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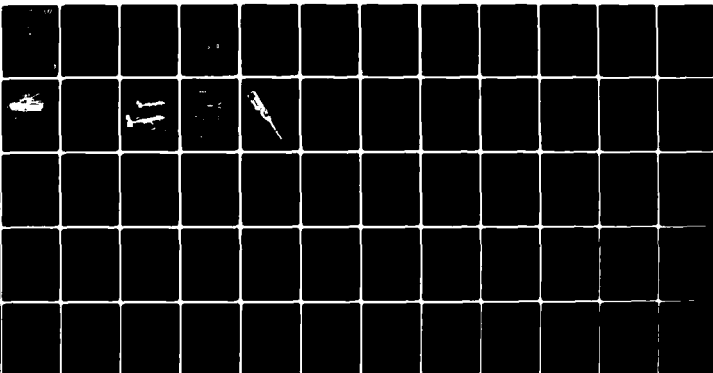
NAVAL POSTGRADUATE SCHOOL MONTEREY CA
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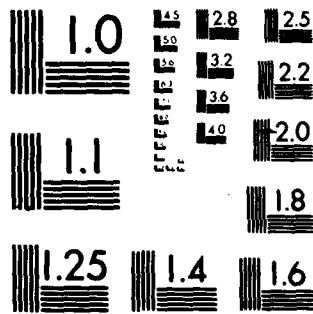
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NAVAL POSTGRADUATE SCHOOL
Monterey, California



COMBAT DAMAGE ASSESSMENT TEAM
A-10/GAU-8 LOW ANGLE FIRINGS
VERSUS
SIMULATED SOVIET TANK COMPANY (ARRAY 25)
(LAVP LOT NUMBER AJD79A181-001)
(4 DECEMBER 1979)

R.H.S. STOLFI
R.R. McEACHIN

OCTOBER 1980

Approved for public release; distribution unlimited.

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

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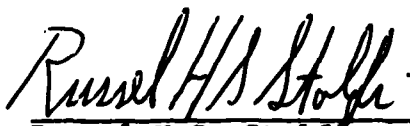
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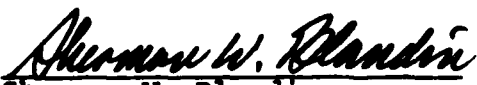
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes LAVP firings of the A-10/GAU-8 weapon system on 4 December 1979 against a Soviet tank company simulated by 10 combat-loaded M-47 tanks. The pilots 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 30mm armor piercing incendiary (API) rounds which proved to be effective damage agents against substantial areas of the US MK 47 tanks used as targets.		

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The pilots in ten successful firing passes fired a total of 381 rounds of which 139 impacted the targets. Of the projectiles impacting on targets, 22 achieved perforations of the armored envelope. The simulated Soviet tank company was destroyed as a combat formation based on the following assessment of damage to individual tanks:

<u>No. Tanks</u>	<u>Damage</u>
5	100% M-Kills (complete immobilization)
1	100% F-Kill (complete silencing)
3	Partial M-and/or F-Kills
<u>1</u>	Negligible Damage
Total 10	

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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 ten (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 pilots of the attacking A-10 aircraft conducted firings at low altitudes and dive angles thus simulating conditions below the minimum altitude for their effective engagement by the opposing air defense (AD) networks employing acquisition and fire control radar. The purpose of the test was to evaluate the performance of the Aerojet 30mm API anti-tank ammunition (Lot Number AJD 79A181-001), fired from the GAU-8 gun during engagement of the A-10/GAU-8 weapon system against realistically simulated Soviet main battle tanks.

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

1. Test Conditions: The target tanks were deployed in open, flat desert terrain with no cover and little concealment. Aerial weather conditions provided unlimited ceiling and visibility. Shortly after the initial firing, clouds of white dust from projectile impacts were evident. Such conditions effectively simulated the actual degree of target obscuration which would have been encountered by pilots in combat.
2. Attack Parameters: The pilots of the A-10 aircraft attacked the simulated Soviet tank company at low altitude and dive angles. The GAU-8 cannon has cockpit-selectable fire rates of either 2100 or 4200 rounds per minute, and the system was set to fire at 4200 rounds per minute during this test. The pilots made a total of 10 passes, each at a primary tank target, scoring projectile impacts on 10 tanks. They fired 381 rounds in ten (10) bursts averaging, 38.1 rounds and 0.62 second per burst.
3. Weapons Effects: The A-10/GAU-8 weapon system achieved 139 impacts on the 10 target tanks. The ratio of direct impacts to total rounds fired was 0.26. The weapon system achieved 22 perforations of the armored envelopes of the tanks, with a ratio of perforations to impacts of 0.16. Some projectiles, which did not perforate armor, damaged exterior track and suspension components of the tanks, as well as gun tubes.
4. Damage Assessment: The attacking A-10/GAU-8 weapon system inflicted no catastrophic kills on tanks in the company array. Five tanks were immobilized, including two tanks with severely restricted fire power. One tank was deprived of the use of its main armament. One tank sustained such light damage that there was no significant degradation of either its mobility or fire power.

5. Results: The breakdown of test results into constituent parameters is summarily shown in Table I. The average number of tanks neutralized per single A-10 aircraft attack was 0.60 in terms of total loss of either mobility or fire power. Neutralization in this sense is a top level weapon effectiveness parameter. These results were obtained under conditions of open and flat desert terrain, calm and clear weather, low altitude attacks, and battle field obscuration by smoke and dust of projectile impacts. Appendix A further contains graphic and summary data of this firing, and Appendix B contains the qualitative and quantitative definitions of terms used in this publication.

TABLE I. Array 25, Summary of Low Angle Gun Attacks by A-10 Aircraft against Simulated Soviet Tank Company
(4 December 1979)

Tank No.	A-10 Primary Pass	APPROACH			ATTACK			GUN EFFECTS				DAMAGE				Tank Immob- ilized ?	Tank Aspect (Degrees)
		Speed (Knots)	Alt (Feet)	Dive Angle (Degrees)	Open Fire Range (Feet)	Round (Each)	Impacts (Each)	Perfs (Each)	M %	F %	K %						
52	1/1	340	550	-6.0*	2550*	30	23	7	100	95	-	Yes	100				
54	2/1	343	731	-8.0	2056	30	13	2	65	70	-		085				
71	1/2	340	550	-6.0*	2550*	30	5	0	**100	-	-	Yes	090				
50	2/2	343	831	-7.0	2129	43	35	11	100	95	-	Yes	086				
53	2/3	343	581	-4.0	2344	46	19	1	100	30	-	Yes	323				
33	2/4	335	556	-4.0	2120	57	4	0	-	-	-		335				
51	2/5	345	681	-5.0	2272	34	5	0	100	-	-	Yes	086				
57	2/6	335	831	-7.0	2263	35	17	0	-	100	-		326				
7	2/7	345	631	-6.0	-	35	11	0	-	10	-		083				
55	2/8	353	831	-7.0	2282	41	7	1	55	85	-		078				
Total:						381	139	22				5					
Average:		342	677	-6.0	2285	38.1	13.9	2.2	5 M-Kills 1 F-Kill 1 Negligible 3 Partial M and/or F							Left front Right Side	

* NOTE: Values are approximate, based on pilot estimates.

**Interdiction type M-Kill after 300-500 meter movement.

BACKGROUND

Since February, 1978, the Armament Directorate, A-10 System Program Office, Wright Patterson Air Force Base, Ohio, has conducted firing tests of 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 in 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.

In conducting the LAVP program, the Armament Directorate cooperated with Headquarters, Tactical Air Command, Langley AFB, Virginia, and 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 to evaluate the results. The CDAT functions under the direction of a Combat Damage Assessment Committee (CDAC), which prepared this report.

TEST PHILOSOPHY

To generate realistic data, the CDAC employed an empirical technique of destructive testing of actual tank targets. Tests consisted of firings at individual tanks in November, 1977 and February - March, 1978 and, more recently, at arrays of vehicles deployed in tactical formations. The experimental setup for the firings of 4 December, 1979 involved aircraft attacks on a multi-target, tactically arrayed tank formation by the A-10/GAU-8 weapon system. The CDAT elected to simulate a Soviet tank company, organized within a tank division, as the target array attacked by two A-10 aircraft. Minimum constraints were placed on the attacking pilots in an effort to develop as much realism as possible. Table II shows test factors which would have been ideal in the exercise of 4 December, 1979 and the practical setup which was achieved.

TABLE II. Comparison of Ideal and Practical Test Conditions

<u>Ideal Test Parameters</u>	<u>Practical Test Parameters</u>
1. <u>Air Attack Realism</u>	1. <u>Air Attack Realism</u>
a. Actual A-10/GAU-8 configuration	a. Actual A-10/GAU-8 configuration
b. 30mm API ammunition	b. 30mm API ammunition
c. European weather & terrain	c. Nevada weather & desert terrain
d. Optimum open-fire ranges (2000 ft)	d. Open-fire ranges (2285 ft. average)
e. Low altitude attack angle (<-6 degrees)	e. Low altitude attack angle (<-6.0 degrees average)
2. <u>Air Defense (AD) Realism</u>	2. <u>Air Defense (AD) Realism</u>
a. Automatic cannon firing at aircraft	a. Low altitude, low angle, minimum exposure attacks against assumed AD system
b. Missile systems firing at aircraft	b. Low altitude, low angle, minimum exposure attacks against assumed AD system
c. Small arms firing at aircraft	c. Low altitude, low angle, minimum exposure attacks against assumed AD system
d. AD suppression by aircraft	d. No simulation of AD suppression in test
3. <u>Threat Targets and Doctrine</u>	3. <u>Threat Targets and Doctrine</u>
a. Soviet T62/T64/T72 high fidelity tank targets	a. Soviet tanks, simulated by US M-47 tanks
b. Combat-stowed loads in Soviet T62/T64/T72 tanks	b. Combat-stowed loads in US M-47 tanks
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 tests of 4 December, 1979 simulated attacks by the US A-10 aircraft on a Soviet tank company. The CDAC hypothesized the Soviet tank company to be the lead march security detachment for its battalion which, in turn, would be the advance guard of a larger mobile formation. The lead detachment normally operates approximately five kilometers in front of the Soviet battalion column. Its primary mission is to ensure an uninterrupted advance of the battalion, and to provide security against attack. Upon meeting heavy resistance, the company either deploys into an appropriate combat formation in order to reduce the opposition, or forms a base of fire for offensive action by the remainder of the battalion, or performs both functions.

A Soviet tank company, simulated in the firing tests, probably would also have other units attached to it for support that could include any or all of the following elements: (1) motorized rifle platoon, (2) engineer detachment, (3) chemical defense specialists, (4) 122mm howitzer battery, and (5) an air defense element. In this case, the lead detachment simulated in the firing tests consisted of tanks alone. This tank formation was deployed with two platoons in front and one in the back, simulating an initial assault posture. The targets 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 tests; the formation remained essentially a stationary snapshot of the company.

TARGET TANKS

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

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

The following sensitive internal items, which contributed to catastrophic kills and to high percentage Mobility (M) and Fire-power (F) kills, were placed in test tanks:

<u>Generic Sensitive Item</u>	<u>Test Item</u>
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

TEST RESULTS

Tests consisted of exposing ammunition, gun, aircraft, pilots, and combat-arrayed and loaded tanks to several minutes of combat simulation. The key elements in the scenario were:

1. Aerojet Ordnance Manufacturing Co. 30mm API ammunition (Lot Number AJD 79A181-001).
2. General Electric GAU-8 Gatling gun.
3. Fairchild Republic A-10 close ground support aircraft.
4. USAF combat pilots
5. US M-47 main battle tanks*, combat loaded.

*Now obsolescent

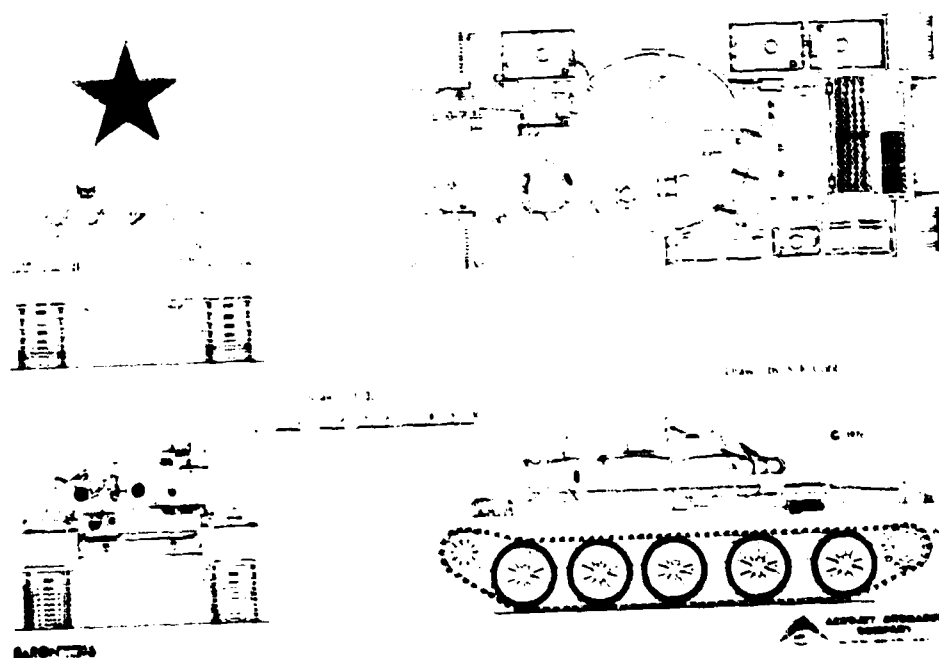


FIGURE 1. Russian T62 Medium Tank.

The combat simulation itself comprised aerial fire and appropriate maneuvers by the attacking A-10 aircraft. A realistic way of presenting combat simulation is to outline the sequence of pertinent events in each firing pass. These developments, and the data which CDAT attempted to collect in order to reconstruct the simulated combat firings of 4 December, 1979, were as follows:

<u>Sequence</u>	<u>Event</u>	<u>Data</u>
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 (K-Kill)

The data above were collected through combined efforts of the CDAT and range support personnel at Nellis AFB. Aerojet Ordnance Manufacturing Company personnel provided the industrial support required to repair, refurbish, and field the target tanks. The CDAT applied the research techniques needed to describe weapon effects and combat damage. The basic materiel used in tests, i.e., the A-10 aircraft, GAU-8/A guns, and 30mm API projectiles, are illustrated sequentially in Figures 2, 3, 4, and 5. The targets, arrayed in the tactical formation of a Soviet tank company, are shown in Figure 6. Actual tank targets used were US M-47 tanks, depicted in the Damage Assessment section. The original intention was to obtain airspeed, altitude, burst length, slant range and dive angle data from the Heads-Up-Display (HUD) gun camera film. One of the two films of this particular test apparently was misplaced or destroyed, and efforts to locate it have been fruitless. Consequently, part of the information provided by HUD films is not available, and there is no other alternate range instrumentation data source.

The attacking pilots flew from the base area, and employed standard operational tactics immediately before the firing passes by approaching targets at low altitude, and simulating their initial acquisition with the help of a forward air controller. They then proceeded to attack the tank company targets at altitudes and dive angles low enough to simulate operations below minimum effective altitudes for radar acquisition and engagement by opposing air defense missile and gun systems.



FIGURE 2. USAF/Fairchild Republic A-10 Close Ground Support Aircraft.

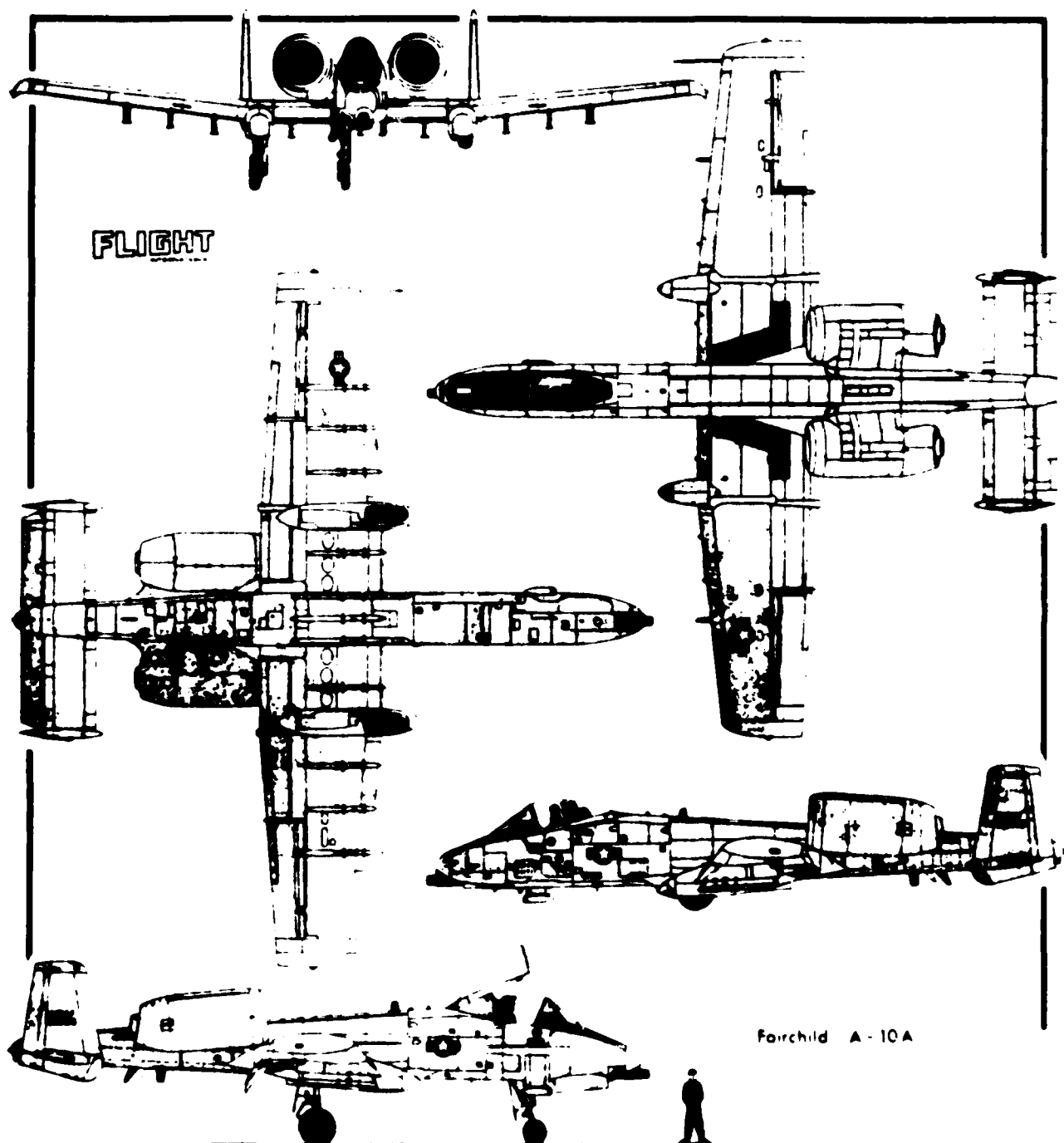


FIGURE 3. USAF/Fairchild Republic A-10 Close Ground Support Aircraft.

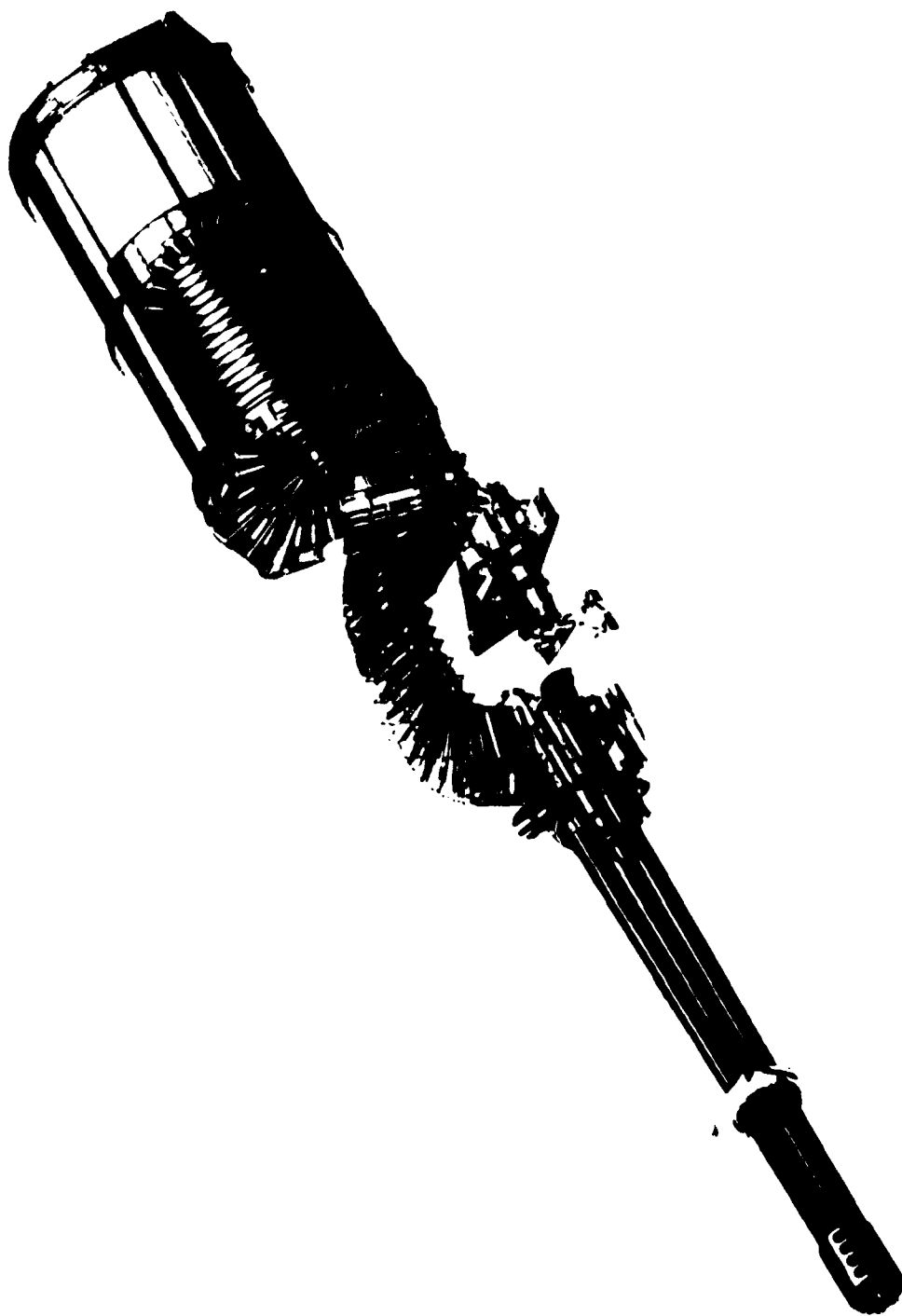


FIGURE 4. GAU-8/A 30mm Automatic Gun System.

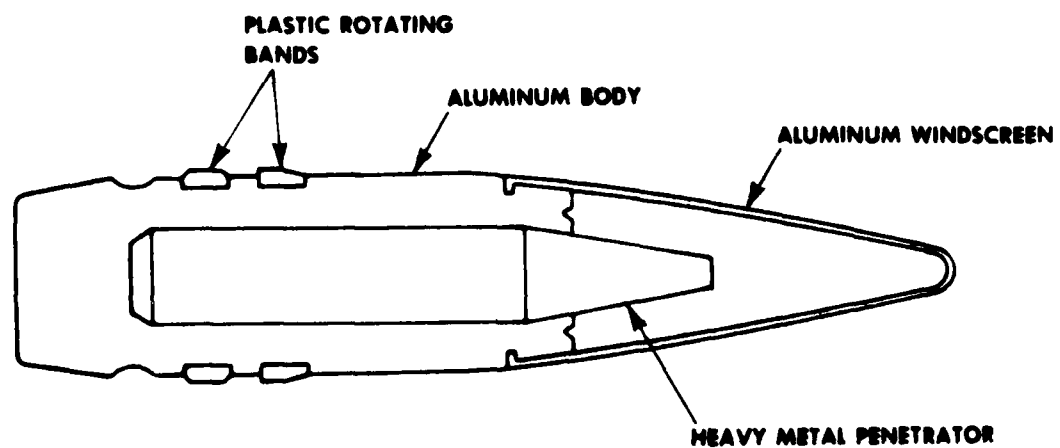
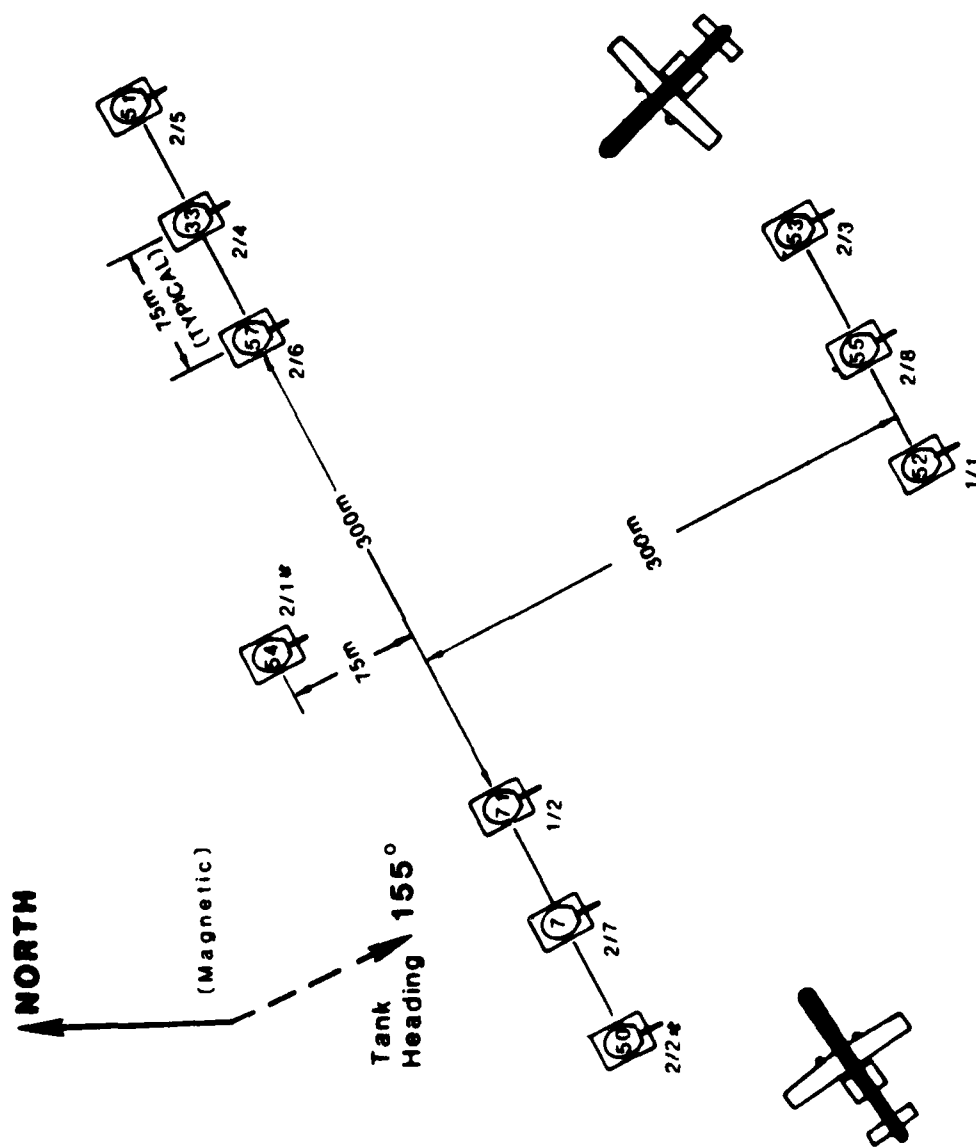


FIGURE 5. Cross Section of a 30mm Armor Piercing Incendiary (API) Projectile.



* 2/1 represents Pilot 2/Pass 1, 2/2 represents Pilot 2/Pass 2, etc.

FIGURE 6. Mission 25, Approximate Target Layout of a Simulated Soviet Tank Company.

DAMAGE ASSESSMENT

Damage assessments, carried out by CDAT, are presented on the following pages. Appendix A, which follows the detailed damage assessment section and includes applicable aircraft parameters and weapon effects, contains graphic and tabular information on the mission.

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

Impacts on targets were sequentially but arbitrarily numbered for identification purposes, first at turret then at hull levels. Additional impacts, discovered during combat damage assessment, were given next sequential numbers, i.e., no attempt was made to correct the sequence. THE READER IS CAUTIONED THAT THIS NUMBERING SYSTEM BEARS NO RELATIONSHIP TO THE ARRIVAL SEQUENCE OF PROJECTILES ON TARGET, OR TO PORTIONS OF BURSTS IMPACTING TARGET TANKS.

TARGET TANK NUMBER 52 DAMAGE SUMMARY

1. Description:

The attacking A-10 aircraft achieved impacts on tank 52 with 23 projectiles fired from an attack aspect angle of 100 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 30 rounds in the firing pass.

2. Kill Assessment:

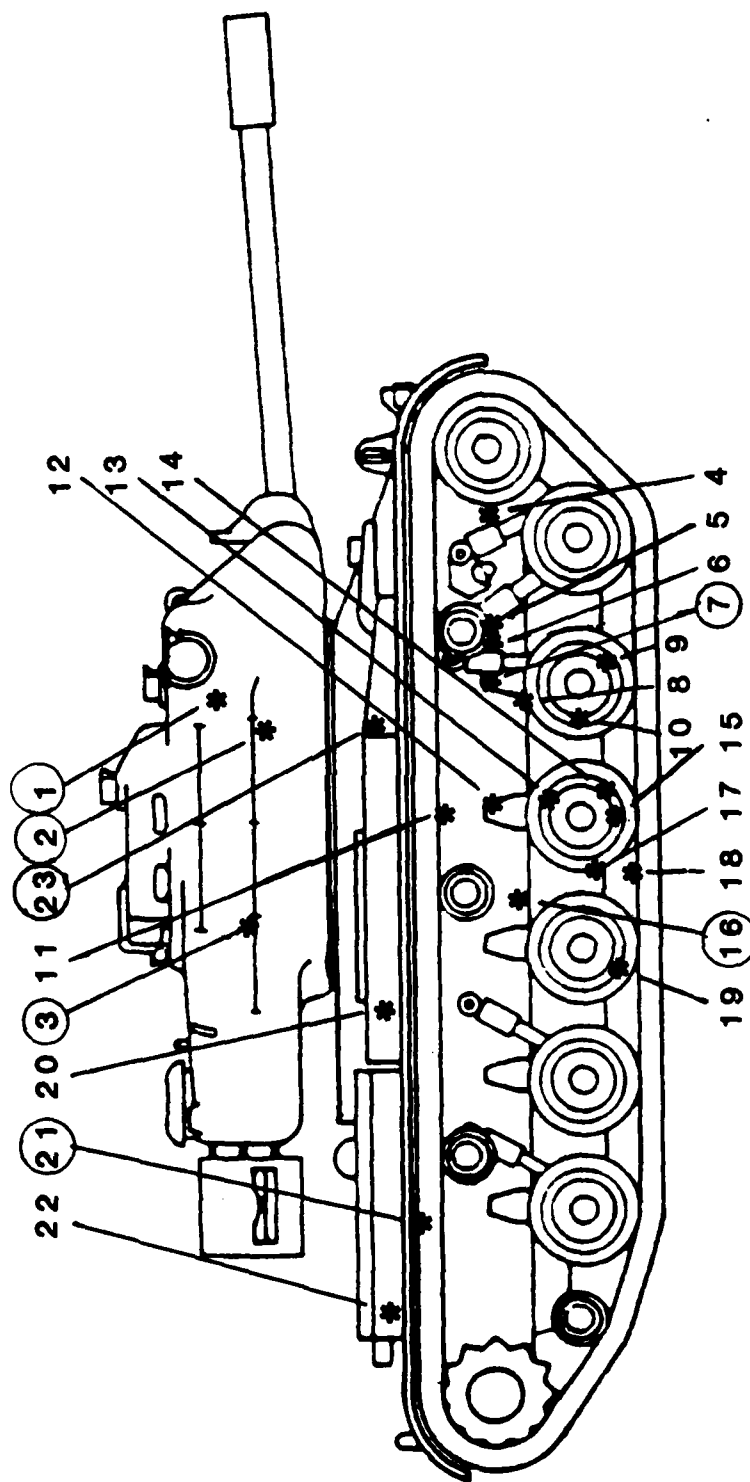
100% M-Kill and 95% F-Kill, resulting from the following observed effects (Figure 7):

- a. Perforations : 7
- b. Significant Impacts : 4
- c. Insignificant Impacts: 12

TOTAL IMPACTS : 23

3. Rationale for Kill Assessment:

- a. M-Kill: A 100% M-Kill was assessed, based on Impacts 16 and 21 which perforated the right hull armor and penetrated the fuel tank and oil cooler, and on cumulative damage to the track and suspension system caused by Impacts 4, 5, 6, and 8.
- b. F-Kill: A 95% F-Kill was assessed, based on Impacts 1, 2, and 3 which perforated the right turret, penetrated the fighting compartment, caused damage to the gunner control panel, destroyed gunner's power control handle, and caused casualties to the commander, gunner, and loader.



Legend:

Circled numbers indicate perforating impacts.

FIGURE 7. Impact Diagram, Target 52.

TARGET TANK NUMBER 54 DAMAGE SUMMARY

1. Description:

The attacking A-10 aircraft achieved impacts on tank 54 with 13 projectiles fired from an attack aspect angle of 085 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 30 rounds in the firing pass.

2. Kill Assessment:

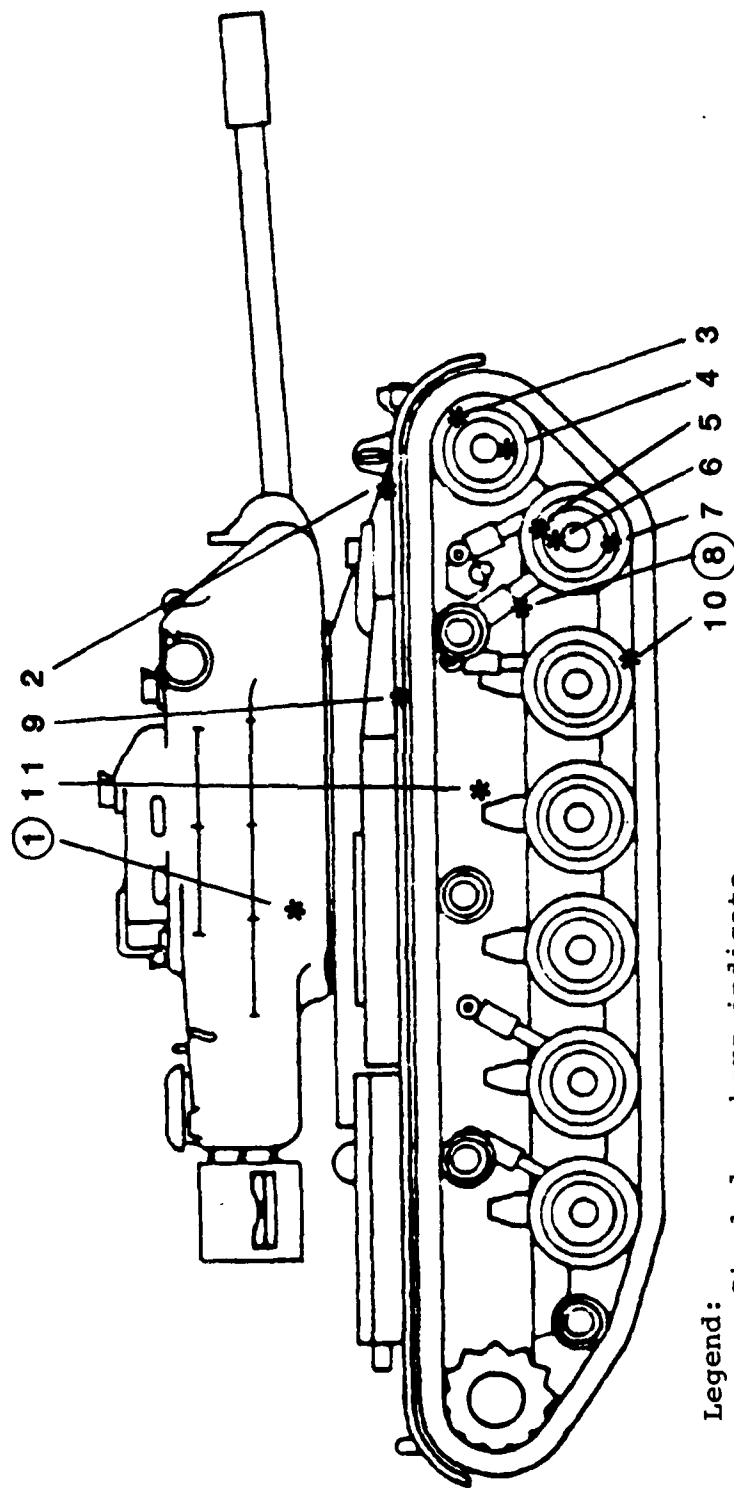
65% M-Kill and 70% F-Kill, resulting from the following observed effects (Figure 8):

a. Perforations	:	2
b. Significant Impacts	:	1
c. Insignificant Impacts:		<u>10</u>

TOTAL IMPACTS : 13

3. Rationale for Kill Assessment:

- a. M-Kill: A 65% M-Kill was assessed, based solely on the contribution to a mobility kill caused by commander and loader casualties. Mechanical damage to mobility components was insignificant.
- b. F-Kill: A 70% F-Kill was assessed, based on Impact 1 which perforated the right turret and penetrated into the fighting compartment, severing the power control wiring harness and causing casualties to the commander and loader.



Legend: Circled numbers indicate
perforating impacts.

NOTE: Impacts 12 and 13 are not shown in this view.

FIGURE 8. Impact Diagram, Target 54, Right Side.

TARGET TANK NUMBER 71 DAMAGE SUMMARY

1. Description:

The attacking A-10 aircraft achieved impacts on tank 71 with 5 projectiles fired from an attack aspect angle of 090 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 30 rounds in the firing pass.

2. Kill Assessment:

100% M-Kill, resulting from the following observed effects:

a. Perforations	:	0
b. Significant Impacts	:	1
c. Insignificant Impacts:		<u>4</u>

TOTAL IMPACTS	:	5
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3. Rationale for Kill Assessment:

The assessment of 100% M-Kill is based on damage caused by Impact 4 which severed one wedge nut, destroyed one center guide and one end connector (Figure 9), all on one pair of track shoes. This would have caused track failure after 300-500 meters of movement.

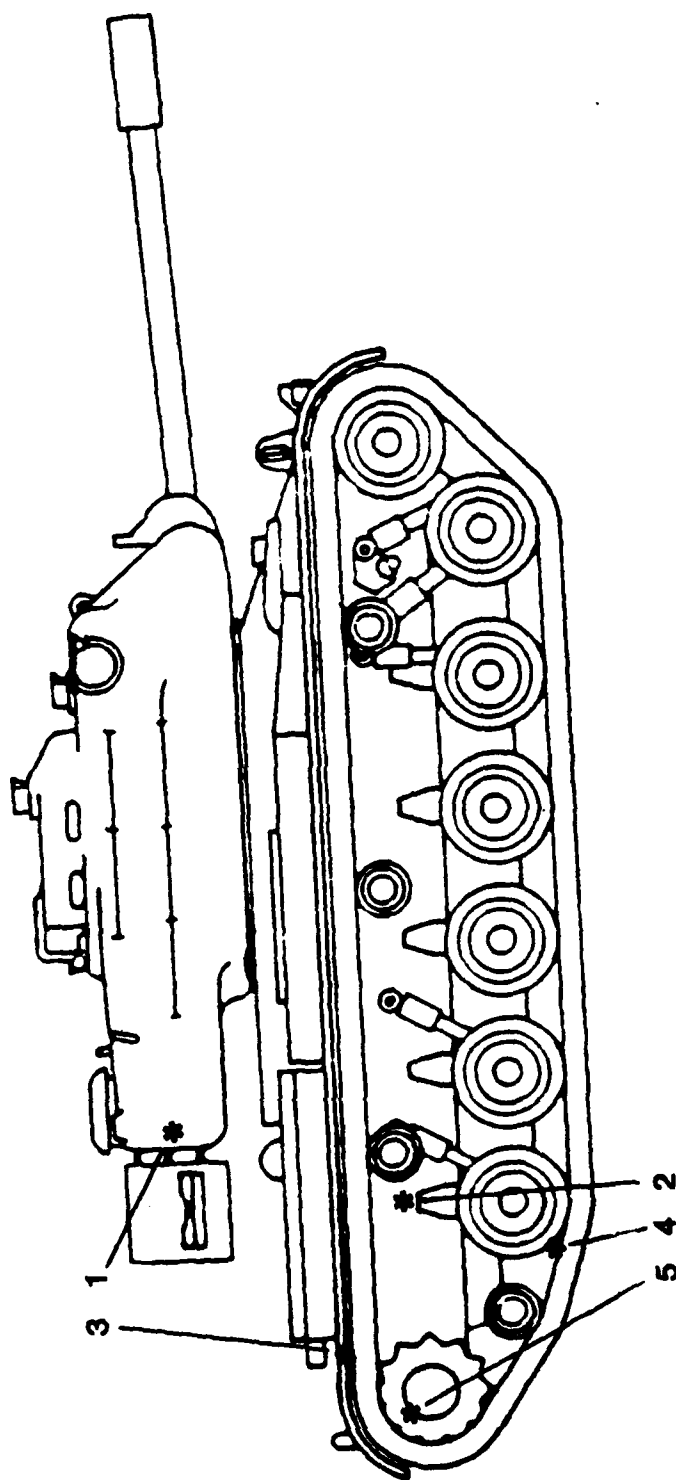


FIGURE 9. Impact Diagram, Target 71.

TARGET TANK NUMBER 50 DAMAGE SUMMARY

1. Description:

The attacking A-10 aircraft achieved impacts on tank 50 with 35 projectiles fired from an attack aspect angle of 086 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 43 rounds in the firing pass.

2. Kill Assessment:

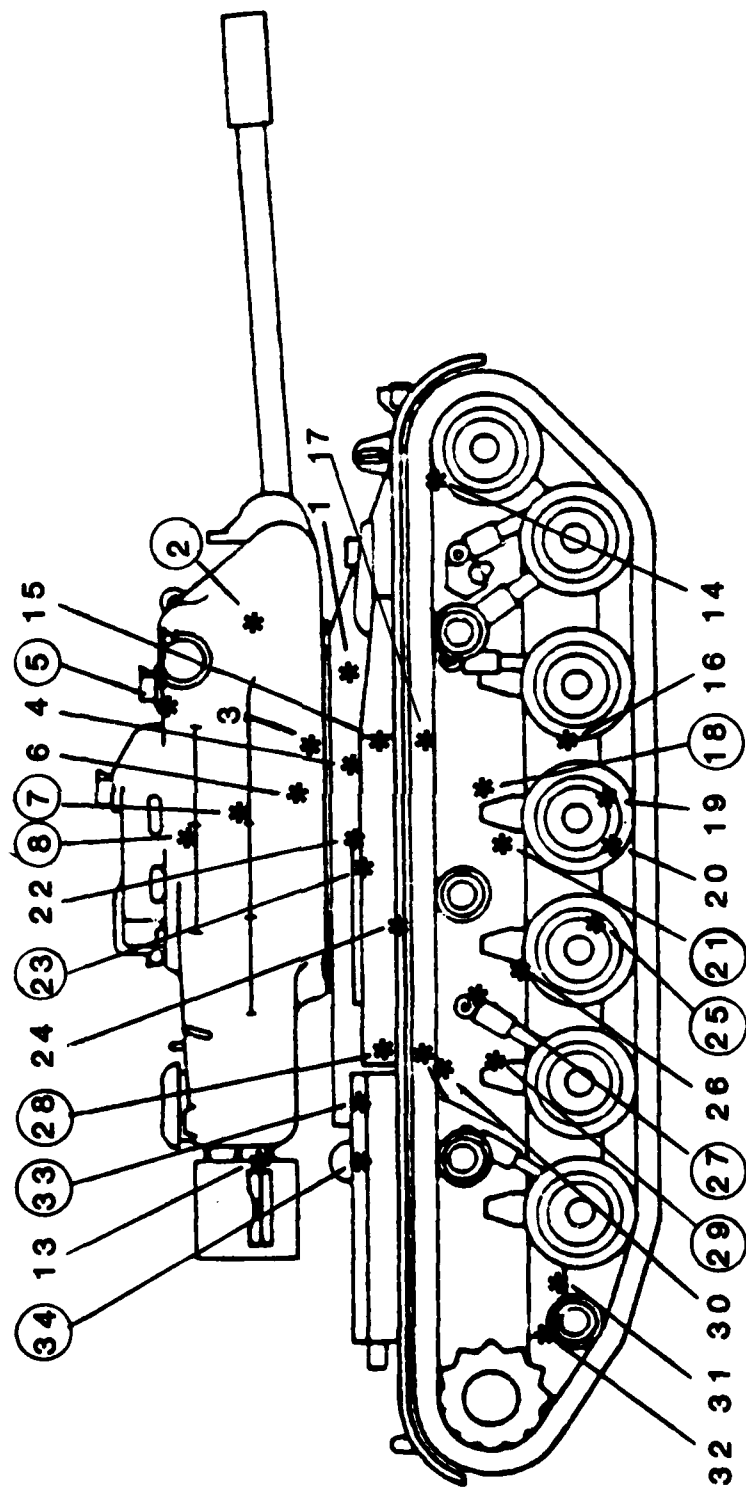
100% M-Kill and 95% F-Kill, resulting from the following observed effects (Figures 10 and 11):

- a. Perforations : 11
- b. Significant Impacts : 5
- c. Insignificant Impacts: 19

TOTAL IMPACTS : 35

3. Rationale for Kill Assessment:

- a. M-Kill: The assessment of 100% M-Kill is based on Impacts 21, 27, 28, and 33 which perforated the right hull armor and penetrated the right fuel turret and two valve covers, and on cumulative damage to the track and suspension system caused by Impacts 14, 16, and 30. Crew casualties caused by Impacts 2, 5, 7, and 8 contributed to the kill.
- b. F-Kill: The assessment of a 95% F-Kill was attributed to Impacts 2, 5, 7, and 8 which perforated the right turret armor and caused casualties to the commander, gunner and loader.



Legend: Circled numbers indicate perforating impacts.

FIGURE 10. Impact Diagram, Target 50, Right Side.

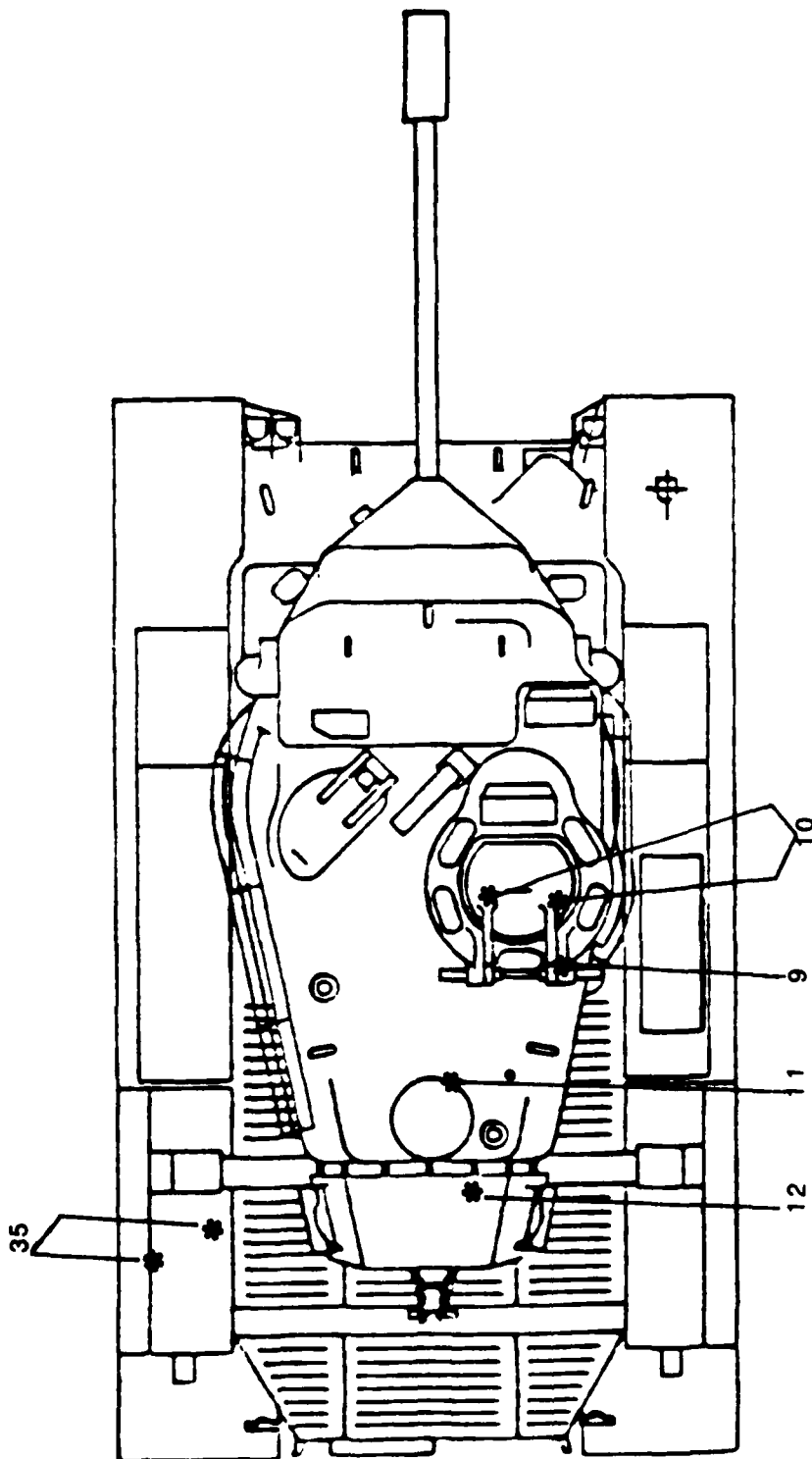


FIGURE 11. Impact Diagram, Target 50, Top.

TARGET TANK NUMBER 53 DAMAGE SUMMARY

1. Description:

The attacking A-10 aircraft achieved impacts on tank 53 with 19 projectiles fired from an attack aspect angle of 323 degrees (left front) during one firing pass at low altitude and low dive angle. The A-10 expended 46 rounds in the firing pass.

2. Kill Assessment:

100% interdiction type M-Kill and 30% F-Kill, resulting from the following observed effects:

- a. Perforations : 1
- b. Significant Impacts : 4
- c. Insignificant Impacts: 14

TOTAL IMPACTS : 19

3. Rationale for Kill Assessment:

- a. M-Kill: A 100% interdiction type M-Kill, based on cumulative damage to the track and suspension system caused by Impacts 9, 11, 17, and 18 (Figures 12, 13, and 14), which would have caused total track failure after 5 to 8 kilometers of travel.
- b. F-Kill: The assessment of 30% F-Kill is based on slight wounds to the loader caused by Impact 1, which perforated the left turret armor.

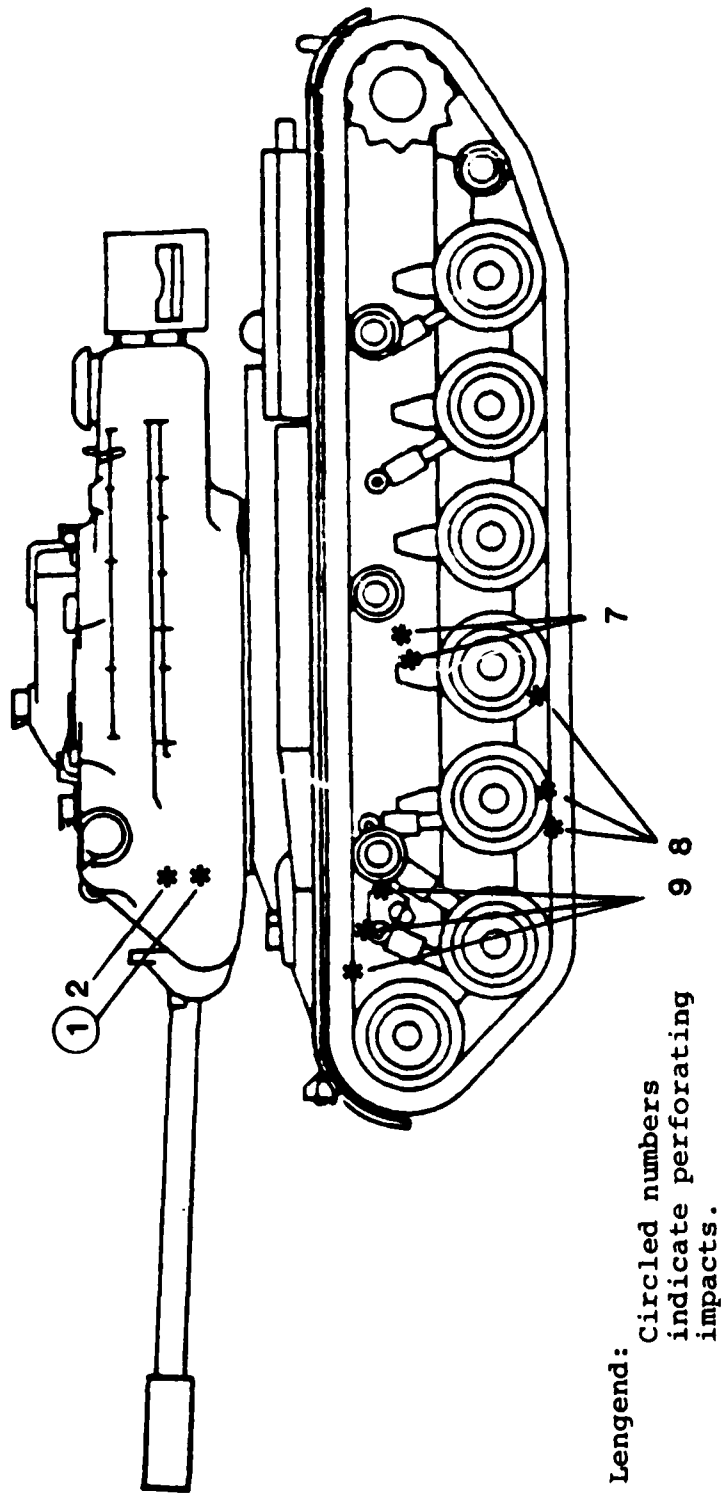
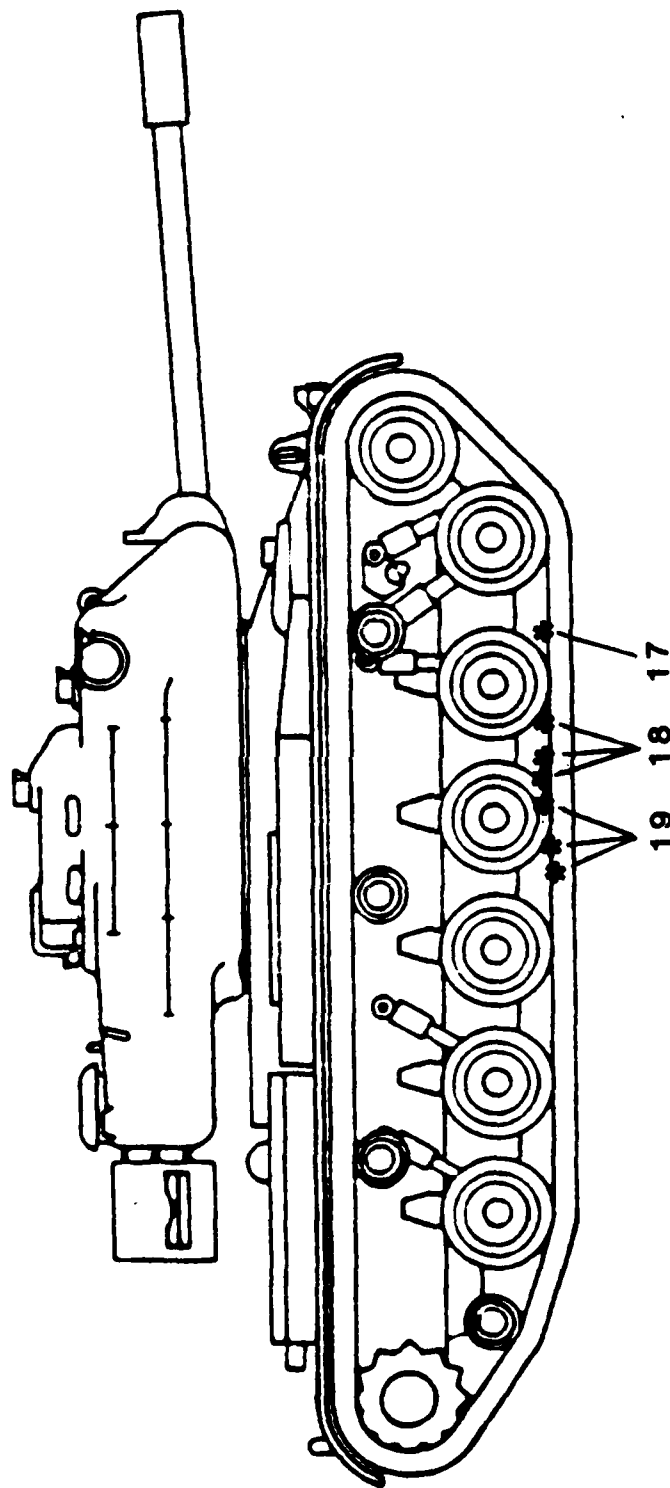
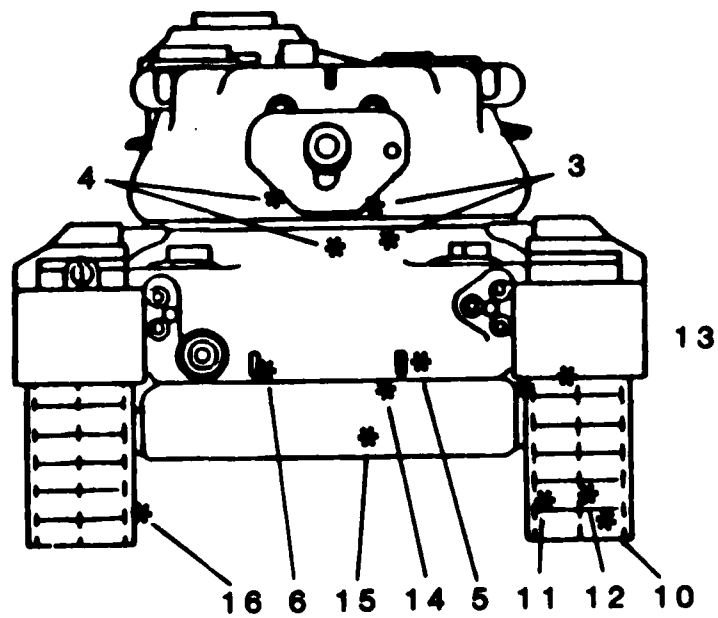


FIGURE 12. Impact Diagram, Target 53, Left Side.



NOTE: Impacts 17, 18, and 19 are from inside to outside of wheels and track.

FIGURE 13. Impact Diagram, Target 53, Right Side.



NOTE: Impact 16 is on inside of number 1 road wheel.

FIGURE 14. Impact Diagram, Target 53, Front.

TARGET TANK NUMBER 33 DAMAGE SUMMARY

1. Description:

The attacking A-10 aircraft achieved impacts on tank 33 with 4 projectiles fired from an attack aspect angle of 335 degrees (left front) during one firing pass at low altitude and low dive angle. The A-10 expended 57 rounds in the firing pass.

2. Kill Assessment:

No degradation in mobility or firepower (Figure 15):

a. Perforations	:	0
b. Significant Impacts	:	0
c. Insignificant Impacts:		<u>4</u>

TOTAL IMPACTS	:	4
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3. Rationale for Kill Assessment:

No perforations or significant impacts were observed on target tank 33.

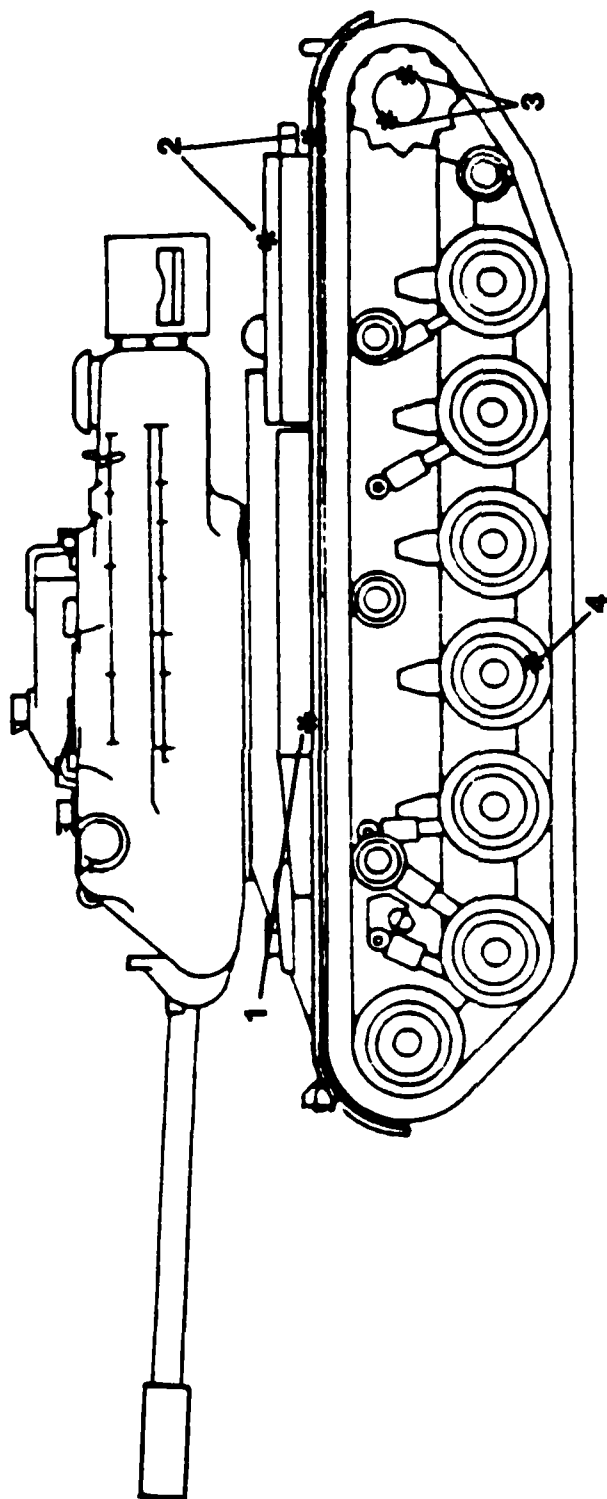


FIGURE 15. Impact Diagram, Target 33.

TARGET TANK NUMBER 51 DAMAGE SUMMARY

1. Description:

The attacking A-10 aircraft achieved impacts on tank 51 with 5 projectiles fired from an attack aspect angle of 086 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 34 rounds in the firing pass.

2. Kill Assessment:

100% M-Kill, resulting from the following observed effects (Figures 16 and 17):

a. Perforations	:	0
b. Significant Impacts	:	2
c. Insignificant Impacts:		<u>3</u>

TOTAL IMPACTS	:	5
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3. Rationale for Kill Assessment:

The assessment of 100% M-Kill is based on damage to the right track adjusting idler, caused by Impact 2, and to Impact 3 which destroyed an end connector and track center guide on the same pair of track shoes. See Figure 16 for locations of Impacts 2 and 3.

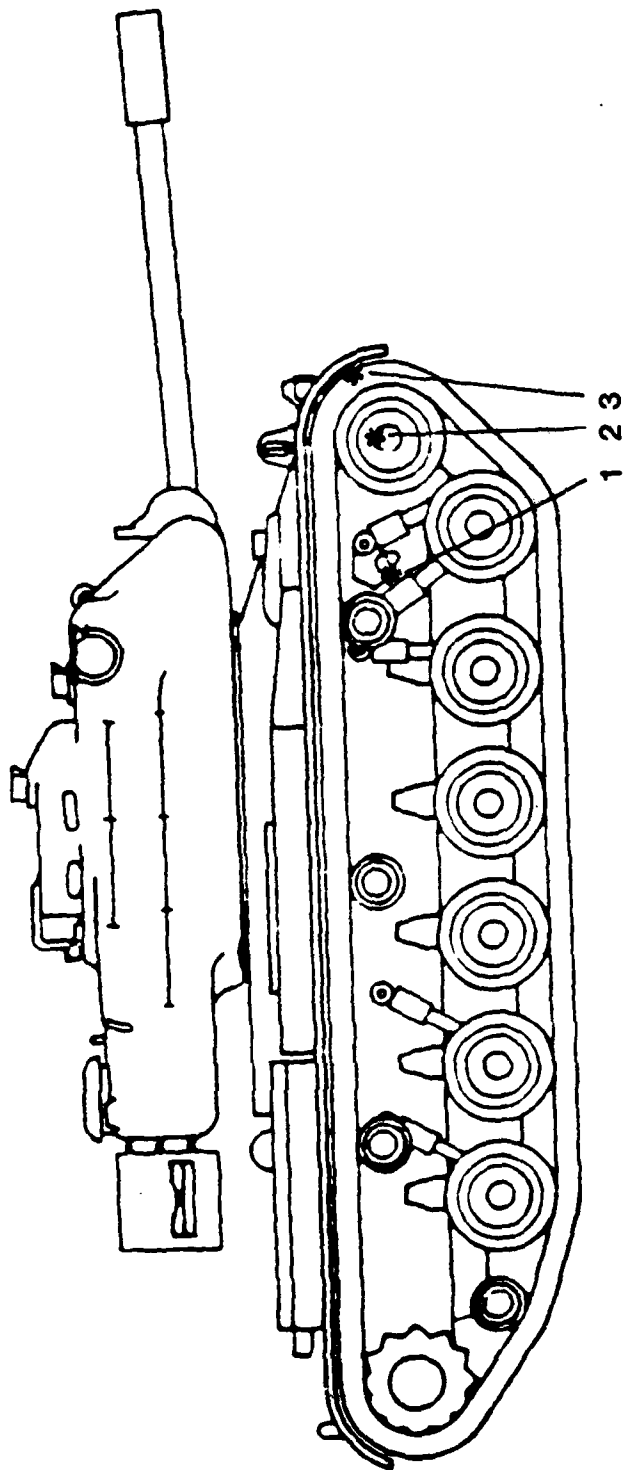


FIGURE 16. Impact Diagram, Target 51, Right Side.

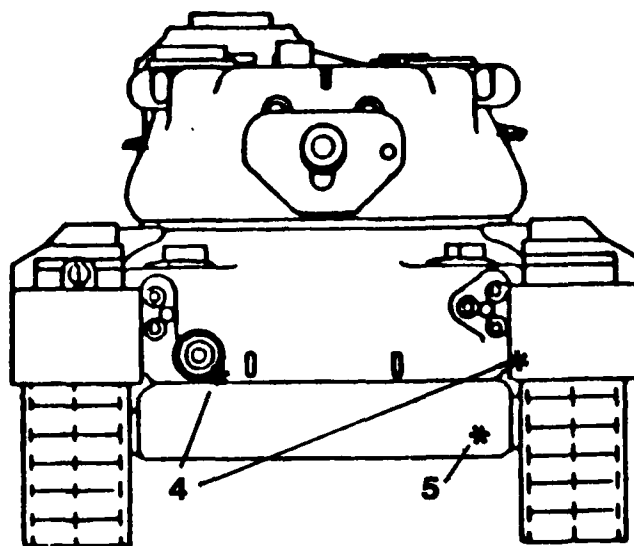


FIGURE 17. Impact Diagram, Target 51, Front.

TARGET TANK NUMBER 57 DAMAGE SUMMARY

1. Description:

The attacking A-10 aircraft achieved impacts on tank 57 with 17 projectiles fired from an attack aspect angle of 326 degrees (left front) during one firing pass at low altitude and low dive angle. The A-10 expended 35 rounds in the firing pass.

2. Kill Assessment:

100% F-Kill, resulting from the following observed effects (Figures 18, 19, and 20):

a. Perforations	:	0
b. Significant Impacts	:	5
c. Insignificant Impacts:		<u>12</u>

TOTAL IMPACTS : 17

3. Rationale for Kill Assessment:

Impacts 3 and 4 jammed the turret, preventing traverse and, consequently, the use of main armament.

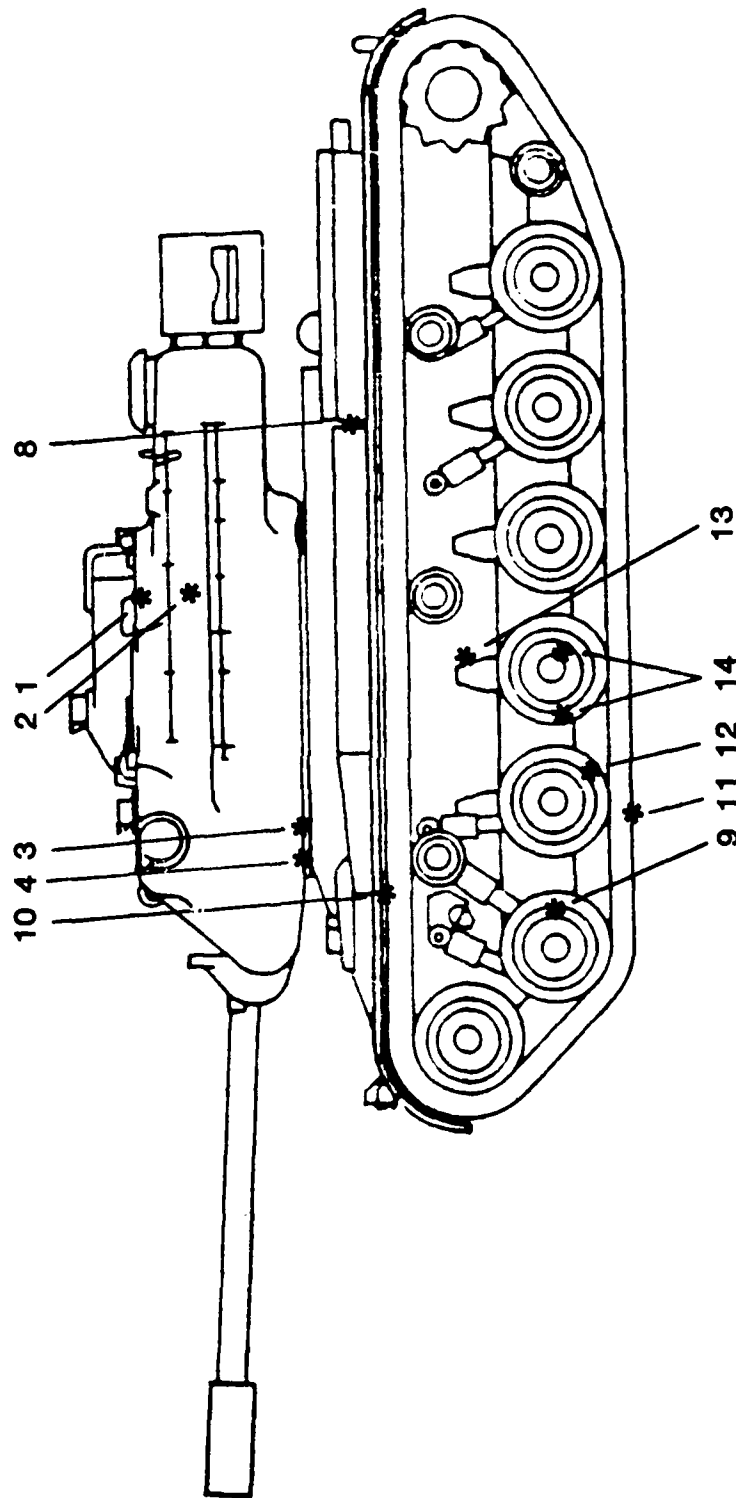
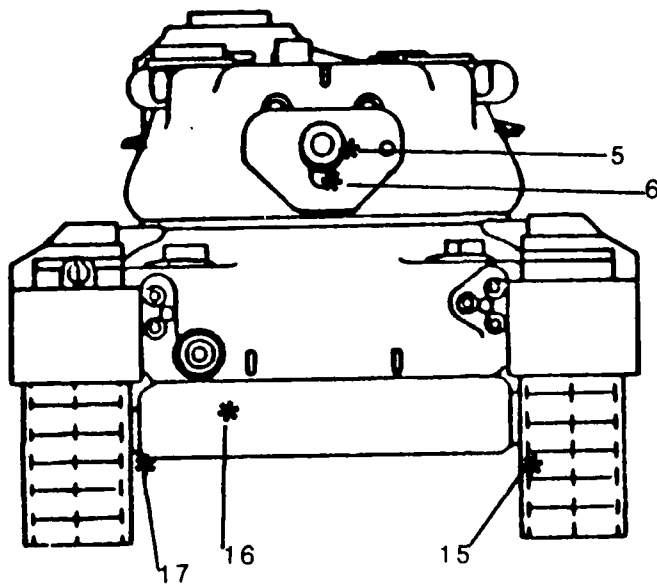


FIGURE 18. Impact Diagram, Target 57, Left Side.



NOTE: #17 impacted #4 roadwheel torsion bar housing.

FIGURE 19. Impact Diagram, Target 57, Front.

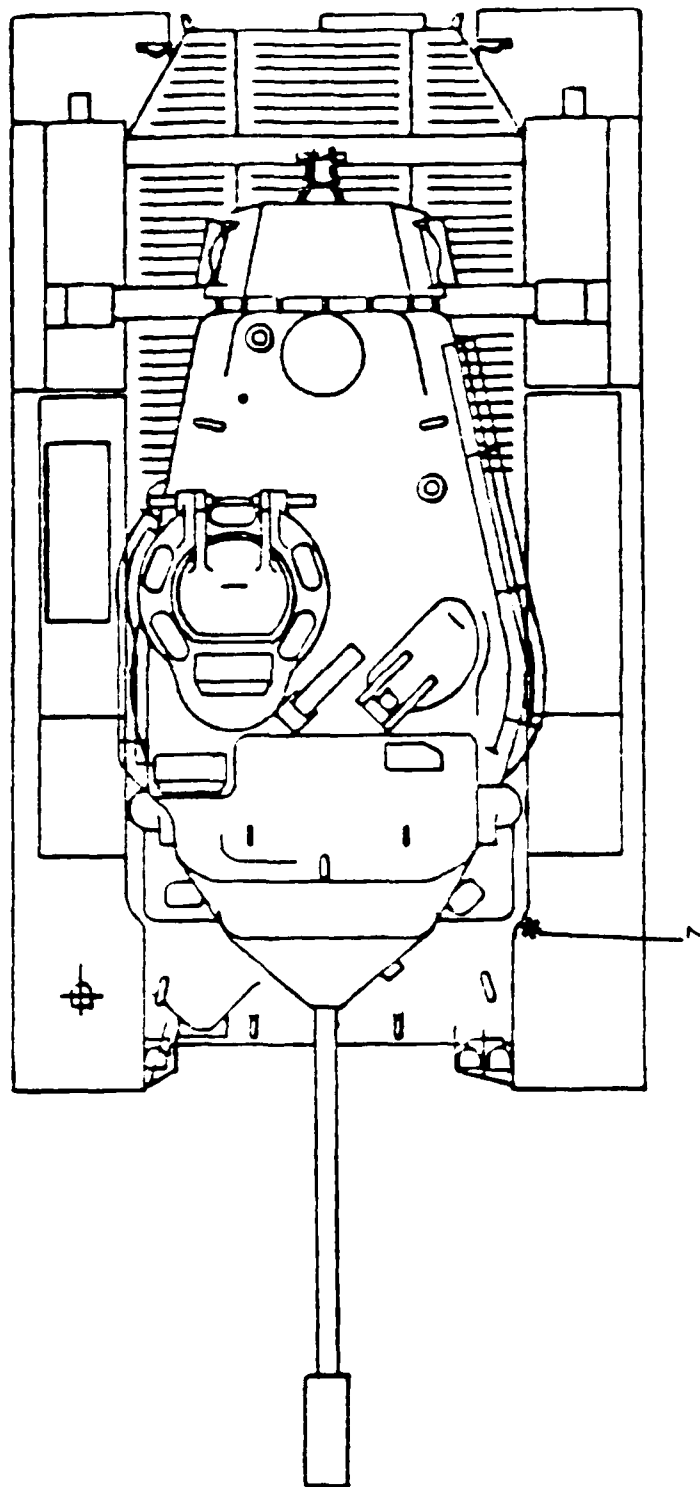


FIGURE 20. Impact Diagram, Target 57, Top.

TARGET TANK NUMBER 7 DAMAGE SUMMARY

1. Description:

The attacking A-10 aircraft achieved impacts on tank 7 with 11 projectiles fired from an attack aspect angle of 083 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 35 rounds in the firing pass.

2. Kill Assessment:

10% F-Kill, resulting from the following observed effects:

a. Perforations	:	0
b. Significant Impacts	:	1
c. Insignificant Impacts:		<u>10</u>

TOTAL IMPACTS	:	11
---------------	---	----

3. Rationale for Kill Assessment:

Impact 1 penetrated one wall of the gun tube, causing a 10% loss of function. The figure presenting impacts on tank number 7 is not shown. The impact diagram normally filled out in the field was not completed for tank number 7. A field description of the impacts exists which can be used to locate the impacts with reasonable accuracy, e.g., on a specific roadwheel, on a particular area of the turret, etc.

TARGET TANK NUMBER 55 DAMAGE SUMMARY

1. Description:

The attacking A-10 aircraft achieved impacts on tank 55 with 7 projectiles fired from an attack aspect angle of 078 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 41 rounds in the firing pass.

2. Kill Assessment:

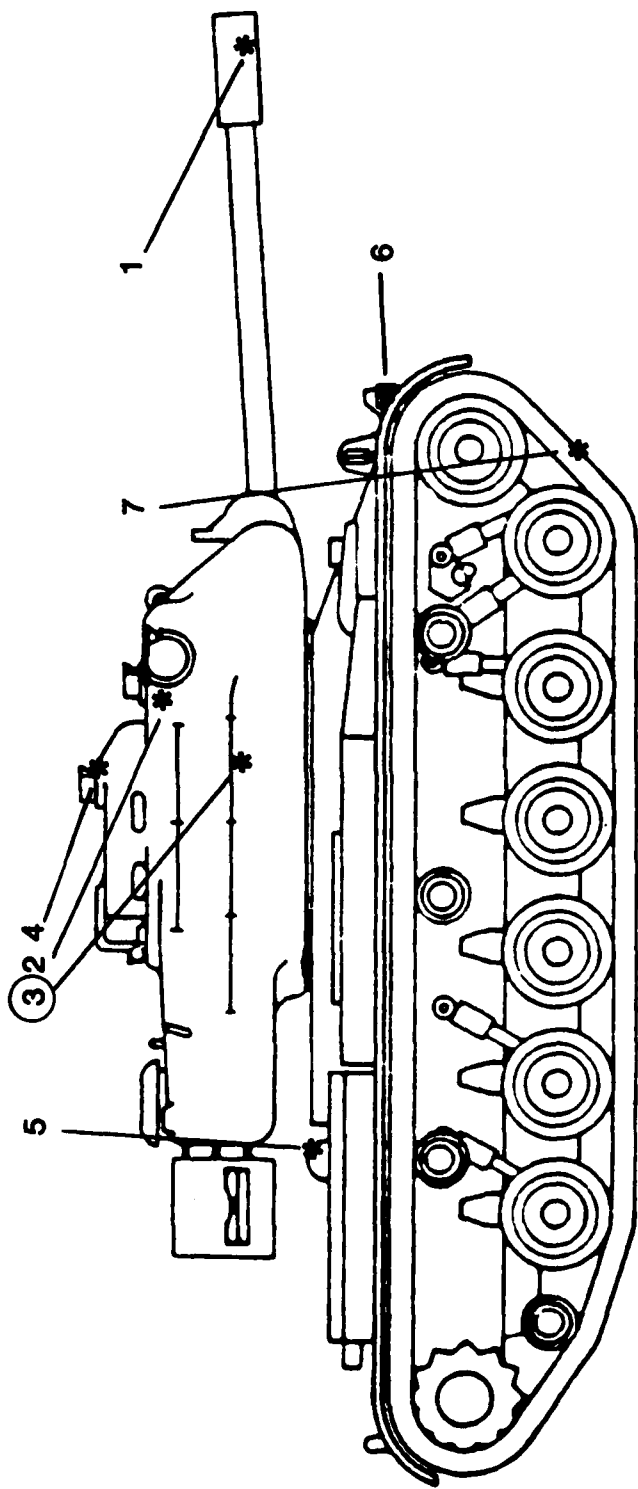
55% M-Kill and 85% F-Kill, resulting from the following observed effects (Figure 21):

- a. Perforations : 1
- b. Significant Impacts : 1
- c. Insignificant Impacts: 5

TOTAL IMPACTS : 7

3. Rationale for Kill Assessment:

- a. M-Kill: A 55% M-Kill was assessed, based solely on the contribution to a mobility kill caused by gunner and loader casualties. Mechanical damage to mobility components was insignificant.
- b. F-Kill: An 85% F-Kill was assessed, based on Impact 3 which perforated the right turret, causing casualties to the gunner and loader and on Impact 1, which penetrated both walls of the gun tube.



Legend: Circled numbers indicate perforating impacts.

FIGURE 21. Impact Diagram, Target 55.

SUMMARY AND CONCLUSIONS

On 4 December, 1979 at Nellis AFB, Nevada, the Combat Damage Assessment Team (CDAT) carried out firings of the A-10/GAU-8 weapon system against an array of ten (10) tanks, simulating a Soviet tank company deployed for attack. The purpose of the test was to evaluate the effects of firing the 30mm API antitank ammunition out of the GAU-8 gun against realistically simulated Soviet tank formations. The CDAT used US M-47 tanks, stowed with main gun ammunition, diesel fuel, lubricating oil, and crew manikins to simulate the Soviet tanks. The pilots of the A-10 aircraft, used in the firings, conducted their attacks at altitudes and dive angles low enough to simulate operations below the minimum altitude for effective engagement by opposing air defense systems using acquisition and fire control radar. Summary results of the firing tests were as follows:

Aircraft Parameters

1. Open Fire Speed (average)----- 579 ft/sec
2. Dive Angle (average)----- -6.0 degrees
3. Open Fire Slant Range (average)-- 2285 feet
4. Burst Length/Rounds (average)---- 0.62 sec/38.1
5. Number of Passes (primary)----- 10
6. Target Aspects (predominantly)--- Left front/right

Weapon Effects

1. Rounds Fired----- 381
2. Impacts----- 139
3. Ricochets (off grnd)-- 39
4. Direct Impacts----- 100
5. Armor Perforations---- 22

Target Damage

1. K-Kills----- 0
2. Hi& M+F-Kills- 3
3. M-Kills----- 5
4. F-Kills----- 1
5. Negligible---- 1

The data that follow are used to demonstrate the effectiveness of the A-10/GAU-8 weapon system as a Soviet tank killer based upon firing tests that simulated combat conditions. Results of these firing tests, conducted on 4 December 1979 follow:

Measures of Weapon System Effectiveness

Accuracy Related Ratio:

Lethality Related Ratio:

$$\frac{\text{Total Impacts (139)}}{\text{Total Rounds Fired (381)}} = 0.36 \quad \frac{\text{Perforations (22)}}{\text{Total Impacts (139)}} = 0.16$$

$$\frac{\text{Direct Impacts (100)}}{\text{Total Rounds Fired (381)}} = 0.26 \quad \frac{\text{Perforations (22)}}{\text{Direct Impacts (100)}} = 0.22$$

Weapon System Effectiveness Ratios:

$$\frac{\text{Tanks Neutralized (6)}}{\text{Aircraft Passes (10)}} = 0.60 \quad \frac{\text{Tanks K-Killed (0)}}{\text{Aircraft Passes (10)}} = 0.00$$

The 10 target tanks were attacked predominately from the front and sides and suffered damage as presented in Tables I and A-I.

The data and measures summarized above together with others contained in this report support the following inferences or conclusions:

1. The A-10/GAU-8 wapon system under conditions of realistic simulation of combat is capable of inflicting M and F type kills on the US M-47 main battle tanks and the similarly protected Soviet T-55 and T-62 tanks.

2. The A-1-/GAU-8 weapon system in low-level attacks can perforate the side and rear armor of the hulls and turrets of M-47 tanks and the similarly protected Soviet T-55 and T-62 tanks.

3. The A-10/GAU-8 weapon system can perforate the side and rear surfaces of the US M-47 tanks and Soviet T-55 and T-62 tanks when firing short to moderate-length bursts (0.5-0.9 second) containing 30-60 rounds of 30mm API ammunition.

4. The lethality of GAU-8 30mm API ammunition against combat-stowed main battle tanks shows the tactics of low-level attacks in this firing test to be successful.

APPENDIX A

Graphic and Summary Data

Table A-1 contains a summary of the results of mission 25 on 4 December, 1979. Table A-II relates the assessment of damage in Table A-I to locations of perforations. Table A-III summarizes the aircraft attack parameters of altitude, attitude, air speed, firing slant range, and burst length for each pass on each target. Figure A-1 relates the aircraft attack aspect by firing pass to aircraft range from target at the beginning and at the end of each burst. The attack directions are shown as arrows on a plan view diagram of the simulated combat engagement. The arrows are located at the ranges from the targets at which firing took place.

Table A-I. Summary of Mission Results
(4 December 1979)

Target Tank No.	Damage Assessment		All Target Impacts	Initial Impact on Armor	Rounds Fired	Total Perforations
	(M%)	(F%) (K%)				
52	100	95	23	13	30	7
54	65	70	13	10	30	2
71	100	-	5	2	30	0
50	100	95	35	24	43	11
53	100	30	19	13	46	1
33	-	-	4	4	57	0
51	100	-	5	5	34	0
57	-	100	17	16	35	0
7	-	10	11	8	35	0
55	55	85	7	5	41	1
TOTALS:			139	100	381	22

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

Table A-II. Summary of Perforation Locations
(4 December 1979)

Target Tank	Damage Assessment (M%) (F%) (K%)		Turret Perforations	Hull Perforations		Total Perforations
				Engine Compartment	Crew Compartment	
52	100	95	-	2	2	7
54	65	70	-	0	1	2
71	100	-	-	0	0	0
50	100	95	-	7	0	11
53	100	30	-	0	0	1
33	-	-	-	0	0	0
51	100	-	-	0	0	0
57	-	100	-	0	0	0
7	-	10	-	0	0	0
55	55	85	-	0	0	1
TOTALS:			10	9	3	22

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

TABLE A-III. Aircraft Attack Parameters
(4 December 1979)

Acft Pass No.	Tank	Slant Range Open/Cease (feet)	Dive Angle Open/Cease (degrees)	Altitude (feet)	Velocity Open/Cease (knots)	Burst Length (Seconds)	Data Source
1/1	52	2550/2260*	-6.0/-6.0*	550*	340/340	0.50	PILOT*
2/1	54	2056/ -	-8.0/-8.0	731	343/343	0.50	HUD
1/2	71	2550/2260*	-6.0/-6.0*	550*	340/340	0.50	PILOT*
2/2	50	2129/ -	-7.0/-7.0	831	343/347	0.69	HUD
2/3	53	2344/ -	-4.0/-4.0	581	343/349	0.73	HUD
2/4	33	2120/ -	-4.0/-3.0	556	335/338	0.90	HUD
2/5	51	2272/ -	-5.0/-3.0	681	345/349	0.56	HUD
2/6	57	2263/ -	-7.0/-6.0	831	335/340	0.58	HUD
2/7	7	- / -	-6.0/-6.0	631	345/349	0.58	HUD
2/8	55	2282/ -	-7.0/-7.0	831	353/356	0.67	HUD

Nominal HUD film Tolerances:

Slant Ranges: Plus 0 minus 150 feet

Dive Angles : Plus 0.5 minus 0.5 degrees

Velocities : Plus 5 minus 5 knots

Burst times : Plus 0 minus 0.021 seconds

* Heads Up Display (HUD) film was not recovered; data therefore were taken from pilot report alone.

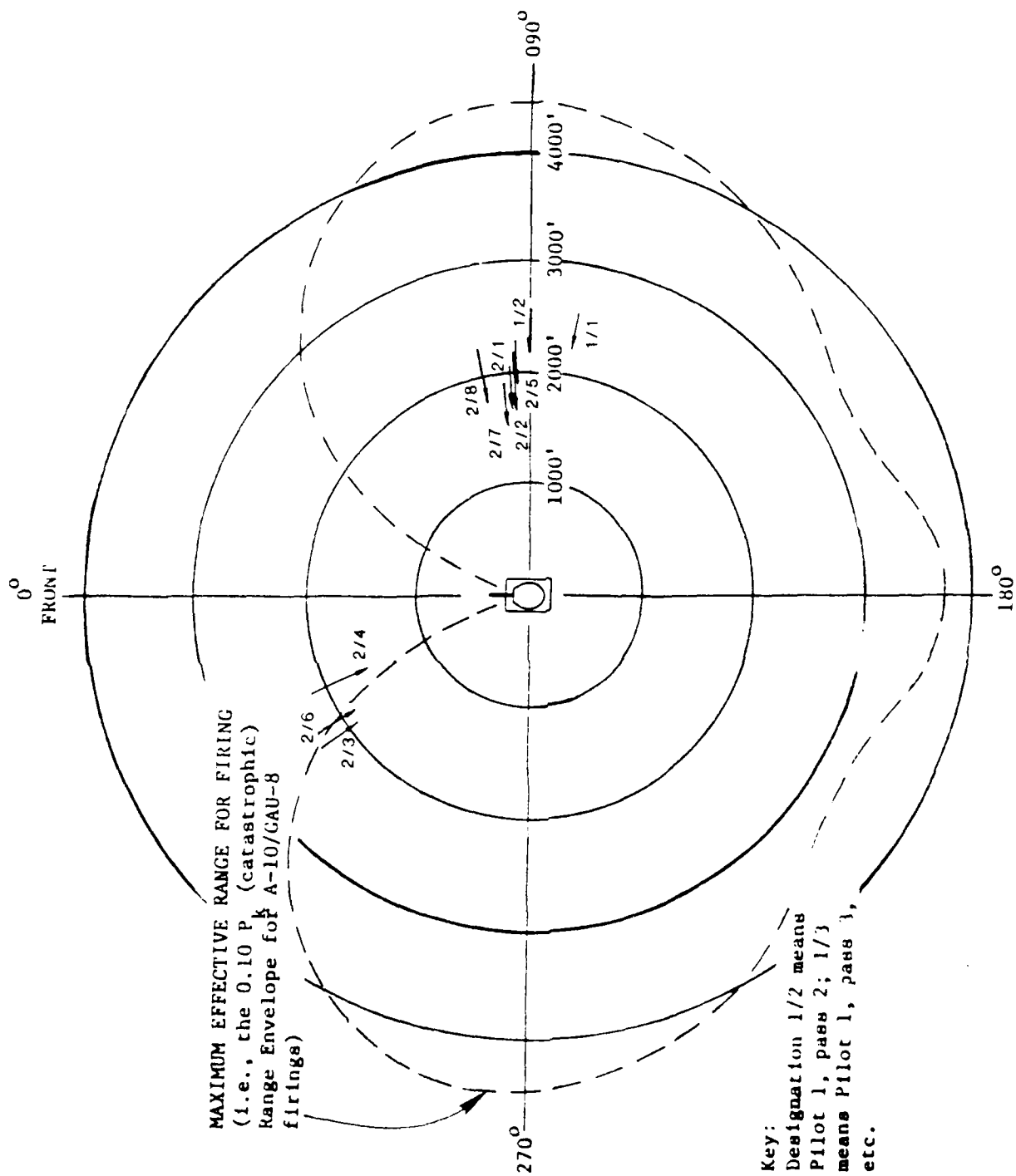


FIGURE A-1. Mission 25 Attack Aspect Summary.

APPENDIX B

DEFINITIONS

The terms used in this report are defined below:

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

PERFORATION -- Complete rupture of the armored envelope of a tank by an impacting projectile or its spall fragments. A perforation can only occur when armor is impacted, except in cases of turret armor discontinuities around weapons, or vision and ranging devices. The word "perforation" was deliberately selected to avoid ambiguities which could 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 through damage which cannot be repaired by crew on the battle field. A tank is considered to have sustained a 100% M-Kill when it is no longer capable of executing controlled movement on the battle field. Mobility is **DEGRADED** when a tank can no longer maintain position in its formation.

FIRE POWER KILL (F-KILL) -- Loss of tactical fire power through damage which cannot be repaired by crew on the battle field. A tank is considered to have sustained a 100% F-Kill when it is no longer capable of delivering controlled fire from its main armament. Fire power 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. Such tank is no longer considered economically repairable, and, by US standards, would be abandoned on the battle field.

ATTACK ASPECT -- Approach angle of the attacking aircraft to tank orientation, with zero (0) degrees representing the front of the tank (gun forward), and 180 degrees representing

ing the rear of the tank. The angle is measured clockwise.

SIGNIFICANT IMPACTS -- Impacts which damage systems, components or sub-systems up to destruction or partial loss of function. Such damage contributes to the assessed kill of a tank.

INSIGNIFICANT IMPACTS -- Impacts which damage non-critical structural, convenience, or accessory components to destruction or partial loss of function, but without impact on the mobility or fire power of a tank. Good maintenance practices provide repair or replacement of such items at the earliest opportunity, consistent with accomplishment of the mission.

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