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ERDEC-TR-441

HISTORY OF CURRENT U.S. RAPID OBSCURATION SYSTEMS (ROS)

DTIC QUALITY INSPECTED 2

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13. ABSTRACT (Maximum 200 words) This report documents the history of armored vehicle smoke/obscurant protection using grenades and dischargers in rapid obscuration systems in the United States. The history begins with the response to the Arab-Israeli conflicts and the threats of the 1960s and ends with the technology and hardware advances made to deal with threats of the year 2000.				
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PREFACE

The work described in this report was authorized under Project No. 1L162622A552, Smoke and Obscurants Munitions. This work was started in January 1970 and completed in May 1997.

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HISTORY OF CURRENT U.S. RAPID OBSCURATION SYSTEMS (ROS)

The term Rapid Obscuration Systems (ROS) describes the means by which vehicles respond to either an aimed or launched threat by creating rapid formations of screening smoke/obscurant clouds to break the acquisition lock the threat has on the vehicle. By decreasing the enemy's view and impeding aiming and tracking sensors on the threat, the probability of vehicle and crew survivability increases.

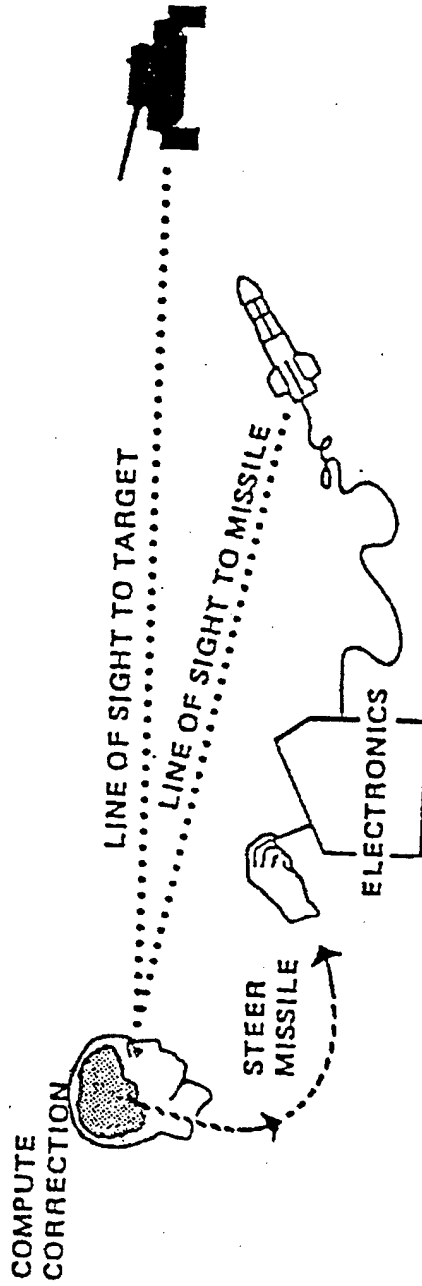
Any ROS must include a threat warning system, a threat identification system, a response selection system, and a response execution system. In its simplest form, the operator is the warning system, the identification system, the response selection system (there may only be one response), and the response execution system initiator. Grenades and dischargers create the protective screening clouds. In its complex form, the threat warning system is a detector-based, multifrequency situation monitor. The threat identification system is a computer-based signal analyzing system that classifies the detector signals and maps them against a classification listing to make a threat identification. Preprogrammed tactics for each classified threat situation are used to select the desired response from the available countermeasure stores; and depending on prior operator decisions, either an automatic response is made with a notification to the operator, or a semiautomatic response is setup and a warning is provided to the operator so he can either alter or initiate the selected response.

The ROS currently installed on the U.S. armored vehicles are an initial response to the advent of the smart weapons, which significantly decreased vehicle survivability. The impact of smart weapons was recognized during the Arab-Israeli Conflicts of the 1960s and 1970s. The 9K11 Malyutka Anti-Tank Guided Missile System (NATO Code-Name "Sagger", U.S. Designator AT-3) is a prime example of the early weapons that caused the installation of smoke protection on U.S. armored vehicles. This infantry weapon system first appeared as a Manual Command to Line-of-Sight [(MCLOS) Figure 1] and then as a Semi-Automatic Command to Line-of-Sight [(SACLOS) Figure 2] and was deployed as a man-portable missile, mounted on a BRDM Amphibious Scout Car and on the Boevaya Mashina Pekhota (BMP-1) Infantry Fighting Vehicle (IFV).*

These systems are similar to the U.S. Army's Tube-launched, Optically tracked, Wire command link guided (TOW) missile systems similar to our basic TOW. Targets are acquired optically; the missile is tracked by following a near infrared (NIR) flare on the rear of the missile; and the missile is guided optically. To defeat systems of this type, obscurants can be used either to block the operator's view of the target or to block the operator's view of the missile. In the first case, the operator is unable to aim the system accurately. In the second case, the operator is unable to provide proper flight corrections to the missile. Because the system operates in the visible and NIR regions of the electromagnetic spectrum, the classic visible smoke materials will satisfactorily screen the aiming and tracking functions of this missile type. Typically, the visible smokes have their maximum effect in the visible range but also have significant effects in the NIR.

*Foss, C.F., Ed., Jane's Armour and Artillery, 15th ed., 94-95.

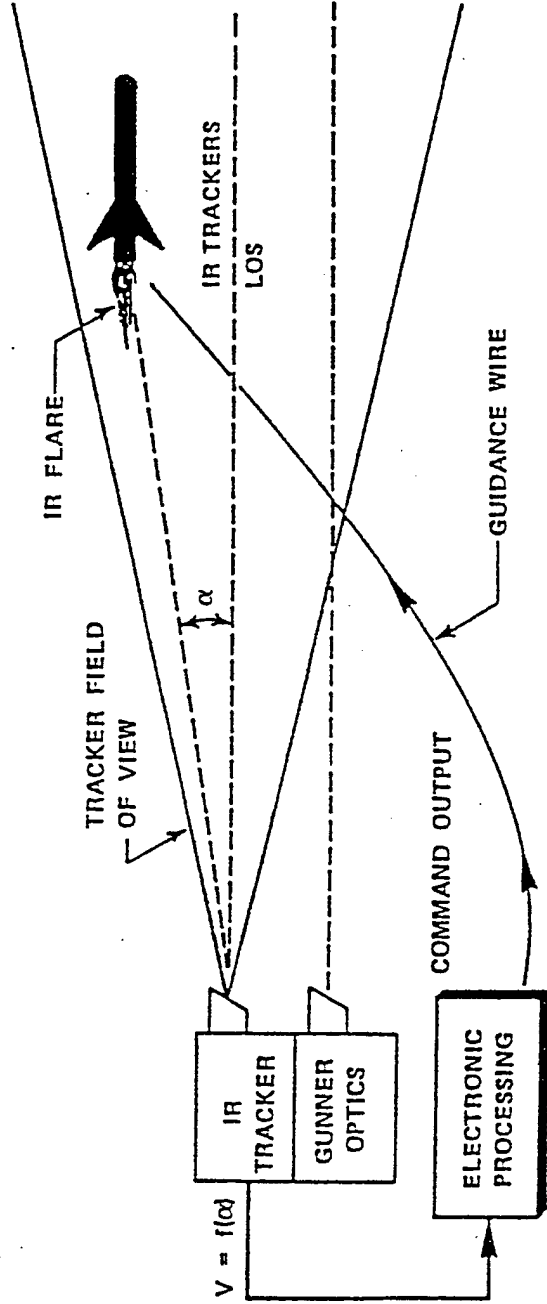
ATGM GUIDANCE AND CONTROL TECHNOLOGY



Gunner must visually track both target and missile

Figure 1. Manual Command Line-of-Sight

ATGM GUIDANCE AND CONTROL TECHNOLOGY



Gunner tracks target only: Missile tracks automatic

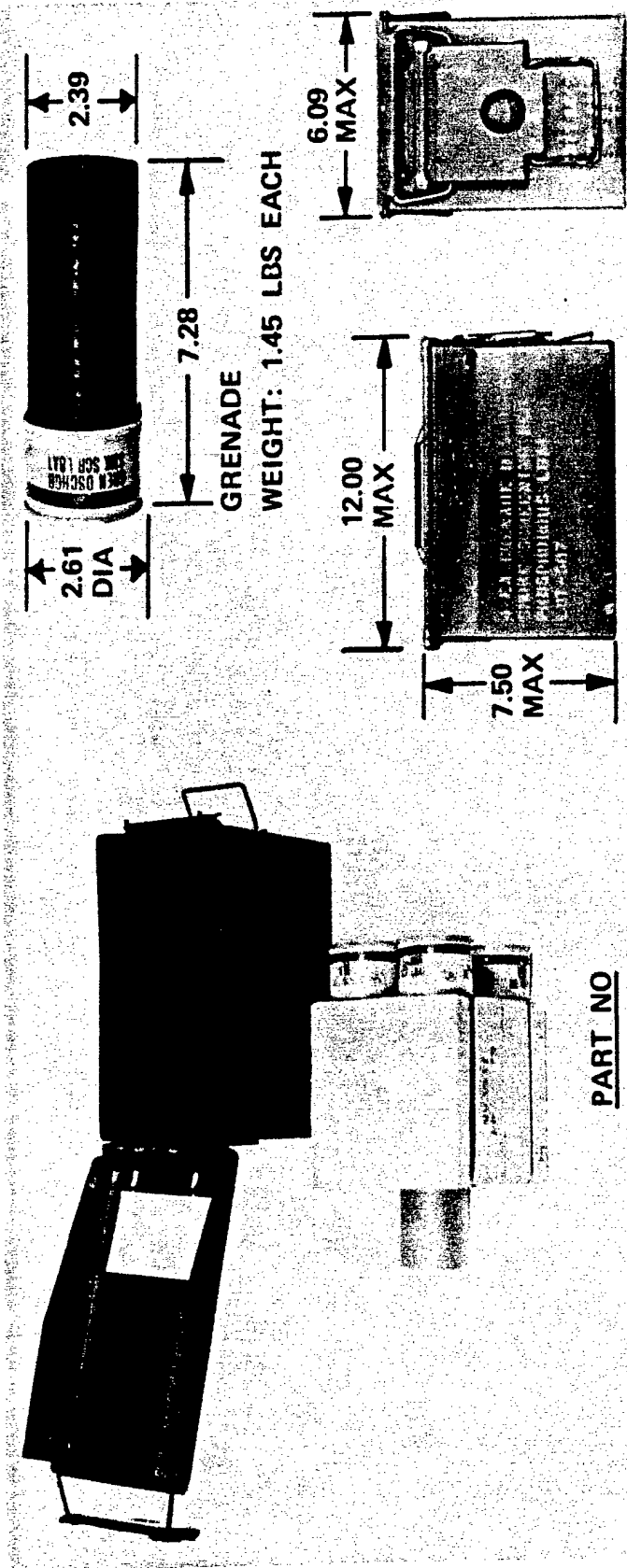
Figure 2. Semi-Automatic Command Line-of-Sight

The first generation ROS installed on U.S. vehicles were adaptations of British dischargers and their Grenade, Launcher, Smoke: Screening RP, UK, L8 (Figure 3). The initial installation on the M60A3 Tank occurred in 1976. The system consisted of the Launcher, Grenade, Smoke Screening, RP, M239 (Figure 4) and 24 L8 Grenades. The launcher uses two six-tube dischargers in a left and right hand configuration, two firing buttons and a safe/arm switch for a manual control system, and two six-grenade storage boxes. When installed on the vehicle, the vehicle crew acted as the detection and warning system, and the threat resolution module, to determine when the ROS should be functioned. The system is designed to provide 120° initial coverage forward of the vehicle turret, 50 m long (about five times the maximum vehicle dimension), greater than 6 m high (Figures 5 and 6), in less than 5 s, and to last for 60-90 s.

To accomplish this, a salvo of six L8 Grenades is fired in a nominal 20° spread in azimuth to function 9 m above the ground, 30 m forward of the launch point. The grenades burst about 1 s after firing, dispersing 350 g of 1-cm red phosphorous pellets. The black powder flash and red phosphorous ignition produce an initial airborne cloud followed by a waterfall of white streamers of burning phosphorous (Figures 7 and 8). The pellets on the ground continue to burn, producing phosphorous pentoxide from the oxygen in the air. Phosphorous pentoxide is hygroscopic and adsorbs water from the atmosphere. The phosphorous pellets continue to generate useful smoke for about 60 s. The screening smoke continuously diffuses in the atmosphere and is transported by the wind to obtain a large protected area. Evasive maneuvers, behind the cloud, by the vehicle (changing direction and/or speed) further reduces the probability of a hit. The installed system provided a second salvo of six grenades to defend against a second attack. In poor smoke conditions (low humidity), both salvos of grenades could be used to defend against a single attack. The ROS also contained 12 additional grenades to be loaded into the dischargers by the crew to provide two more protective salvos before it is necessary to be resupplied from an ammunition resupply point. This ROS was initially installed on several heavy armored vehicles (Figure 9) as the M239 Launcher and L8A1 Grenade. It was later installed on the M1 Abrams with integrated controls as the M250 Launcher and is the system currently available to the operators of the M1A2 Abrams.

For smaller vehicles, an ROS using a 4-tube discharger with a nominal 15° spread in azimuth was installed. This system used the operator for detection and warning, had a single firing button and a safe/arm switch, and had a reload of eight grenades. This system provided the same 120° coverage, compromised for bad smoke conditions by firing an eight grenade salvo instead of a six grenade salvo; however, this system provided only one ready salvo and manual reload before it was necessary to be resupplied from an ammunition resupply point. This system with the Launcher, Grenade, Smoke Screening: RP, M259 (Figure 10) and the L8 Grenade was installed on the M113 Armored Personnel Carrier and on several other vehicles using the M243 and M257 Launchers (Figure 11).

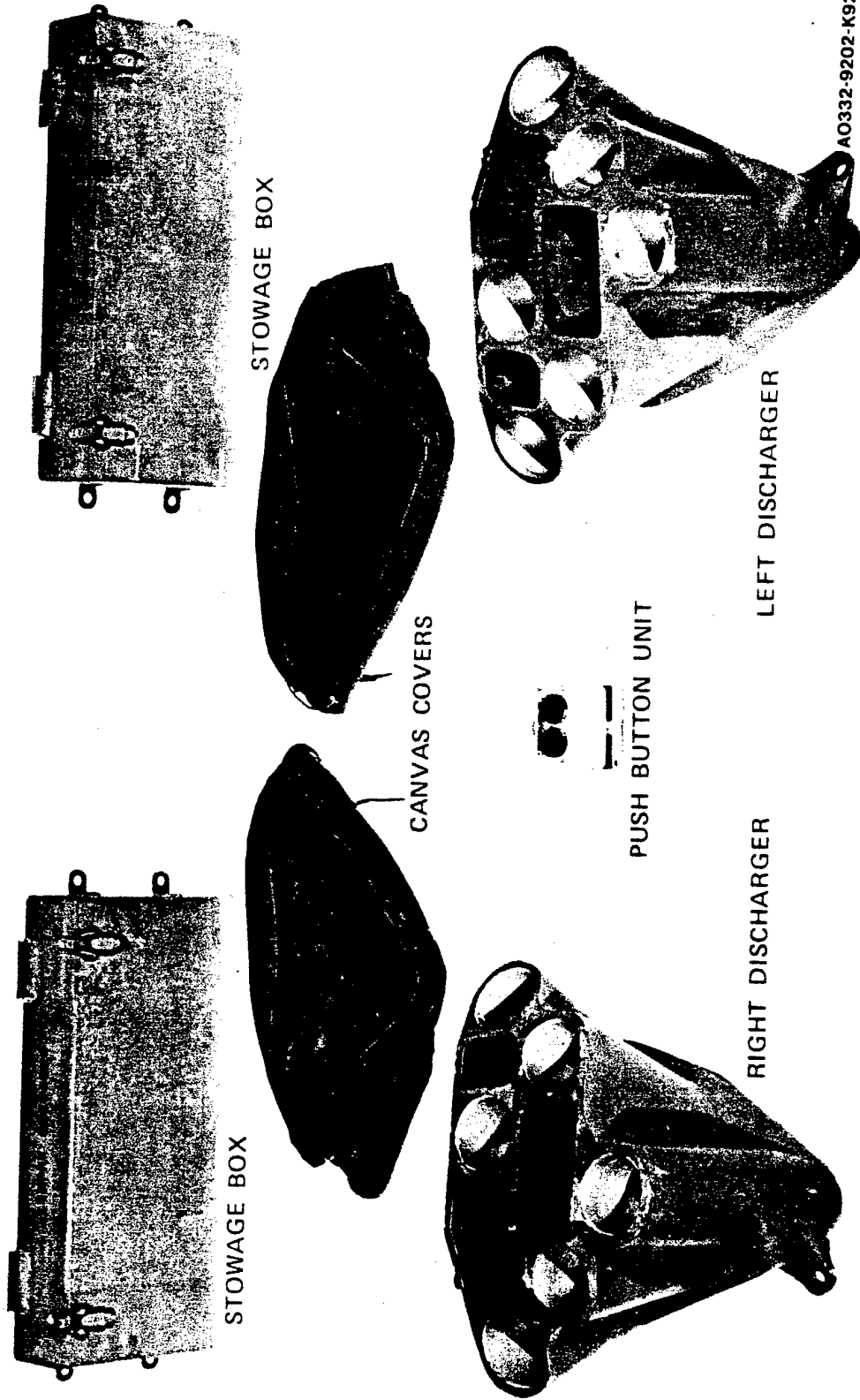
These ROS systems were installed on direct fire weapon systems providing ground level protection against visually guided, direct fire, ground and helicopter launched, smart, Anti-Tank Guided Missiles (ATGM). Tactically, they provided forward 120° ground level protection, with two salvos ready to fire, and two reload salvos available in the tank standard load, against the visible threat of the 1960s and the 1970s. Perceived vehicle limitations led to single salvo systems on smaller vehicles.



	<u>UK</u>	<u>US</u>
GRENADE	TW74GF	13-19-100
CONTAINER GD/10(P)/100308	13-19-128	
WEIGHT: 12.7 LBS (CONTAINER WITH 4 GRENADES)		

CONTAINER ENVELOPE
 DIMENSIONS IN INCHES
 WEIGHT: (CONTAINER WITH PACKING)
 6.9 LBS

Figure 3. UK L8A1 Grenade and Container



STORAGE BOX

CANVAS COVERS

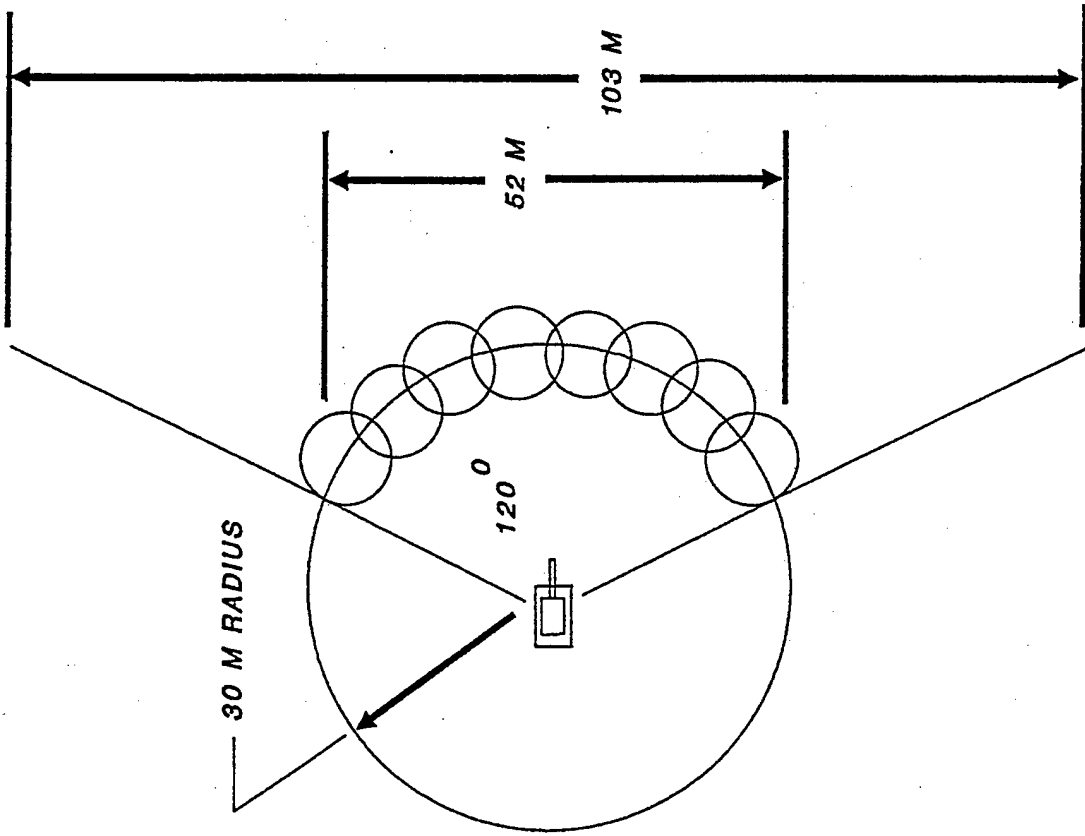
PUSH BUTTON UNIT

RIGHT DISCHARGER

LEFT DISCHARGER

AO332-9202-K92 1-15567

Figure 4. Launcher Grenade Smoke Screening, RP, M239



RANGE	FRONT COVERAGE
30 M	103 M
100 M	346 M
1000 M	3460 M
2000 M	6920 M

Figure 5. Ground Level Smoke Protection

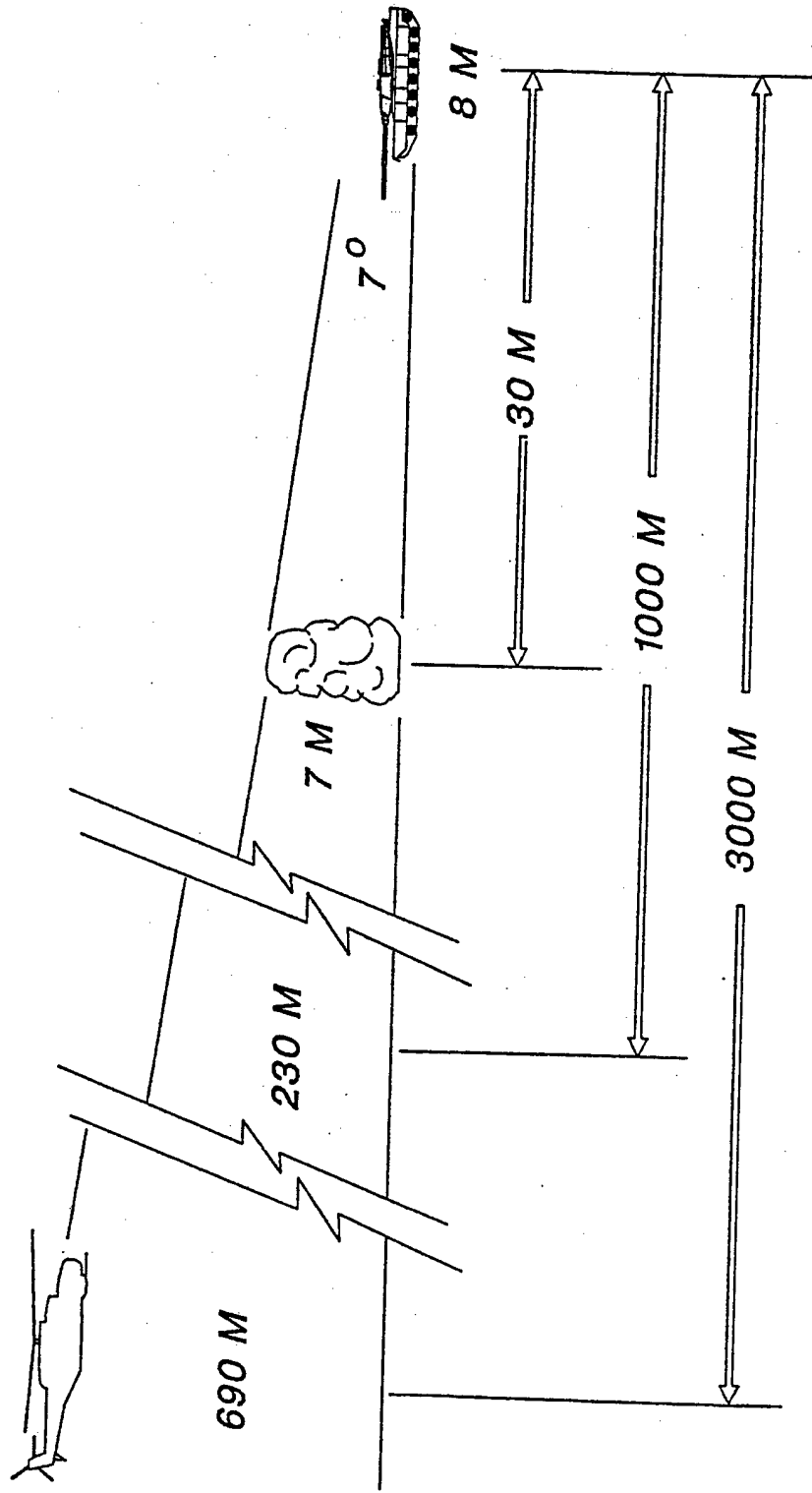
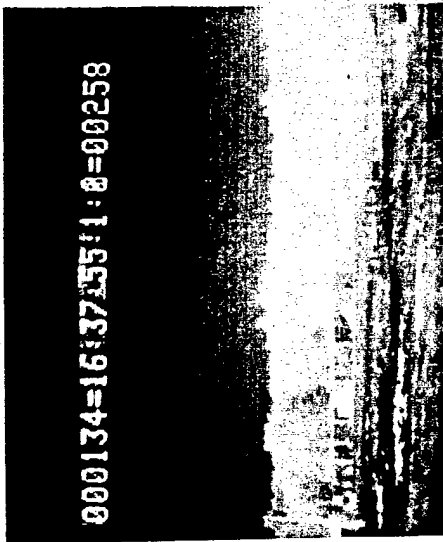
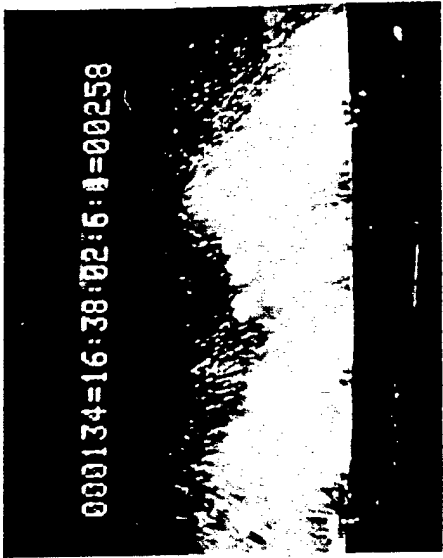


Figure 6. Aerial Protection from Ground Level Smoke

8-12 μm



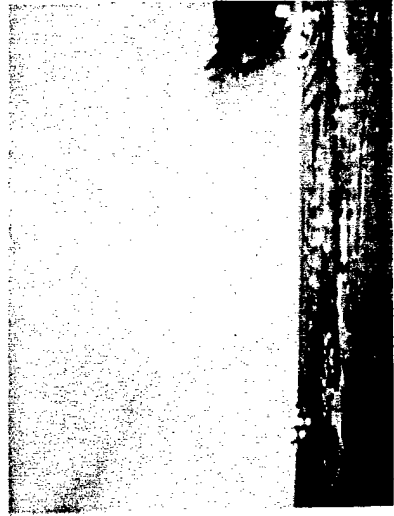
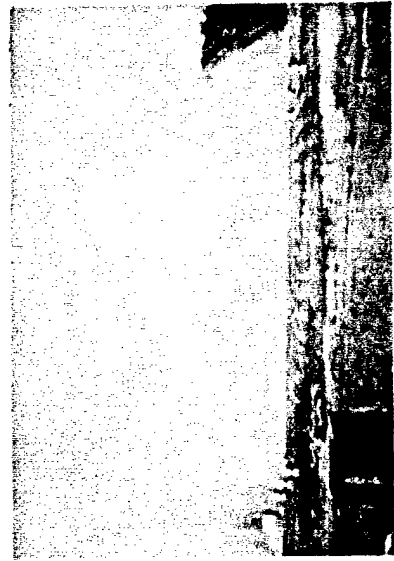
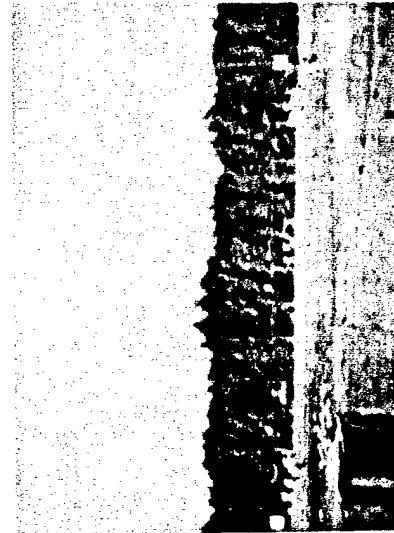
t = -5 sec



t = 2 sec



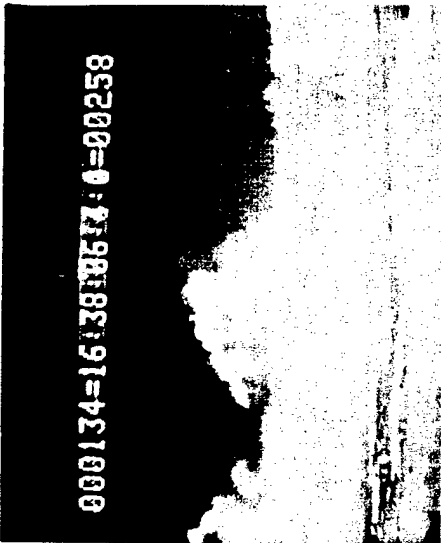
t = 4 sec



VISIBLE

Figure 7. L8A3 Grenade -- Visible Versus Infrared Protection (-5 to 4 s)

8-12 μm



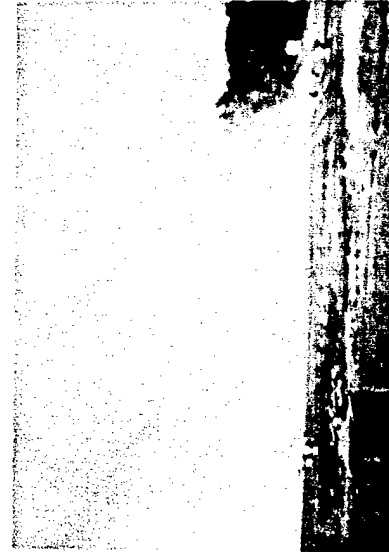
t = 6 sec



t = 8 sec

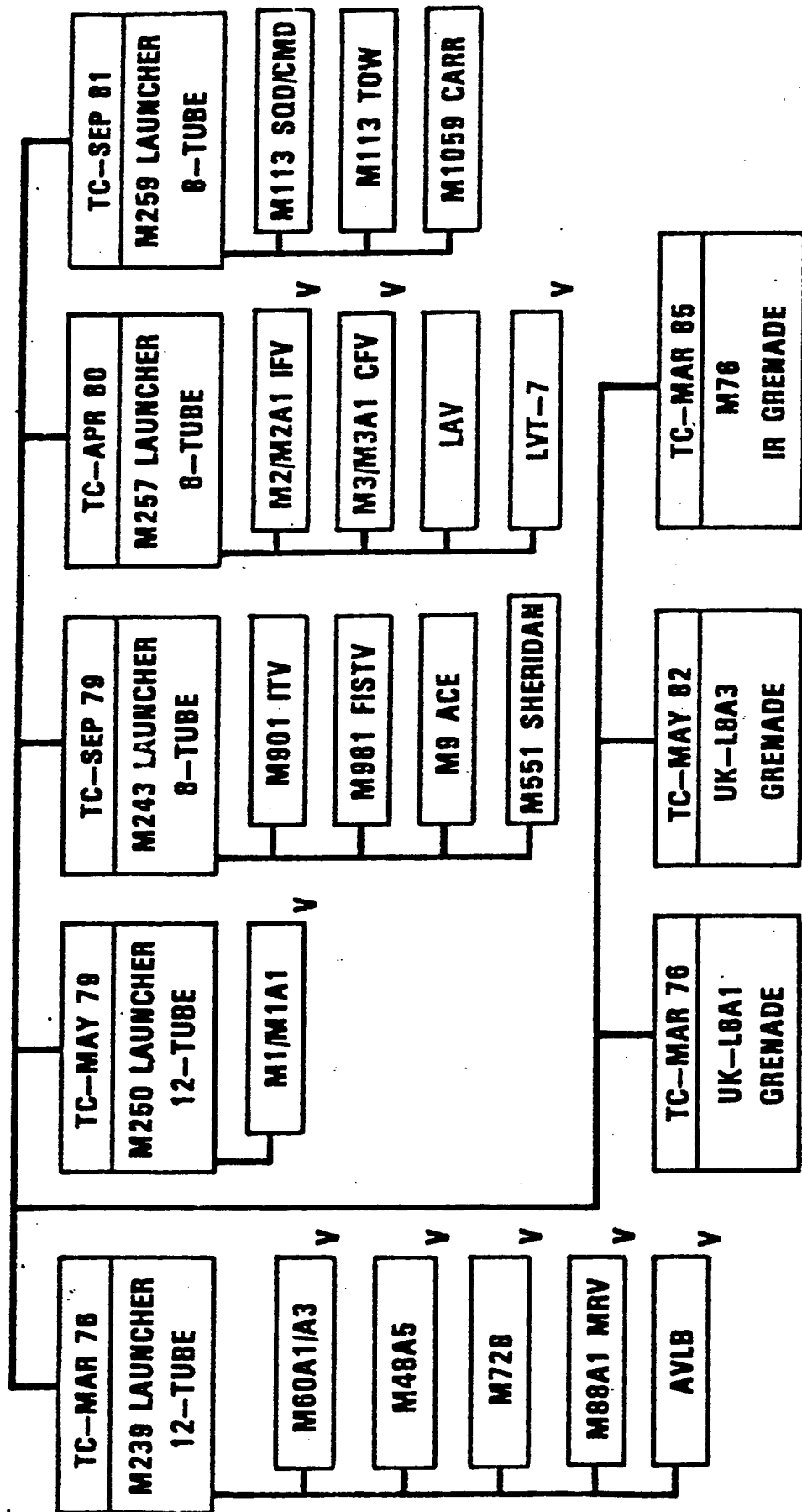


t = 10 sec



VISIBLE

Figure 8. L8A3 Grenade -- Visible Versus Infrared Protection (6 to 10 s)



V - INDICATES VEHICLE ALSO HAS REQUIREMENT FOR VEHICLE ENGINE EXHAUST SMOKE SYSTEM (VESS)

Figure 9. Rapid Obscuration System Applications

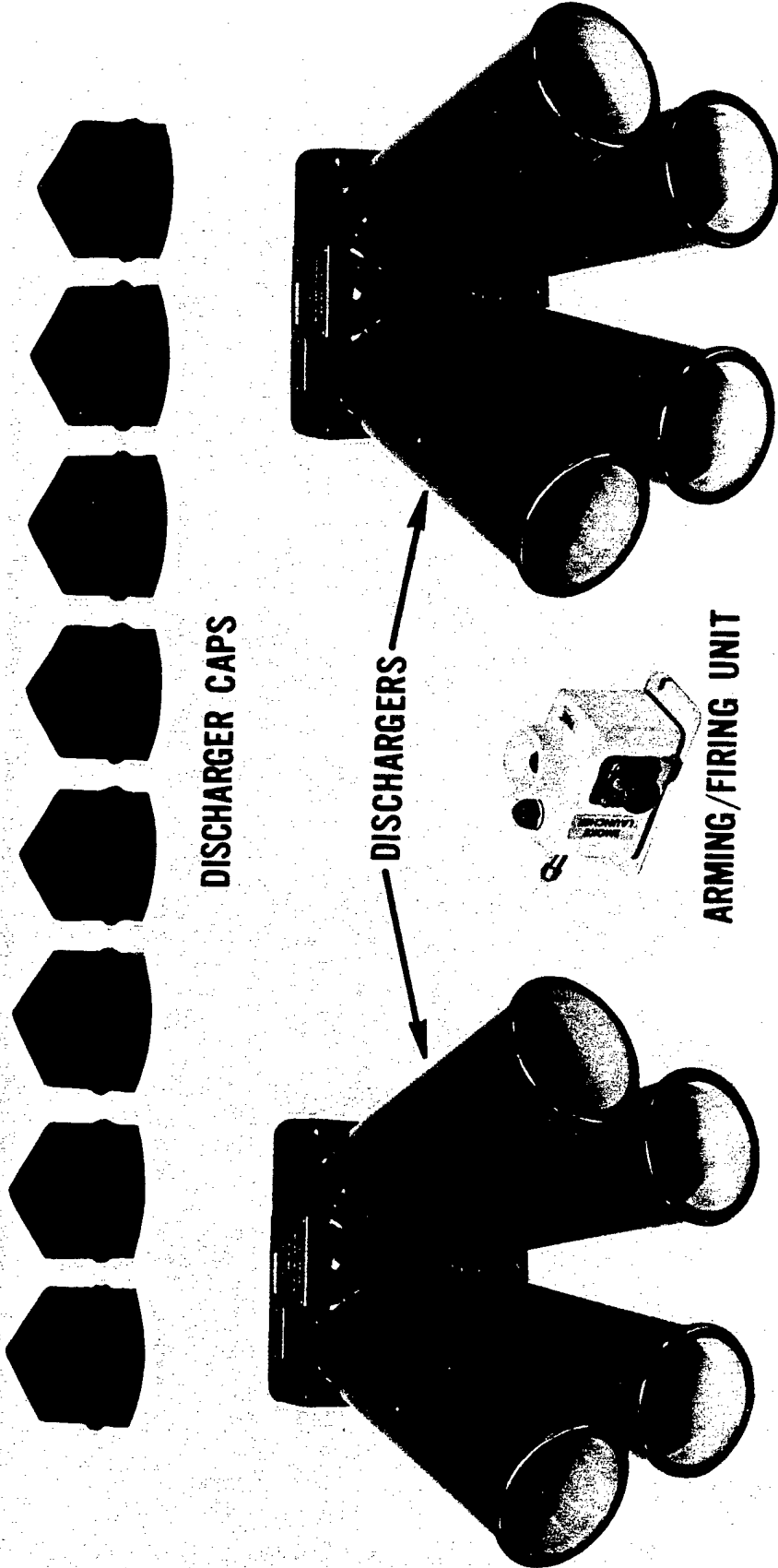
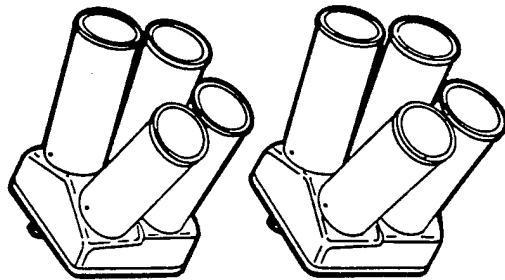


Figure 10. Launcher, Grenade, Smoke Screening: RP, M259

(v blank)/1-0

TM 9-1040-267-20&P

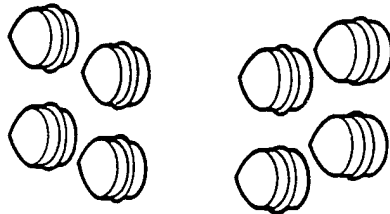


DISCHARGER, SMOKE: GRENADE

M243 LAUNCHER

M257 LAUNCHER

M259 LAUNCHER

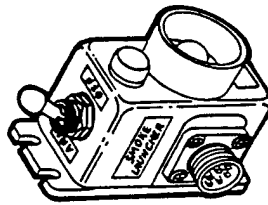


CAP-PLUG, PROTECTIVE, DUST AND MOISTURE SEAL: DISCHARGER

M243 LAUNCHER

M257 LAUNCHER

M259 LAUNCHER

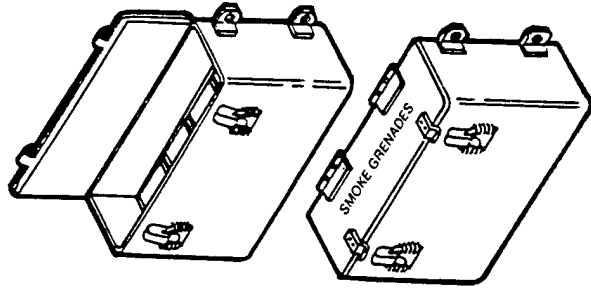


ARMING FIRING UNIT: GRENADE DISCHARGER

M243 LAUNCHER

...

M259 LAUNCHER



BOX, VEHICULAR ACCESSORIES STORAGE: SMOKE GRENADE

M243 LAUNCHER

...

...

Figure 11. Launcher Configurations Using 4-Tube Discharger

As seeker and guidance technology improved, the ATGM threat moved to the mid infrared (MIR) and far infrared (FIR) regions of the electromagnetic spectrum. The smoke/obscurants community looked for a smoke material to extend the ROS capability through the IR region. The Grenade, Launcher, Smoke: IR Screening, M76 (Figures 12 and 13) development program was initiated in 1979 using the M1 Tank Required Operational Capabilities (ROC) and a letter of agreement. This project was completed in 1985, adding a significant change to the components available to build a first generation ROS. The M76 provided approximately uniform protection in the visible and IR regions of the spectrum. However, the duration of a moving protective cloud was 40 s for a salvo of twelve grenades (separated by 10°) and 30 s for a salvo of eight grenades (separated by 15°). A salvo of six grenades (separated by 20°) did not form a satisfactory cloud. (ref. Indep Eval Rpt). The individual grenades launched at a 25° elevation function in 1.7 s, at a nominal range of 30 m, and a height equal to their launch height. The grenades burst and form a toroidal cloud of brass screening material that transports and diffuses with the wind.

Although the new grenade was added to the inventory and was available for wartime use, the launch portions and standard grenade loads for the vehicle ROS were never reevaluated or modified to take maximum advantage of the new capability. Instead, each unit had to decide how and when to incorporate the M76 Grenade into its vehicle protection system and how to trade off visible for IR protection. This situation exists today as it did in 1985 with one minor exception. During Desert Shield, the U.S. Marine Corps modified the launch system on their M1 Tanks by removing the M250 Launcher and replacing it with two M257 Launchers (Figures 14 and 15), thus providing two salvos of eight grenades, ready to fire. This supports either one salvo of L8 and one salvo of M76 Grenades or two salvos of either grenade type.

In January 1987, the Operation and Organization (O&O) Plan for the Combat Vehicle Defensive Obscuration System (CVDOS) was approved. This plan recognized that significant changes in the threat had occurred since the start of the ROS efforts. This requirement addressed the need for millimeter (MM) spectral region protection, the 360° ground level threat, a 360° overhead threat, and the need for an integrated, computer-controlled, automatic detection and response, Vehicle Integrated Defense System (VIDS). The plan also recognized the need for more ROS training and light vehicle protection.

In 1989, development of the Grenade, Launcher, Smoke: Simulant Screening, M82 (Figure 16) was started as a product improvement program to the M76 Grenade for training, without the fire hazard of the L8 and less toxicity hazard than the M76. The system was type classified in 1993 and fielded in 1994.

The advanced development program for the M81 grenade was conducted from 1987 to 1992. In the transition to full scale development, the Operational Requirements Document (ORD) required the grenade to provide IR and MM instead of just MM protection. The Grenade, Launcher, Smoke: Millimeter/Infrared (MM/IR) Screening, M81 (Figure 17) was type classified in 1995 and is scheduled to begin production in 1998.

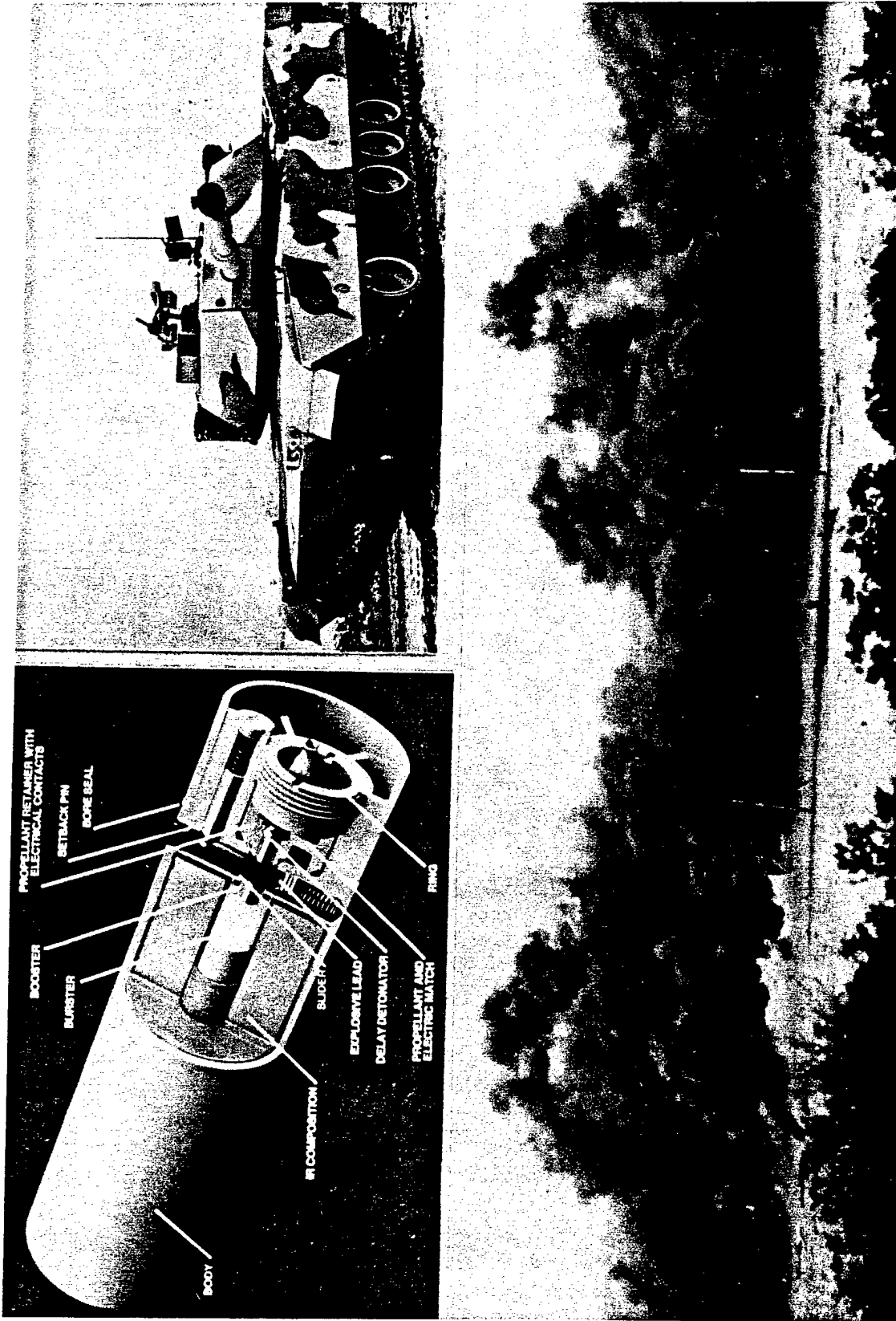


Figure 12. M76 Grenade, Launcher, Smoke: IR Screening

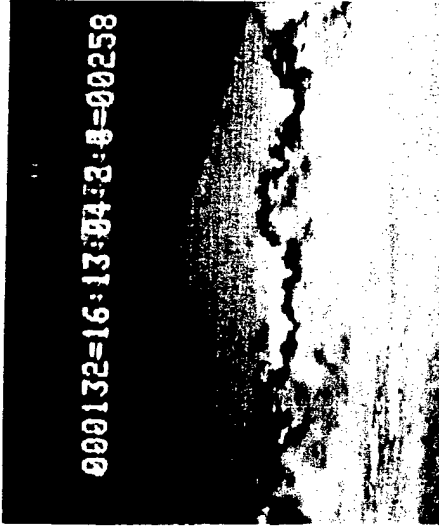
8-12 μm



$t = -6 \text{ sec}$



$t = 2 \text{ sec}$



$t = 4 \text{ sec}$



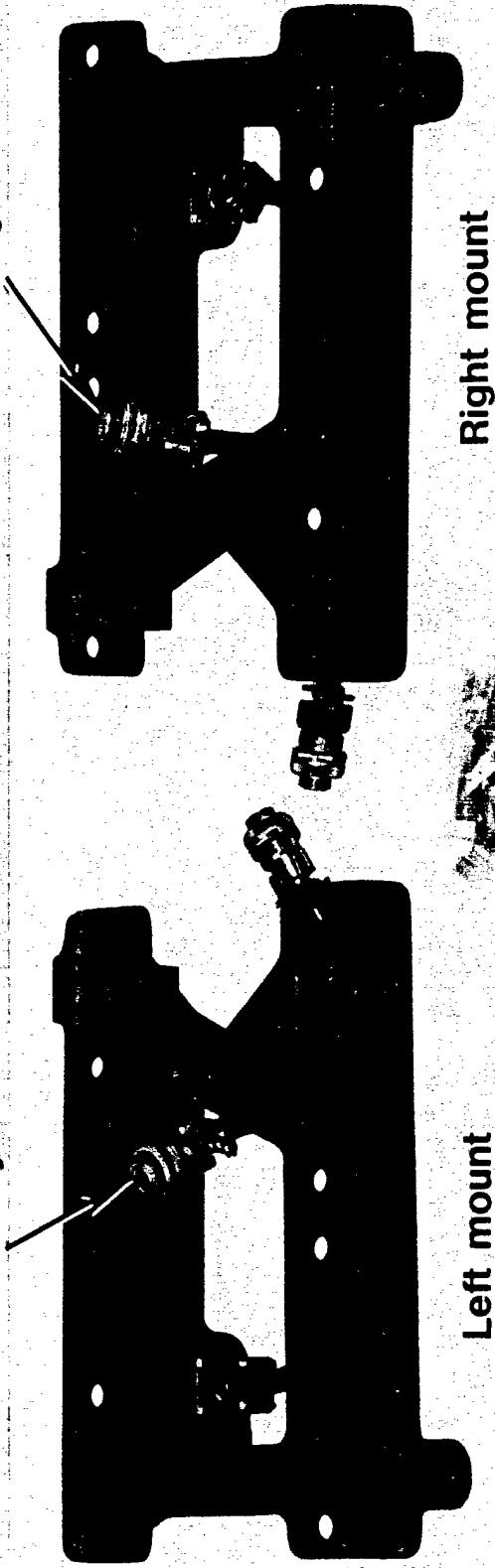
VISIBLE

Figure 13. M76 Grenade -- Visible Versus Infrared Protection (-6 to 4 s)

NSN: 1055-01-333-0636

Left cable assembly

Right cable assembly



Right mount

Left mount

Mounting hardware for:

Dischargers

Mounts

Cable assemblies

Spare parts:	NSN:
Cable assembly right side	6150-01-330-9436
Cable assembly left side	6150-01-330-9435
Right mount	5340-01-333-2301
Left mount	5340-01-333-2300

A0332-9310-A93-1-16154

Figure 14. Installation Kit Assembly



Figure 15. Dual M257 Launchers on an M1 Tank

The M82 is an environmentally acceptable training grenade for the M76 Infrared screening and the LA43 Visual screening grenades. The M82 smoke material is titanium dioxide and the grenade is capable of being launched from all 66mm smoke grenade launchers.

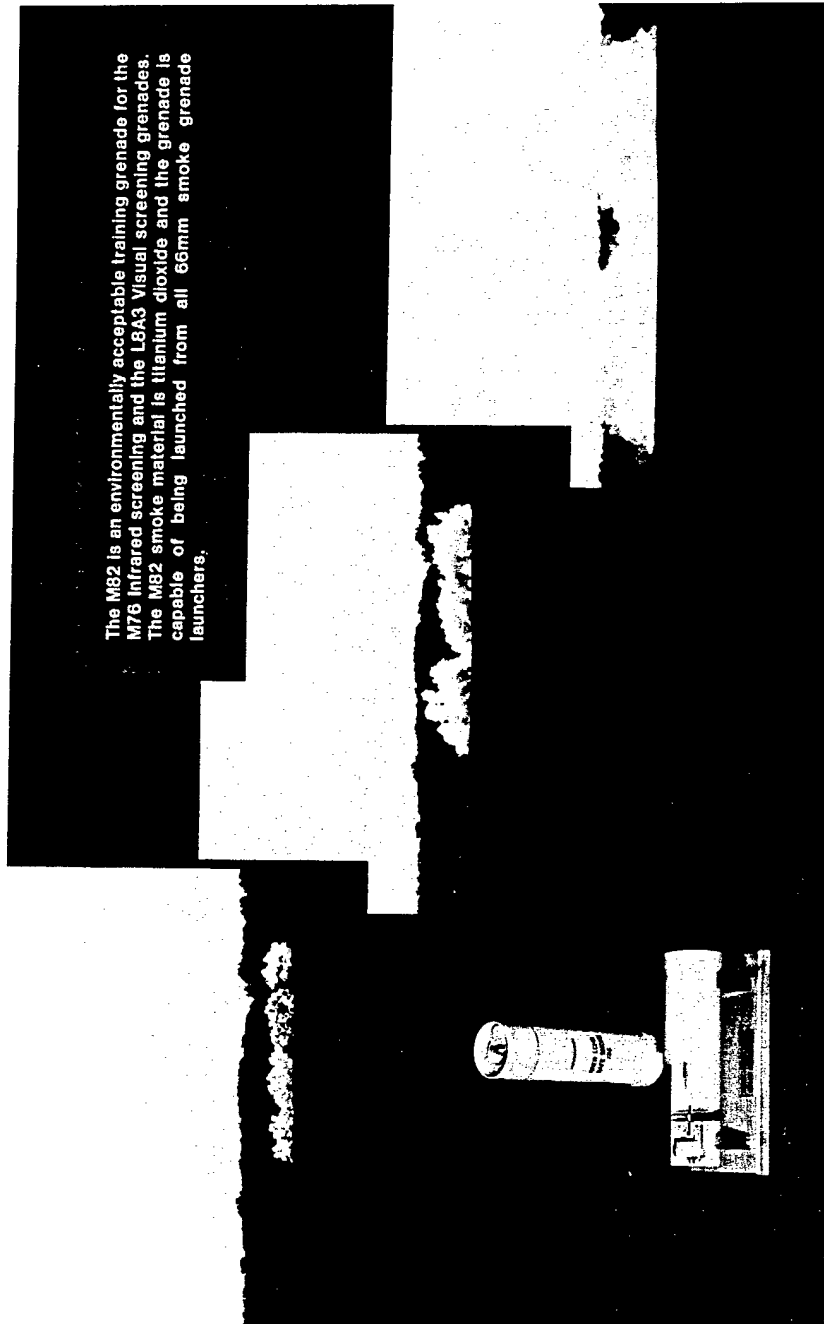
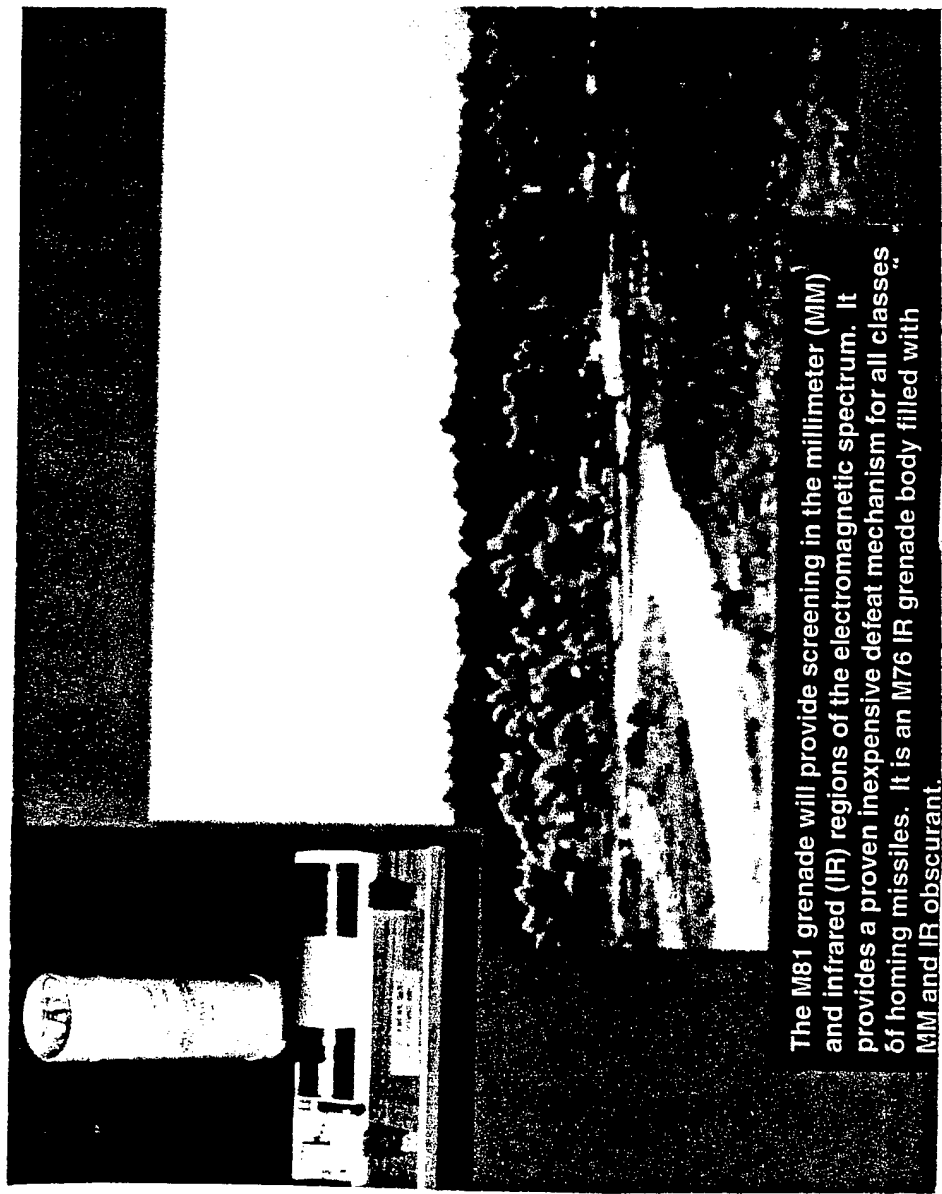


Figure 16. Grenade, Launcher, Smoke: Simulant Screening, M82



The M81 grenade will provide screening in the millimeter (MM) and infrared (IR) regions of the electromagnetic spectrum. It provides a proven inexpensive defeat mechanism for all classes of homing missiles. It is an M76 IR grenade body filled with MM and IR obscurant.

Figure 17. Grenade, Launcher, Smoke: Millimeter/Infrared Screening, M81

The CVDOS O&O program led investigators to rethink the total needs of an ROS. During the program, a notional 96-tube system was defined (Figure 18). This system became the model for future sophisticated multiresponse (automated with variable frequency, direction, elevation, magnitude of response) ROS.

This system would initially be manually controlled (either hard wired or computer directed) (Figures 19 and 20) but easily adaptable to a detector system and threat resolution module, which would make up a VIDS. The system maintained the concept of protection against two attacks in any direction without reload but carried all of its grenades in a ready-to-fire condition. It provided two protective salvoes of L8 grenades to the forward 120° sector, two protective salvoes of M76 grenades to the forward, left rear, and right rear sectors of the vehicle, and two protective 360° salvoes of M81 grenades overhead. The system would have individual control of the discharger tubes so when VIDS became available, the number of grenades expended at one time could be reduced to a minimum. The detection system could continually monitor the situation and initiate the firing of additional grenades as needed.

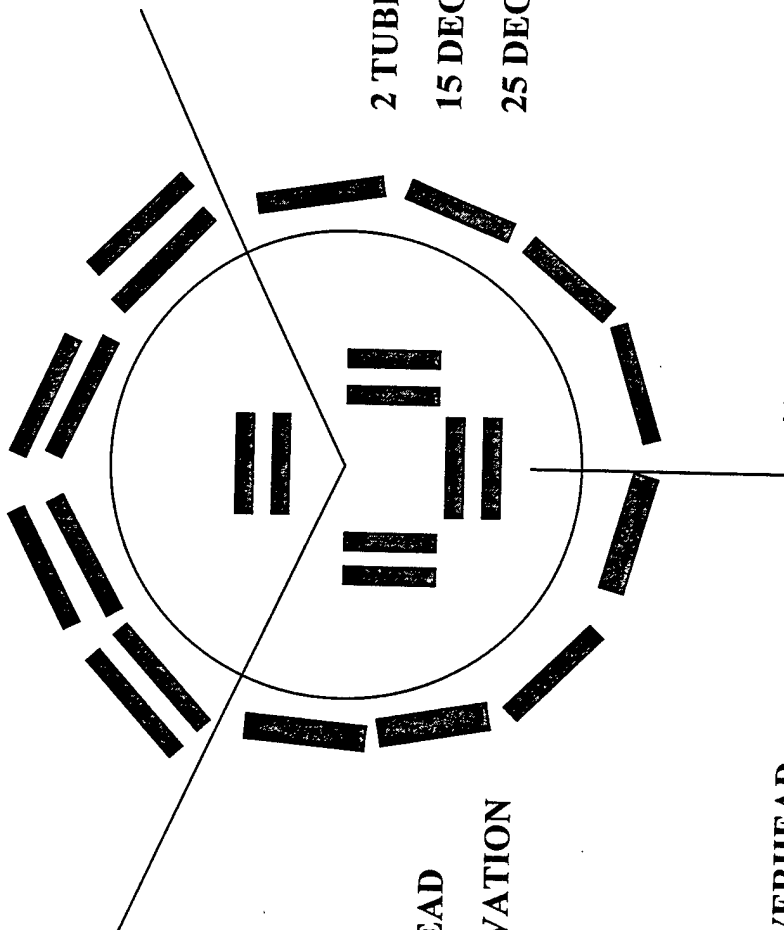
An initial manual demonstration system was built in 1986 and fired at Dugway Proving Ground, UT, in October 1996, including an overhead protection demonstration using M76 grenades (Figures 21 and 22). The Concept Exploration and Definition Phase for the Discharger, Grenade, Smoke, Countermeasure: M6 (Figure 23) was completed with full system testing in 1989.

The Engineering and Manufacturing Development Phase for the new discharger to support this system (with individual tube control, light weight, and inventory control capability) was conducted from 1990 to 1993. Because of the requirement to be compatible with the existing grenade inventory of L8 and M76 Grenades, inventory sensing was limited to grenade presence in a tube; but, preloading the grenade type put in each tube would still allow the threat resolution module to provide the best response available with the remaining grenade inventory. The first demonstration of an automated ROS was on the VIDS/Bradley Demonstrator in August 1992 at Eglin Air Force Base, FL (Figure 24).

The M6 Discharger was type classified standard in October 1993 and is scheduled to start production in 1998.

The ROS improvements defined in the CVDOS O&O Plan were scheduled to be implemented as a portion of the Armored System Modernization Common Chassis Program. This would have allowed the systematic inclusion of a VIDS adapted ROS modified to meet the specific threat environment of each individual variant in the new generation of armored vehicles. Fielding was planned to begin in 2000. Following Desert Storm in 1994, the common chassis program was terminated, and the decision was made to adapt several vehicle variant improvements to the Abrams and Bradley chassis with the exception of the new artillery vehicle and its resupply vehicle, which would include the development of a new chassis. Following the demise of the common chassis program, improvements in vehicle survivability are being addressed individually for each armored vehicle development and block improvement program. Although the decision and control functions have been decentralized, the implementation of improved vehicle smoke/obscurants protection is still directed by the U.S. Army Edgewood Research, Development and Engineering Center, and

4 TUBES 15 DEGREE SPREAD 25 DEGREE ELEVATION



2 TUBES

15 DEGREE SPREAD

25 DEGREE ELEVATION

2 TUBES

15 DEGREE SPREAD

25 DEGREE ELEVATION

OVERHEAD

45 DEGREE SPREAD

4 TUBES

73.5 DEGREE SPREAD

Figure 18. Multisalvo Smoke Grenade Launcher

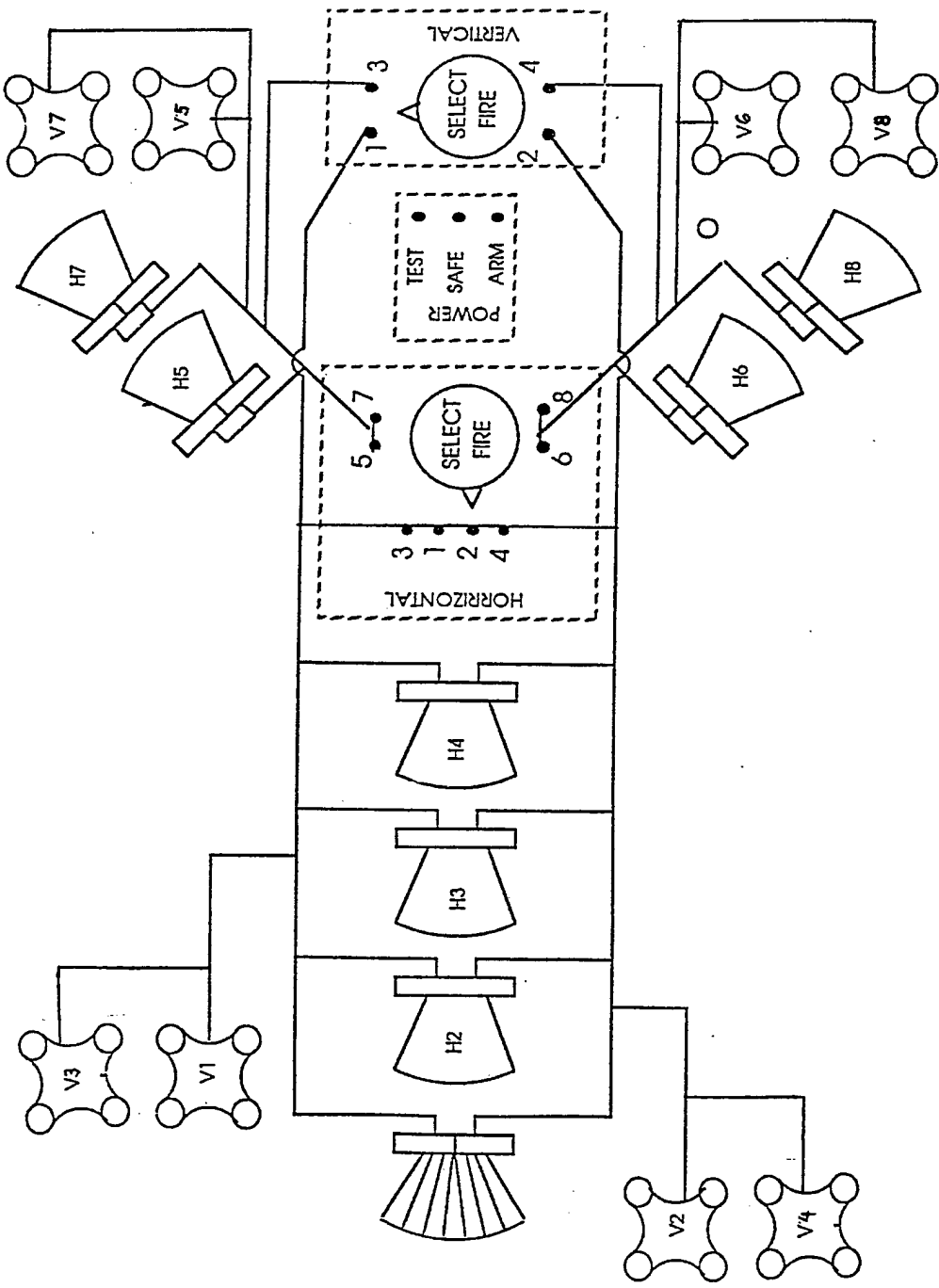


Figure 19. Multisalvo Smoke Grenade Launcher with Controls

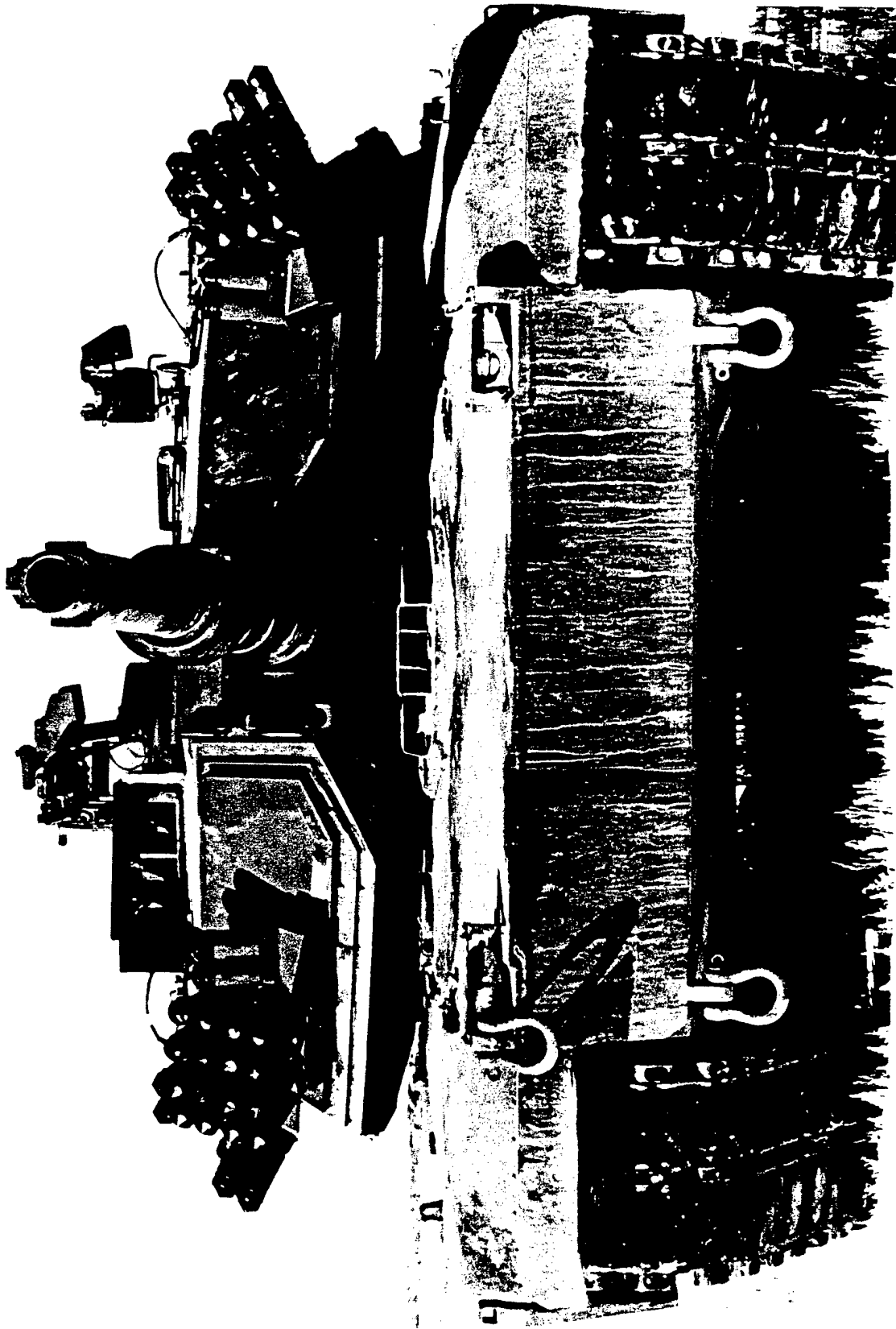


Figure 20. Multisalvo Smoke Grenade Launcher Installed

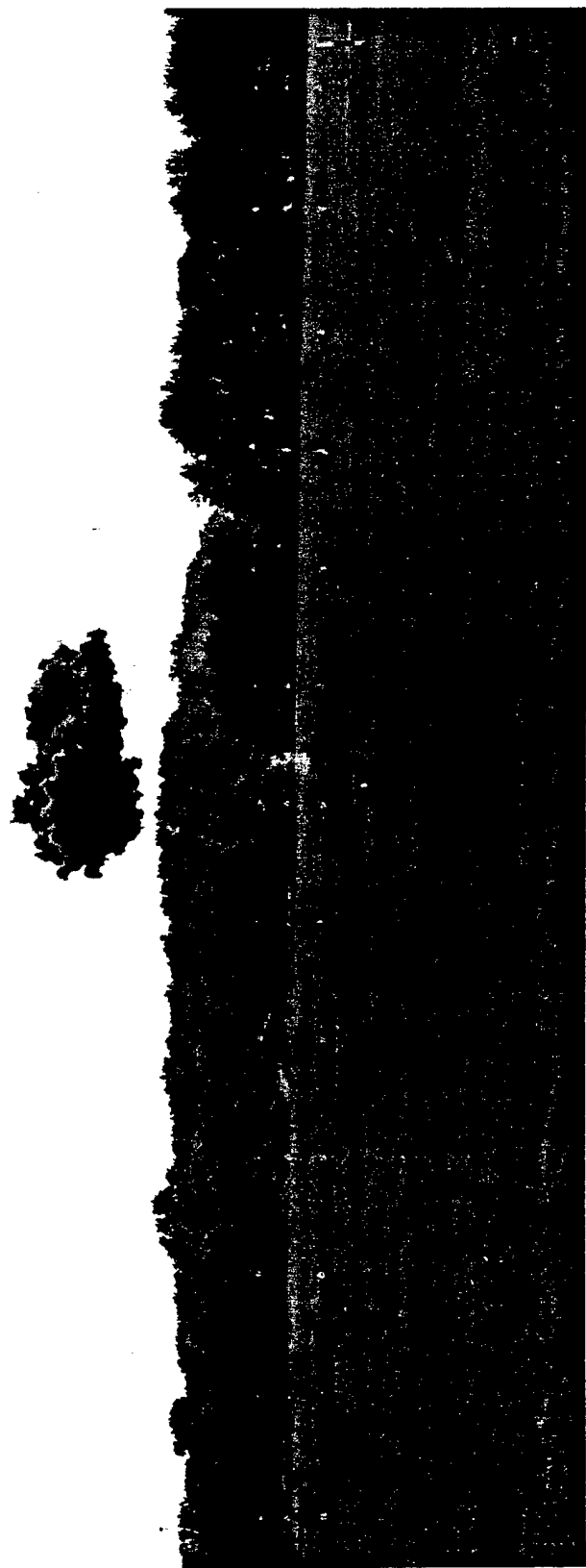
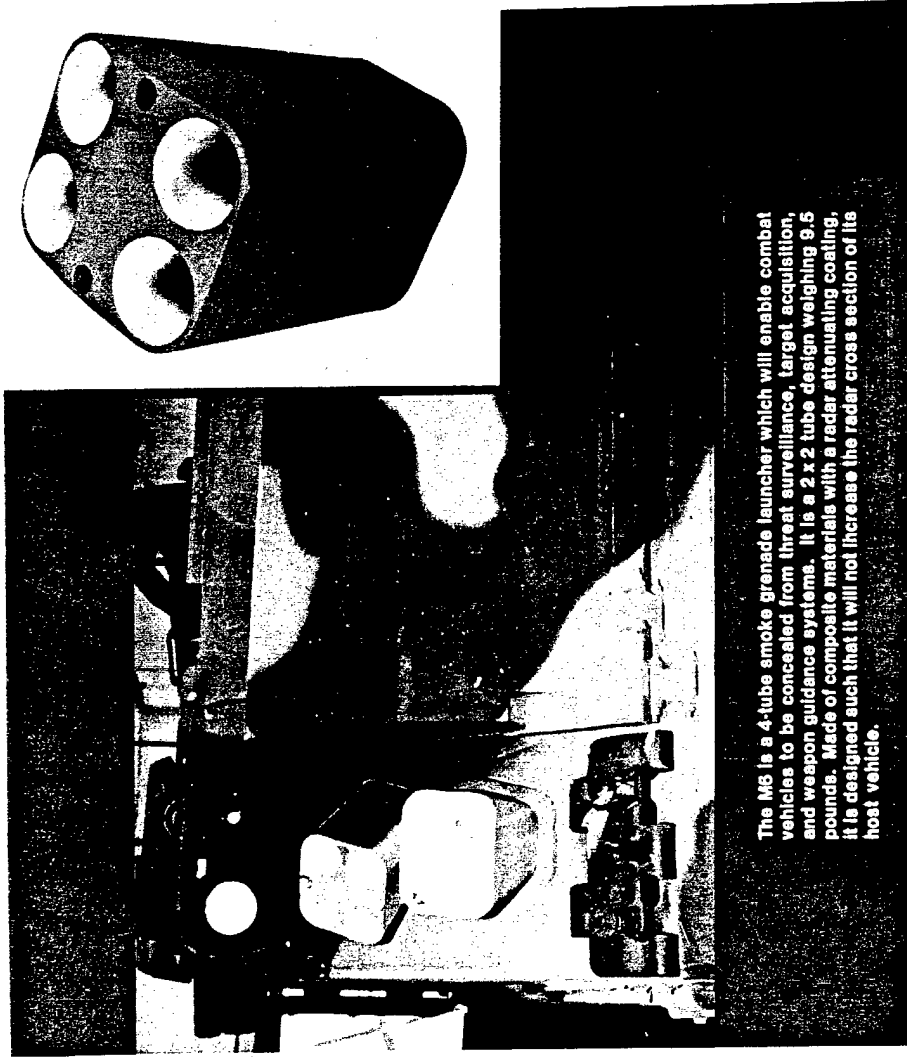


Figure 21. Overhead Protection -- Scene I



Figure 22. Overhead Protection -- Scene II



The M6 is a 4-tube smoke grenade launcher which will enable combat vehicles to be concealed from threat surveillance, target acquisition, and weapon guidance systems. It is a 2 x 2 tube design weighing 9.5 pounds. Made of composite materials with a radar attenuating coating, it is designed such that it will not increase the radar cross section of its host vehicle.

Figure 23. Discharger, Grenade, Smoke, Countermeasure: M6

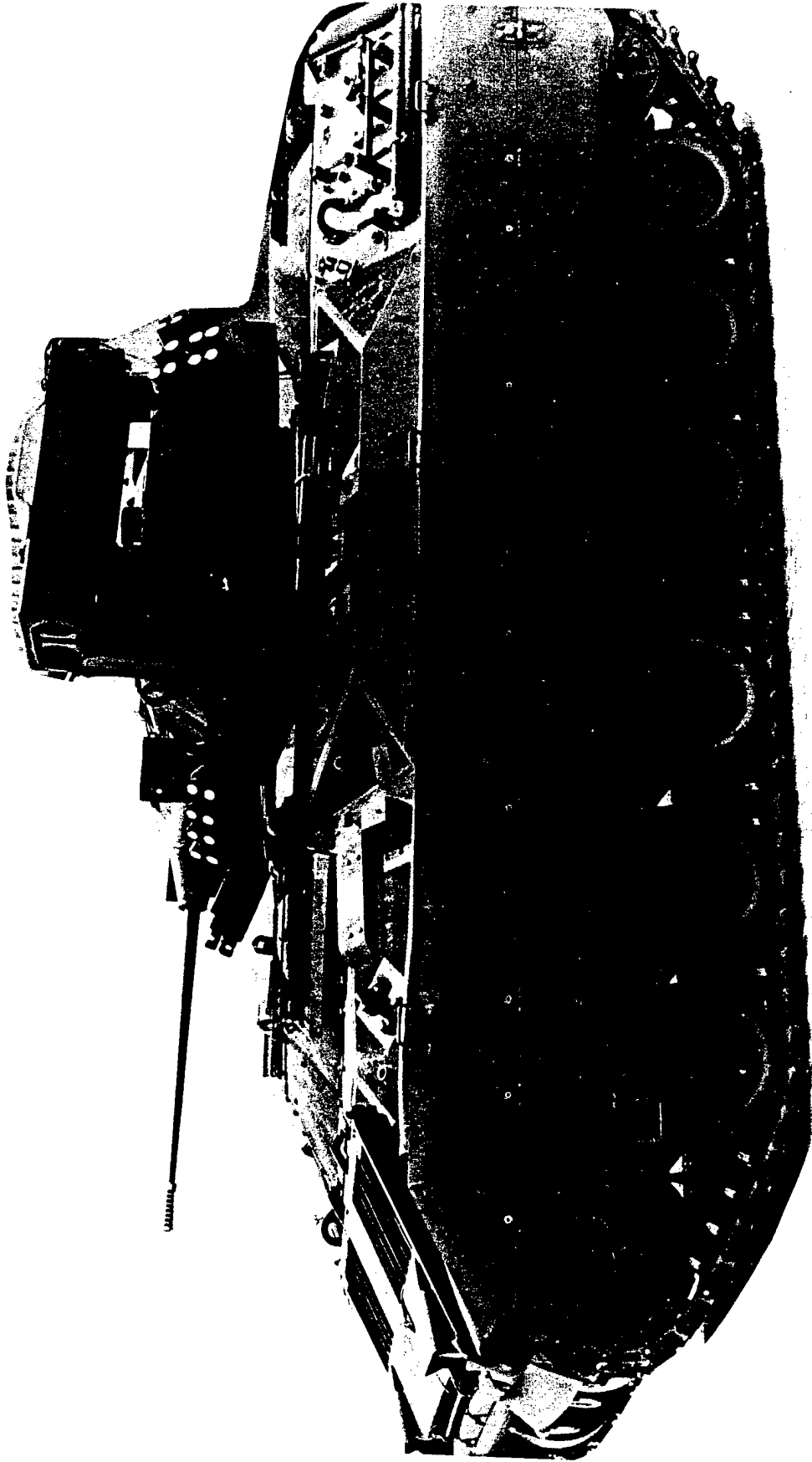


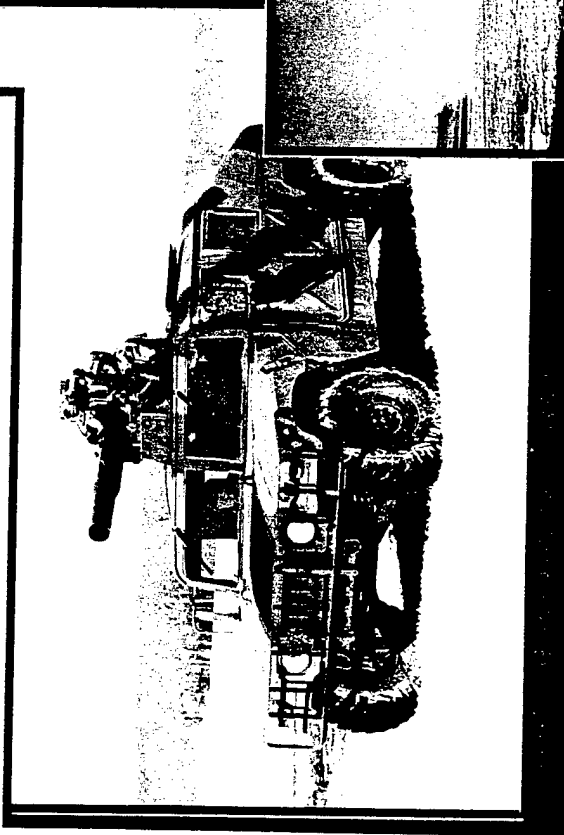
Figure 24. Vehicle Integrated Defense System Demonstrator

consistent guidance for uniform and complementary implementation of the CVDOS goals is being provided to the many TRADOC System Managers, AMC Project Managers, and their U.S. Marine Corps equivalents. Active programs are being addressed for the M1 Abrams, M2 Bradley, Heavy Assault Bridge, Breecher, and Advanced Amphibious Assault Vehicle. The requirement documents for next generation vehicles like the Future Combat Vehicle (FCV), Future Infantry System (FIS), and Future Scout Vehicle (FSV) are being influenced. Individual vehicle threats and mission profiles are being analyzed, and specific ROS designs are being developed based on the CVDOS concepts of coverage, quantity, frequency, and VIDS compatibility.

Initial improvements will be redesigned vehicle launcher systems with more grenade storage capacity and additional fields of coverage. The grenade loads will be modified to reflect threat changes. The control systems will be manually operated; however, the designs will incorporate provisions for connecting them to detector directed computerized systems when they have completed development.

In response to the need for light vehicle protection identified in the CVDOS O&O Plan, the Light Vehicle Obscuration Smoke System (LVOSS) program was started in FY93. The LVOSS consists of the Discharger, Grenade, Countermeasure: Lightweight, M7, the Grenade, Launcher, Smoke: Screening, TA, M90, and a vehicle specific mounting kit and arming and firing switches. The grenades contain 3 terephthalic acid mix canisters, which are launched about 40 m, and burn for 15 s. The grenades are launched in salvos of four, providing an initial 60° spread of low toxicity smoke with a minimum personnel hazard compatible with light vehicle operations. The LVOSS (Figure 25) was type classified standard on 27 August 1997. Work is being done to expand the ROS concept of use by including the CS, 66mm, Anti-Riot, L11 Grenade.

In summary, the first generation ROS technology and hardware are available to significantly improve vehicle survivability. Other ongoing programs are also aggressively seeking to improve vehicle survivability. Significant changes in the ROS capabilities available to vehicle operators will be included in the current vehicle improvements and next generation vehicles.



● Light Vehicle Obscuration Smoke System (LVOSS) is a self defense smoke/obscurant device externally mounted on the vehicle. Potential threats to U.S. areas of interest and national security exist in every region of the world. The LVOSS is expected counter threat weapon systems operating in the visual and near infrared portions of the electromagnetic spectrum. It will interfere with currently used surveillance, target acquisition systems, and weapons guidance systems, thereby giving the host vehicle a better chance of survival. Unlike the armored vehicle version, the LVOSS grenade does not produce fragments, is less toxic, and is a low fire hazard.

Figure 25. Light Vehicle Obscuration Smoke System