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FIGHTING VEHICLES
RESEARCH & DEVELOPMENT
ESTABLISHMENT

REPORT No. T.R. 57.

BELLY ATTACK BY ANTI-TANK MINES Mk 7
AGAINST
CENTURION TANK TARGETS.

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RESEARCH DIVISION

TRIALS GROUP REPORT

ON

BELLY ATTACK BY ANTI-TANK MINES MK.7

AGAINST

CENTURION TANK TARGETS

(u)

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ABSTRACT

This is a report of the damage assessment of belly attacks by Anti-tank Mines Mk.7 (20 lb TNT) against Centurion Tank targets arranged by the "Attack of Armour Committee", Ordnance Board Proceeding Q8993 (Special) 13th April, 1962.

Two effective attacks were made, one centrally below the fighting compartment and the other centrally below the engine compartment. Damage sustained in the former instance was assessed to give 100% lost mobility and 100% lost fire power and in the latter instance 100% lost mobility and 10% loss of fire power.

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REPORT NO: TR.57

1. INTRODUCTION

Trials to determine the effect of Anti-Tank Mine Mk.7 belly attack against Centurion Tank targets were arranged by the Ordnance Board for D.R.E.E. Details of the trial request are given in Ordnance Board Proceedings Q8993 (Special), 13th April, 1962.

This report deals with the damage assessment carried out by F.V.R.D.E. using, as far as it could be applied to mine attack, the new method of assessment as described in Ordnance Board Memorandum No.2/62 issued as an Appendix to Proceeding No.Q8999 (Special), 24th July, 1962.

Instrumentation to determine the effects of blast and acceleration on the crew was arranged and the results will be the subject of a separate report by A.O.R.E. (C & E.P. Division).

The trials were carried out during May, 1962 at P. & E.E. Shoeburyness.

2. TARGET VEHICLES

Two Centurion Tanks Mk.3, Target Nos.2/62 and 4/62, from target vehicles previously used in the Attack of Armour Committee's trials of the 120 mm Tank Gun, were selected for the tests.

The two vehicles were non-runners as a result of damage sustained in the earlier gun trials, but the floor plates and general hull structures were sound. However, Target No.2/62 suffered some structural damage by the first mine attack made beneath the floor of the fighting compartment (Attack Ref. M1) which resulted in a low order detonation and was discounted as being an unrepresentative attack. The required attack in this position was subsequently made on Target No.4/62 and Target No.2/62 was used for the attack beneath the engine compartment (Attack Ref. M2). Due account was taken of this and the damage from the previous gun attacks when assessing damage to the vehicles after Attacks M2 and M3.

3. METHOD

3.1. The following attacks were made with Mine Mk.7 (20 lb) electrically detonated in each case with the mine buried 2 inches below ground level with approximately $1\frac{1}{2}$ inch additional soil mound:-

- (a) Attack M2 against Target No.2/62. Centre of mine vertically below the longitudinal centre line of the floor plate in line with the left and right 5th road wheel centres; beneath the engine compartment.
- (b) Attack M3 against Target No.4/62. Centre of mine vertically below the longitudinal centre line of the floor plate in line with the left and right 3rd road wheel centres; beneath the fighting compartment.

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4. RESULTS DISCUSSION

4.1. Detailed damage assessment data are given in the Appendix.

4.2. Attack M2 - Detonation beneath the engine compartment

Severe deflection of the hull floor brought it into contact with the engine; fuel and oil tanks were ruptured and driver's control rods were rendered inoperable. These items were, therefore, damaged to the extent that either could account for 100% mobility loss. The total distorted area of the floor was 90 inches x 60 inches, the width of the floor, with a maximum permanent displacement of 7 inches. Details of the floor distortion are given in the Appendix, Sheet 7. Photographs showing the hull floor distortion and damage to interior components are given at Figures 2 - 5.

The hull floor and edge welds remained intact without fracture and the 2 inch thick hull side plates were drawn inwards to an appreciable degree in the region of the bulged area of the floor. The two large access covers in the area of the floor affected by blast were displaced downwards when the floor rebounded after having resisted the initial blast from the mine attack. A loss of fire power of 10% is due to failure of the auxiliary engine fuel supply which would result in the powered traverse system being out of action.

The wooden dummies representing the crew were not materially damaged and there did not appear to be any serious disturbance of the fighting compartment components attributable to this attack. More precise assessment in the fighting compartment was impracticable because of previous damage from A.P.D.S. shot attack and the low order detonation resulting from the discounted mine attack M1.

4.3. Attack M3 - Detonation beneath the fighting compartment

Severe deflection of the floor occurred, the total area affected being 80 inches x 60 inches, the width of the floor, with a maximum permanent displacement upwards of $4\frac{1}{2}$ inches; the floor plate was otherwise intact. Detailed measurements of the floor plate distortion are given in the Appendix, Sheet 7. This attack produced less permanent floor displacement than attack M2 probably because of substantial support by the floor stowage bins and their contents.

Although the turret traverse was jammed previously by the preceeding gun trials it was evident that the extensive displacement and damage to the floor stowage, rotary base junction, turret turntable and side supports would have prevented turret traverse by power or hand. Since also damage and distortion to the driver's control rods and linkage was sufficient to render them inoperative the overall effect is assessed at 100% loss of both mobility and fire power.

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Damage to the dummy crew indicated that all the turret crew might well have been incapacitated.

Ammunition stowed in the floor bins was unfit for firing, all the cartridge cases being squashed to a varying degree. Several rounds were recovered loose in the fighting compartment having been projected out of the bins. Floor bin flaps and other components were wrenched from their hinges and fixtures; the batteries were shattered and pieces scattered over the whole compartment.

Photographs of the hull floor plate distortion and of internal components before and after mining are given at Figures 7 - 14.

5. SUMMARISED RESULTS

- 5.1. Attack M2. Made centrally below the engine compartment would have resulted in 100% lost mobility for any one of the following reasons:-

- (a) Irreparable damage to the engine.
- (b) Complete loss of fuel from damaged tanks.
- (c) Damage to driver's control rods and linkage.

The fuel loss would also stop the auxiliary engine and eliminate power traverse; this is assessed at 10% loss of fire power.

- 5.2. Attack M3. Made centrally below the fighting compartment disrupted the turret floor stowage and turret platform and would have prevented traverse by obstruction. All driver's control would be lost due to distortion of the control rods. The combined effect of these two factors would be 100% mobility loss and 100% fire power loss.

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Report TR.57 Appendix Sheet 1

Form No. 1

ANTI-TANK TRIALS
DAMAGE ASSESSMENT DATA

(a)	(b)	(a)	(b)
1. Trial No.	Q 8993	13. Projectile azimuth	-
2. Trial location	Poulness Island	14. Projectile elevation	-
3. Date	22/5/62	15. Coded point of attack	Hull Floor
4. Round No.	M2	16. Location of strike	{ Centre of blast zone 2 in rt. of Long, centre line in line with 5th road wheel centres.
5. Projectile type	A/T Mine	17. XXXXXXXXXXXXXXXXXX Floor Plate	20 in
6. Projectile calibre	Mk.7 (20 lb)	18. XXXXXXXXXXXX Ground Clearance	Buried 2 in below
7. Fuse No.	Static	19. XXXXXXXXXXXX Detail of	ground surface with
8. Charge weight	Detonation	20. XXXXXXXXXXXX Mine Laying	additional 1 1/2 in
9. Striking velocity	-	21. XXXXXXXXXXXX	(soil mound.
10. Range: Gun to target	-	22. Main armour thickness	17 mm Floor Plate
11. Equivalent range with F.S.C.	-	23. Main armour obliquity	0°
12. Target tank and No.	Cent.3 No.2/62	24. Overall repair time and echelon	-

24. Notes on tank condition prior to firing

- (a) Main and Aux. Engines damaged by previous shot attack - non runners.
- (b) Engine Compt. - cooling system pipes, Electrical Harness, water pump, cylinder block and other auxiliaries damaged previously.
- (c) Rotary Base Junction and turret floor ammunition stowage damage by previous attack, M.1.
- (d) Weighted and instrumented dummies in Gunner's and Commander's positions - Driver and Loader represented by unweighted dummies.
- (e) Blast Gauges in turret.
- (f) Rabbits in crew positions.

25. Comments on component damage

- A Hull floor plate bulged inwards, max. 7 in, total bulged area 72 in x 60 in floor width. Floor plate and welds remained intact without fracture.
- B1 Access cover - Oil pump, dislodged outwards - partially held by 2 bolts.
- B2 Access cover - Clutch, completely dislodged outwards.
- C1) Hull side plates bowed inwards - max. approx. 1/2 in at floor edge - drawn inwards
- C2) and held by bowed floor plate.
- D Rear Bulkhead 3/8 in thick buckled.
- E1 & E2 Left and Right engine bearers bowed upwards 1 7/16 in and 1 1/8 in max. respectively.
- E3 & E4 Engine bearer lugs on crankcase right front and rear broken off.
- E5 Engine sump shattered.
- E6 Engine crankcase sump face crushed and sides cracked.
- E7 & E8 Exhaust manifolds fractured and cylinder head fixtures damaged.
- F Oil cooler severely bent - no oil leakage.
- G1 & G2 Right and Left petrol tanks severely buckled and seams split open - all fuel lost.
- H Oil tank severely buckled and seam split open - all oil lost.
- I, J & K Clutch, Steering and Gear Change control rods severely bent and put out of adjustment. Right and Left steering rod bell-cranks on gearbox fractured.

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ANTITANK TRIALS

DAMAGE ASSESSMENT DATA (all measurements are in inches)

Trial No. Q 8993				Round No. M.2				Sheet No.				Penetration path				Fragment effects				Blast		Repair	
(a)	Component (b)	Entry diameter		Exit diameter		Thick. (j)	Location of damage		No. (n)	Area		Hole sizes		Penet. depths		Loss (u)	Fn. (v)	Time (w)	Ech. (x)				
		Max. (c)	Min. (d)	Max. (e)	Min. (f)		Max. (g)	Min. (h)		N (k)	Y (l)	Z (m)	Length (o)	Width (p)	From (q)					To (r)	From (s)	To (t)	
A	Hull floor							0 0 0		72	60					X	100						
B1	Access cover - oil pump							0 + 2 +23		9	9					X	50						
B2	Access cover - clutch							0 + 2 -25		9	9					X	100						
C1	Hull side plate - Right							+18 -28 0									10						
C2	Hull side plate - Left							+18 +32 0									10						
D	Rear Bulkhead							+ 6 0 +30									10						
E1	Engine Bearer - Left Rail							+ 6 +11 - 2									100						
E2	Engine Bearer - Right Rail							+ 6 - 7 - 2									100						
E3	Engine Bearer R. Front Crankcase Lug							+12 - 7 +13									100						
E4	Engine Bearer R. Rear Crankcase Lug							+12 - 7 -18									100						
E5	Engine Sump							+ 4 + 2 - 4									100						
E6	Engine Crankcase							+ 5 - 5 0									100						
E7	Engine Exhaust Manifold - Right							+25 -10 - 3									100						
E8	Engine Exhaust Manifold - Left							+25 +14 - 3									100						
F	Oil Cooler							+45 - 4 - 8									10						
G1	Fuel Tank - Right							+ 2 -19 +12									100						
G2	Fuel Tank - Left							+ 2 +23 + 1									100						
H	Oil Tank							+ 2 -19 -16									100						
I	Control Rod - Clutch							+ 1 -17 0									100						
J1	Control Rods - Steering							+ 1 -12 0									100						
K	Control Rods - Gear Change							+ 1 -15 0									100						
J2	Right Steering Brake Bell							+19 -10 -57									100						
J3	Left Steering Brake Bell							+19 - 4 -57									100						

Note on co-ordinates:

'X' is measured in the Direction of the attack ie vertical and positive up.

'Y' is measured horizontally positive to the right, when looking in the direction of the attack.

'Z' is measured horizontally positive to the front of the vehicle. The origin is taken as the centre of blast zone on the hull floor.

Note on co-ordinates:

'X' is measured in the Direction of the attack ie vertical and positive up.

'Y' is measured horizontally positive to the right, when looking in the direction of the attack.

'Z' is measured horizontally positive to the front of the vehicle. The origin is taken as the centre of blast zone on the hull floor.

ANTI-TANK TRIALS														
FIRING RESULTS														
Round No.	Calibre	Type	Target tank	Attack azimuth	S.V.	Equivalent range	Stand-off	Armour protection (Normal to armour or in direction of projectile)	U.B.L.	Residual penetration	Compartment attacked	M	TH	I
M.2	20 lb	Mine 4/1	Cent. 3	-	-	-	-	17 mm Thick IF 130 Floor Plate	-	-	Engine	100	10	-
Hit location: Centre of blast zone on floor, 2 in right of horizontal centre line in line with 5th road wheel hub centres.														



EXTERIOR DAMAGE													
Component (d)	Jet, frags., blast (b)	% Com- ponent loss (c)	% Loss to tank		Location r (g)	θ (h)	Repair time (j)	Component (k)	Jet, frags., blast (f)	% Com- ponent loss (m)	% Loss to tank		Repair time (q)
			M (d)	F (e)							M (n)	F (o)	
							m-hrs						m-hrs
1								Hull Floor	B	100	0		
2								Access Cover - oil pump	B	50	0		
3								Access Cover - clutch	B	100	0		
4								Hull Side Plate - Right		10	0		
5								Hull Side Plate - Left		10	0		
6	Rear Bulkhead	10	0		34in	79°							
7	Engine Bearer, Left, Rail	100			13in	62°							
8	Engine Bearer, Right, Rail	100			9in	45°							
9	Engine Bearer, Lug, R. Front (crankcase)	100			19in	51°							
10	Engine Bearer, Lug, R. Rear (crankcase)	100			18in	48°							
11	Engine Sump	100	100		6in	48°							
12	Engine Crankcase	100			7in	44°							
13	Engine Exhaust Manifold - Right	100			27in	22°							
14	Engine Exhaust Manifold - Left	100			29in	31°							
15	Oil Cooler	10			46in	12°							
16	Fuel Tank - Right	100	100		23in	85°							
17	Fuel Tank - Left	100			23in	85°							
18	Oil Tank	100	100		25in	85°							
19	Control Rod - Clutch	100			7in	82°							
20	Control Rod - Steering	100			12in	85°							
21	Control Rod - Gear Change	100	100		15in	86°							
22	Right Steering Brake Bell Crank	100			6in	72°							
23	Left Steering Brake Bell Crank	100			60in	72°							
24	Turret Traverse	10									10		
25	Loss of Power control owing to lost fuel supply to Auxiliary engine.												
26													
27													
28													
29													
30													
31													
32													
33													
34													
35													

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Report TR.57 Appendix Sheet 4

Form No. 1

ANTI-TANK TRIALS

DAMAGE ASSESSMENT DATA

(a)	(b)	(a)	(b)
1. Trial No.	Q 8993	13. Projectile azimuth	-
2. Trial location	Foulness Island	14. Projectile elevation	-
3. Date	22/5/62	15. Coded point of attack	Hull Floor
4. Round No.	M.3	16. Location of strike	(Centre of blast zone on long. centre line in line with 3rd road wheel centres.
5. Projectile type	A/T Mine	17. XXXXXXXXXXXXXXXXXXXX	
6. Projectile calibre	CS Mk. 7 (20 lb)	18. XXXXXXXXXXXX	
7. Fuze No.	Static Detonation	19. XXXXXXXXXXXX	
8. Charge weight	-	20. XXXXXXXXXXXX	
9. Striking velocity	-	21. Main armour thickness	17 mm Floor Plate
10. Range:— Gun to target	-	22. Main armour obliquity	0°
11. Equivalent range with F.S.C.	-	23. Overall repair time and echelon	-
12. Target tank and No.	Cent. 3 No. 4/62		

24. Notes on tank condition prior to firing

1. Right front suspension bracket removed by previous shot attack - support placed under track.
2. Nose ammunition bin damaged by shot attack and was not stowed.
3. Ammunition stowed in floor bins and 4 round ready bin in turret platform.
4. Commander and Gunner represented by Weighted Wooden dummies - instrumented. Driver and Loader represented by unweighted wooden dummies.
5. Blast gauges in turret - Hatches closed.
6. Rabbits in instrumented dummy crew positions.

25. Comments on component damage

- A Hull floor plate bulged inwards, max. 4½ in, total bulged area 80 in x 60 in floor width - floor plate and welds remained intact without fracture.
- B Rotary Base Junction completely dislodged from floor and forced up 8 in.
- C 4 round ready ammo. bin distorted with rounds jammed in their containers.
- D Turret turn table platform forced up at centre maximum 8 in - side supports distorted.
- E Alternator motor completely dislodged from mounting on Metadynes.
- F Division plate 5/16 in thick floor stowage, severely buckled.
- G1, G2 & G3 Floor Stowage bins - central rear, left and right inner rear - ammunition and trays ejected into fighting compartment - trays forced up max. 42 in. Bin flaps completely detached from hinges. Ammo. thrown out and damaged.
- G4-G9 Floor stowage bins - bin flaps detached and stowed ammunition ejected and damaged.
- H1 & H2 Batteries shattered - electrolyte and fragments dispersed over whole of the fighting compartment - bin flaps removed.
- J Commander's foot rest and column severely bent.
- K, L1, L2 & M Clutch, Steering and Gear Change Control rods severely bent and out of adjustment. Right steering rod bell crank pivot pin fractured.
- N Commander's Dummy - foot damage.
- O Gunner's Dummy - right arm off and shoulder broken.
- P Loader's Dummy - severe leg and right shoulder damage. Head severe dent.

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ANTITANK TRIALS

DAMAGE ASSESSMENT DATA (all measurements are in inches)

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Report TR. 57 Appendix Sheet 5

Trial No. Q 8993 Round No. M3 Sheet No.			Penetration path				Location of damage			Fragment effects						Blast	Repair	
(a)	Component (b)	Thick mat. pen.	Entry diameter		Exit diameter		X (i)	Y (j)	Z (m)	No. (n)	Area		Hole sizes		Penet. depths		(u)	(v)
			Max. (c)	Min. (d)	Pre-spall (e)	Max. (f)					Spall (g)	Min. (h)	Length (o)	Width (p)	From (q)	To (r)		
A	Hull Floor						0	0	0	0	81	60					X	100
B	Rotary Base Junction						2	0	0									100
C	Ammunition Bin - 4Rd. ready						17	-10	0									100
D	Turret Turntable						17	0	0									100
E	Alternator Motor						33	0	26									100
F	Floor Storage Division Flde						0	0	-5									100
G1	Rear Central						0	0	-23									100
G2	Right Rear Inner						0	-13	-23									100
G3	Left Rear Inner						0	13	-23									100
G4	Left Rear Outer						0	24	-23									100
G5	Right Rear Outer						0	-24	-23									100
G6	Right Front Outer						0	-24	13									100
G7	Right Front Inner						0	-13	13									100
G8	Left Front Outer						0	24	13									100
G9	Left Front Inner						0	13	13									100
H1	Batteries Front						0	9	35									100
H2	Batteries Central						0	0	20									100
J	Foot Rest Commander's						22	-17	-28									20
K	Control Rod - Clutch						1	-9	0									100
L1	Control Rods - Steering						1	-14	0									100
L2	Right Steering Brake Ball						19	-12	130									100
M	Control Rods - Gear Change						1	-17	0									100
N	Commander - seat position						57	-17	-34									100
O	Gunner - seat position						46	-24	0									100
P	Loader - standing position						12	26	0									100

See note on Sheet 2

Note: Centre of presented area of component.

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Projectile

Calibre Type

20 lb TNE Mine
A/T Mk 7

ANTI TANK TRIALS

FIRING RESULTS

Round No.	Target tank	Attack azimuth	S.V.	Equivalent range	Stand-off	Armour protection (Normal to armour or in direction of projectile)	O.B.L.	θ	Residual penetration	Compartment attacked	XX	XXI	XX
M3	Cent. 3	-	-	-	ins	17 mm Thick IT.130 Floor Plate	-	ins	ins	Turret	100	100	-

Hit location: Centre of blast zone on floor plate on longitudinal centre line, in line with the 3rd Road Wheel hub centres.

P.M.

EXTERIOR DAMAGE

INTERIOR DAMAGE

Component (a)	Jet, frags., blast (b)	% Com- ponent loss (c)	% Loss to tank			Repair time (j)	Location r (g) θ (h)	Component (k)	Jet, frags., blast (l)	% Com- ponent loss (m)	% Loss to tank			Repair time (q)
			M (d)	XX (e)	XXI (f)						M (n)	XX (o)	XXI (p)	
Hull Floor														
2 Rotary Base Junction		100					2 in 0°							
3 Ammunition Bin - 4Rd. ready		100					20 in 32°							
4 Turret Turntable		100					17 in 0°							
5 Alternator Motor		100					42 in 38°							
6 Floor Storage - Division Plate		100					5 in 90°							
7 Ammunition Bin floor - rear centre		100					23 in 90°							
8 Ammunition Bin floor - right rear inner		100					26 in 90°							
9 Ammunition Bin floor - left rear inner		100					26 in 90°							
10 Ammunition Bin floor - left rear outer		100					33 in 90°							
11 Ammunition Bin floor - right rear outer		100					33 in 90°							
12 Ammunition Bin floor - right front outer		100			100		27 in 90°							
13 Ammunition Bin floor - right front inner		100					18 in 90°							
14 Ammunition Bin floor - left front outer		100					27 in 90°							
15 Ammunition Bin floor - left front inner		100					18 in 90°							
16 Batteries, Front		100					36 in 90°							
17 Batteries, Central		100					20 in 90°							
18 Foot Rest, Commander's		20			0		39 in 56°							
19 Control Rod, Clutch		100	100				9 in 84°							
20 Control Rods, Steering		100	100				14 in 86°							
21 Control Rods, Gear Change		100	100				17 in 87°							
22 Steering brake control bell crank		100	100				132 in 82°							
23 Commander via (seat position)		50					69 in 34°							
24 Gunner via (seat position)		100			95		52 in 28°							
25 Loader via (standing position)		100					29 in 66°							

APPENDIX TO
REPORT NO: TR. 57
SHEET 7

Measurements are given at 3 inch interval spacing across the floor plate through the maximum point of bulge starting from the left side edge, facing the front.

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FIG. NO. 1.

CENTURION TANK TARGET NO. 2/62. BEFORE ATTACK M2.



FIG. NO. 2.

SHOWING DISTORTION OF THE FLOOR PLATE AFTER ATTACK M2.
MAXIMUM DISPLACEMENT = 7 IN. CHALK LINES INDICATING
CURVATURE 4 IN SPACING.

REPORT NO. TR. 57

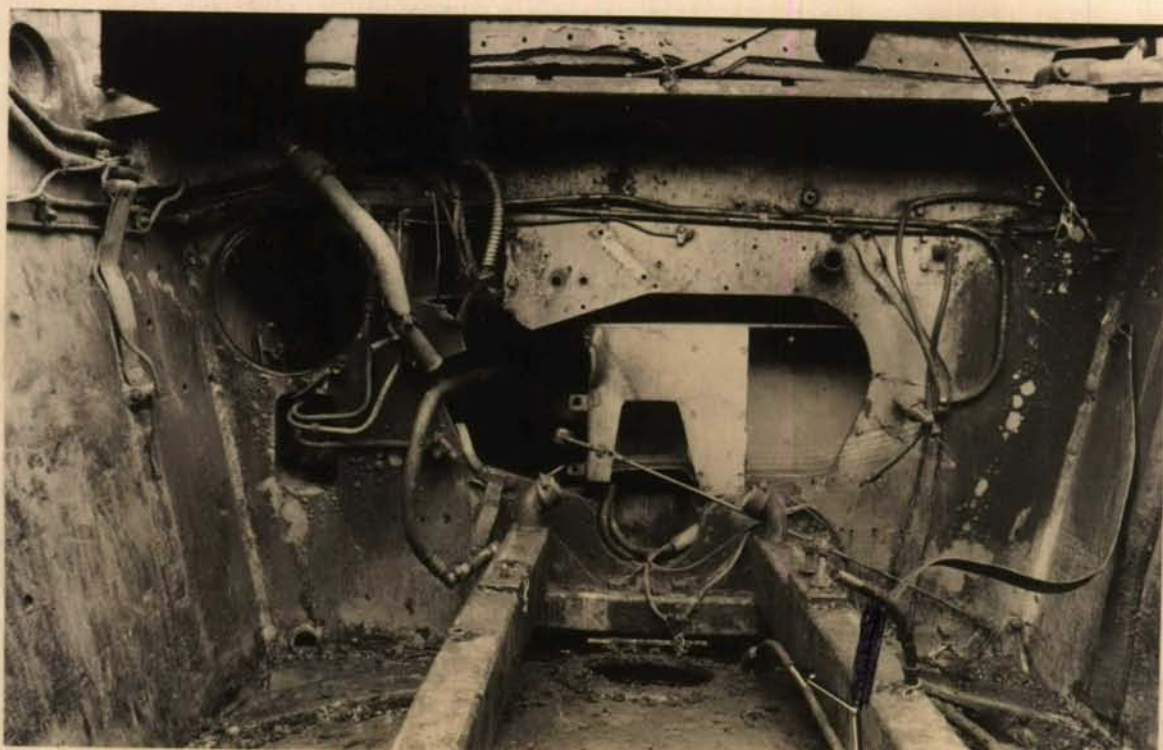


FIG. NO.3.

DRIVER'S CONTROL RODS

ATTACK M2. ENGINE COMPARTMENT AFTER ATTACK
WITH INTERNAL COMPONENTS REMOVED SHOWING FLOOR
DISPLACEMENT AND DISTORTED CONTROL RODS.



FIG. NO.4.

ATTACK M2. SHOWING CONDITION OF CRANKCASE
AND SUMP AS FOUND WHEN ENGINE WAS REMOVED.



FIG. NO. 5.

ATTACK M2. SHOWING DAMAGE TO
FUEL AND ENGINE OIL TANKS.



FIG. NO. 6.

CENTURION TANK TARGET NO. 4/62
BEFORE ATTACK M3.

REPORT NO. TR. 57



FIG. NO.7.



FIG. NO.8.

VIEWS OF FIGHTING COMPARTMENT FLOOR (AMMUNITION
FLOOR STOWAGE FLAPS) PRIOR TO ATTACK M3.

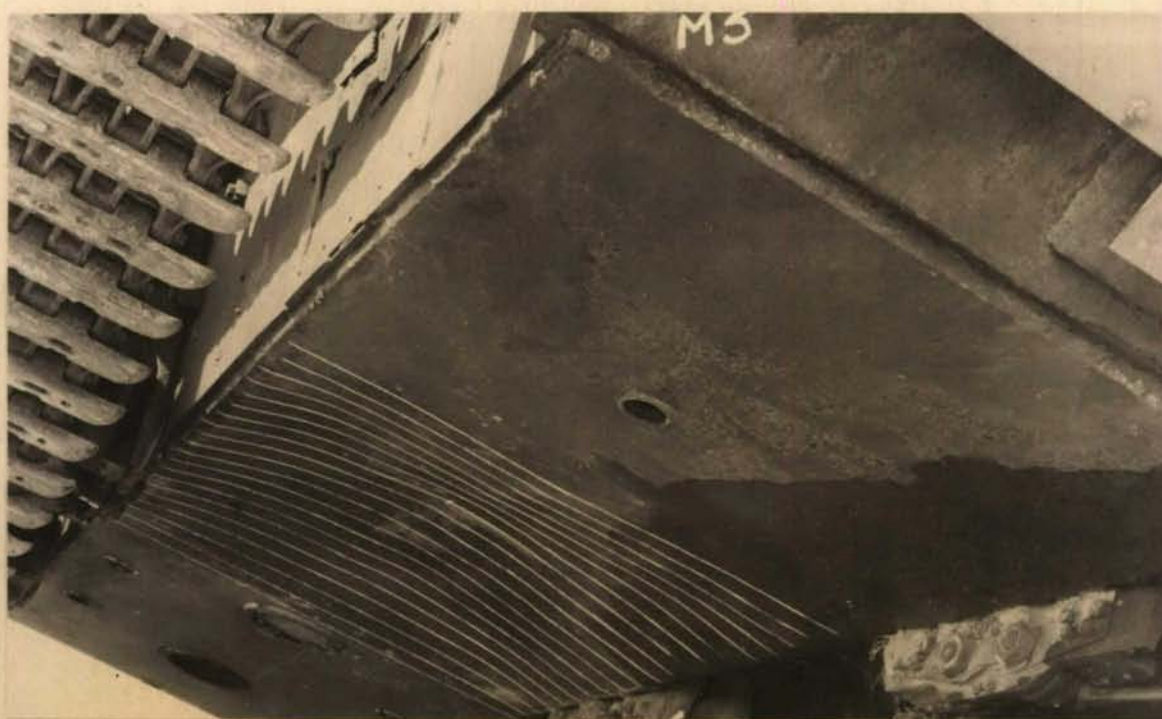


FIG. NO.9.

SHOWING DISTORTION OF FLOOR PLATE AFTER ATTACK M3.
MAXIMUM DISPLACEMENT WAS $4\frac{1}{2}$ IN. CHALK
LINES INDICATING CURVATURE 4 IN SPACING.



FIG. NO.10.

VIEW THROUGH COMMANDER'S HATCH AFTER ATTACK.

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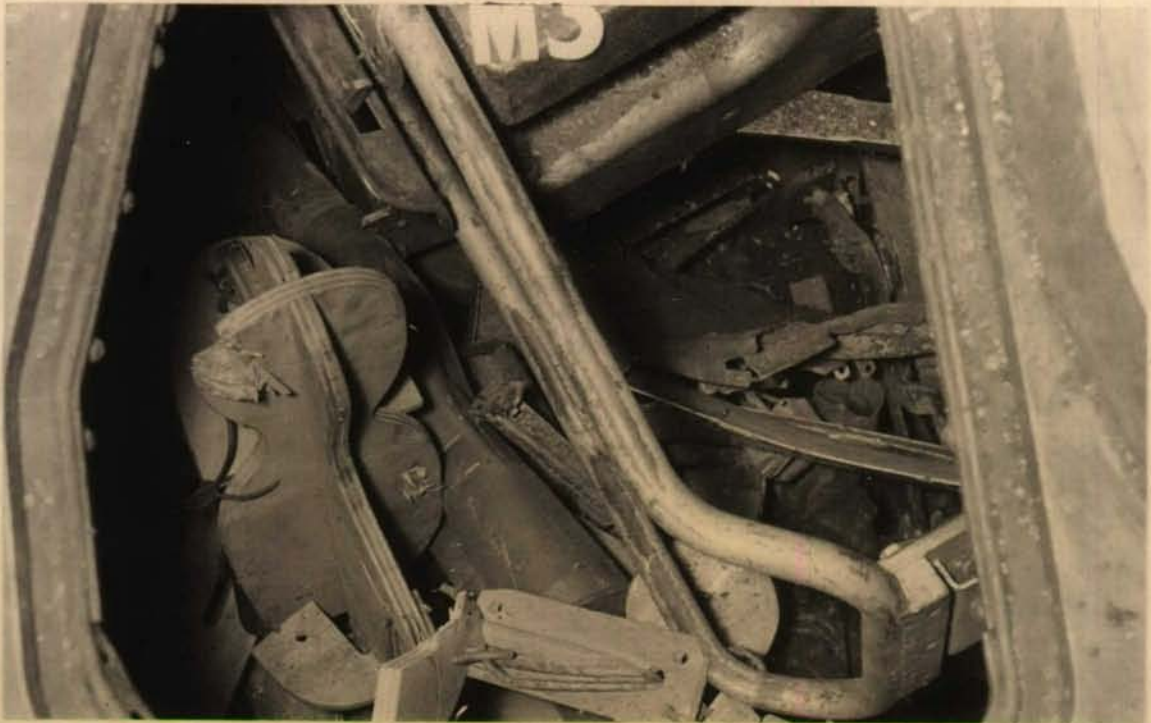


FIG. NO.11.

VIEW THROUGH LOADER'S HATCH AFTER ATTACK M3
SHOWING DAMAGE TO LOADER'S DUMMY AND
DISRUPTED FLOOR STOWAGE.



FIG. NO.12.

ROTARY BASE JUNCTION

SHOWING DISPLACEMENT OF ROTARY BASE JUNCTION PARTLY OBSCURED
BY DISLODGED AMMUNITION TRAY FROM FLOOR STOWAGE BIN ON
ATTACK M3.

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FIG. NO.13.

ATTACK M3.SHOWING DISRUPTED AMMUNITION FLOOR STOWAGE BINS.



FIG. NO.14.

ATTACK M3.SHOWING DAMAGE TO AMMUNITION STOWED IN THE FLOOR BINS.

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