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CONFIDENTIAL
FORTY-SIXTH
PROGRESS REPORT
OF
THE FIRESTONE TIRE & RUBBER COMPANY
ON
BATTALION ANTI-TANK PROJECT
UNDER

42 264

Contract No. DA-33-019-ORD-1202
ORDNANCE DEPARTMENT PROJECTS
TS4-4020—WEAPONS AND ACCESSORIES
TM1-1540—AMMUNITION

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COPY No. 50

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

MAY 1954

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**FORTY-SIXTH
PROGRESS REPORT
OF
THE FIRESTONE TIRE & RUBBER CO.
ON
BATTALION ANTI-TANK PROJECT**

**Contract No.
DA-33-019-ORD-1202**

**RAD Nos. ORDTs 3-3955
ORDTS 3-3957
ORDTA 3-3952**

**THE FIRESTONE TIRE & RUBBER CO.
Defense Research Division
Akron, Ohio**

MAY, 1954

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54AA 51246

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ABSTRACT

BAT 90mm Projectile - After developing a suitable charge, ten BAT 90mm folding fin type projectiles were fired for accuracy at 1000 yards. The projectiles appeared to fly well but the dispersion was large suggesting that the stability of this design of the projectile may be marginal.

The body and ogive were cemented together and there was no indication either in flight or on the target that the union had failed.

T171 Projectile - Two new T171 projectile modifications having 2 and 2.5 caliber ogives are illustrated. It is believed that the longer ogives will result in a flatter trajectory and shorter time of flight.

The static stability and drag coefficients were calculated for the E12 (2 caliber ogive) and the E13 (2.5 caliber ogive) modifications and are presented here. The static stability of the E12 and E13 models were found to be comparable to the E10 modification and it is concluded that the slow roll imparted by the nylon obturator will be sufficient for dynamic stability.

Ten T171E10 projectiles were fired for accuracy at 2000 yards. The seven rounds which hit the target (three expended in getting on target) gave probable errors of dispersion of $\pm .36$ mil vertically and $\pm .35$ mil horizontally.

Ten T171E12 projectiles were fired for accuracy at 1000 yards. All ten rounds hit the target with probable errors of dispersion of $\pm .29$ mil vertically and $\pm .24$ mil horizontally.

Two T171 test slugs were fired at low temperatures (-60°F) to determine the effect of low temperatures on the spin-inducing qualities of the nylon obturator. The spin measured on one round was 12 rps which would be satisfactory for stable flight. The pop-out pins did not function on the second round.

T120 Projectile - A discussion is given of bearing systems and lubricating films for bearing systems for double body projectiles. Both static and dynamic tests were conducted with modified Lube-Lok coating on DRA218-DRA215 bearing systems. In each case the modified coating showed reduced coefficients of friction.

Fifteen T138E57 type projectiles with and without sleeves (to provide added clearance for penetration) were fired for accuracy at a 478 ft target. The data show that the accuracy of these projectiles at 500 ft is adequate to permit their use as carriers in dynamic tests of fluted cones.

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Penetration Studies - Tests were conducted to determine the effect of spin and cone wall thickness on the performance of machined 2S-F aluminum cones at both ordinary projectile standoff of 7.5 in. and at optimum standoffs (for the aluminum cones) of 42 in. and 48 in. The data are presented.

Tests were conducted to determine the penetration efficiency of a heavy apex copper cone. The cone design is illustrated and the inspection and penetration data are presented. The average penetration is higher than for the controls at 7.5 in. standoff and it appears that the design of the apex aids the cone collapse mechanism.

Fuzes - The data are presented for a series of tests to study the sensitivity of "potted lucky" nose elements. The various phases of the study, the conditions of firing, and the results are presented in this report.

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BAT 90 MM. PROJECTILE

Folding Fin Projectile

A new design of the BAT 90mm folding fin projectile, shown in Fig. 1, has been fired for accuracy at 1000 yards. This design is similar to the E4 modification shown on page 5 of the Forty-Third Progress Report with the exception that a 2.5 caliber ogive was used instead of the 3.0 caliber ogive.

Charge Development

A charge establishment firing was conducted prior to the accuracy firing. The range data are shown in Table I.

Although the recoil unbalance of the gun for the established charge was excessive, it was decided to proceed with the accuracy program on the supposition that any jump in the gun would result in the same effect on all of the projectiles.

1000-Yard Accuracy Test

Ten BAT 90mm projectiles of the type shown in Fig. 1 were fired for accuracy at an 18 ft by 18 ft target at 1000 yards. The range data are presented in Table II.

The projectiles appeared to fly well and a minimum of yaw was recorded on the target. Probable errors of dispersion for ten impacts were $\pm .83$ mil vertical and $\pm .81$ mil horizontal.

The large dispersion of this group indicates the marginal stability of this design of the BAT 90mm folding fin projectile. This marginal stability may have resulted from shortened fins and tapered tail section, introduced in an attempt to reduce the drag.

Another factor which may have affected the accuracy was the excessive recoil of the gun. This recoil unbalance will be corrected before another accuracy program is conducted.

The projectile design fired in this accuracy program had a body with a thinner wall (approx. .135 in.) than any previously fired projectile. The body and ogive were cemented together with plastic bonding agent Shell Epon Adhesive VI (see pages 3 and 4 of the Forty-Fifth Progress Report). There was no indication in the flight or on the target that either the body or the union had failed.

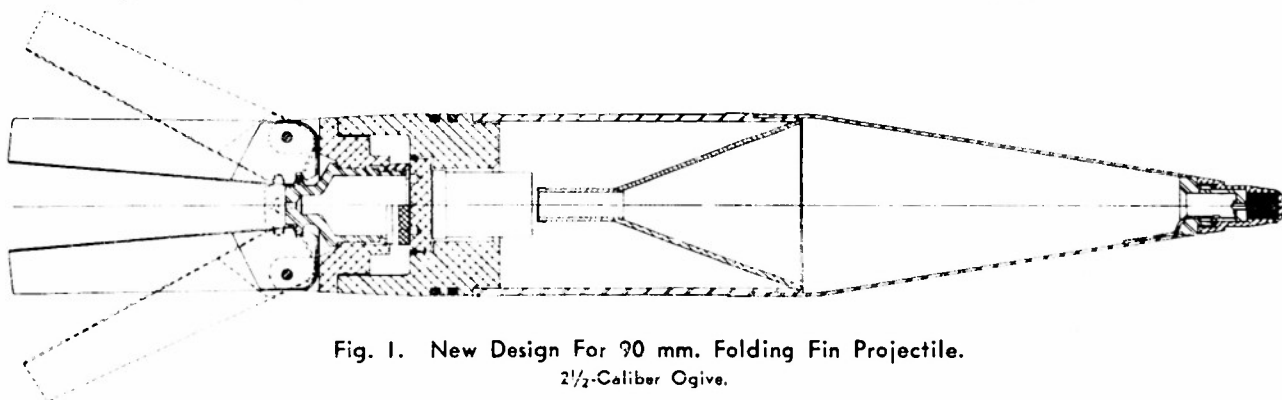


Fig. 1. New Design For 90 mm. Folding Fin Projectile.
2 1/2-Caliber Ogive.

Future Program

1. Forty E2 projectiles are being assembled and 20 will be fired for accuracy at 1000 yards and 20 for accuracy at 2000 yards.

2. Low temperature tests of the fin opening mechanism will be conducted.

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Table I
Range Data
Charge Development
For 90 mm. BAT folding Fin Projectile

Sheet ___ of ___

Date of Test: MAY 29, 1954
Location: Fire Ordnance Dept.
Purpose of Test: CHARGE DEVELOPMENT & BALLISTIC INFORMATION

PROJECTILE

Model: 90 mm. BAT
Type: Recoilless
Serial No.: 1
Chamber: 13.442-2
Bushing: Vert. 22.5-22.6-P (0° Flow Ring)
Tube: B-4443-11 (Smooth Bore)
Sighting Equip: ---
Mount: ---
Type: Penetration Ser. No.
Constant: 2.83 lb/sec/ft
Firing Mech: ---

MISCELLANEOUS DATA

Range: Down Range
Propellant: Type MEMPB Web 54012 Weight Varied
Lot No.: RAD 16915
Primer: M-57
Shell Case: IS3EL
Liner: TL
Temperatures:
Magazine: ---
Max: --- Min: --- Present: ---
Loading Room: --- Ambient: ---

TEST GUN

Model: 90 mm. BAT
Type: Recoilless
Serial No.: 1
Chamber: 13.442-2
Bushing: Vert. 22.5-22.6-P (0° Flow Ring)
Tube: B-4443-11 (Smooth Bore)
Sighting Equip: ---
Mount: ---
Type: Penetration Ser. No.
Constant: 2.83 lb/sec/ft
Firing Mech: ---

Round Number	Proj. Weight (lb)	Proj. Weight (lb)	Chamber Pressure (psi)	Chamber Pressure (psi)	Muzzle Velocity (fps)	Position of Hit (inches)	Elevation (mils)	Azim (mils)	Corrected Pos. of Hit (mils)	Recoil (mils)	Type Flow Ring	Observations
7240-1	51.4	11.94	7-11	18,200	2390	Actual	2390	---	---	---	---	---
7241-2	---	---	---	---	---	---	---	---	---	---	---	---
7242-3	47	10.37	6-14	12,400	2392	2397	---	---	---	---	---	---
7243-4	13	10.35	6-14	12,400	2396	2361	---	---	---	---	---	---
7244-5	48	10.36	7-10	13,500	2409	2424	---	---	---	---	---	---
7245-6	13	10.36	7-10	12,700	2351	2366	---	---	---	---	---	---
7246-7	46	10.36	7-2	13,200	2406	2421	---	---	---	---	---	---
7247-8	---	---	---	---	---	---	---	---	---	---	---	---
7248-9	51.4	11.95	6-13	12,500	---	---	---	---	---	---	---	---
7249-10	51.4	11.96	6-13	11,800	---	---	---	---	---	---	---	---
7250-11	---	---	---	---	---	---	---	---	---	---	---	---
7251-12	---	---	---	---	---	---	---	---	---	---	---	---
7252-13	---	---	---	---	---	---	---	---	---	---	---	---
7253-14	---	---	---	---	---	---	---	---	---	---	---	---
7254-15	---	---	---	---	---	---	---	---	---	---	---	---
7255-16	---	---	---	---	---	---	---	---	---	---	---	---
7256-17	---	---	---	---	---	---	---	---	---	---	---	---
7257-18	---	---	---	---	---	---	---	---	---	---	---	---
7258-19	---	---	---	---	---	---	---	---	---	---	---	---
7259-20	---	---	---	---	---	---	---	---	---	---	---	---
7260-21	---	---	---	---	---	---	---	---	---	---	---	---
7261-22	---	---	---	---	---	---	---	---	---	---	---	---
7262-23	---	---	---	---	---	---	---	---	---	---	---	---
7263-24	---	---	---	---	---	---	---	---	---	---	---	---
7264-25	---	---	---	---	---	---	---	---	---	---	---	---
7265-26	---	---	---	---	---	---	---	---	---	---	---	---
7266-27	---	---	---	---	---	---	---	---	---	---	---	---
7267-28	---	---	---	---	---	---	---	---	---	---	---	---
7268-29	---	---	---	---	---	---	---	---	---	---	---	---
7269-30	---	---	---	---	---	---	---	---	---	---	---	---
7270-31	---	---	---	---	---	---	---	---	---	---	---	---
7271-32	---	---	---	---	---	---	---	---	---	---	---	---
7272-33	---	---	---	---	---	---	---	---	---	---	---	---
7273-34	---	---	---	---	---	---	---	---	---	---	---	---
7274-35	---	---	---	---	---	---	---	---	---	---	---	---
7275-36	---	---	---	---	---	---	---	---	---	---	---	---
7276-37	---	---	---	---	---	---	---	---	---	---	---	---
7277-38	---	---	---	---	---	---	---	---	---	---	---	---
7278-39	---	---	---	---	---	---	---	---	---	---	---	---
7279-40	---	---	---	---	---	---	---	---	---	---	---	---
7280-41	---	---	---	---	---	---	---	---	---	---	---	---
7281-42	---	---	---	---	---	---	---	---	---	---	---	---
7282-43	---	---	---	---	---	---	---	---	---	---	---	---
7283-44	---	---	---	---	---	---	---	---	---	---	---	---
7284-45	---	---	---	---	---	---	---	---	---	---	---	---
7285-46	---	---	---	---	---	---	---	---	---	---	---	---
7286-47	---	---	---	---	---	---	---	---	---	---	---	---
7287-48	---	---	---	---	---	---	---	---	---	---	---	---
7288-49	---	---	---	---	---	---	---	---	---	---	---	---
7289-50	---	---	---	---	---	---	---	---	---	---	---	---
7290-51	---	---	---	---	---	---	---	---	---	---	---	---
7291-52	---	---	---	---	---	---	---	---	---	---	---	---
7292-53	---	---	---	---	---	---	---	---	---	---	---	---
7293-54	---	---	---	---	---	---	---	---	---	---	---	---
7294-55	---	---	---	---	---	---	---	---	---	---	---	---
7295-56	---	---	---	---	---	---	---	---	---	---	---	---
7296-57	---	---	---	---	---	---	---	---	---	---	---	---
7297-58	---	---	---	---	---	---	---	---	---	---	---	---
7298-59	---	---	---	---	---	---	---	---	---	---	---	---
7299-60	---	---	---	---	---	---	---	---	---	---	---	---
7300-61	---	---	---	---	---	---	---	---	---	---	---	---
7301-62	---	---	---	---	---	---	---	---	---	---	---	---
7302-63	---	---	---	---	---	---	---	---	---	---	---	---
7303-64	---	---	---	---	---	---	---	---	---	---	---	---
7304-65	---	---	---	---	---	---	---	---	---	---	---	---
7305-66	---	---	---	---	---	---	---	---	---	---	---	---
7306-67	---	---	---	---	---	---	---	---	---	---	---	---
7307-68	---	---	---	---	---	---	---	---	---	---	---	---
7308-69	---	---	---	---	---	---	---	---	---	---	---	---
7309-70	---	---	---	---	---	---	---	---	---	---	---	---
7310-71	---	---	---	---	---	---	---	---	---	---	---	---
7311-72	---	---	---	---	---	---	---	---	---	---	---	---
7312-73	---	---	---	---	---	---	---	---	---	---	---	---
7313-74	---	---	---	---	---	---	---	---	---	---	---	---
7314-75	---	---	---	---	---	---	---	---	---	---	---	---
7315-76	---	---	---	---	---	---	---	---	---	---	---	---
7316-77	---	---	---	---	---	---	---	---	---	---	---	---
7317-78	---	---	---	---	---	---	---	---	---	---	---	---
7318-79	---	---	---	---	---	---	---	---	---	---	---	---
7319-80	---	---	---	---	---	---	---	---	---	---	---	---
7320-81	---	---	---	---	---	---	---	---	---	---	---	---
7321-82	---	---	---	---	---	---	---	---	---	---	---	---
7322-83	---	---	---	---	---	---	---	---	---	---	---	---
7323-84	---	---	---	---	---	---	---	---	---	---	---	---
7324-85	---	---	---	---	---	---	---	---	---	---	---	---
7325-86	---	---	---	---	---	---	---	---	---	---	---	---
7326-87	---	---	---	---	---	---	---	---	---	---	---	---
7327-88	---	---	---	---	---	---	---	---	---	---	---	---
7328-89	---	---	---	---	---	---	---	---	---	---	---	---
7329-90	---	---	---	---	---	---	---	---	---	---	---	---
7330-91	---	---	---	---	---	---	---	---	---	---	---	---
7331-92	---	---	---	---	---	---	---	---	---	---	---	---
7332-93	---	---	---	---	---	---	---	---	---	---	---	---
7333-94	---	---	---	---	---	---	---	---	---	---	---	---
7334-95	---	---	---	---	---	---	---	---	---	---	---	---
7335-96	---	---	---	---	---	---	---	---	---	---	---	---
7336-97	---	---	---	---	---	---	---	---	---	---	---	---
7337-98	---	---	---	---	---	---	---	---	---	---	---	---
7338-99	---	---	---	---	---	---	---	---	---	---	---	---
7339-100	---	---	---	---	---	---	---	---	---	---	---	---

Program Director M. Manofsky

Muzzle 1-5179' 4-5827' 12
Screen (Coll) Distances

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Table II
Range Data
To Test Accuracy Of BAT 90 mm. Folding Fin Projectile

Sheet 1 of 2

Date of Test: May 26, 1954
Location: Fort Ord Depot

Purpose of Test: Accuracy Test of BAT 90mm. Projectiles

PROJECTILE

Model: BAT 90mm
Type: BAT 90mm E24
Weight: 10.5 lb (Nom.)
C.G. Location: 5.60 in
Borelet Dia: 3.537 in
Reford Factor: 1.0
Special Features: DR-15-R-12 Series 2
Loading Data: From 5 in. long

TEST GUN

Model: BAT 90mm
Type: 90mm Recoilless
Serial No.: 1
Chamber: 8.450 in
Bushing(Vent): 3.450 in
Tube: 8.450 in
Sighting Equip: 6.60 in Telescope, T1601, Gears 5 Right
Mount: Universal Gun Mount M1
Type: 7.52 E7 Ser No: ---
Constant: ---
Firing Mech: ---

MISCELLANEOUS DATA

Range: 990 yd.
Propellant: Type MS MP Web. Cal. Weight 7 lb 3.3
Lot No.: 89076015
Primer: M57
Shell Case: 753E1
Liner: 76
Temperatures:
Magazine: --- Min: --- Present: 78°F
Max: ---
Loading Room: 69°F Ambient: 53°F

Round Number	Proj. Number	Proj. Weight (lb)	Chamber Pressure (psi)	Chamber Pressure (lb-in)	Muzzle Velocity (fps)	Azim (mil)	Elevation (mil)	Position of Hit (inches)	Corrected Pos. of Hit (inches)	Wind Vel & Dir. (mph deg)	Observations
7267	---	---	---	12900	---	---	---	---	---	---	Warm up round
7268	55	10.52	---	12300	2396	+2	7.7-12.0	+5.6	+3 1/2 -1.43	-90 3 1/2 1/4 11 -050	Flight not observed
7269	52	10.52	---	14100	2365	---	---	---	---	---	---
7270	60	10.50	---	13700	2384	+2	7.7-12.0	+9.5	+3.0 -33 -16	3 1/2 3/4 14 -075	Good flight
7271	57	10.51	---	14100	2357	+1	7.7-9.0	-1.6	+9 -1.29	+25 -14 -060	Flight not observed
7272	51	10.50	---	13700	2396	0	7.7-9.0	+3.8	-8.0 -2.07	-2.24 3 1/2 3/4 16 -055	Good flight
7273	58	10.54	---	13900	2362	+1	7.7-9.0	-2.4	+4.5 1/2 -6.7	+1.28 3 1/2 3/4 14 -050	Good flight
7274	59	10.52	---	14300	2337	+1	7.7-9.0	+4	+1.7 1/2 -1.1	+0.9 3 1/2 3/4 12 -060	Good flight
7275	56	10.56	---	14200	2369	+1	7.7-9.0	-4.9 1/2	+5.0 -1.39	+1.68 3 1/2 3/4 13 -065	Good flight
7276	53	10.54	---	13900	2368	+1	7.7-9.0	-1.6	+1.0 -3.25	+2.8 -5 -065	Hit below target
7277	54	10.53	---	13600	2367	+1	7.7-9.0	-1.9	-8.6 1/2 -5.5	-2.43 3 1/2 3/4 15 -075	Good flight
7278	---	---	---	12500	2334	---	---	---	---	---	---
Muzzle		29.9'	48.2'	39.9'	39.9'	39.9'	39.9'	39.9'	39.9'	39.9'	Center of Impact -101 V, -04 H (m.i.)
Screen (Col)		Distances	Distances	Distances	Distances	Distances	Distances	Distances	Distances	Distances	Distances
Vertical (mil)		± .03	± .03	± .03	± .03	± .03	± .03	± .03	± .03	± .03	± .03
Horizontal (mil)		± .01	± .01	± .01	± .01	± .01	± .01	± .01	± .01	± .01	± .01
Proof Director		E. Huffman	E. Huffman	E. Huffman	E. Huffman	E. Huffman	E. Huffman	E. Huffman	E. Huffman	E. Huffman	Program M. Mansky
Observers		L. P. Sweeney	L. P. Sweeney	L. P. Sweeney	L. P. Sweeney	L. P. Sweeney	L. P. Sweeney	L. P. Sweeney	L. P. Sweeney	L. P. Sweeney	Director

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Table II (Cont.)

Sheet 2 of 2

Date of Test May 26, 1954
Location Eric Ord Depot

Purpose of Test Test Accuracy of BAT 90mm. Projectiles

PROJECTILE

Model BAT 90mm.
Type E4X
Weight _____
C.G. Location _____
Barrel Dia. _____
Reload Factor _____
Special Features _____

TEST GUN

Model BAT 90mm.
Type 90mm. Reco. Mass
Serial No. _____
Chamber _____
Bushing(Vent) _____
Tube _____
Sighting Equip _____
Mount _____
Type _____ Ser. No. _____
Constant _____
Firing Mech _____

MISCELLANEOUS DATA

Range 990 yd
Propellant: _____
Type _____ Web _____ Weight _____
Lot No. _____
Primer _____
Shell Case _____
Liner _____
Temperatures: _____
Magazine _____
Max _____ Min _____ Present _____
Loading Room _____ Ambient _____

Round Number	Proj. Number	Orifice (in.)	Range at Nose	Stop-Dia (Knuft) (in.)	C.G. (in.)	Counterbore Dia. Inside	Counterbore Dia. Outside	Fin. Opening of Target (in.)	Observations
1	51	.119	.010	1.5675	5.59	1.551	1.5475	7 1/8 x 7 1/8 x 7 1/8	1
2	52	.120	.011	1.568	5.60	1.5535	1.5555	7 1/8 x 7 1/8 x 7 1/8	2
3	53	.120	.013	1.568	5.60	1.5515	1.5535	Below Target	3
4	54	.119	.012	1.568	5.62	1.556	1.558	7 1/8 x 7 1/8 x 7 1/8	4
5	55	.119	.014	1.5685	5.59	1.5515	1.553	7 1/8 x 7 1/8 x 7 1/8	5
6	56	.119	.010	1.5155	5.60	1.5515	1.5535	7 1/8 x 7 1/8 x 7 1/8	6
7	57	.119	.012	1.569	5.59	1.5525	1.552	8 x 8 x 8	7
8	58	.119	.009	1.568	5.60	1.551	1.562	7 1/8 x 7 1/8 x 7 1/8	8
9	59	.118	.011	1.567	5.60	1.5515	1.553	7 1/8 x 7 1/8 x 7 1/8	9
10	60	.120	.009	1.568	5.60	1.5515	1.5532	7 1/8 x - x -	10
11									11

No Page ping for rounds 7274-7275. Bolt retained before round 7276, blew out on round 7277

No new cards used, measurements taken from target for in openings

Retardation and Time of Flight attempted, but results were inconclusive

Center of Impact -101V, -56M (ail) Proof Director E. Huftines Program M. Monofsky
Probable Error: _____ Director _____
Vertical (mils) $\pm$.83 Observers L.P. Sweetley
Horizontal (mils) $\pm$.81

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T171 PROJECTILE

Projectile Designs

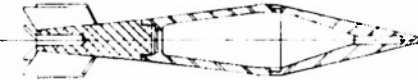
Two new T171 projectiles, designated the E12 and the E13, have been designed. Both of these projectiles use the same body and tail as the T171E10 projectile; the 1.5 caliber ogive of the E10 is replaced with a 2.0 caliber conical ogive to make the E12, and with a 2.5 caliber conical ogive to make the E13 configuration. These configurations, and their component parts, are shown in Table III.

The increased ogive length will serve

to reduce the drag force acting on the projectile, resulting in a flatter trajectory and a shorter time of flight. Thus, the effect on accuracy of variations in range estimation, sighting of the weapon, and muzzle velocity should be less for these two rounds than for the T171E10 projectile.

The penetration potential with the T171 round should be improved by the use of a longer ogive, since the optimum standoff for maximum penetration is greater than 1.5 calibers for this type of round.

Table III
T171 Projectile Types
Components Of E10, E12 and E13 Modifications

Type	Pictures	Component Parts	Drawing No.
T171E10		1 1/2 caliber conical nose Body 6-Finned, End Plated Tail	DRB183-1 DRC193-4 DRC132-3
T171E12		2 caliber conical nose Body 6-Finned, End Plated Tail	DRB-14-951 DRC193-4 DRC132-3
T171E13		2 1/2 caliber conical nose Body 6-Finned, End Plated Tail	DRC-14-778 DRC193-4 DRC132-3

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Stability

A normal force coefficient, restoring moment coefficient, and center of pressure were estimated for the T171E10 configuration, using T131 projectile wind tunnel data (BRL TN 565, Wind Tunnel Tests of the T131, 105mm HEAT Projectile, by R. H. Krieger). Assuming that

$$K_M = K_N(CP-CG) = \underbrace{[K_N(CP-CG)]}_{\text{Nose-Body}} + \underbrace{[K_N(CP-CG)]}_{\text{Tail}}$$

the normal force and restoring moment coefficients and center of pressure of component parts of the T131 projectile were found. Applying this information to the T171E10 configuration, values of normal force and restoring moment coefficients, and centers of pressure were determined.

The normal force coefficient and center of pressure for the 1.5, 2 and 2.5 caliber conical ogives were calculated by Tsien's equations,

$$K_N = \frac{\pi}{4} \frac{n \sqrt{n^2 - 1}}{\cosh^{-1} n + n \sqrt{n^2 - 1}}$$

$$CP = \frac{2\ell}{3}$$

where

$$n = \frac{\cot \theta_s}{\sqrt{M^2 - 1}}$$

θ_s = semi-cone angle

M = Mach number

ℓ = distance from vertex to base of cone.

If the difference in these aerodynamic coefficients and centers of pressure for these three configurations results only from the difference in the aerodynamic coefficients and centers of pressure of the three ogives, the normal force and restoring moment coefficients and centers of pressure for the E12 and E13 can be estimated. These data are tabulated in Table IV.

These estimates indicate that the static stability of the E12 and E13 projectiles is comparable to that of the T171E10. The slow roll imparted to the T171 rounds by the nylon obturator, DRA-14-1281, shown in Fig. 2 should be sufficient to provide dynamic stability for both designs.

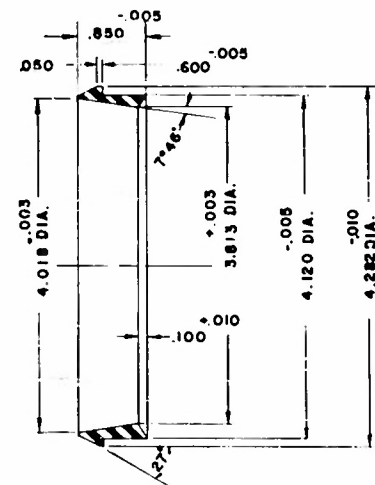


Fig. 2. Nylon Obturator.
Firestone Drawing No. DRA-14-1281.

Table IV
T171 Projectile Aerodynamic Data
At Mach 1.72

Type	K_M	CP-CG (cal.)	K_N	K_D	$i_{7.2}$
E10	-.720	-.471	1.530	.233	1.85
E12	-.670	-.417	1.606	.196	1.57
E13	-.828	-.505	1.640	.190	1.52

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Drag Function

The drag force coefficients for the E12 and E13 projectiles have been estimated on the assumption that the decrease in drag (from the T171E10) is due entirely to the difference in drag force on the conical ogives. Drag coefficients for the 1.5, 2 and 2.5 caliber ogives were calculated using the equation of Karush and Critchfield (The Drag Coefficient for a Cone Moving with High Velocity, NDRC, Armor and Ordnance Report No. A-126), where

$$K_D = .7854 \frac{P_s}{\rho u^2}$$

where

P_s = surface pressure on cone

u = velocity of cone.

ρ = air density

The drag coefficients for the E12 and E13 configurations at Mach 1.72 were obtained by adding the difference in drag coefficients of the cones to the value of the drag coefficient of the T171E10 given in Fig. 16, Thirty-Seventh Progress Report. The form factors, based on Type 7 projectile,

were then calculated for the E12 and E13 configurations. These data are tabulated in Table IV also.

Accuracy Tests

T171E10 At 2000-Yard Range

Ten T171E10 projectiles were fired for accuracy at Erie Ordnance Depot. These projectiles were equipped with nylon obturators, DRA-14-1281, and placed in the shell case as shown in Fig. 25, Forty-First Progress Report. A T19 rifle, with a 1-20 twist tube was used for this program. The target was placed approximately 2000 yards from the muzzle. The firing record for this program is shown in Table V.

Three rounds were expended in getting on the target. The remaining seven rounds hit the target with probable errors of $\pm .36$ mil vertically and $\pm .35$ mil horizontally. This group of rounds, fired at an average muzzle velocity of 1690 fps, with 62 mils elevation and 2 mils right azimuth, had a center of impact .82 mil below and .50 mil to the right of the aiming point. The target plot for this firing is shown in Fig. 3.

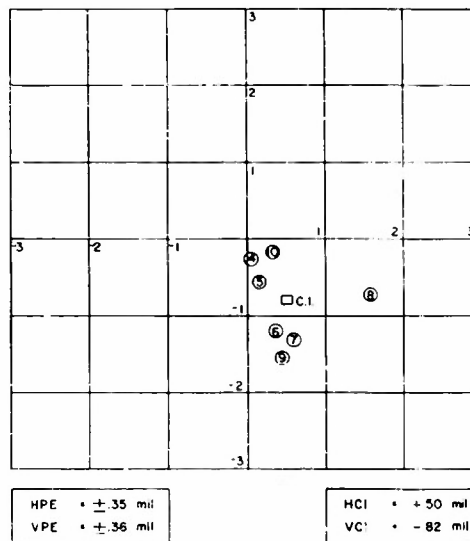


Fig. 3. Target Plot.
T171E10 Projectile At 2000 Yards.

Table V
Range Data
To Determine Accuracy and Flight Characteristics
T17E10 Projectile

Sheet 1 of 2

Purpose of Test: To Determine Accuracy & Flight Characteristics of T17E10

Date of Test: April 30, 1954
Location: Erie Ord. Depot

PROJECTILE

Model: T171
Type: E10
Weight: 17.5 lb. (Nom.)
C.G. Location: 4.132 in.
Borelet Dia: .4132 in.
Retard Factor: 0.22 fpi/ft.
Special Features: None

TEST GUN

Model: T19
Type: 105mm Recoilless
Serial No.: 26594-1-12931 (Liner used)
Chamber: Bushing (Venti) VA884 (T30816)
Tube: 12743-2456-2 (No Twist)
Sighting Equip: Bore Sight, Gunner's Quadrant, M1 Mount
Type: M75 Ser. No. 541
Mount: Constant
Firing Mech: Electric

MISCELLANEOUS DATA

Range: 2000 yd. Line of fire 2° clockwise
Propellant: Type M10 up Web 0.35 in. Weight 716/143
Lot No.: PR30359
Primer: M57 (13 in.)
Shell Case: T53E1 mod. f.
Liner: T6 Special
Temperatures:
Magazine: Max. 73°F Min. 71°F Present 72°F
Loading Room: 59°F Ambient 78°F

Round Number	Proj. Number	Proj. Weight (lb.)	Proj. Weight (lb.)	Chamber Pressure (psi)	Muzzle Velocity (fps)	Actual	Instr.	Actual	Instr.	Elevation (mils)	Position of Hit (mils)	Corrected Posit. of Hit (mils)	Yaw at Target (in.)	Wind Dir & Vel (in.)	Observations
7135	64H	17.53	7-14	9500	1656	1671	0	58-60.0	—	—	—	—	—	7-135	Missed target, to left. Pego Gage No. 13
7136	62H	17.53	7-14	9000	1668	1683	2	58-60.0	-45	-4	+1377	-0.055	12x4	8-125	Hit 51 ft short & 6.9 ft right of center
7137	57H	17.54	7-14	9200	1664	1679	2	58-63.0	—	—	—	—	—	10-120	Missed, over top
7138	60H	17.54	7-14	9200	1618	1693	7	58-62.0	-19	0	-0.263	0.000	8x4	5-145	
7139	55H	17.54	7-14	9700	1685	1700	2	58-62.0	-42	+11	-0.581	0.152	6x4	8-190	Changed Pego Gage after this round, to No. 16
7140	61H	17.54	7-14	9900	1669	1684	2	58-62.0	-86 1/2	+27	-1.197	-0.374	6x4	9-150	
7141	58H	17.54	7-14	9400	1669	1684	2	58-62.0	-91 1/2	+42	-1.266	-0.581	6x4	9-165	Mifine cap reversed. Replaced and fired
7142	61H	17.54	7-14	9400	1669	1684	2	58-62.0	-91 1/2	+42	-1.266	-0.581	6x4	9-165	
7143	61H	17.54	7-14	9400	1669	1684	2	58-62.0	-91 1/2	+42	-1.266	-0.581	6x4	9-165	
7144	61H	17.54	7-14	9400	1669	1684	2	58-62.0	-91 1/2	+42	-1.266	-0.581	6x4	9-165	
7145	61H	17.54	7-14	9400	1669	1684	2	58-62.0	-91 1/2	+42	-1.266	-0.581	6x4	9-165	
7146	61H	17.54	7-14	9400	1669	1684	2	58-62.0	-91 1/2	+42	-1.266	-0.581	6x4	9-165	
7147	61H	17.54	7-14	9400	1669	1684	2	58-62.0	-91 1/2	+42	-1.266	-0.581	6x4	9-165	
7148	61H	17.54	7-14	9400	1669	1684	2	58-62.0	-91 1/2	+42	-1.266	-0.581	6x4	9-165	
7149	61H	17.54	7-14	9400	1669	1684	2	58-62.0	-91 1/2	+42	-1.266	-0.581	6x4	9-165	
7150	61H	17.54	7-14	9400	1669	1684	2	58-62.0	-91 1/2	+42	-1.266	-0.581	6x4	9-165	

Muzzle H: 45.90' ± 4' 18' — 12
Screen (Coll) Distances
Center of Impact: -0.815V; +0.498H
Probable Error:
Vertical (mils) ± 0.36
Horizontal (mils) ± 0.35
Proof Director: E. Huffman Signed: W. McMillan
Observers: D. Thurman & Ford continued on next page
L. P. Swaback

Table V (Cont.)

Sheet 2 of 2
Purpose of Test To Determine Accuracy & Flight Characteristics of 771E10

Date of Test April 30, 1958
Location Erie Ordn Depot

PROJECTILE

Model 771
Type E10
Weight _____
C.S. Location _____
Borelet Dia _____
Reford Factor _____
Special Features _____

TEST GUN

Model 719
Type 20mm Recoiless
Serial No. _____
Chamber _____
Bushings(Vent) _____
Tube _____
Sighting Equip _____
Mount _____
Type _____ Ser. No. _____
Constant _____
Firing Mech. _____

MISCELLANEOUS DATA

Range 2000 yd.
Propellant: _____
Type _____ Web _____ Weight _____
Lot No. _____
Primer _____
Shell Case _____
Liner _____
Temperatures: _____
Magazine _____
Max. _____ Min. _____ Present _____
Loading Room _____ Ambient _____

Round Number	Proj. Number	Proj. Weight (lb.)	Propell. Weight (lb.-oz)	Chamber Pressure (psi) (Cu In./sq. In.)	Muzzle Velocity (fps)	Azin. (mils)	Elevation (mils)	Position of Hit (inches)	Corrected Posit. of Hit - (mils)	Yaw of Target (in.)	Wind Vel & Dir (mph-deg)	Observations				
7142	1	56H	17.53	7-14	9900	1682	1697	2	58-62	-52	+114	-0.79	+1.577	6.4	12-185	
	2				9400											
	3				11,000 (P)											
7143	4	59H	17.54	7-14	9300	1662	1677	2	58-62	-111 1/2	+32	-1.542	+0.443	16.4	10-175	
	5				9500											
	6				10,800 (P)											
7144	7	43H	17.54	7-14	9400	1682	1697	1	58-62	-10	-46 1/2	-0.138	+0.357	16.4	11-160	
	8				9100											
	9				10,900 (P)											
	10															
					9345 (P)	10,874 (P)	11,087									

* No A Y = No Appreciable Yaw. All measurements assumed to have target flat and perpendicular to line of flight. Target actually bowed away from gun during the entire firing period.
(P) indicates Pico pressures

Muzzle 4590' 418' 12
Screen (Coll) Distances _____
Center of Impact 2815', 0.498 H Proof Director E. Huffman Signed W. MacMillan
Probable Error: _____
Observers Dr. Thurman & Ford
Vertical (mils) ± 0.36
Horizontal (mils) ± 0.35

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T171E12 At 1000-Yard Range

Ten T171 E12 projectiles were fired for accuracy at Erie Ordnance Depot, from a T19 rifle at a 1000-yard target. These rounds were equipped with nylon obturator DRA-14-1281, and placed in the shell case as shown in Fig. 4. The firing record for this program is shown in Table VI.

All ten rounds hit the target with probable errors of $\pm .29$ mil vertical and $\pm .24$ mil horizontal. This group of rounds, fired with an average velocity of 1691 fps, at 22 mils elevation and 2 mils left azimuth, had a center of impact .87 mil left and .75 mil above the target center. The target plot for this program is shown in Fig. 5.

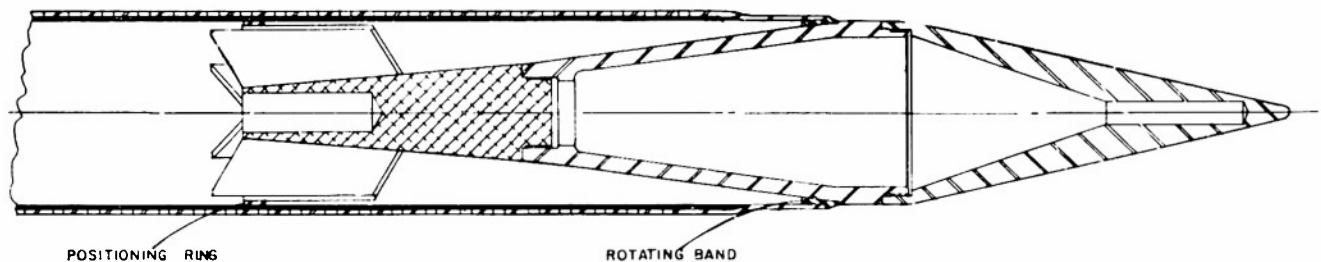


Fig. 4. T171E12 Projectile In Shell Case.

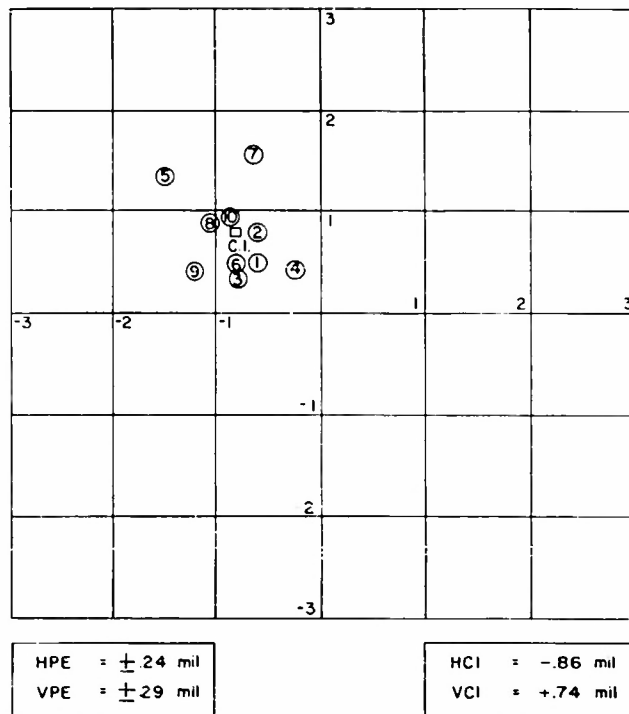


Fig. 5. Target Plot.
T171E12 Projectile At 1000-Yard Range.

Table VI
To Determine Accuracy Of T171E12 Projectile
1000 Yards

Sheet 1 of 2

Date of Test May 21, 1954
Location Erie Ord. Dep't

Purpose of Test To determine Accuracy of T171E12

PROJECTILE

Model T171
Type E12
Weight 17.82 lb (A92)
C.G. Location 4.132 in
Barrel Dia 4.132 in
Reloat Factor 0.23 foz/ft.
Special Features Nylon abutment
Conical Ogive (2ca1)

TEST GUN

Model T19
Type 105mm Recoilless
Serial No. 6
Chamber 26694 11-12931 (liner used)
Bushing (Mem) 14884 7230826
Tube 2242-26542 1/4 Twist
Sighting Equip Bare Sight Gunners
Mount Gunner's
Type M75 Ser No 541
Constant
Firing Mech Solenoid

MISCELLANEOUS DATA

Range 1000 Yd. (Line of fire 28° clockwise from Magn 143)
Propellant: Type M10 WP Web .035 in Weight 7.16 lb
Lot No. PA30259
Primer M57 (13 in.)
Shell Case T53EL mod. f
Liner Td (cut off)
Temperatures:
Magazine Max. 73°F Min. 71°F Present 72°F
Loading Room 63°F Ambient 63°F

Round Number	Proj. Number	Proj. Weight (lb)	Time of Flight (sec)	Chamber Pressure (psi)	Muzzle Velocity (fps)	Azimuth (mils)	Elevation (mils)	Position of Hit (inches)	Corrected Posit. of Hit (inches)	Wind Vel (mph)	Retardation (fps/ft)	Observations
7228	2	17.82	2.0544	9800	1671.8	-2	8.6 - 22	Vert. +17 1/4	Horiz. -23 3/4	1138	4 - 000	Good flight. Some yaw in flight
7229	4	17.82	2.0579	9800	1671.8	-2	8.6 - 22	Vert. +22 1/2	Horiz. -0.631	1178	6 - 355	Good flight
7230	9	17.83	2.0620	9200	1675.9	-2	8.6 - 22	Vert. +10 1/4	Horiz. -0.295	1144	3 - 025	Good flight
7231	1	17.82	2.0632	9500	1674.7	-2	8.6 - 22	Vert. +15	Horiz. -0.252	—	6 - 000	Good flight
7232	5	17.84	2.0577	9800	1694.0	-2	8.6 - 22	Vert. +48 1/4	Horiz. -55	1150	3 - 030	Good flight. After firing gun 0.9 mil up and 0.3 mil left
7233	3	17.82	2.0593	9500	1679.4	-2	8.6 - 22	Vert. +15	Horiz. -0.676	1137	4 - 005	Good flight
7234	7	17.82	2.0618	9700	1678.8	-2	8.6 - 22	Vert. +56 1/4	Horiz. -1.885	—	3 1/2 - 020	Good flight. After firing gun 0.7 mil up and 0.5 mil left
7235	3	17.82	2.0620	9500	1674.7	-2	8.6 - 22	Vert. +30 1/2	Horiz. -0.855	—	4 - 345	Good flight. After firing gun 0.2 mil up 0.3 mil unchanged
7236	6	17.81	2.0643	9700	1673.0	-2	8.6 - 22	Vert. +14 3/4	Horiz. -0.414	—	2 - 015	Good flight
7237	10	17.82	2.0625	9900	1680.6	-2	8.6 - 22	Vert. +32	Horiz. -0.926	—	2 - 355	Good flight
				9700	1667.2	—						
Nuzzle 30.86' 48.15' 39.52' 40.2' 41.2' 42.2' 43.2' 44.2' 45.2' 46.2' 47.2' 48.2' 49.2' 50.2' 51.2' 52.2' 53.2' 54.2' 55.2' 56.2' 57.2' 58.2' 59.2' 60.2' 61.2' 62.2' 63.2' 64.2' 65.2' 66.2' 67.2' 68.2' 69.2' 70.2' 71.2' 72.2' 73.2' 74.2' 75.2' 76.2' 77.2' 78.2' 79.2' 80.2' 81.2' 82.2' 83.2' 84.2' 85.2' 86.2' 87.2' 88.2' 89.2' 90.2' 91.2' 92.2' 93.2' 94.2' 95.2' 96.2' 97.2' 98.2' 99.2' 100.2'												
Center of Impact +0.748 y, -0.676 m Probable Error: Vertical (mils) ± 0.29 By PMS Horizontal (mils) ± 0.24 By PMS												
Proof Director E. Huffman Signed W. M. Miller Observers W. O. Davies L. R. Sweetley												

Table VI (Cont.)

Sheet 2 of 2

Date of Test May 21, 1950
Location Fire Ord Dept

Purpose of Test To determine Accuracy of 7171E12

PROJECTILE

Model 7171
Type E12
Weight _____
C.G. Location _____
Borelet Dia _____
Retard Factor _____
Special Features _____

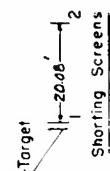
TEST GUN

Model 719
Type 105mm Recoilless
Serial No. _____
Chamber _____
Bushing(Vent) _____
Tube _____
Sighting Equip. _____
Mount _____
Type _____ Ser. No. _____
Constant _____
Firing Mech. _____

MISCELLANEOUS DATA

Range 1000 yds
Propellant: _____
Type _____ Web _____ Weight _____
Lot No. _____
Primer _____
Shell Case _____
Liner _____
Temperatures: _____
Magazine _____
Max. _____ Min. _____ Present _____
Loading Room _____ Ambient _____

Round Number	Proj. Number	Proj. Weight (lb.)	Chamber Pressure (psi) (Cal.)	Muzzle Velocity (fps) (Actual)	Azim. (mils)	Elevation (mils)	Position of Hit (inches)	Corrected Pos. of Hit (mils)	Horiz. Vert.	Horiz. Vert.	Observations
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											



Zero difficult to see so 3rd shot raised to +10 elev. M17 Telescope -1.0 mil left after super elevation put on. After firing bore sight on 0, M17 Telescope 0.3 mil left of bore sight line. Gunners Quadrant at 8.6 mils of +10 mil elevation from target center
* First reading from Col's 1 and 2, second reading from Col's 3 and 4, all activities computed with 0.25 ft/sec retardation

Center of Impact: 0.748V, -0.367H
Probable Error: _____
Vertical (mils) $\pm$ 0.29 by RMS
Horizontal (mils) $\pm$ 0.24 by RMS
Proof Director E. H. Miller Signed W. H. Miller
Observers W. O. Davies
L. P. Swenaby

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Low Temperature (-60°F) Test

Two T171 test slugs, Fig. 6, were fired to determine the effect of low temperature on the roll inducing qualities of the nylon obturator, DRA-14-1281, and the effectiveness of powder ignition by the modified (13 inch) M57 primer. These rounds were placed in the cold box, set at -60°F , at 11:15 on May 6, 1954, and left there until they were fired at approximately 1:30 P. M. on May 10, 1954. The rounds were fired from the T19 rifle, through a series of five yaw cards, and into a recovery box 180 feet from the muzzle. The firing record for this program is shown in Table VII.

These rounds had an average muzzle velocity of 1493 fps, with an average chamber pressure of 5,100 psi, indicating that powder ignition by this primer at this temperature is satisfactory. The spin measured on round 1 was 12 rps, which would be satisfactory for stable flight. At 70°F , spin rates of from 11 to 24 rps have been reported previously (Table IX, Forty-Third Progress Report). The pop-out pins on round 2 did not function, either because of a very low spin, or because the pins were frozen to the projectile. The spin data for round 1 are shown on the firing record.

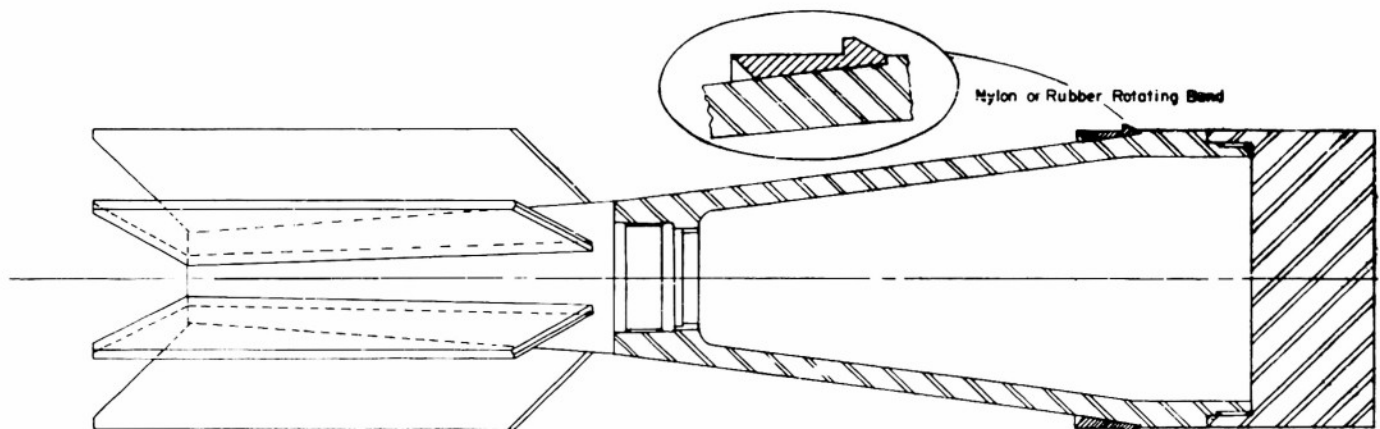


Fig. 6. T171 Test Slug.

Table VII
Range Data
To Test Nylon Band at -60°F

Purpose of Test TO TEST RELIABILITY OF NYLON BAND AS A SPIN INDICATOR
FOR T11Z E10 XB AT -60°F

Date of Test 10 MAY 1954
Location ERIE ORDINANCE DEPOT

PROJECTILE

Model T11Z
Type E 10
Weight 11.5 LB. NOM.
C.G. Location
Borelet Dia 4.132"
Retard Factor 0.5-FL/SEC/ET
Special Features 20P-OUT PIN, BLUNT NOSE,
NYLON BAND.

TEST GUN

Model T19
Type 105 MM. RECOILLESS
Serial No. 6
Chamber 24494-1-1293L
Bushings Verit's 24494-2-300120
Tube 26 12142-2456-2 1-20 TWIST
Sighting Equip. MIL ELBOW TELESCOPE
Mount
Type OLD PENDULUM
Constant 2.52 LB. - SEC./IN.
Firing Mech. ELECTRIC

MISCELLANEOUS DATA

Range RECOVERY BOX
Propellant:
Type MP 110 Web 0.035" Weight 11.8 OZ.
Lot No. PA 30259
Primer 13" M57
Shell Case 73321
Liner DRC - 545
Temperatures: 9°
Magazine
Max. 73 Min. 71 Present 72
Loading Room 75 Ambient 54

Round Number	Proj. Number	Proj. Weight (lb.)	Chamber Pressure (psi) (Cul.)	Muzzle Velocity (fps) (Actual)	Spin	Recoil (in)	Cold Box Temperature (°F)	Observations
7167-1	13	17.49	7-14	1456	14.9	11.9	-67	1 Verit's fully open - Projectile recovered
7168-2	8	17.48	7-14	1464	14.9	11.9	-64	2 Verit's fully open - Projectile recovered
AVERAGE		7-14	5100	1460	14.9	11.9	-64	3 Verit's fully open - Projectile recovered
								4 Verit's fully open - Projectile recovered
								5 NOTE: 8MM faster pin-strikes on both rounds
								6
								7
								8 Rounds placed in Cold Box 1115, 6 May 54. Coll Box set at -60°F.
								9 It is possible that pin was frozen and did not pop-out due to
								10 low spin on round 7168-2. Both pins were visible on same
								11 cards of round 7167-1. Card 3 of 7168-2 had m.A.Y. while the
								12 other five cards showed considerable yaw.
								13
								14
								15
								16
								17
								18
								19
								20
								21
								22

Proof Director EDWARD HUFFMAN

Muzzle to Screen (Coll) Distances
52.30' + 59.67' = 111.97'
Muzzle to 24' + 6.02' + 22.28' + 59.67' + 63.05' + 49.94' = 211.26'

Distances (Yaw Cards) (Spin Screen)

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T120 PROJECTILE

Double Body Projectiles

Various types of bearing systems have been evaluated for the purpose of determining their usability in a double body projectile (Supplements to the Ninth, Thirteenth, Sixteenth, Twenty-Fifth, Twenty-Sixth, Thirty-Fourth, and Thirty-Fifth Progress Reports). It is evident that a double body projectile can operate efficiently only with an adequate bearing system between the two projectile sections. This bearing system must be capable of accepting the thrust load, caused by setback without developing a large frictional torque. Since the thrust loads developed in the BAT weapon are not unreasonable, studies in this laboratory have been directed toward the development of a bearing system capable of accepting the full thrust load.

Early studies with caged thrust bearings indicated that the bearing cage locked the balls or rollers and prevented proper functioning of the bearings, and that cageless bearings gave consistently better results.

Various pivot bearing designs including spherical, hemispherical, and flat types, incorporating different types of oils, greases, and solid lubricants have been evaluated. Tests have continued and

in the latest a DRA 215 and DRA 218 step bearing system coated with Electrofilm Corporation's solid film lubricant Lube-Lok was evaluated and reported in the Supplement to the Thirty-Fourth Progress Report. It should be noted that coefficients of friction of the order of .3 were obtained at low loads for this system, but that with progressively increasing loads the coefficient of friction decreased and was .2 at a bearing pressure of 20,000 psi. Recently Pyrene Manufacturing Company of Newark, New Jersey, suggested a change in the Lube-Lok coating as a possible means of improving the results obtained at low loads and a recent test of the new coating has been completed. For the sake of simplicity in this report, the coating used in the test reported in the Supplement to the Thirty-Fourth Progress Report will be referred to as lubricant No. 1 and the coating used in the current test as lubricant No. 2. (For detailed information on these two coatings see Fig. 8).

Static Tests

Static loads from 500 to 10,000 lbs were applied progressively to the DRA 215-218 bearing system through the testing arrangement shown in Fig. 7. In this test a predetermined load was applied, the torque measured, and the load released, before a succeeding load was applied.

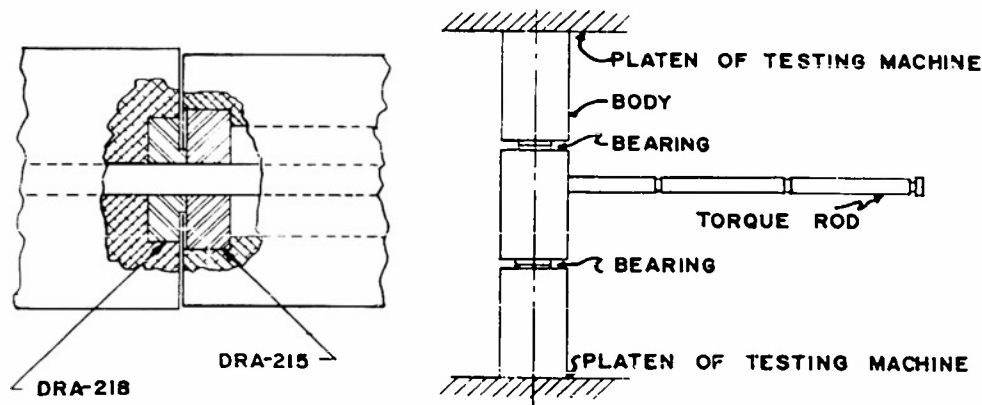


Fig. 7. Bearing System and Static Test Arrangement.

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The loads were increased progressively until the limit of the torque wrench was approached. Table VIII gives the results of this test along with those reported for lubricant No. 1. Fig. 8 shows the load torque curve for the DRA 215-218 bearing system with the two lubricants. At all

loads above 2000 lbs, lubricant No. 2 developed a torque nearly 200 lb-in less than that of lubricant No. 1. However, in neither case, did the static tests with the Lube-Lok coating approach the results obtained using an excess of molycote, (see Fig. 9).

Table VIII
Static Test Data
DRA215-218 Bearing System

Load (Lb.)	Pull (Lb.)	Torque Arm (In.)	Torque Per Two Bearings (Lb.-In.)	Torque Per Bearing System (Lb.-In.)
Lubricant Number 1				
250	8	8	64	17
500	16	8	128	64
750	24	8	192	96
1000	31	8	248	124
1500	42	8	336	168
2250	34	14	476	238
2750	42	14	588	294
3050	45	14	630	315
4050	43	18.63	801.1	400.6
5000	50	18.63	931.5	465.8
6000	57	18.63	1061.9	531.0
Lubricant Number 2				
500	3.0	12	36	18
1000	5.0	12	60	30
3000	14.5	12	174	87
5000	42.0	12	504	252
7000	40.0	18	720	360
8000	53.0	18	954	477
9000	60.0	18	1080	540
10000	46.0	24	1103	551.5

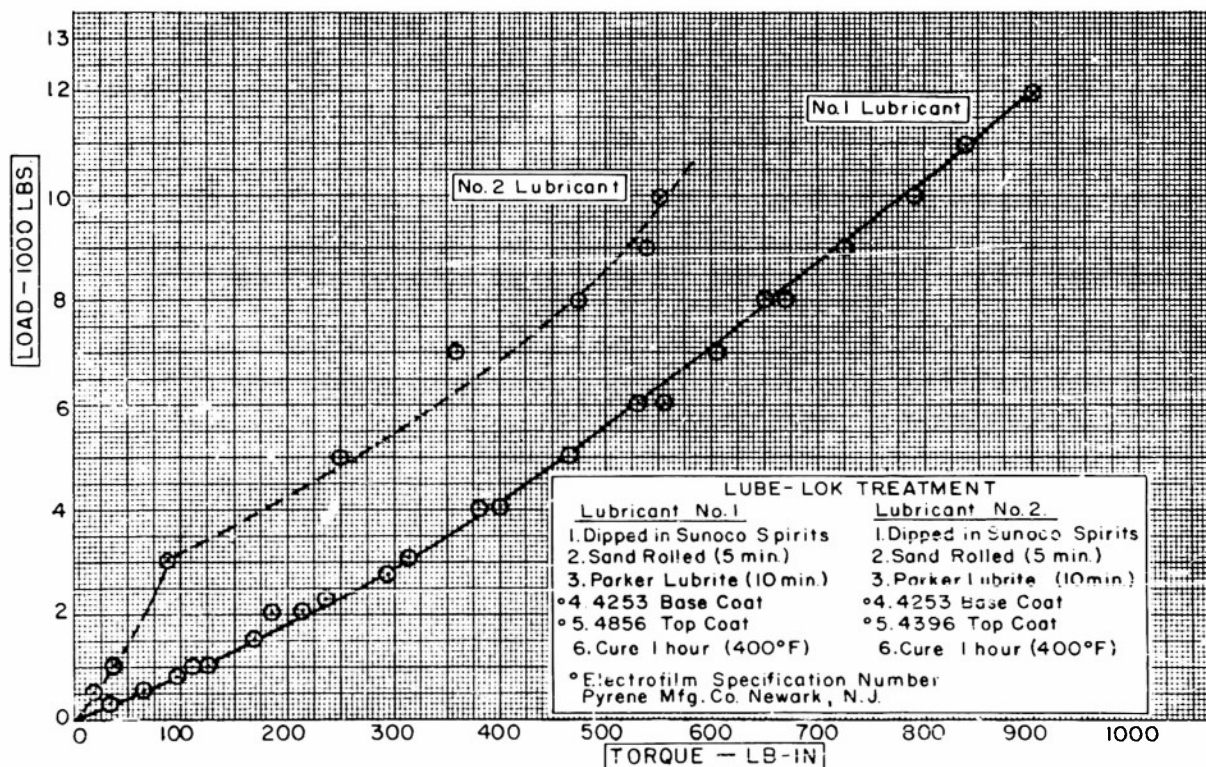


Fig. 8. Load Torque Behavior.
DRA215-218 Bearing System.

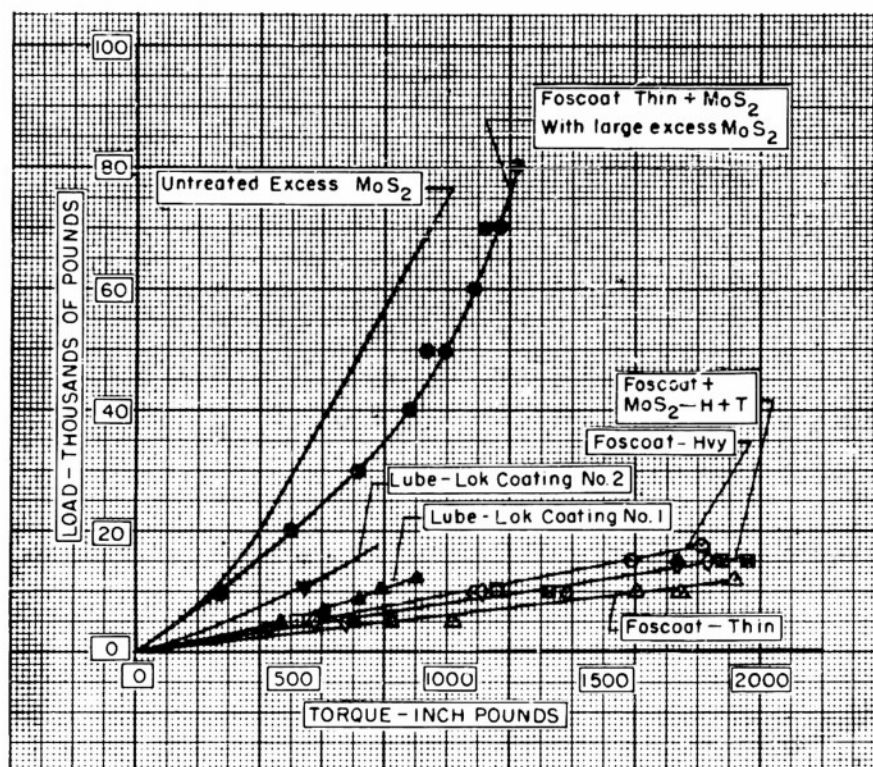


Fig. 9. Load Torque Behavior.
DRA215-218 Bearing System.

Dynamic Tests

To evaluate the No. 2 Lube-Lok coating under dynamic loading conditions, two double-body test projectiles with DRA 215-218 bearing systems treated with this lubricant were fired from a T19 rifle, through spin screens, into a recovery box. Table IX is a record of the firing data and illustrations of the projectiles used appear there.

The first round had a measured spin rate of 26 rps between spin screens 1 and 2, and a spin rate of 28.6 rps between spin screens 2 and 3 (calculated on the assumption that the velocity was the same as for projectile No. 2). The second round had a spin rate of 18.7 rps between spin screens 1 and 2, and a spin rate of 19.9 rps between spin screens 2 and 3. The results indicate the "non-rotating" section of each projectile was rotating at a rate equal to approxi-

mately 10% to 12% of the spin imparted to the projectile by the tube, and that there may have been an approximate 1% increase in spin rate between the first and second screen pairs, a distance of 12.45 ft. The latter observation is not believed to be sufficiently precise to be significant.

No muzzle velocity was obtained for the first round because of a malfunction in the chronograph. A reading was obtained which resulted in a calculated muzzle velocity of 2834 fps (instrumental), but this is obviously in error since earlier firing tests under similar conditions gave velocities of between 1650 and 1700 fps, which is in agreement with the 1655 fps muzzle velocity obtained for the second round. Both projectiles were recovered and an examination of the bearings disclosed severe wear of the Lube-Lok surface and some brinelling of the bearings.

Table IX
Range Data
To Investigate Spin Of Double Body Projectile

Date of Test 26 MARCH 1954
Location ERIE ORDNANCE DEPOT

Purpose of Test TO CHECK SPIN OF DOUBLE BODY PROJECTILE

PROJECTILE

Model DOUBLE BODY

Type 17.5 lb. (Nom.)

C.G. Location 4.182 - .002

Retard. Factor 1.19

Special Features ORA 215-218

BEARING SYSTEM

TEST GUN

Model 7.19

Type 106mm Recoilless

Serial No. 6

Chamber (L) 2642-11391

Bushing (Vent) YA 884

Tube 1532-7-12162

Sighting Equip. M17 E/Bow

Mount Type 12nd Lmk. Ser. No.

Constant 2.38 / 6.35 / in.

Firing Mech.

MISCELLANEOUS DATA

Propellant: Small Recovery Box

Type ME 012 Web 035 in Weight 215-1902

Lot No. 1A-30259

Primer 157

Shell Case 163 EL

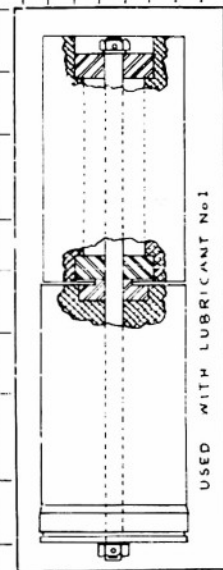
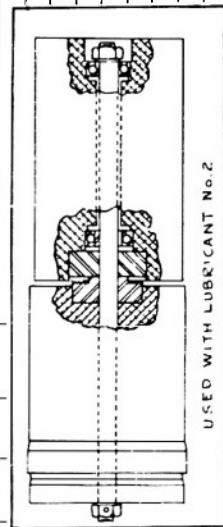
Liner Reco type

Temperatures:

Magazine Max 73°F Min 71°F Present 71°F

Loading Room 68°F Ambient 43°F

Round Number	Proj. Number	Proj. Weight (lb.)	Chamber Press (psi) (Cu)	Muzzle Velocity (fps)	Actual	Azim. (mils)	Elevation (mils)	Position of Hit (inches)	Corrected Posit. of Hit - (mils)	Verit. Horiz.	Observations
7004 1	1752	7-14	9700	1655	1683						2 R 1 Unsealed Bearing ① Misfire
7005 2	1752	7-14	9700	1655	1683						2 R 2 Sealed Bearing
3											3
4											4
5											5
6											6
7											7
8											8
9											9
10											10
11											11
12											12
13											13
14											
15											
16											
17											
18											
19											
20											
21											
22											



Muzzle 100.85' 2 6.19' 1876' 3
Screen (Coll) Distances
Proof Director R. Devue Proof Dia M. Marafsky

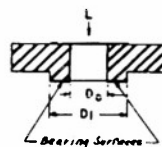
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Coefficient Of Friction, Static and Dynamic

Coefficients of friction for DRA 215-218 bearings with each lubricant were calculated for each of the loads applied in the

static tests of Table VIII. The results are shown in Table X and the bearing pressure-coefficient of friction relationship is shown in Fig. 10.

Table X
Coefficient Of Friction
DRA215-218 Bearing System Under Load



$$T = \frac{\mu L}{3} \left(\frac{D_o^3 - D_i^3}{D_o^2 - D_i^2} \right)$$

T = torque due to resistance of bearing surface
 μ = coefficient of friction of bearing
 L = load applied to bearing
 D_o = outside diameter of bearing surface
 D_i = inside diameter of bearing surface

Unit
 lb-in
 lb
 in
 in

For Collar Step DRA-218

$$\mu = \frac{T}{L} \left(\frac{3}{1.18945} \right) = \left(\frac{T}{L} \right) 2.5653$$

L Load	L/A Bearing Pressure	T Friction Torque	T / L	μ Coefficient of Friction
Lubricant No 1				
1000	1709.1	125	.124	.3207
2000	3418.2	225	.1125	.2886
3000	5127.3	315	.105	.2694
4000	6836.4	390	.0975	.2501
5000	8545.5	465	.0910	.2366
6000	10254.7	530	.0883	.2265
7000	11963.8	595	.0850	.2181
8000	13672.9	665	.0831	.2132
9000	15382.0	725	.0806	.2068
10000	17091.0	785	.0785	.2014
11000	18800.2	840	.0764	.1959
12000	20509.3	900	.0750	.1914
Lubricant No 2				
500	855	18	.036	.0924
1000	1709.1	30	.030	.0769
3000	5127.3	87	.029	.0744
5000	8545.5	242	.051	.1308
7000	11963.8	360	.052	.1354
8000	13672.9	477	.059	.1514
9000	15382.0	540	.060	.1539
10000	17091.0	551.5	.055	.1411

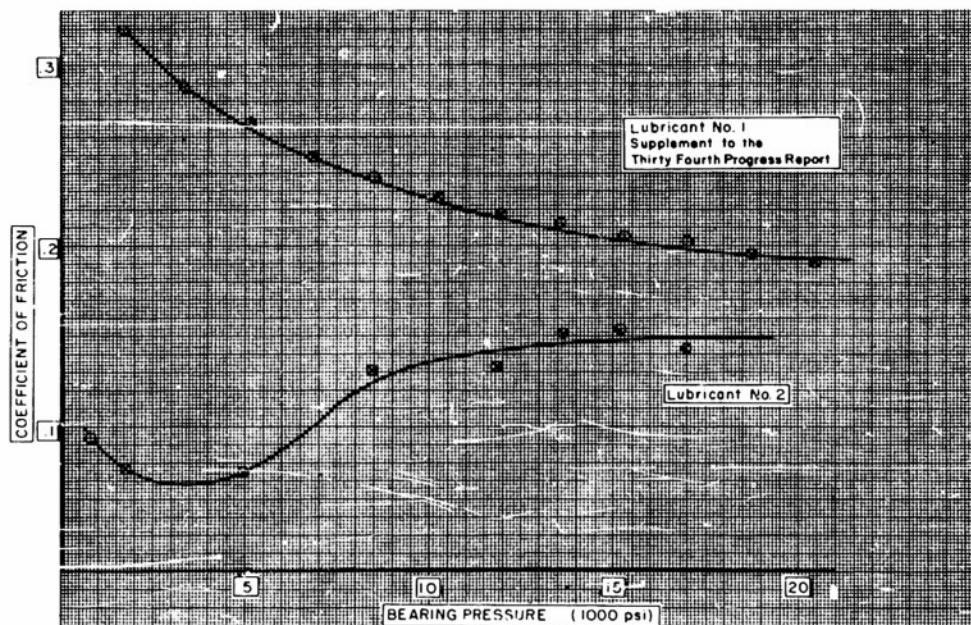


Fig. 10. Effect Of Bearing Pressure.
 On Coefficient Of Friction,
 DRA215-218 Bearing System.

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As was stated earlier in this report, the primary purpose of this current test was to determine whether this new lubricant would be effective in lowering the coefficient of friction at low loads. It is relatively clear from the graphs (Figs. 8 and 10) that this has been accomplished; however, as the loading is progressively increased the new lubricant appears to undergo a change at some point between 2000 and 4000 lbs and additional points seem to parallel very closely those plotted for lubricant No. 1. It appears that the coefficient of friction for lubricant No. 2 is leveling off at a value of approximately 0.15 in comparison with 0.2 reported for lubricant No. 1.

Using the calculated pressure-time curve shown in Fig. 11, page 16, of the Supplement to the Thirteenth Progress Report, and the known physical constants of this system, average effective coefficients of friction for the dynamic test were calculated to be between .028 and .038 with the No. 2 lubricant. However, it should be pointed out that the double body projectile assemblies used in this test differed from those of the earlier test in that they incorporated a Fafnir angular contact bearing, number 7201 K, as a pilot bearing in place of the DRA 215 pilot bearing. It is believed that the 7201 K bearing minimizes side thrust and largely eliminates the torque which would result from this side thrust. Therefore, it is not certain whether the lower spin rates obtained in the dynamic tests with the No. 2 lubricant results from the lubricant alone or from the 7201 K bearing.

Dynamic Tests Of Compensating Liners

The problems involved in selecting a projectile for dynamic firing tests with spin compensating liners were discussed in the Forty-Fourth Progress Report. Initial tests were conducted using T119-E10 projectiles, equipped with rotating bands and fins modified to maintain a pre-

determined spin rate over the desired target range of 500 ft. However, measured spin for these projectiles indicated an approximate decrease of 50% over that spin imparted to the projectile by the tube. Data for this test are reported in the Forty-Fourth Progress Report. In that report a future program was outlined in which T138-E57 projectiles were to be modified to include a cylindrical section between the tee and body, thus providing the added clearance required for penetration. Projectiles with sleeves 1 in and 2 in long were prepared and have been tested for accuracy.

T138E57 Projectiles

Fifteen T138E57 projectile were used for this test. Five rounds were assembled with a 1 inch sleeve placed between the tee and body and a second group of five rounds were assembled with a 2 inch sleeve placed between the tee and body. The remaining five rounds were assembled as standard T138E57 projectiles (without sleeve) and were fired as control rounds (see Fig. 11 for assemblies). All were inert loaded and fired for accuracy at a 478 ft. target. Each projectile was equipped with a DRB 360 rotating band and fired through a T137-E3 rifle with a 1/80 twist tube so as to have a muzzle spin rate of 60 rps at 1700 fps muzzle velocity. Table XI is the firing record for this test. The target used was a plywood panel (4'x8'x1/2") located 478 ft from the muzzle of the gun. Fig. 12 shows the target and position of hit. Table XII is a summary of the results obtained from this test.

These data show that reasonable accuracy can be maintained over a 500 ft range with the T138E57 projectile using both the 1 inch and 2 inch sleeves. Since the spin rate of this projectile can also be controlled by the use of rotating bands and a tube with the proper twist, similar projectiles will be used as carriers for dynamic fluted cone tests.

Table XI
Range Data
Flight Test T13857 Projectile With Sleeve

Date of Test 28 April 1954
Location Eric Ordnance Depot

Purpose of Test Flight Test T13857 Projectile With Sleeve

PROJECTILE

Model T138X
Type TEE
Weight 17.9 lb (Nom)
C.G. Location Varies
Bore/rel Dia 4.132 - .002
Retard Factor 2.35
Special Features TEE RINGS
DRB1034 & DRB1035

TEST GUN

Model T122E3
Type 106 mm Recoilless
Serial No. 3
Chamber 228-5147-L-8
Bushing(Nom) 220-155-K
Tube 100-228-345-E
Sighting Equip T183-521 (Base Sight)
Mount:
Type T152E5 Ser. No. 1
Constant
Firing Mech. ONIOS

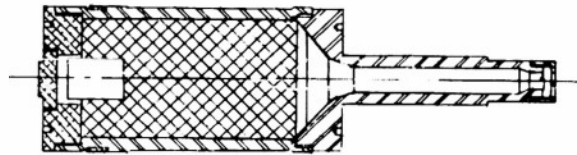
MISCELLANEOUS DATA

Range 4200 Ft.
Propellant:
Type MPMLQ Web 0.85 in Weight 14.143
Lot No. PA-30257
Primer M457
Shell Case 16261
Liner T59
Temperatures:
Magazine
Max. 73°F Min. 71°F Present 73°F
Loading Room 91°F Ambient 52°F

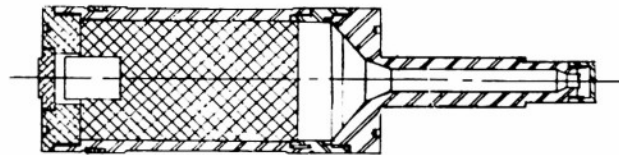
Round Number	Proj. Number	Proj. Weight (lb.)	Propell. Weight (lb.-oz.)	Chamber Pressure (psi) (Cu)	Muzzle Velocity (fps)	Azim. (mils)	Elevation (mils) zero super	Position of Hit (inches)		Corrected Posit. of Hit - (mils)	Observations
								Vert.	Horiz.		
7115-1	TR-1	16.96	7-14	5300	1699			-7	-8	-408	4 1/2
7116-2	TR-2	16.96	7-14	9490	1676			-6 1/2	-5	-379	4 1/2
7117-3	TR-3	16.96	7-14	9900	1682			-12 1/2	0	-729	4 1/2
7118-4	TR-4	16.96	7-14	8700	1691			0	+1	0	4 1/2
7119-5	TR-5	16.98	7-14	9400	1688			+4 1/2	-1 1/2	+262	4 1/2
7120-6	TR-6	17.57	8-0	10600	1659			+14	-8	+817	4 1/2
7121-7	TR-7	17.57	8-0	10600	1657			+12	-8 1/2	+700	4 1/2
7122-8	TR-8	17.57	8-0	10600	1656			-1 1/2	-5	-291	4 1/2
7123-9	TR-9	17.56	8-0	10500	1676			0	+13	0	4 1/2
7124-10	TR-10	17.56	8-0	10600	1657			+4	+7	+535	4 1/2
7125-11	TR-11	18.70	8-0	10300	1622			+2 1/2	+20 1/2	+196	4 1/2
7126-12	TR-12	18.76	8-0	10500	1611			+3 1/2	-18 1/2	+206	4 1/2
7127-13	TR-13	18.74	8-2	10700	1637			+10	+3 1/2	+583	4 1/2
7128-14	TR-14	18.78	8-2	10600	1642			+5	+5 1/2	+291	4 1/2
7129-15	TR-15	18.76	8-2	10500	1625			-10	+10	-583	4 1/2
16											
17											
18											
19											
20											
21											
22											

Muzzle 1 - 5336' + 40.91' 2
Screen (Call) Distances
Proof Director E. HUFMAN PROOF DIR M. MENOFFSKY

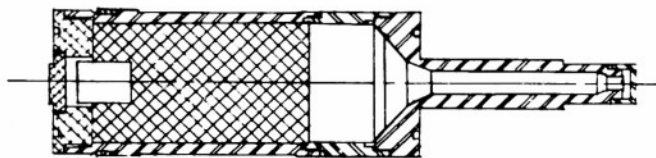
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T138E57 PROJECTILE

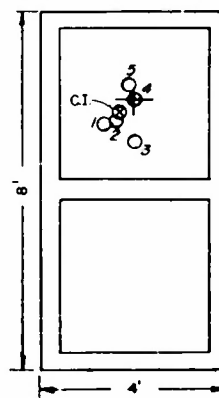
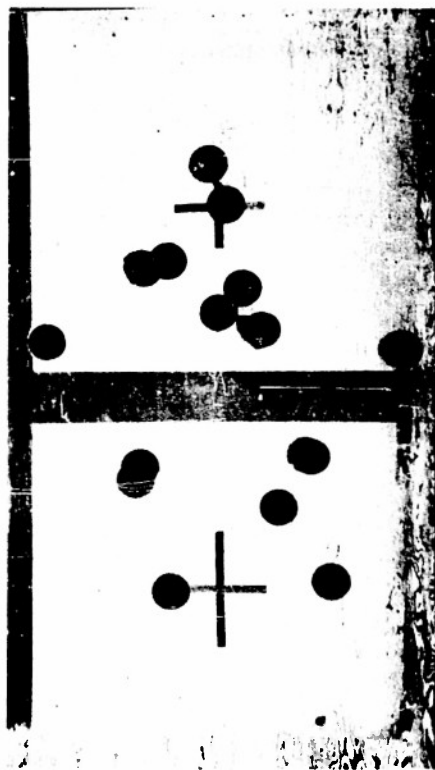


SAME AS ABOVE USING 1" SLEEVE

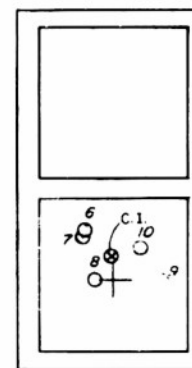


SAME AS ABOVE USING 2" SLEEVE

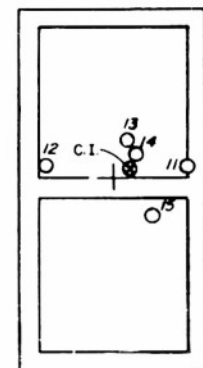
Fig. 11. T138E57 Projectile Assemblies.
With and Without Sleeves.



Group 1 - No Sleeve
TR 1 through TR 5



Group 2 - 1 in. Sleeve
TR 6 through TR 10



Group 3 - 2 in. Sleeve
TR 11 through TR 15

Fig. 12. Target Showing Position Of Hits.
T138E57 Type Projectiles (With and Without Sleeves).

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Table XII
Summary Of Flight Test Results
T138E57 Type Projectiles

Round Number	Aiming Point	Center of Impact (mil)		Probable Error (mil)		
		Vertical	Horizontal	Vertical	Horizontal	
GROUP No. 1 NO SLEEVE		-.250	-.232	±.257	±.250	
TR1-5	Center Of Upper Half Of Target					
GROUP No. 2 1-INCH SLEEVE		+.406	-.017	±.260	±.564	
TR6-10	Center Of Lower Half Of Target					
GROUP NO. 3 2-INCH SLEEVE		+.128	+.244	±.289	±.825	
TR11-15	Center of Band Of Tape					
			Group 1	Group 2	Group 3	
			Average Projectile Weight (lb)	16.46	17.55	18.75
			C.G. Location From Base (in)	4.95	5.36	5.83
			Axial Moment Of Inertia (lb-in ²)	43.0	44.26	46.59
			Transverse Moment of Inertia (lb-in ²)	204.0	231.4	271.0

Future Program

1. Serrated Liners

a. Effect of Index Angle

Two lots of cones of the DRD78 type, described in the Supplement to the Thirty-Fourth Progress Report, having index angles of 5° and 20°, and having minimum wall thickness of .100 in. have been tested and will be reported in the June report.

b. DRD433 item 2 and item 3 cones (Index angle 6° and 2°, respectively) are being manufactured. These cones have 50 "matching" flutes .034 in. deep at the base datum and a wall thickness of .100 in.

c. DRD429 item 2. These cones have 16 "matching" flutes, .034 in. deep at the base datum and a wall thickness of .100 in. Index angle is 6°. Flute orientation is the reverse of DRD78.

d. DRD434 item 2. Same as (c) except flute depth is .060 in.

e. Scaling Studies

DRD267 (3.5 in. base x .100 in. wall);
DRB704 (3.0 in. base x .087 in. wall);
DRB703 (2.5 in. base x .071 in. wall).
These cones to have 60 flutes machined in outside to a depth of .010 in., .0085 in., and .0069 in. at base datum for each of three sizes.

f. Threaded Cones

DRB998, threaded inside, 60°V threads
28/in., .0097 in. deep, .0357 in. pitch.

DRB999, triple threaded inside, 60°V threads, 84/in., .0097 in. deep, .0119 in. pitch, .0357 in. lead.

DRB1000, threaded outside, 60°V threads, 28/in., .0375 in. pitch, .0097 in. deep.

DRB1001, triple threaded outside, 60°V threads, 84/in. .0357 in. lead, .0119 in. pitch, .0097 in. deep.

The above cones are being tested.

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2. Double Body Projectile Study.

a. Six projectiles are to be fired to complete the study on the determination of minimum wall thickness required in non-rotated body. The projectiles have wall thicknesses as follows:

(1) 2 rounds with .180 in. wall (alum) in rear body.

(2) 2 rounds with .120 in. wall (alum) in rear body.

(3) 2 rounds with .060 in. wall (alum) in rear body.

Assemblies are being inspected.

b. Determination of Strength of Tee Or Boom. Tees of five different designs and strength, using both aluminum and steel, are to be tested. Manufacture is completed and tests are scheduled for June.

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PENETRATION STUDIES

Aluminum Cones, Effect Of Spin

The present experiment was undertaken to determine the effect of spin and cone wall thickness on the performance of machined 2S-F aluminum cones at standoffs of 7.5 inches and optimum standoffs of 42 inches for a .100-inch wall and 48 inches for a .200-inch wall cone. The effect of standoff and cone wall thickness and a comparison of 2S-F and Alloy No. 43 aluminum cones were presented in the Thirty-Eighth Progress Report.

In this experiment the cones were made

to DRB 398 HW3 specifications and assembled in DRC 376 test assemblies with No. 2 Nose Rings (Figs. 35 and 36 of the Thirty-Seventh Progress Report). The cones were machined from 2S-F bar stock to wall thicknesses of .100 in. (Item 1) and .200 in. (Item 5). Copper DRB 398 HW3 Item 1 cones were used as controls for the study.

The cone inspection data are recorded in Tables XIII, XIV and XVI. The penetration data are shown in Tables XVII, XVIII and XX and in Fig. 13.

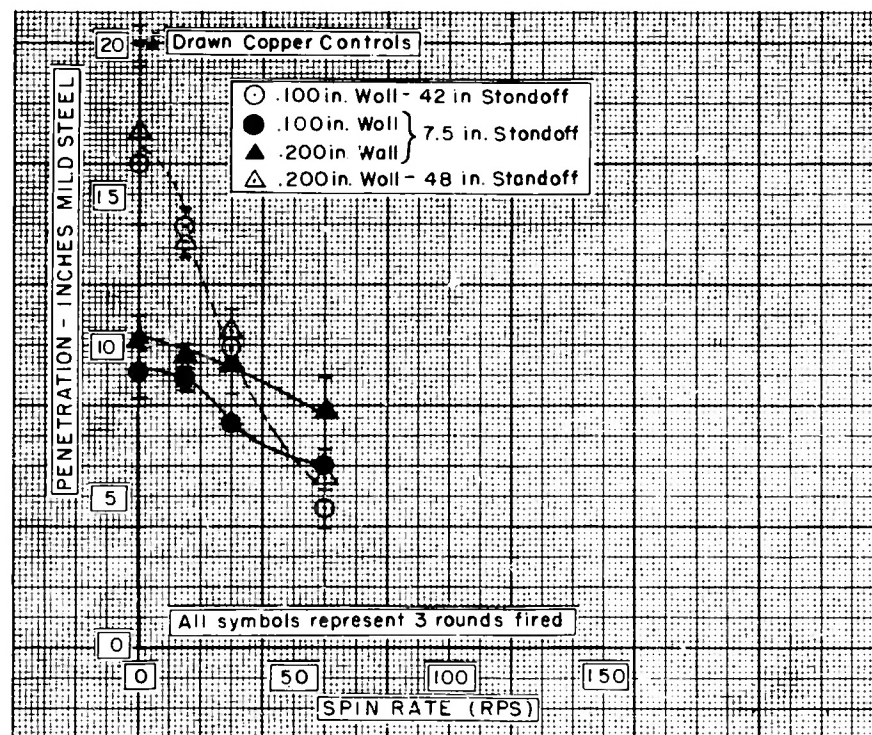


Fig. 13. Penetration Versus Rotation.
Effect Of Spin On Aluminum Cone Performance.

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

The following observations are pertinent:

1. The .200-inch wall cone performs better at the 7.5 in. standoff than the .100-inch wall cone at all the spin rates up to 60 rps.
2. The performances of both the .100 and .200-inch wall cones at their optimum standoffs of 42 and 48 inches, respectively, are quite similar and a single curve can be drawn representing both sets of test data.
3. The level of penetration at the longer standoff is, in each case, higher than at the 7.5 inch standoff for spin rates below 35 rps. At higher spin rates the performance of the rounds fired at longer standoffs falls off more rapidly than at the 7.5-inch standoff and at 60 rps their penetration is lower.

DRB-23-974-2 Heavy Apex Cones

This experiment was performed to determine the penetration efficiency of a heavy apex, copper cone. The cones were made to DRB-23-974-2 specifications as shown

in Fig. 14 and assembled into DRC 376 test assemblies with No. 2 Nose Rings. The cones were machined from copper bar stock to a wall thickness of .100 in. in the lower region which increased to .200 in. at the apex. Copper DRB 398 HW3 item 1 cones were used as controls for this study.

The cone inspection data are shown in Tables XV and XVI and the penetration data are recorded in Tables XIX and XX. A comparison is made with the controls in the following table.

Cane Drawing No.	Average Penetration (inches M.S.)	Max.Spread (in.)	Std.Deviation (in.)
DRB-23-974-2	22.11	3.57	± 1.40
DRB 398 HW3 Item 1	20.02	1.63	± .60

The average penetration of the DRB-23-974-2 cones is considerably higher than the controls at the 7.5-inch standoff considered. It is believed that the design of the apex aids the collapse mechanism of the cone in a manner similar to that of a cone with a flash back tube.

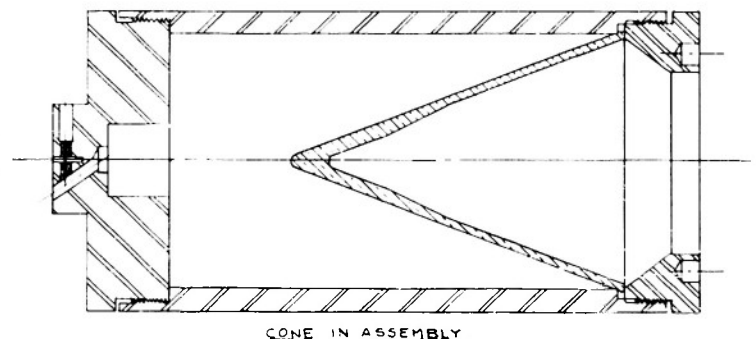
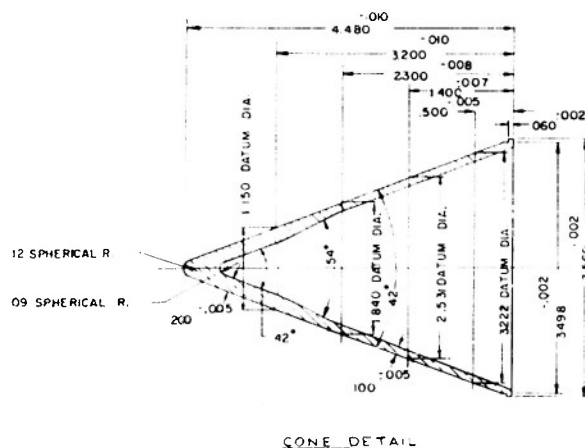


Fig. 14. Heavy Apex Copper Cone.
Firestone Drawing DRD-23-974-2.

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Table XIII
Inspection Data
Aluminum DRB398 HW3 Item 1 Cones

Cone Number	Wall Thickness (inches)			Max Wall Thickness Variation (inch)		Max Wall Waviness (inch)		Concentricity - T.I.R. ^{1,2}		
	Max	Min.	Avg.	Transv.	Longitud.	O. D.	I. D.	Base Datum	Apex Datum	Cone Tip in Assembly
Specification DRB 398 HW3										
Item 1	.105	.100		.002	.006	.006	.006	.003	.003	Nominal .015
A171	.103	.101	.1019	.001	.002	<.001	<.001	.002	.002	.007
A172	.102	.096	.1001	.001	.004	<.001	<.001	.002	.003	<.001
A173	.103	.101	.1019	.001	.002	<.001	<.001	.001	.004	.005
A174	.102	.101	.1015	<.001	.001	<.001	<.001	.001	.001	.003
A175	.103	.102	.1025	<.001	.002	<.001	<.001	.001	.001	.008
A176	.103	.101	.1020	<.001	.002	<.001	<.001	.003	.002	.003
A177	.102	.100	.1014	.001	.002	<.001	<.001	.002	.003	.006
A178	.103	.102	.1024	.001	.001	<.001	<.001	.001	.001	.004
A179	.103	.101	.1021	.001	.002	<.001	<.001	.002	.001	.008
A180	.104	.103	.1035	<.001	.001	<.001	<.001	.002	.001	.004
A181	.103	.100	.1015	<.001	.003	<.001	<.001	.002	.002	.002
A182	.102	.100	.1012	.001	.002	<.001	<.001	.002	.001	.004
A183	.102	.099	.1004	.003	.002	<.001	<.001	.002	.001	.010
A184	.103	.100	.1019	.001	.003	<.001	<.001	.002	.001	.004
A185	.103	.102	.1025	<.001	.001	<.001	<.001	.002	.005	.006
A186	.104	.102	.1030	<.001	.002	<.001	<.001	.004	.003	.008
A187	.104	.101	.1027	.001	.003	<.001	<.001	.001	.001	.012
A188	.104	.101	.1022	.001	.003	<.001	<.001	.003	.001	.009
A189	.104	.100	.1020	.001	.003	<.001	<.001	.003	.003	.006
A190	.104	.103	.1035	<.001	.001	<.001	<.001	.001	.002	.006
A191	.103	.102	.1025	<.001	.001	<.001	<.001	.003	.003	.003
A192	.104	.102	.1032	.001	.002	<.001	<.001	.003	.003	.005
A193	.103	.102	.1025	<.001	.001	<.001	<.001	.003	.005	.003
A194	.103	.102	.1025	<.001	.001	<.001	<.001	.002	.003	.004
A195	.103	.102	.1025	<.001	.001	<.001	<.001	.002	.002	---
Avg.	.1031	.1011	.1021	.0006	.0019	<.001	<.001	.0021	.0022	.0054
Std. Dev.	±.0007	±.0012	±.0008	±.0007	±.0008	----	----	±.0008	±.0012	±.0027
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.										
3. * Held for Display.										

Table XIV
Inspection Data
Aluminum DRB398 HW3 Item 5 Cones

Cone Number	Wall Thickness (inches)			Max Wall Thickness Variation (in)		Max Wall Waviness (inch)		Concentricity - T.I.R. ^{1,2}		
	Max	Min.	Avg.	Transv.	Longitud.	O. D.	I. D.	Base Datum	Apex Datum	Cone Tip in Assembly
Specification DRB 398 HW3										
Item 5	.205	.200		.002	.006	.006	.006	.003	.003	Nominal .015
A196	.203	.201	.2020	<.001	.002	<.001	<.001	.003	.003	.004
A197	.202	.200	.2015	.002	.001	<.001	<.001	.002	.002	.007
A198	.203	.201	.2022	.001	.002	<.001	<.001	.003	.007	.007
A199	.203	.199	.2010	.002	.003	<.001	<.001	.002	.003	.011
A200	.205	.204	.2045	.002	.003	<.001	<.001	.003	.004	.006
A201	.204	.204	.2040	<.001	<.001	<.001	<.001	.002	.002	.008
A202	.203	.202	.2025	<.001	.001	<.001	<.001	.005	.005	.005
A203	.203	.202	.2025	<.001	.001	<.001	<.001	.003	.003	.007
A204	.206	.204	.2048	.001	.002	<.001	<.001	.002	.005	.009
A205	.203	.203	.2030	<.001	<.001	<.001	<.001	.002	.004	.005
A206	.204	.203	.2035	<.001	.001	<.001	<.001	.001	.004	.009
A207	.203	.203	.2030	<.001	<.001	<.001	<.001	.002	.002	.003
A208	.201	.200	.2005	<.001	.001	<.001	<.001	.004	.006	.003
A209	.202	.200	.2010	<.001	.002	<.001	<.001	.004	.005	.006
A210	.202	.201	.2015	.001	.001	<.001	<.001	.003	.007	.006
A211	.203	.202	.2027	.001	.001	<.001	<.001	.002	.004	.003
A212	.203	.201	.2017	.001	.002	<.001	<.001	.002	.006	.006
A213	.202	.201	.2017	.001	.001	<.001	<.001	.002	.006	.006
A214	.202	.201	.2015	<.001	.001	<.001	<.001	.002	.004	.002
A215	.200	.200	.2000	<.001	<.001	<.001	<.001	.002	.003	.002
A216	.200	.200	.2000	<.001	<.001	<.001	<.001	.005	.002	.009
A217	.203	.202	.2025	<.001	.001	<.001	<.001	.001	.003	.006
A218	.202	.201	.2015	<.001	.001	<.001	<.001	.003	.003	.009
A219	.202	.201	.2019	.001	.001	<.001	<.001	.004	.003	.007
A220	.203	.202	.2025	<.001	.001	<.001	<.001	.003	.002	---
Avg.	.2027	.2015	.2021	.0005	.0012	<.001	<.001	.0027	.0039	.0061
Std. Dev.	±.0013	±.0014	±.0012	±.0007	±.0008	----	----	±.0011	±.0016	±.0024
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.										
3. * Held for display.										

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Table XV
Inspection Data
DRB-23-974-2 Heavy Apex Cone

Cone Number	Wall Thickness - 500" Datum			Wall Thickness - 2300" Datum			Wall Thickness - 3200" Datum			Transverse Max. Wall Thickness Variation (in.)			Max. Wall Waviness O. D. (in.)	Concentricity - T. I. R. ^{1,2}		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	500" Datum	2300" Datum	3200" Datum		500" Datum	3200" Datum	Cone Tip in Assembly
Specification DRB-23-974-1	.100	.095		.100	.095		.200	.195		.001	.001	.001	.003	.003	.003	Nominal .015
D21	.101	.100	.1005	.101	.100	.1002	.205	.204	.2042	.001	.001	.001	.002	.002	.002	.005
D22	.102	.100	.1010	.101	.100	.1008	.204	.203	.2032	.002	.001	.001	.002	.003	.003	.002
D23	.099	.097	.0980	.099	.098	.0982	.194	.194	.1940	.002	.001	< .001	.002	.003	.003	.004
D24	.102	.100	.1008	.102	.100	.1008	.195	.195	.1950	.002	.002	< .001	.002	.002	.001	.010
D25	.102	.100	.1015	.101	.100	.1002	.193	.193	.1930	.002	.001	< .001	.002	.002	.001	.005
* D26	.100	.099	.0998	.101	.100	.1008	.203	.203	.2030	.001	.001	< .001	.001	.003	.003	----
Avg.	.1010	.0993	.1002	.1008	.0997	.1002	.1990	.1987	.1987	.0017	.0012	.0003	.0018	.0025	.0020	.0052
Std. Dev.	±.0013	±.0013	±.0012	±.0010	±.0009	±.0010	±.0056	±.0052	±.0052	±.0006	±.0004	±.0006	±.0004	±.0006	±.0009	±.0030

Notes:
1. The datum locations were .500, 2.300, and 3.200 inches above the base of the cone.
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 for display.

Table XVI
Inspection Data
DRB398 HW3 Item 1 Copper Controls

Cone Number	Wall Thickness (inch)			Max. Wall Thickness Variation (in.)		Max. Wall Waviness (inch)		Concentricity - T. I. R. ^{1,2}		
	Max.	Min.	Avg.	Transv.	Longitud.	O. D.	I. D.	Base Datum	Apex Datum	Cone Tip in Ass'y
Specification DRB 398 HW3										Nominal
Item 1	.105	.100		.002	.006	.006	.006	.003	.003	.015
G16	.105	.100	.1027	.002	.004	.002	.001	.004	.004	.011
G17	.103	.102	.1025	< .001	.001	.003	.001	.002	.002	.004
G18	.104	.101	.1031	.002	.003	.002	.001	.004	.004	.003
G19	.106	.103	.1042	.003	.001	.003	.001	.006	.007	.010
G20	.105	.100	.1026	.001	.005	.003	.001	.006	.003	.007
Avg.	.1046	.1012	.1030	.0016	.0028	.0026	.0010	.0044	.0040	.0070
Std. Dev.	±.0012	±.0013	±.0007	±.0012	±.0018	±.0007	-----	±.0017	±.0019	±.0035

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.

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Table XVII
Penetration Data
DRB398 HW3 Item 1, 2S-F Aluminum Cones

Serial No.	Comp. B (lbs.)	Rotation (rps)	Standoff (in.)	Penetration (inches M.S.)	Max. Spread (in.)	Std. Deviation (in.)
A171	2.52	0	7.5	8.44	1.50	± 0.77
A172	2.52	0	7.5	9.94		
A173	2.50	0	7.5	8.88		
				Avg. 9.09		
A174	2.52	15	7.5	8.81	0.69	± 0.36
A175	2.52	15	7.5	9.31		
A176	2.50	15	7.5	8.62		
				Avg. 8.91		
A177	2.52	30	7.5	7.44	0.37	± 0.19
A178	2.50	30	7.5	7.19		
A179	2.52	30	7.5	7.56		
				Avg. 7.40		
A180	2.52	60	7.5	6.12	1.00	± 0.51
A181	2.52	60	7.5	6.44		
A182	2.52	60	7.5	5.44		
				Avg. 6.00		
A183	2.52	0	42.0	14.19	3.87	± 1.95
A184	2.52	0	42.0	18.06		
A185	2.52	0	42.0	15.75		
				Avg. 16.00		
A186	2.52	15	42.0	14.19	1.19	± 0.64
A187	2.52	15	42.0	14.38		
A188	2.52	15	42.0	13.19		
				Avg. 13.92		
A189	2.52	30	42.0	11.38	2.50	± 1.30
A190	2.52	30	42.0	9.50		
A191	2.52	30	42.0	8.88		
				Avg. 9.92		
A192	2.52	60	42.0	4.81	1.38	± 0.71
A193	2.50	60	42.0	5.19		
A194	2.52	60	42.0	3.81		
				Avg. 4.60		

Notes:

1. DRB 398 HW3 Item 1 (.100 wall) machined 2SF aluminum cones were assembled into DRC 376 penetration assemblies using the No. 2 nose ring.
2. All rounds were loaded at Ravenna Arsenal, BAT Lot No. 54 using Holston Comp. B Lot 4-1197.
3. All rounds were fired at the Erie Ordnance Depot.

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Table XVIII
Penetration Data
DRB398 HW3 Item 5, 2S-F Aluminum Cones

Serial No.	Comp. B (lbs.)	Rotation (rps)	Standoff (inches)	Penetration (inches M.S.)	Max. Spread (in.)	Standard Deviation (in.)
A196	2.52	0	7.5	10.94		
A197	2.50	0	7.5	10.38		
A198	2.52	0	7.5	9.38		
				Avg. 10.23	1.56	± .79
A199	2.52	15	7.5	9.31		
A200	2.52	15	7.5	9.94		
A201	2.52	15	7.5	9.94		
				Avg. 9.73	0.63	± .36
A202	2.52	30	7.5	9.00		
A203	2.52	30	7.5	10.81		
A204	2.50	30	7.5	8.75		
				Avg. 9.52	2.06	± 1.12
A205	2.52	60	7.5	7.25		
A206	2.50	60	7.5	9.00		
A207	2.52	60	7.5	6.69		
				Avg. 7.65	2.31	± 1.20
A208	2.52	0	48	19.69		
A209	2.50	0	48	15.50		
A210	2.50	0	48	16.19		
				Avg. 17.13	4.19	± 2.25
A211	2.52	15	48	13.25		
A212	2.52	15	48	12.94		
A213	2.50	15	48	13.94		
				Avg. 13.38	1.00	± 0.51
A214	2.52	30	48	10.69		
A215	2.52	30	48	10.94		
A216	2.50	30	48	9.81		
				Avg. 10.48	1.13	± 0.59
A217	2.52	60	48	6.06		
A218	2.54	60	48	5.56		
A219	2.54	60	48	5.19		
				Avg. 5.60	0.87	± 0.44

Notes:

1. DRB 398 HW3 Item 5 (.200 wall), machined 2SF aluminum cones were assembled into DRC 376 penetration assemblies using the No. 2 nose ring.
2. All rounds were loaded at Ravenna Arsenal, BAT Lot No. 54 using Holston Comp. B Lot 4-1197.
3. All rounds were fired at the Erie Ordnance Depot.

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

Table XIX
Penetration Data
DRB-23-974-2 Copper Cones

Serial No.	Comp. B (lbs.)	Rotation (rps)	Standoff (in.)	Penetration (inches M.S.)	Max. Spread (in.)	Std. Deviation (in.)
D21	2.54	0	7.5	22.44		
D22	2.54	0	7.5	20.12		
D23	2.50	0	7.5	22.94		
D24	2.54	0	7.5	23.69		
D25	2.52	0	7.5	21.38		
				Avg. 22.11	3.57	± 1.40

Notes:

1. DRB-23-974-2 machined, copper cones were assembled into DRC 376 penetration assemblies using the No. 2 nose ring.
2. All rounds were loaded at Ravenna Arsenal, BAT Lot No. 54 using Holston Comp. B Lot 4-1197.
3. All rounds were fired at the Erie Ordnance Depot.

Table XX
Penetration Data
DRB398 HW3 Item 1, Copper Cone Controls

Serial No.	Comp. B (lbs.)	Rotation (rps)	Standoff (in.)	Penetration (inches M.S.)	Max. Spread (in.)	Std. Deviation (in.)
G16	2.52	0	7.5	20.06		
G17	2.52	0	7.5	19.88		
G18	2.52	0	7.5	19.12		
G19	2.54	0	7.5	20.75		
G20	2.52	0	7.5	20.31		
				Avg. 20.02	1.63	± .60

Notes:

1. DRB 398 HW3 Item 1, Drawn, copper cones were assembled into DRC 376 penetration assemblies using the No. 2 nose ring.
2. All rounds were loaded at Ravenna Arsenal, BAT Lot No. 54 using Holston Comp. B Lot 4-1197.
3. All rounds were fired at the Erie Ordnance Depot.

Future Program

1. Composite Cone Study

A series of bimetal cones with aluminum half-shell inserts (.020 in. thick) and copper outer shells (DRB 398 HW3 item 1) have been assembled to evaluate penetration performance at standoffs of 2, 4 and 6 inches and at varying rotational rates.

2. Evaluation Of Cones Made By Electroforming

A series of DRB-268-5 copper cones, made by an electroforming method, have been manufactured for comparison with machined cones of like design. The electroformed cones and controls have been manufactured.

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3. Penetration Into Mild Steel Versus Homogeneous Armor

A series of penetration test rounds composed of DRB 398 HW3 item 1 cones in DRC 376 test bodies have been loaded and will be tested for penetration into homogeneous armor and mild steel at various spin rates.

4. Evaluation Of Cones Made By Zinc Die Casting

A series of DRB 398 HW3 cones have been made by die casting zinc alloy Zamak 3. Standoff and spin tests are planned.

5. Evaluation Of The DRB 398 HW3 Item 1 Copper Drawn Cone In Various Stages Of Manufacture.

A series of cones having varying geometric configurations have been obtained. These cones represent the various steps in the deep drawing of the DRB 398 HW3 Item 1 Copper Cone. Six of the eight drawing stages are included. Standoff and spin tests are planned.

6. Evaluation Of Optimum Wall Thickness For Cones With Various Apex Angles.

This study is being conducted using a

3.0 in. charge. The length of the spit-back tube (.625 in. dia.) will be varied to give the cone an overall height of 5.00 in.

- a. Cone drawing number DRB 834-1, apex angle 30° , wall thickness .050 in., .070 in., .086 in., and .110 in.
- b. Cone drawing number DRB 16-976, apex angle 45° , wall thickness .050 in., .110 in. and .150 in.
- c. Cone drawing number DRB 16-972, apex angle 60° wall thickness .070 in., .110 in. and .150 in.

These cones are being manufactured.

7. Composite Loading: Comp B. And Inert Filler.

A series of penetration test rounds composed of DRB 398 HW3 Item 1 cones in DRC 376 test bodies have been assembled. The rounds will be loaded with four variations in filler. Groups will be loaded to levels of .5 in., 1.0 in. and 1.5 inches of wax above the cone base, the remainder of the charge being Comp. B. Control rounds will contain Comp. B. only.

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FUZES

Potted Lucky Elements

Efforts to increase the reliability of functioning of T119E11 shell upon ground impact have continued. The great sensitivity of "potted lucky" nose elements (Fig. 15) first revealed by the test reported in the Forty-Second Progress Report, has since been confirmed by much

more extensive tests conducted at Aberdeen Proving Ground by Messrs. Wills and Farrell of the Recoilless Rifle Section. Table XXI shows the evaluation program as initially planned. The major portion has been completed, but, because of the extreme sensitivity observed with this type of nose element, phases 5 and 6 were subsequently cancelled. The rounds were

Table XXI
Original Evaluation Program
Sensitivity of Potted Lucky Nose Element

Phase	No. Shell	Range	Target
1	10	400 ft.	Homogeneous Armor Plate at 65° obliquity
2	15	400 ft.	Pine Boards Determine Minimum Thickness for functioning.
3	10	300 ft.	Soft Earth (Graze Functioning)
4	10	1000 ft.	Soft Earth (Graze Functioning)
5	10	1000 yds.	Soft Earth (Ground Impact Functioning)
6	5	2000 yds.	" " " " "
7	10	4000 yds.	" " " " "
8	5	4000 yds.	Water (Water impact functioning)

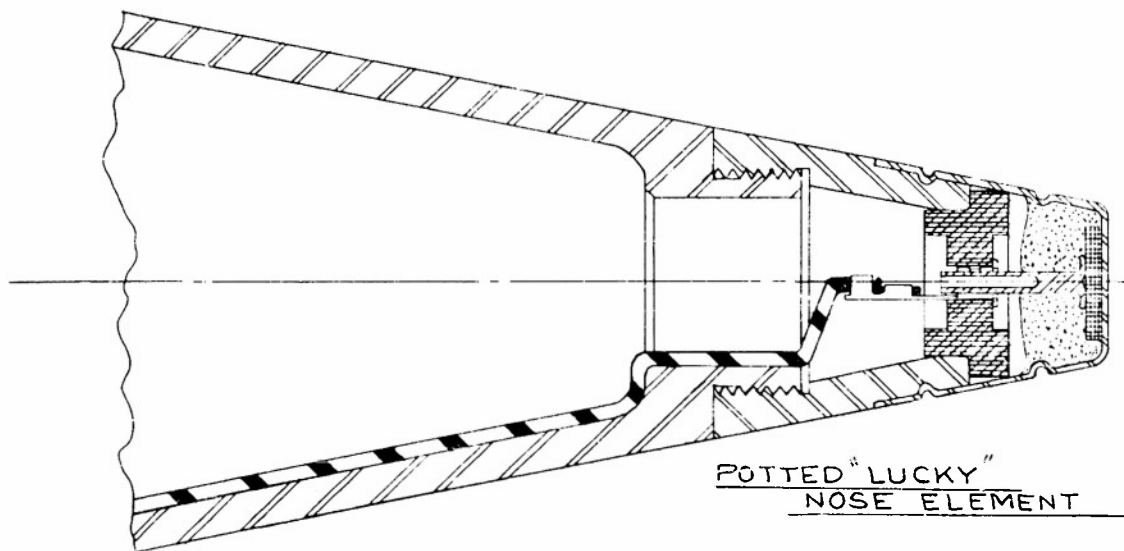


Fig. 15. Potted Lucky In Nose Cap Assembly.

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

loaded at Picatinny Arsenal, Lot No. PA-E-14899. The data for this program may be summarized as follows:

Phase 1

10 rounds at 400 ft against homogeneous armor plate target consisting of one 6-inch and two 1.5-inch plates at 65.5-degree obliquity.

All ten rounds functioned high order. In addition, ten rounds of Lot PA-E12356 with DRB683 (Fig. 5 of Forty-Fifth Progress Report) nose assemblies were fired as control rounds in this test and these also gave high order functions on the plate. No depth of penetration data are available but a comparison of the average penetration for the two groups will be reported at a later date.

Phase 2

14 rounds at 400 ft against pine boards (1 in), chip board (1/4 in) and kraft paper (.0045 in) to determine sensitivity.

The results are:

Serial No.	Target	Functioning
17908	1-inch pine	High Order
18047	"	" "
17996	"	" "
17943	"	" "
17938	"	" "
17981	"	" "
17883	1/4 inch chip board	" "
17959	Kraft paper	High Order
18046	" "	" "
18006	" "	FTF - FDR *
17910		High Order
17843		FTF-FDR
18053		FTF-FDR
--		High Order

* Failed To Function; Functioned Down Range

Phases 3 and 4

20 rounds at various ranges into a cultivated field. The field had been plowed, cultivated, drilled and seeded. Grass was about 4 to 6 in. high. Line of fire was parallel to the rows.

Nineteen of the twenty rounds functioned High Order as tabulated below:

Round No.	Range	Type Functioning
1 and 6	250 ft.	Both High Order
3	275 ft.	High Order
2, 4, 5, 7, 8, 9	300 ft.	All High Order
10	300-325 ft.	FTF

Round 10 did not function although fin marks and body graze marks were evident from 300-325 ft.

18035	525 ft.	High Order
17895	625 ft.	High Order
17957	700 ft.	" "
17937	700 ft.	" "
17920	700 ft.	" "
17927	700 ft.	" "
17960	750 ft.	" "
17865	850 ft.	" "
17891	1000 ft.	" "
18008	1040 ft.	" "

Phase 7

10 rounds at 4000 yards into soft earth (swampy soil).

All 10 rounds functioned high order.

Phase 8

6 rounds at 4000 yards into water

Serial No.	Type of Function
17834	H. O. on water
17824	H. O. possible on beach
17999	FTF not observed to strike
18052	FTF splash observed
17925	FTF " "
17955	H. O. on water

The extreme sensitivity, shown in Phase 2, would make the round unsafe for firing through brush or rain. Consequently, a new program is planned in which various methods for controlling the sensitivity of the "potted lucky" element will be examined. If the sensitivity is found to result from the thin cap it may be sufficient to thicken the cap, but if the detonation is caused by shock some type of absorbing material must be incorporated into the nose element assembly.

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Future Program

(1) To determine shock sensitivity
-.020 in thick cap.

a. Fire 5 rounds with protective covers
over present potted lucky for graze func-
tioning against earth at ranges of 250 ft
to 1000 ft.

b. Fire 5 rounds with protective cover
over the present potted lucky nose cap
against .0045 in. thick Kraft paper at 400
ft. range.

(2) To determine the effect of increased
nose cap wall thickness on fuze sensitivity
using .060, .050, .040, .030, or .020
in. thickness caps.

a. 5 rounds for graze functioning at
200 - 1000 ft.

b. 5 rounds for impact functioning a-
gainst 1" thick pine board.

c. 5 rounds for impact functioning
against 1/2" thick pine board.

d. 5 rounds for impact functioning
against chip board paper.

e. 5 rounds for impact functioning a-
gainst .0045 Kraft paper.

(3) Evaluate the rounds equipped with
nose caps having best wall thickness re-
sulting from program (2).

a. 20 rounds for impact functioning
on earth at 1000 yard range.

b. 10 rounds for impact functioning
on earth at 2000 yards.

c. 20 rounds for impact functioning
on earth at 4000 yards.

d. 10 rounds for impact functioning
on water at 4000 yards.

If program (1) indicates that the rounds
with .020 thick caps can be shock initiated
then the test should be repeated with .060
thick nose caps.

If program (1) shows that rounds with
.020 thick nose caps are not initiated
due to shock then program (2) should be
fired to determine the effect of increased
thickness of nose cap material on sensi-
tivity.

If program (1) indicates that both .020
and .060 nose caps are shock sensitive
the test should be discontinued and the
program revised to include a study of
shock mounting the "Lucky" element.

The firing of all of program (2) will
be determined by the results of parts
a, b, and c, for any nose cap thickness
i.e., part c will be tried only if part
b functions, etc.

Program (3) will be fired if the results
of program (2) are favorable.

It is suggested that when a proper nose
cap is selected on the basis of 1 in. and
1/2 in. pine board, that 10 rounds be fired
to evaluate the standards by firing in heavy
rain, light foliage, etc. It is also desired
that 10 rounds be fired without the bleeder
(R-C) washer in the fuze circuit to check
the tendency to premature.

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MANUFACTURING SUMMARY

In addition to the experimental material prepared for the research and development work under contract 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	May 1, 1954	16,715	All Shipments
	No Shipments in May		

II. Rifles, T170E1 for ONTOS

Prior to	May 1, 1954	120	All Shipments
	May 13, 1954	9	Aberdeen Proving Ground
	Total	129	

III. Mounts, T173 and T26 Tripod for ONTOS

Prior to	May 1, 1954	22	All Shipments
	May 25, 1954	4	Allis-Chalmers

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

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

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