TRAJ--A Two Dimensional Trajectory Program For Personal Computers*

prepared by

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ABSTRACT

The computer code TRAJ was developed to allow relatively complex trajectory calculations to be performed on a desk top personal computer. The code includes the effects of projectile mass, shape, density, launch velocity, and launch angle, as well as multiple ricochets from the ground. Terrain effects, barricades, buildings, etc can also be defined and included in the calculations. The code is briefly described and sample problems and outputs are presented.

BACKGROUND

The computer program TRAJ was originally developed at the Naval Surface Warfare Center (NAVSWC) by Porzel as part of the Naval Explosives Safety Improvement Program (NESIP)[1]. It is based on an analytic solution to the classical "v^2 drag" trajectory problem. Reference 1 provides the basic assumptions and equations around which the program is written. Over the past ten years (since the publication of Reference 1), developments and improvements have continued in the program. This paper presents the latest version of the program and discusses some of the changes which have been made to the program.

These developments include (but are not limited to): (1) terrain effects--sloping terrain, hills, valleys, etc., (2) the ability to "build" structures (barricades, buildings, etc) into the trajectory path, and (3) fragment ricochets from the ground or from structures. They also include various plotting and presentation options. The ricochet and structural interaction portions of the program were developed by the Boeing Military Airplane Company (Mr. Richard A. Lorenz), under contract to NAVSWC.

The ricochet methodology is based on work originally performed by the Army and incorporated into the computer program FRAGHAZ[2,3]. When a fragment impacts the ground or a structure, its impact angle is compared with a critical ricochet angle to determine whether the fragment will ricochet. The critical ricochet angle is dependent on the type of soil. Once it is determined that the fragment will ricochet, the ricochet angle and velocity are determined form the incident angle and velocity as well as the soil type. When ricochet occurs, the trajectory calculation continues until no further ricochets occur and the fragment has come to rest.

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HARDWARE REQUIREMENTS

The program is written in BASIC and is designed to run on any IBM-compatible machine using DOS 3.1 operating system (or higher) with 640 kilobytes of memory and a hard disk. The program supports CGA, EGA, and VGA graphics. An IBM-AT (or faster) machine with math co-processor is highly recommended.

GENERAL

The input to the program is prepared interactively through a series of screens which question the user. At any time, the user may change his mind and replace information which has already been entered. The program is set up to operate in a modified English system of units. All lengths are in feet, areas in ft^2, and velocities in ft/s. All weights are in pounds. Fragment densities are in g/cm^3. Impact energies are calculated in ft-lbs.

Several kinds of information are required to perform the calculations. The most important is a description of the fragment and the initial conditions. The fragment description includes mass, shape, and density. Mass and density are straightforward. The shape is not. The shape of an object is described by its shape factor, length in direction of motion, and cross sectional area. The shape factor is a required input, and is described below. Length in direction of motion, or cross sectional area can be entered as an option; but not both.

Shape Factor. The shape factor can be thought of as the ratio of the volume of the fragment to the volume of a rectangular box with the minimum dimensions required to hold the fragment. Typical explosively-formed fragments have shape factors around 0.333. Pre-formed fragments have a shape factor of 1.000. A sphere has a shape factor of $\pi/6$ (0.524). Experimentally-determined shape factors for concrete debris have ranged from 0.33 to 0.44.

Length in Direction of Motion. This is directly what it seems. If, for instance, it is known or postulated that a fragment flies like a spear, then the total length of the fragment would be the length in the direction of motion. In the program, this is referred to as Characteristic Fragment Length.

DESCRIPTION OF INPUT SCREENS

MAIN MENU

See Figure 1. Upon entering the program, you will see the Main Menu. It defines the six possible decision paths which are allowed within the program.

The first time a particular problem is run, Item 1 should be selected. This will lead to further screens which will be discussed later.

After Item 1 is completed, the trajectories are automatically calculated and stored on the hard disk. At this point, the Main Menu reappears. Here, a screen plot of the trajectories can be displayed through the use of Item 3. Item 4 presents a summary table of the final conditions for each of the trajectories computed. Item 5 presents details of the complete trajectory for each case. Item 2 is used to preview barrier or structure data before trajectory calculations are done (see THIRD INPUT SCREEN). It simply plots the terrain and any associated structures or barriers--but no trajectories. Item 6 causes the program to exit back to DOS.

Let us assume that Item 1 was initially selected.

FIRST INPUT SCREEN

See Figure 2. The program first reads an input data file "TRAJ.IN" from the hard disk. This file contains all of the trajectory input conditions that were used on the last Traj run. If you copy this file in DOS to another name, you can preserve these input conditions for future use, and copy them back to "TRAJ.IN" when needed. If the information on the screen is correct, answer Y to the question "Is this screen O.K. (Y/N)?" If the information requires modification, answer N.

The program is setup to do many trajectory calculations at one time using different initial velocities, angles, and masses. If you have answered N, the first information requested is the initial velocity: beginning, ending, and increment. The beginning and ending initial velocities are obvious. The increment may be either positive or negative. The beginning initial velocity is incremented by the amount chosen until the ending initial velocity is obtained (or exceeded). Thus a series of initial velocities can easily be chosen. The pointer is moved by use of the "Enter" key. If an item does not need to be changed, pressing "Enter" will accept the default value shown.

The second set of required data is the initial angle. This works in exactly the same way as the initial velocity. It must be remembered that each angle selected will be run with all initial velocities selected.

The third item required is the mass (or masses) of the fragments. This is simply a list of all the masses of interest (separated by an "Enter"). Up to 20 masses may be chosen. It should be noted that if the user chooses 10 initial velocities, 10 initial angles, and 10 masses, the program will calculate 1000 trajectories, which will take quite a long time (> 60 minutes). Also a screen plot of these would be far too crowded to allow interpretation.

The final item on this screen is the density of the fragments. If the material is one of the default materials, simply enter the corresponding number and press "Enter". Otherwise, choose "other" and enter the appropriate density.

When this is completed the prompt "Is this screen O.K. (Y/N)?" will appear. If all the information showing on the screen is correct, type Y. Then type space bar to continue to the next screen or M to return to the main menu (use this also if you want to return to a previous screen). If any of the information is still not correct, type N. This will allow you to cycle through the information on that screen again, changing anything needed.

SECOND INPUT SCREEN

See Figure 3. Again, the first thing encountered will be the dialog: "Is this screen O.K. (Y/N)?". To make changes on this screen, type N.

Select a shape factor from one of the options listed or choose other and enter the value.

If desired enter either the cross sectional area or the characteristic length (but not both), and enter zero for the other. If both are entered, the cross sectional area entered will be ignored.

If the trajectory is to be calculated for conditions other than at sea level, then the value of the atmospheric density and sound speed for that altitude will be required.

The fragment starting height allows the trajectory to start somewhere other than at ground level.

A drag coefficient table versus Mach number table is built into the program and is presented on this screen. The table is in terms of Drag Coefficient vs. Mach Number. Two choices are available with this table. The first asks whether interpolation between table entries is requested. If No is selected, the drag coefficient remains constant between Mach number entries. For example , the drag coefficient is assumed to be 0.8 for Mach numbers between 0.0 and 0.75, and 0.88 for 0.75 to 0.9, etc. If Yes is selected, the drag coefficient varies linearly from 0.8 to 0.88 for Mach numbers between 0.0 and 0.75, etc. The second choice allows direct change or modification to the table itself.

Again, when this is completed the prompts "Is this screen O.K. (Y/N)?" and "Type space bar to continue or M to return to main menu" will appear. If all the information showing on the screen is correct, type Y. Then type space bar to continue to the next screen. If any of the information is still not correct, type N. This will allow you to cycle through the information on that screen again, changing anything needed.

THIRD INPUT SCREEN

See Figure 4. This screen defines the terrain and any structures or barriers.

The first item is the minimum altitude. This defines a "lower limit altitude", below which calculations will not be carried out. This can be used for flat ground, but ricochet will not occur.

Next, you are asked if you would like to view the table of soil constants. These are required for the ricochet calculations. This table simply presents descriptions of the soil and their associated constants. It is shown in Figure 5. This is helpful in selecting the proper values.

Finally you are asked to define the terrain and barriers/structures. These are defined

by the coordinates (x,y) of points on the terrain or structure. The terrain is built up in segments--three pairs of points per segment. If only two points are given for a segment, a straight line is fitted between them. If three points are given for a segment, a quadratic is fitted. A soil constant is also required for each segment. If a value of 0 is put in for the soil constant, no ricochets will be allowed over that segment. Up to 10 segments are allowed.

Again, when this is completed the prompts "Is this screen O.K. (Y/N)?" and "Type space bar to continue or M to return to main menu" will appear. If any of the information is still not correct, type N. This will allow you to cycle through the information again, changing anything needed. If all the information showing on the screen is correct, type Y. Then type space bar. The program counts as each trajectory calculation is completed. When all of the calculations are completed, the input data file "TRAJ.IN" is written to disk.

Suppose that you have put in the coordinates of a terrain/barrier system and you wish to preview them before performing the calculations. In that case, instead of typing space bar to continue, type M and return to the Main Menu. On the main menu, select option 2 ("Plot Working Barrier Data"). This will produce a screen plot of the information provided. If it is correct, Enter option 1, and then choose Y on each screen. If the terrain/barrier is not correct, when Screen 3 appears, make the appropriate changes.

When the trajectory computations are completed, you are returned to the Main Menu.

GETTING A PRINTOUT OF SCREEN PLOTS

To obtain a printout of working barrier or fragment trajectory plots, type the DOS command "graphics" before running TRAJ. Then when a plot is displayed on the screen, press the "print screen" key and a copy of the screen will be sent to the printer. Some versions of DOS do not support "print screen" for VGA graphics, so in this case select EGA graphics when doing screen plots.

SAMPLE CALCULATIONS

Let us consider two problems. Each will be described. Then samples of the input screens and the outputs will be presented.

PROBLEM 1 (Figures 2 - 8)

Trajectories are calculated for a 20 pound concrete fragment. Initial velocities are 200 and 300 ft/s at angles of 30, 40, and 50 degrees above the horizontal. The terrain slopes downward from the source 50 feet in 800 feet to the base of a hill. The rounded hill peaks at 150 feet above the source at a distance of 1300 feet. The hill descends to level terrain 55 feet below the source at a distance of 1750 feet. The soil type is dry sand. Ricochet is enabled, but does not occur.

This problem illustrates: (1) the reversal of fragment range after maximum range is achieved; (2) trajectory termination on a downward slope, or linear barrier; (3) trajectory termination on a curved contour, or quadratic barrier; and (4) construction of a complex ground contour by connecting linear and/or quadratic segments.

PROBLEM 2 (Figures 9 - 15)

Trajectories are calculated for a 20 pound concrete fragment. Initial velocities are 200 and 300 ft/s at angles of 5, 7.5, and 10 degrees above the horizontal. The terrain slopes upward from the source 35 feet in 500 feet to a level plateau 200 feet in length. The terrain then returns to source level at a distance of 890 feet from the surface. A 4.4 foot vertical barrier is located about three-quarters of the way up the initial slope. The soil type is dry sand. Ricochet is enabled.

This problem illustrates: (1) ricochet on both ascending and descending slopes; (2) multiple ricochets for a single trajectory; (3) trajectory termination on a vertical barrier.

SUMMARY

The above examples illustrate the versatility of TRAJ, with its ability to handle uneven terrain with multiple barriers, its incorporation of ricochet, and its ability to calculate multiple trajectories with a range of input conditions in one run.

REFERENCES

1. Porzel, F. B., "Technology Base of the Navy Explosives Safety Improvement Program," Minutes of the Nineteenth Explosives Safety Seminar, Los Angeles, CA, 9-11 September 1980.

2. McCleskey, F., "Fragmentation Hazard Computer Model," Minutes of the Twenty-First Explosives Safety Seminar, Houston, TX, 28-30 Aug 1984.

3. McCleskey, F., "Quantity-Distance Fragment Hazard Computer Program (FRAGHAZ)," NSWC TR 87-59, February 1988.

Figure 1: MAIN MENU

```
                    MAIN MENU

    1.  CHANGE INPUT CONDITIONS, CALCULATE NEW TRAJECTORIES

    2.  PLOT WORKING BARRIER DATA

    3.  PLOT FRAGMENT TRAJECTORIES

    4.  DISPLAY FINAL CONDITIONS FOR FRAGMENTS

    5.  DISPLAY COMPLETE TRAJECTORY CONDITIONS FOR FRAGMENTS

    6.  EXIT PROGRAM

          ENTER SELECTION NUMBER AND PRESS ENTER
```

Figure 2: FIRST INPUT SCREEN - PROBLEM 1

```
                FRAGMENT TRAJECTORY DATA INPUT

                          BEGINNING      ENDING         INCREMENT
INITIAL VELOCITY (FT/SEC) 200            300            100
INITIAL ANGLE (DEG)       30             50             10

   LIST OF MASSES (LB)          SELECT FRAGMENT DENSITY (gm/cm^3)

   20                           1.  STEEL          7.8
                                2.  ALUMINUM       2.7
                                3.  CONCRETE     > 2.4 <
                                4.  CAST IRON      7.1
                                5.  OTHER          ____

                IS THIS SCREEN O.K. (Y/N) ?
```

Figure 3: SECOND INPUT SCREEN - PROBLEM 1

```
SELECT FRAGMENT SHAPE FACTOR                    INTERPOLATE THE DRAG
                                                COEFFICIENT TABLE (Y/N)     Y
1.  TYPICAL FRAGMENTS      0.333
2.  PREFORMED FRAGMENTS    1.0
3.  OTHER                > .46 <                DO YOU WANT TO CHANGE THE
                                                DRAG COEFFICIENT
                                                MACH NUMBER TABLE (Y/N)     N
FRAGMENT AREA (SQFT)
(Enter Zero when Area is Unknown)     0         1.08            4
                                                1.14            2
                                                1.26            1.15
CHARACTERISTIC FRAGMENT LENGTH (FT)             1.09            .9
(Enter Zero when Length is Unknown)   0         .88             .75
                                                .8              0

AMBIENT DENSITY (LBS/CUFT)     .07647

AMBIENT SOUND SPEED (FT/SEC)     1116.45

FRAGMENT STARTING HEIGHT (FT)     0

                    IS THIS SCREEN O.K. (Y/N) ?
```

Figure 4: THIRD INPUT SCREEN - PROBLEM 1

```
                    GROUND/TERRAIN AND BARRIER DATA INPUT

MINIMUM ALTITUDE (FT)    -60     VIEW TABLE OF SOIL CONSTANTS (Y/N)    N

   NO.   1ST POINT     2ND POINT     3RD POINT    SOIL   ... Y = A*X^2 + B*X + C ...
 I PTS X(FT) Y(FT)  X(FT) Y(FT)  X(FT) Y(FT)    CONST       A          B          C
                                                 0-4
 1  2   0     0     800   -50                    2.00   +.000D+00-.625D-01+.000D+00
 2  3   800  -50     900   -45     1000   0       2.00   +.200D-02-.335D+01+.135D+04
 3  3   1000  0     1300   150     1600   0       2.00   -.167D-02+.433D+01-.267D+04
 4  3   1600  0     1700  -45     1750  -55      2.00   +.167D-02-.595D+01+.525D+04

                    IS THIS SCREEN O.K. (Y/N) ?
```

Figure 5: TABLE OF SOIL CONSTANTS

SOIL CONSTANTS

HARD GREY CLAY	0.07, 0.47
WET EARTHWORK	0.11
EARTHWORK	0.13
WET CLAY	0.16
SOFT YELLOW CLAY	0.24 - 0.27, 0.66, 1.09
DAMP CLAY	0.39
CLAY SOIL,SAND CLAY EARTHWORK	0.53
CLAY-SAND GRAVEL	0.70
GRASSY EARTHWORK	0.81
SAND GRAVEL	1.67
DRY SAND	1.71 - 2.07
EARTH-SAND GRAVEL	2.24
SAND	2.91 - 4.0

PRESS ANY KEY TO CONTINUE

Figure 6: FINAL CONDITIONS DISPLAY - PROBLEM 1

TRAJ ANGLE (DEG)	PATH LENGTH (FT)	HORIZ. RANGE (FT)	HEIGHT (FT)	ENERGY (FT-LBS)	VELOCITY (FT/SEC)	TIME (SEC)
INITIAL VEL. = 200	MASS = 20	INITIAL ANGLE =30.000	# RICOCHETS = 0			
-44.797	857.394	784.364	-49.023	0.576D+04	136.094	6.10608
INITIAL VEL. = 200	MASS = 20	INITIAL ANGLE =40.000	# RICOCHETS = 0			
-54.947	966.240	820.719	-52.249	0.594D+04	138.215	7.48030
INITIAL VEL. = 200	MASS = 20	INITIAL ANGLE =50.000	# RICOCHETS = 0			
-63.146	1024.297	780.609	-48.788	0.625D+04	141.850	8.61986
INITIAL VEL. = 300	MASS = 20	INITIAL ANGLE =30.000	# RICOCHETS = 0			
-36.976	1187.870	1110.118	89.908	0.645D+04	144.107	6.60515
INITIAL VEL. = 300	MASS = 20	INITIAL ANGLE =40.000	# RICOCHETS = 0			
-50.089	1345.817	1170.052	121.856	0.633D+04	142.693	8.34218
INITIAL VEL. = 300	MASS = 20	INITIAL ANGLE =50.000	# RICOCHETS = 0			
-62.415	1486.509	1142.034	108.411	0.708D+04	150.916	10.14341

DO YOU WISH TO SEE THE OUTPUT AGAIN (Y/N) ?

Figure 7: PLOT OF WORKING BARRIER DATA - PROBLEM 1

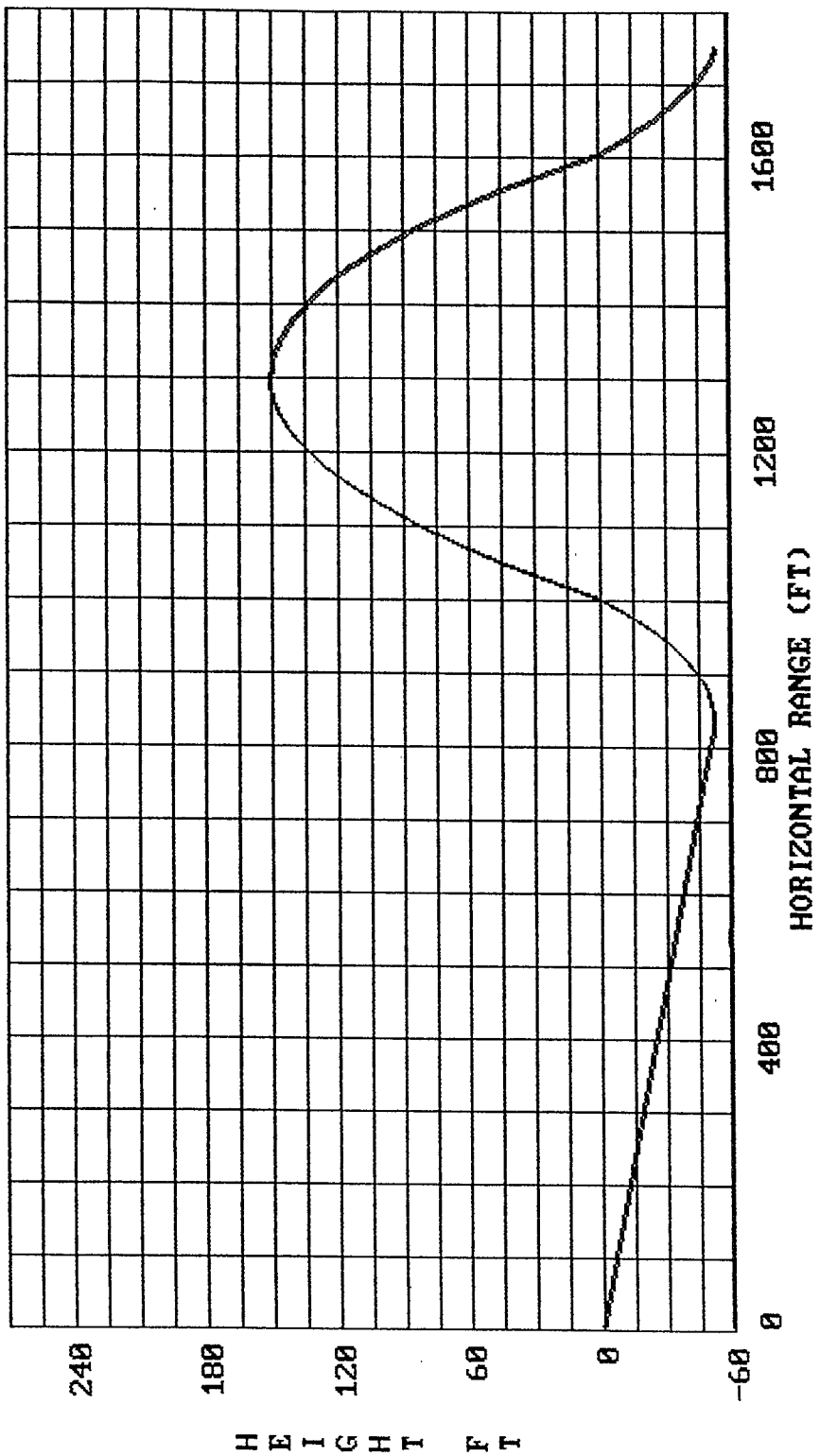

Figure 8: PLOT OF FRAGMENT TRAJECTORIES - PROBLEM 1

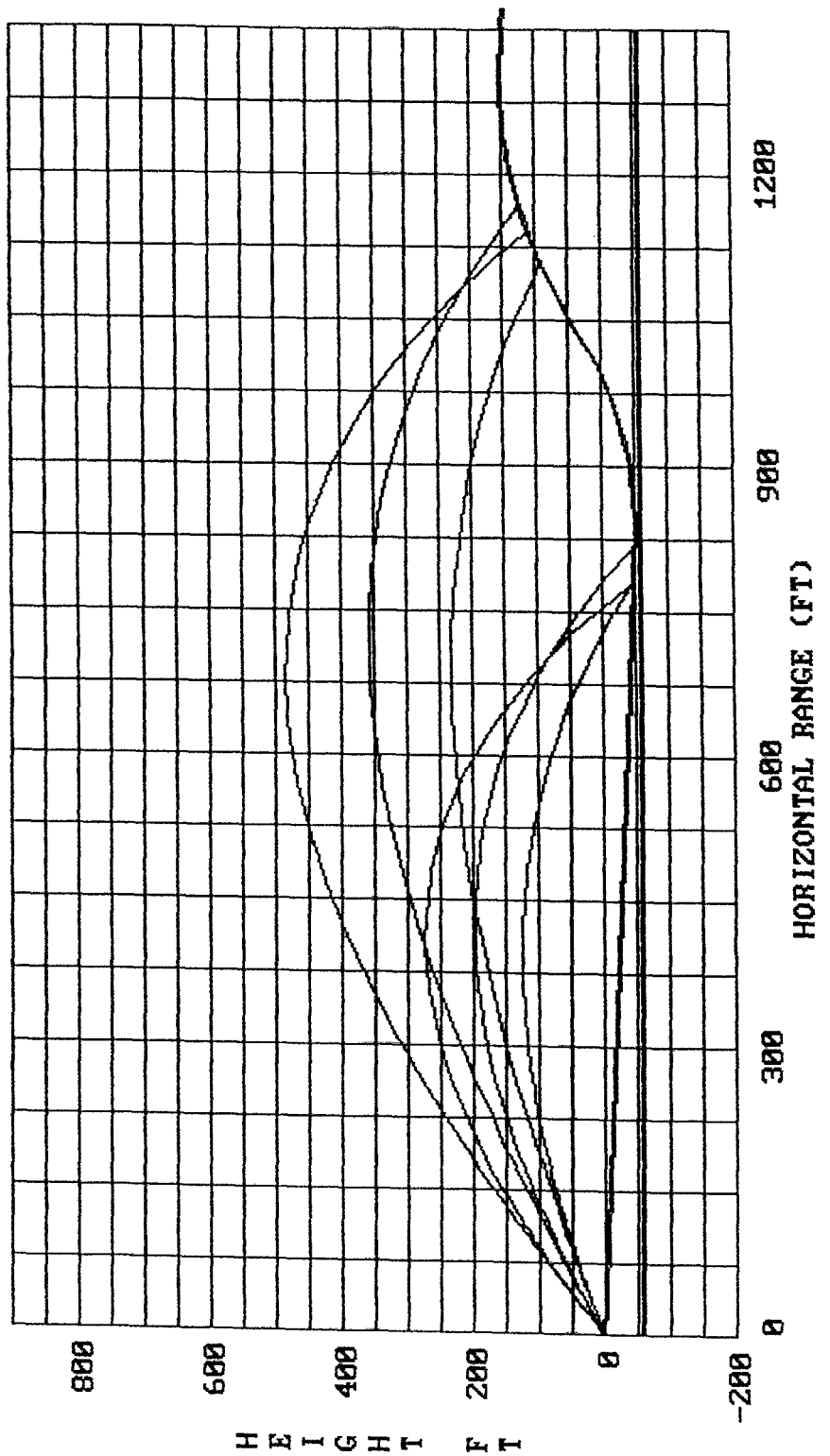

Figure 9: FIRST INPUT SCREEN - PROBLEM 2

```
                    FRAGMENT TRAJECTORY DATA INPUT

                                BEGINNING       ENDING          INCREMENT
INITIAL VELOCITY (FT/SEC)       200             300             100
INITIAL ANGLE (DEG)             5               10              2.5

    LIST OF MASSES (LB)         SELECT FRAGMENT DENSITY (gm/cm^3)

    20                          1.  STEEL           7.8
                                2.  ALUMINUM        2.7
                                3.  CONCRETE      > 2.4 <
                                4.  CAST IRON       7.1
                                5.  OTHER           ____

                        IS THIS SCREEN O.K. (Y/N) ?
```

Figure 10: SECOND INPUT SCREEN - PROBLEM 2

```
SELECT FRAGMENT SHAPE FACTOR

1.  TYPICAL FRAGMENTS       0.333
2.  PREFORMED FRAGMENTS     1.0
3.  OTHER                 > .46 <

FRAGMENT AREA (SQFT)
(Enter Zero when Area is Unknown)     0

CHARACTERISTIC FRAGMENT LENGTH (FT)
(Enter Zero when Length is Unknown)     0

AMBIENT DENSITY (LBS/CUFT)      .07647

AMBIENT SOUND SPEED (FT/SEC)     1116.45

FRAGMENT STARTING HEIGHT (FT)      0

INTERPOLATE THE DRAG
COEFFICIENT TABLE (Y/N)      Y

DO YOU WANT TO CHANGE THE
DRAG COEFFICIENT
MACH NUMBER TABLE (Y/N)      N

1.08            4
1.14            2
1.26            1.15
1.09            .9
.88             .75
.8              0

                        IS THIS SCREEN O.K. (Y/N) ?
```

Figure 11: THIRD INPUT SCREEN - PROBLEM 2

GROUND/TERRAIN AND BARRIER DATA INPUT

MINIMUM ALTITUDE (FT) 0 VIEW TABLE OF SOIL CONSTANTS (Y/N) N

I	NO. PTS	1ST POINT X(FT)	1ST POINT Y(FT)	2ND POINT X(FT)	2ND POINT Y(FT)	3RD POINT X(FT)	3RD POINT Y(FT)	SOIL CONST 0-4	... Y = A*X^2 + B*X + C ... A	B	C
1	2	0	0	500	35			2.00	+.000D+00	+.700D-01	+.000D+00
2	2	500	35	700	35			2.00	+.000D+00	+.000D+00	+.350D+02
3	2	700	35	890	0			2.00	+.000D+00	-.184D+00	+.164D+03
4	2	380	26.6	380	31			2.00	+.000D+00	+.100D+31	+.000D+00

IS THIS SCREEN O.K. (Y/N) ?

Figure 12: FINAL CONDITIONS DISPLAY - PROBLEM 2

TRAJ ANGLE (DEG)	PATH LENGTH (FT)	HORIZ. RANGE (FT)	HEIGHT (FT)	ENERGY (FT-LBS)	VELOCITY (FT/SEC)	TIME (SEC)
INITIAL VEL. = 200		MASS = 20		INITIAL ANGLE = 5.000		# RICOCHETS = 4
6.054	381.766	380.000	28.890	0.654D+04	73.822	2.79901
INITIAL VEL. = 200		MASS = 20		INITIAL ANGLE = 7.500		# RICOCHETS = 2
-0.871	381.813	380.000	29.354	0.672D+04	100.686	2.58409
INITIAL VEL. = 200		MASS = 20		INITIAL ANGLE =10.000		# RICOCHETS = 2
11.934	382.173	380.000	27.909	0.675D+04	74.400	2.54044
INITIAL VEL. = 300		MASS = 20		INITIAL ANGLE = 5.000		# RICOCHETS = 6
-12.045	902.083	894.088	0.000	0.113D+05	31.880	6.20394
INITIAL VEL. = 300		MASS = 20		INITIAL ANGLE = 7.500		# RICOCHETS = 3
-22.674	908.656	899.766	0.000	0.102D+05	32.758	5.68059
INITIAL VEL. = 300		MASS = 20		INITIAL ANGLE =10.000		# RICOCHETS = 3
-15.074	906.747	896.732	0.000	0.106D+05	30.970	5.80167

DO YOU WISH TO SEE THE OUTPUT AGAIN (Y/N) ?

Figure 13: PLOT OF WORKING BARRIER DATA - PROBLEM 2

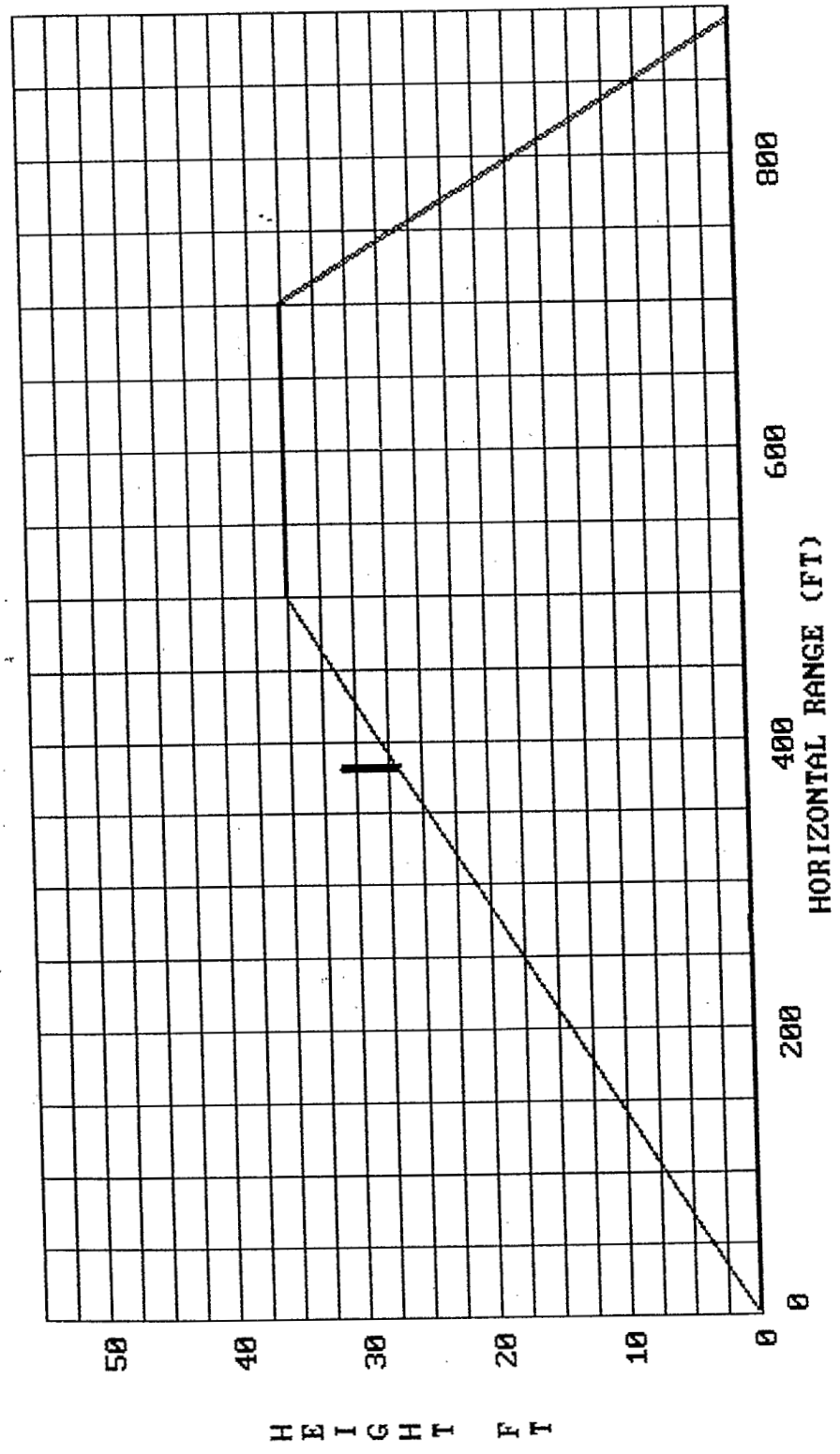

Figure 14: PLOT OF FRAGMENT TRAJECTORIES - PROBLEM 2

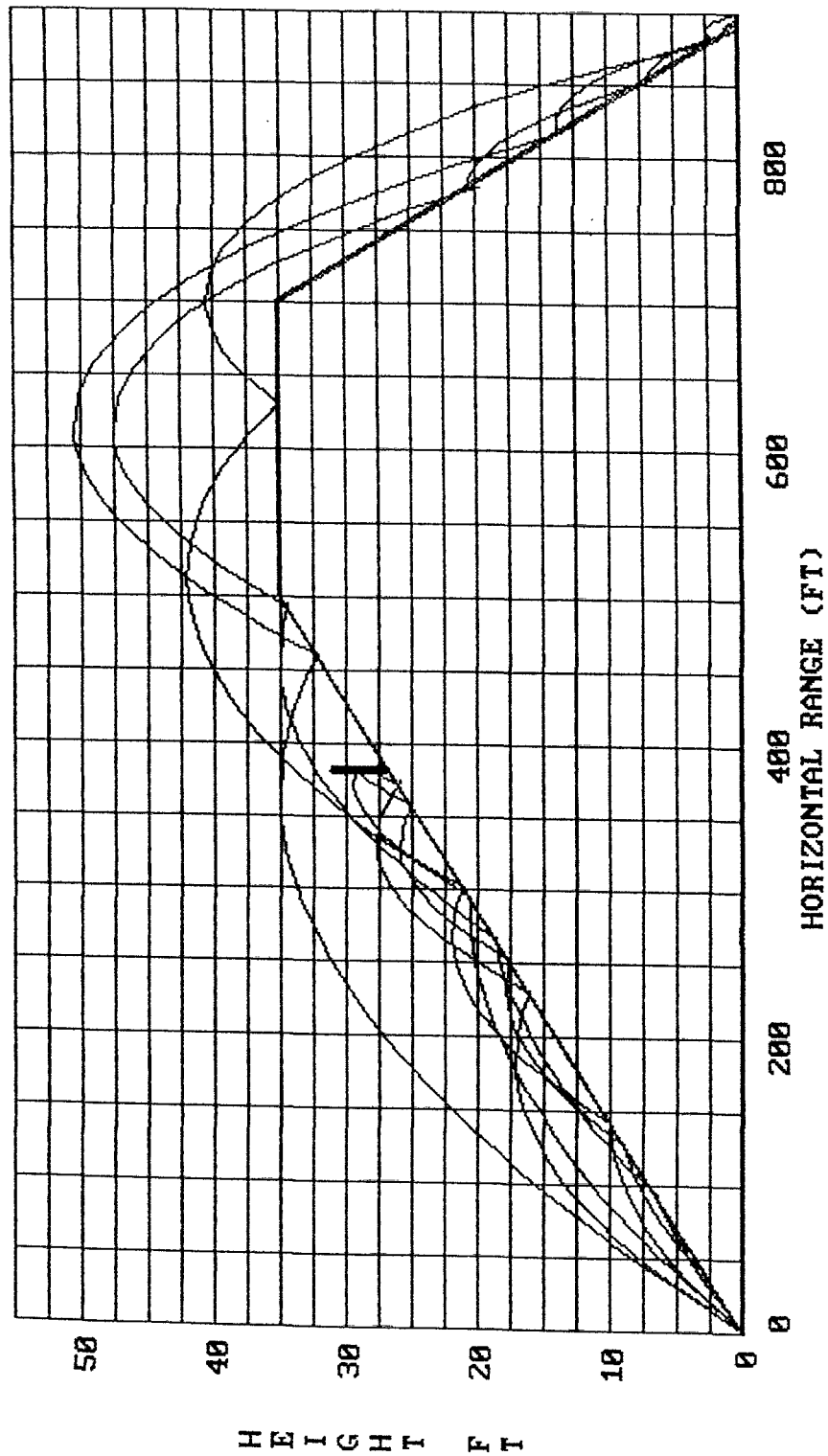

Figure 15: COMPLETE TRAJECTORY CONDITIONS DISPLAY - PROBLEM 2

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ANALYTICAL SOLUTION FOR TRAJECTORY WITH VARIABLE DRAG    06-30-1990

SAMPLE RUN

YMIN= 0           NUMBER OF BARRIERS= 4

1    NUMBER OF POINTS= 2     SOIL CONST= 2      A= 0
       X1= 0        X2= 500      X3= 0          B= .07
       Y1= 0        Y2= 35       Y3= 0          C= 0
2    NUMBER OF POINTS= 2     SOIL CONST= 2      A= 0
       X1= 500      X2= 700      X3= 0          B= 0
       Y1= 35       Y2= 35       Y3= 0          C= 35
3    NUMBER OF POINTS= 2     SOIL CONST= 2      A= 0
       X1= 700      X2= 890      X3= 0          B=-.1842105
       Y1= 35       Y2= 0        Y3= 0          C= 163.9474
4    NUMBER OF POINTS= 2     SOIL CONST= 2      A= 0
       X1= 380      X2= 380      X3= 0          B= 1E+30
       Y1= 27       Y2= 31       Y3= 0          C= 0

 200           VELOCITY # 1
 20            MASS # 1
 5             ANGLE # 1

LENGTH UNIT=FT   MASS UNIT=LBS   TIME UNIT=SEC   ENERGY UNIT=FT-LBS

NUMBER OF (C,U) PAIRS IN THE DRAG COEFFICIENT TABLE =  6
 1.08  4        1.14  2        1.26  1.15     1.09  .9        .88  .75        .8  0

FRAGMENT STARTS AT (FT)     X= 0       Y= 0
TRAJECTORY LIMITS (FT)      X9= 0      Y9= 0
RADIUS OF CURVATURE (FT)    R= 1
INITIAL ANGLE (DEG)          A0= 5      AMB. DENSITY (LBS/CUFT)     D0= 7.647D-02
INITIAL VELOCITY (FT/SEC)   U0= 200    AMB. SOUND SPEED (FT/SEC)   C0= 1116.45

FRAGMENT MASS (LBS)          M= 20           GRAVITY (FT/SEC/SEC)   G= 32.174
SHAPE FACTOR                  B=0.4600       DRAG DECAY CONSTANT    C=0.44330D-03
FRAGMENT AREA (SQFT)         A6= 0.437980    DRAG COEFFICIENT       C1= .8
CHARACTERISTIC LENGTH (FT)  L= 0.661800          (DRAG IS INTERPOLATED)
FRAG. DENSITY (LBS/CUFT)    D= 150          STEP SIZE UP (DEG)     I= .5
ENERGY UNIT (FT-LBS)         E5= 32.174     STEP SIZE DOWN (DEG)   I2= .5
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TRAJ ANGLE (DEG)	PATH LENGTH (FT)	HORIZ. RANGE (FT)	HEIGHT (FT)	ENERGY (FT-LBS)	VELOCITY (FT/SEC)	TIME (SEC)
5.000	0.000	0.000	0.000	0.124D+05	200.000	0.00000
4.500	10.798	10.761	0.894	0.122D+05	198.380	0.05421
4.000	21.417	21.351	1.682	0.120D+05	196.813	0.10795
3.500	31.865	31.776	2.365	0.119D+05	195.297	0.16124
3.000	42.149	42.043	2.948	0.117D+05	193.829	0.21410
2.981	42.539	42.433	2.969	0.117D+05	193.774	0.21611
2.986	42.439	42.333	2.963	0.117D+05	193.788	0.21559
6.476	42.439	42.334	2.963	0.117D+05	181.456	0.21559
5.828	53.967	53.795	4.199	0.115D+05	179.811	0.27942
5.181	65.277	65.053	5.284	0.113D+05	178.231	0.34259
4.533	76.381	76.117	6.225	0.111D+05	176.712	0.40516
3.886	87.290	86.996	7.026	0.109D+05	175.253	0.46715
3.238	98.014	97.699	7.692	0.107D+05	173.850	0.52859
2.590	108.563	108.234	8.229	0.105D+05	172.501	0.58950
1.943	118.945	118.608	8.640	0.104D+05	171.204	0.64992
1.295	129.171	128.830	8.929	0.102D+05	169.958	0.70986
1.432	127.023	126.682	8.877	0.103D+05	170.217	0.69723
1.419	127.234	126.893	8.883	0.103D+05	170.191	0.69847

1.418	127.239	126.898	8.883	0.103D+05	170.191	0.69850
9.078	127.239	126.898	8.883	0.103D+05	155.814	0.69850
8.170	139.203	138.727	10.677	0.101D+05	154.176	0.77569
7.262	150.896	150.313	12.248	0.985D+04	152.623	0.85192
6.354	162.336	161.672	13.604	0.966D+04	151.151	0.92724
5.447	173.541	172.818	14.756	0.948D+04	149.755	1.00171
4.539	184.529	183.763	15.713	0.932D+04	148.431	1.07541
3.631	195.313	194.520	16.482	0.916D+04	147.177	1.14837
2.723	205.909	205.099	17.069	0.901D+04	145.990	1.22066
1.816	216.332	215.513	17.482	0.888D+04	144.866	1.29233
0.908	226.592	225.771	17.726	0.875D+04	143.802	1.36342
0.000	236.704	235.882	17.807	0.862D+04	142.797	1.43398
-1.256	250.475	249.651	17.656	0.847D+04	141.497	1.53086
-1.462	252.708	251.883	17.603	0.844D+04	141.294	1.54665
-1.434	252.405	251.581	17.611	0.845D+04	141.322	1.54451
-1.435	252.410	251.586	17.611	0.845D+04	141.321	1.54454
11.540	252.410	251.586	17.611	0.845D+04	117.926	1.54454
10.386	261.190	260.204	19.281	0.828D+04	116.769	1.61936
9.232	269.771	268.660	20.743	0.813D+04	115.686	1.69319
8.078	278.171	276.963	22.007	0.799D+04	114.676	1.76612
6.924	286.405	285.127	23.083	0.786D+04	113.735	1.83822
5.770	294.489	293.161	23.977	0.774D+04	112.859	1.90957
4.616	302.437	301.076	24.696	0.763D+04	112.047	1.98025
3.462	310.262	308.881	25.247	0.752D+04	111.295	2.05032
2.308	317.977	316.586	25.636	0.743D+04	110.601	2.11986
1.154	325.593	324.198	25.866	0.734D+04	109.964	2.18892
0.000	333.123	331.727	25.942	0.727D+04	109.381	2.25757
-1.958	345.732	344.332	25.728	0.715D+04	108.513	2.37331
-3.917	358.172	356.754	25.091	0.706D+04	107.789	2.48834
-4.071	359.148	357.728	25.023	0.705D+04	107.738	2.49740
-4.051	359.019	357.599	25.032	0.705D+04	107.745	2.49620
-4.051	359.020	357.600	25.032	0.705D+04	107.745	2.49621
13.374	359.020	357.600	25.032	0.705D+04	76.625	2.49621
12.037	363.351	361.825	25.985	0.694D+04	76.000	2.55296
10.700	367.593	365.983	26.821	0.683D+04	75.428	2.60899
9.362	371.756	370.082	27.546	0.674D+04	74.906	2.66436
8.025	375.848	374.127	28.165	0.665D+04	74.433	2.71916
6.687	379.877	378.123	28.681	0.658D+04	74.007	2.77345
6.055	381.761	379.995	28.890	0.654D+04	73.822	2.79895
6.054	381.766	380.000	28.890	0.654D+04	73.822	2.79901

NO. OF RICOCHETS = 4
AVE. DRAG COEFF. = 3.123498 AVE. DRAG DECAY CONST. = 1.730826E-03
X(APPROX.) = 91.1522 Q= .6876818
X(CORCTD.) = 107.9432 Q= 6.383077E-12
FINAL VALUES.....X = 380 Y = 28.89038

200 VELOCITY # 1
20 MASS # 1
7.5 ANGLE # 2

LENGTH UNIT=FT MASS UNIT=LBS TIME UNIT=SEC ENERGY UNIT=FT-LBS

NUMBER OF (C,U) PAIRS IN THE DRAG COEFFICIENT TABLE = 6
1.08 4 1.14 2 1.26 1.15 1.09 .9 .88 .75 .8 0

FRAGMENT STARTS AT (FT) X= 0 Y= 0
TRAJECTORY LIMITS (FT) X9= 0 Y9= 0
RADIUS OF CURVATURE (FT) R= 1
INITIAL ANGLE (DEG) A0= 7.5 AMB. DENSITY (LBS/CUFT) D0= 7.647D-02
INITIAL VELOCITY (FT/SEC) U0= 200 AMB. SOUND SPEED (FT/SEC) C0= 1116.45

FRAGMENT MASS (LBS) M= 20 GRAVITY (FT/SEC/SEC) G= 32.174
SHAPE FACTOR B=0.4600 DRAG DECAY CONSTANT C=0.44330D-03
FRAGMENT AREA (SQFT) A6= 0.437980 DRAG COEFFICIENT C1= .8
CHARACTERISTIC LENGTH (FT) L= 0.661800 (DRAG IS INTERPOLATED)
FRAG. DENSITY (LBS/CUFT) D= 150 STEP SIZE UP (DEG) I= .625

ENERGY UNIT (FT-LBS) E5= 32.174 STEP SIZE DOWN (DEG) I2= .75

TRAJ ANGLE (DEG)	PATH LENGTH (FT)	HORIZ. RANGE (FT)	HEIGHT (FT)	ENERGY (FT-LBS)	VELOCITY (FT/SEC)	TIME (SEC)
7.500	0.000	0.000	0.000	0.124D+05	200.000	0.00000
6.875	13.524	13.417	1.692	0.122D+05	197.881	0.06798
6.416	23.260	23.088	2.819	0.120D+05	196.381	0.11737
5.950	33.000	32.771	3.869	0.118D+05	194.902	0.16715
5.476	42.742	42.465	4.838	0.116D+05	193.445	0.21733
4.994	52.486	52.168	5.728	0.115D+05	192.010	0.26788
4.505	62.231	61.880	6.535	0.113D+05	190.596	0.31883
4.008	71.979	71.600	7.258	0.111D+05	189.206	0.37015
3.504	81.728	81.328	7.897	0.110D+05	187.838	0.42187
2.991	91.479	91.064	8.450	0.108D+05	186.493	0.47397
2.471	101.233	100.806	8.915	0.107D+05	185.171	0.52645
1.943	110.988	110.554	9.290	0.105D+05	183.873	0.57932
1.408	120.746	120.308	9.576	0.104D+05	182.599	0.63258
0.865	130.507	130.066	9.770	0.102D+05	181.349	0.68621
0.314	140.270	139.829	9.870	0.101D+05	180.124	0.74023
0.235	141.644	141.203	9.877	0.101D+05	179.953	0.74786
0.242	141.529	141.088	9.876	0.101D+05	179.968	0.74723
0.242	141.530	141.089	9.876	0.101D+05	179.968	0.74723
10.332	141.530	141.089	9.876	0.101D+05	159.963	0.74723
9.471	153.532	152.912	11.940	0.985D+04	158.242	0.82266
8.760	163.236	162.493	13.478	0.968D+04	156.884	0.88425
8.034	172.947	172.100	14.896	0.952D+04	155.557	0.94642
7.294	182.662	181.728	16.192	0.936D+04	154.261	1.00913
6.541	192.381	191.376	17.363	0.921D+04	152.997	1.07239
5.773	202.105	201.043	18.406	0.906D+04	151.767	1.13620
4.992	211.832	210.728	19.319	0.892D+04	150.569	1.20055
4.197	221.565	220.429	20.099	0.878D+04	149.407	1.26544
3.388	231.303	230.145	20.743	0.865D+04	148.279	1.33087
2.567	241.046	239.875	21.250	0.852D+04	147.188	1.39682
1.732	250.795	249.616	21.615	0.840D+04	146.133	1.46329
0.884	260.550	259.368	21.838	0.828D+04	145.116	1.53028
0.024	270.311	269.129	21.916	0.817D+04	144.137	1.59777
0.000	270.576	269.394	21.916	0.817D+04	144.110	1.59961
-1.364	285.790	284.606	21.736	0.801D+04	142.665	1.70571
-2.728	300.720	299.526	21.204	0.786D+04	141.341	1.81085
-2.935	302.960	301.763	21.093	0.784D+04	141.151	1.82671
-2.911	302.704	301.507	21.106	0.784D+04	141.173	1.82490
-2.912	302.708	301.511	21.106	0.784D+04	141.172	1.82492
12.469	302.708	301.511	21.106	0.784D+04	108.790	1.82492
11.430	309.469	308.125	22.506	0.771D+04	107.877	1.88733
9.916	319.085	317.574	24.287	0.753D+04	106.643	1.97699
8.357	328.718	327.084	25.817	0.737D+04	105.486	2.06781
6.755	338.368	336.649	27.087	0.722D+04	104.409	2.15976
5.113	348.039	346.268	28.087	0.709D+04	103.418	2.25283
3.432	357.732	355.933	28.810	0.696D+04	102.516	2.34697
1.716	367.449	365.638	29.247	0.685D+04	101.705	2.44213
0.000	377.010	375.197	29.391	0.676D+04	101.003	2.53646
-0.868	381.798	379.985	29.354	0.672D+04	100.687	2.58394
-0.871	381.813	380.000	29.354	0.672D+04	100.686	2.58409

NO. OF RICOCHETS = 2
AVE. DRAG COEFF. = 2.120243 AVE. DRAG DECAY CONST. = 1.174891E-03
X(APPROX.) = 135.421 Q= .6913177
X(CORCTD.) = 160.8871 Q= 1.777936E-08
FINAL VALUES.....X = 380 Y = 29.35426

200 VELOCITY # 1
20 MASS # 1
10 ANGLE # 3

LENGTH UNIT=FT MASS UNIT=LBS TIME UNIT=SEC ENERGY UNIT=FT-LBS

NUMBER OF (C,U) PAIRS IN THE DRAG COEFFICIENT TABLE = 6
1.08 4 1.14 2 1.26 1.15 1.09 .9 .88 .75 .8 0

FRAGMENT STARTS AT (FT) X= 0 Y= 0
TRAJECTORY LIMITS (FT) X9= 0 Y9= 0
RADIUS OF CURVATURE (FT) R= 1
INITIAL ANGLE (DEG) A0= 10 AMB. DENSITY (LBS/CUFT) D0= 7.647D-02
INITIAL VELOCITY (FT/SEC) U0= 200 AMB. SOUND SPEED (FT/SEC) C0= 1116.45

FRAGMENT MASS (LBS) M= 20 GRAVITY (FT/SEC/SEC) G= 32.174
SHAPE FACTOR B=0.4600 DRAG DECAY CONSTANT C=0.44330D-03
FRAGMENT AREA (SQFT) A6= 0.437980 DRAG COEFFICIENT C1= .8
CHARACTERISTIC LENGTH (FT) L= 0.661800 (DRAG IS INTERPOLATED)
FRAG. DENSITY (LBS/CUFT) D= 150 STEP SIZE UP (DEG) I= .625
ENERGY UNIT (FT-LBS) E5= 32.174 STEP SIZE DOWN (DEG) I2= 1

TRAJ ANGLE (DEG)	PATH LENGTH (FT)	HORIZ. RANGE (FT)	HEIGHT (FT)	ENERGY (FT-LBS)	VELOCITY (FT/SEC)	TIME (SEC)
10.000	0.000	0.000	0.000	0.124D+05	200.000	0.00000
9.375	13.604	13.410	2.290	0.122D+05	197.774	0.06840
8.919	23.328	23.010	3.836	0.120D+05	196.208	0.11776
8.455	33.058	32.629	5.305	0.118D+05	194.663	0.16755
7.982	42.790	42.260	6.697	0.116D+05	193.138	0.21774
7.502	52.523	51.904	8.008	0.114D+05	191.636	0.26833
7.014	62.257	61.561	9.238	0.112D+05	190.155	0.31932
6.517	71.994	71.229	10.385	0.111D+05	188.697	0.37072
6.012	81.732	80.909	11.448	0.109D+05	187.261	0.42253
5.499	91.471	90.599	12.424	0.107D+05	185.849	0.47474
4.977	101.213	100.300	13.314	0.106D+05	184.459	0.52735
4.447	110.957	110.011	14.115	0.104D+05	183.093	0.58037
3.908	120.703	119.731	14.825	0.103D+05	181.751	0.63380
3.361	130.451	129.460	15.443	0.101D+05	180.433	0.68763
2.806	140.202	139.196	15.968	0.997D+04	179.139	0.74186
2.242	149.955	148.940	16.397	0.983D+04	177.871	0.79650
1.670	159.711	158.690	16.730	0.970D+04	176.627	0.85154
1.090	169.470	168.446	16.966	0.956D+04	175.410	0.90698
0.501	179.232	178.206	17.101	0.943D+04	174.218	0.96282
0.000	187.434	186.408	17.137	0.933D+04	173.237	1.01004
-1.000	203.538	202.511	16.998	0.913D+04	171.366	1.10350
-2.000	219.309	218.276	16.585	0.894D+04	169.606	1.19601
-2.871	232.790	231.745	16.013	0.879D+04	168.159	1.27583
-2.749	230.927	229.884	16.104	0.881D+04	168.356	1.26476
-2.756	231.032	229.989	16.099	0.881D+04	168.345	1.26538
12.364	231.032	229.990	16.099	0.881D+04	130.978	1.26538
11.591	238.326	237.125	17.613	0.867D+04	129.957	1.32129
10.546	247.984	246.602	19.468	0.850D+04	128.647	1.39598
9.475	257.652	256.123	21.149	0.833D+04	127.382	1.47150
8.378	267.328	265.681	22.650	0.817D+04	126.167	1.54783
7.257	277.013	275.276	23.968	0.802D+04	125.003	1.62495
6.111	286.708	284.904	25.097	0.788D+04	123.891	1.70285
4.940	296.413	294.564	26.032	0.775D+04	122.833	1.78153
3.747	306.129	304.251	26.768	0.762D+04	121.832	1.86095
2.531	315.857	313.964	27.301	0.750D+04	120.888	1.94111
1.294	325.598	323.699	27.627	0.739D+04	120.004	2.02198
0.037	335.352	333.451	27.740	0.729D+04	119.181	2.10354
0.000	335.635	333.734	27.740	0.729D+04	119.158	2.10591
-1.845	349.719	347.815	27.515	0.716D+04	118.084	2.22465
-3.691	363.582	361.660	26.846	0.705D+04	117.160	2.34250
-5.428	376.473	374.509	25.822	0.696D+04	116.420	2.45289
-5.070	373.830	371.877	26.064	0.698D+04	116.562	2.43020
-5.097	374.032	372.078	26.046	0.697D+04	116.551	2.43193
-5.098	374.035	372.082	26.046	0.697D+04	116.551	2.43196
14.530	374.035	372.082	26.046	0.697D+04	75.611	2.43196

13.622	376.922	374.881	26.748	0.689D+04	75.165	2.47025
10.581	386.283	384.031	28.712	0.665D+04	73.845	2.59589
11.944	382.142	379.970	27.903	0.675D+04	74.404	2.54003
11.934	382.173	380.000	27.909	0.675D+04	74.400	2.54044

NO. OF RICOCHETS = 2
AVE. DRAG COEFF. = 3.11069 AVE. DRAG DECAY CONST. = 1.723728E-03
X(APPROX.) = 157.1988 Q= .6930333
X(CORCTD.) = 212.6061 Q= 3.415425E-06
FINAL VALUES.....X = 380 Y = 27.9093

300 VELOCITY # 2
20 MASS # 1
5 ANGLE # 1

LENGTH UNIT=FT MASS UNIT=LBS TIME UNIT=SEC ENERGY UNIT=FT-LBS

NUMBER OF (C,U) PAIRS IN THE DRAG COEFFICIENT TABLE = 6
1.08 4 1.14 2 1.26 1.15 1.09 .9 .88 .75 .8 0

FRAGMENT STARTS AT (FT) X= 0 Y= 0
TRAJECTORY LIMITS (FT) X9= 0 Y9= 0
RADIUS OF CURVATURE (FT) R= 1
INITIAL ANGLE (DEG) A0= 5 AMB. DENSITY (LBS/CUFT) D0= 7.647D-02
INITIAL VELOCITY (FT/SEC) U0= 300 AMB. SOUND SPEED (FT/SEC) C0= 1116.45

FRAGMENT MASS (LBS) M= 20 GRAVITY (FT/SEC/SEC) G= 32.174
SHAPE FACTOR B=0.4600 DRAG DECAY CONSTANT C=0.44330D-03
FRAGMENT AREA (SQFT) A6= 0.437980 DRAG COEFFICIENT C1= .8
CHARACTERISTIC LENGTH (FT) L= 0.661800 (DRAG IS INTERPOLATED)
FRAG. DENSITY (LBS/CUFT) D= 150 STEP SIZE UP (DEG) I= .4166667
ENERGY UNIT (FT-LBS) E5= 32.174 STEP SIZE DOWN (DEG) I2= .5

TRAJ ANGLE (DEG)	PATH LENGTH (FT)	HORIZ. RANGE (FT)	HEIGHT (FT)	ENERGY (FT-LBS)	VELOCITY (FT/SEC)	TIME (SEC)
5.000	0.000	0.000	0.000	0.280D+05	300.000	0.00000
4.583	20.118	20.047	1.681	0.272D+05	295.661	0.06755
4.377	29.852	29.751	2.441	0.268D+05	293.589	0.10059
4.168	39.609	39.482	3.168	0.264D+05	291.530	0.13394
3.955	49.367	49.215	3.860	0.260D+05	289.489	0.16753
3.739	59.125	58.951	4.514	0.257D+05	287.465	0.20135
3.521	68.883	68.689	5.132	0.253D+05	285.459	0.23542
3.299	78.642	78.431	5.713	0.250D+05	283.470	0.26972
3.074	88.401	88.175	6.255	0.246D+05	281.499	0.30427
2.939	94.175	93.941	6.558	0.244D+05	280.342	0.32482
2.963	93.152	92.920	6.505	0.245D+05	280.546	0.32118
2.962	93.207	92.974	6.508	0.245D+05	280.535	0.32137
6.526	93.207	92.975	6.508	0.245D+05	262.629	0.32137
5.983	113.373	113.021	8.706	0.237D+05	258.726	0.39873
5.714	123.099	122.696	9.697	0.234D+05	256.871	0.43646
5.441	132.851	132.402	10.645	0.231D+05	255.029	0.47456
5.164	142.603	142.113	11.546	0.227D+05	253.204	0.51294
4.882	152.357	151.828	12.400	0.224D+05	251.397	0.55160
4.597	162.111	161.549	13.206	0.221D+05	249.608	0.59053
4.307	171.865	171.274	13.964	0.218D+05	247.836	0.62975
4.013	181.620	181.003	14.671	0.215D+05	246.082	0.66925
3.715	191.376	190.736	15.329	0.212D+05	244.347	0.70904
3.412	201.132	200.474	15.935	0.209D+05	242.629	0.74910
3.105	210.889	210.215	16.490	0.206D+05	240.929	0.78946
2.793	220.647	219.960	16.992	0.203D+05	239.247	0.83010
2.477	230.405	229.708	17.441	0.200D+05	237.584	0.87103
2.156	240.164	239.459	17.835	0.197D+05	235.939	0.91225
1.831	249.925	249.213	18.175	0.195D+05	234.312	0.95376

1.501	259.686	258.970	18.459	0.192D+05	232.703	0.99556
1.226	267.732	267.014	18.650	0.190D+05	231.391	1.03024
1.256	266.851	266.133	18.631	0.190D+05	231.534	1.02643
1.255	266.891	266.173	18.632	0.190D+05	231.528	1.02661
9.282	266.891	266.173	18.632	0.190D+05	211.240	1.02661
8.508	285.560	284.618	21.520	0.185D+05	208.109	1.11565
8.096	295.269	294.225	22.922	0.182D+05	206.510	1.16248
7.676	305.006	303.869	24.258	0.179D+05	204.926	1.20981
7.249	314.743	313.524	25.523	0.176D+05	203.363	1.25751
6.815	324.482	323.190	26.715	0.174D+05	201.820	1.30558
6.374	334.223	332.866	27.834	0.171D+05	200.297	1.35403
5.925	343.964	342.551	28.878	0.168D+05	198.796	1.40285
5.470	353.707	352.246	29.845	0.166D+05	197.315	1.45204
5.007	363.452	361.950	30.735	0.163D+05	195.856	1.50161
4.537	373.198	371.662	31.546	0.161D+05	194.419	1.55155
4.059	382.946	381.383	32.276	0.159D+05	193.003	1.60187
3.574	392.696	391.110	32.925	0.156D+05	191.610	1.65257
3.082	402.447	400.845	33.492	0.154D+05	190.239	1.70365
2.579	412.260	410.646	33.976	0.152D+05	188.882	1.75541
2.056	422.312	420.690	34.383	0.150D+05	187.517	1.80883
1.513	432.611	430.984	34.704	0.148D+05	186.144	1.86395
0.947	443.162	441.533	34.931	0.145D+05	184.765	1.92085
0.359	453.973	452.342	35.054	0.143D+05	183.381	1.97957
0.000	460.492	458.861	35.074	0.142D+05	182.561	2.01520
-1.312	483.836	482.202	34.809	0.138D+05	179.714	2.14408
-2.052	496.702	495.063	34.432	0.135D+05	178.207	2.21597
-1.922	494.460	492.822	34.510	0.136D+05	178.466	2.20340
-1.929	494.578	492.940	34.506	0.136D+05	178.452	2.20406
-1.929	494.579	492.941	34.506	0.136D+05	178.452	2.20407
11.842	494.579	492.941	34.506	0.136D+05	145.395	2.20407
10.855	505.992	504.130	36.752	0.133D+05	143.770	2.28300
9.771	518.204	516.144	38.939	0.130D+05	142.089	2.36845
8.630	530.713	528.492	40.940	0.127D+05	140.429	2.45700
7.429	543.531	541.183	42.731	0.124D+05	138.798	2.54881
6.167	556.668	554.226	44.286	0.121D+05	137.201	2.64400
4.839	570.133	567.628	45.579	0.118D+05	135.646	2.74270
3.444	583.937	581.396	46.576	0.115D+05	134.140	2.84504
1.979	598.094	595.536	47.247	0.113D+05	132.693	2.95115
0.443	612.616	610.053	47.555	0.111D+05	131.314	3.06116
0.000	616.749	614.186	47.571	0.110D+05	130.942	3.09268
-2.140	636.403	633.834	47.206	0.107D+05	129.293	3.24373
-4.280	655.626	653.022	46.132	0.105D+05	127.881	3.39322
-6.421	674.514	671.825	44.373	0.103D+05	126.691	3.54161
-8.561	693.160	690.309	41.944	0.101D+05	125.711	3.68936
-10.701	711.650	708.536	38.852	0.100D+05	124.930	3.83691
-12.841	730.069	726.564	35.096	0.992D+04	124.340	3.98469
-14.981	748.497	744.449	30.667	0.986D+04	123.933	4.13314
-17.122	767.015	762.242	25.547	0.982D+04	123.705	4.28270
-19.262	785.706	779.995	19.713	0.981D+04	123.653	4.43382
-18.802	781.671	776.181	21.029	0.981D+04	123.649	4.40119
-18.849	782.081	776.569	20.897	0.981D+04	123.649	4.40450
-18.850	782.091	776.579	20.893	0.981D+04	123.649	4.40459
-0.715	782.091	776.579	20.893	0.981D+04	85.405	4.40459
-2.968	790.967	785.448	20.609	0.972D+04	85.001	4.50875
-5.221	799.790	794.247	19.979	0.966D+04	84.733	4.61272
-7.474	808.603	803.005	19.005	0.963D+04	84.599	4.71682
-9.727	817.448	811.748	17.682	0.963D+04	84.596	4.82137
-11.980	826.366	820.505	16.003	0.966D+04	84.723	4.92670
-14.233	835.399	829.301	13.955	0.972D+04	84.982	5.03316
-16.486	844.593	838.165	11.520	0.980D+04	85.372	5.14110
-18.740	853.995	847.124	8.675	0.993D+04	85.896	5.25089
-20.195	860.202	852.975	6.606	0.100D+05	86.308	5.32298
-19.882	858.857	851.712	7.067	0.100D+05	86.215	5.30739
-19.901	858.939	851.789	7.039	0.100D+05	86.220	5.30834
-19.901	858.941	851.791	7.039	0.100D+05	86.220	5.30836
0.589	858.941	851.791	7.039	0.100D+05	53.923	5.30836
0.540	859.018	851.868	7.039	0.100D+05	53.920	5.30980
0.000	859.869	852.718	7.043	0.999D+04	53.886	5.32557
-2.155	863.257	856.106	6.980	0.996D+04	53.802	5.38850

-4.309	866.644	859.487	6.789	0.995D+04	53.793	5.45147
-6.464	870.045	862.872	6.470	0.998D+04	53.860	5.51465
-8.618	873.474	866.271	6.020	0.100D+05	54.004	5.57822
-10.773	876.945	869.692	5.435	0.101D+05	54.225	5.64237
-12.927	880.476	873.146	4.710	0.102D+05	54.525	5.70730
-15.082	884.081	876.644	3.837	0.104D+05	54.905	5.77319
-17.236	887.780	880.196	2.808	0.105D+05	55.369	5.84027
-19.391	891.591	883.813	1.610	0.108D+05	55.918	5.90877
-21.280	895.041	887.048	0.411	0.110D+05	56.474	5.97016
-20.868	894.280	886.338	0.685	0.109D+05	56.347	5.95667
-20.897	894.334	886.388	0.666	0.109D+05	56.356	5.95763
2.299	894.334	886.389	0.665	0.109D+05	31.366	5.95763
2.108	894.436	886.491	0.669	0.109D+05	31.360	5.96089
0.000	895.559	887.614	0.690	0.109D+05	31.315	5.99672
-1.200	896.197	888.252	0.683	0.109D+05	31.308	6.01710
-2.400	896.836	888.890	0.663	0.109D+05	31.316	6.03750
-3.600	897.476	889.529	0.630	0.109D+05	31.337	6.05792
-4.800	898.117	890.169	0.583	0.109D+05	31.371	6.07838
-6.001	898.762	890.810	0.522	0.110D+05	31.420	6.09891
-7.201	899.410	891.454	0.447	0.110D+05	31.482	6.11952
-8.401	900.063	892.101	0.359	0.111D+05	31.559	6.14023
-9.601	900.721	892.751	0.256	0.111D+05	31.650	6.16106
-10.801	901.386	893.405	0.138	0.112D+05	31.755	6.18203
-12.001	902.058	894.064	0.005	0.113D+05	31.875	6.20316
-12.045	902.083	894.088	-0.000	0.113D+05	31.880	6.20394

NO. OF RICOCHETS = 6
AVE. DRAG COEFF. = 2.992448 AVE. DRAG DECAY CONST. = 1.658206E-03
X(APPROX.) = 283.3488 Q= .6987873
X(CORCTD.) = 485.7435 Q= 1.306406E-06
FINAL VALUES.....X = 894.0885 Y = 0
INITIAL ANGLE SENSITIVITY: dX/dA = 95.53631
INITIAL VELOCITY SENSITIVITY: dX/dU = 3.238276
INITIAL HEIGHT SENSITIVITY: dX/dY = 11.42999
CYLINDRICAL AREA INCREASE RATIO = 5473.827
SPHERICAL AREA INCREASE RATIO = 4912781

300 VELOCITY # 2
20 MASS # 1
7.5 ANGLE # 2

LENGTH UNIT=FT MASS UNIT=LBS TIME UNIT=SEC ENERGY UNIT=FT-LBS

NUMBER OF (C,U) PAIRS IN THE DRAG COEFFICIENT TABLE = 6
1.08 4 1.14 2 1.26 1.15 1.09 .9 .88 .75 .8 0

FRAGMENT STARTS AT (FT) X= 0 Y= 0
TRAJECTORY LIMITS (FT) X9= 0 Y9= 0
RADIUS OF CURVATURE (FT) R= 1
INITIAL ANGLE (DEG) A0= 7.5 AMB. DENSITY (LBS/CUFT) D0= 7.647D-02
INITIAL VELOCITY (FT/SEC) U0= 300 AMB. SOUND SPEED (FT/SEC) C0= 1116.45

FRAGMENT MASS (LBS) M= 20 GRAVITY (FT/SEC/SEC) G= 32.174
SHAPE FACTOR B=0.4600 DRAG DECAY CONSTANT C=0.44330D-03
FRAGMENT AREA (SQFT) A6= 0.437980 DRAG COEFFICIENT C1= .8
CHARACTERISTIC LENGTH (FT) L= 0.661800 (DRAG IS INTERPOLATED)
FRAG. DENSITY (LBS/CUFT) D= 150 STEP SIZE UP (DEG) I= .4166667
ENERGY UNIT (FT-LBS) E5= 32.174 STEP SIZE DOWN (DEG) I2= .75

TRAJ ANGLE (DEG)	PATH LENGTH (FT)	HORIZ. RANGE (FT)	HEIGHT (FT)	ENERGY (FT-LBS)	VELOCITY (FT/SEC)	TIME (SEC)
7.500	0.000	0.000	0.000	0.280D+05	300.000	0.00000
7.083	20.203	20.040	2.565	0.271D+05	295.549	0.06785

6.878	29.930	29.694	3.747	0.268D+05	293.433	0.10088
6.669	39.683	39.379	4.897	0.264D+05	291.330	0.13423
6.457	49.436	49.068	6.012	0.260D+05	289.244	0.16783
6.242	59.189	58.761	7.091	0.256D+05	287.175	0.20167
6.024	68.942	68.459	8.133	0.253D+05	285.125	0.23576
5.802	78.696	78.161	9.138	0.249D+05	283.091	0.27009
5.577	88.450	87.867	10.105	0.246D+05	281.076	0.30467
5.349	98.205	97.577	11.034	0.242D+05	279.078	0.33949
5.118	107.959	107.291	11.924	0.239D+05	277.097	0.37457
4.883	117.714	117.009	12.774	0.235D+05	275.134	0.40990
4.644	127.470	126.730	13.584	0.232D+05	273.188	0.44548
4.402	137.226	136.456	14.354	0.229D+05	271.261	0.48132
4.157	146.982	146.185	15.082	0.225D+05	269.350	0.51742
3.908	156.739	155.917	15.768	0.222D+05	267.457	0.55377
3.655	166.496	165.653	16.411	0.219D+05	265.582	0.59038
3.399	176.253	175.392	17.012	0.216D+05	263.724	0.62725
3.139	186.012	185.135	17.568	0.213D+05	261.884	0.66438
2.875	195.770	194.880	18.080	0.210D+05	260.062	0.70177
2.607	205.529	204.628	18.547	0.207D+05	258.257	0.73943
2.336	215.289	214.379	18.968	0.204D+05	256.470	0.77735
2.061	225.050	224.132	19.342	0.202D+05	254.701	0.81554
1.782	234.811	233.887	19.670	0.199D+05	252.949	0.85399
1.499	244.572	243.645	19.949	0.196D+05	251.216	0.89272
1.212	254.335	253.404	20.180	0.193D+05	249.500	0.93171
0.920	264.098	263.166	20.362	0.191D+05	247.802	0.97097
0.625	273.861	272.929	20.494	0.188D+05	246.122	1.01051
0.326	283.626	282.693	20.575	0.186D+05	244.459	1.05032
0.023	293.391	292.458	20.605	0.183D+05	242.815	1.09040
0.000	294.125	293.191	20.605	0.183D+05	242.692	1.09342
-0.037	295.290	294.357	20.604	0.183D+05	242.498	1.09822
-0.036	295.282	294.349	20.604	0.183D+05	242.499	1.09819
10.568	295.282	294.349	20.604	0.183D+05	213.678	1.09819
9.981	309.885	308.718	23.209	0.178D+05	211.152	1.16694
9.581	319.608	318.299	24.861	0.176D+05	209.495	1.21317
9.175	329.341	327.901	26.447	0.173D+05	207.856	1.25981
8.761	339.074	337.515	27.965	0.170D+05	206.237	1.30682
8.341	348.808	347.141	29.412	0.168D+05	204.638	1.35420
7.913	358.543	356.779	30.789	0.165D+05	203.059	1.40196
7.479	368.279	366.427	32.093	0.163D+05	201.500	1.45009
7.037	378.017	376.087	33.323	0.160D+05	199.962	1.49860
6.588	387.756	385.757	34.478	0.158D+05	198.445	1.54749
6.131	397.496	395.437	35.557	0.155D+05	196.949	1.59676
5.667	407.238	405.127	36.559	0.153D+05	195.475	1.64641
5.187	417.156	415.001	37.497	0.151D+05	193.996	1.69734
4.687	427.316	425.123	38.371	0.148D+05	192.504	1.74991
4.167	437.724	435.500	39.175	0.146D+05	191.002	1.80419
3.625	448.386	446.137	39.900	0.144D+05	189.490	1.86023
3.061	459.309	457.041	40.537	0.141D+05	187.969	1.91811
2.473	470.498	468.217	41.077	0.139D+05	186.442	1.97788
1.860	481.961	479.672	41.511	0.137D+05	184.909	2.03962
1.222	493.706	491.412	41.827	0.135D+05	183.373	2.10339
0.557	505.738	503.442	42.014	0.132D+05	181.836	2.16929
0.000	515.660	513.364	42.062	0.131D+05	180.597	2.22404
-1.429	540.519	538.219	41.755	0.126D+05	177.606	2.36284
-2.858	564.604	562.286	40.857	0.122D+05	174.867	2.49950
-4.286	588.007	585.641	39.401	0.119D+05	172.359	2.63430
-5.715	610.809	608.355	37.415	0.116D+05	170.064	2.76748
-7.144	633.086	630.491	34.923	0.113D+05	167.966	2.89929
-7.099	632.394	629.804	35.008	0.113D+05	168.029	2.89517
-7.103	632.463	629.872	35.000	0.113D+05	168.022	2.89558
8.596	632.463	629.872	35.000	0.113D+05	127.939	2.89558
8.119	636.731	634.095	35.620	0.112D+05	127.412	2.92901
6.378	651.960	649.200	37.543	0.109D+05	125.613	3.04938
4.528	667.651	664.818	39.036	0.106D+05	123.898	3.17515
2.572	683.755	680.889	40.035	0.103D+05	122.290	3.30598
0.509	700.293	697.418	40.481	0.101D+05	120.806	3.44205
0.000	704.310	701.435	40.499	0.100D+05	120.472	3.47534
-2.202	721.459	718.578	40.171	0.980D+04	119.164	3.61847
-4.404	738.291	735.379	39.203	0.963D+04	118.071	3.76037

-6.606	754.892	751.900	37.612	0.948D+04	117.180	3.90150
-8.809	771.343	768.200	35.407	0.937D+04	116.483	4.04231
-11.011	787.721	784.331	32.590	0.929D+04	115.970	4.18323
-13.213	804.103	800.345	29.153	0.923D+04	115.637	4.32469
-15.415	820.563	816.291	25.085	0.921D+04	115.479	4.46713
-17.617	837.178	832.217	20.362	0.921D+04	115.492	4.61100
-19.819	854.025	848.171	14.956	0.924D+04	115.675	4.75676
-22.021	871.187	864.198	8.829	0.929D+04	116.027	4.90490
-24.224	888.750	880.347	1.933	0.938D+04	116.549	5.05593
-24.310	889.449	880.984	1.646	0.938D+04	116.573	5.06192
-24.302	889.386	880.927	1.671	0.938D+04	116.571	5.06139
13.388	889.386	880.927	1.671	0.938D+04	31.476	5.06139
12.644	889.795	881.326	1.763	0.932D+04	31.373	5.07440
0.000	896.355	887.804	2.492	0.880D+04	30.478	5.28650
-2.249	897.488	888.937	2.469	0.880D+04	30.478	5.32368
-4.497	898.624	890.072	2.403	0.882D+04	30.525	5.36094
-6.746	899.770	891.211	2.290	0.888D+04	30.620	5.39841
-8.995	900.930	892.360	2.132	0.896D+04	30.762	5.43620
-11.243	902.109	893.521	1.924	0.907D+04	30.954	5.47443
-13.492	903.315	894.698	1.666	0.922D+04	31.196	5.51322
-15.741	904.553	895.896	1.353	0.939D+04	31.491	5.55273
-17.989	905.831	897.119	0.983	0.960D+04	31.841	5.59308
-20.238	907.156	898.371	0.549	0.985D+04	32.248	5.63445
-22.487	908.538	899.657	0.045	0.101D+05	32.717	5.67698
-22.674	908.656	899.766	-0.000	0.102D+05	32.758	5.68059

NO. OF RICOCHETS = 3
AVE. DRAG COEFF. = 3.005248 AVE. DRAG DECAY CONST. = 1.665299E-03
X(APPROX.) = 357.5755 Q= .7034488
X(CORCTD.) = 722.2651 Q= 1.30211E-03
FINAL VALUES.....X = 899.7661 Y = 0
INITIAL ANGLE SENSITIVITY: dX/dA = 93.3437
INITIAL VELOCITY SENSITIVITY: dX/dU = 4.797993
INITIAL HEIGHT SENSITIVITY: dX/dY = 7.550715
CYLINDRICAL AREA INCREASE RATIO = 5348.2
SPHERICAL AREA INCREASE RATIO = 4853653

300 VELOCITY # 2
20 MASS # 1
10 ANGLE # 3

LENGTH UNIT=FT MASS UNIT=LBS TIME UNIT=SEC ENERGY UNIT=FT-LBS

NUMBER OF (C,U) PAIRS IN THE DRAG COEFFICIENT TABLE = 6
1.08 4 1.14 2 1.26 1.15 1.09 .9 .88 .75 .8 0

FRAGMENT STARTS AT (FT) X= 0 Y= 0
TRAJECTORY LIMITS (FT) X9= 0 Y9= 0
RADIUS OF CURVATURE (FT) R= 1
INITIAL ANGLE (DEG) A0= 10 AMB. DENSITY (LBS/CUFT) D0= 7.647D-02
INITIAL VELOCITY (FT/SEC) U0= 300 AMB. SOUND SPEED (FT/SEC) C0= 1116.45

FRAGMENT MASS (LBS) M= 20 GRAVITY (FT/SEC/SEC) G= 32.174
SHAPE FACTOR B=0.4600 DRAG DECAY CONSTANT C=0.44330D-03
FRAGMENT AREA (SQFT) A6= 0.437980 DRAG COEFFICIENT C1= .8
CHARACTERISTIC LENGTH (FT) L= 0.661800 (DRAG IS INTERPOLATED)
FRAG. DENSITY (LBS/CUFT) D= 150 STEP SIZE UP (DEG) I= .4166667
ENERGY UNIT (FT-LBS) E5= 32.174 STEP SIZE DOWN (DEG) I2= 1

TRAJ ANGLE (DEG)	PATH LENGTH (FT)	HORIZ. RANGE (FT)	HEIGHT (FT)	ENERGY (FT-LBS)	VELOCITY (FT/SEC)	TIME (SEC)
10.000	0.000	0.000	0.000	0.280D+05	300.000	0.00000
9.583	20.328	20.031	3.458	0.271D+05	295.427	0.06828

9.379	30.047	29.618	5.059	0.267D+05	293.269	0.10130
9.172	39.795	39.238	6.630	0.263D+05	291.121	0.13466
8.961	49.543	48.865	8.166	0.260D+05	288.990	0.16827
8.747	59.292	58.497	9.667	0.256D+05	286.878	0.20213
8.529	69.040	68.135	11.131	0.252D+05	284.782	0.23623
8.308	78.789	77.779	12.558	0.248D+05	282.705	0.27059
8.084	88.538	87.428	13.948	0.245D+05	280.644	0.30520
7.856	98.288	97.084	15.300	0.241D+05	278.602	0.34007
7.625	108.037	106.744	16.613	0.238D+05	276.576	0.37519
7.391	117.787	116.411	17.887	0.234D+05	274.568	0.41057
7.152	127.537	126.082	19.121	0.231D+05	272.578	0.44621
6.911	137.288	135.759	20.315	0.228D+05	270.605	0.48211
6.665	147.039	145.442	21.468	0.224D+05	268.649	0.51828
6.416	156.790	155.129	22.578	0.221D+05	266.711	0.55470
6.163	166.541	164.822	23.647	0.218D+05	264.791	0.59140
5.906	176.293	174.520	24.672	0.215D+05	262.888	0.62836
5.645	186.045	184.223	25.653	0.212D+05	261.002	0.66559
5.381	195.798	193.931	26.590	0.209D+05	259.135	0.70309
5.112	205.551	203.643	27.482	0.206D+05	257.284	0.74086
4.840	215.305	213.360	28.328	0.203D+05	255.452	0.77891
4.563	225.059	223.081	29.128	0.200D+05	253.637	0.81723
4.282	234.814	232.807	29.880	0.197D+05	251.840	0.85583
3.997	244.570	242.537	30.584	0.194D+05	250.060	0.89470
3.708	254.325	252.271	31.240	0.192D+05	248.298	0.93385
3.415	264.082	262.008	31.846	0.189D+05	246.555	0.97328
3.118	273.839	271.750	32.402	0.186D+05	244.829	1.01300
2.816	283.597	281.494	32.908	0.184D+05	243.121	1.05299
2.510	293.356	291.242	33.361	0.181D+05	241.431	1.09327
2.199	303.115	300.993	33.762	0.179D+05	239.759	1.13383
1.884	312.875	310.747	34.110	0.176D+05	238.105	1.17468
1.565	322.636	320.504	34.404	0.174D+05	236.470	1.21582
1.241	332.398	330.263	34.643	0.171D+05	234.853	1.25724
0.912	342.161	340.024	34.826	0.169D+05	233.254	1.29895
0.579	351.925	349.787	34.954	0.167D+05	231.674	1.34096
0.242	361.689	359.551	35.024	0.165D+05	230.112	1.38325
0.000	368.599	366.461	35.038	0.163D+05	229.018	1.41335
-1.000	396.513	394.372	34.797	0.157D+05	224.695	1.53639
-2.000	423.417	421.267	34.095	0.151D+05	220.676	1.65721
-3.000	449.409	447.233	32.963	0.146D+05	216.933	1.77600
-3.571	463.882	461.682	32.134	0.144D+05	214.909	1.84303
-3.514	462.435	460.237	32.223	0.144D+05	215.110	1.83630
-3.516	462.486	460.288	32.220	0.144D+05	215.103	1.83653
12.914	462.486	460.288	32.220	0.144D+05	159.220	1.83653
12.376	470.015	467.634	33.868	0.142D+05	158.071	1.88399
11.547	481.373	478.746	36.223	0.139D+05	156.370	1.95624
10.677	493.011	490.165	38.466	0.136D+05	154.671	2.03107
9.763	504.931	501.896	40.582	0.133D+05	152.978	2.10856
8.803	517.142	513.946	42.552	0.130D+05	151.294	2.18882
7.795	529.651	526.323	44.358	0.127D+05	149.624	2.27196
6.736	542.467	539.036	45.980	0.124D+05	147.974	2.35809
5.625	555.599	552.092	47.394	0.121D+05	146.347	2.44733
4.458	569.058	565.497	48.578	0.119D+05	144.751	2.53980
3.234	582.852	579.260	49.504	0.116D+05	143.191	2.63561
1.950	596.994	593.386	50.144	0.114D+05	141.674	2.73490
0.605	611.494	607.881	50.468	0.112D+05	140.208	2.83778
0.000	617.915	614.303	50.502	0.111D+05	139.588	2.88368
-2.042	639.205	635.586	50.125	0.108D+05	137.666	3.03725
-4.085	659.973	656.320	49.018	0.105D+05	135.993	3.18903
-6.127	680.322	676.586	47.209	0.103D+05	134.550	3.33947
-8.169	700.349	696.454	44.719	0.101D+05	133.323	3.48899
-10.212	720.142	715.990	41.560	0.993D+04	132.300	3.63802
-12.254	739.785	735.254	37.735	0.981D+04	131.471	3.78696
-14.297	759.361	754.305	33.241	0.971D+04	130.828	3.93623
-16.339	778.950	773.194	28.068	0.964D+04	130.363	4.08622
-18.381	798.629	791.975	22.197	0.960D+04	130.071	4.23735
-20.424	818.480	810.695	15.604	0.958D+04	129.947	4.39004
-21.070	824.812	816.617	13.360	0.958D+04	129.943	4.43877
-20.982	823.945	815.807	13.672	0.958D+04	129.943	4.43210
-20.984	823.970	815.830	13.663	0.958D+04	129.943	4.43228

2.475	823.970	815.830	13.663	0.958D+04	71.500	4.43228
2.372	824.256	816.116	13.675	0.957D+04	71.481	4.43629
0.000	830.794	822.652	13.811	0.947D+04	71.105	4.52800
-2.265	836.986	828.841	13.689	0.941D+04	70.863	4.61523
-4.530	843.155	834.998	13.323	0.937D+04	70.735	4.70236
-6.796	849.331	841.142	12.714	0.937D+04	70.717	4.78968
-9.061	855.542	847.293	11.857	0.939D+04	70.810	4.87746
-11.326	861.819	853.469	10.746	0.945D+04	71.013	4.96597
-13.591	868.192	859.691	9.371	0.953D+04	71.328	5.05552
-15.857	874.694	865.978	7.719	0.965D+04	71.758	5.14640
-18.122	881.359	872.351	5.771	0.979D+04	72.303	5.23894
-20.387	888.225	878.832	3.507	0.998D+04	72.970	5.33347
-22.652	895.334	885.443	0.899	0.102D+05	73.761	5.43036
-22.748	895.642	885.728	0.780	0.102D+05	73.798	5.43453
-22.739	895.610	885.699	0.792	0.102D+05	73.794	5.43410
7.114	895.610	885.699	0.792	0.102D+05	30.363	5.43410
6.817	895.760	885.847	0.810	0.102D+05	30.341	5.43902
0.000	899.132	889.207	1.012	0.100D+05	30.058	5.55070
-1.499	899.867	889.942	1.002	0.100D+05	30.054	5.57515
-2.999	900.603	890.677	0.973	0.100D+05	30.070	5.59962
-4.498	901.341	891.413	0.925	0.100D+05	30.106	5.62414
-5.998	902.082	892.152	0.857	0.101D+05	30.164	5.64875
-7.497	902.829	892.894	0.769	0.101D+05	30.242	5.67349
-8.997	903.583	893.640	0.661	0.102D+05	30.342	5.69838
-10.496	904.346	894.392	0.532	0.103D+05	30.463	5.72347
-11.995	905.119	895.150	0.381	0.104D+05	30.606	5.74879
-13.495	905.905	895.916	0.208	0.105D+05	30.771	5.77438
-14.994	906.704	896.690	0.011	0.106D+05	30.960	5.80028
-15.074	906.747	896.732	-0.000	0.106D+05	30.970	5.80167

NO. OF RICOCHETS = 3
AVE. DRAG COEFF. = 3.016831 AVE. DRAG DECAY CONST. = 1.671718E-03
X(APPROX.) = 413.1463 Q= .705964
X(CORCTD.) = 875.3461 Q= 3.902553E-02
FINAL VALUES.....X = 896.7319 Y = 0
INITIAL ANGLE SENSITIVITY: dX/dA = 76.37755
INITIAL VELOCITY SENSITIVITY: dX/dU = 5.330046
INITIAL HEIGHT SENSITIVITY: dX/dY = 4.739301
CYLINDRICAL AREA INCREASE RATIO = 4376.111
SPHERICAL AREA INCREASE RATIO = 3984736