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A-10/GAU-8 LOW ANGLE FIRINGS VERSUS SIMULATED SOVIET TANK COMPA--ETC(U)
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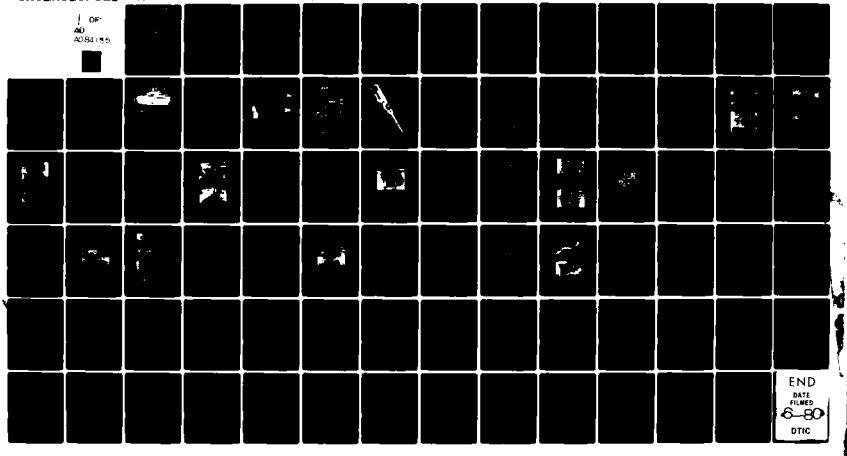

NPS-56-80-004

NAVAL POSTGRADUATE SCHOOL

Monterey, California

Special rpt.

COMBAT DAMAGE ASSESSMENT TEAM

A-10/GAU-8 LOW ANGLE FIRINGS
VERSUS
SIMULATED SOVIET TANK COMPANY (ARRAY 17)
(LAVP Lot Number AJD 79A181-001, AEROJET)
(14 AUGUST 1979).

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APRIL 1980

Prepared for: A-10 System Program Office
Wright Patterson Air Force Base
Ohio 45433

NAVAL POSTGRADUATE SCHOOL
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8. MBT vulnerability & survivability

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes firings of the A-10/GAU-8 weapon system on 14 August 1979 against a Soviet tank company simulated by 10 combat loaded M-47 tanks. The pilots making the firing passes attacked at low altitude and used correspondingly low dive angles in order to simulate movement through a hostile air defense system. Ammunition used in the attacks comprised Aerojet Lot Number AJD 79A181-001 30mm armor piercing incendiary (API) rounds, which proved to be effective damage agents against substantial areas

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of the U.S. MK-47 tanks used as targets. The pilot in nine firing passes (one target was not fired on, and the pilot missed one intended target) fired a total of 565 rounds, of which 140 impacted the targets. Of the projectiles impacting on targets, 17 achieved perforations of the armored envelope. Significant results include:

one tank immobilized and silenced;

one tank silenced, mobility seriously degraded;

three tanks immobilized only;

two tanks immobilized, firepower seriously degraded

one tank light firepower damage;

two tanks suffered no damage.

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FIGURES (concluded)

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COMBAT DAMAGE ASSESSMENT COMMITTEE (CDAC) EXECUTIVE SUMMARY

Under the technical direction of the Combat Damage Assessment Committee (CDAC), the Combat Damage Assessment Team (CDAT) conducted firings of the A-10/GAU-8 weapon system against an array of 10 tanks simulating a Soviet tank company deployed for an attack. The CDAT used M-47 tanks stowed with main gun ammunition, diesel fuel, lubricating oil, and crew manikins to simulate the Soviet tanks. The pilot of the A-10 aircraft used in the firings conducted firings at low altitudes and low dive angles which simulated attack below the altitude of effective engagement for opposing air defense networks employing acquisition and fire control radar. The purpose of the test was to evaluate the effects of Aerojet 30mm API anti-tank ammunition (lot number AJD 79A181-001) of the GAU-8 gun under challenging conditions of engagment for the A-10/GAU-8 system against realistically simulated Soviet main battle tanks.

The CDAC assessed the results of the low angle cannon firings of the A-10 aircraft against the simulated Soviet tank company as follows:

1. Attack Parameters: The pilot of the A-10 aircraft attacked the simulated Soviet tank company for 16 minutes 55 seconds at low altitude and dive angles. The GAU-8 cannon has a ground selectable nominal fire rate of either 4200 rounds per minute or 2100 rounds per minute. The system was set to fire at the 4200 round per minute rate during this test. The pilot made a total of nine passes, each at a primary target tank. The passes resulted in projectile impacts on eight primary target tanks. The attack dive angles averaged 4.5 degrees for the nine passes. Open-fire slant ranges averaged 2939 feet. The pilot fired 565 rounds in nine bursts averaging 63 rounds and 0.96 second each.

2. Weapons Effects: The A-10/GAU-8 weapon system achieved 140 impacts on the eight tanks which were fired on, of which 37 were ricochets off the ground. The ratio of direct impacts to total rounds fired was 0.18. Ricochet hits are also capable of causing damage. If the ricochet hits are added to the direct impacts, the overall ratio of impacts to rounds fired becomes 0.25. The weapon system achieved 17 perforations of the armored envelopes of the tanks with a ratio of perforations to total impacts of 0.12. The ratio of perforations to direct impacts was 0.17. Many projectiles, which did not perforate armor, severely damaged exterior track and suspension components of the tanks as well as command and control optical devices and gun tubes.

3. Damage Assessment: The attacking A-10/GAU-8 weapon system inflicted no catastrophic kills on tanks in the company array. Of the damaged tanks, one was rendered incapable of both fire and movement, one was silenced and seriously degraded in mobility, two were immobilized and seriously degraded in firepower, and three were immobilized with no degradation in firepower. One tank suffered a minor degradation in firepower and two tanks were unscathed (one was missed, the other was not

attacked). As a formation, the simulated Soviet tank company was immobilized and incapable of sustained offensive combat.

4. Test Conditions: The target tanks were sited in open, flat desert terrain with no cover and little concealment. Aerial weather conditions were ones of unlimited ceiling and visibility. Shortly after the initial firing, clouds of white dust from projectile impacts were evident. Such conditions effectively simulated the actual obscuration which would have been presented to the pilots in combat.

5. Results: The overall results of the test are summarized in Table I.

TABLE 1. Array 17 Summary of A-10 Aircraft in Low Angle Gun Attack versus Simulated Soviet Tank Company
(14 AUGUST 1979)

Tank No.	A-10 Primary Pass	A-10 Approach Speed (fps)	A-10 Approach Alt (ft)	A-10 Attack Open Fire Range (ft)	A-10 Attack Dive Angle (degrees)	Gun Effects Rounds (each)	Gun Effects Impacts (each)	Gun Effects Perfs (each)	Damage M %	Damage F %	Damage K %	Tank Immob ?	Attack Aspect (degrees)
38	1	572	218	2516	4.6	69	6	4	100	95	---	Yes	260
41	2	564	284	3090	5.0	41	22	2	100	40	---	Yes	247
7	3*	554	197	3172	3.7	55	0	0	N.A.	N.A.	N.A.	N.A.	---
35**	---	---	---	---	---	---	---	---	---	---	---	---	---
34	4	430	73	3321	2.3	41	2	1	100	---	---	Yes	270
4	5	538	226	2840	4.6	69	38	2	90	100	---	No	235
33	6	539	220	***	4.4	55	25	2	100	100	---	Yes	235
31	7	441	165	***	4.2	97	17	1	0	20	---	No	285
29	8	494	201	2309	6.3	83	21	4	100	---	---	Yes	230
23	9	573	278	3322	5.3	55	9	1	100	---	---	Yes	265
Applicable Totals:		523	207	2939	4.5	565	140	17	1 TANK IMMOBILIZED AND SILENCED; 1 TANK SILENCED; MOBILITY SERIOUSLY DEGRADED 3 TANKS IMMOBILIZED ONLY 2 TANKS IMMOBILIZED; FIREPOWER SERIOUSLY DEGRADED 1 LIGHT FIREPOWER DAMAGE 2 NO DAMAGE			6 TANKS IMMOB.	LEFT REAR
Averages:						63	15.5	1.9					

* The pilot missed the tank on this pass
** Tank not fired on
*** Range uncertain

BACKGROUND

Since February, 1978, the Armament Directorate, A-10 System Program Office, Wright Patterson Air Force Base, Ohio, has conducted firing tests using the A-10/GAU-8 system in low-level, air-to-ground engagements of armored targets. The tests have been conducted within the framework of the GAU-8 30mm ammunition Lot Acceptance Verification Program (LAVP) - Airborne. The LAVP has the following objectives which apply to the present tests:

A. To evaluate the performance of existing production lots of GAU-8 ammunition when fired from the air under operational conditions.

B. To evaluate the lethality of GAU-8 ammunition against armored targets when fired at low level from A-10 aircraft using operational tactics.

To conduct the LAVP program, the Armament Directorate has cooperated with Headquarters, Tactical Air Command, Langley AFB, Virginia and, in turn, with the Tactical Fighter Weapons Center, Nellis AFB, Nevada. Within the framework of that cooperation, the Armament Directorate has set up a Combat Damage Assessment Team (CDAT) to plan and execute the firing tests and evaluate the results. The CDAT functions under the direction of a Combat Damage Assessment Committee (CDAC) which has prepared this report of the firing test of 14 August, 1979.

TEST PHILOSOPHY

To generate realistic data, the CDAC determined to use a highly empirical technique of destructive testing of actual tank targets. Tests have involved firings at individual tanks in November, 1977, and February - March, 1978, and, more recently, arrays of tanks in tactical formations. The experimental setup for the firings of 14 August, 1979 involved the use of a multi-target, tactically arrayed tank formation for attack by the A-10/GAU-8 system. The CDAT elected to simulate a Soviet tank company, as organized within a tank division, as the target array for two attacking A-10 aircraft. As few constraints as possible were placed on the attacking pilots in an attempt to develop as much realism as possible. Table II shows the test factors which would have been ideal in the test of 14 August, 1979 and the practical setup which was achieved.

Table II. Comparison of Ideal and Practical Test Situations

Ideal Test Parameters	Practical Test Parameter
1. Air Attack Realism	1. Air Attack Realism
a. Actual A-10/GAU-8	a. Actual A-10/GAU-8
b. 30mm API	b. 30mm API
c. European weather & terrain	c. Nevada weather & desert terrain
d. Optimum open-fire ranges (2000 ft)	d. Average open fire range: 2939 feet.
e. Low altitude attack angle (< 6 degrees)	e. Low altitude attack angle (< 6 degrees)
2. Air Defense Realism	2. Air Defense Realism
a. Automatic cannon firing at aircraft	a. Low-altitude, low-angle, minimum-exposure attacks versus assumed AD system
b. Missile systems firing at aircraft	b. Low-altitude, low-angle, minimum-exposure attacks versus assumed AD system
c. Small arms firing at aircraft	c. Low-altitude, low-angle, minimum-exposure attacks versus assumed AD system
d. AD suppression by aircraft	d. No suppression simulation in test
3. Threat Targets and Doctrine	3. Threat Targets and Doctrine
a. T62/T64/T72 high fidelity targets	a. Simulated Soviet tanks
b. Stowed combat loads (in T62/T64/T72)	b. Stowed combat loads (in US M-47)
c. Realistic crew station postures	c. Wooden crew manikins
d. Dynamic combat formation	d. Static combat formation
e. Maneuvering evasive targets	e. Stationary targets

SIMULATED GROUND COMBAT SITUATION

The firing test of 14 August 1979 simulated the attack by two A-10 aircraft on a Soviet tank company. One of these aircraft experienced an inflight engine failure prior to actual engagement, necessitating immediate withdrawal from the test. The CDAC hypothesized the Soviet tank company to be the lead march security detachment for its battalion, which in turn, is the advance guard of a larger mobile formation. The lead detachment operates approximately five kilometers in front of the Soviet battalion column. The mission of the advance company is to ensure the uninterrupted advance of the battalion and provide security against attack. Upon meeting heavy resistance, the company deploys into an appropriate combat formation to reduce the resistance, or form a base of fire for offensive action by the remainder of the battalion.

A Soviet tank company would probably have other units attached to it for its support. Attached units might include any one or all of the following elements: (1) motorized rifle platoon; (2) engineer detachment; (3) chemical defense specialists; (4) 122mm howitzer battery; (5) air defense element. The company simulated in the firing test consisted of tanks alone. The pure tank formation was arranged with two platoons up and one back, simulating an assault posture. The tanks used in the firing test were US M-47 tanks, largely intact, containing crew manikins, and stowed with ammunition, fuel, and oil. The tanks were not maneuvered during the firing test and the formation remained essentiallly a snapshot of the company at a single point in time.

TARGET TANKS

The most effective tanks available in sufficient numbers to simulate Soviet T-55 and T-62 (Figure 1) tanks were the US M-47 tanks. Both of the Soviet tank models are similar in armor protection to the M-47. With the appropriate purging of the gasoline fuel system of the US tanks, the CDAT managed to field a tank similar in survivability to the T-55 and T-62 tanks from the viewpoint of ignitable internal material. Few data are available on the Soviet T-64 and later model tanks from the viewpoints of armor protection and the arrangement of internal components. The decision was made, accordingly, to simulate the earlier model Soviet tanks with the readily available US tanks.

The M-47 tanks used for targets were in excellent condition from the viewpoint of damage assessment. The exterior components were complete and the tanks have proven to be effective targets for the collection of exterior mobility damage. Interior components were less complete in the target tanks. All of the most essential items were present, e.g., main gun, engine, transmission, fuel tanks, ammunition racks, etc., but other items such as oil coolers, range finders, vision devices, and radios, have not been present in all tanks.

The most sensitive internal items from the viewpoint of catastrophic kills and high percentage Mobility (M) and Firepower (F) kills are the following, which were placed in the test tanks as noted:

Generic Sensitive Item	Test Item
1. Ammunition	US Cartridge, 90-mm TP-T
2. Fuel	Number 2 Diesel
3. Oil	Oil in Engine, Transmission and Drive Components.
4. Personnel	Articulated Plywood Manikins

The tanks were static during the test and their engines were not running, with the result that the fuel and oil were much cooler and more inert than would have been the case with a moving tank or a static vehicle with its engine running. The kill ratio achieved in the firing test of 14 August, 1979, therefore, is probably conservative from the viewpoint of fires resulting from ignited fuel and oil.

TEST PERFORMANCE AND RESULTS

The test itself consisted of bringing together the ammunition, gun, aircraft, pilots, and combat arrayed and loaded tanks into a several minutes simulation of combat. In essence, the

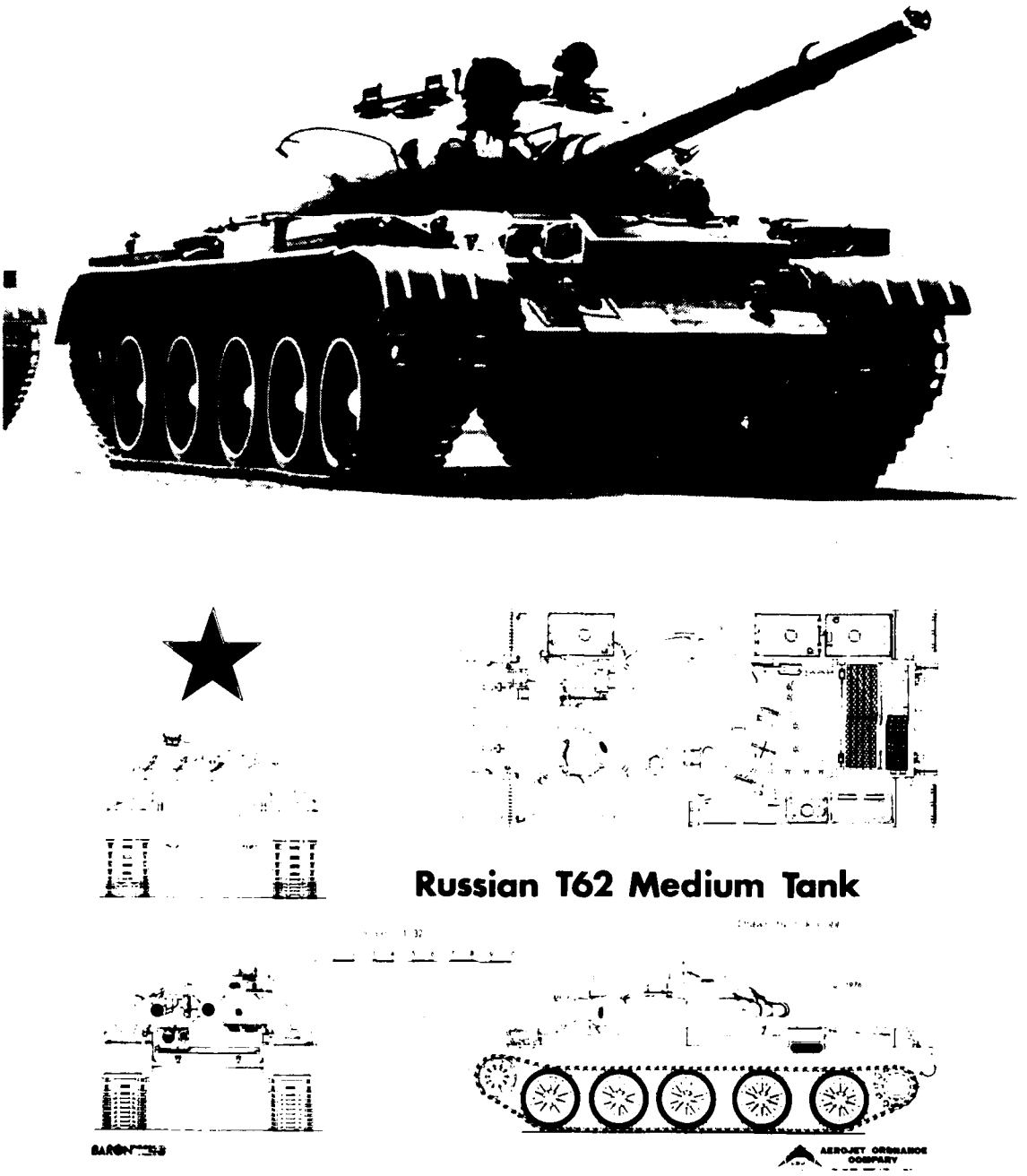


FIGURE 1. Russian T62 Medium Tank

decisive elements which were fed into the test immediately prior to the firing were the following:

1. Aerojet 30mm API ammunition, lot number AJD 79A181-001.
2. General Electric GAU-8 Gatling gun.
3. Fairchild Republic A-10 attack aircraft.
4. Fighter pilots, 66th FWS, Nellis AFB.
5. US M-47 main battle tanks.

The combat simulation itself comprised the aerial fire and maneuver of the attacking A-10 aircraft. A realistic way of presenting the combat simulation is to outline the sequence of pertinent events in each firing pass. These events and the pertinent data which the CDAT attempted to collect, in order to reconstruct the simulated combat firing of 14 August, 1979, were as follows:

Sequence	Event	Data
1.	Aircraft Approach	Speed, Altitude
2.	Aircraft Attack	Open-fire Range, Dive Angle
3.	Aircraft Attack	Burst Time, Rounds Fired
4.	Aircraft Attack	Cease-fire Range, Dive Angle
5.	Gun Effects, (Accuracy)	Impacts on Tanks
6.	Gun Effects, (Lethality)	Perforations through Armor
7.	Tank Damage	Catastrophic (K-Kill), Mobility (M-Kill), and Firepower (F-Kill) Kills

The data noted immediately above were collected through the combined efforts of the CDAT and range support personnel at Nellis AFB, working together and using TSPI equipment, motion picture and still cameras, the industrial efforts required to repair, refurbish, and field the tank targets, and various systematic research techniques used to describe weapon effects and combat damage. The most basic materiel used in the test; i.e., the aircraft, gun, and projectile are illustrated in Figures 2, 3, 4, and 5. The tanks were arrayed in the tactical formation of a Soviet tank company as shown in Figure 6.

The pilots making the attack flew from the base area in a two-ship, mutually supporting element and employed operational tactics immediately before and during the firing passes. The pilots approached the target area at low altitude and simulated target acquisition with the help of a forward air controller. Prior to actual engagement, the lead aircraft experienced an inflight engine failure, necessitating its immediate withdrawal. The remaining pilot then proceeded alone to attack the entire tank company at low altitudes and dive angles, simulating operation below the altitudes for effective acquisition and engagement by opposing air defense missile and gun systems.

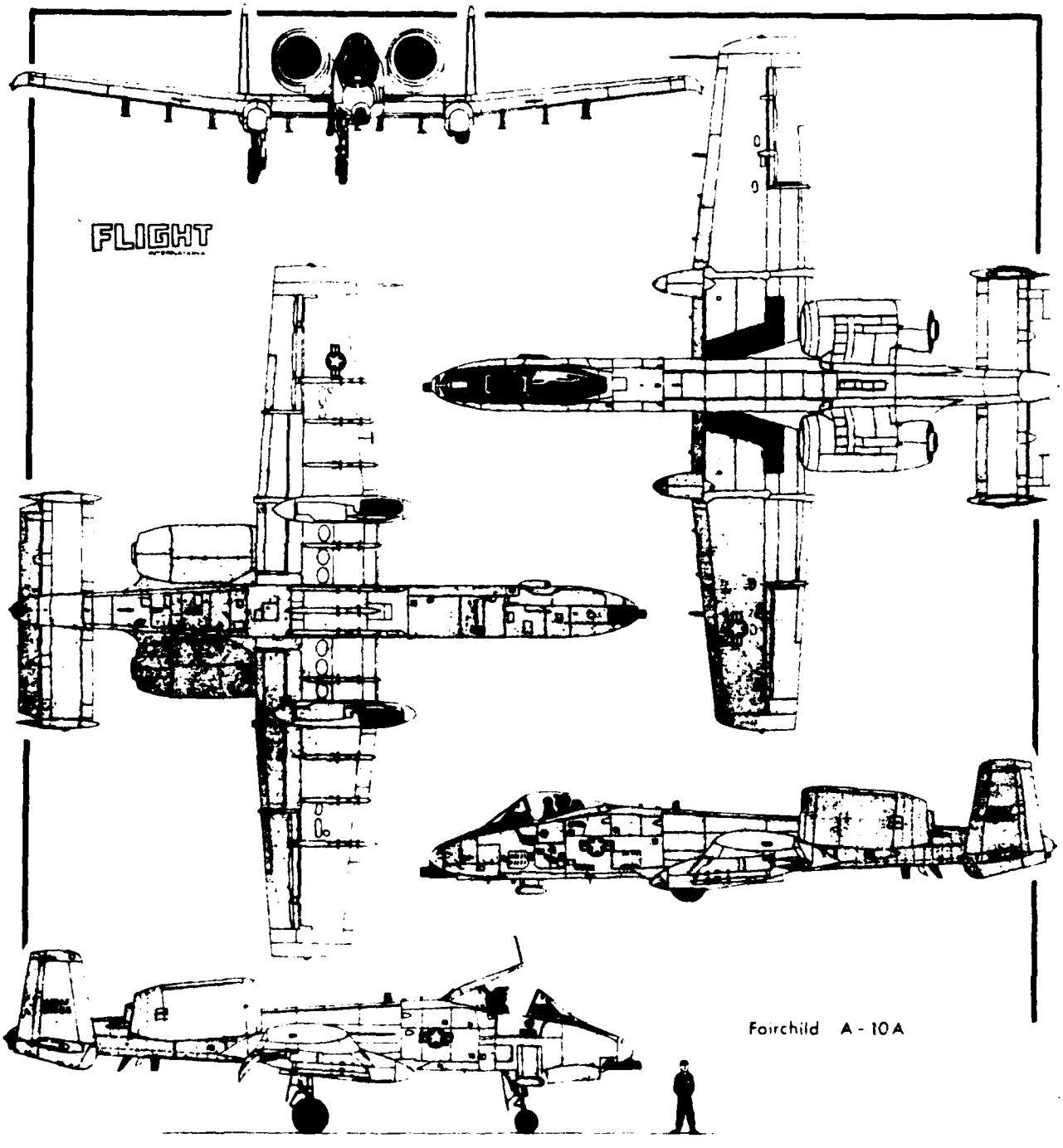


FIGURE 3. Fairchild A-10 Series Aircraft.

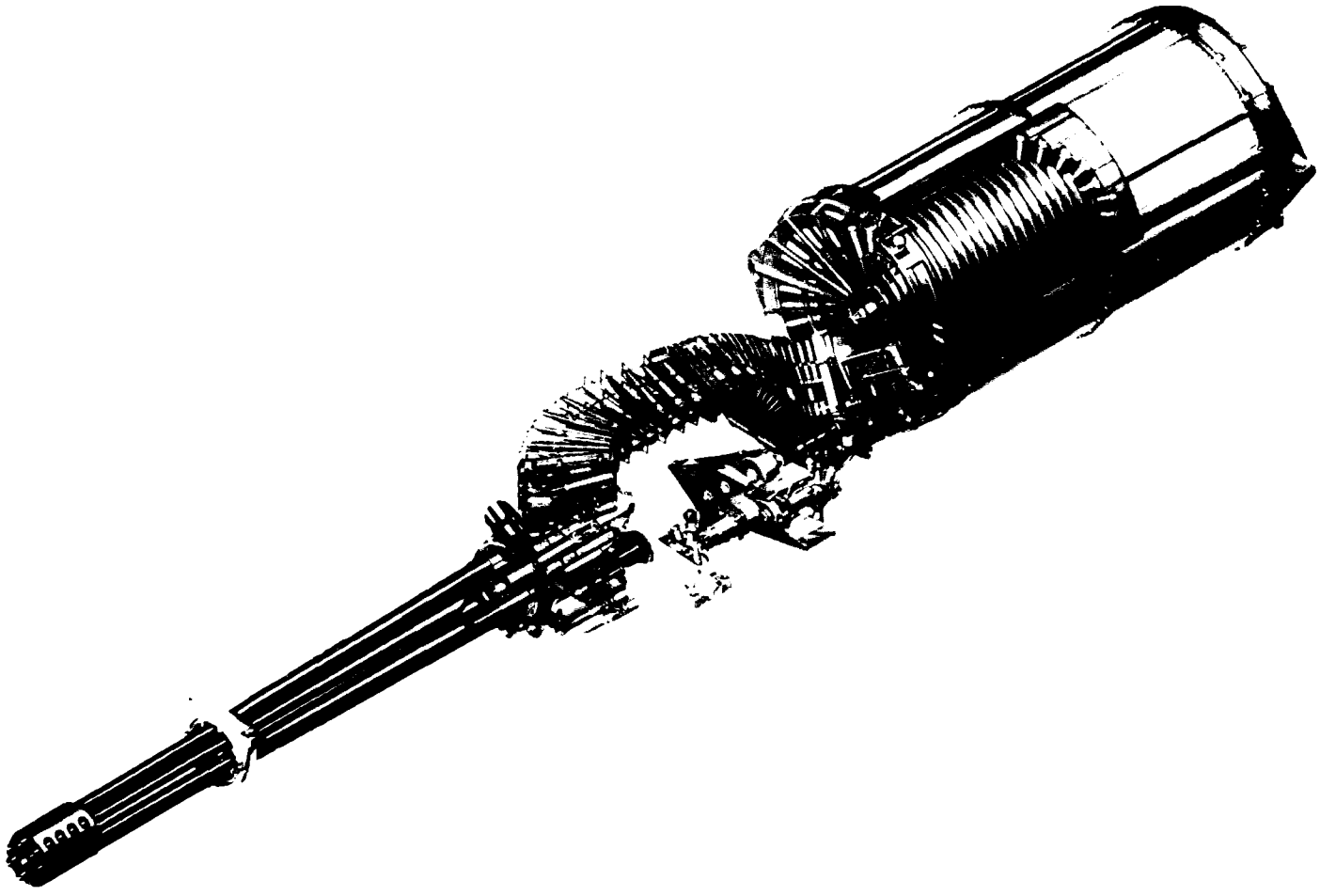


FIGURE 4. GAU-8/A 30mm Gun System

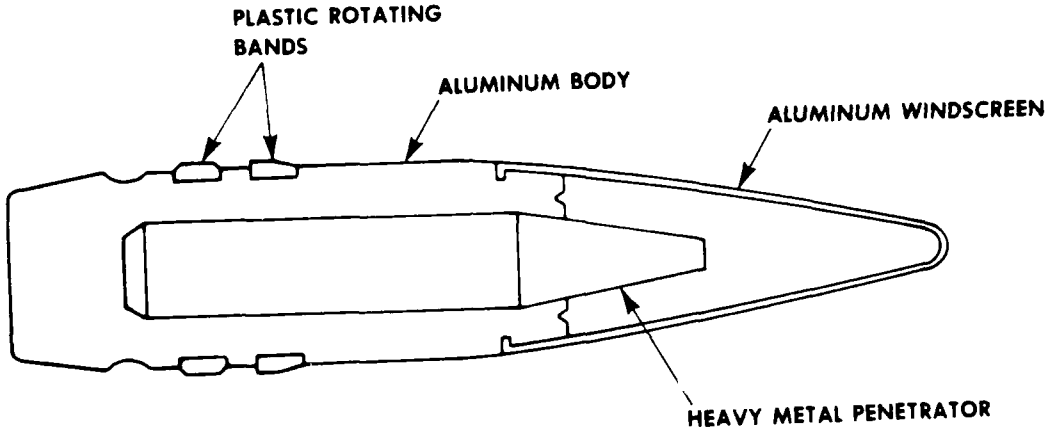


FIGURE 5. 30mm Armor Piercing Incendiary (API) Projectile.

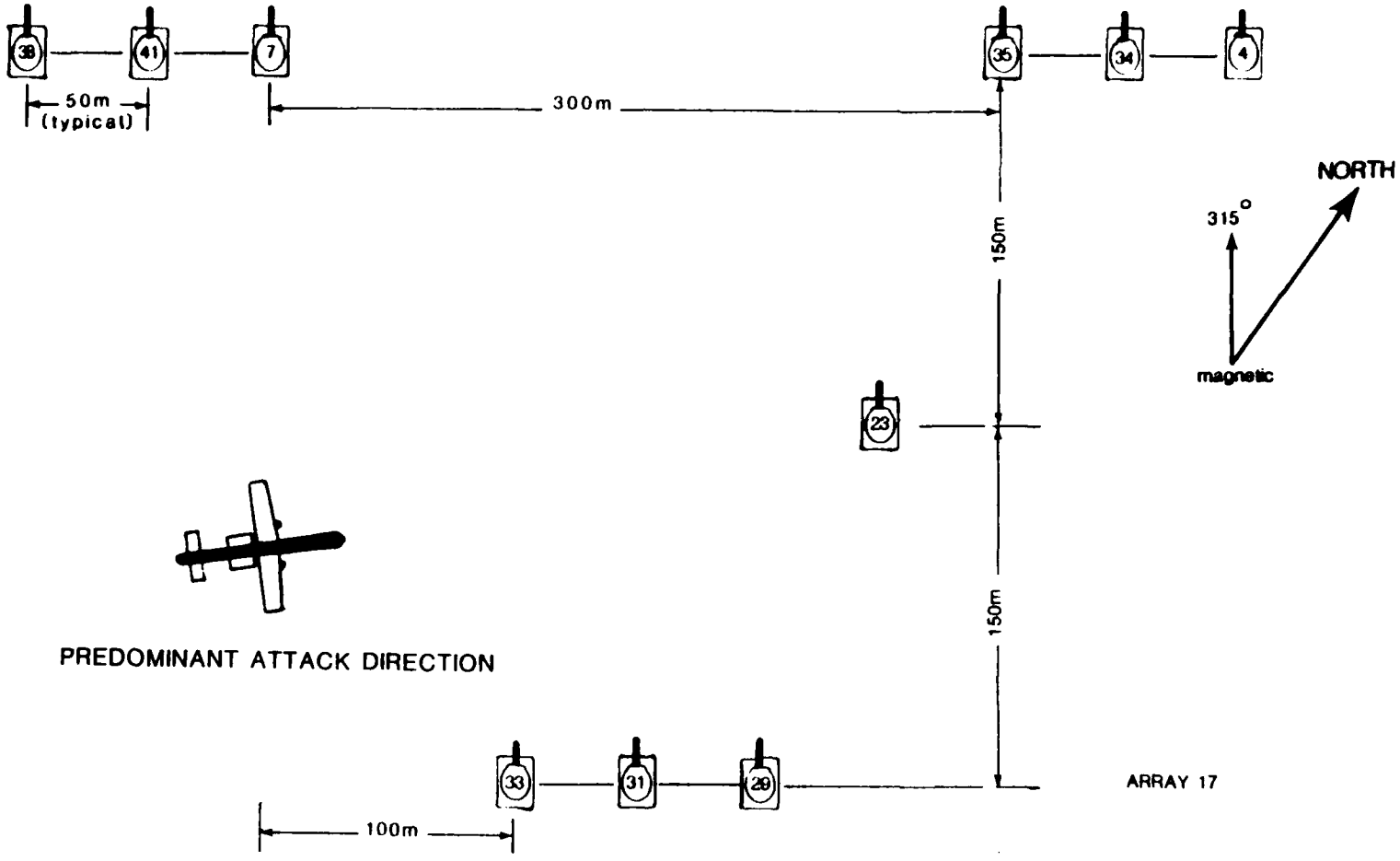


FIGURE 6. Approximate Tank Layout.

DAMAGE ASSESSMENT

Results of the damage assessment conducted by the CDAT are presented on the following pages together with photographs showing results of actual impacts. Tanks 35 and 7, which were not impacted during any firing pass are not included in the damage assessment. Appendix A following the damage assessment section contains graphical and tabular information relative to the mission in general and summaries of the damage assessments; for example, aircraft attack parameters, weapon effects, and summaries of damage.

Terms used in the damage assessment summaries are defined in Appendix B.

Impacts on tanks were arbitrarily numbered for identification purposes. The impacts were numbered sequentially, first at the turret level, then at the hull level. If additional impacts were discovered during the combat damage assessment (as was sometimes the case) they were given the next sequential number, i.e., no attempt was made to "correct" the sequence. THE READER IS CAUTIONED THAT THIS NUMBERING SYSTEM HAS NO RELATIONSHIP WHATSOEVER TO THE ARRIVAL SEQUENCE OF PROJECTILES ON THE TANK OR TO THE PORTION OF THE BURST IMPACTING THE TANK.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 38

1. Description:

The target tank was impacted at an attack aspect of 260 degrees (left side) during one pass in which the attacking aircraft expended 69 rounds.

2. Kill Assessment:

100% M-Kill and 95% F-Kill resulting from the following observed effects (Figure 7):

a.	Perforations :	4
b.	Significant Impacts:	0
c.	Insignificant Impacts:	2
	TOTAL IMPACTS :	6

3. Rationale for Kill Assessment:

a. M-Kill: The assessment of 100% M-Kill is based on perforation 3 (Figure 8) through the turret which caused 3 crew casualties, perforation 4 through the left fuel cell near the bottom, and perforation 6 (Figure 9) through the left side of the engine compartment with damage to major engine components, e.g., oil cooler and carburetor.

b. F-Kill: The assessment of 95% F-Kill is based on perforation 3 which caused fragment and spall impacts on crew manikins. Examination of manikin damage supports a view that the tank commander (Figure 10 and 11) and loader (Figure 12) were killed and the gunner (Figure 13) seriously wounded.

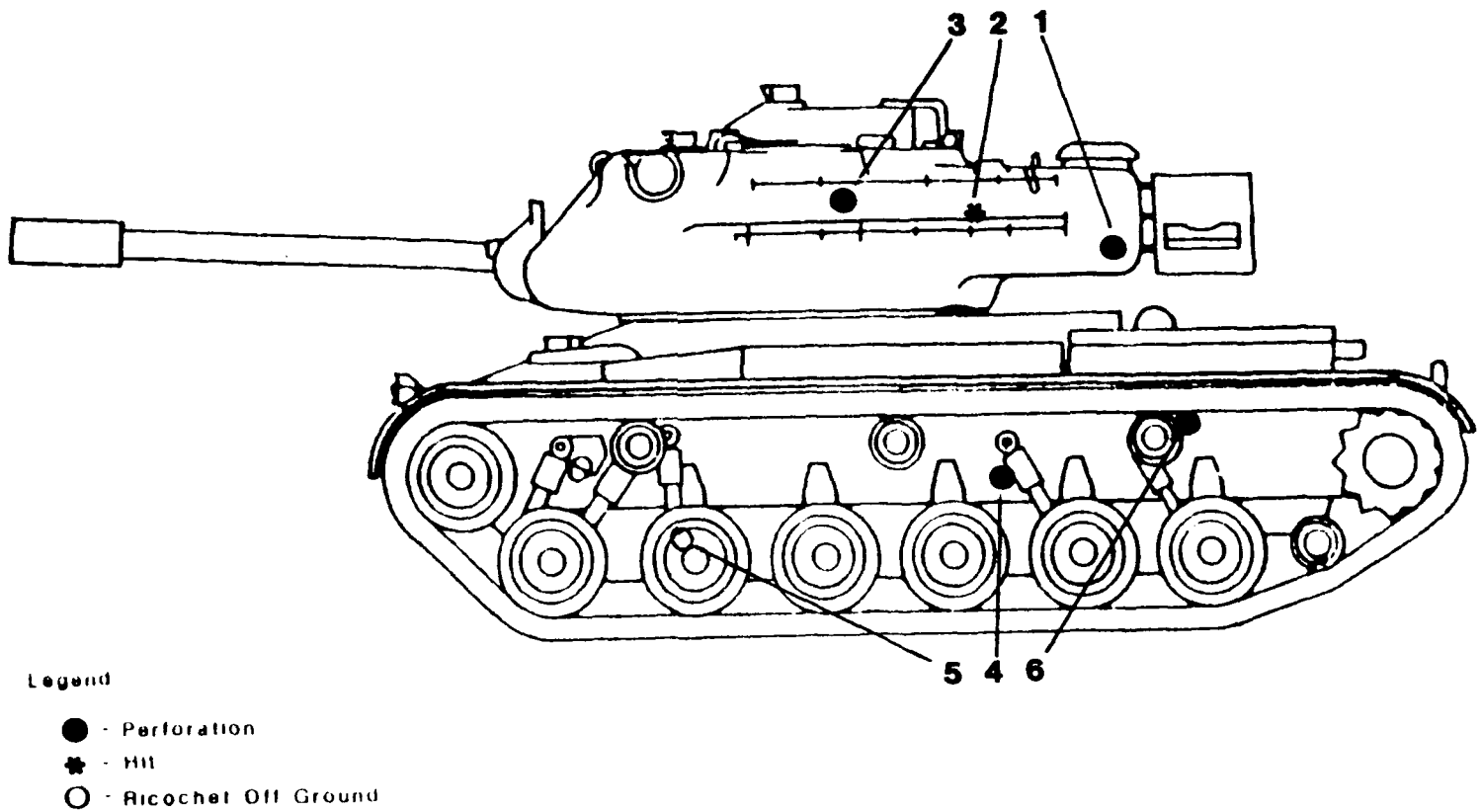


FIGURE 7. Impact Diagram, Tank 38.

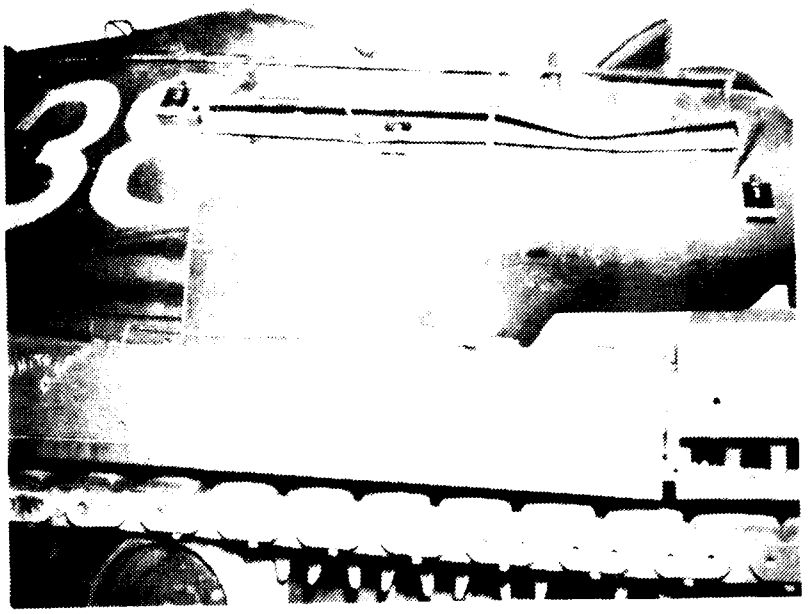


FIGURE 8. Perforation 3 into Fighting Compartment.

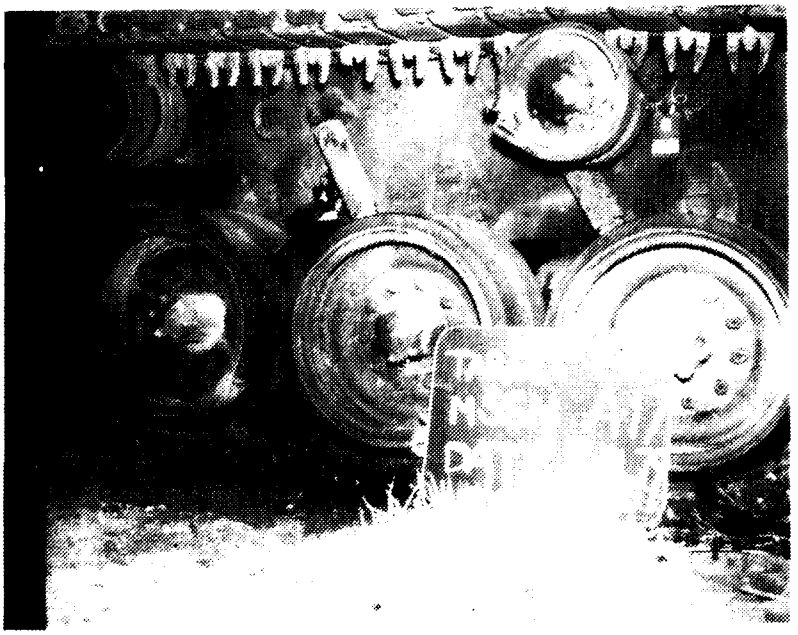


FIGURE 9. Perforation of Left Hull into Fuel Tank.

FIGURE 10. Tank 38 Commander - Front.

FIGURE 11. Tank 38 Commander - Back.

FIGURE 12. Tank 38 Loader.

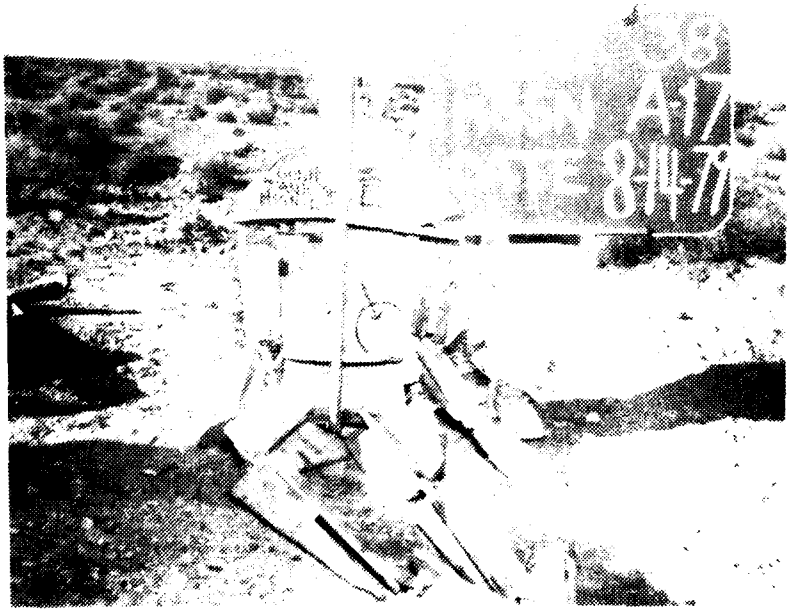


FIGURE 13. Tank 38 Gunner.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 41

1. Description:

The target tank was impacted at an attack aspect of 247 degrees (left side) during one firing pass in which the attacking aircraft expended 41 rounds.

2. Kill Assessment:

100% M-Kill and 40% F-Kill resulting from the following observed effects (Figure 14):

a.	Perforations	: 2
b.	Significant Impacts	: 2
c.	Insignificant Impacts	: 18
	TOTAL IMPACTS	: 22

3. Rationale for Kill Assessment:

a. M-Kill: The assessment of 100% M-Kill is based on impact 19, which perforated the left side of the hull (Figure 15) and penetrated into the left fuel cell, and impact 11, which perforated the driver's compartment wounding the driver and assistant driver.

b. F-Kill: The assessment of 40% F-Kill is based on impact 1 (Figure 16) which perforated one wall of the bore evacuator and gun tube, and impact 11, which degraded the firepower of the tank through crew casualties.

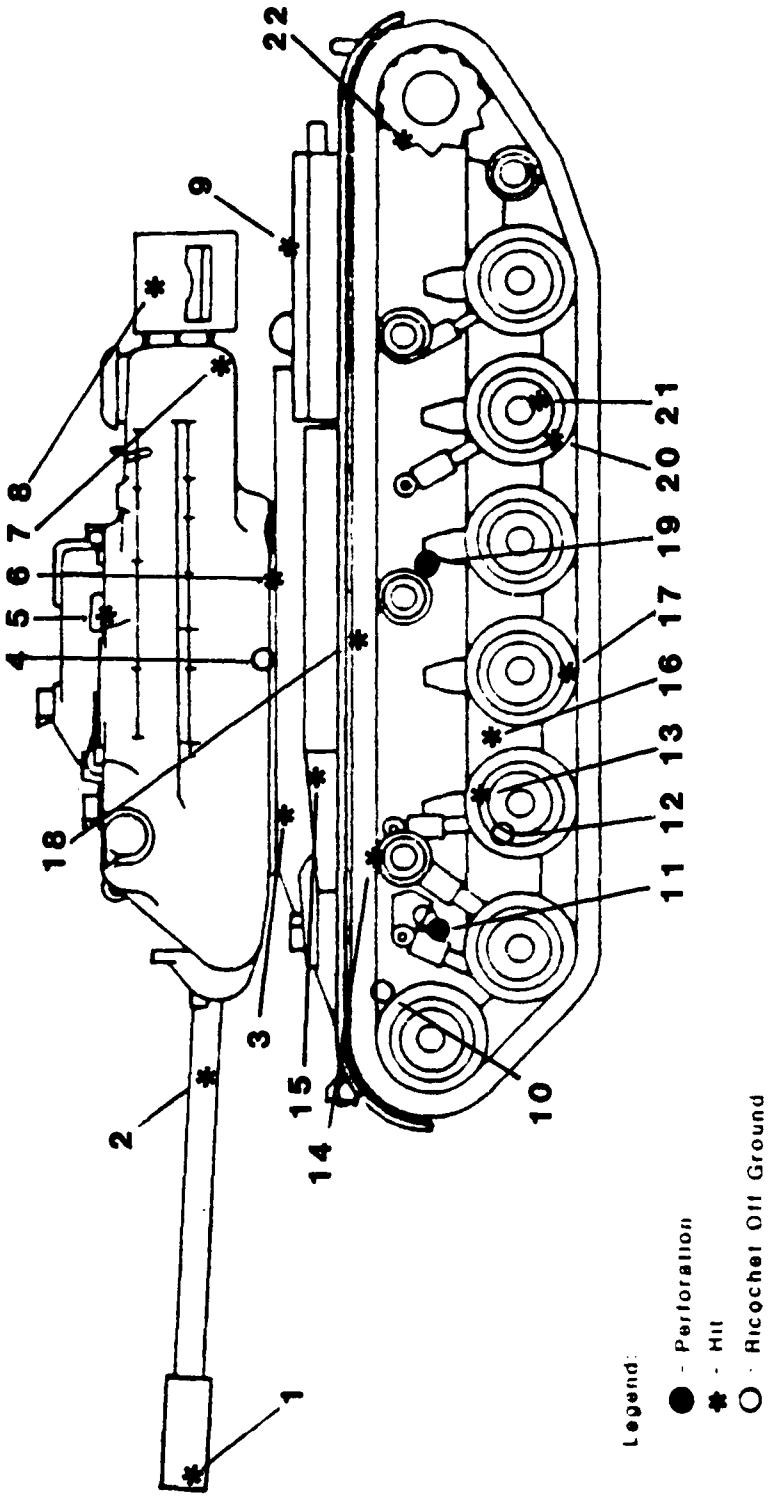


FIGURE 14. Impact Diagram, Tank 41.

FIGURE 15. Tank 41 Hull Perforation into Left Fuel Cell.

FIGURE 16. Tank 41, Casualties

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 34

1. Description:

The target tank was impacted at an attack aspect of 270 degrees (left side) during one firing pass in which the attacking aircraft expended 41 rounds.

2. Kill Assessment:

100% M-Kill resulting from the following observed effects (Figure 17):

a.	Perforations	: 1
b.	Significant Impacts	: 0
c.	Insignificant Impacts	: 1
	TOTAL IMPACTS	: 2

1. Rationale for Kill Assessment:

An assessment of 100% M-Kill is based on impact number 1, which perforated the left side of the hull and penetrated into the left fuel cell (Figure 18). The hazard represented by the fuel running into the floor of the engine and fighting compartments would have to be mastered by the crew immediately.

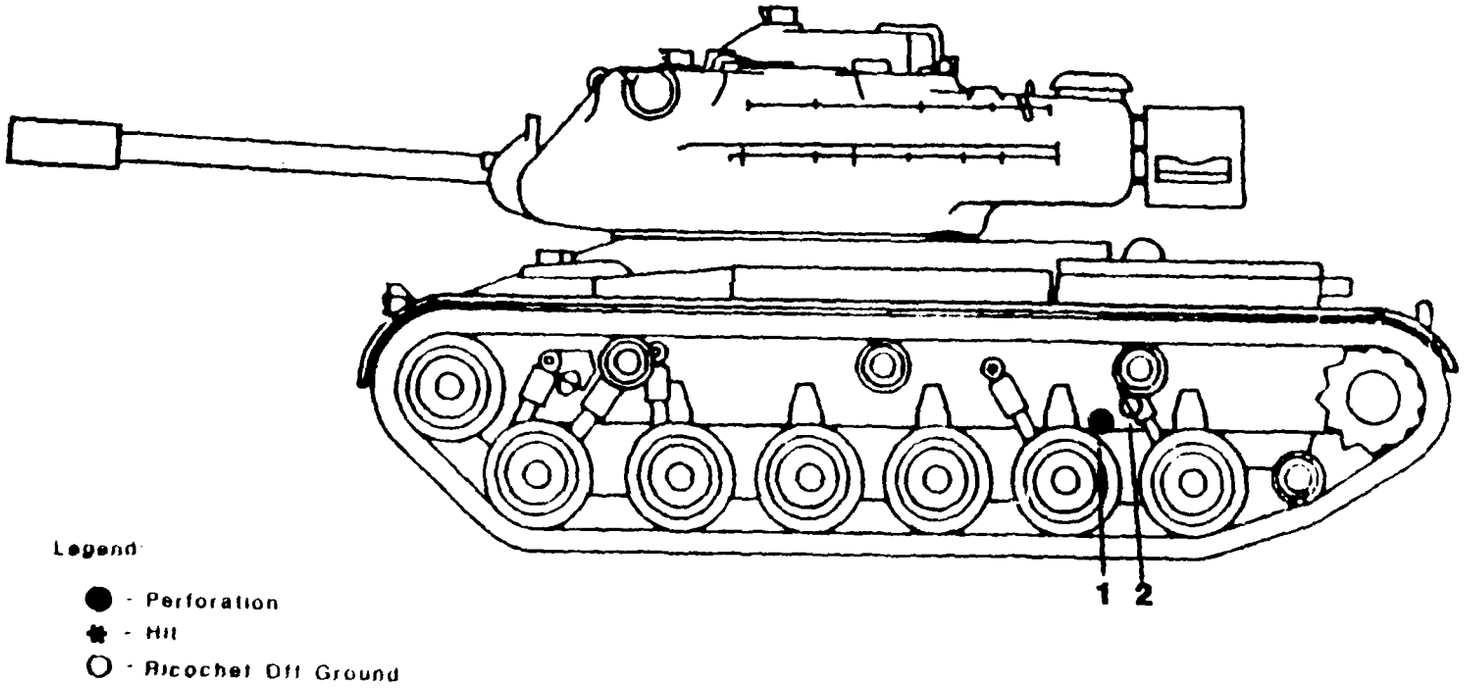


FIGURE 17. Impact Diagram, Tank 34.

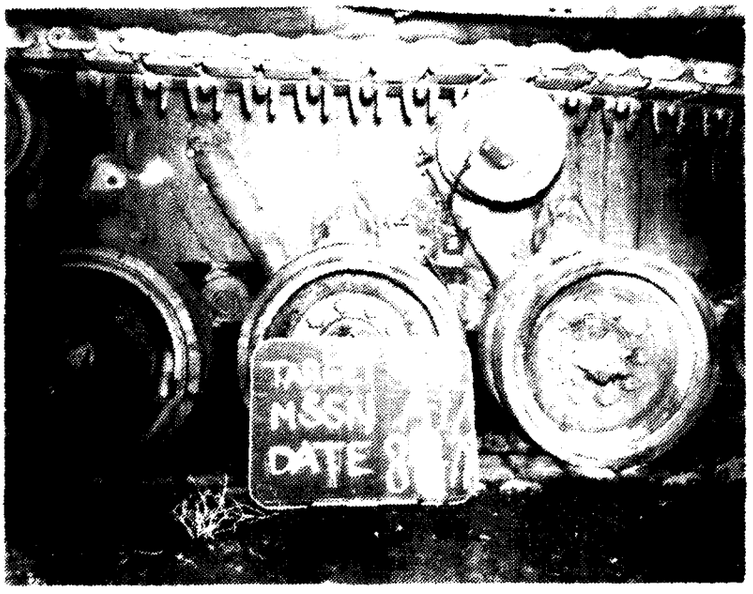


FIGURE 18. Impact 1, Tank 34 Hull Perforation.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 4

1. Description:

The target tank was impacted at an attack aspect of 235 degrees (left side toward rear) during one firing pass in which the attacking aircraft expended 69 rounds.

2. Kill Assessment:

90% M-Kill and 100% F-Kill resulting from the following observed effects (Figure 19):

a.	Perforations	: 2
b.	Significant Impacts	: 8
c.	Insignificant Impacts	: 28
	TOTAL IMPACTS	: 38

3. Rationale for Kill Assessment:

a. M-Kill: The assessment of 90% M-Kill is based on impacts 6 and 7, which incapacitated the tank commander, gunner, and loader, and impacts 13, 20, 22, 24, 25, 30, and 31, which caused significant cumulative damage to the track and suspension system (Figures 20 and 21).

b. F-Kill: The assessment of 100% F-Kill is based on impact 4, which jammed the turret and impacts 6 and 7, which perforated the left side of the turret killing the tank commander (Figure 22) and wounding the gunner and loader, as assessed from fragment damage to crew manikins.

NOTE: Hits 35, 36 and 37 are on the front of the tank. These hits are considered insignificant and are not shown.

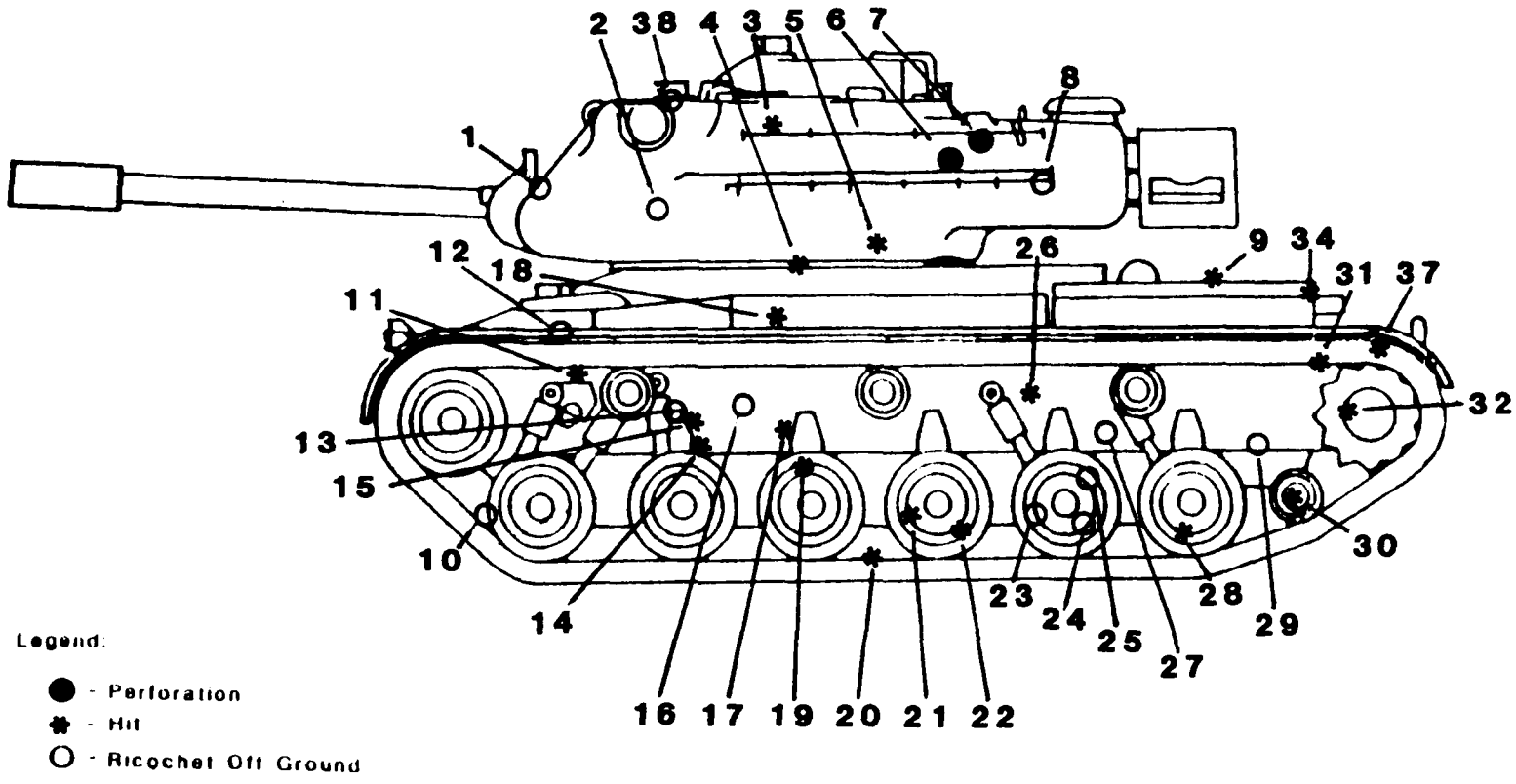


FIGURE 19. Impact Diagram, Tank 4.

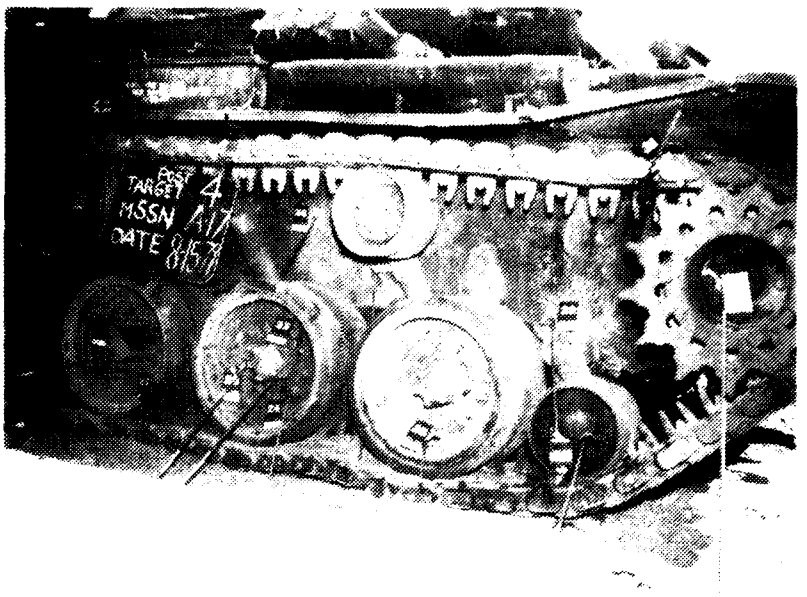


FIGURE 20. Tank 4 Rear/Side Damage.

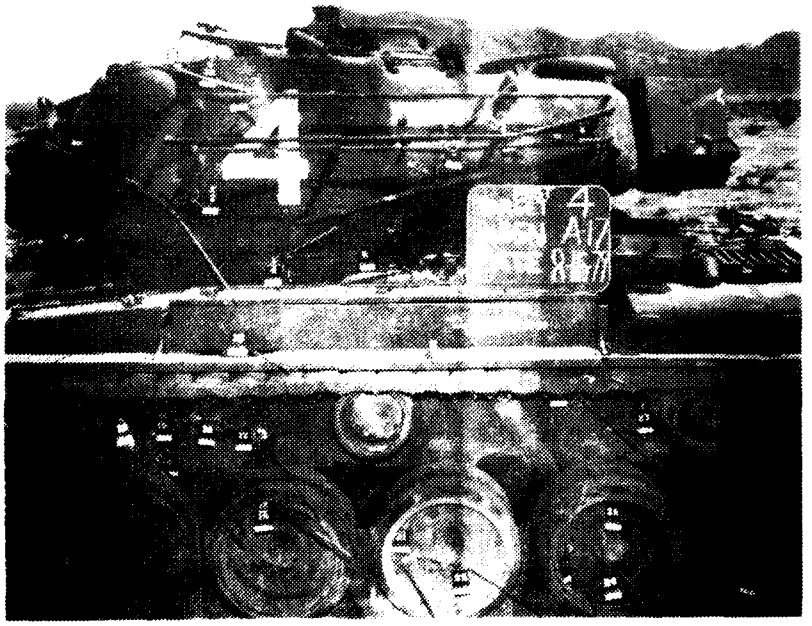


FIGURE 21. Tank 4 Left/Center Damage.

FIGURE 22. Impact 4, Tank 4 Tank Commander.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 33

1. Description:

The target tank was impacted at an attack aspect of 235 degrees (left side toward rear) during one firing pass in which the attacking aircraft expended 55 rounds.

2. Kill Assessment:

100% M-Kill and 100% F-Kill resulting from the following observed effects (Figures 23, 24, and 25):

a. Perforations	:	2
b. Significant Impacts	:	6
c. Insignificant Impacts	:	17
TOTAL IMPACTS	:	25

3. Rationale for Kill Assessment:

a. M-Kill: The assessment of a 100% M-Kill is based on impact 23 which perforated the left hull and penetrated 3 valve covers and the oil cooler and on minor damage to the track and suspension system caused by impacts 10, 13, and 15.

b. F-Kill: The assessment of a 100% F-Kill is attributed to impacts 1, 3, and 6 which jammed the turret and penetrated the gun tube, and to crew casualties (gunner & loader) caused by impact 4 which perforated the left turret into the fighting compartment (Figures 26 through 28):

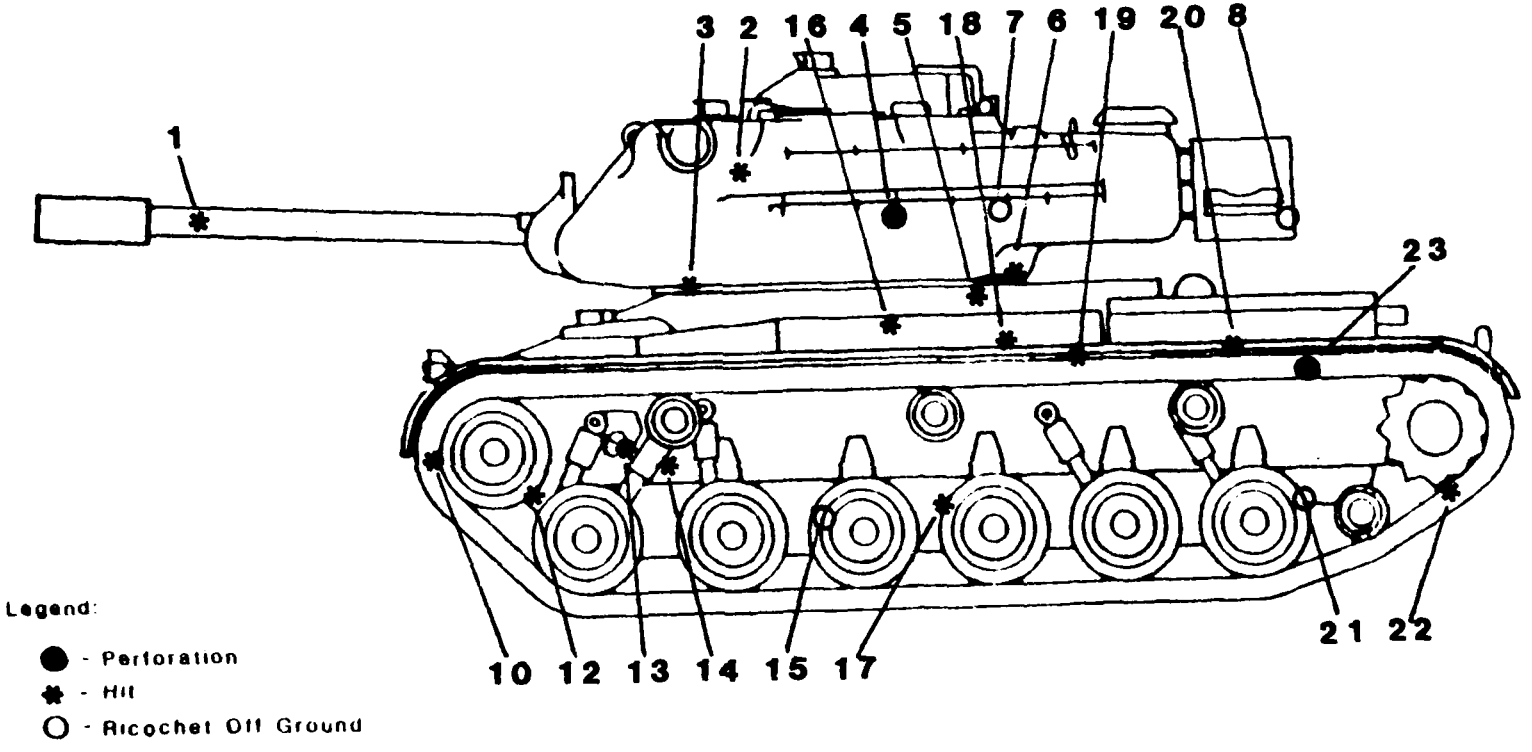
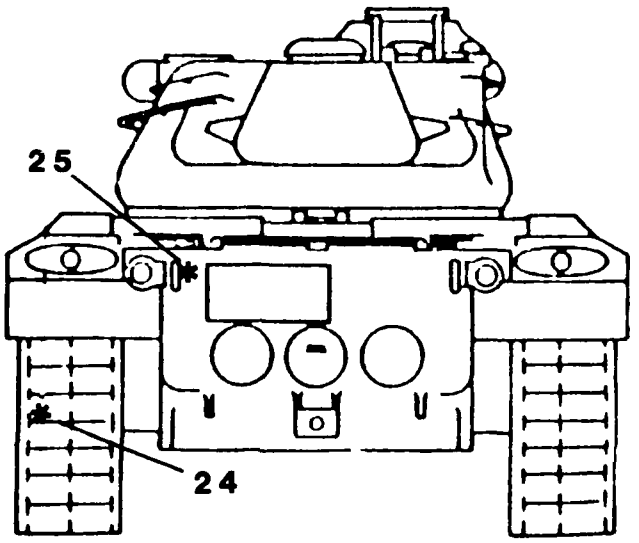


FIGURE 23. Impact Diagram, Tank 33.



Legend:

● - Perforation
✱ - Hit
○ - Ricochet Off Ground

FIGURE 24. Impact Diagram, Tank 33 Rear.

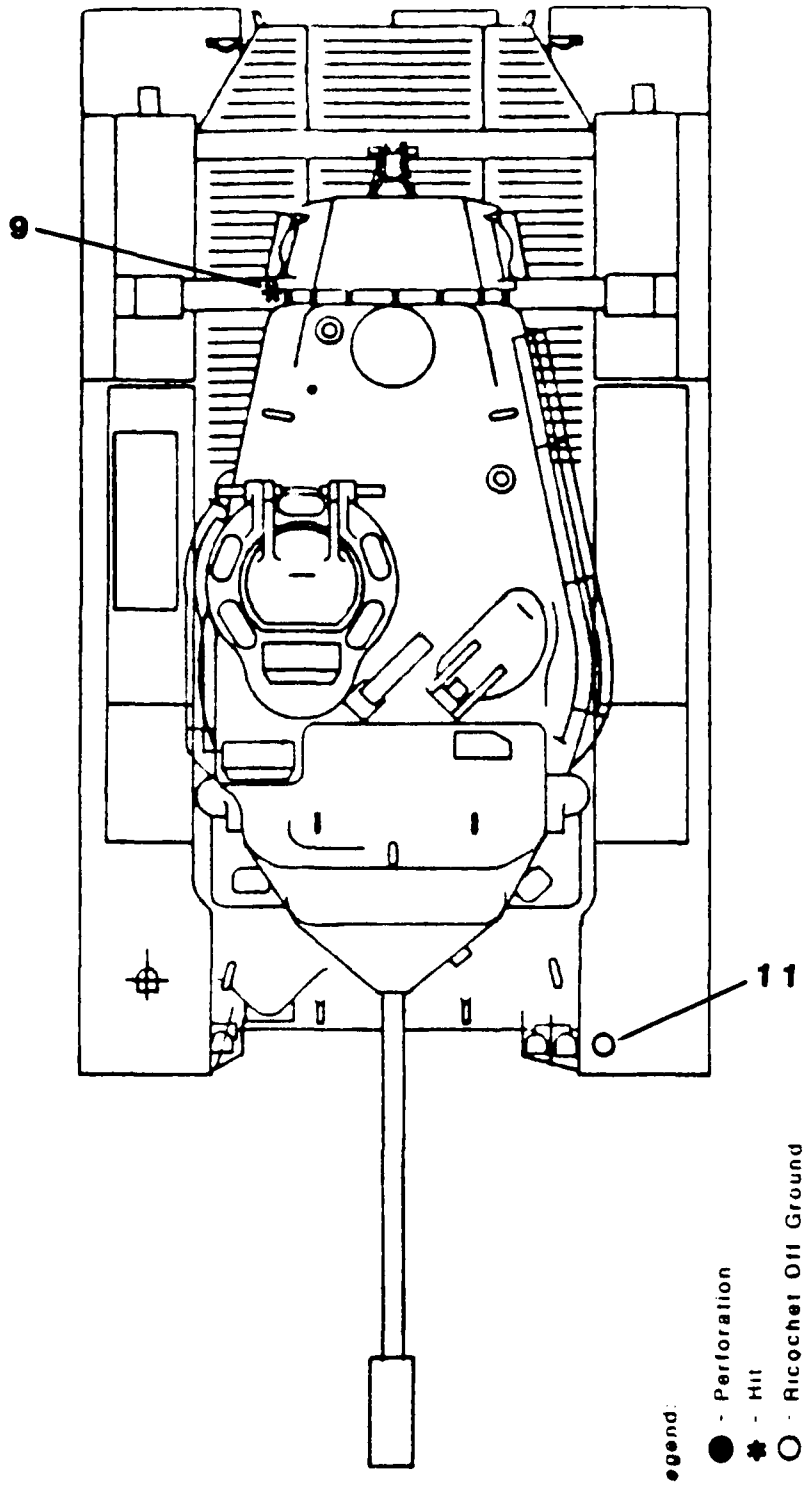


FIGURE 25. Impact Diagram, Tank 33 Top.

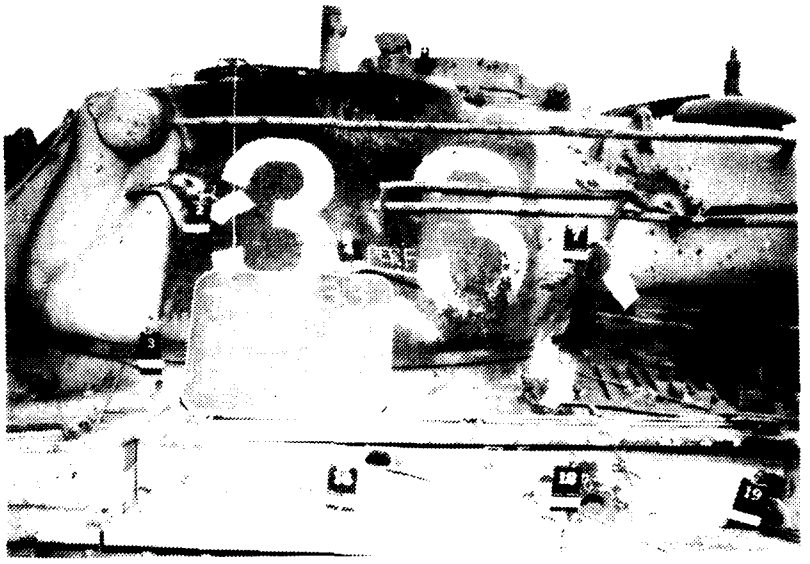


FIGURE 26. Tank 33 Turret.

FIGURE 27. Tank 33 Loader.

FIGURE 28. Tank 33 Gunner.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 31

1. Description:

The target tank was impacted at an attack aspect of 285 degrees (left side) in one firing pass in which the attacking aircraft expended 97 rounds.

2. Kill Assessment:

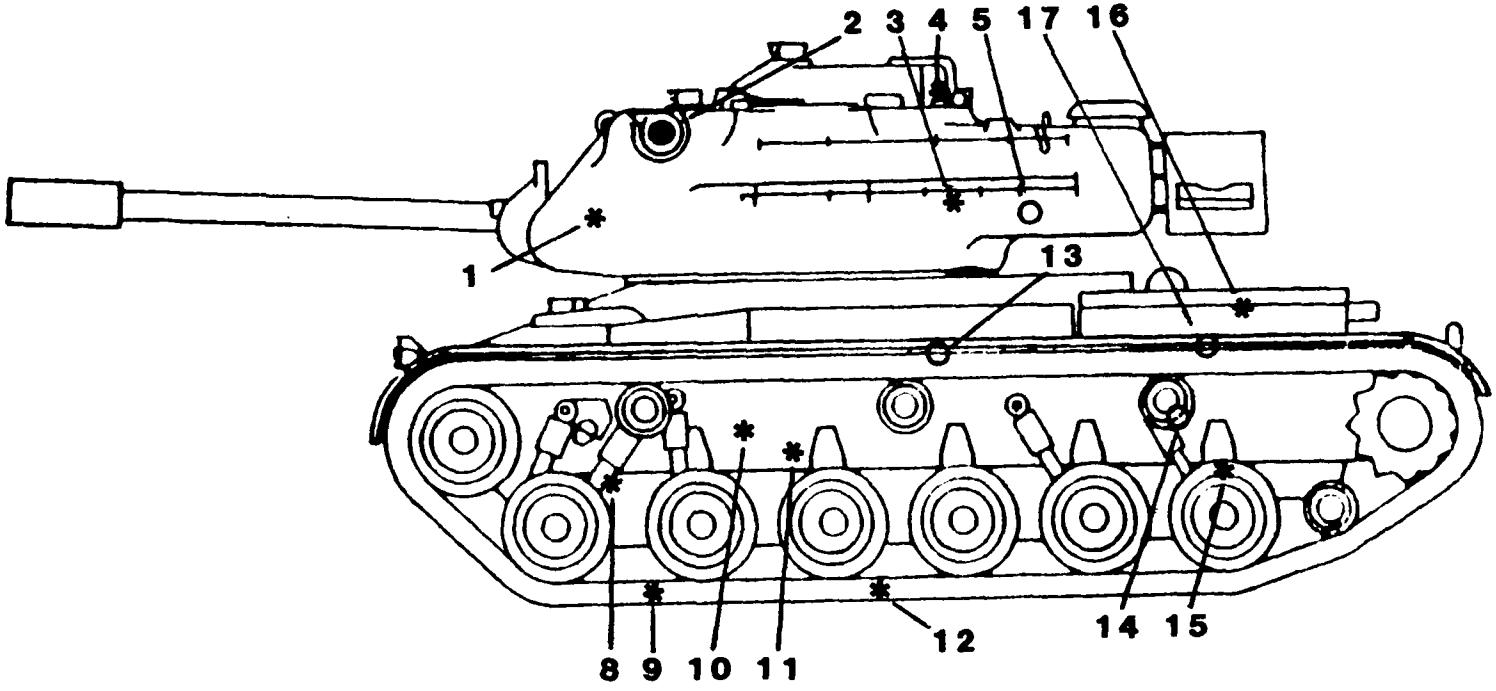
20% F-Kill resulting from the following impacts (Figure 29):

a. Perforations : 1
b. Significant Impacts : Ø
c. Insignificant Impacts: 16

TOTAL IMPACTS : 17

3. Rationale for Kill Assessment:

An assessment of a 20% F-Kill is based on impact 2 which perforated the left range finder blister and damaged the end housing assembly denying use of the range finder in determination of range to target (Figure 3Ø).



Legend:

- ● - Perforation
- ✱ - Hit
- O - Ricochet Off Ground

NOTE: Hits 6 and 7 are on the front of the tank. These hits are considered insignificant and are not shown. Impact two was a richochet off the ground.

FIGURE 29. Impact Diagram, Tank 31.

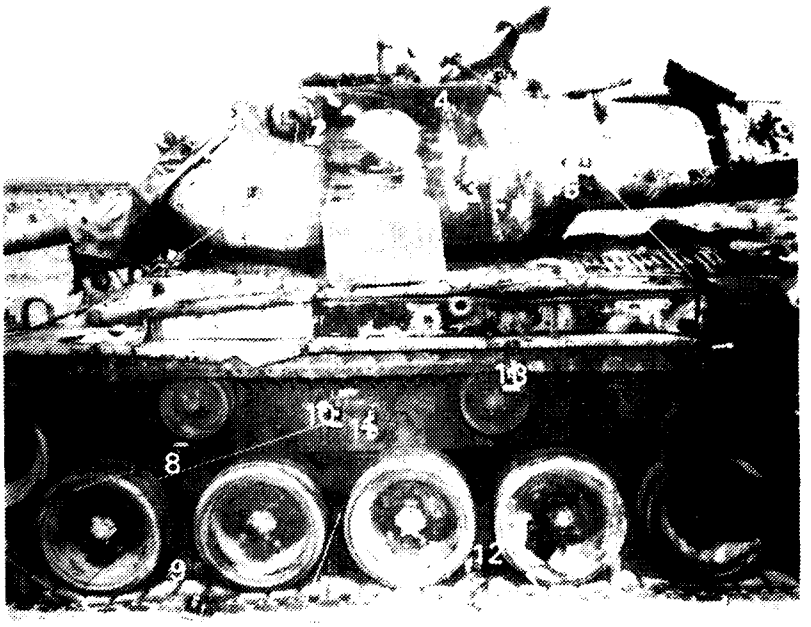


FIGURE 30. Tank 31 Perforation of Range Finder Blister.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 29

1. Description:

The target tank was impacted at an attack aspect of 230 degrees (left rear) during one firing pass in which the attacking aircraft expended 83 rounds.

2. Kill Assessment:

100% M-Kill resulting from the following observed effects (Figures 31 and 32):

a.	Perforations	: 4
b.	Significant Impacts	: 0
c.	Insignificant Impacts	: 17
	TOTAL IMPACTS	: 21

3. Rationale for Kill Assessment:

The assessment of 100% M-Kill is based on impacts 13 and 19 (Figures 33 and 34) which perforated the rear of the hull and penetrated into the transmission case. The resulting effects on the transmission, i.e., loss of transmission oil and fragment and spall damage to gears, would result in complete loss of function of the transmission and immobilization of the tank.

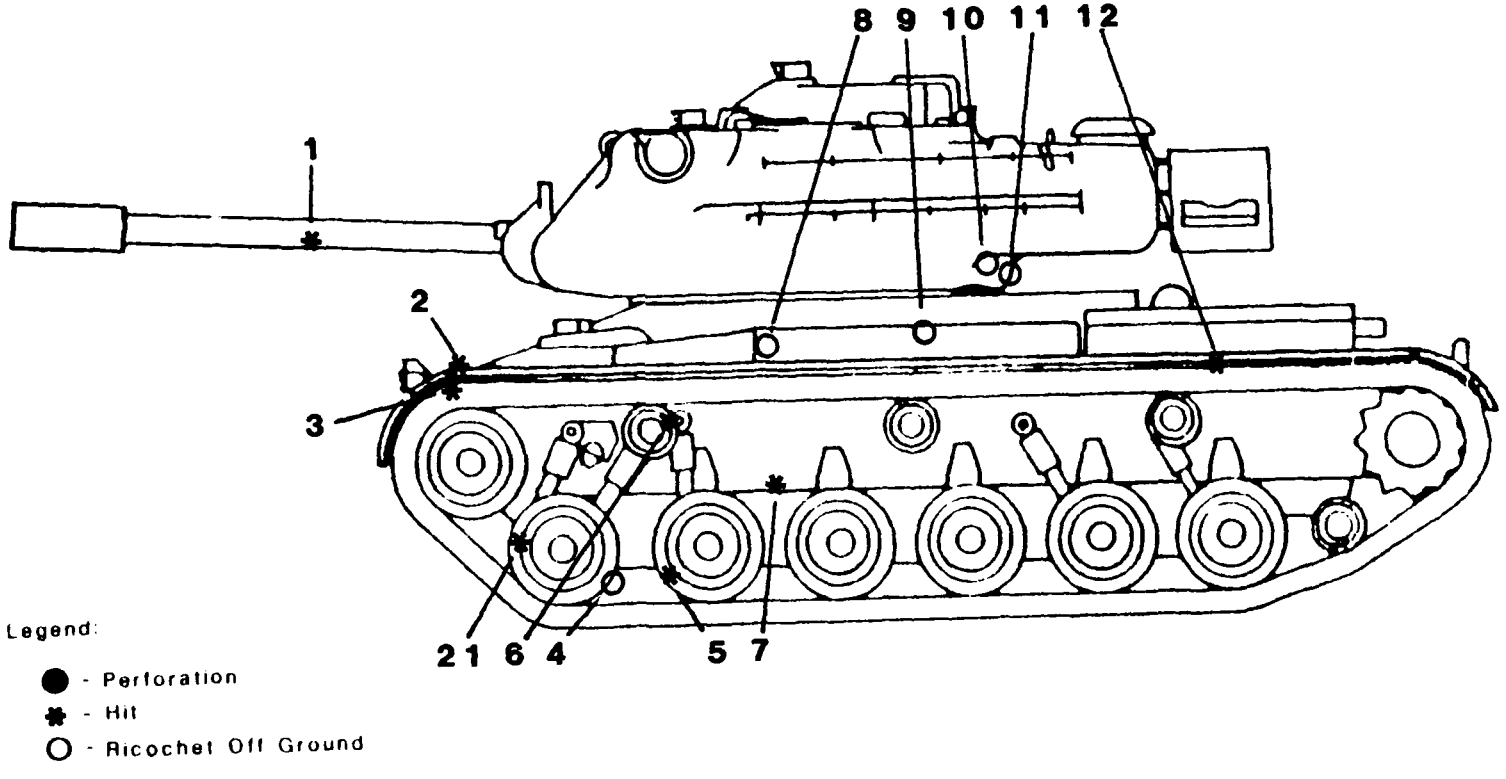


FIGURE 31. Impact Diagram, Tank 29 Left Side.

Legend:

- ● - Perforation
- ✱ - Hit
- O - Ricochet Off Ground

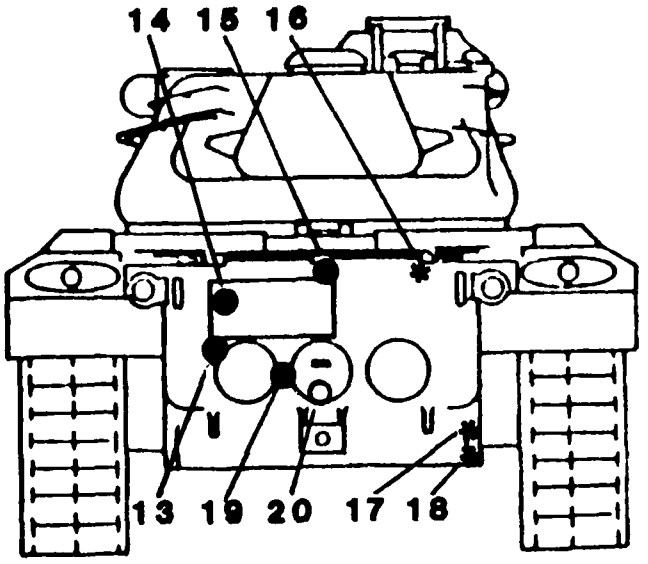


FIGURE 32. Impact Diagram, Tank 29 Rear.

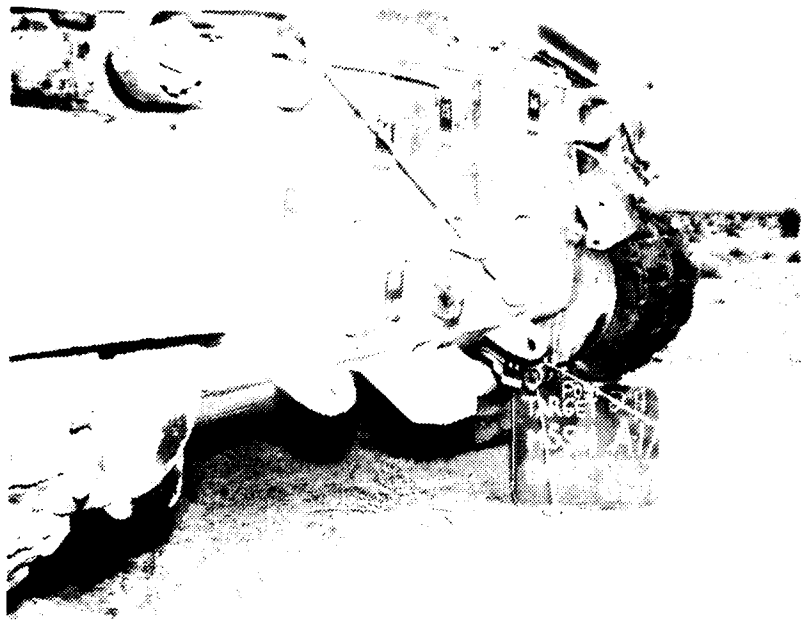


FIGURE 33. Close-in View of Impacts 13 and 19, Tank 29.

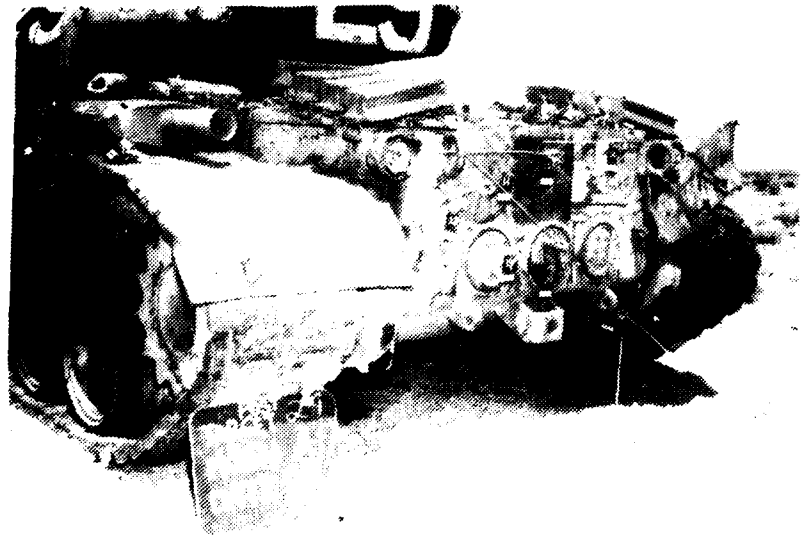


FIGURE 34. Reference View of Impacts 13 and 19, Tank 29.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 23

1. Description:

The target tank was impacted at an attack aspect angle of 265 degrees (left side) during one firing pass in which the attacking aircraft expended 55 rounds.

2. Kill Assessment:

100% M-Kill resulting from the following observed effects (Figures 35 and 36):

a.	Perforations	: 1
b.	Significant Impacts	: 0
c.	Insignificant Impacts	: 8
	TOTAL IMPACTS	: 9

3. Rationale for Kill Assessment:

This tank was observed to be a delayed burn, probably caused by impact 4 which perforated the left hull into the engine compartment penetrating an oil cooler line and a valve cover, apparently igniting a small fire which spread into a killing fire.

Since there were no crew casualties the CDAT assumed that the crew could have controlled a small grease or oil fire thereby limiting damage to a mobility kill.

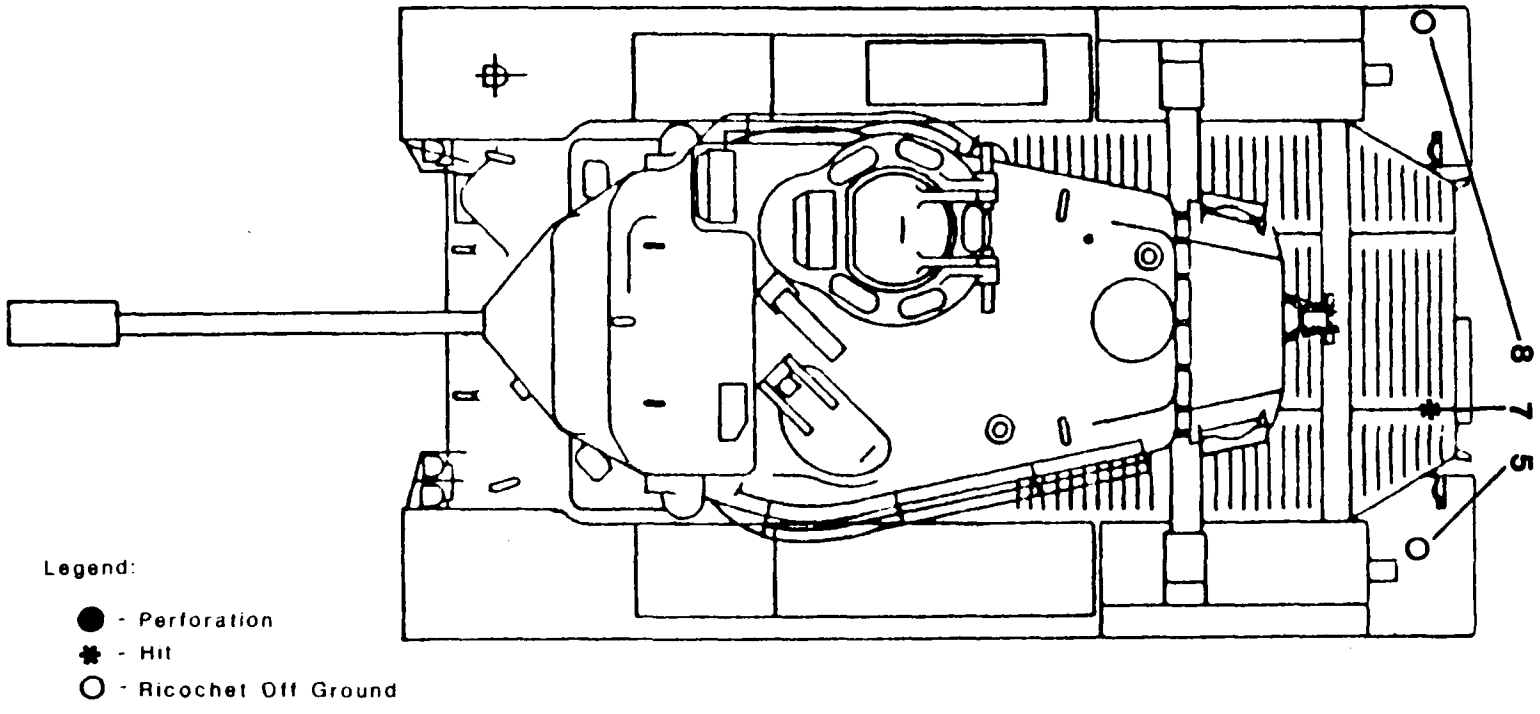


FIGURE 35. Impact Diagram, Tank 23 Top.

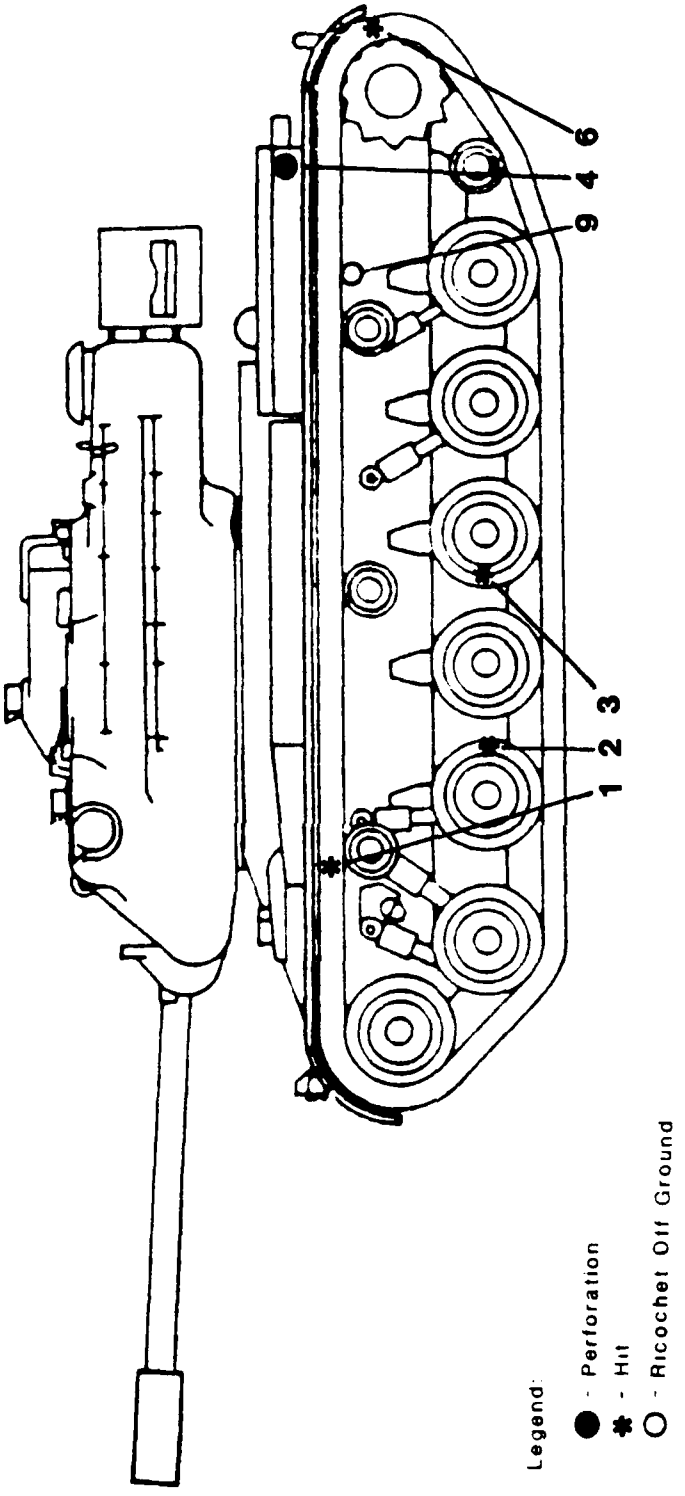


FIGURE 36. Impact Diagram, Tank 23 Left Side.

SUMMARY AND CONCLUSIONS

On 14 August, 1979 at Nellis AFB, Nevada, the Combat Damage Assessment Team (CDAT) conducted firings of the A-10/GAU-8 weapon system against an array of 10 tanks simulating a Soviet tank company deployed for an attack. The purpose of the firing test was to evaluate the effects of Aerojet lot number AJD 79A181-001 30mm API anti-tank ammunition of the GAU-8 gun under challenging conditions of engagement for the A-10/GAU-8 system against realistically simulated Soviet tank formations. The CDAT used M-47 tanks stowed with main gun ammunition, diesel fuel, lubricating oil, and crew manikins to simulate the Soviet tanks. The pilot of the A-10 aircraft used in the firings conducted his attacks at low altitudes and low dive angles which simulated attack below the altitude of the effective engagement for opposing air defense systems using acquisition and fire control radar.

The firing test can be summarized in terms of the following data which were collected and/or extracted from the firings:

Aircraft Parameters

1. Open-fire Speed (average)----------523 ft/sec
2. Altitude (average)----------207 ft
3. Dive Angle (average)----------4.5 degrees
4. Open-fire Slant Range (average)-----2939 ft
5. Burst Length/Rounds (averages)------0.96 sec/63
6. Number Passes (primary)----------9
7. Target Aspects (predominantly)------left rear

Weapon Effects		Target Damage	
1. Rounds Fired	565	1. K-Kills	0
2. Impacts	140	2. M+F-Kills	1
3. Ricochets (off ground)	37	3. M-Kills	5
4. Direct Impacts	103	4. F-Kills	1
5. Perforations	17	5. Light or no damage	2

These data and the more detailed base from which they were extracted can be arranged into measures of effectiveness for the A-10/GAU-8 system under conditions similar to those in the firing test, i.e., empirical combat simulation. The following values of effectiveness are based on the firing test of 14 August 1979.

Measures of Effectiveness

Accuracy Related Ratio:		Lethality Related Ratio:	
$\frac{\text{Total Impacts}}{\text{Rounds Fired}}$	= Ø.25	$\frac{\text{Perforations}}{\text{Total Impacts}}$	= Ø.12
$\frac{\text{Direct Impacts}}{\text{Rounds Fired}}$	= Ø.18	$\frac{\text{Perforations}}{\text{Direct Impacts}}$	= Ø.17

Weapon System Effectiveness Ratio

$\frac{\text{Tanks Immobilized}}{\text{Passes}}$ =Ø.67 $\frac{\text{Tanks K-Killed}}{\text{Passes}}$ =Ø.Ø

The nine target tanks were attacked predominately from the left rear and suffered the damage shown in Table I and Table A-I.

The measures of effectiveness summarized above, and other data contained in this report, support several inferences or conclusions:

1. The A-1Ø/GAU-8 weapon system in realistic simulation of combat may be capable of inflicting catastrophic and F-Kills on M-47 and similarly protected main battle tanks, e.g. Soviet T-55 and T-62 tanks.

2. The weapon system, in low level attacks, can perforate the side and rear surfaces of the hulls and turrets of M-47 and similarly protected main battle tanks.

3. The weapon system is an effective killing agent against the side and rear surfaces of M-47 and similar tanks when firing moderate length bursts of Ø.65 to 1.45 seconds containing 41 to 97 rounds.

4. From the viewpoint of GAU-8 3Ømm API ammunition effects and resulting damage to combat stowed main battle tanks, the tactic of low level attack in this firing test was shown to be a successful one.

APPENDIX A

Graphical and Summary Information

Table A-I contains a summary of the results of Mission 17 of 14 August, 1979. Table A-II contains a summary of damage assessment based on perforation locations. Table A-III contains a summary of aircraft attack parameters. Figure A-1 depicts aircraft attack aspect by tank number as a function of open-fire range.

TABLE A-I. Array 17 Results Summary
(14 August 1979)

Target Tank No.	Damage Assessment* (M%)	(F%)	(K%)	All Target Impacts	Direct Impacts	Rounds Fired	Total Perforations
38	100	95	-	6	5	69	4
41	100	40	-	22	19	41	2
7**	-	-	-	0	0	55	0
35***	-	-	-	-	-	-	-
34	100	-	-	2	2	41	1
4	90	100	-	38	22	69	2
33	100	100	-	25	20	55	2
31	-	20	-	17	12	97	1
29	100	-	-	21	17	83	4
23	100	-	-	9	6	55	1
	TOTALS:			140	103	565	17

*K = Catastrophic Kill; M = Mobility Kill; F = Firepower Kill
**Pilot missed target
***Target not fired on

TABLE A-II. Array 17 Perforation Location Summary
(14 August 1979)

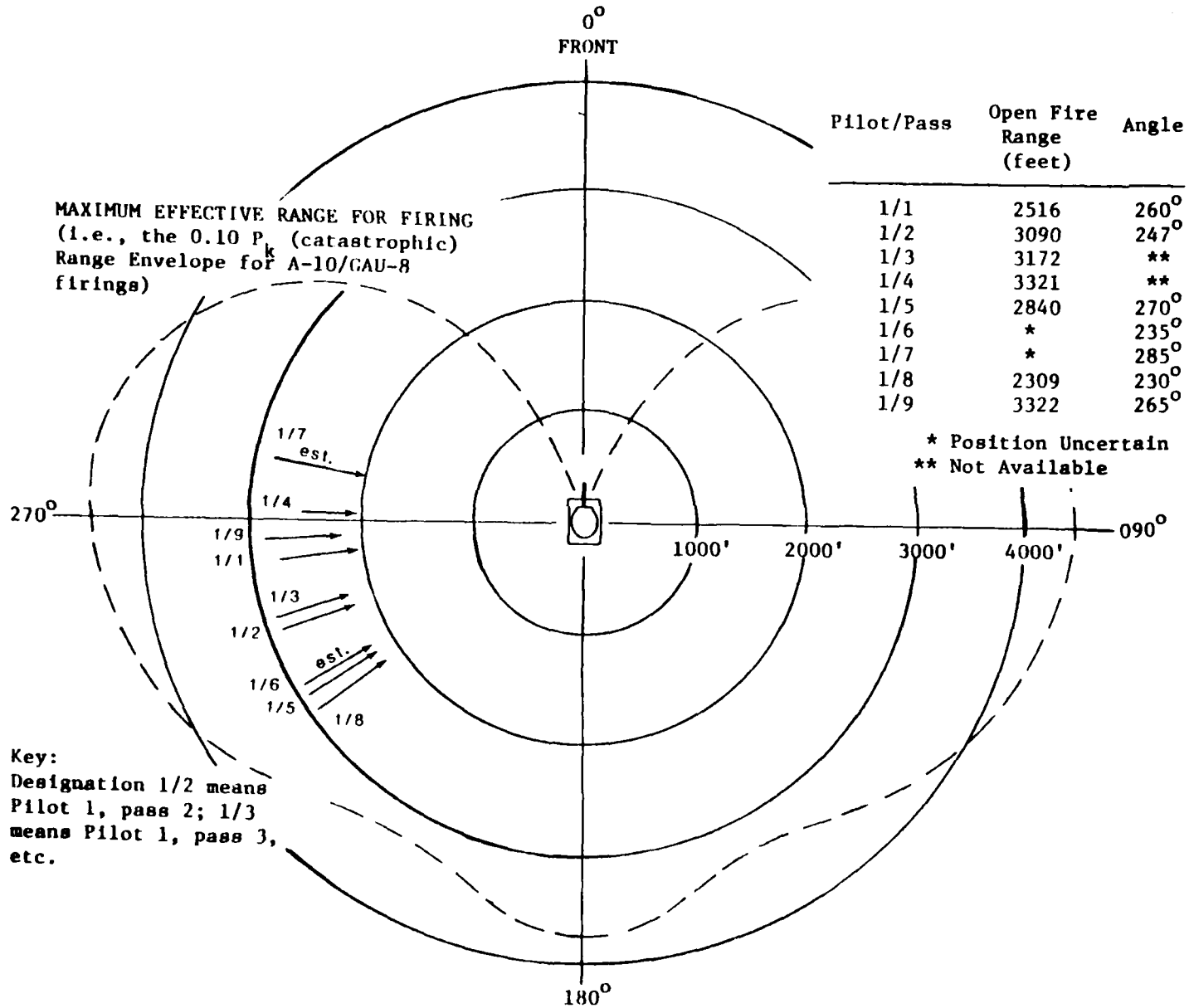
Target Tank	Damage Assessment* (M%)	(F%)	(K%)	Turret Perforations (Fighting Compt)	Hull Perforations: Fighting Compt	Drivers Compt	Engine Compt	Total Perforations
38	100	95	-	2	-	-	2	4
41	100	40	-	-	-	1	1	2
7	-	-		PILOT MISSED TARGET		-	-	-
35	-	-		TARGET NOT FIRED ON		-	-	-
34	100	-	-	-	-	-	1	1
4	90	100	-	2	-	-	-	2
33	100	100	-	1	-	-	1	2
31	-	20	-	1	-	-	-	1
29	100	-	-	-	-	-	4	4
23	100	-	-	-	-	-	1	1
	TOTALS:			6		1	10	17

*K = Catastrophic Kill; M = Mobility Kill; F = Firepower Kill

TABLE A-III. Array 17 Aircraft Attack Parameters
(14 August 1979)

Acft Pass *	Tank No.	Open Fire Slant Rng (feet)	Dive Angle Open/Cease (degrees)	Altitude (feet)	Velocity Open/Cease (ft/sec)	Burst Length (seconds)	Source
1/1	38	2516	5.4/3.7	218	572/568	1.05	TSPI
1/2	41	3090	5.3/4.8	284	564/564	.65	TSPI
1/3	7	3172	4.2/3.1	197	554/551	.85	TSPI
1/4	34	3321	2.5/2.0	73	430/431	.65	TSPI
1/5	4	2840	5.0/4.1	226	538/472	1.05	TSPI
1/6	33	**	5.0/3.8	220	539/547	.85	TSPI
1/7	31	**	5.4/3.0	165	441/452	1.45	TSPI
1/8	29	2309	8.8/3.7	201	494/495	1.25	TSPI
1/9	23	3322	5.4/5.2	278	573/570	.85	TSPI
Averages:		2939	4.5	207	523/517	.96	

*1/1 means pilot 1, pass 1, etc.
**Slant ranges uncertain



Pilot/Pass	Open Fire Range (feet)	Angle
1/1	2516	260°
1/2	3090	247°
1/3	3172	**
1/4	3321	**
1/5	2840	270°
1/6	*	235°
1/7	*	285°
1/8	2309	230°
1/9	3322	265°

* Position Uncertain
** Not Available

FIGURE A-1. Array 17 Attack Aspect Summary.

APPENDIX B

DEFINITIONS

The terms used in this report are defined below:

IMPACT -- Any evidence of a projectile strike against any portion of the target. Ground ricochets striking the target were classified as "impacts".

PERFORATION -- Any rupture of the armored envelope caused by an impacting projectile which results in a complete rupture of an armored surface by the projectile or spall fragments. A perforation can occur only when the armor is impacted. The word "Perforation" was deliberately selected to avoid the ambiquities which may occur through use of the word "penetration". Behind-the-plate effects may or may not result from a perforation.

HIT -- Any impact not classified as a perforation.

MOBILITY KILL (M-KILL) -- Loss of tactical mobility resulting from damage which cannot be repaired by the crew on the battlefield. A tank is considered to have sustained a 100% M-Kill when it is no longer capable of executing controlled movement on the battlefield. Mobility is DEGRADED when a tank can no longer maintain position in its formation.

FIREPOWER KILL (F-KILL) -- Loss of tactical firepower resulting from damage which cannot be repaired by the crew on the battlefield. A tank is considered to have sustained a 100% F-Kill when it is incapable of delivering controlled fire from its main armament. Firepower is DEGRADED when a tank can no longer maintain its "normal" rate-of-fire, velocity, accuracy, time to shift targets, etc.

CATASTROPHIC KILL (K-KILL) -- A tank is considered to have sustained a K-Kill when both an M-Kill and a F-Kill have occurred as the result of killing fires and explosions from ignited fuel and/or ammunition. A tank which has suffered a K-Kill is considered not to be economically repairable, and, by U.S. standards, would be abandoned on the battlefield.

ATTACK ASPECT -- The angle of approach of the aircraft with respect to the orientation of the tank with zero degrees representing the front of the tank (gun forward) and 180 degrees representing the rear of the tank.

SIGNIFICANT IMPACTS -- Impacts which damage systems, components or sub-systems resulting in their destruction or partial loss of function. This type damage contributes to the assessed kill.

INSIGNIFICANT IMPACTS -- Impacts which damage non-critical structural, convenience, or accessory components and which may result in their destruction or partial loss of function, but with no impact on mobility or firepower considerations. Good maintenance practices contemplate repair or replacement of such items at the earliest opportunity consistent with accomplishment of the mission.

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59.	12 AF/DO Bergstrom AFB, TX 78743	2
60.	9 AF/DO Shaw AFB, SC 29152	2
61.	CINCUSAFE/DO Ramstein AFB APO 09012	1
62.	CINCUSAFE/DOOF Ramstein AFB APO 09012	2
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114. 333 TFTS/CC
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