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**Ballistic Research Laboratories**

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FRAGMENTATION OF SINGLE AND DOUBLE WALL CYLINDRICAL WARHEADS

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**BALLISTIC RESEARCH LABORATORIES**

**TECHNICAL NOTE NO. 554**

**FRAGMENTATION OF SINGLE AND DOUBLE WALL CYLINDRICAL WARHEADS**

**Project No. TB3-0112A, of the Research and  
Development Division, Ordnance Corps**

**ABERDEEN PROVING GROUND, MARYLAND**

## FRAGMENTATION OF SINGLE AND DOUBLE WALL CYLINDRICAL WARHEADS

Static fragmentation tests were made to investigate the fragmentation characteristics of a double wall cylindrical warhead as compared to a single wall cylindrical warhead of the same overall dimensions. The purpose of these tests was to obtain a quantitative estimate of the difference in fragment mass, numbers, velocity and spatial distribution between a double and a single wall cylindrical warhead.

## DESCRIPTION OF WARHEADS

Standard 3" M42A1 shells were machined into cylinders 6" in length with the diameter dimensions as follows:

	<u>Single Wall Cylinder</u>	<u>Double Wall Cylinder</u>	
		<u>Outer</u>	<u>Inner Cylinder</u>
Outside diameter	2.70"	2.70"	2.49"
Inside diameter	2.28"	2.49"	2.28"

Tolerances were held to within  $\pm .002"$ . Fibre tubing machined down to the size of the cylinder was attached to each end (Figures 1 and 2). The fibre end extensions were used to reduce end effect which would change the fragmentation characteristics of the ends of the cylinders. The warhead was fully loaded with Composition C-3 and a tetryl booster was imbedded in the explosive near the initiated end. The weights of components, in grams, were as follows:

	<u>Single Wall</u>	<u>Double Wall</u>
Weight of outer cylinder	---	658
Weight of inner cylinder	---	607
Total weight of steel cylinders	1264	1265
Weight of fibre tubing, long	52	50
Weight of fibre tubing, short	36	33
Weight of fibre end disc, rear	15	22
Weight of fibre end disc, front	10	21
Weight of Comp C-3	862	835
Empty Weight	1377	1391
Loaded weight	2239	2226

## METHOD OF TESTING

The field set up for the single wall warhead consisted of placing seven cane fibre filled recovery boxes tangent to a circle of 6' radius measured from the center of the warhead, (Fig. 3). The warhead was suspended with its longitudinal axis vertical 3' 4 1/4" above the ground level, as measured from the top of the warhead, and detonated with a 5/16" engineer's special electric blasting cap.

The field set up for the double wall warhead consisted of placing four cane fibre filled recovery boxes tangent to a circle of 12' 1-3/8" radius measured from the center of the warhead, (Fig. 4). One box (Box No. 3) was faced with .040" aluminum sheet painted black for the purpose of measuring the fragment velocity by the photographic method. Fragments were not recovered from that box. The warhead was suspended with its longitudinal axis vertical 6' above the floor level, as measured from the top of the warhead, and detonated with a 5/16" engineer's special electric blasting cap.

## RESULTS

The percent of the total number of fragments recovered in various weight intervals is given in Table I. The "predicted" values (Column 5) of the double wall warhead were obtained from the mass distribution of the single wall warhead by assuming that the fragments in each weight interval were reduced in mass by 1/2 and doubled in number. It can be seen that the "predicted" values for the double wall warhead are in good agreement with the observed values, indicating that the breakup of the single and double wall warheads were the same with respect to the length and width of the fragments and differed only in thickness. It should be noted that the fragments from 0-10 grains and 0-5 grains of the single and double wall warheads respectively were not considered. If the small fragments were included the two for one breakup of the larger fragments is not evident. This can be seen by examining Table II or Figure 6 where the fragment recoveries, including the smallest fragments recovered, are given. The reason that the two for one breakup is not evident in Table II is not known but it appears that either the breakup of the small fragments is different than the large fragments for the two warheads or the recovery of the small fragments was not complete.

The average weight of recovered fragments greater than 10 grains, single wall, is 34.0 grains, and average weight greater than 5 grains, double wall, is 15.3 grains.

Figure 5 shows fragments recovered from one recovery box for each warhead. The lengths and widths of the larger fragments from the single wall warhead are roughly equal to the lengths and widths of the larger fragments from the double wall warhead. The thicknesses of the double warhead fragments are roughly one-half that of the single wall warhead fragments.

The weight of fragments recovered from the cane fibre board was 83% for the single wall warhead and 84% for the double wall warhead with respect to the theoretical recovery computed from the known geometry of the test setup.

The computed initial fragment velocity for either warhead is 5100 ft/sec as determined from Gurney's<sup>1</sup> formula using the total explosive weight contained in the steel cylinder for C and the steel cylinder weight for M. The observed average initial fragment velocity was not measured for the single wall warhead, but was 5700 f/s for the double wall warhead. This higher value may not be significant and further checks are necessary. It does appear, however, that there is little, if any, loss in fragment velocity due to the use of a double wall.

The spatial distribution of fragments from the double wall warhead was satisfactory in the sense that adjacent fragments from each cylinder were separate in space and showed no evidence when recovered of being fused together. Fragment holes in the first sheet of the celotex appeared to be randomly spaced and there was no evidence of pairing of the fragments.

#### SUMMARY

For the present experiment, a double wall reduced the weight of and increased the number of fragments by an amount which is predictable from the fragments of a single wall warhead, except for the smallest fragments. If the smallest fragments are excluded, the observed average reduction in weight was about 1/2, the number increasing by a factor of 2. One possible application of multi-wall casings is for high explosive artillery or mortar shell where the present weight of the larger fragments is heavier than is necessary against personnel.

Cylindrical warheads of thicker casings and more layers are being made for the purpose of investigating further the fragmentation characteristics of multi-wall cylindrical warheads.

- 
1. Gurney, R., "The Initial Velocity of Fragments from Bombs, Shells, and Grenades," BRL Report No. 405.

TABLE I

Comparison of Fragment Mass Distribution by % of Number Recovered

SINGLE WALL WARHEAD		DOUBLE WALL WARHEAD		Predicted Percent of Total Number
Weight Interval Grains	Percent of Total Number Recovered	Weight Interval Grains	Percent of Total Number Recovered	
10-20	31.41	5-10	36.48	31.41
20-30	25.00	10-15	22.64	25.00
30-40	16.03	15-20	17.61	16.03
40-50	8.33	20-25	8.81	8.33
50-60	8.97	25-30	6.28	8.97
60-70	3.85	30-35	5.03	3.85
70-80	.64	35-40	.63	.64
80-90	2.56	40-45	2.52	2.56
90-100	.64	45-50	0	.64
100-110	.64	50-55	0	.64
110-120	1.29	55-60	0	1.29
120-130	0	60-65	0	0
130-140	.64	65-70	0	.64

TABLE II

## Weight Distribution of Fragments

Wt. Interval Grains	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	
Single Wall Warhead	Observed Number	352	50	29	20	21	18	14	11	5	8	9
	% of Total Number	63.08	8.96	5.20	3.58	3.76	3.23	2.50	1.97	.90	1.43	1.61
	Weight	400.15	354.47	359.57	343.36	469.29	495.21	453.08	405.40	203.70	381.94	476.54
	% of Total Weight	6.69	5.93	6.01	5.75	7.85	8.29	7.58	6.78	3.41	6.39	7.98
Double Wall Warhead	Observed Number	98	58	36	28	14	10	8	1	4	0	
	% of Total Number	38.13	22.57	14.01	10.89	5.45	3.89	3.11	.39	1.56	0	
	Weight	220.37	400.15	439.19	468.98	307.87	273.30	253.39	35.65	166.82	0	
	% of Total Weight	8.59	15.60	17.12	18.27	12.00	10.65	9.88	1.39	6.50	0	

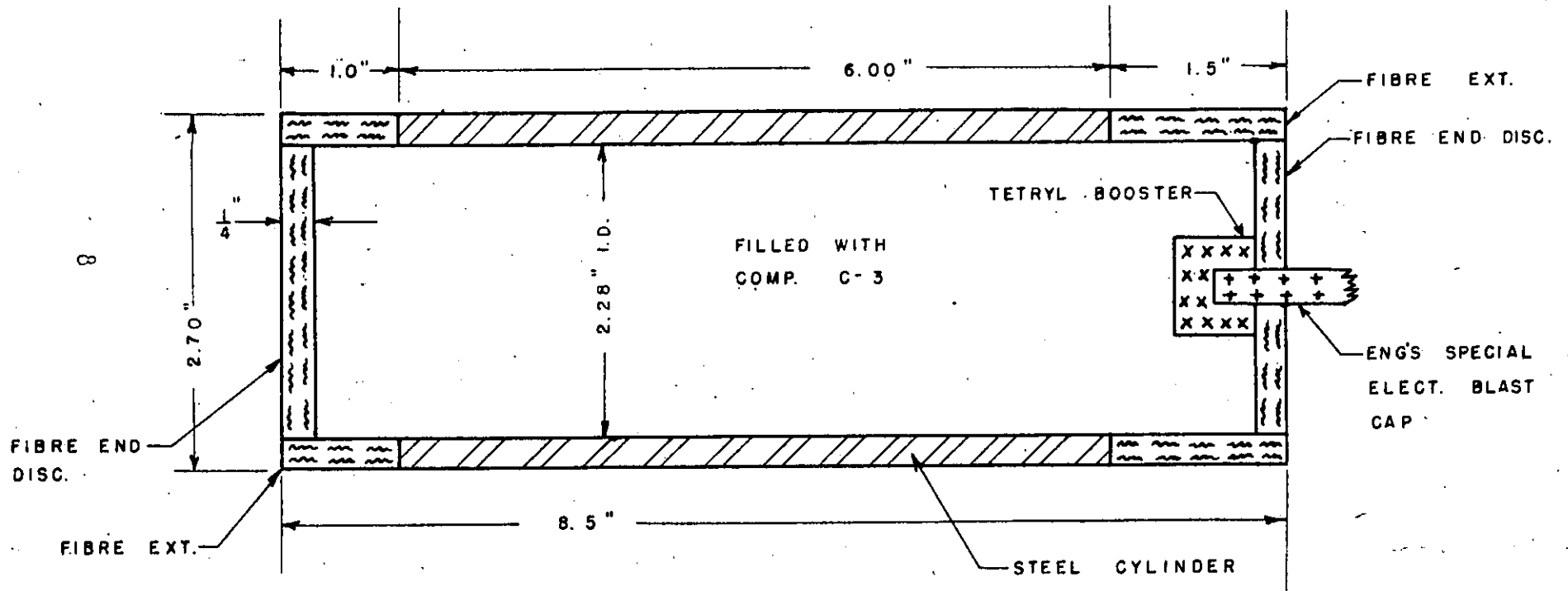
TABLE II (contd)

## Weight Distribution of Fragments

Wt. Interval Grains		110-115	115-120	120-125	125-130	130-135	135-140
Single Wall Warhead	Observed Number	1	1	0	0	1	0
	% of Total Number	.18	.18	0	0	.18	0
	Weight	113.13	115.89	0	0	133.64	0
	% of Total Weight	1.90	1.95	0	0	2.25	0

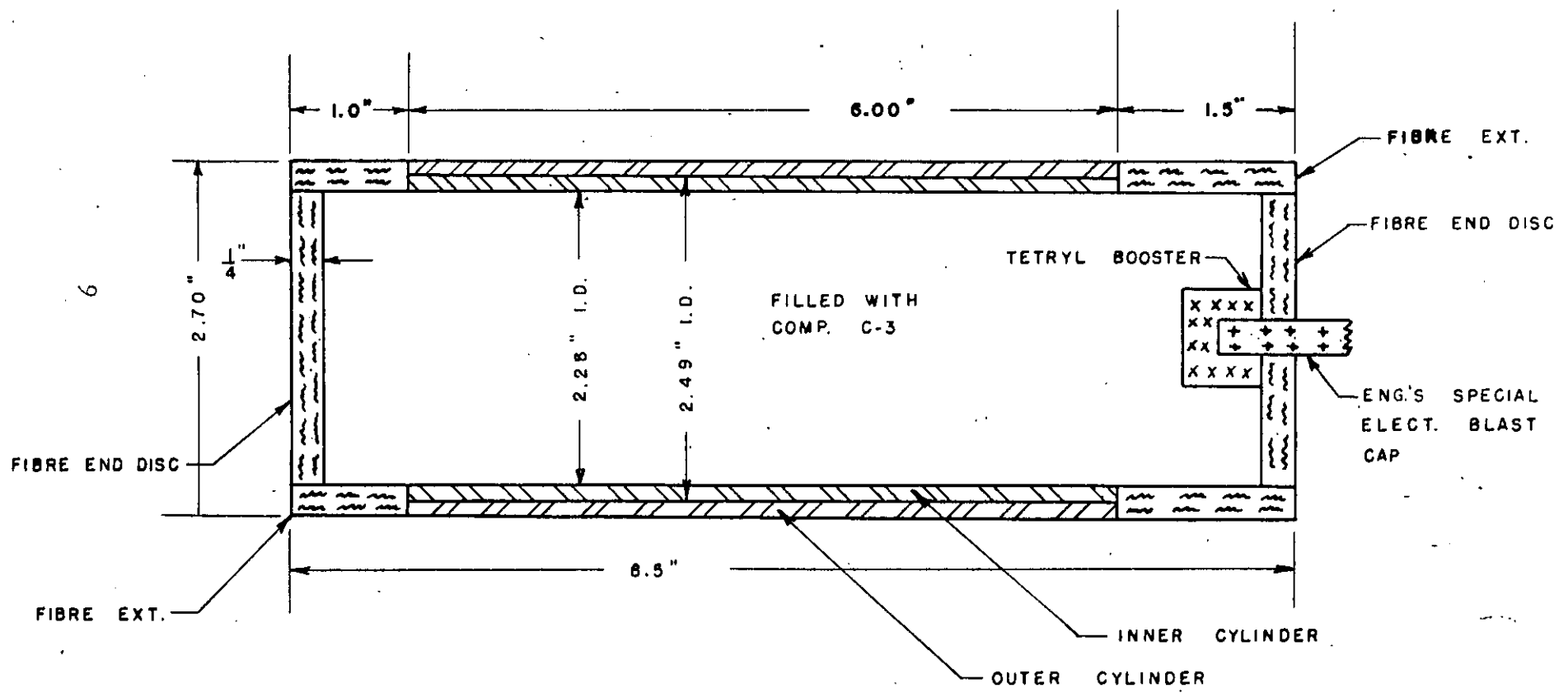


FIGURE 1  
 SINGLE WALL CYLINDRICAL WARHEAD



CYLINDER MACHINED FROM STANDARD  
 3" M 42A1 SHELL

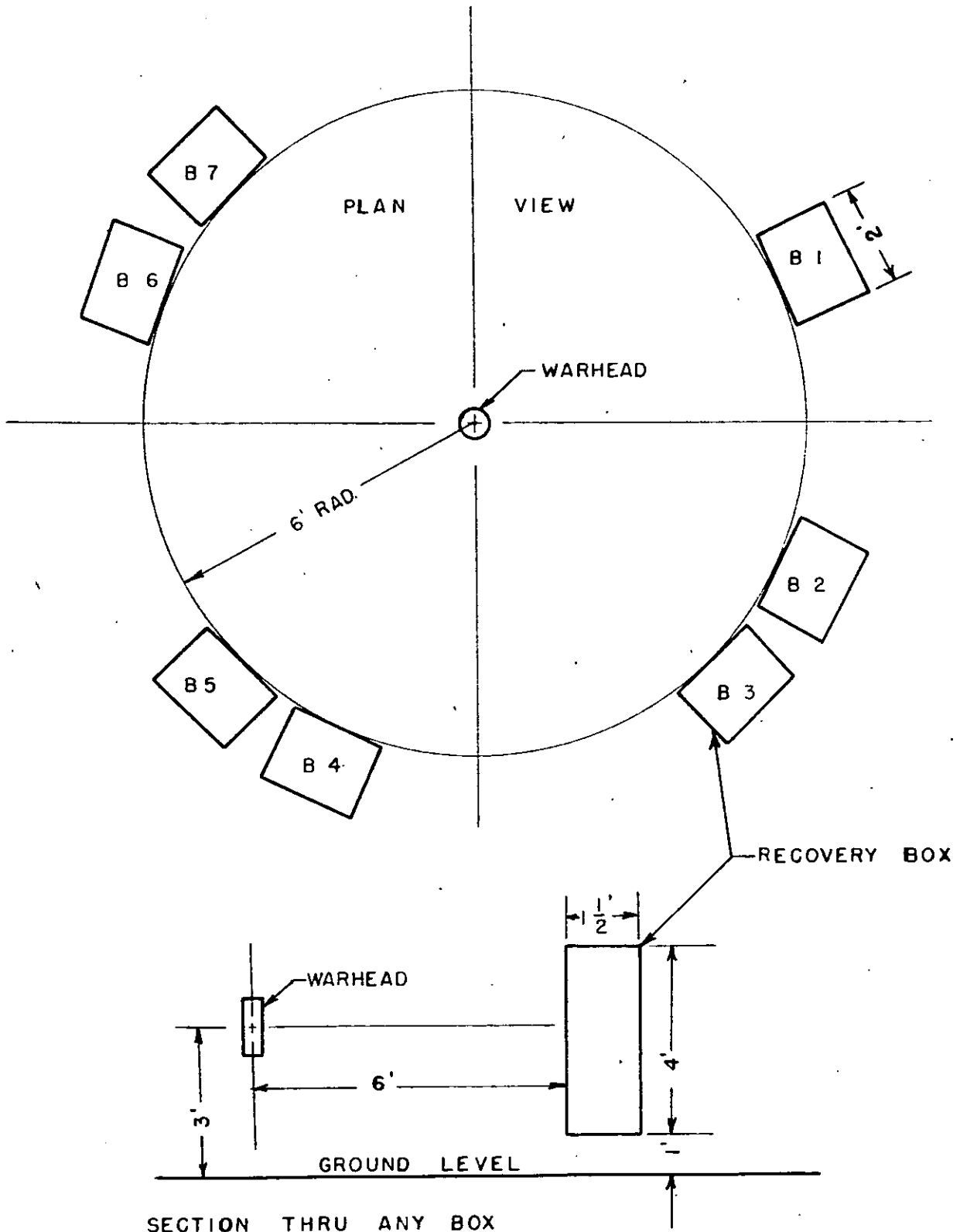
FIGURE 2  
 DOUBLE WALL CYLINDRICAL WARHEAD



CYLINDERS MACHINED FROM STANDARD  
 3" M42A1 SHELL

FIGURE 3

TEST SET-UP SINGLE WALL WARHEAD



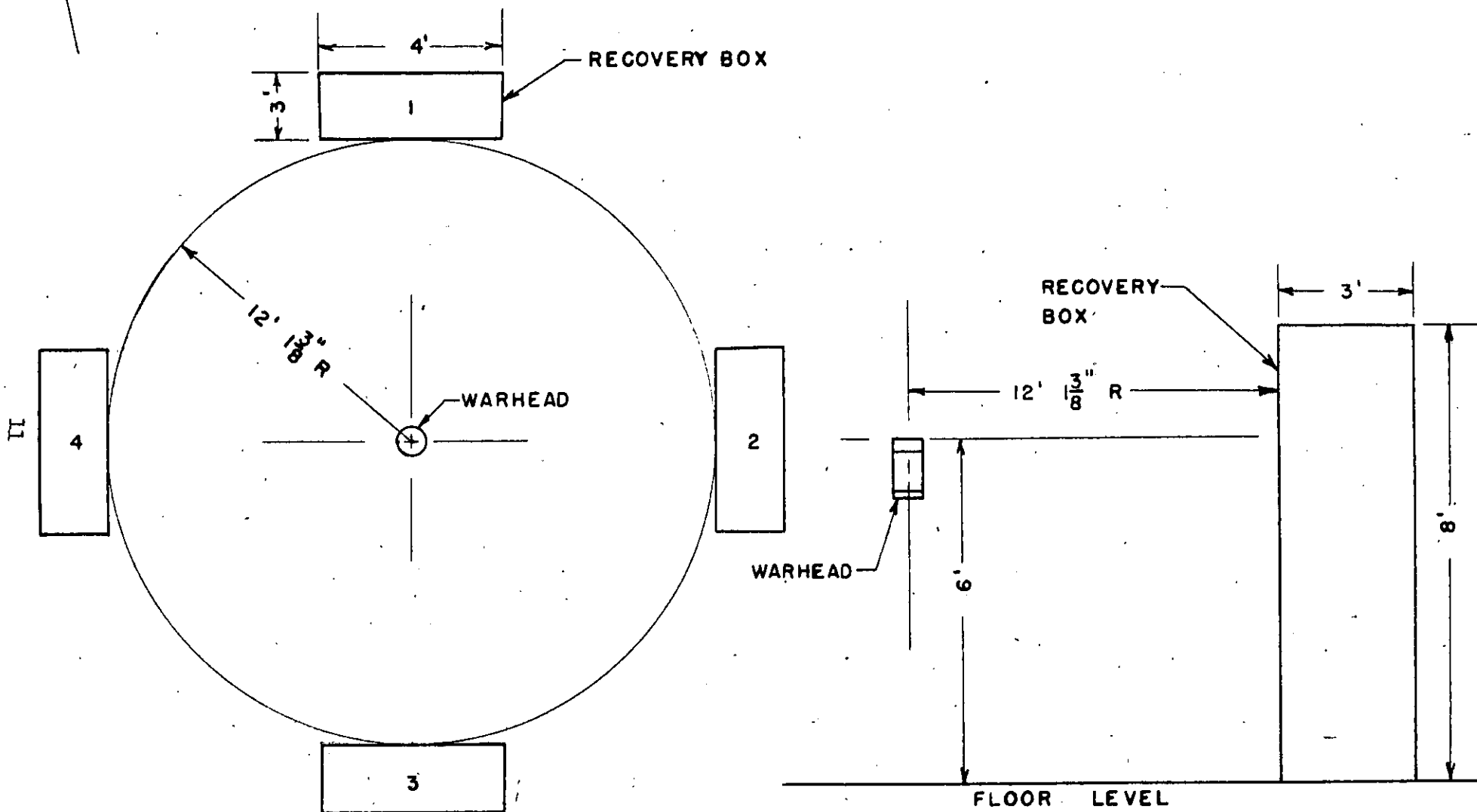
SECTION THRU ANY BOX

NOMENCLATURE:

B1-7 = RECOVERY BOX 4' X 2' X 1 1/2'

FIGURE 4

DOUBLE WALL WARHEAD SETUP



RECOVERY BOX NO. 3 FACED WITH  
.040" ALUMINUM SHEET PAINTED  
BLACK

1-2-3-4 = 8' X 4' X 3' CANE  
FIBRE FILLED RECOVERY BOX

FIGURE 5

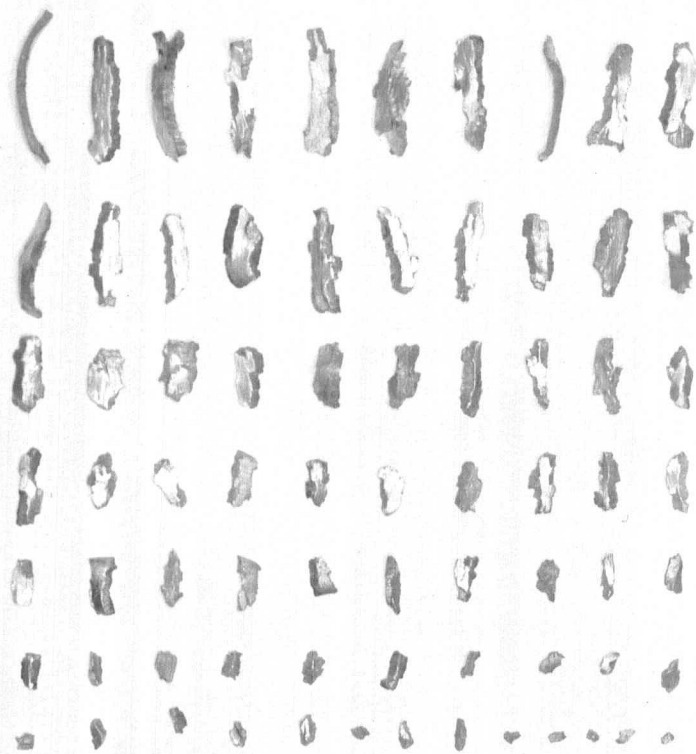
FRAGMENTS FROM SINGLE AND DOUBLE WALL CYLINDRICAL WARHEADS

SINGLE WALL WARHEAD



0-120 GRAINS

DOUBLE WALL WARHEAD



0-45 GRAINS

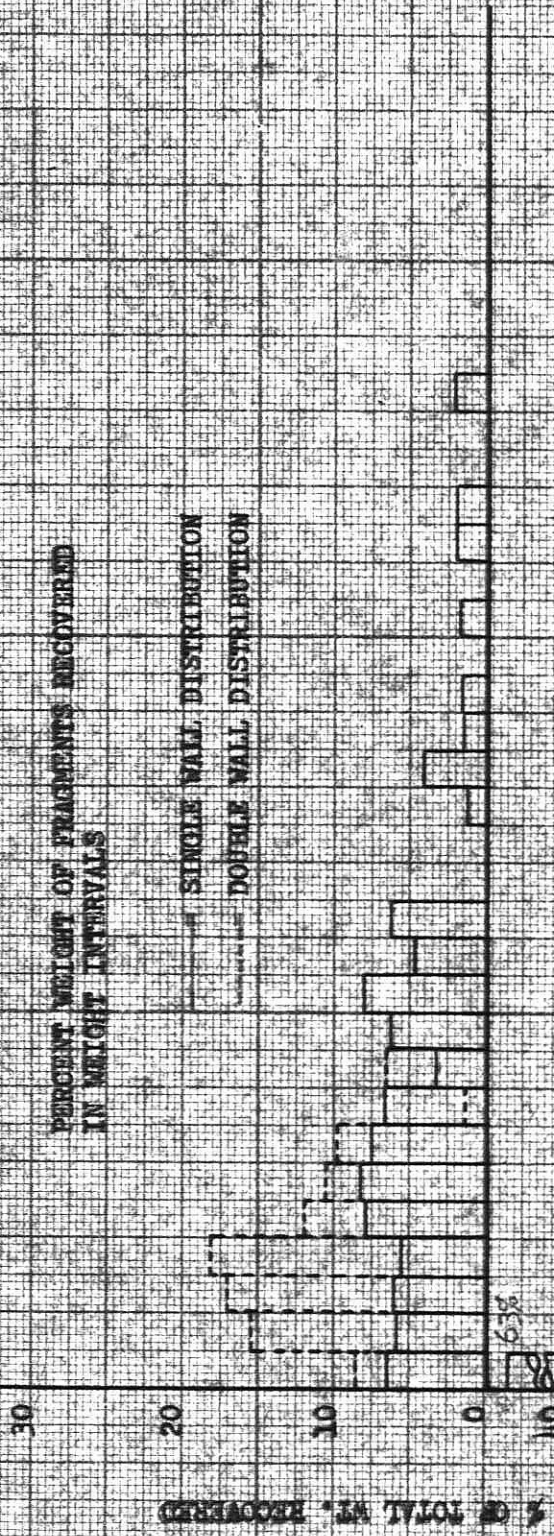
0 1"

FIGURE 5

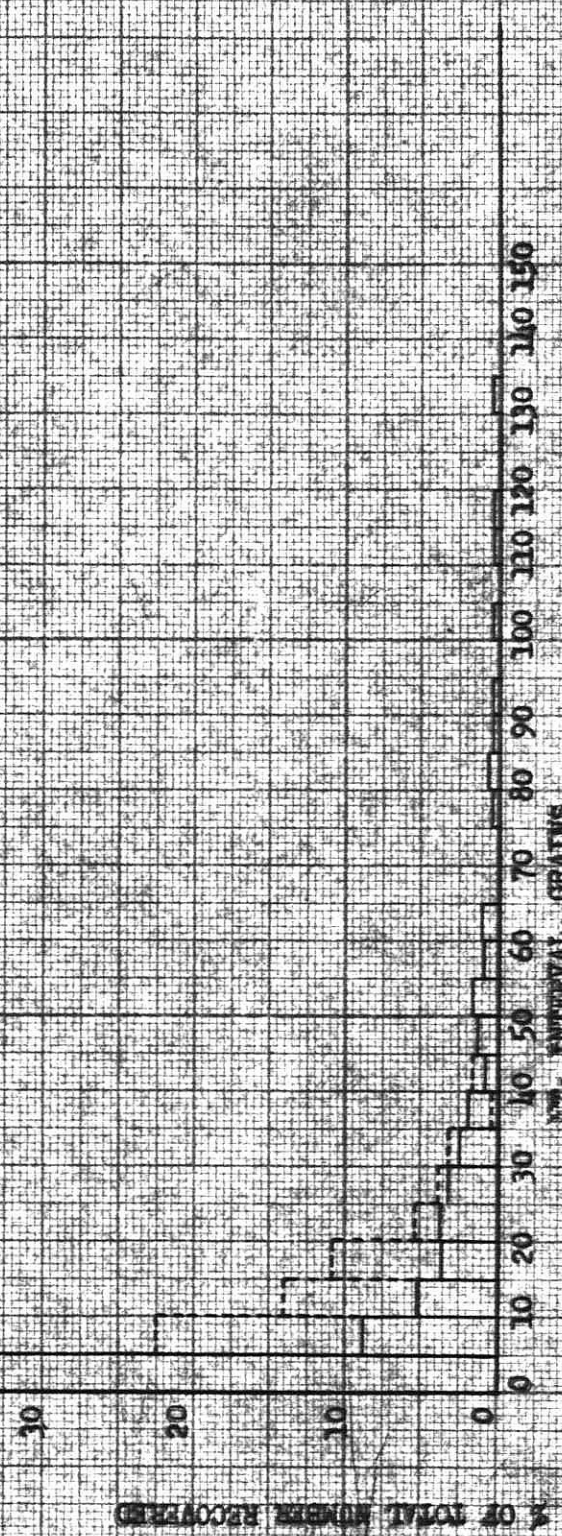
HISTOGRAM OF FRAGMENT MASS DISTRIBUTION FOR SINGLE AND DOUBLE WALL WARHEADS

PERCENT WEIGHT OF FRAGMENTS RECOVERED IN WEIGHT INTERVALS

SINGLE WALL DISTRIBUTION  
DOUBLE WALL DISTRIBUTION



PERCENT NUMBER OF FRAGMENTS RECOVERED IN WEIGHT INTERVALS



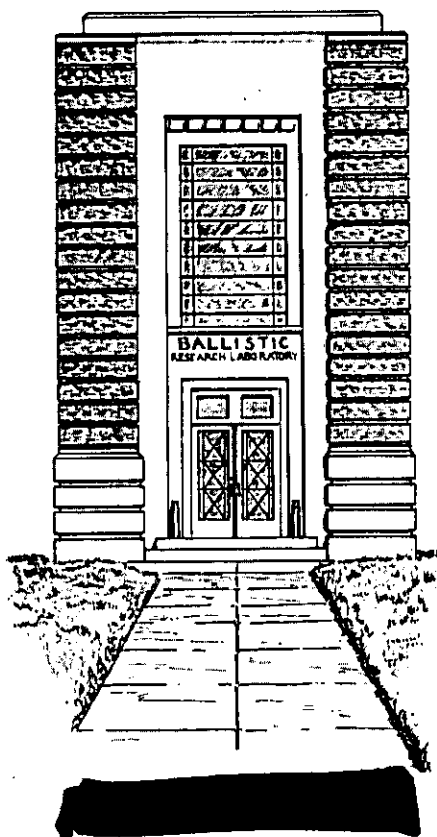
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