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SECURITY INFORMATION
CONFIDENTIAL
THIRTY-SEVENTH
PROGRESS REPORT
OF
THE FIRESTONE TIRE & RUBBER COMPANY
ON
BATTALION ANTI-TANK PROJECT
UNDER

Contract Nos. DA-33-019-ORD-33
DA - 33 - 019 - ORD - 1202
ORDNANCE DEPARTMENT PROJECTS
TS4-4020—WEAPONS AND ACCESSORIES
TM1-1540—AMMUNITION

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THE FIRESTONE TIRE & RUBBER COMPANY
Defense Research Division
Akron, Ohio

AUGUST 1953

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**THIRTY-SEVENTH
PROGRESS REPORT**

OF

THE FIRESTONE TIRE & RUBBER CO.

ON

BATTALION ANTI-TANK PROJECT

Contract Nos.

DA-33-019-ORD-33 (Negotiated)

DA-33-019-ORD-1202

RAD Nos. ORDTS 1-12383

ORDTS 3-3955

ORDTS 3-3957

ORDTA 3-3952

THE FIRESTONE TIRE & RUBBER CO.

Defense Research Division

Akron, Ohio

AUGUST, 1953

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548A 37058

INDEX

	Page
I. Abstract	1
II. The Weapon System	2
III. T119 Projectile	3
IV. T171 Projectile	21
V. Penetration Studies	34
VI. Fuzes	53
VII. Manufacturing Summary	57

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ABSTRACT

The Weapon System - A 90mm BAT weapon system is being manufactured. The ONTOS mount and remote control firing system, manufactured by Firestone, has been delivered to Aberdeen Proving Ground and is being tested.

T119 Projectile - Spin rate data for T119 projectiles, reported in the Thirty-Fifth Progress Report, have been reduced and an equation of roll is developed.

Two experiments concerned with increasing the initial spin rate of the T119E11 projectile in order to improve stability during the initial part of the trajectory, are reported. In one study rubber obturating rings were used and in the other study gilding metal rotating bands were used. Test arrangements and resulting data are reported.

Twenty T119E11 projectiles, prepared and assembled so as to represent extremes (loose or tight) in clearance between certain components of the tail assembly, were tested for mechanical functioning and accuracy. The test conditions are charted and illustrated and the data discussed.

A tail assembly, .475 in. shorter than the standard tail assembly (fin length remaining the same), were fired for accuracy tests. The data are presented.

T171 Projectile - Two modifications of the T171 projectile were fired for accuracy and flight evaluation at Erie Ordnance Depot. The test results are given.

Using the Siacci theory and experimental data, ballistic coefficients for four T171 configurations were determined. The form factor, drag coefficient, terminal velocity, time of flight and elevation were found for various ranges and muzzle velocities for the four configurations. The results are analyzed.

Penetration Studies - Two separate but related scaling studies of penetration have been completed. The first part of the study was reported previously and the second portion is described here and the data from both studies are summarized.

Tests were conducted concerning spin rate behavior of DRB398 cones at high spin rates, penetration behavior of zinc alloy (Zamak 3) cones, effect of tee configuration on penetration. Data for the tests are presented.

Ten M344 (T119E11) prototype projectiles were withdrawn from production and modified for static penetration tests. The test data are given.

Fuzes - Functioning tests were conducted with T267E14 base elements and with T223 E2 fuzes. The test data are presented.

Manufacturing Summary - A summary of rifles, mounts and projectiles manufactured by Firestone under the subject contracts is given.

C O N F I D E N T I A L

THE WEAPON SYSTEM

Ultimate BAT System

The 90mm ultimate BAT weapon system, illustrated and discussed in the Thirty-Sixth Progress Report, is being manufactured. The rifle will be mounted on the T152E7 aluminum mount for preliminary tests. A mount and tripod for the 90mm weapon is being designed.

ONTOS Mount and Firing System

The mount and remote control firing system for the ONTOS vehicle, developed by this division and illustrated in the Thirty-Sixth Progress Report, was delivered to Aberdeen Proving Ground during August. There was some delay in getting the system mounted on a vehicle and no test firing was done until the last week in August. Test results are incomplete at this time and will be reported later.

Future Program

1. Continue the manufacture of the 90mm ultimate BAT rifle.

2. Complete the preliminary design of a 90mm mount.

3. Investigate designs for improved firing effort on BAT rifles.

4. Continue tests of ONTOS firing system.

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T119 PROJECTILE

Derivation of Roll Motion Equation From Experimental Data

The Thirty-Fifth Progress Report presented spin data for five rounds of T119E11 projectiles. These data have been reduced (using a method suggested by Bolz and Nicolaides in BRL Report No. 711) and an equation of roll for the T119E11 projectile has been derived.

The dynamical equation of roll is

$$\phi' = S - C_1 A e^{-C_1 Z} \quad (1)$$

where Z = distance down range (ft)

ϕ' = rate of roll (deg/ft)

S = steady state rolling velocity (deg/ft)

C_1 = damping constant

A = arbitrary constant.

Since S , C_1 , and A may be determined experimentally it is not difficult to establish a relationship between spin rate and distance throughout the entire trajectory of a projectile.

The experimental data for one projectile, X368 (Thirty-Fifth Progress Report), are used in this study. A plot of rotation versus range is presented in Fig. 1. In plotting the curve of Fig. 1 an arbitrary figure (329) was subtracted from each of the measured angles to insure that the curve, when extrapolated back to the muzzle, could be contained in the graph. From this plot a table of values for ϕ' is determined by computing $\frac{\Delta \phi}{\Delta Z}$

in intervals of 20 ft. The resulting values are given in Table I and a graph of ϕ' (rate of roll) versus Z (distance from gun) appears in Fig. 2.

Determination of S

An initial value of S , denoted S_0 , may be calculated from the graph of ϕ' versus Z by the relation

$$S_0 = \phi'_1 + \sum_{i=2}^n \Delta \phi'_i \quad (2)$$

where $\frac{\Delta \phi'_n}{\Delta \phi'_{n-1}} = e^{-C_1 \Delta Z} = \text{constant}$.

A table of data to establish this constant ratio is,

Z	ϕ'	$\Delta \phi'$
0	.290	
150	1.270	.980
300	1.870	.600

The ratio, therefore, is $\frac{.600}{.980} = .6122$.

Values of $\Delta \phi'$ for distances greater than the length of the measured range are extrapolated and are tabulated and are tabulated below:

Z	ϕ'	$\Delta \phi'$
0	0.290	0.980
150	1.270	0.600
300	1.870	0.367
450		0.224
600		0.137
750		0.084
900		0.051
1050		0.031
1200		0.019
1350		0.012
1500		0.007
1650		0.004
1800		0.002
1950		0.001
2100		

From the above table

$$\phi'_1 + \sum_{i=2}^{15} \Delta \phi'_i = 2.809 = S_0$$

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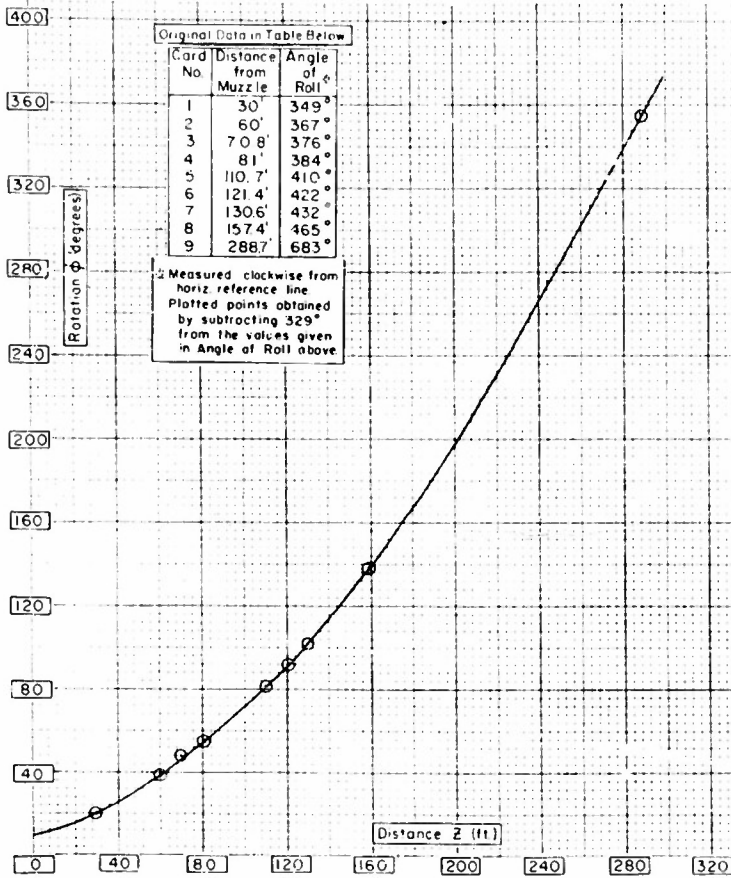


Fig. i. Roll Angle Versus Distance From Gun.
T119E11 Projectile No. X368.

Table I
Values of ϕ'
Determined From Experimental Roll Data
T119E11 Projectile No. X368

Z (ft)	ϕ (°)	$\Delta\phi$	ϕ' (°/ft)
0	8.9		
10	15.9	7.0	.350
20	20.6	4.7	.405
30	26.6	6.0	.495
40	30.6	4.0	.630
50	38.4	7.8	.755
60	53.5	15.1	.880
70	53.5	0.0	1.005
80	71.1	17.6	1.125
90	91.2	20.1	1.125
100	91.2	0.0	1.270
110	110.7	19.5	1.390
120	110.7	0.0	1.475
130	130.6	19.9	1.650
140	130.6	0.0	1.745
150	157.4	26.8	1.840
160	157.4	0.0	1.850
170	196.4	39.0	
180	196.4	0.0	
190	229.4	33.0	
200	229.4	0.0	
210	264.3	34.9	
220	264.3	0.0	
230	286.7	22.4	
240	286.7	0.0	
250	301.1	14.4	
260	301.1	0.0	
270	338.3	37.2	
280	338.3	0.0	
290	375.3	37.0	
300	375.3	0.0	

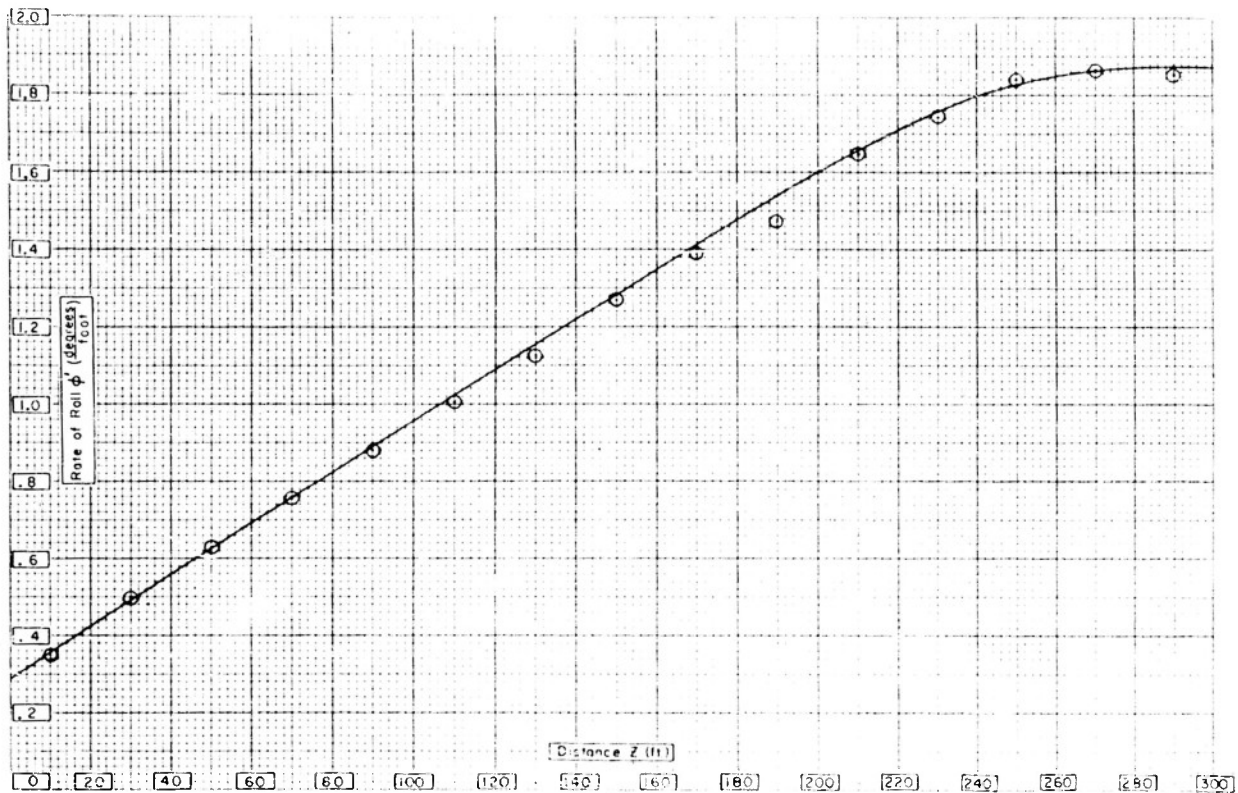


Fig. 2. Rate of Roll Versus Distance From Gun.
T119E11 Projectile No. X368.

Determination of C_1

Equation (1) may be written in the form
 $\ln(S_0 - \phi') = \ln(C_{10}A) - C_{10}Z$, (3)

where C_{10} is an initial value of C_1 . A logarithmic plot of $(S_0 - \phi')$ versus Z is given in Fig. 3. It can be seen that the slope of the straight line is $-C_{10}$; thus,
 $C_{10} = \frac{\ln 2.519 - \ln .939}{300} = .002870$.

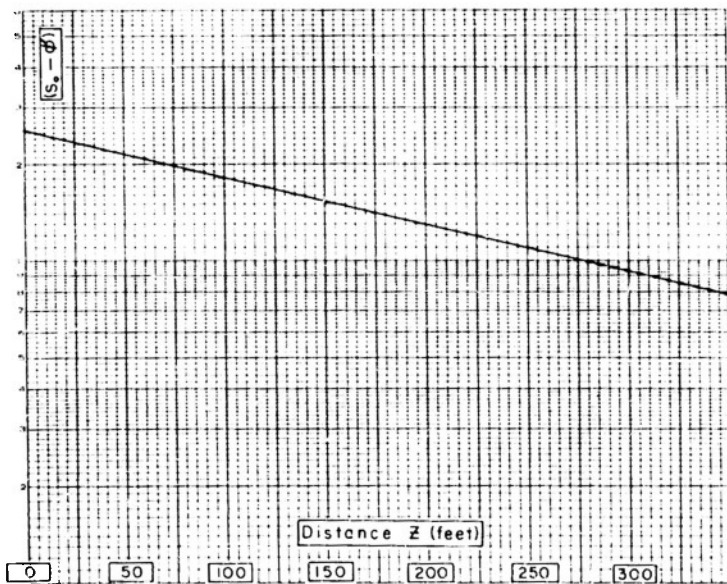


Fig. 3. $(S_0 - \phi')$ Versus Distance.
(Logarithmic Plot.)

Determination of A

A set of boundary conditions for (1) is $Z = 0$, $S = S_0$, $C_1 = C_{1_0}$, $\phi = \phi_1$ and $A = A_0$. Thus,

$$A_0 = \frac{(S_0 - \phi_1)}{C_{1_0}} = 877.8.$$

Roll Motion Equation

The roll motion equation with initial values for S, C and A is

$$\phi' = 2.809 - 2.519 e^{-.002870Z} \quad (4).$$

These parameters can be determined more precisely by the method of "Differential Corrections", but for the approximation sought here it is sufficient to use initial values. Table II is a table of values for equation (4) in which ϕ' is converted to revolutions per second. Fig. 4 is a graph of ϕ' (rps) versus Z for the entire range.

The magnitude of spin, as here found, appears reasonable when compared with spin measurements of the T119E11 projectile as reported by Frankford Arsenal in Report No. R-1086.

Table II
Projectile Spin (rps)
Determined From Roll Motion Equation

Z (ft)	ϕ' (°/ft)	u (ft/sec)	ϕ' (rps)
0	.290	1585	1.36
100	.972	1667	4.50
200	1.430	1698	6.55
250	1.580	1635	7.18
300	1.744	1627	7.48
600	2.359	1569	10.28
1200	2.729	1457	11.05
1600	2.775	1384	10.67
2400	2.806	1247	9.72
3000	2.809	1152	8.99



Fig. 4. Rolling Velocity Versus Distance From Gun.
Calculated From Roll Equation For T119E11 Projectile.

**Studies of Launching Conditions
(Increasing Initial Spin Rate)**

Spin measurement data for the T119E11 projectile, described in the preceding section of this report, indicate that the projectile emerges from the muzzle with a spin rate of one or two revolutions per second. It has been observed in flight photographs that the fins of the T119E11 projectile do not open fully until the projectile has traveled five to seven feet from the muzzle. (Thirty-Sixth Progress Report). It is possible that the projectile is sensitive to perturbations in this interval before the canted fins begin to induce stabilizing spin.

Increasing the spin at the muzzle would tend to minimize the effects of perturbations in that region and ultimate accuracy might then be improved. The most serious limitation on the increased initial spin is the ability of the fin assembly to withstand the increased stress.

In contemplating higher spin rates the degrading effect of spin on penetration must be considered. It can be shown that a large initial spin will damp out quickly by applying the differential equations of motion to an initial spin rate of 40 rps. Fig. 5 shows that even this high spin rate will damp out at 400 ft to slightly less than 22 rps, which would not cause a prohibitive degradation in penetration.

Rubber Obturating Rings

A simple method to increase the muzzle spin rate of a projectile is to place on the projectile a plastic or rubber type rotating or obturating band which would slip or grind away sufficiently to give a reasonable spin. This method has been tried with two projectiles equipped with rubber "O" rings placed in a special machined groove in the chamber as shown in Fig. 6.

The rotation (in degrees) for the two projectiles, as measured with yaw cards,

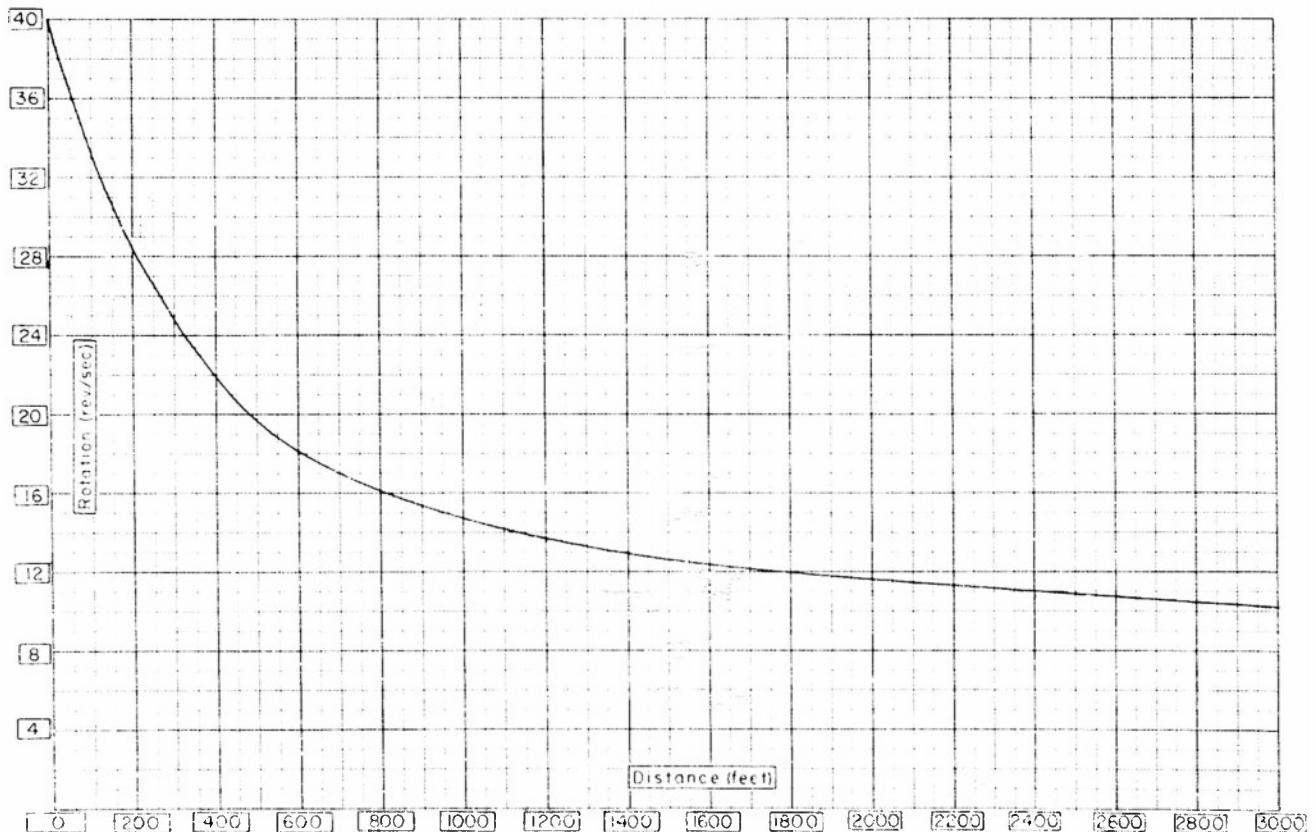


Fig. 5. Calculated Spin Behavior.
T119E11 Projectile Launched With High Initial Spin.

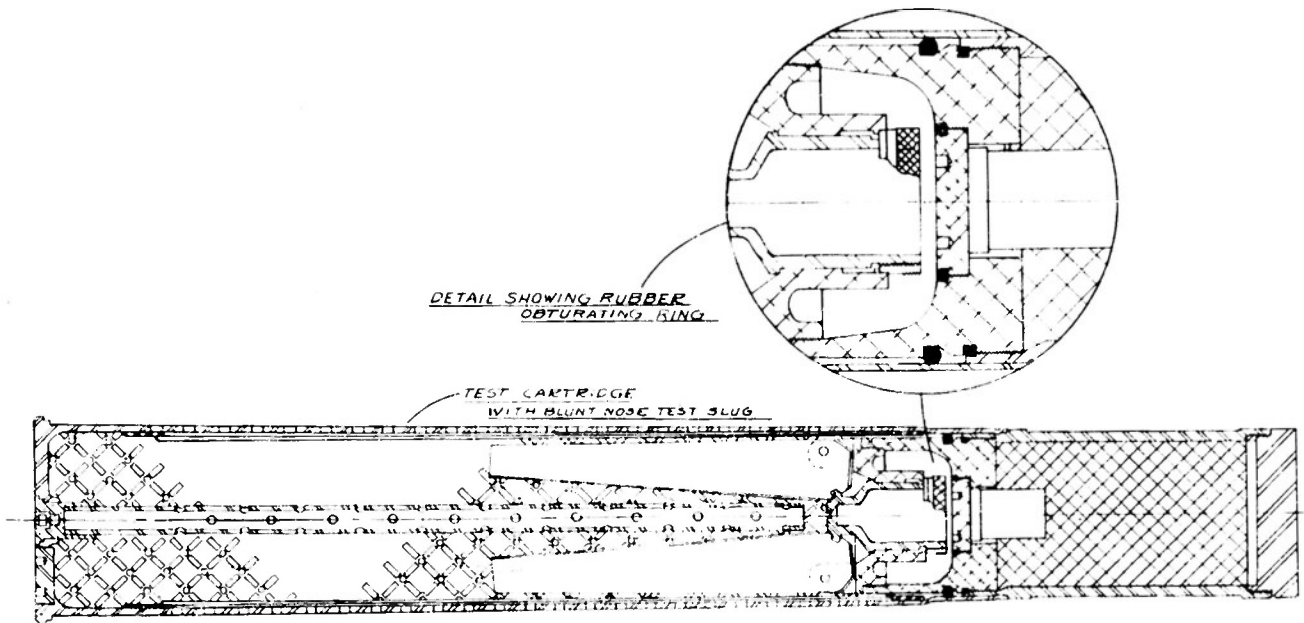


Fig. 6. Rubber Obturating Ring.
In Position in Groove On T119E11 Projectile.

is contained in the firing record, Table III, and a plot of rotation versus distance is shown in Fig. 7. The calculated spin rates at various distances are given in Table IV and are compared with corresponding spin rates for the standard T119E11

projectile in Fig. 8. The original range data for the standard T119E11 projectile used in this comparison are found in Table VI of the Thirty-Fifth Progress Report and a preceding section of this report.

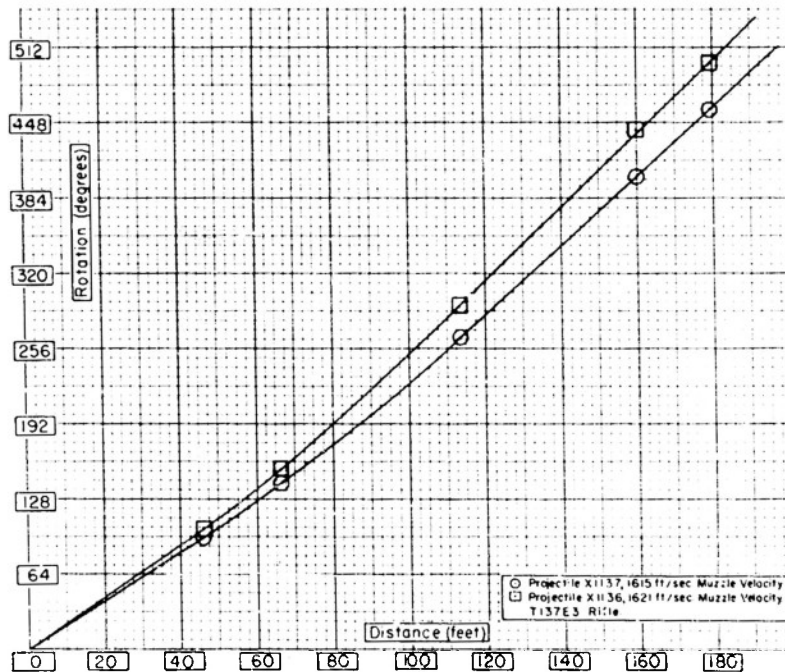


Fig. 7. Rotation Versus Distance From Muzzle.
T119E11 Projectiles With Rubber Obturator Rings.

Table III
Range Data
T119E11 Projectiles With Rubber Obturators

Date of Test Aug 21, 1953 Purpose of Test Obturator Test

PROJECTILE

Model T119
Type EL
Weight 17.5 lbs (Nom)
CG Location _____
Bore/lt Dia 4.132 ± .003 in
Special Features Blow pipe
rubber obturator

TEST GUN

Model T37C-3
Type 205mm Recoilless
Serial No 4
Chamber 800-11-B
Bushing (Vent) 22B-37A-66
Tube _____
Sighting Equipment M.I.E. Illum. Telescope
Mount _____
Type Penetration
Constant 2.88 In./in.
Subsided Mechanical Firing System

MISCELLANEOUS DATA

Range Accuracy 80'
Propellant _____
Type Marb Web 0.33 in Weight 7.6 lbs
Lot No PA 20252
Primer 257
Shell Case 7.53 E1
Liner Dec 545 & 650c 1yd
Temperatures _____
Magazine 05 Min 70 F Present 75 F
Max 78 F Ambient _____
Loading Room 78 F

Round No	Proj. No.	Proj. Weight (lb.)	Powder Charge (lb-oz)	Piezo Pressure (lb-sq in)	Chamber Pressure (lb-sq in)	Muzzle Velocity ft/sec	Muzzle Velocity (mils)		Position of Hit		Corrected Position of Hit		Recoil (in)	Observations
							Instr.	Actual	Vert.	Horiz.	Vert.	Horiz.		
5646	X1137	—	7-1	12,714	4300	1570	1615	—	—	—	—	—	1 1/2 R	Obturator ring missing, small particles found
5647	X1136	—	7-1	13,082	10200	1576	1621	—	—	—	—	—	2 R	Obturator ring missing, small particles found
Note: Rounds were loaded and fired in single units.														
Yow Card 8 Screen Distances														
1st. Coil														
46.66' ———— + 19.67' ———— + 47.25' ———— + 46.75' ———— + 18.75' ————														
Card 1 Card 2 Card 3 Card 4 Card 5														
2nd. Coil														
Angle of Rotation (deg.)														
Distance X1137 X1136														
46.66' 296.4 787.3														
66.33' 342.0 231.3														
113.58' 460.0 369.8														
160.33' 604.0 520.3														
179.08' 660.5 240.0														
* Measured at distance from vertical reference line														

Proof Director E. Hoffman Signed _____
Observers V.E. Lucas
L. Sweeney, R. Walker

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Table IV
Effect of Rubber Obturator On Spin
T119E11 Projectile

Distance (feet)	Projectile X1137			Projectile X1136		
	$\frac{d\phi}{dz}$ (°/ft)	u (ft./sec.)	Spin (r ps)	$\frac{d\phi}{dz}$ (°/ft)	u (ft./sec.)	Spin (r ps)
0	1.94	1615	8.71	--	1621	--
60	2.40	1591	10.61	2.70	1597	11.98
80	2.58	1583	11.34	2.85	1589	12.58
100	2.76	1575	12.08	3.00	1581	13.18
120	2.88	1567	12.54	3.18	1573	13.89
140	2.94	1559	12.73	3.27	1565	14.22
160	3.00	1551	12.93	3.30	1557	14.27
180	3.00	1543	12.86	3.33	1549	14.33

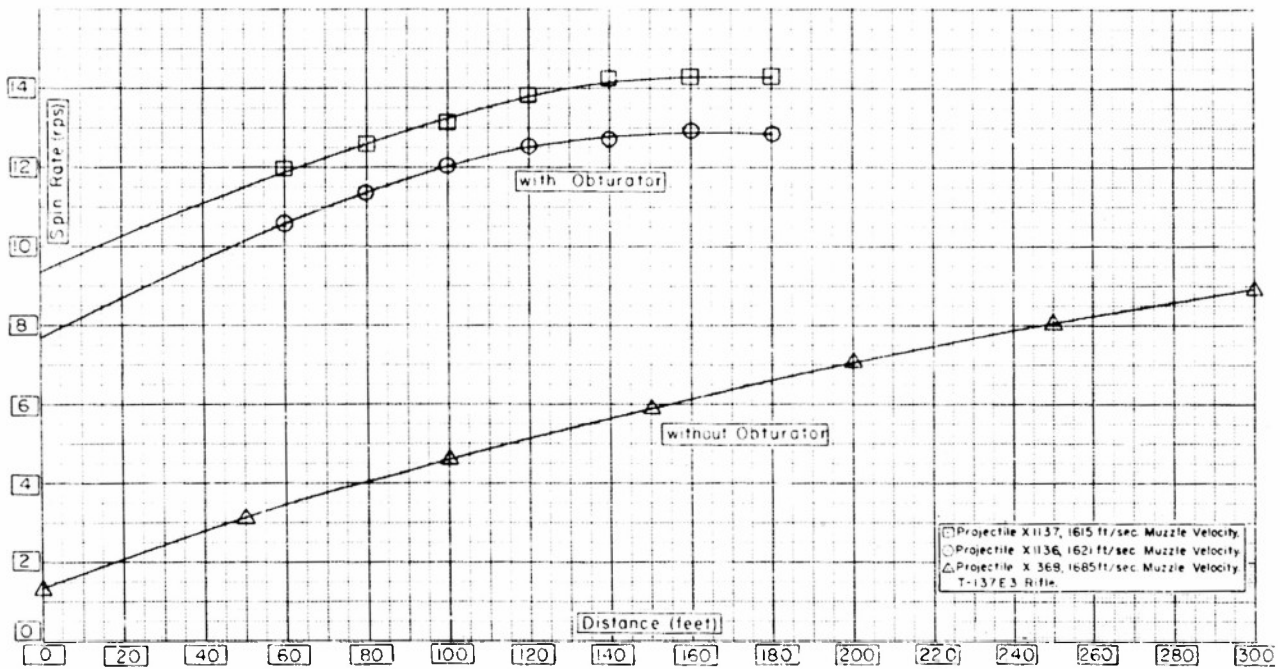


Fig. 8. Comparison of Spin Rates.
 Projectiles With and Without Rubber Obturators.

It is evident from Fig. 8 that the launching spin of the rubber obturated projectiles (approximately nine revolutions per second) is considerably higher than for the unobturated T119E11 projectile (approx. 1.3 rps). The recovered projectiles were in good condition, indicating that the increased spin had not damaged the fins. Small bits of the rubber "O" ring had been forced into the gap between the body and

chamber, by the propellant gases.

In view of the satisfactory performance of these two rounds it is planned to fire a complete program to determine the effect of higher launching spin rate upon accuracy and to establish the consistency of the muzzle spin of a rubber obturated round.

Gilding Metal Rotating Bands

Another method of increasing initial spin is through the use of a gilding metal rotating band. The Twelfth Progress Report included the results of firing three projectiles with gilding metal rotating bands from a tube rifled one turn in 480 calibers. The projectiles suffered severe damage in the tail assembly. Since the tail assembly of the T119E11 projectile is considerably stronger than the tail assembly of the test above it was decided to test the ability of the T119E11 tail assembly to withstand the sudden torque

transmitted to the body by the action of a gilding metal rotating band in the rifling of the tube.

Two projectiles, one with fins 6.92 in. long and one with standard length (8.92 in.) fins were fired from a 1-480 tube, through a series of yaw cards, into a recovery box. The range data are given in Table V, which includes the measured rotation. A plot of rotation versus distance appears in Fig. 9. Values of spin rate (rev/sec) versus distance are given in Table VI and the tabulated values are plotted in Fig. 10.

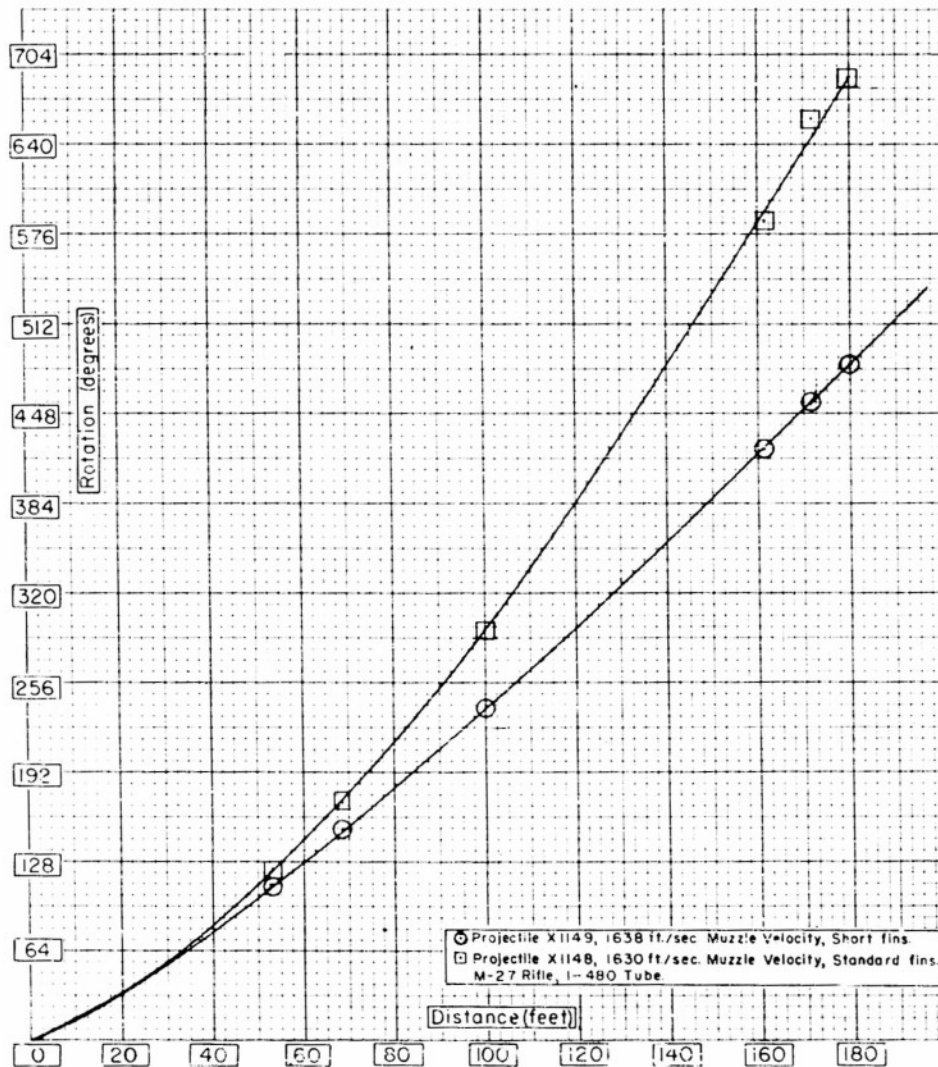


Fig. 9. Rotation Versus Distance From Muzzle.
T119E11 Projectiles With Gilding Metal Rotating Bands.

Table V
Range Data
Y119E11 Projectile With Rotating Band
Fired from 1-480 Tube

Purpose of Test Charge Development & Range Measurement
 Date Aug 23, 1953

PROJECTILE

Model T119
 Type E 11
 Weight 17.52 lb (Nom)
 C.G. Location _____
 Bourrelet Dia 4.132 - .002
 Special Features Blunt nose
wind-up band

TEST GUN

Model M-27
 Type 2.5mm reco-115.3
 Serial No 7230827
 Chamber 7230827
 Bushing (Vent) V21893, 7210926
 Tube 2590-3-12433, 7159, 1-480 Twist
 Sighting Equipment 1917 med Telescope
 Mount _____
 Type Reco-Lum
 Constant 2.68 in/sec/in

MISCELLANEOUS DATA

Range Recovery Box
 Propellant _____
 Type M10 MP Web .0335 in Weight Varies
 Lot No EP230252
 Primer M-57
 Shell Case 7-531
 Liner ORC-545
 Temperatures _____
 Magazine _____
 Max 76°F Min 71°F Present 76°F
 Loading Room 80°F Ambient 96°F

Round No	Proj. No	Proj. Weight (lb)	Powder Charge (lb-oz)	Recoil (in.)	Chamber Pressure (lb/sq in)	Muzzle Velocity (ft/sec)		Elev (mils)	Position of Hit		Corrected Position of Hit - mils		Recoil (in.)	Observations
						Instr	Actual		Vert	Horiz	Vert	Horiz		
5683	X1015	8 0	19 1/2 R	8200	8200	1549	1595	9190	M-3	8174	8182			
5684	X1007	8 4	19 R	8600	8200	1586	1632	10618	M-3	8174	8246			
5685	X1149	8 4	19 1/2 R	9100	8600	1592	1638	10618	M-3	8174	8328			Misfired fired as operating handle was moved
5686	X1148	8 4	20 R	8000	8200	1584	1630	11317	M-3	8174	8399			

Notes: Projectile X1149 (shown first) recovered in good condition fins undamaged, no yaw or cove.
 Projectile X1148 (shown last) yaw cards indicated band fins, from 5° to 10° yaw

Angle of Rotation °	Distance	Yaw Card Distances		Screen Distances
		1	2	
X1149	X1148	5308	6146	1104 + 704
374.5°	191.0°			5
68.41°	351.8°			6
100.19°	436.5°			
161.95°	627.9°			
172.99°	657.9°			
180.03°	187.0°			
	757.8°			

± Measured in degrees clockwise from vertical reference line.

Proof Director E. Hoffman
 Observers C. H. Cox
E. R. Borer
 Signed O. Miller

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Table VI
Spin Rate of T119E11 Projectile
 With Rotating Band; Fired From 1-480 Tube

Distance (feet)	Projectile X1149			Projectile X1148		
	$\frac{d\phi}{dz}$ (°/ft.)	u (ft./sec.)	Spin (rps)	$\frac{d\phi}{dz}$ (°/ft.)	u (ft./sec.)	Spin (rps)
0	--	1638	--	--	1630	--
60	2.43	1614	10.89	3.09	1606	13.78
80	2.61	1606	11.64	3.72	1598	16.51
100	2.79	1598	12.38	4.23	1590	18.68
120	2.91	1590	12.85	4.62	1582	20.30
140	3.06	1582	13.45	5.10	1574	22.30
160	3.18	1574	13.90	5.46	1566	23.75
180	3.30	1566	14.36	5.70	1558	24.67

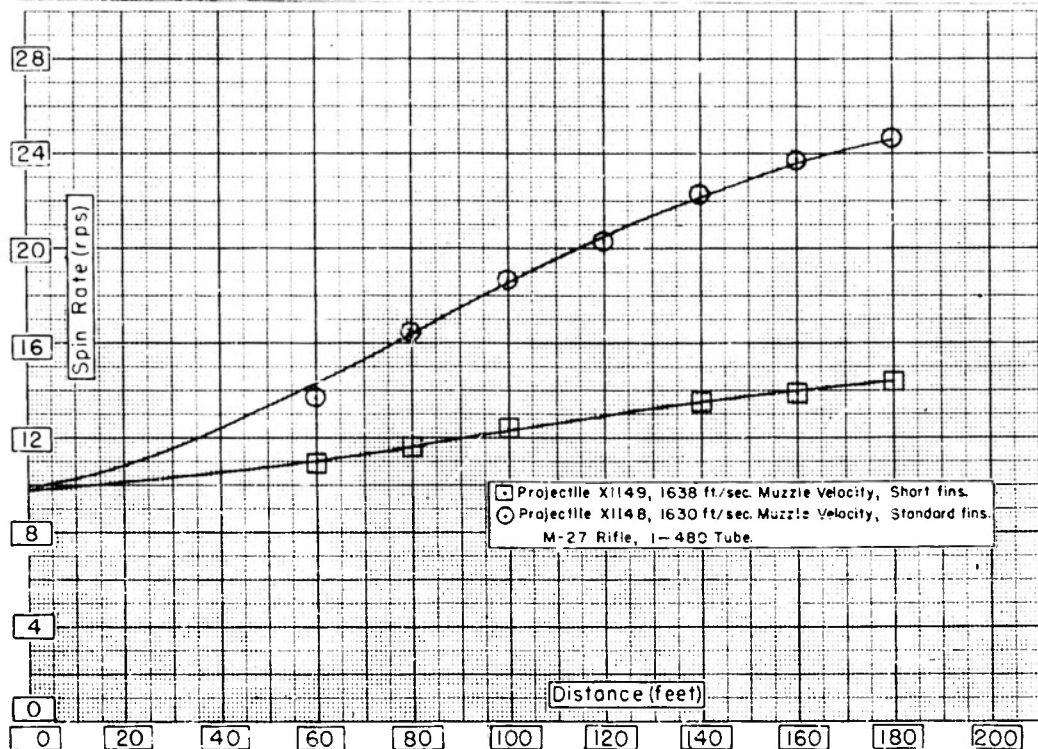


Fig. 10. Spin Rate Versus Distance From Muzzle.
 T119E11 Projectiles With Gilding Metal Rotating Bands.

The spin of the projectile with fins 6.92 in. long was normal but the projectile with standard length (8.92 in.) fins attained an abnormally high spin rate of 24.5 rps at 180 feet. It is believed that this high spin rate was due to fin distortion, giving an abnormal cant to the fins.

From these test results it is evident that the results of launching a T119E11

projectile with a non-slip rotating band from a low spin tube are considerably less satisfactory than the results from launching the same projectile with a slip band from a high spin tube. The fins were damaged by the high initial angular velocity when using the non-slip band and the low spin tube. On the basis of these test results no additional tests from slow spin tubes are planned.

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Performance Tests of T119E11 Projectile

Effect of Dimensional Variations

Twenty T119E11 projectiles, prepared and assembled so as to represent extremes (loose or tight) in clearance between certain components of the tail assembly were tested for mechanical functioning and ac-

curacy. These tests were so made that manufacturing tolerances might be as broad as is justifiable.

Fig. 11 illustrates the tail components involved in the dimensional study and Table VII charts the original and proposed tolerances. The parts were machined for this test and Table VIII is an inspection report of the parts. The firing record for the twenty projectiles is given in Table IX.

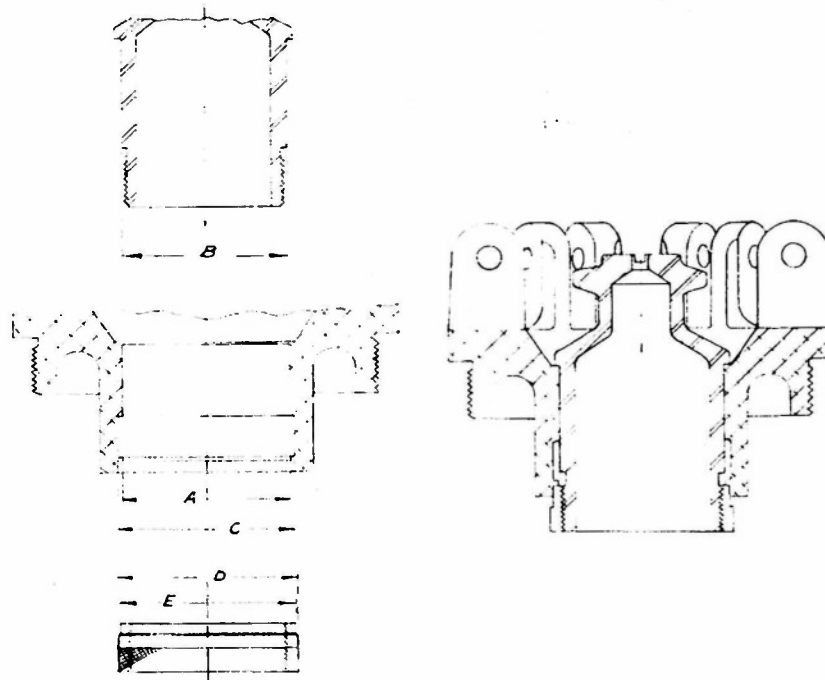


Fig. 11. T119E11 Tail Assembly Components.
For Tolerance Study.

Table VII
Proposed Dimensional Changes
Tolerance Study

Dimension	T119E11 Dimensions	Proposed Dimensions
A	1.6875 + .0010	1.687 + .004
B	1.6860 - .0015	1.686 - .002
C	1.810 + .001	1.810 + .004
D	1.817 - .001	1.819 - .002
E	1.869 - .002	1.809 - .002

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**Table VIII
Inspection Data
T119 Projectile Parts**

Projectile No	DIMENSIONS (in)							
	A	B	C=1.810 +.0002		D=1.819 - .0002		E=1.809 - .0002	
SET I			Max.	Min	Max	Min	Max	Min.
X867	SEE NOTES BELOW		1.8125	1.8125	1.8191	1.8181	1.8094	1.8083
X868			1.8135	1.8135	1.8200	1.8191	1.8099	1.8093
X869			1.8120	1.8120	1.8200	1.8191	1.8102	1.8100
X870			1.8101	1.8101	1.8205	1.8181	1.8103	1.8085
X871			1.8125	1.8125	1.8200	1.8187	1.8099	1.8093
X872			1.8115	1.8115	1.8207	1.8191	1.8101	1.8088
X873			1.8125	1.8125	1.8202	1.8194	1.8107	1.8102
X874			1.8090	1.8090	1.8198	1.8188	1.8095	1.8092
X875			1.8120	1.8120	1.8194	1.8182	1.8103	1.8093
X876			1.8095	1.8095	1.8200	1.8194	1.8100	1.8097
SET II			C=1.814 +.0002		D=1.817 - .0002		E=1.807 - .0002	
			Max	Min	Max	Min	Max	Min
X877			1.8142	1.8140	1.8181	1.8177	1.8082	1.8080
X878			1.8135	1.8135	1.8188	1.8175	1.8092	1.8085
X879			1.8142	1.8140	1.8176	1.8171	1.8074	1.8070
X880			1.8125	1.8125	1.8176	1.8172	1.8085	1.8080
X881			1.8160	1.8160	1.8178	1.8161	1.8070	1.8055
X882			1.8135	1.8135	1.8169	1.8153	1.8075	1.8060
X883			1.8120	1.8120	1.8182	1.8179	1.8087	1.8085
X884			1.8142	1.8140	1.8165	1.816	1.8075	1.8070
X885			1.8142	1.8140	1.8177	1.8172	1.8083	1.8079
X886			1.8115	1.8115	1.8178	1.8167	1.8083	1.8075
Notes:								
1. Dimension A = 1.691 ± .0002. All pieces in tolerance.								
2. Dimension B = 1.684 - .0002. Eighteen pieces in tolerance, two measured at 1.6836.								
3. SET I is close clearance group; Set II is loose clearance group.								

Four of the projectiles were fired through the cards, into a recovery box. Two of the four projectiles were from Group II (loose clearance) of Table VIII and were loaded to give excess pressures at ambient temperature. The other two projectiles from Group I (close tolerances) of Table VIII were loaded for operating pressures and conditioned at -40° F. These temperature limits represent extremes of "looseness" and "tightness" of fit. The cards and the recovered projectiles gave evidence of normal functioning of the assemblies in all four projectiles.

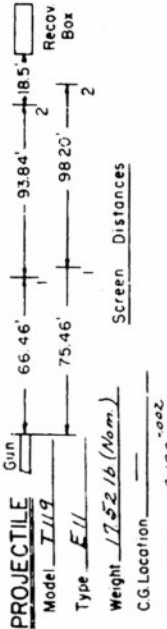
Eight projectiles from Group I (close tolerances) and eight from Group II (loose

tolerances) of Table VIII were fired for accuracy at a range of 998 yards. The first projectile flew over the target and after resetting the elevation the next fifteen rounds all hit the target with probable errors of dispersion of V.P.E. = ±.49 mil and H.P.E. = ±.51 mil.

Since these projectiles were prepared from certain components machined so as to create extremes of fit wider than any fit that could be expected in production manufacture and assembly, the results of the firing tests indicate that tolerances in the tested components may be relaxed to the proposed degree presented in Table VII without being detrimental to the accuracy of the projectile.

Table IX
Range Data
T119E11 Projectile
Effect of Relaxed Tolerances

Purpose of Test To test effect of relaxing tolerances on tail assembly
Program 52



TEST GUN
Model L13E2
Type 103mm Recoilless
Serial No. _____
Chamber LK479
Bushing (Vent) GB437
Tube 27-B-849-C (1-20)
Sighting Equipment Direct Sight M3E2 Boresight Mount T1557
Type Recoilless on Concrete Base

MISCELLANEOUS DATA
Range Accuracy Box & 240 yds Target
Type MPM12 Web-2836 Weight 14.635
Propellant _____
Lot No PA30-239
Primer TBI
Shell Case T-53
Liner RE147
Temperatures
Magazine Max 72° Min 20° Present 26°
Loading Room 80° Ambient 87°

SET I - CLOSE CLEARANCE
SET II - LOOSE CLEARANCE

Solenoid Mechanical Firing System
Corrected for Ammunition

Round No	Proj. No.	Proj. Weight (lb.)	Powder Charge (lb-oz)	Wind Vel & Dir. (mph deg)	Chamber Pressure (lb/sq in)	Muzzle Velocity (ft/sec)	Elev (mils)	Position of Hit (inches)	Corrected Position of Hit - mils	Recoil (in)	Observations
								Horiz. Vert.	Horiz. Vert.		
5549	X874	17.50	7-12 1/2	SET I	8000	1505	1527	15.0	15.0	SET I	Cold box - 41°F 81°F Ambient at Firing
5550	X875	17.51	7-12 1/2	SET I	8000	1505	1527	15.0	15.0	SET I	Cold box - 41°F
5551	X881	17.48	8-5	SET II	10800	1725	1770	17.0	17.0	SET II	Cold box - 41°F
5552	X879	17.52	8-5	SET II	10800	1725	1770	17.0	17.0	SET II	Cold box - 41°F
5553	X868	17.54	7-12 1/2	7-245°	8400	1645	1667	16.6	16.6	SET I	Good flight
5554	X880	17.51	7-12 1/2	10-245°	8400	1645	1667	16.6	16.6	SET I	Good flight
5555	X871	17.52	7-12 1/2	7-245°	8400	1645	1667	16.6	16.6	SET I	Good flight
5556	X878	17.51	7-12 1/2	13-245°	8400	1645	1667	16.6	16.6	SET I	Good flight
5557	X869	17.52	7-12 1/2	15-235°	8400	1645	1667	16.6	16.6	SET I	Good flight
5558	X875	17.52	7-12 1/2	9-245°	8400	1645	1667	16.6	16.6	SET I	Good flight
5559	X877	17.52	7-12 1/2	7-230°	8400	1645	1667	16.6	16.6	SET I	Good flight
5560	X870	17.50	7-12 1/2	6-230°	8400	1645	1667	16.6	16.6	SET I	Good flight
5561	X884	17.52	7-12 1/2	10-240°	8400	1645	1667	16.6	16.6	SET I	Good flight
5562	X883	17.52	7-12 1/2	5-240°	8400	1645	1667	16.6	16.6	SET I	Good flight
5563	X872	17.52	7-12 1/2	9-250°	8400	1645	1667	16.6	16.6	SET I	Good flight
5564	X882	17.52	7-12 1/2	5-240°	8400	1645	1667	16.6	16.6	SET I	Good flight
5565	X872	17.52	7-12 1/2	9-250°	8400	1645	1667	16.6	16.6	SET I	Good flight
5566	X882	17.52	7-12 1/2	7-240°	8400	1645	1667	16.6	16.6	SET I	Good flight
5567	X873	17.52	7-12 1/2	9-240°	8400	1645	1667	16.6	16.6	SET I	Good flight
5568	X886	17.52	7-12 1/2	8-235°	8400	1645	1667	16.6	16.6	SET I	Good flight

Center of Impact V = 7.54 mil. H = 0.60 mil
Probable Error - Vertical ± .489 mil
Probable Error - Horizontal ± .505 mil

Notes: (1) Proj X881 & X879 the copies were removed & placed in recovery box.
(2) Proj X874 not recovered. Projectiles X876, X881 & X879 were recovered. No apparent damage was noted.
(3) Recovered projectile X880 to Akron for examination.
(4) On rounds 5544, 5550, 5551 & 5552 4mm caps were placed in the cap & front recovery box.

Signed O. Miller
Proof Director E. Hoffman
Observers F. Menden, P. DeLo

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With A Short Chamber-Tail Assembly

A tail assembly, .475 in. shorter than the standard tail assembly of the T119E11 projectile has been tested at Erie Ordnance Depot. Fig. 12 illustrates the revised shorter chamber and tail assembly.

Six projectiles incorporating the shorter tail assembly were fired through yaw cards into a recovery box. The firing record is contained in Table X. Three of the six rounds were loaded to give excess pressures at ambient temperature; three were loaded for operating pressures, and prior to firing were conditioned in a cold box at -40°F . The yaw cards showed that the

fin-opening mechanism functioned satisfactorily and the recovered projectiles gave no evidence of failure or malfunction of any of the components.

Fourteen projectiles with the short tail assembly were fired for accuracy at an 18 ft by 18 ft target at a range of 998 yards. The data appear in Table XI. Probable errors of dispersion for 14 impacts were V.P.E. = $\pm .39$ mil and H.P.E. = $\pm .60$ mil.

These test results indicate that the short tail assembly can be incorporated into the T119 projectile if, at some future time, a desired decrease in length and weight justifies the change.

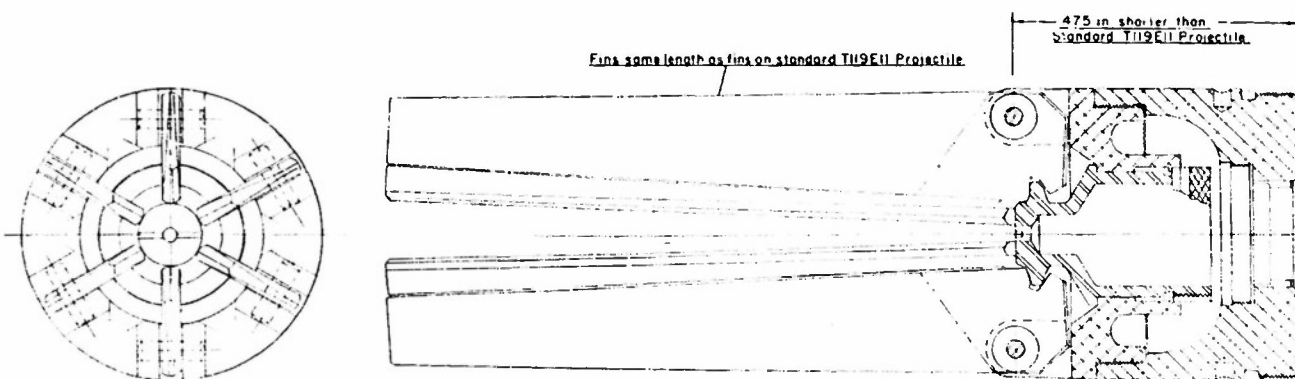


Fig. 12. Short Chamber and Tail Assembly.

Table X
Range Data
T119 Projectile With Short Tail Assembly

Date of Test July 22, 1953

Purpose of Test To Test T119(Ex) with Short Tail Assy.

PROJECTILE

Model T119 Gun 2975 → 3642 → 9475 → 3
Type Experimental
Weight 17.54 Yaw Card Distances
C.G. Location 66.17 Screen Distances
Borelet Dia. 4.132 in.
Special Features Short Tail Assy.
ORC 360.

TEST GUN

Model T157E3
Type 105mm Recoilless
Serial No. 228
Chamber 2.75-1201
Bushing (Vent) 22C-2080
Tube 22B-1493
Sighting Equipment M17 Adapted
Mount Flamethrower Mount
Type Flamethrower Mount
Serial FC-2158 18-3814

MISCELLANEOUS DATA

Range Backpack Box
Propellant PA 9029
Type MELIA Web 0.335 Weight 8.402
Lot No. PA302229
Primer M-32
Shell Case T53E1
Liner REC-53E (3.02344" rayon)
Temperatures
Magazine
Max 77°F Min 71°F Present 73°F
Loading Room 79°F Ambient 75°F

Round No	Proj. No.	Proj. Weight (lb.)	Powder Charge (lb.-oz)	Recoil (in.)	Chamber Pressure (lb./sq in.)	Muzzle Velocity (ft./sec)		Shell Type	Gage No	Position of Hit		Corrected Position of Hit - mils		Recoil (in.)	Observations
						Instr.	Actual			Vert	Horiz	Vert	Horiz		
5348-1	X 801	17.52	8-4	2 1/2 R	12,500			Star	8736	4	Fin Mark at 10°	10	0		1/2 1/2 piece of liner case Chamber clean
5349-2	X 795	17.42	8-4	2 1/2 R	12,500			Star	8736	4	Fin Mark at 10°	10	0		1/2 1/2 piece of liner case Chamber clean
5350-3	X 795	17.52	8-4	2 1/2 R	12,500			Star	8736	4	Fin Mark at 10°	10	0		1/2 1/2 piece of liner case Chamber clean
5351-4	X 805	17.54	7-13 1/2	1 F	9,000			Star	5192	2	No Fin Marks	1	0		1/2 1/2 piece of liner case Chamber clean
5352-5	X 790	17.54	7-13 1/2	1 1/2 F	8,500			Star	5192	2	No Fin Marks	1	0		1/2 1/2 piece of liner case Chamber clean
5353-6	X 789	17.54	7-13 1/2	0	9,400			Star	12438	2	No Fin Marks	1	0		1/2 1/2 piece of liner case Chamber clean
<p>NOTES:</p> <p>Projectiles X793, X795, X805, X790 & X789 recovered for examination. Proj X801 went out of box down range.</p> <p>The small sections of liner rayon with polyethylene buried off, were all found in the shell case.</p> <p>Inspection of the tube and chamber after each round showed only small fragments of shattered propellant.</p> <p>After the fourth round a section of the tip of the liner (REC-53) was found a few feet from the muzzle.</p> <p>After the fifth and sixth rounds a similar section was found close to the muzzle.</p> <p>Evidence indicates (groove & ledge marks) that this section of liner was between propellant and tube wall, obviously acting as an obturator.</p> <p>YAW CARD MEASUREMENTS</p> <p>FIN MEASUREMENTS</p> <p>Atmospheric conditions prevented Fastax pictures.</p> <p>1 4 1/2" x 4 1/2" 4 1/2" x 4 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2"</p> <p>2 4 1/2" x 4 1/2" 4 1/2" x 4 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2"</p> <p>3 4 1/2" x 4 1/2" 4 1/2" x 4 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2"</p> <p>4 4 1/2" x 4 1/2" 4 1/2" x 4 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2"</p> <p>5 No card 4 1/2" x 4 1/2" 4 1/2" x 4 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2"</p> <p>6 4 1/2" x 4 1/2" 4 1/2" x 4 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2" 11 1/2" x 11 1/2"</p>															

Proof Director E. HUFFMAN
Observers E. CLARK, F. MENDEL, J. E. HUNTS, G. L. MERRIN
Signed O. Miller

Table XI
Accuracy Range Data
1119 Projectile With Short Tail Assembly



Purpose of Test: Accuracy of 1119 (Ex) With Short Tail Assy
Program #31

MISCELLANEOUS DATA
Range 578 yds. 1.28 E. of True North
Propellant Type ALP110 Web 60335 Weight 11.12 lbs
Lot No. PA 30223
Primer TR
Shell Case Falchivale & Payne S/G case
Liner _____
Temperatures _____
Magazine _____
Max 77°F Min 71°F Present 74°F
Loading Room 71°F Ambient 91°F

TEST GUN
Model I-137 E2
Type 105 mm Recoilless
Serial No. _____
Chamber JK 679
Bushings (Vent) GB 637
Tube 22B-270-P W22F4 #1000
Sighting Equipment L132 ml. 5
Mount Gunner Quadrant M1-113263
Type I-137 E2
Serial # 13 (Somerset Base) Recoilless Mount, PC-200 10.5 in
Corrected to 0 ft. muth of 20 mils elevation

Round No	Proj No	Proj Weight (lb)	Powder Charge (lb - oz)	Wind Vel. Dir. (ft/sec - °)	Chamber Pressure (lb / sq in)	Muzzle Velocity (ft/sec)		Elev (mils)	Azimuth (mils)	Position of Hit (inches)		Corrected Position of Hit - mils		Recoil (in)	Observations	Normal Wind Component
						Inst	Actual			Vert	Horiz	Vert	Horiz			
5491	X955	17.50	7-12%	---	14,292	1691	1663	---	---	---	---	---	---	---	---	---
5492	X960	17.51	7-12%	---	14,155	1682	1668	---	---	---	---	---	---	---	---	---
5493	X806	17.54	7-12%	50-210°	---	1647	1670	6-24	3L	+74	-35%	+2,060	+1,016	---	---	---
5494	X796	17.55	7-12%	18-210°	13,550	1645	1668	-24	3L	+50%	-7	+1,046	+2,811	---	---	---
5495	X792	17.55	7-12%	18-215°	11,192	1600	1623	-24	3L	+20	-2.5%	+0,857	+2,185	---	---	---
5496	X791	17.53	7-12%	18-210°	---	1616	1639	-24	3L	+54%	-34	+1,517	+2,040	---	---	---
5497	X794	17.54	7-12%	17-220°	12,001	1624	1627	-24	3L	+37%	-35%	+1,049	+2,518	---	---	---
5498	X794	17.54	7-12%	17-205°	12,375	1645	1668	-24	3L	+77	-57%	+2,143	+1,573	---	---	---
5499	X796	17.65	7-12%	17-250°	12,100	1628	1651	-24	3L	+55	+36	+1,531	+4,008	---	---	---
5500	X798	17.55	7-12%	13-195°	12,104	1631	1654	-24	3L	+40%	-64%	+1,684	+0,654	---	---	---
5501	X800	17.54	7-12%	22-215°	---	1627	1650	-24	3L	+92%	-72	+2,574	+1,007	---	---	---
5502	X797	17.54	7-12%	15-205°	---	1691	1644	-24	3L	+60	-17	+1,670	+2,873	---	---	---
5503	X799	17.50	7-12%	15-230°	12,691	1656	1679	-24	3L	+91%	-15%	+2,547	+2,074	---	---	---
5504	X804	17.51	7-12%	18-225°	12,655	1635	1658	-24	3L	+77%	-22%	+2,157	+1,480	---	---	---
5505	X802	17.50	7-12%	18-210°	12,597	1635	1656	-24	3L	+68%	0	+1,906	+3,066	---	---	---
5506	X803	17.54	7-12%	16-225°	12,597	1631	1654	-24	3L	+52	-17%	+1,447	+2,579	---	---	---
Notes: #1) Internal M.S. Cu pressures for rounds 5491-5492 (only once taken). Proj. was 71.9 (blunt nose). #2) Round 5505 & 5506 fired through one yow add on the first 80.1 Gun was set with a horizontal reference line.																
Root Mean Square																
		Round	Body Yaw	Body Yaw	Body Yaw	Body Yaw	Body Yaw	Body Yaw	Body Yaw	Body Yaw	Body Yaw	Body Yaw	Body Yaw	Body Yaw	Body Yaw	Body Yaw
		5498	4% 4%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%
		5495	4% 4%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%
		5498	4% 4%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%
		5505	4% 4%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%
		5506	4% 4%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%	11% 11%
Center of Impact $V = +1.10$ in. $H = +2.17$ mi/s																
Probable Error - Vertical $\pm .387$ mi/s																
Probable Error - Horizontal $\pm .601$ mi/s																

Signed C. Miller
Proof Director E. Huffman
Observers C.H. Cox, E. Hendez, L. Swanney

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Future Program

1. A nylon slip-band will be tried as a means of increasing the muzzle spin of the projectile.

2. Twenty projectiles with rubber "O" ring obturators have been fired for spin and accuracy. The results will be reported in next month's publication.

3. Fifteen projectiles with short bodies,

short ogives and rounded nose caps are being assembled. It is planned to fire these projectiles to check drag and accuracy.

4. Twenty special housings with an O.D. of 4.118 - .005 are still in process. This design should permit a smoother launching condition of the projectile. Results will be included in a later report.

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T171 PROJECTILE

Accuracy Tests

Two modifications of the T171 projectile were fired for accuracy and flight evaluation at Erie Ordnance Depot. Seven T171 MD8 rounds (Fig. 13) and twelve T171 MD10 rounds (Fig. 14) were launched from a T137 rifle having a 1-20 twist tube. The target, 18 ft. by 18 ft., was placed 1000 yards from the gun muzzle. Since the projectiles did not have rotating bands, it is estimated, from spin measurements previously made, that the rounds were rotating 2 to 3 rps at the muzzle.

T171MD8 (Fig. 13)

Of seven rounds of this modification fired one round hit the target. This one round, fired at an elevation of 23 mils and zero azimuth, with a muzzle velocity of 1692 feet per second, hit .28 mil below and 1.28 mils right of the aiming point. Two rounds, after hitting velocity coils, exhibited large yaw during the remainder of their observed flight and another round

tumbled at a point about 600 yards down range. The remaining three rounds appeared stable in flight, but drifted off the line of sight. The firing record for this program is in Table XII.

A yaw card was placed on the first velocity screen and the three projectiles which flew badly (X902, X903, X911) each had a large initial yaw, indicating that poor launching conditions were responsible for the poor flight. The poor launching conditions may be related with the riding surface of the fins - which is narrower and longer than that of the T-4 fin used on the T171 MD10 projectile.

T171MD10 (Fig. 14)

Eleven of the twelve MD10 rounds fired hit the target, with probable errors of $\pm .60$ mil horizontally and $\pm .90$ mil vertically. The dispersion chart is shown in Fig. 15. These rounds, fired at an elevation of 23 mils and zero azimuth, with an average muzzle velocity of 1669

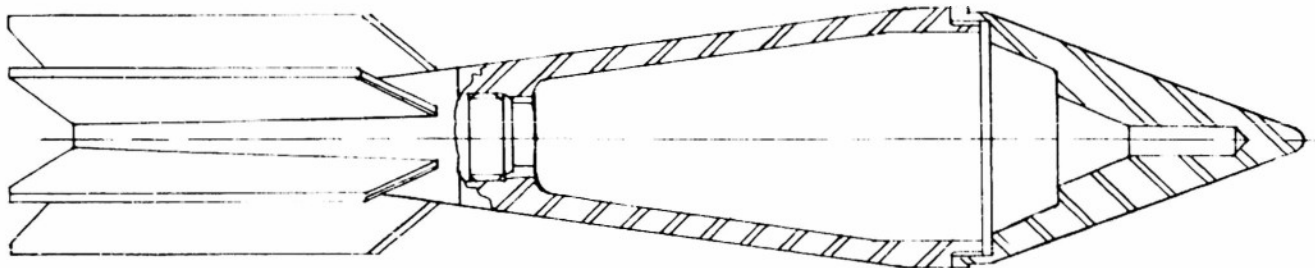


Fig. 13. T171MD8 Projectile.

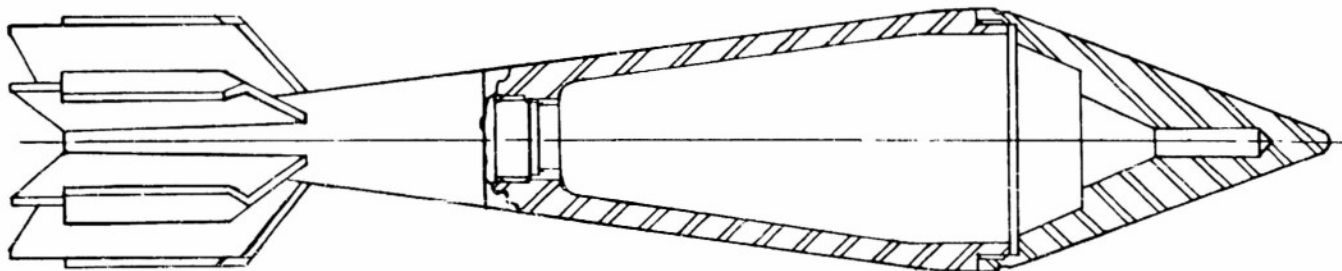


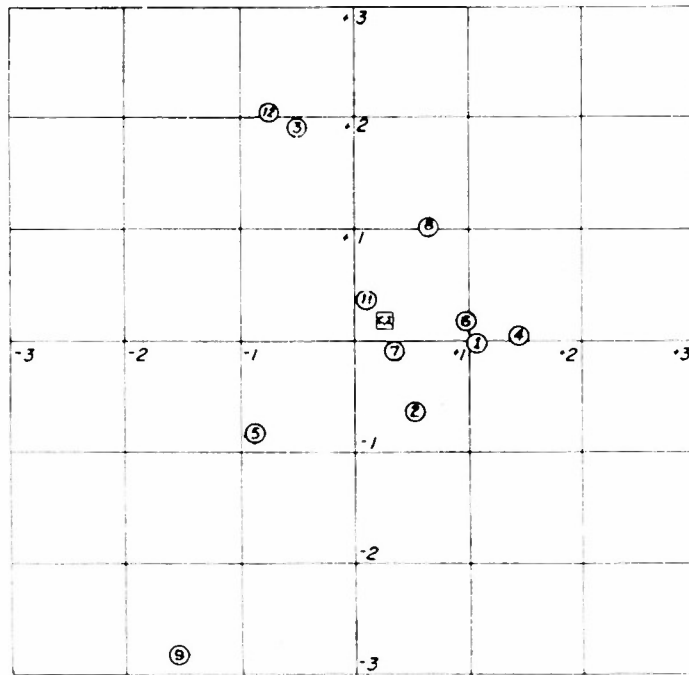
Fig. 14. T171MD10 Projectile.

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feet per second, had a center of impact .11 mil above and .28 mil to the right of the aiming point. The round that missed the target appeared stable in flight but drifted to the right. The firing record for this program is shown in Table XII.

sult either from the difficulty in maintaining a uniform loading density of the separately loaded rounds or from the low initial spin rate, or both. The large horizontal dispersion also suggests that the spin rate of 2 to 3 rps is not sufficient to yield satisfactory performance.

The large vertical dispersion may re-



(Round 10 missed target)

Probable Error ²	
H. P.E.	= ±0.60
V. P.E.	= ±0.90

in mils

Center of Impact ²	
H. C. I.	= +0.283
V. C. I.	= +0.114

Fig. 15. Dispersion Chart
T171MD10 Projectiles.

Table XII
Range Data
7171MD8 and 7171MD10 Projectiles

Purpose of Test Accuracy of 7171MD8 & MD10
 Date of Test Aug 7, 1953

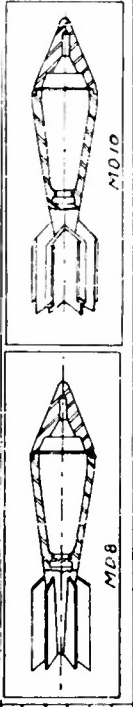
TEST GUN
 Model T-137-E2
 Type 105mm Recoilless
 Serial No 14679
 Chamber 14679
 Bushing (Vent) 6 B 6 37
 Tube 22.8-370-P-1 in 20 in
 Sighting Equipment Gunners Quadrant #11243
 Mount Elbow Tripods, Model #18008
 Type T-152-E4 & concrete base

MISCELLANEOUS DATA
 Range 998 yds. (d)
 Propellant Type 710 MP Web .0335 in Weight 8 1/4 oz
 Lot No PA30235
 Primer T-81
 Shell Case T-152
 Liner T-32 polyethylene
 Temperatures
 Max 72°F Min 71°F Present 75°F
 Loading Room Ambient 82°F

PROJECTILE
 Model T-171
 Type MD8 & MD10
 Weight 17.50 lbs (Nom)
 C.G. Location
 Bourrelet Dia 4.132 - .003 in
 Special Features MD8 (6 in. base)
MD10 (7 in. base)

62.92' | 105.83' | 37.57' | 55.92' | 4th
 1st Wind Card
 2nd Screen Distances
 3rd
 4th

Round No (a)	Time of Flight	Proj Weight (lb)	Proj. No (d)	Wind Vel & Dir (mph)	Wind (c) (degrees)	Chamber Pressure (lb/sq in)	Muzzle Velocity (ft/sec)		Azim (mils)	Elevation Position of Hit (inches)			Corrected Position of Hit - mils		Booy Yaw (in)	Observations
							Instr	Actual		zero	super	Vert	Horiz	Vert		
5514		17.52	X 911	8	055	3800	1634	1659	0	5.4	23					Hit fourth coil
5515	2.3333	17.50	X 905	7	058	3700	1643	1692	0	5.4	23	-10	+46			4 3/4 x 4 1/8 Body yaw; hit 1/2 mil right 1/2 mil low
5516		17.51	X 902	10	045	3800	1640	1653	0	23						Hit lost 3 coils, sighting was correct
5517		17.53	X 907	5	050	3400	1652	1687	1.2	23						Low in front of target
5518		17.52	X 912	9	060	3700	1652	1687	1.2	23						Left and low
5519		17.52	X 913	-	-	3300	1650		1.2	24						Over top the right
5520		17.51	X 903	7	058	3900	1640		1.2	23						Tumbled over to the left
5521	2.22030	17.52	X 916	8	055	3900	1620		0	23	-1/2	+37 1/2	-014	+1.044	4 1/8 x 4 1/8	Body yaw on target. Good flight
5522	2.22896	17.54	X 923	9	075	3800	1645	1774	0	23	-22	+18 1/2	-612	+515	4 1/8 x 4 1/8	Very slight yaw Good flight
5523		17.50	X 918	8	055	3400	1647	1776	0	23	+69	-18	+1.920	-501	4 1/8 x 4 1/8	Good flight
5524		17.53	X 922	11	063	3600	1642	1771	0	23	+2 1/2	+51	+0.070	+1.419	4 1/8 x 4 1/8	do
5525	2.23445	17.52	X 921	9	100	3700	1638	1667	0	23	-29	+31 1/2	-807	+877	4 1/8 x 4 1/8	do
5526		17.53	X 924	8	045	3400	1650	1679	0	23	+6	+35 1/2	+157	+988	4 1/8 x 4 1/8	do
5527		17.53	X 919	9	060	3400	1646	1675	0	23	-3 1/2	+11	-397	+306	4 1/8 x 4 1/8	do
5528		17.52	X 920	6	060	3000	1641	1650	0	23	+37	+23 1/2	+1.030	+654		do
5529		17.52	X 914	7	048	3700	1651	1680	0	23	-101	-55 1/2	-2.811	-1.545	4 1/8 x 4 1/8	Low 2 mils left. Good flight. Slight yaw came out
5530		17.50	X 915	7	055	3700	1649	1678	0	23						Missed target Good flight, 2 mils right
5531	2.22285	17.53	X 925	10	080	3800	1646	1675	0	23	+13	+4 1/2	+362	+725	4 1/8 x 4 1/8	Good flight
5532	2.25411	17.50	X 917	9	065	3200	1627	1656	0	23	+73	-27 1/2	+2.032	-765	4 1/8 x 4 1/8	do
(a) Projectiles were placed in the tube so that the case would be at the rear of the projectile. This was done.																
(b) Rounds 5524 to 5529 were MD8 type, round 5531 5532 were MD10 type.																
(c) Rounds were from Magnetic North.																
(d) Line of fire - 28° East of Magnetic North.																



Center of Impact Vert. ± 11.2 mils, Horiz. ± 2.83 mils
 Probable Error - Vertical ± 9.0 mils
 Probable Error - Horizontal ± 6.0 mils

Pool Director E. Hulstrom
 Observers W. B. Jones
P. B. Jones, J. S. Swasey

Signed C. M. Her

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Ballistic and Range Calculations

Using the Siacci theory and experimental data, ballistic coefficients for the T171MD3, MD5, MD10 and MD11 configurations were determined. From these ballistic coefficients the form factors and drag coefficients were computed. The terminal velocity, time of flight and elevation were found for various ranges and muzzle velocities, and the variations in vertical target strike which would result from errors in range estimation have been calculated.

Ballistic Coefficients

The Ballistic coefficients were found which satisfied the equations

$$C_T = \frac{t}{T_f - T_o}$$

$$C_s = \frac{x}{S_f - S_o}$$

where

- t = time of flight
- x = range
- T_o = Siacci time function at initial velocity.
- T_f = Siacci time function at final velocity.
- S_o = Siacci space function at initial velocity.
- S_f = Siacci space function at final velocity.
- C_T, C_s = Ballistic coefficients determined by time and space conditions.

The times of flight and muzzle velocities were measured, and the range was known. After the initial values of the space and time functions corresponding to the muzzle velocities were obtained from the tables, the terminal velocity was varied until the final values of the space and time functions were found that gave equal values of the ballistic coefficients, C_s and C_T.

This procedure was carried out with standard drag functions 1, 2, 7 and 8, and the standard function chosen was that one which best fit the experimental data. The best fit was assumed to be the function for which the standard deviation of the ballistic coefficients was a minimum.

It was found that the number 2 standard function provides the best fit to the data for the MD11 projectile, and the number 7 standard function was chosen for the MD3, MD5, and MD10 modifications.

The form factors were then determined from the relation $i = \frac{m}{Cd^2}$

where i = form factor

C = ballistic coefficient

m = mass of shell

d = diameter of shell

Values for the ballistic coefficient and the form factor are shown in Table XIII.

Table XIII
Ballistic Coefficients and Form Factors
T171MD3, MD5, MD10 and MD11 Projectiles

Projectile	Ballistic Coefficient	Form Factor	Standard Table
MD3	.3196	3.217	7.2
MD5	.3070	3.349	7.2
MD10	.5557	1.850	7.2
MD11	.5325	1.931	2.2

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Drag Force Coefficients

With the aid of the expression

$$K_D = \frac{iG}{k u}$$

$$k = 5.217 \times 10^{-4}$$

i = form factor

G = drag function

u = velocity

the drag force coefficient - Mach number relationships for these four configurations were computed (Fig. 16). The solid sections of these curves are the portions of the curves to which the experimental data were applied, while the dotted lines are extrapolations of the standard curves using the above listed form factors. These results indicate that the drag force acting on each of these projectiles, using the MD10 modification as a base (=1.0), is 1.09 for the MD11, 1.74 for the MD3 and 1.81 for the MD5.

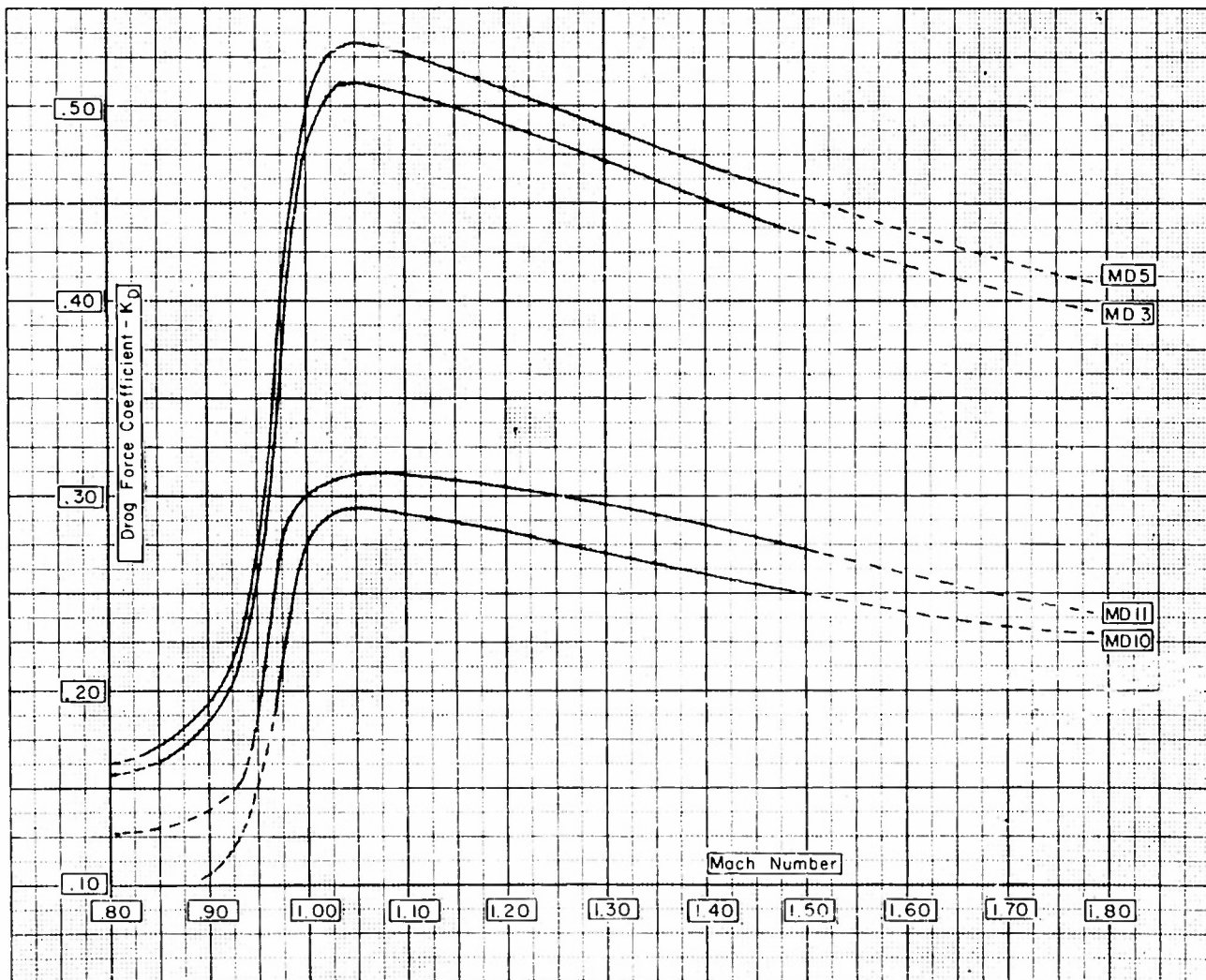


Fig. 16. Drag Force Coefficient Versus Mach Number.
 T17:MD3, MD5, MD10 and MD11 Projectiles.

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Trajectory Elements

The significance of a difference in drag force lies in its effect on the trajectory elements. Using the equations

$$S_f = S_o + \frac{x\epsilon}{c} \sec \theta_o$$
$$y = x \tan \theta_o - \frac{c^2}{2g^2} \left[(A_f - A_o) - I_o \frac{x\epsilon}{c} \right]$$
$$t = \frac{c}{g} \left[\tau_f - \tau_o \right]$$

$S_{o,f}$ = initial, final values of Siacci space function.

$T_{o,f}$ = initial, final values of Siacci space function.

$A_{o,f}$ = initial, final values of Siacci altitude functions.

I_o = initial value of Siacci inclination function.

x = range

c = ballistic coefficient

t = time of flight

y = elevation

ϵ = ratio of density of air to standard density.

the elevations, terminal velocities, and times of flight were related to varying muzzle velocity for ranges of 1000 yards and 2000 yards, (Figures 17-22), and to range for a muzzle velocity of 1650 feet per second (Figures 23-25).

It is easily seen that the MD10 and MD11 modifications are superior to the MD3 and MD5 modifications when drag force alone is considered. The required elevation for the MD10 is 3% less than that for the MD11 at 1000 yards, and 5% less at 2000 yards. The remaining velocities of the MD10 at 1000 yards and 2000 yards are, respectively, 3% and 6% higher than those of the MD11 at the same ranges, while the times of flight for the MD10 at 1000 yards and 2000 yards are 2% and 3% lower than those of the MD11 at those ranges.

Variation in Hit

The variations in vertical target hit as a function of range error, for ranges of 1000 yards and 2000 yards, and as a function of range, for a 15% range error, were determined using the equation

$$y = x \tan \theta - \frac{c^2}{2g^2} \left[(A - A_o) - \frac{I_o x \epsilon}{c} \right]$$

and plotted in Figs. 26, 27 and 28. These graphs also show the superiority of the MD10 and MD11 modifications over the MD3 and MD5 rounds. It is apparent that the MD10 is an improvement over the MD11, especially for extended ranges, when this variation is considered.

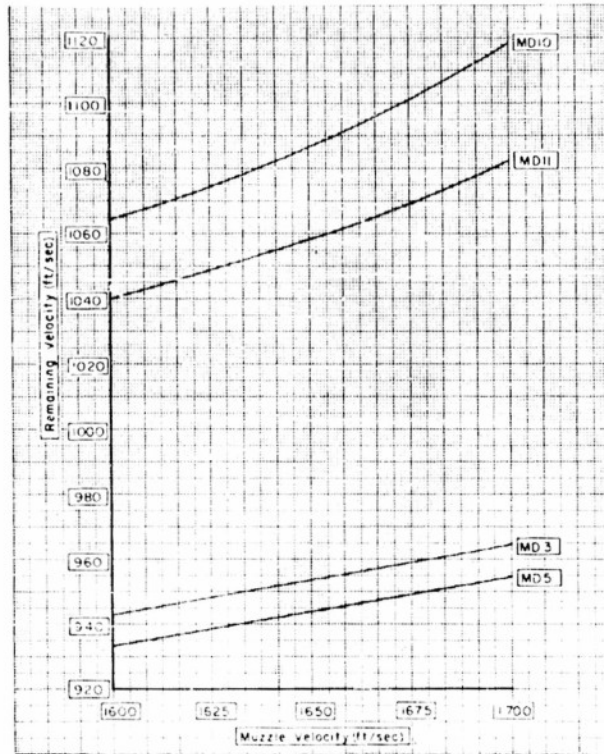


Fig. 17. Remaining Velocity Versus Muzzle Velocity.
T171MD3, MD5, MD10 and MD11 Projectiles, 1,000-yard Range.

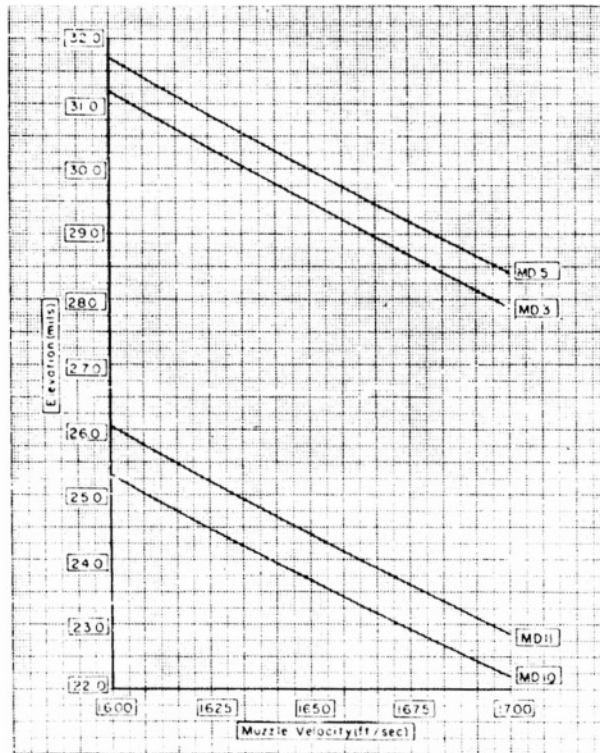


Fig. 18. Elevation Versus Muzzle Velocity.
T171MD3, MD5, MD10 and MD11 Projectiles, 1,000-yard Range.

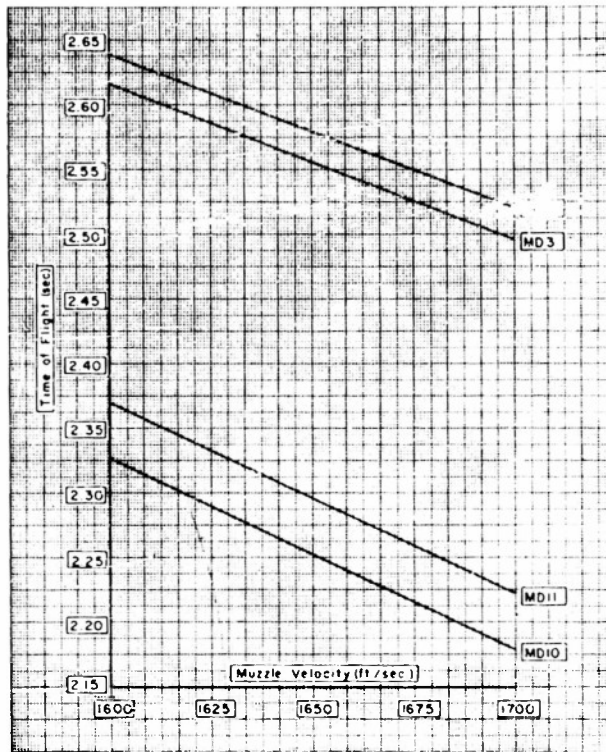


Fig. 19. Time of Flight Versus Muzzle Velocity.
T171MD3, MD5, MD10 and MD11 Projectiles; 1,000-yard Range.

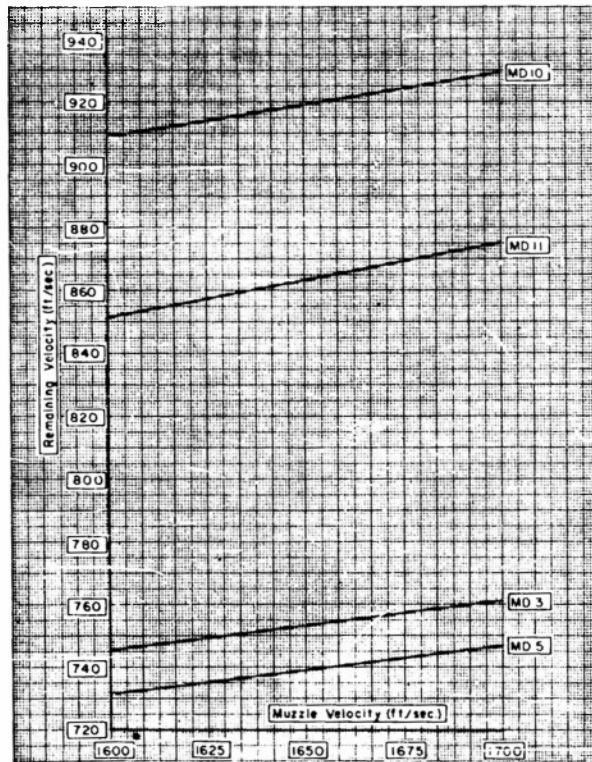


Fig. 20. Remaining Velocity Versus Muzzle Velocity.
T171MD3, MD5, MD10 and MD11 Projectiles; 2,000-yard Range.

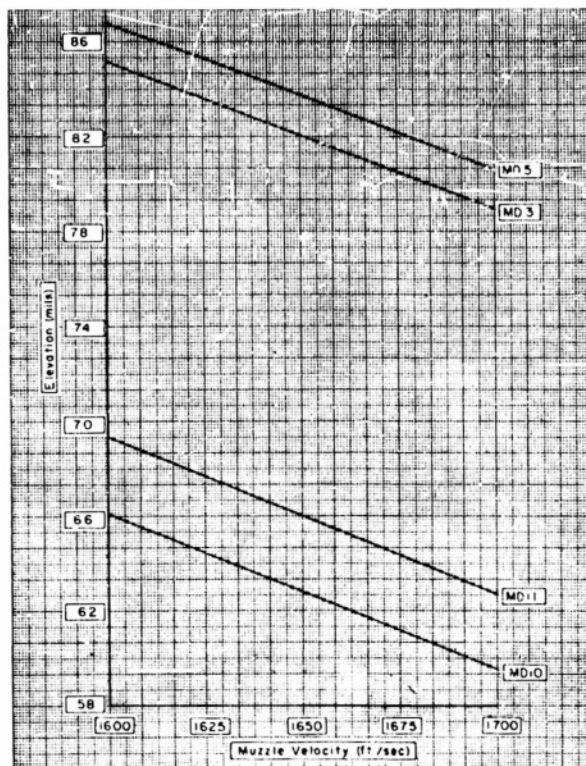


Fig. 21. Elevation Versus Muzzle Velocity.
T171MD3, MD5, MD10 and MD11 Projectiles; 2,000-yard Range.

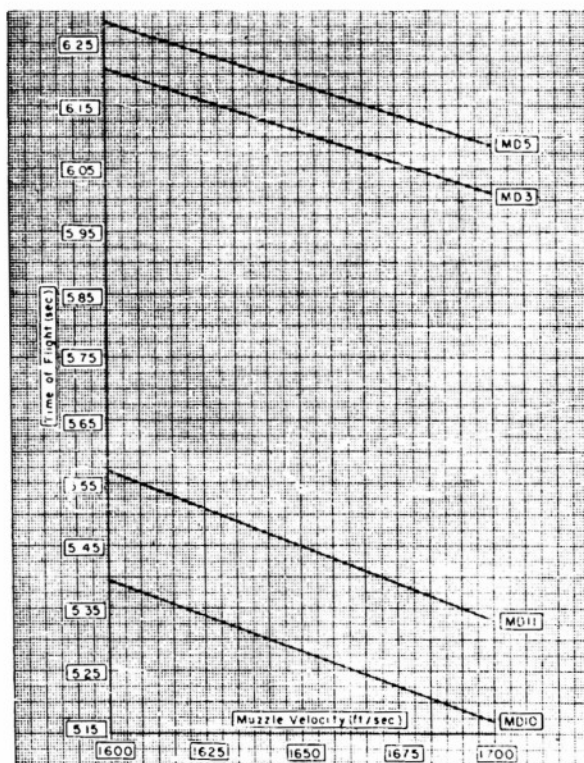


Fig. 22. Time of Flight Versus Muzzle Velocity.
T171MD3, MD5, MD10 and MD11 Projectiles; 2,000-yard Range.

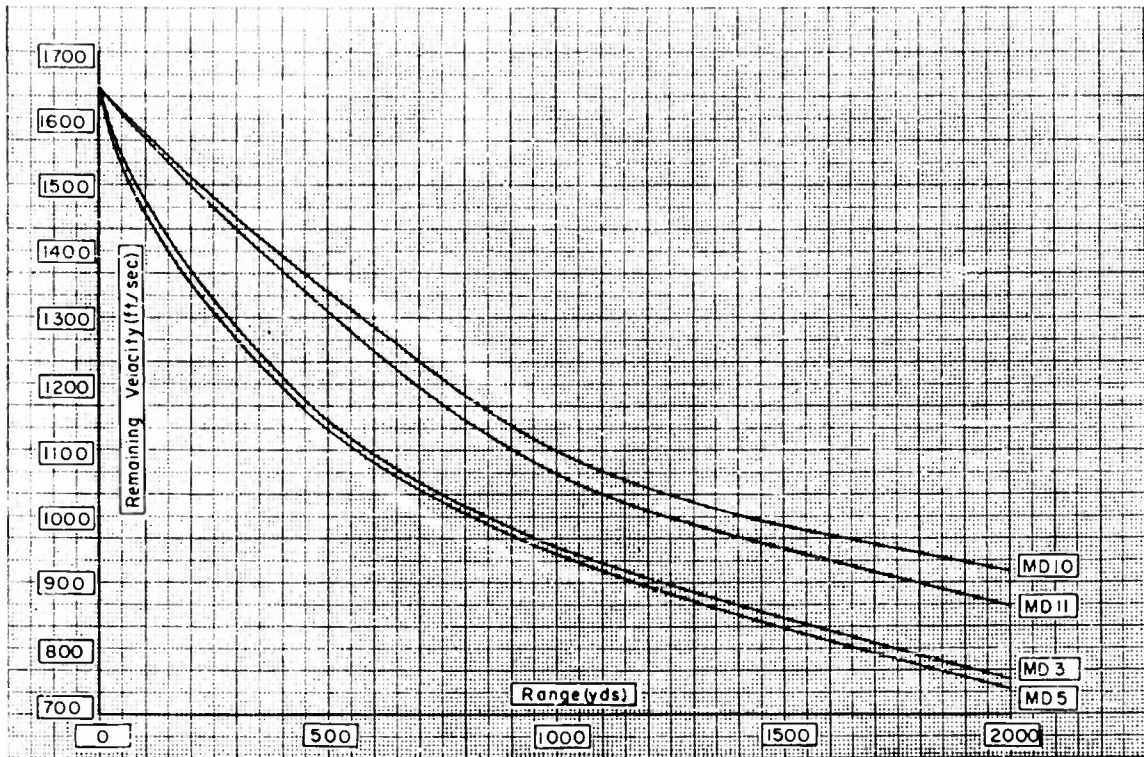


Fig. 23. Remaining Velocity Versus Range.
T171MD3, MD5, MD10 and MD11 Projectiles.

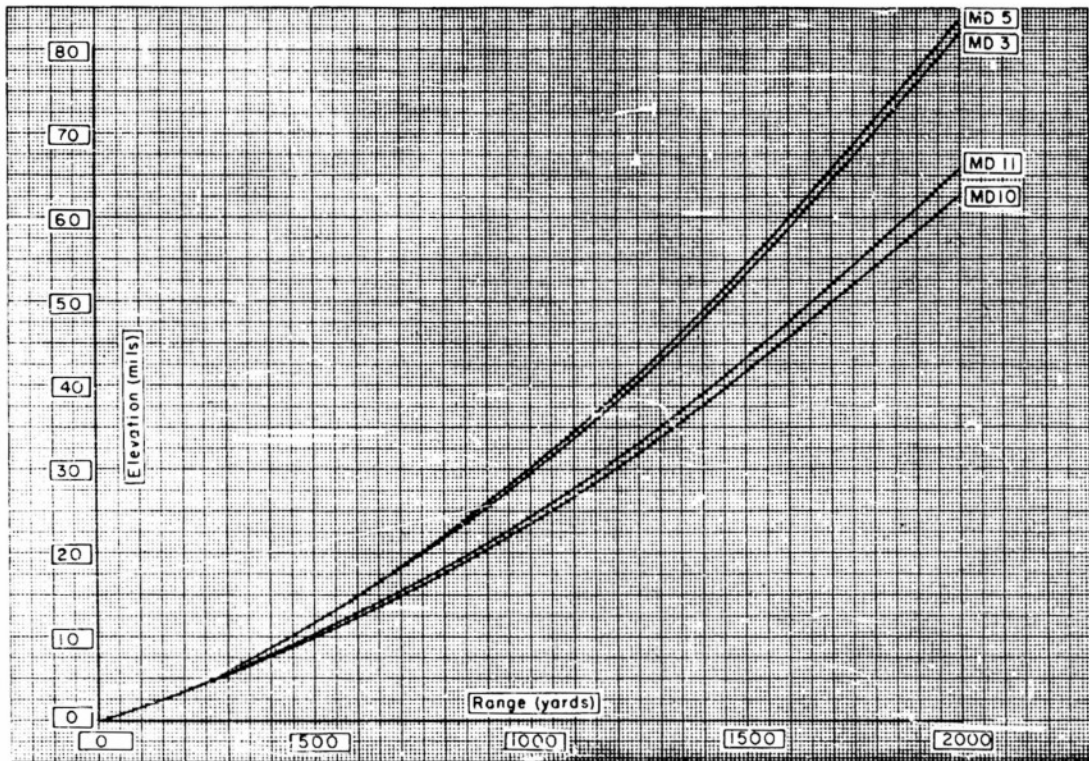


Fig. 24. Elevation Versus Range.
T171MD3, MD5, MD10 and MD11 Projectiles.

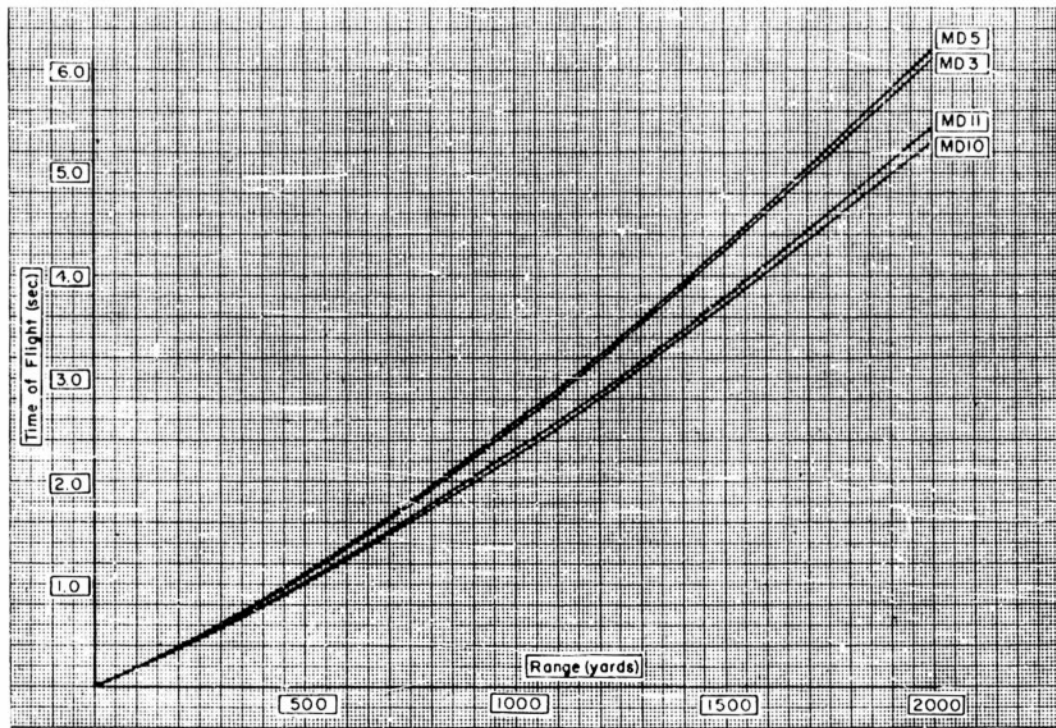


Fig. 25. Time of Flight Versus Range.
T171MD3, MD5, MD10 and MD11 Projectiles.

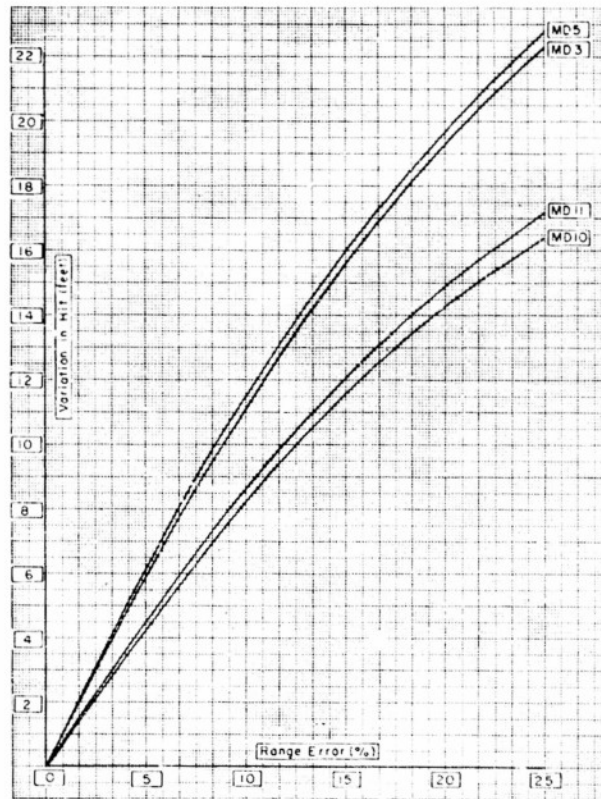


Fig. 26. Variation in Hit Versus Range Error.
T171MD3, MD5, MD10 and MD11 Projectiles: 1,000-yard Range.

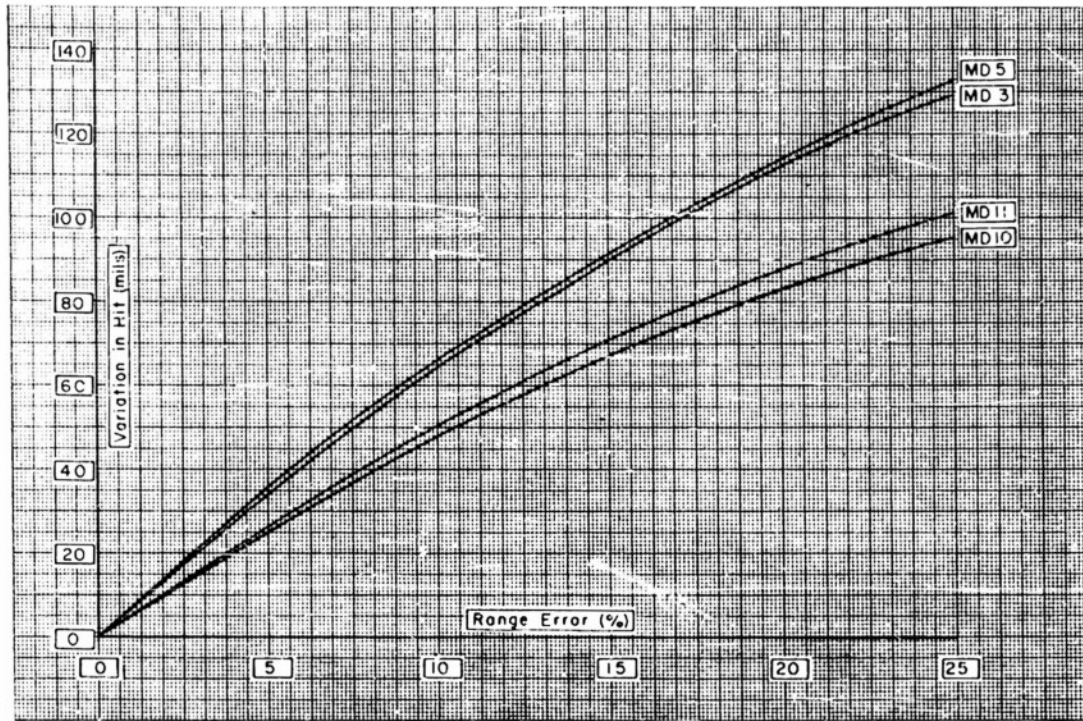


Fig. 27. Variation in Hit Versus Range Error.
T171MD3, MD5, MD10 and MD11 Projectiles; 2,000-yard Range.

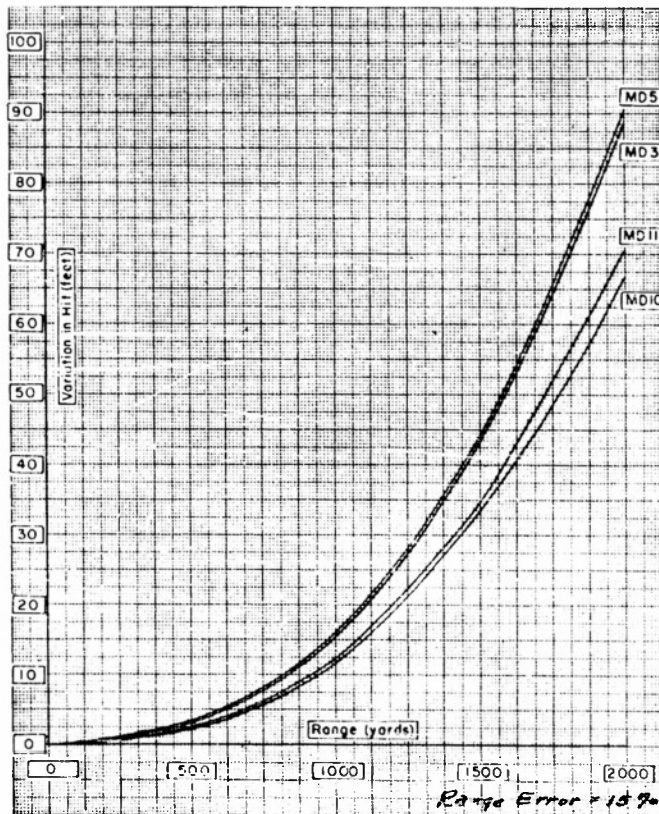


Fig. 28. Variation in Hit Versus Range.
T171MD3, MD5, MD10 and MD11 Projectiles.

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Future Program

1. Because of the advantage the reduced drag force provides and the simplification of penetration problems offered by the conical nose, continued emphasis will be placed on achieving satisfactory accuracy with the MD10 modification. Several T171MD10 projectiles are at Erie Ordnance Depot awaiting firing from a 1-500 twist tube. This test is designed to show the effect of spin rate upon the ac-

curacy of this projectile.

2. A test similar to (1) is planned for T171 MD11 projectiles.

3. T171 MD11 projectiles, modified by replacing the regular tee with the T138 E23M nose (page 19, BRL Memo Report 592, A. S. Platou) are being prepared for evaluation tests.

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PENETRATION STUDIES

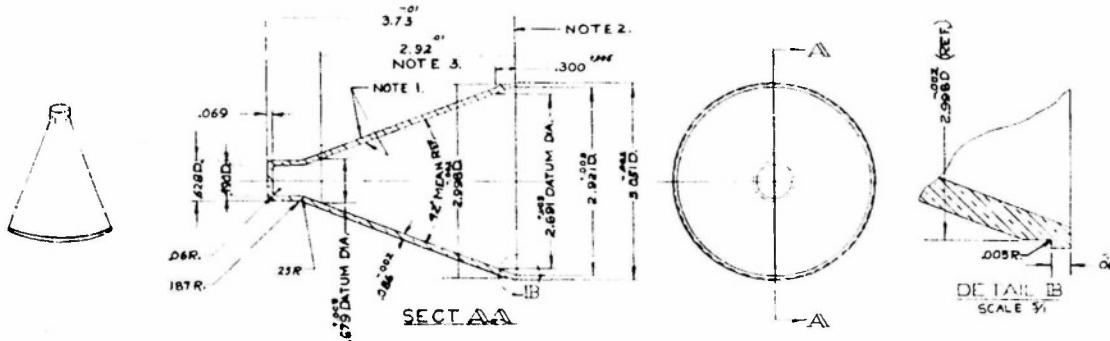
Scaling Studies

Two separate but related scaling studies have now been completed. One is based upon the DRB398 copper cone and the first part of this study (75mm) was presented in the Thirty-Fifth Progress Report. The second considered a family of 45° sharp apex copper cones and was reported in the Thirty-Sixth Progress Report. In this report new data for the 90mm size DRB398 type cone is presented and all data for the two studies are summarized.

The 90/105mm scaled counterpart of the DRB398 cone and DRC376 test assembly consists of a DRB707 cone and

DRC506-1 test assembly (No. 2 nose ring). Fig. 29 shows the cone and Fig. 30 shows a cone and charge assembly. These cones were made from DRB398 drawn cones by cutting them off at the appropriate base diameter (3.0 inch register diameter) and by machining the inside wall surface to the specified wall thickness (.086 inch). The only departure from linear scaling is in the small spitback tube whose dimensions are unchanged from the original DRB398 cone.

The inspection data for the DRB707 cones are shown in Table XIV and the penetration data are shown in Tables XV(A) and XV(B).



NOTE:

1. ALL INDICATED SURFACES TO BE CONCENTRIC WITHIN .003 T.I.R. WITH RESPECT TO 2.998 DIA. REGISTER.
2. INDICATED SURFACE TO BE PERPENDICULAR TO ϕ OF PART WITHIN .003 T.I.R.
3. IN THIS FIGURE VARIATION IN STRAIGHTNESS OF THICKNESS OF WALL SHALL NOT EXCEED .003 IN ANY AXIAL PLANE; WALL THICKNESS IN ANY TRANSVERSE PLANE SHALL NOT EXCEED .003 VARIATION.
4. FINISH OF
5. REFERRED MATERIAL: OXYGEN FREE, NO RESIDUAL DEOXIDANTS, COPPER.
6. ALTERNATIVE MATERIAL: ELECTROLYTIC TIGHT PITCH COPPER.
7. THIS CONE MAY BE MADE BY MODIFYING CONE DRC-398.

Fig. 29. DRB707 90 mm. Smooth Cone.
90/105 Scaled Counterpart of DRB398 Cone.

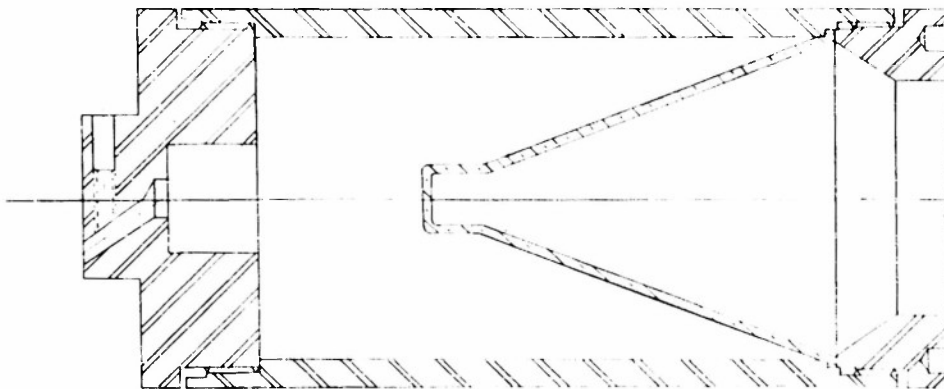


Fig. 30. DRC506-1 90 mm. Penetration Test Assembly.
90/105 Scaled Counterpart of DRC376 Assembly.

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Table XIV
Inspection Data
DRB707 Cones

Cone No.	Wall Thickness (inches)			Max Variation in Wall Thickness(in.)		Max. Wall Waviness-in.		Concentricity T. I. R. (in.) ²		
	Max.	Min.	Avg.	Transverse	Longitud.	O. D.	I. C.	Base ¹ Datum	Apex Datum	Cone Tip in Assembly
Specification DRB707										
Cone	.086	.084	--	.001	.003	.003	.003	.0030	.0030	.015 (Maximum)
FS1049	.086	.085	.0851	.001	.001	.002	.002	.0010	.0020	.005
FS1050	.088	.086	.0865	.002	.002	.001	.002	.0020	.0025	.010
FS1051	.085	.084	.0845	.001	.001	.001	.002	.0040	.0010	.004
FS1052	.090	.085	.0878	.001	.004	.002	.005	.0020	.0015	.002
FS1053	.092	.086	.0890	.001	.005	.002	.003	.0020	.0010	.004
FS1054	.090	.085	.0875	.001	.004	.002	.003	.0020	.0020	.010
FS1055	.094	.086	.0898	.001	.008	.002	.008	.0015	.0040	.008
FS1056	.086	.084	.0851	.001	.002	.002	.003	.0010	.0020	.005
FS1057	.085	.085	.0850	<.001	<.001	.002	.002	.0020	.0020	.008
FS1058	.086	.084	.0851	.001	.002	.002	.003	.0010	.0020	.010
FS1059	.086	.084	.0850	.001	.002	.002	.003	.0020	.0020	.007
FS1060	.087	.086	.0865	.003	.003	.002	.002	.0015	.0040	.006
FS1061	.085	.084	.0845	.002	.002	.002	.002	.0030	.0060	.016
FS1062	.090	.086	.0880	<.001	.004	.002	.004	.0020	.0010	.004
FS1063 ³	---	---	---	NO DATA		---	---	---	---	---
FS1064	.087	.085	.0863	.002	.001	.002	.002	.0020	.0040	.005
FS1065	.087	.085	.0860	.001	.001	.003	.002	.0020	.0040	.012
FS1066	.090	.086	.0879	.003	.003	.002	.003	.0020	.0030	.006
FS1067	.086	.084	.0853	.001	.002	.002	.003	.0010	.0010	.008
FS1068	.088	.085	.0864	.001	.003	.002	.005	.0020	.0010	.005
FS1069	.085	.082	.0843	.002	.003	.002	.004	.0020	.0020	.001
FS1070	.087	.085	.0860	.002	.002	.002	.004	.0020	.0010	.017
FS1071	.087	.084	.0854	.001	.003	.002	.004	.0010	.0010	.002
FS1072	.085	.083	.0840	.001	.002	.002	.003	.0020	.0010	.010
FS1073	.090	.085	.0875	.002	.005	.002	.005	.0020	.0010	.006
FS1074	.086	.085	.0853	.001	.001	.002	.004	.0030	.0010	.010
Avg.	.0875	.0848	.0862	.0013	.0026	.0020	.0033	.0019	.0021	.0072
Std.										
Dev.	±.0024	±.0010	±.0017	±.0007	±.0017	±.0004	±.0014	±.0007	±.0013	±.0039
Notes:										
1. Lower datum is .484 inch above base; the upper datum is 2.92 inches above base.										
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner axis.										
3. Held as sample.										

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Table XV
Penetration Data
DRB707 Cones

Round No.	Lb. Comp B	Standoff (in.)	Penetration (inches M.S.)	Max. Spread (in.)	Std. Deviation (in.)
A. Effect of Standoff					
FS1049	1.56	6.0	18.69		
FS1050	1.58	6.0	16.94		
FS1051	1.60	6.0	15.81		
FS1052	1.58	6.0	17.31		
			Avg. 17.19	2.88	±1.19
FS1053	1.56	9.0	18.31		
FS1054	1.56	9.0	18.25		
FS1055	1.58	9.0	17.94		
FS1056	1.60	9.0	17.44		
			Avg. 17.99	.87	±0.40
FS1057	1.58	12.0	19.12		
FS1058	1.56	12.0	17.44		
FS1059	1.58	12.0	18.62		
FS1060	1.58	12.0	19.12		
			Avg. 18.58	1.68	±0.80
Notes:					
1. Cones were modified from drawn DRB398 HW3 item 1 copper cones, and were assembled in DRC506-1 test bodies, plugs and No. 2 nose rings.					
2. Loaded at Ravenna Arsenal, BAT Lot No. 32, with Composition B from Holston Lot No. 4-1197.					
3. Tested at Erie Ordnance Depot without rotation; mild steel target plate was used.					
B. Effect of Rotation					
Round No.	Lb. Comp B	Rev/Sec	Penetration Inches M.S.	Max. Spread (in.)	Std. Deviation (in.)
FS1049	1.56	0	18.69		
FS1050	1.58	0	16.94		
FS1051	1.60	0	15.81		
FS1052	1.58	0	17.31		
			Avg. 17.19	2.88	±1.19
FS1061	1.56	30	15.25		
FS1062	1.58	30	14.75		
FS1074	1.58	30	13.88		
FS1064	1.60	30	12.75		
			Avg. 14.16	2.50	±1.10
FS1065	1.56	60	8.18		
FS1066	1.56	60	7.75		
FS1067	1.56	60	8.18		
			Avg. 8.04	0.43	±.25
FS1068	1.58	90	6.56		
FS1069	1.56	90	6.62		
FS1070	1.58	90	6.50		
			Avg. 6.56	0.12	±.06
FS1071	1.58	120	5.94		
FS1072	1.56	120	5.56		
FS1073	1.58	120	5.38		
			Avg. 5.63	0.56	±.29
Notes:					
1. Cones were modified from drawn DRB398 HW3 item 1 copper cones, and were assembled in DRC506-1 test bodies, plugs and No. 2 nose rings.					
2. Loaded at Ravenna Arsenal, BAT Lot No. 32, with Composition B from Holston Lot No. 4-1197.					
3. Tested at Erie Ordnance Depot at a standoff of 6.0 inches. Mild steel target plate was used.					

Scaling of Standoff

The penetration data for the effect of standoff are shown in Fig. 31 and are compared directly with similar data for the 75mm and 105mm scaled counterparts. The curves have the same general shape. Fig. 32 is a generalized plot showing the effect of standoff. Data for both scaling studies are included in this curve. Both

depth of penetration and standoff distance are expressed in terms of charge diameters. In confirmation of generally accepted theory a single curve represents the data adequately for standoff distances up to 4 or 5 charge diameters. At longer standoff distances other factors such as precision of manufacture, charge symmetry, etc., become increasingly important.

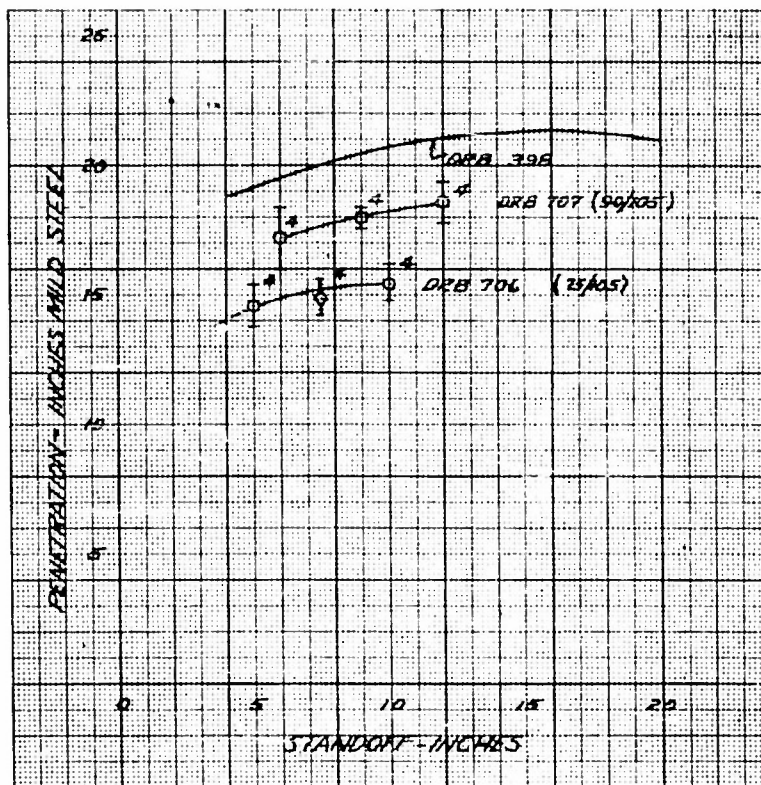


Fig. 31. Penetration Versus Standoff.
75 mm., 90 mm. and 105 mm. Cones Type Cones.

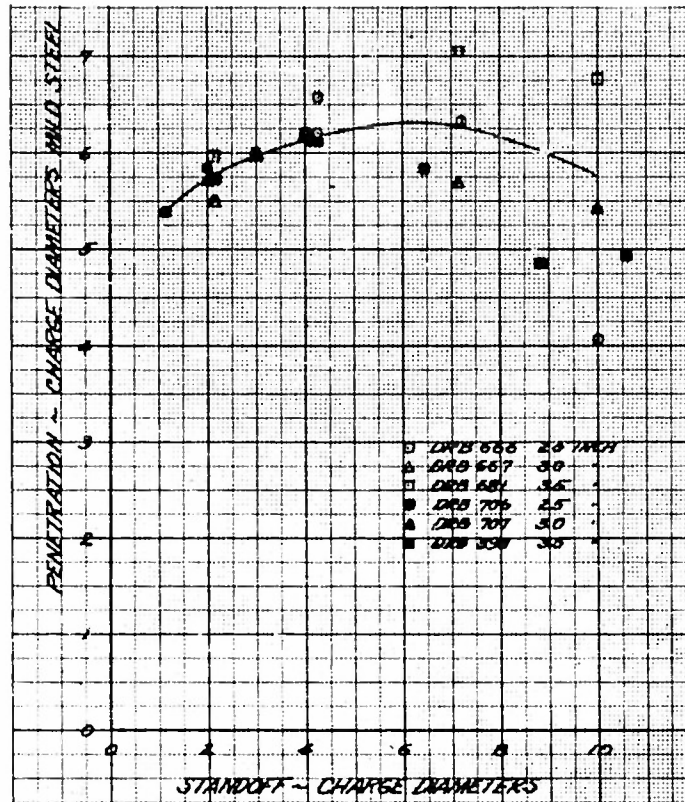


Fig. 32. Penetration Versus Standoff.
In Terms of Charge Diameters.

Scaling of the Rotational Effect

The penetration vs spin rate curve for the 90/105 modification of the DRB 398 type cone is shown in Fig. 33, Fig. 34 is a generalized plot in which the data for both sharp apex and spitback tube types of cones are presented. The data for a 1.63 inch diameter charge (Carnegie Institute of Technology, Report No. CIT-ORD-R18), though not scaled directly, are also shown for comparison. The penetration (P_ω) at any spin rate (ω radians/sec) is expressed as a fraction of the non rotated penetration (P_0) and is equal to $\frac{P_\omega}{P_0}$. The spin rate is expressed in terms of surface speed and is equal to ωr . As expected the effect of spin is

invariant under these transformations and the one curve represents the data for all of the charges quite well. There are, however, certain restrictions upon the general applicability of the relationship between spin rate and penetration shown in Fig. 34. The data were obtained using conical copper cones of such quality that without rotation they would penetrate approximately 6.0 charge diameters into mild steel target. Charges of poorer quality, or of other shapes or materials will lose their penetration at a different rate. Under these latter conditions the empirical relationship presented in the Supplement to the Penetration Studies beginning on page 38 of the Eleventh Progress Report is more nearly applicable.

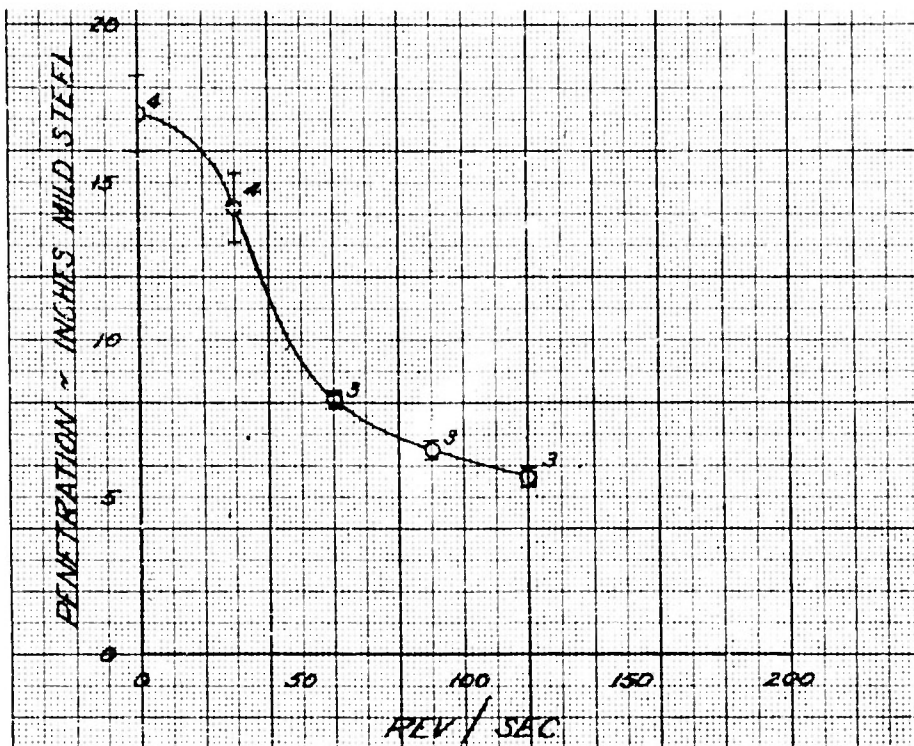


Fig. 33. Penetration Versus Rotation.
90/105 Scaled Counterpart of DRB398 Cone.

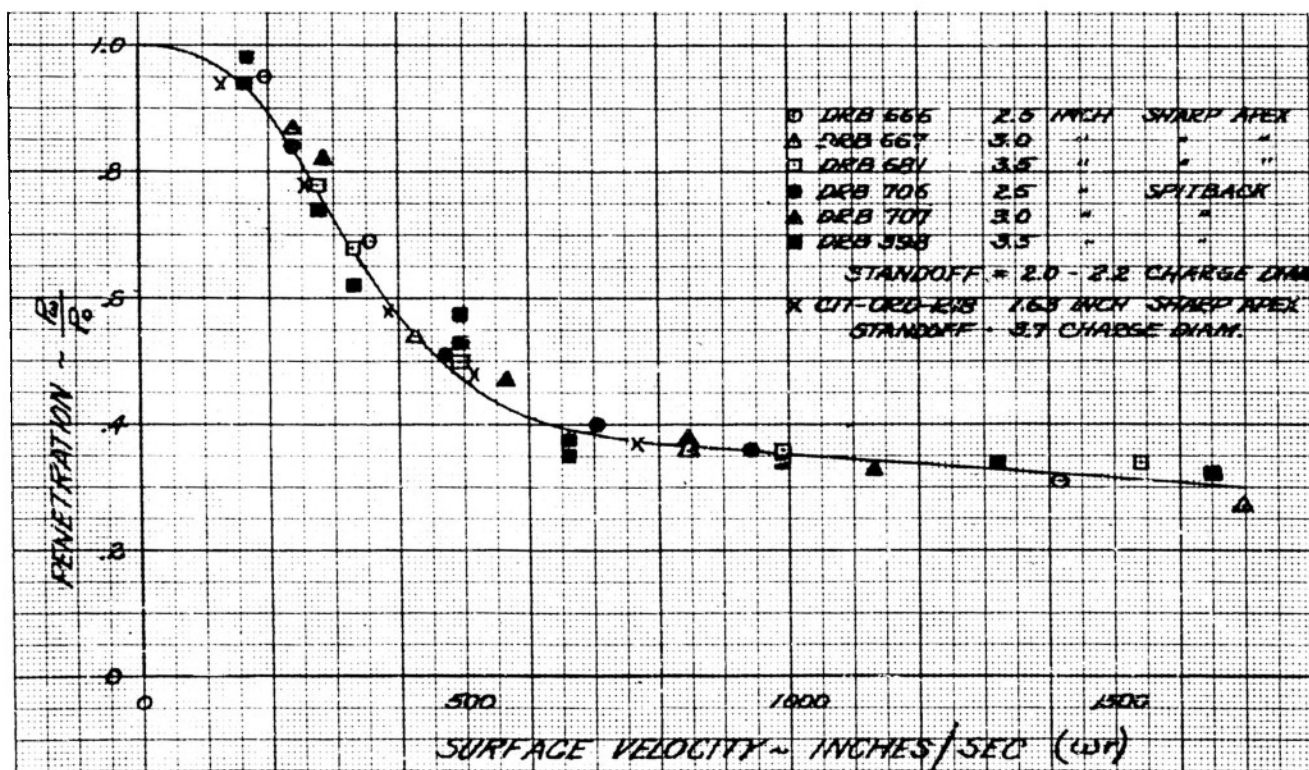


Fig. 34. Penetration Versus Surface Velocity.
2.5-in., 3.0-in., and 3.5-in. Sharp Apex and Spit-back Cones.

Penetration of DRB398 Cones At High Spin Rates

The penetration spin rate behavior of DRB398 copper cones has been well established between the spin rates of -25 rps and +30 rps. These data have been presented in Fig. 6 of the Twenty-Seventh Progress Report. The tests have been continued and data are now available for spin rates up to 250 rps. In this experiment the bases of the cones were modified

to provide a small clamping flange. Fig. 35 shows the cone (DRB398HW3 item 1) and Fig. 36 shows a DRC376 test assembly with No. 2 nose ring. The inspection data for these cones are shown in Table XVI and the penetration data are presented in Table XVII and Fig. 37. The dotted curve shown in Fig. 37 is for the earlier data. (Fig. 6 of the Twenty-Seventh Progress Report). The agreement is excellent.

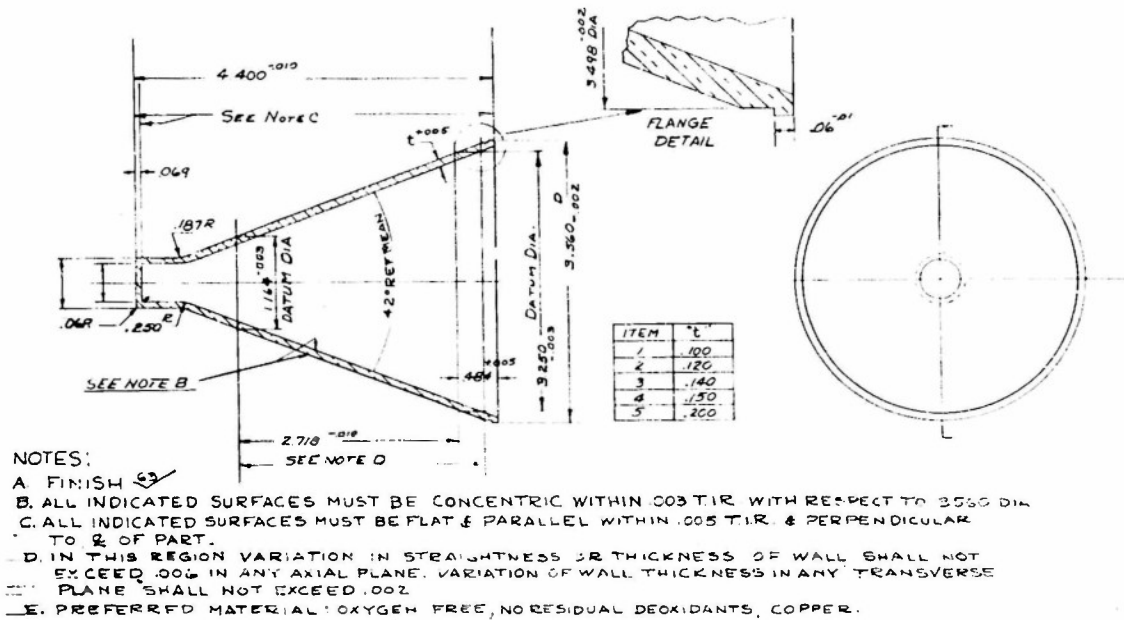


Fig. 35. DRB398 HW3 Item 1 Cone.

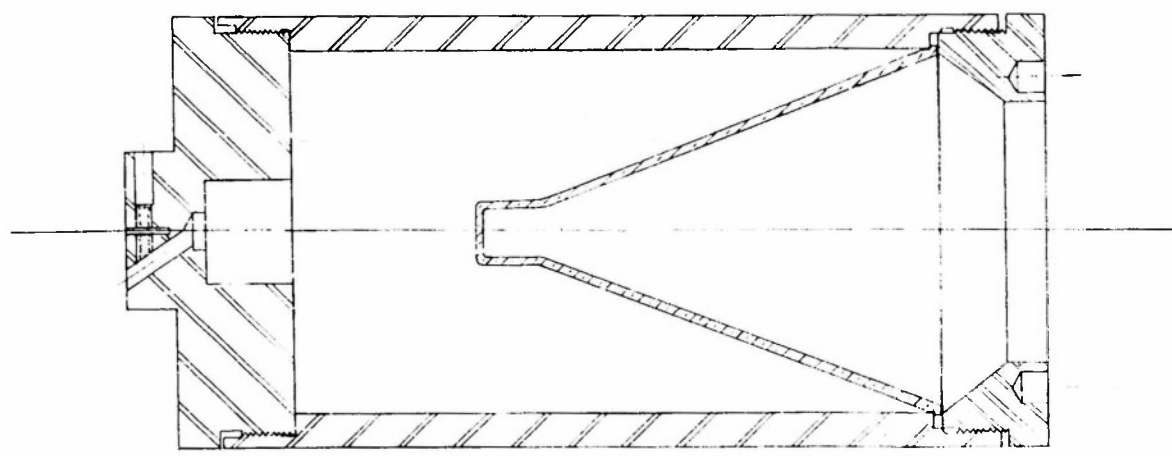


Fig. 36. DRC376 Penetration Test Assembly.
 DRB398 Cone.

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Table XVI
Inspection Data
DRB398 HW3 Item 1 Cones

Cane No.	Wall Thickness (inches)			Max. Wall Thickness Variation (in.)		Max. Wall Waviness (in.)		Concentricity		T. I. R. ^{1,2}
	Max.	Min.	Avg.	Transverse	Longitud.	O. D.	I. D.	Base Datum	Apex Datum	Cane Tip in Assembly
Specification DRB398 HW3 Item 1 Cones	.105	.100	---	.002	.006	.003	.003	.0030	.0030	.015 (Nominal)
R56	.103	.100	.1016	.002	.003	.002	.003	.002	.0010	.002
R57	.105	.102	.1040	.003	.003	.003	.004	.002	.0020	.003
R58	.104	.102	.1024	.002	.002	.003	.003	.002	.0020	.002
R59	.104	.101	.1021	.002	.002	.003	.002	.003	.0020	.003
R60	.103	.101	.1020	.002	.002	.002	.002	.002	.0010	.003
R61	.100	.096	.0988	.002	.004	.004	.004	.002	.0010	.004
R62	.103	.100	.1013	.002	.002	.003	.002	.002	.0020	.006
R63	.101	.099	.0999	.001	.002	.003	.002	.004	.0030	.002
R64	.103	.100	.1018	.002	.002	.002	.002	.004	.0040	.003
R65	.102	.100	.1014	.001	.001	.001	.003	.002	.0010	.002
R66	.102	.100	.1011	.002	.002	.002	.003	.003	.0020	.002
R67	.101	.098	.1000	.003	.002	.003	.003	.002	.0020	.003
R68	.104	.102	.1029	.002	.002	.002	.002	.002	.0030	.005
R69	.103	.100	.1014	.003	.001	.002	.001	.002	.0030	.010
R70	.104	.101	.1024	.003	.002	.002	.002	.001	.0020	.009
R71	.104	.102	.1029	.002	.002	.002	.002	.002	.0020	.002
R72	.102	.098	.1003	.004	.003	.002	.003	.002	.0020	.006
R73	.103	.101	.1016	.002	.002	.002	.002	.002	<.0010	.002
R74	.102	.100	.1009	.002	.002	.002	.002	.002	.0010	.006
R75	.104	.100	.1023	.004	.002	.003	.002	.001	.0020	.002
R76	.103	.101	.1019	.002	.002	.003	.002	.002	.0020	.007
R77	.107	.101	.1034	.005	.004	.002	.004	.003	.0040	.002
R78	.105	.102	.1034	.002	.002	.002	.002	.002	.0010	.003
R79	.103	.102	.1026	.001	.001	.002	.005	.002	.0020	.004
R80	.105	.102	.1036	.003	.002	.002	.003	.002	.0020	.006
R81	.105	.103	.1041	.002	.002	.002	.002	.001	.0020	.002
R82	.105	.102	.1038	.003	.002	.002	.002	.002	.0020	.004
R83	.102	.098	.1000	.004	.002	.003	.002	.002	.0010	.001
R84	.101	.100	.1006	.001	.001	.002	.002	.002	.0020	.008
R85	.101	.100	.1005	.001	.001	.002	.003	.003	.0030	.005
Avg.	.1031	.1005	.1018	.0023	.0021	.0023	.0025	.0022	.0020	.0040
Std. Dev.	±.0015	±.0016	±.0015	±.0010	±.0007	±.0006	±.0009	±.0007	±.0012	±.0023

Notes:

- Lower datum is .484 inch above base; upper datum is 3.302 inches above base.
- The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner's axis.

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Table XVII
Penetration Data
DRB398 HW3 Item 1 Cones

Round No.	Lb. CompB	RPS	Penetration (inches MS.)	Max. Spread (in.)	Std Deviation (in.)
R56	2.50	0	19.18		
R57	2.46	"	19.18		
R58	2.46	"	22.69		
			Avg. 20.35	3.51	±2.03
R59	2.46	15	19.81		
R60	2.46	"	20.25		
R61	2.46	"	20.06		
			Avg. 20.04	0.44	±0.22
R62	2.46	30	13.88		
R63	2.46	"	13.75		
R64	2.46	"	14.06		
			Avg. 13.90	0.31	±0.16
R65	2.46	45	9.69		
R66	2.46	"	9.86		
R67	2.46	"	9.44		
			Avg. 9.67	0.44	±0.22
R68	2.46	60	7.75		
R69	2.46	"	7.75		
R70	2.46	"	7.44		
			Avg. 7.65	0.31	±0.18
R71	2.46	90	6.56		
R72	2.46	"	7.25		
R73	2.48	"	7.00		
			Avg. 6.94	0.69	±0.35
R74	2.46	120	5.81		
R75	2.44	"	7.18		
R76	2.44	"	7.88		
			Avg. 6.96	2.07	±0.85
R77	2.46	150	7.06		
R78	2.44	"	6.94		
R79	2.46	"	5.81		
			Avg. 6.60	1.25	±0.69
R80	2.44	180	4.81		
R81	2.46	"	4.56		
R82	2.46	"	4.31		
			Avg. 4.56	0.50	±0.25
R83	2.48	250	4.69		
R84	2.46	"	4.94		
R85	2.44	"	4.38		
			Avg. 4.67	0.56	±0.28

Notes:

- Cones were drawn DRB398 HW3 item 1 copper cones assembled in DRC376 test bodies, plugs and No. 2 nose rings.
- Loaded at Ravenna Arsenal, BAT Lot No. 34, with Composition B from Holston Lot No. 4-1197.
- Tested at Erie Ordnance Depot, mild steel target plate, 7.5 inch standoff.

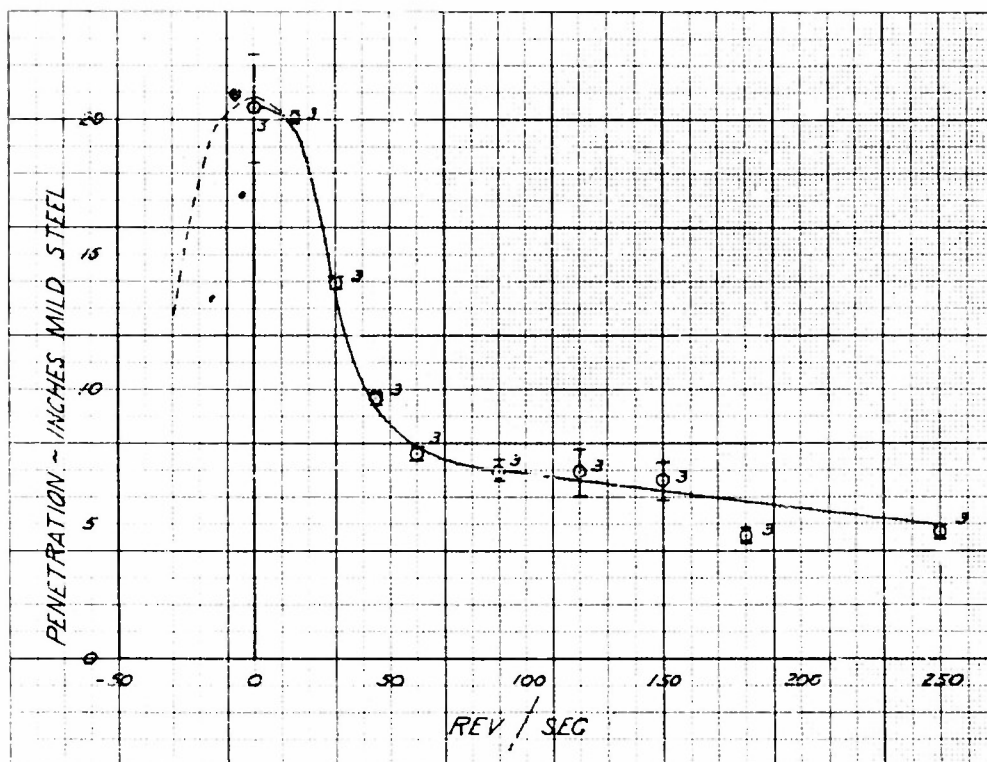


Fig. 37. Penetration Versus Rotation.
At High Spin Rates.

Behavior of Zinc Alloys (Zamak 3)

At the Quarterly Meeting of the Shaped Charge Committee held January 28, 1953, in the Ballistic Research Laboratory at Aberdeen Proving Ground, Mr. Guy Throner (Naval Ordnance Test Station, China Lake, Inyokern, California) reported 26 cast Zamak 5 cones having an apex angle of 42.5° and a 4% wall thickness penetrated 6.2 cone diameters into mild steel target. This level of performance is as good as is normally obtained with well made copper cones of optimum thickness and is well above that reported for "pure" zinc cones by workers at E. I. du Pont de Nemours and Co., (Report for March, 1943, Contract No. W-670-ORD-4331, Section VII). The du Pont cones were drawn from sheet at Frankford Arsenal and were 45° , 1.63-inch base diameter, .037-inch (2.27%) wall cones. The best average penetration observed was 5.5 inches (3.38 cone diameters) of mild steel.

Since the performance reported for zinc by NOTS was so good and since zinc may offer certain advantages over copper for use in shaped charge weapons, the penetration behavior of two zinc die casting alloys, U. S. Army, Specification No. 57-93-2A, Alloys A and B, are being determined in this laboratory. The tests for standoff penetration behavior of Alloy A (Zamak 3) cones has now been completed.

The cones employed in this program were made by machining rough sand castings to DRB398HW3 item 2 and 3 (Fig. 35). The cones were assembled in DRC376 test assemblies using No. 2 nose rings (Fig 36). The item 2 cones have a wall thickness of .120 in. the item 3 cones .140 in. but the outside dimensions of the two series of cones are alike.

The inspection data for these cones are shown in Table XVIII and the penetration data in Table XIX and in Fig. 38.

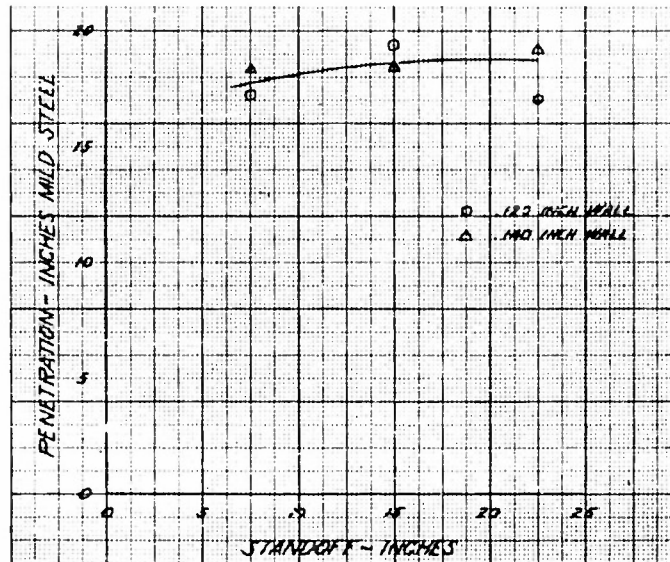


Fig. 38. Penetration Versus Standoff.

DRB398 HW3 Items 2 and 3.

At a standoff distance of 7.5 in., approximately the standoff available in projectiles using a cone 3.5 in. in diameter, the average penetration of these Zamak 3 cones is approximately 18 in. (5.2 charge diameters) compared to the 20.4 in. (5.8 charge diameters) observed with the copper cone controls (Table XVII).

Although there is no substantial difference in the average penetration of the .120-inch wall and .140-inch wall cones, the standard deviation of the .140-inch cones is uniformly less than for the .120-inch wall cones, suggesting that .140-in. is closer to the optimum wall thickness. The sand castings from which these cones were machined were not uniformly dense and some of the porous areas remained in the final cones. It is possible that the .120-inch wall cones would be as satisfactory as the heavier cones if the porosity was eliminated.

The charges used in this test and also those used by NOTS have reasonably heavy confinement while the du Pont charges were unconfined. In view of the difference in confinement, past experience with copper cones would indicate that the difference in wall thickness, 4% vs 2% is of the proper magnitude for satisfactory

performance.

It is typical of these cones that no slug remains in the cavity produced by the jet. Presumably because of the relatively low melting point of zinc the slug appears to have melted and splashed out between the target plates. There was also some evidence of target shock or damage beyond that normally experienced with copper cones. There is a steel box approximately two feet square and three feet deep buried beneath the penetration table. This box is covered by a 3/4-inch steel plate and the target plate is stacked on top of the steel cover. In these tests two rounds, FS1190 and FS1210, caused sufficient shock to overturn the cover and to dump the target plate into the pit. This effect has never been observed in the testing of other rounds.

The excellent performance of these Zamak 3 cones, the low cost and availability of zinc, the high production possibilities of die cast cones and the possibility for increased damage beyond the target invite a continuation of the study of the behavior of zinc cones. Zamak 5 cones are now being manufactured and their performance will be compared with the Zamak 3 cones.

C O N F I D E N T I A L

**Table XVIII
Inspection Data
Zamak No. 3 Cones**

Cone Number	Wall Thickness - in.			Max. Wall Thickness Variation - in.		Max. Wall Waviness (in.)		Concentricity in. T.I.R. ²		
	Max.	Min.	Avg.	Trans.	Long.	O.D.	I.D.	Base ¹ Datum	Apex Datum	Cone Tip in Ass'y.
A. DRB398 HW3 Item 2 Cones (.120-in. Wall)										
Specification										
DRB-398	.125	.120	---	.002	.006	.006	.006	.0030	.0030	.015 (Nominal)
HW3										
Item 2										
Zamak #3										
FS1183	.124	.121	.1226	.002	.002	.001	.002	.0050	.0030	.002
FS1184	.123	.116	.1209	.005	.007	.001	.007	.0030	.0040	.008
FS1185	.124	.117	.1216	.004	.006	.001	.006	.0040	.0080	.010
FS1186	.123	.118	.1206	.002	.004	.001	.005	.0040	.0040	.010
FS1187	.127	.118	.1229	.005	.006	.001	.006	.0030	.0030	.009
FS1188	.123	.117	.1210	.005	.005	.001	.005	.0020	.0030	.005
FS1189	.125	.123	.1244	.001	.002	.001	.002	.0040	.0030	.002
FS1190	.124	.121	.1226	.002	.002	.001	.002	.0030	.0030	.003
FS1191	.124	.122	.1230	.002	.001	.001	.003	.0020	.0010	.004
FS1192	.124	.123	.1233	.001	<.001	.001	.001	.0030	.0020	.005
FS1193	.125	.121	.1231	.002	.002	.001	.003	.0030	.0010	.003
FS1194	.124	.121	.1226	.001	.003	.001	.003	.0030	.0020	.005
FS1195	.122	.124	.1230	.001	.002	.001	.002	.0020	.0030	.009
FS1196	.125	.124	.1245	.001	<.001	.001	.001	.0040	.0050	.003
FS1197	.125	.120	.1211	.001	.002	.001	.003	.0030	.0010	.001
Avg.	.1239	.1204	.1225	.0023	.0029	.0010	.0034	.0032	.0031	.0053
Std.										
Dev.	±.0013	±.0025	±.0012	±.0016	±.0023	---	±.0019	±.0009	±.0019	±.0031
B. DRB398 HW3 Item 3 Cones (.140-in. Wall)										
Specification										
DRB398	.145	.140	---	.002	.006	.006	.006	.0030	.0030	.015 (Nominal)
HW3										
Item 3										
Zamak #3										
Cones										
FS1198	.146	.138	.1425	.004	.006	.001	.005	.0040	.0050	.001
FS1199	.147	.138	.1433	.003	.007	.001	.007	.0020	.0030	.006
FS1200	.150	.143	.1471	.005	.005	.001	.005	.0030	.0030	.004
FS1201	.146	.141	.1435	.001	.004	.001	.004	.0030	.0050	.003
FS1202	.147	.141	.1438	.004	.005	.001	.005	.0060	.0060	.005
FS1203	.144	.136	.1410	.005	.007	.001	.006	.0030	.0010	.003
FS1204	.148	.139	.1440	.006	.005	.001	.005	.0040	.0050	.005
FS1205	.149	.141	.1443	.008	.006	.001	.006	.0060	.0090	.005
FS1206	.147	.137	.1429	.006	.006	.001	.006	.0030	.0050	.009
FS1207	.145	.140	.1424	.002	.005	.001	.004	.0020	.0010	.011
FS1208	.144	.140	.1420	.001	.004	<.001	.003	.0030	.0020	.009
FS1209	.145	.139	.1425	.002	.006	.001	.006	.0030	.0030	.005
FS1210	.145	.138	.1429	.005	.006	.001	.006	.0020	.0030	.001
FS1211	.147	.139	.1434	.004	.005	.001	.005	.0070	.0060	.006
FS1212	.146	.139	.1430	.003	.006	.001	.006	.0020	.0030	.004
Avg.	.1464	.1393	.1432	.0039	.0055	.0010	.0053	.0035	.0039	.0051
Std.										
Dev.	±.0017	±.0018	±.0012	±.0015	±.0009	---	±.0019	±.0016	±.0022	±.0028
Notes:										
1. Lower datum is .484 inch above base; upper datum is 3.202 inches above base.										
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner's axis.										

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**Table XIX
Penetration Data
Zamak No. 3 Cones**

Round No.	Lb.CompB	Standoff (in.)	Penetration (inchesM.S)	Max.Spread (in.)	Std.Deviation (in.)
A. DRB398 HW3 Item 2 Cones (.120-in. Wall)					
FS1183	2.43	7.5	16.50		
FS1184	2.48	7.5	18.00		
FS1185	2.48	7.5	19.12		
FS1186	2.48	7.5	14.94		
FS1187	2.50	7.5	17.69		
			Avg. <u>17.25</u>	4.18	±1.59
FS1188	2.48	15.0	22.18		
FS1189	2.48	15.0	16.18		
FS1190	2.50	15.0	19.88		
FS1191	2.50	15.0	22.18		
FS1192	2.48	15.0	16.62		
			Avg. <u>19.41</u>	6.00	±2.91
FS1193	2.46	22.5	20.00		
FS1194	2.48	22.5	20.50		
FS1195	2.50	22.5	16.06		
FS1196	2.48	22.5	14.25		
FS1197	2.48	22.5	14.25		
			Avg. <u>17.01</u>	6.25	±3.05
B. DRB398 HW3 Item 3 Cones (.140-in. Wall)					
FS1198	2.48	7.5	19.38		
FS1199	2.48	7.5	17.69		
FS1200	2.46	7.5	18.81		
FS1201	2.48	7.5	17.31		
FS1202	2.48	7.5	18.88		
			Avg. <u>18.41</u>	2.07	±.87
FS1203	2.48	15.0	15.25		
FS1204	2.46	15.0	18.94		
FS1205	2.48	15.0	21.12		
FS1206	2.46	15.0	19.25		
FS1207	2.48	15.0	18.12		
			Avg. <u>18.54</u>	5.87	±2.14
FS1208	2.48	22.5	19.12		
FS1209	2.48	22.5	19.12		
FS1210	2.48	22.5	19.18		
FS1211	2.50	22.5	19.31		
FS1212	2.48	22.5	19.38		
			Avg. <u>19.22</u>	0.26	±.12
Notes:					
1. Cones were assembled in DRC376 test bodies, plugs and No. 2 nose rings.					
2. Loaded at Ravenna Arsenal, BAT Lot No. 34 with Composition B from Holston Lot No. 4-1197.					
3. All were tested against mild steel target at zero rps at Erie Ordnance Depot.					
4. It is typical of these cones that no slug remained in the cavity. There was some evidence of increased target damage beyond that normally noted with copper cones. Rd. FS1210 lifted the stack of target plate and lifted a steel plate covering a pit below the table. The target plate then fell into the pit. This effect has not been experienced with other types of concs.					

Effect of Tee Configuration

The effect of interior tee design upon penetration has been reported in several earlier reports (Twenty-Sixth, Twenty-Seventh, Twenty-Ninth, Thirtieth and Thirty-Third). Additional experiments in this program have now been completed. It was shown in the Thirtieth Progress Report that the DRC314HW11 tee has only a very slight detrimental effect upon penetration. This tee has a large bore extending nearly to the nose end of the tee. This large bore reduces the weight of the tee and moves the C.G. of the projectile rearward. In an effort to determine the minimum length of .875-inch diameter counterbore required, two additional tees, DRC314HW18 and DRC314HW19, have been tested. They differ from DRC314HW11 only in the depth of counterbore. To obtain a direct comparison between flanged cones

and pressed in, or snap ring cones, some of both types are included in the present experiments.

Drawn copper cones (DRB398-7) were assembled in DRC376 test assemblies using nose rings and various tees. Fig. 39 shows the various tee modifications studied. Figs. 35 and 36 show the flange type cone (DRB398HW3 item 1) with nose ring No. 2, and Fig. 12 of the Thirty-Third Progress Report shows a typical assembly of the pressed-in type of cone (DRB398) with a No. 1 nose ring.

Inspection data for the DRB398-7 cones are shown in Table XX and for DRB398HW3 item 1 cones in Table XXI. Penetration data for the two series of cones are shown in Tables XXII and XXIII. The following tabulation summarizes the penetration of the various modifications.

	DRB398	DRB398HW3 item 1
Nose Ring	20.40	21.12
DRC314 (Standard tee)	16.10	17.36
DRC314 HW11 (bore extends 6.56 inches from base of cone)	20.19	19.36
DRC314 HW18 (" " 4.56 " " " " " ")	20.43	--
DRC314 HW19 (" " 2.56 " " " " " ")	19.97	--

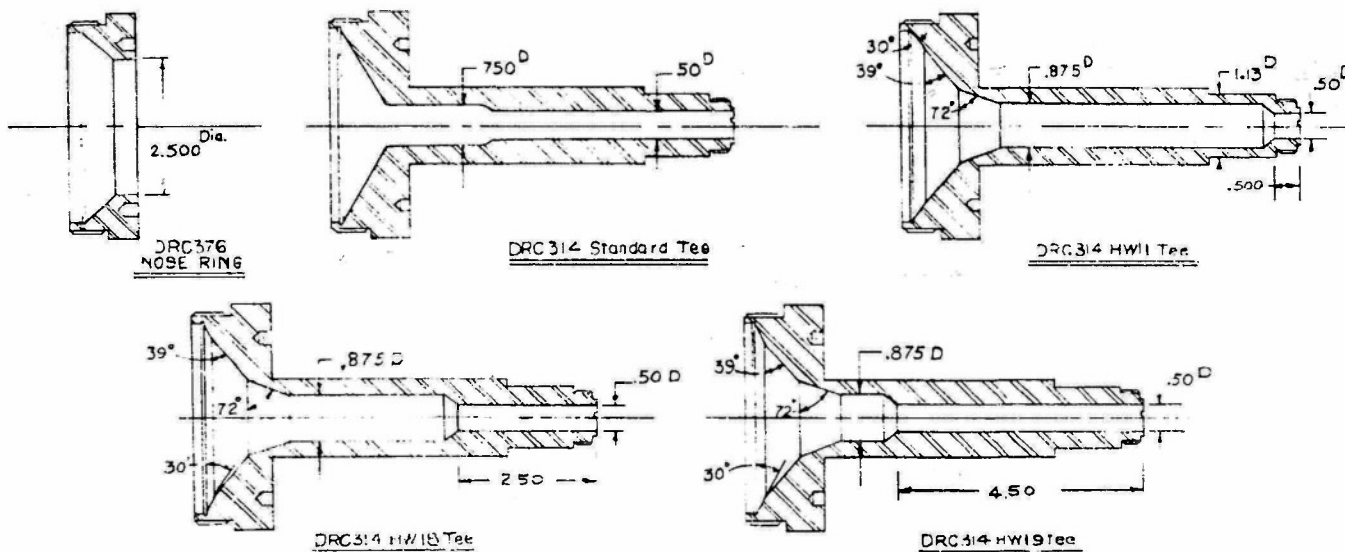


Fig. 39. Various Tee Modifications.
For Penetration Studies.

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It is evident that the deep counterbore of the DRC314HW11 tee is not necessary. Although the counterbore of DRC314HW19, which extends to a distance of 2.56 inches from the base, seems to offer some slight resistance to penetration in this test it should be noted that the penetration with this tee is as great as has been obtained using DRC314HW11 tees in several earlier tests. (Ex. Thirtieth and Thirty-Third Progress Reports). The changes in the basic DRC314 tee required for the HW19 modification are quite slight and cause only a small change in weight and C.G.

location. It is therefore recommended that any projectiles made using a tee or spike boom be so designed as to provide a free space in front of the cone at least as large as that provided by the DRC314 HW19 tee. As described in the Supplement to the Thirty-Fifth Progress Report there is some evidence that even the DRC 314HW11 tee causes a considerable reduction in penetration on dynamic firings against inclined plate. It would therefore be very desirable to provide as large a free space as possible in new projectile designs.

**Table XX
Inspection Data
DRB398-7 Cones**

Cone No.	Wall Thickness (inches)			Max. Wall Thickness Variation (inch)		Max. Wall Waviness (in.)		Concentricity T. I. R. ^{1,2}		
	Max.	Min.	Avg.	Transverse	Longitud.	O. D.	I. D.	Base Datum	Apex Datum	Spitback Tube in Assembly
Specification DRB398-7 Cones	.105	.100	-----	.002	.006	.006	.006	.0030	.0030	.015 (Nominal)
R443	.104	.101	.1021	.002	.001	.001	.001	.0010	.0020	.010
R444	.103	.101	.1020	.002	.001	.001	.002	.0020	.0030	.008
R445	.100	.099	.0998	.001	.001	.001	.002	.0020	.0020	.006
R446	.102	.099	.1011	.003	.003	.001	.002	.0020	.0030	.014
R447	.102	.100	.1013	.002	.002	.001	.001	.0030	.0020	.011
R448	.104	.103	.1033	.001	.001	.002	.002	.0030	.0040	.016
R449	.105	.104	.1046	.001	.001	.002	.002	.0020	.0030	.005
R450	.100	.098	.0993	.002	.002	.002	.002	.0030	.0020	.003
R451	.100	.098	.0993	.002	.002	.001	.001	.0020	.0050	.006
R452	.105	.103	.1041	.002	.001	.001	.002	.0030	.0030	.004
R453	.101	.099	.1001	.001	.001	.001	.001	.0020	.0020	.007
R454	.105	.103	.1048	.001	.001	.001	.001	.0030	.0020	.002
R455	.101	.099	.1001	.001	.001	.001	.002	.0010	.0020	.009
R456	.099	.097	.0978	.001	.001	.001	.002	.0010	.0020	.015
R457	.102	.100	.1008	.002	.002	.002	.002	.0020	.0020	.007
R458	.105	.103	.1043	.002	.001	.002	.002	.0040	.0050	.006
R459	.100	.097	.0980	.003	.003	.002	.002	.0020	.0020	.005
R460	.101	.100	.1003	.001	.001	.001	.001	.0020	.0030	.009
R461	.103	.102	.1026	.001	.001	.001	.001	.0020	.0030	.017
R462	.102	.100	.1008	.002	.002	.001	.001	.0010	.0010	.002
R463	.107	.105	.1059	.001	.001	.002	.001	.0020	.0020	.016
R464	.100	.099	.0999	.001	.001	.002	.001	.0020	.0030	.012
R465	.102	.101	.1012	.001	.001	.002	.001	.0020	.0020	.008
R466	.101	.099	.1003	.002	.002	.001	.002	.0010	.0050	.003
R467	.103	.102	.1024	.001	.001	.002	.002	.0020	.0030	.007
Avg.	.1023	.1003	.1014	.0016	.0014	.0014	.0016	.0021	.0027	.0083
Std.										
Dev.	±.0020	±.0022	±.0021	±.0007	±.0005	±.0005	±.0005	±.0007	±.0011	±.0044

Notes:

1. The lower datum is .484 inch above base; the upper datum is 3.202 inches above base.
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner's axis.

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**Table XXI
Inspection Data
DRB398 HW3 Item 1 Cones**

Cone No.	Wall Thickness (inches)			Max. Wall Thickness Variation (inch)		Max. Wall Waviness (inch)		Concentricity T. I. R.		
	Max.	Min.	Avg.	Transv.	Longitud.	O. D.	I. D.	Base Datum	Apex Datum	Cone Tip in Assembly
Specification DRB398 HW3 Item 1 cones.	.105	.100	---	.002	.006	.006	.006	.0030	.0030	.015(Nominal)
R1	.099	.098	.0983	.001	.001	.003	.002	.0020	.0020	.005
R2	.101	.100	.1003	.001	.001	.003	.003	.0030	.0010	.006
R3	.103	.102	.1021	.001	.001	.003	.003	.0020	.0030	.004
R4	.098	.100	.0995	.002	.002	.003	.003	.0020	.0020	.005
R5	.101	.100	.1006	.001	.001	.004	.003	.0030	.0020	.004
R6	.100	.100	.1000	<.001	<.001	.003	.003	.0020	.0010	.003
R7	.101	.100	.1008	.001	.001	.004	.003	.0030	.0030	.007
R8	.100	.100	.1000	<.001	<.001	.003	.002	.0020	.0010	.003
R9	.103	.102	.1029	.001	.001	.003	.003	.0020	.0030	.004
R10	.104	.103	.1031	.001	.001	.003	.003	.0030	.0030	.003
R11	.099	.097	.0979	.002	.001	.003	.003	.0010	.0020	.006
R12	.100	.099	.0995	.001	.001	.002	.002	.0020	.0030	.005
R13	.102	.099	.1003	.002	.003	.003	.003	.0020	.0020	.003
R14	.103	.102	.1028	.001	.001	.003	.003	.0020	.0030	.003
R15	.103	.102	.1028	.001	.001	.003	.003	.0010	.0020	.006
Average	.1011	.1003	.1008	.0010	.0010	.0031	.0028	.0021	.0022	.0045
Std. Dev.	±.0018	±.0017	±.0016	---	---	±.0005	±.0005	±.0007	±.0008	±.0011

Notes:
 1. The lower datum is .484 inch above base; the upper datum is 3.202 inches above base.
 2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity between the register plane and the liner's axis.

**Table XXII
Penetration Data
DRB398-7 Cones**

Round No.	Type Tee	Comp B (lbs.)	Penetration (inches M.S.)	Max. Spread (inches)	Standard Deviation (inches)
R443	No. 1 Nose Ring	2.58	20.81		
R444	" "	2.56	20.12		
R445	" "	2.58	21.12		
R446	" "	2.58	20.06		
R447	" "	2.56	19.94		
			Avg. 20.40	1.18	±.53
R448	DRC314	2.60	17.31		
R449	"	2.60	17.52		
R450	"	2.58	15.81		
R451	"	2.60	16.38		
R452	"	2.60	13.38		
			Avg. 16.10	4.24	±1.68
R453	DRC314HW11	2.62	19.25		
R454	"	2.60	21.81		
R455	"	2.60	19.31		
R456	"	2.60	19.69		
R457	"	2.60	20.88		
			Avg. 20.18	2.56	±1.12
R458	DRC314HW18	2.60	19.12		
R459	"	2.58	(12.06) ⁴		
R460	"	2.58	20.50		
R461	"	2.60	21.62		
R462	"	2.60	20.38		
			Avg. 20.41	2.50	±1.03
R463	DRC314HW19	2.60	22.31		
R464	"	2.60	21.16		
R465	"	2.60	20.18		
R466	"	2.60	18.50		
R467	"	2.62	17.69		
			Avg. 19.97	4.62	±1.89

Notes:
 1. Rounds were assembled in DRC376 test bodies, plugs and indicated tees and rings.
 2. Loaded at Ravenna Arsenal, BAT Lot No. 33 with Composition B from Holston Lot No. 4-1197.
 3. Tested at Eric Ordnance Depot at a standoff of 7.5 inches and at 0 rps.
 4. Jet went through side of tee. Not included in average.

Table XXIII
Penetration Data
DRB398 HW3 Item 1 Cones

Round No.	Tee	Comp B (lbs.)	Penetration (inches M.S.)	Max. Spread (inches)	Std Deviation (inches)
R1	No. 2 Nose Ring	2.46	21.69	1.25	±.56
R2	"	2.46	22.62		
R3	"	2.46	21.94		
R4	"	2.48	22.81		
R5	"	2.46	21.55		
			Avg. 21.12		
R6	DRC314	2.48	16.62	1.56	±.72
R7	"	2.50	17.81		
R8	"	2.50	18.12		
R9	"	2.50	16.56		
R10	"	2.48	17.69		
			Avg. 17.36		
R11	DRC314HW11	2.54	19.56	3.12	±1.32
R12	"	2.48	17.88		
R13	"	2.50	21.00		
R14	"	2.48	18.18		
R15	"	2.48	20.18		
			Avg. 19.36		

Notes:

1. Rounds were assembled in DRC376 test bodies and plugs. Nose ring and tees were as indicated.
2. Rounds were loaded at Ravenna Arsenal, BAT Lot No.33 with Composition B from Holston Lot No. 4-1197.
3. All rounds were tested at Erie Ordnance Depot at a standoff of 7.5 inches and at 0 rps.

Production Control
M344 (T119E11) Projectiles

Ten M344 (T119E11) prototype projectiles were withdrawn from production and prepared for static penetration tests by replacing the fin and chamber assembly with a DRB861 base plug. Fig. 40 shows the assembly as tested. These assemblies contained DRB398-9 cones, Fig. 41, which

included all latest modifications to the cone. The rounds were fired without rotation against mild steel target at a standoff 1/8 in. longer than that provided by the ogive and cap (9.35 in. from cone base to target). The penetration data are shown in Table XXIV. The average penetration of 20.56 in. indicates normal performance for this cone at the indicated standoff distance.

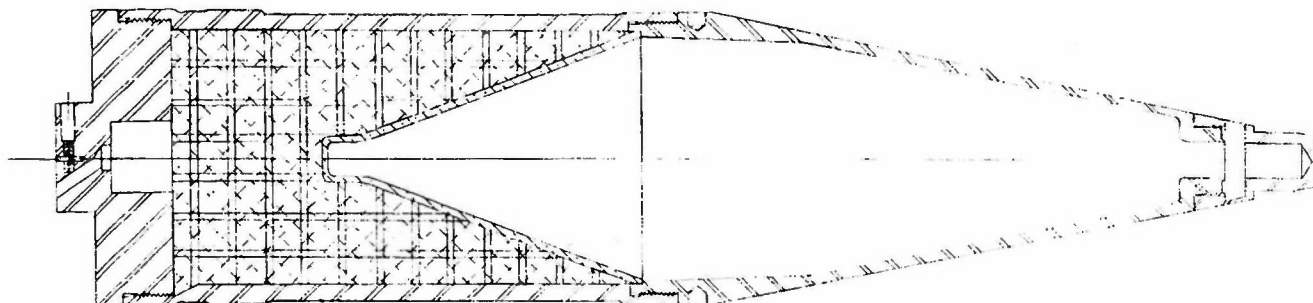


Fig. 40. Static Penetration Round.
T119 Projectile Type.

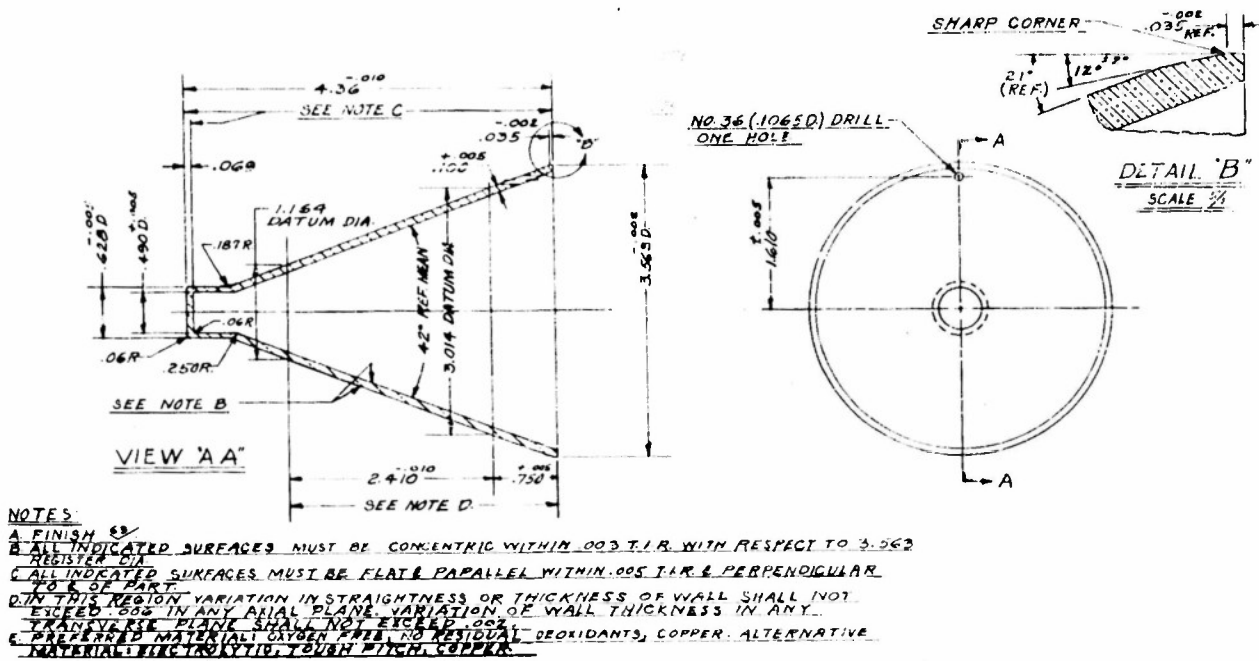


Fig. 41. DRB398-9 Conical Liner.
 Used in T119 Test Assemblies.

Table XXIV
Penetration Data
 M344 (T119E11) Production Control

Round No.	Lb. Comp B	Penetration (inches M.S)	Max. Spread (in.)	Std. Dev. (in.)	Concentricity T.I.R.	
					Cone Apex	Ogive Tip
X777	2.88	21.56			.002	.007
X778	2.88	20.00			.004	.025
X779	2.90	20.50			.005	.007
X780	2.90	18.62			.005	.013
X781	2.88	20.06			.005	.008
X782	2.88	20.44			.005	.003
X783	2.88	21.81			.010	.013
X784	2.88	20.38			.003	.011
X785	2.90	21.06			.006	.008
X786	2.88	21.12			.007	.016
		Avg. 20.56	3.19	±0.91		

Notes:

1. Rounds consist of DRB861 base plugs, DRC497 bodies, DRC342 ogives, DRA699 caps and DRB398-9 copper cones.
2. Loaded at Ravenna Arsenal, BAT Lot No. 33 with Composition B from Holston Lot No. 4-1197.
3. Tested against mild steel target plate at Erie Ordnance Depot using a standoff distance of 1/8" from the nose cap to target (9.35 inches from cone base to target) 0 rps.

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Future Program

1. Cones made of Zamak 5 and aluminum are to be tested for penetration behavior. Penetrations approaching those of copper cones have been obtained for certain aluminum and zinc alloys.

2. Composite Cone Study

A series of tests of bimetal cones with aluminum liners and copper shells are being manufactured for testing.

a. .080-inch thick copper shell and .020 and .040-inch aluminum insert (24S-T4).

b. .100-inch thick copper shell and .020 and .040-inch aluminum insert (24S-T4).

c. Same as (a) and (b) but using 2S-F aluminum instead of 24S-T4.

d. Same as (b) but using two stamped 2S inserts in each cone.

e. Same as (b) except aluminum is sprayed (metalized) into inside of cone and then machined to final dimensions.

3. Evaluation of Cones made by "Spinning".

Forty-two copper cones manufactured by a spinning process will be tested for penetration behavior and compared with cones made by other methods. These cones are P83580Al cones designed for use in the 90mm T108E40 projectile.

4. Evaluation of Cones Made by Electroforming

A series of DRB681 copper cones made by an electroforming method are being manufactured for comparison with machined cones.

5. Effect of T119E11 Body Length Upon Penetration

A new T119 type projectile with a short body is being manufactured for test. The penetration performance of this projectile is to be compared with the T119E11 and the standard penetration assembly.

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FUZES

T267E14 Type Base Element

The last reported test firing of the T267E14 fuze (Thirty-Sixth Progress Report, page 38) was satisfactory for super-quick function but unsatisfactory for delay function. A modification was shown which improved the functioning of the delay explosive train in air gun tests (Fig. 33, Thirty-Sixth Progress Report).

Ten fuzes with this modification were prepared and fired at Erie Ordnance Depot. All ten fuzes were set delay. A 4-inch wood screen at 200 yards was the target. Eight fuzes functioned satisfactorily. It was discovered later that the tetryl pellet had been omitted from one base element and it is presumed that this accounts for one of the two fuze failures. The firing record is given in Table XXV.

Air gun tests were conducted on the inertia portion of the T267E14 fuze. Fig. 42 shows the g's required to function the inertia element for four different impact media. The dense material stops the projectile so quickly that deceleration is completed before the inertia element has completed its action. Therefore, the inertia element must have sufficient kinetic energy, when deceleration ceases,

to complete its travel. In the lighter media the deceleration lasts longer and impulse time is sufficient to cause functioning. Since graze impact falls into this latter class it appears that graze functioning of the T267E14 will occur with approximately 200 g's deceleration providing the deceleration time is sufficiently long.

T223E2 Fuze

Fourteen T223E2 fuzes (Twenty-Fifth, Twenty-Sixth, Twenty-Eighth and Thirty-Second Progress Reports) were tested at Erie Ordnance Depot. The firing record appears in Table XXVI. Seven each of two types, varying only in the position of the center of gravity of the rotor, and therefore in arming time, were tested. Four of the fourteen functioned.

Because of consistently poor results, difficulties in assembly, and the present lack of interest in the T138E57 projectile, no further development of this fuze is planned.

Time Fuze

Pilot models of the Firestone time fuze (Fig. 14, Thirty-Third Progress Report) are currently being fabricated.

Future Program

1. Fire T267E14 base elements for graze functioning at Aberdeen Proving Ground.

2. Manufacture and test 100 T267 fuzes incorporating crystal shorting switches.

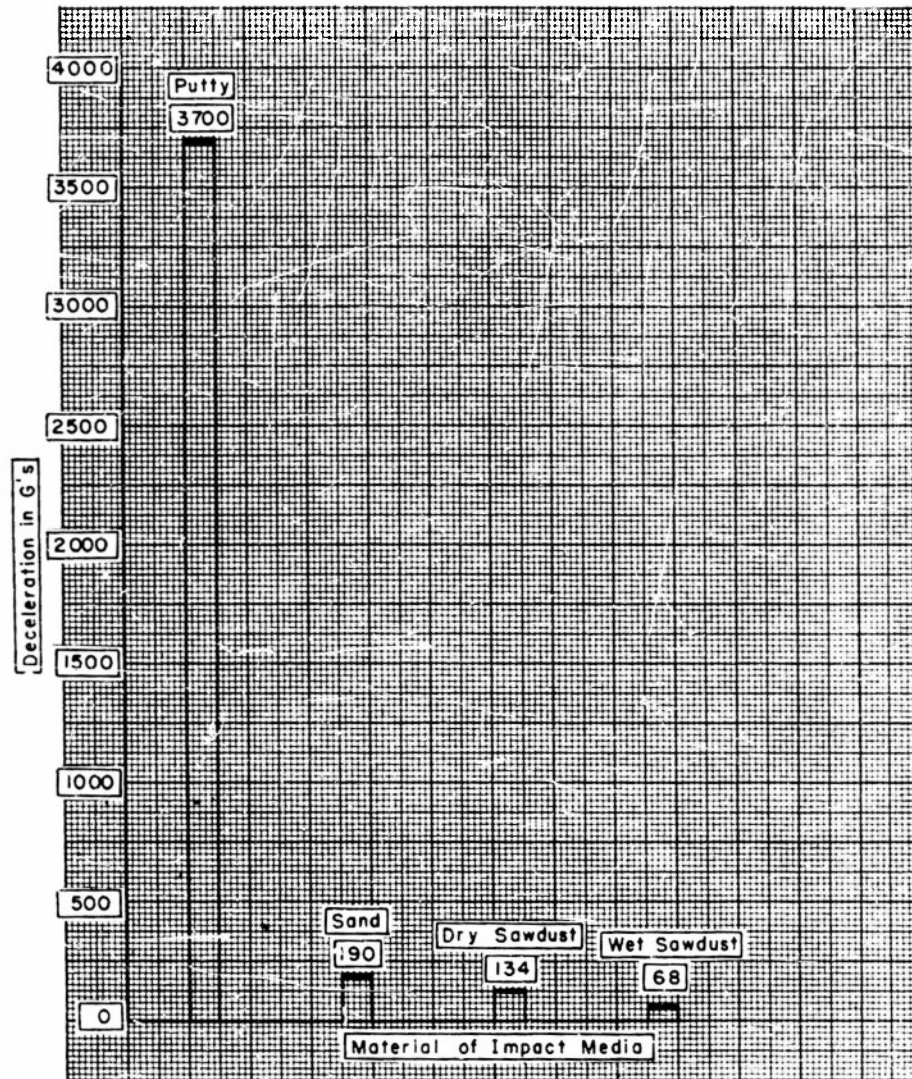


Fig. 42. Deceleration Versus Impact Media.

**Table XXV
Firing Record
To Test T267 Fuze**

Purpose of Test To Test Fuze T-267E14
Date July 31, 1953

TEST GUN

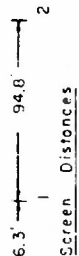
Model T-37E3
Type 12.5mm. Rec. Rifle
Serial No. 28
Chamber 22-C-209-D
Bushings (Went) D-370-6
Tube 22-B-335-B, 1-200 Twist
Sighting Equipment M17 model 270mm Telescope
Mount Provisional
Type 208 10/100/100
Constant 208 10/100/100

PROJECTILE

Model T138
Type E57
Weight 12.2 lb. (Nom.)
G.G. Location ---
Boresight Dia 4/32 ---

MISCELLANEOUS DATA

Range four inch burning screen of 200 yd.
Propellant Type M8 MP Web .033 Weight 76.14 oz.
Lot No. PAC 30239
Primer M57
Shell Case T-12E1
Liner 7-6
Temperatures:
Magazine Max 20° Min 70° Present 70°
Loading Room 80° Ambient 85°



Round No.	Proj. No.	Proj. Weight (lb.)	Powder Charge (lb-oz)	Fuze No.	Recoil (in.)	Muzzle Velocity ft/sec		Elev (mils)	Azimuth (mils)	Position of Hit		Corrected Position of Hit - mils		Recoil (in)	Observations
						Inst.	Actual			Vert	Horiz	Vert	Horiz		
5471	X 935	16.58	7 14	26	6 F	1728	1756								Functioned back (20') of target
5472	X 929	16.56	7 14	22	8 F	1711	1739								" " (20') "
5473	X 931	16.54	7 14	41	9 F	1698	1726								" " (140) "
5474	X 927	16.54	7 14	23	9 F	1710	1738								Failed to function
5475	X 930	16.60	7 14	34	9 F	1701	1729								Functioned back (20') of target
5476	X 926	16.57	7 14	21	10 F	1706	1734								" " (20) "
5477	X 933	16.54	7 14	32	10 F	1706	1734								Failed to function
5478	X 929	16.66	7 14	39	4 F	1721	1749								" " (20) "
5479	X 932	16.60	7 14	44	10 F	1716	1744								Failed to function
5480	X 934	16.60	7 14	27	10 F	1722	1750								" " (20) "

Notes: One of the fuses which failed to function may have been due to neglect on the part of the fuse loaders. The other failure could have been due to erratic impact.
The appearance of the burning screen indicated that every round went through at least 3 inches of wood. The front of the screen was composed of 2 x 4's which were interlaced for the profile of the projectile. The first layer of 1 inch boards beyond the 2 x 4's were somewhat shapely but it was apparent that the shooting was done only by the rounds creeping the profile in the 2 x 4's. The last layer of 1 inch boards was quite badly shattered. It was not possible in each case to determine whether or not the shattering was caused by the projectile which created the profile in the 2 x 4's immediately in front of the shattered section. It could have been caused by another projectile.

Proof Director A. Driver Signed P. Datta
Observers C. Brown
W. Hastings, A. Manohar

**Table XXVI
Range Data
To Test T223 Fuze**

Date of Test Aug 14, 1953 Purpose of Test Test T223 Fuze

PROJECTILE

Model T238
Type E-57M
Weight 17.4 lb (Nom)
C.G Location _____
Borelet Dia 4.32" ± .001
Special Features Reload with T223 Fuze

TEST GUN

Model T137E3
Type 205mm Recoilless
Serial No 1
Chamber 22-B-715-B
Bushing (Venti) 22-B-82-X-B
Tube 22-B-715-B (1,200 Tons)
Sighting Equipment M17 mount, Eikon Telescope
Mount Type T152E4 (Ground Mount)
Serial 13

MISCELLANEOUS DATA

Range Test in burning tunnel of 200 yds.
Propellant Type 700 MP Web 0.335 in. Weight 716 lbs.
Lot No PAE 30239
Primer T57
Shell Case T52E1
Liner T-6
Temperatures _____
Magazine Max 77°F Min 70°F Present 75°F
Loading Hum. 80% Ambient 97°F

Round No	Proj. No.	Proj. Weight (lb.)	Powder Charge (lb-oz)	Fuze No	Chamber Pressure (lb/sq in)	Muzzle Velocity (ft/sec)		Elev (mils)	Azimuth (mils)	Position of Hit		Corrected Position of Hit - mils		Recoil (in)	Observations
						Instr	Actual			Vert	Horiz	Vert	Horiz		
5574	X900	17.44	7 14	31											Functioned at target. Selenoid same as 5573
5575	X901	17.40	7 14	27											do
5576	X889	17.37	7 14	25											Did not function through previous hole.
5577	X899	17.34	7 14	2											do
5578	X896	17.44	7 14	38											do
5579	X893	17.42	7 14	24											do
5580	X897	17.40	7 14	23											do
5581	X890	17.38	7 14	34	Misfired, pin mark on primer case was turned in chamber. Fired on second try.										do
5582	X891	17.38	7 14	39	Misfire, see above.										do
5583	X028	17.40	7 14	19	Misfire, functioned after case was turned.										do
5584	X895	17.42	7 14	100											do
5585	X892	17.42	7 14	7											do
5586	X887	17.42	7 14	6											do
5587	X698	17.42	7 14	13											do

Notes: After Round 5583 was fired, the firing mechanism was adjusted and no subsequent misfires occurred. All rounds were fired for super-quick action. The firing system was composed of two sets of 2 x 2" and set horizontal, one set vertical. All rounds were fired as single rounds, projectiles being pushed into the caps at the firing line. On August 14, 1957, fuze no 23 was recovered. The fuze was broken off down with the bolts.

Prepared by E. Huffman Signed F. Dack
Observed by R. Dean
E. Birnes

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MANUFACTURING SUMMARY

In addition to the experimental material prepared for the research and development work under contracts DA-33-019-ORD-33 and DA-33-019-ORD-1202, described in preceding progress reports and in the preceding pages of this report, the following have been manufactured and shipped to the installations indicated.

Firestone's Defense Research Division, in shipping these items, transfers custody and control of the items to the receiving agencies. However, personnel of Defense Research Division will continue to collaborate with personnel of the other installations.

I. Cartridges, T119E11, Metal Parts Assembly, w/o Fuze T208E7

Prior to August 1, 1953	7695	All Shipments
August 10, 1953 (For Testing T278 Fuze)	125 (Live)	Picatinny Arsenal
August 20, 1953 (For Canadian Army Staff)	120 (Inert)	Picatinny Arsenal
August 24, 1953 (For Charge Development)	50 (Inert)	Aberdeen Proving Ground
Total	7980	

II. Rifles, T170E1 for ONTOS

Prior to July 1, 1953	30	Aberdeen Proving Ground
July 24, 1953	6	" " "
Aug. 10, 1953	6	" " "

III. Mounts, T173 and T26 Tripod for ONTOS

Prior to Aug. 1, 1953	1	Allis Chalmers
Aug. 4, 1953	3	" "

IV. BAT Systems less Jeep, T170E1 (M40) Rifle, T149E3 (M79) Mounts

Prior to July 1, 1953	5	Aberdeen Proving Ground
* July 13, 1953	1	Firestone
July 13, 1953	1	Aberdeen Proving Ground
July 31, 1953	3	Aberdeen Proving Ground
** Aug. 12, 1953	1	Firestone

* For firing effort (pistol grip) tests.

** For ammunition tests at Erie Ordnance Depot.

In addition to the above 2 T170E1 rifles were sent to Aberdeen Proving Ground on August 8, 1953 for Ammunition Acceptance Tests.

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Office, Chief of Ordnance		
1	1	ORDTS
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1	4	ORDTQ
1	5	ORDTB
1	6	ORDGU-SE
1	7	ORDTU
1	8	ORDIM
Arsenals		
10	9-18 incl.	Frankford
2	19-20	Picatinny
1	21	Springfield Armory
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Ordnance Districts		
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Aberdeen Proving Ground		
2	25-26	Ballistics Research Laboratory
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U. S. Navy		
1	42	Bureau of Navy Ordnance
2	43-44	Naval Ordnance Laboratory, White Oak
2	45-46	Naval Ordnance Test Station, Inyokern
1	47	Naval Proving Ground, Dahlgren

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