

UNCLASSIFIED

AD NUMBER	
AD026939	
CLASSIFICATION CHANGES	
TO:	unclassified
FROM:	confidential
LIMITATION CHANGES	
TO: Approved for public release; distribution is unlimited.	
FROM: Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; JAN 1954. Other requests shall be referred to Army Armament Research and Development Center, Dover, NJ.	
AUTHORITY	
ARRADCOM ltr, 4 Sep 1981; ARRADCOM ltr, 4 Sep 1981	

THIS PAGE IS UNCLASSIFIED

AD No. 26 989
ASTIA FILE COPY

CONFIDENTIAL
FORTY-SECOND
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

"This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18 U. S. C., Sections 793 and 794. The transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law."

COPY No. 52

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

JANUARY 1954

CONFIDENTIAL

54A A-17430

CONFIDENTIAL

**FORTY-SECOND
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**

JANUARY, 1954

CONFIDENTIAL

54A A-17430

INDEX

	Page
I. Abstract	1
II. The Weapon System	2
III. 90 MM. BAT Projectile	6
IV. T119 Projectile	16
V. Penetration Studies	23
VI. Fuzes	28
VII. Manufacturing Summary	33

CONFIDENTIAL

ABSTRACT

The Weapon System - The BAT 90mm test rifle No. 1 has been tested on the pendulum mount at pressures in excess of 115 percent of the rated maximum pressure. The test data are presented and discussed.

A charge development program was conducted for the BAT 90mm test rifle No. 1, as a part of a fin opening and spin test of the 90mm folding fin projectile. The test data are given.

The BAT 90mm Projectile - The theoretical estimation and experimental determination of a form factor for the BAT 90mm folding fin projectile are discussed.

A study of fin opening problems as related to this projectile was started and the test results are reported.

T119 Projectile - Two phases of projectile design, as related to this folding fin projectile, were investigated: (1) the effect of increasing the housing diameter to such a degree that it might serve, in effect, as a third bourrelet and perhaps minimize the shift of the projectile in the rifle tube, and (2) the effect of oversize fin hinge pin holes upon projectile accuracy. The data from both investigations are presented.

Penetration Studies - A program was conducted to study the effect of rotation upon standoff-penetration behavior. The test data are presented and the results are discussed.

Fuzes - A study of methods of improving the graze sensitivity of the T222 fuze assembly has continued. A "potted lucky" design was tested in this report period and test results are given.

A quantity of T267E14 fuzes are being assembled for test firings.

A device for producing prematures in electrically fuzed HEAT shell, as an aid in a general study of prematures, has been designed and will be tested.

The design of a point detonator assembly for the T317MT fuze is illustrated and discussed.

CONFIDENTIAL

THE WEAPON SYSTEM

Proof Acceptance Test, 90 mm. Test Rifle No. 1

The 90mm test rifle No. 1 has been proof tested on the pendulum mount at pressures in excess of 115% of the rated maximum pressure of 17,206 psia which was discussed in the Forty-First Progress Report, December, 1953. The test data are presented in Table I.

Round No. 6533 was a modified DRC669 proof slug weighing $11.5 \pm .1$ lb. (Fig. 1)

assembled with a modified T52 polyethylene case liner, M57 percussion primer, and 105mm cartridge case, T53E1, which had been necked down to 90mm size.

Rounds Nos. 6719 and 6720 were DRC 758 proof slugs weighing $12.0 \pm .1$ lb. (Fig. 2) assembled with modified T6 polyethylene case liners, M57 percussion primers, and 105mm Cartridge Cases, T53E1, which had been necked down to 90mm size.

Table I
Proof Acceptance Test
90 mm. Test Rifle No. 1

Round No.	Proj. Wgt. (lb.)	Charge Wt. (lb.-oz.) *	Chamber Press. (M3 Cu)(psi) **	Velocity Instr.(fps)	Recoil (lb-sec)	Flow Ring
6533	11.58	7-13	16,850	2375	9.9	20°
6719	11.95	7-13	18,600		4.2	0°
6720	11.95	7-11	17,550		2.8	0°

* Propellant RAD 16415, MP, M5, .040 - inch web

** Average of two gages

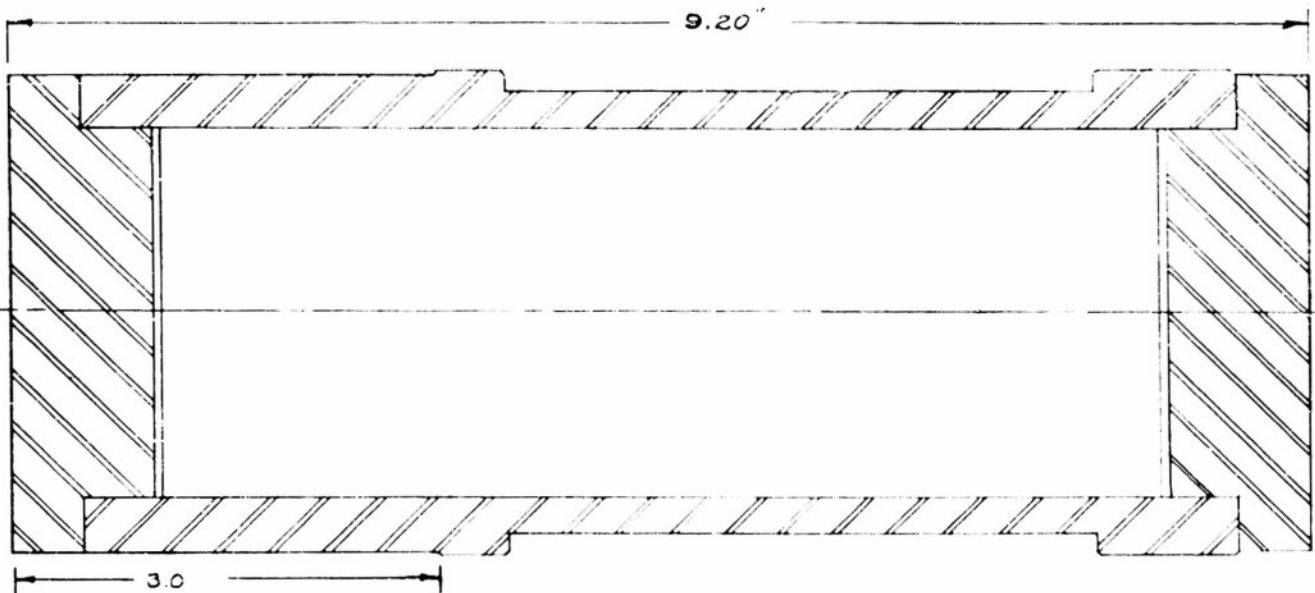


Fig. 1. Modified DRC669 Proof Slug.

CONFIDENTIAL

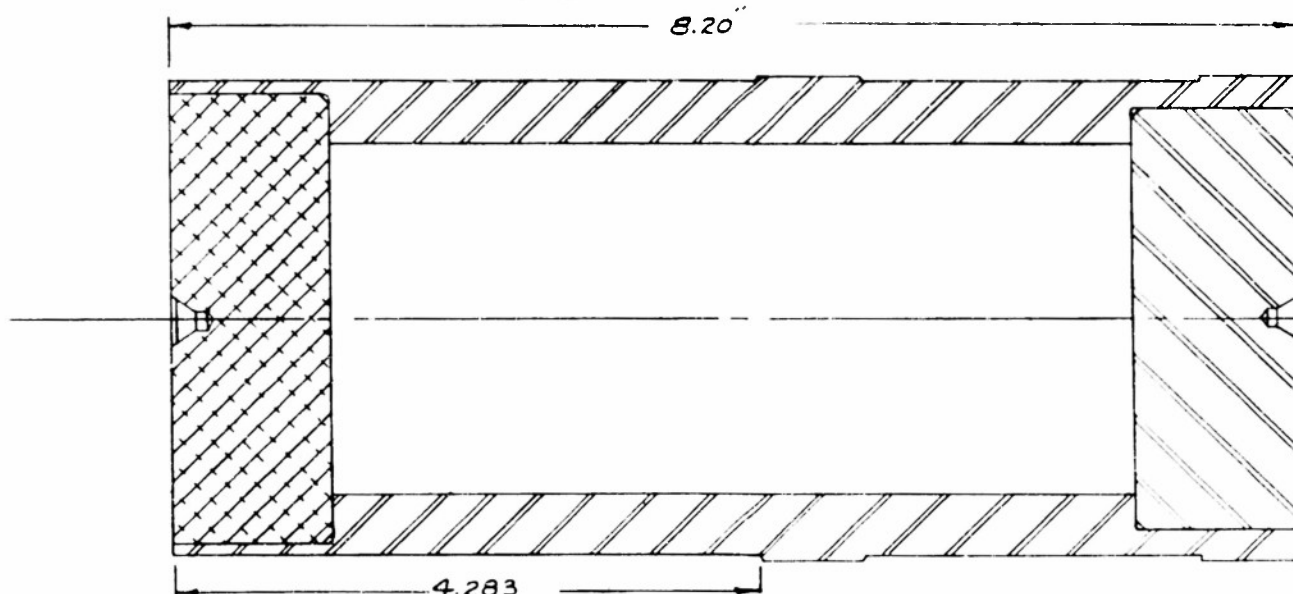


Fig. 2. 90 mm. Proof Slug.
Firestone Dwg. No. DRC758.

The higher pressures for rounds No. 6719 and 6720 are attributed to the greater projectile weight (11.95 lb. compared to 11.58 lb.) and also to the decrease in chamber volume of approximately 20 cu. in. (5%) resulting from the use of the 0° flow ring and the DRC758 proof slug. This combination occupies a greater volume of the chamber than the 20° flow ring and the modified DRC669 proof slug. The forward recoil of round No. 6533 is probably due to the 20° flow ring which offers less gas flow interference at the vent entrance section than the 0° flow ring. (Forty-First Progress Report).

Charge Development, 90 mm. Test Rifle No. 1

A charge development program was conducted as a part of a fin opening and

spin test of the 90mm folding fin projectile, using propellant RAD 16415, MP, M5, .040-inch web in the 90mm test rifle No. 1 with a 0° flow ring. The projectiles, with blunt noses and two rubber "O" ring obturators weighed $12.0 \pm .1$ lb. and were assembled with modified T6 polyethylene case liners, M57 percussion primers and 90mm cartridge cases (DRF80). The test data are shown in Table II.

Pressure-charge relationships are shown in Fig. 3 for the 90mm folding fin projectile and also for modified DRC 669 test slugs (data reported in Fig. 3, Thirty-Ninth Progress Report, October, 1953). The method of least squares was used to obtain the best straight line fit of the data. Projectile velocities were not obtained because of instrumentation difficulties.

Table II
Charge Development
90 mm. Test Rifle No. 1

Round No.	Projectile Wgt (lbs.)	Charge Wgt.* (lb. oz.)	Chamber Press. (M3 Cu)(psi)**	Recoil (lb.-sec)
6651	11.95	6-13	14,200	17.0
6652	12.13	6-13	14,350	12.7
6653	12.14	6-9	12,900	9.9
6654	11.95	6-8	11,800	14.2
6655	12.14	6-12	13,950	17.0

* Propellant RAD 16415, MP, M5, .040-inch web
** Average of two gages

CONFIDENTIAL

CONFIDENTIAL

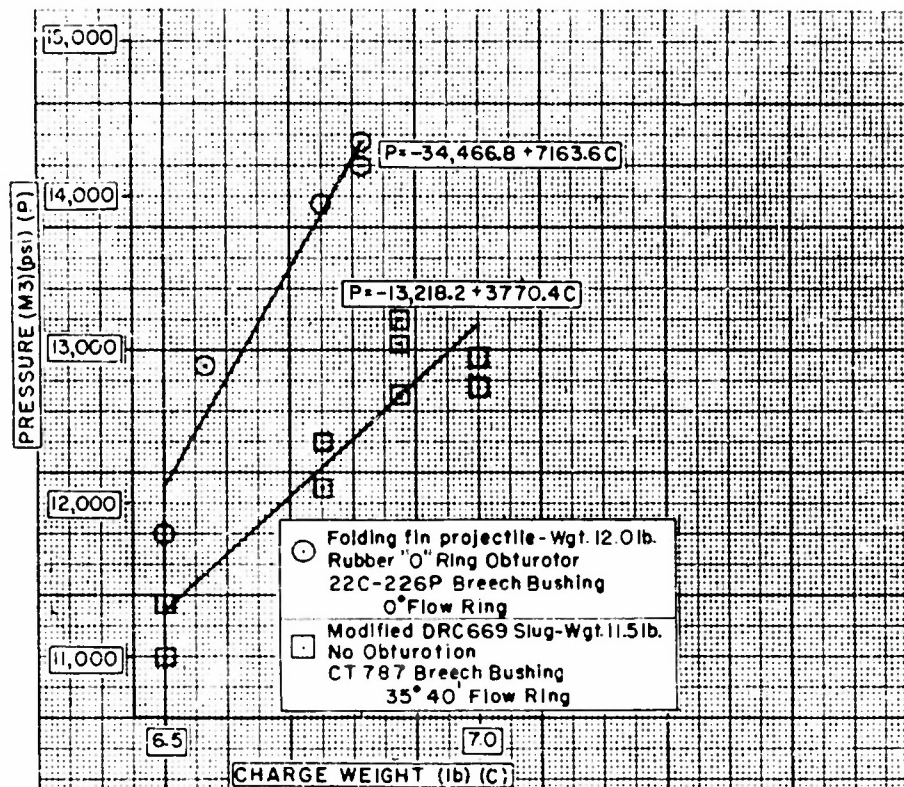


Fig. 3. Pressure - Charge Relationships.
 Propellant RAD16415, MP, M5, .040-inch Web.
 90 mm. Test Rifle No. 1.

The large difference in pressure-charge coefficients, 7163.6 psi/lb for the 90mm projectile compared to 3770.4 psi/lb for the proof slug (see Fig. 3), is probably due to the higher loading density, increased projectile weight (11.5 lb. to 12.0 lb.) and obturation of the 90mm projectile. The higher loading density results from a

decrease in chamber volume of about 30 cu. in. The chamber volume was decreased by the use of the 0° degree flow ring, the 90mm projectile, and the DRF 80 cartridge case all of which occupy more of the chamber volume than the 35°40' flow ring, proof slug and modified T53E1 cartridge case.

Future Program

1. Effect of Obturation of Proof Slug on Interior Ballistics of 90mm Test Rifle No. 1.

Proof slugs with annealed copper obturating bands (DRB-15-1031) Fig. 4, and with grooves for the rubber "O" ring obturator (DRB-15-1032) Fig. 5 have been designed. DRC758-1 proof slugs will be modified to produce the above designs. The proof slugs with copper obturating band, rubber "O" ring obturator, and no obturation will be fired to determine the

effect of the obturators upon the interior ballistics of the 90mm test rifle No. 1. The effects of variable loading density will be eliminated by using the same flow ring, cartridge case, and position of proof slug in the chamber throughout the experiment. A forcing cone will be placed in the 90mm test rifle in order to consistently position the test slugs with obturating bands.

2. Install piezo pressure stations in the 90mm test rifles No. 1 and No. 2.

CONFIDENTIAL

3. Obtain pressure data to determine a Piezo/M-3 Copper conversion factor for the 90mm test rifles.

4. Obtain pressure-time curves with various propellents in the 90mm test rifles.

5. Obtain pressure-time curves at low temperatures to assist in the design of the fin-opening mechanism of the 90mm folding fin projectile.

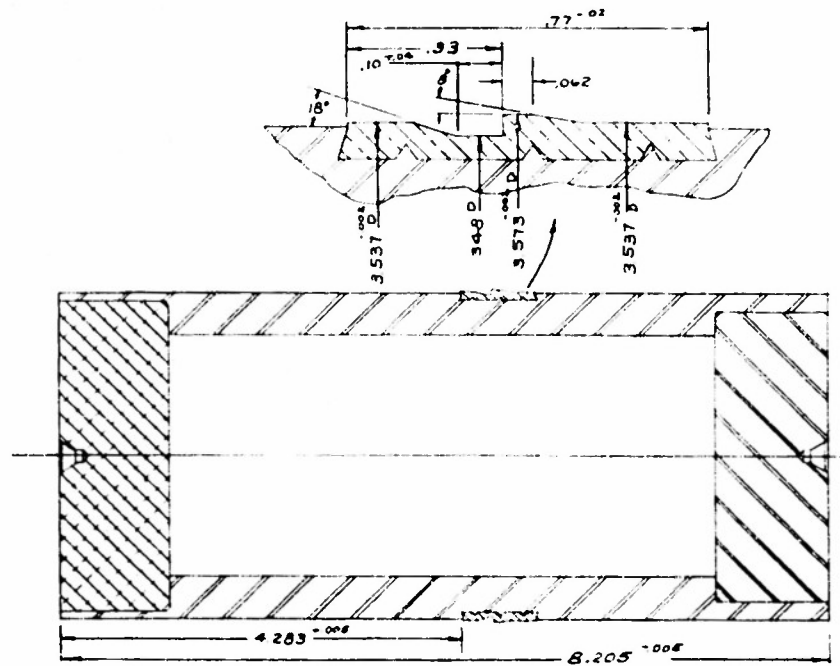


Fig. 4. 90 mm. Proof Slug (DRB-15-1031).
With Annealed Copper Obturating Bands.

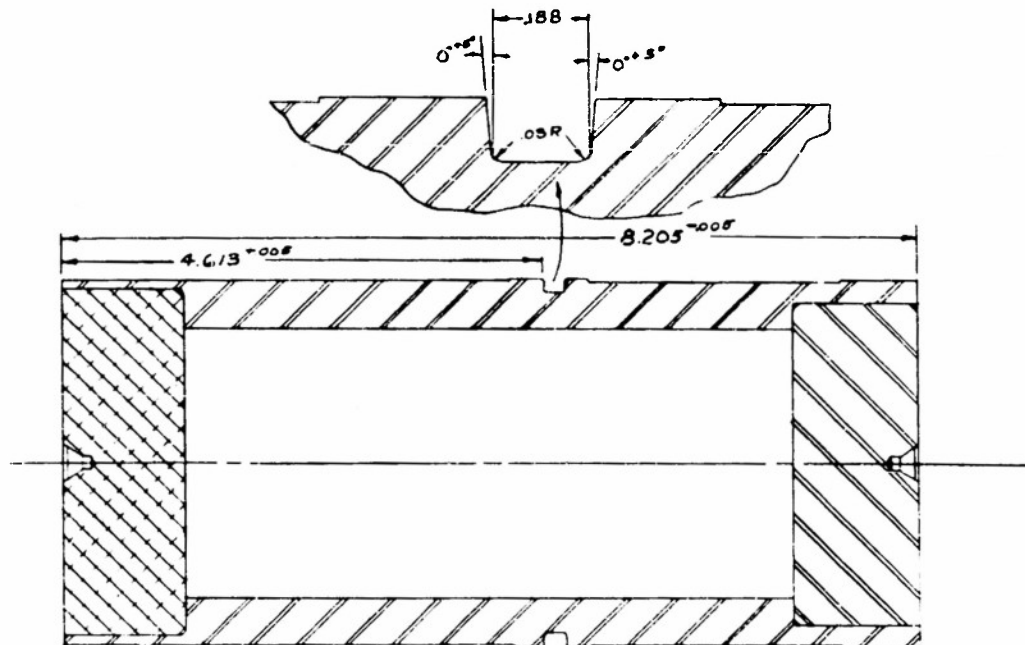


Fig. 5. 90 mm. Proof Slug (DRB-15-1032).
With Groove For Rubber "O" Ring Obturator.

CONFIDENTIAL

90 MM. BAT PROJECTILE

Determination Of The Form Factor For The BAT 90 mm. Folding Fin Projectile

Theoretical Estimation

The design of the folding fin projectile for the BAT 90mm rifle is based upon that of the T119 105mm folding fin projectile. The conical head of the 90mm projectile is approximately one-half caliber longer than the conical head of the T119.

A form factor ($i_{2.2}$) of 1.43 based on the $G_{2.2}$ drag function has been estimated for the 90mm folding fin projectile. The ballistic coefficient ($C_{2.2}$) for the 90mm projectile weighing 12.0 lb. was calculated to be .67 from the equation:

$$C_{2.2} = \frac{m}{i_{2.2} d^2} \quad (1)$$

where

$C_{2.2}$ = ballistic coefficient in
lb/sq in

m = mass of projectile in lb

d = diameter of projectile in inches

$i_{2.2}$ = form factor

The above form factor for the 90mm projectile was estimated from the form factor for the T119 105mm projectile and from experimental data relating head drag and head length in BRL report No. 240, "Drag On Conical Heads", by H. P. Hitchcock. The form factor, $i_{2.2} = 1.6187$, was determined for the T119 105mm projectile in the Twenty-Fourth Progress Report. The head length of the T119 projectile is 2.033 calibers as compared with 2.5 calibers for the 90mm projectile.

The following relations for the total drag coefficient were used to estimate the form factor.

$$K_D = K_{DH} + K_{DF} + K_{DB} \quad (2)$$

$$K_D = \frac{i_{2.2}}{\rho_0 U \frac{1}{G(u)_{2.2}}} \quad (3)$$

where

K_D = total drag coefficient

K_{DH} = head drag coefficient

K_{DF} = skin friction drag coefficient

K_{DB} = base drag coefficient

$i_{2.2}$ = form factor based on $G_{2.2}$
drag function

ρ_0 = standard air density (5.217×10^{-4}
lb/in²/ft).

U = velocity of projectile (fps)

$G(u)_{2.2}$ = drag function (lb/in²/sec)

The value of $K_{D_{2.033}}$ was calculated from equation (3) using the form factor of the T119 and Mach. No. 1.6 for which the experimental data were presented in BRL Report No. 240.

$K_{D_{2.033}} = .218$ for T119 with
2.033 caliber conical head

$K_{DH_{2.033}} = .078$ for 2.033 caliber head
from BRL Report No. 240

$K_{D_{2.033}} - K_{DH_{2.033}} = .140 = K_{DF} + K_{DB}$
from equation (2)

$K_{DH_{2.5}} = .053$ for 2.5 caliber head
from BRL Report No. 240

$\therefore K_{D_{2.5}} = .193$ for folding fin pro-
jectile with 2.5 caliber head

Table III
Firing Record
Proof Test and Ballistic Test, 90 mm. BAT Projectile

Purpose of Test Proof Test & Ballistic Test of BAT 90mm Folding Fin

PROJECTILE

Model 90mm 4702
Type 3000 Slug
Weight 2.14 Mm
CG Location Concrete Base Stake to Muzzle - 10' 10 1/2"
Sighting Equipment 17 E/100 Scope
Mount Proddium Proof Test and
Type 8.22 Ballistic Test
Constant 2.83 10.000
Date of Test January 10, 1954
Base Ordnance Dept.

TEST GUN

Model BAT 90mm
Type 90mm Recoilless
Serial No. 1
Chamber 8.22 1/2
Bushing (Vent) 0 1/2 Low Ring
Tube 8.22 1/2
Sighting Equipment 17 E/100 Scope
Mount Proddium Proof Test and
Type 8.22 Ballistic Test
Constant 2.83 10.000

MISCELLANEOUS DATA

Range Down Range 6 595 yd. Target
Propellant H5 MP Web .040 in. Weight Varies
Type H5 MP Web .040 in. Weight Varies
LOT No. RPD 16.415
Primer 7531 mod. 1
Shell Case 7531 mod. 1
Liner 7531 mod. 1
Temperatures
Magazine 75.5 Min 71.5 Present 71.5
Max 75.5 Min 71.5 Present 71.5
Loading Room 54.5 Ambient 21.5

Round No	Time of Flight (sec)	Proj Weight (lb.)	Powder Charge (lb. oz)	Wind Vel & Dir (mph degrees)	Chamber Pressure (lb./sq in)	Muzzle Velocity (ft. sec)		Total Elev (mils)	Azimuth (mils)	Position of Hit (inches)		Angle of Departure (mils)	Terminal Velocity (fps)	Retard Factor (lbs/ft)	Observations
						In	Actual			Vert	Horiz				
6719		11.95	7-13		18,900										DEC 669 Slug in Pendulum Mt
6720		11.95	7-11		18,900										DEC 669 Slug in Pendulum Mt
6721	59.05	11.95	6-12	10	18,900	2172	157	157	15.1	106	19 1/2	120		.171	Fin Opening not measurable
6722	58.22	11.95	6-12	10	18,900	2190	1695	1695	15.1	106	19 1/2	120	1690	.190	Fin Opening 8 1/2 in. Yaw 3 1/2
6723	121.5506	11.95	6-14	13	18,900	2220	1605	1605	15.1	106	19 1/2	120	1608	.170	Fin Opening 8 1/2 in. Yaw 3 1/2
6724	137.56233	11.95	6-14	12	18,900	2292	1605	1605	15.1	106	19 1/2	120	1609	.178	Fin Opening 9 1/2 in. Yaw 3 1/2
														.171	
Air Temp = 24.9 ± 0.1 °C															

Proof Director E. Hullman
Observers R. Hansen, L. Swoboda, V. Lucas, W. Loye
Signed M. Manofsky

CONFIDENTIAL

The value of $i_{2.2} = 1.43$ was calculated from equation (3) using the value of $K_{0.2.5} = .193$ at Mach No. 1.6. The value of the form factor was assumed to be independent of caliber size and projectile velocity.

Experimental Determination

A form factor ($i_{2.2} = 1.34$) and ballistic coefficient ($C_{2.2} = .71$) of the BAT 90mm folding fin projectile were calculated from time of flight, terminal velocity, initial velocity, and angle of departure data obtained on four projectiles fired at a 1000 yard range. The experimental data are presented in Table III.

The time of flight was measured at a range of 3008 ft. and the terminal velocity was measured as an average value between 2991 and 3008 ft.

The Siacci theory and the $G_{2.2}$ drag function were used to calculate the ballistic coefficient of the BAT 90mm projectile. The following equations were used:

$$C_x = \frac{\rho x}{(S - S_0)} \quad (4)$$

$$C_{\theta_0} = \frac{\rho \sin 2\theta_0}{\left[\frac{A - A_0}{S - S_0} - I_0 \right]} \quad (5)$$

$$C_t = \frac{\rho t}{S_{2C} \theta_0 (T - T_0)} \quad (6)$$

where

C = ballistic coefficient lb/sq in
 ρ = ratio of air density to standard

x = horizontal range (ft)

θ_0 = angle of departure (deg)

t = time of flight (sec)

S, S_0 = Siacci space function

A, A_0 = Siacci Altitude function

T, T_0 = Siacci Time function

I_0 = Siacci Inclination function

The subscript 0 denotes initial values.

Values of C were computed by substituting the proper values of experimental data and Siacci functions, determined from experimental data, in the above equations. Equations (4) and (6) were also used to determine a value of C by assuming various values of terminal velocity until the final values of the space and time functions were found which, along with the initial values, gave equal values of C ($C_x = C_t$) for both equations. The results of the calculations are presented in Table IV.

An average value of $C_{2.2} = .71$, with a standard deviation of $\pm .02$, was determined for rounds 6722-6724. The form factor, $i_{2.2} = 1.34$, was calculated from equation (1) using the average value of $C_{2.2} = .71$, $m = 11.95$, and $d = 3.537$ in.

The calculated and experimentally determined values for both form factor and ballistic coefficient agree well within the value of experimental error.

Table IV
Results Of Calculations

Round No.	C_x	C_{θ_0}	C_t	C_x, C_t	Terminal Velocity Calculated * (fps)	Terminal Velocity
6721	--	--	--	.75	1638.5	--
6722	.69	.69	.69	.72	1639.0	1619.0
6723	.72	.69	.71	.74	1680.0	1661.8
6724	.73	.70	.73	.72	1664.5	1669.9

*Values which made $C_x = C_t$

CONFIDENTIAL

Fin Opening Studies

In anticipation of fin opening problems which may arise during the development of the tail assembly of the BAT 90mm projectile, a fin opening study was planned similar to that followed in the T119 program. (See 40th Progress Report).

It has been established that fin-opening is dependent upon pressure, housing material, orifice diameter, shear ring thickness, and housing-stop interference. The housings of the first 50 BAT 90mm projectiles were made from 75S-T6 aluminum bar stock. An orifice diameter of .136 in. was calculated for a projectile chamber pressure of 6000 psi at the muzzle of the gun, and the shear ring thickness was set at $.030 \pm .005$ in. The housing-stop interference was held between .0075 and .0115 in.

A group of these projectiles was fired for accuracy and the data were reported in the Forty-First Progress Report. Inspection of the target showed that the projectiles had fin openings in excess of the designed spread of $9.2 \pm .2$ inches.

To determine the cause for the excessive opening, two projectiles, similar to the group mentioned above except that one had a housing-stop interference of .0165 inch, were fired through a series of yaw cards into a recovery box. The range data are shown in Table V. The projectile with the housing-stop interference of .0075 to .0115 in. had a fin spread greater than ten inches while the projectile

with the .0165 in. interference gave a normal fin opening.

These results indicate that an adjustment of the balance between orifice diameter and of the stop-housing interference was required. The orifice diameter was reduced to .113 in. from .136 in. and pistons with the .113 in. diameter orifice were assembled into five projectiles. The housing-stop interference was held at .016 in. The projectiles were fired through a series of yaw cards into a recovery box. The range data are presented in Table VI. Four gave normal fin opening and one gave a partial opening which was probably due to the low pressure.

Sixteen projectiles of this type were then fired for accuracy at an 18 ft. by 18 ft. target at 2000 yards. The range data are presented in Table VII. The first round hit the target and a total of nine hits were recorded. Probable errors of dispersion were not computed. Examination of the target impacts showed that the fins of five rounds had opened only partially. It is evident that a satisfactory balance of orifice diameter and interference was not attained.

It is planned to alter the fin design to enable it to absorb a wider range of opening stresses. Under conditions of excessive opening stress the fins have failed at the tooth form as shown in Fig. 6. The tooth form will be moved away from the end of the fin and an increase in thickness of the fin at the tooth form is also being considered.



Fig. 6.
Failure Of Fin Gear Tooth.

11

Center of Impact _____
Probable Error — Vertical _____
Probable Error — Horizontal _____

Table VII
Firing Record
Accuracy Of BAT 90 mm. Projectile
2,000-yard Range

Date of Test January 13, 1954
at Ft. Belvoir, Mo.

Purpose of Test BAT 90mm Accuracy at 2000 yds

PROJECTILE

Model BAT 90mm

Type 3.5 inch

Weight 35.5 lb

CS Location —

Routelet Dia 3.537 inch

Speco Features Office Dia 3.5 inch

Nominal housing stop interference 0.06 in

TEST GUN

Model BAT 90mm

Type 20mm Recoilless Rifle

Serial No —

Chamber 2.4 inch

Bushing (Vent) 0.5 Flow Ring

Tube 2.4 inch (1.1 inch)

Mount 7.52 E 7

MISCELLANEOUS DATA

Range 2000 yds Target

Propellant —

Type Ar 5 m.p. Web 0.40 in

Lot No 240 16 d 15

Primer MS 7

Shell Case 7.52 E model

Liner 7.52 modif

Temperatures

Magazine —

Max Temp Min 71°F Present 72°F

Loading Room 69°F Ambient 39°F

Round No	Time of Flight (sec)	Proj Weight (lb)	Proj No	Wind Vel B Dir mph degrees	Chamber Pressure (lb/sq in)	Muzzle Velocity (ft/sec)		Total Elev (mils)	Fin Pos (in)	Position of Hit (inches)		Yaw (in)	O Ring	Observations
						Instr	Actual			Vert	Horiz			
6776	11.95	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	Yes	Terminal velocity 1151 fps
6777	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	No	Terminal velocity 1151 fps
6778	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	Yes	Terminal velocity 1151 fps
6779	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	Yes	Missed Target
6780	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	Yes	Missed Target
6781	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	Yes	Missed Target
6782	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	No	Missed Target
6783	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	Yes	Missed Target
6784	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	No	Missed Target
6785	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	Yes	Missed Target
6786	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	No	Missed Target
6787	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	No	Missed Target
6788	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	Yes	Missed Target
6789	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	Unknown	Unknown
6790	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	Unknown	Unknown
6791	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	Unknown	Unknown
6792	11.92	32	24	170	2100	2200	2215	34	9.4 ± 0.4	7	5.6	Missed Target	No	Missed Target

* Program Director not present at loading

Centering handle of Spring 4314 presents proper setting of Runners Quadrant on Trunnion Pad.

Three mls sheet of target measured at 200 yds, 314, 315, and 316.

Two mls sheet of target at 200 yds and 314. Bottom of target to ground - 3 ft.

on 100 yds was not by shell case mouth in descending some of the rounds.

on nominal 100 opening 92 in

Signed M. Messersby

Proof Director E. Hoffman

Observers Dr. Miller & Lucas

W. Long, L. Swadlow, O. Miller

R. Fineman

CONFIDENTIAL

Spin Measurements

Spin measurements of BAT 90mm projectiles were included in the firing programs of Tables V and VI. Values of angular rotation versus distance were obtained from yaw card imprints for two rounds listed in Table V. The values were plotted and the points were connected

by smooth curves. The slopes of the plotted curves were measured at intervals of twenty feet and values of spin in revolutions per second were calculated. Table VIII lists these values and plots of spin versus distance are shown in Fig. 7. Measurements at points further down range are required to establish the peak spin rate.

Table VIII
Spin Versus Distance Down Range
BAT 90 mm. Projectile; Orifice Diameter, .136 in.
Fired From Smooth Bore Tube

Distance (feet)	Round 6546			Round 6547		
	$\frac{\Delta\phi}{\Delta Z}$ (°/ft.)	U (fps)	$\frac{\Delta\phi}{\Delta Z}$ (rps)	$\frac{\Delta\phi}{\Delta Z}$ (°/ft.)	U (fps)	$\frac{\Delta\phi}{\Delta Z}$ (rps)
40	.625	2084	3.62	.55	2085	3.19
60	.95	2078	5.48	.85	2079	4.91
80	1.175	2072	6.76	1.10	2073	6.33
100	1.40	2066	8.03	1.375	2067	7.89
120	1.625	2060	9.30	1.625	2061	9.30
140	1.8	2054	10.27	1.8	2055	10.28
160	1.85	2048	10.52	1.875	2049	10.67
180	1.875	2042	10.64	1.925	2043	10.92

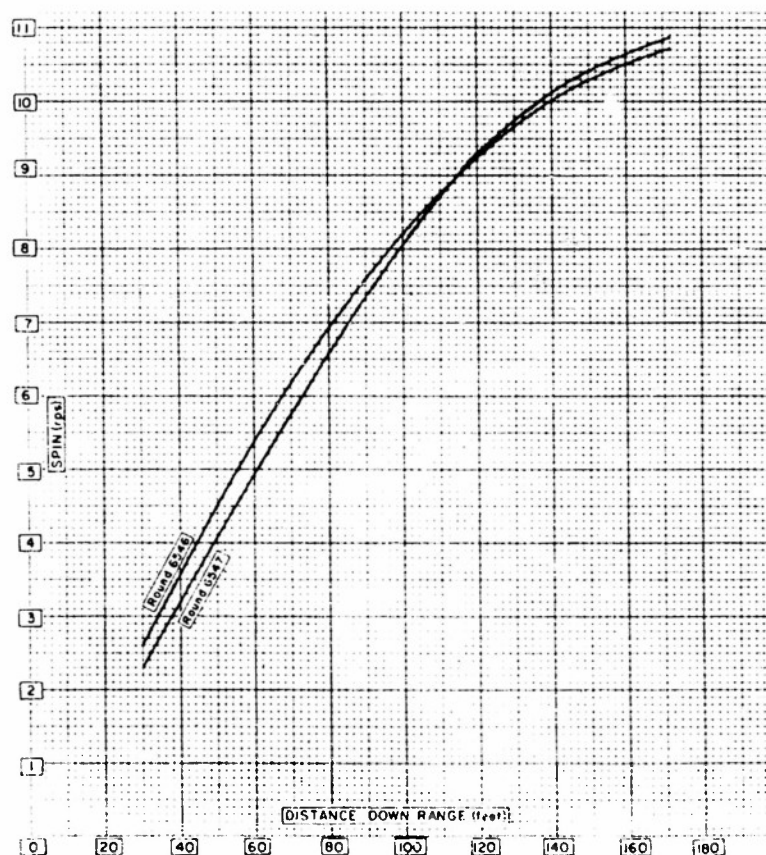


Fig. 7. Spin Versus Distance Down Range.
BAT 90 mm. Folding Fin Projectile.

CONFIDENTIAL

Values of angular rotation and distance for another five projectiles are given in Table IX. Since no projectile velocities were recorded on this program, it was not possible to compute projectile spin in revolutions per second. However, pro-

jectile spin in degrees per foot can be determined from plots of angular rotation versus distance. Projectile spins (deg/ft) versus distance down range are listed in Table X and plots of these values are shown in Fig. 8.

Table IX
Angular Rotation Versus Distance Down Range
BAT 90 mm. Projectile; Orifice Diameter, .113 in.
Fired From Smooth Bore Tube

Card No.	Distance (feet)	Rotation (degrees) ^a				
		Proj. 27	Proj. 28	Proj. 29	Proj. 30	Proj. 31
1	32.3	195	177	282	10	245
2	60.3	207	193	292.5	23.5	259
3	111.2	256	254	334	71	309.5
4	149.2	307	324	380	115.5	367
5	178.4	353	388	424	175	421

a. Angle in each case is measured clockwise from a horizontal reference line starting with Card 1. Multiples of 360° have been added as required.

Table X
Spin (Deg./Ft.) Versus Distance Down Range
BAT 90 mm. Projectile
Fired From Smooth Bore Tube

Distance (feet)	Spin (deg. / ft.)				
	Projectile Number				
	27	28	29	30	31
40	.38	.55	.30	.40	.43
60	.65	.83	.53	.58	.68
80	.88	1.13	.75	.80	.93
100	1.08	1.38	.95	1.00	1.15
120	1.28	1.68	1.15	1.30	1.4
140	1.45	1.98	1.33	1.55	1.6
160	1.55	2.15	1.48	1.80	1.8
180	1.625	2.43	1.65	1.95	1.98

CONFIDENTIAL

It should be noted that the designed cant on the BAT 90mm fin is 24.6 minutes, while the modified fins which were used in the above groups of projectiles had

a cant angle of 40 minutes. Fins with the proper cant will soon be available for test, and it is expected that they will provide a lower level of spin rate.

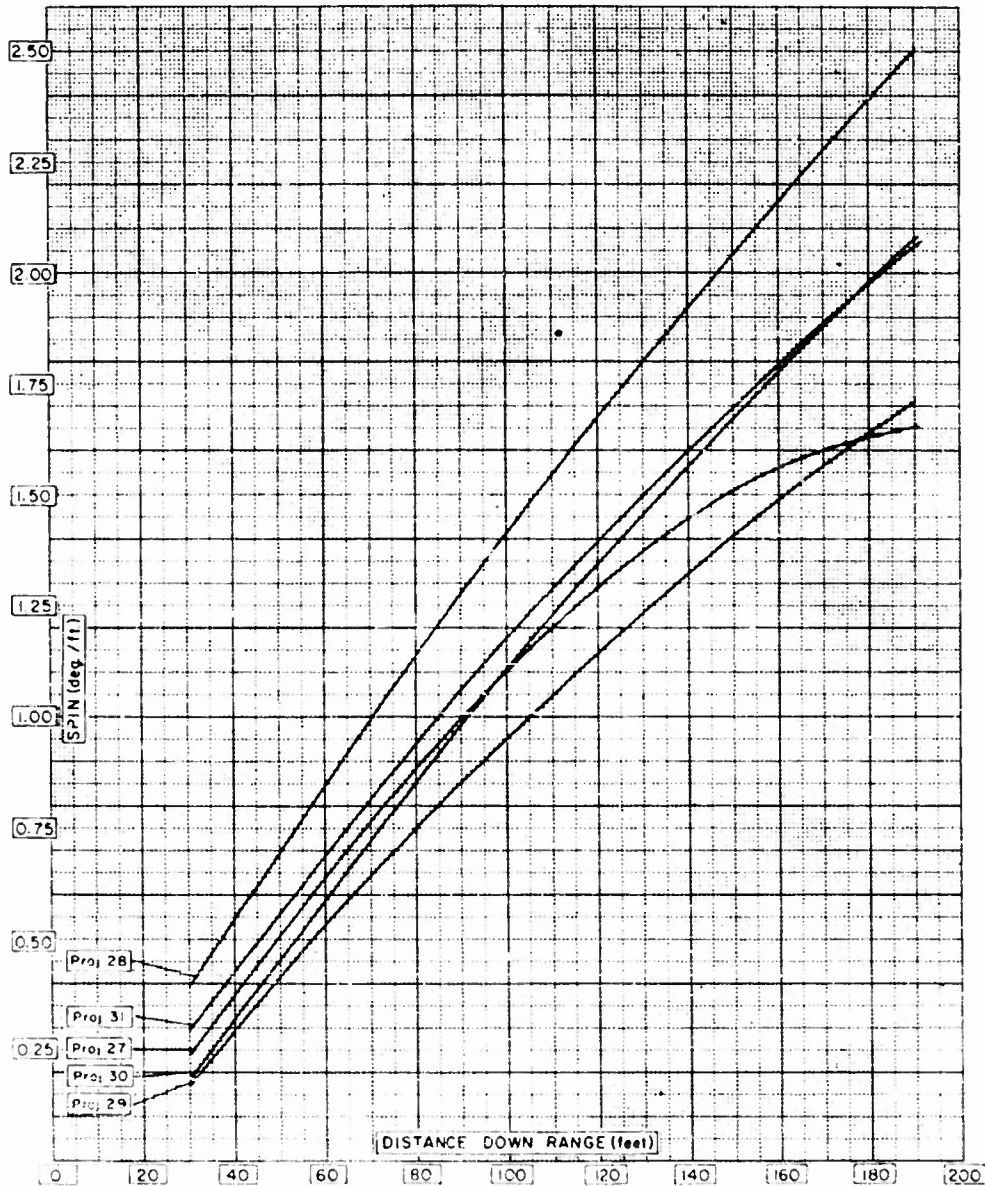


Fig. 8. Spin Versus Distance Down Range.
BAT 90 mm. Folding Fin Projectile.

CONFIDENTIAL

T119 PROJECTILE

Projectiles With Large Diameter Housings

Fin marks in the muzzle of the gun have been observed in previous T119E11 firing programs. It is felt that these fin markings indicated that the undercut tail of the T119E11 projectile permitted the projectile to shift relative to the muzzle as it emerged from the gun. It was therefore, decided to test a group of projectiles with housing diameter large enough to serve, in effect, as a third bourrelet and perhaps minimize the shift of the projectile.

Twenty T119E11X projectiles were assembled with a housing O.D. of $4.118^{-.005}$ in. instead of the standard $3.938^{-.005}$ in. O.D. The modification is shown in Fig. 9.

Five of these projectiles were fitted

with blunt noses and were fired into a sawdust filled recovery box. The range data are presented in Table XI. The remaining fifteen were fired alternately with ten standard T119E11 rounds at an 18 ft. by 18 ft. target at 995 yards. The range data are shown in Table XII.

In the accuracy test, both groups of projectiles flew well and had normal fin openings. Probable errors of dispersion for the experimental group were $\pm .44$ mil vertical and $\pm .50$ mil horizontal while the standard group gave probable errors of dispersion of $\pm .37$ mil vertical and $\pm .53$ mil horizontal. The probable error comparison is only indicative because of the small size of the samples and because sighting difficulties were experienced in the course of firing which necessitated a sub-grouping of both groups for probable error calculations.

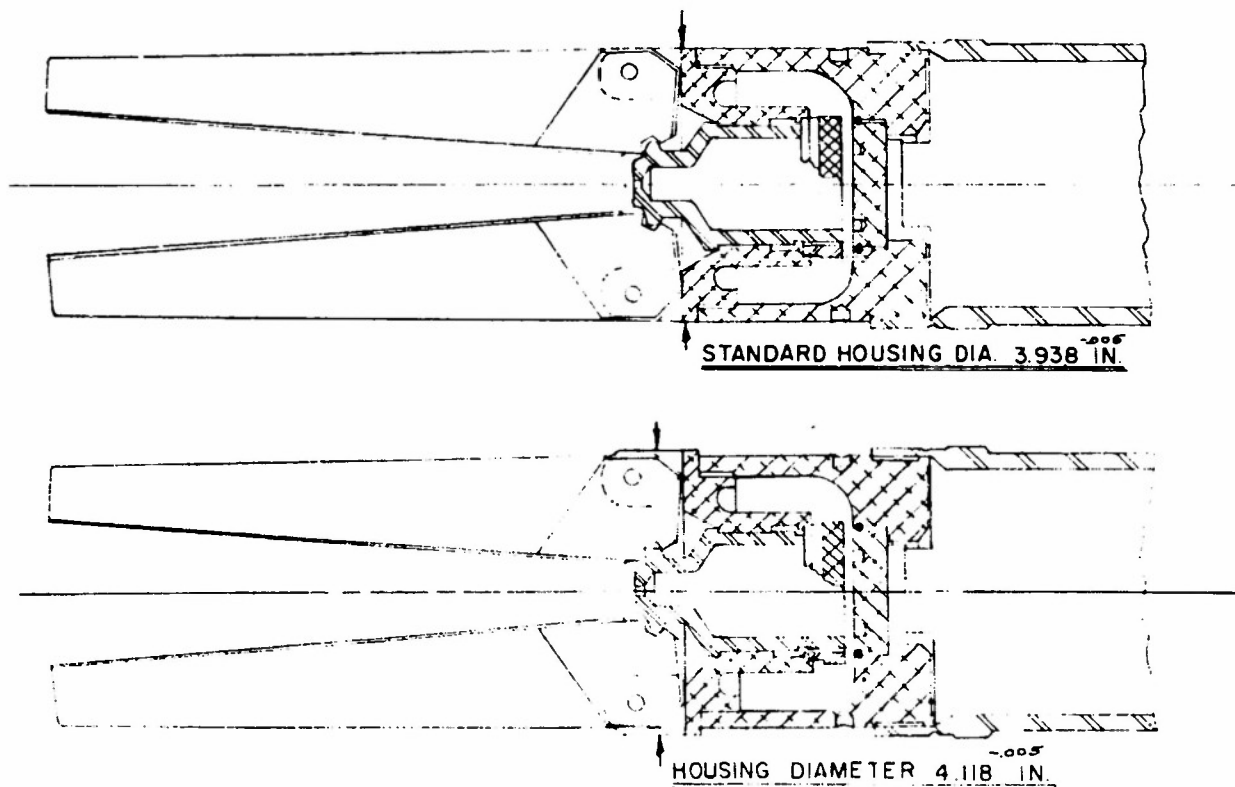


Fig. 9. T119E11X Projectile Modification.
Housing O.D. 4.118 in. Instead Of 3.938 in.

CONFIDENTIAL

Bad erosion was noted on the housings of the recovered projectiles. A photograph of a typical recovered tail assembly is shown in Fig. 10. Such erosion has never been noticed before on the standard T119E11 projectile. It is believed that the flow of powder gases through the con-

stricted area between the enlarged housing and the lands of the gun was responsible for the erosion.

This modification will not be tested further.



Fig. 10. Recovered T119E11X Projectile Tail Assembly.
Showing Erosion On Large Diameter Housing.

Table XI
Range Data
To Test Launching Effect Of Large Diameter Housings
Housing Diameter Of 4.118 in.

Date of Test December 3, 1953
Fire and Report

Purpose of Test Effect of Launching on THGE 1118 Projectile

PROJECTILE

Model T-119
 Type 4.118 (Buntline)
 Weight 17.5 lb (Nom)
 C.G. Location
 Barrellet Dia 4.132 - .012
 Special Features 4.118 in. Hsg. 0.030 in. Shear ring
1.822 in. Turned down barrellet tip

TEST GUN

Model T-170E/1400
 Type 108 mm Recoilless Rifle
 Serial No 61
 Chamber F 23
 Bushing (Vent) F26 (1.5°)
 Tube 22.0 54.3 (20 Twist)
 Sighting Equipment M17 E/How Scope
 Mount
 Type Recoilless
 Constant 2.3 lb/sec/ft

MISCELLANEOUS DATA

Range Recovery Box
 Propellant Type M10 MP Web .035 in. Weight 7 lb. 12 oz.
 Lot No P030259
 Primer M57
 Shell Case 7.53 E1
 Liner PAC 545, 36 oz/4yd
 Temperatures
 Magazine
 Max 72°F Min 70°F Present 70°F
 Loading Room 64°F Ambient 68°F

Round No	Proj No	Proj Weight (lb.)	Powder Charge (lb.-oz)	Wind Vel & Dir	Chamber Pressure (lb./sq.in)	Muzzle Velocity ft/sec		Elev (mils)	Azimuth (mils)	Yaw Cord Measurements (inches)				Recoil (in)	Observations
						Instr	Actual			Cord 1	Cord 2	Cord 3	Cord 4		
6480	X1509	17.50	7-12		9200					4 1/8 - 0 1/8	4 1/8 - 0 1/8	4 1/8 - 0 1/8	4 1/8 - 0 1/8	3 1/8 F	Top three rows of holes taped to prevent propellant loss. Fin housing loose on recovery
6481	X1505	17.50	7-12		8900					4 1/8 - 0 1/8	4 1/8 - 0 1/8	4 1/8 - 0 1/8	4 1/8 - 0 1/8	1 1/8 R	Recovery projectile had two bent fins
6482	X1506	17.50	7-12		8800					4 1/8 - 0 1/8	4 1/8 - 0 1/8	4 1/8 - 0 1/8	4 1/8 - 0 1/8	3 1/8 R	Recovery projectile had one bent fin
6483	X1508	17.50	7-12		8700					4 1/8 - 0 1/8	4 1/8 - 0 1/8	4 1/8 - 0 1/8	4 1/8 - 0 1/8	3 R	Shell case holes taped as above. No projectile attached fin. Recovered pri had three bent fins
6484	X1507	17.50	7-12		8600					4 1/8 - 0 1/8	4 1/8 - 0 1/8	4 1/8 - 0 1/8	4 1/8 - 0 1/8	4 1/8 F	Shell case holes taped as above. Recovered projectile had one broken & three bent fins.
* Fin assembly & rear of chamber housing drilled on all rounds Fastest pictures taken at rounds 6483 & 6484, camera jammed on round 6484															
Gun <u>30' 2 1/2"</u> <u>30' 10"</u> <u>51' 3"</u> <u>66' 10 1/2"</u> <u>Recovery Box</u> Yaw Cord Distances <u>1</u> <u>2</u> <u>3</u> <u>4</u>															
Velocity Screen Distances <u>1</u> <u>2</u> <u>61' 0 1/2"</u> <u>51' 3"</u>															
Proof Director <u>E. Hullman</u> Signed <u> </u>															

Table XII
Range Data
Accuracy Of T119E11X Projectiles With Large Diameter Housing

Date of Test January 7, 1950
Fire Control Report

Purpose of Test Accuracy of T119E11X with 4.118 in O.D. Housing

PROJECTILE

Model T119E11X

Type Std. 6. Exposed Proj.

Weight 17.5 lb. Norm.

CG Location 4.132 - 0.02 in.

Borelet Dia 4.118 in O.D. in Housing

Special Features 4.118 in O.D. in Housing, 0.030 in Shank
Wing, 1.822 in Turned Down Knurled 3/16 in

TEST GUN

Model T170E1 1/2 Spotting Rifle Mount

Type 106 mm Recoilless Rifle

Serial No. 61

Chamber 61

Bushing (Vent) F26

Tube 22-C-511-5 (30 Twist)

Sighting Equipment Bore Sight, M17 E/beam Scope

Mount Gunners Quadrant

Type Rigid

Serial 1

Serials fired mechanically

MISCELLANEOUS DATA

Range 998 yd

Propellant

Type M10 MP Web 0.35 in Weight 7.16 lb

Lot No. PR 30259

Primer M57

Shell Case 753E1

Liner PRC 545 (3.0 oz/44)

Temperatures

Magazine Max 22°C Min 70°F Present 73°F

Loading Room 72°F Ambient 31°F

Round No	Proj Weight (lb.)	Type of Proj.	Wind Vel & Dir mph degrees	Chamber Pressure (lb/sq in)	Muzzle Velocity ft/sec	Azim (mils)	Position of Hit (inches)		Corrected Position of Hit - mils		Recoil (in.)	Observations
							Vert	Horiz	Vert	Horiz		
6620	17.52	Std	1 215	8100	1628	0	-2.289	-1.675	-0.489	-1.675		Warm up round. Good flight. Omitted from PE calculation
6621	17.51	Exp	1 215	8100	1616	0	-2.245	-2.206	-1.105	-2.206		Good flight. Low ricochet into target
6622	17.53	Std	1 215	8000	1634	-1	-2.243	-1.368	-0.726	-0.368		Knocking off lower 2nd
6623	17.54	Exp	1 215	8000	1632	-1	-1.228	-0.893	-1.228	-0.107		Good flight
6624	17.51	Std	1 215	8100	1620	-1	-1.661	-0.517	-1.661	-0.483		
6625	17.54	Exp	1 215	8100	1632	-1	-0.866	-2.373	-0.866	-1.373		
6626	17.50	Std	1 205	8500	1633	-1	-0.363	-1.591	-0.363	-0.591		
6627	17.53	Exp	1 205	8100	1622	-1	-2.722	-2.090	-2.722	-1.890		
6628	17.50	Std	1 205	8000	1625	-1	-1.452	-1.326	-1.452	-0.326		
6629	17.53	Exp	1 200	8400	1606	-1	-0.866	-1.173	-0.866	-0.173		
6630	17.50	Std	1 195	8000	1620	-1	-1.103	-2.164	-1.103	-1.164		Recovered projectile
6631	17.53	Exp	2 190	8100	1617	-1	-2.122	-0.760	-2.122	-0.232		

Page 1 of 2 continued on page 20

Signed W. McMillan

Proof Director E. Nuffman

Observers L. J. Swartz
R. Kincaid

CONFIDENTIAL

Test Of Oversize Hinge Pin Holes

A group of T119E11 projectiles with oversize hinge pin holes was prepared to test the effect of the oversize hinge pin holes upon the accuracy.

Ten housings were inspected and assembled in projectiles. The inspection data are shown below:

The projectiles were fired alternately with ten standard T119E11 projectiles at an 18 ft. by 18 ft. target at 995 yards. The range data are presented in Table XIII. Probable errors of dispersion for the experimental group were $\pm .49$ mil vertical and $\pm .44$ mil horizontal. For the standard group the probable errors of dispersion were $\pm .41$ mil vertical and $\pm .53$ mil horizontal. Only the last eight rounds of each group were used in the probable error calculations because it became necessary to re-lay the T170E1 gun in the rigid mount during the firing.

Projectile Number	Hinge Pin Hole Diameter = .2508 ^{+0.0005} in.					
	Measured Hinge Pin Hole Diameters					
X1619	.256	.256	.2565	.2525	.252	.2525
X1611	.2515	.2533	.254	.251	.2563	.2553
X1605	.2555	.258	.262	.259	.260	.259
X1644	.257	.259	.256	.255	.257	.261
X1629	.254	.254	.253	.255	.254	.255
X1626	.254	.258	.254	.2575	.2545	.255
X1608	.255	.255	.256	.2515	.2515	.257
X1662	.252	.255	.257	.2555	.2593	.2593
X1625	.254	.256	.258	.257	.255	.256
X1617	.260	.2567	.2555	.257	.2645	.264

Future Program

1. An accuracy firing is being planned for three groups of projectiles. One group has short bodies, short ogives, rounded nose caps and T119E11 tail assemblies. The second group has short bodies, long ogives, rounded nose caps and T119E11 tail assemblies. The third group has short bodies but otherwise are standard T119E11 shell. These projectiles will be tested to determine the effect of variable body and ogive lengths on flight performance.

2. Twenty T119E11 projectiles have been assembled with tracer capsules in the tail assembly. The rounds will be fired to determine the visibility and length of trace.

3. Ten T119E11X projectiles with gilding metal obturating bands have been fired for accuracy from a T137E3 gun with a smooth bore tube. The results will be reported in February.

4. Projectiles with 6.92 in. long fins and double "O" ring obturators will be fired for accuracy, and for spin determination in the vicinity of the muzzle and at 1000 yards.

5. A design incorporating a tapered piston stop, which does not require knurling, has been tested in conjunction with tests of maximum and minimum interference in the fin opening mechanism of the T119E11 projectile. The data have not been reduced yet.

Table XIII
Range Data
Accuracy Of T119E11X Projectile
To Test Effect Of Oversize Hinge Pin Holes

Date of Test January 8, 1954
January 15, 1954
February 19, 1954

Purpose of Test Accuracy of T119E11X with Oversize Pin Holes
in 23.3" & 40.0" ranges

PROJECTILE

Model T119

Type E 11 & E 11X

Weight 17.5 lb (nom)

CG Location ---

Sourcelet Dia 4.137" max

Serial Features Elliptical with Oversized Pin Holes & 24.5" Housing

Gun 5533

Velocity Screen Distances

4812'

TEST GUN

Model T119E11/M40

Type 106mm Recoilless Rifle

Serial No 613

Chamber F23

Bushing (Vent) F26

Tube 23.3" & 40.0"

Sighting Equipment M42 & 45mm

Mount Quadrant

Type Rigid

Serial ---

Scenario Fired Mechanically

MISCELLANEOUS DATA

Range 99.5 yd Target

Propellant M40

Type Web 035 in

Lot No PR 30259

Primer M57

Shell Case 7.55 E1

Liner 0.00079 in

Temperatures

Magazine 23°F

Min 71°F

Present 72°F

Loading Room ---

Ambient 30°F

Round No	Proj No & Type	Proj Weight (lb)	Retard Factor (lbs/ft)	Wind Vel & Dir (mph/deg)	Chamber Pressure (lb/psi)	Muzzle Velocity (ft/sec)	Actual Instr	Azim (mils)	Elevation (mils)	Position of Hit (inches)	Corrected Position of Hit (mils)	Normal Wind Comp (mph)	Fin Opening Dia (in)	Body Yaw (in)	Fin Opening Dia (in)	Fin Opening Dia (in)
6649	11602 E 17.52	---	---	13 110	8800	1635	1635	0	25.3	---	---	---	---	---	---	---
6650	11616 E 17.52	---	---	9 110	8800	1622	1622	0	56 291	---	---	---	---	---	---	---
6659	11617 E 17.52	---	---	8 110	8800	1649	1649	0	---	---	---	---	---	---	---	---
6659	11706 E 17.54	---	---	6 1245	9100	1616	1631	0	---	---	---	---	---	---	---	---
6660	11625 E 17.50	---	---	6 1240	9000	1611	1636	0	---	---	---	---	---	---	---	---
6661	11091 E 17.52	---	---	6 1240	8800	1635	1640	0	---	---	---	---	---	---	---	---
6662	11619 E 17.50	---	---	6 1245	8800	1612	1627	0	---	---	---	---	---	---	---	---
6663	11127 E 17.50	---	---	15 1225	8800	1620	1635	0	---	---	---	---	---	---	---	---
6664	11619 E 17.48	---	---	14 1240	8800	1613	1628	0	---	---	---	---	---	---	---	---
6665	11015 E 17.52	---	---	7 1250	8200	1595	1610	0	---	---	---	---	---	---	---	---
6666	11644 E 17.52	---	---	13 1260	8700	1622	1637	0	---	---	---	---	---	---	---	---
6667	11086 E 17.50	---	---	11 1250	8500	1626	1641	0	---	---	---	---	---	---	---	---
6668	11642 E 17.50	---	---	15 1255	9000	1635	1650	0	---	---	---	---	---	---	---	---
6669	11650 E 17.50	---	---	13 1245	8400	1612	1627	0	---	---	---	---	---	---	---	---
6670	11608 E 17.52	---	---	10 1235	8400	1620	1635	0	---	---	---	---	---	---	---	---
6671	11623 E 17.54	---	---	7 1260	8600	1620	1635	0	---	---	---	---	---	---	---	---
6672	11611 E 17.51	---	---	14 1270	7200	1610	1625	0	---	---	---	---	---	---	---	---
6673	11118 E 17.54	---	---	15 1255	8400	1612	1627	0	---	---	---	---	---	---	---	---
6674	11626 E 17.48	---	---	12 1250	9200	1632	1647	0	---	---	---	---	---	---	---	---
6675	11631 E 17.52	---	---	8 1235	7400	1602	1617	0	---	---	---	---	---	---	---	---
6676	11671 E 17.48	---	---	9 1250	7400	1616	1631	0	---	---	---	---	---	---	---	---
6677	11630 E 17.54	---	---	12 1240	8600	1620	1635	0	---	---	---	---	---	---	---	---
6678	11605 E 17.48	---	---	10 1250	8400	1616	1631	0	---	---	---	---	---	---	---	---
6679	11605 E 17.48	---	---	10 1250	8400	1616	1631	0	---	---	---	---	---	---	---	---
6680	11605 E 17.48	---	---	10 1250	8400	1616	1631	0	---	---	---	---	---	---	---	---

Probable Error - Vertical 0.41 mil
 Probable Error - Horizontal 0.53 mil

Proof Director E. Huffman
 Observers R. Fineman

Signed O. Miller

CONFIDENTIAL

PENETRATION STUDIES

Effect Of Rotation Upon Standoff-Penetration Behavior

As the standoff distance is increased the penetration of a non-rotated shaped charge projectile rises to a maximum and then either remains essentially constant or decreases at a rate dependent upon the precision of the cone manufacturing, assembly and loading process. This behavior arises as a result of two facts: (1) that penetration is nearly proportional to jet length and (2) that a velocity gradient exists in jet and as the standoff distance increases the jet lengthens. With unlimited standoff the ultimate effective length attained by the jet is a function of the velocity gradient in the jet, the precision of the assembly and of the properties of the material of which the jet is composed. After the jet has reached as great a length as its ductility will allow, it breaks up into a number of particles which are then each subject to different aerodynamic forces and these particles spread or fan out at a rate dependent largely upon the symmetry of the assembly. When the projectile is rotated a new effect is noted: a rotational velocity gradient is superimposed upon the linear velocity gradient. Under these conditions the length of the jet at the in-

stant of incipient breakup is reduced and a shorter optimum standoff and lower maximum penetration is to be expected. Furthermore, once the jet has broken up into particles the rotational effect causes these particles to spread more rapidly and under these conditions penetration falls more rapidly with increased standoff than would otherwise be true. Thus, for any given shaped charge projectile assembly there is an optimum standoff and a maximum penetration and the values of both optimum standoff and maximum penetration decrease with increasing rotational velocity. The following experiment was undertaken to determine the relative magnitude of these effects.

A number of DRB398HW3 item 1 cones (.100 wall thickness, 3.5 inch effective diameter) were assembled in DRC376 test assemblies with No. 2 nose rings as shown in Fig. 11 and the penetration-standoff curves were determined at 0, 15 and 30 rps. The inspection data for the cones are shown in Table XIV and the penetration data are shown in Table XV and Fig. 12. The following tabulation shows the optimum standoff and maximum average penetrations observed in this test at each spin rate.

Spin Rate (rps)	Optimum Standoff (inches)	Max. Avg. Penetration (inches Mild Steel)
0	15	21.5
15	7.5	19.5
30	less than 7.5	aprox. 14.5

CONFIDENTIAL

It is recognized widely that the optimum standoff for most conical liners is greater than can be provided conveniently within the requirements for aerodynamically stable shell. An important conclusion to be derived from this experiment is that

the above statement is not true when the shell must be rotated at a spin rate which might otherwise be considered acceptable. In such cases provision for increased ogive length or standoff will result in a reduced shaped charge effectiveness.

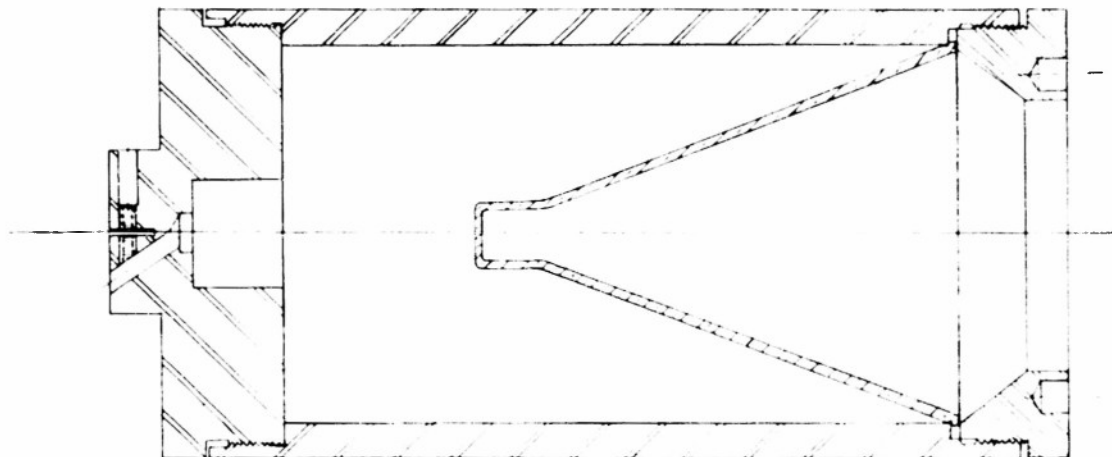


Fig. 11. Test Assembly.
DRC376 Assembly With No. 2 Nose Ring.

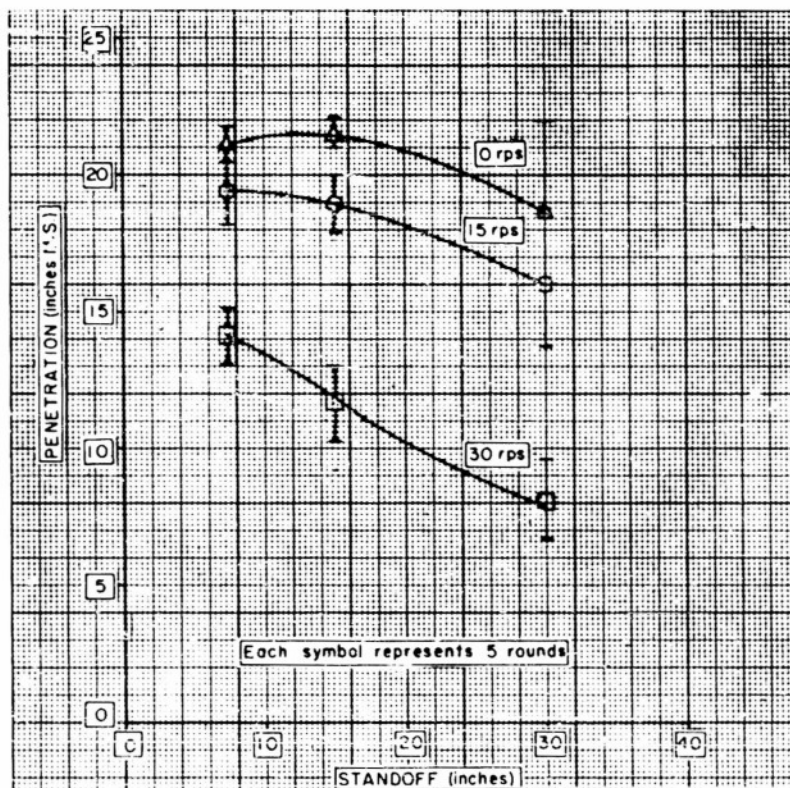


Fig. 12. Penetration Versus Standoff At Various Spin Rates.
DR8398HW3 Item 1 Drawn, Copper Cone.

CONFIDENTIAL

Table XIV
Inspection Data
DRB398HW3 Item 1 Copper, Drawn Cones

Cone Number	Wall Thickness inches			Max Wall Thickness Variation-in.		Max. Wall Waviness inch		Concentricity — T.I.R. ^{1,2}		
	Max.	Min.	Avg.	Transverse	Longitud.	O. D.	I. D.	Base Datum	Apex Datum	Cone Tip in Assembly
Specification DRB398 HW3										
Item 1	.105	.100		.002	.006	.006	.006	.003	.003	.015 (Nominal)
A81	.111	.106	.1080	.003	.004	.001	.002	.008	<.001	.008
A82	.109	.106	.1068	.003	.002	.001	.002	.006	.012	.012
A83	.110	.104	.1065	.003	.005	.001	.002	.002	.004	.004
A84	.109	.105	.1062	.003	.004	.001	.002	.005	.008	.010
A85	.110	.103	.1060	.005	.004	.001	.002	.005	.008	.013
A86	.109	.104	.1065	.001	.004	.001	.002	.005	.004	.004
A87	.108	.104	.1058	.002	.003	.001	.002	.004	.003	.003
A88	.109	.103	.1062	.002	.006	.001	.002	.005	.004	.005
A89	.110	.105	.1065	.002	.005	.001	.002	.005	.009	.002
A90	.110	.105	.1061	.001	.005	.001	.002	.002	.006	.008
A91	.106	.101	.1034	.002	.005	.001	.002	.006	.010	.005
A92	.107	.103	.1050	.002	.002	.002	.002	.002	.008	.015
A93	.110	.106	.1072	.004	.003	.001	.002	.004	.006	.008
A94	.106	.103	.1046	.001	.003	.002	.002	.004	.006	.005
A95	.109	.103	.1059	.004	.004	.002	.002	.004	.006	.002
A96	.108	.102	.1055	.003	.006	.002	.002	.001	.004	.007
A97	.109	.102	.1049	.004	.007	.002	.002	.004	.004	.013
A98	.106	.101	.1039	.003	.005	.002	.002	.003	.005	.007
A99	.107	.103	.1051	.002	.004	.002	.002	.002	.005	.007
A100	.109	.101	.1049	.002	.007	.002	.002	.004	.004	.012
A101	.105	.101	.1031	.004	.003	.002	.002	.004	.002	.003
A102	.109	.102	.1054	.001	.007	.002	.002	.006	.004	.004
A103	.108	.102	.1049	.002	.006	.002	.002	.004	.004	.006
A104	.108	.101	.1048	.002	.005	.002	.002	.004	.008	.004
A105	.108	.102	.1050	.002	.006	.002	.002	.002	.002	.006
A106	.108	.103	.1055	.002	.004	.001	.001	.003	.003	.008
A107	.107	.102	.1039	.003	.004	.001	.002	.003	.004	.008
A108	.108	.102	.1050	.002	.005	.001	.002	.003	.002	.003
A109	.108	.103	.1046	.003	.005	.001	.001	.004	.006	.012
A110	.107	.102	.1040	.004	.005	.001	.002	.006	.007	.012
A111	.107	.103	.1046	.002	.004	.001	.002	.003	.003	.007
A112	.107	.101	.1038	.003	.005	<.001	.002	.004	.007	.008
A113	.108	.103	.1049	.003	.005	<.001	.001	.003	.002	.007
A114	.108	.101	.1038	.004	.007	<.001	.002	.004	.008	.015
A115	.109	.103	.1050	.003	.006	<.001	.002	.004	.005	.008
A116	.109	.102	.1049	.004	.005	.001	.002	.002	.003	.009
A117	.108	.101	.1044	.003	.005	<.001	.002	.003	.005	.010
A118	.109	.104	.1056	.004	.005	.001	.002	.003	.004	.004
A119	.108	.103	.1052	.003	.005	.001	.002	.003	.006	.015
A120	.108	.103	.1055	.002	.004	<.001	.002	.006	.006	.007
A121	.108	.103	.1060	.002	.004	.002	.002	.002	.006	.013
A122	.109	.104	.1065	.002	.005	.002	.002	.004	.003	.006
A123	.109	.104	.1063	.002	.005	.002	.002	.003	.001	.008
A124	.110	.103	.1065	.004	.006	.002	.002	.004	.001	.016
A125	.109	.101	.1052	.003	.007	.002	.002	.003	.006	.012
Avg.	.1083	.1029	.1053	.0027	.0048	.0013	.0019	.0038	.0050	.0080
Std. Dev.	+.0012	+.0014	+.0006	+.0003	+.0012	+.0007	+.0002	+.0014	+.0025	+.0038

Notes:

1. Base datum is .484 inch above base; apex 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 axis.

CONFIDENTIAL

Table XV
Penetration Data
DRB398HW3 Item 1 Copper, Drawn Cones
At Various Standoff Distances and Spin Rates

Round No.	Comp B (lbs)	Standoff (Inches)	Rotation (rps)	Penetration (Inches M. S.)	Max Spread (in.)	Std. Dev. (in.)
A81	2.52	7.5	0	22.00		
A82	2.50	7.5	0	21.06		
A83	2.52	7.5	0	20.50		
A84	2.52	7.5	0	21.44		
A85	2.52	7.5	0	20.69		
				Avg. 21.14	1.50	±.60
A86	2.52	15.0	0	21.44		
A87	2.52	15.0	0	21.75		
A88	2.52	15.0	0	20.62		
A89	2.52	15.0	0	21.56		
A90	2.52	15.0	0	21.94		
				Avg. 21.46	1.32	±.51
A91	2.50	30.0	0	14.50		
A92	2.52	30.0	0	15.12		
A93	2.50	30.0	0	19.94		
A94	2.52	30.0	0	20.56		
A95	2.50	30.0	0	20.75		
				Avg. 18.77	6.25	±3.09
A96	2.50	7.5	15	20.44		
A97	2.52	7.5	15	17.50		
A98	2.52	7.5	15	19.81		
A99	2.52	7.5	15	18.81		
A100	2.50	7.5	15	20.62		
				Avg. 19.44	3.12	±1.29
A106	2.50	15.0	15	19.56		
A107	2.52	15.0	15	19.56		
A108	2.52	15.0	15	20.25		
A109	2.50	15.0	15	16.56		
A110	2.52	15.0	15	19.00		
				Avg. 18.99	3.69	±1.44
A116	2.52	30.0	15	16.69		
A117	2.50	30.0	15	15.44		
A118	2.52	30.0	15	17.00		
A119	2.52	30.0	15	12.38		
A120	2.50	30.0	15	18.62		
				Avg. 16.03	6.24	±2.33
A101	2.54	7.5	30	14.44		
A102	2.52	7.5	30	13.81		
A103	2.50	7.5	30	14.50		
A104	2.50	7.5	30	12.56		
A105	2.52	7.5	30	15.25		
				Avg. 14.11	2.69	±1.00
A111	2.52	15.0	30	10.19		
A112	2.52	15.0	30	11.19		
A113	2.52	15.0	30	13.38		
A114	2.52	15.0	30	10.75		
A115	2.50	15.0	30	12.62		
				Avg. 11.63	3.19	±1.34
A121	2.52	30.0	30	9.31		
A122	2.52	30.0	30	9.44		
A123	2.50	30.0	30	6.25		
A124	2.52	30.0	30	8.81		
A125	2.50	30.0	30	6.62		
				Avg. 8.09	2.82	±1.53

Notes:

1. DRB398 HW3 Item 1 Drawn, Copper Cones were assembled into DRC 37b test bodies using a No. 2 nose ring.
2. All rounds were loaded at Ravenna Arsenal BAT Lot No. 43 with Comp. B Holston Lot No. 4-1197.
3. All rounds were fired at the Erie Ordnance Depot at the above listed standoffs and spins.

CONFIDENTIAL

Future Program

1. Composite Cone Study

A series of bimetal cones with aluminum half shell inserts (.020 in. thick) and copper outer shells (DRB398HW3 item 1) will be assembled to evaluate penetration performance at standoffs of 2, 4 and 6 inches. A spin study is also planned.

2. Evaluation of Cones Made By Electroforming.

A series of DRB268-5 copper cones, made by an electroforming method, have been manufactured for comparison with machined cones of like design.

3. The Effect of Rotation on Aluminum Cone Performance.

A series of DRB398 HW3 item 1 and item 4 cones, machined from 2SF aluminum bar stock, will be tested for penetration at various spin rates (0, 30, 45 and 60 rps at 7.5 in. standoff. Another series will be rotated at the same velocities but at the optimum standoff of about 42 inches.

4. Penetration Into Mild Steel Versus Homogeneous Armor.

A series of penetration test rounds composed of DRB398 HW3 Item 1 cones in DRC376 test bodies were loaded and will be fired at various standoffs and ro-

tations to determine the effect of these factors upon the penetration ratios for mild steel and homogeneous armor.

5. Evaluation of Cones Made By Zinc Die Casting.

A series of DRB398 HW3 cones are being made by die casting zinc alloy Zamak 3. Standoff and spin tests are planned.

6. Damage After Penetration

A series of rounds will be fired through prescribed thicknesses of target plate into an instrumented box. An effort will be made to record the temperatures and pressures in the box. Various types of cores will be used, namely copper, bimetal copper plus aluminum, aluminum and zinc. Similar tests are also planned in which damage to witness plates beyond the target will be evaluated.

7. Evaluation of the DRB398 HW3 Item 1 Copper Drawn Cones In Various States of Manufacture.

A series of cones have been obtained having varying geometric configurations. These cones represent the various steps in the deep drawing of the DRB398HW3 Item 1 copper cone. Six of the 8 drawing stages are included. A standoff and spin program is planned.

CONFIDENTIAL

FUZES

Graze Sensitivity Of The T222 Fuze Assembly

Methods for improving the sensitivity of the T222* fuze assembly (see Fortieth Progress Report, page 42) to ground and graze impact are still being studied. The Fortieth Progress Report contained the test data for two experimental designs being considered. A third design, known as the "potted lucky" design, was tested this month. Seven nose caps containing barium titanate crystals "potted" in thin aluminum caps were obtained from the Sprague Electric Co. These nose assemblies were fitted to T119E11 HEAT projectiles as shown in Fig. 13, and were fired by Mr. Farrell of the Recoilless Rifle Section, Development and Proof Services, Aberdeen Proving Ground. Ten standard T119E11 rounds with grooved caps, Fig. 14, were fired as controls. Five projectiles of each type were fired against homogeneous armor plate inclined at an angle of 64.5° at a range of 400 feet. The

surface was sloped away from the line of fire. Five control rounds and two rounds containing "potted luckies" were fired from the BTB area to the 9600 yard area at APG, the nominal distance of flight being 4000 yards. Table XVI shows the results of the tests as reported unofficially by an observer from The Firestone Tire & Rubber Company.

The penetrations measured were 15.5 in. in each case. At long range, both of the potted nose elements functioned against soft earth, but none of the standard rounds functioned. On the basis of this small sample the rounds with "potted lucky" nose cap assemblies appear to be much superior in ground impact sensitivity to the rounds equipped with grooved nose caps.

A larger sample of "potted lucky" nose cap assemblies will be tested at 4000 yards and at graze impact at shorter ranges.

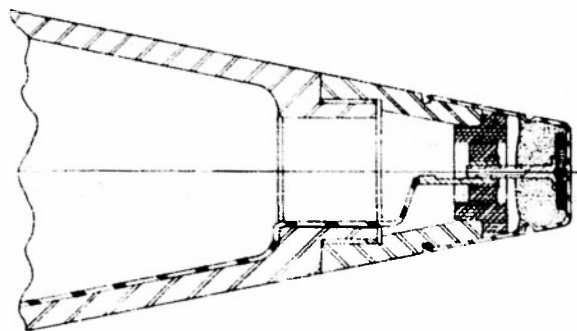


Fig. 13. T119E11 Ogive Assembly.
With Potted Nose Element.

*Any fuze system for a BAT HEAT round, assembled by Firestone is designated T222, regardless of component parts. Fuze systems assembled into projectiles at Firestone, using T208 base elements and any of various nose element assemblies are still designated T222 with appropriate dash number to signify the modification.

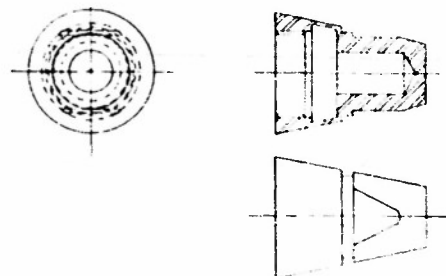


Fig. 14. Grooved Nose Cap.
For T119E11 Projectile Tests.

CONFIDENTIAL

Table XVI
Graze Sensitivity Tests

Rounds fired from a T-170 Rifle #3 at plate set at 64.5° at a range of 400 ft.

Projectile Number	PA E Lot No.	Penetration (inches)	Remarks
X1479	13907	14.4	T119E11 Projectiles with "potted lucky".
X1487	13907	16.4	
X1475	13907	14.1	
X1481	13907	16.4	
X1480	13907	16.4	
		Avg. 15.5	
13875	13906	16.4	T119E11 Projectiles with standard lucky and grooved nose cap.
13877	13906	14.1	
13878	13906	16.4	
13873	13906	16.4	
13882	13906	14.1	
		Avg. 15.5	

Rounds fired from BTB area to 9600 yard range using T-170 rifle #3.
(Nominal distance of projectile travel = 4000 yards).

Projectile Number	Elevation (mils)	Detonation on Impact	Hit Location	Range in Yards (Est.)	Remarks
15881*	200	FTF**	Not Observed	--	Lot PAE 13906 Grooved Cap
13874	190	FTF	9700	4100	
13880	190	FTF	9350	3750	
13879	190	FTF	9250	3650	
13876	190	FTF	9275	3675	
X1488	190	HO	9250	3650	Lot PAE 13907 with potted lucky
X1483	190	HO	9250	3650	

*Probably an error in projectile number.
**FTF=failed to detonate on striking ground.

T267E14 Fuze

All components for 100 T267E14 model 2 fuzes, Fig. 15, have been received. Assembly has begun and test firings both at Erie Ordnance Depot and Aberdeen Proving Ground are planned for the near future.

Drawings are completed for a fuze having all the features of the T267E14 model 2 fuze but of a reduced size. A pilot model will be fabricated for use in static tests.

Premature Functioning Of Electrically Fuzed HEAT Shell

A conference held at Picatinny Arsenal on methods for preventing prematures in electrically fuzed HEAT shell lead to the initiation of a program to devise a method for producing prematures in rounds equipped with Frankford Design D Crystals. A device for producing prematures in these rounds has been designed and tests will be made when projectiles become available.

30
CONFIDENTIAL



Fig. 15. T267E14 Model 2 Base Element.

CONFIDENTIAL

T317 MT Fuze

The point detonator assembly for the T317 MT is shown in Fig. 16 (DRD438). The design of this assembly is based on the point detonator assembly (Ordnance Drawing FF4357) used with the M500 time fuze, and is intended to produce a point detonator whose arming initiation would depend upon setback alone, and be independent of spin.

The arming of this point detonator is controlled by a three pin setback system, such as that used in the Firestone Base Element, which is described in the Eighth

Progress Report. After the third pin functions, the spring-loaded detent pin is free to move, releasing a spring-loaded brass slider. The slider is guided to, and stopped at, the armed position by the guide screw. The M22 detonator is initiated with the same firing pin assembly (FB31180) used in the ordnance point detonator (FF4357).

Component parts for ten timing movements for the T317MT fuze have been received. The gear train does not roll as freely as desired and one assembly is being analyzed with a shadowgraph system.

Future Program

1. Test fire, for functioning evaluation, T267E14 base elements at Erie Ordnance Depot and Aberdeen Proving Ground.

2. Fire additional T119E11 projectiles, equipped with "potted luckies", at various ranges to test ground impact sensitivity.

3. Continue the development of a method for producing prematures with rounds equipped with the Frankford Design D Crystals.

4. Using the premature producing device of (3) above, determine the minimum

resistance permissible in RC washers.

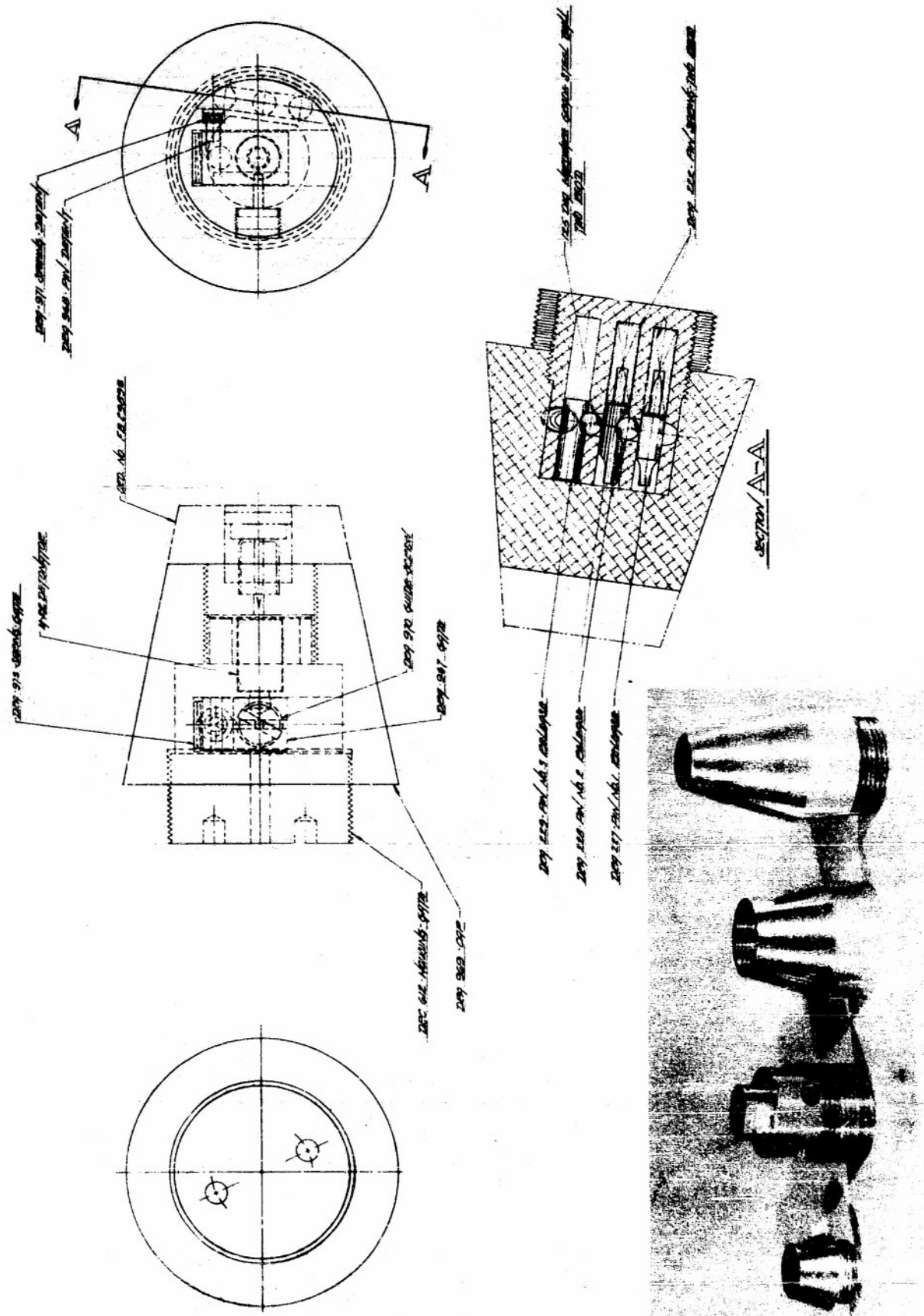
5. Test time fuze assemblies for functioning, using non-destructive laboratory tests.

6. Test functioning of point detonators with bursting screen firing.

7. Measure arming time of point detonator.

8. Analyze operation and functioning of timing movement.

CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

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, HEAT, 106mm, M344 (T119E11) Without Fuzes T208E7

Prior to	January 1, 1954	13,215	All Shipments
	January 8, 1954	500 (Inert)	Picatinny Arsenal
	January 8, 1954	250 (Live)	" "
	January 20, 1954	500 (Inert)	" "
	January 20, 1954	250 (Live)	" "
	January 28, 1954	500 (Inert)	" "
	January 28, 1954	250 (Live)	" "
	Total	15,465	

II. Rifles, T170E1 for ONTOS

Prior to	January 1, 1954	69	All Shipments
No Shipments in January			

III. Mounts, T173 and T26 Tripod for ONTOS

Prior to	January 1, 1954	22	All Shipments
No Shipments in January			

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

Prior to	January 1, 1954	25	All Shipments
No Shipments in January			

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

DISTRIBUTION

Number of Copies	NUMBERS	INSTALLATION
		Office, Chief of Ordnance
1	1	ORDTS
1	2	ORDTA
1	3	ORDTA-EM Fuze Section
1	4	ORDTX-AP
1	5	ORDTB
1	6	ORDTU
1	7	ORDGU-SE
1	8	ORDIM
1	9	Electric Mechanical Ordnance Division
		Arsenals
10	10-19 incl.	Frankford
2	20-21	Picatinny
1	22	Springfield Armory
2	23-24	Redstone
		Ordnance Districts
1	25	Cleveland
		Aberdeen Proving Ground
2	26-27	Ballistics Research Laboratory
1	28	Development and Proof Services
		Contractors
2	29-30	Frigidaire Div. Gen. Motors Corp.
1	31	Winchester Repeating Arms Co.
1	32	Remington Arms Co.
1	33	National Forge & Ordnance Co.
2	34-35	Midwest Research Institute
2	36-37	Armour Research Foundation
1	38	Carnegie Institute of Technology
1	39	Arthur D. Little Co.
1	40	The Budd Company
1	41	Franklin Institute
1	42	Chamberlain Corporation
1	43	American Machine and Foundry Co.
		U. S. Navy
1	44	Bureau of Navy Ordnance
2	45-46	Naval Ordnance Laboratory, White Oak
2	47-48	Naval Ordnance Test Station, Inyokern
1	49	Naval Proving Ground, Dahlgren
		Document Centers
5	50-54 incl.	ASTIA, Dayton, Ohio

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

AD- 026939

SECURITY REMARKING REQUIREMENTS

DOD 5200.1-R, DEC 78

REVIEW ON 28 JAN 74