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**THIRTY-FIFTH
PROGRESS REPORT**

OF

THE FIRESTONE TIRE & RUBBER CO.

ON

BATTALION ANTI-TANK PROJECT

Contract Nos.

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

DA-33-019-ORD-1202

RAD Nos. ORDTS 1-12383

ORDTS 3-3955

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THE FIRESTONE TIRE & RUBBER CO.

Defense Research Division

Akron, Ohio

JUNE, 1953

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ABSTRACT

An inventory of T137 rifles and T152 mounts, manufactured by Firestone, is given.

A review is made of the development of the T52E2 and T53E1 shell cases. A specific problem of the bulging of non-heat treated shell cases lead to an investigation of the feasibility of localized heat treating using induction heating. The data from the investigation are presented and discussed.

Thirty-eight rounds of T119 folding fin projectiles were fired to investigate the effect of the number of fins upon the accuracy of the projectile. The test results are given.

A portion of a larger program concerning projectile yaw and the effect of muzzle blast on accuracy of the T119 projectile, is reported.

In the penetration study program, tests were made to extend the use of data for the 105mm cones and charges to other sizes. To implement this, scale studies were made to determine the effect of size upon penetration. The test data are presented and analyzed.

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THE WEAPON SYSTEM

An inventory of T137 rifles and T152 mounts manufactured by Firestone for

its own research and development activities is given in Table I.

Table I

Inventory of Recoilless Rifles and Mounts

Manufactured by Firestone and Used in Research and Development Activities of Defense Research Division

Rifle or Mount	Location	Comments
RIFLES		
T137E3 Rifles Serial Nos. 1 & 2 No. 13 Nos. 21 & 22	Akron Aberdeen Proving Ground Akron	Returned from Fort Benning Test Facility For Spare Parts
T137E2 Rifles Serial No. 1 No. 2	Akron Erie Ordnance Depot	For Spare Parts Test Facility
T137E1 Rifles Serial No. 4 No. 8	Watertown Arsenal Akron	Metallurgical Study Held for historical value
MOUNTS		
T152E5 Mounts Serial Nos. 1 & 2 No. 3	Akron Aberdeen Proving Ground	
(Rifles and mounts scrapped have been dropped from inventory. For complete accounting see Thirty-Second Progress Report)		

Induction Heat Treated Shell Cases

A preliminary report of the performance of seventeen T53E1 shell cases which had been heat treated over a localized area by induction hardening and tempering was presented in the Thirty-Fourth Progress Report. A complete report of this development is presented here.

Two meetings held in Office, Chief of Ordnance (ORDTS and ORDTA) on August 8 and 16, 1952, were concerned with the BAT project and resulted in certain decisions regarding standardization of the weapons and ammunition. It was requested that the BAT rifle, T137, be modified so as to be capable of firing all types of BAT ammunition i.e., the ammunition developed for the T170 and M27 rifles as well as that developed specifically for the T137. In addition, a decision was

made that in each of the several possible "packages" of ammunition (HEAT, HE, HE-P, WP) only the HEAT round could be finned and that the others must be the more conventional spinning rounds.

In order to comply with these revised requirements it was necessary to make extensive changes in the chamber of the T137 rifle, so that it could accommodate the other types of ammunition. The regular ammunition uses the M32 cartridge case. This case was in production, was readily available, and could be modified easily for use in the T137E3 rifle. Because the pressures in the BAT rifles are higher than in the M27 rifle, for which the M32 case was developed, it was found necessary to heat treat the M32 cartridge cases. Two modifications of the M32

case, designated T52E2 and T53E1 are as follows:

T52E2 - Standard mouth, heat treated, enlarged primer counterbore, for use with conventional spinning ammunition.

T53E1 - Expanded mouth, heat treated, enlarged primer counterbore and plug in the base for rear loading, for use with the T119E11 HEAT round.

Figure 1 is a drawing of the T53E1 case. The smaller mouth of the T52E2 case (standard size for the M32 case) is indicated by the dashed lines. When used without heat treating about 50% of these cases bulge with a 100% charge and all fail at a 115% charge. When hardened to Rockwell C 30 to 35 the cases are satisfactory at a 115% charge (See Table IV of the Twenty-Sixth Progress Report). In this experiment the cases were quenched and tempered in a neutral salt bath to the desired hardness. While this procedure eliminated the case failures, it has proved to be cumbersome and has the disadvantage that final machining and sizing must be done on the hardened case.

It was observed that the bulging of the case was limited to a zone approximately two inches in length extending forward from a point about 2.5 inches from the base. Accordingly, it was proposed that the heat treatment of the case be limited to the area where bulging occurred, leaving the balance of the case in its "as drawn" condition. It was recognized that the required hardness could be obtained by induction heating methods, but that there would be a transition zone at each end of the hardened area where the case would be, in effect, "process annealed" due to the temperature gradient. The extent and degree of this softened portion, and its effect upon performance, were not known. Furthermore, the effect of the cartridge case perforations upon the induced heat pattern and upon the heating efficiency had to be determined.

Twenty-five cases from a shipment of M32 cases were selected for evaluation of the induction heating method. Arrangements were made with the Metallurgical Laboratory of the Tocco Division, The Ohio Crank Shaft Company, to make an inductor and to induction harden the experimental cases. Figure 2 is a sketch of the inductor which was used. The pertinent operating data were as follows:

Frequency	3000 rps
Power	130-100 KW
Heating Time	10 sec
Delay Time	5 sec
Quench Time	15 sec (Water)
Quench Pressure	2.5 lbs.
Rate of flow	75 gpm
Temperature of Quench	80°F
Type Steel	AISI 1030
Tempering	one hour at 700°F

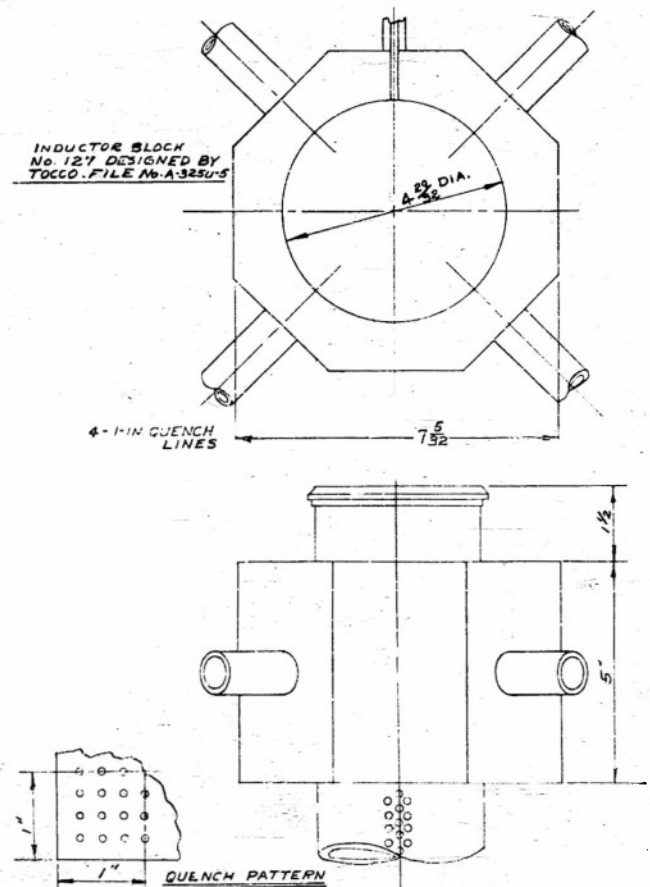


Fig. 2. Inductor Block For Induction Hardening Perforated Shell Case.

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After developing the above procedure, seventeen cases remained from the original twenty-five. The hardness of these cases was measured after hardening and the data are shown in Figure 3. These data are in agreement with the results of hardness measurements made by Tocco on longitudinal strips cut from the hardened zone.

Ten of the seventeen cases were used for firing tests at Erie Ordnance Depot. The firing record for these ten cases is shown in Table II. After each case had been fired once the lot were returned to Akron for inspection. No evidence of bulging or distortion was noted. All seventeen cases were then returned to Erie Ordnance Depot for use in routine firing. A record of the firings for each case was kept until each case had been used five times. One case bulged on the second firing with a 100% charge, but all other cases have been used a minimum of six times each with at least one 115% charge in each case and none has failed.

As a result of these tests it is concluded that:

1. Locally hardening and tempering

a 5 inch zone, beginning at a line 2 inches above the base, to a hardness of R_C 30 to 36 will produce a case which will not bulge at a 115% charge.

2. The induction method of heating is practical. The distortion of the flux, caused by the case perforations, does not greatly affect the process.

3. The transition zones were quite narrow, approximately .25 inch long, and although softer than the balance of the case do not themselves cause failure of the case.

4. The short duration of the heat treating cycle should speed up the heat treating operation and the localized hardening should reduce the cost of the subsequent machining operation.

It is believed that this method of heat treating cases is applicable to the large scale production of high strength cases and should result in substantial savings compared with the use of heavier wall cases, higher strength steels, or heat treatment of the entire case.

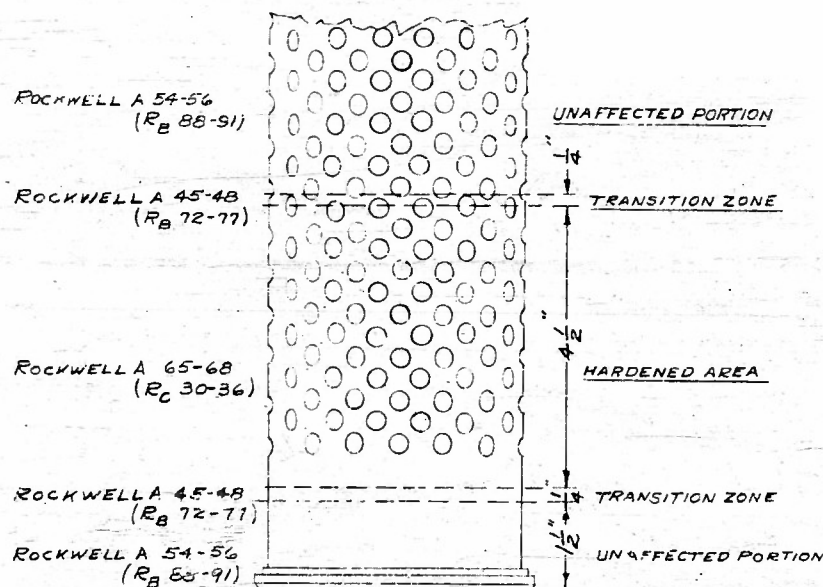


Fig. 3. Hardness Pattern.
For Induction Hardened T53E1 Cartridge Case.

Table II
Test Firing Data
T52E1 Cartridge Case

Date of Test Feb 19, 1953

Purpose of Test Shell Case No. 752E1

PROJECTILE

Model 712
Type Slug PRC-510
Weight 175 lbs (nom)
CG Location
Bouriet Do 4.132 - .002
Special Features No band

TEST GUN

Model T122E3
Type Constant Recoil
Serial No 228-775 B
Chamber 228-775 B
Bushing (Vent) 228-775-2-1
Tube 228-775-2-105 in 20 Twist
Sighting Equipment HIT Adapted Telescope
Mount Pendulum
Type Constant Recoil
Solenoid Mechanical Firing system

MISCELLANEOUS DATA

Propellant
Type M10 Web 03.5 Weight
Lot No PA 30290
Primer A37
Case
Type 752E1
Temperatures
Nozzle
Max 75°F M 70°F Present 70°F
Loading Room 75°F Ambient 78°F

Round No	Powder Depth in Case	Proj Weight (lb)	Powder Charge (lb oz)	Recoil (in)	Chamber Pressure (lb/sq in)	Baricent Pressure	Elev (mils)	Position of Hit		Corrected Position of Hit - mils		Recoil (in)	Observations
								Vert	Horiz	Vert	Horiz		
4471-1	4 3/4	17.27	7 1/4	4 1/4	10,000	100							
4472-2	4 3/4	17.27	7 1/4	1 1/2	10,000	100							
4473-3	5 3/8	17.34	7 1/4	?	10,000	100							
4474-4	5 1/4	17.30	7 1/4	1 1/2	10,000	100							
4475-5	5 3/8	17.24	7 1/4	0	10,000	100							
4476-6	5	17.34	8	1	12,300	115 mm							
4477-7	5	17.24	8	1 1/2	12,300	115 mm							
4478-8	4 3/4	17.28	8 2	1 1/2	12,300	115 mm							
4479-9	5 3/8	17.27	8 2	?	12,300	115 mm							
4480-10	5 3/8	17.30	8 2	1 1/4	12,300	115 mm							

Note: None of the 10 shell cases showed any visible signs of bulging. All rounds were loaded and fired as single units. Powder charge was decreased after round 2 because of high pressures. Powder charge was increased after round 7 because of low pressures.

Proof Director E. H. Linton
Observers L. Swadlow, C. M. H. R.
Signed 12 Feb 1953

T119 PROJECTILE

Effect of Number of Fins

Three lots of T119 projectiles, each having either four, five or six fins, have been fired for accuracy. The target was 18 ft by 18 ft and was placed at a range of 1055 yards. The data are presented in Table III and are summarized below.

No. Fins	No. Rounds	Hits	Misses	Probable Error (mi.)	
				Horiz.	Vert.
Four	13 (a)	7	4	±.92	±.53
Five	15	13	2	±.61	±.64
Six	10	10 (b)	0	±.49	±.33

Notes:

- (a) Two rounds fired for observation only.
- (b) One round struck velocity coil before striking target and was not used in calculation of probable errors.

The four-finned projectiles not only had a considerably higher horizontal probable error of dispersion than the other types but three of the four misses and the two rounds fired for observation were observed to fly erratically. The data indicate that the T119 with four fins is marginally stable, and no further testing of this type of projectile is planned.

The two misses in the group of projectiles with five fins were observed to have good flight. The accuracy obtained for this group was not as good as that of the six-finned projectiles but is not so poor as to suggest a discontinuation of the testing of this type. The gun used in the above test has a forward recoil and further testing is planned with a gun adjusted to give a rearward recoil.

Spin Measurements

Projectile spin rate was measured as part of a more comprehensive program to study projectile yaw and to evaluate the effect of muzzle blast on the ac-

curacy of the T119E11 projectile. The complete data have not been analyzed and only spin measurements are presented here.

For the purpose of determining spin a series of nine yaw card frames were placed at distances varying from 30 ft to 288.74 ft in front of the T137E2 gun.

Five rounds were fired through cardboard yaw cards with the cards being replaced after each round. A horizontal reference line on each yaw card and a small pin pressed into one of the fins of each projectile were used in recording the rotation of the projectile between successive cards.

The details of the range data are presented in Table IV. The yaw card measurements are shown in Table V and Fig. 4 is a plot of the rotation versus distance from the gun. The smoothed curves were used to determine the rolling velocity as shown in Table VI and Fig. 5. To determine the muzzle spin, the spin induced on the projectile by friction in the gun bore, the spin rate curves (Fig. 5) were extrapolated to the muzzle and it was found that the projectile emerges from the muzzle with a spin rate of one to two revolutions per second. Analysis of the spin data is being continued to provide an equation which will describe the roll motion of the T119 projectile throughout its entire range.

Table III
Accuracy Range Data
To Test Accuracy of Four- and Five-Finned Projectiles
T119 Folding Fin Projectile

Date of Test June 12, 1953Purpose of Test To Test Accuracy of 4 & 5 Finned Projectiles**PROJECTILE**Model T119Type 4 & 5

Weight

Caliber 1.75Barrel Dia. 1.75Speed Features 11 Standard
4 & 5**TEST GUN**Model T137E2Type 105 mm Artillery

Serial No.

Chamber 6-B 637Bushing 22 A 269 BATube 22 A 849 CSighting Equipment M62 E 4 18006 5 GunnersMount Quadrant M1 18241Model T152L 4 (on concrete base)Limit 3708 in

Sighting & Mechanical Firing System

MISCELLANEOUS DATARange 1055 yds

Projectile

Type T119 M10 Web 0.335 Weight 7 lbs 12 1/2Lot No. 20 302 3 9Primer T 01Shell Case T 53Liner 1.52 folding line (base cut off)

Temperatures

Magazine

Vias 70°F M. 70°F Present 70°FLeading Room 76°F Ambient 65°F

Round No	No. of Fins	Proj Weight (lb)	No	Wind Dir	Wind Speed (mph)	Chamber Pressure (psi)	Muzzle Velocity (ft/sec)	Elev (in)	Azim (mils)	Position of Hit (inches)	Corrected Position of Hit (inches)	Recoil (in)	Observations
5094	6F	17.56	X356	9	210	9500	—	25.0	1 L	72	-13 1/2	+474	+592
5095	6F	17.57	X382	7	215	9600	—	23.5	1 L	38	+14 1/4	1.000	+1.323
5096	5F	17.30	X622	7.5	210	10200	1639	16.5	1 L	7 1/4	-20	+191	+421
5097	4F	17.07	X593	10	195	10300	1658	16.8	1 L	—	—	—	—
5098	6F	17.52	X453	10	220	10200	1642	16.6	1 L	—	—	—	—
5099	5F	17.31	X621	7	235	10100	1662	16.9	1 L	3 1/2	-52	+829	-421
5100	5F	17.06	X594	7.5	240	10300	1670	16.9	1 L	45 1/2	57 1/2	-1.098	566
5101	6F	17.52	X388	10	235	10100	1664	16.9	1 L	8 1/4	-17	+217	+500
5102	5F	17.32	X623	10	240	10100	1673	16.9	1 L	43 1/2	47 1/2	+1.145	+2.199
5103	4F	17.06	X595	10	240	10000	1684	17.0	1 L	11 1/2	41 1/4	+303	+2.192
5104	6F	17.42	X381	9	230	10000	1651	16.7	1 L	15 1/2	5 1/2	-408	+1.198
5105	5F	17.31	X627	8	220	10000	1664	16.9	1 L	45	31 1/2	+1.185	+1.777
5106	4F	17.07	X592	7	225	9900	1664	16.9	1 L	30	+32	+790	+1.790
5107	5F	17.52	X386	6	235	—	1644	16.7	1 L	29	-2 1/4	-764	+889
5108	5F	17.38	X620	6	260	10600	1663	16.8	1 L	39	+12	+1.027	+1.269
5109	4F	17.06	X597	9	255	10400	1664	16.9	1 L	9 1/4	-4 1/2	+244	+1.229
5110	6F	17.53	X377	6	235	—	1656	16.7	1 L	108	+34	-1.696	+1.843
5111	5F	17.19	X619	6	235	—	1628	16.5	1 L	—	—	—	—
5112	4F	17.09	X599	4	290	—	1642	16.6	1 L	15 1/2	14 1/2	-408	+1.330
5113	6F	17.52	X384	8	16	—	1630	16.5	1 L	5	72	-232	-948
5114	5F	17.30	X612	7	5	—	1633	16.5	1 L	4	+54 1/2	+1.05	+2.383
5115	4F	17.08	X599	7	5	—	1641	16.7	1 L	25	75	-658	+2.923
5116	6F	17.52	X390	8	15	—	—	—	1 L	18 3/4	-38 1/4	-1.494	-1.059
5117	5F	17.30	X626	7	5	—	1629	16.5	1 L	24 1/2	+44	-1.119	+2.106
5118	4F	17.03	X593	6	30	—	1636	16.6	1 L	—	—	—	Not observed

Table III (Cont.)

Date of Test June 12, 1953

Purpose of Test Accuracy test at 4 & 5 fm projectiles

PROJECTILE

Model 1119
Type 2.5 2 FX
Weight 1.91
C.C. Loc 0
Assumed No 4 132 602
Spec. Instr. EA 2.5 5 fm

TEST GUN

Model 1137 E 2
Type 105 mm Recoilless
Serial No 6-B-637
Chamber 22-B-269 BE
Pushing Valve 22-B-269 BE
Tube 22-B-269 BE
Sight EQ. present Muzzle 10006 & Runners
Muzzle 10006 & Runners
Type 1137 E 2 (on concrete base)
Serial 1137 E 2

MISCELLANEOUS DATA

Range 1055 yds
Projectile Type M1137 Web 2335 Weight 716 11/16
Lot No PH 30139
Primer 1.91
Shell Case 1.91
Sight 10006 & Runners (base cut off)
Temperature
Muzzle 10006 Muzzle 10006
Max 10006 Min 10006 Present 10006
Loading Room 10006 Ambient 10006

Round No	Proj. Weight (lb.)	Proj. No.	Mind. Vel. (ft/sec)	Chamber Pressure (lb./sq.in.)	Muzzle Velocity (ft/sec)	Elev. (mils)	Position of Hit (inches)	Corrected Position of Hit (inches)	Recoil (inches)	Observations
5120	5 F 17.30	X 613	5 55	—	1620	240	12 3/4	10	810	Apparent good flight
5121	5 F 17.30	X 613	5 55	—	1633	240	13 1/2	25	829	do
5122	5 F 17.30	X 625	5 25	—	1636	240	—	—	—	Erratic flight
5123	5 F 17.30	X 610	5 30	—	1631	240	31	36	742	Apparent good flight
5124	5 F 17.30	X 611	5 35	—	1668	240	30	42	726	do
5125	5 F 17.30	X 600	5 45	—	1675	240	5	11	606	Erratic flight, survived right
5126	5 F 17.30	X 615	5 50	—	1660	240	—	—	—	Missed target, apparent good flight
5127	5 F 17.30	X 618	5 60	—	1651	240	35	40 1/2	1395	Apparent good flight
5128	5 F 17.30	X 610	5 80	—	1644	240	5	5 3/4	606	do
5129	5 F 17.30	X 614	5 110	—	1657	240	23 1/2	3 1/2	1093	do
5130	5 F 17.30	X 606	3 110	—	1644	240	4 1/2	4 1/2	1086	do
5131	5 F 17.30	X 556	4 190	—	1634	240	4 1/2	4 1/2	1086	do

Note: Asterisks (*) denote rounds which were not positively identified due to poor observation caused by mist, rain, or other factors. The only one marked as exploding (E) was used (No. 5127) in the velocity correction. A corrected M.O.A. of 1.5 mils was used. Inspection of the muzzle of the tube after firing disclosed no marks at 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000.

Yow Card Distances

101.29' 101.29' 101.29'

Type	Number	Cent. of Impact	P.E. (mils)
Project	1	Vert. 32	Horiz. 53
4 Fins	1	Vert. 32	Horiz. 53
5 Fins	1	Vert. 32	Horiz. 53
6 Fins	1	Vert. 32	Horiz. 53

Signed J. Cheney
Observer J. Cheney
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Table V
Yaw Card Measurements
T119 Projectile

Card	Feet from Muzzle	Angle of Roll Measured Clockwise from Horiz. Ref. Line				
		X 362	X 364	X 365	X 368	X 370
#1	30.0	101°	251°	151°	349°	123°
#2	60.0	116°	278°	166°	367°	142°
#3	70.8	124°	283°	173°	376°	151°
#4	61.0	129°	289°	175°	384°	160°
#5	110.7	154°	311°	196°	410°	186°
#6	121.4	164°	324°	204°	422°	199°
#7	130.6	171°	337°	208°	432°	210°
#8	157.4	196°	372°	229°	465°	247°
#9	288.7	376°	582°	358°	683°	479°

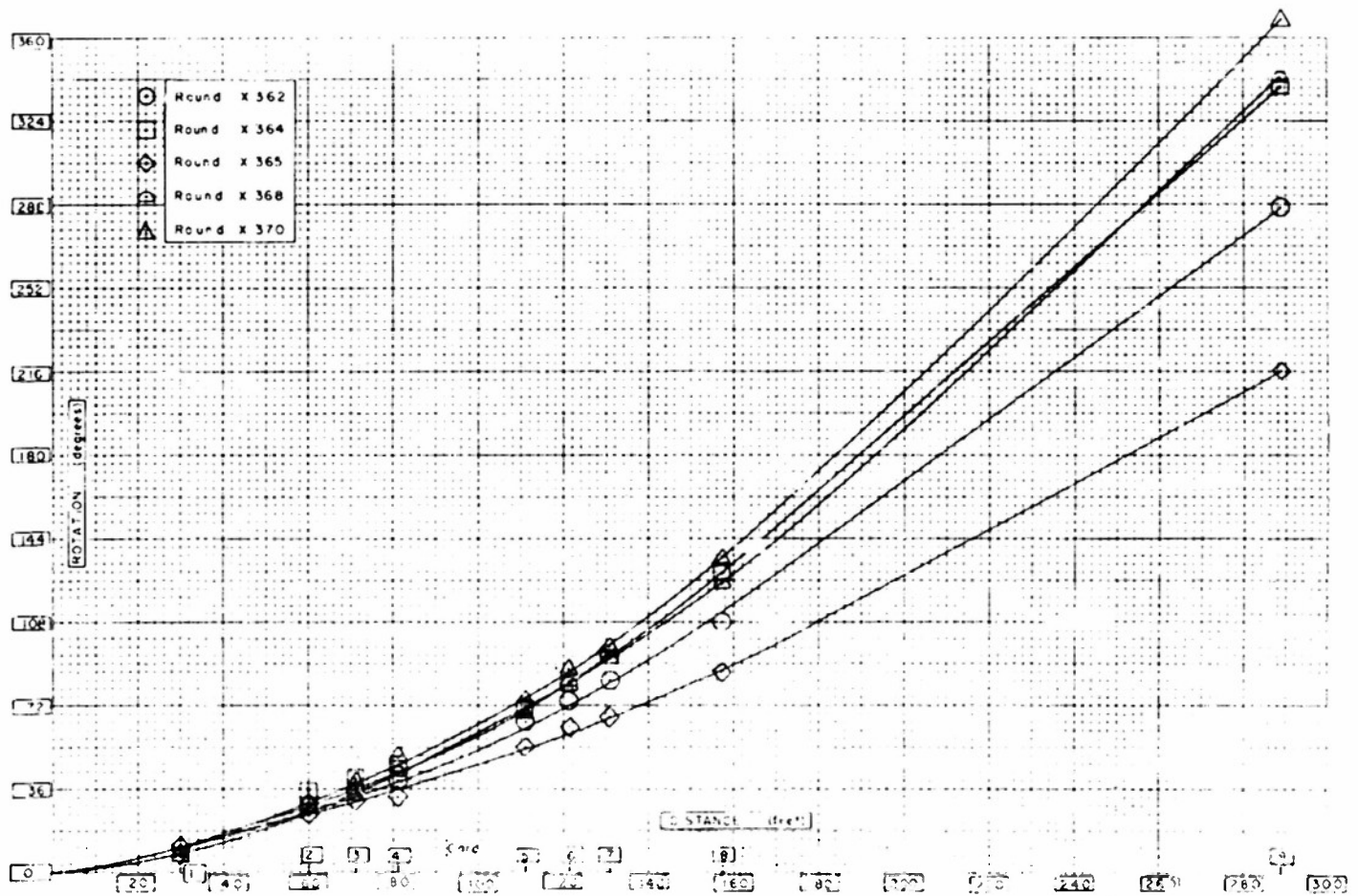


Fig. 4. Roll Angle Versus Distance From Gun.
T119E1 Projectile.

Table VI
T119E11 Spin Measurements

Distance From Muzzle (Ft.)		20	60	100	140
Round X362	Velocity (fps)	1683.1	1675.3	1667.5	1659.7
	Rotation (deg./ ft.)	0.383	0.600	0.800	1.183
	(rps)	1.79	2.79	3.71	5.46
Round X364	Velocity (fps)	1674.1	1666.3	1658.5	1650.7
	Rotation (deg./ ft.)	0.450	0.658	0.900	1.400
	(rps)	2.09	3.05	4.15	6.42
Round X365	Velocity (fps)	1682.1	1674.3	1666.5	1658.7
	Rotational (deg./ ft.)	0.400	0.533	0.633	0.833
	(rps)	1.87	2.48	2.93	3.84
Round X368	Velocity (fps)	1681.1	1673.5	1665.5	1657.7
	Rotation (deg./ ft.)	0.367	0.700	0.983	1.300
	(rps)	1.71	3.25	4.55	5.99
Round X370	Velocity (fps)	1675.1	1667.3	1659.5	1651.7
	Rotation (deg./ ft.)	0.483	0.767	1.050	1.433
	(rps)	2.25	3.55	4.84	6.57

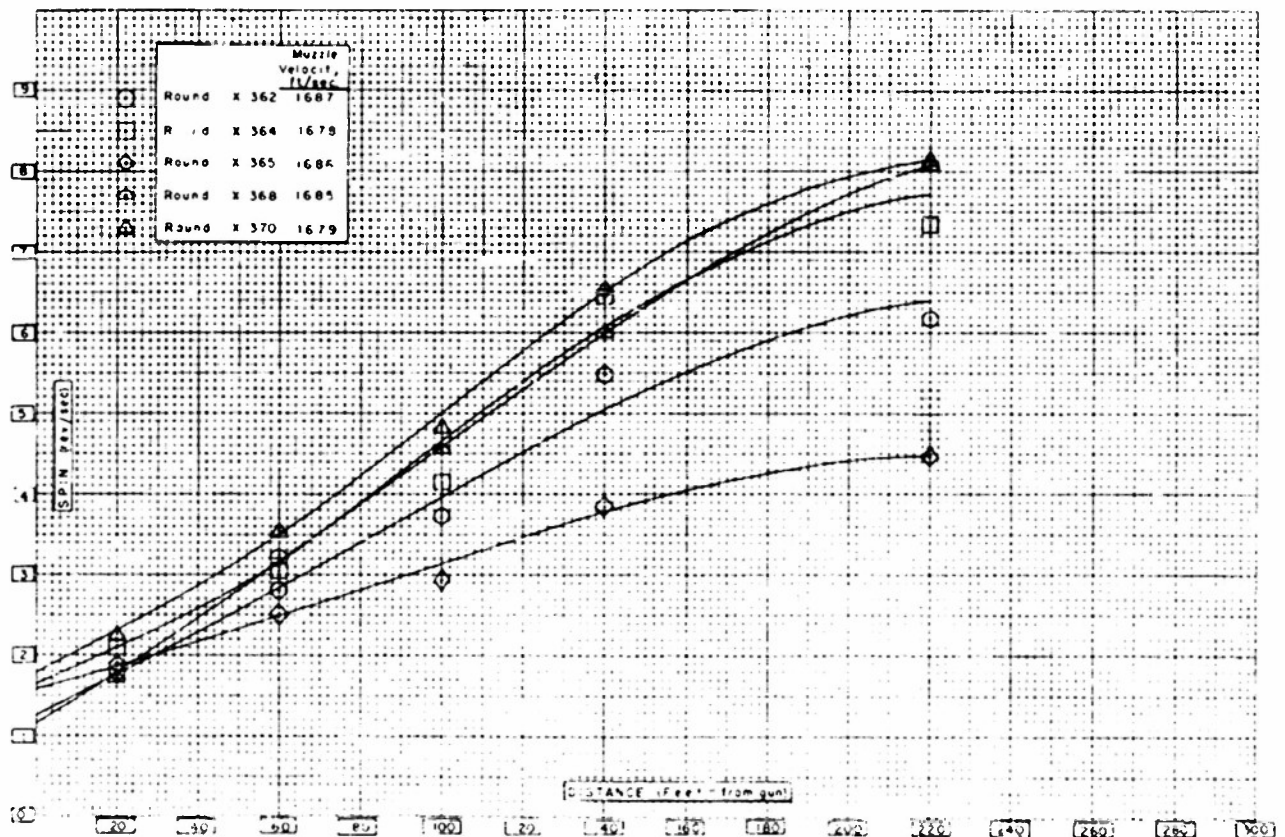


Fig. 5. Rolling Velocity Versus Distance From Gun.
T119E11 Projectile.

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Future Program

1. Projectiles with zinc ogives have been assembled. It is planned to fire groups of these projectiles for tests of strength, accuracy, and penetration.

2. Twenty projectiles, each with a tail assembly shorter and stronger than that of the T119E11 projectile, have been assembled and will be test-fired.

3. A group of 20 T119E11 projectiles has been prepared to study the effect of relaxed dimensional tolerances in the fin assembly. These projectiles will be

fired to determine both mechanical and flight behavior.

4. A program to improve the launching of the T119E11 projectile has been started. It is planned to study projectile behavior near the gun muzzle by means of yaw cards and photography.

5. The effect of ogive length upon the accuracy of the T119E11 projectile is to be determined by tests with both shorter and longer ogives. The projectiles are ready for assembly and tests should follow soon.

PENETRATION STUDIES

Scaling Studies

In extending the use of data for 105mm cones and charges to other sizes it is necessary to determine the effect of size upon performance. From theoretical considerations it appears that geometrically similar shaped charge rounds of widely differing diameter should behave similarly if the diameter "d" is taken as the unit length, (BRL Report 623, Section VI and the references given there). As applied to rotating charges it is to be expected that the relative deterioration in penetration caused by spin, for rounds of different diameter d spinning at ω radians per sec should be determined by the spin parameter ωd . Since a considerable amount of work has been done in this laboratory with DRB398 cones it is planned to evaluate similar charges scaled down in the ratio 75/105 and 90/105. The first tests with the 75/105 size charges have been completed.

The 75/105 scaled counterpart of the DRB398 cone and DRC376 test assembly consists of a DRB706 cone and DRC505 test assembly (No. 2 nose ring). Fig 6

shows the cone and Fig. 7 shows the cone and charge assembly. These cones were made from DRB398 smooth cones by cutting them off at the appropriate diameter (2.50-inch register diameter) and by machining out the inside cone surface to the desired final wall thickness (.071 inch). The only departure from linear scaling is in the small spitback tube whose dimensions are unchanged from the original DRB398 cone. In this scaling study the effect of standoff and rotation have been determined for the 75/105 charge and cone, and the data are to be compared with the corresponding data for the 105mm charge.

The penetration behavior of DRB398 smooth cones has been described in earlier reports. The effect of standoff is shown in Fig. 6 of the Thirty-Second Progress Report and the effect of rotation in Fig. 6 of the Twenty-Seventh Progress Report.

The inspection data for the DRB706 cones are shown in Table VII and the penetration data are shown in Tables VIII and IX and Figs. 8 and 9.

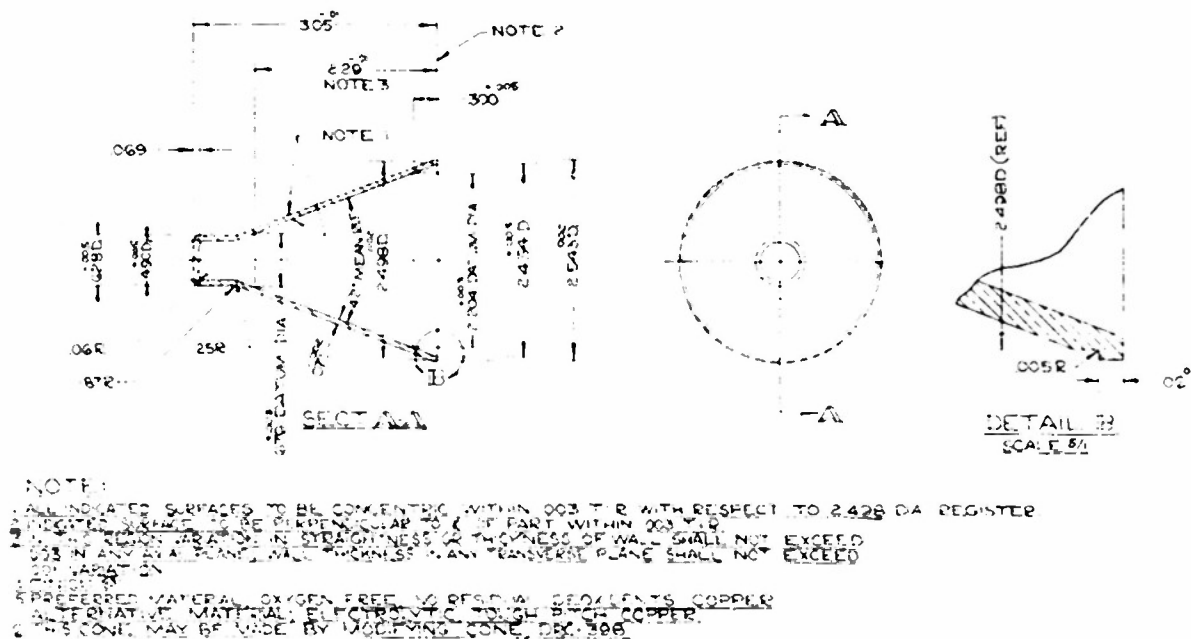


Fig. 6. DRB706 Cone.
Scaled Counterpart of DRB398 Cone.

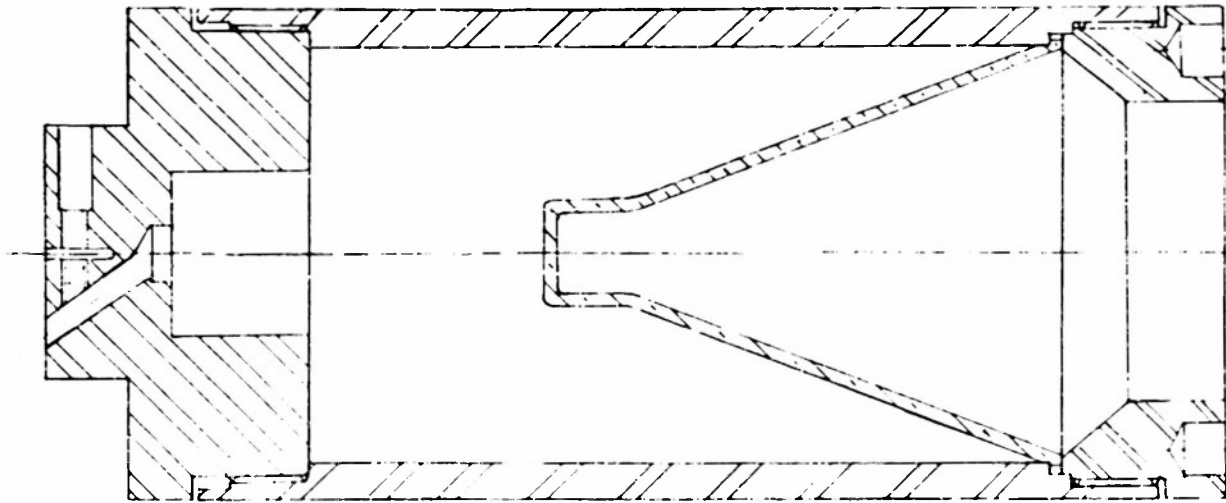


Fig. 7. DRC505 Penetration Test Assembly.
Scaled Counterpart of DRC376 Test Assembly.

Scaling Standoff

Fig. 10 is a generalized plot of the penetration standoff behavior of the type of cone and charge used in this study. Both penetration and standoff are expressed in terms of charge diameters and are therefore dimensionless quantities. As shown by this plot the one curve fits the observed data for both 3.5 inch and 2.5 inch charges quite nicely.

Scaling of the Rotational Effect

Fig. 11 shows the effect of rotation

upon cones of this type. The data are plotted in terms of the "reduced" penetration and spin rate. The reduced penetration may be defined as the observed penetration at spin rate ω divided by the non-rotated penetration. The reduced spin rate is the spin rate expressed in terms of the relative linear surface velocity of the cone base - ωd . As expected the effect of spin is invariant under these transformations and the one curve fits the observed points for both 2.5 and 3.5 cones and charges well within the experimental error.

Future Program

1. Scaling Studies. Two series of scaling studies are planned. One series with simple apex copper cones is geometrically scaled to 75, 90 and 105mm. The other series uses DRB398 cones (with short spitback of constant size) with height and wall thickness adjusted to 75, 90 and 105mm size.

2. Cones Made of Zinc and Aluminum are to be tested for penetration. Penetrations approaching those of copper cones have been reported for certain aluminum and zinc alloys.

3. Composite Cone Study. A series of tests using copper cones with aluminum inserts will be tested.

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

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

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

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

ed and machined samples.

e. Same as (b) except aluminum is sprayed (metalized) into inside of cone. Tests will include "as sprayed" and "spray-

4. Effect of Internal Tee Contour. Two new designs, in which the length of the .875-inch bore of the DRC314HW11 tee is shortened, are to be compared.

Table VII
Inspection Data
75 mm. DRB706 Smooth Cones

Cone No.	Wall Thickness (in.)			Maximum Variation in Wall Thickness (in.)		Max. Wall Waviness (in.)		Concentricity T.I.R. ^{1,2}		
	Max.	Min.	Avg.	Trans.	Long.	O.D.	I.D.	Base Datum	Apex Datum	Cone Tip in Assy
Specification DRB-706 Cones	.071	.069		.001	.003	.0030	.0030	.0030	.0030	.015
										(Nominal)
FS1023	.078	.071	.0741	.001	.007	.0030	.0050	.0020	.0030	.003
FS1024	.080	.073	.0763	.002	.007	.0020	.0050	.0010	.0020	.002
FS1025	.080	.073	.0766	.001	.007	.0020	.0030	.0010	.0020	.006
FS1026	.077	.071	.0739	.001	.006	.0020	.0040	.0010	.0010	.007
FS1027	.078	.071	.0751	.002	.007	.0020	.0040	.0020	.0010	.004
FS1028	.082	.071	.0763	.002	.011	.0020	.0050	.0040	.0020	.004
FS1029	.077	.070	.0736	.001	.007	.0020	.0040	.0020	.0010	.013
FS1030	.076	.070	.0731	.001	.006	.0030	.0040	.0030	.0020	.004
FS1031	.080	.071	.0758	.001	.009	.0030	.0050	.0030	.0040	.004
FS1032	.077	.070	.0738	.001	.006	.0040	.0050	.0030	.0020	.005
FS1033	.075	.068	.0718	.001	.006	.0040	.0030	.0020	.0020	.003
FS1034	.076	.069	.0726	.001	.007	.0030	.0040	.0020	.0010	.006
FS1035	.074	.070	.0723	.001	.004	.0020	.0030	.0020	.0020	.006
FS1036	.076	.072	.0736	.001	.004	.0030	.0040	.0020	.0010	.003
FS1037	.073	.071	.0718	.001	.002	.0010	.0030	.0010	.0010	.005
FS1038	.078	.072	.0746	.002	.006	.0030	.0030	.0010	.0020	.003
FS1039	.078	.071	.0744	.001	.007	.0030	.0030	.0020	.0010	.010
FS1040	.076	.072	.0738	.001	.004	.0020	.0020	.0010	.0020	.003
FS1041	.075	.071	.0731	.001	.004	.0020	.0020	.0010	.0010	.002
FS1042	.078	.073	.0750	.001	.005	.0020	.0030	.0020	.0020	.006
FS1043	.078	.072	.0741	.003	.006	.0030	.0030	.0040	.0030	.006
FS1044	.074	.070	.0718	.001	.004	.0020	.0030	.0030	.0010	.011
FS1045	.078	.071	.0743	.002	.006	.0010	.0050	.0030	.0020	.003
FS1046	.073	.070	.0713	.001	.003	.0020	.0040	.0020	.0020	.002
FS1047	.073	.072	.0751	.001	.006	.0020	.0040	.0030	.0010	.004
FS1048 ³	.080	.075	.0722	.002	.005	.0020	.0050	.0020	.0020	None ³
Avg.	.0771	.0712	.0739	.0013	.0053	.0024	.0038	.0021	.0018	.0050
Std. Dev.	±.0028	±.0014	±.0017	±.0002	±.0018	±.0008	±.0009	±.0009	±.0008	±.0028

Notes:

1. Lower datum is .484 inch above base; upper datum is 2.29 inches above base.
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner axis.
3. Held for display.

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Table VIII
Penetration Data
Effect of Standoff
DRB706 75 mm. Cones

Round No.	Comp. B lbs.	Standoff inches	Penetration inches in M. Stl.	Max. Spread inches	Std. Dev. inches
FS1023	.88	5.0	13.50		
FS1024	.88	5.0	14.62		
FS1025	.92	5.0	14.75		
FS1026	.92	5.0	15.50		
			Avg. 14.59	2.00	±.82
FS1027	.88	7.5	15.56		
FS1028	.86	7.5	14.44		
FS1029	.88	7.5	15.56		
FS1030	.88	7.5	14.18		
			Avg. 14.93	1.38	±.73
FS1031	.86	10.0	14.88		
FS1032	.88	10.0	14.94		
FS1033	.90	10.0	15.94		
FS1034	.90	10.0	16.38		
			Avg. 15.54	1.50	±.74
Notes:					
1. Cones assembled in DRC505-1 test bodies, plugs and rings (No. 2).					
2. Loaded at Ravenna Arsenal, BAT Lot No. 30, with Composition B from Holston Lot No. 4-1197.					
3. All rounds were tested at 0 rev/sec at Erie Ordnance Depot.					

Table IX
Penetration Data
Effect of Rotation
DRB706 75 mm. Cones

Round No.	Comp. B lbs.	Rev/Sec	Penetration inches in M. S.	Max. Spread inches	Std. Dev. inches
FS1023	.88	0	13.50		
FS1024	.88	"	14.62		
FS1025	.92	"	14.75		
FS1026	.92	"	15.50		
			Avg. 14.59	2.00	±.82
FS1035	.90	30	13.00		
FS1036	.90	"	12.06		
FS1037	.88	"	12.50		
FS1038	.88	"	11.62		
			Avg. 12.30	1.38	±.59
FS1039	.88	60	7.69		
FS1040	.86	"	7.25		
FS1041	.88	"	7.18		
			Avg. 7.37	.51	±.27
FS1042	.92	90	6.18		
FS1043	.90	"	6.00		
FS1044	.88	"	5.50		
			Avg. 5.89	.68	±.35
FS1045	.88	120	5.81		
FS1046	.88	"	5.25		
FS1047	.86	"	4.62		
			Avg. 5.23	1.19	±.59
Notes:					
1. Cones assembled in DRC505-1 test bodies, plugs and rings (No. 2).					
2. Loaded at Ravenna Arsenal, BAT Lot No. 30, with Composition B from Holston Lot No. 4-1197.					
3. All rounds were tested at Erie Ordnance Depot using a standoff of 5.0 inches.					

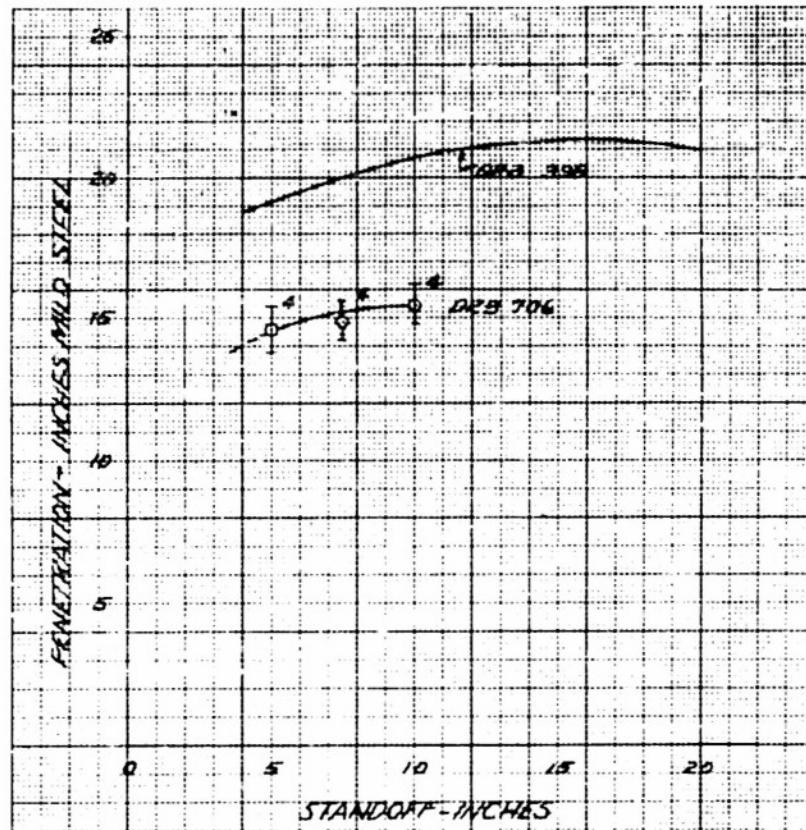


Fig. 8. Penetration Versus Standoff.
DRB398 (105 mm.) and DRB706 (75 mm.) Cones.

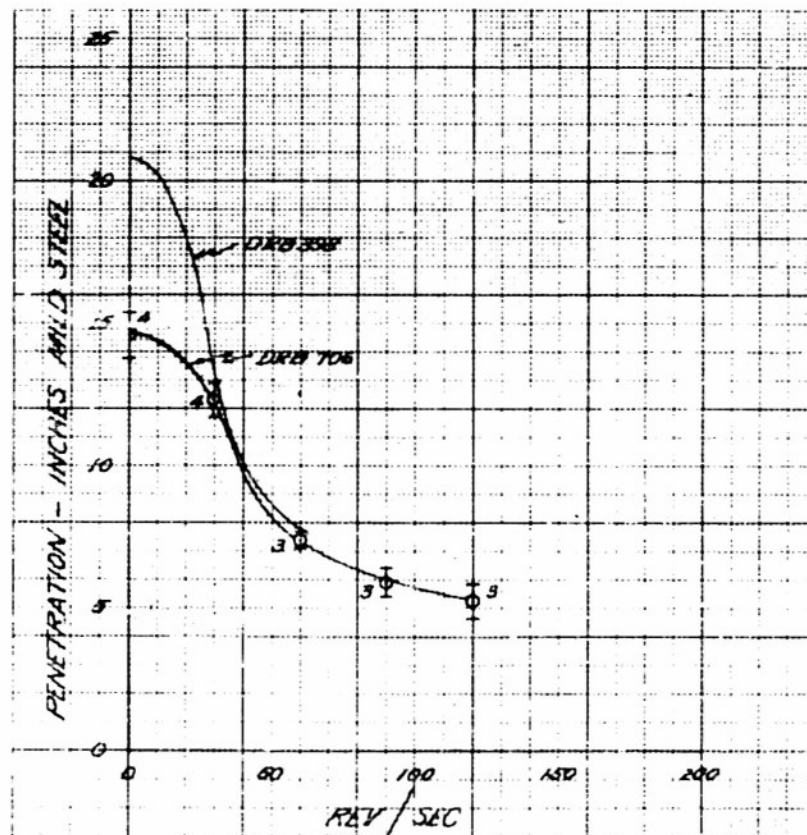


Fig. 9. Penetration Versus Rotation.
DRB398 (105 mm.) and DRB706 (75 mm.) Cones.

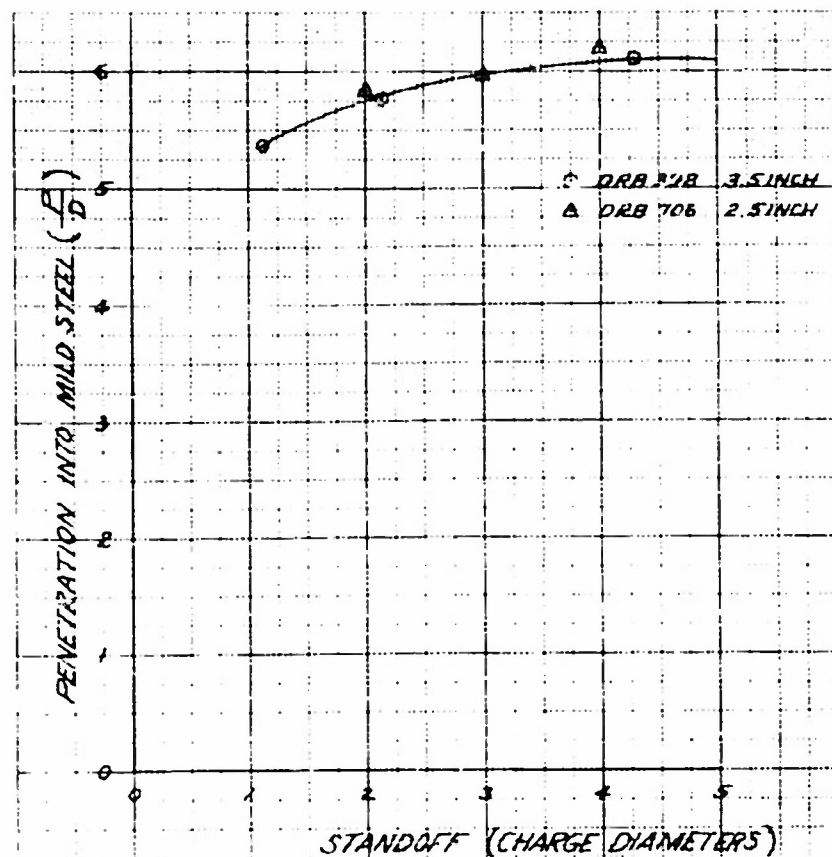


Fig. 10. Penetration Versus Standoff.
In Terms of Charge Diameter.

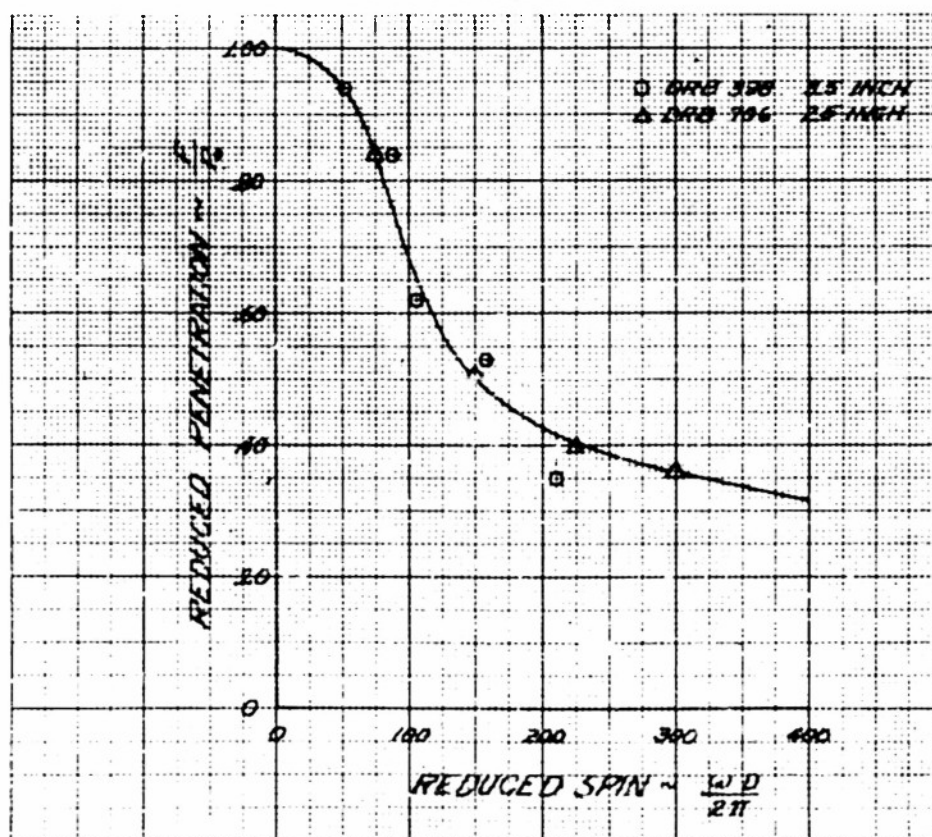


Fig. 11. Penetration Versus Rotation.
In Terms of Reduced Penetration and Spin Rate

FUZES

Testing T267 Type Base Elements

at a range of 200 yards.

The T267 type fuze combines both super-quick and delay functioning. The development has been reported in the Thirtieth, Thirty-First and Thirty-Second Progress Reports. Further changes in design have been made and the tests have been continued.

Sixty T267 fuze base elements were made in accordance with DRD439 (Figure 12) and twenty have been tested in T138 E57 type projectiles equipped with spotting charges. The target consisted of a four inch thick wooden bursting screen located

Ten projectiles were equipped with barium titanate nose elements and were tested for superquick functioning. The remaining ten were not equipped with crystals and therefore any functioning of these rounds is presumed to occur as a result of the delay inertial element in the fuze. The firing record is shown in Table X and the data are summarized below.

The tests are being continued in an effort to determine the cause for the failures to function.

	With Crystal	Without Crystal
No. functioning superquick	4	--
No. functioning inertia	1	7
No. Failures to function	2	2
No. Doubtful Functions	--	1
No. Misses	3	--
Total	10	10

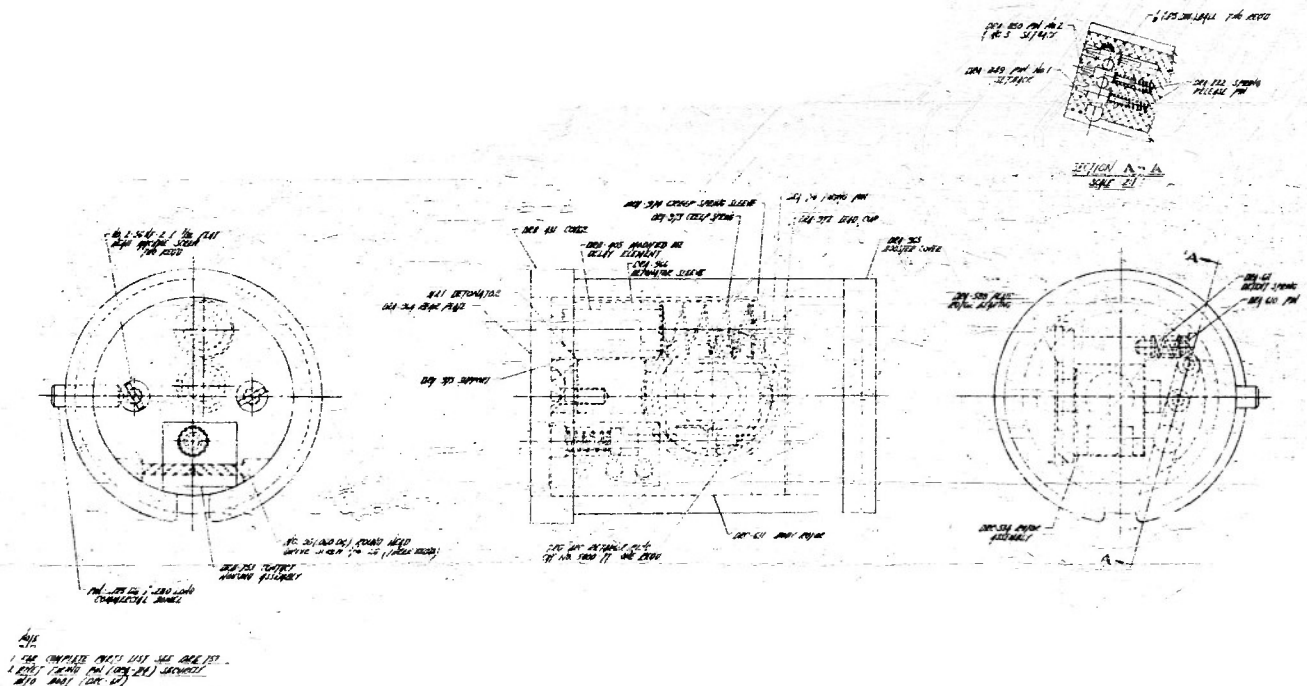


Fig. 12. Fuze Base Element, T267.
Firestone Drawing No. DRD439.

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

M A N U F A C T U R I N G S U M M A R Y

In addition to the experimental material prepared for the research and development work under contracts DA-33-019-ORD-33 and DA-33-019-ORD-i202, described in preceding progress reports and in the preceding pages of this report, the following have been manufactured and shipped to the installations indicated.

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

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

Prior to June 1, 1953	4430	All Shipments
June 1, 1953	300 (Live)	Milan Arsenal
June 2, 1953	30 (Live)	Picatinny Arsenal
June 5, 1953	300 (Inert)	Milan Arsenal
June 11, 1953	300 (Inert)	Milan Arsenal
June 18, 1953	300 (Live)	Milan Arsenal
June 26, 1953	300 (Inert)	Milan Arsenal
June 26, 1953	<u>25</u> (Live)	Picatinny Arsenal
Total to June 30, 1953	5985	

II. Rifles, T170E1 for ONTOS

Prior to June 1, 1953	6	Aberdeen Proving Ground
June 13, 1953	6	" " "
June 22, 1953	6	" " "
June 23, 1953	6	" " "

III. Mounts, T149E3 for ONTOS

June 1, 1953	1	Allis-Chalmers
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IV. BAT Systems, Less Jeep (T170E1 Rifles, T149E3 Mounts)

Prior to June 1, 1953	2	Aberdeen Proving Ground
June 2, 1953	2	" " "
June 8, 1953	1	" " "