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**SAMUEL FELTMAN
AMMUNITION LABORATORIES**

**PICATINNY ARSENAL
DOVER, N. J.**

FRAGMENTATION TEST

RECORD NO. 287

DATE August 1954

SUBJECT:

Shell, HE, 60 mm, Folding Fin, Typed BD-106-1,
Metal Parts Assembly

54AA 60589

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GFlartey/hb/4160
Picatinny Arsenal, Dover, N.J.
6 August 1954

TEST RECORD NO: 287

REFERENCE: Project No. Tal-1402

DESCRIPTION OF AMMO: Shell, HE, 60 mm, Folding Fin Type BD-106-1, manufactured by the Budd Company from Steel, Carbon, Bar Stock, U.S. 1020, Spec QQ-S-633.

DRAWING NUMBERS: Complete Round: WS-5154X, Rev 1/21/54
Shell Loading: WD-5196X, WD-5197X, 2/5/54
Shell Metal Parts: WR-5152-X, Rev 1/12/54
(Assembly & Details)

QUANTITY IN LOT: 3 in each lot

QUANTITY FRAGMENTED: 6

METHOD FUNCTIONING: Modified M52 Fuze, Drawing 73-1-161, initiated with Corps of Engineering blasting cap.

PURPOSE OF TEST: The object of this test was: (a) to compare the fragmentation properties of TNT-loaded type BD-106-1 folding fin Shell metal parts with those of the Comp B Type BD-106-1 folding fin Shell metal parts and (b) to compare the fragmentation properties of the Type BD-106-1 Shell (both TNT and Comp B-loaded) with those of similarly loaded Shell, HE, 60 mm T24.

FRAGMENTATION PROCEDURE: 6 Shell were fragmented at ambient temperature. (3 shell TNT-loaded, 3 shell Comp B-loaded). The shell were assembled equipped with electric ignition and placed in a pine box with $\frac{1}{2}$ " wall thickness. The overall dimensions of the box were 8" x 8" x 16". The box was placed on end over 6' of sawdust in a 14' - 9" deep fragmentation tub, 15' - 5" in diameter at the top and tapering to 13" diameter at the bottom. The box was covered with 5' of sawdust.

FRAGMENTATION RECOVERY
& CLASSIFICATION:

Fragments were recovered from tub by sifting the sawdust on a mechanically-operated screen of No. 8 Mesh (.093" opening, .032 wire diameter), using a magnetic separator. The fragments were classified by weight and grouping according to the following weight zones:

Group 0 - 0 to $\frac{1}{32}$ grain

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6 August 1954

Group 1 - $\frac{1}{2}$ to 2 grains
Group 2 - 2 to 5 grains
Group 3 - 5 to 10 grains
Group 4 - 10 to 25 grains
Group 5 - 25 to 50 grains
Group 6 - 50 to 75 grains
Group 7 - 75 to 150 grains
Group 8 - 150 to 750 grains
Group 9 - 750 to 2500 grains
Group 10 - Over 2500 grains

The 60 mm mortar shell metal parts assemblies, Type BD-106-1 which were fragmented during the course of this test were of two-piece silver soldered base plug construction as shown on Drawing No WB-5152- -X, Rev 1/12/54. The complete round assembly fragmented consisted of both the shell body and folding fin and boom assembly. The folding fin and boom assembly (integral) was attached to the threaded end of the base plug on the shell body. The fin and boom assemblies were manufactured from aluminum alloy, 24 ST - 4, Spec QQ-A-354a. The steel and aluminum fragments were recovered, segregated into two groups, counted, and recorded separately. The steel fragments were recovered by means of a magnetic separator and the aluminum fragments were recovered manually.

Discussion & Conclusions:

Based on the limited data available, the following observations were made:

Considering the opinion that effective lethality is obtained only with fragments occurring over 10 grains in size, Comp B-loaded shell produced a greater total number of effective fragments than the TNT-loaded shell.

The average total number of Comp B-loaded steel shell fragments occurring above 10 grains is 454 and the average total number of TNT-loaded steel shell fragments occurring above 10 grains is 399.

The average total number of Comp B-loaded shell aluminum fragments occurring above 10 grains is 27.

The average total number of TNT-loaded shell aluminum fragments occurring above 10 grains is 34,

A graphical representation of the data given in the preceding three paragraphs is shown in Figure 1.

A curve of percent average cumulative weight of steel shell fragments versus group number for the TNT and Comp B-loaded shell, respectively, is shown in Figure 2.

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The "Percent average cumulative weight" is based on the average weight of fragments (per group number) of each group of 3 projectiles on the inclosed data sheets.

By definition, the average cumulative weight of fragments equals the average weight of fragments in a group, plus the average weight of fragments in all preceding groups. The percent average cumulative weight of fragments is defined as the ratio of the average cumulative weight to the average weight of the empty shell.

Average total weight of Comp B-loaded steel shell
fragments occurring between 10 and 50 grains
divided by weight of empty shell $\times 100 = 44\%$

Average total weight of TNT-loaded steel shell
fragments occurring between 10 and 50 grains
divided by weight of empty shell $\times 100 = 37.5\%$

The statement, made above, that effective lethality is obtained only with fragments occurring over 10 grains in size, and also the statement that fragments in the weight range of 10 to 50 grains constitutes the optimum casualty producing size of fragment, is based entirely on the criterion established by Watertown Arsenal as given in 1st Indorsement, 3-2-54, Watertown Arsenal to Picatinny Arsenal, ORDBE-L 471.2/1824, ORDBB 471.14/10-122, subject: "Fragmentation Characteristics of Shell and Test Cylinders of Case and Forged Steels (Project TAL-1546D)".

However, if the assumptions relative to the nature of terrain, effect of fragment velocities, and wound ballistics contained in various Ballistic Research Laboratories Reports, by: T. Sterne, et al, are followed, the conclusions probably would be changed and the shell and explosive combinations giving fine degrees of fragmentation might be moved up into higher categories of preference. This involved decisions to be made only after consideration by higher echelons, such as Service Board, ORO, and WSEG, and probably would require acquiring information on fragmentation, velocity and distribution patterns which is presently not available.

Regardless of which of above criteria are used, however, it appears that the Comp B-loaded Type BD-106-1 shell yielded fragmentation properties slightly superior to those of the TNT-loaded Type BD-106-1 shell. Both TNT and Comp B-loaded Type BD-106-1 shell metal parts yielded fragmentation characteristics superior to those of similarly loaded Shell, HE, 60 mm, T24 Metal Parts as reflected in Picatinny Arsenal Fragmentation Report No. 279

G. R. FLARNEY

George R. Flarney

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J. E. G. and Co.
JOHN D. ARMITAGE
Col, Ord Corps
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PICATINNY ARSENAL FRAGMENTATION TEST

Mortar 60mm Boat Tail Folding Fin
 Projectile: Steel, Carbon, Bar Stock; FS 1020
 Spec. QQ-S-633 Mfgd by Budd Co
 Explosive Filler: TNT Design BD-106-1

Test Record No: 2340
 Sheet 1 of 4

Type Fuze: P.D. M52 Mod. Initiated with an Eng. Date: 6 May 1954
 Corps Blasting Cap.
 Size of Box: 8" x 8" x 16" 1/2" Pine

Recovery Medium: Sawdust #8 Mesh Screen and Magnetic Separator.

		PROJECTILE NO.				
		1		2		
Requested by Mr. G. Flartey		Steel	Alum	Steel	Alum	
Wt. Empty Lbs.		2.68	.78	2.68	.78	
Wt. Loaded Lbs.		4.30		4.29		
Number and Weight of Recovered Fragments:	No. 0 Group Not 0 to 1/2 Grs. Counted	Through a 10 Mesh Screen (U. S. Std Sieve Series)				
	Wt. Lbs.	.06	.01	.05	.01	
	No. 1 Group 1/2 to 2 Grs.	No.	751	54	712	63
	Wt. Lbs.	.12	.01	.12	.01	
	No. 2 Group 2 to 5 Grs.	No.	440	3	343	74
	Wt. Lbs.	.20	.03	.17	.04	
	No. 3 Group 5 to 10 Grs.	No.	243	25	198	22
	Wt. Lbs.	.25	.02	.21	.02	
	No. 4 Group 10 to 25 Grs.	No.	251	20	219	17
	Wt. Lbs.	.59	.04	.50	.04	
	No. 5 Group 25 to 50 Grs.	No.	107	7	91	10
	Wt. Lbs.	.54	.04	.48	.05	
	No. 6 Group 50 to 75 Grs.	No.	30	6	28	7
	Wt. Lbs.	.26	.05	.25	.06	
	No. 7 Group 75 to 150 Grs.	No.	28	2	37	1
	Wt. Lbs.	.43	.02	.62	.01	
	No. 8 Group 150 to 750 Grs.	No.	8		9	1
	Wt. Lbs.	.22		.24	.09	
	No. 9 Group 750 to 2500 Grs.	No.				
	Wt. Lbs.					
	No. 10 Group 2500 and Larger	No.		1		1
	Wt. Lbs.		.54		.43	
Total No.		1858	173	1637	186	
Total Wt. Lbs.		2.67	.76	2.64	.76	
% of Fragments Recovered		99.6	97.4	98.5	97.4	
Photo No.		M44781		M44782		
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PICATINNY ARSENAL FRAGMENTATION TEST

Projectile: same

Test Record No: 2340

Explosive Filler: TNT Design ED-106-1

Sheet 2 of 4

Type Fuze:

Date: 6 May 1954

Size of Box:

Recovery Medium:

		3 PROJECTILE NO.				
		Steel	Alum			
Wt. Empty Lbs.		2.68	.78			
Wt. Loaded Lbs.		4.30				
Number and Weight of Recovered Fragments	No. 0 Group Not 0 to 1/4 Grs. Counted	Through a 10 Mesh Screen (U. S. Std Sieve Series)				
	Wt. Lbs.	.05	.01			
	No. 1 Group 1/4 to 2 Grs.	No. Wt. Lbs.	725 .11	22 .01		
	No. 2 Group 2 to 5 Grs.	No. Wt. Lbs.	387 .18	58 .03		
	No. 3 Group 5 to 10 Grs.	No. Wt. Lbs.	225 .23	26 .03		
	No. 4 Group 10 to 25 Grs.	No. Wt. Lbs.	225 .49	14 .03		
	No. 5 Group 25 to 50 Grs.	No. Wt. Lbs.	90 .43	9 .05		
	No. 6 Group 50 to 75 Grs.	No. Wt. Lbs.	25 .21	6 .05		
	No. 7 Group 75 to 150 Grs.	No. Wt. Lbs.	32 .51	1 .01		
	No. 8 Group 150 to 750 Grs.	No. Wt. Lbs.	17 .46			
	No. 9 Group 750 to 2500 Grs.	No. Wt. Lbs.				
	No. 10 Group 2500 and Larger	No. Wt. Lbs.		1 .54		
	Total No.		1726	137		
	Total Wt. Lbs.		2.67	.76		
	% of Fragments Recovered		99.6	97.4		
	Photo No.		MAN 783			
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PICATINNY ARSENAL FRAGMENTATION TEST

Projectile: same
 Explosive Filler: Comp B Design BD-106-1
 Type Fuze:
 Size of Box:
 Recovery Medium:

Test Record No: 2340
 Sheet 3 of 4
 Date: 6 May 1954

		PROJECTILE NO. 2					
		1					2
		Steel	Alum		Steel	Alum	
Wt. Empty Lbs.		2.68	.78		2.68	.78	
Wt. Loaded Lbs.		4.36			4.35		
Number and Weight of Recovered Fragments	No. 0 Group Not 0 to 1/4 Grs. Counted	Through a 10 Mesh Screen (U. S. Std Sieve Series)					
		Wt. Lbs.	.12	.01		.10	.01
	No. 1 Group 1/4 to 2 Grs.	No.	1084	38		987	87
		Wt. Lbs.	.17	.02		.15	.01
	No. 2 Group 2 to 5 Grs.	No.	523	68		616	57
		Wt. Lbs.	.25	.03		.28	.02
	No. 3 Group 5 to 10 Grs.	No.	336	22		332	29
		Wt. Lbs.	.34	.02		.34	.03
	No. 4 Group 10 to 25 Grs.	No.	280	14		311	13
		Wt. Lbs.	.60	.03		.69	.03
	No. 5 Group 25 to 50 Grs.	No.	109	4		92	5
		Wt. Lbs.	.54	.02		.45	.03
	No. 6 Group 50 to 75 Grs.	No.	22	9		12	7
		Wt. Lbs.	.19	.07		.10	.06
	No. 7 Group 75 to 150 Grs.	No.	26			27	
		Wt. Lbs.	.38			.41	
	No. 8 Group 150 to 750 Grs.	No.	2			4	
		Wt. Lbs.	.05			.11	
	No. 9 Group 750 to 2500 Grs.	No.					
		Wt. Lbs.					
No. 10 Group 2500 and Larger	No.		1			1	
	Wt. Lbs.		.54			.54	
Total No.		2382	206		2381	199	
Total Wt. Lbs.		2.64	.74		2.63	.73	
% of Fragments Recovered		98.5	94.8		98.1	93.5	
Photo No.		M44784			M44785		
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PICATINNY ARSENAL FRAGMENTATION TEST

Projectile: same
 Explosive Filler: Comp 3 Design 3D-106-1
 Type Fuze:
 Size of Box:
 Recovery Medium:

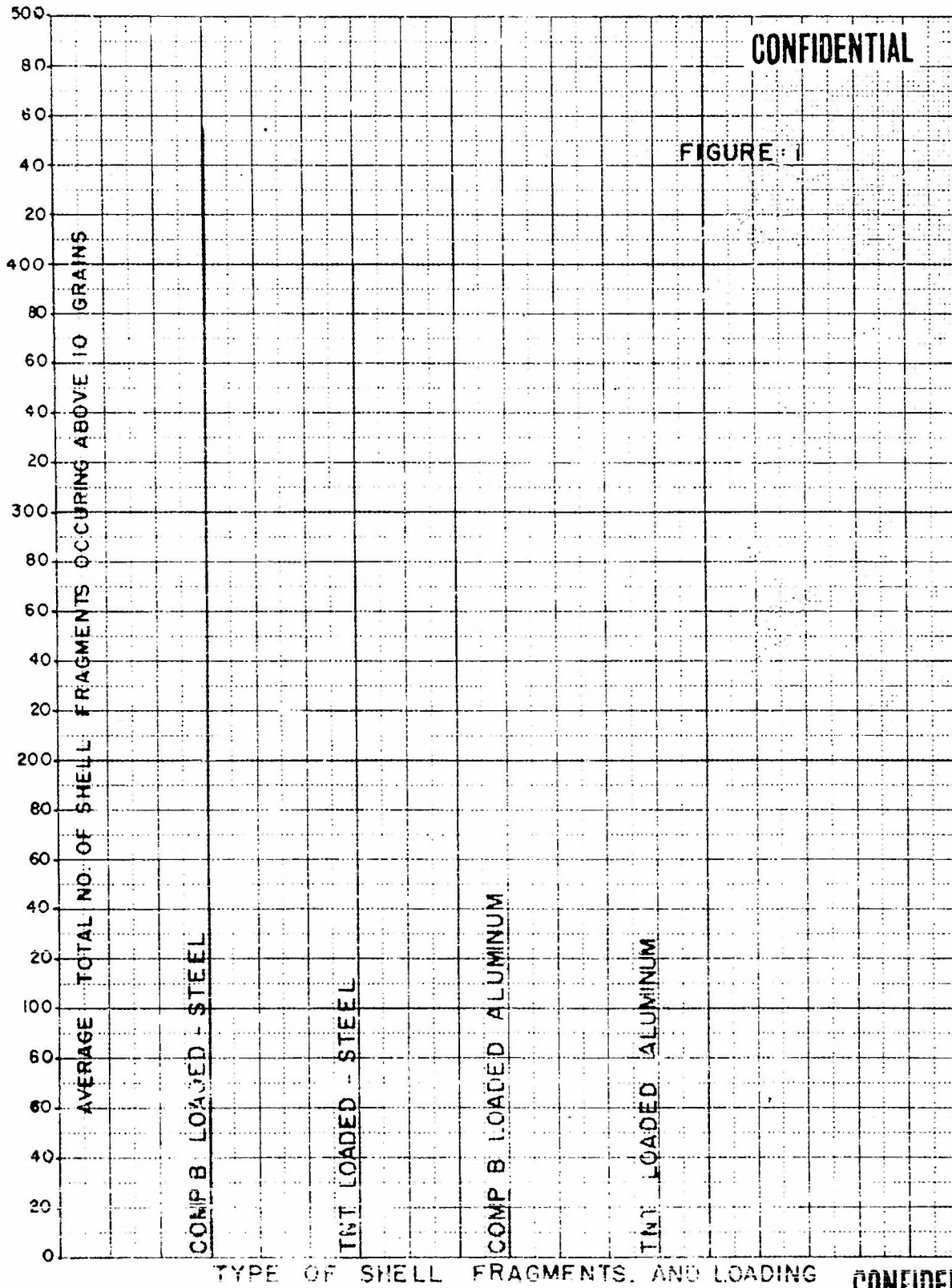
Test Record No: 2340
 Sheet 4 of 4
 Date: 6 May 1954

Approved by L. F. Page
 Chief, Testing Section

Reviewed by L. D. Bercoff
 Chief, Proof Testing Unit

Prepared by J. Smalinski

		3 PROJECTILE NO.				
		Steel	Alum			
Wt. Empty Lbs.		2.68	.78			
Wt. Loaded Lbs.		4.37				
Number and Weight of Recovered Fragments	No. 0 Group Not 0 to 1/4 Grs. Counted	Through a 10 Mesh Screen (U. S. Std Sieve Series) Wt. Lbs.	.08	.01		
	No. 1 Group 1/4 to 2 Grs.	No.	1117	136		
		Wt. Lbs.	.16	.02		
	No. 2 Group 2 to 5 Grs.	No.	488	60		
		Wt. Lbs.	.22	.03		
	No. 3 Group 5 to 10 Grs.	No.	313	37		
		Wt. Lbs.	.32	.04		
	No. 4 Group 10 to 25 Grs.	No.	319	12		
		Wt. Lbs.	.69	.03		
	No. 5 Group 25 to 50 Grs.	No.	100	4		
		Wt. Lbs.	.43	.03		
	No. 6 Group 50 to 75 Grs.	No.	27	9		
Wt. Lbs.		.23	.07			
No. 7 Group 75 to 150 Grs.	No.	26				
	Wt. Lbs.	.42				
No. 8 Group 150 to 750 Grs.	No.	2				
	Wt. Lbs.	.05				
No. 9 Group 750 to 2500 Grs.	No.					
	Wt. Lbs.					
No. 10 Group 2500 and Larger	No.		1			
	Wt. Lbs.		.53			
Total No.		2392	259			
Total Wt. Lbs.		2.65	.76			
% of Fragments Recovered		98.8	97.4			
Photo No.		M44786				
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FIGURE 1

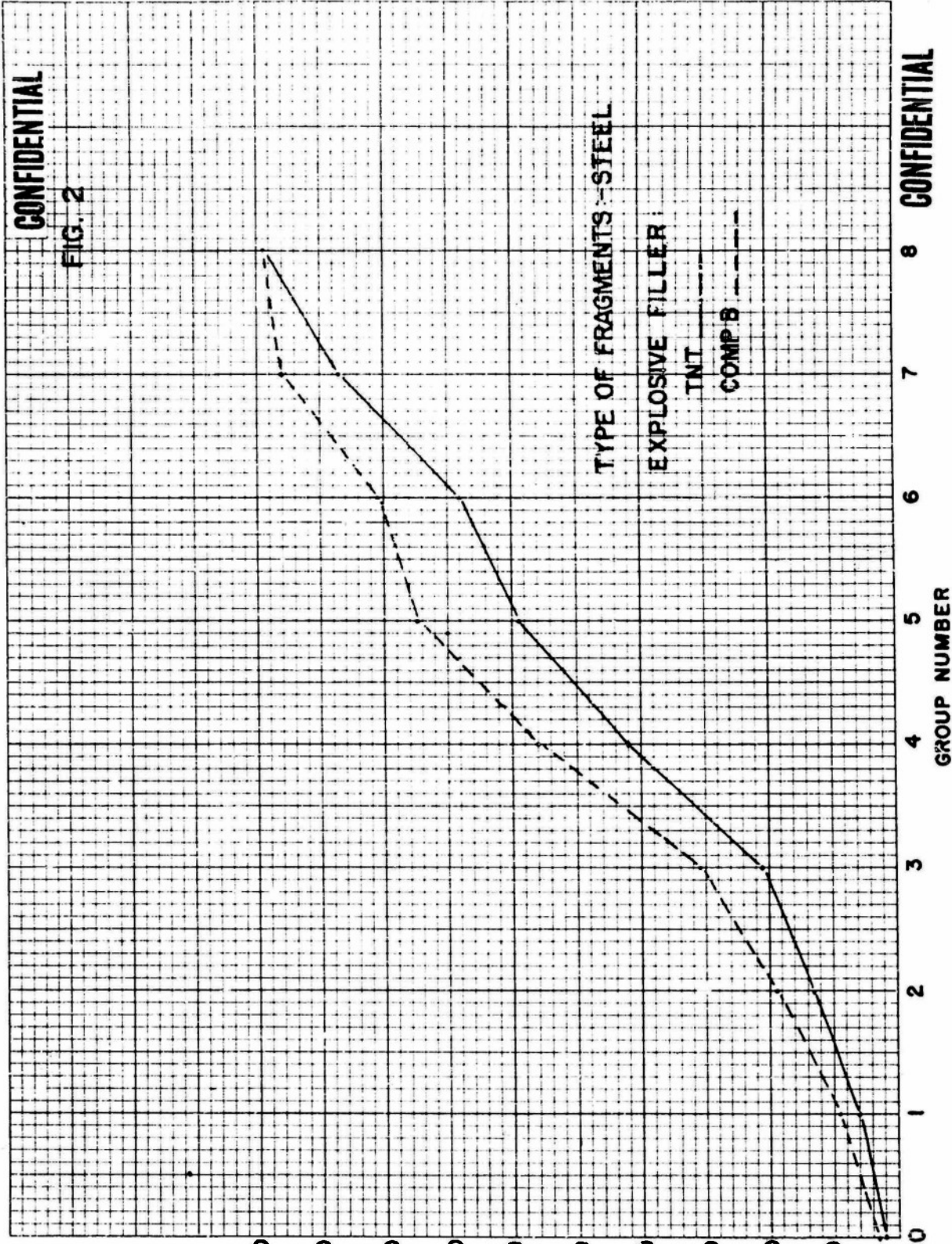
TYPE OF SHELL FRAGMENTS, AND LOADING

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FIG. 2

PERCENT AVERAGE CUMULATIVE WEIGHT



TYPE OF FRAGMENTS - STEEL

EXPLOSIVE FILLER:

TNT

COMP B

GROUP NUMBER

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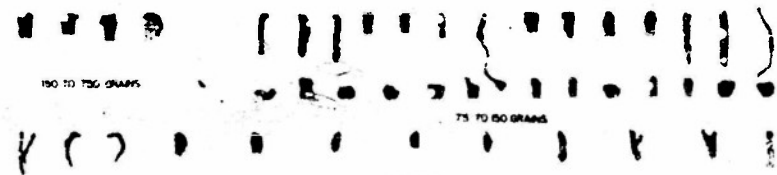
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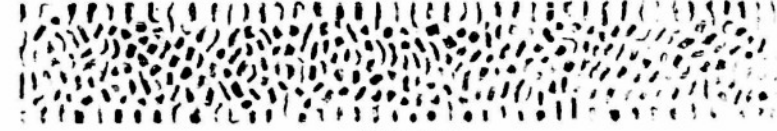
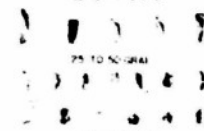
1000 GRAMS AND UP

50 TO 75 GRAMS



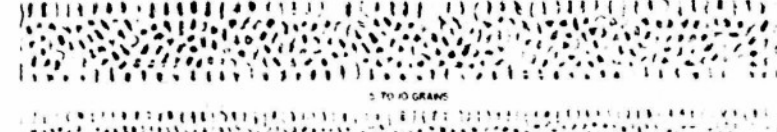
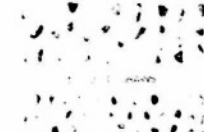
50 TO 75 GRAMS

25 TO 50 GRAMS



25 TO 50 GRAMS

10 TO 25 GRAMS



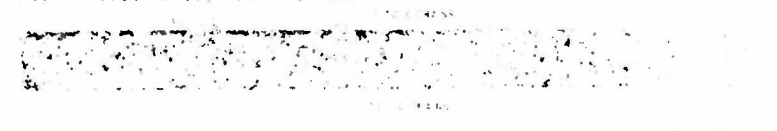
10 TO 25 GRAMS

5 TO 10 GRAMS



5 TO 10 GRAMS

1 TO 5 GRAMS



1 TO 5 GRAMS

LESS THAN 1 GRAM

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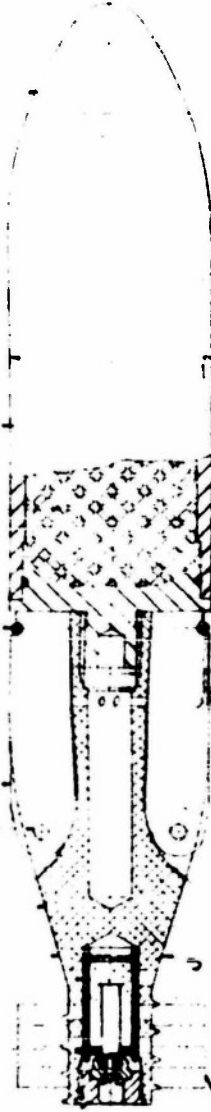
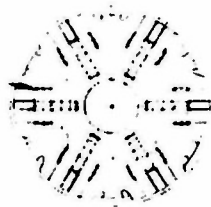
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WD-5154X

RED END OF CARTRIDGE TO BE
MILCO NOT TO FRAME

10 9 8 7 6 5 4 3 2 1

7 HOLES FIT IN 1/2" DIA. HOLES
IN 1/2" DIA. HOLES
FOR 1/2" DIA.



OM 1

OM 2

OM 1 TO BE COV.
EXPLICIT WITH OM
D. INITIAL COORDINATE
INDICATE BOUNDING

SHEET OR BAG
PROPELLANT SUPPLIED
BY ORDNANCE

OM 1 TO BE CONCENTRIC
WITH OM 2. WITHIN 0.002
TOTAL INDICATOR READINGS

13/16 MAX

FACE MOMENTUM 100Z.
FOR ALL PARTS.

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1	PLATE	1	PCB	WD-5154X	1/79	BY	OKO
2	WELD STUDS COMPANION	11	PCB	WD-5154X	1/79	BY	OKO
3	PLATE, RECESS TO MIP	1	PCB	WD-5154X	1/79	BY	OKO
4	CRACK LOG. IGNITION ASSY	1	PCB	WD-5154X	1/79	BY	OKO
5	O-RINGS	1	PCB	WD-5154X	1/79	BY	OKO
6	PLATE	1	PCB	WD-5154X	1/79	BY	OKO
7	BOOM	1	PCB	WD-5154X	1/79	BY	OKO
8	SPRING RINGS 2.00	1	PCB	WD-5154X	1/79	BY	OKO
9	COUPLER	1	PCB	WD-5154X	1/79	BY	OKO
10	BOOBY ASSY	1	PCB	WD-5154X	1/79	BY	OKO

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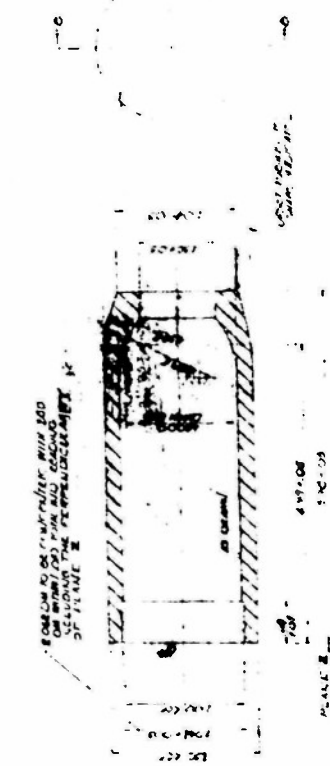
ITEM NO.	DESCRIPTION	QTY	UNIT	REF. DES.	DATE	BY	CHKD
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5	O-RINGS	1	PCB	WD-5154X	1/79	BY	OKO
6	PLATE	1	PCB	WD-5154X	1/79	BY	OKO
7	BOOM	1	PCB	WD-5154X	1/79	BY	OKO
8	SPRING RINGS 2.00	1	PCB	WD-5154X	1/79	BY	OKO
9	COUPLER	1	PCB	WD-5154X	1/79	BY	OKO
10	BOOBY ASSY	1	PCB	WD-5154X	1/79	BY	OKO

WD-5154X
DD-N06-1

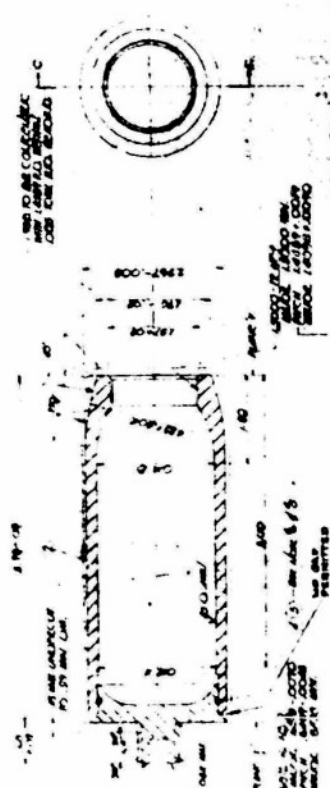
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AD-2096 C.V.



SECTION D-D
DOOR CASE 18" x 24" x 1/2"
SEE PLAN



SECTION C-C
DOOR CASE 18" x 24" x 1/2"
SEE PLAN

SECTION C-C
DOOR CASE 18" x 24" x 1/2"
SEE PLAN

SECTION C-C
DOOR CASE 18" x 24" x 1/2"
SEE PLAN

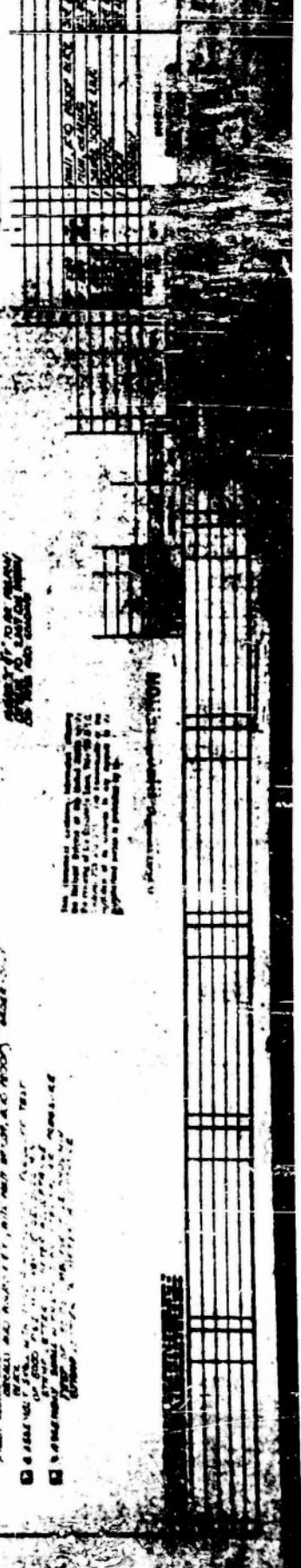
SECTION C-C
DOOR CASE 18" x 24" x 1/2"
SEE PLAN

SECTION C-C
DOOR CASE 18" x 24" x 1/2"
SEE PLAN

SECTION C-C
DOOR CASE 18" x 24" x 1/2"
SEE PLAN

SECTION C-C
DOOR CASE 18" x 24" x 1/2"
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SECTION C-C
DOOR CASE 18" x 24" x 1/2"
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