

UNCLASSIFIED

AD NUMBER

AD371101

CLASSIFICATION CHANGES

TO: unclassified

FROM: confidential

LIMITATION CHANGES

TO:

Approved for public release, distribution unlimited

FROM:

Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; DEC 1963. Other requests shall be referred to Naval Weapons Laboratory, Dahlgren, VA.

AUTHORITY

USNSWC ltr dtd 5 Mar 1975; USNSWC ltr dtd 5 Mar 1975

THIS PAGE IS UNCLASSIFIED

SECURITY

MARKING

The classified or limited status of this report applies to each page, unless otherwise marked.

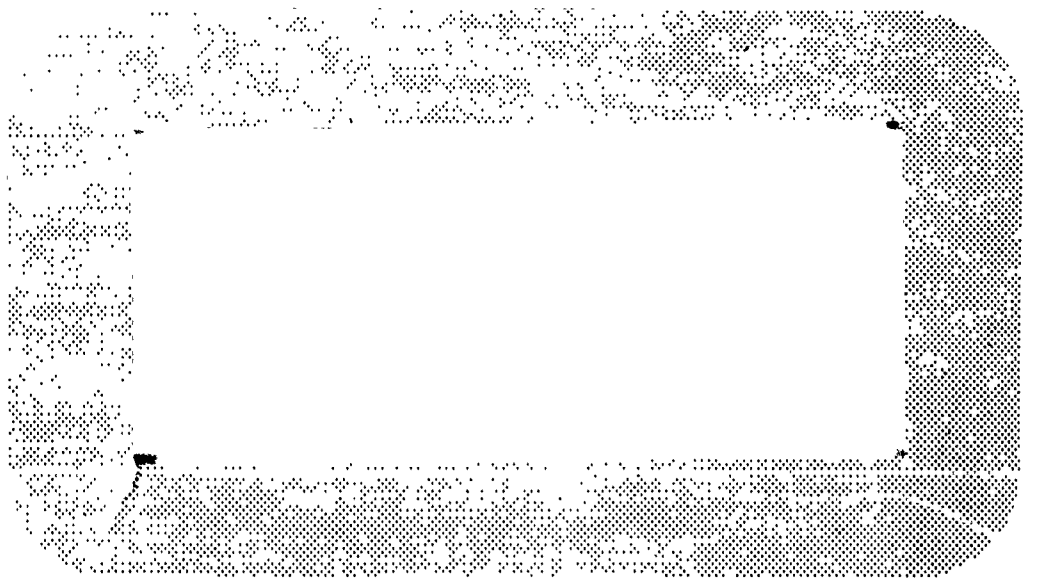
Separate page printouts MUST be marked accordingly.

THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 AND 794. THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

Copy No

CONFIDENTIAL
TECHNICAL
MEMORANDUM



GROUP - 4

DOWNGRADED AT 3 YEAR INTERVALS;
DECLASSIFIED AFTER 12 YEARS.

U. S. NAVAL WEAPONS LABORATORY
DAHLGREN, VIRGINIA

CONFIDENTIAL

101178
871101

CONFIDENTIAL

U. S. NAVAL WEAPONS LABORATORY

9 TECHNICAL MEMO

11 Dec 1963

12 26p

14 NWL-TM-K-98/63

No. K-98/63

6 A COMPUTER PROGRAM FOR FRAGMENTATION
TEST DATA REDUCTION (U) 8

10 Gerald Hertweck
and
Clyde Johnson
Warhead and Terminal Ballistics Laboratory

Approved by:

Ralph A. Niemann

RALPH A. NIEMANN, Director
Computation and Analysis Laboratory

This memorandum is not to be construed as expressing the opinion of the Naval Weapons Laboratory, and while its contents are considered correct, they are subject to modification upon further study.

Copies may be obtained from the Director, Computation and Analysis Laboratory.

CONFIDENTIAL

253 150

James

CONFIDENTIAL

TABLE OF CONTENTS

NWL Technical Memorandum No. K-98/63

	<u>Page</u>
<u>ABSTRACT</u>	3
<u>FOREWORD</u>	4
<u>INTRODUCTION</u>	5
<u>DATA REDUCTION</u>	6
<u>FIGURES</u>	

Figure 1. Typical Arena Set-Up

Figure 2. Flow Chart

APPENDIX A

Figure A-1. Program Deck Listing

Figure A-2. Input Formats

Figure A-3. Sample Input

Figure A-4. Sample Output

* * * * *

<u>Distribution:</u>	<u>No. Copies</u>
Chief of Naval Operations	
Attn: Op-03EG	(1)
Attn: Op-06C	(1)
Bureau of Naval Weapons	
Attn: RMMO	(1)
Attn: RMMO-42	(1)
Attn: RMMO-422	(1)
Attn: RM-24	(1)
David Taylor Model Basin	
Attn: Mr. F. Weinberger	(1)
Picatinny Arsenal, Dover, New Jersey	
Attn: Navy Liaison Officer	(1)
U. S. Army Ballistics Research Laboratory Aberdeen, Maryland	
Attn: Mr. Charles Brown	(1)
Attn: Mr. D. J. Dunn, Jr.	(1)
Attn: Navy Liaison Officer	(1)

CONFIDENTIAL

Distribution (cont'd)

No. Copies

Local:

K	(1)
KP	(2)
KR	(1)
KRT	(5)
T	(1)
TC	(1)
TD	(1)
TDP	(3)
TE-2	(1)
TEF	(1)
TER-3	(1)
TR	(1)
TRE	(1)
TRP	(1)
ACL	(5)
ACMF	(1)

ABSTRACT

A detailed description is given of a computer program for the reduction of fragmentation data obtained from static detonation of warheads in a test arena, including input format, a listing of the FORTRAN program deck, and a sample of the output from the program.

4

FOREWORD

The computer program described in this report was prepared in the Ballistic Sciences Branch of the Computer Programming Division, Computation and Analysis Laboratory, by Miss Beverly A. Cooper. The work was performed under the authority of NWL Technical Assistance Request for Project No. T-06AD by the Computation and Analysis Laboratory in support of the Warhead Supporting Research Program being conducted by the Warhead and Terminal Ballistics Laboratory.

INTRODUCTION

The U. S. Naval Weapons Laboratory is currently preparing a handbook series, "Warhead and Terminal Ballistics Handbook," in conjunction with the Warhead Supporting Research Program established in accordance with Bureau of Naval Weapons Weptask No. RMMO-42-003/210-1/F008-08-06. The objective of this handbook is to provide systematic documentation of kill mechanism technology, target vulnerability data, and warhead terminal ballistic performance data. To be included, is a section on the terminal ballistic performance characteristics of bombs, projectiles, and rocket and missile warheads of current tactical interest to the Navy. A preliminary edition of this section, published as NAVWEPS Report No. 7673, is currently being revised to include data recently acquired through an extensive warhead test program conducted at the U. S. Naval Weapons Laboratory.

A significant portion of this program was a series of arena tests of statically fired warheads to establish measurements of the fragmentation characteristics--velocity, density, mass, and spatial distribution of fragments--for each of several warheads. Typically, these tests are performed in a field arena similar to the one described in Figure 1. The arena consists of two 180-degree circular sectors. One sector is constructed from 22-gauge mild steel plate, and the other is constructed of celotex panels. The warhead to be tested is positioned on a stand at the center of the arena with its axis horizontal and intersecting the sides of the arena where the two sectors meet, with the forward end of the warhead aimed at the 0-degree position on the wall. A ricochet fence is built about the stand between the warhead and the arena to prevent fragments that strike the ground from reaching the wall panels.

High-speed motion picture cameras are placed about the steel sector to record impacts of fragments from the detonated warhead on the arena plates. A kilocycle/second timing trace is superimposed on the film in each camera during operation to allow for the determination of the time lapse from detonation to impact. Given the resulting time data and the distance from the warhead to the arena plate, an estimate of the average velocity of the fragments can be obtained. Fragments impacting on the celotex sector are recovered upon completion of the test, weighed, and categorized by mass interval to obtain estimates of the fragment number and mass distribution associated with the warhead.

A spatial distribution of the fragments is constructed by tabulating the above data for each five-degree polar zone (angular interval measured from horizontal axis of warhead).

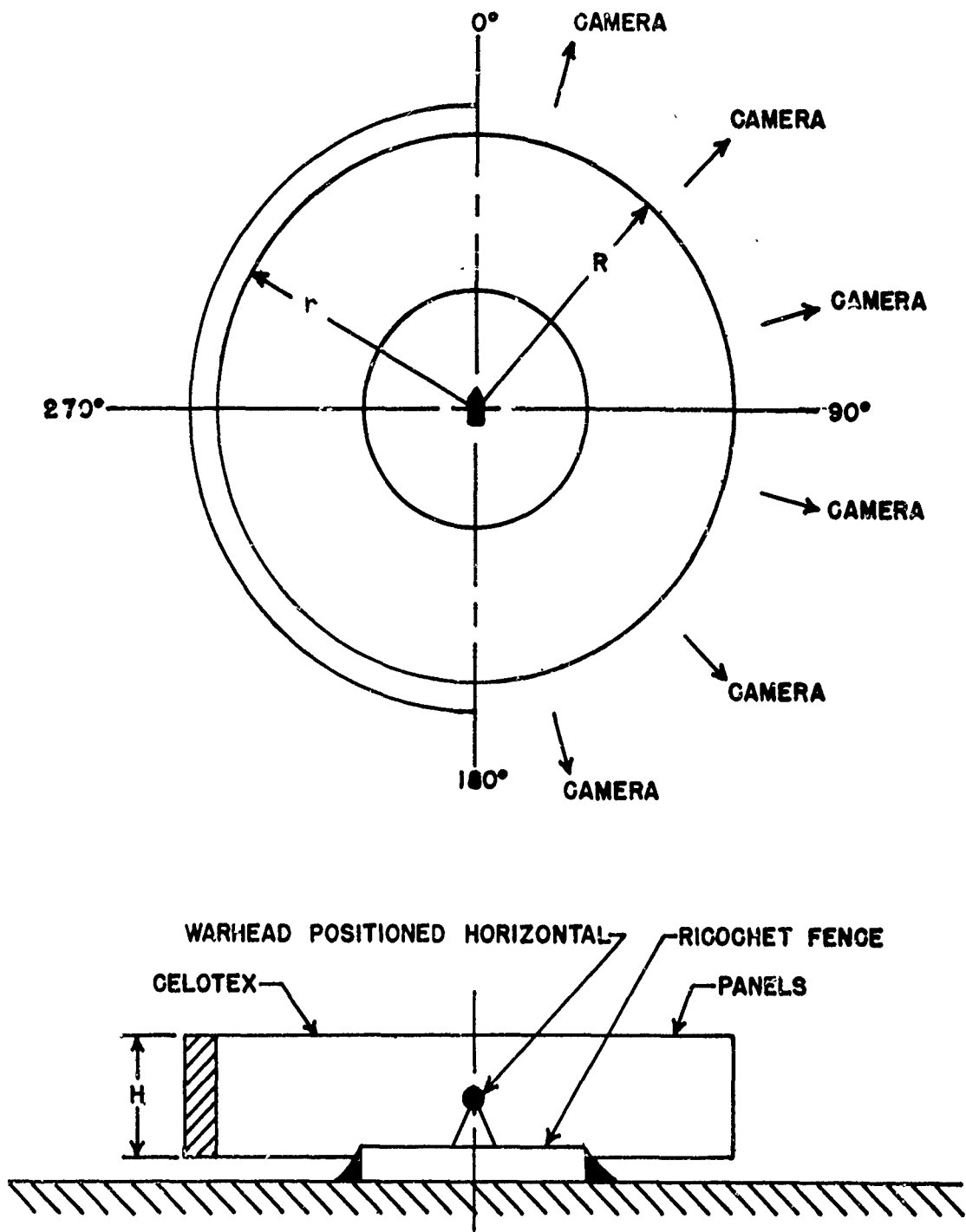


FIGURE I. TYPICAL ARENA SET - UP

DATA REDUCTION

To facilitate and expedite reduction of the raw test data to a useful and meaningful form, a high-speed computer program was formulated and coded in FORTRAN IV for execution on an IBM 7030 computer.

The flow chart given as Figure 2 outlines the major features of the program. For each mass interval (weight group) within a polar zone, the fragment density and average mass are computed. Upon completion of these computations, initial fragment velocity, total fragment weight, and number of fragments per steradian for the polar zone are calculated. Each zone is considered in succession until the total fragment space has been spanned. These output are then tabulated as shown in Figure A-3.

a. The fragment density for each mass interval is obtained by scaling the average number of fragments recovered by the value computed from the equation:

$$\frac{A_k}{a_k} = \frac{2\pi (\cos \theta_{k+1} - \cos \theta_k)}{2 \int_{\theta_{k+1}}^{\theta_k} \sin \theta \arcsin \left(\frac{\sin x}{\sin \theta} \right) d\theta}$$

where,

$$\arctan x = \frac{H}{2r}$$

r = radius of mass arena, feet

H = height of mass arena, feet

θ_k = angular distance from horizontal axis of warhead to the lower bound of k-th polar zone

The average mass is simply the total weight of the recovered fragments divided by the number of fragments.

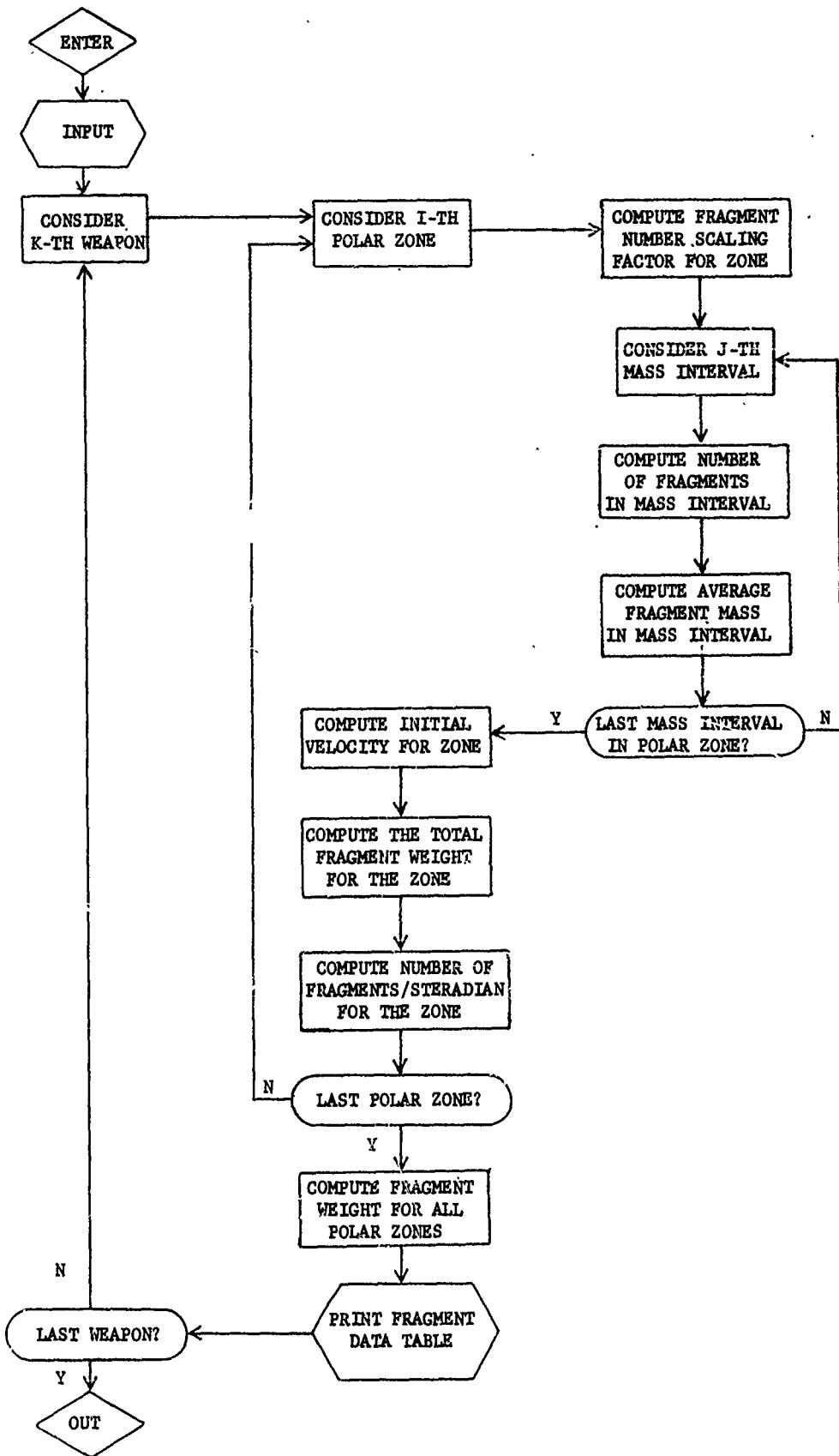


Figure 2. Flow Chart

b. The initial fragment velocity for the polar zone is determined from the equation,

$$V = \bar{V} \left(\frac{e^w - 1}{w} \right)$$

V = initial fragment velocity, feet/second

\bar{V} = average fragment velocity, feet/second

e = base of natural logarithm

and,

$$w = 0.489 \rho_a C_d R \left(\frac{\bar{A}}{M} \right)$$

for,

ρ_a = air density, pounds/feet³

C_d = drag coefficient

R = radius of velocity arena, feet

$\left(\frac{\bar{A}}{M} \right)$ = area mass ratio, centimeters²/grams.

The value of the area mass ratio is given by the relationship,

$$\left(\frac{\bar{A}}{M} \right) = b(m)^{-c}$$

where,

b = fragment area mass constant

c = fragment area mass exponent

m = fragment mass, which in this case is the average fragment mass taken over the entire polar zone.

c. The total fragment weight per polar zone is obtained by merely summing the product of the number of fragments and the average fragment weight for each mass interval over the total polar zone.

d. The steradian measure of the polar zone is,

$$A_k = 2\pi(\cos \theta_{k+1} - \cos \theta_k)$$

where θ_k is as defined in subparagraph a, above. Dividing the total number of fragments in the polar zone by A_k yields the number of fragments per steradian for the zone.

The remainder of the pertinent fragmentation data--heaviest fragment recovered and the number of hits (fragment impacts on velocity arena wall) from which the average velocity is calculated--is obtained by observing the raw test data. These values are inserted manually in the spaces provided in the output format. The total process is then repeated for each successive polar zone until the total fragment space has been spanned.

A listing of the program deck, the input format, and a sample of the input and output from the program are included in Appendix A.

APPENDIX A

PROGRAM DECK

A listing of the FORTRAN IV program deck designed for execution on the IBM 7030 is given as Figure A-1.

INPUT FORMAT

A description of the input format is shown in Figure A-2, and the various input data required by the program identified below:

<u>Card Type 1</u>	NRUNS	Number of fragment data tables to be prepared
<u>Card Type 2</u>	INT	Number of mass intervals per polar zone (≤ 20)
	NZONE	Total number of polar zones (≤ 36)
	MULT	MULT = $36/\text{NZONES}$ (Integer)
<u>Card Type 3</u>	TAB	Table number
	WEAP	Weapon identification (center in these columns)
<u>Card Type 4</u>	EXPLO	Type of explosive
	REFNO	Reference number
	NR	Number of rounds tested
	RADM	Radius of mass arena
	R	Radius of velocity arena
	H	Height of arena
<u>Card Type 5</u>	RHOA	Air density
	CD	Drag coefficient
	B	Fragment area/mass constant
	C	Fragment area/mass exponent
<u>Card Type 6</u>	NFRAG	Number of fragments per mass interval per zone

Starting with the first polar zone, list the number of fragments in the largest mass interval, the next largest mass interval, etc., until all mass intervals have been accounted for. Continue listing in the same order for each successive polar zone until all polar zones have been considered.

```

PROGRAM TO EDIT FRAGMENTATION DATA
  DIMENSION NFRAG(20,36),W(20,36),VBAR(36),THETA(37),AK(37),CAK(37)
  1,CNBAR(20,36),CMBAR(20,36),NO(36),VC(36),AINT(20),RAD(37),
  2WEAP(10),EXPLO(5),FRAG(20,36),REFNO(2),ASIN(37),WBAR(36)
  EQUIVALENCE (NFRAG,FRAG)
10 FORMAT(11A5)
11 FORMAT(7A5,I5,3F5.1)
12 FORMAT(4F10.5)
13 FORMAT(14I5)
14 FORMAT( 7F10.5)
20 FORMAT( 1H1,44X,6HTABLE ,A5,18HFRAGMENTATION DATA/37X,10A5)
21 FORMAT(11H1AVERAGE OF,I5,7H ROUNDS/22H RADIUS OF MASS ARENA ,F5.1,
  14H FT./26H RADIUS OF VELOCITY ARENA ,F5.1,4H FT./19H HEIGHT OF CEL
  2CTEX ,F4.1,4H FT./16H TYPE EXPLOSIVE ,5A5/15H REFERENCE NO. ,2A5)
22 FORMAT(126HK
  1 - - - - - FRAGMENT WEIGHT GROUPS (GRAMS) - - - - -
  2 - - )
23 FORMAT(13H POLAR , F5.1,2H +,3X,6(4XF6.3,1H-,F6.3))
24 FORMAT(123H ZONE
  1 N M N M N M N M
  2 M)
25 FORMAT( 1H ,I3,1H-,I3,2(1XF7.3),6(2XF7.3,1XF7.3))
26 FORMAT(52HON=AVERAGE NUMBER OF FRAGMENTS PER TOTAL POLAR ZONE./
  133H M=AVERAGE FRAGMENT MASS (GRAMS)./46H V=DISTANCE OF FRAGMENT FL
  2IGHT/TIME OF FLIGHT.)
27 FORMAT(1H5,/)
28 FORMAT(50HL- - - - - ,38X,
  122HTOTAL NO. OF FRAG.)
29 FORMAT( 2H ,2(F6.3,1H-,F6.3,4X),F6.3,1H-,F6.3,56H HEAVIEST V
  1ELOCITY (FT/SEC) FRAGMENT PER/108H N M
  2N M N M FRAGMENT HITS AVERAGE INITIAL WE
  3IGHT (GMS) STERADIAN)
30 FORMAT (1H ,F7.3,1X,F7.3,2(2X,F7.3,1X,F7.3), 16X,2(1XF7.2),
  13XF9.2,7XI5)
31 FORMAT(1H ,84XF9.2)
  READ 13,NRUNS
  THETA(1)=0.0
  RAD(1)=0.0
  ASIN(1)=0.0
  DO 400 LL=1,NRUNS
  READ 13,INT,NZONE,IMULT
  READ 10,TAB,WEAP
  READ 11,EXPLO,REFNO,NR,RADM,R,H
  READ 12,RHOA,CD,B,C
  READ 13, ((NFRAG(I,J),I=1,INT),J=1,NZONE)
  READ 14, ((W(I,J),I=1,INT),J=1,NZONE)
  READ 14,(VBAR(J),J=1,NZONE)
  READ 14,(AINT(I),I=1,INT)
  AMULT=IMULT
  SX=H/SQRT(H*H+4.*RADM*RADM)
  CX=SQRT(1.-SX*SX)
  X=ARTNG(SX,CX)
  XD=X*57.2957795131
  NZ=NZONE+1
  DO 100 M=2,NZ
  THETA(M)=THETA(M-1)+5.0*AMULT
  RAD(M)=THETA(M)*.01745329251994

```

Figure A-1. Program Deck Listing.

```
PRINT 26
PRINT 27
PRINT 28
PRINT 29, (AINT(I-1),AINT(I),I=8,INT)
DO 302 J=1,NZONE
302 PRINT 30, (CNBAR(I,J),CMBAR(I,J),I=8,INT),VBAR(J),VO(J),WBAR(J),
INO(J)
PRINT 31,WSUM
400 CONTINUE
RETURN
END
```

Figure A-1 (Cont'd)

```

PRO=.489*RHOA*CD*R
ANR=NR
WSUM=0.0
IST=0
DO 300 J=1,NZONE
JJ=J+1
DIV=SX/SIN(RAD(JJ))
DIV1=SQRT(1.-DIV*DIV)
ASIN(JJ)=ARCTG(DIV,DIV1)
IF(SX.GE.SIN(RAD(JJ)).AND.SX.GE.SIN(RAD(J))) GO TO 140
IF(SX.LE.SIN(RAD(JJ)).AND.SX.LE.SIN(RAD(J))) GO TO 130
IF(IST.EQ.1) GO TO 131
AK(J)=THETA(JJ)-THETA(J)
DEGX=AES(XD-THETA(J))
CAK(J)=2.0*DEGX + (6.28318531*ABS(COS(RAD(JJ))-CX)
1*(THETA(JJ)-XD))/((RAD(JJ)-X)*(SIN(RAD(JJ))*ASIN(JJ)+SX*1.5707963)
2)
IST=1
SAVE=AK(J)
SAVEC=CAK(J)
GO TO 142
131 AK(J)=SAVE
CAK(J)=SAVEC
GO TO 142
140 AK(J)=(COS(RAD(J))-COS(RAD(JJ)))*3.14159265
GO TO 141
130 AK(J)=(SIN(RAD(JJ))*ASIN(JJ)+SIN(RAD(J))*ASIN(J))*(RAD(JJ)-RAD
1(J))
141 CAK(J)=6.28318531*(COS(RAD(J))-COS(RAD(JJ)))
142 CB=CAK(J)/AK(J)
CAK(J)=6.28318531*(COS(RAD(J))-COS(RAD(JJ)))
150 U=0.0
WBAR(J)=0.0
SNBAR=0.0
SMB=0.0
DO 200 I=1,INT
CNBAR(I,J)=CB*(FRAG(I,J)/ANR)
CMBAR(I,J)=W(I,J)/FRAG(I,J)
WBAR(J)=CNBAR(I,J)*CMBAR(I,J)+WBAR(J)
IF(CMBAR(I,J)) 221,221,210
210 U=U+1.0
SMB=CMBAR(I,J)+SMB
221 IF(CNBAR(I,J)) 200,220,220
220 SNBAR=CNBAR(I,J)+SNBAR
200 CONTINUE
SMBAR=(1./U)*SMB
ABAR=B*(SMBAR**(-C))
OMEGA=PRO*ABAR
VO(J)=VBAR(J)*((2.71821828459**OMEGA-1.)/OMEGA)
NO(J)=SNBAR/CAK(J)
WSUM=WSUM+WBAR(J)
300 CONTINUE
PRINT 20,TAB,WEAP
PRINT 21,NR,RADM,R,H,EXPLO,REFNO
PRINT 22
PRINT 23,AINT(1),(AINT(I),AINT(I+1),I=1,6)
PRINT 24
DO 301 J=1,NZONE
301 PRINT 25, THETA(J),THETA(J+1),(CNBAR(I,J),CMBAR(I,J),I=1,7)

```

Figure A-1 (Cont'd)

Card Type 7

W

Total weight of fragments
per mass interval per zone

Starting with the first polar zone, list the total weight of the recovered fragments in the largest mass interval, the next largest mass interval, etc., until all mass intervals have been accounted for. Continue listing in the same order for each successive polar zone until all polar zones have been considered.

Card Type 8

VBAR

Average fragment velocity
per zone

Starting with the first polar zone, list the average fragment velocity, and continue listing for each successive polar zone until all have been considered.

Card Type 9

AINI

Mass interval

Starting with the largest mass interval, list the value of the lower bound, and continue listing until all mass intervals have been considered. Since all polar zones have the same mass intervals, they are listed only once.

INPUT AND OUTPUT

A sample of the input and output from the program is presented in Figures A-3 and A-4. This table is based on data from static detonation tests of four 8'/55 Mk 25 Mod 1 (HC) projectile warheads.

CONFIDENTIAL

CARD TYPE 1

DATA CARD LAYOUT															PROG. IDEN.	CARD NUMBER																																																														
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

KRUP'S

CARD TYPE 2

DATA CARD LAYOUT															PROG. IDEN.	CARD NUMBER																																																															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

INT EZONE MULT

CARD TYPE 3

DATA CARD LAYOUT															PROG. IDEN.	CARD NUMBER																																																															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

TAB

WEAP

Figure A-2. Layout Format.

CONFIDENTIAL

CONFIDENTIAL

PROJECTILE MARK 34 MOD 2 (HEI)										B31		1	
70-33 4 20.0 20.0 8.0													
COMP A-3 0.07650 0.62 0.55 0.23333													
										2	13		
1													2
10	36												3
23													4
COMP A-3													5
0.07650													6A
													6B
													6C
													6D
													6E
													6F
													6G
													6H
													6I
													6J
													6K
													6L
													6M
													6N
													6O
													6P
													6Q
													6R
													6S
													6T
													6U
													6V
													6W
													6X
													6Y
													6Z
													7A
													7B
													7C
													7D
													7E
													7F
													7G
													7H
													7I
													7J
													7K
													7L
													7M
													7N
													7O
													7P
													7Q
													7R
													7S
													7T
													7U
													7V
													7W
													7X
													7Y
													7Z

Figure A-3. Sample Input.

CONFIDENTIAL

CONFIDENTIAL

7.9	34.5	31.2	34.2	27.7	9.6	11.2	A7A
5.0	96.0	9.8	15.5	17.0	29.5	4.2	B7B
11.8	7.2	4.0	.8	25.6	50.6	48.2	C7C
	4.2	9.6	12.0	3.7	2.1	1.74	D7D
28.7		8.6	16.9	18.7	2.2	8.5	E7E
.9	1.4	1.1					F7F
			.8	.3	.4		G7G
	.5						H7H
.4	1.8	1.8	1.1	.9			I7I
				1.8	1.6	1.5	J7J
1.0							K7K
	.9		.8				L7L
					1.0	1.5	M7M
						1.5	N7N
		.7					O7O
			.7		.8		P7P
						.7	Q7Q
1.9	1.0			7.5	13.1	4.2	R7R
2.2			1.2	1.4		10.3	S7S
8.2	6.2		4.8	3.9		1.5	T7T
1.1	54.3	20.0	23.9	11.0	7.1	7.1	U7U
5.3	1.7	4.6	2.9	84.8			V7V
6.2	20.3	10.0	4.8	3.1	7.1	2.5	W7W
156.4		14.4	6.0	12.6	4.2	7.6	X7X
1.7	2.5	1.8					Y7Y
							Z7Z
2937.1	3650.7	4111.4	4192.5	4227.5	4099.2	3278.2	8A
2830.0							8B
					1900.0	2043.3	8C
2510.0							8D
11.0	9.0	7.0	5.0	3.0	2.0	1.0	8E
.625	.25	.0					8F
							9A
							9B

Figure A-3 (Cont'd)

CONFIDENTIAL

TABLE 23 FRAGMENTATION DATA
3/70 PROJECTILE MARK 34 M8D 2 (HEI)

Figure A-4. Sample Output.

CONFIDENTIAL

AVERAGE OF 4 RUNS
 RADIUS OF MASS ARENA 20.0 FT.
 RADIUS OF VELOCITY ARENA 20.0 FT.
 HEIGHT OF CELTEX 8.0 FT.
 TYPE EXPLOSIVE CBMP A-3
 REFERENCE NO. 20-33

POLAR ZONE	11.0 +		11.000- 9.000		9.000- 7.000		7.000- 5.000		5.000- 3.000		3.000- 2.000		2.000- 1.000	
	A	M	N	M	N	M	N	M	N	M	N	M	N	
0- 5	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
5- 10	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
10- 15	0.628	42.500	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	0.628	3.900	-0.000	-0.000	-0.000	
15- 20	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
20- 25	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	2.911	3.350	-0.000	-0.000	-0.000	
25- 30	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
30- 35	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
35- 40	4.786	19.150	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
40- 45	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
45- 50	5.832	33.400	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
50- 55	3.143	40.400	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	3.143	3.100	-0.000	-0.000	-0.000	
55- 60	3.345	38.300	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	3.345	4.200	-0.000	-0.000	-0.000	
60- 65	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
65- 70	3.671	34.700	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	14.682	4.275	-0.000	-0.000	-0.000	
70- 75	7.582	26.050	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	15.164	-0.000	-0.000	-0.000	-0.000	
75- 80	3.882	13.300	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	3.791	5.600	-0.000	-0.000	-0.000	
80- 85	7.886	12.950	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	7.947	3.800	-0.000	-0.000	-0.000	
85- 90	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	3.943	3.300	-0.000	-0.000	-0.000	
90- 95	27.816	16.886	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	7.947	3.800	-0.000	-0.000	-0.000	
95-100	23.558	16.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	31.789	3.900	-0.000	-0.000	-0.000	
100-105	7.764	12.800	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	27.601	4.214	-0.000	-0.000	-0.000	
105-110	7.582	14.350	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	3.882	4.200	-0.000	-0.000	-0.000	
110-115	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	18.954	3.740	-0.000	-0.000	-0.000	
115-120	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
120-125	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
125-130	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
130-135	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
135-140	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
140-145	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
145-150	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
150-155	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
155-160	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
160-165	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	1.456	4.200	-0.000	-0.000	-0.000	
165-170	1.884	18.100	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
170-175	2.500	16.960	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	2.556	3.550	-0.000	-0.000	-0.000	
175-180	2.000	39.100	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	1.500	4.200	-0.000	-0.000	-0.000	

N=AVERAGE NUMBER OF FRAGMENTS PER TOTAL POLAR ZONE.
 M=AVERAGE FRAGMENT MASS (GRAMS).
 V=DISTANCE OF FRAGMENT FLIGHT/TIME OF FLIGHT.

Figure A-4 (Cont'd)

CONFIDENTIAL

CONFIDENTIAL

1.000-0.625		0.625-0.250		0.250-0.000		HEAVIEST FRAGMENT	VELOCITY (FT/SEC) AVERAGE	INITIAL	TOTAL FRAGMENT WEIGHT (LBS)	NO. OF FRAG. PER STERADIAN
N	M	N	M	N	M					
-.000	-.000	1.000	0.450	6.500	0.031		-.00	-.00	0.65	313
2.500	0.800	1.000	0.350	29.500	0.029		-.00	-.00	3.20	461
1.884	0.800	5.653	0.356	39.573	0.025		-.00	-.00	33.67	407
-.000	-.000	5.473	0.480	17.513	0.063		-.00	-.00	3.72	139
1.456	1.000	1.456	0.500	61.141	0.040		-.00	-.00	14.41	319
-.000	-.000	5.365	0.467	51.860	0.055		-.00	-.00	5.36	226
4.201	0.900	6.301	0.433	48.311	0.022		-.00	-.00	18.48	206
-.000	-.000	2.393	0.300	59.829	0.024		-.00	-.00	96.44	207
2.665	0.700	2.665	0.400	34.650	0.054		-.00	-.00	10.93	115
2.916	0.700	2.916	0.600	37.907	0.031		-.00	-.00	206.74	129
3.143	0.700	-.000	-.000	37.717	0.067		-.00	-.00	141.47	108
-.000	-.000	6.691	0.300	56.873	0.047		-.00	-.00	222.47	202
7.043	0.850	7.043	0.300	35.217	0.060		-.00	-.00	78.89	159
3.671	0.750	11.012	0.333	25.694	0.071		-.00	-.00	221.33	137
7.582	0.750	3.791	0.400	34.118	0.100		2937.10	3165.62	315.40	166
-.000	-.000	27.174	0.329	34.937	0.100		3650.70	3933.71	243.79	188
11.829	0.733	31.544	0.375	47.316	0.125		4111.40	4456.99	236.58	239
7.947	0.800	35.763	0.433	91.394	0.109		4192.50	4718.81	79.87	282
47.684	0.800	107.289	0.415	206.630	0.096		4227.50	4574.10	1110.64	1059
35.487	0.800	39.430	0.400	59.145	0.053		4099.20	4424.70	772.04	457
11.646	1.233	19.410	0.420	108.694	0.062		3278.20	3544.35	612.34	449
3.791	0.900	15.164	0.350	53.072	0.079		2830.00	3066.49	329.81	261
3.671	0.800	3.671	0.300	18.353	0.080		-.00	-.00	5.51	50
-.000	-.000	3.522	0.400	45.782	0.038		-.00	-.00	3.17	101
6.691	0.900	6.691	0.550	86.982	0.035		-.00	-.00	18.73	224
6.286	0.800	12.572	0.375	135.152	0.023		-.00	-.00	18.54	361
2.916	0.900	-.000	-.000	107.888	0.022		-.00	-.00	4.96	274
-.000	-.000	7.996	0.333	157.260	0.025		-.00	-.00	6.66	446
-.000	-.000	4.786	-.000	107.692	0.016		-.00	-.00	5.26	344
2.100	0.700	-.000	-.000	115.526	0.015		-.00	-.00	3.15	399
1.788	0.700	7.153	0.4.5	80.472	0.022		-.00	-.00	6.44	353
-.000	-.000	4.367	0.400	80.066	0.025		-.00	-.00	43.09	437
-.000	-.000	4.378	0.375	45.972	0.026		-.00	-.00	39.40	358
1.256	0.850	6.910	0.418	45.854	0.040		1900.00	2048.89	86.62	555
2.000	0.775	8.500	0.418	23.000	0.054		2043.30	2216.29	69.40	601
1.000	0.850	3.500	0.337	20.500	0.044		2510.00	2686.26	103.95	1401
									5173.13	

Figure A-4 (Cont'd)

CONFIDENTIAL