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COMPUTER SIMULATION OF HARD ROCK
TUNNELING. VOLUME II. SUPPORTING INFOR-
MATION

R. R. Hibbard, et al

General Research Corporation

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November 1972

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COMPUTER SIMULATION OF HARD ROCK TUNNELING

AD 763564

Final Technical Report
Volume II - Supporting Information

November 1972

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14 KEY WORDS	LINK A		LINK B		LINK C	
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FOREWORD

This volume contains supporting information and further programming guides to the excavation simulation described in Volume I.

The coordination of the material in Volume II was done by R. R. Hibbard and L. M. Pietrzak. The author credits are as follows:

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| Appendix II: | F. H. Murphy | (Geology Model) |
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| Appendix V: | L. M. Pietrzak | } (Layout Tunnel Data) |
| | W. R. Thomson | |

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APPENDIX I

GEOLOGICAL SURVEYING AND PREDICTION

by

D. S. Hyman

SUMMARY

This study discusses the significance of the knowledge of geological conditions to a tunneling project and briefly describes those measurement techniques and procedures that are in general use for geological surveying and prediction.

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I. INTRODUCTION

It is generally recognized that the geological (and hydrological) conditions more than any other factor determine the degree of difficulty and the cost of a given tunnel project. This is easy to see, since the tunneling system, support and liner design, and total system performance are a direct and strong function of the geologic medium to be tunneled through. In essence, the latter is truly a key variable in the total economic picture of a project. As a result, geologic exploration and prediction techniques have a very important influence on the planning, design, and performance of an excavation system. Although it is not yet possible to identify a return-on-investment relationship for geological exploration it is clear that a more accurate knowledge of geological conditions will permit considerable savings from the improved planning and design of a project.

At present, less than 2% of the total project cost is generally allocated to pre-excavation geological investigations.^{1,2} This probably reflects the fact that the scope and extent of the geological survey is a compromise between technical desirability and economic feasibility. Moreover, the point of compromise may not be reached objectively in many instances. Budgetary considerations of sponsoring agencies, political considerations, etc., may also play a role in the decision process. In addition, no comparative estimates for total project cost versus the geological investigation investment has ever been made, and even if they had, considerable doubt about the validity of the comparison would remain since it is never possible to "excavate again, this time with more geological information." However, some indications of the significant and perhaps unnecessary costs which may be incurred because of poor or limited geological data can be drawn from isolated case histories. As an example, there were only two bore holes made prior to the excavation of the massive underground defense complex in Cheyenne Mountain for the

North American Air Defense Command (NORAD). Further geological exploration was scheduled but never funded because of a controversy about the project itself. When funding for continuation of the project was eventually released it was allocated for excavation alone, not geological exploration, and partly as a result, poor geology was encountered unexpectedly at a critical intersection of two project chambers. Eventually new plans had to be drawn up, rotating the original design in an attempt to avoid bad ground. Even then extensive and costly reinforcement was necessary at the worst intersection.³

Traditionally, geological surveying, measurements, and prediction are accomplished before any detailed designs and cost estimates are attempted. Although geophysical measurements are sometimes made during the course of the excavation process, the current practice is to rely heavily on the geological work prior to excavation. As improved techniques for in situ measurement of geological conditions are developed it is likely that greater emphasis will be placed on evaluating the information provided by these techniques to improve the safety and performance of excavating.

Depending upon the extent of the geological survey and measurement program, the information and data that it evokes might be used in site selection and feasibility determination, preliminary design and cost estimates, or detailed construction planning. However, as a result of both the coarse nature of geological measurements and the cost of detailed exploration programs, such decisions and studies are almost always based on incomplete information. Consequently, engineering judgment tempered by previous experience plays a significant role in the decision processes. We shall have more to say about this in the following pages, but given that the site, geometry, and orientation of a tunnel project have been chosen, we can focus attention on the fundamental data requirements imposed upon the engineering geologist.

The results of a geological exploration program should consist of sufficient amounts of data concerning lithological, hydrological, and rock-mass properties to enable a designer and contractor to plan a construction project with confidence. This includes both the quantitative aspects of engineering and excavation system design, and scheduling plans and cost estimates. In other words, the contractor wants answers to the following key questions:

1. What would be the most suitable excavation method?
2. What are the ground support and tunnel liner requirements along the length of a proposed tunnel?
3. How much ground-water inflow can be expected along the tunnel length?
4. What is the location of potential geologic hazards?

The extent to which such questions can be answered with precision and reliability determines to a large extent the ultimate cost-performance success of the construction project.

II. SURVEY AND PREDICTION TECHNIQUES

We shall present next a brief survey of those measurement techniques and procedures that are now in general use for geological surveying and prediction. Since comprehensive discussions along these lines are readily available in the literature,⁴⁻⁹ we shall focus our attention primarily on the extent to which these various techniques are able to delineate geological discontinuities and inhomogeneities such as faults, joints, bedding planes, rock-soil interfaces, and ground-water concentrations. In addition, we shall present relevant cost data, and discuss the technical and economic factors which influence the scope of a typical geological exploration program.

A comprehensive geological exploration program typically involves the following kinds of activities:

- Review of available data (literature research)
- Surface exploration and mapping
- Subsurface studies
- Laboratory analysis of field samples

The degree to which efforts are directed in each area depends not only on technical and engineering considerations but also on economic factors and judgment. This will be elaborated below.

A. LITERATURE REVIEW

An exploration program generally begins with a survey of available literature dealing with geological and engineering geological information pertaining to the area of interest. The objective is not only to save time and expense but also to utilize the information to plan the remaining elements of the exploration program more efficiently and effectively. Of particular interest is information relating to the spatial distributions of rock formations along the tunnel route, the physical properties and quality of the rock types that might be encountered at depth, and expected or possible ground-water conditions during excavation. If underground construction data for previous projects in the general area are

available, they would most likely be used to assess the structural characteristics of the geological strata, and possible problem areas. The sum total of such sources of information would be expected to aid the geologist in interpreting conditions with respect to possible problem areas, tunnel support requirements, and ground-water conditions. Of course, the amount of useful data that can be gathered depends on the extent of previous surface and underground construction in the general vicinity of the proposed tunnel.

B. SURFACE EXPLORATION

Surface investigations comprise the second step in the sequence of progressively refined studies and measurements. With the exception of built-up urban areas, most geographical settings are suitable for surface geological exploration. The objective of this phase of the program is to survey and map in detail the exposed rock formations in a wide area covering the contemplated excavation. The usefulness of this procedure depends on the degree to which geological formations and structures of interest are exposed at the surface. In some cases, aerial and surface reconnaissance is aided where necessary by bulldozer stripping of surface soil to expose underlying rock formations. This is usually an inexpensive way⁴ to implement the surface work.

The results of this phase of geological exploration are recorded on a topographical map of the type made available by the U.S. Geological Survey. The map scale may vary between 1200:1 and 4800:1 and the following geological features are usually displayed:

- General geology (location and classification of generic rock types)
- Strike and dip of surface outcrops
- Location of fault zones and veins
- Description of foliation and joints
- Fracture densities as a function of location
- Degree of weathering

When the information is displayed in this form, it is useful to the geologist in connection with two main tasks: it serves as the basis for making a preliminary extrapolation of rock conditions to tunnel depth, and it aids in the planning of subsequent geological and geophysical measurements, such as core drillings and seismic surveys. It is worthwhile to emphasize that at this point the geologist cannot predict with a high degree of certainty what geological factors will be encountered at depth. The information, when evaluated and interpreted by an experienced geologist (and we must emphasize interpret) serves as a basis for perhaps semiquantitative estimates of expected conditions. Conditions are rarely predicted easily since much of the earth's outer crust consists of highly variable geological structures and conditions. Therefore, to increase the information usable for design purposes, additional measurements and tests are often planned, as a result of questions raised by the results of the surface geological mapping. Occasionally, field samples are collected during the surface survey for laboratory analyses and identification.

C. SUBSURFACE INVESTIGATIONS

As discussed in the previous sections, the geologist's chief goal is to measure and/or predict the geological conditions at the depth of interest. It is usually necessary to refine the data obtained from surface mapping by detailed investigations of areas of known faults, areas of potential geological problems, and ground-water conditions. Toward this end, a number of procedures and measurements are currently in use:

- Core drilling
- Pilot bore
- Field geophysical measurements

1. Core Drilling

Information concerning subsurface conditions is obtainable by drilling small vertical (or nearly vertical) holes down to tunnel depth, with the concomitant examination and testing of the removed material (core samples). Holes drilled in rock are usually about 3 in. in diameter, and the amount of core recovered is a function of the quality of the rock and the skill of the drillers. Data on rock properties and geological conditions as a function of depth are obtained through core logging, water testing, and laboratory measurements of core samples.

2. Core Logging

This is essentially the systematic recording of observations of rock properties for successive core samples. In particular, parameters such as rock type, fracture and joint spacing and orientation, density, and hardness are of immediate interest. Since heavy ground-water conditions are particularly influential in a tunneling operation, data on changes in the water level encountered, as well as porosity and permeability measurements and pumping tests, are of value.

3. Pilot Bore

In view of the inherent deficiencies in the techniques discussed above, the need for exploratory drilling ahead of a working face has been widely recognized. Current geological investigation techniques do not provide enough information for design purposes, nor are they capable of being applied simultaneously with the excavation process. As a result, it would be desirable to obtain in situ geological information in advance of a working face. Either a pilot bore prior to main tunnel excavation or a pilot bore sufficiently ahead of the main tunnel advance may supply the needed information.

The Straight Creek Tunnel Pilot Bore is an example of excavating a complete pilot tunnel in the immediate vicinity of the intended tunnel. A small pilot tunnel was excavated and subsequently surveyed by geophysical techniques. The resulting data indicated potential trouble spots,

and some correlation of rock properties with construction parameters was made. If such a procedure could be made more economical, it would represent a very effective geological measurement tool.

The Japanese Seikan Tunnel across the Tsugaru Strait is an example of excavating a pilot tunnel simultaneously with the main tunnel, far enough ahead to guide the main tunnel operations. This project, in addition to the pilot tunnel, relies on information provided by the drilling of a small probe hole up to 1000 ft ahead of the excavation to locate potentially bad ground conditions.

4. Field Geophysical Measurements

In addition to the techniques mentioned above, surface measurements are occasionally made using seismic velocities as indicators of intrinsic rock properties and changing geological conditions. However, its effectiveness is frequently limited by insensitivities of the techniques used and by an inability to distinguish clearly between certain kinds of rock. Surface measurements of DC electrical resistivity have also been used to detect changing rock and ground-water conditions, but with modest success. However, data from the Straight Creek Tunnel Pilot Bore^{8,9} indicate that such measurements may be of definite value in conjunction with other in situ techniques.

Some use has been made of borehole photography to provide direct observation of geological conditions inside the borehole.

Geophysical measurements of seismic velocities in boreholes are also made. Depending on the physical differences among the rock types encountered, such data can be used to correlate other surface geophysical measurements. Unfortunately, unless the boreholes are spaced close enough along a proposed tunnel route to reveal all geological changes bearing on engineering design and construction, the resulting information is only generally indicative of conditions to be expected. Core logs

are often incapable of indicating the extent of geological discontinuities. As a result, the data yield only an incomplete picture of geological and hydrological conditions at tunnel depth. However, in mining operations core-boring techniques may provide all the useful information that is needed.¹⁰

D. LABORATORY TESTS

In addition to the logging and measurement techniques used in conjunction with core boring, the intact core samples are usually tested in the laboratory. The object of such tests is to determine those rock properties which influence the excavation method, support and liner design, and probable ground-water conditions. In particular, such parameters as unconfined compressive strength, hardness, fracture and joint spacing, and degree of weathering are of immediate interest. Prospective bidders and/or tunnel machine designers might perform additional tests of their own choosing to enable them to evaluate the relative advantage of drill and blast versus machine tunneling, but such tests are performed after the initial geologic investigation is made. In recent years, the rock quality designation (RQD)^{7,11,12} has come into use as a simply measured indicator of overall rock quality. It is defined as the fraction of the recovered core pieces with a length greater than or equal to 4 in. Thus, it is an approximate measure of the influence of discontinuities on the rock mass encountered. This will be discussed in more detail in a subsequent section, but it suffices to say at this point that the RQD can be correlated at least partially with engineering and construction aspects of tunneling. At the present time, laboratory measurements of intrinsic rock properties are useful only in furnishing guidelines for support design purposes. The measurements are useful, but enough uncertainty remains to require the inclusion of large safety factors in design and construction.

E. COST CONSIDERATIONS

In general, one cannot readily provide rules which determine the optimum allocation of resources to geological exploration. The amount

can vary significantly from one project to another and one geology to another. However, Table I-1 summarizes typical costs associated with current geological surveying and measurement procedures. They can be used to estimate the total cost of postulated exploration programs.

It should be mentioned that the cost per foot of core drilling depends somewhat on the diameter and ultimate depth of the hole. Thus it can be seen that drill holes of 500-foot depth might typically cost \$5,000 or more each. This explains why their locations are chosen with care. Finally, it should be mentioned that in situ engineering tests for design purposes are usually more costly and time consuming than laboratory tests. This includes, in particular, radial jacking tests to measure the deformation of tunnel wall rock under various loading conditions.

TABLE I-1
COST ELEMENT OF GEOLOGICAL SURVEYING

1.	Core drilling into bedrock (3-in. diameter) with boxing of cores	\$5-\$25/ft
2.	Water pressure tests	\$75/test
3.	Mobilization/demobilization (per drill rig and crew)	Variable (several hundred to several thousand dollars)
4.	Observation well (1 1/2 in. diameter)	\$4/ft
5.	Surface mapping	\$100/(day-geologist)
6.	Literature research	\$2100/man-mo. (office)
7.	Laboratory tests	\$25-\$100/sample
8.	Seismic tests (surface)	< \$1/lin. ft

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APPENDIX II

GEOLOGY MODEL

by

F. H. Murphy

SUMMARY

This appendix describes the concept, code structure and user operation of the geology model which is a tool for building a file of data which represents the geological conditions found within a given three-dimensional model of a region of rock.

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I. OVERVIEW

The geology model is a part of the excavation simulation model. One of the requirements established for the simulation model by the Bureau of Mines was that it provide a realistic modeling of the geological conditions encountered during the process of tunneling; specifically, it was established that the rock which was encountered was not to be modeled as a homogeneous medium. It was also established that the excavation model was intended to be used as a research tool which would aid in evaluating the relative cost and performance characteristics of various techniques which might be used for tunneling through hard rock in the near future. This latter consideration led to a decision to design the overall model in such a way that the portion which was concerned with modeling geological conditions was a separate entity.

The geology model is intended to be a convenient tool for building a file of data which represents the geological conditions found within a given three-dimensional region of rock. The representation of the geology is meant to be exemplary. By this it is meant that the geology model is primarily intended for use in building files which represent hypothetical geologies which might be of interest in research. Even so, enough flexibility is provided so that reasonable representation of existing geological regions could be rather easily constructed, if desired. The sizes of the geological regions which are simulated, as well as the spacings of data points within the regions, are under the control of the user.

This appendix is intended to document the inputs, the methods of operation, and the outputs of the geology model. In doing this, it is convenient to discuss first the structure of the geology file which is generated; this gives some insight as to why the model is as it is. The structure of the model is then discussed in some detail. A discussion of the specific formats and uses of the various control cards follows. Finally, a detailed description of the subroutine named BENDER, which is used to simulate the tectonic warping of layers of rock, is given.

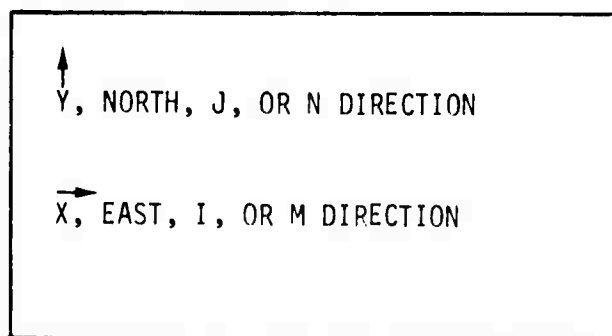
II. OUTPUT FILE STRUCTURE

The geology file produced by the geology model is a simple sequential (i.e., tape-like) file. This file consists of four parts, in order:

1. Dimensional Information
2. Rock Layer Information
3. Rock Property Information
4. Layer Position Information

Each of these four parts will be discussed in turn. It should be noted that there are no end-of-file marks between the parts of the geology file; the only end-of-file mark is located at the end of the file.

The dimensional information specifies the size of the region to be modeled and the horizontal spacing between data points. Implicitly, it also specifies the number of entries which will be found in the fourth part of the geology file--the layer position information. In order to see how this is done, imagine for a moment that you are well up in the air, looking down at a rectangular region of the earth's surface. This region is described, throughout the model, by means of the following directional notation conventions:



The compass-like notation is used for input convenience. The X and Y notation is used when it is convenient to refer to points within the region by means of floating-point coordinates; either the I and J or the M and N notation is used when it is convenient to refer to selected points within the region by means of integer coordinates. Vertical levels are

always referred to by floating-point numbers; the variable name Z is most commonly used for this purpose. The positive vertical direction is upward.

Within the model, this region is divided up into an integral number of grid squares. There are NX grid lines from right to left and NY grid lines from top to bottom. NX need not equal NY. These grid squares need not, in truth, be square. A scale factor can be associated with each of them. Thus, each square is SCALEX wide and SCALEY high. SCALEX need not equal SCALEY. The geology file contains geological layer position information for each point at which the grid lines cross.

Going back for a moment, then, the first part of the geology file contains four entries of dimensional information which specify the size of the region to be modeled and the horizontal spacing of the data points. In order, these four entries contain:

<u>Position</u>	<u>Contents</u>	<u>Format</u>
1	NX	I5
2	NY	I5
3	SCALEX	1PE18.10
4	SCALEY	1PE18.10

At the present time, the model can accommodate regions in which NX and NY are each less than or equal to 30. If these limits are exceeded, the array SURF in the geology model's main program should be redimensioned to SURF(NX_m, NY_m, 7) where NX_m and NY_m are the maximum desired values of NX and NY; no other changes are required. Their values of SCALEX and SCALEY are not subject to any practical limitations.

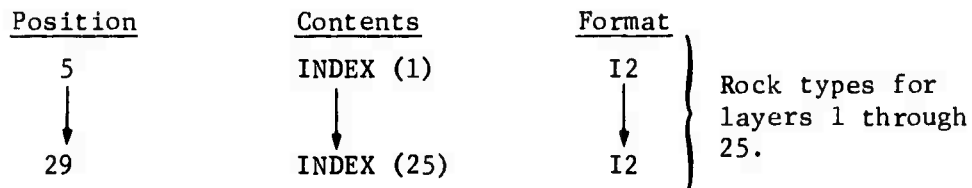
The present version of the geology model allows the user to specify up to 25 different layers of rock, which may correspond to between 2 and 25 kinds of rock. If these limits are exceeded, the array INDEX should be redefined as INDEX(ILAYR_m), where ILAYR_m is the maximum number of layers desired. Depending upon the computer used, it may be necessary to change the PROGRAM card of the geology model to allow for the files

TAPE1, TAPE2, ..., through TAPE(ILAYR_m). The array BUFF should also be redefined as BUFF(ILAYR_m + 2). Additional rock types are accommodated by redefining the array PROP as PROP(6, IROCK_m), where IROCK_m is the maximum number of rock types desired.

The geology model allows the user to easily generate surfaces, which are interpreted as the upper boundaries of layers of specified kinds of rocks. The user is required to number these layers, for identification purposes, as he generates them. There is no requirement that the relative vertical positions of layers be in any way related to the identification numbers assigned to them.

The second part of the geology file is simply a copy of the values which the user placed in the array named INDEX. The value of INDEX(ILAYR) is the number of the rock type which the user specified as being found directly beneath the surface to which he gave the identification number ILAYR. Let us suppose that INDEX(ILAYR) = IROCK. Then, PROP (1 through 6, IROCK) contains the six parameters which the user specified as defining the kind of rock which he gave the rock identification number IROCK. The third part of the geology file is simply a copy of the values which the user placed in the array named PROP.

Explicitly, the second part of the geology file consists of rock layer information in the form:



and the third part of the geology file consists of rock property information in the form:

<u>Position</u>	<u>Contents</u>	<u>Format</u>	
30	PROP (1,1)	1PE18.10	} Parameters for rock type 1
31	PROP (2,1)	1PE18.10	
32	PROP (3,1)	1PE18.10	
33	PROP (4,1)	1PE18.10	
34	PROP (5,1)	1PE18.10	
35	PROP (6,1)	1PE18.10	
36	PROP (1,2)	1PE18.10	
↓	↓	↓	
179	PROP (6,25)	1PE18.10	

The fourth part of the geology file consists of NX times NY entries, in sequence, each entry being of the following form:

<u>Entry Position</u>	<u>Contents</u>	<u>Format</u>
1	I	1PE18.10
2	J	1PE18.10
3	Z ₁	1PE18.10
4	Z ₂	1PE18.10
↓	↓	↓
ILAYR _m + 2	Z _{ILAYR_m}	1PE18.10

Each entry is for a single point at which the grid lines cross; the coordinates of that point are the integers (I,J). The Z_L for L = 1 to ILAYR_m are the vertical positions of the layers which the user has given the identification numbers 1 through ILAYR_m respectively; Z values for layers which he has not specified are set to the value Z = -10⁵¹. In interpreting the entries at a given (I,J) location, it is understood that, in case of overlap, an arbitrary rule determines which layer numbers take precedence.

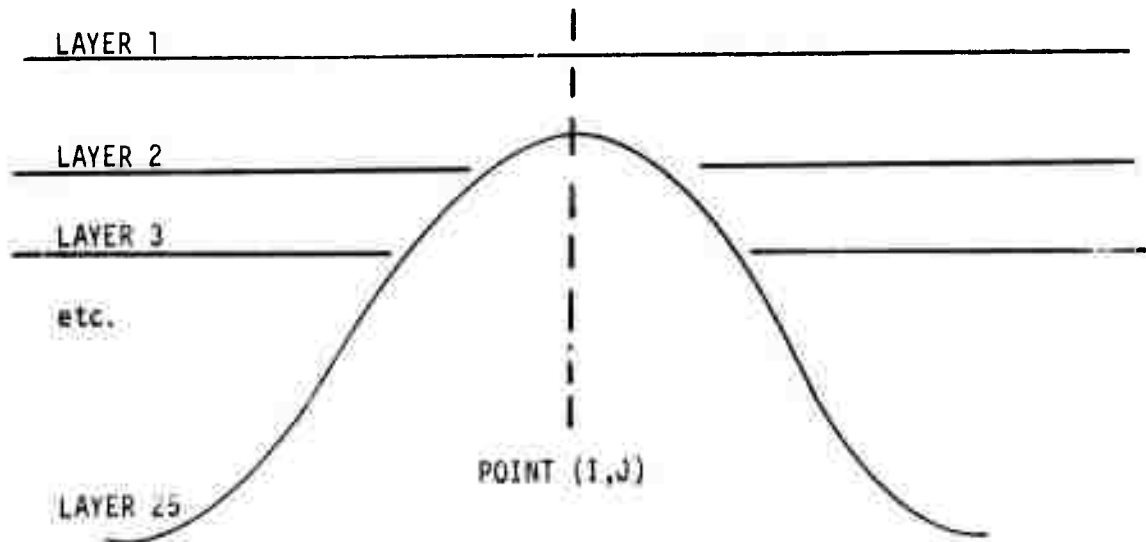
For example, suppose that at location (I,J) we were given the values Z_L for L = 1 through 25. We would receive them in the order given above:

<u>L</u>	<u>Z</u>
1	Z ₁
2	Z ₂
3	Z ₃
↓	↓
25	Z ₂₅

Our first step might be to sort the entries into increasing order by Z, and then use L as a precedence number:

<u>L</u>	<u>Z</u>
1	Z ₁
25	Z ₂₅
2	Z ₂
3	Z ₃
	↓
24	Z ₂₄

This might correspond to the condition:



The above illustration of how layer precedence relationships can be used is meant to be illustrative rather than definitive. No doubt the reader can imagine other geological conditions in which other precedence

relationships would be useful; e.g., perhaps specific layer numbers might always be interpreted as representing the surface of the earth and the water table.

III. GEOLOGY MODEL STRUCTURE

There are two major phases of the geology model. During the first phase, the user is aided in manipulating surfaces on an NX by NY grid. These working surfaces may then be given layer number and rock type identification numbers, and be stored on auxiliary storage (usually disk storage) one surface at a time. The user is allowed to have up to several working surfaces in existence at any one time. As was previously stated, the model as presently implemented will accommodate up to 25 layer surfaces.

The result of the first phase of operation is a collection of individual files, each corresponding to the Z values of a single layer surface; each such file of Z values is in the customary FORTRAN ordering by I and J. What is desired is of course a single file, ordered by I and J, which contains the Z values for every surface at each value of I and J. This phase, which begins upon the receipt of a MAKEFILE card, is essentially a reordering phase. During this phase, the values of NX, NY, SCALEX and SCALEY, as well as the contents of the arrays named INDEX and PROP, are written out onto the new geology file. The rest of the file is constructed by stepping through all values of I and J and, for each data point so defined, reading the corresponding Z value from each of the layer-surface files, consolidating these values into one entry, and writing this information onto the new geology file. When this process is completed, the operation of the geology model is terminated.

Figure II-1 illustrates the two-phase nature of the geology model.

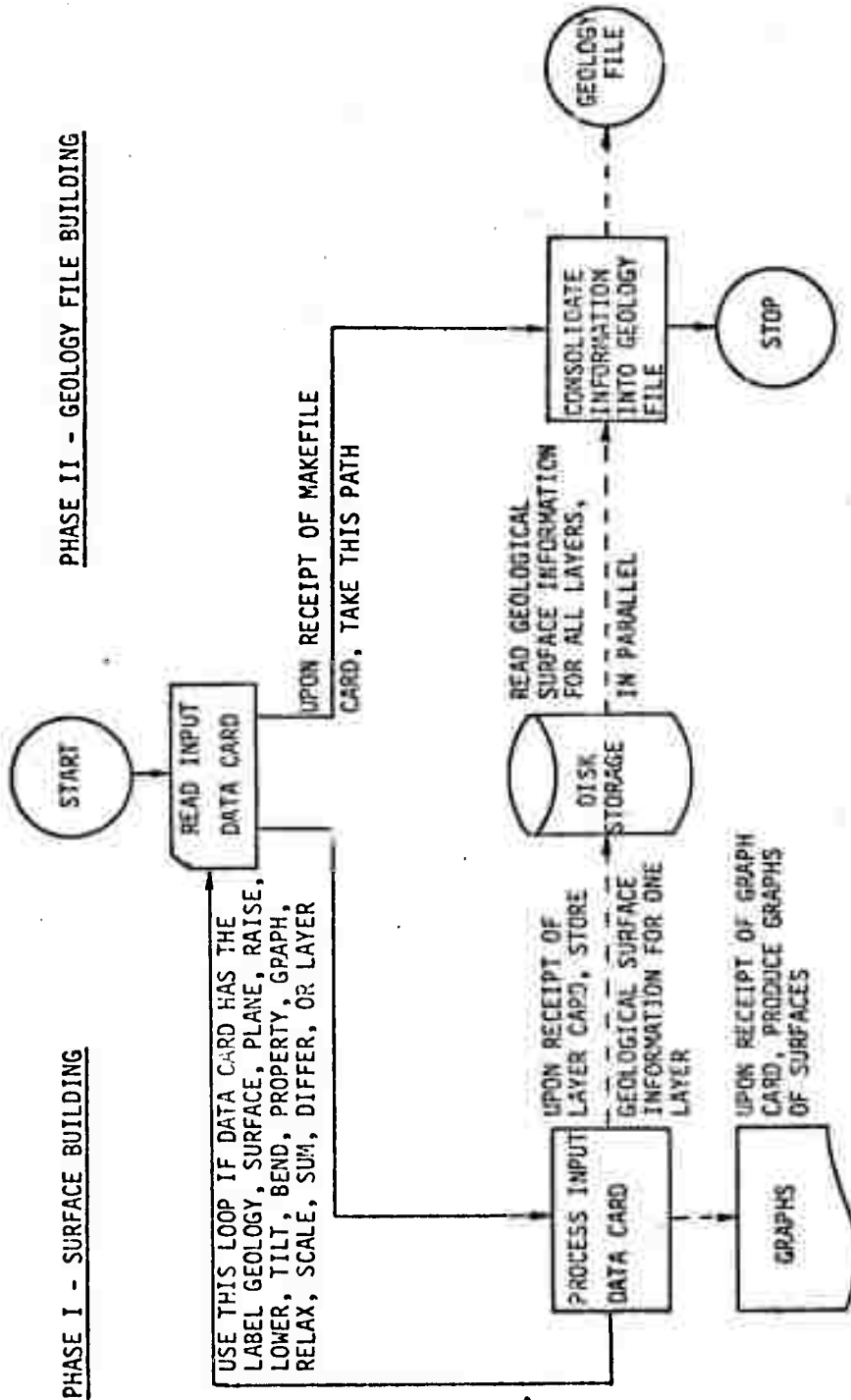


Figure II-1. The Two Phases of Operation of the Geology Model

IV. INPUT DATA CARDS

Sixteen different kinds of input data cards are used to control the operation of the geology model. Each kind is identified by a label which is punched into columns 1 to 10 of each card (left justified). The remaining space on each kind of card is divided up into seven equally sized data fields, each field being ten columns wide. All data entered into any of these data fields must be numerical and must include a decimal point. The formats of the sixteen kinds of input data cards are given in Table II-1. The purpose of each kind of cards and its associated data parameters is discussed in this section.

A. GEOLOGY CARD

The geology card must be the first card of the input data deck. There must be only one geology card per input data deck. Violation of either of these restrictions will cause a diagnostic message to be printed and the current run of the model to be terminated. The meanings of the variables NX, SCALEX, NY, and SCALEY are as given in Sec. II of this appendix.

B. SURFACE CARD

A SURFACE card provides a method of inputting a completely arbitrary surface. The main disadvantage to this is that many point-data cards (blanks in columns 1 through 10) may be required if NX times NY is large. In specifying an arbitrary surface, the SURFACE card must come first. SURFNO is the number by which the working surface which is to be created will be known; SURFNO can be any integer from 1 to 7, inclusive (but remember that decimal point!). The other data fields on the SURFACE card are ignored--unless they contain non-numeric data, which can cause a fatal error in the FORTRAN input-output routines.

The SURFACE card must be immediately followed by enough point-data cards to define the desired points on the surface. Two points can be defined per card; the problem which arises when it is necessary to define

TABLE II-1
INPUT CARD FORMATS

1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
GEOLOGY	NX	SCALEX	NY	SCALEY			
SURFACE	SURFNO	J	SURF(I,J)	I	J	SURF(I,J)	
PLANE	I	DEPTH					
RAISE	SURFNO	DISTANCE					
LOWER	SURFNO	DISTANCE					
SCALE	SURFNO(A)	SURFNO(B)	FACTOR				
SUM	SURFNO(A)	SURFNO(B)	SURFNO(C)				
DIFFER	SURFNO(A)	SURFNO(B)	SURFNO(C)				
TILT	SURFNO(A)	SURFNO(B)	DEGREE	AXIS	PTX	PTY	PTZ
RELAX	SURFNO	TOLER					
BEND	OLD SURF	NEW SURF	OLD MEDIAN	NEW MEDIAN	INFLUN		
GRAPH	SURFNO	SURFNO	SURFNO	SURFNO	SURFNO	SURFNO	SURFNO
LAYER	SURFNO	ROCKNO	LAYERNO				
PROPERTY	ROCKNO	PARAM1	PARAM2	PARAM3	PARAM4	PARAM5	PARAM6
MAKEFILE	MAXROCK	MAXLAYER					

an odd number of points is avoided by checking the value I times J before storing the value SURF(I,J). If I times J is zero (or blank) SURF(I,J) is ignored. The number of point-data cards is not checked. They need not be in any order, as long as all desired cards for the surface to be defined are together and immediately follow the appropriate SURFACE card.

C. PLANE CARD

As was noted above, the definition of large numbers of surface points can require large numbers of point-data cards and, therefore, large amounts of keypunching. This kind of effort is clearly unjustifiable when only very simple surfaces are required. Through the use of the PLANE card, one can establish a working surface with working surface identification number SURFNO, all of whose points are set to the value DEPTH, in one simple operation.

D. RAISE CARD

Geologies having layers whose layer surfaces are virtually identical, except for a vertical separation between layers, are not uncommon. The RAISE card was provided to ease the task of defining such a geological region. The use of the RAISE card simply adds the constant named DISTANCE to every data point of the working surface having the surface identification number SURFNO.

E. LOWER CARD

The same comments made in conjunction with the RAISE card are appropriate here. The use of the LOWER card simply subtracts the constant named DISTANCE from every data point of the working surface having the surface identification number SURFNO.

F. SCALE CARD

The use of the SCALE card is similar in nature to the uses of the RAISE and LOWER cards. In this case, each data point of the working

surface named SURFNO(A) is multiplied by the scale factor named FACTOR, the result being stored in the corresponding location of the working surface named SURFNO(B). SURFNO(A) may equal SURFNO(B), if desired.

G. SUM CARD

The use of the SUM card causes the Z value for each I,J location of working surface number SURFNO(A) to be added to the Z value for the corresponding I,J location of working surface number SURFNO(B); the resulting value is placed in the corresponding I,J location of working surface number SURFNO(C). The Z values for the working surfaces numbered SURFNO(A) and SURFNO(B) remain unchanged unless one or the other or both of the working surfaces have the same number as working surface SURFNO(C). The numbers SURFNO(A), SURFNO(B) and SURFNO(C) may be equal to each other in any combination, if desired.

H. DIFFER CARD

The operation of the DIFFER card is identical to that of the SUM card, except that the corresponding I,J data points of working surface number SURFNO(B) are subtracted from those of working surface number SURFNO(A) in order to obtain the data point values for SURFNO(C). In short, surface A minus surface B equals surface C.

I. TILT CARD

Up until this point, all of the operations performed upon working surfaces have been vertical. It has also been considered desirable to provide some simple method of tilting surfaces, so that it would not be necessary to resort to the definition of surfaces through the use of SURFACE cards whenever the layer structure in a particular geological region happened not to be horizontal. The TILT card provides a simple method of tilting arbitrary surfaces.

The arbitrary surface which is to be tilted is that working surface having the surface identification number SURFNO(A). The data point values

which result when this surface is tilted DEGREE degrees, in a right-handed fashion, around a horizontal vector through the point having the coordinates (PTX, PTY, PYZ) and pointing in a direction AXIS which is measured in degrees, in a compass-like fashion from north (or equivalently, the Y axis), are placed in the appropriate locations of the working surface having the surface identification number SURFNO(B).

This all sounds very complicated at first, but in practice, it is easy. The formulas used are well known.* The only difficult part of the operation stems from the fact that originally our working surface number SURFNO(A) has its Z values recorded at integer values of X and Y; after the tilting operation takes place, this is no longer true, in general. Yet this has to be true before we can store the Z values for working surface number SURFNO(B). It is therefore necessary to use a surface-fitting subroutine SRFIT in order to determine the second-degree equation which best fits that set of data points which is closest to each integer valued I,J pair for which we want a Z value for working surface number SURFNO(B). We then use the equation to interpolate in order to find the desired Z value. This must be done for every I,J pair where $1 \leq I \leq NX$, $1 \leq J \leq NY$.

Normally, the six closest data points should suffice for such a fit. It has been found desirable to use the closest eight in most cases. This results in a small amount of "smoothing" which is helpful at boundaries or at parts of the surface which have sharp bends. If it has trouble in fitting the surface with the eight closest points, the program will next try ten, then twelve points. If the trouble persists, diagnostic information is provided.

* See, for example, pp. A-255 of the Handbook of Chemistry and Physics.

There is no restriction as to how surfaces can be tilted. They can be tilted in a positive or negative direction, in small amounts or in barrel rolls. The only real constraint is that the resulting surface must be singly-defined at each integral value of I and J where $1 \leq I \leq NX$, $1 \leq J \leq NY$; otherwise, trouble will be encountered with SRFIT, as noted above.

J. RELAX CARD

We have discussed the use of completely arbitrary surfaces, specified through the use of the SURFACE card, and the use of planes specified through the use of the PLANE card. The RELAX card provides a means of achieving a middle ground between the relative advantages of realism and simplicity achieved through these two approaches.

Many geological surfaces may be adequately represented by "minimum energy" surfaces. That is, given the boundary points through which the surface would have to pass at the edges of the geological region which we are modeling, this type of surface is the smoothest which could be constructed which would still pass through the boundary points. An infinitely flexible membrane, such as a soap bubble, could be expected to provide the same kind of surface.

Mathematically, this kind of surface is called a harmonic surface; it satisfies Laplace's equation in two dimensions:

$$\frac{\partial^2 F}{\partial x^2} + \frac{\partial^2 F}{\partial y^2} = 0$$

Given the boundary points for such a surface, there is a straightforward algorithm known as the relaxation algorithm which can be used in order to find the interior points which satisfy the above equation. This algorithm is iterative; its values converge to those of the desired surface. In general, this convergence is quite rapid at first, then more and more gradual as the computation continues.

The RELAX card allows us to use this algorithm. A typical approach would be to first use the SURFACE card method to specify only all of the boundary points for working surface number SURFNO. The RELAX card would then be used to find all of the interior points for this surface; these would have the property of representing the smoothest possible surface through the boundary points given.

The parameter TOLER allows the user to control the accuracy with which the surface is determined. The relaxation process will stop when, during one iteration of the algorithm, the value of no data point on the working surface changes by no more than TOLER. Note that TOLER measures the amount of change, not the amount of error as compared to the final, exact surface. Given reasonable surfaces, TOLER should probably be at least an order of magnitude smaller than the maximum error desired; when NX and NY are large, two orders of magnitude might be appropriate. If the user specifies that TOLER = 0 or leaves the specification of TOLER blank, the following automatic definition of TOLER takes place, in order to conserve computer time:

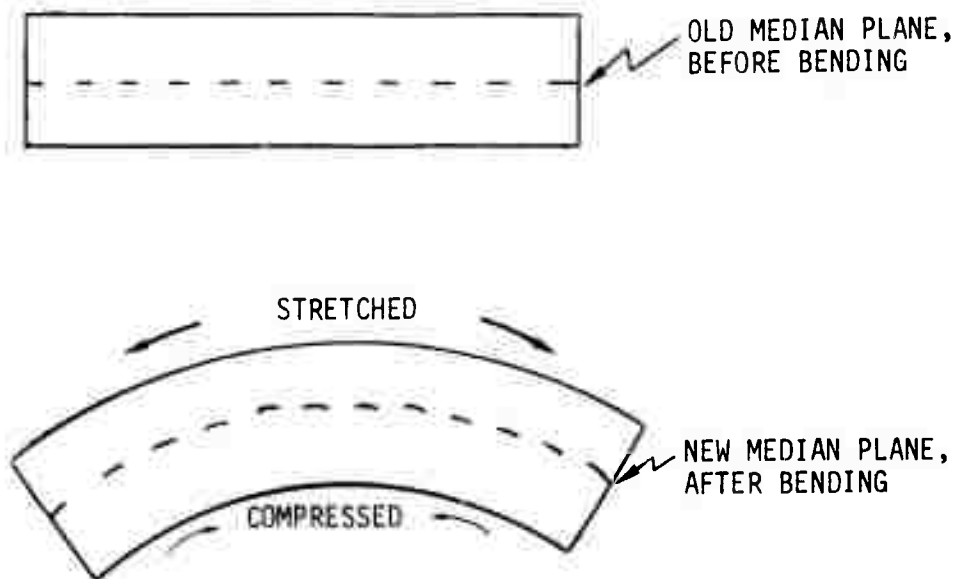
$$\text{TOLER} = \frac{\text{SCALEX} + \text{SCALEY}}{200}$$

Note that the RELAX card can be used in conjunction with any working surface whose boundary points are defined. The user is not restricted to using it in conjunction with the SURFACE card as outlined above.

K. BEND CARD

The subroutine (BENDER) used to implement the operation of the BEND card is the most complex subroutine of the geology model. It is discussed in detail in Sec. V, but an overview of its operation is provided here.

When something is bent, there is a median surface which is neither stretched nor compressed--only displaced. For example, consider a simple beam:



As we can see above, the stretched and compressed sides of the beam are not related to each other by a simple vertical distance relationship. While this is a two-dimensional example, the same kind of thing happens in three dimensions, except that there is a median surface which need not necessarily be a plane or cylinder.

The question which the bending subroutine attempts to answer is, "Given two working surfaces which represent the locations of the old and new median surfaces, prior to and after the bending of the rock, what is the new surface which resulted from the deformation of the old surface during this bending process?"

The exact analytical solution of this question would involve great data processing expense. We have provided an approximate solution, which seems to give reasonable answers, but even then involves significant

expense when NX and NY are large, since the processing time is related to $(NX \text{ times } NY)^2$. Much of this expense is unnecessary since, when NX and NY are large, it is not usual for the displacement of the median surface at one I,J location on the grid to have much effect on surface deformations for I,J locations which are many grid points distant. The INFLUN parameter allows us to take advantage of that fact. Through its use, the consideration of the effect on deformation by causes more than INFLUN grid spacings distant can be eliminated. This makes the running time proportional to $(NX \text{ times } NY) \text{ times } (1 + 2 \text{ times } INFLUN)^2$ --a significant saving when NX and NY are large. If INFLUN is not specified, it is automatically set equal to three.

L. GRAPH CARD

From time to time, one may become curious as to the current Z values of a given working surface--especially after using a BEND card. The GRAPH card allows the user to print out X-Y plots of the surfaces, with X and Y coordinates labeled, and the appropriate Z values displayed. Plots that are too wide are automatically printed out in vertical strips which, when laid side by side, depict the entire surface. There is therefore no problem in producing plots, regardless of how large NX and NY become. Plots for several working surfaces can be produced with the same GRAPH card by placing their working surface identification numbers in sequential data fields on the card; beginning in the leftmost data field. The first blank data field encountered will terminate the process of producing plots. The process of producing plots does not alter any surface in any way.

M. LAYER CARD

The LAYER card is used in changing the status of a working surface to that of a geological surface. In doing this, the working surface is left unchanged; it is merely copied onto a disk file, and given a new number--a layer number as opposed to a working surface number. In addition, an entry is made in the array INDEX. This entry specifies the kind of rock properties which the user wants to have associated with this

geological layer. In effect, in using the LAYER card, the user is saying, "Use working surface number SURFNO, associated with rock type ROCKNO, as geological layer LAYERNO."

N. PROPERTY

The PROPERTY card allows the user to specify the properties which are to be associated with rock type ROCKNO. The meanings of these parameters are not specified at the present time and are not relevant to this discussion.

O. MAKEFILE

The MAKEFILE card is the card which causes the consolidation of geological information into the geology file. In making the geology file, the geology model will assume that the user has specified properties for all types of rock having the numbers 1 through MAXROCK, inclusive. Likewise, it will assume that geological layer information is stored for all layers having layer numbers 1 through MAXLAYER, inclusive.

P. SUMMARY

Except for the first ten columns of any input data card, which must be alphabetic and left justified, all data entered on input data cards must be numeric and must contain decimal points.

The reader is cautioned to be thorough and consistent in redefining arrays within the geology model. For example, if the array SURF were redefined as SURF (27, 53, 7) in the main program GEOMOD, then the arrays named A, B, C, D, BX, and BY in the subroutine BENDER would have to be dimensioned as (27, 53), the array POINT in BENDER would have to be redefined as POINT(3, 1431), and the array GRID in the subroutine GRAPH would have to be redefined as GRID(27, 53). Failure to redefine these arrays outside of the main program GEOMOD would lead to incorrect indexing of these arrays and would cause erroneous results.

V. SUBROUTINE BENDER

The motivation in developing the BENDER program (Fig. II-2) was to create a subroutine which would geometrically alter geological layers in a reasonable and consistent way, and with a reasonable expenditure of computer time. The approach taken was geometrical rather than physical, on the basis of simplicity, available geological knowledge, and programming priorities.

When one begins to think about geometrical approaches to the warping of geological surfaces, some concepts seem to quickly come to mind and persist:

1. Any reasonable way of defining the three-dimensional deformation of a layered geological region seems to involve a description of what happened to the surface which, after deformation is the "median" surface in the sense that it was neither stretched nor compressed, but merely displaced.
2. It is true that, in a given pattern of deformation, there might be a large volume which might be neither stretched nor compressed and therefore, in the above sense, there can be no reasonable definition of any single "median" surface on the basis of its being neither stretched or compressed. While this is true, it is also true that, in this region, any surface would form an acceptable "median" surface, in the above sense.
3. In fact, when one begins to think about the time spans involved, the stresses and strains involved are probably not that well defined or understood; they may be dissipated by slippage, plastic flow, changes in the chemical makeup of the rock, etc. It is probably more realistic to think about deformations rather than stresses and strains, although the concept of a median surface is still an aid to understanding.

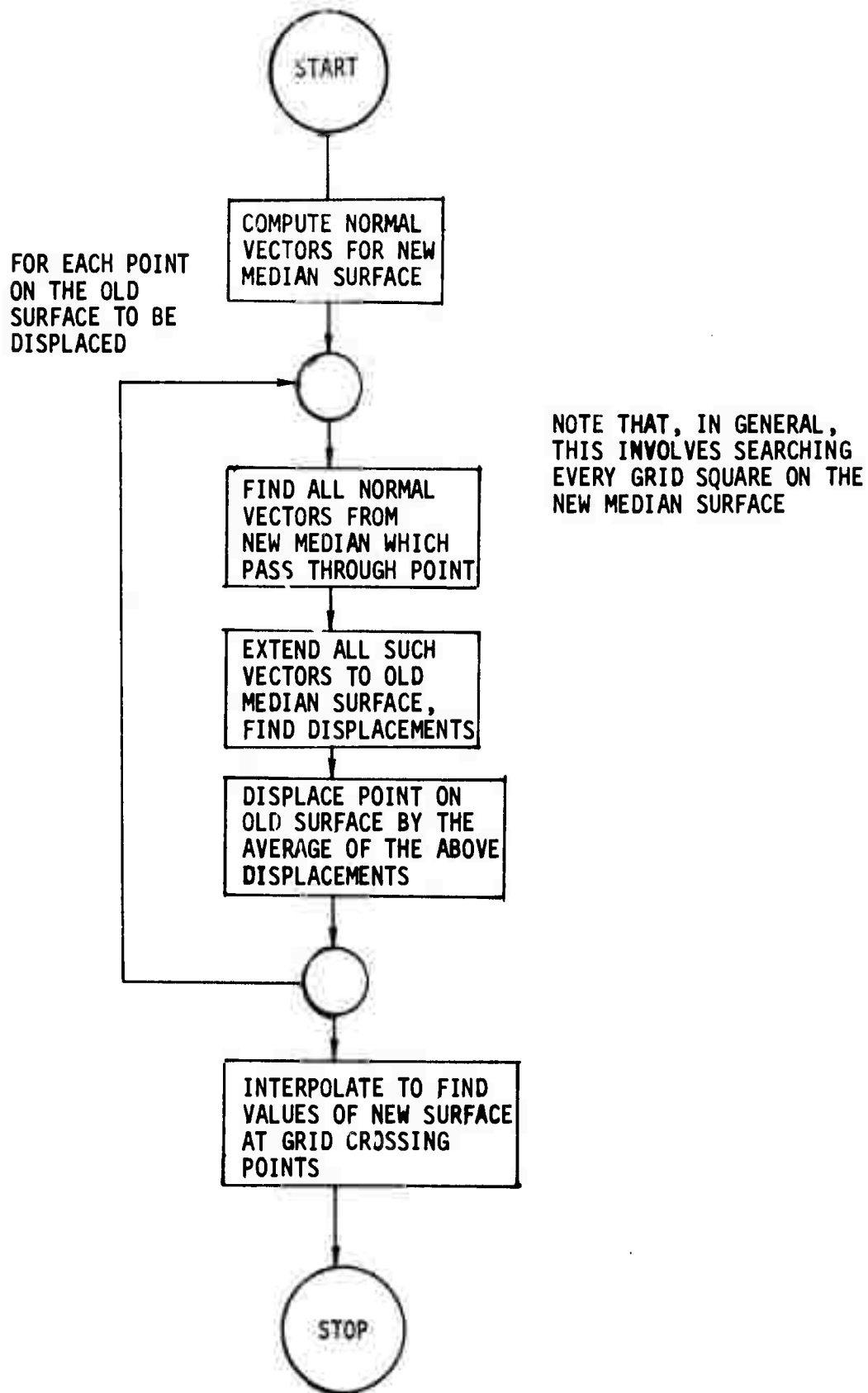


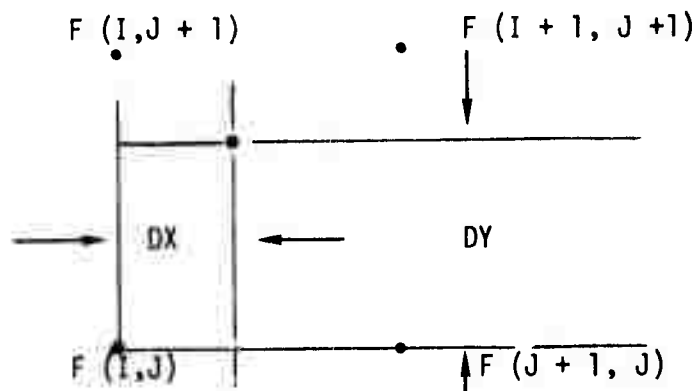
Figure II-2. Flow Chart of Logic of BENDER Subroutine

It is immediately obvious, after glancing at Fig. II-2, that the basic logic of the BENDER is exceedingly simple; it is also obvious, after looking at the 350 lines of FORTRAN in its listing, that its implementation may be straightforward, but it is not simple. For example, computing the normal vectors for the new median surface involves computing the partial derivatives in the X and Y directions at each grid line crossing point and storing them in the BX and BY arrays, respectively. These partial derivatives are then converted to the direction cosines of the desired normal vectors, the results of this computation again being placed in the BX and BY arrays. About 25 lines of FORTRAN code are involved.

Likewise, finding all of these normal vectors which pass through each grid line crossing point on the old surface is no simple task. First of all, this implies that the direction cosines for each grid line crossing point on the new median surface have to be examined in order to determine whether a normal vector from that point on the new median surface could go through each of the grid line crossing points on the old surface which is to be distorted. The mechanics of this operation infer that this processing step would have to be performed $(N_X \text{ times } N_Y)$ times $(N_X \text{ times } N_Y)$ times. This problem, whose solution was discussed in the preceding section, is compounded by the fact that the normal vectors from the new median surface will generally not originate at grid line crossing points, if they pass through grid line crossing points on the old surface which is to be distorted; some method of interpolation is therefore needed. The problem is further compounded by the fact that an iterative procedure is used to find the origination point of the normal vectors; there seems to be no better alternative to this procedure.

Although the iterative procedure could not be avoided, a quick, reasonable method of interpolation was found. If a function has a stated

value at the four corners of a square grid, and if its value at some interior point is desired:



then if $F(I + DX, J + DY)$ is computed as follows:

$$\begin{aligned}
 F(I + DX, J + DY) = & (1 - DX) (1 - DY) F(I, J) \\
 & + DX (1 - DY) F(I + 1, J) \\
 & + DY (1 - DX) F(I, J + 1) \\
 & + DX (DY) F(I + 1, J + 1)
 \end{aligned}$$

The value of $F(I + DX, J + DY)$ obtained is the same as if $F(X, Y)$ were a harmonic function whose boundary values varied linearly along the boundaries between the four points in question. This interpolation scheme is used several times in the BENDER subroutine.

Having found a normal vector (suitably interpolated) from the new median surface which passes through a given grid crossing point on the old surface to be displaced, the next task is to extend the vector--in one direction or the other--until it intersects the old median surface, so that the displacement of the median surface can be calculated; this displacement will contribute to the displacement of point on the old surface to be displaced into the new, displaced surface. Again, it seems

that the only way to do this is by an iterative procedure. The method used is similar to that used with the normal vectors, above. Basically, one makes a guess as to where the desired vector might originate or terminate, as the case may be. One then determines what correction is necessary to make the vector collinear (not necessarily in the same direction) with a previously determined vector. This procedure is repeated until either the computation drives the guesses out of bounds or the process converges to a solution, within a reasonable tolerance.

Finally one encounters the same problems with surface fitting that were discussed in conjunction with the TILT card (previous section). In fact, the same code is used, since the TILT routine is part of the BENDER subroutine. The same comments apply.

APPENDIX III

PROGRAMS TUNNEL AND GENTNL

by

P. K. Parish

SUMMARY

The two programs, TUNNEL and GENTNL, are alternative means of creating the geology file, TUNNEL, required by the excavation model. Program TUNNEL uses as input the GEOLOGY file generated by the geology model; program GENTNL allows direct creation of the TUNNEL file using only card input.

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I. PROGRAM TUNNEL

A. PURPOSE

Program TUNNEL creates, from the GEOLOGY file written by the geology model, a TUNNEL file for input to the excavation model. The TUNNEL file describes the properties of the rock encountered in a specific tunnel through the three-dimensional area defined by the geology model. Execution and information flow is shown schematically in Fig. III-1.

B. GENERAL TECHNIQUE

The geology information is read from the GEOLOGY file and stored internally. The user, meanwhile, inputs (X,Y,Z) coordinates of the end points of any number of straight-line segments which describe the tunnel midline through the given geological area. The program advances along the midline of this tunnel at intervals of DELTA feet (see "OPTION" card), determining what geological layer contains each point. Whenever a new layer is entered (or the end of a segment is reached), a record is written for the TUNNEL file.

C. INPUT

1. The GEOLOGY file, generated by the geology model, containing three-dimensional layer and rock property information
2. User parameter cards

There are four types of input cards (see Table III-1): OPTION, START, NEWLEG, and END. Each card is considered to have up to 6 fields of 10 columns each. The first field contains the alphabetic keyword, beginning in column 1. Values entered in succeeding fields must contain decimal points, but may appear anywhere in the assigned 10 columns. A description of each card type follows.

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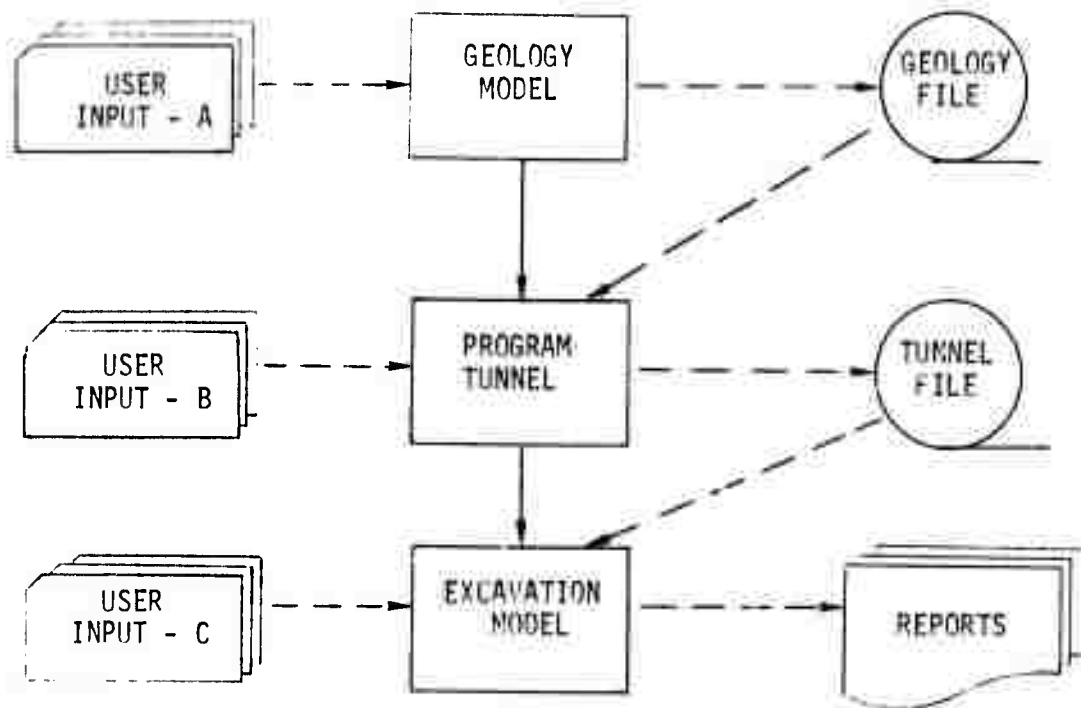


Figure III-1. TUNNEL File Creation by Program TUNNEL

TABLE III-1
INPUT CARD FORMATS FOR PROGRAM TUNNEL

1-10	11-20	21-30	31-40	41-50	51-60	
<u>OPTION</u>	DIAM	XORIG	YORIG	UNIT	DELTA	(Optional)
<u>START</u>	X	Y	Z			(Required)
<u>NEWLEG</u>	X	Y	Z			(Optional)
•						
•						
•						
<u>NEWLEG</u>	X	Y	Z			(Optional)
<u>END</u>	X	Y	Z			(Required)

OPTION Input Card

This card is used to override default values for certain program parameters. If default values are acceptable, this card is not required; if present, however, it must be entered first. For each parameter except XORIG and YORIG (for which zero may be the desired value), a blank or zero entry will cause the default to be in effect. None of these parameters is written to the TUNNEL file.

<u>Field</u>	<u>Description</u>	<u>Default</u>	<u>Comments</u>
DIAM	Tunnel diameter, in feet	10 ft	Currently not used by the TUNNEL program
XORIG	X location (feet) coincident with I=1 in geology model grid. This is the reference point used for X entries on succeeding cards.	1 ft	If OPTION card is present, this field must be filled in.
YORIG	Y location (feet) coincident with J=1 in geology model grid. This is the reference point used for Y entries on succeeding cards.	1 ft	If OPTION card is present, this field must be filled in.
UNIT	Number of feet represented by each SCALEX, SCALEY unit in geology model grid.	1 ft	
DELTA	The number of feet to be used by the program between test points along the tunnel midline.	20 ft	A smaller number here yields greater accuracy and longer processing time.

START Input Card

The X,Y,Z entries define the start of the tunnel midline through the area described in the geology model. The X and Y coordinates refer to the I,J axes of the geology model grid after application of XORIG, YORIG, UNIT, SCALEX, and SCALEY. The Z coordinate corresponds directly to those of the geology model, without transformation.

Hence, the X entered here will be transformed to the position X_I on the geology model grid by:

$$X_I = 1 + \frac{(X - XORIG)}{SCALEX \times UNIT}$$

and similarly for Y_J .

NEWLEG Input Card

If the tunnel is one straight-line segment, this card is not used. If the tunnel is composed of $N_g > 1$ segments, however, there will be $N_g - 1$ "NEWLEG" cards entered sequentially, each one containing the coordinates of the start of each new segment (except for the first segment, the coordinates of which are entered on the START card). There is no practical upper limit for N_g . X, Y, Z are interpreted as for the START card.

END Input Card

The last card entered must be an END card. It contains the position of the end of the tunnel midline. X, Y, Z are interpreted as for the START card.

D. OUTPUT

1. A printed report, showing the OPTIONS in effect, and a copy of the information written to the TUNNEL file.
2. The TUNNEL file, which will be input to the excavation model. Each logical record on the file contains the following fields:
 - a. POSITION: The distance, in feet, from the beginning of the tunnel ($X = 0$) at which the following properties cease to apply. That is, the properties are applicable through the interval from the POSITION given on the preceding record (or from $X = 0$ for the first record) up to, but not including, this POSITION.
 - b. PROPERTY 1: Unconfined compressive strength, psi
 - c. PROPERTY 2: Abrasiveness
 - d. PROPERTY 3: RQD, rock quality designation
 - e. PROPERTY 4: In situ density, lb/ft^3
 - f. PROPERTY 5: Ambient temperature, $^{\circ}\text{F}$
 - g. PROPERTY 6: Water inflow rate, gal/min
 - h. IFLAG: Not used at present. May be utilized later to indicate mixed geology situations.

The FORMAT statement used to write each record is "FORMAT (7(1PE18.10), I2)." End-of-file is indicated by a dummy record containing a POSITION < 0 .

For the logic of the TUNNEL program, as well as for the geology model, the entity assigned to any PROPERTY is completely arbitrary. The definitions shown here are those currently expected by the excavation model.

E. PROGRAM LOGIC

1. Main Program

Program TUNNEL reads the GEOLOGY file, processes the user input cards, and creates the TUNNEL file. The program technique is described in Sec. III-B, "General Technique." A flow chart is shown in Fig. III-2.

2. Subroutine GETLYR

This subroutine is used to determine which geological layer (LL) contains the point (XX,YY,ZZ).

Layer information is given in the GEOLOGY file only at the integral (I,J) grid points, hence interpolation may be required when seeking layer information at (XX,YY). Throughout the following discussion, $Z_{(I,J,L)}$ = vertical position in feet of the upper boundary of layer L at grid point (I,J).

First, (XX,YY) is translated to the geology model's (I,J) grid by:

$$XCOOR = 1 + \frac{(XX - XORIG)}{SCALEX \times UNIT}$$

$$YCOOR = 1 + \frac{(YY - YORIG)}{SCALEY \times UNIT}$$

The integers bounding (XCOOR, YCOOR), then, are given by:

$$ILOW \leq XCOOR < IHI$$

$$JLOW \leq YCOOR < JHI$$

The four grid points surrounding (XCOOR, YCOOR), therefore, are (ILOW, JLOW), (ILOW, JHI), (IHI, JLOW), and (IHI, JHI).

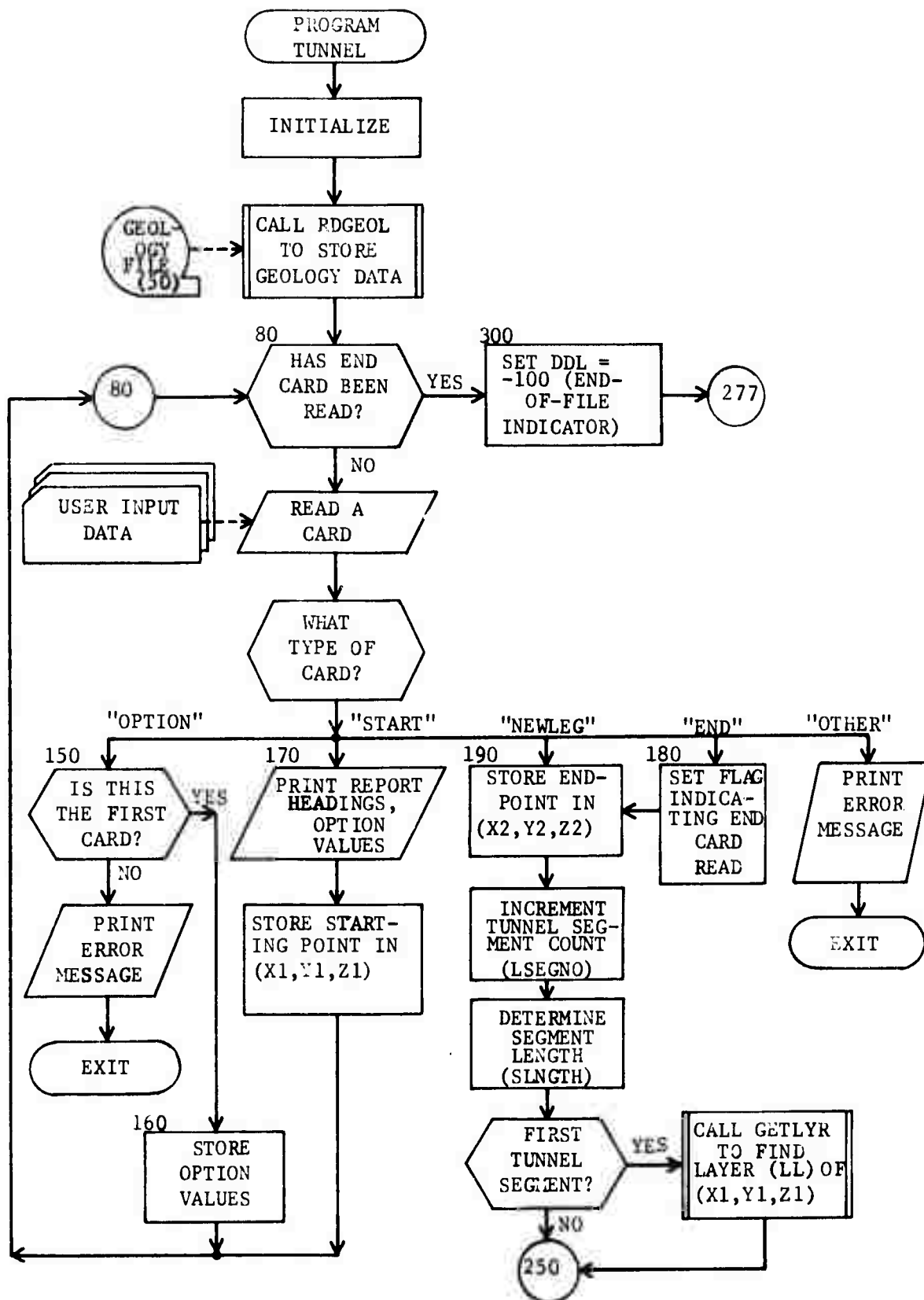


Figure III-2. Program TUNNEL Flow Chart

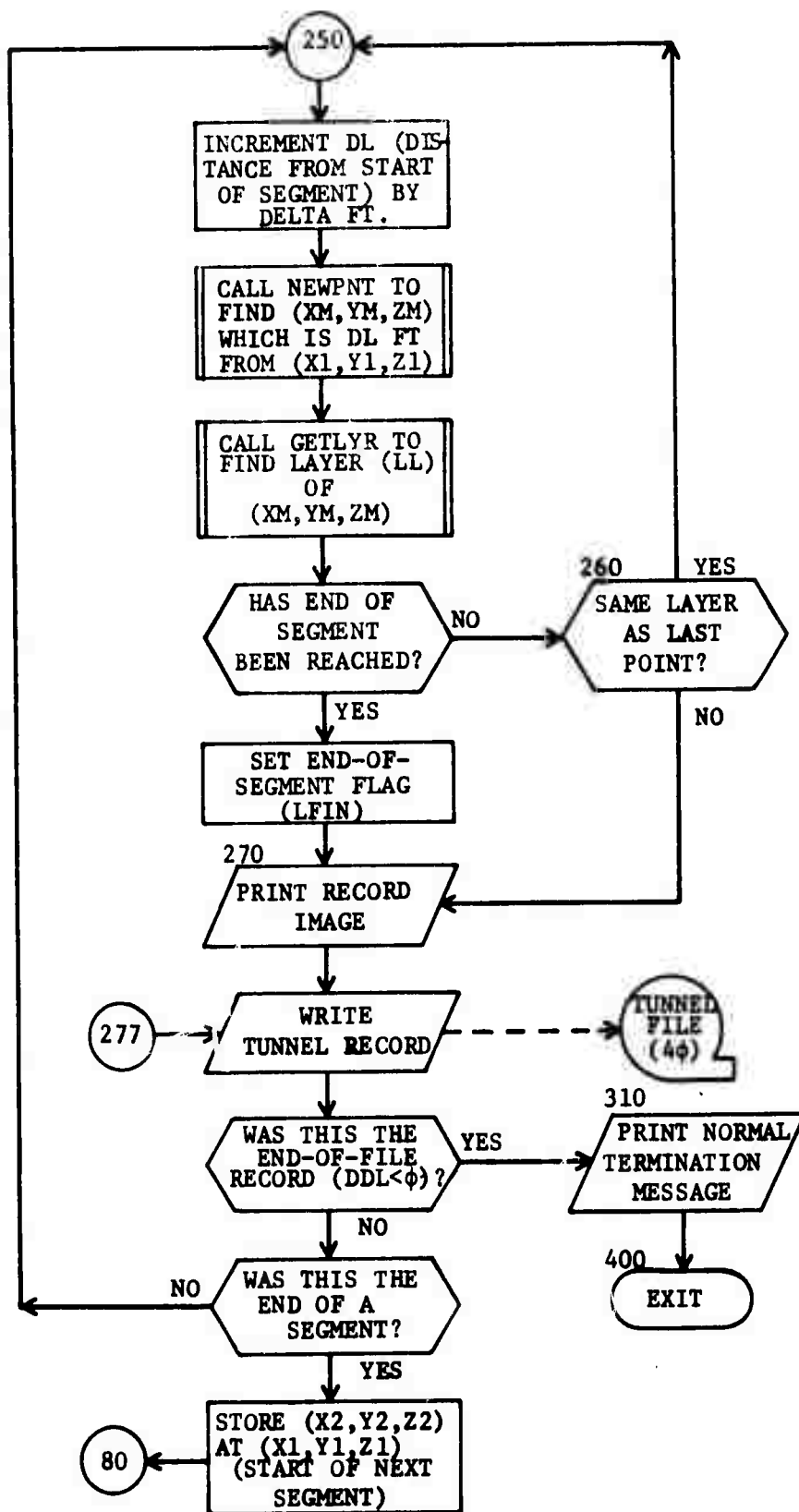


Figure III-2. Program TUNNEL Flow Chart (Cont.)

If (XCOOR, YCOOR) falls within the (I,J) grid (i.e., if $1 \leq ILOW \leq NX - 1$ and $1 \leq JLOW \leq NY - 1$), the processing is as follows

1. The layer information for the four surrounding grid points is examined. If ZZ is contained in the same layer at each point, that layer number is stored in LL, and the subroutine returns.
2. Otherwise, interpolation is required. To do this, the upper boundary of layer L in this grid square is assumed to coincide with the plane defined by the three points:
 - $ILOW, JLOW, Z_{(ILOW, JLOW, L)}$
 - $IHI, JLOW, Z_{(IHI, JLOW, L)}$
 - $(XCOOR, JHI, ZC)$, where ZC is calculated by finding the equation of the line (2-point form) in the (X,Z) plane connecting the points $(ILOW, JHI, Z_{(ILOW, JHI, L)})$ and $(IHI, JHI, Z_{(IHI, JHI, L)})$, substituting XCOOR and solving for ZC.
3. The subroutine, then, cycles through for each layer L defined in the geology file, derives the equation of the plane (3-point form) defined by the above three points, substitutes XCOOR and YCOOR in this equation, and solves for Z. This value Z is stored in ZHOLD(L), and represents $Z_{(XCOOR, YCOOR, L)}$.
4. When ZHOLD(L) has been calculated for all L, the routine finds the lowest ZHOLD(L) such that $ZHOLD(L) \geq ZZ$. This L is stored in LL as the layer containing (XX,YY,ZZ).

Special cases exist if (XX,YY) falls outside the geology model grid. Here, each boundary grid line is assumed to define the area beyond it; e.g., the layer information for $I = NX$ is taken to be true for all $I > NX$. Hence, if the given point (XX,YY,ZZ) is N,S,E, or W of the grid, only two (I,J) grid points need be examined, and interpolation, when necessary

is done in two dimensions. For a point NE, NW, SE, or SW of grid, only one (I,J) gridpoint must be examined, and no interpolation is required.

3. Subroutine NEWPNT

Given the end points of a straight-line segment, $(X1, Y1, Z1)$ and $(X2, Y2, Z2)$, subroutine NEWPNT determines the coordinates (XM, YM, ZM) of the point on the line segment which is DL ft from $(X1, Y1, Z1)$. It is used by program TUNNEL to retrieve each successive point along the tunnel midline, at intervals of DELTA feet, which is to be tested for layer information.

In the normal case, $X1 \neq X2$, $Y1 \neq Y2$, and $Z1 \neq Z2$. The derivation of the calculations performed when this is the situation is as follows:

- a. The formula which is to be solved for (XM, YM, ZM) is that for the distance, DL, between the points $(X1, Y1, Z1)$ and (XM, YM, ZM) :

$$DL = \sqrt{(XM - X1)^2 + (YM - Y1)^2 + (ZM - Z1)^2}$$

- b. In order to reduce the problem in (a) to one unknown, YM and ZM are expressed as functions of XM using the 2-point form of the straight-line equation:

$$YM = Y1 + \frac{(Y2 - Y1)XM}{(X2 - X1)} - \frac{(Y2 - Y1)X1}{(X2 - X1)}$$

$$ZM = Z1 + \frac{(Z2 - Z1)XM}{(X2 - X1)} - \frac{(Z2 - Z1)X1}{(X2 - X1)}$$

- c. Substituting the expression for YM and ZM from (b) into the equation in (a) yields:

$$DL^2 = [XM - X1]^2 \left[1 + \frac{(Y2 - Y1)^2}{(X2 - X1)^2} + \frac{(Z2 - Z1)^2}{(X2 - X1)^2} \right]$$

d. This is then solved for XM as follows: Let

$$A = 1 + \frac{(Y2 - Y1)^2}{(X2 - X1)^2} + \frac{(Z2 - Z1)^2}{(X2 - X1)^2}, \text{ a constant.}$$

a constant. Then

$$A(XM)^2 - 2A(X1)(XM) + A(X1)^2 - DL^2 = 0$$

from (c). Let

$$B = -2A(X1) \text{ and } C = A(X1)^2 - DL^2$$

both constants. Then we have

$$A(XM)^2 + B(XM) + C = 0.$$

XM can now be found by computing

$$\frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

(Note that $B^2 - 4AC$ simplifies to $4A(DL)^2$) and selecting the root which is between X1 and X2.

e. Once the required XM is found, the corresponding YM and ZM can be determined by substituting the value for XM in the expressions of (b).

Special cases exist if $X1 = X2$, $Y1 = Y2$, or $Z1 = Z2$. If only one of these conditions is true, then the same procedure is followed as in the normal case except that the problem is reduced to two dimensions. If two of the conditions exist, then the problem is one-dimensional, and the proper coordinate of $(X1, Y1, Z1)$ is simply incremented (or decremented) by DL .

4. Subroutine RDGEOL

Entry RDGEOL reads the entire GEOLOGY file and stores the information internally for retrieval during program execution. The variables stored as they are on the file are NX , NY , $SCALEX$, $SCALEY$, $INDEX(25)$, and $PROP(6,25)$. Layer information is stored in $ZSTOR(30,30,25)$, where $ZSTOR(I,J,L)$ contains the depth in feet of layer L at grid point (I,J) . A flag array, $LFLAG(25)$, is set during reading such that $LFLAG(L) = 1$ if the GEOLOGY file contains data for layer L ; it is zero otherwise.

Given II , JJ , and ZZ , where II and JJ are integers, entry FINDL examines $ZSTOR(II,JJ,L)$ for all L to determine what geological layer (LL) contains ZZ . It is used by subroutine $GETLYR$.

II. PROGRAM GENTNL

A. PURPOSE

Program GENTNL, using card input only, creates a TUNNEL file for input to the excavation model, thereby bypassing the geology model. Execution and information flow is shown schematically in Fig. III-3.

B. GENERAL TECHNIQUE

The input cards are read, checked for ascending sequence by POSITION, and the values written to the TUNNEL file and to the printer. There are no practical restrictions to the number of cards or the number of PROPERTY combinations input.

C. INPUT

User data cards, containing the values which are to be written to the TUNNEL file, are the only input. The card format is shown in Table III-2. Any number of cards may be submitted, but the last card must contain a negative number in the first word (POSITION) to indicate the end-of-input. Each card is considered to have 8 fields of 10 columns each; each number entered must contain a decimal point, but may appear anywhere within its assigned 10 columns.

D. OUTPUT

1. A TUNNEL file for input to the excavation model. For a file description, see OUTPUT under program TUNNEL.
2. A printed copy of the contents of the TUNNEL file.

E. PROGRAM LOGIC

The program is basically a card-to-tape-and-printer utility which includes a sequence check on the POSITION field.

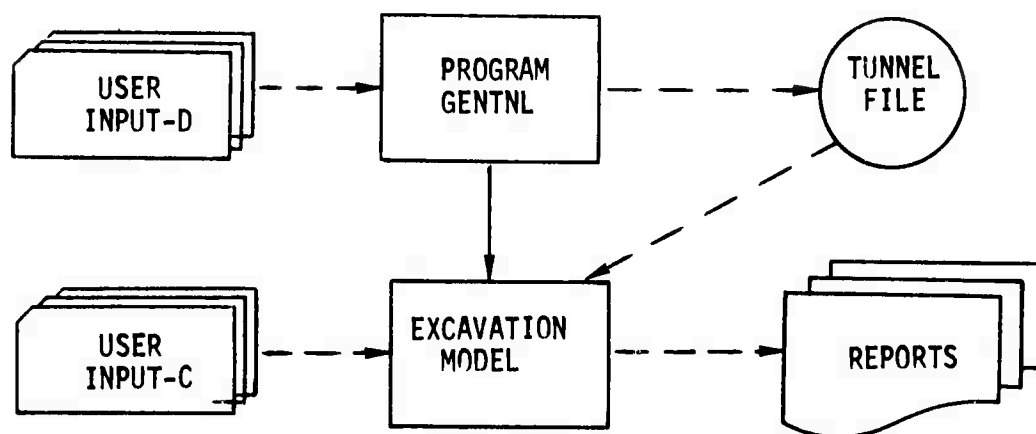


Figure III-3. TUNNEL File Creation by Program GENTNL

TABLE III-2
 INPUT CARD FORMAT FOR PROGRAM GENTNL

1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
POSITION	PROPERTY 1	PROPERTY 2	PROPERTY 3	PROPERTY 4	PROPERTY 5	PROPERTY 6	IFLAG

- Notes:
1. See description of TUNNEL file record for meaning of entries.
 2. All numbers entered must contain decimal points.
 3. Cards must be entered in ascending sequence by POSITION.
 4. A card containing a negative POSITION must be placed at the end of the input deck; the remainder of this card may be blank.

APPENDIX IV

EXCAVATION MODEL

by

M. McJunkin
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B. H. Lieu

SUMMARY

This appendix reviews the programming details of the excavation model and gives a short description of its conceptual basis. The sub-routines simulating the tunneling activities are then described in detail, followed by a description of steps that need to be taken to incorporate the routines described into a control program which will coordinate the tunneling activities. Finally, the control logic required to coordinate any simulation is described, and the construction of a sample control program with its associated input and output routines is discussed.

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1. NOTES ON EXCAVATION MODEL DESIGN

The tunneling model is designed as a time-step simulation program. Each step in the simulation is considered to occur between one well-defined time and state of existence and another. The data required to so proceed is processed by subroutines that correspond to the various activities in the tunneling process being simulated. The subroutines simulate the whole excavation process. A control program must be provided by the user to coordinate the activities of the subroutines, initialize data, and print output reports.

The concept of the simulation proceeding from one well-defined time and state to another is implemented through the use of "old" and "new" working parameter common areas (OLDCOM, NEWCOM). During any given time step, the contents of OLDCOM describes the state of the tunneling system at the beginning of the time step; the NEWCOM contents describes the state of the tunneling system at the end of the current time step. Each subroutine receives its input information from OLDCOM and places its output information in NEWCOM. Each subroutine, therefore, determines the state of the system at the beginning of the new time step according to information received at the beginning of the current time step.

Figure IV-1 illustrates the flow of information which is processed by any given subroutine. Some of the information paths for some subroutines may be absent, but no subroutine has any information path not depicted in Fig. IV-1. It is emphasized that all information transfer to and from subroutines is through common areas; the control program is not in any way involved in information transfer to and from subroutines. From time to time, as the tunnel advances, the control program transfers new geology information to the common area of an old working parameter, but it never transfers information directly to or from a subroutine.

Parameter information for the use of the subroutines is read by the control program and is placed in the common areas. After cards are read

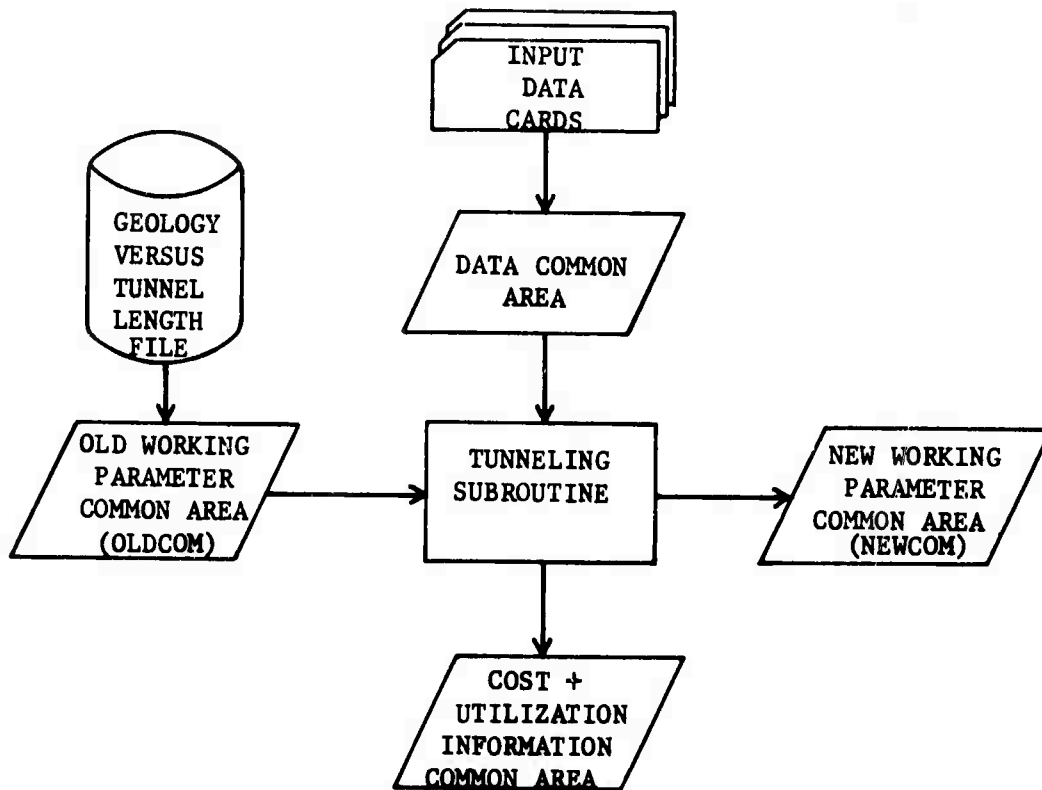


Figure IV-1. Information Flow for Individual Tunneling Model Subroutines

in, each subroutine which has an initialization entry point is called at that entry. The subroutines contain default values for the various parameters. If no card input information has been provided for one or any of them, the model uses the default values. This approach was taken in order to avoid the need to specify large numbers of parameters. Parameter information for one execution of the model need contain specifications only for those subroutine parameters which are of interest.

The time stepping and the approach creating two working common areas leads to a simplification of reality, forcing the simulation model to operate in a discontinuous fashion (in reality, some tunneling processes are continuous). This is not considered to be a significant problem as long as the time steps are kept relatively short--perhaps about 1 to 10 minutes.

As the subroutines are executed, cost, availability, and utilization information is generated and cumulated. This information is placed in common areas by the subroutines involved. These common areas are used to compute values for printing reports.

II. DESCRIPTION AND FLOW CHARTS OF SUBROUTINES IN EXCAVATION MODEL

A. INTRODUCTION

The subroutine descriptions are grouped by the element of excavation and subgrouped by the type of tunneling they represent. For example, the first group of subroutines (Sec. IV-B) covers rock fragmentation, each type of fragmentation (boring machine, water jet, etc.) being described separately. Also discussed are the input and output routines written for the Layout Tunnel (see Vol. I of this report), which may be modified for use in other simulations. Figure IV-2 is a chart of subroutines related to the operations they simulate.

The text of this section of Appendix IV is organized as follows:

- A short description of the process being simulated.
- A list of the common blocks that need to be included in any control program written to simulate an excavation using a given process. Note that, in addition to the common blocks, any TYPE, EQUIVALENCE, and/or DATA statement involving a variable in the common blocks listed must be included in the model.
- A list of input variables, principally a NAMELIST (and its variables).
- A list of status variables through which the subroutines change the status of the process or of another process. Almost all of the status variables exist in two forms: present and future. They belong to the two common areas (of parameters) described in Sec. I of this appendix. The future form is that shown in the descriptions of routines. These variables are used to turn on and off the excavation in the sample control program. However, they can also be used to turn off other processes or change subroutine calls, thus giving the user more flexibility in simulating the tunneling process.

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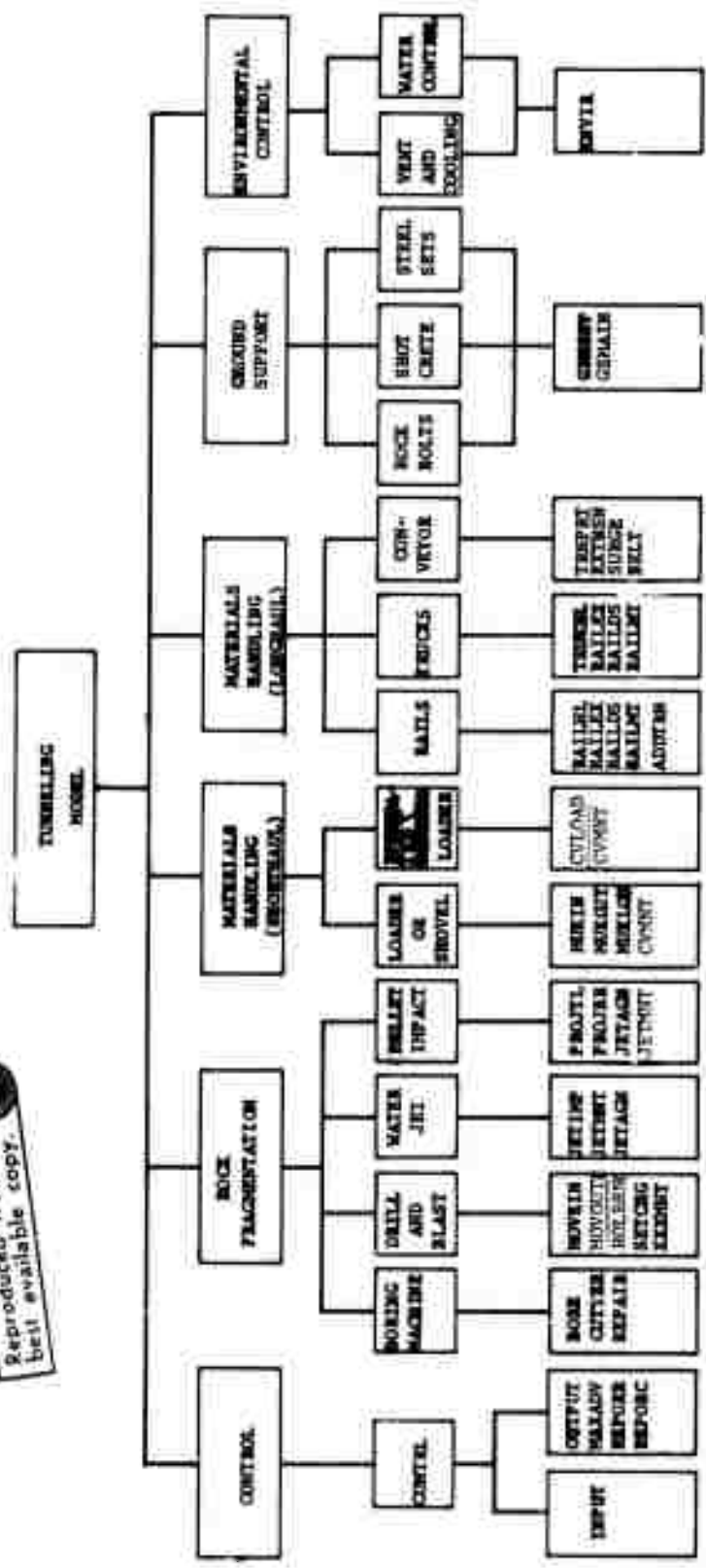


Figure IV-2. Subroutines of the Excavation Model

Input variables and status variables are defined in Appendix VI, and should be studied in conjunction with the listings and definitions in Appendix VI.

Several general statements that apply to the subroutines follow.

1. All subroutines have a normal entry point, used when the routine is called during the run for each time step. A few subroutines have two normal entry points (e.g., SURGE), and these are called by other subroutines, not by the control program.
2. Most subroutines also have an initialization entry point. Unless otherwise stated, the initialization entry should be called only once, at the start of the run immediately following the reading in of cards.
3. As mentioned above, status variables have two forms. The future form of the variable is usually the present form preceded by an F or L. For example, the status variable in CVMNT which indicates whether the loader is being maintained has a present form MCV and a future form LMCV. Each subroutine uses the present form to indicate the present status of the process described, and changes the future form as a result of computations. The subroutine never changes the present form. At the beginning of each time step the control program sets the present status variables equal to the future variables and thus updates the status of processes. For example, in the sample control program, LIEXCA is set equal to 1 in GRNSUP to indicate that ground support is falling too far behind the excavator and as a result the excavator must be turned off in the next cycle to allow ground support to catch up. At the start of the next cycle IEXCA (the present variable) is set equal to LIEXCA in the control program. When the checks are made to determine the status (MBORE) of the boring machine, IEXCA is found to be 1 and MBORE is set equal to 7, indicating that the boring machine is idle.

B. ELEMENT: ROCK FRAGMENTATION

1. Type: Boring Machine

The set of subroutines BORE, CUTTER, and REPAIR simulate rock fragmentation using a boring machine. These routines are currently set up so that their status variables are not in the two parameter common areas (OLDCOM, NEWCOM) but are single variables which have only a present form. This could be changed by having the user insert another form in the routines and put the two forms in COMMON/OLDCOM/, COMMON/NEWCOM/.

Common blocks: COMMON/ALL/
COMMON/BORE/
COMMON/PERFRM/
COMMON/MONEY/

Input variables: NAMELIST/BORE/
CL, CPC, DTA, DTC, DTCD, DTD, DTM, KK, PBM, R,
RC, RPM, TR, XCPC, EBOREQ, ETRANSL, DJMBMM, BOMEN, BOCST

Status variables: MBM
MBORE
LNCUTR

BORE - Rock Fragmenting

Operating time, plant and equipment costs, and labor costs for the boring machine for each time slice are computed and cumulated. If the boring machine is operating it computes the distance traveled by the boring machine and the job material cost of operating the machine.

CUTTER - Changing Cutters

Cutter wear is computed if the boring machine is operating and cutters are not being replaced. Cutter wear is checked and cutters are scheduled for replacement by setting LNCUTR = 1 if necessary. If cutters are in the process of being replaced, then one time step (DT) is added

to the time already spent in replacement. If time spent in replacement is greater than or equal to the replacement time input by the user, then replacement of cutters is scheduled to end in the next cycle by setting LNCUTR = 0.

REPAIR - Repairing Boring Machine

The subroutine cumulates time until the user input time for scheduling maintenance is reached. At that point, maintenance is scheduled for the machine to start in the next time cycle by setting MBM = 1 and cost of the maintenance is computed. If maintenance is in progress, then time is added to the user input maintenance period. When the user input maintenance period has elapsed, maintenance is scheduled to end in the next cycle by setting MBM = 0.

2. Type: Water Jet

The set of subroutines JETMP, JETMNT, and JETAGN simulate rock fragmentation using water jet impact, continuous and intermittent pulses.

Common blocks: COMMON/ALL/
 COMMON/NJETS/
 COMMON/PERFRM/
 COMMON/MONEY/
 COMMON/OLDCOM/
 COMMON/NEWCGM/

Input parameters: NAMELIST/JETS/PNOZZ, DNOZZ, NJETS, MODEJ,
 PPM, PULSED, ETAJ, ETAIMP, ENERGJ, DTCJET,
 DTMJET, DJMWJM, DTRJET, XRJET

Status variables: LMWJ
 LMWJR
 LMWJM
 FHEA:J
 FQWATR

JETIMP - Jet Impact

In a normal entry a check is made to determine if the water jet is operating (MWJ = 0); if not the routine is exited. If it is operating, the subroutine computes the amount of rock disintegrated, the amount of heat and water added to the tunnel by the jet, and the cost for one time step.

JETMNT - Maintenance

A normal entry checks first to find whether maintenance is in progress. If not, then one time step is subtracted from the time left until the next maintenance period (time between maintenance periods input by user). If the remaining time is then 0, and if repositioning is not being done (MWJR \neq 0), the jet is scheduled for maintenance in the next time step by setting LMWJM = 0 and set LMWJ = LMWJ + 1 to indicate jet not operating.

If maintenance is in progress at entry to the routine, the time elapsed for maintenance is increased by one time step. If the user impact time for maintenance (DTMJET) has been reached or exceeded, the jet is scheduled for removal from maintenance in the next time step by setting LMWJMC = 1 and subtracting 1 from LMWJ, and the cost is increased by the cost of a maintenance period.

JETAGN - Repositioning in Progress

The first check in a normal entry determines whether the jet is operating; if not, then if maintenance is in progress the routine is exited. If maintenance is not in progress, if the jet is not operating, and if repositioning is being done, one time step is added to the elapsed repositioning time and a check is made for repositioning completed. If it is completed, then its completion is scheduled for the next time step (LMWJR = 1 and LMWJ = LMWJ - 1).

If the water jet is operating at normal entry to the routine, then the distance traveled by the jet since the last repositioning is checked.

If it is greater than the user input maximum allowed distance, repositioning is scheduled for the next cycle (LMWJR = 0, LMWJ = LMWJ + 1).

3. Type: Projectile Fragmentation

The set of subroutines PROJTL, PRJBR, JETAGN, and JETMNT simulate rock fragmentation using projectile impact. The routine to simulate repositioning of the guns is the same as for the water jet, as is the maintenance routine. The initialization and normal entry points are different, however (PRJAGN and PRJPOS for the repositioning routine, PRJMNT and PRJRPR for the maintenance routine).

Common blocks: COMMON/ALL/
COMMON/NJETS/
COMMON/PERFRM/
COMMON/MONEY/
COMMON/OLDCOM/
COMMON/NEWCOM/

Input parameters: NAMELIST/PELLET/DTCJET, DTMJET, ETAGN, ETAIPT,
WPRJ, VELPRJ, VOLPRJ, NGUNS, CSTPRJ, PRJPM,
CPBRL, TRBRL, BLT, XRJET, DJMWJM, DTRJET

Status variables: LMPI
LNBARL
LMWJR
FHEATJ

PROJTL - Rock Fragmentation

In a normal entry a check is made to determine if projectile guns are operating. If yes, rock fragmented, advance of face, power costs, and heat generated are calculated for one time step. Total job materials cost for rock fragmentation is incremented. If no, the subroutine is exited.

PRJBR - Barrel Replacement

In a normal entry a check is made for barrel replacement in progress; if it is not, time elapsed since replacement is increased by one time step. Time elapsed against user input time between replacements is checked. If it is time for replacement, repositioning of barrel in progress is checked. (MWJR = 0). If it is not, barrel replacement is scheduled for next time step (LNBARL = 0, LMPI = LMPI + 1).

If on the first check in a normal entry barrel replacement is in progress, then time elapsed since barrel replacement began is incremented by one time step. A check is made for replacement completed. If completed, end of replacement is scheduled for next time step (LNBARL = 1, LMPI = LMPI - 1). Job material cost (DJMRD) is incremented by cost of replacement.

4. Type: Drill and Blast

This set of four subroutines simulates rock fragmentation by drilling and blasting. The four subroutines provided are: MOVEIN, MOVEOUT, HOLEBRN, SETCHG. A maintenance routine which can be patterned after the general maintenance routine XXXMNT shown in Appendix VI must be provided by the user. Note that variables chosen for maintenance times and costs must be added to NAMELIST below and to COMMON/BLAST/.

Common blocks: COMMON/ALL/
 COMMON/MONEY/
 COMMON/PERFRM/
 COMMON/BLAST/
 COMMON/OLDCOM/
 COMMON/NEWCAM/

Input variables: NAMELIST/BLAST/PF, TYPEPF, TCHG, MEN, NH, CCAP
 WPL, CPL, CEX, CM, ND, LD, NHB, NDB, LDB, POD,
 ADH, SE, POB, LBIT, LSTEEL, LBURN, TIN, TOUT,
 CSTEEL, CBIT, CBURN, ADH, ADB

Status variables: LNDRLB
LNCHRG
LJUMOT
LJUMIN
LNDRIL

HOLBRN - Drilling

The subroutine simulates the drilling of holes of a burn pattern with drifter drills and burn-cut drills. In a normal entry one time step is subtracted from both time to drill holes with percussion drills and time to drill with burn-cut drills. If the result for percussion drills is positive, then the result for burn drills is checked; if both are positive, then drilling is not finished and the subroutine is exited. If one or both of the results are negative, drilling for one or both is scheduled to end in the next cycle (LNDRIL = 1 and/or LNDRLB = 1) and costs of drilling are calculated before the main program is resumed.

Note: Initialization must be redone for each drilling period. Therefore, the control program must reset to ICYCLE = 1 when drilling is to be done.

SETCHG - Setting Charges

The subroutine simulates setting the blast charge. In a normal entry, one time step is subtracted from the time remaining to set a charge. If time still remains, the main program is executed. If no time remains, the finish of setting charge for the next cycle is indicated (LNCHRG = 1). Job materials costs for setting charges are computed and a return main program is executed.

Note: This routine, like HOLBRN, must be initialized for each drilling period.

MOVOUT - Moving Out Drilling Equipment

This subroutine simulates moving out drilling equipment. In a normal entry the time to move out is decreased by one time step. A check is made to determine whether moving out is completed. If it is, then end of moving is scheduled for the next time cycle by setting LJUMOT = 1.

Note: This routine must be reinitialized each time moving is done by setting ICYCLE = 1.

MOVEIN - Moving Drills In

This subroutine simulates moving drills in. A normal entry first decreases moving time remaining by one time step. Then, if no time remains, the end of moving is scheduled by setting LJUMIN = 1. Also, the number of feet that the tunnel will be advanced (DX) and the volume of muck created (DV) for this drilling and blasting cycle is computed here.

Note: This routine must be reinitialized each time moving is done by setting ICYCLE = 1.

C. ELEMENT: MATERIALS HANDLING (SHORT HAUL)

1. Type: Integrated Conveyor Loader

This set of subroutines simulates moving muck from the face area. It must be used with another set of subroutines for long haul (e.g., rails). Together the two sets simulate removal of the muck to the discharge area. The integrated conveyor loader is simulated by two subroutines CVLOAD and CVMN1.

Common Blocks: COMMON/ALL/
 COMMON/OLDCOM/
 COMMON/NEWCAM/
 COMMON/WHEELS/
 COMMON/CONVEY/
 COMMON/PERFRM/
 COMMON/MONEY/

Input parameters: NAMELIST/LOADER/AB, VBI, SM, TCCV, TMCV, WMR,
MLTYP, ECONEQ, ECONESS, JMCV, CVMEN, CVCST

Status variables: LMCV
LLOADR
LMFLAC

Note: Operating time for the total muck hauling (short haul and long haul) is computed in the long-haul subroutines. Long haul and short haul each compute down time.

CVLOAD - Loading Muck

One time step is added to labor time used for the loader, operating time for materials handling is updated, plant and equipment costs are updated for the time period advance. If the loader was unable to handle all the muck on the last cycle, or no train was available for loading the excess muck remaining is computed, then the total muck to be moved is computed. The muck is then either loaded onto vehicles (MLTYP = 1), or carried away by a conveyor (MLTYP = 2). (A check is made to determine if the long-haul system will take it all. If not LLOADR is set to 1 to indicate that it is overloaded.) If rails or trucks are the long-haul system and none is available for loading, LLOADR is set to 1. After loading the vehicle is sent to the discharge area if it is full.

CVMNT - Maintenance

One time step is added to the time elapsed since the last maintenance period. If the user input time between maintenance periods has been exceeded, maintenance is scheduled for the next time step by setting LMCV = 1.

If maintenance is in progress, then one time step is added to the time already accumulated for this maintenance period. If the time accumulated is greater than or equal to the user input maintenance period, the loader is scheduled to go back into operation in the next time step by setting LMCV = 0.

2. Type: Machine Loaders and Shovels

This set of subroutines simulates removing of muck from the face area and is interchangeable with the integrated conveyor loader set. It is to be used with one of the sets of subroutines for long haul. Together they form the simulation of materials handling in the model. It consists of three subroutines, MUKLOD, MUKIN, MUKOUT; and a fourth routine, CVMNT, is used for simulating maintenance. (The same routine, CVMNT, is used by the integrated conveyor loader.) Note that MUKIN and MUKOUT status variables must be set = 0 in the control program to initialize each move in and out, respectively, from the face.

Common blocks: COMMON/ALL/
 COMMON/COMOLD/
 COMMON/COMNEW/
 COMMON/WHEELS/
 COMMON/CONVEY/
 COMMON/PERFRM/
 COMMON/MONEY/

Input variables NAMELIST/SHOVL/
 STIME, QDMR, DTMO,
 DTMI, TMCV, TCCV,
 MLTYP, JMCV

Status variables: LMKIN, LMUKOT,
 LLODR, FQL

MUKIN - Moving In Shovels

In a normal entry, the routine determines whether muckers are in the process of being moved to the face. If not, nothing is done. If they are being moved in then their moving time is decreased and a check is made to determine if the move has been completed. If it has, LMKIN is set to 1 to indicate completion.

MUKOUT - Moving Out Shovels

This routine handles the moving of muckers away from the face in exactly the same way MUKIN handles their moving to the face.

MUKLOD - Loading Muck

In a normal entry, the routine first determines whether a continuous main-line system (long-haul system is a conveyor belt) is being used. If it is, then the mucking rate is computed and compared with the muck to be moved. If the mucking rate is not adequate, LLODR = 0 is set to indicate mucking still in progress, load as much as possible. If the mucking rate is adequate, muck is loaded. If a unitized main-line system is being used instead of a continuous system, then a first check is made to determine if units (e.g., trains) are being switched. If yes, the time used for switching has one time step added to it. Time used for switching is compared with time needed to complete switching. If still more time is needed, no loading is done. If switching is finished and time is left, then the mucking rate is computed for time remaining. The number of units per vehicle is checked (e.g., muck cars per train). If there exists only one unit per vehicle, the full vehicle just switched with the empty one is released. If there is more than one unit per vehicle, a check determines if all units are filled; if so, the vehicle is released. Whether a vehicle is released or not, the computation for loading muck described below is done for whatever time remains.

If no vehicles are being switched, the calculation of the mucking rate is made. If it is adequate for the muck to be loaded, LLODR is set to 1 to indicate loading is complete. If unit is full after loading, switching time is set (TIMEL) and the check for switching time is made as described above. If the unit is not filled, the routine is exited.

D. ELEMENT: MATERIALS HANDLING (LONG HAUL)

1. Type: Rails

The set of subroutines simulates a long-haul rail system to carry the muck to the discharge area. This set in conjunction with a set of short-haul subroutines from the materials handling element of tunneling. The routines in the set are RAILHL, CUBIC, ADDTRN(1), RAILDS, RAILEX, and RAILMT.

Common blocks: COMMON/ALL/
 COMMON/WHEELS/
 COMMON/OLDCOM/
 COMMON/NEWCOM/
 COMMON/MONEY/
 COMMON/PERFRM/

Note: The routine CUBIC does not need any common blocks.

Input variables: NAMELIST/RAILTS/ AE, AF, AMAX, AMAXL, AMINL, BSL,
 CARCAP, CP, DE, DF, DTAS, DTMA, DTU, NSWCIF,
 NGEO, NEXON, XDE, AB, VBI, SM, EL, FC, FR, FT,
 HPA, HPEV, HPEA, HPFA, HPFV, HPV, LOCO, MC, ML,
 NCARS, NPOINT, NTD, NTM, NTMAX, XP, NTMILP, NTMLPP,
 NTRACK, SL, TCURVX, TCURVY, TMAINT, TWE, VD, VE,
 VF, VS, VMAX, WC, WL, XDX, MAXLD, NVEHCL, NUMSWT,
 SWITCH, ISTA, TPOS, TSPD, TMAIN, KSTOP, MLTYP, WMR,
 ELOCO, EMUCKS, ETRACK, ESWTC, EUNLOA, ERMAIN,
 JMMHM, NUMLD, ISW, RAMEN, RACST.

General status variables: LLUHCL
 LNBYBY
 LNSWCH
 LIFILD
 LKUNLO
 LLSTOP
 LNTRADA
 LNVHCL
 LNMSWT
 NUMLD

Status Variables for Each Train:

FTSTAT (J, I), J Jth Train/Truck

- I = 1 Status (see below)
- = 2 Position, feet from discharge area
- = 3 Speed, mph
- = 4 Days since last maintenance, days

FTSTAT (J, 1)

- = 0 Train/truck is stopped, EMPTY reason given
- = 1 Train/truck is stopped, FULL by JSTOP(J)
- = 2 Train/truck is accelerating, E

- = 3 Train/truck is accelerating, F
- = 4 Train/truck is going at full speed, E
- = 5 Train/truck is going at full speed, F
- = 6 Train/truck is decelerating, E
- = 7 Train/truck is decelerating, F
- = 8 Train/truck is in switch, E
- = 9 Train/truck is in switch, F
- = 10 Train/truck is in discharge area
- = 11 Train/truck is in maintenance area

ISTOP

- = 0 Continue train/truck system
- = 1 Shut down train/truck system
- = 2 Bring up train/truck system

LKSTOP(J)

- = 0 Not stopped
- = 1 At face, loading
- = 2 In switch, train stopped ahead
- = 3 In switch, train approaching
- = 4 External reasons
- = 5 In switch, waiting to enter discharge area
- = 6 In switch, waiting to enter load area
- = 101, 102 ... At face, in queue

FUTIME(J) = Time to unload train J

FTOP (J) = Cumulative operating time of train J

FTFC(J) = Cumulative cost of train J

Status variables for each switch K: Kth switch

FSWICH(K) = Distance in feet of centroid of switch K from discharge area.

RAILHL - Handling Muck by Train

The subroutine first adds DT to the labor time for rails. It also computes plant and equipment costs and down time for the rail system. Then it sets into local variables the (see Table IV-2 for status codes):

Status of each train	(ITSTAT(J, 1))
Position of each train	(TSTAT(J, 2))
Speed of each train	(TSTAT(J, 3))
Maintenance factor	(TSTAT(J, 4))
Reasons train stopped	(KSTOP(J))
Cumulative cost for train	(TFC(J))
Operating time of train	(TOP(J))

It then divides DT into smaller time cycles, and if the system is operating puts each train through the smaller time cycles until DT is reached, changing the train's status as indicated by its status at the beginning of the cycle and what is happening to other trains. For example, if train 1 is waiting to move toward the discharge area, and train 2 is moving back from unloading to loading area, train 2's progress will be calculated and monitored by train 1. When train 2 is back to the loading area then train 1 will be allowed to start for the discharge area.

If the system must be brought up or shut down, this is done first and then each train is put through the small time cycles. After all small time cycles are finished, the global status variables JSTAT (J, 1, etc.) are reset to the updated values of the local variables and the subroutine is exited.

CUBIC

This routine is a function which finds the first real root of a cubic equation.

RAILDS - Unloading Muck at Discharge Area

This subroutine accounts for unloading muck from trains. If unloading has been stopped (KUNLO = 1), the routine does nothing; otherwise, it determines whether any train is unloading. If train J is unloading (ITSTAT(J, 1) = 10), the time remaining before it completes unloading is computed. If it will be finished before the end of the current time cycle, train J is added back into the system (if system is 2 track) or (if system is 1 track) subroutine ADTRN is called and adds the train back into the system if it is possible. If the train has been added, the count of trains in the discharge area is reduced by 1. After all trains have been dealt with, the number of trains left in the loading area at the next cycle is compared to the allowed number. If the number is greater than allowed, the run is stopped. If it is equal to the number allowed, the discharge area is indicated filled for the next cycle by setting LIFILLD = 1. If it is less than number allowed, the discharge area is indicated ready for a train by setting LUFILLD = 0.

RAILEX - Extend Track

This routine handles extension of the track for the trains. If rail extension is stopped (NEXON = 1), the routine does nothing. Otherwise, NSWICH is checked to determine whether the switch is already being moved. If not, the track extension needed is computed using either cyclic operations geometry (NGEO ≠ 1) or continuous operations geometry (NGEO = 1) which has been input by the user. If the computed advance of the track is not enough to allow the excavator to continue operating, then the excavator is turned off for the next cycle by setting LNBYBY = 1. Then there is a check to determine if a new switch needs to be added and/or the last switch needs to be pushed forward. If either of these need to be done, computations described below are done.

If at normal entry a switch was being moved or added, then time to move the switch and/or add a switch is decreased (computed if just beginning move or add) and the completion is scheduled when finished. In

pushing the last switch forward, it is not marked as pushed forward until after the time to push it is finished. It is pushed either a distance equal to the excavator's progress in the cycle (DX) or by a distance preset by the user (AMAXL - AMINL). The latter distance will be used unless AMAXL = AMINL. If a switch is to be added, again it is not indicated as having been added until the time to add it is over. Then, the number of switches is updated and the position of the new switch is put just behind the position of the moveable switch which is always closest to the face.

Finally, a check is made to determine if a train should be added to the system since the rails have been extended. Distance from the portal in miles is computed and compared against user inputs which give NTMILP trains allowed before XP miles and NTMLPP trains allowed after XP miles. If the number of trains in the system is already equal to the number allowed, no train is added. Otherwise, ADDTRN is called if the discharge area is not filled. The new train, if ADDTRN allows it, is entered into the discharge area.

RAILMT

DT is added to the time since last maintenance TSTAT(I, 4) for each train I which is not unloading or already in maintenance. If for any train I, TSTAT(I, 4) is greater than the user input time between maintenance, the train is put into maintenance (if maintenance area is not full).

If a train I is already in maintenance, then its time in maintenance is decreased by DT. If this time has reached 0, the train is returned to the discharge area from the maintenance area and cost of maintenance is computed.

Finally, the number of trains in maintenance, NTMA, is compared to the user input maximum allowed trains. If too many trains are in maintenance an error message is printed and the run is stopped.

2. Type: Conveyor Belt

A set of four routines: TRNPRT, EXTNSN, SURGE, and BELT, simulates hauling muck to the discharge area by the conveyor. Each routine need be initialized only once at the start of the run. Initialization is done by setting ICYCLE to 1 before calling each routine. SURGE need never be initialized.

Common blocks: COMMON/ALL/
 COMMON/MONEY/
 COMMON/PERFRM/
 COMMON/NEWCOM/
 COMMON/OLDCOM/
 COMMON/CONVEY/

Input variables: NAMELIST/BELTS/VBI, WP, AB, ACM, NCEO, SM, DTBS,
 QC, FL, XE, NSURGE, DWM, DTC, DTMB, EE, HP, FLM,
 SMIN, XLF, WBI, DMAINT

Status variables: LMCAPC
 LNSURG
 LMACON
 LNSPLC
 LNBYBY
 FQL
 FSM

TRNPRT

Subroutine simulates the long haul of muck by conveyor belt to the discharge area. In a normal entry, loader capacity required for this time step is calculated. If this capacity WR is less than the available capacity WPCOMP, then muck is loaded and excess muck in the surge bin is taken out and loaded onto a belt. If WR is equal to WPCOMP, then muck is loaded. If capacity $WR > WPCOMP$, then it is determined if a surge bin has been provided. If not, the excavator is scheduled to be stopped on the next cycle (LMCAPC = 1). If a surge bin exists, the excess is loaded into it; then the surge bin is checked for overload. If it is overloaded, an excavation stop is scheduled on the next cycle (LMCAPC = 1).

In any case horsepower used is determined and job material cost DJMMH is incremented. Then the control program is executed.

EXTNSN - Extension of Conveyor Belt and/or Structure

This routine simulates extension of the conveyor belt (either extension of the structure and/or extension by a belt splice). In a normal entry, first a check is made to determine whether the extension is shut down (NEXON = 1). If it is, then a return to the control program is executed. If the extension is not shut down, a check determines if a structural extension is needed. If yes, the extension is carried out for whichever of the three geometries (NGEO = 1, 2, 3) (cyclic or one of two continuous) is being used; if it will be completed at the end of the time step, the end is scheduled by setting LNBYBY = 0; otherwise LNBYBY is set to 1. Another check is made to determine if a belt splice is also needed, and LNSPLC set to 1 if it is needed. Then the belt splice as described below is computed for the time remaining in time step.

If at normal entry a conveyor belt splice is going on, a check is made to determine if a surge bin has been provided. If a bin does not exist, the belt splice is simulated and the excavator is turned off if the splice is not complete at end of the time step (LNSPLC = 1). If a bin does exist, the excavator is turned off only if the surge bin becomes overloaded (LNSURG = 1).

BELT - Maintenance

This subroutine simulates maintenance of the conveyor belt. In a normal entry a check is made to determine whether maintenance is in progress (MACON = 1). If no maintenance is in progress then a check is made for which criterion is being used for maintenance, time (DTCB) or volume of muck loaded (DWM). For whichever criterion is being used a calculation is made to determine if maintenance is required. If maintenance is needed then it is scheduled for the next time cycle by setting LMACON = 1 and the subroutine does calculations for maintenance. If at

entry maintenance was in progress, or if the belt has been put into maintenance, one time step is subtracted from maintenance time left and a check made to determine if maintenance is complete. If so, it is scheduled to end in the next cycle (LMACON = 0) and the cost of maintenance is added to the job materials costs DJMMH.

SURGE

This subroutine handled adding muck to and subtracting muck from the surge bin. It is called by the other conveyor belt routines if a surge bin exists (NSURGE = 1). It has one entry point SURGE for adding to the bin and one for subtracting, SURGE 2. When adding muck, a flag will be set to indicate overloading of the bin if this occurs (LNSURG = 1).

3. Type: Trucks

This set of routines simulates long haul of muck to the discharge area by trucks. The routines in the set are TRUKHL, RAILEX, TRUKDS, TRUKMT. TRUKHL is almost identical to RAILHL described in Sec. II-D-1 (see Vol. I of this report for exceptions). The routines TRUKEX, TRUKDS, and TRUKMT are actually the routines RAILEX and RAILDS described in Sec. II-D-1 with different entry points. Subroutine TRUKHL is identical to RAILHL with the exception of some coding to ensure that the truck stops before it hits the face. This coding is identified in the listing by comment cards. TRUKHL is the initialization entry point and TRUKTR is the normal entry point into the routine.

Common blocks: Identical to those for rails

Input parameters: NAMELIST/TRUCKS/parameters are identical to those
for rails

Status variables: Identical to rails

E. ELEMENT: GROUND SUPPORT

1. Type: Rock Bolts, Shotcrete, Steel Sets, and Combinations of These

Unlike other elements which have a different set of routines for each type, all ground-support types are handled in one set of subroutines (GRNSUP, GSMAIN). Ground support frequently uses combinations of support

types, making it more efficient to put all types in one set of subroutines. The decisions about type of ground support to be used for each geology during the simulation are made with the aid of a primary ground-support table (stored in array PSST). This table may be input by the user, or the default table (Table IV-1) will be used. Any primary ground-support table gives the major and minor support types and their spacing (or thickness) for different rock fragmentation methods (JMETH), and for ranges of rock densities (RDQ). For instructions on inputting the default table, see below.

Common blocks: COMMON/ALL
 COMMON/PERFRM/
 COMMON/MONEY/
 COMMON/OLDCOM/
 COMMON/NEWCOM/
 COMMON/GRND/

Status variables: LMGS(5)
 LIEXCA

Input variables: NAMELIST/GROUND/USC, UCSC, RATERB, RATESC, GSETDO
 RATESS, MAXPSS, ERBDRI, GDOW, ESCPLA, DJMGS,
 GMEN, GCST

A set of cards must be input for the ground support if MAXPSS \neq 0 in the set of cards described above. In this case the user is indicating that he wishes to input his own primary ground-support table in preference to the default table (Table IV-1). See INPUT routine written for the Layout Tunnel for an example of one method of reading in these cards. A sample set of cards is shown in Fig. IV-3. The value of MAXPSS in the set of cards above should be equal to the number of these cards. The columns on the cards correspond to the columns in Table IV-1. These data cards are the last set of input cards for the model, and cards should be ordered such that the RDQ column is decreasing on successive cards. The cards give the type of support that will be used for various ranges of

TABLE IV-1

PRIMARY GROUND SUPPORT

(Default Values Are Shown)

ROD	EXCAVATION PROCESS	UNSUPPORTED LENGTH-MAXFT	INTERFERENCE LENGTH FT	SUPPORT TYPE	SPACING FT	THICKNESS IN	CROWN AND/ OR SIDES	ADDITIONAL SUPPORT
95.00	5.00	999999.90	0.00	1.00	0.00	0.00	0.00	1.00
97.00	5.00	999999.90	0.00	1.00	0.00	0.00	0.00	1.00
99.00	2.00	10.00	0.00	3.00	0.00	5.00	0.00	1.00
75.00	5.00	8.00	0.00	3.00	0.00	1.00	0.00	1.00
75.00	1.00	8.00	4.00	3.00	0.00	1.00	0.00	1.00
75.00	2.00	5.00	0.00	2.00	5.00	0.00	0.00	1.00
50.00	5.00	6.00	0.00	3.00	0.00	3.00	0.00	1.00
50.00	1.00	6.00	4.00	4.00	3.00	0.00	0.00	1.00
50.00	2.00	4.00	0.00	4.00	4.00	0.00	0.00	1.00
25.00	5.00	5.00	0.00	3.00	0.00	5.00	1.00	2.00
25.00	1.00	5.00	4.00	4.00	3.00	0.00	0.00	2.00
25.00	2.00	3.00	0.00	4.00	3.00	0.00	0.00	1.00
0.00	5.00	2.00	0.00	4.00	2.00	0.00	0.00	1.00
0.00	1.00	2.00	4.00	4.00	2.00	0.00	0.00	1.00
0.00	2.00	2.00	0.00	4.00	2.00	0.00	0.00	1.00

NOTE. EXCAVATION PROCESS = 5 INDICATES ANY PROCESS OTHER THAN THOSE IN TABLE

rock RQD and type of rock fragmentation. Each card input gives a major and additional support type to be used for one rock excavation process, and any rock RQD greater than or equal to the one on the card but less than the one on the previous card.

The codes for the rock excavation type to be put on the card are as follows:

<u>Rock Excavation Type</u>	<u>Code</u>
Boring machine	1
Drill and blast	2
Water jet	3
Projectile	4
To be used if actual type is not in table	5

The codes for support types and additional support types are as follows:

<u>Support Type</u>	<u>Code</u>
None	1
Rock bolts	2
Shotcrete	3
Steel sets	4
Lagging	5

The other parameters on each card are as follows:

1. **Unsupported Length - Maximum Feet**
This is the maximum number of feet from the heading that ground support can be before the excavator must be turned off to allow ground support to catch up.
2. **Interference Length - Feet**
Number of feet that must separate ground support and the heading. Ground support will not be allowed closer to the face.

3. Spacing - Feet

This will be ≠0 only if rock bolts or steel sets are being used as support or additional support. It gives the spacing between rock bolts or steel sets.

4. Thickness - Inches

This is the thickness of the shotcrete to be installed and is ≠0 only if shotcrete is being used.

5. Crown and/or Sides

This is ≠0 if shotcrete not being used or if only crown is to be covered. If crown and sides are to be covered it is =1.

GRNSUP - Ground-Support Installation

In a normal entry (ENTRY GROUN), ground support, using the rock density (RQD) and the rock fragmentation method, computes the ground-support parameters for this time step from the primary ground-support table (PSST). Checks are made to determine the ground-support status and position with respect to the face of the tunnel. Labor time used is incremented. For each type of support being used the amount of material needed is computed. The cost and advance of ground support is calculated (either actual or lost due to idleness or maintenance). Finally, operating time and plant and equipment costs are incremented.

GSMAIN - Ground-Support Maintenance

A normal entry to this routine (ENTRY GSMNT) first determines if a combination of types is being used. If yes, then the time step is divided by 2. Then for each of the five ground-support types it asks if the type is being used. It then asks if the type (in use or not) is in maintenance.

If the type is in maintenance, the maintenance time remaining for the type is reduced by one time step and if no time remains it is marked to be removed from maintenance in the next time step.

If the type is not in maintenance and not in use the next type is looked at. If it is not in maintenance and in use, then one time step is subtracted from the time remaining before maintenance. If the time remaining is ≤ 0 , the ground-support type is marked to be put into maintenance for the next time step.

F. ELEMENT: ENVIRONMENTAL CONTROL

1. Type: Ventilation, Cooling Plant, and Water Removal

One subroutine (ENVIR) simulates the environmental control. The environmental element is assumed to need no maintenance and to always be operating. It is assumed also to not interfere with other elements in the tunneling process and therefore has no status variables.

Common blocks: COMMON/ALL/
 COMMON/PERFRM/
 COMMON/MONEY/
 COMMON/ENVC/

Input variables: NAMELIST/ENVIRC/EVENTP, MAXMEN, TDTHP, QM, QD,
 VAMIN, VAMAX, TA, TD, WA, FKD, FKT, CPA, CKA,
 REFRAT, PR, AMC(10), CAVMP

ENVIR

In a normal entry (ENTRY ENVIRC) labor time used, plant and equipment costs, and operating time are incremented. Next the cost of pumping water is computed. Then the amount of heat added to the air from various sources is computed; then the velocity of air is checked if more cooling is needed. Finally, the amount of cooling and ventilation needed in this time step are calculated. Cost of cooling and ventilation are added to job materials costs for environmental control DJMEC.

G. INPUT ROUTINE

This subroutine was written for the Layout Tunnel (see Vol. I). It is described here as a sample of possible way of initializing data in the model. It can easily be modified and used with any control program written to model other excavation systems. The routine is called at the beginning of a run and will read in the input cards for the sub-routines and initialize the geology parameters by reading in the first geology record. It has two entry points, INPUT AND INPUT 2.

Common blocks: All common blocks that the control program contains.

ENTRY INPUT Reads in cards and starts geology file.

First cards are read and their images written onto tape (LOGICAL unit 5 in present control program; see listing of INPUT in Appendix II), card images being printed out. When an end-of-file is encountered, tape 5 is rewound.

After the rock fragmentation and materials handling methods have been read in from the first card image, tape 5 is read by the various NAMELISTs. Note that the card sequence of NAMELISTs must be the same as the reading sequence because the READ statement will search through the NAMELIST images on tapes for the first one to be read and then search subsequent ones for the next, and so on. Therefore if NAMELIST BORE appears on the cards before GENERL, BORE will never be read because in INPUT, BORE is read after GENERL.

After all NAMELISTs which were found on tape 5 have been read and printed out, the first record on the geology file is read. This is not necessarily the starting point in the tunnel for the model but merely starts the geology file. (This file is described in Appendices II and III.) Then the cross section of the tunnel is computed and the local variables used to read in train status, position, speed, and maintenance times are set into a global array TSTAT(J, K) (equivalent to ITSTAT (J, K)). From train status it is also determined which, if any train is available for loading. Finally, if a primary ground-support table is to

be read in (MAXPSS \neq 0), it is read from cards in fixed format (see listing of INPUT in Appendix VI).

ENTRY INPUT 2

This routine is entered at this entry point after all subroutines included in the run have been initialized. Variables which can be initialized (those on NAMELISTs) are again printed. Those that were undefined by the user will have been given default values by the individual routines. See Appendix VI for a sample printout of the routine.

H. OUTPUT ROUTINES

These four routines, OUTPUT, REPORR, REPORC, and MAXADV, were written for the Layout Tunnel. Two of the routines produce the interim reports using variables which are computed in the element subroutines. A third prints out the working storage common variables necessary for restarting the model at an intermediate point in the tunnel. Finally, a fourth routine computes the advance each day and retains the maximum daily advance. These routines may be easily modified and used with another control program to produce output. The last three routines, REPORR, REPORC, and MAXADV, may be used without modification if the notes in Sec. III of this appendix are followed.

Common blocks: (for OUTPUT) All common blocks in control program
(for REPORR, REPORC, MAXADV) COMMON/ALL/
COMMON/MONEY
COMMON/PERFRM/
COMMON/LABOR/
COMMON/TEST/

Input variables: Contained in NAMELIST/GENERAL
REPORT, DTPRNT

OUTPUT

This routine must be modified by the user if he is simulating tunneling with different methods than those in the sample program.

It is essentially a printout of selected variables in various common blocks which give the user a picture of the status of the tunneling elements at intervals during a simulation and at the end of a run. It should contain the variables needed to restart the model.

At present it prints, besides general variables, status variables for the boring machine, integrated conveyor loader, rails, and ground support. These are the processes being used in the sample tunnel, and the variables needed to restart the tunneling at any time or heading.

MAXADV

The advance per operating hour is computed for the past 24 hours elapsed time. If it is greater than the maximum advance already saved, then it becomes the maximum advance and is retained as such.

REPORR

This routine prints out the interim performance reports giving cumulative time, advance, (since beginning of this run) and heading position, maximum daily advance values, (since beginning of run) and utilization and availability figures for each general process.

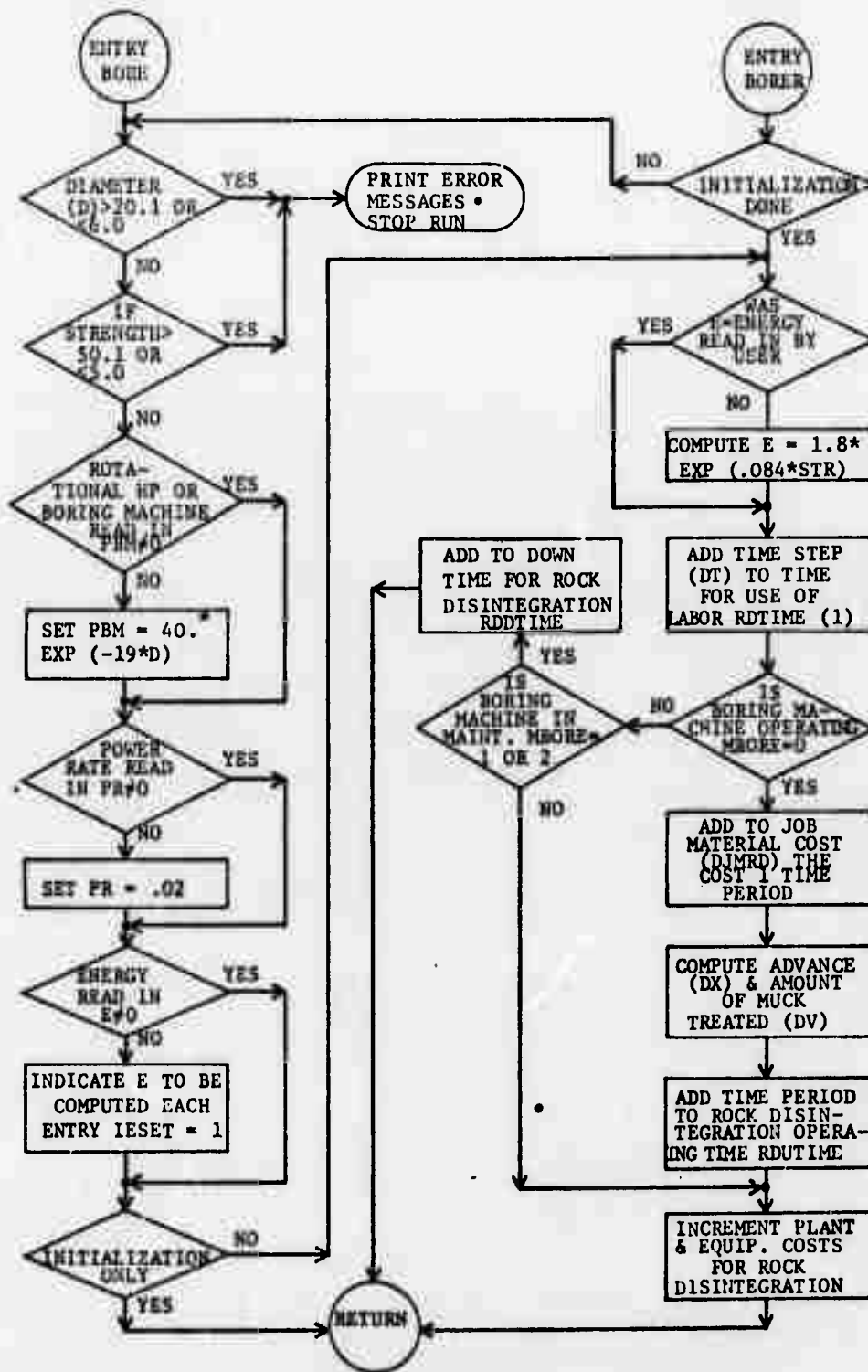
REPORC

Routine prints out cumulative costs since beginning of run. Total costs and costs for each general process are printed out.

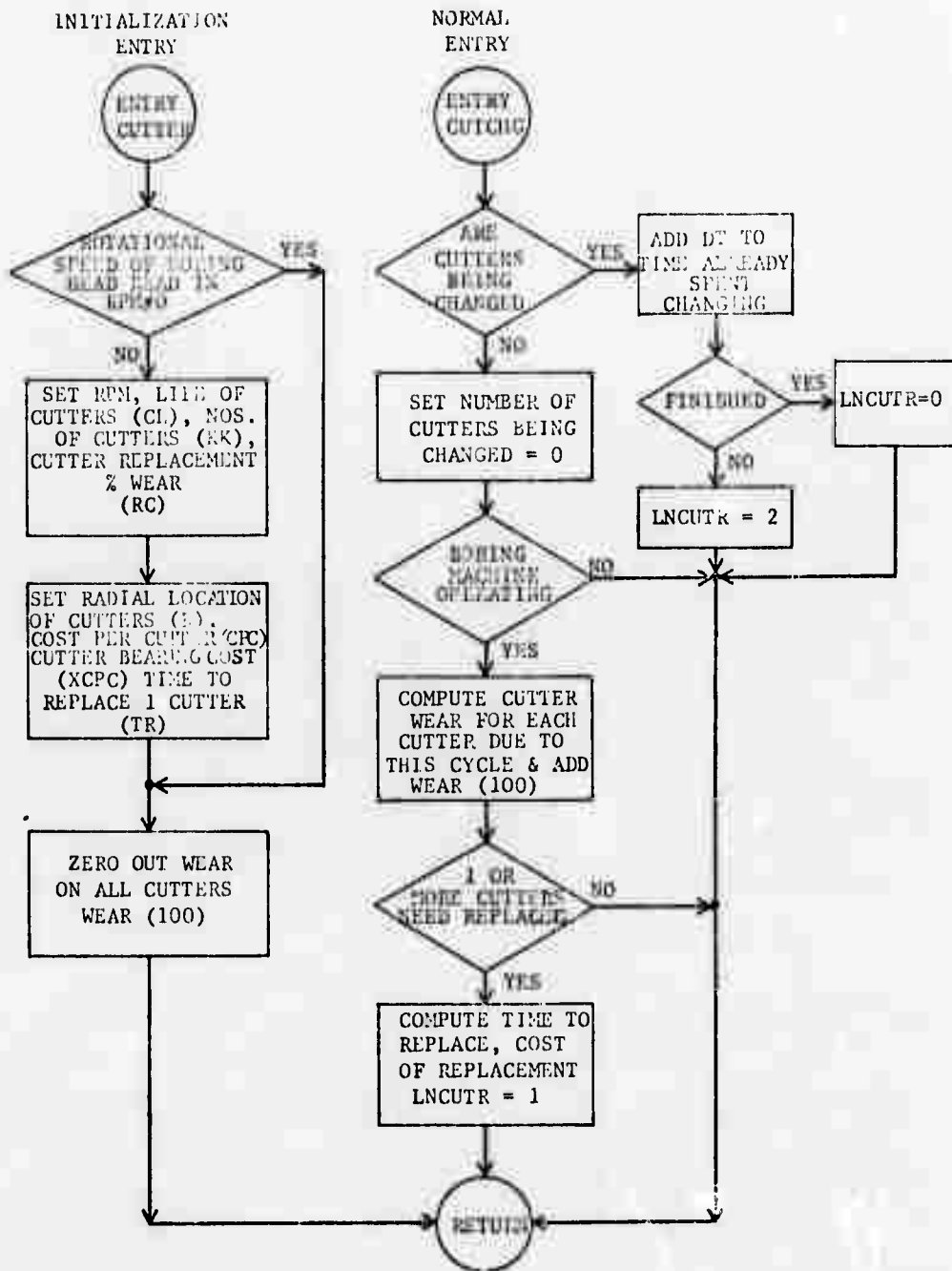
Subroutine BORE

INITIALIZATION ENTRY

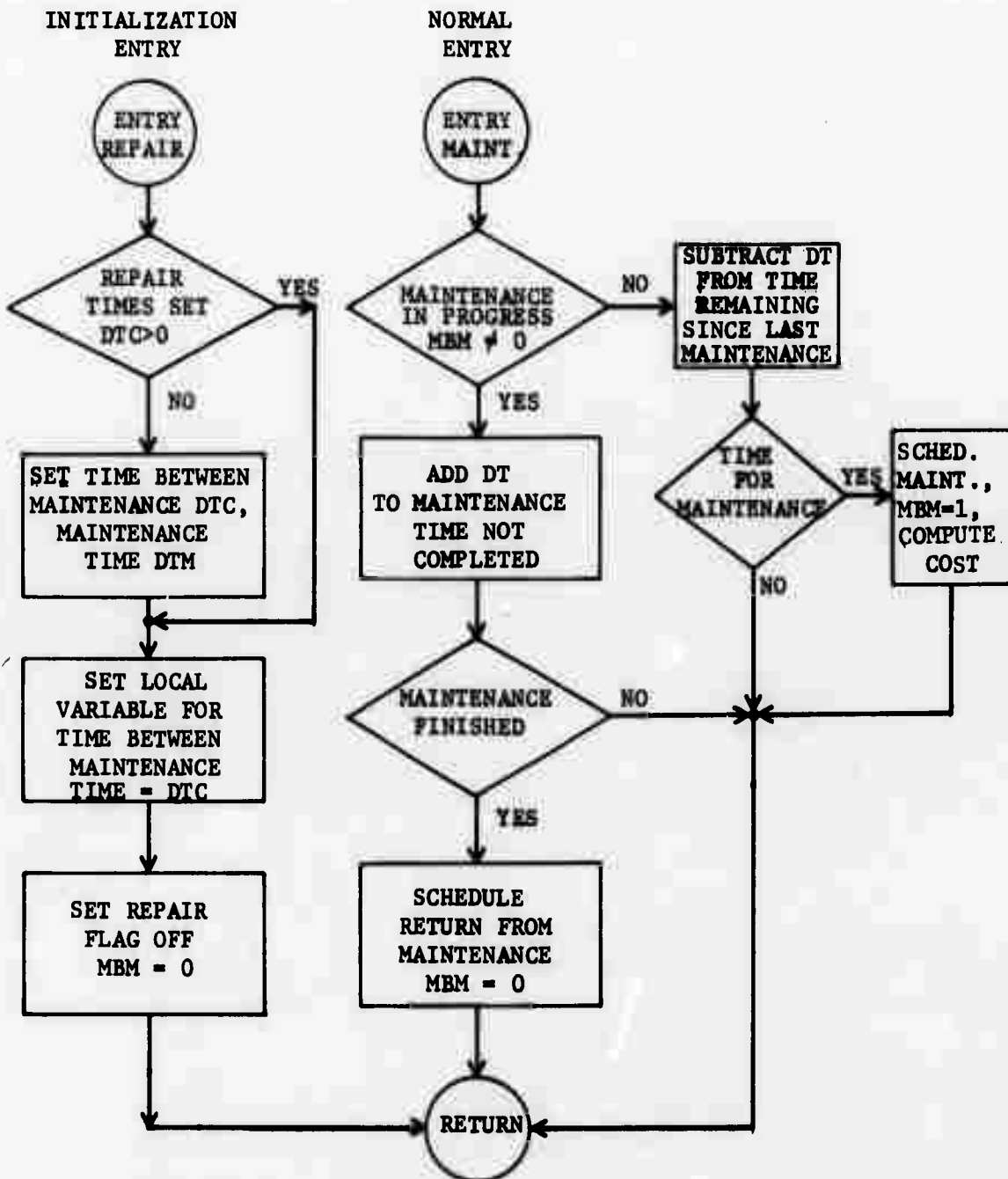
NORMAL ENTRY



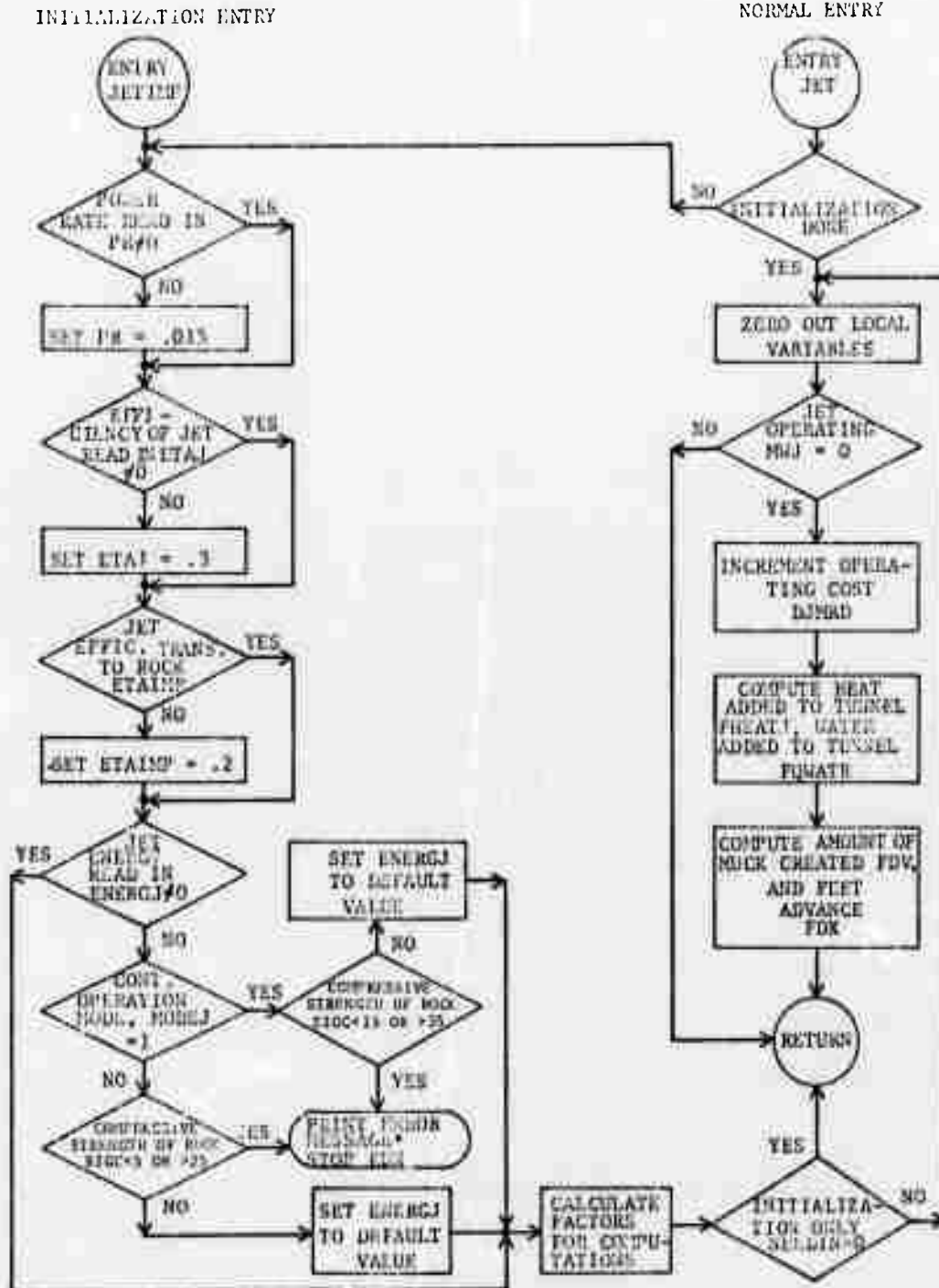
Subroutine CUTTER



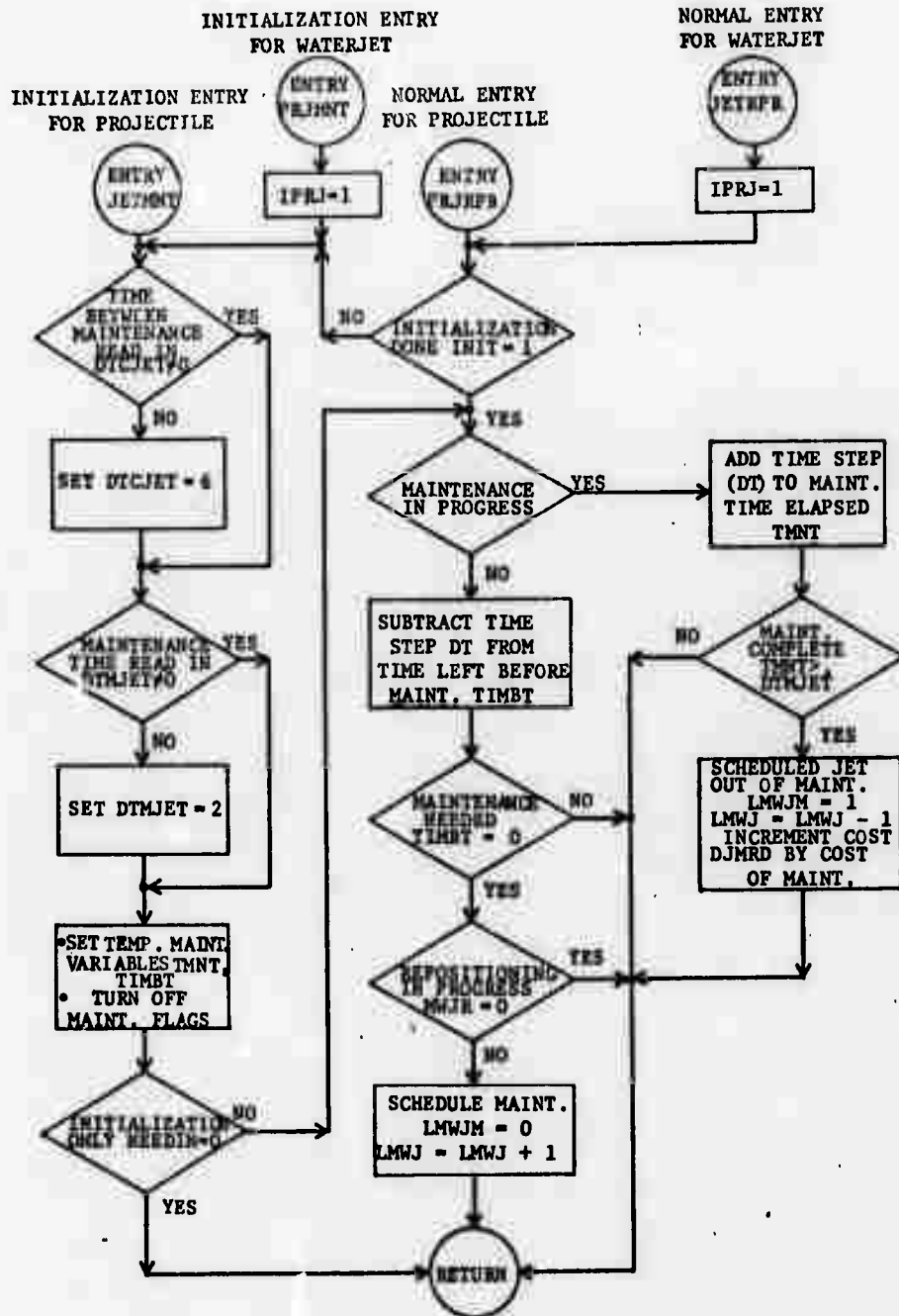
Subroutine REPAIR



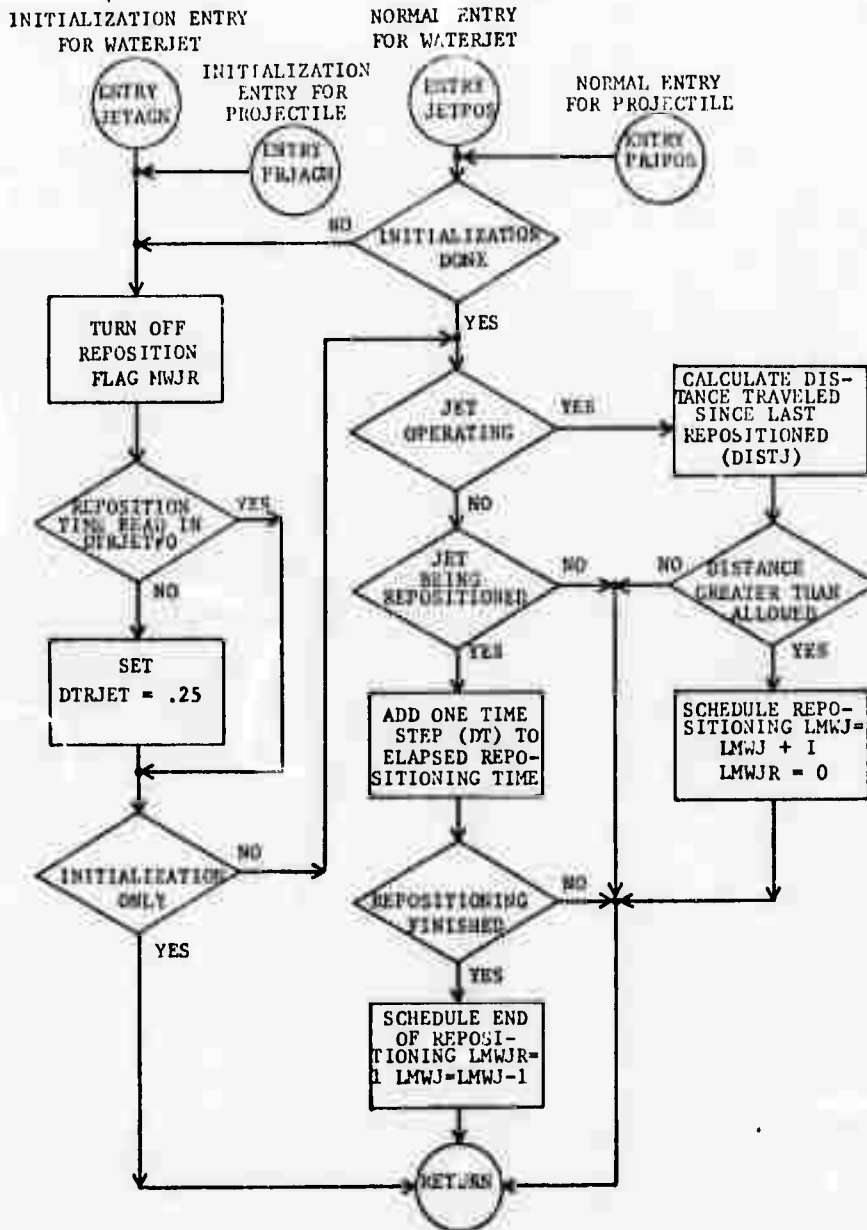
Subroutine JETIMP



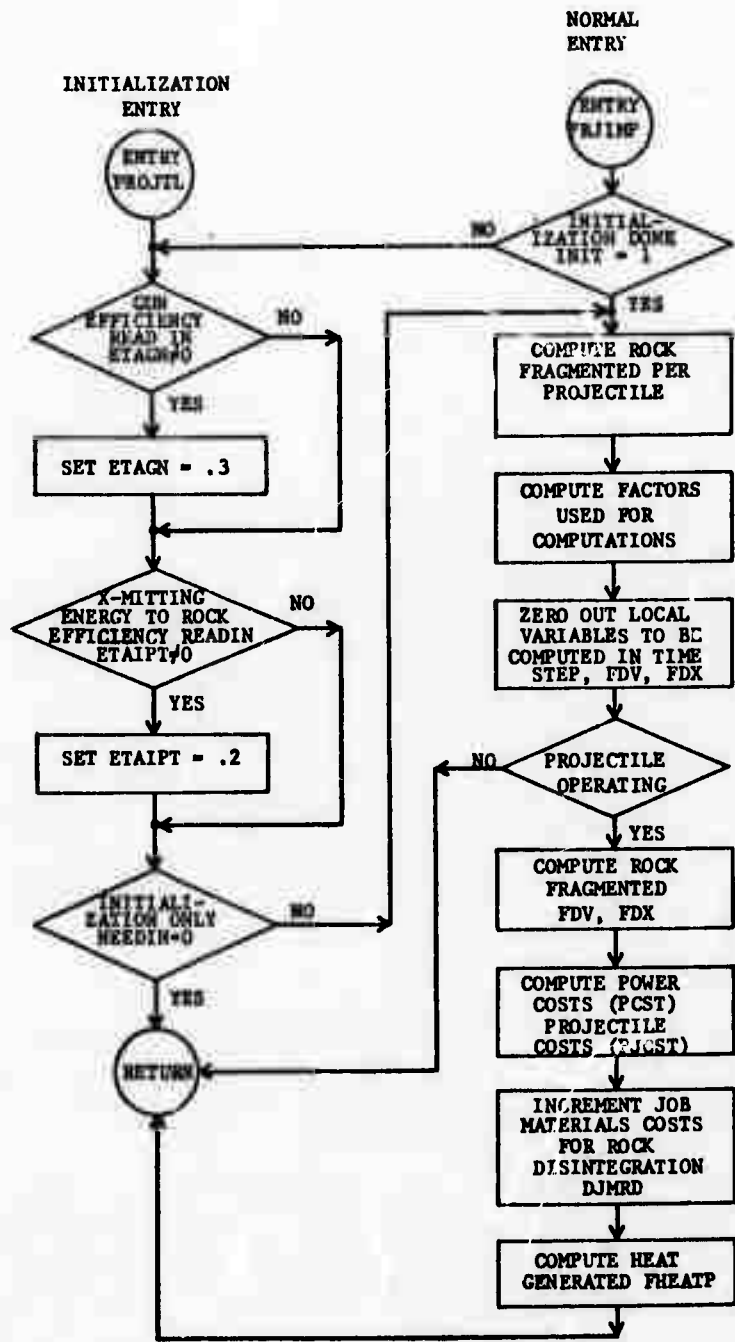
Subroutine JETMNT



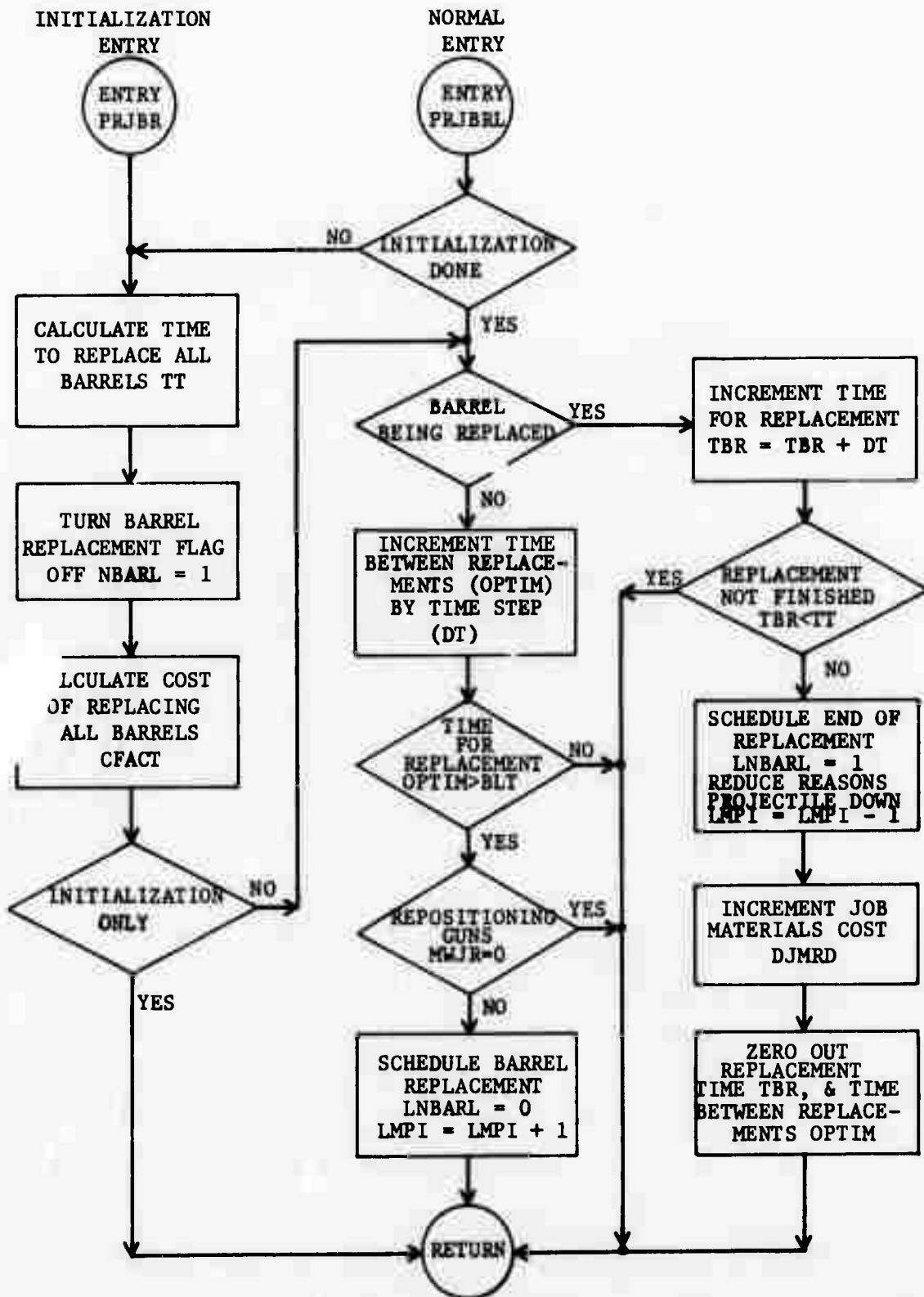
Subroutine JETAGN



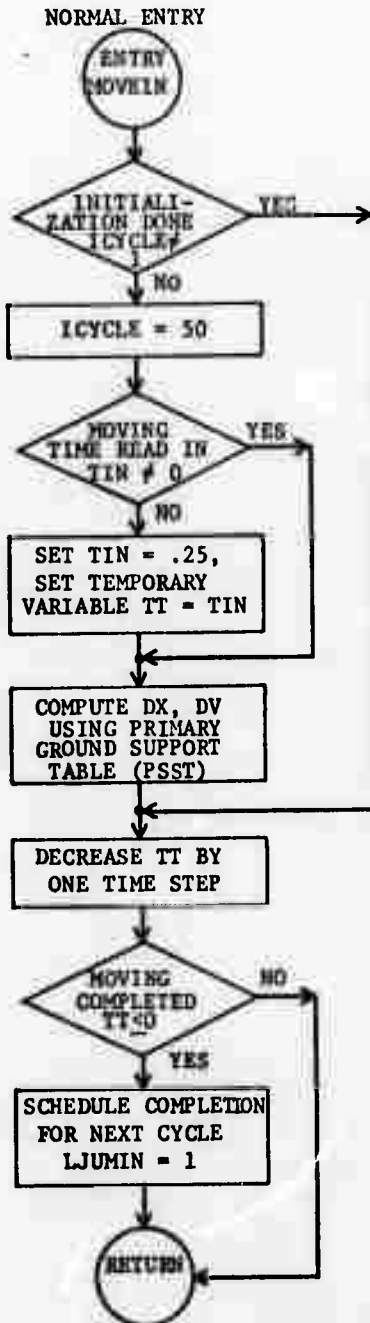
Subroutine PROJTL



Subroutine PRJBR

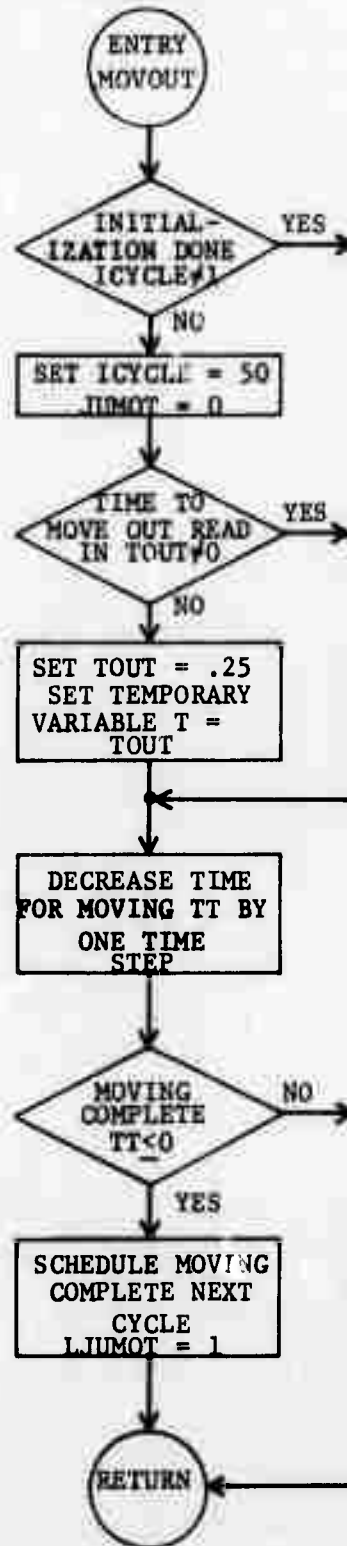


Subroutine MOVEIN

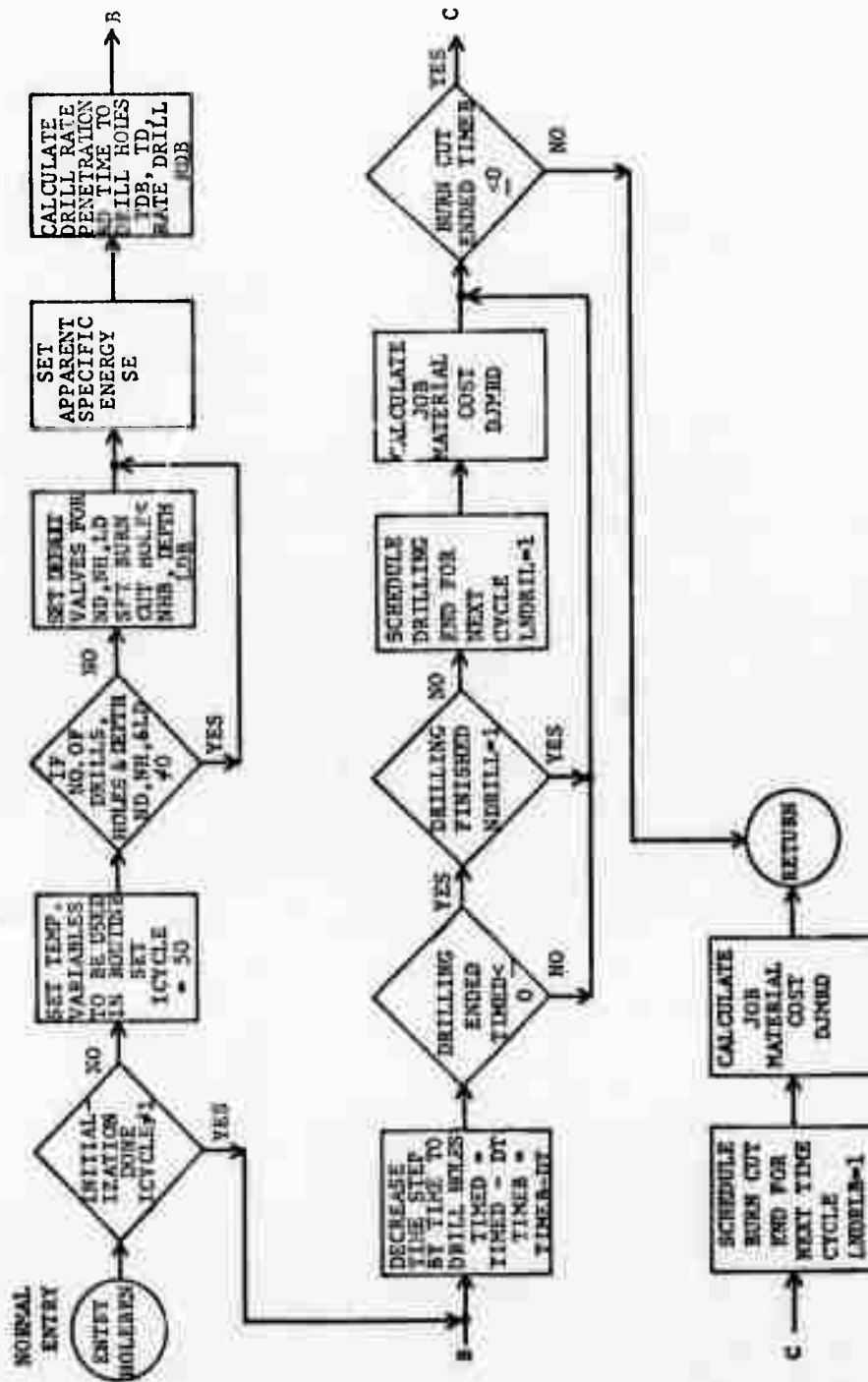


Subroutine MOVOUT

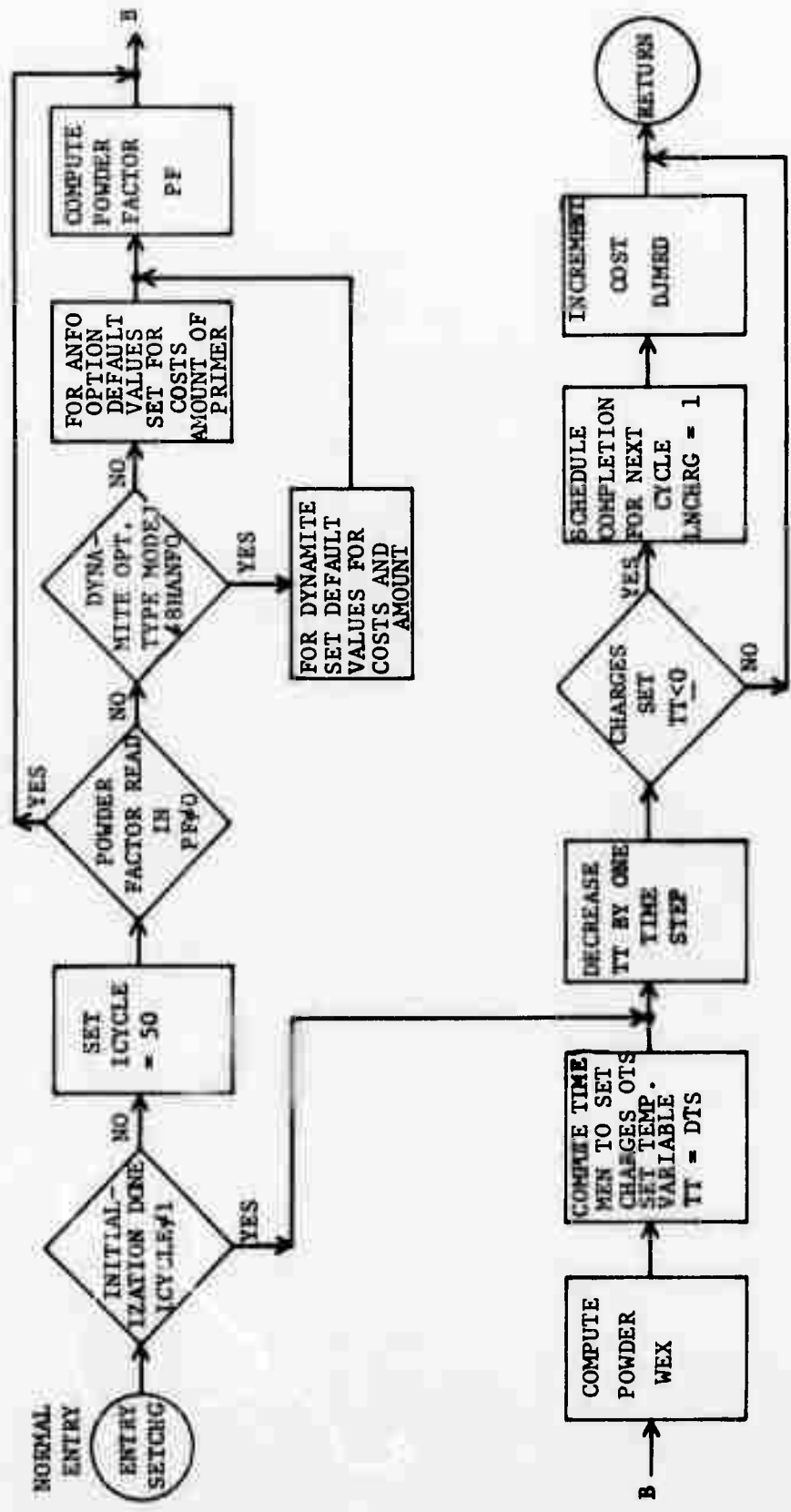
NORMAL ENTRY



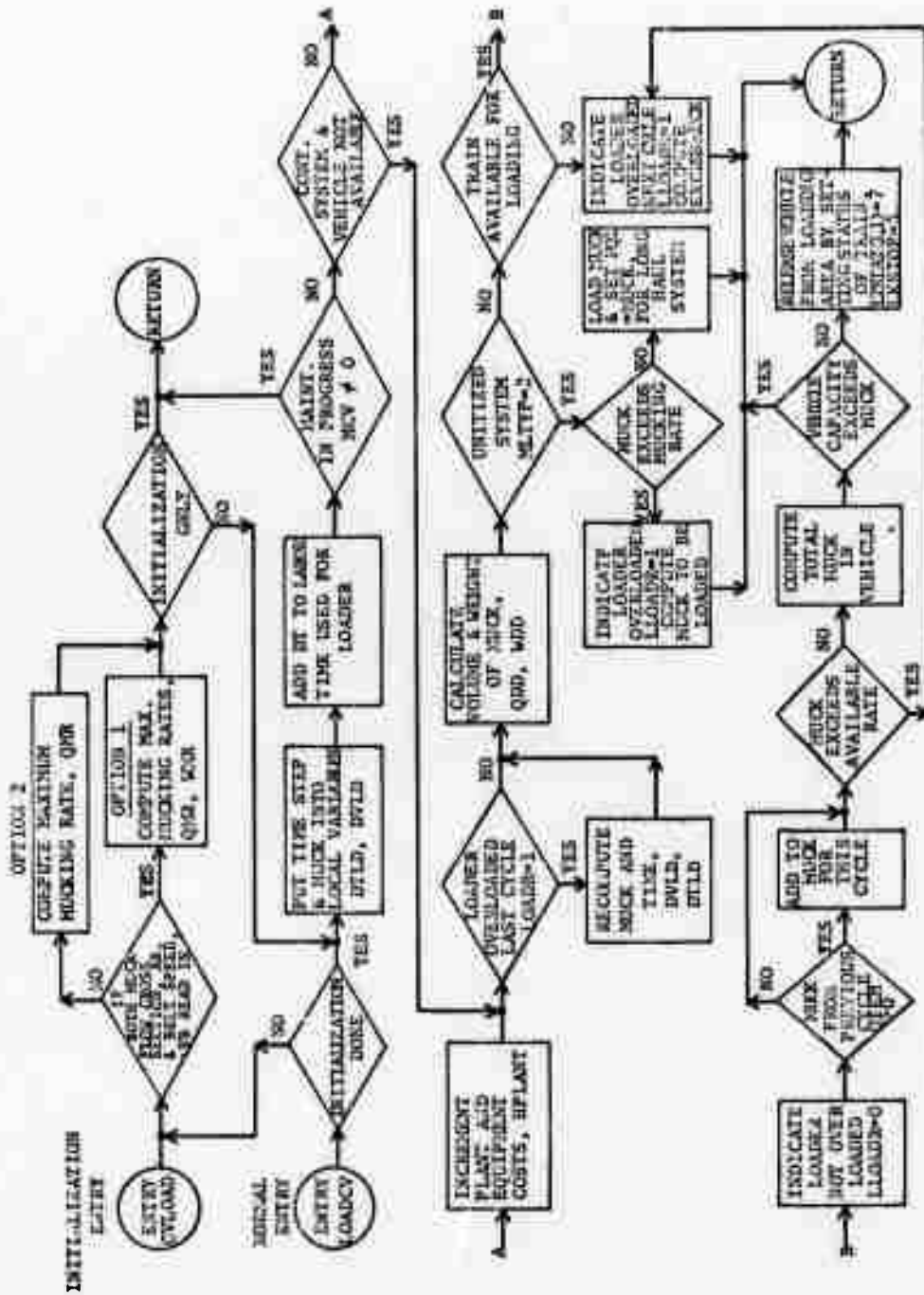
Subroutine HOLBRN



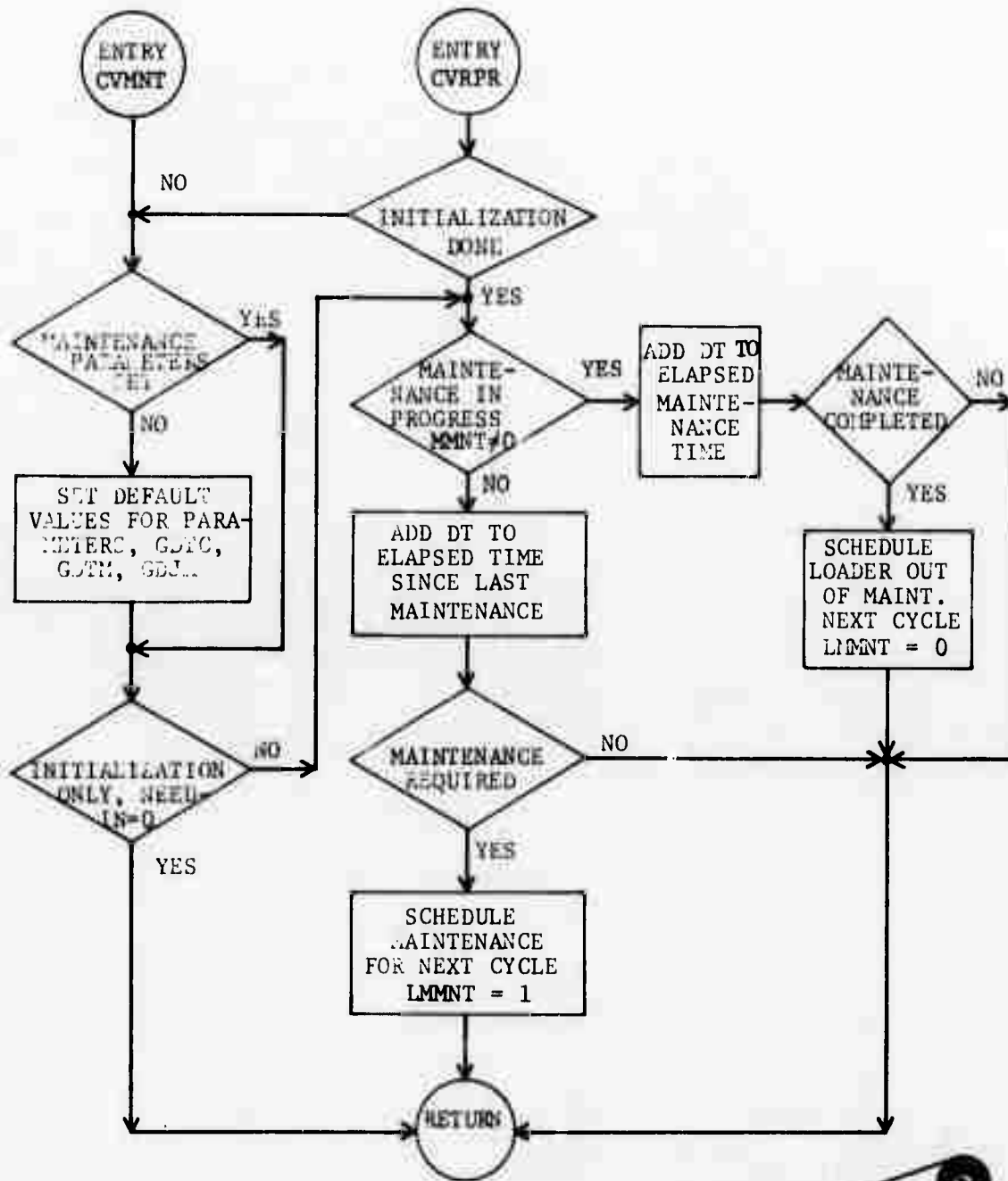
Subroutine SETCHG



Subroutine CVLOAD

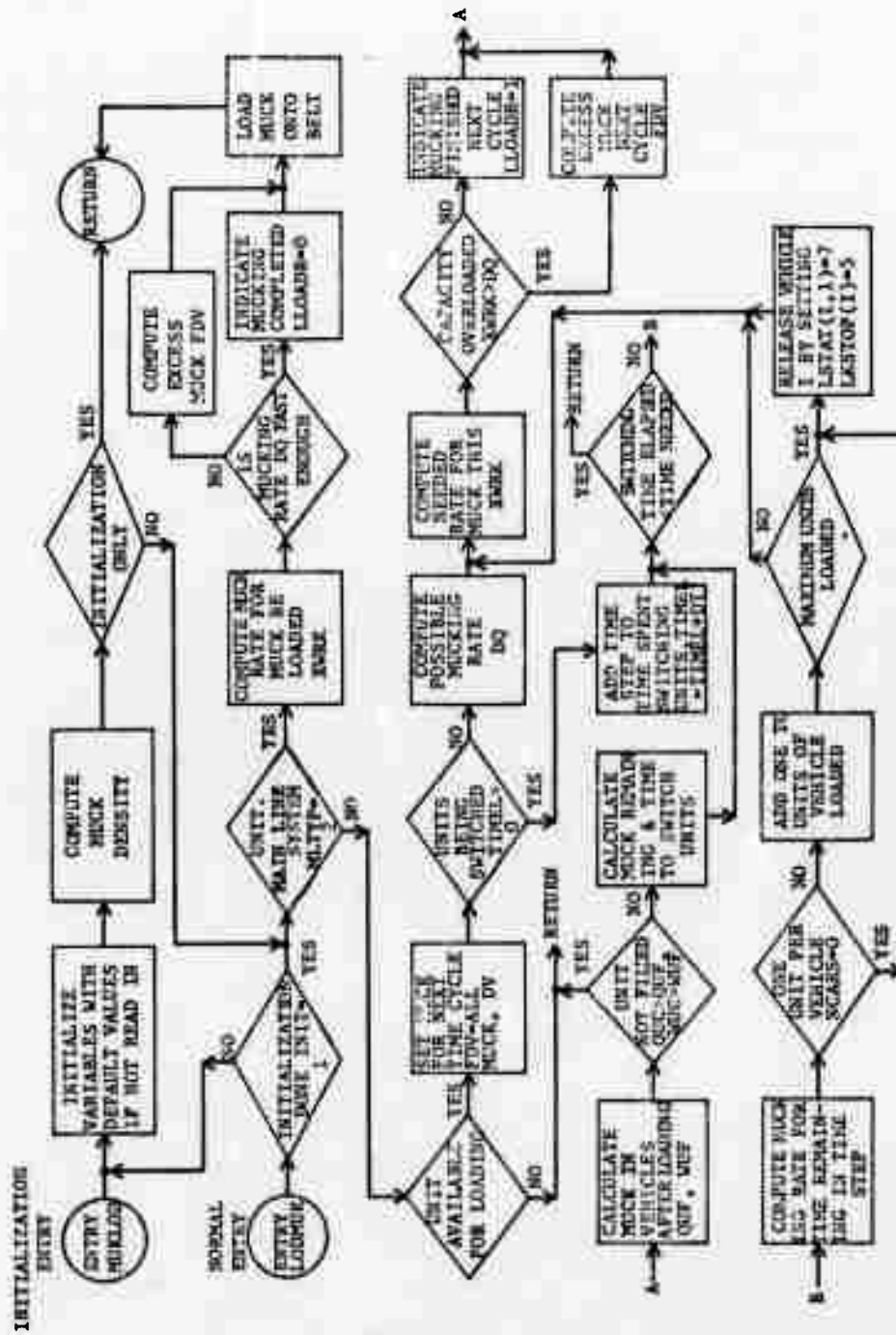


Subroutine CVMNT

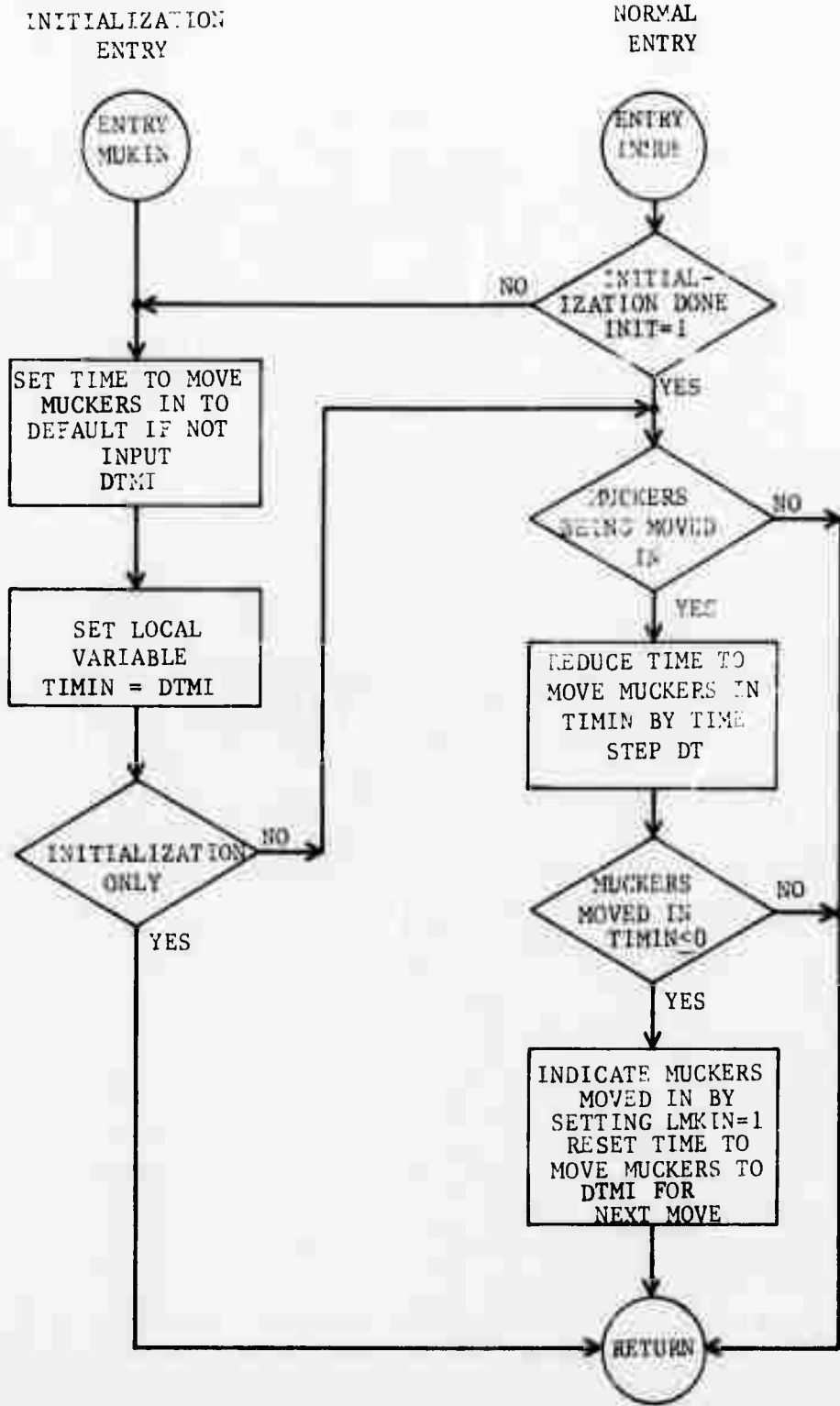


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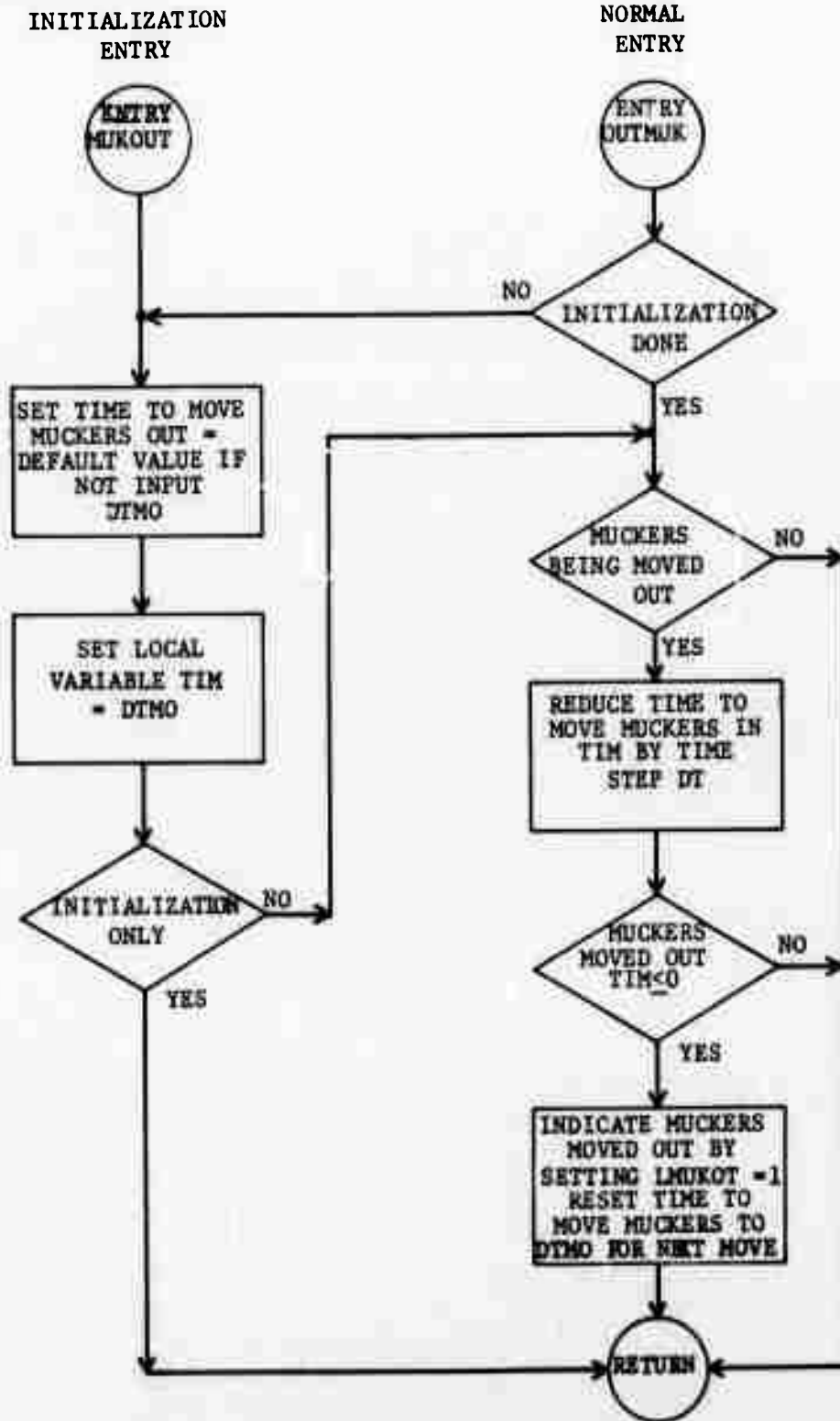
Subroutine MUKLOD



Subroutine MUKIN



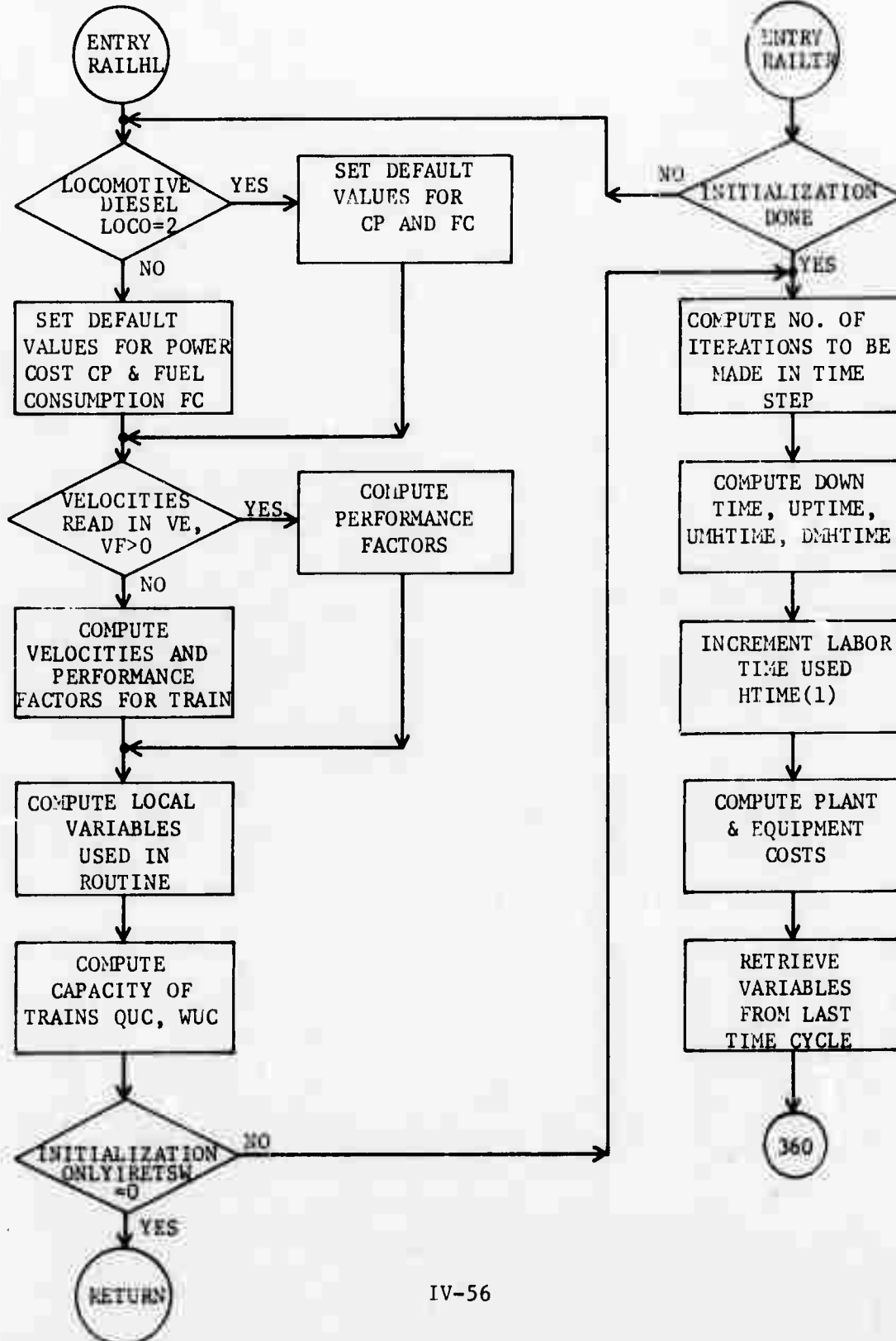
Subroutine MUKOUT



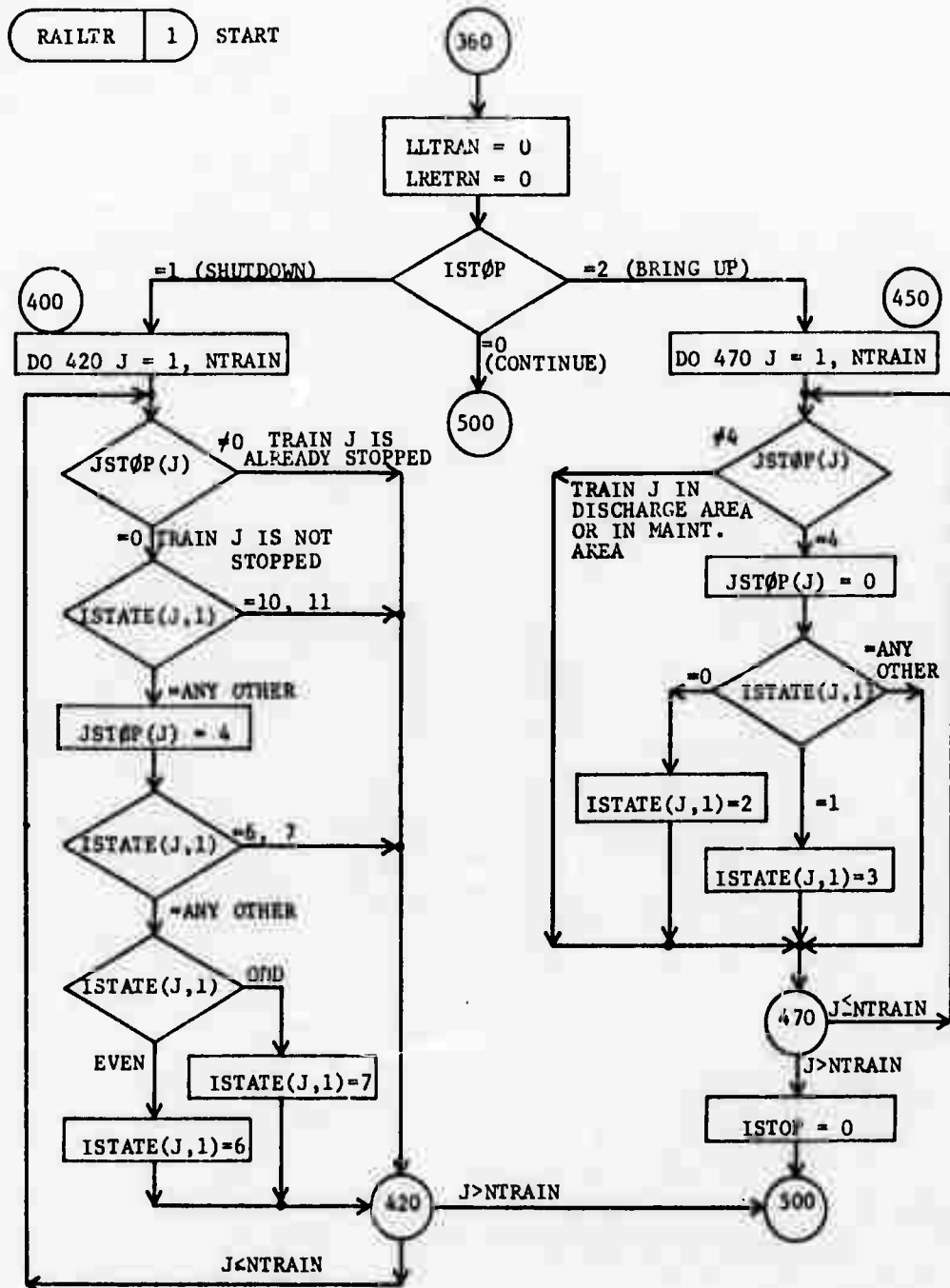
Subroutine RAILHL

INITIALIZATION ENTRY

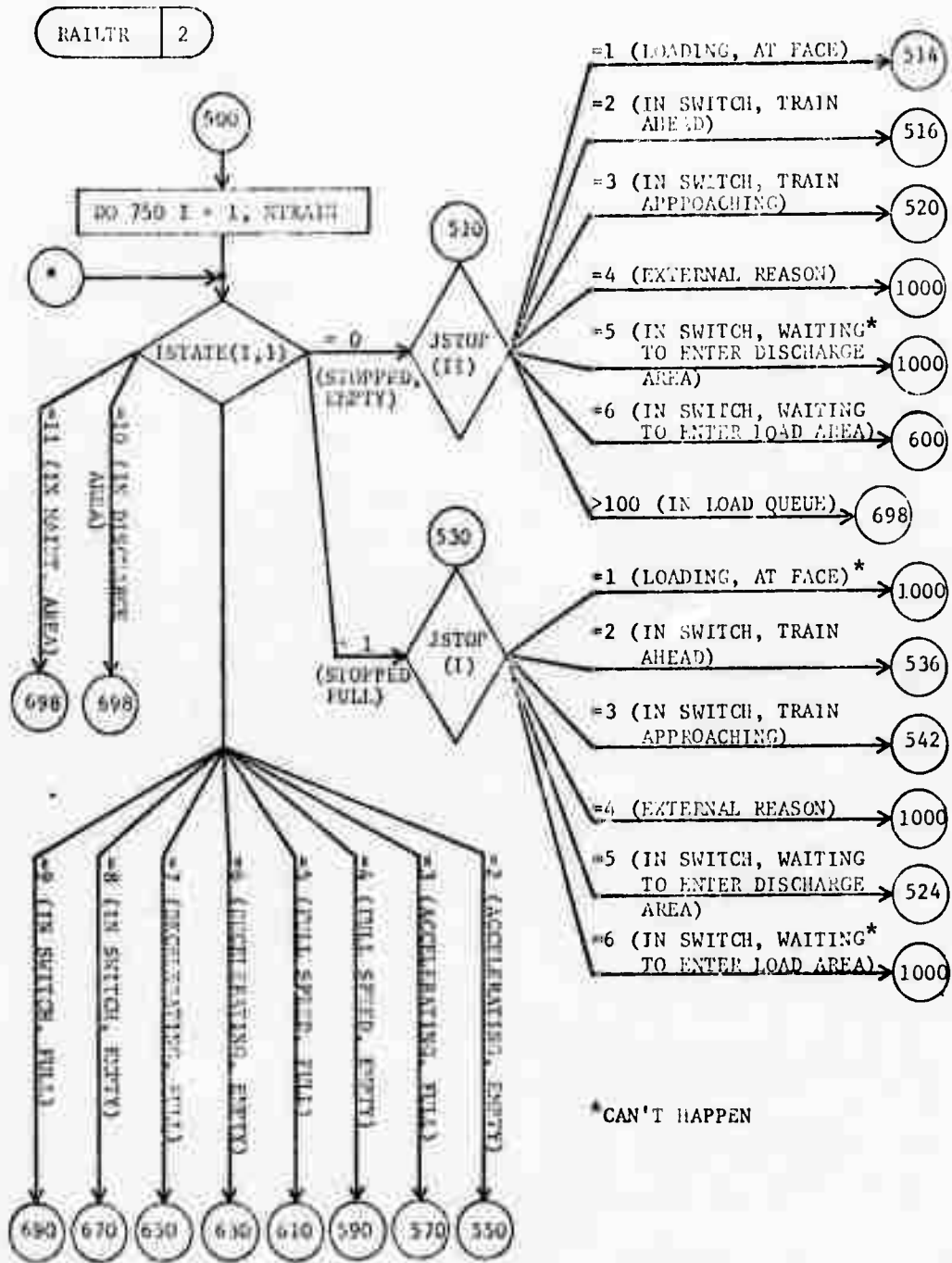
NORMAL ENTRY



Subroutine RAILHL (cont.)



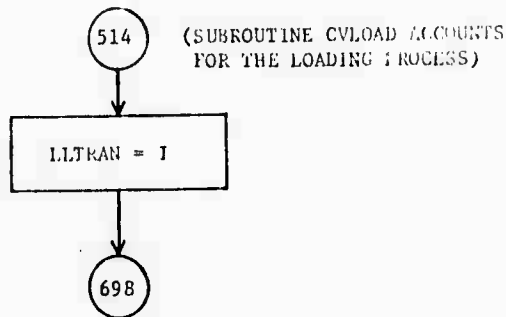
Subroutine RAILHL (cont.)



Subroutine RAILHL (cont.)

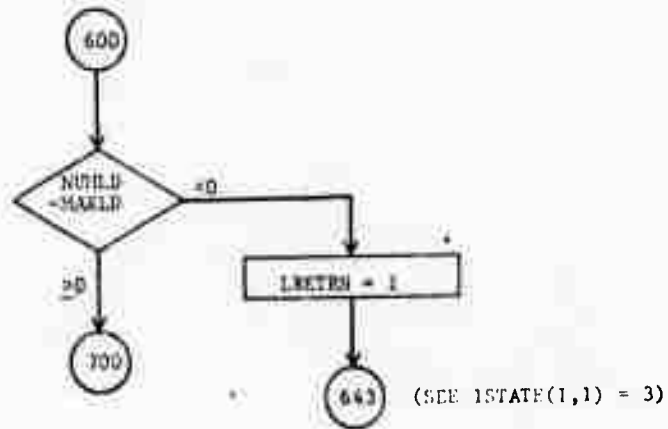
RAILTR 3A

ISTATE(1,1) = 0 } TRAIN IS STOPPED, EMPTY.
 JSTOP(1) = 1 } AT FACE, LOADING.



RAILTR 3B

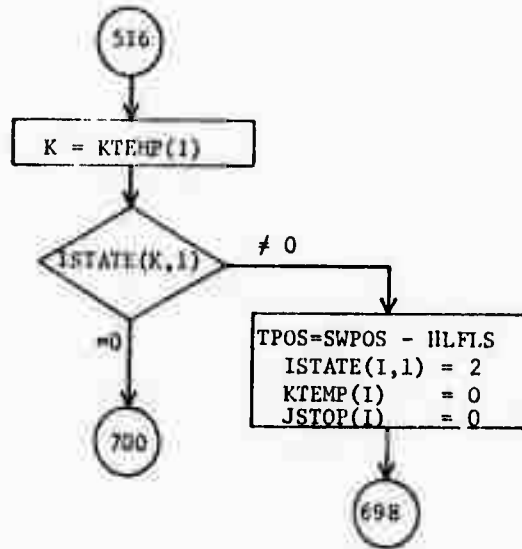
ISTATE(1,1) = 0 } TRAIN IS STOPPED, EMPTY.
 JSTOP(1) = 6 } WAITING TO ENTER LOAD AREA.



Subroutine RAILHL (cont.)

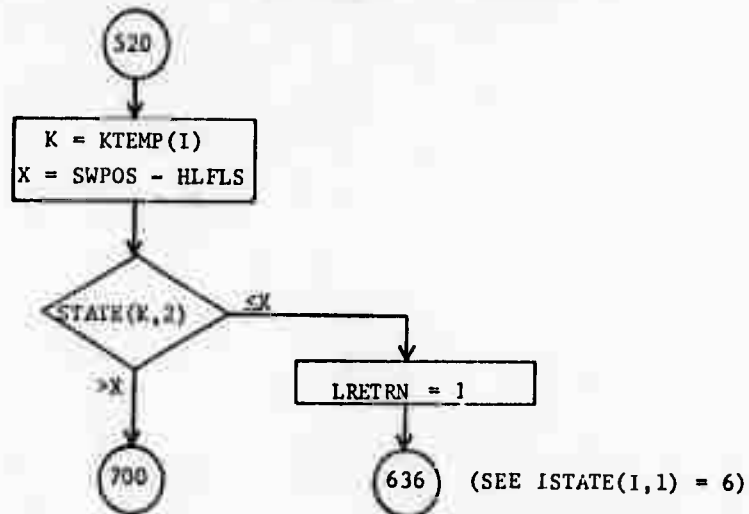
RAILTR 4

$ISTATE(I,1) = 0$ } TRAIN IS STOPPED, EMPTY.
 $JSTOP(I) = 2$ } ANOTHER TRAIN STOPPED AHEAD.



RAILTR 4A

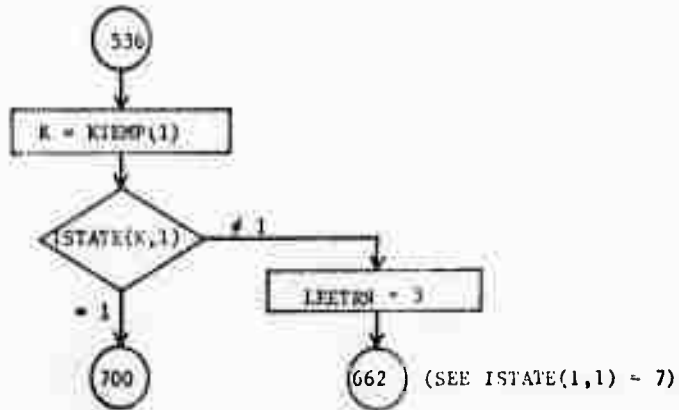
$ISTATE(I,1) = 0$ } TRAIN IS STOPPED, EMPTY.
 $JSTOP(I) = 3$ } ANOTHER TRAIN APPROACHING.



Subroutine RAILHL (cont.)

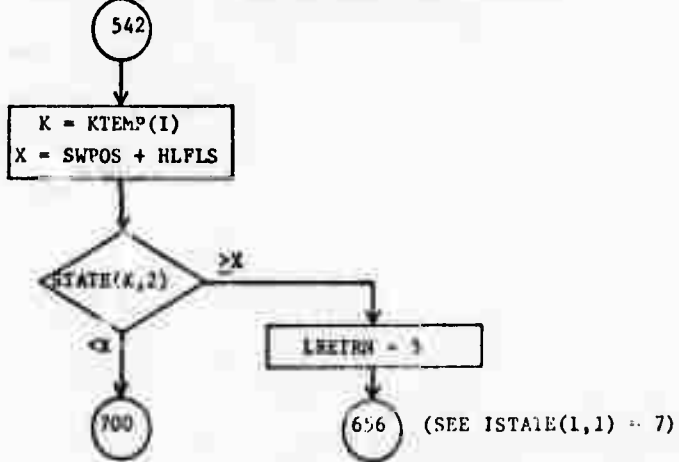
RAILTR 5

ISTATE(I,1) = 1 } TRAIN IS STOPPED, FULL.
 JSTOP(I) = 2 } ANOTHER TRAIN STOPPED AHEAD.



RAILTR 5A

ISTATE(I,1) = 1 } TRAIN IS STOPPED, FULL.
 JSTOP(I) = 3 } ANOTHER TRAIN APPROACHING.

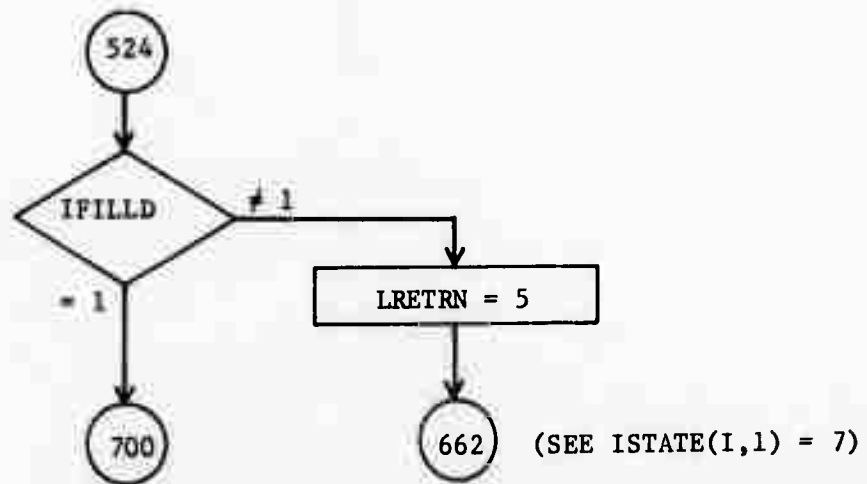


Subroutine RAILHL (cont.)

RAILTR	6
--------	---

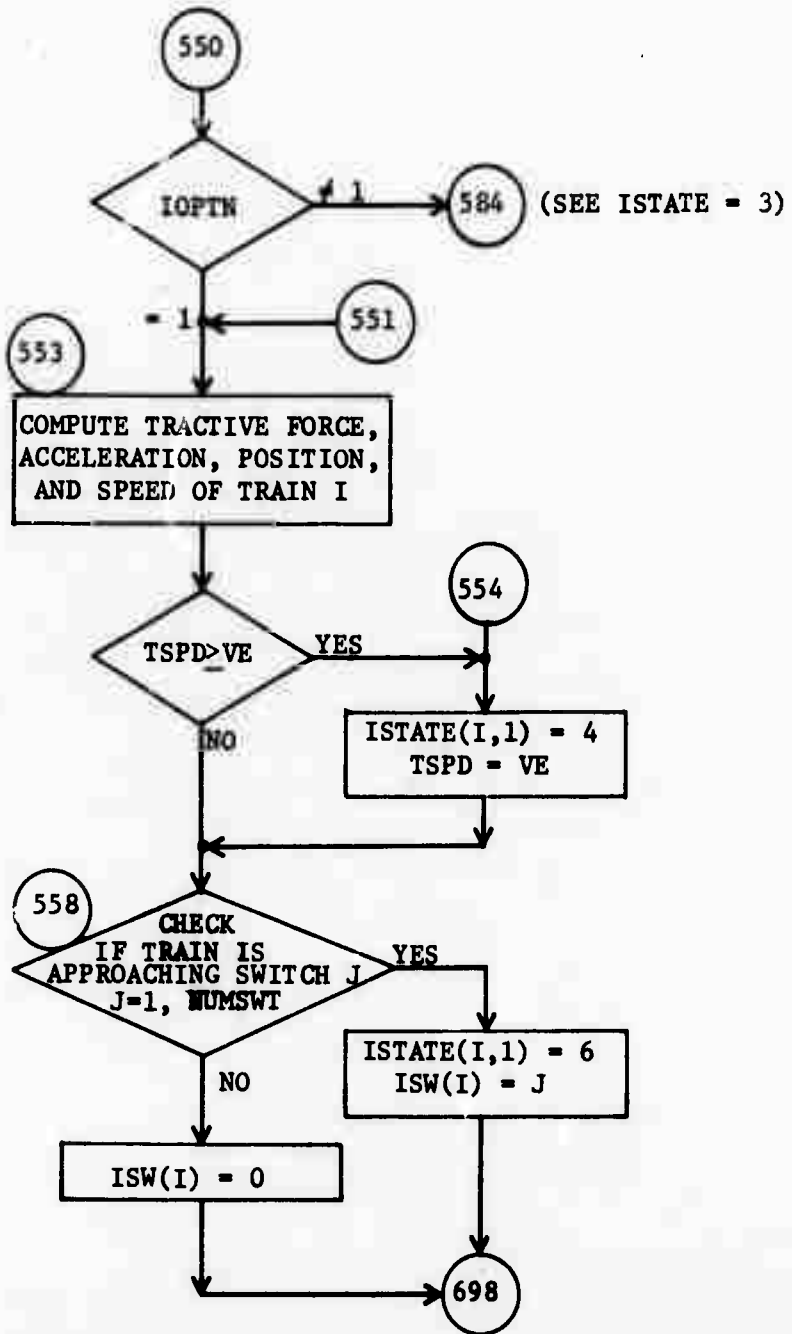
ISTATE(I,1) = 1 }
JSTOP(I) = 5 }

TRAIN IS STOPPED, FULL.
WAITING IN DISCHARGE AREA.

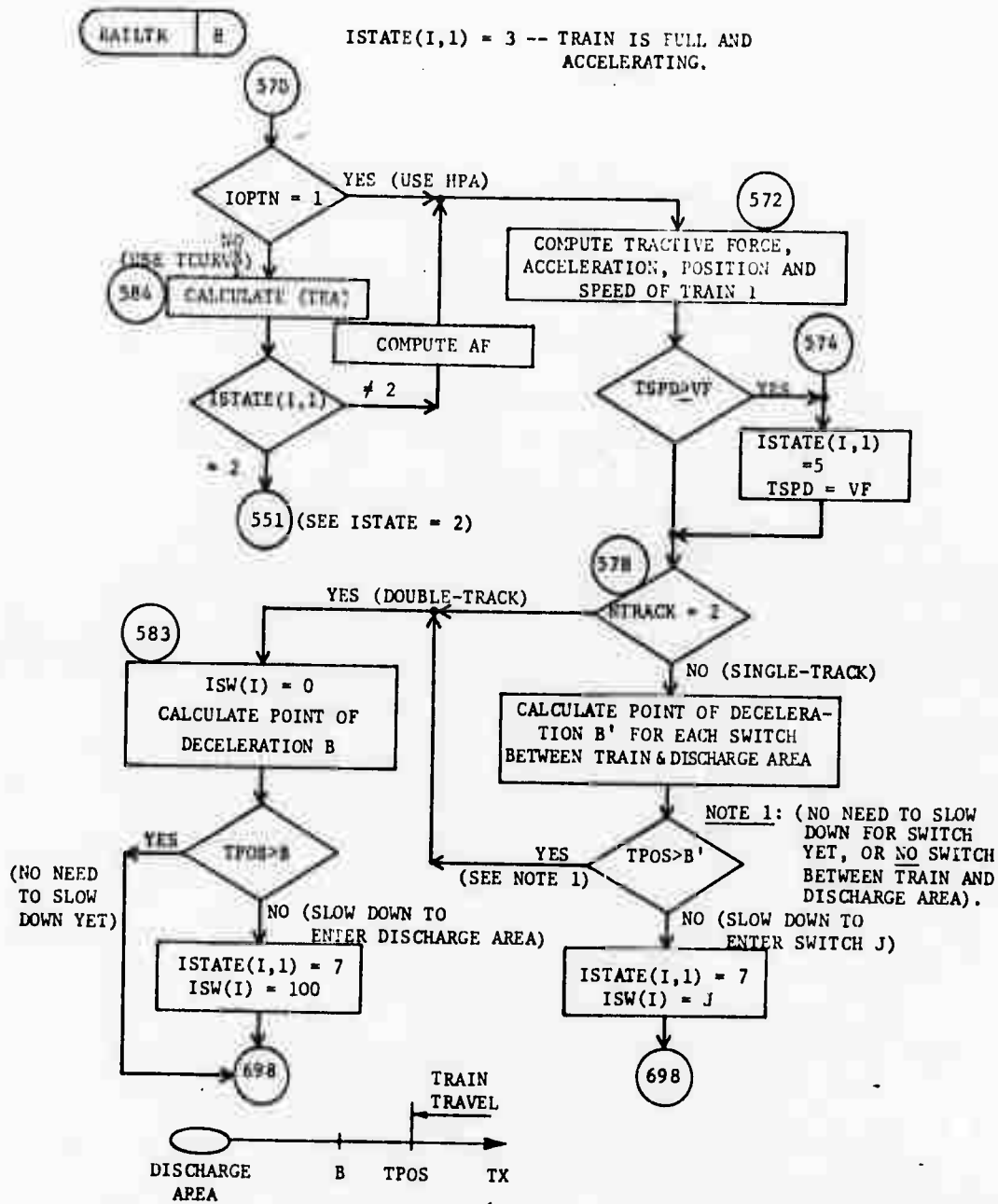


Subroutine RAILHL (cont.)

RAILTR 7 ISTATE(I,1) = 2 -- TRAIN IS EMPTY AND ACCELERATING

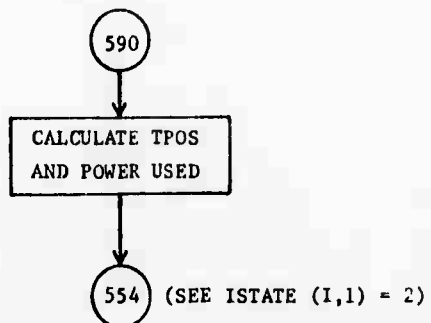


Subroutine RAILHL (cont.)

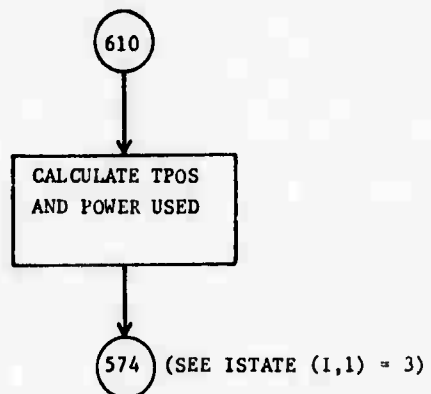


Subroutine RAILHL (cont.)

RAILTR 9 ISTATE(I,1) = 4 -- TRAIN IS GOING FULL SPEED, EMPTY

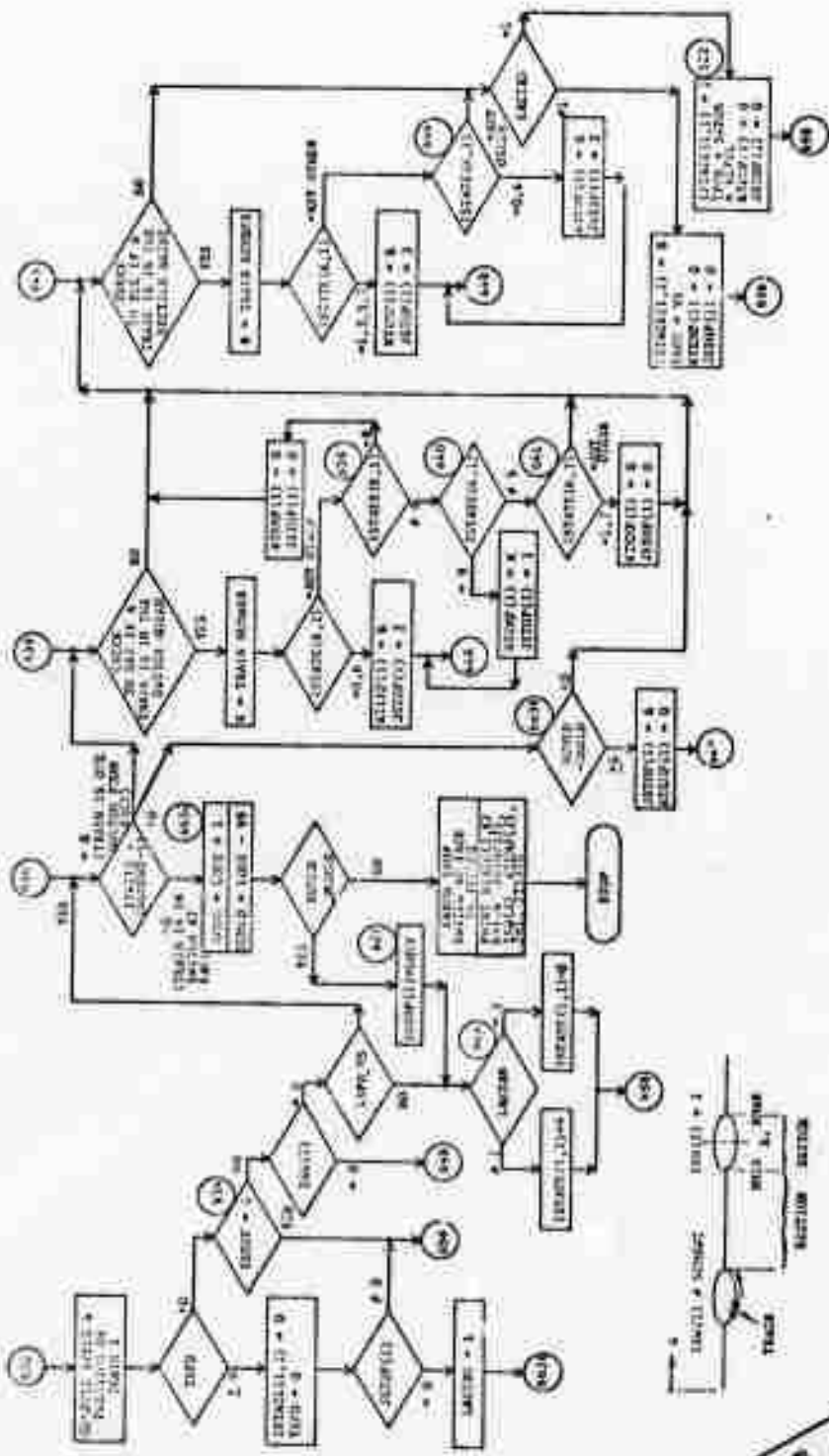


RAILTR 10 ISTATE(I,1) = 5 -- TRAIN IS GOING FULL SPEED, FULL



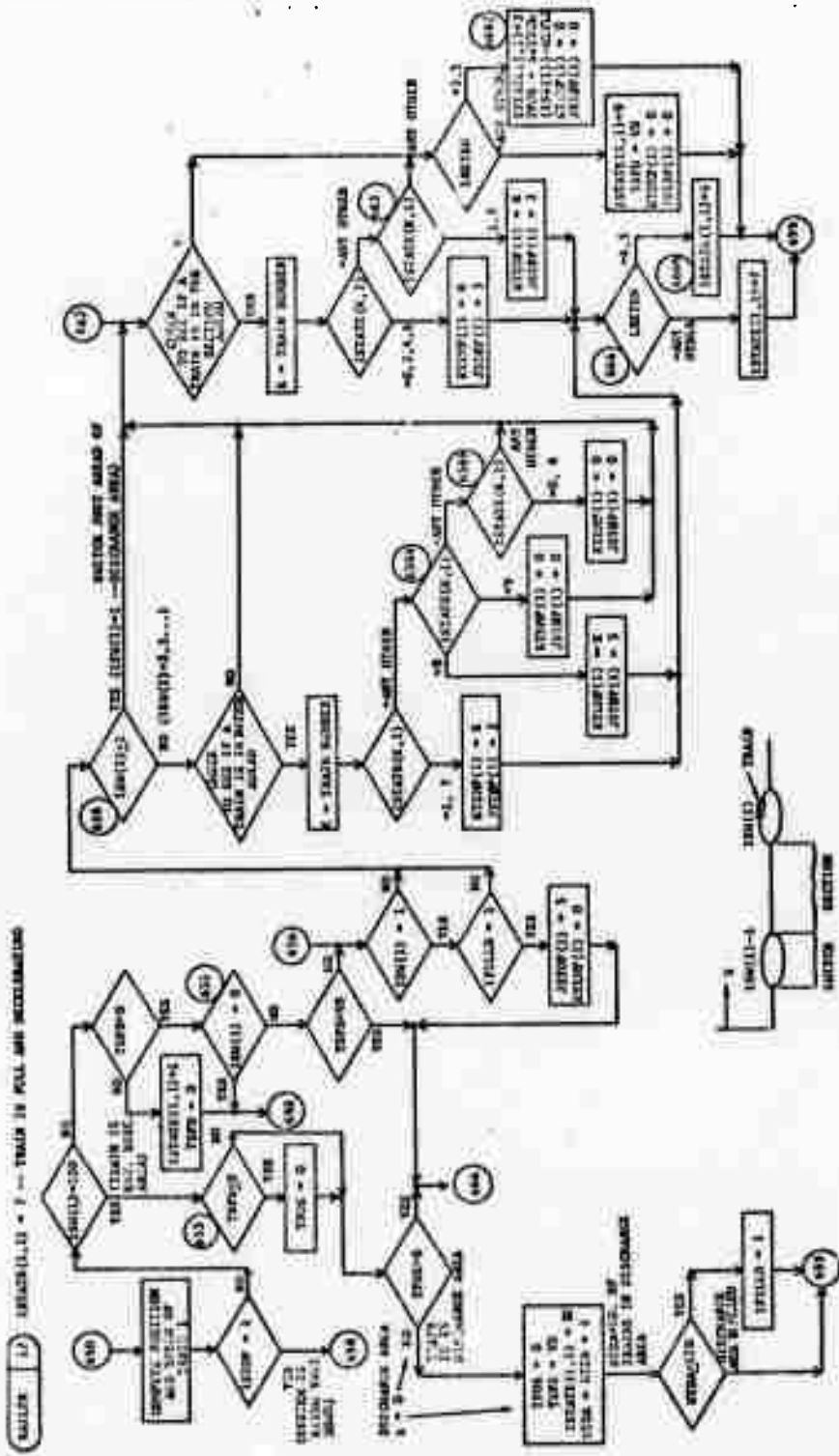
Subroutine RAILHL (cont.)

RAILHL (1,1) = 6 --- TRAINING IS EMPTY AND DECELERATING



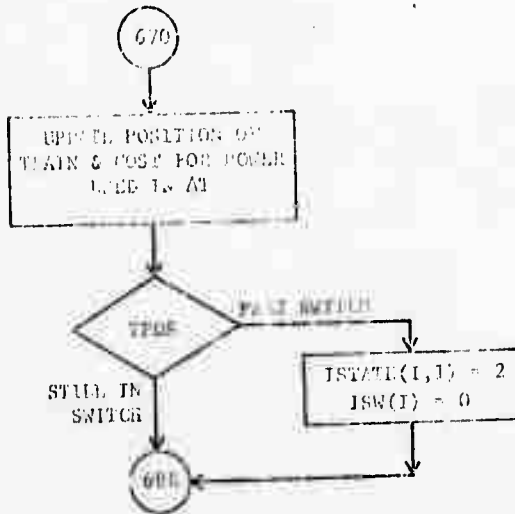
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Subroutine RAILHL (Cont.)

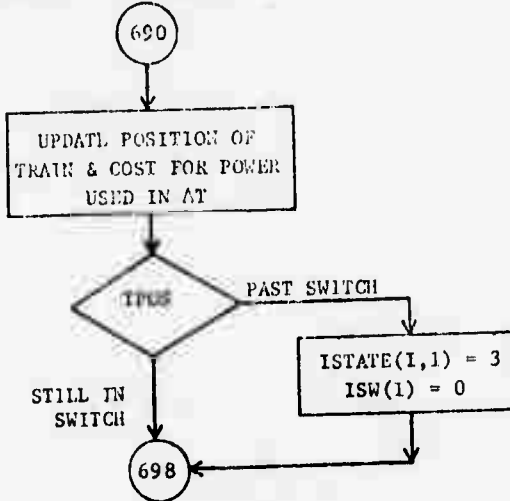


Subroutine RAILHL (cont.)

RAILTR 12 ISTATE(1,1) = 8 -- TRAIN IN SWITCH, EMPTY



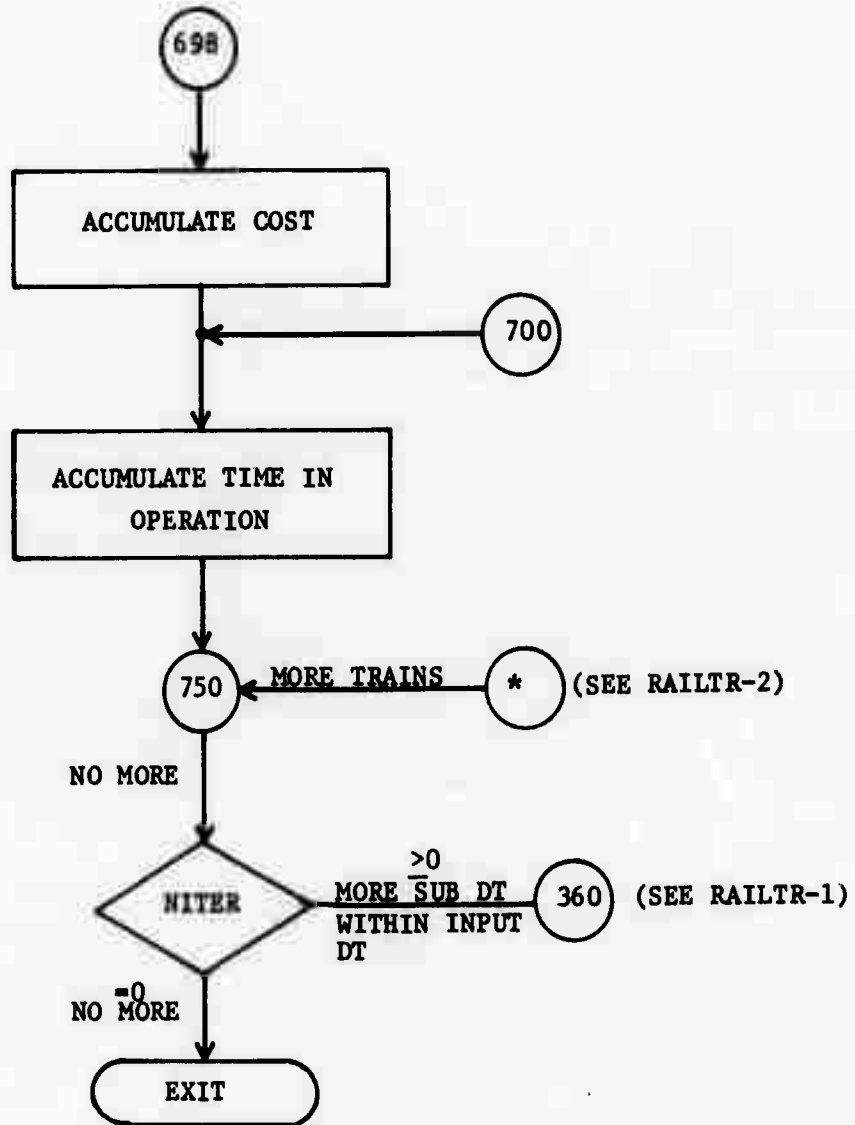
RAILTR 14 ISTATE(1,1) = 9 -- TRAIN IN SWITCH, FULL



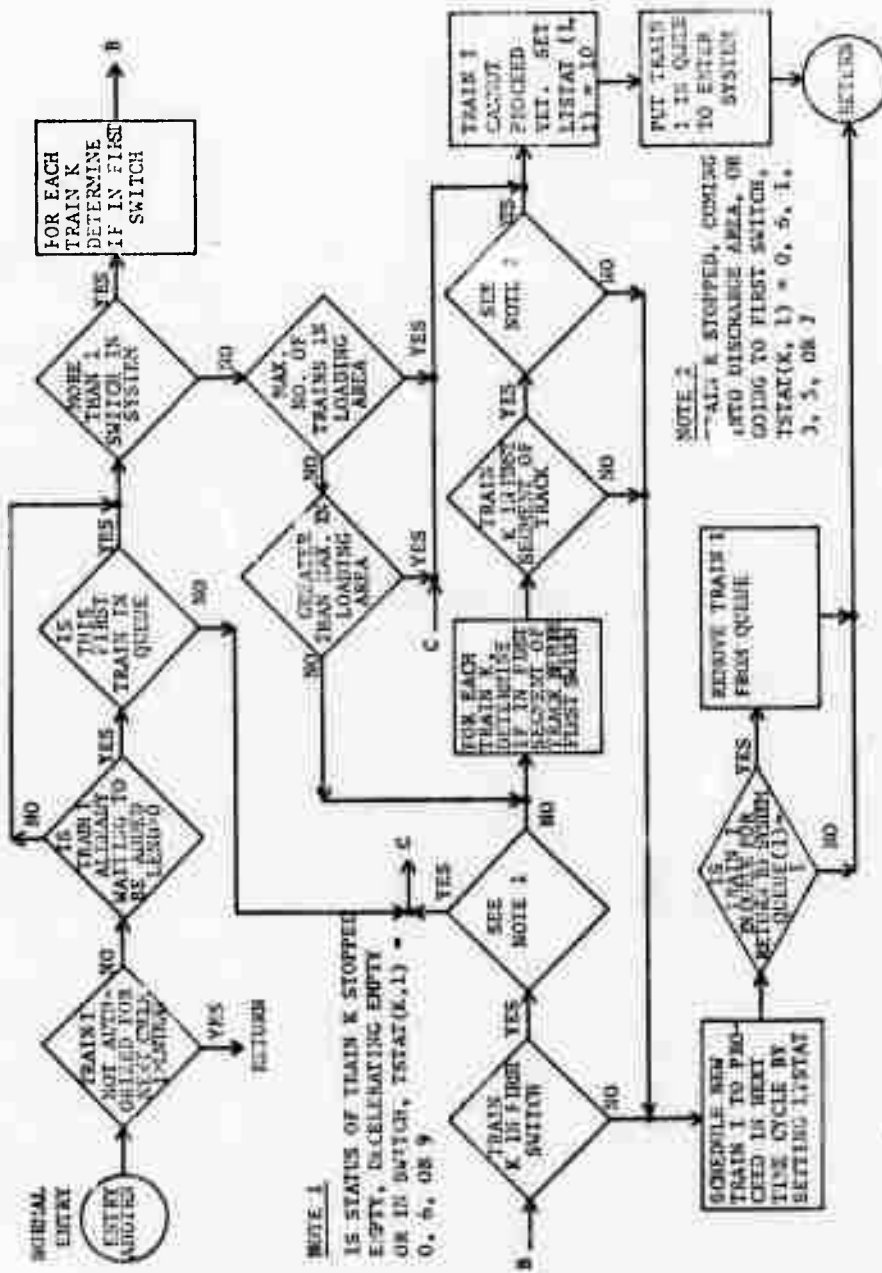
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best available copy.

Subroutine RAILHL (cont.)

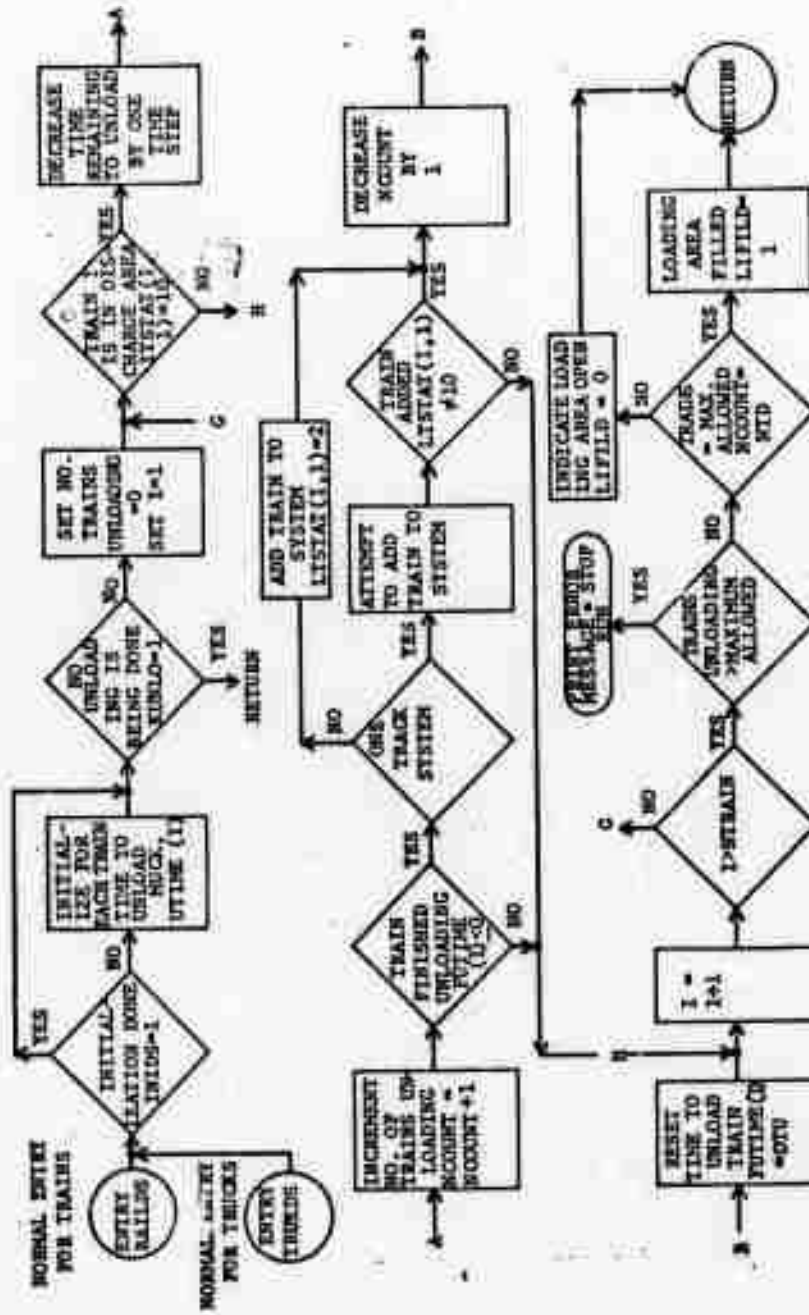
RAILTR 15 END OF LOOP



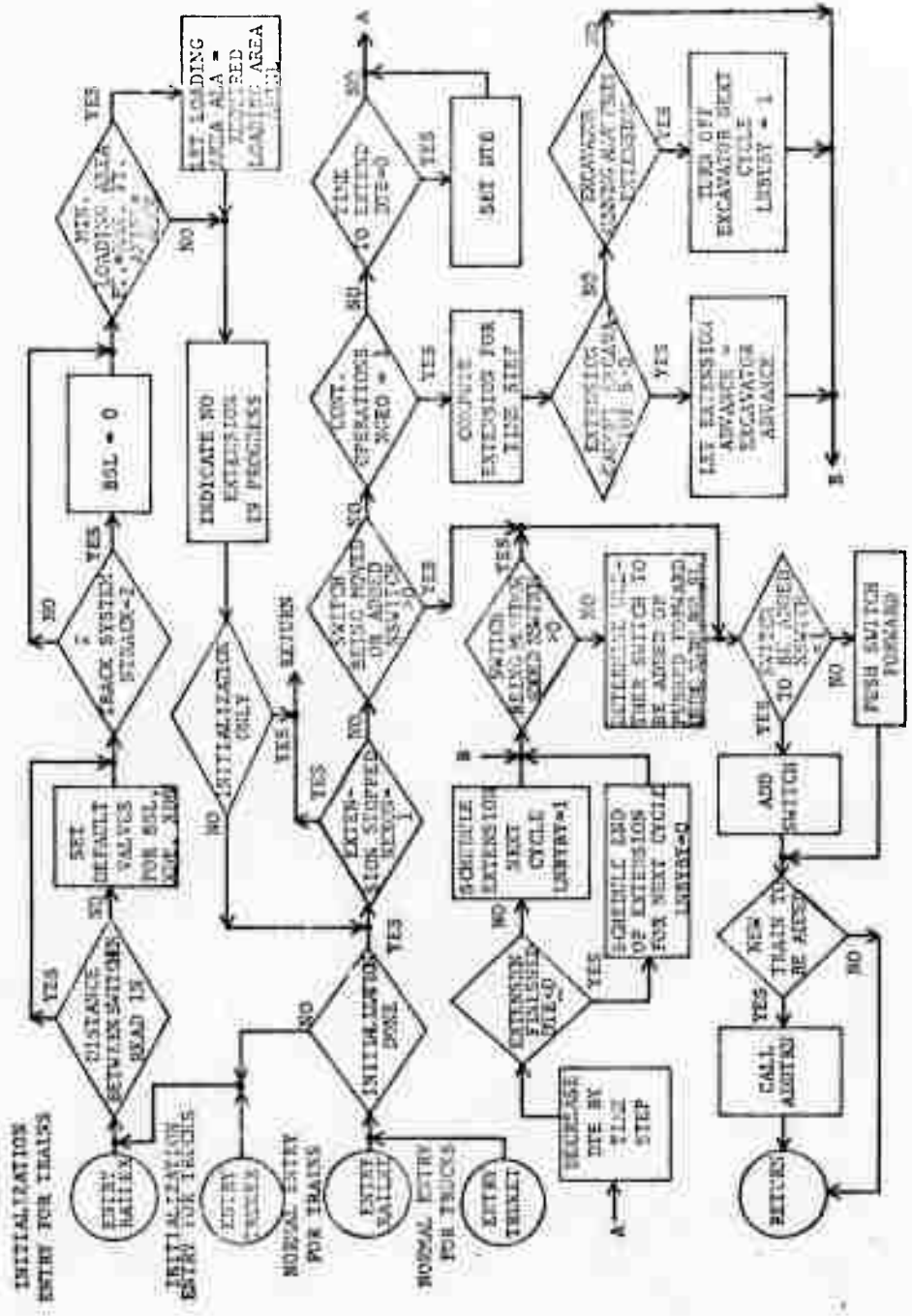
Subroutine ADDTRN



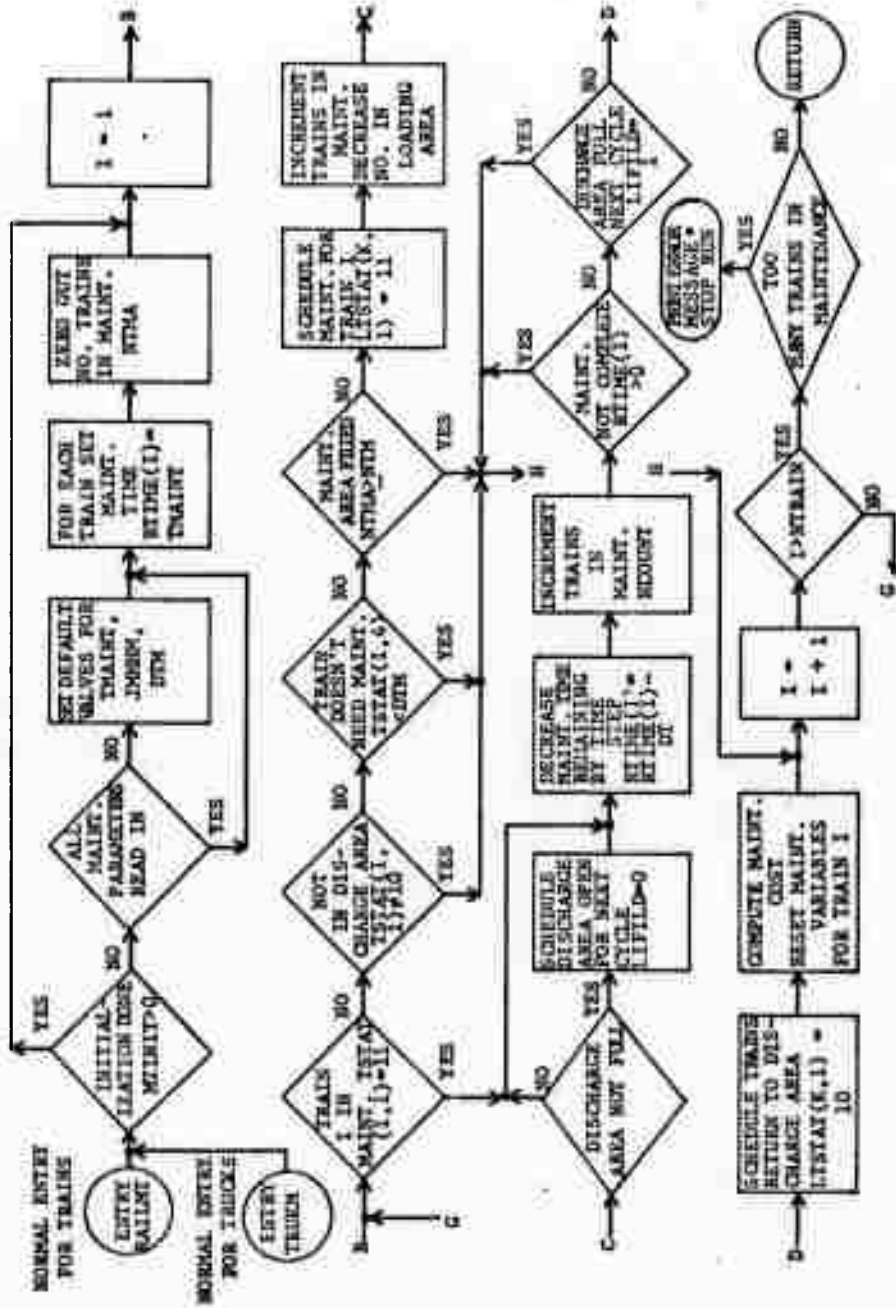
Subroutine RAILDS



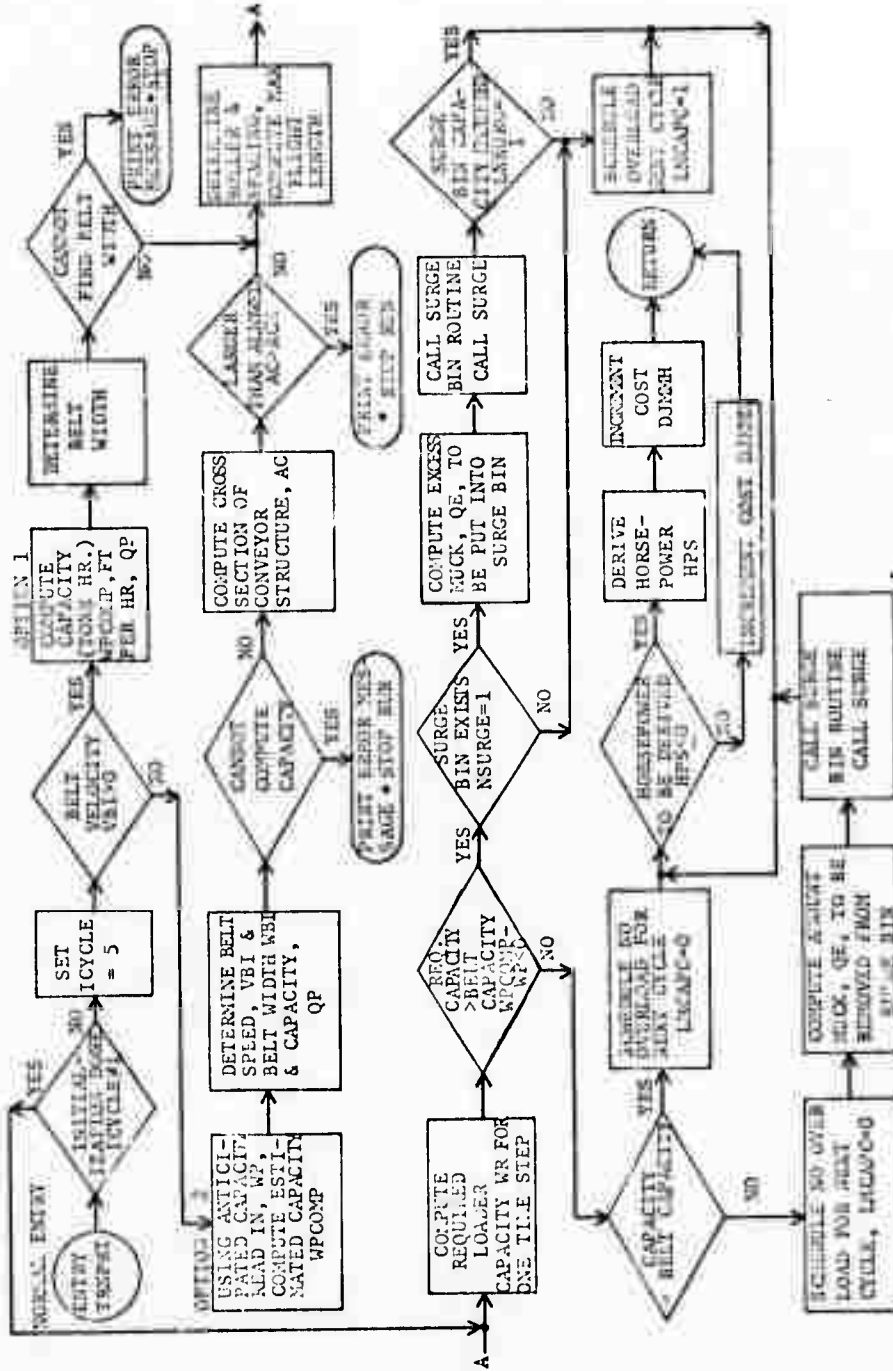
Subroutine RAILEX



Subroutine RAILMT

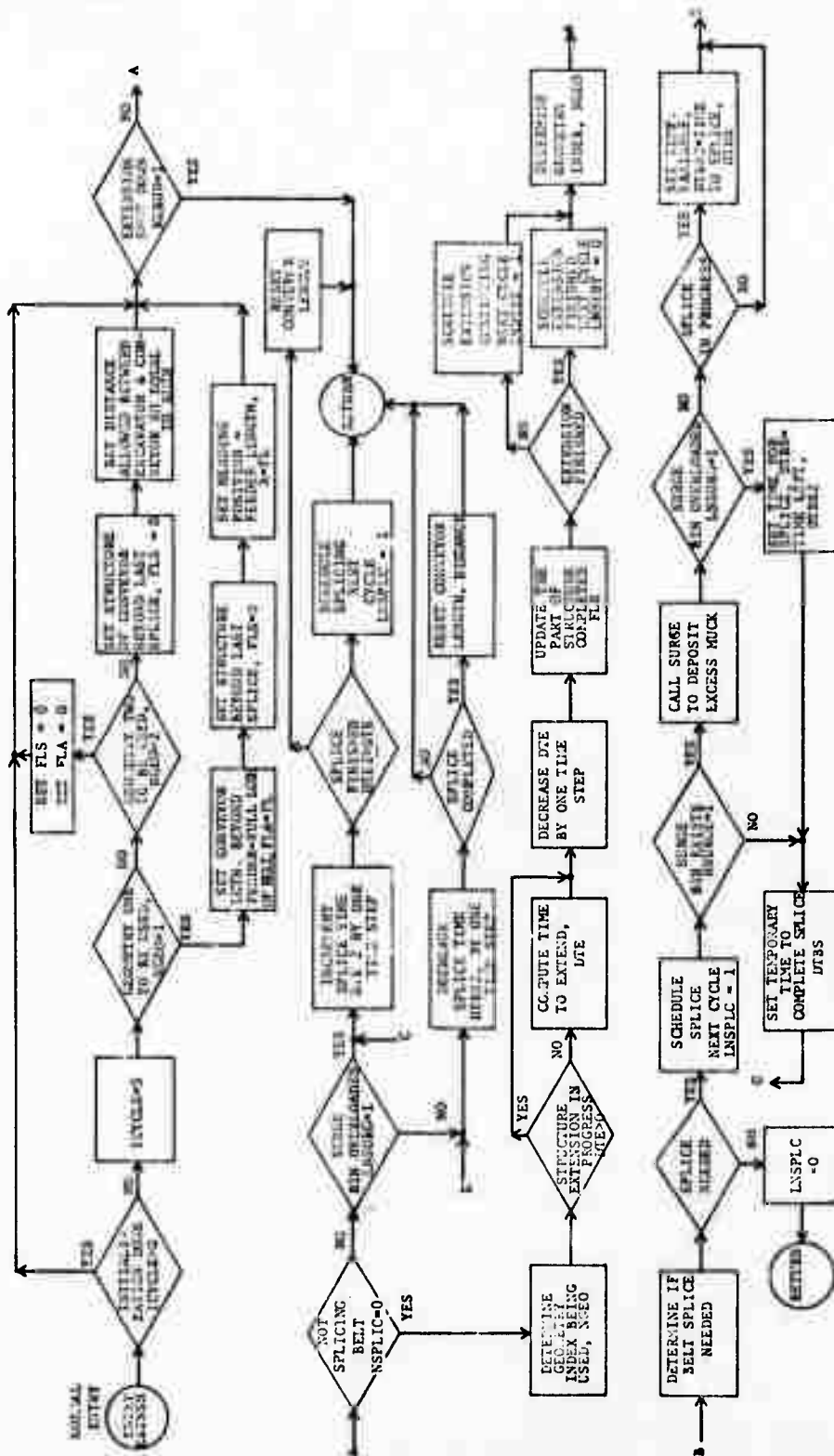


Subroutine TRNPRT

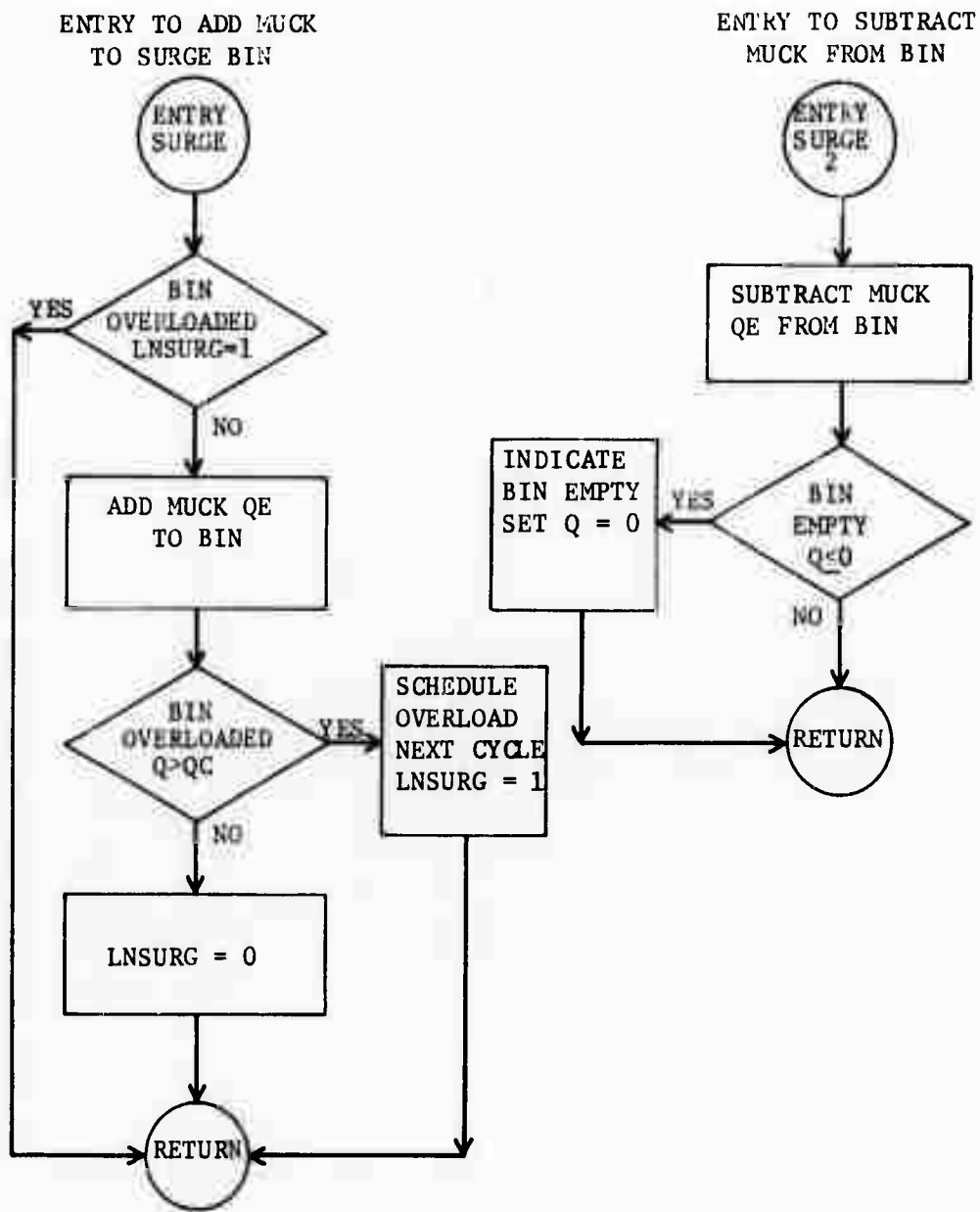


Reproduced from best available copy.

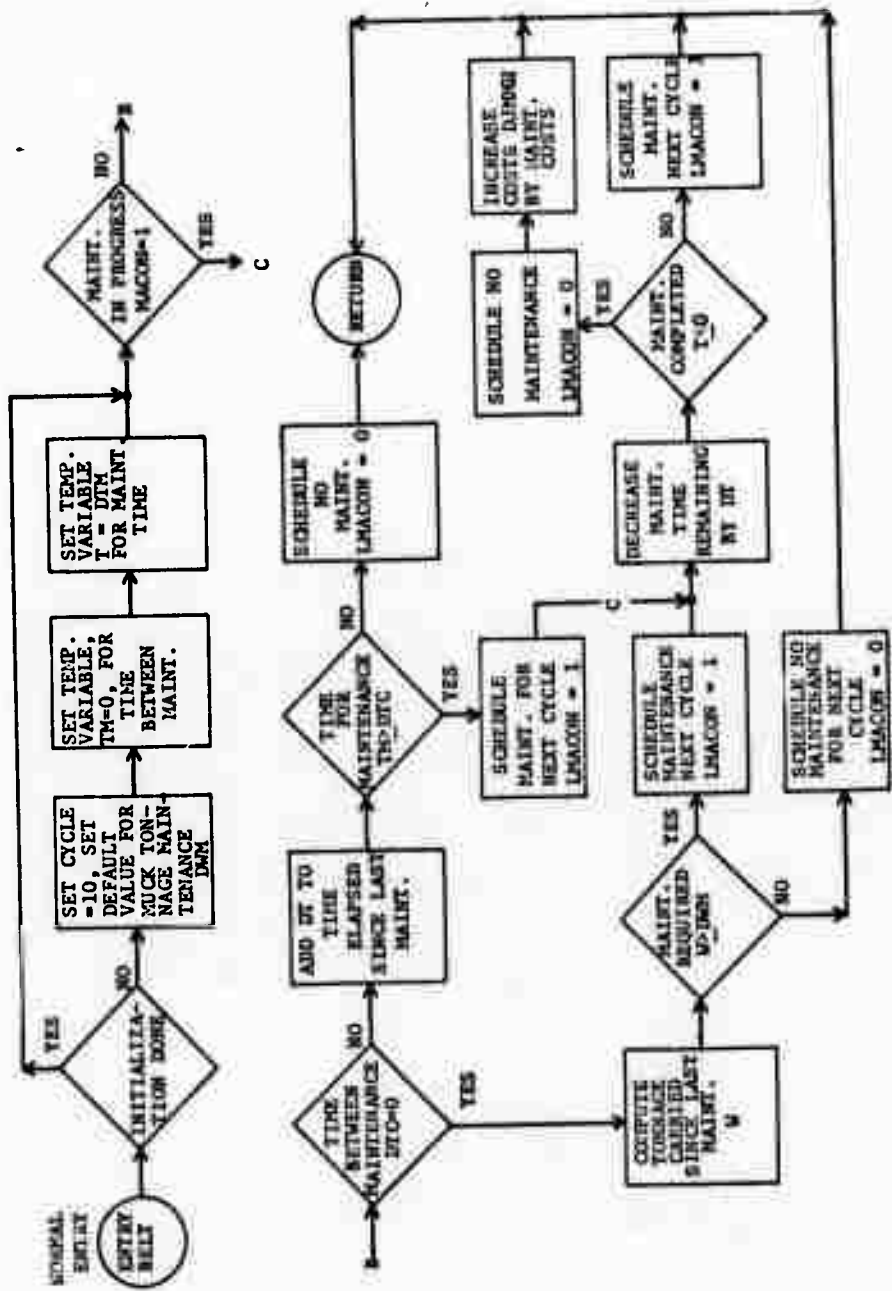
Subroutine EXTNSN



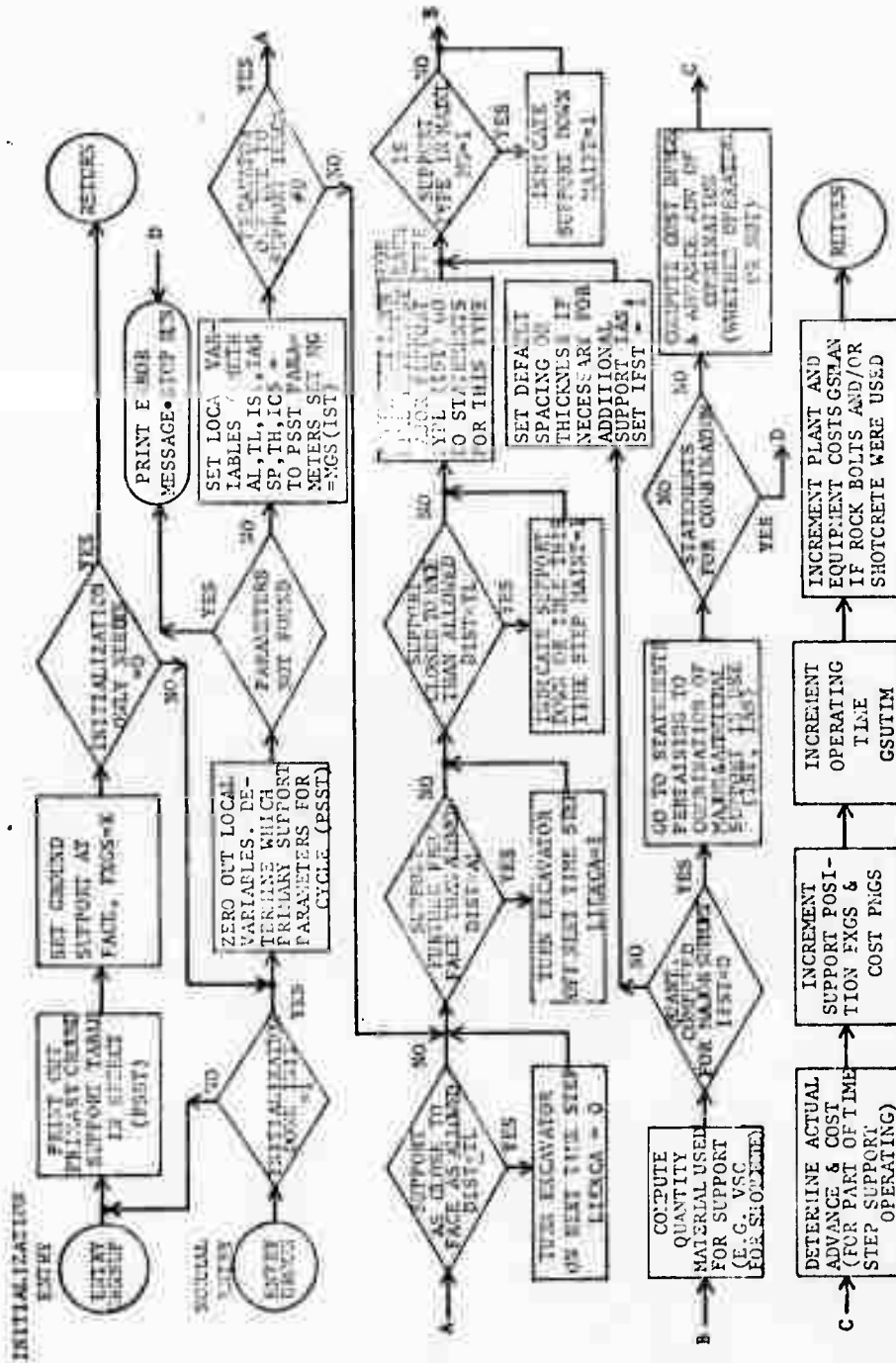
Subroutine SURGE



Subroutine BELT



Subroutine GRNSUP

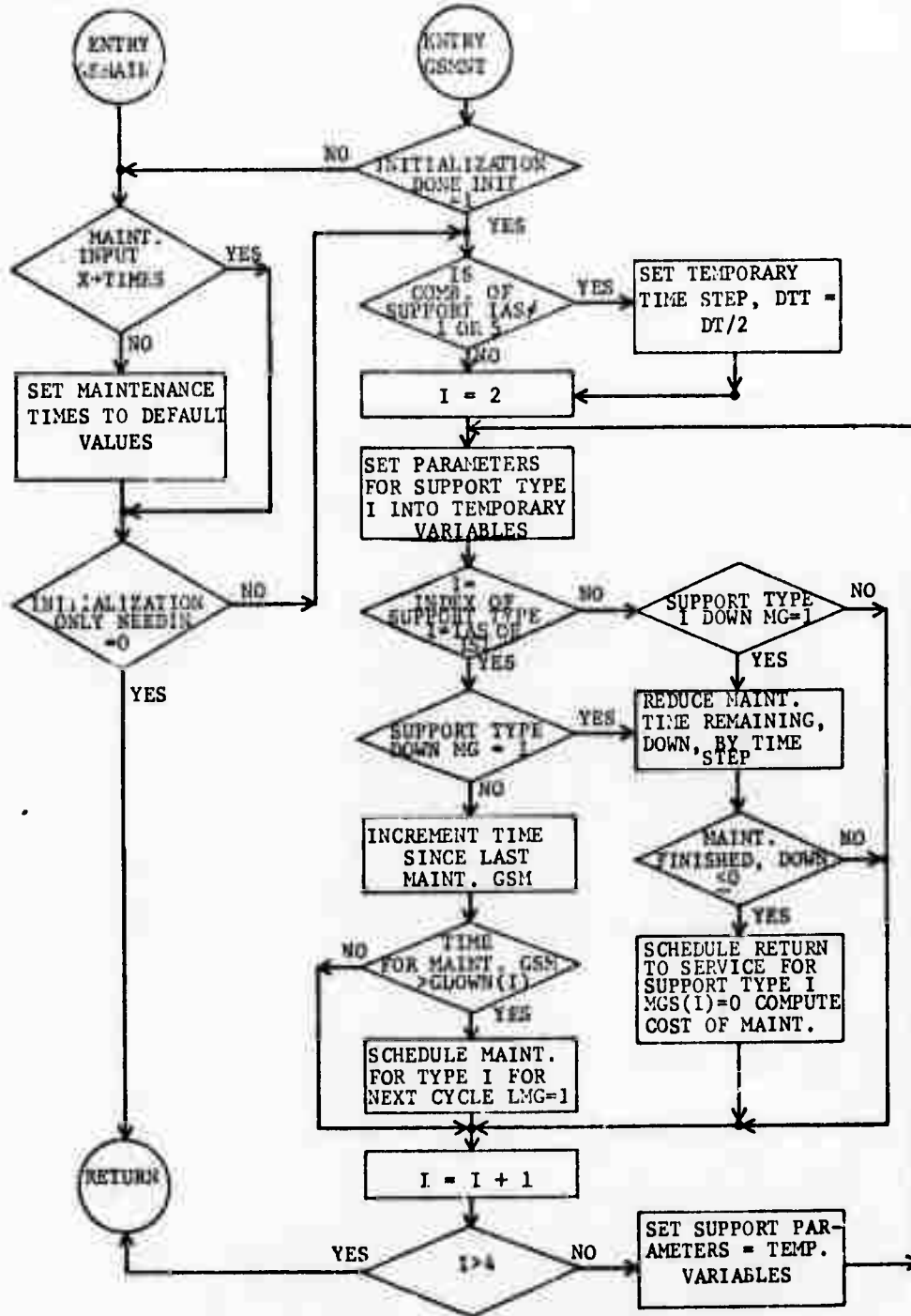


Reproduced from best available copy.

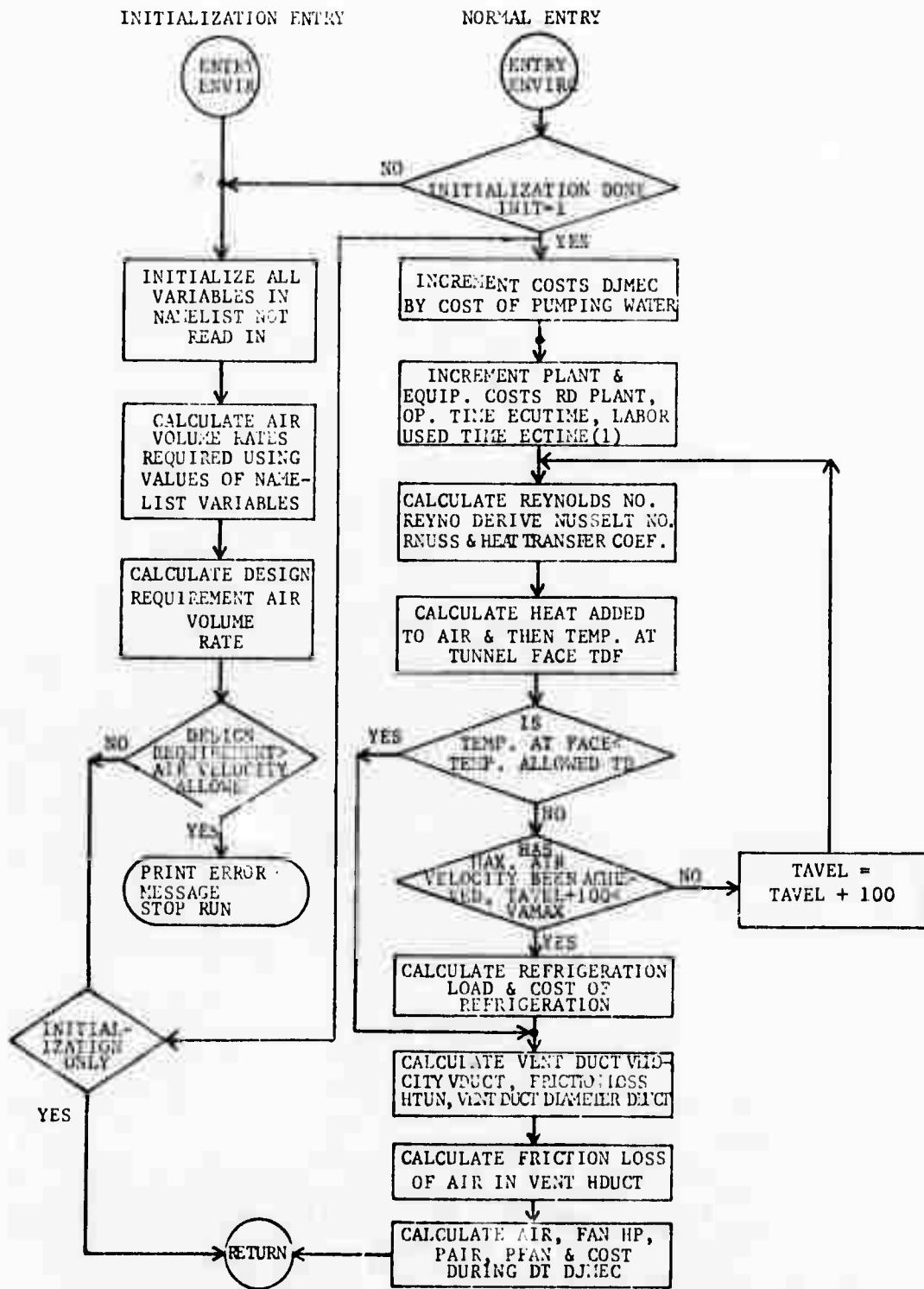
Subroutine GSMAIN

INITIALIZATION ENTRY

NORMAL ENTRY

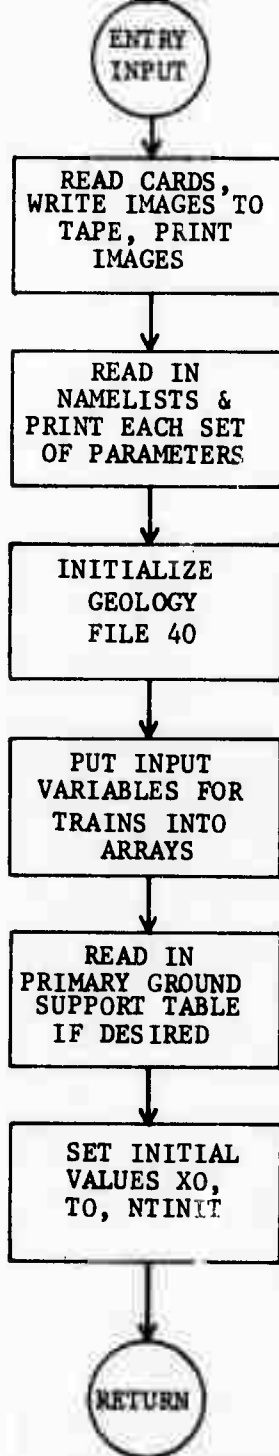


Subroutine ENVIR

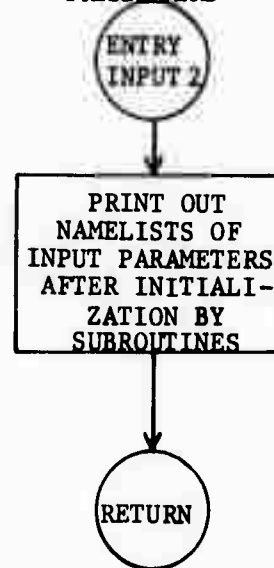


Subroutine INPUT

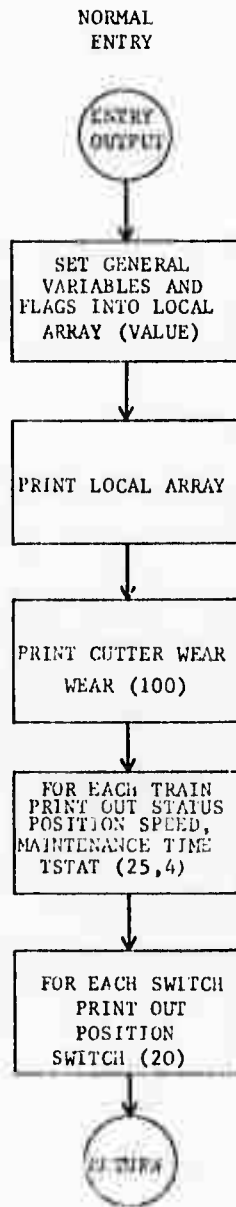
ENTRY TO READ IN
INPUT PARAMETERS



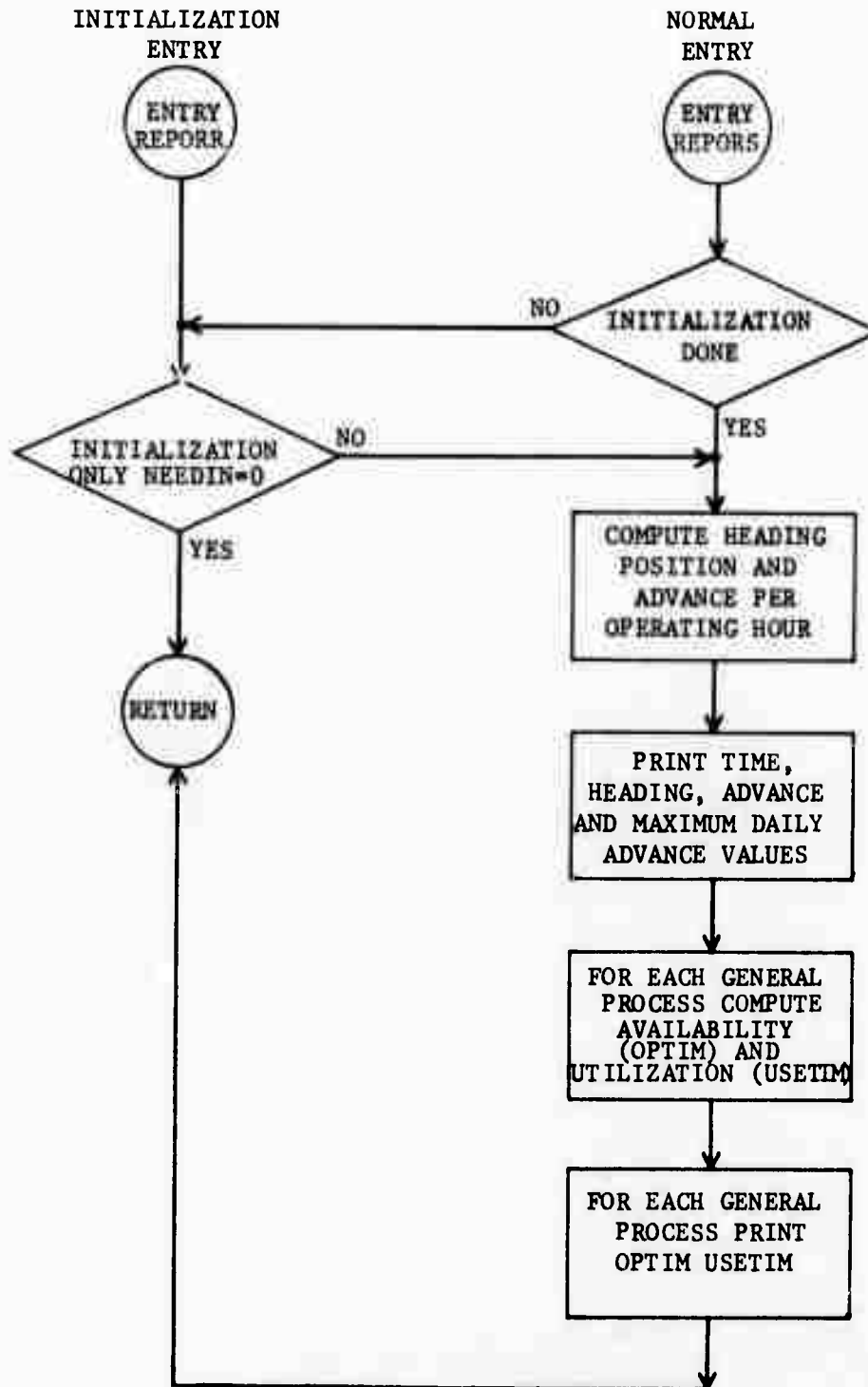
ENTRY TO PRINT
PARAMETERS



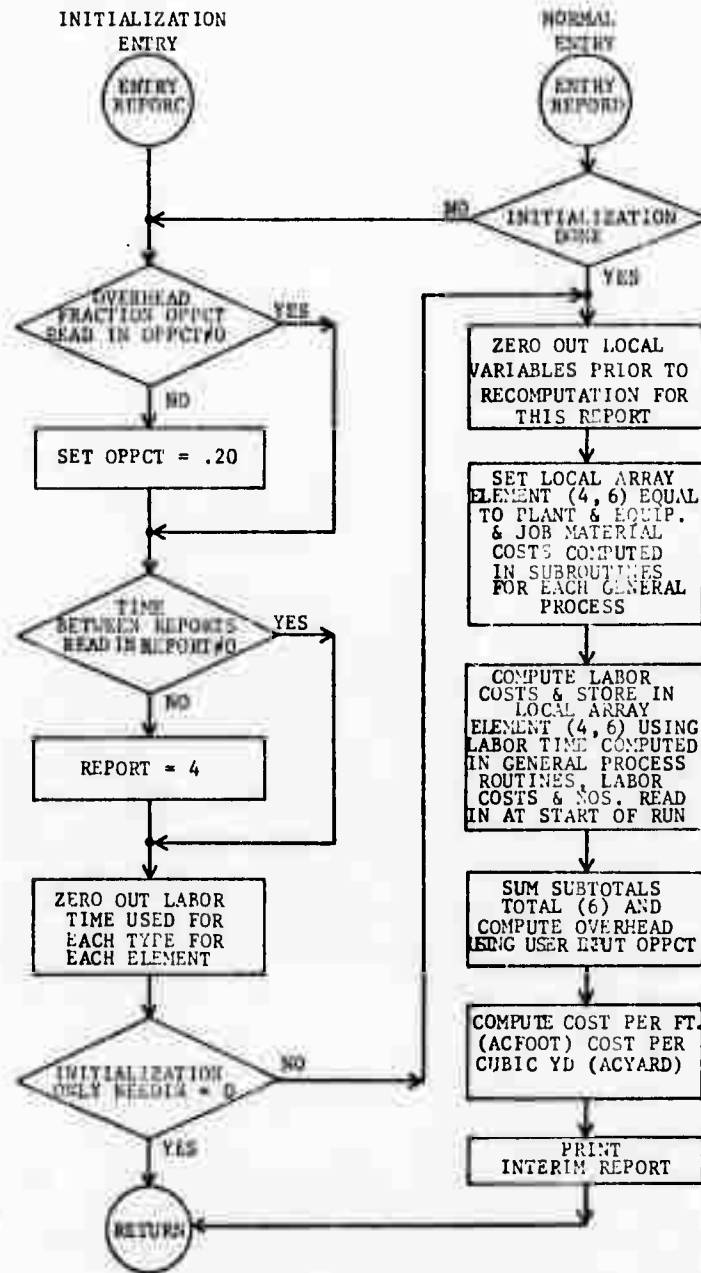
Subroutine OUTPUT



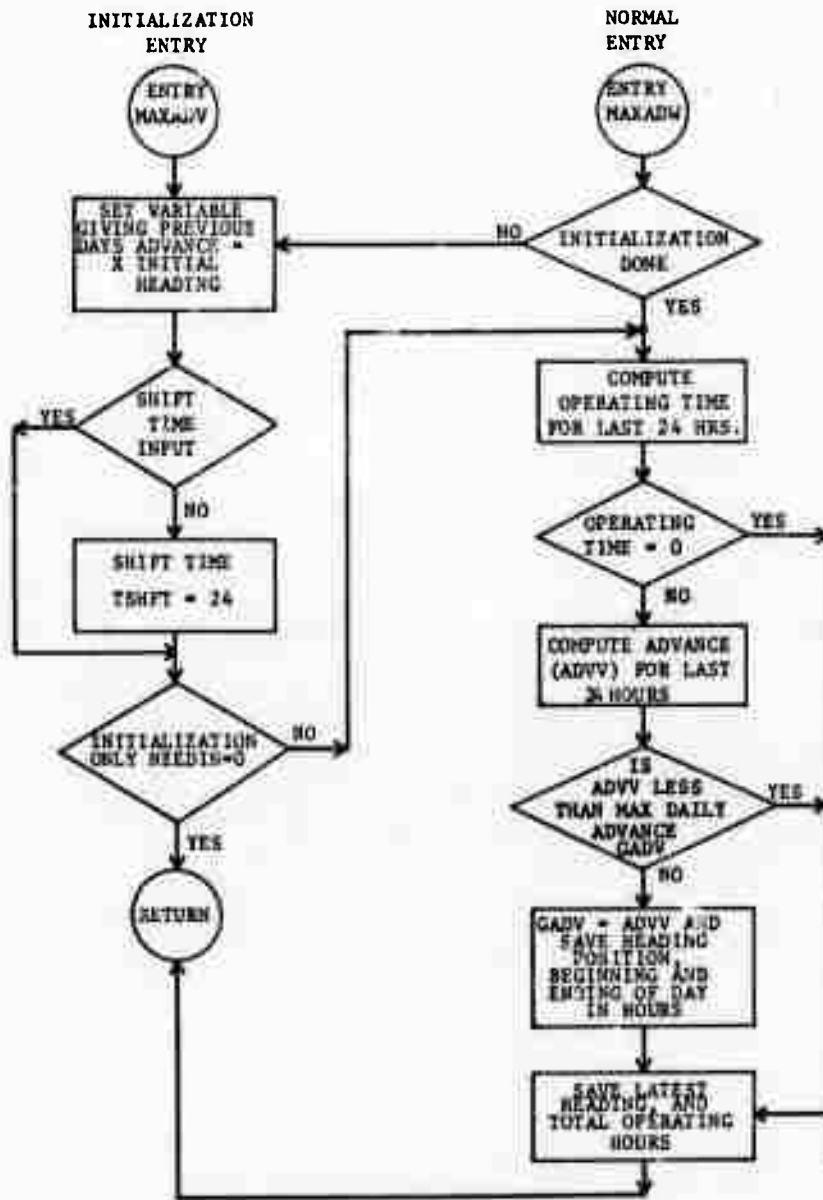
Subroutine REPORR



Subroutine REPORC



Subroutine MAXADV



III. NOTES ON INCORPORATING SUBROUTINES INTO A CONTROL PROGRAM

In writing a control program to incorporate any routines described in Sec. II which are not now in the sample control program, several things must be kept in mind.

- A. Status variables which exist in a new and old form must be placed in NEWCOM and OLDCOM.
- B. Common blocks which are needed but not at present in the routines' decks must be put into the decks. Also any common block in any routine must be put into the control program.
- C. The NAMELIST which is to read in the input variables for the routines must be put into INPUT if the INPUT routine is going to be used to initialize. Both the definition of the NAMELIST and the calls to read it, write it on tape, and print it must be in INPUT.
- D. OUTPUT must be changed to print the common variables associated with the processes being simulated.
- E. Job material costs computations are already in the routine sets. However, computations for labor costs, plant and equipment costs, and utilization values are not in the subroutines. Procedure to add these three is as follows:

- 1. Labor costs - add the following to the NAMELIST which is associated with routine set:

- a. Number of men needed in each of 1 to 10 labor categories

- b. Hourly cost of one man in each category

The variables representing these parameters are dependent on the element the set simulates:

Rock Fragmentation

- a. BOMEN(10) b. BOCST(10)

Materials Handling (Short Haul)

a. RAMEN(10) b. RACST(10)

Ground Support

a. GMEN(10) b. GCST(10)

Environmental Control

a. VCMEN(10) b. VCCST(10)

Next, in one routine of the set accumulate labor time used for each time cycle by one of the following statements depending again upon the element being simulated by the routine set.

- a. Rock disintegration
RDTIME = RDTIME + DT
- b. Materials handling (short haul)
HTIME(2) = HTIME(2) + DT
- c. Materials handling (long haul)
HTIME(1) = HTIME(1) + DT
- d. Ground support
GSTIME = GSTIME + DT
- e. Environmental control
ECTIME = ECTIME + DT

These may be bypassed by checking status variables as desired, so labor costs are not always incremented. The computation of cumulative labor costs is then done in the report routines.

- 2. Plant and equipment costs - first add to the routine set's NAMELIST and common block, variables for costs for plant various types of plant and equipment. Each cost should be either hourly cost or cost per foot.

Next add a statement to one routine in the set which computes the cost for either a time step (DT) or for a foot advance (DX) and cumulates the cost in one of the following variables depending on the element being simulated:

- a. Rock disintegration
RDPLAN
- b. Materials handling (long or short haul)
HPLANT
- c. Ground support
GSPLAN
- d. Environmental control
ECPLAN

Again, as with labor costs, the computing of cost in any time step can be bypassed by a check of status variables.

3. Utilization times:

To determine utilization values, it is necessary to compute operating time and down time. Then knowing shift time, the utilization of each element can be computed in the report subroutines according to the formulas:

$$\text{Availability} = \frac{\text{Shift time} - \text{down time}}{\text{Shift Time}}$$

$$\text{Utilization} = \frac{\text{Operating time}}{\text{Shift time}}$$

Operating time and down time must be cumulated in each time cycle. Status variables should be used to determine which, if either, should be added to in each time cycle. The cumulating is done in routines of the set for each process being simulated. The variables used for cumulating the time are:

	<u>Operating Time</u>	<u>Down Time</u>
Rock Fragmentation	RDUTIM	RDETIM
Materials Handling (long & short haul)	UMHTIM	DMHTIM
Ground Support	GSUTIM	GSDTIM
Environmental Control	ECUTIM	ECDTIM

NOTE: Since there are two sets of routines for materials handling, care must be taken in computing the operating time for materials handling as a whole to avoid double counting.

IV. GENERAL REQUIREMENTS FOR THE CONTROL PROGRAM LOGIC

Figure IV-4 represents the logic for a control program to coordinate the tunneling processes simulated by the subroutines. That figure and this discussion are given to assist a user in writing a control program and not necessarily to be rigidly adhered to.

The first step in the operation of the control program is to read the input parameters into common areas and read the first geology parameters. The control program then calls each subroutine which has an initialization entry (see the flow charts) for initialization of parameters not read in, and initializes the old working parameter common (OLDCOM) area so it portrays the proper initial state for start of processing.

For each time step in the simulation, a check is first made as to whether the tunnel has progressed to the point where new geology information is needed. If this is the case, new geology information is read into common overlaying the old information.

Each subroutine is called for its normal entry point. Note that subroutines for one element (e.g., rock disintegration) may be order-dependent and should be ordered as they are listed in Fig. IV-4. The order in which the elements are called does not matter.

After all routines have been called, the resulting information in the new working parameter common area is then copied into the old working parameter common area. Also, heading position and time are updated. The control program then interrogates the flags* in the old-working-parameter common area and determines the status of the rock disintegration process in the next cycle. This is done in the control program for flexibility.

* Previously called status variables.

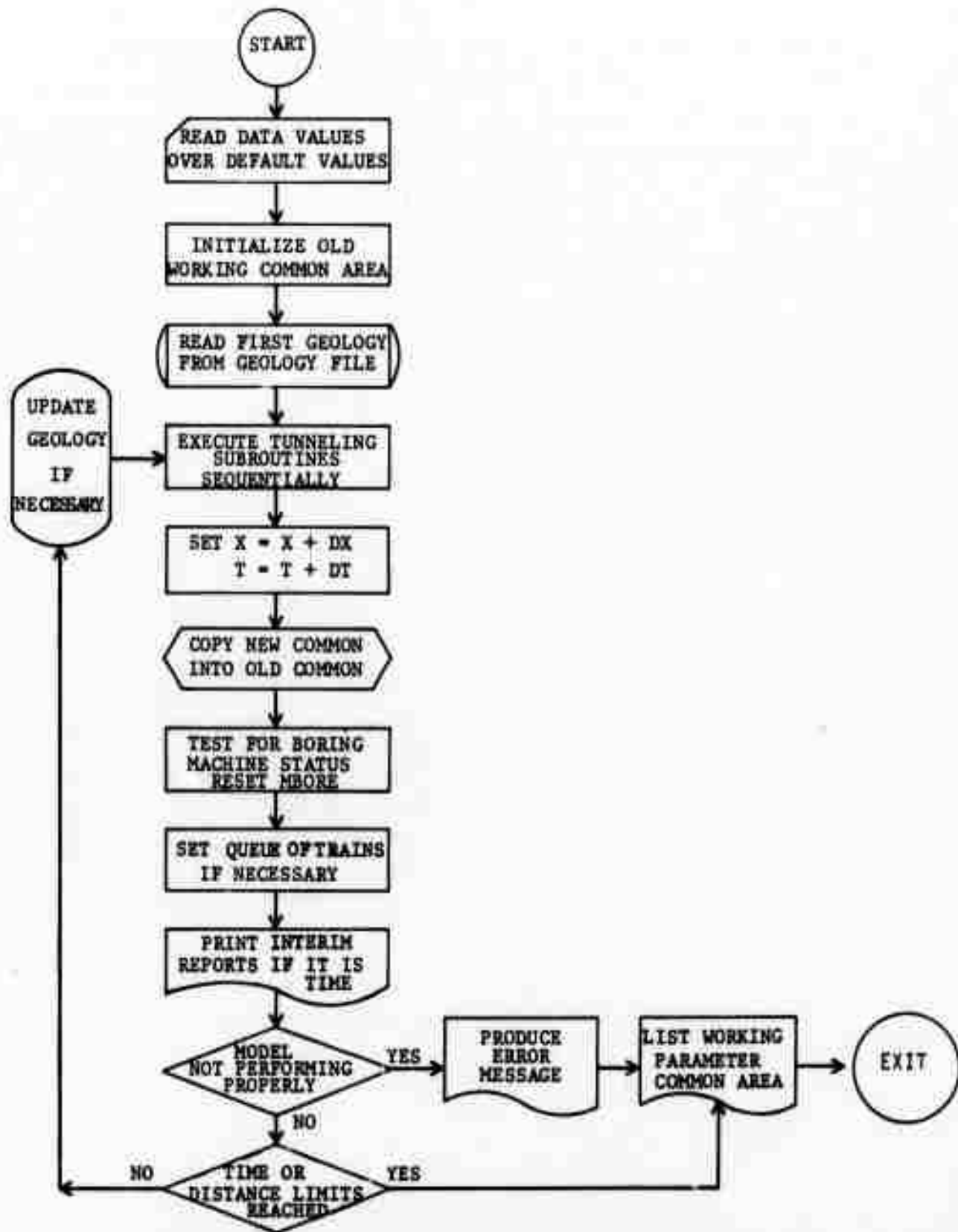


Figure IV-4. Overall Logic of a Control Program for the Tunneling Model

The rock disintegration process is the lead process; it determines the heading advance and the muck created. Other elements follow it automatically, given its progress. The rock fragmentation process, however, must be informed through flags set by the other elements what state it should be in (with the exception of its own maintenance). Looking at these flags in the control program gives the user more flexibility in determining how the excavator reacts to other elements.

The control program also handles the queuing of the long-haul materials-handling element if it requires queuing. The queuing is handled here to retain the order independence of the elements.

The control program's next step is to determine whether output reports are desired at this point and to call routines to produce them. Note that these reports can be spaced in any desired manner with respect to time, length along the tunnel, or whatever. There is no restriction as to how reports are generated.

After output report checking is performed, a check is made to determine if the model should be ended; this would usually be equivalent to asking if the time or distance limits input have been exceeded. If this is the case, the simulation is ended with a printout of working common variables needed to restart the model at the heading position reached. If the simulation is not to be ended, another time step is started by checking to determine if new geology parameters are needed.

The tunneling activities which are being coordinated by the control program are, as previously stated, embodied in subroutines; one or more

of these routines made up a process such as boring machine rock fragmentation. In any simulation one and only one process for each of the following tunneling elements should be included:

1. Rock fragmentation
2. Materials handling (long haul)
3. Materials handling (short haul)
4. Ground support
5. Environmental control

Descriptions of the sets of routines representing the processes available for each element are given in Sec. II.

The user should use the preceding discussion of the control program as a guide in writing his own program. The control program written for the Layout Tunnel which actually consists of several subroutines and a control program is described in the next section and should be studied for further information on writing a control program.

V. CREATING A CONTROL PROGRAM FOR THE LAYOUT TUNNEL

As mentioned in Sec. I, the various tunneling activities are simulated by modular subroutines. The simulation of an entire excavation project can therefore be made by using a building-block technique. Ideally, the program that analyzes a given project would consist of all the subroutines that are pertinent to the simulation and a driver (main) program that ties them together. The subroutines are ideally independent of each other in function and in logic, so that they are not order-dependent in their usage by the main program. This section is concerned with the construction of a control program and secondary input and output routines to initialize data and report results, and discussion will be restricted to a sample control program that simulates the excavation of the Strawberry Aqueduct Layout Tunnel.

A. SUBROUTINES

The tunneling subroutines needed for the Layout Tunnel simulation are as follows:

<u>Element and General Process</u>	<u>Activity</u>	<u>Subroutine Entry Initialization/Normal</u>
Rock fragmentation, boring machine	Bore Cutter change Maintenance	BORE/BORER CUTTER/CUTCHG REPAIR/MAINT
Materials handling, conventional rail system	Train logistics Track laying Discharge Train maintenance Loading Loader maintenance	RAILHL/RAILTR RAILEX/RAILXT RAILDS/RAILDS RAILMT/RAILMT CVLOAD/LOADCV CVMNT/CVRPR
Ground support	Rock bolts, etc. Equipment maintenance	GRNSUP/GROUN GSMAN/GSMNT
Environmental control	Ventilation and cooling	ENVIR/ENVIRC

B. SUBROUTINE USAGE

After proper initialization of data (see Sec. V-D below), each excavation subroutine is called once for each time station T. The time stations are equally spaced at DT, which is input. Each subroutine calculates the progress made in the time DT and sets a flag indicating the status of the progress. For example, CUTTER calculates the incremental cutter wear for the time DT and the cumulative cutter wear up to time T. If one or more cutters have exceeded the maximum-wear criterion (an input), a flag LNCUTR is set to 1. Otherwise, LNCUTR is set to 0. The boring machine is then turned on or off depending on whether LNCUTR is zero or nonzero. As another example, CVLOAD simulates the muck loading activity. The volume of muck created in DT depends on the hardness of the rock and the boring machine operating characteristics. At the end of DT, the muck is assumed loaded onto the trains via the loader. If the train is full, it is sent on its way to the discharge area, and another train (if one is available in the load queue) is moved into the loading area. A flag LOADR is set to 0 in this case. If, however, there is no train available for loading, LOADR is set to 1 which indicates that the boring machine should be turned off until a train becomes available for loading. A control program that simulates the excavation process as a whole must interrogate all the flags (see Table IV-2) set by all the subroutines and then decide on what status the boring machine should have.

C. CONTROL LOGIC

The essential features of the control logic for the sample control program are shown schematically in Fig. IV-5. Note that the rock fragmentation activity BORE/BORER is controlled by the flag MBORE. In general, the boring machine is turned off any time any of the support activities cannot keep up with the rate of advance of the boring machine or if any

TABLE IV-2
DEFINITION OF FLAGS SET IN EXCAVATION MODEL

<u>SUBROUTINE</u>	<u>FLAG</u>	<u>OPTIONS</u>
BORE	MBORE	= 0 normal operation - boring machine going full speed
		= 1 boring machine in maintenance
		= 2 boring machine cutters being changed
		= 3 mil extension rate exceeded
		= 4 new switch being added
		= 5 switch being moved up
		= 6 no train available for loading
		= 7 ground support construction rate exceeded
CUTTER	LNCUTR	= 8 loader in maintenance
		= 0 normal operation--no cutter change needed
		= 1 cutter change started
REPAIR	MBM	= 2 cutter change still in progress
		= 0 normal operation--no maintenance needed on boring machine
ASSMBL	MASSEM	= 1 boring machine due for maintenance
		= 0 normal operation--boring machine assembly completed
DISASM	MDISAS	= 1 boring machine assembly in progress
		= 0 normal operation--boring machine disassembly completed
		= 1 boring machine disassembly in progress

TABLE IV-2 (cont.)

DEFINITION OF FLAGS SET IN EXCAVATION MODEL

<u>SUBROUTINE</u>	<u>FLAG</u>	<u>OPTIONS</u>
RAILTR	LSTOP	= 0 normal operation--continue system
		= 1 shut down system--external reasons
		= 2 bring up system--external reasons
RAILDS	IFILD	= 0 normal operation
		= 1 discharge area filled
CVLOAD	LOADR	= 0 normal operation
		= 1 no train available for loading
CVMNT	LMCV	= 0 normal operation
		= 1 loader maintenance in progress
CVMNT	LMFLAC	= 0 normal operation
		= 1 loader turned off for external reasons
GRNSUP	IEXCA	= 0 normal operation
		= 1 ground support construction rate exceeded
RAILEX	NBYBY	= 0 normal operation
		= 1 rail extension rate exceeded
RAILEX	NSWCH	= 0 normal operation
		= 1 new switch to be added
		= 2 switch to be pushed forward
CVLOAD	IEXCAV	= 0 normal operation
		= 1 boring machine turned off, loader in maintenance

TABLE IV-2 (cont.)
DEFINITION OF FLAGS SET IN EXCAVATION MODEL

SUBROUTINES RAILTR, RAILDS, RAILEX

LTSTAT = 0	stopped, empty
= 1	stopped, full
= 2	accelerating, empty
= 3	accelerating, full
= 4	going full speed, empty
= 5	going full speed, full
= 6	decelerating, empty
= 7	decelerating, full
= 8	in switch, empty
= 9	in switch, full
= 10	in discharge area
= 11	in maintenance area
LKSTOP = 0	not stopped
= 1	at face, being loaded
= 2	in switch, train ahead
= 3	in switch, train approaching
= 4	external reasons
= 5	in switch, waiting to enter discharge area
= 6	in switch, waiting to enter load queue
= 101	in load queue, 1st in line
= 102	in load queue, 2nd in line
= n	in load queue, (n-100)th in line
LLVHCL = 0	no train in load area
= n	train #n is in load area

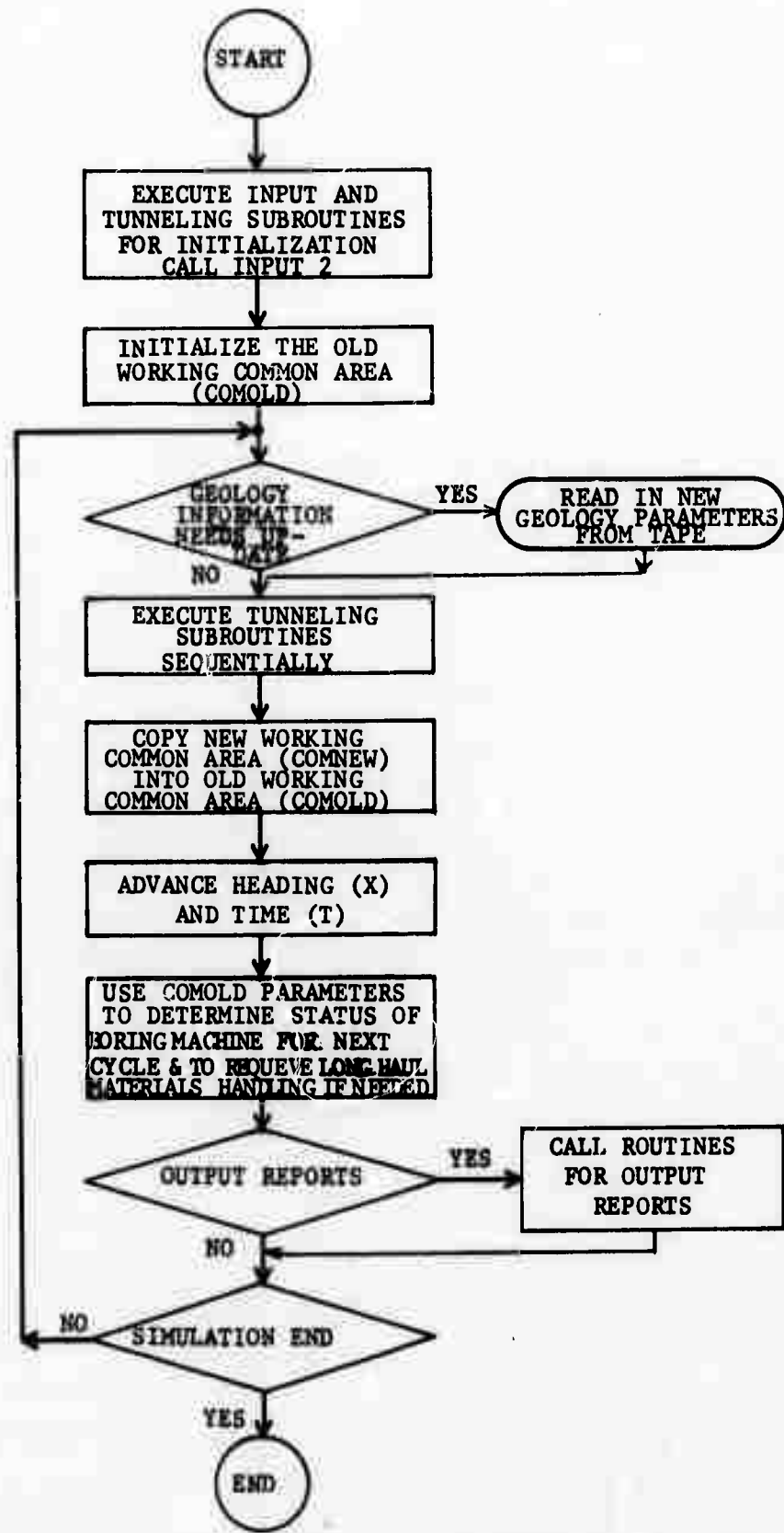


Figure IV-5. Logic of the Control Program for the Layout Tunnel.

of the equipment becomes unavailable because of maintenance requirements. Note also that the boring activity is not resumed unless all of the support activities have caught up with the rock fragmentation process. In other words, boring is the pivotal activity that is affected by all the other activities. The flag MBORE is therefore set according to the table shown below.

MBORE	CONDITION
0	normal operation: boring machine is going full speed
1	no advance: boring machine is in general maintenance
2	no advance: boring machine cutters are being replaced
3	shut-down boring machine: rail extension rate has been exceeded
4	shut-down boring machine: a new switch is being added
5	shut-down boring machine: switch needs to be moved up
6	shut-down boring machine: there is no train available for muck loading
7	shut-down boring machine: ground support activity has fallen behind
8	shut-down boring machine: muck loader is in maintenance

One of the tasks required of the control program is to make certain that the boring machine is not turned on unless the flags from all the subroutines indicate that boring activity should be turned on. This means a series of tests must be made of the flags from all the subroutines and that the boring machine flag MBORE must be set and reset in accordance with these flags.

Another task required of the control program is to move the trains up in the load queue when it is time to do so. The reason that this task is given to the control program is that several conditions have to be satisfied before a train can be moved up. First of all, the train that is currently being loaded must be full. This is tested in subroutine CVLOAD. Then the rail extension activity must be able to keep up with the boring activity. This is tested in subroutine RAILEX. Then the installation of a new switch must be complete if one is needed before a train can move up the load queue. This is also tested in subroutine RAILEX.

A third task required of the control program is to insure that RAILTR is called before any of the other rail subroutines which include CVLOAD and RAILEX. The reason for this requirement is that RAILTR is the subroutine that controls the dynamics of the trains. Since the speed of the trains is on the average several orders of magnitude greater than the rate of excavation, a time interval DT compatible with the excavation activity would be too great for the rail activity. Therefore, RAILTR divides the time interval DT into many subintervals such that no train would have moved more than 50 feet in any one subinterval. The position and the speed of the trains can thus be simulated more realistically. But since different trains would be doing different things at different subintervals, the only way to keep the logic tractable is to update the status of all the trains at the end of DT: i.e., the status flags of all the trains are reset at the end of DT. Now if another rail subroutine is called before RAILTR and if that subroutine resets the flag of one of the trains, that result would be nullified by RAILTR.

A last task of the control program is to produce reports by calling output routines written for the Layout Tunnel (REPORC, REPORS, and OUTPUT) at intervals specified by the user, and to call MAXADV once each day to determine the daily advance (see Sec. V-E below).

D. INITIALIZATION OF DATA

The initialization of data for the simulation is handled by the control program and a subroutine INPUT written to accompany the control program. Figure IV-6 shows the initialization sequence.

Two types of data need to be initialized:

1. Geology parameters which give the geology characteristics along the tunnel. These parameters are on a tape (logical unit 40; see listings in Appendix II). See Appendixes II and III for a description of the creation of this tape. The routine INPUT reads the first parameters from the tape. Then the control program tests at the start of each time interval to determine if a new set of parameters is needed. When one is needed the control program reads a new set.
2. Parameters for each general process and a set of parameters which apply to all processes, such as initial reading, initial time, and time step length. These parameters are read in at the start of each run by INPUT. The FORTRAN NAMELIST data reader capability is used by INPUT for reading in the cards. A special provision is made for reading in a primary ground support table (described in Sec. II-E above). This table is read in on cards in fixed format (9F8.2; see listing in Appendix II) if the user wishes to input his own table.

After INPUT has read in all parameter cards, the control program calls each general process subroutine by its initialization entry. In each routine parameters for the general process will be compared to 0; if found equal to 0, they are then given a default value. Parameters not dealt with in this way will have a default value of 0 if not read in. INPUT then prints out a list of all parameters with the value read in or the default value.

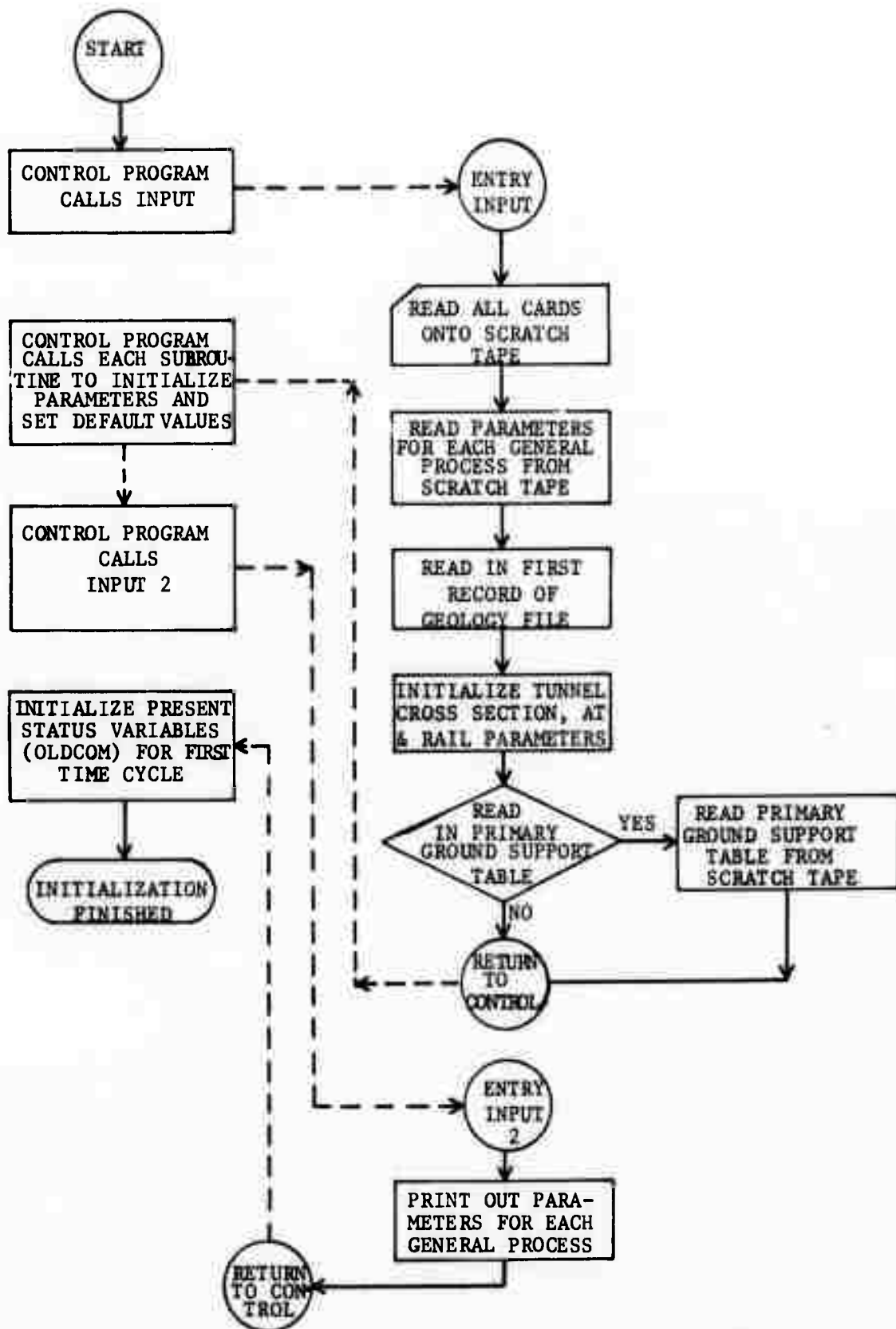


Figure IV-6. Initialization Sequence for Layout Tunnel

Finally, the control program initializes the working common area (OLDCOM) for the first time step.

E. OUTPUT

The output for the Layout Tunnel is of two kinds: (1) a printout of common variables, and (2) interim cost and performance reports. It is handled by subroutines which are called by the control program.

1. OUTPUT - prints out common variables from the various subroutines and from OLD'COM. These parameters show the status of the different general processes at an instant in time. A sample of this printout is shown in Fig. IV-7. The routine is called by the control program at time intervals (DTPRNT) input by the user. It is also called at the end of a run to print out variables to be used for restarting the model at that point.
2. MAXADV - The routine computes each day's advance and saves values for the maximum advance.
3. REPORR - prints cumulative performance figures for each element (subsystem). The performance figures are computed as follows:

Subsystem availability = (shift time - down time)/shift time

Subsystem utilization = operating time/shift time

Shift time = 24 hours in Layout Tunnel. Can be input by user (TSHFT)

```

T= 0.0  NRYHY= 0  X= 5.400E+01  IA= 0  MRDRE= 2  STR= 0  LOADR= 0  NUMSHT= 1  IEXCA= 0  MCV= 0  MFLAGC= 0
LNCUTR= 0  NSWCH= 0  STR= 0  LOADR= 0  NUMSHT= 1  IEXCA= 0  MCV= 0  MFLAGC= 0
IEXCAV= 0.0  MGS(2)= 0.0  MGS(3)= 0  MGS(4)= 0.0
CUTTER #EAR...
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
TRAIN NO. 1.....STOPPED, EMPTY  AT FACE, LOADING  X =-5.3100E+02 FT  V = 0.0  MPH  DSM = 0.0000  0  1
TRAIN NO. 2.....STOPPED, EMPTY  AT FACE, IN QUEUE  X =-5.3100F+02 FT  V = 0.0  MPH  DSM = 0.0000  0  101
TRAIN NO. 3.....STOPPED, EMPTY  AT FACE, IN QUEUE  X =-5.3100E+02 FT  V = 0.0  MPH  DSM = 0.0000  0  102
GROUND SUPPORT AT 54.000
ENVIRONMENTAL CONTROL 000= 0.00

```

Figure IV-7. Printout of Working Storage

Down time and operating time are computed in subroutines for each general process and cumulated in the following variables:

<u>Element - Subroutine</u>	<u>Operating Time</u>	<u>Down Time</u>
Rock disintegration (BORE)	RDUTIM	RDDTIM
Materials handling (CVMNT, RAILHL)	UMHTIM	DMHTIM
Ground support (GRNSUP, GSMAIN)	GSUTIM	GSDTIM
Environmental control (ENVIR)	ECUTIM	ECDTIM

The status variables in Table IV-2 are used to determine in each time step whether the element is operating, down, or neither (idle) for the time interval (DT) in the following manner:

<u>Element</u>	<u>Down</u>	<u>Action Taken</u>	<u>Operating</u>	<u>Action Taken</u>
Boring machine	MBORE > 0 and MBORE ≤ 3	RDDTIM = RDDTIM + DT	MBORE = 0	RDUTIM = RDUTIM + DT
Materials handling rails, conveyor loader	NUMLD = 0 or MCV = 1	DMHTIM = DMHTIM + DT	NUMLD ≠ 0 & MCV = 0	UMHTIM = UMHTIM + DT
Ground support	MGS(I) = 1 where I is support type using	GSDTIM = GSDTIM + DT	MGS(I) = 0 and ground support can proceed (not too close to face)	GSUTIM = GSUTIM + DT
Environmental control	Never		Always	ECUTIM = ECUTIM + DT

See Sec. III of this appendix for further information on handling availability and utilization values for simulation. In Fig. IV-3 a sample of this report is shown.

DAYS SINCE COMMENCED EXCAVATING 2.000
 HEADING POSITION(FEET) 352.686
 AVERAGE ADVANCE RATE(FEET/OPERATING HOUR) 12.764
 MAXIMUM DAILY ADVANCE
 DAYS SINCE COMMENCED EXCAVATING 2.000
 HEADING POSITION-BEGINNING OF THAT DAY(FEET) 207.172
 HEADING POSITION-END OF THAT DAY(FEET) 352.686
 AVERAGE RATE FOR THAT DAY(FEET/OPERATING HOUR) 12.764

CUMULATIVE SUBSYSTEM PERFORMANCE..

ELEMENT/MEASURE	OPERATIONAL	SUBSYSTEM
	AVAILABILITY+	UTILIZATION++

ROCK FRAGMENTATION	.500	.488
MATERIALS HANDLING	.992	.488
GROUND SUPPORT	1.000	1.000
ENVIRONMENTAL CONTROL	1.000	1.000

♦OPERATIONAL AVAILABILITY=(TOTAL SHIFT TIME-DOWN TIME)/TOTAL SHIFT TIME

♦♦SUBSYSTEM UTILIZATION=(TOTAL SHIFT TIME-DOWN TIME-IDLE TIME)/TOTAL SHIFT TIME

Figure IV-8. Interim Performance Report

4. REPORC - prints out cumulative cost values. The cost values are computed for each general process in one of its subroutines (see Sec. III above for a description of variables used). They are cumulated in parameters in COMMON/MONEY/. Totals and overhead costs are recalculated each time REPORD is called. See Fig. IV-9 for a sample of the cost report.

Both REPORS and REPORD (normal entry points for REPORR, REPORC) are called at time intervals specified by the user with input parameter REPORT.

DAYS SINCE COMMENCED EXCAVATING 2.000
 AVERAGE COST PER IN SITU CUBIC YARD EXCAVATED 19.82
 AVERAGE COST PER FOOT OF TUNNEL 96.19

CUMULATIVE COST SUMMARY TO DATE..(DOLLARS)

ELEMENT/CATEGORY	DIRECT LABOR	PLANT + EQUIPMENT	JOB MATERIALS	PERMANENT MATERIALS	OVER-HEAD	ELEMENT TOTAL
ROCK FRAGMENTATION	2153.76	11350.08	809.48	0.00	1431.33	15744.65
MATERIALS HANDLING	4673.76	1899.08	153.03	0.00	572.59	7398.46
GROUND SUPPORT	3379.20	0.00	0.00	0.00	337.92	3717.12
ENVIRONMENTAL CONTROL	1398.24	298.69	2.80	0.00	169.97	1869.70
CATEGORY TOTAL	11604.96	13547.85	965.31	0.00	2611.81	24729.93

Figure IV-9. Interim Cost Report

APPENDIX V

LAYOUT TUNNEL DATA

by

L. M. Pietrzak and W. R. Thomson

SUMMARY

This appendix contains data acquired from the Bureau of Reclamation and other sources concerning the first 5,038 feet of the Layout Tunnel, a part of the Strawberry Aqueduct Project. The tunnel was driven between June 25 and September 22, 1971. Geological reports, machinery specifications, and progress records are included.

ACKNOWLEDGMENTS

The information found in this appendix was kindly supplied by Mr. Booneymixon of the S. A. Healy Co., Project Engineer for the Layout Tunnel; A. S. D'Alessandro, Construction Engineer in the central Utah Projects Office for the Bureau of Reclamation; Ray Moran of Moran Engineering Co. which fabricated the muck cars and the loading and unloading equipment; and Don Shaver of Plymouth Locomotive Works which fabricated the train locomotives. H. F. Haller of Holmes and Narver supplied data on rock properties and muck characteristics.

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I. EQUIPMENT AND SYSTEM DESCRIPTION

The Layout Tunnel is a part of the Strawberry Aqueduct Project and was driven in the summer of 1971 near Heber City, Utah. S. A. Healy Company is excavating Layout and Currant Tunnels with a Robbins Co., Model No. 141-127-1, excavating machine ("the mole") previously used to excavate a tunnel in the Chicago, Illinois, area. The machine was re-built and modified by Robbins Company, 651 S. Orcas, Seattle, Washington. The first section arrived at the work site May 24, and the mole was assembled during the rest of May and June near the outlet portal of Layout Tunnel. Approximately 1,670 man-hours were used to assemble the machine, which is 45 ft long and weighs approximately 200,000 lb. The last shipment of the integrated conveyor loader was delivered to the site at the end of July 1971.

The mole cuts a 12 ft 11 in. diameter tunnel. The rotating head consists of a center tri-disc cutter with a series of 29 disc cutters. The tri-disc center cutter is a cluster of three disc mounted on one shaft. The cutters are numbered from the center out. The cutters are spaced radial as follows: cutters No. 1 through 8, 2-7/8 in.; cutters No. 9 through 21, 2-3/4 in.; cutter No. 22 is 2-11/16 in. from No. 21; cutter No. 23 is 2-1/2 in. from 22; cutters No. 24 through 27 are spaced at 2-1/8 in.; cutter No. 29 is spaced at 1-1/4 in. from No. 27 and gage cutter No. 29 is 1-1/4 in. from No. 28.

The maximum thrust on the head is 892,000 lb with a propel pressure of 3,500 psi. The thrust rating for each of the four drive arms is 223,000 lb at 3,500 psi. The contractor has operated with propel pressure between 1,800 and 2,600 psi.

The mole is powered by six 100 hp, CJ5NB Pacemaker, 440 volt electric motors. These motors create a rated torque of 630,240 ft·lb. Electricity is delivered to the mole at 7,200 volts and transformed to 440 volts through a transformer located at the rear of the mole. Electricity to operate the mole is obtained from commercial supplier, Moon

Lake Electric. The mole is held in place while excavating by two hydraulic powered side grippers, immediately behind the cutter head.

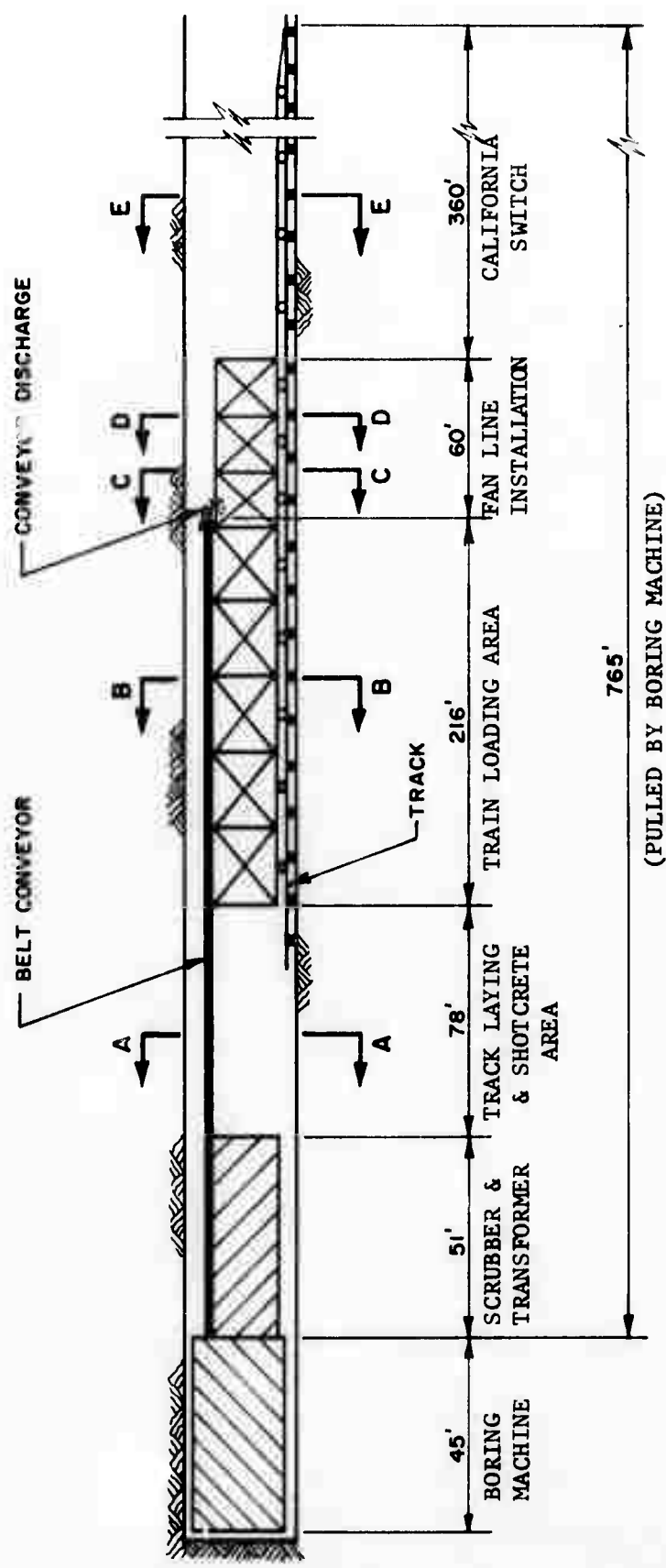
The excavated material was hauled from the tunnel to an 800 ft long dump site located 12,000 ft from the outlet portal. Three trains of ten, $6 \frac{2}{3}$ yd³ (struck) side dump cars, pulled by two 10-ton diesel powered Plymouth Mine-motive, GA-24, Model DMD-24 locomotives were used. The track gauge was 24 in., and rail weight 65 lb per linear yard.

The mucking equipment included an integrated 24 in. troughed belt conveyor, and a California switch for train switching that extended 765 ft behind the boring machine. This configuration is shown schematically in Fig. V-1.

The normal sequence for loading and muck removal starts with three trains in the loading area, i.e., one in the loading position, and the others waiting in the California switch. Once loaded the first train departs for the discharge area, and an empty train moves into the loading position. Thereafter, at any given time one train would typically be loading while one is waiting to be loaded and the third is on its way to the discharge area for dumping. The cars returning from the discharge area carry men and materials to the face as needed.

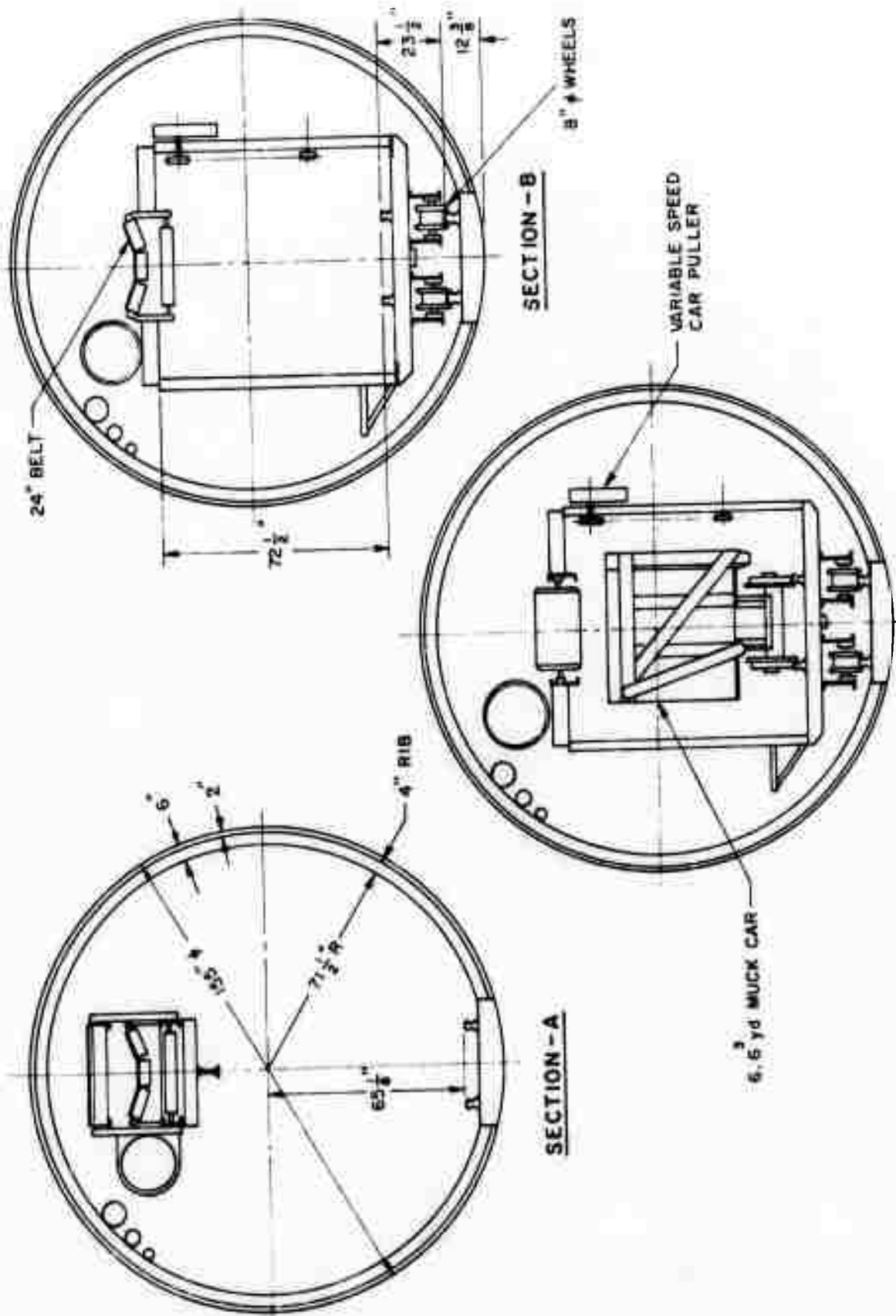
Other than the California switch at the face, there are no switches between the discharge area and the near face zone. Only one train can occupy the track between the loading and discharge area at any given time. This situation applies for the first 8650 ft of tunnel which includes the entire segment being considered for computer simulation at this time.

In the discharge area, each muck car is dumped individually using side dump equipment that runs on a track parallel to the main line track, dumping each car as it proceeds.



V-7

Figure V-1. Muck Loading Equipment Configuration Used in Layout Tunnel
 (Courtesy of Moran Engineering Co.)



SECTION - B

SECTION - C

SECTION - A

Figure V-1. Muck Loading Equipment Configuration Used in Layout Tunnel (Cont.)

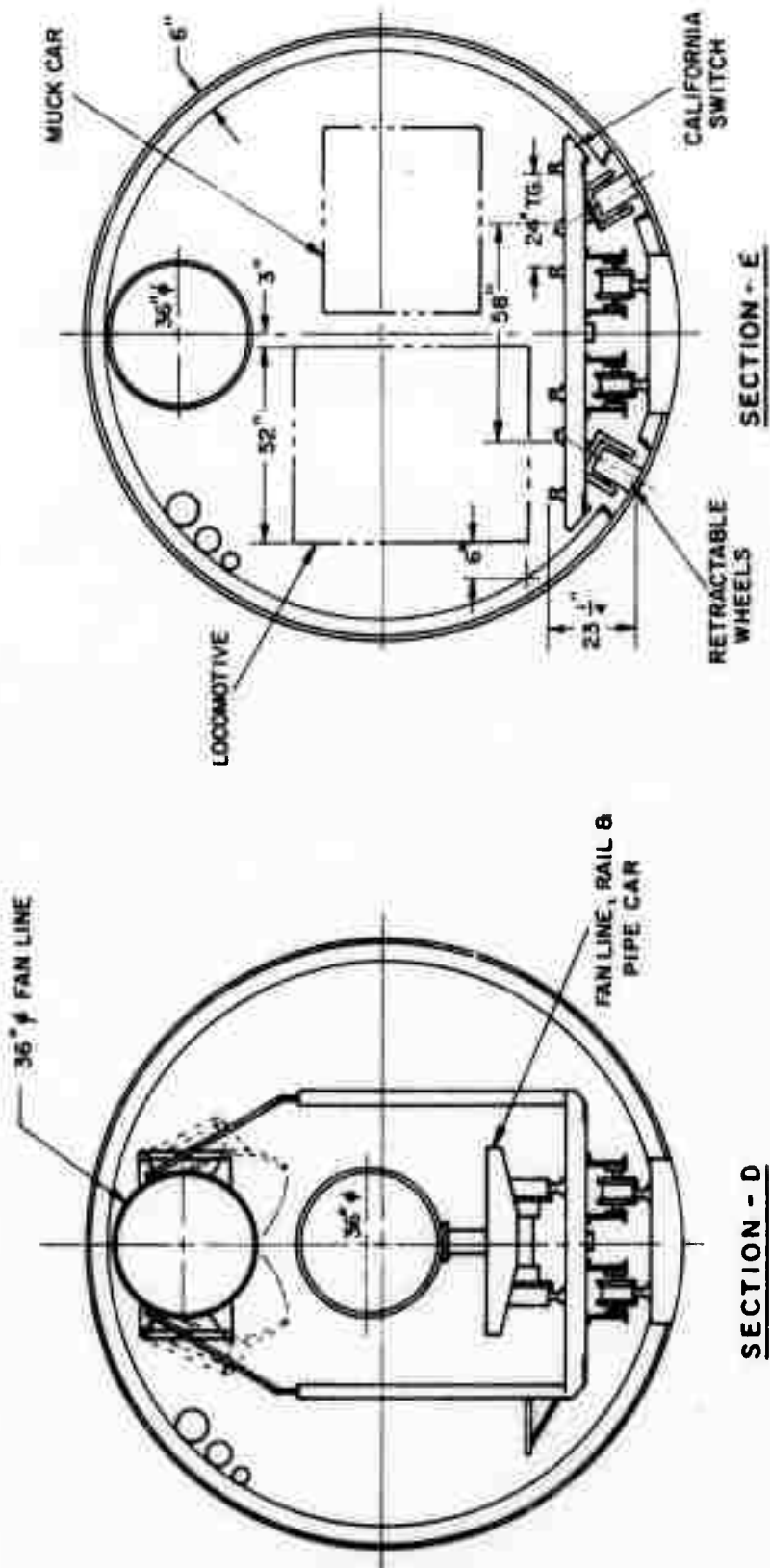


Figure V-1. Muck Loading Equipment Configuration Used in Layout Tunnel (Cont.)

Dust removal and ventilation is accomplished by drawing air from the near-face loading and working area (17,000 cfm at 2405 fpm) through a 36 in. diameter fan line. The equipment includes an Elbair scrubber in the near-face zone and a 100-hp fan motor that supplements a portal fan.

Ground support includes steel ring sets, rock bolts, cribbing and lagging, and shotcrete as required. Actual support installation for the 5038 ft segment is described in the June 29 progress reports summarized in Sec. III of this appendix.

II. GEOLOGY

A. GEOLOGY REPORTS

<u>Date</u>	<u>Station</u>	<u>Geology</u>
6/25/71	1786+26 - 1786+20	Layout Tunnel: Rock is a firm, medium hard, brown sandstone. Dip = 2-3° downstream. Rock is tight and impermeable.
6/28/71	1786+20 - 1785+93	Brown sandstone (medium hard) is periodically cut by lenses of soft, gray, porous sandstone.
6/29/71	1785+93 - 1785+61	Three vertical joints (cracks) at springline at Station 1785+00, LW (left wall) 1 to 2 ft long.
6/30/71	1785+61 - 1785+26	Periodic short vertical joints continue upstream.
7/1/71	1785+26 - 1784+55	Normal entry of formations into tunnel bore is at invert and rising upstream into roof. However, conglomerate enters from roof and trends upstream erratically.
7/2/71	1784+55 - 1783+93	At Station 1784+40 a very hard, well-cemented conglomerate starts in roof. It contains a 3 in. maximum quartzite rock. Conglomerate is lightly fractured and is dripping water.
7/3/71	1783+93 - 1783+41	Vertical joints at Stations 1783+25, 1783+50, 1783+45, all dripping water. No support steel thus far.
7/6/71	1783+41 - 1782+91	

Geologic Material (Cont.)

<u>Date</u>	<u>Station</u>	<u>Geology</u>
7/7/71	1782+91 - 1781+33	Hard conglomerate is now a 4 ft bed at springline with the previously mentioned brown sandstone (medium hard) above and below.
7/8/71	1781+33 - 1780+04	Brown sandstone is interbedded with thin (1-2 in.) brown shales that push out when wet and dried. Mole gripper pads leave small chips and fractures near springline.
7/9/71	1780+04 - 1778+43	Beds dipping downstream 2-3°. Conglomerate (very hard) is now in middle of tunnel near springline.
7/10/71	1778+43 - 1777+89	Brown, silty sandstone (medium hard) is above and below conglomerate and has thin brown shales.
7/12/71	1777+89 - 1777+19	Formations dip 2-3° downstream.
7/13/71	1777+19 - 1776+23	Hard conglomerate is grading upstream into a gray, medium hard sandstone. Gray sandstone contains lenses and thin beds of pebble conglomerates.
7/14/71	1776+23 - 1775+17	Medium hard, brown sandstone becoming fractured with short, closely-spaced joints.
7/15/71	1775+17 - 1774+32	
7/16/71	1774+32 - 1774+01	Loose, channel-fill zone, Stations 1771+30 to 1775+00, a very loose, soft section containing poorly-cemented sandstones with gravel streaks.

Geologic Material (Cont.)

<u>Date</u>	<u>Station</u>	<u>Geology</u>
7/17/71	1774+01 - 1773+87	Above mentioned zone is wet and contains many joints and fractures due to close proximity to fault west of tunnel.
7/19/71	1773+87 - 1773+73	
7/20/71	1773+73 - 1773+59	
7/21/71	1773+59 - 1773+13	
7/22/71	1773+59 - 1772+82	Same conditions as above
7/26/71	1772+82 - 1772+39	Many seeps.
7/27/71	1772+39 - 1771+86	
8/3/71	1771+86 - 1770+56	Joint, filled with white calcite RW: 1770+90, LW: 1770+80. Rock is half hard sandstone and half soft poorly-cemented tan sandstone.
8/4/71	1770+56 - 1769+38	Soft tan sandstone has drips and many fractures.
8/5/71	1769+38 - 1768+56	Whole tunnel is soft, tan sandstone. Rock is firm, medium-hard sandstone at Station 1769+00.
8/6/71	1768+56 - 1767+50	
8/7/71	1767+50 - 1767+50	
8/9/71	1767+50 - 1765+95	Top half of tunnel is medium-hard brown sandstone; bottom half is soft, wet tan sandstone, containing thin shale. Light fallout along thin shales near springline.

Geologic Material (Cont.)

<u>Date</u>	<u>Station</u>	<u>Geology</u>
8/10/71	1765+95 - 1765+70	Fault Zone - Station 1763+42 to 1766+10
8/11/71	1765+70 - 1765+34	Fault is considered to be a side fracture off larger fault located west of tunnel and bearing nearly parallel.
8/12/71	1765+34 - 1764+87	Fault Zone: Stations 1763+42 to 1766+10 Rock is broken mass of soft sandstone and conglomerate. Broken rock is mixed in with a wet mixture of sand and clay.
8/13/71	1764+87 - 1764+01	
8/14/71	1764+01 - 1764+01	4 in. circular steel H-beam supports were installed throughout fault zone because of loose, unstable condition of tunnel walls.
8/16/71	1764+01 - 1763+04	
8/17/71	1763+04 - 1762+05	Rock is medium-hard, brown sandstone containing thin shales.
8/18/71	1762+05 - 1759+96	Vertical joint at 1761+90, with many small fractures.
8/19/71	1759+96 - 1758+02	At Station 1759+00 sandstone grades into hard conglomerate top half of tunnel. Bottom half is soft, tan sandstone containing thin shales.
8/20/71	1758+02 - 1757+43	Conglomerate and sandstone has many small fractures that are dripping water.
8/21/71	1757+43 - 1757+43	Conglomerate pinches out in roof at Station 1757+95. Occasional vertical joints and many small fractures.

Geologic Material (Cont.)

<u>Date</u>	<u>Station</u>	<u>Geology</u>
8/23/71	1757+43 - 1756+57	Top half is medium-hard brown sandstone with thin shales--bottom half is a soft sandstone. Conglomerate enters in roof.
8/24/71	1756+57 - 1755+07	Tunnel bore all hard conglomerate with lenses of soft sandstones.
8/25/71	1755+07 - 1753+35	
8/26/71	1753+35 - 1752+75	Rock is mostly hard conglomerate with lenses of soft sandstone.
8/27/71	1752+75 - 1751+68	Conglomerate has few lumps of shale.
8/28/71	1751+68 - 1751+68	Conglomerate has many fractures and joints from Station 1756+50 to 1756+00.
8/30/71	1751+68 - 1750+68	
8/31/71	1750+68 - 1749+55	Top half of tunnel is medium hard, sandstone; soft, tan sandstone in bottom. Many small fractures and a few vertical joints.
9/1/71	1749+55 - 1748+69	
9/2/71	1748+69 - 1747+46	Tunnel rock is all a soft brown sandstone with thin shales. Small amount of fallout in thin shales.
9/3/71	1747+46 - 1746+20	
9/7/71	1746+20 - 1745+49	Soft, brown, poorly-cemented sandstone.

Geologic Material (Cont.)

<u>Date</u>	<u>Station</u>	<u>Geology</u>
9/8/71	1745+49 - 1744+56	Many joints, and fractures with 5 gal/min water in joint at Station 1745+20 RW.
9/9/71	1744+56 - 1743+90	Fallout in soft, fractured sandstone.
9/10/71	1743+90 - 1743+30	
9/13/71	1743+30 - 1742+38	Gray and tan, soft sandstone with thin brown shales. Many small vertical fractures throughout.
9/14/71	1742+38 - 1741+34	Fallout along shales near springline.
9/15/71	1741+34 - 1740+65	
9/16/71	1740+65 - 1739+86	
9/17/71	1739+86 - 1739+02	Tunnel rock is harder. Sandstone is better cemented.
9/20/71	1739+02 - 1738+17	Fewer joints and fractures than downstream.
9/21/71	1738+17 - 1736+77	<u>Note:</u> Because of nearby fault paralleling tunnel to west, tunnel throughout has many joints and fractures. There are short sections of tunnel supported with steel.
9/22/71	1736+77 - 1736+60	Longer supported sections include soft, channel-fill from Station 1771+30 to 1775+00, the fault zone from Station 1763+42 to 1766+10. The last 1700 ft of tunnel (Stations 1736+60 to 1752+60) is fractured and jointed and is 60% steel supported.

B. ROCK PROPERTIES AND MUCK CHARACTERISTICS

The following information was acquired by Holmes and Narver Inc. as part of the Muck Designation Study under Contract No. H0210013 of the ARPA program. The rock properties cited are for a rock sample taken 4,100 ft from the tunnel portal.

<u>PROJECT & LOCATION</u>	<u>OWNER OR AGENCY</u>	<u>SIZE</u>	<u>LENGTH</u>	<u>CONTRACTOR</u>
Currant & Layout Tunnels Strawberry Aqueduct, Heber City, Utah	U.S. Bureau of Reclamation Denver, Colorado	10'-4" Dia.	Combined Length 4.9 mi	S.A. Healy

A Robbins boring machine has been operating in sandstone. Existing logs of 13 drill holes show lithology. Compressive strength test results, varying from 5,000 psi for a shale to over 38,000 psi in the conglomerate, have been provided by the Bureau of Reclamation. This tunneling was stopped in September 1971 pending provision of additional funds but has since been resumed.

Rock Data:

Lithology: Sedimentary, sandstone, medium grained, light brown to red, massive, porous, poorly cemented.

Uniaxial Compressive Strength: 10 kpsi

RQD: (Estimated) 84%

Dry Unit Weight: 150 lb/ft³

Ground Water: Generally dry.

Hardness: NA 1/11/72

Tunnel Data:

Size: 12 ft, 11 in. diameter. Grade: (+) .125%

Ventilation System: 15-17 kcfm exhaust, 36 in. dia. pipe, 100 hp at 4100 ft

Utility System: 3 1/2 in. water line, 6 in. air line, 8 in. pump line.

Water Inflow: 20-100 gpm

Power System: 7300/480 V

Haulage System: Muck, supplies, personnel, 10 ton locomotives,
6 2/3 CY cars, 24 in. gauge, 65 lb rail.

Support System: 4 in. H full rings, 4 ft centers: 35%; 13 in. ×
9 ft pans 3/4 in. × 7 ft rock bolts: 10%.

Excavation Data:

Machine: Robbins 141-127, total weight: 125 tons

Cutters: 30 Robbins steel disc. Gauge: 6-11 in. Center: 1-11 in.
triple disc. Interior: 23-11 in.

Rotation: Center cutter integral with head, 6 or 3 rpm

Torque: 600 hp

Thrust: 900 K# max., 685 K.# operating. Anchor pressure: 1,000 K#

Muck Collection: Pickup by buckets fixed to head, discharging on
30 in. belt to a 24 in. × 204 ft belt on gantry.

Power System: 6-480/240 V electric motors drive head. Hydraulic
pumps power thrust and gripper cylinders.

Guidance System: Laser

Muck Data (Table V-1; Fig. V-2):

Abrasiveness: N.A. 1/11/72

Pot. Vol. Change, Material Size - 0.056 in.: 0

Spec. Gravity, Material Size -0.75 in.: 2.66

Atterbfrg Limits, Material Size (-)0.056 in.

Liquid Limit 21.20%	Plastic Limit 17.06%	Shrinkage Limit 15.17%
Plasticity Index 3.14%	Toughness Index 0.52	Flow Index 6.00

Material Size (-)2.0 in.

Angle/Repose 1 in. Drop
@ 3.6% Moisture, 37°
Angle Slide Steel Plate
@ 3.6% Moisture, 27°

Apparent Cohesion lb/ft³
@ 3.6% Moisture, 210
Bulk Density lb/ft³
@ 0.0% Moisture, 97.4

Angle/Repose 10 in.
Drop @ 3.6%
Moisture, 35°
Angle Internal
Friction @ 3.6%
Moisture, 38°

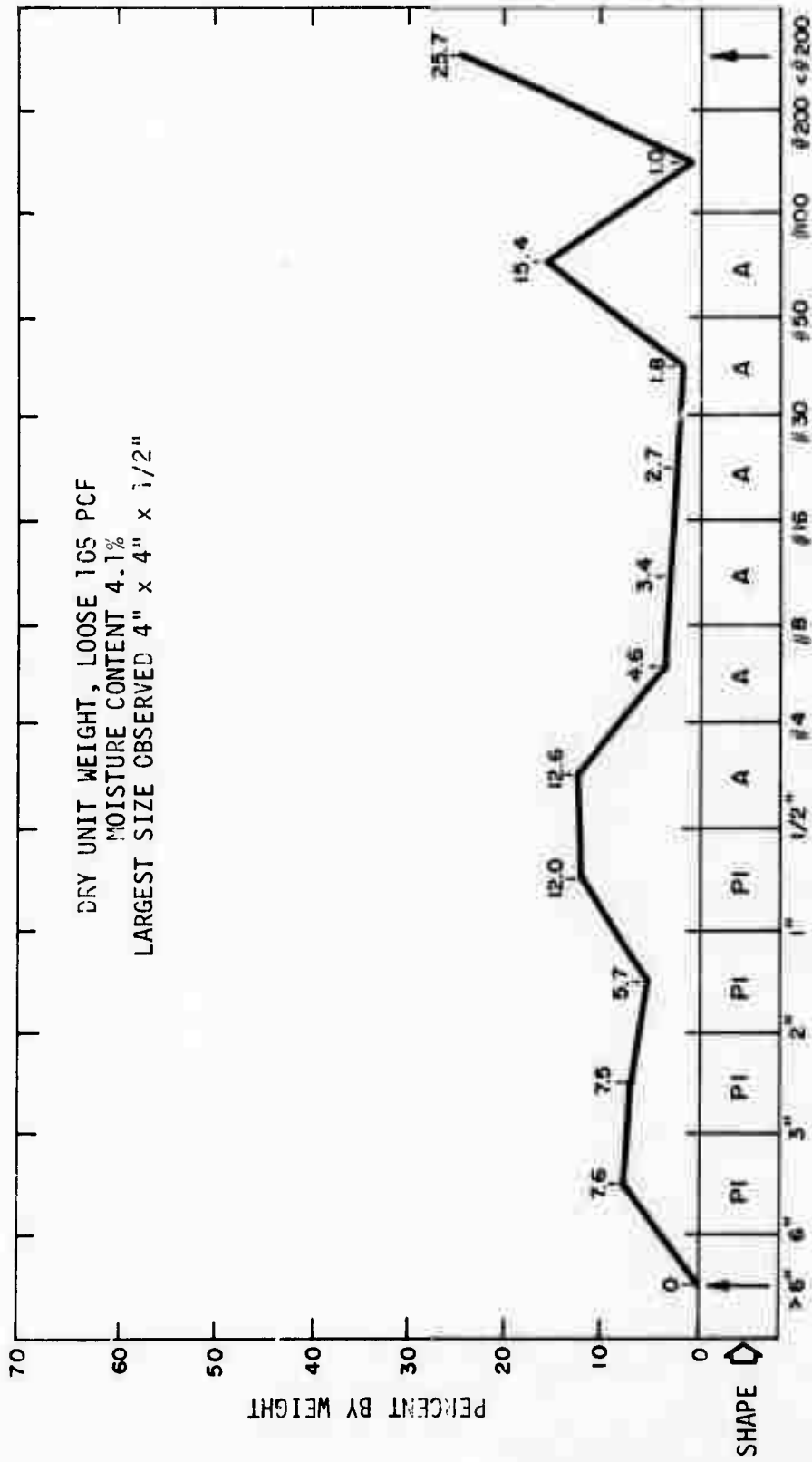


Figure V-2. Layout Tunnel Muck Characteristics

III. PROGRESS REPORTS

The following information is taken from the Bureau of Reclamation L-29 progress reports for the Layout Tunnel.

April 1971

Strawberry Aqueduct, Currant and Layout Tunnels, Diversions and Appurtenant Structures - Specifications No. DC-6855. Contract No. 41-06-D-7058. S. A. Healy Company.

At the close of the month, the percentage of work complete was:

	<u>Part 1</u>	<u>Part 2</u>
This month	0%	1%
To date	0%	1%
Time elapsed	47%	12%

Excavation for outlet portal Layout Tunnel was initiated April 27. The portal excavation of 6,414 yd³ was completed during the month. The contractor plans to excavate 40 ft of tunnel from the outlet portal by conventional methods and the remainder of the tunnel with a mole.

The mole is scheduled for shipping from Robbins Plant in Seattle, Washington, about May 15.

The contractor continued with preparatory work for the camp site completion of developing two culinary water wells and completion of two sediment ponds. One well is located at the contractor's camp site and the other is near the outlet portal of Layout Tunnel. Well water samples were submitted to the State Health Department for tests. The sediment ponds are located downstream from the Water Hollow siphon.

L. G. Everst, Inc., will process sand and aggregate for concrete. Plans are to obtain the aggregate from a deposit owned by Elmer Ray Moon and located in SW1/4, Sec. 1, T.35, R.10W, Uinta Meridian.

All remaining work under Schedule 4 was subcontracted to Jerico-Highland of Murray, Utah. Jerico-Highland plans to excavate the inlet portal and the outlet portal for Layout and Currant Tunnels, respectively, during this summer. The subcontractor also plans to start work on the Water Hollow Diversion works and Layout Creek Access Road about the middle of May.

Contract earnings for the month and earnings to date are \$128,280.00.

May 1971

Currant and Layout Tunnels - S. A. Healy Company excavated, by conventional methods, 54 ft of Layout Tunnel from the outlet portal. The Robbins mole arrived at the work site May 24. Offloading and assembly were started May 25. The access roads and tunnel portals in Layout Creek were cleared.

Strawberry Aqueduct, Currant and Layout Tunnels, Diversions and Appurtenant Structures - Specifications No. DC-6855. Contract No. 14-06-D-7058. S. A. Healy Company.

At the close of the month, the percentage of work complete was:

	<u>Part 1</u>	<u>Part 2</u>
This month	0%	0.3%
To date	0%	1.3%
Time elapsed	56%	14%

S. A. Healy Company excavated 54 ft of Layout Tunnel from the outlet portal by conventional methods in preparation for excavation with a mole. Water and air pipelines were installed to the portal.

The Robbins mole arrived at the work site May 24, and assembly was initiated May 25.

Jerico-Highland, subcontractor, initiated work on a bypass channel at the Water Hollow Diversion Dam.

Hamilton and Skewes, subcontractor for Jerico-Highland, cleared trees and brush from the Layout Creek road, Layout Creek road extension, Layout Tunnel inlet portal, Currant Tunnel outlet portal, Water Hollow Creek road extension, and Water Hollow Diversion Damsite. About half of the Water Hollow feeder pipeline right-of-way was also cleared.

Preparatory work by the prime and subcontractors included fabrication and ventilation of line and laying tracks.

The contractor plans to complete assembling the mole and start tunnel excavation by mole during June.

Jerico-Highland plans to complete the clearing operation and in early June to start building the Layout Creek Access Road and Water Hollow Diversion Dam.

Contract earnings for May were \$14,202.00. Earnings to date are \$142,482.00.

June 1971

Currant and Layout Tunnels - S. A. Healy initiated moling Layout Tunnel June 25 and moled 100 ft during the month. Jerico Construction excavated for Water Hollow Diversion Dam, completed open cut excavation of inlet portals of Currant Tunnel and Layout Tunnel, cleared Water Hollow Feeder Pipeline, and cleared and initiated construction of Layout Creek Access Road and Extension.

Strawberry Aqueduct, Currant and Layout Tunnels, Diversions and
Appurtenant Structures - Specifications No. DC-6855. Contract No. 14-06-
D-7058. S. A. Healy Company.

At the close of the month, the percentage of work complete was:

	<u>Part 1</u>	<u>Part 2</u>
This month	17%	1.7%
To date	17%	3%
Time elapsed	64%	16%

S. A. Healy Company excavated 100 ft of Layout Tunnel from near the outlet portal with a mechanical mole. Moling was initiated June 25, 1971.

Excavation was in hard sandstone and no support was required.

Daily tunneling operations are as follows:

<u>FOOTAGE</u>				
<u>Date</u>	<u>Hours</u> <u>Operated</u>	<u>Day</u>	<u>Accumulated</u>	<u>Remarks</u>
6/24/71				Station 1786+26.
6/25/71	3.9	6	6	Initial exc. by mechanical mole. Had difficulty controlling line and grade caused by grippers against unstable timbers in ribs.
6/28/71	5.3	27	33	Had electrical and gripper trouble.
6/29/71	3.3	32	65	Had an oil leak at the head of the mole and electrical trouble.
6/30/71	3.0	35	100	Moling resumed middle of swing shift without determining cause of oil leak.
<u>Totals</u>	<u>15.5</u>	<u>100</u>		Station 1785+26.

SUMMARY

<u>Item</u>	<u>This Month</u>	<u>Previous</u>	<u>Total</u>
Total operating time in hours	15.5	0	15.5
Total footage	100	0	100
Rate per hour	6.5	0	6.5
Maximum advance per day	35	0	35

Jerico Construction Company, subcontractor, completed excavating a bypass channel and excavated about 80% of the required foundation for Water Hollow Diversion Dam. Work on foundation excavation was slow as the dewatering system was inadequate until the third sump and pump were installed June 24, 1971. Open cut excavation for Layout Tunnel inlet and Currant Tunnel inlet was completed. Pioneering and excavating for Layout Creek Access Road and Layout Creek Access Road extension were initiated.

Hamilton and Skewes, subcontractor for Jerico Construction Company, finished the clearing.

Additional preparatory work by the prime and subcontractors included fabrication of ventilation line and laying tracks.

The contractor plans to excavate by mole on a 3-shift 5-days per week schedule. Plans are to excavate about 40 ft by conventional method from the inlet portal of Layout Tunnel.

Jerico Construction Company plans to work on building the Layout Creek Access Road, Layout Creek Access Road Extension, Water Hollow Diversion Dam earthwork and concrete, and the excavation at the Currant Tunnel outlet portal.

Contract earnings for June were \$202,988.00. Earnings to date are \$345,470.00.

July 1971

Strawberry Aqueduct, Currant and Layout Tunnels, Diversions and Appurtenant Structures - Specifications No. DC-6855. Contract No. 14-06-D-7058. S. A. Healy Company.

At the close of the month, the percentage of work complete was:

	<u>Part 1</u>	<u>Part 2</u>
This month	2%	5%
To date	19%	8%
Time elapsed	73%	18%

S. A. Healy Company excavated 1,329 ft of Layout Tunnel from Station 1785+26 to Station 1771+97 with a mechanical mole. From Station 1774+71 to 1772+40, some fallout and water were encountered. Through this reach, structural steel supports with lagging was installed and timber was used for gripper pads.

Ground formations consisted of hard and softer layers of sandstone with some gravel and conglomerate seams.

Daily tunneling operations are as follows:

<u>Date</u>	<u>Hours Operated</u>	<u>Day</u>	<u>FOOTAGE Accumulated</u>	<u>Remarks</u>
6/30/71			100	Station 1785+26
7/1/71	5.9	71	171	Electric drive motor for hydraulic pumps that run gantry belt failed. Stopped moling, worked to install fanline, tracks, and maintain cat-walk and gantry.

FOOTAGE (Cont.)

<u>Date</u>	<u>Hours Operated</u>	<u>Day</u>	<u>Accumulated</u>	<u>Remarks</u>
7/2/71	4.1	62	233	Changes two cutters, Nos. 10 and 23. Motor was removed graveyard shift. Replaced with new motor during swing shift. High speed RPM cut out drive motors. Used low speed RPM.
7/3/71	3.8	52	285	Material increasing in hardness.
7/6/71	4.5	50	335	Changed three cutters, Nos. 27, 28, and 29, slight fault, 3 in. by 4 ft in crown section well cemented. (No supports required this day.)
7/7/71	12.8	158	493	Changed two cutters, Nos. 1 and 23. Hit small flow of water at left rib, Sta. 1783+76. Belt trouble, shut down from 3:45 p.m. to 4:30 and 30 min during swing shift.
7/8/71	10.6	129	622	(Routine working conditions.) Electrical trouble with 100 hp drive motors. Change three cutters, Nos. 16, 28, and 29.
7/9/71	11.1	161	783	Changed 17 cutters, Nos. 2, 3, 4, 5, 6, 8, 9, 10, 11, 27, 12, 14, 15, 25, 28, and 29. Down because of trouble with trains in disposal area and to check outer seal.
7/10/71	4.4	54	837	Started changing cutters.
7/12/71	5.4	70	907	Changed two cutters, Nos. 12 and 29. Had trouble with pump on scrubber and mole belt. Down to check noisy cutter, and installing spray bar at gantry belt pickup from mole belt.
7/13/71	8.3	96	1003	Changed three cutters, Nos. 17, 22, and 23. Down to revamp spray nozzle bar between mole belt and gantry belt. One train of loaded muck cars derailed at 5:00 a.m. Mole belt plugged and slipped from wet material.

FOOTAGE (Cont.)

<u>Date</u>	<u>Hours Operated</u>	<u>Day</u>	<u>Accumulated</u>	<u>Remarks</u>
7/14/71	8.8	106	1109	Changed seven cutters, Nos. 13, 23, 25, 26, 27, 28 and 29. Had belt problems. Tried new spray bar. Down with broken hydraulic line to mole conveyor.
7/15/71	7.1	85	1194	Excavated 61 ft on graveyard shift. Hit bad ground, sand and gravel washed out with approximately 15 gpm flow of water. Started rib steel supports and lagging as mole advanced. Cribbing behind grippers was necessary in places.
7/16/71	3.6	31	1225	Had trouble gripping and with chunks falling out from above springline.
7/17/71	0.3	3	1228	Cleaned out invert of tunnel. Advanced mole 3 ft when another large fallout from crown occurred. Placed rib support steel.
7/19/71	1.7	14	1242	Changed cutter No. 27. Installed ribs at 3-ft centers and lagged and moled intermittently.
7/20/71	3.8	14	1256	Had trouble with grippers against unstable lagging.
7/21/71	5.2	46	1302	Had trouble with transformer and left side gripper moving rib steel and lagging.
7/22/71	2.6	31	1333	Day shift 7/22 thru graveyard shift 7/26 were spent on mole, airline maintenance and structural steel supporting of bad ground.
7/26/71	4.1	43	1376	Ran mole enough for one set of support steel at a time until mole was stopped due to dust after waterline to scrubber was broken.
7/27/71	<u>5.3</u>	<u>53</u>	<u>1429</u>	Changed seven cutters, Nos. 23, 13, 16, 12, 15, 29, and 26. Installed gantry.
Month Total	113.4	1329		Station 1771+97

SUMMARY

<u>Item</u>	<u>This Month</u>	<u>Previous</u>	<u>Total</u>
Total operating time in hours	113.4	15.5	128.9
Total footage	1,329	100	1,429
Rate per hour	11.7	6.5	11.1
Maximum advance per day	161	35	-----

Structural steel tunnel supports consisting of 4" H beam 13#/ft were installed as follows:

Stations:

1774+71 to 1774+63	Partial ring set on 4 ft centers and pinned 2 ft below springline.
1774+59 to 1774+47	Full ring on 4 ft centers.
1774+43 to 1774+23	Partial ring set on 4 ft centers and pinned 2 ft below springline.
1774+19 to 1774+15	Full ring on 4 ft centers.
1774+15 to 1774+08	Full ring on 3 ft centers.
1774+08 to 1773+98	Full ring on 2 ft centers.
1773+98 to 1772+64	Full ring on 4 ft centers.
1772+60 to 1772+40	Partial ring set on 4 ft centers and pinned at springline.

Jerico Contruction Company, subcontractor, excavated the foundation for Water Hollow Diversion Dam and started compacted embankment. Work on foundation excavation and embankment was slow as the contractor had difficulty with dewatering. Initial concrete placement was made for the footing of the upstream cutoff wall for Water Hollow Diversion Dam. Undesirable material was removed and backfill and compacted backfill for structures were placed for the Water Hollow Tunnel intake structure. Open cut excavation for tunnel portals was substantially completed. Excavating for Layout Creek Access Road and Layout Creek Access Road Extension advanced to about 55%.

The contractor plans to excavate by mole on a 3-shift 5-days per week schedule. Plans are to excavate about 40 ft by conventional method from the inlet portal of Layout Tunnel.

Contract earnings for July were \$612,231.00. Earnings to date are \$957,701.00.

August 1971

Strawberry Aqueduct, Currant and Layout Tunnels, Diversions and Appurtenant Structures - Specifications No. DC-6855. Contract No. 14-06-D-7058. S. A. Healy Company.

At the close of the month, the percentage of work complete was:

	<u>Part 1</u>	<u>Part 2</u>
This month	18%	8%
To date	37%	16%
Time elapsed	82%	20%

S. A. Healy Company excavated 2,314 ft of Layout Tunnel from Station 1771+97 to Station 1748+83 with the mechanical mole.

Ground formations consisted of hard and soft layers of sandstone with some siltstone, conglomerate and shale seams. Supports were required in the following areas:

1767+38 to 1761+94
1759+22 to 1759+06
1758+04 to 1756+17
1752+62 to 1748+83

Through these reaches, steel pans with rock bolts or structural steel supports with lagging and cribbing were installed. Timber was used for gripper pads as needed.

Daily tunneling operations are as follows:

<u>Date</u>	<u>FOOTAGE</u>		<u>Accumulated</u>	<u>Remarks</u>
	<u>Hours Operated</u>	<u>Day</u>		
7/31/71				Station 1771+97
8/2/71	5.2	83	1,512	Hydraulic system repaired, some ground water encountered.
8/3/71	9.6	130	1,642	Changed 16 cutters, Nos. 22, 11, 7, 18, 10, 19, 28, 14, 20, 15, 23, 23, 23, 7, 8, and 9. No. 7 cutter was changed twice, once on day shift and once following graveyard shift; and No. 23 was changed three times on swing shift, when material was hardest.
8/4/71	6.9	118	1,760	Changed 11 cutters, Nos. 24, 25, 26, 28, 6, 3, 16, 21, 15, 28, and 29. Cutter No. 28 changed twice.
8/5/71	6.0	82	1,842	Changed 6 cutters, Nos. 19, 12, 18, 13, 21, and 20. Down day shift waiting on repair parts. No moling 9:30 p.m. to 10:00 p.m. while unsafe conditions were being corrected. Rockbolts with pans were tried as support on left side, between Stations 1769+75 and 1769+90, but 6 ft rockbolts failed to torque.
8/6/71	9.1	106	1,948	Changed 18 cutters, Nos. 23, 14, 27, 11, 17, 5, and 24, 23, 24, 25, 26, 27, 29, 10, 21, 15, 3, and 29. Cutters changed twice at locations No. 23, 27, 24, and 29. Grippers fractured material causing flaking from left side. 10' x 12" x 16 gage pans were anchored with 2 ft rock bolts from Station 1767+04 to 1766+84.
8/7/71	0	0	1,948	Changed center cutter.

FOOTAGE (Cont.)

<u>Date</u>	<u>Hours Operated</u>	<u>Day</u>	<u>Accumulated</u>	<u>Remarks</u>
8/9/71	12.9	155	2,103	Changed cutter No. 23. Had trouble gripping on sides. Pans and rockbolts used from Stations 1766+84 to 1765+86.
8/10/71	2.4	25	2,128	Hit soft, wet, caving ground; water inflow estimated at 70 to 80 gpm. Placed structural steel supports and lagging intermittently.
8/11/71	3.8	36	2,164	Set structural steel supports and lagging.
8/12/71	5.4	47	2,211	Conditions similar to those encountered 10th and 11th except estimated 100 gpm of water.
8/13/71	7.6	86	2,297	Moled, blocked grippers, placed support steel and lagging intermittently and pumped water. Had trouble with mud building up around support wheels for transformer and scrubber platform.
8/14/71	0	0	2,297	Changed 4 cutters, Nos. 1, 15, 26, and 29.
8/16/71	8.3	97	2,394	Changed 5 cutters, Nos. 26, 11, 28, 18, and 16. Ground became firmer.
8/17/71	7.6	99	2,493	Changed 7 cutters, Nos. 26, 18, 10, 19, 21, 23, and 25. Placed support steel and lagging, heading became dry and supports were discontinued.
8/18/71	15.4	209	2,703	Changed 6 cutters, Nos. 24, 28, 22, 7, 14, and 2. The hydraulic "tugger" system for moving muck cars under the gantry was tried. It was slow and could move only 8 cars at a time when loading. Started supporting with rockbolts and pans at Station 1759+90. Empty muck car derailed at 7:30 p.m.

FOOTAGE (Cont.)

<u>Date</u>	<u>Hours Operated</u>	<u>Day</u>	<u>Accumulated</u>	<u>Remarks</u>
8/19/71	13.5	194	2,896	Changed 11 cutters, Nos. 29, 6, 16, 21, 22, 2, 11, 17, 23, 19, and 10. Contractor worked to correct cause of derailment from 8 to 10:40 a.m. and started moling at 10:40. Maximum advance was 4½ in. per min with 2100 lb of propel. Water was encountered above invert on left side at Station 1758+01.
8/20/71	4.4	59	2,955	Changed cutter No. 24. Down 3 hr and 10 min on day shift to set transformer at Station 1768+36 and install 1,000 ft of 7200 volt electric cable. At 3:15 p.m., encountered loose conglomerate which required steel rib supports, moled 4 ft at a time then stopped to place support steel and lagging.
8/21/71	0	0	2,955	Changed 6 cutters, Nos. 5, 11, 17, 23, 25, and 28.
8/23/71	9.4	86	3,041	Changed 7 cutters; Nos. 24, 27, 9, 6, 14, 18 and 22. Continued to mole slowly and installed supports for most of day. Down an hour to repair vent line and scrubber. Material got harder and had more stability.
8/24/71	16.4	150	3,191	Changed 16 cutters, Nos. 1, 29, 15, 18, 12, 10, 16, 11, 12, 13, 19, 17, 22, 23, 8 and 3. Cutter at location No. 12 was changed twice. Down twice on swing shift and once on graveyard shift to change cutters because of hard well cemented conglomerate. Advanced 2 in. per min at propel pressure of 2,800 psi.

FOOTAGE (Cont.)

<u>Date</u>	<u>Hours Operated</u>	<u>Day</u>	<u>Accumulated</u>	<u>Remarks</u>
8/25/71	15.6	172	3,363	Changed 23 cutters, Nos. 15, 16, 20, 18, 14, 22, 19, 25, 24, 26, 28, 27, 29, 22, 21, 7, 17, 23, 13, 24, 21, 11, and 16. Cutters at locations Nos. 16, 21, 22, and 24 were changed twice.
8/26/71	6.5	60	3,423	Water encountered in crown at 3:00 p.m. Started setting pans and rockbolts. Changed water nozzles at throat of the mole for better dust control. At 4:15 p.m. began installing structural steel supports.
8/27/71	11.6	107	3,530	Changed 3 cutters, Nos. 4, 28, 29. Moled and set steel alternately until shut down for hydraulic system repairs.
8/28/71	0	0	3,530	Changed 5 cutters, Nos. 14, 19, 23, 25, and 27, and set some structural steel supports while making hydraulic system repairs.
8/30/71	9.2	100	3,630	Changed 2 cutters, Nos. 12 and 20. Continued repair on hydraulic system and encountered ground that required supports.
8/31/71	7.5	113	3,743	Changed 2 cutters, Nos. 28 and 29. Moled 4 ft and set support steel alternately.
8/31/71				Station 1748+83.

SUMMARY

<u>Item</u>	<u>This Month</u>	<u>Previous</u>	<u>Total</u>
Total operating time in hours	194.3	128.9	323.2
Total footage	2,314	1,429	3,743
Rate per hour	11.9	11.1	11.6
Maximum advance per day	209	161	-----

Jerico Construction Company, subcontractor, placed approximately 25% of the compacted embankment and compacted backfill for Water Hollow Diversion Dam. This material came from borrow. Nearly all of the structural excavation in the diversion dam was oversize and rejected.

About 102 yd³ of concrete was placed for the upstream cutoff wall, cutoff walls under the spillway and sluiceway floors, and the 10' x 31' x 4' sluiceway floor section. At the Water Hollow Tunnel inlet structure, 19 yd³ concrete was placed for the floor and part of the walls.

Excavation and embankments for Layout Creek Access Road, Layout Creek Access Road Extension and Road above the Layout Feeder Pipeline were substantially completed. Earthwork and laying of pipe were initiated for the Layout Feeder Pipeline.

Jerico Construction Company plans to work a 10-hr shift 6 days per week on Water Hollow diversion structures. L. G. Everst plans to process coarse concrete aggregate until winter shutdown about October 1, 1971. Plans are to use a rod-mill next summer to process sand for concrete because current processes have failed to produce sand within the specified gradation.

Contract earnings for August were \$708,358.60. Earnings to date are \$1,666,059.60.

September 1971

Currant and Layout Tunnels - S. A. Healy moled 1,295 ft of Layout Tunnel. On September 22, the contractor discontinued moling because funds were exhausted. About 2,900 ft of pipe was laid for Layout Feeder Pipeline and 235 yd³ of concrete was placed for Water Hollow Diversion Dam and the inlet structure to Water Hollow Tunnel.

Strawberry Aqueduct, Currant and Layout Tunnels, Diversions and
Appurtenant Structures - Specifications No. DC-6855. Contract No.
14-06-D-7058. S. A. Healy Company.

At the close of the month, the percentage of work complete was:

	<u>Part 1</u>	<u>Part 2</u>
This month	22%	6%
To date	59%	22%
Time elapsed	91%	22%

S. A. Healy Company excavated 1,295 ft of Layout Tunnel from Station 1748+83 to 1735+88 with the mechanical mole.

On September 22, at noon, the contractor discontinued tunnel excavation because funds were exhausted. Swing and graveyard shifts were discontinued on September 24 and 25 respectively. By September 30, S. A. Healy had laid off all employees except supervisory personnel.

The material at the heading when work was discontinued is conglomerate in the arch to about 2 ft above springline and shale and sandstone below that.

The contractor has completed the following work to protect the Layout Tunnel and boring machine during the shut down period:

1. Applied shotcrete to 90% of the tunnel except for the invert from the end of the California switch to and including the heading.
2. Installed 4 in. tunnel support steel on 4 ft centers around the mole.
3. Installed a bulkhead at the outlet portal.

4. Installed 8 in. drain pipe at the outlet portal. This line connected to the invert of the tunnel to the original 8 in. pump discharge line outside the portal and was buried about 2 ft. The pipe was insulated when buried.
5. Cleaned invert of tunnel around mole and backup equipment to facilitate drainage of water. Pumping was discontinued October 1, 1971.
6. Performed general cleanup of the mole and backup equipment.
7. Blocked up the mole and retracted all hydraulic rams.
8. Greased all machine surfaces left exposed.
9. Activated internal heaters in the electric drive motors on the mole head.
10. Electricians sprayed a moisture proof preservative coating on all internal electrical wiring for motors, transformers, switches, etc.
11. Covered mole with a plastic covering.

In addition, the contractor plans to have watchmen on the job site during the entire shut down period. Also, electric power will be left on in the tunnel to activate the motor heaters and keep the transformers in operation to prevent deterioration.

Ground formations excavated during the month consisted of hard and soft layers of sandstone with some siltstone, conglomerate and shale seams. Structural steel supports with cribbing and lagging were installed in the following areas:

1748+83 to 1743+42
1740+64 to 1738+80
1736+32 to 1736+00

Timber was used for gripper pads as needed. A small amount of pans with rock bolts were also installed.

Approximately 170 yd³ of shotcrete was placed to retard rock deterioration along the tunnel walls and crown between Stations 1784+50 and 1735+88 on an intermittent basis as needed.

Daily tunneling operations were as follows:

<u>FOOTAGE</u>				
<u>Date</u>	<u>Hours Operated</u>	<u>Day</u>	<u>Accumulated</u>	<u>Remarks</u>
8/31/71			3,743	Station 1748+83
9/1/71	5.3	86	3,829	Changed 9 cutters, Nos. 25, 29, 18, 24, 27, 26, 21, 15, and 9. Alternately moled 4 ft and stopped to set rib support steel at 4 ft centers. Grippers cause rock to slab off.
9/2/71	8.8	123	3,952	Changed 10 cutters, Nos. 23, 17, 20, 8, 19, 22, 16, 10, 28, and 29. Alternately moled 4 ft and stopped to set rib support steel. Material was getting more stable.
9/3/71	9.4	126	4,078	Changed 7 cutters, Nos. 14, 13, 8, 6, 5, 11, and 23. Alternately moled 4 ft and stopped to set rib support steel. Material was getting softer and falling out from both sides.
9/7/71	5.2	71	4,149	Changed 2 cutters, Nos. 23 and 28. Alternately moled 4 ft and stopped to set rib support steel. Ground was blockey and some slabs fell out.
9/8/71	6.2	93	4,242	Changed 5 cutters, Nos. 27, 21, 18, 15, and 2. Alternately moled 4 ft and stopped to set rib support steel, as grippers were breaking slabs out.

FOOTAGE (Cont.)

<u>Date</u>	<u>Hours Operated</u>	<u>Day</u>	<u>Accumulated</u>	<u>Remarks</u>
9/9/71	5.6	66	4,308	Changed 13 cutters, Nos. 29, 26, 27, 12, 23, 22, 28, 24, 23, 26, 25, 27, and 29. Cutters at location No. 23, 26, 27, and 29 were changed twice. Alternately moled 4 ft and stopped to set steel until rib support steel was discontinued at Station 1743+42± at stable ground.
9/10/71	6.1	60	4,368	Changed 5 cutters, Nos. 17, 20, 21, 24, and 26. Ground was harder and moling speed was slow.
9/13/71	11.5	92	4,460	Changed 14 cutters, Nos. 14, 15, 16, 23, 11, 9, 4, 8, 13, 19, 20, 21, 10 and 2. Had trouble with high speed gripper valve, dust control equipment and conveyor belts. Stopped from time to time to repair these.
9/14/71	12.1	104	4,564	Changed 14 cutters, Nos. 5, 7, 10, 17, 18, 23, 24, 25, 26, 27, 28, 29, 1, and the center cutter. Hose to spray bar, dust controller, replaced.
9/15/71	5.4	69	4,633	Changed 2 cutters, Nos. 22 and 23. Moled 4 ft and stopped to install full ring steel supports alternately. Also had trouble getting grippers to hold.
9/16/71	8.5	79	4,712	Alternately moled 4 ft and stopped to set full ring support steel. Lagging behind grippers was required.
9/17/71	10.4	84	4,796	Changed 3 cutters, Nos. 23, twice and 24 once. Alternately moled 4 ft and stopped to set full ring support steel. At Station 1738+80, rib support steel was discontinued.

FOOTAGE (Cont.)

<u>Date</u>	<u>Hours Operated</u>	<u>Day</u>	<u>Accumulated</u>	<u>Remarks</u>
9/20/71	7.0	85	4,881	Changed 14 cutters, Nos. 8, 10, 11, 15, 16, 17, 18, 19, 21, 22, 24, 26, 28, and 29. The lubricating system to the cutter head bearings was repaired.
9/21/71	11.9	140	5,021	Changed 10 cutters, Nos. 14, 20, 23, 24, 25, 27, 3, 6, 8, and 29. Mole was without power for about 7 hr while contractor installed new transformer.
9/22/71	1.6	17	5,038	When softer ground was first encountered at 11:30 a.m., the contractor elected to stop the mole to leave it in stable ground until additional funds are available.
9/30/71				Station 1735+88

SUMMARY

<u>Item</u>	<u>This Month</u>	<u>Previous</u>	<u>Total</u>
Total operating time in hours	115.0	323.2	438.2
Total footage	1,295	3,743	5,038
Rate per hour	11.3	11.6	11.5
Maximum advance per day	140	209	

Jerico Construction Company, subcontractor, is working one 10-hr shift six days per week. About 207 yd³ of concrete was placed for the upstream middle apron, right and left wing walls, left downstream cutoff wall and the remaining spillway floor for Water Hollow Diversion Dam. At the Water Hollow Tunnel inlet structure, about 28 yd³ of concrete was placed for the upper parts of the walls and roof sections.

Earthwork and laying of pipe for the Layout Feeder Pipeline were advanced about 2,900 ft.

L. G. Everest, subcontractor, discontinued processing concrete aggregates until after the winter months. Some fine sand was produced and blended with the coarse sand already produced to obtain sand within specified gradations. This sand was used for shotcrete material in Layout Tunnel.

Contract earnings for September were \$695,912.32. Earnings to date are \$2,361,971.92.

IV. WAGE RATE SPECIFICATIONS: CENTRAL UTAH, 1970-1971

This information is taken from the Schedule, General Provisions, Specification, and Drawings, Strawberry Aqueduct, Currant and Layout Tunnels, Specifications No. DC-6855, U.S. Department of Interior, Bureau of Reclamation.

Pursuant to the provisions of the Davis-Bacon Act, 40 U.S.C. 276(a), as amended, the Secretary of Labor has determined that rates of wages and fringe benefits listed in this paragraph are those prevailing for the classifications specified in the locality of the work covered by these specifications and said rates of wages and fringe benefits shall be the minimum rates per hour to be paid for the work covered by the specifications.

Fringe benefit payments include medical and hospital care, compensation for injuries or illness resulting from occupational activity, unemployment benefits, life insurance, disability and sickness insurance, accident insurance (all designated as health and welfare), pensions, vacation and holiday pay, apprenticeship, or other similar programs, and other bona fide fringe benefits.

While the wage rates and fringe benefits shown are the minimum rates required by these specifications to be paid during the life of the contract, it is the responsibility of bidders to inform themselves as to local labor conditions such as the length of workday or workweek, overtime compensation, fringe benefit contributions, labor supply, and prospective changes or adjustments of wage rates or fringe benefits. No increase in the contract price will be allowed or authorized on account of the payment of wage rates or fringe benefits in excess of those listed herein.

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Decision No. AK-2,013 (3) dated 8-16-70

	BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
		H & W	PENSIONS	VACATION	APP TR	OTHERS
ASBESTOS WORKERS	6.81	.35	.42			
BOILERMAKERS	6.30	.30	.55	.40	.02	
BOILERMAKERS' HELPERS	6.00	.30	.55	.40	.02	
BRICKLAYERS	5.86	.21	.15			
CARPENTERS:						
Carpenters:						
Zone 1: (40 miles or less from Brigham City-Cedar City- Kanab-Logan-Ogden-Price- Provo-Richfield-Salt Lake City-Vernal)	6.30	.15	.20	.13	.02	
Zone 2: (Beyond 40 thru 50 miles from Brigham City-Cedar City- Kanab-Logan-Ogden-Price-Provo- Richfield-Salt Lake City- Vernal)	7.05	.15	.20	.13	.02	
Zone 3: (Beyond 50 thru 60 miles from Brigham City-Cedar City- Kanab-Logan-Ogden-Price-Provo- Richfield-Salt Lake City- Vernal)	7.175	.15	.20	.13	.02	
Zone 4: (Over 60 miles from Brigham City-Cedar City-Kanab-Logan- Ogden-Price-Provo-Richfield- Salt Lake City-Vernal)	7.30	.15	.20	.13	.02	
Saw Filers, Sev Ops., & Carpenters handling crosscut material:						
Zone 1	6.425	.15	.20	.13	.02	
Zone 2	7.175	.15	.20	.13	.02	
Zone 3	7.30	.15	.20	.13	.02	
Zone 4	7.425	.15	.20	.13	.02	
Millwrights (All Zones)	6.55	.15	.20	.13	.02	
Acoustical Carpenters (All Zones)	6.30	.15	.20	.13	.02	
CEMENT MASONS:						
Cement Masons						
Zone 1 (The area less than 45 miles from any county seat except Daggett County)	5.87	.15	.20	.13		
Zone 2 (All of DAGGETT COUNTY and the area beyond a distance greater than a radius of 45 miles from the remaining county seats)	6.27	.15	.20	.13		
Machine Op.: Mastic Floor Materials; Spark Proofing; Scaffold (20 to 40 ft.)						
Zone 1	6.00	.15	.20	.13		
Zone 2	6.40	.15	.20	.13		

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	BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
		H & C	PENSIONS	VACATION	APP. TR.	OTHERS
WALL FINISHERS: fining, finishing and texturing (hand or machine)	5.25	.16	.12		.02	
ELECTRICIANS:						
Cache-Davis (That portion of Davis Co. lying north of the 41st parallel)- Weber Counties.	6.20	.18	1%		3/10%	
Electricians	6.45	.18	1%		3/10%	
Cable Splicers						
Box Elder-Morgan-Rich Counties.	7.20	.18	1%		3/10%	
Electricians	7.45	.18	1%		3/10%	
Cable Splicers						
Salt Lake County & that portion of Davis County lying south of the 41st parallel; and that portion of Utah County lying north of the 40th parallel.						
10 mi. East or West from Interstate Hwy #15:						
Electricians	6.20	.18	1%		8/10%	
Cable Splicers	6.45	.18	1%		8/10%	
Over 10 mi. East or West from Interstate Hwy #15:						
Electricians	6.70	.18	1%		8/10%	
Cable Splicers	6.95	.18	1%		8/10%	
Remainder of State.						
Electricians	7.70	.18	1%		8/10%	
Cable Splicers	7.95	.18	1%		8/10%	
ELEVATOR CONSTRUCTORS	5.56	.16	.185	2% ^a		
ELEVATOR CONSTRUCTORS' HELPERS	70% JR	.16	.185	2% ^a		
ELEVATOR CONSTRUCTORS' HELPERS (PROB.)	50%					
GLAZIERS	4.39	.16		b		
IRONWORKERS:						
Ornamental-Reinforcing-Fence Erector- Structural	6.475	.25	.25		.025	
LABORERS:						
Brick Tenders	4.65	.15	.25			
Plesterers' Tenders	5.195	.20	.25		.01	
LAYERS	5.63	.20	.40		.01	
LEAD BURNERS	5.10	.15		c		
LINE CONSTRUCTION:						
Cable Splicers	6.37	.15	1%		3/4%	
Linemen	5.81	.15	1%		3/4%	
Line Equipment Operator	5.15	.15	1%		3/4%	
Head Groundmen	4.47	.15	1%		3/4%	
Groundmen	4.05	.15	1%		3/4%	

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	BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
		H & V	PENSIONS	VACATION	APP. TR	OTHERS
PAINTERS:						
<u>Area North of 41st Parallel.</u>						
Brush	4.30	.16			.01	
Spray; Structural Steel; Swing Stage	4.50	.16			.01	
Steeple Jack Work	4.50	.16			.01	
<u>Remainder part of State.</u>						
Brush; Roller; Imperhanger; Sheet Rock Taper	4.87	.16	.12		.01	
Brush (Swing Stage); Brush (Steel & Bridge); Spray & Sandblaster; Steeple Jack	5.07	.16	.12		.01	
Spray (Swing Stage); Spray (Steel & Bridge); Sandblaster (Swing Stage); and special Coating Applicator	5.27	.16	.12		.01	
PILEDRIVERS: Bridge, Wharf, & Dock Carpenters, Riggers, Boom Men	7.09	.15	.20	.13	.02	
PLASTERERS	5.86	.20	.20		.01	
PLUMBERS; Pipefitters & Steamfitters:						
Zone 1- 15 mi. radius from center of each city, namely Salt Lake City, Ogden and Provo	6.15	.16	.20		.04	
Zone 2- Zone 1 plus 15 miles	6.45	.16	.20		.04	
Zone 3- Zone 2 plus 15 miles	6.80	.16	.20		.04	
Zone 4- All areas beyond Zone 3.	7.65	.16	.20		.04	
REFRIGERATION & AIR CONDITIONING:						
<u>50 tons or more:</u>						
Zone 1- 15 mi. radius from center of each city, namely Salt Lake City, Ogden and Provo	6.45	.16	.20		.02	
Zone 2- Zone 1 plus 15 miles	6.80	.16	.20		.02	
Zone 3- Zone 2 plus 15 miles	7.15	.16	.20		.02	
Zone 4- All areas beyond Zone 3.	7.50	.16	.20		.02	
<u>Under 50 tons:</u>						
All zones	5.35	.16			.02	
ROOFERS	5.55	.10	.10			
SHINY METAL WORKERS	5.70	.18	.20			
SPINNLER FILTERS	6.50	.20	.30		.05	
TERRAZZO WORKERS	5.00					
TILE SETTERS	5.00					
WELDERS: Receive rate prescribed for craft to which welding is incidental.						
FOOTNOTES:						
a. Employer contributes 4% of basic hourly rate for 5 years' service and 2% basic hourly rate for 6 months to 5 years' service as Vacation Pay Credit. 6 Paid Holidays: A through F.						
b. Employee shall receive 2 weeks' vacation with pay after completion of one year of service; employee who has served continuously with one employer for twelve years to receive a third week's vacation. 7 Paid Holidays. A through F plus July 24th.						
c. Eight paid holidays: A through F plus Washington's Birthday and Good Friday, providing employee has worked 45 full days during the 120 calendar days prior to the holiday, and the regular scheduled work days immediately preceding & following the holiday.						
PAID HOLIDAYS: A-New Year's Day; B-Memorial Day; C-Independence Day; D-Labor Day; E-Thanksgiving Day; F-Christmas Day.						

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That area in the State of Utah within
45 road miles of the county seats
excluding Daggett County

LABORERS

GROUP I

Boxman, Carpenter tender, Cement finisher helper, Chat boxman, Choker setter, Clearing & grading, Cleaning of equipment & parts in connection with concrete, Concrete crew, Dock-hand & cleaning man, Fence erector & installer (includes installation & erection of fences, guard rails, median rails, reference post, guide post, & right-of-way markers), Flagman, Form stripper, Gardener helper, General laborer, Grizzly operator (whether by power or hand), Group pump operators, Heaters tender, Helpers (all not herein separately classified), House mover, Landscaping helper, Laborers on wrecking & Demolition, Nurseryman helper, Pre-watermen, Riprap man (hand placed), Sloper, Spreader & weighman, Stake jumper, Stripping & cleaning of steel & pane, Tool dispatcher & checker (full time), Unloading & packing of reinforcing steel rods & mesh

BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
	H & V	PENSIONS	VACATION	APP. TR.	OTHERS
4.305	.15	.25		.04	
4.43	.15	.25		.04	

GROUP II

Air track helper, Asphalt makers & ironers, Dumpman, Gunite reboundman, Hand & chain saw operator (bucking & falling timber), J. Taper & similar type tapers, Metal form setter (airport paving & highway) Operator & tenders of pneumatic & electric tools & compressors & concrete saw, Operators of power-type form cleaner & oiling machines, Pipe wrapper, Put tender & joint maker, Power type buggies, Rollers, Screen & cleanup man, Signal & Dumpman on concrete construction, Tunnel & belt man,

GROUP III

Barke vibratory roller & similar type, Compacting machines, High pressure water nozzle man, Jackhammer & pavement

Decision No. AK-2,013 (3)

LABORERS-Cont'd	BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
		H & W	PENSIONS	VACATION	APP. TR.	OTHERS
GROUP III- Cont'd						
breaker, Pipelayer, Powderman helper, Pumcrete operators, Refinery tank & vessel cleaners, Sand Blasters, Sand blaster pot tender, Vibrator operator, Work of all type using cutting torches & tools needed in wrecking	4.555	.15	.25		.00	
GROUP IV						
Air track & core diamond drillers, Drill mechanic (on job site), High scler-operating jackhammer or breaker, Main vibrators & similar types - 70 lbs., Multiple side boom driller, Wagon driller	4.68	.15	.25		.00	
GROUP V						
Gunite groundman, gunite nozzleman, gunite rodman, Powderman	5.03	.15	.25		.00	
TUNNEL AND SHAFT WORK:						
GROUP I (Underground) Underground Laborers	4.43	.15	.25		.00	
GROUP II (Underground) Breakman, Chucktender, Dumpman, Powderman helper, Puddler	4.53	.15	.25		.00	
GROUP III (Underground) Nipper, Screedman, Vibrator, Tapman	4.63	.15	.25		.00	
GROUP IV (Underground) Cutting machine operator, Drill doctor, Finisher, Gunite gunman, Miner, Powder make-up man, Speder & Tuggers, Steelman, Timberman	4.73	.15	.25		.00	
GROUP V (Underground) Gunite groundman, Gunite nozzleman, Gunite rodman	5.03	.15	.25		.00	
GROUP VI (Underground) Shifter	5.18	.15	.25		.00	

Decision No. AK-2,013 (3)

*AREA 1

POWER EQUIPMENT OPERATORS

GROUP I

Chainman; Rodman

4.69

.41

.45

.20

.05

GROUP II

Asphalt Plant Fireman; Brakeman-
Locomotive; Elevator Operator; Fireman;
Hydraulic Monitor; Material Loader or
Conveyor Operator; Partman - Field;
Grade Setter - Repairman Helper - Field

5.09

.41

.45

.20

.05

GROUP III

Air Compressor Operator; Concrete
Mixer Operator (skip type); Concrete
Pump or Pumpcrete Gun Operator; Engineer,
Dinkey Operator; Generator (100 KW or
over); Mixer Box Operator (Concrete or
Asphalt plant) (continuous mix or similar);
Pump Operator; Self-propelled, Auto-
matically applied concrete curing
machine (on streets, highways, airports
and canals); Screedman; Truck Crane
Oiler

5.38

.41

.45

.20

.05

GROUP IV

Ballast Jack Tapper; Ballast Regulator;
Ballast Tapper-Multiple Purpose; Front
End Loader up to and including 1 c.y.
Struck K&C; Moist Operator - 1 Drum;
Line Worker; Lubrication & Service
Engineer (Mobile & Grease Rack); Slip
Form Pumps

5.51

.41

.45

.20

.05

GROUP IV-A

Heavy Duty Repairman and Welder
Permanent Shop

5.59

.41

.45

.20

.05

GROUP V

Air Compressor Operator (two or more
compressors); Batch Operator (Asphalt
Plant); Motorman; Pezzent Breaker
Operator (Lusco & similar type);
Signalman; Nuttlecr; Small Rubber
Tired Tractors; Small Self-propelled
Pneumatic Rollers; Towermobile Operator;
Welding Machine (2 or more)

5.59

.41

.45

.20

.05

BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
	H & V	PENSIONS	VACATION	APP. TR.	OTHERS
4.69	.41	.45	.20	.05	
5.09	.41	.45	.20	.05	
5.38	.41	.45	.20	.05	
5.51	.41	.45	.20	.05	
5.59	.41	.45	.20	.05	
5.59	.41	.45	.20	.05	

Decision No. AK-2,013 (3)

*AREA 1

MOTOR EQUIPMENT OPERATORS (Cont'd)

GROUP VI

A-frame crane & trolley hoist; Concrete Saws - self-propelled unit on streets, highways, airports and canals; Engineers, Locomotive; Fork Lift (construction job site); Kelman Loader (and similar); Maginnis Internal Full Size Vibrator (on airports, highways, canals and warehouses); Mixer/obile Operator; Pipe Bending Machine Operator; Pipe Cleaning Machine; Pipe Wrapping Machine; Road Mixing Machine Operator; Ross Carrier, or similar type; Small Rubber Tired Tractor (with attachments, including backhoe); Small Tractor with Boom; Surface Heater (self-propelled); Loader Operator (over 1 c.y. up to and including 2 c.y. struck MHC); Power Jumbo Operator (setting slip forms, etc. in tunnels); Small Rubber Tired Trenching Machine

GROUP VII

Bridge Crane; Chip Box Spreader (Fleeherty type and similar); Concrete Mixer Operator (paving or batch plant); Deck Engineers (Marine); Drilling Machine Operator (well or diamond); Dual Drum Mixers; Elevating Grader Cpr.; Fuller Kenyon Pump and similar types; Heavy Duty Rotary Drill Rigs (such as quarry master, joy drills or equal); Hniet Operator - 2 drums; Instrument Man; Mechanical Finisher Operator (Asphalt or concrete); Mine or Shaft Hoist; Pavement Breaker (Pavement Breaker with compressor combination); Pavement Breaker, truck mounted, compressor combination; Refrigeration Plant; Self-Propelled Pipeline, Wrapping Machine (Perault, CRE, or similar types); Slusher Operator; Tractor Operator (Sweep's foot and compacting equipment); Trenching Machine; Tractor-Compressor Drill Combination; No-Joint Pipe Laying Machine; Full High-Lift (40 ft. or similar); Roller Operator or self-propelled compactor

BASIC HOURLY RATES	FRINGE BENEFIT PAYMENTS				
	H & W	PENSIONS	VACATION	APP TR	OTHERS
5.94	.41	.45	.20	.05	
6.04	.41	.45	.20	.05	

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AREA 1

POWER EQUIPMENT OPERATORS (Cont'd)

	BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
		H & W	PENSIONS	VACATION	APP. TR	OTHERS
<u>GROUP VII-A</u> Side Boom Operator; Asphalt Plant Engineer; Engineer Crushing Plant; Tractor Operator (bulldozer, scraper or drag-type shovel or boom attachment) (up to and including D-7 or similar)	6.09	.41	.45	.20	.05	
<u>GROUP VIII</u> Do-Mor Loader and Adams Elegrader; Euclid Loader and similar types; Chicago Boom (Including Stiff leg and shear pole); Chief of Party; Combination Shovel and Motor Operator; Concrete Batch Plant (Multiple unit); Koenig Skooper (or similar, up to 5c.y. Struck MRC); Loader Operator over 2 c.y. up to and including 5 c.y. Struck MRC; Mucking Machine Operator; Saurman Type Dragline (under 5 c.y. Struck MRC); Self-Propelled Elevating Grade Plans; Soil Stabilizer (P & H or equal); Sub-grader (automatic subgrader - fine - grader); Self-Propelled Boom type lifting device; Mechanical Tranch Shield; Rubber Tired Scraper (under 35 c.y. Struck MRC); Tri-Batch Paver; Tunnel (Mole or similar)	6.35	.41	.45	.20	.05	
<u>GROUP VIII-A</u> Heavy duty Reapirman or balder; Tractor Operator Bulldozer, Scraper or Drag type Shovel or Boom Attachment Larger than D-7 or similar	6.40	.41	.45	.20	.05	
<u>GROUP IX</u> Combination Mixer & Compressor (Gunita); Highline Cableway Signalman; Motor Patrol; Tower Crane (Linden type or similar design and capacity) (in the erection, dismantling & moving of equipment there shall be additional Operator Engineer)	6.45	.41	.45	.20	.05	
<u>GROUP X</u> High Cableway Operator (Signalman required); Lift Slab Machine (Vagborg & similar types); Locomotive (over 100 tons) (single or multiple units); Pre-Stress wire Wrapping Machine; Saurman type dragline (5 c.y. Struck MRC and over						

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*AREA 1

POWER EQUIPMENT OPERATORS (Cont'd)

GROUP X (Cont'd)

Tractor Taped Scrapers; Ds 10.20 etc. (Tandem Scraper); Universal Equipment Operator (snowplow, backhoe, dragline, derrick, derrick barge, clamshell crane, gradall, etc. (up to and including 5 c.y.); Struck MRC; Loader (over 5 c.y. up to and including 12 c.y. Struck MRC) -

BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
	H & W	PENSIONS	VACATION	APP TR	OTHERS
6.57	.41	.45	.20	.05	
GROUP XI					
Automatic Concrete Slip Form Paver (Gradesetter, Screedman); Koehring Scooper (or similar) (5 cu. yds. & over Struck MRC); Multiple Propulsion Power Unit Earth Movers (up to and including 75 c.y. Struck MRC); Remote Controlled Cranes and Derricks; Power Equipment with shovel-type controls (over 5 cu. yds. up to and including 7 cu. yds. Struck MRC; Rubber Tired Scraper (35 cu. yds. and over Struck MRC); Self-Propelled Compactor (with multiple propulsion power units); Slip Form Paver (concrete or asphalt) (1 operator and 2 screedman when required); Tandem Tractors; Tower Cranes Mobile					
6.90	.41	.45	.20	.05	
GROUP XI-A					
Multi-purpose Earth Moving Machines; (Two (2) or more scrapers (over 75 c.y. Struck MRC); Power Shovels & Draglines (over 7 c.y. Struck MRC; Loader over 12 c.y. Struck MRC)					
7.62	.41	.45	.20	.05	
GROUP XI-B					
Operator of Helicopter (when used in erection work)					
7.96	.41	.45	.20	.05	

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00 AREA 2

POWER EQUIPMENT OPERATORS

GROUP I

Chainman; Rodman

GROUP II

Asphalt Plant Fireman; Breakman-
Locomotive; Elevator Operator; Fireman;
Hydraulic Monitor; Material Loader or
Conveyor Operator; Partman - Field;
Grade Setter - Repairman Helper - Field

GROUP III

Air Compressor Operator; Concrete
Mixer Operator (skip type); Concrete
Pump or Pumpcrete Gun Operator; Engineer,
Dinkey Operator; Generator (100 KW or
over); Mixer Box Operator (Concrete or
Asphalt plant) (continuous mix or similar);
Pump Operator; Self-propelled, Auto-
matically applied concrete curing
machine (on streets, highways, airports
and canals); Screedman; Truck Crane
Oiler

GROUP IV

Ballast Jack Tamper; Ballast Regulator;
Ballast Tamper-Multiple Purpose; Front
End Loader up to and including 1 c.y.
Struck W/C; Hoist Operator - 1 Drum;
Line Master; Lubrication & Service
Engineer (Mobile & Grease Rack); Slip
Form Pump

GROUP IV-A

Heavy Duty Repairman and Welder
Permanent Shop

GROUP V

Air Compressor Operator (two or more
compressors); Batch Operator (Asphalt
Plant); Motorman; Pavement Breaker
Operator (Easch & similar type);
Signalman; Shuttlecar; Small Rubber
Tired Tractors; Small Self-propelled
Pneumatic Rollers; Towermobile Operator;
Welding Machine (2 or more)

BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
	H & B	PENSIONS	VACATION	APP. TR.	OTHERS
5.89	.41	.45	.20	.05	
6.09	.41	.45	.20	.05	
6.38	.41	.45	.20	.05	
6.51	.41	.45	.20	.05	
6.59	.41	.45	.20	.05	
6.59	.41	.45	.20	.05	

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**AREA 2

CONTRACT EQUIPMENT OPERATORS (Cont'd)

GROUP VI

A-frame truck & tugger hoist; Concrete Saws (self-propelled unit on streets, highways, airports and canals); Engineer, Locomotive; Fork Lift (construction job site); Roll-on Loader (and similar); Magnolia Internal Pull Slab Vibrator (on airports, highways, canals and warehouses); Mixermobile Operator; Pipe Bending Machine Operator; Pipe Cleaning Machine; Pipe Wrapping Machine; Road Mixing Machine Operator; Ross Carrier, or similar type; Small Rubber Tired Tractor (with attachments, including backhoes); Small Tractor with Boom; Surface Heater (self-propelled); Loader Operator (over 1 c.y. up to and including 2 c.y. struck MRC); Power Jumbo Operator (setting slip forms, etc. in tunnels); Small Rubber Tired Tranching Machine

GROUP VII

Bridge Crane; Chip Box Spreader (flaherty type and similar); Concrete Mixer Operator (paving or batch plant); Deck Engineers (Marina); Drilling Machine Operator (wall or diamond); Dual Drum Mixers; Elevating Grader Operator; Fuller Canyon Pump and similar types; Heavy Duty Rotary Drill Rigs (such as quarry master, joy drills or equal); Hoist Operator - 2 drums; Instrument Man; Mechanical Finisher Operator (Asphalt or concrete); Mine or Shaft Hoist; Pavement Breaker (Pavement Breaker with compressor combination); Pavement Breaker, truck mounted, compressor combination; Refrigeration Plant; Self-Propelled Pipeline, wrapping machine (Perault, CRC, or similar types); Slusher Operator; Tractor Operator (Sheep's foot and compacting equipment); Tranching Machine; Tractor-Compressor Drill Combination; Ho-Joint Pipe Laying Machine; Lull High-Lift (40 ft. or similar); Roller Operator or self-propelled compactor

BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
	H & W	PENSIONS	VACATION	APP. TR.	OTHERS
6.94	.41	.45	.20	.05	
7.04	.41	.45	.20	.05	

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****AREA 2**

POWER EQUIPMENT OPERATORS (Cont'd)

GROUP VII-A

Side Boom Operator; Asphalt Plant Engineer; Engineer Crushing Plant; Tractor Operator (bulldozer, scraper or drag-type shovel or boom attachment) (up to end including D-7 or similar)

GROUP VIII

Do-Mor Loader and Adams Elagreder; Euclid Loader and similar types; Chicago Boom (including Stiff leg and sheer pole); Chief of Party; Combination Slusher and Motor Operator; Concrete Batch Plant (Multiple unit); Koshring Skooper (or similar, up to 5c.y. Struck MRC); Loader Operator over 2 c.y. up to end including 5 c.y. Struck MRC; Mucking Machine Operator; Saurman Type Dragline (under 5 c.y. Struck MRC); Self-Propelled Elevating Grade Plane; Soil Stabiliser (P & H or equal); Sub-grader (automatic outgrader - fine - grader); Self-Propelled Boom type lifting device; Mechanical Trench Shield; Rubber Tired Scraper (under 35 c.y. Struck MRC); Tri-Batch Paver; Tunnel (Mole or similar)

GROUP VIII-A

Heavy duty Repairman or Welder; Tractor Operator Bulldozer, Scraper or Drag type Shovel or Boom Attachment larger than D-7 or similar

GROUP IX

Combination Mixer & Compressor (Gunito); Highline Cableway Signelman; Motor Patrol; Tower Crane (Linden type or similar designs and capacity) (in the erection, dismantling & moving of equipment there shall be additional Operator Engineer)

GROUP X

High Cableway Operator (Signalman required); Lift Slew Machine (Vegborg & similar types); Locomotive (over 100 tons) (single or multiple units); Pre-Stress wire Wrapping Machine; Saurman type dragline (5 c.y. Struck MRC and over

BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
	H & V	PENSIONS	VACATION	APP TR.	OTHERS
7.09	.41	.45	.20	.05	
7.35	.41	.45	.20	.05	
7.40	.41	.45	.20	.05	
7.45	.41	.45	.20	.05	

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****AREA 2**

POWER EQUIPMENT OPERATORS (Cont'd)

GROUP I (Cont'd)

Tractor Tandem Scrapers; DW 10.20 etc. (Tandem Scraper); Universal Equipment Operator (shovel, backhoe, dragline, derrick, derrick barge, clamshell crane, gradall, etc. (up to and including 5 c.y.) Struck MRC; Loader (over 5 c.y. up to and including 12 c.y. Struck MRC)

GROUP II

Automatic Concrete Slip Form Paver (Gredsetter, screedman); Koshring Skooper (or similar) (5 cu. yds. & over Struck MRC); Multiple Propulsion Power Unit Earth Movers (up to and including 75 c.y. Struck MRC); Remote Controlled Cranes and Derricks; Power Equipment with shovel-type controls (over 5 cu. yds. up to and including 7 cu. yds. Struck MRC; Rubber Tired Scraper (3) cu. yds. and over Struck MRC); Self-Propelled Compactor (with multiple propulsion power units); Slip Form Paver (concrete or asphalt) (1 operator and 2 screedmen when required); Tandem Tractors; Tower Cranes Mobile

GROUP II-A

Multi-purpose Earth Moving Machines; (Two (2) or more scrapers (over 75 c.y. Struck MRC); Power Shovels & Draglines (over 7 c.y. Struck MRC; Loader over 12 c.y. Struck MRC)

GROUP II-B

Operator of Helicopter (when used in erection work)

BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
	H & V	PENSIONS	VACATION	APP. TR.	OTHERS
7.57	.41	.45	.20	.05	
7.90	.41	.45	.20	.05	
8.62	.41	.45	.20	.05	
8.96	.41	.45	.20	.05	

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	BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS			
		H & W	PENSIONS	VACATION	APP. TR.
<u>PILEDRIVING</u>					
<u>GROUP 1</u>					
(a) Assistant to Engineer (Fireman, Oiler, Deckhand)	5.60	.41	.45	.20	.05
(b) Compressor Operator (Electrically, gas or diesel powered, etc.)	5.83	.41	.45	.20	.05
(c) Truck Crane Oiler	5.92	.41	.45	.20	.05
<u>GROUP 2</u>					
(a) Operator of Tagger Hoist (Hoisting materials only)	6.35	.41	.45	.20	.05
(b) Compressor Operator (2 to 6) (Electrically, gas or diesel powered); Generator op. (electrically, gas or diesel driven, 100 K.W.); Pump op. (2 to 6); Welding machine op. (2 to 6) (Gas or diesel powered)	6.50	.41	.45	.20	.05
<u>GROUP 3</u>					
"A" Frame; Deck Engineer; Fork Lift Operator; Self propelled Boom Type Lifting Device	6.69	.41	.45	.20	.05
<u>GROUP 3-A</u>					
Heavy Duty Repairman and/or Welder	6.96	.41	.45	.20	.05
<u>GROUP 4</u>					
Operating Engineer in lieu of assistant to engineer tending boiler or compressor attached to crane piledriver; Operator of Piledriving rigs, skid or floating & derrick barges; Operator of diesel or gasoline powered Crane Piledriver (w/o boiler) up to & incl. 1 cu. yd. rating; Truck Crane Op. (up to & incl. 25 tons) (hoisting material only) (assistant to engineer required) (not driving piles)	7.33	.41	.45	.20	.05
<u>GROUP 5</u>					
Operator of diesel or gasoline powered Crane Piledriver (w/o boiler) over 1 cu. yd. rating; Operator of Crane (w/steam, flash boiler, pump or compressor attached); Op. of steam powered engine or Universal Type Driver (Raymond or similar type); Truck Crane Op. (over 25 tons (hoisting material or performing piledriving work)	7.43	.41	.45	.20	.05

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Steel Erection

	BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
		H & W	PENSIONS	VACATION	APP. TR.	OTHERS
<u>GROUP 1</u> Assistant to Engineer (Oiler)	5.90	.41	.45	.20	.05	
<u>GROUP 2</u> Assistant to Engineer (Truck Crane Oiler); Compressor; Generator, gasoline or diesel driven (100 KW)	6.16	.41	.45	.20	.05	
<u>GROUP 3</u> Compressors, Generators &/or Welding Machines or Combination (2 to 6); Deck Engineer; Instrument Man; Signalman (using mechanical equipment); Fork Lift	6.83	.41	.45	.20	.05	
<u>GROUP 4</u> Heavy Duty Repairman; Tractor Op.	6.94	.41	.45	.20	.05	
<u>GROUP 4-A</u> Combination Heavy Duty Repairman; Welder	7.13	.41	.45	.20	.05	
<u>GROUP 5</u> "A" Frame or Boom Truck; Boom Cat; Chicago Boom; Crawler Crane & Truck Cranes (15 tons m.r.c. or less) Selfpropelled Boom Type Lifting Device; Single Drum Hoist; Tugger Hoist; Chief of Party	7.45	.41	.45	.20	.05	
<u>GROUP 6</u> Crawler Crane & Truck Cranes (over 15 tons m.r.c.); Lattice (2 ops. required when using engine remote from hoist); Highline Cablesay (Signalman required); Tower Crane Mobile; Universal Liebherr & Tower Crane (& similar types) (in the erection, dismantling & moving of equipment, there shall be an additional Operating Engineer); Two or more Drum Hoist	7.73	.41	.45	.20	.05	
<u>GROUP 7</u> Operator of Helicopter	8.77	.41	.45	.20	.05	

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AREA 1

TRUCK DRIVERS

DUMP TRUCKS - Water Level Capacity
(bottom and/or side) (including
Dumpster Trucks, Euclid type trucks,
Turnwrigons, Turnrockers & Dumpster)

Less than 8 yards	5.30
8 yards & less than 14 yards	5.45
14 yards & less than 35 yards	5.60
35 yards & less than 55 yards	5.80
55 yards & less than 75 yards	6.00
75 yards & less than 95 yards	6.20
95 yards & less than 105 yards	6.40
Over 105 yards	6.52

Whenever doubles are used, the drivers will be paid under the appropriate yardage schedule as outlined plus 25¢ per hour.

When three (3) or more trailers are put into operation, use the appropriate yardage rate as outlined above plus 25¢ per hour for the third (3rd) and each additional trailer which is pulled by one power unit.

Whenever additional power units are used and operated by one driver, he shall receive an additional 50¢ per hour for operating such equipment.

FLAT RACK TRUCKS, Bulk Cement Trucks, Transport Trucks, Semi-Trailer (Carrying capacity):

Pickup	5.125
Less than 10 tons	5.20
10 tons & less than 15 tons	5.35
15 tons & less than 20 tons	5.45
20 tons & over	5.60

Employee driving any of the above on Flat Rack Trucks with Winch, Hoist Attachments or "A" Frames shall receive \$.125 additional per hour when such winch hoist or "A" Frames are in use.

When drivers load and unload such cement, explosives and/or railroad ties by hand they shall receive \$.15 per hour additional for actual hours worked.

BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
	H & V	PENSIONS	VACATION	APP. TR	OTHERS
Less than 8 yards	.30	.20	.30		
8 yards & less than 14 yards	.30	.20	.30		
14 yards & less than 35 yards	.30	.20	.30		
35 yards & less than 55 yards	.30	.20	.30		
55 yards & less than 75 yards	.30	.20	.30		
75 yards & less than 95 yards	.30	.20	.30		
95 yards & less than 105 yards	.30	.20	.30		
Over 105 yards	.30	.20	.30		
Pickup	.30	.20	.30		
Less than 10 tons	.30	.20	.30		
10 tons & less than 15 tons	.30	.20	.30		
15 tons & less than 20 tons	.30	.20	.30		
20 tons & over	.30	.20	.30		

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**AREA 1

TRUCK DRIVERS - CONT'D

	BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
		H & V	PENSIONS	VACATION	APP. TR.	OTHERS
TRANSIT MIX TRUCKS:						
4' yards capacity & less	5.325	.30	.20	.30		
Over 4' yards capacity to & including 6' yards	5.425	.30	.20	.30		
Over 6' yards	5.525	.30	.20	.30		
Concrete pumping trucks	5.525	.30	.20	.30		
WATER, FUEL & OIL TANK TRUCKS:						
0 to 1200 gallons	5.175	.30	.20	.30		
1200 to 2500 gallons	5.30	.30	.20	.30		
2500 to 4000 gallons	5.45	.30	.20	.30		
4000 to 6000 gallons	5.75	.30	.20	.30		
6000 gallons to less than 10,000 gallons	6.00	.30	.20	.30		
10,000 gallons to less than 15,000 gallons	6.25	.30	.20	.30		
15,000 gallons to less than 20,000 gallons	6.50	.30	.20	.30		
20,000 gallons to less than 25,000 gallons	6.75	.30	.20	.30		
Over 25,000 gallons	7.00	.30	.20	.30		
Whenever two water tanks are pulled, driver will receive 25¢ per hour in addition to the combined water galleage rate.						
Oil Spreader Operator (on single man operation where boot man is not required)	6.00	.30	.20	.30		
CONSTRUCTION JOB SERVICEMEN:						
Telescopic Manlift Truck	5.50	.30	.20	.30		
Fork Lift (under 6 tons) & Straddle Truck	5.50	.30	.20	.30		
Truck Driver Helper	5.075	.30	.20	.30		
Chauffeurs	5.075	.30	.20	.30		
Bunker & Truck Loaders	5.20	.30	.20	.30		
Warehousemen (Counter Clerk)	5.25	.30	.20	.30		
Warehousemen	5.125	.30	.20	.30		
Washers, Greasers & Tiresmen	5.275	.30	.20	.30		
Gas Station Attendants	5.075	.30	.20	.30		
Fork Lift (Over 6 tons)	5.60	.30	.20	.30		
Material Engineer	5.42	.30	.20	.30		
Teamster Mechanic	6.31	.30	.20	.30		
Teamster Mechanic Helper	6.06	.30	.20	.30		
Teamster Welder	6.31	.30	.20	.30		
Teamster Driving Two Horses	5.075	.30	.20	.30		
Teamster Driving Three or More Horses	5.175	.30	.20	.30		

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****AREA 2**

TRUCK DRIVERS

DUMP TRUCKS - Water Level Capacity (bottom end or side) (including Dumpster Trucks, Euclid type trucks, Turnwagons, Turnrockers & Dumpcrete):
 Less than 8 yards
 8 yards & less than 14 yards
 14 yards & less than 35 yards
 35 yards & less than 55 yards
 55 yards & less than 75 yards
 75 yards & less than 95 yards
 95 yards & less than 105 yards
 Over 105 yards

Whenever doubles are used, the drivers will be paid under the appropriate yardage schedule as outlined plus 25¢ per hour.

When three (3) or more trailers are put into operation, use the appropriate yardage rate as outlined above plus 25¢ per hour for the third (3rd) and each additional trailer which is pulled by one power unit.

Whenever additional power units are used and operated by one driver, he shall receive an additional 50¢ per hour for operating such equipment.

FLAT RACK TRUCKS, Bulk Cement Trucks, Transport Trucks, Semi-Trailer (Carrying capacity):
 Pickup
 Less than 10 tons
 10 tons & less than 15 tons
 15 tons & less than 20 tons
 20 tons & over

Employees driving any of the above on Flat Rack Trucks with Winch, Hoist Attachments or "A" Frames shall receive \$.125 additional per hour when such winch hoist or "A" Frames are in use.

When drivers load and unload sack cement, explosives and/or railroad ties by hand they shall receive \$.15 per hour additional for actual hours worked.

	BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
		H & W	PENSIONS	VACATION	APP TR.	OTHERS
Less than 8 yards	6.30	.30	.20	.30		
8 yards & less than 14 yards	6.45	.30	.20	.30		
14 yards & less than 35 yards	6.60	.30	.20	.30		
35 yards & less than 55 yards	6.80	.30	.20	.30		
55 yards & less than 75 yards	7.00	.30	.20	.30		
75 yards & less than 95 yards	7.20	.30	.20	.30		
95 yards & less than 105 yards	7.40	.30	.20	.30		
Over 105 yards	7.52	.30	.20	.30		
Pickup	6.125	.30	.20	.30		
Less than 10 tons	6.20	.30	.20	.30		
10 tons & less than 15 tons	6.35	.30	.20	.30		
15 tons & less than 20 tons	6.45	.30	.20	.30		
20 tons & over	6.60	.30	.20	.30		

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**AREA 2

TRUCK DRIVERS - CONT'D

	BASIC HOURLY RATES	FRINGE BENEFITS PAYMENTS				
		H & V	PENNSON	VACATION	APP. TR.	OTHERS
TRANSIT MIX TRUCKS:						
4½ yards capacity & less	6.325	.30	.20	.30		
Over 4½ yards capacity to & including 6½ yards	6.425	.30	.20	.30		
Over 6½ yards	6.525	.30	.20	.30		
Concrete pumping trucks	6.525	.30	.20	.30		
WATER, FUEL & OIL TANK TRUCKS:						
0 to 1200 gallons	6.175	.30	.20	.30		
1200 to 2500 gallons	6.30	.30	.20	.30		
2500 to 4000 gallons	6.45	.30	.20	.30		
4000 to 6000 gallons	6.75	.30	.20	.30		
6000 gallons to less than 10,000 gallons	7.00	.30	.20	.30		
10,000 gallons to less than 15,000 gallons	7.25	.30	.20	.30		
15,000 gallons to less than 20,000 gallons	7.50	.30	.20	.30		
20,000 gallons to less than 25,000 gallons	7.75	.30	.20	.30		
Over 25,000 gallons	8.00	.30	.20	.30		
Whenever two water tanks are pulled, driver will receive 25¢ per hour in addition to the combined water gallonage rates.						
Oil Spreader Operator (on single man operation where boot man is not required)						
	7.00	.30	.20	.30		
CONSTRUCTION JOB SERVICEMEN:						
Telescopic Manlift Truck	6.50	.30	.20	.30		
Fork Lift (under 6 tons) & Straddle Truck	6.50	.30	.20	.30		
Truck Driver Helper	6.075	.30	.20	.30		
Chauffeurs	6.075	.30	.20	.30		
Bunker & Truck Loaders	6.20	.30	.20	.30		
Warehousemen (Counter Clerk)	6.25	.30	.20	.30		
Warehousemen	6.125	.30	.20	.30		
Washers, Greasers & Tirmen	6.275	.30	.20	.30		
Gas Station Attendants	6.075	.30	.20	.30		
Fork Lift (Over 6 tons)	6.60	.30	.20	.30		
Material Engineer	6.42	.30	.20	.30		
Teamster Mechanic	7.31	.30	.20	.30		
Teamster Mechanic Helper	7.06	.30	.20	.30		
Teamster Welder	7.31	.30	.20	.30		
Teamster Driving Two Horses	6.075	.30	.20	.30		
Teamster Driving Three or More Horses	6.175	.30	.20	.30		

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UTAH
AREA DEFINITIONS
for
Truck Drivers & Operating Engineers

*Area 2: All areas not included within Area 1 as defined below.

*Area 1: All areas included in the description defined below which is based upon township and range-lines as referenced to the Salt Lake City Base and Meridian:

Commencing at the intersection of the Utah-Nevada border and the Northerly line of Township 36S, thence easterly along the northerly lines of Township 36S to the Northeast corner of Township 36S, Range 17W.

Thence Northerly to the N.W. corner of township 35S, range 16W;
Thence Easterly to the N.E. corner of township 35S, range 16 W;
Thence Northerly to the N.W. corner of township 31S, range 15 W;
Thence easterly to the N.E. corner of township 31S, range 15 W;
Thence Northerly to the N.W. corner of township 26S, range 14 W;
Thence Easterly to the N.E. corner of township 26S, range 14 W;
Thence Northerly to the N.W. corner of township 25S, range 13 W;
Thence Easterly to the N.E. corner of township 25S, range 13 W;
Thence Northerly to the N.W. corner of township 24S, range 12 W;
Thence Easterly to the N.E. corner of township 24 S, range 12 W;
Thence Northerly to the N.W. corner of township 19 S, range 11 W;
Thence Easterly to the N.E. corner of township 19 S, range 11 W;
Thence Northerly to the N.W. corner of township 17 S, range 10 W;
Thence Easterly to the N.E. corner of township 17 S, range 10 W;
Thence Northerly to the N.W. corner of township 16 S, range 9 W;
Thence Easterly to the N.E. corner of township 16 S, range 9 W;
Thence Northerly to the N.W. corner of township 15 S, range 8 W;
Thence Easterly to the N.E. corner of township 15 S, range 8 W;
Thence Northerly to the S.W. corner of township 7 S, range 7 W;
Thence Westerly to the S.W. corner of township 7 S, range 10 W;
Thence Northerly crossing the Salt Lake Base line to the N.W. corner of township 6 N, range 10 W;
Thence Easterly to the N.W. corner of township 6 N, range 8 W;
Thence Northerly to the N.W. corner of township 12 N, range 8 W;
Thence Easterly to the N.E. corner of township 12 N, range 8 W;
Thence Northerly along the Westerly line of range 7 W to the Utah/Idaho border
Thence Easterly along the Utah/Idaho border crossing the Salt Lake Meridian to the intersection of the Utah/Idaho/Wyoming borders
Thence Southerly along the Utah/Wyoming Border
Thence Easterly along the Utah/Wyoming border to the Easterly line of range 11 E;
Thence Southerly along the East line of range 11 E, crossing the Salt Lake Base line to the N.E. corner of township 4 S, range 11 E;
Thence Easterly to the N.W. corner of township 4 S, range 18 E;
Thence Northerly to the N.W. corner of township 1 S, range 18 E;
Thence Easterly along the Salt Lake Base line to the N.E. corner of township 1 S, range 24 E;
Thence Southerly to the N.E. corner of township 3 S, range 24 E;
Thence Easterly along the Northern line of township 3 S, to the Utah/Colorado border;

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Thence Southerly along the Utah/Colorado border, to the Southerly line of township 6 S;
Thence Westerly to the N.E. corner of township 7 S, range 23 E;
Thence Southerly to the S.E. corner of township 7 S, range 23 E;
Thence Westerly to the S.W. corner of township 7 S, range 20 E;
Thence Southerly to the S.E. corner of township 8 S, range 19 E;
Thence Westerly to the S.E. corner of township 8 S, range 16 E;
Thence Southerly to the S.E. corner of township 11 S, range 16 E;
Thence Westerly to the S.E. corner of township 11 S, range 14 E;
Thence Southerly to the S.E. corner of township 16 S, range 14 E;
Thence Westerly to the S.E. corner of township 16 S, range 12 E;
Thence Southerly to the S.E. corner of township 20 S, range 12 E;
Thence Westerly to the S.E. corner of township 20 S, range 8 E;
Thence Southerly to the S.E. corner of township 21 S, range 8 E;
Thence Westerly to the S.E. corner of township 21 S, range 6 E;
Thence Southerly to the S.E. corner of township 23 S, range 6 E;
Thence Westerly to the S.E. corner of township 23 S, range 5 E;
Thence Southerly to the N.E. corner of township 27 S, range 5 E;
Thence Easterly to the N.E. corner of township 27 S, range 7 E;
Thence Southerly to the S.E. corner of township 30 S, range 7 E;
Thence Westerly to the S.E. corner of township 30 S, range 4 E;
Thence Southerly to the S.E. corner of township 31 S, range 4 E;
Thence Westerly to the S.W. corner of township 31 S, range 4 E;
Thence Southerly to the S.E. corner of township 35 S, range 3 W;
Thence Westerly to the S.W. corner of township 35 S, range 3 E;
Thence Southerly to the S.E. corner of township 37 S, range 2 E;
Thence Westerly to the S.W. corner of township 37 S, range 2 E;
Thence Southerly to the S.E. corner of township 39 S, range 1 E;
Thence Westerly crossing the Salt Lake Meridian to the S.E. corner of township 39 S, range 2 W;
Thence Southerly to the S.E. corner of township 41 S, range 2 W;
Thence Westerly to the S.E. corner of township 41 S, range 4 W;
Thence Southerly along the Easterly line of range 4 W, to the Utah/Arizona border;
Thence Westerly along the Utah/Arizona border to the S.W. corner of Utah;
Thence Northerly along the Utah/Nevada border to the point of beginning;

* * * * *

Commencing at the intersection of the Utah/Colorado border and the Southerly line of township 34 S,
Thence Westerly to the S.W. corner of township 34 S, range 21 E;
Thence Northerly to the S.W. corner of township 29 S, range 21 E;
Thence Westerly to the S.W. corner of township 29 S, range 19 E;
Thence Northerly to the N.W. corner of township 23 S, range 19 E;
Thence Easterly to the N.W. corner of township 23 S, range 22 E;
Thence Northerly to the N.W. corner of township 21 S, range 22 E;
Thence Easterly to the N.W. corner of township 21 S, range 24 E;
Thence Southerly to the N.E. corner of township 31 S, range 24 E;
Thence Easterly along the Northerly line of township 31 S, to the Utah/Colorado border;
Thence Southerly along the Utah/Colorado border to the point of beginning.

NOTE: Truck Drivers only - If any part of portion of any job or project falls within Area 2, then the Area 2 rate of pay will apply for all work done on said job or project. This means, all actual on-site work, such as dams, bridges, roads, etc., including borrow pits which may be located in Area 1.

APPENDIX VI

PROGRAM LISTINGS

SUMMARY

This appendix contains the FORTRAN listing of the computer program developed for simulating the Layout Tunnel and listings of all tunneling subroutines. Definitions of common variables used in these programs are given.

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I. COMMON VARIABLE DEFINITIONS

COMMON /OLDCOM/ PARAMETERS/FLAGS THAT CHANGE WITH TIME

DUMMY(20) NOT USED AT PRESENT

HEATJ HEAT ADDED TO TUNNEL FROM WATER JET (OR PROJECTILE) RTU

IFXCA STATUS VARIABLE FOR GROUND SUPPORT 1-GROUND SUPPORT FALLEN
BEHIND EXCAVATOR, 0-GROUND SUPPORT NOT BEHIND

IFILD FLAG INDICATING DISCHARGE AREA IS FILLED
1-DISCHARGE AREA FILLED, 0-DISCHARGE AREA NOT FILLED

JUMIN STATUS VARIABLE FOR DRILL AND BLAST MOVING OF JUMBO DRILL
TO FACE 0-MOVING IN PROGRESS, 1-MOVING COMPLETED

JUMOUT STATUS VARIABLE FOR DRILL AND BLAST MOVING JUMBO DRILL FROM FACE
0-MOVING IN PROGRESS, 1-MOVING COMPLETED

KSTOP(25) REASON FOR TRAIN/TRUCK 1 TO HAVE STOPPED
(SEE APPENDIX IV, DESCRIPTION OF RAIL SYSTEM)

KUNLO FLAG FOR UNLOADING IN DISCHARGE AREA 1-UNLOADING STOPPED,
0-UNLOADING CONTINUING

LOADR STATUS VARIABLE FOR INTEGRATED CONVEYOR LOADER 1-LOADER CAPACITY
EXCEEDED, 0-LOADER CAPACITY NOT EXCEEDED VARIABLE ALSO USED FOR
MACHINE LOADERS AND SHOVELS 1-LOADING FINISHED, 0-LOADING IN
PROGRESS

LSTOP FLAG TO SHUT DOWN OR BRING UP LONG HAUL TRAINS/TRUCKS SYSTEM
1-SYSTEM SHUT DOWN, 0-SYSTEM UP

LVEHCL STATUS VARIABLE FOR LONG HAUL TRAINS/TRUCKS 0-VEHICLE NOT
AVAILABLE FOR LOADING, UNEQUAL TO 0- VEHICLE AVAILABLE FOR LOADING
EQUIVALENCE (LVEHCL * LTRAIL * LTRUCK)

MACON STATUS VARIABLE FOR CONVEYOR (LONG HAUL)
1-MAINTENANCE IN PROGRESS, 0- MAINTENANCE COMPLETED

MCAPC STATUS VARIABLE FOR CONVEYOR (LONG HAUL) 0-CAPACITY OF BELT NOT
EXCEEDED, 1-CAPACITY OF BELT EXCEEDED

MCV STATUS VARIABLE FOR INTEGRATED CONVEYOR LOADER (OR MACHINE
LOADERS AND SHOVELS) 1-MAINTENANCE IN PROGRESS, 0-MAINTENANCE
COMPLETED

MFLAGC FLAG TO INDICATE SHORT HAUL MATERIALS HANDLING STOPPED
0-NOT STOPPED, 1 OR GREATER THAN 1-STOPPED

MGS(1) 1=1-5 STATUS VARIABLE FOR GROUND SUPPORT TYPE 1
1=1-NO SUPPORT, 1=2-ROCK BOLTS, 1=3-SHOTCRETE, 1=4-STEEL SETS
1=5-LAGGING
0- MAINTENANCE COMPLETED, 1-MAINTENANCE IN PROGRESS

MKIN STATUS VARIABLE FOR MACHINE LOADERS 1-MUCKERS COMPLETED MOVE
TO FACE, 0-MUCKERS MOVE TO FACE IN PROGRESS

MKOUT STATUS VARIABLE FOR MACHINE LOADERS 1-MUCKERS COMPLETED
MOVE FROM FACE, 0-MUCKERS MOVE FROM FACE IN PROGRESS

MWJ STATUS VARIABLE FOR PROJECTILE AND WATER JET 0-OPERATING,
1 OR GREATER THAN 1 -STOPPED
EQUIVALENCE (MPI * MWJ)

MWJM STATUS VARIABLE FOR WATER JET (OR PROJECTILE) 0-MAINTENANCE IN
PROGRESS, 1-MAINTENANCE COMPLETED

MWJR STATUS VARIABLE FOR REPOSITIONING WATER JET (OR PROJECTILE)
0-REPOSITIONING IN PROGRESS, 1-REPOSITIONING COMPLETED

NRARL STATUS VARIABLE FOR PROJECTILE 0-BARREL REPLACEMENT IN PROGRESS,
1-BARREL REPLACEMENT COMPLETED

NBYRY FLAG TO INDICATE FEEDER RUN AWAY TOLERANCE EXCEEDED
1-TOLERANCE EXCEEDED, 0-TOLERANCE NOT EXCEEDED

NCHRG STATUS VARIABLE FOR DRILL AND BLAST CHARGE SETTING

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1-CHARGE SETTING COMPLETED, 0-CHARGE SETTING IN PROGRESS
 STATUS VARIABLE FOR DRILL AND BLAST 0-DRILLING IN PROGRESS.
 1-DRILLING COMPLETED
 STATUS VARIABLE FOR DRILL AND BLAST 0-BURN CUT DRILLING IN PROGRESS
 1-BURN CUT DRILLING COMPLETED
 STATUS VARIABLE FOR CONVEYOR(LONG HAUL) 0-SPLICING BELT COMPLETED
 1-UNEQUAL TO 0-SPLICING BELT IN PROGRESS
 STATUS VARIABLE FOR TRAINS/TRUCKS
 0-SWITCH MOVE OR ADD COMPLETED, 1-SWITCH BEING ADDED, 2-SWITCH
 BEING MOVED
 EQUIVALENCE (NSWCH, NSWCH)
 NTRDA NUMBER OF TRAINS IN DISCHARGE AREA
 NVEHCL NUMBER OF TRAINS/TRUCKS ACTIVE
 EQUIVALENCE (NVEHCL, NTRAIN, NTRUCK)
 NUMSWT NUMBER OF SWITCHES IN TRAIN/TRUCK SYSTEM
 QL AVERAGE LOADING VOLUME RATE FOR MACHINE LOADERS AND SHOVELS
 FEET**3/HOUR
 QWATR VOLUME OF WATER ADDED TO TUNNEL FROM WATER JET FEET**3
 SM FEEDER RUN AWAY TOLERANCE, FT
 SWITCH(20) LOCATION OF SWITCHES FEET FROM DISCHARGE AREA
 TFC(25) CUMULATIVE COST FOR TRAIN/TRUCK I \$
 TOP(25) CUMULATIVE TIME IN OPERATION FOR TRAIN/TRUCK I HOURS
 TSTAT(25,4) CURRENT STATUS OF TRAIN/TRUCK I
 EQUIVALENCE (TSTAT, ITSTAT)
 (SEE APPENDIX IV, DESCRIPTION OF PAIL SYSTEM)
 UTIME(25) TIME REMAINING IN UNLOADING OF TRAIN/TRUCK I, HR
 XGS DISTANCE FROM DISCHARGE AREA TO GROUND SUPPORT POSITION FEET

COMMON /NEWCOM/ UPDATED VALUES OF THOSE VARIABLES IN /OLDCOM/

EQUIMMY(20) UPDATED VALUES OF DUMMY(20)
 FHEATJ UPDATED VALUE OF HEATJ
 LIFXCA UPDATED VALUE OF IFXCA
 LIFILD UPDATED VALUE OF IFILD
 LJUMIN UPDATED VALUE OF JUMIN
 LJUMOT UPDATED VALUE OF JUMOT
 LKSTOP(25) UPDATED VALUE OF KSTOP(25)
 LKINLO UPDATED VALUE OF KINLO
 LLOADR UPDATED VALUE OF LOADR
 LLSTOP UPDATED VALUE OF LSTOP
 LLVHCL UPDATED VALUE OF LVEHCL
 EQUIVALENCE (LLVHCL, LLTRAN, LLTRUCK)
 LMACON UPDATED VALUE OF MACON
 LMCAFC UPDATED VALUE OF MCAFC
 LMCV UPDATED VALUE FOR MCV
 LMFLAC UPDATED VALUE OF MFLAC
 LMGS(I) UPDATED VALUE FOR MGS(I)
 LMKIN UPDATED VALUE OF MKIN
 LMJKOT UPDATED VALUE OF MJOT
 LMWJ UPDATED VALUE OF MWJ
 EQUIVALENCE (LMWJ, LMWJ)
 LMWJM UPDATED VALUE OF MWJM
 LMWJR UPDATED VALUE OF MWJR
 LNRAHL UPDATED VALUE OF NRAHL
 LNRYHY UPDATED VALUE OF NRYHY
 LNCHRG UPDATED VALUE OF NCHRG
 LNDRIL UPDATED VALUE OF NDRIIL
 LNDRILB UPDATED VALUE OF NDRIILB
 LNSPLC UPDATED VALUE OF NSPLC
 LNSWCH UPDATED VALUE OF NSWCH
 LNTRDA UPDATED VALUE OF NTRDA
 EQUIVALENCE (LNTRDA, NTRDA)
 LNVHCL UPDATED VALUE OF NVEHCL
 EQUIVALENCE (LNVHCL, LNTRAN, LNTRUCK)
 LNUMSWT UPDATED VALUE OF NUMSWT

FOL UPDATED VALUE OF QL
 FOWATR UPDATED VALUE OF QWATR
 FSM UPDATED VALUE OF SM
 FSWTCH(20) UPDATED VALUE OF SWTCH(20)
 FTFC(25) UPDATED VALUE OF TFC(25)
 FTOP(25) UPDATED VALUE OF TOP(25)
 FTSTAT(25,4) UPDATED VALUE OF TSTAT(25,4)
 EQUIVALENCE (FTSTAT,LTSTAT)
 FUTURE(25) UPDATED VALUE OF UTIME(25)
 FXGS UPDATED VALUE OF XGS

COMMON /ALL / GENERAL DATA

XT MAXIMUM DISTANCE FROM PORTAL ASSOCIATED WITH THE FOLLOWING SIX
 CONDITIONS .FEET
 STP UNCONFINED COMPRESSIVE STRENGTH OF ROCK. $1.E3$ LB/IN**2
 IA ROCK ABRASIVE INDEX
 RQI ROCK QUALITY DESIGNATION
 CS IN SITU DENSITY OF ROCKS. LB/FT**3
 TAMR AMBIENT TEMPERATURE. DEGREES FAHRENHEIT
 FLOW WATER INFLOW RATE. GPM
 IFLAG FLAG (NOT USED AT PRESENT)
 EQUIVALENCE (G(1),XT),(G(4),IFLAG)
 AT CROSS SECTIONAL AREA OF TUNNEL. FT**2
 D DIAMETER OF TUNNEL. FT
 DTORNT TIME BETWEEN POINT OUT OF WORKING COMMON HOURS
 DT TIME INCREMENT. HR
 DV VOLUME OF ROCK BROKEN IN DT. FT**3
 DX ADVANCE OF FACE IN DT. FT
 E ENERGY REQUIRED PER ROCK VOLUME BROKEN. IN-LB/1.E3 IN**3
 ICHNG FLAG TO INDICATE THAT GEOLOGY HAS CHANGED 0-GEOLOGY NOT CHANGED
 1-GEOLOGY CHANGED
 ICHNG HEADING POSITION OF LAST GEOLOGY PARAMETER CHANGE FT
 ICHNG TIME FROM START OF RUN OF LAST GEOLOGY PARAMETER CHANGE HOURS
 IMOVE FLAG TO INDICATE METHOD OF LONG HAUL MATERIALS HANDLING
 1-PATLS,2-TRUCKS,3-BELTS
 EQUIVALENCE (IMOVE,IMOVE)
 JMETH FLAG TO INDICATE METHOD FOR ROCK FRAGMENTATION
 1-BORING MACHINE,2-BLAST,3-WATER JET,4-PROJECTILE
 EQUIVALENCE (JMETH,IMETH)
 OPDCT FRACTION OF TOTAL COST FOR OVERHEAD
 PR POWER RATE. \$/KW-HR
 EQUIVALENCE (OPDCT)
 REPORT TIME INTERVALS BETWEEN INTERIM REPORTS(HOURS)
 SK ROCK SWELL FACTOR
 T TIME. HR
 TMAX MAXIMUM TIME FOR CURRENT SIMULATION RUN. HR
 TO INITIAL VALUE OF T HOURS
 TPRINT PRINT OUTPUT WHEN T=TPRINT. HR
 TSHFT TOTAL SHIFT TIME PER DAY HOURS
 X POSITION OF FACE FROM DISCHARGE AREA,FT
 XOTSCH DISTANCE FROM TUNNEL PORTAL TO DISCHARGE AREA FEET
 XMAX MAXIMUM DISTANCE FOR CURRENT SIMULATION RUN. FT
 XO INITIAL VALUE OF X FEET

COMMON /BORING/ BORING MACHINE ACTIVITIES

ROMEN(I) NUMBER OF MEN IN LABOR CATEGORY I (I=1,10) FOR BORING MACHINE
 SYSTEM
 ROCS(I) HOURLY COST OF MAN IN LABOR CATEGORY I FOR BORING MACHINE SYSTEM
 CL(3) LIFE OF CUTTERS FEET OF CUTTER TRAVEL
 CPC COST PER CUTTER. \$
 DTA TIME TO ASSEMBLE BORING MACHINE. HR
 DTC TIME BETWEEN BORING MACHINE MAINTENANCE PERIODS. HR

DTCD TIME TO CHANGE BORE DIAMETER, HR
 DTD TIME TO DISASSEMBLE BORING MACHINE, HR
 OTM DURATION OF BORING MACHINE MAINTENANCE, HR
 EROREQ COST OF BORING MACHINE UNIT/FOOT OF EXCAVATION
 ETRANS COST OF TRANSMISSION LINES/FOOT OF EXCAVATION
 KK NUMBER OF CUTTERS
 LNCHNG NUMBER OF CUTTERS CHANGED
 LNCUTR FLAG FOR CUTTER CHANGE 0-CUTTER CHANGE COMPLETED,
 1-CUTTERS BEING CHANGED
 MASSEM FLAG TO ASSEMBLE BORING MACHINE
 MRM FLAG FOR BORING MACHINE MAINTENANCE
 0-MAINTENANCE COMPLETED, 1-MAINTENANCE IN PROGRESS
 MRORE FLAG TO INDICATE STATUS OF BORING MACHINE 0=UP, UNFUAL 0=DOWN
 OR IOLE
 (SEE APPENDIX IV, DESCRIPTION OF CONTROL PROGRAM FOR LAYOUT TUNNEL)
 MCD FLAG FOR CHANGING BORING DIAMETER
 MDISAS FLAG FOR DISASSEMBLY OF BORING MACHINE
 NCUT(I) NUMBER OF THE CUTTER TO BE CHANGED ON THE I TH CHANGE FOR THIS
 TIME CYCLE I=1.50
 PRM ROTATIONAL HP OF BORING MACHINE, HP
 R(100) RADIAL LOCATIONS OF CUTTERS, IN
 RC CUTTER REPLACEMENT CRITERION, PERCENT WEAR
 RPM ROTATIONAL SPEED OF BORING HEAD, RPM
 TR TIME TO REPLACE ONE CUTTER, HR
 WEAR(I) WEAR OF CUTTER I (I=1,100)
 XPCP CUTTER BEARING COST, PERCENT CUTTER COST

COMMON /BLAST / DRILL AND BLAST ACTIVITIES

ADR AREA OF BURN CUT RELIEF HOLE, IN**2
 ADH AREA OF DRIFTER HOLE, IN**2
 CBIT DRIFTER BIT COST, \$
 CRURN COST OF BURN BIT, \$
 CCAP COST OF FIRING CAPS \$/CAP
 CEX COST OF EXPLOSIVE \$/LR.
 CM MISCELLANEOUS COST \$/HOLE
 CPL COST OF PRIMER \$/LBS
 CSTFFL COST OF STEEL, \$
 LRIT AVERAGE LIFE OF DRILL BIT, FT OF TUNNEL DUG
 LBURN AVERAGE LIFE OF BURN BIT, FT OF TUNNEL DUG
 LO AVERAGE DEPTH OF DRIFTER HOLES, FT
 LDA AVERAGE DEPTH OF BURN CUT HOLES, FT
 LSTEEL AVERAGE LIFE OF STEEL, FT OF TUNNEL DUG
 MEN NUMBER OF MEN OR AUTOMATED UNITS SETTING CHARGE
 ND NUMBER OF DRIFTER DRILLS
 NDR NUMBER OF BURN CUT DRILLS
 NH NUMBER OF DRIFTER HOLES
 NHR NUMBER OF BURN CUT HOLES
 PF POWDER FACTOR, LB/YD**3
 POH POWER OUTPUT OF BURN CUT DRILL, HP
 POD POWER OUTPUT OF DRIFTER DRILL
 SF APPARENT SPECIFIC ENERGY IN-LBS/IN**3
 TCHG TIME TO SET ONE CHARGE, HR
 TIN TIME TO MOVE IN JUMBO AND ALIGN, HR
 TOUT TIME TO MOVE OUT JUMBO, HR
 TYPEPF INDICATES EXPLOSIVE TO BE USED OPTION1-3=AMMONIUM NITRATE
 OPTION2-0=OXYNITE
 WPL AMOUNT OF PRIMER PER HOLE, LBS/HOLE

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COMMON/NJET/ WATER JET AND PROJECTILE ACTIVITIES

BLT BARREL OPERATING LIFETIME HOURS
 CPBRL COST PER BARREL FOR PROJECTILE GUN \$
 CSTPRJ PROJECTILE COST \$/PROJECTILE

DJMWJM JOB MATERIAL COST OF MAINTENANCE PERIOD FOR WATER JET
 (OR PROJECTILE) \$/MAINTENANCE PERIOD
 DNOZZ JET NOZZLE DIAMETER INCHES
 DTCJET TIME BETWEEN MAINTENANCE PERIODS FOR WATER JET (OR PROJECTILE)
 HOURS
 DTMJET LENGTH OF MAINTENANCE PERIOD FOR WATER JET (OR PROJECTILE)
 HOURS
 DTRJET TIME DURATION OF REPOSITIONING OPERATION FOR WATER JET
 (OR PROJECTILE) HOURS
 ENRGJ JET ENERGY REQUIRED PER VOLUME OF ROCK BROKEN
 FTAGN PROJECTILE GUN EFFICIENCY
 ETAJ EFFICIENCY OF WATER JET DEVICE
 ETAMP EFFICIENCY OF TRANSMITTING JET ENERGY
 ETAPT EFFICIENCY OF TRANSMITTING PROJECTILE ENERGY TO ROCK
 MONEJ MODE OF OPERATION 0-CONTINUOUS JET, 1-INTERMITTANT JET
 NGUNS NUMBER OF PROJECTILE GUNS
 NJETS NUMBER OF WATER JETS OPERATING
 PNOZZ WATER JET NOZZLE PRESSURE PSI
 PRM PULSE RATE FOR WATER JET PULSES/MIN
 PRJPM PROJECTILE GUN FEEDING RATE PROJECTILE/MIN
 PULSEO PULSE DURATION FOR WATER JET SECONDS
 TRRL TIME TO REPLACE BARREL FOR PROJECTILE GUN HOURS
 VFLPRJ PROJECTILE SPEED FEET/SEC
 VOLPRJ PROJECTILE VOLUME INCHES**3
 WPRJ PROJECTILE WEIGHT LBS.
 KRJET ADVANCE OF TUNNEL BEFORE REPOSITIONING OF WATER JET (OR PROJECTILE)
 IS REQUIRED FEET

COMMON /WHEELS/ TRAIN/TRUCK AND SHORT HAUL MATERIALS HANDLING ACTIVITIES

AF PEAK ACCELERATION, EMPTY, MPH/H
 AF PEAK ACCELERATION, FULL, MPH/H
 AMAX MAXIMUM ACCELERATION, MPH/H
 AMAXL MAXIMUM LOADING AREA, FT
 AMINL MINIMUM LOADING AREA REQUIRED, FT
 HSL DISTANCE BETWEEN SWITCHES, FT
 CAPCAP CAPACITY OF CAR OR TRUCK, YD**3
 CP COST OF FUEL OR POWER TO DRIVE TRAIN/TRUCK \$/HOUR
 DE AVERAGE DECELERATION RATE, EMPTY, MPH/H
 DF AVERAGE DECELERATION RATE, FULL, MPH/H
 DTAS TIME TO ASSEMBLE CALIFORNIA SWITCH, HR
 DTMA DAYS BETWEEN MAINTENANCE PERIODS, DAYS
 DTU TIME TO UNLOAD ONE TRAIN, HR
 ECONEO COST OF CONVEYOR EQUIPMENT/FOOT OF EXCAVATION
 ECONESS COST OF SUPPORTING STRUCTURE FOR CONV-LOAD/FOOT OF EXCAVATION
 EL EFFICIENCY OF LOCOMOTIVE OR POWER TRAIN
 FLOCO COST OF LOCOMOTIVE UNIT \$/HOUR USE
 FMUCKO COST OF MUCK CAR \$/HOUR OF USE
 FMMAINT COST OF MAINTENANCE SHOP FOR RAILS \$/FOOT OF EXCAVATION
 FSWITCH COST OF SWITCH \$/FOOT OF EXCAVATION
 FTRACKM COST OF TRACK MATERIALS \$/FOOT OF EXCAVATION
 FUNLOAD COST OF UNLOADING EQUIPMENT FOR RAILS \$/FOOT OF EXCAVATION
 FC FUEL CONSUMPTION RATE, GAL/HP-HR
 FR ROLLING RESISTANCE FACTOR
 FT TRACTION COEFFICIENT
 HPA PEAK HP AVAILABLE FOR ACCELERATION, HP
 HPFA POWER CONSUMPTION RATE, PEAK ACCEL, EMPTY, HP
 HPFV POWER CONSUMPTION RATE, PEAK VFL, EMPTY, HP
 HPFA POWER CONSUMPTION RATE, PEAK ACCEL, FULL, HP
 HPFV POWER CONSUMPTION RATE, PEAK VFL, FULL, HP
 HPV RATED HP FOR CONTINUOUS OPERATION, HP
 IIMORE FLAG TO INDICATE STATUS OF MORING MACHINE
 EQUIVALENCE (TIROPE, MROPE)
 (SEE APPENDIX IV, DESCRIPTION OF CONTROL PROGRAM FOR LAYOUT TUNNEL)
 ISW(25) INDICATES WHICH SWITCH TRAIN I- IS IN

LOCO TRAIN OPTION...1=DIESEL, 2=ELECTRIC
 LOUE TRAIN PRIORITY IN LOAD QUEUE
 MAXLD MAXIMUM NUMBER OF TRAINS IN LOADING AREA
 MC NUMBER OF AXLES PER MUCK CAR
 ML NUMBER OF AXLES PER LOCOMOTIVE
 MLTYP INDICATES UTILIZED(2) OR CONTINUOUS(1) CONVEYOR SYSTEM
 NCARS NUMBER OF CARS PER TRAIN
 NPOINT NUMBER OF POINTS IN TCURVX-TCURVY TABLE
 NTD MAXIMUM NUMBER OF TRAINS IN DISCHARGE AREA
 NINIT INITIAL NUMBER OF TRAINS IN SYSTEM
 NTH MAXIMUM NUMBER OF TRAINS IN MAINTENANCE AREA
 NTMAX MAXIMUM NUMBER OF TRAINS AVAILABLE
 XP DISTANCE CRITERION FOR NTMLP AND NTMLPP
 NTMLP NUMBER OF TRAINS PER MILE FOR X.LE.XP
 NTMLPP NUMBER OF TRAINS PER MILE FOR X.GT.XP
 NTRACK TRACK OPTION...1=SINGLE, 2=DOUBLE
 NUMLD NUMBER OF TRAIN/TRUCK AT FACE
 OUC VOLUME CAPACITY OF TRAIN, FT**3
 RAMEN(I) NUMBER OF MEN IN LABOR CATEGORY I (I=1,10) FOR RAIL SYSTEM
 PACST(I) HOURLY COST OF MAN IN LABOR CATEGORY I FOR RAIL SYSTEM
 SL LENGTH OF CALIFORNIA SWITCH, FT
 STATUS(36) TRAIN STATUS (HOLLERITH)
 TCCV MAINTENANCE PERIOD FOR SHORT HAUL MATERIALS HANDLING HOURS
 TMCV TIME BETWEEN MAINTENANCE PERIODS FOR SHORT HAUL MATERIALS
 HANDLING HOURS
 TMAINT DURATION OF MAINTENANCE PERIOD FOR TRAINS/TRUCKS HOURS
 TCURVX(20) VELOCITY ENTRY IN VELOCITY-VS-TRACTIVE FORCE TABLE
 TCURVY(20) TRACTIVE FORCE ENTRY IN VELOCITY-VS-TRACTIVE FORCE TABLE
 TWE WEIGHT OF EMPTY TRUCK, TONS
 VD VELOCITY IN DISCHARGE AREA, MPH
 VS VELOCITY IN SWITCH, MPH
 VE PEAK VELOCITY, EMPTY, MPH
 VF PEAK VELOCITY, FULL, MPH
 VMAX MAXIMUM VELOCITY ALLOWED FOR TRAINS, MPH
 WC WEIGHT OF EMPTY MUCK CARS, TONS
 WHY(24) REASON FOR STOPPING (HOLLERITH)
 WMR MAXIMUM MUCKING RATE TONS/HOUR
 WUC WEIGHT CAPACITY OF TRAIN, TONS
 WL WEIGHT OF LOCOMOTIVE, TONS
 XDS SPEED OF MOVING CALIFORNIA SWITCH, FT/HR

COMMON/CONVEY/ CONVEYOR(SHORT AND LONG HAUL) AND MACHINE LOADER ACTIVITIES .

AR MUCK FLOW CROSS SECTION, FT**2
 ACM MAXIMUM CROSS SECTION OF CONVEYOR STRUCTURE, FT**2
 CVMFN(I) NUMBER OF MEN IN LABOR CATEGORY I (I=1,10) FOR CONVEYOR LOADER
 CVCST(I) HOURLY COST OF MAN IN LABOR CATEGORY I (I=1,10) FOR CONVEYOR LOADER
 DMaint JOB MATERIAL COST FOR LONG HAUL CONVEYOR MAINTENANCE
 \$/MAINTENANCE PERIOD
 DTBS TIME TO DO A BELT SPLICE(LONG HAUL) HOURS
 DTCR TIME BETWEEN MAINTENANCE PERIODS FOR CONVEYOR(LONG HAUL) HOURS
 DTCM LENGTH OF MAINTENANCE PERIODS FOR CONVEYOR (LONG HAUL) HOURS
 DTMI TIME TO MOVE MUCKERS TO THE FACE (FOR MACHINE LOADERS AND
 SHOVELS) HOURS
 DTMO TIME TO MOVE MUCKERS AWAY FROM THE FACE (FOR MACHINE LOADERS
 AND SHOVELS) HOURS
 DWN TONNAGE HAULED BEFORE MAINTENANCE SCHEDULED FOR CONVEYOR(LONG
 HAUL) (ALTERNATIVE TO MAINTENANCE CRITERIA TO DTCR) TONS
 EE MOTOR AND REDUCTION EQUIPMENT EFFICIENCY
 FL LENGTH OF FEEDER FOR CONVEYOR SYSTEM (LONG HAUL) FEET
 FLM MAXIMUM LENGTH OF FEEDER BEFORE BELT SPLICE IS NEEDED(LONG HAUL
 CONVEYOR) USED IF NGE(GEOMETRY INDEX) IS 2 FEET
 HP TOTAL HP/LENGTH TO RUN CONVEYOR
 LNSURG FLAG FOR BELT SYSTEM LONG HAUL 1-SURGE BIN CAPACITY EXCEEDED,
 0-SURGE BIN CAPACITY NOT EXCEEDED

VFKON FLAG FOR BELT/PATL EXTENSION 1-EXTENSION SHUT DOWN
 NGE0 GEOMETRY MODEL INDEX FOR CONVEYOR SYSTEM
 1-CONTINUOUS EXTENSION ASSUMES FEEDER EXTENDS FULL LENGTH OF
 CONVEYOR
 2-CONTINUOUS EXTENSION ASSUMES FEEDER CONVEYOR EXTENSION IS SMALL
 (FL=0) AND EMPTIES INTO SHAFT DIRECTLY
 3-CYCLIC EXTENSION USING MINIMUM AND MAXIMUM ALLOWABLE
 DISTANCE FROM FACE FOR BELT
 NGE0 GEOMETRY MODEL INDEX FOR TRAIN/TRUCK SYSTEM
 1-CONTINUOUS EXTENSION, 2-CYCLIC EXTENSION
 NSURGE STATUS VARIABLE FOR LONG HAUL CONVEYOR SYSTEM
 1-SURGE BIN EXISTS FOR EXCESS MUCK, 0-NO SURGE BIN FOR EXCESS
 MUCK (LONG HAUL CONVEYOR)
 PC EQUIVALENC (PR, PC) SEE COMMON/ALL/

SUM4 AVERAGE MUCKING RATE CAPABILITY OF MACHINE LOADER FEET**3/HOUR
 JC SURGE BIN CAPACITY FEET**3
 DE VOLUME OF MUCK TO BE TAKEN OUT OF OR PUT IN SURGE BIN FEET**3
 DP PEAK VOLUME RATE OF CONVEYOR, FT**3/HR
 SMIN DISTANCE BETWEEN FACE AND CONVEYOR STRUCTURE, FT
 STIME TIME TO SWITCH UNITS WHEN USING MACHINE LOADERS AND SHOVELS
 WITH A UNITIZED SYSTEM OF LONG HAUL HOURS
 VRT BELT SPEED, FT/MIN
 WRT BELT WIDTH, IN
 WP ESTIMATED PEAK TONNAGE RATE, TONS/HR
 XE RAIL/HLT EXTENSION RATE, FT/HR
 EQUIVALENC (XF, XOE)
 XLF FLIGHT LENGTH, FT

COMMON /GRND / GROUND SUPPORT ACTIVITIES

FRDR1 COST OF ROCK BOLT DRILLS \$/HOUR
 FSCPLA COST OF SHOTCRETE \$/HOUR
 GROW TIME BETWEEN GROUND SUPPORT MAINTENANCE PERIODS HOURS
 GNET(I) NUMBER OF MEN IN LABOR CATEGORY I (I=1,10) FOR GROUND SUPPORT
 SYSTEM
 GCST(I) HOURLY COST OF MAN IN LABOR CATEGORY I FOR GROUND SUPPORT SYSTEM
 GSFTDD LENGTH OF GROUND SUPPORT MAINTENANCE PERIODS HOURS
 SFLDS GROUND SUPPORT FEET LOST DUE TO ROCK DISINTEGRATION STOPPED
 IST MAJOR GROUND SUPPORT TYPE BEING USED 1-NO SUPPORT, 2-ROCK BOLTS,
 3-SHOTCRETE, 4-STEEL SETS, 5-LAGGING
 IAS ADDITIONAL GROUND SUPPORT TYPE BEING USED 1-NO SUPPORT,
 2-ROCK BOLTS, 3-SHOTCRETE, 4-STEEL SETS, 5-LAGGING
 MAXPSS SUM-I=1,N NO. OF METHODS OF ROCK DISINTEGRATION FOR PDB(I)
 OR =0 IF DEFAULT TABLE IS TO BE USED
 PDBT(10,0) PRIMARY GROUND SUPPORT TABLE-SUM-I=1,N NO. METHODS OF ROCK
 FRAGMENTATION FOR EACH PDB MAXIMUM OF 60
 RATEHR RATE OF INSTALLATION OF ROCK BOLTS (ROCK BOLTS/HOURS)
 RATESC RATE OF INSTALLATION OF SHOTCRETE YARDS**3/HOURS
 RATESS RATE OF INSTALLATION OF STEEL SETS STEEL SETS/HOURS
 UCS COST OF STEEL \$/LR
 UCSC COST OF SHOTCRETE \$/YARD**3

COMMON /ENVC / ENVIRONMENTAL CONTROL ACTIVITIES

ANC(10) MAXIMUM ALLOWABLE CONCENTRATION OF GAS(N)I PARTS PER 10**6 BY
 VOLUME DEFAULT=0
 CKA CONDUCTIVITY OF AIR BTU/HR FT DEGF OFFAULT=.0147
 CPA SPECIFIC HEAT OF AIR BTU/LB DEG.F
 EVENTP COST OF VENTILATION PLANT \$/FOOT OF EXCAVATION
 FKO FRICTION FACTOR FOR DRIFTING OFFAULT=2.0**9
 FKT FRICTION FACTOR FOR TUNNEL OFFAULT=1.5**9
 HEAT HEAT ADDED TO TUNNEL IN BT FROM MACHINERY BTU
 MAXMEN MAXIMUM NO. OF MEN IN TUNNEL AT ANY TIME DEFAULT =0

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QD MINIMUM AIR VOLUME RATE PER DIESEL HORSEPOWER PER Q. BY LAW (CFM)
 DEFAULT=106.0.334*TOTHP
 QDR DESIGN REQUIREMENT OF AIR VOLUME RATE (CFM)
 QG(10) VOLUME RATE OF TOXIC GAS (N) ENTERING TUNNEL (CFM) DEFAULT=0
 DM MINIMUM AIR VOLUME RATE PER MAN REQUIRED BY LAW (CFM) DEFAULT=200
 REFRAT COST OF MECHANICAL REFRIGERATION PLANT \$/RTU DEFAULT=2.0E-6
 TA AMBIENT TEMPERATURE AT PORTAL DEG.F DEFAULT =0
 TD DESIGNED AIR TEMPERATURE AT TUNNEL FACE DEG.F DEFAULT =90.
 TOTHP MAXIMUM TOTAL DIESEL HORSEPOWER IN TUNNEL AT ANYTIME DEFAULT=0
 TRCK ROCK TEMPERATURE DFGREFS F
 VAMAX MAXIMUM VELOCITY OF AIR AT TUNNEL FACE (FPM) DEFAULT=1000
 VAMIN MINIMUM VELOCITY OF AIR AT TUNNEL FACE (FPM) DEFAULT=50
 VCMEN(I) NUMBER OF MEN IN LABOR CATEGORY I (I=1-10) FOR VENTILATION AND
 COOLING SYSTEM
 VCCST(II) HOURLY COST OF MAN IN LABOR CATEGORY I FOR VENTILATION AND
 COOLING SYSTEM
 WA DENSITY OF AIR LBS/FT**3 OFFALT=.075

COMMON/ PERFORM/ PERFORMANCE OF SYSTEM

DMHTM CUMULATIVE DOWN TIME OF MATERIALS HANDLING ACTIVITIES HOURS
 ECOTM CUMULATIVE DOWN TIME OF ENVIRONMENTAL CONTROL ACTIVITIES HOURS
 ECUTM CUMULATIVE UP TIME OF ENVIRONMENTAL CONTROL ACTIVITIES HOURS
 GADV AVERAGE ADVANCE DURING MAXIMUM ADVANCE DAY FEET/OPERATING HOUR
 GREG POSITION OF FACE FROM PORTAL AT START OF MAX ADVANCE DAY.FT
 GDAY NUMBER OF DAYS SINCE EXCAVATION STARTED AT END OF MAX ADVANCE DAY
 GFND HEADING POSITION (FEET) AT END OF MAXIMUM ADVANCE DAY
 GSOTM CUMULATIVE DOWN TIME OF GROUND SUPPORT ACTIVITIES HOURS
 GSUTM CUMULATIVE UP TIME OF GROUND SUPPORT ACTIVITIES HOURS
 RDOTM CUMULATIVE DOWN TIME OF ROCK DISINTEGRATION ACTIVITIES HOURS
 RDOTM CUMULATIVE UP TIME OF ROCK DISINTEGRATION ACTIVITIES HOURS
 UMHTM CUMULATIVE UP TIME OF MATERIALS HANDLING ACTIVITIES HOURS

COMMON /MONEY / COST ITEMS

DJM JOB MATERIAL COST FOR SETTING CHARGE. \$
 DJMRM CUMULATIVE COST FOR MATERIALS HANDLING MAINTENANCE \$
 DJMRMM JOB MATERIAL COST FOR ROCK FRAGMENTATION MAINTENANCE
 \$/MAINTENANCE PERIOD
 DJMFC CUMULATIVE COST OF JOB MATERIALS FOR ENVIRONMENTAL CONTROL \$
 DJMGS COST FOR GROUND SUPPORT MAINTENANCE \$/MAINTENANCE PERIOD
 DJMHH JOB MATERIAL COST FOR MATERIALS HANDLING. \$ TOTAL
 DJMHD JOB MATERIAL COST FOR ROCK FRAGMENTATION. \$ TOTAL
 DMAMT JOB MATERIAL COST FOR BELT MAINTENANCE. \$/MAINTENANCE PERIOD
 ROTIME CUMULATED LABOR TIME USED FOR ROCK FRAGMENTATION HOURS
 RTIME(II) CUMULATIVE LABOR TIME USED FOR MATERIALS HANDLING HOURS
 I=1-LABOR TIME USED FOR LONG HAUL SYSTEM
 I=2-LABOR TIME USED FOR SHORT HAUL SYSTEM
 ECTIME CUMULATIVE LABOR TIME USED FOR ENVIRONMENTAL CONTROL HOURS
 GSTIME CUMULATIVE LABOR TIME USED FOR GROUND SUPPORT SYSTEM HOURS
 ARE INDICES
 ECPLAN TOTAL COST OF PLANT AND EQUIPMENT FOR ENVIRONMENTAL CONTROLS
 GSPLAN TOTAL COST OF PLANT AND EQUIPMENT FOR GROUND SUPPORT \$
 MPLAN TOTAL COST OF PLANT AND EQUIPMENT FOR MATERIALS HANDLING \$
 JMCV COST OF MAINTENANCE FOR INTEGRATED CONVEYOR \$/MAINTENANCE PERIOD
 JMHMM JOB MATERIAL COST FOR TRAIN/TRUCK MAINTENANCE. \$/MAINTENANCE PERIOD
 PMGS PERMANENT MATERIALS COST FOR GROUND SUPPORT \$ TOTAL
 RPLAN TOTAL COST OF PLANT AND EQUIPMENT FOR ROCK DISINTEGRATION \$

COMMON /LABOR/ LABOR COSTS AND MEN

RDMEN(I,J) I=1-10-LABOR CATEGORIES FOR ROCK FRAGMENTATION
 I=1-NUMBER OF MEN IN LABOR CATEGORY I

J=2-HOURLY COST OF ONE MAN IN LABOR CATEGORY I
 EQUIVALENCE(POMEN(I),POMEN(I),I)
 EQUIVALENCE(POCST(I),POMEN(I,2))
 HMFN(I,J,K) I=1-10-LABOR CATEGORIES FOR MATERIALS HANDLING
 K=1-LONG HAUL LABOR CATEGORIES
 J=2-HOURLY COST OF ONE MAN IN LABOR CATEGORY I
 J=1-NUMBER OF MEN IN LABOR CATEGORY I
 EQUIVALENCE(PAMEN(I),HMFN(I,1,I))
 EQUIVALENCE(PACST(I),HMFN(I,2,I))
 K=2-SHORT HAUL LABOR CATEGORIES
 J=1-NUMBER OF MEN IN LABOR CATEGORY I
 J=2-HOURLY COST OF ONE MAN IN LABOR CATEGORY I
 EQUIVALENCE(CVMEN(I),HMFN(I,1,2))
 EQUIVALENCE(CVCST(I),HMFN(I,2,2))
 GSMFN(I,J) I=1-10-LABOR CATEGORIES FOR GROUND SUPPORT
 J=1-NUMBER OF MEN IN LABOR CATEGORY I
 J=2-HOURLY COST OF ONE MAN IN LABOR CATEGORY I
 EQUIVALENCE(GMFN(I),GSMFN(I,1))
 EQUIVALENCE(GCST(I),GSMFN(I,2))
 ECMEN(I,J) I=1-10-LABOR CATEGORIES FOR ENVIRONMENTAL CONTROL
 J=1-NUMBER OF MEN IN LABOR CATEGORY I
 J=2-HOURLY COST OF ONE MAN IN LABOR CATEGORY I
 EQUIVALENCE(VCMEN(I),ECMEN(I,1))
 EQUIVALENCE(VCST(I),ECMEN(I,2))

II. INPUT FOR LAYOUT TUNNEL

A. CARD IMAGES

CARD	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
CARD-IMAGES...															
1	\$ORF RATLS														
2	\$GENEPL														
3	N=12.917.OT=.1.T=0.0.TMAX=25. X=12054. XMAX=17092. DTPRNT=1.														
4	NPPCT=.1.REFRNT=1. PR=.02.														
5	XD1SCM=12000.														
6	SK=1.7														
7	\$FND														
8	\$ORF														
9	R(1)=2.875.5.75.8.625.11.5.14.375.17.75.20.125.23.25.75.28.5.31.25.														
10	R(12)= 36.36.75.19.5.42.25.45.47.75.50.5.53.25.56.58.75.61.4375.														
CARD-IMAGES...															
11	R(23)=67.9375.66.0625.68.1875.70.3125.72.4375.73.6875.74.9375.														
12	PRM=600. ZPM=9. DTC=1.4. DTM=6.6. CL=1000000. 400000. 100000. PC=90.														
13	KK=24. DTA=176. DTCO=24. TR=.5. FRODFA=36.6. FTRMS=3.6. hJMMH=100.														
14	RDMFN=1.4.1.1														
15	HDCST=4.6.5.12.8.02.7.11.														
16	CPC=90. XCPC=3.38														
17	\$FND														
18	\$RAILS														
19	NUMLD=3.														
20	NVMFL=3. NIMAX=4. NIMLIP=0. NIMLPP=1. NCARS=10. CARCAP=7. WC=4.05. MC=2.														
CARD-IMAGES...															
21	WL=10. ML=24. NCO=1. HRY=100. HRS=140. VMAX=12. AMAX=220. OF=220. OF=220.														
22	YHAI=12. NIMAX=8. NIMAXA=MAXLBY. NTO=1. DTY=17. VMS=0.1. HRY=100.														
23	NL=342. HSL=4450. DTA=11. DTA=2000. VSE=2. TR=12. CM=75. AMAXL=274.														
24	EMT=274. VPR=10. FL=100. NTA=4. FMD=12.17. FTRMS=7.50. FWT=120.														
25	NMS=12.1. NITC=1.440.1400. N5CM=8. NDK=1. NED=0. FTRMS=1.10.100.320.														
26	THAI=240. TCR=250. TTA=200. TRMS=121.440. 220. 150.1.1.200.														
27	RDMFN=2.2.1.2.1.3.1														
28	RACST=7.70.7.20.7.70.7.20.8.00.5.32.7.11														
29	FUNLOA=.60. FRMAIN=1.00. CP=.14. JMMH=50.														
30	\$FND														
CARD-IMAGES...															
31	\$LOADR														
32	CVMFN=1.1														
33	VCCST=7.20.7.20														
34	MLTYP=1. WMR=175. TCCV=312. TMCV=8. ECONFU=4.65. FCONSS =4.00. JMCV=50.														
35	\$FND														
36	\$GROIND														
37	HCS=.1. UCSC=27. RATERH=4. RATEFC=17.5. MAXPSS=0. FRDRT=7.50														
38	GMFN=8.2														
39	GCST=7.00.7.20.														
40	FSCPLA=10.00. NJMS=50. RATESS=5.														
CARD-IMAGES...															
CARD-IMAGES...															
41	\$FND														
42	\$ENVIC														
43	VCMFN=1.1.2														
44	VCCST=8.02.7.11.7.00														
45	MAXMFN=60. TOTMP=300. TA=60. EVENTP=1.														
46	\$FND														

B. PARAMETER VALUES BEFORE INITIALIZATION BY THE SUBROUTINES

SRNFBL
N = 0.12917E+02.
DT = 0.1E+00.
X = 0.12054E+05.
XMAX = 0.17002E+05.
Y = 0.0.
YMAX = 0.25E+02.
DTORNT = 0.1E+01.
SK = 0.17E+01.
PR = 0.2E+01.
PPCT = 0.1E+00.
REPRY = 0.1E+01.
MESH = 0.1E+05.
E = 0.0.
SPIN


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$RORE
CL      = 0.1F+07. 0.4E+06. 0.1E+06.
CPC     = 0.8F+02.
DTA     = 0.176F+03.
DTC     = 0.14F+01.
DTCN    = 0.24E+02.
DTD     = 0.0.
DTM     = 0.66F+01.
KK      = 29.
PRM     = 0.6F+03.
R       = 0.2875F+01. 0.575F+01. 0.8625F+01. 0.115F+02. 0.1475F+02. 0.1775F+02. 0.20125F
          0.2575F+02. 0.285F+02. 0.3125F+02. 0.34F+02. 0.3675F+02. 0.395F+02. 0.4225F+02.
          0.4775F+02. 0.505F+02. 0.5325F+02. 0.56F+02. 0.5875F+02. 0.61475F+02. 0.639375
          0.661875F+02. 0.703125F+02. 0.724375F+02. 0.736875F+02. 0.749375F+02. 0.0. 0.0.
          0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
          0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
          0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
RC      = 0.9F+00.
RPM     = 0.6F+01.
TR      = 0.5F+00.
XCPC    = 0.338F+01.
FROREQ  = 0.346F+02.
FTRANS  = 0.34F+01.
NJMMMM  = 0.1F+03.
ROMFN   = 0.1F+01. 0.4F+01. 0.1F+01. 0.1F+01. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
ROCST   = 0.844F+01. 0.532E+01. 0.802E+01. 0.711F+01. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
SEND

```

RATIOS	
AF	= 0.0.
AF	= 0.0.
AMAX	= 0.72F.03.
AMAXL	= 0.274F.03.
AMINL	= 0.274F.03.
RSL	= 0.965F.04.
CARCAP	= 0.7F.01.
CP	= 0.14F.00.
DF	= 0.72F.03.
DF	= 0.72F.03.
DYAS	= 0.11F.02.
DYMA	= 0.914F.00.
DTU	= 0.17F.00.
NSVCH	= 0.
NGFO	= 1.
NFRON	= 0.
XDF	= 0.12F.02.
AR	= 0.0.
VR1	= 0.0.
SN	= 0.75F.02.
FL	= 0.0.
FC	= 0.0.
FIR	= 0.0.
FT	= 0.0.
HFA	= 0.14F.03.
HDFV	= 0.0.
HDEA	= 0.0.
HDFV	= 0.0.
HPFA	= 0.0.
HDFV	= 0.0.

HPV = 0.1E+03.
 LOCO = 1.
 MC = 2.
 ML = 2.
 NCARS = 10.
 NPOINT = 0.
 NTD = 1.
 NTM = 2.
 NTMAX = 4.
 X5 = 0.1E+02.
 NTMILP = 0.
 NYMLPP = 1.
 NTPACK = 1.
 SL = 0.1E+03.
 TCHRVA = 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 TCHRVV = 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 YMATNY = 0.2E+01.
 TWE = 0.0.
 VD = 0.1E-01.
 VS = 0.2E+01.
 VF = 0.0.
 VF = 0.0.
 VMAX = 0.1E+02.
 WC = 0.405E+01.
 WL = 0.1E+02.
 XNS = 0.2E+04.
 MAXCO = 1.
 NVERCL = 1.
 NIMSWT = 1.
 SWITCH = 0.11E+05 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0

YSTA	=	0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
YDAS	=	0.11449F.05. 0.11449F.05. 0.11449F.05. 0.0. 0.0. 0.0. 0.1. 0.0. 0.0. 0.0. 0.
YSPD	=	0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.
YMAIN	=	0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.
KSTOP	=	1. 101. 102. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
MLTYP	=	0.
WNR	=	0.0.
FLOC0	=	0.15F.01.
FMUICK	=	0.17F.00.
FTRACK	=	0.75F.01.
FSWITC	=	0.0.
FINLQA	=	0.6F.00.
FRMATH	=	0.1F.01.
JMMMM	=	0.5F.02.
NIMLD	=	0.
ISW	=	1. 1. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
RAMFN	=	0.2F.01. 0.2F.01. 0.1F.01. 0.2F.01. 0.1F.01. 0.3F.01. 0.1F.01. 0.0. 0.0. 0.0.
RACST	=	0.77F.01. 0.72F.01. 0.77F.01. 0.72F.01. 0.8F.01. 0.532F.01. 0.711F.01. 0.0. 0.
SFND	=	

\$LOADER											
AR	=	0.0.									
VRI	=	0.0.									
SM	=	0.75E+02.									
TCCV	=	0.312E+03.									
TMCV	=	0.8E+01.									
WWR	=	0.175E+03.									
MLTYP	=	1.									
ECONFO	=	0.465E+01.									
FCONSS	=	0.4E+01.									
JMCV	=	0.5E+02.									
CVMFN	=	0.1E+01.	0.1E+01.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.
CVCST	=	0.72E+01.	0.72E+01.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.
SFND											

\$GRIND										
UCS	=	0.175	0.0							
UPSC	=	0.275	0.0							
RATFOR	=	0.65	0.0							
RATFSC	=	0.175	0.0							
RATFSS	=	0.55	0.0							
MAXPSS	=	0.								
FRANDI	=	0.75	0.0							
FSCPLA	=	0.15	0.0							
DUMGS	=	0.55	0.0							
GNOW	=	0.0								
GSFTDD	=	0.0								
GMFN	=	0.45	0.0	0.25	0.0	0.0	0.0	0.0	0.0	0.0
GSY	=	0.75	0.0	0.75	0.0	0.0	0.0	0.0	0.0	0.0
\$END										

SFNVIRC

EVENTP = 0.1E+01.

MAXMFM = 40.

TOTHP = 0.3E+03.

TA = 0.4E+02.

DM = 0.0.

DD = 0.0.

VAHTN = 0.0.

VAHAY = 0.0.

TD = 0.0.

MA = 0.0.

CMA = 0.0.

CVA = 0.0.

MPYRAY = 0.0.

AUC = 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.

VCMFN = 0.1E+01. 0.1E+01. 0.2E+01. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.

VCCST = 0.402E+01. 0.711E+01. 0.7E+01. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.

CPIHP = 0.0.

PKT = 0.0.

SFND

TUNNEL CROSS SECTION = 131.0428 SQ FT

RAIL PARAMETERS -	VF	VF	RF	RF	GE	GF	HPFV	HPFV
	12.000	12.000	742.170	916.050	50.500	145.000	29.687	76.642

TRAIN CAPACITY = 1890.0000 CUBIC FEET AND 94.5000 TONS

RAIL EXTENSION - EXT. RATE = 12.00 SWITCH MOVE RATE = 2000.00 DISTANCE BETWEEN SWITCHES = 8

RAIL MAINT. PARAMETERS - TIME TO REPAIR = 2.00 COST OF MATERIALS = 50.00 DAYS BETWEEN MAI

R00	PRIMARY GROUND SUPPORT		INTERFERENCE LENGTH-FT	SUPPORT TYPE	SPACING FT	THICKNESS T	COLUMN SIZE IN	AS
	EXCAVATION PROCESS	UNSUPPORTED LENGTH-FAVET						
95.00	5.00	999999.00	0.00	1.00	0.00	0.00	0.00	0.00
90.00	5.00	999999.00	0.00	1.00	0.00	0.00	0.00	0.00
90.00	2.00	10.00	0.00	1.00	0.00	0.00	0.00	0.00
75.00	5.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00
75.00	1.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00
75.00	2.00	5.00	0.00	1.00	0.00	0.00	0.00	0.00
50.00	5.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00
50.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
50.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.00	5.00	0.00	0.00	1.00	0.00	5.00	1.00	0.00
25.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.00	2.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NOTE. EXCAVATION PROCESS = 5 INDICATES ANY PROCESS OTHER THAN THOSE IN TABLE

C. PARAMETER VALUES AFTER INITIALIZATION BY THE SUBROUTINES

SIGNEWL	
D	= 0.12917E+02.
DT	= 0.1E+00.
X	= 0.12054E+05.
XMAX	= 0.17092E+05.
Y	= 0.0.
YMAX	= 0.25E+02.
OTPRNT	= 0.1E+01.
SR	= 0.1E+01.
PR	= 0.2E+01.
OPPCT	= 0.1E+00.
RFPRT	= 0.1E+01.
XDISCH	= 0.12E+05.
E	= 0.0.
SPND	

SRDF

CL = 0.1F+07. 0.4E+06. 0.1E+06.

CPC = 0.8E+02.

DTA = 0.176E+03.

DTC = 0.14E+01.

DYCD = 0.24E+02.

DTD = 0.0.

DTM = 0.66E+01.

KK = 20.

PRM = 0.4E+03.

R	=	0.2075E+01.	0.575E+01.	0.4625E+01.	0.115E+02.	0.14375E+02.	0.1775E+02.	0.20125E
		0.2575E+02.	0.248E+02.	0.3125E+02.	0.74E+02.	0.7675E+02.	0.795E+02.	0.4225E+02.
		0.4775E+02.	0.585E+02.	0.5125E+02.	0.56E+02.	0.5875E+02.	0.614375E+02.	0.619375
		0.491875E+02.	0.703125E+02.	0.724375E+02.	0.736875E+02.	0.749375E+02.	0.0.	0.0.
		0.0.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.
		0.0.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.
		0.0.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.
		0.0.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.

RC = 0.9E+00.

RPM = 0.6E+01.

TR = 0.5E+00.

XPC = 0.339E+01.

FRDFD = 0.746E+02.

FTRANS = 0.74E+01.

DJMRYM = 0.1E+03.

ROMEN = 0.1E+01. 0.4E+01. 0.1E+01. 0.1E+01. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.

RDCST = 0.846E+01. 0.532E+01. 0.802E+01. 0.711E+01. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.

SFND

SRATLS	
AF	= 0.0.
AF	= 0.0.
AMAX	= 0.72E+03.
AMAXL	= 0.276E+03.
AMINL	= 0.276E+03.
ASL	= 0.865E+04.
CARCAP	= 0.7E+01.
CP	= 0.14E+00.
DF	= 0.72E+03.
DF	= 0.72E+03.
DTAS	= 0.11E+02.
DTMA	= 0.914E+00.
DTU	= 0.17E+00.
NSACH	= 0.
NGEO	= 1.
NFXDN	= 0.
XDF	= 0.12E+02.
AR	= 0.0.
VAT	= 0.0.
SM	= 0.75E+02.
EL	= 0.8E+00.
FC	= 0.455E-01.
FR	= 0.0.
FT	= 0.25E+00.
HDA	= 0.14E+03.
HPEV	= 0.29688781909005E+02.
HPFA	= 0.0.
HPEV	= 0.29688781909005E+02.
HPFA	= 0.0.
HPFV	= 0.36641991909005E+02.

HPV = 0.1F+03.
 LOCO = 1.
 MC = 2.
 ML = 2.
 NCARS = 10.
 NPOINT = 0.
 NTO = 1.
 NTM = 2.
 NTMAX = 4.
 XP = 0.1F+02.
 NTMLP = 0.
 NTMLPP = 1.
 NTRACK = 1.
 SL = 0.36F+03.
 TCURVX = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0
 0.0, 0.0.
 TCURVY = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0
 0.0, 0.0.
 TMAINT = 0.2F+01.
 TWF = 0.0.
 VN = 0.1F+01.
 VS = 0.2F+01.
 VF = 0.12F+02.
 VF = 0.12F+02.
 VMAX = 0.12F+02.
 WC = 0.405F+01.
 WL = 0.1F+02.
 XNS = 0.2F+04.
 MAXLD = 3.
 NVFHCL = 3.
 NIHSWT = 1.
 SWITCH = 0.11449F+05, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
 0.0, 0.0, 0.0.

```

ISTA = 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
TPQS = 0.11489E+05. 0.11489E+05. 0.11489E+05. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
ISPD = 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
IMAIN = 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
KSTOP = 1. 101. 102. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
MLTYP = 1.
WWR = 0.175E+03.
FLOCO = 0.15E+01.
FMURK = 0.17E+00.
ETBACK = 0.75E+01.
ESWTC = 0.0.
FIMDQA = 0.5E+00.
FRMAIN = 0.1E+01.
JMUHM = 0.5E+02.
MIMD = 3.
ISV = 1. 1. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
RAMEY = 0.2E+01. 0.2E+01. 0.1E+01. 0.2E+01. 0.1E+01. 0.3E+01. 0.1E+01. 0.0. 0.0. 0.0.
RACST = 0.77E+01. 0.72E+01. 0.77E+01. 0.72E+01. 0.8E+01. 0.532E+01. 0.711E+01. 0.0. 0.
SEND

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SRRDIND										
UICS	=	0.13E+00.								
UICSC	=	0.27E+02.								
RATERB	=	0.4E+01.								
RATFSC	=	0.175E+02.								
RATFSS	=	0.5E+01.								
MAXPSS	=	0.								
FRRDRT	=	0.75E+01.								
FSCPLA	=	0.1E+02.								
QJMS	=	0.5E+02.								
GDDW	=	0.0.								
GSEFDD	=	0.0.								
GWFN	=	0.4E+01.	0.2E+01.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.
GCST	=	0.7E+01.	0.7E+01.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.	0.0.
SPND										

```

SLOADPR
AR = 0.0.
VRI = 0.0.
SM = 0.75E+02.
TCPV = 0.712E+03.
TMCV = 0.4E+01.
NMR = 0.175E+03.
MLTYP = 1.
FCONEQ = 0.465E+01.
FCOHSS = 0.4E+01.
JMCV = 0.5E+02.
CVMEN = 0.1E+01. 0.1E+01. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
CVCST = 0.72E+01. 0.72E+01. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
SFND

```

```

SFNVIRC
-----
EVENTP = 0.1F+01.
-----
MAXMFN = 40.
-----
TOTHP  = 0.3F+03.
-----
TA     = 0.6F+02.
-----
QM     = 0.2F+03.
-----
QN     = 0.2062F+03.
-----
VAMIN  = 0.5F+02.
-----
VAMAX  = 0.1F+04.
-----
TN     = 0.8F+02.
-----
WA     = 0.75F+01.
-----
CPA    = 0.24F+00.
-----
CKA    = 0.147F+01.
-----
DIFFRAT = 0.2F+05.
-----
AMC    = 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
-----
VCMFN  = 0.1F+01. 0.1F+01. 0.2F+01. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
-----
VCCST  = 0.802F+01. 0.711F+01. 0.7F+01. 0.0. 0.0. 0.0. 0.0. 0.0. 0.0.
-----
CPIJMP = 0.0.
-----
FKT    = 0.15F+07.
-----
SFND

```


III. PROGRAMS AND SUBROUTINES

A. PROGRAM GEOMOD

```

PROGRAM GEOMOD
C
C GENERATES GEOLOGY FILE
C
COMMON /IOCOM/ NLINE,NPAGE
C
C DIMENSION SURF(30,30,7),PROP(6,25),SPEC(7),INDEX(25),BUFF(27)
C
10 FORMAT (1H1,//////////,25X,86HEEEEEEE X X CCCCCC AAAA
A V V AAAA TTTTTT I 000000 NN N,/,25X,86HE
B X X C N A A V X A A T I O
C O N N N,/,25X,86HEEEEE X C AAAAAAA V
D V AAAAAAA T I O O N N N,/,25X,86HE X
E X C A A V V A A T I O O
F N N N,/,25X,86HEEEEEEE X X CCCCCC A A V A
G A T I 000000 N NN,/,
H 45X,40HM M 000000
I 00000 EEEEEEE L,/,45X,40HMM MM O O D O E
J L,/,45X,40HMM M M M O O D O EEEE L,/,45X,40HM
K M M O O D U E L,/,45X,46HM M 000000
L 00000 EEEEEEE LLLLLL,//////////,27X,14HPREPARED FOR ,59X
M,46BY ,/,14X,40UNITED STATES DEPARTMENT OF THE INTERIOR,34X,28H
N,GENERAL RESEARCH CORPORATION,/,26X,15HBUREAU OF MINES,50X,21HWASH
O,INGTON OPERATIONS,/,17X,34HBUILDING 20, DENVER FEDERAL CENTER,35X
P,20M1501 WILSON BOULEVARD, SUITE 700,/,22X,24HOENVER, COLORADO B
Q,025,43A,26HARLINGTON, VIRGINIA 22209,/,53X,30HUNDR CONTRACT N
R,UMBER H0110238)
C
C NLINE=999
C NPAGE=0
C *****5500
C READ (30,20,END=30) TAG1,TAG2, (SPEC(I),I=1,7)
C
C GO TO 50
C *****
C *****C0C0400
C READ 20, TAG1,TAG2,(SPEC(I),I=1,7)
C IF (EQ,49) 30,50
C *****
C
20 FORMAT (2A5,7F10.0)
30 PRINT 40
40 FORMAT (1H1,31(1H*),68H ABNORMAL ENDING - END OF INPUT FILE REACHE
-D - EXECUTION TERMINATED ,32(1H*))
45 PRINT 10
PRINT 10
CALL EXIT
50 PRINT 10
PRINT 10
60 IF (TAG1,EQ,5H0E0L0) GO TO 60
PRINT 70
70 FORMAT (1H1,13(1H*),104H THE FIRST CARD HAS TO BE A GEOLOGY CARD -
- PLEASE REFER TO PROGRAM DOCUMENTATION - EXECUTION TERMINATED ,
- 13(1H*))
STOP
80 N=SPEC(1)
SCALEX=SPEC(2)
NY=SPEC(3)
SCALEY=SPEC(4)
CALL PAGER(2)
PRINT 90, TAG1,TAG2,(SPEC(I),I=1,7)
NLINE=NLINE+2
90 FORMAT (/,26X,2A5,7F10.4)
C
C *****5500
C
100 READ (30,20,END=30) TAG1,TAG2, (SPEC(I),I=1,7)

```

```

C      ****
C      ****COC6400
100 READ 20, TAG1, TAG2, (SPEC(I), I=1, 7)
    IF (EOF, 49) 30, 110
C      ****
110 CALL PAGER(2)
    PRINT 90, TAG1, TAG2, (SPEC(I), I=1, 7)
    NLINE=NLINE+2
C
    IF (TAG1.NE.5HGEOLO) GO TO 130
    PRINT 120
120 FOPMAT (1H0, 38(1H*), 58H ERROR - TWO GEOLOGY CAROS PRESENT - EXECUT
    -ION TERMINATED , 37(1H*))
    GO TO 45
C
130 IF (TAG1.NE.5HSURFA) GO TO 160
    K=SPEC(1)
C      ****B5500
C 140 READ (30, 20, ENO=30) TAG1, TAG2, (SPEC(I), I=1, 7)
C      ****
C      ****COC6400
140 READ 20, TAG1, TAG2, (SPEC(I), I=1, 7)
    IF (EOF, 49) 30, 145
C      ****B5500
C 145 IF (TAG1 .NE. 5H      ) GO TO 110
    CALL PAGER(2)
    PRINT 90, TAG1, TAG2, (SPEC(I), I=1, 7)
    NLINE=NLINE+2
    I=SPEC(1)
    J=SPEC(2)
    IF (I*J.LE.0) GO TO 150
    SURF(I, J, K)=SPEC(3)
150 I=SPEC(4)
    J=SPEC(5)
    IF (I*J.LE.0) GO TO 140
    SURF(I, J, K)=SPEC(6)
    GO TO 140
C
160 IF (TAG1.NE.5HPLANE) GO TO 190
    K=SPEC(1)
    OEPTH=SPEC(2)
    DO 180 I=1, NX
    DO 170 J=1, NY
    SURF(I, J, K)=OEPTH
170 CONTINUE
180 CONTINUE
    GO TO 100
C
190 IF (TAG1.NE.5HRAISE) GO TO 230
200 K=SPEC(1)
    OIST=SPEC(2)
    DO 220 I=1, NX
    DO 210 J=1, NY
    SURF(I, J, K)=SURF(I, J, K)+OIST
210 CONTINUE
220 CONTINUE
    GO TO 100
C
230 IF (TAG1.NE.5HLOWER) GO TO 240
    SPEC(2)=-SPEC(2)
    GO TO 200
C
240 IF (TAG1.NE.5HTILT ) GO TO 250
    IA=SPEC(1)
    IR=SPEC(2)
    DEG=SPEC(3)

```

```

      AXIS=SPEC(4)
      PTX=SPEC(5)
      PTY=SPEC(6)
      PTZ=SPEC(7)
      CALL TILT(NX,NY,SCALEX,SCALEY,SURF(1,1,1A),
1      DEG,AXIS,SURF(1,1,1B),PTX,PTY,PTZ)
      GO TO 100
C
250 IF (TAG1.NE.5HBEND) GO TO 260
      IA=SPEC(1)
      ID=SPEC(2)
      IC=SPEC(3)
      IH=SPEC(4)
      SCOPE=SPEC(5)
      IF (SCOPE.EQ.0.0) SCOPE=AMINO(NX,NY,3)
      CALL BENDER(NX,NY,SCALEX,SCALEY,SURF(1,1,1A),SURF(1,1,1B),
1      SURF(1,1,1C),SURF(1,1,1D),SCOPE,DUMMY,DUMMY)
      GO TO 100
C
260 IF (TAG1.NE.5HPROPE) GO TO 280
      J=SPEC(1)
      DO 270 I=1,6
      PPOP(I,J)=SPEC(I*1)
270 CONTINUE
      GO TO 100
C
280 IF (TAG1.NE.5HGRAPH) GO TO 290
      CALL EPAGE
      N=1
283 K=SPEC(N)
      IF (SPEC(N).LE.0.0) GO TO 266
      CALL GRAPH (SURF(1,1,K),NX,NY,K)
      N=N+1
      IF (N.LT.8) GO TO 283
286 CALL PAGER(999)
      GO TO 100
C
290 IF (TAG1.NE.5HLAYER) GO TO 310
      ISURF=SPEC(1)
      IROCK=SPEC(2)
      ILAY=SPEC(3)
      INDEX(ILAY)=IROCK
      WRITE(ILAY,300) ((SURF(1,J,ISURF),J=1,NX),J=1,NY)
300 FORMAT ((1PE18.10))
      GO TO 100
310 IF (TAG1.NE.5HRELAX) GO TO 320
      K=SPEC(1)
      TOLER=SPEC(2)
      IF (TOLER.EQ.0.0) TOLER=0.005*(SCALEX*SCALEY)
      CALL RELAX(SURF(1,1,K),NX,NY,TOLER)
      GO TO 100
320 IF (TAG1.NE.5HMAKEF) GO TO 460
      IMAK=SPEC(1)
      IMAJ=SPEC(2)
      REWIND 50
      WRITE (50,330) NX,NY,SCALEX,SCALEY,(INDEX(ILAY),ILAY=1,25),
1      ((PROP(1,IROCK),I=1,6),IROCK=1,25)
330 FORMAT (2I5,2(1PE18.10),25I2,(1PE18.10))
      DO 340 I=1,IMAXL
      REWIND 1
340 CONTINUE
      DO 350 J=1,NY
      DO 370 I=1,NX
      BUFF(1)=I
      BUFF(2)=J
      DO 350 K=3,27

```

```

      BUFF(K) = -10.0 E+50
350 CONTINUE
      DD 360 K=1,IMAXL
C      *****B5500
C      READ (K,300,END=420) BUFF (K*2)
C      *****
C      *****CDC6400
      READ (K,300) BUFF(K*2)
      IF (EDF,K) 420,360
C      *****
360 CONTINUE
      WRITE (50,300) (BUFF(K),K=1,27)
370 CONTINUE
380 CONTINUE
      CALL EPAGE
      PRINT 390
390 FORMAT (27HIGEOMOD TERMINATED NORMALLY)
      GO TO 45
400 PRINT 410
410 FORMAT (1H,24H***** UNRECOGNIZED *****
1      82X,24H***** UNRECOGNIZED *****)
      GO TO 100
420 CALL EPAGE
430 PRINT 440,K
440 FORMAT (44HLOGICAL ERROR - YOU ATTEMPTED TO USE LAYER *11,
1      52H, BUT DID NOT SPECIFY IT BY MEANS OF A LAYER CARD - *
2      30HGEOLOGY FILE BUILDING DELETED.)
450 IF (K.GE.IMAXL) GO TO 45
      K=K+1
C      *****H5500
C      READ (K,300,END=430) BUFF (K*2)
C      GO TO 450
C      *****
C      *****CDC6400
      READ(K,300) BUFF(K*2)
      IF (EDF,K) 430,450
C      *****
C      460 IF (TAG1.NE.SMSCALE) GO TO 490
      ISURFA=SPEC(1)
      ISURFB=SPEC(2)
      SCALE=SPEC(3)
      DO 480 J=1,NY
      DO 470 I=1,NX
      SURF(I,J,ISURFB)=SCALE*SURF(I,J,ISURFA)
470 CONTINUE
480 CONTINUE
      GO TO 100
490 IF (TAG1.NE.SMSUM ) GO TO 520
      ISURFA=SPEC(1)
      ISURFB=SPEC(2)
      ISURFC=SPEC(3)
      DO 510 J=1,NY
      DO 500 I=1,NX
      SURF(I,J,ISURFC)=SURF(I,J,ISURFA)+SURF(I,J,ISURFB)
500 CONTINUE
510 CONTINUE
      GO TO 100
520 IF (TAG1.NE.SMDIFFE) GO TO 400
      ISURFA=SPEC(1)
      ISURFB=SPEC(2)
      ISURFC=SPEC(3)
      DO 540 J=1,NY
      DO 530 I=1,NX
      SURF(I,J,ISURFC)=SURF(I,J,ISURFA)-SURF(I,J,ISURFB)
530 CONTINUE
540 CONTINUE

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```

      GO TO 100
      END
      SUBROUTINE BENDER(NX,NY,SCALEX,SCALEY,A,B,C,D,E,F,G)
C
      DIMENSION A(30,30),B(30,30),C(30,30),D(30,30),BX(30,30),
1      BY(30,30),CLOSE(50,4),POINT(3,900),Q(6)
C
      COMPUTE THE PARTIAL DERIVATIVES FOR SURFACE B, THE NEW MEDIAN.
C
      DX=0.5/SCALEX
      DY=0.5/SCALEY
      INFLUN=E
      LIMX=NX-1
      LIMY=NY-1
      TOLER=0.005*(SCALEX*SCALEY)
C
      THE ACCURACY TOLERANCE FOR THE BENDER IS SET AT ONE-HUNDREDTH OF
C      THE AVERAGE OF THE SCALEX AND SCALEY VALUES. THIS SEEMS TO BE
C      ACCURATE ENOUGH - SOME SMOOTHING IS PERFORMED BY SRFIT.
C
      DO 20 JB=1,NY
      HX(1,JB)=DX*(-3.0*B(1,JB)+4.0*B(2,JB)-B(3,JB))
      DO 10 IB=2,LIMX
      BX(1B,JB)=DX*(B(1B+1,JB)-B(1B-1,JB))
10      CONTINUE
      HX(NX,JB)=DX*(B(NX-2,JB)-4.0*B(NX-1,JB)+3.0*B(NX,JB))
      DO 20 CONTINUE
      DO 40 IB=1,NX
      BY(1B,1)=DY*(-3.0*B(1B,1)+4.0*B(1B,2)-B(1B,3))
      DO 30 JB=2,LIMY
      BY(1B,JB)=DY*(B(1B,JB+1)-B(1B,JB-1))
30      CONTINUE
      BY(1B,NY)=DY*(B(1B,NY-2)-4.0*B(1B,NY-1)+3.0*B(1B,NY))
40      CONTINUE
C
      COMPUTE THE X AND Y DIRECTION COSINES OF THE VECTORS NORMAL TO
C      SURFACE B AT ITS GRID POINTS. ARRAY BX(1B,JB) IS USED FOR THE
C      X DIRECTION COSINES AND ARRAY BY(1B,JB) IS USED FOR THE Y
C      DIRECTION COSINES.
C
      DO 60 IB=1,NX
      DO 50 JB=1,NY
      VECMAG=SQRT(BX(1B,JB)*BX(1B,JB)+BY(1B,JB)*BY(1B,JB)+1.0)
      HX(1B,JB)=BX(1B,JB)/VECMAG
      HY(1B,JB)=BY(1B,JB)/VECMAG
50      CONTINUE
60      CONTINUE
C
      FOR EACH POINT ON SURFACE A, FIND THE NORMAL VECTORS ON SURFACE B
C      WHICH PASS THROUGH THAT POINT. EXTEND EACH OF THESE VECTORS FROM
C      SURFACE B TO SURFACE C. IN ORDER TO DETERMINE HOW FAR THE MEDIAN
C      PLANE HAS BEEN DISPLACED ALONG THAT VECTOR, ADD ALL OF THESE
C      DISPLACEMENTS TOGETHER AND DIVIDE BY THE NUMBER OF VECTORS FOUND,
C      IN ORDER TO COMPUTE THE DISPLACEMENT OF THAT POINT ON SURFACE A.
C
      A = THE NAME OF THE ARRAY FOR THE OLD SURFACE WHICH IS TO BE BENT.
      H = THE NAME OF THE ARRAY FOR THE NEW MEDIAN SURFACE.
      C = THE NAME OF THE ARRAY FOR THE OLD MEDIAN SURFACE.
      D = THE NAME OF THE ARRAY FOR THE NEW SURFACE, AFTER BENDING.
C
      NPTS=0
      DO 160 IA=1,NX
      DO 170 JA=1,NY
      SUMX=0.0
      SUMY=0.0
      SUMZ=0.0

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COUNT=0.0
IHEG=MAX0(1,(IA-INFLUN))
IEND=MIN0(LIMX,(IA+INFLUN))
JHEG=MAX0(1,(JA-INFLUN))
JEND=MIN0(LIMY,(JA+INFLUN))

C
C   FOR EACH SCALEX-BY-SCALEY REGION ON SURFACE B, DETERMINE WHETHER
C   IT IS POSSIBLE TO SELECT A NORMAL VECTOR FROM THE REGION WHICH
C   PASSES THROUGH THE POINT CURRENTLY BEING PROCESSED ON SURFACE A.
C
C   WE START BY GUESSING THAT THE DESIRED NORMAL VECTOR GOES THROUGH
C   THE CORNER OF THE REGION. WE THEN TRY TO REFINER THAT GUESS. IF IN
C   DOING SO WE MOVE THE NORMAL VECTORS STARTING LOCATION OUT OF THE
C   REGION, WE QUIT. OTHERWISE, WE QUIT WHEN WE HAVE EITHER FOUND THE
C   DESIRED VECTOR OR WHEN WE HAVE MOVED IT LESS THAN ONE-HUNDRETH OF
C   THE GRID SPACINGS, IN ANY ITERATION. THE VECTOR IS (VX,VY,VZ).
C
DO 140 IB=IHEG,IEND
DO 130 JB=JHEG,JEND
DX=0.0
DY=0.0
70 VX=SCALEX*(IA-IB-DX)
VY=SCALEY*(JA-JB-DY)

C
C   THE FOLLOWING IS THE HARMONIC INTERPOLATION SCHEME.
C
VZ=A(IA,JA)-((1-DX)*(1-DY)*B(IB,JB)+DX*(1-DY)*B(IB+1,JB)
1  +DY*(1-DX)*B(IB,JB+1)+DX*DY*B(IB+1,JB+1))
VMAG=SQRT(VX*VX+VY*VY+VZ*VZ)
IF (VMAG.EQ.0.0) GO TO 72
VX=VX/VMAG
VY=VY/VMAG
VZ=VZ/VMAG
GO TO 74
72 VX=0.0
VY=0.0
VZ=0.0

C
C   THE FOLLOWING IS THE HARMONIC INTERPOLATION SCHEME.
C
74 VECEX=(1-DX)*(1-DY)*BCEX(IB,JB)+DX*(1-DY)*BCEX(IB+1,JB)
I  +DY*(1-DX)*BCEX(IB,JB+1)+DX*DY*BCEX(IB+1,JB+1)
VECEY=(1-DX)*(1-DY)*BCEY(IB,JB)+DX*(1-DY)*BCEY(IB+1,JB)
I  +DY*(1-DX)*BCEY(IB,JB+1)+DX*DY*BCEY(IB+1,JB+1)
VECEZ=SQRT(1.0-VECEX*VECEX-VECEY*VECEY)
COSANG=VECEX*VX+VECEY*VY+VECEZ*VZ
SINANG=SQRT(1.0-COSANG*COSANG)

C
C   MAKING THE SIMPLIFYING ASSUMPTION THAT A AND B ARE LEVEL SURFACES,
C
DIST=VMAG*SINANG
OVX=(VX-VECEX)*SIGN(1.0,COSANG)
OVY=(VY-VECEY)*SIGN(1.0,COSANG)
DVMAG=SQRT(OVX*OVX+OVY*OVY)
IF (DVMAG.EQ.0.0) DVMAG=10.0E+50
DVX=OVX/DVMAG
DVEY=OVY/DVMAG
DX=DX+DIST*DVX/SCALEX
DY=DY+DIST*DVEY/SCALEY

C
C   NOTE THAT NO LOGIC IS INCLUDED FOR STEPPING OVER GRID LINE
C   BOUNDARIES, IN THE GENERAL SENSE. THE PROGRAM IS ALLOWED TO
C   WANDER ONE-QUARTER OF A GRID-LINE SPACING INTO ADJACENT GRID
C   SQUARES. IN ORDER TO ENSURE THAT DESIRED POINTS WHICH FALL EXACTLY
C   ON GRID LINES ARE FOUND, HOWEVER, IF THE PROGRAM INTRUDES FARTHER
C   THAN ONE-QUARTER OF THE GRID-LINE SPACING INTO AN ADJACENT GRID

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C      SQUARE. THE SEARCH IS ENDED - THE DESIRED NORMAL VECTOR IS ABSENT.
C
C      IF (DX.LT.-0.25) GO TO 120
C      IF (DX.GT. 1.25) GO TO 120
C      IF (DY.LT.-0.25) GO TO 120
C      IF (DY.GT. 1.25) GO TO 120
C      IF (GIST.GE.TOLER) GO TO 70
C
C      AT THIS POINT, A NORMAL VECTOR PASSING THROUGH THE DESIRED POINT
C      ON SURFACE A HAS BEEN FOUND. IT IS A UNIT VECTOR HAVING THE
C      COMPONENTS (VX,VY,VZ). IT PASSES THROUGH SURFACE B AT THE POINT
C      WHERE X=(IB-1+DX)*SCALEX AND Y=(JB-1+DY)*SCALEY. NEXT WE WILL FIND
C      THE POINT AT WHICH IT INTERSECTS SURFACE C. WE WILL FIRST GUESS
C      THAT IT INTERSECTS SURFACE C AT THE SAME COORDINATES AT WHICH IT
C      INTERSECTS SURFACE B. WE WILL THEN REFINE OUR GUESS.
C
C      IC=IB
C      JC=JB
C      DXC=DX
C      DYC=DY
C      ZA=X*(IA+JA)
C      80 VFCX=SCALEX*(IA-IC-DXC)
C         VFCY=SCALEY*(JA-JC-DYC)
C
C      THIS IS THE HARMONIC INTERPOLATION SCHEME.
C
C      VECZ=ZA-((1-DXC)*(1-DYC)*C(IC,JC)+DXC*(1-DYC)*C(IC+1,JC)
C      1      +DYC*(1-DXC)*C(IC,JC+1)+DXC*DYC*C(IC+1,JC+1))
C      VECMAG=SQRT(VECX*VECX+VECY*VECY+VECZ*VECZ)
C      IF (VECMAG.EQ.0.0) GO TO 82
C      VFCX=VECX/VECMAG
C      VFCY=VECY/VECMAG
C      VFCZ=VECZ/VECMAG
C      GO TO 84
C      82 V-CX=0.0
C         VFCY=0.0
C         VECZ=0.0
C      84 COSANG=VECX*VX+VECY*VY+VECZ*VZ
C         SINANG=SQRT(1.0-COSANG*COSANG)
C
C      MAKING THE SIMPLIFYING ASSUMPTION THAT C IS A LEVEL SURFACE,
C
C      DIST=VECMAG*SINANG
C      DVX=(XA-VFCX)*SIGN(1.0,COSANG)
C      DVY=(YJ-VFCY)*SIGN(1.0,COSANG)
C      DVMAG=SQRT(DVX*DVBX+DVY*DVY)
C      IF (DVMAG.EQ.0.0) DVMAG=10.0E+50
C      DX=X+DVX/DVMAG
C      DYY=DY+DVY/DVMAG
C
C      THE VALUE OF DIST GIVES THE DISTANCE AT WHICH THE NEXT ITERATION
C      IS TO BEGIN. THE VALUES OF DVX AND DVY GIVE THE DIRECTION.
C
C      DDCN=DXC+DIST*DVX/SCALEX
C      DDCN=DYC+DIST*DVY/SCALEY
C      IX=DXCN
C      JY=DYCN
C      DXCN=DXCN-IX
C      DYCN=DYCN-JY
C
C      THIS IS THE LOGIC FOR STEPPING BACKWARD OVER GRID SQUARE EDGES.
C
C      IF (DACH.GE.0.0) GO TO 90
C      ODCN=DXCN+1.0
C      IX=IX-1
C      90 IF (DYCN.GE.0.0) GO TO 100

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DYCN=DYCN*1.0
JY=JY-1
C
C THIS IS THE LOGIC FOR STEPPING FORWARD OVER GRID SQUARE EDGES.
C
100 IC=IC+IX
    JC=JC+JY
    DXC=DXCN
    DYC=DYCN
    IF (IC.LT.1) GO TO 120
    IF (IC.GT.NX) GO TO 120
    IF (JC.LT.1) GO TO 120
    IF (JC.GT.NY) GO TO 120
    DIST=(IB+DX-IC-DXC)*SCALEX
    DIST=(JB+DY-JC-DYC)*SCALEY
    DISTZ=VZ*VMAG-VE CZ*VECMAG*SIGN(1.0,COSANG)
    TEST=DIST/SQRT(DISTX*DISTX+DISTY*DISTY+DISTZ*DISTZ)
    IF (TEST.LT.0.01) GO TO 110
    IF (DIST.GE.TOLER) GO TO 80
C
C STORE DISPLACEMENT FROM SURFACE C TO SURFACE B ALONG (VX,VY,VZ).
C
110 SUMX=SUMX+DISTX
    SUMY=SUMY+DISTY
    SUMZ=SUMZ+DISTZ
    COUNT=COUNT+1.0
120 CONTINUE
130 CONTINUE
140 CONTINUE
    IF (COUNT.LE.0.0) GO TO 160
    NPTS=NPTS+1
    POINT(1,NPTS)=(IA-1)*SCALEX+SUMX/COUNT
    POINT(2,NPTS)=(JA-1)*SCALEY+SUMY/COUNT
    POINT(3,NPTS)=A*(IA+JA)*(SUMZ/COUNT)
    IF (POINT(1,NPTS).LT.-SCALEX) GO TO 150
    IF (POINT(2,NPTS).LT.-SCALEY) GO TO 150
    IF (POINT(1,NPTS).GT.(NX+1)*SCALEX) GO TO 150
    IF (POINT(2,NPTS).LE.(NY+1)*SCALEY) GO TO 160
150 NPTS=NPTS-1
160 CONTINUE
170 CONTINUE
180 CONTINUE
C
C WE HAVE NOW DISPLACED ALL OF THE GRID POINTS OF SURFACE A. WE HAVE
C PLACED THE RESULTS IN THE POINT ARRAY. WE HAVE DISCARDED THE
C RESULTS FOR GRID POINTS WHICH WERE DISPLACED MORE THAN ONE GRID
C SPACING OFF OF THE SIDE OF THE GRID. WE MUST NOW DETERMINE THE
C HEIGHT OF THIS DISTORTED SURFACE AT EACH GRID POINT. THE RESULTS
C OF THIS COMPUTATION WILL BE PLACED IN THE D ARRAY.
C
185 N=12
    IF (N.GT.NPTS) N=NPTS
    DO 310 I=1,NX
        X=(I-1)*SCALEX
    DO 300 J=1,NY
        Y=(J-1)*SCALEY
C
C FIND THE N POINTS WHICH ARE CLOSEST TO THE GRID POINT (I,J).
C STORE THEM IN ORDER OF CLOSENESS IN THE ARRAY NAMED CLOSE.
C
    DO 190 K=1,N
        CLOS*(K,4)=10.0E+50.
190 CONTINUE
    DO 250 K=1,NPTS
        DX=X-POINT(1,K)
        DY=Y-POINT(2,K)

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DISTSQ=0A*0A+0Y*0Y
IF (DISTSQ.GE.CLOSE(N,4)) GO TO 240
L=L-1
200 IF (DISTSQ.GT.CLOSE(L,4)) GO TO 210
L=L-1
IF (L.GT.0) GO TO 200
210 L=L-1
N=N-N
220 IF (N.NE.L) GO TO 230
CLOSE(NN,1)=CLOSE(NN-1,1)
CLOSE(NN,2)=CLOSE(NN-1,2)
CLOSE(NN,3)=CLOSE(NN-1,3)
CLOSE(NN,4)=CLOSE(NN-1,4)
N=N-1
GO TO 220
230 CLOSE(L,1)=POINT(1,K)
CLOSE(L,2)=POINT(2,K)
CLOSE(L,3)=POINT(3,K)
CLOSE(L,4)=DISTSQ
240 CONTINUE
250 CONTINUE

```

```

C
C AFTER FITTING A SECOND-DEGREE POLYNOMIAL TO THE CLOSEST POINTS, WE
C CALCULATE AND STORE THE HEIGHT OF THE SURFACE AT THE GRID POINT.
C

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NUMBER=8
260 CALL SRFIT(2,NUMBER,CLOSE(1,1),CLOSE(1,2),CLOSE(1,3),0,IFLAG)
IF (IFLAG.LE.0) GO TO 290
NUMBER=NUMBER*2
IF (NUMBER.LE.N) GO TO 260
POINT 270, 1,0,0,0
270 FORMAT (40H0E FROM AT STMT 270 OF BENDR - SRFIT CANNOT FIT A,
1 1H VALUE TO POINT I=,13,4H, J=,13,15H, THAT IS EAST=,
2 10,1,0H, NORTH=,F10,1,7H, USING,/,1H0,26X,5HPPOINT,
3 7H NUMBER,5X,9HEAST OR X,4X,10HNORTH OR Y,4X,6HHEIGHT,
4 5H OR Z,6X,6HD)ISTSQ,/,27X,12H-----,4X,
5 10H-----,4X,10H-----,4X,11H-----,4X,
6 10H-----)
DC 285 L=1,0
POINT 280, L,(CLOSE(L,K),K=1,4)
280 FORMAT (30X,14,9X,F10,1,4X,F10,1,4X,F11,1,4X,F10,1)
285 CONTINUE
W(1)=-10,0E+50
290 D(1,0)=W(1)+Q(2)*X+Q(3)*Y+Q(4)*X*X+Q(5)*X*Y+Q(6)*Y*Y
300 CONTINUE
310 CONTINUE
RETURN

```

```

C
C THIS ENTRY POINT IS USED IN TILTING THE SURFACE (CALLED A), A
C NUMBER OF DEGREES (DEG), IN A RIGHT-HANDED FASHION, AROUND A
C HORIZONTAL VECTOR THROUGH THE POINT X=PTX,Y=PTY,Z=PTZ, WHICH
C POINTS IN A DIRECTION PHI WHICH IS MEASURED IN DEGREES, IN A
C COMPASS-LIKE FASHION FROM NORTH (OR EQUIVALENTLY, THE Y AXIS).
C

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```

C
C *****
C ENTRY TILT(NX,NY,SCALEX,SCALEY,A,DEG,AXIS,D,PTX,PTY,PTZ)
C *****
C *****C006400
C ENTRY TILT
C ENTRY TILT
C DPC=6
C AXIS=C
C PTX=E
C PTY=F
C PTZ=G

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C      *****
C      GAMMA=DEG/57.2957795
C      PH1=-AX15/57.2957795
C      SINPH1=SIN(PH1)
C      COSPH1=COS(PH1)
C      NPTS=0
C      OO 410 I=1,NX
C      OO 400 J=1,NY
C      Y=(J-1)*SCALEY
C      X=(I-1)*SCALEX
C      NPTS=NPTS+1
C      Z=A(I,J)-PTZ
C      P= (X-PTX)*COSPH1+(Y-PTY)*SINPH1
C      QQ=(PTX-X)*SINPH1+(Y-PTY)*COSPH1
C      THETA=SIGN(1.57079633,Z)
C
C      (1.57079633 IS EQUAL TO PI OVER TWO)
C
C      IF (P.NE.0.0) THETA=ATAN(Z/P)
C      R=SQRT(Z*Z+P*P)
C      PPRIME=R*COS(THETA-GAMMA)*SIGN(1.0,P)
C      POINT(1,NPTS)=PPRIME*COSPH1-QQ*SINPH1+PTX
C      POINT(2,NPTS)=PPRIME*SINPH1+QQ*COSPH1+PTY
C      POINT(3,NPTS)=PPRIME*TAN(THETA-GAMMA)+PTZ
400 CONTINUE
410 CONTINUE
GO TO 185
END
SUBROUTINE PAGER(N)
C
COMMON /IOCOM/ NLINE,NPAGE
C
DATA MARKER /1/
C
IF (N*NLINE.LE.40) RETURN
NPAGE=NPAGE+1
IF (MARKER.EQ.1) GO TO 20
PRINT 10
10 FORMAT (1H0,25X,80H0      1      2      3      4
A 5      6      7      8./,26X,80H12345678901234567890123
B45678901234567890123456789012345678901234567890)
20 PRINT 30,NPAGE
30 FORMAT (1H1,50X,30HIMAGES OF CONTROL CARDS FOLLOW,43X,5HPAGE ,13)
PRINT 10
NLINE=NLINE-4
MARKER=0
RETURN
C
ENTRY EPAGE
C
IF (MARKER.EQ.1) RETURN
PRINT 10
MARKER=1
RETURN
END
SUBROUTINE GRAPH(GR10,M,N,NPLOT)
C
C THIS SUBROUTINE PRODUCES X - Y (THAT IS, EAST - NORTH) PLOTS OF
C GEOLOGICAL SURFACES. IF THE SURFACES ARE MORE THAN TWELVE DATA
C POINTS WIDE, IT PRINTS THEM OUT IN NORTH-TO-SOUTH STRIPS WHICH
C ARE EACH NO MORE THAN TWELVE DATA POINTS WIDE, AND WHICH CAN
C BE PLACED SIDE BY SIDE SO THAT THE WHOLE SURFACE CAN BE SEEN.
C A SIMPLE FORM OF DATA-CONTROLLED FORMATTING IS USED.
C
C DIMENSION GR10(30,30),NLABEL(12)

```

```

C
  NSTRIP=1
  LOWM=1
  LIMM=MI*(M.12)
10  LIM1=LIMM-LOWM+1
   DO 20 I=1,LIM1
20  NEARL(I)=LOWM+I-1
   PRINT 30, NPLUT,NSTRIP
30  FORMAT (22H1Z VALUES FOR SURFACE ,11,26H - NORTH IS TOWARD THE TOP
1     55H OF THE PAGE, EAST IS TOWARD THE RIGHT. (EAST = X OR I,
2     23H NORTH = Y OR J) STRIP ,11)
   DO 280 K=1,N
   JN=1-K
   HIG=0.0
   DO 70 I=LOWM,LIMM
   SIZE=ABS(GRID(1,J))
   IF (SIZE-HIG) 60,60,50
50  HIG=SIZE
60  CONTINUE
70  CONTINUE
   IF (HIG-1.0) 80,100,100
80  PRINT 90,J,(GRID(1,J),I=LOWM,LIMM)
90  FORMAT (//////.1A,14.5X,12(F8.6,2X))
   GO TO 270
100 IF (HIG-10.0) 110,130,130
110 PRINT 120,J,(GRID(1,J),I=LOWM,LIMM)
120 FORMAT (//////.1X,14.5X,12(F8.5,2X))
   GO TO 270
130 IF (HIG-100.0) 140,160,160
140 PRINT 150,J,(GRID(1,J),I=LOWM,LIMM)
150 FORMAT (//////.1X,14.5X,12(F8.4,2X))
   GO TO 270
160 IF (HIG-1000.0) 170,190,190
170 PRINT 180,J,(GRID(1,J),I=LOWM,LIMM)
180 FORMAT (//////.1X,14.5X,12(F8.3,2X))
   GO TO 270
190 IF (HIG-10000.0) 200,220,220
200 PRINT 210,J,(GRID(1,J),I=LOWM,LIMM)
210 FORMAT (//////.1X,14.5X,12(F8.2,2X))
   GO TO 270
220 IF (HIG-100000.0) 230,250,250
230 PRINT 240,J,(GRID(1,J),I=LOWM,LIMM)
240 FORMAT (//////.1X,14.5X,12(F8.1,2X))
   GO TO 270
250 PRINT 260,J,(GRID(1,J),I=LOWM,LIMM)
260 FORMAT (//////.1X,14.5X,12(F8.0,2X))
270 CONTINUE
280 CONTINUE
   PRINT 290, (NEARL(I),I=1,LIM1)
290 FORMAT (//////.11X,12(14.6X))
   IF (M-LEWAM) 310,310,300
300 LEW=LOWM+12
   NEW=LIMM+11
   LIMM=MI*(M,NEW)
   NSTRIP=NSTRIP+1
   GO TO 10

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310 RETURN
END
SUBROUTINE RELAX(GRID,M,N,TDLER)
C
C THIS SUBROUTINE RELAXES AN M BY N GRID OF DATA POINTS SO THAT
C LAPLACES EQUATION IS SATISFIED WITH RESPECT TO THE BOUNDARY
C POINT VALUES GIVEN. M IS THE COLUMN INDEX, N IS THE ROW INDEX.
C
DIMENSION GRID(30,30)
C
C FIRST, INITIALIZE THE GRID BY LINEAR APPROXIMATION.
C
LIMM=M-1
LIMN=N-1
DO 20 I=2,LIMM
DIFF=(GRID(I,N)-GRID(I,1))/LIMN
DO 10 J=2,LIMN
GRID(I,J)=GRID(I,1)+(J-1)*DIFF
10 CONTINUE
20 CONTINUE
ITER=1
C
C FOUR DIFFERENT RELAXATION PATTERNS ARE USED ALTERNATELY.
C THIS SPEEDS UP ERRDR PRDPOGATION, AND THEREBY, CONVERGENCE.
C
30 LOWM = 2
LOWN = 2
LIMM = M - 1
LIMN = N - 1
INCRM = 1
INCRN = 1
GO TO 70
40 LOWM = M-1
LOWN = 2
LIMM = 2
LIMN = N-1
INCRM = -1
INCRN = 1
GO TO 110
50 LOWM = M-1
LOWN = N-1
LIMM = 2
LIMN = 2
INCRM = -1
INCRN = -1
GO TO 70
60 LOWM = 2
LOWN = N - 1
LIMM = M - 1
LIMN = 2
INCRM = 1
INCRN = -1
GO TO 110
C
C J WITHIN I RELAXATION (INDICES CAN GO UP OR DOWN)
C
70 BIGDIF=0.0
I=LOWM
80 J=LOWN
90 TESTVAL=GRID(I,J)
GRID(I,J)=0.25*(GRID(I+1,J)+GRID(I-1,J)+GRID(I,J+1)+GRID(I,J-1))
CHANGE=ABS(TESTVAL-GRID(I,J))
BIGDIF=AMAX1(CHANGE,BIGDIF)
IF (J.EQ.LIMN) GO TO 100

```

```

      J=J+INCRN
      GO TO 90
100 IF (I.EQ.LIMM) GO TO 150
      I=I+INCRM
      GO TO 80
C
C      I WITHIN J RELAXATION (INDICES CAN GO UP OR DOWN)
C
110 BIGDIF=0.0
      J=LOWN
120 I=LOWM
130 TESTVAL=GRID(I,J)
      GRID(I,J)=0.25*(GRID(I+1,J)+GRID(I-1,J)+GRID(I,J+1)+GRID(I,J-1))
      CHANGE=ABS(TESTVAL-GRID(I,J))
      BIGDIF=AMAX1(CHANGE,BIGDIF)
      IF (I.EQ.LIMM) GO TO 140
      I=I+INCRM
      GO TO 130
140 IF (J.EQ.LIMN) GO TO 150
      J=J+INCRN
      GO TO 120
C
C      CHECK FOR CONVERGENCE
C
150 IF (BIGDIF-TOLER) 170,170,160
C
C      IF NOT WITHIN TOLERANCE, REPEAT RELAXATION USING NEXT PATTERN.
C
160 ITER=ITER+1
      IF (ITER.GT.4) ITER=1
      GO TO (30,40,50,60),ITER
C
C      OTHERWISE, RETURN
170 RETURN
      END
      SUBROUTINE SRFIT (NORD,M,X,Y,Z,A,IF)
      INTEGER FK,FJ
      DIMENSION A(50),B(50),F(50),X(50),Y(50),
1          Z(50),PHI(50,50),BIN(50,50)
      IF=0
      LMIN=0.0001
      NOP=NORD+1
      NENDP=(NOP+1)/2
      DO 240 JS=1,NOP
      DO 240 KS=1,JS
      I=JS*(JS-1)/2+KS
      DO 40 K=1,M
      XX=1.0
      YY=1.0
      IF (I-1) 250,80,10
10 IF (I-3) 20,30,40
20 XX=X(K)
      GO TO 80
30 YY=Y(K)
      GO TO 80
40 FK=JS-KS
      FJ=KS-I
      IF (FK) 60,60,50
50 XX=X(K)**FK
60 IF (FJ) 80,80,70
70 YY=Y(K)**FJ
80 CONTINUE
90 F(K)=XX*YY
      A(I)=0.0
      C=0.0
      IF (I-1) 100,100,120

```

```

100 DO 110 J=1,M
110 D=D+F(J)*F(J)
    D=SQRT(D)
    GO TO 200
120 IM=I-1
    DO 130 K=1,IM
    T=0.0
    DO 130 J=1,M
130 T=T-F(J)*PHI(J,K)
    B(K)=T
    DO 140 J=1,M
140 F(J)=F(J)-T*PHI(J,K)
150 CONTINUE
    DO 160 J=1,M
160 D=D+F(J)*F(J)
    D=SQRT(D)
    IF (D-DMIN) 250,250,170
170 CONTINUE
    DO 190 K=1,M
    T=0.0
    DO 180 J=K,IM
180 T=T-BIN(K,J)*B(J)
190 BIN(K,I)=T/D
200 CONTINUE
    BIN(I,I)=1.0/D
    DO 210 J=1,M
210 PHI(J,I)=F(J)/D
    T=0.0
    DO 220 K=1,M
220 T=T*PHI(K,I)*Z(K)
    DO 230 K=1,I
230 A(K)=A(K)+T*BIN(K,I)
240 CONTINUE
    RETURN
250 IF=1
    RETURN
    END

```

B. PROGRAM TUNNEL

```

PROGRAM TUNNEL
C                                     READ GEOLOGY FILE, CREATE TUNNEL FILE
C
COMMON /FPOLE/ XX,YY,ZZ,II,JJ,LL
COMMON /GEOFL/ NX,NY,SCALEX,SCALEY,INDEX(25),PROP(6,25)
COMMON /NEWPT/ X1,Y1,Z1,X2,Y2,Z2,XM,YM,ZM,DL,LSEGNO
COMMON /UPARM/ DIAM,XORIG,YORIG,UNIT,DELTA

C
DIMENSION CARDIN(5)
DATA CUMOL /0./
DATA ICOUNT /0/
DATA IFLAG /0/
DATA INEND /0/
DATA LFIN /0/
DATA LSTLL /0/
DATA SLNGTH /0./
DATA CARDIN /5*0./

C                                     INITIALIZE
DIAM = 10.
XORIG = 1.
YORIG = 1.
UNIT = 1.
DELTA = 20.
LSEGNO = 0
X1 = 0.
Y1 = 0.
Z1 = 0.
XP = 0.
YP = 0.
ZP = 0.
REWIND 50
REWIND 40

C                                     READ GEOLOGY FILE
C
CALL HDGEOI                                     READ PARAMETER CARDS
C
80 IF (INEND .EQ. 1) GO TO 300
READ 100, IKEY, (CARDIN(I),I=1,5)
100 FORMAT (A6,4X,5(F10.4))
ICOUNT = ICOUNT + 1
IF (IKEY .EQ. 6HNEWLEG) GO TO 190
IF (IKEY .EQ. 6HSTART ) GO TO 170
IF (IKEY .EQ. 6HEND ) GO TO 180
IF (IKEY .EQ. 6HOPTION) GO TO 150
PRINT 110, IKEY
110 FORMAT (39H0ERROR - INVALID KEYWORD ON INPUT CARD ,A6 )
GO TO 400

C                                     OPTION CARD READ
150 IF (ICOUNT .EQ. 1) GO TO 160
PRINT 155
155 FORMAT (47H0ERROR - OPTION CARD, IF PRESENT, MUST BE FIRST )
GO TO 400
160 IF (CARDIN(1) .GT. 0.) DIAM = CARDIN(1)
XORIG = CARDIN(2)
YORIG = CARDIN(3)
IF (CARDIN(4) .GT. 0.) UNIT = CARDIN(4)
IF (CARDIN(5) .GT. 0.) DELTA = CARDIN(5)
GO TO 80

C                                     START CARD READ
170 PRINT 172, DIAM,XORIG,YORIG,UNIT,DELTA
172 FORMAT (26HITUNNEL OPTIONS - DIAM,9X,5HXORIG,11X,5HYORIG,10X,
* 4HUNIT,8X,5HDELTA/17X,F10.3,2X,2(F14.3,2X),2(F10.3,2X))//

```

```

      • 50HOTUNNEL FILE - POSITION PROPERTY 1 PROPERTY 2 ,
      • 5X,55HPROPERTY 3 PROPERTY 4 PROPERTY 5 PROPERTY 6,
      • 3X,4HFLAG /)
      X1 = CARDIN(1)
      Y1 = CARDIN(2)
      Z1 = CARDIN(3)
      GO TO 80
C      END CARD FEAD
180 INEND = 1
C      NEWLEG CARD READ
190 X2 = CARDIN(1)
      Y2 = CARDIN(2)
      Z2 = CARDIN(3)
      LSEGNO = LSEGNO + 1
C
C      PROCESS TUNNEL LEG BETWEEN (X1,Y1,Z1)
C      AND (X2,Y2,Z2)
      XWRK = (X2-X1)*(X2-X1)+(Y2-Y1)*(Y2-Y1)+(Z2-Z1)*(Z2-Z1)
      SLNGTH = SQRT (XWRK)
      OL = 0.
      IF (LSEGNO .GT. 1) GO TO 250
C      FIND LAYER OF BEGINNING POINT
      XX = X1
      YY = Y1
      ZZ = Z1
      CALL GETLYR
      LSTLL = LL
C
C      TEST POINTS ALONG TUNNEL MIDLINE IN
C      INCREMENTS OF DELTA FT.
250 OL = OL + DELTA
      IF (OL .GT. SLNGTH) OL = SLNGTH
      CALL NEWPNT
      XX = XM
      YY = YM
      ZZ = ZM
      CALL GETLYR
      IF (OL .LT. SLNGTH) GO TO 260
      LFIN = LSEGNO
      GO TO 270
260 IF (LSTLL .EQ. LL) GO TO 250
C      NEW LAYER ENCOUNTERED
270 DDL = OL + CUMOL
      LPROP = INDEX(LSTLL)
      PRINT 275,DDL, (PROP(1,LPROP),I=1,6),IFLAG
275 FORMAT (11X,7(F14.4,1X),2X,14)
277 IROPTEM=PROP(2,LPROP)
      WRITE(40,280) DDL,PROP(1,LPROP),IROPTEM,(PROP(1,LPROP),I=3,6),IFLA
      IG
280 FORMAT(2E18.10,15,4E18.10,15)
      IF (DDL .LT. 0.) GO TO 310
      LSTLL = LL
      IF (LFIN .LT. LSEGNO) GO TO 250
C
C      END OF TUNNEL SEGMENT HAS BEEN REACHED
C
      X1 = X2
      Y1 = Y2
      Z1 = Z2
      CUMDL = CUMDL + DL
      GO TO 80
C      END OF JOB
300 DDL = -100.
      GO TO 277
310 PRINT 320
320 FORMAT (27HOTUNNEL TERMINATED NORMALLY )

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400 CALL EXIT
   END
   SUBROUTINE GETLYR
C
C   PURPOSE - FIND LAYER (LL) IN WHICH THE POINT
C             (XX,YY,ZZ) IS LOCATED
C
COMMON /FPOLE/ XX,YY,ZZ,II,JJ,LL
COMMON /GEULFL/ NX,NY,SCALEX,SCALEY,INDEX(25),PROP(6,25)
COMMON /UPARM/ DIAM,XORIG,YORIG,UNIT,DELTA
COMMON /ZSAVE/ ZSTOR (30,30,25),LFLAG(25)
DIMENSION ZHOLD(25)
DATA ZHOLD /25*0./
DATA LHOLD /0/
C
LHOLD = 0
DO 120 J = 1,25
ZHOLD(J) = -10.0 ESI
120 CONTINUE
C             FIND I INTERVAL FOR XX
XCDOR = 1 + (XX-XDRIG) / (SCALEX*UNIT)
ILCW = XCDOR
IHI = ILOW + 1
C             FIND J INTERVAL FOR YY
YCOOR = 1 + (YY -YORIG) / (SCALEY * UNIT)
JLQW = YCOOR
JHI = JLOW + 1
C             SEE IF POINT IS OUTSIDE I J GRID
IF (ILOW .LT. 1) GO TO 700
IF (IHI .GT. NX) GO TO 730
IF (JLOW .LT. 1) GO TO 750
IF (JHI .GT. NY) GO TO 760
C             EXAMINE THE 4 (I,J) POLES SURROUNDING
C             (XX,YY,ZZ) FOR LAYER(S) INVOLVED
II = ILOW
JJ = JLOW
CALL FINDL
LHOLD = LL
C
JJ = JHI
CALL FINDL
IF (LHOLD - LL) 310,240,310
C
240 II = IHI
CALL FINDL
IF (LHOLD - LL) 310,280,310
C
280 JJ = JLOW
CALL FINDL
IF (LHOLD - LL) 310,950,310
C
C             INTERPOLATION REQUIRED
C
310 XA = ILOW
YA = JLOW
XA = J-1
YA = JLOW
XC1 = ILOW
XC = XCOOR
YC = JHI
DO 500 J=1,25
IF (LFLAG(J) .EQ. 0) GO TO 500
LYR = J
ZA = ZSTOR (ILOW,JLOW,LYR)
ZH = ZSTOR (IHI,JLOW,LYR)
ZC1 = ZSTOR (ILOW,JHI,LYR)
ZC2 = ZSTOR (IHI,JHI,LYR)

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C          FIND POINT ON LINE BETWEEN (ILOW,JMI,ZC1)
C          AND (IMI,JMI,ZC2) WHICH IS AT XX
C          ZC = (XCOOR - XC1) * (ZC2 - ZC1) + ZC1
C          DERIVE EQUATION OF PLANE DEFINED BY
C          (XA,YA,ZA),(XB,YB,ZB),(XC,YC,ZC)
C          A = YA*ZB*YC*ZA+YB*ZC-YC*ZB-YB*ZA-YA*ZC
C          B = ZA*XB*ZC*XA+ZB*XC-ZC*XB-ZB*XA-ZA*XC
C          C = XA*YB*XC*YA+XB*YC-XC*YB-XB*YA-XA*YC
C          D = XA*YB*ZC+YA*ZB*XC+ZA*XB*YC-ZA*YB*XC-YA*XB*ZC-XA*ZB*YC
C          STORE Z FOR PLANE AT POINT (XX,YY)
C          ZHOLD(J) = D - B*YCOOR - A*XCOOR / C
500 CONTINUE
C          FIND LOWEST ZHOLD(J) S.T. ZHOLD(J) GT ZZ
510 ZLOW = 999999.
    LL = 0
    DO 550 J=1,25
    IF (LFLAG(J) .EQ. 0) GO TO 550
    TESTZ = ZHOLD(J)
    IF (TESTZ .LT. ZZ) GO TO 550
    IF (TESTZ .GT. ZLOW) GO TO 550
    ZLOW = TESTZ
    LL = J
550 CONTINUE
    IF (LL .GT. 0) GO TO 950
    PRINT 570, XX,YY,ZZ
570 FORMAT (3A#DERROR - NO LAYER FOUND FOR POINT ,3(F14.3,IX) )
    GO TO 900
C
C
C          POINT WEST OF GRID
700 II = 1
702 IF (JMI .GT. NY) GO TO 740
    IF (JLOW .LT. 1) GO TO 745
    JJ = JLOW
    CALL FINDL
    LHOLD = LL
    JJ = JMI
    CALL FINOL
    IF (LL .EQ. LHOLD) GO TO 950
    DO 705 J=1,25
    IF (LFLAG(J) .EQ. 0) GO TO 705
    ZC1 = ZSTOR(II,JLOW,J)
    ZC2 = ZSTOR(II,JMI,J)
    ZHOLD(J) = (YCOOR - JLOW) * (ZC2-ZC1) + ZC1
705 CONTINUE
    GO TO 510
C          POINT EAST OF GRID
730 II = NX
    GO TO 702
C          POINT NW OR NE OF GRID
740 JJ = NY
    GO TO 790
C          POINT SW OR SE OF GRID
745 JJ = 1
    GO TO 790
C          POINT SOUTH OF GRID
750 JJ = 1
752 IF (IMI .GT. NX) GO TO 770
    IF (ILOW .LT. 1) GO TO 775
    II = ILOW
    CALL FINDL
    LHOLD = LL
    II = IMI
    CALL FINOL
    IF (LL .EQ. LHOLD) GO TO 950

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      DO 755 J=1,25
      IF (LFLAG(J) .EQ. 0) GO TO 755
      ZC1 = ZSTOR(ILOW,JJ,J)
      ZC2 = ZSTOR(IM1,JJ,J)
      ZHOLD(J) = (XCOORD - ILOW) * (ZC2 - ZC1) + ZC1
755  CONTINUE
      GO TO 510
C
      POINT NORTH OF GRID
760  JJ = NY
      GO TO 752
C
      POINT NE OF GRID
770  II = NX
      GO TO 790
C
      POINT NW OF GRID
775  II = 1
790  CALL FINOL
      GO TO 950
C
      .....
C
900  CONTINUE
      CALL EXIT
950  CONTINUE
      RETURN
      ENO
      SUBROUTINE NEWPNT
C
C   PURPOSE - GIVEN ENDPOINTS (X1,Y1,Z1) AND (X2,Y2,Z2) OF LINE,
C             FIND (XM,YM,ZM) WHICH IS DL FT. FROM (X1,Y1,Z1) ON LINE
C   TECHNIQUE-EXPRESS YM AND ZM IN TERMS OF XM, USING 2-POINT FORM
C             OF STRAIGHT-LINE EQUATION.
C             SUBSTITUTE IN FORMULA FOR DISTANCE BETWEEN 2 POINTS,
C             (X1,Y1,Z1) AND (XM,YM,ZM), AND SOLVE FOR XM.
C             RECONSTRUCT YM AND ZM FROM XM.
C             SPECIAL CASES EXIST IF XDIF, YDIF, OR ZDIF ARE ZERO,
C             THUS REDUCING PROBLEM TO 1 OR 2 DIMENSIONS.
C   NOTE - IF DL IS GT LENGTH OF SEGMENT, ROUTINE WILL ABORT.
C
      COMMON /NEWPT/ X1,Y1,Z1,X2,Y2,Z2,XM,YM,ZM,DL,LSEGNO
      DATA LSTSEG /0/
      DATA MCODE /0/
      DATA IBRNCH /0/
      DATA XDIF,YDIF,ZDIF,A,B,T1,T2 /7*0./
C
      NPGOT = 0
      XM = 0.
      YM = 0.
      ZM = 0.
      IF (LSEGNO .EQ. LSTSEG) GO TO 30
      .....
C
      INITIALIZE FOR NEW LINE SEGMENT
      MCODE = 0
      XDIF = X2 - X1
      YDIF = Y2 - Y1
      ZDIF = Z2 - Z1
      IF (XDIF .EQ. 0.) MCODE = 1
      IF (YDIF .EQ. 0.) MCODE = MCODE + 10
      IF (ZDIF .EQ. 0.) MCODE = MCODE + 100
      .....
C
      BRANCH ACCORDING TO CASE INVOLVED
30  IF (MCODE .EQ. 0 ) GO TO 80
      IF (MCODE .EQ. 11 ) GO TO 600
      IF (MCODE .EQ. 101) GO TO 625
      IF (MCODE .EQ. 113) GO TO 650
      IF (MCODE .EQ. 1 ) GO TO 675

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IF (MCODE .EQ. 10 ) GO TO 700
IF (MCODE .EQ. 100) GO TO 725
PRINT 50
50 FORMAT (28H0ERROR - ENOPOINTS IDENTICAL)
GO TO 880
C .....
C                                NORMAL CASE (XDIF,YOIF,ZOIF NON-ZERO)
80 IBRNCH = 1
IF (LSEGNO .EQ. LSTSEG) GO TO 110
C                                SET UP COEFFICIENTS OF QUADRATIC EQUATION
A = 1. + (YDIF * YDIF + ZOIF * ZOIF) / (XOIF * XOIF)
B = -2. * A * X1
T1 = X1
T2 = X2
GO TO 100
C                                RECONSTRUCT YM AND ZM
90 XM = RT
XFRAC = (XM - X1) / XOIF
YM = Y1 + (YDIF * XFRAC)
ZM = Z1 + (ZDIF * XFRAC)
GO TO 750
C .....
C .....
C                                SOLVE QUADRATIC EQUATION
100 IF (A .EQ. 0.) GO TO 450
110 ARG = 4. * A * DL * DL
C                                TEST FOR EXISTENCE OF REAL ROOT(S)
IF (ARG .GE. 0.) GO TO 300
PRINT 200, A,B,ARG
200 FORMAT (36H0ERROR - ARG IN NEWPNT NEGATIVE. A= ,F14.3,4H B= ,
* F14.3,6H ARG= ,F14.3)
GO TO 880
C                                FIND ROOTS OF QUADRATIC
300 ARGP = SQRT(ARG)
DEN = 2. * A
IF (DEN .EQ. 0.) GO TO 450
RT = (-B + ARGP) / DEN
C                                SELECT ROOT ON GIVEN SEGMENT OF LINE
400 IF (T1 .LE. RT .AND. RT .LE. T2) GO TO 500
IF (T2 .LE. RT .AND. RT .LE. T1) GO TO 500
NRDOT = NRDOT + 1
IF (NRDOT .EQ. 2) GO TO 450
RT = (-B - ARGP) / DEN
GO TO 400
450 PRINT 470, A, B, ARG
470 FORMAT (51H0ERRDR - NEWPNT FOUND NO ROOT ON GIVEN SEGMENT. A= ,
* F14.3,4H B= ,F14.3,6H ARG= ,F14.3)
GO TO 880
500 GD TO ( 90,680,705,730),IBRNCH
C .....
C .....
C                                SPECIAL CASES
C                                XDIF AND YOIF ARE ZERO
600 YM = Y1
XM = X1
IF (ZDIF) 610,605,605
605 ZM = Z1 + OL
GO TO 750
610 ZM = Z1-DL
GO TO 750
C                                XDIF AND ZOIF ARE ZERO
625 X4 = X1
Z4 = Z1
IF (YDIF) 635,630,630
630 YM = Y1 + DL
GO TO 750

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```

635 Y1 = Y1 - DL
GO TO 750
C
650 YM = Y1
Z1 = Z1
IF (XDIF) 660,655,655
655 XM = X1 + DL
GO TO 750
660 XM = X1 - DL
GO TO 750
C
ONLY XDIF IS ZERO
675 IRRNCH = 2
IF (LSTSEG .EQ. LSEGNO) GO TO 110
A = 1. * (YDIF*YOIF)/(ZDIF*ZDIF)
678 B = -2. * A * Z1
T1 = Z1
T2 = Z2
GO TO 100
680 XM = X1
ZM = RT
YM = Y1 + (ZM - Z1) * YDIF / ZDIF
GO TO 750
C
ONLY YOIF IS ZERO
700 IRRNCH = 3
IF (LSTSEG .EQ. LSEGNO) GO TO 110
A = 1. * (XDIF*XDIF)/(ZDIF*ZDIF)
GO TO 678
705 YM = Y1
ZM = RT
XM = X1 + (ZM-Z1) * XDIF/ZDIF
GO TO 750
C
ONLY ZDIF IS ZERO
725 IRRNCH = 4
IF (LSEGNO .EQ. LSTSEG) GO TO 110
A = 1. * (YDIF*YDIF) / (XDIF*XDIF)
B = -2 * A * X1
T1 = X1
T2 = X2
GO TO 100
730 ZM = Z1
XM = RT
YM = Y1 + (XM-X1) * YOIF/XDIF
.....
C
CHECK RANGE OF RESULTING POINT
750 IF (X1 .LE. XM .AND. XM .LE. X2) GO TO 760
IF (X2 .LE. XM .AND. XM .LE. X1) GO TO 760
GO TO 850
760 IF (Y1 .LE. YM .AND. YM .LE. Y2) GO TO 770
IF (Y2 .LE. YM .AND. YM .LE. Y1) GO TO 770
GO TO 850
770 IF (Z1 .LE. ZM .AND. ZM .LE. Z2) GO TO 999
IF (Z2 .LE. ZM .AND. ZM .LE. Z1) GO TO 999
.....
C
850 PRINT 870, XM, YM, ZM
870 FORMAT (48H0E8H0R - POINT GIVEN BY NEWPNT NOT ON LINE. XM= ,
, F14.3,5H YM= ,F14.3,5H ZM= ,F14.3)
880 CALL EXIT
999 LSTSEG = LSEGNO
RETURN
END
SUBROUTINE HOGEO
C
ENTRY HOGEO READS AND STORES ALL GEOLOGY FILE DATA
C
ENTRY FINDL DETERMINES WHAT LAYER (LL) INCLUDES POSITION ZZ
AT POLE (II,JJ)
C

```

```

C
COMMON /FPOLE/ XX,YY,ZZ,I1,JJ,LL
COMMON /GEOLFL/ NX,NY,SCALEX,SCALEY,INDEX(25),PROP(6,25)
COMMON /ZSAVE/ ZSTOR (30,30,25),LFLAG(25)
C
DIMENSION HOLD(27)
C
DO 30 I = 1,25
LFLAG(I) = 0
30 CONTINUE
READ (50,60) NX, NY, SCALEX, SCALEY, (INDEX(ILAYR), ILAYR=1, 25),
* ((PROP(I, IROCK), I=1, 6), IROCK=1, 25)
60 FORMAT (2I5, 2(E18.10), 25I2, (E18.10))
LIM = NX * NY
DO 200 K = 1, LIM
READ (50, 80) (HOLD(L), L=1, 27)
80 FORMAT ((E18.10))
I = HOLD(1)
J = HOLD(2)
DO 150 IZ = 1, 25
ZSTOR(I, J, IZ) = HOLD(IZ+2)
150 CONTINUE
IF (K .GT. 1) GO TO 200
DO 170 IY = 1, 25
IF (HOLD(IY+2) .GT. -10.0 E5) LFLAG(IY) = 1
170 CONTINUE
200 CONTINUE
RETURN
C
ENTRY FINDL
C
C FIND LOWEST HOLDZ(K) FOR WHICH
C HOLDZ(K) GE ZZ
ZLOW = 999999.
LL = 0
600 DO 700 K = 1, 25
IF (LFLAG(K) .EQ. 0) GO TO 700
TESTZ = ZSTOR (11, JJ, K)
IF (TESTZ .LT. ZZ) GO TO 700
IF (TESTZ .GT. ZLOW) GO TO 700
ZLOW = TESTZ
LL = K
700 CONTINUE
IF (LL .GT. 0) GO TO 800
PPRINT 720, XX, YY, ZZ
720 FORMAT (14HQERROR = POINT ,3(F14.3, 2X), 12HABOVE GROUND)
CALL EXIT
800 LSTII = II
LSTJJ = JJ
RETURN
END

```

C. PROGRAM GENTNL

```

PROGRAM GENTNL
C
C THIS PROGRAM GENERATES A TUNNEL FILE USING CARO INPUT ONLY,
C BYPASSING GEOLOGY FILE REQUIREMENT
C
DIMENSION CD(8)
DATA OPOS /-10./
C
REWIND 40
PRINT 4005
4005 FORMAT(///,20X,33H GEOLOGY PARAMETERS FOR TUNNEL )
PRINT 4006
4006 FORMAT(//,5X,105H THIS GEOLOGY UNCONFINED ABRASIVENESS ROC
1K QUALITY IN SITU AMBIENT WATER INFLOW )
PRINT 4007
4007 FORMAT(2X,105H CEASES AT(FEET) COMPRESSIVE OES
1IGNITION TEMPERATURE RATE )
PRINT 4008
4008 FORMAT(5X,105H STRENGTH(PSI)
1 (LB/FT**3) (FT) (GAL/MIN)
1 )
C
100 READ 110, (CO(I),I=1,8)
110 FORMAT (8F10.4)
CD(2)=CD(2)/1000.
IF (CD(1) .LT. 0. .OR. CD(1) .GT. OPOS) GO TO 140
PRINT 120, CO(1)
120 FORMAT (34HERROR - CARO SPECIFYING POSITION ,F10.4,
• 16H OUT OF SEQUENCE)
CALL EXIT
C
140 IFLAG = CD(8)
IA=CO(3)
OPOS = CO(1)
WRITE(40,210) (CO(I),I=1,2),IA,(CD(J),J=4,7),IFLAG
210 FORMAT(2E18.10,15,4E18.10,15)
IF (CD(1) .LT. 0.) GO TO 400
PRINT 250, (CO(I),I=1,7),IFLAG
250 FORMAT ( 3X,7(F14.4,1X),2X,14)
GO TO 100
C
900 PRINT 910
910 FORMAT (43HOTUNNEL FILE GENERATION TERMINATED NORMALLY )
REWIND 40
CALL EXIT
END

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D. PROGRAM CONTROL

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000003	PROGRAM CONTPL COMMON /WHEELS/ AF,AF,AMAX,AMAXL,AMINL,BSL,CARCAP,CP,OF,DF,DTAS	CONTRL	2
	1. DTMA,DTU,FL,FC,FR,FT,HPA,HPEA,HPEV,HPFA,HPFV,HPV,LOCO,MC,ML	WHEELS	2
	2. NCAPS,NPOINT,NTD,NTM,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL	WHEELS	3
	3. TCURVX(20),TCURVY(20),TMAINT,TME,VD,V5,VE,VF,VMAX,WC,WL,XDS	WHEELS	4
	4. MAXLD,NUMLD,LDUE,QUC,WUC,STATUS(36),WHY(24),MLTYP,WMR,ECONEQ,	WHEELS	5
	5. ECONSS,ELOCO,EMUCKC,ETRACK,ESWITC,EUNLOA,ERMATN,IIBORE,	WHEELS	6
	6. ISW(25),NTINIT,TCCV,TMCV	WHEELS	7
000003	COMMON /OLDCOM/ IFILD,KSTOP(25),KUNLO,LSTOP,LVEHCL,NBYRY,NSWCH	WHEELS	8
	1. NTRDA,NVFHCL,NHMSWT,SWITCH(20),TFC(25),TOP(25),TSTAT(25,4)	WHEELS	9
	2. UTIME(25),LOADR,MUKOT,XGS,TEXCA,MGS(5),MCV,MFLAGC,OUHMY(20)	WHEELS	10
000003	COMMON /NEWCOM/ LIFILO,LKSTOP(25),LKUNLO,LLSTOP,LLVMHCL,LNBYRY	WHEELS	11
	1. LNSWCH,LNTRDA,LNVHCL,LNMSWT,FSWTC(20),FTFC(25),FTOP(25)	WHEELS	12
	2. FTSTAT(25,4),FUTIME(25),LLOADR,LMUKOT,FXGS,LTEXCA,LMGS(5)	WHEELS	13
	3. LMCV,LMFLAC,FOUMMY(19)	WHEELS	14
000003	DIMENSION COMOLD(260),COMNEW(260),LTSTAT(25,4),ITSTAT(25,4)	WHEELS	15
000003	EQUIVALENCE (NVEHCL,NTRAIN,NTRUCK), (LVEHCL,LTRAIN,LTRUCK)	WHEELS	16
	1. (COMOLD,IFILD), (COMNEW,LIFILD,IFILLO), (NTDA,LNTRDA)	WHEELS	17
	2. (FTSTAT,LTSTAT), (TSTAT,ITSTAT)	WHEELS	18
	3. (LLVHCL,LTRAIN,LLTRUK), (LNVHCL,LNTRAIN,LNTRUK)	WHEELS	19
000003	COMMON /BORING/ CL(3),CPC,OTA,OTC,OTCD,OTO,OTM,KK,PRM,R(100),RC	BORING	2
	A. RPM,TR,XCPC, MASSEM,MBM,MHORE,MCD,MDISAS,LNCHNG,LNCUTR,NCUT(20)	BORING	3
	B. WEAR(100),EBORFQ,ETRANS	BORING	4
000003	COMMON /BLAST / ADB,AOH,AM,CBIT,CBURN,CCAP,CEX,CM,CPL,CSTEEL	BLAST	2
	B. LD,LOB,LBIT,LBURN,LSTEEL, MEN,ND,NOR,NH,NHR,PF,POB,POD,TCHG	BLAST	3
	C. TIN,TOUT,TYPEPF,WPL,JUMIN,JUMOUT,NORILR,NDRILL	BLAST	4
000003	COMMON /CONVEY/ ACM,OTRS,OWM,EF,FL,HP,OC,SMIN,WRI	BELTS	2
	1. WD,XLF,NSURGE,OF,OP,SM,OTCR,OTMR,AR,VRI,NFXON,NGEO,XF,LNSURG,		
	2. STIME,OPMP,OTMI,OTMO,FLM		
000003	COMMON /ALL / XI,SIH,IA,ROD,CS,TAMB,FLOW,IFLAG	ALL	2
	1. AT,O,E,SK,T,DT,X,PP,XMAX,TMAX,DX,OV,TPRINT,OTPRNT,IMOVE,JMETH	ALL	3
	2. TSHFT,REPORT,OPPCT,TO,XO,XOISCH,ICHNG,XCHNG,TCHNG	ALL	4
000003	EQUIVALENCE (JMOVE,IMOVE), (JMETH,JMETH)	ALL	5
000003	COMMON /MONEY/ JMMH,OMJ,OMJMM,OMJRO,OMJMMH,DMATN,DJMM,DJMGS	ALL	6
	1. PMGS,JMCV,OMJEC,ROPLAN,HPLANT,GSPLAN	ALL	7
	2. ECPLAN,ROTIME,HTIME(2),GSTIME,ECTIME	ALL	8
000003	COMMON /PERFRM/ RDUTIM,RDDTIM,UMHTIM,OMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	9
	1. ECOTIM,GOAY,GADV,GEND,GREG	ALL	10
000003	COMMON /LABOR/ RDMEN(10,2),HMEN(10,2,2),GSMEN(10,2),ECHEN(10,2)	ALL	11
000003	REAL JMMH,LD,LOB,LBIT,LBURN,LSTEEL,JMCV	ALL	12
000003	DIMENSION G(8)	ALL	13
000003	EQUIVALENCE (G,XT),(XE,XOE),(PR,PC)	ALL	14
000003	COMMON /GRND/ PSST(60,9),MAXPSST,UCS,UCSC,RATERR,RATESE,RATESS	SUPPORT	2
	1. GSLOS,IAS,IST,ERRORI,FSCPLA,GOOD,GSETOD,MAXPS	SUPPORT	3
000003	COMMON /ENVC/ MAXMEN,TOTHP,QM,QD,VAMIN,VAMAX,OG(10),	ENVIRON	2
	1. TA,TD,WA,FKD,FKT,CPA,CKA,REFRAT,AMC(10),DDR,EVFNTP,CPIMP	ENVIRON	3
000003	DIMENSION JSTOP(25)	CONTRL	10
000003	EQUIVALENCE (JSTOP,LKSTOP)	CONTRL	11
000003	DATA (STATUS=6HSTOPPE,6HD, EMP,2HTY, 6HSTOPPE,6HD, FUL,IML,	CONTRL	12
	1. 6HACFL,6H EMPTY,1H , 6HACCEL,5H FULL,1H , 6HFULL 5,6HPEED, ,	CONTRL	13
	2. SEMPTY, 6HFULL 5, 6HPEED, , 6HFULL, 6HDECEL,5HEMPTY, 1H ,	CONTRL	14
	3. 6HDECEL,5H FULL, 1H , 6HIN SWI, 6HTCH, E, 6HMPY,	CONTRL	15
	4. 6HIN SWI,6HTCH, F,3HULL, 6HIN DIS,6HCHARGE,5H AREA, 6HIN MAT,	CONTP	16
	6. 6HNTENAN,2HCE)	CONTRL	17
	7. (WHY=6HAT FAC,6HE, LOA,4HDING, 6HTRAIN ,5HAMEAO,1H ,	CONTRL	18

	8 6MTRAIN,6HCOMING,14 , 6MEXTERN,AMAL REA,4HSONS,	CONTRL	19
	9 6HWAITIN,6HG TO U,5HNLOAD, 6HWAITIN,6HG TO L,3HOAD,	CONTRL	20
	A 6MAT FAC,6HE, IN , 5HQUEUE, 3*6H,.....)	CONTRL	21
000003	DATA (COSTS=30*0.), (DX=0.), (DV=0.), (LOADR=0.), (MRORE=0.), (MBN=0)	CONTRL	22
000003	I, (LNCUTR=0), (RATMAX=0), (IDLE=0), (NOTIDL=0)	CONTRL	23
	DATA INIX/0/	CONTRL	24
	C**	CONTRL	25
	C	CONTRL	26
	C INITIALIZATION ONLY	CONTRL	27
	C	CONTRL	28
	C**	CONTRL	29
000003	CALL INPUT	CONTRL	30
000004	CALL ROPE	CONTRL	31
000005	CALL CUTTER	CONTRL	32
000006	CALL RFPATR	CONTRL	33
000007	CALL CVLOAD	CONTRL	34
000010	CALL CVMNT	CONTRL	35
000011	CALL RAILHL	CONTRL	36
000012	CALL RAILFX	CONTRL	37
000013	CALL RAILDS	CONTRL	38
000014	CALL RAILMT	CONTRL	39
000015	CALL GRNSUP	CONTRL	40
000016	CALL GSMAIN	CONTRL	41
000017	CALL ENVIR	CONTRL	42
000020	CALL RFPORR	CONTRL	43
000021	CALL MAXADV	CONTRL	44
000022	CALL REPORC	CONTRL	45
000023	CALL INPUT2	CONTRL	46
000024	DO 310 II=1,260	CONTRL	47
000026	COMNFW(II)=COMOLD(II)	CONTRL	48
000030	310 CONTINUE	CONTRL	49
	C***	CONTRL	50
000032	PRINT 410	CONTRL	51
000036	410 FJPMAT (IM)	CONTRL	52
000036	TPRINT=T,DTPRNT	CONTRL	53
000040	CALL OUTPUT	CONTRL	54
000041	400 CONTINUE	CONTRL	55
	C***	CONTRL	56
	C	CONTRL	57
	C START LOOP ON DT	CONTRL	58
	C	CONTRL	59
	C***	CONTRL	60
000041	401 XTEMP=X-XDISCH	CONTRL	61
000043	IF(XTEMP .LE. XT) GO TO 405	CONTRL	62
	C***	CONTRL	63
	C	CONTRL	64
	C READ NEW GEOLOGY	CONTRL	65
	C	CONTRL	66
	C***	CONTRL	67
000046	READ(40,402) G	CONTRL	68
000053	TCHNG=1	CONTRL	69
000054	TCHNG=(T-T0)/24.	CONTRL	70
000057	XCHNG=X-XDISCH	CONTRL	71
000061	IF(EOF,40) 600,404	CONTRL	72
000064	402 FORMAT(2E18.10,15,4E18.10,15)	CONTRL	73

000064	404 GO TO 401	CONTRL	74
	C***	CONTRL	75
	C	CONTRL	76
	C ROCK DISINTEGRATION	CONTRL	77
	C	CONTRL	78
	C***	CONTRL	79
000065	405 CONTINUE	CONTRL	80
000065	420 CALL RORER	CONTRL	81
000066	CALL MAINT	CONTRL	82
000067	CALL CUTCHG	CONTRL	83
000070	CALL RAILTR	CONTRL	84
000071	406 CALL RAILOS	CONTRL	85
000072	CALL RAILXT	CONTRL	86
000073	CALL RAILMT	CONTRL	87
000074	CALL LOADCV	CONTRL	88
000075	CALL CVRPR	CONTRL	89
000076	CALL GROUN	CONTRL	90
000077	CALL GSMNT	CONTRL	91
000100	CALL ENVIRC	CONTRL	92
	C**	CONTRL	93
	C	CONTRL	94
	C UPDATING X.T. AND FLAGS	CONTRL	95
	C	CONTRL	96
	C***	CONTRL	97
000101	T=T*OT	CONTRL	98
000103	X=X*DX	CONTRL	99
000105	DO 446 II=1,260	CONTRL	100
000107	COMOLD(II)=COMNEW(II)	CONTRL	101
000111	446 CONTINUE	CONTRL	102
000113	IF (MARM.EQ.0) GOTO 480	CONTRL	103
000114	MRORE=1	CONTRL	104
000115	GOTO 492	CONTRL	105
000116	480 IF (MRORE.EQ.1) MRORE=0	CONTRL	106
000121	IF (LNCCTR.EQ.0) GOTO 482	CONTRL	107
000122	MRORE=2	CONTRL	108
000123	GOTO 492	CONTRL	109
000124	482 IF (MRORE.EQ.2) MRORE=0	CONTRL	110
000127	IF (MRYRY.EQ.0) GOTO 484	CONTRL	111
000130	MRORE=3	CONTRL	112
000131	GOTO 492	CONTRL	113
000132	484 IF (MRORE.EQ.3) MRORE=0	CONTRL	114
000135	IF (MFWCH-1) 490,488,486	CONTRL	115
000140	486 MRORE=5	CONTRL	116
000141	GOTO 492	CONTRL	117
000142	488 MRORE=4	CONTRL	118
000143	GO TO 492	CONTRL	119
000144	490 IF (MRORE.EQ.4 .OR. MBORE.EQ.5) MBORE=0	CONTRL	120
000154	492 IF (LOADR .EQ. 0) GO TO 494	CONTRL	121
000155	NUQU=NUQU*1	CONTRL	122
000157	GO TO 500	CONTRL	123
000157	494 IF (MBORE .NE. 6) GO TO 496	CONTRL	124
000161	MRORE=0	CONTRL	125
000162	NUQU=0	CONTRL	126
000162	GOTO 530	CONTRL	127
000163	496 NUQU=0	CONTRL	128

000164	GO TO 530	CONTRL	129
000165	500 IF ((MRORE.EQ.3).OR.(MRORE.EQ.4).OR.(MRORE.EQ.5)) GOTO 530	CONTRL	130
000201	IF(LVHCL.GT.0) GO TO 530	CONTRL	131
C		CONTRL	132
C	TRAIN QUEUE IS CHECKED TO MOVE ANOTHER TRAIN INTO THE LOADING ARE	CONTRL	133
C	TRAIN STATUS IS CHANGED ON ALL TRAINS AFFECTED BY QUEUECHANGE	CONTRL	134
C		CONTRL	135
000204	LLTR=0	CONTRL	136
000204	00 515 ITR=1,NTRAIN	CONTRL	137
000206	IF ((ITSTAT(ITR,1).NE.0).OR.(JSTOP(ITR).LE.100)) GOTO 515	CONTRL	138
000217	KSTOP(ITR)=JSTOP(ITR)-1	CONTRL	139
000221	JSTOP(ITR)=KSTOP(ITR)	CONTRL	140
000223	LLTR=LLTR+1	CONTRL	141
000225	IF (JSTOP(ITR).NE.100) GOTO 515	CONTRL	142
000230	KSTOP(ITR)=1	CONTRL	143
000231	515 CONTINUE	CONTRL	144
000234	NUMLO=LLTR	CONTRL	145
000235	LOUE=LLTR+100	CONTRL	146
000237	IF (NUMLO.EQ.0) MRORE=6	CONTRL	147
000241	530 CONTINUE	CONTRL	148
000241	IF (NUMLO.GE.2) MRORE=6	CONTRL	149
000245	IF (IFXCA.EQ.0) GOTO 531	CONTRL	150
000246	IF (MRORE.EQ.0) MRORE=7	CONTRL	151
000250	GOTO 532	CONTRL	152
000251	531 IF (MRORE.EQ.7) MRORE=0	CONTRL	153
000254	532 CONTINUE	CONTRL	154
000254	IF (MCV.EQ.0) GO TO 540	CONTRL	155
000255	IF (MRORE.EQ.0) MRORE=8	CONTRL	156
000257	GOTO 542	CONTRL	157
000260	540 IF (MRORE.EQ.8) MRORE=0	CONTRL	158
000263	542 CONTINUE	CONTRL	159
000263	ITRORE=MRORE	CONTRL	160
C	PRINT OUTPUT REPORTS	CONTRL	161
000265	460 IF (T.LT.TPRINT) GO TO 461	CONTRL	162
000270	CALL OUTPUT	CONTRL	163
000271	TPRINT=TPRINT+OTPRNT	CONTRL	164
000273	461 IREPORT=REPORT+100	CONTRL	165
000277	IT=T*100+	CONTRL	166
000304	LK=MOD(IT,2400)	CONTRL	167
000310	IF (LK.NE.0) GO TO 462	CONTRL	168
000311	CALL MAXROW	CONTRL	169
000312	462 LK=MOD(IT,IREPORT)	CONTRL	170
000316	IF (LK.NE.0) GO TO 470	CONTRL	171
000317	CALL REPORS	CONTRL	172
000320	CALL REPORO	CONTRL	173
000321	470 CONTINUE	CONTRL	174
000321	IF (OX.NE.0.) GO TO 471	CONTRL	175
000322	INIX=INIX+1	CONTRL	176
C**		CONTRL	177
C		CONTRL	178
C	SHOULD SIMULATION BE ENDED BECAUSE NO ADVANCE FOR 5 DAYS	CONTRL	179
C		CONTRL	180
C**		CONTRL	181
000324	IF (INIX.GT.720) GO TO 605	CONTRL	182
000327	GO TO 472	CONTRL	183

000327	471 INIX=0	CONTRL	184
000330	472 CONTINUE	CONTRL	185
000330	IF (T.LT.TMAX .AND. X.LT.XMAX) GOTO 400	CONTRL	186
	C**	CONTRL	187
	C	CONTRL	188
	C	CONTRL	189
	C	CONTRL	190
	C**	CONTRL	191
000341	473 CALL OUTPUT	CONTRL	192
000342	CALL WREPORTS	CONTRL	193
000343	CALL REPORT	CONTRL	194
000344	RETURN	CONTRL	195
000346	600 PRINT 401	CONTRL	196
000352	601 FORMAT (24H0 GEOLOGY FILE EXHAUSTED)	CONTRL	197
000352	RETURN	CONTRL	198
000354	605 PRINT 474	CONTRL	199
000360	474 FORMAT(//.1X,40H SIMULATION ENDED-NO ADVANCE FOR 5 DAYS	CONTRL	200
000360		CONTRL	201
000362	END	CONTRL	202

*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED

NTRUCK
 LTRAIN
 LTRUCK
 IFIELD
 LIFIELD
 IFILLD
 LNTRDA
 LLTRAN
 LLTRUK
 LNTRAN
 LNTRUK
 IMOVE
 JMETH
 XDE
 PC
 NVEHCL
 NTDA
 LLVHCL
 LNVHCL
 JMOVE
 JMETH
 XE
 PR

E. SUBROUTINE INPUT

GOLETA FORTRAN 1.3 * AUTO RFL * (07-12-72)

07/25/72

SUBROUTINE INPUT		INPUT	
	C***	INPUT	2
000002	COMMON /WHEELS/ AE,AF,AMAX,AMXL,AMINL,BSL,CARCAP,CP,DE,DF,DTAS	INPUT	3
	1. DTMA,DTU,FL,FC,FR,FT,HPA,HPFA,HPEV,HPFA,HPFV,HPV,LOCO,MC,ML	WHEELS	2
	2. NCAPS,NPOINT,NTD,NT4,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL	WHEELS	3
	3. TCIQVX(20),TCURVY(20),TMAINT,TWE,VD,VS,VE,VF,VMAX,WC,WL,XDS	WHEELS	4
	4. MAXLD,NUMLD,LOUE,QUC,WUC,STATUS(36),WHY(24),MLTYP,WMR,ECONEQ,	WHEELS	5
	5. ECONSS,ELOCO,EMUCKC,ETRACK,ESWITC,EUNLOA,ERMATN,IIBORE,	WHEELS	6
	6. ISW(25),NTINIT,TCCV,TMCV	WHEELS	7
000002	COMMON /OLDCON/ IFILD,KSTOP(25),KUNLO,LSTOP,LVHCL,NRYRY,NSWCH	WHEELS	8
	1. NTRDA,NVHCL,NUMSWT,SWITCH(20),TFC(25),TOP(25),TSTAT(25,4)	WHEELS	9
	2. UTIME(25),LDADR,MUKDT,XGS,IFXCA,MGS(5),MCV,MFLAG,DUMMY(20)	WHEELS	10
000002	COMMON /NEWCON/ LIFILD,LKSTOP(25),LKUNLO,LLSTOP,LLVHCL,LNRYRY	WHEELS	11
	1. LNSWCH,LNTRDA,LNVHCL,LNMSWT,FSWCH(20),FTFC(25),FTOP(25)	WHEELS	12
	2. FTSTAT(25,4),FUTIME(25),LLOADR,LMUKDT,FXGS,LIFXCA,LMGS(5)	WHEELS	13
	3. LMCV,LMFLAG,FDDUMMY(19)	WHEELS	14
000002	DIMENSION COMOLD(260),COMNEW(260),LTSTAT(25,4),ITSTAT(25,4)	WHEELS	15
000002	EQUIVALENC (NVHCL,NTRAIN,NTRUCK),(LVHCL,LTRAIN,LTRUCK)	WHEELS	16
	1. (COMOLD,IFILD),(COMNEW,LIFILO,IFILLO),(NTDA,LNTRDA)	WHEELS	17
	2. (FTSTAT,LTSTAT),(ITSTAT,ITSTAT)	WHEELS	18
	3. (LLVHCL,LLTRAIN,LLTRUK),(LNVHCL,LNTRAIN,LNTRUK)	WHEELS	19
000002	COMMON /BORING/ CL(3),CPC,DTA,DTC,DTCD,DTD,DTM,KK,PBM,R(100),RC	BORING	2
	A. RPM,TR,XCPC, MASSEM,MRM,MBORE,MCD,MDISAS,LNCHNG,LNCUTR,NCUT(20)	BORING	3
	B. WEAR(100),EROREG,ETRANS	BORING	4
000002	COMMON /CONVY/ ACM,DTBS,DWM,EE,FL,HP,GC,SMIN,WRI	BELTS	2
	1. WP,XLF,NEHRC,DF,OP,SM,OTCP,DTMR,AR,VRI,NEKON,NGFO,XF,LNSURG,		1
	2. STIME,DDMP,DTMI,DTMO,FLM		2
000002	COMMON /BLAST / ADH,ADH,AH,CRIT,CRURN,CCAP,CEX,CH,CPL,CSTEEL	BLAST	2
	B. LD,LDB,LRIT,LRURN,LSTEEL, MEN,ND,NDR,NH,NHR,PE,POB,POD,TCHG	BLAST	3
	C. TIN,TOUT,TYPEPF,WPL,JUMIN,JUMOUT,NDRILR,NORILL	BLAST	4
000002	COMMON /ALL / XT,STR,IA,POD,CS,TAMB,FLOW,IFLAG	ALL	2
	1. AT,DE,SK,T,DT,X,PR,XMAX,TMAX,DX,DV,TPRINT,DTPRINT,IMDVE,JMETH	ALL	3
	2. TSHFT,RFPRT,OPPCT,TO,XO,XDISCH,ICHNG,XCHNG,TCHNG	ALL	4
000002	EQUIVALENC (JMOV,IMOVE),(JMETH,JMETH)	ALL	5
000002	COMMON/JMNFY/ JMMH,OJM,DJMMH,DJMRD,DJMHRM,DMAINT,DJMHRM,DJMG	ALL	6
	1. PMGS,JMCV,DJMEC,ROPLAN,HPLANT,GSPLAN	ALL	7
	2. ECPLAN,ROTIME,HTIME(2),GSTIME,ECTIME	ALL	8
000002	COMMON/PERFR/ ROOTIM,ROOTIM,UMHTIM,OMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	9
	1. ECOTIM,GDAY,GADV,GEND,GREG	ALL	10
000002	COMMON/LAROR/ QDMFN(10,2),HMFN(10,2),GSMEN(10,2),ECMEN(10,2)	ALL	11
000002	REAL JMMH,LD,LDR,LRIT,LRURN,LSTEEL,JMCV	ALL	12
000002	DIMENSION G(4)	ALL	13
000002	EQUIVALENC (G,XT),(XF,XOF),(PR,PC)	ALL	14
000002	COMMON /GRND/ PSS(60,9),MAXPSS, UCS,UCSC,RATERA,RATESC,RATESS	SUPPORT	2
	1. GSLOS,IAS,IST,FRBRI,ESCPLA,GOOW,GSETDO,MAXPSS	SUPPORT	3
000002	COMMON /ENVV/ MAXHEN,TOTHP,OM,OO,VAMIN,VAMAX,OG(10),	ENVIRON	2
	1. TA,TD,WA,FXD,FKT,CBA,CYA,REFRAT,AMC(10),QDR,FVENTP,CPUMP	ENVIRON	3
	C***	INPUT	11
000002	DIMENSION IMAGE(14),METHOD(10),MOVFR(10)	INPUT	12
000002	DATA (METHOD(I),I=1,10)/4HRDR,5HBLAST,3HJET,6HPELLET,6*SHDUMMY/	INPUT	13
000002	DATA (MOVFR(J),J=1,10)/SHRAILS,6HTRUCKS,SHBELTS,7*SHDUMMY/	INPUT	14
000002	DATA (PI=3.1415926535898)	INPUT	15
000002	DIMENSION ISTA(25),TPDS(25),TSPD(25),TMAIN(25)	INPUT	16
000002	DIMENSION ROMEN(10),ROCST(10),RAMEN(10),RACST(10),CVHEN(10),	INPUT	17
	1. CVCST(10),GMEN(10),GCST(10),VCMEN(10),VCCST(10)	INPUT	18

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000002	NAMFLIST /RORF /	INPUT	19
	1 CL,CPC,DTA,DTC,DTCD,DTD,DTM,KK,PBM,R,RC,RPM,TR,XCPC	INPUT	20
	2,ERORFQ,ETRANS,DJHBM,ROMFN,BOCST	INPUT	21
000002	NAMFLIST /RLAST /	INPUT	22
	1 Z	INPUT	23
000002	NAMFLIST /JET /	INPUT	24
	1 Z	INPUT	25
000002	NAMFLIST /PELLET/	INPUT	26
	1 Z	INPUT	27
000002	NAMFLIST /RAILS /	INPUT	28
	1 AE,AF,AMAX,AMAXL,AMINL,BSL,CARCAP,CP,DE,DF,DTAS,DTMA,DTU	INPUT	29
	A. NSWCH,NGFO,NEXON,XDE,AR,VRI,SM	INPUT	30
	2. EL,FC,FR,FT,HPA,HPFV,HPEA,HPFV,HPFA,HPFV,HPV,LOCD,MC,ML	INPUT	31
	3. NCARS,NPOINT,NTD,NTM,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL	INPUT	32
	4. TOURVX,TOURVY,THAINT,TWE,VD,VS,VE,VF,VMAX,WC,WL,XDS,MAXLD	INPUT	33
	5. NVFCL,NUMSWT,SWITCH,ISTA,TPOS,TSPD,THAIN,KSTOP,MLTYP,WMR	INPUT	34
	6. ELOCD,EMUCKC,ETRACK,ESWITC,EUNLDA,ERMAIN,JMMHM,NUMLD,ISW	INPUT	35
	7. RMEN,RACST	INPUT	36
000002	NAMFLIST /TRUCKS/	INPUT	37
	1 AE,AF,AMAX,AMAXL,AMINL,BSL,CARCAP,CP,DE,DF,DTAS,DTMA,DTU	INPUT	38
	A. NSWCH,NGFO,NEXON,XDE,AR,VRI	INPUT	39
	2. EL,FC,FR,FT,HPA,HPFV,HPEA,HPFV,HPFA,HPFV,HPV,LOCD,MC,ML	INPUT	40
	3. NCARS,NPOINT,NTD,NTM,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL	INPUT	41
	4. TOURVX,TOURVY,THAINT,TWE,VD,VS,VE,VF,VMAX,WC,WL,XDS,MAXLD	INPUT	42
	5. NVFCL,NUMSWT,SWITCH,ISTA,TPOS,TSPD,THAIN,KSTOP,MLTYP,WMR	INPUT	43
	6. ELOCD,EMUCKC,ETRACK,ESWITC,EUNLDA,ERMAIN,JMMHM,NUMLD,ISW	INPUT	44
	7. TRMEN,TRCST	INPUT	45
000002	NAMFLIST /BELTS /	INPUT	46
	1 Z	INPUT	47
000002	NAMFLIST /GENERAL/	INPUT	48
	1 D,DT,X,YMAX,T,THAX,DTPRNT,SK,PR,OPPCT,REPORT,XOISCH,E	INPUT	49
000002	NAMFLIST/GROUND/	INPUT	50
	1 UCS,UCSC,RATERR,RATESS,MAXPSS,ERBDR,ESCPLA,DJMG	INPUT	51
	2. GDN,GSETDD,GMFN,GCST	INPUT	52
000002	NAMFLIST/LOADER/	INPUT	53
	1 AR,VRI,SM,TCCV,TMCV,WMR,MLTYP,ECONEQ,ECONSS,JMCV	INPUT	54
	2. CMEN,CVCST	INPUT	55
000002	NAMFLIST/ENVIRC/	INPUT	56
	1 EVENTP,MAXMEN,TOTHP,TA	INPUT	57
	1. QM,OD,VAMIN,VAMAX,TD,WA,CPA,CKA,REFRAT,AMC,VCMEN,VCCST,CPUMP	INPUT	58
	2. FKT	INPUT	59
000002	EQUIVALENCE (RMEN(1),RDMEN(1,1))	INPUT	60
000002	EQUIVALENCE (RACST(1),RDMEN(1,2))	INPUT	61
000002	EQUIVALENCE (VCMEN(1),FCMEN(1,1))	INPUT	62
000002	EQUIVALENCE (VCCST(1),FCMEN(1,2))	INPUT	63
000002	EQUIVALENCE (RMEN(1),HMEN(1,1,1))	INPUT	64
000002	EQUIVALENCE (RACST(1),HMEN(1,2,1))	INPUT	65
000002	EQUIVALENCE (VCMEN(1),HMEN(1,1,2))	INPUT	66
000002	EQUIVALENCE (VCCST(1),HMEN(1,2,2))	INPUT	67
000002	EQUIVALENCE (GMEN(1),GSMEN(1,1))	INPUT	68
000002	EQUIVALENCE (GCST(1),GSMEN(1,2))	INPUT	69
000002	C***	INPUT	70
	EFUNC(X)=1.8*EXP(.084*X)	INPUT	71
	C	INPUT	72
	C THE FIRST SECTION OF SUBROUTINE INPUT	INPUT	73

	C	COPIES CARO-IMAGES FROM FILE4 (CARD READER)	INPUT	74
	C	ONTO FILE5 (INPUT FILE FOR REMAINDER OF PROGRAM)	INPUT	75
	C	AND FILE6 (OUTPUT FILE FOR THE PROGRAM)	INPUT	76
	C		INPUT	77
	C		INPUT	78
000013	C	LINE = 0	INPUT	79
	C		INPUT	80
	C	COC 6000 FORTRAN	INPUT	81
	C		INPUT	82
	C		INPUT	83
	C		INPUT	84
000014	C	I READ (4,10) IMAGE	INPUT	85
000022	C	IF (EOF,4) 3,2	INPUT	86
	C		INPUT	87
	C		INPUT	88
	C	B5500 FORTRAN	INPUT	89
	C		INPUT	90
	C	I READ (4,10,END=3) IMAGE	INPUT	91
	C		INPUT	92
	C		INPUT	93
000025	C	10 FORMAT (13A6,A2)	INPUT	94
000025	C	2 WRITE (5,10) IMAGE	INPUT	95
000033	C	IF (MOD(LINE,40).EQ.0) WRITE (6,11)	INPUT	96
000043	C	11 FORMAT (1H1, 9X14HCARD-IMAGES.../)	INPUT	97
000043	C	IF (MOD(LINE,10).EQ.0) WRITE (6,12) (K, K=5,80,5)	INPUT	98
000060	C	12 FORMAT (1H0, 19X1615/ 14X6MCARD , 8(10H.....))	INPUT	99
000060	C	LINE = LINE+1	INPUT	100
000062	C	WRITE (6,13) LINE, IMAGE	INPUT	101
000071	C	13 FORMAT (11R, 2X13A6, A2)	INPUT	102
000071	C	GOTO 1	INPUT	103
000072	C	3 ENDFILE 5	INPUT	104
000074	C	REWIND 5	INPUT	105
	C		INPUT	106
	C		INPUT	107
	C	READ FRAGMENTATION AND REMOVAL METHODS	INPUT	108
	C		INPUT	109
	C		INPUT	110
000076	C	READ (5,21) M,N	INPUT	111
000106	C	21 FORMAT (A6, 4XA6)	INPUT	112
000106	C	00 30 I=1,10	INPUT	113
000110	C	IF (M.EQ.METHOD(I)) GOTO 31	INPUT	114
000112	C	30 CONTINUE	INPUT	115
000114	C	WRITE (6,36) M	INPUT	116
000121	C	36 FORMAT (1H0, 9X21HFRAGMENTATION METHOD , A6,	INPUT	117
	C	1 36H CANNOT BE SIMULATED AT THIS TIME....	INPUT	118
	C	2 31HJOB ABORTED BY SUBROUTINE INPUT)	INPUT	119
	C	I = 0	INPUT	120
000121	C	31 00 32 J=1,10	INPUT	121
000124	C	IF (N.EQ.MOVFR(J)) GOTO 33	INPUT	122
000126	C	32 CONTINUE	INPUT	123
000130	C	37 FORMAT (1H0, 9X16HMUCK REMOVAL BY , A6,	INPUT	124
	C	1 36H CANNOT BE SIMULATED AT THIS TIME....	INPUT	125
	C	2 31HJOB ABORTED BY SUBROUTINE INPUT)	INPUT	126
	C	J = 0	INPUT	127
000130	C	33 IF (I.EQ.0 .OR. J.EQ.0) STOP	INPUT	128
000131	C		INPUT	128

000141	IMETH = I	INPUT	129
000143	JMOVE = J	INPUT	130
000144	READ (5,GENERAL)	INPUT	131
000147	WRITE (6,GENERAL)	INPUT	132
000152	GOTO (110,120,130,140), IMETH	INPUT	133
000162	110 READ (5,PORF)	INPUT	134
000165	WRITE (6,PORF)	INPUT	135
000170	GOTO 205	INPUT	136
000171	120 READ (5,BLAST)	INPUT	137
000174	WRITE (6,BLAST)	INPUT	138
000177	GOTO 205	INPUT	139
000200	130 READ (5,JET)	INPUT	140
000203	WRITE (6,JET)	INPUT	141
000206	GOTO 205	INPUT	142
000207	140 READ (5,PELLET)	INPUT	143
000212	WRITE (6,PELLET)	INPUT	144
000215	205 GOTO (210,220,230), JMOVE	INPUT	145
000224	210 READ (5,RAILS)	INPUT	146
000227	WRITE (6,RAILS)	INPUT	147
000232	GOTO 305	INPUT	148
000233	220 READ (5,TRUCKS)	INPUT	149
000236	WRITE (6,TRUCKS)	INPUT	150
000241	GOTO 305	INPUT	151
000242	230 READ (5,RELTS)	INPUT	152
000245	WRITE (6,RELTS)	INPUT	153
000250	305 CONTINUE	INPUT	154
000250	READ (5,LOADER)	INPUT	155
000253	WRITE (6,LOADER)	INPUT	156
000256	READ (5,GROUND)	INPUT	157
000261	WRITE (6,GROUND)	INPUT	158
000264	READ (5,ENVIRC)	INPUT	159
000267	WRITE (6,ENVIRC)	INPUT	160
000272	REWIND 40	INPUT	161
000274	READ (40,402) G	INPUT	162
000302	ICHNG=1	INPUT	163
000303	TCHNG=T/24.	INPUT	164
000305	XCHNG=X-XDISCH	INPUT	165
000307	402 FORMAT(2F18.10,15.4E18.10,15)	INPUT	166
000307	AT = PI*0.0/4.0	INPUT	167
000312	PRINT 403	INPUT	168
000316	403 FORMAT(1H1)	INPUT	169
000316	PRINT 404, AT	INPUT	170
000324	404 FORMAT (25H0 TUNNEL CROSS SECTION = F 10.4, 6H SQ FT)	INPUT	171
000324	LVEHCL=0	INPUT	172
000325	DO 306 I=1,25	INPUT	173
000327	ITSTAT(I,1)=ISTA(I)	INPUT	174
000331	TSTAT(I,2)=TPOS(I)	INPUT	175
000334	TSTAT(I,3)=TSPD(I)	INPUT	176
000336	TSTAT(I,4)=TMAIN(I)	INPUT	177
000340	IF (ISTA(I).EQ.0 .AND. KSTOP(I).EQ.1) LVEHCL=I	INPUT	178
000350	306 CONTINUE	INPUT	179
000352	IF (MAXPSS .EQ. 0) GO TO 325	INPUT	180
000353	DO 320 I=1,MAXPSS	INPUT	181
000355	READ (5,322) (PSST(I,K),K=1,9)	INPUT	182
000370	322 FORMAT(9F8.2)	INPUT	183

000370	320 CONTINUE	INPUT	184
000373	325 CONTINUE	INPUT	185
000373	XO=X	INPUT	186
000375	TO=T	INPUT	187
000376	NTINIT=NVEHCL	INPUT	188
000400	RETURN	INPUT	189
	C	INPUT	190
000400	ENTRY INPUT2	INPUT	191
000405	PRINT 78	INPUT	192
000411	78 FORMAT(1H1)	INPUT	193
000411	PRINT 77	INPUT	194
000415	77 FORMAT (50H0 INPUT DATA AFTER INITIALIZATION BY SUBROUTINES)	INPUT	195
000415	WRITE(6,GENEPL)	INPUT	196
000420	GOTO (501,502,503,504),JMETH	INPUT	197
000430	501 WRITE (6,BORF)	INPUT	198
000433	GOTO 505	INPUT	199
000434	502 WRITE (6,BLAST)	INPUT	200
000437	GOTO 505	INPUT	201
000440	503 WRITE (6,JET)	INPUT	202
000443	GOTO 505	INPUT	203
000444	504 WRITE (6,PELLET)	INPUT	204
000447	505 GOTO (511,512,513),JMOVE	INPUT	205
000456	511 WRITE (6,RAIL5)	INPUT	206
000451	GOTO 520	INPUT	207
000452	512 WRITE (6,TRUCK5)	INPUT	208
000455	GOTO 520	INPUT	209
000466	513 WRITE (6,BELTS)	INPUT	210
000471	520 WRITE (6,GROUND)	INPUT	211
000474	WRITE(6,LOADER)	INPUT	212
000477	WRITE(6,ENVIPC)	INPUT	213
000502	RETURN	INPUT	214
000503	END	INPUT	215

*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED

NTRAIN
 NTRUCK
 LTRAIN
 LTRUCK
 IFILE
 LIFILE
 IFILLO
 LNPDA
 LLTRAN
 LLTRUK
 LNTRAN
 LNTRUK
 INOVE
 JMETH
 XT
 FC
 NTDA
 LLVHCL
 LNVHCL
 XE

F. SUBROUTINE OUTPUT

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000002	SUBROUTINE OUTPUT	OUTPUT	2
	COMMON /WHEELS/ AF,AF,AMAX,AMAXL,AMINL,BSL,CARCAP,CP,OE,DF,DTAS	WHEELS	2
	1. OTMA,DTU,FL,FP,FP,FT,MPA,MPFA,MPFV,MPFA,MPFV,HPV,LOCO,MC,ML	WHEELS	3
	2. NCARS,NPOINT,NTD,N:4,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL	WHEELS	4
	3. TCURVX(20),TCURVY(10),TMAINT,TWE,VD,VS,VE,VF,VMAX,W,ML,XOS	WHEELS	5
	4. MAXLD,NUMLO,LOUE,DOC,WUC,STATUS(36),WHY(24),MLTYP,WMR,ECONEQ,	WHEELS	6
	5. ECONSS,FLOCO,FHUCKC,FTRACK,FSWITC,EUNLOA,ERMATN,IIBORF,	WHEELS	7
	6. ISW(25),NTINIT,TCV,TMCV	WHEELS	8
000002	COMMON /OLDCOM/ IFILD,KSTOP(25),KUNLO,LSTOP,LVEHCL,NRYBY,NSWCH	WHEELS	9
	1. NTRDA,NVHCL,NUMSWT,SWITCH(20),TFC(25),TOP(25),TSTAT(25,4)	WHEELS	10
	2. UTIME(25),LOADR,MUKOT,XGS,IFXCA,MGS(5),MVC,MFLAGC,OUMMY(20)	WHEELS	11
000002	COMMON /NFWCOM/ LIFILD,LKSTOP(25),LKUNLO,LLSTOP,LLVHCL,LNBYBY	WHEELS	12
	1. LNSWCH,LNTRDA,LNVHCL,LNMSWT,FSWICH(20),FTFC(25),FTOP(25)	WHEELS	13
	2. FTSTAT(25,4),FITIME(25),LLOADR,LMUKOT,FXGS,LIFXCA,LMGS(5)	WHEELS	14
	3. LMCV,LMFLAG,FOUMMY(19)	WHEELS	15
000002	DIMENSION COMOLD(260),COMNEW(260),LTSTAT(25,4),ITSTAT(25,4)	WHEELS	16
000002	EQUIVALENCE (NVEHCL,NTRAIN,NTRUCK),(LVEHCL,LTRAIN,LTRUCK)	WHEELS	17
	1. (COMOLD,IFILD),(COMNEW,LIFILD,IFILLO),(NTDA,LNTRDA)	WHEELS	18
	2. (FTSTAT,LTSTAT),(ITSTAT,ITSTAT)	WHEELS	19
	3. (LLVHCL,LLTRAN,LLTRUK),(LNVHCL,LNTRAN,LNTRUK)	WHEELS	20
000002	COMMON /BORING/ CL(3),CPC,DTA,DTC,DTCO,OTD,OTH,KK,PBM,R(100),RC	BORING	2
	A. RPM,TR,XCPC,MASSEM,MRM,MBORF,MCD,MDISAS,LNCHNG,LNCUTR,NCUT(20)	BORING	3
	B. WEAR(100),EBORFQ,ETRANS	BORING	4
000002	COMMON /ALL / XT,STR,IA,ROD,CS,TAHR,FLOW,IFLAG	ALL	2
	1. AT,D,E,SK,T,DT,X,PR,XMAX,TMAX,DX,DV,TPRINT,DTPRNT,IMOVE,JMETH	ALL	3
	2. TSHFT,REPORT,OPPCT,TO,XO,XDISCH,ICHNG,XCHNG,TCHNG	ALL	4
000002	EQUIVALENCE (JMOV,IMOVE),(IMETH,JMETH)	ALL	5
000002	COMMON/MONEY/ JMMHM,DJM,OJMMH,DJMRD,OJMRHM,DMAINT,DJMRM,OJMG5	ALL	6
	1. PMGS,JMVC,DJMEC,RDPLAN,HPLAN,GSPLAN	ALL	7
	2. ECPLAN,RDTIME,HTIME(2),G5TIME,ECTIME	ALL	8
000002	COMMON/PERFRM/ RDUTIM,RODTIM,UMHTIM,OMHTIM,GSUTIM,GSDTIM,ECUTIM	ALL	9
	1. ECDTIM,GDAY,GADV,GENO,GREG	ALL	10
000002	COMMON/LABOR/ RDMFN(10,2),HMFN(10,2,2),GSMEN(10,2),ECHEN(10,2)	ALL	11
000002	REAL JMMHM,LD,LDB,LBIT,LBURN,LSTEEL,JMVC	ALL	12
000002	DIMENSION G(R)	ALL	13
000002	EQUIVALENCE (G,XT),(XE,XDE),(PR,PC)	ALL	14
000002	DIMENSION IVAL(20)	TEST	2
000002	COMMON/TEST/VALUF(30),NAME(30)	TEST	3
	1. IHFAD(110),JHEAD(100)	TEST	4
000002	EQUIVALENCE (IVAL,VALUE)	TEST	5
000002	DATA (NAME=2HT=,2HX=,3HIA=,4HSTR=,3HDX=,4HMRM=,7HLNCUTR=,	OUTPUT	7
	1. 6HNRYBY=,6HNSWCH=,6HMROR=,6HLOADR=,7HNUMSWT=,	OUTPUT	8
	2. 6HIEXCA=,4HMVC=,7HMFLAGC=,7HIEXCAV=,7HMGS(2)=	OUTPUT	9
	7HMGS(3)=,7HMGS(4)=,4HXGS=,5HMG5=,4HQDR=,8*1M).(NNAME=22)	OUTPUT	10
C***		OUTPUT	11
C		OUTPUT	12
C	OUTPUT FOR TEST CASE	OUTPUT	13
C		OUTPUT	14
C***		OUTPUT	15
000002	VALUE(1)=T	OUTPUT	16
000004	VALUE(2)=X-XDISCH	OUTPUT	17
000006	IVAL(3)=IA	OUTPUT	18
000007	VALUE(4)=STR	OUTPUT	19
000011	VALUE(5)=DX	OUTPUT	20
000012	IVAL(6)=MFM	OUTPUT	21

000014	I VAL (7)=LNCUTR	OUTPUT	22
000015	I VAL (8)=NRYRY	OUTPUT	23
000017	I VAL (9)=NSWCH	OUTPUT	24
000020	I VAL (10)=NRORE	OUTPUT	25
000022	I VAL (11)=LOADR	OUTPUT	26
000023	I VAL (12)=NUMSWT	OUTPUT	27
000025	I VAL (13)=LEXCA	OUTPUT	28
000026	I VAL (14)=MCV	OUTPUT	29
000030	I VAL (15)=MFLAGC	OUTPUT	30
000031	I VAL (16)=NUMLD	OUTPUT	31
000033	I VAL (17)=MGS (2)	OUTPUT	32
000034	I VAL (18)=MGS (3)	OUTPUT	33
000036	I VAL (19)=MGS (4)	OUTPUT	34
000037	VALUE (20)=XGS=XDI5CH	OUTPUT	35
000041	VALUE (21)=PMGS	OUTPUT	36
000043	VALUE (22)=QDR	OUTPUT	37
000044	PRINT 5	OUTPUT	38
000050	5 FORMAT (///,1X,16H WORKING STORAGE)	OUTPUT	39
000050	PRINT 411, (NAME (I),VALUE (I),I=1,NNAME)	OUTPUT	40
000065	411 FORMAT (//2(3XA7,E10.3),3XA7,I4,2(3XA7,E10.3),3XA7,I4/ 1 9(3XA7,I4)/ 4(3XA7,I4),3(3XA7,E10.3))	OUTPUT	41
000065	PRINT 412, (WEAR (K),K=1,KK)	OUTPUT	42
000100	412 FORMAT (16H0 CUTTER WEAR... / (I(10.3))	OUTPUT	43
000100	IF (LNCUTR.NE.1) GOTO 420	OUTPUT	44
000102	PRINT 413, (NCUT (I),I=1,LCNCHG)	OUTPUT	45
000115	413 FORMAT (26H0 CUTTERS BEING CHANGED... / (I(10.3))	OUTPUT	46
000115	420 CONTINUE	OUTPUT	47
000115	104 DO 108 I=1,NVEMCL	OUTPUT	48
000117	IS=1TSTAT (I,I)	OUTPUT	49
000121	KS=IS*3+1	OUTPUT	50
000123	MS=KS*2	OUTPUT	51
000125	JS=KSTOP (I)	OUTPUT	52
000127	LS=JS*3-2	OUTPUT	53
000130	IF (JS.GT.100) L5=19	OUTPUT	54
000133	IF (JS.EQ.0) L5=22	OUTPUT	55
000135	NS =LS*2	OUTPUT	56
000137	TTT=TSTAT (I,2)-XDI5CH	OUTPUT	57
000142	PRINT 105, I, (STATUS (K),K=KS,MS), (WHY (L),L=LS,NS) 1-TTT, (TSTAT (I,J),J=3,4),I5,JS	OUTPUT	58
000203	105 FORMAT (11H TRAIN NO. I2: 4M..... 3A6, 2X3A6, 1 4M X = E11.4, 8H FT V = E11.4, 12H MPH DSM = F7.4, 2I5)	OUTPUT	59
000203	108 CONTINUE	OUTPUT	60
000206	RETURN	OUTPUT	61
000206	END	OUTPUT	62
	*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED	OUTPUT	63
	NTPAIN	OUTPUT	64
	NTRUCK	OUTPUT	65
	LTPAIN		
	LTRUCK		
	IFILD		
	LIFILD		
	IFILLO		
	LINTRDA		
	LLTRAN		
	LLTRUK		

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OUTPUT

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LNTRAN
LNTRUK
JMOVE
JMETH
XT
XDE
PC
LVEHCL
NTDA
LLVHCL
LNVHCL
JMOVE
JMETH
XE
PR

3. SUBROUTINE BORE

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	SUBROUTINE BORE	BORE	2
C	ELEMENT - ROCK DISINTEGRATION	BORE	3
C	GENERAL PROCESS - BORING MACHINE	BORE	4
C	ACTIVITY - BORE	BORE	5
C	TECHNIQUE - ROLLING DISC CUTTERS	BORE	6
000002	COMMON /BORING/ CL(3),CPC,OTA,DTC,DTCD,DTD,DTM,PK,PBM,R(100),RC	BORING	2
	A. RPM,TR,XCPC, MASSEM,MBM,MBORF,MCD,MDISAS,LNCMNG,LNCUTR,NCUT(20)	BORING	3
000002	B. WEAR(100),ERORFO,ETRANS	BORING	4
	COMMON /ALL / XT,STR,IA,RQD,CS,TAMB,FLOW,IFLAG	ALL	2
	1. AT,D,E,SK,T,DT,X,PR,XMAX,TMAX,DX,DV,TPRINT,DTPRINT,IMOVE,JMETH	ALL	3
000002	2. TSHFT,REPORT,OPPCT,TO,XO,XDISCH,ICHNG,XCHNG,TCHNG	ALL	4
000002	EQUIVALENCE (JMOVF,IMOVE),(IMETH,JMETH)	ALL	5
000002	COMMON/MONEY/ JMMHM,DJM,DJMMH,DJMRD,DJMRM,DMAINT,DJMBM,DJMG5	ALL	6
	1. PMGS,JMCV,DJHFC,ROPLAN,HPLANT,GSPLAN	ALL	7
	2. ECPLAN,RDTIME,MIIME(2),GSTIME,ECTIME	ALL	8
000002	COMMON/PERFRM/ ROUTIM,RDRTIM,UMHTIM,DMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	9
	I. ECOTIM,GDAY,GADV,GEND,GREG	ALL	10
000002	COMMON/LAROR/ RDMFN(10,2),HMEN(10,2,2),GSMEN(10,2),ECMEN(10,2)	ALL	11
000002	REAL JMMHM,LD,LDR,LBIT,LAURN,LSTEEL,JMCV	ALL	12
000002	DIMENSION G(4)	ALL	13
000002	EQUIVALENCE (G,XT),(XE,XOE),(PR,PC)	ALL	14
000002	DATA (RDUTIME=0.),(RDDTIME=0.)	BORE	9
000002	DATA NEEQIN,INIT,IESET/3*0/	BORE	10
C	OPTION 2 - DIAMETER WITHIN 6-20 FT. AND STRENGTH WITHIN 5-30E3PSI	BORE	11
000002	1 IF(D.GT. 20.1 .OR. D.LT. 6.0) GO TO 10	BORE	12
000013	IF (STR.GT. 30.1 .OR. STR.LT. 5.0) GO TO 10	BORE	13
000023	INIT=1	BORE	14
000024	IF(PRM.EQ. 0.) PBM=40.*EXP(.19*0)	BORE	15
000032	IF(PR.EQ. 0.) PR=.02	BORE	16
000034	IF(E.NE. 0.) GO TO 5	BORE	17
000035	IESET=1	BORE	18
000036	5 IF(NEEQIN.EQ. 0) GO TO 999	BORE	19
000037	NEEQIN=0	BORE	20
000040	GO TO 25	BORE	21
000040	10 PRINT 20	BORE	22
000044	20 FORMAT (87H BORING MACHINE PARAMETERS MUST BE SPECIFIED FOR THIS	BORE	23
	1 TUNNEL DIAMETER OR ROCK STRENGTH)	BORE	24
000044	STOP	BORE	25
C	ENTRY BORER	BORE	26
000046	25 IF(INIT.EQ. 1) GO TO 28	BORE	27
000053	NFEQIN=1	BORE	28
000055	GO TO I	BORE	29
000055	28 IF(IESET.EQ. 0) GO TO 29	BORE	30
000057	E=I.*EXP(.094*STR)	BORE	31
000060	29 CONTINUE	BORE	32
000066		BORE	33
C		BORE	34
C	COMPUTING LABOR TIME USED FOR THIS ACTIVITY	BORE	35
C		BORE	36
000066	RDTIME=RDRTIME*DT	BORE	37
000070	IF (MRORE.NE.0) GOTD 40	BORE	38
000071	30 DJMRD=DJMRD * PBM * .746 * PR * DT	BORE	39
000076	DX=PBH*DT/AT/E*550.*3600./144000.	BORE	40
000102	DV=DX*AT	BORE	41
C		BORE	42

	C	COMPUTING UP TIME FOR ROCK DISINTEGRATION	BORE	43
	C		BORE	44
000103		RDTIM=RDTIM*DT	BORE	45
	C		BORE	46
	C	COMPUTING PLANT AND EQUIPMENT COSTS FOR BORING	BORE	47
	C		BORE	48
000105		35 RDPLAN=RDPLAN*DX*EBOREG*DX*ETRANS	BORE	49
000111		RETURN	BORE	50
	C		BORE	51
000112		40 DX=0.	BORE	52
000113		DV=0.	BORE	53
000114		IF (MBORE .GE. 3) GO TO 35	BORE	54
000117		RDDTIM=RDDTIM*DT	BORE	55
000121		999 CONTINUE	BORE	56
000121		RETURN	BORE	57
000122		END	BORE	58

*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED

IMOVE
JMETH
XT
XOE
PC
JMOVE
IMETH
XE

H. SUBROUTINE CUTTER

GOLETA FORTRAN 1.3 • AUTO RFL • (07-12-72)

07/25/72

	SUBROUTINE CUTTER	CUTTER	2
C	ELEMENT - ROCK DISINTEGRATION	CUTTER	3
C	GENERAL PROCFS - BORING MACHINE	CUTTER	4
C	ACTIVITY - CUTTER CHANGE	CUTTER	5
C	TECHNIQUE - ROLLING DISC CUTTERS	CUTTER	6
000002	COMMON /BORING/ CL(3),CPC,DTA,DTC,DTCO,DTO,DTH,KK,PBM,R(100),RC	BORING	2
	A, RPM,TR,XCPC, MASSEM,MRM,MRORE,MCD,MNDSAS,LNCHNG,LNCUTR,NCUT(20)	BORING	3
	B, WEAR(100),ERORFO,ETRANS	BORING	4
000002	COMMON /ALL / XY,STR,IA,ROD,CS,TAMB,FLOW,IFLAG	ALL	2
	1, AT,D,E,SK,T,DT,X,PR,XMAX,TMAX,DX,DV,TPRINT,DTPRINT,IMOVE,JMETH	ALL	3
	2, TSHFT,REPORT,OPPCT,TO,XO,XDISCH,ICHNG,XCHNG,TCHNG	ALL	4
000002	EQUIVALENCE (JMOVE,IMOVE),(JMETH,JMETH)	ALL	5
000002	COMMON/MONEY/ JMMH,DJM,DJMH,DJHRD,DJMBM,DMANT,DJMB,DJMGS	ALL	6
	1, PMGS,JMCV,OJMF,RDPLAN,HPLANT,GSPLAN	ALL	7
	2, ECPLAN,ROTIME,HTIME(2),GSTIME,ECTIME	ALL	8
000002	COMMON/PERFRM/ RDUTIM,RDOTIM,UMHTIM,DMHTIM,GSUTIM,GSDTIM,ECUTIM	ALL	9
	1, ECDTIM,GDAY,GADV,GENO,GREG	ALL	10
000002	COMMON/LABOR/ RDMEN(10,2),HMEN(10,2,2),GSMEN(10,2),ECMEN(10,2)	ALL	11
000002	RFL JMMH,LD,LOB,LBIT,LABURN,LSTEEL,JMCV	ALL	12
000002	01MENSION G(R)	ALL	13
000002	EQUIVALENCE (G,XT),(XE,XDE),(PR,PC)	ALL	14
000002	DATA (TENPI=31.415926235898)	CUTTER	9
000002	IF (RPM .GT.0.0) GOTO 11	CUTTER	10
000005	RPM = 5.0	CUTTER	11
000006	CL(1)=1000000.	CUTTER	12
000007	CL(2)=400000.	CUTTER	13
000010	CL(3)=100000.	CUTTER	14
000012	RC = .75	CUTTER	15
000013	KK=D/.4R *.9	CUTTER	16
000017	R(1)=2.8R	CUTTER	17
000021	DO 10 K=2,KK	CUTTER	18
000022	R(K)=R(K-1)*2.88	CUTTER	19
000025	10 CONTINUE	CUTTER	20
000027	CPC = 80.	CUTTER	21
000030	XCPC=3.38	CUTTER	22
000032	TR = .5	CUTTER	23
000033	11 DO 15 K = 1,KK	CUTTER	24
000035	15 WEAR(K) = 0.0	CUTTER	25
000040	TIME = 0.0	CUTTER	26
000041	LNCUTR=0	CUTTER	27
000042	RETURN	CUTTER	28
000042	C ENTRY CUTCHG	CUTTER	29
000047	C IF (LNCUTR .NE. 0) GO TO 30	CUTTER	30
000050	LNCHNG=0	CUTTER	31
000051	MK = 0	CUTTER	32
000052	IF (MRORE.NE.0) RETURN	CUTTER	33
000053	DO 21 K=1,KK	CUTTER	34
	C CALCULATE CUTTER WEAR	CUTTER	35
000055	WEAR(K)=WEAR(K)+TENPI*RPM*DT*R(K)/CL(IA)	CUTTER	36
000064	IF (WEAR(K).GE.1.) LNCUTR=1	CUTTER	37
000071	21 CONTINUE	CUTTER	38
000074	IF (LNCUTR.NE.1) RETURN	CUTTER	39
000076	DO 22 K=1,KK	CUTTER	40
		CUTTER	41
		CUTTER	42

000100	IF (WEAR(K) .LT. PC) GO TO 22	CUTTER	43
000103	WEAR(K) = 0.	CUTTER	44
000104	LNCUTR=1	CUTTER	45
000105	LNCHNG = LNCHNG + 1	CUTTER	46
000107	MK= MK+1	CUTTER	47
000110	NCUT(MK)=K	CUTTER	48
000111	22 CONTINUE	CUTTER	49
000114	IF (LNCUTR .EQ. 0) GO TO 40	CUTTER	50
000115	TTIME = LNCHNG * TR	CUTTER	51
000117	DJMRD=DJMRD+LNCHNG*(1.0*XCPC)*CPC	CUTTER	52
000124	RETURN	CUTTER	53
000125	30 TIME = TIME + DT	CUTTER	54
000127	IF (TIME .GE. TTIME) GOTO 35	CUTTER	55
000131	LNCUTR=2	CUTTER	56
000132	RETURN	CUTTER	57
	C CUTTER CHANGE COMPLETED	CUTTER	58
000133	35 TIME = 0.0	CUTTER	59
000134	LNCUTR = 0	CUTTER	60
000135	40 RETURN	CUTTER	61
000136	END	CUTTER	62
	*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED		
	IMOVE		
	JMETH		
	XT		
	XOE,		
	PC		
	JMOVE		
	JMETH		
	XE		
	PR		

I. SUBROUTINE REPAIR

GOLETA FORTRAN 1.3 • AUTO RFL • (07-12-72)

07/25/72

		SUBROUTINE REPAIR	REPAIR	2
	C	GENERAL PROCFSS - BORING MACHINE	REPAIR	3
	C	ACTIVITY - GENERAL MAINTENANCE AND REPAIR	REPAIR	4
000002		COMMON /BORING/ CL(3),CPC,DTA,DTC,DTCO,DTD,DTM,DK,PBM,R(100),RC	BORING	2
		A. RPM,TR,XCPC, MASSEM,MRM,MRDRE,MCD,MDISAS,LNCHNG,LNCUTR,NCUT(20)	BORING	3
		B. WEAR(100),EBREQ,ETRANS	BORING	4
000002		COMMON /ALL / XT,STP,1A,RQD,CS,TAMB,FLDW,IFLAG	ALL	2
		1. AT,D,E,SK,T,DT,X,PR,XMAX,TMAX,DX,DV,TPRINT,DTPRNT,IMOVE,JMETH	ALL	3
		2. TSHFT,RFPRT,OPPCT,TD,XO,XOISCH,ICHNG,XCHNG,TCHNG	ALL	4
000002		EQUIVALENCE (JMDVF,IMOVE),(IMETH,JMETH)	ALL	5
000002		COMMON/MONEY/ JMMHM,DJM,DJMMH,DJMRD,DJMBHM,DMAINT,DJHRM,DJMG	ALL	6
		1. PMGS,JMVC,DJMEC,RDPLAN,HPLANT,GSPLAN	ALL	7
		2. ECPLAN,RDTIME,HTIME(2),GSTIME,FACTIME	ALL	8
000002		COMMON/PERFM/ RDUTIM,RDDTIM,UMHTIM,DMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	9
		1. ECOTIM,GDAY,GADV,GEND,GREG	ALL	10
000002		COMMON/LABOR/ RDMEN(10,2),HMEN(10,2,2),GSMEN(10,2),ECMEN(10,2)	ALL	11
000002		REAL JMMHM,LD,LDB,LBIT,LBURN,LSTEEL,JMVC	ALL	12
000002		DIMENSION G(8)	ALL	13
000002		EQUIVALENCE (G,XT),(XE,XDE),(PR,PC)	ALL	14
000002		IF (DTC.GT. 0.0) GO TO 5	REPAIR	7
000005		DTC = 7.	REPAIR	8
000006		DTM = 1.	REPAIR	9
000007		DJMBHM=0.	REPAIR	10
000010	5	TM=0.	REPAIR	11
000011		TIME=DTC	REPAIR	12
000013		MRM=0	REPAIR	13
000014		RETURN	REPAIR	14
000014	C	ENTRY MAINT	REPAIR	15
	C	IS MAINTENANCE IN PROGRESS	REPAIR	16
000021	10	IF (MRM.NE.0) GOTO 20	REPAIR	17
000022		TIME=TIME-DT	REPAIR	18
	C	IS MAINTENANCE REQUIRED	REPAIR	19
000024		IF (TIME.GT.0.) RETURN	REPAIR	20
000026		MRM=1	REPAIR	21
000027		TM=0.	REPAIR	22
000030		TIME=DTC	REPAIR	23
000032		DJMRM=DJMRM+DJMBHM	REPAIR	24
000034		RETURN	REPAIR	25
	C	IF IN PROGRESS, UPDATE PROGRESS	REPAIR	26
000034	20	TM = TM + DT	REPAIR	27
000036		IF (TM.LT.DTM) RETURN	REPAIR	28
000041		MRM=0	REPAIR	29
000042		TIME=DTC	REPAIR	30
000044		RETURN	REPAIR	31
000044		END	REPAIR	32
		*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED	REPAIR	33
		IMOVE		
		JMETH		
		XT		
		XDE		
		PC		
		JMOVE		
		IMETH		
		XE		
		PR		

J. SUBROUTINE CVLOAD

GOLETA FORTRAN 1.3 • AUTO REL • (07-12-72)

07/25/72

	SUBROUTINE CVLOAD	CVLOAD	2
C		CVLOAD	3
C	ELEMENT - MATERIALS HANDLING	CVLOAD	4
C	GENERAL PROCESS - INTEGRATFO CONT. EXCAVATOR-CONVEYOR LOADER	CVLOAD	5
C	ACTIVITY - LOADING	CVLOAD	6
C		CVLOAD	7
000002	COMMON /WHEELS/ AF,AF,AMAX,AMAXL,AMTIL,RSL,CARCAP,CP,DE,DF,OTAS	WHEELS	2
	1. DTMA,DTM,FL,FC,FR,FT,HPA,HPEA,HPEV,HPFA,HPFV,HPV,LOCO,MC,ML	WHEELS	3
	2. NCARS,NPOINT,NTD,NTM,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL	WHEELS	4
	3. TCURVX(20),TCURVY(20),TMAINT,TWE,VD,VS,VE,VF,VMAX,WC,WL,XDS	WHEELS	5
	4. MAXLD,MINLD,LOPE,WHC,WHC,STATUS(36),WHY(24),MLTYP,WHR,ECONEQ.	WHEELS	6
	5. ECONSS,FL000,FRUCHC,ETRACK,ESWITC,EUNLDA,ERMATN,ITB0RE,	WHEELS	7
	6. TSW(25),INITIT,TCV,TMCV	WHEELS	8
000002	COMMON /OLOCOM/ IFILD,KSTOP(25),KUNLO,LSTOP,LVHCL,NRYRY,NSWCH	WHEELS	9
	1. NTRDA,NVF,ACL,NMMSWT,SWTCH(20),TFC(25),TOP(25),TSTAT(25,4)	WHEELS	10
	2. UTIME(25),LOADR,MUXDT,XGS,IFXCA,MGS(5),MCM,MFLAGC,DUMMY(20)	WHEELS	11
000002	COMMON /NFWCOM/ LIFILD,LKSTOP(25),LKUNLO,LLSTOP,LLVHCL,LNRYBY	WHEELS	12
	1. LNSWCH,LNTRDA,LLVHCL,LNMMSWT,FSWTC(20),FTFC(25),FTOP(25)	WHEELS	13
	2. FTSTAT(25,4),FUTIME(25),LLOADR,LMUXDT,FXGS,LIFXCA,LMGS(5)	WHEELS	14
	3. LMC,LMFLAG,FDUMMY(19)	WHEELS	15
000002	DIMENSION COMOLD(260),COMNEW(260),LTSTAT(25,4),TTSTAT(25,4)	WHEELS	16
000002	EQUIVALENCE (NVHCL,NTRAIN,NTRUCK),(LVHCL,LTRAIN,LTRUCK)	WHEELS	17
	1. (COMOLD,IFILD),(COMNEW,LIFILD,IFILLD),(NTDA,LNTRDA)	WHEELS	18
	2. (FTSTAT,LTSTAT),(TSTAT,TTSTAT)	WHEELS	19
	3. (LLVHCL,LLTRAIN,LLTRUK),(LVHCL,LNTRAIN,LNTRUK)	WHEELS	20
000002	COMMON /ALL / AT,STR,IA,ROD,CS,TAMB,FLOW,IFLAG	ALL	2
	1. AT,D,F,SK,T,DT,X,PP,XMAX,TMAX,DX,DV,TPRINT,DTPRNT,IMOVE,JMETH	ALL	3
	2. TSHET,RRPORT,RRPT,TO,XO,XDISCH,ICHNG,XCHNG,TCHNG	ALL	4
000002	EQUIVALENCE (JMOVE,IMOVE),(JMETH,JMETH)	ALL	5
000002	COMMON /JMMV/ JMMH,DJH,DJMMH,DJMRD,DJMRM,DMAINT,OJMRM,OJMG	ALL	6
	1. PMOS,JMCV,DJHC,ROPLAN,HPLANT,GSPLAN	ALL	7
	2. ECPAN,ROTIME,HTIME(2),GSTIME,ECTIME	ALL	8
000002	COMMON /PERFRM/ RDTIM,RODTIM,UMHTIM,DMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	9
	1. ECDTIM,GDAY,GADV,GEND,GREG	ALL	10
000002	COMMON /LABOR/ RMEN(10,2),HMEN(10,2,2),GSMEN(10,2),ECMEN(10,2)	ALL	11
000002	REAL JMMH,L,D,LDP,LBIT,LBURN,LSTEEL,JMCV	ALL	12
000002	DIMENSION G19	ALL	13
000002	EQUIVALENCE (G,XT),(X,XCF),(PP,PC)	ALL	14
000002	COMMON /CONVEY/ ACM,DTRS,DWH,FE,FL,HP,OC,SMTN,WRT	RELTS	2
	1. WP,XLF,NSURGE,QE,QP,SM,DTCR,DTMR,AB,VRI,NEXON,NGEO,XE,LSURGE	UPDA7	1
	2. STIME,QDPR,DTMI,DTMO	UPDA7	2
000002	EQUIVALENCE (VB,VBI)	CVLOAD	11
000002	DATA INIT /0/	CVLOAD	12
000002	DATA NFEDIN /0/	CVLOAD	13
000002	DATA DTLO /0/	CVLOAD	14
000002	DATA QTEH /0/	CVLOAD	15
000002	DATA QUF /0/	CVLOAD	16
000002	DATA WUF /0/	CVLOAD	17
C		CVLOAD	18
000002	100 IF (AR * VR .EQ. 0.) GO TO 200	CVLOAD	19
C		CVLOAD	20
	OPTION 1	CVLOAD	21
000004	XWRK = AR * VR	CVLOAD	22
000005	WWR = .03 * XWRK * CS / SK	CVLOAD	23
000011	QMR = 60. * XWRK	CVLOAD	24
000012	PRINT 101, QMR,WWR	CVLOAD	24

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000022	101	FORMAT (I0H0 QMR,WMR= 2E14.61	CVLOAD	25
000022		GO TO 250	CVLOAD	26
	C	OPTION 2	CVLOAD	27
000023	200	QMR = 2000. • WMR • SK / CS	CVLOAD	28
	C	BOTH OPTIONS	CVLOAD	29
000027	250	INIT = I	CVLOAD	30
000030		IF (NFEQIN .EQ. 0) GO TO 900	CVLOAD	31
000031		NEEQIN = 0	CVLOAD	32
000032		GO TO 370	CVLOAD	33
	C	NORMAL ENTRY	CVLOAD	34
000032		ENTRY LOAOCV	CVLOAD	35
000037	350	IF (INIT .EQ. 1) GO TO 370	CVLOAD	36
	C	INITIALIZATION REQUIRED	CVLOAD	37
000041		NEEQIN = 1	CVLOAD	38
000042		GO TO 100	CVLOAD	39
	C	PERFORM LOADING	CVLOAD	40
000043	370	OTLD = OT	CVLOAD	41
000045		OVL D = OV	CVLOAD	42
	C		CVLOAD	43
	C	COMPUTING LABOR TIME USED FOR THIS ACTIVITY	CVLOAD	44
	C		CVLOAD	45
000046		HTIME(2)=HTIME(2)+OT	CVLOAD	46
000050		IF (MCV .NE. 0) GO TO 900	CVLOAD	47
000051		IF (MLTYP .NE. 2) .AND. (LVHCL .EQ. 0) GO TO 380	CVLOAD	48
	C		CVLOAD	49
	C	COMPUTING PLANT AND EQUIPMENT COSTS	CVLOAD	50
	C		CVLOAD	51
000060		HPLANT=HPLANT+ECONEQ*DX+ECONSS*OX	CVLOAD	52
000064	380	IF (LOAOR .NE. 1) GO TO 390	CVLOAD	53
000066		OTLO = 2. • OT	CVLOAD	54
000070		DVLO = OV • QTEM	CVLOAD	55
000072	390	QOD = DVLD • SK / OTLO	CVLOAD	56
000075		WOD = DVLD • CS / (OTLO • SK • 2000.)	CVLOAD	57
000100		IF (MLTYP .EQ. 2) GO TO 600	CVLOAD	58
	C	UNITIZED MAIN LINE SYSTEM	CVLOAD	59
000102		IF (LLVHCL.LF.0) GOTO 700	CVLOAD	60
000104		LLOAOR = 0	CVLOAD	61
000105		IF (QTEM .EQ. 0.) GO TO 550	CVLOAD	62
	C	ACCOUNT FOR MUCK FROM LAST CYCLE	CVLOAD	63
000106		QUF = QUF • QTEM	CVLOAD	64
000107		WUF = WUF • WTEM	CVLOAD	65
000111		QTEM = 0.	CVLOAD	66
000112		WTEM = 0.	CVLOAD	67
000112	550	IF (QOD .GT. QMR .OR. WOD .GT. WMR) GO TO 700	CVLOAD	68
000124		QUF = QUF • QOD • DTLD	CVLOAD	69
000126		WUF = WUF • WOD • DTLO	CVLOAD	70
000131		IF (QUC .GT. QUF .AND. WUC .GT. WUF) GO TO 900	CVLOAD	71
	C	MAINLINE UNIT FULL, CAN BE RELEASED	CVLOAD	72
000142		I=LLVHCL	CVLOAD	73
000143		LKSTOP(I)=5	CVLOAD	74
000145		LTSTAT(I,1)=7	CVLOAD	75
000146		QTEM = QUF - QUC	CVLOAD	76
000150		WTEM = WUF - WUC	CVLOAD	77
000152		QUF = 0.	CVLOAD	78
000153		WUF = 0.	CVLOAD	79

000153		GO TO 900		CVLOAD	80
	C		CONTINUOUS MAINLINE SYSTEM	CVLOAD	81
000154		600 IF (QDD .GT. QMR .OR. WDD .GT. WMR) GO TO 700		CVLOAD	82
000166		FQL = Q00		CVLOAD	83
000167		GO TO 900		CVLOAD	84
	C		CONVEYOR CAPACITY EXCEEDED - TURN OFF	CVLOAD	85
	C		EXCAVATOR NEXT CYCLE TO AVG. EXCESS OUT	CVLOAD	86
000167		700 LLOADR = 1		CVLOAD	87
000170		QTEM = DVLD		CVLOAD	88
000172		WTEM = WDD * DTLD		CVLOAD	89
000174		900 CONTINUE		CVLOAD	90
000174		RETURN		CVLOAD	91
000175		END		CVLOAD	92

*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED

NTRAIN
NTRUCK
LTRAIN
LTRUCK
IFIL0
LIFILD
IFILLD
LNTRDA
LLTRAN
LLTRUK
LNTRAN
LNTRUK
IMOVE
JMETH
XT
XDE
PC
VRI
NVEHCL
NTDA
LNVHCL
JMOVE
IMETH
XE
PR

K. SUBROUTINE CVMNT

GOLETA FORTRAN I.3 * AUTO RFL * (07-12-72)

07/25/72

		CVMNT	
	SUBROUTINE CVMNT	CVMNT	2
C		CVMNT	3
C	ELFMENT MATERIALS HANDLING	CVMNT	4
C	GENERAL PROCESS INTEGRATED CONVEYER EXCAVATOR, CONVEYER LOADER	CVMNT	5
C	ACTIVITY MAINTENANCE	CVMNT	6
000002	COMMON /ALL / XT,STR,IA,ROD,CS,TAMB,FLOW,IFLAG	ALL	7
	1. AT,DE,SK,T,DT,X,PR,XMAX,TMAX,DX,DV,TPRINT,DTPRINT,MOVE,JMETH	ALL	2
	2. TSHFT,REPORT,OPPCT,TO,XO,ADTSCH,ICHNG,XCHNG,TCHNG	ALL	3
000002	EQUIVALENCE (JMOV,MOVE),(IMETH,JMETH)	ALL	4
000002	COMMON/MONEY/ JMMH,DJM,DJMH,DJHRD,DJMBH,DMAINT,DJMBH,DJMG	ALL	5
	1. PMS,JMCV,DJMEC,ROPLAN,MPLANT,GSPLAN	ALL	6
	2. ECPLAN,ROTIME,HTIME(2),GSTIME,ECTIME	ALL	7
000002	COMMON/PERFM/ ROUTIM,RODTIM,UMHTIM,DMHTIM,GSUTIM,GSDTIM,ECUTIM	ALL	8
	1. ECDTIM,GDAY,GADV,GEND,GREG	ALL	9
000002	COMMON/LABOR/ RMEN(10,2),HMEN(10,2),GSMEN(10,2),ECMEN(10,2)	ALL	10
000002	REAL JMMH,LD,LDR,LBIT,LBURN,LSTEFF,JMCV	ALL	11
000002	DIMENSION G(8)	ALL	12
000002	EQUIVALENCE (G,XT),(XE,XDF),(PR,PC)	ALL	13
000002	COMMON /WHEELS/ AF,AF,AMAX,AMAXL,AMINL,BSL,CARCAP,CP,DE,DF,DTAS	WHEELS	14
	1. DTMA,DTU,FL,FC,FR,FT,HFA,HPEA,HPEV,HPEA,HPEV,HPV,LOCO,MC,ML	WHEELS	2
	2. NCARS,NPOINT,NTD,NTM,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL	WHEELS	3
	3. TCURVX(20),TCURVY(20),TMAINT,TWE,VO,VS,VE,VF,VMAX,WC,WL,XDS	WHEELS	4
	4. MAXLD,NUMLD,LOUE,QUC,WUC,STATUS(36),WHY(24),MLTYP,WHR,ECONEQ	WHEELS	5
	5. ECONSS,ELOCO,EMUCKC,ETRACK,FSWITC,EUNLOA,ERMATN,IIROF,	WHEELS	6
	6. ISW(25),NTINIT,TCCV,TMCV	WHEELS	7
000002	COMMON /OLDCOM/ IFILD,KSTOP(25),KUNLO,LSTOP,LVEHCL,NRYBY,NSWCH	WHEELS	8
	1. NTRDA,NVEHCL,NUMSWT,SWITCH(20),TFC(25),TOP(25),TSTAT(25,4)	WHEELS	9
	2. UTIME(25),LOADR,MUKOT,XGS,IFEXCA,MGS(5),MVC,MFLAGC,DUMMY(20)	WHEELS	10
000002	COMMON /NECOM/ LIFILO,LKSTOP(25),LKUNLO,LLSTOP,LLVHCL,LNRYBY	WHEELS	11
	1. LNSWCH,LNTRDA,LNVHCL,LNMSWT,FSWITCH(20),FTFC(25),FTOP(25)	WHEELS	12
	2. FTSTAT(25,4),FUTIME(25),LLOADR,LMUKOT,FXGS,LIFEXCA,LMGS(5)	WHEELS	13
	3. LMCV,LMFLAG,FDDUMMY(19)	WHEELS	14
000002	DIMENSION COMOLD(260),COMNEW(260),LTSTAT(25,4),ITSTAT(25,4)	WHEELS	15
000002	EQUIVALENCE (NVEHCL,NTRAIN,NTRUCK),(LVEHCL,LTRAIN,LTRUCK)	WHEELS	16
	1. (COMOLD,IFILD),(COMNEW,LIFILD,IFILLO),(INTDA,LNTRDA)	WHEELS	17
	2. (FTSTAT,LTSTAT),(ITSTAT,ITSTAT)	WHEELS	18
	3. (LLVHCL,LLTRAN,LLTRUK),(LNVHCL,LNTRAN,LNTRUK)	WHEELS	19
000002	DATA LMCV,MVC/2*0/	CVMNT	20
000002	DATA TRET,THNT /2*0/	CVMNT	10
000002	DATA INIT,NEFDIN /2*0/	CVMNT	11
	EQUIVALENCE FOR SPECIFIC GENERAL PROCESS	CVMNT	12
000002	EQUIVALENCE (GOJM,JMCV)	CVMNT	13
000002	EQUIVALENCE (MMNT,MVC)	CVMNT	14
000002	EQUIVALENCE (GDTC,TCCV)	CVMNT	15
000002	EQUIVALENCE (GDM,TMCV)	CVMNT	16
000002	EQUIVALENCE (LMMNT,LMCV)	CVMNT	17
000002	EQUIVALENCE (MFLAG,MFLAGC)	CVMNT	18
000002	EQUIVALENCE (DJMG,DJMMH)	CVMNT	19
000002	EQUIVALENCE (LMFLAG,LMFLAG)	CVMNT	20
	INITIALIZATION	CVMNT	21
		CVMNT	22
		CVMNT	23
		CVMNT	24
000002	10 MMNT=0	CVMNT	25
000003	IF(GDTC.EQ.0.) GDTC=7.	CVMNT	26

000005	IF(GDJM .EQ. 0.) GDJM=0.	CVMNT	27
000007	IF(GDTM .EQ. 0.) GDTM=1.	CVMNT	28
000011	ITRET=GDTM	CVMNT	29
000012	INIT =)	CVMNT	30
000013	IF (NEEDIN .EQ. 0) GO TO 999	CVMNT	31
000014	NEEDIN = 0	CVMNT	32
000015	GO TO 200	CVMNT	33
	C	CVMNT	34
	C	CVMNT	35
000015	ENTRY CVRPP	CVMNT	36
000022	IF (INIT .EQ. 1) GO TO 200	CVMNT	37
000024	NEEDIN = 1	CVMNT	38
000025	GO TO 10	CVMNT	39
	C	CVMNT	40
	200	CVMNT	41
000026	IF (MMNT.NE.0) GOTO 400	CVMNT	42
000027	IF (MFLAG .NE. 0) GO TO 999	CVMNT	43
	C	CVMNT	44
000030	ITRET = ITRET - 0T	CVMNT	45
000032	IF (ITRET .GT. 0.) GO TO 999	CVMNT	46
	C	CVMNT	47
	C	CVMNT	48
	C	CVMNT	49
	C	CVMNT	50
000034	ACCUMULATING DOWN TIME	CVMNT	51
000035	MMNT=1	CVMNT	52
000036	MFLAG=1	CVMNT	53
	GO TO 999	CVMNT	54
	C	CVMNT	55
000036	400	CVMNT	56
000040	TMNT = TMNT + 0T	CVMNT	57
	OMHTIM=OMHTIM+0T	CVMNT	58
	C	CVMNT	59
000042	IF (TMNT .LT. GDTM) GO TO 999	CVMNT	60
000044	DJMGP = DJMGP + GDJM	CVMNT	61
000046	ITRET = GDTM	CVMNT	62
000047	TMNT = 0.	CVMNT	63
000047	MMNT=0	CVMNT	64
000050	MFLAG=0	CVMNT	65
000051	999 RETURN		
	C		
000052	NOTE -- CHECK TESTING OF MFLAG IN RELATED SUBROUTINES		
	ENO		
*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED			
IMOVE			
JMETH			
XT			
XOE			
PC			
NTRAIN			
NTRUCK			
LTRAIN			
LTRUCK			
IFILD			
LIFILD			
IFILLO			
LNTROA			
LLTRAN			
LLTRUK			

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CVMNT

07/25/72

LNTRAN
LNTRUK
TCCV
TNCV
MFLAGC
DJMMH
LMFLAC
JMOVE
IMETH
XE
PR
NVEHCL
LVEHCL
NTDA
LLVHCL
LNVHCL

L. SUBROUTINE RAILHL

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07/25/72

			RAILHL	2
			RAILHL	3
			RAILHL	4
			RAILHL	5
			RAILHL	6
			RAILHL	7
			RAILHL	8
			RAILHL	9
			RAILHL	10
			RAILHL	11
			WHEELS	2
			WHEELS	3
			WHEELS	4
			WHEELS	5
			WHEELS	6
			WHEELS	7
			WHEELS	8
			WHEELS	9
			WHEELS	10
			WHEELS	11
			WHEELS	12
			WHEELS	13
			WHEELS	14
			WHEELS	15
			WHEELS	16
			WHEELS	17
			WHEELS	18
			WHEELS	19
			WHEELS	20
			ALL	2
			ALL	3
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			ALL	10
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			ALL	12
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			ALL	14
			RAILHL	14
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			RAILHL	24
			RAILHL	25
			RAILHL	26

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SUBROUTINE RAILHL
ELEMENT - MATERIALS HANDLING
GENERAL PROCESS - CONVENTIONAL RAIL SYSTEM
ACTIVITY - LONG HAUL MUCK TRANSPORT (INCLUDES RETURN AND
TRAFFIC DELAYS)
TECHNIQUE - TRACKS-DOUBLE OR SINGLE WITH CALIFORNIA SWITCHES
ORIVE - DIESEL OR ELECTRIC LOCOMOTIVE

INSERT COMMON
COMMON /WHEELS/ AF,AF, /MAX,AMAXL,AMINL,BSL,CARCAP,CP,DE,DF,DTAS
1. DTMA,DTU,FL,FC,FR,FT,HPA,HPEA,HPEV,HPFA,HPFV,HPV,LOCO,MC,ML
2. NCARS,NPOINT,NTD,NTM,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL
3. TCURVX(20),TCURV(20),TMAINT,TWF,VD,VS,VE,VF,VMAX,WC,WL,DS
4. MAXLD,NUMED,LOP,EOUC,WUC,STATUS(36),WHY(24),MLTYP,WHR,ECONEQ
5. ECONSS,ELOCO,FMCKC,ETRACK,ESWITC,EUNLOA,ERMAIN,ITBORE,
6. ISW(25),NTINT(1),TCCV,THCV

COMMON /DLDCOM/ IFILD,KSTOP(25),KUNLO,LSTOP,LVEHCL,NRYRY,NSWCH
1. NTRDA,LVEHCL,NMWSWT,SWITCH(20),TFC(25),TOP(25),TSTAT(25,4)
2. UTIME(25),LOADR,MUKOT,XGS,LEXCA,MGS(5),MVC,MFLAGC,DUMMY(20)

COMMON /NEFCOM/ LIFILD,LKSTOP(25),LKUNLO,LLSTOP,LLVHCL,LNBYBY
1. LNSWCH,LNTRDA,LNVHCL,LNMSWT,FSWITCH(20),FTFC(25),FTOP(25)
2. FTSTAT(25,4),FUTIME(25),LLOADR,LMUKOT,FXGS,LLEXCA,LMG(5)
3. LMCV,LMFLAG,FDUMMY(19)

DIMENSION COMOLD(260),COMNEW(260),LTSTAT(25,4),ITSTAT(25,4)
EQUIVALENCE (LVEHCL,NTRAIN,NTRUCK),(LVEHCL,LTRAIN,LTRUCK)
1. (COMOLD,IFILD),(COMNEW,LIFILD,IFILLO),(NTDA,LNTRDA)
2. (FTSTAT,LTSTAT),(ITSTAT,ITSTAT)
3. (LLVHCL,LTRAIN,LLTRUK),(LNVHCL,LNTRAIN,LNTRUK)

COMMON /ALL / XT,STR,IA,ROD,CS,TAMB,FLOW,IFLAG
1. AT,DE,SK,T,DT,X,PR,XMAX,TMAX,DX,OV,TPRINT,DTPRNT,IMOVE,JMETH
2. TSNFT,REPORT,OPPCT,TO,YO,XDISCH,ICHNG,XCHNG,TCHNG
EQUIVALENCE (JMOVE,IMOVE),(JMFIM,JMETH)

COMMON /MONEY/ JMHM,OMJ,DJMH,OMJRO,OMJBM,OMAIN,OMJBH,OMJGS
1. PMGS,JMVC,DJMF,ROPLAN,HPLANT,GSPLAN
2. ECPLAN,ROTIME,HTIME(2),GSTIME,ECTIME

COMMON /PERFRM/ ROUTIM,RODTIM,UMHTIM,DMHTIM,GSUTIM,GSOTIM,ECUTIM
1. ECOTIM,GNAY,GADV,GENO,GBEG

COMMON /LABOR/ ROMFN(10,2),HMEN(10,2,2),GSMEN(10,2),ECMEN(10,2)
REAL JMHM,LD,LDR,LBIT,LBURN,LSTEEL,JMVC
DIMENSION G(8)
EQUIVALENCE (G,XT),(XE,XOE),(PR,PC)
DATA INITSW,IRETSW /2*0/
DATA IOPTN /1/
DIMENSION KTFMP(25),KTRAIN(25),ISTATE(25,4),STATE(25,4)
1. JSTOP(25),TTFC(25),TTOP(25)
DATA (KTEMP=25*0),(KTRAIN=25*0),(STATE=100*0.)
1. (JSTOP=25*0),(TTFC=25*0),(TTOP=25*0),(V=0.)
EQUIVALENCE (STATE,ISTATE)

PARAMETER INITIALIZATION

100 INITSW = 1
MFLS = SL/2.
IF(LOCO.EQ. 2) GO TO 110
    
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000007	IF (FC .EQ.0.) FC = 0.0455	RAILML	27
000011	IF (CP .EQ.0.) CP = 0.14	RAILML	28
000013	GO TO 120	RAILML	29
000014	110 FC=.746	RAILML	30
000016	IF (CP .EQ. 0.) CP=.02	RAILML	31
000020	120 IF (VE * VF .GT.0.) GO TO 200	RAILML	32
	OPTION 2	RAILML	33
	C	RAILML	34
000024	IOPTN = 2	RAILML	35
000025	IF (FT .EQ. 0.) FT = 0.25	RAILML	36
000027	IF (AMAX .EQ. 0.) AMAX = 9999.	RAILML	37
000031	IF (EL .EQ. 0.) EL=0.8	RAILML	38
000033	HPFAC = EL * 375.	RAILML	39
000035	HPAFAC = HPFAC * HPA	RAILML	40
000037	GE = (NCARS * WC) * WL	RAILML	41
000042	GF = NCARS * (WC * 1.35 * CARCAP) * WL	RAILML	42
000047	X1 = NCARS * MC * ML	RAILML	43
000053	WE = GE / X1	RAILML	44
000054	WF = GF / X1	RAILML	45
000056	TTEA = FT * WL * 2000.	RAILML	46
000060	AC = 6.65 * (CARCAP ** 0.39) * .00 ;	RAILML	47
	COMPUTE VE, RE, VF, RF	RAILML	48
	C	RAILML	49
000066	C1 = 1.3 * (29. / WE)	RAILML	50
000071	C2 = AC / (WF * MC)	RAILML	51
000074	C4 = HPV * HPFAC	RAILML	52
000076	REF1 = C1	RAILML	53
000077	REF2 = C2	RAILML	54
000101	A = .045 / C2	RAILML	55
000102	B = C1 / C2	RAILML	56
000103	C = -C4 / (C2 * GE)	RAILML	57
000106	VE = CURIC (A, B, C)	RAILML	58
000111	IF (VE .GT. VMAX) VE = VMAX	RAILML	59
000114	RE = GE * (C1 * (C2 * VE * VE) * (.045 * VE))	RAILML	60
000123	C1 = 1.3 * (29. / WF)	RAILML	61
000126	C2 = AC / (WF * MC)	RAILML	62
000131	RFF1 = C1	RAILML	63
000132	RFF2 = C2	RAILML	64
000134	A = .045 / C2	RAILML	65
000135	B = C1 / C2	RAILML	66
000136	C = -C4 / (C2 * GF)	RAILML	67
000141	VF = CUBIC (A, B, C)	RAILML	68
000144	IF (VF .GT. VMAX) VF = VMAX	RAILML	69
000147	RF = GF * (C1 * (C2 * VF * VF) * (.045 * VF))	RAILML	70
	COMPUTE MPEV, HPFV	RAILML	71
	C	RAILML	72
000156	MPEV = (RE * VF) / HPFAC	RAILML	73
000161	HPFV = (RF * VF) / HPFAC	RAILML	74
000163	GO TO 250	RAILML	75
	C	RAILML	76
	OPTION 1	RAILML	77
000163	200 CONTINUE	RAILML	78
000163	MPEAM = MPEA	RAILML	79
000165	HPFAM = HPFA	RAILML	80
	C	RAILML	81
	BOTH OPTIONS		
000166	250 DINCRA=150.		
000170	YWRK = VO		
000171	IF (VS .GT. VD) YWRK = VS		
000174	XWRK = 2640. * (VF * VF - YWRK * YWRK) / DF		

000200	IF (XWRK .LT. DINCR) DINCR = XWRK	RAILML	82
000203	XWRK = 2640. * (VE * VE - VS * VS) / OE	RAILML	83
000207	IF (XWRK .LT. DINCR) DINCR = XWRK	RAILML	84
000212	DELMAX = DINCR / (5280. * VE)	RAILML	85
000214	IF (INTRACK .EQ. 2) NUMSWT = 1	RAILML	86
000217	CPFC = CP * FC	RAILML	87
000221	SWHPE = HPEV * VS / VE	RAILML	88
000224	SWHPF = HPFV * VS / VF	RAILML	89
000226	PRINT 260, VF, VF, RE, RF, GE, GF, HPEV, HPFV	RAILML	90
000252	260 FORMAT (23HORAIL PARAMETERS = VE, 7X, 2HVF, 7X, 2HRE, 7X, 2HRF, 7X,	RAILML	91
	2HGE, 7X, 2HGF, 6X, 4HHPEV, 5X, 4HHPFV / 17X, 8(F8.3, 1X))	RAILML	92
000252	QUC=CARCAP*NCARS*27.	RAILML	93
000255	WUC=QUC*.05	RAILML	94
000257	PRINT 261, QUC, WUC	RAILML	95
000266	261 FORMAT (1840 TRAIN CAPACITY = F10.4, 17H CUBIC FEET AND	RAILML	96
	1 F10.4, 5H TONS)	RAILML	97
	C WAS CALL FOR INITIALIZATION ONLY	RAILML	98
000266	IF (IRETSW) 270, 999, 270	RAILML	99
000267	270 IRETSW = 0	RAILML	100
000270	GO TO 350	RAILML	101
	C	RAILML	102
	C	RAILML	103
	C	RAILML	104
	C	RAILML	105
000271	ENTRY RAILTR	RAILML	106
	C	RAILML	107
	C	RAILML	108
	C	RAILML	109
000276	IF (INITSW) 350, 320, 350	RAILML	110
000277	320 IRETSW = 1	RAILML	111
000300	GO TO 100	RAILML	112
000301	350 NITER=DT/DELMAX	RAILML	113
000304	TFRAC=DT-NITER*OELMAX	RAILML	114
	C	RAILML	115
	C	RAILML	116
	C	RAILML	117
000307	HTIME(1)=HTIME(1)*OT	RAILML	118
000310	IF (MFLAGC .NE. 0) GO TO 351	RAILML	119
000311	IF (NUMLD .EQ. 0) GO TO 352	RAILML	120
000312	IF (ITRORE .NE. 0) GO TO 351	RAILML	121
	C	RAILML	122
	C	RAILML	123
	C	RAILML	124
	C	RAILML	125
000313	UMHTIM=UMHTIM*OT	RAILML	126
	C	RAILML	127
	C	RAILML	128
	C	RAILML	129
	C	RAILML	130
000315	351 CONTINUE	RAILML	131
000315	HPLANT=MPLANT*DT*(NTRAIN*ELOCO+NTRAIN*NCARS*EMUCKC)*	RAILML	132
	10X*(ETRAK*NS*ESWITC*EUNLOA*ERMAIN)	RAILML	133
000333	GO TO 353	RAILML	134
	C	RAILML	135
	C	RAILML	136
	C	RAILML	137
000334	352 OMHTIM=OMHTIM*OT	RAILML	138
000336	353 CONTINUE	RAILML	139
	C	RAILML	140
	C	RAILML	141
000336	00 355 J=1, NTRAIN	RAILML	142
		RAILML	143
		RAILML	144
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		RAILML	198
		RAILML	199
		RAILML	200

000340	ISTATF(J,1) = ITSTAT(J,1)	RAILML	137
000342	STATE(J,2) = TSTAT(J,2)	RAILML	138
000345	STATE(J,3) = TSTAT(J,3)	RAILML	139
000347	STATE(J,4) = TSTAT(J,4)	RAILML	140
000351	JSTOP(J) = KSTOP(J)	RAILML	141
000353	TFC(J) = TFC(J)	RAILML	142
000355	TTOP(J) = TOP(J)	RAILML	143
000357	355 CONTINUE	RAILML	144
000361	ISTOP = LSTOP	RAILML	145
000362	360 LLTRAN = 0	RAILML	146
000363	LRETRN = 0	RAILML	147
000364	DELTAT = OELMAX	RAILML	148
000365	IF (NITER.NE.0) GOTO 362	RAILML	149
000366	DELTAT=TFRAC	RAILML	150
000370	362 CONTINUE	RAILML	151
000370	LOUE=100	RAILML	152
000371	DO 364 ITR=1,NTRAIN	RAILML	153
000373	IF (ISTATE(ITR,1).NE.0) GOTO 364	RAILML	154
000375	IF (JSTOP(ITR).GT.100) LOUE=LOUE*1	RAILML	155
000401	364 CONTINUE	RAILML	156
000404	IRRNCH = ISTOP * 1	RAILML	157
000406	GO TO (500,400,450) IBRNCH	RAILML	158
	SYSTEM MUST BE SHUT DOWN	RAILML	159
000414	C 400 DO 420 J=1,NTRAIN	RAILML	160
000416	IF (JSTOP(J) .NE. 0) GO TO 420	RAILML	161
000420	IWRK = ISTATE(J,1)	RAILML	162
000421	IF ((IWRK-10) * (IWRK-11) .EQ. 0) GO TO 420	RAILML	163
000426	JSTOP(J) = 4	RAILML	164
000430	IF ((IWRK-6)*(IWRK-7) .EQ. 0) GO TO 420	RAILML	165
000435	JWRK = (IWRK * 1) / 2	RAILML	166
000437	IWRK = IWRK / 2	RAILML	167
000441	IS = 7	RAILML	168
000442	IF (IWRK .EQ. JWRK) IS = 6	RAILML	169
000445	ISTATF(J,1) = IS	RAILML	170
000447	420 CONTINUE	RAILML	171
000452	GOTO 500	RAILML	172
	SYSTEM MUST BE BROUGHT UP	RAILML	173
000452	C 450 DO 470 J=1,NTRAIN	RAILML	174
000454	IF (JSTOP(J) .NE. 4) GO TO 470	RAILML	175
000457	JSTOP(J) = 0	RAILML	176
000460	JWRK = ISTATE(J,1)	RAILML	177
000461	IF (JWRK .EQ. 0) ISTATE(J,1) = 2	RAILML	178
000464	IF (JWRK .EQ. 1) ISTATE(J,1) = 3	RAILML	179
000470	470 CONTINUE	RAILML	180
000473	475 ISTOP = 0	RAILML	181
	APPLY DELTA-T TO ALL TRAINS	RAILML	182
000474	C 500 DO 750 I = 1,NTRAIN	RAILML	183
000476	DELTAC = 0.	RAILML	184
000477	STATE(I,4) = STATE(I,4) * (DELTAT / 24.)	RAILML	185
000502	ISTAT = ISTATE(I,1)	RAILML	186
000504	TPOS = STATE(I,2)	RAILML	187
000506	TSPO = STATE(I,3)	RAILML	188
000507	IKTEMP = KTEMP(I)	RAILML	189
000511	IJSTOP = JSTOP(I)	RAILML	190
000512	IISW = ISW(I)	RAILML	191

000514	SWPOS = 0	RAILHL	192
000515	IF (IISW .GT. 0) SWPOS = SWITCH(IISW)	RAILHL	193
000520	IBRNCH = ISTAT * 1	RAILHL	194
000522	GO TO (510,510,550,570,590,610,630,650,670,690,700,700) IBRNCH	RAILHL	195
	TRAIN IS EMPTY, AND HAS STOPPED	RAILHL	196
C		RAILHL	197
000541	510 IF (IJSTOP.GT.100) GOTO 511	RAILHL	198
000545	GOTO (514,516,520,1000,1000,600) IJSTOP	RAILHL	199
	TRAIN IS IN LOAD QUEUE	RAILHL	200
C		RAILHL	201
000556	511 CONTINUE	RAILHL	202
000556	GOTO 698	RAILHL	203
	TRAIN IS BEING LOADED	RAILHL	204
C		RAILHL	205
000557	514 LLTRAN=1	RAILHL	206
000561	GOTO 698	RAILHL	207
	TRAIN IN SWITCH, WITH ANOTHER STOPPED AHEAD	RAILHL	208
C		RAILHL	209
000561	516 IF(ISTATE(IKTEMP,1) .EQ. 0) GO TO 700	RAILHL	210
000563	TPOS = SWPOS - HLFLS	RAILHL	211
000565	ISTAT = 2	RAILHL	212
000566	IKTEMP = 0	RAILHL	213
000567	IJSTOP = 0	RAILHL	214
000570	GO TO 698	RAILHL	215
	TRAIN IN SWITCH, WITH ANOTHER APPROACHING	RAILHL	216
C		RAILHL	217
000570	520 IF(STATE(IKTEMP,2) .GT. SWPOS-HLFLS) GO TO 700	RAILHL	218
000576	LRETRN = 1	RAILHL	219
000577	GO TO 636	RAILHL	220
000577	522 ISTAT = 2	RAILHL	221
000600	TPOS = SWPOS * HLFLS	RAILHL	222
000602	IKTEMP = 0	RAILHL	223
000603	IJSTOP = 0	RAILHL	224
000604	GO TO 698	RAILHL	225
	TRAIN IN 1ST SWITCH, AWAITING DISCHARGE	RAILHL	226
C		RAILHL	227
000604	524 IF (IFILLD .EQ. 1) GO TO 700	RAILHL	228
000606	LRETRN = 5	RAILHL	229
000607	GOTO 662	RAILHL	230
	TRAIN IS FULL AND STOPPED	RAILHL	231
C		RAILHL	232
000610	530 IF (IJSTOP.GT.5) GOTO 1000	RAILHL	233
000614	GOTO (1000,536,542,1000,524) IJSTOP	RAILHL	234
	TRAIN IN SWITCH, ANOTHER STOPPED AHEAD	RAILHL	235
C		RAILHL	236
000624	536 IF (ISTATE(IKTEMP,1) .EQ. 1) GO TO 700	RAILHL	237
000627	LRETRN = 3	RAILHL	238
000630	GO TO 662	RAILHL	239
	TRAIN IN SWITCH, ANOTHER APPROACHING	RAILHL	240
C		RAILHL	241
000630	542 IF(STATE(IKTEMP,2) .LT. SWPOS-HLFLS) GO TO 700	RAILHL	242
000635	LRETRN = 5	RAILHL	243
000636	GO TO 656	RAILHL	244
	TRAIN IS ACCELERATING EMPTY	RAILHL	245
C		RAILHL	246
000637	550 IF (IOPTN =) 584,553,584	RAILHL	247
000642	551 RE = GE * (RFF1 * (TSPD*(REF2*TSPD*0.045)))	RAILHL	248
000650	AFA = TEA - RE	RAILHL	249
000652	IF (AFA .LT. 0.) AFA = 0.	RAILHL	250
000654	AE = 39.4 * AFA / GE	RAILHL	251
000657	IF (AMAX .LT. AE) AE = AMAX	RAILHL	252
000662	553 Y1 = AE * DELTAT	RAILHL	253
000664	TPOS = TPOS+DELTAT*((2640.*Y1)+(5280.*TSPD))	RAILHL	254
000672	TSPD = TSPD * Y1	RAILHL	255
000673	IF (IOPTN.EQ.2) HPEAH= (AE * GE/39.4 *RE) * (TSPD/HPFAC)	RAILHL	256

000703	IF (HPA .GT. 0. .AND. HPEAH .GT. HPA) HPEAH = HPA	RAILML	247
000713	OELTAC = HPEAH	RAILML	248
000714	IF (TSPD = VE) 558,554,554	RAILML	249
000717	554 ISTAT = 4	RAILML	250
000720	TSPD = VE	RAILML	251
000722	558 00 562 J=1,NUMSWT	RAILML	252
000724	A = SWITCH(J) - MLFLS - TPOS	RAILML	253
000730	IF (A .LT. 0.) GO TO 562	RAILML	254
000731	B = 2640. * ((TSPD*TSPD)-(VS*VS)) / DE	RAILML	255
000736	IF (A .GT. B) GO TO 562	RAILML	256
000741	ISTAT = 6	RAILML	257
000742	IISW = J	RAILML	258
000743	GO TO 698	RAILML	259
000744	562 CONTINUE	RAILML	260
000747	IISW = 0	RAILML	261
000750	GO TO 698	RAILML	262
	C TRAIN IS ACCELERATING FULL	RAILML	263
000750	570 IF (IOPTN - 1) 584,572,584	RAILML	264
000753	571 RF = GF * (RFF1 * (TSPD * (RFF2*TSPD * 0.045)))	RAILML	265
000761	AFA = TEA - PF	RAILML	266
000763	IF (AFA .LT. 0.) AFA = 0.	RAILML	267
000765	AF = 39.4 * AFA / GF	RAILML	268
000770	IF (AMAX .LT. AF) AF = AMAX	RAILML	269
000773	572 Y) = AF * DELTAT	RAILML	270
000775	TPOS = TPOS - DELTAT*((5280.*TSPD)+(2640.*Y1))	RAILML	271
001002	TSPD = TSPD + Y1	RAILML	272
001004	IF (IOPTN.EQ.2) HPFAH= (AF*GF/39.4 * RF) * (TSPD/HPFAC)	RAILML	273
001014	IF (HPA .GT. 0. .AND. HPFAH .GT. HPA) HPFAH = HPA	RAILML	274
001024	OELTAC = HPFAH	RAILML	275
001025	IF (TSPD = VF) 578,574,574	RAILML	276
001030	574 ISTAT = 5	RAILML	277
001031	TSPD = VF	RAILML	278
001033	578 IF (NTRACK .EQ. 2) GO TO 583	RAILML	279
001035	00 582 J=1,NUMSWT	RAILML	280
001037	A = TPOS - (SWITCH(J) * MLFLS)	RAILML	281
001043	IF (A .LT. 0.) GO TO 582	RAILML	282
001044	B = 2640. * ((TSPD*TSPD)-(VS*VS)) / DF	RAILML	283
001051	IF (A .GT. B) GO TO 582	RAILML	284
001054	ISTAT = 7	RAILML	285
001055	IISW = J	RAILML	286
001056	GO TO 698	RAILML	287
001057	582 CONTINUE	RAILML	288
001062	583 IISW = 0	RAILML	289
001063	B = 2640. * ((TSPD*TSPD)-(VD*VD)) / DF	RAILML	290
001070	IF (TPOS .GT. B) GO TO 698	RAILML	291
001073	ISTAT = 7	RAILML	292
001074	IISW = 100	RAILML	293
001075	GO TO 698	RAILML	294
	C FIND TEA	RAILML	295
001075	584 TEA = TTEA	RAILML	296
001077	IF (HPA .EQ. 0.) GO TO 585	RAILML	297
001100	Y1 = TEA	RAILML	298
001101	IF (TSPD .NE. 0.) Y1 = HPFAH/TSPD	RAILML	299
001103	GO TO 589	RAILML	300
001104	585 IF (TSPD .GT. TCURVX(1)) GO TO 586	RAILML	301

001110	Y1 = TCURVY(1)	RAILML	302
001111	GO TO 589	RAILML	303
001111	586 DO 588 K = 2,NPOINT	RAILML	304
001113	XWRK = TCURVX(K)	RAILML	305
001115	IF(XWRK .LT. TSPD) GO TO 588	RAILML	306
001117	YWRK = TCURVY(K)	RAILML	307
001121	Y1 = YWRK - ((XWRK - TSPD) * (YWRK - TCURVY(K-1)) / (XWRK - TCURVX(K-1)))	RAILML	308
001131	GO TO 589	RAILML	309
001131	588 CONTINUE	RAILML	310
001134	Y1 = TCURVY(NPOINT)	RAILML	311
001135	589 CONTINUE	RAILML	312
001135	IF (Y1 .LT. TEA) TEA = Y1	RAILML	313
001140	IF (ISTAT - 2) 571,551,571	RAILML	314
	C TRAIN EMPTY, GOING AT FULL SPEED	RAILML	315
001143	590 TPOS = TPOS * (5280. * VE * DELTAT)	RAILML	316
001147	DELTA = HPEV	RAILML	317
001150	GOTO 554	RAILML	318
	C TRAIN IN SWITCH, WAITING TO ENTER LOAD AREA	RAILML	319
001150	600 IF (NUMLO.GE.MAXLD) GOTO 700	RAILML	320
001153	LRETRN=1	RAILML	321
001154	GOTO 643	RAILML	322
	C TRAIN FULL, GOING AT FULL SPEED	RAILML	323
001154	610 TPOS = TPOS * (5280. * VF * DELTAT)	RAILML	324
001160	DELTA = HPEV	RAILML	325
001161	GOTO 574	RAILML	326
	C TRAIN IS DECELERATING EMPTY	RAILML	327
001161	630 Y1 = 0E * DELTAT	RAILML	328
001163	TPOS = TPOS * DELTAT * ((5280.*TSPD)-(2640.*Y1))	RAILML	329
001170	TSPD = TSPD - Y1	RAILML	330
001172	IF (TSPD .GT. 0.) GO TO 634	RAILML	331
001174	ISTAT = 0	RAILML	332
001174	TPOS=SWITCH(IISW)	RAILML	333
001176	TSPD = 0.	RAILML	334
001177	IF (IJSTOP.NF.0) GOTO 698	RAILML	335
001200	LRETRN=1	RAILML	336
001201	GOTO 6636	RAILML	337
001201	634 IF (IJSTOP .EQ. 1) GO TO 698	RAILML	338
001203	IF (IISW .EQ. 0) GO TO 698	RAILML	339
001204	IF (TSPD .GT. VS) GO TO 648	RAILML	340
001210	636 IF (IISW-(NUMSWT-1)) 638, 6638,6636	RAILML	341
001213	6636 LOUE=LOUE+1	RAILML	342
001215	NUMLD=LOUE-99	RAILML	343
001217	IF (NUMLD.LE.MAXLD) GOTO 627	RAILML	344
001221	PRINT 6637	RAILML	345
001225	6637 FORMAT (30H0 TOO MANY TRAINS AT THE FACE)	RAILML	346
001225	CALL EXIT	RAILML	347
001226	627 CONTINUE	RAILML	348
001226	IJSTOP=LOUE	RAILML	349
001230	GOTO 648	RAILML	350
001230	637 IJSTOP=6	RAILML	351
001231	IKTEMP=0	RAILML	352
001232	GOTO 648	RAILML	353
001233	6638 IF (NUMLO-MAXLO) 643,637,637	RAILML	354
001236	638 X1 = SWITCH(IISW * 1)	RAILML	355
001240	RMAX = X1 * MLFLS	RAILML	356

001242	RMIN = X1 - MLFLS	RAILML	357
001243	DO 642 K=1,NTRAIN	RAILML	358
001245	IF (I .EQ. K) GO TO 642	RAILML	359
001246	X1 = STATE(K,2)	RAILML	360
001250	IF (X1 .GT. RMAX) GO TO 642	RAILML	361
001253	IF (X1 .LT. RMIN) GO TO 642	RAILML	362
001255	IWRK = ISTATE(K,I)	RAILML	363
001257	IF (IWRK * (IWRK-6) .NE. 0) GO TO 639	RAILML	364
001262	IKTEMP = K	RAILML	365
001263	IJSTOP = 2	RAILML	366
001264	GO TO 648	RAILML	367
001264	639 IF (IWRK .NE. 8) GO TO 640	RAILML	368
001266	IKTEMP = 0	RAILML	369
001267	IJSTOP = 0	RAILML	370
001270	GO TO 642	RAILML	371
001270	640 IF (IWRK .NE. 9) GO TO 641	RAILML	372
001272	IKTEMP = K	RAILML	373
001274	IJSTOP = 3	RAILML	374
001274	GO TO 648	RAILML	375
001275	641 IF ((IWRK-1) * (IWRK-7) .NE. 0) GO TO 642	RAILML	376
001275	IKTEMP = 0	RAILML	377
001302	IJSTOP = 0	RAILML	378
001303	642 CONTINUE	RAILML	379
001304	643 CONTINUE	RAILML	380
001307	RMAX = SWITCH(IISW * I) - MLFLS	RAILML	381
001312	RMIN = SWITCH(IISW) * MLFLS	RAILML	382
001314	DO 646 K=1,NTRAIN	RAILML	383
001316	IF (I .EQ. K) GO TO 646	RAILML	384
001317	X1 = STATE(K,2)	RAILML	385
001321	IF (X1 .GT. RMAX) GO TO 646	RAILML	386
001324	IF (X1 .LT. RMIN) GO TO 646	RAILML	387
001326	IWRK = ISTATE(K,I)	RAILML	388
001330	IF ((IWRK-1)*(IWRK-3)*(IWRK-5)*(IWRK-7) .NE. 0) GO TO 644	RAILML	389
001344	IKTEMP = K	RAILML	390
001345	IJSTOP = 3	RAILML	391
001346	GO TO 648	RAILML	392
001346	644 IF (IWRK * (IWRK -6) .NE. 0) GO TO 646	RAILML	393
001351	IKTEMP = K	RAILML	394
001353	IJSTOP = 2	RAILML	395
001354	GO TO 648	RAILML	396
001354	646 CONTINUE	RAILML	397
001357	IF (LRETRN .EQ. 1) GO TO 522	RAILML	398
001361	ISTAT = 8	RAILML	399
001362	TSPD = VS	RAILML	400
001363	IKTEMP = 0	RAILML	401
001364	IJSTOP = 0	RAILML	402
001365	GO TO 698	RAILML	403
001365	648 IF (LRETRN .EQ. 1) GO TO 649	RAILML	404
001367	ISTAT = 6	RAILML	405
001370	GO TO 698	RAILML	406
001371	649 ISTAT = 0	RAILML	407
001372	GO TO 698	RAILML	408
		RAILML	409
		RAILML	410
		RAILML	411
001373	C 650 IF (JSTOP(I) .NE. 5) GO TO 652		
001376	LRETRN=5		

TRAIN IS DECELERATING FULL

001377	GO TO 656	RAILML	412
001377	652 Y1=DF*DELTAT	RAILML	413
001401	TPOS = TPOS * DELTAT * ((2640.*Y1)-(5280.*TSPD1)	RAILML	414
001407	TSPD = TSPD - Y1	RAILML	415
001410	IF (ISTOP .EQ. 1) GO TO 698	RAILML	416
001412	IF (IISW .EQ. 100) GO TO 653	RAILML	417
001414	IF (TSPD .GT. 0.) GO TO 651	RAILML	418
001416	ISTAT = 1	RAILML	419
001417	TSPD = 0	RAILML	420
001417	GO TO 698	RAILML	421
001420	651 IF (IISW .EQ. 0) GO TO 69A	RAILML	422
001421	IF (TSPD .GT. VSI) GO TO 666	RAILML	423
001425	GO TO 656	RAILML	424
001425	653 IF (TSPD .LE. 0.) TPOS=0.	RAILML	425
001430	IF (TPOS .GT. 0.) GO TO 666	RAILML	426
001433	ISTAT = 10	RAILML	427
001434	TPOS = 0	RAILML	428
001434	TSPD = VO	RAILML	429
001436	NTDA = NTDA * 1	RAILML	430
001437	IF (NTDA .GE. NTO1) IFILLO = 1	RAILML	431
001442	GO TO 698	RAILML	432
001443	656 IF (IISW .NE. 1) GO TO 658	RAILML	433
001445	IF (IFILLO .NE. 1) GO TO 658	RAILML	434
001447	IJSTOP = 5	RAILML	435
001450	IKTEMP = 0	RAILML	436
001451	GO TO 666	RAILML	437
001451	658 IF (IISW .LE. 1) GO TO 662	RAILML	438
001454	X1 = SWITCH(IISW - 1)	RAILML	439
001455	RMAX = X1 * HLFLS	RAILML	440
001457	RMIN = X1 - HLFLS	RAILML	441
001460	OO 660 K=1,NTRAIN	RAILML	442
001462	IF (I .EQ. K) GO TO 660	RAILML	443
001463	XI = STATF(K,2)	RAILML	444
001465	IF (XI .GT. RMAX) GO TO 660	RAILML	445
001470	IF (XI .LT. RMIN) GO TO 660	RAILML	446
001472	IWRK = ISTATF(K,1)	RAILML	447
001474	IF ((IWRK-1)*(IWRK-7) .NE. 0) GO TO 6584	RAILML	448
001501	IKTEMP = K	RAILML	449
001502	IJSTOP = 2	RAILML	450
001503	GO TO 666	RAILML	451
001504	6584 IF (IWRK .NE. 9) GO TO 6586	RAILML	452
001506	IKTEMP = 0	RAILML	453
001507	IJSTOP = 0	RAILML	454
001510	GO TO 660	RAILML	455
001510	6586 IF (IWRK .NE. 8) GO TO 6588	RAILML	456
001512	IKTEMP = K	RAILML	457
001514	IJSTOP = 3	RAILML	458
001515	GO TO 666	RAILML	459
001515	6588 IF ((IWRK-6)*IWRK .NE. 0) GO TO 660	RAILML	460
001520	IKTEMP = 0	RAILML	461
001521	IJSTOP = 0	RAILML	462
001522	660 CONTINUE	RAILML	463
001525	662 RMAX = SWITCH(IISW) - HLFLS	RAILML	464
001530	RMIN=0.	RAILML	465
001531	IF (IISW.NE.1) RMIN=SWITCH(IISW-1)*HLFLS	RAILML	466


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001535 DO 664 K=1,NTRAIN
001537 IF (I .EQ. K) GO TO 664
001540 Y1 = STATF(K,2)
001542 IF (Y1 .GT. PMAX) GO TO 664
001545 IF (Y1 .LT. RMIN) GO TO 664
001547 IWRK = ISTATE(K,1)
001551 IF (IWRK • (IWRK-2) • (IWRK-4) • (IWRK-6) .NE. 0) GO TO 663
001561 IKTEMP = K
001562 IJSTOP = 3
001563 GO TO 666
001563 663 IF ((IWRK-1) • (IWRK-7) .NE. 0) GO TO 664
001570 IKTEMP = K
001572 IJSTOP = 2
001573 GO TO 666
001573 664 CONTINUE
001576 IF ((LRETRN-3) • (LRETRN-5) .EQ. 0) GO TO 6662
001603 ISTAT = 9
001604 TSPD = VS
001606 IKTEMP = 0
001607 IJSTOP = 0
001610 GO TO 698
001610 666 IF ((LRETRN-4) • (LRETRN-5) .EQ. 0) GO TO 6666
001615 ISTAT = 7
001616 GO TO 698
001617 6662 ISTAT = 3
001620 TPOS = SWITCH(IISW) - HLFLS
001623 IKTEMP = 0
001624 IJSTOP = 0
001625 LRETRN=0
001626 GO TO 698
001626 6666 ISTAT = 1
001627 GO TO 698

C TRAIN EMPTY, TRAVELING IN SWITCH AT VS
001630 670 TPOS = TPOS • (5280. • VS • DELTAT)
001634 TSPD = VS
001634 DELTAC = SWHPE
001636 IF (TPOS - SWPOS - HLFLS .LT. 0.) GO TO 698
001641 ISTAT = 2
001642 IISW = 0
001643 GO TO 698

C TRAIN FULL, TRAVELING IN SWITCH AT VS
001644 690 TPOS = TPOS - (5280. • VS • DELTAT)
001650 DELTAC = SWHPE
001651 IF (SWPOS - HLFLS - TPOS .LT. 0.) GO TO 698
001654 ISTAT = 3
001655 IISW = 0
001656 698 ISTATE(I,1) = ISTAT
001660 STATE(I,2) = TPOS
001662 STATE(I,3) = TSPD
001664 ISW(I) = IISW
001666 KTEMP(I) = IKTEMP
001670 JSTOP(I) = IJSTOP
001671 DELTAC = DELTAC • CPFC • DELTAT
001674 DJMMH = DJMMH • DELTAC
001675 TTFC(I) = TTFC(I) • DELTAC
    
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001777	700	TTOP(I) = TTOP(I) + DELTAT	RAILML	522
001702	750	CONTINUE	RAILML	523
	C		RAILML	524
	C	IS ANOTHER ITERATION REQUIRED FOR THIS DT	RAILML	525
	C		RAILML	526
001704		NITER = NITER - 1	RAILML	527
001706		IF (NITER.GE.0) GOTO 360	RAILML	528
	C	UPDATE /NEWWRK/	RAILML	529
001707	900	DO 920 J= 1,NTRAIN	RAILML	530
001711		LTSTAT(J,1) = ISTATE(J,1)	RAILML	531
001713		FTSTAT(J,2) = STATE(J,2)	RAILML	532
001716		FTSTAT(J,3) = STATE(J,3)	RAILML	533
001720		FTSTAT(J,4) = STATE(J,4)	RAILML	534
001722		LKSTOP(J) = JSTOP(J)	RAILML	535
001724		FTFC(J) = TTFC(J)	RAILML	536
001726		FTOP(J) = TTOP(J)	RAILML	537
001730	920	CONTINUE	RAILML	538
001732		LLSTOP = ISTOP	RAILML	539
001733	999	RETURN	RAILML	540
001734	1000	PRINT 1010	RAILML	541
001740	1010	FORMAT (20H0IMPOSSIBLE PATHS)	RAILML	542
001740		CALL EXIT	RAILML	543
001741		END	RAILML	544
		*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERNCED		
		NTRUCK		
		LTRAIN		
		LTRUCK		
		IFILD		
		LIFILD		
		LNTRDA		
		LLTRUK		
		LNTRAN		
		LNTRUK		
		IMOVE		
		JMETH		
		XT		
		XDE,		
		PC		
		NVEHCL		
		LVEHCL		
		LLVHCL		
		LNVEHCL		
		JMOVE		
		JMETH		
		XE		
		PR		

M. FUNCTION CUBIC

GOLETA FORTRAN 1.3 • AUTO RFL • (07-12-72)

07/25/72

	FUNCTION CUBIC (A,B,C)	CUBIC	2
C		CUBIC	3
C	THIS FUNCTION FINDS THE FIRST REAL ROOT OF A CUBIC	CUBIC	4
C	EQUATION OF FORM $X^3 + AX^2 + BX + C = 0$	CUBIC	5
C	USING CARDAN'S SOLUTION	CUBIC	6
		CUBIC	7
000006	P = B - ((A*A) / 3.)	CUBIC	8
000010	Q = (2. * (A/3)**3) - (A*B/3.) + C	CUBIC	9
000017	T = P/3.	CUBIC	10
000021	U = Q/2.	CUBIC	11
000023	QL = T*T*T + U*U	CUBIC	12
000026	T = SORT(QL)	CUBIC	13
000030	U = -U	CUBIC	14
000032	EX = 1./3.	CUBIC	15
000033	BAS = U + T	CUBIC	16
000034	AL = (ABS(BAS)) ** EX	CUBIC	17
000041	IF (BAS .LT. 0.) AL = -AL	CUBIC	18
000046	BAS = U - T	CUBIC	19
000050	BL = (ABS(BAS)) ** EX	CUBIC	20
000054	IF (BAS .LT. 0.) BL = -BL	CUBIC	21
000057	CUBIC = AL + BL - (A/3.)	CUBIC	22
000063	RETURN	CUBIC	23
000063	END	CUBIC	24

N. SUBROUTINE ADDTRN(1)

GOLETA FORTRAN 1.3 * AUTO RFL * (07-12-72)

07/25/72

		SUBROUTINE ADDTRN (1)	ADDTRN	2
C			ADDTRN	3
C		FLPMNT - MATERIALS HANDLING	ADDTRN	4
C		GENERAL PRDCESS - CONVENTIONAL RAIL SYSTEM	ADDTRN	5
C		ACTIVITY - TRAIN INSERTION INTO SYSTEM FROM DISCHARGE AREA	ADDTRN	6
C		(SINGL TRACK SYSTEMS)	ADDTRN	7
C			ADDTRN	8
C		INSERT COMMON	ADDTRN	9
000003		COMMON /WHFFLS/ AF,AF,AMAX,AMAXL,AMINL,BSL,CARCAP,CP,DE,DF,NTAS	WHFFLS	2
	1.	DIMA,DTU,EL,FC,FR,FT,HPA,HPEA,HPEV,HPFA,HPFV,HPV,LOCO,MC,ML	WHEELS	3
	2.	NCARS,NPOINT,NTD,NTM,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL	WHFFLS	4
	3.	TCURVX(20),TCURVY(20),TMAINT,TWF,VD,VS,VE,VF,VMAX,WC,WL,XDS	WHFFLS	5
	4.	MAXLD,NUMLD,LOUE,GUC,WUC,STATUS(36),WHY(24),MLTYP,WHR,ECONED,	WHFFLS	6
	5.	ECONSS,ELOCD,EMUCKC,FTRACK,FSWITC,FUNLOA,ERMAIN,IIBORE,	WHFFLS	7
	6.	ISW(25),NTINIT,ICCV,IMCV	WHFFLS	8
000003		COMMON /OLDCOM/ IFILD,KSTOP(25),KIUNLD,LSTOP,LVEHCL,NRYBY,NSWCH	WHFFLS	9
	1.	NTRDA,NVEHCL,NMMSWT,SWITCH(20),TFC(25),TDP(25),TSTAT(25,4)	WHFFLS	10
	2.	UTIME(25),LLOADR,MUKOT,XGS,TEXCA,MGS(5),MVC,MF,AGC,DUMMY(20)	WHFFLS	11
000003		COMMON /NEWCOM/ LIFILD,LKSTOP(25),LKUNLD,LLSTOP,LVHCL,LNRYBY	WHEELS	12
	1.	LNSWCH,LNTRDA,LNVHCL,LNMSWT,FSWITCH(20),FTFC(25),FTDP(25)	WHFFLS	13
	2.	FTSTAT(25,4),FUTIME(25),LLOADR,LMUKOT,FXGS,LTEXCA,LMGS(5)	WHEELS	14
	3.	LMCV,LMFLAC,FDDUMMY(19)	WHFFLS	15
000003		DIMENSION COMDLD(260),COMNEW(260),LTSTAT(25,4),ITSTAT(25,4)	WHFFLS	16
000003		EQUIVALENCE (NVEHCL,NTRAIN,NTRUCK),(LVEHCL,LTRAIN,LTRUCK)	WHFFLS	17
	1.	(COMDLD,IFILD),(COMNEW,LIFILD,IFILLD),(NTRDA,LNTRDA)	WHFFLS	18
	2.	(FTSTAT,LTSTAT),ITSTAT,ITSTAT)	WHFFLS	19
	3.	(LLVHCL,LTRAIN,LLTRUK),(LNVHCL,LNTRAN,LNTRUK)	WHEELS	20
000003		COMMON /ALL / XT,SIR,IA,ROD,CS,TAMB,FLOW,IFLAG	ALL	2
	1.	AT,DF,SK,T,DT,X,PR,XMAX,TMAX,DX,DV,TPRINT,OTPRNT,IMOVE,JMETH	ALL	3
	2.	TSHFT,REPORT,OPPCT,TO,XD,XDISCH,ICHNG,XCHNG,TCHNG	ALL	4
000003		EQUIVALENCE (JMOVF,IMDVF),(JMETH,JMETH)	ALL	5
000003		COMMON/MONEY/ JMHM,DJM,DJMHM,DJHRD,DJMBM,DMAINT,DJMBM,DJMGS	ALL	6
	1.	PMGS,JMVC,DJHEC,ROPLAN,HPLANT,GSPLAN	ALL	7
	2.	ECPLAN,ROTIME,HTIME(2),GSTIME,FCTIME	ALL	8
000003		COMMON/PERFRM/ RDOTIM,RODTIM,UMHTIM,DMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	9
	1.	ECOTIM,GDAY,GADV,GEND,GBEG	ALL	10
000003		COMMON/LAROR/ RDHEN(10,2),HMEN(10,2,2),GSMEN(10,2),ECHEN(10,2)	ALL	11
000003		REAL JMHM,LB,LDB,LBIT,LBURN,LSTEEL,JMCV	ALL	12
000003		DIMENSION G(8)	ALL	13
000003		EQUIVALENCE (G,XT),(XE,XDE),(PR,PC)	ALL	14
000003		DATA LEND /0/	ADDTRN	12
000003		DIMENSION IQHUE (25)	ADDTRN	13
000003		DATA IQHUE /25*0/	ADDTRN	14
000003		HLFSL = SL / 2.	ADDTRN	15
000005		IF (I.LE.LNTRAN) GO TO 100	ADDTRN	16
000007		PRINT 50, I,LNTRAN	ADDTRN	17
000017		50 FORMAT (25H ***REQUEST TO ADD TRAIN ,I3,I9H IGNORED. NTRAIN = ,I2)	ADDTRN	18
000017		GO TO 900	ADDTRN	19
000021	100	IF (LEND .LE. 0) GO TO 300	ADDTRN	20
000023		IF (IQUEUE(I) - I) 600,300,600	ADDTRN	21
		NO TRAIN PRECEDING TRAIN I IN LOADING AREA	ADDTRN	22
000024	C	300 CONTINUE	ADDTRN	23
		IS THERE A TRAIN IN SWITCH I	ADDTRN	24
000024	C	IF (NUMSWT.GT.1) GO TO 310	ADDTRN	25
000030		IF (NUMLD-MAXLD) 410,600,600	ADDTRN	26

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000033	310	CONTINUE		ADDTRN	27
000033		RMAX= SWITCH(1) • HLFLS		ADDTRN	28
000035		RMIN= SWITCH(1) - HLFLS		ADDTRN	29
000037		DO 400 K=1,NTRAIN		ADDTRN	30
000040		XWRK = TSTAT(K,2)		ADDTRN	31
000042		IF (XWRK .GT. RMAX) GO TO 400		ADDTRN	32
000045		IF (XWRK .LT. RMIN) GO TO 400		ADDTRN	33
	C		TRAIN K IS IN SWITCH 1	ADDTRN	34
000047		IWRK = ITSTAT(K,1)		ADDTRN	35
000051		IF (IWRK • (IWRK-6) • (IWRK-9) .EQ. 0) GO TO 600		ADDTRN	36
000055	400	CONTINUE		ADDTRN	37
000060	410	CONTINUE		ADDTRN	38
	C		IS THERE A TRAIN IN 1ST SEGMENT OF TRACK	ADDTRN	39
000060		RMAX = SWITCH(1) - HLFLS		ADDTRN	40
000062		DO 500 K=1,NTRAIN		ADDTRN	41
000064		IF (TSTAT(K,2) .GT. RMAX) GO TO 500		ADDTRN	42
000070		IWRK = ITSTAT(K,1)		ADDTRN	43
000071		IF (IWRK • (IWRK-6) • (IWRK-1) • (IWRK-3) • (IWRK-5) • (IWRK-7)		ADDTRN	44
		.EQ. 0) GO TO 600		ADDTRN	45
000107	500	CONTINUE		ADDTRN	46
	C		NEW TRAIN MAY PROCEED	ADDTRN	47
000112		LTSTAT(I,1) = 2		ADDTRN	48
000114		FTSTAT(I,2) = 0.		ADDTRN	49
000115		FTSTAT(I,3) = VD		ADDTRN	50
000117		LKSTOP(I) = 0		ADDTRN	51
000120		IF (IQUEUE(I) .NE. 1) GO TO 900		ADDTRN	52
000122		FTSTAT(I,3) = 0.		ADDTRN	53
000123		LEND = LEND - 1		ADDTRN	54
000124		DO 550 J=1,LEND		ADDTRN	55
000126		IQUEUE(J) = IQUEUE(J+1)		ADDTRN	56
000130	550	CONTINUE		ADDTRN	57
000132		IQUEUE(LEND+1) = 0		ADDTRN	58
000133		GO TO 900		ADDTRN	59
	C		NEW TRAIN CAN'T PROCEED	ADDTRN	60
000134	600	LTSTAT(I,1) = 10		ADDTRN	61
000134		FUTIME(I) = 0.		ADDTRN	62
000137		IF (LEND .LE. 0) GO TO 670		ADDTRN	63
000141		DO 650 J=1,LEND		ADDTRN	64
000142		IF (IQUEUE(J) .EQ. 1) GO TO 900		ADDTRN	65
000144	650	CONTINUE		ADDTRN	66
000144	670	LEND = LEND + 1		ADDTRN	67
000150		IQUEUE(LEND) = 1		ADDTRN	68
000152	900	CONTINUE		ADDTRN	69
000152		RETURN		ADDTRN	70
000153		END		ADDTRN	71

*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED

NTRUCK
LTRAIN
LTRUCK
IFILD
LIFILD
IFILLD
LNTRDA
LLTRAN
LLTRUK

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ADOTRN

07/25/72

LNTRUK
IMOVE
JMETH
XT
XDE
PC
NVEHCL
LVEHCL
NTDA
LLVHCL
LNVHCL
JMOVE
JMETH
XE
PR

O. SUBROUTINE RAILDS

GOLETA FORTRAN 1.3 * AUTO RFL * (07-12-72)

07/25/72

	SUBROUTINE RAILDS	RAILDS	2
C		RAILDS	3
C	ELFMENT - MATERIALS HANDLING	RAILDS	4
C	GENERAL PROCESS - CONVENTIONAL RAIL SYSTEM	RAILDS	5
C	ACTIVITY - UNLOAD MUCK AT DISCHARGE POINT	RAILDS	6
C	TECHNIQUE - SEVERAL, DEPENDING ON NTD AND DTU	RAILDS	7
C	INSERT COMMON	RAILDS	8
000002	COMMON /WHEELS/ AF,AF,AMAX,AMAXL,AMINL,BSL,CARCAP,CP,DE,DF,DTAS	WHEELS	2
	1. OTMA,DTU,FL,FC,FR,FT,HPA,HPEA,HPEV,HPFA,HPEV,HPV,LDCD,MC,ML	WHEELS	3
	2. NCARS,NPD,INT,NTD,NTM,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL	WHEELS	4
	3. TCURVX(20),TCURVY(20),TMAINT,TWE,VD,VS,VE,VF,VMAX,WC,WL,XDS	WHEELS	5
	4. MAXLD,NUMLD,LDOE,QUC,WUC,STATUS(36),WHY(24),MLTYP,WHR,ECONEQ.	WHEELS	6
	5. ECONSS,ELOCD,EMUCKC,ETRACK,ESWITC,EUNLOA,ERMATN,IIBORE,	WHEELS	7
	6. ISW(25),NTINIT,TCCV,TMCV	WHEELS	8
000002	COMMON /OLDCOM/ IFILD,KSTOP(25),KUNLD,LSTOP,LVHCL,NBYRY,NSWCH	WHEELS	9
	1. NTRDA,NVEHCL,NUMSWT,SWITCH(20),TFC(25),TOP(25),TSTAT(25,4)	WHEELS	10
	2. UTIME(25),LADDR,MUKOT,XGS,IFXCA,MGS(5),MVC,MFLAGC,DUMMY(20)	WHEELS	11
000002	COMMON /NEWCOM/ LIFILD,LKSTOP(25),LKUNLD,LLSTOP,LLVHCL,LNRYBY	WHEELS	12
	1. LNSWCH,LNTRDA,LNVHCL,LNMSWT,FSWITCH(20),FTFC(25),FTDP(25)	WHEELS	13
	2. FTSTAT(25,4),FUTIME(25),LLOADR,LMUKOT,FXGS,LIEXCA,LMGS(5)	WHEELS	14
	3. LMCV,LMFLAGC,FDUMMY(19)	WHEELS	15
000002	DIMENSION COMOLD(260),COMNEW(260),LTSTAT(25,4),ITSTAT(25,4)	WHEELS	16
000002	EQUIVALENCE (NVEHCL,NTRAIN,NTRUCK),(LVHCL,LTRAIN,LTRUCK)	WHEELS	17
	1. (COMOLD,IFILD),(COMNEW,LIFILD,IFILLO),(NTDA,LNTRDA)	WHEELS	18
	2. (FTSTAT,LTSTAT),(ITSTAT,ITSTAT)	WHEELS	19
	3. (LLVHCL,LLTRAIN,LLTRUK),(LNVHCL,LNTRAIN,LNTRUK)	WHEELS	20
000J02	COMMON /ALL / XT,STR,IA,ROD,CS,TAMB,FLOW,IFLAG	ALL	2
	1. AT,D,E,SK,T,DT,X,PR,XMAX,TMAX,DX,DV,TPRINT,DTPRINT,IMOVE,JMETH	ALL	3
	2. TSHFT,REPORT,DPPCT,TO,XO,XD,ISCH,ICHNG,XCHNG,TCHNG	ALL	4
000002	EQUIVALENCE (JMOVF,IMDVE),(JMETH,JMETH)	ALL	5
000002	COMMON/MONEY/ JMHMM,DJM,DJMHH,DJMHD,DJMBMM,DMAINT,DJMHD,DJMGS	ALL	6
	1. PMGS,JMCV,DJMEC,ROPLAN,HPLAN,GSPLAN	ALL	7
	2. ECPLAN,ROTIME,HTIME(2),GSTIME,ECTIME	ALL	8
000002	COMMON/PERFRM/ RDTIM,RODTIM,UMHTIM,DMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	9
	1. ECOTIM,GOAY,GAOV,GEND,GREG	ALL	10
000002	COMMON/LABOR/ RDMEN(10,2),HMEN(10,2,2),GSMEN(10,2),ECMEN(10,2)	ALL	11
000002	RFL JMHMM,LQ,LDB,LBIT,LBURN,LSTEEL,JMCV	ALL	12
000002	DIMENSION G(4)	ALL	13
000002	EQUIVALENCE (G,XT),(XE,XDE),(PR,PC)	ALL	14
000002	EQUIVALENCE (LNTRDA,NCOUNT)	RAILDS	11
000002	DATA INITDS /0/	RAILDS	12
000002	ENTRY TRUKDS	RAILDS	13
000007	IF (INITDS .EQ. 1) GO TO 100	RAILDS	14
C	INITIALIZE	RAILDS	15
000011	INITDS = 1	RAILDS	16
000012	DO 50 I=1,25	RAILDS	17
000014	UTIME(I) = DTU	RAILDS	18
000016	50 CONTINUE	RAILDS	19
000017	100 IF (KUNLD .EQ. 1) GO TO 800	RAILDS	20
C	UPDATE TIMES FOR TRAINS UNLOADING	RAILDS	21
000021	NCOUNT = 0	RAILDS	22
000022	DO 500 I=1,NTRAIN	RAILDS	23
000023	IF (ITSTAT(I,1) .NE. 10) GO TO 500	RAILDS	24
000026	FUTIME(I) = UTIME(I) - OT	RAILDS	25
000031	NCOUNT = NCOUNT + 1	RAILDS	26

000032	IF (FUTIME(I) .GT. 0.) GO TO 500	RAILDS	27
000036	IF (NTRUCK .EQ. 1) GO TO 300	RAILDS	28
000040	LTSTAT(I,1) = 2	RAILDS	29
000041	GO TO 400	RAILDS	30
000042	300 CALL ADDRNR(I)	RAILDS	31
000044	IF (LTSTAT(I,1) .EQ. 10) 400,500,400	RAILDS	32
	C TRAIN HAS BEEN ADDED	RAILDS	33
000047	400 NCOUNT = NCOINT - 1	RAILDS	34
000051	FUTIME(I) = DTU	RAILDS	35
000053	500 CONTINUE	RAILDS	36
000056	IF (NCOUNT - NTD) 600,620,640	RAILDS	37
000060	600 LIFILD = 0	RAILDS	38
000061	GO TO 800	RAILDS	39
000062	620 LIFILD = 1	RAILDS	40
000063	GO TO 800	RAILDS	41
000064	640 PRINT 645 , NCOUNT	RAILDS	42
000072	645 FORMAT (45H0700 MANY TRAINS IN DISCHARGE AREA. NCOUNT = ,I5)	RAILDS	43
000072	CALL EXIT	RAILDS	44
000073	800 RETURN	RAILDS	45
000074	END	RAILDS	46

*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED

NTRUCK
 LTRAIN
 LTRUCK
 IFILD
 IFILLD
 LNTRDA
 LLTRAN
 LLTRUK
 LNTRAN
 LNTRUK
 INOVE
 JMETH
 XT
 XDE
 PC
 NVEHCL
 LVEHCL
 NYDA
 LLVHCL
 LNVHCL
 JMOVE
 IMETH
 XE
 PR

P. SUBROUTINE RAILEX

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	SUBROUTINE RAILEX	RAILEX	
	ELEMENT - MATERIALS HANDLING	RAILEX	2
	GENERAL PROCESS - CONVENTIONAL RAIL SYSTEM	RAILEX	3
	ACTIVITY - SYSTEM EXTENSION	RAILEX	4
	TECHNIQUE - SINGLE TRACK PLACED AHEAD OF CALIF. SWITCH	RAILEX	5
		RAILEX	6
		RAILEX	7
		RAILEX	8
		RAILEX	9
	INSERT COMMON	WHFELS	2
000002	COMMON /WHEELS/ AF,AF,AMAX,AMAXL,AMINL,BSL,CAPCAP,CP,DF,DF,DTAS	WHFELS	3
	1. DTMA,DTU,FL,FC,FR,FT,HPA,HPFA,HPEV,HPFA,HPFV,HPV,LOCO,MC,ML	WHFELS	4
	2. NCARS,NPOINT,NTD,NTM,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL	WHFELS	5
	3. TCURVX(20),TCURVY(20),TMAINT,TME,VD,VS,VE,VF,VMAX,WC,WL,XDS	WHFELS	6
	4. MAXLD,NUMLD,LDUE,QUC,WUC,STATUS(36),WHY(24),MLTYP,WMR,ECONEQ,	WHFELS	7
	5. ECONSS,ELOCO,FMUCKC,ETRACK,ESWITC,EUNLOA,EPMAIN,ITRDR,	WHFELS	8
	6. ISW(25),NTINIT,TCCV,TMCV	WHFELS	9
000002	COMMON /OLDCON/ IFILO,KSTOP(25),KUNLO,LSTOP,LVEHCL,NRYBY,NSWCH	WHFELS	10
	1. NTRDA,NVEHCL,NUMSWT,SWITCH(20),TFC(25),TOP(25),TSTAT(25,4)	WHFELS	11
	2. UTIME(25),LOADR,MUKOT,XGS,IECA,MGS(5),MCM,MFLAGC,DUMMY(20)	WHFELS	12
000002	COMMON /NEWCON/ LIFILO,LKSTOP(25),LKUNLO,LLSTOP,LLVHCL,LNRYBY	WHFELS	13
	1. LNSWCH,LNTRDA,LNVHCL,LNMSWT,FSWCH(20),FTFC(25),FTOP(25)	WHFELS	14
	2. FTSTAT(25,4),FITIME(25),LLOADR,LMUKOT,FXGS,LIEXCA,LMGS(5)	WHFELS	15
	3. LMCV,LMFLAC,FOIMMY(19)	WHFELS	16
000002	DIMENSION COMOLD(260),COMNEW(260),LTSTAT(25,4),ITSTAT(25,4)	WHFELS	17
000002	EQUIVALENCE (NVEHCL,NTRAIN,NTRUCK),(LVEHCL,LTRAIN,LTRUCK)	WHFELS	18
	1. (COMOLO,IFILD),(COMNEW,LIFILE,IFILLD),(NTDA,LNTRDA)	WHFELS	19
	2. (FTSTAT,LTSTAT),(TSTAT,ITSTAT)	WHFELS	20
	3. (LLVHCL,LTRAIN,LLTRUK),(LNVHCL,LNTRAIN,LNTRUK)	ALL	2
000002	COMMON /ALL / XT,STR,IA,RDD,CS,TAMB,FLOW,IFLAG	ALL	3
	1. AT,D,F,SK,T,DT,X,PR,XMAX,TMAX,DX,DV,TPRINT,DTPRNT,IMOVE,JMETH	ALL	4
	2. TSHFT,REPORT,OPPCT,TO,XO,XDISCH,ICHNG,XCHNG,TCMNG	ALL	5
000002	EQUIVALENCE (JMOVE,IMOVE),(JMETH,JMETH)	ALL	6
000002	COMMON/MONEY/ JMMHM,OJM,DJMMH,OJMRD,OJMBHM,DMANT,DJMBM,DJMG	ALL	7
	1. PMGS,JMCV,OJMEC,RDPLAN,HPLANT,GSPLAN	ALL	8
	2. ECPAN,ROTIME,HTIME(2),GSTIME,ECTIME	ALL	9
000002	COMMON/PERFRM/ RDUJTM,ROOTIM,UMHTIM,DMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	10
	1. ECDTIM,GDAY,GADV,GFNO,GREG	ALL	11
000002	COMMON/LAROR/ RDMFN(10,2),HMEN(10,2,2),GSMEN(10,2),ECMEN(10,2)	ALL	12
000002	REAL JMMHM,LD,LDB,LBIT,LBURN,LSTFEL,JMCV	ALL	13
000002	DIMENSION G(A)	ALL	14
000002	EQUIVALENCE (G,XT),(XE,XDE),(PR,PC)	BELTS	2
000002	COMMON /CONVEY/ ACH,DTRS,DWH,FE,FL,MP,OC,SMIN,WRI	UPDA7	1
	1. WP,XLF,NSURGE,OE,OP,SM,OTCB,DTMR,AB,VRI,NEXDN,NGEO,XE,LNSURG,	UPDA7	2
	2. STIME,QOMP,DTMI,DTMO	RAILEX	13
000002	DATA ALA /0./	RAILEX	14
000002	DATA DTE /0./	RAILEX	15
000002	DATA DTS /0./	RAILEX	16
000002	DATA NFEDIN /0/	RAILEX	17
000002	DATA S /0./	RAILEX	18
000002	DATA INITEX /0/	RAILEX	19
	INITIALIZE	RAILEX	20
000002	ENTRY TRUKEX	RAILEX	21
000007	100 INITEX = I	RAILEX	22
000010	IF (XDE * XDS * BSL .GT.0.) GDTO 200	RAILEX	23
	OPTION 2 (TEMPORARY VALUES)	RAILEX	24
000014	XDE = 5.		

000015	XDS = 3.		RAILEX	25
000016	BSL = 52A0.		RAILEX	26
	C	BOTH OPTIONS HERE	RAILEX	27
000017	200 IF (INTRACK .EQ. 2) BSL = 0		RAILEX	28
000022	IF (AMINL .EQ. AMAXL) ALA=AMINL		RAILEX	29
000025	NDUMMY = 0		RAILEX	30
000026	NRYBY = 0		RAILEX	31
000027	PRINT 205, XDE, XDS, BSL		RAILEX	32
000040	205 FORMAT (30HPAIL EXTENSION - EXT. RATE = F8.2, U 20H SWITCH MOVE RATE = F8.2, 2 29H DISTANCE BETWEEN SWITCHES = F8.2)		RAILEX	33
	C	WAS CALL FOR INITIALIZATION ONLY	RAILEX	34
000040	IF (NFFDIN) 900,900,210		RAILEX	35
000042	210 NFEODIN = 0		RAILEX	36
000043	GO TO 270		RAILEX	37
	C	NORMAL ENTRY AFTER FIRST CALL	RAILEX	38
000044	ENTRY RAILXT		RAILEX	39
000051	ENTRY TRUKXT		RAILEX	40
	C	HAS INITIALIZATION BEEN DONE	RAILEX	41
000056	IF (INITEX) 250,250,270		RAILEX	42
000060	250 NEEDIN = 1		RAILEX	43
000061	GO TO 100		RAILEX	44
000062	270 IF (NEXON .EQ. 1) GO TO 950		RAILEX	45
000064	NSWCH = NSWCH		RAILEX	46
000066	IF (NSWCH) 300,300,530		RAILEX	47
000067	300 IF (NGEO .EQ. 1) GO TO 350		RAILEX	48
	C	CYCLIC OPERATIONS GEOMETRY	RAILEX	49
000071	IF (DTE .EQ. 0.) OTE = OX / XDE		RAILEX	50
000074	DTE = DTE - DT		RAILEX	51
000076	ALA = ALA + DX		RAILEX	52
000100	IF (DTE) 310,310,320		RAILEX	53
000101	310 LNRYBY = 0		RAILEX	54
000102	DTE = 0		RAILEX	55
000103	GO TO 330		RAILEX	56
000103	320 LNRYBY = 1		RAILEX	57
000104	330 GO TO 450		RAILEX	58
	C	CONTINUOUS OPERATION	RAILEX	59
000105	350 ALA = ALA + (XDE * OT)		RAILEX	60
000110	S = S + OX - (XOF * OT)		RAILEX	61
000113	IF (S .GT. 0) GO TO 400		RAILEX	62
	C	EXTENSION HAS CAUGHT EXCAVATOR	RAILEX	63
000115	XWRK = XOF * DT		RAILEX	64
000116	ALA = ALA - XWRK * OX		RAILEX	65
000121	S = S - OX + XWRK		RAILEX	66
000123	GO TO 450		RAILEX	67
000124	400 LNRYBY = 0		RAILEX	68
000125	IF (S .GE. SM) LNRYBY = 1		RAILEX	69
000131	420 CONTINUE		RAILEX	70
000131	450 IF (NSWCH .GT. 0) GO TO 530		RAILEX	71
000134	IF (ALA .LT. AMAXL) GO TO 750		RAILEX	72
	C	IS SWITCH TO BE ADDED	RAILEX	73
000136	IF (BSL .EQ. 0) GO TO 510		RAILEX	74
000137	IF (NUMSWT .EQ. 1) GO TO 470		RAILEX	75
000141	XWRK = SWITCH(NUMSWT) - SWITCH(NUMSWT - 1)		RAILEX	76
000144	IF (XWRK - BSL - SL1) 510,490,490		RAILEX	77
			RAILEX	78
			RAILEX	79

000147	470	IF(SWITCH(NUMSWT) -BSL-SL-XDISCH) 510,490,490	RAILEX	80
000155	490	NSWTCH = 1	RAILEX	81
000156		GO TO 530	RAILEX	82
000157	510	NSWTCH = 2	RAILEX	83
000160	530	CONTINUE	RAILEX	84
000160	550	IF (NSWTCH .EQ. 1) GO TO 650	RAILEX	85
		PUSH SWITCH FORWARD	RAILEX	86
	C		RAILEX	87
000162		IF (DTS .NE. 0.) GO TO 600	RAILEX	88
000163		DTS = (AMAXL - AMINL) / XDS	RAILEX	89
000166		LNRYBY = 0	RAILEX	90
000167	600	DTS = DTS - DT	RAILEX	91
000171		IF (DTS .GT. 0.) GO TO 750	RAILEX	92
000173		DTS = 0.	RAILEX	93
000173		NSWTCH = 0	RAILEX	94
000174		LNRYBY = 0	RAILEX	95
000175		ALA = AMINL	RAILEX	96
000176		IF(AMAXL .NE. AMINL) GO TO 620	RAILEX	97
000200		FSWTC(H(NUMSWT)) = SWITCH(NUMSWT) * DX	RAILEX	98
000203		DO 605 K=1,NTRAIN	RAILEX	99
000204		IF((KSTOP(K) .GE. 100) .OR. (KSTOP(K) .EQ. 1)) FTSTAT(K,2)=TSTAT(K	RAILEX	100
		1,2)*DX	RAILEX	101
000221	605	CONTINUE	RAILEX	102
000224		GO TO 750	RAILEX	103
000224	620	FSWTC(H(NUMSWT))=SWITCH(NUMSWT)*AMAXL-AMINL	RAILEX	104
000231		DO 610 K=1,NTRAIN	RAILEX	105
000232		IF((KSTOP(K) .GE. 100) .OR. (KSTOP(K) .EQ. 1)) FTSTAT(K,2)=TSTAT(K	RAILEX	106
		1,2)*AMAXL-AMINL	RAILEX	107
000250	610	CONTINUE	RAILEX	108
000253		GO TO 750	RAILEX	109
	C	ADD NEW SWITCH	RAILEX	110
000253	650	IF (DTS) 700,672,700	RAILEX	111
000254	672	DTS=DTAS	RAILEX	112
000256		NSWTCH=1	RAILEX	113
000257		LNRYBY = 0	RAILEX	114
000260	700	DTS = DTS - DT	RAILEX	115
000262		IF (DTS) 710,710,750	RAILEX	116
	C	NEW SWITCH HAS BEEN ADDED	RAILEX	117
000263	710	DTS = 0.	RAILEX	118
000264		NSWTCH = 0	RAILEX	119
000265		LNRYBY = 0	RAILEX	120
000266		LNMSWT = NUMSWT + 1	RAILEX	121
000270		FSWTC(H(LNMSWT))=SWITCH(NUMSWT)	RAILEX	122
000272		FSWTC(H(NUMSWT))=SWITCH(NUMSWT)-SL	RAILEX	123
	C	MUST NEW TRAIN BE ADDED	RAILEX	124
000275	750	XWRK=(X-XDISCH)/5280.	RAILEX	125
000300		YWRK = 0.	RAILEX	126
000301		IF (XWRK .LE. XP) GO TO 770	RAILEX	127
000303		X1 = XP/5280.	RAILEX	128
000305		YWRK = XWRK - X1	RAILEX	129
000306		XWRK = X1	RAILEX	130
000307	770	NTFIT=NTINIT+NTMILP*XWRK+NTMLPP*YWRK	RAILEX	131
000317		IF (NTFIT .GT. NTMAX) NTFIT = NTMAX	RAILEX	132
000322		IF (NTFIT - NTRAIN) 900,900,820	RAILEX	133
	C	MUST NEW TRAIN BE ADDED	RAILEX	134
000325	820	IF (IFILLD .EQ. 1) GO TO 900		

```

000327      LNTRAN = NTRAIN * 1
000331      L = LNTRAN
000332      FTSTAT(L,4) = 0.
000333      CALL ADDRIV(L)
000335      IF (LTSTAT(L,1) - 10) 900,870,900
000340      870 NTDA = NTDA * 1
000342      IF (NTDA .GE. NTD) IFILLD = 1
000345      900 LNSWCH = NSWCH
000347      950 RETURN
000350      END
*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED
NTRUCK
LTRAIN
LTRUCK
IFILD
LIFILD
LNTRDA
LLTRAN
LLTRUK
LNTRUK
IMOVE
JMETH
XT
PC
NVEHCL
LVEHCL
LLVHCL
LNVEHCL
JMOVE
IMETH
XE
PR
    
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RATLEX 135
RATLEX 136
RATLEX 137
RATLEX 138
RATLEX 139
RATLEX 140
RATLEX 141
RATLEX 142
RATLEX 143
RATLEX 144
    
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Q. SUBROUTINE RAILMT

GOLETA FORTRAN 1.3 • AUTO RFL • (07-12-72)

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	SUBROUTINE RAILMT	RAILMT	2
		RAILMT	3
	ELFMENT - MATERIALS HANDLING	RAILMT	4
	GENERAL PROCESS - CONVENTIONAL RAIL SYSTEM	RAILMT	5
	ACTIVITY - GENERAL MAINTENANCE AND REPAIR OF LOCOMOTIVES • CAR	RAILMT	6
		RAILMT	7
		RAILMT	8
	INSERT COMMON	WHEELS	2
000002	COMMON /WHEELS/ AF,AF,AMAX,AMAXL,AMINL,BSL,CARCAP,CP,DE,DF,DTAS	WHEELS	3
	1. DTMA,DTU,EL,FC,FR,FT,HPA,HPFA,HPEV,HPFA,HPEV,HPV,LOCO,MC,HL	WHEELS	4
	2. NCARS,NPOINT,NTD,NTM,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL	WHEELS	5
	3. TCURVX(20),TCURVY(20),TMAINT,TMF,VD,VS,VE,VF,VMAX,WC,WL,XDS	WHEELS	6
	4. MAXLD,NUMLD,LOUE,OUU,WUC,STATUS(36),WHY(24),MLTYP,WMR,ECONFO.	WHEELS	7
	5. ECONSS,FLOOD,EMUCKC,ETRACK,FSWITC,EUNLOA,ERMALN,IBORE,	WHEELS	8
	6. ISW(25),NTINIT,TCCV,THCV	WHEELS	9
000002	COMMON /OLDCOM/ IFILD,KSTOP(25),KUNLO,LSTOP,LVHCL,NBYPY,NSWCH	WHEELS	10
	1. NTRDA,NVHCL,NUMSWT,SWITCH(20),TFC(25),TOP(25),TSTAT(25,4)	WHEELS	11
	2. UTIME(25),LOADP,MUKOT,XGS,TEXCA,MGS(5),MCV,MFLAGC,OUHMY(20)	WHEELS	12
000002	COMMON /NEWCOR/ LIFILO,LKSTOP(25),LKUNLO,LLSTOP,LLVHCL,LNRYBY	WHEELS	13
	1. LNSWCH,LNTRDA,LNVHCL,LNMSWT,FSWITC(20),FTFC(25),FTOP(25)	WHEELS	14
	2. FTSTAT(25,4),FUTIME(25),LLOADR,LMUKOT,FXGS,LTEXCA,LMG(5)	WHEELS	15
	3. LMCV,LMFLAC,FUUMMY(19)	WHEELS	16
000002	DIMENSION COMOLD(260),COMNEW(260),LTSTAT(25,4),ITSTAT(25,4)	WHEELS	17
000002	EQUIVALENCE (NVHCL,NTRAIN,NTRUCK),(LVHCL,LTRAIN,LTRUCK)	WHEELS	18
	1. (COMOLD,IFILD),(COMNEW,LIFILO,IFILLO),(NTOA,LNTRDA)	WHEELS	19
	2. (FTSTAT,ITSTAT),(TSTAT,ITSTAT)	WHEELS	20
	3. (LLVHCL,LLTRAN,LLTRUK),(LNVHCL,LNTRAN,LNTRUK)	ALL	2
000002	COMMON /ALL / XT,STR,IA,RDD,CS,TAMB,FLOW,IFLAG	ALL	3
	1. AT,OE,SK,T,DT,X,PR,XMAX,TMAX,DX,DV,TPRINT,DTPRINT,IMOVE,JMETH	ALL	4
	2. TSHFT,REPORT,OPPCT,TO,XO,XOISCH,ICHNG,XCHNG,TCHNG	ALL	5
000002	EQUIVALENCE (JMOVE,IMOVE),(JMETH,JMETH)	ALL	6
000002	COMMON/MONEY/ JMHM,DJM,OJMHM,OJMRD,OJMBMM,OMAIN,OMJRM,OMJMS	ALL	7
	1. PMGS,JMCV,OJMEC,ROPLAN,HPLANT,GSPLAN	ALL	8
	2. ECPLAN,PDTIME,HTIME(2),GSTIME,ECTIME	ALL	9
000002	COMMON/PERFRM/ RDUTIM,RODTIM,UMHTIM,OMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	10
	1. ECOTIM,GDAY,GADV,GEND,GREG	ALL	11
000002	COMMON/LAROR/ ROMEN(10,2),RMEN(10,2),GSMEN(10,2),ECMEN(10,2)	ALL	12
000002	REAL JMHM,LD,LOB,LBIT,LBURN,LSTEEL,JMCV	ALL	13
000002	DIMENSION G(P)	ALL	14
000002	EQUIVALENCE (G,XT),(XE,XDE),(PR,PC)	RAILMT	11
000002	EQUIVALENCE (DTM,OTMA)	RAILMT	12
000002	DATA NTMA /0/	RAILMT	13
000002	DATA MTINIT /0/	RAILMT	14
000002	DIMENSION RTIME(25)	RAILMT	15
000002	ENTRY TRUKMT	RAILMT	16
000007	IF (MTINIT) 100,100,200	RAILMT	17
		RAILMT	18
000011	100 IF (TMAINT • JMHM • OTM •GT, 0.) GO TO 150	RAILMT	19
	HERE FOR OPTION 2 (VALUES TEMPORARY)	RAILMT	20
		RAILMT	21
000015	TMAINT = 1.5	RAILMT	22
000016	JMHM = 100.	RAILMT	23
000017	OTM = 20.	RAILMT	24
000020	150 CONTINUE	RAILMT	25
000020	MTINIT = 1	RAILMT	26
000021	DO 170 I=1,25		
000.23	RTIME(I) = TMAINT		

000025	170 CONTINUE	RAILMT	27
000026	NTMA = 0	RAILMT	28
000027	PRINT 180, TMAINT, JMMMM, DTM	RAILMT	29
000041	180 FORMAT (43HRAIL MAINT. PARAMETERS - TIME TO REPAIR = ,F8.2,	RAILMT	30
	• 21H COST OF MATERIALS = ,F8.2,23H DAYS BETWEEN MAINT. = ,	RAILMT	31
	• F8.2)	RAILMT	32
	C	RAILMT	33
	IS IT TIME FOR MAINTENANCE	RAILMT	34
000041	200 NCDUNT = 0	RAILMT	35
000042	DD 400 I=1,NTRAIN	RAILMT	36
000044	IWRK = ITSTAT(1,1)	RAILMT	37
000046	IF (IWRK .EQ. 11) GO TO 300	RAILMT	38
000050	IF (IWRK .NE. 10) GO TO 400	RAILMT	39
	C	RAILMT	40
	TRAIN IS IN DISCHARGE AREA	RAILMT	41
000052	IF (ITSTAT(1,4) .LT. DTM) GO TO 400	RAILMT	42
000055	IF (NTMA .GE. NTM) GO TO 400	RAILMT	43
	C	RAILMT	44
	TRAIN I NEEDS MAINTENANCE	RAILMT	45
000060	LTSTAT(1,1) = 11	RAILMT	46
000061	NTMA = NTMA + 1	RAILMT	47
000062	NTDA = NTDA - 1	RAILMT	48
000063	IF (NTDA .LT. NTD) LIFILD = 0	RAILMT	49
000066	300 RTIME(I) = RTIME(I) - DT	RAILMT	50
000071	NCDUNT = NCDUNT + 1	RAILMT	51
000072	IF (RTIME(I) .GT. 0.) GO TO 400	RAILMT	52
	C	RAILMT	53
	MAINTENANCE FINISHED	RAILMT	54
000075	IF (LIFILD .EQ. 1) GO TO 400	RAILMT	55
000076	LTSTAT(1,1) = 10	RAILMT	56
000077	FTSTAT(1,4) = 0.	RAILMT	57
000100	DJMMH = DJMMH + JMMMM	RAILMT	58
000102	RTIME(I) = TMAINT	RAILMT	59
000104	NTMA = NTMA - 1	RAILMT	60
000105	NTDA = NTDA + 1	RAILMT	61
000106	IF (NTDA .GE. NTD) LIFILO = 1	RAILMT	62
000111	NCDUNT = NCDUNT - 1	RAILMT	63
000113	400 CONTINUE	RAILMT	64
000116	NTMA = NCDUNT	RAILMT	65
000117	IF (NTMA .GT. NTM) GO TO 500	RAILMT	66
000122	RETURN	RAILMT	67
000122	500 PRINT 550, NTMA,NTM	RAILMT	68
000132	550 FORMAT (1X,I4,40H TRAINS IN MAINTENANCE AREA. CAPACITY = ,I4)	RAILMT	69
000132	CALL EXYT	RAILMT	70
000133	END	RAILMT	71

*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED

NTRUCK
 LTRAIN
 LTRUCK
 IFILD
 IFILLD
 LNTDA
 LLTRAN
 LLTRUK
 LNTRAN
 LNTRUK
 IMOVE
 JMETH
 XT

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RAILMT

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XDE
PC
DTMA
NVEHCL
LVEHCL
LLVHCL
LNVHCL
JMOVE
IMETH
XE
PR

R. SUBROUTINE GRNSUP

GOLETA FORTRAN 1.3 • AUTO REL • (07-12-72)

07/25/72

	SUBROUTINE GRNSUP	GRNSUP	
	C ELEMENT-PRIMARY GROUND SUPPORT	GRNSUP	2
	C GENERAL PROCESS-ROCKROLLS,STFEL RIB SETS,SHOTCRETE,COMBINATION	GRNSUP	3
	C CS OF THOSE	GRNSUP	4
	C ACTIVITY-INSTALLATION	GRNSUP	5
	C	GRNSUP	6
000002	COMMON /GPND/ PSST(60,9),MAXPSS, UCS,UCSC,RATERR,RATESC,RATESS	SUPPORT	7
	1. GSLOS,TAS,TST,FRRDR1,ESCPLA,GDDW,GSETDO,MAXPSS	SUPPORT	8
000002	COMMON /WHEELS/ AF,AF,AMAX,AMAXL,AMINL,RSL,CARCAP,CP,DE,DF,DTAS	WHEELS	2
	1. OTHA,DTU,FL,FC,FR,FT,HPA,HPFA,HPEV,HPFA,HPFV,HPV,LOCO,MC,ML	WHEELS	3
	2. NCARS,NPOINT,NTD,NTM,NTMAX,XP,NTMILP,NTMLPP,NTRACK,SL	WHEELS	4
	3. TCHRVX(20),TCURVY(20),TMAINT,TWE,VO,VS,VE,VF,VMAX,WC,WL,XDS	WHEELS	5
	4. MAXLD,NUMLD,LOUF,QUC,WIC,STATUS(36),WHY(24),MLTYP,WMR,ECONEQ,	WHEELS	6
	5. ECONSS,FLACC,FMUCKC,FTRACK,ESWITC,FUNLOA,FRMAIN,11RRRF,	WHEELS	7
	6. ISW(25),NINIT,TCOV,IMCV	WHEELS	8
000002	COMMON /OLOCOM/ IFILO,XSTOP(25),KUNLO,LSTOP,LVHCL,NBYRY,NSWCH	WHEELS	9
	1. NTPDA,NVHCL,NUMSWT,SWTCH(20),FTC(25),TOP(25),TSTAT(25,4)	WHEELS	10
	2. UTIME(25),LOADP,MUKOT,XGS,EXCA,MGS(5),MCV,MFLAGC,OUHMY(20)	WHEELS	11
000002	COMMON /NEWCOM/ LIFILO,LKSTOP(25),LKUNLO,LLSTOP,LLVHCL,LNRYRY	WHEELS	12
	1. LNSWCH,LNTPDA,LNVHCL,LNMSWT,FSWTCH(20),FTFC(25),FTOP(25)	WHEELS	13
	2. FTSTAT(25,4),FUTIME(25),LLOADP,LMUKOT,FXGS,LIFXCA,LMGS(5)	WHEELS	14
	3. LMCV,LMFLAG,FOUHMY(19)	WHEELS	15
000002	DIMENSION COMOLD(260),COMNEW(260),LTSTAT(25,4),ITSTAT(25,4)	WHEELS	16
000002	EQUIVALENCE (NVHCL,NTRATH,NTRUCK),(LVHCL,LTRAIN,LTRUCK)	WHEELS	17
	1. (COMOLD,IFILO),(COMNEW,LIFILO,IFILLO),(NTDA,LNTRDA)	WHEELS	18
	2. (FTSTAT,LTSTAT),(ITSTAT,ITSTAT)	WHEELS	19
	3. (LLVHCL,LLTRAN,LLTRUK),(LNVHCL,LNTRAN,LNTRUK)	WHEELS	20
000002	DATA PSST / 95.,90.,90.,75.,75.,75.,50.,50.,50.,25.,25.,25.,0.,0.,0.,	GRNSUP	11
	1 0.,45*0.,	GRNSUP	12
	2 2*5.,7.,5.,1.,2.,5.,1.,2.,5.,1.,2.,5.,1.,2.,45*0.,	GRNSUP	13
	3 999999.,999999.,10.,8.,5.,6.,6.,4.,5.,5.,3.,2.,2.,2.,45*0.,	GRNSUP	14
	4 4*0.,4.,5*0.,4.,2*0.,4.,46*0.,	GRNSUP	15
	6 1.,1.,3.,3.,3.,2.,3.,7.,4.,3.,5*4.,45*0.,	GRNSUP	16
	7 5*0.,5.,0.,0.,4.,0.,7.,3.,3*2.,45*0.,	GRNSUP	17
	8 0.,0.,5.,2*1.,0.,2*3.,0.,5.,5*0.,45*0.,	GRNSUP	18
	9 0.,0.,0.,0.,0.,0.,0.,0.,1.,0.,0.,0.,0.,0.,0.,45*0.,	GRNSUP	19
	A 1.,1.,1.,1.,1.,1.,1.,1.,1.,2.,2.,1.,1.,1.,1.,45*0./	GRNSUP	20
000002	DATA MAXPSS/15/	GRNSUP	21
000002	COMMON /ALL / XT,STR,TA,RDD,CS,TAMB,FLOW,IFLAG	ALL	2
	1. AT,0,F,SK,T,DT,X,PR,XMAX,TMAX,OX,OV,TPRINT,DTPRNT,MOVE,JMETH	ALL	3
	2. TSHFT,REPRRT,RRPCT,TO,XD,XOTSCH,ICHNG,XCHNG,TCHNG	ALL	4
000002	EQUIVALENCE (MOVE,MOVE),(JMETH,JMETH)	ALL	5
000002	COMMON /MONEY/ JMMHM,DJM,DJMMH,DJMRD,DJMPHM,DMAINT,OJMBM,DJMGS	ALL	6
	1. PMGS,JMCM,DJMEC,PDPLAN,PLANT,GSPLAN	ALL	7
	2. ECPLAN,RDTIME,HTIME(2),GSTIME,ECTIME	ALL	8
000002	COMMON /PERFRM/ ROUTIM,RDOTHM,UMHTIM,OMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	9
	1. ECOTIM,GDAY,GANV,GENG,GREG	ALL	10
000002	COMMON /LABOR/ RDHFN(10,2),MHFN(10,2),GSMEN(10,2),ECMEN(10,2)	ALL	11
000002	REAL JMMHM,LD,LDR,LBIT,LBURN,LSTEEL,JMCMV	ALL	12
000002	DIMENSION G(R)	ALL	13
000002	EQUIVALENCE (G,XT),(XE,XDF),(PR,PC)	ALL	14
000002	DIMENSION SSCOE(9,3),WEIGSS1(11),WEIGSS2(11)	GRNSUP	23
C		GRNSUP	24
C	PRE SETTING TABLES FOR STEEL RIB INSTALLATION	GRNSUP	25

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000002	C	DATA SSCOE / 90.,75.,75.,50.,50.,75.,25.,0.,0.,5.,5.,2.,5.,2.,	GRNSUP	26
		1 5.,2.,5.,2.,0.,2.,45.,7.,95.,13.,1.65,1.9,2.4/	GRNSUP	27
000002		DATA WFIGSS1 /2.7330400,2.8032257,4.0346495,3.2721616,2.590875,	GRNSUP	28
		13.4323957,3.7604603,6.4257773,3.5155762,3.113781,3.1443458/	GRNSUP	29
000002		DATA WFIGSS2 / 1.8697457,2.0608183,1.9951426,2.3051969,2.5269964,	GRNSUP	30
		1 2.5839495,2.7372833,2.8635011,3.2152662,3.4443974,3.6613087/	GRNSUP	31
000002		DATA INIT,NEFDIN/0.0/	GRNSUP	32
000002		DATA LMETH,ICS,MG,MAINT,IFST/5*0/	GRNSUP	33
000002		DATA AL,TL,SP,SP1,TH,DIST,BPF,WRB/8*0./	GRNSUP	34
000002		DATA TMETH,VSC,WRIB/3*0./	GRNSUP	35
	C		GRNSUP	36
	C	NOTE- GROUND SUPPORT TYPE =IST,ADDITIONAL SUPPORT =IAS	GRNSUP	37
	C	IST,IAS ARE..	GRNSUP	38
	C	1 IF NO SUPPORT REQUIRED	GRNSUP	39
	C	2 IF ROCKROLLS ARE BEING INSTALLED	GRNSUP	40
	C	3 IF SHOTCRETE IS BEING INSTALLED	GRNSUP	41
	C	4 IF STEEL RIB SETS ARE BEING INSTALLED	GRNSUP	42
	C	5 IF LAGGING IS SUPPORT(ONLY IAS MAY =5)	GRNSUP	43
	C		GRNSUP	44
	C	FIRST TIME INITIALIZATION	GRNSUP	45
	C		GRNSUP	46
000002		5 PRINT 10	GRNSUP	47
000006		10 FORMAT(//,IX.,,2AH PRIMARY GROUND SUPPORT)	GRNSUP	48
000006		PRINT 11	GRNSUP	49
000012		11 FORMAT(IX.,,R00 EXCAVATION UNSUPPORTED INTERFERENCE SUPPOR	GRNSUP	50
		IT SPACING THICKNESS CROWN AND/ ADDITIONAL*)	GRNSUP	51
000012		PRINT 12	GRNSUP	52
000016		12 FORMAT(IX.,,PROCFS LENGTH=MAXFT LENGTH FT TYP	GRNSUP	53
		1E FT IN OR SIDES SUPPORT*)	GRNSUP	54
000016		IF(MAXPSS .NE. 0) MAXPSS=MAXPSS	GRNSUP	55
000020		DO 14 I=1,MAXPSS	GRNSUP	56
000022		PRINT 13,(PSST(I,K),K=1,9)	GRNSUP	57
000035		13 FORMAT (F7.2,F10.2,2F14.2,2F11.2,F10.2,2F13.2)	GRNSUP	58
000035		14 CONTINUE	GRNSUP	59
000040		PRINT 15	GRNSUP	60
000043		15 FORMAT(IX.,,NOTE, EXCAVATION PROCESS =5 INDICATES ANY PROCESS OTHE	GRNSUP	61
		R THAN THOSE IN TABLE*//)	GRNSUP	62
000043		FXGS=X	GRNSUP	63
000045		INIT=1	GRNSUP	64
000046		IF(NEEDIN .EQ. 0) GO TO 3000	GRNSUP	65
000047		NEFDIN=0	GRNSUP	66
000047		GO TO 6	GRNSUP	67
	C		GRNSUP	68
	C	INITIALIZATION EACH ENTRANCE	GRNSUP	69
	C		GRNSUP	70
000050		ENTRY GROUND	GRNSUP	71
000055		IF(INIT .NE. 0) GO TO 6	GRNSUP	72
000056		NEFDIN=1	GRNSUP	73
000057		GO TO 5	GRNSUP	74
000060		6 MAINT=0	GRNSUP	75
000061		ADV=0.	GRNSUP	76
000062		DPMG=0.	GRNSUP	77
000063		ADVLOS=0.	GRNSUP	78
000064		PMGLOS=0.	GRNSUP	79
			GRNSUP	80

000065	LAR=0	GRNSUP	81
000066	WRIR=0.	GRNSUP	82
000067	IFST=0.	GRNSUP	83
000070	WRR=0.	GRNSUP	84
000071	BPF= 0	GRNSUP	85
000072	SP=0	GRNSUP	86
000073	VSC=0	GRNSUP	87
000074	DO 25 I=1,MAXPS	GRNSUP	88
000075	IF (PSST(I,1) .LE. R00) GO TO 30	GRNSUP	89
000100	25 CONTINUE	GRNSUP	90
000103	30 IP=I	GRNSUP	91
000105	DO 35 I=IP,MAXPS	GRNSUP	92
000106	IF(PSST(I,1) .NE. PSST(IP,1)) GO TO 36	GRNSUP	93
000111	IPPST=PSST(I,2)	GRNSUP	94
000114	IF (IPPST.EQ.JMETH) GO TO 40	GRNSUP	95
000116	35 CONTINUE	GRNSUP	96
000120	36 IQ=I	GRNSUP	97
000122	DO 37 J=IP,IQ	GRNSUP	98
000124	IF(PSST(J,2) .EQ. 5) GO TO 39	GRNSUP	99
000127	37 CONTINUE	GRNSUP	100
000132	GO TO 1800	GRNSUP	101
000132	39 IP=J	GRNSUP	102
000134	GO TO 42	GRNSUP	103
000134	40 IP=I	GRNSUP	104
000136	42 LMETH=PSST(IP,2)	GRNSUP	105
000141	JMETH=JMETH	GRNSUP	106
000143	AL=PSST(IP,3)	GRNSUP	107
000144	TL=PSST(IP,4)	GRNSUP	108
000146	IST=PSST(IP,5)	GRNSUP	109
000150	SP=PSST(IP,6)	GRNSUP	110
000152	TH=PSST(IP,7)	GRNSUP	111
000153	ICS=PSST(IP,8)	GRNSUP	112
000156	IAS=PSST(IP,9)	GRNSUP	113
000160	MG=MGS(IST)	GRNSUP	114
	C	GRNSUP	115
	C STATUS CHECK FOR GROUND SUPPORT	GRNSUP	116
	C	GRNSUP	117
	C	GRNSUP	118
000162	DIST=X-XGS	GRNSUP	119
000164	IF(LFXCA .EQ. 0) GO TO 43	GRNSUP	120
000165	IF(DIST .LE. TL) L1EXCA=0	GRNSUP	121
000171	43 IF(DIST .GT. AL) L1EXCA=1	GRNSUP	122
000175	IF(DIST .LT. TL) MAINT=1	GRNSUP	123
	C	GRNSUP	124
	C	GRNSUP	125
	C COMPUTING LABOR TIME USED FOR THIS ACTIVITY	GRNSUP	126
	C	GRNSUP	127
000201	GSTIME=GSTIME*OT	GRNSUP	128
	C COMPUTING MATERIALS FOR GROUND SUPPORT	GRNSUP	129
000203	GO TO(1000,200,300,400,500),1ST	GRNSUP	130
	C	GRNSUP	131
	C COMPUTING GROUND SUPPORT USING ROCK BOLTS	GRNSUP	132
	C	GRNSUP	133
	C	GRNSUP	134
000214	200 IF(MG .EQ. 1) MAINT=1	GRNSUP	135
000217	BPF=3.1415*D/(2*.866*(SP)**2)		
000224	WRB=.284*3.1415*D		

000226	GO TO 1000	GRNSUP	136
C		GRNSUP	137
C	COMPUTING GROUND SUPPORT USING SHOTCRETE	GRNSUP	138
C		GRNSUP	139
000226	300 IF(MG .EQ. 1) MAINT=1	GRNSUP	140
000231	IF (ROD .LE. 25.) GO TO 1900	GRNSUP	141
000234	IF (ICS .EQ. 1) GO TO 306	GRNSUP	142
000236	VSC=3.1415*0*TM/(324.*2.)	GRNSUP	143
000241	GO TO 310	GRNSUP	144
000242	306 VSC=3.*3.1415*0*TM/(324.*4.)	GRNSUP	145
000246	310 GO TO 1000	GRNSUP	146
C		GRNSUP	147
C	COMPUTING GROUND SUPPORT USE OF STEEL RIBS	GRNSUP	148
C		GRNSUP	149
000247	400 IF(MG .EQ. 1) MAINT=1	GRNSUP	150
000252	DO 410 I=1,9	GRNSUP	151
000254	IF (SSCOEF(I,1) .LE. ROD) GO TO 415	GRNSUP	152
000257	410 CONTINUE	GRNSUP	153
000261	415 IP=1	GRNSUP	154
000263	IF(SSCOEF(IP,2) .EQ. TMETH) IP=IP+1	GRNSUP	155
000270	PLOAD=SSCOEF(IP,3) *0*SP*CS	GRNSUP	156
000275	DO 420 I=1,1	GRNSUP	157
000276	PK=(1.6)*2*1	GRNSUP	158
000301	IF(0 .LE. PK) GO TO 422	GRNSUP	159
000304	420 CONTINUE	GRNSUP	160
000306	GO TO 1950	GRNSUP	161
000306	422 SWEIG=WEIGSS2(I)*(10.**-3)*PLOAD*WEIG551(I)	GRNSUP	162
000315	430 WPIB=3.1415*0*55WEIG	GRNSUP	163
000320	500 GO TO 1000	GRNSUP	164
C		GRNSUP	165
C	DETERMINING WHICH COST CALCULATION TO USE	GRNSUP	166
C		GRNSUP	167
C		GRNSUP	168
C	DETERMINING ADDITIONAL SUPPORT COMPUTATIONS	GRNSUP	169
C		GRNSUP	170
000321	1000 IF(IFST .EQ. 1) GO TO 1050	GRNSUP	171
000323	IFST=1	GRNSUP	172
000324	SP=SP	GRNSUP	173
000326	MG=MGS(IAS)	GRNSUP	174
000330	GO TO(1050,1020,1030,1040,1050) ,IAS	GRNSUP	175
C		GRNSUP	176
C	WITH ADDITIONAL SUPPORT = ROCK BOLTS SET UP ROCKBOLT COMPUTATIONS	GRNSUP	177
C		GRNSUP	178
000340	1020 IF(IST .NE. 3) GO TO 1025	GRNSUP	179
000342	IF(ROD .GT. 50.) GO TO 1050	GRNSUP	180
000346	SP=5.	GRNSUP	181
000347	GO TO 200	GRNSUP	182
000347	1025 IF(IST .NE. 4) GO TO 1028	GRNSUP	183
000351	SP=5.	GRNSUP	184
000353	GO TO 200	GRNSUP	185
000353	1028 IF(SP .EQ. 0.) SP=5.	GRNSUP	186
000355	GO TO 200	GRNSUP	187
C		GRNSUP	188
C	ADDITIONAL SUPPORT = SHOTCRETE SET UP FOR SHOTCRETE COMPUTATIONS	GRNSUP	189
C		GRNSUP	190

000356	1030	IF (TH .EQ. 0.) TH=.5*D	GRNSUP	191
000361		GO TO 300	GRNSUP	192
	C		GRNSUP	193
	C	ADDITIONAL SUPPORT=STEEL RIBS SET UP STEEL RIBS COMPUTATION	GRNSUP	194
	C		GRNSUP	195
000362	1040	IF (1ST .NE. 2) GO TO 1045	GRNSUP	196
000364		SP=4.	GRNSUP	197
000366		GO TO 400	GRNSUP	198
000366	1045	IF (SP .EQ. 0.) SP=4.	GRNSUP	199
000370		GO TO 400	GRNSUP	200
	C		GRNSUP	201
	C	DETERMINING WHICH COST CATEGORY TO USE	GRNSUP	202
	C		GRNSUP	203
000371	1050	IF ((IAS .NE. 5) .AND. (IAS .NE. 1)) GO TO 1060	GRNSUP	204
000401		GO TO (1100,1200,1300,1400) , 1ST	GRNSUP	205
000411	1060	IF (IAS .NE. 2) GO TO 1070	GRNSUP	206
000413		GO TO (1200,1200,1500,1600,1200), 1ST	GRNSUP	207
000424	1070	IF (IAS .NE. 3) GO TO 1080	GRNSUP	208
000426		GO TO (1300,1500,1300,1700,1300) , 1ST	GRNSUP	209
000437	1080	IF (IAS .NE. 4) GO TO 1090	GRNSUP	210
000441		GO TO (1400,1600,1700,1400,1400) , 1ST	GRNSUP	211
000452	1090	GO TO 1825	GRNSUP	212
	C		GRNSUP	213
	C	COMPUTING ADVANCE AND COST WITH NO SUPPORT	GRNSUP	214
	C		GRNSUP	215
000453	1100	FXGS=X-TL	GRNSUP	216
000455		GO TO 2000	GRNSUP	217
	C		GRNSUP	218
	C	COMPUTING ADVANCE AND COST WITH ROCK BOLTS	GRNSUP	219
	C		GRNSUP	220
000456	1200	ADV=RATERR*DT/PPF	GRNSUP	221
000461		FXGS=ADV*XGS	GRNSUP	222
000463		RRLBS=ADV*PPF*WRB	GRNSUP	223
000465		DPMGS=RRLBS*UCS	GRNSUP	224
000467		PMGS=PMGS*DPMGS	GRNSUP	225
000470		GO TO 2000	GRNSUP	226
	C		GRNSUP	227
	C	COMPUTING ADVANCE AND COST USING SHOTCRETE	GRNSUP	228
	C		GRNSUP	229
000471	1300	ADV=RATESC*DT/VSC	GRNSUP	230
000474		FXGS=XGS*ADV	GRNSUP	231
000476		CUYD=ADV*VSC	GRNSUP	232
000477		DPMGS=CUYD*UCSC	GRNSUP	233
000501		PMGS=PMGS*DPMGS	GRNSUP	234
000502		GO TO 2000	GRNSUP	235
	C		GRNSUP	236
	C	COMPUTING ADVANCE AND COST USING STEEL RIBS	GRNSUP	237
	C		GRNSUP	238
000503	1400	ADV=RATESS*DT*SP	GRNSUP	239
000506		FXGS=XGS*ADV	GRNSUP	240
000510		SRLBS=(ADV/SP)*WRIB	GRNSUP	241
000512		DPMGS=SRLBS*UCS	GRNSUP	242
000514		PMGS=PMGS*DPMGS	GRNSUP	243
000515		GO TO 2000	GRNSUP	244
	C		GRNSUP	245

	C	COMPUTING ADVANCE AND COST USING SHOTCRETE AND ROCK BOLTS	GRNSUP	246
	C		GRNSUP	247
000516	1500	ADV=(RATERR/RPF*RATESC/VSC)*DT/2	GRNSUP	248
000524		FXGS=XGS*ADV	GRNSUP	249
000526		CUYD=ADV*VSC	GRNSUP	250
000527		RRLRS=ADV*RPF*WRB	GRNSUP	251
000531		OPMGS=CUYD*UCSC *RRLBS*UCS	GRNSUP	252
000535		PMGS=PMGS*OPMGS	GRNSUP	253
000536		GO TO 2000	GRNSUP	254
	C		GRNSUP	255
	C	COMPUTING COST AND ADVANCE USING STEEL RIBS AND ROCK BOLTS	GRNSUP	256
	C		GRNSUP	257
000537	1600	IF(IST.EQ.4) SP=SP1	GRNSUP	258
000543		ADV=(RATES5*SP*RATERB/RPF)*OT/2.	GRNSUP	259
000551		FXGS=XGS*ADV	GRNSUP	260
000553		SRLRS=(ADV/SP)*WRIB	GRNSUP	261
000556		RRLBS=ADV*RPF*WRB	GRNSUP	262
000560		OPMGS=(SRLRS*RRLBS)*UCS	GRNSUP	263
000563		PMGS=PMGS*OPMGS	GRNSUP	264
000564		GO TO 2000	GRNSUP	265
	C		GRNSUP	266
	C	COMPUTING ADVANCE AND COST USING SHOTCRETE AND STEEL RIBS	GRNSUP	267
	C		GRNSUP	268
000565	1700	ADV=(RATESC/VSC*RATES*SP)*OT/2.	GRNSUP	269
000573		FXGS=XGS*ADV	GRNSUP	270
000575		CUYD=ADV*VSC	GRNSUP	271
000577		SRLRS=(ADV/SP)*WRIB	GRNSUP	272
000601		OPMGS=CUYD*UCSC*SRLBS*UCS	GRNSUP	273
000604		PMGS=PMGS*OPMGS	GRNSUP	274
000606		GO TO 2000	GRNSUP	275
	C		GRNSUP	276
	C	ERROR MESSAGES	GRNSUP	277
	C		GRNSUP	278
000606	1800	PRINT 1801	GRNSUP	279
000612	1801	FORMAT(//1X,* UNABLE TO PERFORM GROUND SUPPORT,CANNOT FIND EXCAVATI ION METHOD IN PSST TABLE AND NOOTHER METHOD IS IN TABLE*)	GRNSUP	280
		GO TO 1975	GRNSUP	281
000612	1825	PRINT 1826,145	GRNSUP	282
000613	1826	FORMAT(//1X,* ADDITIONAL SUPPORT *.15,* IS NONEXISTANTIN PROGRAM*)	GRNSUP	283
000621		GO TO 1975	GRNSUP	284
000622	1900	PRINT 1901	GRNSUP	285
000626	1901	FORMAT(1X,75H UNABLE TO PERFORM SUPPORT,SHOTCRETE CANNOT BE USED I F PDD IS LESS THAN 25)	GRNSUP	286
		GO TO 1975	GRNSUP	287
000626	1950	PRINT 1951	GRNSUP	288
000633	1951	FORMAT(185HUNABLE TO PERFORM SUPPORT STEEL RIB WEIGHT INDETERMINATE 1 FOR DIAMETER GREATER THAN 34)	GRNSUP	289
		GO TO 1975	GRNSUP	290
000633	1975	FXGS=XGS	GRNSUP	291
000635		FRACT=0.	GRNSUP	292
000636		STOP	GRNSUP	293
	C		GRNSUP	294
	C	COMPUTING ACTUAL GROUND SUPPORT IF TOO CLOSE TO FACE OR BEYOND	GRNSUP	295
	C		GRNSUP	296
000640	2000	DIST1=X-TL	GRNSUP	297
000640		FRACT=1.	GRNSUP	298
			GRNSUP	299
			GRNSUP	300

000644	IF(MAINT .EQ. 1) GO TO 2500	GRNSUP	301
000646	IF (FXGS .LE. 0IST1) GO TO 2005	GRNSUP	302
000650	FRACT=(0IST1-XGS)/AOV	GRNSUP	303
000653	AOV=0IST1-XGS	GRNSUP	304
000654	AOVLOS=FXGS-(X-TL)	GRNSUP	305
000657	GSLOS=GSLOS+ADVLOS	GRNSUP	306
000660	FXGS=XGS+ADV	GRNSUP	307
000662	PMGLOS=DPMG5*(1.-FRACT)	GRNSUP	308
000665	PMGS=PMGS-PMGLOS	GRNSUP	309
000667	2005 GO TO 3000	GRNSUP	310
C		GRNSUP	311
C	COMPUTING FEET LOST FOR GROUND SUPPDRT IF IN MAINTENANCE OR IF ID	GRNSUP	312
C	LE FOR ALL OT	GRNSUP	313
C		GRNSUP	314
000670	2500 PMGS=PMGS-PPMG5	GRNSUP	315
000672	GSLOS=GSLOS+(FXGS-XGS)	GRNSUP	316
000675	FXGS=XGS	GRNSUP	317
000676	FRACT =0	GRNSUP	318
000676	3000 CONTINUE	GRNSUP	319
C		GRNSUP	320
C	COMPUTING UP TIME OF GROUND SUPPORT	GRNSUP	321
C		GRNSUP	322
000676	GSUTIM=GSUTIM+FRACT*OT	GRNSUP	323
C		GRNSUP	324
C	COMPUTING PLANT AND EQUIPMENT COSTS	GRNSUP	325
C		GRNSUP	326
000701	IF((IST .EQ. 2) .OR. (IAS .EQ. 2)) GO TO 3025	GRNSUP	327
000711	IF((IST .NE. 3) .AND. (IAS .NE. 3)) GO TO 3050	GRNSUP	328
000717	IF((IST .EQ. 5) .OR. (IAS .EQ. 5)) GO TO 3015	GRNSUP	329
000725	IF((IST .EQ. 1) .OR. (IAS .EQ. 1)) GO TO 3015	GRNSUP	330
000733	OTT=OT/2.	GRNSUP	331
000735	GO TO 3020	GRNSUP	332
000735	3015 OTT=OT	GRNSUP	333
000737	3020 GSPLAN=GSPLAN+OTT*FRACT*ESCPA	GRNSUP	334
000743	GO TO 3050	GRNSUP	335
000744	3025 IF((IST .EQ. 5) .OR. (IAS .EQ. 5)) GO TO 3027	GRNSUP	336
000754	IF((IST .EQ. 1) .OR. (IAS .EQ. 1)) GO TO 3027	GRNSUP	337
000762	DTT=OT/2.	GRNSUP	338
000764	GO TO 3030	GRNSUP	339
000764	3027 DTT=OT	GRNSUP	340
000766	3030 GSPLAN=GSPLAN+OTT*FRACT*ERRORI	GRNSUP	341
000772	IF((IST .EQ. 3) .OR. (IAS .EQ. 3)) GO TO 3015	GRNSUP	342
001002	3050 CONTINUE	GRNSUP	343
001002	RETURN	GRNSUP	344
001003	END	GRNSUP	345

*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED
 NTRAIN
 NTRUCK
 LTRAIN
 LTRUCK
 IFILO
 LIFILD
 IFILLD
 LNTROA
 LLTRAN

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GRNSUP

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LLTRUK
LNTRAN
LNTRUK
IMOVE
XT
XOE
PC
NVEHCL
LVEHCL
NTDA
LLVHCL
LNVHCL
JMOVE
IMETH
XE
PR

S. SUBROUTINE GSMAIN

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			SUBROUTINE GSMAIN	GSMAIN	2
	C			GSMAIN	3
	C		ELEMENT-PRIMARY GROUND SUPPORT	GSMAIN	4
	C		GENERAL PROCESS-ROCK BOLTS, STEEL RIB SETS, SHOTCRETE, COMBINATION	GSMAIN	5
	CS OF THOSE			GSMAIN	6
	C		ACTIVITY-MAINTENANCE	GSMAIN	7
	C			GSMAIN	8
000002			COMMON /GRND/ PSST(60,9), MAXPSS, UCS, UCSC, RATERR, RATESC, RATESS	SUPPDRT	2
			1. GSLOS, IAS, IST, ERRDR1, FSCPLA, GDOW, GSET00, MAXPSS	SUPPORT	3
000002			COMMON /WHEELS/ AF, AF, AMAX, AMAXL, AMINL, RSL, CARCAP, CP, DF, DF, DTAS	WHEELS	2
		1.	DTMA, DTU, FL, FC, FR, FT, HPA, HPEA, HPEV, HPFA, HPFV, HPV, LOCO, MC, ML	WHEELS	3
		2.	NCAPS, NPOINT, NTD, NTM, NTMAX, XP, NTMILP, NTMLPP, NTRACK, SL	WHEELS	4
		3.	TCURVY(20), TCURVY(20), THAINT, TWE, VO, VS, VE, VF, VMAX, WC, WL, XDS	WHEELS	5
		4.	MAXLD, NUMLD, LOHE, OUC, WUC, STATUS(36), WHY(24), MLTYP, WMR, ECONED,	WHEELS	6
		5.	ECONSS, FLOAD, EMUCKG, ETRACK, ESWITC, EUNLOA, FRMAIN, IIBORE,	WHEELS	7
		6.	TSW(25), NTINIT, TCCV, TMCV	WHEELS	8
000002			COMMON /OLDCOM/ IFILD, ISTOP(25), KUNLO, LSTOP, LVEHCL, NRYBY, NSWCH	WHEELS	9
		1.	NTRDA, NVEHCL, NUMSWT, SWITCH(20), TFC(25), TOP(25), TSTAT(25,4)	WHEELS	10
		2.	UTIME(25), LOADR, MUKOT, XGS, IEXCA, MGS(5), MCV, MFLAG, OUMMY(20)	WHEELS	11
000002			COMMON /NEWCOM/ LFILO, LKSTOP(25), LKUNLO, LLSTOP, LLVHCL, LNRYBY	WHEELS	12
		1.	LNSWCH, LNTRDA, LNVHCL, LNMSWT, FSWTCH(20), FTFC(25), FTOP(25)	WHEELS	13
		2.	FTSTAT(25,4), FUTIME(25), LLOADR, LMUKOT, FXGS, L IEXCA, LMGS(5)	WHEELS	14
		3.	LMCV, LMFLAC, FUMMY(19)	WHEELS	15
000002			DIMENSION COMOLO(260), COMNEW(260).		
			LTSTAT(25,4), ITSTAT(25,4)	WHEELS	16
			EQUIVALENCE (NVEHCL, NTRAIN, NTRUCK), (LVEHCL, LTRAIN, LTRUCK)	WHEELS	17
000002			1. (COMOLD, IFILO), (COMNEW, LFILO), (IFILO), (INTOA, LNTRDA)	WHEELS	18
			2. (FTSTAT, LTSTAT), (TSTAT, ITSTAT)	WHEELS	19
			3. (LLVHCL, LLTRAIN, LLTRUK), (LNVHCL, LNTRAIN, LNTRUK)	WHEELS	20
000002			COMMON /ALL / XT, STR, IA, ROD, CS, TAMB, FLOW, FLAG	ALL	2
			1. AT, D, E, SK, T, DT, X, PR, YMAX, TMAX, OX, DV, TPRINT, DTPRNT, IMOVE, JMETH	ALL	3
			2. TSHFT, REPORT, OPPCT, TO, XO, XDISCH, ICMNG, XCHNG, YCHNG	ALL	4
000002			EQUIVALENCE (JMOVE, IMOVE), (JMETH, JMETH)	ALL	5
000002			COMMON /HONEY/ JMMH, DJM, OJMH, OJMRD, OJMBM, OMAINT, DJMBM, DJMGS	ALL	6
			1. PMGS, JMCV, DJMFC, RDPLAN, HPLANT, GSPLAN	ALL	7
			2. ECPLAN, RDTIME, HTIME(2), GSTIME, ECTIME	ALL	8
000002			COMMON /PERFRM/ RDTIM, RDDTIM, UMHTIM, DMHTIM, GSUTIM, GSOTIM, ECUTIM	ALL	9
			1. ECOTIM, GDAY, GADV, GEND, GREG	ALL	10
000002			COMMON /LAROR/ RDMEN(10,2), MMEN(10,2,2), GSMEN(10,2), ECMEN(10,2)	ALL	11
000002			REAL JMMH, LD, LOR, LBIT, LBURN, LSTEEL, JMCV	ALL	12
000002			DIMENSION G(4)	ALL	13
000002			EQUIVALENCE (G, XT), (XE, XOE), (PR, PC)	ALL	14
000002			DIMENSION GSMT(5), DOWNT(5), GOOWN(5), SETDOW(5)	GSMAIN	12
000002			DATA GSMT/ 5*0./	GSMAIN	13
000002			DATA DOWNT/ 5*0./	GSMAIN	14
000002			DATA GOOWN/ 5*7.S/	GSMAIN	15
000002			DATA SETDOW/ 5*.S/	GSMAIN	16
000002			DATA INC/ I/	GSMAIN	17
000002			DATA INIT, NEFDIN/ 0.0/	GSMAIN	18
				GSMAIN	19
				GSMAIN	20
			NOTE- GROUND SUPPORT TYPE =1ST, ADDITIONAL SUPPORT =IAS	GSMAIN	21
			IST, IAS ARE..	GSMAIN	22
			1 IF NO SUPPORT REQUIRED	GSMAIN	23
			2 IF ROCK BOLTS ARE BEING INSTALLED	GSMAIN	24
			3 IF SHOTCRETE IS BEING INSTALLED	GSMAIN	24
			4 IF STEEL RIB SETS ARE BEING INSTALLED	GSMAIN	25

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	C	S IF LAGGING IS SUPPORT(ONLY IAS MAY =5)	GSMAIN	26
	C		GSMAIN	27
000002		1 INIT=1	GSMAIN	28
000003		00 4 J=1,5	GSMAIN	29
000005		IF(GDOWN .NE. 0.) GDOWN(J)=GDOWN	GSMAIN	30
000007		IF(GSFTDO .NE. 0.) SETOOW(J)=GSETOO	GSMAIN	31
000012		4 CONTINUE	GSMAIN	32
000014		IF (NFEQIN .EQ. 0) GO TO 150	GSMAIN	33
000015		NFEQIN=0	GSMAIN	34
000016		GO TO 5	GSMAIN	35
	C	NORMAL ENTRY	GSMAIN	36
000016		ENTRY GSMNT	GSMAIN	37
000023		IF(INIT .EQ. 1) GO TO 5	GSMAIN	38
000025		NFEQIN=1	GSMAIN	39
000026		GO TO 1	GSMAIN	40
000027		5 IF((IAS .NE. 1) .AND. (IAS .NE. 5)) INC=2	GSMAIN	41
000040		00 110 I=2,4	GSMAIN	42
000042		GDOWN=GDOWN(I)	GSMAIN	43
000044		GSM=GSM(I)	GSMAIN	44
000045		MG=MGS(I)	GSMAIN	45
	C		GSMAIN	46
	C	DETERMINING IF GROUND SUPPORT TYPE I IS IN USE DURING OT	GSMAIN	47
	C		GSMAIN	48
000047		IF((I .EQ. 1ST) .OR. (I .EQ. IAS)) GO TO 50	GSMAIN	49
	C		GSMAIN	50
	C	DETERMINING IF GROUND SUPPORT TYPE I IS IN MAINTENANCE	GSMAIN	51
	C		GSMAIN	52
000056		IF(MG .EQ. 0) GO TO 100	GSMAIN	53
	C		GSMAIN	54
	C	REDUCING MAINTENANCE TIME BY OT FOR GROUND SUPPORT TYPE I	GSMAIN	55
	C		GSMAIN	56
000057		25 DOWN =DOWN-DT	GSMAIN	57
000061		IF(DOWN .GT. 0.) GO TO 100	GSMAIN	58
	C		GSMAIN	59
	C	REMOVING GROUND SUPPORT TYPE I FROM MAINTENANCE	GSMAIN	60
	C		GSMAIN	61
000063		DOWN=0.	GSMAIN	62
000063		LMG=0	GSMAIN	63
000064		GO TO 100	GSMAIN	64
000064		50 IF(MG .EQ. 1) GO TO 25	GSMAIN	65
000066		GSM=GSM+DT/INC	GSMAIN	66
	C		GSMAIN	67
	C	DETERMINING IF GROUND SUPPORT TYPE I IS DUE FOR MAINTENANCE	GSMAIN	68
	C		GSMAIN	69
000072		IF(GSM .LE. GDOWN(I)) GO TO 100	GSMAIN	70
	C		GSMAIN	71
	C	PUTTING GROUND SUPPORT TYPE I INTO MAINTENANCE	GSMAIN	72
	C		GSMAIN	73
000075		LMG=1	GSMAIN	74
000076		DOWN=SETOOW(I)	GSMAIN	75
000077		PMGS=PMGS+OJMG	GSMAIN	76
000101		GSM=0.	GSMAIN	77
000102		GSOTIM=GSOTIM+DOWN	GSMAIN	78
000104		100 GDOWN(I)=DOWN	GSMAIN	79
000106		GSM(I)=GSM	GSMAIN	80

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000110      LMGS(I)=LMG
000111      110 CONTINUE
000113      150 CONTINUE
000113      RETURN
000114      END
*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED
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NTRAIN
NTRUCK
LTRAIN
LTRUCK
IFIL0
LIFIL0
IFILL0
LNTRDA
LLTRAN
LLTRUK
LNTRAN
LNTRUK
IMOVE
JMETH
XT
XDE
PC
NVEHCL
LVEHCL
NTOA
LLVHCL
LNVHCL
JMOVE
IMETH
XE
PR

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GSMAIN      01
GSMAIN      02
GSMAIN      03
GSMAIN      04
GSMAIN      05
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T. SUBROUTINE ENVIR

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		SUBROUTINE ENVIR	ENVIR	2
C		ELEMENT - ENVIRONMENTAL CONTROL	ENVIR	3
C		GENERAL PROCSS - VENTILATION • COOLING	ENVIR	4
C		***HEAT# MUST BE RETRIEVED FROM ROCK DISINTEGRATION ROUTINE	ENVIR	5
C		***#TROCK# # # # TUNNEL FILE INPUT	ENVIR	6
C			ENVIR	7
000002		COMMON /ALL / XT,STR,TA,ROD,CS,TAMB,FLOW,IFLAG	ENVIR	8
		1. AT,D,E,SK,T,OT,X,PR,XMAX,TMAX,DX,OV,TPRINT,OTPRINT,IMDVE,JMETH	ALL	2
		2. TSHFT,REPORT,OPPCT,TD,XO,XDISCH,ICHNG,XCHNG,TCHNG	ALL	3
000002		EQUIVALENCE (JMVE,IMDVE),(IMETH,JMETH)	ALL	4
000302		COMMON/MDNEY/ JMMH,DJM,DJMRD,DJMBH,DMANT,DJMBN,DJNGS	ALL	5
		1. PMS,JMVC,DJMEC,ROPLAN,WPLAN,GSPLAN	ALL	6
		2. ECPLAN,ROTIME,MTIME(2),GSTIME,ECTIME	ALL	7
000002		COMMON/PERFRM/ ROUTIM,RODTIM,UMHTIM,DMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	8
		1. ECDTIM,GDAY,GADV,GEND,GREG	ALL	9
000002		COMMON/LARDR/ RDMEN(10,2),HMEN(10,2,2),GSMEN(10,2),FCMEN(10,2)	ALL	10
000002		RFAL JMMH,LQ,LDR,LBIT,LBURN,LSTEEL,JMVC	ALL	11
000002		DIMENSION G(A)	ALL	12
000302		EQUIVALENCE (G,XT),(XE,XDE),(PR,PC)	ALL	13
000002		COMMON /ENVC/ MAXMEN,TOTHP,OM,OD,VAMIN,VAMAX,OG(10),	ENVIRON	2
		1 TA,TD,WA,FKD,FKT,CPA,CKA,REFRAT,AMC(10),ODR,EVFNTD,CPIHP	ENVIRON	3
000002		EQUIVALENCE (TROCK,TAMB),(HEAT,HEATJ)	ENVIR	11
000002		DIMENSION OGG(10)	ENVIR	12
000002		DATA INIT /0/	ENVIR	13
000002		DATA NEEDIN /0/	ENVIR	14
000002		DATA PI /3.1415927/	ENVIR	15
000002		DATA DFACT,VFACT,ODMP,ODMP,GAV,ODR /6*0./	ENVIR	16
000002		DATA FACT1,FACT2,FACT3,FACT4,TAVELM /5*0./	ENVIR	17
000002		DATA FACT2A /0./	ENVIR	18
000002		DATA ODS /10*0./	ENVIR	19
		INITIALIZATION	ENVIR	20
000002	C	10 DJMEC = 0.	ENVIR	21
000003	C	ECDTIME=0.	ENVIR	22
000004		ECUTIME=0.	ENVIR	23
000005		IF (OM .EQ. 0.) OM = 200.	ENVIR	24
000007		IF (OD .EQ. 0.) OD = 106. + 0.334 * TOTHP	ENVIR	25
000013		IF (VAMIN .EQ. 0.) VAMIN = 50.	ENVIR	26
000015		IF (VAMAX .EQ. 0.) VAMAX = 1000.	ENVIR	27
000017		IF (TD .EQ. 0.) TD = 80.	ENVIR	28
000021		IF (WA .EQ. 0.) WA = 0.075	ENVIR	29
000023		IF (FKD .EQ. 0.) FKD = 2.0E-9	ENVIR	30
000025		IF (FKT .EQ. 0.) FKT = 1.5E-8	ENVIR	31
000027		IF (CPA .EQ. 0.) CPA = 0.240	ENVIR	32
000031		IF (CKA .EQ. 0.) CKA = 0.0147	ENVIR	33
000033		IF (REFRAT .EQ. 0.) REFRAT = 2.0E-6	ENVIR	34
000035		IF (PR .EQ. 0.) PR = 0.015	ENVIR	35
000037		DFACT = D * PI / 4.	ENVIR	36
000042		VFACT = D * DFACT.	ENVIR	37
		OMP = AIR VOLUME RATE REQUIRED BY MANPOWER	ENVIR	38
000043	C	OMP = OM * MAXMEN	ENVIR	39
		ODMP = AIR VOL. RATE REQUIRED BY DIESEL HP	ENVIR	40
000046	C	ODMP = OD * TOTHP	ENVIR	41
		GAV = AIR VOL. RATE REQUIRED BY AIR VELOCIT	ENVIR	42
			ENVIR	43

000050		QAV = VAMIN * VFACT		ENVIR	44
	C		QDG(IN) = AIR VOL. RATE REQUIRED BY DILUTION	ENVIR	45
	C		OF GAS N	ENVIR	46
000052		DD 50 I = I.10		ENVIR	47
000053		IF (AMC(I) .EQ. 0.) GO TO 50		ENVIR	48
000055		QDG(I) = 1.0E6 * OG(I) / AMC(I)		ENVIR	49
000060		50 CONTINUE		ENVIR	50
	C		QDR = DESIGN REQUIREMENT AIR VOLUME RATE	ENVIR	51
000062		QDR = QMP		ENVIR	52
000064		IF (QDHP .GT. QDR) QDR = QDHP		ENVIR	53
000067		IF (QAV .GT. QDR) QDR = QAV		ENVIR	54
000072		DD 70 I = I.10		ENVIR	55
000074		IF (QDG(I) .GT. QDR) QDR = QDG(I)		ENVIR	56
000101		70 CONTINUE		ENVIR	57
	C		CHECK DESIGN REQUIREMENT VS ALLOWABLE AIR V	ENVIR	58
000103		TAVEL = QDR / VFACT		ENVIR	59
000105		IF (TAVEL .LE. VAMAX) GO TO 95		ENVIR	60
000107		PRINT 90, TAVEL, VAMAX		ENVIR	61
000117		90 FORMAT (33H)VENTILATION DESIGN REQUIREMENT, ,F14.3,43H,EXCEEDS ALL		ENVIR	62
		ALLOWABLE AIR VELOCITY IN TUNNEL, ,F14.3,17H, RUN TERMINATED.)		ENVIR	63
000117		CALL EXIT		ENVIR	64
	C		COMPLETE INITIALIZATION	ENVIR	65
000120		95 FACT1 = CMA / D		ENVIR	66
000122		FACT2 = PI * 0		ENVIR	67
000124		FACT2A = FACT2 * (TA * 80.) / 2.		ENVIR	68
000127		FACT3 = WA * CPA * 60.		ENVIR	69
000132		FACT4 = I.3 * 0		ENVIR	70
000134		TAVELM = TAVEL		ENVIR	71
000135		INIT = I		ENVIR	72
000136		IF (NFEDIN .EQ. 0) GO TO 999		ENVIR	73
000137		NFEODIN = 0		ENVIR	74
000140		GO TO 100		ENVIR	75
	C		NORMAL ENTRY	ENVIR	76
000140		ENTRY ENVIRC		ENVIR	77
000145		TAVEL = TAVELM		ENVIR	78
000147		IF (INIT .EQ. I) GO TO 97		ENVIR	79
000151		NEEDIN = I		ENVIR	80
000152		GO TO 10		ENVIR	81
	C			ENVIR	82
	C		COMPUTING LABOR TIME USED FOR THIS ACTIVITY	ENVIR	83
	C			ENVIR	84
000152		97 ECTIME=ECTIME*DT		ENVIR	85
	C		NOTE ENVIR NEVER STOPS AT PRESENT THIS MAY BE CHANGED IN THE FUTU	ENVIR	86
	C			ENVIR	87
	C		COMPUTING UP TIME	ENVIR	88
	C			ENVIR	89
000154		ECUTIM=ECUTIM*DT		ENVIR	90
	C			ENVIR	91
	C		COMPUTING PLANT AND EQUIPMENT COSTS	ENVIR	92
	C			ENVIR	93
000156		ECPLAN=ECPLAN*DX*EVENTP		ENVIR	94
	C		CALCULATE COST OF PUMPING WATER OUT OF TUNNEL	ENVIR	95
000161		OJMEC=DJMEC*CPUMP*DT*60.*(FLOW*QWATR)		ENVIR	96
	C		CALCULATE REYNOLDS NUMBER FOR TUNNEL AIL FLOW CONDITIONS	ENVIR	97
000165		100 REYND=TAVEL*O/0.165		ENVIR	98

000170		QDR = TAVEL * OFACT	ENVIR	99
	C	DERIVE NUSSELT NO.	ENVIR	100
000172		IF (REYNO .GT. 10000.) GO TO 120	ENVIR	101
000174		IF (REYNO .LE. 2100.) GO TO 130	ENVIR	102
000177		RNUSS=5.0*(26.7*(REYNO-2100.)/7900.)	ENVIR	103
000203		GO TO 150	ENVIR	104
000203	120	RNUSS = 0.02 * REYNO ** 0.8	ENVIR	105
000210		GO TO 150	ENVIR	106
000210	130	RNUSS = 0.5 * REYNO ** 0.3	ENVIR	107
	C	CALC HEAT TRANSFER COEFFICIENT	ENVIR	108
000215	150	HEATC = RNUSS * FACT1	ENVIR	109
	C	CALC HEAT ADDED TO AIR FROM WALL SURFACE	ENVIR	110
000217		XWRK=HEATC*(X-XDISCH)	ENVIR	111
000222		ORFAC = (FACT2*XWRK*TROCK) - (XWRK*FACT2A)	ENVIR	112
	C	CALC HEAT ADDED TO AIR FROM MACHINERY	ENVIR	113
000226		OMFAC = HEAT / OT	ENVIR	114
	C	CALC TEMPERATURE AT TUNNEL FACE	ENVIR	115
000230		TDF= (ORFAC + OMFAC) / (FACT3 * QDR) * TA	ENVIR	116
000235		IF (TOF .LE. TD) GO TO 500	ENVIR	117
000237		IF (TAVEL * 100. .GT. VMAX) GO TO 400	ENVIR	118
	C	MAX VELOCITY NOT YET ACHIEVED	ENVIR	119
000244		TAVEL = TAVEL * 100.	ENVIR	120
000245		GO TO 100	ENVIR	121
	C	CALC MECHANICAL REFRIGERATION LOAD	ENVIR	122
000245	400	QREFRG = QDR * FACT3 * (TDF - TD)	ENVIR	123
	C	CALC OPERATING COST OF REFRIGERATION IN DT	ENVIR	124
000251		DJMEC = DJMEC + QREFRG * REFRAT * DT	ENVIR	125
	C	SELECT SUITABLE VENT DUCT VELOCITY	ENVIR	126
000254	500	VDUCT = 2380. * 0.0483 * QDR	ENVIR	127
	C	CALC FRICTION LOSS OF AIR FLOWING IN TUNNEL	ENVIR	128
000257		HTUN = (FKT * X * TAVEL * TAVEL) / FACT4	ENVIR	129
	C	CALC VENT DUCT DIAMETER	ENVIR	130
000263		XWRK = QDR / (PI * VDUCT)	ENVIR	131
000266		DOUCT = 2. * SQRT (XWRK)	ENVIR	132
	C	CALC FRICTION LOSS OF AIR IN VENT DUCT	ENVIR	133
000271		HDUCT = (FKD * (X-XDISCH) * VDUCT * VDUCT) / (1.3 * DOUCT)	ENVIR	134
	C	CALC AIR HORSEPOWER	ENVIR	135
000277		PAIR = QDR * (HTUN + HDUCT) / 6350.	ENVIR	136
	C	CALC FAN HORSEPOWER	ENVIR	137
000302		PFAN = PAIR / 0.75	ENVIR	138
	C	CALC VENTILATION POWER COST DURING DT	ENVIR	139
000304		FKWHR = PFAN * 0.7452 * DT	ENVIR	140
000306		DJMEC = DJMEC + PR * FKWHR	ENVIR	141
000311		XI = QREFRG * REFRAT * DT	ENVIR	142
000313		X? = PI * FKWHR	ENVIR	143
000314	999	CONTINUE	ENVIR	144
000314		RETURN	ENVIR	145
000315		END	ENVIR	146

*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED

IMOVE
JMETH
XT
XDE
PC
TAMB

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ENVIR

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JMOVE
IMETH
XE

U. SUBROUTINE MAXADV

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		SUBROUTINE MAXADV	RFPRT	2
		COMPUTING ADVANCE EACH DAY IN FEET. STORING MAXIMUM	RFPRT	3
	C		REPORT	4
000002		COMMON /ALL / XT,STR,IA,RD,CS,TAMB,FLOW,IFLAG	ALL	2
		1. AT,D,F,SK,T,OT,X,PR,XMAX,TMAX,DX,DV,TPRINT,OTPRNT,INOVE,JMETH	ALL	3
		2. TSHFT,REPORT,OPPCT,TD,XO,XOISCH,ICHNG,XCHNG,TCHNG	ALL	4
000002		EQUIVALENCE (JNOVE,INOVE),(JMETH,JMETH)	ALL	5
000002		COMMON/HDNEY/ JMMH,DJM,DJMH,DJMR,DJMBH,DMAINT,DJMBH,DJMS	ALL	6
		1. PMGS,JMCV,DJMEC,RDPLAN,HPLANT,GSPLAN	ALL	7
		2. ECPLAN,RDTIME,HTIME(2),GSTIME,ECTIME	ALL	8
000002		COMMON/PFRFRM/ RDTIM,RDUTIM,UMHTIM,DMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	9
		1. ECOTIM,GDAY,GADV,GENO,GREG	ALL	10
000002		COMMON/LABOR/ RDMEN(10,2),HMEN(10,2),GSMEN(10,2),ECMEN(10,2)	ALL	11
000002		REAL JMMH,LD,LDR,LBIT,LBURN,LSTEEL,JMCV	ALL	12
000002		DIMENSION G(8)	ALL	13
000002		EQUIVALENCE (G,XT),(XE,XOE),(PR,PC)	ALL	14
000002		DATA INIT,NEFOIN/2*0/	REPORT	6
000002		DATA DLOX,ROUT/2*0/	REPORT	7
	C	INITIALIZATION	RFPRT	8
000002		I INIT=1	RFPRT	9
000003		IF (TSHFT .EQ. 0.) TSHFT=24.	RFPRT	10
000005		OLDX=X	REPORT	11
000007		IF (NEFIN .EQ. 0) GO TO 999	REPORT	12
000010		NEFIN=0	REPORT	13
000010		GO TO 15	REPORT	14
	C	NORMAL ENTRY	REPORT	15
000011		ENTRY MAXADV	REPORT	16
000016		10 IF (INIT .EQ. 1) GO TO 15	REPORT	17
000020		NEFIN=1	REPORT	18
000021		GO TO 1	REPORT	19
000022		15 RDT=RDTIM-RDUT	REPORT	20
000024		IF (RDT .EQ. 0.) GO TO 999	REPORT	21
000025		ADVV=(X-OLDX)/RDT	REPORT	22
000027		IF (ADVV .LE. GADV) GO TO 999	REPORT	23
000031		GDAY=(T-T0)/24.	REPORT	24
000034		GEND=X-XOISCH	REPORT	25
000036		GREG=OLDX-XOISCH	REPORT	26
000040		GADV=ADVV	REPORT	27
000041		999 CONTINUE	REPORT	28
000041		OLDX=X	REPORT	29
000043		RDT=RDTIM	REPORT	30
000044		RETURN	REPORT	31
000045		END	REPORT	32

*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED

INOVE
JMETH
XT
XOE
PC
JNOVE
JMETH
XE
PR

V. SUBROUTINE REPORR

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	SUBROUTINE REPORR	REPORT	33
C	PRINTING INTERIM PERFORMANCE REPORT	REPORT	34
C		REPORT	35
000002	COMMON /ALL / XT,STR,IA,POD,CS,TAMB,FLOW,IFLAG	REPORT	36
	1. AT,D,E,SK,T,DT,X,PR,XMAX,TMAX,DX,OV,TPRINT,OTPRINT,MOVE,JMETH	ALL	2
	2. TSHFT,REPORT,OPCT,TD,XD,XDISCH,ICHNG,XCHNG,ICHNG	ALL	3
000002	EQUIVALENCE (JMOV,MOVE),(14FT,JMETH)	ALL	4
000002	COMMON/MONEY/ JMMH,DJM,DJMMH,OJMRD,OJMBM,DMAINT,OJMBM,OJMG5	ALL	5
	1. PMG5,JMCV,DJMF,ROPLAN,HPLANT,GSPLAN	ALL	6
	2. ECPLAN,ROTIME,HTIME(2),GSTIME,ECTIME	ALL	7
000002	COMMON/PERFRM/ RDTIM,RDOTIM,UMHTIM,OMHTIM,GSUTIM,GSOTIM,ECUTIM	ALL	8
	1. ECOTIM,ODAY,GADV,GENO,GBEG	ALL	9
000002	COMMON/LARR/ RDMN(10,2),HMEN(10,2),GSMEN(10,2),ECMEN(10,2)	ALL	10
000002	REAL JMMH,LD,LDR,LBIT,LBURN,LSTEEL,JMCV	ALL	11
000002	DIMENSION G(R)	ALL	12
000002	EQUIVALENCE (G,XT),(XE,XDE),(PR,PC)	ALL	13
000002	DATA INIT,NEFDIN/2*0/	ALL	14
000002	DIMENSION IVAL(20)	REPORT	38
000002	COMMON/TEST/VALUE(30),NAME(30)	TEST	2
	1,IHEAD(110),JHEAD(100)	TEST	3
	EQUIVALENCE (IVAL,VALUE)	TEST	4
000002	DATA IHEAD/7HINTERIM,7H PERFOR,7HMANCE R,7HEP(RTS ,	TEST	5
000002	17HDAYS SI,7HNCE COM,7HMENCED ,7HEXCAVAT,7HING ,2*7H ,	REPORT	40
	27MHEADING,7H POSITI,7HON(FEET,7H) ,2*7H ,	REPORT	41
	37HAVERAGE,7H ADVANC,7HE RATE(,7HFFET/OP,7HERATING,7H HOUR) ,	REPORT	42
	47HMAXIMUM,7H DAILY ,7HADVANCE,7HDAYS SI,7HNCE COM,7HMENCED ,	REPORT	43
	57HEXCAVAT,7HING ,7H ,4H ,7MHEADING,7H POSITI,	REPORT	44
	67HON-REGI,7HNING O,7HE THAT ,7HDAY(FEE,4HT) ,7HHEADING,	REPORT	45
	77H POSITI,7HON-END ,7HOF THAT,7H DAY(FE,7HET) ,4H ,7HAVERAGE	REPORT	46
	8,7H RATE F,7HOR THAT,7H DAY(FE,7HET/OPER,7HATING M,4HOUR),	REPORT	47
	97HCUMULAT,7HIVE SUB,7HSYSTEM ,7HPERFORM,6HANCE...7HELEMENT,	REPORT	48
	A7H/MEASUR,7HE ,7H OPE,7HRATIONA,7HL ,7H S,	REPORT	49
	B7HURSYSTE,7HM ,7HAVAILAB,7HILITY, ,7H UTILI,	REPORT	50
	C7HZATION,2H, ,9*7H-----,2H--,7H*OPERAT,7HTONAL A,7HVAILARI,	REPORT	51
	D7HILITY=(T,7HTOTAL SH,7HIFT TIM,7HE-DOWN ,7HTIME)/T,7HTOTAL SH,	REPORT	52
	E7HIFT TIM,IME,7H,SURSY,7HSTEM UT,7HILIZATI,7HON=(TOT,7HAL SHIF,	REPORT	53
	F7HT TIME-,7HDOWN TI,7H4E-IDLE,7H TIME)/,7HTOTAL S,7HIFT TI,	REPORT	54
	G2HME/	REPORT	55
000002	DATA JHEAD/7HINTERIM,7H COST R,7HEPORT ,7HDAYS SI,7HNCE COM,	REPORT	56
	17HMENCED ,7HEXCAVAT,7HING ,7H ,3H ,7HAVERAGE,7H COST P,	REPORT	57
	2 7HER IN S,7HITU CUB,7HIC YARD,7H EXCAVA,3HTED,7HAVERAGE,	REPORT	58
	47H COST P,7HR FOOT,7H OF TUN,7HNEL ,7H ,3H ,7HCUMULAT,	REPORT	59
	57HIVE COS,7HT SUMMA,7HRY TO O,7HATE,,(O,7HOLLARS),7HELEMENT,	REPORT	60
	67H/CATEGO,7HRY ,7HIRECT ,7H PL,7HANT ,7H JO,	REPORT	61
	67HB ,7H PERM,7HAGENT ,7H OVE,7HR ,7H ELEMEN,1HT,	REPORT	62
	77HLABOR ,	REPORT	63
	7 7H EQU,7HIPMENT ,7H MAT,7HERIALS ,7H MAT,	REPORT	64
	87HFRIALS ,7H HE,7HMO ,7H TOTAL,14*7H-----,3H---,	REPORT	65
	914*7H-----,3H---	REPORT	66
	A7HGEOLGY,7H CHANGE,4HO AT,5H DAYS,7H FEET F,7HROM POR,4HTAL.,	REPORT	67
	A7HNEW CHA,	REPORT	68
	B7HRACTER,7HSTICS A,7HRE. UN,7HCONFINE,7HD COMPR,7HESSIVE ,	REPORT	69
	C7HSTRENGT,6HMKSI)/	REPORT	70
C		REPORT	71
		REPORT	72

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	C	INITIALIZATION	REPORT	73
	C		REPORT	74
000002		1 INIT=1	REPORT	75
000003		IF (REPORT .EQ. 0.) REPORT=24.	REPORT	76
000005		IF (TSHFT .EQ. 0.) TSHFT=24.	REPORT	77
000007		IF (NEEDIN .EQ. 0) GO TO 999	REPORT	78
000010		NEEDIN=0	REPORT	79
000011		GO TO 3	REPORT	80
	C		REPORT	81
	C	NORMAL ENTRY	REPORT	82
	C		REPORT	83
000011		ENTRY REPORS	REPORT	84
000016		IF (INIT .EQ. 1) GO TO 3	REPORT	85
000020		NEFOIN =1	REPORT	86
000021		GO TO 1	REPORT	87
	C	COMPUTING DAY OF REPORT AND AVERAGE ADVANCE	REPORT	88
000022		3 DAYS=(T-T0)/24.	REPORT	89
000025		TSHFT=T-T0	REPORT	90
000026		ADV=X-X0/5CH	REPORT	91
	C		REPORT	92
	C	OPERATING TIME IS ASSUMED TO BE ROCK DISINTEGRATION UP TIME	REPORT	93
000030		AVGADV=(X-X0)/RDUTIM	REPORT	94
	C		REPORT	95
	C	PRINTING INTERIM PERFORMANCE REPORTS	REPORT	96
000033		PRINT 4	REPORT	97
000036		4 FORMAT (1M1)	REPORT	98
000036		PRINT 5, (1MFAD(I), I=1,10), DAYS, (1HEAD(I), I=12,17), ADV, (1HEAD(I),	REPORT	99
		I=18,23), AVGADV	REPORT	100
000072		5 FORMAT (////, 46X, 4A7, ////, 26X, 6A7, F10.3, //, 26X, 6A7, F10.3, //, 26X,	REPORT	101
		16A7, F10.3)	REPORT	102
000072		PRINT 40, (1MFAD(I), I=24,33), GOAY, (1HEAD(I), I=34,40), GBEG, (1HEAD(I)	REPORT	103
		1, I=41,47), GFND, (1HEAD(I), I=48,54), GADV	REPORT	104
000136		40 FORMAT (//, 26X, 3A7, //, 34X, 6A7, A4, F10.3, //, 34X, 6A7, A4, F10.3, //, 34X,	REPORT	105
		16A7, A4, F10.3, //, 34X, 6A7, A4, F10.3)	REPORT	106
		PRINT 80, (1MFAO(I), I=55,84)	REPORT	107
000136		80 FORMAT (//, 26X, 4A7, A6, //, 26X, 9A7, //, 51X, 5A7, A2, //, 26X, 9A7, A2)	REPORT	108
000150		OPTIM=(TSHFT-RDUTIM)/TSHFT	REPORT	109
000150		USETIM=RDUTIM/TSHFT	REPORT	110
000153		PRINT 120, OPTIM, USETIM	REPORT	111
000154		120 FORMAT (//, 25X, 19H ROCK FRAGMENTATION , F13.3, 10X, F13.3)	REPORT	112
000164		OPTIM=(TSHFT-DMHTIM)/TSHFT	REPORT	113
000164		USETIM=DMHTIM/TSHFT	REPORT	114
000167		PRINT 130, OPTIM, USETIM	REPORT	115
000170		130 FORMAT (//, 25X, 19H MATERIALS HANDLING , F13.3, 10X, F13.3)	REPORT	116
000200		OPTIM=(TSHFT-GSOTIM)/TSHFT	REPORT	117
000200		USETIM=GSOTIM/TSHFT	REPORT	118
000203		PRINT 140, OPTIM, USETIM	REPORT	119
000204		140 FORMAT (//, 25X, 19H GROUND SUPPORT , F13.3, 10X, F13.3)	REPORT	120
000214		OPTIM=(TSHFT-ECOTIM)/TSHFT	REPORT	121
000214		USETIM=ECOTIM/TSHFT	REPORT	122
000217		PRINT 150, OPTIM, USETIM	REPORT	123
000220		150 FORMAT (//, 25X, 22H ENVIRONMENTAL CONTROL , F10.3, 10X, F13.3)	REPORT	124
000230		PRINT 160, (1HEAD(I), I=85,107)	REPORT	125
000230		160 FORMAT (//, 25X, 10A7, A1, //, 24X, 11A7, A2)	REPORT	126
000242		999 CONTINUE	REPORT	127
000242				

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REPORR

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000242 RETURN
000243 END
• FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED
IMOVE
JMETH
XT
XDE
PC
JMOVE
IMETH
XE
PR

REPORT 128
REPORT 129

W. SUBROUTINE REPORC

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07/25/72

	SUBROUTINE REPORC	REPORT	130
		REPORT	131
C	PRINTING INTERIM COST REPORT	REPORT	132
C		REPORT	133
000002	COMMON /ALL / XT,STR,IA,RQO,CS,TAMB,FLOW,IFLAG	ALL	2
	1. AT,D,E,SK,T,OT,X,PR,XMAX,TMAX,DX,OV,TPRINT,DTPRNT,IMOVE,JMETH	ALL	3
	2. TSMFT,REPORT,OPPCT,TO,XO,XOISCH,ICHNG,XCHNG,TCHNG	ALL	4
000002	EQUIVALENCE (JMOVE,IMOVE),(JMETH,JMETH)	ALL	5
000002	COMMON/MONEY/ JMMHM,OJM,DJMMH,DJMRD,OJMBHM,OMAIN,T,DJMRM,DJMGS	ALL	6
	1. PNGS,JMCV,OJMEC,ROPLAN,HPLANT,GSPLAN	ALL	7
	2. FCPLAN,ROTIME,HTIME(2),GSTIME,ECTIME	ALL	8
000002	COMMON/PERFRM/ ROUTIM,ROOTIM,UMHTIM,OMHTIM,GSUTIM,GSDTIM,ECUTIM	ALL	9
	1. ECOTIM,GOAY,GADV,GENO,GREG	ALL	10
000002	COMMON/LAROR/ ROMEN(10,2),HMEN(10,2,2),GSMEN(10,2),ECHEN(10,2)	ALL	11
000002	REAL JMMHM,LD,LOB,LBIT,LBURN,LSTEEL,JMCV	ALL	12
000002	OTMENSION G(R)	ALL	13
000002	EQUIVALENCE (G,XT),(XE,XDE),(PR,PC)	ALL	14
000002	OTMENSION IVAL(20)	TEST	2
000002	COMMON/TEST/VALUE(30),NAME(30)	TEST	3
000002	I,THEAD(1)O1,JHEAO(100)	TEST	4
000002	EQUIVALENCE (IVAL,VALUE)	TEST	5
C	INITIALIZATION	REPORT	136
000002	OTMENSION ELEMEN(4,6),TOTAL(6)	REPORT	137
000002	1 INIT=1	REPORT	138
000003	IF(OPPCT .EQ. 0.) OPPCT=.20	REPORT	139
000005	IF(REPOR1 .EQ. 0.) REPORT=4.	REPORT	140
000007	OO 2 I=1,2	REPORT	141
000011	HTIME(I)=0	REPORT	142
000012	2 CONTINUE	REPORT	143
000014	GSTIME=0.	REPORT	144
000015	ROTIME=0.	REPORT	145
000016	ECTIME=0.	REPORT	146
000017	IF(NEEOIN .EQ. 0) GO TO 999	REPORT	147
000020	NFEDIN=0	REPORT	148
000020	GO TO 3	REPORT	149
C	NORMAL ENTRY	REPORT	150
000021	ENTRY REPORC	REPORT	151
000026	IF (INIT .EQ. 1) GO TO 3	REPORT	152
000030	NEEOIN=1	REPORT	153
000031	GO TO 1	REPORT	154
000032	3 DO 5 I=1,4	REPORT	155
000034	OO 4 J=1,6	REPORT	156
000035	ELEMEN(I,J)=0.	REPORT	157
000040	TOTAL(J)=0.	REPORT	158
000041	4 CONTINUE	REPORT	159
000042	5 CONTINUE	REPORT	160
C	COMPUTE JOB MATERIAL ,PLANT AND EQUIPMENT COSTS FOR EACH PROCESS	REPORT	161
C		REPORT	162
000044	ELEMEN(1,4)=0.	REPORT	163
000045	ELEMEN(2,4)=0.	REPORT	164
000046	ELEMEN(4,4)=0.	REPORT	165
000047	ELEMEN(3,3)=0.	REPORT	166
000050	ELEMEN(1,2)=ROPLAN	REPORT	167
000051	ELEMEN(2,2)=HPLANT	REPORT	168
000053	ELEMEN(3,2)=GSPLAN	REPORT	169

000054	ELEMEN(4.2)=FCPLAN	RFPORC	170
000056	ELEMEN(1.3)=DJMRO•DJMRM	REPORT	171
000060	ELEMEN(2.3)=DJMHM	REPORT	172
000061	ELEMEN(3.4)=PMGS	REPORT	173
000063	ELEMEN(4.3)=DJMEC	REPORT	174
		REPORT	175
	C	REPORT	176
	COMPUTING LABOR COSTS FOR EACH GENERAL PROCESS	REPORT	177
	C	REPORT	178
000064	DO 6 I=1.10	REPORT	179
000066	ELEMEN(1.1)=ELEMEN(1,I)*ROMEN(1,I)*ROMEN(1,2)*ROTIME	REPORT	180
000072	ELEMEN(3.1)=ELEMEN(3,I)*GSMEN(I,I)*GSMEN(I,2)*GSTIME	REPORT	181
000076	ELEMEN(4.1)=ELEMEN(4,I)*ECMEN(I,I)*ECMEN(I,2)*ECTIME	REPORT	182
000102	6 CONTINUE	REPORT	183
000104	DO 7 J=1.2	REPORT	184
000105	DO 7 I=1.10	REPORT	185
000106	ELEMEN(2.1)=ELEMEN(2,I)*HMEN(I,I,J)*HMEN(I,2,J)*HTIME(J)	REPORT	186
000117	7 CONTINUE	REPORT	187
000121	70 CONTINUE	REPORT	188
000123	DO 9 I=1.4	REPORT	189
000124	DO 8 J=1.4	REPORT	190
000125	ELEMEN(I.5)=ELEMEN(I,5)*OPPCT*ELEMEN(I,J)	REPORT	191
000133	8 CONTINUE	REPORT	192
000135	9 CONTINUE	REPORT	193
000137	DO 11 I=1.4	REPORT	194
000140	DO 10 J=1.5	REPORT	195
000141	ELEMEN(I.6)=ELEMEN(I,6)*ELEMEN(I,J)	REPORT	196
000146	10 CONTINUE	REPORT	197
000150	11 CONTINUE	REPORT	198
000152	DO 13 I=1.4	REPORT	199
000153	DO 12 J=1.6	REPORT	200
000154	TOTAL(J)=TOTAL(J)+ELEMEN(I,J)	REPORT	201
000162	12 CONTINUE	REPORT	202
000163	13 CONTINUE	REPORT	203
000165	DAYS=(T-T0)/24.	REPORT	204
000170	ACYARO=TOTAL(6)*108./(3.1415*(D**2)*(X-X0))	REPORT	205
000176	ACFOOT=TOTAL(6)/(X-X0)	REPORT	206
000200	PRINT 14	REPORT	207
000204	14 FORMAT(1H1)	REPORT	208
	PRINT 15. (JHEAD(I),I=1.10),DAYS,(JHEAD(I),I=11.17),ACYARO,	REPORT	209
	I(JHEAD(I),I=18.24),ACFOOT	REPORT	210
000240	15 FORMAT(///,49X,3A7,///,8X,6A7,A3,F14.3,///,8X,6A7,A3,F13.2,///,8X,	REPORT	211
	26A7,A3,F13.2)	REPORT	212
000240	PRINT 50.(JHEAD(I),I=25.69)	REPORT	213
000252	50 FORMAT(///,8X,6A7,///,8X,13A7,A1,///,29X,10A,///,8X,14A7,A3)	REPORT	214
000252	PRINT 90.(ELEMEN(I,J),J=1.6)	REPORT	215
000264	90 FORMAT(/,7X,22H ROCK FRAGMENTATION ,F9.2,F11.2,3X,F11.2,3X,F	REPORT	216
	111.2,F10.2,F12.2)	REPORT	217
000264	PRINT 100.(ELEMEN(2,J),J=1.6)	REPORT	218
000276	100 FORMAT(/,7X,22H MATERIALS HANDLING ,F9.2,F11.2,3X,F11.2,	REPORT	219
	1 3X,F11.2,F10.2,F12.2)	REPORT	220
000276	PRINT 110.(ELEMEN(3,J),J=1.6)	REPORT	221
000310	110 FORMAT(/,7X,22H GROUND SUPPORT ,F9.2,F11.2,3X,F11.2,3X,	REPORT	222
	1 F11.2,F10.2,F12.2)	REPORT	223
000310	PRINT 120.(ELEMEN(4,J),J=1.6)	REPORT	224
000322	120 FORMAT(/,7X,22H ENVIRONMENTAL CONTROL ,F9.2,F11.2,3X,F11.2,3X	REPORT	224

000322	1,F11.2,F10.2,F12.2)		REPORT	225
000334	PRINT 130,(JHEAD(I),I=70,84)		REPORT	226
000334	130 FORMAT(/,8X,14A7,A3)		REPORT	227
000346	PRINT 140,(TOTAL(J),J=1,6)		REPORT	228
000346	140 FORMAT(// 7X,22H CATEGORY TOTAL	•F9.2,F11.2,F14.2,F14.2,	REPORT	229
	1F10.2,F12.2)		REPORT	230
000346	IF (1CHNG .EQ. 0) GO TO 999		REPORT	231
000347	1CHNG=0		REPORT	232
000350	PRINT 150,(JHEAD(I),I=85,87),TCHNG,(JHEAD(I),I=88,88),XCHNG,		REPORT	233
	1(JHEAD(I),I=89,100),STR		REPORT	234
000403	150 FORMAT(///,8X,2A7,A4,F10.3,A5,F10.3,2A7,A4,///,26X,8A7,A6,F12.4)		REPORT	235
000403	PRINT 165,1A		REPORT	236
000411	165 FORMAT(SIX,37H ABRASIVENESS	•I7)	REPORT	237
000411	PRINT 170,RQD		REPORT	238
000417	170 FORMAT(SIX,37H ROCK QUALITY DESIGNATION	•F12.4)	REPORT	239
000417	PPINT 180,CS		REPORT	240
000425	180 FORMAT(SIX,37H IN SITU DENSITY(LRS/FT**3)	•F12.4)	REPORT	241
000425	PRINT 190,TAMB		REPORT	242
000433	190 FORMAT(SIX,37H AMBIENT TEMPERATURE(DEG F)	•F12.4)	REPORT	243
000433	PRINT 200,FLOW		REPORT	244
000441	200 FORMAT(SIX,37H WATER INFLOW(GAL/MIN)	•F12.4)	REPORT	245
000441	999 CONTINUE		REPORT	246
000441	RETURN		REPORT	247
000442	END		REPORT	248

*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED

IMOVE
JMETH
XT
XOE
PC
JMOVE
JMETH
XE
PR

X. SUBROUTINE HOLBRN (ICYCLE)

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SUBROUTINE HOLBRN(ICYCLE)
000003 COMMON/ALL/ XT,STR,IA,RQD,CS,TAMB,FLDW,IFLAG,AT,D,E,SK,T,DT,X,PR
      1. XMAX,TMAX,TD,XD,XDISCH
      2.DX,DV
000003 COMMON/MONEY/ DJMRD
000003 COMMON/BLAST/ ADH,ADH, CRIT,CRURN,CCAP,CEX,CM,CPL,CSTEF,LRIT
      1. LBURN,LD,LDR,LSTEEL,MEN,ND,NH,NHB,PF,POB,PDD,TCHG,TIN,TOUT
      2.TYFPP,WPL
000003 COMMON/OLOCDM/ JUMIN,JUMOUT,NCHRG,NDRILB,NDRILL
000003 COMMON/NEWCDM/LJUMIN,LJUMDT,LNCHRG,LNDRLB,LNDRIL
C
C ELEMENT - ROCK DISINTEGRATION
C GENERAL PROCESS - DRILL AND BLAST
C ACTIVITY - DRILL HOLES OF BURN PATTERN
C TECHNIQUE - PERCUSSION DRIFTSR AND BURN CUT DRILLS
C
000003 DATA TIMED,TIMFR,PHI,SE,RD,TD,RDB,TDR /8*0./
000003 IF(ICYCLE.NE. I) GO TO 50
000005 NDRILL=0
000005 NDRILB=0
000006 ICYCLF = 50
000007 IF (NH.NE. 0 .AND. NO.NE. 0 .AND. LD.NE. 0) GO TO 10
      C OPTION ?
000017 PHI = 1.0
000020 NH = INT (( D + 0.1*D)*PHI + .5)
000025 ND = INT (NH/8.0 + .5)
000030 IF (D.GT.15.) NHB =3
000034 IF (D.LE.15.) NHB =2
000037 NDR=I
000040 LD = DX + 1.0
000043 LDR=DX*1.0
000046 10 IF(STR.GT. 50.0) SE=60.
000052 IF (STR.LT. 50.0) SE=15.*EXP(0.031*STR)
000063 RD=1.9RE3*POB/(ADH*SE)
      C TIME TO DRILL HOLES
000066 TD = LD/RD * NH/ND
000073 RDR=1.9RE3*POB/(ADB*SF)
000076 TDR=LDR/RDR * NHB/NDR
000103 TIMED=TD
000105 TIMER=TDB
000107 PRINT 20,TD,TDR,NH
000120 ) FORMAT (* TIME TO DRILL HOLES - TD=*,F10.5,* TDR=*,F10.5/
      * * NO. OF HOLES =*,I10)
      C KEEP TRACK OF TIME AND COSTS
000120 50 TIMED=TIMED-DT
000122 TIMER=TIMER-DT
000123 LNDRIL=0
000124 LNDRLB=0
000124 IF (TIMED.GT. 0.0) GO TO 60
000130 IF(NDRILL.EQ. I) GO TO 57
000132 LNDRIL = I
000132 IF (LRIT.LE.0.0 .OR. LSTEEL.LE. 0.0) GO TO 55
000143 DJMRD= CRIT/LRIT * NH* LD + CSTEF * LD * NH/LSTEEL +DJMRD
000154 GO TO 60
000154 55 DJMRD= .I*NH*LD + 0.25 * .I*NH*LD + DJMRD
000162 GO TO 60
000163 57 LNDRIL=I

000164 60 IF (TIMED.GT. 0.0) RETURN
000166 IF(NDRILB.EQ. I) GO TO 67
000170 LNDRLB=I
000171 IF (LBURN.LE. 0.0 .OR. LSTEEL.LE. 0.0) GO TO 65
000201 DJMRD=CBURN/LBURN*NHB*LDB+CSTEF*LDB*NHB/LSTEEL+DJMRD
000212 GO TO 70
000212 65 DJMRD=.25*.I*NHB*LDB+DJMRD
000217 GO TO 70
000217 67 LNDRLB=1
000220 70 RETURN
000221 END

```

Y. SUBROUTINE MOVEIN (ICYCLE)

SUBROUTINE MOVEIN(ICYCLE)

C
C
C
C
C
C

ELEMENT - ROCK FRAGMENTATION
GENERAL PROCESS - DRILL AND BLAST
ACTIVITY - REPOSITION AND ALIGN DRILLING EQUIPMENT
TECHNIQUE - DRILL JUMBO (FULL FACE)

```
000003 COMMON /GRND/ PSST(60,9)
000003 COMMON/ALL/ XT,STR,IA,RQD,CS,TAMB,FLOW,IFLAG,AT,D,E,SK,T,DT,X,PR
1, XMAX,TMAX,TO,XO,XDISCH
2,DX,DV
000003 COMMON/MONEY/ DJMRD
000003 COMMON/BLAST/ ADR,ADH, CRIT,CBURN,CCAP,CEX,CM,CPL,CSTFFL,LBIT
1, LBURN,LD,LDR,LSTEEL,MEN,ND,NH,NHB,PF,POB,POD,TCHG,TIN,TOUT
2,TYPEPF,WPL
000003 COMMON/OLDCOM/ JUMIN,JUMOUT,NCHRG,NDRILB,NDRILL
000003 COMMON/NEWCOM/LJUMIN,LJUMOT,LNCHRG,LNDRLR,LNDRIL
000003 DATA TT/0./
000003 IF (ICYCLE .GT. 1)GO TO 10
000006 JUMIN=0
000006 ICYCLE = 50
000007 IF (TIN .LE. 0.0) TIN=.25
000012 TT=TIN
000013 DO 5 I=1,15
000015 IF(PSST(I,1) .LE. RQD) GO TO 6
000020 5 CONTINUE
000021 6 IF(PSST(I,3) .GT. 10.) GO TO 7
000025 DX=PSST(I,3)
000026 GO TO 8
000026 7 DX=10.
000030 8 DV=AT*DX
000032 10 TT=TT-DT
000034 LJUMIN=0
000035 IF(TT .LE. 0.0) LJUMIN=1
000037 RETURN
000040 END
```

Z. SUBROUTINE MOVOUT (ICYCLE)

```
      SUBROUTINE MOVOUT (ICYCLE)
C
C   ELEMENT - ROCK FRAGMENTATION
C   GENERAL PROCESS - DRILL AND BLAST
C   ACTIVITY - MOVE OUT DRILLING EQUIPMENT AND BLAST
C   TECHNIQUE - DRILL JUMBO (FULL FACE)
C
000003   COMMON/ALL/ XT,STR,IA,RQD,CS,TAMB,FLOW,IFLAG,AT,D,E,SK,T,DT,X,PR
        1, XMAX,TMAX,TO,XO,XDISCH
        2,DX,DV
000003   COMMON/MONEY/ DJMRD
000003   COMMON/BLAST/ ADB,ADH,   CBIT,CBURN,CCAP,CEX,CM,CPL,CSTEFFL,LBIT
        1, LBURN,LD,LDR,LSTEEL,MEN,ND,NH,NHB,PF,POB,POD,TCHG,TIN,TOUT
        2,TYPEPF,WPL
000003   COMMON/OLDCOM/ JUMIN,JUMOUT,NCHRG,NDRILB,NDRILL
000003   COMMON/NEWCOM/LJUMIN,LJUMOT,LNCHRG,LNDRLB,LNDRIL
000003   DATA TT/0./
000003   IF (ICYCLE .GT. 1) GO TO 10
000006   ICYCLE = 50
000006   JUMOUT=0
000007   IF (TOUT .LE. 0.0) TOUT=.25
C
000012   SET INITIAL CONDITIONS
        TT=TOUT
000013   10 TT=TT-DT
000015   LJUMOT=0
000015   IF (TT .LE. 0.0) LJUMOT=1
000020   RETURN
000021   END
```


AA. SUBROUTINE SETCHG (ICYCLE)

```

SUBROUTINE SETCHG(ICYCLE)
000003 COMMON/ALL/ XT,STR,IA,RQD,CS,TAMR,FLOW,IFLAG,AT,D,F,SK,T,DT,X,PR
1, XMAX,TMAX,TO,XO,XDISCH
2,DX,DV
000003 COMMON/MONEY/ DJMRD
000003 COMMON/BLAST/ ADB,ADH, CRIT,CRURN,CCAP,CEX,CM,CPL,CSTEFF,LRIT
1, LBURN,LD,LDR,LSTEEL,MEN,ND,NH,NHB,PF,POB,POD,TCHG,TIN,TOUT
2,TYPEPF,WPL
000003 COMMON/OLDCOM/ JUMIN,JUMOUT,NCHRG,NDRILB,NDRILL
000003 COMMON/NEWCOM/LJUMIN,LJUMOT,LNCHRG,LNDRLR,LNDRIL

C
C ELEMENT - ROCK DISINTEGRATION
C GENERAL PROCSS - DRILL AND BLAST
C ACTIVITY - SET CHARGE
C TECHNIQUE = INDIVIDUAL HAND METHOD OR AUTOMATED
C

000003 DATA CE,WEX,DTS,TT /4*0./
000003 IF (ICYCLE .NE. 1) GO TO 30
000005 ICYCLE = 50
000005 NCHRG=0
000006 IF (PF .NE. 0.0) GO TO 20
000007 10 IF (TYPEPF .NE. 3.) GO TO 15
000011 CE = 50.
000012 WPL=0.5
000014 CCAP=0.3
000015 CPL=0.2
000017 CEX = 0.06
000020 CM=1.
000022 GO TO 18
000023 15 CE = 70.
000024 WPL=0.
000025 CPL=0.
000026 CCAP = 0.3
000030 CEX = 0.3
000031 CM=1.

C
000033 18 COMPUTE POWDER REQUIRED
000041 20 PF=(27./144)*(ADH*CE/AT)*NH
WEX = PF/27.0 * AT * DX
C
000044 COMPUTE TIME TO SET CHARGES
000047 IF (TCHG.LE. 0.0) TCHG = 4./60.
000052 IF (MEN .GT. 0) GO TO 21
000055 TMEN=NH/R.*.5
000055 MEN=INT(TMEN)
000056 21 DTS=TCHG*NH/MEN
000061 TT=DTS
000063 PRINT 25,PF,DTS
000073 30 TT=TT-DT
000075 LNCHRG=0
000075 IF (TT .GT. 0.0) RETURN
000100 LNCHRG = 1
000101 DJMRD=DJMRD+NH*(WPL*CPL)+NH*CCAP+WEX*CEX+DX*CM
000113 25 FORMAT (* POWDER FACTOR=*,F10.5,5X,*TIME TO SET CHARGES=*,F10.5)
000113 RETURN
000113 END

```

BB. SUBROUTINE JETIMP

```

SUBROUTINE JETIMP
C
C C C C
ELEMENT = ROCK DISINTEGRATION
GENERAL PROCESS = WATER JET IMPACT, CONTINUOUS OR INTERMITTANT PULSES
ACTIVITY = JET IMPACT
C
COMMON/ALL/ XT,STR,IA,POD,CS,TAMB,FLOW,IFLAG,AT,D,F,SK,Y,DT,V,PR
1. XMAX,TMAX,TD,DO,XDISCH
COMMON/MONEY/ DJMPD)
COMMON/NJET / RLT,CPSRL,CSTPRJ,DJMWJM,DNOZZ,DTJFT,DIMJET,OTRJET
1. ENRGJ,ETAJ,ETAJ,ETAIMP,ETAIMP,MODEJ,NGUNS,NJETS,PNOZZ,PPM
2. PULSE,IMPULSED,TPRRL,VOLPRJ,VFLPRJ,VPRJ,XRJET,VFLJET
COMMON/NEACOM/ LNRRL,LMWJ,LMWJM,LMWJR. FHEATJ,FOHATR,FOY
1. FOY
COMMON/OLDCOM/ NRRL,MWJ,MWJM,MWJR. HEATJ,OHATR,DX,OV
EQUIVALENCE (SIGC,STR)
EQUIVALENCE (NRCK,RDD)
EQUIVALENCE (MPI,MWJ)
EQUIVALENCE (LNPI,LMWJ)
DATA PI / 3.1415927/
DATA INIT / 0/
DATA NEEDIN / 0/
DATA FACTA,FACTR,FACTC,XFACT,QFACT / 5*0./
C
C INITIALIZE VARIABLES
10 IF (PR .EQ. 0.) PR = 0.015
IF (ETAJ .EQ. 0.) ETAJ = 0.3
IF (ETAIMP .EQ. 0.) ETAIMP = 0.2
IF (ENRGJ .EQ. 0.) GO TO 100
IF (MODEJ .EQ. 1) GO TO 70
C
ENRGJ NOT INPUT, MODEJ = CONTINUOUS
IF (SIGC .LT. 5.0 .OR. SIGC .GT. 25.0) GO TO 80
ENRGJ = 47.0 * EXP (.09 * SIGC)
GO TO 100
C
ENRGJ NOT INPUT, MODEJ = INTERMITTENT
70 IF (SIGC .LT. 15.0 .OR. SIGC .GT. 35.0) GO TO 80
ENRGJ = 100. * EXP (.072 * SIGC)
GO TO 100
80 PRINT 85
85 FORMAT (10) (JET ENERGY PER VOLUME OF ROCK BROKEN MUST BE SPECIFIED
FOR THE ROCK STRENGTH ENCOUNTERED. RUN TERMINATED. )
CALL EXIT
C
GENERATE FACTORS REQUIRED FOR CALCS
100 YFACT = PI * D * D / 4.
YFACT = PI * DNOZZ * DNOZZ / 4.
ZFACT = PULSE * PPM / 60.
XWRK = PNOZZ * 193.2 / 1.3
VFLJET = SQRT (XWRK)
QFACT = VFLJET * NJETS * YFACT * 25.
POWREA = 0.0174 * DNOZZ * DNOZZ * PNOZZ ** 1.5
IF (MODEJ .EQ. 0) GO TO 110
QFACT = QFACT * ZFACT
POWREA = POWREA * ZFACT
110 CONTINUE
TOTPWR = NJETS * POWREA
PWRIN = TOTPWR / ETAJ
FACTA = PWRIN * PR * 0.7452
FACTR = (1. - ETAJ * ETAIMP) * PWRIN * 2545.2
FACTC = 13.75 * TOTPWR / (XFACT * ENRGJ)
C
IS CALL FOR INITIALIZATION ONLY
INIT = 1
IF (NEEDIN .EQ. 0) GO TO 999
NEEDIN = 0
GO TO 300

```

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NORMAL ENTRY

C
C
C

```
ENTRY JET
IF (INIT .EQ. 1) GO TO 300
NFEDIN = 1
GO TO 10
300 FHEATJ = 0.
    RDTIME=RDTIME*DT
    FDX = 0.
    FDV = 0.
    FQWATR = 0.
    IF (MWJ .GE. 1) GO TO 999
    DJMRD = DJMRD + (FACTA * DT)
    RDPLAN=RDPLAN+5.
    FHEATJ = FACTR * DT
    FDX = FACTC * DT
    FDV = XFACT * FDX
    FQWATR = QFACT * DT
999 RETURN
END
```

CC. SUBROUTINE JETAGN

```

SUBROUTINE JETAGN
C
C ELEMENT - ROCK DISINTEGRATION
C GENERAL PROCSS - WATER JET
C ACTIVITY - REPOSITION * ALIGN
C OR PROJECTILE FRAGMENTATION
COMMON/ALL/ XT,STR,IA,RDD,CS,TAMR,FLOW,IFLAG,AT,D,F,SK,T,DT,X,PR
1. XMAX,TMAX,TD,XD,DISCH
COMMON/MONEY/ DJMRO
COMMON/NJET / PLT,CPRPL,CSTPRJ,DJMWMJ,DNOZZ,DTJCT,DTMJET,DTRJET
1. ENFRGJ,FTAGN,ETAJ,FTAIMP,FTAIP,NOEJ,NGUNS,NJETS,PNOZZ,PPM
2. PRJPM,PULSED,TRRL,VOLPRJ,VFLPRJ,WPRJ,XRJET,VFLJET
COMMON/NEWCOM/ LNRARL,LMWJ,LMWJM,LMWJR, FNFATJ,FOWATR,FDX
1. FDV
COMMON/OLDCOM/ NRARL,MWJ,MWJM,MWJR, HEATJ,QWATR,DX,DV
EQUIVALENCE (SIGC,STR)
EQUIVALENCE (WROCK,RDD)
EQUIVALENCE (MPI,MWJ)
EQUIVALENCE (LMPI,LMWJ)
DATA DISTJ /0./
DATA ELPSD /0./
DATA OLDPOS /0./
DATA INIT /0/
DATA NEEDIN /0/
ENTRY PRJAGN
C INITIALIZE
10 MWJR=1
IF (DTRJET .EQ. 0.) DTRJET = 0.25
OLDPOS=X
INIT = 1
IF (NEEDIN .EQ. 0) GO TO 999
NEEDIN = 0
GO TO 50
C NORMAL ENTRIES
ENTRY JETPOS
ENTRY PRJPOS
IF (INIT .EQ. 1) GO TO 50
NEEDIN = 1
GO TO 10
50 IF (MWJ .EQ. 0) GO TO 100
C WATER JET (OR PROJECTILE GUN) STOPPED
IF (MWJR .EQ. 1) GO TO 999
C REPOSITIONING NOT YET COMPLETED
ELPSD = FLPSD * DT
IF (ELPSD .LT. DTRJET) GO TO 999
LMWJR = 1
LMWJ = LMWJ - 1
OLDPOS = X
ELPSD = 0.
GO TO 999
C WATER JET (OR PROJECTILE GUN) IS OPERATING
100 DISTJ = X - OLDPOS * FDX
C NOTE *** FOR A GIVEN CYCLE, FDX MUST BE CALCULATED BEFORE THIS
C STATEMENT IS EXECUTED, SINCE, TO BE CONSISTENT WITH OTHER
C LOGIC, DISTJ MUST REFLECT THE DISTANCE AT THE END OF THE
C CURRENT CYCLE. HENCE, JET OR PRJIMP MUST BE CALLED BEFORE
C CALLING JETPOS OR PRJPOS.
IF (DISTJ .LT. XRJET) GO TO 999
LMWJ = LMWJ * I
LMWJR = 0
999 RETURN
END

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DD. SUBROUTINE JETMNT

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SUBROUTINE JETMNT
C
C ELEMENT - ROCK DISINTEGRATION
C GENERAL PROCESS-WATER JET AND PROJECTILE
C ACTIVITY - GENERAL MAINTENANCE + REPAIR
C
COMMON/ALL/ XT,STR,IA,R0D,CS,TAMR,FLOW,IFLAG,AT,D,E,SK,T,DT,X,PR
1, XMAX,TMAX,TD,XD,XDISCH
COMMON/MONEY/ DJMRD
COMMON/NJET / RL,CPRRL,CSTPRJ,DJMWJM,DNOZZ,DT CJET,DTMJET,DTPIJT
1, ENRGJ,ETAGN,ETAJ,ETAIMP,ETAIPT,MODEJ,NGUNS,NJETS,PNOZZ,PCM
2, PRJPM,PULSED,TRAPL,VOLPRJ,VFLPRJ,WPRJ,XRJET,VFLJET
COMMON/NEWCOM/ LNRARL,LMWJ,LMWJM,LMWJR, FHFATJ,FOWATR,FDX
1, FDV
COMMON/OLDCOM/ NRARL,MWJ,MWJM,MWJR, HEATJ,QWATR,DX,OV
EQUIVALENCE (SIRC,STR)
EQUIVALENCE (WROCK,X0D)
EQUIVALENCE (MPI,MWJ)
EQUIVALENCE (LMPI,LMWJ)
DATA INIT /0/
DATA NFFDIN /0/
DATA IPRJ /0/
C
C INITIALIZATION
10 IF (DT CJET .EQ. 0.) DT CJET = 6.
IF (DTMJET .EQ. 0.) DTMJET = 2.
IF (IPRJ .EQ. 1 .AND. DJMWJM.EQ.0.) DJMWJM = 200.
IPRJ = 0
TMNT = 0.
TIMBT = DT CJET
MWJM=0
MWJM=1
INIT = 1
IF (NFFDIN .EQ. 0) GO TO 999
NFFDIN = 0
GO TO 200
ENTRY PRJMR
IPRJ = 1
GO TO 10
C
C NORMAL ENTRIES
ENTRY PRJMR
IPRJ = 1
ENTRY JETMR
IF (INIT .EQ. 1) GO TO 200
NFFDIN = 1
GO TO 10
C
C IS MAINTENANCE IN PROGRESS
200 IF (MWJM .EQ. 0) GO TO 400
C IS MAINTENANCE REQUIRED
TIMBT = TIMBT - DT
IF (TIMBT .GT. 0.) GO TO 999
C IS REPOSITIONING IN PROGRESS
IF (MWJR .EQ. 0) GO TO 999
LMWJM = 0
LMWJ = LMWJ + 1
GO TO 999
C
C UPDATE PROGRESS OF MAINTENANCE
400 TMNT = TMNT + DT
C IS IT COMPLETED
IF (TMNT .LT. DTMJET) GO TO 999
LMWJM = 1
LMWJ = LMWJ - 1
NOTE ** TO FORCE REPOSITIONING AFTER COMPLETION OF MAINTENANCE.
REPLACE STATEMENT #LMWJ = LMWJ-1# WITH #LMWJR=0# .
DJMRD = DJMWJM % DJMRD
TIMBT = DT CJET
TMNT = 0.
999 RETURN
END

```

EE. SUBROUTINE PROJTL

```

SUBROUTINE PROJTL
C
C ELEMENT - ROCK DISINTEGRATION
C GENERAL PROCESS - PROJECTILE FRAGMENTATION
C ACTIVITY - PROJECTILE IMPACT
C OR PROJECTILE FRAGMENTATION
C
COMMON/ALL/ XT,STR,IA,RQD,CS,TAMB,FLOW,IFLAG,AT,D,E,SK,T,DT,X,PR
1. XMAX,THAX,TD,XQ,XDISCH
COMMON/MONEY/ NJMRD
COMMON/NJET / ALT,CPRRL,CSTPRJ,DJMWJM,DNOZZ,DTJFT,DTMJFT,DTPJFT
1. ENERGI,ETAGN,ETAJ,ETAIMP,ETAIPT,MODEJ,NGUNS,NJETS,PNOZZ,PPM
2. PRJPM,PULSEQ,TR3RL,VOLPRJ,VFLPRJ,WPRJ,XRJET
COMMON/NEWCOM/ LNRARL,LMWJ,LMWJM,LMWJR, FHEATJ,QWATR,FOX
1. FDV
COMMON/OLDCOM/ NRARL,MWJ,MWJM,MWJR, HEATJ,QWATR,DX,DV
EQUIVALENC(WROCK,CS)
EQUIVALENC(SIGC,STR)
EQUIVALENC(MPI,MWJ)
EQUIVALENC(LWPI,LMWJ)
DATA INIT /0/
DATA NEEDIN /0/
DATA FACTA,FACTB,FACTC,FACTD,FACTE /500./
C
C INITIALIZE
10 IF (ETAGN .EQ. 0.) ETAGN = 0.3
IF (ETAIPT .EQ. 0.) ETAIPT = 0.2
C
C PROJECTILE ENERGY
IS CALL FOR INITIALIZATION ONLY
C
INIT = 1
IF (NEEDIN .EQ. 0) GO TO 999
NEEDIN = 0
GO TO 200
C
C NORMAL ENTRY
ENTRY PRJIMP
IF (INIT .EQ. 1) GO TO 200
NEEDIN = 1
GO TO 10
200 EPFT = WPRJ * VELPRJ * VELPRJ / 64.4
C
C PROJECTILE DENSITY
RHOP=1728.*WPRJ/VOLPRJ
C
C ROCK DENSITY
RHOR=WROCK
C
C ROCK FRAGMENTED PER PROJECTILE
XWRK = RHOP / RHOR
RMASS=1.63E-5*(SQRT(XWRK)*EPFT)**1.189
RVOLFT=RMASS/WROCK
C
C CONSTRUCT FACTORS USED FOR EACH TIME INCREMENT
IF (IFST .EQ. 1) GO TO 11
IFST=1
PRINT 111,EPFT,RHOP,RHOR
111 FORMAT(1X, 5EPFT=.E14.4,6H RHOP=.F14.4,6H RHOR=.E14.4)
PRINT 112,XWRK,RMASS,RVOLFT
112 FORMAT(1X, 6H XWRK=.E14.4,7H RMASS=.E14.4,8H RVOLFT=.E14.4)
C
C END OF DERUG
11 XWRK = PRJPM * 60.
FACTA = RVOLFT * NGUNS * XWRK
FACTB = 3.1415927 * D * D / 4.

```

```

FACTC = EPFT * NGUNS * XWRK * 3.766E-7 / ETAGN
FACTD = CSTRPJ * XWRK
FACTE = 3413.0 * (1 - ETAGN * ETAIPT)
FDV=0.
FDX = 0.
FHEATJ=0.
IF (MPI .GE. 1) GO TO 999
C      ROCK FRAGMENTED DURING DELTA-T
      FDV = FACTA * DT
      FOX = FDV / FACTR
C      POWER COSTS
      TOTKWH = FACTC * DT
      PCST = TOTKWH * PR
C      PROJECTILE COSTS
      PJCST = FACTD * DT
C      TOTAL COST
      DJMRD = DJMRD + PCST + PJCST
      FHEATJ=TOTKWH*FACTE
999 RETURN
END

```

FF. SUBROUTINE PRJBR

```

SUBROUTINE PRJBR
C
C ELEMENT - ROCK DISINTEGRATION
C GENERAL PROCESS - PROJECTILE FRAGMENTATION
C ACTIVITY - BARREL REPLACEMENT
C
COMMON/ALL/ AT,STR,TA,ROD,CS,TAMB,FLOW,IFLAG,AT,D,F,SK,T,RT,X,PR
1. XMAX,TMAX,TD,XD,XDISCH
COMMON/MONEY/ Q,MEQ
COMMON/NUJET / RTI,CPARL,CSTPRJ,DJWJM,DNOZZ,DTJFT,DTMJFT,DTJFT
1. ENFRQJ,FTJEN,ETAU,ETAIR,ETAIRP,MODEJ,NGUNS,NJETS,RNOZZ,PPM
2. PROJPM,PULSEQ,TPARL,VOLPRJ,VFLPHJ,WPRJ,XRJET
COMMON/NEWCOM/ LNPARL,LMWJ,LMWJM,LMWJR, HEATJ,OWATR,FDX
1. FOV
COMMON/OLDCOM/ NHARL,MWJ,MWJM,MWJR, HEATJ,OWATR,DX,DV
EQUIVALENCE (SIGD,STR)
EQUIVALENCE (INROCK,CS)
EQUIVALENCE (MPI,MWJ)
EQUIVALENCE (LMPI,LMWJ)
DATA TR /0./
DATA OPTIM /0./
DATA INIT /0/
DATA NEEDIN /0/
DATA TT,CFACT /2*0./
C
C INITIALIZE
10 IT = YPARL * NGUNS
    NPARL = 1
    CFACT = CPARL * NGUNS
    INIT = 1
    IF (NEEDIN .EQ. 0) GO TO 999
    NEEDIN = 0
    GO TO 200
C
C NORMAL ENTRY
ENTRY PRJBR
IF (INIT .EQ. 1) GO TO 200
NEEDIN = 1
GO TO 10
C
C IS BARREL REPLACEMENT IN PROGRESS
200 IF (NPARL .EQ. 0) GO TO 400
REPLACEMENT NOT IN PROGRESS. IS IT REQUIRED
C
OPTIM = OPTIM + DT
IF (OPTIM .LT. RL) GO TO 999
C
C IS REPOSITIONING IN PROGRESS
IF (MWJR .EQ. 0) GO TO 999
LNPARL = 0
LMPI = LMPI + 1
GO TO 999
C
C REPLACEMENT IN PROGRESS. UPDATE PROGRESS
400 TR = TR + DT
IF (TR .LT. TT) GO TO 999
REPLACEMENT COMPLETED
C
LNPARL = 1
LMPI = LMPI - 1
DUMRD = DJMRD + CFACT
TR = 0.
OPTIM = 0.
999 RETURN
END

```

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GG. SUBROUTINE MUKL0D

```

SUBROUTINE MUKL0D
C
C ELEMENT - MATERIALS HANDLING
C GENERAL PROCESS - MACHINE LOADERS + SHOVELS
C ACTIVITY - LOADING MUCK AT FACE
C
COMMON/ALL/ XT,STR,IA,R00,CS,TAMR,FLOW,IFLAG,AT,D,E,SK,T,DT,X,PR
1. XMAX,THAX,TO,X0,XDISCH
COMMON/WHEELS/ NCARS,MLTYP,OUIC,WUC
COMMON/CONVEY/ ACM,OTRS,DWM,FF,FL,HP,OC,SMIN,WPI.
1. WP,XLF,NSURGE,OE,OP,SM,OTCB,OTMR,AR,VRI,NFXON,NGEO,XE,LNSURG.
2. STIME,ODMR,DTMI,DTMO,FLM
COMMON/NEWCOM/ LMACON,LMCAPC,LNSPLC,LLOADR,FOL,LMKIN,LMUKOT,LNBYHY
1. LTSTAT(25,4),LKSTOP(25),LLVHCL,FOV
COMMON/OLDCOM/ MACON,MCAPC,NSPLIC,LOADR,QL,MKIN,MUKOT,NBYHY
1. LTSTAT(25,4),KSTOP(25),LVEHCL,DV
LVALENCE(LLOADR,LLOADR)
DATA TIMEL,DX,OUF,WUF,CSPERK /5*0./
DATA NCARS,INIT,NEEDIN /3*0/
C
C INITIALIZATION
100 IF (COMP .EQ. 0.) ODMR = 5400.
IF (STIME .EQ. 0.) STIME = .05
CSPERK = CS / (SK * 2000.)
INIT = 1
IF (NEEDIN .FO. 0) GO TO 900
NEEDIN = 0
GO TO 120
C
C NORMAL ENTRY
ENTRY LODMUK
IF (INIT.EQ. 1) GO TO 120
NEEDIN = 1
GO TO 100
120 IF (MLTYP .EQ. 2) GO TO 500
C
C UNITIZED MAIN LINE SYSTEM
IF (LVEHCL .FO. 0) GO TO 900
C
C A UNIT IS AVAILABLE FOR LOADING
FDV=DV
LLOADR = 0
IF (TIMEL .GT. 0.) GO TO 300
DD = ODMR * DT
130 XWRK=FDV*SK
IF (XWRK - DD .GE. 0.) GO TO 150
DD = XWRK
LLOADR = 1
FDV=0.
GO TO 160
150 FDV=FDV-(DD/SK)
C
C VOL * WEIGHT CAP OF UNIT NOW BEING FILLED
160 OUF = OUF + DD
WUF = WUF + (DD * CSPERK)
IF (OUC .GT. OUF .AND. WUC .GT. WUF) GO TO 900
C
C UNIT IS FILLED * CAN BE RELEASED
XWRK = OUF - OUC
FDV=FDV+XWRK/SK
OUF=0.
WUF=0.
TIMEL = XWRK / ODMR

```

```

C      GO TO 320                                UNITS ARE BEING SWITCHED
300  TIME1 = TIME1 + DT
320  IF (TIME1 .LT. STIME) GO TO 400
      DO = QDMR * (TIME1 - STIME)
      TIME1 = 0.
      IF (NCARS .EQ. 0) GO TO 350
      NCRS = NCRS + 1
      IF (NCRS .LE. NCARS) GO TO 130
      RELEASE VEHICLE.
C
350  I = LVSACL
      LYSTAT(I,1)=7
      LKSTOP(I)=5
      QUF = 0.
      WUF = 0.
      GO TO 130
C
CONTINUOUS MAIN LINE SYSTEM
500  DO = QDMR * DT
      NCRS=0
      LLOOP = 0
      XWRK = DV * CK
      IF (XWRK - DO .GE. 0.) GO TO 550
      DO = XWRK
      LLOOP = 1
      EDV=0.
      GO TO 600
550  EDV=DV-DO/CK
600  FOL=DO/DT
900  DIFF=QUF/1.7
      PRINT 199,NCRS,QUF,WUF
399  FORMAT(66X,17,2F10.2)
      RETURN
      END

```

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HH. SUBROUTINE MUKIN

```

SUBROUTINE MUKIN
C
C ELEMENT - MATERIALS HANDLING
C GENERAL PROCESS - MACHINE LOADERS + SHOVELS
C ACTIVITY - MOVE MUCKERS TO MUCK PILE
C
C ***CURRENTLY, THE CONTROL PROGRAM MUST SET MKIN TO 0 TO
C INITIATE MOVING IN.
COMMON/ALL/ XT,STP,IA,POD,CS,TAMH,FLOW,IFLAG,AT,D,F,SK,T,DT,X,PR
1. XMAX,TMAX,TO,XO,XDISCH
COMMON/HHEELS/ NCAPS,MLTYP,OC,WUC
COMMON/CONVEY/ ACM,DTBS,DWM,FF,FL,HP,OC,SMIN,WRI,
1 WP,XLF,NSURGE,RE,QR,SM,DTCS,DTMR,AR,VHI,NFXGN,NGFO,XF,LNSURG,
2 STINE,ODMR,DTMI,DTMO,FLM
COMMON/NEWCOM/ LMACON,MCAPC,LNSPLC,LLOADR,FOL,LMKIN,LMUKOT,LNRYHY
1,LTSTAT(25,4),LKSTOP(25),LLVHCL,FDV
COMMON/OLDCON/ MACON,MCAPC,NSPLIC,LOADR,QL,MKIN,MUKOT,NRYRY
1,ITSTAT(25,4),KSTOP(25),LVEHCL,DV
EQUIVALENCE (LLADR,LLOADR)
DATA INIT,NEEDIN /2*0/
DATA TIMIN /0./

C INITIALIZATION
100 IF (DTMI .EQ. 0.) DTMI = 1./12.
TIMIN = DTMI
INIT = 1
IF (NEEDIN .EQ. 0) GO TO 900
NEEDIN = 0
GO TO 200

C NORMAL ENTRY
ENTRY INMUK
IF (INIT .EQ. 1) GO TO 200
NEEDIN = 1
GO TO 100
200 IF (MKIN .NE. 0) GO TO 900
MUCKERS BEING MOVED TO MUCKPILE

C
TIMIN = TIMIN - DT
IF (TIMIN .GT. 0.) GO TO 900
LMKIN = 1
TIMIN = DTMI
900 RETURN
END

```

II. SUBROUTINE MUKOUT

```

SUBROUTINE MUKOUT
C
C ELEMENT = MATERIALS HANDLING
C GENERAL PROCESS = MACHINE LOADERS • SHOVELS
C ACTIVITY = MOVE MUCKERS AWAY FROM FACE
C
C ***CURRENTLY, THE CONTROL PROGRAM MUST SET MUKOT TO 0 TO
C INITIATE MOVING OUT.
COMMON//X,STR,IA,ROD,CS,TAMB,FLOW,IFLAG,AT,OE,SK,T,DT,Y,PR
1. XMAX,IMSK,TD,TD,XTSCH
COMMON//HVELS/ACARS,MLTP,POC,WHC
COMMON//CONVEY/ACM,DTPS,DWM,EE,FL,HP,OC,SHIN,WRT.
1. WP,XLF,NSURF,DE,DP,SM,DTOR,DTMR,AR,VRI,NE,AN,NGE,TF,LSURF.
2. STIME,COM,DTM,DTMO,FLM
COMMON//F,COM/ LMACO,LMCAPC,LSPLC,LLADR,FCL,LMKIN,LMUKOT,LMRYBY
1. LTSTAT(25,4),LKSTOP(25),LLVHCL,FDV
COMMON//OLCOM/ MACON,MCAPC,NSPLC,LOADR,OL,MKIN,MUKOT,MRBY
1. ITSTAT(25,4),KSTOP(25),LVEHCL,DV
EQUIVALENCE(LLADR,LLADR)
DATA INIT,NEFDIN /2*0/
DATA TIM /0./

C INITIALIZE
100 IF (DTMO .EQ. 0.) DTMO = 1./12.
TIM = DTMO
INIT = 1
IF (NEFDIN .EQ. 0) GO TO 900
NEFDIN = 0
GO TO 200

C NORMAL ENTRY
ENTRY OUTMJK
IF (INIT .EQ. 1) GO TO 200
NEFDIN = 1
GO TO 100
200 IF (MUKOT .NE. 0) GO TO 900
TIM = TIM - DT
IF (TIM .GT. 0.) GO TO 900
MUKOT = 1
TIM = DTMO
900 RETURN
END

```

JJ. SUBROUTINE TRUKHL

C
C
C
C
C

SUBROUTINE TRUKHL

ELEMENT - MATERIALS HANDLING
GENERAL PROCESS - TRUCK SYSTEM
ACTIVITY - LONG HAUL TRUCK TRANSPORT
TECHNIQUE - RUBBER-TIRED INDIVIDUAL DIESEL POWER TRUCK UNITS
(DUAL ROADWAY)

```

COMMON/ALL/ XT,STP,TA,RDD,CS,TAMB,FLOW,IFLAG,AT,D,F,SK,T,OT,X,PP
1. XMAX, Tmax, TD, XD, DISCH, OX, DV
COMMON/REFL/ AE, AF, AMAX, AMIN, HSL, CARCAP, CP, OF, OF, OTAS, OTMA, OTV
1. EL, FC, FR, FT, HPA, HPEA, HPEV, HPEV, HPV, ISW(25), LOCO, MC, ML, MLTYP
2. NCARS, YPOINT, NTD, NTRUCK, NTRUCK, NTRUCK, NUMLO, XP, NTRAIL, NTRAIL, NTRAIL
3. QUC, SL, STATUS(20), TOURX(20), TOURY(20), TRAIT, T, F, VD, VS, VE, VF
4. VMAX, WC, XL, XHY(24), WAP, WUC, XDS, AMAXL
COMMON/CONVEY/ AR, ACM, DMAINT, DTCH, DTHS, DTHA, DTMI, DTMO, DWW, EF, FL
1. HP, LNSURG, NEXON, NGEN, NSURGE, OC, OE, ODP, OP, SM, SM, STIME, VRI
2. WBI, WPE, XLF
COMMON/NEWCOM/ LIFILO, LKSTOP(25), LKUNLD, LLSTOP, LLVHCL, LNRYR
1. LNSWCH, LNTRDA, LNVHCL, LNMST, FSWTCH(20), FTFC(25), FTOP(25)
3. FTSTAT(25,4), FTIME(25), LLOADR
COMMON/OLDCOM/ IFILO, KSTOP(25), KUNLD, LSTOP, LVHCL, NRYR, NSWCH
1. NTRDA, NVEHCL, NIMSST, SWITCH(20), TFC(25), TOP(25), TSTAT(25,4)
2. UTIME(25), LLOADR
DIMENSION LTSTAT(25,4), ITSTAT(25,4)
EQUIVALENCE (COMOLD, IFILO), (COMNEW, LIFILO), (NVEHCL, NTRAIN, NTRUCK)
1. (LVHCL, LTRAIN, LTRUCK), (NTRDA, NTRDA)
2. (FTSTAT, LTSTAT), (ITSTAT, ITSTAT)
3. (LVHCL, LLTRAM, LLTRUK), (LNVHCL, LNTRAN, LNTRUK)
DIMENSION STATE(25,4)
DIMENSION ISTATE(25,4)
EQUIVALENCE (STATE, ISTATE)
DATA STATE /1000./
DIMENSION JSTOP(25)
DATA JSTOP /2500/
DIMENSION TEMS(25)
DIMENSION TEMT(25)
DATA INITSW, IPETSW /200/
DATA IOPTN /1/
EQUIVALENCE (TVE, VE)
DATA TEMS /2500./
DATA TEMT /2500./
DATA APMAX, TLIM, TLIMF, WCCI, WFC?, WFFAC1, WFFAC2, HPEVP /800./
DATA HPAFAC, HPAFAC, HPAFAC, WFFAC, FRFAC, FRWF, AEMAX /700./
DATA HPEVP, HPEFAH, HPEFAH, DINCP, CPFC, VEFT, VFFT, VDSQ, DELMAX /900./

```

C
C
C

PARAMETER INITIALIZATION

```

100 INITSW = 1
IF (INTRUCK .EQ. 0) NTRUCK = 1
ITSTAT(1,1) = 2
TSTAT(1,2) = 0.
TSTAT(1,3) = 0.
TSTAT(1,4) = 0.
DO 120 I=1,25
ISW(I) = 0
TEMT(I) = 0.
TEMS(I) = 0.
120 CONTINUE
IF (WE .EQ. 0.) GO TO 200
OPTION 2
C
IOPTN = 2
IF (FR .EQ. 0.) FR = 65.
IF (EL .EQ. 0.) EL = 0.85
IF (FT .EQ. 0.) FT = 0.36
IF (AF .EQ. 0.) AE = 99999.
IF (AF .EQ. 0.) AF = AE
HPAFAC = EL * 375.
HPAFAC = HPAFAC * HPA
HPVFAC = HPAFAC * HPV

```

```

WEFAC = WE * (1.35 * CARCAP)
FRFAC = FR * WEFAC
FRWF = FR * WE
AEMAX = AF
AFMAX = AF
XWRK = FT * 2000.
TLIM = XWRK * WE
TLIME = XWRK * WEFAC
WEC1 = WE / 39.4
WFC2 = 39.4 / WE
WFFAC1 = 39.4 / WEFAC
WFFAC2 = WEFAC / 39.4
XWRK = HRFAC / FRWF
IF (VE * (VF - XWRK) .GE. 0.) VF = XWRK
XWRK = HRFAC / FRFAC
IF (VF * (VF - XWRK) .GE. 0.) VF = XWRK
HPEVD = FRWF * VF / HRFAC
HPEVD = FRFAC * VF / HRFAC
GO TO 250

```

```

C                                     OPTION 1
200 CONTINUE
    HRFAC = HRFAC
    HPEVD = HPEVD

```

```

C                                     BOTH OPTIONS
250 DINCR = 50.
    IF (IDPTR .EQ. 2) GO TO 255
    XWRK = 2640. * VF * VF / DE
    IF (XWRK .LT. DINCR) DINCR = XWRK
    XWRK = 2640. * (VF * VF - VD * VD) / DF
    IF (XWRK .LT. DINCR) DINCR = XWRK
255 DELMAX = DINCR / (5280. * VE)
    IF (CP .EQ. 0.) CP = 0.14
    IF (FC .EQ. 0.) FC = 0.06
    CRFC = CP * FC
    VEFT = VF * 5280.
    VFT = VF * 5280.
    VSD = VD * VD
    PRINT 260, VF, VFT

```

```

260 FORMAT (12HTRUCK VF = ,F10.3,5H VF = ,F10.3)
C                                     WAS CALL FOR INITIALIZATION ONLY
    IF (IPETSW) 270,999,270
270 IPETSW = 0
    GO TO 350

```

```

C                                     NORMAL ENTRY
C

```

```

C ENTRY TRUCKR
C                                     HAS INITIALIZATION BEEN PERFORMED

```

```

    IF (INITSW) 350,320,350
320 IPETSW = 1
    GO TO 100
350 XWRK = (DT / DELMAX) * 1
    NITER = XWRK
    YWRK = NITER
    TFRAC = XWRK - YWRK

```

```

C                                     RETRIEVE /OLDWRK/ VARIABLES

```

```

    DO 355 J = 1,NTPTICK
    STATE(J,1) = TSTAT(J,1)
    STATE(J,2) = TSTAT(J,2)
    STATE(J,3) = TSTAT(J,3)
    STATE(J,4) = TSTAT(J,4)
    JSTOP(J) = KSTOP(J)
355 CONTINUE
    ISTOP = LSTOP
360 LLTPK = 0
    DELTAT = DELMAX
    IF (NITER .EQ. 1) DELTAT = TFRAC * DELMAX
    DT2640 = DELTAT * 2640.
    DTVEFT = DELTAT * VEFT

```

```

DTVFFT = DELTAT * VFFT
DTCPFC = DELTAT * CPFC
OTDAYS = DELTAT / 24.
IWRK = ISTOP * I
GO TO (500,400,450),IWRK
C          SYSTEM MUST BE SHUT DOWN
400 DO 420 J=I,NTRUCK
IF (JSTOP(J) .NE. 0) GO TO 420
IWRK = ISTATE(J,1)
IF ((IWRK-10) * (IWRK-11) .EQ. 0) GO TO 420
JSTOP(J) = 4
IF ((IWRK - 6)*(IWRK-7) .EQ. 0) GO TO 420
JWRK = (IWRK + 1) / 2
IWRK = IWRK / 2
ISTATE(J,1) = 7
IF (IWRK .EQ. JWRK) ISTATE(J,1) = 6
420 CONTINUE
GO TO 475
C          SYSTEM MUST BE BROUGHT UP
450 DO 470 J=I,NTRUCK
IF (JSTOP(J) .NE. 4) GO TO 470
JSTOP(J) = 0
JWRK = ISTATE(J,1)
IF (JWRK .EQ. 0) ISTATE(J,1) = 2
IF (JWRK .EQ. 1) ISTATE(J,1) = 3
470 CONTINUE
475 ISTOP = 0
C          APPLY DELTA-T TO ALL TRUCKS
500 DO 750 I = I,NTRUCK
DELTA = 0.
STATE(I,4) = STATE(I,4) + DTDAYS
ISTAT=INT(STATE(I,1))
TPOS = STATE(I,2)
TSPD = STATE(I,3)

C          CRASH CODING
ISTATO = ISTAT
OTPOS = TPOS
OTSPD = TSPD

C          END CRASH CODING
IJSTOP = JSTOP(I)
IFMSI = FMSI
TENTI = TENT(I)
IWRK=ISTAT*I
GO TO (510,750,550,570,590,610,630,650,750,750,750),IWRK
C          TRUCK IS EMPTY, AND HAS STOPPED
510 IF (IJSTOP .GT. 1) GO TO 750
C          TRUCK IS BEING LOADED
LTRUCK = 1
GO TO 750

C          TRUCK IS ACCELERATING EMPTY
550 IF (IOPTN - 1) 584,553,584
551 AFA = PPA - FRWE
IF (AFA .LT. 0.) AFA = 0.
AE = AFA * AFCP
IF (AE .GT. AEMAX) AE = AEMAX
IF (IDF .GT. 0.) GO TO 553
TENTI = TENTI + DELTAT
IFMSI = IFMSI + DT2640 * (AE * DELTAT + 2. * TSPD)
553 YI = AE * DELTAT
TPOS = TPOS + DT2640 * (YI + 2. * TSPD)
TSPD = TSPD + YI
IF (IOPTN .EQ. 2) HPEAH = (AE*WFCI+FRWF) * TSPD/HPFAC
IF (HPA .GT. 0. .AND. HPEAH .GT. HPA) HPEAH = HPA
DELTA = HPEAH
IF (TSPD - VF) 554,554,554
554 ISTAT = 4

```

```

      TSPD = VF
C      IS TRUCK APPROACHING FACE AREA
558 IF (IOPIN .EQ. 1) GO TO 560
      IF (DF .GT. 0.) GO TO 560
      IF (I. * TPOS .GT. X) ISTAT = 6
C      CRASH CODING NEEDED WHEN DE/DF = 0 FIXED
      GO TO 698
560 R = TSPD * TSPD * 2640. / DF
C      CRASH CODING
      XWRK = TPOS * R
      IF (XWRK .GT. X) ISTAT = 6
      IF (XWRK .GT. X .AND. ISTATO .EQ. 2) GO TO 698
C      END CRASH CODING
      GO TO 698
C      CRASH CODING
C      PREVENT TRUCK FROM CRASHING EMPTY
565 YLPPK = (DF * (DF * (X - OTPOS) + (2640. * TSPD * OTSPD))) / (2640. * (DF * 4E))
      IF (XWRK .LT. 0.) GO TO 698
      TSPDX = SQRT(XWRK)
      OTPP = (TSPDX - OTSPD) / AF
      TPOSX = OTPOS + (OTPP * 2640.) * (AF * OTPP + 2. * OTSPD)
      IF (TPOSX .LT. TPOS) GO TO 698
      DELTAC = HPA * TSPDX / TSPD
      OTPPP = DELTAT - OTPP
      YI = DE * OTPPP
      TPOS = TPOSX + (2640. * OTPPP) * (2. * TSPDX - YI)
      TSPD = TSPDX
      GO TO 632
C      END CRASH CODING
C      TRUCK IS ACCELERATING FULL
570 IF (IOPIN = 1) 574,572,584
571 AFA = HPA - FFFAC
      IF (AFA .LT. 0.) AFA = 0.
      AF = FFFAC + AFA
      IF (AF .GT. AFMAX) AF = AFMAX
      IF (DF .GT. 0.) GO TO 572
      TMTI = TMTI + DELTAT
      TMSI = TMSI + DTRND * (AF * DELTAT + 2. * TSPD)
572 YI = AF * DELTAT
      TPOS = TPOS - DELTAT * 2640. * (YI * 2. * TSPD)
      TSPD = TSPD * YI
      IF (IOPIN .EQ. 2) HFFAH = (AF * FFFAC + FFFAC) * TSPD / HFFAC
      IF (HPA .GT. 0. .AND. HFFAH .GT. HPA) HFFAH = HPA
      DELTAC = HFFAH
      IF (TSPD = VF) 574,574,574
574 ISTAT = 5
      TSPD = VF
C      IS TRUCK APPROACHING DISCHARGE POINT
578 IF (IOPIN .EQ. 1) GO TO 580
      IF (DF .GT. 0.) GO TO 580
      IF (X - TPOS .LT. TPOS) GO TO 698
C      CRASH CODING NEEDED WHEN DE/DF = 0 FIXED
      ISTAT = 7
      TMTI = TMTI * (TSPD - VD) / TSPD
      ISW(I) = 100
      GO TO 698
580 R = 2640. * (TSPD * TSPD - VDSD) / DF
      IF (TPOS .GT. R) GO TO 698
      ISTAT = 7
      ISW(I) = 100
C      CRASH CODING
      IF (TPOS .LT. R .AND. ISIATO .EQ. 3) GO TO 582
C      END CRASH CODING
      GO TO 698
C      CRASH CODING
C      PREVENT TRUCK FROM CRASHING FULL

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582 XWRK=(DF*(AF*OTPOS+2640.*OTSPD*OTSPD)+2640.*AF*VDSO) /
      (2640.*(DF*AF))
      IF (XWRK .LT. 1.) GO TO 698
      TSPDX = SQRT(XWRK)
      DTPP = (TSPDX - OTSPD) / AF
      TPOSX = OTPOS - (DTPP*2640.)*(AF*DTPP + 2.*OTSPD)
      IF (TPOSX .GT. OTPOS) GO TO 698
      DELTAC = MPFA * TSPDX / TSPD
      DTAPP = DELTAT - DTPP
      YI = DF * DTAPP
      TPOS = TPOSX - (2640. * DTAPP) * (1. * TSPDX - YI)
      TSPD = TSPDX
      GO TO 652
C      END CRASH CODING
584 RPA = TLIM
      IF (ISTAT .EQ. 3) RPA = TLINF
      IF (HRA .EQ. 0.) GO TO 585
      YI = RPA
      IF (TSPD .GT. 0.) YI = MPFAC / TSPD
      GO TO 589
585 IF (TSPD .GT. TCURVX(1)) GO TO 586
      YI = TCURVY(1)
      GO TO 589
586 DO 588 K=2,NPOINT
      XWRK = TCURVX(K)
      IF (XWRK .LT. TSPD) GO TO 588
      YWRK = TCURVY(K)
      YI = YWRK - ((XWRK-TSPD)*(YWRK-TCURVY(K-1))/(XWRK-TCURVX(K-1)))
      GO TO 589
588 CONTINUE
      YI = TCURVY(NPOINT)
589 CONTINUE
      IF (YI .LT. RPA) RPA=YI
      IF (ISTAT=2) S71,S51,S71
C      TRUCK EMPTY, GOING AT FULL SPEED
590 TPOS = TPOS + DTVEFT
      IF (INDTN .EQ. 1) HPEVP = HPEV
      DELTAC = HPEVP
      GO TO 55A
C      TRUCK FULL, GOING AT FULL SPEED
610 TPOS = TPOS - DTVEFT
      IF (INDTN .EQ. 1) HPEVP = HPEV
      DELTAC = HPEVP
      GO TO 578
C      TRUCK IS DECELERATING EMPTY
630 IF (DF .EQ. 0.) GO TO 636
      YI = DF * DELTAT
      TPOS = TPOS + DT2640 * (2.*TSPD-YI)
632 TSPD = TSPD - YI
      IF (TSPD .GT. 0.) GO TO 698
      ISTAT = 0
      TSPD = 0.
      TFM TI = 0.
      TFM SI = 0.
      IF (IJUSTOP=4) 640,698,640
C      RIMPULL OPTION 2
636 TFM TI = TFM TI - DELTAT
      IF (TFM TI .GT. 0.) GO TO 698
      ISTAT = 0
      TFM TI = 0.
      TSPD = 0.
      IF (IJUSTOP .NE. 4) GO TO 640
      TPOS = TPOS + TFM SI
      TFM SI = 0.
      GO TO 698
C      TRUCK IN LOADING AREA

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640 TPOS = X
    IJSTOP = 1
    TEMSI = 0.
    GO TO 698
C
                                TRUCK IS DECELERATING FULL
650 IF (DF .EQ. 0.) GO TO 654
    Y1 = DF * DELTAT
    TPOS = TPOS - DT2640 * (2.*TSPD - Y1)
652 TSPD = TSPD - Y1
    IF (TSPD .LE. 0.) GO TO 658
    IF (ISW(I) .EQ. 100 .AND. TPOS .LE. 0.) GO TO 660
    GO TO 698
C
                                RIMPULL OPTION 2
654 TFMTI = TEMTI - DELTAT
    IF (TEMTI .GT. 0.) GO TO 698
    IF (IJSTOP .EQ. 4) TPOS = TPOS + TEMSI
    IF (ISW(I) .EQ. 100) GO TO 660
658 ISTAT = 1
    TSPD = 0.
    GO TO 662
660 ISW(I) = 0
    ISTAT = 10
    TSPD = VD
    TPOS = 0.
662 TEMTI = 0.
    TEMSI = 0.
698 STATE(I,1)=ISTAT
    STATE(I,2) = TPOS
    STATE(I,3) = TSPD
    JSTOP(I) = IJSTOP
    TFMS(I) = TEMSI
    TEMT(I) = TEMTI
C
                                DEBUG PRINT
C
    IF (ISTATO .LT. 2 .OR. ISTATO .GT. 3) GO TO 700
C
                                FND OF DEBUG PRINT
700 DJMMH = DJMMH + (DELTAC * DTCPEC)
750 CONTINUE
C
C
C
                                IS ANOTHER ITERATION REQUIRED FOR THIS DT
C
    NITER = NITER - 1
    IF (NITER) 900,900,360
C
                                UPDATE /NEWWRK/
900 DO 920 J=1,NTRUCK
    FTSTAT(J,1)=STATE(J,1)
    FTSTAT(J,2) = STATE(J,2)
    FTSTAT(J,3) = STATE(J,3)
    FTSTAT(J,4) = STATE(J,4)
    LKSTOP(J) = JSTOP(J)
920 CONTINUE
    LLSTOP = ISTOP
999 RETURN
    END

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KK. SUBROUTINE TRNPRT(ICYCLE)

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SUBROUTINE TRNPRT(ICYCLE)
C
C ELEMENT - MATERIALS HANDLING
C GENERAL PROCESS - CONVEYOR
C ACTIVITY - LONG HAUL MUCK TRANSPORT
C TECHNIQUE - TROUGH BELT CONVEYOR
C
000003 COMMON/ALL/ XT,STR,IA,RQD,CS,TAMB,FLOW,IFLAG,AT,D,E,SK,T,DT,X,PR
1, XMAX,TMAX,TO,XO,XDISCH,DX
000003 COMMON/MONEY/ DJMMH
000003 COMMON/CONVEY/ ACM,DTBS,DWM,EE,FL,HP,QC,SMIN,WBI,
1 WP,XLF,NSURGE,QE,QP, DTCB,DTMB,AB,VBI,NEXON,NGEO,XE,LNSURG,
2 STIME,QDMR,DTMI,DTMO,FLM,DMAINT
000003 COMMON/NEWCOM/ LMACON,LMCAPC,LNSPLC,LLOADR,FQL,LMKIN,LMUKOT,LNRYRY
000003 COMMON/OLDCOM/ MACON,MCAPC,NSPLIC,LOADR,QL,MKIN,MUKOT,NBYRY
000003 EQUIVALENCE (PR,PC),(XDE,XE)
000003 REAL LIR, LRP, LAM
000003 DIMENSION YKY(3)
000003 DIMENSION WB(11), VB(11), XIIR(11), XIRR(11), PLIES (11),QB(11)
000003 DATA XIIR/5., 4.5,4.,4.,4.,3.5,3.5,3.5,3.,3.,3./
000003 DATA XIRR/10.,10.,10.,10.,10.,10.,10.,10.,10.,8.,8./
000003 DATA PLIES/3.,4.,5.,6.,7.,8.,9.,10.,12.,12.,12./
000003 DATA QB/4., 4.5,5.7, 7.2, 9.6, 11.5, 14.2, 16.9, 19.4, 21.8, 24.3/
000003 DATA WB/18.,20.,24.,30.,36.,42.,48.,54.,60.,66.,72./
000003 DATA VB/300.,350.,400.,450.,500.,550.,600.,600.,600.,600.,600./
000003 DATA WPCOMP,AC,LIR,LRR,LAM,WR,X1 /7*0./
000003 DATA YKY /3*0./
000003 DATA ARG1,ARG2,ARG3,ARG4,HPS /5*0./
000003 DATA LIMIT,N,II,I /4*0/
C
000003 DETERMINE BELT CAPACITY
000006 IF (ICYCLE .GT. 1) GO TO 110
000006 ICYCLE=5
000006 IF (VBI .LE. 0.0) GO TO 20
C
000010 OPTION 1
000014 WPCOMP = 60./2000. * AB * VBI * CS/SK
000015 QP = 60.*AB*VBI
000015 DO 10 I=1,11
000017 IF (WBI .NE. WB(I)) GO TO 10
000021 II=I
000022 GO TO 90
000023 10 CONTINUE
000025 PRINT 11,WBI
000033 11 FORMAT ( 13H BELT WIDTH = ,F10.2, 15H IS NOT IN LIST)
000033 STOP
C
000035 DESIGN CONVEYOR OPTION 2
20 DO 30 I = 1, 11
C
C SOLVE FOR WPCOMP (EST. PEAK TONNAGE COMPUTED) THAT MATCHES OR IS
C GREATER THAN WP (EST. PEAK TONNAGE INPUTTED)
000040 AB= (1./144.)*(0.1247*WB(I)*WB(I) - 0.8245*WB(I) +1.311)
000046 WPCOMP=60./2000.*AB*VB(I)*CS/SK
000053 IF (WPCOMP .LT. WP) GO TO 30
000055 II=1
000057 VBI=VB(I)
000060 WBI=WB(I)
000062 QP=60.*AB*VBI
000064 GO TO 50
000065 30 CONTINUE

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35 PRINT 40
40 FORMAT (100H CONVEYOR DESIGN CAN NOT BE FOUND FOR GIVEN PEAK TONAG
IE AND MAXIMUM TOTAL CROSS SECTION OF STRUCTURE)
STOP
C CHECK FOR MAX. TOTAL CROSS SECTION OF CONVEYOR STRUCTURE
50 AC=10.44*.357*AR1+.00203*WR1*WR1+.000414*WR1*BI*WR1
IF (AC.GT. ACM) GO TO 35
C SELECT IMFLER ROLLER AND ROLLER SPACING
C II IS THE SUBSCRIPT OF THE BELT WIDTH BEING USED
90 LIP = X112 (II)
LRR=X112(II)
LAM = .00048*(DR(II)+100.*AR)*2.13/LIP+.035*DR(II)
1 .2.*AR
IF (XLF.NE. 0.) GO TO 110
XLF = PLIES(II) * 55.*AR/(1.62*LAM) - 500./LAM
C COMPARE CONVEYOR CAPACITY WITH THAT REQUIRED FOR GIVEN ADVANCE RATE
C COMPUTE REQUIRED CAPACITY
110 WP=(1./2000.)*PL*CS/SA
PRINT 200,WP,COMP,WR
200 FORMAT(60A,2F10.2)
IF (WP,COMP-WR) 130,120,125
120 LMCAPC = 0
GO TO 160
125 LMCAPC = 0
GO TO 150
C CAPACITY OF CONVEYOR EXCEEDED
C IS THERE A SURGE BIN TO HOLD EXCESS MUCK
130 IF (NSURGE.NE. 1) GO TO 140
C CASE 1 - NO SURGE BIN
C TURN OFF EXCAVATOR ON NEXT CYCLE
LMCAPC = 1
134 PRINT 135, X10T,WP,WP,COMP,WR1,VR1,AR
135 FORMAT (33H100 CONVEYER CAPACITY EXCEEDED AT X=. F10.2,10H AND TIME=.
1 F10.2/10X,12H TON/HR TO/HR AND LMD =. F10.3/10X,10H TON/HR PROVIDED=.
2 F10.2/10X,12H BELT WIDTH=. F10.3/10X,12H BELT SPEED=.F10.2/
310X,20H FLOW CROSS SECTION=.F10.2/)
GO TO 150
C CASE 2 - SURGE BIN HAS BEEN PROVIDED
140 DE = (DL - DR) * DT
CALL SURGE
IF (LNSURGE.NE. 1) GO TO 150
C IF CAPACITY HAS BEEN EXCEEDED THEN STOP EXCAVATOR IN NEXT CYCLE
LMCAPC = 1
GO TO 134
C FOR A SYSTEM CONTAINING A SURGE BIN IT MAY BE NECESSARY TO
C SUBTRACT MUCK FROM THE BIN WHEN WPCOMP IS GREATER THAN WR
150 DE=(DR-DR1)*DT
CALL SURGE2
C MOTOR SHAFT HORSEPOWER
C FOR OPTION 2 - HP MUST BE DERIVED
160 IF (HP.GT.0.0) GO TO 160
N=X/XLF
C THERE ARE TWO EQUATIONS FOR HP, ONE FOR N=0, ONE FOR N GREATER
C THAN 0.
C XI IS THE LAMBDA (FT) WHICH IS DESCRIBED IN THE VBITRUP. IT CAN
C BE X, XLF, OR X-XLF. FOR XI=X, I IS SET TO 1. FOR XI=XLF,
C I IS SET TO 2. FOR XI=X-XLF, I IS SET TO 3. YKY IS KY IN THE
C DOCUMENTATION.

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IF (N.GT.0) GO TO 157
I=1
LIMIT=2
X1=X
GO TO 159
157 LIMIT=1
I=2
X1=X-LF
GO TO 159
158 LIMIT=2
I=3
X1=X-XLF
159 IF (X1 .GT. 100.) GO TO 161
YKY(I)= .035
GO TO 161
161 IF (X1 .GT. 1000.) GO TO 162
YKY(I)=.032
GO TO 162
162 IF (X1.GT. 1400.) GO TO 163
YKY(I)= .030
GO TO 163
163 IF (X1 .GT. 2000.) GO TO 164
YKY(I)= .024
GO TO 164
164 IF (X1 .GT. 2500.) GO TO 165
YKY(I)= .020
GO TO 165
165 IF (X1 .GT. 3000.) GO TO 166
YKY(I)= .019
GO TO 166
166 YKY(I)= .018
168 IF (LIMIT .NE. 2) GO TO 158
ARG1 = VRI/17700.
ARG2= .00048* (OR(1)) *100. *A9) *2.13/LIR
ARG3=PCOMP/220.
ARG4= ARG1*550.
IF (N .GT. 0) GO TO 170
MPS=X*ARG1*(ARG2*(YKY(1)*.015)*OR(1))+ARG3*YKY(1)*X*ARG4
GO TO 175
170 MPS= N*(XLF*ARG1*(ARG2*(YKY(2)*.015) *OR(1)) + YKY(2)*
1 ARG3*XLF * ARG4) +
2 (X-N*XLF)*ARG1*(ARG2*(YKY(3)* .015)*OR(1)) + YKY(3)*
3 (X-N*XLF)*ARG3*ARG4
C OPTION 2 - E MAY BE SPECIFIED
IF (FE .LE. 0.0) FE=0.76
175 DJMMH=PC*MPS*0.746*DT/EE *DJMMH
RETURN
C OPTION 1 - MD AND E MUST BE SPECIFIED
180 IF (FE.LE. 0.)FE=0.76
DJMMH= PC*MD*X*0.746*DT/EE *DJMMH
RETURN
END

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LL. SUBROUTINE EXTNSN(ICYCLE)

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SUBROUTINE EXTNSN(ICYCLE)
C
C ELEMENT - MATERIALS HANDLING
C GENERAL PROCESS - LONG HAUL CONVEYOR BELT
C ACTIVITY - EXTENSION OF THE BELT
C
000003 COMMON/ALL/ XT,STR,IA,RQD,CS,TAMB,FLOW,IFLAG,AT,D,E,SK,T,DT,X,PR
000003 1, XMAX,TMAX,TO,XO,XDISCH,DX
000003 COMMON/MONEY/ DJMMH
000003 COMMON/CONVEY/ ACM,DTRS,DWM,EF,FL,HP,QC,SMIN,WRI,
000003 1 WP,XLF,NSURGE,QE,OP, DTCR,DTMR,AR,VRI,NEXON,NGEO,XE,LNSURG,
000003 2 STIME,QDMR,DTMI,DTMO,FLM,DMAINT
000003 COMMON/NEWCOM/ LMACON,LMCAPC,LNSPLC,LLOADR,FOL,LMKIN,LMUKOT,LNRYBY
000003 1, FSM
000003 COMMON/OLDCOM/ MACON,MCAPC,NSPLIC,LOADR,QL,MKIN,MUKOT,NRYBY,SM
000003 DATA T/0./,DTE2/0./,DTRS2/0./
000003 DATA DTE /0./
000003 DATA FLA,FLS,S /3*0./
000003 IF (ICYCLE .GT.1) GO TO 30
000006 ICYCLE = 5
000006 GO TO (1,2,3),NGEO
C GEOMETRY 1 - ASSUME FLA EXTENDS THE FULL LENGTH OF CONVEYOR
000015 1 FLA = FL
000016 FLS = 0.
000017 X = FL
000021 GO TO 10
C GEOMETRY 2 - ASSUME FEEDER CONVEYOR EXTENSION IS SMALL (FL=0)
C AND EMPTIES INTO SHAFT DIRECTLY
000021 2 FLA = 0.
000022 FLS = 0.
000023 GO TO 10
C GEOMETRY 3
000023 3 FLS = 0.
000024 SM = SMIN
C DETERMINE CONVEYOR STRUCTURE EXTENSION PARAMETERS
C OPTION1 - XE,DTRS INPUT
C OPTION 2 - XF = F (WB,LIR)
C OPTION 2 - DTRS =
000026 10 CONTINUE
C NORMAL ENTRY POINT AFTER FIRST CALL - INCREMENT DT
C IS EXTENSION SHUT DOWN
000026 30 IF (NEXON .EQ. 1) RETURN
C BELT SPLICE OR STRUC. EXTENSION
000031 PRINT 501,FLA,FLS
000041 501 FORMAT(96X,2F10.2)
000041 IF(NSPLIC .EQ. 0) GO TO 31
000043 IF(LNSURG .EQ. 1) GO TO 112
000045 GO TO 122
C CONVEYOR STRUCTURE ONLY
000046 31 IF (NGEO .NE. 3) GO TO 40
C GEOMETRY 3 - CYCLIC OPER.
000050 IF (DTE .NE. 0.0) GO TO 32
000051 DTE = DX/XE
000053 32 DTE = DTE - DT
C UPDATE CONVEYOR STR. COMPLETED
000055 FLS = FLS + DX
000057 IF (DTE .GT. 0.) GO TO 33

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LNRYRY = 0
DTE = 0.
GO TO 100
33 LNRYRY = 1
GO TO 100
C GEMDFTRY 1 + 2 - CONTINUOUS OPERATIONS
C CONVEYOR STRUCT. COMPLETED IN DT
40 FLS = FLS + XE*DT
C AVAILABLE CONVEYOR AFTER DT
IF (NGEO .NE. 1) GO TO 45
FLA = FLA - DX
GO TO 60
45 FLA = 0.
FL = FL + DX
C CHECK TO SEE IF CONVEYOR EXTENSION HAS CAUGHT UP TO EXCAVATOR
60 S = FL - FLS - FLA
IF (S .GT. 0.) GO TO 80
C CONVEYOR EXTENSION HAS CAUGHT UP. LET ADVANCE OF CONVEYOR
C EQUAL EXCAVATOR FOR THIS DT.
FLS = FLS - DT*XE + DX
GO TO 100
C CHECK TO SEE IF FEEDER RUNAWAY TOLERANCE IS EXCEEDED
80 IF (S .GE. SM) GO TO 90
LNRYRY = 0
GO TO 100
C EXCEEDED - THEREFORE TURN OFF EXCAVATOR NEXT DT
90 LNRYRY = 1
C CHECK TO SEE IF BELT SPLICE NEEDED
100 GO TO (105,106,107). NGEO
C BELT SPLICE NOT NEEDED
101 LNSPLC = 0
RETURN
105 IF (FLA .GT. 0.) GO TO 101
GO TO 109
106 IF (FL .LT. FLM) GO TO 101
GO TO 109
107 IF (S .LT. SM) GO TO 101
SPLICE NEEDED
C
109 LNSPLC = 1
IF (NSURGE .EQ. 1) GO TO 118
IF (NGEO .EQ. 3) GO TO 111
C ARE THERE SURGE BINS TO HOLD MUCK DURING SPLICE
C CASE 1 - NO SURGE BINS (NSURGE = 0)
C LET CONVEYOR STRUCTURE CATCH UP TO EXCAVATOR AND SPLICE BELT
110 DTE = (FL - FLA - FLS) / XE + DTR
GO TO 112
111 DTE = DTR
C TURN OFF EXCAVATOR UNTIL THIS IS COMPLETED
112 DTE2 = DTE + DT
IF (DTE2 .GE. DTE) GO TO 113
LNSPLC = 1
RETURN
C SPLICE COMPLETED - REINITIALIZE
113 LNSPLC = 0
GO TO (114,115,116). NGEO
114 FLA = 0.
DTE2 = 0.
RETURN

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```

115 FL = 0.
    DTF2 = 0.
    RETURN
116 FSW = SWIN
    DTF2 = 0.
    FLS = 0.
    RETURN
C   CASE 2 - SURGE BIN HAS BEEN PROVIDED - (NSURGE = 1)
11A QF = (CL - QP) * DT
    CALL SURGE
    IF (LNSURGE .EQ. 1) GO TO 130
    IF (DTRSP .NE. 0.) GO TO 122
    DTRSP = DTPS
122 DTRSP = DTRSP - DT
    LNSURGE = 0
    IF (DTRSP .GT. 0.) RETURN
C   SPLICE COMPLETED - REINITIALIZE
    GO TO (123,124,125) ,NGEO
123 FL = FLS
    RETURN
124 FL = FL - FLS
    RETURN
125 FSW = SWIN
    FLS = 0.
    RETURN
C   IF SUBROUTINE SURGE RETURNS WITH A FLAG INDICATING CAPACITY
C   OF SURGE BIN HAS BEEN EXCEEDED (LNSURGE=1) DURING DT, THEN TREAT
C   AS IF THERE IS NO SURGE BIN
130 DTRSP = DTRSP
    GO TO ( 115,110,111 ), NGEO
    END

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MM. SUBROUTINE SURGE

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SUBROUTINE SURGE
TWO ENTRY POINTS INTO THIS SUBROUTINE
ENTRY SURGE - TO PUT MUCK INTO BIN
ENTRY SURGE2 - TO TAKE MUCKOUT

ELEMENT - MATERIALS HANDLING
GENERAL PROCESS - LONG HAUL CONVEYOR BELT
ACTIVITY - LOADING EXCESS MUCK INTO SURGE BIN OR UNLOADING FROM BIN

COMMON/ALL/ XT,STR,IA,PDD,CS,TAMR,FLOW,IFLAG,AT,D,F,SK,T,DT,X,PR
1. XMAX,TMAX,TD,XD,XDISCH,DX
COMMON/MONEY/ DUMM4
COMMON/CONVEY/ ACM,DTR5,D,M,FF,FL,HP,OC,SMIN,WPI.
1 WP,XLF,NSURGE,OE,OP, DTCH,DTHR,AR,VRI,NFCON,NGEO,XE,LNSURG.
2 STIME,ODMR,DTMI,DTMO,FLM,DMANT
COMMON/NERCOM/ LMACON,LMCAPC,LNSPLC,LLOADR,FOL,LKIN,LWUKOT,LHRYAY
COMMON/OLDCOM/ MACON,MCAPC,NSPLC,LOADR,OL,MKIN,MUKOT,HRYAY
EQUIVALENCE (PR,PC),(XDE,XE)
DATA 0/0./
C ENTRY SURGE
IF (LNSURG .EQ. 1) RETURN
Q=0-QE
IF (Q .GT. OC) GO TO 10
LNSURG = 0
RETURN
10 LNSURG = 1
RETURN
C ENTRY SURGE2
Q=0-QE
IF (Q .GT. 0.) RETURN
Q= 0.0
RETURN
END

```

NN. SUBROUTINE BELT(ICYCLE)

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SUBROUTINE BELT(ICYCLE)
C
C ELEMENT - MATERIALS HANDLING
C GENERAL PROCESS - LONG HAUL CONVEYOR BELT
C ACTIVITY - MAINTENANCE OF BELT
C
000003 COMMON/ALL/ XT,STR,IA,RQD,CS,TAMB,FLOW,IFLAG,AT,D,E,SK,T,DT,X,PR
1, XMAX,TMAX,TO,XO,XDISCH,DX
000003 COMMON/MONEY/ DJMMH
000003 COMMON/CONVEY/ ACM,DTBS,DWM,EE,FL,HP,QC,SMIN,WBI,
1 WP,XLF,NSURGE,QE,QP, DTCB,DTMR,AB,VBI,NEXON,NGEO,XE,LNSURG,
2 STIME,QDMR,DTMI,DTMO,FLM,DMAINT
000003 COMMON/NEWCOM/ LMACON,LMCAPC,LNSPLC,LLOADR,FQL,LMKIN,LMUKOT,LNBYBY
000003 COMMON/OLDCOM/ MACON,MCAPC,NSPLIC,LOADR,QL,MKIN,MUKOT,NBYRY
000003 EQUIVALENCE (PR,PC),(XDE,XE)
000003 DATA PI/3.141592/
000003 DATA W,TM,T /3*0./
C INITIALIZE PARAMETERS
000003 IF (ICYCLE .NE. 1) GO TO 10
000005 ICYCLE = 10
000006 W=0.
C DWM MUST HAVE A DEFAULT VALUE SPECIFIED. SET=1. FOR COMPILATION
000006 IF (DWM .LE. 0.) DWM=1.
000011 TM=0.
000012 TT=DTMR
000014 10 IF (MACON .EQ. 1) GO TO 30
000016 IF(DTCB .EQ. 0.) GO TO 20
000017 TM = TM + DT
000021 IF(DTCB .GT. TM) GO TO 15
000024 LMACON = 1
000025 TM = 0.
000025 GO TO 30
000026 15 LMACON = 0
000027 RETURN
C TONAGE OF MUCK CRITERIA SPECIFIED
000030 20 W=(PI*D*D/4.)/2000. *CS *DX *W
000037 IF (W .GE. DWM) GO TO 25
000041 LMACON = 0
000042 RETURN
000042 25 LMACON = 1
000043 W = 0.
C TIMEKEEPER ON MAINTENANCE
000044 30 TT=TT-DT
000046 IF(TT .LE. 0) GO TO 40
000047 LMACON = 1
000050 RETURN
000051 40 LMACON = 0
C DMAINT NEEDS A VALUE IF IT HAS NOT BEEN SPECIFIED,
C DMAINT SET =1. FOR COMPILATION
000052 IF (DMAINT .LE. 0.) DMAINT =1.
000055 DJMMH = DJMMH + DMAINT
000057 RETURN
000057 END

```

*FOLLOWING VARIABLES EQUIVALENCED BUT NOT REFERENCED

PC
XE
PR

00. SUBROUTINE XXXMNT (General Maintenance Routine to Be Adapted by User
for Specific Processes)

```

SUBROUTINE XXXMNT
C
C ELEMENT -
C GENERAL PROCESS -
C ACTIVITY - GENERAL MAINTENANCE • REPAIR
C
COMMON /
DATA TRFT, TMNT /2*0./
DATA INIT, NEEDIN /2*0./
C
C EQUIVALENCE FOR SPECIFIC GENERAL PROCESS
C
EQUIVALENCE (GOTC, )
EQUIVALENCE (GDTM, )
EQUIVALENCE (GOJM, )
EQUIVALENCE (DJMGP, )
EQUIVALENCE (MMNT, )
EQUIVALENCE (LMMNT, )
EQUIVALENCE (LMFLAG, )
EQUIVALENCE (LMFLAG, )
C
C
C INITIALIZATION
C
10 TRFT = GOTC
MMNT = 1
IF (GOTC .EQ. 0.) GOTC =
IF (GDTM .EQ. 0.) GDTM =
IF (GOJM = 0.) GOJM =
INIT = 1
IF (NEEDIN = 0) GO TO 999
NEEDIN = 0
GO TO 200
C
C NORMAL ENTRY
C
ENTRY XXXRPR
IF (INIT .EQ. 1) GO TO 200
NEEDIN = 1
GO TO 10
C
C IS MAINTENANCE IN PROGRESS
C
200 IF (MMNT .EQ. 0) GO TO 400
IS MAINTENANCE REQUIRED
C
TRFT = TRFT - DT
IF (TRFT .GT. 0.) GO TO 999
DOES ANY OTHER SITUATION EXIST SUCH THAT MAINTENANCE SHOULD
NOT BE PERMITTED. IF SO, GO TO 999
C
LMMNT = 0
LMFLAG = LMFLAG + 1
GO TO 999
C
C UPDATE PROGRESS OF MAINTENANCE
C
400 TMNT = TMNT + OT
IS MAINTENANCE COMPLETED
C
IF (TMNT .LT. GDTM) GO TO 999
DJMGP = DJMGP + GOJM
TRFT = GOTC
TMNT = 0.
LMMNT = 1
LMFLAG = LMFLAG - 1
999 RETURN
C
NOTE -- CHECK TESTING OF MFLAG IN RELATED SUBROUTINES
END

```