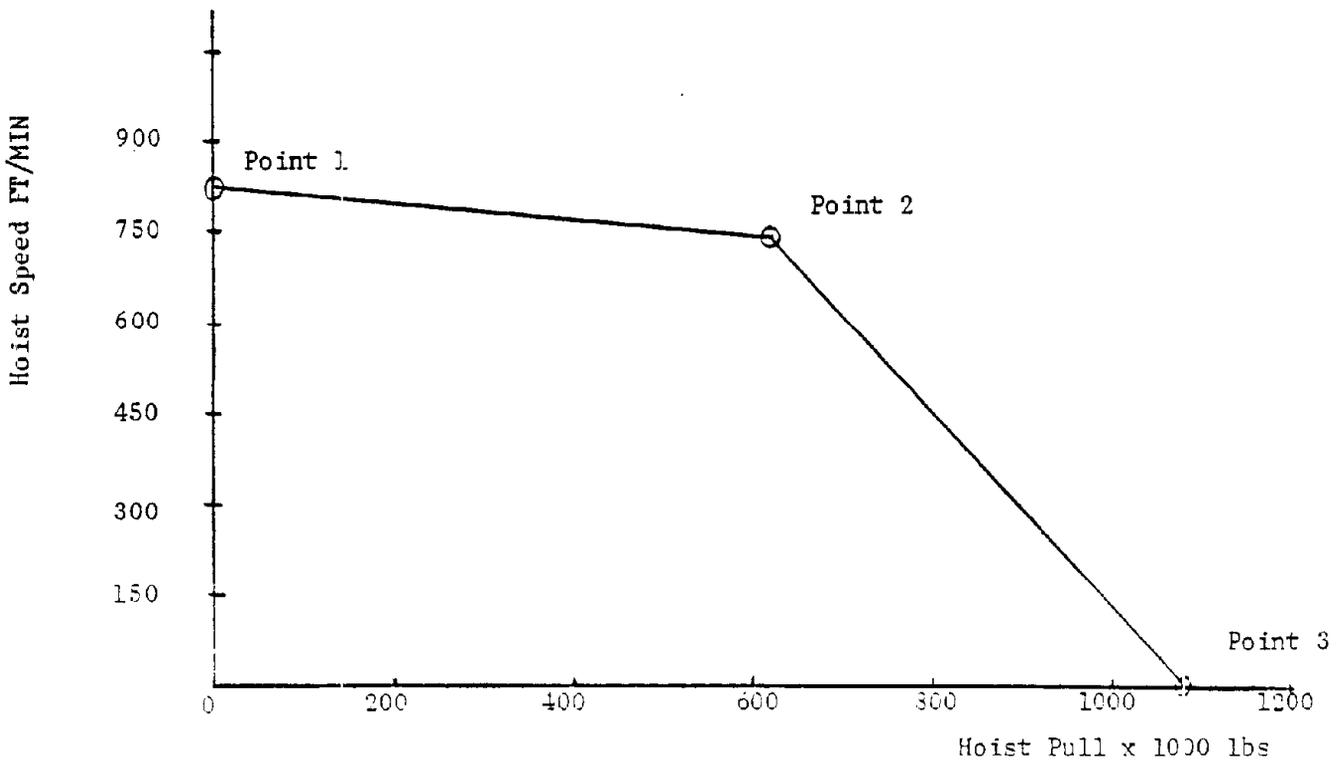
A. Bail Speed vs Pull Table, Reference Figure 3.

Point	Speed (FT/MIN)	Pull (# x 1000)
1		
2		
3		

B. Maximum Lower Speed = \_\_\_\_\_ FT/MIN

C. Maximum Suspended Load = \_\_\_\_\_ #

D. Hoist Efficiency = \_\_\_\_\_ %



Hoist Performance

Figure 3

6.0 DRAG

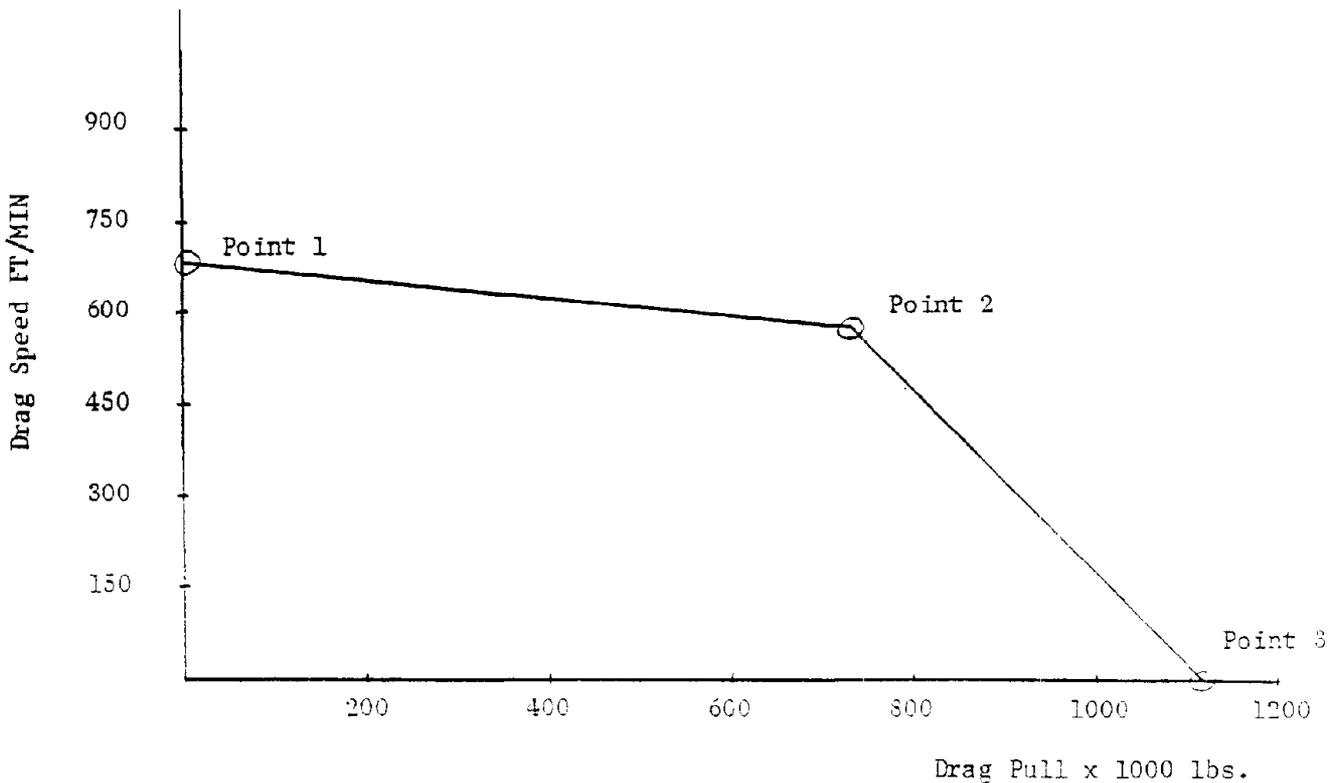
The following information is required to define the drag performance of the dragline.

A. Bail Speed vs Pull Table, Reference Figure 4.

Point	Speed (FT/MIN)	Pull (# x 1000)
1		
2		
3		

B. Maximum Payout Speed = \_\_\_\_\_ FT/MIN

C. Drag Efficiency = \_\_\_\_\_ %



drag Performance

Figure 4

7.0 SWING

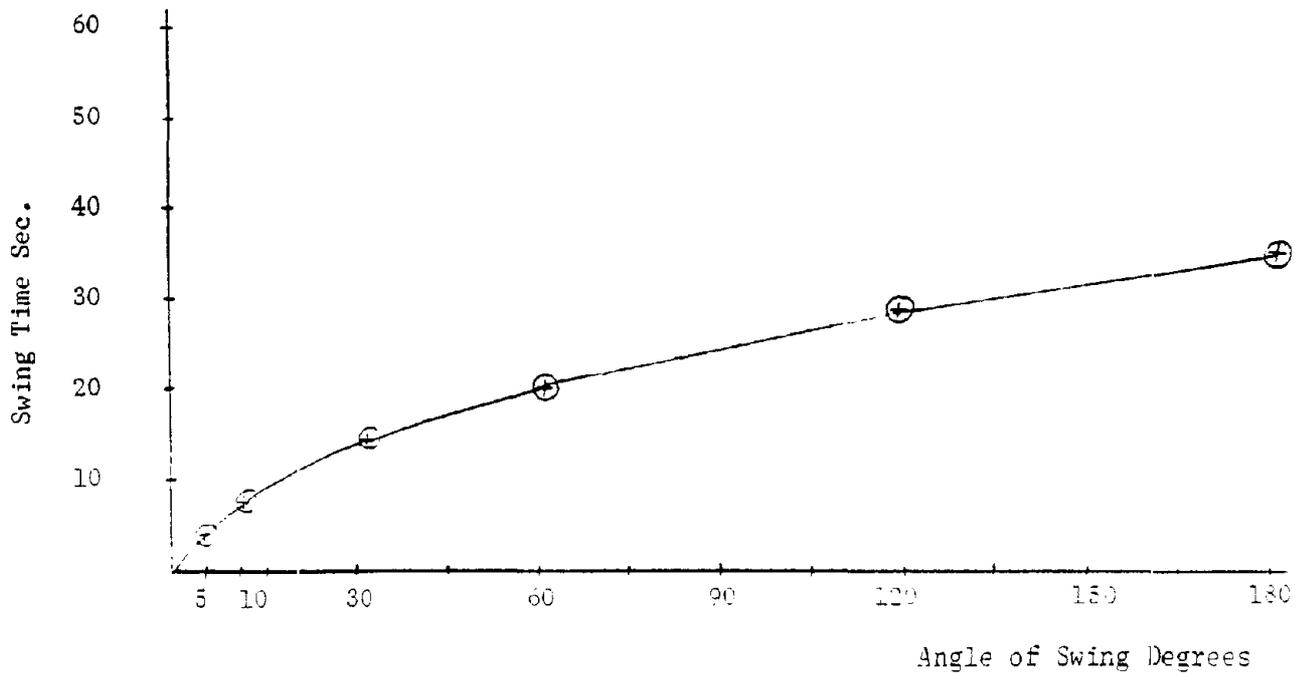
The following information is required to define the swing performance of the dragline.

A. Swing Time Table, Reference Figure 5.

Graph Point	Angle (DEG)	Time (SEC)
1	5	
2	10	
3	30	
4	60	
5	120	
6	180	

B. Swing Deceleration Rate = \_\_\_\_\_% x Swing Acceleration Rate

C. Swing Efficiency = \_\_\_\_\_%



Swing Performance

Figure 5

8.0 DRAGLINE PERFORMANCE

The following information is required to define dragline performance.

- A. Machine utilization \_\_\_\_\_ PERCENT
- B. Minimum distance between highwall crest and the edge of the tub \_\_\_\_\_ FT.
- C. Carry angle (smallest angle the hoist ropes make with the vertical at which the bucket will not empty) \_\_\_\_\_ DEGREES
- D. Length of step = \_\_\_\_\_ FT.
- E. Time to complete a step = \_\_\_\_\_ SEC.
- F. When dumping what is the average time from when the swing is stopped to when the return swing is started?

  1   sec              2   sec            \_\_\_\_\_ sec

Does this vary with different operations, i.e., bench filling or spoiling on the pile?

Does this vary as the digging becomes nearer the coal seam?

- G. How much time does it take to spot the bucket? By this we mean the average time from the end of the swing to the start of the bucket loading.

  1   sec              2   sec            \_\_\_\_\_ sec

- H. The dump angle is the angle the dragline swings through from the start of the dump to the end of the dump when the swing is stopped. Please comment on what you feel the average dump angle is and if it varies for different operations such as bench fill or spoiling?

9.0 BUCKET

The following information is required to define the bucket characteristics, reference Figure 6.

- A. Bucket capacity = \_\_\_\_\_ BYD<sup>3</sup>
- B. Bucket fill = \_\_\_\_\_ %
- C. Bucket weight = \_\_\_\_\_ #
- D. Bucket width = \_\_\_\_\_ FT.
- E. Bucket length = \_\_\_\_\_ FT.
- F. Horizontal distance between the drag and hoist connectors = \_\_\_\_\_ FT.
- G. Vertical distance between the bottom of the bucket and the hoist connector = \_\_\_\_\_ FT.
- H. Vertical distance between the drag and hoist connectors = \_\_\_\_\_ FT.
- I. Hoist chain length = \_\_\_\_\_ FT.
- J. Drag chain length = \_\_\_\_\_ FT.
- K. Dump cable length = \_\_\_\_\_ FT.
- L. Depth of cut = \_\_\_\_\_ FT.
- M. Average time to fill bucket = \_\_\_\_\_ SEC.



#### 10.0 COMPARISON DATA

The following information is requested to improve and insure the accuracy of the dragline simulation:

- A. A graph of energy usage vs cycle time as in Figure 7 or a similar substitute.
- B. Any energy usage data on the dragline recorded on the monthly, weekly or daily basis.
- C. A breakdown of the mass distribution of the dragline.
- D. Data on the area over which a bucket can be dumped and the distribution of dumped material within this area.
- E. A description of dragline operating procedures describing the dragline positions, material removed from each position, and its spoil location.

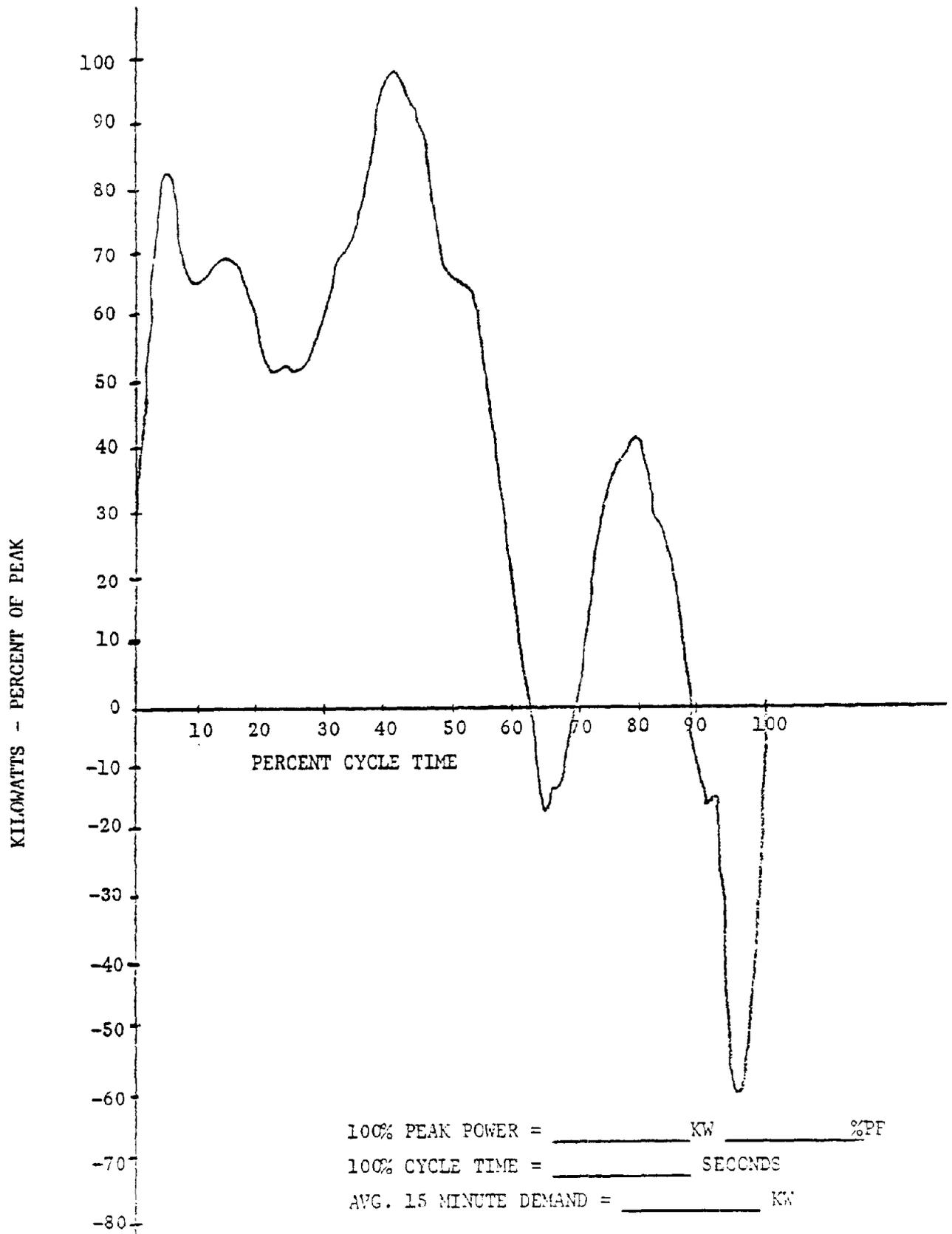


FIGURE 7

DATE:

DESCRIPTION	PRESENT MONTH TOTAL	PER CENT OF TOTAL
<u>Overburden Removal:</u> Total Minutes Total Swings Average Swing Angle		
<u>Bench Removal:</u> Total Minutes Total Swings Average Swing Angle		
<u>Bench Fill:</u> Total Minutes Total Swings Average Swing Angle		
<u>Clean Coal:</u> Total Minutes Total Swings Average Swing Angle		

YARDS MOVED \_\_\_\_\_

TOTAL ENERGY USED \_\_\_\_\_

TOTAL TIME \_\_\_\_\_

PERCENT ACTIVITY \_\_\_\_\_

PERCENT AVAILABILITY \_\_\_\_\_

Percent activity includes overburden removal, bench removal, and clean coal.

Percent availability includes overburden removal, bench removal, bench fill, clean coal, lubrication, power cable change, moving, shooting, waiting on other mine vehicles, and taking on supplies.

APPENDIX B  
COMMON BLOCK SYMBOLS

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	296







SYMBOL	UNITS	DESCRIPTION
UTIL		Machine Utilization
EFD		Efficiency of Drag Motion
EFH		Efficiency of Hoist Motion
EFTH		Efficiency of Swing Motion
DIWC	FEET	Distance from Tub Edge to Highwall Crest
HCLR	FEET	Clearance Height - Height Required to Clear Obstacles
CA	DEG	Carry Angle
DPAN	DEG	Dump Angle
DPTM	SEC	Dump Time
TPS1	SEC	Bucket Positioning Time
TPS2	SEC	Bucket Positioning Time Near Coal
BWMP		Buckwall Percentage
STEP	FEET	Length of Step
STIM	SEC	Time to Step
SPTM	SEC	Positioning Time to Step
		$T = (1 + SPTM) * (TSEP + TTRANSIT)$

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001
SCALE	REVISION	



SYMBOL	UNITS	DESCRIPTION
HBANK (1,1)	FEET	First Layer Above Coal - Height
HBANK (2,1)	#/YD <sup>3</sup>	First Layer Above Coal - Density (-, Buckwall Material)
HBANK (3,1)		First Layer Above Coal - Swell
HBANK (4,1)		First Layer Above Coal - Angle of Repose (Rise/Run)
HBANK (5,1)	FT#/YD <sup>2</sup>	First Layer Above Coal - Cutting Force
HBANK (1,2)	FEET	Second Layer Above Coal - Height
HBANK (2,2)	#/YD <sup>3</sup>	Second Layer Above Coal - Density
HBANK (3,2)		Second Layer Above Coal - Swell
HBANK (4,2)		Second Layer Above Coal - Angle of Repose
HBANK (5,2)	FT#/YD <sup>2</sup>	Second Layer Above Coal - Cutting Force
HBANK (1,3)	FEET	Third Layer Above Coal - Height
HBANK (2,3)	#/YD <sup>3</sup>	Third Layer Above Coal - Density
HBANK (3,3)		Third Layer Above Coal - Swell
HBANK (4,3)		Third Layer Above Coal - Angle of Repose
HBANK (5,3)	FT#/YD <sup>2</sup>	Third Layer Above Coal - Cutting Force
HBANK (1,4)	FEET	Fourth Layer Above Coal - Height
HBANK (2,4)	#/YD <sup>3</sup>	Fourth Layer Above Coal - Density
HBANK (3,4)		Fourth Layer Above Coal - Swell
HBANK (4,4)		Fourth Layer Above Coal - Angle of Repose
HBANK (5,4)	FT#/YD <sup>2</sup>	Fourth Layer Above Coal - Cutting Force
HBANK (1,5)		Fifth Layer Above Coal
HBANK (2,5)		Fifth Layer Above Coal
HBANK (3,5)		Fifth Layer Above Coal
HBANK (4,5)		Fifth Layer Above Coal
HBANK (5,5)		Fifth Layer Above Coal

SIZE	CODE IDENT NO.	
<b>A</b>	<b>12464</b>	WE02M001
SCALE	REVISION	SHEET
		302

SYMBOL	UNITS	DESCRIPTION
ST (1,1)	DEG	Swing Curve
ST (2,1)	SEC	Swing Curve
ST (1,2)	DEG	Swing Curve
ST (2,2)	SEC	Swing Curve
ST (1,3)	DEG	Swing Curve
ST (2,3)	SEC	Swing Curve
ST (1,4)	DEG	Swing Curve
ST (2,4)	SEC	Swing Curve
ST (1,5)	DEG	Swing Curve
ST (2,5)	SEC	Swing Curve
ST (1,6)	DEG	Swing Curve
ST (2,6)	SEC	Swing Curve
BP (1)	#	Hoist Curve - Pull
BP (2)	#	Hoist Curve - Pull
BP (3)	#	Hoist Curve - Pull
BS (1)	FT/MIN	Hoist Curve - Speed
BS (2)	FT/MIN	Hoist Curve - Speed
BS (3)	FT/MIN	Hoist Curve - Speed
DP (1)	#	Drag Curve - Pull
DP (2)	#	Drag Curve - Pull
DP (3)	#	Drag Curve - Pull
DS (1)	FT/MIN	Drag Curve - Speed
DS (2)	FT/MIN	Drag Curve - Speed
DS (3)	FT/MIN	Drag Curve - Speed

Common A6STP

SIZE	CODE IDENT NO.	
<b>A</b>	<b>12464</b>	WE02M001
SCALE	REVISION	SHEET
		303













SYMBOL	UNITS	DESCRIPTION
KEND		Exit Flag - Terminate Program
KB01		Diagnostic Flag - DUMP, SPILE
KB02		Diagnostic Flag - BCORD
KB03		Diagnostic Flag - INITIALIZATION
KB04		Diagnostic Flag - IPWR
KB05		Diagnostic Flag - DIG
KB06		Diagnostic Flag - BUCKET
KB07		Diagnostic Flag - BPWR
KB08		Diagnostic Flag - MOVE
KB09		Diagnostic Flag - DATA FILE
KB10		Diagnostic Flag - SWG HISTOGRAM
KB11		Diagnostic Flag - CYCLE PERFORMANCE
KB12		Diagnostic Flag -
KB13		Diagnostic Flag -

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	WE02M001
SCALE	REVISION	



SYMBOL	UNITS	DESCRIPTION
KDEV (L)		L = 1 + 5
		1 = Command
		2 = Parameter
		3 = Case
		4 = Operation
		5 = Diagnostic
		K = 1 + 12
ISPEC (K)		ISPEC (1) = Oper. Number for Operation #1
		Valid Oper. Numbers
		0 = End of Sequence
		1 = Overburden to Spoil
		2 = Bench Fill
		3 = Bench Removal
		4 = Move
		5 = Delete
		Operation Data
OPDAT (J, K)		J = 1 + 21 Operation Data Elements
		K = 1 + 12 Operation #

Common IOPER

SIZE <b>A</b>	CODE IDENT NO. <b>12464</b>	<b>WE02M001</b>
SCALE	REVISION	SHEET <b>312</b>





SYMBOL	UNITS	DESCRIPTION
TBFL (1)	CYCLES	Total BFL - CYCLES
TBFL (2)	MIN	Total BFL - TIME
TBFL (3)	YD <sup>3</sup>	Total BFL - VOLUME
TBFL (4)	KW·HR	Total BFL - ENERGY
TBFL (5)	DEG	Total BFL - SWING ANGLE
TBFL (6)	MIN	Total BFL - LOAD TIME
TBFL (7)	MIN	Total BFL - SWING TIME
TBFL (8)	MIN	Total BFL - DUMP TIME
TBFL (9)	KW·HR	Total BFL - LOAD ENERGY
TBFL (10)	KW·HR	Total BFL - TRANSIT ENERGY
TBFL (11)	KW·HR	Total BFL - POSITIONING ENERGY
TBFL (12)	MIN	Total BFL - POSITIONING TIME
TBFL (13)	MIN	Total BFL - HEELING TIME
TBFL (14)	MIN	Total BFL - SECOND PASS TIME
TBFL (15)		Total BFL - SECOND PASS NUMBER
TBFL (16)		Total BFL -
TBFL (17)	YD <sup>3</sup>	Total BFL - VOLUME REHANDLE
TBFL (18)		Total BFL - NUMBER OF HEELS
TBFL (19)		Total BFL - NUMBER OF SWINGS
TBFL (20)		Total BFL -
ABFL (1)		Average BFL - STRIPPING RATE
ABFL (2)		Average BFL - BUCKET FILL
ABFL (3)		Average BFL - ENERGY/CYCLE
ABFL (4)		Average BFL - SWING ANGLE
ABFL (5)		Average BFL - LOAD TIME
ABFL (6)		Average BFL - SWING TIME

Common RBFL (Sheet 1 of 2)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	315



SYMBOL	UNITS	DESCRIPTION
TBNR (1)	CYCLES	Total BNR - CYCLES
TBNR (2)	MIN	Total BNR - TIME
TBNR (3)	YD <sup>3</sup>	Total BNR - VOLUME
TBNR (4)	KW•HR	Total BNR - ENERGY
TBNR (5)	DEG	Total BNR - SWING ANGLE
TBNR (6)	MIN	Total BNR - LOAD TIME
TBNR (7)	MIN	Total BNR - SWING TIME
TBNR (8)	MIN	Total BNR - DUMP TIME
TBNR (9)	KE•HR	Total BNR - LOAD ENERGY
TBNR (10)	KW•HR	Total BNR - TRANSIT ENERGY
TBNR (11)	KW•HR	Total BNR - POSITIONING ENERGY
TBNR (12)	MIN	Total BNR - POSITIONING TIME
TBNR (13)	MIN	Total BNR - HEELING TIME
TBNR (14)	MIN	Total BNR - SECOND PASS TIME
TBNR (15)		Total BNR - SECOND PASS NUMBER
TBNR (16)		Total BNR -
TBNR (17)	YD <sup>3</sup>	Total BNR - VOLUME REHANDLE
TBNR (18)		Total BNR - NUMBER OF HEELS
TBNR (19)		Total BNR - NUMBER OF SWINGS
TBNR (20)		Total BNR -
ABNR (1)		Average BNR - STRIPPING RATE
ABNR (2)		Average BNR - BUCKET FILL
ABNR (3)		Average BNR - ENERGY/CYCLE
ABNR (4)		Average BNR - SWING ANGLE
ABNR (5)		Average BNR - LOAD TIME
ABNR (6)		Average BNR - SWING TIME

SIZE	CODE IDENT NO.	
<b>A</b>	<b>12464</b>	WEO2M001
SCALE	REVISION	SHEET
		317



SYMBOL	UNITS	DESCRIPTION
TOBS (1)	CYCLES	Total OBS - CYCLES
TOBS (2)	MIN	Total OBS - TIME
TOBS (3)	YD <sup>3</sup>	Total OBS - VOLUME
TOBS (4)	KW•HR	Total OBS - ENERGY
TOBS (5)	DEG	Total OBS - SWING ANGLE
TOBS (6)	MIN	Total OBS - LOAD TIME
TOBS (7)	MIN	Total OBS - SWING TIME
TOBS (8)	MIN	Total OBS - DUMP TIME
TOBS (9)	KW•HR	Total OBS - LOAD ENERGY
TOBS (10)	KW•HR	Total OBS - TRANSIT ENERGY
TOBS (11)	KW•HR	Total OBS - POSITIONING ENERGY
TOBS (12)	MIN	Total OBS - POSITIONING TIME
TOBS (13)	MIN	Total OBS - HEELING TIME
TOBS (14)	MIN	Total OBS - SECOND PASS TIME
TOBS (15)		Total OBS - SECOND PASS NUMBER
TOBS (16)		Total OBS -
TOBS (17)	YD <sup>3</sup>	Total OBS - VOLUME REHANDLE
TOBS (18)		Total OBS - NUMBER OF HEELS
TOBS (19)		Total OBS - NUMBER OF SWINGS
TOBS (20)		Total OBS -
AOBS (1)		Average OBS - STRIPPING RATE
AOBS (2)		Average OBS - BUCKET FILL
AOBS (3)		Average OBS - ENERGY/CYCLE
AOBS (4)		Average OBS - SWING ANGLE
AOBS (5)		Average OBS - LOAD TIME
AOBS (6)		Average OBS - SWING TIME

Common ROBS (Sheet 1 of 2)

SIZE	CODE IDENT NO.		
<b>A</b>	<b>12464</b>	WE02M001	
SCALE	REVISION	SHEET	319











SYMBOL	UNITS	DESCRIPTION
TOTX (1)		Total - CYCLES
TOTX (2)	MIN	Total - TIME
TOTX (3)	BYDS	Total - VOLUME
TOTX (4)	KW-HR	Total - ENERGY
TOTX (5)	DEG	Total - SWING ANGLE
TOTX (6)	MIN	Total - LOAD TIME
TOTX (7)	MIN	Total - SWING TIME
TOTX (8)	MIN	Total - DUMP TIME
TOTX (9)	KW-HR	Total - LOAD ENERGY
TOTX (10)	KW-HR	Total - TRANSIT ENERGY
TOTX (11)	KW-HR	Total - POSITION ENERGY
TOTX (12)	MIN	Total - POSITION TIME
TOTX (13)	MIN	Total - HEEL TIME
TOTX (14)	MIN	Total - 2ND PASS TIME
TOTX (15)		Total - 2ND LOADING PASSES
TOTX (16)	BYDS	Total - 2ND PASS MINIMUM LOAD
TOTX (17)	BYDS	Total - REHANDLE VOLUME
TOTX (18)		Total - NUMBER OF HEELS
TOTX (19)		Total - NUMBER OF SWINGS
TOTX (20)		Total - NUMBER OF OPERATION
TMOV (1)	STEPS	Total MOVE - X STEPS
TMOV (2)	STEPS	Total MOVE - Y STEPS
TMOV (3)	MIN	Total MOVE - TIME
TMOV (4)	KW-HR	Total MOVE - ENERGY
TMOV (5)	MIN	Total MOVE - POSITION TIME

Common Total

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SYMBOL	UNITS	DESCRIPTION
NSTOP	I = 1 → 4	Stop Flags for Loading Bucket
NREJ	I = 1 → 7	Reject Flags for Loading Bucket
IC		Index for Bucket Loading Path
ICS		First Material Loaded at this Index
NSCP		Look or Load Flag
NSPC		Second Pass Counter (Not Used)
LD		Bucket Path Index
NOR		Range Flag
NSN		Number of Bucket Paths this Layer
NSPIF		Second Pass Indicator Flag
NOAF		Volume 'Load or Look' Exit Flag
NCD		Number of Cable Rubs
NOC		Flag to Prohibit Multiple Passes
KSP		Spoil Location Segment
NICR		Flag Used to process Bucket Paths

Common IOER

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SYMBOL	UNITS	DESCRIPTION
SPL (1)	FEET	Spoil Position - X
SPL (2)	FEET	Spoil Position - Y
SPL (3)	FEET	Spoil Position - Z
BTV (5,30)	YD <sup>3</sup>	BTV (I,J) I = 1 + 5, J = 1 + 30
		Volume of Material from Ith Layer Removed in Jth Bucket Path
		Increment
BCT (5,30)	YD <sup>2</sup>	BCT (I,J) I = 1 + 5, J = 1 + 30
		Cutting Area in Ith Layer in Jth Bucket Path Increment
BPX		I = 1 + 30
BPY		X - Coordinates of Bucket Loading Path
		I = 1 + 30
BPZ		Y - Coordinates of Bucket Loading Path
		I = 1 + 30
SXT		Z - Coordinates of Bucket Loading Path
SYT		X - Coordinate of Dig Start
SZT		Y - Coordinate of Dig Start
SDA	RAD	Z - Coordinate of Dig Start
SHD	FEET	Dig Angle
SPLX		Dig Height
SPLY		Attitude Number of Lower Plane
SPLZ		Attitude Number of Lower Plane
SPLC		Attitude Number of Lower Plane
SPFX		Constant of Lower Plane
SPFY		Attitude Number of Front Plane
SPFZ		Attitude Number of Front Plane
SPFC		Constant of Front Plane

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SYMBOL	UNITS	DESCRIPTION
HD (I)	FEET	Height of Ith Layer I = 1 → 5
SDAN1	RAD	Angle of Dig Bias for Tilting Side Plane
SDAN2	RAD	Angle of Dig Bias for Tilting Side Plane
SI	RAD	Dig Angle Increment
RM	FEET	Range of Dig
TCYC	MIN	Total Time Digging
DIGL (I)		I = 1 → 21
		Array Used to Pass Operation Parameters, OPDAT (-,21), to the Digging Subroutines
CYCN		Number of Cycles for Operation
TOBR	MIN	Total Time for Operation
VOBR	YD <sup>3</sup>	Total Volume for Operation
EOBR	KW-HR	Total Energy for Operation
SOBR	RAD	Total Swing Angle for Operation
TLDT	MIN	Total Loading Time for Operation
TSWT	MIN	Total Swing Time for Operation
TDPT	MIN	Total Dump Time for Operation
TLP	KW-HR	Total Loading Energy for Operation
TPC	KW-HR	Total Transit Energy for Operation
PE	KW-HR	Total Positioning Energy for Operation
PT	MIN	Total Positioning Time for Operation
THLT	MIN	Total Heeling Time for Operation
TSPT	MIN	Total Second Pass Time for Operation
SPCT		Number of Second Passes for Operation
ZROBRI		Spare
VOLR	YD <sup>3</sup>	Total Rehandle Volume
HELN		Number of Heels

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SYMBOL	UNITS	DESCRIPTION
SWGN		Number of Swings
OPRN		Operation Number
ADIG	DEG	Angle of Dig
ASPL	DEG	Angle of Spoil
SWGT	MIN	Swing Time
VWV	YD <sup>3</sup>	Volume of Buckwall Material
CNST		Constant Used in Range
RMAX	FEET	Maximum Range of Dig
SDA1	RAD	Left Dig Angle Limit
SDA2	RAD	Right Dig Angle Limit
HDFL	FEET	Lower Cut Height Limit
HDP	FEET/SEC	Hoist Velocity of Previous Motion
THDP	RAD/SEC	Swing Velocity of Previous Motion
DDP	FEET/SEC	Drag Velocity of Previous Motion
SFH		Hoist Plug Flag
SFD		Drag Plug Flag
SFTH		Swing Plug Flag
VS	YD <sup>3</sup>	Volume Rehandled This Cycle
TSP	RAD	Angle of Spoil
VIT(I)	YD <sup>3</sup>	I = 1 + 5
		Volume of Material from Ith Layer
TCLD	MIN	Total Load Time Cycle
TCSWG	MIN	Total Swing Time Cycle
CYCT	MIN	Total Cycle Time
TLTC	MIN	Total Load Time
TSWG	MIN	Total Swing Time

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SYMBOL	UNITS	DESCRIPTION
AMV (1,J)	FEET	Start Coord J = 1 → 2 1 = x, 2 = y
AMV (2,J)	STEPS	Steps
AMV (3,J)	MIN	Step Time
AMV (4,J)	MIN	Swing Time - TSWG
AMV (5,J)	KW·HR	Step Energy
AMV (6,J)	KW·HR	Swing Energy - TPC = TPH + TPTH + TPD
AMV (7,J)	KW·HR	Swing Energy - TPH Transit (Swing) - Hoist
AMV (8,J)	KW·HR	Swing Energy - TPTH Transit (Swing) - Swing
AMV (9,J)	KW·HR	Swing Energy - TPD Transit (Swing) - Drag
S (1)	STEPS	Current Move, X Steps = AMV (2,1)
S (2)	STEPS	Current Move, Y Steps = AMV (2,2)
S (3)	MIN	Current Move, Time = AMV (3,J) + AMV (4,J) + S (5)
S (4)	KW·HR	Current Move, Energy = AMV (5,J) + AMV (6,J)
S (5)	MIN	Current Move, Position Time = 40% S (3)
JXY (1)		Integer Number of X Steps
JXY (2)		Integer Number of Y Steps
JM		Opposite of KM
KM		Direction of Move 1 = X, 2 = Y

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Common RMOV

SYMBOL	UNITS	DESCRIPTION
IXDL		Integer Used by Subroutines PINIT and SFILL to Initialize the
		Pit
IYDL		Integer Used by Subroutines PINIT and SFILL to Initialize the
		Pit
IXC		Integer Used by Subroutines PINIT and SFILL to Initialize the
		Pit
IYC		Integer Used by Subroutines PINIT and SFILL to Initialize the
		Pit
IBY		Integer Used by Subroutines PINIT and SFILL to Initialize the
		Pit
INBY		Integer Used by Subroutines PINIT and SFILL to Initialize the
		Pit

Common INITL

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SYMBOL	UNITS	DESCRIPTION
CL (I)	FEET	I = 1 → 5 Cut Length Entries
CW (I)	FEET	I = 1 → 5 Cut Width Entries
PW (I)	FEET	I = 1 → 5 Pit Width Entries
NRS (I, J)		I = 1 → 10, J = 1 → 4
		J = 1 - Line Number
		J = 2 - Location of Cut
		J = 3 - Type of Cut
		J = 4 - Location of Spoil
		I - Line
DC (10, 3)	FEET	Depth of Cut Entries
WC (10, 3)	FEET	Width of Cut Entries
ARU (10, 3)	DEG	Angle of Right Wall Entries
ALW (10, 3)	DEG	Angle of Left Wall Entries
SM (10, 2)	%	Spoil Method Entries
KSD (10, 2)		Direction of Spoil Entries
KDD (10, 2)		Direction of Dig Entries
KTSS (10, 2)		360 Flag Entries
KSP (10, 2)		Shortest Path Entries
KHO (10, 2)		Hoist Over Entries
NOC (10)		Number of Cut Depth Entries Per Line
NWC (10)		Number of Cut Width Entries Per Line
NARW (10)		Number of Right Wall Angle Entries Per Line
NALW (10)		Number of Left Wall Angle Entries Per Line
NSM (10)		Number of Spoil Method Entries Per Line
NSD (10)		Number of Spoil Direction Entries Per Line
NDD		Number of Dig Direction Entries Per Line
NTSS (10)		Number of 360° Swing Flag Entries Per Line

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