PREFACE

This manual provides guidance for planning and executing training on the 5.56-mm M16Al and M16A2 rifles to include the conduct of basic rifle marksmanship and advanced rifle marksmanship. It is a guide for commanders, leaders, and instructors to develop training programs, plans, and lessons that meet the objectives/intent of the United States Army rifle marksmanship program and FM 25-100.

This manual is organized to lead the trainer through the material needed to conduct training in IET and units. Preliminary subjects include discussions on mechanical training, the weapons' capabilities, and the principles and fundamentals of marksmanship. Live-fire applications are scheduled after the soldier has demonstrated preliminary skills. Initial firing will be a grouping exercise that leads to the soldier adjusting the sights on the weapon and to setting the battlesight zero.

The proponent of this publication is HQ TRADOC. Submit changes for improving this publication on DA Form 2028 (Recommended Changes to Publications and Blank Forms) and forward it to Commandant, US Army Infantry School, ATTN: ATSH-I-V-P, Fort Benning, GA 31905-5593.

Unless otherwise stated, whenever the masculine gender is used,both men an women are included.

CHAPTER 1

Introduction

The procedures and methods used in the Army rifle marksmanship program are based on the concept that soldiers must be skilled marksmen who can effectively apply their firing skills in combat. FM 25-100 *stresses marksmanship as a paramount soldier skill. The basic firing skills and exercises outlined in this manual must be a part of every unit's marksmanship training program. Unit commanders must gear their advanced marksmanship training programs to their respective METLs. The proficiency attained by a soldier depends on the proper training and application of basic marksmanship fundamentals. During initial marksmanship training, emphasis is on learning the firing fundamentals, which are taught in a progressive program to prepare soldiers for combat-type exercises*.

TRAINING STRATEGY

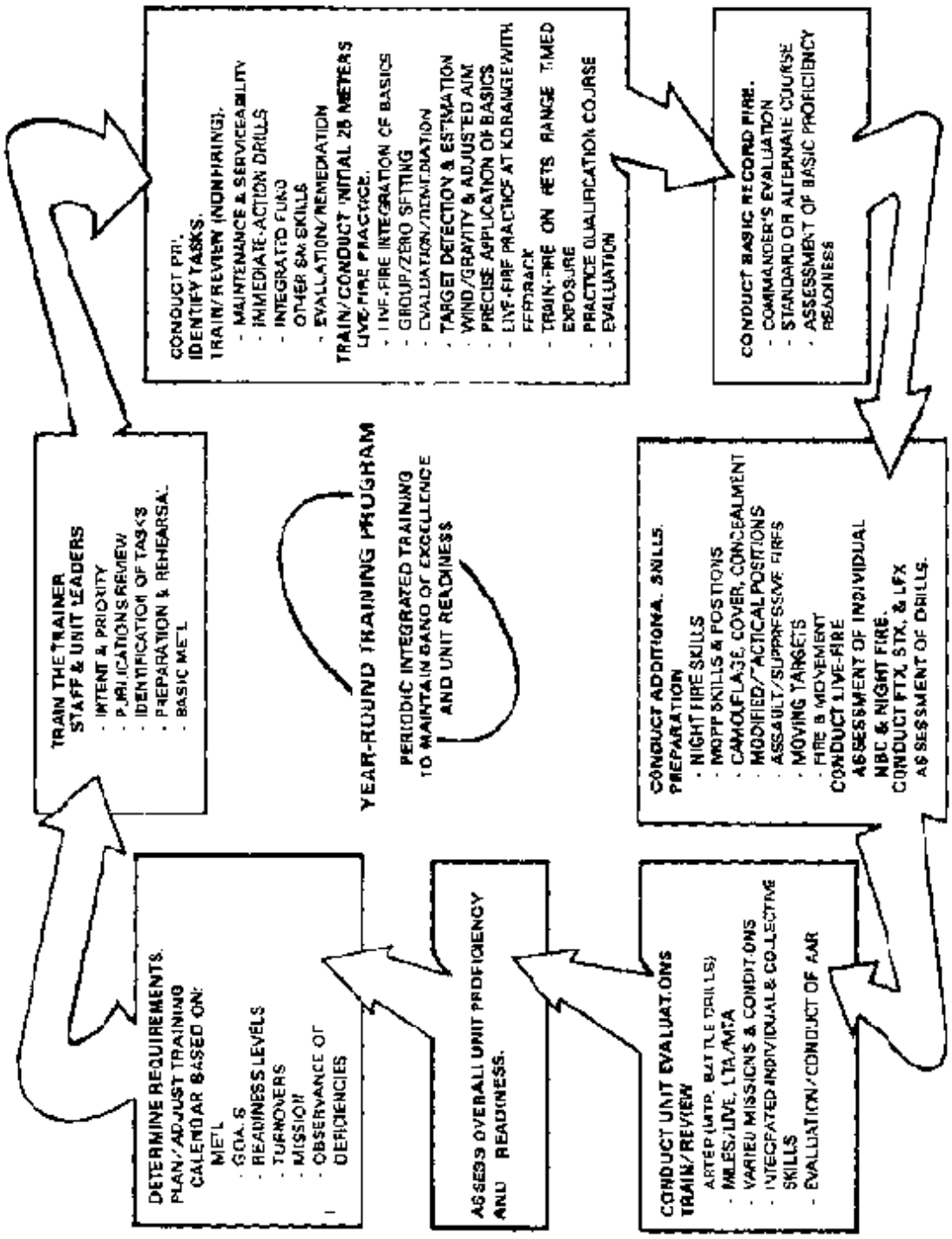
Training strategy is the overall concept for integrating resources into a program to train individual and collective skills needed to perform a unit's wartime mission.

Training strategies for rifle marksmanship are implemented in TRADOC institutions (IET, NCOES, basic and advanced officer's courses) and in units. The overall training strategy is multifaceted and is inclusive of the specific strategies used in institution and unit programs. Also included are the supporting strategies that use resources such as publications, ranges, ammunition, training aids, devices, simulators, and simulations. These strategies focus on developing critical soldier skills, and on leader skills that are required for success in combat.

Two primary components compose the training strategies: **initial training** and **sustainment training.** Both may include individual and collective skills. Initial training is critical. A task that is taught correctly and learned well is retained longer and skills can be quickly regained and sustained. Therefore, initial training must be taught correctly the first time. However, eventually an individual or unit loses skill proficiency. This learning decay depends on many factors such as the difficulty and complexity of the task. Personnel turnover is a main factor in decay of collective skills, since the loss of critical team members requires retraining to regain proficiency. If a long period elapses between initial and sustainment training sessions or training doctrine is altered, retraining may be required.

The training strategy for rifle marksmanship begins in IET and continues in the unit. An example of this overall process is illustrated in Figure 1-1 and provides a concept of the flow of unit sustainment training (Appendix A). JET provides field units with soldiers who have been trained and who have demonstrated proficiency to standard in basic marksmanship tasks. The soldier graduating from these courses has been trained to maintain the rifle and to hit a point target. He has learned target detection, application of marksmanship fundamentals, and other skills needed to engage a target. The specific tasks and programs taught in IET are explained in Appendix A, FM 21-3, and in commanders' manuals.

Figure 1-1. Unit marksmanship sustainment strategy.



Training continues in units on the basic skills taught in IET. Additional skills such as area fire are trained and then integrated into collective training exercises, which include platoon and squad live-fire STXs. (A year-round unit marksmanship training program is explained in Appendix A.) The strategy for sustaining the basic marksmanship skills taught in IET is periodic preliminary rifle instruction, followed by instructional and qualification range firing. However, a unit must set up a year-round program to sustain skills. Key elements include training of trainers, refresher training of non firing skills, and use of the Weaponeer or other devices for remedial training.

Additional skills trained in the unit include semiautomatic and automatic area fires, night fire, MOPP firing, and moving target training techniques. Related soldier skills of camouflage, cover and concealment, fire and movement, and preparation and selection of a fighting position are addressed in FM 21-3, which must be integrated into tactical training.

In the unit, individual and leader proficiency of marksmanship tasks are integrated into collective training to include squad, section, and platoon drills and STXS; and for the collective tasks in these exercises, and how they are planned and conducted, are in the MTP and battle drills books for each organization. (Force-on-force exercises using MILES are discussed in detail in TC 25-6). Based on the type organization, collective tasks are evaluated to standard and discussed during leader and trainer after-action reviews. Objective evaluations of both individual and unit proficiency provide readiness indicators and future training requirements.

A critical step in the Army's overall marksmanship training strategy is to train the trainers and leaders first. Leader courses and unit publications develop officer and NCO proficiencies necessary to plan and conduct marksmanship training and to evaluate the effectiveness of unit marksmanship programs. Training support materials are provided by the proponent schools to include field manuals, training aids, devices, simulators, and programs that are doctrinal foundations and guidance for training the force.

Once the soldier understands the weapon and has demonstrated skill in zeroing, additional live-fire training and a target acquisition exercise at various ranges are conducted. Target types and scenarios of increasing difficulty must be mastered to develop proficiency.

Initial individual training culminates in the soldier's proficiency assessment, which is conducted on the standard record fire range or approved alternates. This evaluation also provides an overview of unit proficiency and training effectiveness.

General marksmanship training knowledge and firing well are acquired skills, which perish easily. Skill practice should be conducted for short periods throughout the year. Most units have a readiness requirement that all soldiers must zero their rifles within a certain time after unit assignment. Also, soldiers must confirm the zeros of their assigned rifles before conducting a qualification firing. Units should conduct preliminary training and practice firing throughout the year due to personnel turnover. A year-round marksmanship sustainment program is needed for the unit to maintain the individual and collective firing proficiency requirements to accomplish its mission (see Appendix A).

COMBAT FACTORS

The ultimate goal of a unit rifle marksmanship program is well-trained marksmen. In order for a unit to survive and win on the battlefield, the trainer must realize that rifle qualification is not an end but a step toward reaching this combat requirement. To reach this goal, the soldier should consider some of the factors of combat conditions.

- Enemy personnel are seldom visible except when assaulting.
- Most combat fire must be directed at an area where the enemy has been detected or where he is suspected of being located but cannot be seen. Area targets consist of objects or outlines of men irregularly spaced along covered and concealed areas (ground folds, hedges, borders of woods).
- Most combat targets can be detected by smoke, flash, dust, noise, or movement and are visible only for a moment.
- Some combat targets can be engaged by using nearby objects as reference points.
- The range at which enemy soldiers can be detected and effectively engaged rarely exceeds 300 meters.
- The nature of the target and irregularities of terrain and vegetation may require a firer to use a variety of positions in addition to the prone or supported position to fire effectively on the target. In a defensive situation, the firer usually fires from a supported position.
- Choosing an aiming point in elevation is difficult due to the low contrast outline and obscurity of most combat targets.
- Time-stressed fire in combat can be divided into three types:

  - A single, fleeing target that must be engaged quickly.
  - Area targets that must be engaged with distributed fires that cover the entire area. The firer must maintain sustained fire on the sector he is assigned.
  - A surprise target that must be engaged at once with accurate, instinctive fire.

CHAPTER 2

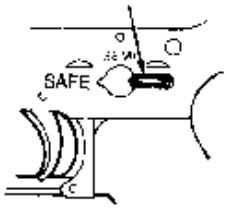
Operation and Function

The procedures and techniques described in this chapter provide commanders, planners, and trainers information on the M16A1 and M16A2 rifles. These include mechanical training, operation, functioning, preventive maintenance, and common malfunctions. Technical data are presented in a logical sequence from basic to the more complex. Additional information is provided in technical manuals for the rifle.

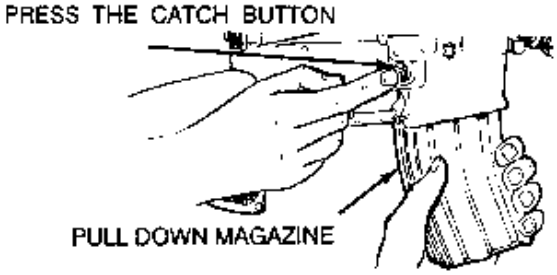
CLEAR the RIFLE

Figure 2-1. Clearing the Rifle.

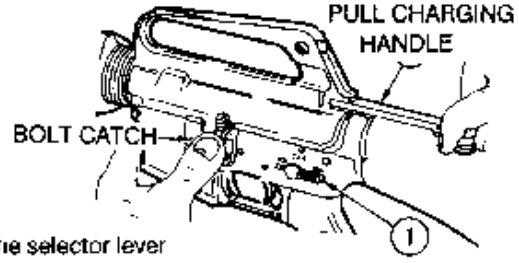
1. Place the selector on SAFE. The weapon must be cocked, to point the lever toward SAFE.



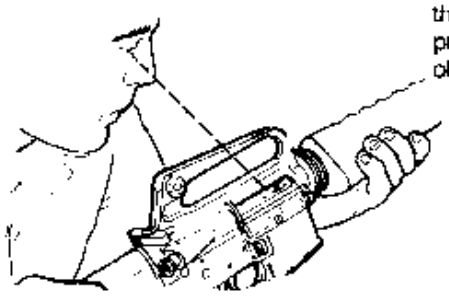
2. Remove the magazine.



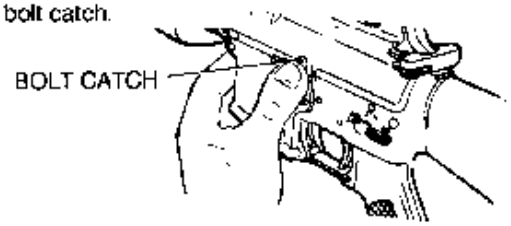
3. Lock the bolt open, pull the charging handle rearward and press the bottom of the bolt catch; allow the bolt to move forward until it engages the bolt catch. Return the charging handle forward. If you havent already done so, place weapon on SAFE.



4. Check the receiver and the chamber areas for ammunition.



5. With the selector lever pointing toward SAFE allow the bolt to go forward by pressing the upper portion of the bolt catch.



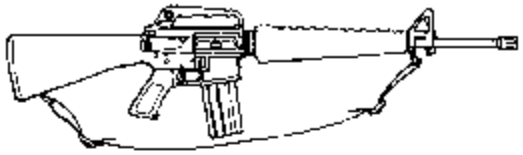
Section I. OPERATIONAL CHARACTERISTICS

This section describes general characteristics of the M16A1 and M16A2 rifles.

M16A1 RIFLE

The M16A1 rifle (Figure 2-2) is a 5.56-mm, magazine-fed, gas-operated, shoulder-fired weapon. It is designed for either semiautomatic or automatic fire through the use of a selector lever (SAFE, SEMI, and AUTO).

Figure 2-2. Rifle, 5.56-mm, M16A1.



WEIGHT:	**Kilograms**	**Pounds**
M16A1 rifle, without cartridge magazine and sling	2.97	6.55
Firing weight with sling and loaded magazine:		
20-round	3.45	7.6
30-round	3.60	7.9
Bipod, M3	.27	.60
Bipod case	.09	.20
Bayonet knife, M7	.27	.60
Scabbard	.14	.30
Sling, M1	.18	.40
LENGTH:	**Centimeters**	**Inches**
M16A1 rifle with bayonet knife	112.40	44.25
M16A1 rifle overall with flash suppressor	99.06	39.00
Barrel with flash suppressor	53.34	21.00
Barrel without flash suppssor	41.80	20.00
AMMUNITION:		
M16A1, M193		
Complete round	179 grains	
Projectile	.55 grains	

M16A2 RIFLE

The M16A2 rifle features several product improvements illustrated in this chapter and the operator's manual. The rifle (Figure 2-3) is a 5.56-mm, magazine-fed, gas-operated, shoulder-fired weapon. It is designed to fire either semiautomatic or a three-round burst through the use of a selector lever (SAFE, SEMI, and BURST).

Figure 2-3. Rifle, 5.56-mm, M16A2.

WEIGHT:	Kilograms	Pounds
M16A2 rifle, without cartridge magazine and sling	3.53	7.78
Firing weight with sling and loaded magazine:		
20-round	3.85	8.48
30-round	3.99	8.79
Bipod, M3	.27	.60
Bipod case	.09	.20
Bayonet knife, M9	.68	1.50
Scabbard	.14	.30
Sling, M1	.18	.40
LENGTH:	**Centimeters**	**Inches**
M16A2 rifle with bayonet knife,	113.99	44.88
M16A2 rifle overall with compensator	100.66	39.63
Barrel with compensator	53.34	21.00
Barrel without compensator	41.80	20.00
AMMUNITION:		
M16A2, M855		
Complet e round	190 grains	
Projectile	.62 grains	

NOTE: The procedures for disassembly, inspection, and maintenance of the M16A1 and M16A2 rifles are contained in the appropriate operator's technical manual.

Section II. FUNCTION

The soldier must understand the rifles' components and the mechanical sequence of events during the firing cycle. The M16A1 rifle is designed to function in either the semiautomatic or automatic mode. The M16A2 is designed to function in either the semiautomatic or three-round burst mode.

STEPS OF FUNCTIONING

The eight steps of functioning (feeding, chambering, locking, firing, unlocking, extracting, ejecting, and cocking) begin after the loaded magazine has been inserted into the weapon.

STEP 1: Feeding (Figure 2-4). As the bolt carrier group moves rearward, it engages the buffer assembly and compresses the action spring into the lower receiver extension. When the bolt carrier group clears the top of the magazine, the expansion of the magazine spring forces the follower and a new round up into the path of the forward movement of the bolt. The expansion of the action spring sends the buffer assembly and bolt carrier group forward with enough force to strip a new round from the magazine.

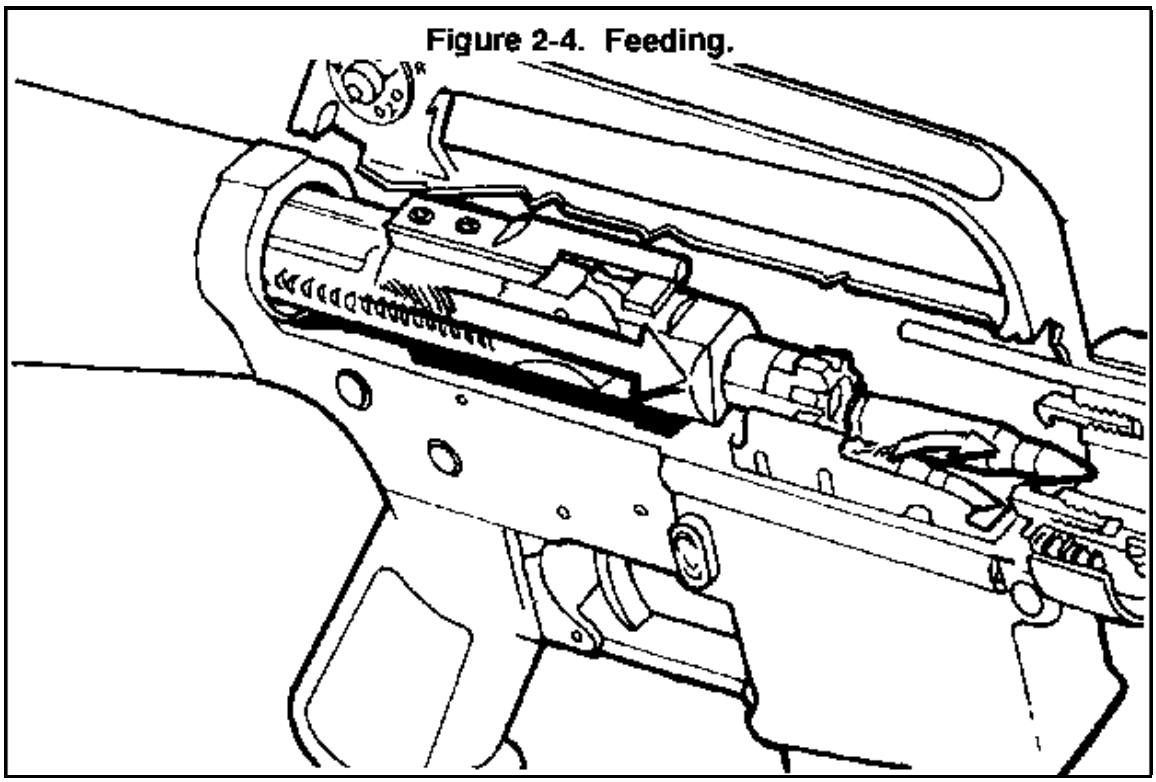


Figure 2-4. Feeding.

STEP 2: Chambering (Figure 2-5). As the bolt carrier group continues to move forward, the face of the bolt thrusts the new round into the chamber. At the same time, the extractor claw grips the rim of the cartridge, and the ejector is compressed.

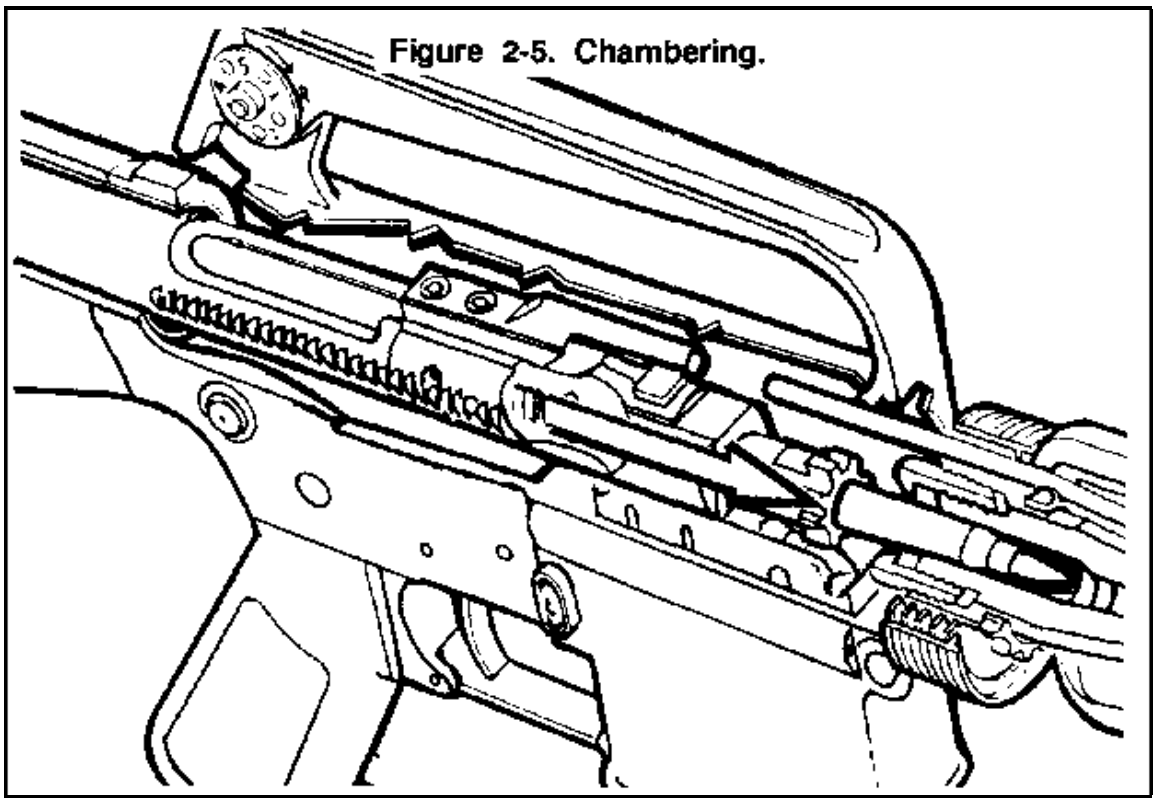


Figure 2-5. Chambering.

STEP 3: Locking (Figure 2-6). As the bolt carrier group moves forward, the bolt is kept in its most forward position by the bolt cam pin riding in the guide channel in the upper receiver. Just before the bolt locking lugs make contact with the barrel extension, the bolt cam pin emerges from the guide channel. The pressure exerted by the contact of the bolt locking lugs and barrel extension causes the bolt cam pin to move along the cam track (located in the bolt carrier) in a counterclockwise direction, rotating the bolt locking lugs in line behind the barrel extension locking lugs. The rifle is then ready to fire.

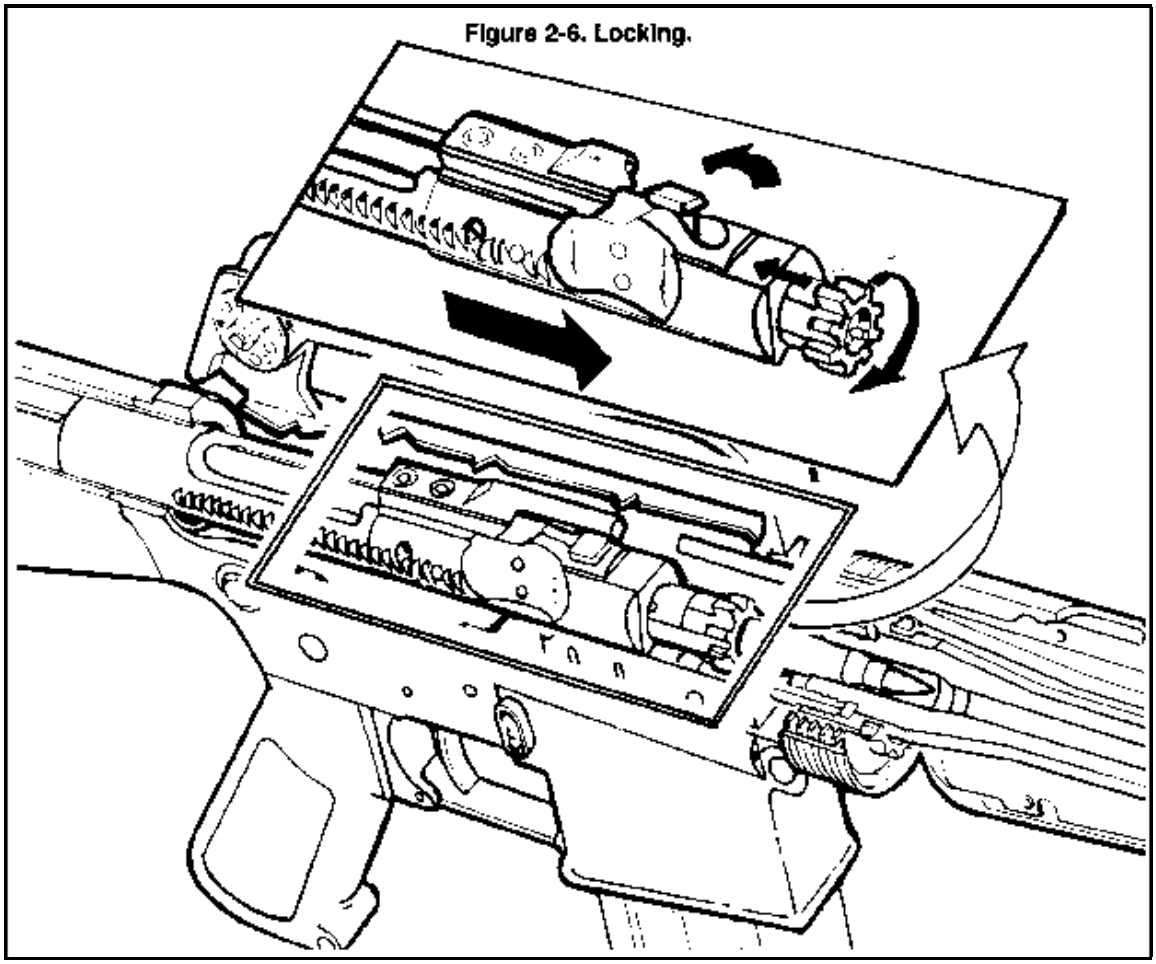


Figure 2-6. Locking.

STEP 4: Firing (Figure 2-7). With a round in the chamber, the hammer cocked, and the selector on SEMI, the firer squeezes the trigger. The trigger rotates on the trigger pin, depressing the nose of the trigger and disengaging the notch on the bottom on the hammer. The hammer spring drives the hammer forward. The hammer strikes the head of the firing pin, driving the firing pin through the bolt into the primer of the round.

When the primer is struck by the firing pin, it ignites and causes the powder in the cartridge to ignite. The gas generated by the rapid burning of the powder forces the projectile from the cartridge and propels it through the barrel. After the projectile has passed the gas port (located on the upper surface of the barrel under the front sight) and before it leaves the barrel, some gas enters the gas port and moves into the gas tube. The gas tube directs the gas into the bolt carrier key and then into the cylinder between the bolt and bolt carrier, causing the carrier to move rearward.

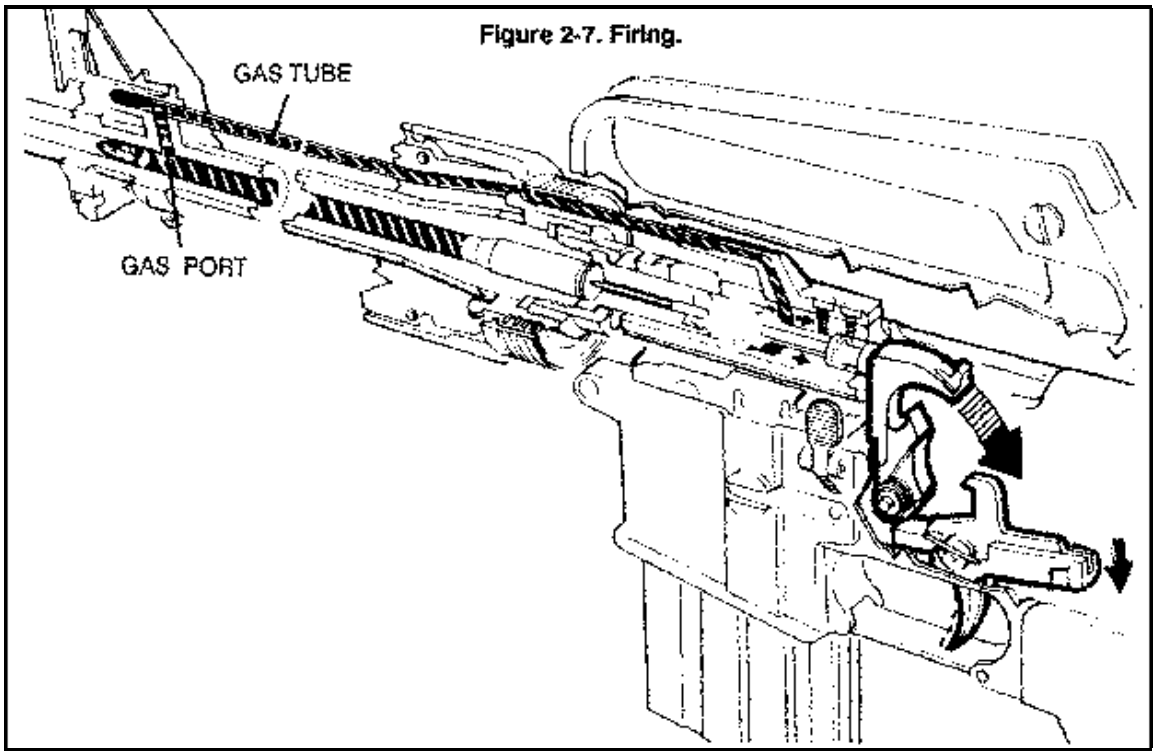


Figure 2-7. Firing.

STEP 5: Unlocking (Figure 2-8). As the bolt carrier moves to the Tear, the bolt cam pin follows the path of the cam track (located in the bolt carrier). This action causes the cam pin and bolt assembly to rotate at the same time until the locking lugs of the bolt are no longer in line behind the locking lugs of the barrel extension.

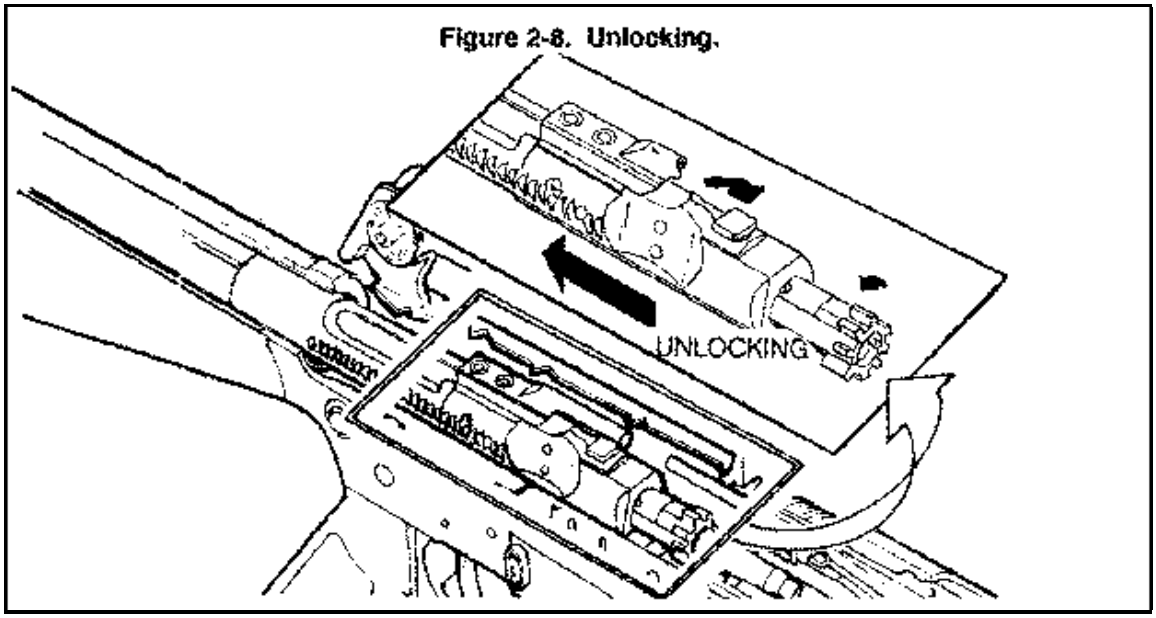
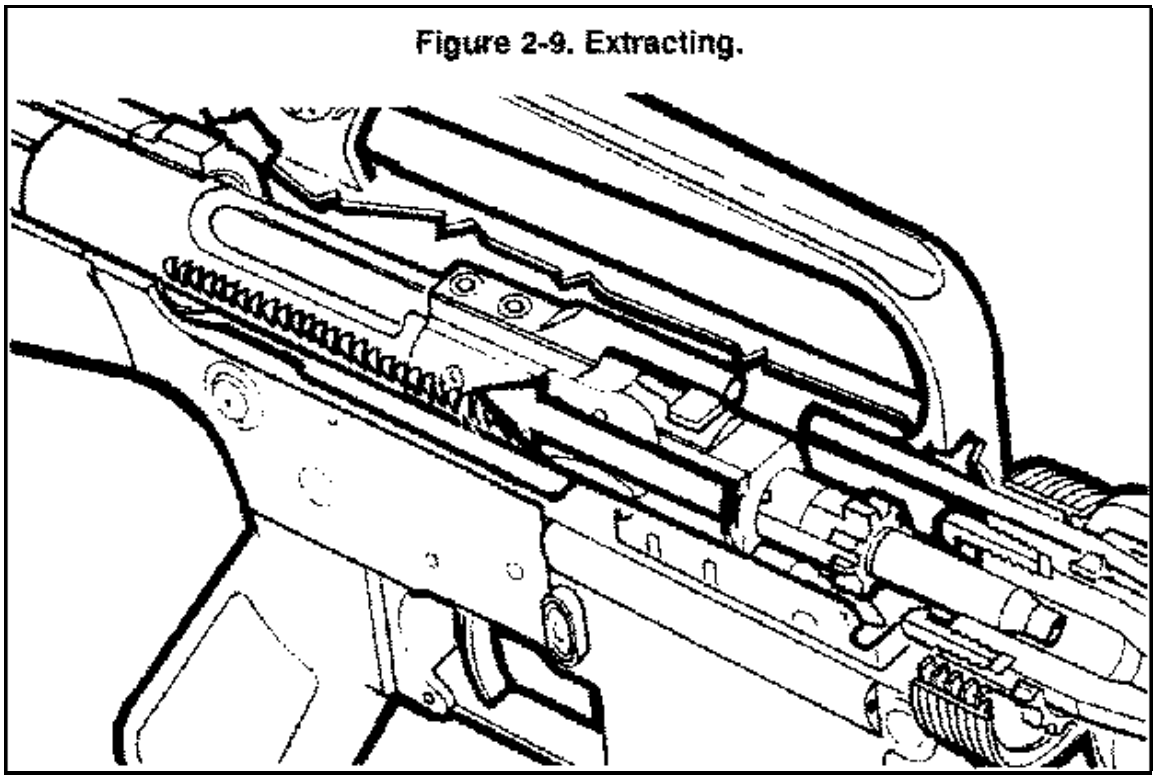


Figure 2-8. Unlocking.

STEP 6: Extracting (Figure 2-9). The bolt carrier group continues to move to the rear. The extractor (which is attached to the bolt) grips the rim of the cartridge case, holds it firmly against the face of the bolt, and withdraws the cartridge case from the chamber.

Figure 2-9. Extracting.



STEP 7: Ejecting (Figure 2-10). With the base of a cartridge case firmly against the face of the bolt, the ejector and ejector spring are compressed into the bolt body. As the rearward movement of the bolt carrier group allows the nose of the cartridge case to clear the front of the ejection port, the cartridge is pushed out by the action of the ejector and spring.

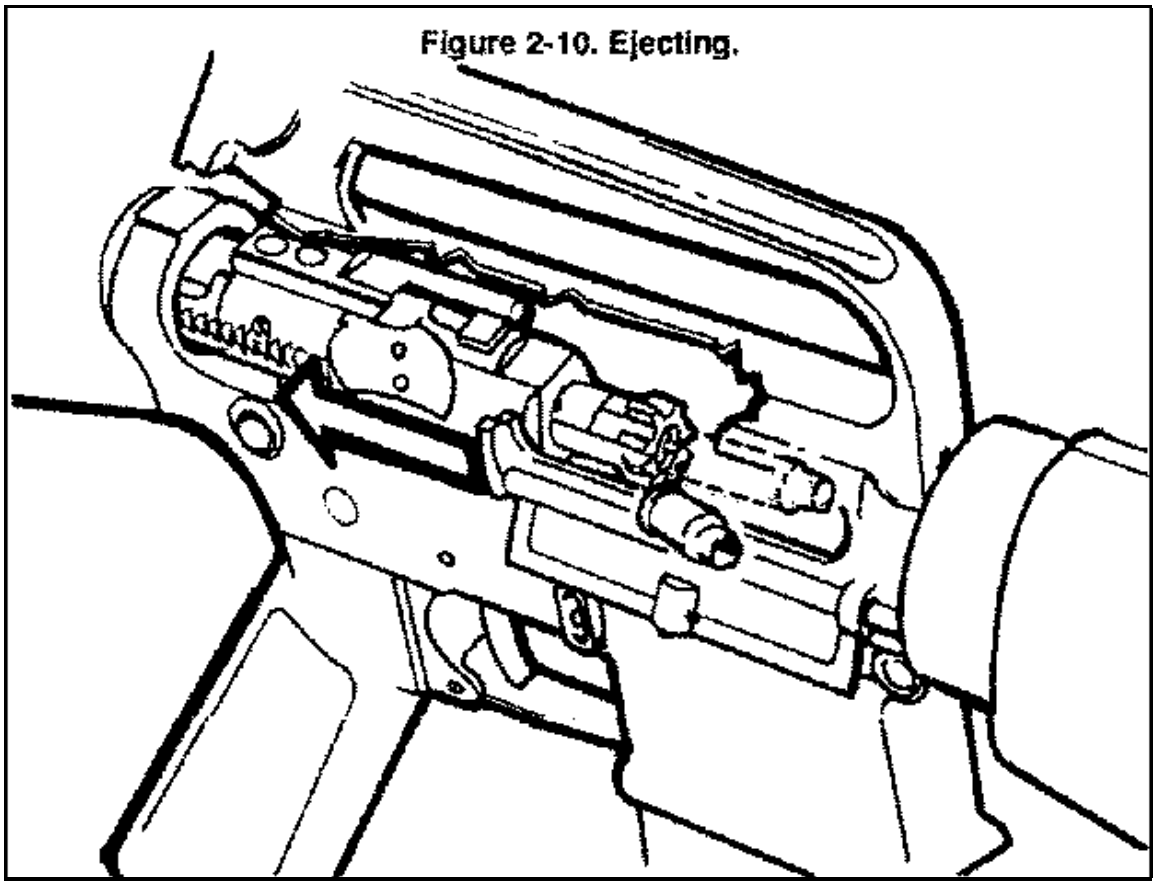


Figure 2-10. Ejecting.

STEP 8: Cocking (Figure 2-11). The rearward movement of the bolt carrier overrides the hammer, forcing it down into the receiver and compressing the hammer spring, cocking the hammer in the firing position. The action of the rifle is much faster than human reaction; therefore, the firer cannot release the trigger fast enough to prevent multiple firing.

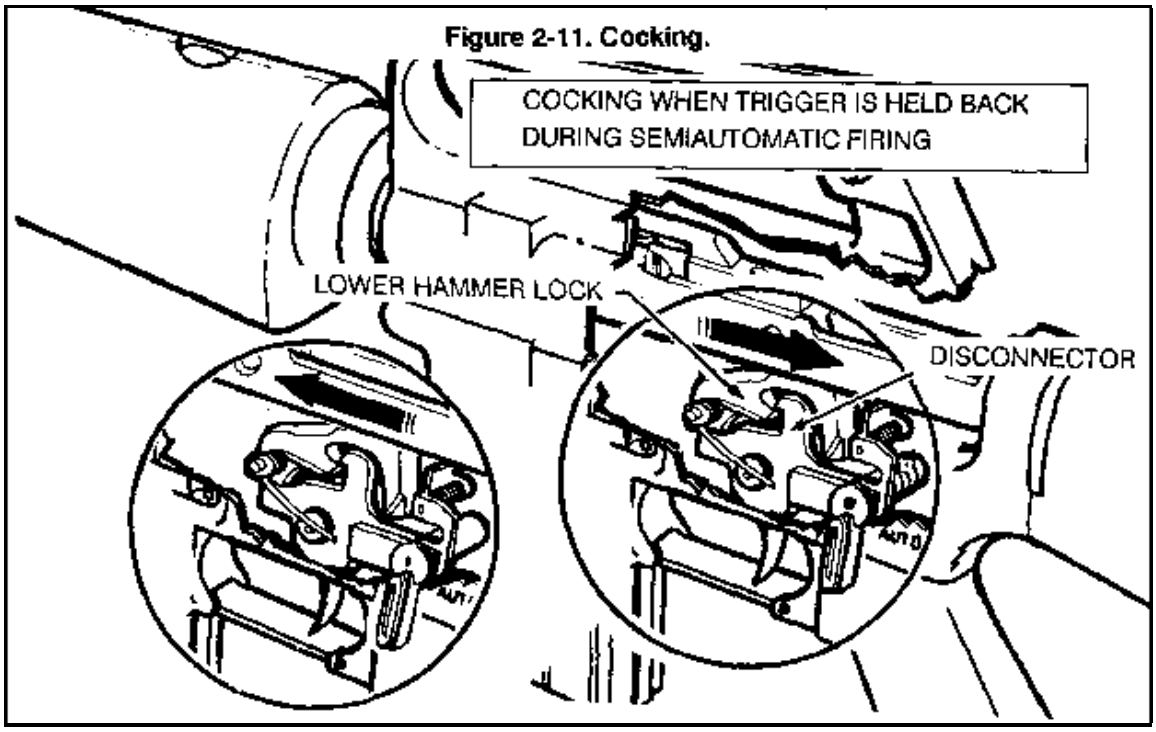


Figure 2-11. Cocking.

SEMIAUTOMATIC MODE (M16A1 AND M16A2)

The disconnector is mechanism installed so that the firer can fire single rounds in the M16A1 and M16A2 rifles. It is attached to the trigger and is rotated forward by action of the disconnector spring. When the hammer is cocked by the recoil of the bolt carrier, the disconnector engages the lower hook of the hammer and holds it until the trigger is released. Then the disconnector rotates to the rear and down, disengaging the hammer and allowing it to rotate forward until caught by the nose of the trigger. This prevents the hammer from following the bolt carrier forward and causing multiple firing. The trigger must be squeezed again before the next round will fire.

AUTOMATIC FIRE MODE (M16A1)

When the selector lever (Figure 2-12) is set on the AUTO position, the rifle continues to fire as long as the trigger is held back and ammunition is in the magazine. The functioning of certain parts of the rifle changes when firing automatically.

Once the trigger is squeezed and the round is fired, the bolt carrier group moves to the rear and the hammer is cocked. The center cam of the selector depresses the rear of the disconnector and prevents the nose of the disconnector from engaging the lower hammer hook. The bottom part of the automatic sear catches the upper hammer hook and holds it until the bolt carrier group moves forward. The bottom part strikes the top of the sear and releases the hammer, causing the rifle to fire automatically.

If the trigger is released, the hammer moves forward and is caught by the nose of the trigger. This ends the automatic cycle of fire until the trigger is squeezed again.

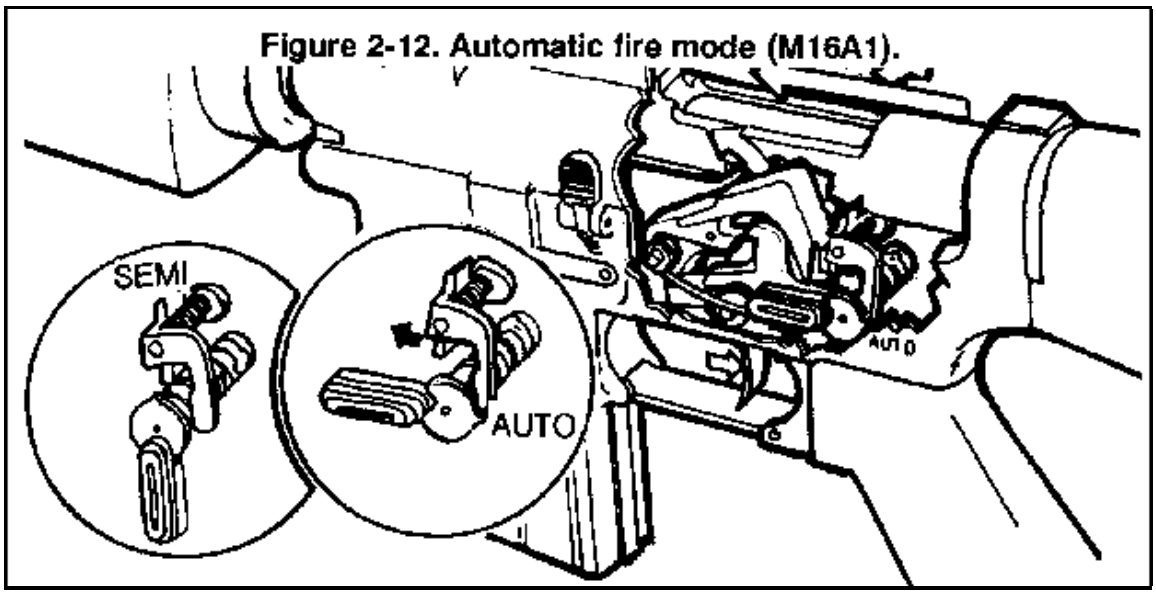


Figure 2-12. Automatic fire mode (M16A1).

BURST FIRE MODE (M16A2)

When the selector lever is set on the BURST position (Figure 2-13), the rifle fires a three-round burst if the trigger is held to the rear during the complete cycle. The weapon continues to fire three-round bursts with each separate trigger pull as long as ammunition is in the magazine. Releasing the trigger or exhausting ammunition at any point in the three-round cycle interrupts fire, producing one or two shots. Reapplying the trigger only completes the interrupted cycle -it does not begin a new one. This is not a malfunction. The M16A2 disconnector has a three-cam mechanism that continuously rotates with each firing cycle. Based on the position of the disconnector cam, the first trigger pull (after initial selection of the BURST position) can produce one, two, or three firing cycles before the trigger must be pulled again. The burst cam rotates until it reaches the stop notch.

NOTE: See the operator's manual for a detailed discussion on the burst position.

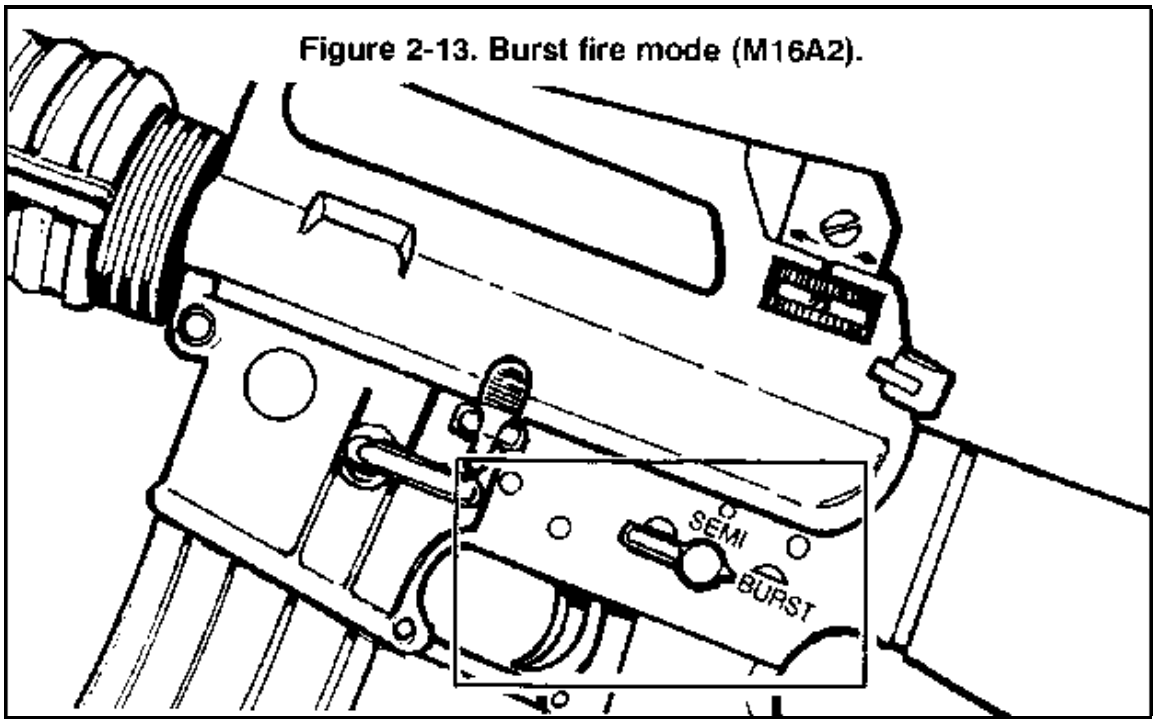


Figure 2-13. Burst fire mode (M16A2).

Section III. MALFUNCTIONS AND CORRECTIONS

Commanders and unit armorers are responsible for the organizational and direct support maintenance of weapons. Soldiers are responsible for keeping their weapons clean and operational at all times -in training and in combat. Therefore, the soldier should be issued an operator's technical manual and cleaning equipment for his assigned weapon.

STOPPAGE

A stoppage is a failure of an automatic or semiautomatic firearm to complete the cycle of operation. The firer can apply immediate or remedial action to clear the stoppage. Some stoppages that cannot be cleared by immediate or remedial action could require weapon repair to correct the problem. A complete understanding of how the weapon functions is an integral part of applying immediate-action procedures.

Immediate Action. This involves quickly applying a possible correction to reduce a stoppage based on initial observation or indicators but without determining the actual cause. To apply immediate action, the soldier would perform these steps: Gently slap upward on the magazine to ensure it is fully seated, and the magazine follower is not jammed. Pull the charging handle fully to the rear and check the chamber (observe for the ejection of a live or expended cartridge). Release the charging handle (do not ride it forward). Strike the forward assist assembly to ensure bolt closure. Try to fire the rifle.

Apply immediate action only one time for a given stoppage. Do not apply immediate action a second time. If the rifle still fails to fire, inspect it to determine the cause of the stoppage or malfunction and take appropriate remedial action.

Remedial Action. Remedial action is the continuing effort to determine the cause for a stoppage or malfunction and to try to clear the stoppage once it has been identified.

WARNING

IF AN AUDIBLE "POP" OR REDUCED RECOIL OCCURS DURING FIRING, IMMEDIATELY CEASE FIRE. THIS POP OR REDUCED RECOIL CAN BE THE RESULT OF A ROUND BEING FIRED WITHOUT ENOUGH FORCE TO SEND THE PROJECTILE OUT OF THE BARREL. DO NOT APPLY IMMEDIATE ACTION. REMOVE THE MAGAZINE, LOCK THE BOLT TO THE REAR, AND PLACE THE SELECTOR LEVER IN THE SAFE POSITION. VISUALLY INSPECT THE BORE TO ENSURE A PROJECTILE IS NOT LODGED IN THE BARREL. IF A PROJECTILE IS LODGED IN THE BARREL, DO NOT TRY TO REMOVE IT. TURN THE RIFLE IN TO THE ARMORER.

MAJOR CATEGORIES OF MALFUNCTIONS

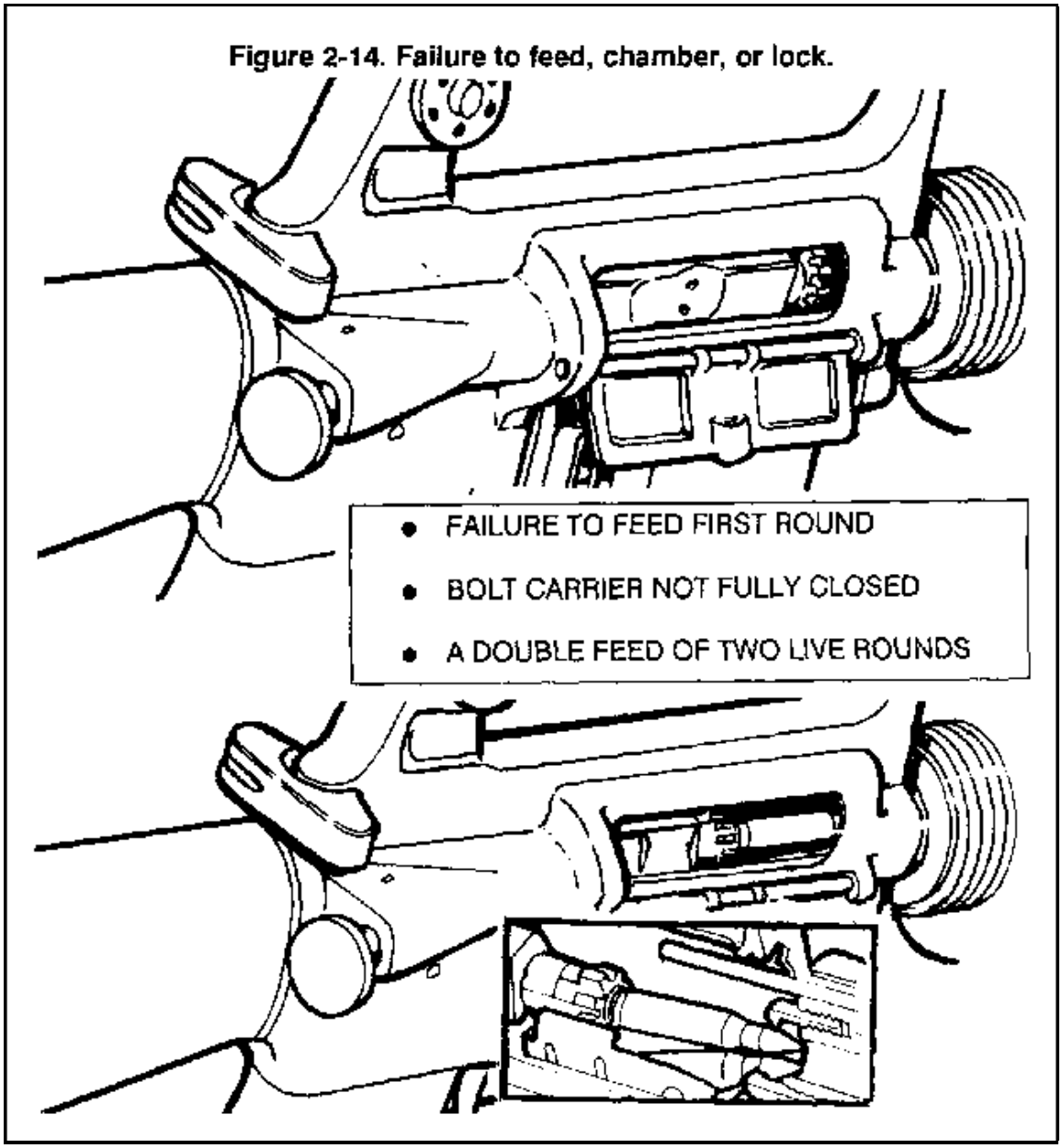
A malfunction is caused by a procedural or mechanical failure of the rifle, magazine, or ammunition. Pre-firing

checks and serviceability inspections identify potential problems before they become malfunctions. Three primary categories of malfunctions are:

1. Failure to Feed, Chamber, or Lock.

Description. A malfunction can occur when loading the rifle or during the cycle of operation. Once the magazine has been loaded into the rifle, the forward movement of the bolt carrier group could lack enough force (generated by the expansion of the action spring) to feed, chamber, and lock the first round. While firing, the cycle of function is interrupted by a failure to strip a round from the magazine, to chamber the round, and to lock it (Figure 2-14).

Figure 2-14. Failure to feed, chamber, or lock.



Probable causes. The cause could be the result of one or more of the following: excess accumulation of dirt or fouling in and around the bolt and bolt carrier, defective magazine (dented or bulged), magazine improperly loaded. A defective round (projectile forced back into the cartridge case that could result in a "stubbed round") or the base of the previous field cartridge could be separated, leaving the remainder in the chamber. Other causes could be: damaged or broken action spring, exterior accumulation of dirt in the lower receiver extension, or fouled gas tube resulting in short recoil.

Corrective action. Applying immediate action usually corrects the malfunction. However, to avoid the risk of further jamming, the firer should watch for ejection of a cartridge and ensure that the upper receiver is free of any loose rounds. If immediate action fails to clear the malfunction, remedial action must be taken. The carrier should not be forced. If resistance is encountered, which can occur with an unserviceable round, the bolt should be locked to the rear, magazine removed, and malfunction cleared-for example, a bolt override is when a cartridge has wedged itself between the bolt and charging handle. The best way to relieve this problem is by--

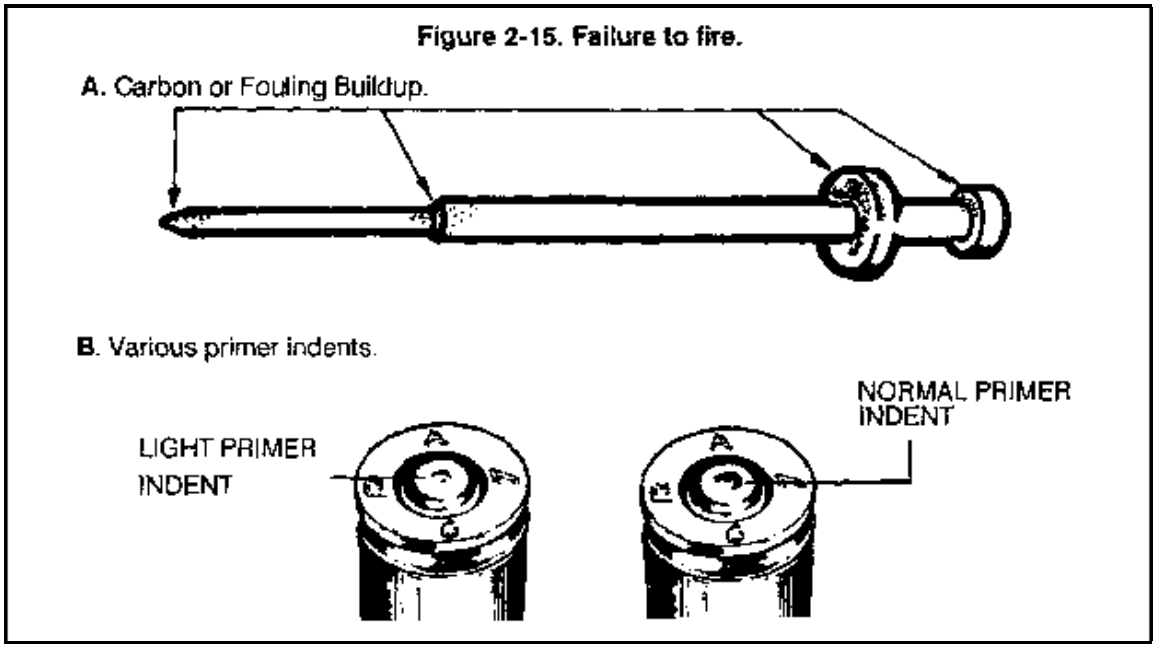
- Ensuring that the charging handle is pushed forward and locked in place.
- Holding the rifle securely and pulling the bolt to the rear until the bolt seats completely into the buffer well.
- Turning the rifle upright and allowing the overridden cartridge to fall out.

2. Failure to Fire Cartridge.

Description. Failure of a cartridge to fire despite the fact that a round has been chambered, the trigger is pulled, and the sear has released the hammer. This occurs when the firing pin fails to strike the primer with enough force or when the ammunition is bad.

Probable causes. Excessive carbon buildup on the firing pin (Figure 2-15A) is often the cause, because the full forward travel of the firing pin is restricted. However, a defective or worn firing pin can give the same results. Inspection of the ammunition could reveal a shallow indentation or no mark on the primer, indicating a firing pin problem (Figure 2-15B). Cartridges that show a normal indentation on the primer but did not fire indicate bad ammunition.

Figure 2-15. Failure to fire.



Corrective action. If the malfunction continues, the firing pin, bolt, carrier, and locking lug recesses of the barrel extension should be inspected, and any accumulation of excessive carbon or fouling should be removed. The firing pin should also be inspected for damage. Cartridges that show a normal indentation on the primer but failed to fire could indicate a bad ammunition lot. Those that show a complete penetration of the primer by the firing pin could also indicate a bad ammunition lot or a failure of the cartridge to fully seat in the chamber.

NOTE: If the round is suspected to be faulty, it is reported and returned to the agency responsible for issuing ammunition

3. Failure to Extract and Eject.

Failure to extract. The cartridge must extract before it can eject.

Description. A failure to extract results when the cartridge case remains in the rifle chamber. While the bolt and bolt carrier could move rearward only a short distance, more commonly the bolt and bolt carrier recoil fully to the rear, leaving the cartridge case in the chamber. A live round is then forced into the base of the cartridge case as the bolt returns in the next feed cycle. This malfunction is one of the hardest to clear.

NOTE: Short recoil can also be caused by a fouled or obstructed gas tube.

WARNING

A FAILURE TO EXTRACT IS CONSIDERED TO BE AN EXTREMELY SERIOUS MALFUNCTION, REQUIRING THE USE OF TOOLS TO CLEAR. A LIVE ROUND COULD BE LEFT IN THE CHAMBER AND BE ACCIDENTALLY DISCHARGED. IF A SECOND LIVE ROUND IS FED INTO THE PRIMER OF THE CHAMBERED LIVE ROUND, THE RIFLE COULD EXPLODE AND CAUSE PERSONAL INJURY. THIS MALFUNCTION MUST BE PROPERLY IDENTIFIED AND REPORTED. FAILURES TO EJECT SHOULD NOT BE REPORTED AS EXTRACTION FAILURES.

Probable cause. Short recoil cycles and fouled or corroded rifle chambers are the most common causes of failures to extract. A damaged extractor or weak/broken extractor spring can also cause this malfunction.

Corrective action. The severity of a failure to extract determines the corrective action procedures. If the bolt has moved rearward far enough so that it strips a live round from the magazine in its forward motion, the bolt and carrier must be locked to the rear.

The magazine and all loose rounds must be removed before clearing the stoppage. Usually, tapping the butt of the rifle on a hard surface causes the cartridge to fall out of the chamber. However, if the cartridge case is ruptured, it can be seized. When this occurs, a cleaning rod can be inserted into the bore from the muzzle end. The cartridge case can be forced from the chamber by tapping the cleaning rod against the inside base of the fired cartridge. When cleaning and inspecting the mechanism and chamber reveal no defects but failures to extract persist, the extractor and extractor spring should be replaced. If the chamber surface is damaged, the entire barrel must be replaced.