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NSWC TR 87-89

DRAG COEFFICIENTS FOR IRREGULAR FRAGMENTS

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EXPLOSIVES SAFETY BOARD

FEBRUARY 1988

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REPORT DOCUMENTATION PAGE			
1. OFFICIAL USE ONLY.		2. REPORT DATE. 1988, February	3. TYPE OF REPORT AND DATES COVERED Final
4. TITLE AND SUBTITLE. Drag Coefficients for Irregular Fragments		5. FUNDING NUMBERS.	
6. AUTHOR(S) McCleskey, Frank		8. PERFORMING ORGANIZATION REPORT NUMBER. 2009 N. 14th St. Suite-408 Arlington, VA 22201	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Kilkeary, Scott & Associates, Inc.		10. SPONSORING MONITORING AGENCY REPORT NUMBER. NSWC TR 87-89	
9. SPONSORING MONITORING AGENCY NAME(S) AND ADDRESS(ES) DOD Explosives Safety Board Room 856-C, Hoffman Building I 2461 Eisenhower Avenue/Alexandria, VA 22331-0600		11. SUPPLEMENTARY NOTES.	
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.		12b. DISTRIBUTION CODE	
13. ABSTRACT (MAXIMUM 200 WORDS). Drag coefficients for irregular fragments were determined for 96 fragments in a vertical wind tunnel at Mch numbers of approximately 0.1. Correlation of drag coefficient with the maximum-to-average presented area ratio is presented. A method for approximating the whole drag curve is also given. Physical characteristics, photos, and wind tunnel test results are given in the appendixes. <i>Keywords:</i> DTIC ELECTE DEC 27 1988 S D H			
14. SUBJECT TERMS. Irregular Fragments; Drag Coefficient; Vertical Wind Tunnel; Correlation.		15. NUMBER OF PAGES 111	
17a. SECURITY CLASSIFICATION (OF REPORT). UNCLASSIFIED		17b. SECURITY CLASSIFICATION (OF PAGE) UNCLASSIFIED	
17c. SECURITY CLASSIFICATION (OF ABSTRACT). UNCLASSIFIED		18. MEDIA TYPE.	

FOREWORD

The work on fragment drag coefficients contained in this report is part of a continuing effort for the Department of Defense Explosives Safety Board (DDESB). In addition to testing, the Naval Surface Warfare Center (NSWC) is tasked with establishing analytical techniques for predicting the hazards from fragments produced by the inadvertent detonation of ordnance stacks.

All tests and data reduction for this report were directed by the author while an employee of NSWC. This documentation was done by the author while an employee of Kilkeary, Scott and Associates, Inc.

The wind tunnel tests and data reduction were conducted by the Aerodynamics Research and Concepts Assistance Branch, Research Directorate, U.S. Army Chemical Research, Development and Engineering Center, Aberdeen Proving Ground, Maryland. The author acknowledges the following personnel of the Aerodynamics Research and Concepts Assistance Branch: Miles C. Miller; Richard R. Raup; Owen C. Smith, Jr.; and Daniel J. Weber. Deborah Rollins and Rose Baker of NSWC performed the fragment presented area measurements. Rose Baker made the linear measurements of the fragments and made all necessary calculations and graphical plots. Stephen F. McCleskey derived the equations for maximum presented area and the variance of the presented areas for a given fragment modeled as a rectangular parallelepiped.

This report has been reviewed by W. H. Bohli, Head, Explosion Dynamics Branch.

Approved by:



K. F. MUELLER, Head
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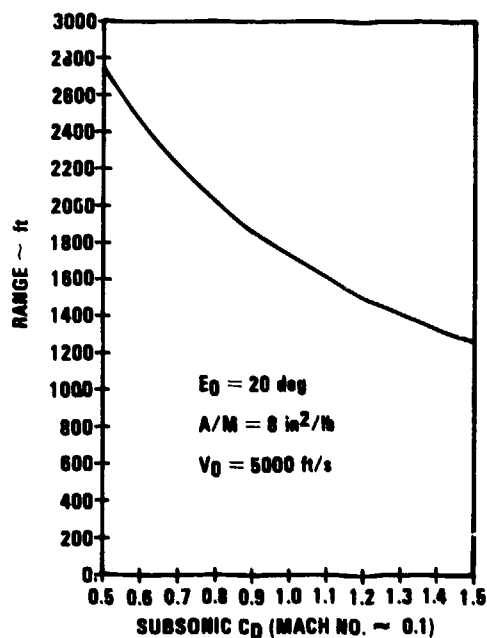
INTRODUCTION

The Naval Surface Warfare Center (NSWC) has a continuing task from the Department of Defense Explosives Safety Board (DDESB) to establish methods for predicting the fragment hazards due to the inadvertent explosion of ordnance items. As part of this task, NSWC has established a computer model,¹ which predicts fragment hazards for specified targets.

The computer model calculates individual trajectories for each fragment recovered in small-scale fragmentation arena tests. The following variables affect the flight dynamics of a fragment which is modeled as a point mass: gravity, velocity, area to mass ratio, air density, wind speed, and drag coefficient.

Except for the drag coefficient, all of these variables can be established with a fair degree of accuracy by tests, measurements and calculations. The drag coefficient for any fragment is a function of shape only. For regular fragments, like spheres and cubes, the drag coefficients are reasonably well-defined. For irregular fragments, like those from bombs or concrete walls, no two fragments have exactly the same shape. As a result, no two irregular fragments have exactly the same drag coefficient. Additionally, drag coefficient is a function of Mach number.

The uncertainty of drag coefficients for irregular fragments produces an associated uncertainty in far-field impact range. Figure 1 shows range versus low subsonic drag coefficient (C_D) for a typical fragment trajectory. The initial elevation angle, average presented area to mass ratio, and initial velocity are shown in Figure 1. The range of low subsonic C_D varies from 0.5 to 1.5, a factor of three. The associated ranges vary by a factor of more than two. This represents a large range of uncertainty in the trajectory calculations for establishing fragment hazards for use in quantity-distance determinations. If this uncertainty is to be reduced, some correlation must be established between drag coefficient (C_D) and the characteristics of irregular fragments.

FIGURE 1. C_D --RANGE SENSITIVITY

Since C_D is a function of shape only, any correlating parameter must be dimensionless; i.e., geometrically similar fragments that have the same drag coefficient should have the same value for the correlating parameter. For example, the ratio of maximum to minimum presented area might be used as a measure of shape. This ratio would be dimensionless. For a sphere, this ratio would always be one no matter what the size or material of the sphere. For a cube, this ratio would always be 1.732.

The impetus for this program was provided by an observation of the data contained in one of the first systematic reports on drag coefficients for irregular fragments.² Three regular fragments were studied in the report; i.e., a sphere, a cube, and a bar. The bar length, width, and thickness were in the ratio of 5:1:1. Since these fragments were regular, exact ratios of maximum to minimum presented area could be calculated. The results, at a Mach number of about 0.75, were as follows:

	Sphere	Cube	Bar
C_D (AVG)	0.60	0.88	1.12
A_{MAX}/A_{MIN}	1.00	1.73	7.14

Note that as the correlation ratio increases so does the C_D . The report also shows that the average C_D for irregular fragments was greater than those for the sphere or cube. For most irregular fragments, the area ratio could be expected to be on the order of that for the bar. Everything seemed to support the idea that the C_D for irregular fragments could be correlated with dimensionless parameters.

DRAG COEFFICIENT PROGRAM

FRAGMENT SELECTION

Ninety-six fragments were selected to provide a wide range of shapes to ensure a good statistical sample. In all cases, the fragments were made of steel. Photographs of each fragment are contained in Appendix B. The fragments were recovered from the detonation of the following ordnance items:

1. 155mm M107 projectile
2. 76mm Mk 165 projectile
3. Mk 84 low drag bomb
4. Mk 82 low drag bomb

The matchup between ordnance item and fragment is given in Table A-2 of Appendix A under the heading SOURCE.

FRAGMENT MEASUREMENTS

Five different kinds of measurements were made for each fragment:

1. Linear maximum length (L), width (W), and thickness (T),

2. Linear average L, W, and T,
3. Perimeters in the three coordinate planes,
4. Presented areas:
 - a. maximum
 - b. average
 - c. minimum
 - d. variance
 - e. standard deviation
5. Moment of inertia (three axes)

Linear dimensions were measured as shown in Figure 2. Note that in measuring average dimensions, the average thickness is calculated to produce an equivalent weight and volume rectangular parallelepiped. Maximum and average dimensions for all fragments are contained in Table A-2 of Appendix A. The convention for L, W, and T is as follows:

$$L \geq W \geq T$$

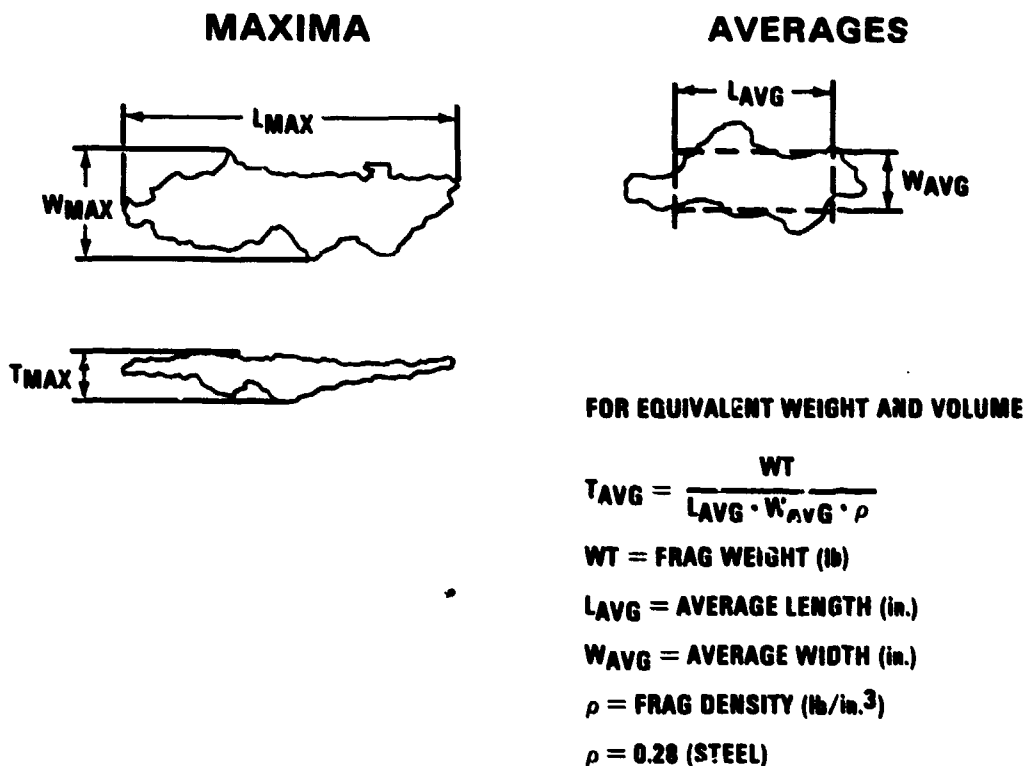
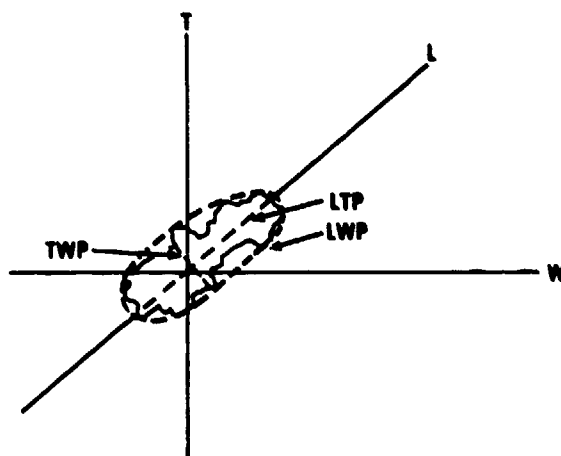


FIGURE 2. FRAGMENT LINEAR DIMENSIONS

Perimeters were measured in three planes as shown in Figure 3. Note that the perimeters do not follow the jagged contour of the fragment. In fact, the measurements were made by stretching a string around the fragment in each of the three mutually perpendicular planes. The perimeter measurements for all fragments are shown in Table A-2 of Appendix A.



LWP - PERIMETER IN L-W PLANE

LTP - PERIMETER IN L-T PLANE

TWP - PERIMETER IN T-W PLANE

FIGURE 3. PERIMETER MEASUREMENTS

Fragment presented areas were measured in two ways. First, measurements were made using an Icosahedron Gage and second, calculations were performed using equivalent weight and volume rectangular parallelepipeds. The parallelepipeds were constructed using the average linear dimensions discussed above. Figures 4 and 5 show the essentials of these measurements and calculations. The Icosahedron Gage is an electro-optical device which throws a shadow of a fragment onto a sensing surface. The associated electronics produce a readout of presented area. The optical axis is positioned at 16 approximately equally spaced aspects so as to produce 16 distinct presented areas. The Icosahedron Gage cannot mount a fragment weighing more than 1500 grains. For larger fragments, presented area statistics were calculated using rectangular parallelepipeds as shown in Figure 5. The Icosahedron Gage presented areas for the first 84 fragments are given in Table A-1 of Appendix A. The minimum, maximum, average, standard deviation, and variance of the presented areas, calculated from the rectangular parallelepipeds, are given in Table A-3 of Appendix A.

The weight moments of inertia³ for rectangular parallelepipeds are as follows:

$$I_T = \frac{M(L^2 + W^2)}{12}$$

$$I_W = \frac{M(L^2 + T^2)}{12}$$

$$I_L = \frac{M(W^2 + T^2)}{12}$$

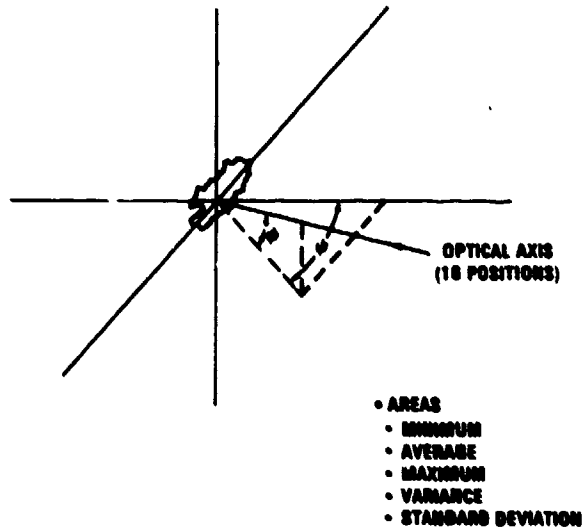
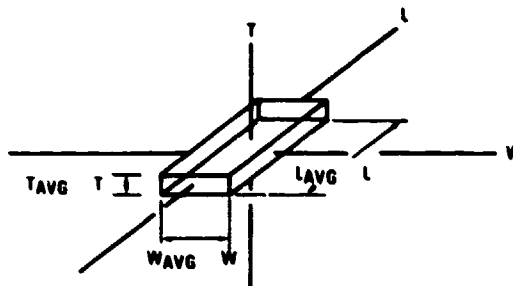


FIGURE 4. PRESENTED AREA MEASUREMENTS
(ICOSAHEDRON GAGE)



AREAS

MINIMUM = $W \cdot T$

AVERAGE = $0.5 (L \cdot W + L \cdot T + W \cdot T)$

MAXIMUM = $((L \cdot W)^2 + (T \cdot L)^2 + (T \cdot W)^2)^{1/2}$

VARIANCE = $1/12 [(L \cdot T)^2 + (W \cdot T)^2 + (L \cdot W)^2] + [4/(3\pi) - 1/2] \cdot [L \cdot W \cdot (T^2 + T \cdot W \cdot (L^2 + T \cdot L \cdot (W^2$

STANDARD DEVIATION = $(\text{VARIANCE})^{1/2}$

FIGURE 5. PRESENTED AREA MEASUREMENTS
(EQUIVALENT WEIGHT AND VOLUME RECTANGULAR PARALLELEPIPED)

where

I_T --moment of inertia about T axis

I_W --moment of inertia about W axis

I_L --moment of inertia about L axis

M --weight of fragment (grains)

L --average length (in.)

W --average width (in.)

T --average thickness (in.)

The weight moments of inertia are given in Table A-7 of Appendix A.

VERTICAL WIND TUNNEL

The vertical wind tunnel used for this program is located at the U.S. Army Chemical Research, Development and Engineering Center in Aberdeen, Maryland. The Aerodynamics Research and Concepts Assistance Branch of the Research Directorate operates the vertical wind tunnel.

The essential aspects of the vertical wind tunnel are shown in Figure 6. In operation, a fragment is placed on the fragment support screen in either the upper or lower test section depending on the air velocity necessary to raise the fragment. The air speed is controlled by opening or closing the inlet vanes of the constant speed fan. The air speed is adjusted until the fragment rises from the screen and assumes relatively stable vertical equilibrium. At this time, the air stream velocity is read directly from the velocity calibrated manometer. Air density is calculated from the ambient pressure and temperature. Ambient conditions are acceptable because of the relatively low air velocities produced in the tunnel. These parameters together with the weight and average presented area of the fragment are then used to calculate the low subsonic drag coefficient (C_D).

Each fragment was tested in the vertical wind tunnel. The velocity of the air stream was increased until the fragment hovers at a near constant vertical height. In this vertical equilibrium position, the drag and gravity forces will be equal. From the wind tunnel, the velocity of the air stream is established. Air density (ρ) is established from ambient pressure and temperature. The average presented area (A) of the fragment is obtained from measurements discussed above. As shown in Figure 7, once we know these values, we can calculate C_D . Since we operate at a single air velocity for each fragment, we can only obtain a single point on the drag curve. This point is in the low subsonic region, roughly about a Mach number of 0.1. The remainder of the drag curve must be inferred from other sources.

RESULTS

The test record for each fragment is contained in Appendix C. Each record gives three views of the fragment. These views in conjunction with the photographs of Appendix B give a good indication of fragment shape. The L, W, and T axes are shown. Remember that the convention for L, W, and T is:

$$L \geq W \geq T$$

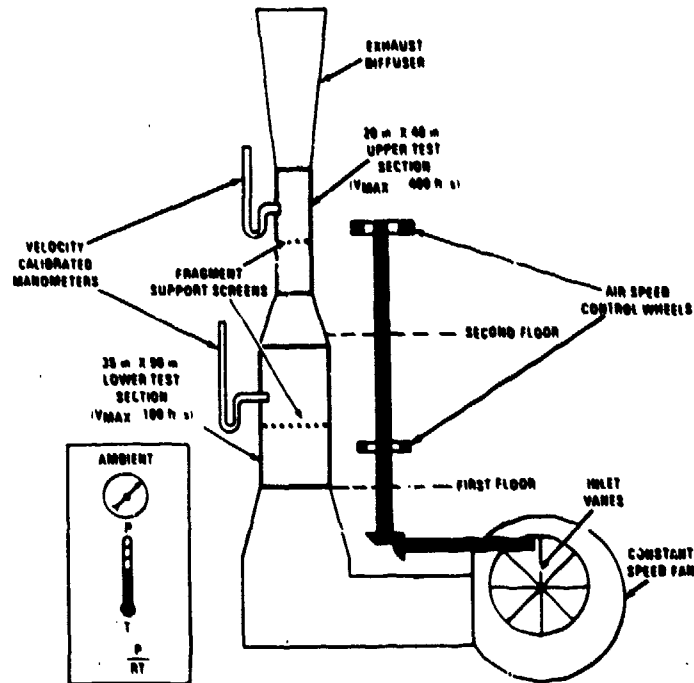
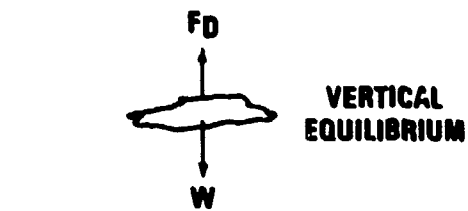


FIGURE 6. SUBSONIC VERTICAL WIND TUNNEL



$$F_D = \text{DRAG FORCE} = \frac{C_D \rho A V^2}{2}$$

$W = \text{FRAG WEIGHT}$

$$F_D = W = \frac{C_D \rho A V^2}{2}$$

$$C_D = \frac{2W}{\rho A V^2}$$

FIGURE 7. EXPERIMENTAL DRAG COEFFICIENT

The calculated C_D is shown on the test records along with the values of the variables necessary for the calculation. Remarks for each test are given that include the motion of the fragment in the vertical wind tunnel.

Tables A-4, A-5, A-6, and A-7 of Appendix A list all the dimensionless ratios considered for correlation with the low subsonic C_D . Ratios containing the minimum presented area were not used because of the errors inherent in the Icosahedron Gage. This is explained in the notes on Table A-3 at the beginning of Appendix A. Correlations were attempted using the dimensionless ratios singly and in pairs. When considering pairs of dimensionless ratios, the object was to draw lines of constant value for the second ratio within the uncertainty obtained with the first ratio and thus refine the correlations. In all cases, the lines of constant value plotted vertically and yielded no additional information. The second ratios were always dependent on the first ratios. When all plots were completed, the best correlation was obtained with the ratio of maximum to average presented area (A_{max}/A_{avg}). The correlation plot is shown in Figure 8.

Figure 8 shows the plotted points for the 96 fragments and the maximum and minimum boundary lines and their equations. The three fragments used as a baseline (sphere, cube, and bar) are identified. The value for A_{max}/A_{avg} is an average of the values obtained using the icosahedron gage and the equivalent rectangular parallelepipeds. The total range of C_D uncertainty for all irregular fragments is about 1.0; i.e., from 0.5 to 1.5. The range of uncertainty at an average A_{max}/A_{avg} of about 1.5 is approximately 0.6. On average then, it can be said that the correlation reduces C_D uncertainty by about 40 percent. In order to reduce range uncertainty to about ± 10 percent, it would be necessary to reduce the C_D uncertainty by about 75 percent.

The three regular fragments (sphere, cube, and bar) tested by Dunn and Porter² gave C_D values in the high subsonic region at Mach numbers of approximately 0.75. In the vertical wind tunnels tests, the Mach numbers were nearer 0.1. C_D values for the three baseline fragments are compared at the two Mach number levels in Table 1.

TABLE 1. COMPARISON OF BASELINE FRAGMENTS

	C_D Wind Tunnel ($M \approx 0.1$)	C_D (AVG) Dunn and Porter ($M \approx 0.75$)	Delta
Sphere	0.42	0.60	+ 0.18
Cube	0.64	0.88	+ 0.24
Bar	0.94	1.12	+ 0.18

As seen in Table 1, C_D at Mach 0.75 is about 0.2 higher than C_D at Mach 0.1 for all three fragments. Owing to the consistency in the rise of C_D from Mach 0.1 to 0.75 for the three regular fragments, it seems reasonable at this time to accept the same rise in C_D for irregular fragments. In this way, the shape of the subsonic drag curve for irregular fragments is established. This is important because range is more sensitive to changes in subsonic C_D than to similar changes in supersonic C_D . This is demonstrated in Figure 9 where velocity is plotted against range ratio for a typical farfield fragment trajectory. The range ratio is the fraction of the total trajectory range traversed. From Figure 9 it can be seen that only 25 percent of the trajectory is supersonic while 75 percent is subsonic. The next point to consider is fragment motion in the wind tunnel.

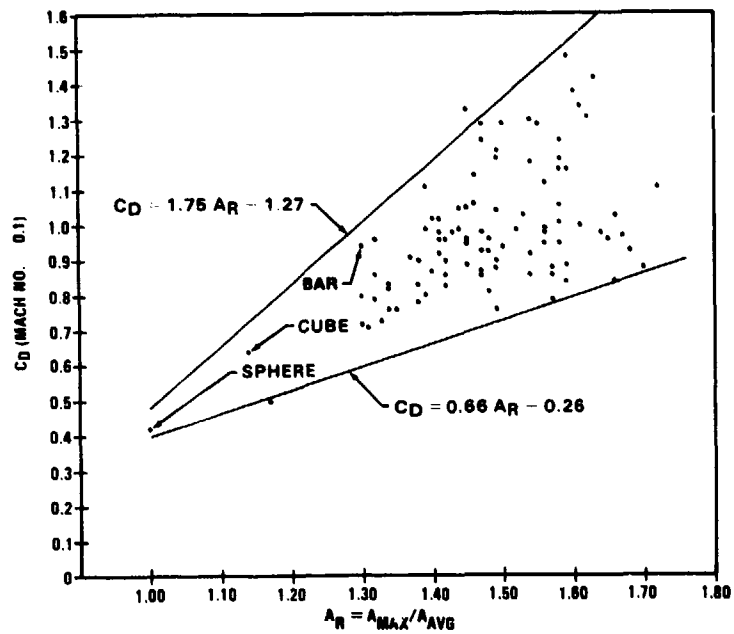


FIGURE 8. DRAG COEFFICIENT (C_D) VERSUS PRESENTED AREA RATIO (A_R)

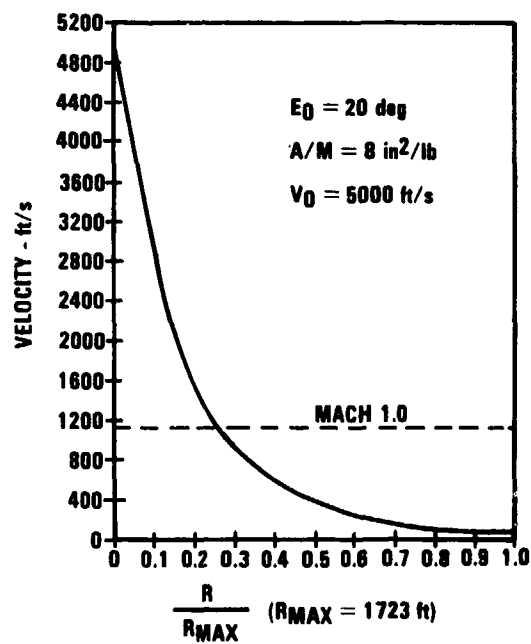


FIGURE 9. VELOCITY VERSUS RANGE RATIO

Each test record in Appendix C describes fragment motion in the vertical wind tunnel at near vertical equilibrium. In a further attempt at correlation, the 96 motions were divided into eight categories of typical motion. The eight categories and their associated fragments are shown in Figures D-1 through D-8 of Appendix D. No systematic correlation was discovered. One surprise, however, was observed. Only about one-third of the fragments tumbled randomly in the wind tunnel. This is contrary to the traditional assumption that all irregular fragments tumble randomly in flight. It was because of this assumption that C_D for each fragment was calculated using the average presented area. Had a larger presented area (A) been used for fragments which exhibited a motion such as flat rotation, then a smaller C_D would have been calculated. Similarly, a smaller presented area (A) would have produced a larger C_D . In practice, it is only necessary that the $C_D \cdot A$ product be the same for the test and the trajectory calculation. Again, this knowledge did not yield any systematic correlation. It must also be borne in mind that the motion of a fragment at low subsonic velocities may differ from the motion of supersonic velocities because of such factors as shock waves.

USING THE LOW SUBSONIC DRAG COEFFICIENT TO CALCULATE FRAGMENT TRAJECTORIES

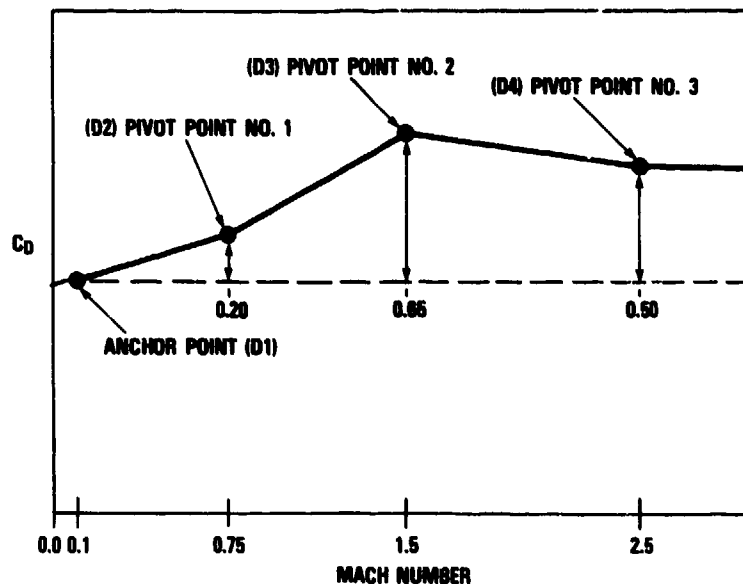
The low subsonic drag coefficient obtained from the vertical wind tunnel tests is only one point on the drag curve. To draw an entire drag curve, points must be inferred from other sources. The current state of knowledge about drag coefficients for irregular fragments does not warrant a complex curve. A series of straight line approximations is sufficient at this time. Using data from previous drag reports,^{2,4} transonic and supersonic pivot points can be approximated. From the RESULTS section, we have shown a 0.2 rise in C_D from Mach 0.1 to 0.75. Table 2 shows the points necessary to define straight line approximations to the drag curve for any fragment.

TABLE 2. APPROXIMATION OF STRAIGHT LINE POINTS

Point	Point Name	Mach No.	C_D
D1	Anchor	0.10	D1
D2	Pivot #1	0.75	D1 + 0.20
D3	Pivot #2	1.50	D1 + 0.65
D4	Pivot #3	2.50	D1 + 0.50

The points and straight line approximations are shown in Figure 10. Note that above Mach 2.5, C_D is considered constant. The anchor point is taken from Figure 8 for a particular A_{max}/A_{avg} at Mach 0.10. Once the anchor point is determined then all the straight line approximations are defined. This results in the straight line approximations for all fragments being parallel to one another. Although exact parallelism would hardly be the case in all instances, there are grounds for the assumption. The Dunn and Porter report² shows that the drag curve for spheres is essentially parallel to the drag curve for long rectangular parallelepipeds and shell fragments. The drag curve for cubes and cylinders ($L/D = 1$) is parallel to the previous two except for a small discrepancy in the transonic region.

The anchor point may be selected in a variety of ways. For a particular fragment with a given A_{max}/A_{avg} , the anchor point may be selected anywhere within the uncertainty defined by the upper and lower boundary lines of Figure 8. The anchor point could be an average, a maximum, a minimum, or an intermediate value. It could also be chosen by random selection within the boundary lines.

FIGURE 10. STRAIGHT LINE APPROXIMATION TO FRAGMENT C_D CURVES

The following equations for air density and Mach number may be of help in using fragment drag coefficients.

where
$$\rho = 0.0765 e^{-\left(\frac{A}{33900}\right)}$$

ρ = air density (lb/ft³)
 A = altitude (+) above sea level and (-) below sea level (ft)

where
$$M = \frac{V_F}{V_S}$$

M = Mach number
 V_F = velocity of fragment
 V_S = velocity of sound

where
$$V_S = 1116.4 e^{-\left(\frac{A}{286000}\right)}$$

V_S = velocity of sound (ft/sec)
 A = altitude (+) above sea level and (-) below sea level (ft)

FUTURE CONSIDERATIONS

Significant problems remain unresolved. For an acceptable range uncertainty of about ± 10 percent, it will be necessary to reduce C_D uncertainty by about 75 percent. The work to date has only reduced the C_D uncertainty by about 40 percent. This additional reduction in C_D uncertainty might be accomplished in a variety of ways. More efficient correlation parameters might be established. The typical motion of the fragments in the vertical wind tunnel (Figures D-1 through D-8 of Appendix D) might be used as an added correlation provided the motion could be predicted based on the physical characteristics of irregular fragments. Possibly, the use of presented areas other than the average might be used in calculating C_D .

Another unresolved problem involves the shape of the transonic and supersonic portions of the drag curve. It would be a help if a practical method for testing irregular fragments could be established for a supersonic wind tunnel. Possibly, some sort of gimbal device could be designed which would allow the fragment to move freely and, at the same time, continually measure drag force. Such a device might be calibrated by using spheres or cubes for which drag curves are fairly well known.

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3. Myers, Jack A., *Handbook of Equations for Mass and Area Properties of Various Geometrical Shapes*, NAVWEPS Report 7827, April 1962.
4. Daniels, P., et al., *Subsonic, Transonic and Supersonic Drag Characteristics of Nine Shape Categories of Warhead Fragments*, Naval Surface Warfare Center TR 81-112, May 1981.

APPENDIX A
TABLES OF FRAGMENT CHARACTERISTICS

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These tables contain dimensional characteristics for all 96 fragments. Additionally, they contain the dimensionless ratios used for correlation with the drag coefficients calculated from vertical wind tunnel tests. The following comments are made to the seven tables:

Table A-1 - This table contains the 16 presented areas measured by the Icosahedron Gage for the first 84 fragments. The last 12 fragments were too heavy to mount on the gage. The presented areas have been sorted and listed in ascending order for each fragment.

Table A-2 - The weapon from which each fragment was taken is listed under SOURCE. Maximum and average length, width, and thickness are listed after the fragment weight in grains. The linear dimensions are described in Figure 2 of the DRAG COEFFICIENT PROGRAM Section. Perimeter as described in Figure 3 is listed next. Finally, the drag coefficient (C_D) obtained from tests in the vertical wind tunnel is listed.

Table A-3 - The minimum, maximum, and average presented areas are listed for each fragment. The standard deviation and variance of the presented areas are given next. Under each of the five headings, values are given based on Icosahedron Gage (ICOS) measurements, and calculations (CALC) based on equal weight and volume parallelepipeds as described in Figure 5 of the DRAG COEFFICIENT PROGRAM Section. Note the large differences in the ICOS and CALC values for minimum presented area. This is due to the inherent limitations of the Icosahedron Gage caused by its preset mechanical stops. In all cases, the minimum CALC values are more near the truth. The CALC value for fragment number 1, the bar fragment, is very accurate while the ICOS value is almost three times as big.

Table A-4 - Fragments are renumbered in accordance with ascending C_D . This is done to provide a quick picture of correlation. The OLD fragment number is the number assigned in Tables A-1 through A-3 and in Appendixes B, C, and D. Three dimensionless area ratios are given and values are given for both Icosahedron Gage measurements and parallelepiped calculations.

Table A-5 - Again, fragment drag coefficients (C_D) are listed in ascending order. All dimensionless ratio headings are explained at the end of the table.

Table A-6 - Here dimensionless perimeter ratios are given. Headings are explained at the bottom of the table.

Table A-7 - Weight moments of inertia and their associated dimensionless ratios are given. Weight moments of inertia are explained in the FRAGMENT MEASUREMENTS Subsection of the DRAG COEFFICIENT PROGRAM Section.

TABLE A-1. PRESENTED AREA (SQ. IN.)
(ICOSAHEDRON GAGE)

FRAG NO.	PRESENTED AREA															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.198	0.210	0.274	0.284	0.311	0.323	0.323	0.326	0.340	0.357	0.367	0.397	0.406	0.405	0.409	0.433
2	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785
3	0.638	0.687	0.805	0.809	0.827	0.854	0.888	0.890	0.890	0.893	0.920	0.932	0.944	0.952	0.976	0.983
4	0.192	0.229	0.236	0.242	0.278	0.288	0.293	0.296	0.306	0.307	0.311	0.338	0.339	0.353	0.359	0.365
5	0.171	0.240	0.245	0.270	0.280	0.290	0.359	0.373	0.393	0.408	0.418	0.443	0.452	0.492	0.536	0.576
6	0.157	0.216	0.228	0.247	0.247	0.256	0.270	0.276	0.304	0.311	0.339	0.361	0.361	0.376	0.376	0.412
7	0.197	0.203	0.237	0.243	0.249	0.256	0.290	0.291	0.309	0.312	0.327	0.366	0.373	0.388	0.399	0.412
8	0.183	0.213	0.247	0.271	0.274	0.291	0.335	0.360	0.367	0.404	0.426	0.475	0.475	0.526	0.551	0.580
9	0.183	0.190	0.283	0.285	0.307	0.315	0.327	0.334	0.337	0.401	0.401	0.401	0.433	0.476	0.476	0.496
10	0.230	0.240	0.262	0.271	0.328	0.340	0.367	0.391	0.438	0.445	0.570	0.573	0.580	0.585	0.622	0.700
11	0.201	0.217	0.257	0.267	0.275	0.288	0.292	0.316	0.337	0.360	0.404	0.407	0.413	0.416	0.434	0.486
12	0.214	0.222	0.226	0.240	0.256	0.270	0.277	0.290	0.336	0.358	0.385	0.385	0.443	0.455	0.484	0.510
13	0.206	0.231	0.239	0.240	0.245	0.260	0.260	0.269	0.280	0.296	0.303	0.310	0.320	0.349	0.353	0.355
14	0.190	0.266	0.278	0.278	0.290	0.298	0.303	0.339	0.347	0.357	0.366	0.374	0.400	0.442	0.445	0.457
15	0.222	0.237	0.266	0.276	0.300	0.303	0.325	0.335	0.337	0.349	0.389	0.396	0.400	0.425	0.442	0.457
16	0.206	0.236	0.329	0.359	0.379	0.383	0.388	0.423	0.423	0.438	0.472	0.492	0.522	0.546	0.561	0.566
17	0.210	0.239	0.295	0.327	0.330	0.337	0.337	0.349	0.359	0.413	0.432	0.454	0.467	0.496	0.506	0.532
18	0.247	0.257	0.294	0.311	0.313	0.316	0.374	0.401	0.404	0.421	0.423	0.423	0.445	0.453	0.475	0.521
19	0.213	0.225	0.252	0.255	0.267	0.308	0.330	0.345	0.348	0.372	0.414	0.443	0.473	0.477	0.480	0.517
20	0.223	0.296	0.343	0.360	0.377	0.399	0.424	0.436	0.443	0.487	0.500	0.519	0.522	0.522	0.544	0.617
21	0.200	0.296	0.308	0.313	0.382	0.391	0.416	0.421	0.462	0.480	0.512	0.639	0.641	0.649	0.668	0.744
22	0.281	0.350	0.380	0.410	0.410	0.434	0.508	0.538	0.577	0.622	0.632	0.641	0.676	0.701	0.704	0.804
23	0.272	0.339	0.341	0.373	0.380	0.412	0.437	0.451	0.468	0.471	0.490	0.500	0.510	0.591	0.598	0.613
24	0.265	0.275	0.275	0.290	0.299	0.400	0.400	0.441	0.444	0.464	0.593	0.603	0.618	0.630	0.640	0.745
25	0.260	0.262	0.407	0.409	0.429	0.431	0.458	0.505	0.508	0.519	0.612	0.637	0.678	0.701	0.704	0.794
26	0.294	0.355	0.387	0.441	0.455	0.470	0.495	0.589	0.539	0.610	0.615	0.615	0.634	0.720	0.749	0.764
27	0.339	0.353	0.424	0.446	0.473	0.505	0.515	0.522	0.539	0.547	0.571	0.640	0.642	0.696	0.740	0.745
28	0.333	0.364	0.421	0.445	0.475	0.477	0.480	0.536	0.536	0.558	0.565	0.614	0.644	0.666	0.697	0.751
29	0.351	0.361	0.390	0.417	0.437	0.488	0.523	0.530	0.542	0.559	0.562	0.572	0.606	0.630	0.670	0.692
30	0.295	0.329	0.348	0.429	0.432	0.454	0.503	0.530	0.537	0.554	0.579	0.581	0.606	0.633	0.669	0.735
31	0.344	0.379	0.393	0.400	0.411	0.418	0.423	0.440	0.477	0.494	0.520	0.551	0.556	0.556	0.540	0.570
32	0.289	0.487	0.501	0.531	0.536	0.546	0.590	0.620	0.659	0.679	0.699	0.699	0.730	0.760	0.792	0.812
33	0.360	0.365	0.400	0.439	0.439	0.458	0.458	0.471	0.478	0.478	0.500	0.510	0.547	0.576	0.591	0.596
34	0.313	0.491	0.496	0.526	0.536	0.565	0.565	0.587	0.594	0.609	0.611	0.697	0.732	0.744	0.832	0.842
35	0.312	0.322	0.410	0.489	0.499	0.590	0.600	0.627	0.716	0.765	0.825	0.854	0.889	0.894	0.907	1.047
36	0.361	0.391	0.393	0.464	0.518	0.545	0.582	0.592	0.599	0.631	0.677	0.697	0.730	0.795	0.859	0.906
37	0.300	0.432	0.444	0.447	0.523	0.572	0.599	0.599	0.621	0.643	0.667	0.709	0.743	0.740	0.812	0.853
38	0.349	0.349	0.371	0.425	0.459	0.501	0.501	0.508	0.569	0.594	0.633	0.653	0.670	0.692	0.721	0.787
39	0.418	0.467	0.477	0.494	0.536	0.587	0.665	0.683	0.734	0.800	0.822	0.864	0.906	0.937	0.962	1.045
40	0.277	0.525	0.544	0.544	0.569	0.571	0.571	0.659	0.689	0.691	0.694	0.694	0.700	0.745	0.750	0.767
41	0.484	0.499	0.501	0.531	0.543	0.548	0.553	0.575	0.580	0.582	0.592	0.631	0.636	0.636	0.663	0.695
42	0.422	0.472	0.496	0.501	0.610	0.639	0.654	0.659	0.659	0.659	0.689	0.700	0.750	0.763	0.772	0.876
43	0.553	0.731	0.760	0.780	0.888	0.928	0.977	1.007	1.056	1.056	1.125	1.125	1.194	1.203	1.312	1.431
44	0.391	0.440	0.506	0.516	0.540	0.540	0.543	0.550	0.570	0.572	0.577	0.594	0.599	0.604	0.624	0.660
45	0.405	0.429	0.481	0.488	0.522	0.535	0.576	0.591	0.591	0.618	0.635	0.635	0.687	0.706	0.721	0.789
46	0.406	0.452	0.469	0.492	0.543	0.543	0.585	0.651	0.670	0.680	0.722	0.724	0.807	0.810	0.820	0.825
47	0.467	0.472	0.536	0.543	0.553	0.580	0.604	0.617	0.622	0.634	0.675	0.715	0.739	0.739	0.795	0.820
48	0.398	0.425	0.477	0.489	0.510	0.531	0.594	0.653	0.712	0.722	0.802	0.832	0.893	0.905	0.917	0.974
49	0.370	0.458	0.472	0.509	0.512	0.548	0.551	0.590	0.646	0.659	0.759	0.776	0.781	0.784	0.864	0.896
50	0.427	0.449	0.518	0.537	0.581	0.589	0.591	0.594	0.633	0.653	0.704	0.719	0.765	0.797	0.799	0.831

TABLE A-1. PRESENTED AREA (SQ. IN.)
(ICOSAHEDRON GAGE) (Continued)

PRESENTED AREA															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0.482	0.427	0.568	0.609	0.737	0.757	0.787	0.821	0.856	0.885	0.898	0.895	0.928	0.925	0.989	1.033
0.488	0.432	0.492	0.526	0.578	0.625	0.625	0.625	0.832	0.866	0.876	0.876	1.039	1.078	1.172	1.282
0.543	0.548	0.567	0.715	0.725	0.725	0.758	0.768	0.779	0.784	0.884	0.814	0.839	0.839	0.888	0.838
0.538	0.581	0.535	0.619	0.634	0.663	0.747	0.821	0.934	1.033	1.231	1.248	1.384	1.443	1.526	1.678
0.456	0.476	0.633	0.673	0.698	0.742	0.786	0.821	0.831	0.944	0.989	1.018	1.053	1.067	1.132	1.281
0.538	0.644	0.684	0.713	0.773	0.882	0.832	0.921	0.938	1.069	1.069	1.079	1.148	1.246	1.256	1.385
0.458	0.498	0.562	0.686	0.646	0.678	0.749	0.754	0.779	0.784	0.818	0.828	0.828	0.863	0.931	0.961
0.289	0.619	0.619	0.713	0.723	0.738	0.777	0.918	0.918	0.915	1.084	1.084	1.078	1.132	1.281	1.344
0.452	0.516	0.536	0.568	0.625	0.728	0.877	0.856	0.866	0.876	1.212	1.266	1.281	1.385	1.318	1.592
0.486	0.586	0.598	0.614	0.674	0.688	0.653	0.723	0.748	0.767	0.772	0.882	0.822	0.915	0.926	0.985
0.525	0.525	0.684	0.732	0.742	0.821	0.948	0.949	1.048	1.048	1.385	1.385	1.394	1.453	1.453	1.688
0.639	0.683	0.732	0.841	0.856	0.861	0.878	0.885	0.985	0.985	0.935	0.985	0.915	0.935	0.935	0.994
0.398	0.447	0.713	0.718	0.733	0.882	0.837	0.856	0.945	0.965	1.824	1.868	1.246	1.325	1.335	1.394
0.517	0.638	0.635	0.668	0.773	0.783	0.882	0.988	1.197	1.237	1.434	1.533	1.617	1.738	1.884	1.942
0.435	0.488	0.618	0.628	0.677	0.697	0.727	0.786	0.786	0.868	0.984	0.938	0.988	1.088	1.027	1.131
0.531	0.558	0.555	0.555	0.624	0.733	0.762	0.772	0.782	0.792	1.063	1.088	1.098	1.113	1.117	1.358
0.622	0.637	0.735	0.768	0.888	0.834	0.839	0.849	0.898	0.962	1.189	1.288	1.214	1.248	1.258	1.451
0.585	0.688	0.619	0.624	0.633	0.733	0.887	0.876	0.896	0.925	0.938	1.084	1.088	1.088	1.113	1.137
0.565	0.565	0.737	0.737	0.737	0.836	0.871	0.838	0.979	1.084	1.043	1.083	1.187	1.127	1.147	1.288
0.434	0.572	0.687	0.661	0.788	0.788	0.725	0.779	0.788	0.788	0.814	0.853	0.873	0.888	0.983	0.912
0.586	0.546	0.792	0.882	0.882	0.978	0.998	1.079	1.079	1.315	1.365	1.454	1.464	1.788	1.788	1.878
0.614	0.663	0.673	0.712	0.934	0.938	1.013	1.087	1.339	1.363	1.536	1.685	1.758	1.822	1.938	2.083
0.523	0.671	0.788	0.718	0.728	0.883	0.922	1.086	1.031	1.088	1.341	1.351	1.438	1.458	1.458	1.682
0.635	0.678	0.788	0.759	0.912	0.912	0.951	0.976	1.038	1.035	1.099	1.188	1.237	1.272	1.336	1.438
0.588	0.681	0.854	0.859	0.873	0.893	1.036	1.051	1.138	1.188	1.327	1.376	1.381	1.411	1.411	1.646
0.467	0.669	0.748	0.758	0.758	0.882	0.891	1.044	1.217	1.232	1.241	1.488	1.577	1.688	1.725	2.088
0.482	0.571	0.837	0.916	1.085	1.025	1.035	1.064	1.133	1.262	1.291	1.311	1.538	1.686	1.745	1.755
0.839	0.948	0.977	1.087	1.056	1.155	1.224	1.234	1.383	1.333	1.472	1.588	1.558	1.588	1.747	1.886
0.682	0.761	0.888	0.988	0.988	1.117	1.186	1.186	1.196	1.294	1.618	1.638	1.719	1.788	1.788	2.074
0.674	0.694	0.961	0.971	1.119	1.158	1.287	1.227	1.267	1.385	1.415	1.464	1.494	1.525	1.563	1.781
0.682	0.838	1.046	1.075	1.185	1.125	1.125	1.154	1.174	1.283	1.322	1.342	1.371	1.588	1.548	1.888
0.685	0.763	0.813	0.842	0.872	0.897	0.986	1.085	1.089	1.188	1.183	1.281	1.296	1.488	1.583	1.953
0.688	0.618	0.776	0.858	0.899	0.988	1.023	1.314	1.343	1.397	1.447	1.624	1.688	1.876	1.985	1.979
0.683	0.871	0.858	1.038	1.038	1.157	1.196	1.196	1.374	1.512	1.718	1.729	1.828	1.957	2.045	2.285

TABLE A-2. FRAGMENT DATA

FRAG NO.	SOURCE	WEIGHT GRAINS	LMAX IN.	WMAX IN.	THAX IN.	LMNG IN.	WMNG IN.	THNG IN.	LMP IN.	LTP IN.	TMP IN.	CD
1	1	159.3	1.29	0.29	0.25	1.3	0.3	0.23	3.25	3.19	1.13	0.94
2	2	1038.4	SPHERE		DIAMETER = 1.00 IN.		ALL PERIMETERS = 3.14 IN.					CD = .42
3	3	833.0	0.76	0.76	0.76	0.8	0.8	0.76	3.06	3.06	3.06	0.64
4	5	110.7	0.93	0.60	0.49	0.9	0.5	0.13	2.30	2.19	1.75	0.91
5	5	112.3	1.73	0.40	0.21	1.6	0.4	0.09	3.63	3.50	1.25	1.19
6	5	113.2	1.02	0.60	0.25	1.0	0.5	0.12	2.36	2.13	1.30	1.06
7	5	113.2	1.01	0.60	0.27	1.0	0.5	0.12	2.63	2.23	1.30	1.05
8	5	119.7	1.29	0.01	0.21	1.2	0.6	0.00	3.25	2.75	1.75	1.34
9	5	121.5	1.24	0.30	0.29	1.1	0.5	0.11	3.06	2.60	1.30	0.93
10	5	121.0	1.40	0.72	0.22	1.2	0.7	0.07	3.44	2.30	1.30	0.97
11	5	120.6	1.04	0.71	0.27	1.1	0.5	0.12	2.01	2.31	1.30	0.76
12	5	120.0	0.94	0.79	0.20	0.8	0.0	0.10	2.75	2.00	1.75	0.00
13	5	130.0	0.03	0.00	0.44	0.7	0.6	0.16	2.31	2.00	1.94	0.03
14	5	132.9	1.00	0.75	0.33	1.0	0.5	0.14	2.00	2.31	1.94	0.96
15	5	133.5	1.02	0.76	0.32	0.9	0.6	0.13	2.75	2.30	1.60	0.90
16	5	150.1	1.74	0.35	0.20	1.7	0.4	0.11	3.00	3.50	1.30	0.95
17	5	153.5	1.20	0.63	0.32	1.3	0.5	0.12	3.00	2.63	1.30	0.94
18	5	150.6	1.36	0.71	0.34	1.4	0.4	0.14	3.06	2.75	1.01	0.03
19	5	161.1	0.90	0.74	0.26	1.0	0.6	0.14	2.01	2.13	1.60	1.21
20	5	170.2	1.43	0.02	0.37	1.3	0.6	0.12	3.30	2.01	1.01	1.29
21	5	180.5	1.70	0.74	0.27	1.5	0.6	0.11	3.75	3.30	1.63	1.30
22	5	203.7	1.04	0.65	0.30	1.5	0.6	0.12	4.00	4.00	1.44	1.10
23	5	213.0	1.33	0.73	0.30	1.1	0.6	0.17	3.13	2.75	1.00	1.02
24	5	214.6	1.07	0.90	0.26	1.0	0.0	0.14	3.19	2.30	1.94	1.40
25	5	236.4	1.51	0.01	0.29	1.5	0.6	0.13	3.36	2.00	1.94	1.30
26	5	239.4	1.40	0.79	0.41	1.5	0.6	0.14	3.03	3.06	1.75	1.19
27	5	241.6	1.54	0.03	0.43	1.4	0.6	0.15	3.01	3.44	1.63	0.00
28	5	244.0	1.50	0.70	0.40	1.3	0.6	0.16	3.50	3.31	2.06	1.33
29	6	240.7	1.30	0.74	0.30	1.3	0.6	0.16	3.19	3.06	1.63	0.96
30	5	253.1	1.74	0.77	0.35	1.7	0.5	0.15	3.94	3.63	1.75	1.24
31	5	260.9	1.05	0.00	0.47	1.1	0.6	0.21	2.00	2.44	2.06	0.96
32	5	277.4	1.07	0.77	0.46	1.9	0.5	0.15	4.06	3.94	1.94	0.96
33	7	280.2	1.20	1.00	0.46	1.1	0.6	0.22	2.00	2.44	2.13	0.06
34	6	291.1	1.40	0.09	0.44	1.4	0.7	0.15	3.94	3.31	2.06	1.29
35	4	322.0	1.01	0.60	0.32	1.9	0.6	0.14	4.30	4.00	1.01	0.79
36	4	304.0	1.09	0.00	0.36	1.5	0.7	0.15	3.75	3.44	1.75	1.16
37	6	309.4	1.50	0.02	0.37	1.4	0.7	0.16	3.75	3.31	1.00	0.96
38	4	313.1	1.54	0.06	0.30	1.3	0.7	0.10	3.44	3.19	1.01	0.90
39	4	321.9	1.42	1.13	0.36	1.3	0.9	0.14	4.36	2.01	2.60	0.06
40	5	325.7	1.36	0.70	0.57	1.4	0.6	0.20	3.44	3.44	1.01	0.02
41	4	333.2	1.12	1.00	0.00	1.1	0.0	0.19	2.00	2.75	2.60	0.76
42	6	335.0	1.73	0.66	0.35	1.5	0.6	0.19	4.25	3.94	1.75	0.90
43	4	352.0	2.71	0.04	0.19	2.6	0.7	0.10	7.25	5.25	1.94	0.95
44	4	354.0	1.17	0.07	0.74	1.1	0.7	0.23	3.31	3.06	2.25	0.72
45	4	354.9	1.34	0.95	0.50	1.2	0.7	0.22	3.30	3.06	2.25	0.00
46	5	357.9	1.35	1.14	0.51	1.3	0.7	0.20	3.01	3.06	2.25	0.03
47	6	359.2	1.43	0.02	0.67	1.4	0.7	0.19	3.00	3.13	2.31	0.07
48	5	360.2	1.30	1.23	0.46	1.2	0.9	0.17	4.00	2.00	2.01	1.04
49	5	370.3	1.30	0.05	0.43	1.3	0.0	0.10	3.00	2.00	2.06	1.14
50	4	381.0	1.12	0.99	0.62	1.2	0.0	0.20	3.63	2.94	2.36	1.11

TABLE A-2. FRAGMENT DATA (Continued)

FRAG NO.	SOURCE	WEIGHT GRAMS	LMAX IN.	MMAX IN.	TMAX IN.	LMVG IN.	MMVG IN.	TMVG IN.	LMP IN.	LTP IN.	TMP IN.	CD
51	4	398.2	2.25	0.64	0.51	2.0	0.6	0.17	4.00	4.75	1.69	1.05
52	6	393.3	1.65	1.07	0.40	1.6	0.8	0.16	4.44	3.31	2.31	1.16
53	4	399.1	1.62	0.75	0.52	1.5	0.7	0.19	4.36	4.06	2.13	0.76
54	4	404.6	2.09	1.16	0.27	2.0	0.9	0.11	5.25	4.31	2.50	1.11
55	5	432.7	2.03	0.75	0.42	1.9	0.7	0.17	4.40	4.30	1.69	0.80
56	4	435.9	2.75	0.76	0.37	2.5	0.6	0.16	5.00	5.69	1.01	1.03
57	6	461.7	1.36	0.96	0.47	1.3	0.8	0.23	3.63	3.30	2.13	0.70
58	6	464.0	2.03	0.90	0.52	2.1	0.7	0.16	4.01	4.25	2.25	1.12
59	4	483.2	1.30	1.36	0.33	1.6	1.0	0.15	4.01	3.13	2.94	1.03
60	6	484.1	1.34	0.93	0.61	1.3	0.8	0.24	3.63	3.44	2.30	0.90
61	4	486.7	2.47	1.05	0.37	2.1	0.9	0.13	5.60	5.06	2.31	0.96
62	4	489.3	1.03	0.90	0.30	1.0	0.7	0.20	3.96	4.44	2.01	0.73
63	6	490.9	2.13	1.02	0.39	2.1	0.8	0.15	5.13	4.69	2.00	0.86
64	4	493.1	1.96	1.59	0.30	2.0	1.0	0.13	6.30	3.01	3.25	0.80
65	5	505.0	1.72	0.91	0.41	1.0	0.6	0.24	4.44	3.75	1.94	0.86
66	6	519.6	1.62	1.20	0.39	1.4	1.0	0.19	4.30	3.06	2.01	1.06
67	6	531.9	2.12	1.06	0.40	2.0	0.8	0.17	5.36	4.31	2.30	0.92
68	5	547.9	1.00	1.00	0.42	1.6	0.8	0.22	3.63	3.90	3.44	0.92
69	6	556.2	1.97	1.07	0.42	1.9	0.8	0.19	5.06	4.44	2.25	0.87
70	4	561.2	1.73	0.60	0.67	1.5	0.7	0.27	4.19	4.13	2.06	0.71
71	4	600.4	2.57	0.96	0.33	2.3	0.9	0.15	6.06	5.25	2.13	0.90
72	6	631.7	2.19	1.30	0.30	2.1	1.1	0.14	5.63	4.31	2.75	0.93
73	6	633.4	1.59	1.37	0.44	1.6	1.1	0.19	4.94	3.63	2.94	0.84
74	4	636.0	1.03	1.16	0.66	1.9	0.8	0.22	4.63	4.00	3.00	0.86
75	6	660.5	2.31	1.07	0.44	2.1	0.8	0.20	5.36	5.06	2.69	0.99
76	5	713.9	2.12	1.24	0.30	1.0	1.0	0.20	5.06	4.31	3.00	0.84
77	6	719.1	2.61	0.93	0.30	2.6	0.8	0.10	6.00	5.06	2.19	1.29
78	4	767.0	2.05	1.16	0.53	2.0	0.7	0.20	7.44	6.13	2.00	0.90
79	6	776.7	2.53	1.27	0.45	2.3	1.0	0.17	7.13	5.06	2.69	1.31
80	4	777.0	2.05	0.86	0.59	2.0	0.7	0.20	6.63	6.06	2.19	0.96
81	6	782.2	2.43	0.97	0.43	2.1	0.8	0.21	5.63	5.63	2.13	0.99
82	4	804.0	1.60	1.49	0.30	1.6	1.1	0.23	4.00	3.36	3.44	0.81
83	6	833.7	1.76	1.59	0.40	1.6	1.4	0.19	5.69	3.69	3.30	0.89
84	6	866.3	2.99	1.07	0.43	3.0	0.9	0.16	7.00	5.01	2.31	1.00
85	4	1617.7	3.23	1.27	0.56	2.7	1.1	0.20	7.01	6.75	2.01	0.93
86	6	1630.0	3.37	1.35	0.45	3.3	1.2	0.21	8.01	6.75	4.19	1.24
87	4	1799.4	3.53	2.05	0.66	3.3	1.2	0.23	8.00	6.36	3.69	0.90
88	6	1973.2	3.92	1.06	0.49	3.0	1.2	0.22	9.31	8.00	3.01	0.95
89	4	2005.7	2.59	1.49	0.97	2.5	0.9	0.45	5.75	5.69	3.00	0.80
90	6	2006.2	2.71	2.00	0.73	2.4	1.0	0.43	6.19	5.01	3.36	0.79
91	6	2033.6	3.30	1.04	0.46	3.0	1.4	0.25	8.00	6.25	3.00	0.99
92	4	2763.3	4.50	2.69	0.57	4.3	1.5	0.22	12.25	8.00	5.36	1.42
93	6	3140.0	4.59	1.90	0.46	4.1	1.5	0.26	13.06	10.00	3.31	1.01
94	4	3270.2	5.17	1.09	0.74	2.9	1.4	0.41	8.36	6.01	4.69	1.02
95	7	15393.1	3.17	2.01	2.33	3.1	2.0	1.20	9.63	8.00	0.19	0.90
96	7	23413.5	4.50	3.77	1.79	4.2	3.4	0.04	13.63	9.01	0.63	0.99

SOURCE CODE

1 - BAR (1/4 X 1/4 X 1 1/4)
 2 - 1.00 IN. DIAMETER SPHERE
 3 - .75 IN. PER SIDE CUBE
 4 - 155MM M107 PROJECTILE

5 - 76MM MK 165 PROJECTILE
 6 - MK 84 LOW DRAG BOMB
 7 - MK 82 LOW DRAG BOMB

TABLE A-3. ICOSAHEDRON VS CALCULATED AREAS

FRAG NO.	MIN AREA		MAX AREA		AVG AREA		STD DEV		VARIANCE	
	ICOS	CALC	ICOS	CALC	ICOS	CALC	ICOS	CALC	ICOS	CALC
1	0.20	0.07	0.43	0.50	0.34	0.38	0.07	0.09	0.005	0.008
2	0.79	0.79	0.79	0.79	0.78	0.79	0.00	0.00	0.000	0.000
3	0.64	0.58	0.98	1.00	0.87	0.87	0.10	0.09	0.009	0.008
4	0.19	0.06	0.37	0.47	0.30	0.31	0.03	0.11	0.003	0.012
5	0.17	0.04	0.58	0.66	0.37	0.41	0.11	0.16	0.013	0.027
6	0.16	0.06	0.41	0.52	0.30	0.34	0.07	0.12	0.005	0.015
7	0.20	0.36	0.41	0.52	0.30	0.34	0.07	0.12	0.005	0.015
8	0.18	0.05	0.58	0.73	0.37	0.44	0.12	0.19	0.015	0.036
9	0.18	0.06	0.50	0.57	0.35	0.37	0.09	0.14	0.009	0.019
10	0.23	0.05	0.70	0.85	0.43	0.49	0.15	0.22	0.023	0.050
11	0.20	0.06	0.49	0.57	0.34	0.37	0.08	0.14	0.007	0.018
12	0.21	0.08	0.51	0.65	0.33	0.40	0.10	0.16	0.010	0.027
13	0.21	0.10	0.36	0.44	0.28	0.31	0.05	0.10	0.002	0.009
14	0.19	0.07	0.46	0.52	0.34	0.35	0.07	0.12	0.006	0.014
15	0.22	0.08	0.46	0.56	0.34	0.37	0.07	0.13	0.005	0.017
16	0.21	0.05	0.57	0.71	0.42	0.46	0.11	0.17	0.011	0.029
17	0.21	0.06	0.55	0.67	0.38	0.43	0.10	0.16	0.009	0.026
18	0.25	0.06	0.52	0.68	0.38	0.41	0.08	0.13	0.007	0.018
19	0.21	0.08	0.52	0.62	0.36	0.41	0.10	0.15	0.010	0.021
20	0.22	0.07	0.62	0.80	0.44	0.50	0.10	0.20	0.010	0.039
21	0.20	0.06	0.74	0.92	0.48	0.56	0.16	0.23	0.026	0.054
22	0.28	0.07	0.80	0.92	0.55	0.57	0.16	0.23	0.025	0.053
23	0.27	0.10	0.61	0.69	0.45	0.47	0.10	0.16	0.010	0.024
24	0.27	0.11	0.75	0.82	0.46	0.52	0.16	0.20	0.025	0.040
25	0.26	0.06	0.79	0.93	0.53	0.59	0.17	0.23	0.029	0.051
26	0.29	0.08	0.76	0.93	0.54	0.59	0.14	0.23	0.020	0.051
27	0.34	0.09	0.75	0.87	0.54	0.57	0.12	0.21	0.015	0.043
28	0.33	0.10	0.75	0.81	0.54	0.54	0.12	0.19	0.014	0.036
29	0.35	0.10	0.69	0.81	0.52	0.54	0.11	0.19	0.011	0.035
30	0.30	0.08	0.74	0.89	0.51	0.59	0.12	0.21	0.016	0.043
31	0.34	0.12	0.57	0.71	0.46	0.51	0.07	0.15	0.005	0.022
32	0.29	0.07	0.81	0.99	0.62	0.65	0.14	0.23	0.019	0.055
33	0.36	0.13	0.60	0.71	0.48	0.51	0.07	0.15	0.005	0.022
34	0.31	0.11	0.84	1.01	0.61	0.65	0.14	0.24	0.018	0.059
35	0.31	0.08	1.05	1.17	0.68	0.74	0.23	0.29	0.053	0.084
36	0.36	0.10	0.99	1.08	0.62	0.69	0.18	0.26	0.031	0.069
37	0.30	0.11	0.85	1.01	0.61	0.66	0.15	0.24	0.023	0.058
38	0.35	0.12	0.79	0.95	0.55	0.63	0.14	0.22	0.019	0.048
39	0.42	0.13	1.05	1.19	0.71	0.74	0.20	0.30	0.040	0.089
40	0.28	0.12	0.77	0.89	0.62	0.62	0.12	0.20	0.015	0.039
41	0.48	0.15	0.70	0.92	0.58	0.62	0.06	0.21	0.004	0.043
42	0.42	0.11	0.88	0.95	0.65	0.65	0.12	0.21	0.015	0.046
43	0.55	0.07	1.43	1.84	1.02	1.07	0.24	0.49	0.056	0.236
44	0.39	0.16	0.66	0.83	0.55	0.60	0.07	0.17	0.004	0.029
45	0.41	0.15	0.79	0.89	0.59	0.62	0.11	0.19	0.012	0.037
46	0.41	0.14	0.83	0.96	0.64	0.66	0.14	0.21	0.020	0.046
47	0.47	0.13	0.82	1.02	0.63	0.69	0.11	0.24	0.012	0.055
48	0.40	0.15	0.97	1.11	0.68	0.72	0.19	0.27	0.037	0.071
49	0.37	0.15	0.90	1.06	0.64	0.71	0.16	0.25	0.025	0.064
50	0.43	0.16	0.83	1.00	0.64	0.68	0.12	0.23	0.015	0.052

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TABLE A-3. ICOSAHEDRON VS CALCULATED AREAS (Continued)

FRAG NO.	MIN AREA		MAX AREA		AVG AREA		STD DEV		VARIANCE	
	ICOS	CALC	ICOS	CALC	ICOS	CALC	ICOS	CALC	ICOS	CALC
51	0.40	0.10	1.05	1.25	0.78	0.82	0.19	0.30	0.037	0.088
52	0.41	0.13	1.20	1.31	0.77	0.83	0.26	0.32	0.068	0.104
53	0.54	0.13	0.90	1.10	0.75	0.74	0.11	0.25	0.012	0.064
54	0.34	0.10	1.67	1.82	0.96	1.07	0.41	0.48	0.169	0.228
55	0.46	0.12	1.20	1.37	0.85	0.88	0.23	0.33	0.051	0.111
56	0.36	0.09	1.39	1.55	0.93	0.99	0.27	0.38	0.172	0.144
57	0.46	0.18	0.96	1.10	0.73	0.76	0.15	0.24	0.022	0.059
58	0.29	0.11	1.34	1.51	0.87	0.96	0.26	0.37	0.069	0.138
59	0.45	0.15	1.55	1.63	0.92	1.00	0.35	0.41	0.121	0.169
60	0.49	0.19	0.97	1.10	0.73	0.77	0.14	0.24	0.020	0.057
61	0.53	0.12	1.66	1.91	1.03	1.14	0.36	0.50	0.131	0.246
62	0.64	0.14	0.99	1.32	0.86	0.88	0.10	0.31	0.010	0.094
63	0.40	0.12	1.39	1.71	0.93	1.06	0.30	0.43	0.089	0.187
64	0.52	0.13	1.94	2.02	1.15	1.19	0.47	0.53	0.225	0.280
65	0.46	0.14	1.13	1.17	0.79	0.83	0.20	0.25	0.040	0.063
66	0.53	0.19	1.36	1.44	0.85	0.93	0.26	0.35	0.067	0.120
67	0.62	0.14	1.45	1.64	0.97	1.04	0.25	0.40	0.064	0.164
68	0.59	0.17	1.14	1.34	0.86	0.90	0.20	0.31	0.039	0.094
69	0.57	0.15	1.28	1.57	0.92	1.01	0.21	0.38	0.044	0.143
70	0.43	0.19	0.91	1.14	0.75	0.82	0.13	0.24	0.018	0.055
71	0.51	0.13	1.88	2.10	1.15	1.27	0.42	0.54	0.174	0.290
72	0.61	0.16	2.09	2.34	1.26	1.39	0.49	0.61	0.242	0.370
73	0.52	0.21	1.69	1.80	1.06	1.14	0.36	0.44	0.127	0.196
74	0.64	0.18	1.44	1.59	1.01	1.06	0.24	0.37	0.059	0.136
75	0.51	0.16	1.65	1.74	1.10	1.13	0.31	0.42	0.097	0.173
76	0.47	0.20	2.00	1.85	1.14	1.18	0.44	0.45	0.196	0.202
77	0.48	0.14	1.76	2.13	1.17	1.34	0.38	0.53	0.147	0.281
78	0.84	0.14	1.86	2.04	1.29	1.33	0.30	0.49	0.088	0.238
79	0.68	0.17	2.07	2.34	1.30	1.43	0.42	0.59	0.175	0.352
80	0.67	0.14	1.70	2.05	1.24	1.33	0.30	0.49	0.090	0.238
81	0.60	0.17	1.61	1.99	1.20	1.29	0.26	0.48	0.067	0.227
82	0.69	0.26	1.55	1.82	1.08	1.19	0.28	0.43	0.078	0.184
83	0.61	0.27	1.98	2.28	1.27	1.40	0.46	0.57	0.216	0.329
84	0.68	0.15	2.20	2.75	1.41	1.67	0.46	0.70	0.210	0.494
85		0.31		3.08		2.01		0.73		0.535
86		0.26		4.03		2.46		1.03		1.053
87		0.28		4.04		2.50		1.02		1.034
88		0.26		4.64		2.83		1.18		1.400
89		0.41		2.55		1.90		0.50		0.245
90		0.43		2.64		1.93		0.54		0.286
91		0.35		4.28		2.64		1.08		1.161
92		0.33		6.53		3.86		1.71		2.908
93		0.39		6.25		3.81		1.60		2.549
94		0.58		4.27		2.92		0.96		0.925
95		2.57		7.60		6.37		1.11		1.232
96		2.84		14.98		10.32		3.33		11.078

EXPLANATION OF COLUMN HEADINGS

MIN AREA - MINIMUM PRESENTED AREA (SQ. IN.)
 MAX AREA - MAXIMUM PRESENTED AREA (SQ. IN.)
 AVG AREA - AVERAGE PRESENTED AREA (SQ. IN.)
 STD DEV - STANDARD DEVIATION OF PRESENTED AREA (SQ. IN.)
 VARIANCE - VARIANCE OF PRESENTED AREA (IN. 4TH)
 ICOS - AREAS CALCULATED FROM ICOSAHEDRON GAGE DATA
 CALC - AREAS CALCULATED FROM APPROXIMATING RECTANGULAR PARALLELEPIPEDS

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TABLE A-4. PRESENTED AREA RATIOS

FRAO NEW	NO. OLD	CD	MAX / MIN		MAX / AVG		AVG / MIN	
			ICOS	CALC	ICOS	CALC	ICOS	CALC
1	2	0.42	1.00	1.00	1.00	1.00	1.00	1.00
2	95	0.50		3.04		1.22		2.48
3	3	0.64	1.54	1.73	1.13	1.15	1.36	1.50
4	70	0.71	2.10	5.99	1.22	1.39	1.73	4.32
5	44	0.72	1.69	5.05	1.20	1.39	1.41	3.63
6	62	0.73	1.56	9.49	1.16	1.50	1.34	6.33
7	53	0.76	1.65	8.16	1.20	1.49	1.38	5.48
8	41	0.76	1.44	5.94	1.20	1.47	1.19	4.03
9	11	0.76	2.42	9.53	1.45	1.53	1.67	6.21
10	57	0.78	2.10	6.05	1.31	1.45	1.60	4.18
11	35	0.79	3.36	14.41	1.55	1.58	2.17	9.09
12	90	0.79		6.20		1.37		4.51
13	45	0.80	1.95	5.91	1.34	1.43	1.46	4.14
14	89	0.80		6.24		1.35		4.64
15	82	0.81	2.27	7.00	1.43	1.52	1.58	4.66
16	40	0.82	2.77	7.52	1.23	1.44	2.26	5.21
17	13	0.83	1.72	4.67	1.26	1.42	1.37	3.29
18	46	0.83	2.03	6.81	1.29	1.46	1.57	4.67
19	18	0.83	2.11	10.35	1.37	1.46	1.54	7.09
20	73	0.84	3.24	8.60	1.59	1.58	2.03	5.44
21	76	0.84	4.20	9.13	1.75	1.56	2.44	5.85
22	63	0.86	3.50	14.36	1.51	1.62	2.33	8.06
23	33	0.86	1.66	5.49	1.24	1.39	1.33	3.96
24	74	0.86	2.27	9.01	1.43	1.50	1.59	6.00
25	39	0.86	2.50	9.37	1.47	1.61	1.70	5.82
26	65	0.86	2.49	8.18	1.42	1.42	1.75	5.77
27	47	0.87	1.76	7.81	1.30	1.49	1.35	5.24
28	69	0.87	2.27	10.50	1.39	1.55	1.63	6.70
29	55	0.88	2.63	11.81	1.42	1.56	1.86	7.58
30	64	0.88	3.76	15.99	1.69	1.70	2.22	9.42
31	12	0.88	2.38	7.92	1.52	1.62	1.56	4.90
32	27	0.89	2.20	9.87	1.37	1.53	1.60	6.44
33	83	0.89	3.25	8.56	1.56	1.62	2.00	5.20
34	78	0.90	2.21	14.62	1.43	1.54	1.54	9.51
35	32	0.90	2.81	13.35	1.31	1.52	2.15	8.78
36	60	0.90	1.99	5.00	1.32	1.43	1.50	4.05
37	4	0.91	1.90	7.46	1.23	1.50	1.54	4.99
38	67	0.92	2.33	12.10	1.50	1.58	1.56	7.65
39	68	0.92	1.94	7.66	1.33	1.48	1.47	5.16
40	85	0.93		10.07		1.53		6.59
41	72	0.93	3.41	14.75	1.66	1.69	2.05	6.75
42	9	0.93	2.71	10.05	1.41	1.55	1.93	6.48
43	1	0.94	2.19	6.92	1.29	1.30	1.70	5.33
44	17	0.94	2.63	11.01	1.45	1.55	1.82	7.13
45	88	0.95		17.53		1.64		10.69
46	43	0.95	2.59	26.57	1.41	1.71	1.84	15.50
47	16	0.95	2.75	15.71	1.35	1.54	2.04	10.17
48	80	0.96	2.52	14.44	1.37	1.53	1.84	9.42
49	31	0.96	1.66	5.69	1.23	1.40	1.35	4.06
50	29	0.96	1.97	8.34	1.33	1.49	1.48	5.58

TABLE A-4. PRESENTED AREA RATIOS (Continued)

FRAG NO.		CD	MAX / MIN		MAX / AVG		AVG / MIN	
NEW	OLD		ICOS	CALC	ICOS	CALC	ICOS	CALC
51	37	0.96	2.84	8.97	1.41	1.54	2.02	5.85
52	61	0.96	3.16	16.18	1.61	1.68	1.96	9.66
53	14	0.96	2.41	7.71	1.34	1.49	1.79	5.19
54	10	0.97	3.04	16.34	1.61	1.73	1.89	9.47
55	87	0.98		14.53		1.62		8.99
56	71	0.98	3.71	15.58	1.63	1.65	2.28	9.45
57	15	0.98	2.06	7.26	1.34	1.52	1.54	4.76
58	38	0.98	2.26	7.70	1.43	1.50	1.57	5.13
59	42	0.98	2.08	8.33	1.36	1.46	1.53	5.69
60	75	0.99	3.24	10.72	1.50	1.53	2.17	6.98
61	96	0.99		5.27		1.45		3.63
62	91	0.99		12.36		1.62		7.64
63	81	0.99	2.67	11.97	1.34	1.54	2.00	7.77
64	84	1.00	1.23	18.65	1.57	1.65	2.06	11.33
65	93	1.01		15.97		1.64		9.72
66	94	1.02		7.41		1.46		5.06
67	23	1.02	2.25	6.98	1.35	1.47	1.67	4.74
68	59	1.03	3.43	10.55	1.68	1.63	2.04	6.49
69	56	1.03	3.87	16.68	1.48	1.57	2.61	10.64
70	48	1.04	2.45	7.25	1.44	1.54	1.70	4.69
71	51	1.05	2.62	12.55	1.35	1.53	1.95	8.19
72	7	1.05	2.09	8.80	1.36	1.53	1.54	5.75
73	6	1.06	2.62	8.94	1.39	1.53	1.89	5.83
74	66	1.06	2.56	7.59	1.61	1.55	1.59	4.90
75	50	1.11	1.95	6.18	1.31	1.47	1.49	4.21
76	54	1.11	4.94	17.51	1.74	1.70	2.84	10.33
77	58	1.12	4.65	13.40	1.54	1.57	3.03	8.51
78	49	1.14	2.42	7.41	1.41	1.51	1.72	4.89
79	36	1.16	2.73	10.40	1.60	1.57	1.70	6.64
80	52	1.16	2.95	10.45	1.57	1.58	1.88	6.60
81	22	1.18	2.86	13.27	1.47	1.61	1.95	8.24
82	5	1.19	3.37	18.34	1.55	1.60	2.17	11.44
83	26	1.19	2.60	11.38	1.41	1.56	1.84	7.28
84	19	1.21	2.43	7.55	1.45	1.52	1.68	4.98
85	86	1.24		15.79		1.64		9.63
86	30	1.24	2.49	11.65	1.43	1.50	1.74	7.75
87	77	1.29	3.64	15.13	1.51	1.59	2.42	9.50
88	34	1.29	2.69	9.50	1.38	1.55	1.94	6.12
89	20	1.29	2.77	11.41	1.41	1.59	1.97	7.16
90	35	1.30	3.05	11.51	1.50	1.57	2.04	7.35
91	79	1.31	3.04	13.58	1.60	1.63	1.90	8.32
92	28	1.33	2.26	8.46	1.40	1.50	1.61	5.64
93	8	1.34	3.17	14.32	1.55	1.67	2.05	8.57
94	21	1.38	3.72	14.29	1.56	1.63	2.38	8.77
95	92	1.42		19.91		1.69		11.77
96	24	1.48	2.81	7.48	1.61	1.57	1.74	4.78

ICOS - PRESENTED AREA RATIOS CALCULATED FROM ICOSAHEDRON GAGE DATA

CALC - PRESENTED AREA RATIOS CALCULATED FROM APPROXIMATING RECTANGULAR PARALLELE PIPEDS

TABLE A-5. LINEAR AND STATISTICAL RATIOS

FRAG NO.	CD	L/T	W/T	L' / T'	W' / T'	SD / AAVG	VAR / AAVG+2
NEW OLD		(SPHERE)				ICOS CALC	ICOS CALC
1 2	0.42						
2 95	0.50	2.42	1.56	1.74	1.33	0.17	0.03
3 3	0.64	1.00	1.00	1.00	1.00	0.11	0.01
4 70	0.71	5.50	2.57	3.43	1.46	0.18	0.03
5 44	0.72	4.69	2.98	2.33	1.56	0.12	0.01
6 62	0.73	9.08	3.53	4.61	2.03	0.11	0.01
7 53	0.76	7.81	3.65	4.38	2.04	0.15	0.02
8 41	0.76	5.69	4.14	2.24	1.90	0.11	0.01
9 11	0.76	9.22	4.19	5.50	3.11	0.25	0.06
10 57	0.78	5.74	3.53	4.11	2.53	0.20	0.04
11 35	0.79	14.02	4.43	8.36	2.81	0.34	0.12
12 90	0.79	5.63	2.34	4.42	2.66	0.28	0.08
13 45	0.80	5.57	3.25	3.55	2.31	0.18	0.03
14 89	0.80	5.50	1.98	3.57	1.68	0.26	0.07
15 82	0.81	6.86	4.71	4.03	3.16	0.26	0.07
16 40	0.82	7.08	3.03	3.86	1.80	0.20	0.04
17 13	0.83	4.41	3.78	2.55	2.34	0.16	0.03
18 46	0.83	6.48	3.49	3.73	2.59	0.22	0.05
19 18	0.83	9.69	2.77	5.70	2.29	0.21	0.05
20 73	0.84	8.42	5.79	5.06	3.92	0.34	0.11
21 76	0.84	8.90	4.94	5.58	3.19	0.39	0.15
22 63	0.86	14.09	5.37	7.85	3.38	0.32	0.10
23 33	0.86	5.08	2.77	3.40	2.50	0.15	0.02
24 74	0.86	8.63	3.63	4.24	2.23	0.24	0.06
25 39	0.86	9.20	6.37	5.43	4.05	0.28	0.08
26 65	0.86	7.55	2.52	5.43	2.33	0.25	0.06
27 47	0.87	7.49	3.74	3.49	1.86	0.17	0.03
28 69	0.87	10.18	4.29	6.38	3.08	0.23	0.05
29 55	0.88	11.45	4.22	6.71	2.47	0.27	0.07
30 64	0.88	15.84	7.92	6.32	4.14	0.41	0.17
31 12	0.88	7.79	7.79	4.55	4.15	0.30	0.09
32 27	0.89	9.54	4.09	5.10	2.48	0.23	0.03
33 83	0.89	8.43	7.37	5.70	5.07	0.37	0.13
34 78	0.90	14.02	3.51	7.74	2.55	0.23	0.05
35 32	0.90	12.75	3.36	6.19	2.09	0.22	0.05
36 60	0.90	5.47	3.37	3.35	2.04	0.19	0.04
37 4	0.91	7.17	3.98	2.97	1.79	0.17	0.03
38 67	0.92	11.79	4.72	7.23	3.27	0.26	0.07
39 68	0.92	7.33	3.66	5.01	2.82	0.23	0.05
40 85	0.93	9.72	3.96	7.08	2.83	0.36	0.13
41 72	0.93	14.59	7.64	9.66	5.41	0.39	0.15
42 9	0.93	9.76	4.44	5.81	2.68	0.27	0.07
43 1	0.94	5.17	1.15	5.16	1.15	0.21	0.04
44 17	0.94	10.65	4.10	5.84	2.56	0.26	0.07
45 88	0.95	17.21	5.44	10.86	4.31	0.42	0.17
46 43	0.95	26.29	7.08	18.38	5.33	0.23	0.05
47 16	0.95	15.10	3.55	8.76	2.42	0.25	0.06
48 80	0.96	13.84	3.46	8.05	2.22	0.24	0.06
49 31	0.96	5.29	2.89	3.17	2.18	0.15	0.02
50 29	0.96	7.99	3.69	4.94	2.47	0.20	0.04

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TABLE A-5. LINEAR AND STATISTICAL RATIOS (Continued)

FRAG NO.	NO.						SD /	AAVG	VAR /	AAVG+2
NEW	OLD	CD	L/T	W/T	L' / T'	W' / T'	ICDS	CALC	ICDS	CALC
51	37	0.96	8.69	4.35	5.61	2.86	0.25	0.37	0.06	0.20
52	61	0.96	15.98	6.85	9.11	3.89	0.35	0.43	0.12	0.17
53	14	0.96	7.37	3.69	4.30	2.68	0.22	0.34	0.05	0.33
54	10	0.97	16.22	9.46	9.12	4.83	0.35	0.46	0.12	0.43
55	87	0.98	14.23	5.18	7.66	3.64		0.41		0.17
56	71	0.98	15.34	6.00	9.74	3.72	0.36	0.42	0.13	0.14
57	15	0.98	7.03	4.69	4.29	3.04	0.21	0.36	0.05	0.35
58	38	0.98	7.41	3.99	5.11	2.81	0.25	0.35	0.06	0.19
59	42	0.98	7.88	3.15	5.98	2.33	0.19	0.33	0.04	0.17
60	75	0.99	10.34	3.94	6.86	2.91	0.28	0.37	0.08	0.12
61	96	0.99	5.02	4.06	3.34	2.73		0.32		0.10
62	91	0.99	12.13	5.66	8.91	4.58		0.41		0.17
63	81	0.99	11.55	3.85	7.57	2.77	0.22	0.37	0.05	0.11
64	84	1.00	18.33	5.50	10.09	3.32	0.33	0.42	0.11	0.11
65	93	1.01	15.70	5.74	12.05	4.83		0.42		0.18
66	94	1.02	7.04	3.40	5.27	2.86		0.33		0.11
67	23	1.02	6.66	3.63	4.46	2.44	0.22	0.33	0.05	0.24
68	59	1.03	10.38	6.49	6.57	4.88	0.38	0.41	0.14	0.17
69	56	1.03	16.12	3.87	10.00	2.59	0.29	0.38	0.08	0.15
70	48	1.04	7.05	5.29	4.09	3.38	0.28	0.37	0.08	0.19
71	51	1.05	12.06	3.62	6.30	1.83	0.24	0.36	0.06	0.16
72	7	1.05	8.51	4.25	5.19	2.84	0.23	0.36	0.05	0.39
73	6	1.06	8.66	4.33	5.53	3.23	0.24	0.37	0.06	0.40
74	66	1.06	7.39	5.28	5.21	3.80	0.30	0.37	0.09	0.15
75	50	1.11	5.91	3.94	2.82	2.18	0.19	0.33	0.04	0.16
76	54	1.11	17.44	7.85	10.63	5.36	0.43	0.45	0.18	0.19
77	58	1.12	13.02	4.34	6.06	2.47	0.30	0.39	0.09	0.16
78	49	1.14	7.16	4.40	4.25	2.70	0.25	0.36	0.06	0.18
79	36	1.16	10.13	4.73	6.26	2.95	0.29	0.38	0.08	0.21
80	52	1.16	10.21	5.10	5.86	3.36	0.34	0.39	0.12	0.18
81	22	1.18	12.99	5.20	8.04	3.01	0.29	0.40	0.08	0.28
82	5	1.19	17.87	4.47	11.12	2.94	0.31	0.40	0.10	0.39
83	26	1.19	11.05	4.42	5.46	2.55	0.26	0.38	0.07	0.24
84	19	1.21	7.30	4.38	4.99	3.38	0.28	0.36	0.08	0.31
85	86	1.24	15.52	5.64	10.07	4.75		0.42		0.17
86	30	1.24	11.10	3.27	6.84	2.52	0.24	0.35	0.06	0.21
87	77	1.29	14.74	4.54	9.36	3.11	0.33	0.40	0.11	0.12
88	34	1.29	9.24	4.62	4.69	2.69	0.22	0.38	0.05	0.22
89	20	1.29	11.15	5.15	5.61	2.92	0.23	0.40	0.05	0.31
90	25	1.30	11.19	4.48	7.10	3.33	0.32	0.38	0.10	0.25
91	79	1.31	13.35	5.80	7.76	3.65	0.32	0.41	0.10	0.12
92	28	1.33	8.12	3.75	4.19	2.16	0.22	0.35	0.05	0.22
93	8	1.34	14.15	7.07	8.45	4.78	0.33	0.43	0.11	0.43
94	21	1.38	14.04	5.61	8.49	3.56	0.34	0.41	0.12	0.30
95	92	1.42	19.67	6.86	11.16	5.31		0.44		0.20
96	24	1.48	7.31	5.85	5.22	4.28	0.34	0.38	0.12	0.28

HEADINGS

L - AVERAGE LENGTH W - AVERAGE WIDTH T - AVERAGE THICKNESS

L' = MAXIMUM LENGTH PLUS AVERAGE LENGTH

W' = MAXIMUM WIDTH PLUS AVERAGE WIDTH

T' = MAXIMUM THICKNESS PLUS AVERAGE THICKNESS

SD - STANDARD DEVIATION OF PRESENTED AREAS (SQ. IN.)

VAR - VARIANCE OF PRESENTED AREAS (IN. 4TH)

AAVG+2 - AVERAGE PRESENTED AREA SQUARED (IN. 4TH)

ICDS - AREAS CALCULATED FROM ICOSAHEDRON GAGE DATA

CALC - AREAS CALCULATED FROM APPROXIMATING RECTANGULAR PARALLELEPIPEDS

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TABLE A-6. PERIMETER RATIOS

FRAG NO.	NEW	OLD	CD	LWP/LTP	LWP/TWP	LTP/TWP	LWP/LMAX	TWP/WMAX
1	2		0.42	1.00	1.00	1.00	3.14	3.14
2	95		0.50	1.08	1.18	1.08	3.04	2.91
3	3		0.64	1.00	1.00	1.00	4.03	4.03
4	70		0.71	1.01	2.03	2.00	2.42	3.03
5	44		0.72	1.08	1.47	1.36	2.83	2.74
6	62		0.73	1.25	1.98	1.58	3.04	3.12
7	53		0.76	1.12	2.14	1.91	2.81	2.84
8	41		0.76	1.05	1.07	1.02	2.57	2.47
9	11		0.76	1.22	1.87	1.54	2.70	2.11
10	57		0.78	1.07	1.70	1.59	2.33	2.22
11	35		0.79	1.10	2.42	2.21	2.29	2.66
12	90		0.79	1.07	1.74	1.63	2.28	1.71
13	45		0.80	1.10	1.50	1.36	2.52	2.37
14	89		0.80	1.01	1.48	1.47	2.22	2.60
15	82		0.81	1.37	1.42	1.03	2.90	2.31
16	40		0.82	1.00	1.90	1.90	2.21	2.32
17	13		0.83	1.16	1.19	1.03	2.78	2.43
18	46		0.83	1.25	1.69	1.36	2.82	1.97
19	18		0.83	1.11	1.69	1.52	2.25	2.55
20	73		0.84	1.36	1.68	1.23	3.11	2.15
21	76		0.84	1.17	1.69	1.44	2.39	2.42
22	63		0.86	1.09	2.57	2.35	2.41	1.96
23	33		0.86	1.18	1.35	1.15	2.40	1.95
24	74		0.86	1.16	1.54	1.33	2.53	2.59
25	39		0.86	1.62	1.70	1.04	3.21	2.38
26	65		0.86	1.18	2.29	1.93	2.58	2.13
27	47		0.87	1.24	1.60	1.35	2.68	2.82
28	69		0.87	1.14	2.25	1.97	2.57	2.10
29	55		0.88	1.11	2.89	2.59	2.40	2.25
30	64		0.88	1.67	1.96	1.17	3.26	2.04
31	12		0.88	1.38	1.57	1.14	2.93	2.22
32	27		0.89	1.11	2.34	2.11	2.47	1.96
33	83		0.89	1.54	1.63	1.05	3.23	2.20
34	78		0.90	1.21	2.58	2.13	2.61	2.48
35	32		0.90	1.03	2.09	2.03	2.17	2.52
36	60		0.90	1.06	1.53	1.45	2.36	2.56
37	4		0.91	1.09	1.36	1.25	2.56	2.92
38	67		0.92	1.29	2.34	1.81	2.62	2.25
39	68		0.92	1.04	1.06	1.02	2.27	3.44
40	85		0.93	1.16	2.78	2.40	2.42	2.21
41	72		0.93	1.31	2.05	1.57	2.57	2.12
42	9		0.93	1.14	2.04	1.79	2.47	2.59
43	1		0.94	1.02	2.88	2.82	2.52	3.92
44	17		0.94	1.14	2.00	1.75	2.34	2.38
45	88		0.95	1.16	2.44	2.10	2.37	2.05
46	43		0.95	1.16	3.74	3.22	2.68	2.31
47	16		0.95	1.05	2.46	2.33	2.12	2.73
48	80		0.96	1.09	3.03	2.77	2.33	2.55
49	31		0.96	1.10	1.31	1.18	2.56	2.34
50	29		0.96	1.04	1.96	1.88	2.31	2.20

TABLE A-6. PERIMETER RATIOS (Continued)

FRAG NO.	CD	LWP/LTP	LWP/TWP	LTP/TWP	LWP/LMAX	TWP/WMAX
NEW OLD						
51 37	0.96	1.13	1.99	1.76	2.37	2.29
52 61	0.96	1.12	2.46	2.19	2.30	2.20
53 14	0.96	1.25	1.48	1.19	2.88	2.59
54 10	0.97	1.45	2.29	1.59	2.32	2.08
55 87	0.98	1.35	2.41	1.78	2.52	1.80
56 71	0.98	1.15	2.85	2.46	2.36	2.22
57 15	0.98	1.16	1.63	1.41	2.70	2.22
58 38	0.98	1.08	1.90	1.76	2.23	2.10
59 42	0.98	1.08	2.43	2.25	2.46	2.65
60 75	0.99	1.10	2.07	1.88	2.41	2.51
61 96	0.99	1.39	1.58	1.14	2.98	2.29
62 91	0.99	1.42	2.29	1.61	2.69	2.11
63 81	0.99	1.00	2.64	2.64	2.32	2.20
64 84	1.00	1.36	3.41	2.52	2.64	2.16
65 93	1.01	1.31	3.95	3.02	2.85	1.67
66 94	1.02	1.26	1.83	1.45	2.70	2.48
67 23	1.02	1.14	1.66	1.46	2.35	2.58
68 59	1.03	1.54	1.64	1.06	3.04	2.16
69 56	1.03	1.03	3.25	3.14	2.14	2.38
70 48	1.04	1.39	1.42	1.02	2.90	2.28
71 51	1.05	1.03	2.89	2.81	2.16	2.64
72 7	1.05	1.20	1.79	1.50	2.66	2.50
73 6	1.06	1.20	1.71	1.42	2.51	2.21
74 66	1.06	1.47	1.60	1.09	2.78	2.34
75 50	1.11	1.26	1.44	1.15	3.29	2.59
76 54	1.11	1.22	2.10	1.72	2.51	2.16
77 58	1.12	1.13	2.14	1.89	2.37	2.30
78 49	1.14	1.35	1.88	1.40	2.98	2.42
79 36	1.16	1.09	2.14	1.97	2.23	2.19
80 52	1.16	1.34	1.92	1.43	2.67	2.16
81 22	1.18	1.00	2.78	2.78	2.17	2.22
82 5	1.19	1.04	2.90	2.80	2.10	2.68
83 26	1.19	1.27	2.22	1.75	2.62	2.22
84 19	1.21	1.32	1.66	1.26	2.87	2.28
85 86	1.24	1.31	2.10	1.61	2.61	2.15
86 30	1.24	1.09	2.25	2.07	2.26	2.27
87 77	1.29	1.19	2.74	2.31	2.30	2.35
88 34	1.29	1.19	1.91	1.61	2.64	2.31
89 20	1.29	1.20	1.87	1.55	2.36	2.21
90 25	1.30	1.24	1.84	1.48	2.36	2.40
91 79	1.31	1.41	2.65	1.88	2.82	2.12
92 28	1.33	1.06	1.70	1.61	2.54	2.64
93 8	1.34	1.18	1.86	1.57	2.52	2.16
94 21	1.38	1.11	2.30	2.07	2.21	2.20
95 92	1.42	1.38	2.20	1.60	2.72	2.07
96 24	1.48	1.34	1.64	1.23	2.98	2.16

HEADINGS

LWP - PERIMETER IN LW PLANE (IN.)

LTP - PERIMETER IN LT PLANE (IN.)

TWP - PERIMETER IN TW PLANE (IN.)

LMAX - MAXIMUM LENGTH (IN.)

WMAX - MAXIMUM WIDTH (IN.)

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TABLE A-7. MOMENT OF INERTIA RATIOS

FRAG NO.	NO.	WEIGHT		----- GRAINS-IN+2 -----							IT+2/
NEW	OLD	GRAINS	CD	IT	IW	IL	IT/IW	IT/IL	IW/IL	IL+IW	
1	2	1030.4	0.42								
2	95	15595.1	0.50	17687.4	14618.3	7327.6	1.21	2.41	1.99	2.92	
3	3	835.0	0.64								
4	70	561.2	0.71	128.1	108.6	26.3	1.18	4.87	4.13	5.74	
5	44	354.0	0.72	50.2	37.3	16.0	1.35	3.13	2.33	4.22	
6	62	489.3	0.73	152.1	133.7	21.6	1.14	7.04	6.19	8.00	
7	53	395.1	0.76	90.2	75.3	17.3	1.20	5.21	4.35	6.24	
8	41	333.2	0.76	51.4	34.6	18.8	1.48	2.74	1.84	4.06	
9	11	128.6	0.76	15.6	13.1	2.8	1.19	5.52	4.63	6.58	
10	57	461.7	0.78	89.6	67.1	26.7	1.34	3.36	2.52	4.50	
11	35	302.8	0.79	100.2	91.6	9.6	1.09	10.46	9.56	11.44	
12	90	2006.2	0.79	1130.2	993.9	198.1	1.14	5.71	5.02	6.49	
13	45	354.9	0.80	57.1	44.0	15.9	1.30	3.58	2.76	4.65	
14	89	2005.7	0.80	1180.0	1078.5	169.2	1.09	6.97	6.37	7.63	
15	82	804.8	0.81	252.8	175.2	84.7	1.44	2.99	2.07	4.31	
16	40	325.7	0.82	63.0	54.3	10.9	1.16	5.80	5.00	6.73	
17	13	130.8	0.83	9.3	5.6	4.2	1.65	2.20	1.34	3.63	
18	46	357.9	0.83	65.0	51.6	15.8	1.26	4.11	3.26	5.18	
19	18	158.6	0.83	28.0	26.2	2.4	1.07	11.80	11.02	12.64	
20	73	655.4	0.84	205.9	141.8	68.1	1.45	3.03	2.08	4.39	
21	76	713.9	0.84	252.2	195.1	61.9	1.29	4.08	3.15	5.27	
22	63	490.9	0.86	206.6	181.3	27.1	1.14	7.62	6.69	8.68	
23	33	280.2	0.86	36.7	29.4	9.5	1.25	3.84	3.08	4.80	
24	74	656.0	0.86	232.3	200.0	37.6	1.16	6.17	5.31	7.17	
25	39	323.9	0.86	67.5	46.1	22.4	1.46	3.01	2.06	4.41	
26	65	505.0	0.86	151.5	138.8	17.6	1.09	8.62	7.90	9.41	
27	47	359.2	0.87	73.3	59.7	15.7	1.23	4.66	3.79	5.72	
28	69	556.2	0.87	197.0	169.0	31.3	1.17	6.29	5.39	7.33	
29	55	432.7	0.88	147.8	131.2	18.7	1.13	7.90	7.01	8.90	
30	64	495.1	0.88	206.3	165.7	42.0	1.24	4.92	3.95	6.12	
31	12	128.8	0.88	13.7	7.0	7.0	1.97	1.97	1.00	3.88	
32	27	241.6	0.89	46.7	39.9	7.7	1.17	6.07	5.18	7.10	
33	83	833.7	0.89	314.0	180.4	138.7	1.74	2.26	1.30	3.94	
34	78	767.0	0.90	532.4	503.7	33.9	1.06	15.72	14.87	16.61	
35	32	277.4	0.90	89.2	84.0	6.3	1.06	14.17	13.33	15.05	
36	60	484.1	0.90	94.0	70.5	28.1	1.33	3.34	2.51	4.45	
37	4	110.7	0.91	9.8	7.6	2.5	1.28	3.97	3.10	5.09	
38	67	531.9	0.92	205.7	178.6	25.6	1.15	6.94	6.02	7.93	
39	68	547.9	0.92	146.1	119.1	31.4	1.23	4.65	3.79	5.70	
40	85	1617.7	0.93	1145.9	993.3	173.7	1.15	6.60	5.72	7.61	
41	72	651.7	0.93	305.2	243.6	66.8	1.27	4.57	3.60	5.80	
42	9	121.5	0.93	14.8	12.4	2.7	1.19	5.57	4.66	6.65	
43	1	159.3	0.94	23.6	23.3	2.0	1.02	11.67	11.49	11.86	
44	17	155.5	0.94	25.1	22.1	3.4	1.14	7.34	6.45	8.35	
45	88	1973.2	0.95	2611.2	2382.4	244.7	1.10	10.67	9.73	11.69	...
46	43	352.8	0.95	213.1	199.0	14.7	1.07	14.50	13.54	15.53	
47	16	150.1	0.95	38.2	36.3	2.2	1.05	17.72	16.86	18.63	
48	80	777.0	0.96	539.4	510.2	34.3	1.06	15.72	14.87	16.61	
49	31	268.9	0.96	35.2	28.1	9.1	1.25	3.89	3.10	4.86	
50	29	248.7	0.96	42.5	35.6	8.0	1.19	5.32	4.45	6.35	

TABLE A-7. MOMENT OF INERTIA RATIOS (Continued)

FRAG NO.		WEIGHT		----- GRAINS-IN+2 -----			IT+2/				
NEW	OLD	GRAINS	CD	IT	IW	IL	IT/IW	IT/IL	IW/IL	IL*IW	
51	37	309.4	0.96	63.2	51.2	13.3	1.23	4.75	3.85	5.86	
52	61	486.7	0.96	211.7	179.5	33.5	1.16	6.31	5.35	7.44	
53	14	132.9	0.96	13.8	11.3	3.0	1.23	4.64	3.78	5.68	
54	10	121.8	0.97	19.6	14.7	5.0	1.34	3.90	2.92	5.21	
55	87	1799.4	0.98	1848.9	1640.9	223.9	1.13	8.26	7.33	9.31	
56	71	608.4	0.98	309.3	269.3	42.2	1.15	7.33	6.38	8.41	
57	15	135.5	0.98	13.2	9.3	4.3	1.41	3.10	2.19	4.39	
58	38	313.1	0.98	56.9	44.9	13.6	1.27	4.17	3.30	5.28	
59	42	335.0	0.98	73.0	64.0	11.1	1.14	6.59	5.77	7.52	
60	75	668.5	0.99	281.3	247.9	37.9	1.13	7.43	6.54	8.43	
61	96	23413.5	0.99	56972.9	35794.6	23931.7	1.59	2.38	1.50	3.79	
62	91	2035.6	0.99	1859.2	1537.3	343.1	1.21	5.42	4.48	6.55	
63	81	782.2	0.99	417.2	376.3	44.6	1.10	9.36	8.48	10.32	
64	84	866.3	1.00	708.2	651.6	60.3	1.09	11.74	10.80	12.76	
65	93	3148.0	1.01	5000.1	4427.6	608.0	1.13	8.22	7.28	9.29	
66	94	3278.2	1.02	2832.9	2343.4	581.4	1.21	4.87	4.03	5.89	
67	23	213.8	1.02	28.0	22.1	6.9	1.27	4.04	3.19	5.12	
68	59	483.2	1.03	143.3	104.0	41.2	1.38	3.48	2.53	4.60	
69	56	455.9	1.03	251.1	238.4	14.6	1.05	17.14	16.27	18.06	
70	48	360.2	1.04	67.5	44.1	25.2	1.53	2.68	1.75	4.11	
71	51	390.2	1.05	141.8	131.0	12.6	1.08	11.21	10.36	12.13	
72	7	115.2	1.05	12.0	9.7	2.5	1.23	4.73	3.84	5.83	
73	6	113.2	1.06	11.8	9.6	2.5	1.23	4.73	3.84	5.83	
74	66	519.6	1.06	128.2	86.4	44.9	1.48	2.86	1.93	4.24	
75	50	381.8	1.11	66.2	47.1	21.6	1.41	3.06	2.18	4.30	
76	54	404.6	1.11	162.2	135.3	27.7	1.20	5.85	4.88	7.01	
77	58	464.8	1.12	189.8	171.8	20.0	1.10	9.58	8.60	10.58	
78	49	370.3	1.14	71.9	53.2	20.7	1.35	3.47	2.56	4.69	
79	36	304.8	1.16	69.6	57.7	13.0	1.21	5.35	4.43	6.45	
80	52	393.3	1.16	104.9	84.7	21.8	1.24	4.81	3.88	5.95	
81	22	203.7	1.18	44.3	38.4	6.4	1.15	6.97	6.05	8.04	
82	5	112.3	1.19	25.5	24.0	1.6	1.06	16.18	15.28	17.14	
83	26	239.4	1.19	52.1	45.3	7.6	1.15	6.88	5.98	7.91	
84	19	161.1	1.21	18.3	13.7	5.1	1.33	3.58	2.69	4.78	
85	86	1650.8	1.24	1696.2	1504.2	204.2	1.13	8.31	7.37	9.37	
86	30	255.1	1.24	66.8	61.9	5.8	1.08	11.52	10.69	12.42	
87	77	719.1	1.29	443.4	407.0	40.3	1.09	11.01	10.10	11.99	
88	34	291.1	1.29	59.4	48.1	12.4	1.24	4.78	3.87	5.91	
89	20	178.2	1.29	30.4	25.3	5.6	1.20	5.48	4.55	6.59	
90	25	236.4	1.30	51.4	44.7	7.4	1.15	6.92	6.01	7.97	
91	79	776.7	1.31	407.1	344.3	66.6	1.18	6.11	5.17	7.23	
92	28	244.8	1.33	41.8	35.0	7.9	1.19	5.32	4.45	6.35	
93	8	119.7	1.34	18.0	14.4	3.7	1.24	4.91	3.95	6.11	
94	21	188.5	1.38	41.0	35.5	5.8	1.15	7.01	6.08	8.09	
95	92	2763.3	1.42	4775.9	4268.9	529.3	1.12	9.02	8.07	10.10	
96	24	214.6	1.48	29.3	18.2	11.8	1.61	2.49	1.55	4.00	

HEADINGS

IT - MOMENT OF INERTIA ABOUT THE T AXIS

IW - MOMENT OF INERTIA ABOUT THE W AXIS

IL - MOMENT OF INERTIA ABOUT THE L AXIS

IT/IW - RATIO OF IT TO IW

IT/IL - RATIO OF IT TO IL

IW/IL - RATIO OF IW TO IL

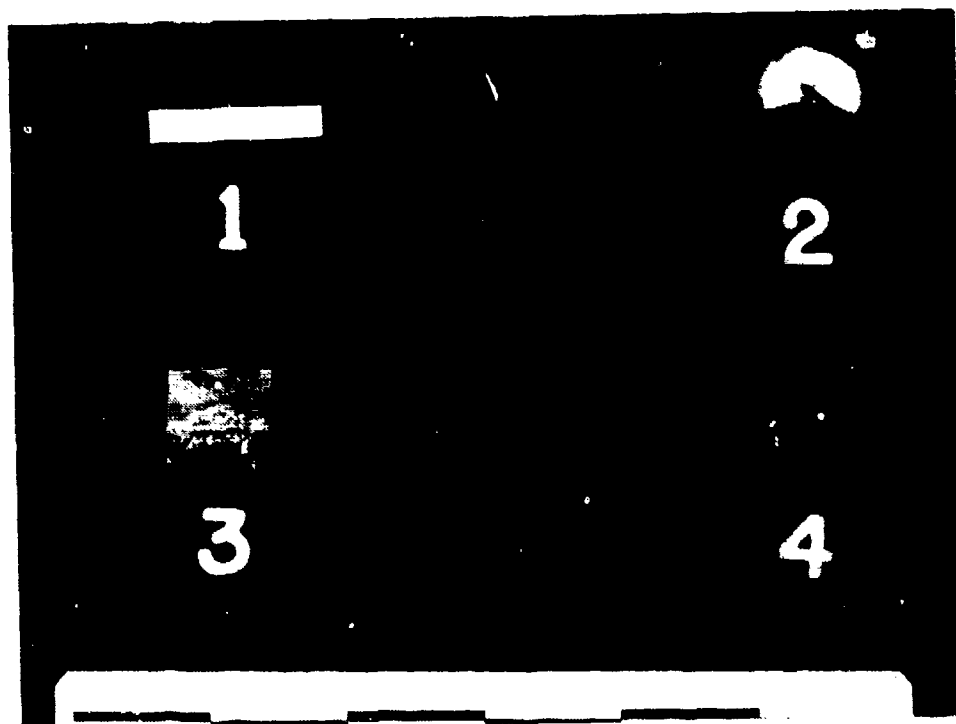
IT+2/(IL*IW) - RATIO OF IT+2 TO IL*IW

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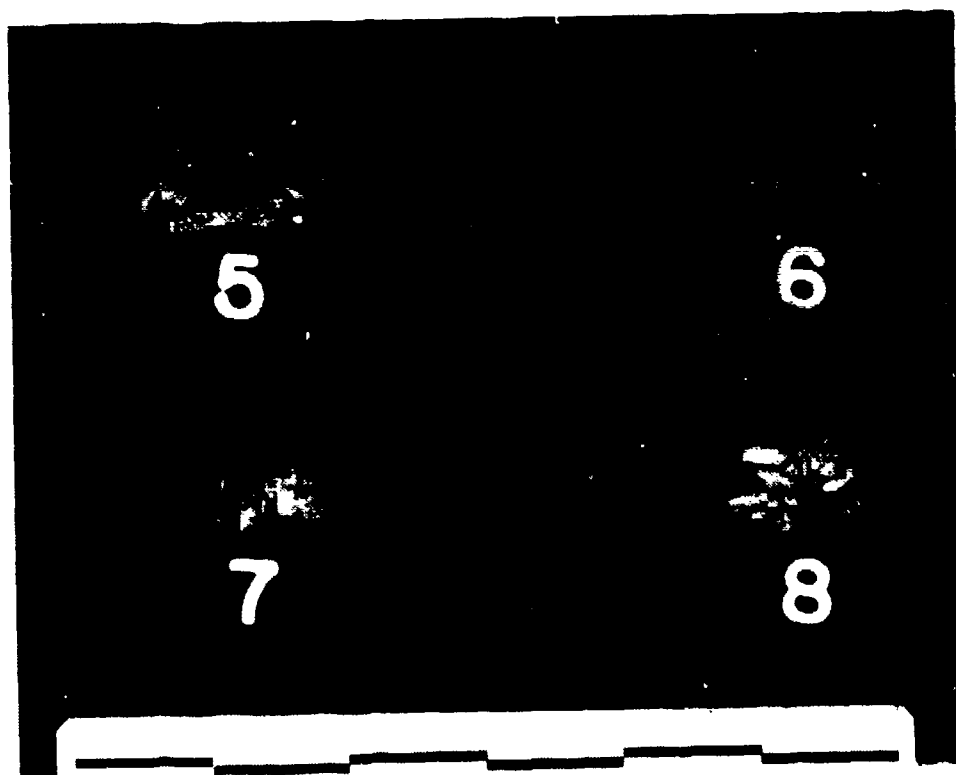
APPENDIX B
FRAGMENT PHOTOGRAPHS

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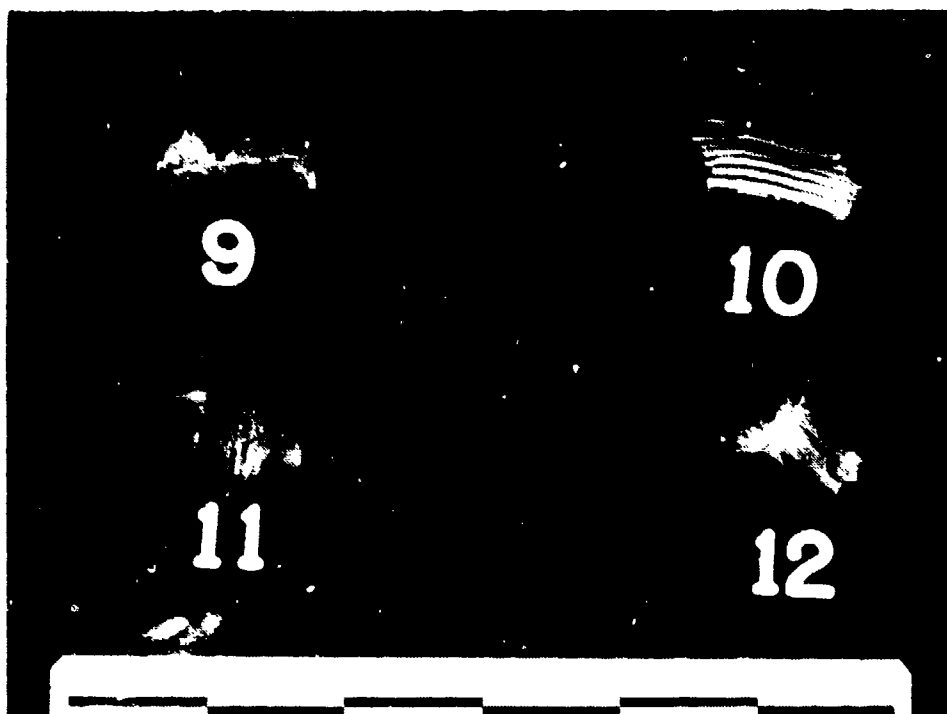
Photographs of fragments 1 through 96 are contained in this Appendix. The photographs show the shapes and sizes of the fragments. Comparison with Appendixes C and D present a good description of the overall fragment shapes and sizes.



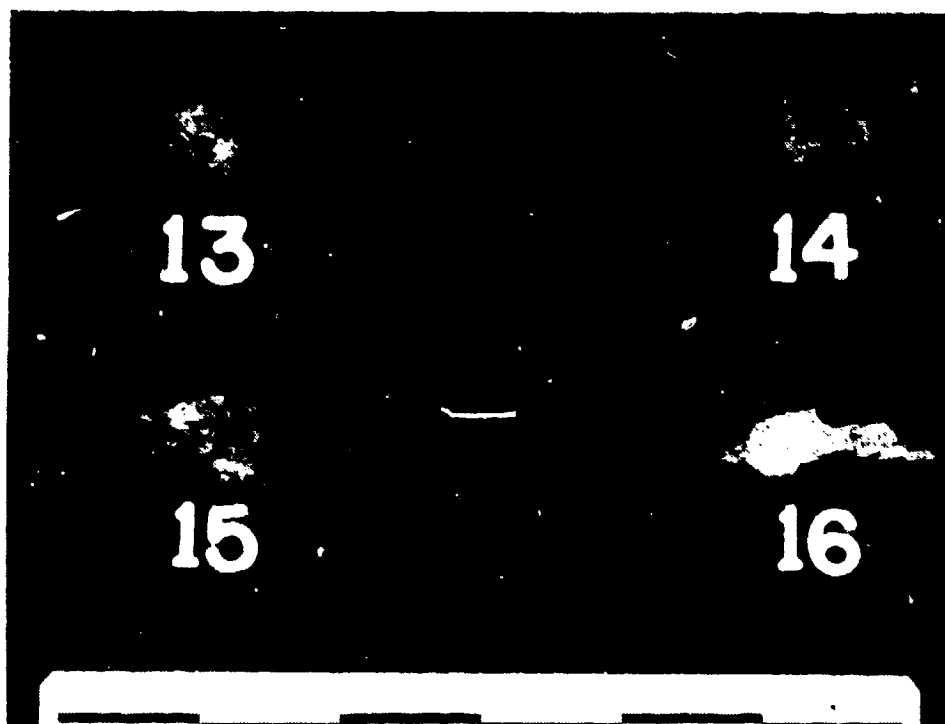
FRAGMENTS 1 THROUGH 4



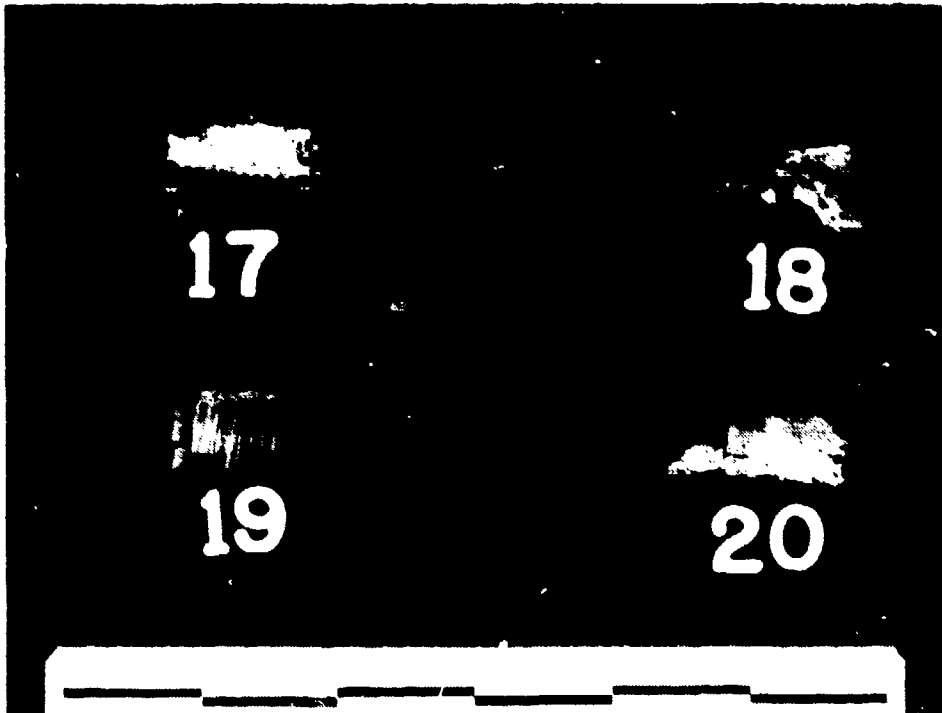
FRAGMENTS 5 THROUGH 8



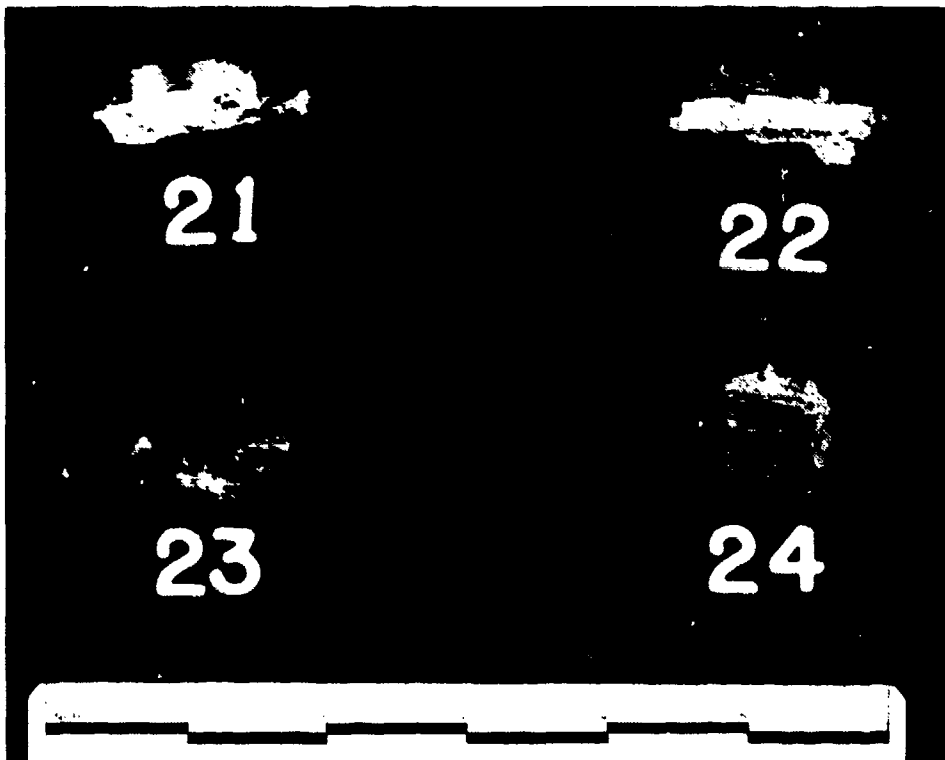
FRAGMENTS 9 THROUGH 12



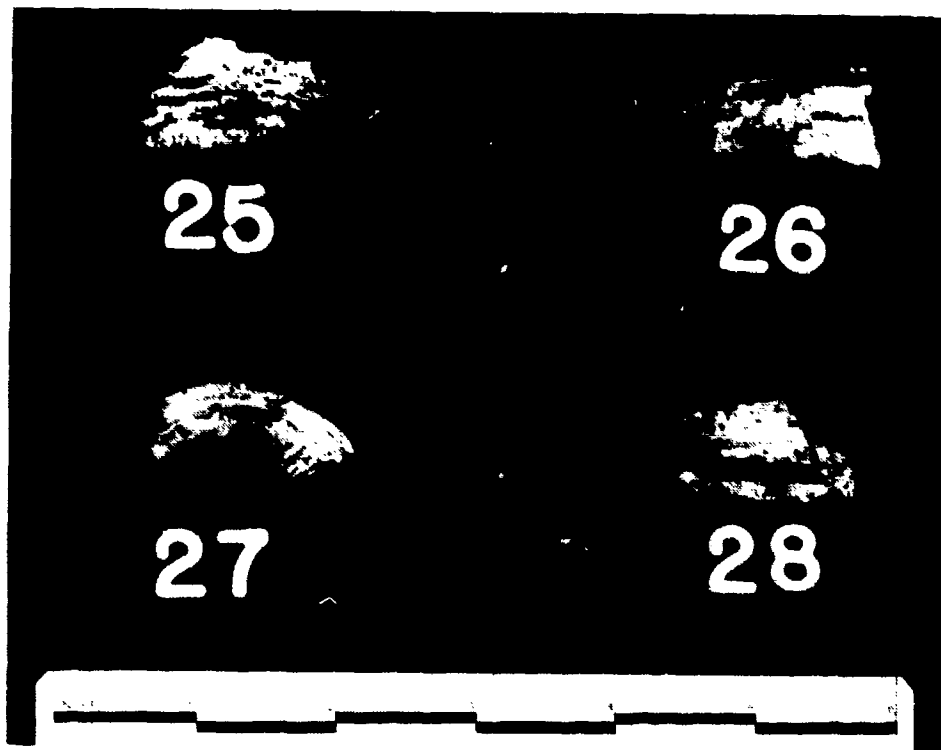
FRAGMENTS 13 THROUGH 16



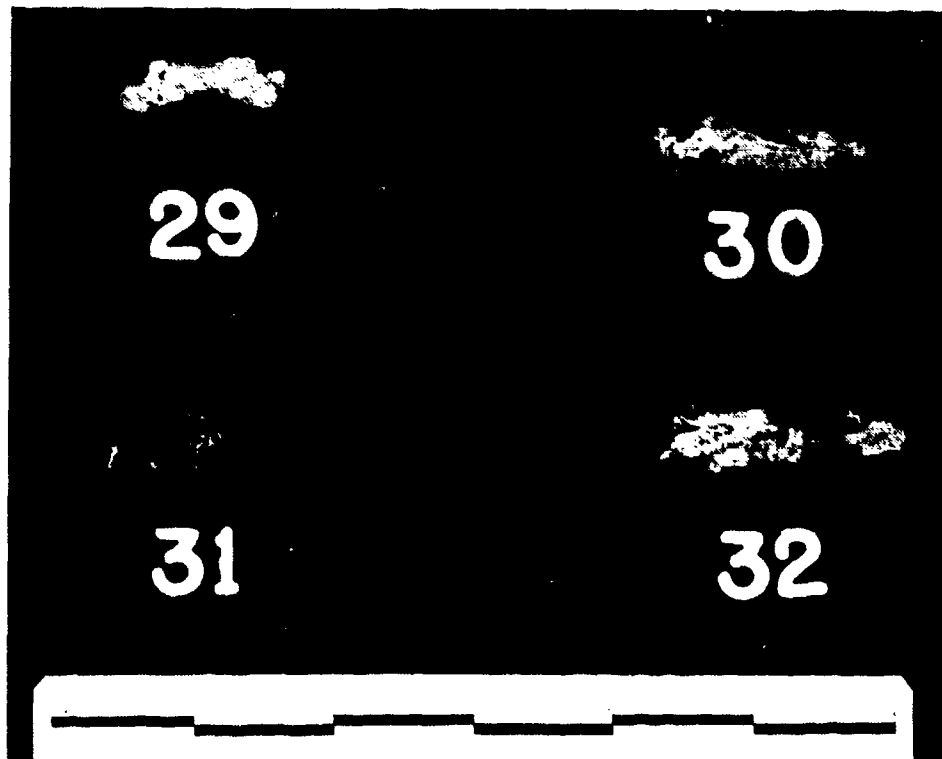
FRAGMENTS 17 THROUGH 20



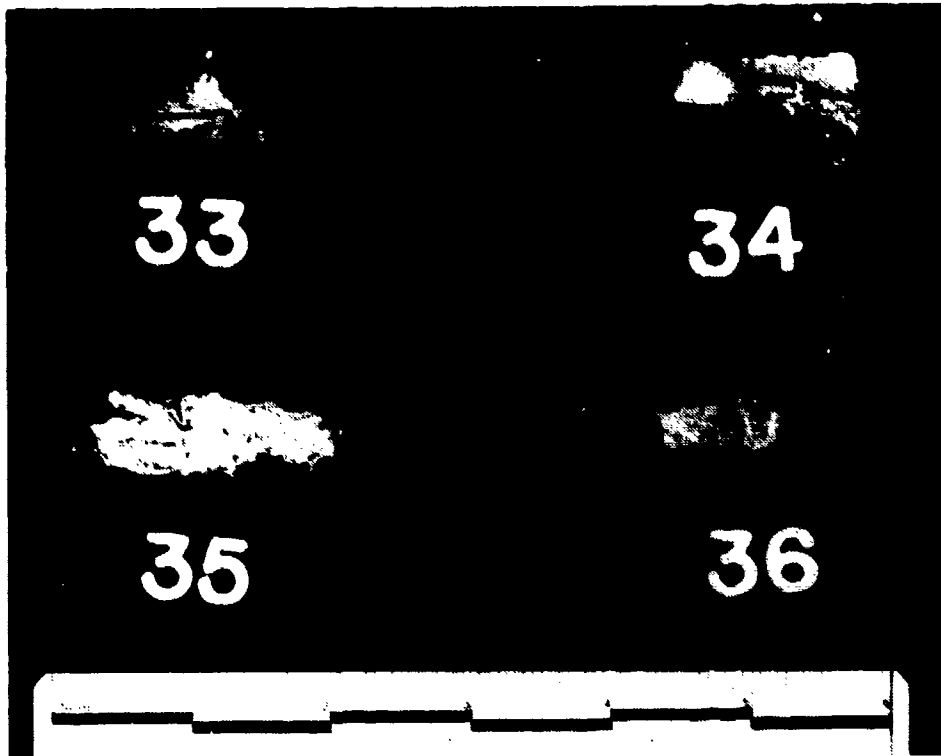
FRAGMENTS 21 THROUGH 24



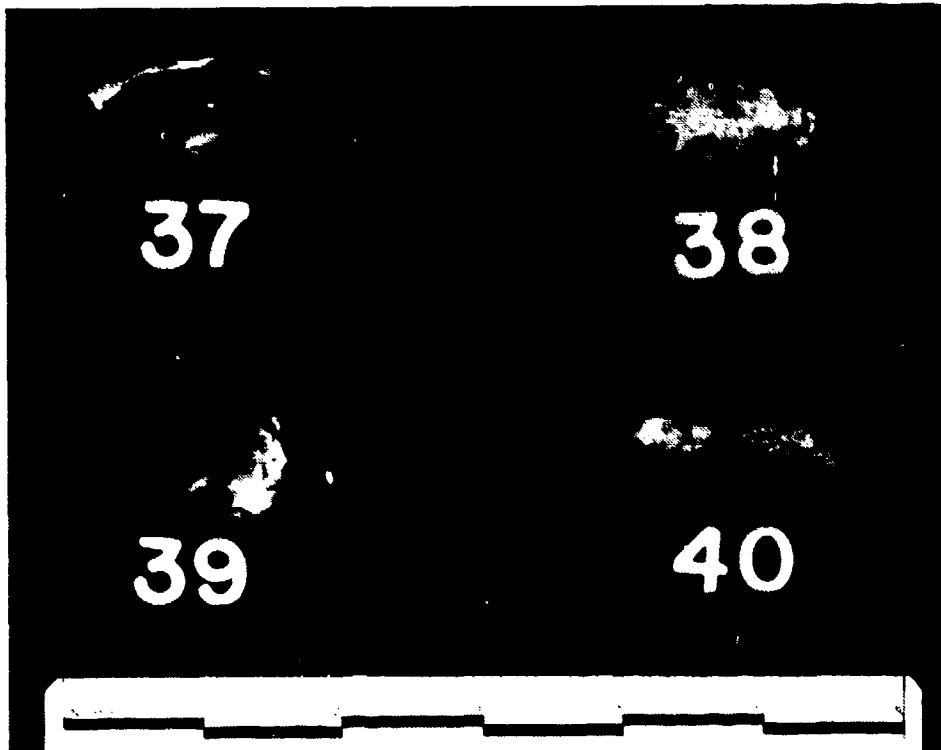
FRAGMENTS 25 THROUGH 28



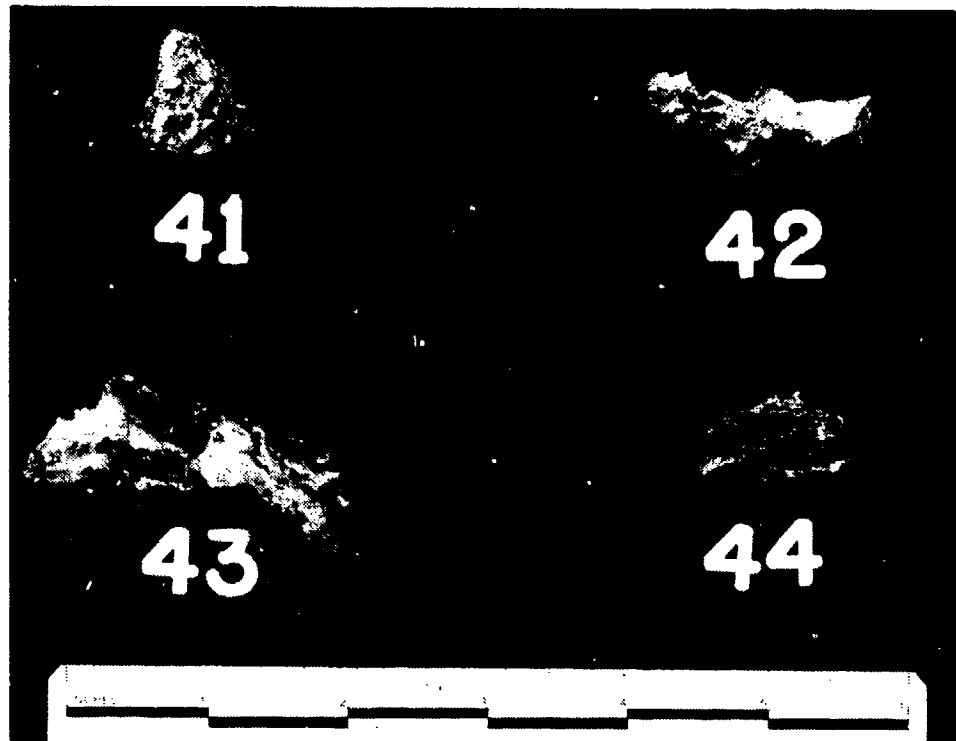
FRAGMENTS 29 THROUGH 32



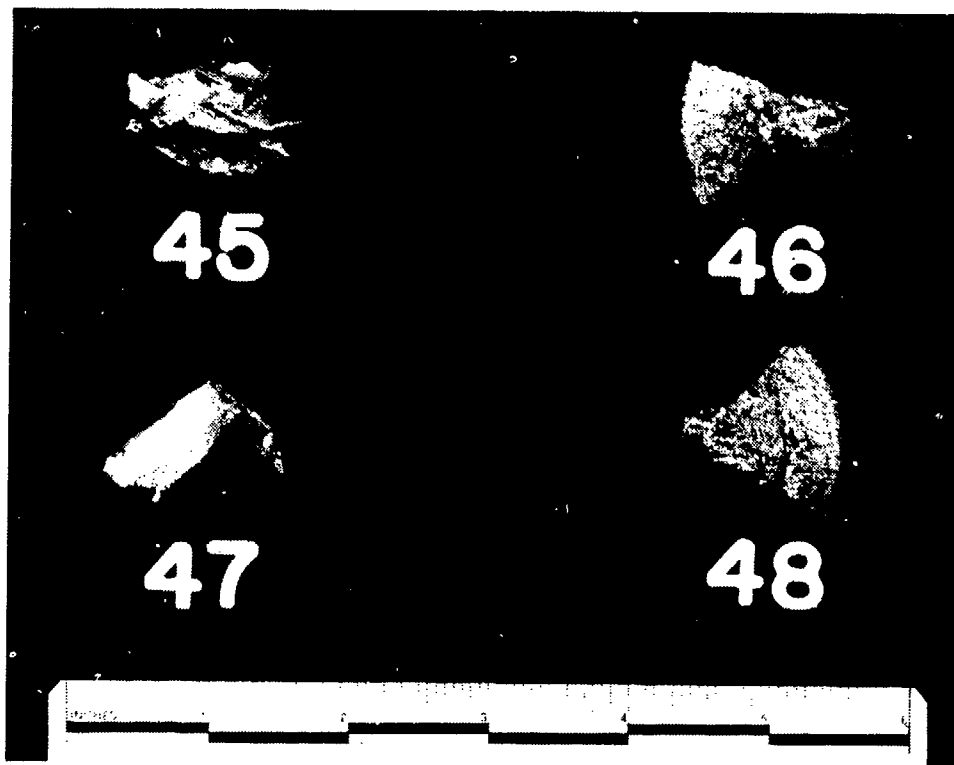
FRAGMENTS 33 THROUGH 36



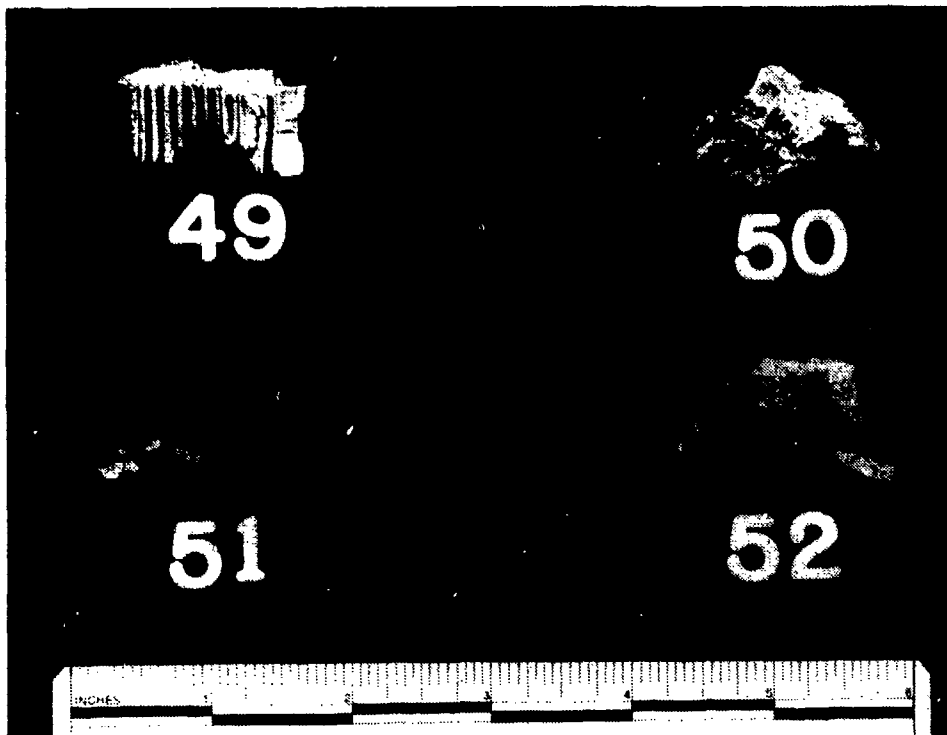
FRAGMENTS 37 THROUGH 40



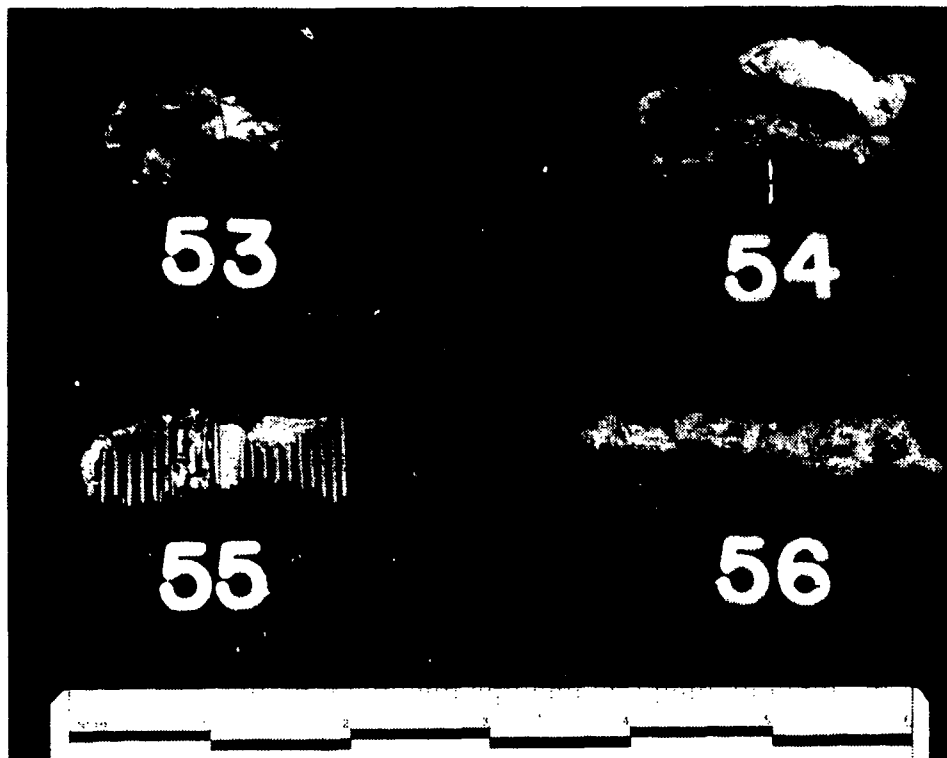
FRAGMENTS 41 THROUGH 44



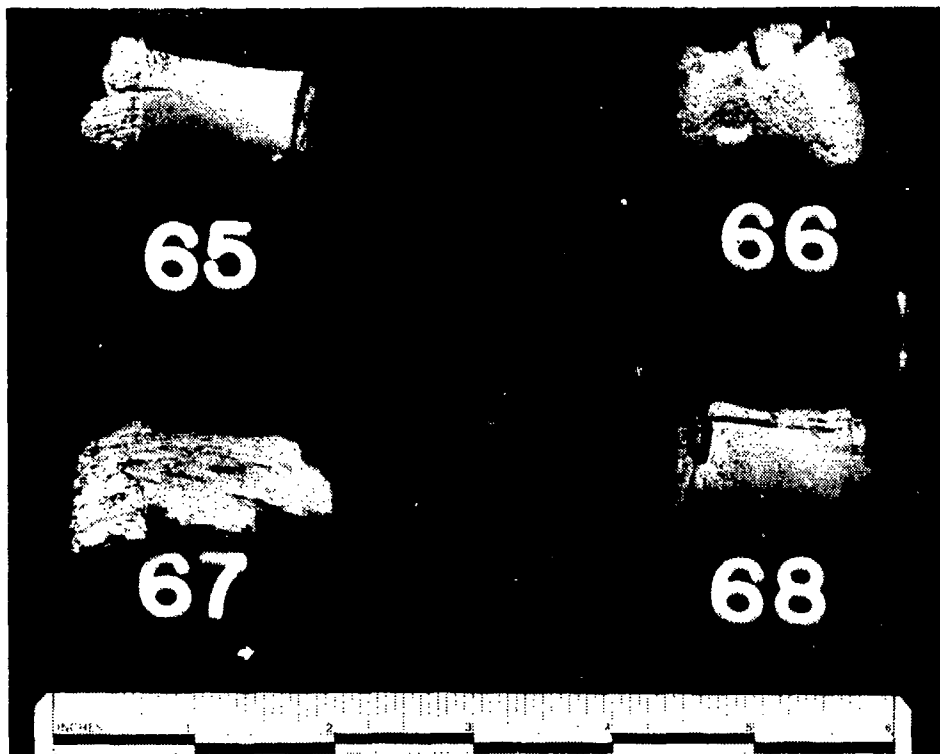
FRAGMENTS 45 THROUGH 48



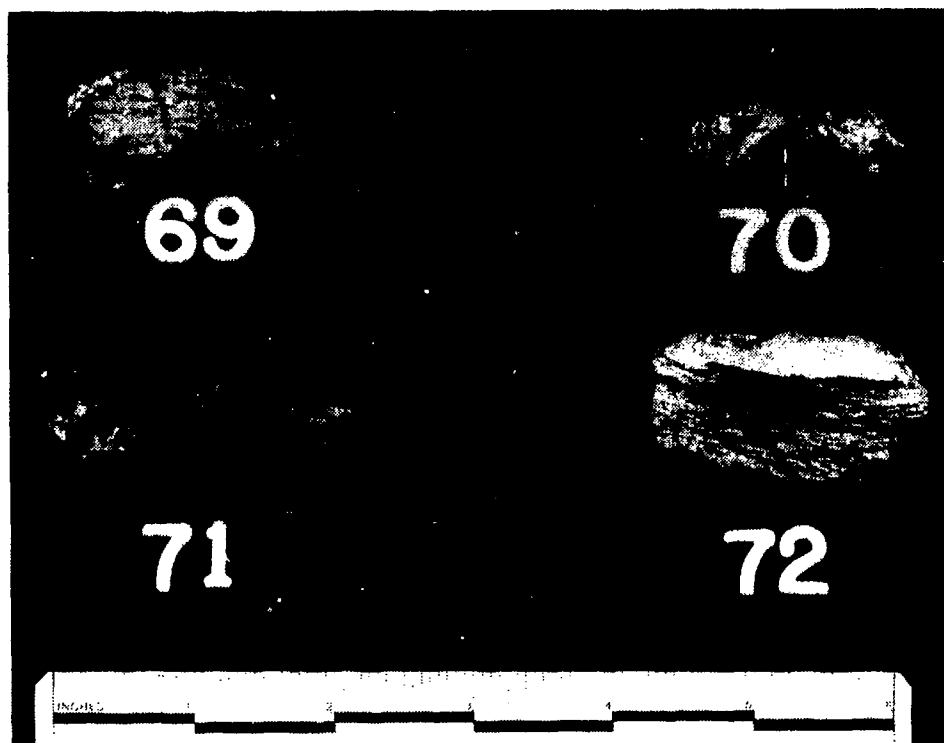
FRAGMENTS 49 THROUGH 52



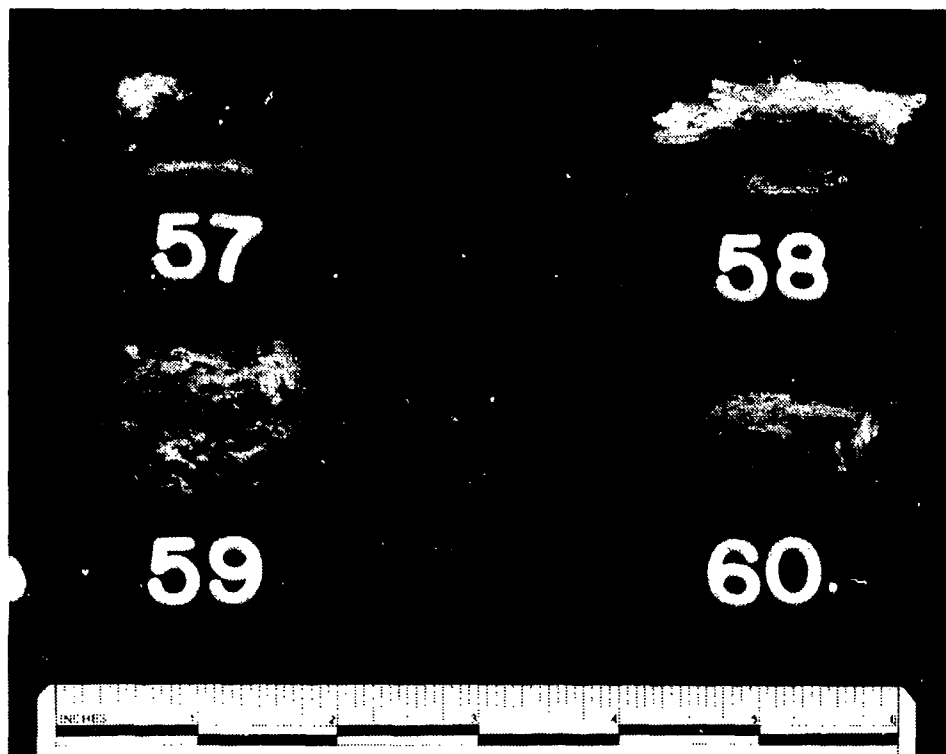
FRAGMENTS 53 THROUGH 56



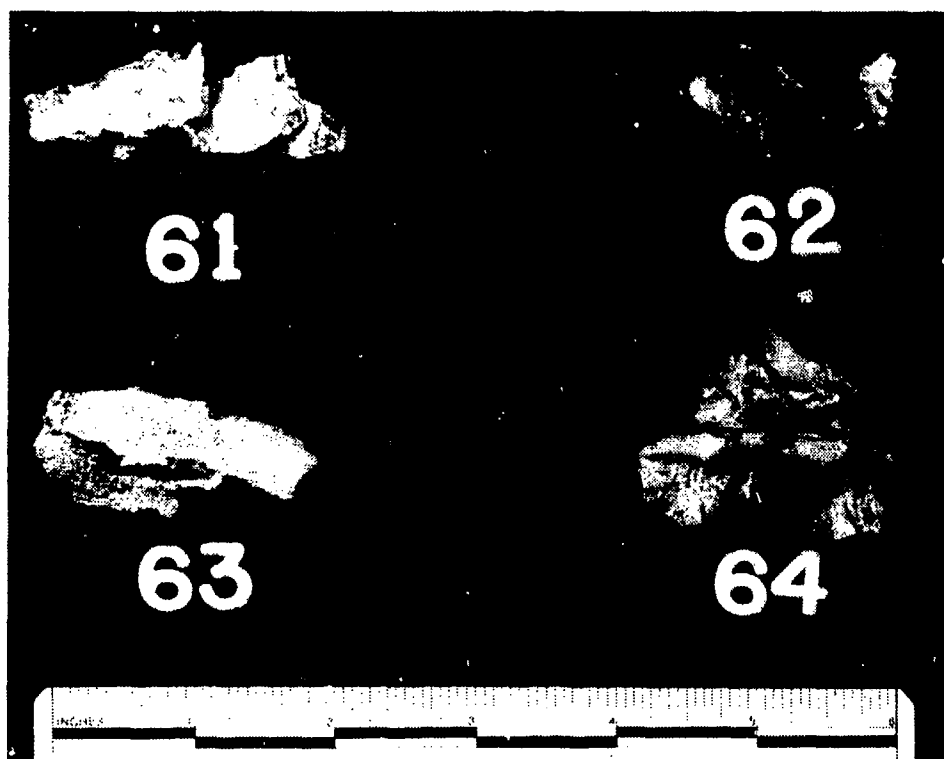
FRAGMENTS 65 THROUGH 68



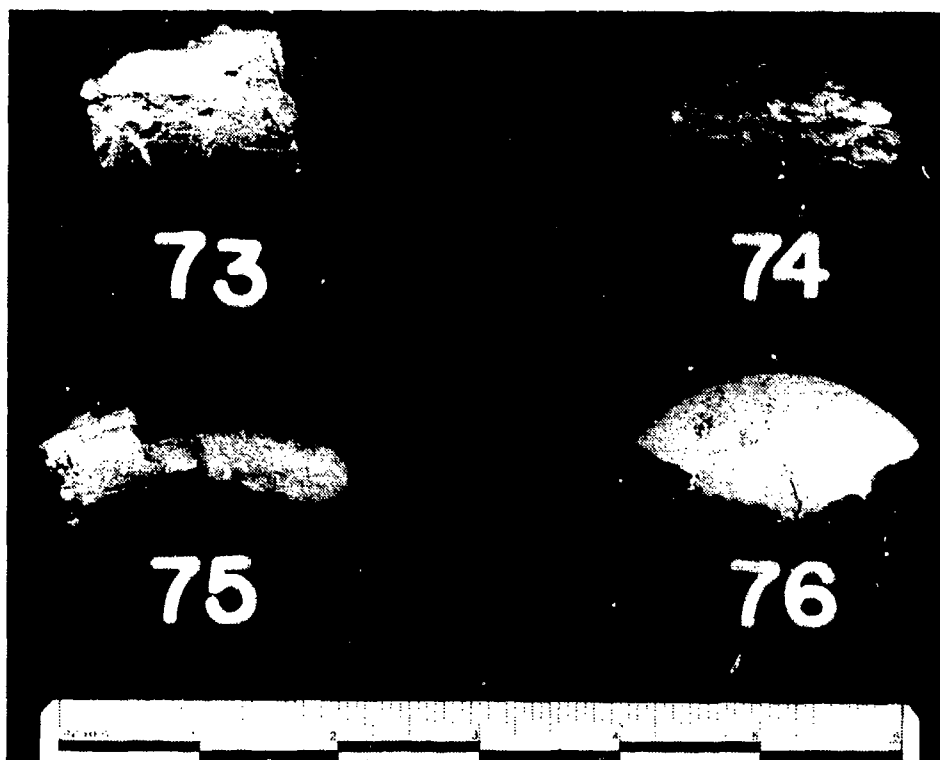
FRAGMENTS 69 THROUGH 72



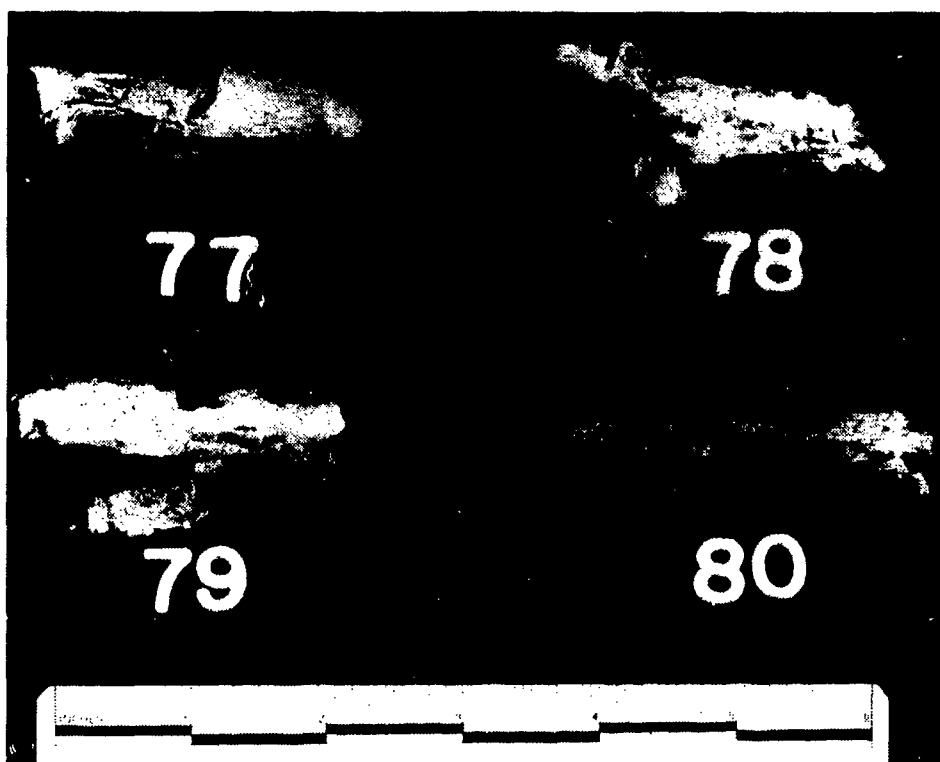
FRAGMENTS 57 THROUGH 60



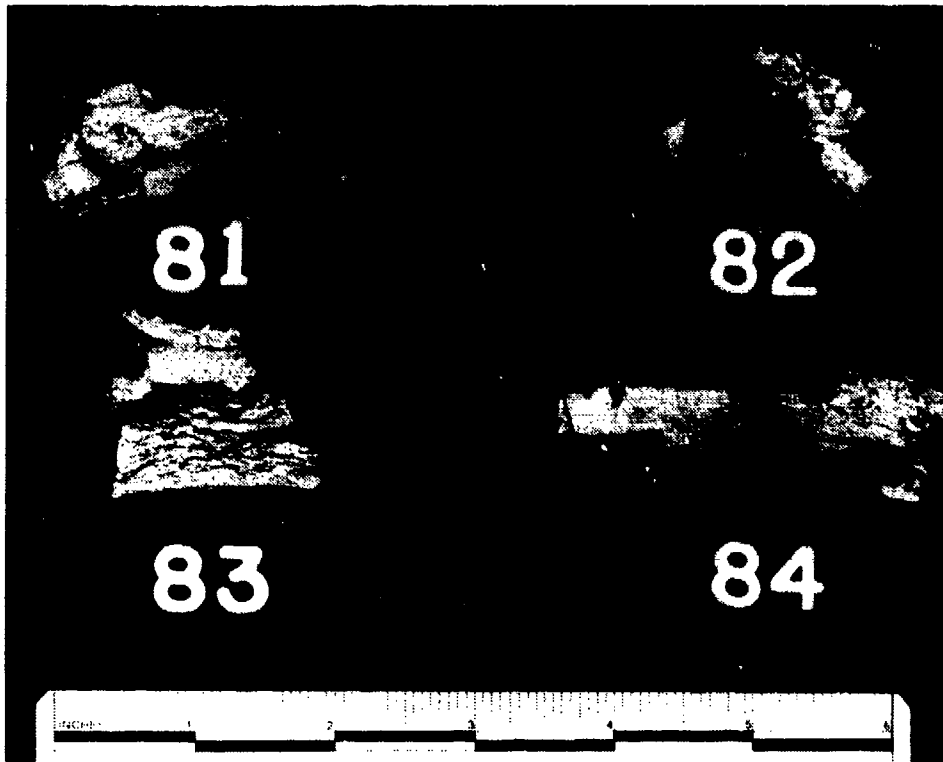
FRAGMENTS 61 THROUGH 64



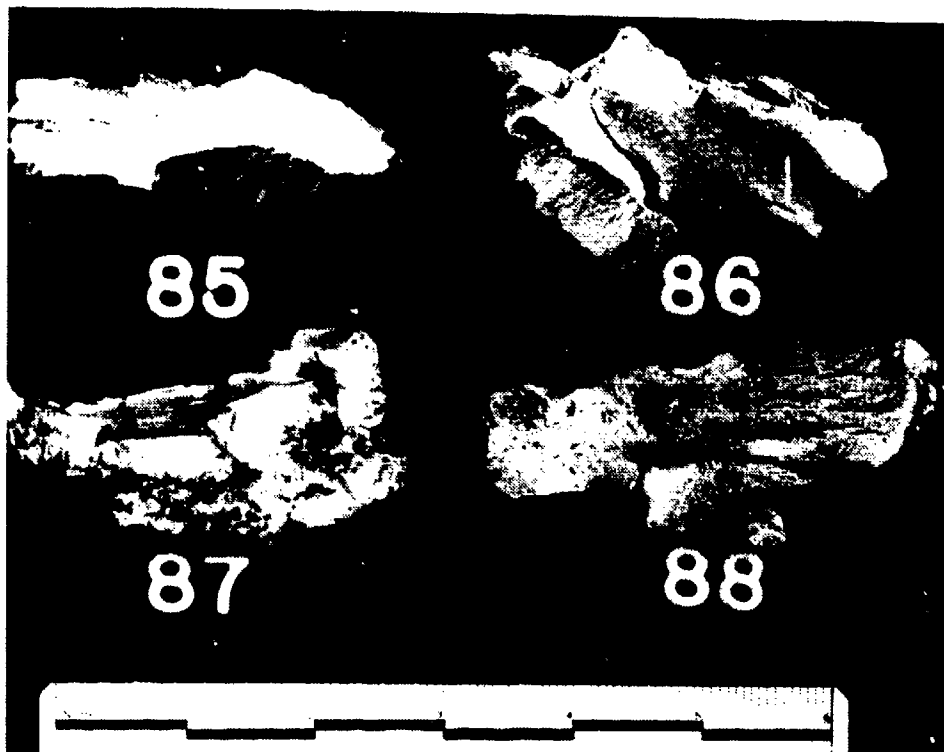
FRAGMENTS 73 THROUGH 76



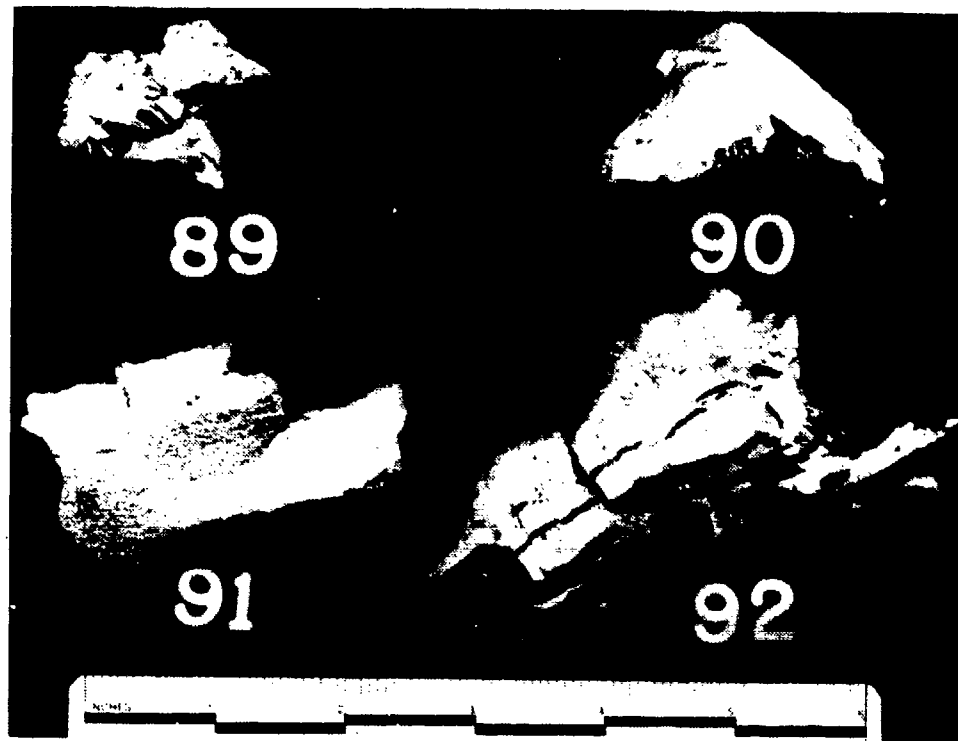
FRAGMENTS 77 THROUGH 80



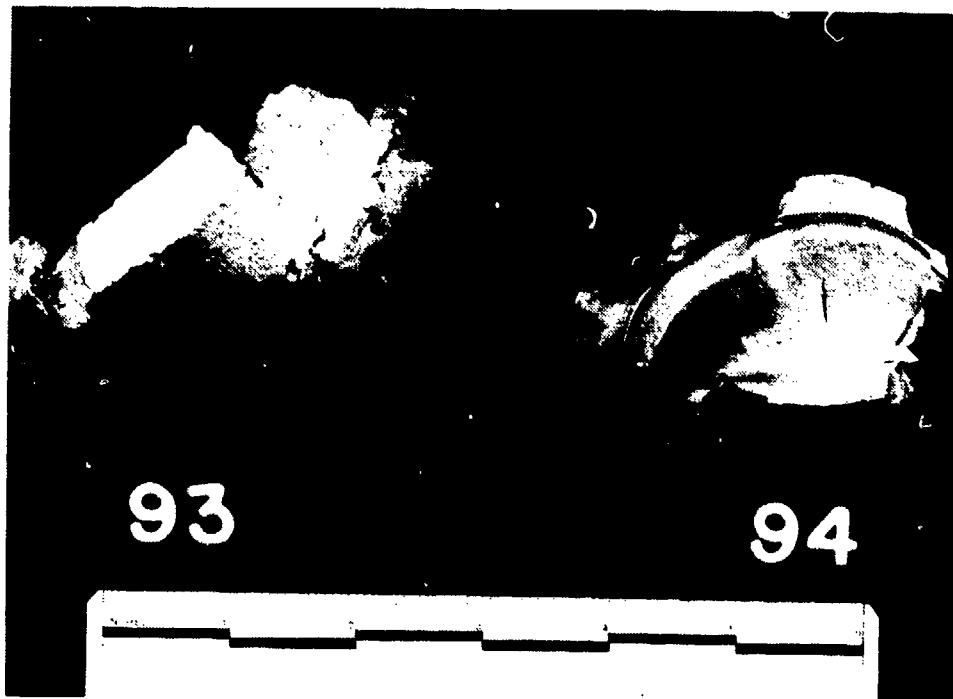
FRAGMENTS 81 THROUGH 84



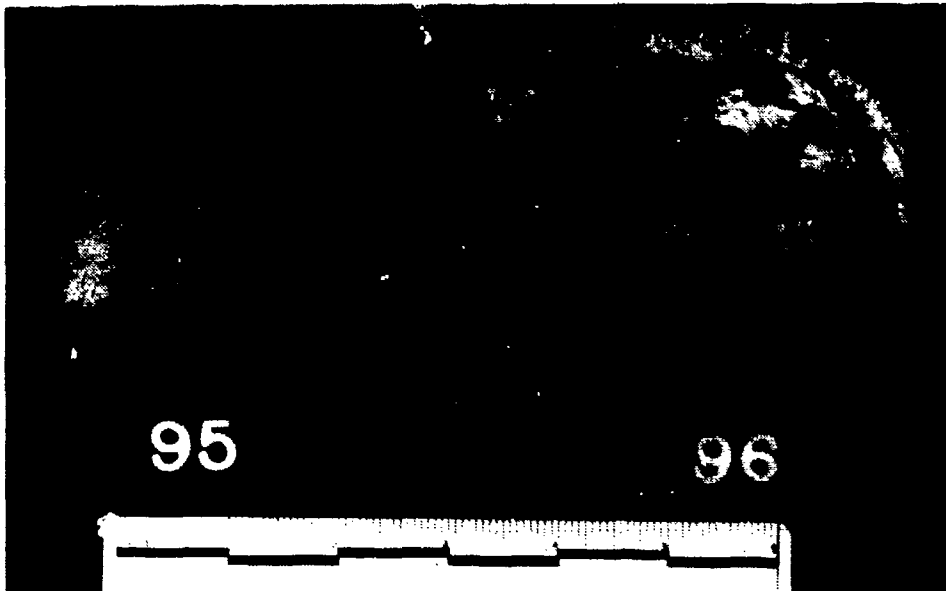
FRAGMENTS 85 THROUGH 88



FRAGMENTS 89 THROUGH 92



FRAGMENTS 93 THROUGH 94



FRAGMENTS 95 THROUGH 96

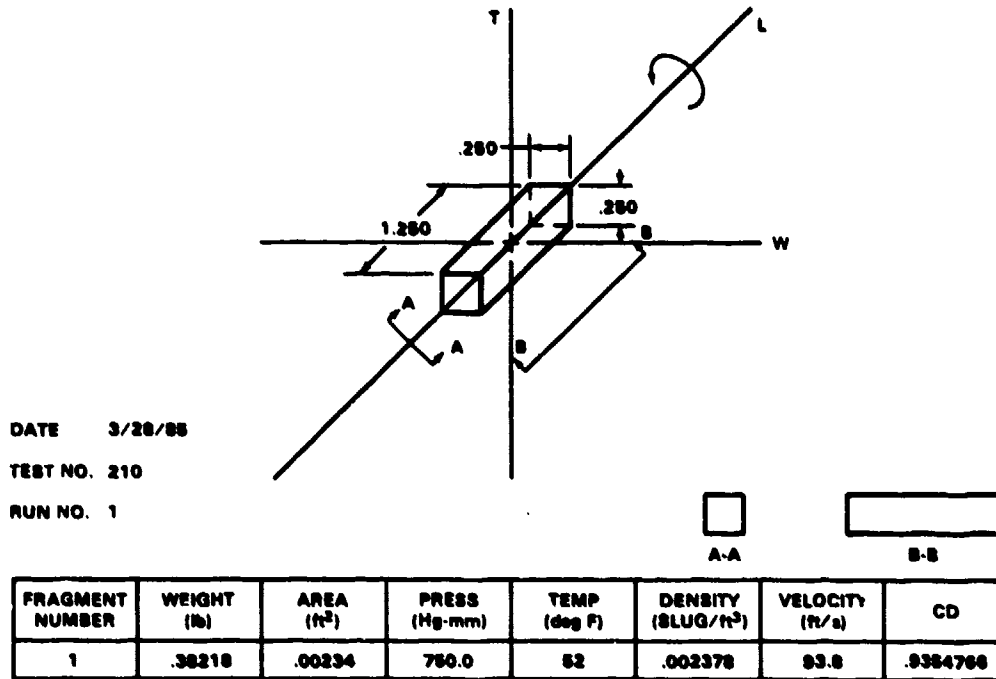
APPENDIX C
VERTICAL WIND TUNNEL TEST RECORDS

NSWC TR 87-89

This appendix contains the individual test records for the 96 fragments tested in the vertical wind tunnel. Each record contains three diagrams (views) of the fragment which are faithful representations of the fragment shape but not to scale. The dimensions of the three views can be inferred by reference to Table A-2 of Appendix A and the plan views in Appendix D.

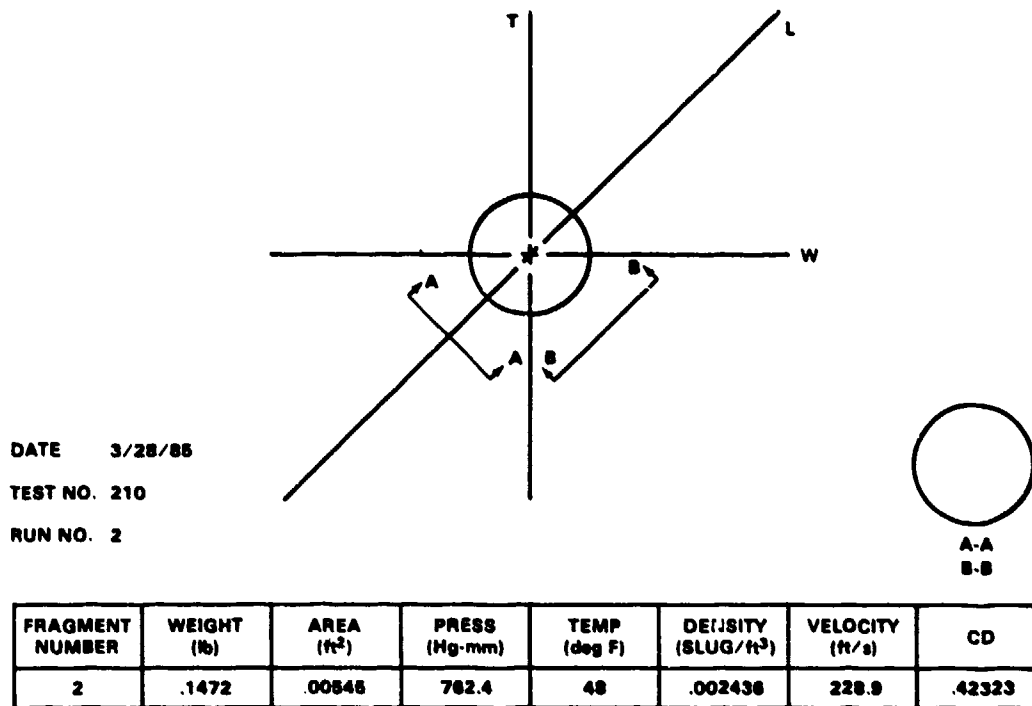
Each record shows the axes about which fragment motion in the wind tunnel is referenced in the comments at the bottom of the test record. The calculated C_D and the values of variables necessary to calculate it are also given. In all cases the area refers to the average presented area of the fragment.

NSWC TR 87-89



COMMENTS: PARALLELEPIPED HAS REPLACED THE 1.625 SPHERE AS FRAGMENT # 1
ROTATES AROUND L AXIS AND IF DISTURBED WILL START TO CONE
AROUND THE SAME AXIS

FIGURE C-1. TEST RECORD FOR FRAGMENT NO. 1



COMMENTS: SPHERE

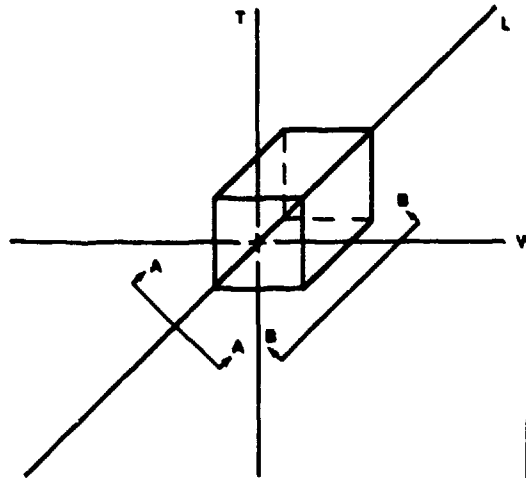
FIGURE C-2. TEST RECORD FOR FRAGMENT NO. 2

NSWC TR 87-89

DATE 3/28/85

TEST NO. 210

RUN NO. 3



A-A

B-B

FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
3	.1193	.00603	762.4	48	.002436	169.8	.63610

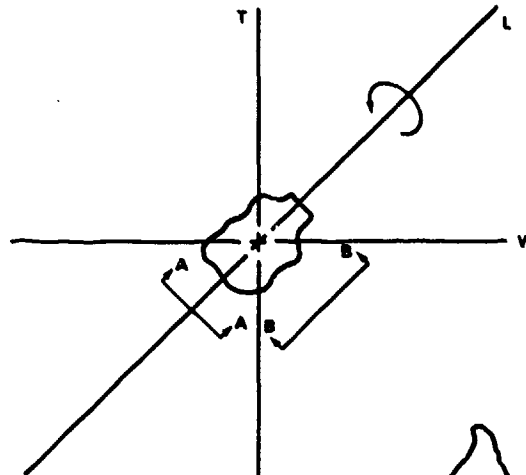
COMMENTS: CUBE (%) WILL ROTATE AROUND ANY AXIS

FIGURE C-3. TEST RECORD FOR FRAGMENT NO. 3

DATE 3/28/85

TEST NO. 210

RUN NO. 4



A-A

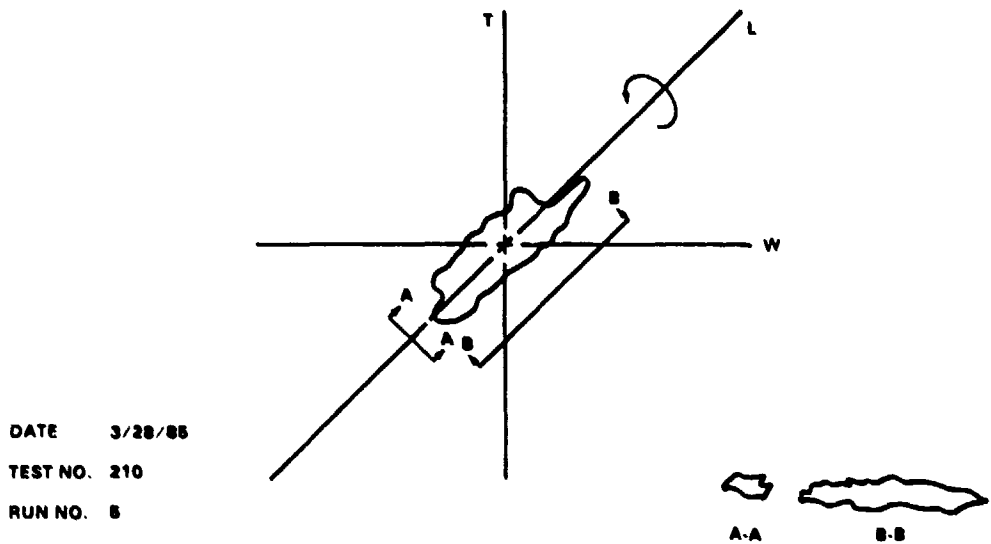
B-B

FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
4	.0188	.002054	766.4	76	.002291	85.8	.91220

COMMENTS: TUMBLES IN ALL DIRECTIONS

FIGURE C-4. TEST RECORD FOR FRAGMENT NO. 4

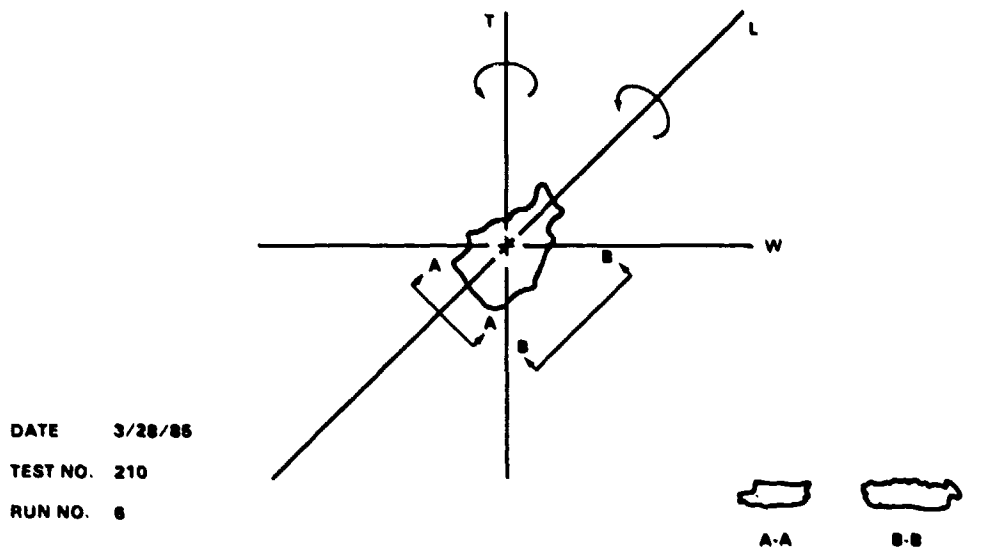
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FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
5	.01804	.00258	754.8	82	.002261	88.1	1.18882

COMMENTS: ROTATES ALONG THE LONGITUDINAL AXIS AND WILL CONE ABOUT THE

FIGURE C-5. TEST RECORD FOR FRAGMENT NO. 5

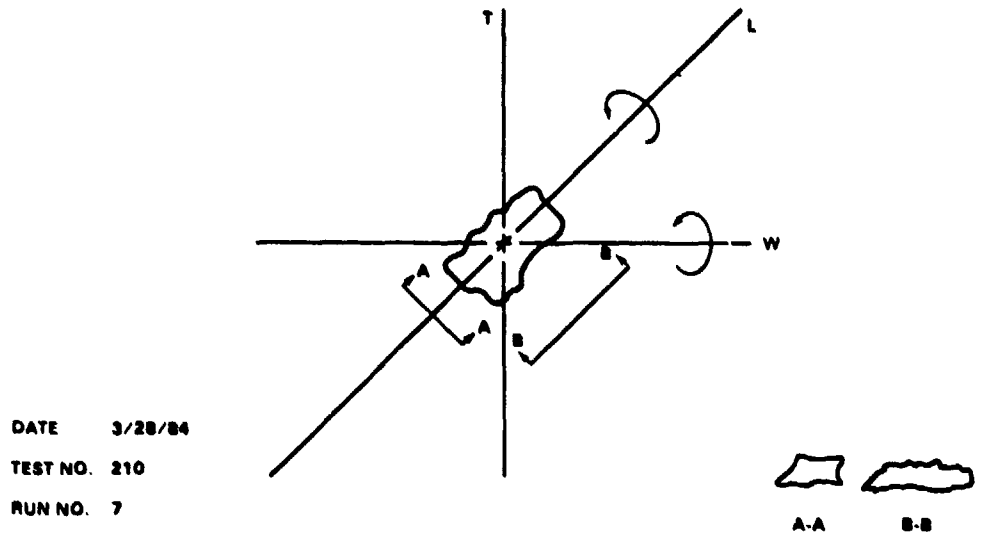


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
6	.01617	.00206	754.8	82	.002261	81	1.05828

COMMENTS: ROTATES AROUND BOTH T AND L AXIS — WHEN DISTURBED, IT TUMBLES

FIGURE C-6. TEST RECORD FOR FRAGMENT NO. 6

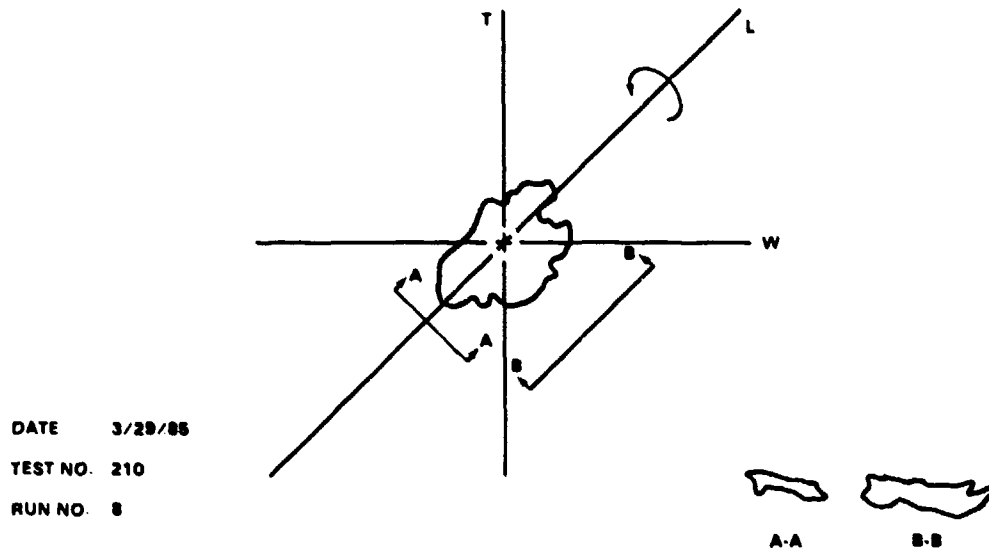
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FRAGMENT NUMBER	WEIGHT (lb)	AREA (in ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
7	.01646	.002106	754.8	82	.002261	81	1.06374

COMMENTS: WILL ROTATE ABOUT THE L AND W AXIS

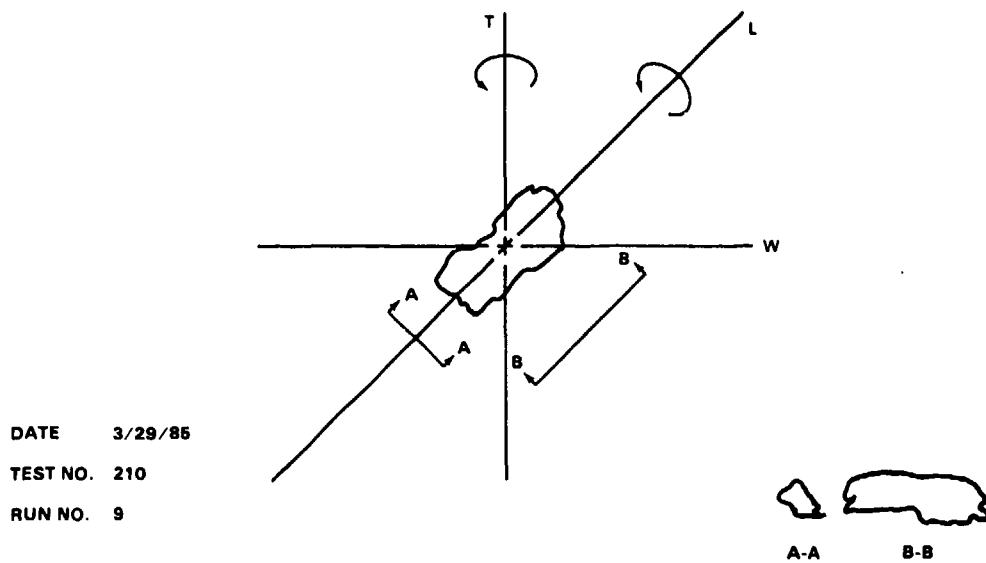
FIGURE C-7. TEST RECORD FOR FRAGMENT NO. 7



FRAGMENT NUMBER	WEIGHT (lb)	AREA (in ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
8	.0171	.002603	755.3	86	.002331	84.9	1.33820

COMMENTS: ROTATES AROUND THE L AXIS

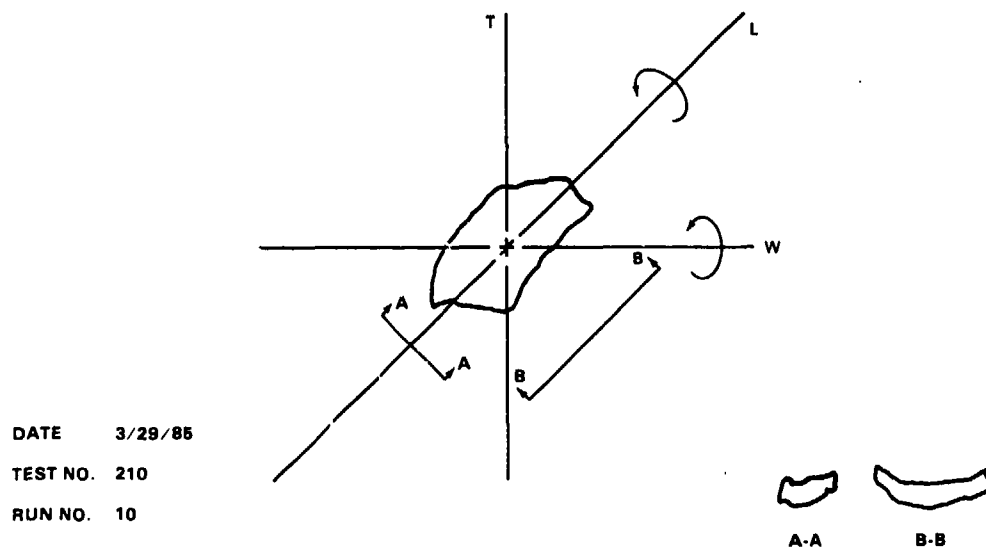
FIGURE C-8. TEST RECORD FOR FRAGMENT NO. 8



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
9	.01736	.002451	755.3	66	.002331	81	.92624

COMMENTS: ROTATES AROUND L AND T AND ALSO CONING AROUND THE L AXIS

FIGURE C-9. TEST RECORD FOR FRAGMENT NO. 9



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
10	.0174	.003013	755.3	62	.002349	71.3	.96720

COMMENTS: ROTATES AROUND L AND W

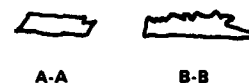
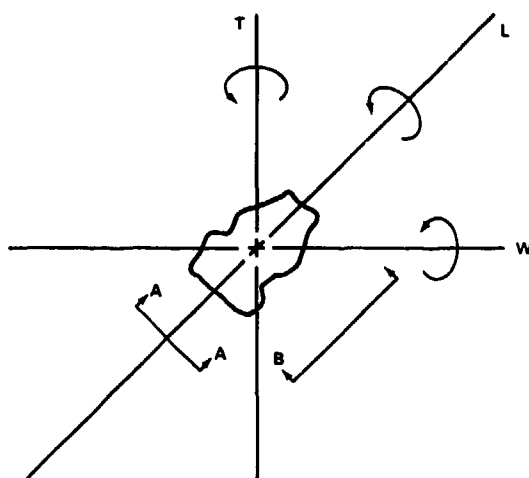
FIGURE C-10. TEST RECORD FOR FRAGMENT NO. 10

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RUN NO. 11



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
11	.08137	.0023307	755.3	61	.002353	93.8	.76142

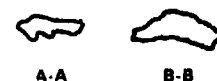
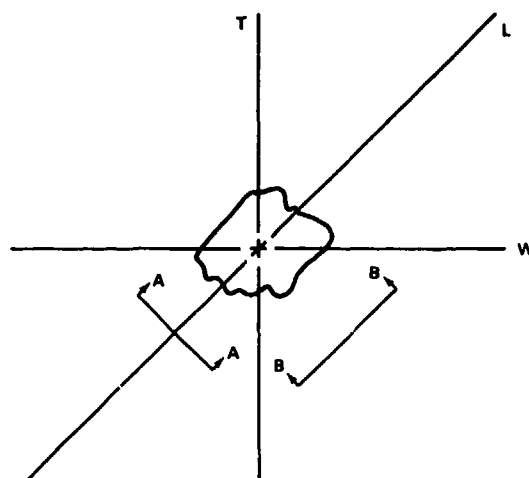
COMMENTS: AT LIFT OFF IT WAS SPINNING FLAT AROUND T — THEN WOULD ROTATE AROUND ALL 3 AXES

FIGURE C-11. TEST RECORD FOR FRAGMENT NO. 11

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TEST NO. 210

RUN NO. 12

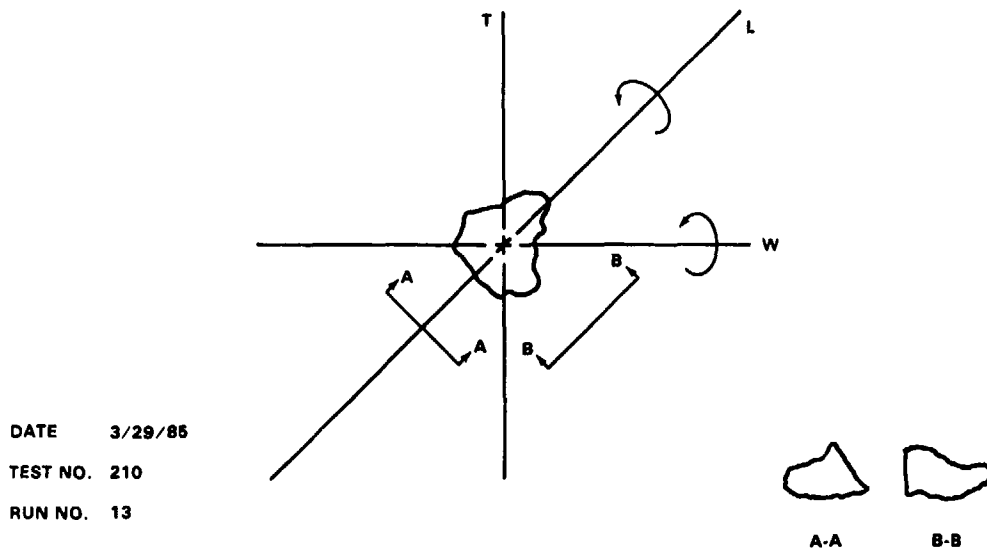


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
12	.0184	.0023224	755.3	61	.002353	87.4	.88159

COMMENTS: LIFT'S OFF FLOATING FLAT. THEN ROTATES AROUND ALL 3 AXES

FIGURE C-12. TEST RECORD FOR FRAGMENT NO. 12

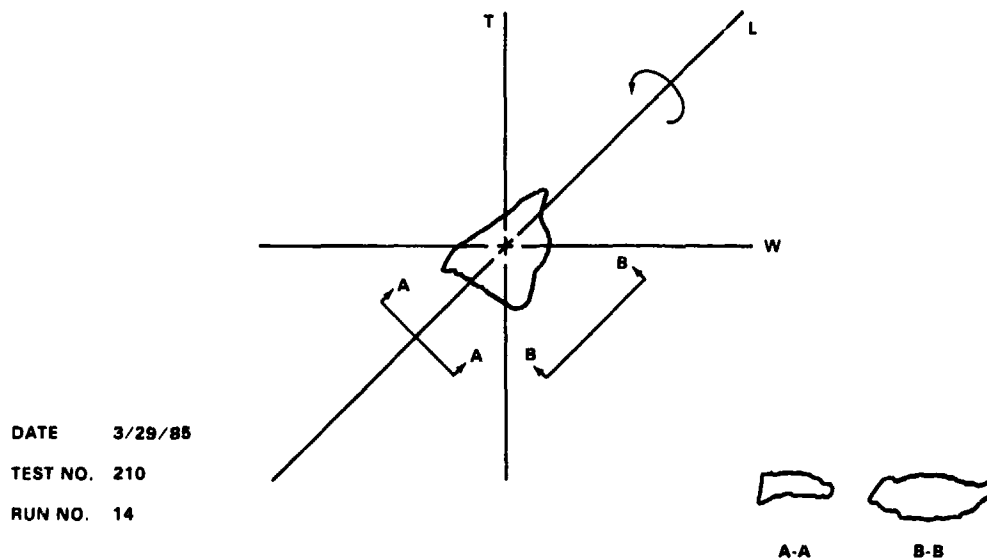
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FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
13	.01868	.00196	755.3	61	.002353	98.7	.83156

COMMENTS: ROTATES AROUND L AND W — GOES FLAT AND THEN TUMBLES

FIGURE C-13. TEST RECORD FOR FRAGMENT NO. 13



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
14	.01898	.00236	755.4	61	.002354	84.2	.96379

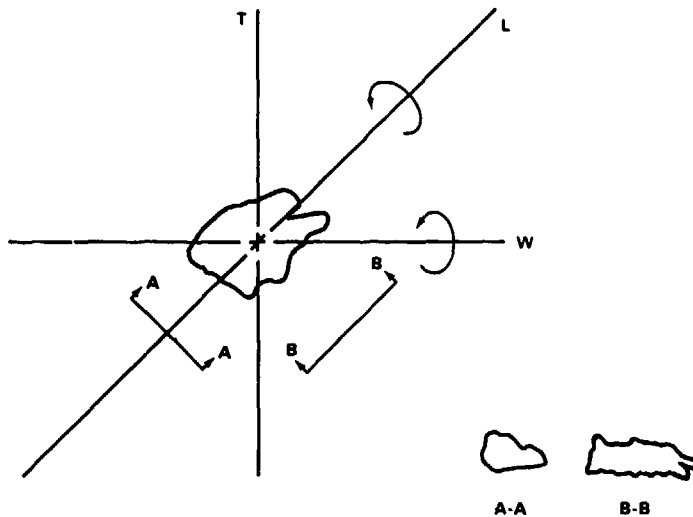
COMMENTS: ROTATES AROUND L TO START AND THEN TUMBLES

FIGURE C-14. TEST RECORD FOR FRAGMENT NO. 14

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TEST NO. 210

RUN NO. 15



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
15	.01936	.002373	755.4	61	.002354	84.2	.97770

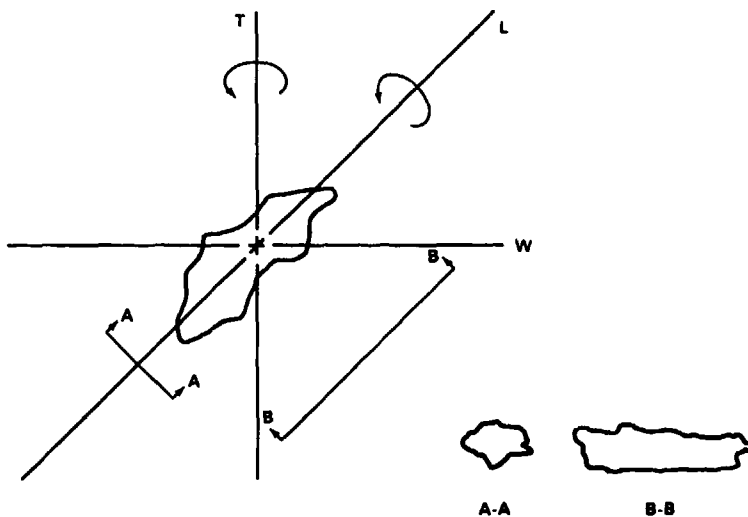
COMMENTS: ROTATES IN L AXIS THEN W

FIGURE C-15. TEST RECORD FOR FRAGMENT NO. 15

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TEST NO. 210

RUN NO. 16



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
16	.02144	.002918	755.4	61	.002354	81	.95146

COMMENTS: ROTATES AROUND L AND T

FIGURE C-16. TEST RECORD FOR FRAGMENT NO. 16

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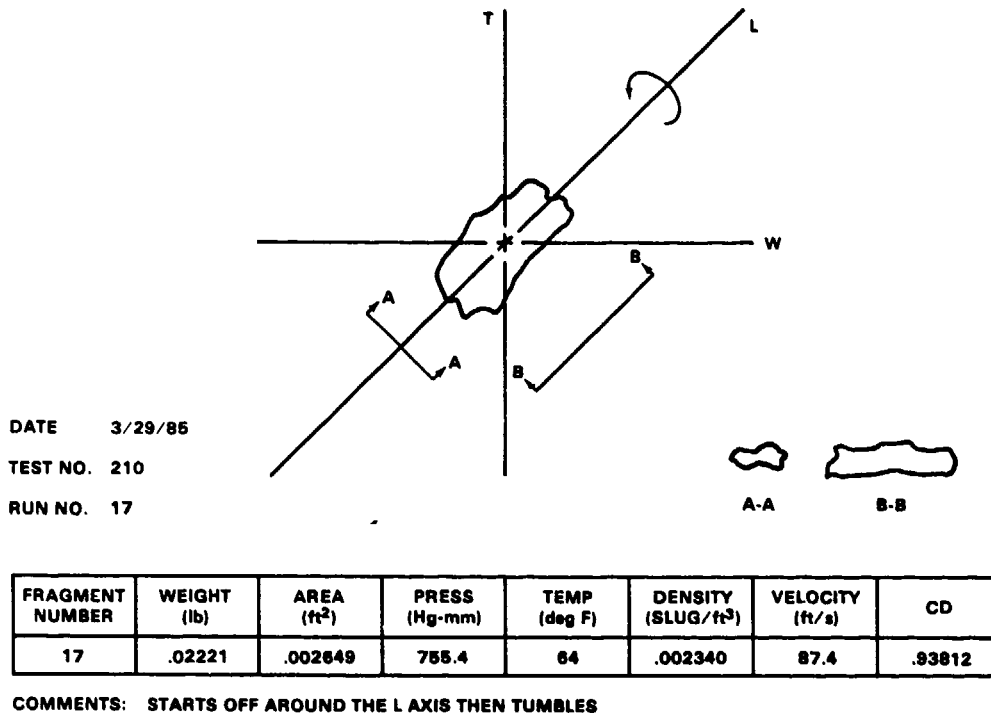


FIGURE C-17. TEST RECORD FOR FRAGMENT NO. 17

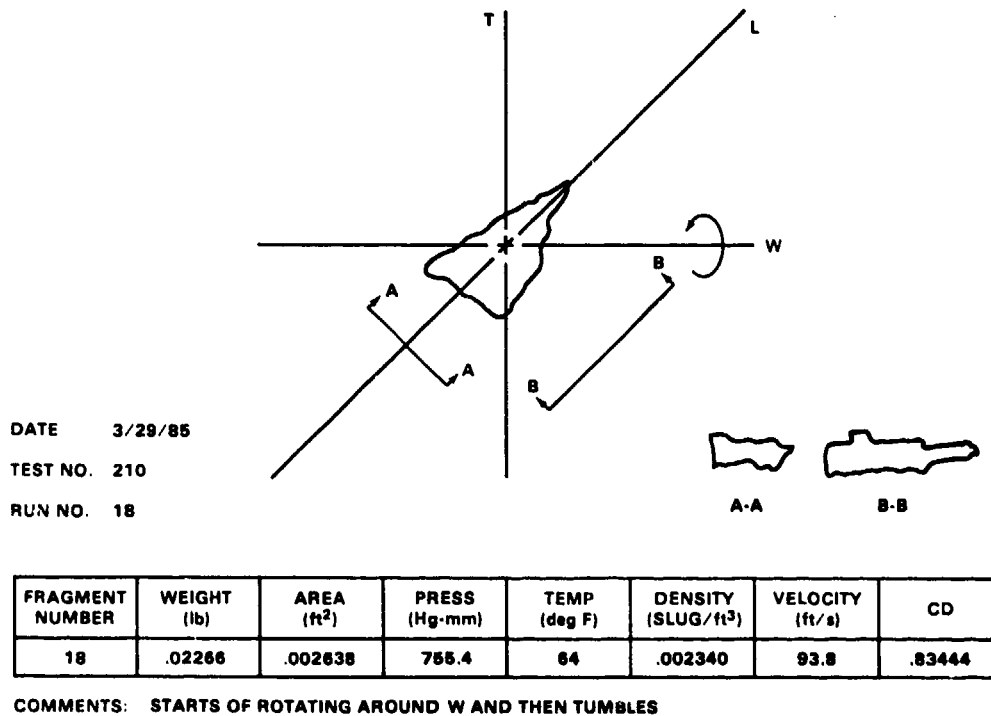
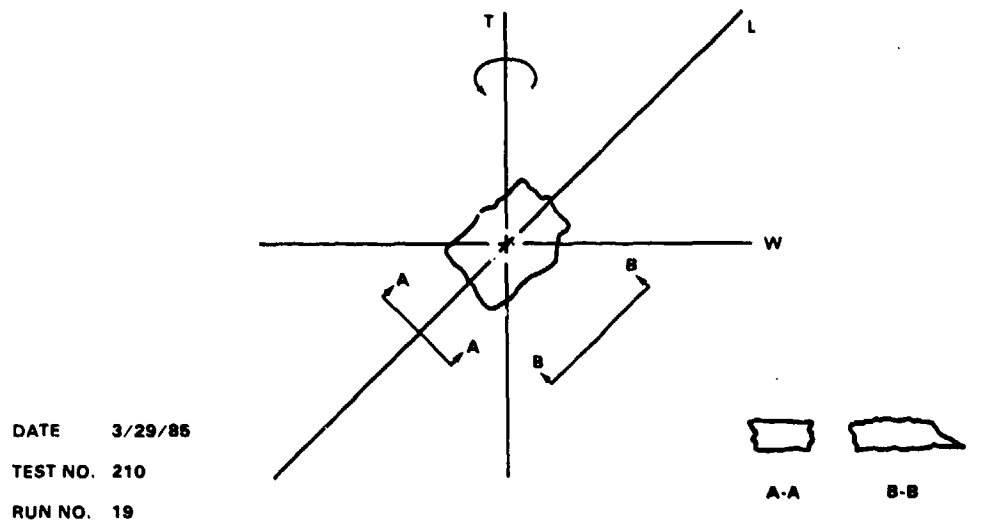


FIGURE C-18. TEST RECORD FOR FRAGMENT NO. 18

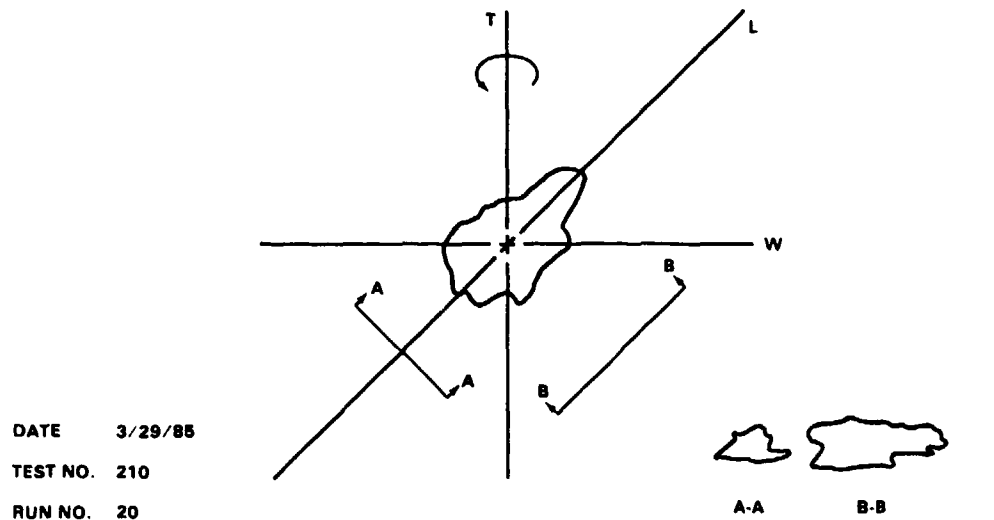
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FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
19	.02301	.00248	755	66	.002330	81	1.21386

COMMENTS: FLAT SPIN AROUND T

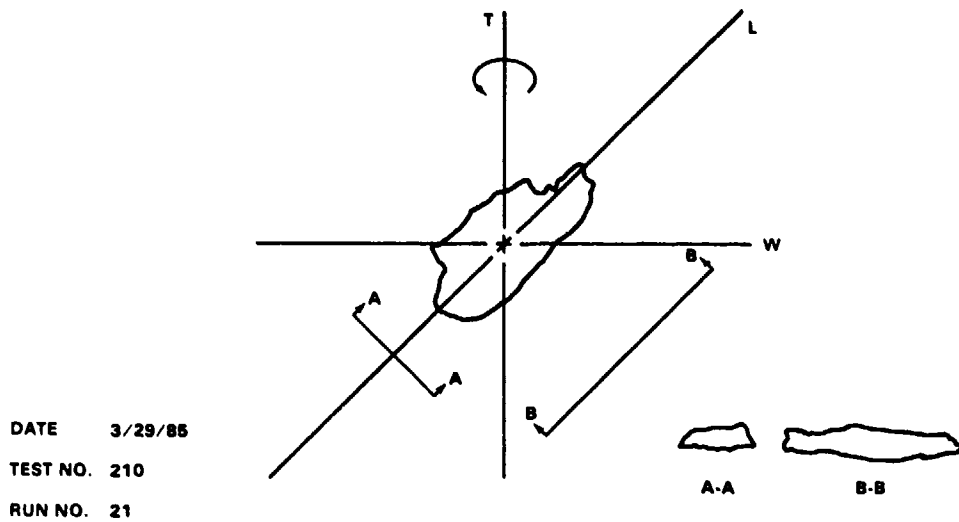
FIGURE C-19. TEST RECORD FOR FRAGMENT NO. 19



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
20	.02546	.003043	755	67	.002325	74.6	1.29326

COMMENTS: FLAT ROTATION

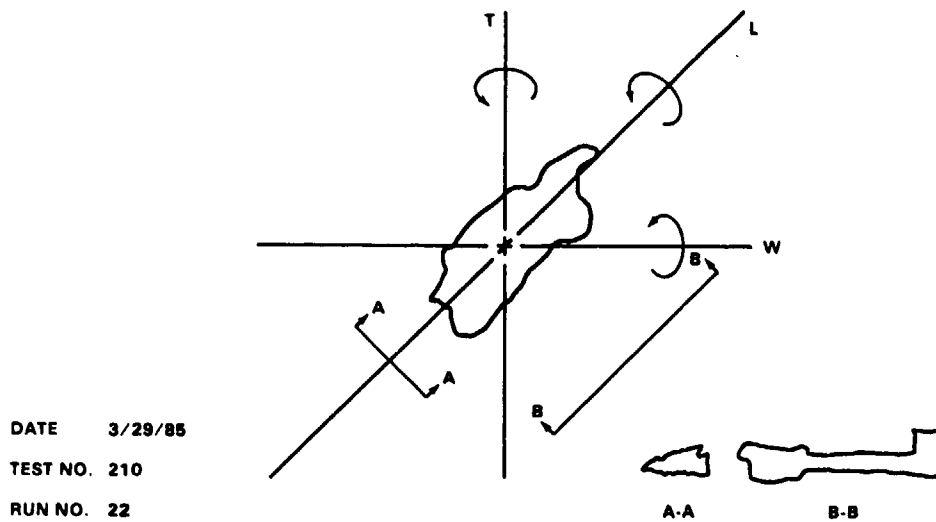
FIGURE C-20. TEST RECORD FOR FRAGMENT NO. 20



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
21	.02693	.00331	755	67	.002325	71.3	1.37669

COMMENTS: FLAT SPIN AND TUMBLE

FIGURE C-21. TEST RECORD FOR FRAGMENT NO. 21



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
22	.0291	.00380	755	67	.002325	74.6	1.18369

COMMENTS: STARTS ROTATING AROUND L THEN T AND W

FIGURE C-22. TEST RECORD FOR FRAGMENT NO. 22

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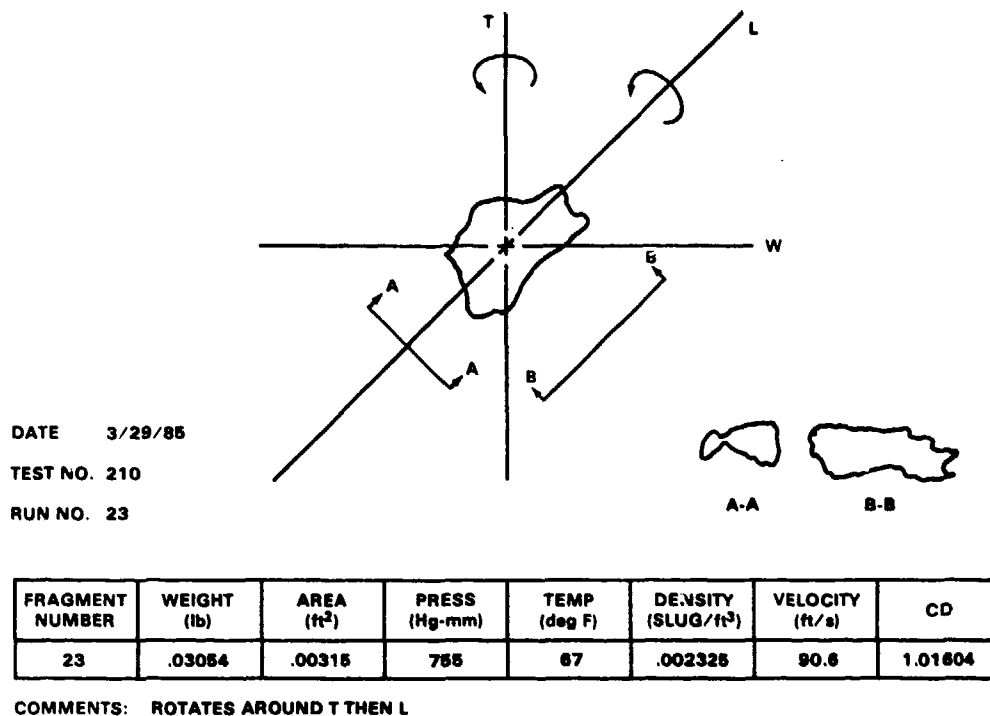


FIGURE C-23. TEST RECORD FOR FRAGMENT NO. 23

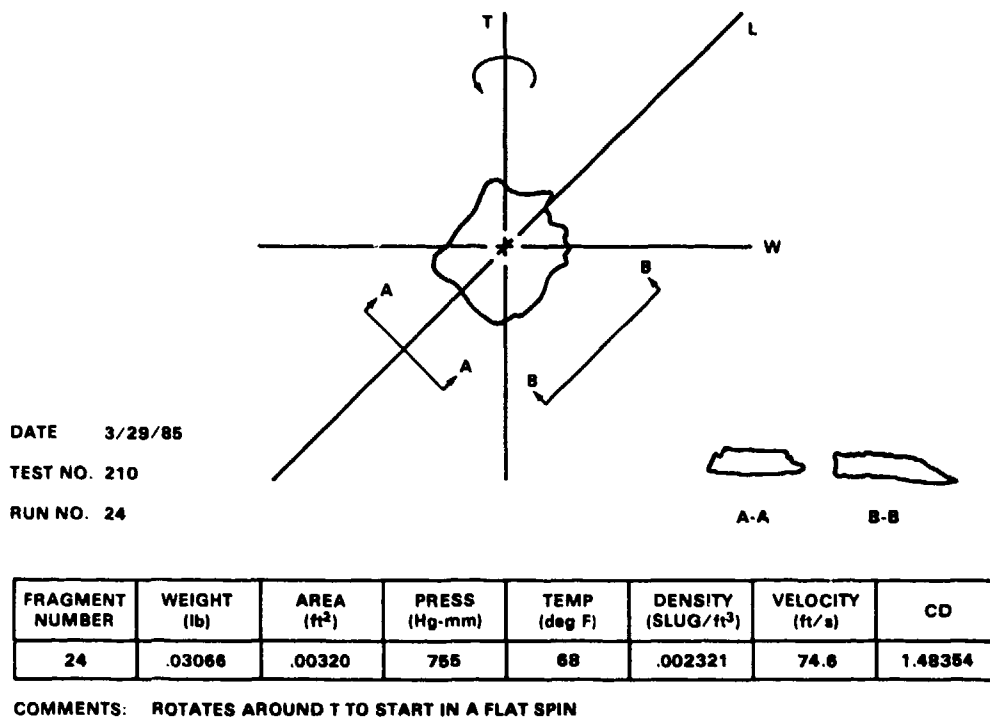
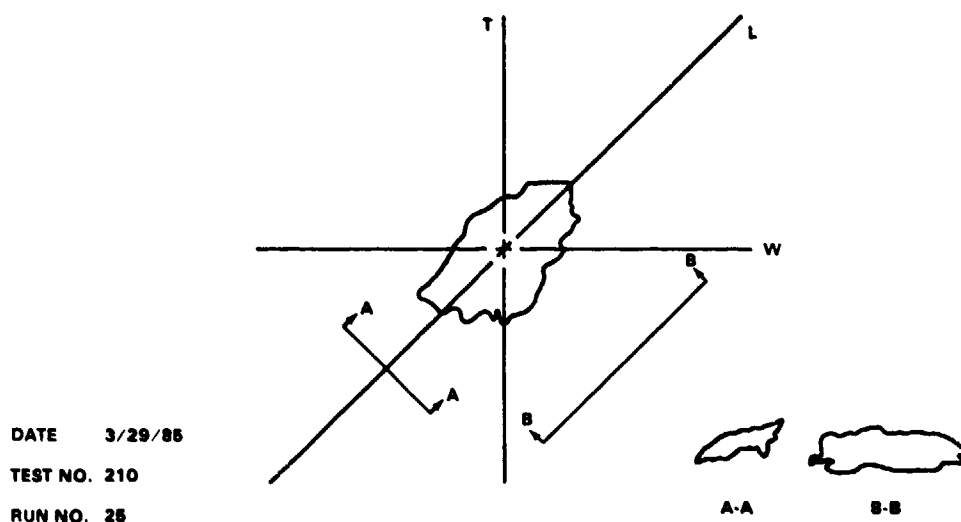


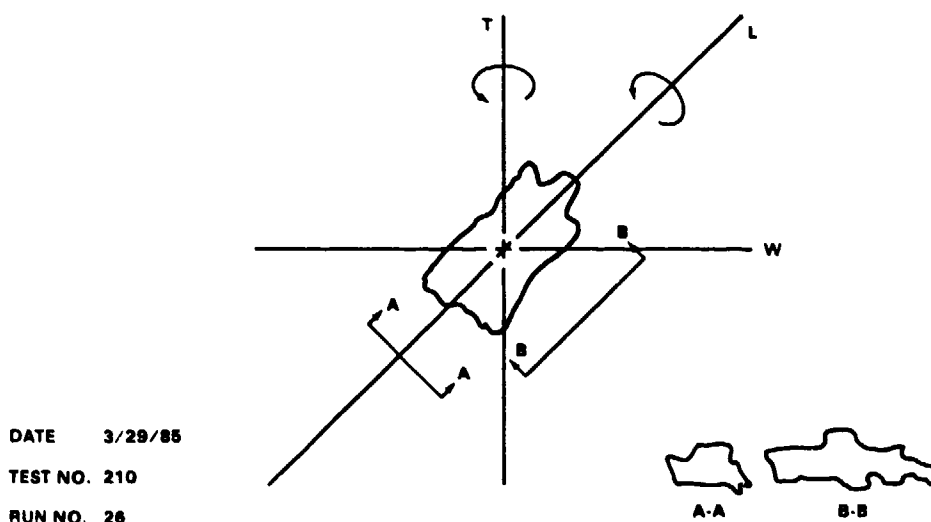
FIGURE C-24. TEST RECORD FOR FRAGMENT NO. 24



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
25	.03377	.0036779	755.2	66	.002331	77.8	1.30155

COMMENTS: FLAT ROTATION AROUND T

FIGURE C-25. TEST RECORD FOR FRAGMENT NO. 25



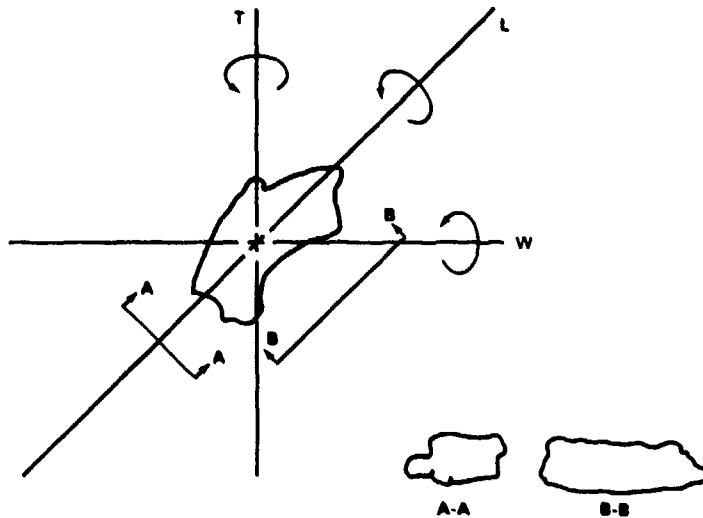
FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
26	.0342	.00376	755.1	66	.002330	81	1.18999

COMMENTS: FLAT SPIN AROUND T AND ALSO ROTATES AROUND THE L AXIS

FIGURE C-26. TEST RECORD FOR FRAGMENT NO. 26

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RUN NO. 27

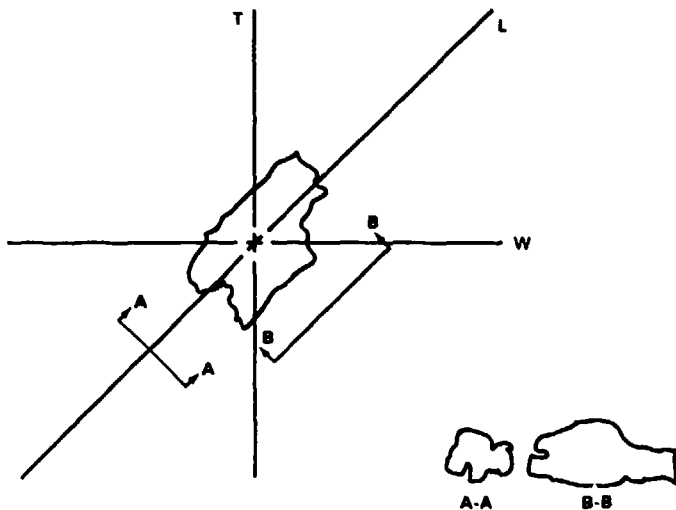


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
27	.03481	.00377	755.1	66	.002330	93.8	.89304

COMMENTS: ROTATES AROUND ALL 3 AXES

FIGURE C-27. TEST RECORD FOR FRAGMENT NO. 27

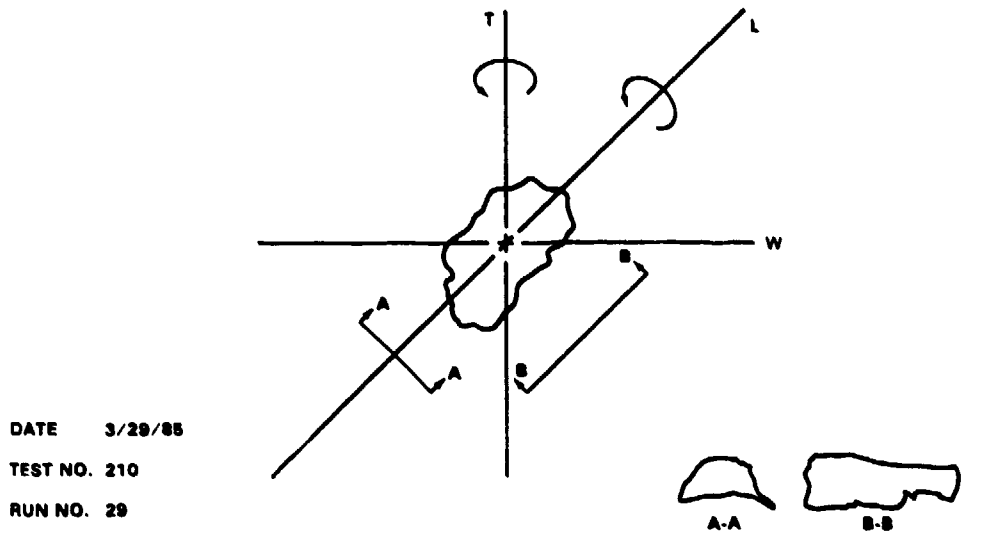
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TEST NO. 210
RUN NO. 28



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
28	.03497	.0037161	755.1	66	.002330	77.8	1.33462

COMMENTS: FLAT SPINNING AROUND T

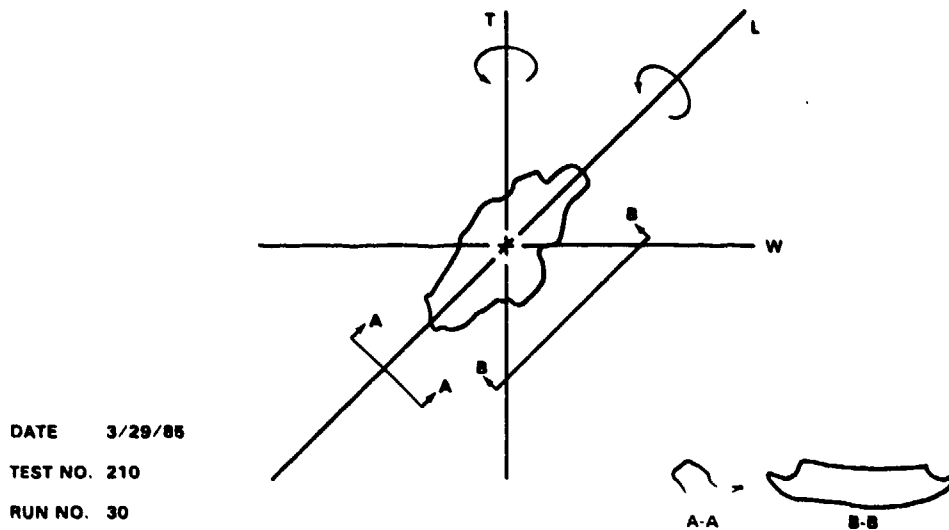
FIGURE C-28. TEST RECORD FOR FRAGMENT NO. 28



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
29	.03863	.00362	755.5	67	.002327	93.8	.95877

COMMENTS: ROTATES AROUND T AND L

FIGURE C-29. TEST RECORD FOR FRAGMENT NO. 29



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
30	.03844	.00357	755.5	67	.002327	84.2	1.23743

COMMENTS: ROTATES AROUND T AND L

FIGURE C-30. TEST RECORD FOR FRAGMENT NO. 30

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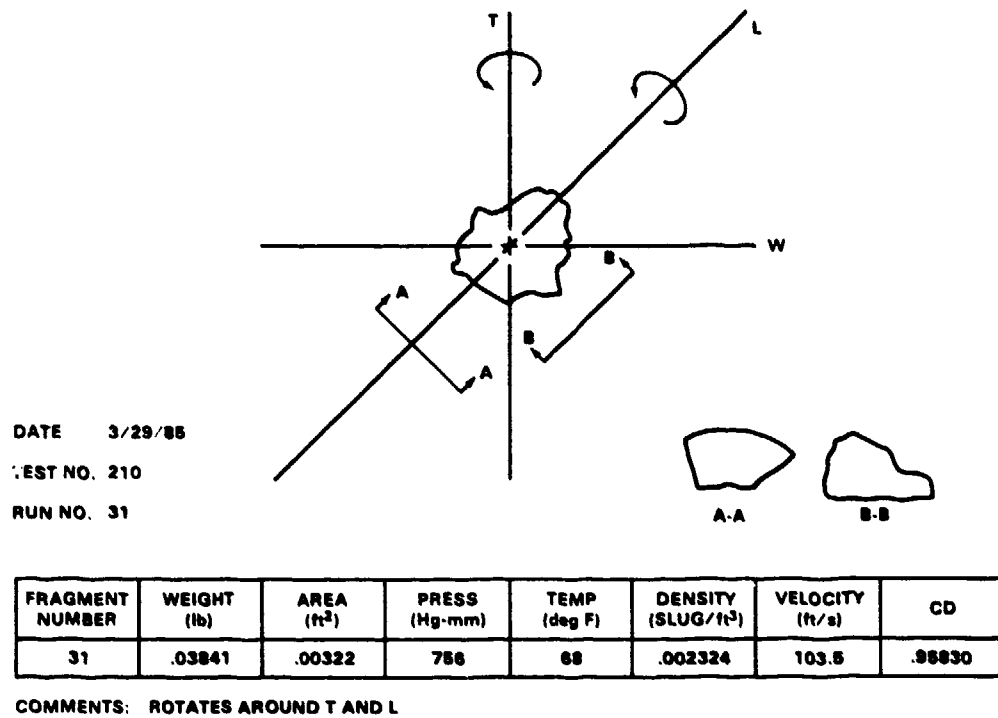


FIGURE C-31. TEST RECORD FOR FRAGMENT NO. 31

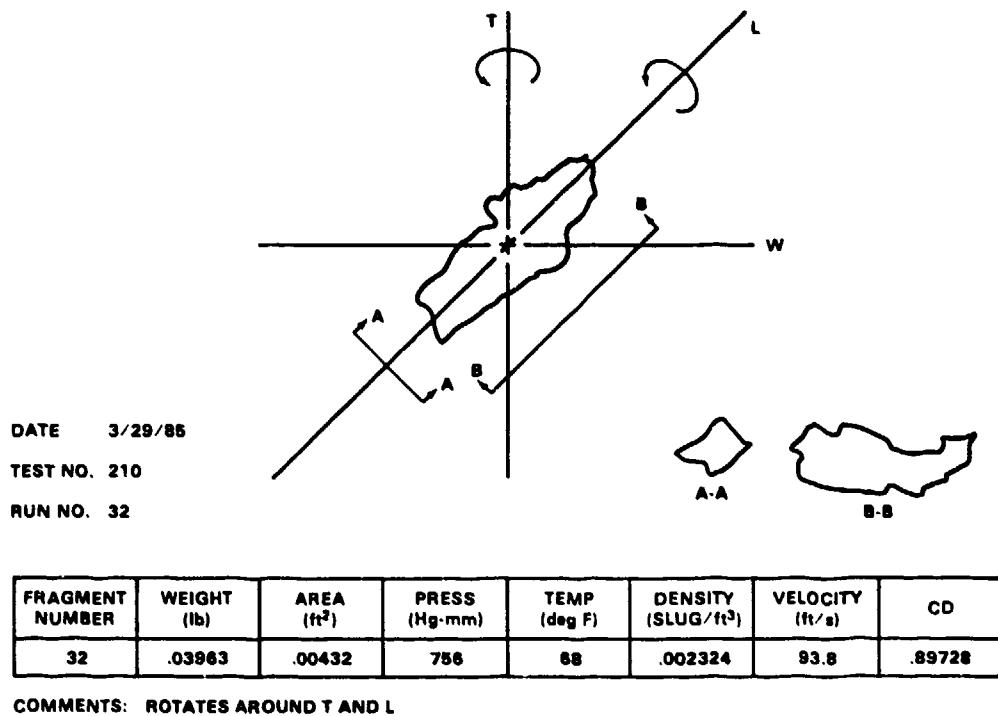


FIGURE C-32. TEST RECORD FOR FRAGMENT NO. 32

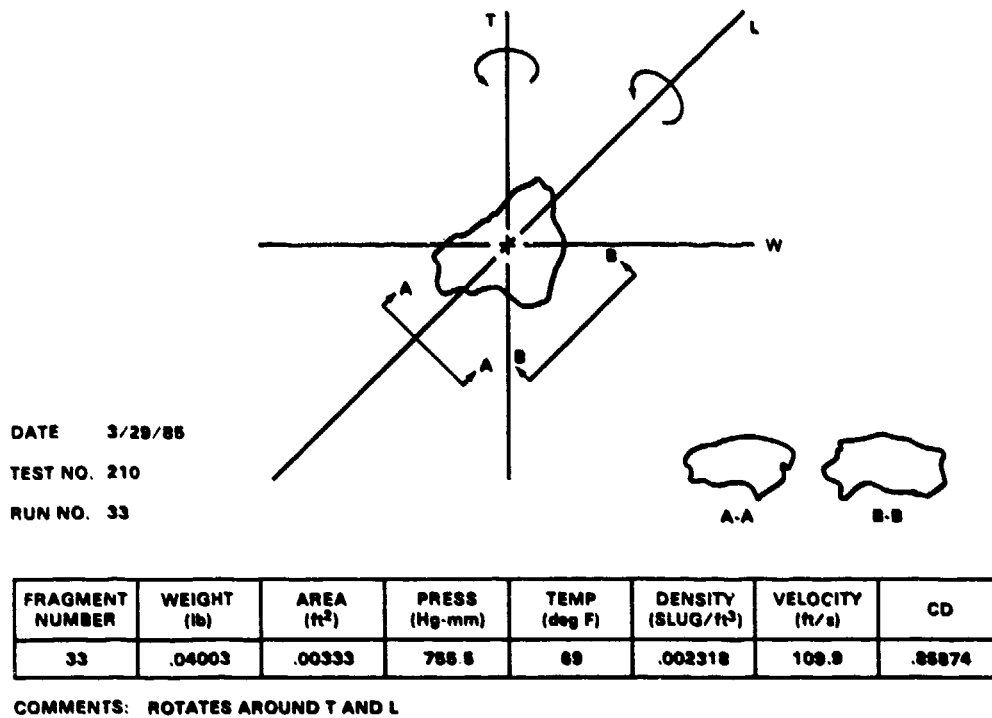


FIGURE C-33. TEST RECORD FOR FRAGMENT NO. 33

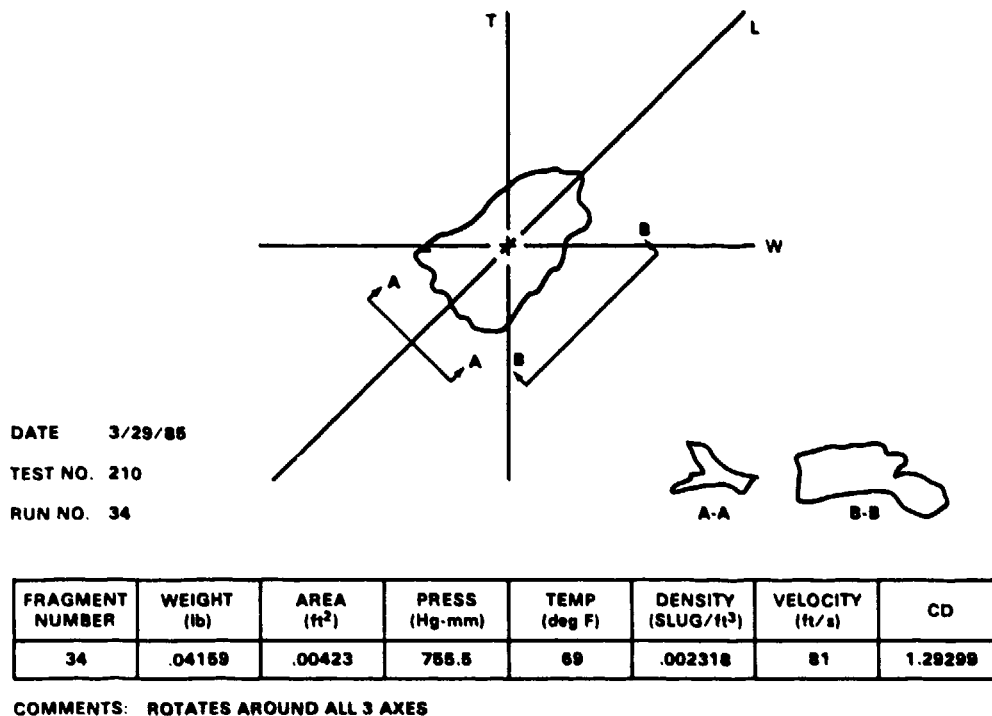


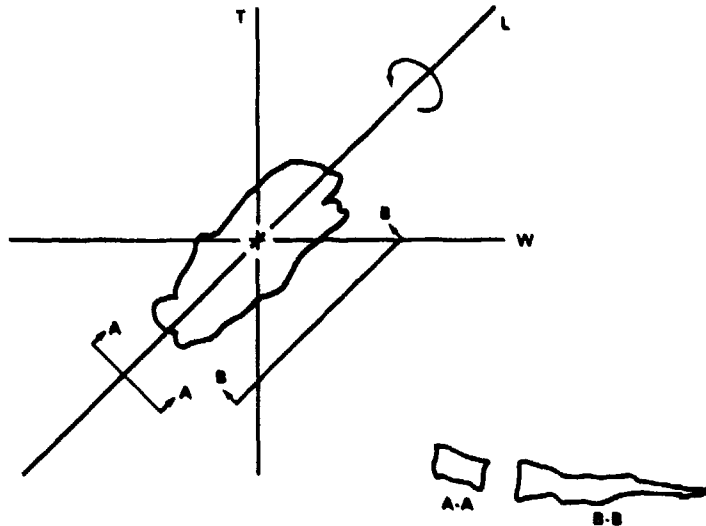
FIGURE C-34. TEST RECORD FOR FRAGMENT NO. 34

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RUN NO. 35



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
35	.04326	.00471	755.5	69	.002318	100.3	.78774

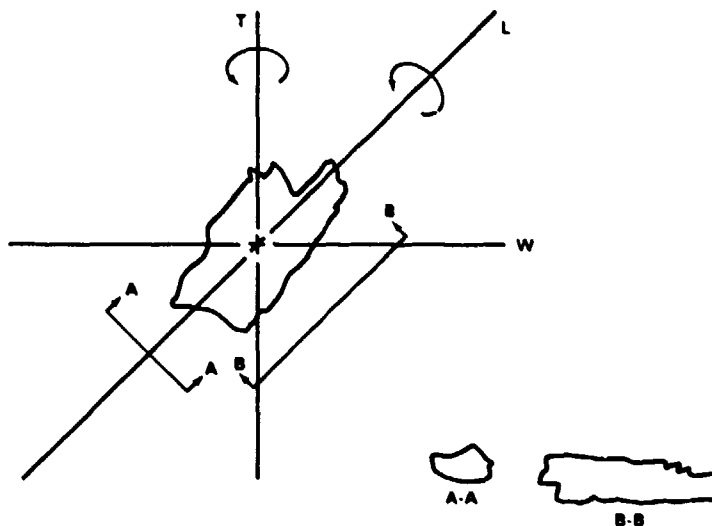
COMMENTS: STARTED OFF ROTATING AROUND L AND THEN WENT INTO ALL 3

FIGURE C-35. TEST RECORD FOR FRAGMENT NO. 35

DATE 3/29/85

TEST NO. 210

RUN NO. 36



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
36	.04354	.00427	755.5	71	.002309	87.4	1.15517

COMMENTS: ROTATES AROUND T AND L

FIGURE C-36. TEST RECORD FOR FRAGMENT NO. 36

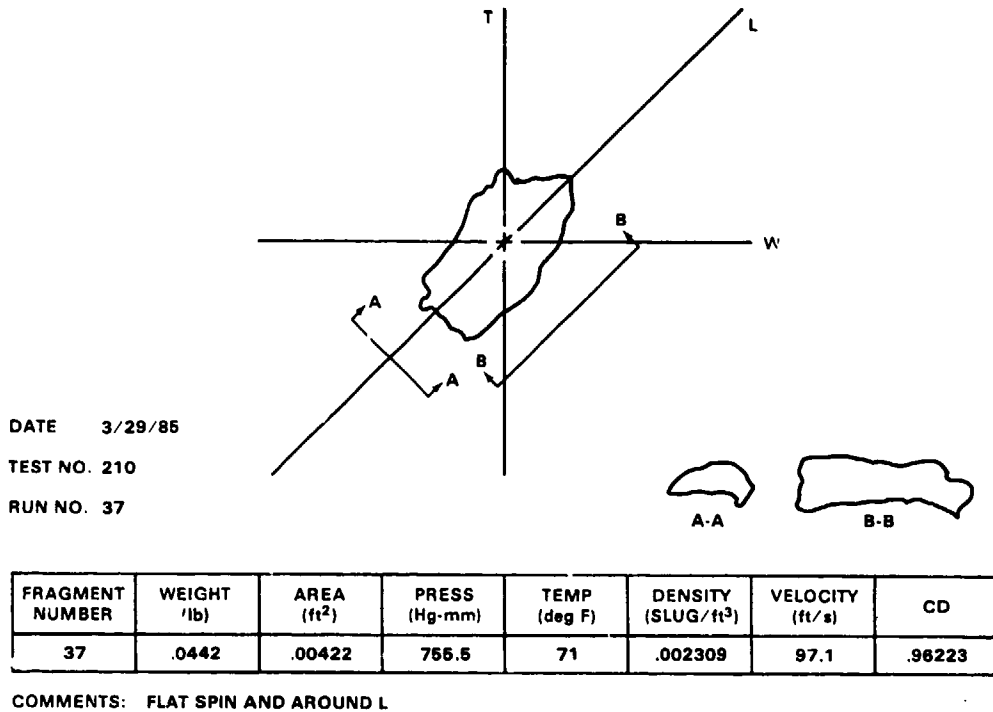


FIGURE C-37. TEST RECORD FOR FRAGMENT NO. 37

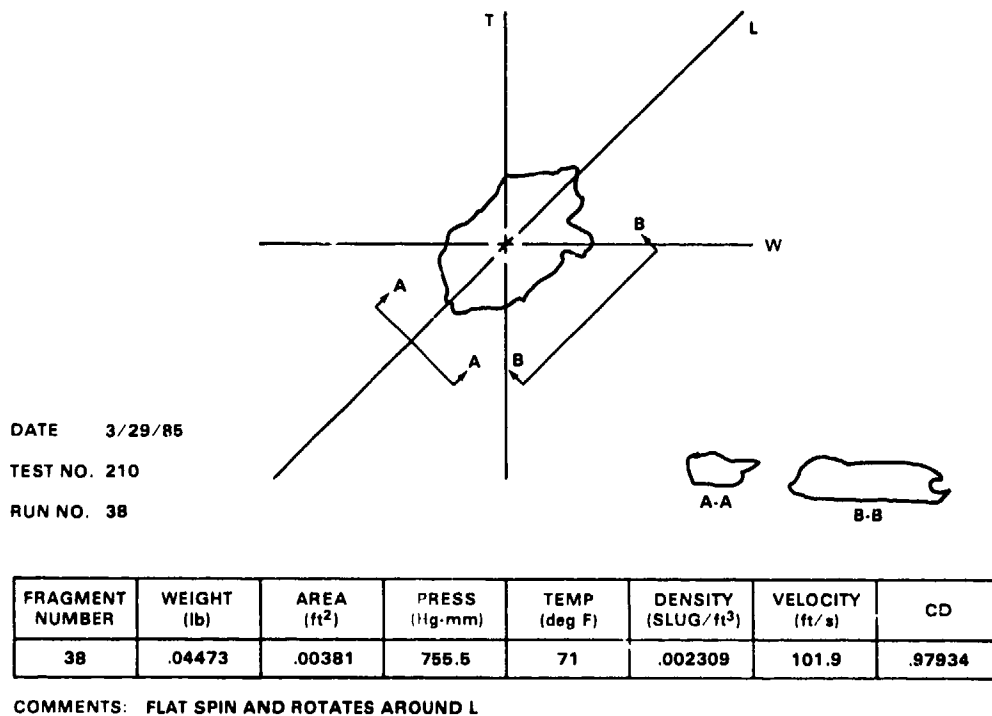
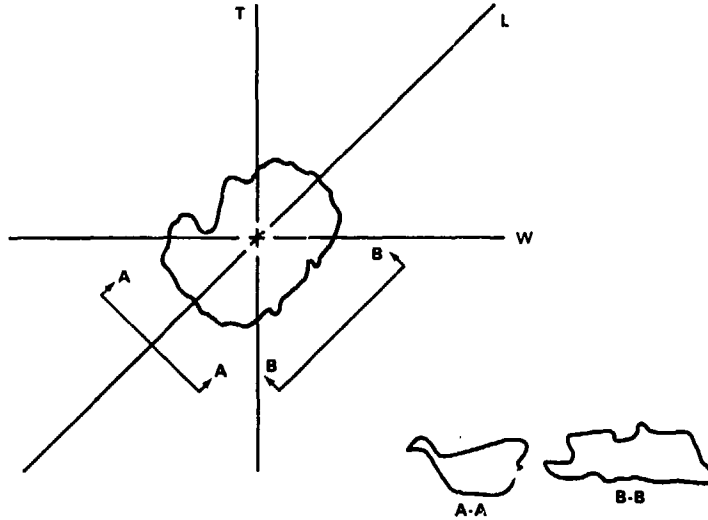


FIGURE C-38. TEST RECORD FOR FRAGMENT NO. 38

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TEST NO. 210

RUN NO. 39



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
39	.04627	.00495	755	72	.002304	97.1	.86060

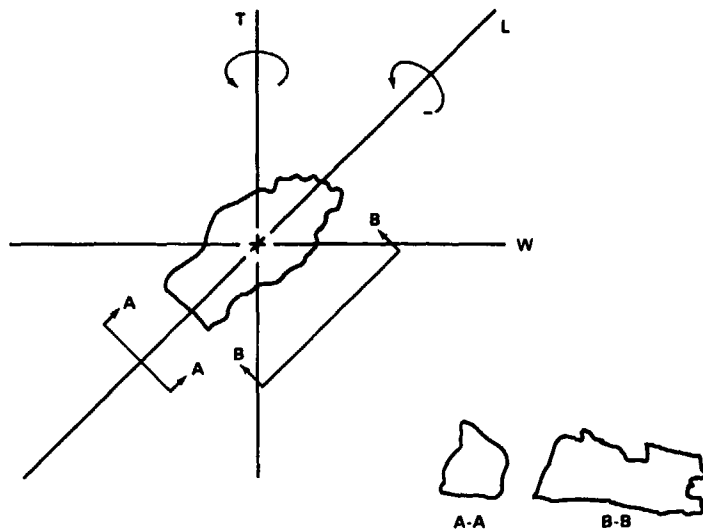
COMMENTS: ROTATES AROUND ALL AXES

FIGURE C-39. TEST RECORD FOR FRAGMENT NO. 39

DATE 3/29/86

TEST NO. 210

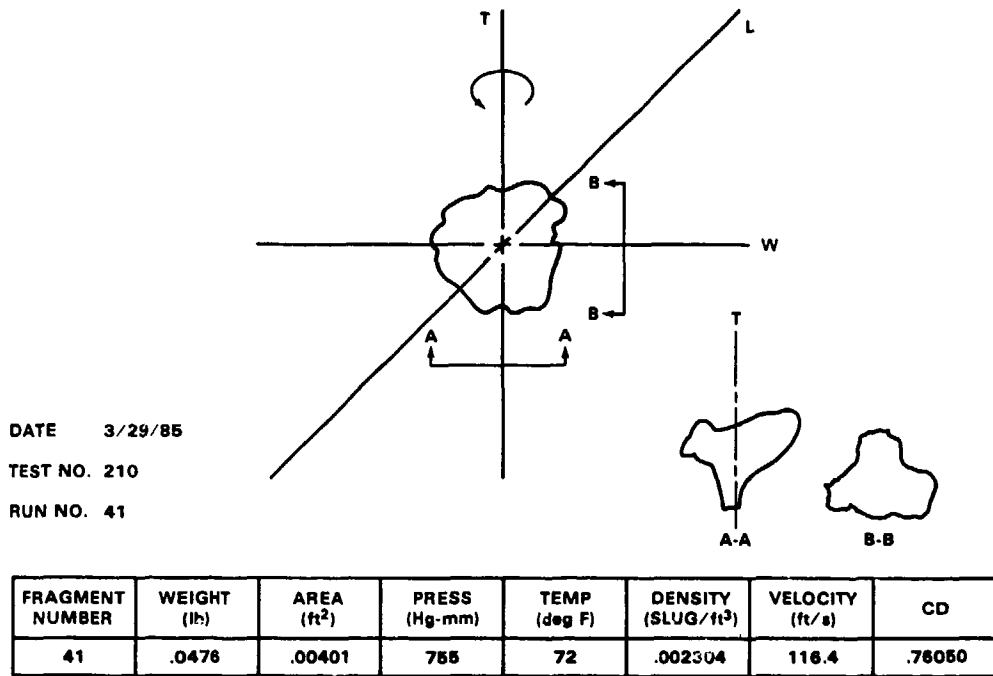
RUN NO. 40



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
40	.04653	.00434	755	72	.002304	106.7	.81745

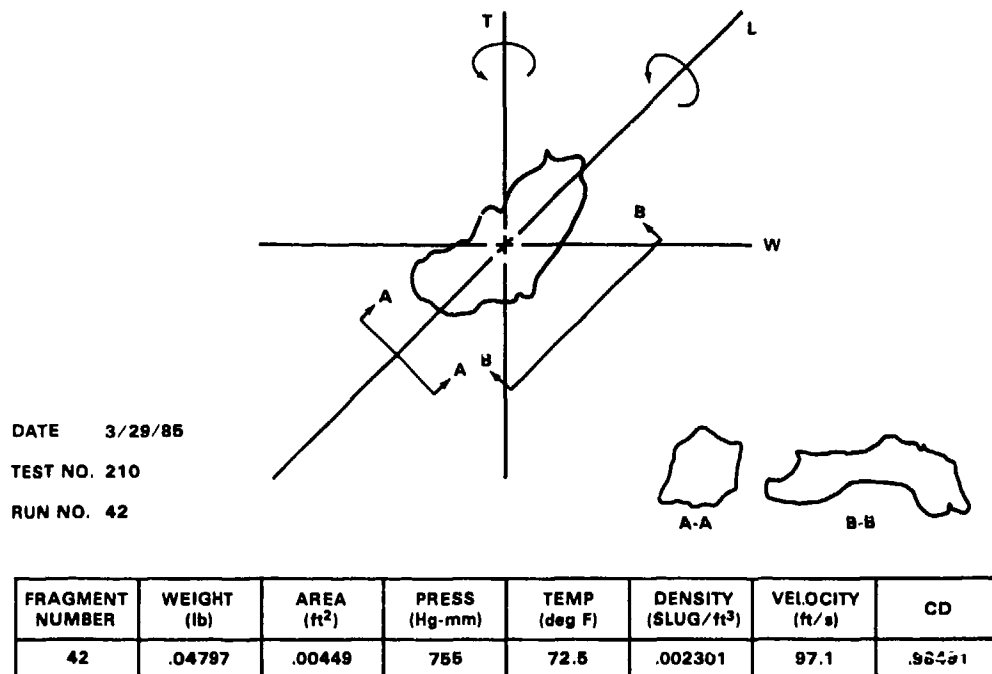
COMMENTS: ROTATES AROUND T AND L AND THEN CONING

FIGURE C-40. TEST RECORD FOR FRAGMENT NO. 40



COMMENTS: ROTATES AROUND T, SPINS LIKE A TOP EITHER AS SHOWN OR INVERTED

FIGURE C-41. TEST RECORD FOR FRAGMENT NO. 41



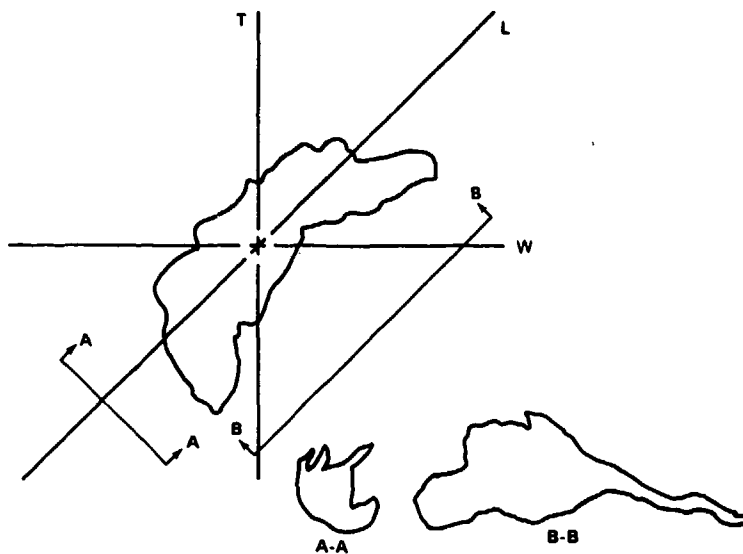
COMMENTS: ROTATES AROUND T AND L AND CONING

FIGURE C-42. TEST RECORD FOR FRAGMENT NO. 42

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TEST NO. 210

RUN NO. 43



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
43	.0504	.00705	755	74	.002295	81	.94955

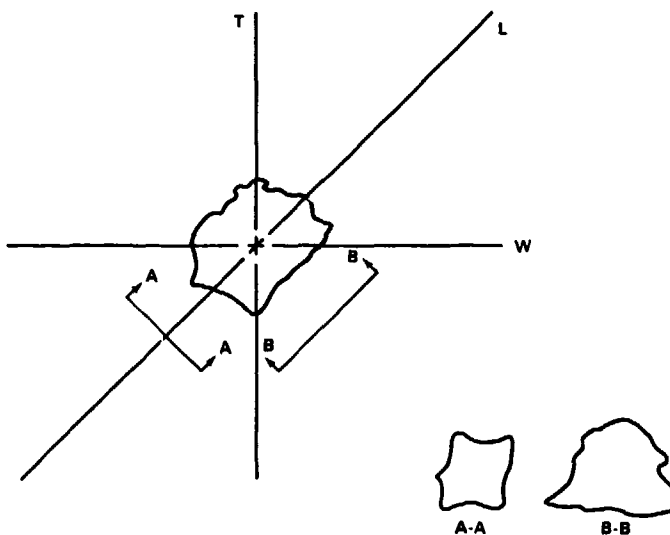
COMMENTS: ROTATES AROUND ALL 3 AXES - CHANGES FROM ONE TO ANOTHER WHEN IT CONTACTS THE

FIGURE C-43. TEST RECORD FOR FRAGMENT NO. 43

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TEST NO. 210

RUN NO. 44



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
44	.05057	.00383	755	74	.002295	125	.72477

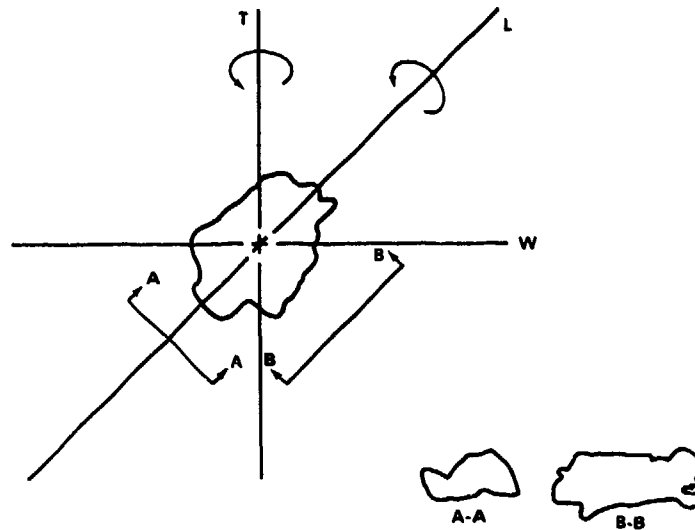
COMMENTS: ACTS LIKE FRAGMENT NO. 3 (CUBE) ROTATES AROUND ALL 3

FIGURE C-44. TEST RECORD FOR FRAGMENT NO. 44

DATE 3/29/85

TEST NO. 210

RUN NO. 45



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
45	.0507	.00409	755	74	.002295	116.4	.79731

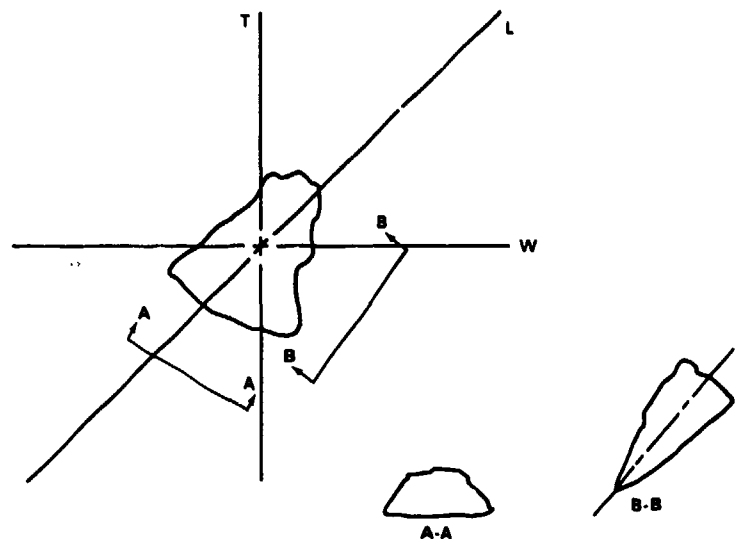
COMMENTS: ROTATES AROUND T AND L

FIGURE C-45. TEST RECORD FOR FRAGMENT NO. 45

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TEST NO. 210

RUN NO. 46



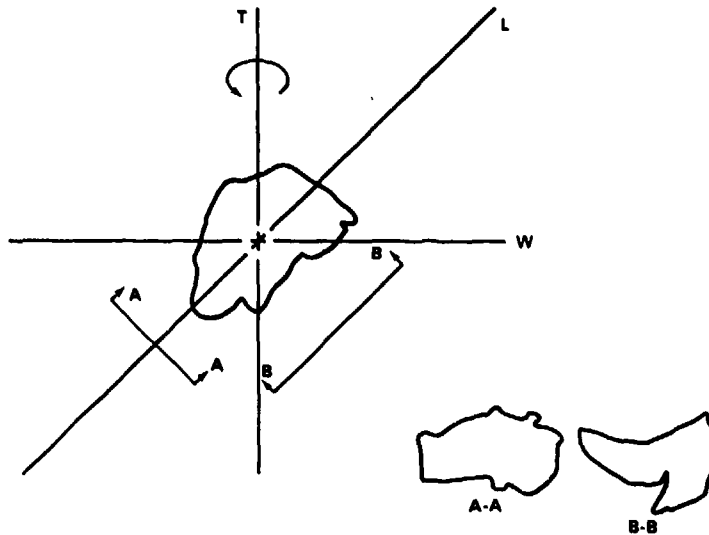
FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
46	.05113	.00443	755	74	.002295	109.9	.83277

COMMENTS: ROTATES AROUND L

FIGURE C-46. TEST RECORD FOR FRAGMENT NO. 46

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TEST NO. 210
RUN NO. 47

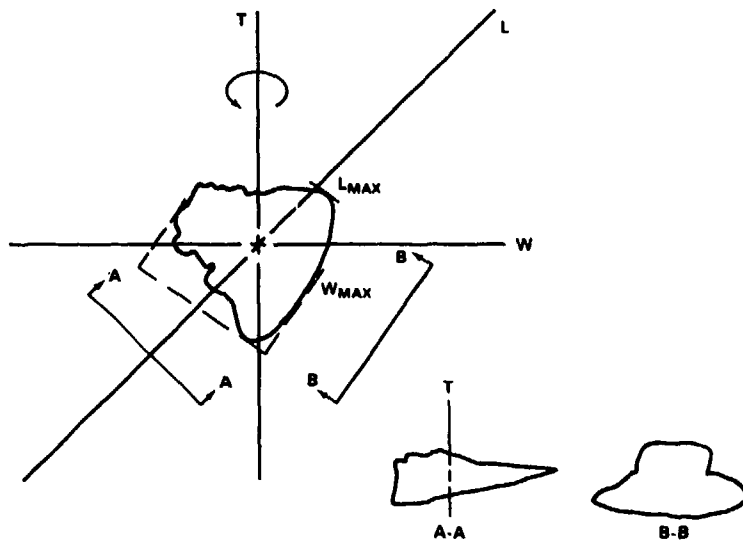


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
47	.05131	.00439	755	74	.002296	108.3	.86842

COMMENTS: FLAT SPIN AROUND T, THEN TUMBLES

FIGURE C-47. TEST RECORD FOR FRAGMENT NO. 47

DATE 3/29/85
TEST NO. 210
RUN NO. 48



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
48	.05146	.00471	755.2	74	.002296	95.5	1.04352

COMMENTS: ROTATES AROUND T

FIGURE C-48. TEST RECORD FOR FRAGMENT NO. 48

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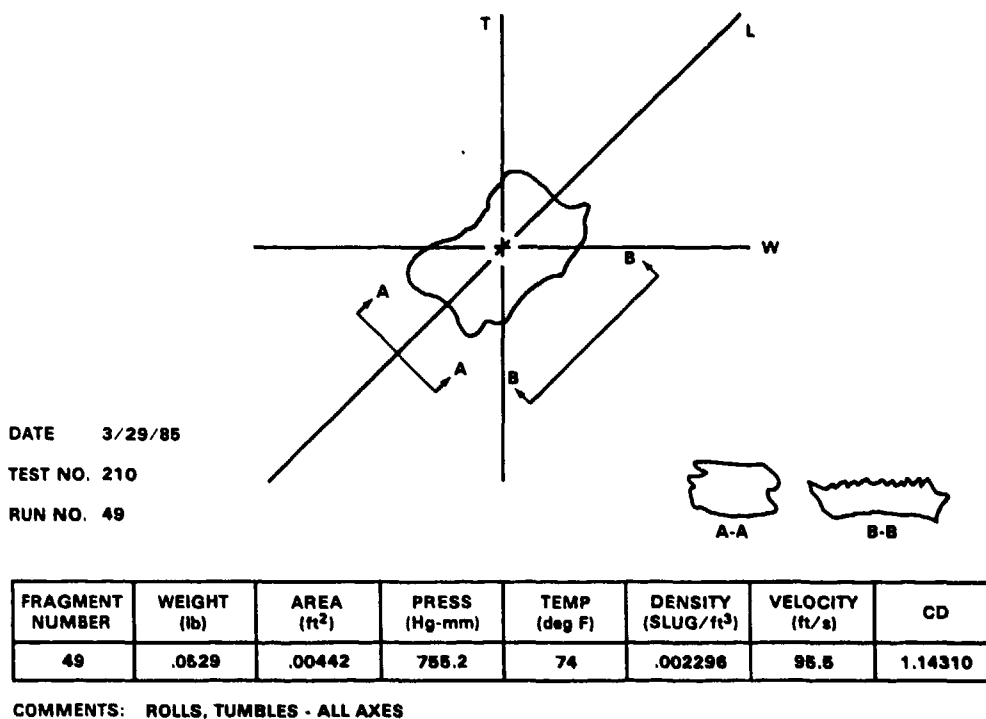


FIGURE C-49. TEST RECORD FOR FRAGMENT NO. 49

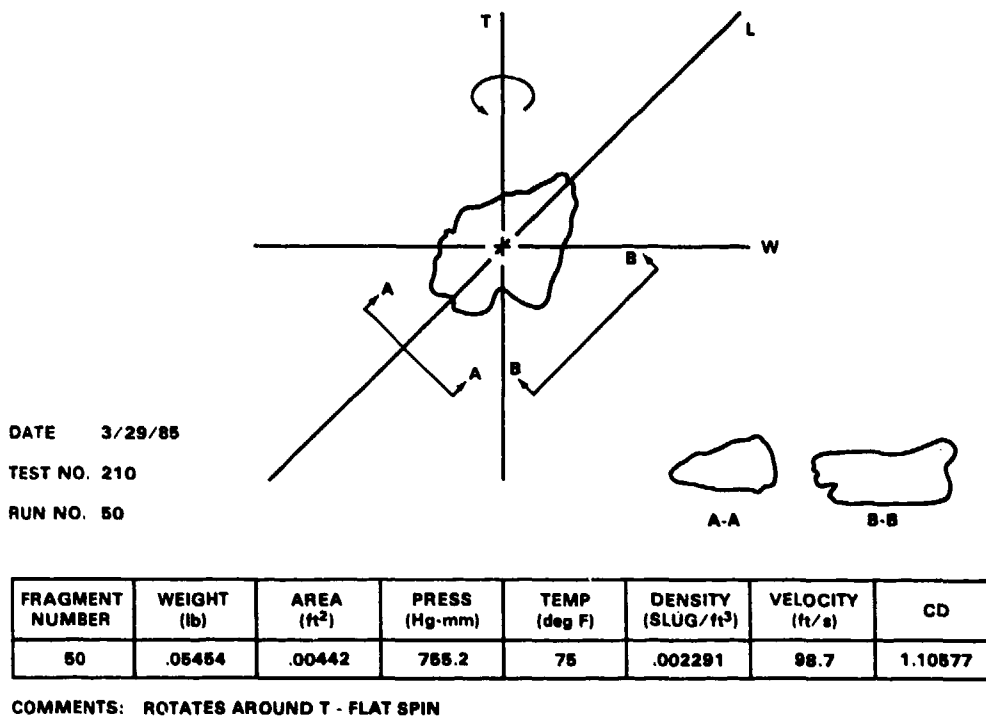
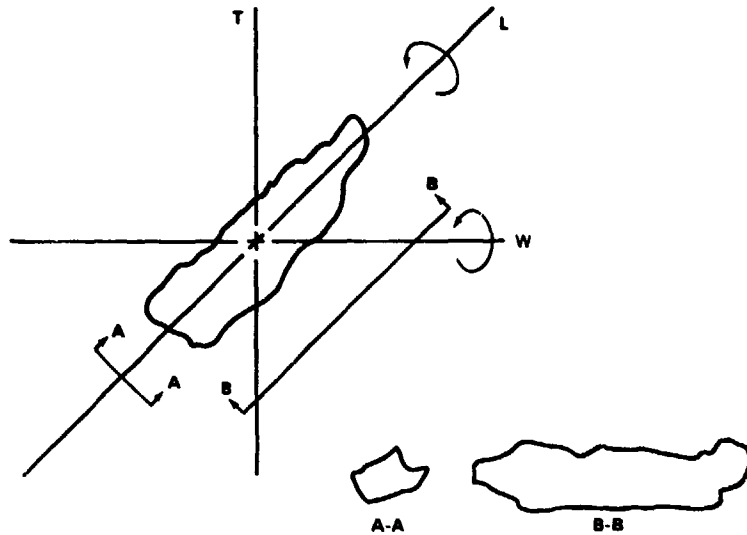


FIGURE C-50. TEST RECORD FOR FRAGMENT NO. 50

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DATE 4/1/85
TEST NO. 210
RUN NO. 51

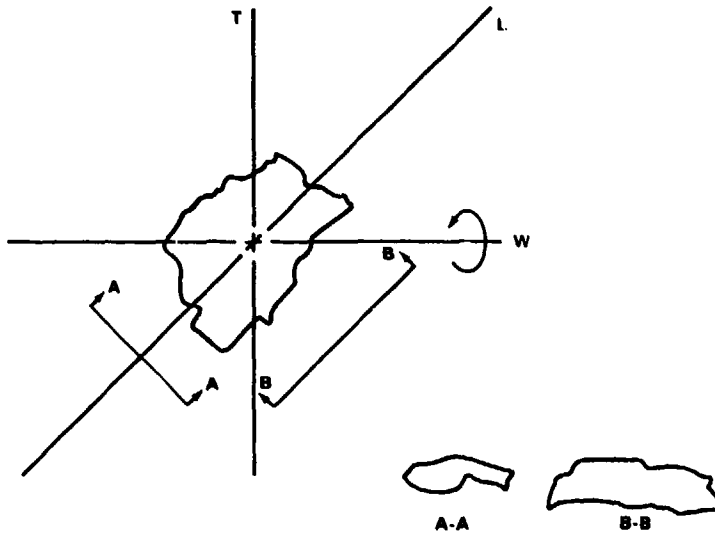


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
51	.05574	.00543	752.5	54	.002376	90.6	1.05268

COMMENTS: ROTATES AROUND L AND W AND CONING

FIGURE C-51. TEST RECORD FOR FRAGMENT NO. 51

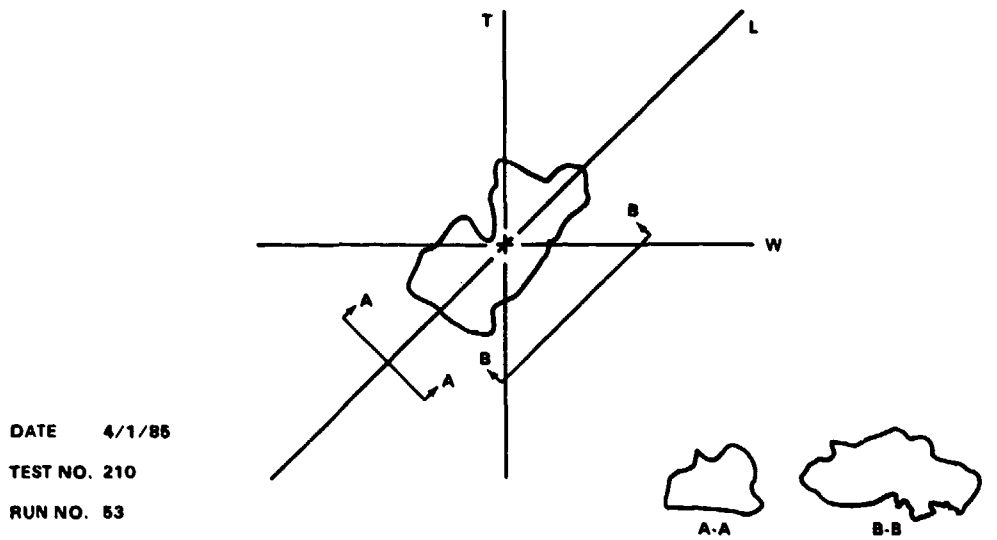
DATE 4/1/85
TEST NO. 210
RUN NO. 52



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
52	.05619	.00532	752.5	54	.002376	87.4	1.16388

COMMENTS: FLAT SPIN

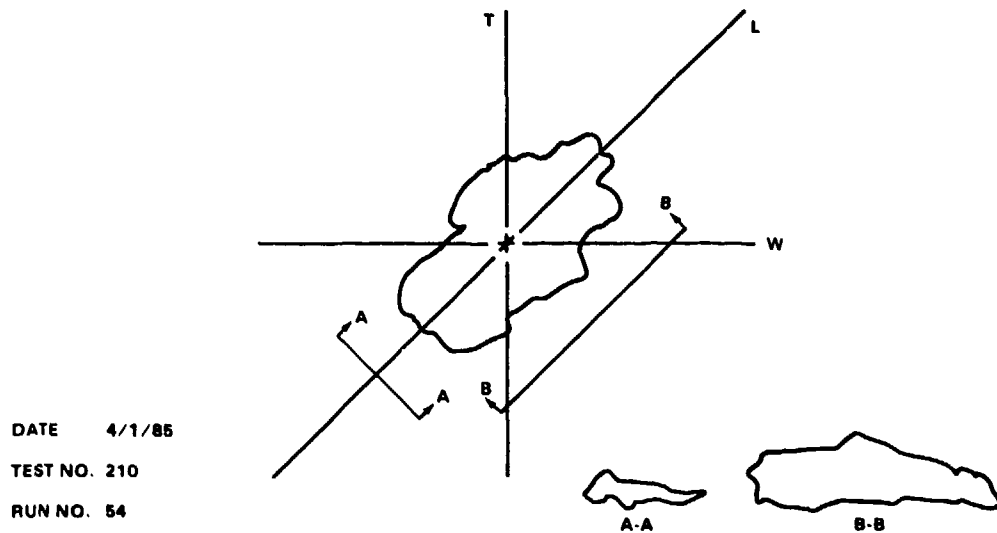
FIGURE C-52. TEST RECORD FOR FRAGMENT NO. 52



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
53	.05644	.00520	752.5	54	.002376	109.9	.75644

COMMENTS: ROTATES AROUND ALL AXES AND TUMBLES

FIGURE C-53. TEST RECORD FOR FRAGMENT NO. 53



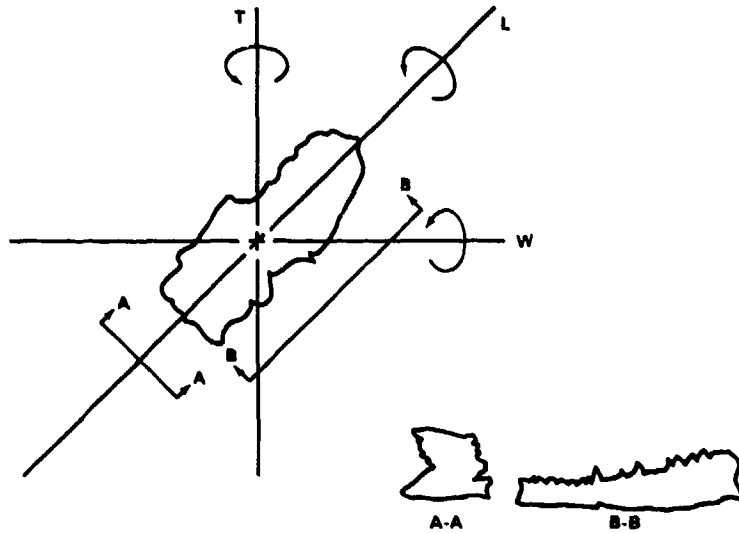
FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
54	.0578	.00667	752.5	54	.002376	81	1.11177

COMMENTS: FLUTTERS LIKE A FALLING LEAF

FIGURE C-54. TEST RECORD FOR FRAGMENT NO. 54

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DATE 4/1/85
TEST NO. 210
RUN NO. 55

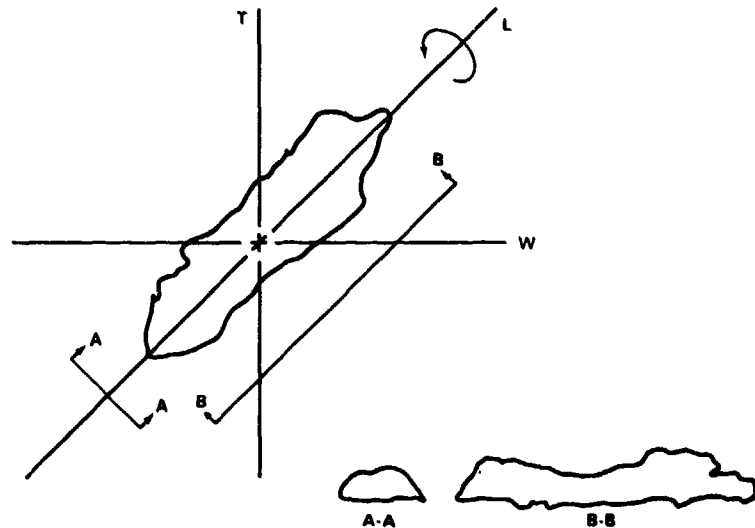


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
55	.06181	.00588	752.5	54	.002376	100.3	.87956

COMMENTS: ALL AXES - TUMBLES

FIGURE C-55. TEST RECORD FOR FRAGMENT NO. 55

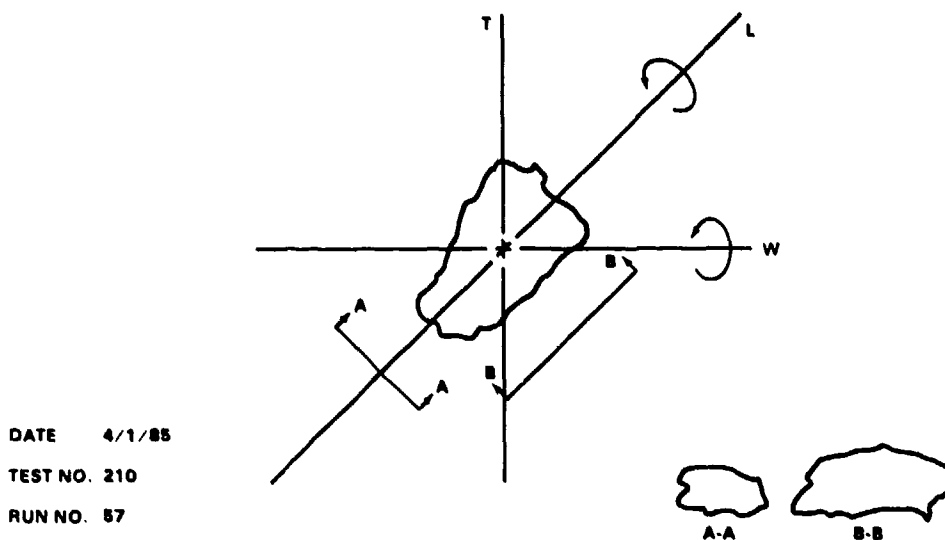
DATE 4/1/85
TEST NO. 210
RUN NO. 56



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
56	.06513	.00649	752.5	54	.002376	90.6	1.02911

COMMENTS: ROTATES AROUND L AND FLOATS MOTIONLESS

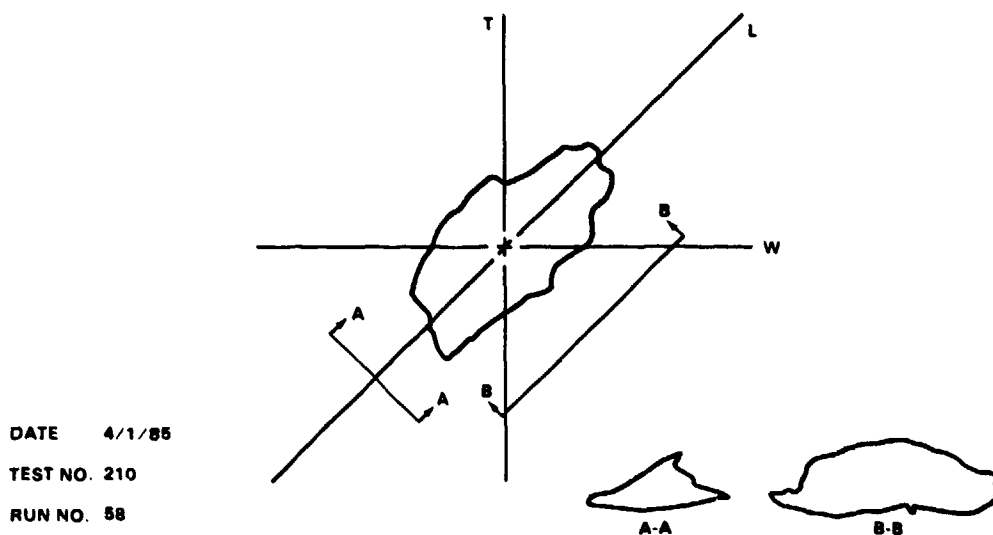
FIGURE C-56. TEST RECORD FOR FRAGMENT NO. 56



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
57	.06596	.00510	752.5	54	.002376	118.0	.78186

COMMENTS: ROTATES AROUND L AND W AND TUMBLES

FIGURE C-57. TEST RECORD FOR FRAGMENT NO. 57

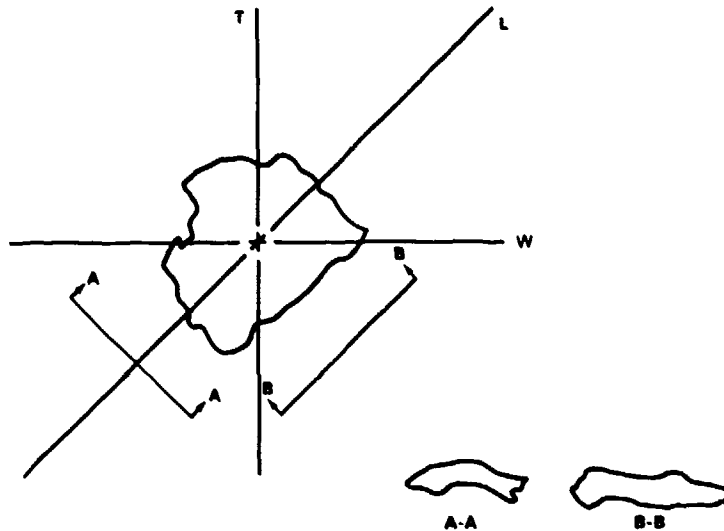


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
58	.0664	.00607	752.5	54	.002376	90.6	1.12178

COMMENTS: WITH THE FLAT SIDE DOWN AS SHOWN IN A-A - THE FRAG FLOATS; WITH THE FLAT SIDE UP (OR ON TOP) THE FRAG DOES A FLAT SPIN

FIGURE C-58. TEST RECORD FOR FRAGMENT NO. 58

DATE 4/1/85
TEST NO. 210
RUN NO. 59

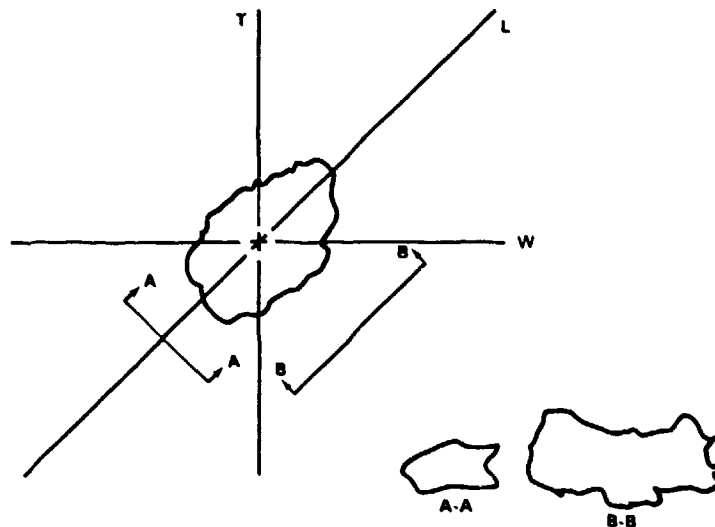


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
59	.06903	.00642	752.5	54	.002376	93.8	1.02868

COMMENTS: ROTATES AROUND T AND L AND FLAT SPIN

FIGURE C-59. TEST RECORD FOR FRAGMENT NO. 59

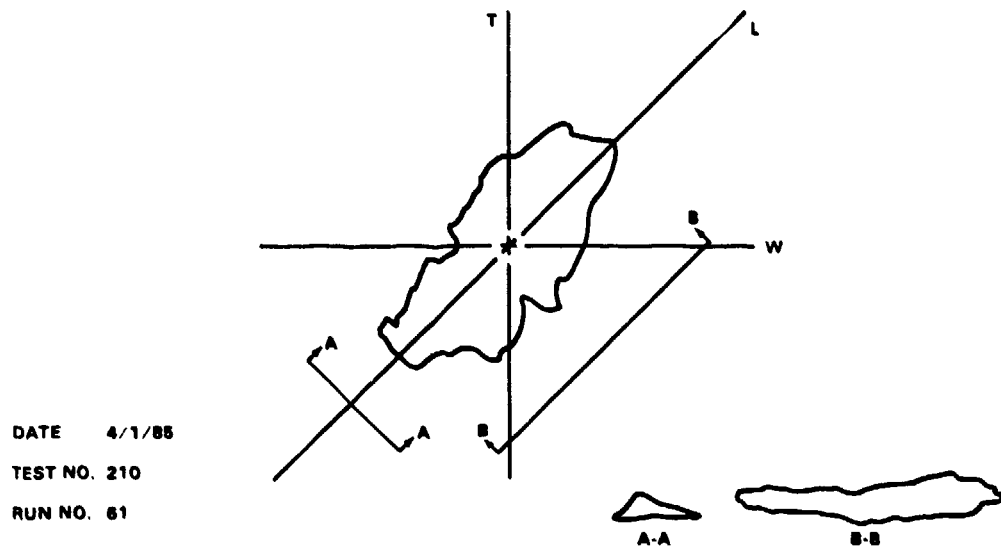
DATE 4/1/85
TEST NO. 210
RUN NO. 60



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
60	.06916	.00507	752.5	54	.002376	113.1	.8976

COMMENTS: ROTATES AROUND T - FLAT SPIN

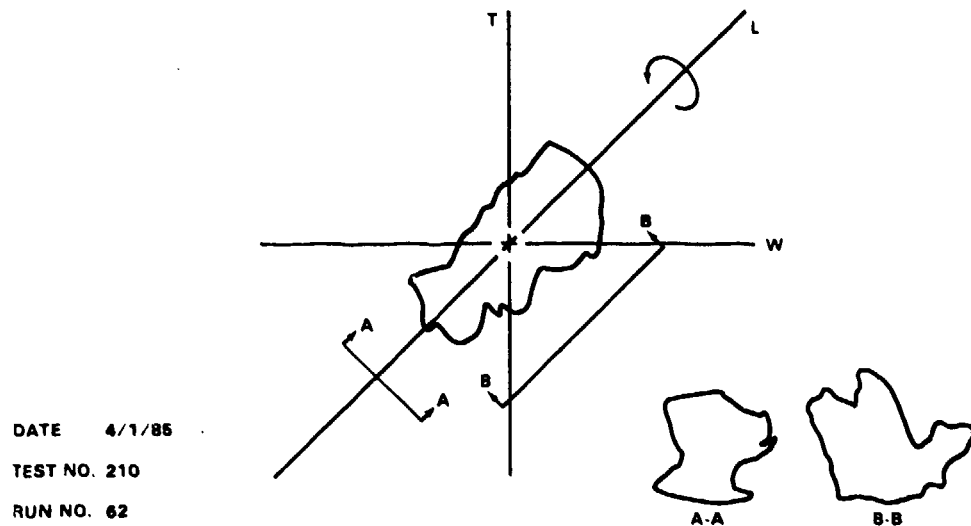
FIGURE C-60. TEST RECORD FOR FRAGMENT NO. 60



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
61	.06953	.00716	752.5	55	.002372	92.2	.96319

COMMENTS: ROTATES AROUND ALL 3 AXES AND FLAT

FIGURE C-61. TEST RECORD FOR FRAGMENT NO. 61



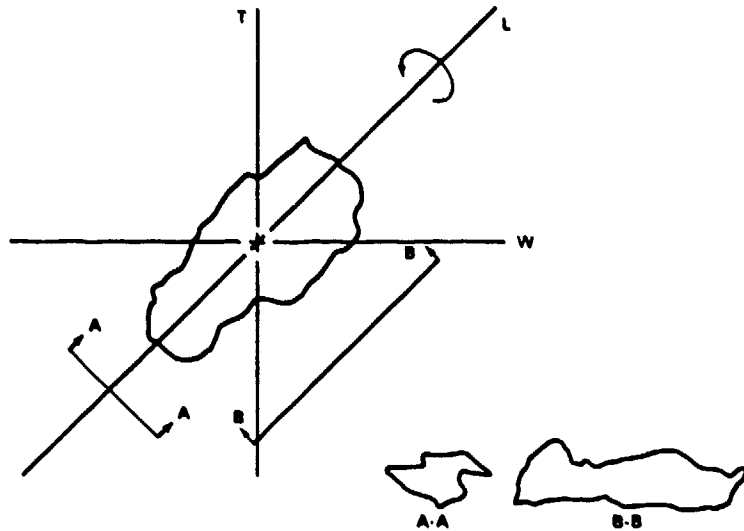
FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
62	.0699	.00597	752.5	55	.002372	116.4	.72864

COMMENTS: ROTATES AROUND L AND GOOD TUMBLE

FIGURE C-62. TEST RECORD FOR FRAGMENT NO. 62

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DATE 4/1/85
TEST NO. 210
RUN NO. 63

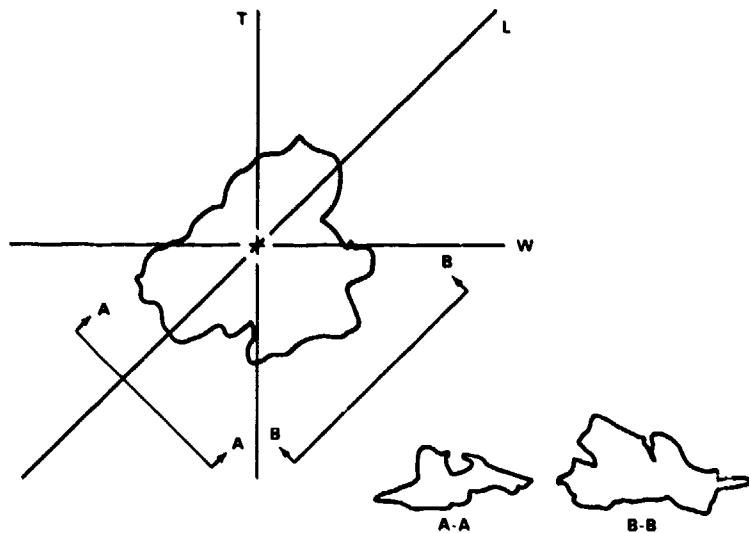


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
63	.07013	.00643	752.5	55	.002372	103.5	.85847

COMMENTS: FLAT SPIN OR TUMBLE

FIGURE C-63. TEST RECORD FOR FRAGMENT NO. 63

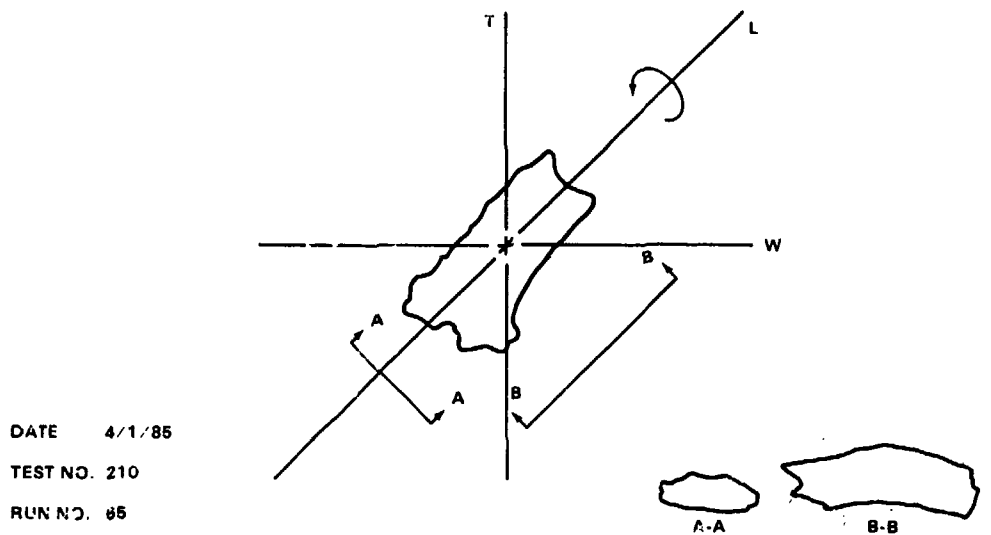
DATE 4/1/85
TEST NO. 210
RUN NO. 64



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
64	.07073	.00797	752.5	55	.002372	92.2	.88024

COMMENTS: WILL FLOAT OR TUMBLE

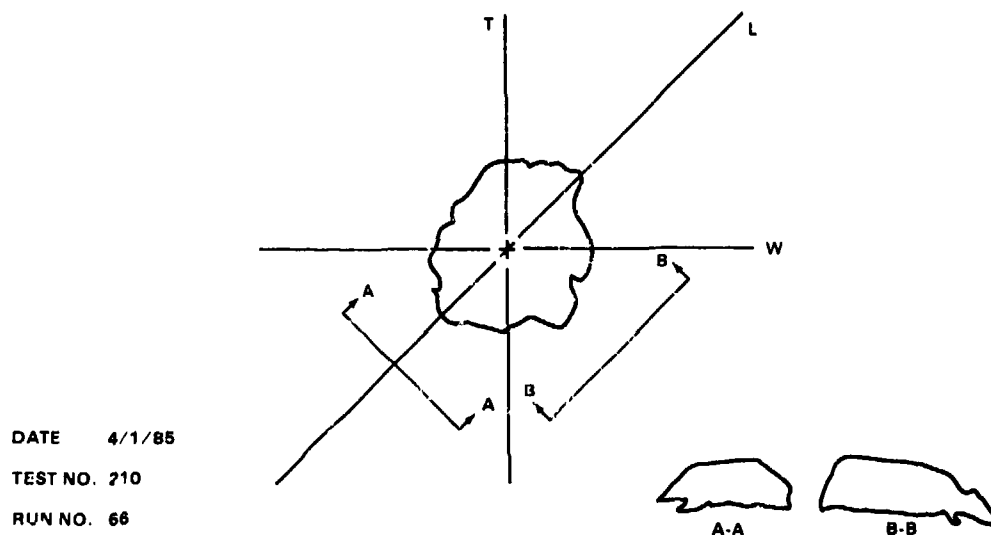
FIGURE C-64. TEST RECORD FOR FRAGMENT NO. 64



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
65	.07214	.00552	752.5	55	.002372	113.	.86144

COMMENTS: WILL FLOAT MOTIONLESS OR TUMBLE

FIGURE C-65. TEST RECORD FOR FRAGMENT NO. 65

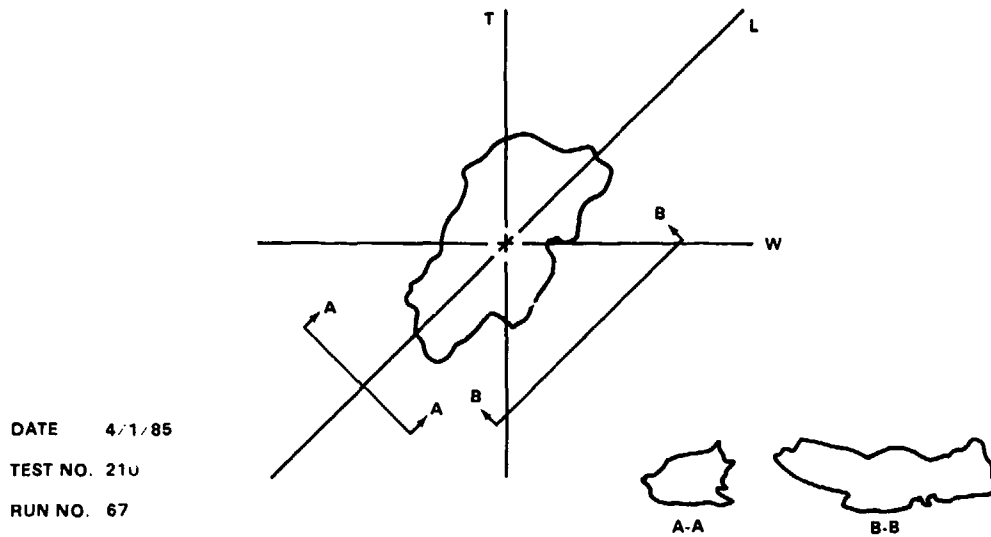


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
66	.07423	.00588	752.5	56	.002367	100.3	1.08031

COMMENTS: FLOAT - SLOW OR NO ROTATION AROUND THE T AXIS

FIGURE C-66. TEST RECORD FOR FRAGMENT NO. 66

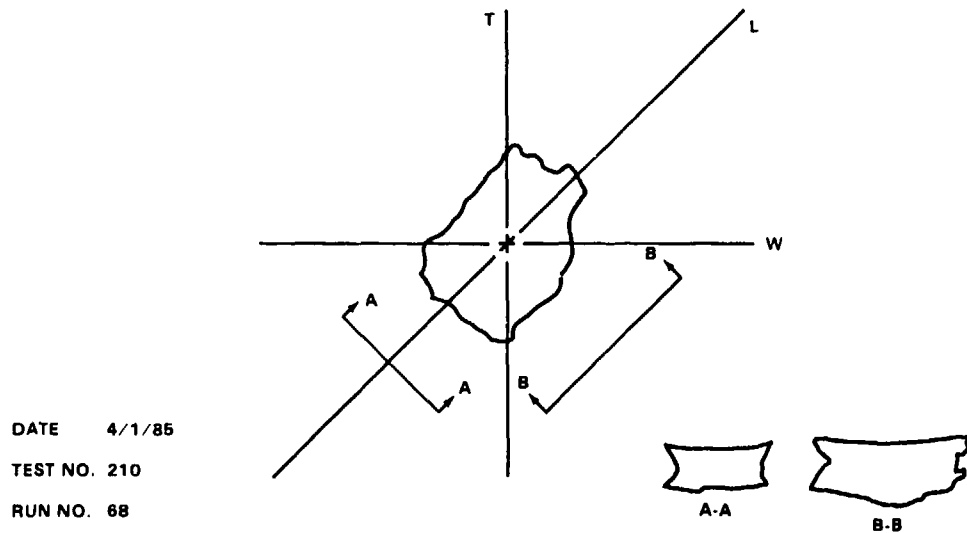
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FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
67	.07599	.0067382	752.5	56	.002367	101.9	.91769

COMMENTS: FLAT SPIN OR WILL FLOAT

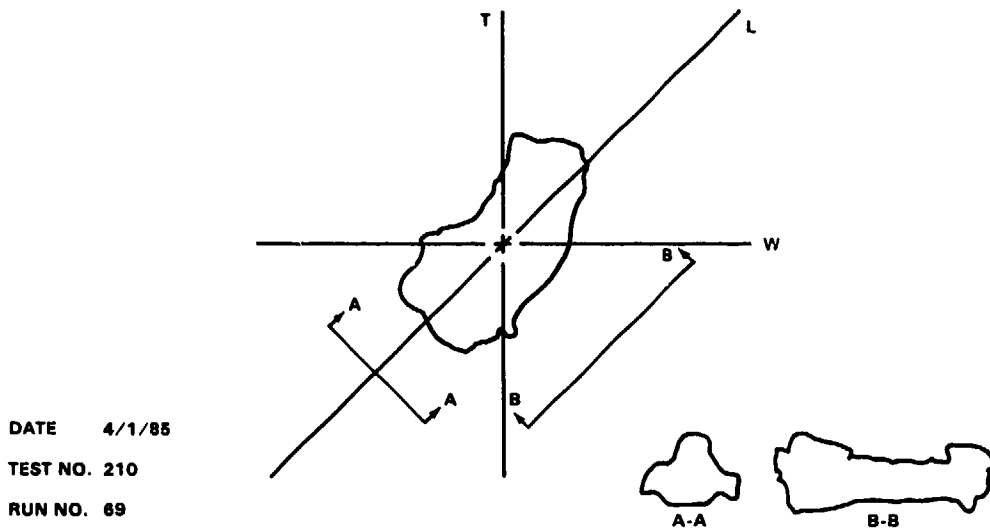
FIGURE C-67. TEST RECORD FOR FRAGMENT NO. 67



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
68	.07827	.00595	752.3	58	.002357	109.9	.92417

COMMENTS: WILL FLOAT MOTIONLESS OR GO INTO A FLAT SPIN

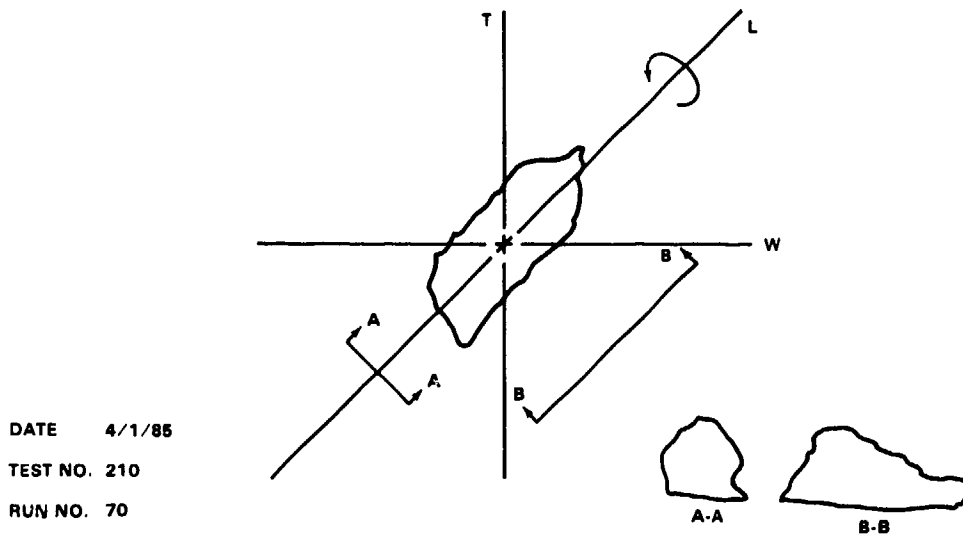
FIGURE C-68. TEST RECORD FOR FRAGMENT NO. 68



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
69	.07946	.00639	752.3	58	.002357	109.9	.87362

COMMENTS: WILL TUMBLE AND CONING AROUND L AXIS

FIGURE C-69. TEST RECORD FOR FRAGMENT NO. 69



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
70	.08017	.00621	752.3	58	.002357	135.6	.71011

COMMENTS: ROTATES AROUND L AXIS AND TUMBLES

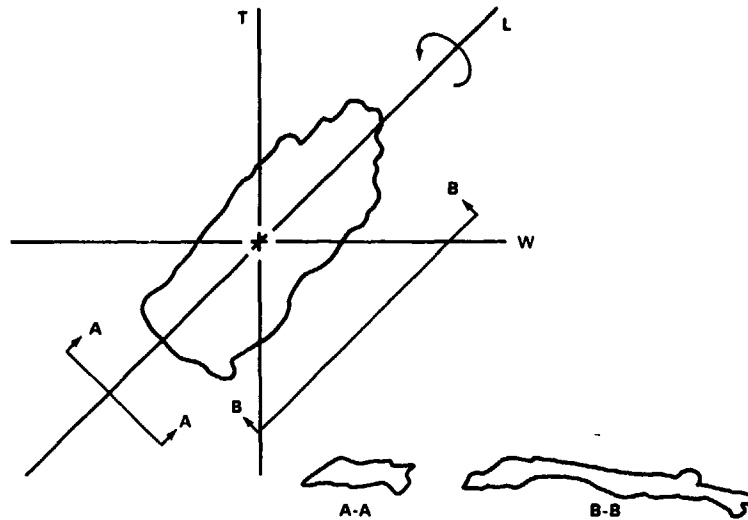
FIGURE C-70. TEST RECORD FOR FRAGMENT NO. 70

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DATE 4/1/85

TEST NO. 210

RUN NO. 71



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
71	.08691	.00800	752.3	58	.002357	97.1	.97771

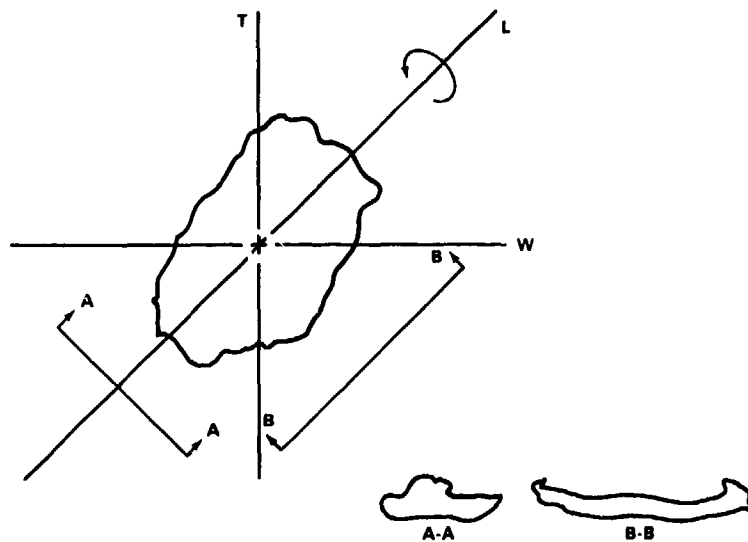
COMMENTS: ROTATES AROUND L AXIS AND CONING

FIGURE C-71. TEST RECORD FOR FRAGMENT NO. 71

DATE 4/1/85

TEST NO. 210

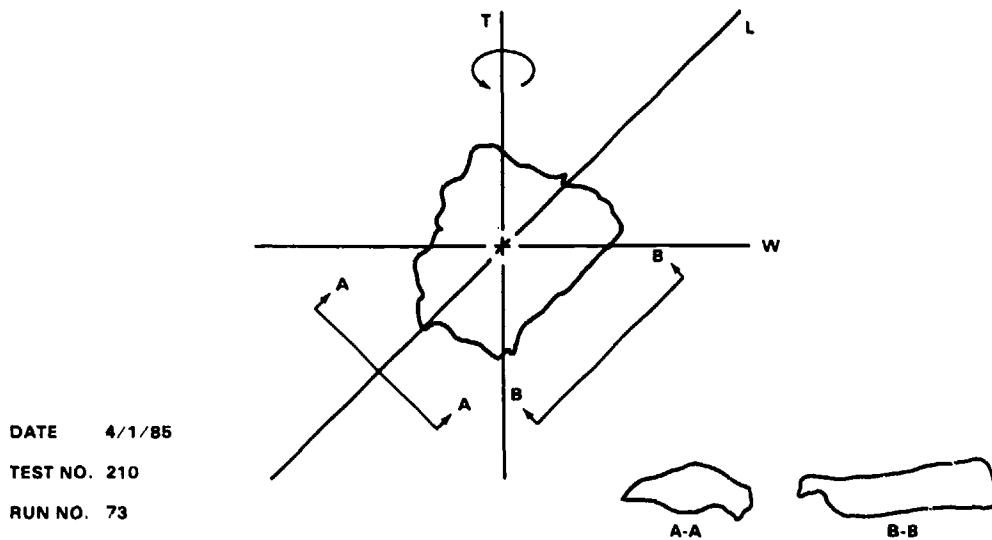
RUN NO. 72



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
72	.0931	.00876	752.3	58	.002357	98.7	.92572

COMMENTS: FLOATS MOTIONLESS, ROTATES AROUND L AXIS AND TUMBLES

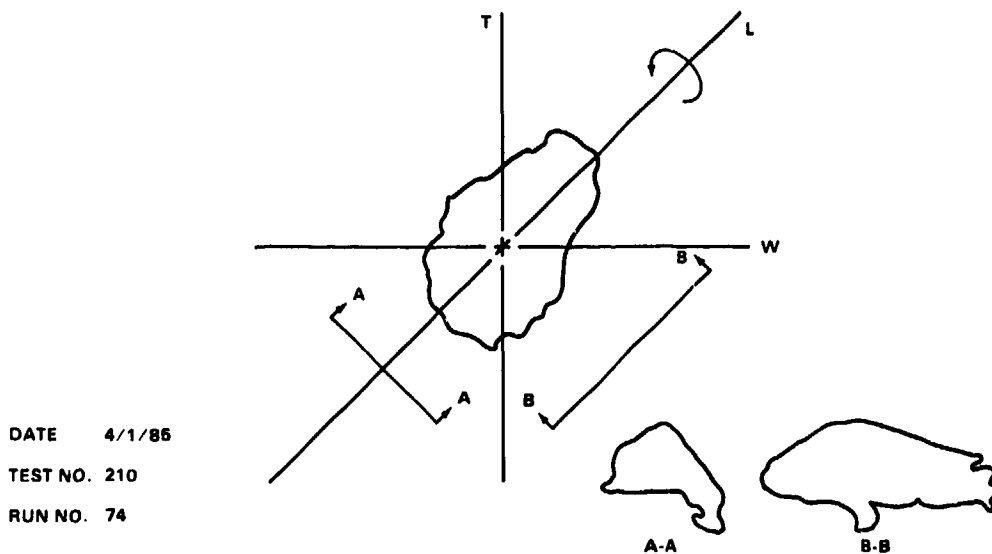
FIGURE C-72. TEST RECORD FOR FRAGMENT NO. 72



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
73	.09363	.00738	762.2	57	.002362	113.1	.83981

COMMENTS: FLAT SPIN AND FLOATS MOTIONLESS

FIGURE C-73. TEST RECORD FOR FRAGMENT NO. 73



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
74	.08371	.00701	762.2	57	.002362	114.7	.86038

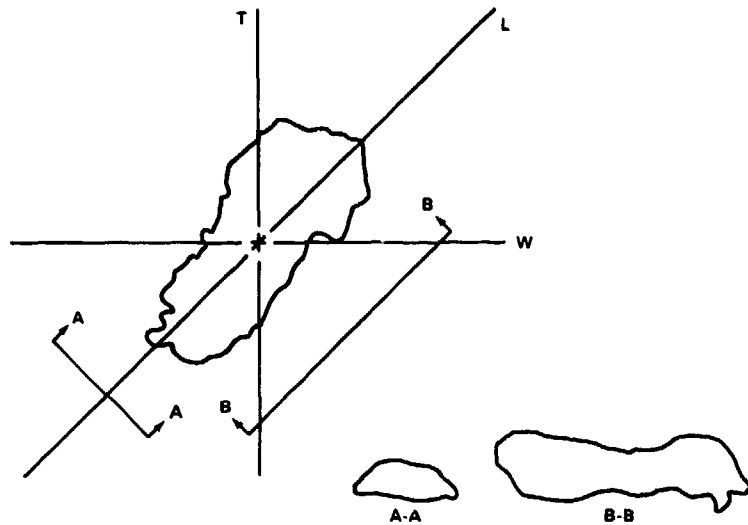
COMMENTS: ROTATES AROUND L AND WILL TUMBLE

FIGURE C-74. TEST RECORD FOR FRAGMENT NO. 74

DATE 4/1/85

TEST NO. 210

RUN NO. 75



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
75	.0955	.00764	752.2	57	.002362	103.5	.98805

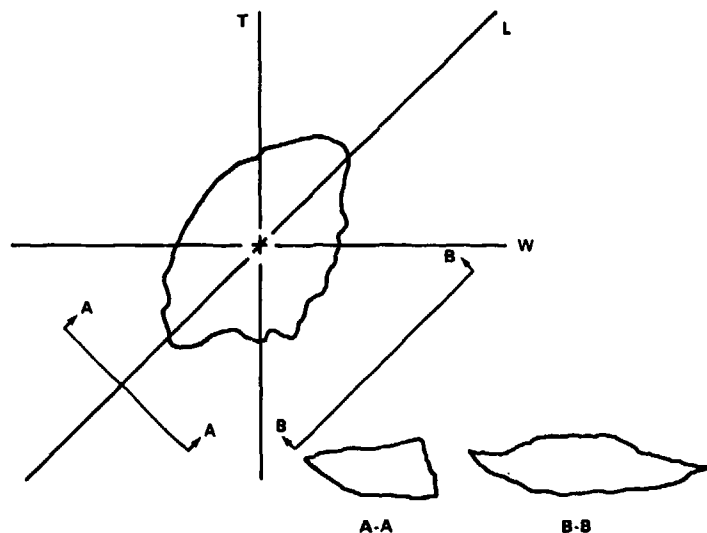
COMMENTS: LITTLE BIT OF EVERYTHING - ROLL, TUMBLE, CONE

FIGURE C-75. TEST RECORD FOR FRAGMENT NO. 75

DATE 4/1/85

TEST NO. 210

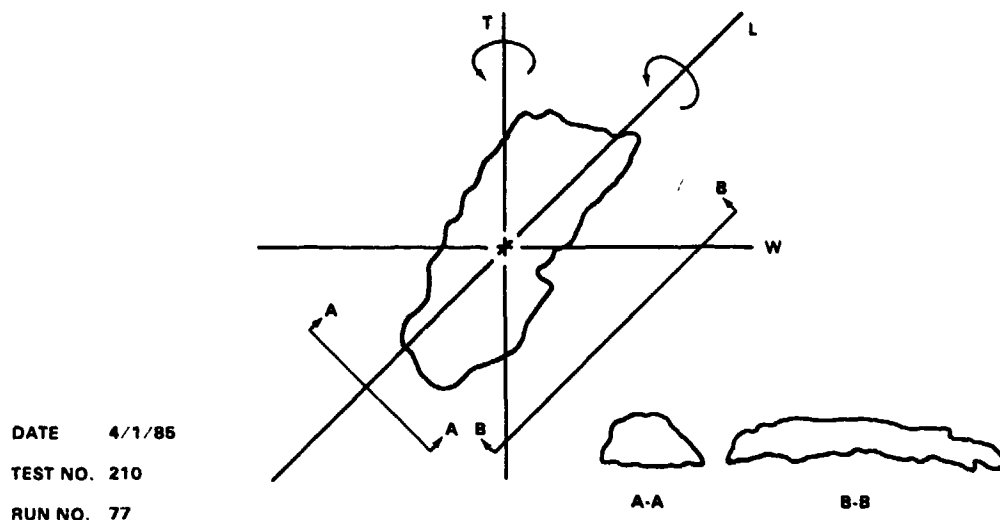
RUN NO. 76



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
76	.10198	.00792	751.4	50	.002392	113.1	.84165

COMMENTS: ROTATES AND TUMBLES IN ALL DIRECTIONS

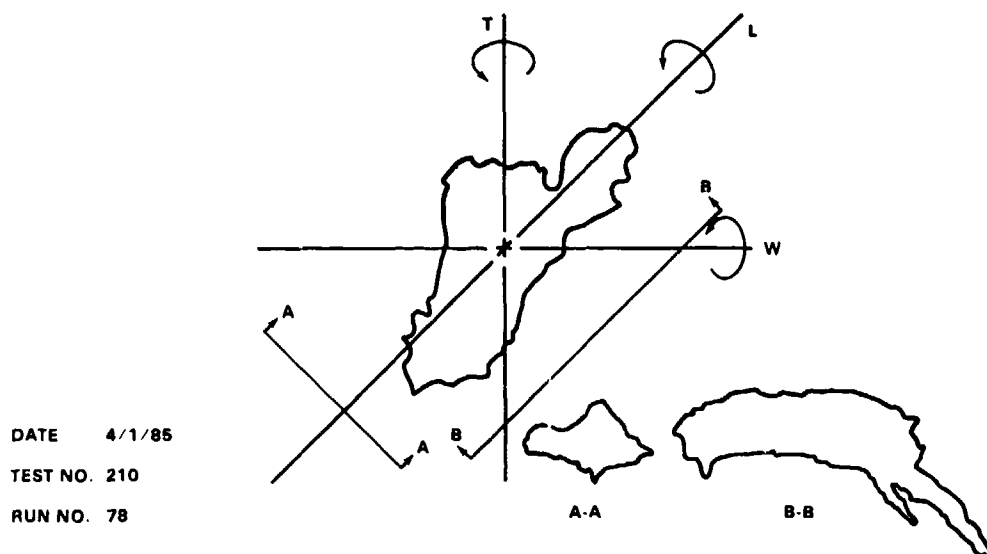
FIGURE C-76. TEST RECORD FOR FRAGMENT NO. 76



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
77	.10273	.00810	751.4	50	.002392	90.6	1.29151

COMMENTS: FLAT SPIN (LIKE A PROPELLER) WILL ROTATE AROUND THE L AXIS ALSO

FIGURE C-77. TEST RECORD FOR FRAGMENT NO. 77



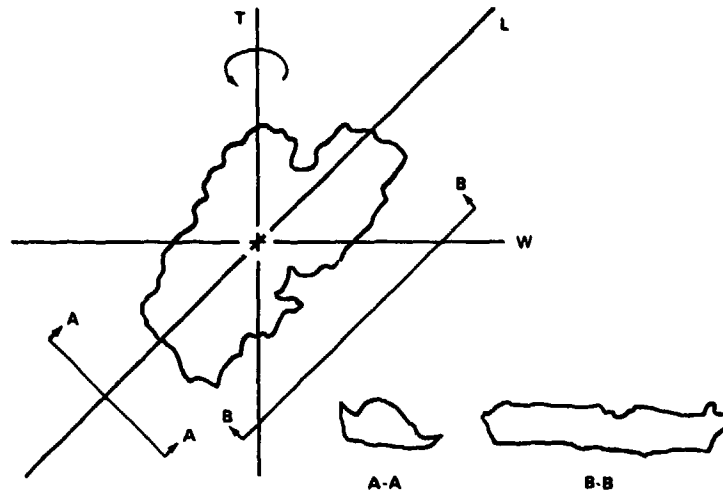
FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
78	.10957	.00899	751.4	50	.002392	106.7	.8953

COMMENTS: ROTATES AROUND ALL 3 AXES AND CONING

FIGURE C-78. TEST RECORD FOR FRAGMENT NO. 78

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DATE 4/1/85
TEST NO. 210
RUN NO. 79

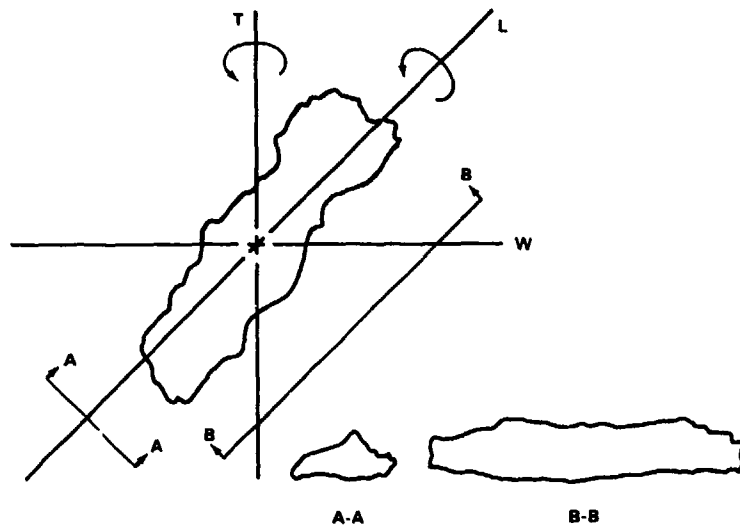


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
79	.11096	.00901	751	54	.002372	89	1.31092

COMMENTS: FLAT SPIN AROUND T

FIGURE C-79. TEST RECORD FOR FRAGMENT NO. 79

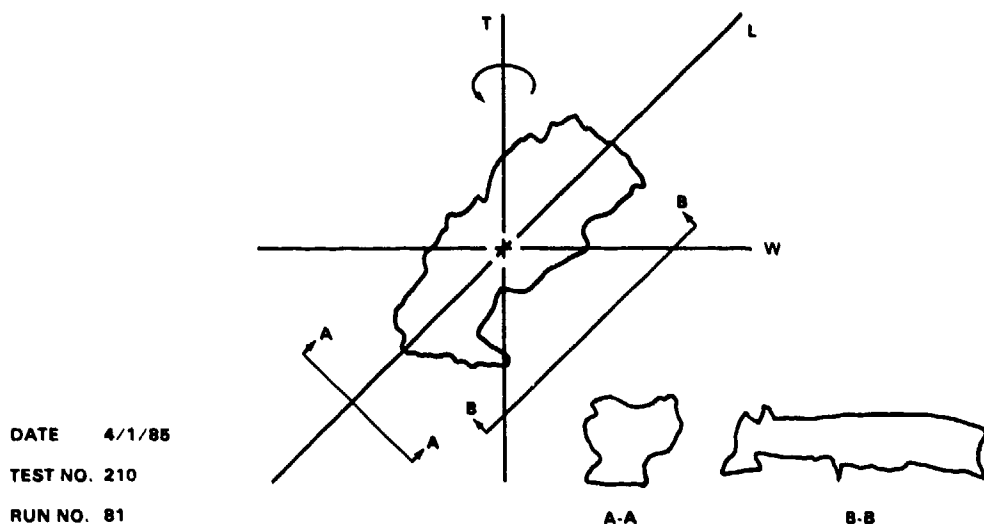
DATE 4/1/85
TEST NO. 210
RUN NO. 80



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
80	.111	.00880	751	54	.002372	106.7	.95580

COMMENTS: ROTATES AROUND L AND T

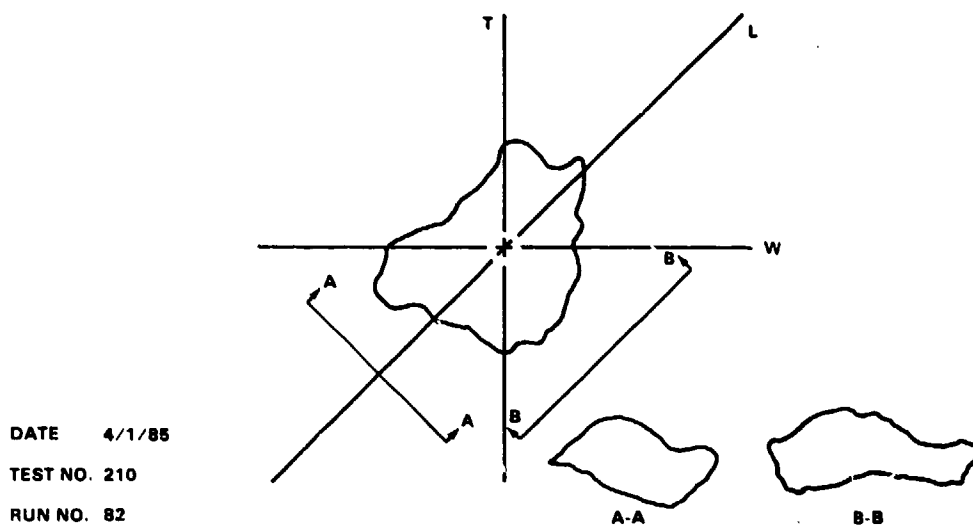
FIGURE C-80. TEST RECORD FOR FRAGMENT NO. 80



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
81	.11174	.00834	751	54	.002372	106.7	.99227

COMMENTS: FLAT SPIN AROUND T

FIGURE C-81. TEST RECORD FOR FRAGMENT NO. 81

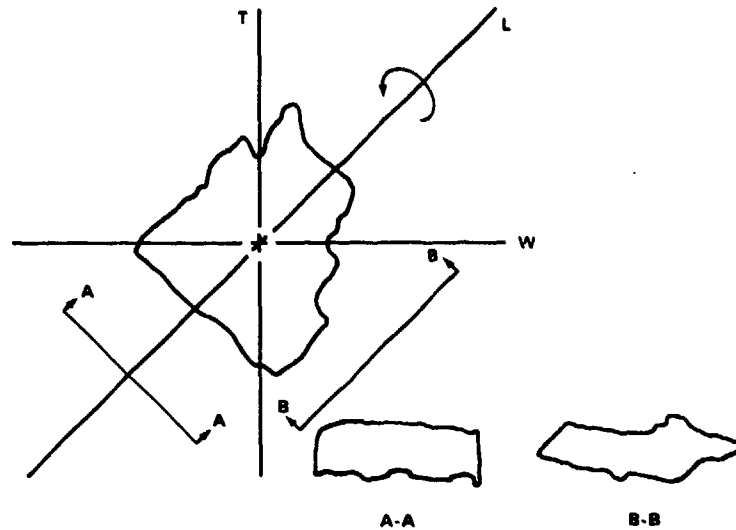


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
82	.11497	.00753	750.6	54	.002370	126.0	.81158

COMMENTS: TUMBLES AROUND ALL AXES

FIGURE C-82. TEST RECORD FOR FRAGMENT NO. 82

DATE 4/1/85
TEST NO. 210
RUN NO. 83

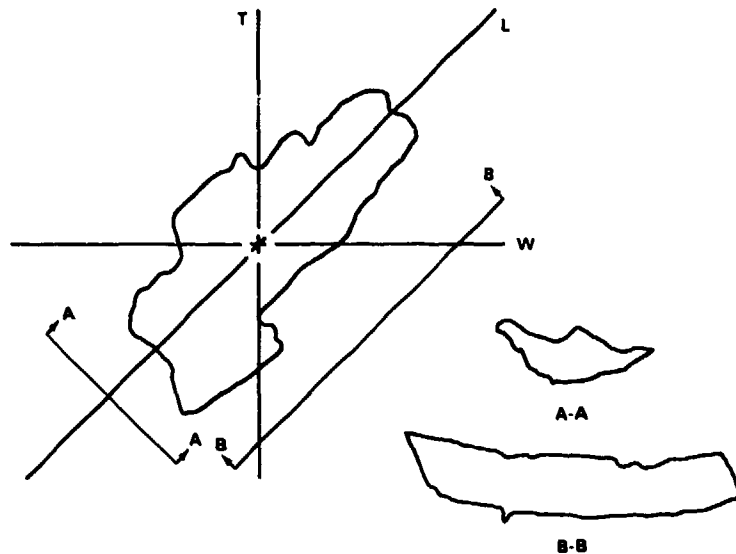


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
83	.1191	.00879	750.6	54	.002370	113.1	.89388

COMMENTS: ROTATES AROUND L AND TUMBLES

FIGURE C-83. TEST RECORD FOR FRAGMENT NO. 83

DATE 4/1/85
TEST NO. 210
RUN NO. 84

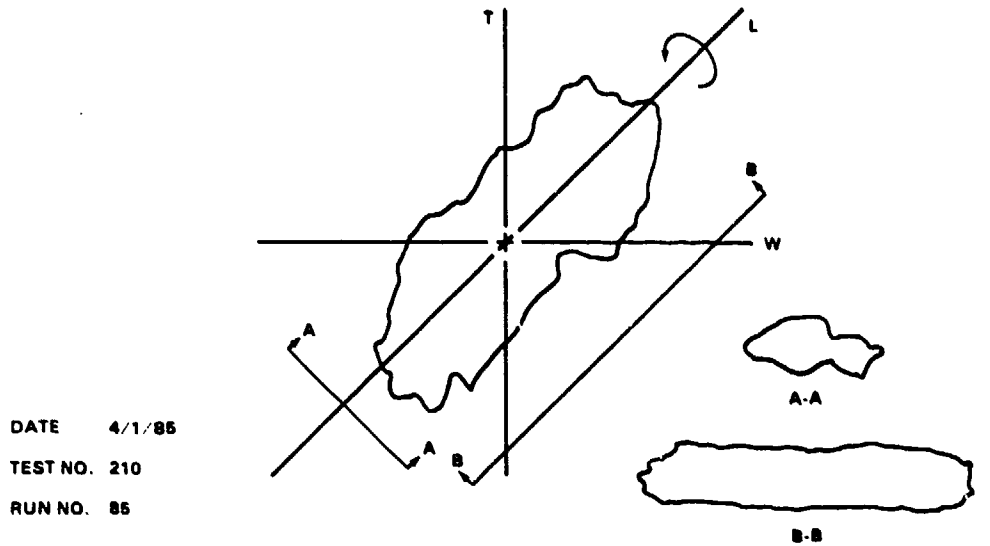


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
84	.12376	.00976	750.6	54	.002370	103.5	.99924

COMMENTS: LOOKED LIKE A FLOATING LEAF TO START AND THEN WENT INTO A FLAT SPIN

FIGURE C-84. TEST RECORD FOR FRAGMENT NO. 84

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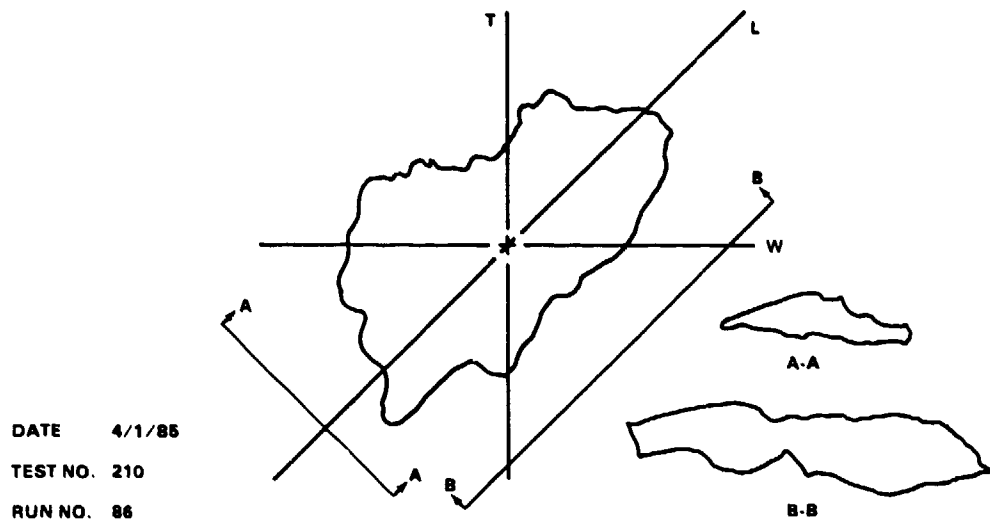


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
85	.2311	.0139409	750.5	53	.002375	122.8	.92572

COMMENTS: ROTATES AROUND L AND A FLAT SPIN

*FRAGMENT INFORMATION FOR NUMBERS 85 THRU 96 WAS TAKEN FROM TABLE A-2

FIGURE C-85. TEST RECORD FOR FRAGMENT NO. 85

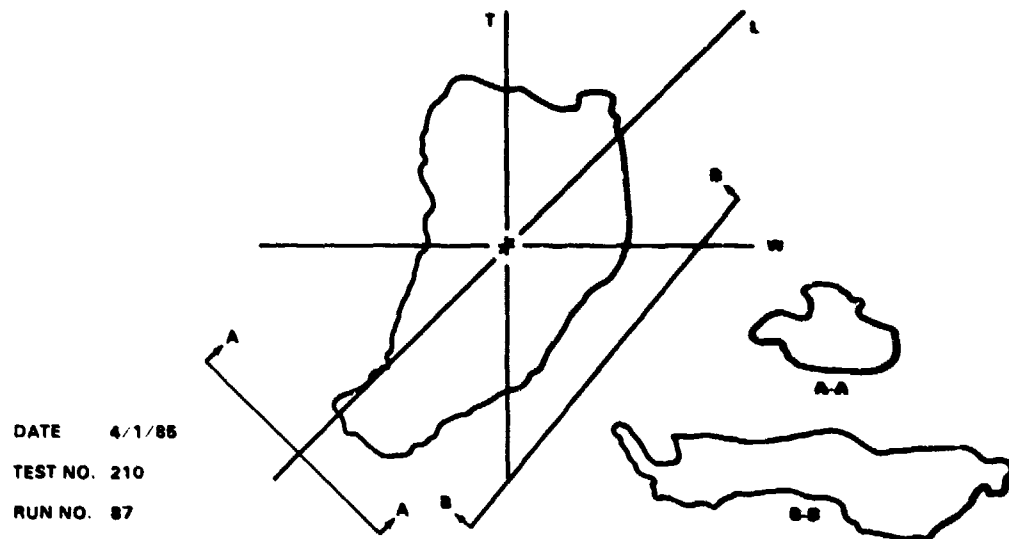


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
86	.23583	.0170312	750.5	53	.002375	97.1	1.23674

COMMENTS: FLAT SPIN AND WOULD ALSO FLOAT MOTIONLESS

FIGURE C-86. TEST RECORD FOR FRAGMENT NO. 86

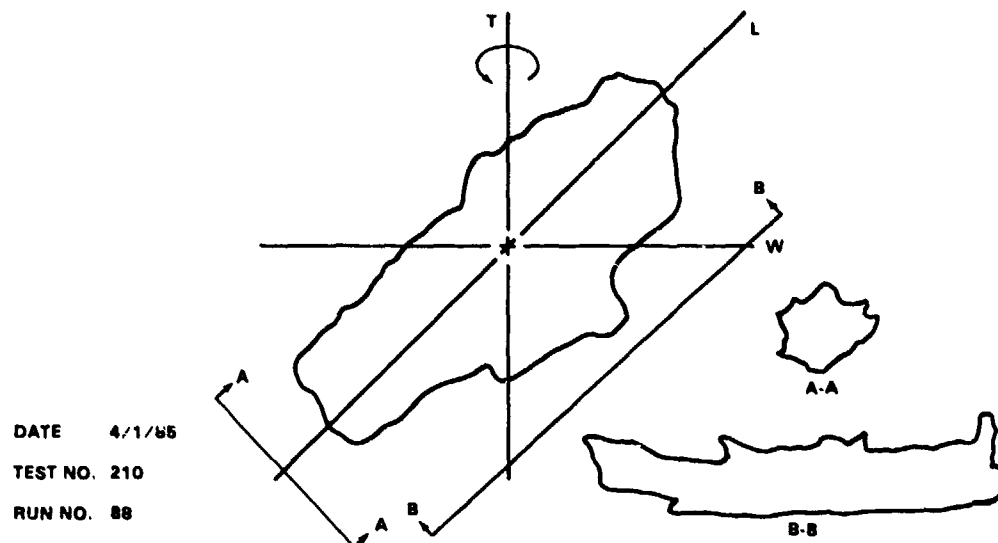
NSWC TR 87-89



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
87	.25706	.0173281	750.5	53	.002376	113.1	.97882

COMMENTS: TUMBLES AND FLAT SPIN AROUND T

FIGURE C-87. TEST RECORD FOR FRAGMENT NO. 87

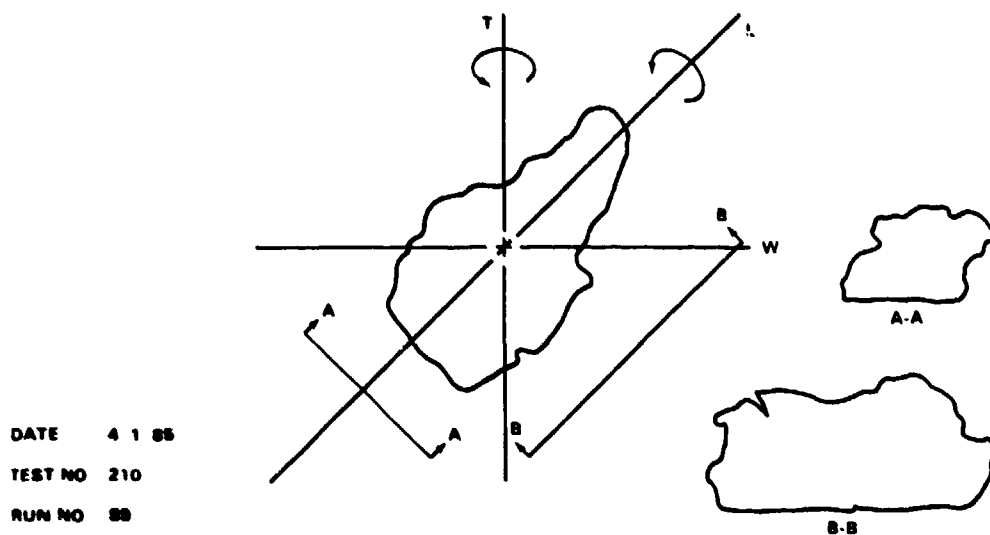


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
88	.28189	.019618	750.5	54	.002370	113.1	.94784

COMMENTS: FLAT SPIN AROUND T

FIGURE C-88. TEST RECORD FOR FRAGMENT NO. 88

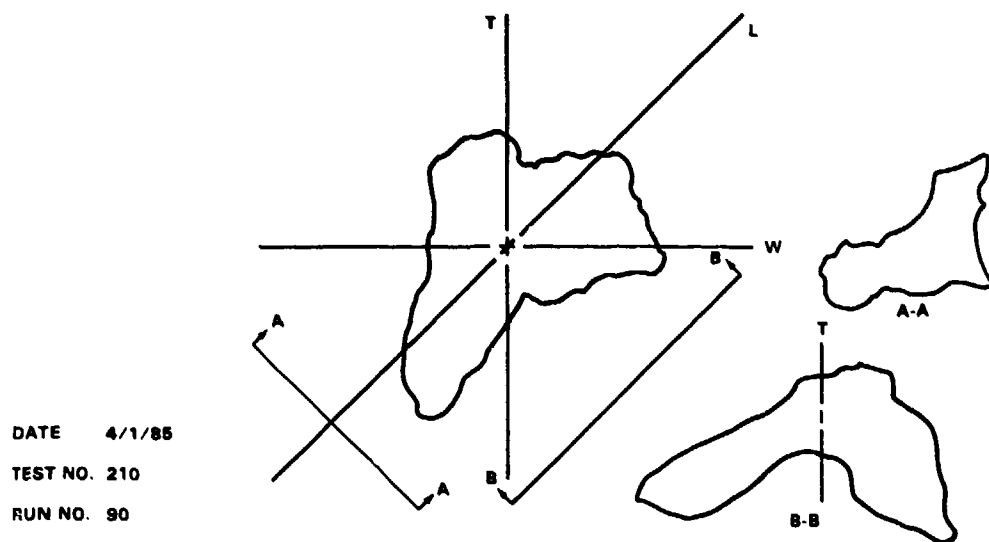
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FRAGMENT NUMBER	WEIGHT (lb)	AREA (in ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
89	.2883	.013125	750.5	54	.002370	151.7	.80054

COMMENTS ROTATES AROUND T AND L

FIGURE C-89. TEST RECORD FOR FRAGMENT NO. 89



FRAGMENT NUMBER	WEIGHT (lb)	AREA (in ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
90	.2866	.0133152	750.5	54	.002370	151.7	.78929

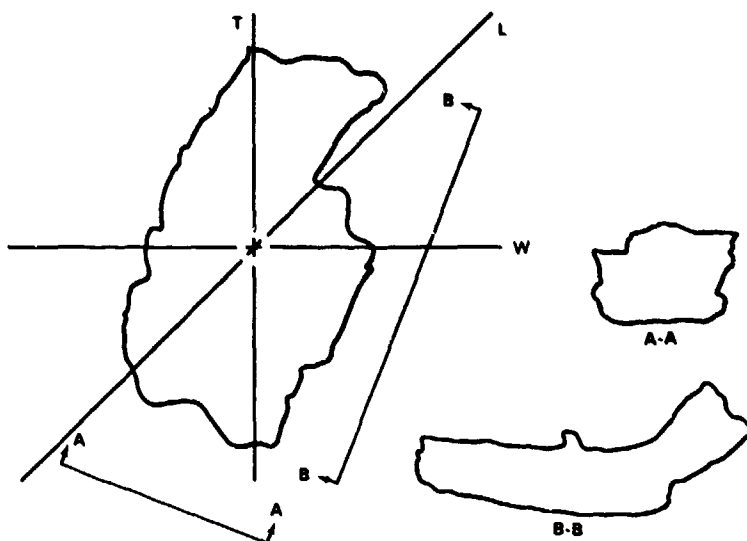
COMMENTS: SPIN AROUND T AND TUMBLES

FIGURE C-90. TEST RECORD FOR FRAGMENT NO. 90

DATE 4/1/85

TEST NO. 210

RUN NO. 91



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
91	.2908	.0183263	750.0	54	.002369	116.4	.98873

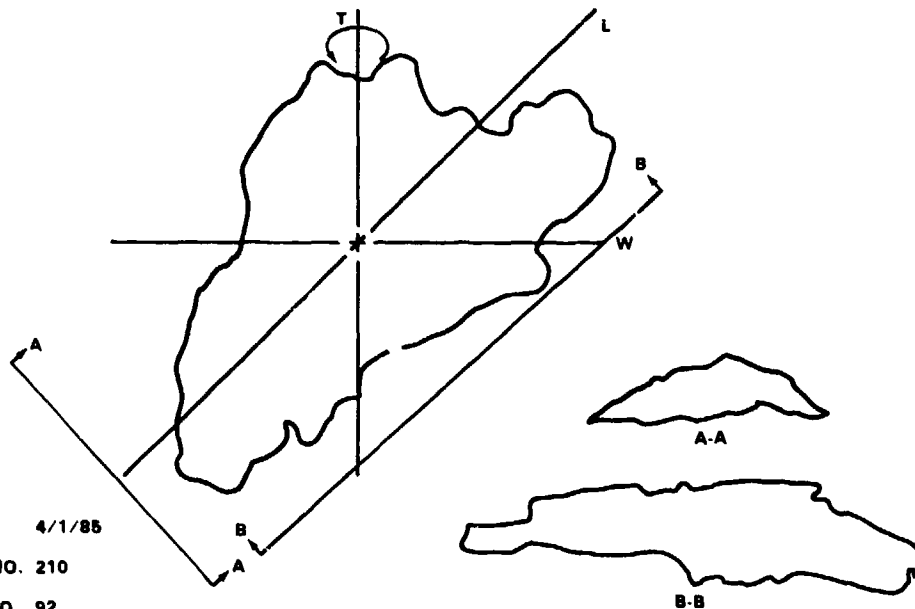
COMMENTS: FLAT SPIN AND FLOATS MOTIONLESS

FIGURE C-91. TEST RECORD FOR FRAGMENT NO. 91

DATE 4/1/85

TEST NO. 210

RUN NO. 92

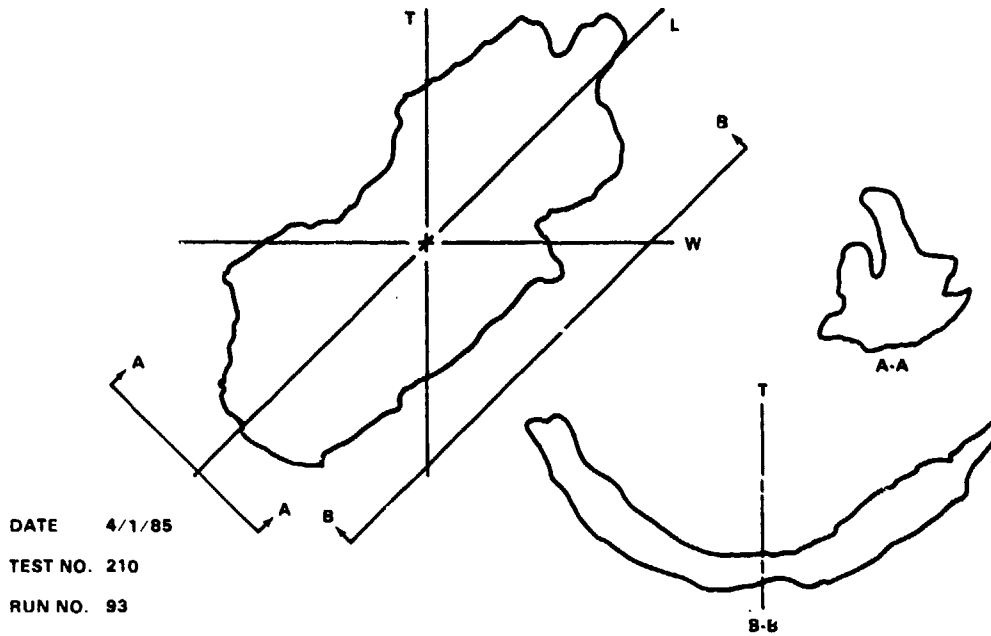


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
92	.39476	.0267458	750.0	54	.002369	93.8	1.41624

COMMENTS: GOOD FLAT SPIN AROUND T

FIGURE C-92. TEST RECORD FOR FRAGMENT NO. 92

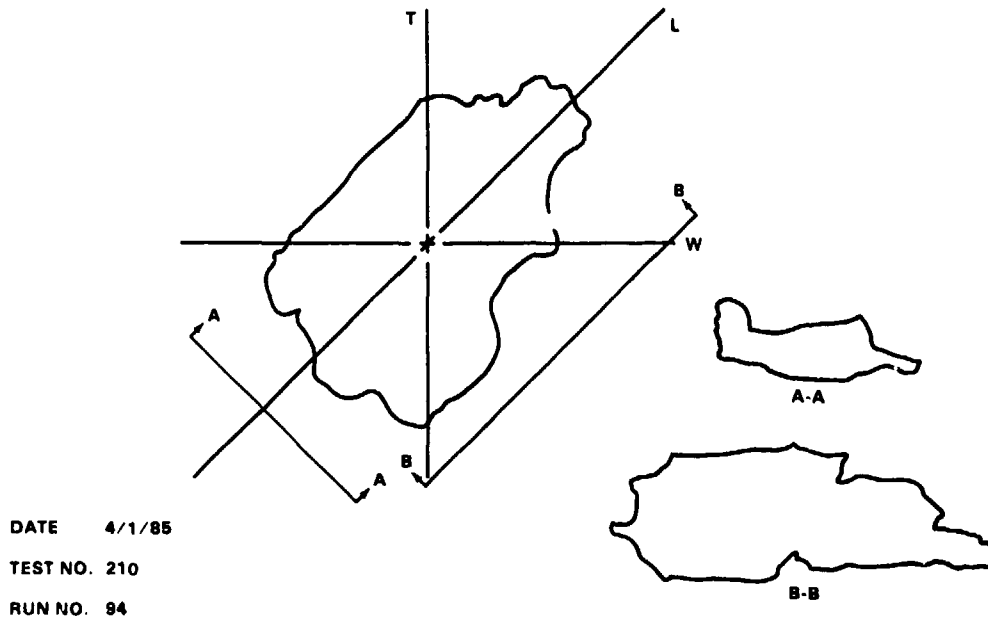
NSWC TR 87-89



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
93	.4487	.0263708	750	54	.002369	119.6	1.00647

COMMENTS: ROTATES AROUND T

FIGURE C-93. TEST RECORD FOR FRAGMENT NO. 93

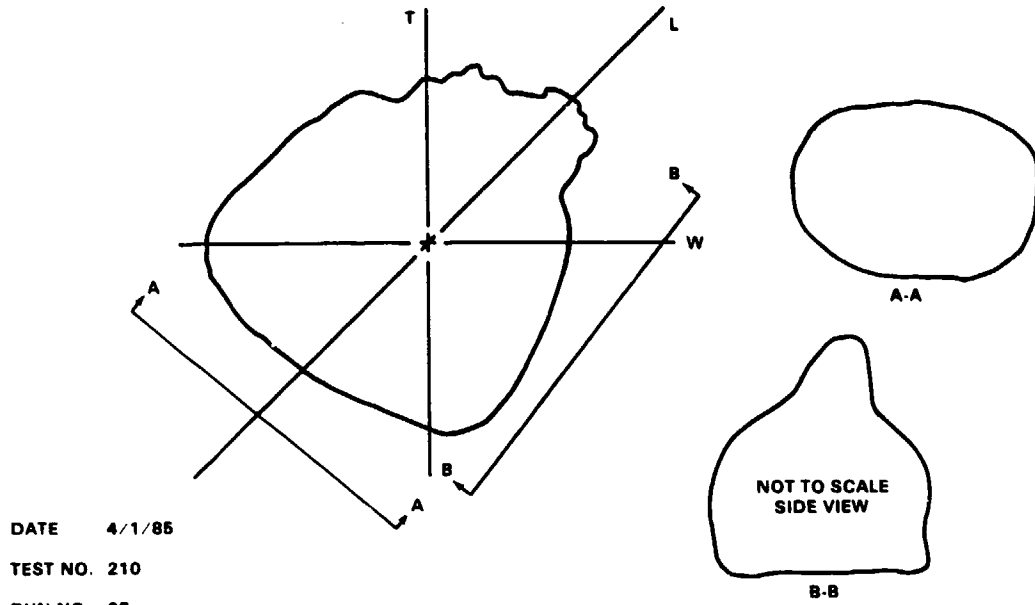


FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
94	.46831	.0201888	750	54	.002369	138.9	1.01502

COMMENTS: ROTATES ANY DIRECTION AND TUMBLES

FIGURE C-94. TEST RECORD FOR FRAGMENT NO. 94

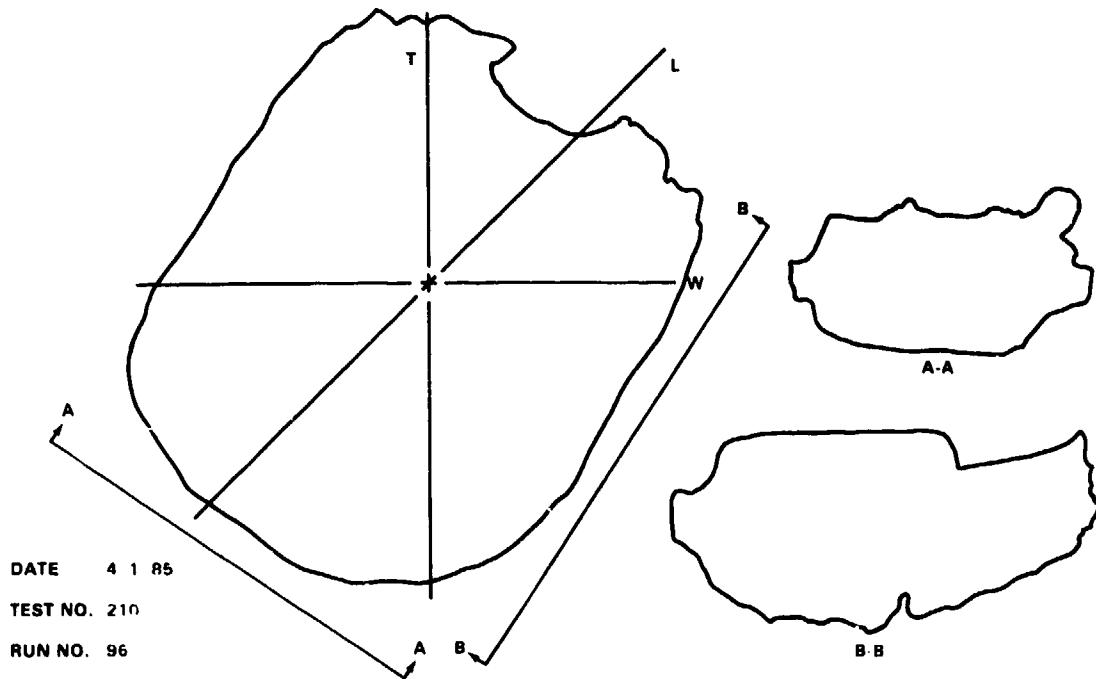
NSWC TR 87-89



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
95	2.22787	.0440173	750.0	54	.002369	293.2	.49706

COMMENTS: THIS FRAGMENT WOULD FLOAT MOTIONLESS

FIGURE C-95. TEST RECORD FOR FRAGMENT NO. 95



FRAGMENT NUMBER	WEIGHT (lb)	AREA (ft ²)	PRESS (Hg-mm)	TEMP (deg F)	DENSITY (SLUG/ft ³)	VELOCITY (ft/s)	CD
96	3.34478	.0714333	750	54	.002369	200	.98827

COMMENTS: ROTATES AROUND T AXIS

FIGURE C-96. TEST RECORD FOR FRAGMENT NO. 96

APPENDIX D
CATEGORIES OF FRAGMENT MOTION

The fragment motions in the wind tunnel given in the COMMENTS of test records of Appendix C were divided in eight categories in an attempt at further correlation with the drag coefficients. The eight categories together with their associated fragments are given in Figures D-1 through D-8.

The eight categories are listed as follows:

1. Random Tumbling,
2. Floats Motionless,
3. Flat Rotation,
4. Rotates about L & T axes,
5. Rotates about L & W axes,
6. Rotates around T axis,
7. Rotates around the L axes,
8. Coning

The L, W and T axes are those given in the test records of Appendix C. When two axes are given for the motion, the fragments will rotate about either at different times. The difference between flat rotation and rotates around the T axis is that rotation around the T axis involves much more wobble than flat rotation. Flat rotation is also about the T axis.

Coning can be explained by imagining a thin rod held fixed at its center. One end of the rod is then moved to describe a circle such that the half rod length sweeps out a cone with apex at the fixed center. As a result the other half of the rod also sweeps out a cone with its apex also at the fixed center. Viewed from the side, it would appear to be something like a bow tie.

Below each fragment plan view, there are two numbers. The first is the fragment number given in Appendix C; second, in parenthesis, is the low subsonic drag coefficient obtained from the vertical wind tunnel tests.

This appendix, together with Appendixes A, B and C give a good idea of both the shape and size of the fragments.

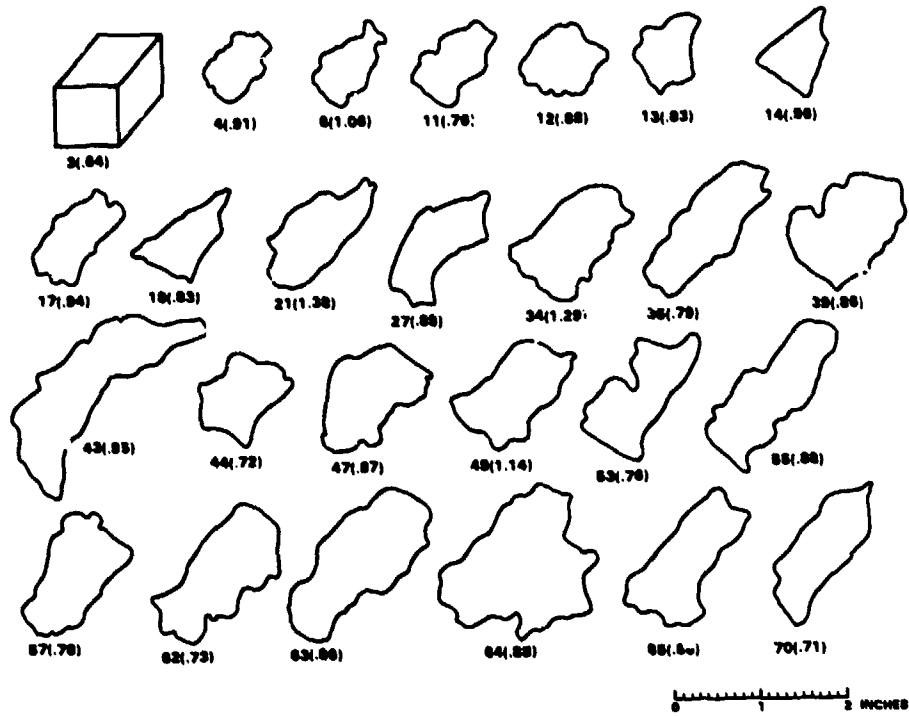


FIGURE D-1. RANDOM TUMBLING

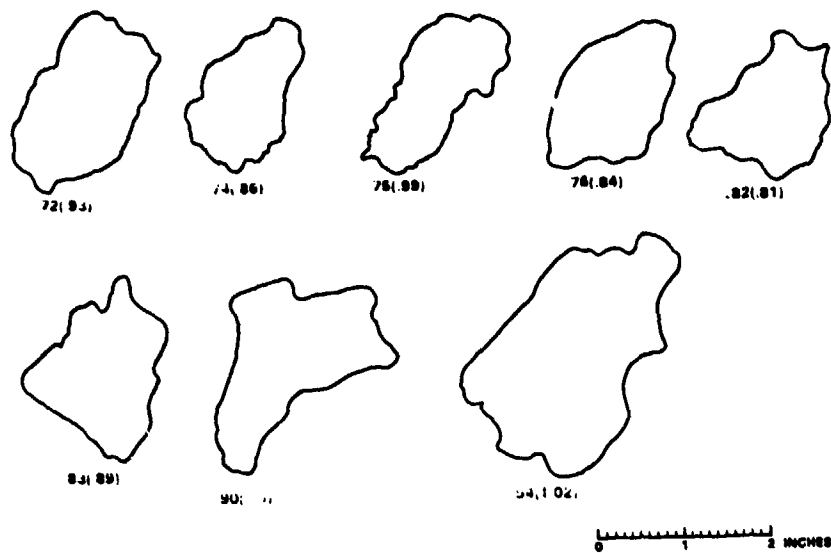


FIGURE D-1. RANDOM TUMBLING (Continued)

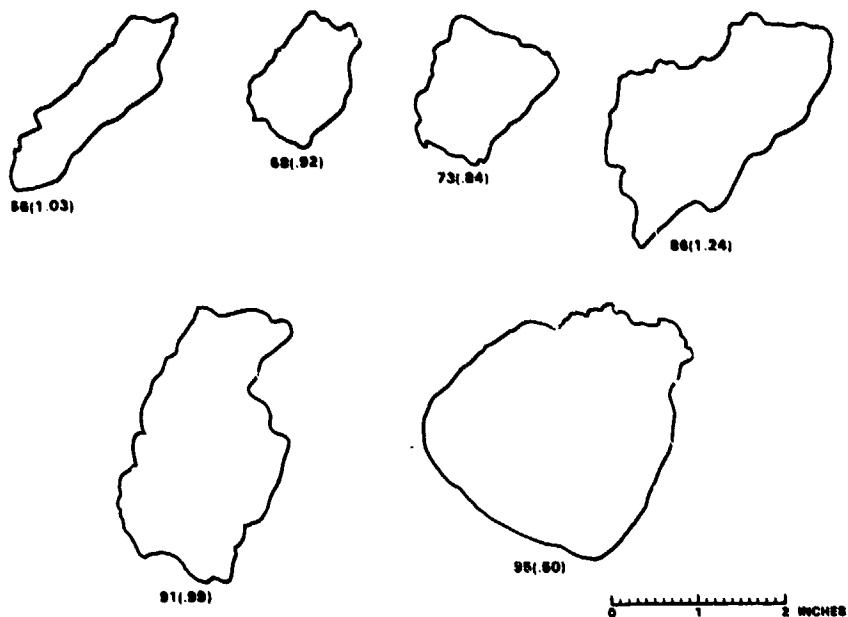


FIGURE D-2. FLOATS MOTIONLESS

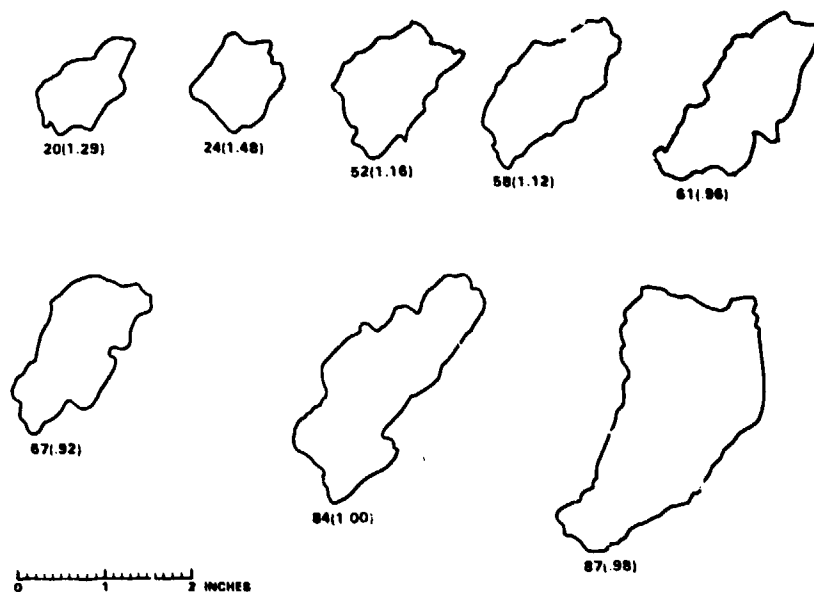


FIGURE D-3. FLAT ROTATION

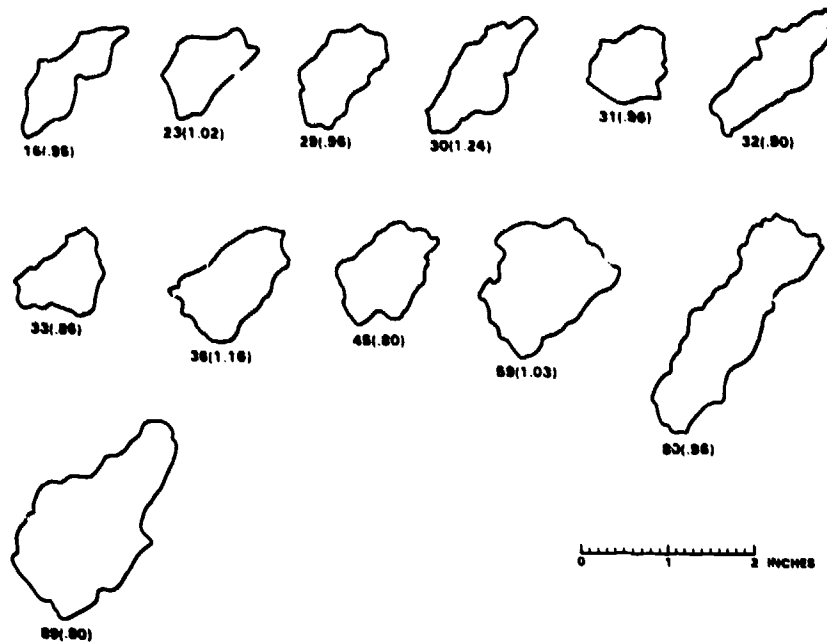


FIGURE D-4. ROTATES ABOUT THE L AND T AXIS

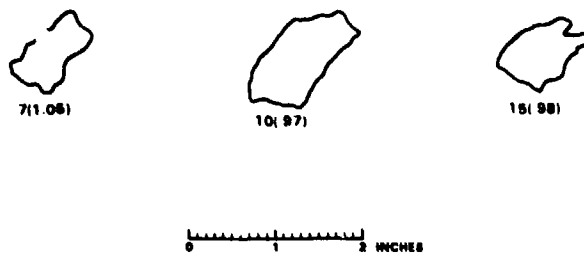


FIGURE D-5. ROTATES ABOUT THE L AND W AXIS

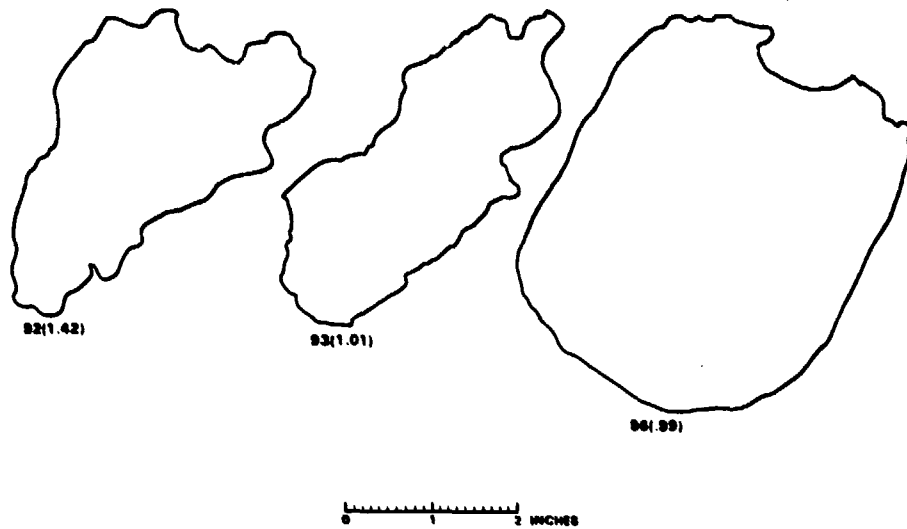


FIGURE D-6. ROTATES AROUND THE T-AXIS

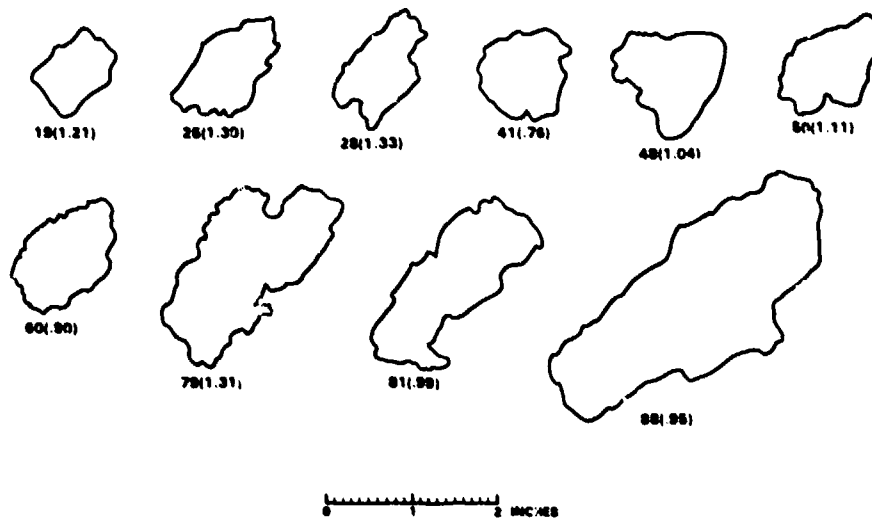


FIGURE D-6. ROTATES AROUND THE T-AXIS (Continued)

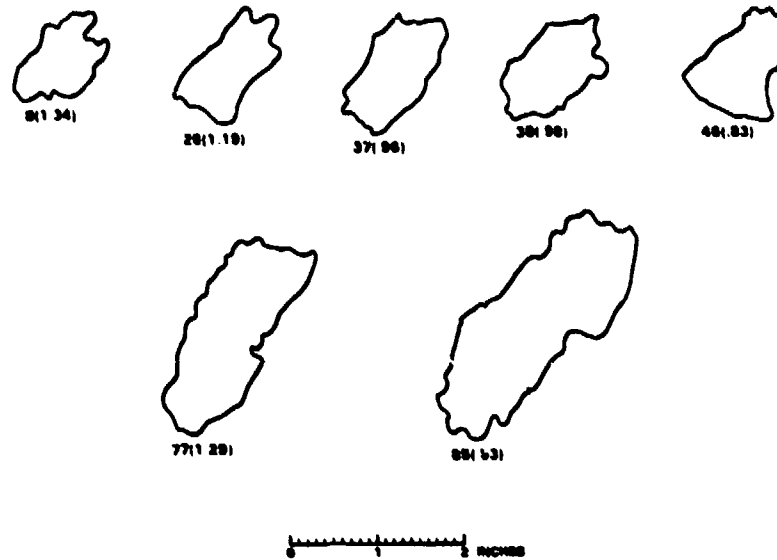


FIGURE D-7. ROTATES AROUND THE L-AXIS

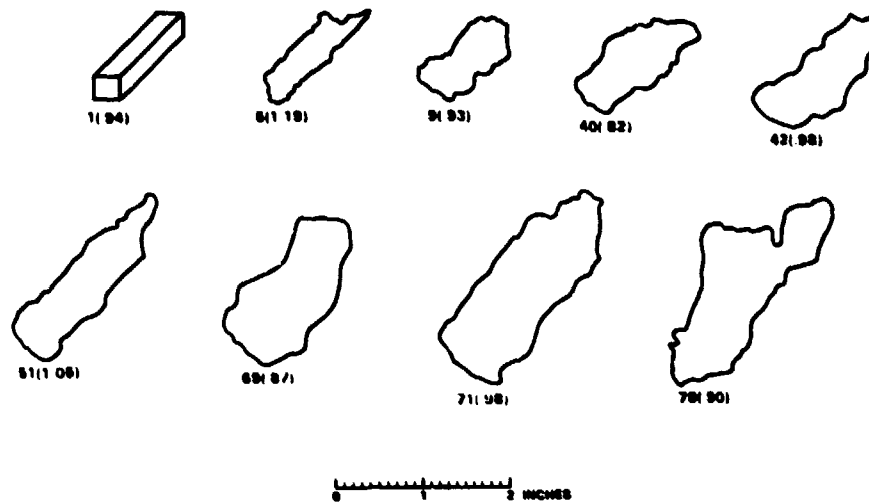


FIGURE D-8. CONING

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