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TECHNICAL REPORT 2281

DETERMINATION OF THE TIME INTERVAL BETWEEN IMPACT AND DEFLAGRATION OF 75 MM T165E11 COMPOSITION A-3 HEP-T SHELL (C)

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MARCH 1956

SAMUEL FELTMAN AMMUNITION LABORATORIES
PICATINNY ARSENAL
DOVER, N. J.

ORDNANCE PROJECT TA1-5002H
DEPT. OF THE ARMY PROJECT 5A04-01-001

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DEFLAGRATION OF 75MM T165E11 COMPOSITION A-3 HEP-T
SHELL (C)

MAR 56 1V MARGOLIN,MARTIN J.;SKETTINI,EOWARO
A.;
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OESCRIPTORS: *HIGH EXPLOSIVE AMMUNITION, *IMPACT FUZES,
*PROJECTILES, OETONATIONS, TERMINAL BALLISTICS, TESTS (M)
IDENTIFIERS: 75-MM ORDNANCE ITEMS, T-165
CARTRIDGES(75-MM) (M)

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by

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March 1956

Picatinny Arsenal
Dover, N. J.

Technical Report 2281

Ordnance Project TA1-5002H

Dept of the Army Project 5A04-01-001

Approved:

I. O. DREWRY
Col, Ord Corps
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Samuel Feltman
Ammunition Laboratories

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OBJECT

To determine the time interval between impact of a 75 mm T165E11 Composition A-3 HEP-T shell on a target and deflagration of the explosive charge in the shell.

SUMMARY

Effective HEP shell functioning requires fuze action before the explosive charge deflagrates. It is therefore necessary to know the length of time between impact and deflagration in order to design effective HEP shell. Accordingly, Picatinny Arsenal began an investigation to determine this time interval at varying velocities and angles of obliquity.

At impact velocities beginning at about 2400 fps and decreasing by steps of approximately 100 fps to a minimum impact velocity of about 1150 fps, 75 mm T165E11 HEP-T shell loaded with Composition A-3 and assembled with inert-loaded M91A1 fuzes were fired to impact armor plate at both 0° and 30° obliquity. Inert control rounds were also fired at each velocity to aid in distinguishing between plate flash and deflagration. No deflagration occurred at velocities up to and including 1750 fps at 0° obliquity and 2000 fps at 30° obliquity. Deflagration occurred at velocities of 1934 fps and higher at 0° obliquity and 2070 fps and higher at 30° obliquity. The interval between impact and deflagration varied from a maximum of 193 microseconds to a minimum of 23 microseconds, with the time decreasing as the velocity was increased.

CONCLUSIONS

It is concluded that deflagration may occur at impact velocities above 1900 fps normal to the target, the interval between impact and deflagration decreasing with increasing impact velocities.

Effective HEP shell functioning at high impact velocities is impossible unless a means of increasing the time interval between impact and deflagration is developed.

RECOMMENDATION

It is recommended that no further work be conducted to determine the relationship between impact velocity and the time interval between impact and deflagration, because of the promising results being obtained with inert nose pads as a means of extending this time interval.

INTRODUCTION

1. The objective of HEP shell design is to produce a projectile with a thin ductile nose, which when loaded with an explosive of high brisance can defeat armor plate by spalling. When the shell impacts armor plate, its nose crushes so that the explosive mushrooms against the armor plate. The fuze then detonates the explosive from the rear of the shell, directing the explosion front against the armor plate. This causes a violent separation of a section of the armor plate (the spall) from the opposite side of the plate. The spall's size and velocity depend upon the plate area in contact with the explosive charge at detonation. This contact area is governed by the amount of crush-up which takes place before detonation.

2. Effective spalling requires not only the proper amount of crush-up, but also that the fuze functions before the explosive deflagrates by impact. When deflagration occurs before fuze action, either very poor spalling or no spalling at all may be expected. This is because the interference by deflagration prevents the explosion's full force from being directed toward the plate. Therefore the time interval between impact and deflagration must be known in order to design effective HEP shell which will crush to a suitable extent before fuze action, but will detonate by fuze action before deflagration occurs.

3. Accordingly, Picatinny Arsenal initiated an investigation to determine the time interval between impact and deflagration of HEP shell, at varying velocities and angles of obliquity, and selected the 75 mm T165E11 Composition A-3 HEP-T shell as the test vehicle. Because it is difficult to distinguish between plate flash and deflagration, inert-loaded rounds were used to help determine which action occurred upon impact. This report covers the results of this investigation.

RESULTS

4. Tables 1 and 2 present the results of firing 75 mm T165E11 Composition A-3 HEP-T shell to impact 3-inch-thick armor plate at velocities beginning at about 2400 fps and decreasing until no deflagrations were observed, both at 0° and 30° obliquity. For those rounds which deflagrated, the time interval between impact and deflagration was determined by examination of streak films of each impact. Figure 1, showing plate flash, and Figure 2, showing

deflagration, are enlargements of typical streak films taken during this test. Pertinent data may be summarized as follows:

Test Number	Angle of Obliquity, Degrees	Impact Velocity feet/sec	Deflagration Visual	Deflagration Camera	Time Between Impact and Deflagration, Microseconds
1	30	2395	yes	yes	91
2	30	2310	yes	yes	51
3	30	2261	yes	yes	lost
4	30	2173	yes	lost	lost
5	30	2070	no	yes	112
6 thru 17	30	1996 down to 1577	no	no	--
18	0	2341	yes	yes	lost
19	0	2268	yes	yes	23
20	0	2177	yes	yes	124
21	0	1934	no	yes	193
22 thru 43	0	1795 down to 1157	no	no	--

DISCUSSION OF RESULTS

5. The authors of this report examined streak films (Fig 1) of the inert-loaded control rounds impacting on armor plate to determine the characteristic markings caused by plate flash on streak films. Application of this knowledge to subsequent examination of streak films (Fig 2) of HEP rounds impacting on armor plate allowed positive differentiation between plate flash and deflagration for these rounds.

6. Test results indicate that HEP shell probably will not deflagrate upon impact at velocities of 1750 fps or less, at 0° obliquity, the most critical condition. At 1900 fps and above, deflagration can be expected. Analysis of the limited results shows that the time between impact and deflagration decreases with increased velocity. For example, at 0° obliquity deflagration occurs 193 microseconds after impact at 1934 fps impact velocity and only 23 microseconds after impact at 2268 fps. Because so few rounds deflagrated, additional tests of a considerable number of rounds fired within the velocity range of 1800 to 2400 fps would be necessary to more accurately establish the relationship between impact velocity and deflagration time.

7. It is desirable that HEP shell have exterior ballistics comparable with those of equal caliber HE shell. This requires impact velocities as high as about 2700 fps. Because at such velocities HEP shell may deflagrate

in even less than 23 microseconds after impact, and because the M91A1 fuze now used with HEP shell requires about 210 microseconds to function, it would appear that a new and faster fuze or a means of extending the time between impact and deflagration is necessary for such high velocities.

8. But use of a fuze which would act before deflagration at 23 microseconds or less would not result in effective spalling. Data obtained from test firings (Ref A) which related crush-up with resultant spall size indicate that the crush-up after 23 microseconds would be far less than enough for effective spalling. For example, at 1950 fps impact velocity, about 270 microseconds must elapse after impact before 75 mm T165E11 HEP shell crush sufficiently to produce optimum spalls. Consequently, a means of extending the time between impact and deflagration is of primary importance if effective HEP shell action is to be obtained at higher velocities.

9. It now appears that a means of extending this time interval beyond that necessary for normal fuze action has been developed. Preliminary results (Ref B) of an investigation conducted by Picatinny Arsenal showed that when 76 mm T170E3 HEP-T shell containing nose pads of inert material in place of the first increment of Composition A-3 were fired at 2600 fps velocity, no deflagration occurred and adequate spalling took place. At 2800 fps impact velocity no deflagration occurred but the metal parts failed on impact prior to fuze action. Hence, the use of nose pads apparently extends the time between impact and deflagration beyond that necessary for the fuze to act. The results of additional tests now in progress should further confirm the effectiveness of inert nose pads in HEP shell.

10. Because of the promising results obtained with inert nose pads as a means of extending the time interval between impact and deflagration, no further work on determining the relationship between impact velocity and this time interval is necessary.

EXPERIMENTAL PROCEDURE

11. The 75 mm T165E11 HEP-T shell used as the test vehicle during this investigation is shown in Figure 3. The explosive charge was Composition A-3, Spec JAN-C-440, dated 31 January 1947. The inert charge was a blend of the following components:

a. Potassium sulphate, Spec JAN-P-193, Amendment 1, dated

15 October 1952, except that the granulation was 100% through No. 20 sieve, 100% retained on No. 200 sieve---30%.

b. Borax, Type B, Spec SS-D-611, Amendment 1 dated 8 January 1942---65%.

c. Graphite, Grade I, Spec JAN-G-155 dated 13 December 1944---5%.

12. T165E11 shell were press-loaded with Composition A-3 and with inert filler as follows: Both types of filler were pressed in 5 increments (12 oz, 12oz, 10 oz, 6 oz, and 4 oz, in that order) by a 1.984-inch-thick-diameter punch under a force of 12.4 tons (8000 psi). The minimum accepted specific gravity was 1.57.

13. The base plug and fuze cavities were then drilled to the dimensions shown in Figure 4. Shell were then assembled in accordance with Figure 4, except that inert-loaded M91A1 fuzes were used.

14. The shell were assembled to stock components and fired at a 6-foot square of 3-inch-thick armor plate, 300 feet from the muzzle of the gun. A streak camera was placed 100 feet to the side of the plate and aligned with the plate face. A Fastax camera was placed 35 feet to the side of the plate and about 4 feet forward (toward the gun) of the line of vision of the streak camera. The cameras and the electrical lanyard puller were all connected to a common circuit that allowed the cameras to reach satisfactory speed before the weapon was fired. Copper screen wire, mounted on insulation frames, was placed over the face of the armor plate with about one-inch clearance between plate and screen wire. M36A1 electric detonators were placed alongside the plate and connected in an electric circuit through the screen and the plate. When the projectile pressed the screen against the plate it completed the circuit and fired the detonator, providing a mark on the streak camera film to indicate the exact moment of impact.

15. Firing in both the 0° obliquity and 30° obliquity phases was initiated with a Composition A-3 loaded shell and M1 propellant adjusted to give 112% of service pressure. After each live shell was fired, an inert-loaded shell was fired at the same velocity and angle of obliquity to assist in distinquishing between minor deflagration and plate flash. The impact velocity was lowered by adjusting the propellant charge until no deflagration

or plate flash was observed. Additional rounds were fired to insure that the minimum impact velocity had been reached at which no deflagration occurred. Complete details of this test are given in Reference C.

REFERENCES

A. Jefferson Proving Ground Firing Record, No. A-13698.

B. B. A. Rausch, D. E. Seeger, K. G. Sheffield, *Effect of Inert Nose Pads on Functioning of T170E3 76 MM HEP-T Shell,* PA Technical Report 2207, dated October 1955.

C. Jefferson Proving Ground Firing Record, No. A-8321.

TABLE 1

Results of Firing 75 MM T165E11 Composition A-3 HEP-T Shell at 30° Obliquity and Varied Velocities at a 3-Inch-Thick Armor Plate

Test No.	JPG Round No.	Impact Velocity, feet/sec.	Deflagration Visual	Deflagration Camera	Time between Impact and Deflagration, microseconds
1	196	2395	yes	yes	91
2	198	2310	"	"	51
3	200	2261	"	"	lost
4	202	2173	"	lost	lost
5	204	2070	no	yes	112
6	206	1996	"	no	
7	208	1933	"	"	
8	211	1802	"	"	
9	213	1749	"	"	
10	215	1760	"	"	
11	216	1637	"	"	
12	218	1577	"	"	
13	220	1577	"	"	
14	221	1594	"	"	
15	222	1600	"	"	
16	223	1592	"	"	
17	224	1600	"	"	

NOTES:

a. Inert-loaded control rounds were fired at each of the velocities listed above to characterize plate flash on film, so that in the case of the HEP rounds deflagration could be distinguished from plate flash.

b. Data presented above are extracted from JPG Firing Record No. A-8321, except for the impact to deflagration times, which were determined by an analysis of streak films which were evaluated by the authors.

TABLE 2

Results of Firing 75 MM T165E11 Composition A-3 HEP-T Shell at 0° Obliquity and Varied Velocities at a 3-Inch-Thick Armor Plate

Test No.	JPG Round No.	Impact Velocity, feet/sec.	Deflagration Visual	Deflagration Camera	Time between Impact and Deflagration, microseconds
18	231	2341	yes	yes	lost
19	233	2268	"	"	23
20	235	2177	"	"	124
21	238	1934	no	"	193
22	240	1759	"	no	
23	242	1633	"	"	
24	244	1741	"	"	
25	245	1632	"	"	
26	246	1584	"	"	
27	247	1526	"	"	
28	248	1525	"	"	
29	249	1509	"	"	
30	250	1529	"	"	
31	251	1523	"	"	
32	252	1514	"	"	
33	255	1453	"	"	
34	257	1377	"	"	
35	258	1361	"	"	
36	259	1266	"	"	
37	260	1262	"	"	
38	261	1159	"	"	
39	262	1157	"	"	
40	263	1451	"	"	
41	264	1464	"	"	
42	265	1467	"	"	
43	266	1469	"	"	

NOTES:

a. Inert-loaded control rounds were fired at each of the velocities listed above to characterize plate flash on film, so that in the case of the HEP rounds deflagration could be distinguished from plate flash.

b. Data presented above are extracted from JPG Firing Record No. A-8321 except for the impact to deflagration times, which were determined by analysis of streak films which were evaluated by the authors.

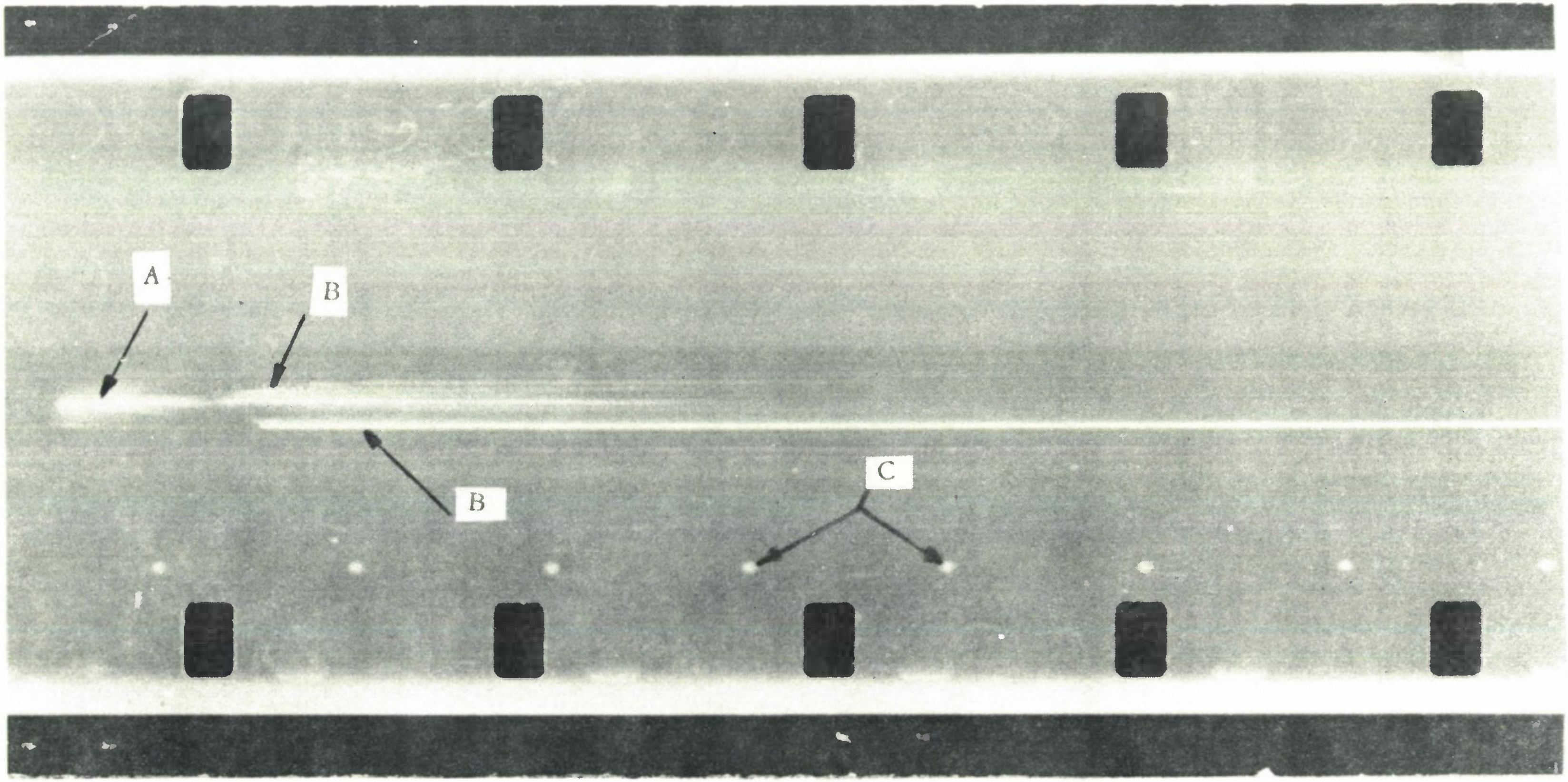

Fig 1 Enlarged Streak Film Showing Typical Plate Flash Markings on JPG Round No. 214. (Round was an inert-loaded 75 MM T165E11 HEP-T shell with inert-loaded M91A1 fuze. The impact velocity was 1762 fps. Duration of interval between timing dots was 100 microseconds [0.000100 second]. A – Detonator flash. B – Plate flash. C – Timing dots.)

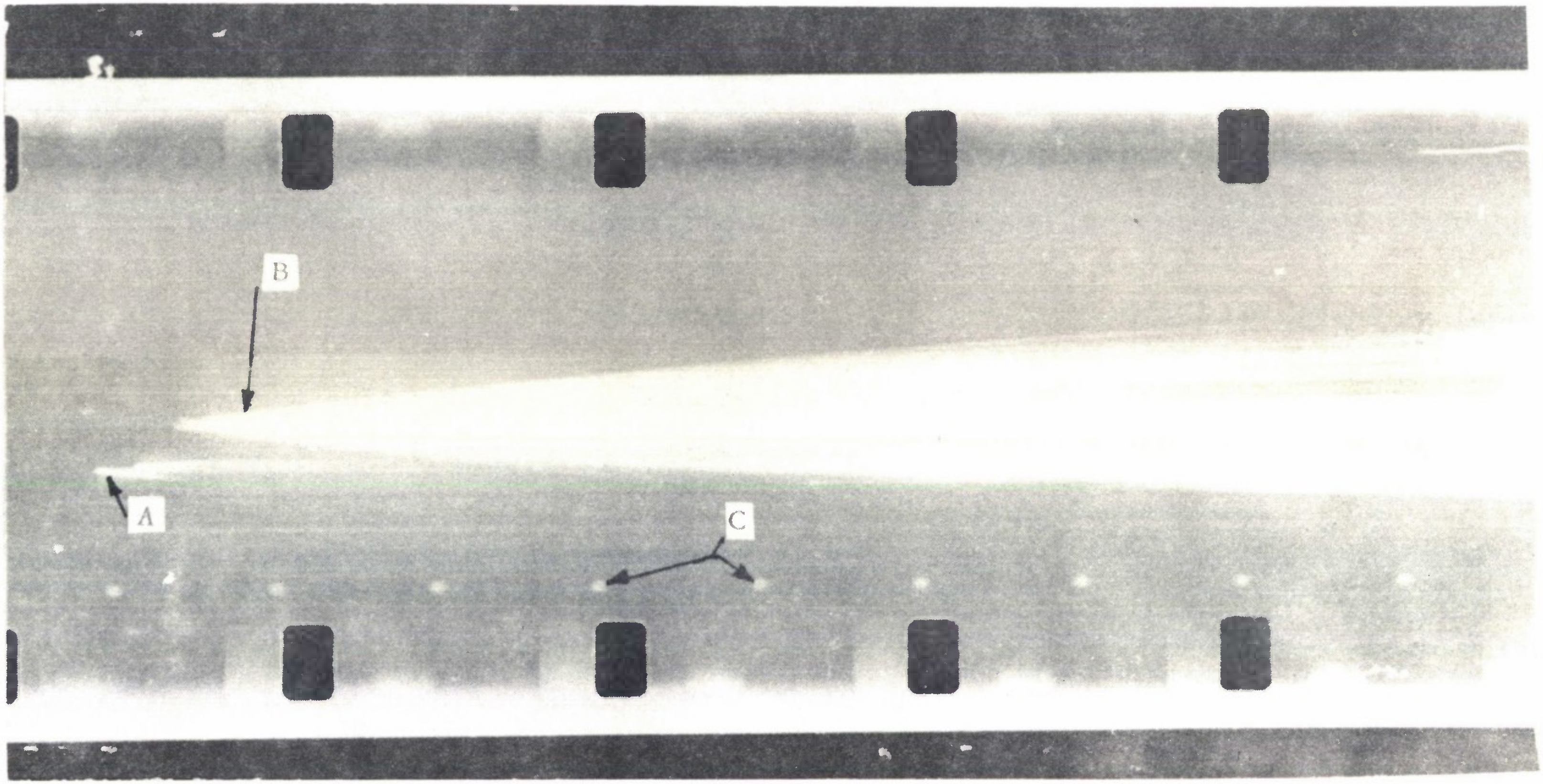

Fig 2 Enlarged Streak Film Showing Typical Deflagration Markings on JPG Round No. 198. (Round was a 75 MM T165E11 Composition A-3 HEP-T shell with inert-loaded M91A1 fuze. The impact velocity was 2310 fps. The deflagration delay was 51 microseconds, and interval between timing dots, 100 microseconds [0.000100 second]. A – Detonator flash. B – Deflagration. C – Timing dots.)

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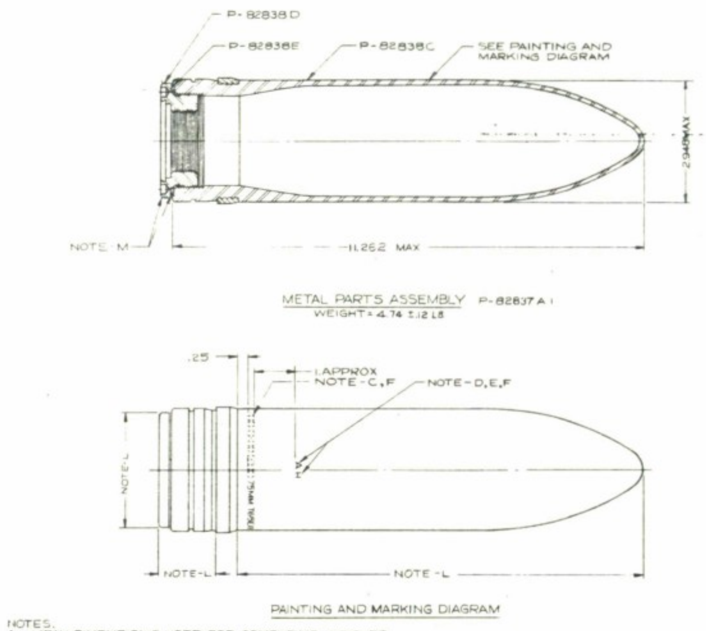

LIST OF PARTS

LINE NO.	NAME OF PART	NUMBER REQD PER COMPONENT	PIECE MARK	MATERIAL: SIZE OR FORM	MATERIAL: KIND	MATERIAL: GRADE	MATERIAL: SPEC NUMBER	APPROXIMATE UNIT WEIGHT (POUNDS)	APPROX GROSS WT. OF RAW STOCK PER 1000 ASSEMBLIES	REMARKS
1	METAL PARTS ASSEMBLY		P-82837A					4.74		
2	BODY ASSEMBLY		P-82838A					4.36		
3	BAND, ROTATING	1	P-82838B	TUBING	GILDING METAL, ANNEALED	CLASS B	MIL-B-20292	.17		
4	BODY	1	P-82838C	PLATE	STEEL	FS 1030	MIL-S-3289	4.17		
5										
6										
7	GASKET	1	P-82838E	SHEET	COPPER	LIGHT	QQ-C-576	.02		
8										
9										
10	PLUG, BASE	1	P-82838D	BAR	STEEL, AS COLD FINISHED	FS 1117 TO 1137 OR 1045	QQ-S-633	.62		b
11										
12										
13					ENAMEL, GREEN, NO 3412		MIL-E-10687			
14					PAINT, ACID PROOF, BLACK	TYPE I OR II	JAN-P-450			
15										

a- SPECIFICATION 50-30-1 APPLIES EXCEPT FOR PARAGRAPH D-5d AND E-1
b- ALTERNATIVE MATERIAL: STEEL, FORGING, FS1117, OR FS 1030, SPEC 57-105
c- ALTERNATIVE MATERIAL: LACQUER, GREEN, NO 3412, SPEC MIL-L-11195

LINE NO.	LIST OF SPECIFICATIONS AND STANDARDS	SPEC OR STD NO. *	REQUIRED BY
1	AMMUNITION EXCEPT SMALL ARMS, GENERAL SPEC FOR	MIL-G-2550	DWG P-82837
2			
3	BLANKS, ROTATING BAND, FOR PROJECTILES	MIL-B-20292	DWG P-82838
4	CLEANING, PREPARATION AND PAINTING OF METAL ETC	PA-PD-191	DWG P-82837
5			
6	COPPER PLATES, SAWED BARS, SHEETS AND STRIPS	QQ-C-576	DWG P-82838
7	ENAMEL, LUSTRELESS, QUICK, DRYING (FOR AMMUNITION)	MIL-E-10687	DWG P-82837
8			
9	FORGINGS, LIGHT, DROP AND MISC: STEEL, CARBON ETC	57-105	DWG P-82838
10	LACQUER, LUSTRELESS, HOT SPRAY (FOR AMM)	MIL-L-11195	DWG P-82837
11	PAINT, ACID-PROOF, BLACK (FOR AMM)	JAN-P-450	DWG P-82837
12			
13			
14			
15			
16	SHELL, STEEL, MANUFACTURED FROM FORGINGS	50-30-1	DWG P-82838
17	STEEL, CARBON, BARS (GENERAL PURPOSE)	QQ-S-633	DWG P-82838
18	STEEL, PLATE AND DISC FOR ARTILLERY AMM, ETC	MIL-S-3289	DWG P-82838
19			
20			
21			
22			
23			
24	ORDNANCE FINISHES, (SURFACE ROUGHNESS)	URAX 6	DWG P-82838
25	STANDARD FOR DIMENSIONING AND TOLERANCING	30-1-7	DWG P-82838
26	SURFACE ROUGHNESS, WAVINESS AND LAY	MIL-STD-10	DWG P-82838
27			
28			

* THE SPECIFICATION AND STANDARD NUMBERS SHOWN ARE BASIC NUMBERS ONLY. WHEN REVISED A LETTER IS AFFIXED TO THE BASIC NUMBER.

LINE	LIST OF DRAWINGS	DRAWING NUMBER
1	METAL PARTS ASSEMBLY	DWG P-82837
2	DETAILS	DWG P-82838
3	BLANKS, ROTATING BAND	75-4-41d
4		
5		
6		
7		

d- TYPE 75B DESIGN SHOWN NOT MANDATORY

NOTES.
A- MEAN DIMENSIONS USED FOR COMPUTING WEIGHTS.
B- WEIGHT TOLERANCE NOT EQUIVALENT TO DIMENSION TOLERANCES. CONTROL DIMENSION TOLERANCES TO BRING SHELL BODY WITHIN WEIGHT REQUIREMENT.
C- STAMP LOT NUMBER, YEAR OF MANUFACTURE, CALIBER AND DESIGNATION OF SHELL.
D- ASSEMBLY BEFORE PAINTING SHALL WITHSTAND A HYDROSTATIC PRESSURE TEST OF 750 PSI MIN FOR 5 SECONDS MIN. MAY BE CONDUCTED PRIOR TO BANDING AND MACHINING OF THREADS. STAMP LETTER "H" AFTER ACCEPTANCE.
E- ASSEMBLY MUST WITHSTAND AN INTERNAL AIR PRESSURE TEST OF 100 PSI MIN FOR 15 SECONDS, AFTER HYDROSTATIC TEST. MAY BE CONDUCTED PRIOR TO BANDING AND MACHINING OF THREADS. STAMP LETTER "A" AFTER ACCEPTANCE.
F- LETTERS AND FIGURES .125 HIGH BY .01 DEEP.
G- PREPARE OR CLEAN ALL INTERIOR SURFACES OF SHELL AND ENTIRE BASE PLUG IN ACCORDANCE WITH GRADE I OR II, TYPE OPTIONAL, SPEC PA-PD-191, BEFORE PAINTING.
H- PREPARE ALL EXTERIOR SURFACES IN ACCORDANCE WITH GRADE I, SPEC PA-PD-191, BEFORE PAINTING.
K- COAT ENTIRE INTERIOR SURFACE OF SHELL, EXCEPT THREADS, BOTTOM OF BASE PLUG AND FUZE CAVITY WITH ACID-PROOF BLACK PAINT, TYPE I OR II.
L- COAT ENTIRE EXTERIOR SURFACE OF SHELL AND BASE PLUG FLANGE, EXCEPT ROTATING BAND WITH GREEN, NO. 3412, ENAMEL.
M- BASE PLUG AND GASKET TO BE SHIPPED SEPARATELY.
N- UNTOLERANCED DIMENSIONS NEED NOT BE GAGED.

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SHELL, HEP-T 75MM, T150E11 AND T165E11, METAL PARTS ASSEMBLY
ORDNANCE CORPS DEPT OF THE ARMY
P-82837

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Fig. 3 Shell, HEP-T 75 MM, T150E11 and T165E11, Metal Parts Assembly

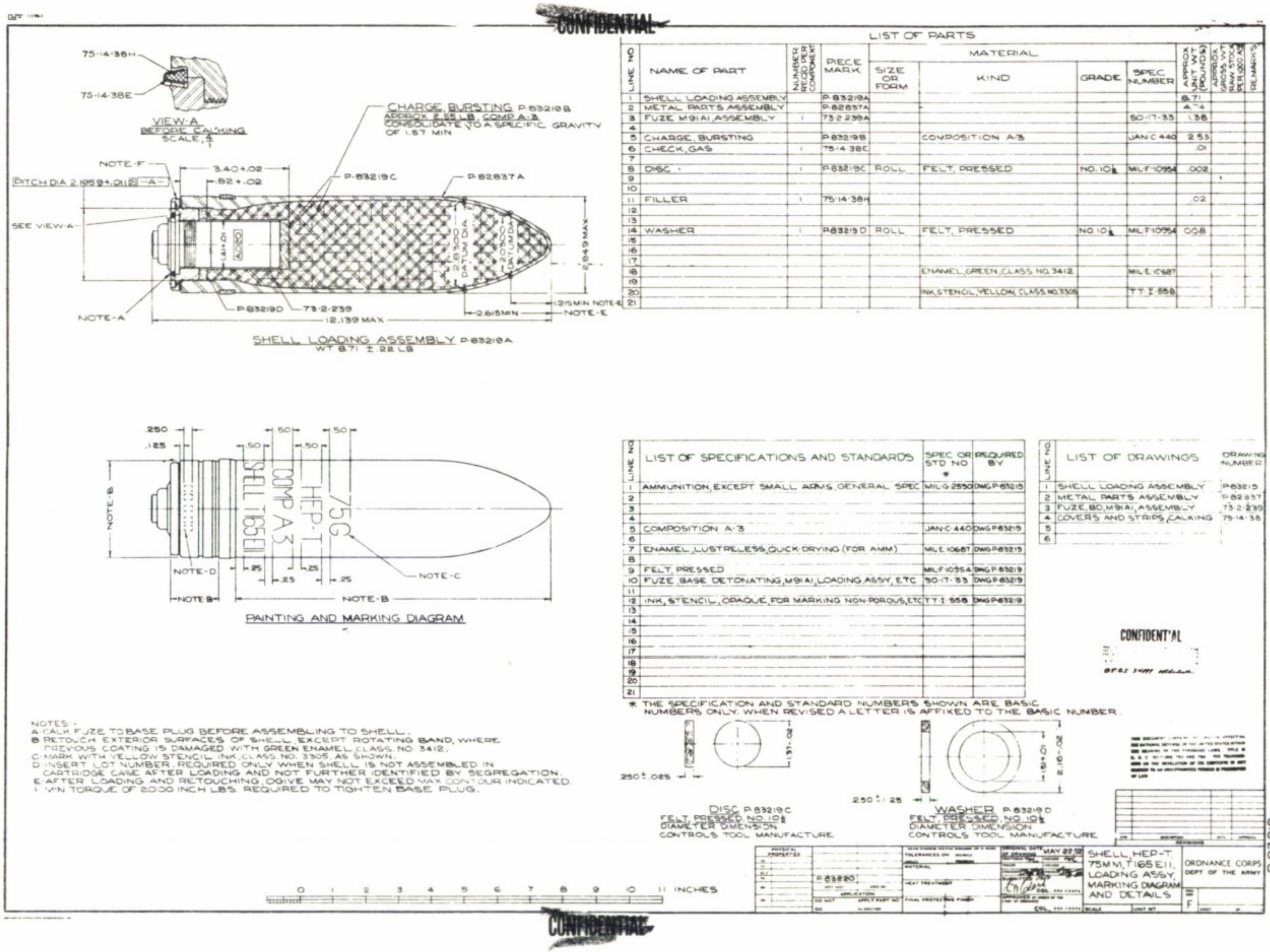

Fig. 4 Shell, HEP-T, 75 MM, T165E11, Loading Assembly, Marking Diagram and Details

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