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**TWENTY-THIRD  
PROGRESS REPORT  
OF  
THE FIRESTONE TIRE & RUBBER CO.  
ON  
105 MM BATTALION ANTI-TANK PROJECT**

**Contract No.  
DA-33-019-ORD-33 (Negotiated)  
RAD ORDTS 1-12383**

**THE FIRESTONE TIRE & RUBBER CO.  
Defense Research Division  
Akron, Ohio  
JUNE, 1952**

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## ABSTRACT

There are four Firestone 105mm BAT weapon systems in use. The location and use of each is given. A schedule of manufacture for four additional weapon systems is presented and the changes incorporated in these additional weapons are explained. New developments in the weapon design are discussed.

The direct sights which have been subjected to extended firing programs have developed some difficulties and are being returned to Frankford Arsenal for reworking. The design for indirect sight mounting is shown.

The accuracy of the T46 spotting rifle has been measured using the spotting cartridges T175 and T176. The data for the firings are presented and the results discussed.

The various modifications to the nose element mounting and tee cap, studied in investigating the causes for the malfunctions of the T138E57 HEAT projectiles, have been listed. The test data are presented and the tests discussed.

Two accuracy firings were made at a 2000-yard range with the T138E57 projectile. The firing data are given.

There were no tests conducted with the T171 projectile during the month.

The firing tests using a new housing design for the T119 projectile are reported and the results analyzed. A revised housing is illustrated.

Various programs in the field of penetration are presented. Data are given for studies of penetration using T171 bodies, the effect of the booster system, machined versus drawn liners and the effect of rotation.

A calculation and measurement of impulse by the T138E57 projectile when passing through a wood bursting screen is presented and a firing program to check results is reported. Other investigations involving the role, in the malfunctions, of the various fuze system elements are discussed. Performance tests of the Fuze, PD, T222E4 were made and the data are given.

## THE WEAPON SYSTEM

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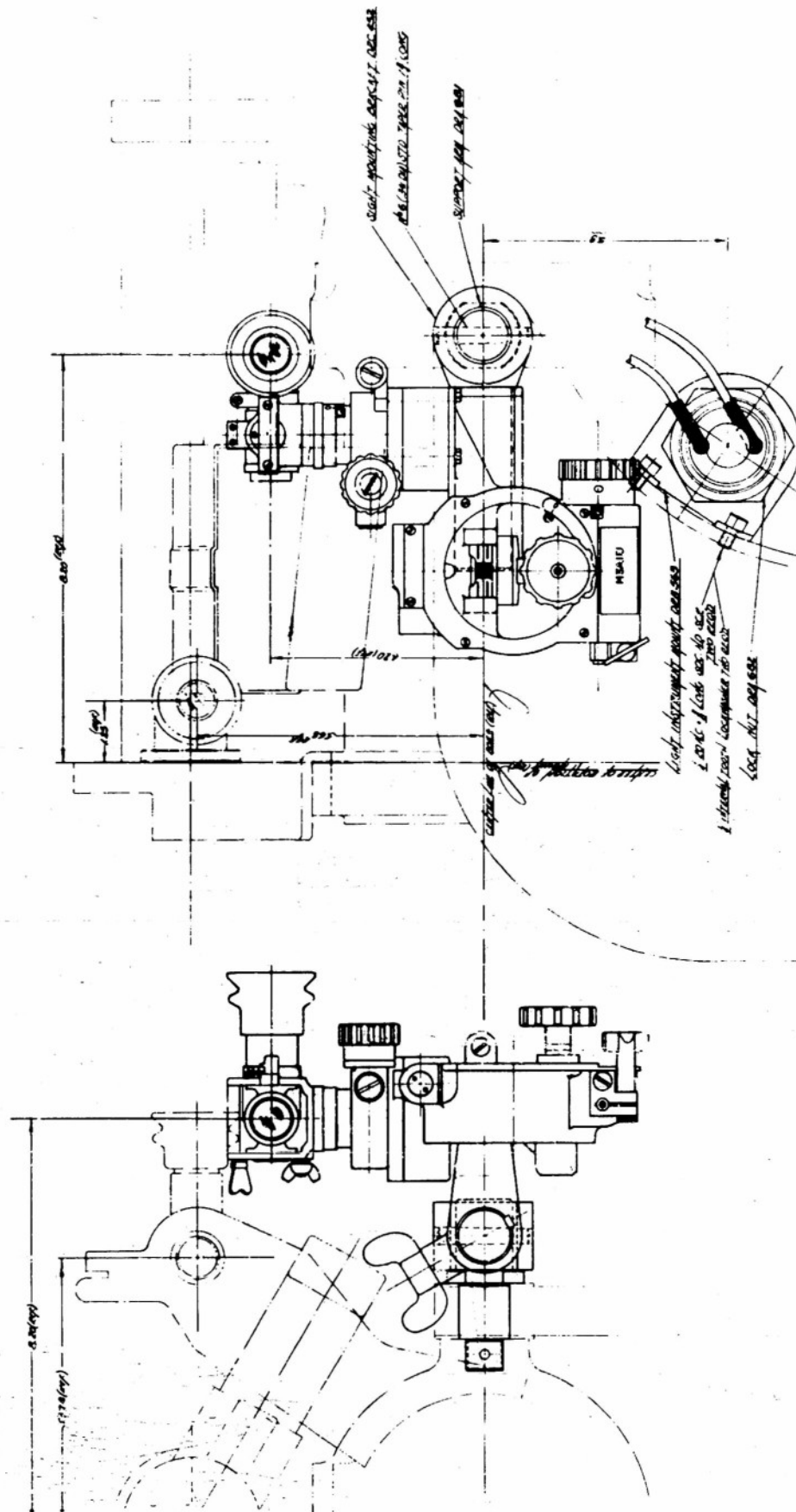


Fig. 2. Mount for Modified M3A1 Indirect Sight.

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## New Developments

A rubber shock pad is being designed and will be manufactured for the direct sight. When completed, vibration tests are to be made.

A recoil mount for the spotting rifle has been discussed with Springfield Armory and it is concluded that such a mount would seriously affect the operation of this type of rifle; therefore, no further work is contemplated on such a mount.

A major caliber mount to be made of aluminum is in the preliminary design stage. It is believed that sufficient rigidity can be obtained in a mount weighing only 90 pounds.

## Sighting System

Although it is intended that the T137 weapon system will include both a direct and an indirect sight, the weapon assemblies produced to date have not included an indirect sight.

## Direct Sight

Frankford Arsenal has reported (Report No. R-1068) that the telescope mounts, T183, which have been subjected to extended firing programs have developed a boresight backlash of the order of 0.5 mil and have attributed the difficulty to the brinelling of the protective surface finishes used on internal parts. Consequently all T183 direct sight mounts have been recalled for removal of the protective finish, general reconditioning, and installation of a new molded-type head rest.

One direct sight, mount No. 12, telescope M62E4 No. 18009, was shipped to Frankford June 28, 1952. The remaining three sights will be returned for processing as rapidly as circumstances permit.

## Indirect Sight

The following indirect sights have been received from Frankford Arsenal:

| Mount<br>M3A1 E1 | Telescope<br>M62 | Adapter<br>M9 |
|------------------|------------------|---------------|
| #2               | #286             | #HO1641       |
| #7389            | 3490             | #4612         |
| #2438            | 7883             | #1379         |
| #7449            | 4735             | No Serial No. |
| #7446            | 8392             | #HO2199       |

Indirect sight brackets are being manufactured. A sketch of the proposed mounting bracket is shown in Fig. 2.

## Spotting Rifle

(Tests at Erie Ordnance Depot)

The accuracy of the spotting rifle T46 No. 1 has been measured using the spotting cartridges T175 and T176. The T175 was designed by Frankford Arsenal and has an air gap fuze; the T176 was designed by Winchester Repeating Arms Company and is of the 'differential crimp' type. The spotting rifle was mounted on a T152E2 mount. The target, a homogeneous armor plate 107 in. wide by 137 1/2 in. high by 3/4 in. thick, was located at a range of 1030 yards. The optical axis of the sight (M62E4-T183) and the rifle bore-sight were adjusted to intersect at the center of the target. Tracer cartridges, T177, were employed to assist in ranging in on the target.

No difficulty was experienced in maintaining rifle and sight alignment or in chambering any of the cartridges, but 22 of the 53 cartridges fired failed to eject properly from the chamber. The difficulty was found to be caused by a bent extractor spring.

## T175 Spotting Cartridge

(Tests at Erie Ordnance Depot)

Fifteen rounds were fired for accuracy and nine for determination of velocity. The accuracy rounds all struck the target

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and functioned by giving a plainly visible flash of light and puff of smoke. The V.P.E. was  $\pm .27$  mil; the H.P.E. was  $\pm .17$  mil.

The nine velocity rounds functioned on the shorting screen (two layers of lead foil separated by heavy kraft paper), thereby demonstrating the sensitivity of the bullet, but casting some uncertainty upon the reliability of the measurements which showed the average instrumental velocity to be 1828 ft/sec at a distance of 79.3 ft. from the muzzle.

The firing record is shown in Table I.

## **T176 Spotting Cartridge**

(Tests at Erie Ordnance Depot)

Fourteen T176 cartridges were fired for accuracy and five for velocity determination. All of the fourteen accuracy rounds struck the target, with visible light and smoke, and showed a V.P.E. of  $\pm .26$  mil and a H.P.E. of  $\pm .46$  mil.

The average instrumental velocity of the five velocity rounds was 1868 ft/sec at a distance of 80.4 ft. from the muzzle. This average velocity is in general agreement with previous tests with ammunition from the same lot, using the same rifle.

The firing record is shown in Table II.

## **Future Program**

1. Evaluate the design changes in T137E2 rifle and T152E4 mount.

2. Continue trajectory-matching studies of spotting and major caliber ammunition.

3. Stress analysis studies of the T152 E2 mount, using strain gages, have been initiated and will be continued.

4. Complete design study of an aluminum mount.

5. Start design layouts for semi-automatic rifles.

6. Continue study of rifle design using annular ring of propellant.

**Table I**  
**Accuracy Firing Data**  
**T46 Spotting Rifle, T175 Spotting Cartridge**  
**Homogeneous Armor Target at 1030-yard Range**

Date June 23, 1952

Program Supplementary VII  
System Shoot**TEST GUN**

Model T46-46-1

Type Spotting

Length of Tube 32.0 in.

TEMPERATURES

Ammunition Storage - 73°

Ambient - 83°

Twist of Rifling 1-12

Sighting Equipment M302 Elbow Telescope

Bore Dia. (Lands)

Corrected to center of target from 1000 yd

ballistic reticle setting at top of target. Top

of target to center = 1.88 mils

**PROJECTILE**

Model T175-177

Type Spotting &amp; Tracer Rounds

Weight (Nominal)

C.G. Location

Borelet Dia (Nom)

Special Features

Screen Distances

5710' 380'

**MISCELLANEOUS DATA**

Range 1030-yard Spot Target

Propellant IME 4991, AL 298B3

Type web Chicago Wt. Machine

Proof Director E. HUEENAU

Observers M. Tawney C. ENGELSTADTSON

| Round No. | Type of Cartridge | Type of Bullet | Powder Charge (grains) | Wind Vel. & Dir. | Chamber Pressure | Muzzle Velocity Instr. | Actual | Elev. (mils)                | Azimuth (mils) | Position of Hit (inches) |        | Corrected Position of Hit - mils |        | Borelet Diameter |      | Clearance |      | Observations |
|-----------|-------------------|----------------|------------------------|------------------|------------------|------------------------|--------|-----------------------------|----------------|--------------------------|--------|----------------------------------|--------|------------------|------|-----------|------|--------------|
|           |                   |                |                        |                  |                  |                        |        |                             |                | Vert.                    | Horiz. | Vert.                            | Horiz. | Front            | Rear | Front     | Rear |              |
| 2406-1    | T-177             | Tracer         | 125                    |                  |                  | 1835                   |        |                             |                |                          |        |                                  |        |                  |      |           |      |              |
| 2407-2    | T-177             | Tracer         | 125                    |                  |                  | 1835                   |        |                             |                |                          |        |                                  |        |                  |      |           |      |              |
| 2408-3    | T-177             | Tracer         | 125                    |                  |                  |                        |        |                             |                |                          |        |                                  |        |                  |      |           |      |              |
| 2409-4    | T-177             | Tracer         | 125                    |                  |                  |                        |        |                             |                |                          |        |                                  |        |                  |      |           |      |              |
| 2410-5    | T-177             | Tracer         | 125                    |                  |                  |                        |        |                             |                |                          |        |                                  |        |                  |      |           |      |              |
| 2411-6    | T-177             | Tracer         | 125                    |                  |                  |                        |        |                             |                |                          |        |                                  |        |                  |      |           |      |              |
| 2412-7    | T-175             | Spotting       | 126                    |                  |                  | 1880                   |        | Spotted behind first screen |                |                          |        |                                  |        |                  |      |           |      |              |
| 2413-8    | T-175             | Spotting       | 126                    |                  |                  | 1875                   |        | Spotted behind first screen |                |                          |        |                                  |        |                  |      |           |      |              |
| 2414-9    | T-175             | Spotting       | 126                    |                  |                  | 1854                   |        | Spotted behind first screen |                |                          |        |                                  |        |                  |      |           |      |              |
| 2415-10   | T-177             | Tracer         | 125                    |                  |                  |                        |        | 2446                        | +1.43          |                          |        |                                  |        |                  |      |           |      |              |
| 2416-11   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | 2.00           |                          |        |                                  |        |                  |      |           |      |              |
| 2417-12   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | +1.43          | +2.55                    | +30.50 | +6.4                             | +8.2   |                  |      |           |      |              |
| 2418-13   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | +1.43          | +18.81                   | +26.00 | +6.1                             | +7.2   |                  |      |           |      |              |
| 2419-14   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | +1.43          | +41.81                   | +28.00 | +11.2                            | +7.6   |                  |      |           |      |              |
| 2420-15   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | +1.43          | -27.44                   | +4.50  | -7.4                             | +1.8   |                  |      |           |      |              |
| 2421-16   | T-175             | Spotting       | 126                    |                  |                  | 1882                   |        | 2446                        | +1.43          |                          |        |                                  |        |                  |      |           |      |              |
| 2422-17   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | +1.43          |                          |        |                                  |        |                  |      |           |      |              |
| 2423-18   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | +1.43          | +4.44                    | +34.00 | +1.2                             | +7.2   |                  |      |           |      |              |
| 2424-19   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | +1.43          | +7.44                    | +24.50 | +2.0                             | +6.6   |                  |      |           |      |              |
| 2425-20   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | +1.43          | +2.94                    | +22.00 | +0.8                             | +5.7   |                  |      |           |      |              |
| 2426-21   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | +1.43          | +14.91                   | +49.00 | +6.2                             | +1.6   |                  |      |           |      |              |
| 2427-22   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | +1.43          | +25.81                   | +31.00 | +7.0                             | +8.4   |                  |      |           |      |              |
| 2428-23   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | +1.43          | +20.94                   | +39.00 | +5.7                             | +8.9   |                  |      |           |      |              |
| 2429-24   | T-175             | Spotting       | 126                    |                  |                  |                        |        | 2446                        | +1.43          | +5.14                    | +38.00 | +1.4                             | +1.0   |                  |      |           |      |              |

Continued on next page.

Center of Impact

Probable Error - Vertical

Probable Error - Horizontal

Signed - W. Harvey



**Table II**  
**Accuracy Firing Data**  
**T46 Spotting Rifle, T176 Spotting Cartridge**  
**Homogeneous Armor Target at 1030-yard Range**

Date June 18, 1952 Program Supplementary VII  
Accuracy Program Against  
Armor Plate

**TEST GUN**

Model T46 No. 1  
Type 50 Cal. Rifle  
Length of Tube 32.12  
Twist of Rifling 1:12  
Sighting Equipment T123 sight mount No. 12

Ambient Temp. 76°F

**PROJECTILE**

Model T176 Cartridge

Type Spotting

Weight (Nominal) \_\_\_\_\_

C.G. Location \_\_\_\_\_

Bourrelet Dia (Nom.) \_\_\_\_\_

Special Features Abnormal Muzzle

Velocity 1800 ft/sec

T177 tracer cartridges, MV = 1807 f/s (nominal)  
were used as range finders. See Table I for details.

Bore Dia. (Lands) \_\_\_\_\_

Screen Distances  
55' ± 54.85'

Observers E. Lowry, E. Clark  
Velocities measured with starting streams. Velocities  
are at 80.4 ft from the muzzle.  
All rounds functioned on impact

**MISCELLANEOUS DATA**

Range 1030 yds.

Propellant  
Type \_\_\_\_\_ web \_\_\_\_\_ Charge Wt. \_\_\_\_\_

Proof Director MEI-20018

| Round No.                                                                                                                                                   | Type of Cartridge | Type of Bullet | Purpose  | Wind Vel. & Dir. | Chamber Pressure | Muzzle Vel. (Instr.) (ft/sec.) | Elevation* |      | Azimuth (mils) | Position of Hit (inches) |         | Corrected Position of Hit - mils |        | Bourrelet Diameter |      | Clearance |      | Gun Functioning   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|----------------|----------|------------------|------------------|--------------------------------|------------|------|----------------|--------------------------|---------|----------------------------------|--------|--------------------|------|-----------|------|-------------------|
|                                                                                                                                                             |                   |                |          |                  |                  |                                | yards      | mils |                | Vert.                    | Horiz.  | Vert.                            | Horiz. | Front              | Rear | Front     | Rear |                   |
| 2437 - 1                                                                                                                                                    | T176              | Spotting       | Velocity | 5 - 4°           |                  | 1858                           |            |      |                |                          |         |                                  |        |                    |      |           |      |                   |
| 2438 - 2                                                                                                                                                    | T176              | "              | "        | 5 - 8°           |                  | 1882                           |            |      |                |                          |         |                                  |        |                    |      |           |      |                   |
| 2439 - 3                                                                                                                                                    | T176              | "              | "        | 6 - 5°           |                  | 1864                           |            |      |                |                          |         |                                  |        |                    |      |           |      |                   |
| 2440 - 4                                                                                                                                                    | T177              | Tracer         | Ranging  |                  |                  |                                | 1000       | 2403 | 0              |                          |         |                                  |        |                    |      |           |      |                   |
| 2441 - 5                                                                                                                                                    | T177              | "              | "        |                  |                  |                                | 900        | 2113 | 0              |                          |         |                                  |        |                    |      |           |      |                   |
| 2442 - 6                                                                                                                                                    | T177              | "              | "        |                  |                  |                                | 1000       | 2332 | 0              |                          |         |                                  |        |                    |      |           |      |                   |
| 2443 - 7                                                                                                                                                    | T176              | Spotting       | Accuracy |                  |                  |                                | 1000       | 2332 | 0              | -43                      | +8      | -41                              | +22    |                    |      |           |      |                   |
| 2445 - 8                                                                                                                                                    | T176              | "              | "        |                  |                  |                                | 1000       | 2407 | 0              | -36                      | +11     | -97                              | +30    |                    |      |           |      |                   |
| 2446 - 9                                                                                                                                                    | T176              | "              | "        |                  |                  |                                | "          | "    | 0              | +48                      | +26     | +150                             | +70    |                    |      |           |      | Failed to extract |
| 2447 - 10                                                                                                                                                   | T176              | "              | "        |                  |                  |                                | "          | "    | 0              | +26 1/2                  | +43     | +72                              | +116   |                    |      |           |      |                   |
| 2448 - 11                                                                                                                                                   | T176              | "              | "        |                  |                  |                                | "          | "    | -145           | +44                      | +1      | +119                             | +148   |                    |      |           |      |                   |
| 2449 - 12                                                                                                                                                   | T176              | "              | "        |                  |                  |                                | "          | "    | "              | +37                      | -7      | +100                             | +126   |                    |      |           |      | Failed to extract |
| 2450 - 13                                                                                                                                                   | T176              | "              | "        |                  |                  |                                | "          | "    | "              | +34                      | -7      | +92                              | +126   |                    |      |           |      |                   |
| 2451 - 14                                                                                                                                                   | T176              | "              | "        |                  |                  |                                | "          | "    | "              | +28 1/2                  | -7 1/2  | +77                              | +124   |                    |      |           |      | Failed to extract |
| 2452 - 15                                                                                                                                                   | T176              | "              | Velocity |                  |                  | 1871                           |            |      |                |                          |         |                                  |        |                    |      |           |      |                   |
| 2453 - 16                                                                                                                                                   | T176              | "              | Accuracy |                  |                  |                                | "          | "    | "              | +32                      | -20     | +86                              | +41    |                    |      |           |      | Failed to extract |
| 2455 - 17                                                                                                                                                   | T176              | "              | "        |                  |                  |                                | "          | "    | "              | +29 1/2                  | +3      | +64                              | +155   |                    |      |           |      |                   |
| 2456 - 18                                                                                                                                                   | T176              | "              | "        |                  |                  |                                | "          | "    | "              | +19                      | -4      | +51                              | +134   |                    |      |           |      | Failed to extract |
| 2457 - 19                                                                                                                                                   | T176              | "              | "        |                  |                  |                                | "          | "    | "              | -22                      | -12 1/2 | -59                              | +111   |                    |      |           |      |                   |
| 2458 - 20                                                                                                                                                   | T176              | "              | "        |                  |                  |                                | "          | "    | "              | +3                       | -15     | +08                              | +104   |                    |      |           |      |                   |
| 2459 - 21                                                                                                                                                   | T176              | "              | "        |                  |                  |                                | "          | "    | "              | +27 1/2                  | +3      | +74                              | +155   |                    |      |           |      |                   |
| 2460 - 22                                                                                                                                                   | T176              | "              | Velocity |                  |                  | 1865                           |            |      |                |                          |         |                                  |        |                    |      |           |      |                   |
|                                                                                                                                                             |                   |                |          |                  | Overage          | 1868 f/s                       |            |      |                |                          |         |                                  |        |                    |      |           |      |                   |
| * Elevation is given in terms of the ballistic reticle and the aiming point is the top of the target except %<br>† Elevation in mils from center of target. |                   |                |          |                  |                  |                                |            |      |                |                          |         |                                  |        |                    |      |           |      |                   |
| Center of Impact <u>V = +44 mils; H = +108 mil</u><br>Probable Error - Vertical <u>+3.6 mil</u><br>Probable Error - Horizontal <u>.26 mil</u>               |                   |                |          |                  |                  |                                |            |      |                |                          |         |                                  |        |                    |      |           |      |                   |

Target Size - 107 in wide x 137 1/2 in. high.  
x 3/4 in thick (armor plate)

Corrected to vertical center of target from 100 yd ballistic reticle

Corrected to vertical center of target from 100 yd ballistic reticle

Corrected to vertical center of target from 100 yd ballistic reticle

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## T138 PROJECTILE

### Performance Studies Using T138E57 HEAT Projectiles

The Twenty-First and Twenty-Second Progress Reports presented data on the functioning of one hundred and ten T138E57 HEAT projectiles and nineteen T264 WP projectiles. Approximately 50% of these projectiles detonated properly upon impact with the target. The search for the cause or causes for the malfunctions has continued.

The higher proportion of functioning rounds noted when the rounds are fired without tee caps against a 2-inch pine screen (Twenty-Second Progress Report) suggests that a tee cap of lighter construction might increase the percentage of functioning rounds. Thirty-one T138 E57 HEAT projectiles, embodying various modifications of the nose element mounting and tee cap have therefore been tested. The test data are shown in Table III.

In each of the tests, described in the following paragraphs, the T137E1 No. 4 rifle and mount were used for firing live loaded T138E57 HEAT projectiles of Lot No. PA-E 9588. The target consisted of a 2-inch thick pine board screen at zero degrees obliquity and located 400 ft. from the gun. In previous tests the projectiles of this ammunition lot have shown one function out of ten when fired with tee caps, against 60° armor and eight out of ten when fired without tee caps against a normal 2-inch pine screen.

#### Test 1 Evaluation of Compression Washers (Figure 3)

Six rounds, modified by inserting a flat spring compression washer (compressed height .010 in., free height .030

in. minimum) between the crystal and the tee were fired against a bursting screen. In addition to the compression washer, other modifications were: wrapping two layers of cellulose tape around the outside of the crystal, and replacing the cambric insulator by a felt pad placed between the terminal and the tee cap. Three rounds functioned on the bursting screen and three rounds impact-detonated on the steel back-up plate. This performance is much better than that of projectiles without modification but much poorer than the performance of those fired without tee caps. The firing record is given in Table III.

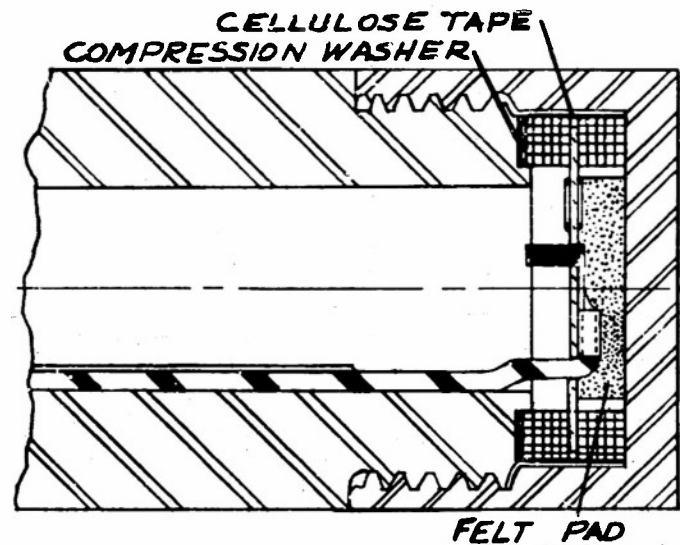


Fig. 3. Tee Cap and Nose Element.  
With Compression Washer.

#### Test 2 Thin-Wall Tee Caps With Reduced Clearance (Figure 4)

Ten rounds having tee caps as shown in Fig. 4 were tested. Nine rounds functioned on the screen and one round impact-detonated on the steel plate.

Five rounds having caps as above, but with the felt washer of Fig. 3 substituted for the cambric insulating washer, were

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fired. Four of these rounds functioned on the bursting screen, the other round impact-detonated on the steel back-up plate. Table III is the firing record for these rounds.

This record of thirteen functions out of fifteen rounds is at least as good as previously obtained by firing without tee caps and is regarded as satisfactory.

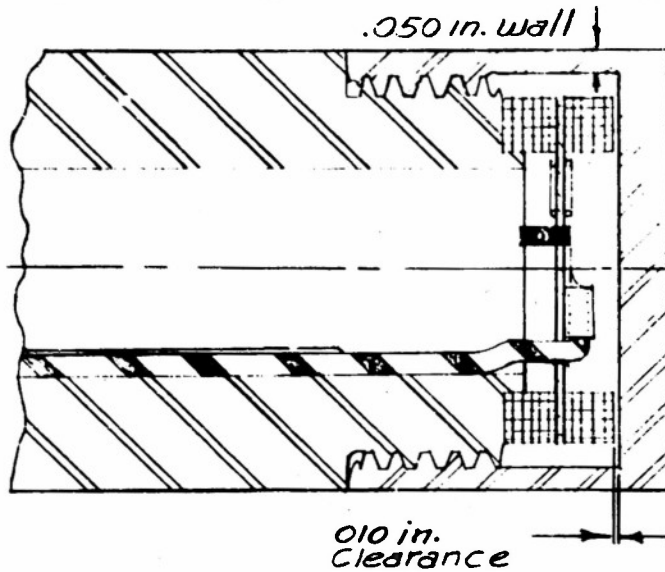


Fig. 4. Tee Cap and Nose Element.  
Thin-Wall Cap, Reduced Clearance.

## Test 3 Thin-Wall Tee Caps With Normal Clearance (Figure 5)

Five rounds having tee caps as shown in Fig. 5 were fired through the bursting screen. Four of the five rounds func-

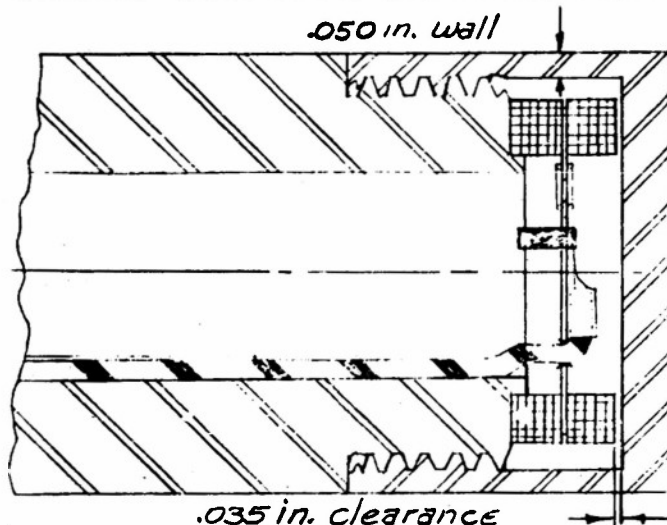


Fig. 5. Tee Cap and Nose Element.  
Thin-Wall Cap, Normal Clearance.

tioned on the screen and the fifth round impact-detonated against the steel plate. The firing record is found in Table III.

This performance record is similar to that of Test 2 and indicates that the thin cap, not the reduced clearance, is responsible for the improved performance.

## Test 4 Heavy-Wall Tee Caps With Reduced Clearance (Figure 6)

Five rounds having tee caps with normal wall thickness (.100 in.) and a clearance of .010 in. between crystal and cap (Fig. 6) were fired through a bursting screen. Two rounds functioned on the screen and a third functioned on the steel plate. The two remaining rounds impact-detonated on the steel plate. The firing data is given in Table III.

These results are much better than were obtained in earlier tests with heavy-wall caps and with a greater clearance.

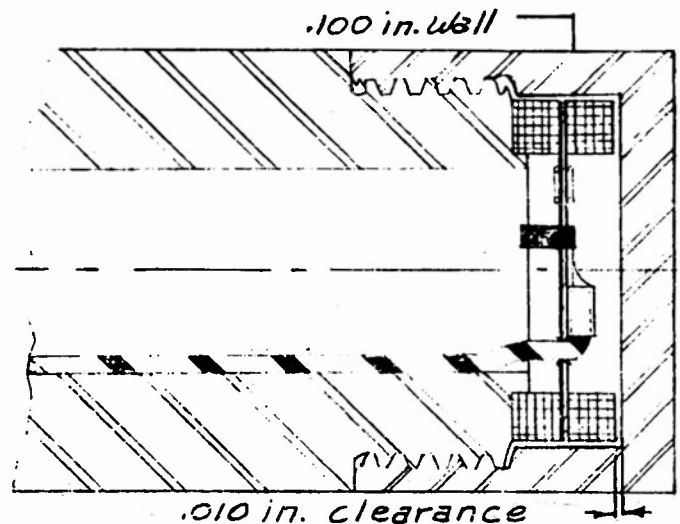


Fig. 6. Tee Cap and Nose Element.  
Heavy-Wall Cap, Reduced Clearance.

**Table III**  
**Functioning Test Data**  
**Various Modifications of T138E57 Projectile**  
**400-ft. Range, Bursting Screen**

Date 6-12-52 Program to determine fuse functioning of T138E57 HEAT rounds.

**TEST GUN**

Model T138E57 No. 4  
 Type LOS LOS Recoilless R. fle.  
 Length of Tube 95 in.  
 Twist of Rifling 1-200  
 Sighting Equipment M&E-E with T138 Mount

Bore Dia. (Lands) \_\_\_\_\_

**MISCELLANEOUS DATA**

Range 400 ft. Wood Bursting Screen  
 Propellant Low Street withers plate.  
 Type M&E-E web 200 in. Change Wt. 1 lb. 14 oz.  
 Lot PA-E-50239

Proof Director M&E-E

Observers C. M. Cox

**PROJECTILE**

Model T138E57 Live  
 Type Lot E-50500 Base Element Lot PA-E-0053  
 Weight (Nominal) 17.4 lb.  
 C.G. Location 5.25 in. from base.  
 Bourrellet Dia (Nom.) 4.132 in.  
 Special Features See information below for each test.

| Round No. | Time of Flight                           | Proj. Weight (lbs)                             | Powder Charge (lb. oz.)          | Wind Vel. & Dir. | Chamber Pressure                            | Muzzle Velocity Instr.                      | Elev. (mils)                       | Distance - Top of Crystal to the Shldr. | Depth of Cap           | Clearance of Cap (Orig.)        | Clearance After Inst. oil, or Weather | Dist. Crystal to Tee Shldr. Meas. Whr. Mains | Tee Cap Wall Thickness Meas. | Tee Cap Face Thickness Meas. | Resistance of Crystal to Ground | Depth of Old Cap | Functioning  |
|-----------|------------------------------------------|------------------------------------------------|----------------------------------|------------------|---------------------------------------------|---------------------------------------------|------------------------------------|-----------------------------------------|------------------------|---------------------------------|---------------------------------------|----------------------------------------------|------------------------------|------------------------------|---------------------------------|------------------|--------------|
| TEST 1    | Compression Washer Between Crystal & Tee | Felt Pad Insulator Between Tee Cap and Crystal | Center Rate                      | Depth of Cap     | Clearance of Crystal After Test (Cap Orig.) | Clearance of Crystal After Test (Cap Orig.) | Dist. Crystal to Tee Shldr. (Inch) | Tee Cap Face Thickness                  | Tee Cap Face Thickness | Resistance of Crystal to Ground | Depth of Old Cap                      | Functioning                                  |                              |                              |                                 |                  |              |
| 598       | 17.4                                     | 7-14                                           | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 785       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Low Order    |
| 911       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 850       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Non-Function |
| 868       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Non-Function |
| 764       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| TEST 2    | Thin Wall Tee Caps, Reduced Clearance    | See Fig. 4                                     |                                  |                  |                                             |                                             |                                    |                                         |                        |                                 |                                       |                                              |                              |                              |                                 |                  |              |
| 997       | 17.4                                     | 7-14                                           | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 772       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 908       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 438       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 918       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 996       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 878       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 457       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 957       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Low Order    |
| 459       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
|           | Same as Above                            | Test 2                                         | Except Felt Insulating Pad Added |                  |                                             |                                             |                                    |                                         |                        |                                 |                                       |                                              |                              |                              |                                 |                  |              |
| 784       | 17.4                                     | 7-14                                           | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 775       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 902       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |
| 798       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Low Order    |
| 888       | "                                        | "                                              | 16.4                             | 16.4             | 16.4                                        | 16.4                                        | 16.4                               | 16.4                                    | 16.4                   | 16.4                            | 16.4                                  | 16.4                                         | 16.4                         | 16.4                         | 16.4                            | 16.4             | Good         |

Center of Impact \_\_\_\_\_  
 Probable Error - Vertical \_\_\_\_\_  
 Probable Error - Horizontal \_\_\_\_\_

Signed - C. M. Cox.

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Center of Impact \_\_\_\_\_  
 Probable Error - Vertical \_\_\_\_\_  
 Probable Error - Horizontal \_\_\_\_\_

# CONFIDENTIAL

## Summary

The data for the various modifications of Lot PA-E 9588 that have been tested are shown below in Table IV.

The results of the functioning tests indicate that:

1. A reduced wall thickness of the tee

cap increased the proportion of functioning rounds.

2. A reduction in the clearance between the crystal and the tee cap appears helpful when a heavy-wall cap is used, but is not, of itself, sufficient to solve the problem of malfunctions.

**Table IV**  
**Summary of Functioning Tests**  
**Lot PA-E 9588**

| Modification                                                                        | Fired | Functioned | Target                |
|-------------------------------------------------------------------------------------|-------|------------|-----------------------|
| Heavy-wall cap, .030 in. clearance                                                  | 10    | 1          | 60° homogeneous armor |
| No tee cap                                                                          | 10    | 8          | 2-in. pine screen     |
| Heavy-wall cap, comp. spring, felt insulator                                        | 6     | 3          | "                     |
| Thin-wall cap, .010 in. clearance                                                   | 10    | 9          | "                     |
| Thin-wall cap, .010 in. clearance, felt insulator                                   | 5     | 4          | "                     |
| Thin-wall cap, .035 in. clearance                                                   | 5     | 4          | "                     |
| Heavy-wall cap, .010 in. clearance                                                  | 5     | 2* (3)     | "                     |
| *A third round functioned on a steel witness plate placed behind the wooden screen. |       |            |                       |

## CONFIDENTIAL

### T138E57 Projectiles At 2000-yard Range

The Eighteenth and Nineteenth Progress Reports presented data for the performance of the T138E57 projectile when fired at a 1500-yard range. This report presents data for two T138E57 accuracy programs fired at a range of 2044 yards. The two programs were fired at Erie Ordnance Depot from two different T137E1 rifles but the same T152 E3 mount was used in both cases. Complete cartridges as shown in Fig. 7 were used.

#### Program I

Table V is a copy of the firing record for the first twenty-eight T138E57 inert rounds, fired as received from Picatinny Arsenal, at an 18 ft. by 18 ft. target placed 2044 yards from the gun. The first six rounds were used in "ranging in" on the target. Thirteen of the remaining twenty-two rounds hit the target. The probable

errors for the thirteen hits were, V.P.E. =  $\pm .67$  mil and H.P.E. =  $\pm .63$  mil.

The observers reported that three of the nine rounds which missed the target flew well. The remaining six appeared to become somewhat unstable after passing the peak of the trajectory.

#### Program II

Table VI is a copy of the firing record for the second group of twenty-eight rounds. In this program the target was 24 ft. by 24 ft. The first six rounds were used in "ranging in" on the target. Seventeen of the twenty-two rounds fired after getting "on the target" hit the target with a V.P.E. =  $\pm .76$  mil and H.P.E. =  $\pm .83$  mil. The measured yaw at the target for all hits was between  $1^{\circ}$  and  $14^{\circ}$ . The observers reported that one of the five misses appeared to have good flight but passed about 1 mil right of the target. The other four misses appeared to precess and struck short and left of the target.

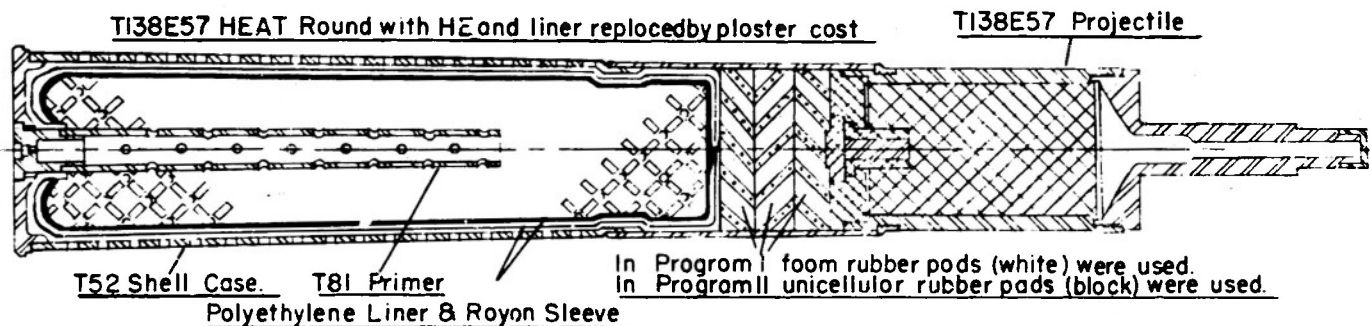


Fig. 7. Complete T138 E57 HEAT Cartridge.

### Future Program

Tests to evaluate the various possible causes of malfunctions of the T222 E3 fuze assemblies will continue.

**Table V**  
**Accuracy Range Data**  
**T138E57 Projectile At 2044-yard Range**  
**T137E1 Rifle, 18-ft. by 18-ft. Target, Fired 6-5-52**

**PROJECTILE**  
 Model T138  
 Type E57  
 Weight (Nominal) 17.5 lbs.  
 C.G. Location 53.1 in. from base  
 Bourrelet Dia. (Nom.) 4.138 in.  
 Special Features 2044-360 Rotating Band

**MAGAZINE TEMPERATURE**  
 Minimum 70°  
 Maximum 71°  
 Present 70°

**LOADING ROOM TEMP** 72°  
**AMMO. STORAGE TEMP** 75°  
**AMBIENT TEMPERATURES**  
10 AM 71° 11:30 AM 71°  
10:45 AM 73° 2 PM 77°  
11: AM 75° 3 PM 70°

**TEST GUN**  
 Model T137E1  
 Type 10.5mm Recoilless  
 Length of Tube 95 in.  
 Twist of Rifling 1-200  
 76° Sighting Equipment McElwain Telescope

**PROPELLANT** PA 90239  
 Type M2NF web-33561a Change Wt. 2.1 lbs. - 1.433  
 Sight Mount T162 E3  
 Mount T162 E3  
 Tube 218128 C  
 Chamber 2282498-B  
 Range 3044 yds.

**MISCELLANEOUS DATA**  
 Primer M57 Warm-Up Rounds  
 TBI Accuracy Rounds  
 Proof Director PLACER & CANNERS  
 Observers Dr. Miller, C.M. Cox, M. Toohig

**Program** T138 AB  
**2044 Yd. Accuracy Program**  
 Chamber 2282498-B  
 Tube 218128 C  
 Mount T162 E3  
 Sight Mount T162 E3  
 MC2 #10009

**Date** June 5, 1952

SCREEN DISTANCES

Rotating Band

93.3' - 69.5' - 1

73.5 in. - 1 mil at 2044 yds.

Zero zero is top left of target

Corrected to 684 mils elevation, 0 mils azimuth.

| Round No. | Proj. No. | Proj. Weight (lb.) | Powder Charge (lb. - 0.01 in. gph. dia.) | Wind Vel. & Dir. | Wind Components | Muzzle Velocity |        | Elev. (mils) | Azimuth (mils) | Position of Hit (inches) |        | Corrected Position of Hit - mils |        | Bourrelet Diameter |      | Clearance                    |      | Observations |
|-----------|-----------|--------------------|------------------------------------------|------------------|-----------------|-----------------|--------|--------------|----------------|--------------------------|--------|----------------------------------|--------|--------------------|------|------------------------------|------|--------------|
|           |           |                    |                                          |                  |                 | Instr.          | Actual |              |                | Vert.                    | Horiz. | Vert.                            | Horiz. | Front              | Rear | Front                        | Rear |              |
| 2297-a    | 5149      | 17.34              | 7-14                                     | ---              | ---             | ---             | ---    | ---          | ---            | ---                      | ---    | ---                              | ---    | ---                | ---  | Warm Up Round                | ---  | ---          |
| 2298-b    | 5149      | 17.34              | 7-14                                     | ---              | ---             | 1615            | 1662   | ---          | ---            | ---                      | ---    | ---                              | ---    | ---                | ---  | Warm Up Round                | ---  | ---          |
| 2299-1    |           |                    | 7-14                                     | 5-205            | 2.0 4.5         | 1660            | 1673   | 62.9         | 0              | ---                      | ---    | ---                              | ---    | ---                | ---  | Good flight characteristics. | ---  | ---          |
| 2300-2    |           |                    | 7-14                                     | 6-230            | 4.5 3.9         | 1660            | 1683   | 61.5         | 0              | ---                      | ---    | ---                              | ---    | ---                | ---  | Good flight characteristics. | ---  | ---          |
| 2301-3    |           |                    | 7-14                                     | 5-245            | 6.4 4.1         | 1665            | 1678   | 66.2         | 0              | ---                      | ---    | ---                              | ---    | ---                | ---  | Good flight characteristics. | ---  | ---          |
| 2302-4    |           |                    | 7-14                                     | 7-205            | 3.0 6.4         | 1660            | 1683   | 66.2         | 0              | ---                      | ---    | ---                              | ---    | ---                | ---  | Round hit velocity screen.   | ---  | ---          |
| 2303-5    |           | Yow                | 7-14                                     | 4-195            | 1.2 3.9         | 1665            | 1678   | 66.2         | 0              | ---                      | ---    | ---                              | ---    | ---                | ---  | Good flight characteristics. | ---  | ---          |
| 2304-6    |           | (in.)              | 7-14                                     | 7-210            | 3.6 6.1         | 1660            | 1683   | 71.0         | 0              | ---                      | ---    | ---                              | ---    | ---                | ---  | Not observed in flight.      | ---  | ---          |
| 2305-7    |           |                    | 7-14                                     | 5-210            | 2.6 4.5         | 1665            | 1688   | 68.6         | 0              | -90%                     | +100   | -1.23                            | +1.36  | ---                | ---  | Good flight characteristics. | ---  | ---          |
| 2306-8    |           |                    | 7-14                                     | 7-210            | 3.6 6.1         | 1660            | 1683   | 68.6         | 0              | ---                      | ---    | ---                              | ---    | ---                | ---  | Good flight characteristics. | ---  | ---          |
| 2307-9    |           | 6%                 | 7-14                                     | 7-215            | 4.2 5.8         | 1655            | 1678   | 68.6         | 0              | -70%                     | +159   | -.96                             | +2.16  | ---                | ---  | Good flight characteristics. | ---  | ---          |
| 2308-10   |           | ---                | 7-14                                     | 7-230            | 5.5 3.9         | 1665            | 1688   | 68.6         | 0              | +32                      | +185   | +.44                             | +2.11  | ---                | ---  | "                            | ---  | ---          |
| 2309-11   |           | ---                | 7-14                                     | 5-235            | 4.2 2.9         | 1660            | 1683   | 67.4         | 0              | -2.51                    | +204   | -2.22                            | +2.78  | ---                | ---  | "                            | ---  | ---          |
| 2310-12   |           | 5                  | 7-14                                     | 7-225            | 5.0 5.0         | 1665            | 1688   | 68.1         | 0              | -7                       | +42    | -1.0                             | +6.7   | ---                | ---  | "                            | ---  | ---          |
| 2311-13   | 1469      |                    | 7-14                                     | 8-160            | -2.4 7.5        | 1655            | 1678   | 68.6         | 0              | ---                      | ---    | ---                              | ---    | ---                | ---  | "                            | ---  | ---          |
| 2312-14   | 1461      |                    | 7-14                                     | 5-170            | -8 4.9          | 1665            | 1688   | 67.6         | +1.5           | ---                      | ---    | ---                              | ---    | ---                | ---  | "                            | ---  | ---          |
| 2313-15   | 1473      |                    | 7-14                                     | 10-210           | 5.0 8.7         | 1660            | 1683   | 68.6         | +1.5           | ---                      | ---    | ---                              | ---    | ---                | ---  | "                            | ---  | ---          |
| 2314-16   | 1478      |                    | 7-14                                     | 4-200            | 1.2 3.8         | 1655            | 1678   | 68.6         | 0              | ---                      | ---    | ---                              | ---    | ---                | ---  | "                            | ---  | ---          |
| 2315-17   | 1457      | 7                  | 7-14                                     | 10-210           | 5.2 8.7         | 1650            | 1673   | 68.4         | 0              | -62                      | +111   | -.64                             | +1.51  | ---                | ---  | Good flight characteristics. | ---  | ---          |
| 2316-18   | 1488      |                    | 7-14                                     | 7-285            | -6.8 -1.8       | 1645            | 1668   | 68.4         | 0              | ---                      | ---    | ---                              | ---    | ---                | ---  | "                            | ---  | ---          |
| 2317-19   | 1499      |                    | 7-14                                     | 8-200            | 3.0 7.5         | 1665            | 1678   | 68.4         | 0              | ---                      | ---    | ---                              | ---    | ---                | ---  | "                            | ---  | ---          |
| 2318-20   | 1466      | 6%                 | 7-14                                     | 5-195            | 1.4 4.9         | 1655            | 1678   | 68.4         | 0              | -130                     | +43    | -1.57                            | +5.8   | ---                | ---  | Good flight characteristics. | ---  | ---          |
| 2319-21   | 1460      | 5                  | 7-14                                     | 8-180            | 0.0 8.0         | 1650            | 1673   | 68.4         | 0              | -177                     | +11    | -2.21                            | +1.15  | ---                | ---  | "                            | ---  | ---          |
| 2320-22   | 1395      | 5%                 | 7-14                                     | 6-195            | 1.6 5.8         | 1655            | 1678   | 68.4         | +1.0           | -100%                    | +136%  | -2.26                            | +8.6   | ---                | ---  | "                            | ---  | ---          |

Center of Impact

Probable Error - Vertical

Probable Error - Horizontal

Continued on Next Page

Signed - W. Harvey

Signed - W. Harvey

Continued on Next Page

Center of Impact

Probable Error - Vertical

Probable Error - Horizontal

Table V (Cont.)  
Accuracy Range Data  
T138E57 Projectile At 2044-yard Range

PROJECTILE  
Model T138  
Type E57  
Weight (Nominal) 17.5 lbs.  
C.G. Location 5.31 in. from base  
Borelet Dia (Nom.) 1.612 in.  
Special Features DPA-360  
Rotating Band

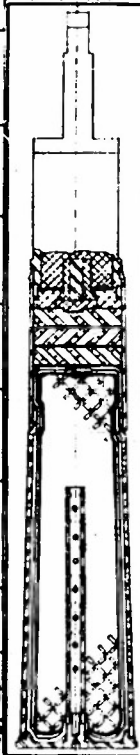
MAGAZINE TEMPERATURES  
Minimum 70°  
Maximum 71°  
Present 70°  
Loading Room Temp 72°  
Range Storage Temp 78°  
Ambient Temperature 78°  
10:00 AM 71° 11:00 AM 72°  
10:45 AM 73° 2:00 PM 77°  
11:00 AM 75° 3:00 PM 75°

TEST GUN  
Model T138E1  
Type 2044 Recoilless Rifle  
Length of Tube 95 in.  
Twist of Rifling 1-200  
Sighting Equipment M42 Elbow Telescope  
Bore Dia. (Lands) 1.612 in.

Date June 5, 1952  
Program T138E57  
2044 Accuracy Program  
Chamber 218159C  
Branch 228249B-8  
Tube 218128C  
Mount T132E3  
Sight Mount T183 #12  
M42 #18009

MISCELLANEOUS DATA  
Range 2044 yds  
Propellant PA 90239  
Type M42C web base in. Charge Wt 1.45 lbs.  
Primer M47 Worn Up Rounds  
T81 Accuracy Rounds  
Proof Director Please J. C. Miller  
Observer D. Miller, C. M. G. M. Taylor

| Round No.                                                         | Proj. No. | Proj. Weight (lb.) | Powder Charge (lb.) | Wind Vel & Dir (mph, deg) | Wind Component | Muzzle Velocity (ft/sec) | Elev. (mils) | Azimuth (mils) | Position of Hit (feet) | Corrected Position of Hit - mile | Borelet Diameter | Clearance |      | Observations                                                                     |
|-------------------------------------------------------------------|-----------|--------------------|---------------------|---------------------------|----------------|--------------------------|--------------|----------------|------------------------|----------------------------------|------------------|-----------|------|----------------------------------------------------------------------------------|
|                                                                   |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  | Front     | Rear |                                                                                  |
| 2321-23                                                           | 1422      | 5 1/2              | 7-14                | 9-145                     | 1.8            | 5.8                      | 1660         | 1603           | 681                    | +1.0                             | +1.0             | +1.0      | +1.0 | After about 100 yards the projectile finally dropped off well to right of target |
| 2322-24                                                           | 1415      | 6 1/2              | 7-14                | 9-160                     | -1.0           | 2.8                      | 1665         | 1608           | 684                    | +1.0                             | +1.0             | +1.0      | +1.0 | climbing precession, finally dropped off well to right of target                 |
| 2323-25                                                           | 1435      | 6 1/2              | 7-14                | 7-200                     | 1.6            | 6.2                      | 1680         | 1679           | 686                    | +1.0                             | +1.0             | +1.0      | +1.0 | Smooth regular precession after passing trajectory peak                          |
| 2324-26                                                           | 1484      | -                  | 7-14                | 5-200                     | 1.8            | 4.7                      | 1655         | 1678           | 681                    | +1.0                             | +1.0             | +1.0      | +1.0 | Started to precess after passing trajectory peak, completed                      |
| 2325-27                                                           | 1468      | 6"                 | 7-14                | 9-180                     | 0.0            | 9.0                      | 1665         | 1688           | 641                    | +1.0                             | +1.0             | +1.0      | +1.0 | several precession/revolutions, then broke down and went left                    |
| 2326-28                                                           | 1402      | -                  | 7-14                | 5-210                     | 2.6            | 4.9                      | 1665         | 1688           | 686                    | +1.0                             | +1.0             | +1.0      | +1.0 | of target.                                                                       |
| Rounds were completely assembled by Rocketry Arsenal              |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| Lot PA-E 9511                                                     |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| Rounds consisted of:                                              |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| T52 prototype cases with polyethylene and rayon liners            |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| Three sponge rubber disks placed on top of propellant             |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| charge between outer liner (polyethylene) and base of projectile. |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| T138E57 type projectile crimped to case (T363 Inert)              |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| Powder PA 90239 M10, M1A used.                                    |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| Primer T81 used, Lot PA-E 9022                                    |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| Dummy Fuse T208E7 used                                            |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| Ammunition Lot No. PA-E 9511                                      |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| Inert Filler:                                                     |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| 81% PEN Hydroelectric Chemical Co.                                |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| 10% Iron Oxide                                                    |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| 9% Celite Johns Manville                                          |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| Center of Impact V=7.48; H=7.02                                   |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| Probable Error - Vertical .69 mil                                 |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |
| Probable Error - Horizontal .63 mil                               |           |                    |                     |                           |                |                          |              |                |                        |                                  |                  |           |      |                                                                                  |



Signed - W. Harvey

Table VI  
Accuracy Range Data  
T138E57 Projectile At 2044-yard Range  
T137E1 Rifle, 24-ft. by 24-ft. Target, Fired 6-20-52

PROJECTILE  
Model T138  
Type E57A  
Weight (Nominal) 7.5 lbs.  
C.G. Location 5.31 in. from base.  
Borelet Dia. 1.4132 in.  
Special Feature: Barometrical: 752 Shell Case.  
T52 polyethylene & rayon liners.  
9 or 4 whicellular pads.  
T81 primer.  
7 lb. - 16 oz. PA 30239 powder

TEST GUN  
Model T137E1  
Type J033333 Recoilless  
Length of Tube 95 in.  
Twist of Rifling 1:200  
Sighting Equipment T132 sight & sumers quadrant.  
Bore Dia. (Lands) .4134 in.

COMMENTS:  
Chamber - 220 3324-A  
Ring - 220 2448-A  
Tube - 220 3357  
T103 - 10  
M42 - 1  
T44 - 26

DATE 6-20-52  
Program T138AB  
2044 yd. Program.

SCREEN LOCATIONS  
92' 3" 45' 15" 2044 yd.  
92' 25" 45' 15" 2044 yd.

MISCELLANEOUS DATA  
Range 2044 yd.  
Propellant PA 30239 Primer T81  
Type M42 web 3357 in. Charge. Vt. 7.16 - 15.02

Proof Director E. HUFFMAN  
Observers Dr. MILLER, TURNER, Cox  
CLARK, BROWN, O. MILLER

| Round No. | Case No. | Proj. Weight (lb.) | Powder Charge (lb.-oz.) | Wind Vel. & Dir. mph. dir. | C.G. inches from base | Muzzle Velocity Actual | Reference Points: Vertical - center Horizontal - center |                | Position of Hit (inches) | Corrected Position of Hit - mls |        | Borelet Diameter | Depth  |       | Zero Setting (mils) | Yaw Angle |
|-----------|----------|--------------------|-------------------------|----------------------------|-----------------------|------------------------|---------------------------------------------------------|----------------|--------------------------|---------------------------------|--------|------------------|--------|-------|---------------------|-----------|
|           |          |                    |                         |                            |                       |                        | Elev. (mils)                                            | Azimuth (mils) | Vert.                    | Horiz.                          | Vert.  | Horiz.           | Powder | Pads  |                     |           |
| 2373-349  | 522      | 17.41              | 7-15                    | —                          | —                     | 1641                   | 0                                                       | 0              | —                        | —                               | —      | —                | 4 1/2  | 1     | —                   | —         |
| 2374-349  | 521      | 17.40              | "                       | —                          | —                     | 1641                   | 0                                                       | 0              | —                        | —                               | —      | —                | 4 1/2  | 1 1/2 | —                   | —         |
| 2375-307  | 523      | 17.46              | "                       | 7-60                       | 5.35                  | 1731                   | 70.75                                                   | 42             | missed                   | missed                          | missed | 4.129            | 5      | 3/8   | 3.7                 | —         |
| 2376-240  | —        | 17.43              | "                       | 8-65                       | 5.34                  | 1731                   | "                                                       | 44             | missed                   | missed                          | missed | 4.130            | 5      | 1 3/8 | 3.8                 | —         |
| 2377-346  | 525      | 17.46              | "                       | 9-68                       | 5.34                  | 1724                   | "                                                       | 45             | +62 1/2                  | -49                             | +87    | 4.130            | 5      | 1 1/8 | 3.8                 | 4.5       |
| 2378-300  | 517      | 17.42              | "                       | 9-80                       | 5.33                  | 1725                   | "                                                       | 45             | missed                   | missed                          | missed | 4.129            | 5      | 1 1/8 | —                   | —         |
| 2379-309  | 528      | 17.44              | "                       | 7-46                       | 5.34                  | 1725                   | "                                                       | 45             | missed                   | missed                          | missed | 4.130            | 5 1/2  | 1     | 4.0                 | —         |
| 2380-304  | 511      | 17.49              | "                       | 7-47                       | 5.35                  | 1720                   | "                                                       | 49             | missed                   | missed                          | missed | 4.129            | 5      | 1     | —                   | —         |
| 2381-307  | 529      | 17.42              | "                       | 8-38                       | 5.34                  | 1722                   | "                                                       | 45             | -16                      | +80                             | -22    | 4.130            | 5 1/2  | 1 1/2 | 6.5                 | 6.5       |
| 2382-209  | 510      | 17.44              | "                       | 9-45                       | 5.32                  | 1723                   | "                                                       | 45             | missed                   | missed                          | missed | 4.129            | 5 1/2  | 1 1/2 | —                   | —         |
| 2383-209  | 510      | 17.41              | "                       | 8-44                       | 5.35                  | 1719                   | "                                                       | 45             | -188                     | +34                             | -48    | 4.130            | 5      | 1 1/2 | —                   | —         |
| 2384-202  | 514      | 17.45              | "                       | 8-49                       | 5.34                  | 1715                   | "                                                       | 45             | -157                     | +8 1/2                          | -186   | 4.128            | 5 1/2  | 1 1/2 | —                   | —         |
| 2385-306  | 529      | 17.45              | "                       | 8-53                       | 5.34                  | 1717                   | "                                                       | 45             | -92                      | -81                             | -57    | 4.130            | 5 1/2  | 1 1/2 | 12                  | 10        |
| 2386-300  | 519      | 17.48              | "                       | 11-49                      | 5.34                  | 1725                   | "                                                       | 45             | +77                      | -81                             | +105   | 4.129            | 5 1/2  | 1 1/2 | 6.6                 | 6.6       |
| 2387-206  | 518      | 17.42              | "                       | 11-45                      | 5.32                  | 1716                   | "                                                       | 44             | +45 1/2                  | -30                             | +69    | 4.130            | 5 1/2  | 1 1/2 | —                   | —         |
| 2388-304  | 515      | 17.52              | "                       | 10-31                      | 5.34                  | 1715                   | "                                                       | 44             | -118                     | -77                             | -160   | 4.130            | 6 1/2  | 1 1/2 | 1                   | 1         |
| 2389-206  | 525      | 17.41              | "                       | 9-50                       | 5.35                  | 1716                   | "                                                       | 44             | +86                      | +69                             | +49    | 4.130            | 5 1/2  | 1 1/2 | Very Large          | —         |
| 2390-204  | 521      | 17.44              | "                       | 11-30                      | 5.34                  | 1713                   | "                                                       | 44             | -88                      | -15                             | -120   | 4.129            | 5 1/2  | 1 1/2 | 6.6                 | 6.6       |
| 2391-301  | 523      | 17.46              | "                       | 11-36                      | 5.34                  | 1713                   | "                                                       | 44             | -67                      | -127                            | -91    | 4.130            | 5 1/2  | 1 1/2 | —                   | —         |
| 2392-302  | 510      | 17.47              | "                       | 9-47                       | 5.34                  | 1707                   | "                                                       | 44             | -142                     | -84                             | -198   | 4.130            | 6      | 3/8   | —                   | —         |
| 2393-206  | 517      | 17.46              | "                       | 8-36                       | 5.34                  | 1702                   | "                                                       | 44             | -72                      | +84                             | -148   | 4.129            | 6      | 3/8   | 6.5                 | 6.5       |
| 2394-301  | 520      | 17.41              | "                       | 8-39                       | 5.34                  | 1709                   | "                                                       | 44             | missed                   | missed                          | missed | 4.130            | 5 1/2  | 1 1/2 | —                   | —         |
| 2395-302  | 522      | 17.39              | "                       | 8-51                       | 5.33                  | 1716                   | "                                                       | 45             | +51                      | +80 1/2                         | +19    | 4.130            | 5 1/2  | 1 1/2 | 14                  | 14        |
| 2396-204  | 514      | 17.46              | "                       | 10-47                      | 5.35                  | 1714                   | "                                                       | 45             | +27 1/2                  | -87                             | -118   | 4.129            | 5 1/2  | 1     | 6.5                 | 6.5       |

Center of Impact  
Probable Error - Vertical  
Probable Error - Horizontal

**Table VI (Cont.)**  
**Accuracy Range Data**  
**Y138E57 Projectile At 2044-yard Range**

MISCELLANEOUS DATA  
Range 2014 156  
Propellant P450299 Primer T81  
Type ALUMINUM web CASTING Charge Wt. 7.16 - 1523  
Proof Director E. HUFFMAN  
Observers DR. MAHER, THURMAN, COX  
CLARK, BROWN, O'NEALE

PROJECTILE  
Model I 38  
Type E 67A  
Weight (N. min.) 17.5 lbs.  
C.G. Location 5.51 in. from base  
Bourrelet Dia. (Nom.) 5.132 in.  
Special Features Ammunition:

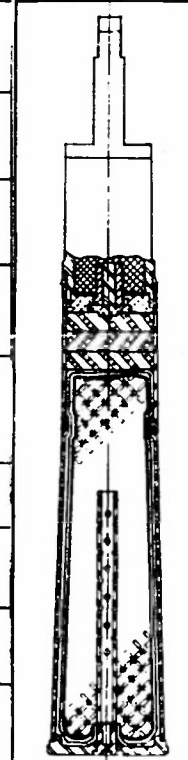
752 Shell Cases  
752 Rhythmic & Rayon Lines  
3rd - Unicellular pads

COMPONENTS:  
Chamber - 220324-A  
Ring - 220269-B-4  
Tube - 220365-T  
T/103 - 10  
M42 - 1  
T-46 - 26

TEST GUN  
Model I 375E/  
Type 103 mm. Recoilless R./fl.  
Length of Tube 95 in.  
Twist of Rifling 1-200  
Sighting Equipment 103 sight & Gunners Quadrant  
Bore Dia. (Lands) 5.134 in.

SCREEN DISTANCES  
63.26' 63.71'  
Rvs 3-20

Date 6-20-52 Program I 38 B8  
2044 yd Program



Center of Impact  $V = -63^\circ H = 1.10$  mils  
 Probable Error - Vertical .76 mil  
 Probable Error - Horizontal .83 mil

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**T171 PROJECTILE**

There were no firings conducted with the T171 projectile during the month of June, 1952.

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## T119 PROJECTILE

In planning for a pilot lot of 500 T119 projectiles, certain modifications were made to ease manufacturing difficulties. As described in the Twenty-First Progress Report attempts to obtain a cast housing of sufficient strength were unsuccessful. A modified housing, shown in Fig. 8, which could be easily machined from 24S-T4 aluminum bar, was then tested. The first housing tested failed in the gun. It was evident from an examination of the recovered fragments that the housing had collapsed at

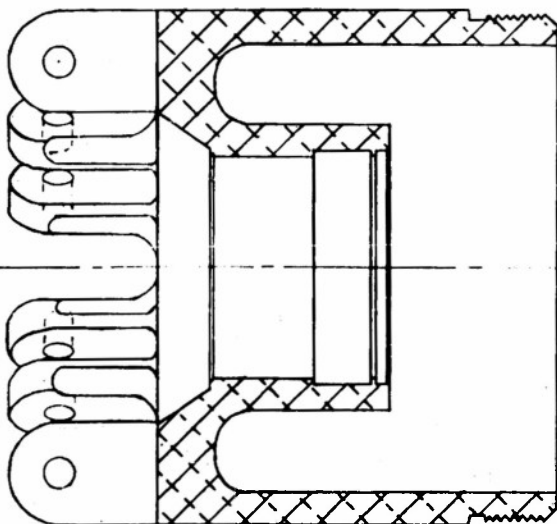
the threaded end due to the high pressure of the propellant gases. An estimate was made of the stress at the point of failure, and a steel sleeve was designed to strengthen this region (see Fig. 9). The sleeve was pressed into the threaded end of the housing and four samples of the strengthened housing were fired successfully. The steel sleeve is therefore incorporated in this projectile design.

Table VII contains the data for the firing tests.

### Future Program

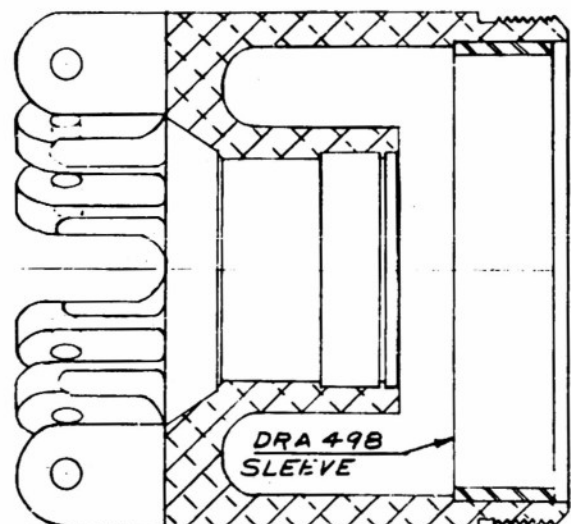
1. Fire a combined accuracy and penetration program using an M27 rifle.
2. Continue the manufacture of a pilot lot of 500 T119 production-type projectiles.

The first sample of the forged aluminum fin, planned for use in these rounds has been received and appears to be satisfactory.



HOUSING DRC412-2

Fig. 8. Modified Housing for T119 Projectile.



HOUSING & SLEEVE ASS'Y

Fig. 9. Housing With Steel Sleeve.

**Table VII**  
**Range Data, T119 Projectile**  
**To Test Aluminum Hoving DRC 412**

Date June 14-59 Program T119C2

## PROJECTILE

Model 1119  
Type Blunt Nose for Recovery  
Weight (Nominal) 127 lb.  
C.G. Location ---  
Bourrelet Dia. (Nominal) 4 1/4 in.  
Special Features Atom Housing

## TEST GUN

**TEST GUN**  
Model Modified T19 Recoilless  
Type 20 mm launch, 570 cu in chamber liner.  
Length of Tube 106 in.  
Twist of Rifling Smallest bore.  
Sighting Equipment Adapted M11 Elbow Telescope.  
Bore Dia. (Lands) .4154 <sup>r.002</sup>/<sub>16</sub>  
Modified To Case  
M57 Primer  
Fully ethylene Liner

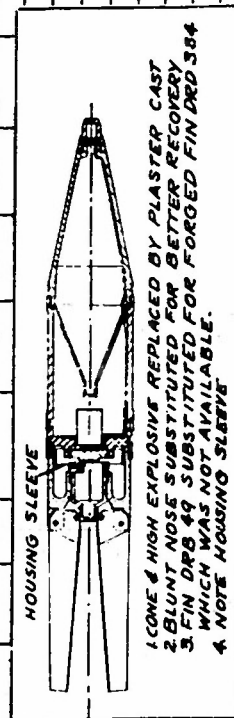
## MISCELLANEOUS DATA

Range Recovery Box - four new cards  
Propellant  
Type BLIND web 2035 in Charge w/ Variable  
Lot No. PA 50259  
Proof Director E. HUFFMAN  
Observers ENDERBETSON, HANLEY  
LUCAS, TONIG.

| Round No. | Date Fired | Proj. Weight (lb.)                                                                                                                                                                                                     | Powder Charge (lb. oz.) | Recall Inches-rear | Chamber Pressure | Housing Sleeve |                  | Observations                                                                          |
|-----------|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|--------------------|------------------|----------------|------------------|---------------------------------------------------------------------------------------|
|           |            |                                                                                                                                                                                                                        |                         |                    |                  | Length (in.)   | Thick-ness (in.) |                                                                                       |
| 2327-364  | 6-4-52     | —                                                                                                                                                                                                                      | 7-14                    | 1                  | 8810             | —              | —                | Projectile No. 137 failed in the gun. Aluminum bell marks were found in the gun tube. |
| 2328-137  | "          | 1749                                                                                                                                                                                                                   | 7-14                    | 5 1/4              | 8930             | No sleeve      | —                | The first view said, at 30 ft from the muzzle showed projectile separation. Re-       |
| 2329-169  | 6-16-52    | 1771                                                                                                                                                                                                                   | 8-0                     | —                  | 10100            | .75            | .094             | Covered parts showed collapse of housing at threaded end. Projectile No. 169          |
| 2403-148  | 6-23-52    | 1792                                                                                                                                                                                                                   | 8-0                     | —                  | 10180            | "              | .063             | Escaped from recovery box and was lost, but yaw cards indicated satisfactory          |
| 2404-171  | "          | 1791                                                                                                                                                                                                                   | 8-0                     | —                  | 9485             | "              | .094             | performance.                                                                          |
| 2405-170  | "          | 1792                                                                                                                                                                                                                   | 8-0                     | —                  | 9460             | "              | .063             | All other projectiles recovered. No failures occurred when housing sleeve was used.   |
|           |            | (a) Piston orifice diameter .245 in.                                                                                                                                                                                   |                         |                    |                  |                |                  |                                                                                       |
|           |            | (b) Housing sleeves for these tests were machined from SAE 4340 steel bar which was bored, heat treated and then finished to the final dimensions. The finished sleeves had Rockwell hardness of 37-38 on the C scale. |                         |                    |                  |                |                  |                                                                                       |

HOUSING SLEEVE

1 CONE & HIGH EXPLOSIVE REPLACED BY PLASTER CAST  
 2 BLUNT NOSE SUBSTITUTED FOR BETTER RECOVERY  
 3 FIN DRB 49 SUBSTITUTED FOR FORGED FIN DRD 384  
 WHICH WAS NOT AVAILABLE.  
 4 NOTE HOUSING SLEEVE



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## PENETRATION STUDIES

### Tests With T171 Type Projectile Body

Table X of the Sixteenth Progress Report showed data obtained in tests at the Ballistics Research Laboratories at Aberdeen Proving Ground with the T171 type projectile (DRC193 body and a DRB83 nose ring as shown in Fig. 15 of the Sixteenth Progress Report). The poor performance of the round was attributed to the nose ring design. Accordingly ten rounds were prepared using DRC 193 bodies and DRB91 nose rings as shown in Fig. 10. As before, DRB2, 45°, 100-in. wall copper cones were used. These rounds were loaded with Comp B at Ravenna Arsenal and fired at Erie Ordnance Depot. The test data are presented in Table VIII.

The change in the ring resulted in a doubling of the penetration. The slight effect of increased standoff is of considerable interest.

Penetration type rounds with DRB2 cones normally have a penetration of 18.0 in. at a standoff of 7.5 in. and 22.0 in. at a standoff of 18.0 in. It would therefore appear that less standoff is required for optimum performance when the charge is tapered. Further tests are being considered.

Now that the potential penetration of the T171 type round has been established further accuracy tests would be appropriate.

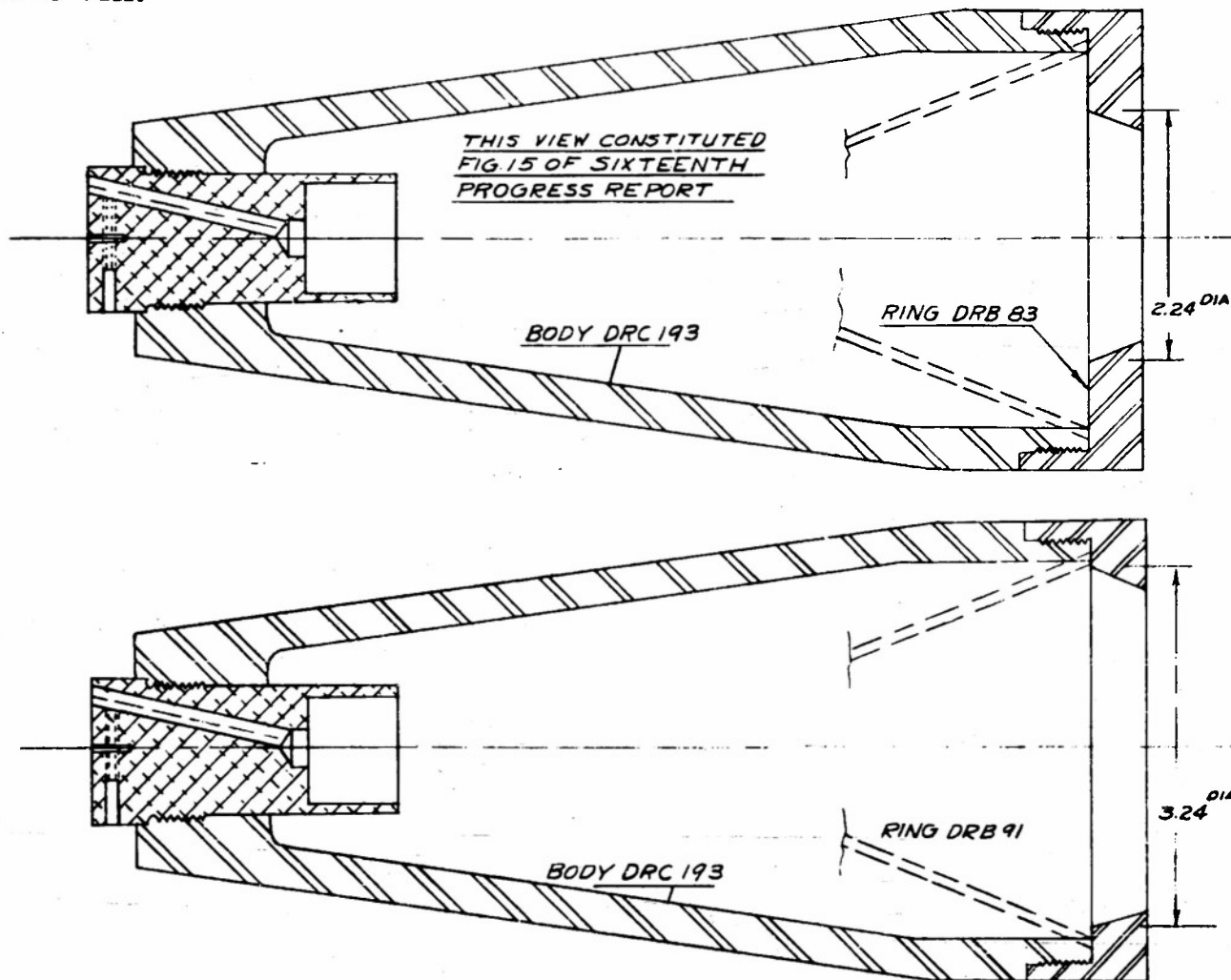


Fig. 10. T171 Type Penetration Assemblies.

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**Table VIII**  
**Penetration Data for T171 Type Projectile**

| Round No. | Lbs. Comp B | Rev/Sec | Standoff (inches) | Penetration inches M.S. | Max. Spread (in.) | Std. Deviation (in.) |
|-----------|-------------|---------|-------------------|-------------------------|-------------------|----------------------|
| P551      | 1.86        | 0       | 7.5               | 19.38                   |                   |                      |
| P552      | 1.86        | "       | "                 | 19.18                   |                   |                      |
| P553      | 1.86        | "       | "                 | 21.69                   |                   |                      |
| P554      | 1.88        | "       | "                 | 21.25                   |                   |                      |
| P560      | 1.88        | "       | "                 | 19.50                   |                   |                      |
|           |             |         |                   | Avg. 20.20              | 2.51              | ±1.11                |
| P555      | 1.86        | 0       | 18.0              | 18.56                   |                   |                      |
| P556      | 1.86        | "       | "                 | 20.00                   |                   |                      |
| P557      | 1.88        | "       | "                 | 22.69                   |                   |                      |
| P558      | 1.88        | "       | "                 | 21.56                   |                   |                      |
| P559      | 1.88        | "       | "                 | 20.94                   |                   |                      |
|           |             |         |                   | Avg. 20.75              | 4.13              | ±1.58                |

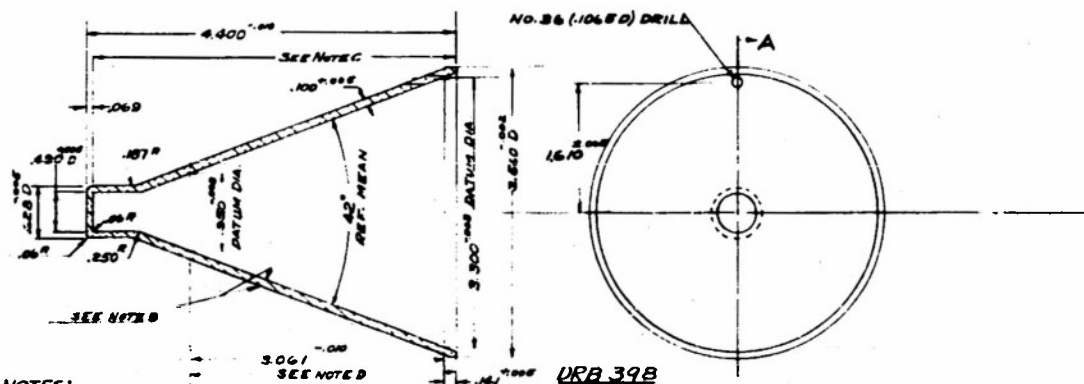
**Notes:**

1. DRC193 bodies, DRB91 Nose Rings, DRA53 base plug.
2. Loaded at Ravenna Arsenal, BAT Lot No. 9, Comp B Holston Lot 3-126
3. Tested at Erie Ordnance Depot.

## DRB 398 Copper Cones

The copper cones being used in the T138E57 and T119 HEAT projectiles are drawn from copper sheet and finished in accordance with DRB398 as shown in Fig. 11. The penetrating power of these

cones in both DRC376 test bodies and T138 E57 projectiles, with different boosting systems, and at different spin rates has been determined. The inspection data for all of the cones included in these experiments are shown in Table IX.



- NOTES:**
- A. FINISH
  - B. ALL INDICATED SURFACES MUST BE CONCENTRIC WITHIN .003 T.I.R. WITH RESPECT TO 3.540 REGISTER DIA.
  - C. ALL INDICATED SURFACES MUST BE FLAT & PARALLEL WITHIN .008 F.I.R. & PERPENDICULAR TO X OF PART
  - D. IN THIS REGION VARIATION IN STRAIGHTNESS OR THICKNESS OF WALL SHALL NOT EXCEED .006 IN ANY AXIAL PLANE. VARIATION OF WALL THICKNESS IN ANY TRANSVERSE PLANE SHALL NOT EXCEED .006
  - E. PREFERRED MATERIAL: OXYGEN FREE, NO RESIDUAL DEOXIDANTS, COPPER. ALTERNATIVE MATERIAL: ELECTROLYTIC, TROUGH PITCH COPPER. COPPER DEEP DRAWING; SEE NOTE F SPEC QQ-C-676

Fig. 11. DRB 398, 42-degree Copper Cone.

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Table IX

**Inspection Data for DRB 398 Cones**  
See Tables X and XI for Penetration Results

| Cone No. | Max. Trans.<br>Variation | Max. Long.<br>Variation | Min.<br>Wall Thickness | Max.<br>Wall Thickness |
|----------|--------------------------|-------------------------|------------------------|------------------------|
| Q341     | .002                     | .007                    | .098                   | .105                   |
| Q342     | .003                     | .006                    | .097                   | .103                   |
| Q343     | .003                     | .004                    | .098                   | .102                   |
| Q344     | .005                     | .008                    | .095                   | .103                   |
| Q345     | .002                     | .004                    | .097                   | .102                   |
| Q346     | .003                     | .005                    | .097                   | .103                   |
| Q347     | .002                     | .004                    | .097                   | .102                   |
| Q349     | .002                     | .003                    | .099                   | .102                   |
| Q350     | .004                     | .003                    | .099                   | .103                   |
| Q351     | .002                     | .002                    | .099                   | .101                   |
| Q352     | .003                     | .003                    | .098                   | .102                   |
| Q353     | .002                     | .002                    | .098                   | .100                   |
| Q354     | .004                     | .005                    | .097                   | .102                   |
| Q355     | .003                     | .002                    | .099                   | .102                   |
| Q383     | .003                     | .005                    | .097                   | .102                   |
| Q384     | .003                     | .006                    | .098                   | .104                   |
| Q385     | .004                     | .007                    | .096                   | .104                   |
| Q386     | .003                     | .005                    | .099                   | .105                   |
| Q387     | .004                     | .006                    | .098                   | .104                   |
| Q388     | .004                     | .006                    | .096                   | .102                   |
| Q389     | .003                     | .007                    | .095                   | .103                   |
| Q390     | .004                     | .006                    | .097                   | .104                   |
| Q397     | .003                     | .006                    | .096                   | .103                   |
| Q398     | .003                     | .006                    | .098                   | .105                   |
| Q399     | .003                     | .005                    | .099                   | .105                   |
| Q400     | .003                     | .006                    | .097                   | .104                   |
| Q401     | .003                     | .006                    | .097                   | .103                   |
| Q402     | .003                     | .005                    | .098                   | .103                   |
| Q403     | .003                     | .005                    | .098                   | .104                   |
| Q404     | .003                     | .005                    | .097                   | .103                   |
| Q405     | .003                     | .006                    | .098                   | .104                   |
| Q422     | .003                     | .006                    | .096                   | .102                   |
| Q428     | .003                     | .005                    | .098                   | .103                   |
| Q429     | .004                     | .007                    | .096                   | .103                   |
| Q430     | .002                     | .006                    | .096                   | .102                   |
| Q431     | .003                     | .005                    | .098                   | .105                   |
| Q432     | .003                     | .006                    | .098                   | .104                   |
| Q433     | .003                     | .006                    | .096                   | .102                   |
| Q483     | .004                     | .006                    | .097                   | .104                   |
| FS518    | .002                     | .002                    | .102                   | .104                   |
| FS521    | .001                     | .004                    | .103                   | .107                   |
| FS523    | .001                     | .001                    | .103                   | .104                   |
| FS524    | .000                     | .001                    | .103                   | .104                   |
| FS528    | .000                     | .002                    | .105                   | .107                   |

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## Effect of the Booster System

In actual projectiles initiation of the Composition B is accomplished by means of the T208E7 base element. In static penetration tests it is more convenient to employ a dummy base element system. Figure 12 illustrates the two systems. Nine DRB398 cones, cased in DRC376 test assemblies, were loaded at Ravenna Arsenal and tested for penetration into mild steel at Erie Ordnance Depot. Five rounds utilized the penetration test base element system and four rounds contained T208E7 base elements which had previously been armed in a centrifuge. All rounds were tested at 0 rev/sec and at a standoff of 7.50 inches. The penetration data are presented in Table X, Part A. The average penetration measured for the two booster systems agrees within the known experimental error. It is concluded (1) that the T208E7 base element provides adequate boosting for either the T138E57 or the T119 HEAT round, and (2) that the penetration booster system may be used interchangeably with the T208E7 base element in static penetration tests.

An examination of the radiographs of all rounds has revealed that three of the cones used with the penetration booster system and one of the cones used with the T208E7 system had been distorted in being pressed into the nose rings, as shown in Fig. 13. The average penetration of the four distorted cones is 17.8

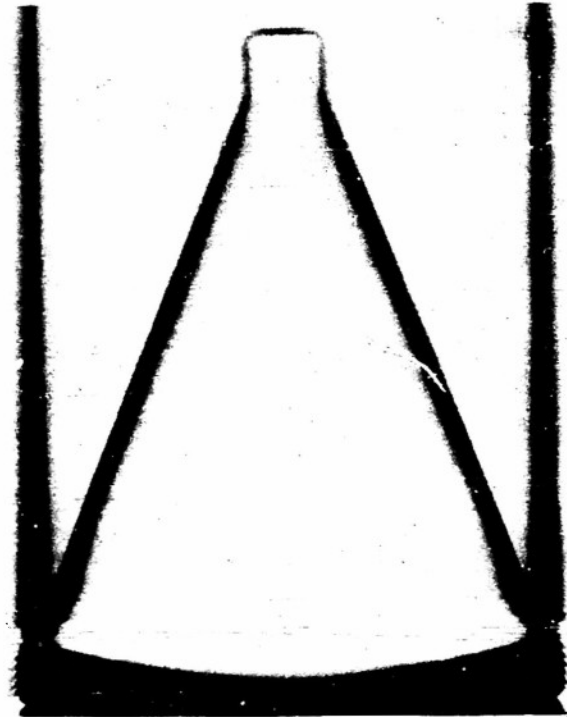


Fig. 13. Radiograph Showing Distorted Cone.

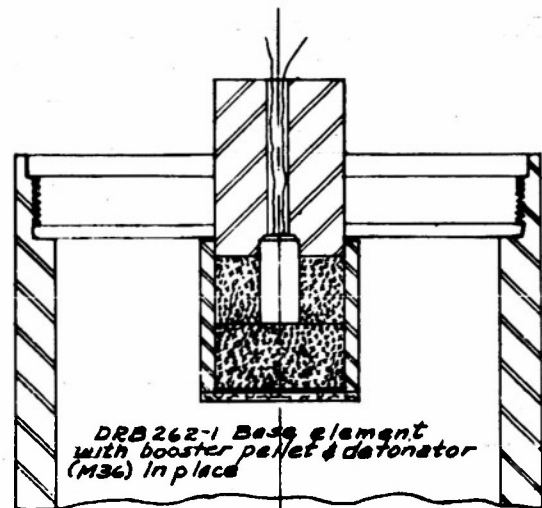
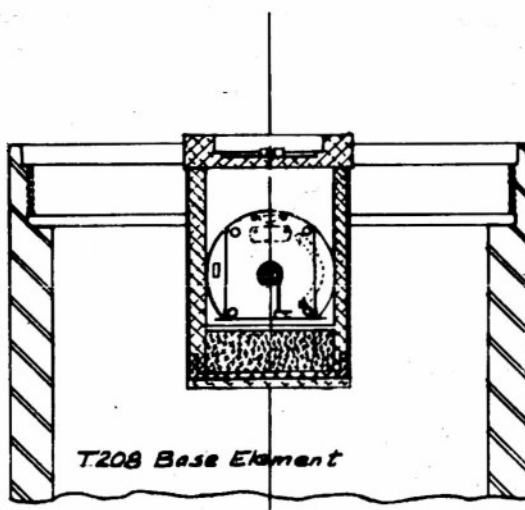


Fig. 12. Two Means of High Explosive Initiation.

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inches, while the average for the undistorted cones is 19.8 inches. It is apparent that great care must be exercised in the assembly of cones into tees (or rings) to prevent such distortion.

## Machined Versus Drawn Liners

Five cones were carefully machined

to drawing DRB398 from hard drawn copper bar. These cones were assembled in DRC376 test assemblies and tested for penetration into mild steel at 0 rev/sec and 7.50 inches standoff. The data are shown in Table X, Part B. The average penetration of 19.5 inches shows that machined and drawn cones penetrate equally well when well made.

**Table X**  
**Penetration Test Data**  
**Effect of Booster System On Penetration**  
**and**  
**Penetration Results With Machined DRB 398 Cones**

| DRC 376 Test Assemblies<br>Standoff - 7.50 inches<br>Spin - 0 rev/sec<br>Loaded at Ravenna Arsenal, BAT Lot No. 8, Holson Lot 3-126 |                |             |                           |                   |                      |
|-------------------------------------------------------------------------------------------------------------------------------------|----------------|-------------|---------------------------|-------------------|----------------------|
| Round No.                                                                                                                           | Booster System | Lbs. Comp B | Penetration (inches M.S.) | Max. Spread (in.) | Std. Deviation (in.) |
| Part A Effect of Booster System (Fig. 12), DRB398, Drawn Cones                                                                      |                |             |                           |                   |                      |
| Q383                                                                                                                                | Test           | 2.46        | 18.81*                    | 3.62              | ±1.65                |
| Q384                                                                                                                                | Test           | 2.48        | 20.31                     |                   |                      |
| Q385                                                                                                                                | Test           | 2.48        | 17.25*                    |                   |                      |
| Q386                                                                                                                                | Test           | 2.46        | 16.69*                    |                   |                      |
| Q387                                                                                                                                | Test           | 2.48        | 20.18                     |                   |                      |
|                                                                                                                                     |                |             | Avg. 18.63                |                   |                      |
| Q388                                                                                                                                | T208E7         | 2.48        | 19.62                     | 2.56              | ±.71                 |
| Q389                                                                                                                                | T208E7         | 2.50        | 18.56*                    |                   |                      |
| Q390                                                                                                                                | T208E7         | 2.50        | 18.88                     |                   |                      |
| Q397                                                                                                                                | T208E7         | 2.48        | 20.12                     |                   |                      |
|                                                                                                                                     |                |             | Avg. 19.29                |                   |                      |
| *Distorted Liners                                                                                                                   |                |             |                           |                   |                      |
| Average penetration for all distorted liners                                                                                        |                |             |                           |                   | 17.83 inches         |
| Average penetration for all undistorted liners                                                                                      |                |             |                           |                   | 19.82 inches         |
| Part B Machined DRB398 Cones                                                                                                        |                |             |                           |                   |                      |
| FS518                                                                                                                               | Test           | 2.44        | 18.62                     | 1.19              | ±.48                 |
| FS521                                                                                                                               | Test           | 2.48        | 19.44                     |                   |                      |
| FS523                                                                                                                               | Test           | 2.48        | 19.81                     |                   |                      |
| FS524                                                                                                                               | Test           | 2.46        | 19.62                     |                   |                      |
| FS528                                                                                                                               | Test           | 2.46        | 19.75                     |                   |                      |
|                                                                                                                                     |                |             | Avg. 19.45                |                   |                      |
| (Compare with average for undistorted cones - 19.82 in.)                                                                            |                |             |                           |                   |                      |

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## Effect of Rotation

The effect of rotation upon the penetration of drawn copper cones when cased in DRC376 test assemblies and when cased in T138E57 assemblies is shown in Table XI and Fig. 14. All rounds utilized the penetration test booster systems.

Certain of the rounds shown in Table XI contained cones which had been distorted during assembly of the rounds. The penetration data clearly shows the loss in penetration resulting from this cone

distortion.

At 25 rev/sec the penetration is independent of the type of assembly but at zero rev/sec the penetration is nearly five inches greater using the DRC376 test assembly than with the T138E57 assembly. These data suggest that the tee does not interfere with penetration at 25 rev/sec, but that it reduces penetration substantially at zero rev/sec. Additional tests are now being conducted to more precisely determine the magnitude of the effect of the tee.

**Table XI**

### Penetration Test Data

*Effect of Rotation Upon Penetration of DRC 376 Drawn Cones*

| Round No.                                                      | Lbs.<br>Comp B | Rev/Sec | Penetration<br>(inches M.S.) | Max. Spread<br>(in.) | Std. Deviation<br>(in.) |
|----------------------------------------------------------------|----------------|---------|------------------------------|----------------------|-------------------------|
| DRC 376 Test Assembly: Ravenna BAT Lot No. 8 Holston Lot 3-126 |                |         |                              |                      |                         |
| Q384                                                           | 2.48           | 0       | 20.31                        |                      |                         |
| Q387                                                           | 2.48           | 0       | 20.18                        |                      |                         |
| Q388                                                           | 2.48           | 0       | 19.62                        |                      |                         |
| Q390                                                           | 2.50           | 0       | 18.88                        |                      |                         |
| Q397                                                           | 2.48           | 0       | 20.12                        |                      |                         |
|                                                                |                |         | Avg. 19.82                   | 1.43                 | ±.59                    |
| Q398                                                           | 2.48           | 25      | 13.31                        |                      |                         |
| Q399                                                           | 2.50           | 25      | 13.56                        |                      |                         |
| Q400                                                           | 2.48           | 25      | 13.69                        |                      |                         |
| Q401                                                           | 2.50           | 25      | 13.18                        |                      |                         |
| Q402                                                           | 2.46           | 25      | 13.69                        |                      |                         |
|                                                                |                |         | Avg. 13.49                   | .51                  | ±.24                    |
| Q429                                                           | 2.46           | 30      | 12.00                        |                      |                         |
| Q430                                                           | 2.48           | 30      | 13.88                        |                      |                         |
| Q431                                                           | 2.48           | 30      | 11.94                        |                      |                         |
|                                                                |                |         | Avg. 12.44                   | 1.94                 | ±1.13                   |
| Q403                                                           | 2.48           | 45      | 12.25                        |                      |                         |
| Q404                                                           | 2.46           | 45      | 10.25                        |                      |                         |
| Q405                                                           | 2.44           | 45      | 13.06                        |                      |                         |
| Q422                                                           | 2.50           | 45      | 7.75                         |                      |                         |
| Q428                                                           | 2.48           | 45      | 11.69                        |                      |                         |
|                                                                |                |         | Avg. 11.00                   | 5.31                 | ±2.09                   |

Continued on next page

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Table XI (Cont.)

| Round No.                                                         | Lbs.<br>Comp B | Rev/Sec | Penetration<br>(Inches M.S.) | Max. Spread(in.) | Std.Deviation(in.) |
|-------------------------------------------------------------------|----------------|---------|------------------------------|------------------|--------------------|
| Q432                                                              | 2.48           | 60      | 7.06                         |                  |                    |
| Q433                                                              | 2.48           | 60      | 7.38                         |                  |                    |
| Q483                                                              | 2.50           | 60      | 7.18                         |                  |                    |
|                                                                   |                | Avg.    | <u>7.21</u>                  | .32              | ±.16               |
| T138E57 Assembly: Picatinny Arsenal, PA-E 9695, Holston Lot 3-166 |                |         |                              |                  |                    |
| Q341                                                              | 2.30           | 0       | (13.31)*                     |                  |                    |
| Q344                                                              | 2.26           | 0       | 15.50                        |                  |                    |
| Q345                                                              | 2.28           | 0       | 16.50                        |                  |                    |
| Q349                                                              | 2.24           | 0       | 14.69                        |                  |                    |
| Q352                                                              | 2.28           | 0       | 13.75                        |                  |                    |
|                                                                   |                | Avg.    | <u>15.11</u>                 | 2.75             | ±1.17              |
| Q343                                                              | 2.27           | 25      | (10.75)*                     |                  |                    |
| Q346                                                              | 2.29           | 25      | 13.44                        |                  |                    |
| Q351                                                              | 2.29           | 25      | 13.80                        |                  |                    |
| Q354                                                              | 2.30           | 25      | 13.94                        |                  |                    |
| Q355                                                              | 2.31           | 25      | 13.81                        |                  |                    |
|                                                                   |                | Avg.    | <u>13.77</u>                 | .50              | ±.23               |
| Q342                                                              | 2.27           | 30      | (11.75)*                     |                  |                    |
| Q347                                                              | 2.29           | 30      | 13.06                        |                  |                    |
| Q350                                                              | 2.29           | 30      | 12.81                        |                  |                    |
| Q353                                                              | 2.31           | 30      | (12.06)*                     |                  |                    |
|                                                                   |                | Avg.    | <u>12.94</u>                 | .25              | --                 |
| T138E57 Assembly: Picatinny Arsenal, PA-E 9806, Holston Lot 3-89  |                |         |                              |                  |                    |
| 768                                                               | 2.28           | 0       | 15.06                        |                  |                    |
| 811                                                               | 2.30           | 0       | 14.75                        |                  |                    |
| 821                                                               | 2.30           | 0       | 14.75                        |                  |                    |
| 877                                                               | 2.27           | 0       | 16.38                        |                  |                    |
| 989                                                               | 2.31           | 0       | 15.56                        |                  |                    |
|                                                                   |                | Avg.    | <u>15.30</u>                 | 1.63             | ±.69               |
| 254                                                               | 2.28           | 25      | 16.12                        |                  |                    |
| 356                                                               | 2.28           | 25      | 12.56                        |                  |                    |
| 769                                                               | 2.28           | 25      | 15.62                        |                  |                    |
| 773                                                               | 2.30           | 25      | 14.56                        |                  |                    |
| 819                                                               | 2.26           | 25      | 15.50                        |                  |                    |
|                                                                   |                | Avg.    | <u>14.89</u>                 | 3.56             | ±1.41              |
| Notes: * Cones distorted, not included in average.                |                |         |                              |                  |                    |

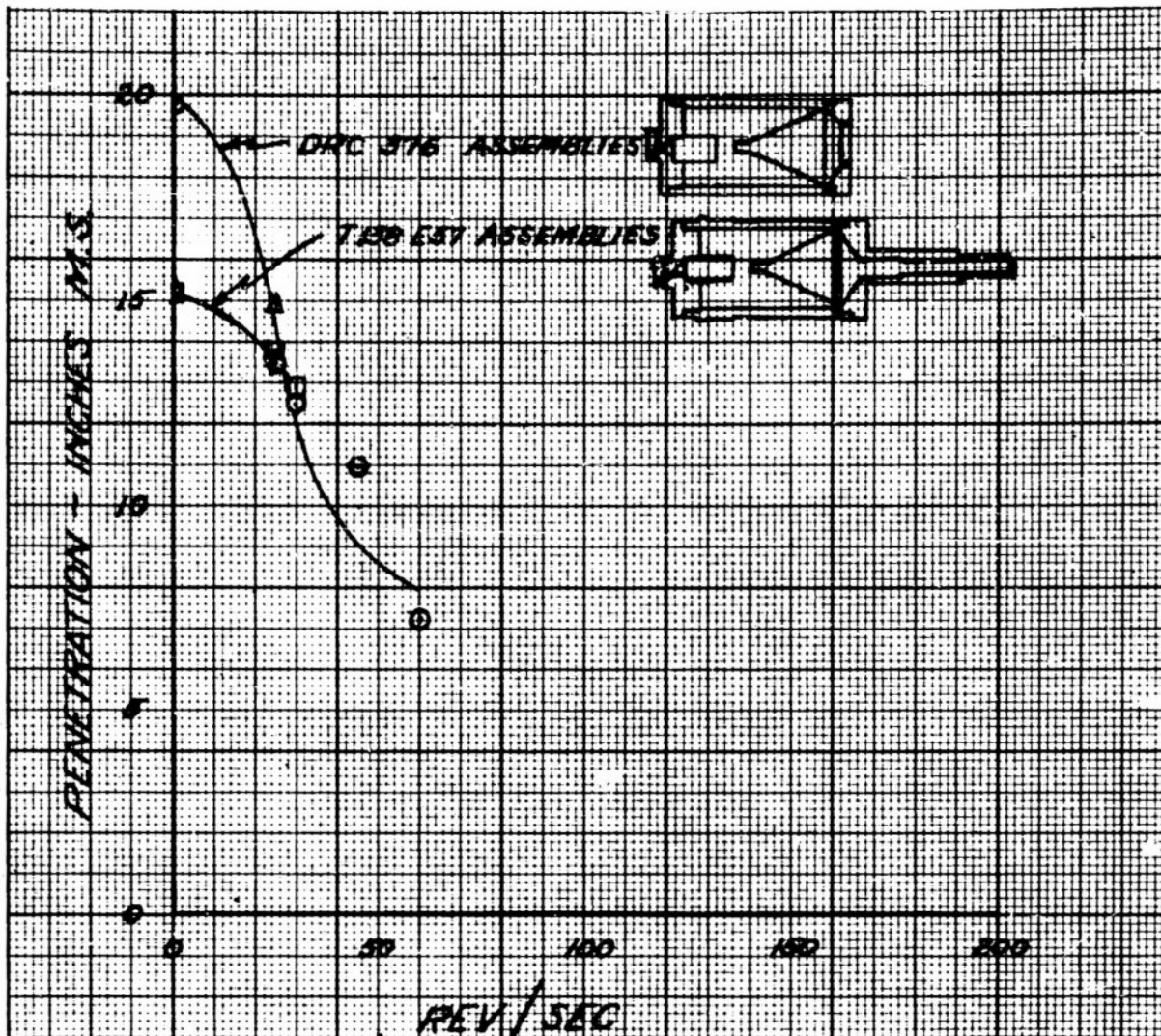


Fig. 14. Rotation Versus Penetration.  
DRC 376 Assemblies and T138 E57 Assemblies.

### Future Program

1. Conduct penetration versus stand-off tests for 45° and 20° copper cones (.100-inch wall) with the head of H.E. held constant at 3.63 inches.

2. Evaluate the influence of DRC314 tees made of (a) mild steel (b) high ductility malleable iron, and (c) low ductility malleable iron.

3. Compare DRC314 tees and DRC376 nose rings with respect to their effect upon penetration.

4. Compare DRC376 test assemblies employing the penetration test base element assembly and similar rounds with the booster set in the base plug (No dummy base element).

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## FUZES

### Calculation and Measurement of Impulse Sustained by a T138E57 Projectile In Passing Through a Bursting Screen

The impulse sustained by a projectile, in perforating a wood bursting screen, is equal to the sum of (1) the impulse required to shear out a plug of wood and (2) the impulse required to accelerate the wood punched out of the target. Neglecting the shear impulse, a value for the ratio of the velocity after hitting the screen to the velocity before hitting the screen, can be calculated as follows:

Let A=cross sectional area of proj. -sq. in.  
 t=thickness of screen - inches  
 d=density of screen - lb/cu. in.  
 g=gravitational constant-32 ft/sec/sec.  
 m=mass of wood punched out  
 M=mass of projectile  
 $V_1$  =striking velocity of projectile-ft/sec  
 $V_2$  =exit velocity of projectile-ft/sec.  
 =velocity attained by wooden plug

$$\text{Then, } m = \frac{Atd}{g} \quad (1)$$

$$M(V_1 - V_2) = mV_2 \quad (2)$$

$$MV_1 = V_2(M + m) \quad (3)$$

$$\frac{M}{M+m} = \frac{V_2}{V_1} \quad (4)$$

A firing program to test Equation (4) has been completed. One set of velocity screens was set up in front of a bursting screen and a second set was placed behind the bursting screen. The firing data and the comparison of experimental and calculated ratios are shown in Table XII.

The experimental ratio is corrected for the loss of velocity that occurs in air, as determined by rounds 2484, 2485 and 2486 in Table XII.

It appears that the loss in momentum experienced by a projectile passing through

**Table XII**  
**Firing Data**  
**Measurement of Impulse Sustained By T138E57 Projectile**  
**Passing Through a Bursting Screen**

| Round No. | Weight of Projectile(lb) | Screen Thickness (in.) | Instrumental Velocity(f/s) |       | $V_2 - V_1$ | $(V_2 - V_1)$ corr'd | $V_1$ corr'd | $V_2$ corr'd | $\frac{V_2}{V_1}$ |       |
|-----------|--------------------------|------------------------|----------------------------|-------|-------------|----------------------|--------------|--------------|-------------------|-------|
|           |                          |                        | $V_1$                      | $V_2$ |             |                      |              |              | Exp.              | Calc. |
| 2484-1    | 17.14                    | 0                      | 1652                       | 1626  | 26          |                      |              |              |                   |       |
| 2485-2    | 17.12                    | "                      | 1681                       | 1660  | 21          |                      |              |              |                   |       |
| 2486-3    | 16.84                    | "                      | 1698                       | 1677  | 21          |                      |              |              |                   |       |
| Avg.      | 17.03                    | "                      | 1677                       | 1654  | 23          | 0                    | --           | --           | --                | --    |
| 2488-5    | 17.43                    | 1.62                   | 1672                       | 1596  | 76          |                      |              |              |                   |       |
| 2489-6    | 17.37                    | "                      | 1675                       | 1617  | 58          |                      |              |              |                   |       |
| 2490-7    | 17.10                    | "                      | 1687                       | 1619  | 68          |                      |              |              |                   |       |
| Avg.      | 17.30                    | "                      | 1678                       | 1611  | 67          | 44                   | 1666         | 1622         | .974              | .979  |
| 2492-9    | 16.56                    | 3.25                   | 1714                       | 1623  | 91          |                      |              |              |                   |       |
| 2493-10   | 17.20                    | "                      | 1693                       | 1585  | 108         |                      |              |              |                   |       |
| 2496-13   | 17.37                    | "                      | 1672                       | 1594  | 78          |                      |              |              |                   |       |
| Avg.      | 17.04                    | "                      | 1693                       | 1601  | 92          | 69                   | 1681         | 1612         | .959              | .958  |

Notes: 1. Screen spacing Muzzle 112'6" A 72'3 1/2" B 21'4 1/2" C 58'3 1/2" D  
 2. Target screen placed midway between screens B and C  
 3. Density of dry screen taken as 30 lb/cu. ft.  
 4. T137E1 Rifle and T152E2 Mount.

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a wood bursting screen at 1700 ft/sec is nearly equal to the momentum acquired by the wood that is removed from the target. The small difference between the measured and calculated ratio is a measure of shear impulse. It is apparent that, in the case of a wooden screen, the shear impulse is negligible.

## Evaluation of the Effect of RC Washer

In considering the malfunctions encountered in the T138E57 HEAT rounds fired at Aberdeen Proving Ground the question arose as to the effect of this RC washer upon the sensitivity of the fuze system. An experiment to show the effect of this RC washer on fuze sensi-

tivity has been performed, using the drop-tester. A crystal, tee and tee cap assembly was mounted in the tester and dropped from various heights. The tee cap had .030-in. walls and .010 in. clearance between cap and crystal. A heat squib (the equivalent of the T18 detonator from an energy requirement) was connected across the crystal and was used to determine functioning. In the first experiment the heat squib was used alone, in the second an RC washer was placed in parallel with the heat squib, and in the third .100-in. wall caps were used.

Table XIII shows the data for these tests. Some experimental difficulties

**Table XIII**  
**Test Data**  
**Evaluation of the Effect of RC Washer**

| Drop Sequence                                                                                         | Drop Height (in.) | Squib Resistance | RC Resistance | Parallel Res. of Squib and RC | Tee Cap Wall | Clearance | Tee Cap Distortion | Condition of Lucky after Drop | Results                  |
|-------------------------------------------------------------------------------------------------------|-------------------|------------------|---------------|-------------------------------|--------------|-----------|--------------------|-------------------------------|--------------------------|
| 1                                                                                                     | 36                | --               |               |                               | .030         | .010      |                    | Powdered                      | OK                       |
| 2                                                                                                     | 12                | --               |               |                               | .030         | .010      |                    | "                             | No Probable open circuit |
| 3                                                                                                     | 12                | 4300             |               |                               | .030         | .010      |                    | Crumbled                      | OK                       |
| 4                                                                                                     | 6                 | 3400             |               |                               | .030         | .010      |                    | Chipped                       | OK                       |
| 5                                                                                                     | 3                 | 1800             |               |                               | .030         | .010      |                    | No Damage                     | NO                       |
| 6                                                                                                     | 6                 | 1800             |               |                               | .030         | .006      |                    | Chipped                       | No Probable short        |
| 7                                                                                                     | 6                 | 1700             |               |                               | .030         | .010      |                    | "                             | OK                       |
| 8                                                                                                     | 5                 | 1700             |               |                               | .030         | .010      |                    | "                             | OK                       |
| 10                                                                                                    | 4                 | 3800             |               |                               | .030         | .010      |                    | No Damage                     | OK                       |
| 11                                                                                                    | 4                 | 4100             |               |                               | .030         | .010      |                    | "                             | OK                       |
| Drops 12 & 13 used the same heat squib and different caps.                                            |                   |                  |               |                               |              |           |                    |                               |                          |
| 12                                                                                                    | 3                 | 4200             |               |                               | .030         | .010      |                    | "                             | NO                       |
| 13                                                                                                    | 4                 | 4200             |               |                               | .030         | .010      |                    | "                             | OK                       |
| Drops 17, 18 & 19 used the same heat squib and different caps.                                        |                   |                  |               |                               |              |           |                    |                               |                          |
| 17                                                                                                    | 3                 | 3000             |               |                               | .030         | .009      | .007               | "                             | NO Open circuit          |
| 18                                                                                                    | 3                 | 4200             |               |                               | .030         | .008      | .003               | "                             | NO " "                   |
| 19                                                                                                    | 3                 | 4500             |               |                               | .030         | .010      | .003               | "                             | OK                       |
| 20                                                                                                    | 3                 | 2400             |               |                               | .030         | .010      | .008               | "                             | NO                       |
| 21                                                                                                    | 4                 | 1900             |               |                               | .030         | .010      | .010               | "                             | OK                       |
| Drops 22, 23, 24, & 25 used the same heat squib and different caps, except 24 & 25 used the same cap. |                   |                  |               |                               |              |           |                    |                               |                          |
| 22                                                                                                    | 4                 | 3600             |               |                               | .030         | .012      | .011               | Same cap                      | NO Open Circuit          |
| 23                                                                                                    | 4                 | 3300             |               |                               | .030         | .012      | .010               |                               | NO                       |
| 24                                                                                                    | 4                 | 3500             |               |                               | .030         | .012      | .009               |                               | NO Bad Squib             |
| 25                                                                                                    | 4                 | 3600             |               |                               | .030         | .001      | .003               |                               | NO                       |
| 9                                                                                                     | 5                 |                  | 120K          | 2800                          | .030         | .010      |                    | Chipped<br>No Damage          | OK                       |
| 14                                                                                                    | 4                 |                  | 120K          | 3200                          | .030         | .010      |                    |                               | OK                       |
| 26                                                                                                    | 4                 | same squib       | 156K          | 2600                          | .030         | .010      | .008               | No Damage                     | OK                       |
| 27                                                                                                    | 4                 |                  | 156K          | 2200                          | .030         | .010      | .009               |                               | NO                       |
| 28                                                                                                    | 4                 |                  | 156K          | 2150                          | .030         | .010      | .009               |                               | OK                       |
| 29                                                                                                    | 4                 |                  | 156K          | 3800                          | .030         | .010      | .008               |                               | NO                       |
| 30                                                                                                    | 5                 |                  | 110K          | 2400                          | .030         | .010      | .012               |                               | OK                       |
| 31                                                                                                    | 5                 |                  | 110K          | 1650                          | .030         | .010      | .011               |                               | OK                       |
| 32                                                                                                    | 5                 |                  | 110K          | 3200                          | .030         | .010      | .009               |                               | OK                       |
| 33                                                                                                    | 5                 |                  | 160K          | 3500                          | .030         | .010      | .013               |                               | OK                       |
| 34                                                                                                    | 5                 |                  | 160K          | 1500                          | .030         | .010      | .012               |                               | OK                       |
| 15                                                                                                    | 48                | 4500             |               |                               | .100         | .005-.9   | .069               | Powdered                      | OK                       |
| 16                                                                                                    | 24                | 4600             |               |                               | .100         | .008      | .028               | "                             | OK                       |
| 35                                                                                                    | 12                | 2600             |               |                               | .100         | .010      | .009               |                               | NO                       |
| 36                                                                                                    | 12                | 3000             |               |                               | .100         | .010      | .011               |                               | OK                       |
| 37                                                                                                    | 12                | 1300             |               |                               | .100         | .010      | .011               |                               | OK                       |
| 38                                                                                                    | 12                | 2400             |               |                               | .100         | .010      | .009               |                               | OK                       |
| 39                                                                                                    | 12                | 2100             |               |                               | .100         | .010      | .010               |                               | OK                       |
| 40                                                                                                    | 12                | 4100             |               |                               | .100         | .010      | .011               |                               | OK                       |

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such as shorts, open circuits and faulty techniques were experienced. However, the results of Part I show that a drop of 3 inches was sometimes sufficient for functioning; a drop of four inches was frequently sufficient, and a drop of six inches was usually sufficient. When an RC washer was placed in parallel with the heat squib very consistent functioning was observed with five-inch drops. With a heavy wall cap (.100 in.) a drop of twelve inches functioned the heat squib in five of six tests. No shorter drops were tried.

These data indicate that:

- (1) The RC washer causes no important decrease in the sensitivity of the system.
- (2) A tee assembly mounted in the drop tester with a cap having .100-in. wall functions the heat squib on a 12-in. drop.

### **Performance Test of Fuze, PD, T222E4 (T222E3 Nose Element, FBE 6 [DRD 260] Base Element)**

Ten FBE6 base elements (DRD260), loaded with heat squibs, (T18 detonator without lead azide) were assembled in T138 E57 projectiles, and fired through a bursting screen into a recovery box. The tee caps had wall thicknesses of .010 in. and the base elements had all armed satisfactorily when tested in the centrifuge. Five of the units had been modified by putting projections on the base terminals, in an effort to get more positive electrical contact. Nine of the ten rounds were recovered. Six of the nine base elements had armed, but none of the heat squibs had functioned. Examination of the three unarmed base elements showed that the pins were rusty and upon removal of this rust the rounds armed, as expected, when retested in the centrifuge. The base elements had been permitted to stand for some days in freshly filled

inert rounds and it seems likely that the moisture from the plaster cast caused the rusting. In five of the six armed base elements recovered, the base terminal had been driven forward by impact. Since this can occur only if the rotor is in the armed position at impact, the best explanation for the failure to set off the heat squibs is that insufficient electrical energy was supplied.

Failure to supply sufficient electrical energy can be caused by a failure in the electrical circuit, an open or short, or by some failure of the nose element. Since the tee caps were thin-walled (.010 in.) it was decided to investigate other possibilities. A base element which had armed but which had failed to fire the heat squib was reassembled in the unarmed position, placed in centrifuge, and accelerated sufficiently to arm. The exact time of arming was determined by means of suitable slip rings connected to the terminals. The armed base element was removed from the centrifuge and an attempt was made to fire it by compressing a crystal assembly connected across the terminals. It was not possible to fire the heat squib but the heat squib itself was fired easily when connected directly to the crystal assembly.

These tests, together with those reported in the Twenty-Second Progress Report, indicate that some of the trouble encountered with poor functioning of the FBE6 base element is caused by failure of the sliding contact. This contact system is very similar to that used in the T208 base element.

A model of a redesigned contact has been made and tested. The base element was run in the centrifuge in the reversed position and it was found that over 2000 g's acceleration were necessary to cause the modified contact to open. Further tests with base elements, embodying this modified contact, are planned.

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| 1                              | 1          | ORDTS                                     |
| 2                              | 2-3        | ORDTA                                     |
| 1                              | 4          | ORDTQ                                     |
| 1                              | 5          | ORDTR                                     |
| 1                              | 6          | ORDTB                                     |
| <b>Arsenals</b>                |            |                                           |
| 10                             | 7-16 incl. | Frankford                                 |
| 2                              | 17-18      | Picatinny                                 |
| 1                              | 19         | Springfield Armory                        |
| <b>Ordnance Districts</b>      |            |                                           |
| 1                              | 20         | Cleveland                                 |
| <b>Aberdeen Proving Ground</b> |            |                                           |
| 2                              | 21-22      | Ballistics Research Laboratory            |
| 1                              | 23         | Development and Proof Services            |
| <b>Contractors</b>             |            |                                           |
| 2                              | 24-25      | Frigidaire Div. Gen. Motors Corp.         |
| 1                              | 26         | Winchester Repeating Arms Co.             |
| 1                              | 27         | Remington Arms Co.                        |
| 1                              | 28         | National Forge & Ordnance Co.             |
| 2                              | 29-30      | Midwest Research Institute                |
| 2                              | 31-32      | Armour Research Foundation                |
| 1                              | 33         | Carnegie Institute of Technology          |
| 1                              | 34         | Arthur D. Little Co.                      |
| 1                              | 35         | The Budd Company                          |
| 1                              | 36         | Franklin Institute                        |
| <b>U. S. Navy</b>              |            |                                           |
| 1                              | 37         | Bureau of Navy Ordnance                   |
| 2                              | 38-39      | Naval Ordnance Laboratory,<br>White Oak   |
| 1                              | 40         | Naval Ordnance Test Station,<br>Inyokern  |
| 1                              | 41         | Naval Proving Ground, Dahlgren            |

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