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THESIS

AN ON-LINE SIMULATION OF ASW IN A
MULTI-BURST NUCLEAR ENVIRONMENT

by

David Lee McMichael

May 1966

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AN ON-LINE SIMULATION OF ASW IN A MULTI-BURST NUCLEAR ENVIRONMENT

by

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Submitted in partial fulfillment
for the degree of

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from the

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May 1966

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ABSTRACT

A general approach is documented as a guide to aid in the formulation and implementation of on-line, real time computer simulations. A computer program MULNUC1, is developed as an on-line, real time computer simulation of antisubmarine warfare in a multiple burst nuclear environment. The principals of the game are a submarine armed with torpedoes, and two destroyers equipped with stand-off antisubmarine weapons. The simulation is intended as a demonstration of the on-line capabilities of the United States Naval Postgraduate School computer system and as a tool for further study of the factors involved in a representative ASW operational environment.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

1. INTRODUCTION

Simulation is a useful tool of the operations analyst. This is not a new concept, the first recorded simulations were conducted by the Chinese in the form of "war chess" and were probably used to teach young men some of the concepts of battle without the inherent danger of loss of life. Later accounts of simulations have been recorded by the Prussians, French and Germans [7].

This technique of analyzing a problem by simulation is now employed by all branches of the scientific community. The present day high speed digital computer has given rise to a rapid expansion in the use of simulation as a method of solution to military, scientific, management and many other types of problems.

Convincing the reader or observer that a simulation "models the real world" is one of the primary problems confronting the analyst who uses simulation techniques in the solution of a problem. One way to minimize this doubt is to increase the role of the human in the simulation. This can, in many cases, be done by the techniques of on-line simulation. While on the one hand, on-line simulation increases the complexity of the problem by nature of the man machine interface, at the same time, on-line simulation adds very complex logic (the man) to the problem with minimal effort on the part of the designer.

The design of a simulation, and in particular an on-line simulation, can appear to be a formidable task when first considered. However, if the designer has an approach in mind and proceeds in an organized manner, the problem usually divides into small parts that are each relatively simple. It is the aim of this thesis to take a representative problem and develop a computer simulation that can be used as a reference for the construction of on-line, real time, computer simulations in general.

2. FORMULATION OF ON-LINE SIMULATIONS

In the formulation of on-line simulations the designer must first lay down a good foundation in the form of a well-planned outline. This outline must begin by initializing and setting the scene for the simulation. When this has been accomplished the designer must turn his attention to the development of a loop that will include all the actions and interactions expected to occur in the simulation. Included as an integral part of this loop is a timing mechanism that is flexible enough to allow the simulation to proceed at any rate required. A third part of the formulation is concerned with providing a critique of the simulation, either as a running critique or a compilation of pertinent facts at the end of the simulation.

INITIALIZING

Initializing is the term applied to that portion of the simulation which is executed before "play" begins. It includes data input, assignment of particular values to the parameters and entering starting values required for indexing the logic. Herein is provided the flecibility required of any useful simulation. In the initializing portion the ground work must be formed for performing sensitivity analysis if such analysis is required. The initializing portion of the simulation must allow enough flexibility to provide for the various scenarios possible in the particular simulation. Clearly then, the initializing portion must be designed with these purposes as primary criteria and subject to boundary conditions, such as equipment capabilities.

AN ITERATIVE LOOP

In general, many on-line simulations contain an iterative loop that is cycled for each time period. Therefore, one of the first considerations to be made in this phase of the design is the determination of the stepping interval. Several factors are involved in this selection, the most important being the assurance that the stepping interval is compatible with the logic flow of the situation being simulated. The designer must then consider the amount of time required to accomplish the most complicated simulation situation that can occur in one cycle. These considerations complete, the simulator must insure that the cycling is such that the player is not bored with the data/action as presented and also that this data/action is not presented at a rate too rapid for the player to fully comprehend. With these considerations in mind, a tentative looping cycle can be constructed and the designer may continue to develop the necessary routines required to complete the iterative loop.

The loop should now be fashioned in its most elementary form. The designer must consider several tasks that must be accomplished during each cycle. These include, for example, advancing all participants one time cycle, consideration of the possible interactions that can occur due to these moves, tabulation of the results of such interactions, presentation of output to the player, permitting the player to communicate with the simulation, delaying the next cycle until the proper time interval has transpired, and possible other considerations dependent upon the particular simulation.

Care and planning must be exercised in the construction of this loop since this is the foundation upon which the designer is to build his simulation. If logical errors appear in the order of these routines or a component is not considered in this loop, the remaining portion of the design will be difficult, if not impossible. Planning in this portion of the development will be time well spent.

THE CRITIQUE

The critique is that portion of the simulation in which the entire simulation, or any integral part, is analyzed and the results compiled in condensed form. There are several basic techniques that may be explored in this part of the simulation. The least complex of which is, in most cases, a complete "recording" of the game that can be "replayed" at a later time at any speed desired. A more complex approach to the problem of performing a critique of a simulation is that of including a recording/analysing routine in the iterative loop. This routine would extract the desired information during each cycle of the loop. It is apparent that not every cycle need be recorded, and therefore, a decision logic must be included that will extract all necessary information. Associated with this technique must be a recording routine that can be queried at intervals or at the conclusion of the simulation.

Much care must be exercised in formulating the design and location of the critique routine since this is the major mode of analysis available to the analyst. Flexibility and adaptability are considerations that must be made to allow the simulation to be fully appreciated as an analytical tool and not just a "parlor game."

3. PROGRAM MODULARIZATION

In general, programmers attempt to modularize their programs. There are several reasons for this, the most obvious being that of providing logical grouping of ideas. The large scale simulation is usually modularized by the use of subroutines. This use of subroutines is convenient because:

a. Several separate groups may be working on various sections of the problem, and in many instances the use of subroutines is the best technique.

b. Computations which are to be called upon several times in the main program are best handled by the use of subroutines.

c. The program may be of a magnitude such that the entire program cannot be compiled in one pass.

These reasons are valid for the large scale simulation. In simulations which are moderate to small in size the use of subroutines may add unnecessary factors to be considered, with the exception of reason (b) above which is a valid reason for the use of subroutines in most computer applications.

By careful construction of the statement numbering scheme, available in languages such as FORTRAN, the programmer of the moderate to small size simulation can modularize his program without the additional consideration of designating common storage and the other difficulties experienced when programming subroutines.

ADVANTAGES

The above technique allows the designer to use the familiar computer languages, such as FORTRAN, in place of special simulation languages.

It also alleviates the requirement of either providing the reader with a description of a special language or causing him to go to another source to interpret the program. Using a "standard" language, such as FORTRAN, the designer can reasonably assume that the reader needs little or no explanation.

FLEXIBILITY

The use of modularization with statement numbers gives all the herent flexibility observed in the special languages when the simulation s of such a magnitude as to allow compilation in one pass. When simulations are in the design and programming stages, the use of the above technique can allow as much flexibility as the simulation requires. Exit from the blocks when programming in FORTRAN can be accomplished at any logical point with nothing more than a simple GO TO or COMPUTED GO TO statement, and thus the logic flow is easily accomplished by this method.

4. SYSTEM VARIABLES, COORDINATES AND NOTATION

Certain special simulation languages provide for dynamic allocation of storage for tables which facilitates the designation of data in a flexible and expandable form. This is not necessarily required by the moderate size simulation. The designer of these moderate size simulations may find the techniques as explained below more desirable, since his problem is not generally one of storage limitations. The criterion for the dynamic versus preset storage decision is felt to be that of program size. In programming the moderate size simulation the programmer may find that constructing a scheme for naming variables may create easier to work with variables than the complex tabular form of the special simulation language. This was found to be true in the programming of the example simulation, MULNUC1, of this thesis.

The general approach to the naming of variables in the example program was that of using vectors to represent a given parameter, each component of the vector being representative of the value of that parameter with respect to the unit concerned. An example, that of the X-coordinate of the i^{th} destroyer, being DDX(I). Once the scheme is understood the programming moves along without a great amount of thought required by the programmer as far as variable names are concerned. Certain variables must be set aside as dummy or temporary and these logically take on forms such as: ITEMP, TEMP3, DUMMY(I), and forms that immediately classify them in this category.

In general, several different coordinate systems are required in simulations. In the war game an overall "area of play" must be established. This can be either rectangular or polar, two or three dimensional. The axes of the rectangular coordinate system are not necessarily graduated in the same units. In the example program, for instance, it will be seen that the third axis (depth) is dimensioned in feet, while the two major axes are dimensioned in yards. Further, the third axis has the normally negative direction established as positive. These, perhaps unorthodox, measures are taken to facilitate programming; however, they must be spelled out in the documentation of the simulation to prevent possible misunderstanding.

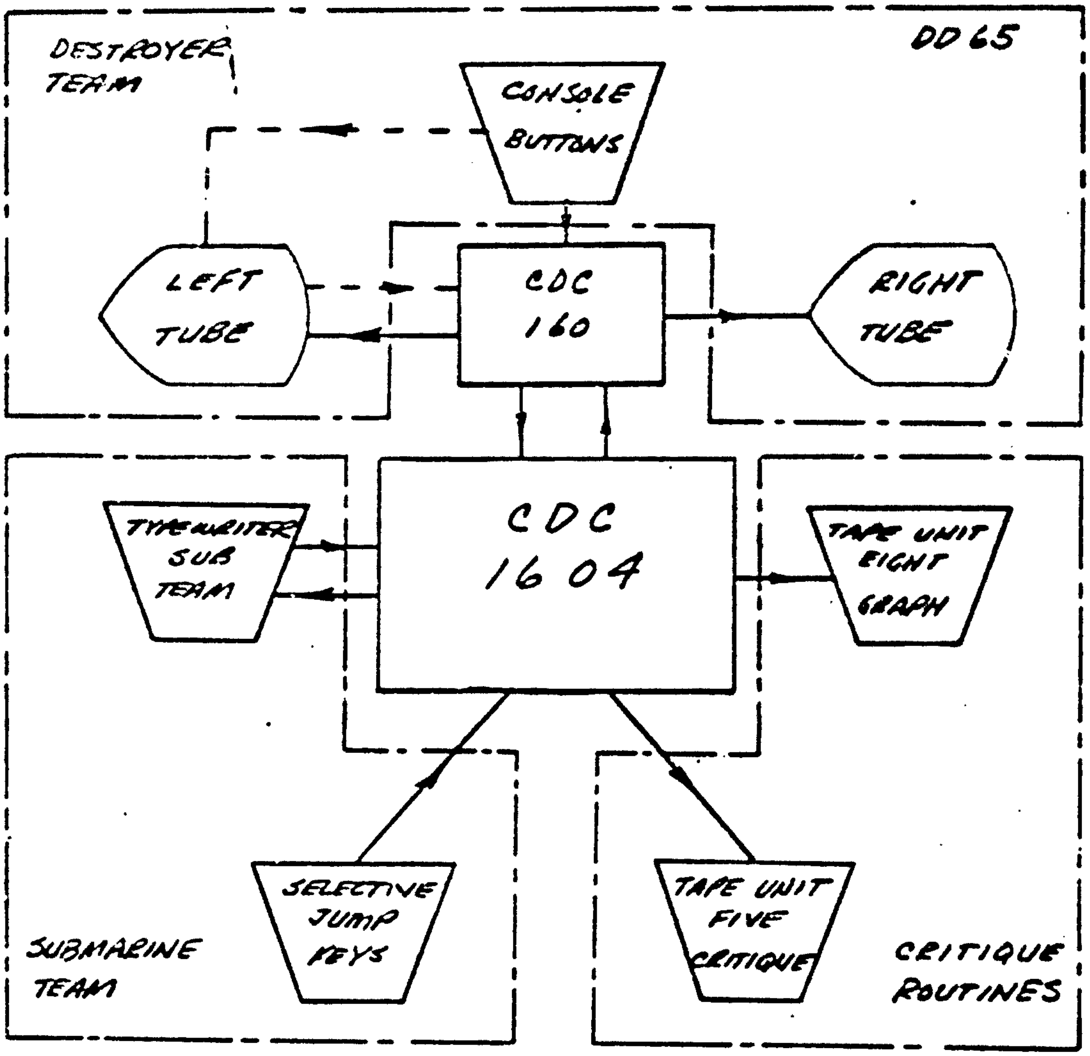
Many simulations require more than one coordinate system to be employed. The overall play is perhaps in a rectangular coordinate system, while range and bearing information may be required during the play of the game. This will necessitate the incorporation of an overlay of one, or perhaps several, polar coordinate systems upon the base system. If a "close-up" view is required during the play a translation and/or expansion to another rectangular system may be required. It can now be seen that, in general, several coordinate systems will be used in a war game type of simulation. Therefore, a plan for the designation of these various coordinate systems and their respective transformations must be established early in the formulation of a simulation.

5. MULNUC1 - AN EXAMPLE

MULNUC1 is an on-line, real time simulation used as an example of the application of ideas presented in sections one through four. The simulation had its beginning at the Naval Radiological Defense Laboratory, Hunters Point, in the summer of 1965. During a six-week tour of the Naval Radiological Defense Laboratory, it was found that little had been done in the exploration of tactics and possible reactions of surface antisubmarine destroyers exposed to a self-inflicted multiple burst nuclear environment. At this time the simulation used as an example in this thesis had its beginning. In the example program, MULNUC1, all classified input parameters have been assigned fictitious values so that the computer program, as presented in this thesis, could remain unclassified.

In 1965, Lieutenant J. E. Johnson programmed the on-line display, Display Data Corporation model DD 65, using a rather simple simulation situation [2]. He did make a contribution in the form of an advancement in the techniques of on-line programming of simulations. Having observed a demonstration of Johnson's program, it was felt that the technique of on-line display would be ideal for the envisioned program, MULNUC1.

Several links were missing in the chain necessary to put the envisioned program on-line. The first link was a requirement for a routine to generate circles of arbitrary size and location. This was accomplished with subroutine CIRCLE (see Appendix III). After completing subroutine CIRCLE, attention was turned to the necessity for a random number generator capable of generating several types of random variables. The distributions of random variables required were uniform, normal, and circular normal. These generators were written in the form of subroutines



——►—— actual communication link

– –►– apparent communications

FIGURE 1

UNIFORM, NORMAL, and ERROR. The subroutine RANVAR is the basic random number generator called by these subroutines in the generation of their respective random variables. The above routines completed, only the communication routines required to link the Control Data Corporation 1604 and 160 computers remained. This requirement was satisfied by subroutines DCIRCLE, DTRACK, PARAMS and DSTATUS (see Appendix III and Acknowledgements).

At this point the preliminary work was complete and the formulation of the initializing, iterative loop, and critique portions of the simulation was begun. These three basic steps, as discussed in section two, were incorporated into an executive control block.

EXECUTIVE CONTROL

The Executive Control routine is flow charted in Appendix II and consists of three major parts. The first of these parts is the initializing portion. It is made up of four blocks:

1. Inputs
2. Set Constants
3. Initialize
4. Enter Input Changes

In this subsection we shall consider the first three, leaving the latter for discussion in the subsection titled Man Machine Interface.

The Inputs block is the one in which "standard" or nominal input parameters are set. These parameters are listed below.

Number of Destroyers

Time Factor

Destroyer and Submarine Maximum Speed

Submarine Hull Parameters

Initial Positions

Initial Courses and Speeds

Nominal Yield of Nuclear Weapons

Depth of Thermocline

Maximum Range of Weapons

Detonation Parameters for Weapons

Random Number Generator Initializer

Any of these parameters may be changed in the enter input changes block (see Man Machine Interface subsection). These parameters were chosen as the minimal requirements necessary to produce a simulation that has some realism and yet is not too complex. The structure of this program is such that any block can be expanded to include more parameters, thereby creating a more realistic simulation.

Set Constants in a block used, as the name implies, to initialize non-changeable inputs. In this block, all the logic indicators are set to orient the game. All damage and radiation levels are set at zero. The indices for tracking, firing, and sonar contact are set at zero. This is easily followed by cross referencing Appendices I and IV.

The Initializing block begins by initializing the random number generator subroutine and then calculates the following parameters:

Water Temperature Gradient

Submarine Crush Depth

Operational Depth of Submarine

Wind Direction and Velocity

Minimum Safe Range of Weapons [6]

Effective Sonar Range

Sea State

These calculations are straight forward and can easily be followed by cross referencing Appendices I and IV. The block also presents input parameters of interest to the destroyer team, submarine team (if selected), and critique routine.

Subsurface nuclear bursts are divided into four classifications:

1. Very Shallow
2. Shallow
3. Deep
4. Very Deep [4]

The criteria for selection of classification are depth of burst and yield. The determination of classification of burst is made at this point in the program and an index IDEEP is set (see Appendix I). The four matrices of output data are filled with negative zero, since negative zero is programmed not to print on the display. Finally, if the role of the submarine is to be played by the computer, the basic strategy of the submarine is randomly determined (see Submarine Logic Model).

The next major part of the Executive Control Routine is the iterative loop. It is made up of eight blocks:

1. Plot Positions
2. Display Data
3. Plot Generator
4. Interactions
5. Radiation Model
6. Enter Changes
7. Submarine Logic Model
8. Time Loop

The first three of these will be considered now, while the remaining blocks will be explained in later subsections.

The Plot Positions block is utilized to transmit output information to the left tube of the DD 65 (see Figure 2). This output information consists of the following data:

Destroyer Tracks

Sonar Contact Plots

Destroyer Courses, Speeds and Coordinates

Orientation and Size of Area Displayed

Important Messages to the Player

This information presentation is covered in more detail in the section on Man Machine Interface.

The Display Data block performs the same function with respect to the right tube of the DD 65 (see Figure 3). Figure 3 lists the data displayed by this block and for this reason it will not be listed at this point.

The final major part of the Executive Control Routine to be considered at this time is the Critique block. This block critiques the simulation by performing several tasks. The entire simulation is recorded on magnetic tape and can be reviewed at a later time. If any significant action or interaction occurs game time and the nature of the action/interaction are recorded by the Critique I block. A narrative print out is made at the conclusion of the simulation by the Critique II block. To correlate this information a graph plot of the tracks of destroyers, submarines, and all pools and clouds of radiation is made. Detail of these operations is documented in Appendix IV.

PLOT GENERATOR

The Plot Generator block advances all participants each time step (see Appendix II). The block then determines if there are any clouds or pools of radiation. If there are clouds, they are advanced using wind

LEFT TUBE DISPLAY

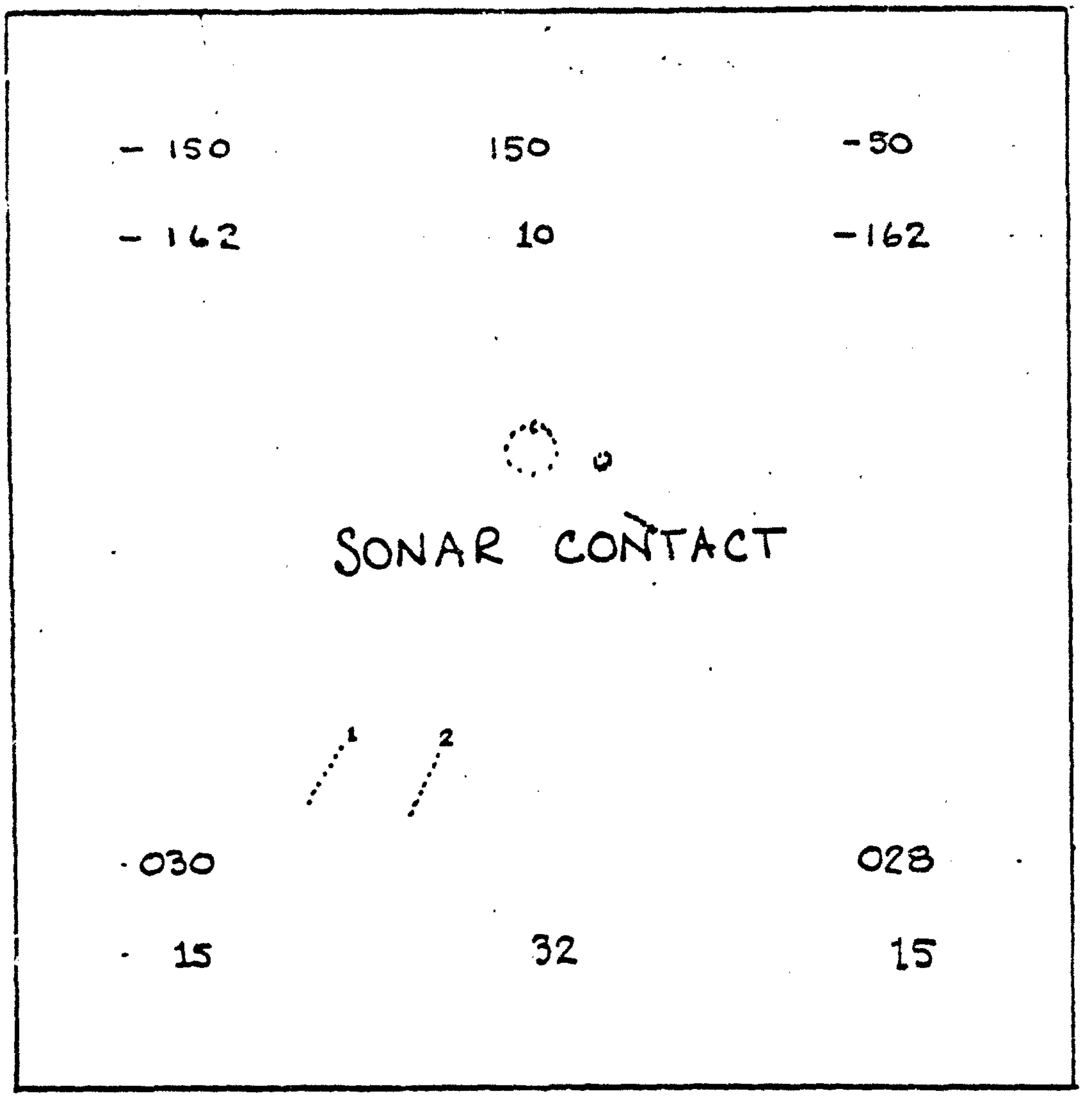


FIGURE 2

RIGHT TUBE DISPLAY

```
INPUT PARAMETERS
NUMBER OF DESTROYERS ...  2
SIZE OF ASROC WARHEAD ... 2.0  KT
DEPTH OF THERMOCLINE ...120.0  FT
MAXIMUM RANGE OF ASROC . 9000.0 YARDS
DEPTH OF BURST .........  700.0 FT
SINK RATE OF WARHEAD ... 18.0   FT/SEC
TIME FACTOR ............  5.0
WATER TEMP GRADIENT .... -.535 DEG/100FT
```

```
EFF SONAR RANGE    5171.        WIND DIRECTION      179
GAME TIME            42.5       WIND VELOCITY        28.
WARHEAD SIZE          2.0       SEA STATE             7

                    DD1         DD2
MAX SPEED AVAIL      33.         33.
CONTACT CLASS                     1
SONAR RANGE                    4899.
SONAR BEARING                    65
DOPPLER                           1
TARGET COURSE                     2
TARGET SPEED                     22.
FIRING SOLUTION                   1
RADIATION RATE        .           .
RADIATION DOSE        .           .
```

FIGURE 3

velocity and direction to determine motion, and the radius is computed [1]. Pools are considered to be stationary since their drift is negligible.

INTERACTIONS

Interaction is the largest block and for clarity has been broken into sub-blocks. These sub-blocks are:

1. Sonar Contact Model
2. Contact Tracking Model
3. Weapon Firing Model
4. Evaluation Model

The interactions block is constructed in the form of a loop that considers the interactions of each unit in succession. The organization is well documented in Appendices II and IV and will not be further explored at this time, however, the details of the four sub-blocks listed will be considered below.

SONAR CONTACT MODEL

The Sonar Contact Model uses a ray path theory detection scheme in a deterministic manner [3]. This deterministic detection range then has a variance superimposed upon it. The net result is a fairly realistic sonar detection model. The major limitation of this model is that it only handles the constant temperature gradient case. The inclusion of other gradients causes the sonar detection problem to assume a much more complex nature. Included in the model is a degradation of sonar range due to excessive destroyer speed. The range and bearing given as outputs from this model have range and bearing errors included. The data, with these errors, is then utilized by the tracking and firing models. Doppler is also calculated in the model and sent to the display as:

1. Up Doppler
2. Down Doppler
3. No Doppler

CONTACT TRACKING MODEL

The Contact Tracking Model uses as input data the output of the Sonar Contact Model. A simple criteria, requiring three consecutive marks from the sonar model, is used to distinguish non-contacts from contacts. Once three consecutive marks are received, the model determines the contact course and speed. This is done with a simple no parameter track model that considers at least three but no more than five marks. The course and speed of the contact are determined from the first and last of these marks. This track model is unsophisticated but the error induced in the output is fairly realistic. This model is of the first that should be improved upon if more work is to be done on this simulation. The output of this model is in the form of contact course and speed. This model provides dual routing, dependent upon the track. This will be discussed further in the subsection on Block Sequencing. Determination of whether or not the target is in firing range is made just before exiting the routine.

WEAPON FIRING MODEL

The Weapon Firing Model takes the last position of the contact from the Sonar Model, the contact course and speed from the Tracking Model, and then determines a firing solution. The range is considered, with time of flight and sink time, and the time of burst is determined. A dead reckoning position of the target is computed from the track data and this position becomes the aim point of the weapon. The model then calls subroutine ERROR from which the true fall of shot is determined. The weapon is given a reliability check in the model and if this test is failed, the player will be notified that the weapon has misfired (see Man Machine Interface subsection).

EVALUATION MODEL

The evaluation model initializes the pool and cloud of radiation created by the subsurface nuclear burst. To accomplish this the model takes data from the firing model for the location of ground zero and data from the inputs block for yield, depth of burst, and type of burst. The radius of the radioactive pool is then determined [4] (the cloud parameters are computed in the plot generator model).

A simple criteria for damage to the submarine is used. The lethal range is determined using submarine hull parameters, yield of warhead, and submarine depth as received from the submarine logic model. Slant range to the burst from the submarine is computed. If the submarine is within the lethal range, damage is 100%. If the submarine is outside a radius equal to twice the lethal range, damage is zero. Values of submarine damage between zero and 100% are computed by a linear relationship, then, if at any time the submarine's total damage reaches the 75% level, the game is terminated with the submarine considered as having been sunk.

RADIATION MODEL

The Radiation Model determines if any weapons have been detonated. If none have been detonated, the block is bypassed and the program continues. If weapons have been detonated, the model computes the distance of each destroyer from all pools and clouds of radiation. The location and size of all pools and clouds is received from the plot generator model along with the location of the destroyers. The model then determines if the destroyers are within the perimeter of any pool or cloud. If this condition exists, the radiation level in the cloud or pool is calculated [1, 4]. The total radiation being received by each destroyer is then calculated. The radiation rate and total radiation dose for each destroyer are computed and sent to the display (see Man Machine Interface subsection).

SUBMARINE LOGIC MODEL

The submarine can be controlled in two ways:

1. By a submarine team.
2. By the computer.

This decision is made in the enter input changes routine. The program is such that the computer will play the role of the submarine unless the variable ISUB is set equal to one by the enter input changes routine. If ISUB is set equal to one, control of submarine depth, course, speed, and weapon firing is turned over to the submarine team. This team will receive passive sonar bearings and screw beat information from the console typewriter of the CDC 1604. They will be able to control the movements of the submarine and its weapon firing by means of the console typewriter and selective jump keys. The program will query selective jump key number two, once each cycle, to determine if orders to the submarine are to be received. If selective jump key two is set the computer will request orders (see Man Machine Interface subsection). The weapons (torpedoes) can be fired by setting selective jump key three on the CDC 1604 console (see Man Machine Interface subsection). Under this condition the simulation becomes a conflict between two teams:

1. A submarine team using the CDC 1604 console.
2. A destroyer team using the DD 65 display console.

If ISUB is unchanged by enter input changes (inputs block sets this variable equal to zero), the moves of the submarine are controlled by the computer. This being the case, two basic initial tactical situations are available to the player. The first of these places the submarine on the surface, at the origin of the playing area. The submarine knows that he has been sighted and the game proceeds. The second situation has the submarine randomly located in the upper half of the playing area. In this case the submarine's position is not known by the player. It should be noted that this is the initial situation if the submarine is to be controlled by a submarine team.

Initial situation one is selected by setting INITIAL equal to zero, while situation two is selected by setting this variable equal to one. Having selected the initial situation the computer then selects one of three basic strategies:

1. The submarine runs for it.
2. The submarine tries to transit between the two destroyers.
3. The submarine tries an end run, flanking the two destroyers.

These strategies are easily followed in Appendix II and will not be explored further at this point.

SEQUENCING OF PROGRAM BLOCKS

The blocks in this simulation are of two basic types:

1. A single point of exit.
2. Multiple points of exit.

The block that has a single exit point might be called a standard block, in that, the block is called upon to perform a computation but no branching of logic is done within the block. The multiple exit block is one in which the program is routed differently depending upon logic decisions made within the block. The sonar contact block is an example of this type. In this block the routing depends upon the results of a sonar search. If contact is made, the block exists to the contact tracking block. If no contact is made, the block exits to consider the next destroyer.

The executive control routine flow chart in Appendix II illustrates the time sequencing of the major program blocks. The simulation is delayed at four points in the program which are:

1. Enter input changes routine.
2. Enter changes.
3. Submarine logic block.
4. The time loop.

The first of these interruptions takes place only during the initializing portion. At this point any change to the input parameters is made. The second of these interruptions is made once during each time step. This is the point at which destroyer team changes are sent to the CDC 1604. The third of these interruptions takes place if the situation using the submarine team has been selected. In this case the simulation may be interrupted every time step to allow the submarine team to enter changes. The fourth of these interruptions occurs each cycle and maintains the time stepping interval.

It will be noted that in the executive control routine, each block is considered in turn, no block is bypassed. In the interactions block, it will be noted that, sub-blocks are not always considered. No sonar contact by the sonar contact block causes the contact tracking block to be bypassed. The same is true of the weapon firing block if the tracking block does not generate a satisfactory track.

MAN MACHINE INTERFACE

This subsection is concerned with communications, both into and out of the computer. These man-machine communications fall into four types:

1. Data to and from the destroyer team.
2. Data to and from the submarine team.
3. Data to the various modes of the critique routine.
4. Input changes.

The first type breaks into three parts:

1. Right tube information.
2. Left tube information.
3. Changes sent to the CDC 1604.

The right tube gives the destroyer team data in tabular form as illustrated in Figure 3. The left tube will display the tracks of the destroyers, any sonar contacts, and all pools and clouds of radiation. Also included in the display on the left tube is a series of windows in which data can be displayed. The windows are numbered as shown in Figure 2. Window data assignments are as listed below.

Window	Data Assignment	Units
1	X-coordinate of destroyer 1	100 yards
2	X-coordinate of destroyer 2	100 yards
3	Y-coordinate of destroyer 1	100 yards
4	Y-coordinate of destroyer 2	100 yards
5	Course of destroyer 1	Degrees true
6	Speed of destroyer 1	Knots

Window	Data Assignment	Units
7	Course of destroyer 2	Degrees true
8	Speed of destroyer 2	Knots
9	X-coordinate of left tube center	100 yards
10	Y-coordinate of left tube center	100 yards
11-14	Available for flash messages	Alfa-numeric
15	Not used	
16	Radius of display on left tube	1000 yards

Windows 5-10 and 16 are controllable from the DD 65 console by means of a discrete digital type control system. In this manner the player is able to change the destroyer course and speed, or "zoom" the display in on any point in the area of play. Let us first consider windows five through eight.

On the DD 65 console (see Figure 4) there are buttons labelled CONN DD 1 and CONN DD 2. By depressing one or both of these buttons the player is given control of the course and speed of the destroyer or destroyers selected. Near the button just selected is a group of four buttons (see Figure 4) labelled RIGHT, LEFT, FAST/UP, and SLOW/DOWN. Depressing one of these buttons will cause the appropriate variable in windows five through eight to change in the desired direction. As an example, if the player depresses both CONN buttons and then the button labelled RIGHT - both destroyers will commence a turn to the right. They will continue this turn until the button labelled RIGHT is released. The player can "come to a course" by depressing the correct button until the desired course is displayed in the respective window. The same procedure is used for changing speed. It should be noted that the windows can be changed to values that are unacceptable, such as -5 knots, in this case the program will cause this value to be changed back into the acceptable range during the following cycle. The value of course can be increased to values greater than 360 degrees, in which case the program will correct to the acceptable value. For example, if the player increases the course to 390 degrees, the program will convert this to 030 degrees during the next cycle.

The same basic procedure is utilized to "zoom" the display to any location desired. First the player selects the button labelled SHIFT (see Figure 4). He now has control of windows nine and ten. Depressing the button labelled RIGHT will cause the display to shift to the right, LEFT accomplishes the same action but to the left, and similarly with UP and DOWN. To zoom in, the rotary switch in the upper right hand corner of the console is used (see Figure 4). This switch has six positions labelled 4, 8, 16, 32, 64, and 128. Selection of one of the six positions will cause the radius of the displayed area to be that of the value selected, in thousands of yards. As an example, selecting SHIFT and changing windows nine and ten to 240 and 150 respectively, then setting the rotary switch to eight, will cause the area centered at (24000,15000) with a radius of 8000 yards to be displayed on the left tube. Note that window 16 will show the value eight, while windows nine and ten will show 240 and 150 respectively.

Windows 11 through 14 are used to send the player the following flash messages.

SONAR CONTACT

ASROC FIRED

ASROC MISFIRE

SUB SUNK

DD SUNK

DD65 CONSOLE ARRANGEMENT

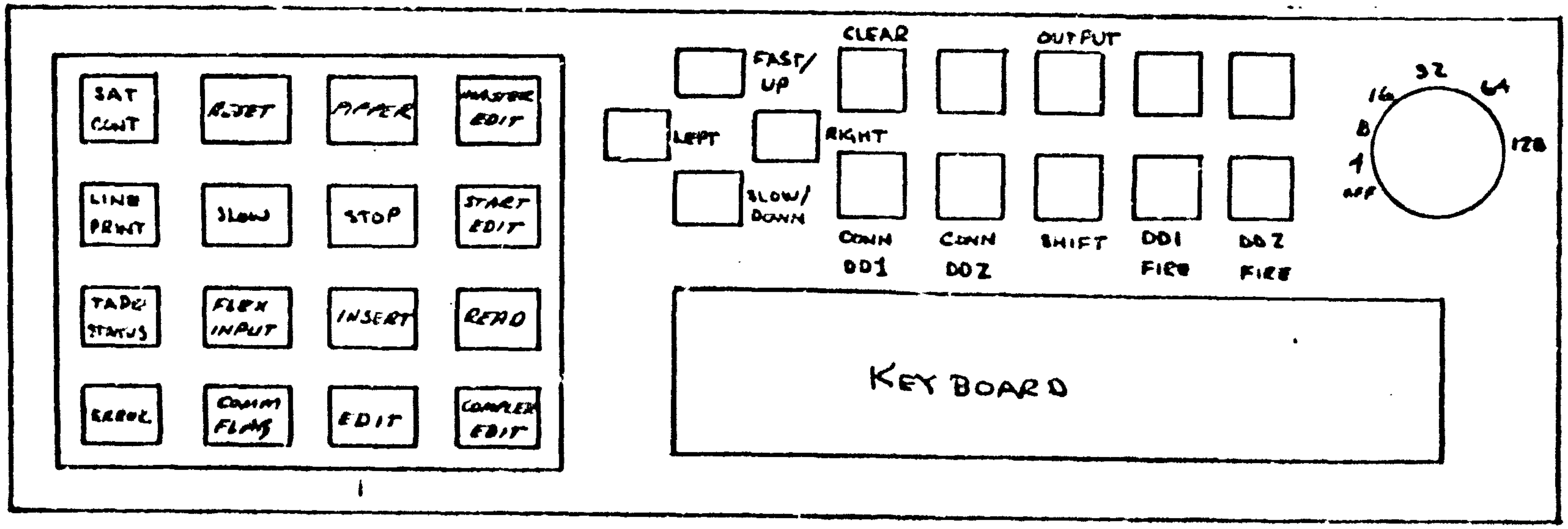


FIGURE 4

TARGET IN RANGE

TARGET TOO CLOSE TO SHOOT

TARGET OUT OF RANGE

Another method of communications is available to the destroyer team. By depressing the DD 1 FIRE button, destroyer number one fires an ASROC. The same procedure is used with the DD 2 FIRE button.

The next type of communications available is that of the submarine team. This is, of course, non-existent if the option is chosen in which the submarine is played by the computer. The submarine team will receive messages each cycle containing bearing and screw beat information. The submarine team may then choose to maneuver the submarine by setting selective jump key number two on the console of CDC 1604. The computer will then type COURSE ORDERS on the console typewriter. This is the indication that the computer is ready to receive course changes. If no change is desired, the old course is typed in. If a change is requested, the new course is typed in. The course typed in should be of the form 090. followed by a carriage return. This will change the course and the computer will return NEW SUB COURSE 090. This completes the course change cycle and the computer will then type SPEED ORDERS, the same procedure is used to enter speed changes. Upon completion of the speed entry the computer will return NEW SUB SPEED 15, followed by DEPTH ORDERS. The new depth is now entered, and the computer will return NEW SUB DEPTH 1050. The routine is now finished and the program continues.

The only other action available to the submarine team is that of firing torpedoes. This is accomplished by depressing selective jump key number three until the typewriter returns TORPEDO FIRED. At this time the selective jump key should be returned to the normal position, unless

DD65 CONSOLE OVERLAY

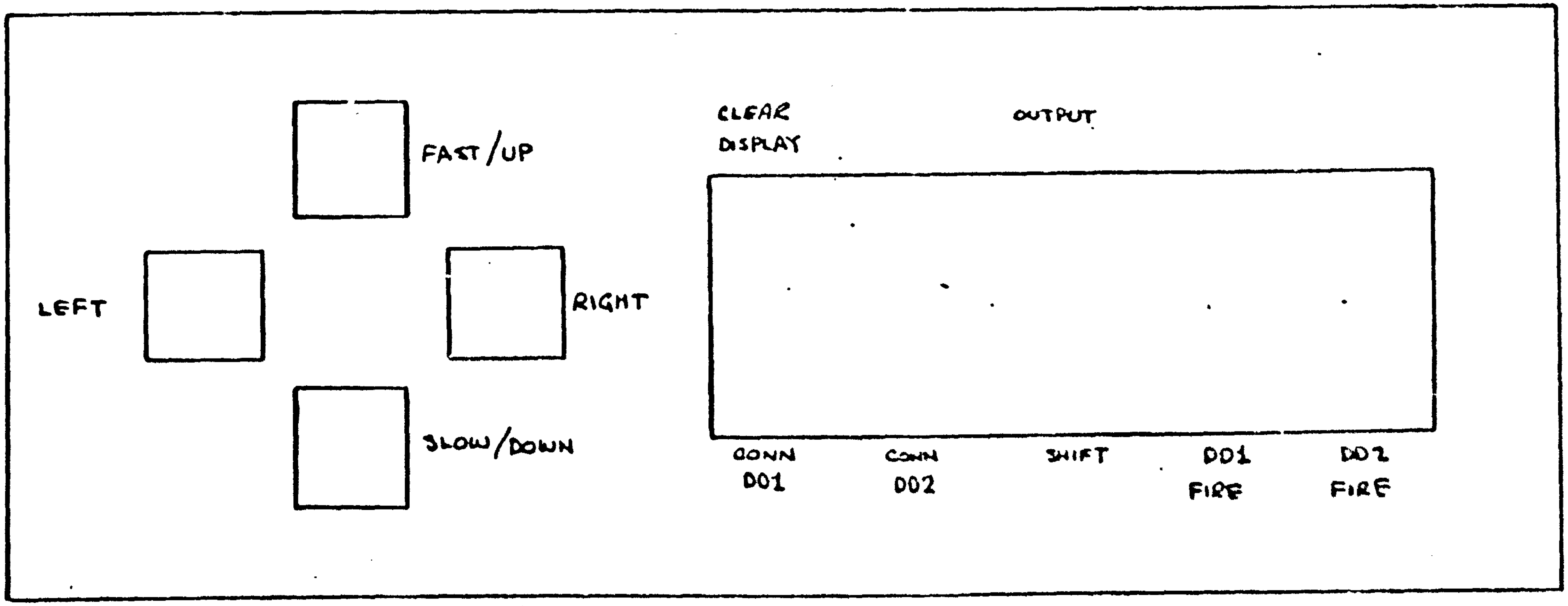


FIGURE 5

another torpedo is desired. If a hit is scored, the typewriter will return DESTROYER SUNK. When both destroyers are sunk the typewriter will return GAME OVER. At the beginning of the game, the typewriter will give the submarine team the following information:

1. Maximum speed available to submarine.

2. Maximum depth allowable.

The third type of communication is with the various critique routines. Critique is accomplished in three ways:

1. A recording of all information on the DD 65 display is recorded by the tape unit near the DD 65.

2. A graph of the tracks of the DD's, submarine, and all radiation is made on tape unit eight of the CDC 1604 (the graph has game time recorded by each mark to aid in correlating with the various other parts of the critique routine).

3. A critique of all important events and their time is recorded on tape unit five of the CDC 1604 for print out at the conclusions of the game.

These three methods of critique, if correlated, will give an excellent "replay" of the simulation. Any communication with the program other than listed above will be accomplished as described by Leach and Perrella [5].

TIMING

The timing of this simulation is done by means of a time loop block. In this block, the contents of cell 5006B in the CDC 1604 is tested and stored as ICLOCK. A variable, NEXT, is generated as the sum of ICLOCK and ISTEP, the stepping interval. ISTEP is determined from another variable TFACTOR that is equal to one for real time. TFACTOR equal to three would, for example, cause the game to run at three times real time. When ICLOCK becomes greater than or equal to NEXT the loop is exited and the simulation continues. This procedure is easily followed in Appendices II and IV.

6. CONCLUSIONS AND ACKNOWLEDGEMENTS

The considerations made in the formulation and construction of this simulation have made some observations possible. Only the basic modular structure of the simulation has been considered in detail. Each individual modular block has been designed in as simple a form as possible while maintaining some degree of realism. The simulation is sound in its general organization. New program blocks may be substituted making the simulation as realistic as desired. It is hoped that this simulation will be played with more sophisticated models and on-line equipment of greater capacity so that doctrine and tactics in the area of self-inflicted nuclear environment may be explored.

It was found that the general purpose computer language was completely satisfactory for the construction of this simulation. The modularization technique made the logical organization of the simulation straight forward and is recommended for use in future simulations.

The author wishes to express his appreciation to Professor Mitchell L. Cotton and Professor Alvin F. Andrus for their aid and encouragement in the preparation of this thesis. In addition, the author would like to thank Miss Patricia Hoang for her assistance in programming the linking subroutines and LCDR Richard E. DeWinter for his comments in proofreading the manuscript.

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APPENDIX I

LIST OF VARIABLES

This Appendix contains a listing of the variables used in the simulation MULNUC1, arranged in alphabetical order.

Variable	Definition
AROCMAX	Maximum range of the ASROC, in yards. This is an input parameter, set equal to 9,000 yards by the inputs block and can be changed in the change inputs block.
AROCMIN	Minimum safe range for the ASROC, in yards. This value is computed in the initializing block, and is a function of warhead size.
B	Last bearing the submarine held of the nearest destroyer, in degrees true.
BNPTS	A dummy variable used in the contact tracking block for the determination of contact speed.
CENTERB	The course such that the submarine will split the channel between the destroyers, in degrees true.
CLOUDR(I)	Radius of the i^{th} cloud of radiation, in yards.
CLOUDX(I)	X-coordinate of the i^{th} cloud of radiation with respect to the main coordinate system, in yards.
CLOUDY(I)	Y-coordinate of the i^{th} cloud of radiation with respect to the main coordinate system, in yards.
CONTB(I)	Bearing of sonar contact of i^{th} destroyer, in degrees true.
CONTC(I)	Contact course, as computed by the contact tracking block, in degrees true.
CONTR(I)	Sonar range to contact, as measured by the i^{th} destroyer.
CONTS(I)	Contact speed as computed by the contact tracking model, in knots.
CONTX(I)	X-coordinate of the i^{th} destroyer's contact, in yards, with respect to the main coordinate system.
CONTY(I)	Y-coordinate of the i^{th} destroyer's contact, in yards, with respect to the main coordinate system.

Variable	Definition
D	Difference between the true bearing to the submarine from the destroyer and the submarine's true course, in degrees. This is used in the determination of doppler.
DA	Absolute value of D.
DAMAGE	Percent damage to the submarine from the current detonation.
DAMAGET	Cumulative damage to the submarine, in percent.
DDC(I)	Course of the i^{th} destroyer, in degrees true.
DDS(I)	Speed of the i^{th} destroyer, in knots.
DDSMAX(I)	Maximum speed available to the i^{th} destroyer, in knots.
DDX(I)	X-coordinate of the i^{th} destroyer, in yards, with respect to the main coordinate system.
DDY(I)	Y-coordinate of the i^{th} destroyer, in yards, with respect to the main coordinate system.
DETR	Detection range, in yards. This is a random variable with mean DETRM and normally distributed with sigma of .3 times DETRM.
DETRM	Mean detection range, in yards. A function of GRAD SUBD.
DISTC(I,J)	Distance of the i^{th} destroyer from the center of the j^{th} cloud of radiation.
DISTP(I,J)	Distance of the i^{th} destroyer from the center of the j^{th} pool of radiation.
DOB	Depth of burst, in feet, of ASROC warhead.
DR	Advance of the destroyer considered, in yards, between marks as considered by the tracking model.
DTIME	Total time delay from the firing of an ASROC and the detonation, in seconds. This includes time of flight and time of sinking.
DUMMY	A dummy variable used throughout the program.
DX	East-west advance of the destroyer considered, in yards, between marks as considered by the tracking model.

Variable	Definition
DY	North-south advance of the destroyer considered, in yards, between marks as considered by the tracking model.
ESR	Effective sonar range, in yards. Computed by the initializing block.
GRAD	Water temperature gradient, in degrees per hundred feet of depth.
GTIME	Game time, in minutes. At the start of the game GTIME is zero.
GZX	X-coordinate of ground zero for the detonation considered, in yards, with respect to the main coordinate system.
GZY	Y-coordinate of ground zero for the detonation considered, in yards, with respect to the main coordinate system.
HULL	Submarine hull thickness, in inches of steel.
IASROC	Hull number of the destroyer that fired the last ASROC. If no ASROC has been fired, IASROC is zero.
ICLASS(I)	Sonar classification of the i^{th} destroyer's contact. 0 - no contact, 1 - possible submarine, 2 - probable submarine.
ICLOCK	Contents of location 5006B in the CDC 1604. The CDC 1604 steps this cell once every second.
ICIRCX(I)	A dummy vector of X-coordinates of points to transmit circles to the display.
ICIRCY(I)	A dummy vector of Y-coordinates of points to transmit circles to the display.
ICONTB(I)	Fixed point version of CONTB(I), used to transmit to the display.
ICONTC(I)	Fixed point version of CONTC(I), used to transmit to the display.
ICRIT#	A series of critique indicators. 0 - pass.
1	1 - sonar contact
2	1 - ASROC fired

Variable	Definition
ICRIT#	
3	1 - torpedo fired
4	1 - ASROC misfire
5	1 - target in range
6	1 - sub sunk
7	1 - destroyer sunk
8	1 - target too close to shoot at
9	1 - target out of ASROC range
11	1 - game is a draw, submarine escaped
12	1 - submarine wins, destroyer 1 sunk with submarine escaping
13	1 - submarine wins, destroyer 2 sunk with submarine escaping
14	1 - submarine wins, both destroyers sunk
15	1 - destroyers win, submarine sunk by destroyer 1
16	1 - destroyers win, submarine sunk by destroyer 2
17	1 - submarine wins by transiting between the destroyers
IDDC(I)	Fixed point version of DDC(I), used to transmit to the display.
IDDS(I)	Fixed point version of DDS(I), used to transmit to the display.
IDDX(I)	Fixed point version of DDX(I), used to transmit to the display.
IDDY(I)	Fixed point version of DDY(I), used to transmit to the display.
IDEEP	An index used to indicate the classification of nuclear burst. 1 - very shallow, 2 - shallow, 3 - deep, 4 - very deep.
IDOPLER(I)	An index used to indicate the doppler of the i^{th} destroyer's contact. 0 - no doppler, 1 - up doppler, 2 - down doppler.

Variable	Definition
IEND	An index used to indicate game over. 0 - game not over, 1 - game over.
IFIRE	An index used to indicate if the submarine has fired a torpedo. 0 - torpedo not active, 1 - torpedo still active.
ILOGIC	A logic index used in the submarine model.
IONE	The lowest destroyer hull number. Equal to 1 at the beginning of the game. If destroyer number one is sunk the IONE is equal to two.
INITIAL	An index of the initial situation. 0 - submarine at the origin, 1 - submarine randomly distributed in the upper half of the playing area.
IR	Radius of display area, in thousands of yards.
IRANDOM	A random number selected to initialize the random number generator. This number must be an odd integer in the interval 1 to 67108863.
ISHOOT1	A flag used to activate the firing sequence for destroyer 1. 0 - do not shoot, 1 - shoot.
ISHOOT2	A flag used to activate the firing sequence for destroyer 2. 0 - do not shoot, 2 - shoot.
ISOL(I)	A progressive index of the quality of the firing solution the i^{th} destroyer has on its target. 0 - no solution, thru 5 - best solution.
ISS	Sea state.
ISTEP	Fixed point version of TSTEP.
ISTRAT	Submarine basic strategy when the submarine is controlled by the computer. 0 - run for it, 1 - go up the middle, 2 - end run.
ISUBC	Fixed point version of SUBC.
ITURN	Logical index that records the submarine's initial turn. 0 - left turn, 1 - right turn.
IX0	X-coordinate of center of displayed area, in hundreds of yards with respect to the main coordinate system.
IXDD(I,J)	A dynamic table of track data, recording the X-coordinate of the j^{th} mark of the i^{th} destroyer. The maximum value of j is eight. Entries are in yards, with respect to the main coordinate system.

Variable	Definition
IXDD1(I)	This variable is equal to IXDD(1, I).
IXDD2(I)	This variable is equal to IXDD(2, I).
IXSUB(I,J)	A dynamic table of track data, recording the X-coordinate of the jth mark of the ith destroyer's sonar contact. The maximum value of j is eight. Entries are in yards, with respect to the main coordinate system.
IXSUB1(I)	This variable is equal to IXSUB(1,I).
IXSUB2(I)	This variable is equal to IXSUB(2,I).
IY0	Y-coordinate of center of displayed area, in hundreds of yards with respect to the main coordinate system.
IYDD(I,J)	A dynamic table of track data, recording the Y-coordinate of the jth mark of the ith destroyer. The maximum value of j is eight. Entries are in yards, with respect to the main coordinate system.
IYDD1(I)	This variable is equal to IYDD(1,I).
IYDD2(I)	This variable is equal to IYDD(2,I).
IYSUB(I,J)	A dynamic table of track data, recording the Y-coordinate of the jth mark of the ith destroyer's sonar contact. The maximum value of j is eight. Entries are in yards, with respect to the main coordinate system.
IYSUB1(I)	This variable is equal to IYSUB(1, I).
IYSUB2(I)	This variable is equal to IYSUB(2, I).
IWINDD	Fixed point version of WINDD, used to transmit data to the display.
MARKS(I)	Number of continuous marks, up to five, the ith destroyer has on his sonar contact.
N	A dummy variable.
NCONBER	Number of constant bearing the submarine has on the nearest destroyer.
NEXT	Time of the next cycle, in seconds of computer time.
NMARKS(I)	Same as MARKS(I) except NMARKS(I) does not stop at five.

Variable	Definition
NOSHOOT	Index to limit destroyers to one active weapon at a time. 0 - there are no active weapons, alright to shoot, 1 - there is an active weapon, cannot shoot.
NPTS	Index used to control display data until there are eight point available on destroyer tracks.
NPTS1	A dummy variable.
NPTS2	A dummy variable.
NRDD	The highest destroyer hull number. Equal to 2 at the beginning of the game. If destroyer number two is sunk then NRDD is equal to one.
NSHOTS	Total number of ASROC's fired during the game.
PHIT	A random variable used to determine if a torpedo, fired by the submarine, hit the destroyer.
POOLR(I)	Radius of the i^{th} pool of radiation, in yards.
POOLX(I)	X-coordinate of the i^{th} pool of radiation, in yards, with respect to the main coordinate system.
POOLY(I)	Y-coordinate of the i^{th} pool of radiation, in yards, with respect to the main coordinate system.
R	Radius of the displayed area, in yards.
REL	A random variable used to determine ASROC reliability.
RADDOSE(I)	Total radiation dose the i^{th} destroyer has been exposed to during the game, in roentgens.
RADRATE(I)	The rate at which the i^{th} destroyer is receiving radiation, in roentgens/hr.
RANDOM	The random variable used to link the various random generators.
RANGE	A dummy variable used as a temporary storage in range calculations.
RLETHAL	The lethal range of the ASROC warhead, in yards.
SAFETY	Safety factor used to compute submarine maximum operating depth as a function of the crush depth of the hull.
SB(I)	Screw beat count of the i^{th} destroyer as measured by the submarine.

Variable	Definition
SIGMA	A dummy variable used in the calling of normally distributed random variables.
SR	Sink rate of the ASROC warhead, in feet per second.
SSB(I)	The actual bearing of the submarine from the i^{th} destroyer, in degrees true.
STRESS	Yield strength of the steel used in the submarine hull, measured in thousands of pounds per square inch.
SUBC	The true submarine course, in degrees true.
SUBD	The actual submarine depth in feet.
SUBDMAX	The maximum allowable operational depth of the submarine, in feet.
SUBS	The actual speed of the submarine, in knots.
SUBSMAX	The maximum speed available to the submarine, in knots.
SUBX	The actual submarine X-coordinate with respect to the main coordinate system, in yards.
SUBY	The actual submarine Y-coordinate with respect to the main coordinate system, in yards.
SUM	A dummy variable used in the computation of radiation dose.
TBURST(I)	Time of detonation of the i^{th} ASROC warhead, measured in game time.
TEMP	A dummy variable.
TEMP1	A dummy variable.
TEMP2	A dummy variable.
TEMP3	A dummy variable.
TEMP4	A dummy variable.
TEMP5	A dummy variable.
TEMPCR(I,J)	The radiation rate received by the i^{th} destroyer from the j^{th} cloud of radiation, in roentgens per hour.
TEMPPR(I,J)	The radiation rate received by the i^{th} destroyer from the j^{th} cloud of radiation, in roentgens per hour.

Variable	Definition
TFACTOR	A time factor, 1 - real time, 2 - double time, .5 - half time.
THERMO	Depth of the thermocline, in feet.
THETA	A dummy variable used in the computation of courses and bearings.
TINTER	Time to intercept of a torpedo fired by the submarine, in minutes.
TLOGIC	A time storage point used to control timed logic.
TOB	Time of burst, this includes time of flight and sink time of the ASROC warhead, measured in minutes of game time.
TOF	Time of flight of the ASROC warhead, in seconds.
TOS	Sink time of the ASROC warhead, in seconds.
TSTEP	The time step for each cycle of the game, in seconds.
TXDD(I,J)	A temporary storage of the j^{th} past position X-coordinate of the i^{th} destroyer used in preparing track data for the display, measured in yards.
TYDD(I,J)	A temporary storage of the j^{th} past position Y-coordinate of the i^{th} destroyer used in preparing track data for the display, measured in yards.
TXSUB(I,J)	A temporary storage of the j^{th} past position X-coordinate of the i^{th} destroyer's sonar contact used in preparing track data for the display, measured in yards.
TYSUB(I,J)	A temporary storage of the j^{th} past position Y-coordinate of the i^{th} destroyer's sonar contact used in preparing track data for the display, measured in yards.
VEL	The relative velocity of the torpedo fired by the submarine, with respect to the destroyer target, in knots.
W1	A dummy variable used to determine the destroyer that is closest to the submarine.
W2	A dummy variable used to determine the destroyer that is closest to the submarine.
WINDD	Wind direction in degrees true.
WINDV	Wind velocity, in knots.

Variable	Definition
X(I,J)	The X-coordinate of the i^{th} destroyer's j^{th} continuous mark on its sonar contact, in yards, with respect to the main coordinate system.
XDD(I,J)	The X-coordinate of the i^{th} destroyer j-1 steps ago, in yards, with respect to the main coordinate system.
X0	The X-coordinate of the center of the displayed area, in yards, with respect to the main coordinate system.
XTEMP	A dummy variable used for temporary storage of X-coordinates.
Y(I,J)	The Y-coordinate of the i^{th} destroyer's j^{th} continuous mark on its sonar contact, in yards, with respect to the main coordinate system.
YDD(I,J)	The Y-coordinate of the i^{th} destroyer j-1 steps ago, in yards, with respect to the main coordinate system.
YIELD	The yield of the ASROC warhead in kilotons.
Y0	The Y-coordinate of the center of the displayed area, in yards, with respect to the main coordinate system.
ZZX	A vector of destroyer and submarine X-coordinates used by the graph plot routine in Critique I.
ZZY	A vector of destroyer and submarine Y-coordinates used by the graph plot routine in Critique I.

APPENDIX II

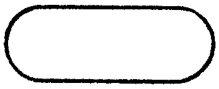
LOGIC FLOW DIAGRAMS

This Appendix contains a series of logic flow diagrams as listed below.

- Executive Control
- Plot Generator
- Interactions
- Radiation Model
- Submarine Logic Model
  - Run for It
  - Up the Middle
  - End Run
  - Submarine Team Control
- Sonar Contact Model
- Contact Tracking Model
- Weapon Firing Model
- Evaluation Model
- Critique I
- Critique II

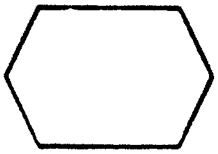
It will be noted that the statement number from the program listing is shown in the upper right hand corner of each symbol in the block diagram. This should aid in correlating this Appendix, with Appendix IV.

FLOW CHART SYMBOLS

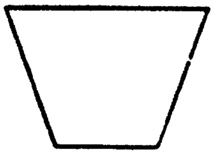


A connector or terminal.

An offpage connector.



A predefined process or module/subroutine.
A more detailed flow chart of this subroutine is also included.



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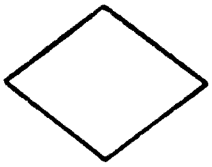
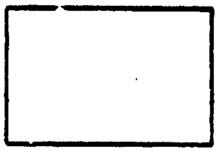
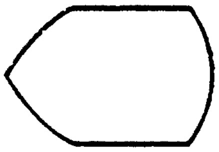


Decision.

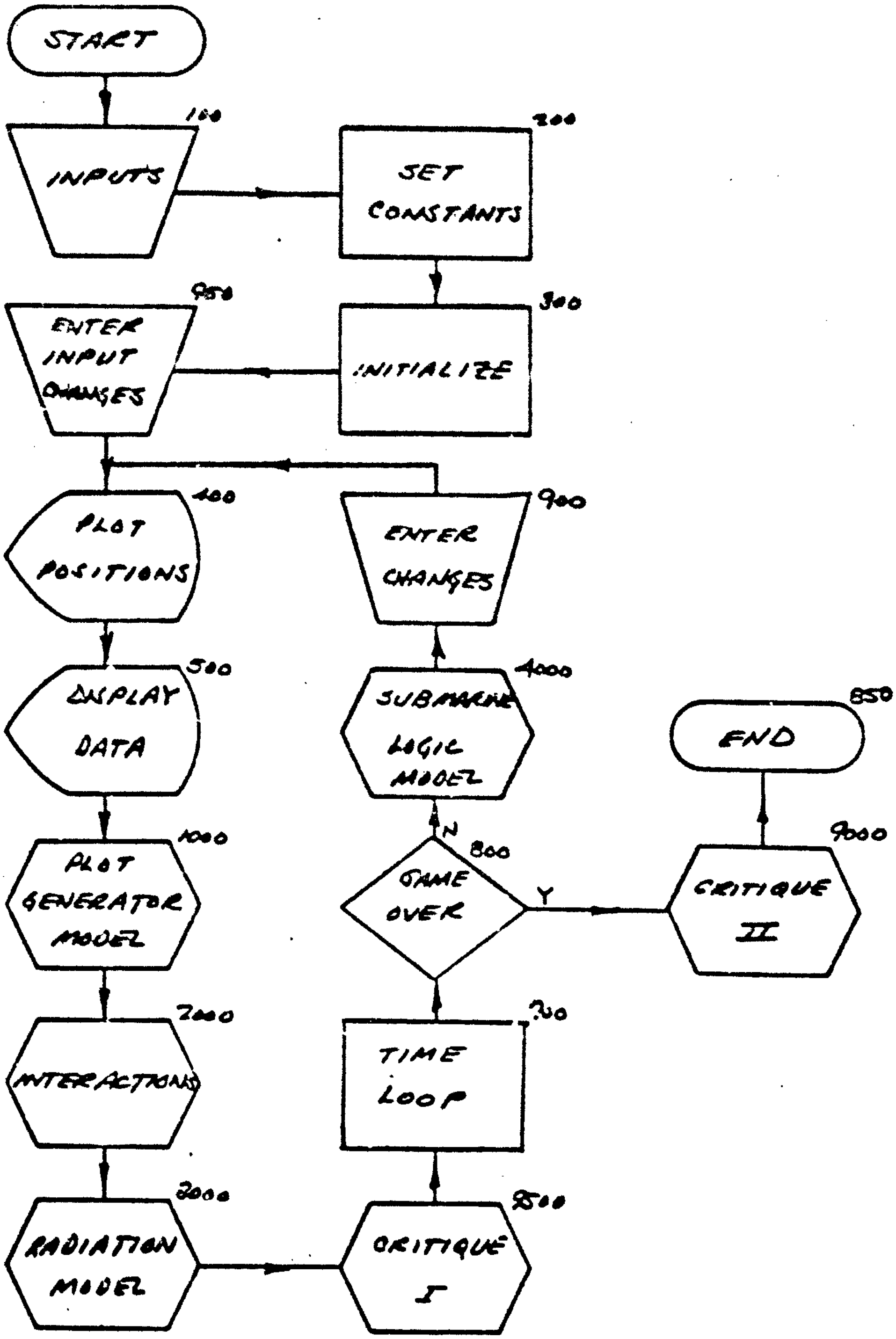


Processing, annotation.

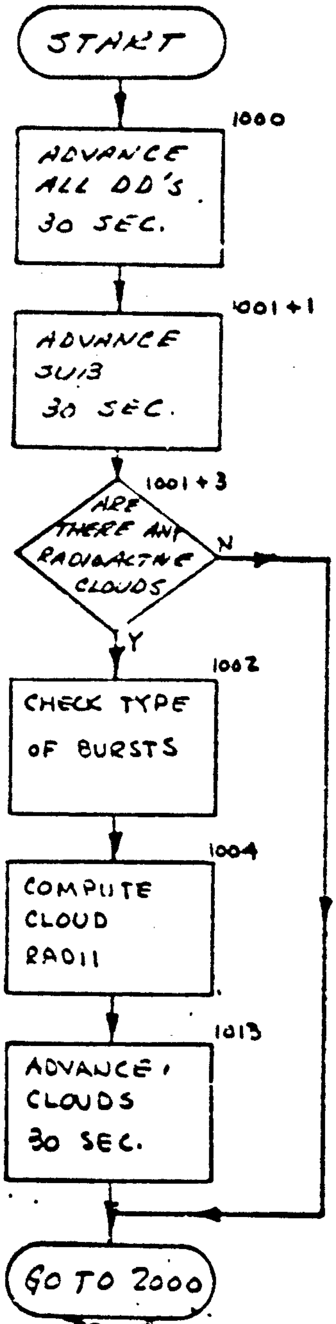


Display.

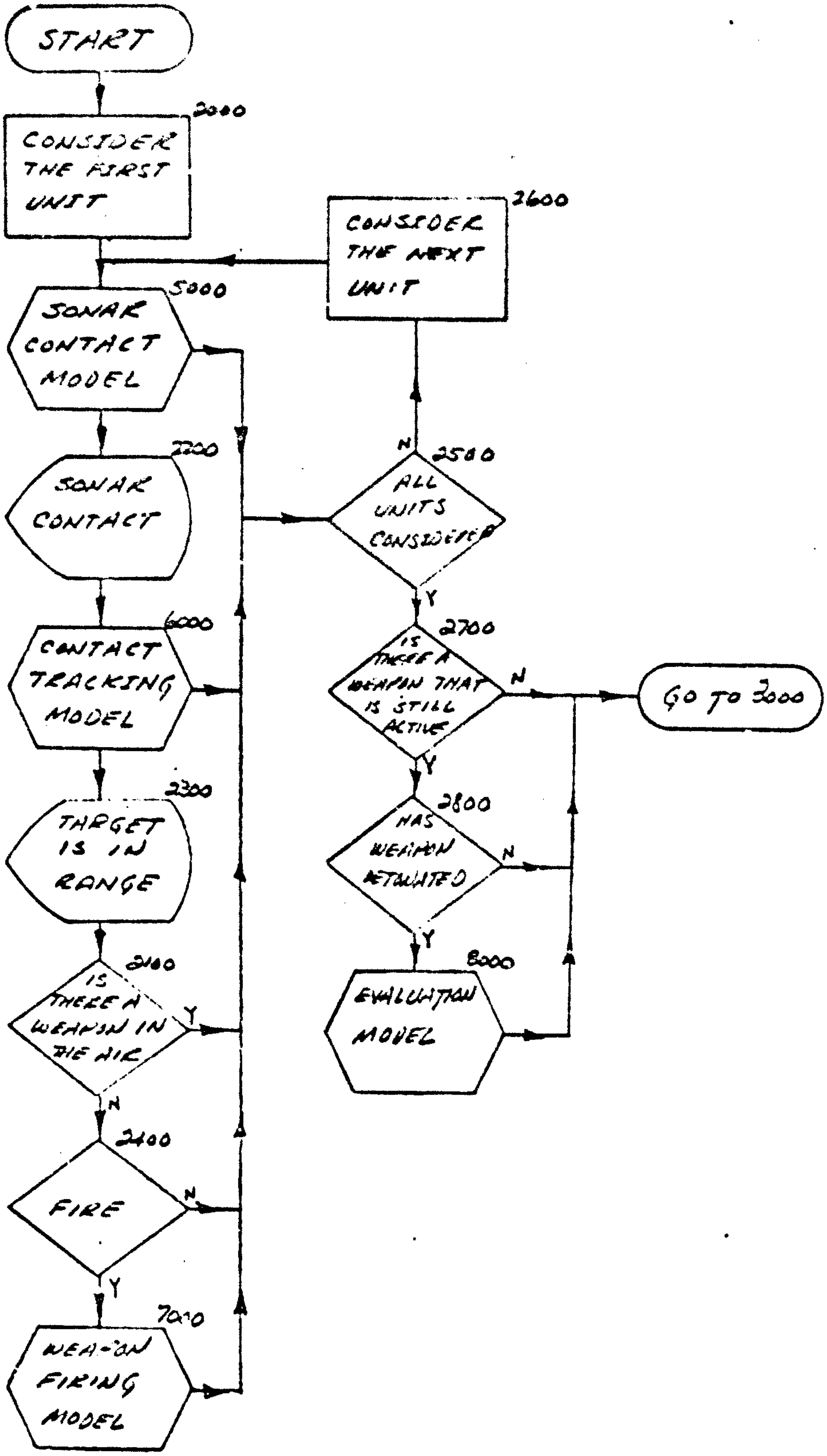
EXECUTIVE CONTROL



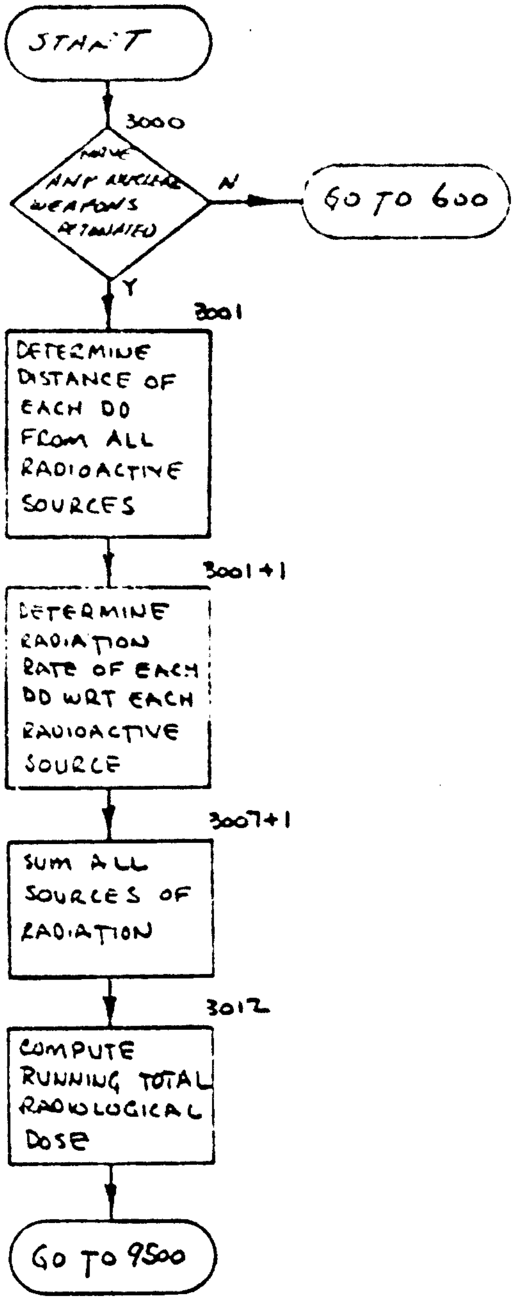
PLOT GENERATOR MODEL



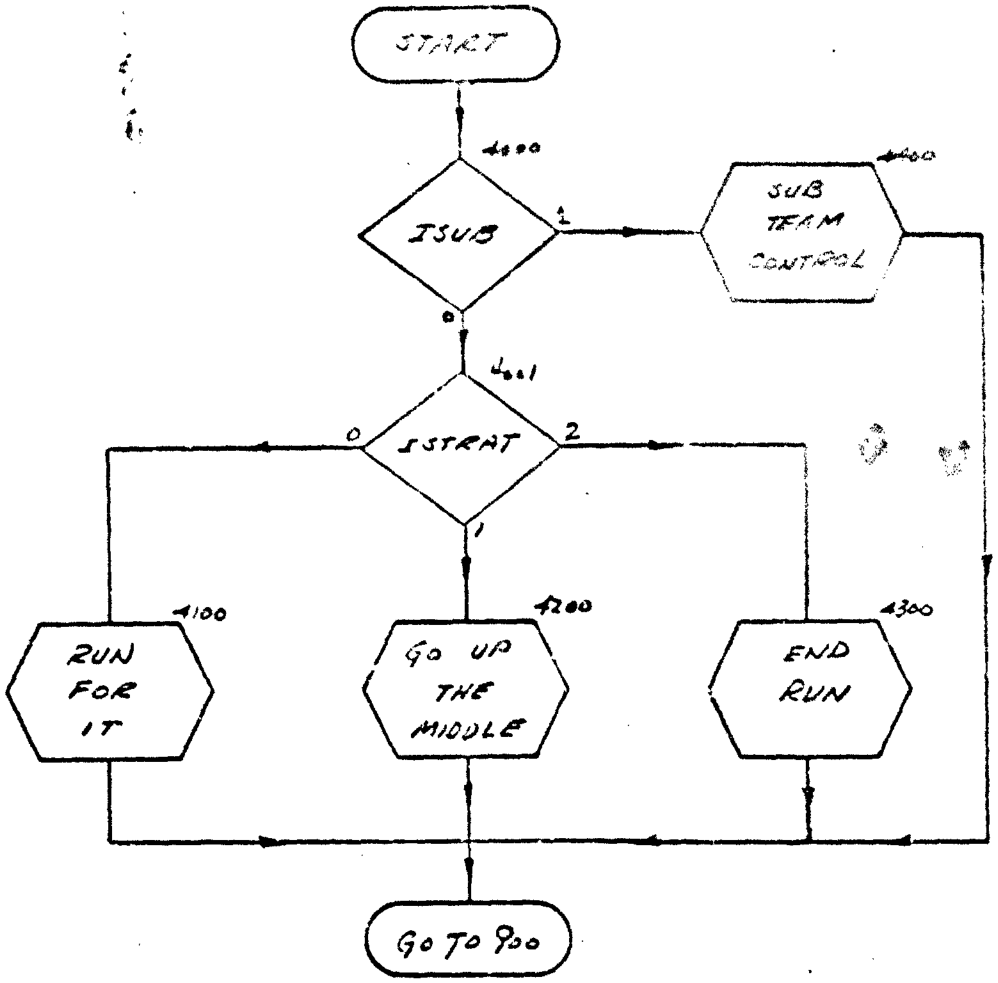
INTERACTIONS



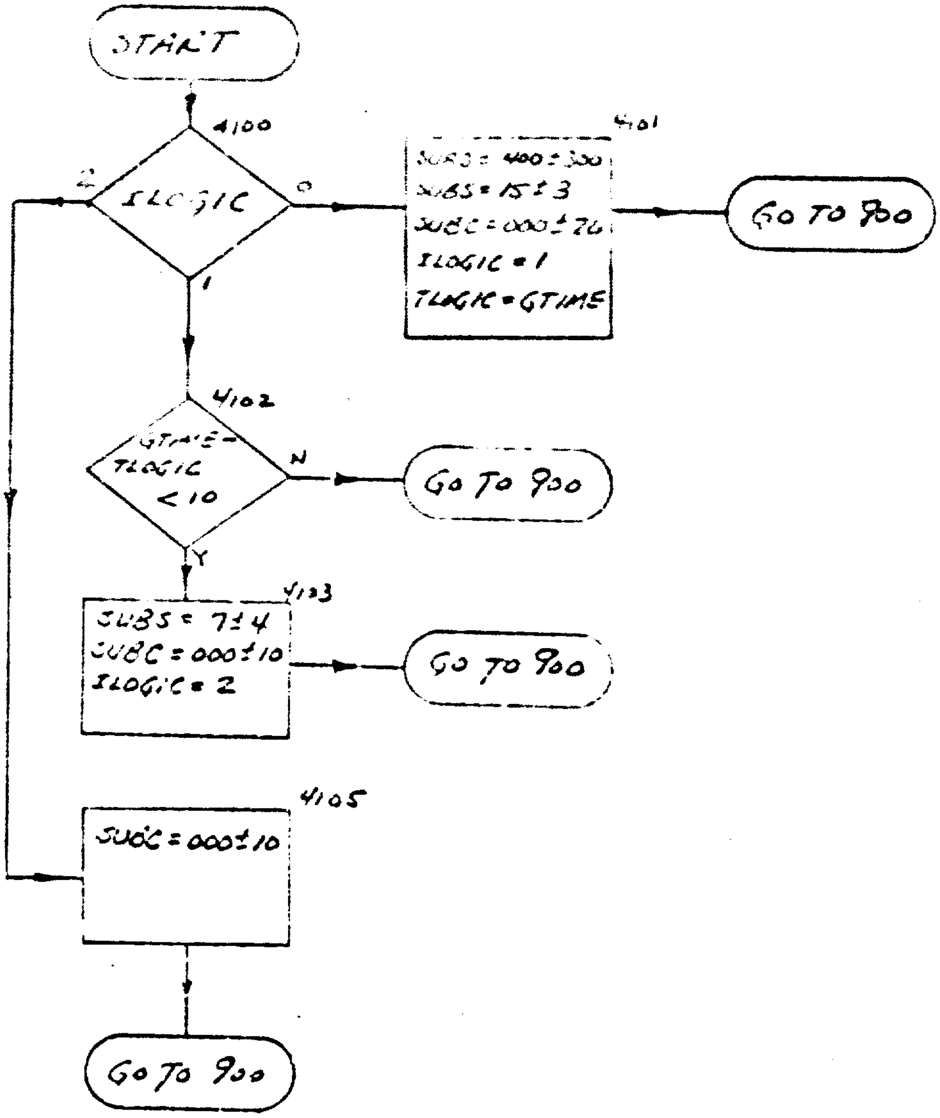
RADIATION MODEL



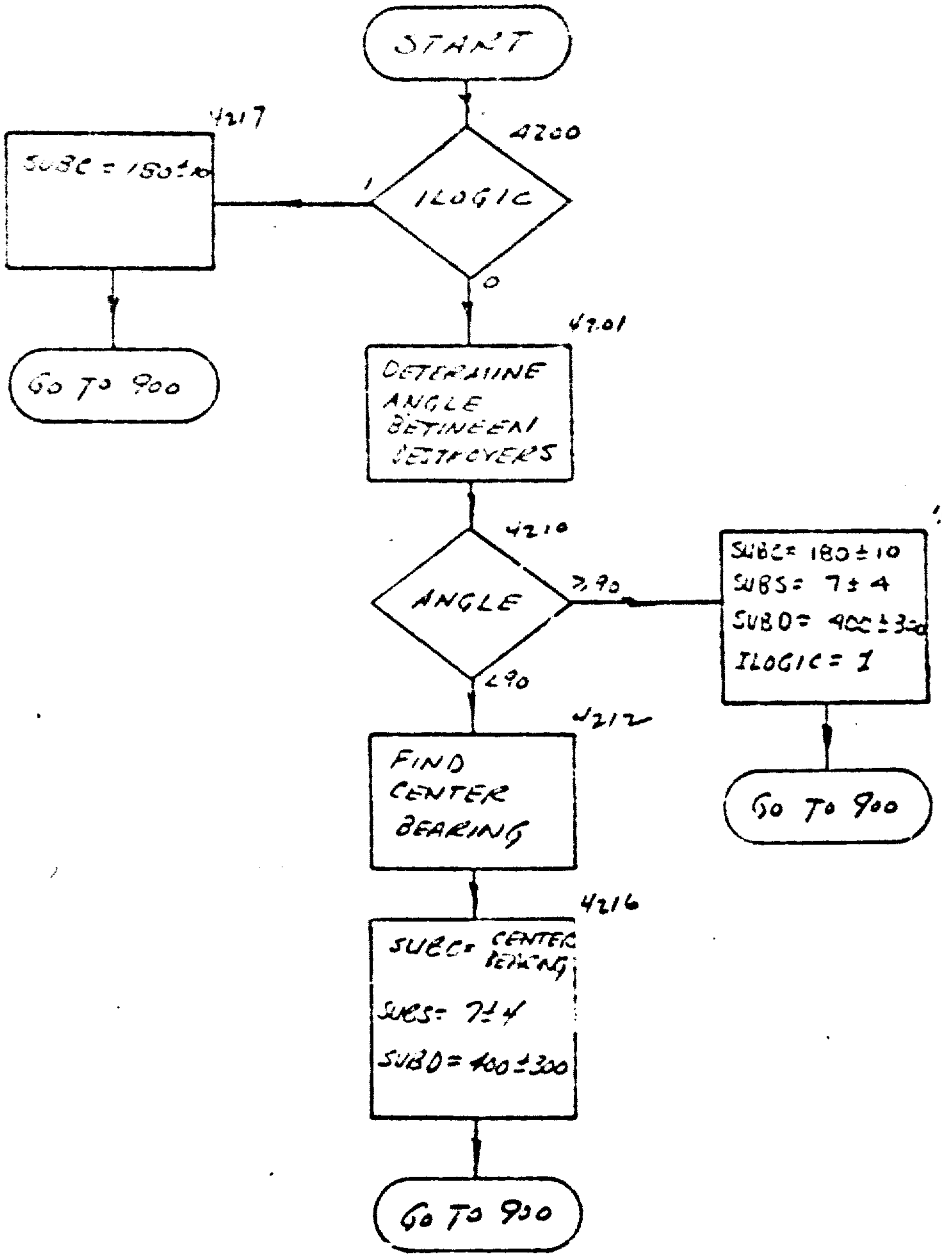
SUBMARINE LOGIC MODEL



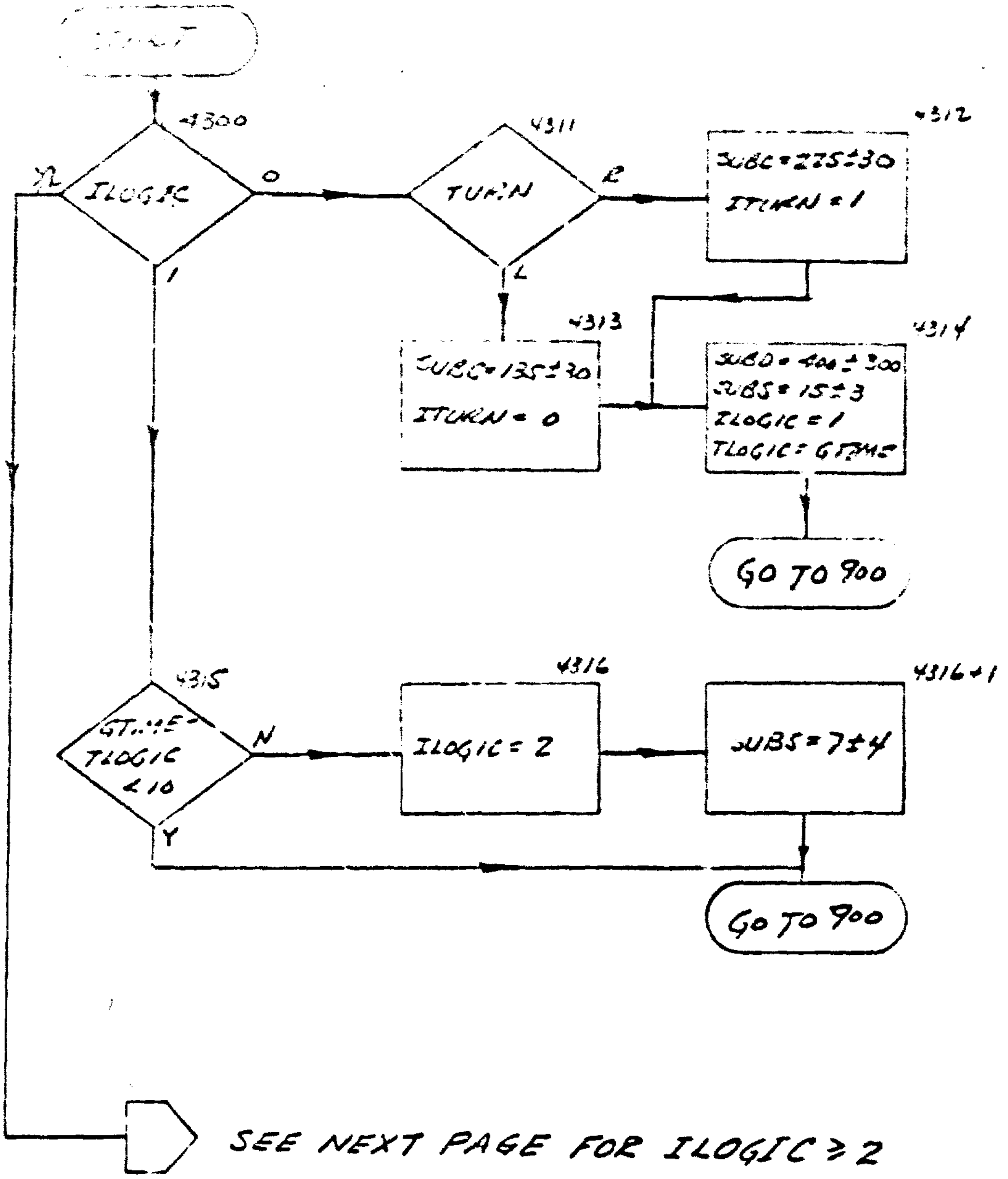
RUN FOR IT


START
4100
ILOGIC
2
0
1
4101
SUBR = 400±300
SUBS = 15±3
SUBC = 000±20
ILOGIC = 1
TLOGIC = GTIME
GO TO 900
4102
GTIME-
TLOGIC
< 10
N
Y
GO TO 900
4103
SUBS = 7±4
SUBC = 000±10
ILOGIC = 2
GO TO 900
4105
SUBC = 000±10
GO TO 900

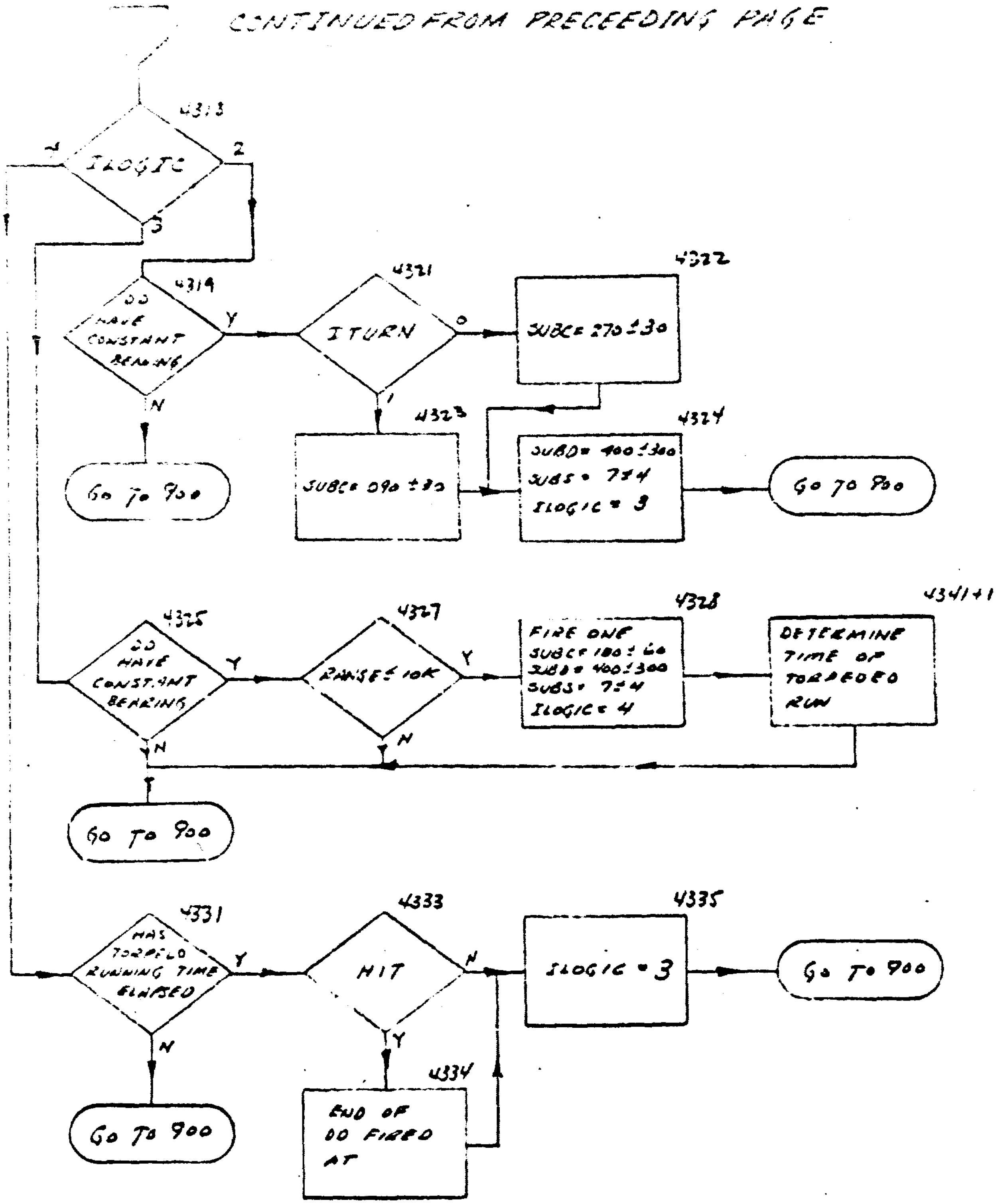
UP THE MIDDLE



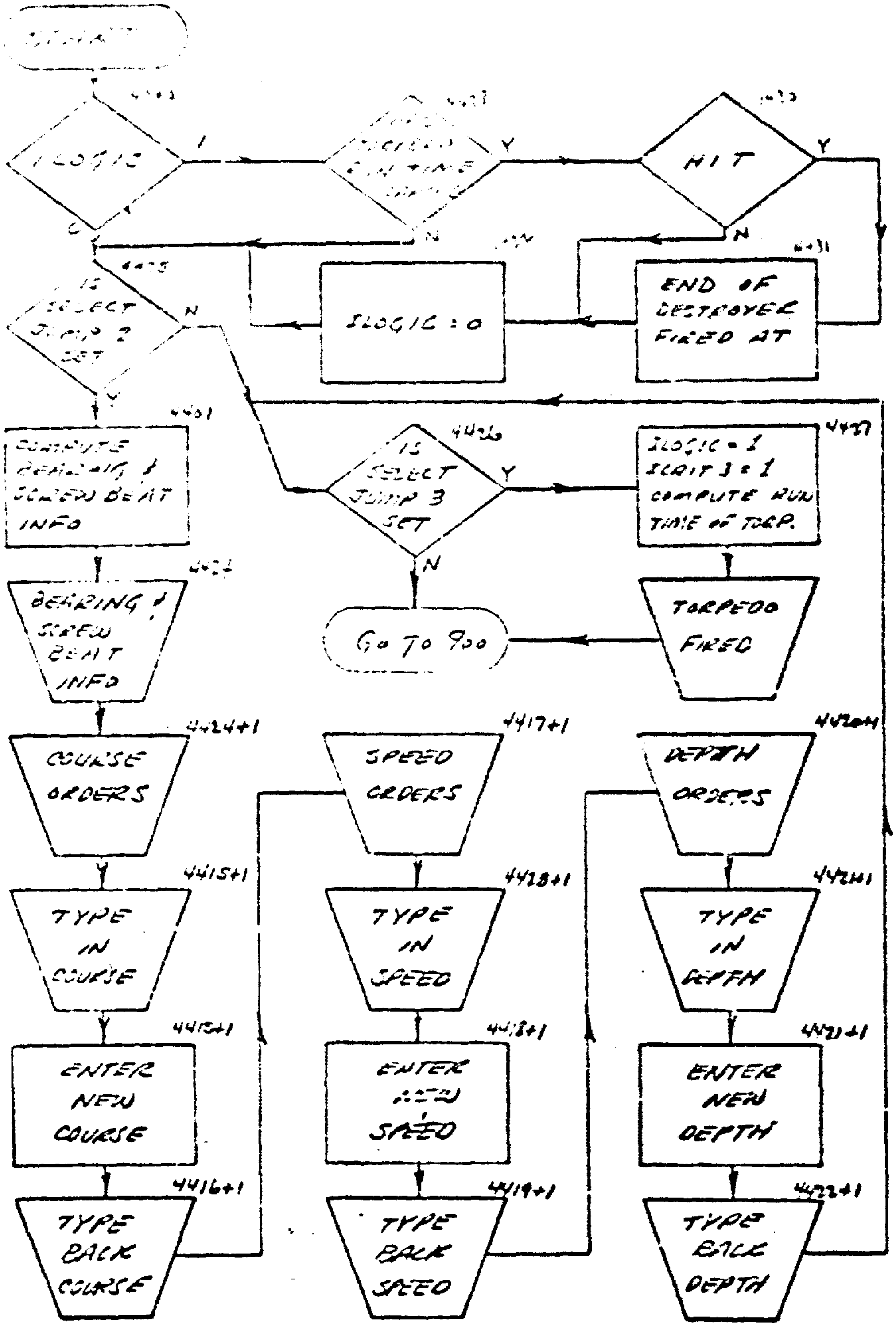
Reproduced From Best Available Copy


START
4300
ILOGIC
2
0
1
4311
TURN
R
L
4312
SUBC = 225 ± 30
ITURN = 1
4313
SUBC = 135 ± 30
ITURN = 0
4314
SUBD = 400 ± 300
SUBS = 15 ± 3
ILOGIC = 1
TLOGIC = GTIME
GO TO 900
4315
GTIME - TLOGIC < 10
N
Y
4316
ILOGIC = 2
4316+1
SUBS = 7 ± 4
GO TO 900
SEE NEXT PAGE FOR ILOGIC ≥ 2

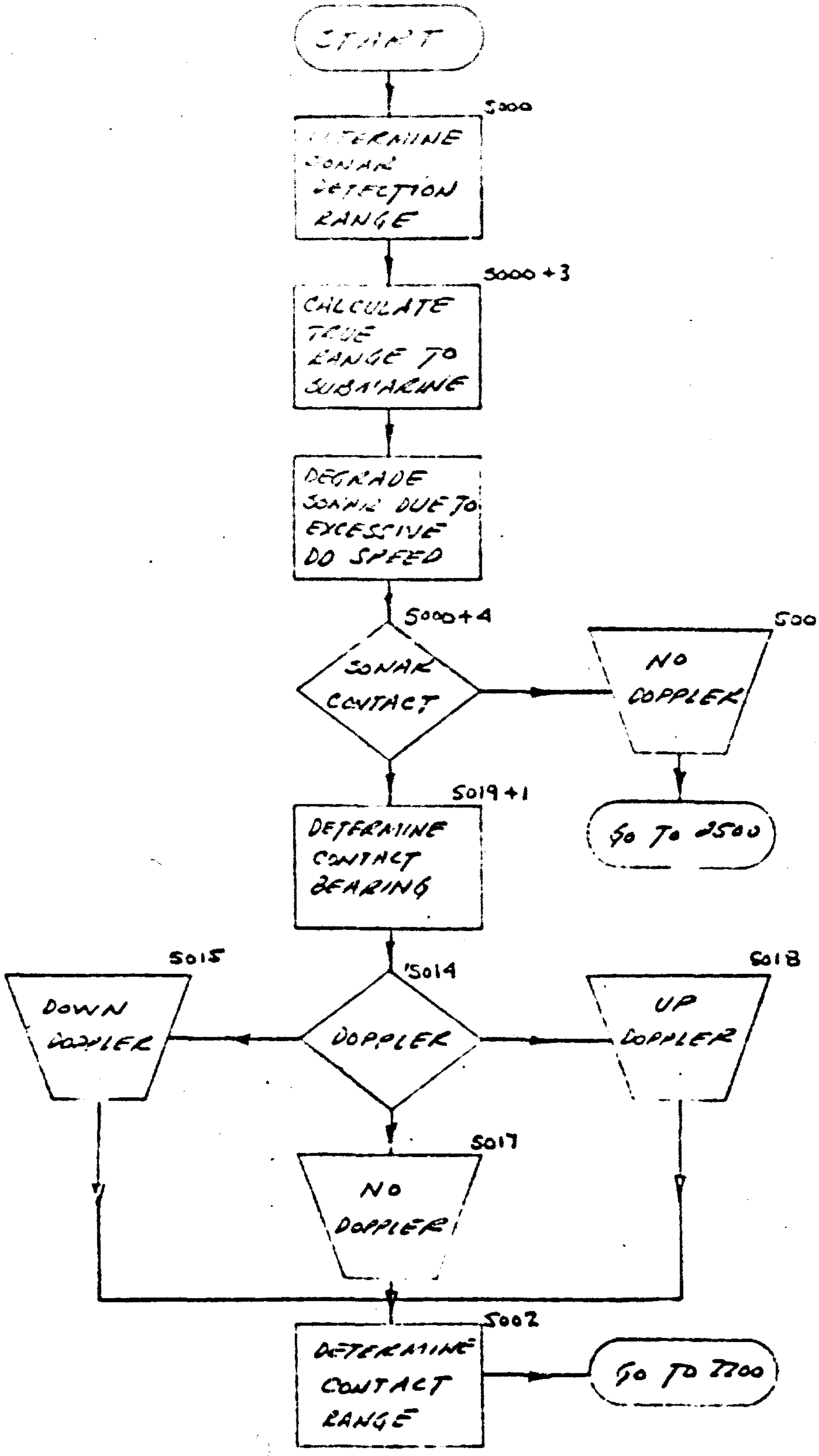
CONTINUED FROM PRECEEDING PAGE



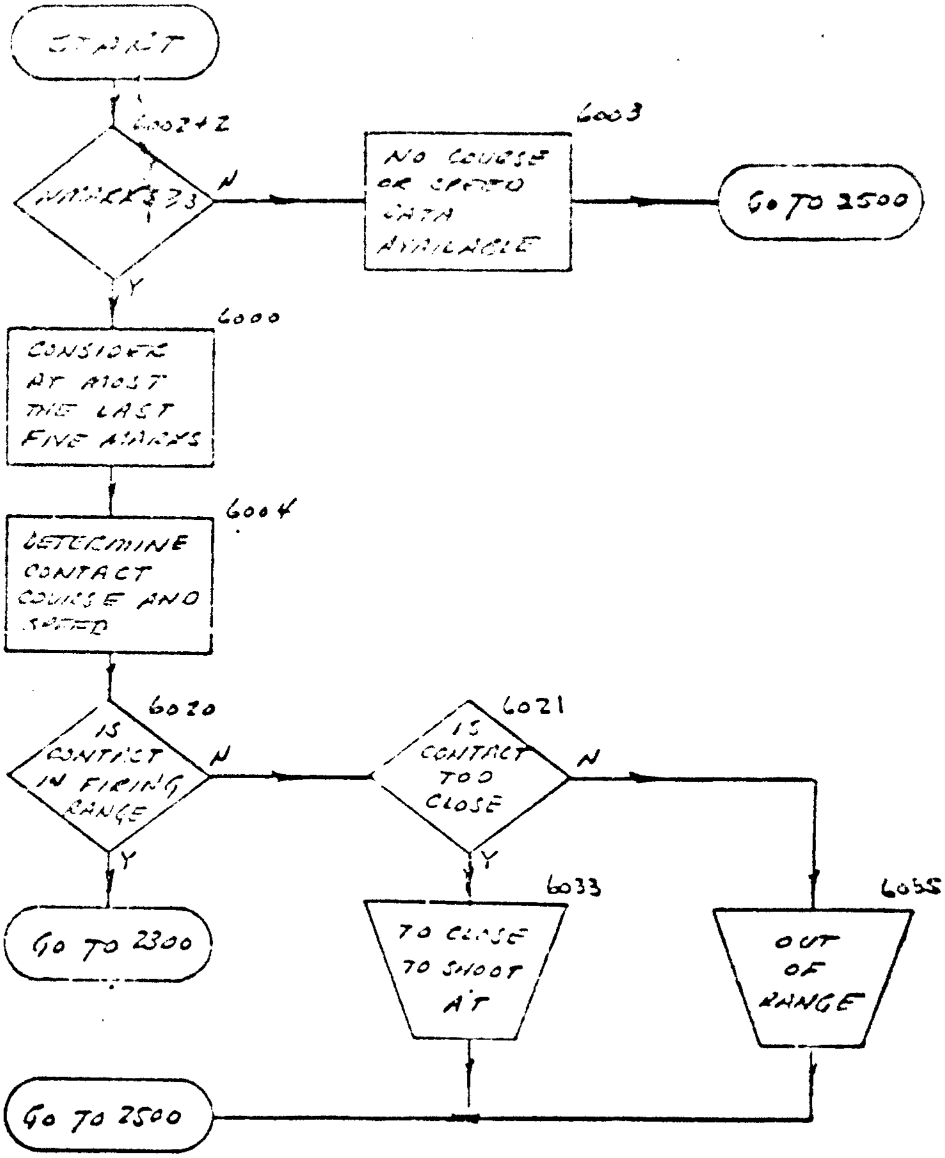
SUBMARINE TEAM CONTROL



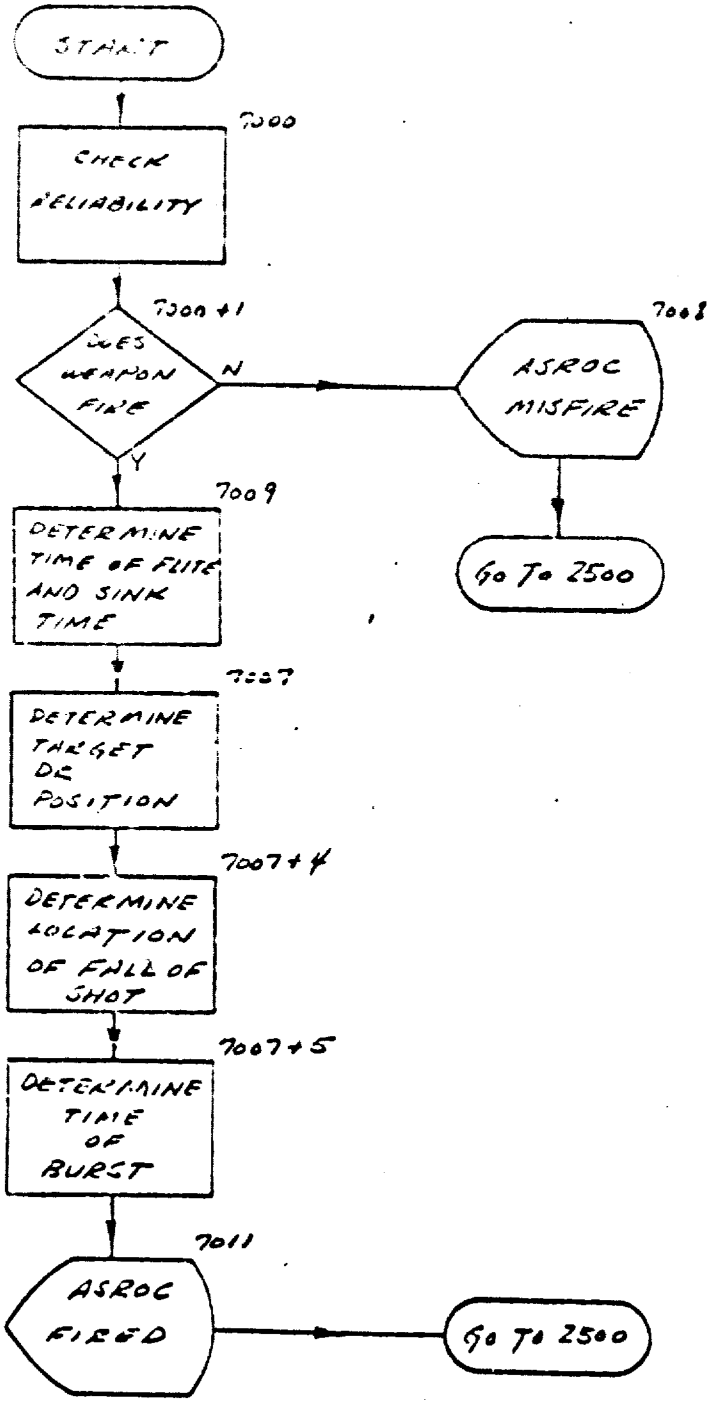
SONAR CONTACT MODEL



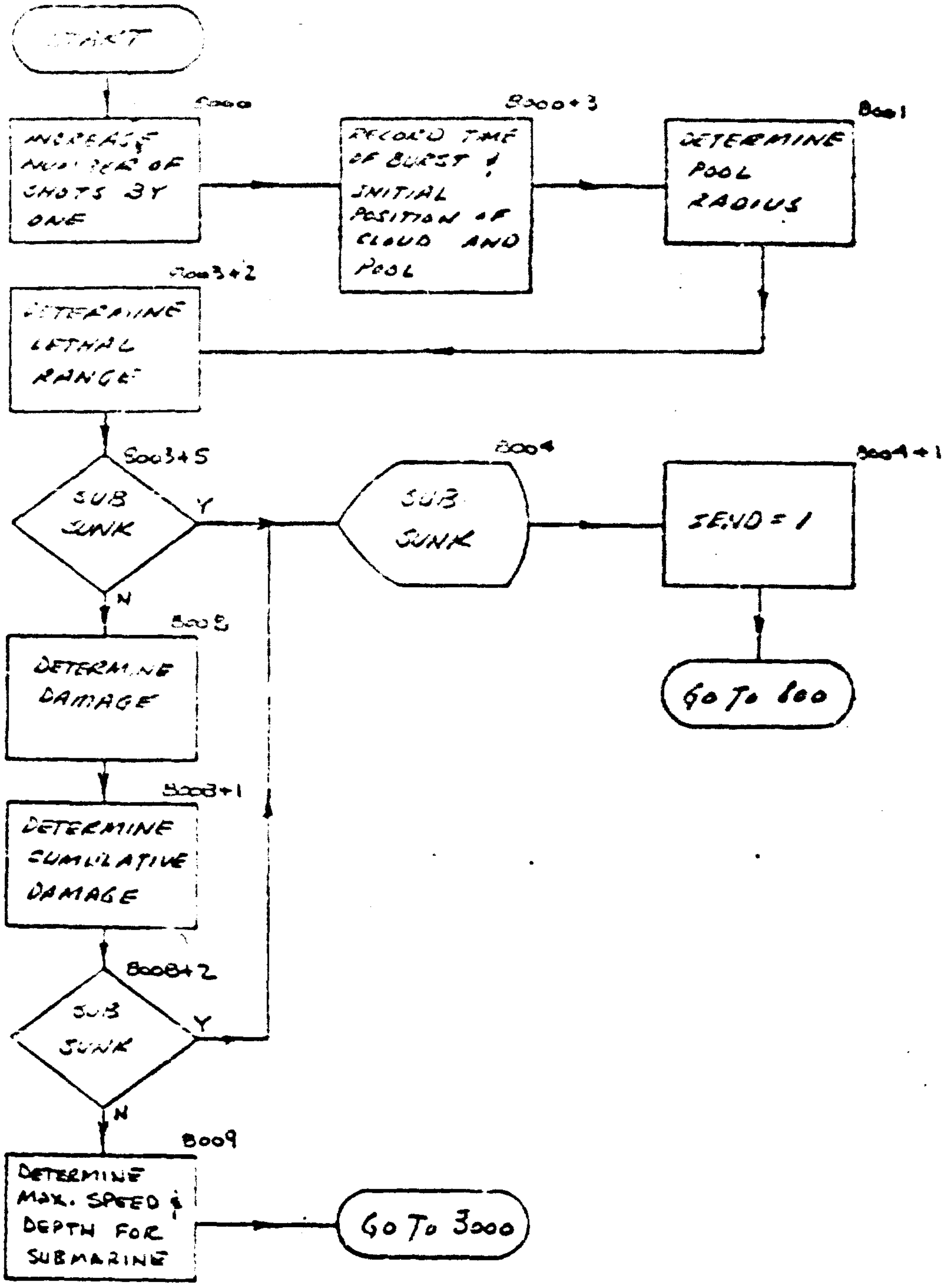
CONTACT TRACKING MODEL



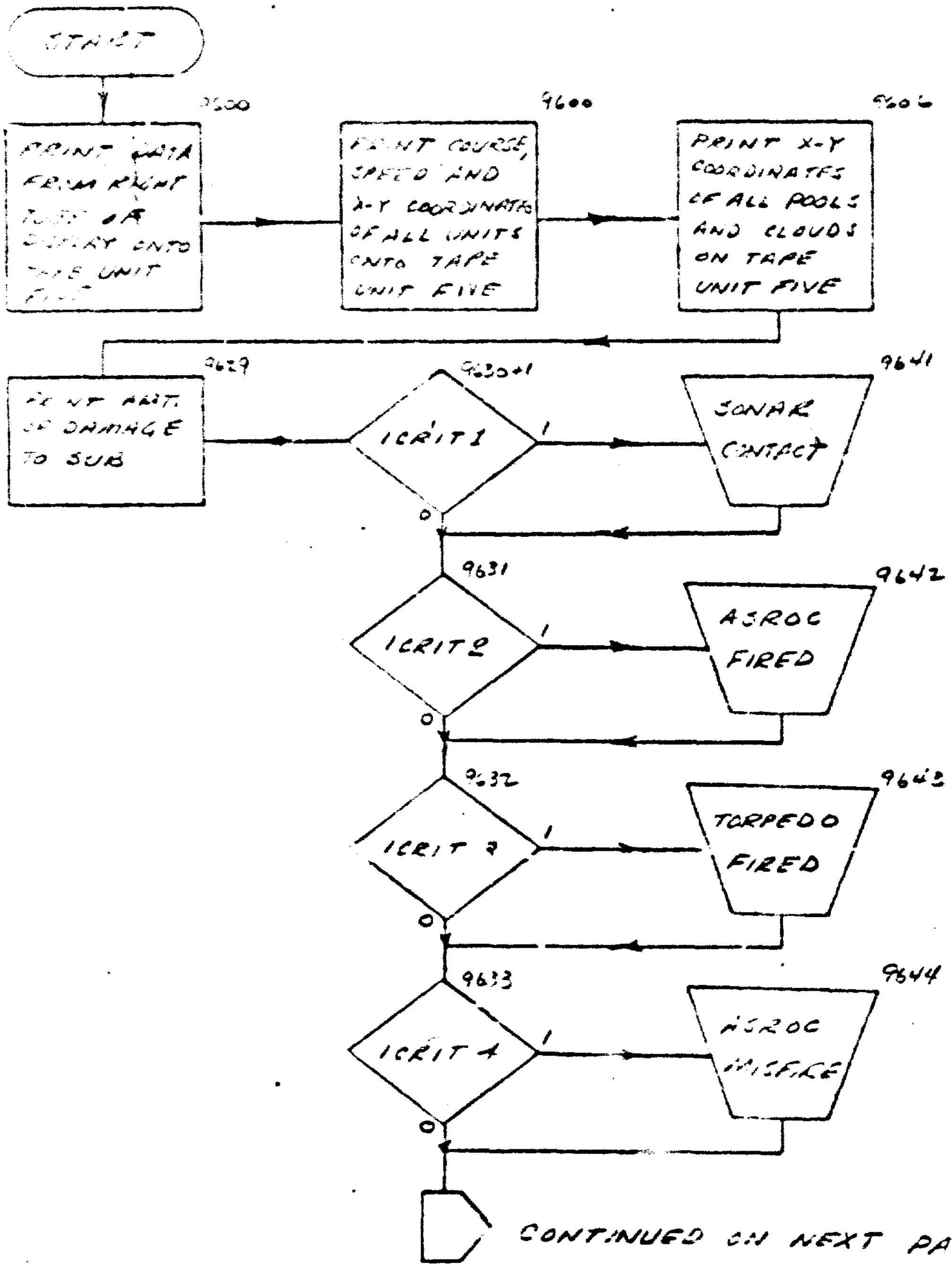
WEAPON FIRING MODEL



EVALUATION MODEL



CRITIQUE I



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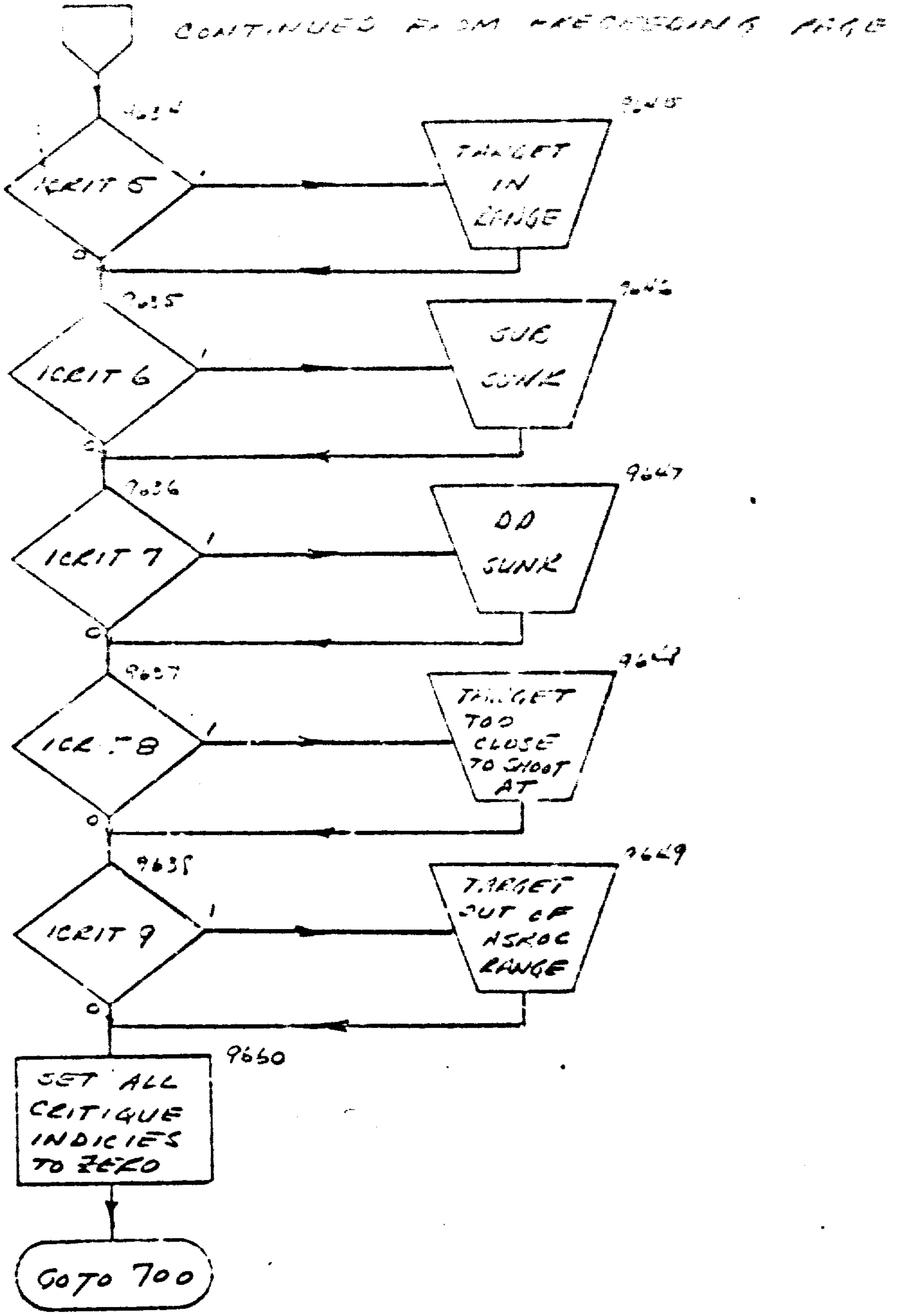
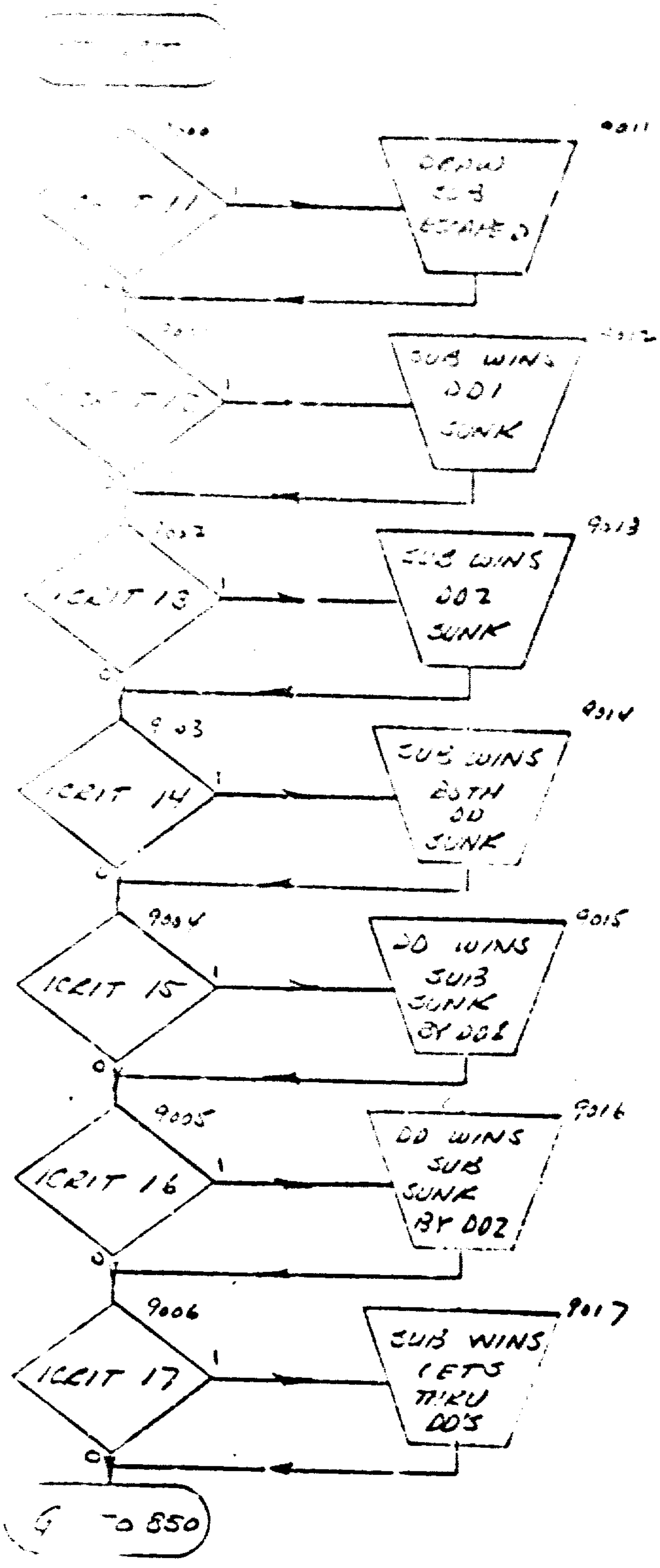

CONTINUED FROM PRECEDING PAGE
9634
ICRIT 5
1
0
9645
TARGET IN RANGE
9635
ICRIT 6
1
0
9646
SUB SUNK
9636
ICRIT 7
1
0
9647
DD SUNK
9637
ICRIT 8
1
0
9648
TARGET TOO CLOSE TO SHOOT AT
9638
ICRIT 9
1
0
9649
TARGET OUT OF ASROC RANGE
9650
SET ALL CRITIQUE INDICIES TO ZERO
GOTO 700

FIGURE II



9000
ICRIT 11
1
9011
DRAW
SUB
ESCAPED
9001
ICRIT 12
1
9012
SUB WINS
DD1
SUNK
9002
ICRIT 13
1
0
9013
SUB WINS
DD2
SUNK
9003
ICRIT 14
1
0
9014
SUB WINS
BOTH
DD
SUNK
9004
ICRIT 15
1
0
9015
DD WINS
SUB
SUNK
BY DD1
9005
ICRIT 16
1
0
9016
DD WINS
SUB
SUNK
BY DD2
9006
ICRIT 17
1
0
9017
SUB WINS
GETS
THRU
DD'S
GO TO 850

APPENDIX III

SUBROUTINES AND CDC 160 EXECUTIVE ROUTINE

This Appendix contains an explanation of the subroutines used in the main program and the CDC 160 executive routine used to connect the CDC 1604 with the DD 65 display. A listing of these subroutines can be found in Appendix IV.

SUBROUTINE RANVAR

Subroutine RANVAR is used as the basic random number generator. It generates random floating point numbers in the interval zero to one that are distributed uniformly in that interval. The random variables used in the main program are called from either UNIFORM, NORMAL or ERROR subroutines which in turn call RANVAR for input. The generator is a simple fixed point division utilizing the remainder from the Q register as the random number. This number is then mapped into the zero to one interval. Only one input is required to initialize this generator, namely IRANDOM.

SUBROUTINE UNIFORM

Subroutine UNIFORM is a three argument subroutine used to generate uniformly distributed random numbers in any interval. The arguments are:

1. The center of the interval.
2. The half width of the interval.
3. The output random number.

An example would be UNIFORM (5.0, 2.0, SUBS). This call would yield the variable SUBS, submarine speed, uniformly distributed in the interval with center at five knots and plus or minus two knots.

SUBROUTINE NORMAL

Subroutine NORMAL is a three argument subroutine used to generate normally distributed random numbers with any mean and standard deviation. This normal distribution is generated by means of the sum of identically distributed (uniform) random variables. Twelve uniform numbers are used because:

1. The truncation is not significant.
2. Twelve reduces the formula to a summation and no division is required.

The arguments to this subroutine are:

1. The mean of the distribution.
2. The sigma of the distribution.
3. The output random number.

SUBROUTINE ERROR

Subroutine ERROR is a five argument subroutine used to generate circular normal distributed random variables. This subroutine is used to determine the true fall of shot given the aiming point and CEP or sigma of the distribution of fall or shot. The arguments are:

1. The X-coordinate of the aim point.
2. The Y-coordinate of the aim point.
3. The sigma of the circular normal distribution.
4. The X-coordinate of the fall of shot.
5. The Y-coordinate of the fall of shot.

SUBROUTINE CIRCLE

Subroutine CIRCLE is used to generate a series of points, 24 in number, every 15 degrees around the perimeter of a circle of predetermined center and radius. The circle is then used in the formation of the circular clouds and pools of radiation displayed to the destroyer team. The arguments are:

1. The X-coordinate of the center of the circle with respect to the main coordinate syste-

2. The Y-coordinate of the center of the circle with respect to the main coordinate system.

3. The radius of the circle with respect to the main coordinate system.

4. The X-coordinate of the center of the display with respect to the main coordinate system.

5. The Y-coordinate of the center of the display with respect to the main coordinate system.

6. The radius of the displayed area.

7. A vector of X-coordinates of the 24 points in the circle with respect to the display coordinate system.

8. A vector of Y-coordinates of the 24 points in the circle with respect to the display coordinate system.

SUBROUTINE DCIRCLE

DCIRCLE is a subroutine used to transmit the circle coordinates, generated in subroutine CIRCLE, to the CDC 160 from the CDC 1604. The arguments to this subroutine are:

1. ITRKNO - the track of circle number by which this particular circle can be designated.

2. CHAR - a single letter or number in hollerith form that is to be displayed as one of the points in the circle

3. In the program MULNUC1 the letter c and p are used to distinguish between clouds and pools of radiation.

4. NUMPTS - the number of points in the circle.

5. IX - a vector of X-coordinates for the circle.

6. IY - a vector of Y-coordinates for the circle.

SUBROUTINE DTRACK

Subroutine DTRACK is used to transmit track data to the CDC 160 from the CDC 1604. This subroutine will send tracks of up to eight points to the CDC 160. The arguments to this subroutine are the same as those in DCIRCLE, in fact the two routines are identical with the exception of the allowable number of points.

SUBROUTINE DSTATUS

DSTATUS is a subroutine used to transmit information to the windows described in the section on Man Machine Interface. This information can be in two forms:

1. Program variables in fixed point form.
2. Messages in hollerith form.

The arguments are:

1. ITYPE - zero represents a numerical program variable is to be sent, while one indicates that an eight hollerith character word is to be sent.

2. NWIND - the number of the window to which the variable or word is to be sent.

3. IW - the field width of the variable.

4. INAME - the name of the variable to be transmitted.

5. IX - the X-coordinate of the lower left hand corner of the window.

6. IY - the Y-coordinate of the lower left hand corner of the window.

It should be noted that windows are 128 display coordinates units long. If a message in the form of words is to be sent to the display and it is longer than eight letters (the length of one window) it can be sent by means of more than one window. These windows should be displaced by 128 units in the X direction, thus the windows may form a continuous word of more than eight characters.

SUBROUTINE PARAMS

PARAMS is an eight argument subroutine used to query the CDC 160 as to the contents of eight selected windows. This subroutine allows the main program, in the CDC 1604, to enter changes that have been made to the windows of the display by the player. This is the only method the player has of communicating with the program without interrupting the play. The eight arguments to this subroutine are:

1A - the contents of window 5
2A - the contents of window 6
3A - the contents of window 7
4A - the contents of window 8
5A - the contents of window 9
6A - the contents of window 9
7A - the contents of window 16
8A - the numeric value of a location in the CDC 160 that is controlled by the DD1 FIRE and DD2 FIRE buttons.

APPENDIX IV

PROGRAM LISTING

This Appendix contains the computer program listing of the simulation MULMEC1. The program blocks are in numerical order and the logic can be followed by cross referencing this Appendix with Appendix I. In this program all classified input parameters have been assigned fictitious values so that the program, as presented in this thesis, could remain unclassified.

```
••JOB*444F•MCMICHAEL•D•L•
      PROGRAM MULNUC1                                                   MUL00010
C                                                                       MUL00020
C     IN RUNNING THIS PROGRAM THE PLAYER WILL HAVE THE OPTION
C
C     OF CHANGING THE FOLLOWING INPUT PARAMETERS.
C
C        YIELD       SIZE OF ASROC WARHEAD
C
C        AROCMAX     ASROC MAXIMUM RANGE
C
C        DOB         DEPTH OF BURST
C
C        TFACTOR     1 - REAL TIME 2 - DOUBLE TIME
C
C        GRAD        WATER TEMPERTURE GRADIENT
C
C        DDSMAX(1) DD1 MAXIMUM SPEED AVAILABLE
C
C        DDSMAX(2) DD2 MAXIMUM SPEED AVAILABLE
C
C        SUBSMAX     SUBS MAXIMUM SPEED AVAILABLE
C
C        NRANDOM     A RANDOM NUMBER TO START GAME
C
C        STRESS      YIELD STRESS OF THE SUBMARINE HULL
C
C        HULL        SUBMARINE HULL THICKNESS
C
C        DDX(1)      DD1 X-COORDINATE
C
C        DDX(2       DD2 X-COORDINATE
C
C        DDY(1)      DD1 Y-COORDINATE
C
C        DDY(2)      DD2 Y-COORDINATE
```

```
C
C         ISUB      0 - COMPUTER CONTROL  1 - SUB TEAM CONTROL
C
C         INITIAL   0 - SUB AT ORIGIN 1 - SUB POSIT RANDOM
C
C         ISTRAT    0 - RUN 1 - UP MIDDLE 2 - END RUN
C
C THESE PARAMETERS ARE SET TO NOMINAL INITIAL VALUES AND
C
C WILL BE DISPLAYED AS INPUT PARAMETERS.  IF A CHANGE OF THESE
C
C VALUES IS DESIRED IT CAN BE MADE AT THE TIME THE SCREEN
C
C DISPLAYS (VARIABLES ARE) AND A LIST OF VARIABLES.  AT THIS
C
C TIME  THE N-TH VARIABLE IN THE LIST CAN BE CHANGED BY
C
C TYPING A AND THE NUMBER N, AND THEN =, AND THE NEW VALUE OF
C
C THE SELECTED PARAMETER.  AS AN EXAMPLE IF THE THIRD
C
C VARIABLE IS TO BE CANGED TO 3.1 THE PLAYER WOULD TYPE
C
C A3=3.1 AND THEN DEPRESS THE OUTPUT BUTTON ON THE DD65.
C
C THE COMPUTE WILL THEN RETURN (OK) IF THE PARAMETER IS OF
C
C THE CORRECT FORM.  AFTER ALL CHANGES HAVE BEEN ENTERED
C
C THE PLAYER WILL TYPE END AND THE GAME WILL CONTINUE.
C
C HAVING ENTERED ALL PARAMETER CHANGES THE GAME WILL
C
C PROCEED AUTOMATICALLY.  THE PLAYER MAY THEN MANEUVER THE
C
C THE DESTROYERS BY THE PROCEEDURE OUTLINED IN THE SECTION
```

```
C
C OF THE THESIS TITLED MAN MACHINE INTERFACE.
      DIMENSION DDX(2),DDY(2),CONTR(2),CONTB(2),CONTC(2),CONTS(2),
     1          IDOPLER(2),MARKS(2),X(2,5),Y(2,5),DDC(2),DDS(2),
     2          NMARKS(2),DDB(2),CONTX(2),CONTY(2),SSB(2),DDSMAX(2),
     3          ICLASS(2),IDDC(2),RADRATE(2),RADDOSE(2),ISOL(2),
     4          SB(2),ICONTC(2),ICONTB(2),TBURST(10),CLOUDR(10),
     5          CLOUDX(10),CLOUDY(10),POOLX(10),POOLY(10),POOLR(10),
     6          DISTC(2,10),DISTP(2,10),TEMPCR(2,10),TEMPPR(2,10),
     7          IDDX(2),IDDY(2),IDDS(2),XDD(2,8),YDD(2,8),
     8          TXDD(2,8),TYDD(2,8),IXDD(2,8),IYDD(2,8),IXDD1(8),ZZY(3),
     9          IXDD2(8),IYDD1(8),IYDD2(8),XSUB(2,8),YSUB(2,8),ZZX(3)
      DIMENSION TXSUB(2,8),TYSUB(2,8),IXSUB(2,8),IYSUB(2,8),IXSUB1(8),
     1          IYSUB1(8),IXSUB2(8),IYSUB2(8),ICIRCX(24),ICIRCY(24)
      COMMON IRANDOM,RANDOM
C
C INPUTS 100
C
  100 NRDD=2
      TFACTOR=1.0
      EXF(1000B)
      DO 101 I=1,NRDD
  101 DDSMAX(I)=30.0
      SUBSMAX=20.0
      STRESS=50.0
      HULL=2.50
      SAFETY=.5
      DDX(1)=-5000.0
      DDY(1)=-20000.0
      DDX(2)=5000.0
      DDY(2)=-20000.0
      DDC(1)=010.0
      DDS(1)=15.0
      DDC(2)=010.0
      DDS(2)=15.0
      YIELD=2.0
```

```
      THERMO=120.0                                                      MUL00370
      AROCMAX=8000.0                                                    MUL00380
      DOB=700.0                                                         MUL00390
      SR=18.0                                                           MUL00400
      IRANDOM=574523                                                    MUL00410
      NRANDOM=300                                                       MUL00420
      ISUB=0                                                            MUL00430
      K=0                                                               MUL00440
      KGRAF=0                                                           MUL00450
      CALL UNIFORM(.5,.5,TEMP)                                          MUL00460
      IF(TEMP-.5)102,102,103                                            MUL00470
  102 INITIAL=0                                                         MUL00480
      GO TO 104                                                         MUL00490
  103 INITIAL=1                                                         MUL00500
  104 CONTINUE                                                          MUL00510
      CALL NORMAL(-.472,.096,GRAD)                                      MUL00520
      IF(GRAD+.37)106,105,105                                           MUL00530
  105 GRAD=-.37                                                         MUL00540
  106 CONTINUE                                                          MUL00550
      CALL UNIFORM(.5,.5,TEMP)                                          MUL00560
      IF(TEMP-.3)108,108,107                                            MUL00570
  107 IF(TEMP-.6)109,109,110                                            MUL00580
  108 ISTRAT=0                                                          MUL00590
      GO TO 111                                                         MUL00600
  109 ISTRAT=1                                                          MUL00610
      GO TO 111                                                         MUL00620
  110 ISTRAT=2                                                          MUL00630
  111 CONTINUE                                                          MUL00640
      GO TO 200                                                         MUL00650
C                                                                       MUL00660
C SET CONSTANTS 200                                                     MUL00670
C                                                                       MUL00680
  200 TSTEP=30.0/TFACTOR                                                MUL00690
      ISTEP=TSTEP                                                       MUL00700
      X0=100.0                                                          MUL00710
      Y0=100.0                                                          MUL00720
```

```
      R=25000.0                                                         MUL00730
      ILOGIC=0                                                          MUL00740
      DO 201 I=1,NRDD                                                   MUL00750
      RADRATE(I)=0.0                                                    MUL00760
      RADDOSE(I)=0.0                                                    MUL00770
      ISOL(I)=0                                                         MUL00780
      ICLASS(I)=0                                                       MUL00790
      NMARKS(I)=0                                                       MUL00800
  201 MARKS(I)=0                                                        MUL00810
      NEXT=0                                                            MUL00820
      GTIME=0.0                                                         MUL00830
      NSHOTS=0                                                          MUL00840
      NOSHOOT=0                                                         MUL00850
      DAMAGE=0.0                                                        MUL00860
      DAMAGET=0.0                                                       MUL00870
      TOB=0.0                                                           MUL00880
      B=0.0                                                             MUL00890
      NCONBER=0                                                         MUL00900
      IFIRE=0                                                           MUL00910
      NPTS=0                                                            MUL00920
      IEND=0                                                            MUL00930
      NZERO=-0                                                          MUL00940
      IONE=1                                                            MUL00950
      GO TO 300                                                         MUL00960
C                                                                       MUL00970
C INITIALIZE 300                                                        MUL00980
C                                                                       MUL00990
  300 DO 332 I=1,NRANDOM                                                MUL01000
  332 CALL RANVAR                                                       MUL01010
      IF(INITIAL)330,330,331                                            MUL01020
  330 SUBX=0.0                                                          MUL01030
      SUBY=0.0                                                          MUL01040
      SUBD=0.0                                                          MUL01050
      SUBC=180.0                                                        MUL01060
      SUBS=5.0                                                          MUL01070
      GO TO 333                                                         MUL01080
```

```
  331 CALL UNIFORM(5000.0-5000.0,SUBY)                                  MUL01090
      CALL UNIFORM(0.0,10000.0,SUBX)                                    MUL01100
      SUBD=300.0                                                        MUL01110
      SUBC=180.0                                                        MUL01120
      SUPS=5.0                                                          MUL01130
  333 CONTINUE                                                          MUL01140
      CRUSH=13.33*HULL-STRESS                                           MUL01150
      SUBDMAX=SAFETY*CRUSH                                              MUL01160
      CALL UNIFORM(180.0,179.9,WINDD)                                   MUL01170
      IWINDD=WINDD                                                      MUL01180
      CALL UNIFORM(15.0,15.0,WINDV)                                     MUL01190
      AROCMIN=1470.0*YIELD**.333                                        MUL01200
      ESR=33.3*SQRTF(-300.0/(GRAD*.05+.018))                            MUL01210
      IF(WINDV-3.0)301,301,302                                          MUL01220
  301 ISS=1                                                             MUL01230
      GO TO 313                                                         MUL01240
  302 IF(WINDV-6.0)303,303,304                                          MUL01250
  303 ISS=2                                                             MUL01260
      GO TO 313                                                         MUL01270
  304 IF(WINDV-10.0)305,305,306                                         MUL01280
  305 ISS=3                                                             MUL01290
      GO TO 313                                                         MUL01300
  306 IF(WINDV-16.0)307,307,308                                         MUL01310
  307 ISS=4                                                             MUL01320
      GO TO 313                                                         MUL01330
  308 IF(WINDV-21.0)309,309,310                                         MUL01340
  309 ISS=5                                                             MUL01350
      GO TO 313                                                         MUL01360
  310 IF(WINDV-27.0)311,311,312                                         MUL01370
  311 ISS=6                                                             MUL01380
      GO TO 313                                                         MUL01390
  312 ISS=7                                                             MUL01400
  313 CONTINUE                                                          MUL01410
      TEMP1=YIELD**.333                                                 MUL01420
      TEMP2=YIELD**.25                                                  MUL01430
      IF(DCB-75.0*TEMP1)316,314,314                                     MUL01440
```

```
314 IF(DOB-240.0*TEMP2)317,315,315                                      MUL01450
315 IF(DOB-600.0*TEMP2)318,319,319                                      MUL01460
316 IDEEP=1                                                             MUL01470
    GO TO 320                                                           MUL01480
317 IDEEP=2                                                             MUL01490
    GO TO 320                                                           MUL01500
318 IDEEP=3                                                             MUL01510
    GO TO 320                                                           MUL01520
319 IDEEP=4                                                             MUL01530
320 CONTINUE                                                            MUL01540
    DO 321 I=1,NRDD                                                     MUL01550
    DO 321 J=1,8                                                        MUL01560
    IXDD(I,J)=-0                                                        MUL01570
    IYDD(I,J)=-0                                                        MUL01580
    IXSUB(I,J)=-0                                                       MUL01590
321 IYSUB(I,J)=-0                                                       MUL01600
334 WRITE OUTPUT TAPE 5,335,NRDD,SUBSMAX,STRESS,HULL,SAFETY,YIELD,      MUL01610
   1THERMO,AROCMAX,DOB,SR,IRANDOM,NRANDOM,TFACTOR,ISUB,GRAD             MUL01620
335 FORMAT(6X,16HINPUT PARAMETERS/6X,24HNUMBER OF DESTROYERS ....,I3/  MUL01630
   16X,24HMAXIMUM SUB SPEED .......,F5.1,2X,5HKNOTS/6X,24HHULL YIELD STMUL01640
   2RESS .......,F5.1,2X,4HKPSI/6X,24HHULL THICKNESS ..........,F5.1,2X,MUL01650
   36HINCHES/6X,24HHULL SAFETY FACTOR ......,F5.1/6X,24HSIZE OF ASROC WMUL01660
   4ARHEAD ...,F5.1,2X,2HKT/6X,24HDEPTH OF THERMOCLINE ....,F5.1,2X,2HFTMUL01670
   5/6X,24HMAXIMUM RANGE OF ASROC ..,F7.1,1X,5HYARDS/6X,24HDEPTH OF BURMUL01680
   6ST ..........,F7.1,3H FT/6X,24HSINK RATE OF WARHEAD ....,F5.1,3X,6HFMUL01690
   7T/SEC/6X,24HIRANDOM .................,I8/6X,24HNRANDOM ...........MUL01700
   8.....,I4/6X,24HTIME FACTOR .............,F5.1/6X,24HISUB ..........MUL01710
   9.........,I3/6X,24HWATER TEMP GRADIENT .....,F6.3,10H DEG/100FT)   MUL01720
346 WRITE OUTPUT TAPE 5,347,SUBDMAX,ISTRAT                              MUL01730
347 FORMAT(6X,24HMAXIMUM SUB DEPTH .......,F6.1,5H FEET/6X,24HISTRAT ..MUL01740
   1...............,I3)                                                 MUL01750
336 DO 337 I=1,2                                                        MUL01760
    DO 337 J=1,8                                                        MUL01770
    XDD(I,J)=-0.0                                                       MUL01780
337 YDD(I,J)=-0.0                                                       MUL01790
338 DO 339 I=1,2                                                        MUL01800
```

```
      DO 339 J=1,8                                                      MUL01810
      XSUB(I,J)=-0.0                                                    MUL01820
  339 YSUB(I,J)=-0.0                                                    MUL01830
  340 IF(ISUB)343,343,341                                               MUL01840
  341 WRITE OUTPUT TAPE 9,342,NRDD,SUBSMAX,STRESS,HULL,SAFETY,THERMO,   MUL01850
     1TFACTOR,GRAD,SUBDMAX                                              MUL01860
  342 FORMAT(6X,16HINPUT PARAMETERS/6X,24HNUMBER OF DESTROYERS ....,I3/ MUL01870
     16X,24HMAXIMUM SUB SPEED .......,F5.1,2X,5HKNOTS/6X,24HHULL YIELD STMUL01880
     2RESS .......,F5.1,2X,4HKPSI/6X,24HHULL THICKNESS ..........,F5.1,2X,MUL01890
     36HINCHES/6X,24HDEPTH OF THERMOCLINE ....,F5.1,4H  FT/             MUL01900
     46X,24HTIME FACTOR ............,F5.1/6X,24HWATER TEMP GRADIENT ....MUL01910
     5,F6.3,10H DEG/100FT/6X,24HMAXIMUM SUB DEPTH .......,F6.1,5H FEET) MUL01920
  343 CONTINUE                                                          MUL01930
  344 PRINT 345,NRDD,YIELD,THERMO,AROCMAX,DOB,SR,TFACTOR,GRAD           MUL01940
  345 FORMAT(6X,16HINPUT PARAMETERS/6X,24HNUMBER OF DESTROYERS ....,I3/ MUL01950
     16X,24HSIZE OF ASROC WARHEAD ...,F5.1,4H  KT/6X,24HDEPTH OF THERMOCLMUL01960
     2INE ....,F5.1,4H  FT/6X,24HMAXIMUM RANGE OF ASROC ..,F7.1,6H YARDS/ MUL01970
     36X,24HDEPTH OF BURST ..........,F7.1,3H FT/6X,24HSINK RATE OF WARHEMUL01980
     4AD ....,F5.1,9H   FT/SEC/6X,24HTIME FACTOR ............,F5.1/6X,24HMUL01990
     5WATER TEMP GRADIENT .....,F6.3,10H DEG/100FT///////)              MUL02000
      GO TO 950                                                         MUL02010
C                                                                       MUL02020
C PLOT POSTIONS 400                                                     MUL02030
C                                                                       MUL02040
  400 DO 401 I=IONE,NRDD                                                MUL02050
      IDDX(I)=DDX(I)/100.0                                              MUL02060
      IDDY(I)=DDY(I)/100.0                                              MUL02070
      IDDC(I)=DDC(I)                                                    MUL02080
  401 IDDS(I)=DDS(I)                                                    MUL02090
      IX0=X0/100.0                                                      MUL02100
      IY0=Y0/100.0                                                      MUL02110
      IR=R/1000.0                                                       MUL02120
      CALL DSTATUS(0,1,8,IDDX(1),-200,200)                              MUL02130
      CALL DSTATUS(0,2,8,IDDX(2),136,200)                               MUL02140
      CALL DSTATUS(0,3,8,IDDY(1),-200,176)                              MUL02150
      CALL DSTATUS(0,4,8,IDDY(2),136,176)                               MUL02160
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      CALL DSTATUS(0,5,3,IDDC(1),-200,-176)                             MUL02170
      CALL DSTATUS(0,6,2,IDDS(1),-200,-200)                             MUL02180
      CALL DSTATUS(0,7,3,IDDC(2),136,-176)                              MUL02190
      CALL DSTATUS(0,8,2,IDDS(2),136,-200)                              MUL02200
      CALL DSTATUS(0,9,8,IX0,-32,200)                                   MUL02210
      CALL DSTATUS(0,10,8,IY0,-32,176)                                  MUL02220
      CALL DSTATUS(0,11,8,NZERO,-254,0)                                 MUL02230
      CALL DSTATUS(0,12,8,NZERO,-126,0)                                 MUL02240
      CALL DSTATUS(0,13,8,NZERO,2,0)                                    MUL02250
      CALL DSTATUS(0,14,8,NZERO,130,0)                                  MUL02260
      CALL DSTATUS(0,15,8,NZERO,-32,-176)                               MUL02270
      CALL DSTATUS(0,16,8,IR,-32,-200)                                  MUL02280
      IF(NPTS-8)402,433,434                                             MUL02290
  402 NPTS=NPTS+1                                                       MUL02300
      GO TO 433                                                         MUL02310
  434 NPTS=8                                                            MUL02320
  433 DO 404 I=IONE,NRDD                                                MUL02330
      DO 403 J=1,7                                                      MUL02340
      XDD(I,9-J)=XDD(I,8-J)                                             MUL02350
  403 YDD(I,9-J)=YDD(I,8-J)                                             MUL02360
      XDD(I,1)=DDX(I)                                                   MUL02370
  404 YDD(I,1)=DDY(I)                                                   MUL02380
      DO 408 I=IONE,NRDD                                                MUL02390
      DO 408 J=1,NPTS                                                   MUL02400
      TXDD(I,J)=XDD(I,J)-X0                                             MUL02410
      TYDD(I,J)=YDD(I,J)-Y0                                             MUL02420
      IXDD(I,J)=TXDD(I,J)*255.0/R                                       MUL02430
      IYDD(I,J)=TYDD(I,J)*255.0/R                                       MUL02440
      IF(XABSF(IXDD(I,J))-255)406,406,405                               MUL02450
  405 IXDD(I,J)=-0                                                      MUL02460
  406 IF(XABSF(IYDD(I,J))-255)408,408,407                               MUL02470
  407 IYDD(I,J)=-0                                                      MUL02480
  408 CONTINUE                                                          MUL02490
      DO 409 I=1,NPTS                                                   MUL02500
      IXDD1(I)=IXDD(1,I)                                                MUL02510
      IXDD2(I)=IXDD(2,I)                                                MUL02520
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      IYDD1(I)=IYDD(1,I)                                                MUL02530
  409 IYDD2(I)=IYDD(2,I)                                                MUL02540
      IT=8H1                                                            MUL02550
      CALL DTRACK(1,IT,NPTS,IXDD1,IYDD1)                                MUL02560
      IT=8H2                                                            MUL02570
      CALL DTRACK(2,IT,NPTS,IXDD2,IYDD2)                                MUL02580
  410 IF(NMARKS(1))411,411,412                                          MUL02590
  411 NA=2                                                              MUL02600
      GO TO 413                                                         MUL02610
  412 NA=1                                                              MUL02620
  413 IF(NMARKS(2))414,414,415                                          MUL02630
  414 NB=1                                                              MUL02640
      GO TO 416                                                         MUL02650
  415 NB=2                                                              MUL02660
  416 IF(NB-NA)425,417,417                                              MUL02670
  417 DO 419 I=NA,NB                                                    MUL02680
      DO 418 J=1,7                                                      MUL02690
      XSUB(I,9-J)=XSUB(I,8-J)                                           MUL02700
  418 YSUB(I,9-J)=YSUB(I,8-J)                                           MUL02710
      XSUB(I,1)=CONTX(I)                                                MUL02720
  419 YSUB(I,1)=CONTY(I)                                                MUL02730
      DO 423 I=NA,NB                                                    MUL02740
      DO 423 J=1,8                                                      MUL02750
      TXSUB(I,J)=XSUB(I,J)-X0                                           MUL02760
      TYSUB(I,J)=YSUB(I,J)-Y0                                           MUL02770
      IXSUB(I,J)=TXSUB(I,J)*255.0/R                                     MUL02780
      IYSUB(I,J)=TYSUB(I,J)*255.0/R                                     MUL02790
      IF(XABSF(IXSUB(I,J))-255)421,421,420                              MUL02800
  420 IXSUB(I,J)=-0                                                     MUL02810
  421 IF(XABSF(IYSUB(I,J))-255)423,423,422                              MUL02820
  422 IYSUB(I,J)=-0                                                     MUL02830
  423 CONTINUE                                                          MUL02840
      DO 424 I=1,8                                                      MUL02850
      IXSUB1(I)=IXSUB(1,I)                                              MUL02860
  424 IYSUB1(I)=IYSUB(1,I)                                              MUL02870
      DO 432 I=1,8                                                      MUL02880
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      IXSUB2(I)=IXSUB(2,I)                                              MUL02890
  432 IYSUB2(I)=IYSUB(2,I)                                              MUL02900
      GO TO 427                                                         MUL02910
  425 DO 426 I=1,8                                                      MUL02920
      IXSUB1(I)=-0                                                      MUL02930
      IYSUB1(I)=-0                                                      MUL02940
      IXSUB2(I)=-0                                                      MUL02950
  426 IYSUB2(I)=-0                                                      MUL02960
  427 IT=8HX                                                            MUL02970
      CALL DTRACK(3,IT,8,IXSUB1,IYSUB1)                                 MUL02980
      IT=8HX                                                            MUL02990
      CALL DTRACK(4,IT,8,IXSUB2,IYSUB2)                                 MUL03000
      CONTINUE                                                          MUL03010
      IF(NSHOTS)431,431,428                                             MUL03020
  428 DO 429 I=1,NSHOTS                                                 MUL03030
      CALL CIRCLE(CLOUDX(I),CLOUDY(I),CLOUDR(I),X0,Y0,R,ICIRCX,ICIRCY)  MUL03040
      IT=8HC                                                            MUL03050
  429 CALL DCIRCLE(I,IT,24,ICIRCX,ICIRCY)                               MUL03060
      DO 430 I=1,NSHOTS                                                 MUL03070
      CALL CIRCLE(POOLX(I),POOLY(I),POOLR(I),X0,Y0,R,ICIRCX,ICIRCY)     MUL03080
      IPLUS=I+NSHOTS                                                    MUL03090
      IT=8HP                                                            MUL03100
  430 CALL DCIRCLE(IPLUS,IT,24,ICIRCX,ICIRCY)                           MUL03110
  431 CONTINUE                                                          MUL03120
      GO TO 500                                                         MUL03130
C                                                                       MUL03140
C DISPLAY DATA 500                                                      MUL03150
C                                                                       MUL03160
  500 IF(MARKS(1)) 502,502,504                                          MUL03170
  502 IF(MARKS(2)) 511,511,503                                          MUL03180
  503 IF(MARKS(2)-3)512,513,513                                         MUL03190
  504 IF(MARKS(2)) 505,505,506                                          MUL03200
  505 IF(MARKS(1)-3) 515,514,514                                        MUL03210
  506 IF(MARKS(1)-3)508,507,507                                         MUL03220
  5C7 IF(MARKS(2)-3)517,516,516                                         MUL03230
  508 IF(MARKS(2)-3)519,518,518                                         MUL03240
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511 PRINT 521,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(I),I=1,NRDD),  MUL03250
   1(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)                       MUL03260
    GO TO 599                                                         MUL03270
512 PRINT 522,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(I),I=1,NRDD),  MUL03280
   1ICLASS(2),CONTR(2),ICONTB(2),IDOPLER(2),                          MUL03290
   2(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)                       MUL03300
    GO TO 599                                                         MUL03310
513 PRINT 523,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(I),I=1,NRDD),  MUL03320
   1ICLASS(2),CONTR(2),ICONTB(2),IDOPLER(2),                          MUL03330
   2ICONTC(2),CONTS(2),ISOL(2),                                       MUL03340
   3(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)                       MUL03350
    GO TO 599                                                         MUL03360
514 PRINT 524,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(I),I=1,NRDD),  MUL03370
   1ICLASS(1),CONTR(1),ICONTB(1),IDOPLER(1),                          MUL03380
   2ICONTC(1),CONTS(1),ISOL(1),                                       MUL03390
   3(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)                       MUL03400
    GO TO 599                                                         MUL03410
515 PRINT 525,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(I),I=1,NRDD),  MUL03420
   1ICLASS(1),CONTR(1),ICONTB(1),IDOPLER(1),                          MUL03430
   2(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)                       MUL03440
    GO TO 599                                                         MUL03450
516 PRINT 526,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(I),I=1,NRDD),  MUL03460
   1(ICLASS(I),I=1,NRDD),(CONTR(I),I=1,NRDD),(ICONTB(I),I=1,NRDD),    MUL03470
   2(IDOPLER(I),I=1,NRDD),                                            MUL03480
   3(ICONTC(I),I=1,NRDD),(CONTS(I),I=1,NRDD),(ISOL(I),I=1,NRDD),      MUL03490
   4(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)                       MUL03500
    GO TO 599                                                         MUL03510
517 PRINT 527,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(I),I=1,NRDD),  MUL03520
   1(ICLASS(I),I=1,NRDD),(CONTR(I),I=1,NRDD),(ICONTB(I),I=1,NRDD),    MUL03530
   2(IDOPLER(I),I=1,NRDD),                                            MUL03540
   3ICONTC(1),CONTS(1),ISOL(1),                                       MUL03550
   4(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)                       MUL03560
    GO TO 599                                                         MUL03570
518 PRINT 528,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(I),I=1,NRDD),  MUL03580
   1(ICLASS(I),I=1,NRDD),(CONTR(I),I=1,NRDD),(ICONTB(I),I=1,NRDD),    MUL03590
   2(IDOPLER(I),I=1,NRDD),                                            MUL03600
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     3ICONTC(2),CONTS(2),ISOL(2),                                       MUL03610
     4(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)                       MUL03620
      GO TO 599                                                         MUL03630
  519 PRINT 529,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(I),I=1,NRDD),  MUL03640
     1(ICLASS(I),I=1,NRDD),(CONTR(I),I=1,NRDD),(ICONTB(I),I=1,NRDD),    MUL03650
     2(IDOPLER(I),I=1,NRDD),                                            MUL03660
     3(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)                       MUL03670
      GO TO 599                                                         MUL03680
  521 FORMAT(     5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL03690
     1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,         MUL03700
     212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL03710
     35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                            MUL03720
     45X,13HCONTACT CLASS/5X,11HSONAR RANGE/5X,13HSONAR BEARING/5X,     MUL03730
     57HDOPPLER/5X,13HTARGET COURSE/5X,12HTARGET SPEED/5X,15HFIRING SOLUMUL03740
     6TION/5X,14HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,   MUL03750
     75X,F5.0,6X,F5.0//)                                                MUL03760
  522 FORMAT(     5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL03770
     1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,         MUL03780
     212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL03790
     35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                            MUL03800
     45X,13HCONTACT CLASS,20X,I1/5X,11HSONAR RANGE,18X,F6.0/5X,13HSONAR MUL03810
     5BEARING,18X,I3/5X,7HDOPPLER,26X,I1/5X,13HTARGET COURSE/5X,        MUL03820
     612HTARGET SPEED/5X,15HFIRING SOLUTION/5X,                         MUL03830
     714HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,   MUL03840
     86X,F5.0//)                                                        MUL03850
  523 FORMAT(     5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL03860
     1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,         MUL03870
     212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL03880
     35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                            MUL03890
     45X,13HCONTACT CLASS,20X,I1/5X,11HSONAR RANGE,18X,F6.0/5X,13HSONAR MUL03900
     5BEARING,18X,I3/5X,7HDOPPLER,26X,I1/5X,13HTARGET COURSE,18X,I3/5X, MUL03910
     612HTARGET SPEED,20X,F3.0/5X,15HFIRING SOLUTION,18X,I1/5X,         MUL03920
     714HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,   MUL03930
     86X,F5.0//)                                                        MUL03940
  524 FORMAT(     5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL03950
     1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,         MUL03960
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     212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL03970
     35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                            MUL03980
     45X,13HCONTACT CLASS, 9X,I1/5X,11HSONAR RANGE, 7X,F6.0/5X,13HSONAR MUL03990
     5BEARING, 7X,I3/5X,7HDOPPLER,15X,I1/5X,13HTARGET COURSE, 7X,I3/5X, MUL04000
     612HTARGET SPEED, 9X,F3.0/5X,15HFIRING SOLUTION, 7X,I1/5X,         MUL04010
     714HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,   MUL04020
     86X,F5.0//)                                                        MUL04030
 525 FORMAT(    5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL04040
     1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,         MUL04050
     212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL04060
     35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                            MUL04070
     45X,13HCONTACT CLASS, 9X,I1/5X,11HSONAR RANGE, 7X,F6.0/5X,13HSONAR MUL04080
     5BEARING, 7X,I3/5X,7HDOPPLER,15X,I1/5X,13HTARGET COURSE/5X,        MUL04090
     612HTARGET SPEED/5X,15HFIRING SOLUTION/5X,                         MUL04100
     714HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,   MUL04110
     86X,F5.0//)                                                        MUL04120
 526 FORMAT(    5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL04130
     1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,         MUL04140
     212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL04150
     35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                            MUL04160
     45X,13HCONTACT CLASS,9X,I1,10X,I1/5X,11HSONAR RANGE,7X,F6.0,5X,F6.0MUL04170
     5/5X,13HSONAR BEARING,7X,I3,8X,I3/5X,7HDOPPLER,15X,I1,10X,I1/      MUL04180
     65X,13HTARGET COURSE,7X,I3,8X,I3/5X,12HTARGET SPEED,9X,F3.0,8X,F3.0MUL04190
     7/5X,15HFIRING SOLUTION,7X,I1,10X,I1/5X,                           MUL04200
     814HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,   MUL04210
     96X,F5.0//)                                                        MUL04220
 527 FORMAT(    5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL04230
     1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,         MUL04240
     212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL04250
     35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                            MUL04260
     45X,13HCONTACT CLASS,9X,I1,10X,I1/5X,11HSONAR RANGE,7X,F6.0,5X,F6.0MUL04270
     5/5X,13HSONAR BEARING,7X,I3,8X,I3/5X,7HDOPPLER,15X,I1,10X,I1/      MUL04280
     65X,13HTARGET COURSE,7X,I3/5X,12HTARGET SPEED,9X,F3.0              MUL04290
     7/5X,15HFIRING SOLUTION,7X,I1/5X,                                  MUL04300
     814HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,   MUL04310
     96X,F5.0//)                                                        MUL04320
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 528 FORMAT(     5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL04330
    1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,         MUL04340
    212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL04350
    35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                             MUL04360
    45X,13HCONTACT CLASS,9X,I1,10X,I1/5X,11HSONAR RANGE,7X,F6.0,5X,F6.0MUL04370
    5/5X,13HSONAR BEARING,7X,I3,8X,I3/5X,7HDOPPLER,15X,I1,10X,I1/       MUL04380
    65X,13HTARGET COURSE,18X,I3/5X,12HTARGET SPEED,20X,F3.0             MUL04390
    7/5X,15HFIRING SOLUTION,18X,I1/5X,                                  MUL04400
    814HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,    MUL04410
    96X,F5.0//)                                                         MUL04420
 529 FORMAT(     5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL04430
    1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,         MUL04440
    212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL04450
    35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                             MUL04460
    45X,13HCONTACT CLASS,9X,I1,10X,I1/5X,11HSONAR RANGE,7X,F6.0,5X,F6.0MUL04470
    5/5X,13HSONAR BEARING,7X,I3,8X,I3/5X,7HDOPPLER,15X,I1,10X,I1/       MUL04480
    65X,13HTARGET COURSE/5X,12HTARGET SPEED/5X,15HFIRING SOLUTION/5X,   MUL04490
    714HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,    MUL04500
    86X,F5.0//)                                                         MUL04510
 599 GO TO 1000                                                         MUL04520
C                                                                       MUL04530
C TIME LOOP 700                                                         MUL04540
C                                                                       MUL04550
 700 LDA(5006B),STA(DUMMY),LDA7(DUMMY),STA(ICLOCK)                      MUL04560
     IF(ICLOCK-NEXT)701,702,702                                         MUL04570
 701 GO TO 700                                                          MUL04580
 702 NEXT=ICLOCK+ISTEP                                                  MUL04590
     GTIME=GTIME+.5                                                     MUL04600
     GO TO 800                                                          MUL04610
C                                                                       MUL04620
C GAME OVER 800                                                         MUL04630
C                                                                       MUL04640
 800 IF(IEND)801,801,802                                                MUL04650
 801 GO TO 4000                                                         MUL04660
 802 GO TO 9000                                                         MUL04670
C                                                                       MUL04680
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C ENTER CHANGES 900                                                     MUL04690
C                                                                       MUL04700
  900 CALL PARAMS(IDDC(1),IDDS(1),IDDC(2),IDDS(2),IX0,IY0,IR,M)        MUL04710
      DO 914 I=1,2                                                      MUL04720
      IF(IDDC(I)-360)902,901,901                                        MUL04730
  901 IDDC(I)=IDDC(I)-360                                               MUL04740
  902 IF(IDDC(I))903,914,914                                            MUL04750
  903 IDDC(I)=IDDC(I)+360                                               MUL04760
  914 DDC(I)=IDDC(I)                                                    MUL04770
      DO 907 I=IONE,NRDD                                                MUL04780
      IF(IDDS(I))904,905,905                                            MUL04790
  904 IDDS(I)=0                                                         MUL04800
  905 DDS(I)=IDDS(I)                                                    MUL04810
      IF(DDS(I)-DDSMAX(I))907,907,906                                   MUL04820
  906 DDS(I)=DDSMAX(I)                                                  MUL04830
  907 CONTINUE                                                          MUL04840
      X0=100*IX0                                                        MUL04850
      Y0=100*IY0                                                        MUL04860
      R=1000*IR                                                         MUL04870
      IF(M-1)908,909,910                                                MUL04880
  908 ISHOOT1=0                                                         MUL04890
      ISHOOT2=0                                                         MUL04900
      GO TO 913                                                         MUL04910
  909 ISHOOT1=1                                                         MUL04920
      ISHOOT2=0                                                         MUL04930
      GO TO 913                                                         MUL04940
  910 IF(M-3)911,912,912                                                MUL04950
  911 ISHOOT1=0                                                         MUL04960
      ISHOOT2=1                                                         MUL04970
      GO TO 913                                                         MUL04980
  912 ISHOOT1=1                                                         MUL04990
      ISHOOT2=1                                                         MUL05000
  913 CONTINUE                                                          MUL05010
      GO TO 400                                                         MUL05020
C                                                                       MUL05030
C ENTER INPUT CHANGES 950                                               MUL05040
```

```
C
  950 IF(K-1)951,400,400
  951 K=1
      PRINT 952
  952 FORMAT(40HVARIABLES ARE YIELD,AROCMAX,DOB,TFACTOR,/40HGRAD,DDSMAX(
     11),DDSMAX(2),SUBSMAX,NRANDOM)
      CALL CHANGE(YIELD,AROCMAX,DOB,TFACTOR,GRAD,DDSMAX(1),DDSMAX(2),
     1SUBSMAX,NRANDOM)
      PRINT 953
  953 FORMAT(40HVARIABLES ARE STRESS,HULL,DDX(1),DDY(1),/33HDDX(2),DDY(2
     11),ISUB,INITIAL,ISTRAT)
      CALL CHANGE(STRESS,HULL,DDX(1),DDY(1),DDX(2),DDY(2),ISUB,INITIAL,
     1ISTRAT)
  955 GO TO 200
C
C PLOT GENERATOR MODEL 1000
C
 1000 DO 1001 I=IONE,NRDD
      DDX(I)=DDX(I)+DDS(I)*16.67*SINF(DDC(I)/57.295)
 1001 DDY(I)=DDY(I)+DDS(I)*16.67*COSF(DDC(I)/57.295)
      SUBX=SUBX+SUBS*16.67*SINF(SUBC/57.295)
      SUBY=SUBY+SUBS*16.67*COSF(SUBC/57.295)
      IF(NSHOTS)1015,1015,1002
 1002 IF(IDEEP-2)1004,1006,1003
 1003 IF(IDEEP-4)1008,1010,1010
 1004 DO 1005 I=1,NSHOTS
 1005 CLOUDR(I)=237.0*YIELD**.333*(5.85*LOGF((GTIME-TBURST(I))/
     1(0.4450*YIELD**.167)+.73)+.802)
      GO TO 1012
 1006 DO 1007 I=1,NSHOTS
 1007 CLOUDR(I)=125.0*DOB**.167*YIELD**.278*(5.85*LOGF((GTIME-TBURST
     1(I))/(0.3240*YIELD**.944*DOB**.167)+.73)+.802)
      GO TO 1012
 1008 DO 1009 I=1,NSHOTS
 1009 CLOUDR(I)=500.0*(YIELD/(DOB+33.0))**.333*(16.7*LOGF((GTIME-TBURST
     1(I))/(0.6450*(YIELD/(DOB+33.0))**.167))+4.54)
```

```
      GO TO 1012                                                        MUL05410
 1010 DO 1011 I=1,NSHOTS                                                MUL05420
 1011 CLOUDR(I)=500.0*(YIELD/(DOB+33.0))**.333*(16.7*LOGF((GTIME-TBURST MUL05430
     1(I))/(0.6450*(YIELD/(DOB+33.0))**.167)-1.0)+4.54)                 MUL05440
 1012 CONTINUE                                                          MUL05450
 1013 DO 1014 I=1,NSHOTS                                                MUL05460
      CLOUDX(I)=CLOUDX(I)-WINDV*16.67*SINF(WINDD/57.295)                MUL05470
 1014 CLOUDY(I)=CLOUDY(I)-WINDV*16.67*COSF(WINDD/57.295)                MUL05480
 1015 GO TO 2000                                                        MUL05490
C                                                                       MUL05500
C INTERACTIONS 2000                                                     MUL05510
C                                                                       MUL05520
 2000 I=1                                                               MUL05530
      GO TO 5000                                                        MUL05540
 2100 IF(NOSHOOT)2102,2102,2101                                         MUL05550
 2101 GO TO 2500                                                        MUL05560
 2102 GO TO 2400                                                        MUL05570
 2200 IF(NMARKS-1)2201,2201,2203                                        MUL05580
 2201 INAME=8H  SONAR                                                   MUL05590
      CALL DSTATUS(1,12,8,INAME,-126,0)                                 MUL05600
      INAME=8H                                                          MUL05610
      CALL DSTATUS(1,11,8,INAME,-254,0)                                 MUL05620
      CALL DSTATUS(1,14,8,INAME,130,0)                                  MUL05630
      INAME=8HCONTACT                                                   MUL05640
      CALL DSTATUS(1,13,8,INAME,2,0)                                    MUL05650
      ICRIT1=1                                                          MUL05660
 2203 GO TO 6000                                                        MUL05670
 2300 IF(CONTR(I)-AROCMAX)2301,2301,2302                                MUL05680
 2301 INAME=8H       T                                                  MUL05690
      CALL DSTATUS(1,11,8,INAME,-254,0)                                 MUL05700
      INAME=8HARGET IS                                                  MUL05710
      CALL DSTATUS(1,12,8,INAME,-126,0)                                 MUL05720
      INAME=8H IN RANG                                                  MUL05730
      CALL DSTATUS(1,13,8,INAME,2,0)                                    MUL05740
      INAME=8HE                                                         MUL05750
      CALL DSTATUS(1,14,8,INAME,130,0)                                  MUL05760
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```
      ICRIT5=1
 2302 GO TO 2100
 2400 IF(I-1)2401,2401,2402
 2401 IF(ISHOOT1)2500,2500,2403
 2402 IF(ISHOOT2)2500,2500,2404
 2403 ISHOOT1=0
      GO TO 2405
 2404 ISHOOT2=0
 2405 IASROC=I
      NOSHOOT=1
      GO TO 7000
 2500 IF(I-NRDD)2600,2700,2700
 2600 I=I+1
      GO TO 5000
 2700 IF(NOSHOOT)3000,3000,2800
 2800 IF(GTIME-TOB)3000,8000,8000
C
C RADIATION MODEL 3000
C
 3000 IF(NSHOTS)9500,9500,3001
 3001 DO 3002 I=1,NRDD
      DO 3002 J=1,NSHOTS
      DISTC(I,J)=SQRTF((CLOUDX(J)-DDX(I))**2+(CLOUDY(J)-DDY(I))**2)
      DISTP(I,J)=SQRTF((POOLX(J)-DDX(I))**2+(POOLY(J)-DDY(I))**2)
 3002 CONTINUE
      DO 3007 I=1,NRDD
      DO 3006 J=1,NSHOTS
      IF(DISTC(I,J)-CLOUDR(J))3016,3016,3004
 3016 IF(IDEEP-3)3014,3015,3014
 3014 TEMP1=.1
      GO TO 3003
 3015 TEMP1=.333
 3003 TEMPCR(I,J)=1.58*10.0**14*(10.0-LOGF(60.0*(GTIME-TBURST(J))))*TEMP
     11*YIELD/(CLOUDR(J)**2*CLOUDZ(J))*(2.78/((60.0*(GTIME-TBURST(J)))**
     21.23)-2.41/((60.0*(GTIME-TBURST(J)))**1.45))
      GO TO 3017
```

```
 3004 TEMPCR(I,J)=0.0                                                   MUL06130
 3017 IF(DISTP(I,J)-POOLR(J))3005,3005,3018                             MUL06140
 3005 TEMPPR(I,J)=710.0*.25*YIELD/(THERMO*POOLR(J)**2)*(60.0/(GTIME-    MUL06150
     1TBURST(J)))**1.32*EXPF(-4.0*DISTP(I,J)**2/POOLR(J)**2)            MUL06160
      GO TO 3006                                                        MUL06170
 3018 TEMPPR(I,J)=0.0                                                   MUL06180
 3006 CONTINUE                                                          MUL06190
 3007 CONTINUE                                                          MUL06200
      DO 3009 I=IONE,NRDD                                               MUL06210
      SUM=0.0                                                           MUL06220
      DO 3008 J=1,NSHOTS                                                MUL06230
 3008 SUM=SUM+TEMPCR(I,J)                                               MUL06240
 3009 RADRATE(I)=SUM                                                    MUL06250
      DO 3011 I=IONE,NRDD                                               MUL06260
      SUM=0.0                                                           MUL06270
      DO 3010 J=1,NSHOTS                                                MUL06280
 3010 SUM=SUM+TEMPPR(I,J)                                               MUL06290
 3011 RADRATE(I)=RADRATE(I)+SUM                                         MUL06300
      DO 3012 I=1,NRDD                                                  MUL06310
 3012 RADDOSE(I)=RADDOSE(I)+.5*RADRATE(I)                               MUL06320
 3013 GO TO 9500                                                        MUL06330
C                                                                       MUL06340
C SUBMARINE LOGIC MODEL 4000                                            MUL06350
C                                                                       MUL06360
 4000 IF(ISUB)4001,4001,4400                                            MUL06370
 4001 IF(ISTRAT-1)4100,4200,4300                                        MUL06380
 4100 IF(ILOGIC-1)4101,4102,4105                                        MUL06390
 4101 CALL UNIFORM(400.0,300.0,SUBD)                                    MUL06400
      CALL UNIFORM(15.0,3.0,SUBS)                                       MUL06410
      CALL UNIFORM(0.0,20.0,SUBC)                                       MUL06420
      IF(SUBC)4106,4107,4107                                            MUL06430
 4106 SUBC=SUBC+360.0                                                   MUL06440
 4107 ILOGIC=1                                                          MUL06450
      TLOGIC=GTIME                                                      MUL06460
      GO TO 900                                                         MUL06470
 4102 IF(GTIME-TLOGIC-10.0)4104,4103,4103                               MUL06480
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4103 CALL UNIFORM(7.0,4.0,SUBS)                                     MUL06490
     CALL UNIFORM(0.0,10.0,SUBC)                                    MUL06500
     IF(SUBC)4108,4109,4109                                         MUL06510
4108 SUBC=SUBC+360.0                                                MUL06520
4109 ILOGIC=2                                                       MUL06530
4104 GO TO 900                                                      MUL06540
4105 CALL UNIFORM(0.0,10.0,SUBC)                                    MUL06550
     IF(SUBC)4110,4111,4111                                         MUL06560
4110 SUBC=SUBC+360.0                                                MUL06570
4111 GO TO 900                                                      MUL06580
4200 IF(SSB(1)-090.0)4201,4215,4215                                 MUL06590
4215 IF(SSB(1)-270.0)4216,4216,4201                                 MUL06600
4216 IF(SSB(2)-090.0)4201,4217,4217                                 MUL06610
4217 IF(SSB(2)-270.0)4214,4214,4201                                 MUL06620
4201 IF(SSB(1)-180.0)4203,4203,4202                                 MUL06630
4202 TEMP1=360.0-SSB(1)                                             MUL06640
     GO TO 4204                                                     MUL06650
4203 TEMP1=SSB(1)+180.0                                             MUL06660
4204 IF(SSB(2)-180.0)4206,4206,4205                                 MUL06670
4205 TEMP2=360.0-SSB(2)                                             MUL06680
     GO TO 4207                                                     MUL06690
4206 TEMP2=SSB(2)                                                   MUL06700
4207 ANGLE=ABSF(TEMP1-TEMP2)                                        MUL06710
     IF(TEMP1-180.0)4208,4208,4210                                  MUL06720
4208 IF(TEMP2-180.0)4209,4209,4211                                  MUL06730
4209 CALL UNIFORM(210.0,10.0,SUBC)                                  MUL06740
     GO TO 4213                                                     MUL06750
4210 IF(TEMP2-180.0)4212,4211,4211                                  MUL06760
4211 CALL UNIFORM(150.0,10.0,SUBC)                                  MUL06770
     GO TO 4213                                                     MUL06780
4212 CENTERB=(TEMP1+TEMP2)/2.0                                      MUL06790
     SUBC=CENTERB                                                   MUL06800
4213 CALL UNIFORM(8.0,3.0,SUBS)                                     MUL06810
     CALL UNIFORM(300.0,100.0,SUBD)                                 MUL06820
4214 GO TO 900                                                      MUL06830
4300 W1=SQRTF((SUBX-DDX(1))**2+(SUBY-DDY(1))**2)                    MUL06840
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      W2=SQRTF((SUBX-DDX(2))**2+(SUBY-DDY(2))**2)                       MUL06850
      IF(W1-W2)4301,4301,4302                                           MUL06860
 4301 RANGE=W1                                                          MUL06870
      J=1                                                               MUL06880
      GO TO 4303                                                        MUL06890
 4302 RANGE=W2                                                          MUL06900
      J=2                                                               MUL06910
 4303 IF(ABSF(SSB(J)-B)-2.0)4304,4304,4305                              MUL06920
 4304 NCONBER=NCONBER+1                                                 MUL06930
      GO TO 4306                                                        MUL06940
 4305 NCONBER=0                                                         MUL06950
 4306 B=SSB(J)                                                          MUL06960
 4308 IF(ILOGIC-1)4311,4315,4318                                        MUL06970
 4311 CALL UNIFORM(0.0,1.0,TURN)                                        MUL06980
      IF(TURN)4312,4312,4313                                            MUL06990
 4312 ITURN=1                                                           MUL07000
      CALL UNIFORM(135.0,30.0,SUBC)                                     MUL07010
      GO TO 4314                                                        MUL07020
 4313 ITURN=0                                                           MUL07030
      CALL UNIFORM(225.0,30.0,SUBC)                                     MUL07040
 4314 CALL UNIFORM(400.0,300.0,SUBD)                                    MUL07050
      IF(SUBD-SUBDMAX)4344,4344,4343                                    MUL07060
 4343 SUBD=SUBDMAX                                                      MUL07070
 4344 CALL UNIFORM(15.0,3.0,SUBS)                                       MUL07080
      IF(SUBS-SUBSMAX)4342,4336,4336                                    MUL07090
 4336 SUBS=SUBSMAX                                                      MUL07100
 4342 ILOGIC=1                                                          MUL07110
      TLOGIC=GTIME                                                      MUL07120
      GO TO 900                                                         MUL07130
 4315 IF(GTIME-TLOGIC-10.0)4317,4316,4316                               MUL07140
 4316 ILOGIC=2                                                          MUL07150
      CALL UNIFORM(7.0,4.0,SUBS)                                        MUL07160
      IF(SUBS-SUBSMAX)4317,4337,4337                                    MUL07170
 4337 SUBS=SUBSMAX                                                      MUL07180
 4317 GO TO 900                                                         MUL07190
 4318 IF (ILOGIC-3)4319,4325,4331                                       MUL07200
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4319 IF(NCONBER-8)4320,4321,4321                                        MUL07210
4320 GO TO 900                                                          MUL07220
4321 IF(ITURN)4322,4322,4323                                            MUL07230
4322 CALL UNIFORM(270.0,30.0,SUBC)                                      MUL07240
     GO TO 4324                                                         MUL07250
4323 CALL UNIFORM(090.0,30.0,SUBC)                                      MUL07260
4324 CALL UNIFORM(400.0,300.0,SUBD)                                     MUL07270
     IF(SUBD-SUBDMAX)4346,4346,4345                                     MUL07280
4345 SUBD=SUBDMAX                                                       MUL07290
4346 CALL UNIFORM(7.0,3.0,SUBS)                                         MUL07300
     IF(SUBS-SUBSMAX)4339,4338,4338                                     MUL07310
4338 SUBS=SUBSMAX                                                       MUL07320
4339 ILOGIC=3                                                           MUL07330
     GO TO 900                                                          MUL07340
4325 IF(NCONBER-8)4326,4327,4327                                        MUL07350
4326 GO TO 900                                                          MUL07360
4327 IF(RANGE-10000.0)4328,4326,4326                                    MUL07370
4328 IFIRE=1                                                            MUL07380
4330 CALL UNIFORM(180.0,60.0,SUBC)                                      MUL07390
     CALL UNIFORM(400.0,300.0,SUBD)                                     MUL07400
     IF(SUBD-SUBDMAX)4348,4348,4347                                     MUL07410
4347 SUBD=SUBDMAX                                                       MUL07420
4348 CALL UNIFORM(7.0,4.0,SUBS)                                         MUL07430
     IF(SUBS-SUBSMAX)4341,4340,4340                                     MUL07440
4340 SUBS=SUBSMAX                                                       MUL07450
4341 ILOGIC=4                                                           MUL07460
     VEL=DDS(J)+18.0                                                    MUL07470
     TINTER=.03*RANGE/VEL+GTIME                                         MUL07480
     GO TO 900                                                          MUL07490
4331 IF(TINTER-GTIME)4333,4333,4332                                     MUL07500
4332 GO TO 900                                                          MUL07510
4333 CALL UNIFORM(0.5,0.5,PHIT)                                         MUL07520
     IF(PHIT-.3)4334,4334,4335                                          MUL07530
4334 IF(J-1)4335,4349,4350                                              MUL07540
4349 NRDD=NRDD-1                                                        MUL07550
     DDX(2)=-0.0                                                        MUL07560
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      DDY(2)=-0.0
      DDS(2)=0.0
      GO TO 4351
 4350 IONE=IONE+1
      DDX(1)=-0.0
      DDY(1)=-0.0
      DDS(1)=0.0
 4351 IF(NRDD-IONE)4352,4353,4353
 4352 ICRIT14=1
      IEND=1
      GO TO 800
 4353 INAME=8H      DD
      CALL DSTATUS(1,12,8,INAME,-126,0)
      INAME=8H
      CALL DSTATUS(1,14,8,INAME,130,0)
      CALL DSTATUS(1,11,8,INAME,-254,0)
      INAME=8HSUNK
      CALL DSTATUS(1,13,8,INAME,2,0)
      ICRIT7=1
 4335 ILOGIC=3
      GO TO 900
 4400 IF(ILOGIC)4425,4425,4428
 4425 SLJ2(4401)
 4426 SLJ3(4427)
      GO TO 900
 4427 ILOGIC=1
      ICRIT3=1
      VEL=DDS(J)+18.0
      TINTER=.03*RANGE/VEL+GTIME
      GO TO 900
 4401 DO 4402 I=1,NRDD
 4402 SB(I)=8.4*DDS(I)
      DO 4414 I=1,2
      DX=DDX(I)-SUBX
      DY=DDY(I)-SUBY
      IF(DX) 4405,4403,4404
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4403 IF(DY) 4410,4410,4409                                             MUL07930
4404 IF(DY) 4408,4406,4407                                             MUL07940
4405 IF(DY) 4412,4411,4413                                             MUL07950
4406 DDB(I)=090.                                                       MUL07960
     GO TO 4414                                                        MUL07970
4407 DDB(I)=90.-ATANF( DY/DX)*57.295                                   MUL07980
     GO TO 4414                                                        MUL07990
4408 DDB(I)=90.+ATANF(-DY/DX)*57.295                                   MUL08000
     GO TO 4414                                                        MUL08010
4409 DDB(I)=000.0                                                      MUL08020
     GO TO 4414                                                        MUL08030
4410 DDB(I)=180.0                                                      MUL08040
     GO TO 4414                                                        MUL08050
4411 DDB(I)=270.0                                                      MUL08060
     GO TO 4414                                                        MUL08070
4412 DDB(I)=270.0-ATANF(DY/DX)*57.295                                  MUL08080
     GO TO 4414                                                        MUL08090
4413 DDB(I)=270.0+ATANF(-DY/DX)*57.295                                 MUL08100
4414 CONTINUE                                                          MUL08110
     WRITE OUTPUT TAPE 9,4424,DDB(1),SB(1),DDB(2),SB(2)                MUL08120
4424 FORMAT(6X,10HDD1 BEARS ,F4.0,12H SCREW BEAT ,F4.0/6X,10HDD2 BEARS MUL08130
    1,F4.0,12H SCREW BEAT ,F4.0/)                                      MUL08140
     WRITE OUTPUT TAPE 9,4415                                          MUL08150
4415 FORMAT(6X,13HCOURSE ORDERS/)                                      MUL08160
     READ INPUT TAPE 9,4416,SUBC                                       MUL08170
4416 FORMAT(F4.0)                                                      MUL08180
     WRITE OUTPUT TAPE 9,4417,SUBC                                     MUL08190
4417 FORMAT(6X,15HNEW SUB COURSE ,F4.0/)                               MUL08200
     WRITE OUTPUT TAPE 9,4418                                          MUL08210
4418 FORMAT(6X,12HSPEED ORDERS/)                                       MUL08220
     READ INPUT TAPE 9,4419,SUBS                                       MUL08230
4419 FORMAT(F3.0)                                                      MUL08240
     WRITE OUTPUT TAPE 9,4420,SUBS                                     MUL08250
4420 FORMAT(6X,14HNEW SUB SPEED ,F3.0/)                                MUL08260
     WRITE OUTPUT TAPE 9,4421                                          MUL08270
4421 FORMAT(6X,12HDEPTH ORDERS/)                                       MUL08280
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      READ INPUT TAPE 9,4422,SUBD                                       MUL08290
 4422 FORMAT(F5.0)                                                      MUL08300
      WRITE OUTPUT TAPE 9,4423,SUBD                                     MUL08310
 4423 FORMAT(6X,14HNEW SUB DEPTH ,F5.0/)                                MUL08320
      GO TO 4426                                                        MUL08330
 4428 IF(TINTER-GTIME)4430,4430,4429                                    MUL08340
 4429 GO TO 4425                                                        MUL08350
 4430 CALL UNIFORM(.5,.5,PHIT)                                          MUL08360
      IF(PHIT-.3)4431,4431,4432                                         MUL08370
 4431 W1=SQRTF((SUBX-DDX(1))**2+(SUBY-DDY(1))**2)                       MUL08380
      W2=SQRTF((SUBX-DDX(2))**2+(SUBY-DDY(2))**2)                       MUL08390
      IF(W1-W2)4435,4435,4436                                           MUL08400
 4435 IONE=IONE+1                                                       MUL08410
      GO TO 4437                                                        MUL08420
 4436 NRDD=NRDD-1                                                       MUL08430
 4437 IF(NRDD-IONE)4438,4439,4439                                       MUL08440
 4438 ICRIT14=1                                                         MUL08450
      IEND=1                                                            MUL08460
      GO TO 800                                                         MUL08470
 4439 CONTINUE                                                          MUL08480
 4432 ILOGIC=0                                                          MUL08490
      GO TO 4425                                                        MUL08500
C                                                                       MUL08510
C SONAR CONTACT MODEL 5000                                              MUL08520
C                                                                       MUL08530
 5000 DETRM=33.3*SQRTF(-SUBD/(GRAD*.05+.018))                           MUL08540
      SIGMA=.3*DETRM                                                    MUL08550
      CALL NORMAL(DETRM,SIGMA,DETR)                                     MUL08560
      IF(ISS-2)5029,5030,5028                                           MUL08570
 5028 IF(ISS-4)5031,5032,5033                                           MUL08580
 5029 IF(DDS(I)-22.0)5034,5034,5035                                     MUL08590
 5030 IF(DDS(I)-20.0)5034,5034,5035                                     MUL08600
 5031 IF(DDS(I)-18.0)5034,5034,5035                                     MUL08610
 5032 IF(DDS(I)-17.0)5034,5034,5035                                     MUL08620
 5033 IF(DDS(I)-16.0)5034,5034,5035                                     MUL08630
 5034 DETR=.7*DETR                                                      MUL08640
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5035 RANGE=SQRTF((DDX(I)-SUBX)**2+(DDY(I)-SUBY)**2)                       MUL08650
     IF(RANGE-DETR)5002,5001,5001                                          MUL08660
5001 IDOPLER(I)=0                                                          MUL08670
     MARKS(I)=0                                                            MUL08680
     NMARKS(I)=0                                                           MUL08690
     ICLASS(I)=0                                                           MUL08700
     GO TO 2500                                                            MUL08710
5002 SIGMA=.04*RANGE                                                       MUL08720
     CALL NORMAL(RANGE,SIGMA,CONTR(I))                                     MUL08730
     DY=SUBY-DDY(I)                                                        MUL08740
     DX=SUBX-DDX(I)                                                        MUL08750
     IF(DX) 5005,5003,5004                                                 MUL08760
5003 IF(DY) 5010,5010,5009                                                 MUL08770
5004 IF(DY) 5008,5006,5007                                                 MUL08780
5005 IF(DY) 5012,5011,5013                                                 MUL08790
5006 SSB(I)=090.                                                           MUL08800
     GO TO 5014                                                            MUL08810
5007 SSB(I)=90.-ATANF( DY/DX)*57.295                                       MUL08820
     GO TO 5014                                                            MUL08830
5008 SSB(I)=90.+ATANF(-DY/DX)*57.295                                       MUL08840
     GO TO 5014                                                            MUL08850
5009 SSB(I)=000.0                                                          MUL08860
     GO TO 5014                                                            MUL08870
5010 SSB(I)=180.0                                                          MUL08880
5011 SSB(I)=270.0                                                          MUL08890
     CO TO 5014                                                            MUL08900
     GO TO 5014                                                            MUL08910
5012 SSB(I)=270.0-ATANF(DY/DX)*57.295                                      MUL08920
     GO TO 5014                                                            MUL08930
5013 SSB(I)=270.0+ATANF(-DY/DX)*57.295                                     MUL08940
5014 D=SSB(I)-SUBC                                                         MUL08950
     DA=ABSF(D)                                                            MUL08960
     IF(DA-45.0)5015,5015,5016                                             MUL08970
5015 IDOPLER(I)=2                                                          MUL08980
     GO TO 5019                                                            MUL08990
5016 IF(DA-135.0)5017,5018,5018                                            MUL09000
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 5017 IDOPLER(I)=0                                                          MUL09010
      GO TO 5019                                                            MUL09020
 5018 IDOPLER(I)=1                                                          MUL09030
 5019 SIGMA=4.5                                                             MUL09040
      CALL NORMAL(SSB(I),SIGMA,CONTB(I))                                    MUL09050
      IF(CONTB(I)) 5020,5021,5021                                           MUL09060
 5020 CONTB(I)=CONTB(I)+360.0                                               MUL09070
      GO TO 5023                                                            MUL09080
 5021 IF(CONTB(I)-360.0)5023,5022,5022                                      MUL09090
 5022 CONTB(I)=CONTB(I)-360.0                                               MUL09100
 5023 NMARKS(I)=NMARKS(I)+1                                                 MUL09110
      IF(NMARKS(I)-2)5027,5025,5024                                         MUL09120
 5024 IF(NMARKS(I)-10)5025,5026,5026                                        MUL09130
 5025 ICLASS(I)=1                                                           MUL09140
      GO TO 5027                                                            MUL09150
 5026 ICLASS(I)=2                                                           MUL09160
 5027 ICONTB(I)=CONTB(I)                                                    MUL09170
      GO TO 2200                                                            MUL09180
C                                                                           MUL09190
C CONTACT TRACKING MODEL 6000                                               MUL09200
C                                                                           MUL09210
 6000 IF(MARKS(I)-5) 6001,6002,6002                                         MUL09220
 6001 MARKS(I)=MARKS(I)+1                                                   MUL09230
 6002 CONTX(I)=DDX(I)+CONTR(I)*SINF(CONTB(I)/57.296)                        MUL09240
      CONTY(I)=DDY(I)+CONTR(I)*COSF(CONTB(I)/57.296)                        MUL09250
      IF(MARKS(I)-3) 6003,6004,6004                                         MUL09260
 6003 IF(MARKS(I)-1)6005,6006,6007                                          MUL09270
 6006 X(I,1)=CONTX(I)                                                       MUL09280
      Y(I,1)=CONTY(I)                                                       MUL09290
      GO TO 6005                                                            MUL09300
 6007 X(I,2)=X(I,1)                                                         MUL09310
      Y(I,2)=Y(I,1)                                                         MUL09320
      X(I,1)=CONTX(I)                                                       MUL09330
      Y(I,1)=CONTY(I)                                                       MUL09340
 6005 GO TO 2500                                                            MUL09350
 6004 NPTSP1=MARKS(I)+1                                                     MUL09360
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      NPTSP2=MARKS(I)+2                                                 MUL09370
      N=MARKS(I)                                                        MUL09380
      DO 6023 J=2,N                                                     MUL09390
      X(I,NPTSP2-J)=X(I,NPTSP1-J)                                       MUL09400
 6023 Y(I,NPTSP2-J)=Y(I,NPTSP1-J)                                       MUL09410
      X(I,1)=CONTX(I)                                                   MUL09420
      Y(I,1)=CONTY(I)                                                   MUL09430
      DX=X(I,1)-X(I,N)                                                  MUL09440
      DY=Y(I,1)-Y(I,N)                                                  MUL09450
      DR=SQRTF(DX**2+DY**2)                                             MUL09460
      BNPTS=MARKS(I)                                                    MUL09470
      CONTS(I)=.06*DR/(BNPTS-1.0)                                       MUL09480
      IF(NMARKS(I)-8)6027,6028,6026                                     MUL09490
 6026 IF(NMARKS(I)-10)6029,6030,6031                                    MUL09500
 6027 ISOL(I)=1                                                         MUL09510
      GO TO 6032                                                        MUL09520
 6028 ISOL(I)=2                                                         MUL09530
      GO TC 6032                                                        MUL09540
 6029 ISOL(I)=3                                                         MUL09550
      GO TO 6032                                                        MUL09560
 6030 ISOL(I)=4                                                         MUL09570
      GO TO 6032                                                        MUL09580
 6031 ISOL(I)=5                                                         MUL09590
 6032 CONTINUE                                                          MUL09600
      IF(DX) 6008,6009,6010                                             MUL09610
 6008 IF(DY) 6014,6015,6016                                             MUL09620
 6009 IF(DY) 6017,6018,6018                                             MUL09630
 6010 IF(DY) 6011,6012,6013                                             MUL09640
 6011 THETA=ATANF(-DY/DX)                                               MUL09650
      CONTC(I)=90.0+THETA*57.296                                        MUL09660
      GO TO 6019                                                        MUL09670
 6012 CONTC(I)=090.0                                                    MUL09680
      GO TO 6019                                                        MUL09690
 6013 THETA=ATANF(DY/DX)                                                MUL09700
      CONTC(I)=090.0-THETA*57.296                                       MUL09710
      GO TO 6019                                                        MUL09720
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6014 THETA=ATANF(DY/DX)                                                        MUL09730
     CONTC(I)=90.0-THETA*57.296                                                MUL09740
     GO TO 6019                                                                MUL09750
6015 CONTC(I)=270.0                                                            MUL09760
     GO TO 6019                                                                MUL09770
6016 THETA=ATANF(-DY/DX)                                                       MUL09780
     CONTC(I)=270.0+THETA*57.296                                               MUL09790
     GO TO 6019                                                                MUL09800
6017 CONTC(I)=180.0                                                            MUL09810
     GO TO 6019                                                                MUL09820
6018 CONTC(I)=000.0                                                            MUL09830
6019 ICONTC(I)=CONTC(I)                                                        MUL09840
     IF(MARKS(I)-4)6005,6020,6020                                              MUL09850
6020 IF(CONTR(I)-AROCMAX)6021,6035,6035                                        MUL09860
6021 IF(CONTR(I)-AROCMIN)6033,6022,6022                                        MUL09870
6022 GO TO 2300                                                                MUL09880
6033 INAME=8H  TARGET                                                          MUL09890
     CALL DSTATUS(1,11,8,INAME,-254,0)                                         MUL09900
     INAME=8H TOO CLO                                                          MUL09910
     CALL DSTATUS(1,12,8,INAME,-126,0)                                         MUL09920
     INAME=8HSE TO SH                                                          MUL09930
     CALL DSTATUS(1,13,8,INAME,2,0)                                            MUL09940
     INAME=8HOOT AT                                                            MUL09950
     CALL DSTATUS(1,14,8,INAME,130,0)                                          MUL09960
     ICRIT8=1                                                                  MUL09970
     GO TO 2500                                                                MUL09980
6035 INAME=8H   TARGE                                                          MUL09990
     INAME=8HT OUT OF                                                          MUL10000
     CALL DSTATUS(1,12,8,INAME,-126,0)                                         MUL10010
     INAME=8H ASROC R                                                          MUL10020
     CALL DSTATUS(1,13,8,INAME,2,0)                                            MUL10030
     INAME=8HANGE                                                              MUL10040
     CALL DSTATUS(1,14,8,INAME,130,0)                                          MUL10050
     ICRIT9=1                                                                  MUL10060
     GO TO 2500                                                                MUL10070
C                                                                              MUL10080
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C WEAPON FIRING MODEL 7000                                                      MUL10090
C                                                                               MUL10100
 7000 CALL UNIFORM(.5,.5,REL)                                                   MUL10110
      IF(REL-.9)7009,7009,7008                                                  MUL10120
 7008 INAME=8H  ASROC                                                           MUL10130
      CALL DSTATUS(1,12,8,INAME,-126,0)                                         MUL10140
      INAME=8H                                                                  MUL10150
      CALL DSTATUS(1,11,8,INAME,-254,0)                                         MUL10160
      CALL DSTATUS(1,14,8,INAME,130,0)                                          MUL10170
      INAME=8HMISFIRE                                                           MUL10180
      CALL DSTATUS(1,13,8,INAME,2,0)                                            MUL10190
      ICRIT4=1                                                                  MUL10200
      WRITE OUTPUT TAPE 5,7010                                                  MUL10210
 7010 FORMAT(13HASROC MISFIRE)                                                  MUL10220
      GO TO 2500                                                                MUL10230
 7009 TOF=.004*R+20.0                                                           MUL10240
      TOS=DOB/SR                                                                MUL10250
      DTIME=TOF+TOS                                                             MUL10260
      IF(DTIME-45.0)7001,7001,7002                                              MUL10270
 7002 IF(DTIME-75.0)7003,7003,7004                                              MUL10280
 7004 IF(DTIME-105.0)7005,7005,7006                                             MUL10290
 7001 DTIME=.5                                                                  MUL10300
      GO TO 7007                                                                MUL10310
 7003 DTIME=1.0                                                                 MUL10320
      GO TO 7007                                                                MUL10330
 7005 DTIME=1.5                                                                 MUL10340
      GO TO 7007                                                                MUL10350
 7006 DTIME=2.0                                                                 MUL10360
 7007 XTEMP=CONTX(I)+16.667*CONTS(I)*SINF(CONTC(I))                             MUL10370
      YTEMP=CONTY(I)+16.667*CONTS(I)*COSF(CONTC(I))                             MUL10380
      SIGMA=1.2+(3.1/8000.0)*CONTR(I)                                           MUL10390
      CALL ERROR(XTEMP,YTEMP,SIGMA,GZX,GZY)                                     MUL10400
      TOB=GTIME+DTIME                                                           MUL10410
      INAME=8H                                                                  MUL10420
      CALL DSTATUS(1,11,8,INAME,-254,0)                                         MUL10430
      CALL DSTATUS(1,14,8,INAME,130,0)                                          MUL10440
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      INAME=8H   ASROC                                                   MUL10450
      CALL DSTATUS(1,12,8,INAME,-126,0)                                  MUL10460
      INAME=8H FIRED                                                     MUL10470
      CALL DSTATUS(1,13,8,INAME,2,0)                                     MUL10480
      ICRIT2=1                                                           MUL10490
      WRITE OUTPUT TAPE 5,7011,I                                         MUL10500
 7011 FORMAT(2HDD,I1,12H FIRED ASROC)                                    MUL10510
      GO TO 2500                                                         MUL10520
C                                                                        MUL10530
C EVALUATION MODEL 8000                                                  MUL10540
C                                                                        MUL10550
 8000 NSHOTS=NSHOTS+1                                                    MUL10560
      NOSHOOT=0                                                          MUL10570
      TBURST(NSHOTS)=TOB                                                 MUL10580
      POOLX(NSHOTS)=GZX                                                  MUL10590
      POOLY(NSHOTS;=GZY                                                  MUL10600
      CLOUDX(NSHOTS)=GZX                                                 MUL10610
      CLOUDY(NSHOTS)=GZY                                                 MUL10620
      CLOUDZ(NSHOTS)=2000.0*(YIELD/10.0)**.167                           MUL10630
      TEMP1=DOB**1.33/(1500.0*YIELD**.333)                               MUL10640
      IF(TEMP1-1.0)8002,8001,8001                                        MUL10650
 8001 POOLR(NSHOTS)=1580.0*(YIELD/TEMP1)**.25                            MUL10660
      GO TO 8003                                                         MUL10670
 8002 POOLR(NSHOTS)=1580.0*YIELD**.25                                    MUL10680
 8003 CONTINUE                                                           MUL10690
      TEMP1=SQRTF(17100000.0*YIELD/(STRESS*HULL))                        MUL10700
      RLETHAL=(CRUSH-300.0)*TEMP1/(CRUSH-SUBD)                           MUL10710
      TEMP2=SQRTF((GZX-SUBX)**2+(GZY-SUBY)**2+((SUBD-DOB)/3.0)**2)       MUL10720
      IF(TEMP2-RLETHAL)8004,8004,8006                                    MUL10730
 8004 INAME=8H    SUB                                                    MUL10740
      CALL DSTATUS(1,12,8,INAME,-126,0)                                  MUL10750
      INAME=8H                                                           MUL10760
      CALL DSTATUS(1,11,8,INAME,-254,0)                                  MUL10770
      CALL DSTATUS(1,14,8,INAME,130,0)                                   MUL10780
      INAME=8HSUNK                                                       MUL10790
      CALL DSTATUS(1,13,8,INAME,2,0)                                     MUL10800
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      ICRIT6=1                                                          MUL10810
      IEND=1                                                            MUL10820
      IF(IASROC-1)8005,8005,8010                                        MUL10830
 8005 ICRIT15=1                                                         MUL10840
      GO TO 8011                                                        MUL10850
 8010 ICRIT16=1                                                         MUL10860
 6011 GO TO 800                                                         MUL10870
 8006 IF(TEMP2-2.0*RLETHAL)8008,8008,8007                               MUL10880
 8007 GO TO 3000                                                        MUL10890
 8008 DAMAGE=2.0-TEMP2/RLETHAL                                          MUL10900
      DAMAGET=DAMAGET+DAMAGE                                            MUL10910
      IF(DAMAGET-.75)8009,8009,8004                                     MUL10920
 8009 SUBDMAX=(1.0-DAMAGE)*CRUSH*SAFETY                                 MUL10930
      SUBSMAX=(1.0-DAMAGE)*SUBSMAX                                      MUL10940
      GO TO 3000                                                        MUL10950
C                                                                       MUL10960
C CRITIQUE II 9000                                                      MUL10970
C                                                                       MUL10980
 9000 IF(ICRIT11)9001,9001,9011                                         MUL10990
 9001 IF(ICRIT12)9002,9002,9012                                         MUL11000
 9002 IF(ICRIT13)9003,9003,9013                                         MUL11010
 9003 IF(ICRIT14)9004,9004,9014                                         MUL11020
 9004 IF(ICRIT15)9005,9005,9015                                         MUL11030
 9005 IF(ICRIT16)9006,9006,9016                                         MUL11040
 9006 IF(ICRIT17)9007,9007,9017                                         MUL11050
 9007 GO TO 700                                                         MUL11060
 9011 WRITE OUTPUT TAPE 5,9021                                          MUL11070
      GO TO 9018                                                        MUL11080
 9012 WRITE OUTPUT TAPE 5,9022                                          MUL11090
      GO TO 9018                                                        MUL11100
 9013 WRITE OUTPUT TAPE 5,9023                                          MUL11110
      GO TO 9018                                                        MUL11120
 9014 WRITE OUTPUT TAPE 5,9024                                          MUL11130
      GO TO 9018                                                        MUL11140
 9015 WRITE OUTPUT TAPE 5,9025                                          MUL11150
      GO TO 9018                                                        MUL11160
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 9016 WRITE OUTPUT TAPE 5,9026                                         MUL11170
      GO TO 9018                                                       MUL11180
 9017 WRITE OUTPUT TAPE 5,9027                                         MUL11190
 9018 GO TO 700                                                        MUL11200
 9021 FORMAT(27HGAME IS A DRAW, SUB ESCAPED)                           MUL11210
 9022 FORMAT(34HSUB WINS. DD1 SUNK AND SUB ESCAPED)                    MUL11220
 9023 FORMAT(34HSUB WINS. DD2 SUNK AND SUB ESCAPED)                    MUL11230
 9024 FORMAT(30HSUB WINS. BOTH DESTROYERS SUNK)                        MUL11240
 9025 FORMAT(24HDD WINS. SUB SUNK BY DD1)                              MUL11250
 9026 FORMAT(24HDD WINS. SUB SUNK BY DD2)                              MUL11260
 9027 FORMAT(30HSUB WINS BY AVOIDING DETECTION)                        MUL11270
C                                                                      MUL11280
C CRITIQUE I 9500                                                      MUL11290
C                                                                      MUL11300
 9500 IF(MARKS(1)) 9502,9502,9504                                      MUL11310
 9502 IF(MARKS(2)) 9511,9511,9503                                      MUL11320
 9503 IF(MARKS(2)-3)9512,9513,9513                                     MUL11330
 9504 IF(MARKS(2)) 9505,9505,9506                                      MUL11340
 9505 IF(MARKS(1)-3) 9515,9514,9514                                    MUL11350
 9506 IF(MARKS(1)-3)9508,9507,9507                                     MUL11360
 9507 IF(MARKS(2)-3)9517,9516,9516                                     MUL11370
 9508 IF(MARKS(2)-3)9519,9518,9518                                     MUL11380
 9511 WRITE OUTPUT TAPE 5,9521,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX MUL11390
     1(I),I=1,NRDD),(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)        MUL11400
      GO TO 9599                                                       MUL11410
 9512 WRITE OUTPUT TAPE 5,9522,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX MUL11420
     1(I),I=1,NRDD),ICLASS(2),CONTR(2),ICONTB(2),IDOPLER(2),           MUL11430
     2(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)                      MUL11440
      GO TO 9599                                                       MUL11450
 9513 WRITE OUTPUT TAPE 5,9523,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(MUL11460
     1I),I=1,NRDD),ICLASS(2),CONTR(2),ICONTB(2),IDOPLER(2),            MUL11470
     2ICONTC(2),CONTS(2),ISOL(2),                                      MUL11480
     3(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)                      MUL11490
      GO TO 9599                                                       MUL11500
 9514 WRITE OUTPUT TAPE 5,9524,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(MUL11510
     1I),I=1,NRDD),ICLASS(1),CONTR(1),ICONTB(1),IDOPLER(1),            MUL11520
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     2ICONTC(1),CONTS(1),ISOL(1),
     3(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)
      GO TO 9599
9515 WRITE OUTPUT TAPE 5,9525,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX
     1(I),I=1,NRDD),ICLASS(1),CONTR(1),ICONTB(1),IDOPLER(1),
     2(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)
      GO TO 9599
9516 WRITE OUTPUT TAPE 5,9526,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(
     1I),I=1,NRDD ),(ICLASS(I),I=1,NRDD),(CONTR(I),I=1,NRDD),(ICONTB(I),
     2I=1,NRDD),(IDOPLER(I),I=1,NRDD),
     3(ICONTC(I),I=1,NRDD),(CONTS(I),I=1,NRDD),(ISOL(I),I=1,NRDD),
     4(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)
      GO TO 9599
9517 WRITE OUTPUT TAPE 5,9527,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(
     1I),I=1,NRDD ),(ICLASS(I),I=1,NRDD),(CONTR(I),I=1,NRDD),(ICONTB(I),
     2I=1,NRDD),(IDOPLER(I),I=1,NRDD),
     3ICONTC(1),CONTS(1),ISOL(1),
     4(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)
      GO TO 9599
9518 WRITE OUTPUT TAPE5,9528,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(
     1I),I=1,NRDD ),(ICLASS(I),I=1,NRDD),(CONTR(I),I=1,NRDD),(ICONTB(I),
     2I=1,NRDD),(IDOPLER(I),I=1,NRDD),
     3ICONTC(2),CONTS(2),ISOL(2),
     4(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)
      GO TO 9599
9519 WRITE OUTPUT TAPE 5,9529,ESR,IWINDD,GTIME,WINDV,YIELD,ISS,(DDSMAX(
     1I),I=1,NRDD ),(ICLASS(I),I=1,NRDD),(CONTR(I),I=1,NRDD),(ICONTB(I),
     2I=1,NRDD),(IDOPLER(I),I=1,NRDD),
     3(RADRATE(I),I=1,NRDD),(RADDOSE(I),I=1,NRDD)
      GO TO 9599
9521 FORMAT(     5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X,
     1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,
     212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/
     35X,15HMAX SPEED AVAIL,6X,F3.0,3X,F3.0/
     45X,13HCONTACT CLASS/5X,11HSONAR RANGE/5X,13HSONAR BEARING/5X,
     57HDOPPLER/5X,13HTARGET COURSE/5X,12HTARGET SPEED/5X,15HFIRING SOLU
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     6TION/5X,14HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,   MUL11890
     75X,F5.0,6X,F5.0)                                                  MUL11900
9522 FORMAT(    5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL11910
     113/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,        MUL11920
     212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL11930
     35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                            MUL11940
     45X,13HCONTACT CLASS,20X,I1/5X,11HSONAR RANGE,18X,F6.0/5X,13HSONAR MUL11950
     5BEARING,18X,I3/5X,7HDOPPLER,26X,I1/5X,13HTARGET COURSE/5X,        MUL11960
     612HTARGET SPEED/5X,15HFIRING SOLUTION/5X,                         MUL11970
     714HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,   MUL11980
     86X,F5.0)                                                          MUL11990
9523 FORMAT(    5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL12000
     113/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,        MUL12010
     212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL12020
     35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                            MUL12030
     45X,13HCONTACT CLASS,20X,I1/5X,11HSONAR RANGE,18X,F6.0/5X,13HSONAR MUL12040
     5BEARING,18X,I3/5X,7HDOPPLER,26X,I1/5X,13HTARGET COURSE,18X,I3/5X, MUL12050
     612HTARGET SPEED,20X,F3.0/5X,15HFIRING SOLUTION,18X,I1/5X,         MUL12060
     714HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,   MUL12070
     86X,F5.0)                                                          MUL12080
9524 FORMAT(    5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL12090
     113/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,        MUL12100
     212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL12110
     35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                            MUL12120
     45X,13HCONTACT CLASS, 9X,I1/5X,11HSONAR RANGE, 7X,F6.0/5X,13HSONAR MUL12130
     5BEARING, 7X,I3/5X,7HDOPPLER,15X,I1/5X,13HTARGET COURSE, 7X,I3/5X, MUL12140
     612HTARGET SPEED, 9X,F3.0/5X,15HFIRING SOLUTION, 7X,I1/5X,         MUL12150
     714HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,   MUL12160
     86X,F5.0)                                                          MUL12170
9525 FORMAT(    5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL12180
     113/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,        MUL12190
     212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL12200
     35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                            MUL12210
     45X,13HCONTACT CLASS, 9X,I1/5X,11HSONAR RANGE, 7X,F6.0/5X,13HSONAR MUL12220
     5BEARING, 7X,I3/5X,7HDOPPLER,15X,I1/5X,13HTARGET COURSE/5X,        MUL12230
     612HTARGET SPEED/5X,15HFIRING SOLUTION/5X,                         MUL12240
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    714HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,    MUL12250
    86X,F5.0)                                                           MUL12260
 9526 FORMAT(    5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL12270
    1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,          MUL12280
    212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL12290
    35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                             MUL12300
    45X,13HCONTACT CLASS,9X,I1,10X,I1/5X,11HSONAR RANGE,7X,F6.0,5X,F6.0MUL12310
    5/5X,13HSONAR BEARING,7X,I3,8X,I3/5X,7HDOPPLER,15X,I1,10X,I1/       MUL12320
    65X,13HTARGET COURSE,7X,I3,8X,I3/5X,12HTARGET SPEED,9X,F3.0,8X,F3.0MUL12330
    7/5X,15HFIRING SOLUTION,7X,I1,10X,I1/5X,                            MUL12340
    814HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,    MUL12350
    96X,F5.0)                                                           MUL12360
 9527 FORMAT(    5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL12370
    1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,          MUL12380
    212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL12390
    35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                             MUL12400
    45X,13HCONTACT CLASS,9X,I1,10X,I1/5X,11HSONAR RANGE,7X,F6.0,5X,F6.0MUL12410
    5/5X,13HSONAR BEARING,7X,I3,8X,I3/5X,7HDOPPLER,15X,I1,10X,I1/       MUL12420
    65X,13HTARGET COURSE,7X,I3/5X,12HTARGET SPEED,9X,F3.0               MUL12430
    7/5X,15HFIRING SOLUTION,7X,I1/5X,                                   MUL12440
    814HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,    MUL12450
    96X,F5.0)                                                           MUL12460
 9528 FORMAT(    5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL12470
    1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,          MUL12480
    212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL12490
    35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                             MUL12500
    45X,13HCONTACT CLASS,9X,I1,10X,I1/5X,11HSONAR RANGE,7X,F6.0,5X,F6.0MUL12510
    5/5X,13HSONAR BEARING,7X,I3,8X,I3/5X,7HDOPPLER,15X,I1,10X,I1/       MUL12520
    65X,13HTARGET COURSE,18X,I3/5X,12HTARGET SPEED,20X,F3.0             MUL12530
    7/5X,15HFIRING SOLUTION,18X,I1/5X,                                  MUL12540
    814HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,    MUL12550
    96X,F5.0)                                                           MUL12560
 9529 FORMAT(    5X,15HEFF SONAR RANGE,3X,F6.0,8X,14HWIND DIRECTION,6X, MUL12570
    1I3/5X,9HGAME TIME,9X,F7.1,7X,13HWIND VELOCITY,8X,F3.0/5X,          MUL12580
    212HWARHEAD SIZE,9X,F4.1,7X,9HSEA STATE,13X,I1//25X,3HDD1,8X,3HDD2/MUL12590
    35X,15HMAX SPEED AVAIL,6X,F3.0,8X,F3.0/                             MUL12600
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    45X,13HCONTACT CLASS,9X,I1,10X,I1/5X,11HSONAR RANGE,7X,F6.0,5X,F6.0MUL12610
    5/5X,13HSONAR BEARING,7X,I3,8X,I3/5X,7HDOPPLER,15X,I1,10X,I1/       MUL12620
    65X,13HTARGET COURSE/5X,12HTARGET SPEED/5X,15HFIRING SOLUTION/5X,   MUL12630
    714HRADIATION RATE,6X,F4.0,7X,F4.0/5X,14HRADIATION DOSE,5X,F5.0,    MUL12640
    86X,F5.0)                                                           MUL12650
 9599 CONTINUF                                                          MUL12660
 9600 ISUBC=SUBC                                                        MUL12670
      DO 9601 I=1,NRDD                                                  MUL12680
 9601 IDDC(I)=DDC(I)                                                    MUL12690
 9602 WRITE OUTPUT TAPE 5,9620                                          MUL12700
      WRITE OUTPUT TAPE 5,9621,(DDX(I),I=1,NRDD),SUBX,(DDY(I),I=1,NRDD),MUL12710
    1SUBY,(IDDC(I),I=1,NRDD),ISUBC,(DDS(I),I=1,NRDD),SUBS,SUBD          MUL12720
 9603 IF(NSHOTS)9604,9604,9605                                          MUL12730
 9604 GO TO 9628                                                        MUL12740
 9605 WRITE OUTPUT TAPE 5,9625                                          MUL12750
      DO 9606 I=1,NSHOTS                                                MUL12760
 9606 WRITE OUTPUT TAPE 5,9626 ,I,POOLX(I),POOLY(I),POOLR(I)            MUL12770
      WRITE OUTPUT TAPE 5,9627                                          MUL12780
      DO 9608 I=1,NSHOTS                                                MUL12790
 9608 WRITE OUTPUT TAPE 5,9628,I,CLOUDX(I),CLOUDY(I),CLOUDR(I)          MUL12800
 9620 FORMAT (18X,3HDD1,10X,3HDD2,10X,3HSUB)                            MUL12810
 9621 FORMAT(7X,1HX,7X,F8.1,5X,F8.1,5X,F8.1/7X,1HY,7X,F8.1,5X,F8.1,5X,F MUL12820
    18.1/5X,6HCOURSE,8X,I3,10X,I3,10X,I3/5X,5HSPEED,9X,F4.1,9X,         MUL12830
    2F4.1,9X,F4.1/5X,9HSUB DEPTH,F8.1)                                  MUL12840
 9625 FORMAT(10X,4HPOOL,6X,1HX,9X,1HY,9X,6HRADIUS)                      MUL12850
 9626 FORMAT(10X,I1,(9X,3F8.1))                                         MUL12860
 9627 FORMAT(10X,5HCLOUD,5X,1HX,9X,1HY,9X,6HRADIUS)                     MUL12870
 9628 FORMAT(10X,I1,(9X,3F8.1))                                         MUL12880
 9629 WRITE OUTPUT TAPE 5,9630,DAMAGET                                  MUL12890
 9630 FORMAT(19HTOTAL DAMAGE TO SUB,2X,F4.1/)                           MUL12900
      IF(ICRIT1)9631,9631,9641                                          MUL12910
 9631 IF(ICRIT2)9632,9632,9642                                          MUL12920
 9632 IF(ICRIT3)9633,9633,9643                                          MUL12930
 9633 IF(ICRIT4)9634,9634,9644                                          MUL12940
 9634 IF(ICRIT5)9635,9635,9645                                          MUL12950
 9635 IF(ICRIT6)9636,9636,9646                                          MUL12960
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9636 IF(ICRIT7)9637,9637,9647                                          MUL12970
9637 IF(ICRIT8)9638,9638,9648                                          MUL12980
9638 IF(ICRIT9;9660,9660,9649                                          MUL12990
9641 WRITE OUTPUT TAPE 5,9651                                          MUL13000
     GO TO 9660                                                        MUL13010
9642 WRITE OUTPUT TAPE 5,9652                                          MUL13020
     GO TO 9660                                                        MUL13030
9643 WRITE OUTPUT TAPE 5,9653                                          MUL13040
     GO TO 9660                                                        MUL13050
9644 WRITE OUTPUT TAPE 5,9654                                          MUL13060
     GO TO 9660                                                        MUL13070
9645 WRITE OUTPUT TAPE 5,9655                                          MUL13080
     GO TO 9660                                                        MUL13090
9646 WRITE OUTPUT TAPE 5,9656                                          MUL13100
     GO TO 9660                                                        MUL13110
9647 WRITE OUTPUT TAPE 5,9657                                          MUL13120
     GO TO 9660                                                        MUL13130
9648 WRITE OUTPUT TAPE 5,9658                                          MUL13140
     GO TO 9660                                                        MUL13150
9649 WRITE OUTPUT TAPE 5,9659                                          MUL13160
9651 FORMAT(13HSONAR CONTACT/)                                         MUL13170
9652 FORMAT(11HASROC FIRED/)                                           MUL13180
9653 FORMAT(13HTORPEDO FIRED/)                                         MUL13190
9654 FORMAT(13HASROC MISFIRE/)                                         MUL13200
9655 FORMAT(15HTARGET IN RANGE/)                                       MUL13210
9656 FORMAT(8HSUB SUNK/)                                               MUL13220
9657 FORMAT(7HDD SUNK/)                                                MUL13230
9658 FORMAT(26HTARGET TOO CLOSE TO SHOOT AT/)                          MUL13240
9659 FORMAT(25HTARGET OUT OF ASROC RANGE/)                             MUL13250
9660 ICRIT1=0                                                          MUL13260
9661 ICRIT2=0                                                          MUL13270
9662 ICRIT3=0                                                          MUL13280
9663 ICRIT4=0                                                          MUL13290
9664 ICRIT5=0                                                          MUL13300
9665 ICRIT6=0                                                          MUL13310
9666 ICRIT7=0                                                          MUL13320
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9667 ICRIT8=0                                                                MUL13330
9668 ICRIT9=0                                                                MUL13340
9700 DO 9701 I=1,2                                                           MUL13350
     ZZX(I)=DDX(I)                                                           MUL13360
9701 ZZY(I)=DDY(I)                                                           MUL13370
     ZZX(3)=SUBX                                                             MUL13380
     ZZY(3)=SUBY                                                             MUL13390
     IF(KGRAF)9702,9702,9704                                                 MUL13400
9702 LABEL=8HDD1   SUB                                                       MUL13410
     DO 9703 I=1,12                                                          MUL13420
9703 ITITLE=8H                                                               MUL13430
     CALL DRAW(3,ZZX,ZZY,1,2,LABEL,ITITLE,10000.0,10000.0,4,4,2,2,8,8,  MUL13440
    11,LAST)                                                                 MUL13450
     GO TO 9706                                                              MUL13460
9704 KGRAF=KGRAF+1                                                           MUL13470
     IF(KGRAF-6)9706,9706,9705                                               MUL13480
9705 KGRAF=1                                                                 MUL13490
     ITITLE=8H                                                               MUL13500
     LABEL=8H                                                                MUL13510
     CALL DRAW(3,ZZX,ZZY,2,2,LABEL,ITITLE,10000.0,10000.0,4,4,2,2,8,8,  MUL13520
    11,LAST)                                                                 MUL13530
9706 CONTINUE                                                                MUL13540
     GO TO 700                                                               MUL13550
 850 END                                                                     MUL13560
     SUBROUTINE RANVAR                                                       MUL13570
     COMMON IRANDOM,RANDOM                                                   MUL13580
     CON(K1=67108864)                                                        MUL13590
     IRANDOM=IRANDOM*3125                                                    MUL13600
     IF(IRANDOM-67108863)2,2,1                                               MUL13610
   1 ENQ(0),LDA(IRANDOM),DVI(K1),STQ(IRANDOM)                                MUL13620
   2 Y=IRANDOM                                                               MUL13630
     RANDOM=Y/67108864.0                                                     MUL13640
     RETURN                                                                  MUL13650
     END                                                                     MUL13660
     SUBROUTINE NORMAL(A,B,C)                                                MUL13670
     COMMON IRANDOM,RANDOM                                                   MUL13680
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      SUM=0.0                                                           MUL13690
      DO 1 I=1,12                                                       MUL13700
      CALL RANVAR                                                       MUL13710
    1 SUM=SUM+RANDOM                                                    MUL13720
      X=SUM-6.0                                                         MUL13730
      C=X*B+A                                                           MUL13740
      RETURN                                                            MUL13750
      END                                                               MUL13760
      SUBROUTINE UNIFORM(A,B,C)                                         MUL13770
      COMMON IRANDOM,RANDOM                                             MUL13780
      CALL RANVAR                                                       MUL13790
      C=2.0*B*(RANDOM-.5)+A                                             MUL13800
      RETURN                                                            MUL13810
      END                                                               MUL13820
      SUBROUTINE ERROR(A,B,C,D,E)                                       MUL13830
      CALL UNIFORM(180.0,179.9,THETA)                                   MUL13840
      CALL NORMAL(0.0,C,R)                                              MUL13850
      R=ABSF(R)                                                         MUL13860
      D=A+R*SINF(THETA/57.295)                                          MUL13870
      E=B+R*COSF(THETA/57.295)                                          MUL13880
      RFTURN                                                            MUL13890
      END                                                               MUL13900
      SUBROUTINE CIRCLE(A,B,C,D,E,F,K,L)                                MUL13910
      DIMENSION U(24),V(24),K(24),L(24)                                 MUL13920
      U(1)=.991*C*255.0/F                                               MUL13930
      U(2)=.924*C*255.0/F                                               MUL13940
      U(3)=.793*C*255.0/F                                               MUL13950
      V(1)=.131*C*255.0/F                                               MUL13960
      V(2)=.383*C*255.0/F                                               MUL13970
      V(3)=.609*C*255.0/F                                               MUL13980
      DO 1 I=4,6                                                        MUL13990
      U(I)=V(9-I)                                                       MUL14000
    1 V(I)=U(9-I)                                                       MUL14010
      DO 2 I=7,9                                                        MUL14020
      U(I)=-U(17-I,                                                     MUL14030
    2 V(I)=V(17-I)                                                      MUL14040
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      DO 3 I=10,12                                                      MUL14050
      U(I)=-U(17-I)                                                     MUL14060
    3 V(I)=V(17-I)                                                      MUL14070
      DO 4 I=13,24                                                      MUL14080
      U(I)=-U(I-16)                                                     MUL14090
    4 V(I)=-V(I-16)                                                     MUL14100
      DO 5 I=1,24                                                       MUL14110
      U(I)=U(I)-D+A*255.0/F                                             MUL14120
    5 V(I)=V(I)-E+B*255.0/F                                             MUL14130
      DO 6 I=1,24                                                       MUL14140
      K(I)=U(I)                                                         MUL14150
    6 L(I)=V(I)                                                         MUL14160
      DO 10 I=1,24                                                      MUL14170
      IF(XABSF(K(I))-255)8,8,7                                          MUL14180
    7 K(I)=-0                                                           MUL14190
    8 IF(XABSF(L(I))-255)10,10,9                                        MUL14200
    9 L(I)=-0                                                           MUL14210
   10 CONTINUE                                                          MUL14220
      RETURN                                                            MUL14230
      END                                                               MUL14240
      SUBROUTINE DCIRCLE (ITRKNO,  CHAR, NUMPTS, IX, IY)                MUL14250
      LOC (Z=0, BUF=600)                                                MUL14260
      CON (CODE1=2525252525252525B, MASK=0000000000000077B,             MUL14270
     *      MASK1=0000000000000777B,SCODE=0002000000000706B)            MUL14280
      CON (FILL=0000000007770777B)                                      MUL14290
      DIMENSION IX(32), IY(32)                                          MUL14300
*                                                                       MUL14310
*  SAVE ALL INDEXES                                                     MUL14320
1SAVE SIU1(1REST)        SIL2(1REST)         .SAVE                      MUL14330
      SIU3(2REST)        SIL4(2REST)         . ALL                      MUL14340
      SIU5(3REST)        SIL6(3REST)         . INDEXES                  MUL14350
      ENA (-0)           ENI3(17)            .                          MUL14360
      STA3(BUF)          IJP3(L)             .                          MUL14370
      EXF (62540B)       LDA (SCCDE)         .SET COMM FLAG 1           MUL14380
      STA (BUF)          ENA (1)             .SET 169 CODE WD.          MUL14390
      ENQ (6)            SLJ4(Z+26B)         .SEND TO SATELLITE         MUL14400
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      EXF (62560B)     ENI (0)            . CLEAR COMM FLAG 1
      LDA(CODE1)       STA(1CODE)         .INITIALIZE
      ENI1(1)          ENI2(0)            .
      LDA (ITRKNO)     AJP3(1000)         .CHECK VALUES
      AJPO(1000)       INA (-17)          .
      AJP3(1CONT)      SLJ(1000)          .
1CONT LDA(NUMPTS)      AJP3(2000)         .
      AJPO(2000)       SAU (1CHEK)        .
      SAU (2CHEK)      INA (-33)          .
      AJP3(2CONT)      SLJ(2000)          .
2CONT LDA(CHAR)        ALS (6)            .
      STA(1CHAR)       ENA(0)             .
      LDQ(MASK)        ADL (ITRKNO)       .PACK WORDS
      ALS (6)          ADL (NUMPTS)       .
      ALS (12)         LDQ (MASK1)        .
      ADL(1CHAR)       SLJ(2STRT)         .
1STRT ENA (0)          ENI (0)            .
2STRT ALS (12)         ADL1(IX)           .
      ALS (12)         ADL1(IY)           .
      SSH (1CODE)      SLJ (1STOR)        .
1CHEK ISK1(N)          SLJ (2STRT)        .
      ALS (24)         ADD (FILL)         .
      STA2(BUF)        SLJ (1THRU)        .
1STOR STA2(BUF)        INI2(1)            .
2CHEK ISK1(N)          SLJ (1STRT)        .
1THRU ENA (17)         ENQ (6)
      SLJ4 (Z+26B)     ENI (0)
      EXF (62560B)     SLJ(1REST)         . CLEAR COMM FLAG 1
1CHAR ZRO(0)           ZRO (0)            .
1CODE ZRO(0)           ZRO (0)            .
 1000 PRINT 120
  120 FORMAT (//20H TRACK NO. IN ERROR,/)
      SLJ (1REST)      ZRO (0)            .
 2000 PRINT 130
  130 FORMAT (// 23H NUMBER OF PTS IN ERROR ,/)
      SLJ (1REST)      ZRO(0)             .
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1REST ENI1(N)            ENI2(N)           .RESTORE                           MUL14770
2REST ENI3(N)            ENI4(N)           . ALL                              MUL14780
3REST ENI5(N)            ENI6(N)           . INDEXES                          MUL14790
      END                                                                     MUL14800
      SUBROUTINE DTRACK (ITRKNO, CHAR, NUMPTS, IX, IY)                        MUL14810
      LOC (Z=0, BUF=600)                                                      MUL14820
      CON (CODE1=2525252525252525B, MASK=0000000000000077B,                   MUL14830
*          MASK1=0000000000000777B,SCODE=0001000000000706B)                   MUL14840
      CON (FILL=0000000007770777B)                                            MUL14850
      DIMENSION IX(8),IY(8)                                                   MUL14860
*                                                                             MUL14870
*  SAVE ALL INDEXES                                                           MUL14880
1SAVE SIU1(1REST)        SIL2(1REST)       .SAVE                              MUL14890
      SIU3(2REST)        SIL4(2REST)       . ALL                              MUL14900
      SIU5(3REST)        SIL6(3REST)       . INDEXES                          MUL14910
      ENA (-0)           ENI3(17)          .                                  MUL14920
      STA3(BUF)          IJP3(L)           .                                  MUL14930
      EXF (62540B)       LDA (SCODE)       .SET COMM FLAG 1                   MUL14940
      STA (BUF)          ENA (1)           .SET 160 CODE WORD                 MUL14950
      ENQ (6)            SLJ4(Z+26B)       .SEND TO SATELLITE                 MUL14960
      EXF (62560B)       ENI (0)           . CLEAR COMM FLAG 1                MUL14970
      LDA(CODE1)         STA(1CODE)        .INITIALIZE                        MUL14980
      ENI1(1)            ENI2(0)           .                                  MUL14990
      LDA (ITRKNO)       AJP3(1000)        .CHECK VALUES                      MUL15000
      AJP0(1000)         INA (-9)          .                                  MUL15010
      AJP3(1CONT)        SLJ(1000)         .                                  MUL15020
1CONT LDA(NUMPTS)        AJP3(2000)        .                                  MUL15030
      AJP0(2000)         SAU (1CHEK)       .                                  MUL15040
      SAU (2CHEK)        INA (-9)          .                                  MUL15050
      AJP3(2CONT)        SLJ(2000)         .                                  MUL15060
2CONT LDA(CHAR)          ALS (6)           .                                  MUL15070
      STA(1CHAR)         ENA(0)            .                                  MUL15080
      LDQ(MASK)          ADL (ITRKNO)      .PACK WORDS                        MUL15090
      ALS (6)            ADL (NUMPTS)      .                                  MUL15100
      ALS (12)           LDQ (MASK1)       .                                  MUL15110
      ADL(1CHAR)         SLJ(2STRT)        .                                  MUL15120
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1STRT ENA (0)         ENI (0)          .                              MUL15130
2STRT ALS (12)        ADL1(IX)         .                              MUL15140
      ALS (12)        ADL1(IY)         .                              MUL15150
      SSH (1CODE)     SLJ (1STOR)      .                              MUL15160
1CHEK ISK1(N)         SLJ (2STRT)      .                              MUL15170
      ALS (24)        ADD (FILL)       .                              MUL15180
      STA2(BUF)       SLJ (1THRU)      .                              MUL15190
1STOR STA2(BUF)       INI2(1)          .                              MUL15200
2CHEK ISK1(N)         SLJ (1STRT)      .                              MUL15210
1THRU ENA(17)         ENQ (6)          .SEND TO                       MUL15220
      SLJ4(Z+26B)     ENI (0)          .SATELLITE                     MUL15230
      EXF(625606)     SLJ (1REST)      .CLEAR COMM FLAG 1             MUL15240
1CHAR ZRO(0)          ZRO (0)          .                              MUL15250
1CODE ZRO(0)          ZRO (0)          .                              MUL15260
 1000 PRINT 120                                                       MUL15270
  120 FORMAT (//20H TRACK NO. IN ERROR,/)                             MUL15280
      SLJ (1REST)     ZRO (0)          .                              MUL15290
 2000 PRINT 130                                                       MUL15300
  130 FORMAT (// 23H NUMBER OF PTS IN ERROR ,/)                       MUL15310
      SLJ (1REST)     ZRO(0)           .                              MUL15320
1REST ENI1(N)         ENI2(N)          .RESTORE                       MUL15330
2REST ENI3(N)         ENI4(N)          . ALL                          MUL15340
3REST ENI5(N)         ENI6(N)          . INDEXES                      MUL15350
      EXF (425608)    EXF (625608)     .RESET COMM FLAG 1             MUL15360
      END                                                             MUL15370
      SUBROUTINE DSTATUS (ITYPE, NWIND, IW, INAME, IX, IY)            MUL15380
      LOC(Z=0, BUF=600)                                               MUL15390
      CON(SCODE=000300000000706B, MASK=00000000000000077B,            MUL15400
     *     MASK1=0000000000000777B,MASK2=0000000000000001B,           MUL15410
     *     MASK3=0000000000000007B,MASK4=000077777777777 7B)          MUL15420
*                                                                     MUL15430
*  SAVE ALL INDEXES                                                   MUL15440
1SAVE SIU1(1REST)     SIL2(1REST)      .SAVE                          MUL15450
      SIU3(2REST)     SIL4(2REST)      . ALL                          MUL15460
      SIU5(3REST)     SIL6(3REST)      . INDEXES                      MUL15470
      EXF (625408)    LDA (SCODE)      .SET COMM FLAG 1               MUL15480
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        STA (BUF)           ENA (1)             .SET 160 CODE WORD              MUL15490
        ENQ (6)             SLJ4(Z+26B)         .SEND TO SATELLITE              MUL15500
        EXF (62560B)        ENI (0)             . CLEAR COMM FLAG 1             MUL15510
        ENA (77777B)        ENI3(17)            .                               MUL15520
        STA3(BUF)           IJP3(L)             . CLEAR BUFFER                  MUL15530
        LDA (NWIND)         AJP3(1000)          .CHECK                          MUL15540
        AJP0(1000)          INA (-17)           .WINDOW                         MUL15550
        AJP3(1GO)           SLJ (1000)          .NO.                            MUL15560
1GO     ENA (INAME)         ENQ (0)             .SHIFT ADDRESS                  MUL15570
        LRS (12)            STA (1ADD)          .                               MUL15580
        STQ(2ADD)           LDA (INAME)         .                               MUL15590
        ENQ (0)             LRS (12)            .SHIFT CONTENTS                 MUL15600
        STA (1CONT)         STQ (2CONT)         .OF ADDRESS                     MUL15610
        ENA (0)             LDQ (MASK)          .                               MUL15620
        ADL (NWIND)         ALS (6)             .                               MUL15630
        ADL (IW)            ALS (12)            .                               MUL15640
        LDQ (MASK1)         ADL (IX)            .                               MUL15650
        ALS (12)            ADL (IY)            .                               MUL15660
        ALS (1)             LDQ (MASK2)         .                               MUL15670
        ADL (ITYPE)         ALS (11)            .                               MUL15680
        LDQ (MASK3)         ADL (1ADD)          .                               MUL15690
        STA (BUF)           LDA (2ADD)          .                               MUL15700
        LDQ (MASK4)         ADL (1CONT)         .                               MUL15710
        STA (BUF+1)         LDA (2CONT)         .                               MUL15720
        STA (BUF+2)         ENI (0)             .                               MUL15730
1SEND   ENA (17)            ENQ (6)             .SEND TO                        MUL15740
        SLJ4(Z+26B)         ENI(0)              . SATELLITE                     MUL15750
        EXF (62560B)        SLJ (1REST)         .CLEAR COMM FLAG 1              MUL15760
1ADD    ZRO (0)             ZRO (0)             .                               MUL15770
2ADD    ZRO (0)             ZRO (0)             .                               MUL15780
1CONT   ZRO (0)             ZRO (0)             .                               MUL15790
2CONT   ZRO (0)             ZRO (0)             .                               MUL15800
 1000   PRINT 100                                                               MUL15810
  100   FORMAT(// 21H WINDOW NO. IN ERROR   ./)                                 MUL15820
        SLJ (1REST)         ZRO (0)             .RESTORE                        MUL15830
1REST   ENI1(N)             ENI2(N)             . ALL                           MUL15840
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2REST ENI3(N)           ENI4(N)          . INDEXES                      MUL15850
3REST ENI5(N)           ENI6(N)          .                              MUL15860
      END                                                               MUL15870
      MACHINE PARAMS (1A,2A,3A,4A,5A,6A,7A,8A)                          MUL15880
      LOC (Z=0, BUF=600)                                                MUL15890
      CON (SCODE = 0000000000000707B)                                   MUL15900
*                                                                       MUL15910
1STAR SLJ (N)           SLJ (L+9)        .EXIT/ENTRY                    MUL15920
1A    ZRO (0)           ZRO (0)          .                              MUL15930
2A    ZRO (0)           ZRO (0)          .                              MUL15940
3A    ZRO (0)           ZRO (0)          .                              MUL15950
4A    ZRO (0)           ZRO (0)          .                              MUL15960
5A    ZRO (0)           ZRO (0)          .                              MUL15970
6A    ZRO (0)           ZRO (0)          .                              MUL15980
7A    ZRO (0)           ZRO (0)          .                              MUL15990
8A    ZRO(0)        ZRO(0)                .                             MUL16000
1SAVE SIU1(1REST)       SIL2(1REST)      .                              MUL16010
      SIU3(2REST)       SIL4(2REST)      .                              MUL16020
      SIU5(3REST)       SIL6(3REST)      .                              MUL16030
      EXF (62540B)      LDA (SCODE)      .SET COMM FLAG 1               MUL16040
      STA (BUF)         ENA (1)          .SET 160 CODE WD.              MUL16050
      ENQ (6)           SLJ4(Z+26B)      .SEND TO SATELLITE             MUL16060
      EXF (62560B)      ENI (0)          .CLEAR COMM FLAG 1             MUL16070
      ENA (8)           ENQ(5)           .READ FROM 160                 MUL16080
      SLJ4(Z+26B)       ENI (0)          .                              MUL16090
      ENI1(0)           ENA (7)          .                              MUL16100
      SAU (1CHEK)       ENI (0)          .                              MUL16110
1TRAN LDA1(1A)          SAL (L+2)        .TRANSFER BUFFER               MUL16120
      LDA1(BUF)         ALS (36)         . TO ARGS                      MUL16130
      ARS (36)          STA (N)          .                              MUL16140
1CHEK ISK1(N)           SLJ (1TRAN)      .                              MUL16150
1REST ENI1(N)           ENI2(N)          .RESTORE INDEXES               MUL16160
2REST ENI3(N)           ENI4(N)          .                              MUL16170
3REST ENI5(N)           ENI6(N)          .                              MUL16180
      SLJ (1STAR)       ZRO (0)          .                              MUL16190
      END                                                               MUL16200
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A general approach is documented as a guide to aid in the formulation and implementation of on-line, real time computer simulations. A computer program MULNUC1, is developed as an on-line, real time computer simulation of antisubmarine warfare in a multiple burst nuclear environment. The principals of the game are a submarine armed with torpedoes, and two destroyers equipped with stand-off antisubmarine weapons. The simulation is intended as a demonstration of the on-line capabilities of the United States Naval Postgraduate School computer system and as a tool for further study of the factors involved in a representative ASW operational environment.

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