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FIELD ARTILLERY CANNON WEAPONS SYSTEMS AND AMMUNITION

HANDBOOK

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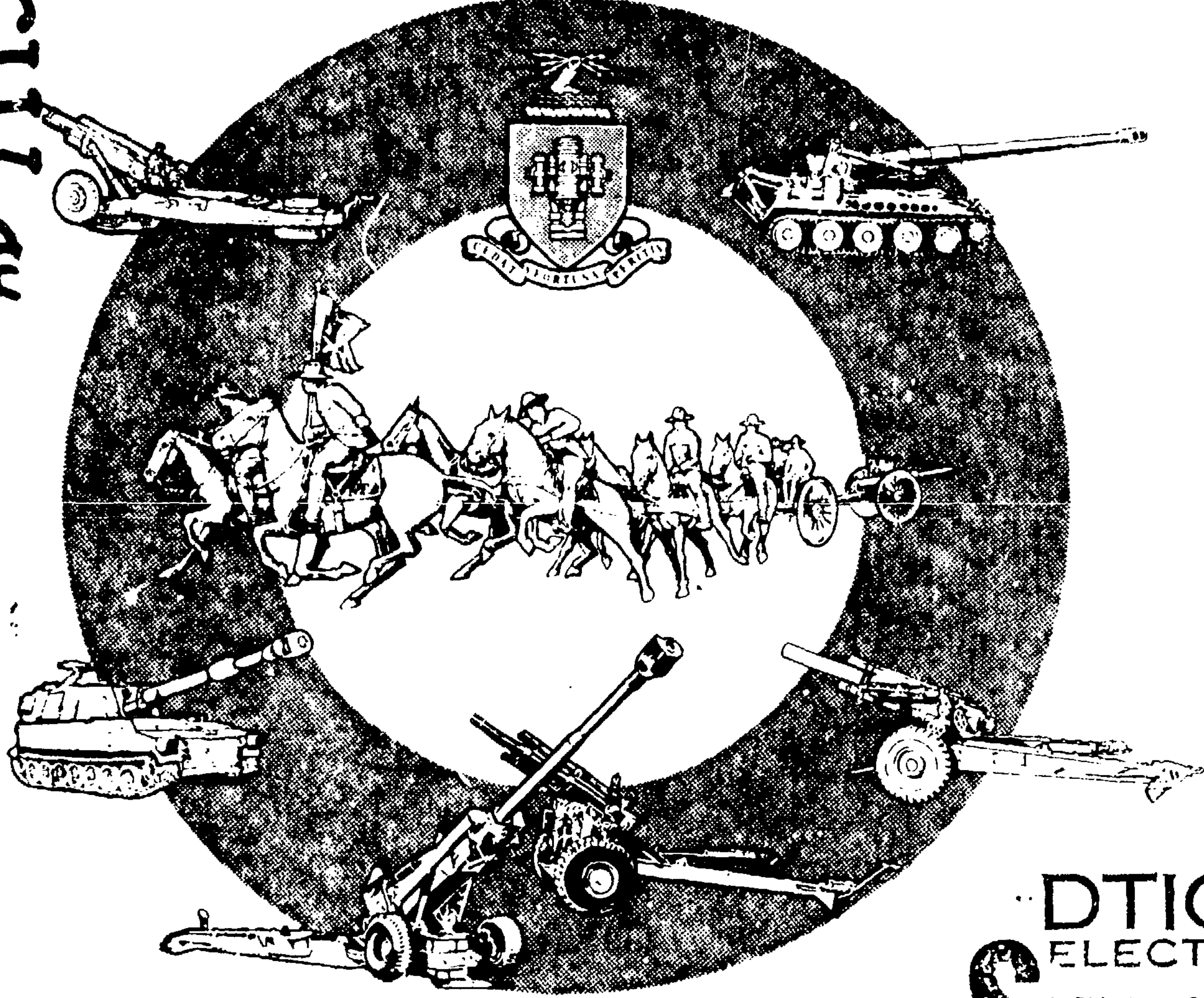

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U.S. ARMY FIELD ARTILLERY SCHOOL

Weapons Department
Fort Sill, Oklahoma

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FIELD ARTILLERY CANNON WEAPON SYSTEMS AND AMMUNITION HANDBOOK

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U. S. ARMY
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CHAPTER 1

CANNON WEAPON SYSTEMS OF THE FIELD ARTILLERY

Section I. GENERAL

1-1. References

TM 9-1015-203-12, TM 9-1015-234-12, TM 9-1025-200-12, TM 9-1025-211-10, TM 9-2300-216-10, TM 9-6920-361-13, and TM 9-6920-357-10-2.

1-2. Introduction

a. In order to acquaint ourselves with the historical development of modern artillery we must take a step back in the pages of history. To compare a Roman catapult with a modern artillery cannon seems absurd. Yet, the only difference is the kind of energy that sends the projectile on its way.

b. Every artillery officer should be familiar with the characteristics and functioning of modern artillery weapons; and as a matter of interest, he also should have knowledge of the historical development of these weapons.

Section II. EXPLANATION

1-3. Period: ? B.C.—A.D. 1100

a. In the dawn of history, war engines were performing the function of artillery (which may be loosely defined as a means of hurling missiles too heavy to be thrown by hand), and it was from the use of these crude weapons that the basic principles of artillery originated. The Scriptures record the use of ingenious machines—probably predecessors of the catapult and ballista, getting power from twisted ropes made of hair, hide, or sinew—on the walls of Jerusalem eight centuries BC.

b. The ballista (fig 1-1) had horizontal arms like a bow and was used to reduce fortifications. The arms were set in rope; a cord, fastened to the arms like a bowstring, fired arrows, darts, and stones. Like a modern field gun, the ballista shot low and directly toward the enemy.

c. The catapult (fig 1-2) was the howitzer or mortar of its day. It could throw a 100-pound stone 600 yards in a high arc to strike the enemy behind his wall or to batter down his defenses.

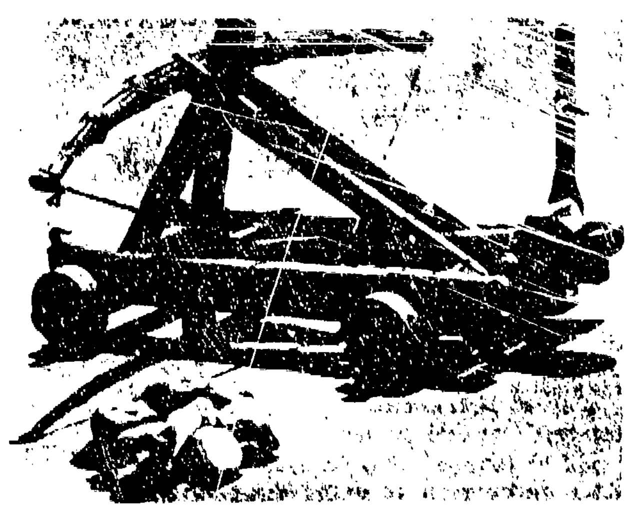

Figure 1-1. Ballista.

1-4. Period: A.D. 1100—A.D. 1962

a. A ninth century Latin manuscript found in Europe contains a formula for gunpowder. However, the first show of firearms in western Europe is credited to the Moors at Saragossa in A.D. 1118. The earliest known cannon was a cast iron weapon (fig 1-3) shaped like a jug—large round body, narrow neck, and flared mouth. The projectile was an iron dart. The shaft of the dart was wrapped in leather to fit tightly into the neck of the piece. Range was about 700 yards and

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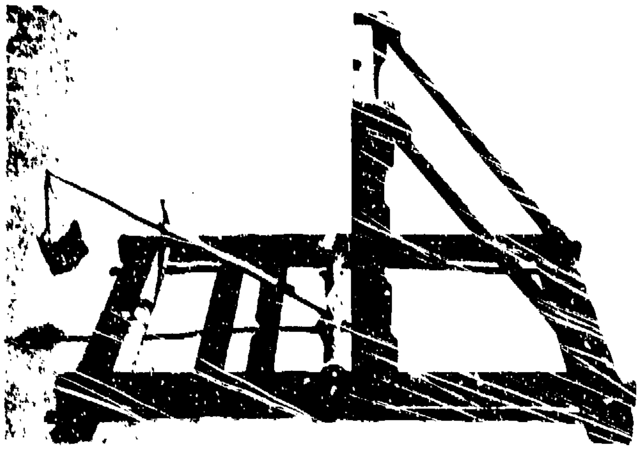


Figure 1-2. Catapult.

Figure 1-3. Pot de fer.

accuracy was doubtful. Due to its peculiar shape, this cannon was called the pot de fer (iron jug).

b. For approximately 300 years cannons remained small crude tubes which tossed 1- or 2-pound lead or iron balls. By the middle of the 15th century cannons had developed into enormous bombards (fig 1-4) with calibers up to 25 inches. One of these tremendous weapons was the Mons Meg of Edinburgh Castle, which threw a 19½-inch iron ball 1,400 yards or a stone ball twice as far. The formidable bombards of the Turks are another example of the 15th century cannon. Some of these weapons were of cast bronze, weighed 19 tons, and could fire 600-pound stones at the rate of seven shots a day. The technique of employing these weapons was to emplace them about 100 yards from the wall or fortress to be battered down.

Figure 1-4. Bombard.

This placed the crew well within range of expert bowmen so there was usually a massive wooden shield arranged over the gun to protect the personnel while they loaded the weapon. This shield could then be raised for firing.

c. During the period 1600–1850, tremendous advances were made in the field of bronze and cast iron metallurgy. This era saw the development and standardization of calibers, the use of wheels and carriages for mobility (fig 1-5), and the first attempts to use a rifled bore with elongated projectiles for increased accuracy and range. This era also saw the end of the giant bombards which had defeated and eliminated the huge stone castles and fortresses which had dominated that period of history.

d. In 1855, England's Lord Armstrong designed a rifled, breech-loading cannon (fig 1-6) which meant the beginning of the end for the old, cast iron, round-shot, muzzle-loading cannon. This particular design was the first to use a cast tube with exterior hoops shrunk on over the tube to reinforce the metal, thus permitting longer ranges from lighter weapons. During the period of our own Civil War, Capt. T.J. Rodman, Army

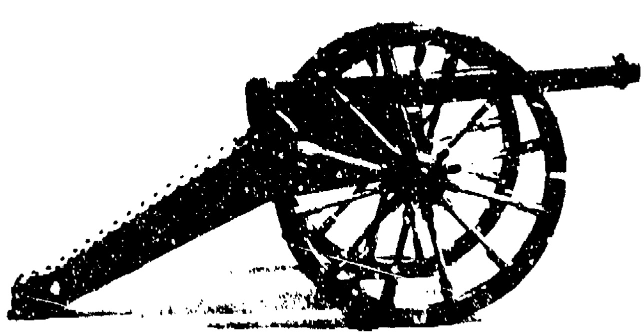


Figure 1-5. Mobile artillery piece circa 1650.

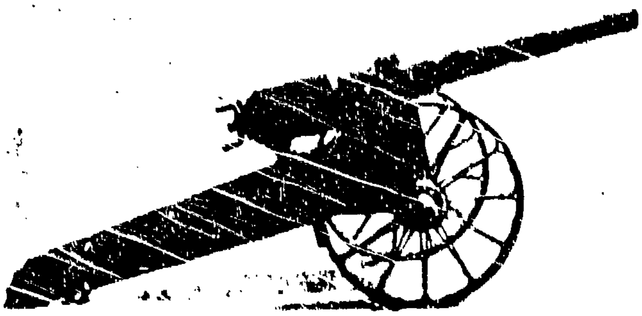


Figure 1-6. Mobile artillery piece circa 1855.

Ordnance, perfected a method of casting barrels which was the greatest "breakthrough" for muzzle-loading artillery in over 700 years. Basically, his method was to pour molten cast iron around a water-cooled core. The inner walls of the bore solidified first and were compressed by the contraction of the outer metal, which cooled down more slowly. This resulted in a tube which had much greater strength to resist explosion of the charge. It was also during the Civil War that a newly designed rifle (Parrott's gun) startled the world with its range and accuracy. However, the heyday of the cast iron weapon was short-lived. With the development of the steel industry, perfection of breech and recoil mechanisms became possible. This allowed the use of smokeless powder and high explosives and marked the end of the black powder muzzle-loader. Almost as important as these developments was the invention of more efficient sighting and laying mechanisms. In essence, artillery had assumed the modern form. The next changes were the results of startling developments in motor transport, signal communication, chemical warfare, tanks, aviation, mass production, and finally, missiles.

Figure 1-7. 105-mm howitzer M101A1.

1-5. Characteristics of Modern Cannon Weapon Systems

Today, the artilleryman has available to him the latest types of cannon weapon systems. The following are weapons common to the United States armed forces and our allies.

a. 105-mm Howitzer M101A1. The following data pertain to the 105-mm howitzer M101A1 (fig 1-7):

Muzzle velocity	472 meters per second
Maximum range	11,000 meters
Type breechblock	Horizontal sliding wedge
Type firing mechanism	Continuous pull, M13
Type recoil mechanism	Hydropneumatic
Maximum recoil	39 to 42 inches (44 inches is allowable)
Recoil gas pressure at 70°	1,100 pounds per square inch
Minimum elevation	-89 mils
Maximum elevation	1,156 mils
Type traverse	Pintle
Maximum right traverse	409 mils
Maximum left traverse	400 mils
Type equilibrators	Open spring (puller)
Tire pressure	40 pounds per square inch
Weight in firing position	4,980 pounds
Weight traveling	4,980 pounds
Maximum rate of fire	10 rounds per minute for the first 3 minutes
Sustained rate of fire	3 rounds per minute thereafter
Prime mover	2-ton, 6×6 truck, or helicopter
Technical manual	TM 9-1015-203-12
Tube life (equivalent full charge)	
M2A1	5,000 rounds
M2A2	7,500 rounds

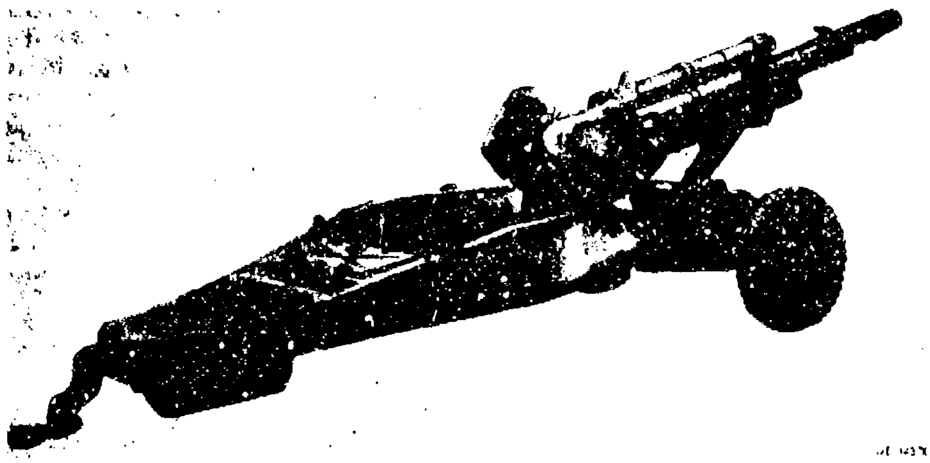


Figure 1-8. 105-mm light howitzer M102 in traveling position.

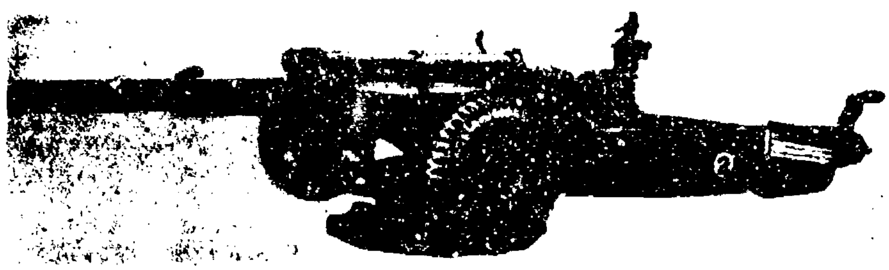


Figure 1-9. 105-mm light howitzer M102 in firing position.

b. 105-mm Howitzer M102. The following data pertain to the 105-mm howitzer M102 (figs 1-8 and 1-9):

Muzzle velocity	494 meters per second
Maximum range	11,500 meters
Type breechblock	Vertical sliding wedge
Type firing mechanism	Spring-actuated inertia percussion
Type recoil mechanism	Hydropneumatic
Minimum recoil	30 inches
Maximum recoil	50 inches
Recoil gas pressure at 70°	1,150 pounds per square inch
Minimum elevation	-89 mils
Maximum elevation	1,333 mils
Type traverse	Ball socket
Maximum right traverse	6,400 mils
Maximum left traverse	6,400 mils
Type equilibrators	Spring
Tire pressure	40 pounds per square inch on super highways 20 pounds per square inch on unimproved roads
Weight in firing position	3,171 pounds
Weight traveling	3,338 pounds
Maximum rate of fire	10 rounds per minute for the first 3 minutes
Sustained rate of fire	3 rounds per minute thereafter
Prime mover	Helicopter, parachute, or 5/4-ton truck
Technical manual	TM 9-1015-234-12
Tube life (equivalent full charge	5,000 rounds, but see table 6 of TM 9-1000-202-10 for special inspection criteria

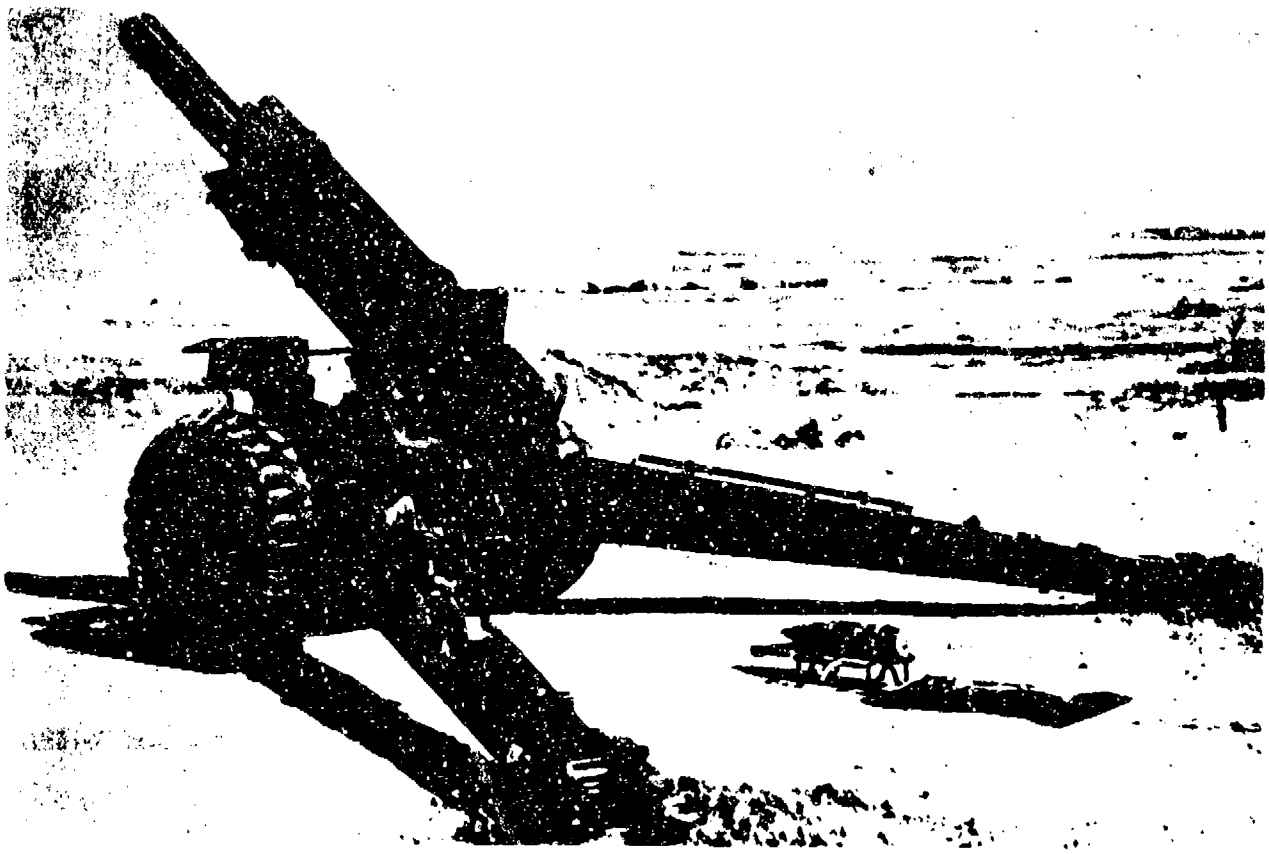


Figure 1-10. 155-mm howitzer M114A1/A2.

c. 155-mm Howitzer M114A1. The following data pertain to the 155-mm howitzer M1141 (fig 1-10):

Muzzle velocity	564 meters per second
Maximum range	14,600 meters
Type breechblock	Stepped thread, interrupted screw
Type firing mechanism	Percussion, M1
Type recoil mechanism	Hydropneumatic
Maximum recoil at maximum elevation	41 inches
Maximum recoil at minimum elevation	60 inches
Recoil gas pressure at 70°	1,650 pounds per square inch
Minimum elevation	0 mils
Maximum elevation	1,156 mils
Type traverse	Pintle
Maximum right traverse	448 mils
Maximum left traverse	418 mils
Type equilibrators	Open spring (lifter
Tire pressure	50 pounds per square inch
Weight in firing position	12,700 pounds
Weight traveling	12,700 pounds
Maximum rate of fire	4 rounds per minute for the first 3 minutes
Sustained rate of fire	1 round per minute thereafter
Prime mover	5-ton, 6×6 truck, or heavy-lift helicopter
Technical manual	TM 9-1025-200-12
Tube life (equivalent full charge)	
M1	2,000 rounds
M1A1	7,500 rounds
M1A2	

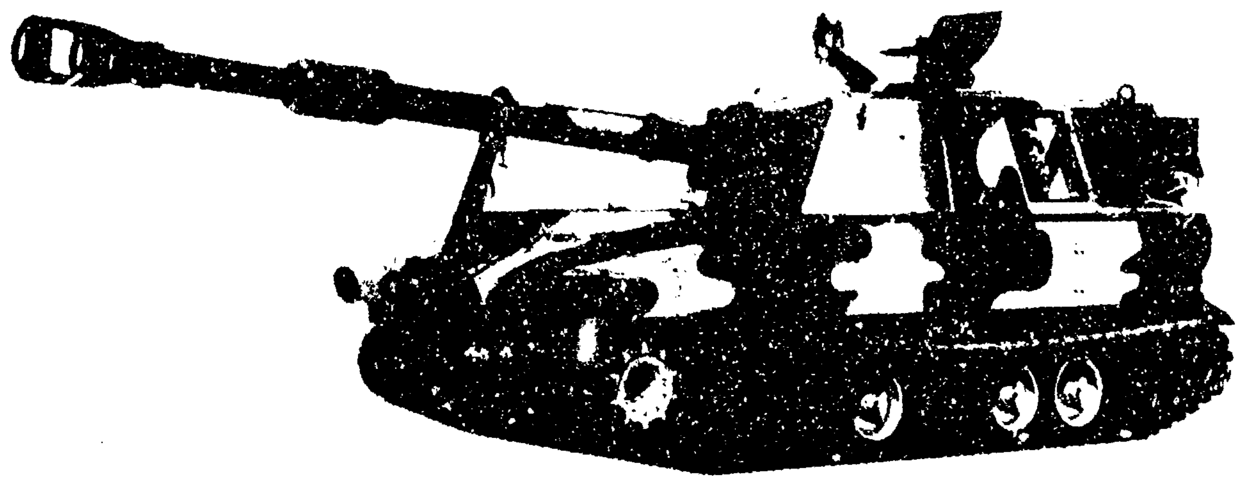


Figure 1-11. 155-mm howitzer M109A2/A3, SP.

d. 155-mm Howitzer, M109A2/A3, SP. The following data pertain to the 155-mm howitzer M109A2/A3, SP (fig 1-11):

Muzzle velocity	701 meters per second
Maximum ranges	14,600 meters (charge 7) 18,100 meters (charge 8)
Type breechblock	Thread, interrupted screw
Type of firing mechanism	Continuous pull, M35
Type of recoil mechanism	Hydropneumatic
Minimum recoil	24 inches
Maximum recoil	36 inches
Recoil gas pressure at 70°	700 pounds per square inch
Minimum elevation	-53 mils
Maximum elevation	1,333 mils
Type traverse	Base ring and race
Maximum right traverse	6,400 mils
Maximum left traverse	6,400 mils
Type equilibrator	Hydropneumatic
Tire pressure	Track vehicle
Weight in firing position	53,940 pounds for M109A1
Weight in traveling position	55,000 pounds for the M109A2/A3
Maximum rate of fire	4 rounds per minute for 3 minutes
Sustained rate of fire	Charge 1-7 1 round per minute Charge 8 1 round per minute for 60 minutes, then 1 round per 3 minutes thereafter
Prime mover	Self-propelled
Technical manual	TM 9-2350-217-10N (A1/A3) TM 9-2550-303-10 (A2)
Tube life (equivalent full charge)	M185 tube, 5,000 rounds
EFC values	Charge 8 = 1.00 Charge 7 = 0.75 Charge 1-6 = 0.25

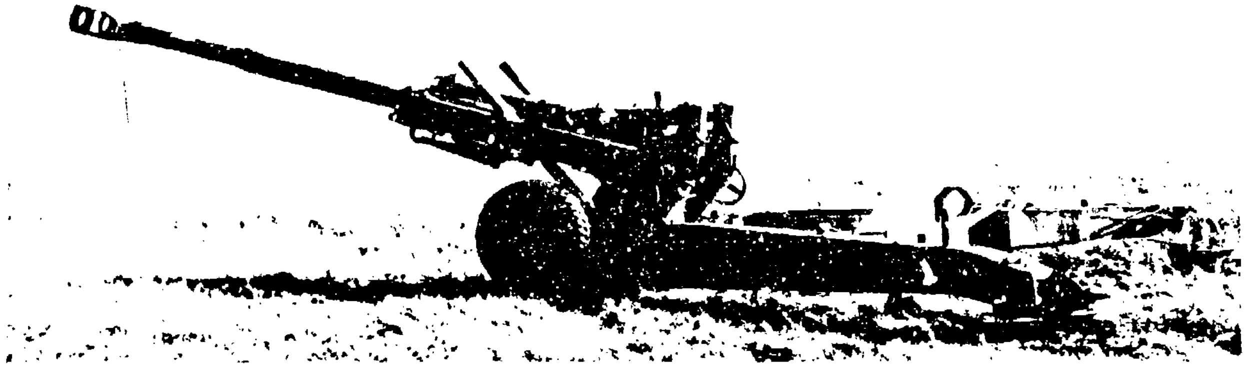


Figure 1-12. 155-mm howitzer M198.

e. 155-mm Howitzer M198, Towed. The following data pertains to 155-mm howitzer M198, towed (fig 1-12):

Muzzle velocity	826 meters per second
Maximum ranges	24,000 meters NONRAP 30,000 meters with RAP
Type of breechblock	Threaded, interrupted screw
Type of firing mechanism	Continuous pull, M35
Type of recoil mechanism	Hydropneumatic
Minimum recoil	50 inches ±2
Maximum recoil	70 inches ±2
Minimum elevation	-75 mils
Maximum elevation	1,275 mils
Type traverse	
Maximum right traverse	400 mils or 6,400 with speed shift
Maximum left traverse	400 mils
Type equilibrator	Pneumatic lifter
Tire pressure	45 pounds per square inch
Weight in firing position	15,800 pounds
Weight in traveling position	15,800 pounds
Maximum rate of fire	4 rounds per minute for 3 minutes
Sustained rate of fire	2 rounds per minute for 30 minutes/1 round per minute thereafter
Prime mover	5-ton truck
Technical manual	
Tube life (equivalent full charge)	M199 tube, 1,750 rounds
EFC values	M203 Charge 8s = 1.00 M119A1 Charge 8 = 0.33 M4 Charge 7 = 0.10 Charge 6-3= 0.05 M3 Charge 5-3= 0.05

Note. Do not fire below Charge 3.

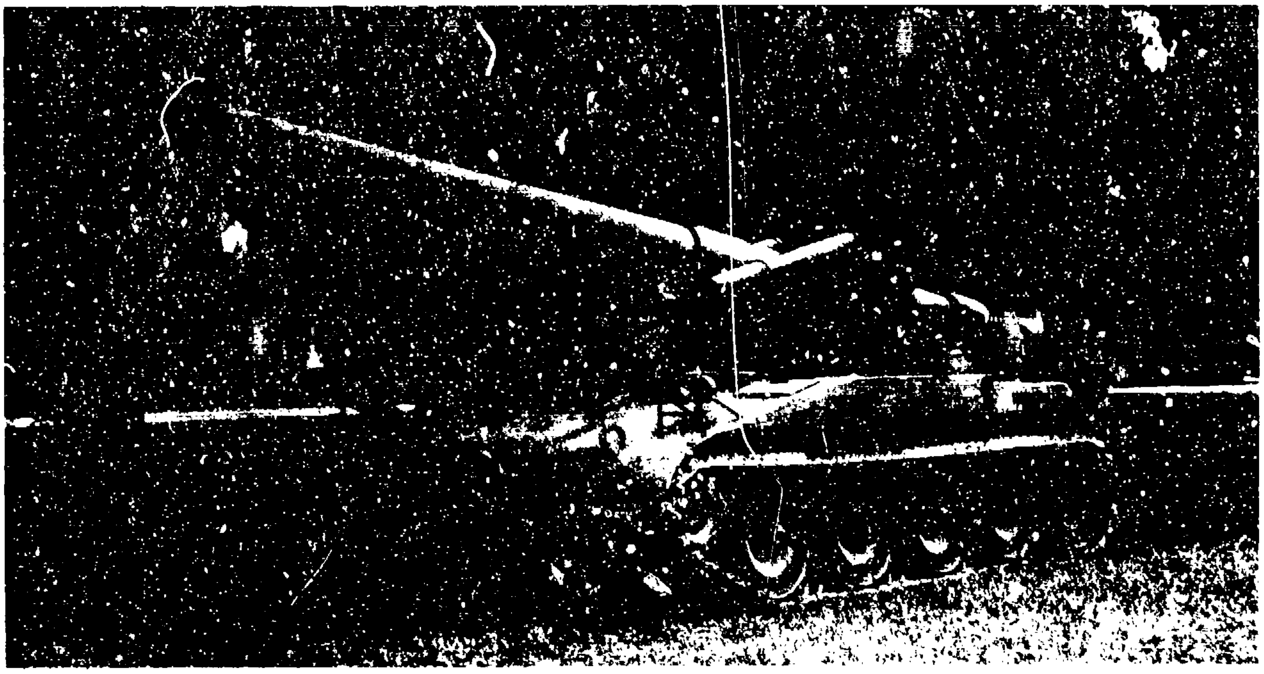


Figure 1-13. 8-inch howitzer M110A2, SP.

f. 8-inch Howitzer M110A2, SP. The following data pertain to 8-inch howitzer M110A2, SP (fig 1-13):

Muzzle velocity	747 meters per second
Maximum range	Non-RAP 22,900 meters; RAP 30,000
Type of breechblock	Stepped threaded, interrupted screw
Type of firing mechanism	Continuous pull, M35
Type of recoil mechanism	Hydropneumatic
Minimum recoil	25 inches
Maximum recoil	70 inches
Recoil gas pressure at 70°	2,130 pounds per square inch
Minimum elevation	35 mils
Maximum elevation	1,156 mils
Type traverse	Base ring and race
Maximum right traverse	533 mils
Maximum left traverse	533 mils
Type equilibrator	Pneumatic lifter
Tire pressure	Track vehicle
Muzzle break weight	550 pounds
Weight in firing position	62,500 pounds
Weight in traveling position	62,500 pounds
Maximum rate of fire	1.5 rounds per minute for 3 minutes
Sustained rate of fire	1 round every 2 minutes thereafter
Prime mover	Self-propelled
Technical manual	TM 9-2300-216-10
Tube life (equivalent full charge)	M201 tube, 7,500 rounds
EFC values	Charge 9 = 1.00
	Charge 7-8 = 0.70
	Charge 1-6 = 0.25

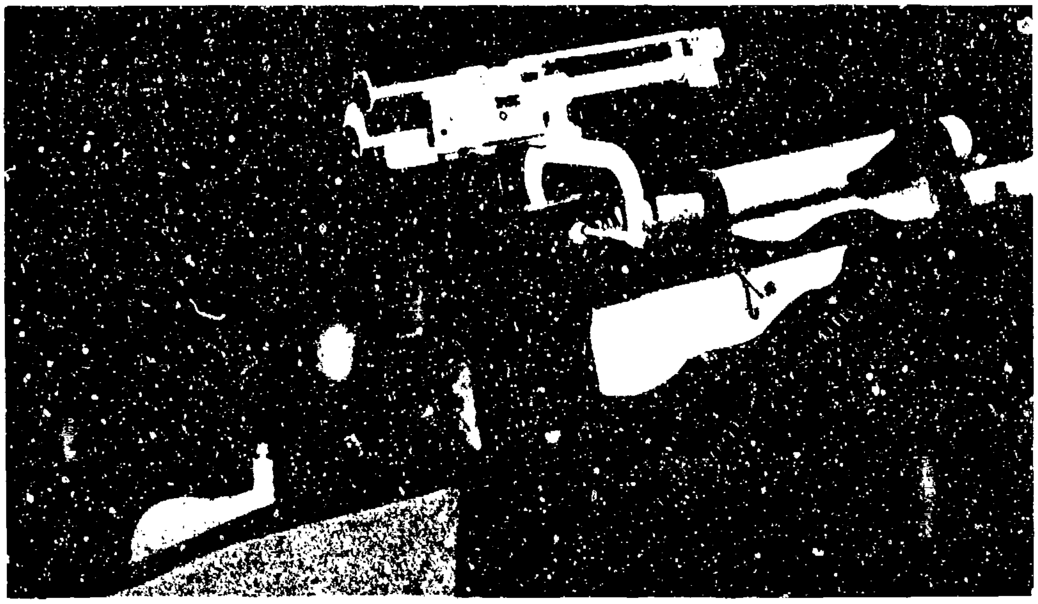
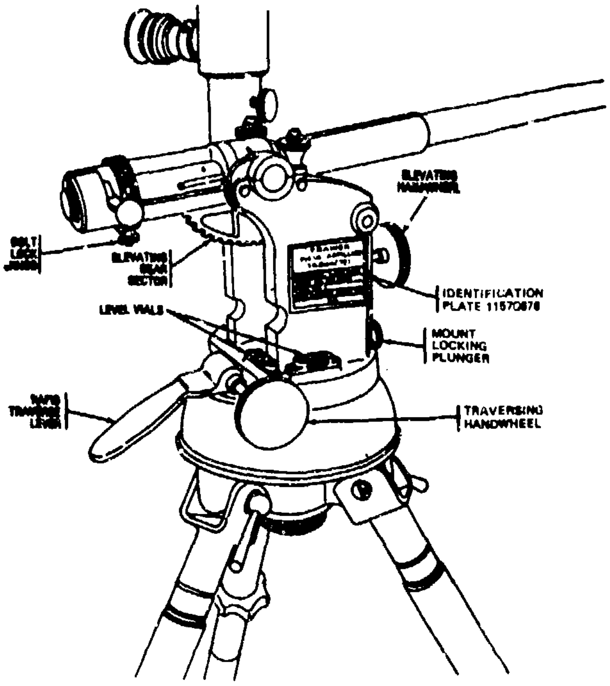


Figure 1-14. Laser, Gunnery Trainer M55.

g. Laser, Gunnery Trainer M55. The following data pertain to the ADFT. This device can be used with the M101A1-M102-M109A2-M198 Howitzers. At present there is no mount for the M110A2 Howitzer (fig 1-14):

***Power Requirements*:**	
Input voltage	24 +6 vdc
Input current (nominal)	1.3 amperes
Input current (maximum)	3 amperes
***Operating Characteristics*:**	
Modes of operation	Continuous and flash
Power output	0.5 to 2.0 milliwatts (nominal)
Beam diameter	Approximately ⅝-inch (16 millimeters) at 200 feet (61 meters)
Flash duration	100 +25 milliseconds
Repetition rate	Retriggerable 200 milliseconds after release of trigger
***Temperature*:**	
Operating	0° F (-18° C) to +100° F (+56° C)
Nonoperating (storage)	-65° F (-54° C) to +155° F (+??)
***Altitude*:**	
Operating	Sea level to 10,000 feet (3,048 meters)
Nonoperating (transporting)	Sea level to 50,000 feet (15,240 meters)



h. 14.5 Field Artillery Trainer. The following data pertain to the trainer (fig 1-15):

Barrel	Rifled portion 13¼-inches long, uniform right hand twist, one turn in 8.5 calibers
Breech	Bolt action with safety
Firing mechanism	Trigger located at left rear of breech
Elevating limits	Minus 52 mils and plus 1,617 mils
Loading limits	Minus 52 mils and plus 1,070 mils
Traverse	6,400 mils
Mils per turn of handwheel	
Elevating	52 mils
Traversing	66 mils
Ammunition (fixed round 14.5-mm cartridge)	
M181—Charge 1 (1305A365)	3-second delay fuze
M182—Charge 1 (1305A366)	6-second delay fuze
M183—Charge 1 (1305A367)	Point detonating fuze
Muzzle velocity (all cartridges)	100 meters per second
Maximum range	730 meters

Section III. SUMMARY

1-6. Review

a. This chapter has covered briefly 2,500 years of history on the development of artillery from the early days of the Roman Empire to the present time. During these past centuries both the gun and the gunner have passed through a series of phases. The early gunner was first considered a practitioner of the art of witchcraft, in league with the devil. Then artillery became an art. Today, artillery is a military profession embracing all the technical and scientific developments of modern culture.

b. The artillery weapon has progressed from the early, crude implements used to hurl rocks, etc., to the highly mobile, accurate, and long-range cannons utilizing chemical, high explosive, and nuclear projectiles and warheads. Development of weapons, ammunition, tactics, and techniques are not attributable to any one race or nationality. A detailed study of the history of artillery will show that China, some Arabic nations, Turkey, Sweden, Russia, Scotland, England, France, Germany, Belgium, Spain, and the United States, as well as many other nations, have all contributed their part in developing artillery through the centuries.

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CHAPTER 2

FUNDAMENTALS OF CANNON WEAPON SYSTEMS

Section I. GENERAL

2-1. References

TM 9-3305-1, chapters 1 through 6, 8, and 9.

2-2. Introduction

The mission of the field artillery is to destroy, neutralize, or suppress the enemy by cannon, rocket and missile fires and to integrate all supporting fires into combined arms operation. This mission requires that the weapons be in position and ready to fire at the appointed time. To fulfill this requirement, the field artillery weapons must have certain characteristics, three of which are considered basic. These three basic characteristics are mobility, stability, and flexibility.

a. Mobility. Mobility is the ability to move over terrain at relatively high speeds. Mobility is achieved in two ways—by the use of pneumatic tires on towed weapons to reduce road shock at high speeds and by the use of highly mobile, full-tracked, self-propelled vehicles on which the weapons are mounted. In addition, all current field artillery weapons are air transportable.

b. Stability. Stability is the ability of an emplaced weapon to remain in place and withstand the shock of firing. Stability is achieved in the medium towed weapon of today by use of three points of suspension—two trails and a firing jack float. The towed 105-mm howitzer M102, a lightweight weapon with a low silhouette, employs a firing platform, which must be staked to the ground to attain stability. Most of the stability of self-propelled weapons is obtained by the weight of the weapon, the weight of the carriage, and the design of the track and suspension system; however, the self-propelled weapons are equipped also with some type of recoil spades to improve stability. In addition, a lockout feature in the track suspension system of the self-propelled 8-inch howitzer further enhances the stability of this heavy weapon.

c. Flexibility. Flexibility is the ability of a weapon to deliver fire over a wide front and at all angles of elevation without time-consuming shifts. Flexibility is achieved by maximum on-carriage elevation and traverse. Flexibility of towed weapons is achieved through the use of rear-mounted trunnions, split trails, and pintle traverse or a pivot and socket and a firing platform; flexibility of self-propelled weapons is achieved through the use of ring and race traverse and rear-mounted trunnion.

Note. Some of the characteristics and capabilities of field artillery weapons are given in appendix A.

Section II. ARTILLERY CARRIAGES, GENERAL

2- . Classification of Carriages

A weapon is classified by the carriage as either self-propelled or towed. The carriage supports the weapon in the firing and traveling positions.

a. Self-propelled carriage. A self-propelled carriage is one that contains its own means of propulsion. Current models of self-propelled weapons are air transportable.

b. Towed carriages. A towed artillery weapon is one that must be moved by some external source of power, such as a truck or a tractor. A lunette on the end of the trail(s) and a coupling on the rear of the prime mover provide a rapid and secure means of coupling the carriage to the prime mover. Because of their relatively light weight, towed weapons are transportable by both rotary-wing and fixed-wing aircraft.

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2-4. Components of the Carriage

The carriage consists of some combination of the following major components (figs 2-1 through 2-15): bottom carriage, equalizer, top carriage, cradle, sleigh, equilibrator, elevating mechanism, traversing mechanism, axle, trails, and wheels. Some towed artillery weapons are equipped with shields to protect the crew from enemy small-arms fire. On some self-propelled weapons, a similar protection is provided by an enclosed turret.

a. Bottom carriage. The bottom, or lower, carriage (figs 2-1 and 2-2) is that part of the weapon that supports the top carriage. Portions of the mechanism for rotating the top carriage in traverse are attached to the bottom carriage. The pintle—a vertical pin about which the top carriage rotates—secures the top carriage to the bottom carriage. The trail end (or ends) may be attached to the bottom carriages, and, on some weapons, a firing jack or spade (fig 2-3) may also be attached. The bottom carriage may be fixed to the axle, or it may replace the axle and carry the wheels. The construction of the towed howitzer M102 differs considerably from that of earlier models in that it has no bottom carriage. When the weapon is in the firing position, the entire weapon and carriage rest on a platform and pivot in traverse about a pivot and socket joint located in the center of the firing platform (fig 2-4).

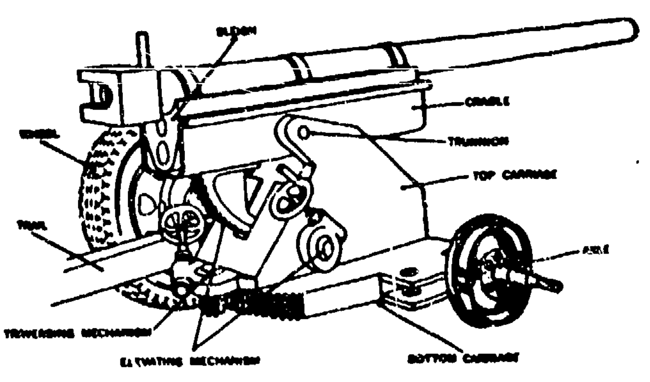


Figure 2-1. Components of the carriage.

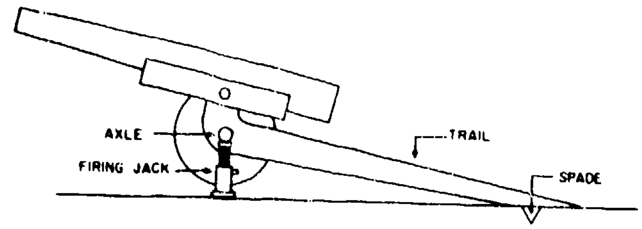


Figure 2-3. Firing jack.

b. Axle. The axle is that part of the carriage that supports the weight of the weapon. Spindles on the ends of the axle provide a means for mounting the wheels. The size and shape of the bottom carriage may eliminate the need for a standard axle, in which case, spindles for mounting the wheels are mounted on either side of the carriage (fig 2-3).

c. Equalizer. Certain towed weapons are equipped with an equalizer (fig 2-5), a mechanical device that permits the four points of contact with the ground (the two wheels and two trail ends) to be in different planes. The equalizer compensates for irregularity of the terrain so that the weight of the weapon and the shock of firing are transmitted to the ground through all four points. The most common type of equalizer is a horizontal support secured to the axle by a horizontal pivot pin. The support, located behind the axle, can rotate through a small vertical angle about the horizontal pivot pin that secures the support to the midpoint of the axle. The trails are attached to the ends of the support. The horizontal pivot pin and the two trail spades provide the three-point suspension for stability of the weapon in firing. A pin (called a pintle) passes vertically through the center of the support and provides a pivot point about which the top carriage traverses. When the weapon is placed in the traveling position, the axle and support are locked together. Equalizers are generally used with light artillery carriages.

d. Firing jack. The firing jack supports the forward weight of the carriage during firing; the firing jack and the two trail spades provide three-point suspension. A firing jack is used with the towed medium artillery carriage.

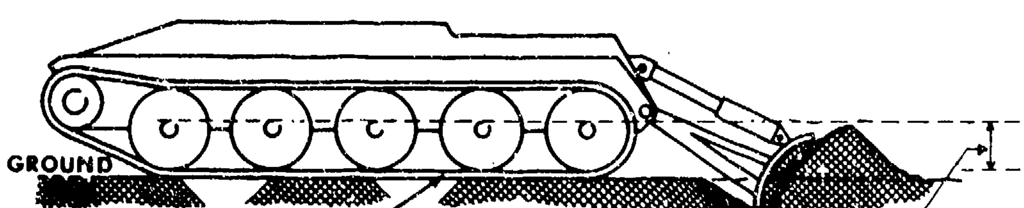
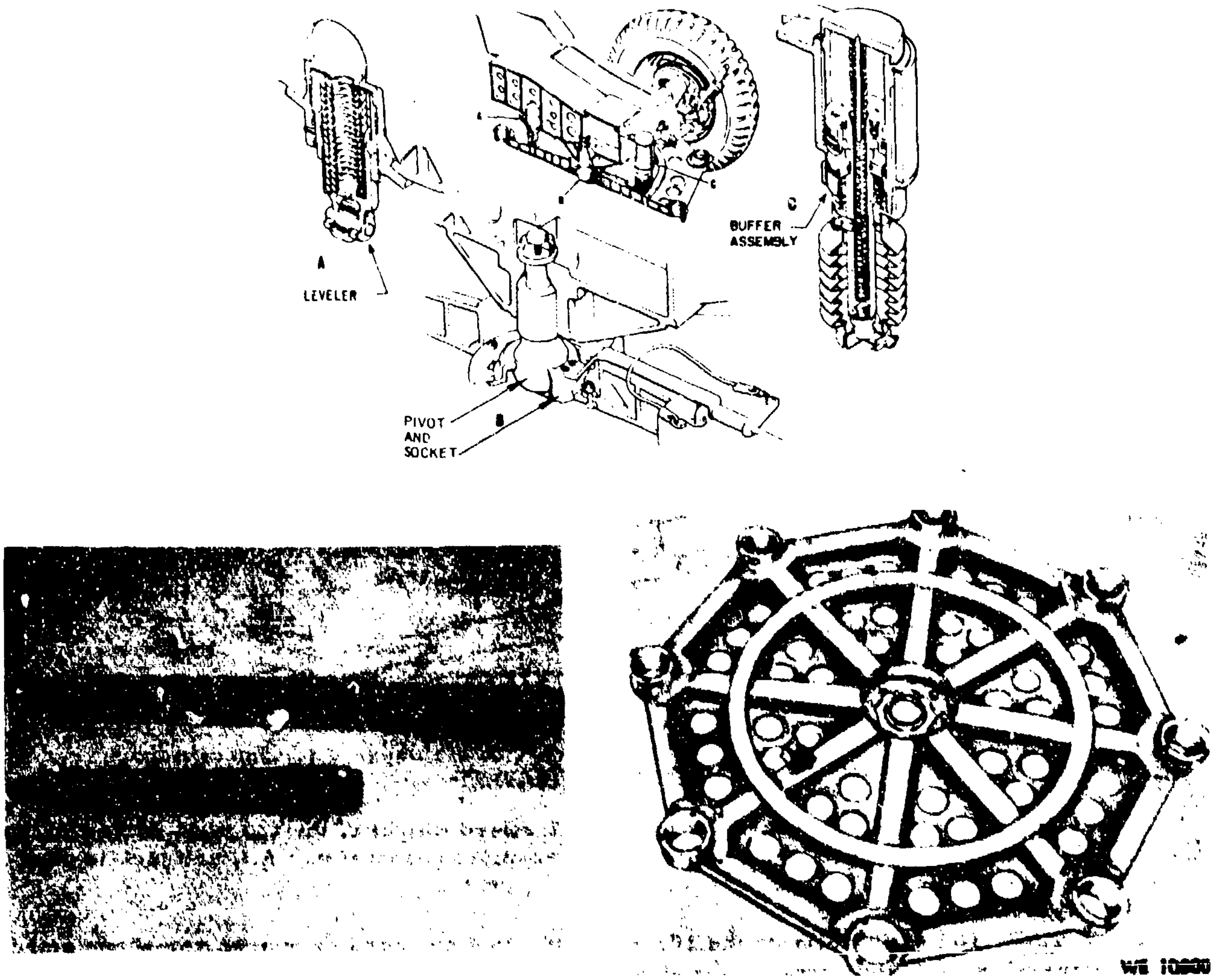


Figure 2-2. Self-propelled bottom carriage.



D
FIRING STAKE

E
FIRING PLATEFORM

Figure 2-4. The M102 howitzer leveler, pivot, buffer assembly, firing platform, and firing stakes.

e. Trails. The split trails on the 105-mm and 155-mm towed carriages serve two principal purposes—they transmit most of the shock of firing through the trail spades to the ground, and they provide a means for coupling the weapon to its prime mover. Brackets mounted on the trails are attached to the bottom (or lower) carriage and are divided into two sections. For firing, they are spread to form an angle of approximately 800 mils, or 45°. The lightweight 105-mm howitzer M102 uses a modified box trail made in a single section. Most of the shock of firing is transmitted through the firing platform to the ground. The M102 does not have spades—displacement is prevented by eight metal stakes driven through holes located at each point of the octagon-shaped firing platform (fig 2-4).

f. Spades. The spades, positioned at the rear end of the trails on towed weapons (except the M102, see *e* above) and at the rear of self-propelled carriages, are forced or dug into the ground to minimize displacement of the weapon during recoil. The spades on the 105-mm towed howitzer M101A1 are fixed to the trails (fig 2-6). The spades

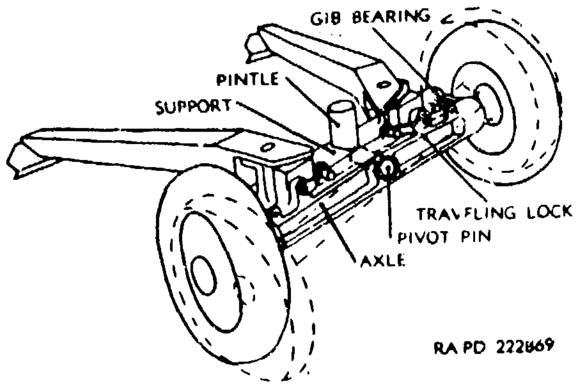


Figure 2-5. Equalizer.

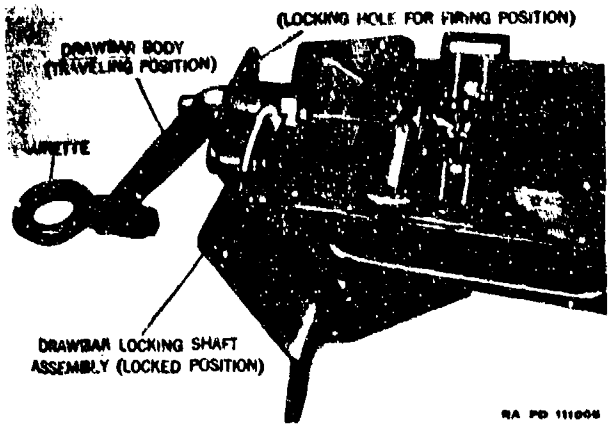


Figure 2-6. Fixed spade.

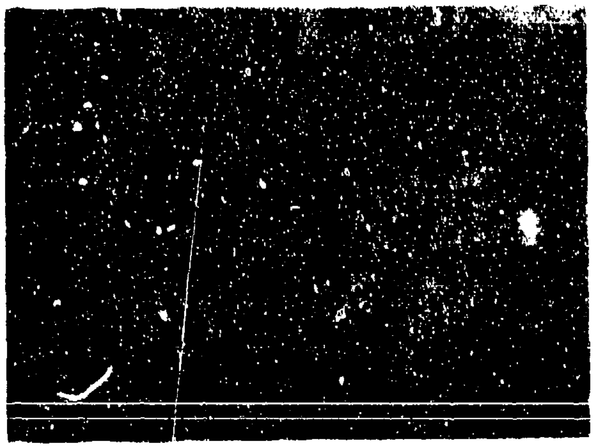


Figure 2-7. Detachable spade.

on the 155-mm towed howitzer are detachable and are removed for traveling and carried in brackets on the side of the trails (fig 2-7).

g. Top carriage. The top carriage (fig 2-8) supports the cradle in its trunnion bearings and includes the elevating mechanism. It moves with the cradle in traverse but not in elevation. When the weapon is traversed, the top carriage rotates horizontally on the bottom carriage. (As noted in *a* above, the 105-mm howitzer M102 has no bottom carriage.)

h. Types of traverse. The types of traverse are classified according to the manner in which the cannon pivots in a horizontal plane about the stationary parts of the weapon. The types of traverse employed by artillery weapons are described in (1) through (3) below.

(1) *Pintle.* The pintle is a vertical pin about which the top carriage revolves. Pintle traverse (fig 2-9) is employed on the split trail 105-mm and 155-mm towed howitzers. This type of traverse was used on most of the towed weapons of the past 30 years.

(2) *Ring and race.* Ring and race traverse is employed on self-propelled weapons. A race, containing balls or roller bearings, is mounted between two rings, one of which is attached to the carriage and the other, to the turret. This arrangement minimizes friction and reduces the effort required to traverse the weapon.

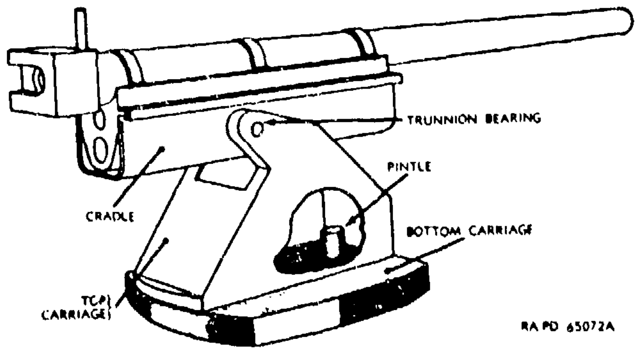


Figure 2-8. Top carriage.

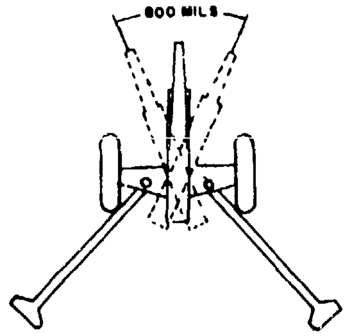


Figure 2-9. Pintle traverse.

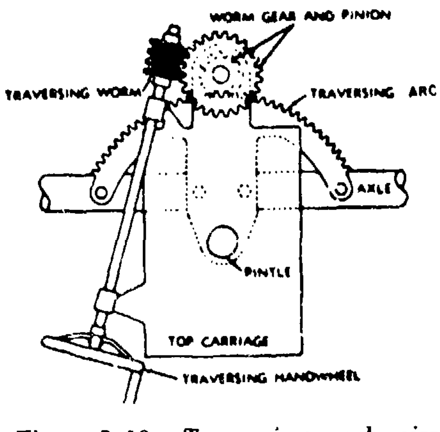


Figure 2-10. Traversing mechanism.

(3) *Pivot and socket.* The carriage of the 105-mm howitzer M102 is supported on a firing platform by a pivot and socket and four stabilizing devices, which ride on the firing platform stiffening ring, permitting a full 6,400-mil traverse (fig 2-4). A roller tire, which is operated by a handwheel on the left side of the trail, is located at the rear of the trail and facilitates fine traversing of the weapon. For large changes in direction, the weapon can be traversed about the pivot and socket joint located in the center of the aluminum platform. If necessary, one man can lift the lunette to traverse the weapon to the desired azimuth.

i. Traversing mechanism. The traversing mechanism is a mechanical device used for making lateral changes in the direction of the tube and for holding the tube in that position. A typical traversing mechanism (the arc and pinion type) is shown in figure 2-10. The M102 is traversed as described in *h*(3) above. Traversing mechanisms may be either manually or power operated, or they may incorporate both capabilities.

j. Cradle. The cradle (fig 2-11) is that part of the carriage that supports the tube and sleigh. If the weapon is not equipped with a sleigh, the cradle houses the tube and the recoil mechanism. In general, the cradle is a U-shaped trough with slides or rails along which certain weapon components recoil and counterrecoil. If a sleigh is used, the cradle provides a means of securing the recoil piston rod or rods. If a sleigh is not used, the cradle provides mountings for the recoil cylinders. *The trunnions of the cradle furnish an axis about which the tipping parts rotate in elevation.* The trunnions rest in trunnion bearings on the carriage. The elevating mechanism is coupled to the cradle by means of the elevating arc, which normally is fastened to the bottom or side of the cradle. The cradle supports the recoiling parts and moves in elevation with them.

k. Sleigh. The sleigh (fig 2-11) is that part of the carriage that provides the immediate support for the tube. In some weapons, the sleigh houses the recoil mechanism and recoils with the tube on the cradle. In some cases, the recoil cylinders are bored directly into the sleigh; in others, the cylinders are separate tubes that are rigidly attached to the sleigh. The tube is firmly secured to the sleigh, which slides on the cradle in recoil and counterrecoil.

l. Elevating mechanism. The elevating mechanism (fig 2-12) consists of devices for elevating or depressing the tube and holding it at the desired angle while it is being fired. The final action generally is applied through an elevating arc attached to the cradle and an elevating pinion attached to the top carriage. When an arc and pinion are used, a worm and worm wheel usually are placed in the gear train to make the system irreversible so that the tube is held at the elevation set. Elevating mechanisms may be either manually or power operated, or they may incorporate both capabilities.

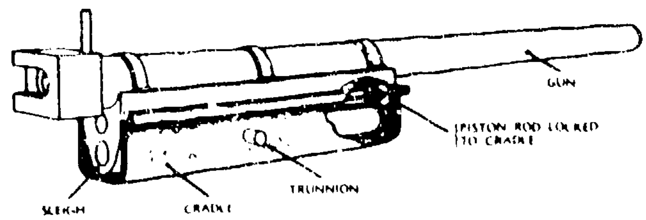


Figure 2-11. Sleigh and cradle.

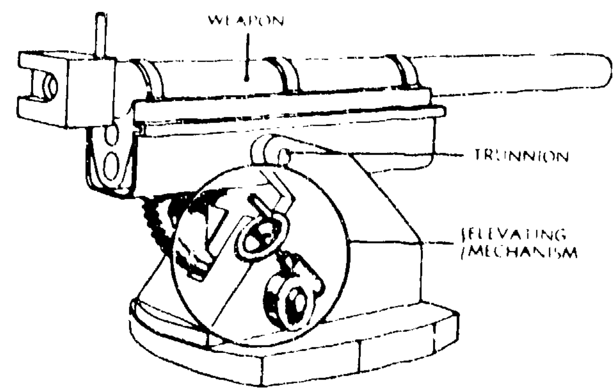


Figure 2-12. Elevating mechanism.

m. Equilibrator. On artillery weapons, the horizontal axis (trunnions) about which the tube revolves is located well to the rear of the center of gravity of the tube to permit high angles of elevation. Thus, the tube is unbalanced, with the preponderance of weight toward the muzzle. An equilibrator is a mechanical device that overcomes the unbalanced weight and keeps the tube in balance at all angles of elevation so that it can be easily elevated or depressed. All types of equilibrators are designed to reduce the manual effort required to elevate the tube. *The equilibrator is in proper adjustment when the tube can be elevated and depressed* with equal ease. The general types of equilibrators are spring, pneumatic, and hydropneumatic.

(1) *Spring equilibrator.* The spring equilibrator (fig 2-13) consists of a spring(s), stops, and guide rods. The spring(s) is held in place under tension by the stops, which are connected to guide rods. When the tube is in its horizontal position, the spring is compressed by the weight of the barrel. The resultant force of the spring against the cradle balances the tube. As the tube is elevated, less force is required to hold it in balance.

The spring stop moves with the cradle, allowing the spring to expand and thereby reducing the force of the spring. The force of the spring is always great enough to hold the tube in balance.

Figure 2-13. Spring equilibrators.

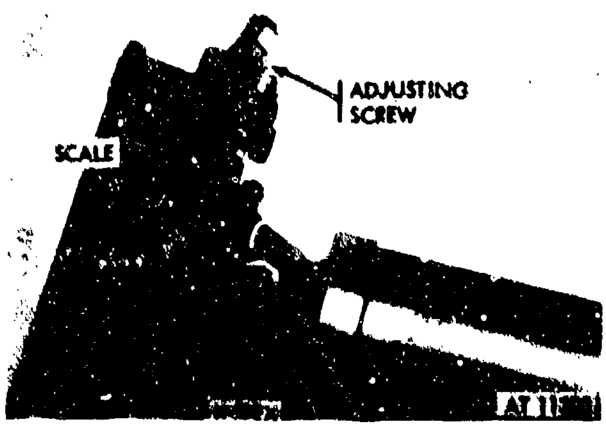


Figure 2-14. Pneumatic equilibrator with adjustment scale.

(2) *Pneumatic equilibrator.* The pneumatic equilibrator (fig 2-14) consists essentially of two gas-filled telescoping cylinders with suitable packing glands and pistons to confine the compressed gas. As the tube is depressed, the cylinders move apart, bringing the pistons close together and thereby increasing the gas pressure and producing a greater lifting force on the tube. As the tube is elevated, the cylinders are telescoped, decreasing the gas pressure to produce a smaller lifting force on the tube.

(3) *Hydropneumatic equilibrator.* The hydropneumatic equilibrator (fig 2-15) consists of a cylinder with a movable piston and rod and a pressure tank connected to the cylinder by a short pipe. These parts are permanently fastened to the top carriage. The piston rod is fastened to the cradle. Liquid from the cylinder passes through the pipe connection to the tank. As the tube is depressed, the piston moves to the rear, forcing the liquid into the tank against the gas pressure. The increasing pressure on the piston keeps the tube in balance. As the tube is elevated, the gas pressure forces the liquid back into the cylinder, moving the piston forward. This pressure aids in elevating the tube and holdng it in position.

Note. Pneumatic and hydropneumatic equilibrators must be adjusted by the cannon crew to compensate for changes in ambient temperature; spring-type equilibrators normally require adjustment only if components are replaced or, rarely, to compensate for spring fatigue.

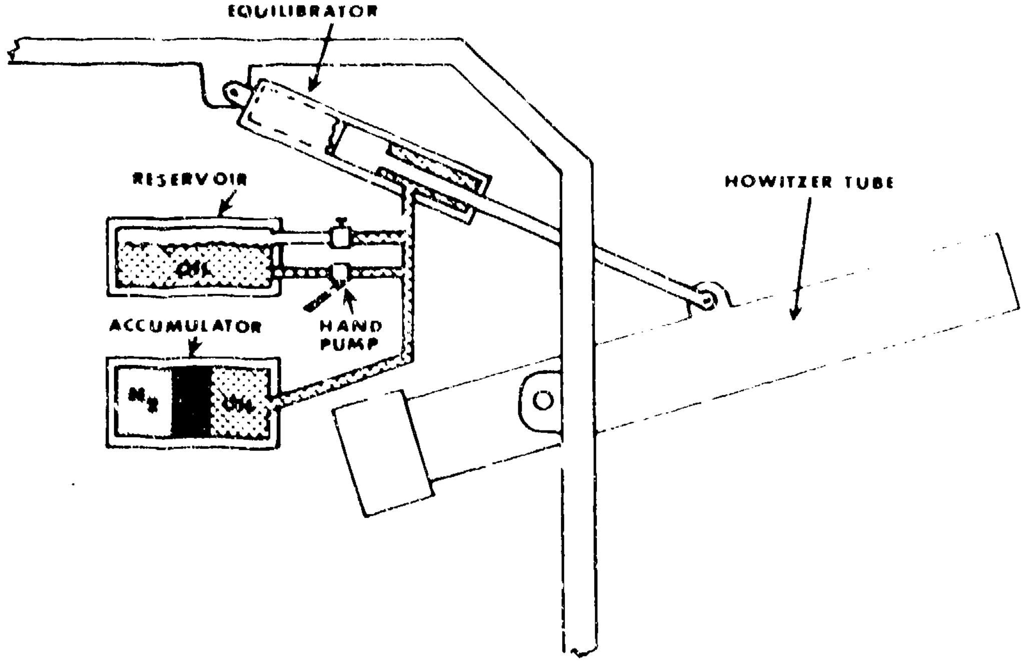


Figure 2-15. Hydropneumatic equilibrator.

Section III. RECOIL MECHANISMS

2-5. Definition of Recoil

Recoil is the rearward movement of the tube and connecting parts after the weapon has been fired. It is caused by the reaction of the tube to the forward motion of the projectile as the projectile is driven through the tube by the expanding propellant gases of the powder charge. Recoil follows Newton's law of motion, which states, in effect, that for every action there is an equal and opposite reaction.

2-6. History of the Development of Recoil Mechanisms

a. The earliest cannons, prior to the year 1350, were positioned on mounds of dirt or blocks of wood. When a cannon was fired, quite a disturbance was created around the weapon position. When the smoke cleared, the cannoneers began a search to the rear for their weapon. When they found the we n, they attached tow ropes and dragged it b to its in-battery position; hence, the term "in-battery," meaning the normal firing position.

b. In 1350 the Venetians put their cannons on wheeled mounts. This did not help to check recoil; however, it did make it easier for the cannoneers to move the weapon back to battery, and it improved the mobility of the weapon.

c. The French introduced the first efficient recoil mechanism in 1897, in the famous "French 75." The weapon used the hydropneumatic liquid and gas principle of checking recoil and returning the tube to battery. Recoil was checked primarily by the throttling of oil, and the tube was returned to battery by the energy of the compressed gas.

d. Development of artillery cannons has always been directed toward improving accuracy and increasing the rate of fire. With the primitive carriages used until approximately 110 years ago, firing a shot caused the entire gun and mount to jump violently. It was then necessary for the guncrew to return the weapon to its original aim before firing the next shot. With the use of the hydropneumatic recoil mechanism, the gun tube slides along the mount and then returns to its in-battery position without excessive shock or movement. The gun remains pointed in its original direction and can be reloaded and fired much more rapidly.

2-7. Purpose of a Recoil Mechanism

The primary purpose of a recoil mechanism is to eliminate weight and at the same time retain stability. It also minimizes the requirement for ruggedness. A recoil mechanism is designed to absorb the energy of recoil gradually, thus avoiding violent shock to, or movement of, the carriage, and to return the recoiling parts to the in-battery position with a minimum of shock. It must also hold the recoiling parts in battery until the weapon is fired again. The four functions of the recoil mechanism are to—

a. Stop the recoiling parts.

b. Return the recoiling parts to the firing position; that is, to the in battery position.

c. Perform the actions in *a* and *b* above without excessive shock to the carriage.

d. Hold the tube ad recoiling parts in the firing position throughout all angles of elevation.

2-8. Major Systems of a Recoil Mechanism

A recoil mechanism is composed of three major systems—*a recoil system*, which provides the stopping action by limiting the length of recoil and stopping the recoiling parts; *a counterrecoil system*, which returns the recoiling parts to the in-battery position and holds them in that position until the weapon is fired again; and *a counterrecoil buffering system*, which diminishes the shock of the recoiling parts as they return to the in-battery position.

2-9. Types of Recoil Mechanism

a. The basic type of recoil mechanism used on current field artillery weapons is the hydropneumatic mechanism (fig 2-16). "Hydro" indicates that the mechanism employs a liquid; the liquid used is recoil oil. Recoil oil is a petroleum-base hydraulic fluid. "Pneumatic" indicates that a gas is used. The gas used in these recoil mechanisms is nitrogen gas. When the weapon is fired, the recoil movement of the weapon is controlled by the *flow of the recoil oil through certain throttling devices of the recoil system, the compression of the nitrogen gas in the recuperator cylinder, and the friction of the moving parts of the weapon.* After the force of recoil has been absorbed by these three actions (*throttling of the oil, compression of the nitrogen gas, and friction of the moving parts*), recoil action ceases. The energy of the compressed nitrogen gas then causes the counterrecoil system of the weapon to move the tube back to the in-battery position.

b. Recoil mechanisms of today are identified as being of the constant, variable, and dependent, or variable and independent type.

(1) *Constant.* A constant recoil mechanism has no mechanical means of changing the length of recoil. The tube recoils approximately the same distance at all elevations when fired under similar circumstances; that is, same powder charge, same atmospheric temperature and so forth.

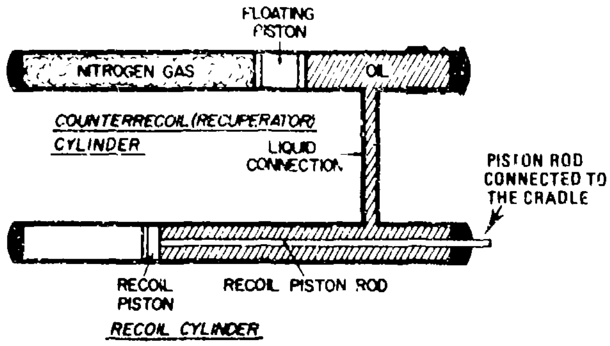


Figure 2-16. Dependent hydropneumatic recoil mechanism.

(2) *Variable.* A variable recoil mechanism has a mechanical means of changing the length of recoil. This change is accomplished automatically by the variable cam assembly (fig 2-17) as the tube is elevated or depressed. This type of action allows the tube to recoil over a longer length at low angles of elevation but reduces the length at higher elevations without creating unnecessary displacement of the carriage. Thus, we have a much more reliable and stable firing platform from which to fire at all angles of elevation.

(3) *Dependent.* A recoil mechanism is dependent if there is a liquid connection between the recoil and counterrecoil systems (fig 2-16). The oil flows from one cylinder to the other through the connection. Thus, the oil is common to both systems (recoil and counterrecoil), and each system is dependent on the other for its operation. This type of recoil mechanism is used on the light field artillery weapons.

(4) *Independent.* A recoil mechanism is independent if there is no liquid connection between the recoil and counterrecoil systems (fig 2-18). The oil in one cylinder does not affect the operation of the oil in the other cylinder because each system is independent of the other for its function. This type of recoil mechanism is used on medium and heavy field artillery weapons.

2-10. Functioning of a Hydropneumatic Dependent Recoil Mechanism

a. Action in recoil. When the howitzer is fired, the force of the expanding gas propels the projectile out of the bore. This same force also reacts against the breechblock and forces the recoiling parts rearward, except for the recoil piston in the recoil cylinder. The piston is held from recoiling by the piston rod, which is secured to the front of the cradle by the piston rod nut (fig 2-19). As the sleigh moves back in recoil, the recoil oil in the recoil cylinder is forced through the oil orifices into the regulator body of the recuperator cylinder. The regulator body contains a one-way

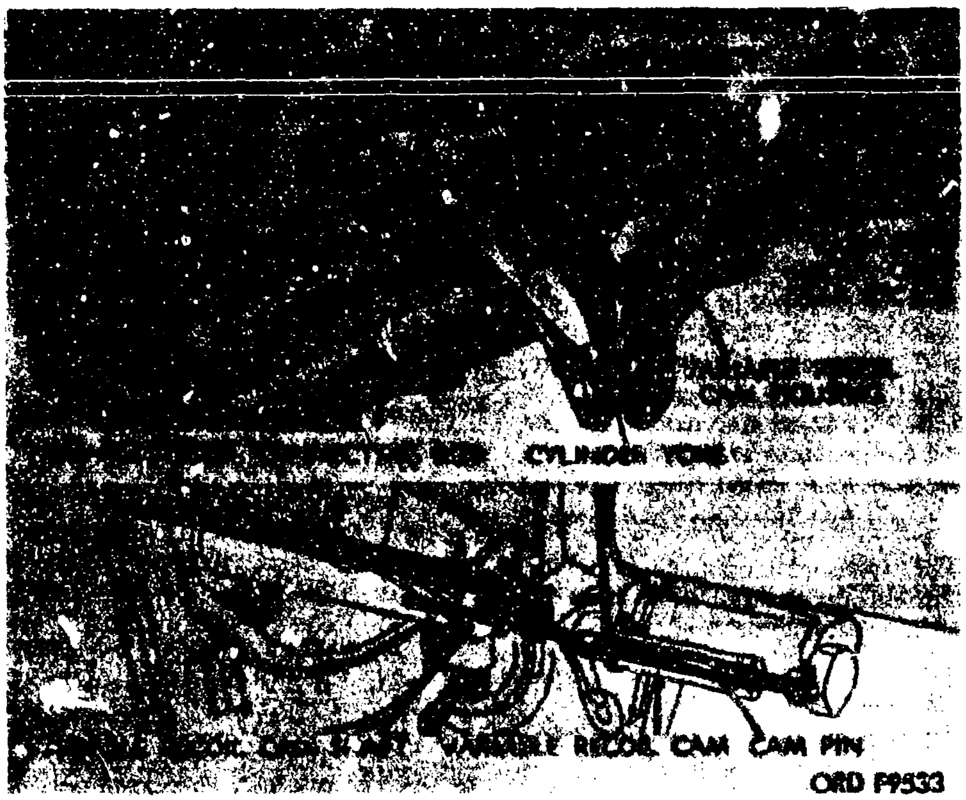


Figure 2-17. Variable recoil cam—assembled and phantom views.

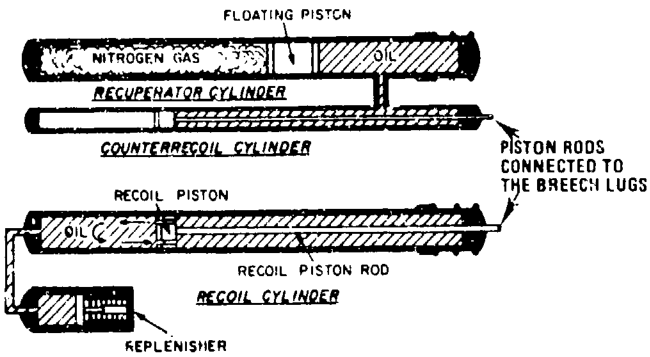


Figure 2-18. Independent hydropneumatic recoil mechanism.

valve and a throttling opening through which the oil passes and where it acts upon the floating piston diaphragm in the recuperator cylinder, forcing it to the rear and further compressing the nitrogen behind the floating piston. As the floating piston moves to the rear, a control rod, which is fastened to the diaphragm, is drawn through the throttling orifice. The area through which oil can flow is then gradually reduced to a point at which the remaining energy of recoil is unable to force the oil to the rear. At that time, since the resistance is equal to the force, further motion is impossible and the recoiling parts are brought to rest. Thus, we can say that the energy of the recoiling parts is dissipated by—

(1) The throttling of the recoil oil.

(2) The compression of the nitrogen gas.

(3) The friction of the moving parts.

b. Action is counterrecoil. When the recoiling parts are brought to rest at the end of recoil, the unbalanced force of the greatly compressed nitrogen gas forces the floating piston and diaphragm forward, pushing the recoil oil back through the regulator into the recoil cylinder against the back of the recoil piston, and thereby returning the recoiling parts to battery.

Note. The recoiling parts are returned to battery without shock by the counterrecoil buffer.

2-11. Functioning of a Hydropneumatic Independent Recoil Mechanism—Recoil Cycle

a. Recoil cylinder. When the weapon is fired, the tube recoils in or on the cradle. Since the hollow piston rod (piston and liner assembly) is connected to a lug on the bottom of the breech ring, it is drawn to the rear with the tube. As the recoil piston is drawn to the rear, oil is forced through two ports in the recoil piston and through the throttling grooves to the forward side of the piston (fig 2-20). As the oil passes through the tapered throttling grooves, the flow of oil from the rearward side to the forward side of the piston is gradually reduced and finally stopped. This throttling action absorbs most of the recoil energy.

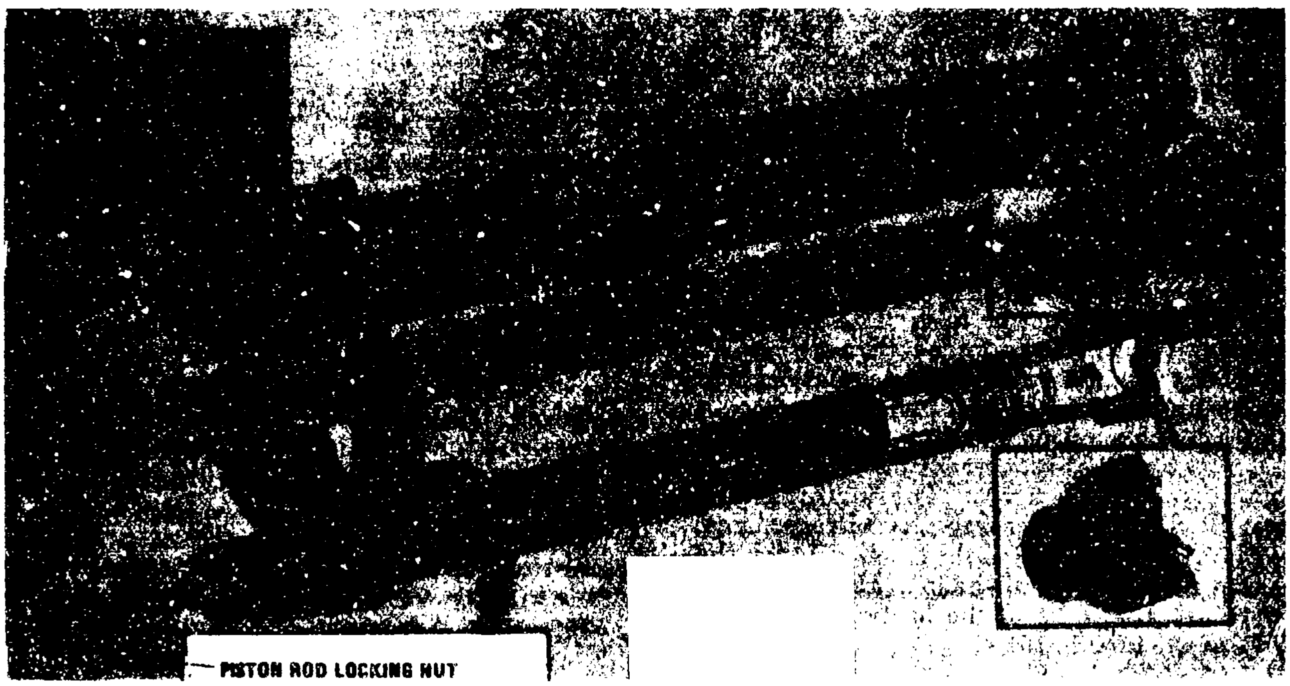
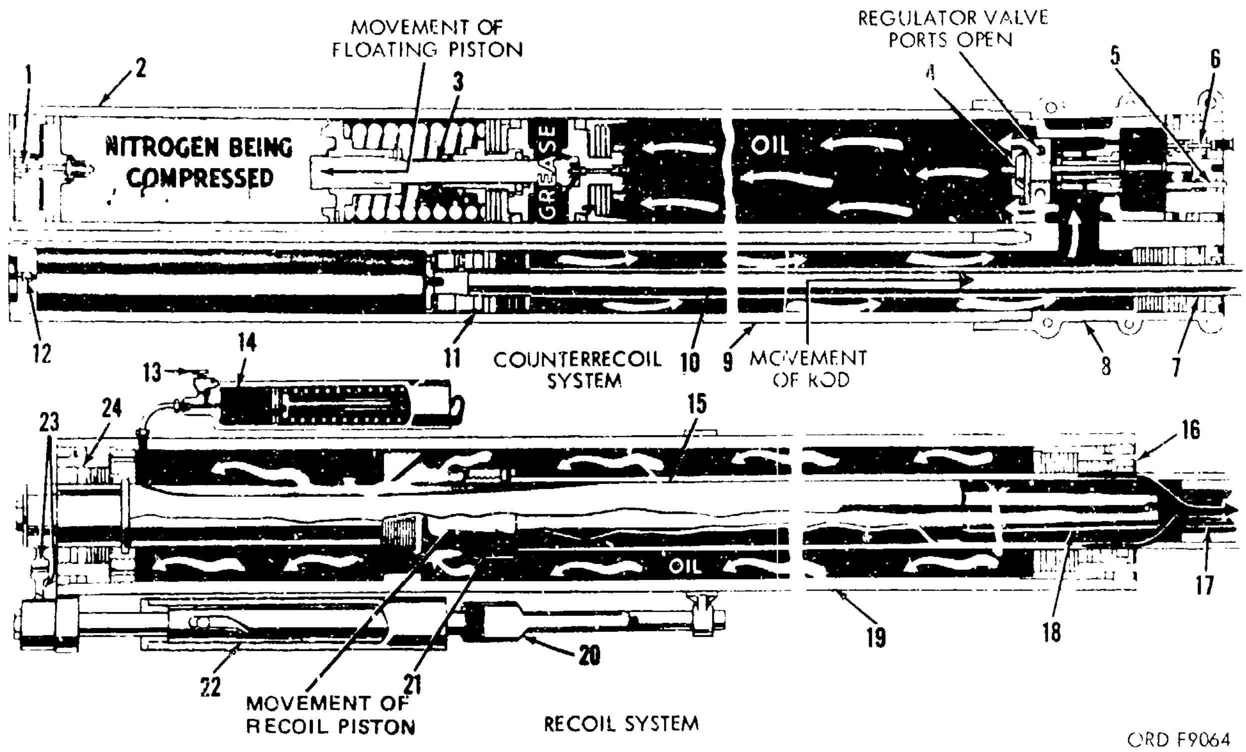


Figure 2-19. Hydropneumatic dependent recoil mechanism.



1—Recuperator charging valve
2—Recuperator cylinder
3—Recuperator floating piston
4—Recuperator cylinder regulator valve
5—Oil index
6—Recuperator cylinder filling valve
7—Counterrecoil rod stuffing box head
8—Counterrecoil and recuperator cylinder head stuffing box
9—Counterrecoil cylinder
10—Counterrecoil piston rod
11—Counterrecoil piston assembly
12—Counterrecoil cylinder respirator assembly
13—Replenisher oil filling valve plug
14—Oil reserve in replenisher
15—Recoil throttling rod
16—Recoil rod stuffing box head
17—Buffer chamber in bore of recoil piston rod and liner assembly
18—Recoil throttling rod
19—Recoil cylinder
20—Variable recoil cam shaft
21—Recoil piston and liner assembly
22—Variable recoil cam
23—Gear sectors
24—Throttling rod packing head

Figure 2-20. Hydropneumatic independent recoil mechanism during recoil action.

b. Counterrecoil and recuperator cylinders. When the weapon is fired, the counterrecoil piston, being connected to the top of the breech ring, moves rearward with the tube. The oil in the counterrecoil cylinder is forced through an oil passage and into the recuperator regulator valve assembly by the counterrecoil piston. The flow of oil under pressure opens a spring-loaded valve in the regulator assembly, permitting a free flow of oil against the floating piston. The floating piston moves forward, compressing the nitrogen gas. Thus, the throttling of oil in the recoil cylinder, the increased compression of the nitrogen gas in the recuperator cylinder, and the friction of moving parts stop the tube in recoil.

2-12. Functioning of a Hydropneumatic Independent Recoil Mechanism—Counterrecoil Cycle

a. Counterrecoil and recuperator cylinders. After the tube has stopped at the end of the recoil cycle, the counterrecoil system takes over to return the tube back to the in-battery position as follows—

(1) The flow of recoil oil stops, and the spring-loaded valve in the regulator valve assembly closes itself. In the head of the recuperator regulator valve are two small counterrecoil controlling ports (fig 2-21), each of which is about 1/16-inch in diameter. These ports control the flow of recoil oil back through the regulator valve assembly and into the counterrecoil cylinder.

(2) Since the floating piston is free to move, the energy stored in the nitrogen gas reacts to displace the floating piston to its normal in-battery position. As the floating piston moves

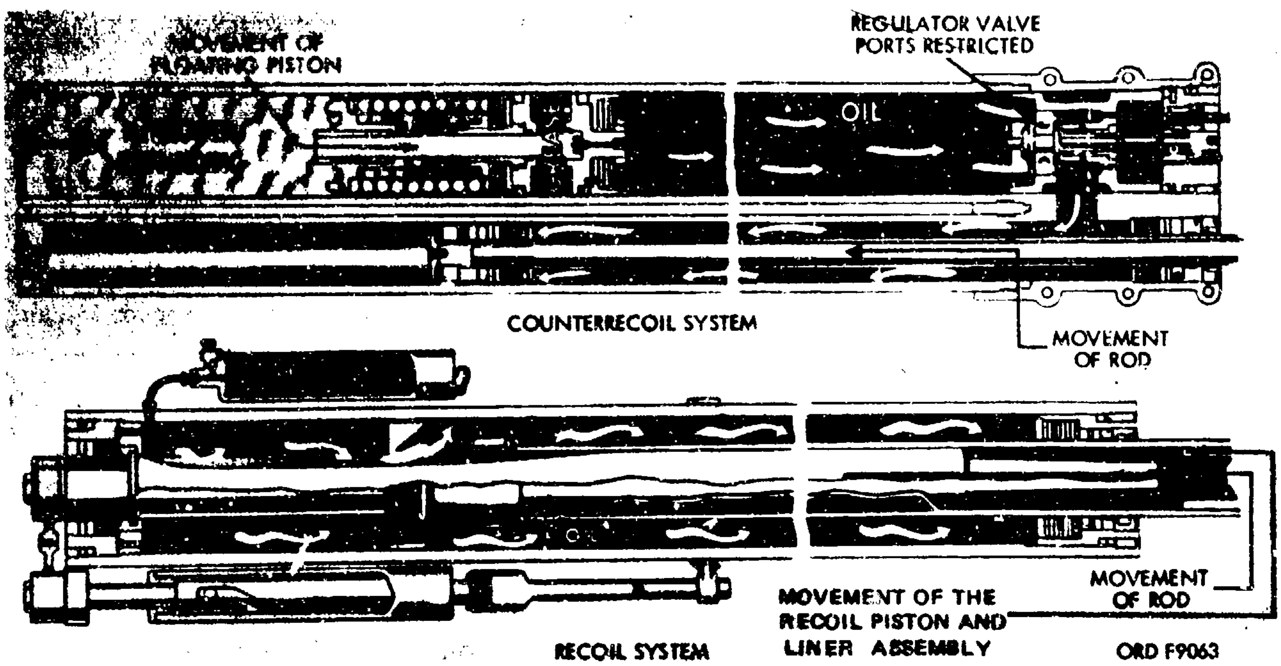


Figure 2-21. Hydropneumatic independent recoil mechanism during counterrecoil action.

toward its in-battery position, it displaces the oil from the recuperator cylinder through two small controlling ports in the regulator valve into the counterrecoil cylinder. The oil exerts pressure on the rear of the counterecoil piston, moving the counterrecoil piston forward and thereby pulling the tube to the in-battery position.

b. Recoil cylinder. As the counterrecoil piston rod pulls the tube into battery, the recoil oil in front of the recoil piston flows through two ports in the piston and the exposed throttling grooves in the recoil throttling rod. Little throttling action occurs at this time in the recoil cylinder as compared to that in the recuperator cylinder; however, as the tube nears the in-battery position, it is slowed down and eased into battery by the spearhead-type buffer. The oil trapped in the buffer chamber must escape through the centrally bored rotatable throttling rod. Thus, the final movement of the tube is cushioned as the tube returns to battery.

2-13. Types of Hydropneumatic Independent Variable Recoil Mechanisms and Their Components

All current medium and heavy field artillery cannons use the hydropneumatic independent recoil mechanism. In addition, all hydropneumatic independent recoil mechanisms are of the variable type, in which a variable cam assembly automatically changes the throttling grooves, or orifices, which control the flow of oil, thus lengthening or shortening the length of recoil, depending on the angle of elevation at which the weapon is fired. When the weapon is fired at low angles of elevation, all the throttling grooves, or orifices, are open so that the barrel and breech assembly is allowed to recoil over a long distance, providing less shock to the carriage. As the weapon is elevated to higher angles of elevation, the length of recoil is shortened so that the barrel and breech assembly will not strike the ground and the force of recoil can be absorbed more directly by the carriage and the ground. A typical variable cam assembly is shown in figure 2-17 and explained in para *a* below.

a. Functioning of a variable cam assembly. An arc gear sector is mounted on the forward end of the throttling rod. This gear sector is meshed with a similar gear sector mounted on the end of the variable recoil cam assembly. The tubular cam is machined with a spiral, or S-shaped, slot. A cam pin, mounted on the camshaft, rides in the spiral slot. The shaft is connected to the top carriage by the variable recoil connecting rod. As the tube is elevated or depressed, the connecting rod moves the shaft either forward or rearward, causing the cam pin on the shaft to turn the cam and its gear sector, which in turn rotates th gear sector on the rotatable throttling rod. The turning of the throttling rod regulates the opening of the oil passages in the throttling rod located in the recoil cylinder, thereby changing the length of recoil automatically as the tube is elevated or depressed.

b. Recoil and counterrecoil actions. All hydropneumatic independent variable recoil mechanisms function basically as described in this handbook. However, there are some minor differences, which will become apparent as you work with each individual weapon. For example, the recoil mechanism of the 155-mm M109 (M109A1) has no counterrecoil cylinder, as such, but has two variable recoil cylinders, a replenisher, and a recuperator cylinder to perform the same functions of the recoil mechanism. In addition, the M109 (M109A1) has a muzzle brake on the end of the tube to help absorb some of the force of recoil and shorten the length of recoil when the weapon is fired.

c. *Replenisher*. Only the hydropneumatic independent variable recoil mechanisms use a replenisher; the dependent recoil mechanisms do not. The replenisher is a small cylinder containing a spring-loaded piston. The replenisher is connected to the recoil cylinder (or cylinders on certain weapons); it is not connected to the recuperator or to the counterrecoil cylinder. The purpose of the replenisher is to maintain the proper amount of recoil oil in the recoil cylinder under pressure at all times. The replenisher compensates for the contraction and expansion of oil due to temperature changes and for changes in the volume of oil required in the recoil cylinder during recoil and counterrecoil. The replenisher also provides a means of checking the quantity of oil in the recoil system. On newer models of the M109/M109A1 howitzers, the replenisher has an accumulator and a pressure gage. The accumulator contains an acorn-shaped bladder, which is charged with nitrogen gas (by support maintenance personnel) to keep pressure on the oil.

d. *Counterrecoil buffer system*. The counterrecoil buffer system controls the last few inches of the final movement of the recoiling parts as they return to the in-battery position, thus preventing shock to the carriage as the tube returns to battery. A typical arrangement is a cone-shaped buffer chamber working in conjunction with a tapered rod (fig 2-21). As the counterrecoil action nears its completion, the tapered rod enters the buffer chamber and displaces the oil. As the rod moves farther into the chamber, the clearance between the two becomes less and less as the oil is metered, or buffed. This action causes the counterrecoiling parts to return to rest without slamming and without shock to the carriage.

2-14. Maintenance of a Recoil Mechanism

Maintenance of a recoil mechanism is limited generally to external cleaning, lubricating, replenishing the reserve oil, and exercising the recoil mechanism on nonfiring weapons.

a. *Maintenance prior to firing*.

(1) To maintain the slides—

(a) Clean and lubricate the external bearing surfaces.

(b) If the weapon has not been fired recently, retract the tube and clean and lubricate the slides. (Check the lubrication order for the M102 weapon as an exception to this statement.)

(c) Insure that any burrs or nicks are depressed by support personnel.

Note. Some of the later model weapons have plastic strips on the slides or gunways that do not need to be lubricated; therefore, always check the latest lubrication order for the specific weapon and comply with the current instructions.

(2) To service the oil in the recoil mechanism—

(a) Add recoil oil, as necessary.

(b) Drain excess oil, as necessary.

(3) Check the recoil mechanism to insure that it is properly connected to the tube, sleigh, or cradle.

(4) Exercise the recoil mechanism every 6 months if the weapon is not fired.

b. *Recoil oil*. Recoil oil is a petroleum-base hydraulic fluid. There are presently three types of recoil oil (OHT, OHA, and OHC) authorized for use in field artillery weapons. OHT is the preferred oil because it provides greater protection against corrosion. The oils can be mixed; however, mixing should be avoided if possible because mixing may tend to dilute the protection additives of one or more of the oils. A recoil mechanism that contains a mixture of oils should be drained and refilled with the preferred OHT as soon as it becomes available. All three oils are red in color and have a temperature range of operation from -65° F to +150° F.

c. *Care of recoil oil*. To properly care for recoil oil—

(1) Be certain that the oil is free of water.

(2) Be sure that the oil is clean.

(3) Purge all lines and connections when filling cylinders.

(4) Store the oil in clearly marked containers apart from lubricating oils.

(5) Destroy the container when it is empty.

Section IV. BARREL AND BREECH ASSEMBLY

2-15. General

One of the major assemblies of an artillery cannon is the barrel and breech assembly. Artillerymen must understand the functioning and required maintenance of the barrel and breech in order to keep their weapons firing.

2-16. History

a. In the pregunpowder period, man tried to increase the range of his weapons by using various types of catapults and ballistae. These devices were nothing more than great slings used to hurl stones and other large, heavy objects considerable distances.

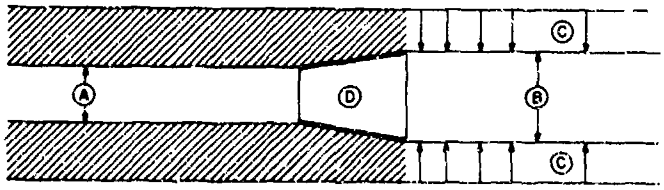
b. The development of cannon preceded that of small arms by about 50 years. The first firearms were large, heavy, and inefficient and were not capable of being carried by an individual soldier. The tube of a gun was made of wooden staves bound together with hoops of iron; hence, the name "barrel."

c. Later, the smoothbore weapons (in which iron and bronze were used for cast tubes) were improved and some of the first attempts were made to obtain mobility.

d. A period of transition followed (from about 1845 to 1885), during which breech loading and rifling were tried and accepted.

e. The development of cannon artillery over the ages and down to the modern period has resulted in the field artillery tube as it is today.

(1) *Construction.* Today's tube is made from an alloy steel ingot, which is poured and then hot-forged into a cylindrical shape by means of a high-pressure press. A hole is bored through the center, the outer surface is rough-turned, and the barrel is machined. The inside of the barrel is machined with a bore guidance system, which insures the straightness of the tube within 0.005 inch throughout its entire length.



A Diameter of the bore before prestressing.
B Diameter of the bore after prestressing.
C Stress action on the finished bore.
D Tungsten carbide slug.

Figure 2-22. Cross section of the tube during manufacture.

(2) *Stressing.* During the sequence of machining steps, the tube is permanently prestressed by a process known as autofrettage. There are two types of autofrettage being used today: light and medium cannon tubes are swaged open by swage autofrettage (*(a)* below and fig 2-22); heavy cannon tubes are hydraulically prestressed (*(b)* below).

(a) Swage autofrettage. In the swage autofrettage process (light and medium cannon tubes), an oversize tungsten carbide slug (D fig 2-22) is pushed through the bore and physically deforms the material by a predetermined amount. When the slug is removed, the bore is in a state of residual compressive stress, a desirable condition for resisting the pressure generated during firing. This process of prestressing increases the strength of the tube without markedly reducing the overall toughness of the steel and thus increases the fatigue life of the tube.

(b) Prestress autofrettage. In the prestress autofrettage process (heavy cannon tubes), the ends of the tube are hydraulically sealed and the cannon tube is lowered into a large cylinder, where controlled hydraulic pressure is added to the interior of the tube until such time as the molecules of steel immediately surrounding the bore are set. Like the process described in *(a)* above, this process of prestressing increases the strength of the tube without markedly reducing the overall toughness of the steel and thus increases the fatigue life of the tube.

2-17. Types of Barrel and Breech Assemblies

The barrel and breech assembly of an artillery cannon (fig 2-23) is composed of a tube, a breech ring, a breech mechanism, and, in some cases, hoops, jackets, or liners. Basically, there are two types of barrel and breech assemblies used on current artillery cannons—the assembly in which semifixed ammunition (ammunition with a cartridge case) is fired and the assembly in which separate-loading ammunition (ammunition without a cartridge case) is fired.

a. The barrel assembly of a cannon that fires semifixed ammunition is composed of six interior components ((1) through (6) below). In this assembly, the cartridge case provides rearward obturation (prevents the propelling gases from escaping to the rear).

(1) The *breech recess* is the space in the interior of the breech ring at the rear of the barrel assembly. It receives the breechblock, which affords a means of mechanically opening and closing the rear of the barrel to permit loading the weapon.

(2) The *powder chamber* is that portion of the tube that houses the propelling charge.

(3) The *centering slope* is the tapered forward portion of the powder chamber. It causes the projectile to center itself in the main bore.

(4) The *forcing cone* is the rear portion of the main bore formed by tapered lands (raised portions of the rifling). It allows the rotating band of the projectile to be engaged gradually by the rifling.

(5) The *main bore* is the rifled portion of the interior of the tube.

(6) The *counterbore* is that portion of the muzzle end of the tube from which the lands have been removed. The purpose of the counterbore is to relieve stress when the weapon is fired and thus prevent the tube from cracking.

b. The barrel assembly of a cannon that fires separate-loading ammunition has the six components listed in *a*(1) through (6) above and, in addition, has a gas-check seat, for a total of seven components. The gas-check seat is the tapered portion of the tube at the rear end of the powder chamber. The gas-check seat, in conjunction with the obturator assembly of the breechblock, provides the rearward seal (rearward obturation).

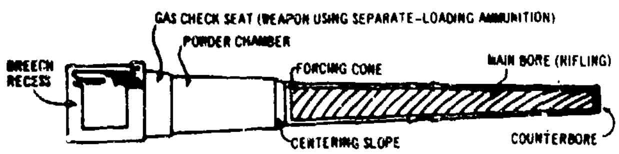


Figure 2-23. Interior components of a barrel and breech assembly.

Note. Obturation is the sealing process that prevents the escape of propelling gases from the tube during firing. Forward obturation in all cases is obtained by the rotating band on the projectile conforming to the lands and grooves of the tube, thus preventing gases from escaping around the projectile. Rearward obturation is described in paragraph 19.

2-18. Breechblock

a. The breechblock is that component of the breech mechanism that permits loading the weapon from the rear. The breechblock requires the same maintenance as that required for the tube (para 23). The type of breechblocks used are the sliding-wedge breechblock and the interrupted-screw breechblock.

(1) *Sliding-wedge breechblock.* The sliding-wedge breechblock (fig 2-24) is used on weapons that fire semifixed ammunition. The breechblock slides into a rectangular recess in the breechring to open and close the breech. This breechblock does not form a gastight seal (rearward obturation) when it is closed; however, it does keep the cartridge case blocked in the powder chamber so that rearward obturation is obtained by the expansion of the cartridge case against the walls of the powder chamber when the weapon is fired.

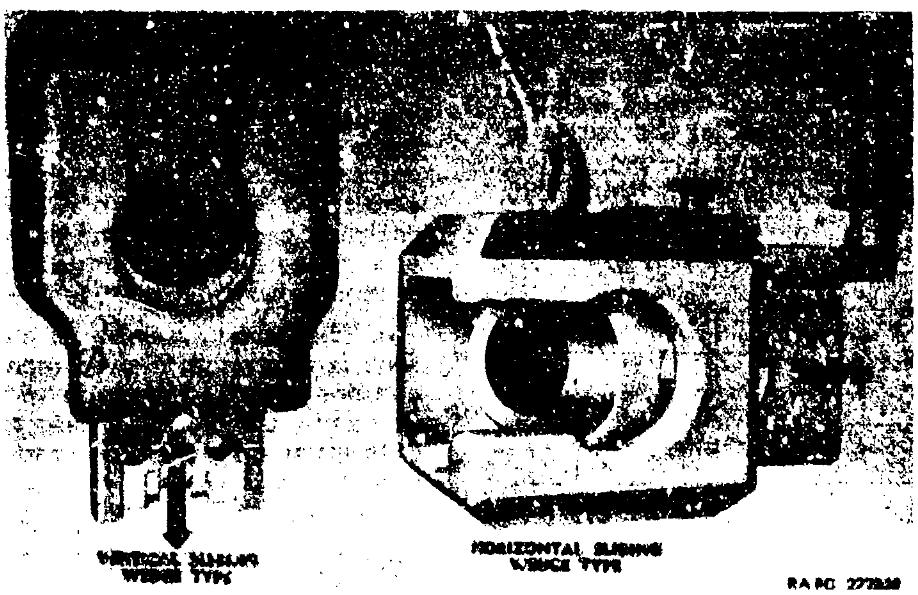


Figure 2-24. Sliding wedge breechblock.

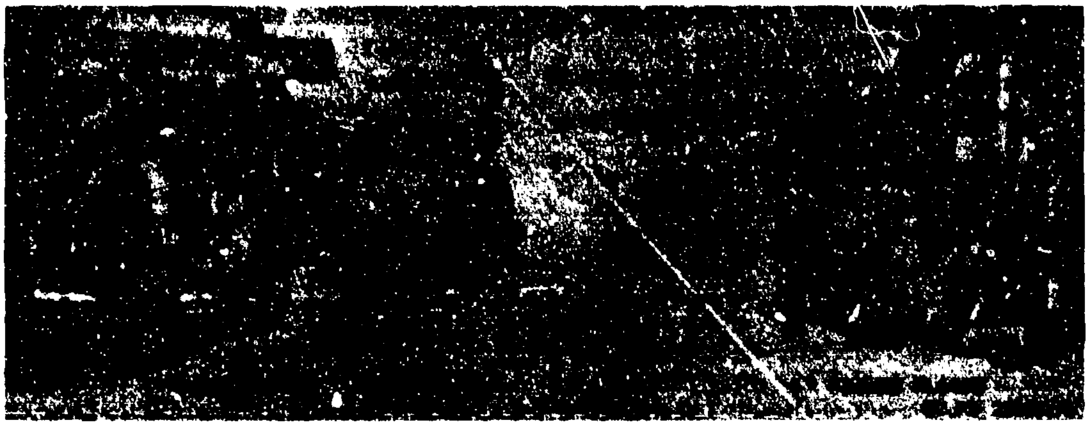


Figure 2-25. Stepped-thread, interrupted-screw breechblock.

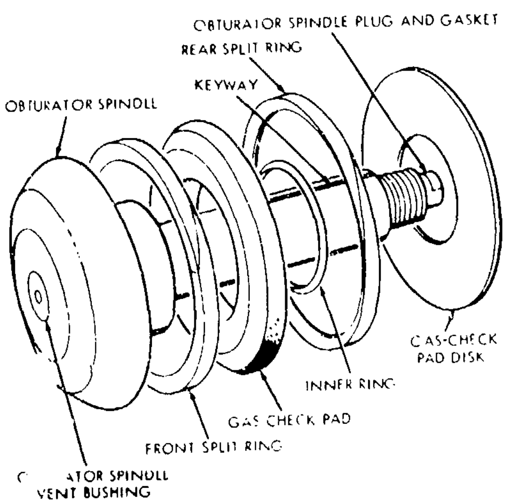


Figure 2-26. Obturator assembly.

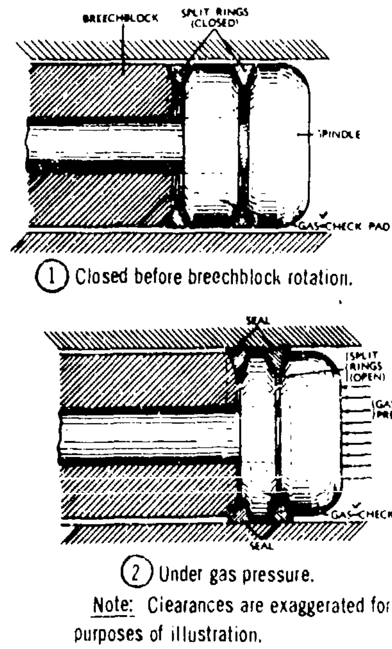


Figure 2-27. Obturator.

(2) *Interrupted-screw breechblock.* The interrupted-screw breechblock (fig 2-25) is used on the weapons that fire separate-loading ammunition; that is, ammunition without a cartridge case. There are two variations in use—the interrupted-screw breechblock without steps in the threads, which is semiautomatic, and the stepped-thread, interrupted-screw breechblock, which holds it in the completely opened position to facilitate loading and which also helps to swing it to the closed position as the cannoneer operates the breechblock operating handle. The semiautomatic interrupted-screw breechblock is held in the open position by an operating cam lever, and when the cannoneer raises the lever, the breechblock closing springs cause the breechblock to close automatically.

b. The interrupted-screw breechblock and the stepped-thread, interrupted-screw breechblock (*a*(2) above) each has an obturator assembly (fig 2-26). This assembly consists of a mushroom head and spindle, two split rings, an inner ring, a gas-check pad, and a gas-check pad disk. When the breechblock is closed, the mushroom head protrudes into the powder chamber, alining the split rings and gas-check pad with the gas-check seat. Rearward obturation is accomplished by the compression of the split rings and gas-check pad being forced against the gas-check seat by the forward movement of the breechblock as it rotates about the obturator spindle and is pulled forward by the thread segments. When the weapon is fired, the pressure from the gases forces the mushroom head slightly to the rear against the front of the breechblock. This action further compresses the gas-check pad, which expands radially and forces the two split rings firmly against the gas-check seat, thus preventing the gas from escaping (fig 2-27).

2-19. Firing Mechanism

The firing mechanism is a device located on or in the breech mechanism of a weapon to ignite the primer. The following types of firing mechanisms are used:

a. Inertia percussion mechanism. The inertia percussion firing mechanism is used on weapons that have a vertical sliding—wedge breechblock and fire semifixed ammunition. This firing mechanism is characterized by a heavy firing pin and guide assembly, which moves forward by inertia to strike the primer after the action of the firing pin spring has stopped. The firing pin and guide assembly is retracted by a separate retracting spring. The mechanism cocks when the breechblock is opened and remains cocked during loading and closing of the breechblock. It is fired by pulling a lanyard on the M102 howitzer.

b. Firing lock M13 mechanism (continuous pull). The firing lock M13 mechanism is used on weapons that have horizontal sliding-wedge breechblocks and that fire semifixed ammunition. The complete operation of the firing mechanism is effected by one continuous pull of the lanyard, and its safety feature is that it is not cocked until the instant before firing.

c. Firing mechanism M1 (percussion hammer). The 155-mm towed howitzer M114A1 fires separate-loading ammunition and is equipped with firing mechanism M1 and the percussion hammer. The firing mechanism with primer is screwed into the breechblock by the cannoneer when the weapon is loaded and ready to fire. The hammer is attached to the breechblock carrier. When the lanyard is pulled, the hammer strikes the firing pin, which in turn strikes the primer, causing the weapon to fire.

d. Firing mechanism M35 (continuous pull). The firing mechanism M35 is used on all self-propelled field artillery weapons that fire separate-loading ammunition. The M35 firing mechanism uses a cartridge-type primer, which is ejected from the mechanism automatically when the breech mechanism is opened. The complete operation of the firing mechanism is activated by one continuous pull of the lanyard (cocking and firing), and its safety feature is that it is not cocked until the instant before firing.

2-20. Auxiliary Devices

a. Chamber evacuators. Chamber evacuators (fig 2-28) are used in combat vehicles to remove the propellant gases from the bore after the weapon has been fired, thus preventing contamination of the fighting compartment. The chamber evacuator, which fits over the cannon tube, forces the gases to flow outward through the bore. Part of the gases flow through valves, which may be inserts in the evacu tor or or ices in the tube itself. The evacuator functions as follows:

(1) When a weapon is fired and the projectile has passed the evacuator valves, located some distance to the rear of the muzzle, some of the propellant gases flow into the evacuator chamber ((2), fig 2-29) creating a high pressure in the chamber. This action continues until the projectile leaves the muzzle, at which time the gases in the bore are suddenly released. When the pressure in the bore drops, the gases flow from the evacuator chamber through the evacuator valves into the bore ((3), fig 2-29).

(2) As the gases flow through the valves at a high velocity, they tend to draw gases from the rear portion of the bore. While gases are escaping from the evacuator chamber into the bore, the breech is opened, allowing air and gases to flow through the bore and out the muzzle ((4), fig 2-29). The breech must be opened before all the gases have escaped from the evacuator chamber; therefore, an evacuator can be used only on a weapon equipped with a semiautomatic breech mechanism.

b. Muzzle brake. A muzzle brake (fig 2-28) is a device that is mounted on the muzzle of a cannon. It has a centrally bored hole, through which the projectile passes, and one or more baff s. The primary purpose of a muzzle brake is to retard the force of recoil. As the projectile leaves the muzzle, the high-velocity gases following the projectile through the tube strike the baffles of the muzzle brake and are deflected toward the rear and sides into the atmosphere. The gases exert a forward force on the baffles; this force partially counteracts the force of recoil, thereby reducing the force of recoil.

2-21. Barrel Measurement, Definitions, and Classifications

a. The *caliber* of a tube is the diameter of the bore measured at the muzzle between opposite lands. The caliber length of a tube is the distance from the muzzle to the face of the breech recess and is expressed in calibers. For example, the barrel of the 8-inch howitzer is 25 times as long as the diameter of its bore; therefore, it is 25 calibers long.

b. Rifling consists of a number of grooves cut in the surface of the bore and the raised portions between the grooves, known as lands. The rifling imparts rotation to the projectile about its longitudinal axis, thereby increasing its stability in flight. The soft rotating band of the projectile is forced to assume the contour of the rifling as the projectile moves forward; thus, rotation is imparted to the projectile.

(1) In most cases, the rifling in the field artillery weapons of today has a uniform right-hand twist. This means that the direction of the twist forward from the breech is clockwise. The twist is uniform throughout the bore, usually one turn in about 20 to 25 calibers.

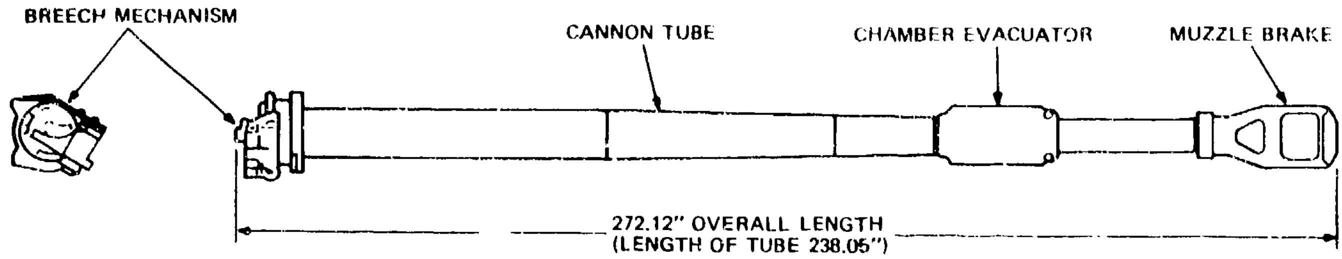


Figure 2-28. Cannon, 155-mm M185 chamber evacuator, muzzle brake.

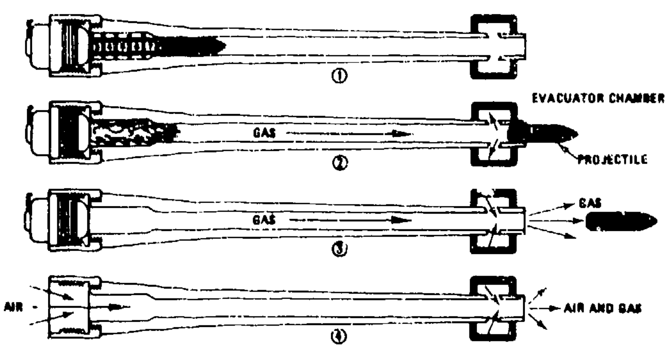


Figure 2-29. Bore evacuating principles.

Type	Range	Muzzle velocity	Trajectory	Caliber length
Mortar	Short	Low	High	10 to 20
Howitzer	Medium	Medium	Medium	20 to 30
Gun	Long	High	Flat	Over 30

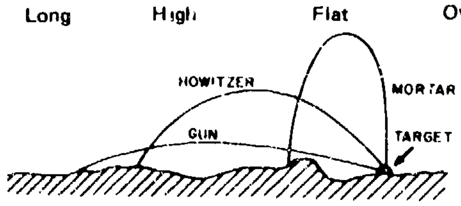


Figure 2-30. Firing trajectories of field artillery weapons.

(2) The rifling in the towed 105-mm howitzer M102 has an increasing right-hand twist, increasing from one turn in 35 calibers at the breech end to one turn in 18 calibers at the muzzle end. The increased spin imparted to the projectile with this type of rifling makes possible greater ranges with increased accuracy.

c. *Cannon* artillery weapons are classified according to their trajectory, range, and muzzle velocity. The muzzle velocity is the speed of the projectile as it leaves the muzzle; it varies with the type of weapon and with the type and quantity of propellant. The general classification data for typical trajectories are shown in figure 2-30.

2-22. Barrel Maintenance

No field artillery weapon is of value unless it receives proper care so that it is ready to fire. To properly care for his weapons, a field artilleryman must understand the causes of damage to the weapons and know how to minimize the damage. Two causes of damage to the tube are corrosion caused by chemical decomposition of the tube (rust) and erosion caused by gas wear, gas wash, and mechanical wearing away.

a. *Corrosion.* Corrosion, or rust, is caused by the absorption of moisture from the air by the hygroscopic primer salts deposited in the tube during firing. These minute salt grains penetrate the pores in the metal and are covered over by protective coatings of powder foulings or carbon during subsequent firing. Gradually, the grains work back to the surface of the metal as they absorb moisture from the air. This process is called sweating. Rusting and pitting will result unless prompt action is taken. Slight pitting is not particularly harmful, but heavy pitting permits the propelling gases to escape, thereby reducing the muzzle velocity, increasing the tube wear, and degrading the accuracy of the weapon. *Corrosion can be eliminated by proper cleaning of the tube.*

(1) An artillery tube should be cleaned immediately after firing and for at least 3 consecutive days thereafter or until the sweating stops. On the third day after firing, if the weapon is not to be fired within 48 hours, it should be cleaned,

wiped dry, and coated with oil. A tube should be cleaned weekly when not being fired.

(2) Rifle bore cleaner, the standard cleaner for field artillery weapons, removes residue more easily and 30 percent faster than other agents. It acts as a rust inhibitor for a period of 24 to 48 hours. *It is not a lubricant.* Rifle bore cleaner will evaporate at 150° F. The tube should be cool enough to touch before the cleaner is used. Rifle bore cleaner should never be diluted with water.

(3) Cleaning compound, solvent, may be used in lieu of rifle bore cleaner. The solvent is a highly penetrating liquid that also provides a temporary rust-resistant coating for the cleaned surface.

(4) If rifle bore cleaner or cleaning compound, solvent, is not available, an authorized substitute is ¼-pound of GI soap to a gallon water. Warm or hot water is preferred. Water alone can be used. In freezing weather, alcohol, glycerine, or ethylene glycol can be added to the cleaning solution to prevent it from freezing.

(5) The cleaning procedure for eliminating corrosion is the same for all cleaning solutions except that the tube must be dried and oiled after each cleaning with a substitute solution such as in paragraphs (3) and (4) above. First, the tube should be swabbed with the cleaning solution. (If GI soap solution is used, the tube must be rinsed thoroughly to remove the soap because of its caustic action.) Then the tube should be rinsed and dried thoroughly. After the tube has been cleaned, it should have a uniform dull gray appearance throughout its surface. Next, the tube should be oiled. If the temperature is above 32° F, oil, lubricating and preservative, medium, should be used. If the temperature is below 32° F, oil, lubricating and preservative, special, should be used.

Note. Specific instructions are contained in the current lubrication order for each weapon. Check it for the latest instructions.

b. Erosion. Erosion is the mechanical wearing away of the tube. The main causes of erosion are *heat* and *pressure*. As the temperature of the metal increases, the metal becomes more pliable, thereby accelerating the rate of erosion. The passage of the projectile through the bore results in metal-to-metal contact. The rate of wear resulting from this contact remains relatively constant. At the instant of firing, before the projectile begins its travel through the bore, the propelling gases escape past the rotating band. The escaping gases cause wear, known as gas wash, because of their velocity and extreme heat. Dirt is another cause of erosion. The rate of erosion is accelerated by the abrasive action of dirt, sand, and grit if allowed to accumulate in the tube or on the projectile. Erosion cannot be eliminated, but certain firing battery practices and procedures can be employed during firing to retard the rate of erosion. Some of these practices are described as follows:

(1) Use the lowest charge that will permit efficient and effective accomplishment of the mission. Using the lowest charge commensurate with the mission reduces heat and reduces the pressure in the breech with a consequent decreased in the amount and velocity of gases escaping past the rotating band.

(2) At all times *use the lowest rate* of fire that will efficiently and effectively accomplish the mission. Using the lowest rate of fire reduces heat.

(3) *Rest a weapon 10 minutes each hour* during sustained firing to permit cooling.

(4) *Swab the tube* with cool water during lulls in firing and swab the powder chamber of a weapon firing separate-loading ammunition after each round. Swabbing reduces heat and removes any dust, grit, or sand that has settled in the tube as a result of firing. Swabbing also removes some of the primer salts, as well as extinguishing any smoldering pieces of the previous powder bag or charge that might be left in the powder chamber.

(5) *Use clean ammunition* at all times. Before loading, clean the projectile and propellant to remove any dirt and sand. Keep the muzzle and breech covers in place during travel and wipe the tube dry before firing. Punching a dry rag through the tube before firing will remove the oil and also prove that the bore is clear of any obstructions.

Section V. NEW WEAPONS

2-23. General

The basic principles of mobility, stability, and flexibility are being put to use in the new weapons that have been introduced during the 1970s. Most of these weapons are still in the experimental or testing stages; however, all of the new weapons are now in the hands of the troops.

2-24. M109A2/A3 Howitzer, Self-Propelled

These are the newest versions of the 155-mm M109 self-propelled howitzer (fig 2-31). These weapons are currently in the hands of some field artillery units; the remaining units will receive them as they become available. This weapon has basically the same capabilities as the M109A1. The main difference is that they have received a total of 19 product improvements (PIPs) or modifications that were designed to increase reliability and maintainability. The primary difference between the M109A2 and the M109A3 is that the M109A2 is a completely new weapon from the ground up whereas the M109A3 is a retrofit or a rebuild of existing M109 and M109A1 howitzers.

2-25. M198 Howitzer, Towed

This is the newest addition to the cannon artillery family. The M198 is a 155-mm towed howitzer capable of achieving ranges of approximately 30,000 meters when firing the rocket assisted projectile (RAP) and a new M203 propelling charge. This weapon has a 6400m rapid shift float being incorporated on the weapon. It is anticipated that the M198 will replace selected 155-mm towed howitzer M114A1 or M114A2 in nondivisional units; also, the M101A1 105-mm towed howitzer of the Marine Corps and most active Army units.

2-26. M110A2 Howitzer, Self-Propelled

This is the latest version of the 8-inch self-propelled howitzer. The most noticeable difference between the old and new weapons is the longer tube and the muzzle break on the newer version. The M110A2 has an increased range capability over the old M110. As a result of the longer tube and muzzle break the M110A2 can fire higher zones or charges of propellants than the M110. The M110A2 has replaced all M110s and the M107 (175-mm guns) in the Army and Marine Corps.

Figure 2-31. M109A2/A3 155-mm howitzer, self-propelled.

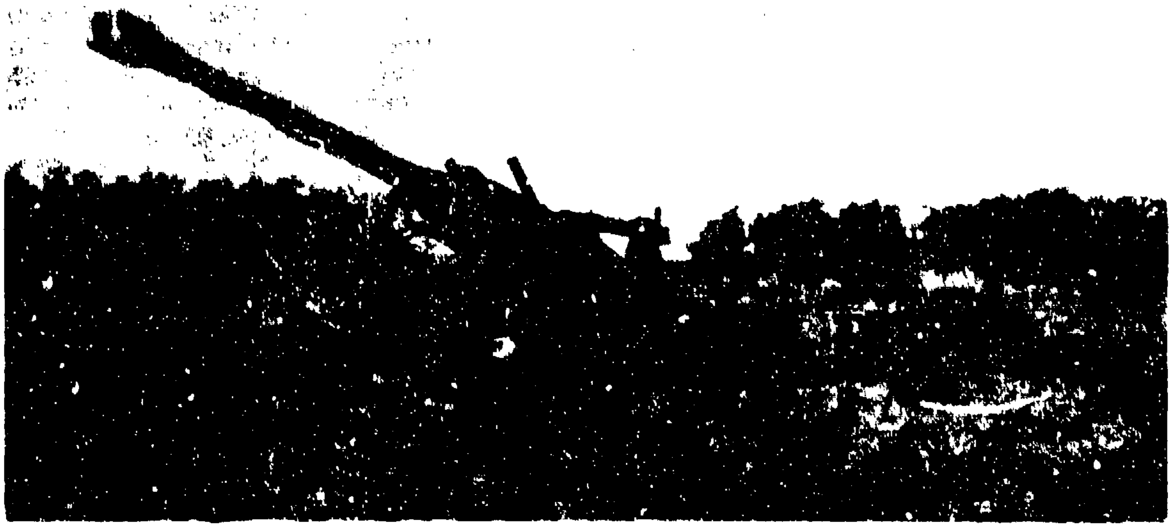


Figure 2-32. M198 howitzer, towed.

Section VI. SUMMARY

2-27. Review

a. The three major components of an artillery weapon are the carriage, the recoil mechanism, and the barrel and breech assembly. You must have a basic knowledge of the design, purpose, function, and general maintenance of these components to understand the more complex functioning of components, which you will study in later classes.

b. The new and experimental weapons you have just read about, and the new powder charges to go with them, are the means whereby the Field Artillery branch is staying abreast of technology to make our artillery cannons the best in the world. Thus, our cannoneers will still be able to put steel on the target and to support the ground-gaining arms by accurate and timely firepower. The basic fundamentals you have learned in this chapter will still be appropriate in the future. Know your weapons, what they will do and what they will not do, and know how to take care of them.

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APPENDIX A
SELECTED CHARACTERISTICS OF FIELD ARTILLERY CANNONS

*As indicated by thermal warning device
**Chg 8: 1 rd/min for 60 min, then 1 rd/3 min thereafter
***Maximum of 300 zone 3 rounds
HSW--Horizontal sliding wedge
VSW--Vertical sliding wedge
STIS--Stepped thread, interrupted screw
TIS--Thread interrupted screw
PH--Percussion hammer
CP--Continuous pull
SIP--Spring actuated, inertia percussion
HPC--Hydropneumatic constant
HPV--Hydropneumatic variable
HP--Hydropneumatic
Pneu--Pneumatic
BG--Box girder

Caliber and model	Maximum range w RAP (meters) Maximum range w/o RAP (meters)	Tube life in EFC rounds	Type of breechblock	Type of firing mechanism	Type of recoil mechanism	Minimum recoil (inches) (max chg, high el)	Maximum recoil (inches) (max chg, low el)	Minimum elevation (mils)	Maximum elevation (mils)	Mils per turn of handwheel (elevation)	Type of traverse	Maximum right traverse (mils)	Maximum left traverse (mils)	Mils per turn of handwheel (traverse)	Type of trails	Equilibrators	Panoramic telescope
105-mm howitzer M101A1, towed	NA 11,000	M2A1 5,000 M2A2 7,500	HSW	CP M13	HPC	39	42	-89	1,156	10	Pintle	409	400	19	Split	Spring	M12A7S
105-mm howitzer M102, towed	NA 11,500	5,000	VSW	SIP	HPV	30	50	-89	1,333	10	Ball and socket	6,400	6,400	21	BG	Spring	M113A1
155-mm howitzer M114A1, towed 155-mm howitzer M114A2, towed	19,400 (A2 only) 14,600	M1 2,000 M1A1 & M1A1(Mod) 7,500	STIS	PH M1	HPV	41	60	0	1,156	15	Pintle	448	418	10	Split	Spring	M12A7Q
155-mm howitzer M198, towed	30,000 24,000	1,750	TIS	CP M35	HPV	50	70	-89	1,279	10	Pintle	400 (6,400	400 speed)	10	Split	Pneu	M137
155-mm howitzer M109A1, A2, A3, SP	23,500 18,100	[illegible]000	TIS	CP M35	HPV	24	36	-53	1,333	10	Ring and race	6,400	6,400	10	Veh spade	HP	M117
8-inch howitzer M110A2, SP	30,000 22,900	10,000	STIS	CP M35	HPV	25	70	+35	1,156	2.5	Ring and race	533	533	5	Veh spade	Pneu	M115

SELECTED CHARACTERISTICS OF FIELD ARTILLERY CANNONS—*Continued*

Telescope mount	Elbow telescope	Range or elevation quadrant	Approximate operating weight (pounds)	Length, traveling	Width, travelling	Height, traveling	Time to emplace (minutes) (IAW ARTEP)	Maximum rate of fire (rd/min) (first 3 min)	Sustained rate of fire (rd/min)	Prime mover	FM	TM	Notes
M21A1	M16A1D	M4A1	4,980	19'8"	7'½"	5'2"	1	10	3	Hel 2½-ton	6-75	9-1015-203-12	
M134A1	M114A1	M14A1	3,170	22'	6'4"	5'3"	2	10	3	2½-ton Hel Prcht 5/4-ton		9-1015-234-10	
M25		M1A1	12,700	24'	8'	5'11"	3½	4	1	5-ton	6-81	9-1025-200-12	
M171	M138	M17 M18	15,800	39'3"	9'2"	9'6"	TBD	4	*	5-ton		9-1025-211-10	
M146	M118CA1	M15	53,940	29'8"	10'4"	10'1"	½	4	**1	SP	6-88	9-2350-303-10(A2) 9-2350-217-10N(A1/A3)	
M137	M139	M15	62,500	35'3"	10'4"	9'11"	2½	1.5	0.5	SP	6-94	9-2350-304-10	

Prcht--Parachute
2½-ton--Truck
5-ton--Truck
5/4-ton--Truck
10-ton--Truck
Hel--Helicopter

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U. S. ARMY
FIELD ARTILLERY SCHOOL
Weapons Department
Fort Sill, Oklahoma

CHAPTER 3

105-MM HOWITZER M101A1, TOWED

Section I. GENERAL

3-1. References

TM 9-1015-203-12, FM 6-75, and LO 9-1015-203-10.

3-2. Introduction

The 105-mm howitzer M101A1 is a light towed field artillery weapon normally used in direct support of an infantry division. The 105-mm battalion includes three firing batteries equipped with six howitzers each. The M101A1 (fig 3-1) weighs 4,980 pounds and fires a 33-pound projectile of semifixed ammunition to a maximum range of 11,000 meters. The prime mover for the howitzer is the 2½-ton cargo truck and can be transported by CH-47 helicopters. This chapter describes the nomenclature, operation, functioning, adjustment, maintenance, disassembly, and assembly of the major components of the weapon.

Figure 3-1. 105-mm howitzer M101A1

*Supersedes HB-3 WCXXWS, Dec 81.

Section II. CARRIAGE

3-3. Trails

a. Purpose. The trails are used to connect the weapon and the prime mover for traveling, to stabilize the weapon in the firing position, and to carry the aiming posts, trail handspikes, and the old wooden style cleaning staff sections.

b. Construction. The trails are constructed of welded steel, built up and reinforced with transoms inside.

c. Parts. The parts of the trails are:

(1) Trail extensions, which connect the trails to the equalizing mechanism by means of trail hinge pins (fig 3-2).

(2) Trail locking pins, which lock the trails when spread to prevent them from closing during firing (fig 3-2).

(3) Trail bumpers, which limit the spread of each trail to approximately 30° from center, for total spread of 60° (fig 3-2).

(4) Cradle traveling lock brackets. See paragraph 6*b*(7)(*b*)2.

(5) The fixed spades, which provide stability for the weapon during firing (fig 3-3).

(6) The lunette and drawbar assembly, which allows connection of the weapon to the prime mover for traveling (fig 3-3).

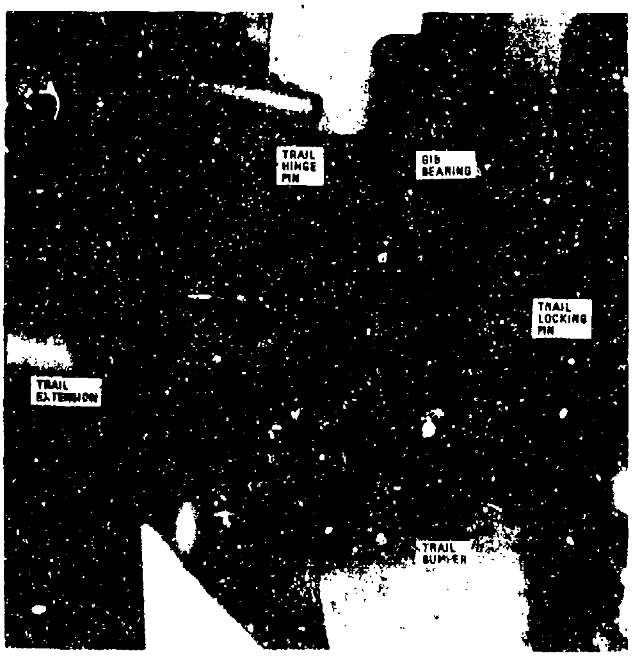


Figure 3-2. Parts of the trail.

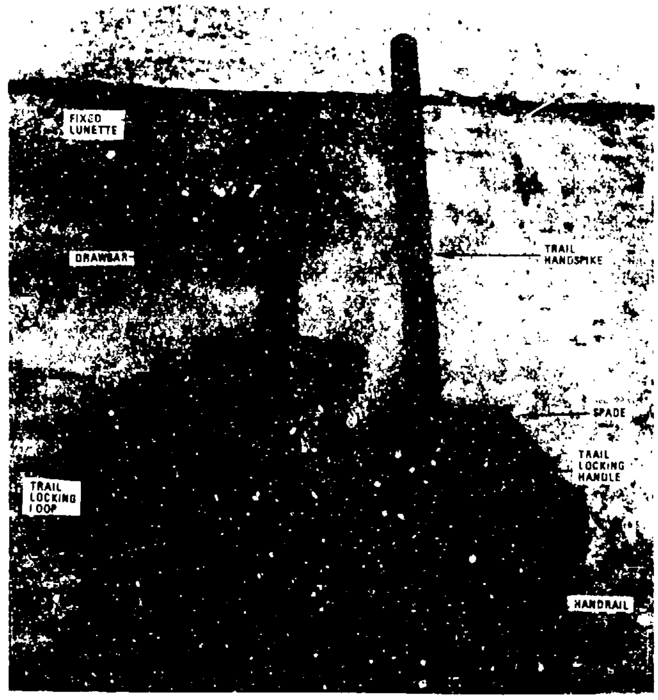


Figure 3-3. Lunette and drawbar assembly.

3-4. Equalizing Mechanism

a. Purpose. The equalizing mechanism permits the weapon to be emplaced in the firing position on uneven terrain with the four points of contact on the ground, the two wheels and two spades, in different planes.

b. Components. The equalizing mechanism consists of an axle, gib bearings, an equalizing support, a horizontal pivot pin, and an axle lock crank assembly.

c. Functioning.

(1) When the weapon is fired, the shock of firing is transmitted to the horizontal pivot pin and the two trails. This results in three points of suspension, even though four points of the weapon rest on the ground.

(2) When the weapon is emplaced on uneven terrain, the equalizing support rotates on the horizontal pivot pin, placing the tilting parts of the weapon in a firing position within the limits of the gib bearings 10° (178 mils) (fig 3-2).

d. Axle assembly. The axle assembly is an I-beam forged construction with a spindle on each end for mounting hubs. Gib bearings on both sides maintain alinement with the equalizing mechanism. Mounted in front on both sides of the weapon are handcranks (fig 3-4) for axle locks to lock the equalizing support and axle together when in the traveling position. The horizontal pivot pin is mounted in a center bearing (fig 3-4).

e. Support group. The support group is a built-up, welded tube, the surface of which moves in the axle gib bearings. The contact between the screw stops on the axle and the lugs on the support limits the amount of inclination.

3-5. Cradle

a. Purpose. The cradle—

(1) Supports the sleigh, the recoil mechanism, and the barrel and breech assembly.

(2) Provides a means of attaching the recoil piston rod to the carriage.

b. Construction.

(1) The cradle is a U-shaped trough made of reinforced steel that supports the recoiling parts and moves in elevation with them. The front end is closed, and the rear end is open.

(2) The recoil piston rod passes through a hole in the front of the cradle and is held in place by a piston rod outer locking nut.

(3) The rear end of the cradle is open to allow the recoiling parts to move rearward.

(4) The recoil sleigh assembly rests and slides on bronze strips attached to the top of the cradle. The breech ring rests and slides on steel rails.

(5) The trunnions, located approximately 38 inches from the rear of the cradle, rest in bearings in the top carriage and provide the pivot point for elevation.

(6) Cradle lock strut:

Figure 3-4. Right- and left-hand axle locks.

Figure 3-5. Cradle lock strut assembly.

(a) Purpose. The cradle lock strut (fig 3-5) supports the overhanging weight of the barrel and breech assembly and the recoil mechanism in the traveling position and thus removes the strain from the elevating mechanism, which would otherwise be subjected to excessive wear.

(b) Construction.

1. The upper end of the cradle lock strut is mounted to the bottom of the cradle by two plain bearings and a hinge pin.

2. The cradle lock strut consists of a brace, a piece, a turnbuckle, and two jamnuts (fig 3-5).

(c) Positions.

1. In the traveling position, the cradle lock strut is swung down and locked to the center and bottom of the bottom carriage and is held in place by the lower strut latch assembly (fig 3-5).

2. In the firing position, the cradle lock strut is swung upward and locked in place by the upper strut latch assembly (fig 3-5).

(d) Adjustment.

1. The cradle lock strut can be adjusted, if it is too long or too short to engage the lower strut latch when the trails are closed, by loosening the jamnuts on the strut, turning the turnbuckle until the proper length is obtained, and retightening the jamnuts.

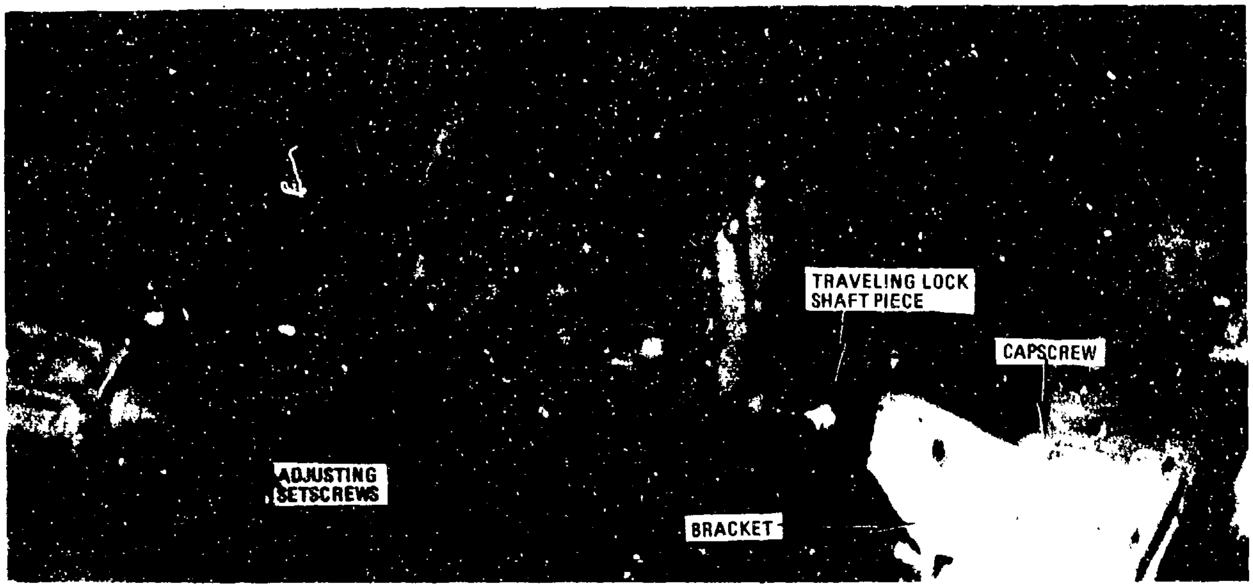


Figure 3-6. Cradle traveling lock.

2. The cradle lock strut must be adjusted so that the upper bearing surface of the cradle lock brace engages the lower strut latch.

3. The trails must be closed, and the cradle traveling lock must be secured.

Note. If the strut is not properly centered with the trails closed, the traveling lock brackets on the trails should be adjusted.

(7) Cradle traveling lock:

(a) Purpose. The cradle traveling lock—

1. Locks the cradle in the center of traverse for traveling.

2. Relieves the strain from the elevating and traversing mechanisms.

(b) Construction.

1. The cradle traveling lock (fig 3-6) consists of two ball-shaped pieces mounted on the rear bottom end of the cradle.

2. Matching brackets on the trails engage the ball-shaped pieces when the trails are closed and hold the cradle in the center of traverse for traveling.

3. The cradle traveling lock brackets may be adjusted to tighten the fit and to center the tube so that the cradle lock strut will operate properly.

3-6. Handbrakes

a. Purpose. The handbrakes hold the weapon in position when it is not connected to the prime mover.

b. Disassembly, adjustment, and assembly. Disassemble, adjust, and assemble the handbrakes as described in TM 9-1015-203-12.

c. Proper adjustment. The handbrakes are in proper adjustment when the levers can be pulled about halfway down the rack before the brake is completely set. To verify the adjustment, the wheels must be raised and rotated when the handbrake is applied.

3-7. Wheels and Hubs

a. Remove and assemble the wheels and hubs as described in TM 9-1015-203-12.

b. Adjust the wheel bearings as described in TM 9-1015-203-12.

Note. Maintenance of this component and of all other components of the 105-mm howitzer M101A1 described in subsequent paragraphs of this chapter will include lubrication of the item concerned. Lubrication of all components will be performed in accordance with Lubrication Order 9-1015-203-10.

3-8. Top Carriage

a. Purpose. The top carriage provides flexibility in traverse and supports the cradle and the elevating and traversing mechanisms on the stationary mount provided by the equalizing support.

b. Components. The top carriage consists of everything that moves in traverse, but not in elevation, except the shields, traversing mechanisms, and elevating arcs. The top carriage is locked in the center of traverse by the cradle traveling lock.

c. Assembly. The vertical pintle pin passes through the top carriage and support. The cradle pivots on the trunnion bearings at the rear of the top carriage. The pintle is the axis for traverse, and the trunnions are the axis for elevation.

d. Lubrication. The top carriage is lubricated as prescribed by LO 9-1015-203-10.

3-9. Traverse

The type of traverse is pintle. The pintle is the vertical bearing about which the top carriage revolves.

a. The total amount of on-carriage traverse is 800 mils, 400 mils to the left and 400 mils to the right of the center of traverse.

b. The amount of traverse, left and right, is limited by stops on the top carriage contacting the equalizing mechanism.

3-10. Traversing Mechanism

a. Purpose. The traversing mechanism allows the tube of the weapon to be moved either left or right in a horizontal plane.

b. Type. The traversing mechanism on the towed 105-mm howitzer is of the screw-and-nut type.

(1) Each complete turn of the handwheel moves the tube 19 mils.

(2) The muzzle moves to the right when the handwheel is turned to the right, and the muzzle moves to the left when the handwheel is turned to the left.

c. Components. The traversing mechanism consists of a nut housing bracket, a screw, a shaft, a handwheel, and a pivot mounting bracket for screws.

d. Disassembly and assembly. End play in the traversing wormshaft is adjusted by means of a collar. The collar may be removed and replaced. The handwheel may be removed, installed, and adjusted as described in TM 9-1015-203-12. The allowable backlash in the handwheel is 1/6 turn.

e. Lubrication. The traversing mechanism is lubricated as prescribed by the current LO 9-1015-203-10.

3-11. Elevating Mechanism

a. Purpose. The elevating mechanism allows the tube to be moved in a vertical plane.

b. Type. The elevating mechanism is of the arc and pinion type.

(1) Total elevation is from 0 to 1,156 mils. Elevation is limited by the equilibrator spring front seat contacting the fulcrum.

(2) Total depression is from 0 to -89 mils. Depression is limited by the stops screwed on the bottom of the elevating arcs.

(3) One complete turn of the handwheel moves the tube 10 mils.

c. Components. The elevating mechanism consists of a left elevating handwheel with an elevating cross-shaft, two bevel gears, a flexible joint, and a bevel pinion shaft and of a right elevating handwheel with two bevel gears, a flexible joint, an elevating wormshaft, an elevating worm, an elevation worm wheel, an elevating worm wheel shaft, spur pinions, and two elevating arcs.

(1) The worm and worm wheel make the elevating mechanism an irreversible type.

(2) Plain bronze and antifriction roller bearings are used in the elevating mechanism.

d. Disassembly and assembly. Only the elevating handwheel may be removed and adjusted as described in TM 9-1015-203-12. The maximum allowable backlash in the elevating handwheel is 1/6 turn.

e. Lubrication. The elevating mechanism is lubricated as prescribed by the current LO 9-1015-203-10.

3-12. Equilibrator

a. Purpose. The equilibrator compensates for the preponderance of the weight toward the muzzle caused by the rear-mounted trunnions and thus reduces the manual effort required to elevate and depress the tube.

b. Type. The equilibrator is an open-spring, puller-type mechanism that connects the rear end of the cradle to the top carriage.

c. Adjustment.

(1) If the tube is hard to elevate and easy to depress, tighten the adjusting nut on each rod an *equal amount* by turning it clockwise ¼ turn until the same amount of effort is required to elevate the tube as to depress the tube.

(2) If the tube is easy to elevate and hard to depress, loosen the adjusting nut on each rod an *equal amount* by turning it counterclockwise ¼ turn until the same amount of handwheel effort is required to depress the tube as to elevate the tube.

Note. If the nuts are not adjusted equally, the rear seat of the spring will bind on the spring rod. The distance from the end of each guide rod to the adjusting nut should be measured to insure equal adjustment.

3-13. Shields

The shields are constructed to protect the crew from fragmentation or small-arms fire from the front. The shields may be removed by the using unit, although this is seldom necessary. The sight box is mounted on the left shield.

Section III. BARREL AND BREECH ASSEMBLIES

3-14. Barrel Assembly

a. General. The barrel assembly consists of the tube, breech ring, cannon locking ring, and guides. The barrel is screwed into the breech ring and secured by the breech ring locking screw. The barrel is secured to the recoil sleigh by the cannon locking ring, which is locked in place by the cannon locking ring screw. Two lugs on the breech ring fit into matching notches in the rear yoke of the recoil sleigh, thus preventing the barrel group from rotating inside the sleigh during firing.

b. Construction. The tube is made by pouring an alloy steel ingot, which is hot forged into a cylindrical shape by use of a high-pressure press. A hole is then bored through the center and the outside surface is rough-turned and machined. The inside of the barrel is machined with a bore guidance system that insures the straightness of the barrel to within 0.005 inch for the entire length of the tube. The tube is made of high strength steel.

c. Characteristics.

(1) *Caliber*—105-mm, or 4.13 inches between opposite lands.

(2) *Length*—(muzzle to rear face of breech ring)—101.35 inches.

(3) *Length of tube*—93.05 inches (22.5 cal).

(4) *Length of rifling (bore)*—78.02 inches.

(5) *Muzzle velocity*—472 meters per second (maximum charge).

(6) *Maximum chamber pressure*—32,000 pounds per square inch.

(7) *Lands and grooves*—36.

(8) *Rifling*—uniform right-hand twist, 1 turn in 20 calibers.

(9) *Maximum range*—11,000 meters.

(10) *Rate of fire*—sustained is 3 rounds per minute; maximum is 10 rounds per minute for the first 3 minutes.

(11) *Weight of barrel assembly*—973 pounds.

(12) *Weight of breech mechanism*—91 pounds.

d. Tube and breech life. Each round of ammunition fired through a cannon tube causes wear and erosion of the tube and results in a change in the dimensions of the bore. The extent of wear for most gun tubes and some howitzer tubes determines the remaining life of the tube. In addition to wear and erosion, each round produces metal fatigue, a process in which heat and expanding gases weaken the metal in the tube and reduce tube life. The method for determining the remaining life for these tubes is to convert rounds fired to equivalent full charge (EFC) rounds and subtract the EFC rounds fired from the remaining rounds authorized. The tube and breech life for the 105-mm howitzers M101 and M101A1 are shown in table 3-1. The information in the table was extracted from TM 9-1000-202-10 and change 1 to TM 9-1000-202-35.

(1) To convert rounds fired to EFC rounds, multiply the number of rounds fired (by charge) by the EFC factor for the charge as shown in table 3-1.

(2) Since the condemnation criteria for the tube and breech, as listed in table 3-1, is based on

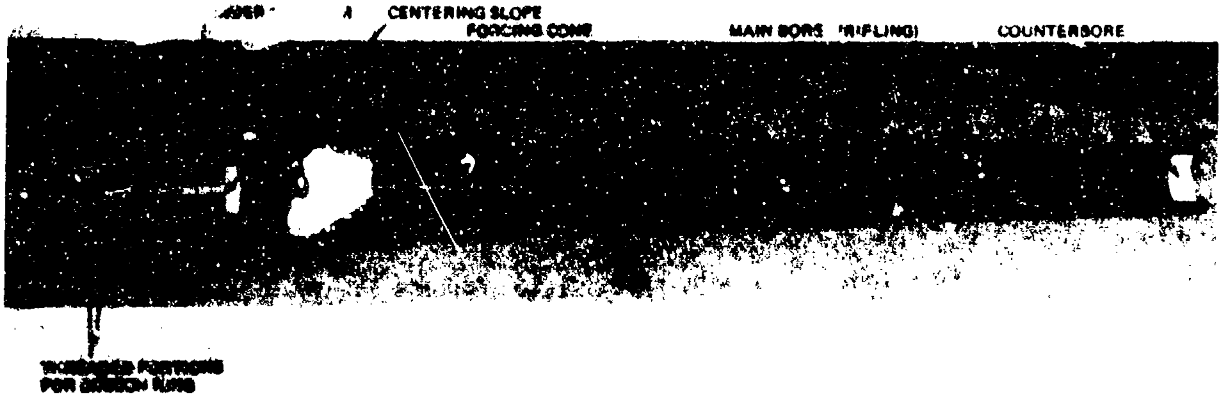


Figure 3-7. Cross section of 105-mm tube.

Table 3-1. Condemnation Criteria for Tubes and Breech Assemblies

Condemnation Criteria for Tubes and Breech Assemblies 105-mm Howitzer M101 and M101A1			
Cannon tube	**EFC life of tube**	**EFC factor**	**Breech life**
M2A1	5,000 rounds	Charge 7 = 1.00 Charge 1-6 = 0.25	Original, plus 2 tubes
M2A2	7,500 rounds	Charge 7 = 1.00 Charge 1-6 = 0.25	Original, plus 2 tubes

EFC rounds fired, the charge for each round fired must be entered on the Weapon Record Data Card (DA Form 2408-4) maintained in the log book for each weapon. The total rounds fired by charge must be carried forward to the new data card upon closeout and submission of the old card to the U.S. Army Weapons Command on the dates indicated in TM 38-750.

e. Borescoping requirements.

(1) Since there is no direct correlation between wear measurements and metal fatigue, the requirement to borescope cannon tubes still exists. Cracks, material defects, and other damage, although they bear little relation to cannon age or number of rounds fired, can grow progressively worse through continued firing. Therefore, a cannon tube may be condemned even though the EFC condemnation limit may not have been reached.

(2) As a minimum, insure that technically trained personnel visually inspect cannon tubes with a borescope as follows:

(a) Cannon tubes will be inspected with a borescope within 90 days prior to the initial firing of the weapon and at 90-day intervals when the weapon is used for continuous or recurring firing.

(b) Cannon tubes will be inspected with a borescope within 90 days prior to the initial firing of the weapon and within 90 days prior to semiannual, annual, or other firing intervals.

(c) At the time of inspection, the maintenance personnel should check to insure the user is maintaining TAMMS records in accordance with TM 38-750, is accurately recording rounds fired by charge, and is accurately computing remaining EFC rounds.

3-15. Interior Portion of Barrel and Breech

a. The *breech recess* is the space at the rear of the barrel assembly formed in the interior of the breech ring, which is designed to receive the breechblock, and thereby affords a means of mechanically opening and closing the rear of the assembly for loading and firing the weapon.

b. The *powder chamber* is that portion of the tube designed to house the propelling charge which is contained in the cartridge case.

c. The *centering slope* is the tapered portion forward of the powder chamber that causes the projectile to center itself in the bore during the loading operation.

d. The *forcing cone* is the rear portion of the main bore formed by tapered lands. The forcing cone allows the rotating band of the projectile to be engaged gradually by the rifling, thus insuring the proper seating of the projectile.

e. The *main bore* includes all the portion forward of the centering slope; that is, the entire rifled portion of the bore.

f. The *counterbore* is that portion of the muzzle end of the tube that has been rebored a predetermined distance to increase the diameter by removing the lands and grooves from that portion. The purpose of the counterbore is to relieve stress when the weapon is fired to prevent the end of the tube from cracking. It does this by allowing the gasses to escape past the rotating band, before it reaches the end of the tube.

3-16. Exterior of the Barrel Assembly

a. General.

(1) The rear end of the barrel is threaded externally so that the breech ring can be screwed onto the tube.

(2) The four scribed lines (or dots) on the muzzle end of the tube are witness marks for alining the crosshairs used in boresighting.

b. Cannon locking ring.

(1) The cannon locking ring is screwed onto the tube just in front of the front yoke of the sleigh assembly. It attaches the barrel and breech assembly to the recoil sleigh assembly.

(2) The threads of the cannon locking ring are lubricated with grease, molybdenum disulfide (GMD). This lubricant is an improvement over graphite grease and should be used if available. Both lubricants have heat-resistant qualities.

c. Seat ring. The seat ring is the bearing surface directly behind the threads on the tube that receive the cannon locking ring and fits inside the bearing surface in the front yoke of the recoil sleigh assembly. It serves the purpose of seating the tube properly in the sleigh assembly.

d. Fixed ring. The fixed ring is the raised portion just to the rear of the seat ring. It stops the forward motion of the tube as it is installed inside the sleigh assembly and fits snugly behind the front yoke as the cannon locking ring fits in front of the front yoke.

3-17. Breech Ring

a. The breech mechanism allows the breech to be opened so that a round of ammunition can be inserted and be closed so that the round can be fired.

b. The breech ring is screwed on the tube and locked in place by a locking screw. Two lugs on the bottom of the breech ring prevent the tube from rotating during firing.

c. There are two bronze slides on the bottom of the breech ring and two quadrant leveling plates on the top.

3-18. Breech Mechanism

a. The breech mechanism allows the breech to be opened so that a round of ammunition can be inserted and to close so that the round can be fired.

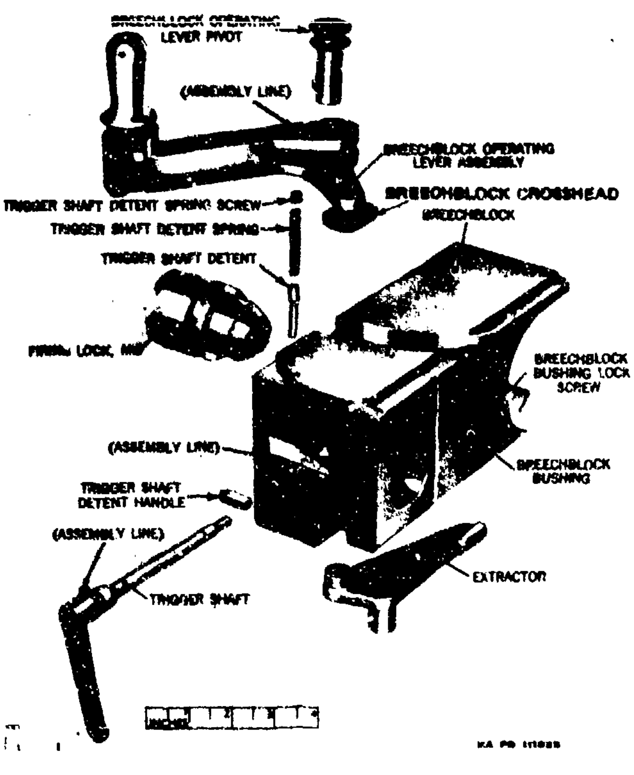


Figure 3-8. Breech mechanism—components.

b. The breech mechanism (fig 3-8) is housed in the breech ring. It is composed principally of a horizontal sliding-wedge breechblock, the breechblock operating lever and lever pivot, and an extractor and also houses the firing lock and trigger shaft, which are considered components of the firing mechanism.

c. Two safety features are inherent in a sliding wedge-type breechblock employing a continuous pull-type firing lock. First, if the breechblock is not fully closed, the firing pin cannot strike the primer; second, the firing lock cannot be actuated if the tube is more than ¾ inch out of battery, because the trigger shaft cannot be rotated far enough to actuate the lock.

d. Two German silver quadrant seats are located on top of the breech ring. These machined surfaces provide a level plane on which to seat the M1A1 gunner's quadrant. These seats should be wiped clean and should not be abraded, cut, dented, or otherwise damaged. They should provide a smooth surface on which to place the shoes of the gunner's quadrant.

e. The breech life of this weapon is three tubes, the original tube plus two retubings (see table 3-1). The number of retubings for each weapon should be stamped on the rear face of the breech ring.

3-19. Firing Mechanism and Firing Lock

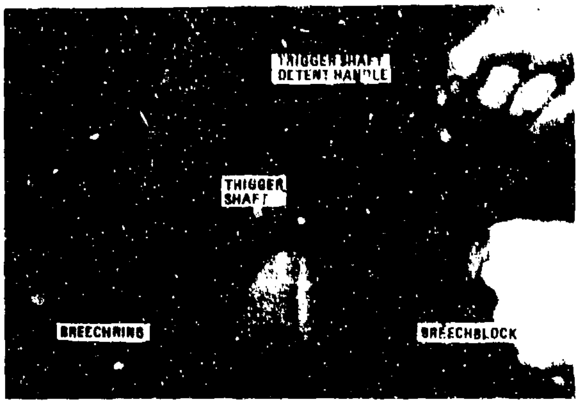
a. The firing mechanism consists of the lanyard, firing shaft, bracket, and firing shaft pawl.

b. Firing lock M13 is a continuous-pull-self-cocking-type firing lock.

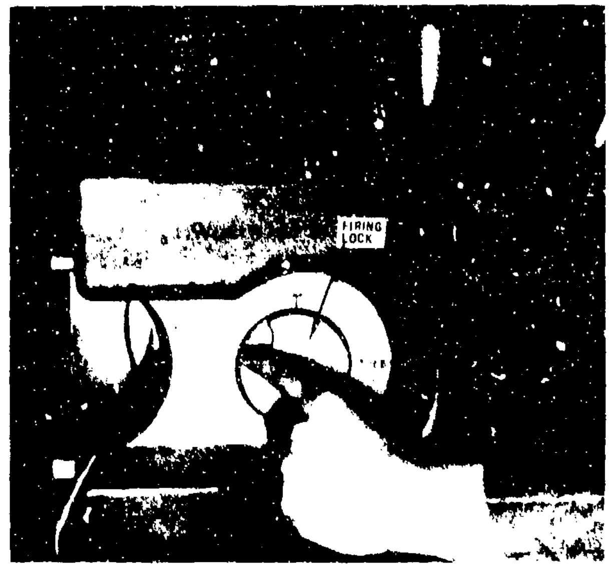
3-20. Operation of the Firing Lock

a. Firing. When the arm of the trigger shaft is moved to the rear, the shaft is rotated clockwise and its squared end, fitting inside the trigger fork causes the trigger fork to be rotated forward. As the trigger fork is rotated forward, it forces the firing pin holder sleeve forward which compresses the firing spring and at the end of its forward motion depresses the sear. As the sear is depressed, it releases the firing pin holder and the compressed firing spring drives the firing pin holder and firing pin forward, and the firing pin strikes the primer.

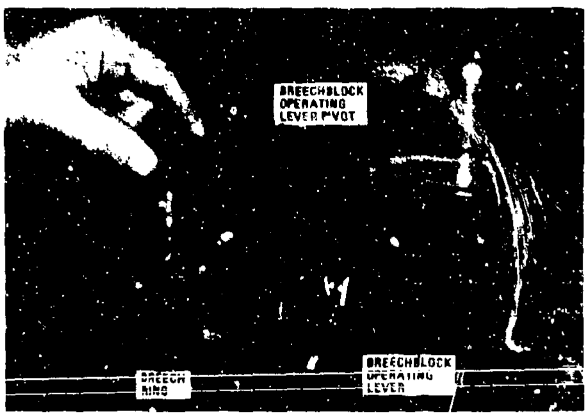
b. Cocking. When the lanyard is released, the pressure from the trigger fork is no longer exerted on the firing pin holder. Since the firing spring is still under partial compression, it continues to exert pressure and expand. The leverage to the rear is greater; therefore, the firing pin holder sleeve and firing pin holder are forced to the rear and the sear engages the firing pin holder, and keeps it in this position until the lanyard is pulled again.



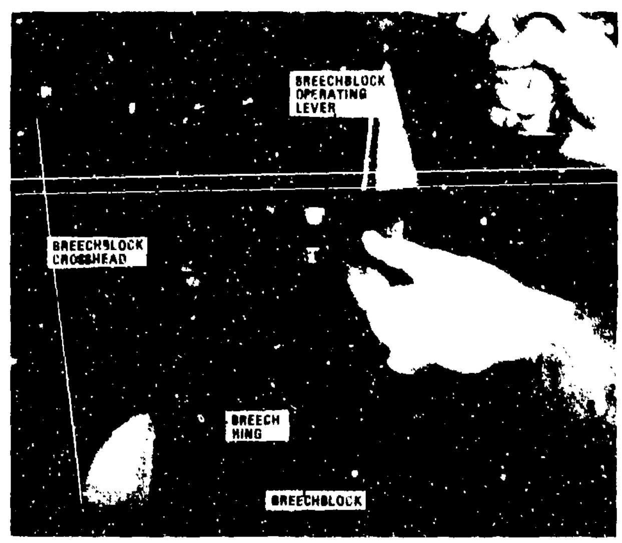
1. Lift detent handle and withdraw trigger shaft.



2. Turn firing lock 1/6 turn and remove it from breechblock.

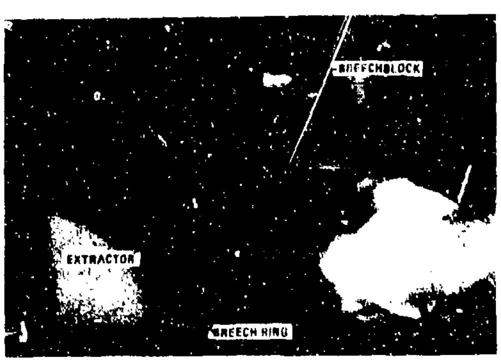


3. Open breech until assembly line on lever is at edge of breech ring. Remove operating lever pivot.



4. Pull breechblock to right until the crosshead on operating lever clears the breech ring. Remove lever.

Note. New manufacture of breechblock crosshead will be round design, free fitting without setscrew (5998391).



5. Push breechblock just far enough to the left to clear the extractor. Rotate the extractor out of its seat and lift it so that the extractor trunnion clears its recess in the breech ring. Remove extractor.

6. Slide breechblock to extreme right and lift it out of the breech ring. To install breechblock, reverse procedure.

Figure 3-9. Disassembly and assembly of the breech mechanism.

3-21. Disassembly and Assembly of the Breech Mechanism

The procedure for disassembly and assembly of the breech mechanism is described and illustrated in figure 3-9.

3-22. Disassembly of the Firing Lock M13

a. Remove the trigger fork by grasping the firing case with the trigger fork down and pressing the firing pin against a solid surface. The trigger fork will fall free of the firing lock onto the surface.

b. Press the front end of the sear out of engagement with the firing pin holder; at the same time, push the assembled firing pin holder and sleeve forward until they can be grasped and pulled from the firing case. Remove the sear and sear spring.

c. To disassemble the firing pin holder and sleeve, grasp the rear end of the firing pin holder sleeve and place the firing pin on a solid surface. Push the firing pin holder sleeve down to unhook it from the holder. Allow the holder to recede out of the sleeve, freeing the spring.

d. Remove the cotter pin from the firing pin holder and unscrew the firing pin.

Note. In some firing locks, the firing pin and firing pin bushing are one piece.

e. While the firing lock (fig 3-10) is disassembled, the component parts should be cleaned thoroughly with rifle bore cleaner, wiped dry, inspected, lubricated and reassembled.

3-23. Assembly of the Firing Lock

a. Screw the firing pin into the firing pin holder, insert the cotter pin, and spread its ends carefully so that they will not rub against the firing case. Assemble the firing spring over the holder and the sleeve over the spring and holder. Compress the spring below the top of the T of the holder and keep it compressed until the T enters the T-slot of the sleeve. Put the firing pin on a solid surface and press downward on the sleeve until the hook of the holder shank hooks into the notch at the rear of the firing pin holder sleeve.

b. Insert the sear spring into its seat in the bottom of the firing case. Insert the sear into the case (fork part first) so that the sear spring stud enters the sear spring.

c. Keep the sear pressed down by grasping the fork end with the little finger of the hand holding the firing case and insert the assembled firing pin holder and sleeve into the case with the flat portion of the sleeve and the sear notch of the holder against the sear so that they will engage the sear. Hold the sear from slipping backward, withdraw the finger, and push the holder back until it is latched by the sear. In order for the sear to engage the sear notch of the firing pin holder, the rear of the sear should be pushed inward.

d. Insert the trigger fork into the opening in the bottom of the case with the side marked MUZZLE FACE toward the front. Push the trigger fork until it snaps into position.

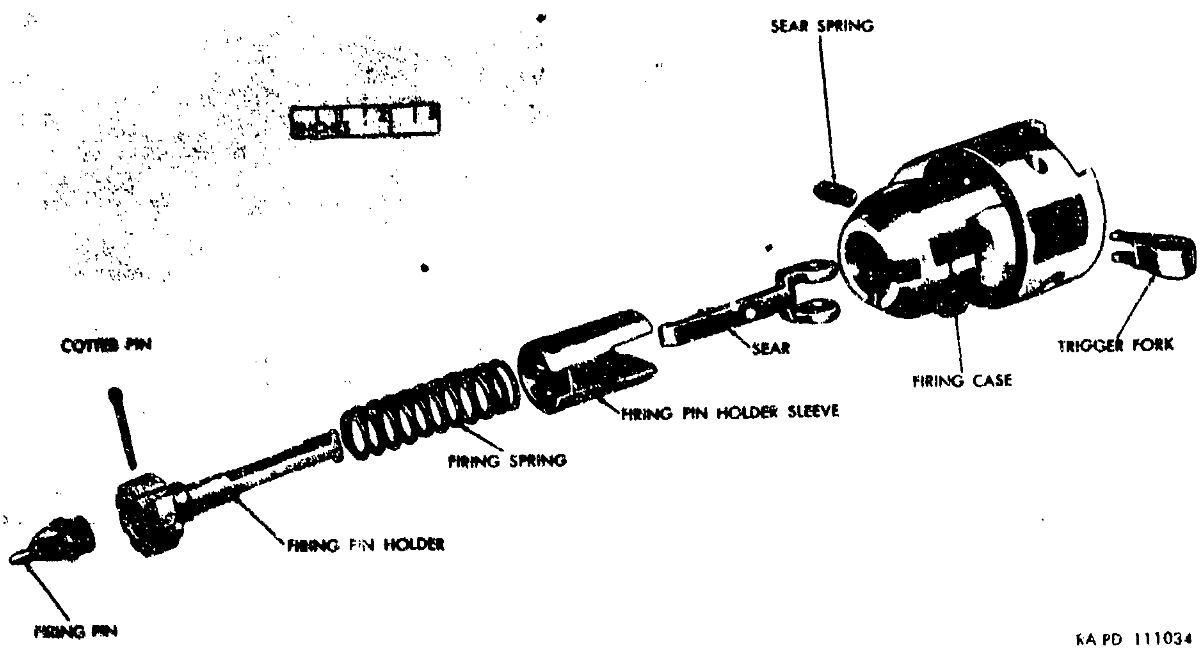


Figure 3-10. Firing lock M13—components.

3-24. Maintenance of the Barrel and Breech Assemblies

a. Lubricants.

(1) Grease, molybdenum disulfied (GMD), is used on and under the cannon locking ring.

(2) Oil, lubricating, preservative, medium (PLM), is used on all bearing surfaces in temperatures above 32° F.

(3) Oil, lubricating, preservative, special (PLS), is used on all bearing surfaces in temperatures below 32° F.

b. Cleaning and lubricating the tube.

(1) After firing, clean and lubricate the tube as follows:

(a) With rifle bore cleaner.

1. Using rifle bore cleaner (RBC), clean the tube the day of the firing and for 3 consecutive days thereafter or until sweating stops (a minimum of four cleanings). The tube should be cool enough to touch with the bare hand before you use rifle bore cleaner, since it evaporates at 150° F and causes dark spots.

2. On the fourth day, if the weapon is not to be fired within 24 hours, clean, dry, and inspect the tube and lubricate it with PLM or PLS.

3. Rifle bore cleaner is *not* a lubricant, but it will inhibit rust for 24 to 48 hours.

4. Rifle bore cleaner removes residue more easily and 30 percent faster than other solutions.

Note. If cleaning compound or solvent is issued in lieu of RBC, the cleaning procedure is the same as that described in *(a)* above.

(b) Without rifle bore cleaner.

1. Swab the tube thoroughly with a mixture of ¼-pound of GI or castile soap per gallon of hot or warm water.

2. After each cleaning, by swabbing, rinse the tube thoroughly with clear water, dry it, inspect it, and lubricate it with PLM or PLS.

(2) When rifle bore cleaner is available, the weekly maintenance is performed as follows:

(a) Clean the tube as described in (1)*(a)* above.

(b) Reoil the tube with PLM or PLS.

(3) When rifle bore cleaner is *not* available, the weekly maintenance is performed as follows:

(a) Clean the tube as described in (1)*(b)* above.

(b) Rinse the tube thoroughly with clear water and dry and inspect it.

(c) Reoil the tube with PLM or PLS.

Note. The breech mechanism and the firing mechanism should be disassembled and cleaned each time the tube is cleaned.

(4) Retract the tube to service the forward slides.

(a) Block the equilibrator with a wooden block 3 inches by 3 inches by 12 inches.

(b) Remove the cannon locking ring screw and unscrew the cannon locking ring.

(c) Push the tube 2 to 3 feet to the rear.

(d) Clean and lubricate—

1. The slides that have exposed bearing surfaces with PLM or PLS and the grease fittings with grease, automotive artillery (GAA).

Note. Use crocus cloth to remove rust from all (unpainted) bearing surfaces.

2. The threads of the cannon locking ring with GMD.

3. The fixed seat ring with GAA.

4. The breech recess with PLM or PLS.

(5) Slide the tube to battery and replace the breech mechanism.

Section IV. RECOIL MECHANISM

3-25. Purpose of Recoil Mechanism

The purpose of the recoil mechanism is to—

a. Stop the rearward movement of the recoiling parts.

b. Return the recoiling parts to the normal firing position.

c. Accomplish the functions in *a* and *b* above without shock.

d. Hold the tube in battery at all angles of elevation.

3-26. Type of Recoil Mechanism

The recoil mechanism employed is a hydropneumatic, constant, dependent-type mechanism, employing a floating piston.

a. Hydro means a liquid is used. This liquid is one of three petroleum-based hydraulic fluids now in the supply system. The hydraulic fluids are commonly known as recoil oil OHA, OHC, or OHT. Because OHT provides more protection against corrosion, it is the preferred oil. The mixing of these oils is not recommended because this would tend to dilute the additives of one oil not contained in the other. A recoil mechanism containing a mixture of these oils should be drained and refilled with the preferred OHT as soon as it becomes available. All three oils are red in color and have a temperature range from -65° F to +150° F.

b. Pneumatic means a gas is used; in this case, nitrogen gas. The gas, which is installed by ordnance personnel, is installed at 1,100 pounds per square inch at a temperature of 70° F without oil reserve. Nitrogen is relatively inert, highly compressible, and nonflammable.

c. Dependent means there is a liquid connection for the flow of recoil oil between the recoil and recuperator cylinders.

d. Constant means there is no mechanical means of changing the length of recoil.

e. Floating piston means that a free piston separates the liquid from the gas in the recuperator cylinder. It forms a movable, liquid tight, gas tight seal.

3-27. Components of the Recoil Mechanism

a. Recoil sleigh assembly. The recoil sleigh assembly supports the recoil mechanism.

(1) The yokes hold the parts together and support and secure the tube by means of a locking ring.

(2) The rails slide on the cradle recoil guides to guide and support the recoiling parts.

b. Recuperator cylinder. The recuperator cylinder houses the nitrogen gas and recoil oil and contains a regulator assembly, floating piston assembly, and recuperator cylinder front head assembly.

(1) The regulator assembly regulates the flow of oil during recoil and counterrecoil and contains the following:

(a) The four one-way valves, which are open during recoil and closed during counterrecoil.

(b) The throttling orifice.

(c) The oil passages.

(2) The *floating piston assembly* includes the floating piston, diaphragm, and tapered control rod

(a) The *floating piston* separates the nitrogen gas from the recoil oil and moves during recoil and counterrecoil.

(b) The *tapered control rod* is attached to the diaphragm and controls the flow of oil through the throttling orifice during recoil, and controls the oil through the variable depth grooves cut in the walls of the regulator central bore during counterrecoil in order to control the buffing action.

(3) The *recuperator cylinder front head assembly* contains a filling valve mechanism, an oil index, and an oil index control rod. The oil index indicates whether there is an insufficient amount of oil reserve in the recuperator cylinder.

c. Recoil cylinder.

(1) The *recoil piston and piston rod* are stationary in the recoil cylinder and are attached to the cradle by the piston rod outer locking nut.

(2) The *pneumatic respirator* (fig 3-12), an adjustable buffer is located at the rear head of the recoil cylinder. The respirator controls the escape of air from the rear of the recoil cylinder by means of an adjustable orifice. By admitting air freely during recoil and restricting the escape of air during counterrecoil, the respirator provides the additional buffing action that is sometimes necessary to prevent the howitzer from slamming into battery. It has four settings: 0, 1, 2, and 3. To set the respirator on 0, turn the respirator valve head counterclockwise as far as it will go. To set the respirator at any other setting, turn the respirator valve head clockwise, one click for a setting of 1, two clicks for a setting of 2, and three clicks for a setting of 3.

(a) 0 is the travel setting.

(b) 0 or 1 for low-angle firing.

(c) Set at 2 for low-angle and sustained high-angle firing.

(d) Set at 3 for minimum buffing action.

3-28. Functioning of the Recoil Mechanism

a. Action in recoil (fig 3-11).

(1) When the weapon is fired, the tube, the sleigh, and the recoil mechanism move to the rear. The recoil piston, which remains stationary because it is attached to the front end of the cradle, forces oil out of the recoil cylinder, through the connecting passages in the front yoke of the sleigh, and into the regulator assembly of the recuperator cylinder.

(2) The pressure of the recoil oil entering the regulator assembly opens the four one-way valves, permitting oil to flow freely. The recoil oil passes through the throttling orifice in the regulator and forces the diaphragm to the rear. The diaphragm forces the floating piston to the rear, thus, compressing the nitrogen gas.

(3) As the diaphragm is moved to the rear, the tapered control rod is drawn through the throttling orifice, gradually closing it and stopping the flow of recoil oil, thereby stopping the rearward movement of the tube.

(4) The energy of the recoiling parts is dissipated by—

(a) The throttling of the recoil oil.

(b) The compression of the nitrogen gas.

(c) The friction of the moving parts.

b. Action in counterrecoil (fig 3-12).

(1) The energy of the compressed nitrogen gas acts on the floating ston, which forces the oil

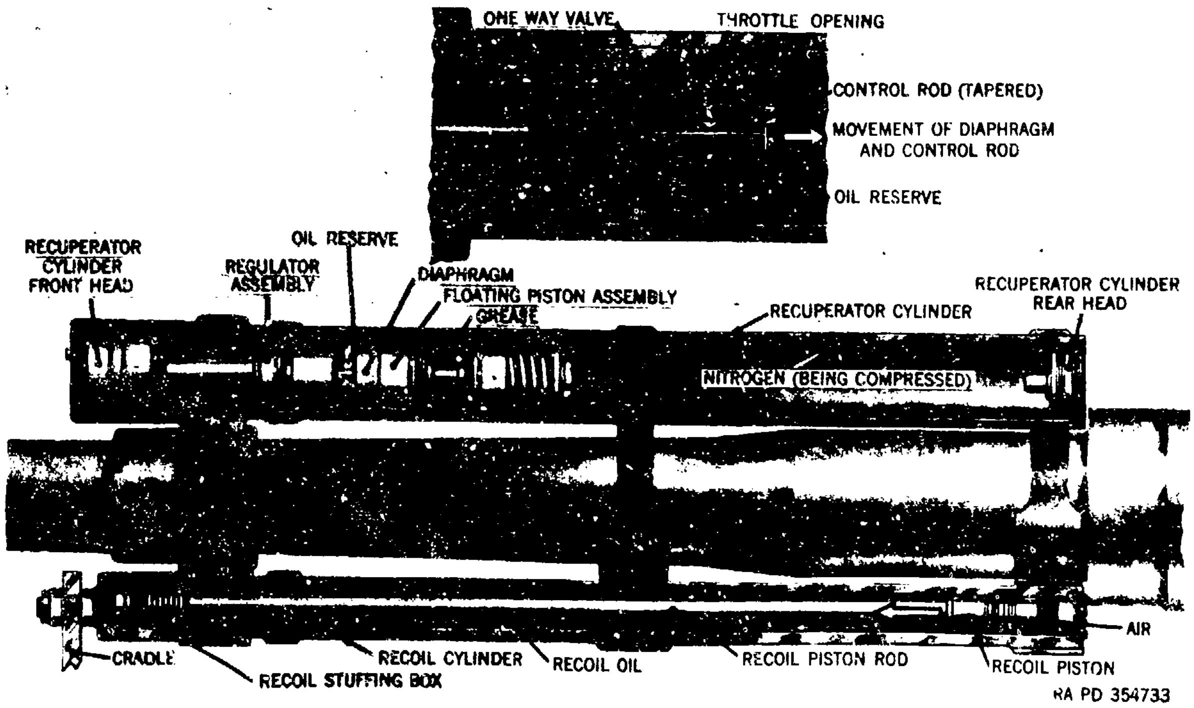


Figure 3-11. Action in recoil.

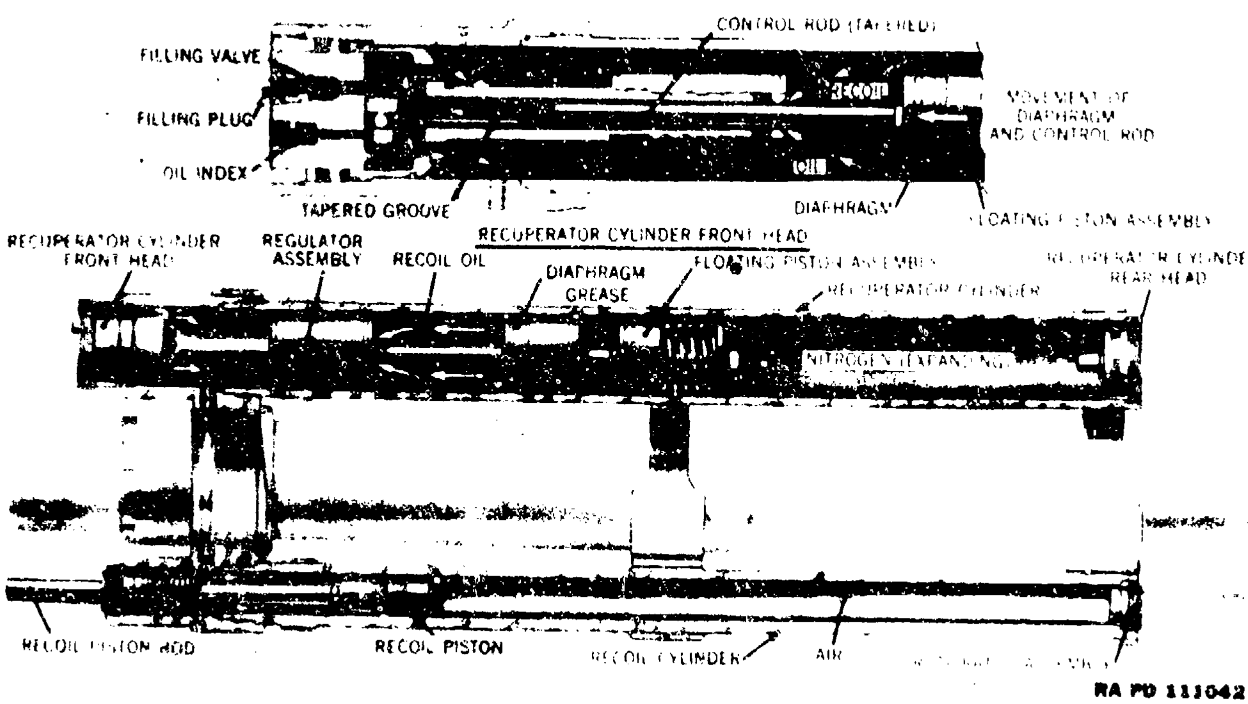


Figure 3-12. Action in counterrecoil.

back into the recoil cylinder. The oil pressing against the front face of the recoil piston and the forward face of the recoil cylinder forces the tube back into the firing position.

(2) Since the four one-way valves of the regulator assembly are closed, the oil passes through the central bore of the regulator assembly. As the recoil oil passes the tapered control rod, it is throttled through the variable depth grooves cut in the walls of the regulator central bore. This throttling action returns the tube to battery *without shock*. This counterrecoil buffer is the internal rod and tapered groove type.

(3) The adjustable respirator (pneumatic-type buffer), at the rear end of the recoil cylinder, *aids* in controlling the velocity of counterrecoil; i.e., it assists the internal rod in the buffing action.

c. Oil index and oil reserve.

(1) The recoil mechanism is designed to operate properly when the correct recoil oil reserve is forced into the system so as to separate the diaphragm from the regulator assembly. This oil reserve serves as a means of transmitting the pressure of the nitrogen gas in the recuperator cylinder, through the connecting port and into the recoil cylinder. The tube is held in battery, at al angles of elevation and during travel, by the pressure of the recoil oil acting on the recoil piston. The proper amount of oil in the reserve is 6 ounces, or approximately 1½ screw fillers.

(2) The oil index pin gives only two indications.

(a) A recessed index pin indicates an insufficient oil reserve. When the amount of reserve oil is less than prescribed, a rod attached to the diaphragm moves forward and actuates a rack and pinion mechanism, which causes the index pin to recede into the oil index recess.

(b) When the index pin is flush with the front head of the recuperator cylinder, it indicates that there is *at least* the proper amount of reserve oil. Since the index pin *can not* extend further than flush, it will not indicate an excessive amount of reserve oil.

3-29. Servicing the Recoil Mechanism

a. Battery maintenance of the recoil mechanism is limited to—

(1) Exterior cleaning, painting, and lubricating.

(2) Draining and replenishing the oil reserve.

Note. To drain the oil reserve, use the liquid releasing tool as indicated in *b* below. To replenish the oil reserve, use the oil screw filler as indicated in *c* and *d* below.

(3) Adjusting the pneumatic respirator.

(4) Disconnecting, connecting, and adjusting the recoil piston rod outer locking nut.

b. Take certain precautions when inserting the liquid releasing tool.

(1) Check for burred or damaged threads.

(2) Clean the threads of any foreign matter.

(3) Do not cross thread.

(4) Do not screw the liquid releasing tool in too far.

c. To fill and purge the oil screw filler--

(1) Remove the handle and head as a unit.

(2) Pour recoil oil directly into t ' arrel, avoiding air bubbles.

(3) Replace the head and tighten.

(4) Hold the nozzle end up and remove the bronze cap from the nozzle head.

(5) Wait a minute or two for air bubbles to rise to the surface.

(6) Turn the handle and purge the oil screw filler by turning the handle until no more air bubbles appear in the oil.

d. Take certain precautions while inserting the oil screw filler.

(1) Depress, or elevate the howitzer tube until it is approximately level.

(2) Insure that the filling hole is clean.

(3) Do not cross-thread the oil screw filler when inserting it into the filling hole.

(4) Purge the air from the filling hole before tightening the oil screw filler.

(5) Maintain an equal pressure on both sides of the handle.

(6) Avoid any lateral pressure to prevent breaking off the threaded nozzle.

(7) Use the correct size wrench on the filling plug and the oil screw filler.

e. To establish a correct recoil oil reserve—

(1) *If the index pin is recessed*, replenish the system until the index pin becomes flush with the front head of the recuperator cylinder.

(2) *If the index pin is flush*, drain oil from the reserve until the index pin begins to recede. Remove the liquid releasing tool and replenish the system as indicated in (1) above.

3-30. Adjustment of the Recoil Piston Rod Outer Nut

The procedure for adjusting the recoil piston rod outer nut is to screw the recoil piston rod outer nut onto the recoil piston rod. Tighten the nut just enough to prevent end play and then loosen it one castellation. This action will permit the piston rod to find its natural position without binding or causing a leak at the stuffing box. Insert the cotter pin and bend it over.

3-31. Lubrication of Slides

a. The slides should be cleaned and inspected for burrs.

b. The slides should be lubricated as described in LO 9-1015-203-10.

3-32. Recoil Indicator

The purpose of the recoil indicator is to measure the length of recoil. It is located on the right side of the cradle behind the elevating arc. The procedure for determining the length of recoil is as follows:

a. Grease the underside of the right sleigh rail in line with the recoil indicator.

b. Release the spring-loaded indicator.

c. Measure the length of the mark made in the grease when the weapon is fired. The measurement should be from 39 to 42 inches, when the maximum charge is fired

Note. If the length of recoil exceeds a maximum of 44 inches, reestablish the correct oil reserve; if trouble persists, notify the direct support unit.

3-33. Malfunctions--Causes and Corrections

Malfunction	*Cause*	*Correction*
a. The tube returns to battery with shock.	(1) Excessive oil reserve.	(1) Drain and replenish the oil reserve.
	(2) Improperly adjusted pneumatic respirator.	(2) Adjust the respirator.
	(3) Excessive nitrogen pressure.	(3) Notify the direct support unit.
b. The tube returns to battery too slowly or fails to return.	(1) Insufficient oil reserve.	(1) Drain and replenish the oil reserve.
	(2) Improperly adjusted pneumatic respirator.	(2) Adjust the respirator.
	(3) Insufficient nitrogen pressure.	(3) Notify the direct support unit.
c. The tube returns to battery with a jerky motion.	(1) Lack of lubrication on the slides.	(1) Lubricate the slides.
	(2) Nitrogen or air in the recoil oil.	(2) Drain and replenish the oil reserve. If motion is still jerky, notify the direct support unit.

Section V. SIGHTING AND LAYING EQUIPMENT

3-34. Definitions of Common Terms

a. Fire control instruments—Include both on- and off-carriage instruments. On-carriage fire control instruments are built in or placed on the weapon by the gun crew and are used to lay the weapon in deflection and/or elevation. Such instruments as the panoramic telescope, range quadrant, elbow telescope, and gunner's quadrant are on-carriage equipment. The aiming circle, battery commander's telescope, and M2 compass are examples of off-carriage fire control instruments.

b. Trajectory—The trajectory is the curve traced by the center of gravity of the projectile in its flight from the muzzle of the weapon to the point of impact or point of burst. The muzzle of the weapon is placed in the correct firing attitude (position) by applying certain announced horizontal and vertical angular measurements to the sighting and laying equipment and laying the weapon.

c. Reticle—A measuring scale placed in the focus of an optical instrument. Some reticles have graduations that allow the operator to make small angualr or range measurements.

d. Sighting—The process of directing a line of sight toward an aiming point.

e. Laying—The process of pointing the tube of a weapon in a given direction for a given range.

f. Indirect fire—Fire from a weapon that is laid by sighting on a point other than the target. Normally, the target and weapon are not intervisible.

g. Direct fire—Fire from a weapon that is laid by sighting directly on the target.

h. Cant—The tilting of the trunnions of the weapon out of the true horizontal plane. Cant causes the tube to travel out of the true horizontal plane in traverse and out of the true vertical plane in elevation. Cant is always present if the trunnions of a weapon are not level.

i. Boresighting—Boresighting is the process of alining the on-carriage sighting and fire control equipment so that the lines of sight of the telescopes are parallel to the axis of the bore of the weapon. This is to insure accuracy in laying for elevation and direction.

3-35. Panoramic Telescope M12A7S

a. The panoramic telescope M12A7S (fig 3-13) is a 4-power, fixed-focus, fire control instrument that may be used for either direct or indirect fire.

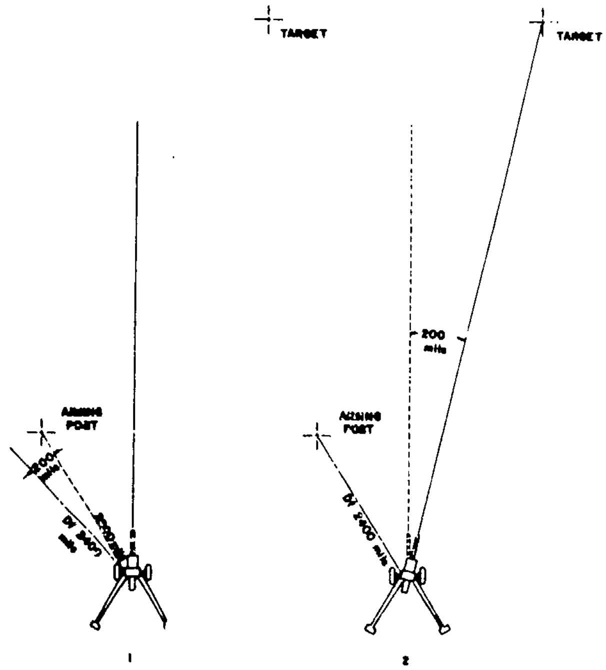


Figure 3-14. Deflection change.

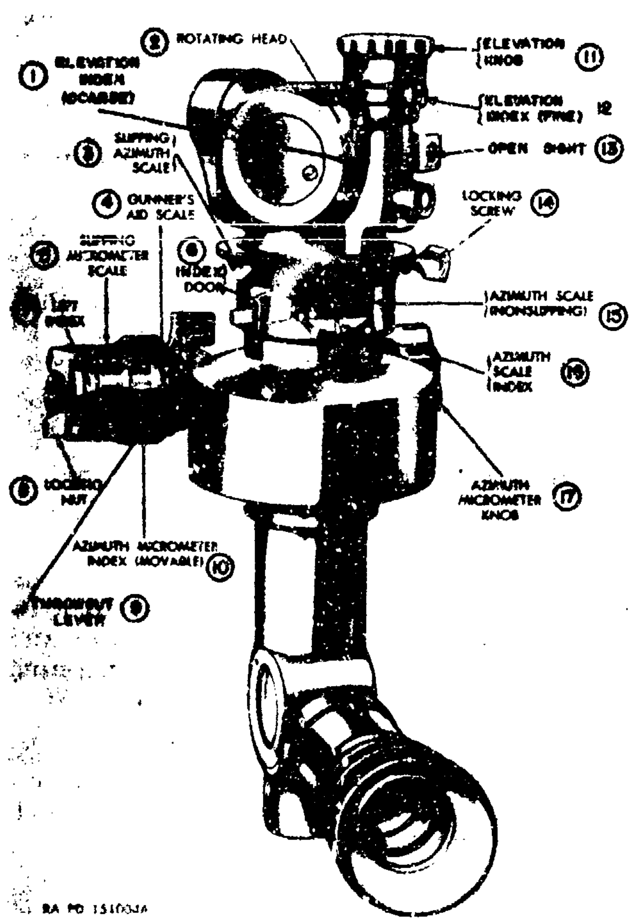


Figure 3-13. Panoramic telescope M12A7S.

When used in its most common role of indirect fire, it allows the operator to apply a specified change in direction (deflection) to the tube of the weapon by changing the line of sight of the telescope the same specified amount and then traversing back on the fixed aiming point (fig 3-14). For example, to change the direction of the tube 200 mils to the right, the operator refers the line of sight of the telescope 200 mils to the left of the fixed aiming point and then traverses the tube until the line of sight of the telescope is back on the aiming points. The tube is then pointed 200 mils right of its original direction (fig 3-14). The panoramic telescope M12A7S has a slipping azimuth scale and a slipping azimuth micrometer scale, which allows all weapons of a battery to have a common deflection regardless of the position of their fixed aiming points.

b. The elevation knob, at the top of the telescope rotating head, raises or lowers the line of sight plus or minus 300 mils when it is rotated throughout its limits. A fine index and a coarse index indicate the level position. The operator may adjust the fine index by loosening the three screws on the top of the elevation knob and then slipping the collar containing the 0 index into coincidence with the fixed index. The coarse index is adjusted by support unit personnel only. An open sight, on the right side of the rotating head, is used for rough alinement with an aiming point. The slipping azimuth scale, immediately below the rotating head, consists of a ring graduated into 64 divisions of 100 mils each and is numbered every 200 mils from 0 to 3,200 in two consecutive semicircles. A slipping scale locking screw enables the operator to secure or release the slipping azimuth scale from the rotating head. When the scale is released, it may be set at any deflection; but, when it is locked, its movement is controlled by the azimuth micrometer knob. The nonslipping azimuth scale, located below the slipping azimuth scale, can be moved only by the azimuth micrometer knob and the motion of the rotating head. A door covers the nonslipping azimuth scale when it is not in use and provides an index for the slipping azimuth scale. The slipping azimuth micrometer scale on the left side of the telescope, is graduated into 100 divisions of 1 mil each. A locking nut on the end of the azimuth micrometer knob enables the operator to release the slipping micrometer scale, set it at a desired deflection reading, and lock the scale in place. A left index (nonslipping) on the micrometer end of the azimuth micrometer knob turns with the micrometer knob. A right fixed index on the telescope body does not move. At the time of the modification of the telescope, the left index is synchronized with the right fixed index and the graduations on the nonslipping azimuth scale. When the left index is opposite the right fixed index, the azimuth scale index should coincide with a graduation on the nonslipping azimuth scale. If the three indexes do not coincide, the instrument should be turned in to the direct support unit for repair. The movable azimuth micrometer index on the inside of the slipping azimuth micrometer scale is adjustable in relation to a fixed scale graduated on the worm throuwout lever and is used to apply *special corrections.*

c. For boresighting with panoramic telescope M12A7S, all indexes, including the left index, must be at 0. Any adjustment to make the line of sight parallel to the tube must be made with the tangent screws on the telescope mount.

3-36. Telescope Mount M21A1

a. The telescope mount M21A1 (fig 3-15) is bracketed to the left side of the cradle. It is used in conjunction with the panoramic telescope and provides a means for laying the weapon in direction.

b. Two tangent screws at the top of the telescope mount socket keep the panoramic telescope from moving laterally. The two tangent screws are locked in place by two tangent screw locking screws. The panoramic telescope is secured in the socket by a retaining shaft which is rotated by a wing knob. Turning the upper part of the wing knob toward the muzzle of the weapon allows the telescope to be removed from the mount. A longitudinal level, operated by the longitudinal leveling knob, and a cross level, operated by a cross-leveling knob, are just below the socket. The azimuth compensating mechanism, including the actuating arm, bearing, and pivots, provides a means of transmitting the motion of the tube to the

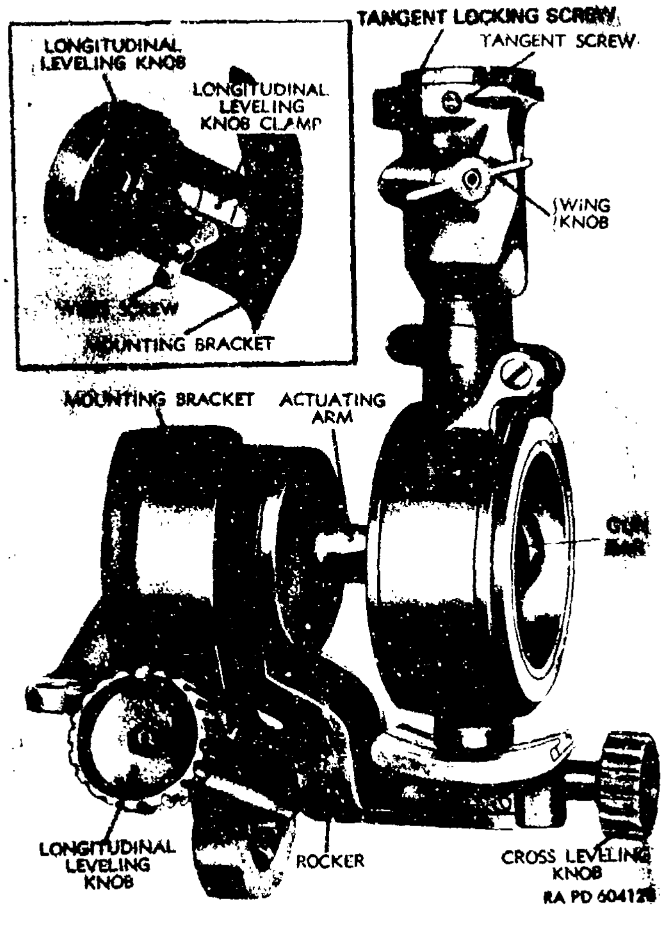


Figure 3-15. Telescope mount M21A1.

telescope mount so that any deviation in direction caused by elevating a canted weapon may be corrected. By cross-leveling and longitudinally leveling the telescope mount and traversing back on the aiming point, the panoramic telescope measures a true horizontal angle and the telescope mount compensates for errors caused by the cant of the weapon if that cant is not greater than 10° (178 mils).

c. For boresighting, the tangent screws are used to adjust the 0—3200 line of sight of the panoramic telescope parallel to the axis of the tube in direction (deflection). (This action should not be performed until the M21A1 telescope mount has been checked to see that it is in coincidence with the tube at zero elevation.) To adjust the 0—3200 line of sight of the telescope, look through the eyepiece, insert a screwdriver in each tangent screw, and turn them both in the same direction until the vertical hairline in the reticle pattern is superimposed over the aiming point.

3-37. Elbow Telescope M16A1D and Mount M23

a. The elbow telescope M16A1D, mounted in the telescope mount M23 (fig 3-16) on the right side of

Figure 3-16. Telescope mount M23 with elbow telescope M16A1D.

the weapon, is a 3-power, fixed-focus instrument used in the two-man, two-sight system for direct fire.

b. A rubber eyeshield attached to the eyepiece protects the operator when the weapon is fired. An illumination window provides a means of illuminating the reticle with the instrument light M36. The reticle of the telescope has range lines representing elevations for ranges from 0 to 2,200 yards. The zero range line is lettered "N" and passes through the optical axis of the telescope. The range graduations are based on the muzzle velocity for the 105-mm high-explosive antitank (HEAT) M67 ammunition, which is approximately the same muzzle velocity as charge 6, high-explosive (HE) ammunition. A range correction chart for the M16A1D elbow telescope is available for high-explosive plastic tracer (HEP-T) M327 ammunition.

c. For boresighting by the testing target or the distant aiming point methods, the telescope may be adjusted in elevation by loosening the clamping bolt on the mount housing and turning the elevation worm with a screwdriver until the N range line of the reticle coincides with the testing target aiming diagram or the distant aiming point. The reticle lines may be leveled by means of the bracket rotating knob on the upper portion of the telescope mount. The telescope may, therefore, be adjusted for elevation and cant but *not* for deflection.

3-38. Range Quadrant M4A1

a. The range quadrant M4A1 (fig 3-17), mounted on the right side of the 105-mm howitzer cradle, provides a means for laying the weapon for elevation.

b. The elevation scale is graduated in 100-mil increments from minus 100 to plus 1,200. The elevation micrometer scale is graduated in 1-mil increments from 0 to 100. One complete revolution of the elevation micrometer scale causes the elevation scale index to move one graduation (100 mils).

c. The longitudinal-level bubble is moved by any movement of the elevating handwheel of the weapon or the elevation micrometer knob. The cross-leveling worm knob controls the leveling of the cross-level bubble.

d. To operate the range quadrant, the announced quadrant elevation is set on the elevation and micrometer scales by turning the elevation knob. The longitudinal-level bubble is centered by turning the elevating handwheel of the weapon. During the final cross- and longitudinal-leveling, the range quadrant moves in a true vertical plane. It, therefore, measures a true vertical angle, although the trunnions of the weapon may be canted up to approximately 10°.

Note. Since the quadrant elevation determined by the fire direction center includes site, the angle of site scale and the angle of site micrometer on the range quadrant M4A1 are no longer used. They should be "frozen" in place at 300.

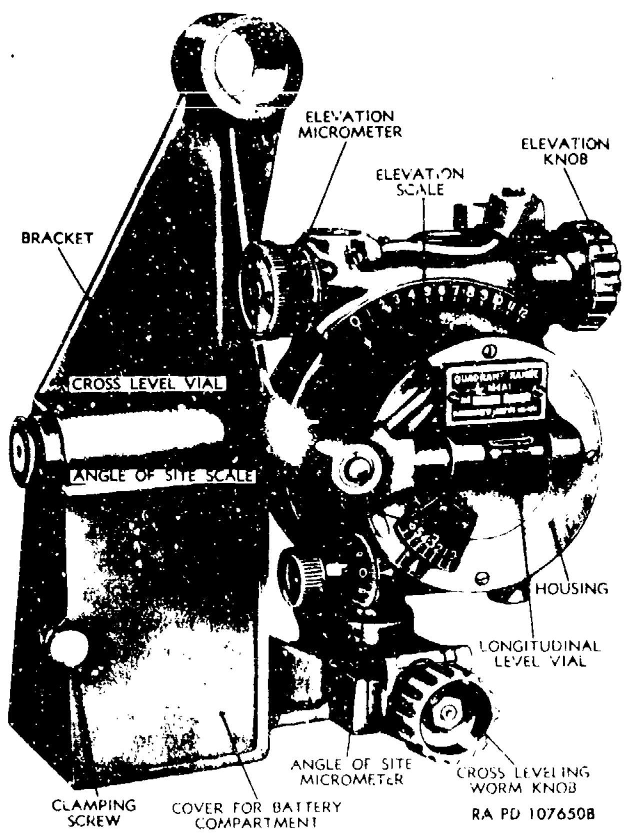


Figure 3-17. Range quadrant M4A1.

3-39. Gunner's Quadrant M1A1

a. The gunner's quadrant (fig 3-18) is used on the 105-mm howitzer primarily during sight tests and adjustments; however, it may be used when the range quadrant is inoperative or, when necessary, to split a mil in elevation. The gunner's quadrant will not measure a true vertical angle when it is used on the breech ring of a canted weapon.

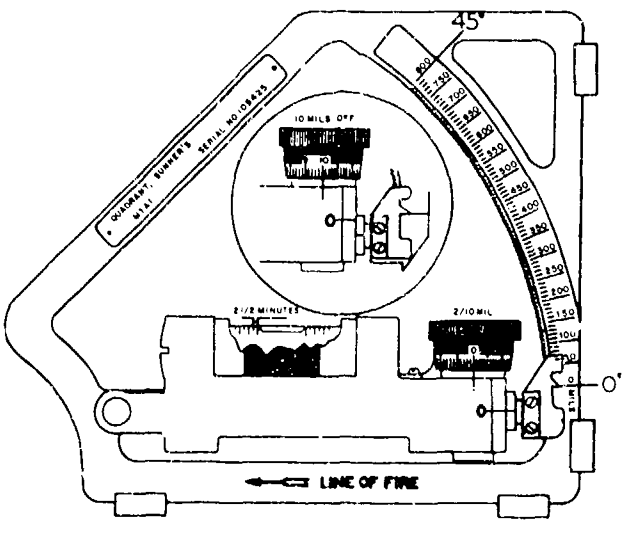


Figure 3-18. Gunner's quadrant M1A1.

b. The gunner's quadrant consists of a frame with a graduated arc, an index arm, a micrometer knob and scale, a bubble, and reference surfaces. The arc is graduated in 10-mil increments from 0 to 800 mils on one side and from 800 to 1,600 mils on the other side. The teeth on the arc position the index plunger at the 10-mil graduations. The index micrometer scale is graduated in 0.2-mil increments from 0 to 10 mils. One complete revolution of the index micrometer raises or lowers the bubble 10 mils. The index micrometer scale is numbered with black figures. Two direction of fire arrows indicate the manner in which the gunner's quadrant is placed on the quadrant seats.

Note. The gunner's quadrant M1A1 differs from the M1 in the following respects: the M1A1 is provided with a micrometer mask to insure use of the correct scale, it has an indicator on the index arm, and the index mark on the micrometer is numbered 10 rather than 0. It has all black figures.

c. To test the gunner's quadrant for accuracy, perform the following end-for-end test before performing the sight tests and adjustments (figs 3-19, 3-20, and 3-21).

(1) Zero the scales of the gunner's quadrant and place the gunner's quadrant on the quadrant seats on the breech ring with the line-of-fire arrow pointed toward the muzzle. Using the elevation handwheel, center the bubble in the gunner's quadrant by elevating or depressing the tube.

(2) Reverse the quadrant (end-for-end) on the quadrant seats and check the bubble. If the bubble centers, then the tube is level, the end-for-end test is complete, and the error in the gunner's quadrant is 0. However, if the bubble does not center, then you must continue the end-for-end test and determine the sign (+ or -) and the amount of error in the gunner's quadrant as described in (3) or (4) below.

(3) If the bubble does not center ((2) above), turn the micrometer knob and try to center the bubble.

(a) If you can center the bubble by turning the micrometer knob, read the black figures on the micrometer scale and divide the reading by 2. Set the results on the micrometer scale.

(b) Place the gunner's quadrant back on the quadrant seats with the arrow pointed toward the muzzle and, using the elevating handwheel, level the tube by centering the bubble.

(c) Reverse the gunner's quadrant (end-for-end) on the quadrant seats. The bubble should center. The reading on the gunner's quadrant is the amount of the positive (+) error in the gunner's quadrant, and the end-for-end test is complete.

(4) If the bubble does not center ((3)*(a)* above), move the gunner's quadrant arm down one graduation (10 mils).

(a) Turn the micrometer knob until the bubble centers.

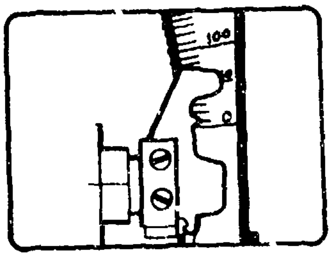
(b) Take the reading on the micrometer scale, add 10 to it, and divide the sum by 2. Place the results on the micrometer scale.

(c) With the arm of the gunner's quadrant set at minus 10 and the results in *(b)* above set on the micrometer scale, place the gunner's quadrant back on the quadrant seats, with the arrow pointed toward the muzzle, and, using the elevating handwheel, level the tube by centering the bubble.

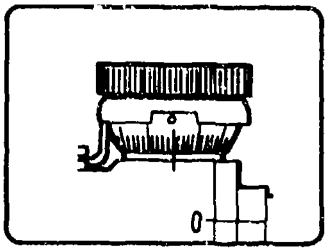
(d) Reverse the gunner's quadrant (end-for-end) on the quadrant seats. The bubble should center. If the bubble centers, subtract the reading on the micrometer scale from 10 to obtain the error. This is known as the negative (-) error, and the end-for-end test is complete.

Note. If an error (+ or -) has been determined during the end-for-end test of the gunner's quadrant, it will be carried only during sight tests and adjustments and will not be applied to elevations in fire missions. However, if the error is more than 0.4 mil, the gunner's quadrant must be sent to the support unit at the earliest possible date for correction and adjustment.

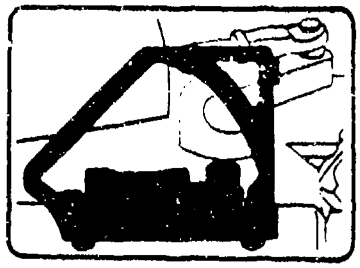
Gunner's Quadrant Micrometer Test



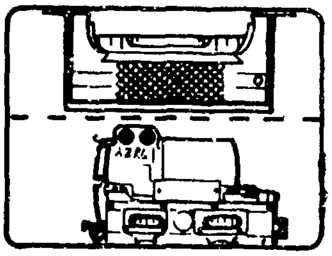
1. Set index at plus 10.



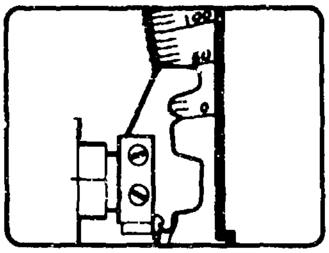
2. [illegible] the micrometer.



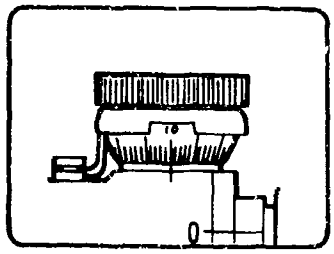
3. Place quadrant on breech quadrant seats with line-of-fire arrows pointing toward muzzle.



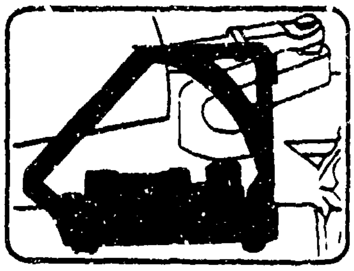
4. Depress/elevate tube to center bubble.



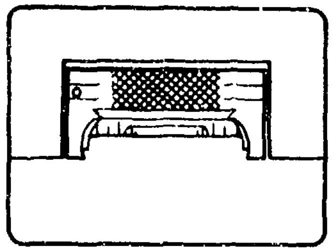
5. Remove the gunner's quadrant and set index at 0.



6. Set micrometer at 10.



7. Replace quadrant on breech quadrant seats with line-of-fire arrows pointing toward the muzzle.



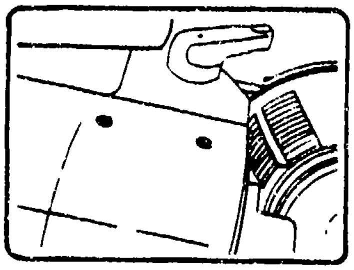
8. If the bubble centers, the micrometer scale is in correct adjustment.

9. If bubble does not center, the micrometer is in error. The quadrant should be turned in to support maintenance for repair.

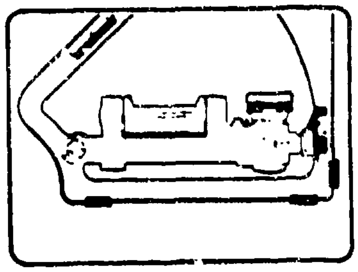
Figure 3-19. Gunner's Quadrant Micrometer Test.

Gunner's Quadrant End-For-End Test

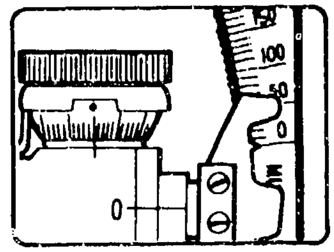
In tolerance +0.4 to -0.4 mils. Anything greater is not acceptable.



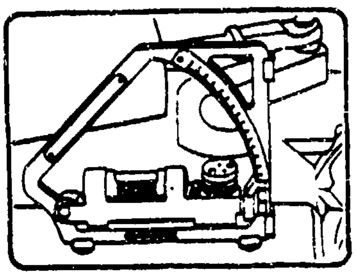
1. Inspect breech quadrant seats (1) for nicks and dirt.



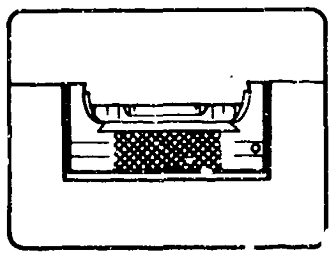
2. Inspect quadrant shoes for nicks and dirt.



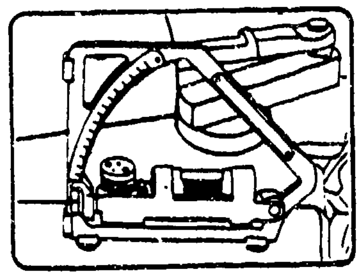
3. Zero the scales.



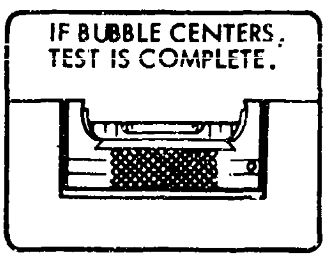
4. Point line-of-fire arrow on quadrant toward muzzle.



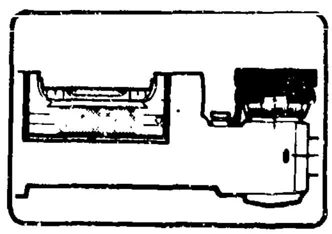
5. Depress/elevate tube to center bubble.



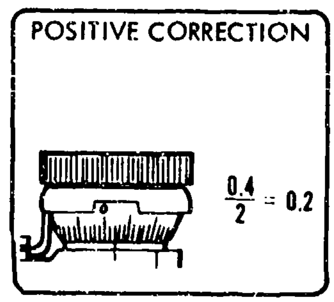
6. Reverse direction of quadrant.



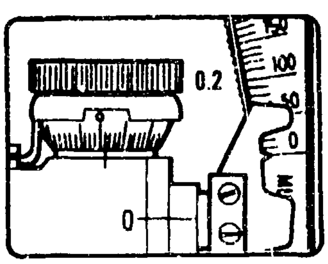
7. Bubble should center. If bubble does not center, go to step 8.



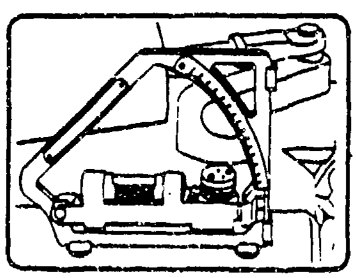
8. Center bubble with micrometer knob. If bubble centers, go to step 9. If not, go to step 16.



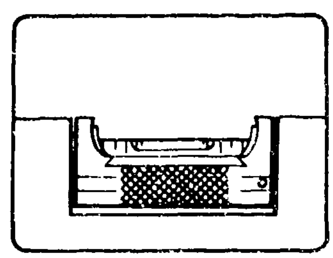
9. Divide micrometer reading by 2. This is your trial correction.



10. Put result on micrometer scale.

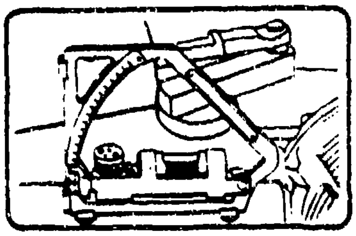


11. Place on breech quadrant seats and point quadrant at muzzle.

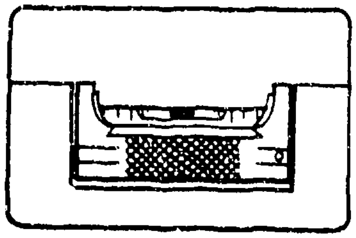


12. Depress/elevate tube to center bubble.

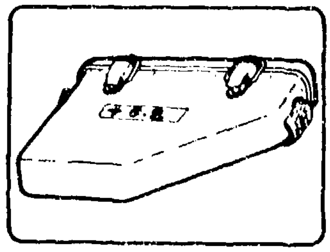
Figure 3-20. Gunner's Quadrant End-For-End Test.



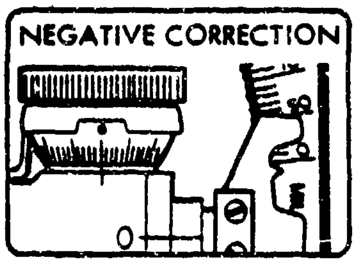
13. Reverse direction of quadrant.



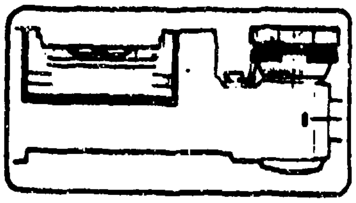
14. If bubble centers, go to step 15. If not, go back to step 1 and start over.



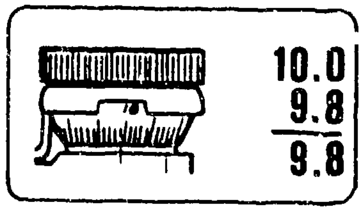
15. Record end-for-end correction.



16. Remove gunner's quadrant; set index at minus 10 by using the high angle side (1600).



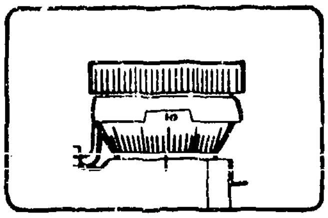
17. Place quadrant on seats facing breech end of the weapon. Center bubble with micrometer knob.



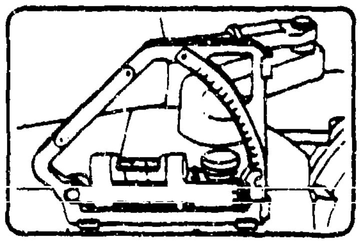
18. Add micrometer reading to 10.0.

$$\frac{19.8}{2} = 9.9$$

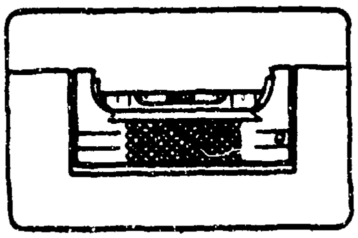
19. Divide answer in step 18 by 2; this is your trial correction.



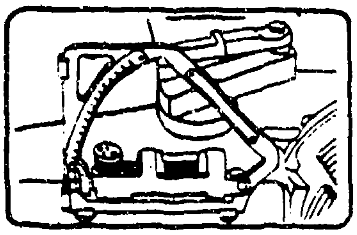
20. Place findings from 19 on micrometer scale.



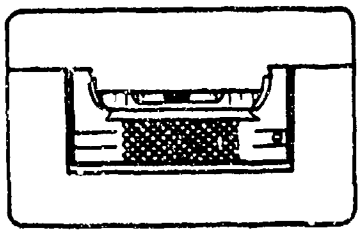
21. Point quadrant at muzzle.



22. Depress/elevate tube to center bubble.



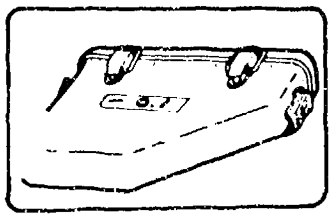
23. Reverse direction of quadrant.



24. Bubble should center. If bubble does not center, go back to step 16.

25. Subtract micrometer reading from 10.0 since this is a negative correction (step 16), a minus sign must be placed in front of the correction factor (-0.2).

$$\begin{array}{r} 10.0 \\ -9.9 \\ \hline -0.1 \end{array}$$



26. Record end-for-end correction.

Figure 3-21. Gunner's Quadrant End-For-End Test.

3-40. Care and Maintenance of Sighting and Laying Equipment

a. General care.

(1) Avoid rough handling of the equipment.

(2) Limit disassembly to the extent authorized in the field manual or technical manual pertaining to a particular weapon.

(3) Keep the equipment dry; never put the equipment in carrying cases when it is damp or wet.

(4) When not in use, keep the equipment in the carrying cases.

(5) Send any instrument not performing properly to the direct support unit for repair.

(6) Never paint any of the equipment.

(7) Depress *fully* all throwout levers, when used.

(8) Before assembly, remove all dust and grit from the contact surfaces.

(9) Wipe off all excess lubricant to prevent the accumulation of dust and grit.

b. Telescopes and sight mounts.

(1) Remove dust or grit with a *clean* camel's-hair brush or lens tissue paper.

(2) Use oil, lubricating, light, on the sight mount M23; oil through the hole on top of the housing.

(3) Use oil, lubricating, preservative, special, on the felt washers, on the range quadrant and telescope mount, and on exposed bearing surfaces of the sight and sight mount.

(4) Remove oil or grease from rubber eyeshield immediately.

(5) Keep the level vials covered when not in use.

(6) Do not attempt to force a mechanism beyond its stop.

(7) Have the equipment lubricated periodically by the direct support unit personnel.

c. Gunner's quadrant.

(1) Do not burr, dent, or nick reference surfaces or the notched portion of frame.

(2) Clean the arc frequently with a small brush or with a brush and drycleaning solvent.

(3) *Never* leave the gunner's quadrant on the weapon during firing.

d. Coated optical elements. The optics of some instruments are coated with a reflection-reducing film of magnesium fluoride. Rub coated optics as little as possible. If such a coating is partly removed, *do not remove* the remainder of the coating, since any left will help make the sight clearer.

Section VI. SIGHT TESTS AND ADJUSTMENTS

3-41. General

The accuracy of artillery weapons depends, to a great extent, on the adjustment of the sighting and laying equipment and its relation to the axis of the bore of the weapon. There are certain tests and adjustments that are performed to insure that the proper relation exists between the sighting and laying equipment and the axis of the tube of the weapon.

3-42. Leveling the Trunnions

a. To level the trunnions, suspend a plumbline in front of the muzzle of the tube. Insert a boresighting disk in the breech end of the tube and affix crosshairs on the muzzle end. Aline the vertical hair on the muzzle of the tube and the plumbline. (The plumbline should be at least 9 feet long.) Elevate and depress the tube and check to see that the vertical hair tracks and the plumbline throughout its length. If it does not, raise one of the trails until the vertical hair on the muzzle does track the plumbline. When the trunnions are level, the raised trail should be blocked to make it solid.

b. If it is not possible to suspend a plumbline of suitable length for leveling the trunnions, they may be approximately leveled in either of the following ways, listed in order of preference:

(1) Place a tested gunner's quadrant set on 0 in the breech recess parallel to the trunnions. Raise one trail until the bubble on the gunner's quadrant is centered.

(2) Match the white scribed lines on the telescope mount (scribed after fire control alinement test) and raise one trail until the telescope mount cross-level bubble is centered.

3-43. Fire Control Alinement Tests

Fire control alinement tests are performed by the section under the supervision of the battery executive. These tests are performed at the discretion of the unit commander. Suggested times for performance are once each year if the gun is used only for nonfiring training; once every 3 months if the gun is fired; as soon as possible after extensive use, accidents, or traversing extremely rough terrain; and when the gun fires inaccurately for no readily apparent reason. The tests reveal whether or not the on-carriage sighting equipment and certain off-carriage sighting equipment are in correct adjustment.

3-44. Test of Range Quadrant

a. Cross-level tests.

(1) With the gun and carriage level (axis of bore and axis of trunnions), center the cross-level bubble.

(2) Turn the elevation knob throughout its limits of motion.

(3) The cross-level bubble should remain centered to within one-half vial graduation. If the bubble does not remain centered, the level vial is incorrectly alined, and the weapon should be sent to the direct support unit for adjustment.

b. Pivot azimuth alinement test.

(1) Place the breech and muzzle boresights in their proper positions in the tube.

(2) Center the previously tested cross-level bubble.

(3) Elevate and depress the tube and check to see that the boresights track a plumbline placed in front of the tube; at the same time, watch the cross-level bubble.

(4) The bubble should remain centered to within one-half vial graduation.

(5) If the bubble moves off center more than one-half vial graduation, the pivot is not alined in azimuth with the tube, and the weapon should be sent to the direct support unit for adjustment.

c. Pivot vertical alinement test.

(1) Level the tube by using a previously tested gunner's quadrant.

(2) Center the longitudinal-level bubble by turning the elevation knob.

(3) Operate the cross-leveling knob throughout the limits of the motion; the longitudinal-level bubble should remain centered.

(4) If the bubble moves off center more than one-half vial graduation, either the pivot is not alined vertically with the tube or the level vial is not correctly alined, the weapon should be sent to the direct support unit for adjustment.

d. Comparison test.

( ) Compare the readings indicated by the gunner's quadrant with those on the elevation quadrant at low medium, and high elevations of the tube.

(2) If the two instruments do not agree at all elevations, the weapon should be sent to the direct support unit for adjustment.

3-45. Test of Azimuth Compensating Mechanism of Panoramic Telescope Mount

The purpose of testing the azimuth compensating mechanism of the telescope mount is to determine whether it actually keeps the tube in the correct vertical plane at all elevations. One of the tests listed below, in order of preference, should be performed.

a. Test wherein trunnions need not be level—plumbline required. By using a plumbline as a vertical reference plane, the test below reveals the total amount of error that exists between the center of the reticle pattern and the direction in which the tube points. Steps are as follows:

(1) With the boresights in place and the tube near zero elevation, traverse the tube so that the line of sight through it is on the plumbline.

(2) With the sight mount leveled, move only the sight and refer to a distant sharply defined aiming point (in any direction). Use the elevation knob of the sight to bring the horizontal reticle to the aiming point.

(3) Elevate the tube to maximum elevation or to the top of the plumbline. Traverse the tube, if necessary, to bring the line of sight through it back to the plumbline.

(4) Level the panoramic telescope mount both laterally and longitudinally.

(5) Sight through the telescope to determine whether it is still on the aiming point.

(6) If the sight is off the aiming point in excess of 1 mil in deflection and/or one-half vial graduation in elevation, the weapon should be sent to the direct support unit for adjustment.

b. Test with trunnions level. The test below with trunnions and tube leveled for control indicates whether errors exist in the actuating arm pivot and/or level vials. Leveling may be performed by a plumbline check or by cross-leveling with the gunner's quadrant on the breech ring. If cross-leveling is accomplished with the gunner's quadrant on the breech ring, the results of the test are accurate only to the extent of the parallel relationship of the trunnions to the top surface of the breech ring. The tests are as follows:

(1) *Cross-level test of telescope mount.* The telescope mount cross-level bubble must be in proper adjustment before the test of the azimuth compensating mechanism is completed.

(a) Center the cross-level bubble and place the line of sight of the panoramic telescope on a sharply defined aiming point.

(b) Elevate the tube to maximum elevation while keeping the telescope mount level longitudinally.

Note. Do not readjust the cross-level bubble after the initial setting.

(c) The line of sight must not deviate from the target by more than 1 mil at any elevation checked and the cross-level bubble must not travel more than one-half vial graduation. If the amount of deviation exceeds the tolerance, the level vial or pivot is incorrectly alined, and the weapon must be sent to the direct support unit for adjustment.

(2) *Vertical alinement test of telescope mount.*

(a) Level the tube longitudinally with the gunner's quadrant.

(b) Center the longitudinal-level bubble.

(c) Operate the cross-leveling knob throughout the limits of motion; the longitudinal-level bubble should remain centered within one-half vial graduation. If the bubble moves in excess of the tolerance, either the level vial or the actuating arm pivot is not alined correctly, and the weapon should be sent to the direct support unit for adjustment.

3-46. Boresighting

Boresighting is the process of alining the on-carriage sighting and fire control equipment so that the lines of sight of the telescopes are parallel to the axis of the bore of the weapon. The purpose of boresighting is to properly adjust the line of sight of the sighting and fire control equipment in relation to the axis of the bore of the weapon in order to obtain accurate fire. Vibration, temperature changes, shock, and other factors tend to alter the adjustment after it has been made. Therefore, boresighting should be performed as frequently as possible--before firing and, when necessary, during lulls in firing.

3-47. Methods of Boresighting

In order of preference, the two general methods of boresighting are the distant aiming point and the test target method. The standard angle can *be used in an emergency to check boresighting.*

3-48. Preparation for Boresighting

a. Regardless of the method used, the tube should be near the center of its traverse and pointed in the general direction of the distant aiming point or testing target.

b. Accurate cross-leveling of the trunnions is unnecessary for boresighting on a distant aiming point; however, trunnions should be as level as possible.

c. The breech and muzzle boresights must be in their proper positions.

d. All instruments and mounts must be positioned securely without free play.

3-49. Testing Target Method of Boresighting

To boresight, using the testing target method, follow the nine steps as outlined in *a* through *i* below.

a. Level the trunnions. The trunnions are leveled as prescribed in paragraph 3-43.

b. Zero the tube. Level the tube (set to zero elevation) by performing the end-for-end test with the gunner's quadrant. When the tube is zeroed, *it is not to be moved* during the rest of the boresighting procedures.

c. Level the cross-level and longitudinal-level bubbles. Level both bubbles on the panoramic telescope mount.

d. Zero the scales. Set all 10 scales to 0 and aline all indexes on the panoramic telescope and mount M21A1.

e. Level the cross-level and longitudinal-level bubbles. Level both bubbles on the range quadrant.

f. Zero the scales. Set the elevation scale to 0 and the elevation micrometer on 0. If the arrow on the elevation scale does not read 0, loosen the two screws on the plate and slip the arrow until it does read 0, then tighten the screws. If the micrometer scale does not read 0, loosen the three screws on the knob and slip the scale to 0, and tighten the three screws on the knob.

g. Adjust testing target to tube. Place the testing target (fig 3-22) 50 to 100 meters in front of the howitzer tube, and position the testing target so that the base diagram is alined with the boresights without moving the tube. The testing target must be placed on a stand and held firmly in place during boresighting.

h. Adjust the panoramic telescope to the testing target. The vertical and horizontal cross-hairs of the panoramic telescope are adjusted to the testing target as follows:

(1) While looking through the panoramic telescope, adjust the vertical line of the reticle pattern to the aiming diagram of the testing target by turning the tangent screws on the mount. The weapon is boresighted for deflection (azimuth) when the vertical line of the panoramic telescope coincides with the vertical center of the aiming diagram.

(2) While looking through the panoramic telescope, adjust the horizontal line of the reticle pattern to the aiming diagram of the testing target by turning the elevation micrometer knob so that the horizontal crosshair of the reticle of the panoramic telescope is alined on the horizontal line of the aiming diagram of the testing target. The elevation micrometer scale should read *0*. If it does not, loosen the three screws on the knob, hold the knob and slip the scale to 0, and tighten the three screws. The panoramic telescope is boresighted for elevation.

Note. Check to insure that the bubbles are still centered, the scales are at 0, all indexes are alined, and the alinement of the telescope mount and tube has not been disturbed.

i. Adjust the elbow telescope. Place the elbow telescope into the M23 telescope mount and adjust the telescope as follows:

(1) Adjust the N range line of the reticle in the elbow telescope so that it coincides with the horizontal line of the aiming diagram of the testing target (see paragraph 38*c*).

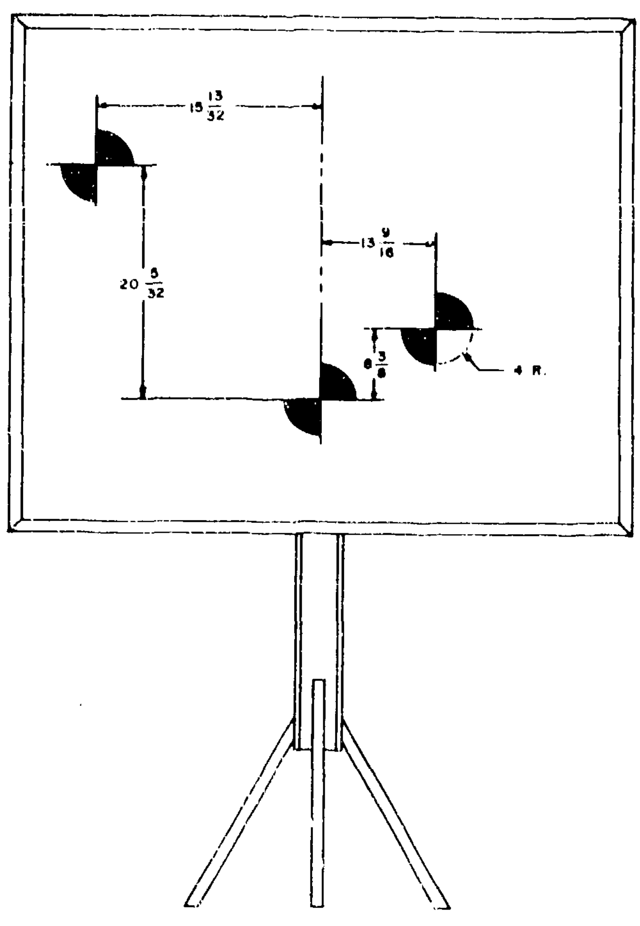


Figure 3-22. Testing target with stand.

(2) If the reticle is canted, the reticle lines may be leveled by means of the bracket rotating knob on the upper portion of the telescope mount. The elbow telescope may be adjusted for elevation and cant but *not* for deflection. The elbow telescope is now boresighted for direct fire.

Note. A weapon will be properly boresighted only when the following conditions exist: The trunnions are level (or as level as possible), the tube is level, all bubbles are centered, all scales read 0, all mounts are in coincidence with the tube, the 0—3200 line of sight of the panoramic telescope is parallel to the mechanical axis of the tube, both in elevation and deflection, the line of sight of the elbow telescope is parallel to the mechanical axis of the tube in cant and elevation, and the mounts and instruments are securely attached with neither bind nor play in the equipment.

3-50. Distant Aiming Point Method of Boresighting

A distant aiming point may be used in boresighting if a testing target is unavailable or if the tactical situation is such that the use of a testing target is impractical. The aiming point selected should be a sharply defined point *at least* 1,500 meters from the howitzer and as near to the zero elevation of the howitzer as possible. All steps prescribed for the testing target method of boresighting apply to the distant aiming point method of boresighting as pertains to checking the mounts against the tube at 0 elevation; the exception is that the boresights of the tube and the optical sights of the telescopes are alined on the same distant aiming point, after the mounts have been checked against the tube, (see fig 3-23) instead of on separate aiming diagrams. Accurate cross-leveling of the trunnions is unnecessary for boresighting on a distant aiming point, however, the trunnions should be as level as possible.

3-51. Standard Angle Check of Boresighting

a. General. When positions are occupied in combat, the necessity for speed in opening fire or the necessity for observing camouflage discipline may make the boresighting methods previously described impracticable. Under such circumstances, the alinement of the optical axis of the panoramic telescope parallel to the axis of the bore may be checked by referring to a selected point on the muzzle. The deflection and elevation angles necessary to refer the line of sight of the telescope to the selected point on the muzzle are referred to as the standard angles. During the fire control alinement tests, when the panoramic telescope is in correct alinement, is an ideal time to establish the standard angles for later use. When they have been determined, they may be used for a quick check of the alinement of the panoramic telescope when more precise methods cannot be used. Misalinement discovered as a result of this check should be verified by a more accurate method at the earliest opportunity. When using the standard angle check of boresighting, be sure that the position of the recoiling parts with respect to the nonrecoiling parts is the same as it was when the standard angles were determined. Also, check the recoil mechanism to see that it contains the proper amount of recoil oil before determining the standard angle.

b. Preliminary operations. The procedure for establishing standard angles is as follows:

(1) With the tube in battery, scribe lines in the paint to mark the position of parts that move in recoil with respect to parts that do not move in recoil (recoil sleigh and cradle).

(2) Carefully level the trunnions.

(3) Boresight the gun with a testing target.

(4) With adhesive tape, fasten a common pin in the left horizontal witness mark. Allow the pin to project to the left of the muzzle.

(5) Fasten a telescope parallax shield in place over the eyepiece.

(6) Verify that the elevation index and the micrometer on the telescope are at 0.

(7) Using the azimuth micrometer knob and the longitudinal leveling knob, move the line of sight of the panormaic telescope down and to the right until the intersection of the reticle in the panoramic telescope is on the pin where it extends from the muzzle. (*Do not* use the panoramic telescope elevation knob.)

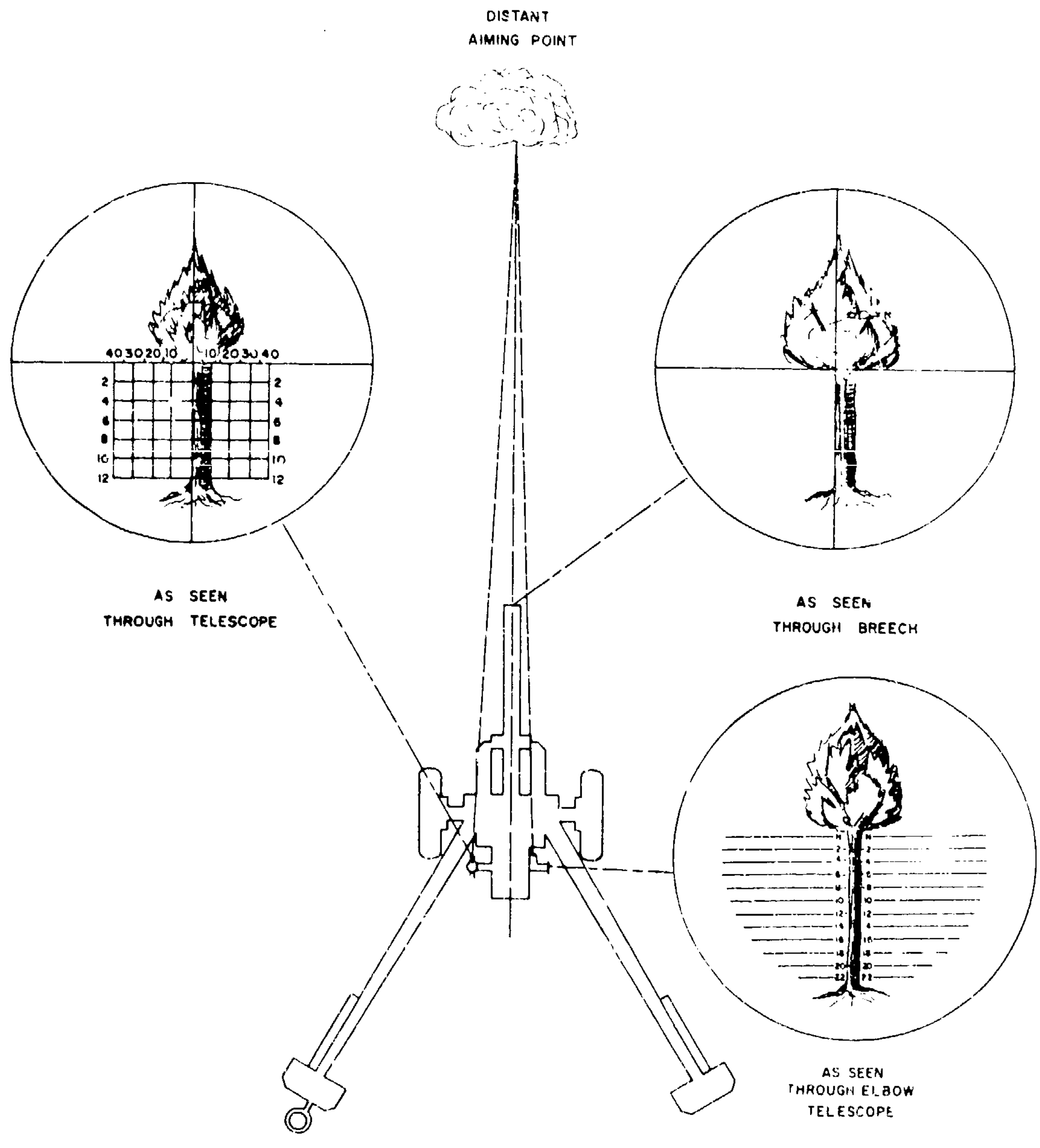


Figure 3-23. Distant aiming point boresight pictures, using a lone tree.

(8) Read the value on the azimuth and azimuth micrometer scales to the nearest 1 mil. Elevate the tube until the bubble in the longitudinal leveling vial centers. Read the elevation of the tube to the nearest 1 mil with the range quadrant. Record these two values on the inside of the panoramic telescope case.

(9) With a knife blade or other sharp metal point, scribe lines in the paint on the following parts:

(a) Straight across the junction of the cross-leveling segment and the cross-leveling worm housing of the panoramic telescope mount.

(b) Straight across the junction of the cross-leveling worm housing and the cross-leveling worm knob shaft.

(c) Straight across the junction of the rocker and the actuating arm.

(d) Straight across the junction of the longitudinal leveling knob shaft and the bracket.

(10) Fill the scribed lines with red paint and wipe off the excess.

c. Procedure for checking in the field. After the standard angles have been determined, the steps in performing the standard angle check of boresighting are as follows:

(1) Verify that the parts that move in recoil are in the same position with respect to the nonrecoiling parts as they were when the standard angles were determined.

(2) Using the range quadrant or gunner's quadrant, elevate the tube to the standard elevation angle.

(3) Fasten a telescope parallax shield in place over the eyepiece.

(4) Place the panoramic telescope in its mount. Make sure that the red scribed lines are in coincidence and set off the standard azimuth angle on the panoramic telescope.

(5) Place a pin in the left witness mark.

(6) If the vertical line of the reticle is not exactly on the junction of the pin and the muzzle, adjust the tangent screws until the vertical line of the reticle is properly alined. If the horizontal line of the reticle is not exactly on the junction of the pin and the muzzle, turn the elevating knob of the panoramic telescope until it is properly alined. Adjust the zero of the elevation knob scale so that it is in alinement with the index.

Note. If an error in boresighting is discovered by the standard angle check, then the weapon should be boresighted by a more accurate method at the first opportunity, to include establishing new standard angles, if appropriate. All of the methods of boresighting described in this section are described in detail in chapter 5 of FM 6-75 with appropriate pictures and drawings.

Section VII. SAFETY PROCEDURES

3-52. Malfunctions

When a weapon fails to fire, all personnel concerned must follow specific procedures, depending on the type of weapon being fired and the condition of the tube (hot or cold). The executive officer must know the misfire procedures and must apply them in case of a misfire in order to afford maximum safety in the firing battery. Malfunctions in the firing of artillery ammunition, such as misfires, hangfires, and cookoffs, are defined and discussed in *a* through *c* below. When authorized and properly maintained ammunition is fired from properly maintained and operated weapons, these malfunctions rarely occur. In order to avoid injury to personnel and damage to equipment, all personnel concerned must understand the nature of each malfunction and the proper preventive and corrective procedures.

a. Misfire. A misfire is a complete failure to fire. It may be caused by a faulty firing mechanism or a faulty element in the propelling charge explosive train. A misfire, in itself, is not dangerous; however, since it cannot be immediately distinguished from a delay in the functioning of the firing mechanism or from a hangfire (*b* below), it should be considered as a delayed firing until such possibility has been eliminated. Such delay in the functioning of the firing mechanism, for example, could result from the presence of foreign matter (such as grit, sand, frost, ice, or improper or excessive oil or grease), which might create, initially, a partial mechanical restraint. This restraint, after some indeterminate delay, is overcome as a result of the continued force applied by the spring and the firing pin is then driven into the primer in the normal manner.

b. Hangfire. A hangfire is a delay in the functioning of the propelling charge explosive train at the time of firing. In most cases, the delay, though unpredictable, ranges from a split second to several minutes. Thus, a hangfire cannot be distinguished immediately from a misfire (*a* above) and therein lies the principal danger—that of assuming that a failure of the weapon to fire immediately upon actuation of the firing mechanism is a misfire whereas in fact it may prove to be a hangfire. It is for this reason that time intervals are prescribed and should be observed before the breech is opened after a failure to fire.

CAUTION: During the prescribed time intervals, the weapon will be kept trained on the target and all personnel will stand clear of the muzzle and the path of recoil.

c. *Cookoff.* A cookoff is a functioning of any or all of the explosive components of a round chambered in a very hot weapon due to heat from the weapon. The primer and propelling charge, in that order, are generally more likely to cookoff than the projectile or the fuze. If the primer or the propelling charge should cookoff, the projectile could be propelled (fired) from the weapon with normal velocity even though no attempt was made to fire the primer by actuating the firing mechanism. In such a case, although there may be uncertainty about whether or when the round will fire, the precautions to be observed are the same as those prescribed for a hangfire. However, should the bursting charge explosive train cookoff, injury to personnel and destruction of the weapon could result. To prevent heating to the point at which a cookoff may occur, a round of ammunition that has been loaded into a very hot weapon should be fired or removed within 5 minutes.

3-53. Procedures After Failure to Fire—Cold Tube

After the howitzer fails to fire, actuate the firing mechanism two more times in an attempt to fire the piece. If the weapon still fails to fire, the chief of section reports to the executive officer MISFIRE NUMBER (so-and-so). The chief of section then waits 2 minutes from the last attempt to fire before he opens the breech, removes the cartridge case, and inspects the primer to see if it has been dented. If the primer is not dented, the firing mechanism should be repaired. If the primer is dented, he replaces the cartridge case with a new one and fires the weapon. If the executive officer does not wish to fire the round after the 2-minute waiting period, the projectile must then be removed from the tube. Using the bell rammer to avoid damaging the fuze, the cannoneer pushes the round out the rear of the tube. The breechblock should be closed and rags should be stuffed into the powder chamber to cushion the shock of the projectile. A common cause of misfire with a 105-mm howitzer is that the breechblock is not fully closed. This will cause the firing pin to miss the primer. Broken or bent firing pins will cause misfires, as will wet powder or a faulty primer.

3-54. Loading Precautions

When a hot tube condition exists, specific loading procedures should be followed. The executive officer is responsible for determining whether a hot tube condition exists. In making his decision, he takes into account such things as ambient temperature, rate of fire, amount of ammunition fired, and charge fired. Applicable general loading considerations are as follows:

a. Do not chamber a round until immediately prior to firing.

b. A chambered round in a hot tube should be fired or removed from the piece within 5 minutes of chambering.

c. If a round is in a hot tube more than 5 minutes and a misfire is not involved—

(1) Remove the cartridge case immediately.

(2) Evacuate all personnel to a safe distance.

(3) Keep the weapon laid on safe data.

(4) Request assistance from explosive ordnance demolition (EOD) personnel. Release the weapon to ordnance if required.

3-55. Procedures After Failure to Fire—Hot Tube

After the howitzer fails to fire, actuate the firing mechanism two more times in an attempt to fire the weapon. If the weapon still fails to fire, the chief of section reports to the executive officer MISFIRE NUMBER (so-and-so). The chief of section waits 2 minutes from the last attempt to fire before he opens the breech, removes the cartridge case, and inspects to see if the primer is dented. If the primer is not dented, the firing mechanism should be repaired. If the primer is dented, he replaces the canister with a new one and fires the weapon. The above procedures must be accomplished within 5 minutes after loading; if the weapon can not be fired or unloaded within 5 minutes the following procedures are followed:

a. Evacuate all personnel to a safe distance.

b. Keep the weapon laid on safe data.

c. Request assistance from explosive ordnance disposal. Release the weapon to ordnance if required.

Section VIII. SUMMARY

3-56. Review

The four major components of the 105-mm howitzer M101A1 are the carriage, barrel and breech assemblies, recoil mechanism, and sighting and laying equipment. In order for the weapon to function properly and deliver accurate fire, each component must be kept in proper working condition. It has been the purpose of this chapter to give a general insight into the characteristics, nomenclature, functioning, and maintenance of the major components of the weapon. For more detailed information, see FM 6-75, TM 9-1015-203-12, and LO 9-1015-203-10.

U. S. ARMY
FIELD ARTILLERY SCHOOL
Weapons Department
Fort Sill, Oklahoma

CHAPTER 4

105-MM HOWITZER, LIGHT, M102, TOWED

Section I. GENERAL

4-1. References

FM 6-70, TM 9-1015-234-12, TM 9-1015-234-10, and LO 9-1015-234-10.

4-2. Introduction

a. The 105-mm howitzer M102 is a lightweight towed weapon, which has a very low silhouette when in the firing position. It can be airlifted, dropped by parachute, or towed into position.

b. The M102 howitzer fires the same types of ammunition as the M101A1 howitzer and at charge 7 will fire a round 11,500 meters, or 500 meters farther than the M101A1. A roller tire (No. 19, figure 4-1) attached to the trail assembly (No. 26, figure 4-1) of the M102 permits the weapon to be rotated 6,400 mils around a firing platform (No. 14, figure 4-1), which provides the pivot point for the weapon. The weapon can be elevated from -89 mils (-5°) to a maximum of 1,333 mils (75°).

Section II. CARRIAGE

4-3. Description

a. General. The carriage consists of a welded aluminum box trail and cradle. The single box trail is shaped like a wishbone and its features provide mobility, stability, flexibility, and storage space.

(1) *Mobility.* On the rotatable drawbar (No. 22, fig 4-1) at the rear of the box trail is a lunette (No. 20, fig 4-1) that is mated with the pintle of the prime mover when the weapon is to be towed. When the weapon is towed by the M561 Gama Goat,with fixed towing pindel the drawbar is locked in the down position and the locking plate underneath the lunette is positioned to allow free movement of the lunette. When the M102 is to be towed by a 2½-ton truck, the drawbar should be placed in the up position because of the higher towing pintle. Two helicopter lifting brackets (No. 10) are located on the top of trail forward of the section chest. When the howitzer is to be transported by a CH-47 helicopter, slings are attached to these brackets and to the bracket located on the front yoke of the recoil sleigh (No. 6).

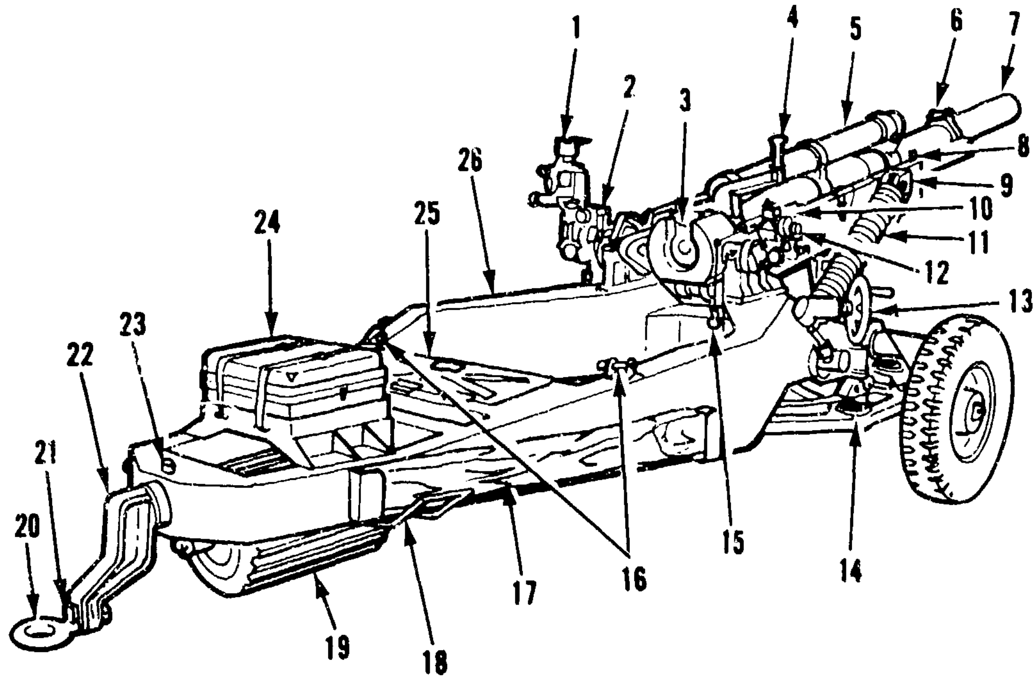
(2) *Stability.* The roller tire provides one of the two points of contact with the ground during firing. The firing platform is affixed to the carriage and provides the other point of contact with the ground and transmits most of the shock of firing to the ground.

(3) *Flexibility.* Trail lifting handles (No. 18) are presently located on the sides of the trail to enable cannoneers to lift the trail and pivot the weapon for large shifts in azimuth. Problems encountered with these handles are discussed in c(2) below.

(4) *Storage space.* The sight storage box (No. 24) is located at the rear of the trail over the roller tire and it is used to store the M113 panoramic telescope and M114 elbow telescope during travel. In the firing position, when the panoramic telescope is mounted to the M134 mount, the telescope mount cover is stored in the sight storage box. When the storage box is closed, an airtight seal is achieved by latching the four outer latches. Before the sight storage box is unlatched, the outer vent should be depressed, since variations in ambient temperature will cause the internal pressure to vary. The on-carriage section chest (No. 25) is located in the crossmember of the box trail. A lip around the upper edge of the chest deters water seepage, and drainage holes in the floor of the chest allow proper drainage. The chest is designed to hold section equipment such as the firing platform stakes, actuator crank, and sledge hammer. Brackets for three rammer staff sections are located on the side of the trail. The fourth rammer staff section (also used as a stake extractor) is stowed to the rear of the traversing

*Supersedes HB-4 WCXXWS, Dec 81.

M102 HOWITZER - RIGHT REAR VIEW (TRAVEL POSITION)



1—Panoramic telescope M113	14—Firing platform
2—Telescope mount M134	15—Lanyard assembly
3—Breechblack and firing mechanism	16—Lifting bracket (rear)
4—Breech mechanism handle	17—Aiming post M1A2 w/brackets
5—Recuperator cylinder	18—Trail lifting handle
6—Lifting bracket (front)	19—Roller tire
7—Cannon tube	20—Lunette
8—Recoil length indicator	21—Piece, drawbar bracket (lunette lock plate)
9—Cradle assembly	22—Drawbar bracket
10—Elbow telescope M114	23—Quick-release pin (drawbar bracket)
11—Ball-screw and equilibrator assembly	24—Sight storage box
12—Fire control quadrant M14	25—Section chest
13—Elevating handwheel	26—Box trail ass mbly

Figure 4-1. M102, rear view.

handwheel. On some weapons, aiming posts brackets (No. 17) are located to the rear of the elevation handwheel (No. 13). When brackets are not located on the weapon, the aiming posts are carried in the primer mover. The brackets for the night lighting devices are on the side of the trail beneath the sights.

b. T il and brackets assembly. The trail and brackets assembly consists of a pair of trunnion brackets that are secured to the top front corners of the box trail by capscrews.

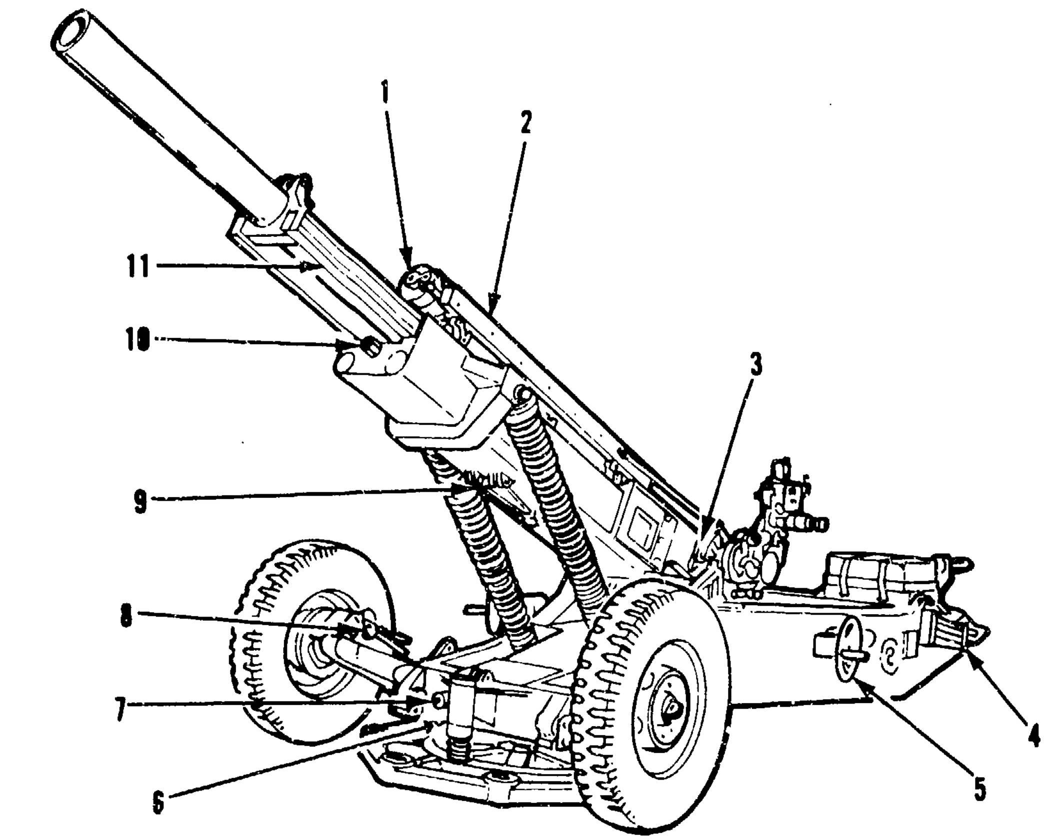
c. Maintenance problem areas. There are two potential maintenance problem areas, on the M102 wishbone trail (fig 4-3).

(1) The first area involves cracks that have developed in the trail welds. Investigation into this area has shown that these cracks develop primarily in and around the on-carriage section chest and the actuator access opening. These cracks are not in the structural part of the trail and are not serious. However, the section box is being reinforced during rebuild to reduce the deterioration. Armament Command field maintenance technicians have been made aware of special welding procedures to repair the actuator access opening cracks.

(2) The second area involves the trail lifting handles, which are being damaged when the howitzer is towed with the M561 Gama Goat. To resolve the problem, Armament Command engineers have designed a special p rpose kit that relocates the lifting handles in the howitzers of those units equipped with the Gama Goat.

(a) Any unit using the Gama Goat for

M102 HOWITZER-LEFT FRONT VIEW (FIRING POSITION)



1—Indicator rod (recoil oil)
2—Rail and link assembly (variable recoil mech)
3—Cam (variable recoil mech)
4—Rammer staff brackets
5—Traversing handwheel
6—Buffer assembly
7—Actuator control
8—Parking brake assembly
9—Travel lock
10—Recoil rod and locking nut
11—Recoil mechanism rails

Figure 4-2. M102, front view.

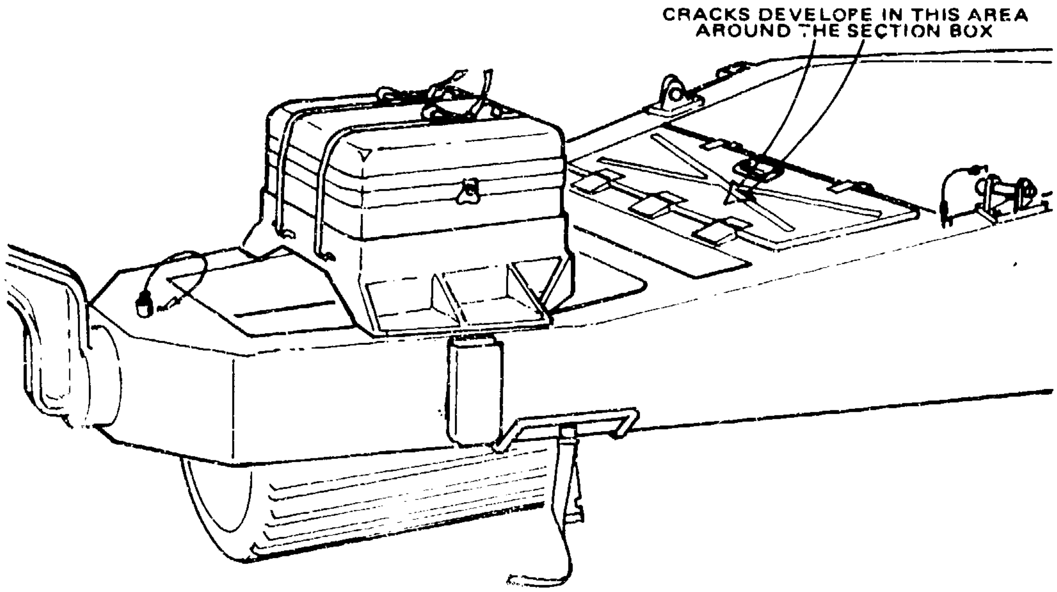


Figure 4-3. M102 wishbone trail.

towing the M102 can have the kit installed by its direct support unit.

(b) Until the kit is installed personnel should exercise caution when towing the M102. They should avoid making sharp turns as this is when the handles are damaged by the Gama Goat.

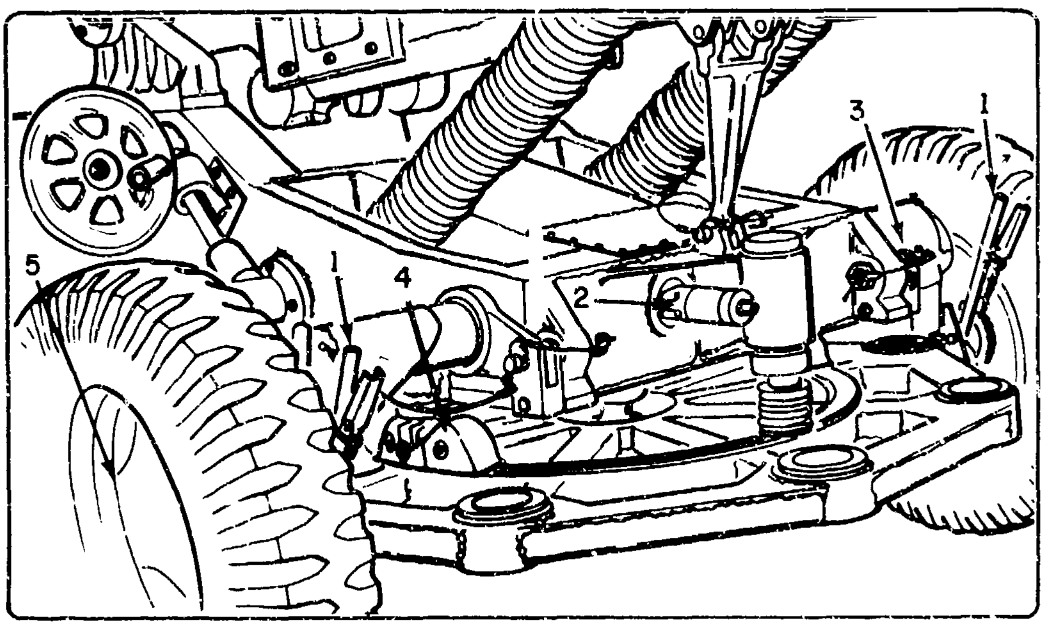
4-4. Suspension Assembly

a. Components. The components of the suspension are a pair of spindle brake and wheel assemblies, an actuator, and a pair of support assemblies. The mechanical actuator provides the means for raising and lowering the wheels. The spindle, brake, and wheel assemblies of the M102 howitzer are the same as the lightweight (magnesium) wheels and hand-operated parking brakes of the ¼-ton truck M151. On improved surfaces, the tire pressure should be maintained at 40 pounds per square inch (psi); on rough terrain, the pressure should be 22 psi. A tire tread depth of ⅛-inch is considered serviceable. The wheel bearing must be removed, cleaned, and packed annually, after driving extended distances in sandy terrain, or after fording hub-deep water. The brakes should be adjusted in accordance with the guidelines presented in the user's manual, TM 9-1015-234-12.

b. Problem area. A problem area involving the M102 suspension system is that of reported failures of the wheel bearings during highway towing operations.

(1) Engineers have conducted tests of the M102 wheel bearings and report that the bearings are adequate for the system. Indications are that units reporting the wheel bearing problem have not properly lubricated or installed the bearings during servicing. The user's manual, TM 9-1015-254-12, prescribes step-by-step procedures for servicing the wheel bearings.

(2) The wheel bearings must be serviced annually as prescribed in change 8 to TM 9-1015-234-12. The maximum towing speed is 35 mph (or 45 mph if GPG aircraft bearing lubricant is used) for the M102 on paved roads. Also, you must reduce the service interval specified on the lubrication order to compensate for abnormal or extreme conditions, such as high or low temperatures, prolonged periods of travel, continued use in sand or dust, immersion in water, or exposure to moisture. Any one of these conditions may cause contamination and quickly destroy the protective properties of the wheel bearing lubricant.



1—Brakes
2—Actuator control mechanism
3—Suspension locks
4—Roller support assembly
5—Wheel, tire and hub assembly

Figure 4-4. Suspension assembly.

4-5. Firing Platform

a. *Description*. The front end of the carriage is supported by an aluminum platform (fig 4-5) that is located between the carriage wheels and must be staked to the ground prior to firing operations for stability in the firing position. The carriage is supported on the firing platform by a pivot and socket and four stabilizing devices that ride on the firing platform stiffening ring to permit a full 6,400 mil traverse. The firing platform is an octagon-shaped, welded aluminum structure that serves as a supporting base for the weapon during firing. A socket for receiving the box trail pivot is located in the center of the firing platform, about which the weapon is traversed. This arrangement permits the base to accommodate itself to varying angles between the ground and weapon. A hole is provided at each of the eight corners for staking purposes. The stiffening ring provides the bearing surface which the leveler assembly, roller support, and buffer assembly bear upon. These components are listed in (6) through (8) below:

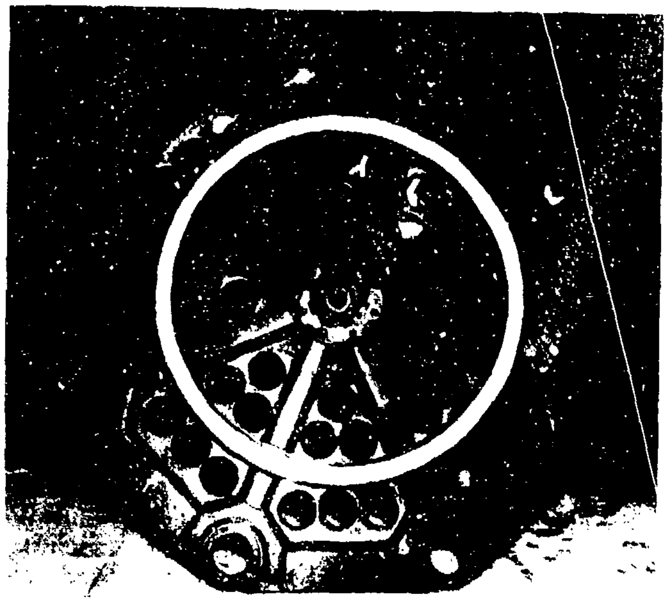


Figure 4-5. Firing platform.

(1) *Leveler assembly*. A spring-loaded leveler assembly has been added to the box trail directly behind the carriage pivot. The leveler assembly roller bears upon the platform stiffening ring and holds the platform in a horizontal position during travel (fig 4-6).

(2) *Supports*. Two supports are mounted to the underside of the box trail on each side of the pivot. The four rollers of these supports bear upon the stiffening ring of the firing platform (fig 4-7). The roller support on the assistant gunner's side is spring loaded to compensate for the torque created by the increasing right-hand twist of the round leaving the tube. On the outside of the roller support housing are two grease fittings (fig 4-7) which must be lubricated with GAA monthly or after disassembly.

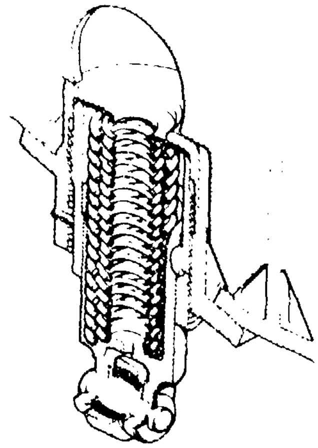


Figure 4-6. Leveler assembly.

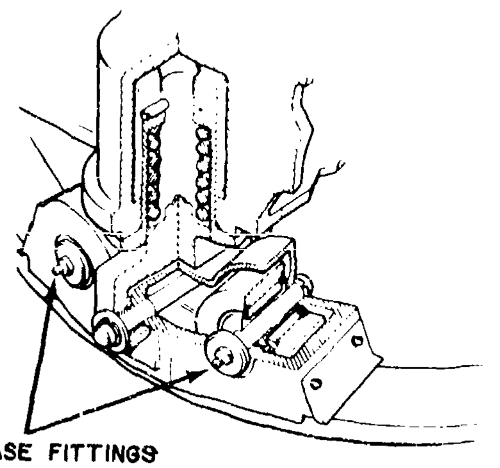


Figure 4-7. Roller support.

(3) *Buffer assembly*. A hydraulic buffer assembly (fig 4-8) is secured to the front of the box trail. The buffer shoe bears upon the firing platform stiffening ring. This assembly acts as a buffer and prevents the carriage from tipping forward when the recoiling parts return into battery. The hydraulic buffer must be checked periodically for leaks. Any leak in the buffer is considered serious and must be checked by support maintenance personnel. A quick-release type of locking assembly is provided for securing the platform to the box trail assembly pivot. This platform locking assembly is secured in its engaged position by a quick-release pin. The firing platform can be disengaged for separate emplacement or for abandonment if necessary.

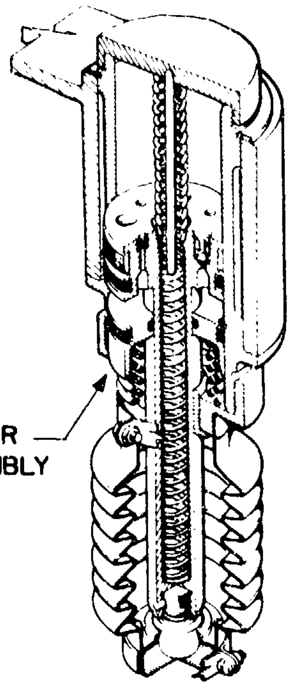


Figure 4-8. Buffer assembly.

b. Problem areas. There are three interrelated potential maintenance problems involving components of the M102 firing platform and its locking handle assembly (fig 4-9).

(1) The first problem involves the retaining bolts on the platform locking ring (item 1, fig 4-9), which vibrate loose during firing and can cause the platform to warp and become unserviceable.

(a) The cause of this problem is that the retaining bolts are too short and do not seat the locking positions of the self-locking nuts. Longer bolts have been made available.

(b) The maintenance allocation chart indicates that the user is not authorized to repair the firing platform, but he can check it. Personnel should inspect each retaining bolt of the nut side to see if the bolt protrudes all the way through. If the bolt is of the right length, one to four threads will be visible. If no threads are visible, the user should notify the direct support unit (DSU) and it will replace the bolts. After the improper bolts have been replaced, or even if the weapon has the correct bolts, periodic checks should be made to insure that the bolts remain tight. The best time to check the bolts for tightness is whenever the firing platform is disengaged from the weapon.

(2) The second and third potential maintenance problems in the firing platform area are on the platform locking handle assembly. The locking handle (item 2, fig 4-9) may bend or break when the platform is being installed or removed, and the locking handle retaining machine screws (item 3, fig 4-9) vibrate loose and then are sheared and lost during firing operations.

(a) To resolve these problems, a strong handle has been developed and the retaining machine screws have been replaced by bolts with lockwashers. Both the new handle and the bolts can be replaced in the field without removing the howitzer pivot from the carriage.

(b) A broken locking handle or lost retaining screw generally indicates the lack of proper preventive maintenance. The locking handle bends or breaks because excess muscle is applied. The screws vibrate loose and are lost because somebody forgets to check them for tightness.

4-6. Lowering the Firing Platform (and Suspension Assembly)

When the weapon arrives at the firing position, the firing platform must be emplaced. The weapon is initially positioned with the tube facing the back-azimuth of fire. Because the actuator gear train is subject to failure while the platform is being lowered, certain precautions must be taken. The tube should be elevated to approximately 800 mils and all personnel should be warned to keep their feet clear of the firing platform. Before the platform is lowered, the brakes must be disengaged, the suspension locks must be disengaged and stored, and the travel lock must be disengaged and stored. The bracket for attaching the travel lock is located above and behind the buffer assembly. The travel lock connects the box trail with the cradle, supports the overhanging weight of the tube, and prevents undue wear of the elevating mechanism during travel. Once the number 1 and number 2 cannoneers have taken the preparatory steps, they will connect the actuator crank to the actuator mechanism and crank the actuator in a counterclockwise direction until the suspension assembly contacts the roller supports. Two men are always used to lower the firing platform—one to hold the crank and one to turn the crank. At this time the wheels will be off the ground in the firing position and the brakes must be reengaged.

4-7. Emplacing the Firing Platform

The procedure for emplacing the M102 in the firing position is spelled out in chapter 1, section III, of TM 9-1015-234-12 and page 2-21 of TM 9-1015-234-10. However, investigations within the USAFAS have shown that some questions exist concerning the normal emplacement procedure. Additionally, the US Army Armament Command has initiated actions to provide a method of emplacing the weapon on rocky or frozen ground.

a. When charges 1 through 6 are being fired, firing may commence when a minimum of two stakes have been emplaced. This is not

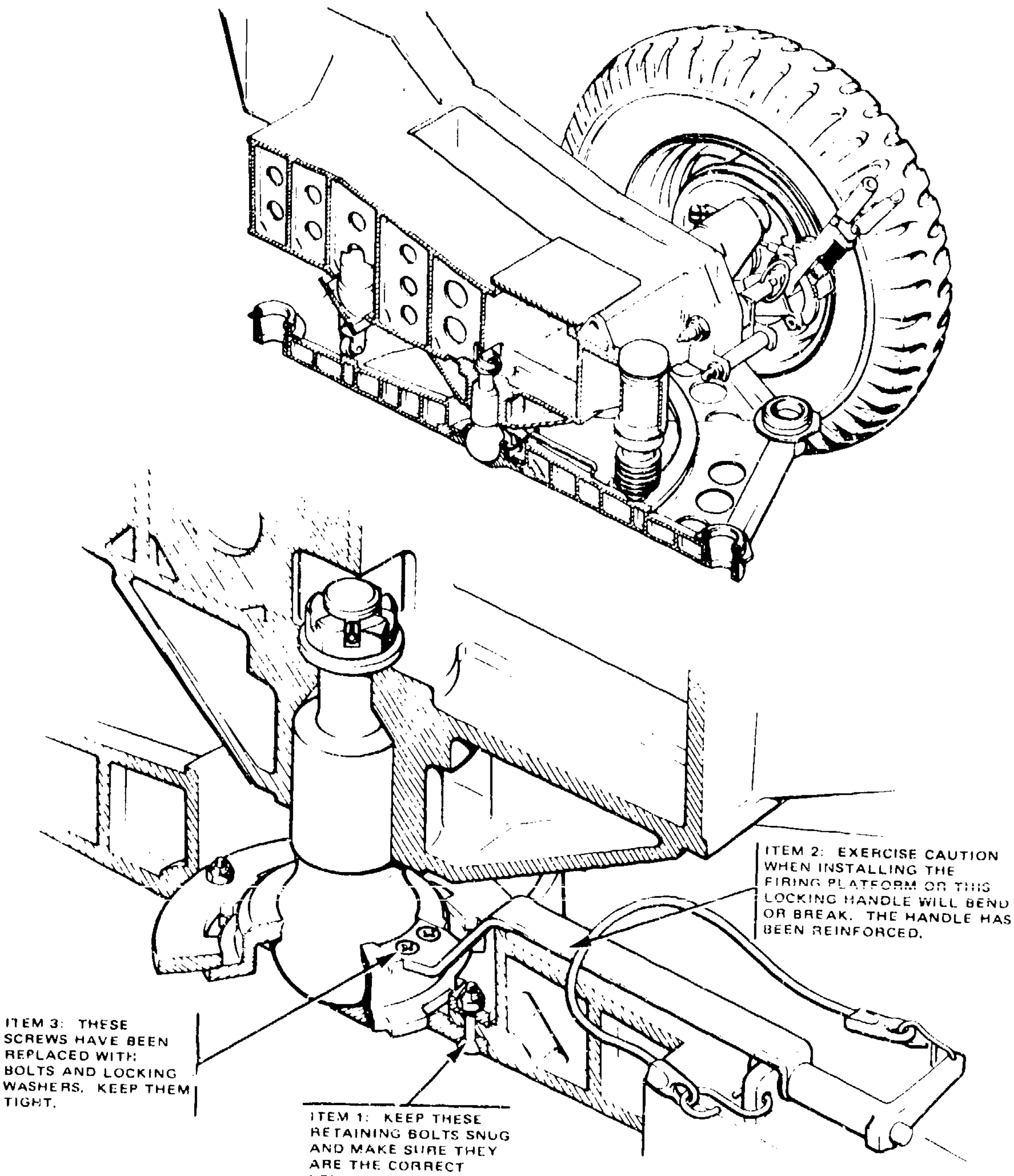


Figure 4-9. Firing platform and locking handle assembly.

recommended, however, because a high potential of damaging the M102 firing platform exists under this condition. All eight stakes must be emplaced before charge 7 is fired.

(1) The USAFAS had determined that the fastest method of emplacing and laying the M102 is as follows: Bring the weapon into position 3,200 mils from the primary direction of fire, lower the weapon onto the firing platform, drive the front stakes, traverse the weapon 3,200 mils, and then begin laying operations and drive the remaining stakes.

WARNING: The M102 howitzer must remain elevated to approximately 800 mils while the weapon is lowered and the firing platform is emplaced.

Note. Elevating the M102 howitzer to 800 mils is required primarily for safety reasons but is also required to prevent damage to the weapon during emplacement. As stated in the user's manual, the stakes must be driven from the front of the weapon to prevent damage to the carriage and fire control instruments.

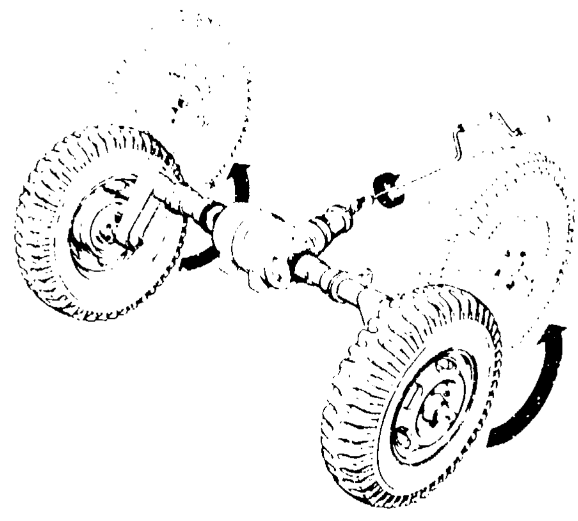


Figure 4-10. Lowering the suspension assembly.

(2) This USAFAS recommended emplacement procedure has been found to be faster, more accurate, to cause less damage to the weapon, and to be safer than other procedures that have been tried. When this procedure cannot be utilized, common sense should prevail.

b. Two stakes have been produced for emplacing the firing platform—a 38-inch stake for sandy/soft terrain, a 24-inch stake for normal terrain. (*Note.* Units stationed in cold areas have been authorized to cut some stakes down to 15 ± ⅛ inches.)

c. The problem of emplacing the M102 on rocky or frozen ground is caused by the difficulty involved in driving the stakes. The problem has existed since the weapon was first introduced and has resurfaced because of the issue of the M102 to Korea-based units.

(1) To resolve the problem, the US Army Armament Command tested a miniature-shaped charge, known as the jet tapper, for blasting holes in rocky or frozen ground. The hole facilitates the driving of special steel forged stakes which are also programed for issue. The jet tapper is fired by means of a detonating cord strung through a traverse hole on the charges. There are no fragmentation or pressure hazards to personnel and equipment 40 feet from the charge.

(2) There is little doubt that your immediate reaction, like that of many field artillerymen at the USAFAS, is skepticism. Questions like "Can a charge of this nature be detonated within a battery position?" or "What are the safety factors involved?" plus more questions concerning the jet tapper have been raised. The jet tapper has not been accepted by the field artillery community; however, feasibility tests and demonstrations will be conducted to determine if we, as field artillerymen, can live with such devices.

d. For those of you who are currently having M102 emplacement problems on frozen or rocky ground, Armament Command engineers have devised a method of cutting down the current 24-inch stakes (fig 4-11) to 15 inches. These modified stakes can generally withstand the driving force required to penetrate frozen or rocky ground, and because they are shorter, will require less emplacement time and depth penetration. This modification can be made at the organizational level. The only tools required are a hacksaw to cut and taper the stakes and a grinder or file to sharpen the edges as required.

e. The stakes should be driven to a depth at which the next to top lip is flush with the firing platform as shown in figure 4-12.

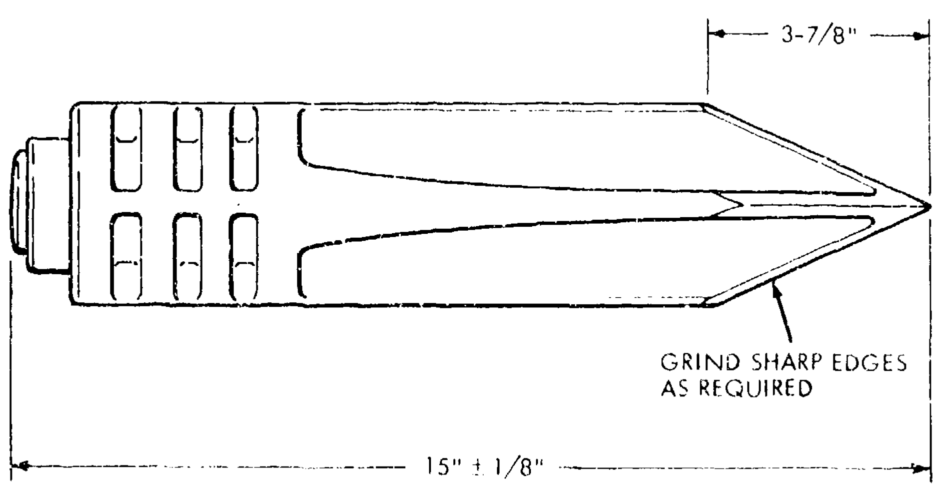


Figure 4-11. Modified (short) stake.

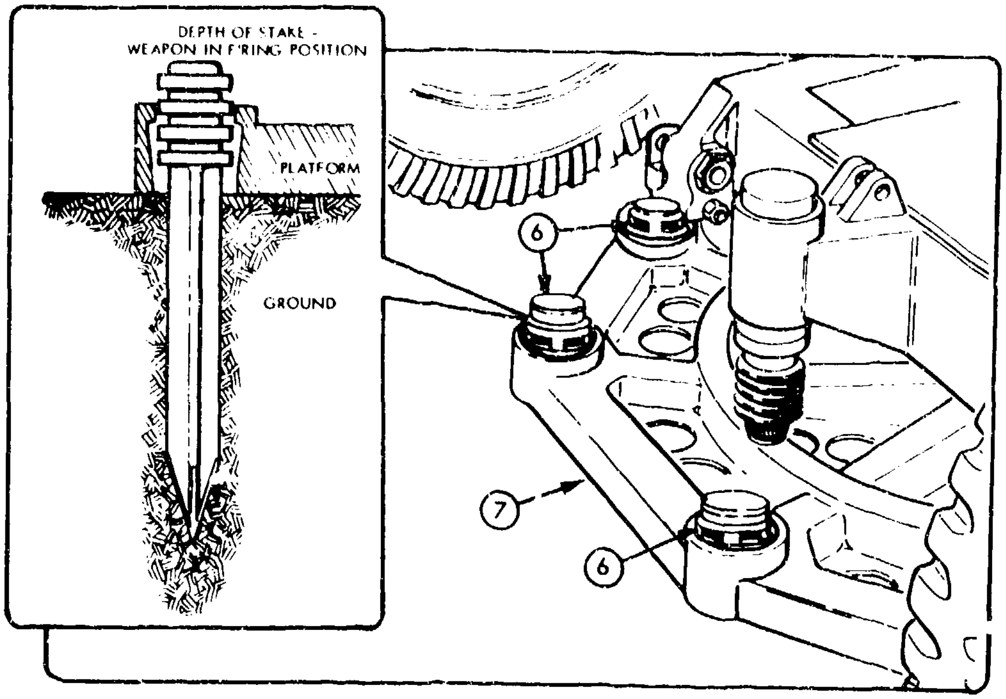


Figure 4-12. Firing stake emplacement.

4-8. March Order of Firing Platform

a. To march order the firing platform, elevate the tube to 800 mils elevation. Traverse the howitzer so that the cannoneers have access to the stakes in front of the platform. Using the stake extractor and the sledge hammer as a fulcrum, extract the front stakes as shown in figure 4-13. Traverse the howitzer and repeat the procedure until all stakes have been removed. Unlock the hand brakes on the wheels. Place actuator crank on actuator gear shaft and turn handle clockwise to raise platform. Lock wheels with hand brakes and install suspension locking pins. Depress the tube and secure travel lock in locked position.

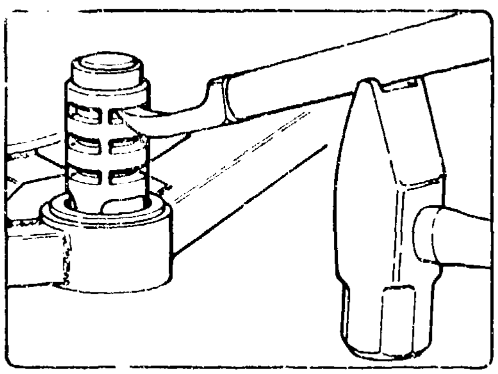


Figure 4-13. Extracting the firing stake.

WARNING: On the actuator crank is a shear pin made of soft metal that is designed to break if too much pressure is applied to the actuator as the firing platform is being raised. If this pin breaks, do not simply replace it with a nail or similar item. When repairing the actuator crank, always use the proper shear pin.

b. Personnel should be aware of an extreme safety hazard that involves the failure of the wheel actuator assembly (item 2, fig 4-4) during emplacement or march order of the firing platform. Simply stated, the problem is that a gear failure within the assembly often permits the howitzer to drop into the firing position. If the cannoeer operating the crank assembly has his foot under the firing platform when the failure occurs, his foot will be crushed; if the tube is elevated less than 800 mils and a cannoneer is under it, his head may be split open.

(1) Investigations to isolate the failing wheel actuator assembly component are still underway, but certain assemblies have been identified as those most likely to fail. In order to prevent personnel injuries during M102 emplacement or march order, you should insure that your personnel comply with the provisions of the M102 user's manual. Unnecessary personnel should stand clear of the weapon during emplacement until the firing platform is on the ground. The cannoneers emplacing the weapon should exercise caution to keep their feet clear of the firing platform. Just as important, the weapon tube should be elevated to approximately 800 mils. The same procedures apply during march order operations until the suspension travel lock pins have been installed.

(2) Until the problem involving failure of the wheel actuator assembly has been resolved, TM

9-1015-234-12 and TM 9-1015-234-10 also require that the user conduct a preventive maintenance check on the assembly as part of the before- and after-firing checks. The test is spelled out in table 3, Monthly Preventive Maintenance Checks and Services, in the user's manual. If the wheel actuator assembly of your weapon fails, you must modify the appropriate direct support unit (DSU) to make repairs and you should submit an equipment improvement recommendation (EIR) on DA Form 2407. If at all possible, find out from your DSU who manufactured the faulty actuator assembly and include that information on the EIR.

4-9. Elevating Mechanism

a. Description. The M102 employs the concept of rear-mounted trunnion elevation. The elevating mechanism is the ball screw type that employs a bevel gear trai

(1) Total elevation is from 0 to 1,333 mils on level terrain.

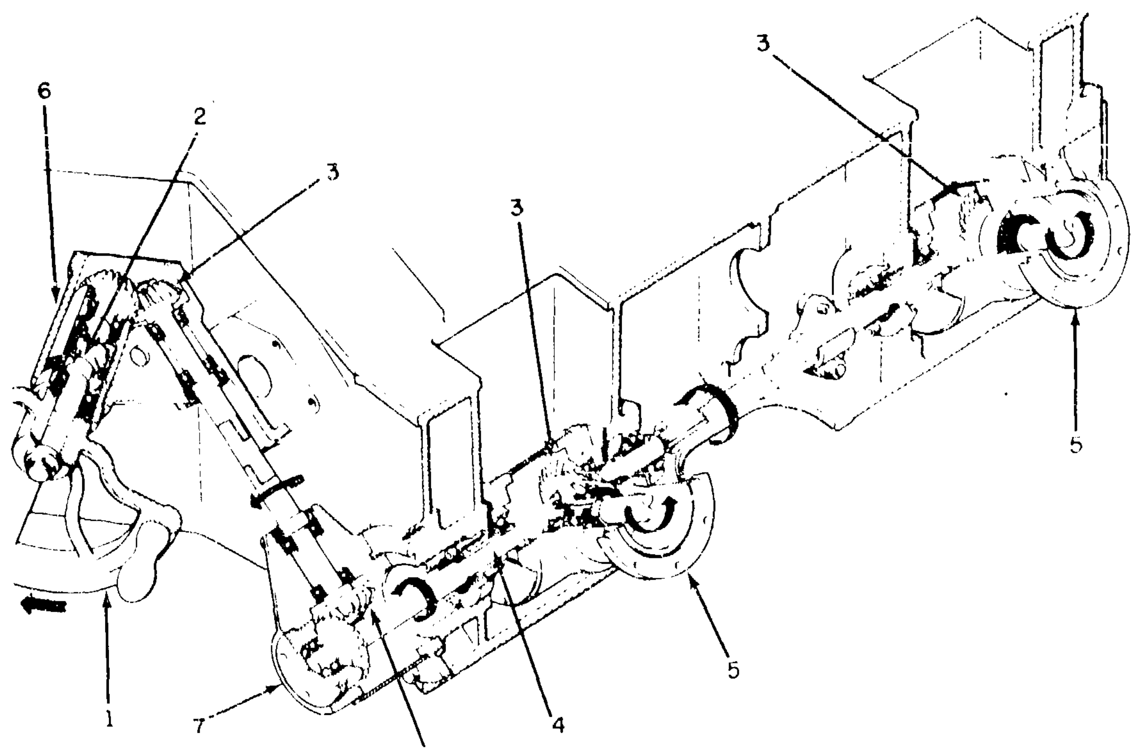
(2) Total depression is from 0 to -89 mils on level terrain.

(3) Each complete turn of the handwheel moves the tube 10 mils.

(4) Maximum allowable backlash of the elevation handwheel is 1/8 turn.

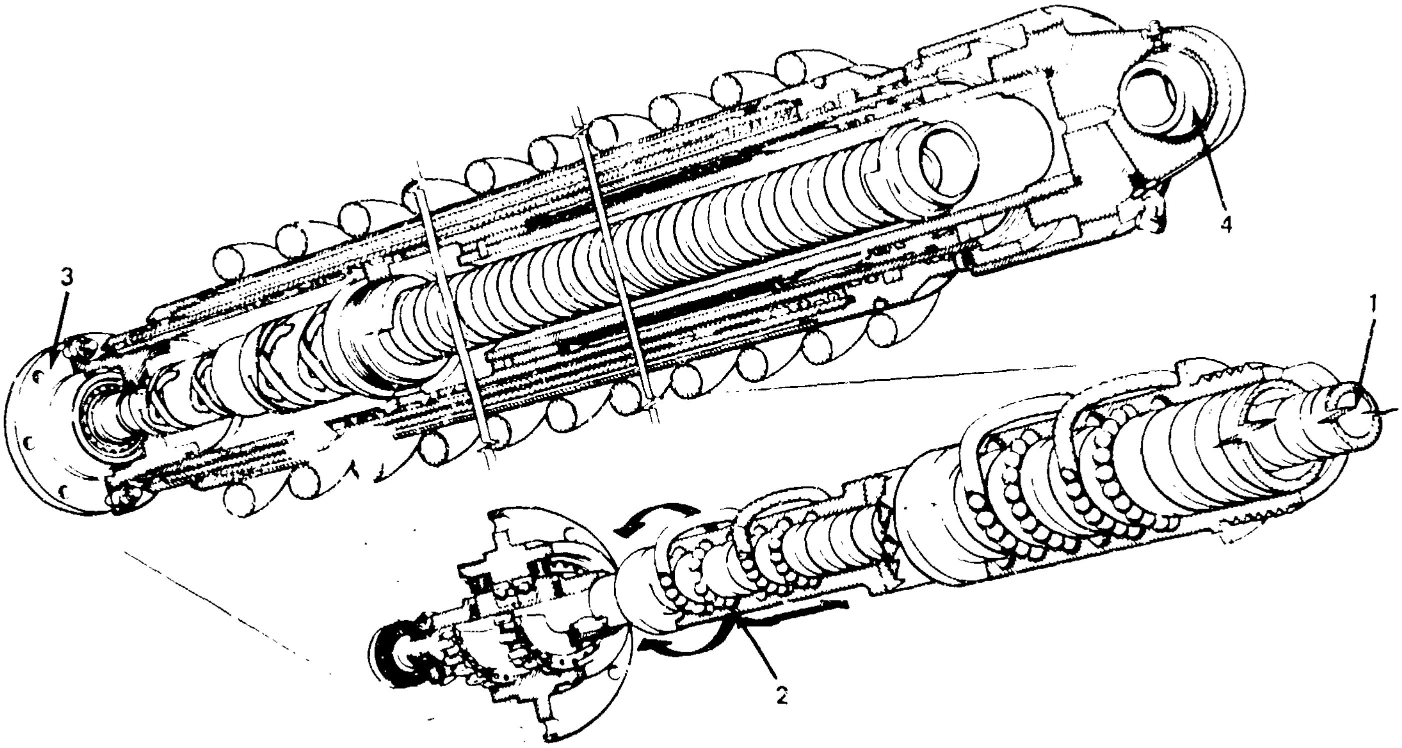
b. Purpose. The purpose of the elevating mechanism is to raise and lower the tube to achieve various ranges to targets, thus lending flexibility to the howitzer.

c. Components. Components of the elevating mechanism assembly (fig 4-14) are a counterbalanced elevation handwheel, upper and lower gear housing, a clutch (no-back device), bevel gears, a pair of shafts that are connected by a coupling, a drive shaft assembly, and a pair of ball screw housings (fig 4-14). The upper gear housing, which contains a pair of mating bevel gears and the clutch, is mounted to the box trail directly in front of the right trunnion bracket. The lower gear housing is bolted to the box trail in front and below the upper gear housing. The elevating handwheel is connected to the drive shaft assembly through the clutch, a set of bevel gears, the two shafts with connecting coupling, and a bevel gear, which engages the drive shaft assembly bevel gear. (The no-back clutch device makes the gear action irreversible.) The drive shaft assembly, which is mounted in the box trail, is composed of a pair of shafts with attached bevel gears, a coupling shaft, and a clamp. The bevel gears of this shaft assembly engage the mating gears in each of the ball screw housings (fig 4-14). The forward or



1—Elevation handwheel
2—No-back clutch
3—Bevel gears
4—Drive shaft
5—Elevation cylinder base
6—Uppergear housing
7—Lower gear housing

Figure 4-14. Elevation drive train.



1—Screw-type cylinder
2—Ball bearings
3—Housing base
4—Hinging point (bolted to cradle)

Figure 4-15. Ball screw housings.

upper extremes of the ball screw housings are pinned to the forward portion of the cradles and brackets assembly. The large compression helical springs, which encircle each ball screw housing, serve as pusher-type equilibrators.

d. Functioning. When the elevation handwheel is turned, the direction of the flow of power is changed and transmitted to the telescoping elevation cylinders. The elevation cylinders telescope in a screw-type fashion, with the ball bearings reducing the friction between moving metallic parts. As the cylinders telescope, the upward pressure is exerted on the cradle to elevate the tube.

e. Maintenance. The elevation cylinders will be lubricated monthly by organizational maintenance. Backlash of the handwheel must be checked periodically; if it exceeds 1/12 turn, the direct support unit must be notified. The handwheel grease fitting will be serviced monthly with GAA.

4-10. Equilibrators

a. Type. The M102 utilizes open-spring pusher-type equilibrators.

b. Purpose. The purpose of the equilibrators is to reduce the manual effort required to elevate the tube due to the rear-mounted trunnions, and thus to relieve some stress from the elevating mechanism. No adjustment of the equilibrators can be made at organizational level.

c. Function. As the tube is depressed, the equilibrator springs are compressed and energy is stored to assist in elevating the tube at a later time.

d. Maintenance. There have been some reports from the field that units are experiencing problems with the equilibrators (fig 4-16). Indications are that the equilibrators lock or creep and thus fail to maintain the tube at the correct elevation.

(1) Little information on the cause of the equilibrator problem is currently available. Further information, through EIRs from the users, is needed; however, investigation into the problem area has been initiated. Two of the probable causes of the equilibrator problem are the lack of lubrication and the plugging of the drain holes. A drain hole is located in the lower housing on the underside of each equilibrator. The drain holes are being enlarged to reduce the possibility of plugging, but you must insure that the holes remain clear. The drain holes can be cleaned with a thin wire. Then, the equilibrators can be cleaned and lubricated with general purpose lubricating oil. The M102 lubrication order, LO 3-1015-234-10, 1 June 197[illegible], requires that organizational maintenance personnel accomplish this lubrication on a monthly basis; however, the

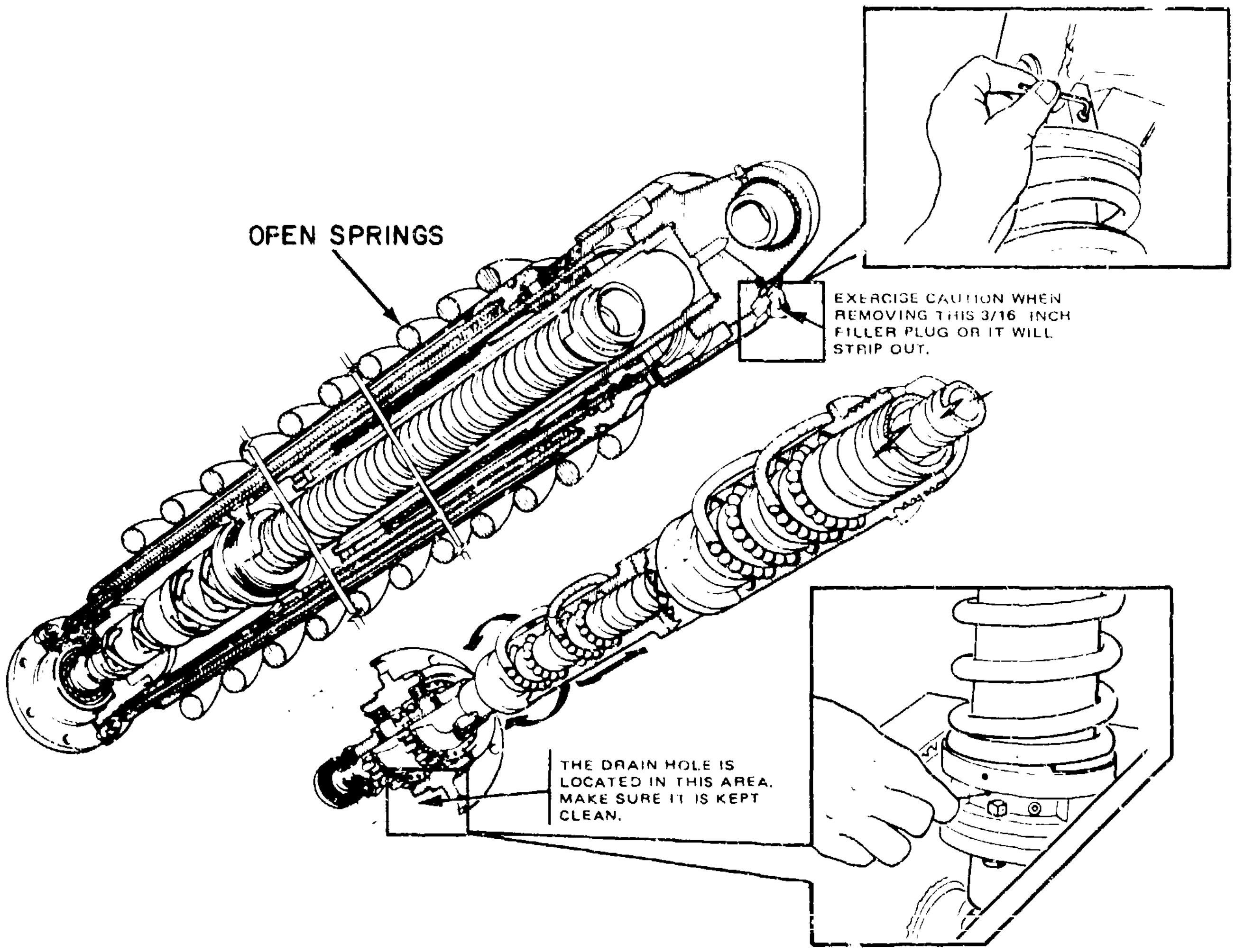


Figure 4-16. M102 open spring pusher-type equilibrators.

lubrication instructions prescribed in note 5 on the lubrication order have been found to be inadequate. Personnel should lubricate the equilibrators according to the instructions in *(a)* through *(f)* below. (These instructions will be incorporated in the next change of the lubrication order.)

(a) Elevate the cannon to 1,200 mils.

(b) Use a thin wire to clean the drain hole at the bottom of each equilibrator.

Note. Failure to clean the drain holes will result in improper lubrication of the equilibrators.

(c) Being careful to avoid stripping the plugs, remove the 3/16-inch filler plug from the top of each equilibrator.

(d) Using a hand oiler, add 1 pint of general-purpose lubricating oil to each equilibrator and allow the weapon to stand until oil seepage from each drain hole stops.

(e) Being careful to avoid stripping the plugs, replace the 3/16-inch filler plug at the op of each equilibrator.

(f) Depress and elevate the cannon three or four times throughout the elevation limits to thoroughly lubricate the equilibrator ball and screw assemblies.

(2) The grease fitting located at the top of each equilibrator must be lubricated with GAA monthly.

4-11. Traversing Mechanism

a. Type. The type of traverse is pivot and socket. The pivot is attached to the carriage and fits in the socket of the firing platform (fig 4-17). When the weapon is in the firing position, the socket supports the weight of the carriage by providing a bearing surface in which the pivot rotates during traverse (fig 4-17). The total amount of on-carriage traverse is 6,400 mils. The traversing mechanism on this weapon is the bevel gear type with a roller tire.

b. Purpose. The traversing mechanism controls the movement of the weapon in azimuth so that rounds can be rapidly delivered over wide fronts.

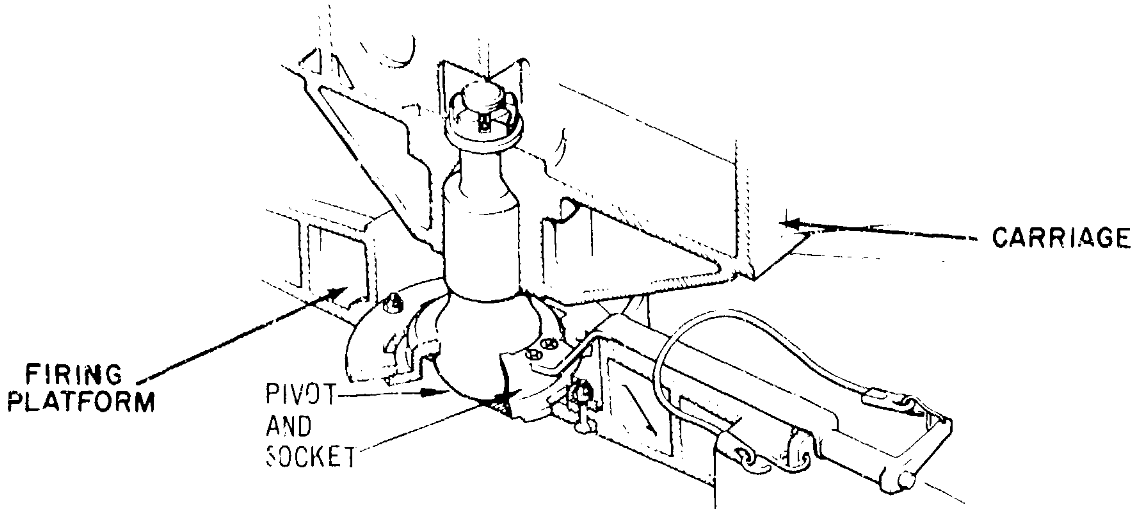


Figure 4-17. Traversing mechanism pivot and socket.

c. *Components.* Components of the traversing mechanism (fig 4-18) are a handwheel, bevel gears, a flexible shaft, a connecting shaft with U-joints, helical gears, an axle, and a roller tire filled with solid foam.

d. *Functioning.* The traversing handwheel transmits power to the roller tire through the bevel gears, shafts, U-joints, and helical gears (worm and worm wheel). The handwheel housing is secured to the left side of the trail, the bevel gears change the direction of the flow of power. The flexible shaft, mounted inside the left side of the box trail eliminates the need for a series of rigid shafts and U-joints. The helical gears in the trail crossmember make the mechanism irreversible; i.e., the weapon cannot be traversed by moving the roller tire. The wheel moves the tube 21 mils. The tube moves to the right when the handwheel is rotated to the right and moves to the left when the handwheel is rotated to the left.

e. *Maintenance.* The traversing mechanism is lubricated semiannually by DS or GS maintenance personnel (LO 9-1015-234-10). When the weapon is to be shifted over 200 mils the cannoneers will use the trail lifting handles to lift the trail and shift the direction of the tube. This prevents undue wear of the traversing mechanism. The roller tire should never be dragged on the ground. The maximum allowable backlash of the traversing handwheel is 1/12 turn. If this tolerance is exceeded, the deficiency will be reported to DS or GS maintenance personnel. Field units have indicated some problems with the traversing mechanism (fig 4-18); however, all known failure problems have been corrected. Failure of the gearbox, caused by large trail shifts, was corrected by means of a stronger gearset and additional support bearings. The only other reported problem concerned wearing of the lockng pin holes in the universal joints. This caused excessive backlash in the mechanism. This problem was corrected by an improvement in the mechanism universal joints.

Section III. BARRELS AND BREECH ASSEMBLIES

4-12. Barrel Assembly

a. *Type.* The M137A1 tube is a 105-mm cannon that fires semifixed ammunition and has the following characteristics and capabilities:

(1) *Caliber*—105-mm, or 4.13 inches between opposite lands.

(2) *Length*—124.40 inches, or 30 calibers.

(3) *Length of rifling (bore)*—110 inches.

(4) *Muzzle velocity*—approximately 494 meters per second.

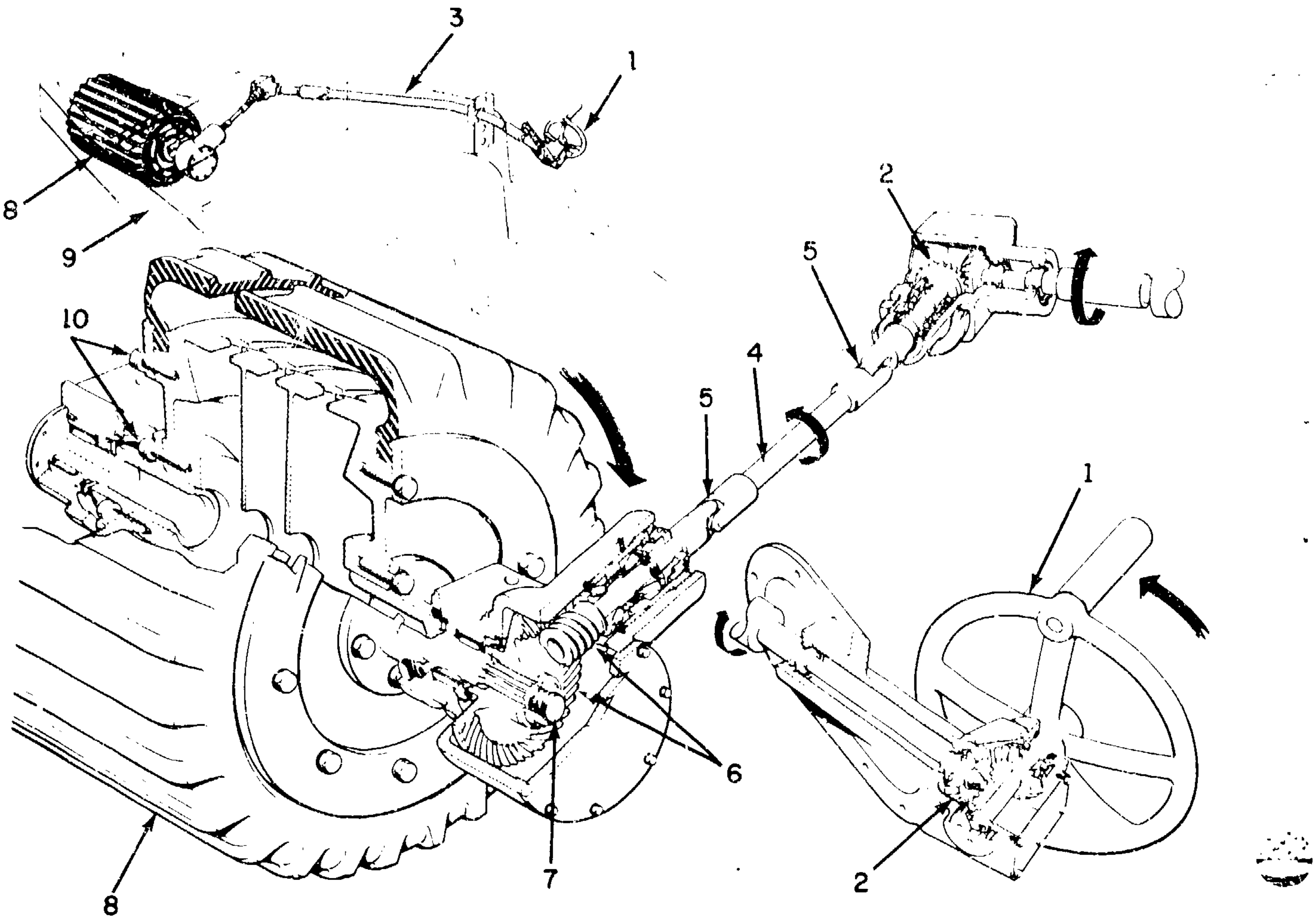
(5) *Lands and grooves*—36.

(6) *Rifling*—increasing right-hand twist of one turn in 35 calibers to one turn in 18 calibers.

(7) *Maximum range*—11,500 meters.

(8) *Rate of fire*—maximum, 10 rounds per minute for the first 3 minutes; sustained, 3 rounds per minute, thereafter.

(9) *Weight*—900 pounds.



1—Traversing handwheel
2—Bevel gears
3—Flexible shaft
4—Connecting shaft
5—Universal joints
6—Helical gears
7—Axle
8—Roller tire
9—Box trail
10—Roller tire supports

Figure 4-18. Bevel gear roller tire drive train.

b. Construction. The tube is made from an alloy steel ingot, which is poured and then hot-forged into a cylindrical shape by means of a high-pressure press. A hole is then bored through the center, the outer surface is rough-turned, and the barrel is machined. The inside of the barrel is machined with a bore guidance system that insures the straightness of the tube to within 0.005 inch throughout its entire length. During this sequence of machining steps, the tube is permanently prestressed by hydraulic pressure in a process known as autofrettage.

c. Tube life. Each round of ammunition fired through a cannon tube causes wear and erosion of the tube, which gradually changes the dimensions of the bore. For most gun tubes and some howitzer tubes, the extent of wear determines the remaining life of the tube. In addition to causing wear and erosion, each round fired produces metal fatigue, a process in which heat and expanding gases weaken the metal in the tube and breech and reduce the tube and breech life. The remaining life of a tube can be determined by converting the rounds fired to equivalent full charge (EFC) rounds and subtracting the EFC rounds fired from the EFC life of the tube. An EFC is equal to the firing of charge 7 (maximum charge for the M102). When any other charge (1 through 6) is fired only 0.10 EFC is exhausted. Table 1 shows the tube and breech life and the EFC factors for the 105-mm howitzer M102.

d. Exterior components. The exterior of the tube is threaded at the breech end. The threaded end of the tube is screwed into the breech ring, and the front face of the breech ring has a threaded section that screws into the rear yoke of the recoil assembly. As the tube is fitted into position, two semicircular disks (the cannon ring) are wedged

Table 4-1. Condemnation Criteria for Tubes and Breech Assemblies

Major Item	Cannon Tube	EFC Life of Tube	EFC Factor	Breech Life
105-mm howitzer M102	M137*	—	—	—
105-mm howitzer M102	M137A1 (M137E1)	5,000 rounds	Charge 7 = 1.00 Charge 1-6 = 0.10	Original and 3 tubes
*For special information on cannon tube M137, see TM 9-1000-202-10 and special notes concerning inspections to be made of the original tube.				

and bolted between the tube and the second yoke to secure the forward portion of the tube. The tube-locking key secures the tube to the breech, and the breech mechanism key secures the breech to the recoil mechanism. Four punchmarks are stamped on the face of the muzzle end of the tube 1,600 m apart at the vertical and horizontal axes. The front boresights are placed on these punchmarks for boresighting.

e. Interior components. The interior components (fig 4-19) of the tube are the same as those of other weapons that fire semifixed ammunition and are described below in the order of their location, from muzzle to breech.

(1) *Counterbore.* The counterbore is formed by reboring the muzzle end of the tube a predetermined distance to increase the muzzle diameter. The reboring consists of removing the lands from that portion of the tube. The purpose of the counterbore is to relieve stress when the weapon is fired. This is done to prevent cracking of the tube.

(2) *Main bore.* The main bore is the entire rifled portion of the bore. The rifling is of increasing right-hand twist design. When the round is fired, it turns at a rate of one turn per 35 calibers. When it reaches the end of the tube, it is turning at the rate of one turn per 18 calibers.

(3) *Forcing cone.* The forcing coe is the rear portion of the main bore formed by tapering the rear of the lands. The function of this forcing cone is to allow the rotating band of the projectile to be engaged gradually by the rifling, thus insuring the proper seating of the projectile.

(4) *Centering slope.* The centering slope is the tapered portion forward of the powder chamber that causes that projectile to center itself in the bore during the loading operation.

(5) *Powder chamber.* The powder chamber is that portion of the bore designed to receive the powder increments that are contained in the cartridge case.

(6) *Breech recess.* The breech recess is formed in the interior of the breech ring and is designed tc receive the breechblock, which affords a means of mechanically opening and closing the rear of the assembly for loading and firing the weapon.

f. Functioning. When the semifixed round is loaded into the M102 tube, the round is centered by the centering slope and the forcing cone engages the rotating band of the projectile to form a gastight seal. The powder cannister fits snugly into the powder chamber. As the round is fired, the hot gases created by the burning powder cause the powder cannister to expand and form a gastight seal to the rear of the projectile. This is called rearward obturation. Since there is a gastight seal between the rotating band of the projectile and the forcing cone of the tube (forward obturation), the expanding gases force the projectile toward the muzzle of the tube. The rifling twists in a right-hand direction increasing from one turn per 35 calibers to one turn per 18 calibers and thus imparts a clockwise spin to the projectile as it leaves the tube.

4-13. Breech Ring

a. General. The breech ring is mated to the tube prior to installation of the weapon. The breech ring is the component that houses the breechblock. The

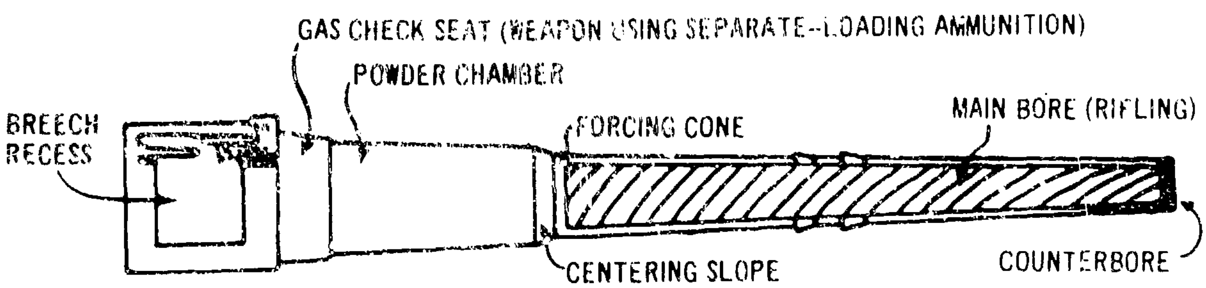


Figure 4-19. Cross section.

breech recess is the open portion of the breech ring that allows the breechblock to be opened and closed. The breech mechanism key locks the breech ring to the recoil mechanism; the tube locking key locks the breech ring to the howitzer tube. The breech ring is flat on the top to facilitate zeroing the tube and leveling the trunnions. These functions are covered in the discussion of boresighting in paragraph 26.

b. Breech life. A breech ring may be retubed three times after the original tubing; then it is considered unserviceable.

c. Embedded correction. An embedded correction, also known as a breech correction factor, appears on most current field artillery weapons. This correction factor is stamped on the howitzer breech, normally between the breech elevation leveling plates (fig 4-20), and represents the angular difference between the tube bore centerline and the elevation leveling plates on the breech. This difference is caused by manufacturing tolerances, and the value varies from weapon to weapon. On most field artillery weapons, this value is generally less than 1 mil. However, on the M102, in some instances, this value is as great as 5 mils. Problems involving the embedded correction are discussed in (1) through (5) below. You should read and understand all the information presented before initiating any corrective action.

(1) The embedded correction is used whenever it is necessary to level the tube during fire control alinement tests or when the elevation checks and adjustments are conducted on the fire control instruments as explained in TM 9-1015-234-12. If the value stamped on the breech is preceded by a plus sign (+), the numerical value is added to the M1A1 gunner's quadrant reading. If the value stamped on the breech is preceded by a minus sign (-), the numerical value is subtracted from the quadrant reading. An embedded correction with neither a plus sign nor a minus sign is considered to be a positve (+) value. The embedded correction must be used during tests of fire control instruments because it is that value that actually levels the howitzer tube. Failure to compensate for the embedded correction will allow misalinement of the fire control instruments on the weapon being checked.

(2) During investigations involving the

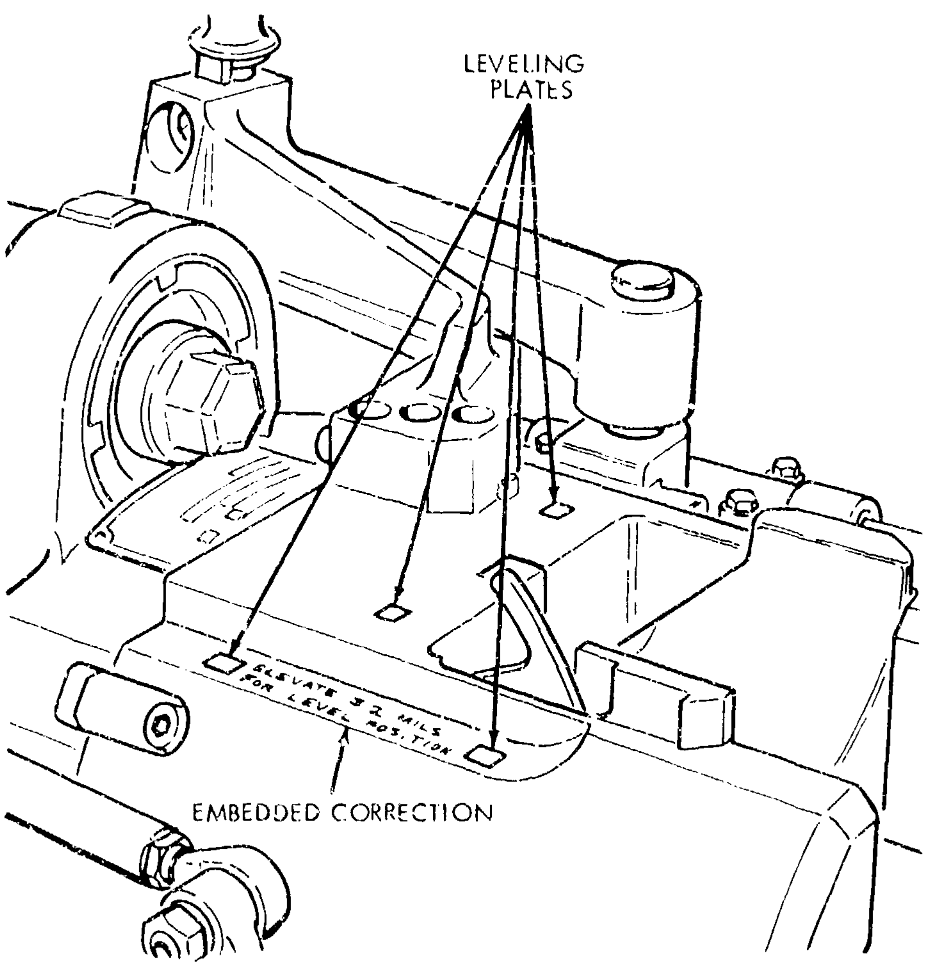


Figure 4-20. Location of breech-leveling plates and embedded correction.

accuracy of fire with the M102, it was determined that in most instances using units were not considering embedded corrections under any circumstances. The case was determined to be a lack of understanding because the use of embedded corrections was not explained in the M102 user's manual. Change 9 to M102 user's manual incorporates the use of embedded corrections into the manual text; however, that change will not solve the total problem because the embedded corrections on most M102s are erroneous.

(3) The embedded correction is not a constant value. It will change whenever the howitzer tube, breech, or recoil is changed. Nearly every M102 in the inventory has had a tube, breech, or recoil change since the weapon was introduced into the inventory. However, the direct support units that accomplished these changes did not have the equipment to accurately level the tube and measure the new correction value. Therefore, the DSUs did not change the embedded corrections. Additionally, an M102 that has not had a tube, breech or recoil change can still have an erroneous embedded correction because of the weapon system manufacturing procedures. During manufacture, the tube and breech are mated, the embedded correction is determined, and that value is stamped on the breech. Later, the tube and breech are mated to the recoil and carriage without a measurement of the embedded correction. Although mating the tube and breech to the recoil mechanism does not change the value of the embedded correction greatly, it does make the value stamped on the breech erroneous.

(4) As a user, you should take two actions involving embedded corrections.

(a) First, you must have your DSU verify the embedded corrections stamped on your weapons. If your DSU does not currently have the equipment necessary to accomplish this action, request that the DSU contact the local Armament Command maintenance representative. This representative has, or can obtain through his channels, a tube-leveling fixture that will allow your DSU to accurately level each howitzer tube and determine the accuracy of the embedded correction.

(b) Second, be sure that you understand the use of embedded corrections and that you use the correct value when you level the tube during fire control alinement test or during the elevation checks and adjustments prescribed in the user's manual, TM 9-1015-234-12.

(5) The ultimate goal is to eliminate the need for embedded corrections. What is being accomplished to achieve that goal is also a twofold process:

(a) First, cannon engineers have developed the tube-leveling fixture (fig 4-21) mentioned in (4)*(a)* above. This device, as its name implies, is used to level the howitzer tube. This fixture is

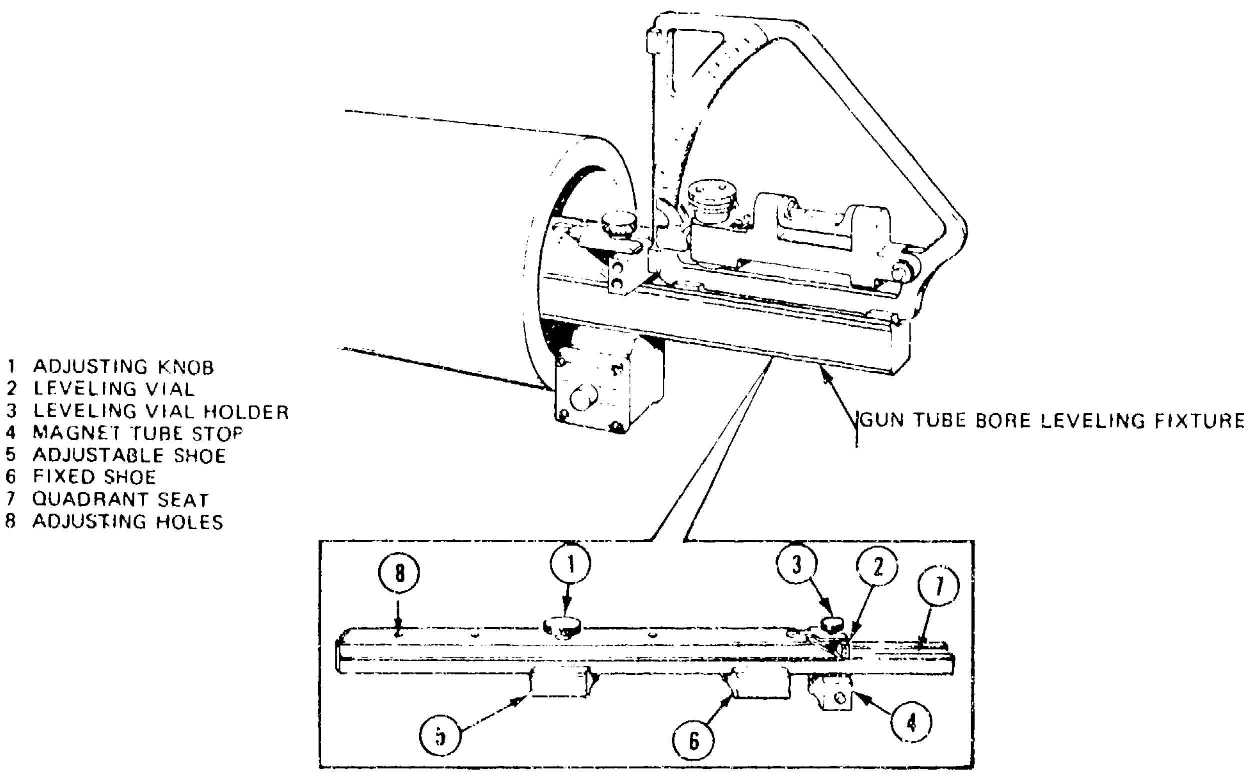


Figure 4-21. Tube bore leveling fixture.

simple and rugged, requires little maintenance, can be used with all calibers of current field artillery cannons, and is used in conjunction with the M1A1 gunner's quadrant. The significance of the tube-leveling fixture is that it eliminates using the breech as the reference point in tube leveling and thus eliminates the need for embedded corrections. The USAFAS has recommended that one tube-leveling fixture be issued to each field artillery battery and to each direct support unit. Plans call for the fixture with instruction for its use to be issued as soon as sufficient quantities can be manufactured.

(b) The second step in the elimination of embedded corrections resulted from disatisfaction expressed by members of the USAFAS toward the introduction of the tube-leveling fixture. Arguments were that the tube-leveling fixture was another tool that would require some type of calibration and that it would increase the proliferation of equipment at battery level. At the same time, members of the USAFAS became aware of a process being developed whereby leveling plates could be machined on the howitzer tube. The process was only beginning its initial testing but could eliminate the need for embedded corrections and the tube-leveling fixture. The tube-leveling plates are machined on the forward position of the tube to correspond to the centerline of the tube bore (fig 4-22). There are many questions regarding the feasibility of the process; among these is the question of whether the leveling plates could cause early tube failure. However, to insure that the process is fully investigated, the USAFAS has requested that the plates be applied to the M110A1 long tube, 8-inch self-propelled howitzer; the M198, and the XM204 105-mm soft-recoil howitzer, all of which undergo tests at various stages of development within the US Army materiel acquisition system. If the leveling plates prove successful you will be able to level your howitzer tube by using only the M1A1 gunner's quadrant without any correction factors.

4-14. Barrel and Breech Maintenance

a. Cleaning.

(1) The tube, breech, and all firing parts should be cleaned with rifle bore cleaner (RBC) the day of firing and for 3 consecutive days after firing, for a total of at least four cleanings. After each cleaning, a coating of rifle bore cleaner should be left in the tube overnight. If the weapon is not to be fired within 24 hours after the fourth cleaning, it should be wiped dry, inspected, and lubricated with oil, as described in LO 9-1015-234-10-.

(2) If the tube continues to sweat after the fourth cleaning, cleaning should be continued until the sweating stops. Sweating is evidenced by condensation of moisture on the inside of the tube.

(3) When the weapon is not being fired, the tube should be cleaned with rifle bore cleaner (RBC) weekly and then wiped dry, inspected, and reoiled as described in (1) above.

b. Cleaning solutions.

(1) *Rifle bore cleaner.* Rifle bore cleaner evaporates at 150° F. If you can place your bare hand on the tube without being burned, the tube is cool enough to clean. Rifle bore cleaner is not a lubricant, but it is a rust inhibitor effective for 24 to

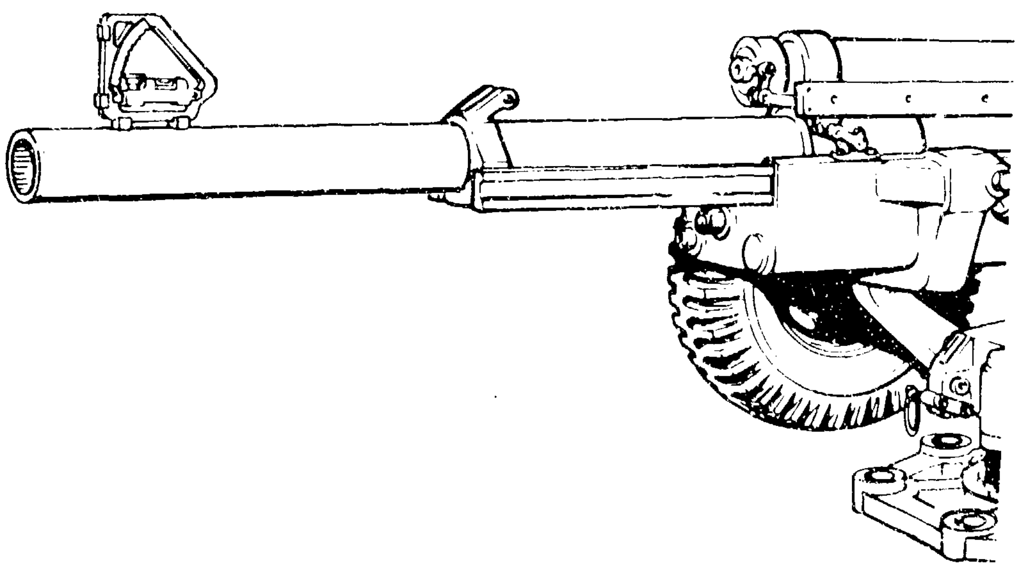


Figure 4-22. Proposed positioning of tube leveling plates.

48 hours. Rifle bore cleaner should never be diluted.

(2) *Alternate solution.* When rifle bore cleaner (RBC) is not available for cleaning the tube, an alternate solution of ¼-pound of castile or GI soap dissolved in a gallon of hot water may be used. Hot water is preferable because it will dissolve soap more readily. The tube should be cleaned while it is still hot so that the solution will wash the primer salts from the pores of the metal. The cycles described in *a* above should be used in the cleaning process, except that the tube must be rinsed, dried, inspected, and lubricated after each daily cleaning.

c. *Reducing tube wear.*

(1) Corrosion, or rust, is a chemical decomposition of tube metal, caused by moisture being withdrawn from the air by hygroscopic primer salts deposited in the tube by firing. To stop tube wear caused by corrosion, clean the tube with rifle bore cleaner immediately after firing and for 3 consecutive days thereafter or until sweating ceases.

(2) Erosion is the wearing away of the tube by the escape of propelling gases (known as gas wash) around the rotating band at the instant of firing. It is also caused by friction. Erosion can be reduced by—

(a) Using the lowest charge commensurate with the mission.

(b) Using the lowest rate of fire commensurate with the mission. Never exceed maximum/sustained rates of fire.

(c) Letting the weapon rest 10 minutes per hour. The rest periods should be used to clean and maintain the weapon.

(d) Swabbing the tube with cold water during lulls in firing.

(e) Cleaning the ammunition before loading.

CAUTION: The bore should be completely dry before firing. This reduces the erosion factor, since all foreign matter will be removed by wiping the bore dry.

4-15. Breechblock and Breech Mechanism

a. *Type.* The breechblock is a vertical sliding wedge which must be opened and closed manually. The mechanism uses a series of shafts, bevel gears, cranks, and a pivot to raise and lower the breechblock.

b. *Purpose.* The purpose of the breechblock and breech mechanism is to allow the rear (breech) of the tube to be opened for loading.

c. *Components.* The components of the breech operating group (breech mechanism) are shown in figure 4-23; the breechblock components are shown in figure 4-24.

d. *Functioning.*

(1) *Opening the breech.* To open the breech, depress the handle latch and rotate the handle.

(a) Rotation of the handle transmits motion through the breech operating shaft to the breech operating crank and torsion spring.

(b) The breech operating crank rotates downward, moving the pivot downward in the T-slot of the breechblock to lower the breechblock into the open position.

(c) Camming grooves in the sides of the breechblock lower the ends of the extractors rapidly, causing the extractor lips to extract and eject the empty cartridge case.

(2) *Cocking the firing mechanism.*

(a) As the breechblock is opened, the cocking lever is cammed rearward by the camming surface on the left wall of the breech recess in the breech ring.

(b) Rotation of the cocking level is transmitted to the cocking mechanism.

(c) The firing pin guide is forced to the rear by the cocking mechanism, and the firing spring is compressed.

(d) As the firing pin guide approaches the cocked position, a sear lug on the guide passes through a notch on the sear.

(e) When the sear lug has passed through the sear notch, the sear spring expands, rotating the sear to retain the firing pin guide and firing pin in the cocked position.

(f) The cocking mechanism is returned to its original position by the cocking lever spring when the breech is closed.

(3) *Closing the breech.*

(a) When a round is inserted into the chamber, the rim of the cartridge case engages the extractor lips and pushes them forward.

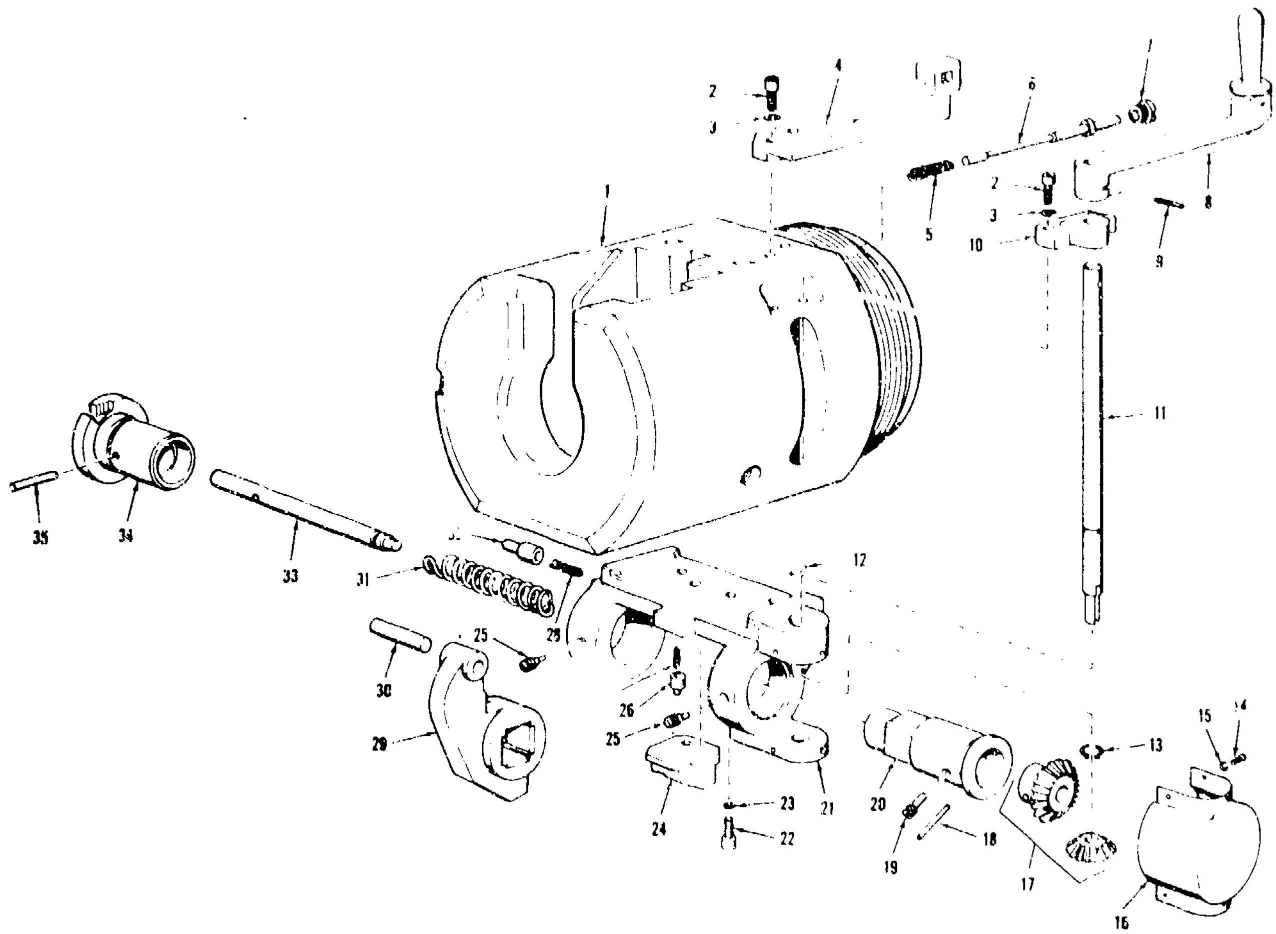
(b) The extractors are forced off the flats of the breechblock, unlocking the breech.

(c) Manually rotating the handle assembly, which is pinned to the handle assembly shaft, actuates the operating crank.

(d) The arm of the breech operating crank rotates upward, slides the pivot in the T-slot of the breechblock, and thereby raises the breechblock to the closed position.

(4) *Firing.*

(a) Actuation of the firing mechanism causes the firing pawl to engage the firing plunger and forces the firing plunger to rotate the trigger.

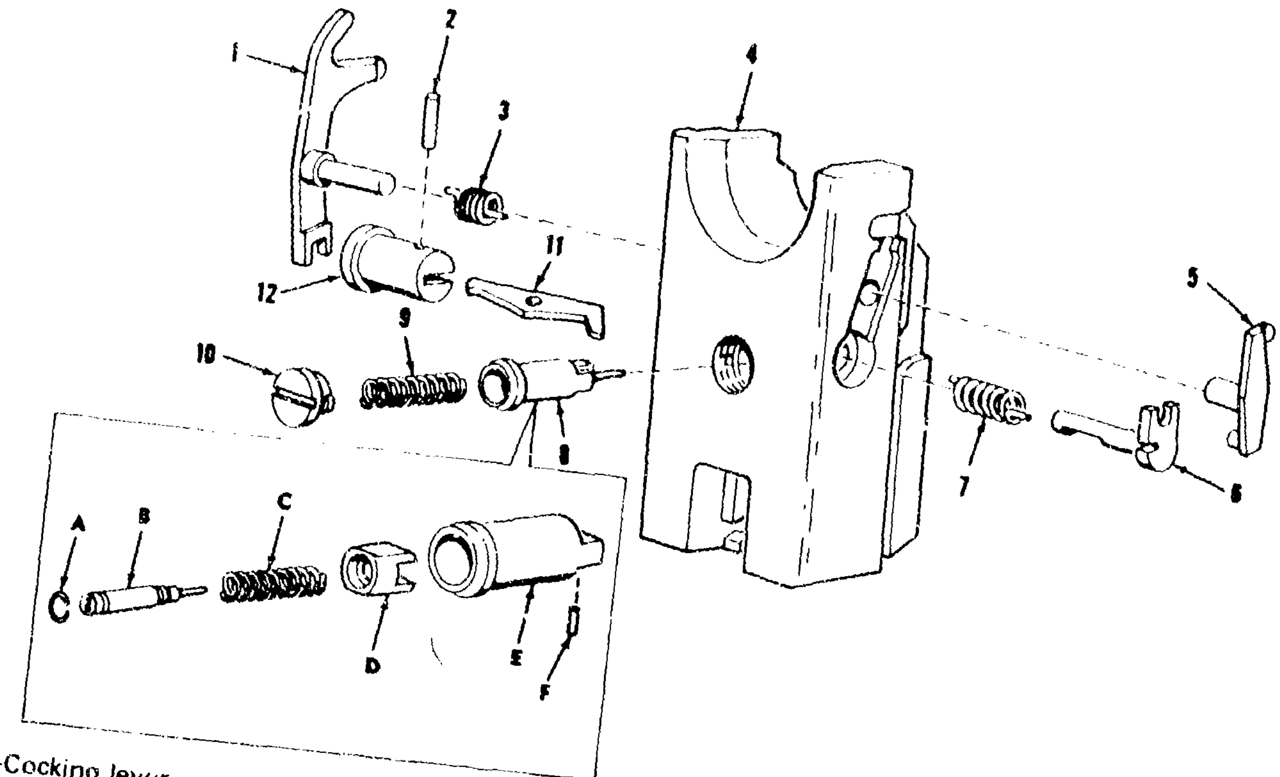


1—Breech assembly ring
2—3/8 × 1¼ socket head cap screw
3—3/8 lock washer
4—Stop assembly
5—Compression helical spring
6—Firing plunger
7—Bushing
8—Handle assembly
9—3/8 × 1¾ spring pin
10—Stop bracket
11—Handle assembly shaft
12—Spring pin
13—Retaining ring
14—Self-locking screw
15—No. 8 lockwasher
16—Gear assembly cover
17—Matched bevel gear set and machine key (not shown)
18—5/16 × 2½ spring pin
19—Breech crank assembly pin
20—Breech operating crank shaft
21—Breech ring bracket
22—½ × 1¼ socket head cap screw
23—½ lockwasher
24—Breechblock crank stop
25—Detent
26—Detent plunger
27—Compression helical spring
28—Plunger adjustor spring
29—Breechblock operating crank
30—Pivot
31—Torsion helical spring
32—Closing mechanism plunger
33—Closing spring shaft
34—Closing spring adjustor
35—Breech crank assembly pin

Figure 4-23. Breech operating group--exploded view.

(b) **The trigger, which is engaged with the sear, rotates the sear, compresses the sear spring and disengages the sear lug; then the compressed firing spring drives the firing pin forward to strike the primer.**

(c) The firing pin is retracted from the primer instantaneously by the pressure of the small compression helical spring (firing pin spring) that is applied to the firing stop. The entire inertia percussion firing mechanism is not retracted until the cocking action occurs when the breech is opened once again.



1—Cocking lever
2—5/16 × 1¼ spring pin
3—Torsion helical spring
4—Breechblock body
5—Firing trigger
6—Sear
7—Torsion helical spring, 10½ coils
8—Percussion mechanism
A—Firing pin retaining ring
B—Firing pin
C—Compression helical spring, 12½ coils
D—Firing stop
E—Firing pin guide
F—Spring pin
9—Compression helical spring, 14 coils
10—Retainer
11—Retractor
12—Bushing

Figure 4-24. Breechblock group—exploded view.

(d) When firing the M102, insure that the assistant gunner holds the lanyard until the tube has returned to the in-battery position. If he does not, the lanyard could flip between the tube and cradle as the tube returns and thus crush the lanyard handle and wedge the lanyard in the cradle. A vertical sliding wedge type of breech mechanism has two inherent safety features. First, if the breechblock is not fully closed, the firing pin cannot strike the primer; second, if the tube is out of battery ¾-inch or more, the firing pawl cannot move the firing plunger rearward enough to actuate the firing mechanism.

e. Maintenance.

(1) Instructions for cleaning the breech are presented in paragraph 15.

(2) The M102 firing mechanism is experiencing a high failure rate in that it breaks or is bent during firing operations. The cause of this problem has been determined to be wear. The detent plunger and the plunger housing bushing wear and allow the firing mechanism pawl to drop and catch on the recoil mechanism yokes during firing (fig 4-25). M102 maintenance engineers have completed tests on new items that will greatly reduce the wear rate. These new items will be incorporated into new production, overhaul, and spare parts in the near future. However, until these new items are available, you should regularly inspect the firing mechanism for excessive wear. To determine the extent of wear, measure the clearance between the firing mechanism pawl and recoil rear yoke. If the clearance is less than 1/16-inch, notify your direct support unit which will replace the plunger housing bushing. This will prevent you from possibly having a deadline weapon or having extensive damage to the firing mechanism.

(3) Reported malfunctions of the M102 breech are expected to be eliminated by improvements included in the product improvement package

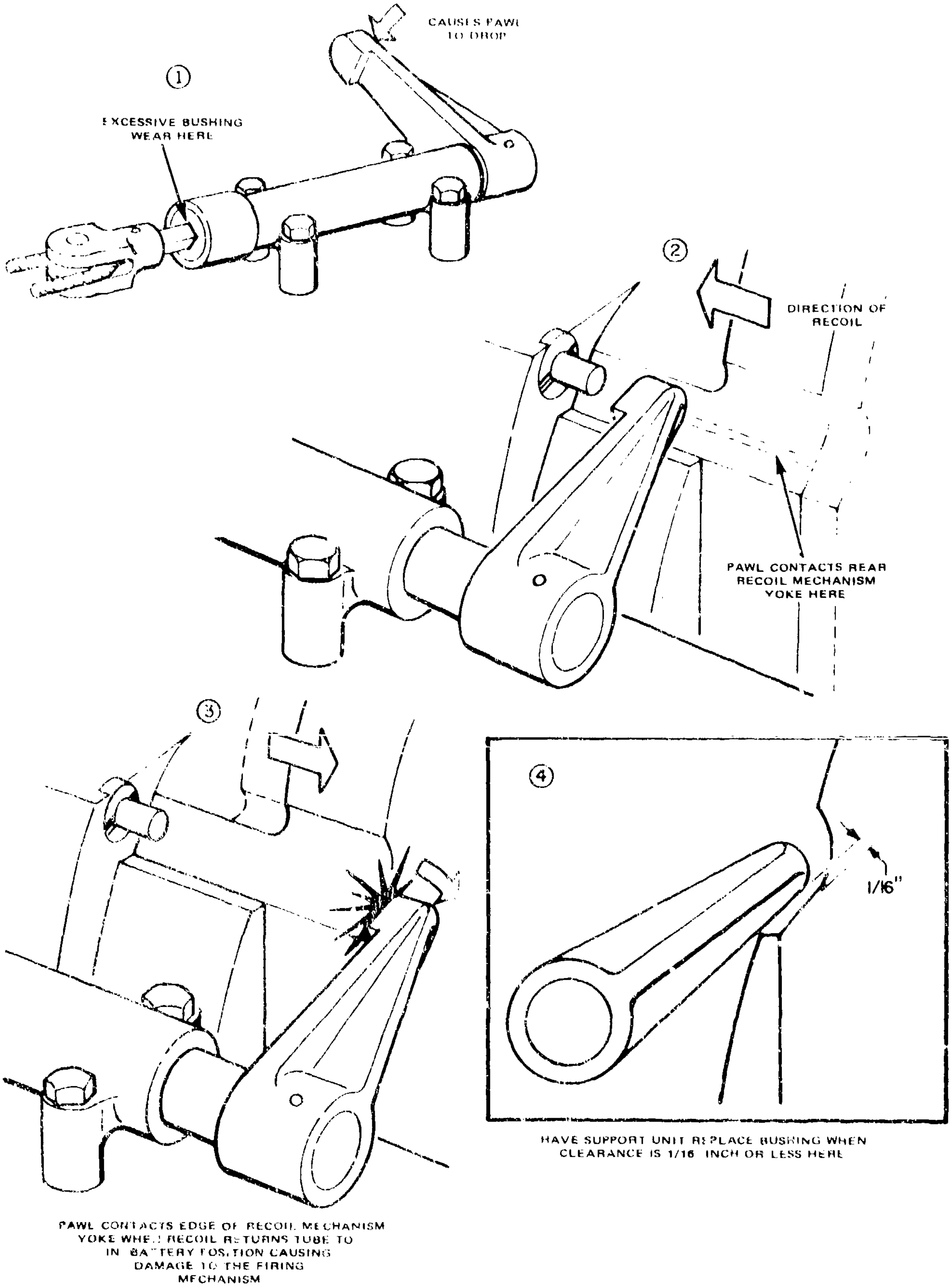


Figure 4-25. Firing mechanism.

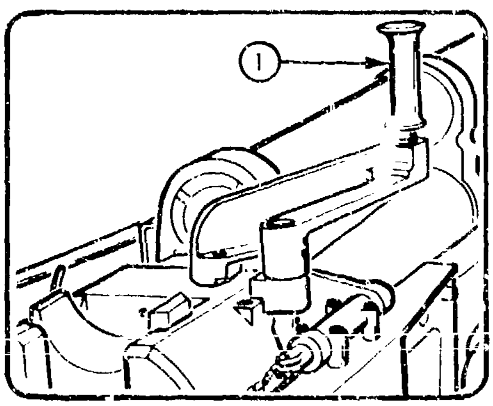
discussed in paragraph 27. However, one potential problem area, currently under investigation is of concern to M102 field units because it involves the weapon system accuracy. The M102 breech has a slight wobble. This problem has only recently been detected, and its full effects are not known. It is not considered to be a significant problem, but when considered with the embedded correction area of investigation (para 14), it reinforces the plans to eliminate the M102 breech as the reference point for fire control instruments by use of the tube leveling fixture (para 14*c*(5)(*b*)) and then the wobble will not create any problem for fire control alinement tests.

f. Removal of breechblock from breech ring.

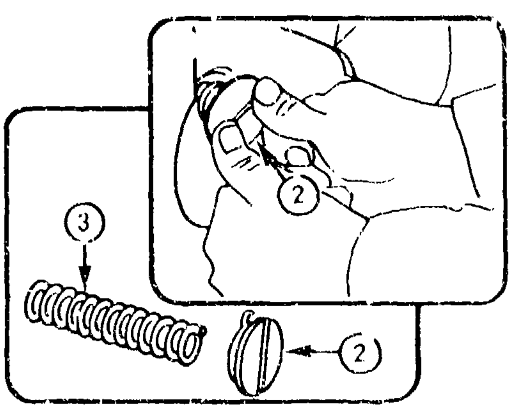
(1) For easy removal of the breechblock, place the weapon in firing position.

(2) Inspect the chamber and bore to see that they are clear.

(3) Pull the lanyard to fire the weapon.

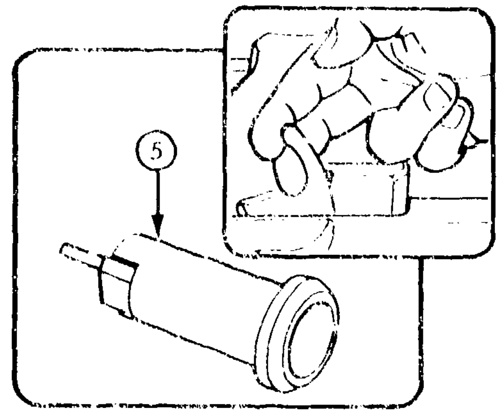


(4) Close the breech and check to see that the breech handle (1) is in the locked position.

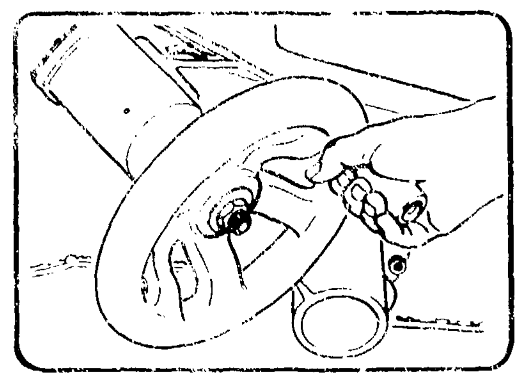


(5) Press in on the spring retainer (2) and rotate it 1,600 mils in either direction to remove the retainer and the percussion spring (3).

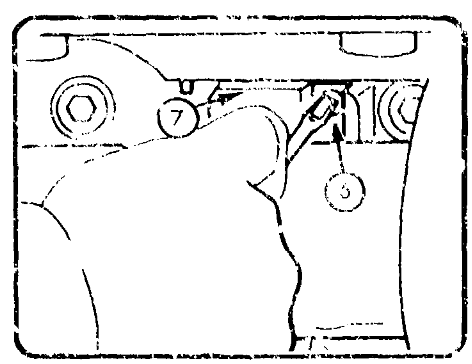
Note. If the weapon had not been fired ((3) above) the percussion spring would be under too much pressure and removing it could possibly cause injury.



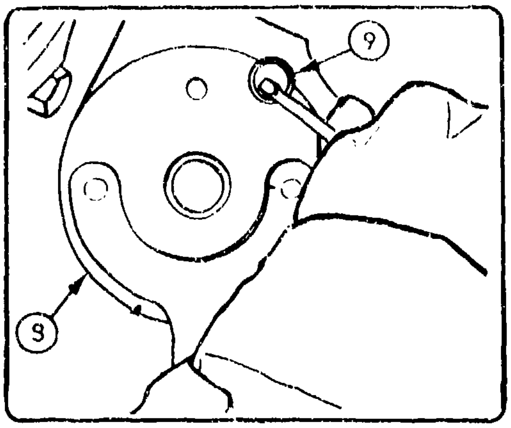
(6) Pull back the cocking lever (4). Remove the percussion mechanism (5).



(7) Elevate the cannon to approximately 1,200 mils.



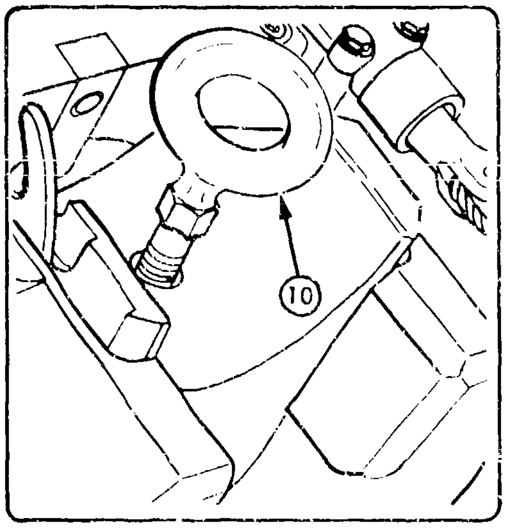
(8) Facing the underside of the cradle, depress the detent plunger (6) and move the breechblock crank stop (7) to the right (unlock) position.



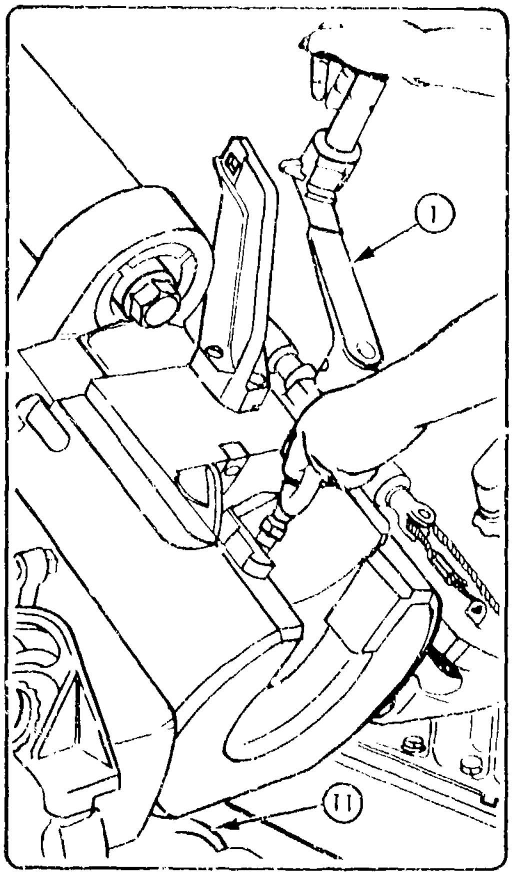
(9) Lower the cannon to 600 mils.

(10) Using a spanner wrench and a screwdriver, release tension on the torsion helical spring. Apply leverage counterclockwise on the closing spring adjuster (8) with a wrench. Then depress the closing mechanism plunger (9) with a screwdriver and allow the adjuster to rotate clockwise and relieve tension on the spring.

CAUTION: Don't turn the adjuster clockwise more than necessary to relieve tension on the spring or you may damage the spring.

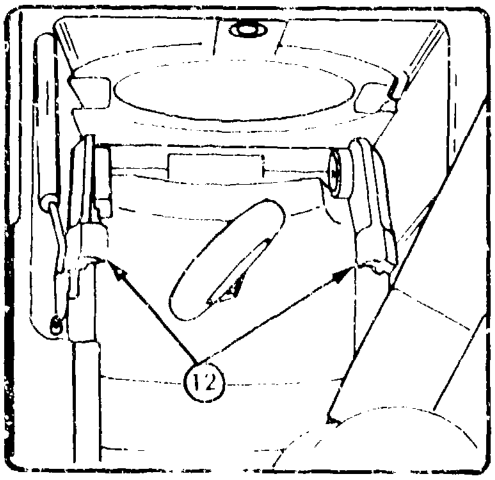


(11) Screw the eyebolt (10) into the top of the breechblock.



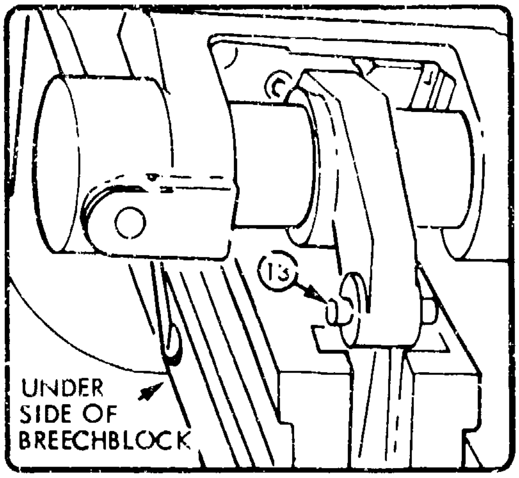
(12) Place a rag (11) on the carriage to prevent chipping paint when you lower the breechblock.

(13) With your left hand, grasp the eyebolt (10), and with your right hand, unlatch the breechblock until it rests on the carriage.

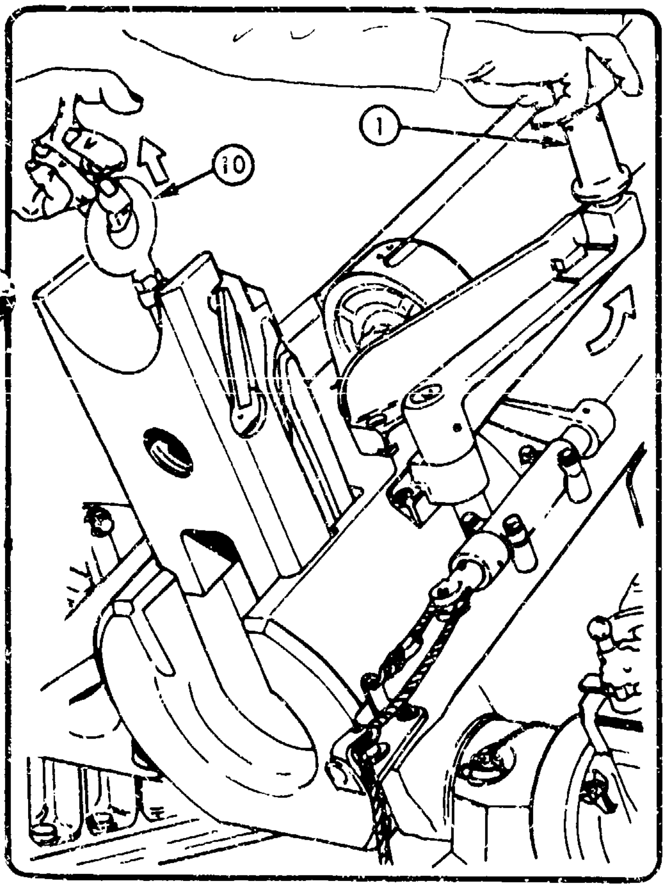


(14) Remove the extractors (12)

Note. If you can't remove them, elevate the cannon just enough to allow removal.



(15) Move the breechblock handle clockwise and allow the pivot pin ⑬ to disengage from the slot in the breechblock and remove the pivot pin.



(16) Grasp the eyebolt ⑩ with your left hand and lift up on the breechblock. With your right hand, move the handle ① counterclockwise into the locked position.

Note. Make sure the handle remains in locked position.

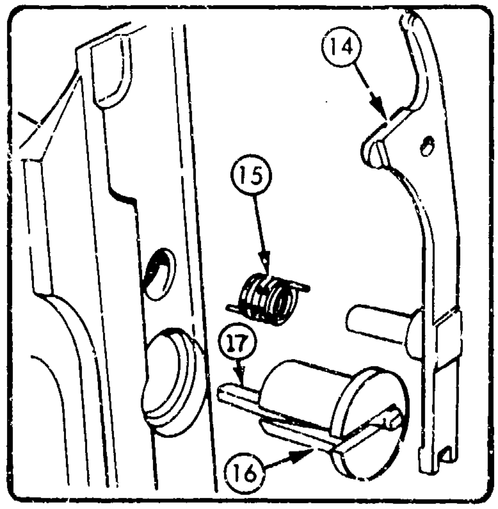
(17) Using both hands, lift the breechblock completely out of the breech ring.

g. Disassembly of breechblock.

(1) Move the cocking lever ⑭ to the forward position and take it out. Remove the cocking lever spring ⑮ from the pivot hole.

(2) Grasp the knob on the retractor and withdraw the cocking mechanism ⑯.

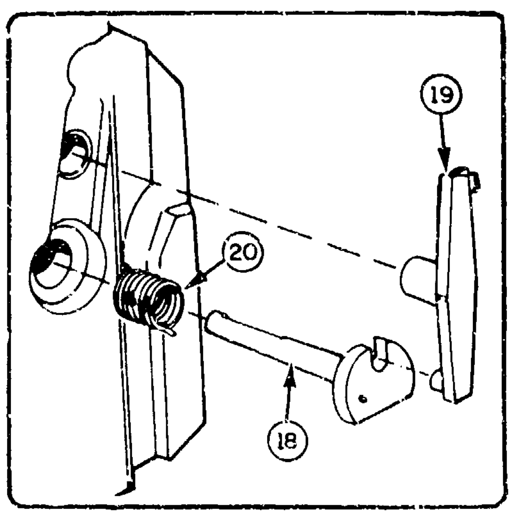
(3) Remove the retractor ⑰ from the cocking mechanism bushing by removing the spring pin.



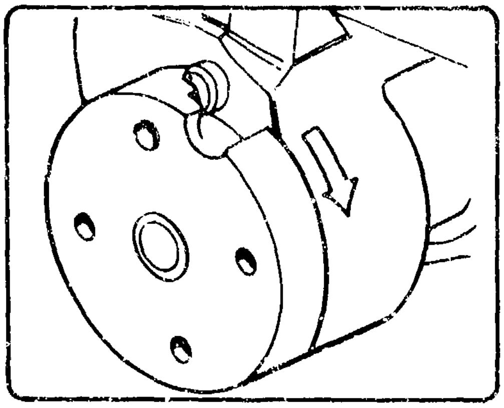
(4) Rotate the sear ⑱ slightly counterclockwise, removing pressure from the trigger lug. Remove the trigger ⑲.

(5) Remove the sear. If the sear sticks, insert a finger into the bored hole of the breechblock and push the sear out.

(6) Insert a finger into the sear hole and remove the sear spring ⑳.



h. Assembly of breechblock. To assemble the breechblock, reverse the procedure described in *g*(1) through (6) above. Be careful not to confuse the sear spring with the cocking lever spring. The



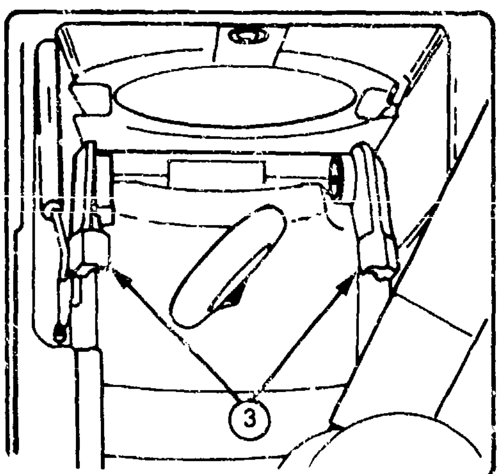
cocking lever spring is shorter in length than the sear spring.

i. Installation of breechblock.

(1) Elevate the cannon to 600 mils.

(2) Release the operating handle clockwise ①to the open position.

(3) Using the eyebolt②, insert the breechblock into the breech ring from the top, and lower the breechblock until it rests on the carriage. Remember to have a rag on the carriage while doing this.



(4) Install the left and rig t extractor assemblies③.

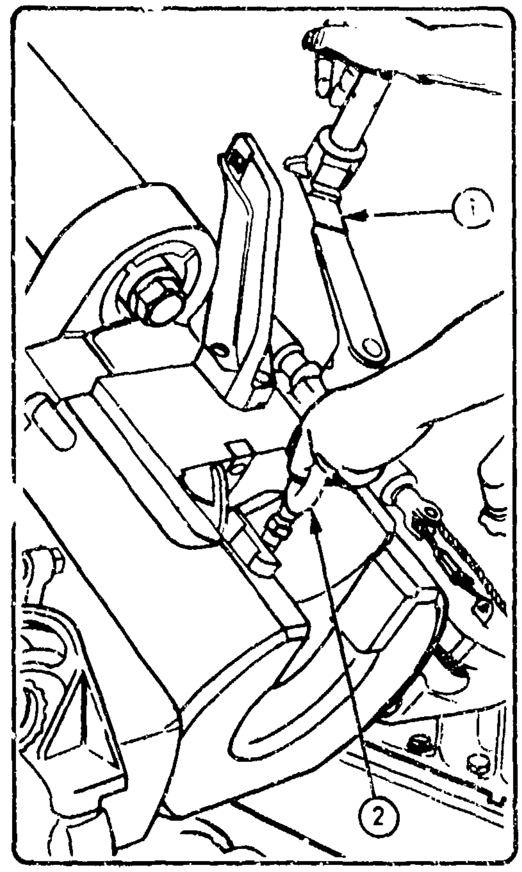
(5) Grasp the eyebolt with your left hand, raise the breechblock slightly and with your right hand turn the operating handle counterclockwise until the operating crank pivot④engages the slot in the breechblock.

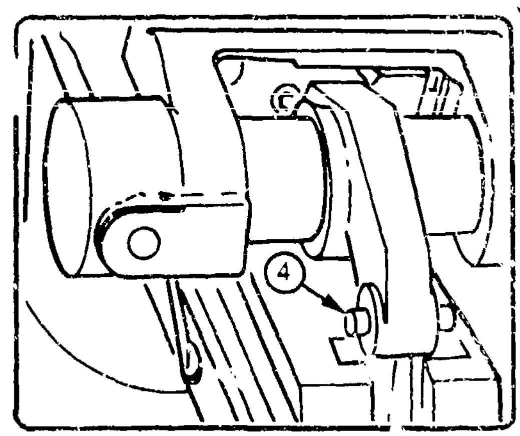
(6) Raise the breechblock until the extractors stop the breechblock.

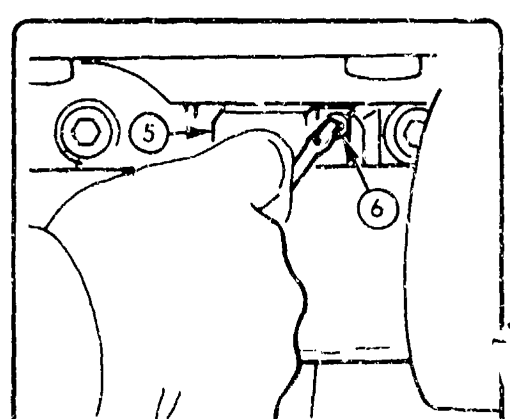
(7) Trip the extractors by pushing them forward and close the breechblock. ure that the latch is fully locked.

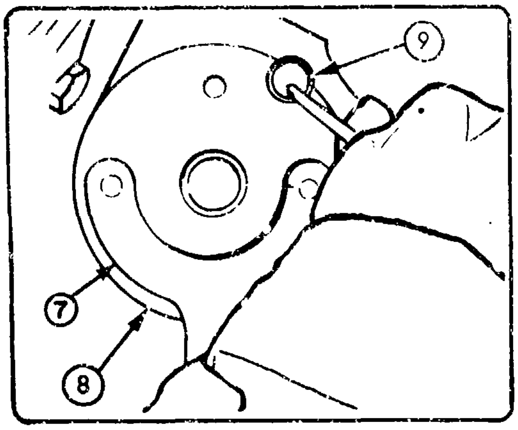
(8) Remove the eyebolt.

(9) Slide the breechblock crank stop⑤to the left until it is secured by the detent⑥.

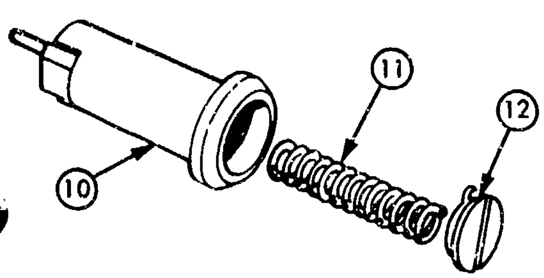


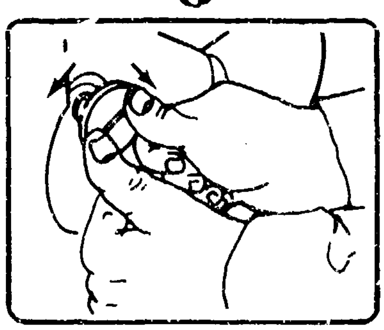






(10) With a spanner wrench ⑦, turn the closing spring adjuster ⑧ counterclockwise until the closing mechanism plunger ⑨ engages the first, second, or third detent notch. The proper notch engagement is determined by the spring tension required for easy opening and closing of the breechblock.





(11) Install the percussion mechanism ⑩, spring ⑪, and retainer ⑫. Twist the retainer 1,600 mils in either direction to lock.

4-16. Safety Procedures

When a weapon fails to fire, all personnel concerned must follow specific procedures, depending on the type of weapon being fired and the condition of the tube (hot or cold). The executive officer must know the misfire procedures and must apply the appropriate procedures in case of a misfire in order to afford maximum safety in the firing battery. Malfunctions in the firing of artillery ammunition, such as misfires, hangfires, and cookoffs, are defined and discussed in *a* and *b* below. When authorized and properly maintained ammunition is fired from properly maintained and operated weapons, these malfunctions rarely occur. To avoid injury to personnel and damage to equipment, all personnel concerned must understand the nature of each malfunction and the proper preventive and corrective procedures. Figures 4-26 and 4-27 summarize misfire and check firing procedures.

a. Definitions.

(1) *Misfire.* A misfire is a failure of a round to fire after initiating action has been taken. The failure may be caused by a faulty firing (percussion) mechanism or a faulty element in the propelling charge explosive train. A misfire in itself is not dangerous; however, it cannot be immediately distinguished from a delay in functioning of the weapon firing mechanism or from a hangfire. Therefore, a misfire must be treated as a delayed firing until such a possibility has been eliminated.

(2) *Hangfire.* A hangfire is a delay in the functioning of a propelling charge explosive train at the time of firing. The delay, though unpredictable, ranges from a fraction of a second to several minutes. Thus, a hangfire cannot be distinguished immediately from a misfire.

WARNING: In the event that a weapon fails to fire, keep the weapon trained on the target. Have personnel stand clear of the muzzle and path of recoil.

WARNING: When firing is interrupted, remove the projectile from the chamber of a hot weapon within 5 minutes of the time it was loaded to prevent cookoff.

(3) *Sticker.* A sticker is a projectile that is lodged in the tube after the weapon has been fired. Stickers result from insufficient chamber pressure.

(4) *Cookoff.* A cookoff is a functioning of any or all of the explosive components of a round chambered in a very hot weapon due to heat from the weapon. The primer and propelling charge, in that order, are generally more likely to cook off than the projectile or the fuze. If the primer or the propelling charge should cook off, the projectile could be propelled (fired) from the weapon with normal velocity even though no attempt was made to the fire the primer by actuating the firing mechanism. Should the bursting charge explosive train cook off, injury to personnel and destruction of the weapon could result. To prevent heating to the point at which a cookoff may occur, a round of ammunition that has been loaded into a hot weapon should be fired or removed within 5 minutes.

(5) *Hot weapon.* A hot weapon is one in which the tube and breech have been brought to a sufficiently high temperature by previous firings so that they can, in several minutes, transmit enough heat to the round to activate its explosive

components. When a hot tube condition exists, specific loading procedures should be followed. The executive officer is responsible for determining whether a hot tube condition exists. In making his decision, he takes into account such things as ambient temperature, rate of fire, amount of ammunition fired, and charge fired. Applicable general loading considerations are as follow:

(a) Do not chamber a round until immediately prior to firing.

(b) A chambered round in a hot tube must be fired or removed from the piece within 5 minutes.

(c) If a round has been in a hot tube more than 5 minutes and a misfire is not involved—

1. Remove the cartridge case immediately.

2. Evacuate all personnel to a safe distance.

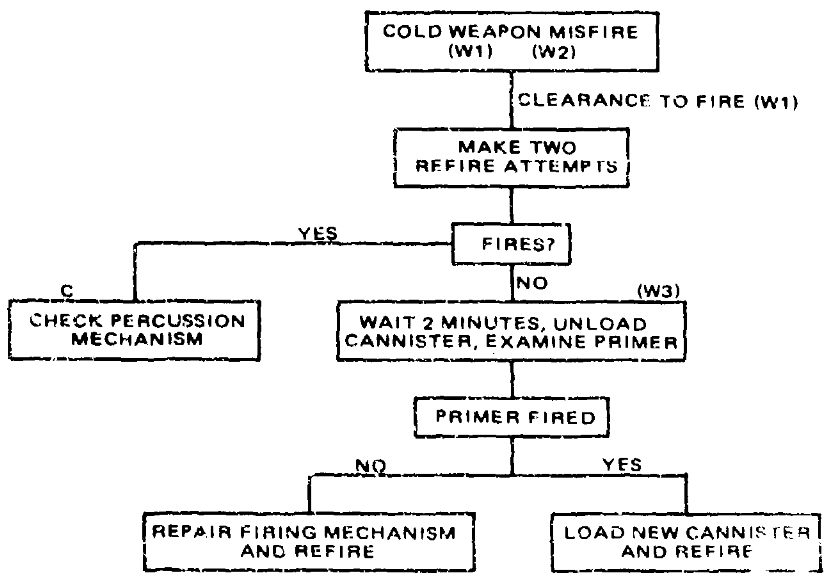
3. Request assistance from explosive ordnance disposal (EOD) personnel. Release the weapon to ordnance if required.

(6) *Check firing*. Check firing is a command normally given by the battery executive officer; however, in an emergency, it may be given by anyone present. At this command, regardless of its source, firing will cease immediately.

b. Misfire/check firing preventive or corrective procedures.

(1) *General.* Misfire and delayed firings are not dangerous in themselves; however, two conditions hazardous to crew and equipment can develop if the proper corrective procedures are not followed. First, in the case of either a delayed firing or a misfire the weapon may unexpectedly fire. All personnel should, therefore, stay clear of the muzzle and path of recoil and the weapon should be kept trained on the target until the cartridge case and propellant have been removed from the weapon. Secondly, in the case of a misfire, if the round is chambered in a hot weapon, the possibility of a cookoff exists.

WARNING: If an explosive round cannot be fired or unloaded from a hot weapon within 5 minutes after being chambered, personnel should be evacuated from the area and explosive ordnance disposal (EOD) personnel notified.



Legend

C—Weapon cleared.

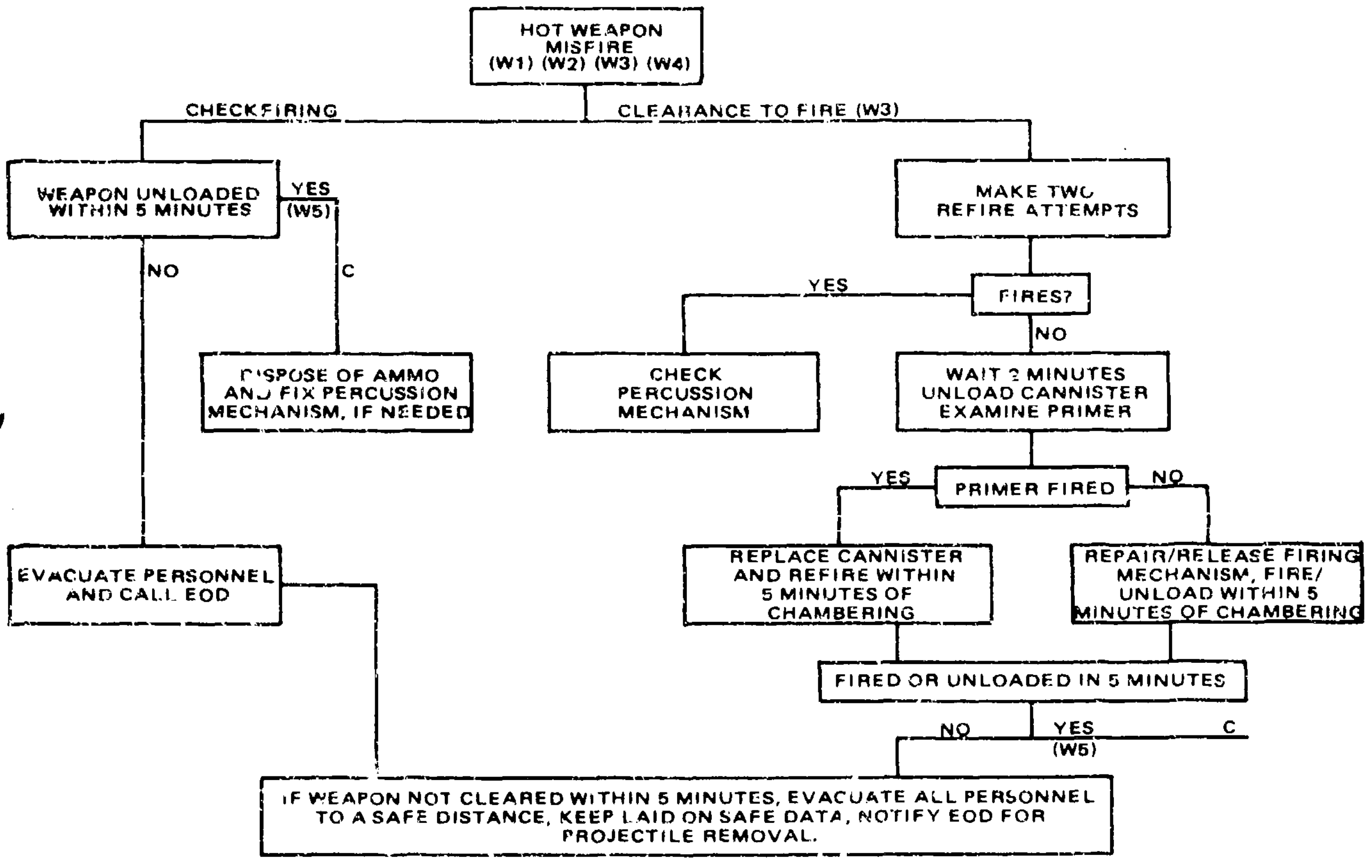
WARNINGS:

W1—Misfires must be treated as hangfires until determined otherwise.
W2—In the event of a misfire, keep weapon trained on target and keep all personnel clear of the muzzle and path of recoil until the cartridge case and propellant are removed from the weapon.
W3—Evacuate unnecessary personnel.
W4—**DO NOT** reuse projectiles that have been unloaded from the weapon.

**Note.* Powder and cannister will be separated from each other. This is to prevent injury to personnel should the powder ignite.

Figure 4-26. Misfire procedures for a weapon with a cold tube firing semifixed ammunition.

(2) *Misfire—cold tube.* After the howitzer fails to fire, actuate the firing mechanism two more times in an attempt to fire the piece. Before each additional attempt to fire, the gunner recocks the firing mechanism. If the weapon still fails to fire, the chief of section reports to the executive officer MISFIRE NUMBER (so-and-so). The chief of section then waits 2 minutes from the last attempt to fire before he opens the breech—the cannister will be tossed to the rear separating the powder from the cannister to prevent injury to personnel should the powder ignite—and inspects the primer to see if it has been dented. If the primer is not dented, the firing mechanism should be repaired. If the primer is dented, he replaces the cartridge case with a new one and fires the weapon. If the executive officer does not wish to fire the round after the 2-minute waiting period, the projectile must then be removed from the tube. The breechblock should be closed and rags should be stuffed into the powder chamber to cushion the shock of the projectile. Using the bell rammer to avoid damaging the fuze, the cannoneer pushes the round out of the rear of the tube. A common cause of misfire with a 105-mm howitzer is that the breechblock is not fully closed. This will cause the firing pin to miss the primer. Broken or bent firing pins will cause misfires, as will wet powder or a faulty primer. Figure 4-26 outlines misfire procedures for a weapon with a cold tube.



Legend

C—Weapon cleared.

WARNINGS:

W1—All projectiles chambered in a hot tube should be removed from the weapon within 5 minutes.
W2—In the event a projectile is chambered in a hot weapon and cannot be removed within 5 minutes, evacuate all personnel and notify EOD for projectile removal.
W3—Misfires must be treated as *hangfires* until determined otherwise.
W4—In the event of a misfire, keep weapon trained on target and keep all personnel clear of the muzzle and path of recoil until the cartridge case and propellant are removed from the weapon.
W5—**DO NOT** reuse projectiles that have been unloaded from the weapon.

Figure 4-27. Misfire procedures for a weapon with a hot tube firing semifixed ammunition.

(3) *Misfire—hot tube.* After the howitzer fails to fire, actuate the firing mechanism two more times in an attempt to fire the piece. Before each additional attempt to fire, the gunner recocks the firing mechanism. If the weapon still fails to fire, the chief of section reports to the executi officer MISFIRE NUMBER (so-and-so). The nief of se tion then waits 2 minutes from the last attempt to fire before he opens the breech (see note, fig 4-26), removes the cartridge case, and inspects the primer to see if it has been dented. If the primer is not dented, the firing mechanism should be repaired. If the primer is dented, he replaces the cartridge case with a new one and fires the weapon. The above procedures must be accomplished within 5 minutes after loading; if the weapon cannot be fired or unloaded within 5 minutes the following procedures are followed:

(a) Evacuate all personnel to a safe distance.

(b) Request assistance from explosive ordnance disposal personnel. Release the weapon to ordnance if required. Figure 4-27 outlines hot tube misfire procedures.

4-17. Cradle Assembly

The cradle assembly (item 9, fig 4-1) holds the recoiling parts of the tube. The sleigh assembly, which is attached to the yokes, slides in the gunways of the cradle during firing, and thus allows the recoiling parts to recoil and counterrecoil. The gunways and the rails of the sleigh assembly are made of nonfriction metal; neither component should ever be lubricated. Periodic application of a solid-film lubricant to the rails is not necessary.

a. Cradle travel lock. The cradle travel lock is located on the underside of the cradle and is designed to relieve stress on the elevating mechanism during travel.

b. Airborne operations. The tube can be slid out of battery for airborne operations. When this is done, the out-of-battery locking pin must be engaged through the side of the cradle into the sleigh assembly.

c. Maintenance problems. Korea-based units have reported that snow and ice accumulate in the M102 cradle during inactive periods. Later, when this weapon is fired, the snow and ice are compressed and this precludes the weapon from returning to the full in-battery position. This, in turn, causes a separation between the firing mechanism pawl and the breech firing plunger, which prevents the weapon from being fired.

(1) Investigations have confirmed that this problem can occur when any type of foreign material gets into the cradle. Foreign material is most likely to enter the cradle during inactive periods or road travel. However, further confirmation of this problem is required from you, the user. If you have experienced this problem, submit an equipment improvement report. On the basis of your input, Armament Command engineers will determine the best method of resolving this problem.

(2) To prevent the accumulation of foreign material in your weapon, you should tie a piece of canvas around the cradle during inactive periods or during road travel.

Section IV. RECOIL MECHANISM

4-18. Purpose, Types, and Components of Recoil Mechanism

a. Type of recoil mechanism. The recoil mechanism employed on the towed 105-mm howitzer M102 is of the hydropneumatic, variable, dependent type with floating piston. An explanation of this nomenclature follows:

(1) *Hydro* means that a liquid is used: this liquid is recoil oil. Recoil oil is a petroleum-base hydraulic fluid. There are presently three types of recoil oil (OHT, CHA, and OHC) authorized for use in field artillery weapons. OHT is the preferred oil because it provides greater protection against corrosion. The oils can be mixed; however, mixing should be avoided if possible, since it may tend to dilute the protective additives of one or more of the oils. A recoil mechanism that contains a mixture of oils should be drained and refilled with the preferred OHT as soon as it becomes available. All three oils are red in color and have a temperature range of operations from -65° F to +150° F. The total capacity of the recoil mechanism is approximately 10 pints, including the reserve.

(2) *Pneumatic* means that a gas is used. Nitrogen gas is used because it can be highly compressed without exploding, will not corrode the metal parts, and is readily available. The recuperator is precharged with nitrogen pressure of 1,150 pounds per square inch at 70° Fahrenheit (ambient temperature).

(3) *Variable* means there is a mechanical method of varying the length of recoil. This eliminates the need for digging a recoil pit in order to fire at high angles of elevation. Under normal operating conditions, the length of recoil can vary from 30 inches to 50 inches.

(4) *Dependent* means that there is a liquid connection for the flow of recoil oil between the recoil and recuperator cylinders.

(5) *Floating piston* means that a free piston separates the liquid from the gas in the recuperator cylinder. The diaphragm portion of the floating piston forms a movable, liquid-tight, gastight seal.

b. Purpose of the recoil mechanism. The purposes of the recoil mechanism are—

(1) *To stop the recoiling parts.* The recoil mechanism must absorb and control the rearward thrust of the weapon without excessive displacement of the carriage or excessive shock. This action is accomplished by the throttling of oil through the orifice (*d* below), the compression of the nitrogen gas, and the friction of the moving parts.

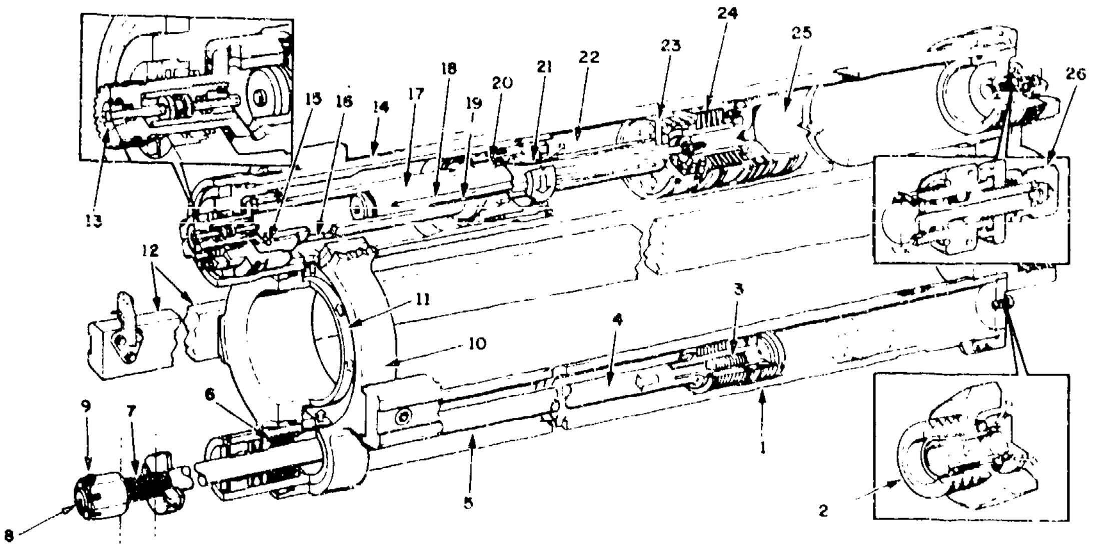
(2) *To return the recoiling parts.* The recoil mechanism causes the recoiling parts to return to the in-battery position by the expansion of the nitrogen gas that is compressed in the recuperator cylinder during the recoiling phase (*d* below).

(3) *To prevent shock.* The recoiling parts must be returned to their in-battery positions without excessive shock. This is accomplished during the last few inches of counterrecoil by a counterrecoil buffer. During recoil this function is accomplished by the gradual throttling of recoil oil, the compression of nitrogen gas, and the friction of the moving parts.

(4) *To hold the recoiling parts.* The howitzer tube must be held in the in-battery position and at all angles of elevation. This is accomplished by the reserve oil located between the floating piston and the regulator assembly in the recuperator cylinder (*d* below). It insures that constant pressure from the nitrogen gas is applied to the front of the recoil cylinder to hold the tube in the in-battery position.

c. Components of the recoil mechanism. The major components of the recoil mechanism (fig 4-28 and 4-29) are the—

(1) *Recoil sleigh assembly.* The recoil sleigh assembly houses and supports the recuperator cylinder, the recoil cylinder, and the cannon. The sleigh includes four yokes that hold the parts together and two rails that slide on the cradle to guide and support the recoiling parts. The breech is screwed into the rear yoke and the cannon is supported by a bearing in the front yoke and a locking ring in the second yoke. The second yoke also contains the oil filling valve.



1—Recoil cylinder
2—Breather valve
3—Recoil piston
4—Recoil piston rod
5—Recoil oil
6—Stuffing box
7—Cradle gap
8—Recoil piston rod nut
9—Cotter pin
10—Second yoke
11—Connecting oil passage
12—Recoil sleigh assembly
13—Oil index indicator
14—Recuperator
15—Oil return ports
16—Oil passage
17—Regulator
18—Control rod
19—Variable depth groove
20—One-way valve
21—Throttling orifice
22—Oil reserve
23—Diaphragm
24—Floating piston
25—Nitrogen gas
26—Nitrogen filling valve

Figure 4-28. Hydropneumatic variable dependent recoil mechanism (components).

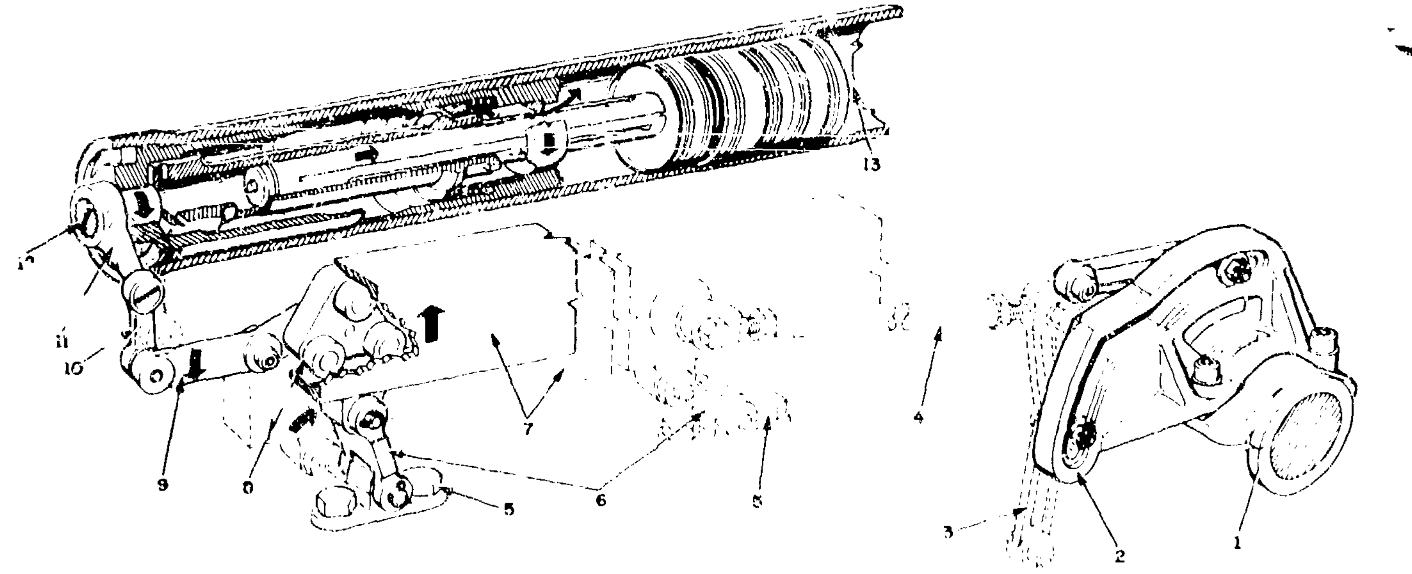
(2) *Recuperator cylinder.* The recuperator cylinder (fig 4-28) contains compressed nitrogen gas between the floating piston and the rear head. The front part of the cylinder contains record oil, which fills the regulator body and the space between the floating piston and the regulator. The front head contains the oil index indicator rod and the variable recoil housing. A control rod is connected to the floating piston and slides within the regulator.

(3) *Recoil cylinder.* The recoil cylinder (item 1, fig 4-28) contains recoil oil, which can pass back and forth between the recoil cylinder and the recuperator cylinder by means of connecting passages. A recoil piston, which is secured to the cradle by a piston rod, holds this oil and separates it from air, which fills the rear portion of the cylinder. A stuffing box prevents leakage of oil past the piston rod.

(4) *Variable recoil actuator.* The variable recoil actuating mechanism (fig 4-29) is a component of the carriage and is composed of a control cam, a cam lever tube, a rail and plate assembly, a rail support arm, a cam actuating lever, an arm link, a variable recoil mechanism arm, and assembly links. The cam is secured to the left trunnion cap and is linked to the rail assembly by an adjustable connecting rod. Two pivoting supports (brackets, pins, and links) are used to suspend the rail above the carriage cradle. The arm connects the rail assembly with the clamp arm through a knuckle joint arrangement. The variable recoil mechanism is splined to the recuperator regulator housing.

d. Functioning of the recoil mechanism.

(1) *Action in recoil.* When the howitzer is fired, the force of the expanding gas propels the projectile out of the bore. This same force also reacts against the breechblock and forces the recoiling parts rearward, except for the recoil piston in the recoil cylinder. The piston is held from recoiling by the piston rod, which is secured to the front of the cradle by the recoil piston rod nut. As the sleigh moves back in recoil, the recoil oil in the recoil cylinder is forced through the oil passage into the regulator body of the recuperator cylinder. The regulator body contains a one-way valve and a throttling orifice through which the oil passes, and it acts upon the floating piston diaphragm in the recuperator cylinder, forcing it to the rear, further compressing the nitrogen behind the floating piston. As the floating piston moves to the rear, a control rod that is fastened to the diaphragm is drawn through the throttling orifice. The area through which oil can flow is then reduced by throttling the oil gradually through



1—Trunnion adapters
2—Control cam
3—Cam actuating lever (with variable recoil mechanism roller)
4—Cam lever tube
5—Rotating shaft eye bracket
6—Rail assembly link
7—Rail and plate assembly
8—Roller support
9—Actuating rail support arm
10—Arm link
11—Variable recoil mechanism arm
12—Regulator
13—Recuperator

Figure 4-29. Variable recoil actuating mechanism (components).

variable depth grooves until the remaining energy of recoil is unable to force the oil to the rear. At that time, since the resistance is equal to the force, further motion is impossible and the recoiling parts are brought to rest. As the weapon is elevated or depressed, the cam follower is actuated. This actuation causes the regulator body to turn. The turning of the regulator body regulates the opening of the oil passage and determines the length of recoil. The energy of the recoiling parts is principally exhausted in the process of forcing the oil through the variable depth grooves. Some of the energy, however, is spent in compressing the nitrogen gas and in overcoming the combined friction of all moving parts. Figure 4-30 shows the flow of oil from the recoil cylinder through the regulator and the subsequent pressure against the floating piston, which compresses the nitrogen gas.

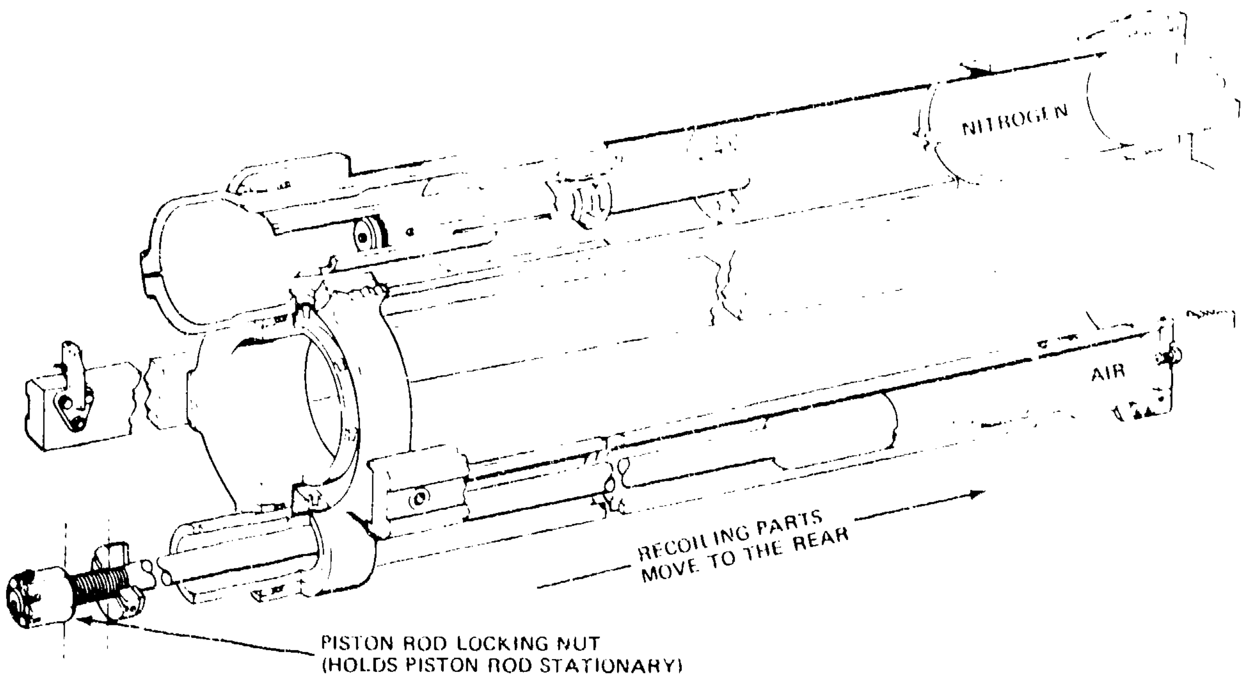


Figure 4-30. Variable dependent recoil system during recoil action.

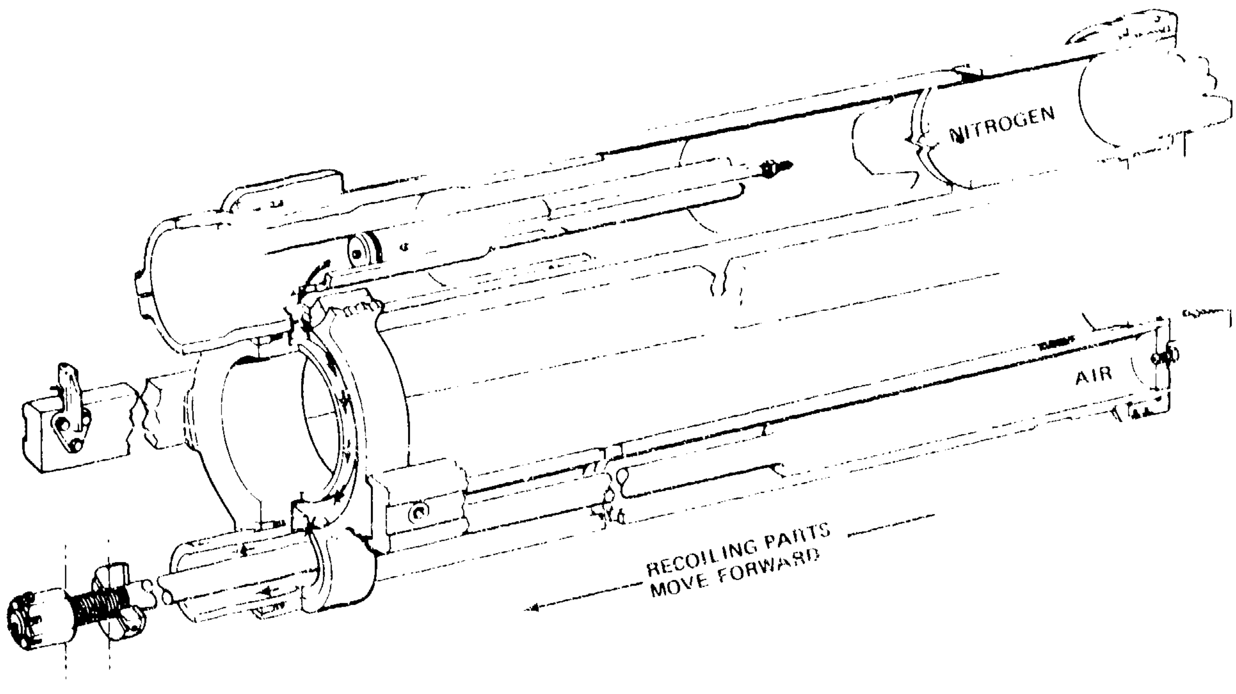


Figure 4-31. Variable dependent recoil system during counterrecoil action.

(2) *Action in counterrecoil.* When the recoiling parts are brought to rest at the end of recoil, the unbalanced force of the greatly compressed nitrogen gas forces the floating piston and diaphragm forward, pushing the recoil oil back through the regulator into the cylinder against the back of the recoil piston. Since the recoil piston is stationary, the force is transmitted to the front inside face of the recoil cylinder, and the recoiling parts are thereby pushed back to the in-battery position (fig 4-31).

(3) *Recoil and counterrecoil without shock.* During recoil the oil is throttled gradually through the variable depth grooves. Because the grooves are tapered, the flow of oil is diminished without shock. The long variable depth grooves are deepest where the short grooves terminate; this contributes to smooth recoil action at low angles of elevation. Friction of moving parts and compression of the nitrogen gas also contribute to recoil action without shock. During counterrecoil the one-way valve is shut by the pressure of the returning oil as the split rings around the valve form an oiltight seal. The oil is then forced to return through a groove located inside the regulator. As this groove tapers toward the front of the regulator, the oil flows more slowly and the tube eases back to the in-battery position.

(4) *Variable recoil mechanism.* The variable recoil mechanism (fig 4-32) provides the weapon with a means of shortening recoil length at high angles of elevation. As the tube is elevated, the roller tracks along the control cam, which pivots toward the rear of the weapon. The tube and the rail and plate assembly form the link between the lever and the roller support. As the roller support pulls the support arm and arm link to the rear, the mechanism arm is rotated downward, forcing the regulator to turn. As the regulator turns, the throttling orifice is gradually rotated so that it disengages the long variable depth grooves. From 0 to 178 mils the length of recoil is 50 inches; from 178 to 711 mils the length of recoil varies; from 711 to 1,333 mils the length of recoil is 30 inches.

(5) *Oil index and oil reserve.* The recoil mechanism is designed to operate properly when the correct recoil oil reserve is forced into the system so as to separate the floating piston diaphragm from the regulator and thereby transmit the pressure of the nitrogen gas through the floating piston to the oil column. The pressure of the recoil oil acting on the recoil piston holds the recoiling parts in the battery position. An insufficient oil reserve may allow the cannon to fall out of battery at high elevations. *The correct recoil oil reserve exists when the end of the oil*

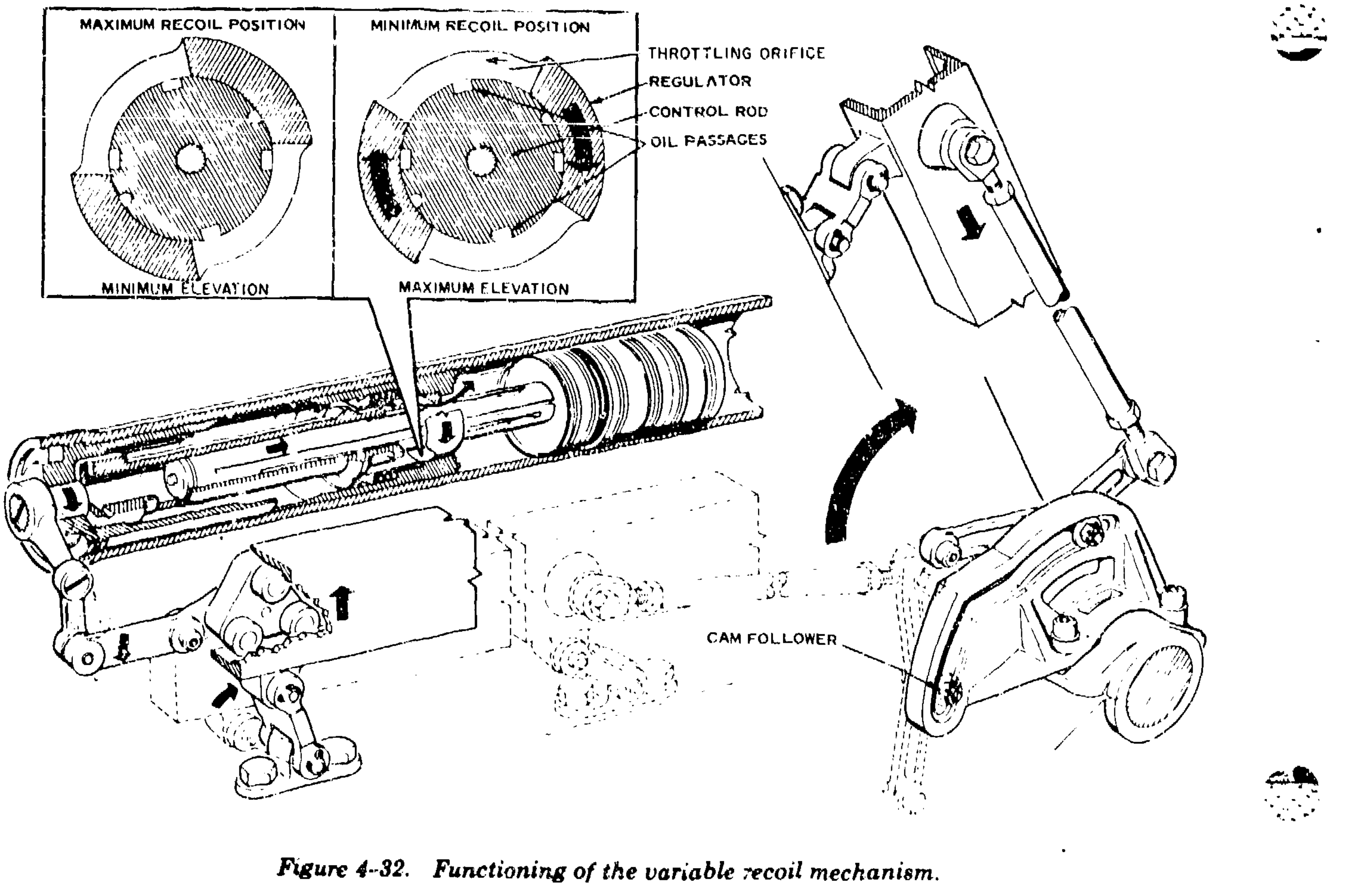


Figure 4-32. Functioning of the variable recoil mechanism.

index indicator rod is flush with the front face of the recuperator cylinder front head (1½ screw fillers 6 oz). Whenever the amount of reserve oil is less than that prescribed, a rod attached to the diaphragm moves forward with the floating piston diaphragm and causes the *indicator rod to protrude, indicating insufficient reserve oil.* The oil reserve is low when the indicator rod protrudes more than 3/16-inch from the regulator housing, *and the weapon must not be fired.* On newer model M102s a red scribe line on the index indicates 3/16-inch.

Note. Sufficient operating reserve oil is present when the indicator rod protrudes 3/16-inch from the regulator housing; however, proper oil reserve should be reestablished at the first opportunity.

e. Maintenance of the recoil mechanism.

(1) *To drain the oil reserve.* Place tube at 0 mils elevation. To drain the oil reserve (fig 4-33) remove the filling plug with a suitable wrench. Connect the filling and drain hose to the liquid-release tool, insert the tool into the filling hole, and hand-tighten it. Using a suitable wrench, further tighten the tool until the reserve oil spurts out in a stream. In checking the reserve oil before firing, drain only enough oil to cause the oil index indicator rod to protrude slightly and catch the oil in a suitable receptacle. For complete draining of oil reserve, allow the oil to spurt out until the flow stops. Inspect the oil for evidence of water, air, or nitrogen.

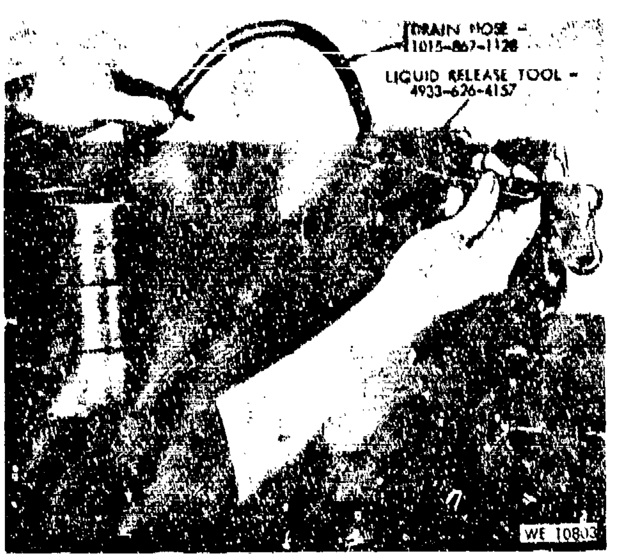


Figure 4-33. Draining oil reserve.

(2) *To fill the recoil oil gun.* To refill the recoil oil gun, turn the handle counterclockwise until it is screwed completely back, loosen the locking screw on the head, and remove the handle and head as a unit. Pour oil directly into the barrel of the gun, avoiding the formation of air bubbles. Replace the handle and head as a unit and tighten the locking screw. Remove the cap from the nozzle head, hold the nozzle end up for a minute or two until all air in the oil has risen to the surface, and purge the gun by turning the handle until no more air bubbles appear at the nozzle end.

(3) *To reestablish the oil reserve.* To reestablish the oil reserve (fig 4-34) screw the nozzle of the gun into the filling hole, taking care not to cross the threads. Before tightening, turn the handle and force out any air in the filling hole. Operate the gun with both hands and avoid any lateral pressure, which might possibly break the threaded nozzle. When the oil index indicator rod shows a full reserve, unscrew the gun and install the filling plug.

(4) *Troubleshooting recoil malfunctions.* If the tube slams out of battery, normally the recoil oil level is low; if the tube slams into battery, the recoil oil level is probably too high. Jerky motion during recoil indicates either a dirty sleigh assembly or emulsified oil. To check emulsified oil (which is pink in color), pour some into a container and let it stand. If the bubbles dissipate, air is mixed with the oil. Drain the oil and reestablish the oil reserve. If the bubbles do not dissipate, nitrogen is mixed with the oil. Contact support personnel. If recoil oil leaks at a rate of three drops per minute, refer the weapon to support maintenance.

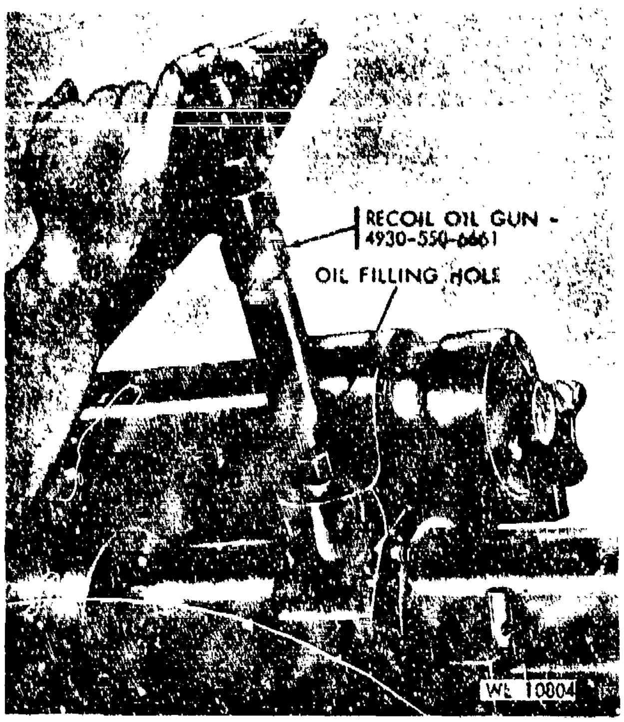


Figure 4-34. Establishing oil reserve.

(5) *Variable recoil actuating assembly problems.* The hardware that composes the variable recoil actuating assembly (fig 4-35) has

been a constant source of problems for M102 crewmen. Three components are of immediate concern to M102 users.

(a) First is the variable recoil shoulder bolt (item 1, fig 4-35). Investigations and reports from the field indicate that the shoulder bolt has a tendency to vibrate loose and then shear during firing operations.

1. Plans are to replace the bolt with a bolt and self-locking nut. This modification is currently being accomplished in the overhaul program. Direct support units are being made aware of a field fix so that, if the shoulder bolt on any of your weapons fails, your DSU can repair it.

2. In the meantime, you should insure that the bolt now in use remains snug. After tightening the bolt, make sure that the actuating rail support arm moves freely. You must also check the Allen-type setscrew used in conjunction with the bolt now in use. It should be tight and staked. Painting over this setscrew will make it difficult to check for tightness and staking.

(b) The second item of interest on the M102 variable recoil actuating assembly is the variable recoil machine bolts (item 2, fig 4-35). Investigations and field reports have revealed that these bolts will also vibrate loose and then be sheared during firing operations.

1. This problem has been attributed to improper timing of the variable recoil system and failure of the bolthole threads in the cradle. Timing is a function of direct support units, and the proper timing procedure is prescribed and emphasized in change 6 of the direct support maintenance manual, TM 9-1015-234-35. So that the user can insure that the recoil mechanism is properly timed, a check of recoil timing will be incorporated into the next revision of the user's manual. As for the failure of the bolthole threads in the cradle, M102 maintenance engineers have developed steel inserts for the boltholes in the cradle to prevent the bolts from stripping the threads. Currently, these steel inserts are to be applied only at overhaul facilities. Plans are to make a field fix available to direct support units so that they can repair the

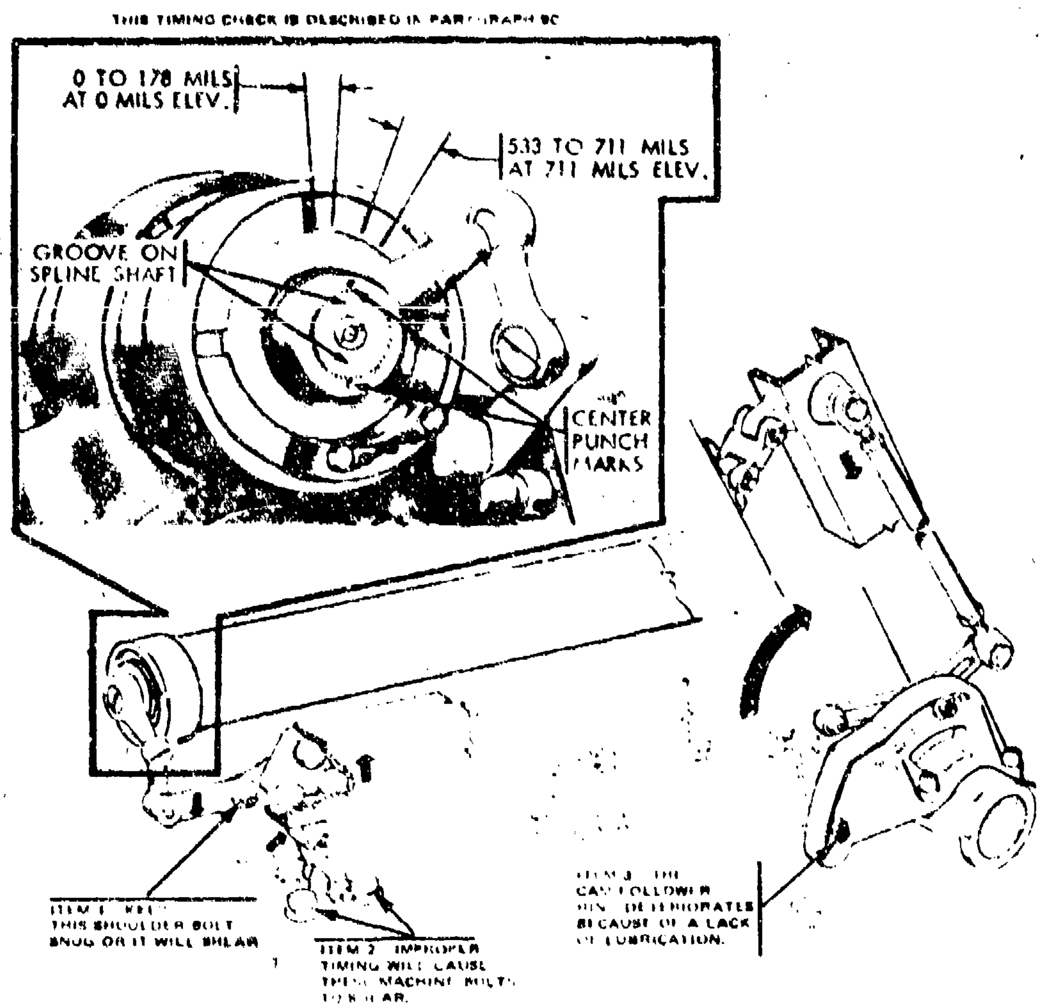


Figure 4-35. Variable recoil actuating or assembly with timing check procedures.

boltholes when the bolts strip the threads.

2. In the meantime, you should make sure that the machine bolts are sufficiently tight during firing of the M102. Bolts must not be too tight or they will strip the threads in the boltholes. Also, you should check to see that the recoil mechanism is properly timed according to the procedures in *(c)* below. (These procedures will be incorporated in the next revision of the user's manual.)

(c) Variable recoil actuating assembly timing check. The timing check of the M102 variable recoil actuating assembly should be performed as follows:

1. Depress the cannon to 0 mils elevation and insure that the center punchmarks are between the ranges indicated by the painted area for 0 to 178 mils (fig 4-35).

Note. Throughout this entire check of the variable recoil mechanism, the groove on the splined shaft should remain alined with the center punchmarks on the recoil control arm.

2. Elevate the cannon to 178 mils and insure that the center punchmarks are between the ranges indicated by the painted area for 0 to 178 mils.

3. Elevate the cannon to 533 mils and insure that the center punchmarks are between the ranges indicated by the painted area for 533 mils to 711 mils elevation.

4. Elevate the cannon to maximum elevation and check the following:

(a) The center punchmarks should be between the ranges indicated by the painted area for 533 mils to maximum elevation.

(b) A clearance of 0.020 to 0.040 inch should exist between the recoil control arm and the recoil control arm stop.

5. Repeat the steps presented in 1 through 4 above.

6. If the variable recoil actuator mechanism does not perform as indicated, the mechanism is improperly timed and should be turned into direct support maintenance for repair.

(d) Cam follower ring. The last item of interest on the variable recoil actuator assembly is the cam follower ring (item 3, fig 4-35). Reports from the field indicate that the ring deteriorates or breaks during firing and thus causes maladjustment of the howitzer variable recoil system.

1. Cam follower ring deterioration has been attributed to either improper lubrication or improper timing of the variable recoil actuator mechanism.

2. At this time, the problem with the cam follower ring can be corrected only by you, the user. As pointed out in *(c)* above, you can check to see if the recoil actuating assembly is properly timed. If it is not, turn in the weapon to the DSU for adjustment. As for the lubrication problem, Armament Command engineers have prepared a change to the lubrication order which will be published shortly. It requires the user to lubricate all moving parts of the recoil actuating assembly daily with general-purpose lubricating oil when the weapon is being fired daily. These moving parts include the arm linkage, actuating rail support arm, needle bearing cam follower, rail assembly links, cam actuating lever, control cam, and cam follower ring.

Section V. FIRE CONTROL EQUIPMENT

4-19. Sighting and Laying Equipment

Some of the common terms relating to sighting and laying equipment are defined in *a* through *i* below.

a. Fire control instruments—Include both on- and off-carriage instruments. On-carriage fire control instruments are those that are of built-in design or are placed on the weapon by the gun crew and serve the purpose of laying the weapon in deflection and/or elevation. Such instruments as the panoramic telescope, range quadrant, elbow telescope, and gunner's quadrant are on-carriage equipment. The aiming circle, battery commander's telescope, and M2 compass are examples of off-carriage control instruments.

b. Trajectory—The curve described by the center of gravity of a projectile in flight. The trajectory has two elements that are controlled by sighting and laying equipment—the vertical angular measurement and the horizontal angular measurement.

c. Reticle—A measuring scale or mark placed in the focus of an optical instrument. Some reticles have graduations that allow small angular or range measurements to be made while the operator looks through the instrument.

d. Sighting—The process of directing a line of sight toward an aiming point.

e. Referring—The process of moving the line of sight to an object without moving the tube. The purpose is to determine the angular distance from the line of fire or rearward extension of the line of fire to the designated object.

f. Laying—The process of pointing the tube of a weapon in a given direction for a given range.

g. Indirect fire—Fire from a weapon that is laid by sighting on a point other than the target. Normally, the target and weapon will not be intervisible.

h. Direct fire—Fire from a weapon that is laid by sighting directly on the target.

i. Cant—The tilting of the trunnions of a weapon out of the true horizontal plane. Cant causes the tube to travel out of the true horizontal plane in traverse and out of the true vertical plane in elevation. Cant is always present if the trunnions of a weapon are not level.

4-20. Fire Control Instruments

a. Panoramic telescope M113A1.

(1) The panoramic telescope M113A1 (fig 4-36) is the basic instrument used in laying the weapon in direction. A 1,600 mil prism, reticle, and the objective lenses are mounted rigidly with respect to one another in a rotating assembly that minimizes "reticle shift." Azimuth readings are made from a mechanical mil counter unit. Included is a reset counter that can be set to show a reading of 3,200 mils without changing the line of sight of the telescope. This permits all weapons to have a common deflection even though the collimator for each piece is placed at a different referred deflection. The panoramic telescope M113A1 is a 4-power, fixed-focus telescope with a 178-mil field of view. It is mounted directly to telescope mount M134A1.

(2) A parallax shield is hinged to the top edge of the rotatable head. The shield may be closed over the front of the sight to protect the lens during travel. During boresighting and certain other tests, the shield is also closed. Closing the shield will allow only a minute ray of light to enter the telescope and therefore reduces the problem of a "moving" sight picture (parallax).

(3) The elevation knob located on the top of the rotatable head is used to raise and lower the line of sight. The range of the elevation knob is from -300 mils to +300 mils, but no determination

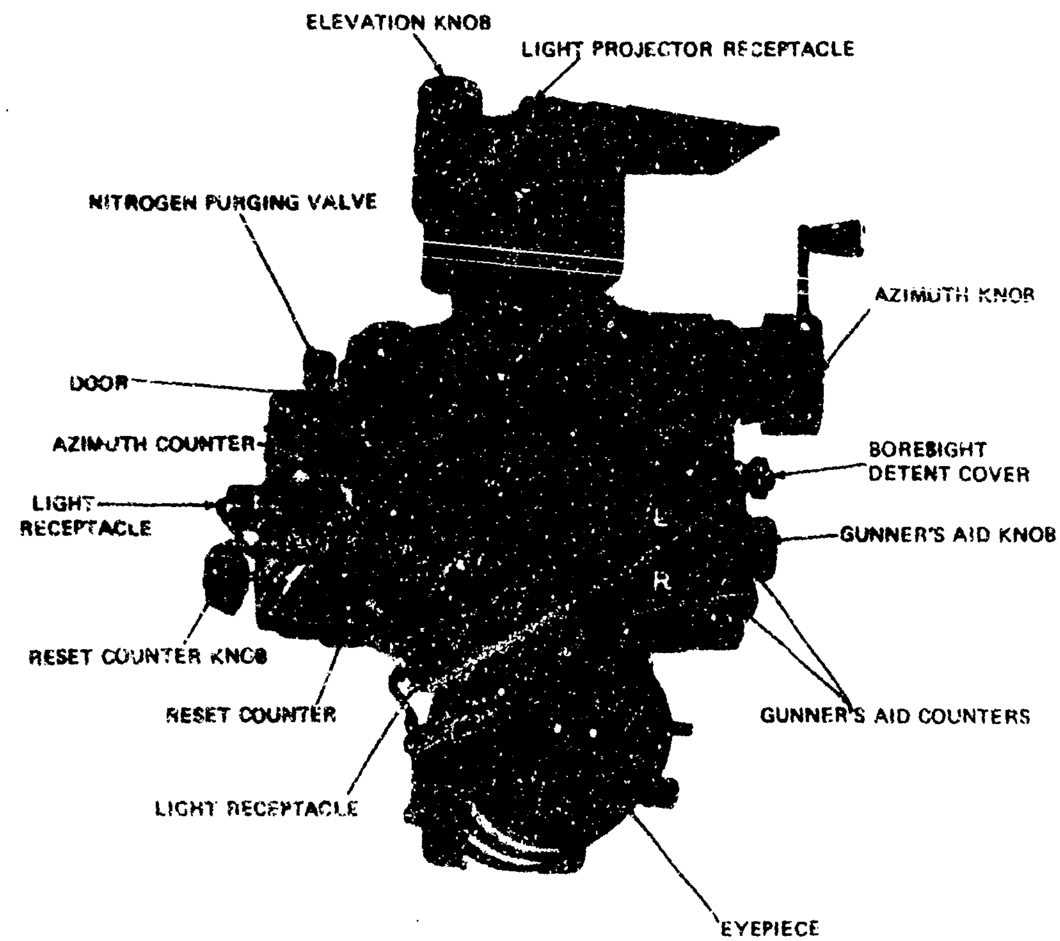


Figure 4-36. Panoramic telescope M113.

of vertical angles can be made with this mechanism.

(4) A light projector is located on the sight of the rotatable head. Originally, the device was designed for illumination of aiming points, but its effectiveness is minimal.

(5) The azimuth knob is used to turn the rotatable head and thus move the line of sight. When the azimuth knob is turned, values on both the azimuth counter and reset counter change. We may utilize the slow motion by simply turning the knob itself or the fast motion by extending the crank that should be used to avoid turning the knob too fast and wearing out the internal gear train.

(6) Also located on the body of the azimuth knob is a bar knob, which may be rotated to one of two selector positions: direct fire or indirect fire. If the bar knob is rotated to the indirect fire position, the gear train will click once for every mil the azimuth knob is turned. If the bar knob is rotated to the direct fire position, the gear train will click once for every 5 mils the azimuth knob is turned, thus enabling the gunner to lead a target by 5-mil increments without looking at the azimuth scale.

(7) The azimuth counter is marked every ¼ mil, numbered every mil from 0000 to 6399.75, and the reading on the counter reflects the true deflection measured to the line of sight from the rearward extension of the line of fire. The azimuth counter is the upper digital counter on the sight. When the azimuth counter reads 0000, the line of sight should be parallel to the rearward extension of the line of fire; when it reads 3200, the line of sight should be parallel to the line of fire. The azimuth counter is used for laying, for emplacing aiming points, for referring to alternate aiming points, for boresighting, and for direct fire. These functions will be discussed below.

(8) The reset counter (marked every ¼ mil, numbered every 1 mil from 0000 to 9999.75) is the lower digital counter on the sight. It is designed to give the user the capability to read an artificial value that coincides with the readings of all other panoramic telescopes within the battery. Pushing the reset counter knob in and turning it until it pops back out resets the counter to read 3200 mils. This action does not affect the azimuth counter. So for any direction the line of sight may be pointed we may give it an artificial value of 3200 mils. The reasons will be made clear in (9)*(f)* below. The reset counter is used in indirect fire for determining site to crest, and as an aid in putting out azimuth stakes.

(9) Functions of the azimuth counter and reset counter are described below.

(a) Laying. Because the azimuth counter shows the true deflection from the rearward extension of the line of fire to the line of sight, it is used to lay the weapon.

(b) Aiming points. After the weapon has been laid, the gunner will turn the azimuth knob until the line of sight is pointed where the primary aiming point is to be emplaced. He will direct the cannoneer to emplace the collimator/aiming posts for the proper sight picture, and then he will record the deflection to that aiming point. The same procedure is used for emplacing the secondary aiming point.

Note. This step is accomplished without moving the tube off of the azimuth of fire.

(c) Referring. After alternate aiming points have been selected, the sight may be turned to them to read the deflection from the azimuth counter. Referring simply means obtaining a deflection to a given point without moving the tube.

(d) Direct fire. If the weapon has been properly boresighted, the azimuth counter can be turned to deflection 3200 and the gunner can sight directly on a target that he plans to engage with direct fire.

(e) Boresighting. When the weapon is laid, actually the executive officer is laying the 0—3200 line of the sight instead of the tube itself. Because the 0—3200 line of the sight and the line of fire may not be parallel to each other, the weapon must be boresighted. This procedure is discussed in paragraph 26. Basically, when the azimuth counter shows deflection 3200, the line of fire and the line of sight must be parallel to each other.

(f) Reset counter.

1. Indirect fire. After the aiming points have been emplaced, the gunner insures that the tube is still on the azimuth of fire and turns the line of sight to the primary aiming point. He will then turn the reset counterknob until it pops out and deflection 3200 is on the reset counter. After he has insured that the true deflection to the aiming point is still on the azimuth counter, he will record that value and close the hinged door over the azimuth counter. Since all gunners within the battery will have done the same thing, each tube will be on the azimuth of fire and each reset counter will show deflection 3200 to the primary aiming point. Therefore, the FDC will now send fire commands in relation to deflection 3200. If the battery is to fire 300 mils to the left of the azimuth of fire, deflection 3500 is sent in the fire command (LARS rule). The reset counter enables all weapons to receive the same fire command with relation to a common deflection of 3200 mils even though the primary aiming points of all the weapons were not emplaced at the same true deflection. If the primary aiming point were rendered unserviceable the gunner would simply open the hinged door over the azimuth counter, turn to the deflection of his secondary aiming point, reset the reset counter, and close the hinged door. At this time he could place the deflection from the next fire command on the reset counter and take up the proper sight picture on the secondary aiming point.

2. *Site to crest.* The chief of section will determine what obstructions in front of his weapon may limit his field of fire. He will have the gunner traverse the tube to the direction of the obstruction and then determine the deflection with respect to the azimuth of fire. The gunner will simply refer the line of sight to the primary aiming point, and read the deflection from the reset counter to the chief of section.

3. *Azimuth markers.* Azimuth stakes are indicators that show the cardinal directions 6400, 1600, 3200, and 4800. To emplace the stakes, the gunner first determines which cardinal direction is closest to the line of fire. If the weapon is laid on azimuth 1400, the closest cardinal direction is 1600. The gunner then turns the line of sight to that cardinal direction. By using the azimuth scale, he can turn to deflection 3400 which is 200 mils past the line of fire in a clockwise direction. This is also 200 mils in a clockwise direction past azimuth 1400, or azimuth 1600. The gunner then directs the cannoneer to emplace the 1600 azimuth marker, closes the azimuth counter door, and resets the reset counter to 3200. If 3200 on the reset counter is now pointed at azimuth 1600, the gunner turns the line of sight to deflection 4800 and has the 3200 azimuth stake emplaced. As the line of sight is turned to deflections 6400 and 8000, the gunner has the cannoneer emplace azimuth stakes for 4800 and 6400 respectively.

(10) Opposite the azimuth and reset counters are two small gunner's aid counters. By turning the gunner's aid knob, the gunner can place special corrections on the sight. If the FDC wants the weapon to continuously fire 16 mils to the right of the azimuth of fire, the gunner's aid knob is turned until a 16 appears in the R (right) gunner's aid counter. This will cause the numbers in the reset counter to increase by 16 mils without moving the line of sight. In order for the gunner to fire the deflection announced in the fire command, he must use the azimuth knob to decrease the setting on the reset counter by 16 mils and thus force the tube 16 mils to the right of the azimuth of fire. The maximum correction that can be applied to the panoramic telescope varies but is normally approximately 55 mils. If the correction is to exceed that amount, the FDC will have to announce in the fire command a special deflection to that weapon. Special corrections are placed on the sight before the deflection in the fire command is applied. Corrections are taken off before the panoramic telescope is referred to 3200 to return to the original azimuth of fire.

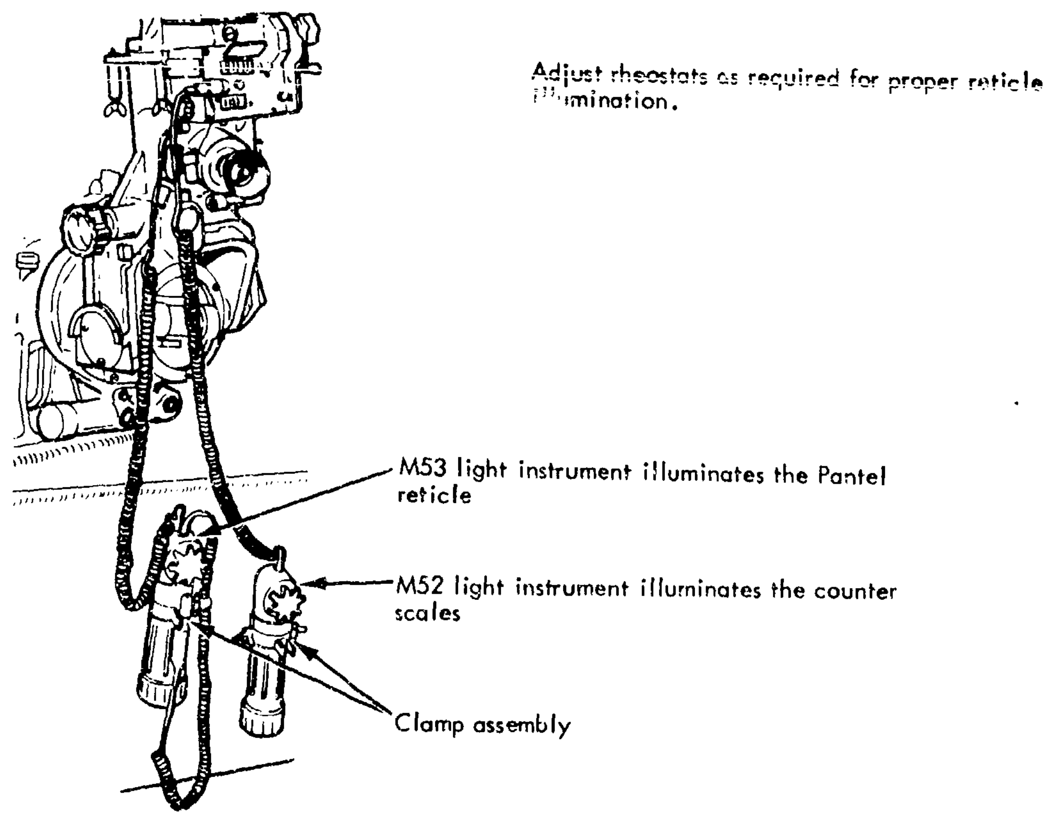


Figure 4-37. Emplacement of night lighting devices M52 and M53 on the M117

(11) The night lighting devices will be installed as shown in figure 4-37. The newer weapons have radioactively illuminated sights and mounts.

(12) The telescope has four position settings for the convenience of the gunner, and the telescope should be parallel to the body of the weapon during travel to prevent it from catching on obstacles and breaking. Other components of the panoramic telescope will be discussed in later paragraphs.

b. Telescope mount M134. Telescope mount M134 (fig 4-38) provides an adjustable base for leveling the panoramic telescope M113. The mount is installed on the left trunnion. The mechanism of the telescope mount M134 is essentially a "Hook's" universal joint that makes possible adjustment of the vertical axis of the panoramic telescope to plumb regardless of pitch or cant (within the range ± 178m) of the weapon. The mechanism also contains a gun bar pivot that is maintained parallel to the weapon tube at all times, since it is mounted directly on the weapon trunnion. This gun bar pivot serves as a reference about which the mount is adjusted to compensate in azimuth for the effects of trunnion cant. The mount provides a vertical support for the panoramic telescope to provide true measurements of weapon azimuth.

c. Fire control quadrant M14. The fire control quadrant M14 (fig 4-39) which is mounted on the right-hand trunnion, is used for adjustment of the weapon in elevation. Fire control quadrant M14 is equipped with a mechanical mil counter for elevation readings. By turning the elevation knob, the assistant gunner can place the announced quadrant elevation on the elevation counter. He then elevates or depresses the tube to level the bubble in the longitudinal leveling vial and thus lays the weapon for quadrant elevation.

(1) *Gunner's aid counters.* The gunner's aid counters function similarly to those on the M113 panoramic telescope. By turning the gunner's aid knob, the assistant gunner can place a positive or negative correction on the counters. If a positive correction is placed on the counter, the elevation counter digits are decreased; this causes the weapon to be elevated even more to achieve the announced quadrant elevation. Corrections are placed on the gunner's aid counters before the announced quadrant is placed on the fire control

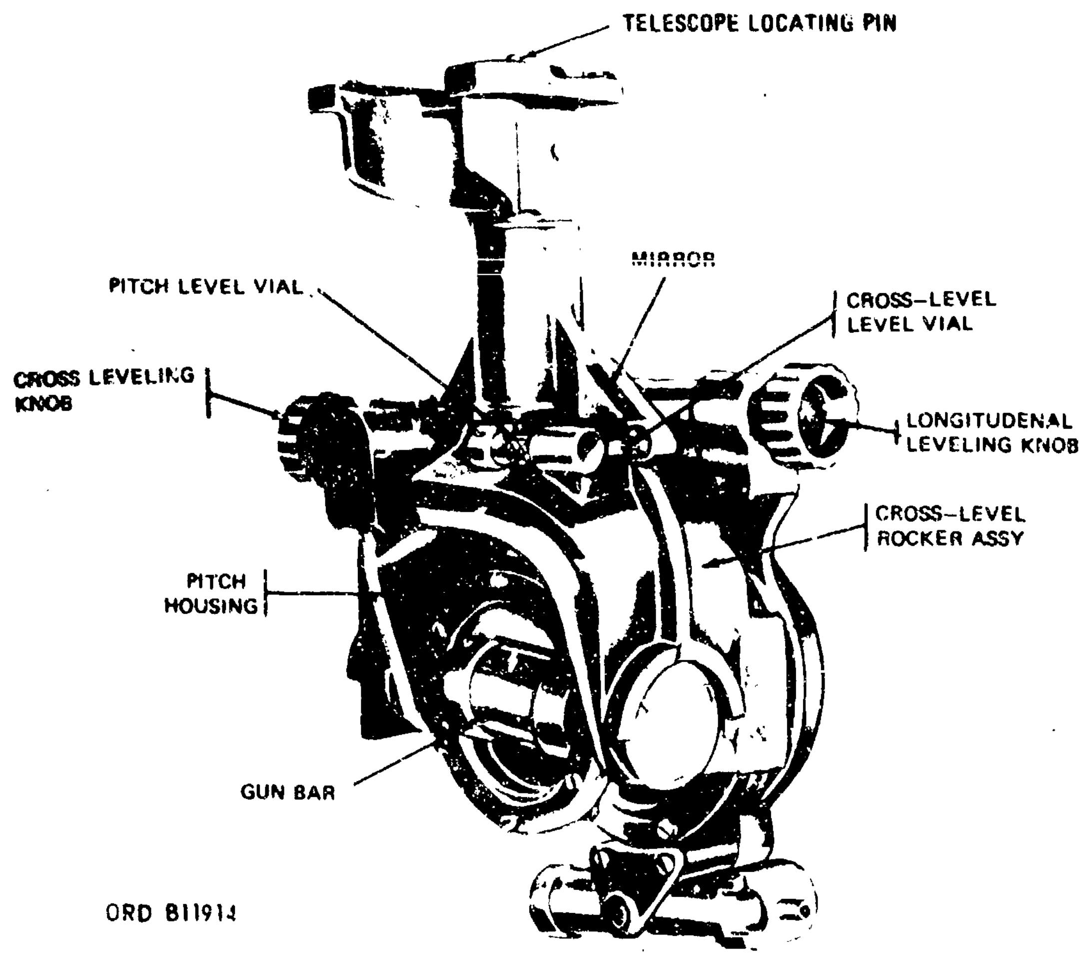


Figure 4-38. Telescope mount M134.

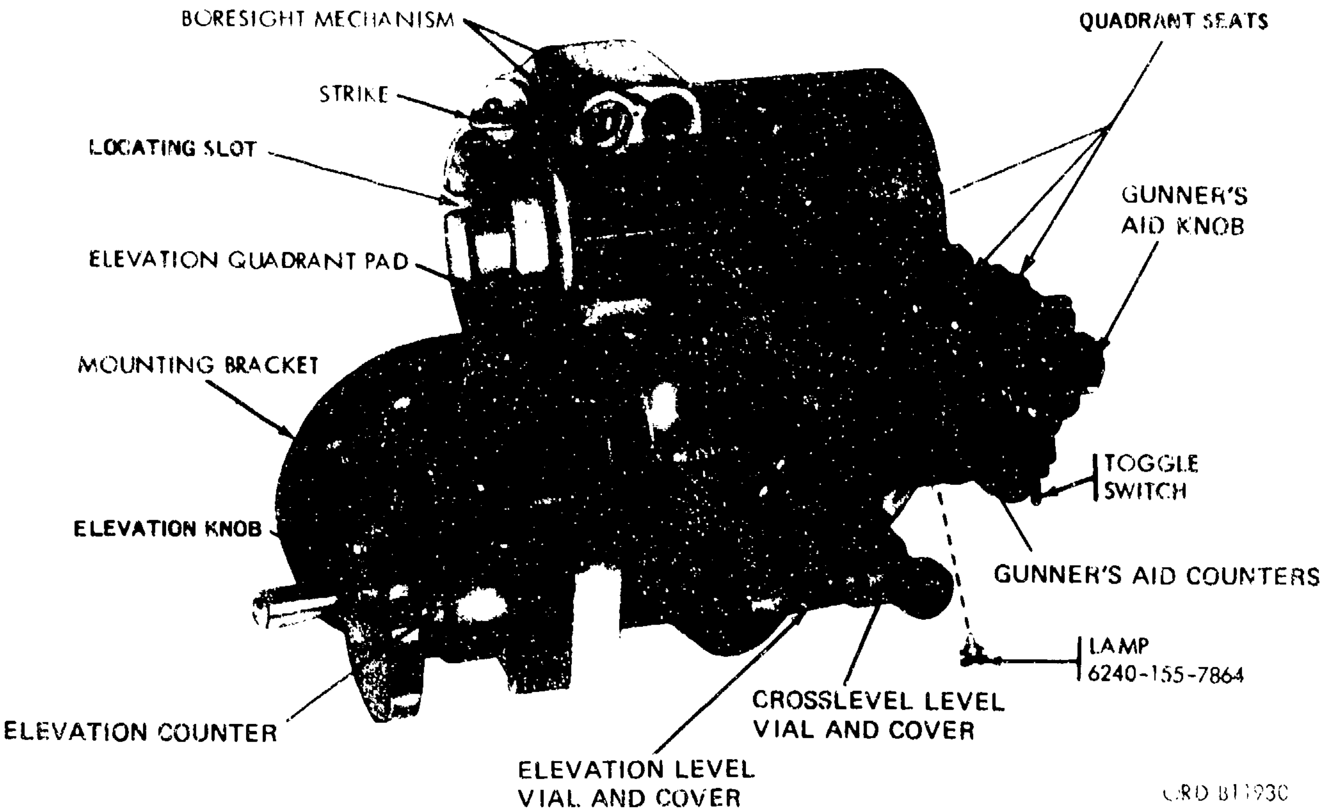


Figure 4-39. Fire control quadrant M14.

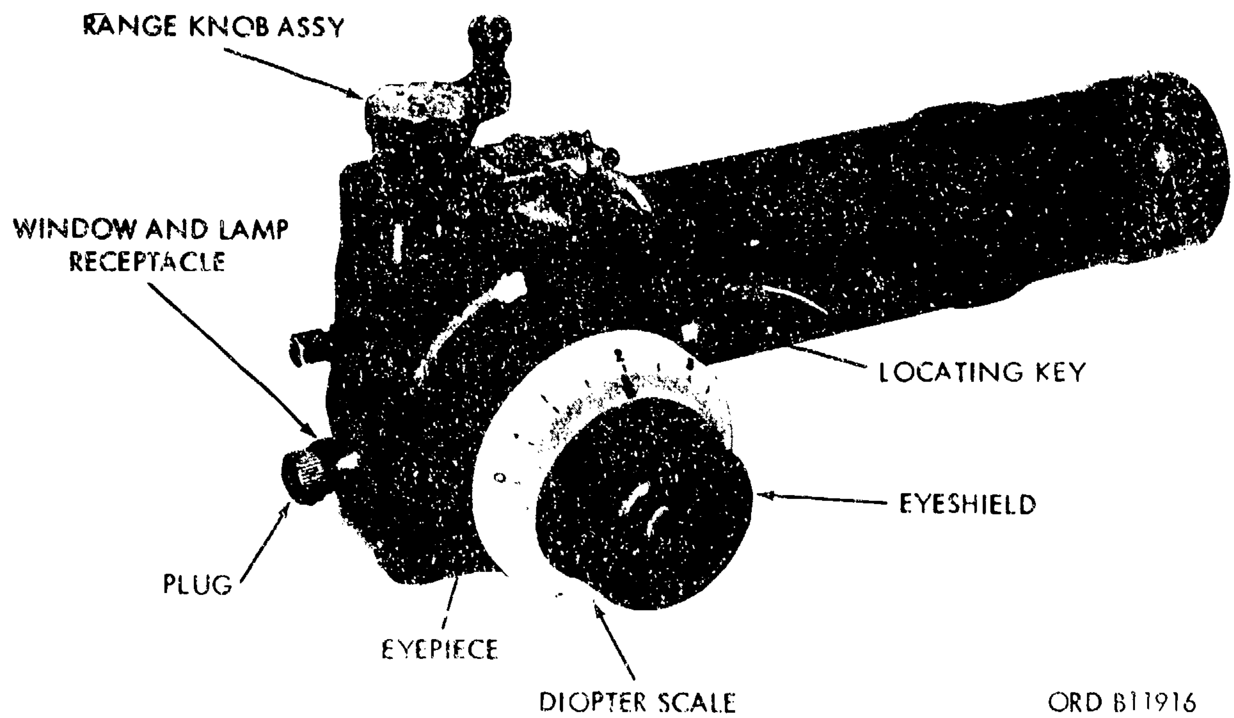


Figure 4-40. Elbow telescope M114.

quadrant; they are removed before the weapon is returned to the original elevation of lay.

(2) *Elbow telescope mount.* The mount for the M114 direct fire telescope is located on the top of the M14. Installation of the direct fire telescope is discussed in paragraph 22*b*.

(3) *Lighting devices.* Emplacement of the lighting devices is shown in figure 4-44. A toggle switch located underneath the correction scale is used to turn the counter lights on and off.

(4) *Quadrant seats.* Two sets of quadrant seats are located on top of the M14. One set may be used to cross-level the fire control quadrant with a gunner's quadrant. The longitudinal quadrant seats form a line that is parallel with the end of the tube. They are used in determining the accuracy of the gunner's quadrant or during firing when the gunner's quadrant is used for greater accuracy in quadrant elevation.

d. Elbow telescope M114. The elbow telescope M114 (fig 4-40) is the basic instrument used for laying the weapon in elevation for direct fire. The elbow telescope M114 is mounted and boresighted in a mechanism integral with the upper part of fire control quadrant M14. This instrument is basically similar in function to other direct fire telescopes now in use except for a reticle presentation of multiple ballistic data and the use of a movable range gageline that can be set to range values for direct fire by use of the range gage knob. Magnification has also been increased to 8-power, and a diopter has been added that can be adjusted to change the focus of the telescope to suit the observer's eye.

Note. The sighting equipment for the 105-mm howitzer M102 is designed for two-man operation. One man, on the left side of the breech, uses the panoramic telescope for azimuth adjustments. The second man, on the right side of the breech, uses the fire control quadrant M14 for elevation adjustments.

4-21. Installation of Fire Control Equipment

a. Installing M113 panoramic telescope. The M113 panoramic telescope (pantel) is installed by the gunner as shown in figure 4-41 and described in (1) through (10) below:

(1) Remove the canvas cover from the M134 mount.

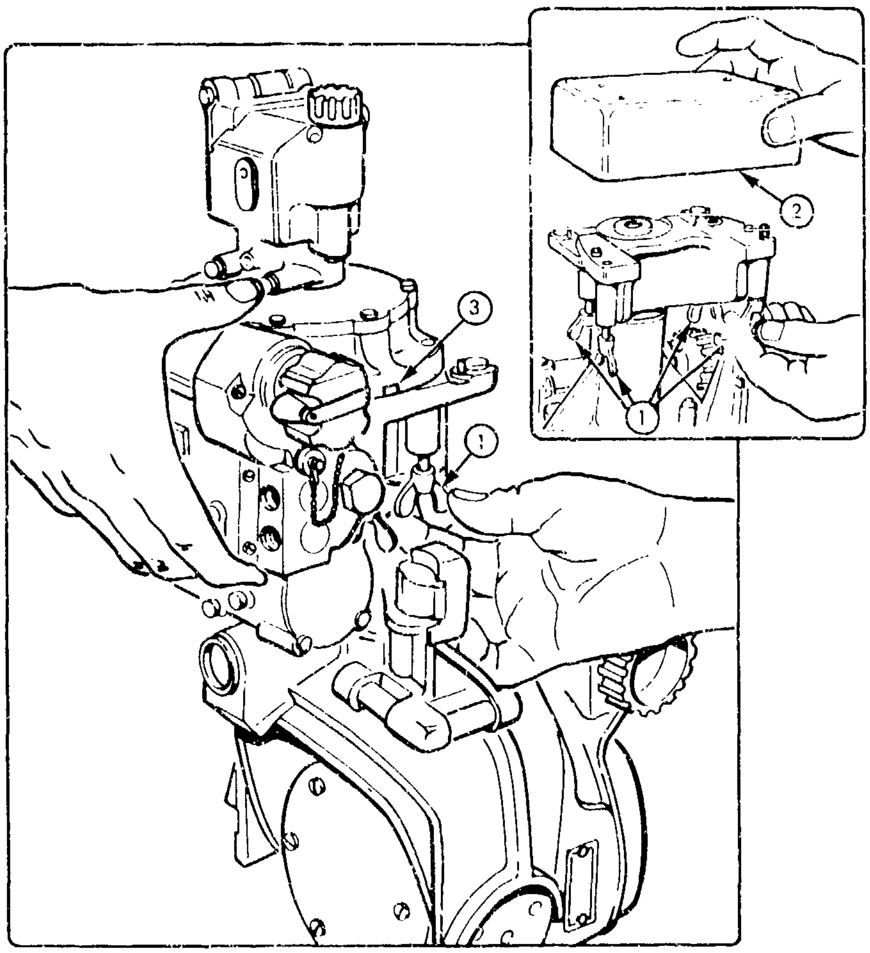


Figure 4-41. Installing the M113 panoramic telescope.

(2) Loosen the four wing nuts (1 fig 4-41) and remove the protective cover (2 fig 4-41).

CAUTION: Vent the stowage check before opening it.

(3) Place the cover (2 fig 4-41) in the stowage chest and remove the panoramic telescope from the stowage chest.

(4) Position the panoramic telescope by means of the locating pins (3 fig 4-41) on the M134 mount. Hand-tighten the four wing screws (1 fig 4-41) to fasten the panoramic telescope in place.

(5) Uncover the level vials (3 fig 4-42) azimuth counter (5 fig 4-42) and set the gunner's aid counter (2 fig 4-42) to 0. Level the M134 mount.

(6) Open the parallax shield (1 fig 4-42) by releasing the lock.

(7) Release the lock plunger (4 fig 4-42) and turn the panoramic telescope elbow perpendicular to the weapon tube. The elbow can be rotated 140 mils by releasing the plunger (4 fig 4-42).

(8) Perform required before-operations Preventive Maintenance Checks and Services, (PMCS).

(9) If you have radioactively illuminated fire control instruments, be aware of the user's manual warning.

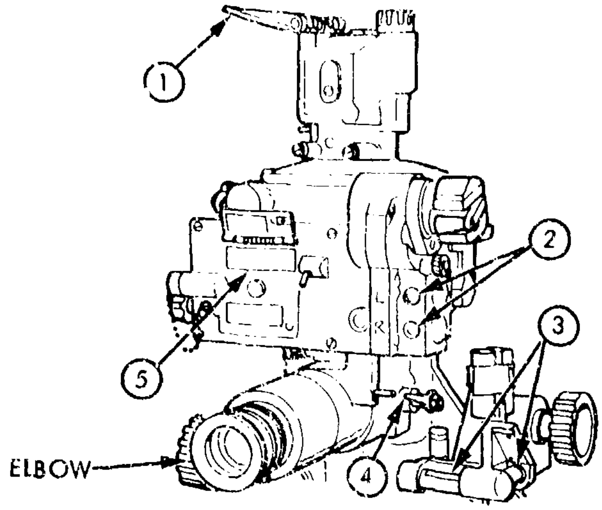


Figure 4-42. Preparing the M113 panoramic telescope for action.

(10) If you do not have radioactively illuminated fire control instruments, install the M52 and M53 light instruments as shown in figure 4-37.

b. Installing M114 elbow telescope. The M114 elbow telescope is installed by the assistant gunner as shown in figure 4-43 and described below.

(1) Remove the canvas cover from the M114 mount.

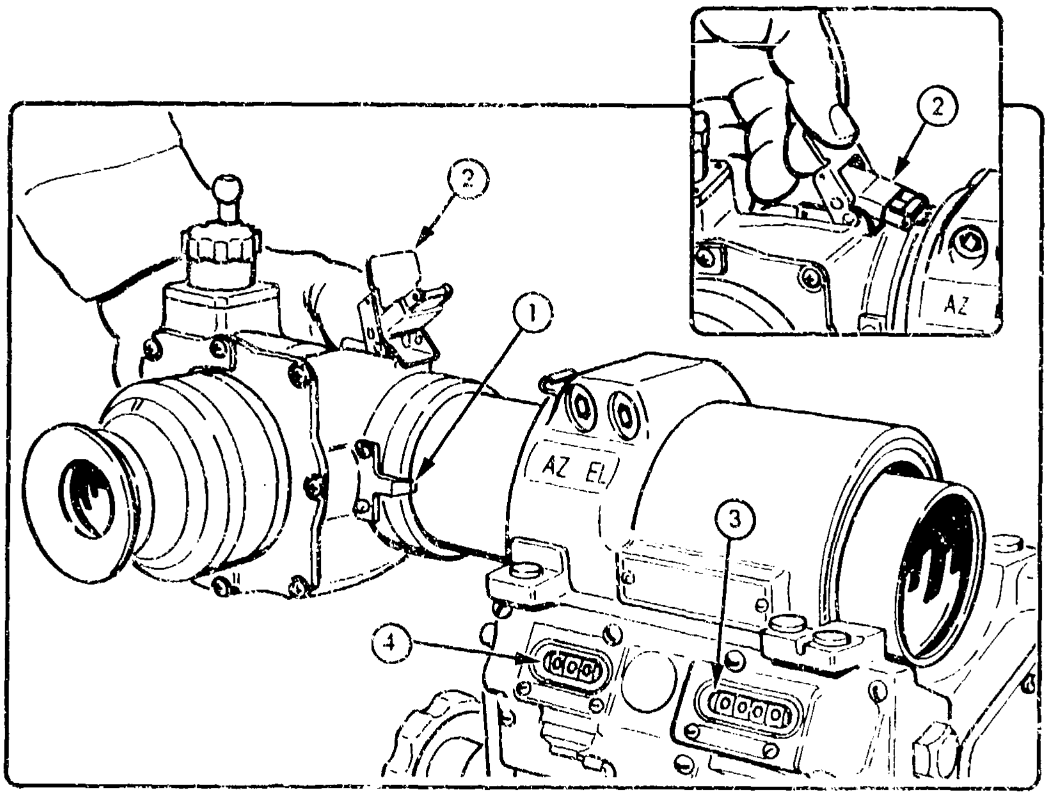


Figure 4-43. Installing the M114 elbow telescope.

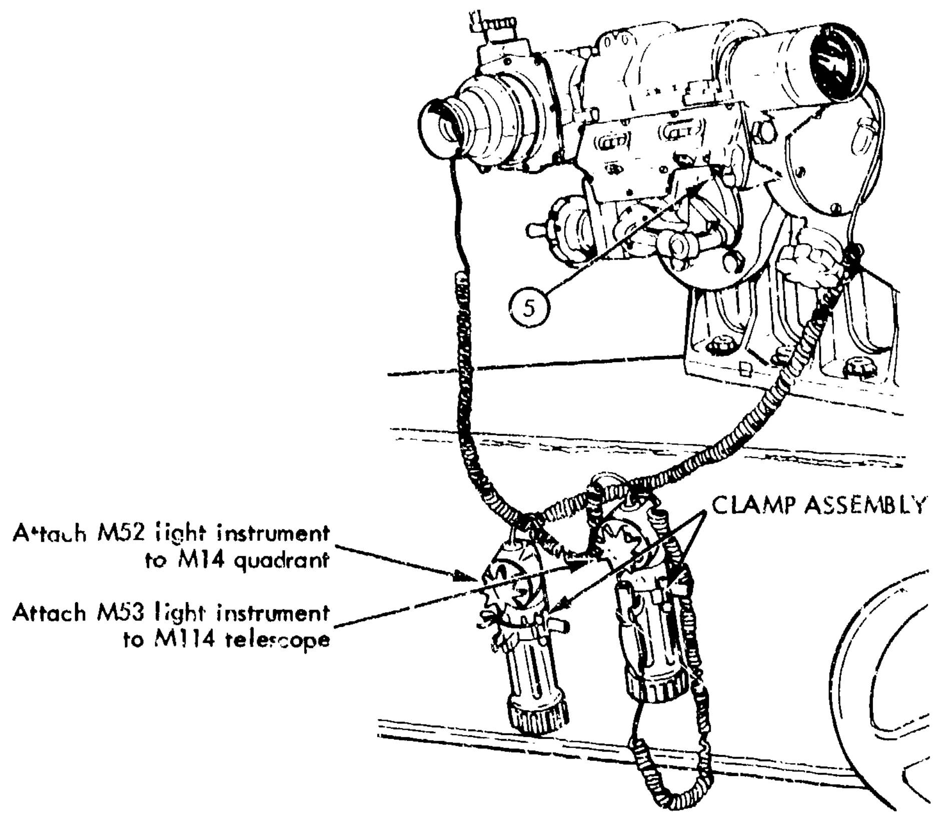


Figure 4-44. Night lighting device emplacement for the M14/M114.

(2) Remove the elbow telescope from the stowage chest and insert it into the M14 fire control quadrant, making certain that the locating key ① engages in the slot.

(3) Fasten the latch ② as shown in the insert to figure 4-43.

(4) Perform required before-operation PMCS.

(5) Set the gunner's aid counter ③ to 0 and the elevation counter ④ to 300.

(6) Level the elevation quadrant.

(7) Make sure that the elbow telescope eyepiece is perpendicular to the weapon tube. The eyepiece can be rotated 3200 mils by releasing the latch ② and pulling the telescope to the keyway.

(8) If you have radioactively illuminated fire control instruments, be aware of the warning on the inside front cover of the user's manual.

(9) If you do not have radioactively illuminated fire control instruments, install the M52 and M53 lighting instruments as shown in figure 4-44.

(10) Adjust the rheostats as required for proper reticle illumination.

(11) The toggle switch (⑤ fig 4-44) controls the lights for the elevation and gunner's aid counters.

4-22. M102 Fire Control Instrument Maintenance Problem Areas

There are four primary areas of interest involving maintenance problem areas on the M102 fire control and related equipment (fig 4-45 and 4-46).

a. The first problem area involves the M113 panoramic telescope. As a result of poor quality control, improper torque values were applied during the fire control equipment rebuild program (item 1, fig 4-45). These improper torque values caused play of 1 to 3 mils in the heads of a significant number of M113 panoramic telescopes. Quality control measures have been strengthened to correct this deficiency; however, faulty instruments remain in the field both at the user level and at higher support levels.

(1) As a user, you need to inspect the instruments on hand to verify their serviceability. If play exists, turn the M113 panoramic telescope in for repair. Additionally, you should inspect your float items, if issued, because these may also be defective.

(2) To determine if play exists in the head of an instrument, aline the telescope crosshair on a well-defined distant aiming point while the instrument is mated to the weapon mount. Grasp the telescope head and gently attempt to rotate it

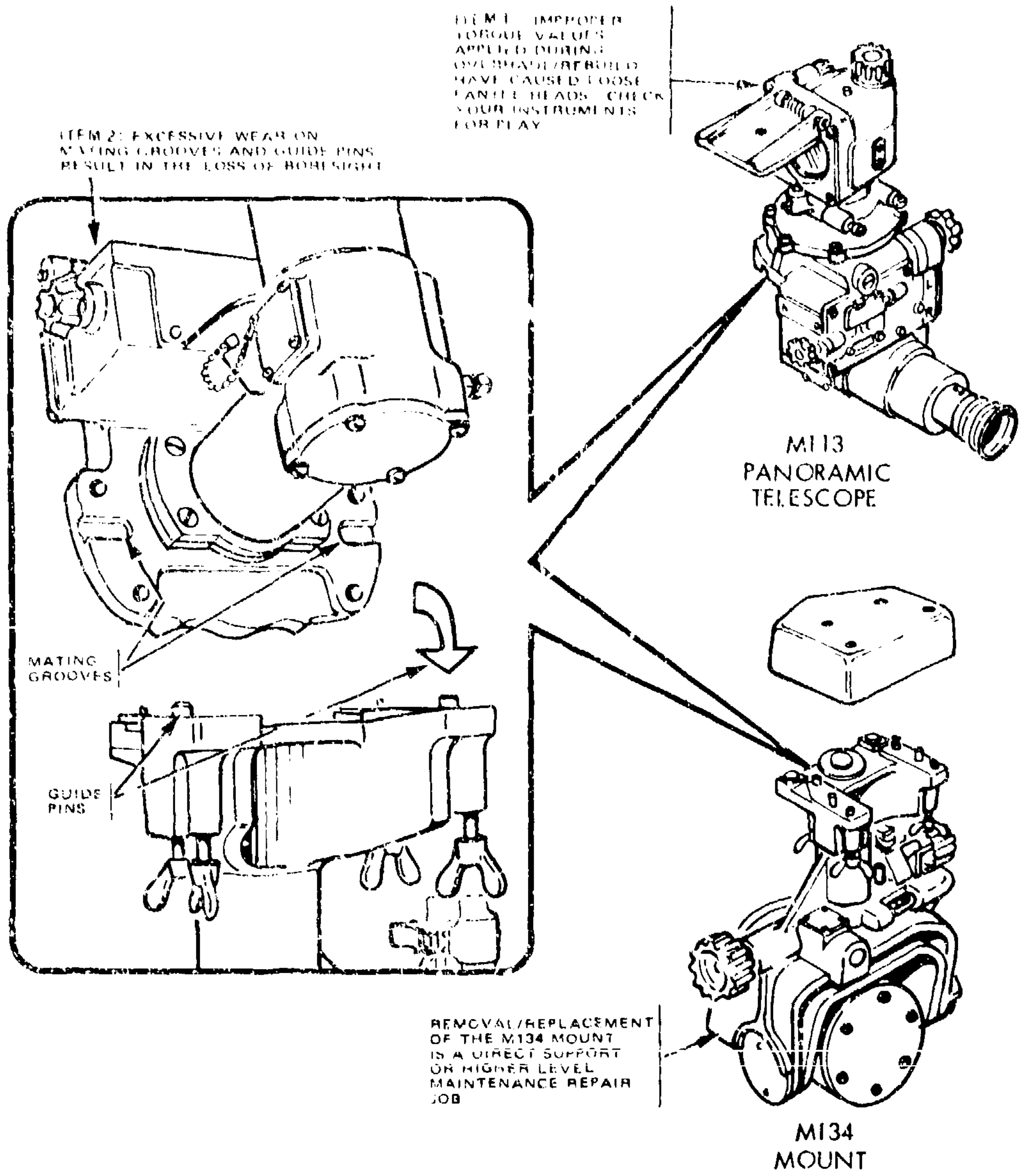


Figure 4-45. M134 panoramic telescope mount with M113 panoramic telescope.

in either direction. Release your grasp on the instrument and verify the crosshair alinement. If the crosshair has moved more than 1 mil from its original alinement, the telescope is defective. Turn in the instrument to direct support; indicate on the DA Form 2407 that the telescope head is loose.

Note. A prerequisite to any inspection of M102 fire control instruments is to insure that there is no obvious defect in any item when it is installed on the weapon. Check the M134 mount for looseness or wobble in the mechanism. The M113 panoramic telescope must be tightly secured to the M134 mount by the four wingnuts.

b. The second problem area involves both the M113 panoramic telescope and the M134 panoramic telescope mount. Standard procedures for M102 march order and travel call for removing the panoramic telescope and storing it, with the elbow telescope, in the carrying case on the wishbone trail. This continual removal and replacement has caused excessive wear on the M134 mount guide pins and in the mating grooves of the M113 panoramic telescope (fig 4-41). The result of this wear is a loss of boresight during firing operations. The amount of loss of boresight varies, but investigations have uncovered losses as great as 5 mils in deflection.

(1) To correct this wear problem, the M134 mount will be modified to replace the guide pins with a key configuration. The key configuration will increase the bearing surface between the M134 mount and the M113 panoramic telescope and eliminate the excessive wear between the two components. This modification will be applied on an attrition basis.

(2) At the present time, each user should inspect the M113 panoramic telescope grooves and the M134 mount guide pins for wear.

Note. Also inspect the M134 mount guide pins to determine if they are snug. Loose pins have been found on some weapons.

(3) To determine if excessive wear exists, you should boresight the weapon immediately prior to firing in a firing position. After several rounds have been fired, boresight should be verified. If loss of boresight of over 1 mil has occured, turn the weapon in to direct support maintenance personnel for repair; indicate on DA Form 2407 that the weapon fails to retain boresight during firing.

Note. The distant aiming point method can be used to verify boresight. Additionally, you must insure that the M113 panoramic telescope is not defective because of play in the head of the instrument as indicated in *a* above.

c. The third problem area involves both the M134 mount and the M14 fire control quadrant (fig 4-45 and 4-46). Investigations have shown that during normal elevation of the M102 cannon the weapon trunnions spread, or flex. This, in turn, affects the alinement of the M134 and M14, which are mated to the trunnions by adapter plates. The spreading, which is inherent in the weapon system, is due to the lightweight aluminum carriage and cannot be corrected except by major redesign of the weapon system. However, it has been determined that the misalinement caused by the spreading trunnions can be compensated for by adjustment of the M134 mount and M14 fire control quadrant level vials when the mounts are mated to the weapon. This operation, which has been termed "marrying" the mounts to the weapon, must be accomplished under stringent test conditions.

(1) The primary problem of the M134 and M14 misalinement has been overcome by the operation of marrying the mounts to the M102. This operation must be performed only at direct support or higher level maintenance. *Thus, you, the user, are no longer allowed to remove or replace the M134 mount or M14 fire control quadrant.* Change 7 to TM 9-1015-234-12 deleted the user's authority to remove or replace these items Change 8, June 1973, deleted the removal/replacement information from the technical manual text.

(2) The problem now is to insure that everyone gets the word. *Do not remove or replace the M134 mount or M14 fire control quadrant at your, the user, level.* If uncertainty exists as to when or where these items were last removed from or installed on your weapon, conduct fire control alinement tests prescribed in TM 9-1015-234-12. If the weapon passes the tests, the mounts are properly alined. If the weapon fails to meet the test tolerances, turn the weapon in to direct support maintenance personnel; indicate on the DA Form 2407 that the weapon failed the fire control alinement tests.

d. The final maintenance problem area involving M102 fire control and related items is that of moisture buildup in the M113 panoramic telescope, the M114 direct fire elbow telescope, and the M1 infinity reference collimator. This moisture buildup causes these instruments to fog and makes

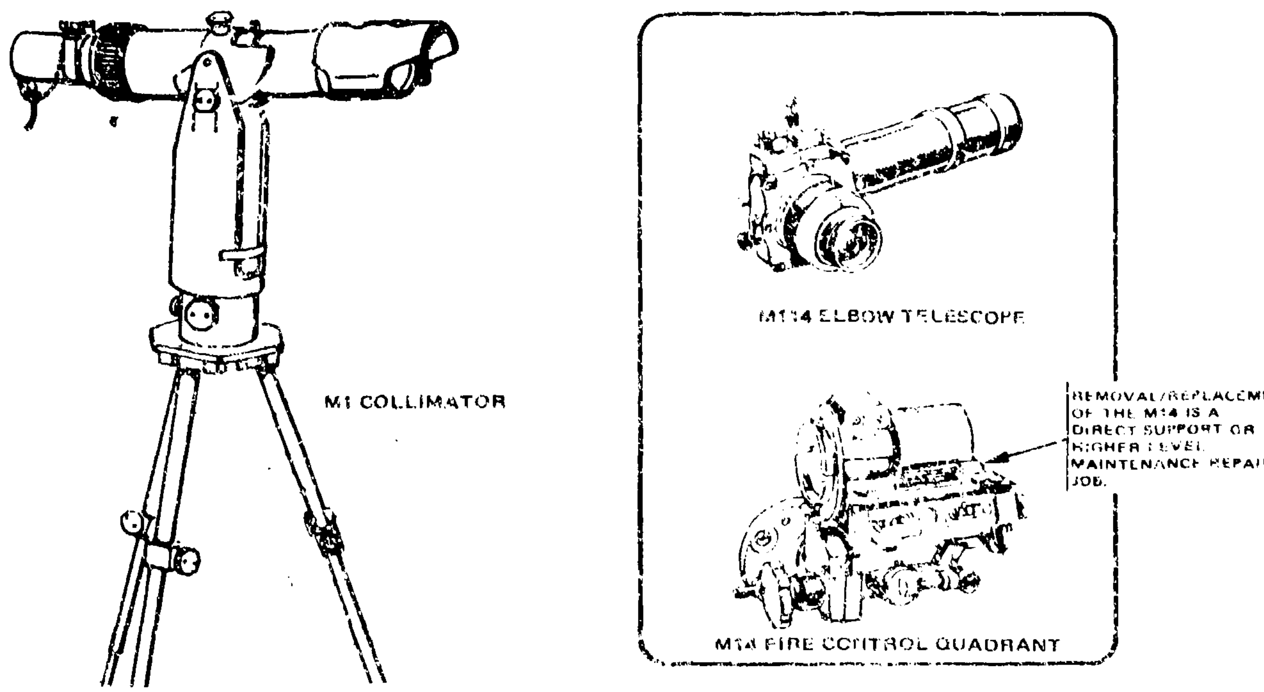


Figure 4-46. M14 fire control quadrant with M114 elbow telescope and M1 collimator.

it difficult or impossible to read the counters or obtain proper aiming point alinement through the optics.

(1) Investigations have shown that in most instances the moisture buildup is a direct result of the user failing to properly purge the instruments or to insure that adequate nitrogen pressure is maintained. However, in some high-humidity climates, even though proper preventive maintenance is performed, condensation still builds up in the instruments. Frankford Arsenal Development Engineering Laboratory has been directed to initiate investigations into this problem area to determine if additional sealing or waterproofing of these instruments is necessary or feasible.

(2) In the meantime, your organizational maintenance personnel can reduce the problem by insuring that the fire control instruments are purged and charged every 90 days or when condensation is evident in the instruments. TM 750-116 (Oct 71) prescribes the procedures for purging and charging fire control instruments and is the authority for requisitioning the necessary items.

4-23. Boresighting

a. In order of preference, there are three methods of boresighting the M102 howitzer.

(1) M140 alinement device.

(2) Distant aiming point.

(3) Test target.

b. For detailed procedures on boresighting, see pages 2-34 through 2-42 of TM 9-1015-234-10.

4-24. Product Improvement Package

As part of a continuing program, the US Army Armament Command is developing an $8,297,000 product improvement package (PIP) for the M102 howitzer. The improvements are based on data collected during the period of extensive usage of the weapon system in the Republic of Vietnam and are divided into four subproposals.

a. The first subproposal addressed the limited recoil oil supply of the M37 recoil mechanism. Because of critical weight limitations during development, the recoil mechanism was designed with a marginal oil reserve. When the M102 was fielded in Vietnam, where temperatures fluctuated as much as 70° within a day, recoil oil had to be drained from a hot weapon and replaced after the weapon had cooled. This portion of the PIP calls for modification of the recoil internal components to provide a larger oil reserve.

b. The second subproposal covers the M37 recoil hardware. The M37 recoil has a history of high demand for replacement parts, maintenance time, and overhaul requirements. A study is presently being conducted to isolate, analyze, and redesign high-failure components. The goal is to double the present 6,000-round average life of the recoil mechanism. The improvement is scheduled to be accomplished during overhaul in the fiscal year 1976 time frame.

c. The third subproposal is designed to improve the breech mechanism of the M137A1 cannon. Through the past years, four problem areas involving the breech have been identified: (1) The bevel gears, (2) the extractors, (3) the firing mechanism, and (4) the counterbalance spring. This improvement is projected to increase reliability, and to reduce maintenance problems of the breech by simplifying these components.

d. The fourth subproposal covers self-illumination of the M102 fire control and related items. Because the current night lighting system on the M102 is the source of numerous problems, the improvement is designed to eliminate the entire system by providing individual radioactive illumination sources for fire control digital counter, reticles, and leveling vials. Additionally, radioactive illumination will be applied to the collimator and the gunner's quadrant. New radioactive aiming post lights and the M140 alinement device used for checking boresighting (fig 4-47) are also included in the PIP. The first converted sets of these M102 fire control items were fielded in calendar year 1976.

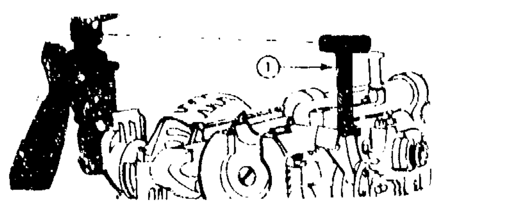


Figure 4-47. M140 alinement device used for checking boresighting.

Section VI. SUMMARY

4-25. Review

The four major components of the 105-mm howitzer M102 are the carriage, barrel and breech assemblies, recoil mechanism, and fire control equipment. In order for the weapon to function properly and deliver accurate fire, each component must be kept in proper working condition. It has been the purpose of this chapter to give a general insight into the characteristics, nomenclature, functioning, and maintenance of the major components of the weapon. For more detailed information, see FM 6-70, TM 9-1015-234-12, and LO 9-1015-234-10.

U. S. ARMY
FIELD ARTILLERY SCHOOL
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CHAPTER 5

155-MM HOWITZERS M114A1 AND M114A2, TOWED

Section I. GENERAL

5-1. References

TM 9-1025-200-12; LO 9-1025-200-10; and FM 6-81.

5-2. Introduction

The M114A1/M114A2 155-mm howitzer is a medium towed field artillery weapon (figs 5-1a and 5-1b) of the infantry and airmobile divisions. A 155-mm battalion consists of three batteries of six weapons each. The 155-mm howitzer weighs 12,700 pounds and fires a 95-pound separate-loading HE projectile to a maximum range of 14,600 meters. The prime mover for the weapon is a 5-ton cargo truck. The main difference between the M114A2 (fig 5-1a) and the M114A1 (fig 5-1b) is in the riflery. The M114A2 has a 1 in 20 twist vice a 1 in 25 like the M114A1. This change has made the M114A2 compatible with all projectiles and propelling charges used with the M109. The M114A2 has a machined groove approximately 4 inches behind the muzzle which (fig 5-1a) is the only physical difference between it and the M114A1.

Section II. CARRIAGES M1A1 AND M1A2

5-3. Trails, Trail Lock, and Spades

a. Trails. The trails are tapered, welded-steel, box griders with plates and rib supports welded to the inside surfaces to provide reinforcement.

(1) The trails are used to connect the weapon and the prime mover (normally a 5-ton truck) when traveling to stabilize the weapon in the firing position; and to carry the spades, aiming posts, six rammer staff sections, sledge hammer, weapon handling bars, spade keys, firing jack float, and loading tray.

(2) The trails (fig 5-2) are hinged to the bottom carriage; when they are spread, each trail forms a 30° angle with the center of the carriage. On each trail are arms with shoulders, which contact wedge-shaped stops welded to the top and bottom of the bottom carriage to control maximum spread.

(3) The trails are equipped with trail handles to assist in moving the weapon.

(4) When the top carriage is properly centered, plates welded to the top trail hinges contact steps welded to the bottom plate of the top carriage. This prevents movement of the top carriage during travel.

(5) The rear end of each trail has a smooth bottom surface with a recess for attaching a trail spade lug. On these end surfaces is a square hole for inserting the spade key, which secures the trail spade in position.

b. Trail lock. The trail lock holds the trails in the closed position for traveling.

(1) The trail lock is a toggle-type clamping mechanism and is operated by the trail lock handle.

(2) The trail locking retainer pin is inserted into a hole in the projecting ledge of the left trail as an additional safety device to prevent the trails from spreading during travel.

(3) The trail lock is adjusted by loosening the trail lock link jamnut and turning the trail lock link ½ turn at a time, either right or left, depending on the adjustment needed. When the trail lock is properly adjusted, a slight downward pressure should force the lock handle down and cause the trail lock hook to engage with the trail lock link.

c. Spades. The spades, being two of the three points of suspension, absorb the force of recoil and transmit the shock of firing to the ground. They limit the amount of displacement of the weapon. For greater clearance of the rear of the weapon

*Supersedes HB-5 WCXXWS, Dec 81.

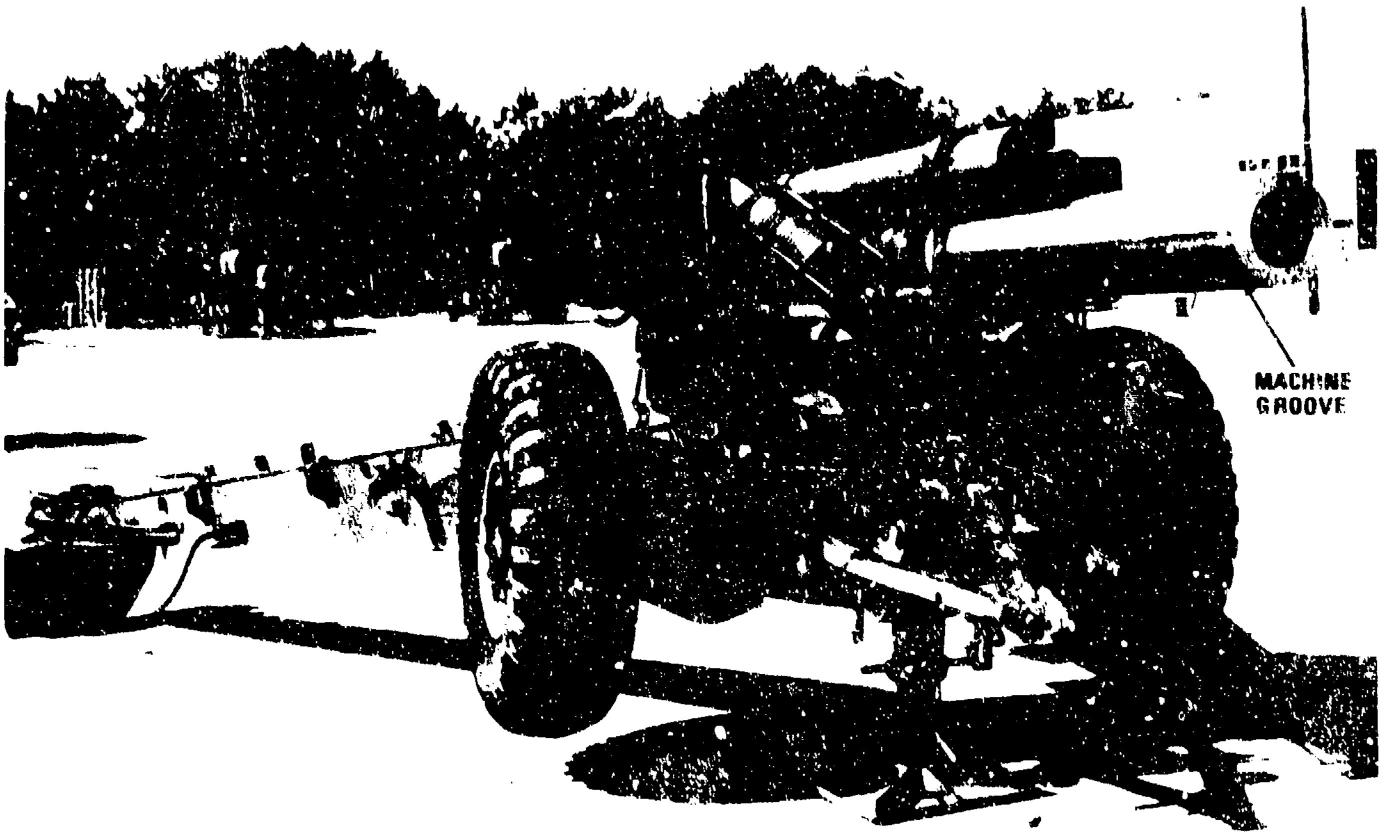


Figure 5-1a. 155-mm howitzer, M114A2, towed.

during travel, the spades are removed from the ends of the trails and placed in the traveling position on the trails. Handles on the spades are used for lifting and carrying the spades from the traveling position on the howitzer to the firing position at the end of each trail.

(1) In the firing position, the trail spades are attached to the underside of the trails by engaging the spade lugs in the recesses of the trails. The spades are secured to the trails by means of the spade keys. A spade alignment lug is welded to the side of the spade that, when flush with the side of the trails, will align the spade key socket.

(2) During travel, the spades are carried in brackets on the outer surface of the trails.

(3) During travel, the spade keys are carried in the key carrier on the outer surface of the left trail.

d. Maintenance.

(1) The trail hinge pins should be lubricated weekly with lubricating oil, general purpose (PL). The waste material should not be removed

(2) The trail lock should be lubricated weekly with PL.

(3) The drain plugs in the trails should be removed weekly to allow the trails to drain. If the trails are not provided with drain plugs, notify the support maintenance personnel.

Note. Maintenance of this component and of all other components of the 155-mm howitzers M114A1 and M114A2 described in subsequent paragraphs of this chapter will include lubrication of the item concerned. Lubrication of all components will be performed in accordance with Lubrication Order 9-1025-200-10.

5-4. Brakes

a. General. When the howitzer is being towed by the prime mover, the carriage brakes are actuated by compressed air furnished by an air compressor on the prime mover and conducted to the carriage by the service and emergency air brake lines. The carriage brakes are controlled by the brake pedal of the prime mover. The brakes can also be controlled individually by hand levers mounted on the carriage.

b. Principal parts. The principal parts of the air brake system are two air lines (service and emergency), two air filters, an emergency relay valve, an air tank, two air brake diaphragms, two slack adjusters, two handbrake levers, and two brake actuating mechanisms (fig 5-3).

c. Air lines. The air lines consist of air hoses and tubes interconnecting the various units of the brake system. The service air line leads from the

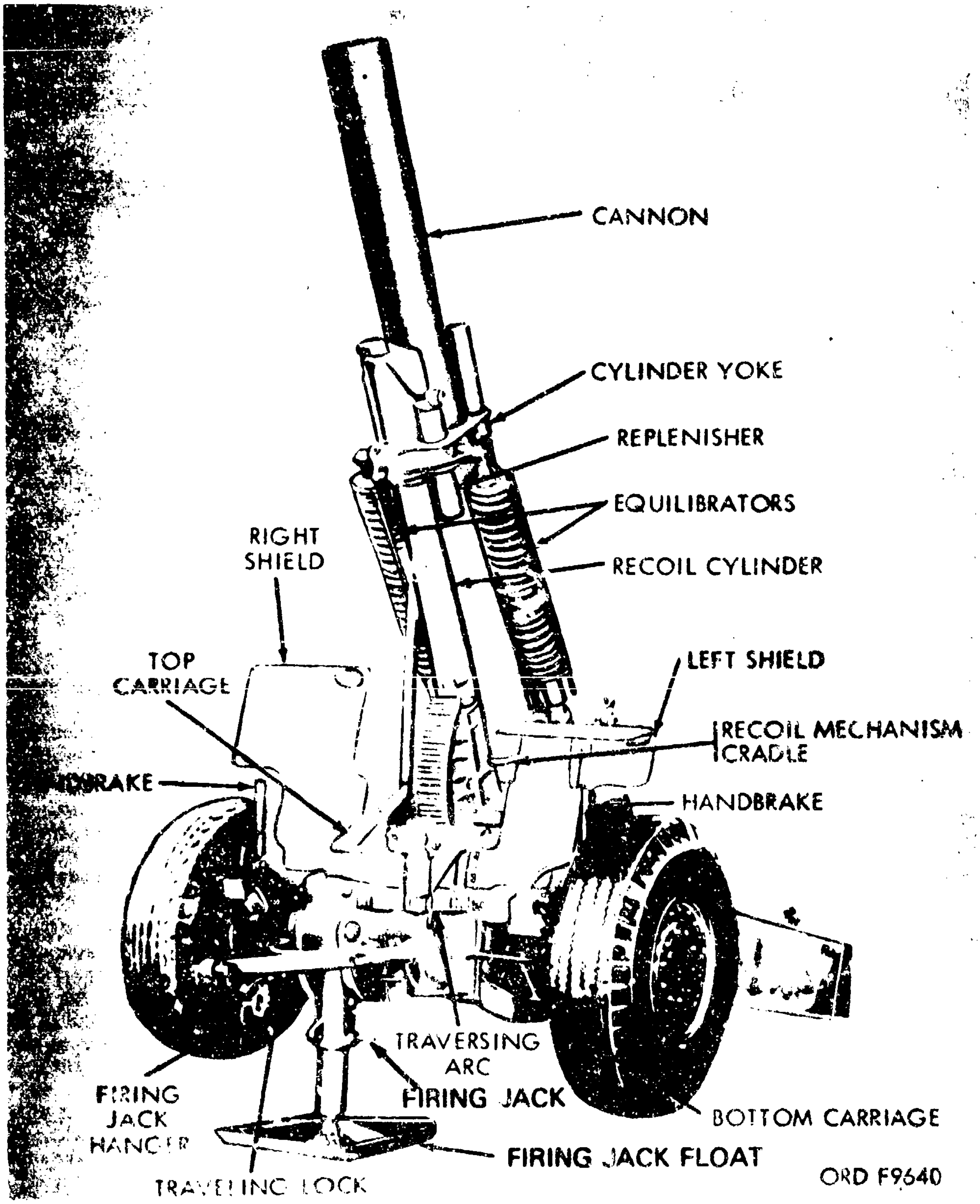


Figure 5-1b. 155-mm cannon and 155-mm howitzer carriage M1A2—firing position, maximum elevation—left front view.

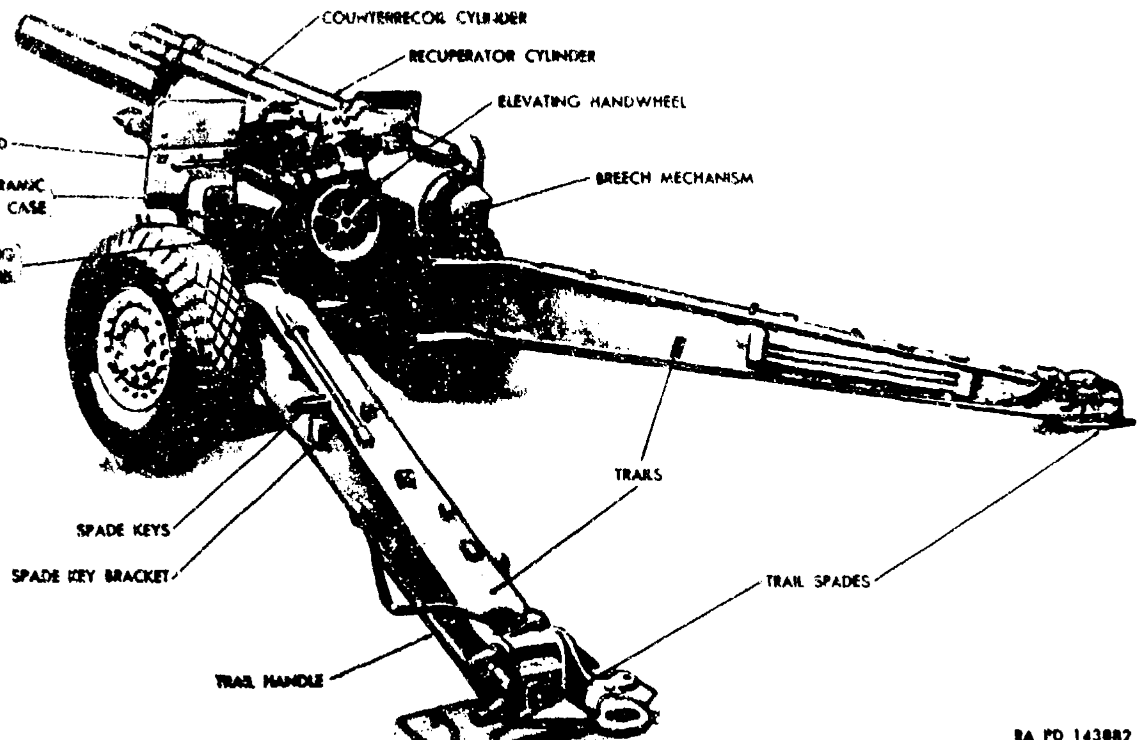


Figure 5-2. 155-mm cannon M1 and 155-mm howitzer carriage M1A1—firing position—left rear view.

prime mover to the top of the emergency relay valve (fig 5-3) and controls all service brake applications. The emergency air line leads from the prime mover to the lower part of the emergency relay valve. Its purpose is to keep the air tank charged at all times. The tank, in turn, supplies the compressed air which actually makes all brake applications. Dummy couplings on the outer sides and near the rear ends of the trails are provided to retain the air brake hose couplings and to exclude dirt when the couplings are not connected to the prime mover.

d. Air filters. The air filters (fig 5-4) are mounted on the trails and connected in the service and emergency air lines to filter water and dirt from the air before it enters the emergency relay valve. Drain plugs in the bottom of the filters permit draining accumulated water and dirt.

e. Emergency relay valve. The emergency relay valve (fig 5-3) is mounted on the rear of the bottom carriage and is protected by a guard. The valve is a combined relay valve (which speeds up the brake action from the prime mover to the carriage) and emergency valve (which controls automatic brake application in the event the carriage breaks loose from the prime mover).

f. Air tank. The air tank (fig 5-3) is mounted on the rear of the bottom carriage and is equipped with a drain cock for draining moisture and for relieving pressure prior to firing or when the brakes become locked. It stores compressed air both for service and emergency brake applications.

g. Air brake diaphragms. Two air brake diaphragms, one for each brake, convert the energy of the compressed air into the mechanical force necessary to operate the brake mechanisms. The air hose connection is protected by the brake diaphragm guard (fig 5-5).

h. Slack adjusters. The slack adjusters serve as levers to connect the brake mechanisms with the air brake diaphragms. They also provide a convenient method of brake adjustment.

i. Handbrake levers. A handbrake lever is provided for each carriage brake. It is pivoted on the brake camshaft just inside the wheel. The handbrake lever is positioned under the slack adjuster so that, when the lever is pushed to the rear, it lifts the slack adjuster, causing the brake camshaft to rotate and apply the brake. A handbrake lever latch, controlled by a spring-loaded hand grip lever, engages the teeth of the handbrake lever latch plate (rack) and retains the handbrake lever in position when the brake is applied.

j. Brake actuating mechanisms. Each brake actuating mechanism consists principally of the brakeshoes, brake camshaft, and brakeshoe springs. The brakeshoes and camshaft are

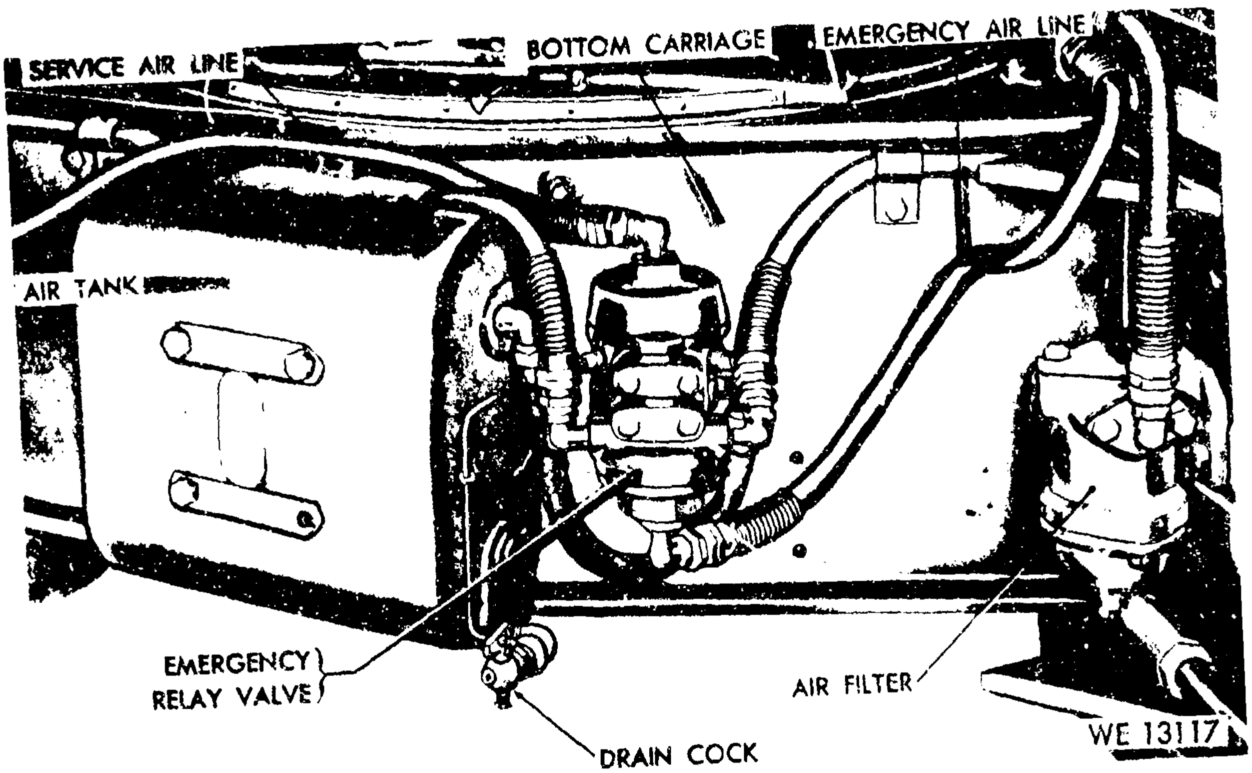


Figure 5-3. Air brake components.

attached to the bottom carriage by means of a brake shield. Each brakeshoe pivots at one end of the brake anchor pin, and both are expanded against the brakedrum by the rotation of the camshaft when the brakes are applied. When the brakes are released, the camshaft releases the shoes, which are then pulled away from the drum by the brakeshoe springs.

5-5. Care and Maintenance of the Air Brake System

a. Test emergency brake application. Test the emergency brake application daily by closing the emergency air line cutout cock on the prime mover and disconnecting the emergency air brake hose coupling from the prime mover, if the tactical situation permits coupling the weapon to the prime mover for this test. If the brakes do not apply

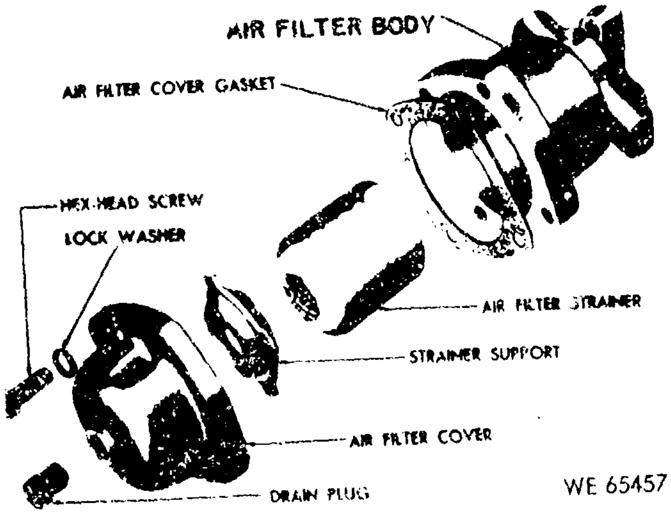


Figure 5-4. Air filter—exploded view.

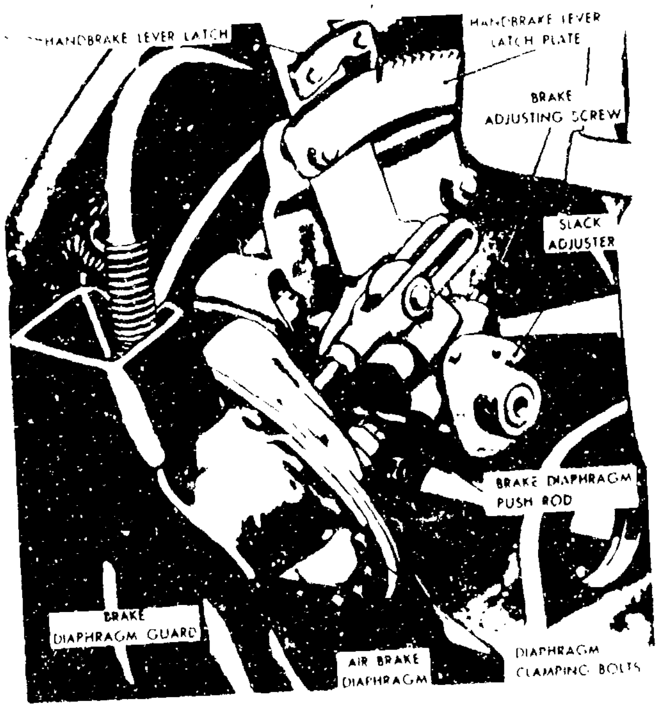


Figure 5-5. Air brake diaphragm and slack adjuster.

automatically, notify support maintenance personnel.

b. Drain water from air filters and air tank.

(1) Drain accumulated water weekly from the air tank and air filters. In cold weather, drain these units every 8 hours of continuous travel. If the water freezes in the unit, apply sufficient heat to melt the ice and drain the water, taking care not to damage the air brake hoses.

Note. Do not drain the air filters or air tank while the air brake system is under pressure. If draining is performed during travel, temporarily disconnect the air brake hose couplings from the prime mover.

(2) To drain the air filters, remove the drain plug from the bottom of the air filter cover, allow the water to drain, and install the plug.

(3) To drain the air tank, open the drain cock at the lower right of the air tank long enough to expel all moisture and then close the drain cock.

c. Clean air filters. Clean the air filters bimonthly by disassembling the filters, brushing off accumulated foreign matter, and washing the air filter strainers and air filter cover and strainer support with drycleaning solvent or volatile mineral spirits. Allow the parts to dry thoroughly and assemble the air filters.

Note. Do not use compressed air to dry the air filter strainer.

d. Adjust air brakes.

(1) To clean the brakes you must have the wheels off the ground, spread trails only enough for stability but still allow air lines to be connected, then lower firing jack.

(2) Check the travel of the brake diaphragm push rods monthly by measuring the distance each push rod extends from its air brake diaphragm with the brakes released and with the brakes applied. If the push rod travel is less than ¾ inch, or more than 1 inch, adjust the brakes. Also, when the handbrake latch is positioned in the third notch of the rack, the brake should be fully engaged.

(3) Spread the trails to their fully open position and raise the carriage on the firing jack until the wheels are clear of the ground. Release the carriage handbrakes.

(4) Rotate the wheel and, at the same time, turn the brake adjusting screw on the slack adjuster until the brake stops the wheel from turning. Then back off the adjusting screw until the wheel turns freely.

(5) Remove the wheel and tire assembly and insert a thickness gage or feeler through the inspection hole in the brakedrum to check the clearance between the brake lining and the brakedrum. Rotate the drum, taking care not to twist or damage the gage. The clearance between the lining and drum should not be less than 0.025 inch or greater than 0.050 inch. If it does not fall within these limits, readjust the brakes as in (3) above.

(6) When the brakes are properly adjusted, install the wheel and tire assembly.

(7) If adjustment cannot be made using steps (1) through (6) above, turn into direct support maintenance.

e. Test for air leakage.

(1) Test the entire air barke system for air leaks bimonthly or when a leak is evidenced by weak or intermittent brakes by applying soapsuds, with the system under pressure, to all air hoses, air brake hose connectors and other hose connections, air brake hose couplings, air filters, and air brake diaphragms and to the emergency valve and air tank. Any leak causing a soap bubble 2 inches in diameter in 5 seconds is considered serious. If it cannot be remedied by the methods herein outlined or if a leak is found in any air brake hose, notify ordnance maintenance personnel.

(2) Apply soapsuds to the edges of the air brake diaphragms and around all diaphragm clamping bolts. If a leakage of air is evidenced by the formation of a soap bubble, tighten all clamping bolts in such sequence that successively tightened bolts are positioned on the diaphragm as nearly opposite each other as possible. If this fails to stop the leak, notify ordnance maintenance personnel.

(3) Test all air brake hose connectors for leakage. If a leak occurs at the joint between the connector body and connector nut, tighten the nut. If this does not correct the leak, notify ordnance maintenance personnel.

(4) Apply soapsuds to the air brake hose couplings. If a leak occurs at a coupling and the coupling is securely in position, detach the coupling from the prime mover, remove the air brake hose coupling packing ring, and replace it with a new one.

(5) Apply soapsuds to the joint between the air filter cover and the air filter body. If a leak is evident, tighten the hexagon head screws holding the cover to the body. If this fails to stop the leak, notify ordnance maintenance personnel.

(6) Apply soapsuds to all joints and connections on the air tank and emergency relay valve. If any leakage is found, notify ordnance maintenance personnel.

f. Lubricate. Lubricate as prescribed in the lubrication order.

g. Check tire pressure. Keep the pressure at 50 pounds in each tire. A tire that is soft will have more road contact and will cause the other tire to skid sooner.

5-6. Wheels, Hubs, and Tires

a. Wheels. The early model 155-mm howitzer wheel consists of a wheel disk and rim, a wheel tire rim, and 18 wheel ring retaining nuts. The later model wheel consists of a wheel disc and rim and a side rim. The wheel is held in place by 10 nuts. The studs for these nuts are in the wheel hub and are inscribed with the letters "L" or "R" to indicate the type of threading on that stud.

b. Hubs.

(1) Each hub is supported on the axle spindle by two tapered roller bearings.

(2) Grease retainers prevent grease from leaking into the brakedrum.

(3) Each hub has 10 mounting bolts for securing the brakedrum.

c. Tires. Each tire assembly consists of a 14.00 × 20 tire, a 14.00 × 20 tire tube, and a tire bead lock. When the tire is mounted on the wheel, the bead lock holds the tire beads against the rear wheel disc bead and the outside ring, which serves as the outer wheel disc bead. On the early model, the outside ring is secured to the wheel by the 18 wheel ring retaining nuts. The outside ring of the later model wheel is a tension ring which locks behind a small front bead of the wheel disc and acts as the outer bead for retaining the tire. The correct air pressure is 50 pounds.

d. Care and maintenance.

(1) Keep tire pressure uniform.

(2) Check to insure that the tire tread depth is at least ⅛ inch and that there are no severe cuts or breaks in the tires.

(3) Repack the wheel bearings with grease, automotive and artillery (GAA), annually or if the grease is found to be emulsified after fording operations.

5-7. Firing Jack and Traveling Lock

a. General. The firing jack and traveling lock used on the M1A1 carriage of the M114 howitzer differs from that used on the M1A2 carriage (fig 5-6) of the M114A1 howitzer in the following ways:

(1) The firing jack for carriage M1A1 has a rack gear type of plunger.

(2) The firing jack for carriage M1A2 has an internal screw type of plunger (fig 5-7).

(3) The traveling lock for carriage M1A2 is equipped with a firing jack hanger (fig 5-8), whereas the traveling lock for carriage M1A1 is not so equipped.

b. Location. The firing jack on both models is attached to the front part of the bottom carriage.

c. Purpose. The firing jack supports the weight of the front part of the weapon while the wheels are off the ground and provides one point of the three-point suspension system for stability during firing.

d. Traveling lock. The traveling lock is a triangular-shaped casting which is hinged to the front part of the bottom carriage by means of the traveling lock bracket. Its purpose is to support the tipping parts of the weapon during travel.

5-8. Firing Jack (Rack and Pinion Type) For Carriage M1A1

a. Components.

(1) Rack gear plunger.

(2) Ratchet plunger.

(3) Firing jack handles.

(4) Firing jack key.

(5) Housing bottom cover.

(6) Firing jack float.

(7) Wormshaft ratchet wheel.

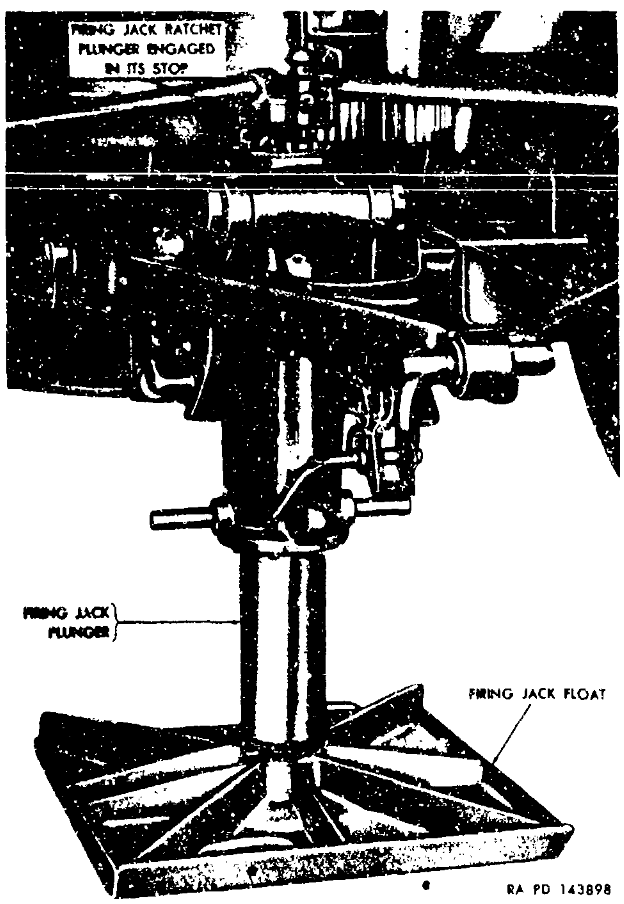


Figure 5-6. Carriage M1A2 firing jack and traveling lock—firing position.

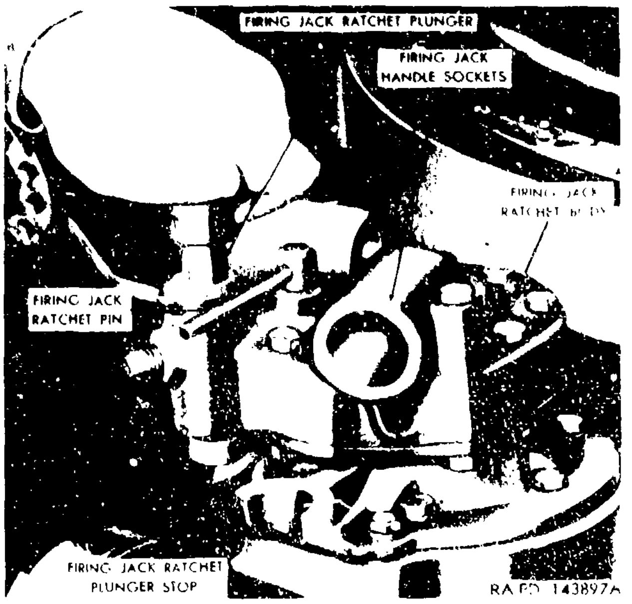


Figure 5-7. Carriage M1A2 rotating firing jack ratchet body.

(8) Wormshaft.

(9) Pinion shaft.

(10) Pinion shaft worm wheel.

b. Functioning. To lower the rack-type jack (raise the carriage on the firing jack), proceed as follows: Turn the two ratchet plungers until the arrows point downward. Remove the firing jack plunger locking lever. Lower the firing jack plunger by rotating the ratchet housings by their handles until the plunger is near the ground. Remove the jack housing bottom cover from the lower end of the jack plunger. Install the jack float on the flat-sided ball end of the plunger by placing the float socket over the ball. Secure the float by rotating it ¼ turn. Install the jack handles in the sockets provided in the ratchet cases and operate the handles vertically to raise the carriage until the plunger reaches its limits Open the keyway cover and install the firing jack key. Reverse the arrows on the ratchet plunger handles and lower the carriage until the weight is supported by the firing jack key, thereby releasing the load from the jack mechanism.

c. Maintenance. Remove the plunger and—

(1) Check for burs, rust, and dirt.

(2) Lubricate.

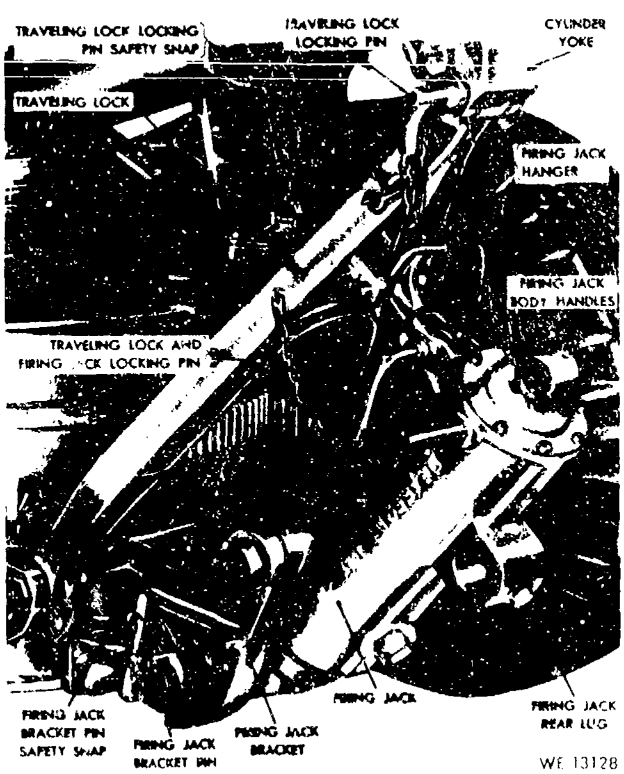


Figure 5-8. Carriage M1A2 firing jack and traveling lock—traveling position.

5-9. Firing Jack (Internal Screw Type) For Carriage M1A2

a. Components.

(1) Firing jack plunger.

(2) Firing jack ratchet body.

(3) Firing jack ratchet plunger.

(4) Ratchet plunger stop.

(5) Firing jack ratchet pin.

(6) Firing jack handle sockets.

(7) Firing jack handles.

(8) Traveling lock and firing jack locking pin.

(9) Firing jack hanger.

b. Functioning. To lower the screw-type jack (raise the carriage on the firing jack), proceed as follows: Remove the firing jack bracket pin from the bracket. Remove the traveling lock and firing jack locking pin. Raise the jack to unlatch the firing jack hanger. Lower the jack to the vertical position and secure it in the firing jack bracket by reinstalling the bracket pin. Place the jack float under the jack. Remove the traveling lock locking pin. Lower the traveling lock and elevate the weapon. Move the ratchet pin toward the ratchet plunger as far as it will go. Rotate the ratchet body clockwise to lower the jack plunger near the ground. Secure the float to the flat-sided ball end of the jack plunger by placing the float socket over the ball and rotating the float ¼ turn. Install the jack handles in the sockets of the ratchet housing and operate them in a horizontal plane until the plunger is fully extended. Failure to jack the howitzer to the fully raised position will preclude reaching maximum elevation. Lock the jack in the extended position by depressing the ratchet plunger until it engages the plunger stop. Make sure the ratchet pin is in its position nearest the ratchet plunger.

c. Flow of power. The power flows from the jack handles through the firing jack ratchet body to the internal screw which is housed in the firing jack plunger. The screw telescopes within the plunger, thus moving the plunger up or down.

CAUTION: If the firing jack plunger reaches the fully extended position, care must be exercised to avoid breaking the firing stop. The firing jack ratchet pin must be in its position nearest the firing jack ratchet plunger, with the ratchet plunger engaged in its stop, in order to lock the firing jack in the firing position.

d. Maintenance. Every 6 months, remove the breather element and clean it with drycleaning solvent or volatile mineral spirits. Dry and saturate the element with oil, lubricating and preservative, as prescribed in the lubrication order. Keep the firing jack plunger clean.

Note. Insure to keep the four breather parts clean at all times.

5-10. Bottom Carriage

a. Construction. The bottom carriage (fig 5-9) of the 155-mm howitzer, towed, is constructed of welded steel.

b. Purpose. The bottom carriage—

(1) Supports the weight of the top carriage and the tipping parts.

(2) Transmits firing stresses to the firing jack and trails.

(3) Provides a mount for the firing jack, traveling lock, and traversing arc.

(4) Provides a base for the trails, which are hinged to each side of the bottom carriage. (Bushing-lined bores are in each side of the bottom carriage to receive the trail hinge pins.)

(5) Serves as a base for the wheel spindles and brake mechanisms, which are attached to each side of the bottom carriage.

5-11. Top Carriage Assembly

a. Definition. The top carriage assembly consists of all parts which move in traverse and in elevation, except the shields.

b. Construction. The top carriage is constructed of welded steel. It has a circular base and two arms that extend rearward and upward.

c. Purpose. The top carriage supports the howitzer and recoil mechanism, the elevating and traversing mechanisms, the shields, and the sighting equipment. It is supported by and rotates on the bottom carriage. Equilibrator brackets are on the upper ends of the top carriage arms. The bracket for the variable recoil control rod is on the upper edge of the right top carriage arm.

d. Functioning. The top carriage is fastened to the bottom carrage by means of a pintle (fig 5-10). The pintle is a tubular projection extending downward from the center of the top carriage. It rotates in the pintle bushing of the bottom carriage and is the pivot about which the top carriage rotates in traverse. The weight of the top carriage

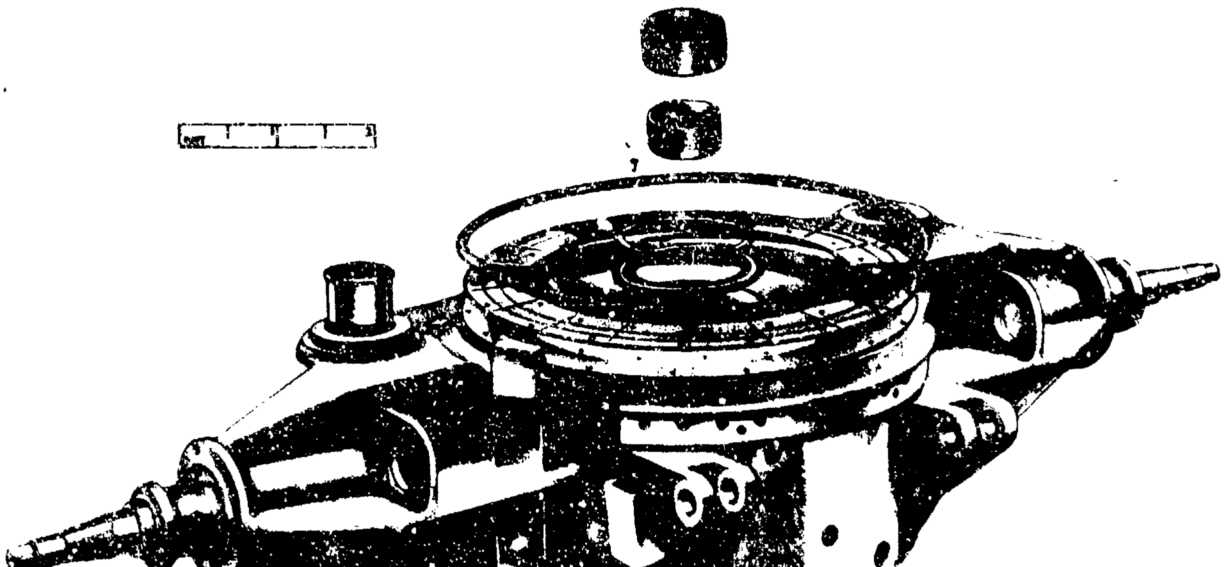


Figure 5-9. Bottom carriage.

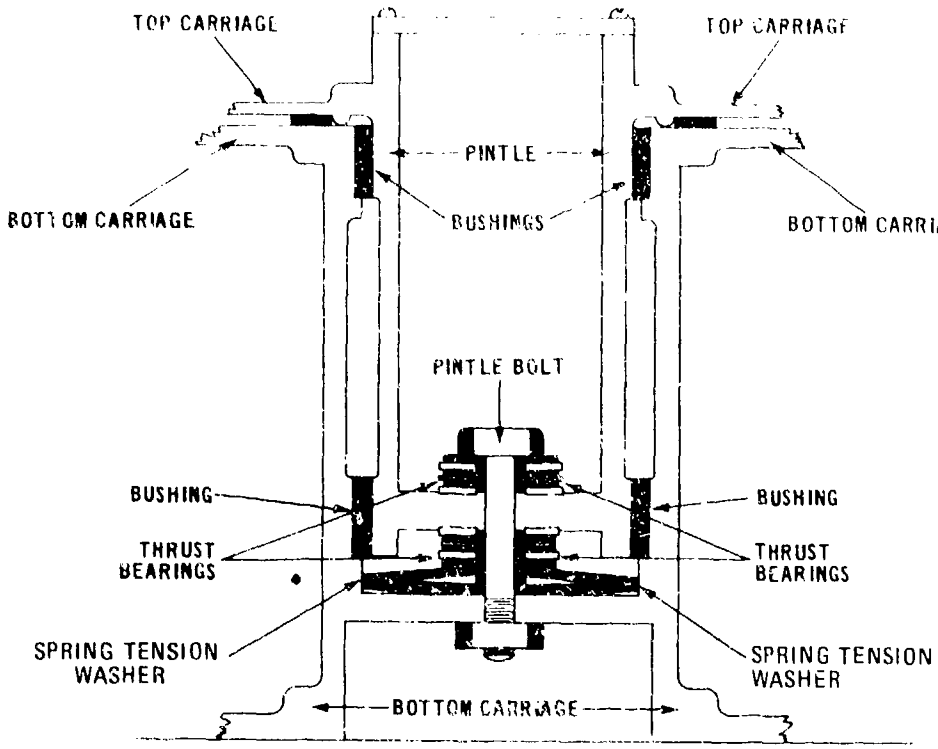


Figure 5-10. Pintle and pintle bearing schematic, 155-mm howitzer M1A1 and M1A2.

and associated parts is supported on the two belville springs, which transmit the load through antifriction bearings to the bottom carriage and raise the pintle and top carriage off the liner of the bottom carriage about 0.005 inch. When the weapon is fired, the belville springs are compressed and the load is then transmitted from the smooth underside of the top carriage to the bottom carriage. This arrangement (the top carriage being mounted on antifriction bearings) results in easy traverse and relieves the antifriction bearings of the stresses of firing.

e. Maintenance. Loose parts should be tightened and the assembly cleaned and lubricated as prescribed in the lubrication order.

5-12. Traverse

a. General. The traverse used on the towed 155-mm howitzer is the pintle type. The total angle of on-carriage traverse is 866 mils—448 mils right and 418 mils left of center. Traverse is limited by the top carriage contactng stops welded to the bottom carriage.

b. Traversing mechanism. The traversing mechanism (fig 5-11) controls the movement of the weapon in azimuth and is of the arc and pinion type, employing a worm and worm wheel. The worm and worm wheel create an irreversible flow of power, thus preventing the weapon from traversing due to shock of firing. The rate of traverse per turn of the handwheel is approximately 10 mils. Turning the handwheel clockwise moves the tube to the left; turning the handwheel counterclockwise moves the tube to the right.

c. Maintenance. Check the traversing mechanism for—

(1) Ease of traverse to both limits.

(2) Burrs, damage, loose play, and need of lubrication.

(3) Loose connections.

(4) Backlash. Backlash exceeding 1/6 turn of the handwheel should be reported to direct support maintenance personnel for correction.

(5) Tightness of the safety nut on the handwheel.

(6) Handwheel handle lubrication. The handwheel handle and the arc and pinion should be oiled weekly.

Note. When operating in extremely sandy or dusty terrain, wipe the arc and pinion gears clean of all oil before traversing.

5-13. Elevation

a. General. The trunnions of the cradle are mounted in bearings on the top carriage arms and form the pivot about which the cannon rotates in elevation. The total angle through which the cannon can be elevated is from 0 to 1,156 mils.

b. Elevating mechanism. The elevating mechanism (fig 5-12) controls the movement of the

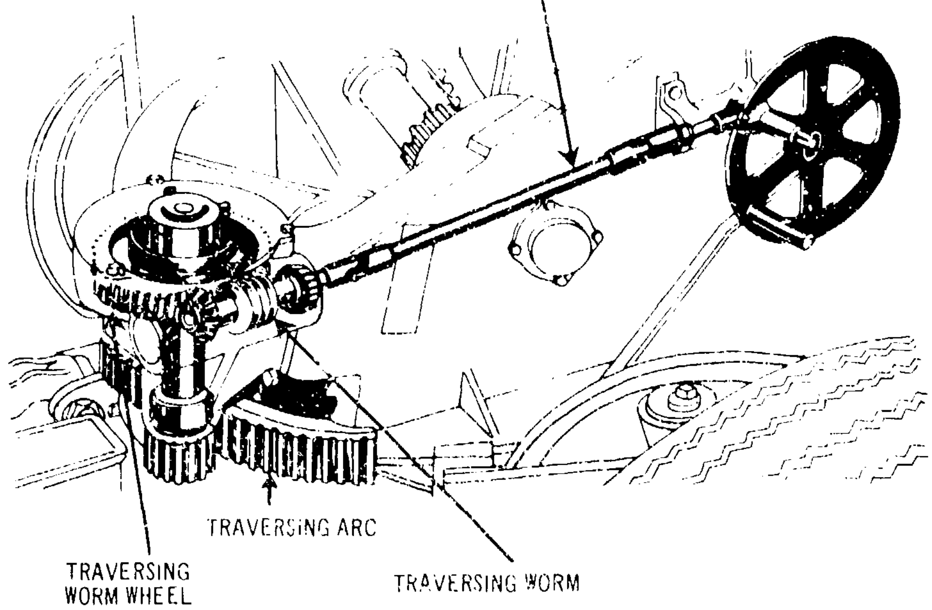


Figure 5-11. Arc and pinion type of traversing mechanism.

weapon in elevation and, like the traversing mechanism, is of the arc and pinion type, employing a worm and worm wheel. The worm and worm wheel make the elevating mechanism an irreversible type. The rate of elevation per turn of the handwheel is approximately 15 mils. Elevation is limited by stops on the ends of the arc.

c. Maintenance.

(1) Check for ease of operation in elevating and depressing the tube.

(2) Check the teeth on the elevating arc for burs or damage.

(3) Check for backlash. Backlash exceeding 1/6 turn of the handwheel should be reported to direct support maintenance personnel for correction.

(4) Check for loose connections.

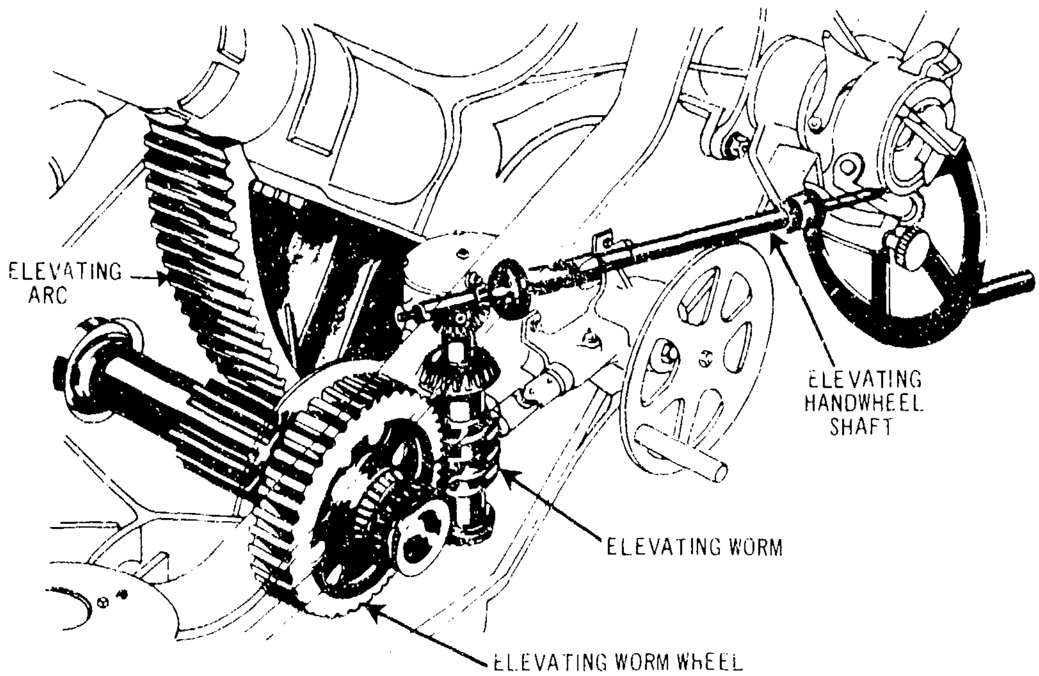


Figure 5-12. Arc and pinion type of elevating mechanism.

(5) Always maintain a light coat of lubricant on the gear trains.

(6) Check the safety nut on the handwheel (must be tight).

(7) Oil the handwheel handle and the arc and pinion weekly.

Note. When the weapon operates in extremely sandy or dusty terrain, wipe the arc and pinion gears clean of all oil before elevating.

(8) Check the function of the variable recoil cam. (The cam rotates the throttling rod in the recoil cylinder when the tube is elevated.)

5-14. Equilibrators

a. Purpose. The equilibrators compensate for the unbalanced weight of the tube caused by the rear-mounted trunnions and reduce the manual effort required to elevate the tube.

b. Type and construction. The equilibrators used on the towed 155-mm howitzer are of the open spring lifter type. The four springs in each equilibrator are assembled in pairs with one spring inside the other. The two pairs of springs are assembled to the equilibrator tube and are separated by a spacer. The spacer is built so that it may slide up and down the tube. The springs are retained at the front by the front end of the equilibrator tube and at the rear by the rear spring seat. The rear spring seat slides to compress the springs. The equilibrator guide rods are connected to the front of the equilibrator tube which, in turn, is connected to the cylinder yoke. The rear end of the equilibrator tube is fastened to the equilibrator bracket. The assembly is kept in alinement by the front end of the tube spacer and rear spring seat sliding on the tube and rods.

c. Functioning. The equilibrators connect the cylinder yoke with the equilibrator mounting brackets on the top carriage. Th springs are compressed as the howitzer is depressed, counterbalancing the muzzle-heavy weight of the tipping parts and eliminating the need for manually braking their descent. Energy is stored in the springs as they are compressed. The compressed springs expand as the howitzer is elevated, releasing energy and exerting an upward force on the weapon, thereby easing the manual effort required to elevate it.

d. Testing for proper adjustment.

(1) The equilibrators are properly adjusted when the following conditions exist:

(a) The howitzer is slightly muzzle-heavy without a round in the breech.

(b) The three adjusting nuts on each equilibrator are equally distant from the ends of the equilibrator guide rods.

(2) To test the equilibrators for proper adjustment, level the carriage and load approximately 54 pounds into the powder chamber to simulate one-half the weight of a projectile and propelling charge. Elevate and depress the tube through the full range of movement. If the tube can be elevated and depressed with approximately the same handwheel effort, the adjustment is satisfactory with respect to the balance of the weapon.

e. Adjustment of equilibrators.

(1) Make the test for proper adjustment described in *d*(2) above.

(2) If the three adjusting nuts on each equilibrator are not equally distant from the ends of the rods, adjust the nuts until each one is an equal distance from the end of the rod. This can be accomplished by removing the jamnuts and measuring or counting the number of exposed threads from the end of the guide rod to each adjusting nut.

WARNING: Under *no* circumstances will the adjusting nuts be removed fom the rods except by authorized support maintenance personnel.

(3) If more handwheel effort is required to elevate the tube than to depress it, tighten the adjusting nuts (clockwise) to increase spring compression.

Note. If one adjusting nut is turned a complete turn, more than one turn, or less than a full turn, all other adjusting nuts must be turned the same amount.

(4) If more handwheel effort is required to depress the tube than to elevate it, loosen the adjusting nuts (counterclockwise) to reduce compression.

(5) Check adjustment and, if the adjustment is satisfactory, replace and tighten all jamnuts.

f. Maintenance. Wipe the equilibrator springs, rods, and tubes weekly; clean them with a clean cloth and then apply a coat of lubricating oil, general purpose (PL).

Section III. BARREL AND BREECH ASSEMBLIES

5-15. Barrel Assembly

The barrel assembly of the 155-mm howitzer, towed, consists of the tube, breech ring, brackets, guides, and keys.

a. Construction. The tube is made from an alloy steel ingot, which is poured and then hot-forged into a cylindrical shape by means of a high-pressure press. A hole is then bored through the center, the outer surface is rough-turned, and the barrel is machined. The inside of the barrel is machined with a bore guidance system, which insures the straightness of the tube to within 0.005-inch throughout its entire length.

b. Exterior parts. The exterior of the tube is a smoothly finished bearing surface which slides in the recoil mechanism cradle and cylinder yoke during recoil. It is not tapered but is stepped up to the rear of the cylinder yoke inside the gun cover. The rear end of the tube is threaded so that the breech ring may screwed onto the tube and locked in place by key on top of the breech ring. Rotation of the tube during recoil is prevented by two recoil guide keys located on the upper right side of the tube, one which is near th breech ring and the other midway along the tube. These two recoil guide keys ride in the keyway in the upper right side of the cradle and the cylinder yoke.

c. Interior parts. The interior parts consist of the following:

(1) *Breech recess*--Houses the breechblock when the breechblock is in the closed position.

(2) *Gas-check seat*—That part of the rear portion of the bore which is tapered to receive the split rings and the gas-check pad, thereby sealing the breech (performing rearward obturation).

(3) *Powder chamber*—That portion of the bore designated to house the propelling charge.

(4) *Centering slope*—The tapered portion of the bore forward of the powder chamber, designed to cause the projectile to be centerd and seated in the bore.

(5) *Forcing cone*—The rear portion of the main bore, which is formed by tapering the rear of the lands. Its function is to gradually engage the rotating band of the projectile, thereby sealing the forward end of the powder chamber (performing forward obturation).

(6) *Main bore*—Includes all that portion forward of the centering slope; that is, the entire rifled portion of the bore.

(7) *Counterbore*—That portion of the muzzle end of the tube that is rebored for a predetermined distance so as to increase the tube diameter by removing the lands from that portion of the tube. The purpose of the counterbore is to relieve stress when the weapon is fired.

d. Characteristics. The characteristics of the barrel assembly are as follows:

(1) *Caliber*—155-mm or 6.102 inches between opposite lands.

(2) *Length of tube from the muzzle to the rear of the gas-check seat*—23 calibers or 140.336 inches.

(3) *Length of rifling (bore)*—113.10 inches.

(4) *Muzzle velocity*—564 meters per second.

(5) *Maximum chamber pressure*—31,000 pounds per square inch.

(6) *Lands and grooves*—48.

(7) *Rifling*—Uniform right-hand twist of 1 turn in 25 calibers for the M114A1 and 1 turn in 20 calibers for the M114A2.

(8) *Maximum range*—14,600 meters. 19,400 meters on the M114A2 firing the M549 RAP with charge 7.

(9) *Rate of fire*—Maximum rate is 4 rounds per minute for the first 3 minutes; sustained rate of fire is 1 round per minute.

e. Tube and breech life. Each round of ammunition fired through a cannon tube causes wear and erosion of the tube, which results in a change of the dimensions of the bore. For most gun tubes and some howitzer tubes, the extent of wear determines the remaining life of the tube. In addition to wear and erosion, each round produces metal fatigue, a process in which heat and expanding gases weaken the metal in the tube and breech and reduce the tube and breech life. The remaining life of a tube can be determined by converting the rounds fired to equivalent full charge (EFC) rounds and subtracting the EFC rounds fired from the EFC life of the tube. Table 5-1 shows the tube and breech life and the EFC factors for the M114, M114A1, and M123A1 howitzers, extracted from TM 9-1300-202-10.

Table 5-1. Condemnation Criteria for Tubes and Breech Assemblies

Major Item	Cannon Tube	EFC Life of Tube	EFC Factor	Breech Life
155-mm howitzers M114A1 and M114A2	M1	2,000 rounds	Charge 7 = 1.00 Charge 1-6 = 0.25	No retubing
155-mm howitzer M114A1	M1A1	7,500 rounds	Charge 7 = 1.00 Charge 1-6 = 0.25	No retubing
155-mm howitzer M114A2	M1A2	7,500 rounds	Charge 7 = 1.00 Charge 1-6 = 0.25	No retubing

5-16. Barrel Maintenance

a. General. The two cardinal enemies of a cannon are corrosion and erosion. Corrosion, or rust, is caused primarily by the propellant residue (primer salts) deposited in the cannon after firing. The salts absorb moisture from the atmosphere, and the solution thus formed combines chemically with the metal of the barrel to form corrosion. Erosion is a wearing away of the metal and is caused primarily by heat, pressure, and abrasion. Corrosion can be prevented; erosion cannot be completely prevented but can be retarded. Procedures for preventing corrosion, the cleaning solution and lubricants to be used, and practices for retarding erosion are discussed in *b* through *e* below.

b. Corrosion. To prevent corrosion, use the following cleaning procedures:

(1) Clean the tube with rifle bore cleaner (RBC) the day of firing and for 3 consecutive days after firing, making a total of a least four cleanings. After each cleaning, leave a coating of RBC in the tube overnight. After the fourth cleaning, if the weapon is not to be fired within 24 hours, wipe the tube dry, inspect the tube, and lubricate with oil, lubricating, preservative, medium, at temperatures above 32° F. When the temperature is below 32° F, use oil, lubricating, preservative, special.

(2) If the tube continues to sweat after the fourth cleaning, continue daily cleaning until the sweating stops.

(3) When the weapon is not being fired, clean the tube weekly with RBC and then wipe dry, inspect, ad reoil as described in (1) above.

c. Cleaning solutions.

(1) *Rifle bore cleaner.* Rifle bore cleaner, abbreviated on lubrication orders as CR, evaporates at 150° F; therefore, the tube should be cool when being cleaned. Rifle bore cleaner is not a lubricant, but it is effective as a rust inhibitor for 24 to 48 hours, and it should never be diluted.

(2) *Alternate solution.* When rifle bore cleaner is not available, an alternate solution of ¼-pound of castile or GI soap mixed in a gallon of water may be used. Hot water is preferable because it will dissolve soap more readily. The tube should be cleaned while it is still hot so that the solution may get into the pores of the metal to wash out the primer salts. The same procedures as those described in *b* above will be used in cleaning the tube with this solution except that the tube must be rinsed, dried, and lubricated after each daily cleaning.

d. Lubricants.

(1) Oil, lubricating, preservative, will be used on the front bearing surface of the tube.

(2) Oil, lubricating, preservative, medium, will be used on all other bearing surfaces in temperatures above 32° F.

(3) Oil, lubricating, preservative, special, will be used if the temperature is below 32° F.

e. Erosion. To retard erosion, employ the following practices:

(1) Use the lowest charge commensurate with the mission.

(2) Use the lowest rate of fire commensurate with the mission.

(3) Let the weapon rest 10 minutes per hour. (These rest periods are to be used for cleaning and maintenance of the weapon.)

(4) Swab the tube with cold water during lulls in firing.

(5) Use clean ammunition.

(6) Be sure that the projectile is properly rammed.

5-17. Breech Ring and Breechblock

a. The breech ring is threaded internally and screwed onto the end of the tube. It is locked in position by a key inserted through the upper forward wall of the breech ring. It supports the breech mechanism (fig 5-13) and forms the housing for the breechblock. It has lugs on the top and bottom near the front edge for attaching the counterrecoil and recoil piston rods. Quadrant seats are located on the top of the breech ring.

b. The breechblock is of the stepped-thread, interrupted-screw type. It employs the DeBang obturator device for preventing gasses from escaping to the rear. The firing mechanism M1, which is a percussion hammer type of mechanism, is used with the breechblock.

5-18. Counterbalance Assembly

a. The counterbalance assembly (fig 5-13) is a cylinder with closed ends. The cylinder contains a relatively strong compression spring and is mounted on the breech ring. The spring is compressed between the head of the cylinder and the counterbalance piston. The counterbalance is connected to the breechblock carrier hinge pin by means of the counterbalance piston rod.

b. The purpose of the counterbalance is to assist in closing the breech. It also holds the breechblock in the fully open position to facilitate loading the cannon.

5-19. Disassembly and Maintenance of the Breech Mechanism

CAUTION: Do not attempt to disassemble the breech mechanism with the breech partially or fully closed. If the mechanism is disassembled when the breech is partially or fully closed, the

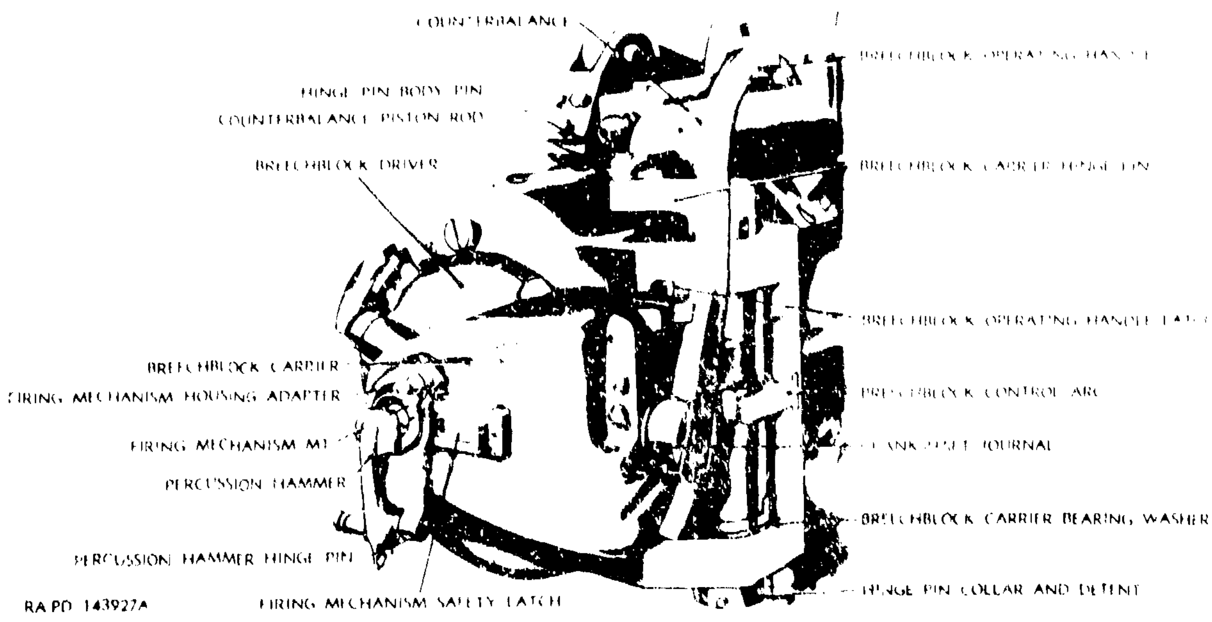


Figure 5-13. Breech mechanism—right rear view.

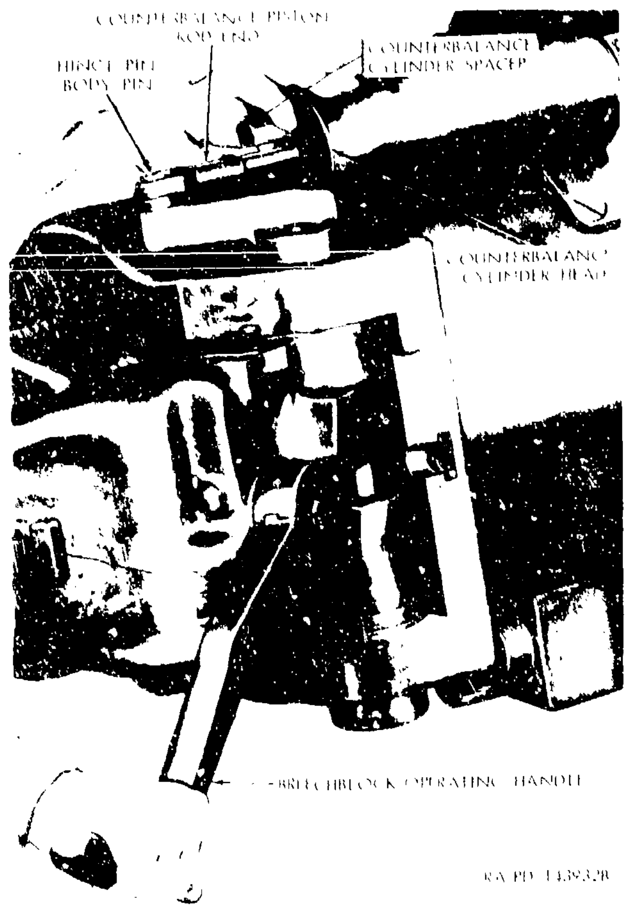


Figure 5-14. Installing the counterbalance cylinder spacer on (or removing it from) the counterbalance piston rod.

split rings and gas-check pad will drop into the threads of the breech recess, which could cause serious damage to the rings and threads and prevent opening or closing of the breech.

a. Disassembly. To disassemble the breechblock (figs 5-13, 5-14, 5-15, 5-16, and 5-17)—

(1) Remove the firing mechanism.

(2) With the breech mechanism in the closed position, remove the breechblock control arc.

(3) Open the breech and place the counterbalance cylinder spacer between the shoulder of the eye on the counterbalance piston rod and the counterbalance cylinder head. Then swing the carrier toward the closed position until the eye on the counterbalance piston rod can be lifted over the head of the hinge pin body pin.

CAUTION: When the counterbalance spacer is in position on the counterbalance piston rod, the counterbalance should be handled *only* by the cylinder body.

(4) Rotate the breechblock operating handle and swing the breech to the fully open position and remove the firing mechanism housing lock screw. Remove the socket head capscrew and then remove the safety latch stop and spring. Rotate the breechblock operating handle to the closed position and slide the safety latch and safety latch plunger to the right. Unscrew the firing mechanism housing and remove the firing mechanism housing adapter, the obturator spindle assembly, and the gas-check pad

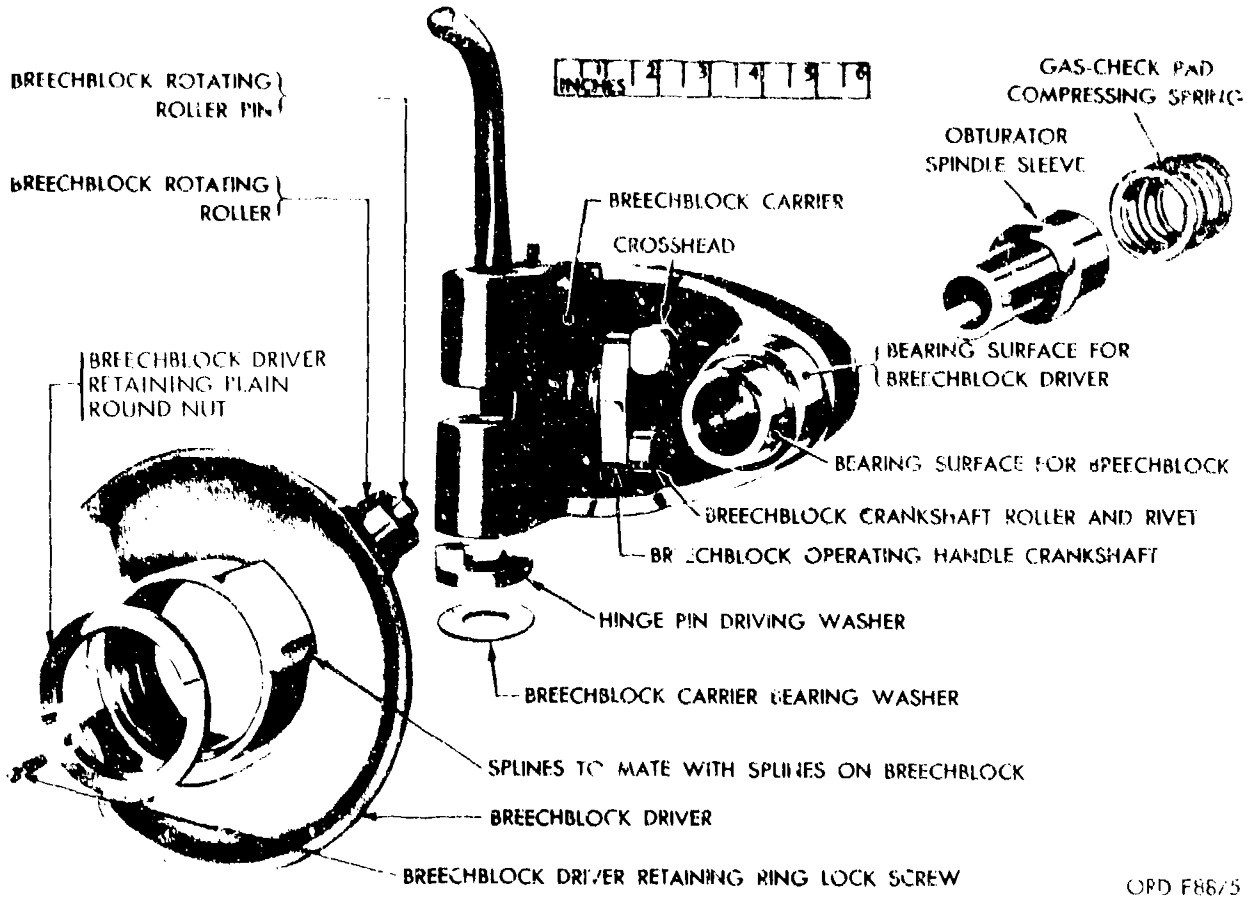


Figure 5-15. Breechblock carrier and breechblock actuating parts—exploded view.

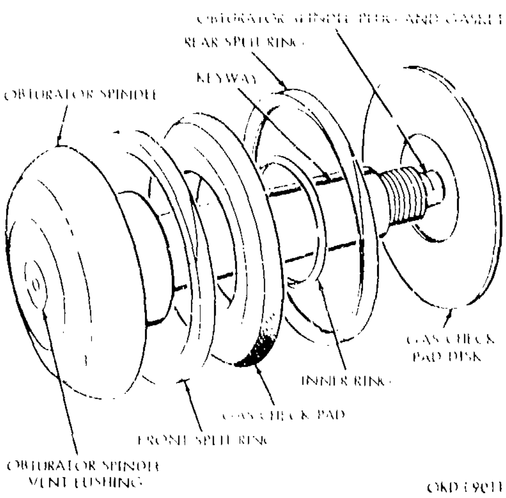


Figure 5-16. Obturator parts.

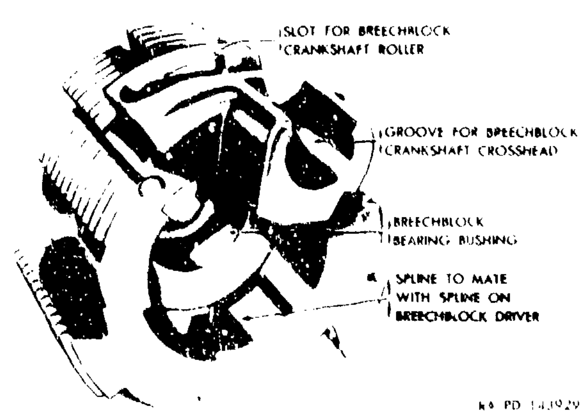


Figure 5-17. Breechblock from rear.

compressing spring. When the obturator spindle is removed, check the obturating spindle plug (for proper seating of the primer) by inserting an unfired primer into the spindle plug (fig 5-18) and pressing it in with thumb pressure. The flange of the primer should not be less than ⅛ inch from the rear face of the plug. If this distance is less than ⅛ inch, notify ordnance maintenance personnel.

(5) Remove the safety latch, plunger, and obturator spindle sleeve.

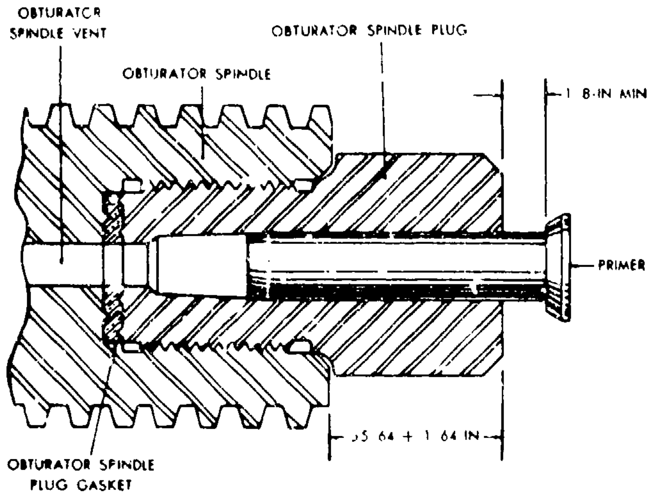


Figure 5-18. Checking primer seat in obturator spindle plug.

(6) Remove the breechblock from the breechblock carrier.

(7) Remove the breechblock driver retaining ring lock screw which holds the breechblock driver retaining plain round nut to the carrier, unscrew the retaining plain round nut from the carrier, and remove the driver.

(8) Remove the breechblock operating handle retaining shoulder bolt and remove the breechblock operating handle. Unscrew and remove the crankshaft journal detent.

(9) Slide the cross head off its pivot. Withdraw the crankshaft journal from its bore and remove the breechblock operating handle crankshaft.

(10) Drive the detent out of the hinge pin collar and remove the collar. Withdraw the hinge pin from the hinge lug and remove the breechblock carrier from the hinge pin lug. Remove the breechblock alining carrier bearing washer.

b. Maintenance. The breech mechanism is subject to contamination from powder residue working its way to and through the obturating parts. For this reason, the mechanism must be disassembled and cleaned periodically to insure proper functioning of the weapon. Clean the obturating parts in the same manner as prescribed for cleaning the barrel on the day of firing and for 3 consecutive days hereafter. Clean the breech mechanism, except the gas-check pad, with rifle bore cleaner. Remove all powder stains, rust, or burs by using crocus cloth if necessary. Wipe the gas-check pad with a clean dry cloth or clean it with hot soapy water and wipe it dry. After cleaning and drying the mechanism, use the proper lubricants as prescribed by LO 9-1025-200-10 before reassembling the parts.

5-20. Assembly of the Breech Mechanism

To assemble the breech mechanism—

a. Place the breechblock carrier bearing washer on the lower lug of the breech ring which supports the breechblock carrier hinge pin lug on the breechblock carrier. Then place the carrier assembly with the washer assembly into position between the hinge pin lugs on the right side of the breech ring.

b. Support the carrier in the above position and insert the breechblock carrier hinge pin from the top. Push the pin downward through the hinge pin lug and breechblock carrier.

c. Slowly rotate the hinge pin so that the square portion, at the lower end, will enter the square hole in the driving washer and be positioned in such a manner that an extension of the two flat surfaces at the bottom end of the hinge pin would run rearward and to the left. If the hinge pin sticks, use a wooden or leather mallet to tap it downward, being careful not to strike the oilcan point in the top of the pin.

d. Place the breechblock carrier hinge pin in such a position that it will receive the counterbalance when the breech is in the partially closed position.

e. From the inside of the breechblock carrier, insert the operating handle crankshaft assembly into the bore through the right side of the carrier.

f. Insert the crankshaft journal, small diameter end first, into the crankshaft bore from the outside of the carrier. Screw the crankshaft journal detent into the rear of the carrier to secure the journal.

g. Fit the breechblock operating handle to the slot in the crankshaft journal and secure the handle to the end of the crankshaft with the operating handle retaining bolt.

h. Place the breechblock crosshead on the arm of the crankshaft.

i. Slide the breechblock driver onto the hub of the breechblock carrier and screw the breechblock driver retaining plain round nut onto the carrier hub. Secure the breechblock driver retaining ring lock screw.

j. Place the operating handle in the vertical position and slide the breechblock assembly onto the splined hub of the breechblock driver. Hold the driver in such a position that the lug on the breechblock body will fit the open side of the large circular flange on the right side of the driver. Aline the breechblock body so that the crosshead can be guided into its groove in the breechblock assembly.

k. Insert the obturator spindle sleeve into the breechblock carrier, aline the key on the sleeve to the keyway in the carrier bore, and slide the sleeve forward. Replace the safety latch and safety latch plunger. Insert the obturator spindle assembly into the bore of the breechblock, insuring that the split rings are in the proper position (splits opposite one another), and through the bore of the obturator spindle sleeve. Place the gas-check pad compressing spring into the rear bore of the carrier and press the firing mechanism housing adapter in behind the spring.

WARNING: Failure to install the firing mechanism safety latch plunger will permit installation of the firing mechanism M1 before the breech is completely closed and locked. Firing the howitzer, with the breech not locked, will produce breech blowback with possible serious injury to personnel. The practice of omitting the firing mechanism safety latch plunger during assembly of the breech mechanism is strictly prohibited.

l. Screw the firing mechanism housing and firing mechanism housing adapter onto the obturator spindle as far as it will go and then back it off slightly to the nearest position in which the hole in the housing will aline with the safety latch plunger. This must be done to allow the plunger to enter the hole freely and to allow installation of the firing mechanism housing lock screw. Rotate the breechblock operating handle to the open position and replace the firing mechanism housing lock screw. Install the safety latch stop spring and socket head capscrew.

m. Set the headspace. The headspace, as measured by the headspace gage, is the distance between the rear face of the firing mechanism housing and the end of the obturator spindle plug. Excessive headspace can result in a ruptured primer and early failure of the spindle due to gas erosion, commonly known as gas wash, in the primer seat. To check the headspace (fig 5-19), insert the headspace gage into the firing mechanism housing. If the headspace is adjusted correctly, there will be a space of 1/16 inch (plus or minus 1/32 inch) between the rear face of the firing mechanism housing and the shoulder of the headspace gage.

n. With the operating handle downward, insert the breechblock control arc into its recess on the right side of the breech ring and secure it with the breechblock control arc screw.

o. Swing the breechblock toward the closed position until the eye on the counterbalance piston rod can be replaced over the head of the hinge pin body pin. Open the breechblock and remove the spacer from the counterbalance piston rod.

p. Carefully swing the breechblock into the closed position, easing the breechblock into the

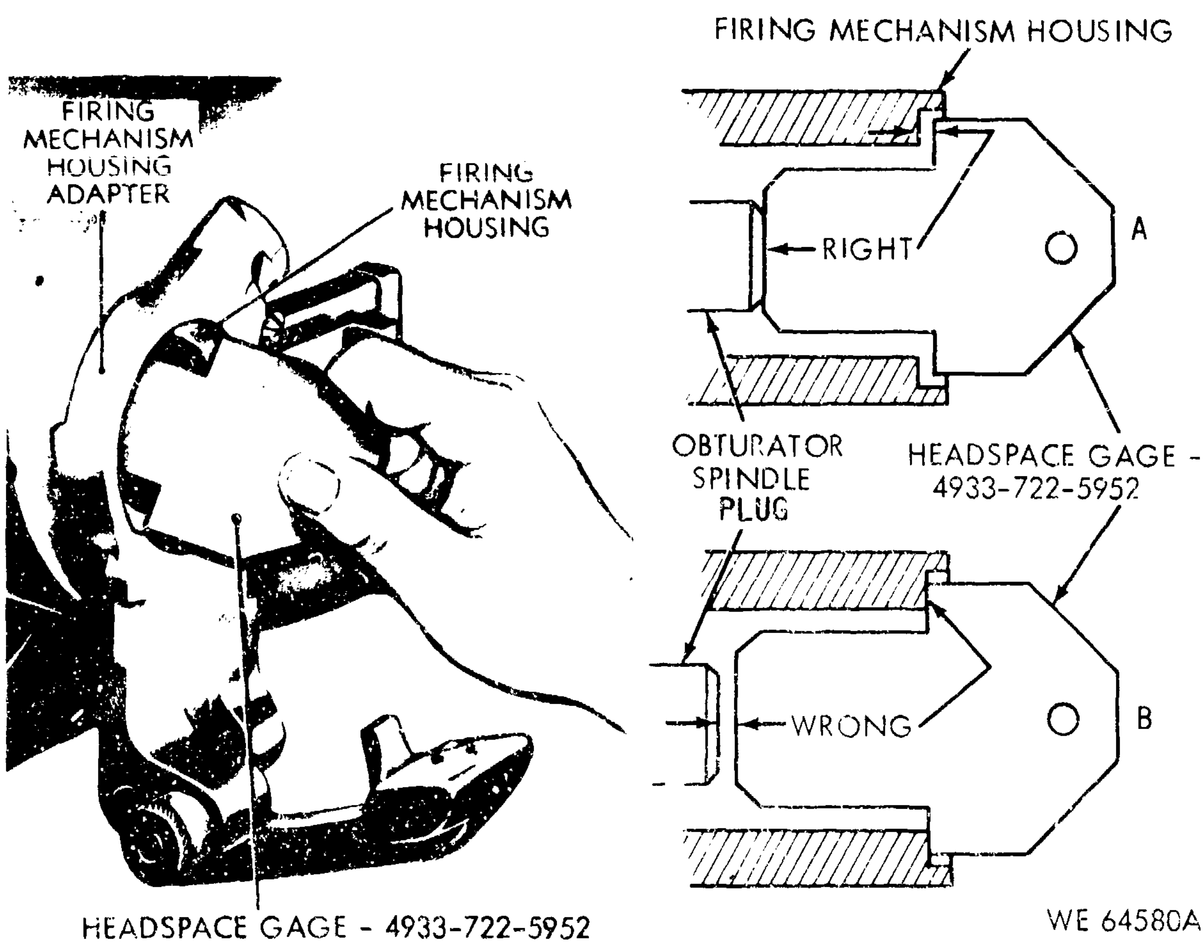
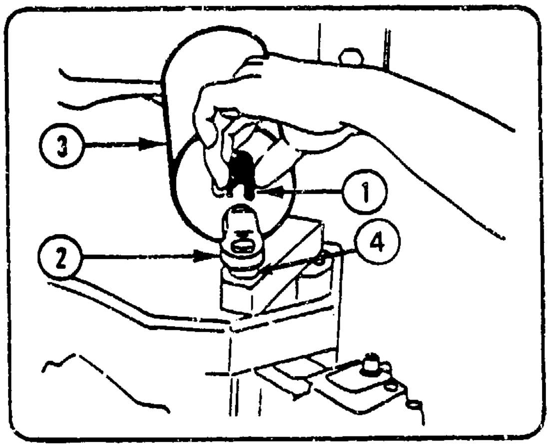


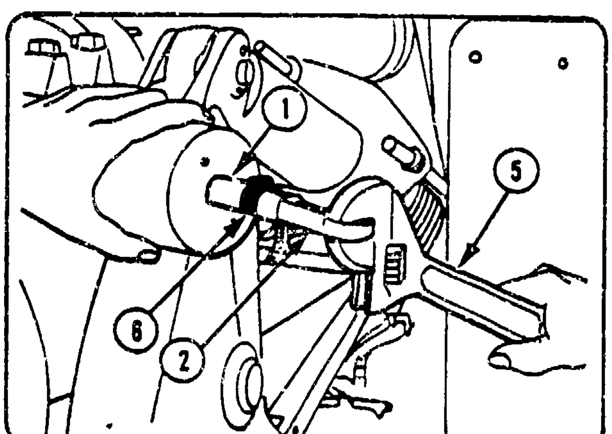
Figure 5-19. Checking headspace.

breech recess without permitting the edges of one part to strike those of another. Check the operation of the breech mechanism and the adjustment of the counterbalance. If the counterbalance is out of adjustment, adjust it as follows:



(1) Open the breechblock enough to insert counterbalance cylinder spacer ① between the counterbalance piston rod end ② and the counterbalance cylinder head ③.

(2) Close the breechblock sufficiently to lift the counterbalance piston rod end ② from the hinge pin ④.



Note. To prevent the counterbalance cylinder spacer 1 from slipping off of the counterbalance piston rod ② when the rod is turned, a hose clamp ④ should be placed on the spacer to secure it to the rod.

(3) To adjust the counterbalance, use a wrench ⑤ to turn the piston rod ②. To decrease the breech closing effort, turn the piston rod ② clockwise to tighten the spring. If the counterbalance closes the breech with too much force, turn the piston rod counterclockwise to loosen the spring.

Note. Do not turn the piston rod more than ten complete turns in a counterclockwise direction from its original position; to do so may reverse the piston rod and render the mechanism inoperative.

(4) Reconnect the piston rod and test the adjustment by opening and closing the breech mechanism. If further adjustment is required, repeat the adjustment in paragraph (3).

5-21. Firing Mechanism M1

a. General. The firing mechanism M1 (figs 5-20 and 5-21) consists of the firing mechanism housing assembly, the firing pin, and related parts. The firing pin housing, the firing pin guide, and the primer holder retain the firing pin in position. The firing mechanism M1 screws as a unit into the firing mechanism housing in the rear end of the breechblock carrier.

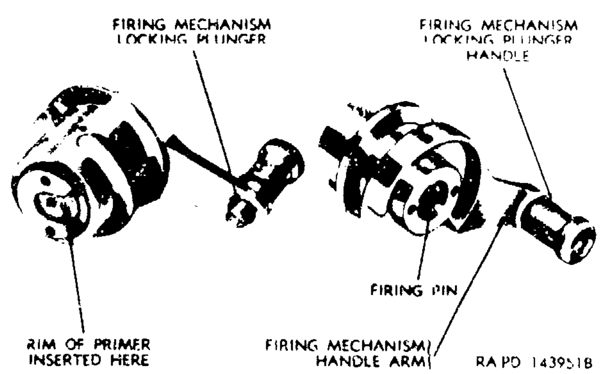


Figure 5-20. Firing mechanism M1— front and rear views.

b. Functioning. With the primer inserted in the primer holder, the firing mechanism is screwed clockwise into its housing. A strong pull on the lanyard attached to the percussion hammer will cause the percussion hammer to strike the firing pin; the firing pin will move forward, striking the primer. The firing pin spring will retract the firing pin from the primer. If the breechblock is not completely closed, the firing mechanism cannot be screwed completely into its housing. This will position the safety rim on the firing mechanism

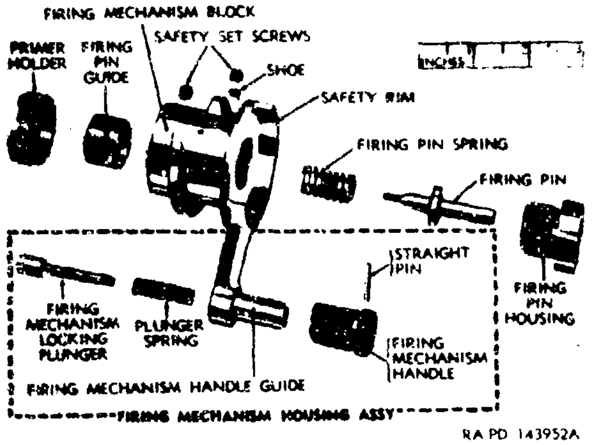


Figure 5-21. Firing mechanism M1—detailed view.

M1 in such a way that it will prevent the percussion hammer from striking the firing pin.

5-22. Disassembly of the Firing Mechanism M1

a. Remove both safety setscrews from the firing mechanism block (figs 5-20 and 5-21). Do not loosen the shoe under the setscrew from the firing pin housing. Unscrew the firing pin housing counterclockwise from the rear of the firing mechanism block.

b. Remove the firing pin and the firing pin spring from the rear of the block.

c. Unscrew the primer holder clockwise from the front of the block. Remove the firing pin guide.

d. Clean all parts with rifle bore cleaner. Wipe the parts dry. Inspect the parts and oil them with oil, lubricating, preservative, medium or special.

5-23. Assembly of the Firing Mechanism M1

a. Insert the firing pin guide and screw the primer holder counterclockwise into the firing mechanism block from the front of the block.

b. Insert the firing pin and firing pin spring from the rear of the block.

c. Screw the firing pin housing clockwise into the rear of the firing mechanism block. Insert both safety setscrews into the firing mechanism block. These setscrews must be flush with or below the firing mechanism block.

Section IV. RECOIL MECHANISM

5-24. Type of Recoil Mechanism

The recoil mechanism employed in the 155-mm howitzer, towed, is of the hydropnematic, variable, independent type with floating piston. An explanation of the nomenclature follows.

a. Hydro indicates that the mechanism employs a liquid; the liquid used is recoil oil. Recoil oil is a petroleum-base hydraulic fluid. There are presently three types of recoil oil (OHT, OHA, and OHC) authorized for use in field artillery weapons. OHT is the preferred oil because it provides greater protection against corrosion. The oils can be mixed; however, mixing should be avoided if possible because mixing may tend to dilute the protection (additives) of one or more of the oils. A recoil mechanism that contains a mixture of oils should be drained and refilled with the preferred OHT as soon as it becomes available. All three oils are red and have a temperature range of opertion from -65° F to +150° F.

b. Pneumatic indicates that a gas is used. The gas used in this weapon is nitrogen, which is relatively inactive and will not react on metal to cause corrosion.

c. Variable indicates that there is a mechanical means for varying the length of recoil. Under normal operating conditions, the length of recoil varies from 41 inches to 60 inches, depending on the angle of elevation.

d. Independent indicates that there is no passage for liquid between the recoil cylinder and the recuperator cylinder.

5-25. Purposes of the Recoil Mechanism

The purposes of the recoil mechanism are—

a. To stop the recoiling parts. The recoil portion of the recoil mechanism must absorb and control the rearward thrust of the weapon when it is fired to prevent excessive shock to or displacement of the carriage.

b. To return the recoiling parts. The recoil mechanism causes the recoiling parts to return to the in-battery position.

c. To prevent shock. The recoiling parts must be returned to the in-battery position without excessive shock.

d. To hold the recoiling parts. The tube and other recoiling parts must be held in the in-battery position during travel and at all angles of elevation prior to firing.

5-26. Components of the Recoil Mechanism

The recoil mechanism (fig 5-22) is mounted on the cradle and held by the cylinder yoke. It is composed of the recoil cylinder, the variable recoil cam assembly, the replenisher, and the counterrecoil and recuperator cylinders.

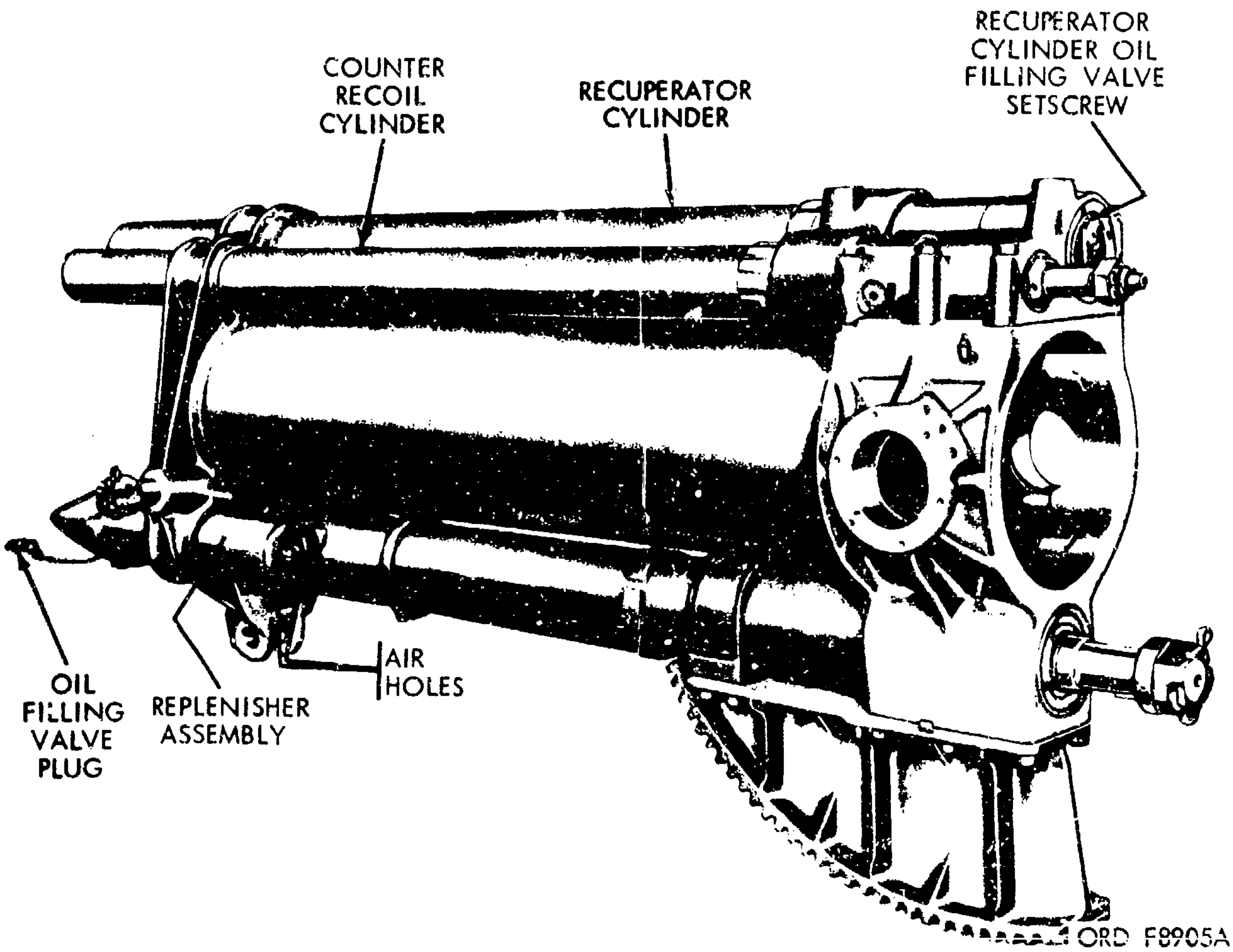
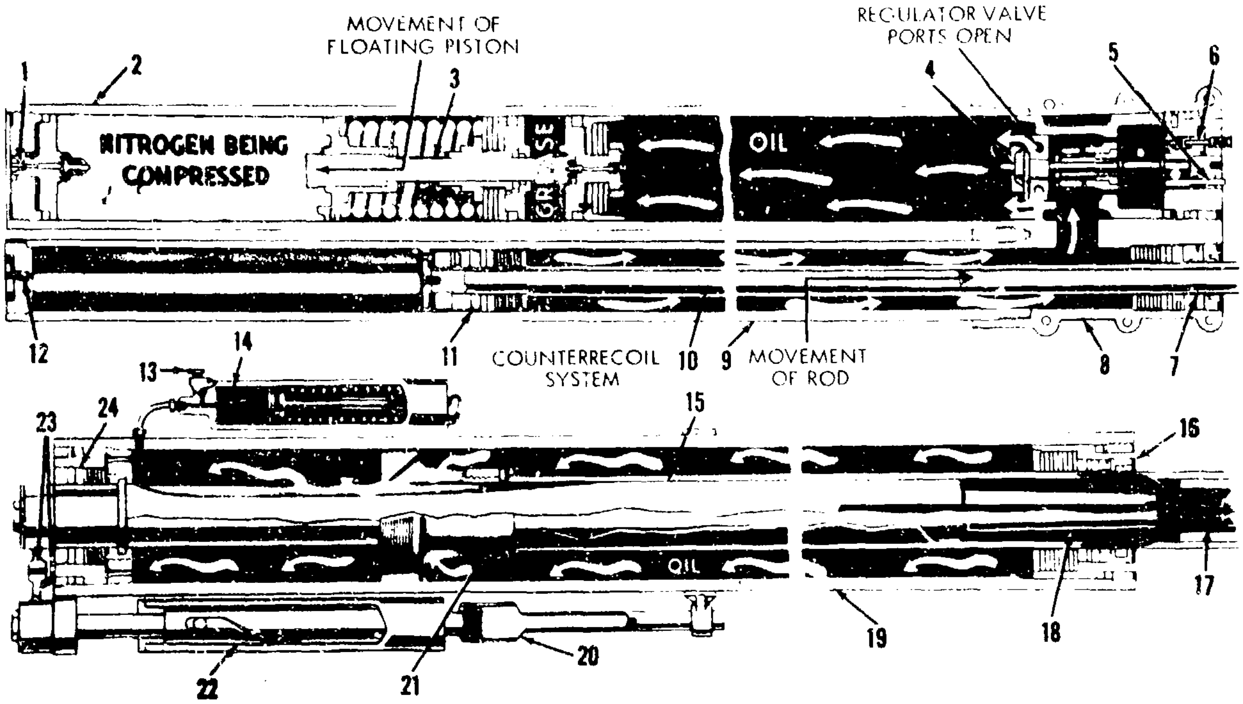


Figure 5-22. Recoil mechanism removed from carriage—left side view.

a. Recoil cylinder. The recoil cylinder (fig 5-23) is the large cylinder beneath the tube. The recoil piston, liner assembly, and piston rod are drilled concentrically to provide the bore in which the recoil throttling rod is located. The rear end of the throttling rod is tapered to form a spearhead type of buffer, and the end of the hollow piston rod forms a dashpot type of buffer chamber. The recoil throttling rod is attached to the packing head at the front end of the recoil cylinder. The throttling rod has two long and two short grooves of varying depths cut lengthwise in its surface. Two of these grooves are 180° apart, and each is 41 inches long. The other two grooves are 180° apart, and each is 60 inches long. Recoil oil must flow through the grooves in the throttling rod in order to pass from one side of the recoil piston to the other. At least two of the four grooves must be alined with the two ports in the recoil piston to permit the flow of oil.

b. Replenisher. The replenisher (figs 5-22 and 5-23) is a small cylinder containing a spring-loaded piston and is located on the left side of the recoil cylinder yoke. The purpose of the replenisher is to maintain the proper amount of recoil oil in the recoil cylinder at all times. The replenisher compensates for the contraction and expansion of oil due to temperature changes and changes in volume of oil required in the recoil cylinder during the recoil and the counterrecoil strokes. The replenisher also provides a means of checking the quantity of oil in the recoil system.

c. Counterrecoil cylinder. The counterrecoil cylinder is the smaller of the two cylinders above the tube. It contains a piston rod and a piston. The counterrecoil piston rod is connected to the lug on the breech ring. The piston is fitted with an oiltight packing. The counterrecoil respirator in the front end of the counterrecoil cylinder is equipped with a spring-loaded ball check valve. The purpose of the valve is to release air and any oil which may seep past the piston from the front of the cylinder when the piston moves forward during counterrecoil. The counterrecoil cylinder is interconnected with the recuperator cylinder by an oil passage.



1—Recuperator charging valve
2—Recuperator cylinder
3—Recuperator floating piston
4—Recuperator cylinder regulator valve
5—Oil index
6—Recuperator cylinder filling valve
7—Counterrecoil rod stuffing box head
8—Counterrecoil and recuperator cylinder head stuffing box
9—Counterrecoil cylinder
10—Counterrecoil piston rod
11—Counterrecoil piston assembly
12—Counterrecoil cylinder respirator assembly
13—Replenisher oil filling valve plug
14—Oil reserve in replenisher
15—Recoil throttling rod
16—Recoil rod stuffing box head
17—Buffer chamber in bore of recoil piston rod and liner assembly
18—Recoil throttling rod
19—Recoil cylinder
20—Variable recoil cam shaft
21—Recoil piston and liner assembly
22—Variable recoil cam
23—Gear sectors
24—Throttling rod packing head

Figure 5-23. Recoil mechanism—recoil action

d. Recuperator cylinder. The recuperator cylinder is the larger of the two cylinders above the tube. It contains a floating piston and the regulator valve assembly. Th floating piston provides a movable liquidtight and gastight seal to separate the nitrogen gas in one end of the cylinder from the oil in the other end. The regulator valve assembly is housed in the rear end of the recuperator cylinder. It permits a free flow of oil from the counterrecoil cylinder during recoil but regulates the flow of oil back into the counterrecoil cylinder during counterrecoil. A recuperator oil index is located at the rear end of the recuperator cylinder. It indicates the presence of an oil reserve, which is necessary for the proper functioning of the recoil mechanism. When no oil reserve is present, the rear end of the floating piston presses on the oil index actuating rod. This rod actuates a gear which, in turn, moves the oil index. This action withdraws the rear end of the oil index into the outside face of the recuperator cylinder head. *The weapon should not be fired when the oil index has been withdrawn into the recuperator cylinder head, since this indicates that no oil reserve is present.*

e. Variable recoil cam assembly. The variable recoil cam assembly is a device for controlling the rotation of the recoil throttling rod.

5-27. Functioning—Recoil Cycle

a. Recoil cylinder. When the weapon is fired, the tube recoils in the cradle (fig 5-23). Since the hollow piston rod (piston and liner assembly) is connected to a lug on the bottom of the breech ring, it is drawn to the rear with the tube. As the recoil piston is drawn to the rear, oil is forced through two ports in the recoil piston and through the throttling grooves to the forward side of the piston. As the oil passes through the tapered throttling grooves, the flow of oil from the rearward side to the forward side of the piston is gradually reduced and finally stopped. This throttling action absorbs the greatest portion of the recoil energy.

b. Counterrecoil and recuperator cylinders. When the weapon is fired, the counterrecoil piston, being connected to the top of the breech ring, moves rearward with the tube. The oil in the counterrecoil cylinder is forced through an oil passage and into the recuperator regulator valve assembly by the counterrecoil piston. The flow of oil under pressure opens a spring-loaded valve in the regulator assembly, permitting a free flow of oil against the floating piston. The floating piston moves forward, compressing the nitrogen gas. Thus, the throttling of oil in the recoil cylinder, the increased compression of the nitrogen gas in the recuperator cylinder, and the friction of moving parts stop the tube in recoil.

5-28. Functioning—Counterrecoil Cycle

a. Counterrecoil and recuperator cylinder.

(1) When the force of recoil is overcome, the tube stops, the flow of recoil oil stops, and the spring-loaded valve in the regulator valve assembly closes itself. In the head of the recuperator regulator valve are two small counterrecoil controlling ports (fig 5-24), each of which is about 1/16 inch in diameter. These ports control the flow of recoil oil back through the regulator valve assembly and into the counterrecoil cylinder.

(2) Since the floating piston is free to move, the energy stored in the nitrogen gas reacts to displace the floating piston to its normal in-battery position. As the floating piston moves toward its in-battery position, it displaces the oil from the recuperator cylinder through two small controlling ports in the regulator valve into the counterrecoil cylinder. The oil exerts pressure on the rear of the counterrecoil piston, moving the counterrecoil piston forward and thereby pulling the tube to the in-battery position.

b. Recoil cylinder. As the counterrecoil piston rod pulls the tube into battery, the recoil oil in front of the recoil piston flows through two ports in the piston and the exposed throttling grooves in the recoil throttling rod. Little throttling action occurs at this time in the recoil cylinder as compared to that in the recuperator cylinder; however, as the tube nears the in-battery position, it is slowed down and eased into battery by the spearhead-type buffer. The oil trapped in the buffer chamber must escape through the centrally bored rotatable throttling rod. Thus, the final movement of the tube is cushioned as the tube returns to battery.

5-29. Functioning of the Variable Recoil Cam Assembly

a. An arc gear sector is mounted on the forward end of the throttling rod. This gear sector is

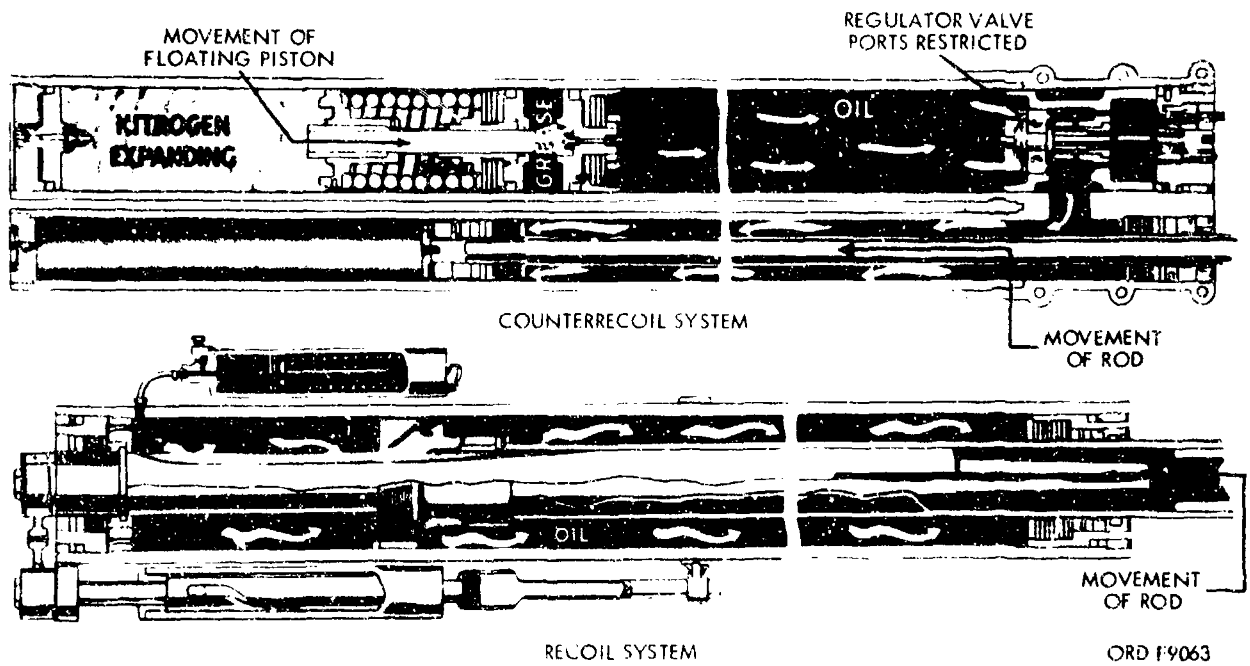


Figure 5-24. Recoil mechanism—counterrecoil action.

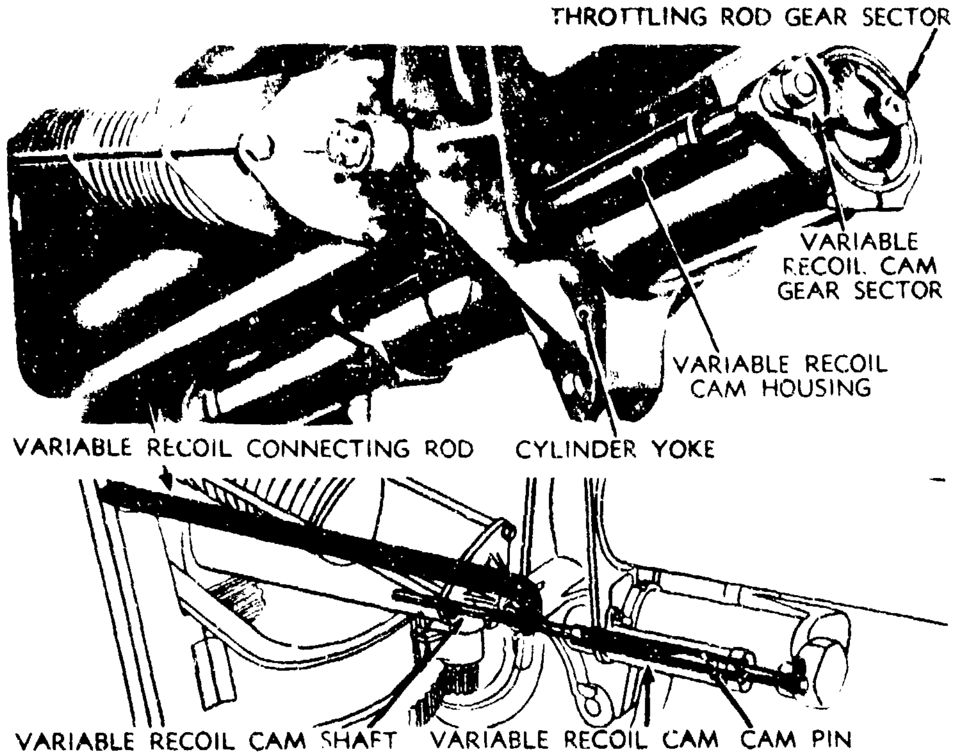


Figure 5-25. Variable recoil cam—assembled and phantom views.

meshed with a similar gear sector mounted on the end of the variable recoil cam assembly (fig 5-25). The tubular cam is machined with a spiral, or S-shaped, slot. A cam pin, mounted on the cam shaft, rides in the spiral slot. The shaft is connected to the top carriage by the variable recoil connecting rod. As the tube is elevated or depressed, the connecting rod moves the shaft either forward or rearward, causing the cam pin on the shaft to turn the cam and its gear sector, which in turn rotates the gear sector on the rotatable throttling rod. The turning of the throttling rod regulates the opening of the oil passages in the throttling rod located in the recoil cylinder, thereby changing the length of recoil automatically as the tube is elevated or depressed.

b. For the first 444 mils of elevation, the cam pin does not rotate the cam. At elevations of 444 to 711 mils, the cam pin rides in the curved portion of the spiral slot and rotates the cam, and the two 60-inch grooves are moved partially out of line with the ports in the piston. This motion decreases the size of the oil passages. At elevation above 711 mils, the two 60-inch grooves are completely out of line with the ports in the piston; therefore, at elevations between 711 to 1,156 mils, the length of recoil can be only 41 inches because a greater throttling action is caused and the flow of oil is stopped quicker in the shorter grooves. As the tube is depressed, the opposite action occurs, and the length of recoil is increased.

c. When long recoil is required at all angles of elevation, as when firing the special projectile M454, the variable recoil cam assembly must be inactivated. To inactivate the assembly proceed as follows:

(1) Bring the howitzer to zero elevation.

(2) Remove the ¼-inch pin (fig 5-26) from its stowage bracket below the variable recoil shaft and install it in the drilled hole near the rear (breech) end of the variable recoil shaft.

(3) Disconnect the variable recoil connecting rod from the variable recoil shaft by removing the ½-inch pin from the front (muzzle) end of the connecting rod.

(4) Install the ½-inch pin in the stowage bracket on the variable recoil connecting rod.

CAUTION: The variable recoil cam assembly will be damaged if the weapon is elevated with the ¼-inch pin installed in the variable recoil shaft and the variable recoil rod connected to the shaft.

d. With the variable recoil cam assembly disconnected, a recoil pit, deep enough to allow for 60 inches of recoil when firing at high angles of elevation, must be dug.

e. To reactivate the variable recoil cam

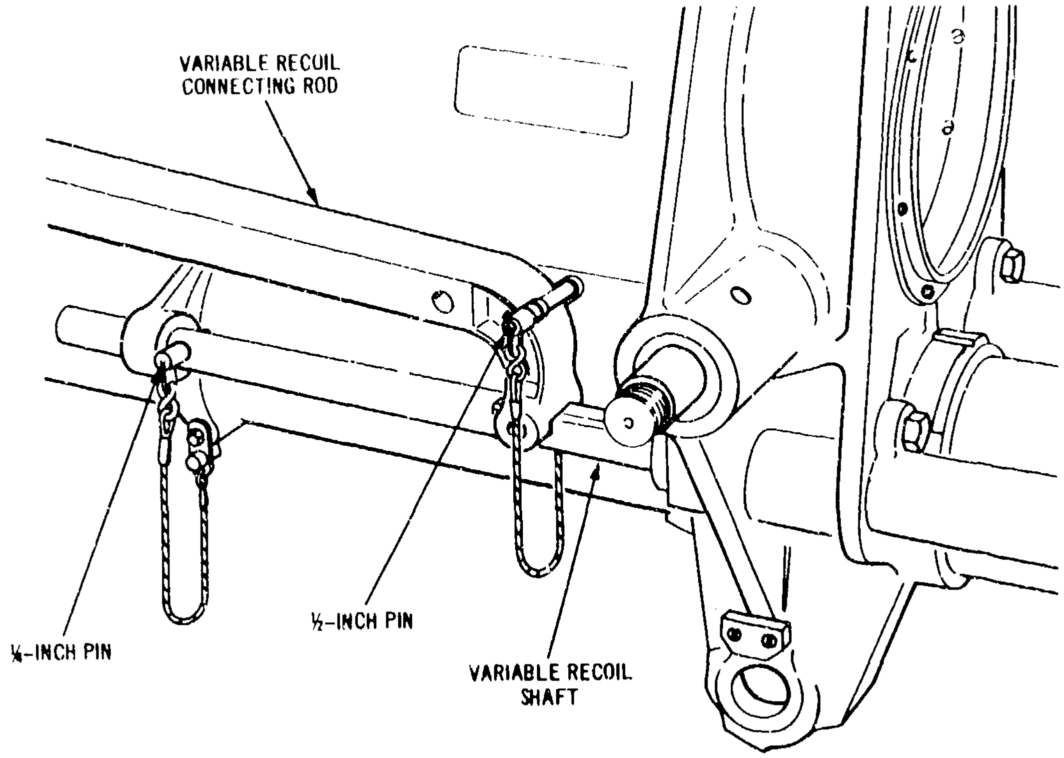


Figure 5-26. Positioning pin in variable recoil shaft for firing M454 projectile.

assembly, bring the weapon to zero elevation, reconnect the variable recoil connecting rod to the variable recoil shaft with the ½-inch pin, and reinstall the ¼-inch pin in its stowage bracket below the variable recoil shaft.

5-30. Checking and Servicing the Recoil Mechanism

a. General. Battery-level checking and servicing of the recoil mechanism is limited to exterior cleaning, painting, and lubricating; draining and establishing the oil reserve in the recuperator; and draining and establishing the correct amount of oil in the replenisher. The replenisher and the recuperator cylinders must contain the proper quantity of oil at all times; otherwise the weapon will be damaged by firing. The oil reserve in the recuperator cylinder separates the floating piston from the regulator valve assembly. The compressed nitrogen gas in the recuperator cylinder will exert pressure on the oil in the counterrecoil system only as long as there is oil between the regulator valve assembly and the floating piston. If the regulator valve assembly and the floating piston come in contact with each other, further movement of the floating piston is prevented, and the pressure on the recoil oil drops to zero.

b. Replenisher. To check the oil in the replenisher, remove the plug from the rear end of the replenisher cylinder, insert a ruler into the replenisher piston guide, and measure the distance from the rear face of the replenisher cylinder to the end of the replenisher piston extension. The proper reading is 5½ inches, which indicates the correct amount of oil in the replenisher. A reading of 3½ inches or less indicates too much oil in the replenisher, and a reading of 7½ inches or more indicates an insufficient amount of oil in the replenisher. If reading is 7½ inches or more, attach the pump, purge the hose, and add oil (fig 5-27) until the reading is 5½ inches. If the reading is 3½ inches or less, attach the liquid releasing and filling tool and drain the oil (fig 5-27) in the replenisher until a reading of 5½ inches is obtained. For exact adjustment, the reading should be 5½ inches; however, the weapon can be safely fired when the replenisher oil is within the limits of 3½ to 7½ inches. The replenisher should be checked prior to firing and after every 10 rounds fired. When rapid fire is to take place and the weapon is at ambient temperature, release the oil from the replenisher until the rear end of the piston extension is 7½ inches from the rear face of the replenisher. In an emergency, firing may be continued until the end of the piston extension is 2 inches from the rear face of the replenisher.

Note. The replenisher of a nonfiring weapon should be exercised monthly.

c. Recuperator cylinder. Checking the position of the oil index indicates the presence or absence of fluid reserve in the recuperator cylinder. If a

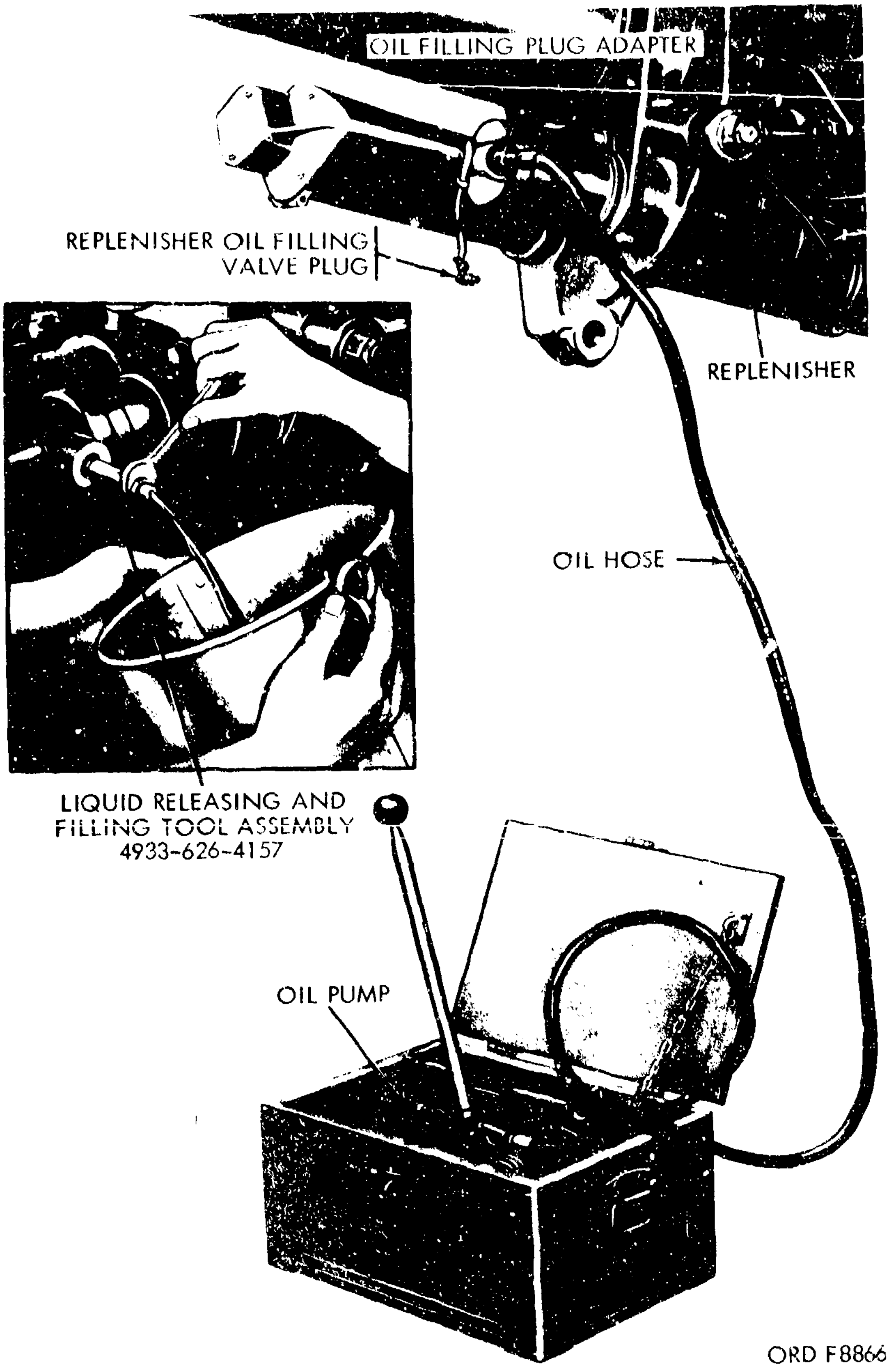


Figure 5-27. Draining and filling replenisher.

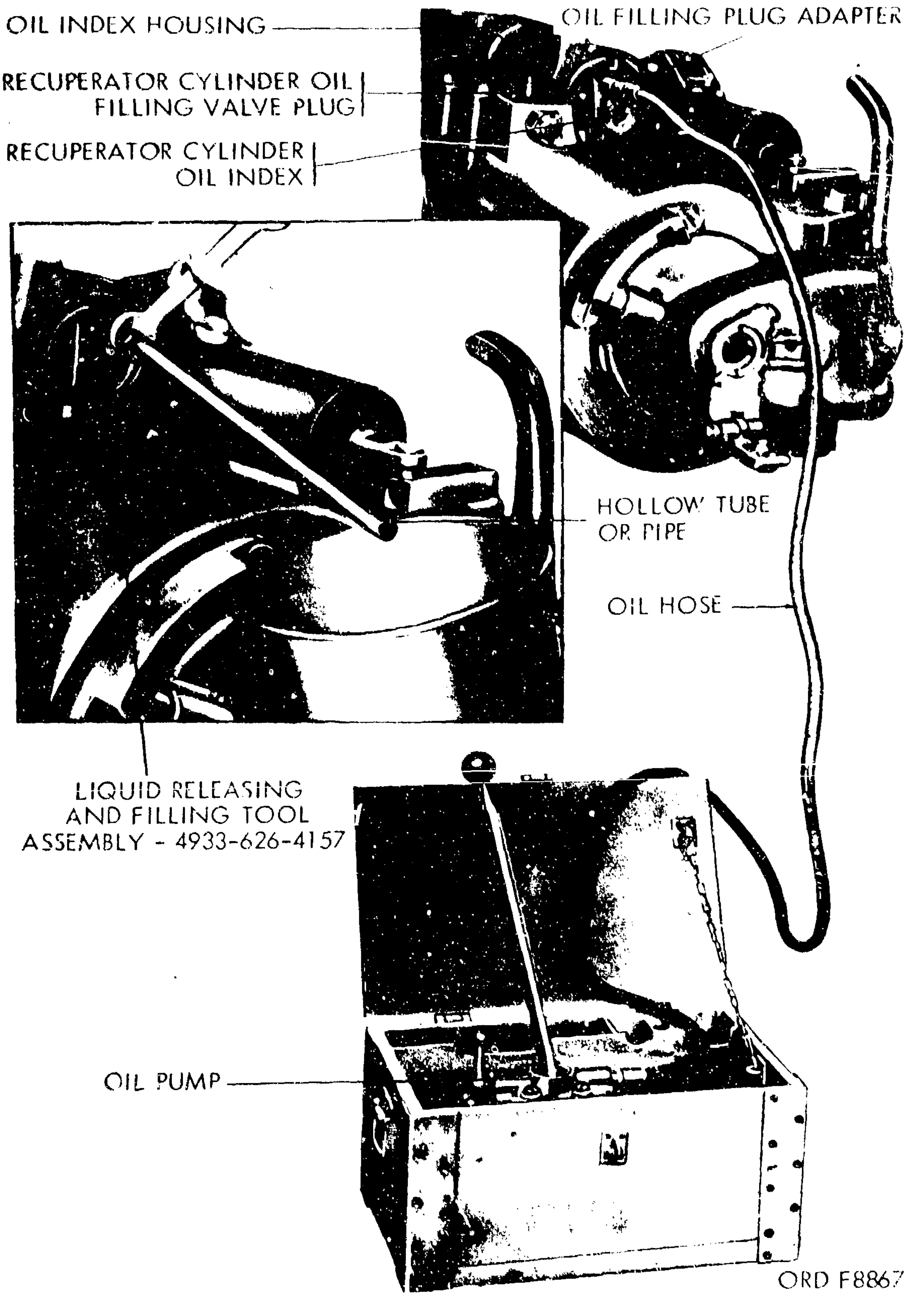


Figure 5-28. Draining and filling recuperator cylinder.

reserve of fluid is present, the oil index will protrude between ¼ and 3/8 inch beyond the rear face of the housing. If the oil index protrudes less than ¼ inch, fluid should be added to establish the proper reserve. To establish the oil reserve, drain off the existing reserve before refilling. This is accomplished by removing the recuperator oil filling valve plug and installing the liquid releasing and filling tool assembly (fig 5-28). The reserve fluid will spurt out in a stream and suddenly drop to a trickle. At this point, the flow of fluid should be stopped by unscrewing the liquid releasing and filling tool assembly. It will be noted that the oil index has moved out of sight before all of the reserve fluid has been released. If the oil index has not moved, tap it gently with a small piece of wood.

(1) Remove the oil filling valve plug.

(2) Install the liquid releasing and filling tube assembly, using a tube or pipe to carry fluid released to an appropriate container.

Note. You can expect approximately 1 pint of reserve fluid to escape.

(3) When fluid flow becomes a trickle, remove the liquid releasing and filling tool assembly.

Note. Oil index 1 should have moved in.

(4) Attach the oil filling plug adapter to the oil hose.

(5) Loosely screw the filling plug adapter into the filling valve.

(6) Attach the other end of the oil hose to the oil pump.

(7) Operate oil pump handle until no air bubbles appear at the filling plug adapter.

(8) Tighten the filling plug adapter.

(9) Place a finger on the oil index; start working the oil pump handle. When the oil index starts moving to the rear, commence counting the strokes. Count the strokes until the oil index stops moving, which will be the farthest outward position. Multiply the number of strokes required to accomplish this by two and add this number of strokes to establish full oil reserve in the recuperator.

Note. If it takes 25 pump strokes to extend the fluid index to its farthest point, add 50 more strokes to establish full oil reserve.

(10) Remove the filling pump adapter and install the filling valve plug.

5-31. Malfunctions

It is essential that personnel know and understand the causes of malfunctions in the recoil mechanism so that they can take the appropriate corrective actions. Causes of various malfunctions and the actions prescribed for correcting the malfunctions are as follows:

Malfunction	*Cause*	*Corrective action*
a. Oil drips from counterrecoil rod, recoil rod, or control rod stuffing box in excess of three drops per 5 minutes.	(1) Gland and packing worn damaged.	(1) Notify support maintenance unit.
	(2) Worn or damaged parts.	(2) Notify support maintenance unit.
b. Fluid leaks from rear of replenisher.	(1) If weapon has been at 0° elevation for some time, fluid may drip rapidly (or run in a stream) from the rear of the replenisher for several seconds when the howitzer is elevated. Neither this temporary leakage nor a drip at any packing that does not exceed three drops per minute are considered serious.	(1) If leakage at any packing exceeds three drops per minute, notify ordnance maintenance personnel.
c. Tube returns slowly or fails to return to battery.	(1) Insufficient reserve oil in the recuperator cylinder.	(1) Drain and replenish the oil reserve.
	(2) Excess oil in the replenisher.	(2) Drain the recoil oil to the normal level.
	(3) Insufficient nitrogen pressure.	(3) Notify support maintenance unit.
d. Tube returns to battery with too much shock.	(1) Insufficient recoil oil in the replenisher.	(1) Refill the replenisher to the normal level.
	(2) Excess oil reserve in the recuperator cylinder.	(2) Drain and replenish the oil reserve.

Malfunction	Cause	Corrective action
e. Tube is slow in returning to battery when the oil index is normal.	(1) Dirty or scored bearing surfaces.	(1) Clean and lubricate the bearing surfaces.
	(2) Excessive friction from the packing.	(2) Notify support maintenance unit.
	(3) Insufficient nitrogen pressure.	(3) Notify support maintenance unit.
f. Uneven or jerky counter-recoil.	(1) Emulsified oil.	(1) Drain and replenish oil reserve. If still emulsified, notify ordnance.
	(2) Dirty or scored bearing surfaces.	(2) Clean and lubricate the bearing surfaces.
	(3) Excessive friction from the packing.	(3) Notify support maintenance unit.
g. Tube recoils more than the normal allowable distance.	(1) Malfunction of the variable recoil mechanism.	(1) Notify support maintenance unit.
	(2) Insufficient oil in the replenisher	(2) Refill the replenisher to the correct level.
	(3) Insufficient nitrogen pressure.	(3) Notify support maintenance unit.

Section V. SIGHTING AND LAYING EQUIPMENT

5-32. Definition of Common Terms

Common terms pertaining to sighting and laying equipment are defined below.

a. Fire control instruments—Include both on- and off-carriage instruments. On-carriage fire control instruments are those which are built in or are placed on the weapon by the guncrew and are used for laying the weapon in deflection and/or elevation. Such instruments as the panoramic telescope, range quadrant, elbow telescope, and gunner's quadrant are on-carriage equipment. The aiming circle, battery commander's telescope, and M2 compass are examples of off-carriage fire control instruments.

b. Trajectory—The curve described by the center of gravity of a projectile in flight. The trajectory has two elements, which are controlled by sighting and laying equipment—the vertical angular measurement and the horizontal angular measurement.

c. Reticle—A measuring scale or mark placed in the focus of an optical instrument. Some reticles have graduations which allow the operator to make small angular or range measurements while he is looking through the instrument.

d. Sighting—The process of directing a line of sight toward an aiming point.

e. Laying—The process of pointing the tube of a weapon in a given direction for a given range.

f. Indirect fire—Fire from a weapon which is laid by sighting on a point other than the target. Normally, the target and weapon will not be intervisible.

g. Direct fire—Fire from a weapon which is laid by sighting directly on the target.

h. Cant—The tilting of the trunnions of the weapon out of the true horizontal plane. Cant causes the tube to travel out of the true horizontal plane in traverse and out of the true vertical plane in elevation. Cant is always present if the trunnions of a weapon are not level.

i. Boresighting—Boresighting is the process of alining the on-carriage sighting and fire control equipment so that the line of sight of the telescope is parallel to the axis of the bore of the weapon. This insures accuracy in laying for elevation and direction. Boresighting is conducted before firing and, when necessary, during lulls in firing.

5-33. Panoramic Telescope M12A7Q

a. The panoramic telescope M12A7Q (fig 5-29) is a 4-power, fixed-focus, fire control instrument which may be used for either direct or indirect fire. It is a modified telescope M12A7C. When used in its most common role, indirect fire, the M12A7Q telescope allows the operator to apply a specified change in direction (deflection) to the tube of the weapon by changing the line of sight of the telescope the same specified amount and then traversing back on the fixed aiming point. For example, to change the direction of the tube 200 mils to the right, the operator refers the line of sight 200 mils to the left of the fixed aiming point and then traverses the tube until the line of sight of the telescope is back on the aiming point. The tube will then be pointed 200 mils right of its original direction. The panoramic telescope M12A7Q has a slipping azimuth scale and slipping azimuth micrometer scale, which allows all weapons of a battery to have a common deflection, regardless of the positions of their fixed aiming points.

b. The elevation knob, located at the top of the telescope rotating head, will raise or lower the line of sight plus or minus 300 mils when rotated throughout its limits. A fine elevation index and a coarse elevation index indicate the level position. The fine index may be adjusted by loosening the three screws on the top of the elevation knob and then slipping the collar containing the zero index into coincidence with the fixed index. The coarse index is adjusted by support maintenance personnel only. An open sight, located on the right side of the rotating head, is used for rough alinement with an aiming point. The slipping azimuth scale, located immediately below the rotating head, consists of a ring graduated into 64 divisions of 100 mils each and numbered every 200 mils from 0 to 3,200 in two consecutive semicircles. A slipping scale locking screw enables the operator to secure the slipping azimuth scale to the rotating head or to release it. When released, the slipping azimuth scale may be set at any deflection, but, when the scale is locked, its movement is controlled by the azimuth micrometer knob. The nonslipping azimuth scale, located below the slipping azimuth scale, can be moved only by the azimuth micrometer knob and the motion of the rotating head. A door covers the nonslipping azimuth scale when it is not in use and provides an index for the slipping azimuth scale. The slipping azimuth micrometer scale, located on the left side of the telescope, is graduated into 100 divisions of 1 mil each. A locking nut located on the end of the azimuth micrometer knob, enables the operator to release the slipping azimuth micrometer scale, set it at a desired deflection reading, and lock the scale in place. A left index (nonslipping), located on the micrometer end of the azimuth micrometer knob, turns with the micrometer knob. A right fixed index, located on the telescope body, does not move. The left index is synchronized with the right fixed index and the graduations on the (nonslipping) azimuth scale. Whenever the left index is opposite the right fixed index, the azimuth scale index should coincide with a graduation on the (nonslipping) azimuth scale. If the three indexes do not coincide, the instrument should be turned in to the support maintenance unit for repair. The movable azimuth micrometer index, located immediately to the inside of the slipping azimuth micrometer scale, is adjustable in relation to a fixed gunner's aid scale graduated on the worm throwout lever and is used in the application of special corrections.

c. For boresighting with the panoramic telescope M12A7Q, all indexes, including the left index, must be at zero. Any adjustment to make the line of sight parallel to the tube must be made with the tangent screws on the telescope mount (figs 5-30 and fig 5-31).

d. Modification Work Order (MWO) 9-1240-236-30/1 applies to all M12A7 series of panoramic telescopes and allows for the purging of the optical system with nitrogen gas to remove moisture and prevent fogging of the lenses.

5-34. Telescope Mount M25

a. Purpose.

(1) The telescope mount M25 (fig 5-30) provides a means of mounting the telescope M12A7Q, which is used in laying for deflection and/or measuring elevation.

(2) The telescope mount provides a means of compensating for errors due to cant.

b. Description and functioning of the components. The major components of the mount are the rocker bracket, rocker actuating arm, actuating arm pivot, actuating arm bracket, cross- and longitudinal-level bubbles, telescope socket, and tangent screws.

(1) *Rocker bracket.*

(a) The rocker bracket secures the sight mount to the carriage at the trunnions.

(b) The rocker bracket holds the actuating arm bracket, which is mounted on ball bearings within the bracket

(2) *Rocker.*

(a) The rocker is mounted on the rocker bracket on ball bearings.

(b) The rocker carries the cross-leveling mechanism.

(c) The rocker rotates about the rocker bracket when the elevation knob is turned.

(3) *Actuating arm assembly.*

(a) The actuating arm assembly is mounted to rotate vertically with the tube.

(b) The actuating arm bracket is bolted to the cradle, thereby transmitting the movement of the tube to the actuating arm bracket.

(c) By turning the eccentric pin, the actuating arm bracket is adjustable in relation to the tube so that the actuating arm pivot and quadrant mount may be adjusted in a vertical direction to make the quadrant mount parallel to a

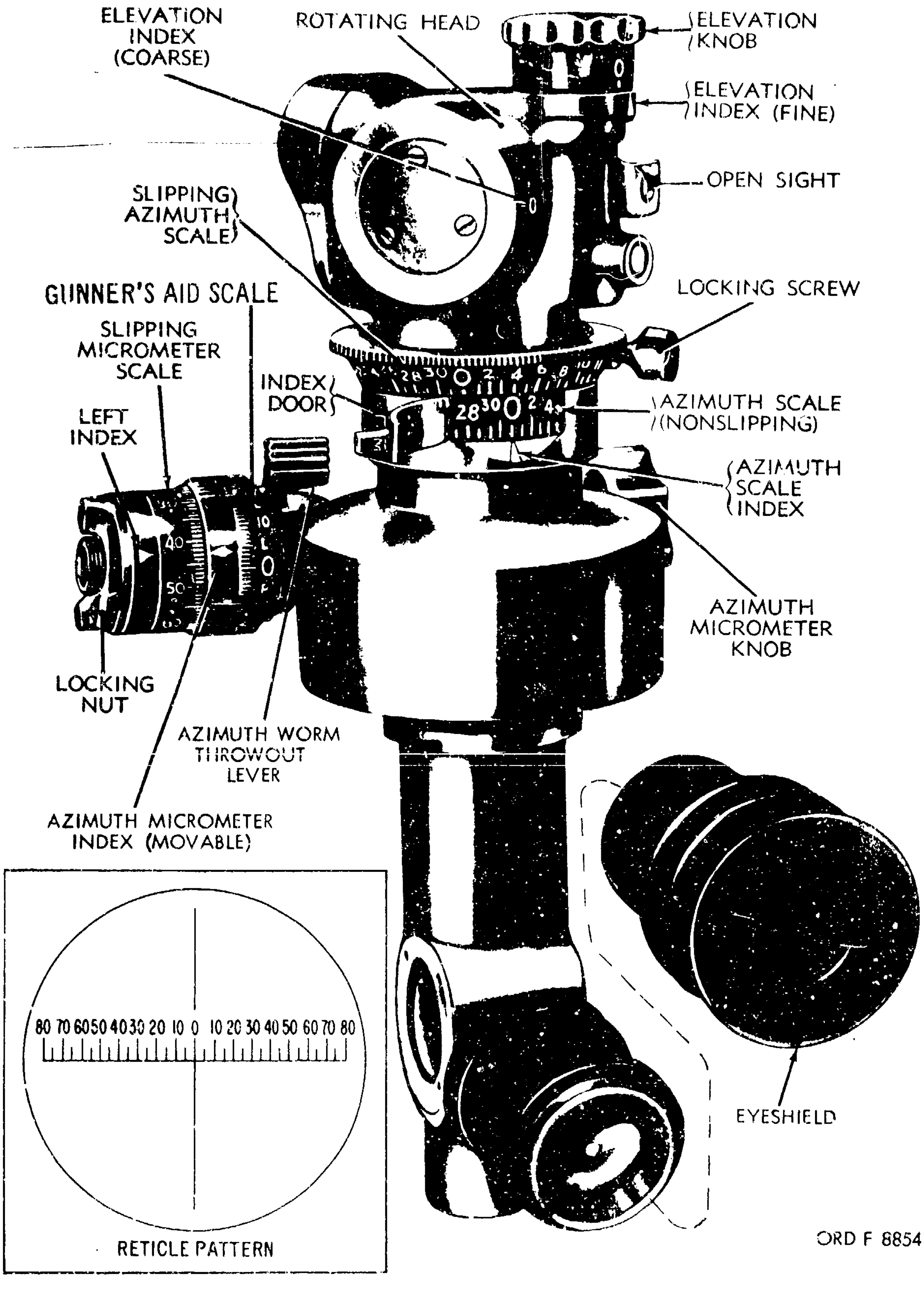


Figure 5-29. Panoramic telescope M12A7Q.

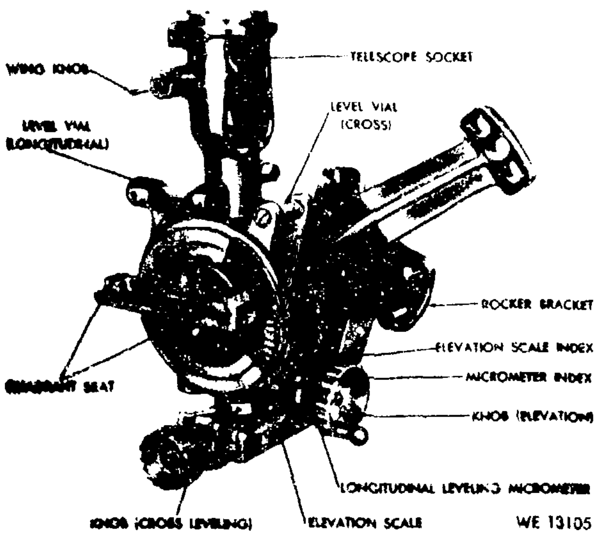


Figure 5-30. Telescope mount M25.

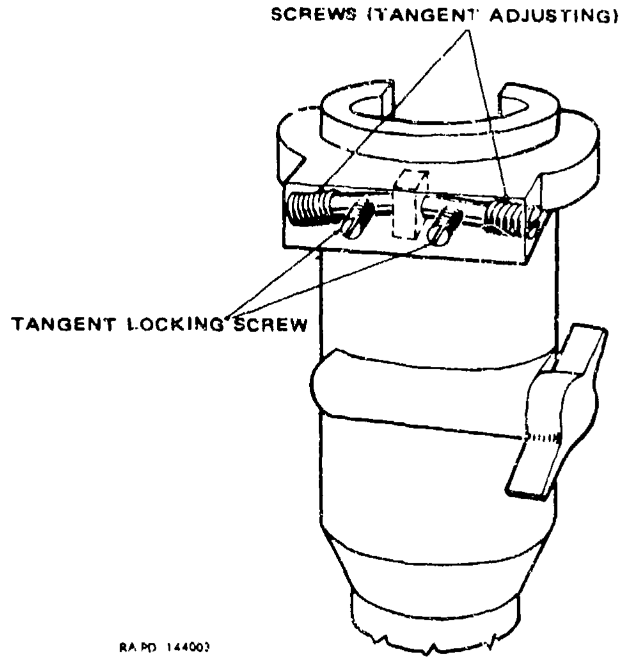


Figure 5-31. Tangent adjusting screws in the telescope socket of the telescope mount.

horizontal plane passing through the tube. Quadrant seats on the actuating arm bracket are used in making this adjustment.

(d) The actuating arm bracket is located at right angles to the axis of the tube and the actuating arm pivot. The pivot is parallel to the axis of the tube. Accurate azimuth compensation depends on the actuating arm pivot being exactly parallel to the tube.

(4) *Cross- and longitudinal-level bubbles.*

(a) The cross-level bubble is centered by means of the cross-leveling knob. The centering of the cross-level bubble automatically introduces an azimuth correction, which compensates for any error produced if the tube is elevated when the trunnions are not level.

(b) The longitudinal-level bubble is centered by turning the elevation knob. The centering of the longitudinal-level bubble places the azimuth scale of the telescope in a true horizontal plane when the cross-level bubble is centered so that deflection angles can be set accurately.

(5) *Telescope socket.*

(a) The telescope socket is held in place by a pin through it and the body of the mount.

(b) The socket provides for a 45° offset.

(c) The telescope is positioned and tightened in the socket by means of the tangent screws.

(d) The locating surfaces on the socket match those of the panoramic telescope.

(e) The wing knob holds the panoramic telescope in the socket.

(6) *Tangent screws.* The tangent screws (fig 5-31) are used to center the panoramic telescope in its mount, to eliminate any looseness between the telescope and the mount, and to adjust the line of sight of the vertical reticle of the panoramic telescope.

c. Procedure for seating the telescope.

(1) To install the telescope in the telescope mount, turn the wing knob on the telescope socket against its spring pressure and carefully place the telescope in the socket, taking care that the locating lug on the panoramic telescope enters the slot in the telescope socket. Release the wing knob. Exert slight downward pressure on the telescope to insure that it is properly seated. Next check the telescope for rotational looseness.

(2) If looseness is present, loosen the tangent lock screws and tighten one of the tangent screws until the panoramic telescope fits in the socket snugly without looseness or binding.

(3) Make the vertical reticle adjustment and then retighten the tangent lock screws.

d. Azimuth compensation.

(1) The effect of cant present in the trunnions is transmitted to the telescope mount. The mount will compensate for up to 178 mils of cant by leveling the cross-leveling mechanism.

(2) Accurate compensation can be obtained

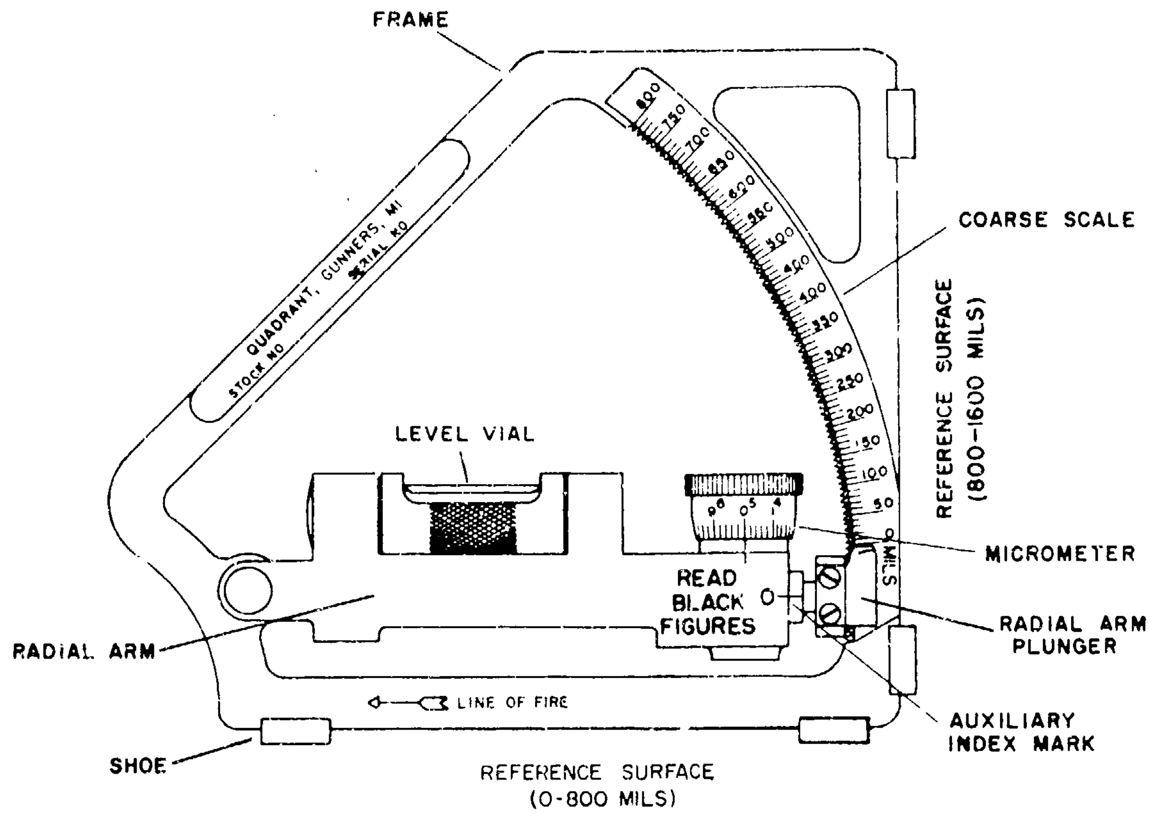


Figure 5-32. Gunner's quadrant M1.

only when the actuating arm pivot is exactly parallel to the tube.

(3) The process of laying the weapon for direction and elevation compensates for cant.

5-35. Gunner's Quadrants M1 and M1A1

a. The gunner's quadrant (fig 5-32) is used on the 155-mm howitzer primarily during sight test and adjustments; however, it may be used when the sight mount elevation scale is inoperable or to split a mil in elevation in firing a destruction mission. The gunner's quadrant will not measure a true vertical angle when used on the breech ring of a canted weapon.

b. The gunner's quadrant consists of a frame with a graduated arc, and index arm, a micrometer knob and scale, a level vial, reference surfaces, and frame shoes. The arc is graduated in 10-mil increments from 0 to 800 mils on one side and from 800 to 1,600 mils on the other side. The teeth on the arc position the radial arm plunger at these 10-mil graduations. The index micrometer scale is graduated on 0.2-mil increments from 0 to 10 mils. One complete revolution of the index micrometer raises or lowers the arm 10 mils. The index micrometer scale is numbered with black and red figures. The black figures are read for measuring an angle from 0 to 800 mils, and the red figures are read for measuring an angle from 800 to 1,600 mils. Two direction-of-fire arrows indicate the position in which the gunner's quadrant is placed on the quadrant seats. The gunner's quadrant M1A1 differs from the M1 in the following respects: the M1A1 is provided with a micrometer mask to insure use of the correct scale, it has an indicator on the index arm, and the index mark on the micrometer is numbered 10 rather than 0.

c. Gunner's quadrant micrometer test.

d. To test the gunner's quadrant for accuracy, perform the following end-for-end test before performing the sight tests and adjustments.

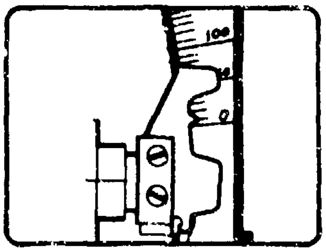
(1) Zero the scales of the gunner's quadrant, place the gunner's quadrant on the quadrant seats on the breech ring with the direction-of-fire arrow pointing toward the muzzle, and level the tube with the elevating handwheel. Be sure to center the bubble accurately.

(2) Reverse the quadrant (end-for-end) on the quadrant seats and check the bubble. If the bubble recenters by itself, then the tube is level, and the end-for-end test is complete, and the error in the gunner's quadrant is 0. However, if the bubble does not recenter by itself, then you must continue the end-for-end test and determine the sign (+ or -) and the amount of error in the gunner's quadrant as described in paragraphs (3) or (4) below.

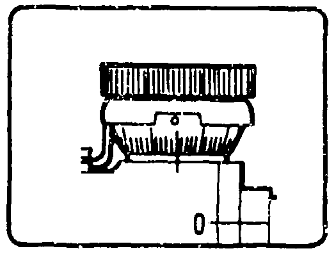
(3) If the bubble does not recenter itself ((2) above), turn the micrometer knob and try to center the bubble.

Gunner's Quadrant Micrometer Test

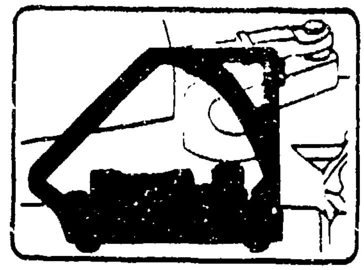
WARNING: If you have radioactively illuminated lights, be aware of the radiation hazard procedures listed in the front of this manual.



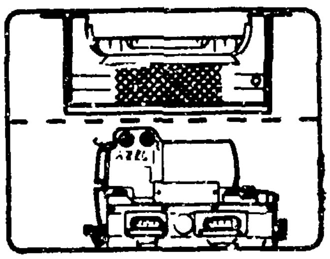
1. Set index at plus 10.



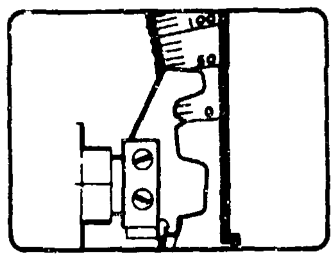
2. Zero the micrometer.



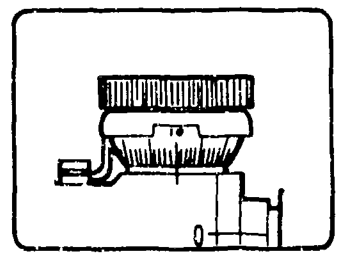
3. Point quadrant toward muzzle.



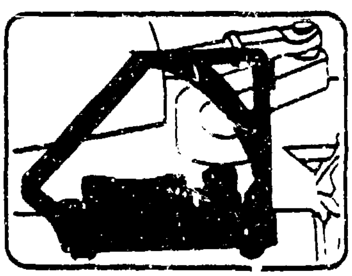
4. Depress/elevate tube to center bubble.



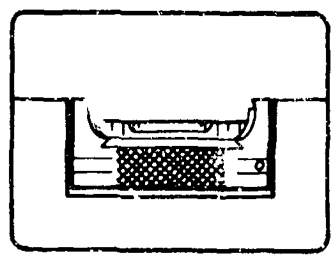
5. Set index at zero.



6. Set micrometer at 10.



7. Point quadrant toward muzzle.



8. Bubble should center.

9. If bubble does not recenter, the micrometer is in error. The quadrant should be turned in to organizational support for repair.

(a) If the bubble centers by turning the micrometer knob, read the black figures on the micrometer scale and divide the reading by 2. Set the results on the micrometer scale.

(b) Place the gunner's quadrant back on the quadrant seats with the direction-of-fire arrow pointed toward the muzzle and, using the elevating handwheel level the tube by centering the bubble.

(c) Reverse the gunner's quadrant (end-for-end) on the quadrant seats. The bubble should center by itself. The reading on the gunner's quadrant is the amount of the positive (+) error in the gunner's quadrant, and the end-for-end test is complete.

(4) If the bubble does not center ((3)(a) above), move the gunner's quadrant arm down one graduation (10 mils).

(a) Turn the micrometer knob until the bubble centers.

(b) Take the reading on the micrometer scale, add 10 to it, and divide the sum by 2. Place the results on the micrometer scale.

(c) With the arm of the gunner's quadrant set at minus 10 and the results in (b) above set on the micrometer scale, place the gunner's quadrant back on the quadrants seats, with the direction-of-fire arrow pointed toward the muzzle, and, using the elevating handwheel, level the tube by centering the bubble.

(d) Reverse the gunner's quadrant (end-for-end) on the quadrant seats. The bubble should center by itself. If the bubble centers, subtract the reading on the micrometer scale from 10 to obtain the error. This is known as the negative (-) error, and the end-for-end test is complete.

Note. If an error (+ or -) is determined during the end-for-end test of the gunner's quadrant, it will be carried only during sight tests and adjustments and will not be applied to elevations in fire missions. However, if the error determined amounts to more than plus or minus 0.4 mil, the gunner's quadrant must be sent to a support maintenance unit at the earliest possible date.

5-36. Care and Maintenance of Sighting and Laying Equipment

a. General care.

(1) Avoid rough handling.

(2) Disassemble equipment only to the extent authorized in the field manual or technical manual pertaining to that particular weapon.

(3) Keep equipment dry; never put the equipment in carrying cases when it is damp or wet.

(4) When the equipment is not in use, keep it in the carrying cases provided.

(5) Send any instrument not functioning properly to the appropriate support maintenance unit for repair.

(6) No painting is permitted.

(7) All throwout levers, when used, must be *fully* depressed.

(8) Before assembly, remove all dust and grit from the contact surfaces.

(9) Wipe off all excess lubricant to prevent the accumulation of dust and grit.

b. Panoramic telescopes and telescopic sights.

(1) Remove dust or grit with a *clean* camel's-hair brush or lens tissue paper.

(2) Use oil, lubricating, light, on the sight mount M25; apply oil through the hole on top of the housing.

(3) Use oil, lubricating, preservative, special, on the felt washers on the range quadrant and telescope mount and also on exposed bearing surfaces of the sight and sight mount.

(4) Remove oil or grease from the rubber eyeshields immediately.

c. Telescope mounts and range quadrants.

(1) Keep the level vials covered when they are not in use.

(2) Do not attempt to force a mechanism beyond its stop.

(3) Lubrications will be performed by support maintenance personnel periodically.

d. Gunner's quadrant.

(1) Do not burr, dent, or nick reference surfaces or the notched portion of the frame.

(2) Clean the arc frequently with a small brush or with a brush and drycleaning solvent.

(3) *Never* leave the gunner's quadrant on the weapon during firing.

e. Coated optical elements. Coated optics are optics coated with a reflection-reducing film of magnesium fluoride. Rub coated optics only to the extent necessary for cleaning. If such a coating is partly removed, do not remove the remaining coating, since any amount of coating will make the sights clearer.

Section VI. SIGHT TESTS AND ADJUSTMENTS

5-37. General

The accuracy of artillery weapons depends to a great extent on the proper adjustment of the sighting and laying equipment and the relationship of that equipment to the axis of the bore of the weapon. Certain tests and adjustments are performed to insure the proper relationship between the sighting and laying equipment and the axis of the bore of the weapon. The tests and adjustments and the procedures for accomplishing them are described in this section.

5-38. Leveling the Trunnions

a. To level the trunnions, suspend a plumbline 12 inches in front of the muzzle of the tube. Insert a boresighting disk in the breech end of the tube and affix crosshairs on the muzzle end. Aline the vertical hair on the muzzle of the tube and the plumbline. (The plumbline should be at least 11 feet long.) Elevate and depress the tube, checking to see that the vertical hair tracks the plumbline throughout its length. If it does not, raise one of the trails until the vertical hair on the muzzle does track the plumbline. The trunnions will then be level. The raised trail should be blocked to make it stable.

b. If it is not possible to suspend a plumbline of suitable length for leveling the trunnions, they may be approximately leveled by either of the following methods (listed in order of preference):

(1) Using a leveling plate, place a tested gunner's quadrant, set on zero, (or set with the correction determined from the end-for-end test), on the counterrecoil piston lug on top of the breech, parallel to the trunnions. Raise one trail until the bubble on the gunner's quadrant is centered.

(2) Match the white scribed lines on the telescope mount (scribed after fire control alinement tests) and raise one trail until the telescope mount cross-level bubble is centered.

c. The trunnions of the 155-mm towed howitzer should be as nearly level as possible when boresighting to insure that the proper relationship exists between the tube and the panoramic telescope mount. Under no circumstances should there be more than 20 mils of cant during boresighting. If for some reason the trunnions cannot be leveled, boresighting can be accomplished by use of scribe lines (*d* below) placed on the panoramic telescope mount during a fire control alinement test with the trunnions level. The scribe lines also make it possible to complete boresighting with the tube out of level. If scribe lines are used to boresight a weapon, the accuracy of the scribe lines and the alinement of the panoramic telescope should be verified at the first opportunity when both the tube and trunnions can be leveled.

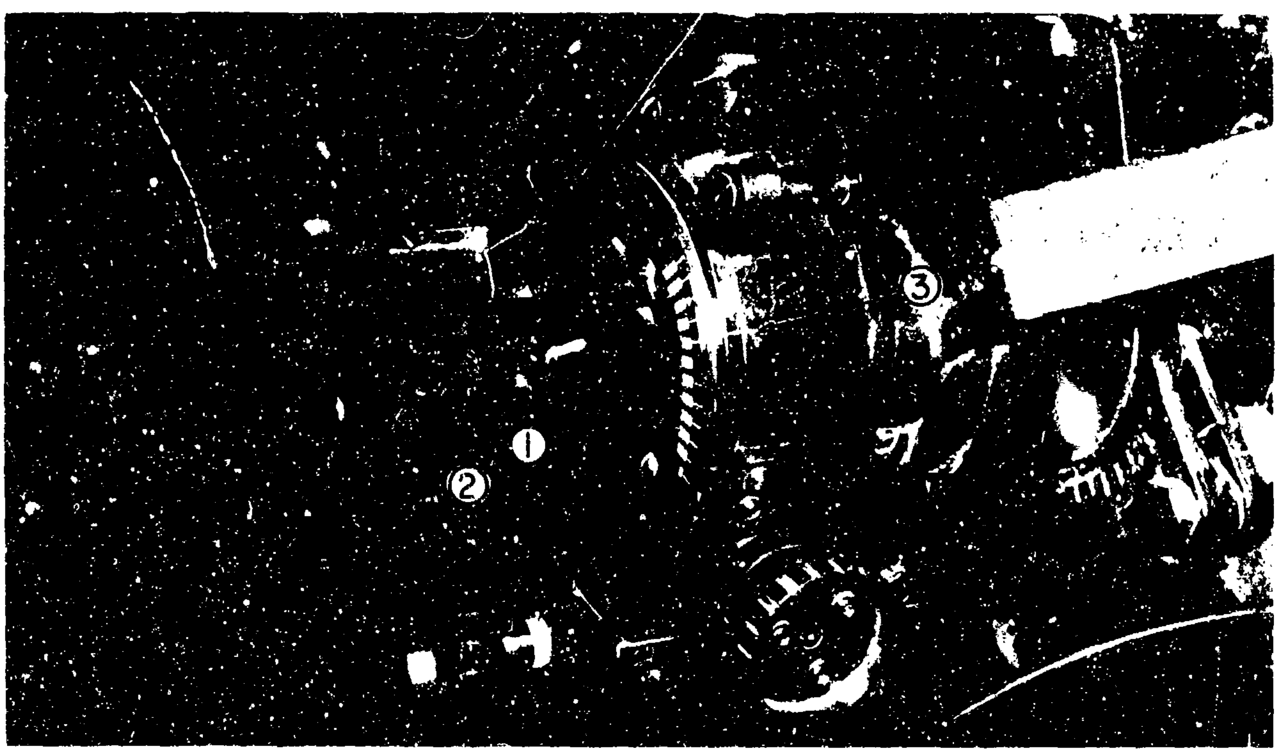


Figure 5-33. Scribe lines for positioning mount.

d. The scribe lines should be placed on the weapon after fire control alinement tests have been performed with the tube and the sights in perfect alinement. While the tube is in this alinement for the fire control alinement tests, the following scribe lines (fig 5-33) should be placed on the weapon:

(1) Straight across the junction of the cross-leveling segment and the cross-leveling worm housing of the panoramic telescope mount.

(2) Straight across the junction of the cross-leveling worm knob shaft and the cross-leveling worm housing.

(3) Straight across the junction of the inner and outer rings of the sight mount.

e. Fill the scribe lines with white paint and wipe off the excess. If conditions prevent boresighting with the tube level, longitudinal compensation for an unlevel tube may be made by matching the scribe lines.

5-39. Boresighting

Boresighting is the process of alining the on-carriage sighting and fire control equipment with the axis of the bore of the weapon. The purpose of boresighting is to properly adjust the sighting and fire control equipment in relation to the axis of the bore of the weapon in order to obtain accurate fire. Vibration, temperature changes, shock, and other factors tend to alter the adjustment after if has been made. Therefore, boresighting should be performed frequently—before firing and after each displacement when firing.

5-40. Methods of Boresighting

In order of preference, the two general methods of boresighting are the distant aiming point and the test target method. The standard angle can be used in an *emergency to check* boresighting. Regardless of the method used, the tube should be near the center of its traverse and pointed in the general direction of the testing target or the aiming point. The breech and muzzle boresights must be in their proper positions. All instruments must be positioned securely without free play.

a. The testing target method of boresighting is the most accurate of the three methods. However, boresighting by this method requires more time than do the other methods, and it must be performed in a relatively level area, where the trunnions can be leveled.

b. The distant aiming point method of boresighting is the method most often used in the field. With this method, the trunnions do not have to be accurately leveled, but they must be within 90 mils of level. The distant aiming point method requires much less time than the testing target method, but it also yields less accurate results.

c. The standard angle check is a *check* only. The standard angle can be determined only after the weapon has been boresighted by the testing target method. Once the standard angle is established, this method can be used to make a quick check of boresighting in the field. If the standard angle procedure discloses inaccuracies in the sighting and fire control equipment, the weapon must be accurately boresighted by one of the three methods of boresighting.

5-41. Testing Target Method of Boresighting

Boresighting by the testing target method is accomplished as follows:

a. Level the trunnions. This may be done by the plumbline method or the leveling plate method. The plumbline method is the preferred method. Place the tube in the center of traverse.

b. Perform the end-for-end test as outlined in paragraph 5-35*c*.

c. Using the tested gunner's quadrant and applying any corrections determined from the end-for-end test, set the tube at zero elevation.

d. Place the gunner's quadrant on the seats between the telescope mount and the trunnions. If the bubble of the gunner's quadrant does not center within ½ mil, loosen two cap screws and turn the actuating arm eccentric pin until the bubble of the quadrant centers; then carefully retighten the cap screws.

e. Center the cross-level bubble with the cross-leveling worm knob. Place the gunner's quadrant on the outer quadrant seats and check the bubble (plus or minus ½ mil in elevation is the allowable error). If the outer quadrant seats are out of alinement more than the allowable error, they should not be used and the weapon should be referred to support maintenance personnel.

f. Recheck the cross-level bubble. Center the longitudinal-level bubble with the elevation knob. Adjust the elevation scale to zero by loosening the screws in the elevation scale and slipping the scale. Adjust the elevation micrometer scale to zero by loosening the three screws in the head of the micrometer and slipping the scale. Retighten the screws.

g. Place the breech and muzzle boresights in their proper positions. Place the testing target (fig 5-34) at least 50 meters in front of the weapon. Aline the proper aiming diagram with the line of sight through the tube (move the testing target and not the tube for this operation). If the trunnions of the howitzer are slightly canted, the testing target must be canted an equal amount in the same direction.

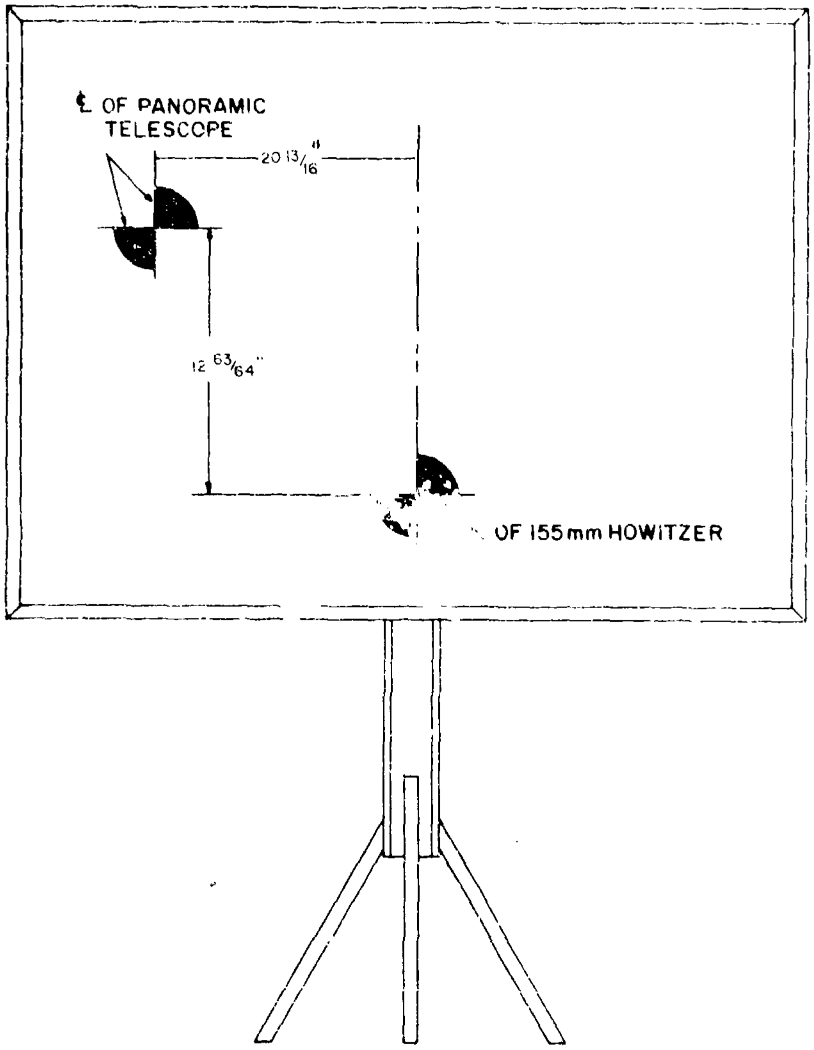


Figure 5-34. Testing target and stand.

h. Place the panoramic telescope in its socket in the mount and set all scales of the telescope and the telescope mount at zero (with the bubbles of the mount still centered). If the vertical reticle line is not alined with the vertical line of the aiming diagram, loosen the tangent locking screws on the telescope socket and adjust the tangent screws until the vertical reticle line is properly alined. Tighten the locking screws and verify the adjustment. If the horizontal reticle in the telescope does not aline with the horizontal line of the aiming diagram, the elevation knob on the telescope must be adjusted. Adjust the elevation knob as follows:

(1) Place the horizontal hair (optical center) of the reticle on the proper horizontal line of the testing target by turning the elevation knob of the telescope.

(2) If the elevation indexes do not coincide, loosen the locking screws and shift the movable index into coincidence with the fixed index. At this time the coarse elevation index should read zero. The coarse elevation index cannot be adjusted by the using personnel and must be referred to the support maintenance unit if it does not read zero.

(3) Tighten the locking screws and verify the line of sight and the matching of the indexes.

(4) Remove the panoramic telescope from its mount and replace it in the mount to determine if there is any looseness in the seating or if the tangent screws have been adjusted too tightly. This operation may reveal that the tangent screws must be readjusted to bring the line of sight on the distant aiming point.

Note. The nonslipping azimuth scale must not be adjusted by the using unit.

5-42. Distant Aiming Point Method of Boresighting

Boresighting by the distant aiming point method is accomplished by sighting on a common point at a minimum distance of 1,500 meters from the weapon. This minimum distance insures that the mechanical axis of the tube and the optical axis of the telescopes intersect to form an angle not greater than ¼ mil and are thereby approximately parallel.

a. Place the weapon near its center of traverse with the tube pointed in the general direction of the distant aiming point.

b. Cross-level the trunnions. Accurate cross-leveling of the trunnions is unnecessary for boresighting on a distant aiming point; however, they should be as level as possible.

Note. If the trunnions cannot be leveled within 90 mils, the cross-level bubbles on the telescope mount cannot be used and scribe lines must be used as described in paragraph 39*c* to insure the proper relationship between the telescope mount and the tube. If scribe lines are used, omit steps *f*, *g*, *h*, and *i* below.

c. Place the breech and muzzle boresights in their proper positions.

d. Insure that all instruments and mounts are positioned securely without free play.

e. Perform the end-for-end test on the gunner's quadrant as described in paragraph 5-35*c* and set the tube at zero elevation.

f. Level the telescope mount in both directions by centering the cross- and longitudinal-level bubbles with the cross-leveling and elevation knobs.

g. Place the gunner's quadrant (adjusted to the setting determined from the end-for-end test) on the inner quadrant seats. If the bubble of the gunner's quadrant does not center, loosen the two capscrews and turn the actuating arm eccentric pin until the bubble of the gunner's quadrant centers. While tightening the two capscrews, check to insure that the bubble remains centered.

h. Recheck the cross- and longitudinal-level bubbles. If they are not centered, repeat the step described in *f* above.

i. Adjust the elevation scale to zero by loosening the two screws in the elevation scale and slipping the scale. Retighten the screws and verify the adjustment. Adjust the elevation micrometer scale by loosening the three screws in the micrometer knob and slipping the scale. Retighten the three screws and verify the adjustment.

j. While looking through the breech boresight, elevate and traverse the tube until the intersection of the crosslines of the muzzle boresight is alined on the distant aiming point.

k. Place the panoramic telescope in its mount; check to insure that the azimuth and micrometer scales are set at zero.

(1) Adjust the vertical line of the reticle of the telescope on the distant aiming point by means of the tangent screws.

(2) Adjust the horizontal line on the distant aiming point by means of the elevation knob on top of the telescope. If the fine indexes do not coincide, loosen the three screws on top of the elevating knob and slip the scale. Tighten the three screws and verify the adjustment. Adjustment of the coarse index by battery personnel is *not* authorized.

(3) Remove the panoramic telescope from its mount and replace it in the mount to determine if there is any looseness in the seating or if the tangent screws have been adjusted too tightly. This operation may reveal that the tangent screws must be readjusted to bring the line of sight on the distant aiming point.

5-43. Standard Angle Method of Boresighting

a. The standard angle should be determined and recorded after the weapon has been boresighted and the fire control alinement tests have been performed. The procedure for obtaining the standard angle is as follows:

(1) Check the recoil system with the tube in battery. Carefully measure the distance from the end of the tube to the wiper. Record this distance.

(2) Carefully level the trunnions.

(3) Turn the cross-level knob and center the bubble in the cross-level vial. Turn the elevation knob and center the bubble in the elevation-level vial.

(4) Place a common straight pin in the left horizontal muzzle witness mark and secure the pin with adhesive tape. (If a straight pin is not available, a straightened paper clip can be used.) The pin must project to the left of the muzzle.

(5) Install a parallax shield over the panoramic telescope eyepiece lens. Check to be sure that the elevation index and micrometer on the telescope are at 0.

(6) Turn the azimuth micrometer knob and the elevation knob (on the panoramic telescope mount) to move the panoramic telescope line of sight down and to the right. Carefully turn the knobs until the panoramic telescope reticle is alined with the pin where it extends from the muzzle.

(7) On the inside of the panoramic telescope case, record the azimuth setting to the nearest mil. This is the standard azimuth angle. Also record the elevation in mils to the nearest legible fractional part. This is the standard elevation angle.

(8) With a sharp-bladed knife, scribe lines on

the telescope mount just above or below the scribed lines used for boresighting. (See paragraphs 5-38*d*(1) through (3).)

(9) Paint these scribed lines red or yellow or any color other than white, which is the color used for the boresighting scribed lines.

b. The standard angle check of boresighting is accomplished as follows:

(1) Verify that the parts that move in recoil are in the same position with respect to the nonrecoiling parts as they were when the standard angles were determined. If they are not in the same position, the amount of recoil oil in the recoil mechanism must be modified until the distance from the end of the tube to the wiper is the same as the recorded measurement (*a*(1) above).

(2) Verify that the trunnions are not canted more than 90 mils; if convenient, level the trunnions.

(3) With tape, fasten a pin in the left horizontal witness mark so that the pin projects out to the left of the muzzle.

(4) Place the aprallax shield on the eyepiece of the telescope.

(5) Bring the red (or yellow) scribe lines into coincidence, refining the setting by turning the elevation micrometer knob to the standard elevation angle.

(6) Set off the standard azimuth angle on the panoramic telescope.

(7) If the vertical line of the reticle is not exactly on the junction of the pin and the muzzle, adjust the tangent screws until the vertical line of the reticle is properly alined. If the horizontal line of the reticle is not exactly on the junction of the pin and the muzzle, turn the elevating knob of the panoramic telescope until it is properly alined. Adjust the zero of the elevation knob scale so that it is in alinement with the index.

Note. If an error in boresighting is discovered by the standard angle check and corrected by using the standard angle data, the weapon should be boresighted by a more accurate method at the first opportunity. All of the methods of boresighting described in this section are described in detail in chapter 7 of FM 6-81 with appropriate pictures and drawings.

Section VII. SPECIAL SAFETY PROCEDURES (MISFIRE)

5-44. Malfunctions

Malfunctions in the firing of artillery ammunition are defined and discussed in *a* through *c* below. Malfunctions are rarely encountered when authorized and properly maintained ammunition is fired from properly maintained and operated weapons. In order to avoid injury to personnel and damage to equipment, all personnel concerned must understand the nature of each malfunction and the proper preventive and corrective procedures. General procedures for removing chambered rounds associated with these malfunctions are described in paragraphs 5-45 and 5-46.

a. Misfire. A misfire is a complete failure to fire. A misfire may be due to a faulty firing mechanism or to a faulty element in the propelling charge explosive train. A misfire in itself, is not dangerous, but since it cannot be immediately distinguished from a delay in the functioning of the firing mechanism or from a hangfire (*b* below), it should be considered as a delayed firing until such possibility has been eliminated. A delay in the functioning of the firing mechanism, for example, could result from the presence of foreign matter (such as grit, sand, frost, or ice) or from the use of improper or excessive oil or grease. The foreign matter might create, initially, a partial mechanical restraint, which, after some undeterminate delay, is overcome by the continued force applied by the spring. The firing pin is then driven into the primer in the normal manner.

b. Hangfire. A hangfire is a delay in the functioning of the propelling charge explosive train at the time of firing. The delay is unpredictable and may range from a split second to several minutes. Thus, a hangfire cannot be distinguished immediately from a misfire (*a* above). The principal danger is in assuming that a failure of the weapon to fire immediately upon actuation of the firing mechanism is a misfire when, in fact, it may be a hangfire. It is for this reason that the time intervals described in paragraphs 5-45 and 5-46 should be observed before the breech is opened after a failure to fire.

CAUTION: During the prescribed time intervals, the weapon will be kept trained on the target and all personnel will stand clear of the muzzle and the path of recoil.

c. Cookoff. A cookoff is a functioning of any or all of the explosive components of a round chambered in a very hot weapon and is due to heat from the weapon. The primer and propelling charge, in that order, are, in general, more likely to cookoff than the projectile or the fuze. If the primer or propelling charge should cookoff, the projectile may be propelled (fired) from the weapon with normal velocity even though no attempt has been made to fire the primer by actuating the firing mechanism. In such a case, although there may be uncertainty as to whether or when the round will fire, the precautions to be observed are the same as those prescribed for a hangfire. However, should the bursting charge explosive train cookoff, injury to personnel and destruction of the weapon may result. To prevent heating to the point at which a cookoff may occur, a round of ammunition that has been loaded into a very hot weapon should be fired or removed within the time prescribed in paragraph 5-45.

5-45. Hot Tube Loading Precautions

Certain precautions must be taken when artillery ammunition is being fired from a hot tube; therefore, the officer in charge of firing must determine when the tube is hot enough for the procedures and precautions to be applicable. Several factors that may cause a hot tube situation to exist are the ambient temperature, temperature of the ammunition, rate of fire or number of rounds fired within a specific period, and the charge being fired. In any event a hot tube situation exists when a combination of factors could possibly cause a cookoff or exudation of the high-explosive filler from a chambered round that cannot be fired immediately. The person in charge of firing must determine whether a hot tube situation exists and, if so, observe the following precautions:

a. Do not chamber a round in the tube until immediately prior to firing.

b. Fire or remove from the weapon within 5 minutes a round that has been chambered in a hot tube.

c. If the round in a hot tube cannot be fired or removed within 5 minutes after being loaded and if a misfire is not involved, take the following actions:

(1) Remove the primer and propelling charge immediately.

(2) Evacuate all personnel to a safe distance.

(3) Keep the weapon laid on safe data.

(4) Notify EOD for projectile removal.

5-46. Misfire Procedures

a. Misfire procedures for weapons firing separate-loading ammunition—cold tube. After a failure to fire, actuate the firing mechanism two additional times in an attempt to fire. If the weapon still fails to fire, wait 2 minutes from the last attempt to fire and then remove and inspect the primer.

(1) *If the primer is not dented*—the fault is in the firing mechanism. Repair the firing mechanism, replace the primer and then fire the weapon.

(2) *If the primer is dented*—then the primer is at fault. Replace the primer with another primer and then fire the piece.

(3) *If the primer fired*—then the fault is with the propelling charge. Wait 10 minutes (8 minutes after removal and inspection of the primer), open the breech and remove the propelling charge for disposal as defective. Reload the weapon with a new propelling charge and primer for firing.

b. Misfire procedures for weapons firing separate-loading ammunition—hot tube. After a failure to fire on activation of the firing mechanism, actuate the firing mechanism two additional times in an attempt to fire. If the weapon still fails to fire, wait 2 minutes from the last attempt to fire, remove and inspect the primer, and follow one of the two safety procedures below.

(1) *If the primer has fired*—evacuate all personnel a safe distance and follow the safety procedures and precautions presented in paragraphs 5-45*c*(2) through (4) concerning loading a round in a hot weapon.

WARNING: Do not open the breechblock to remove the propellant until a 2-hour waiting period has elapsed.

Note. In a combat emergency if the primer has fired, insert a new primer and attempt to fire the weapon. If the weapon still fails to fire, follow the procedures in paragraphs 5-45*c*(2) through (4).

(2) *If the primer has not fired*—insert a new primer or correct the faulty mechanism and attempt to fire the weapon. If the weapon cannot be fired within 3 additional minutes (total of 5 minutes from the time the round was chambered in the weapon), remove the propelling charge and follow the safety procedures and precautions contained in paragraphs 5-45*c*(2) through (4) concerning loading a round in a hot weapon.

Section VIII. SUMMARY

5-47. Summary

The four major components of the 155-mm howitzer, towed, are the carriage, the barrel and breech assemblies, the recoil mechanism, and the sighting and laying equipment. In order for the weapon to function properly and deliver accurate fire, each component must be kept in proper working condition. The purpose of this handbook is to give students a general insight into the characteristics, nomenclature, functioning, and maintenance of the major components of the weapons. For more detailed information, see TM 9-1025-200-12, LO 9-1025-200-10, and FM 6-81.

5-48. Special Notes

The M109 howitzers TFT, GFT, and GST must be used when computing firing data for the M114A2, 155-mm howitzer.

U. S. ARMY
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CHAPTER 6

155-MM HOWITZER, TOWED, M198

Section I. GENERAL

6-1. References

TM 9-1025-211-10.

6-2. Introduction

The M198 155-mm towed, howitzer, is a medium artillery weapon (fig 6-1) designed to provide general support and direct support field artillery fire in the infantry and air assault divisions and in corps general support battalions. This chapter will describe the nomenclature, operation, functioning, maintenance, adjustment, disassembly and assembly of the major components of the weapon.

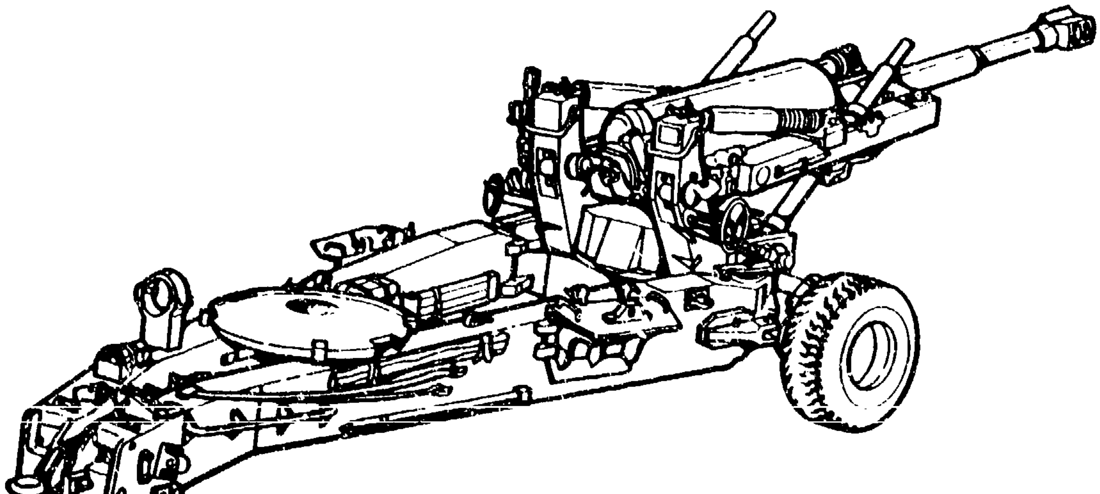


Figure 6-1. Howitzer, medium, towed: 155-mm, M198.

Section II. CARRIAGE M39

6-3. Trails, Trail Lock and Spades

a. Trails. The trails are tapered, welded aluminum with box-type girders welded inside to provide reinforcement.

(1) The trails are used to connect the weapon and the prime mover. When traveling they are used to stabilize the weapon in the towed position and to carry the spades, aiming post, rammer staff sections, sledge hammer, weapon handling bars, M13 ramming pad bell rammer pick, spade keys, base plate, loading tray and sight box with sights inside.

(2) The trails (fig 6-2) are hinged to the bottom carriage; when they are spread, each trail forms a 30° angle with the center of the carriage. On each trail are arms with shoulders which contact wedge-shaped stops welded to the top and bottom of the bottom carriage to control maximum spread.

(3) The trails are equipped with trail handles to help lift the weapon.

(4) When the top carriage is properly centered, plates welded to the top trail hinges contact stops welded to the bottom plate of the top carriage. This prevents movement of the top carriage during travel.

*Supersedes HB-6 WCXXWS, Dec 81.

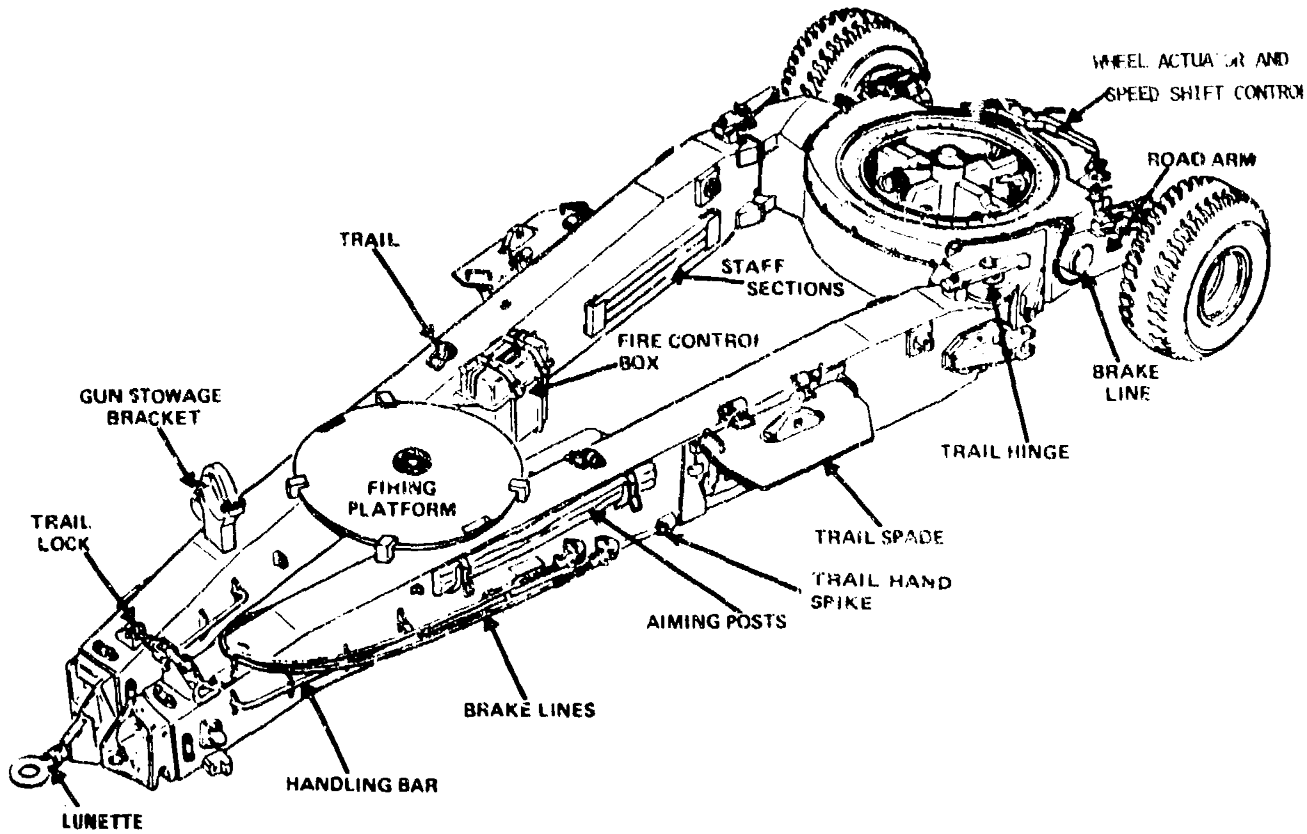


Figure 6-2. Trails.

(5) The rear end of each trail has a smooth bottom surface with a recess for attaching a trail spade lug. On these end surfaces is a square hole for inserting the spade key which secures the trail spade in position. On each side of the trails are sockets for inserting the spade retainer pin.

b. Trail lock. The trail lock holds the trails in the closed position for traveling.

(1) The trail lock is a toggler-type clamping mechanism and is operated by the trail lock handle.

(2) The trail locking retainer pin is inserted into a hole in the projecting ledge of the left trail as an additional safety device to prevent the trails from spreading during travel.

(3) The trail lock is adjusted by loosening the trail lock link jamnut and turning the trail lock link ½ turn at a time, either right or left, depending on the adjustment needed. When the trail lock is properly adjusted, a slight downward pressure should force the lock handle down and cause the trail lock hook to engage with the trail lock link.

c. Spades. The spades, being two of the three points of suspension, absorb the force of recoil and transmit the shock of firing to the ground. They limit the amount of displacement of the weapon. For greater clearance of the rear of the weapon during travel, the spades are removed from the ends of the trails and placed in the traveling position on the trails. Handles on the spades are used for lifting and carrying the spades from the traveling position on the howitzer to the firing position at the end of each trail.

(1) In the firing position the trail spades are attached to the underside of the trails by engaging the spade retainer pins and spade keys in the recesses of the trails.

(2) During travel the spades are carried in brackets on the outer surface of the trails.

(3) During travel the spade keys are carried in the key carrier on the outer surface of the left trail.

d. Maintenance.

(1) The trail hinge pin's bushings should be lubricated monthly with GPG.

(2) The trail lock should be lubricated weekly with PL-S.

Note. Maintenance of this component and all other components of the 155-mm howitzer M198 described in subsequent paragraphs of this chapter will include lubrication of the item concerned. Lubrication of all components will be performed in accordance with lubrication order on pages 3-1 through 3-14 of TM 9-1025-211-10.

6-4. Brakes

a. General. When the howitzer is being towed by the prime mover, the carriage brakes are activated by compressed air furnished by an air compressor on the prime mover and conducted to the relay valve by the service and emergency air brake hoses. The brakes can also be controlled individually by hand levers stowed on the carriage.

b. Principal parts. The principal parts of the air brake system are two air lines (service and emergency), two air cleaners, an emergency relay valve, an air tank, a drain cock, an assembly and a disk brake head assembly (fig 6-3).

c. Air lines. The air lines consist of air hoses and tubes interconnecting the various units of the brake system. The service air line leads from the prime mover to an air cleaner and the emergency line to another air cleaner. Dummy couplings on the outer side of the right trail are to provide a place to retain the air lines when not attached to the prime mover; this is to prevent dirt from getting into the brake system.

d. Air cleaners. The air cleaners are mounted on the trail and connected in the service and emergency air lines to filter water and dirt from the air before it enters the relay valve. Drain plugs in the bottom of the air cleaners permit the drainage of dirt and water.

e. Relay valve. The relay valve (fig 6-3) is mounted on the trails.

f. Air tank. The air tank is mounted on the trail. It stores compressed air for emergency brake applications.

g. Power booster. The power booster is composed of an air cylinder and a hydraulic brake cylinder. The air comes from the relay valve into the air cylinder when it controls a float piston inside the hydraulic brake cylinder that applies pressure on the brake fluid inside the hydraulic brake cylinder and causes the brakes to lock the tires.

h. Disk brake head assembly. The disk brake head assembly is where the brake fluid is forced to from the power booster and to the head and forces the brake pads against the brake disk.

i. Hand brakes. To apply the hand brakes insert the brake lever into the hand brake socket and pull the socket in a counterclockwise direction. This forces the brake pads against the brake disk.

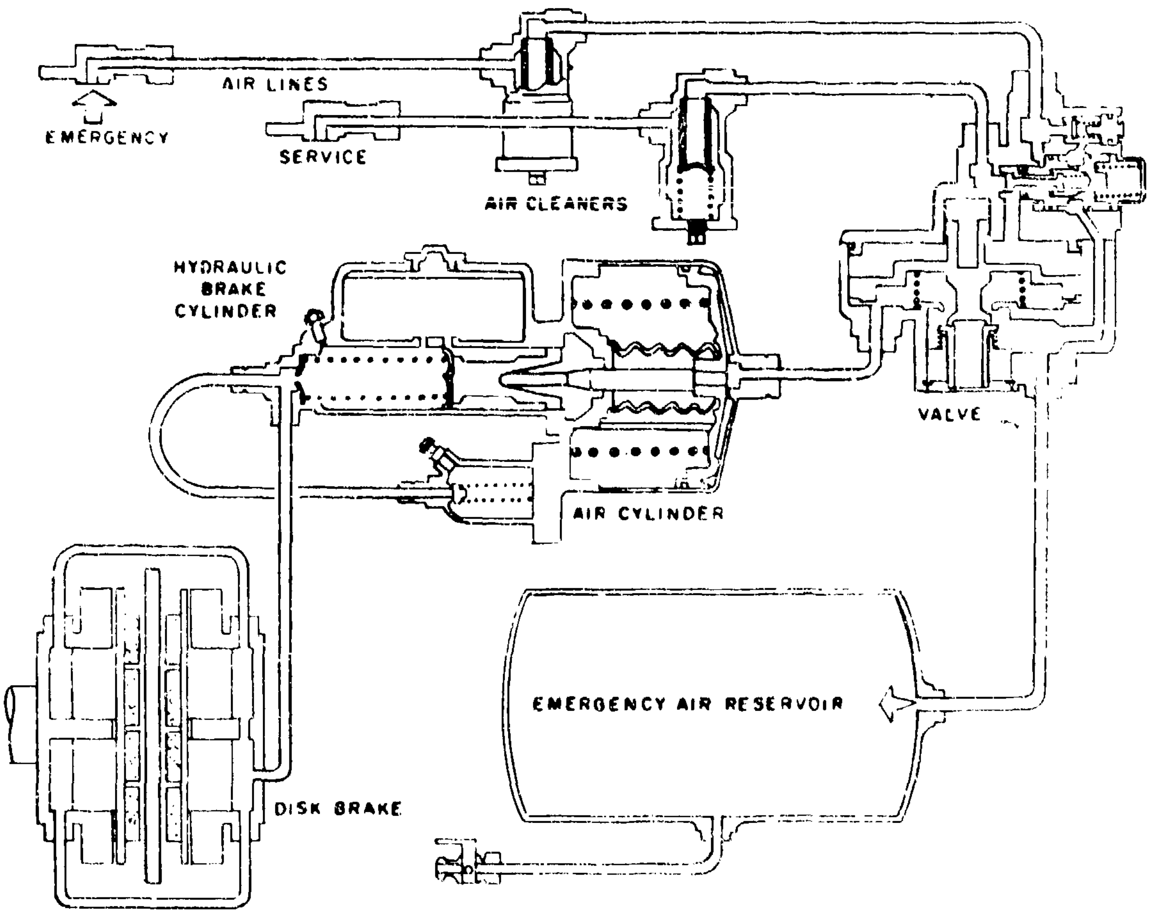


Figure 6-3. Charging

6-5. Care and Maintenance of the Air Brake System

a. Test emergency brake application. Test the emergency brake application daily by closing the emergency air lines cutout cock on the prime mover and disconnecting the emergency air brake-hose coupling from the prime mover if the tactical situation permits coupling the weapon to the prime mover for this test. If the brakes do not apply automatically, notify support maintenance personnel.

b. Drain water from air cleaner and air tank. Drain water from the air cleaner and tank weekly. In cold weather drain these units after 8 hours of continuous travel.

c. Clean air cleaners. Clean air cleaners bimonthly by disassembly of the cleaners, brushing off foreign matter, and washing the air cleaner strainers and cleaner covers with drycleaning solvent. Allow the parts to air dry.

d. Test for air leakage. Test the brake system for air leaks by applying soap suds to all the joints and fittings from the air cylinder by where the lines connect to the prime mover.

6-6. Wheel, Hubs and Tires

a. Wheels. There are 10 lug nuts holding the wheel on.

b. Hubs. The wheel, hubs and tires rotate on a set of bearings.

c. Tires. The M198 tires are interchangeable with the M40, M61, M54, M813, M51, M52, M62, M139, and M41 trucks; also, the M114A1 howitzer. These tires should only be used in emergency situations. The appropriate tire pressure is 45 pounds.

d. Care and maintenance.

(1) Check tire pressure. Keep tire pressure uniform (45 pounds) as the tires act as shocks for the weapon.

(2) Check tire for cuts and slashes down to the core.

6-7. Manifold Assembly

a. General. This assembly is located on the right forward section of the bottom carriage assembly and provides power to raise and lower the wheels (fig 6-4).

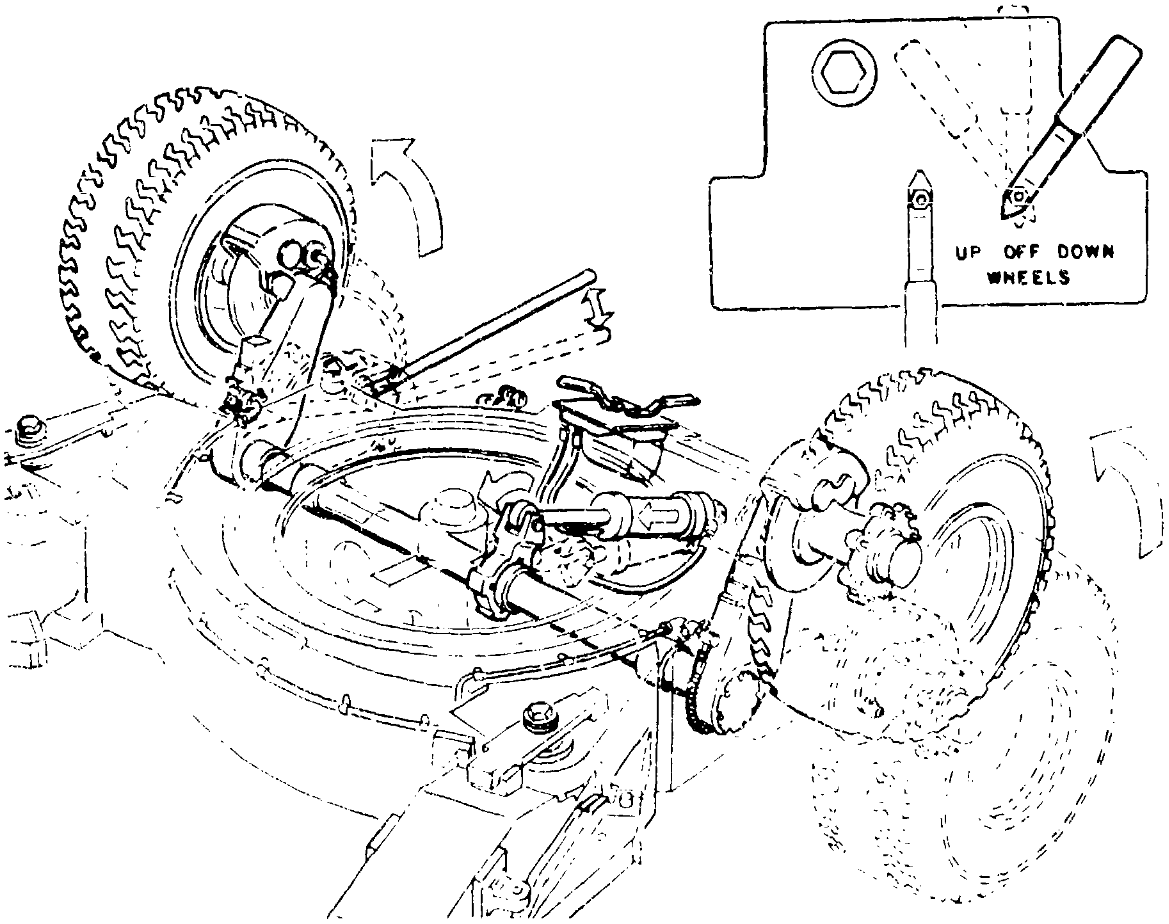


Figure 6-4. Actuator cylinder assembly.

b. Speed shift assembly. This assembly is mounted inside the bottom carriage assembly at the on-carriage traverse centerline. It is a hydraulic ram cylinder that provides rapid shifting of the carriage to insure 6,400 mil fire coverage.

c. Firing baseplate. The firing baseplate is suspended underneath the bottom carriage. The firing baseplate is a circular aluminum structure mounted on a ball socket. The firing baseplate is designed to absorb the vertical reaction, and the ball joint compensates for uneven ground contours. The firing baseplate is operated by the speed shift lever located to the top left of the wheel shift lever.

d. Functioning. To lower the baseplate to the ground you must make sure the speed shift lever is in the OFF position and then push down and move the wheels lever to the DOWN position. Insert pump handles in hydrau'' adapter sockets and pump until the pressure is off wheel lock handles; then move lock handles to UNLOCK position, place wheel lever to UP position, and insert pump handles into hydraulic adapter sockets. Pump until wheels are all the way up and turn wheel lock handles to LOCKED position. Next, place wheel lever to OFF position.

e. Maintenance. Check manifold oil dip stick. Inspect for dirty, loose, broken or missing parts. Notify organizational maintenance to correct any problems.

6-8. Bottom Carriage

a. Construction. The bottom carriage (fig 6-5) of the 155-mm howitzer, towed M198, is constructed of welded aluminum.

b. Purpose. The bottom carriage—

(1) Supports the weight of the top carriage and the tipping parts.

(2) Transmits firing stress to the baseplate and trails.

(3) Provides a mount for the baseplate, travel lock, and actuator assembly.

6-9. Top Carriage

a. Definition. The top carriage (fig 6-6) contains the elevating brackets and traversing mechanism and forms the connection with cradle trunnion attachment, the upper end of the equilibrators, and the bottom carriage.

b. Construction. The top carriage is constructed of welded aluminum. It has a circular base.

c. Purpose. The top carriage supports the howitzer and recoil mechanism, the elevating and traversing mechanisms and the sighting equipment. It is supported by and rotates on the bottom carriage.

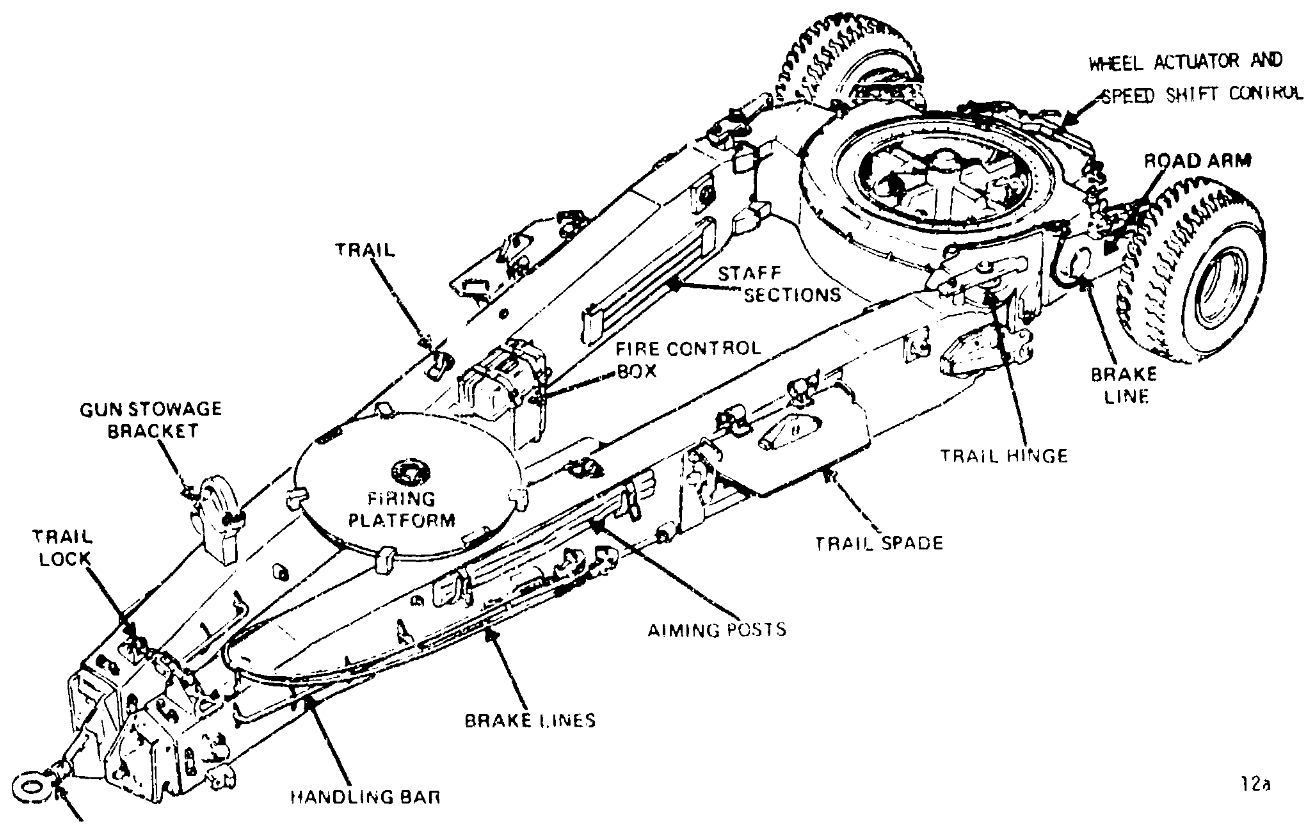


Figure 6-5. Bottom carriage assembly.

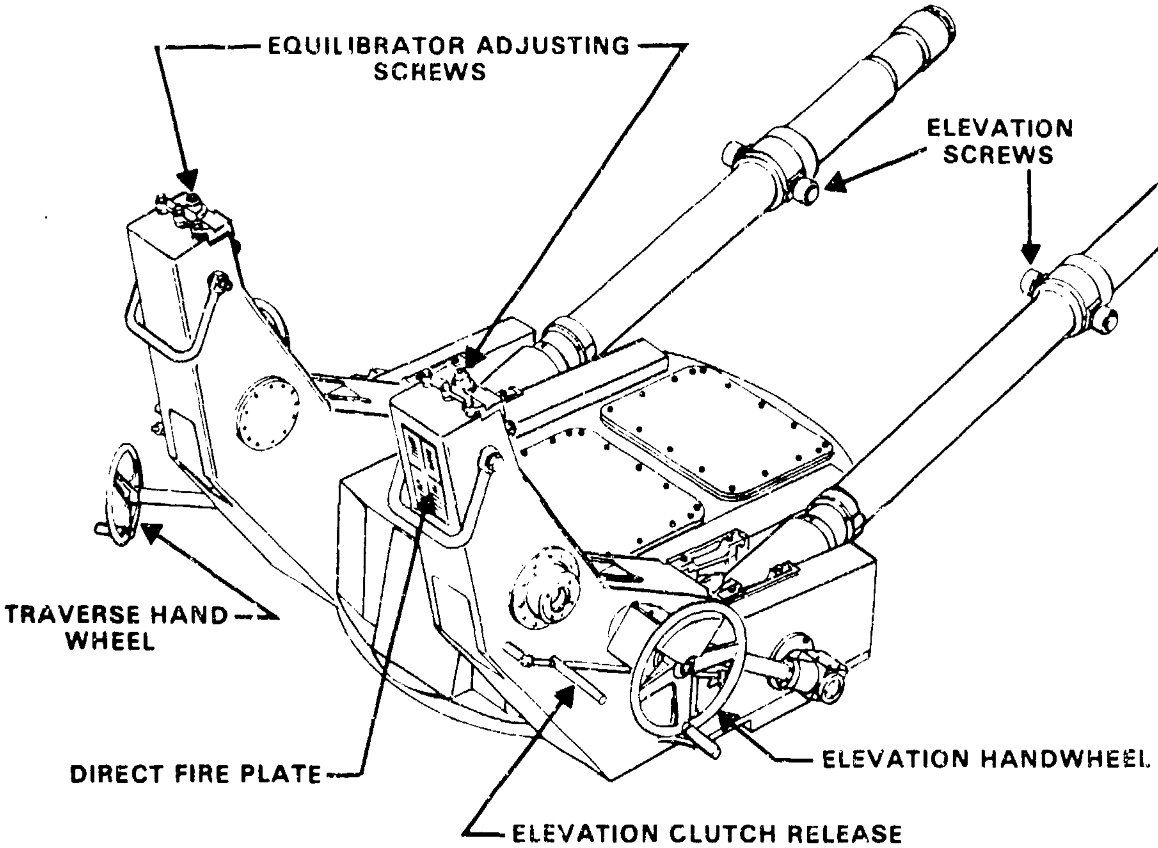


Figure 6-6. Top carriage assembly.

d. Functioning. The top carriage is fastened to the bottom carriage by means of a pintle. The top carriage rotates when traversing hand wheel is turned.

6-10. Traverse

a. General. The traverse used on the towed 155-mm howitzer M198 is the pintle type. The weapon traversing limit in the firing position is 400 mils left and 400 mils to the right. A traversing ring scale is placed on the lower carriage to indicate left and right traverse limits of the howitzer in the firing position. The traversing ring scale is located just below the breech end of the tube. The 400-mil traverses left and right are limited by the top carriage coming in contact with the stops bolted on the trails. With the trails closed approximately 1/10 of the way, the weapon can be traversed a complete 6,400 mils.

b. Traversing mechanism. The traversing mechanism (fig 6-7) controls the movement of the weapon in azimuth and is the angular drive type. One turn of the traversing hand wheel moves the tube left or right approximately 10 mils.

c. Maintenance. Check for smooth operation, if backlash is greater than 1/12 of a turn, notify organizational maintenance.

6-11. Elevation

a. General. The trunnions of the cradle are mounted in bearings on the top carriage arms and form the pivot point about which the cannon rotates in elevation. The total angle through which the cannon can be elevated is from -75 to +1275 mils.

b. Elevating mechanism. The elevating mechanism (fig 6-8) controls the movement of the weapon in elevation. The type elevating mechanism is screw assembly with a clutch assembly to provide irreversibility. One turn of the elevation hand wheel moves the tube up or down approximately 10 mils.

c. Maintenance.

(1) Check for ease of operation in elevating and depressing the tube.

(2) Check for backlash. Backlash exceeding 1/12 of a turn should be reported to organizational maintenance personnel.

(3) Check the function of the variable recoil cam. (The recoil cam rotates the throttling rod in the recoil cylinders when the tube is elevated or depressed.)

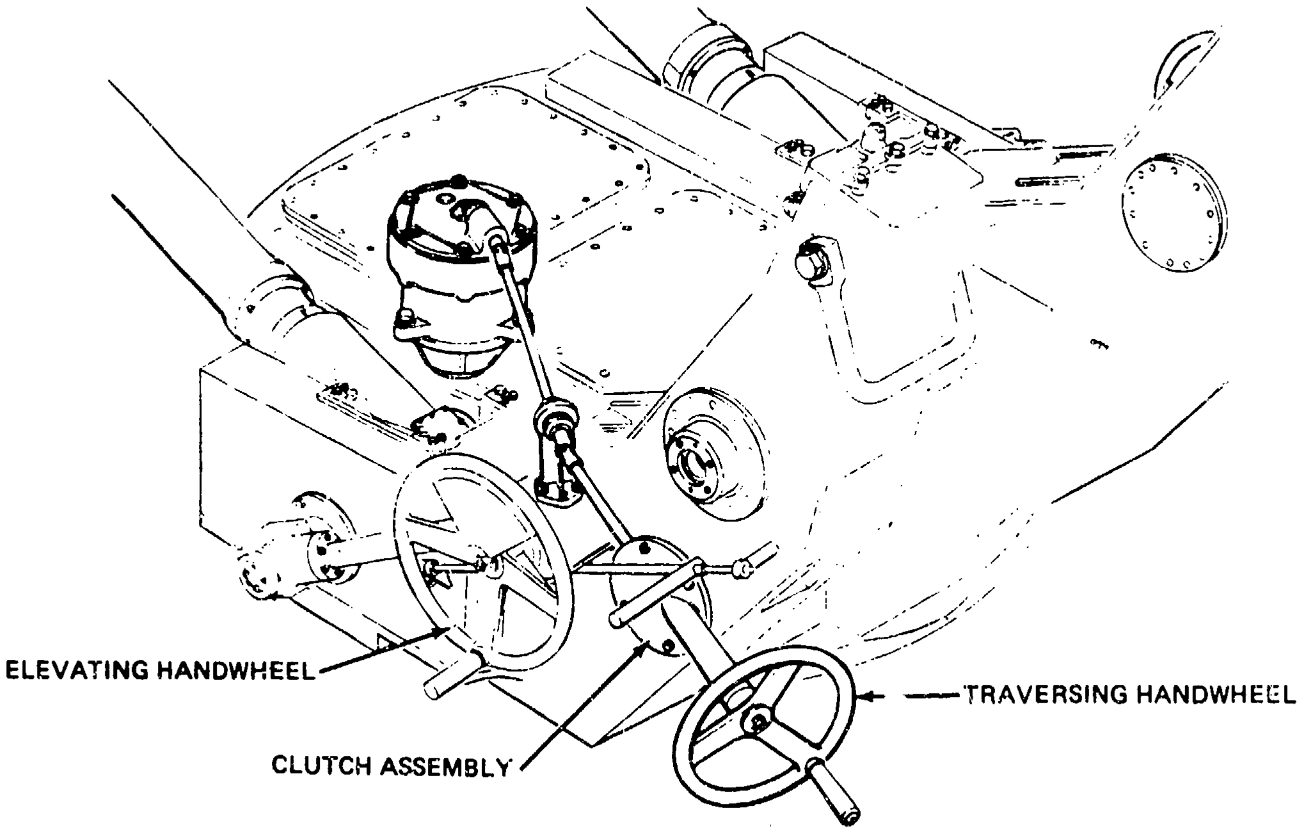


Figure 6-7. Traversing mechanism assembly.

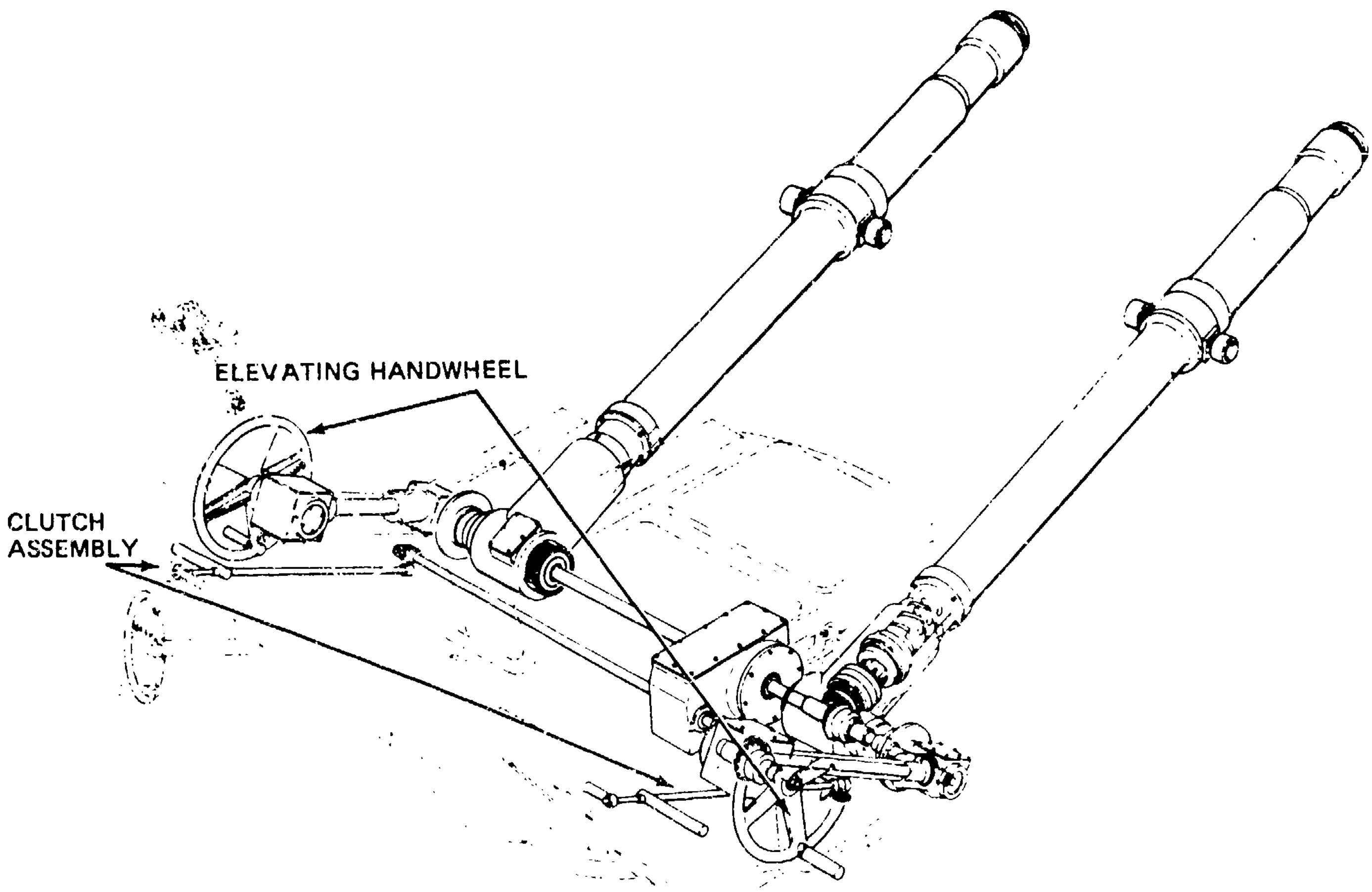


Figure 6-8. Elevating mechanism assembly—interface of internal components.

6-12. Equilibrators

a. Purpose. The equilibrators (fig 6-9) compensate for the unbalanced weight of the tube caused by the rear mounted trunnions and reduces the manual effort required to elevate the tube.

b. Type and construction. The type used on the towed 155-mm howitzer M198 is pneumatic; the equilibrators have nitrogen gas inside. As the tube is elevated the nitrogen expands. As the tube is depressed the nitrogen is compressed. One end of the equilibrators is connected to the arms of the top carriage; the other end is connected to the cradle.

c. Testing for proper adjustment. Elevate or depress the tube to travel lock elevation; then test to be sure the tube is as easy to elevate as it is to depress.

Note. The adjustment of the equilibrators should be made with the tube in the travel lock position.

d. Adjustment of equilibrators. If the tube is harder to elevate than it is to depress, you must use a ½ inch drive socket wrench handle and increase the mechanical advantage by rotating the adjusting bolt in a clockwise manner. If it is harder to depress than it is to elevate, rotate the adjusting bolt counterclockwise. If the equilibrator scale pointer points below -1 or above +4, notify organizational maintenance.

e. Maintenance. Check equilibrators for leaks. (If it leaks, notify organizational maintenance.)

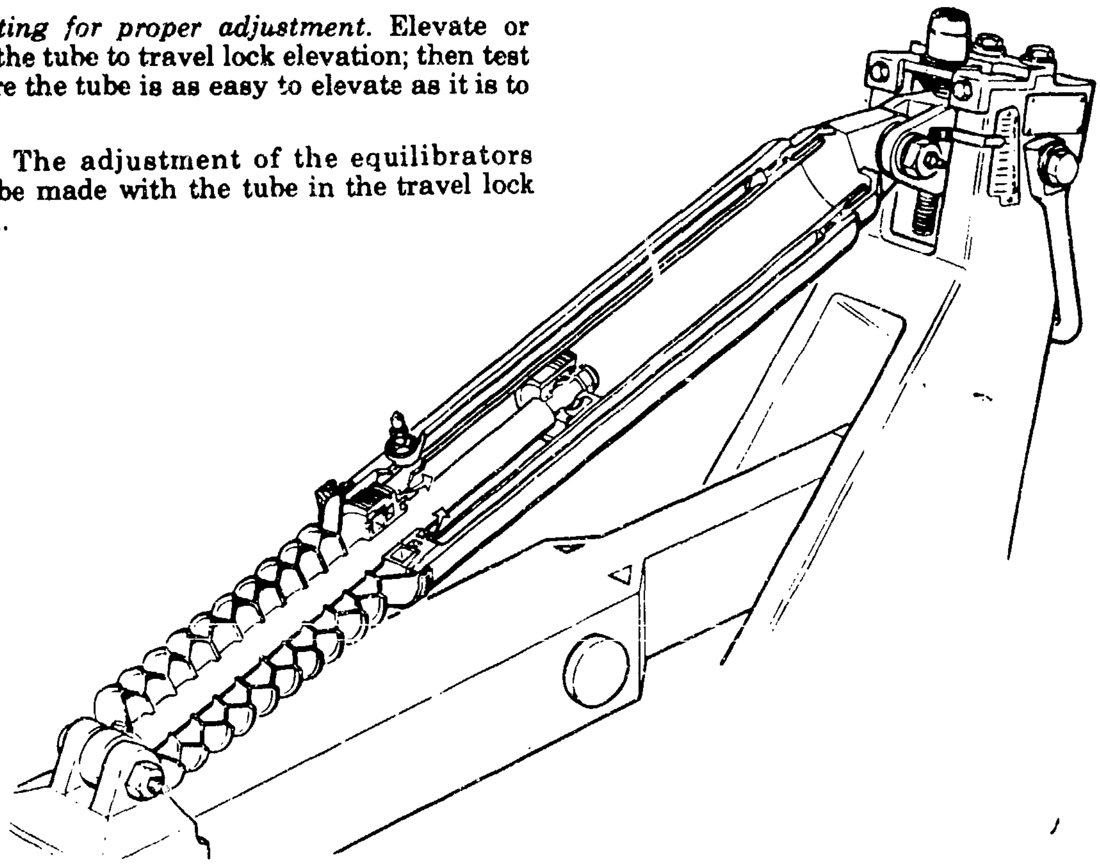


Figure 6-9. Equilibrator assembly--internal components.

Section III. CANNON ASSEMBLY

6-13. Cannon Assembly

The cannon assembly of the 155-mm howitzer M198, towed. consists of the tube, breech thermal warning device, muzzle brake, and keys (fig 6-10).

a. Construction. The tube is made of alloy steel and is of monoblock (one piece) construction. It is formed by the centrifugal cast method and is prestressed by hydraulic pressure. Hot molten metal is poured into a cylindrical mold which is rotated approximately 1,500 revolutions per minute. Heavy impurities of the metal are thrown toward the outside portion of the mold and are later machined away. Light impurities migrate toward the center of the mold, and they are also cut away when the tube is bored. This leaves the best metal of the centrifugal casting as the tube.

b. Exterior parts. The exterior of the tube is a smooth finish bearing surface which slides into the recoil mechanism cradle and cylindrical yolk during recoil. The rear end of the tube is threaded so that the breech ring may be screwed on to the tube and locked into place by a key on top of the breech ring. The front end of the tube is threaded so the muzzle break can be screwed onto it and a key to hold it in place.

c. Interior parts. The interior parts consist of the following:

(1) *Breech recess.* Houses the breech block when the breech block is in closed position.

(2) *Gas check seat.* That part of the rear section of the bore which is tapered to receive the split ring and the gas check pad; thereby, sealing the breech (performing rearward obturation).

(3) *Swiss groove.* The cutaway portion in the powder chamber where the powder lies prior to firing.

(4) *Powder chamber.* Portion of the bore designated to house the propelling charge. Also, where the explosion takes place.

(5) *Centering slope.* The tapered section of the bore forward of the powder chamber designed to cause the projectile to be centered in the bore.

(6) *Forcing cone.* The rear portion of the main bore which is formed by tapering the rear of the lands. Its function is to gradually engage the rotating band of the projectile; thereby, sealing the forward end of the powder chamber (performing forward obturation).

(7) *Main bore.* It is the entir rifled portion forward of the centering slope.

(8) *Counterbore.* That portion of the muzzle end of the tube that is rebored for a predetermined distance so as to increase the tube diameter by removing the lands from that portion of the tube. The purpose of the counterbore is to relieve stress when the weapon is fired.

d. Characteristics. The characteristics of the tube assembly are as follows:

(1) *Lands and grooves*—48.

(2) *Travel of projectile*—200 inches.

(3) *Powder chamber*—40 inches.

(4) *Tube wear life*—1,750 EFC (M549A1 projectile, M203 charge).

6-14. Tube Maintenance

a. General. The two cardinal enemies of a cannon are corrosion and erosion. Corrosion or rust is mainly caused by the propellant residue (primer salt) deposited in the cannon after fire. The salts absorb moisture from the atmosphere and the solution thus formed combines chemically with the metal of the barrel to form corrosion. Erosion is a wearing away of the metal and is caused primarily by wear, pressure and abrasion. Corrosion can be prevented. Erosion cannot be completely prevented but can be retarded.

b. Corrosion. To prevent corrosion, use the following cleaning procedures:

(1) Clean the tube the day of firing with water after firing. Push a ball of rags through the tube to remove the water. For 3 consecutive days clean the tube with RBC; on the third day after cleaning with RBC, dry the tube with rags, put a light coat of PL in the tube, and install the muzzle plug. On the next day, inspect the tube to insure that sweating has stopped, if using CLP for two consecutive days.

(2) If the tube continues to sweat aft the *fourth* cleaning, continue daily cleaning until sweating stops.

(3) On nonfiring weapons clean weekly with RBC; then wipe dry and reoil.

c. Erosion. To retard erosion employ the following practices:

(1) Use the lowest charge and the lowest rate of fire commensurate with the mission.

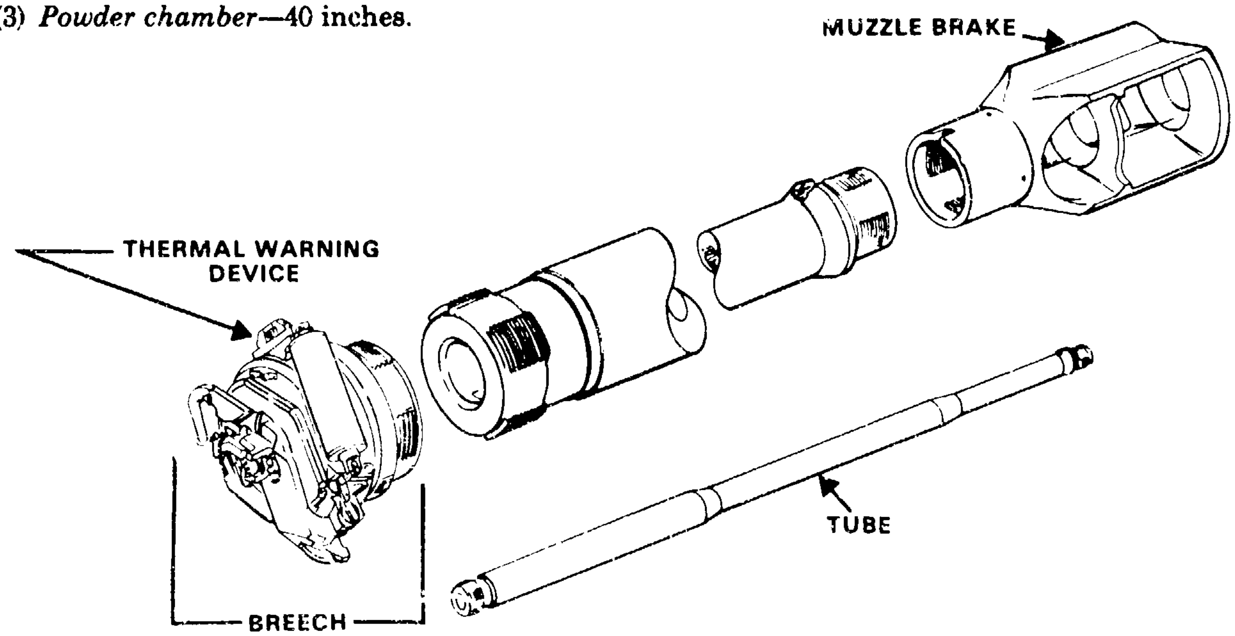


Figure 6-10. Cannon, 155-mm, M199.

(2) Swab the tube with cold water during lulls in firing.

(3) Use clean ammunition.

(4) Be sure the projectile is properly rammed.

6-15. Breech Ring and Breechblock

a. The breech ring is threaded internally and screwed onto the end of the tube. It is locked in position by a key inserted through the upper forward wall of the breech ring. It supports the breech mechanism and forms the housing for the breechblock.

b. The breechblock is of the interrupted screw type. It employs the DeBang obturator device for preventing gases from escaping to the rear. The M35 firing mechanism is a continuous pull type mechanism used with the breechblock.

6-16. Using Thermal Warning Device

The thermal warning device (fig 6-11) shows the temperature of the cannon tube so that you may take the proper action in the event of a misfire or checkfire.

a. Cold tube. Color is green—0° to +170° F (-17.92° to +77° C).

b. Warm tube. Color is yellow—+170° to +350° F (+77° to +177° C).

c. Hot tube. Color is red—above +350° F (+177° C).

Note. If tube is warm, notify the fire direction center. If tube is hot, fire only in a combat emergency situation.

6-17. Counterbalance Assembly

a. Construction. The counterbalance assembly (fig 6-12) is a cylinder with closed ends. The cylinder contains a relatively strong compression spring and is mounted on the breech ring. The spring is compressed between the head of the cylinder and the counterbalance piston. The counterbalance is connected to the breechblock carrier hinge pin by means of the counterbalance piston rod.

b. Purpose. The purpose of the counterbalance is to assist in closing the breech. It also holds the breechblock in the fully open position to facilitate loading the cannon.

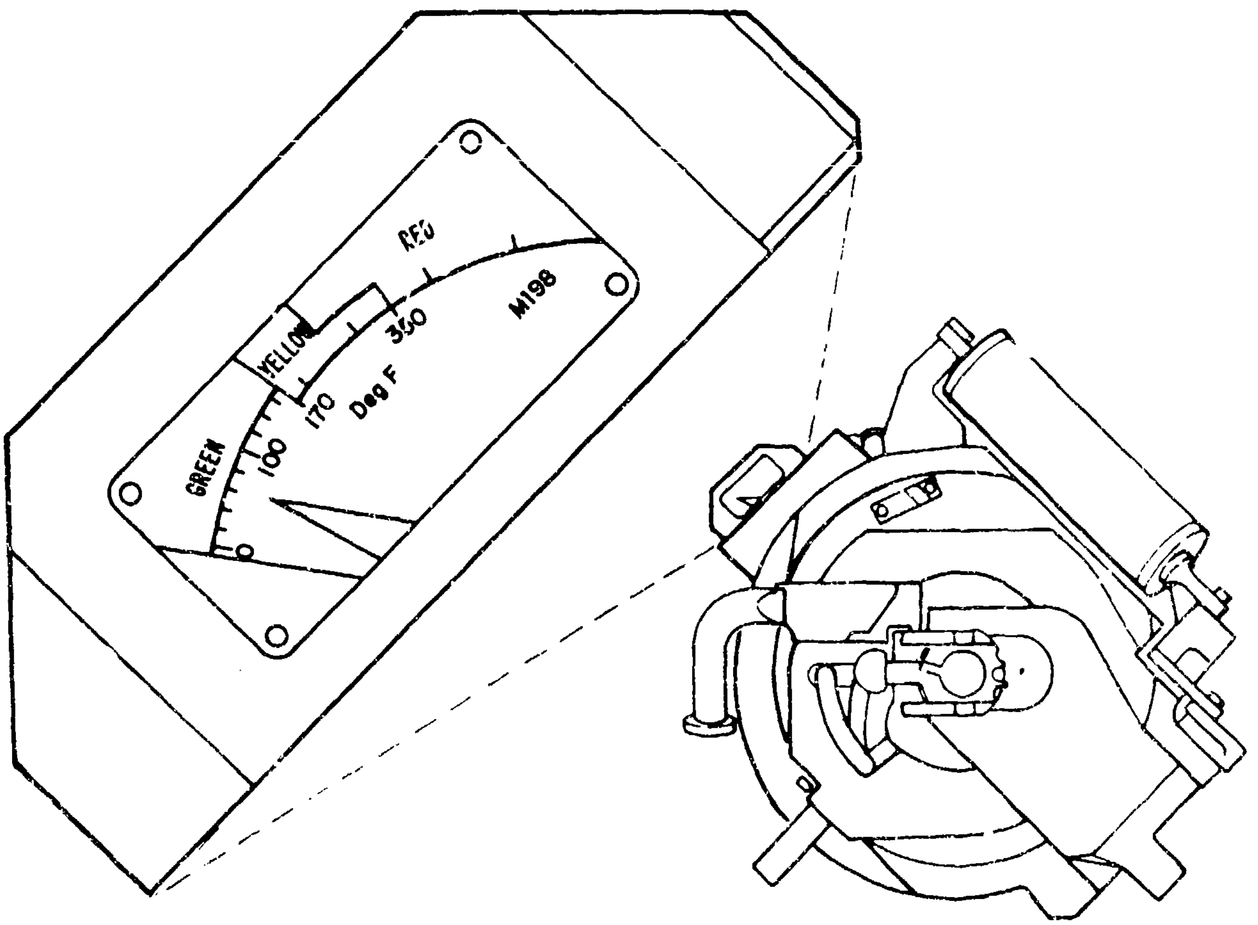


Figure 6-11. TWD temperature scale.

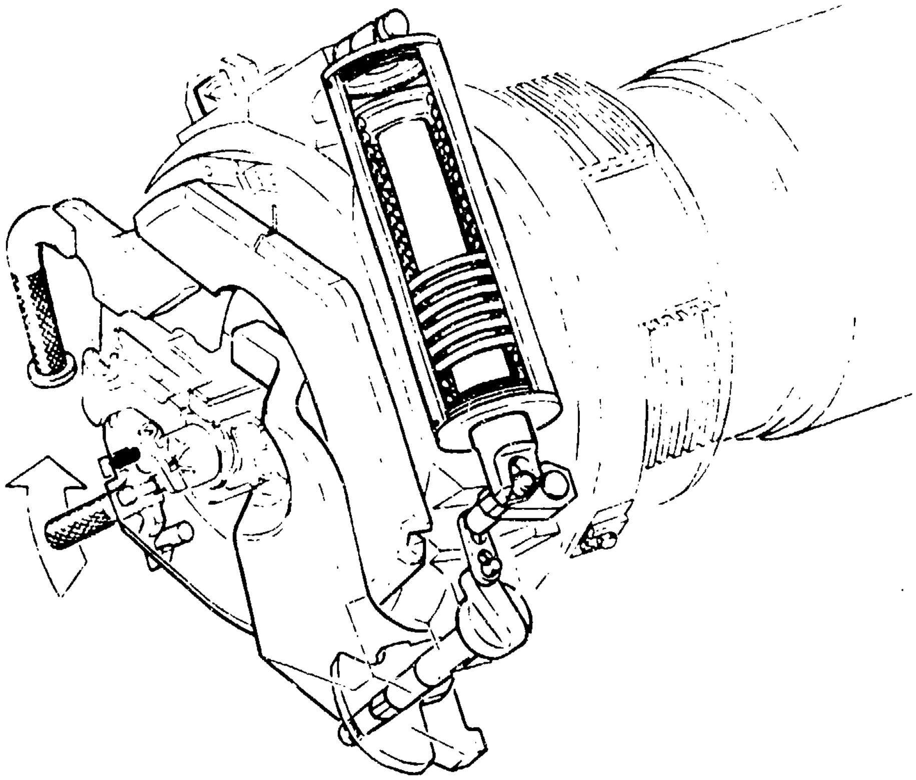


Figure 6-12. Counterbalance assembly.

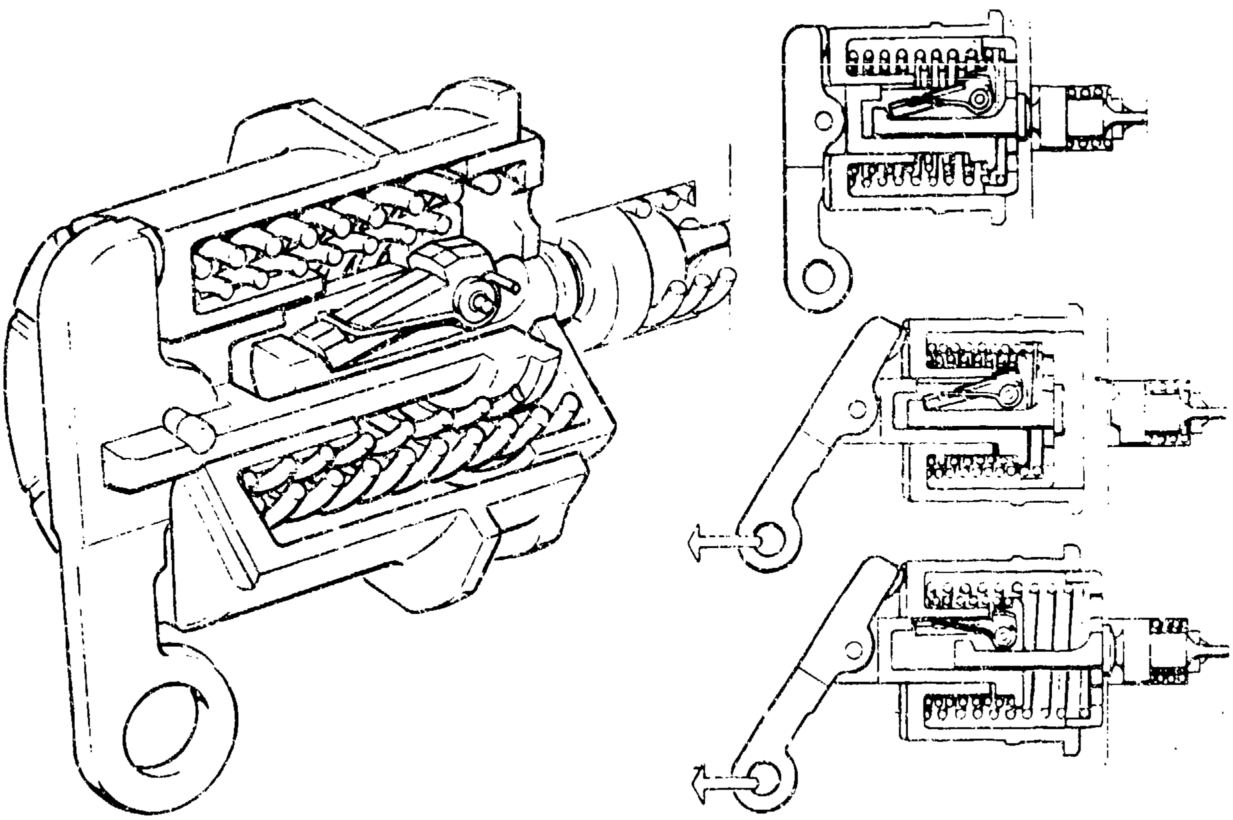


Figure 6-13. Firing mechanism, M35 self-locking continuous pull sequence.

6-18. Disassembly and Maintenance of the Breech Mechanism

a. Disassembly.

(1) Remove M35 firing mechanism.

(2) Rotate breechblock assembly until slot is in the horizontal position.

(3) Pull out on spring pin and slide firing mechanism block assembly to the right and remove.

(4) Lift extractor away from obturator spindle assembly (toward you).

(5) Open breechblock support firing mechanism housing assembly and depress plunger at the end of the obturator spindle assembly.

(6) Turn obturator spindle assembly clockwise (opposite direction of arrow on obturator spindle assembly) until firing mechanism housing assembly can be removed.

(7) Lift obturator spindle assembly off the breechblock assembly.

(8) Remove disk, rear split ring, inner ring, obturator pad and front split ring from obturator spindle assembly.

b. Maintenance. Clean all parts with RBC and apply light coat of PL-S except the gas check pad. Clean it with soap and water or wipe clean with clean dry cloth.

6-19. Firing Mechanism M35

a. General. The firing mechanism M35 consists of the case follower lanyard lever and related parts.

b. Functioning. With the primer inserted in the prime holder (fig 6-13), the firing mechanism is then pulled to the right into the firing position. A strong, even, smooth pull on the lanyard will cause the hammer to strike the firing pin.

c. Disassembly. The eight steps for disassembling the firing mechanism are shown in figure 6-14.

d. Servicing, inspection, and reassembly. The steps for servicing, inspecting, and reassembling the firing mechanism are shown in figure 6-15.

Section IV. RECOIL

6-20. Recoil Mechanism

The recoil mechanism (fig 6-16) employed on the 155-mm howitzer towed M198 is of the hydropneumatic, variable, dependent type. An explanation of the nomenclature follows:

a. Hydro. The mechanism employs a liquid. OHT is the preferred oil since it contains certain additives designed to reduce galvanic corrosion. OHT has a temperature range of -65° F to +150° F.

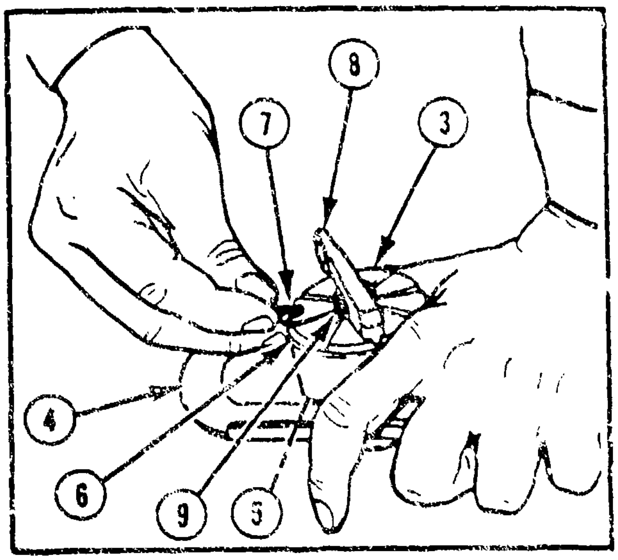
b. Pneumatic. A gas is used. The gas used is nitrogen which is relatively inactive in its free state and will not react on metal to cause corrosion.

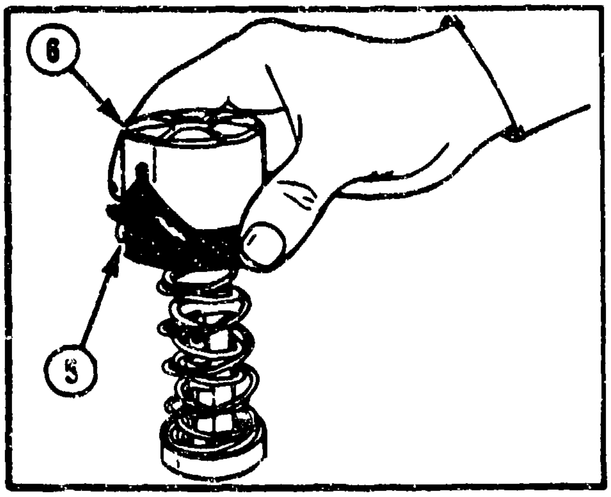
c. Variable. Length of recoil can be varied mechanically to prevent the breechblock from striking the top carriage when firing at a high angle. Under normal operating conditions, the length of recoil can vary from 50 inches to 70½ inches when firing charge 8 (M203).

d. Dependent. The recoil cylinders and the recuperator cylinder have an oil passage to connect the two.

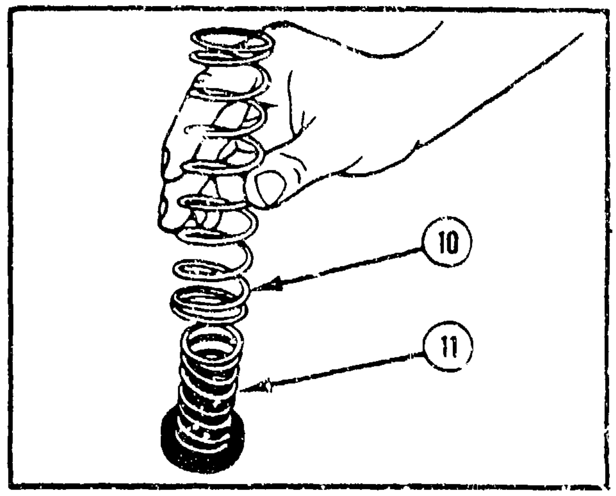
Disassembly

1. Place firing mechanism (3) on solid surface. Place M18 fuzesetter wrench (4) over the case (5) and follower (6) and depress until pin (7) can be removed from lanyard lever (8) and yoke (9). Release spring tension slowly. Lift off lanyard lever.





2. Remove and separate case ⑤ and follower ⑥.



3. Remove cup spring ⑩ and yoke spring ⑪.

4. Remove sear pin ⑫.

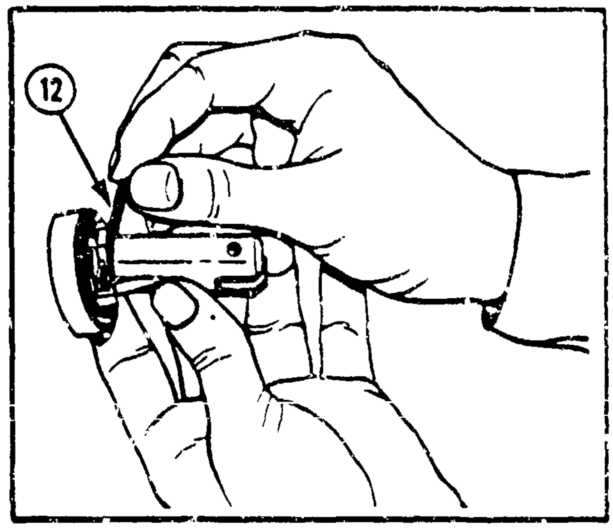
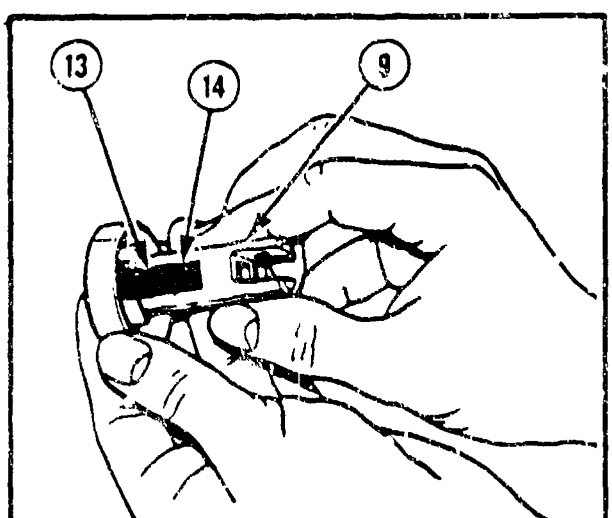
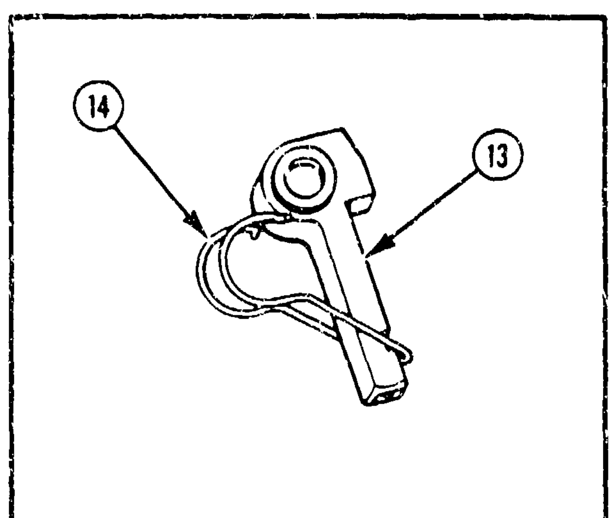


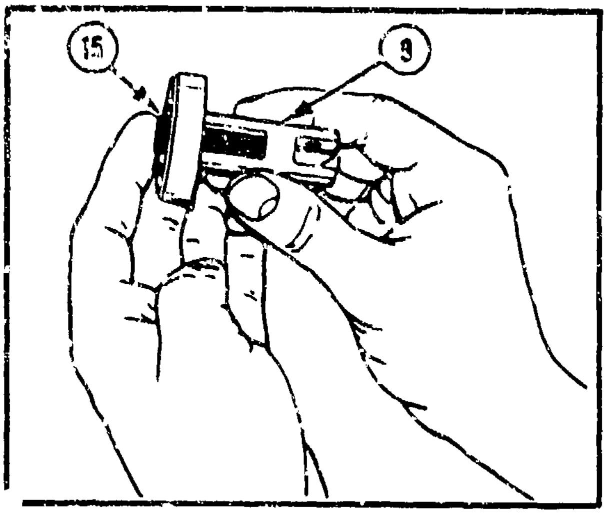
Figure 6-14. Firing mechanism maintenance.



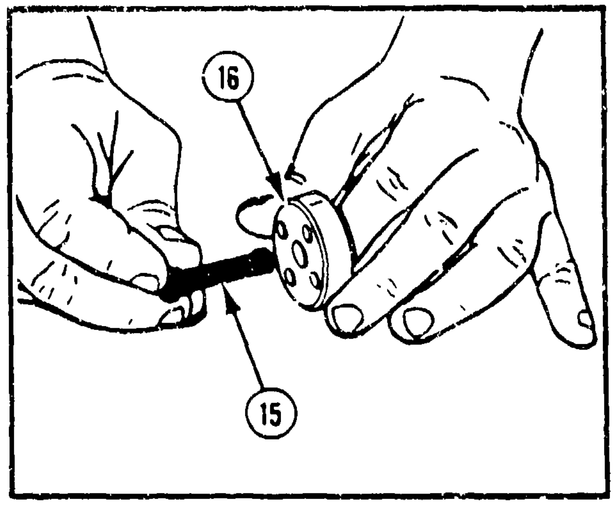
5. Remove sear ⑬ with firing hammer spring ⑭ from yoke ⑨.



6. Separate sear 13 and firing hammer spring ⑭



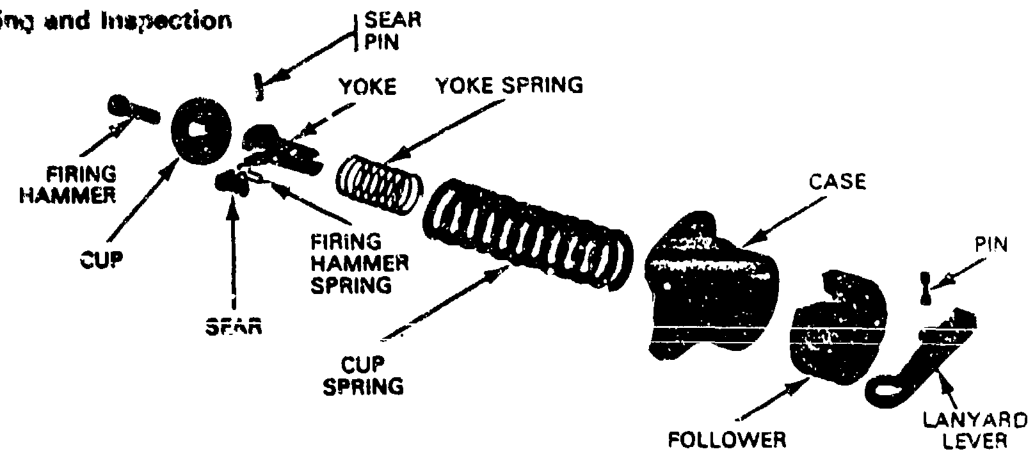
7. Remove yoke ⑨ from firing hammer ⑮.



8. Remove firing hammer ⑮ from cup ⑯.

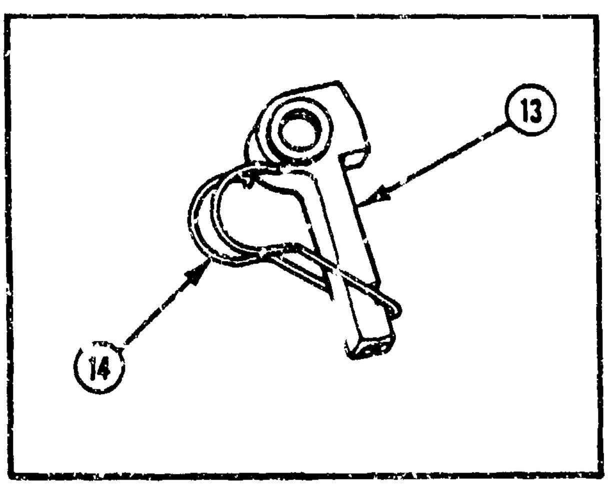
Figure 6-14. Firing mechanism maintenance—Continued.

Servicing and Inspection

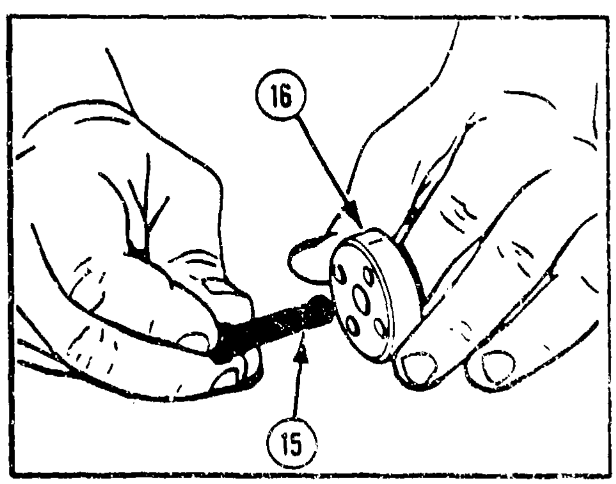


1. Clean all parts with RBC (item 4, app D), wipe dry, and lubricate with PL-S (item 11, app D).

2. Inspect for damaged or worn parts. If any defective parts are found, notify organizational maintenance.

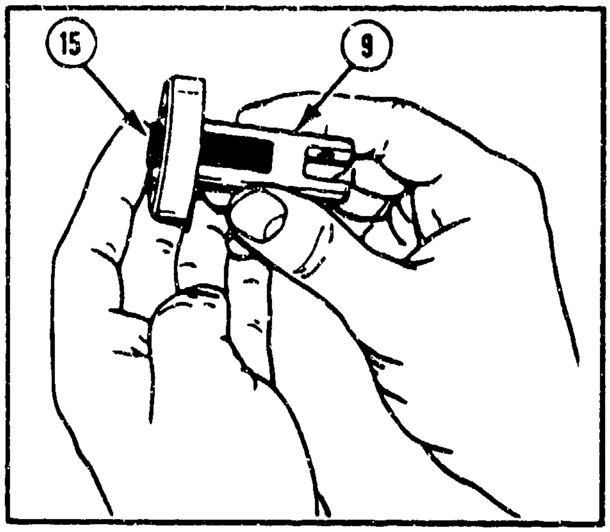


1. Put firing hammer spring ⑭ on sear ⑬.

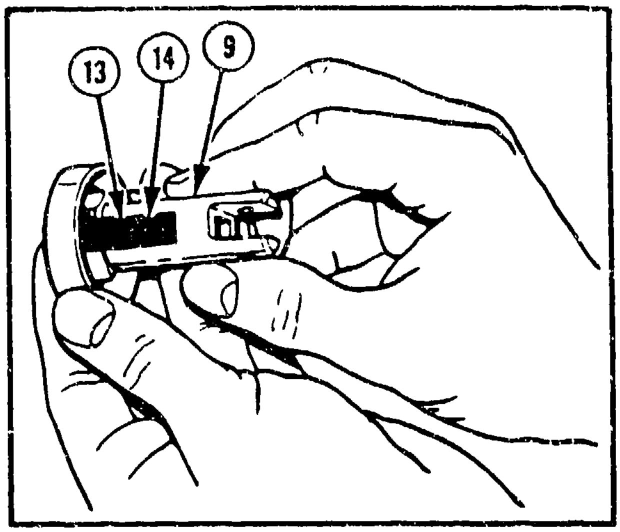


2. Place cup ⑯ on firing hammer ⑮.

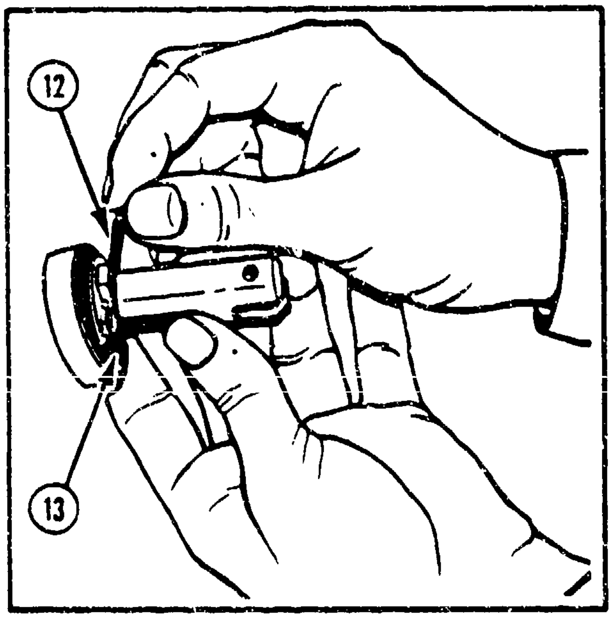
Figure 6-15. Servicing, inspection, and reassembling.



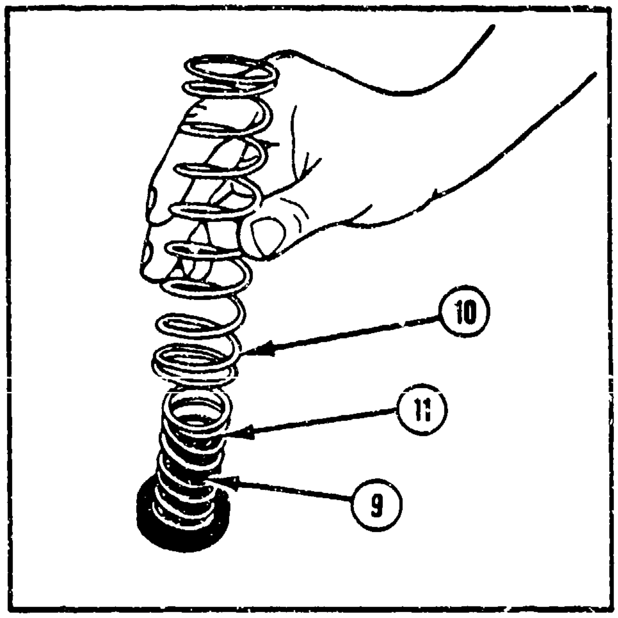
3. Place yoke (9) on firing hammer (15).



4. Place sear (13) with firing hammer spring (14) into yoke (9).

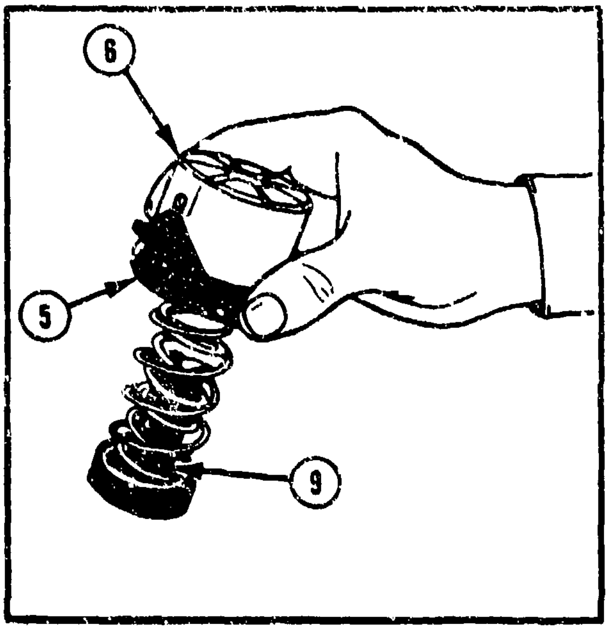


5. Secure sear (13) with sear pin (12).

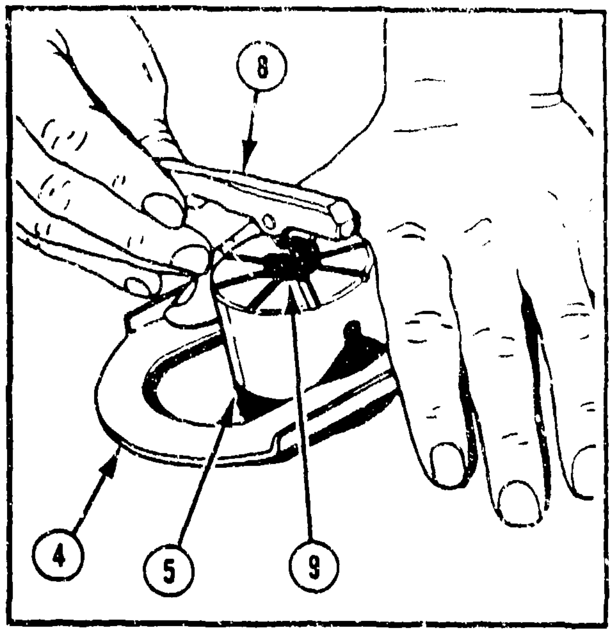


6. Place yoke spring (11) on yoke (9), and place cup spring (10) over yoke spring.

Figure 6-15. Servicing, inspection, and reassembling—Continued.



7. Slide follower ⑥ over case ⑤, and place over assembled yoke ⑨.



8. With assembled parts on solid surface, put M18 fuze-setter wrench ④ over case ⑤, depress, and hold down. Place lanyard lever ⑧ in yoke ⑨.

9. Secure lanyard lever ⑧ with pin ⑦.

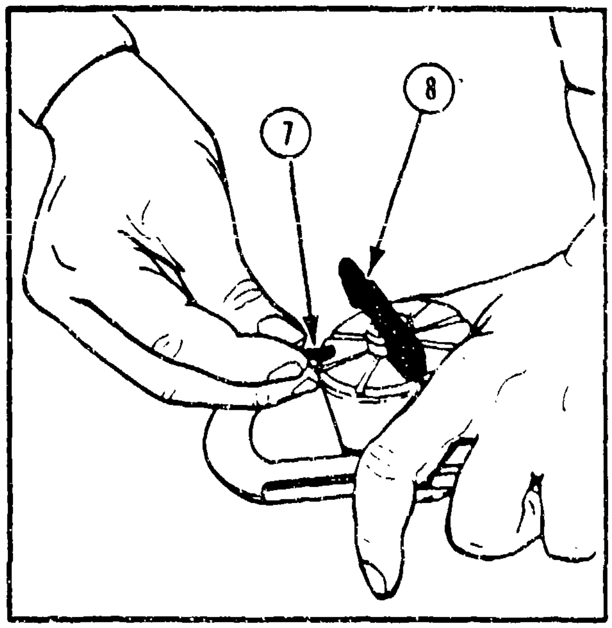


Figure 6-15. Servicing, inspection, and reassembling—Continued.

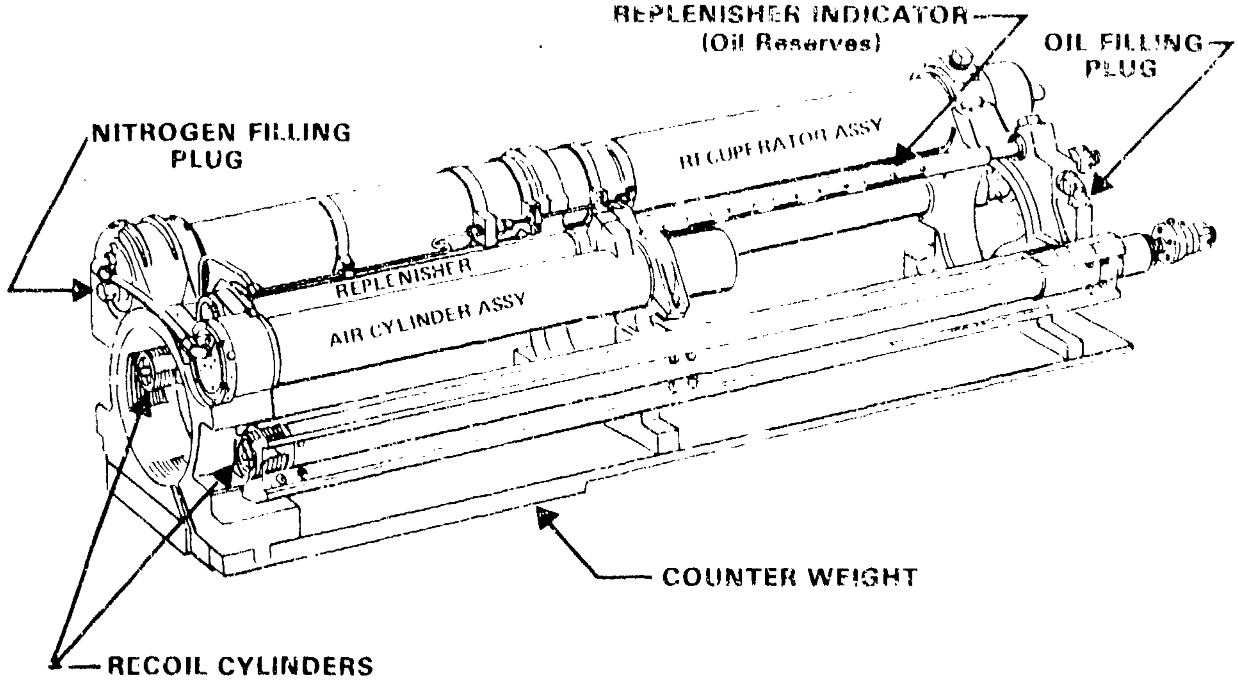


Figure 6-16. Recoil mechanism, M45.

6-21. Purpose of the Recoil Mechanism

The purposes of the recoil mechanism are:

a. To stop the recoiling parts. The recoil mechanism must absorb and control the rearward thrust of the weapon without displacement of the carriage or excessive shock. This action is accomplished by the throttling of the oil throughout the orifices, the compression of the nitrogen gas, and the friction of the moving parts.

b. To return the recoiling parts. The recoil mechanism must cause the recoiling parts to return to the in-battery position. This is accomplished by the expansion of the nitrogen gas inside the recuperator cylinder which was compressed during the recoiling phase.

c. To prevent shock. The recoiling parts must be stopped in recoil without shock and returned to the in-battery position without shock. During recoil this action is accomplished by the increased throttling of the oil flow due to the gradual tapering of the slots and grooves; during counterrecoil it is accomplished by the displacement and restriction of the oil flow in the counterrecoil buffer.

6-22. Major Components and Functioning of the Recoil Mechanism

The recoil mechanism is located in and is part of the howitzer mount. It is composed essentially of two recoil cylinders, a recuperator cylinder, an air cylinder assembly, and a replenisher cylinder assembly.

a. Recuperator cylinder. The recuperator is charged with 600 PSI dry nitrogen gas to hold the tube in-battery at all angles of elevation. When the howitzer is fired, the piston is drawn rearward through the cylinder, further compressing the gas. When the force of recoil is overcome, the gas expands forcing the piston forward and the piston forces the hydraulic fluid back into the recoil cylinder causing the tube to return to the in-battery position.

b. Replenisher. The purpose of the replenisher is to allow for change in quantity of oil required by the recoil cylinder as the weapon cycles in recoil and counterrecoil and to allow for the expansion and contraction of the hydraulic fluid due to temperature changes. The replenisher cylinder indicator should be between 2 to 10 oil reserve. The most preferred hydraulic fluid is OHT.

c. Variable recoil system. The variable recoil system (fig 6-17) is composed of two recoil systems and associated mechanical controls. Each cylinder contains a piston assembly, an inner orifice and an outer orifice. Each piston assembly consists of a piston, a piston tube, and a piston plug.

6-23. Maintenance of Recoil System

a. Checking the replenisher. The replenisher should be checked daily before firing and periodically during firing. The replenisher cylinder indicator should be between 2 to 10 oil reserves. If the reading is incorrect, notify the artillery mechanic.

b. Lubricating the recoil system. Lubricate by the most current LO.

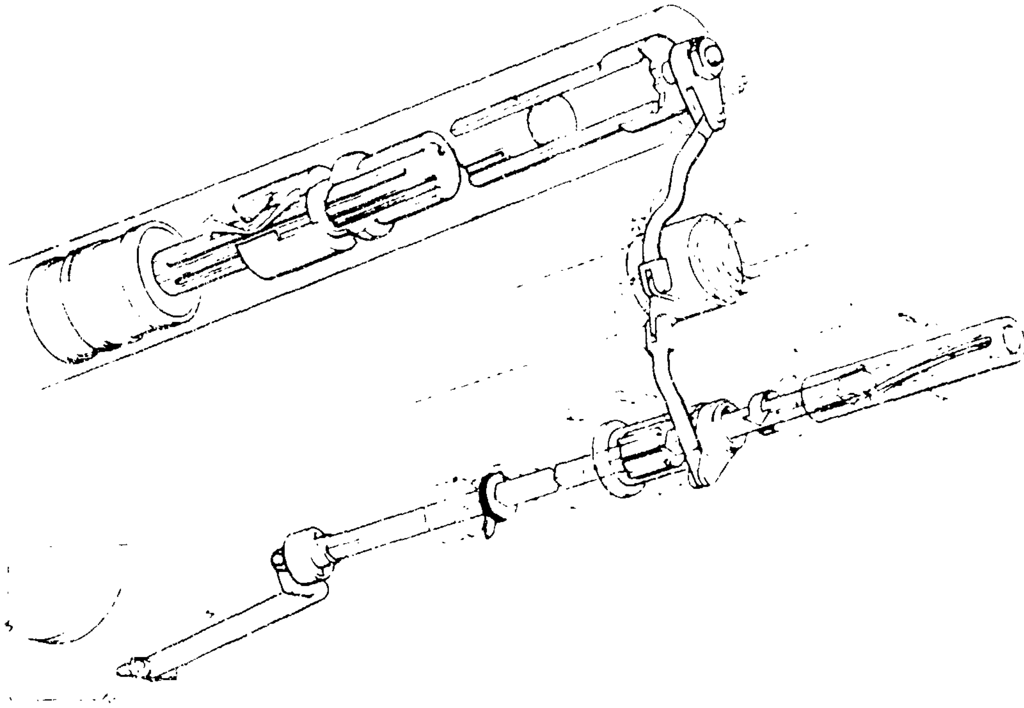


Figure 6-17. Variable recoil mechanism interface of internal components.

Table 6-1. Controls and indicators—M137 panoramic telescope.

Control or Indicator	Function
1. Elevation knob	Elevates the head prism to move field of view through a vertical angle.
2. Azimuth knob	Rotates the panoramic telescope head to the desired azimuth.
3. Click lead detent knob	Engage a detent to indicate 5-mil lead steps for direct fire.
4. Gunner's aid knob	Places relatively constant azimuth correction onto the bearing azimuth counter after initial alignment on aiming posts.
5. Elbow release pin	Holds the panoramic elbow to suit the convenience of the individual operator and stowing in the carrying case.
6. Azimuth counter door	Covers the azimuth reference counter.
7. Azimuth counter (upper 6400 mil)	Provides a numerical display that indicates the azimuth angle of where the panoramic telescope head is with respect to the weapon bore.
8. Boresight clutch release shaft	Disengages azimuth counter from panoramic telescope head movement allowing azimuth counter to be held at 4800 and the telescope head boresighted.
9. Deflection counter (lower 6400 mil)	Provides a numerical display that indicates the azimuth angle in units enabling an operator to quickly lay the weapon on a desired deflection setting with respect to the aiming posts.
10. Gunner's aid	Indicates relatively constant deflection correction.
11. Clutch release lever for deflection	Disengages deflection counter from panoramic telescope head movement enabling an operator to set any deflection reference given when aligned with the collimator or aiming posts.
12. Open sight	Provides a simple means of pointing the panoramic head in a desired direction.

Section V. FIRE CONTROL EQUIPMENT

6-24. Panoramic Telescope M137

The panoramic telescope M137 (fig 6-18) is the basic instrument used in laying the weapon in azimuth. It is a 4-power, fixed-focus telescope with a 10-degree field of view. Sealed sources containing radioactive tritium illuminate the reticle and counter dials. The azimuth counter is set on 4800 of its 6400 mils when the telescope/boresight is checked using the alignment device M139. The gunner's aid counter mechanism permits azimuth corrections for factors peculiar to the individual weapon and its emplacement. Five-mil click lead settings have been provided for direct fire. (See table 6-1 and fig 6-18 for controls and indicators.)

6-25. Telescope and Quadrant Mount M171

The telescope and quadrant mount M171 (fig 6-19) provides an adjustable base of leveling the panoramic telescope. Sealed sources containing radioactive tritium gas are employed to illuminate the level vials. The mechanism of this mount permits adjustment of the vertical axis of the panoramic telescope to plumb regardless of the pitch or cant (within the range +10 degrees) of the

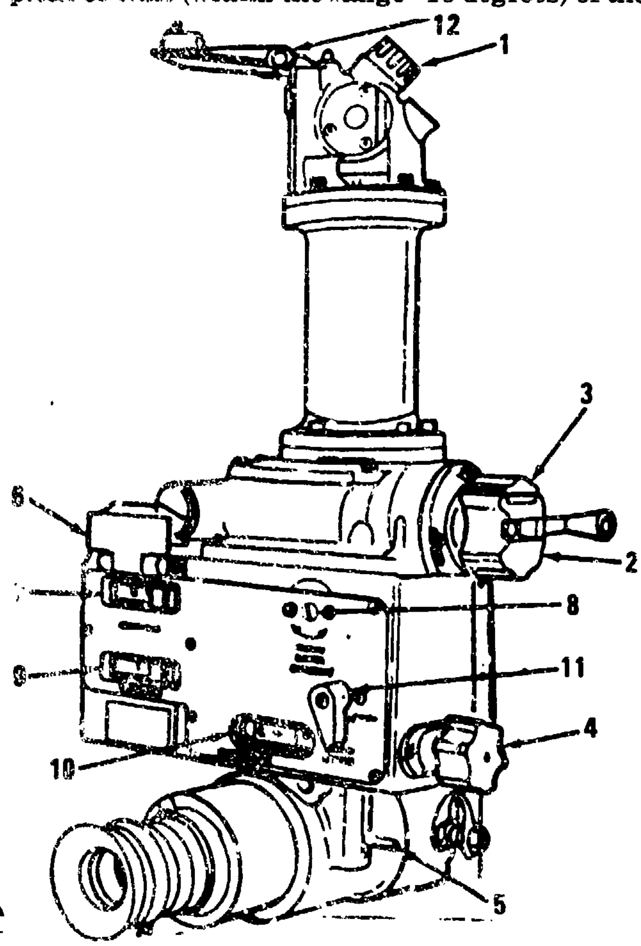


Figure 6-18. Panoramic telescope M137.

weapon. The mechanism also contains a pivot (gun bar) which is maintained parallel to the weapon tube since it is mounted directly on the weapon trunnion. (See fig 6-19 and table 6-2 for controls and indicators.)

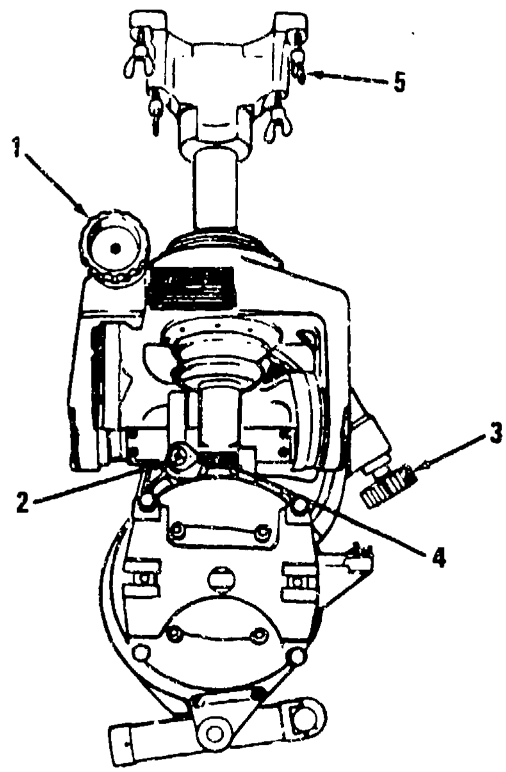


Figure 6-19. Telescope and quadrant mount M171.

6-26. Fire Control Quadrant M17

The fire control quadrant M17 (fig 6-19) is used for adjustment of the weapon in elevation when one man is laying the weapon. Sealed sources containing radioactive tritium are used to illuminate the counter dials and level vial. A correction counter is built in to permit quick, accurate insertion of elevation correction factors peculiar to the individual weapon and its emplacement. The mount provides the cross and pitch leveling motion for the quadrant. This establishes the vertical plane to obtain "true" measurements of weapon elevation. This quadrant has only an elevation level vial; the cross level vial is part of the M171 mount.

6-27. Telescope and Quadrant Mount M172

The telescope and quadrant mount M172 (fig 6-20) provides an adjustable base for leveling the fire control quadrant M18 and elbow telescope M138. A mechanism is provided to clamp and boresight the elbow telescope in elevation and azimuth. Quadrant seats are also provided on the instrument to allow use of a gunner's quadrant when fine elevation settings are required. (See table 6-3 and fig 6-20 for controls and indicators.)

Table 6-2. Controls and indicators for M171 telescope and quadrant mount

Control or Indicator	Function
1. Cross level knob	Positions the mount to correct for weapon cant.
2. Cross level vial	Provides accurate horizontal reference for azimuth correction and measurements.
3. Pitch level knob	Positions the mount to correct for weapon pitch.
4. Pitch level vial	Provides accurate horizontal reference for azimuth corrections and measurements.
5. Wing screws	Secures panoramic telescope XM137 to telescope and quadrant mount XM171.

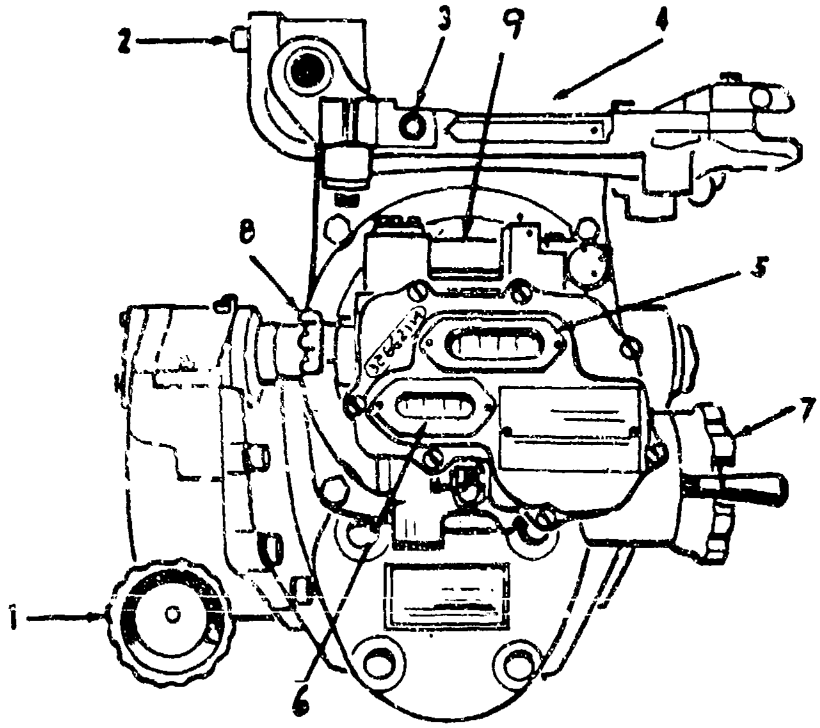


Figure 6-20. Telescope and quadrant mount M172.

Table 6-3. Controls and indicators for telescope and quadrant mount M172

Control or Indicator	Function
1. Cross level knob	Positions the mount to correct for weapon cant.
2. Elevation boresight	Rotates on eccentrically mounted pin that mounts the elbow telescope.
3. Azimuth boresight	Opposing screws that jack the telescope mount in an azimuth plane after mounting screws are loosened.
4. Gunner's quadrant pads	Provides an adjustable reference surface to check fire control equipment or measure fire elevation settings by use of a gunner's quadrant.
5. Elevation correction counter	Registers elevation corrections in mils.
6. Elevation counter	Register cannon elevation in mils.
7. Elevation control knob	Changes the readings in the elevation counter.
8. Elevation correction knob	Changes the readings in the elevation correction counter.
9. Longitudinal levelinguial	Level positi( ). The tube will be at the same elevation as the elevation counter reading.

6-28. Fire Control Quadrant M18

The fire control quadrant M18 (fig 6-20) is used for adjustment of weapon in elevation when two men are laying the weapon. Sealed sources containing radioactive tritium are used to illuminate the counter dials and level vials. This instrument is equipped with a mechanical mil counter for elevation readings. A gunner's aid counter is built into permit quick, accurate insertion of elevation correction factors peculiar to the individual weapon and its emplacement. Fire control quadrant M18 must be used with and attached to telescope and quadrant mount M172.

6-29. Elbow Telescope M138

The elbow telescope M138 (fig 6-21) is the basic instrument for laying the weapon in elevation for direct fire. This telescope is mounted and boresighted in a mechanism integral with the upper part of the telescope and quadrant mount M172. This instrument is basically similar in function to other direct fire telescopes now in use except a reticle presentation of a movable range marker that can be set to super elevation. This model has a mil-scale reticle. Sealed sources containing radioactive tritium are used to illuminate the reticle.

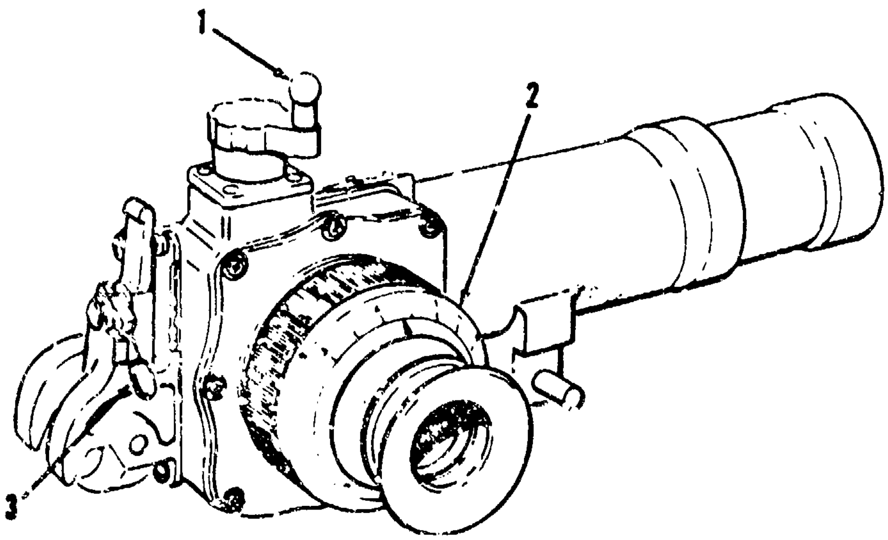


Figure 6-21. Elbow telescope M138.

Table 6-4. Controls and indicators—elbow telescope M138

Control or Indicator	Function
1. Range marker knob	Slides a reference line up or down on the reticle enabling the operator to use a central laying technique.
2. Diopter adjustment scale	Adjust the eyepiece focus to suit the eye of the individual operator.
3. Latch	Locks the telescope to the eccentrically mounted pin in the mount.

Section VI. SUMMARY

6-30. Review

The purpose of this chapter was to describe the nomenclature, operation, functioning, maintenance, adjustment, disassembly and assembly of the major components of the weapon. In order for the weapon to function properly and deliver accurate fire, each component must be kept in proper working condition. For more detailed equipment information, see TM 9-1025-211-10. For proper lubrication procedures and lubricants, always refer to pages 3-1 through 3-14 of the operators manual (TM 9-1025-211-10).

U. S. ARMY
FIELD ARTILLERY SCHOOL
Weapons Department
Fort Sill, Oklahoma

CHAPTER 7

155-MM HOWITZER M109A1/M109A2/M109A3, SELF-PROPELLED

Section I. GENERAL

7-1. References

FM 6-88, TM 9-2350-217-10N, TM 9-2350-303-10, and TM 9-2350-217-20.

7-2. Introduction

a. The 155-mm M109A1/A2/A3, an armored self-propelled medium howitzer, is a highly mobile combat support weapon. It is air transportable in phase III of airborne operations and has an amphibious capability when equipped with a flotation kit. It has a cruising range of 220 miles at speeds up to 35 miles per hour. Combat loaded, the M109A1 weighs 53,940 pounds. The M109A2 has a number of product improvements applied to an off-the-assembly line M109A1. The M109A3 has the same product improvements as the M109A2, except that the improvements have been applied to an M109A1 which has been in the field and used for quite some time. A discussion of these product improvements in the back of this book.

b. The M109A1 is equipped with the longer M185 cannon and achieves a range of 18,100 meters. The 155-mm projectile weighs 95 pounds. The maximum rate of fire is 4 rounds per minute for the first 3 minutes; the sustained rate of fire, 1 round per minute. Sustained rate of fire for M109A1/A2/A3 for charge 8 is 1 round per minute for the first 60 minutes, then 1 round every 3 minutes.

c. The weapon is equipped with a 24-volt electrical system with four 12-volt batteries connected in series-parallel. A hydraulic system provides power for traversing and elevating the cannon, for ramming the projectile, and the equilibrator system. Two recoil spades, located on the rear of the vehicle (one behind each track), are provided to improve the stability of the cannon in the firing position.

Section II. BARREL AND BREECH MECHANISM

7-3. Exterior Components

a. Muzzle brake.

(1) The muzzle brake assembly consists of a muzzle brake, a key, a thrust collar, collar dent ball, spring, and two allen-head screws. The muzzle brake (fig 7-2) is a double-baffle cylinder, internally threaded at the rear section to screw over the muzzle of the tube. The front section extends forward from the muzzle face. Two alternate keyways are provided in the threaded section to accommodate the key. A tapped hole near each of the keyways receives the screw that secures the lock to the muzzle brake. The key is a rectangular block with a cylindrical stud projecting upward from the center of the top surface of the key. The rectangular portion of the key fits in the keyway in the muzzle brake and seats in the keyway in the tube. The key prevents the muzzle brake from rotating on the tube.

(2) The purpose of the muzzle brake is to absorb part of the force of recoil (approximately 45 percent). The muzzle brake should be removed and cleaned monthly or after 300 rounds have been fired, whichever occurs first (for M109A1 only). To remove and replace the muzzle brake, follow the instructions given in figure 7-2 and 7-3 or in TM 9-2350-217-10N (paragraphs 3-42 and 3-43). Five crewmen are required to remove the muzzle brake because of its weight (350 pounds). It should be cleaned with RBC (rifle bore cleaner) and CR (corrosion remover) and checked for cracks 1 inch long or longer, which would render the weapon unsafe to fire. It should then be lubricated according to the lubrication order and reinstalled.

b. Chamber evacuator. The evacuator for the M109A1/A2/A3 (fig 7-2) is a welded steel chamber equipped with 10 ball bearings and valve ring. The evacuator is mounted on the tube by means of one ball bearing spring and two allen-head screws. The unit serves to evacuate toxic gases from the tube and breech area by means of a metered discharge to relieve pressure built up within the evacuator chamber when the howitzer is fired. The chamber evacuator valves should be removed and cleaned daily after firing (fig 7-2). If the weapon has not been fired, the valves should be cleaned

*Supersedes HB-7 WCXXWS, Dec 81.

Figure 7-1. 155-mm, self-propelled howitzer, M109A1/A2/A3.

once a month. The chamber evacuator should be removed and cleaned monthly or after 300 rounds have been fired, whichever occurs first (M109A1 only). Care should be taken that the ball bearings are not lost during servicing. A portion of the gas pressure is trapped in the chamber evacuator during firing. This is accomplished by the free flow of pressure through the 10 ball bearings. When the force in the chamber is equal to or greater than the pressure in the tube of the M109A1/A2/A3, it has three metering orifices to aid in the evacuations of gases from the tube.

c. Gun travel lock. The gun travel lock (figs 7-3 and 7-4) supports the overhanging weight of the tube and relieves stress on the elevating and traversing mechanisms. It is adjustable to insure proper locking of the tube during travel.

d. Torque key. The torque key is constructed primarily of brass stock with a wear surface. Its purpose is to prevent the tube from rotating in the cradle cam during recoil and counterrecoil.

(1) *Components and function.* The torque key assembly is made up of the torque key, cap screws, washers, and safety wire. The torque key rides in a keyway machined into the top portion of the cannon tube during recoil, thereby preventing the tube from rotating or canting.

(2) *Maintenance.* Remove the torque key after firing the initial 1,500 rounds. Measure the key along the wearing surface. If the reading is 31/32 inch or less, replace the key. If the reading is 31/32 inch or greater, lubricate, reinstall, and schedule reinspection on the next quarterly service. Use grease, general purpose (GGP), on the key and exposed keyway. At the same time, perform cradle cam adjustment.

e. Exterior components.

(1) *Commander's cupola and machinegun mount.* The commander's cupola and machinegun mount is the chief of section station during travel. The machingun mount has a .50 caliber machinegun that may be traversed 6400 mils.

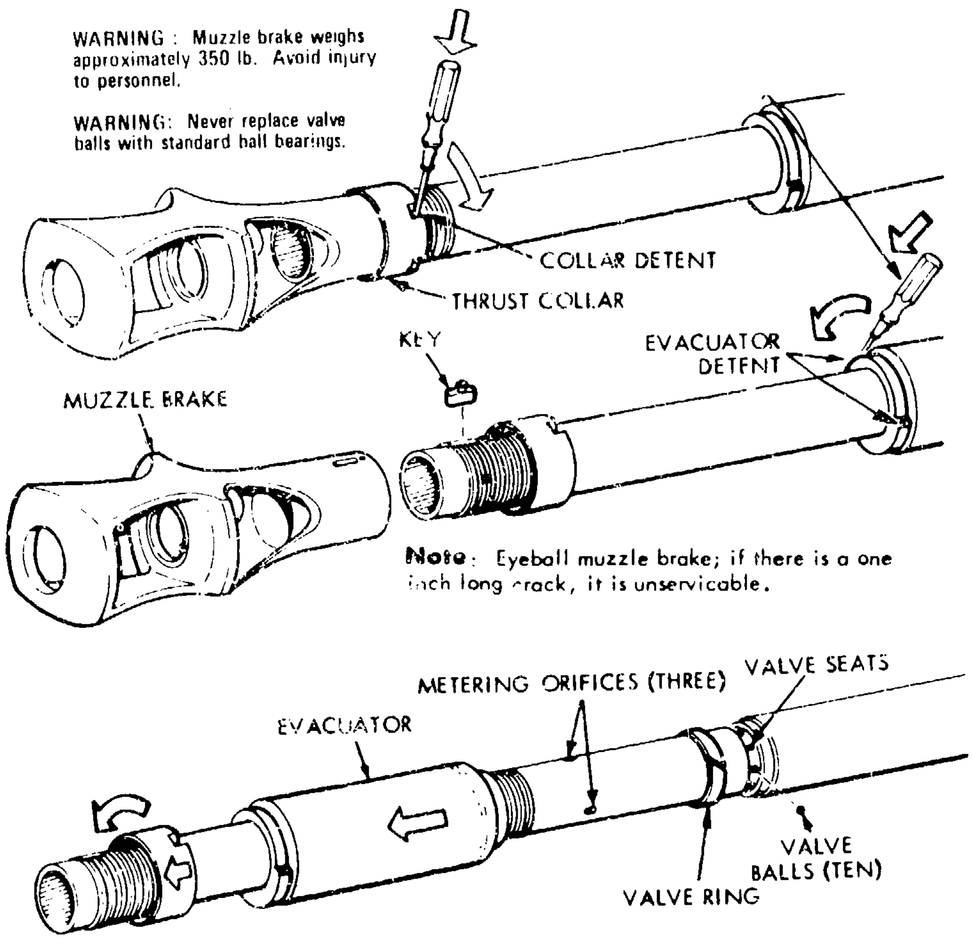
(2) *Gunner's escape hatch.* The gunner's escape hatch allows the gunner an additional means of exiting the vehicle in an emergency situation.

(3) *Ballistic telescope cover (lift and lock).* Lift and lock is the command given by the gunner to the driver to lift and lock the ballistic cover on the M109A1 only. The ballistic telescope cover protects the panoramic telescope from overhead fire when the telescope is mounted.

CAUTION: Use cloth or container to catch valve balls when sliding valve ring forward.

Note. Ten valve seats and three metering orifices may be cleaned monthly or every 300 rounds with muzzle brake still in position on nonfiring weapon. Reverse procedure to install. Use light coat of GAA on valve seats before installing balls.

(4) *Ballistic cover fig 7-30).* For some time, many have believed that we could increase responsiveness if travel from one position to



1. Depress thrust collar detent with screwdriver and screw collar rearward enough to uncover key.
2. Remove key from brake and tube.
3. Unscrew muzzle brake until threads in muzzle brake just clear threads on cannon tube. Attach a sling and hoist to muzzle brake and remove brake from tube.
4. Screw thrust collar forward and remove.
5. Unlock one evacuator detent, depress other detent; unscrew evacuator and slide forward.
6. Slide valve ring forward and catch valve balls.

Note. Ten valve seats and three metering orifices may be cleaned (LO 9-2350-217-12) with muzzle brake still in position.

7. Reverse procedure to install.

Figure 7-2. Removing/installing M109A1/A2/A3 muzzle brake and evacuator.

another could be accomplished with the panoramic telescope mounted. A ballistic cover with a plexiglas cover over the front has been installed to allow travel with the pantel mounted. Initially, the interior of the cover was painted the same color as the pantel making sighting of the pantel with aiming circle very difficult. To alleviate this problem, the interior of the cover will be painted a different color. White has been considered but it does result in significant signature which could be a tactical mistake.

(5) *M42 offset periscope.* The M42 offset periscope is used in conjunction with the direct fire telescope to engage targets in the direct fire mode by allowing the direct fire telescope to sight around the chamber evacuator and double baffel muzzle brake.

(6) *Section equipment brackets.* Section equipment brackets are located on the top of the cab for storage of section equipment.

(7) *Slave receptacle.* A slave receptacle is located on the rear wall of the battery compartment and also on the side wall of the driver's compartment.

(8) *Recoil spades.* Two recoil spades are located on the rear of the vehicle.

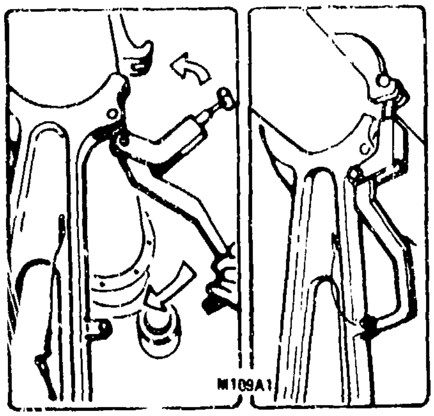


Figure 7-3. M109A1/A2/A3 gun travel lock.

7-4. Barrel and Breech—Howitzer Breech Mechanism Assembly

The breech mechanism is of the semiautomatic, interrupted-screw type designed for separate-loading ammunition. Initial opening of the breech mechanism is accomplished manually through the use of the breech operating handle. Opening of the breech mechanism during counterrecoil is accomplished automatically by the breech operating cam. When the rear end of the operating cam is manually raised, the breech mechanism is released and is automatically closed by the energy of the torsion assembly, the obturator group, the operating crank assembly, the carrier, and the M35 firing mechanism. For a detailed description of the howitzer breech mechanism assembly, refer to TM 9-2350-217-10N for M109A1/A3 and TM 9-2350-303-10N for M109A2.

a. Breech ring assembly. The breech ring assembly consists of a band, a body, a bracket, a key, quadrant seats, a shelf, catches, a cam, and associated hardware.

(1) *Band.* The band, a flat threaded ring, screws onto the breech ring body. Three holes in the band permit attachment of the piston tubes of the recoil cylinders and the piston rod of the recuperator. A keyway is machined adjacent to the center hole for installing a key, which locks the band, howitzer tube, and breech ring body together.

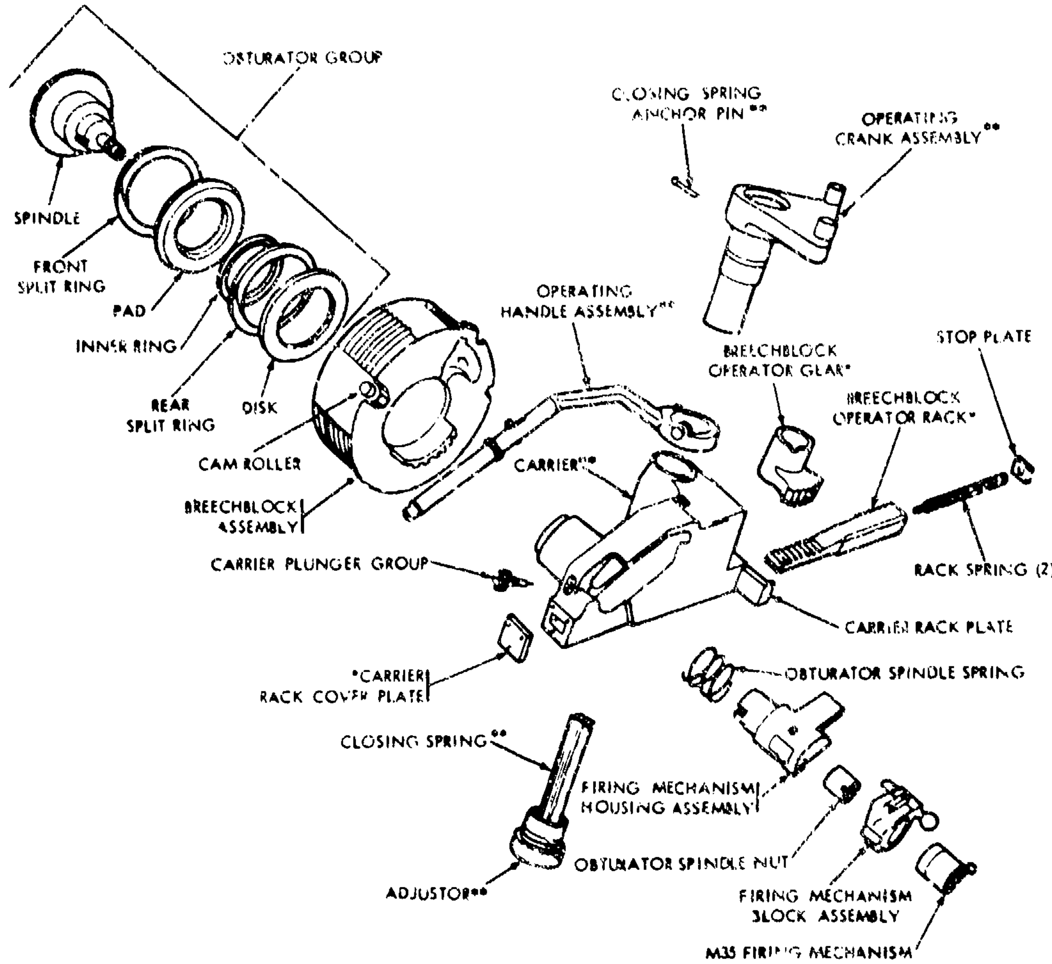
(2) *Body.* The breech ring body is cylindrical, with integral brackets located on the right side for supporting the breechblock carrier assembly. The forward end of the body is externally threaded to receive the band. The forward body forms the breech recess, which is internally threaded. The threads are machined segments of the breechblock. The interrupted-screw arrangement permits opening, closing, and locking the breech by rotating the breechblock only ¼ turn (approximately). The life of the breech ring is the original tube plus 2. Embedded leveling plates for use with the gunner's quadrant and embedded corrections are also located on the breech ring.

b. Breechblock assembly. The breechblock assembly is a circular piece of steel that provides a means of opening and closing the breech of the cannon. It is threaded externally with four threaded segments designed to engage the threaded segments of the breech ring body. A hole is bored through the center of the block for mounting it on the breechblock and obturator group to the breechblock carrier. A triangular camway is machined into the rear surface of the breechblock to control the movement of the firing mechanism block and the ejection of the primer. A projection on the rear surface is machined to form an arc gear segment, which engages the rack gear of the breechblock carrier group. The arc gear on the breechblock and the rack on the carrier group control rotation of the breechblock.

c. Obturator group. The obturator group (fig 7-5) provides the means of obtaining a gastight seal at the rear of the powder chamber (rearward obturation). It includes the spindle, two split rings, a gas-check pad, an inner ring, and a disk (sometimes called a thrust washer). These parts are alined and held on the front face of the breechblock by the spindle. When the breech is closed, the split rings and gas-check pad press against the gas-check seat of the cannon tube, thereby providing rearward obturation. When the cannon is fired, the gas pressure acts upon the mushroom head of the obturator spindle, forcing the spindle to the rear. The rearward movement of the spindle compresses the split rings and the gas-check pad between the rear face of the mushroom head of the spindle and the disk at the front face of the breechblock. Compression of the pad and the split rings causes them to expand radially, thereby tightening the seal as gas pressure builds up in the tube. As a result, the seal becomes tighter until the projectile leaves the cannon and the pressure is released.

d. Carrier. The carrier (fig 7-4) is the hinge that supports the breechblock assembly and maintains proper alinement of the breechblock with the breech recess. It also serves as a housing for the breechblock gear and rack. The rack springs, which supply the energy to rotate the breechblock to the unlocked and locked positions, are contained in the carrier. These springs are held in position by the stop plate and the carrier rack plate.

e. Operating crank assembly/cradle cam assembly. The operating crank assembly (fig 7-4) is a large hollow pin that serves as a hinge pin for mounting the breechblock carrier on the breech ring body. The lower end of the crank is squared for mounting the breechblock gear. The upper end has a triangular-shaped projection on which the two breech operating cam rollers are mounted. The breechblock closing spring assembly is mounted



*These items not to be removed from carrier in first echelon.
**These items not authorized for removal by using unit on weapons having weapon-mounted rammer.

Figure 7-4. 155-mm howitzer cannon M185 breech mechanism—exploded view.

in the hollow center of the crank. As the weapon moves forward in counterrecoil, the cam rollers of the operating crank ride in the camways of the breech operating cam, causing the breechblock to first rotate to the unlocked position and then swing and be locked in the open position automatically. Raising the rear end of the breech mechanism operating cam releases the operating crank; the closing spring assembly causes the breechblock to automatically close and lock. The breechblock must be opened initially with the breech operating handle, which is mounted on the operating crank near the upper end of the crank.

f. Cam damper. The cam damper maintains tension on the cradle arm.

g. Closing spring. The closing spring is made up of 52 individual leaf springs which are responsible for the closing of the breechblock.

h. Firing mechanism. The firing mechanism M35 (fig 7-4) is a continuous-pull, percussion-type mechanism, which is actuated by a lanyard. The firing block into which it fits has three positions: firing, prime, and disassembly.

7-5. Functioning of Breech Mechanism

When the weapon is fired, the recoiling parts move rearward during the recoil cycle. It is during the counterrecoil cycle (recoiling parts are going back to the in-battery position) that the semiautomatic breechblock functions. As the recoiling parts move back to the in-battery position, the primary roller on the operating crank assembly engages with the S-shaped camway on the cradle cam. As the primary roller passes along this camway, the breechblock is rotated approximately 1/4 turn counterclockwise to the unlocked position. At this time the secondary roller engages the C-shaped camway on the cradle cam; as it passes along the camway, it pulls the breechblock open.

7-8. Maintenance of Tube and Breech

a. Barrel maintenance.

(1) *Cleaning.* The tube should be cleaned at the conclusion of the day's firing and 3 consecutive days after, making a total of at least four cleanings. If the weapon is not to be fired within 24 hours after the fourth cleaning, it should be wiped dry, inspected, and lubricated with oil, lubricating, preservative, special. If the tube continues to sweat after the fourth cleaning, cleaning should be continued until the sweating stops. When the weapon is not being fired, the tube should be cleaned weekly and then wiped dry, inspected, and reoiled.

(a) Rifle bore cleaner. The preferred solution for cleaning the tube is rifle bore cleaner. Rifle bore cleaner evaporates at 150° F. (If you can place your hand on the tube without being burned, the tube is cool enough to be cleaned.) Rifle bore cleaner is not a lubricant, but it is a rust inhibitor, effective for 24 to 48 hours. After each daily cleaning, a coating of rifle bore cleaner should be left in the tube overnight. Rifle bore cleaner should never be diluted.

(b) Soap and water. When rifle bore cleaner is not available, an alternate solution of ¼ pound of castile or GI soap dissolved in a gallon of water may be used for cleaning the tube. Hot water is preferable because it will dissolve the soap more readily. The soap and water solution should be used while the tube is still hot so that the solution will wash the primer salts from the pores of the metal. After each cleaning with soap and water, the tube must be rinsed, dried, inspected, and lubricated.

(2) *Lubricants.* Oil, lubricating, preservative special, is used on all bearing surfaces.

b. Breech maintenance. The breech mechanism is subject to contamination from powder residue which works its way into and through the obturating parts. For this reason, the obturating parts are disassembled and cleaned in the same manner as that prescribed for the barrel—on the day of firing and for 3 consecutive days thereafter. All components of the breech mechanism, except the gas-check pad, are cleaned with rifle bore cleaner. All powder stains, rust, and burrs are removed with crocus cloth if necessary. The gas-check pad is cleaned with hot soapy water and wiped dry with a clean dry cloth. After the breech mechanism has been cleaned and dried, and before it is reassembled, it should be lubricated with the proper lubricants, as prescribed by LO 9-2 0-217-12.

WEAPON RECORD DATA

For use of this form, see TM 38-750, the proponent agency is DCSLOG.

REQUIREMENT CONTROL SYMBOL CSGLD 1051

1. TUBE SERIAL NO: 23415
2. CANNON TYPE, MODEL OR SERIES: 155MM M185
3. ORGANIZATION (UIC): A/4/50 FA WAQ234
4. SPECIAL LIFE DATA: 5000 EFC ROUND LIFE
5. END ITEM IDENTIFICATION: HOWITZER, MED, SP, 155MM, M109A1, SN: 2345
6. RDS/EFC COMPUTATION:

ZONE	EFC
1-6	0.25
7	0.75
8	1.00

7. CANNON SERIAL NO: 18911
8. RETUBINGS: 0
9. REBUSHINGS:

10 Date a	Projectile Type b	Zone or Charge c	Rounds Fired d	EFC RDS Fired e	Cumulative RDS Fired f	Cumulative EFC RDS 1-6	7	8	Remaining Life (EFC RDS) h	Remarks: Recoil Exercise (RE), Gage or Velocity Reading, Safety Inspection (SI)	Signature
10 APR 80	(Previous DA Form 2408-4 final entries)				8028	1507.75	1343.25	206.0	1943.00	RE 3 APR 80 BORESCOPE, GAGED PO 6.134 4 APR 80 VE 7-1.4-4-1.2	J Wheel CDR
7 JUN 80	HE M107	3 M4A1	7	1.75	8035	1509.50	1343.25	206.0	1941.25		J Chief SSG
	SMK M116	7 M4A1	3	2.25	8038	1509.50	1345.50	206.0	1939.00		
2 Jul 80										BORESCOPED IAW TM9-1000-202-14 SERVICEABLE	D Jones SSG 225TH MT CO.
2 SEP 80	HE M549A1	8 M119A1	10	10.00	8048	1509.50	1345.50	216.0	1929.00		J Chief SSG
9 SEP 80	HE M107	4 M3A1	40	10.00	8088	1519.50	1345.50	216.0	1919.00		J Chief SSG
	HE M107	7 M4A1	10	7.50	8098	1519.50	1353.00	216.0	1911.50		
2 OCT 80										BORESCOPED IAW TM9-1000-202-14 SERVICEABLE	D Jones SSG 225TH MT CO
10 OCT 80										10 OCT REPORT NEW FORM INITIATED	J Wheel CDR

CONTINUE ON REVERSE

DA FORM 1 JAN 79 2408-4 EDITION OF 1 DEC 77 WILL BE USED

Figure 7-5. DA Form 2408-4, Weapon Record Data.

c. Effective full charge rounds. Effective full charge (EFC) rounds are computed as follows:

(1) M109A1—A round fired at charge 1—6 is equal to 0.25 EFC round; charge 7, 0.75 EFC round; charge 8, 1 EFC round.

(2) EFC rounds are recorded on DA Form 2408-4 in the weapon logbook. A sample of a completed DA Form 2408-4 is given in figure 7-5.

7-7. Rates of Fire

The maximum rate of fire is 4 rounds per minute for the first 3 minutes. The sustained rate of fire is 1 round per minute after the first 3 minutes.

7-8. Disassembly of Breech Mechanism

For disassembly of the breech mechanism, follow the steps indicated in figure 7-6.

7-9. Assembly of Breech Mechanism

For assembly of the breech mechanism, follow the steps indicated in figure 7-7.

7-10. Cradle Cam Adjustment

a. Function of the cradle cam. The breech mechanism operating cam opens the breech in counterrecoil and holds it open for the next swabbing and loading operation through a series of camways on the operating cam and rollers on the operating crank. Therefore, the operational adjustments are critical and must be performed quarterly or whenever the torque key is removed.

b. Adjustment.

(1) Have the breechblock closed and the tube at 0 mils.

(2) Remove the cotter key and castle head nut from the recuperator piston rod; hold the piston rod with a pipe wrench to keep it from turning.

Table 7-1. Misfire procedures for the M109A1/A2/A3

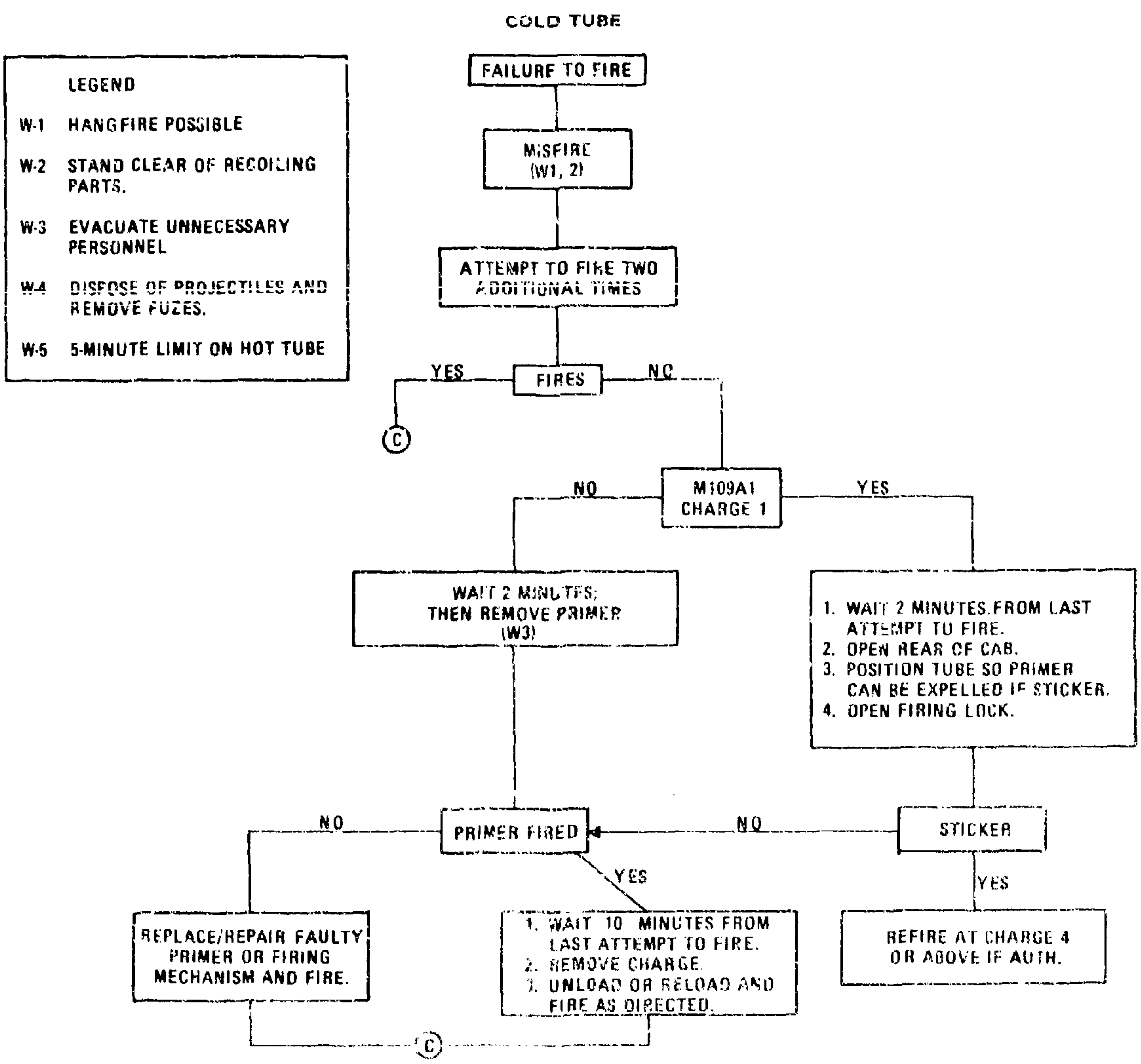
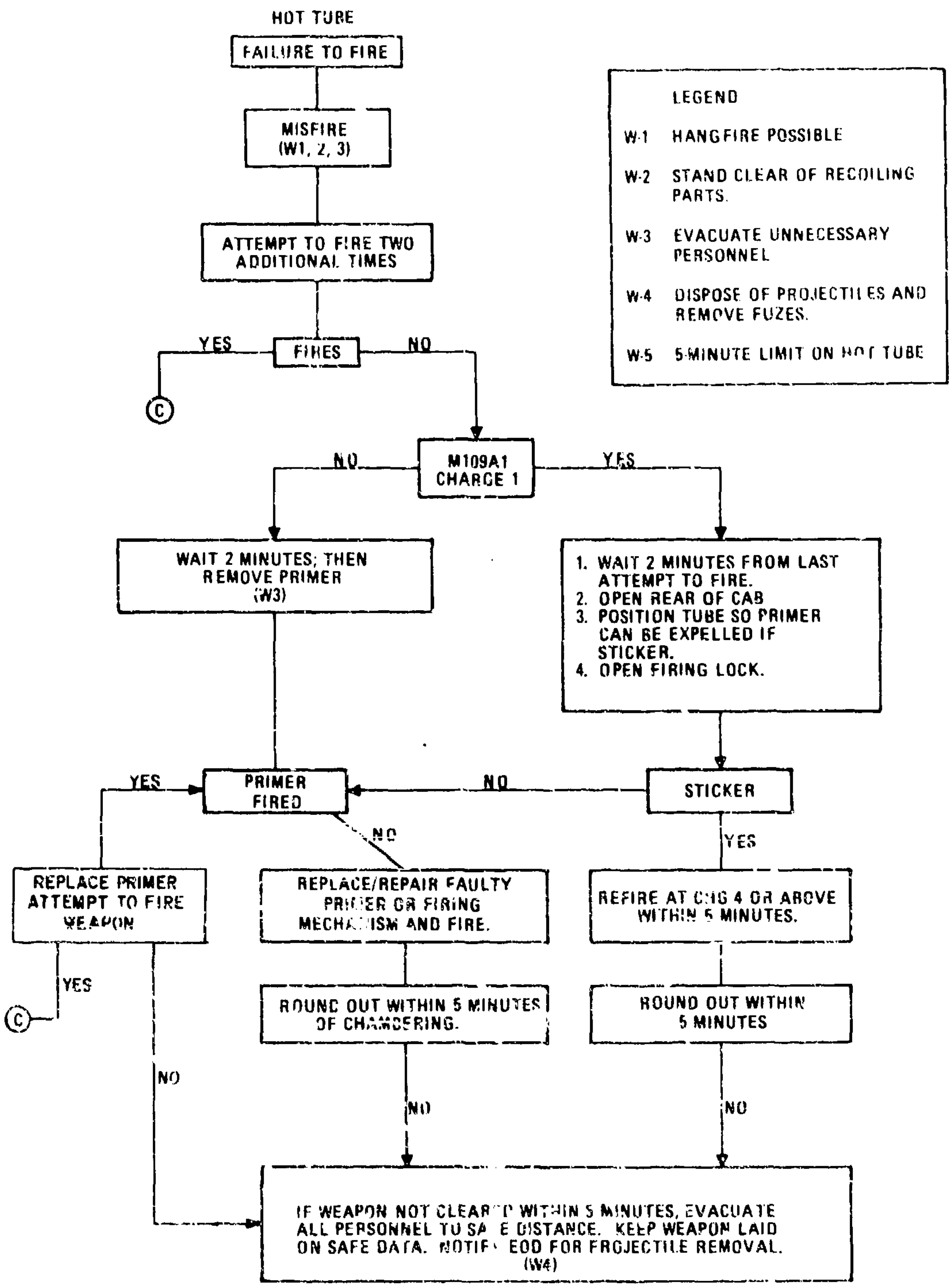


Table 7-1. Misfire procedures for the M109A1/A2/A3—continued



(3) Force the tube out of battery until the center of the primary roller is alined with the adjustment mark on the cradle cam.

(4) Check the clearance and adjust as necessary.

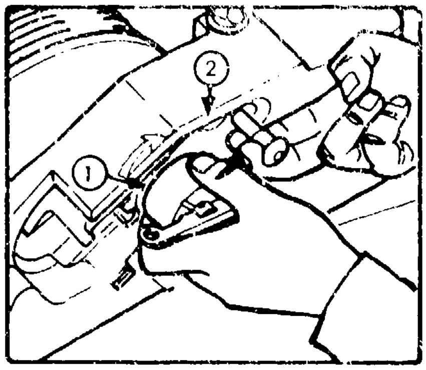
Note. The tolerances are ¼ to 3/16 inch (vertical) (use ruler) and 0.001 inch to 0.002 inch (horizontal) (use feeler gage).

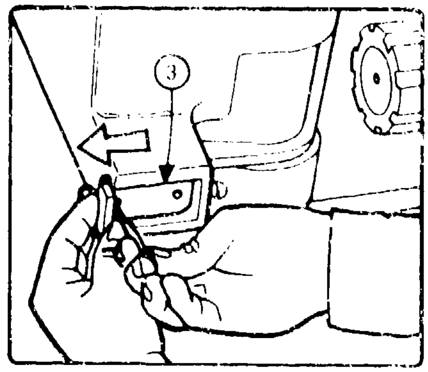
(5) Return the tube to the in-battery position and drain the bleeder tee if necessary.

(6) Secure the castle head nut and the cotter key.

WARNING: Only remove breechblock operator rack springs when breechblock is in closed position. Springs are under heavy pressure. **Under no circumstances** must removal of springs be attempted with breechblock open.

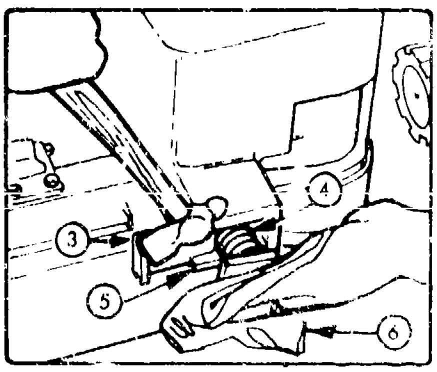
Note. Before disassembling breech mechanism, remove direct fire telescope.

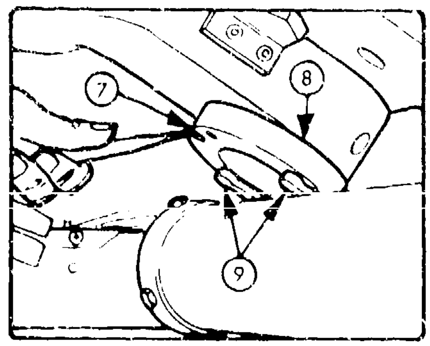




1. With firing mechanism block (2) in center position, push firing mechanism (1) into block (2) and rotate clockwise to remove.

2. Slide rack plate (3) rearward until rack plate disengages from plunger.





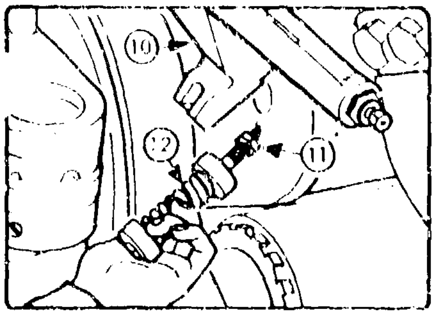
3. Is breechblock closed? (See above *WARNING*.) Drive rack plate (3) rearward; stop plate (5) and rack springs (4) will pop out. Catch plate and springs with a clean rag (6).

4. Release preload on closing spring using spanner wrench (9). Apply counterclockwise pressure on adjustor (3) and depress adjustor plunger (7). Rotate adjustor slowly clockwise until all torque has been relieved.

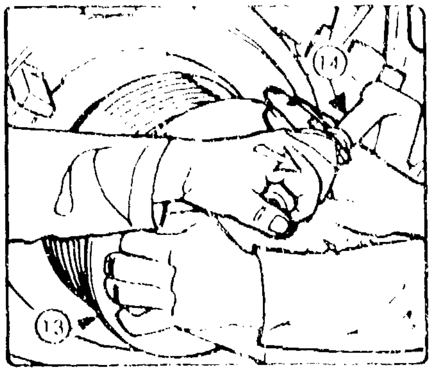
Note. You may have a different type adjuster with ears for a crescent wrench rather than holes for a spanner wrench.

CAUTION: Never attempt to disassemble the breech mechanism with breech partially or fully closed.

Figure 7-6. Disassembly/assembly of breech mechanism—weapon-mounted rammer.

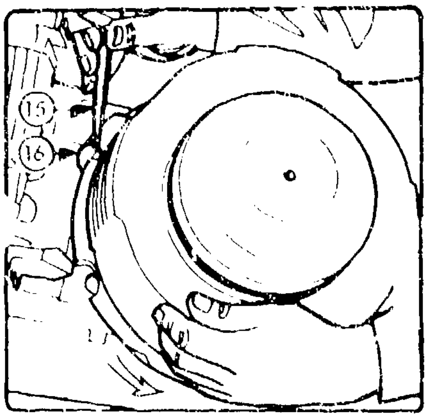


5. Loosen jam nut (11) and remove cam damper (12). Cannon should be elevated slightly, and cam (10) raised and secured with a strap to cab roof.



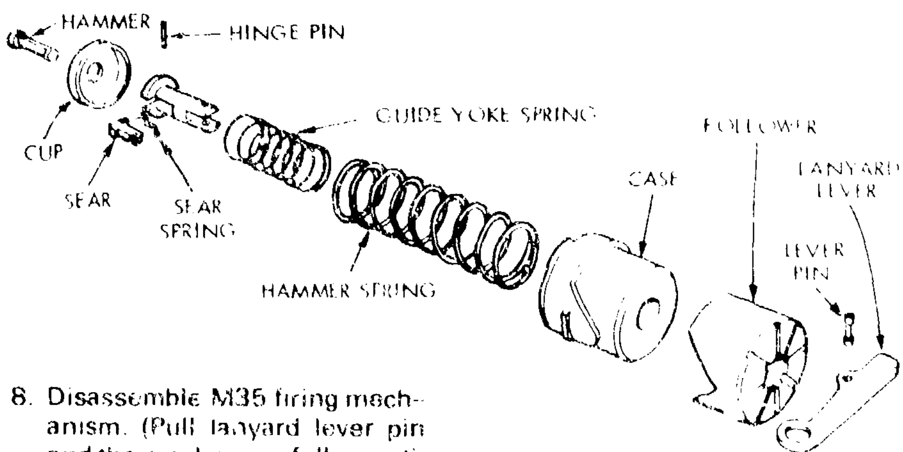
6. Open breech (13) observing the following *CAUTION:*

CAUTION: Since all spring tension has been released, be extra careful when opening breechblock (13). Use operating handle (14) and support breechblock as it is being opened. Otherwise, carrier will slam open and may be damaged.



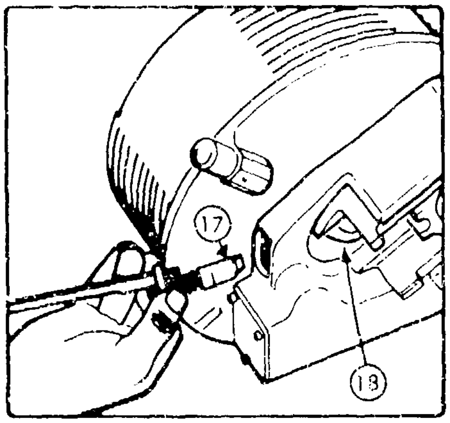
7. Using drive punch (15), depress detent plunger (16) and rotate breechblock to lock position.

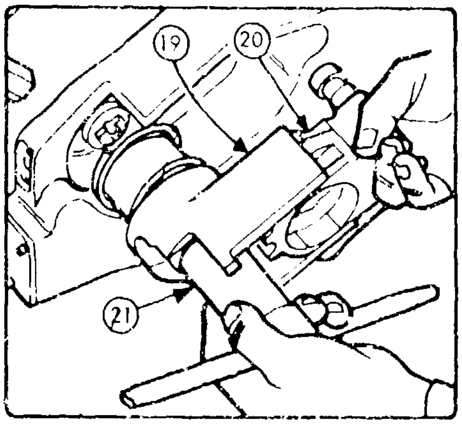
Note. Disassembly of firing mechanism, mechanism block, and obturator group do not have to be done in sequence shown. They could just as well be taken apart afterwards.



8. Disassemble M35 firing mechanism. (Pull lanyard lever pin and the mechanism falls apart).

Figure 7-6. Disassembly of breech mechanism—weapon mounted cannon—continued



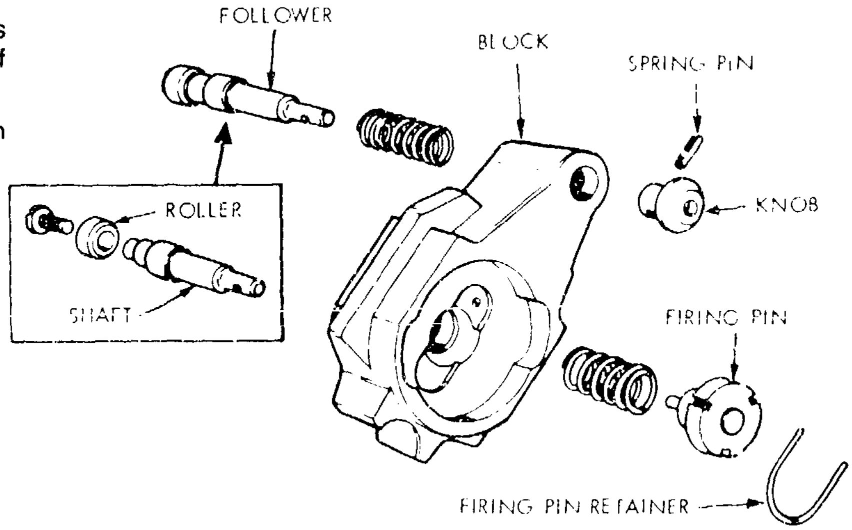


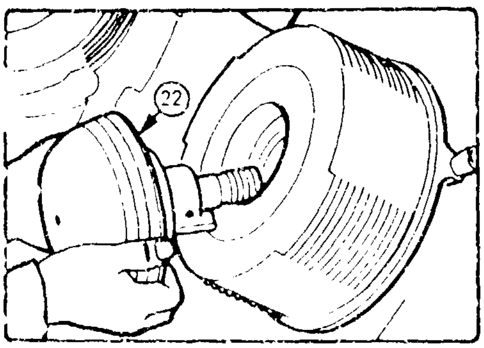
9. Remove two screws and plunger group (17). Slide firing mechanism housing to disassemble position (all the way to the right).

10. Move extractor away from obturator nut (18), support firing mechanism block (20) and housing (19) and unscrew obturator nut with spanner wrench (21). Remove firing mechanism housing and block.

Note. The firing pin retainer is under pressure and will spring out if not restrained during disassembly.

11. Disassemble firing mechanism block.

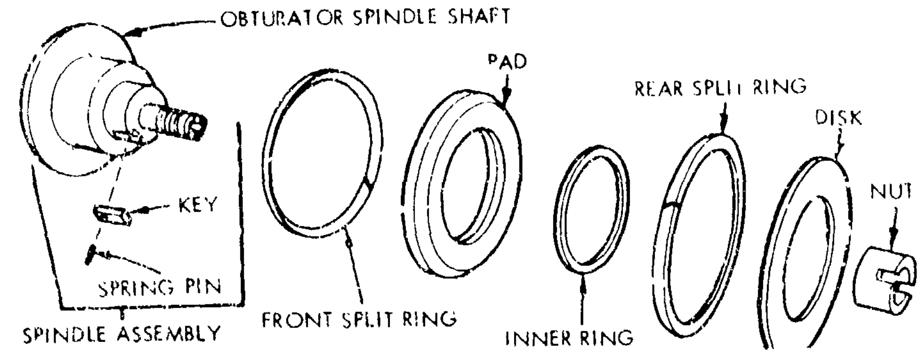




12. Pull obturator group (22) out from breechblock.

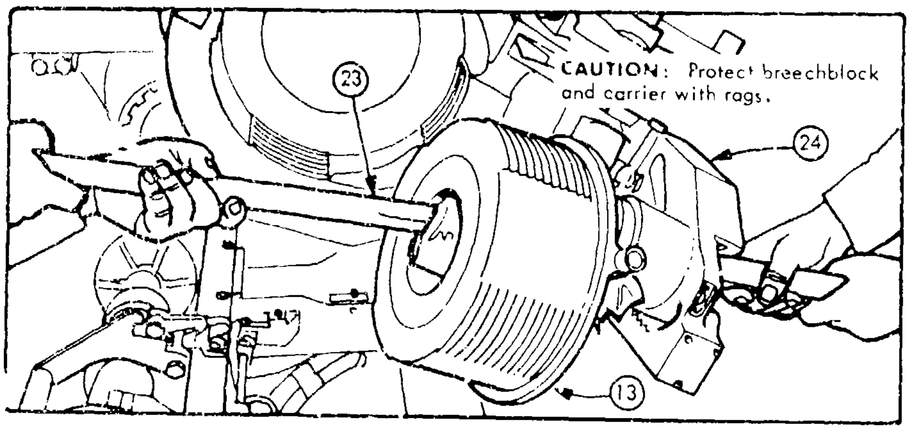
CAUTION: Do not apply oil or cleaning solvent to pad.

Figure 7-6. Disassembly/assembly of breech mechanism—weapon-mounted rammer—continued.



13. Disassemble obturator group to clean, inspect or repair.

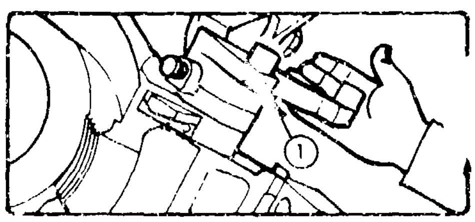
WARNING: It take vo men to remove a breechblock.



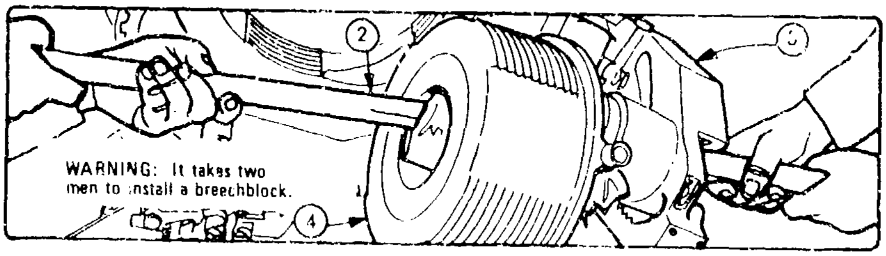
14. Insert cleaning staff (23) through breechblock (13) and carrier (24). Slide breechblock off, onto staff.

Figure 7-6. Disassembly/assembly of breech mechanism—weapon-mounted rammer—continued.

Note: Cannon should be elevated slightly, and cam raised and secured with a strap to cab roof.



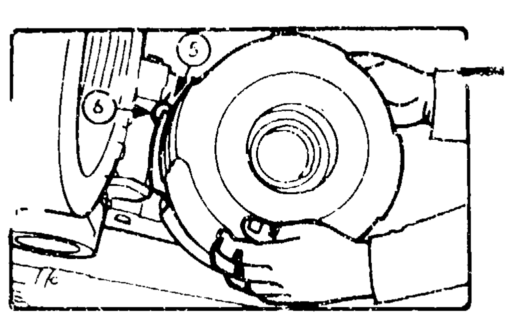
1 Rotate operating crank (1) to move breech block operating gear and operating rack timing marks to the center of the inspection hole under the carrier.

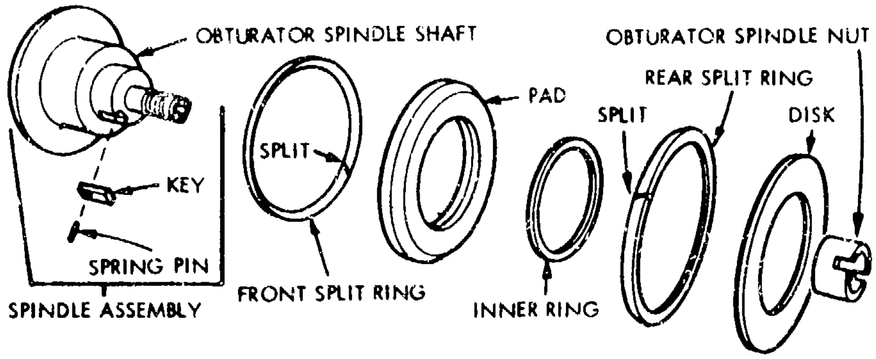


2. With carrier (3) in fully open position, install breechblock (4). Use cleaning staff (2) and wrap staff with rags to protect carrier and breechblock.

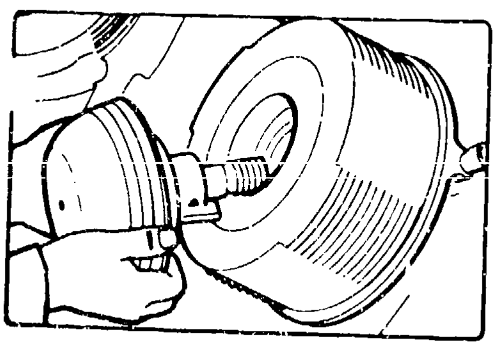
Figure 7-7. Assembly of breech mechanism.

3. With carrier in fully open position, align closing lug (5) with detent plunger (6). With operating rack and operating gear timing marks aligned in the center of the inspection hole, slide breechblock completely on. Now, recheck alinement marks.

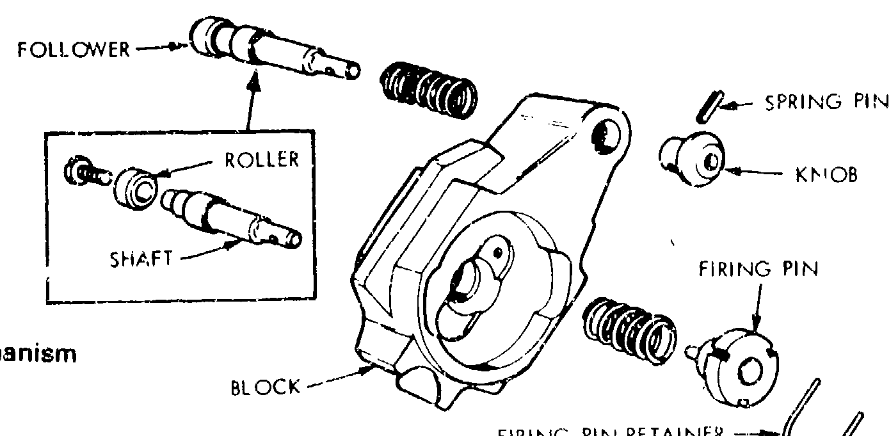




4. Assemble obturator group. Be sure rings, disc and pad are assembled in proper order on obturator spindle. The splits in the front and rear split rings should be 180° apart as shown above.

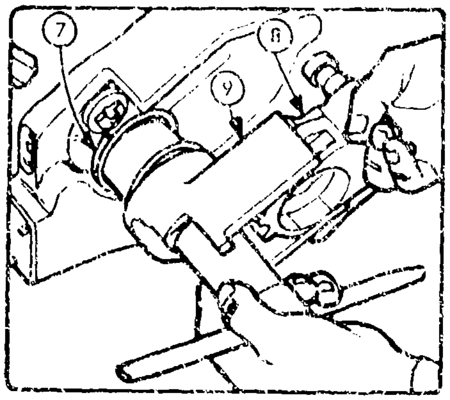


5. Install obturator group in breechblock.

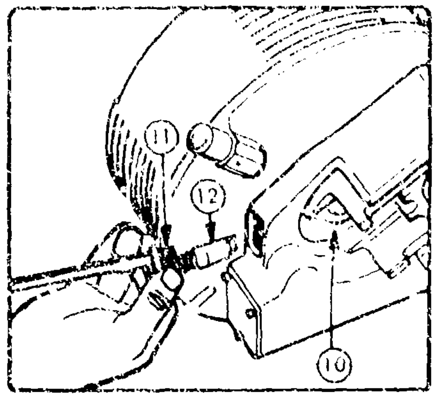


6. Assemble firing mechanism block.

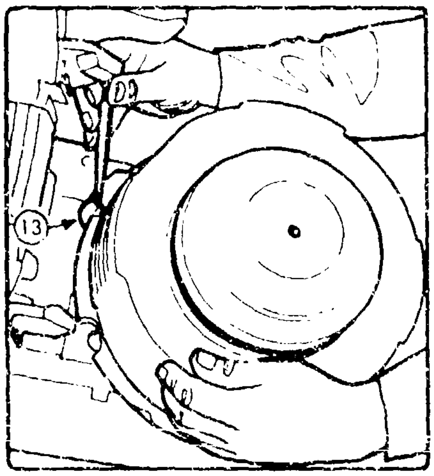
Figure 7-7. Assembly of breech mechanism—continued.



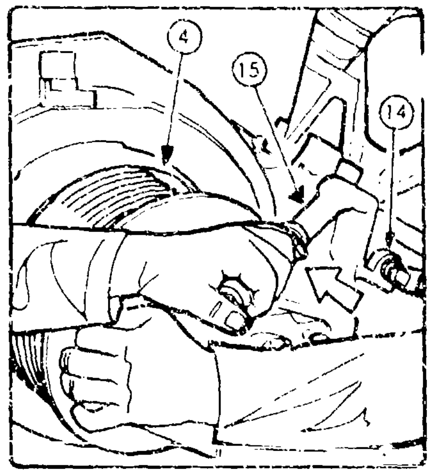
7. Replace obturator spring (7). Install firing mechanism block (8) and housing (9) and secure obturator nut (10).



8. Install plunger (12) and two screws (11). Be sure plunger tip seats in narrow slot of the obturator nut (10).

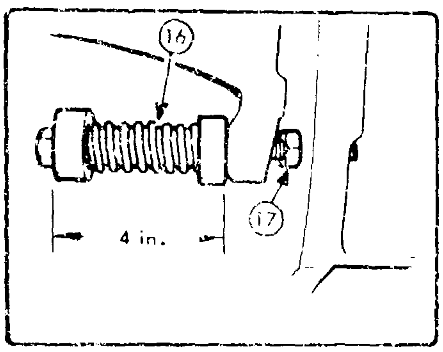


9. Using drive punch, depress detent plunger (13) and rotate breechblock to unlock position.

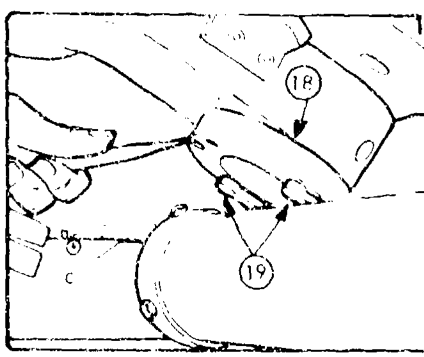


10. Engage clutch pin (14) to close breechblock (4). Return operating handle (15) to stop.

11. Release strap holding cam to room and lower cam.



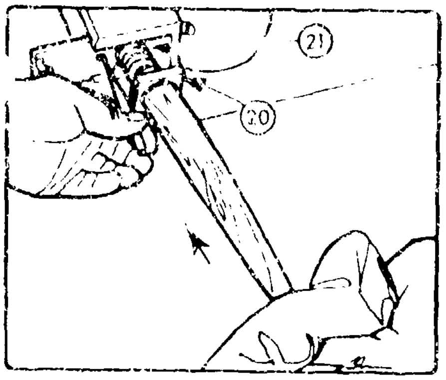
12. Install cam damper (16). Adjust distance between spring cap ends to 4 inches for correct cam tension. Tighten jam nut (17).



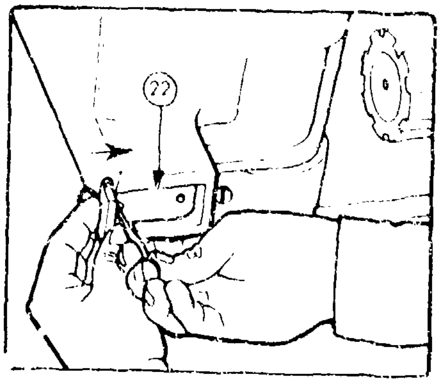
13. Apply preload tension on breech mechanism closing springs. Use spanner wrench (19) installed in holes of adjustor (18). The two notches in the adjustor provide two graduations of adjustment. Do not apply more preload than is necessary to close breechblock securely. Use of the final (second) notch reduces life of the leaf springs and should be used only if necessary.

Note. You may have a different type adjustor with ears for a crescent wrench rather than holes for a spanner wrench.

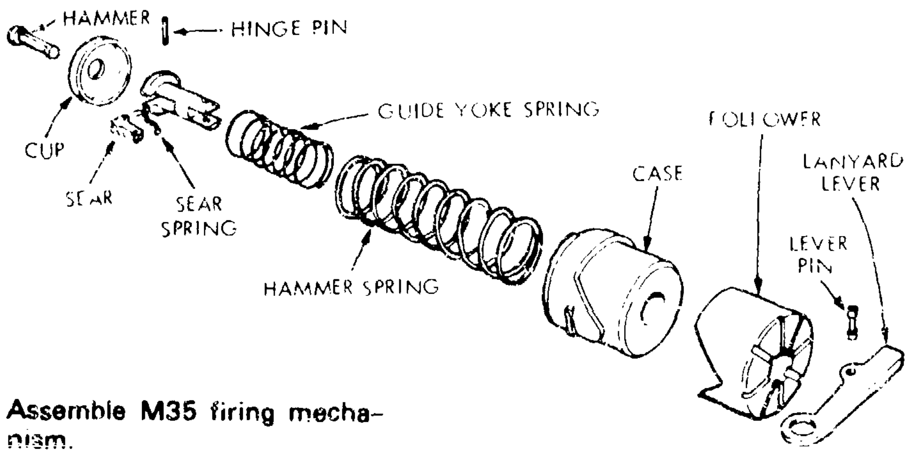
Figure 7-7. Assembly of breech mechanism—continued.



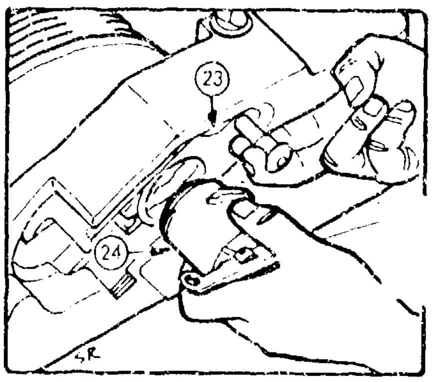
14. Apply pressure to stop plate (20) and rack springs (21) with hammer handle and slide rack plate over stop plate.



15. Slide rack plate (22) forward until rear hole of rack plate engages plunger.



16. Assemble M35 firing mechanism.



17. With firing mechanism block (23) in extreme right-hand position, insert firing mechanism (24) and rotate counterclockwise.

Figure 7-7. Assembly of breech mechanism—continued.

Section III. RECOIL MECHANISM

7-11. Types of Recoil Mechanism

The recoil mechanism employed on the self-propelled 155-mm howitzer M109A1/A2/A3 is the hydropneumatic, variable, independent type. An explanation of the nomenclature follows:

a. Hydro. The mechanism employs a liquid. It can be oil, recoil, petroleum base, hydraulic fluid MIL-O-5606 (OHA), or hydraulic fluid MIL-O-60883, type 1 (OHC), or hydraulic fluid MIL-H-6083, REV C (81349) (OHT). OHT is the preferred oil, since it contains certain additives designed to reduce galvanic corrosion. These oils may be mixed in the recoil mechanism if necessary; however, the diluting of OHT by the addition of OHC or OHA reduces the galvanic corrosion protection, and thus the mixture should be drained and replaced whenever OHT becomes available. All three types of oil are red and have temperature ranges of -65° to +150° F.

b. Pneumatic. A gas is used. The gas used is nitrogen, which is relatively inactive in its free state and will not react on metal to cause corrosion.

c. Variable. Length of recoil can be varied mechanically to prevent the breech mechanism from striking the floor in the crew compartment when the weapon is fired at high angles of elevation. Under normal operating conditions, the length of recoil can vary from 24 inches to 36 inches.

d. Independent. There is no passage for liquid between the recoil cylinders and the recuperator cylinder.

7-12. Purposes of the Recoil Mechanism

The purposes of the recoil mechanism are—

a. To stop the recoiling parts. The recoil mechanism must absorb and control the rearward thrust of the weapon without displacement of the carriage or excessive shock. This action is accomplished by the throttling of oil through the orifices, the compression of the nitrogen gas, and the friction of the moving parts.

b. To return the recoiling parts. The recoil mechanism must cause the recoiling parts to return to the in-battery position. This is accomplished by the expansion in the recuperator cylinder, of the nitrogen gas that was compressed during the recoiling phase.

c. To prevent shock. The recoiling parts must be stopped in recoil without shock and returned to the in-battery position without shock. During recoil this action is accomplished by the increased throttling of the oil flow due to the gradual tapering of the slots and grooves; during counterrecoil it is accomplished by the displacement and restriction of the oil flow in the counterrecoil buffer.

d. To hold tube in the in-battery position in all angles of elevations.

7-13. Major Components and Functioning of the Recoil Mechanism

The recoil mechanism is located in and is part of the howitzer mount. It is composed essentially of two recoil cylinders, a recuperator cylinder, a counterrecoil buffer, and a replenisher cylinder.

a. Recuperator cylinder. The recuperator is mounted in the cradle to the lower left of the cannon tube, with the piston rod secured to the breech ring band. The recuperator is charged with sufficient dry nitrogen gas under pressure (700 psi) on M109A1/A2/A3 to hold the tube in battery at all angles of elevation. When the howitzer is fired, the piston is drawn rearward through the cylinder, further compressing the gas. When the force of recoil is overcome, the gas expands, forcing the piston forward and through returning the weapon to battery. The recuperator cylinder contains a piston group, a piston rod, and a cylinder head group. The major components of the piston group are the outer piston section, which is bolted solidly to the front end of the piston rod, and the inner piston section, which is mounted on the piston rod near the outer section. The inner section is free to move on the piston rod. Two guide pins mounted in the inner section pass through holes bored in the outer section to maintain alinement of the two sections. Oil, pumped through a fitting in the outer section, separates the two sections and serves to lubricate the assembly as it moves in the cylinder. The quantity of oil between the two sections can be determined by measurement of the distance that the guide pins protrude through the outer piston section. The guide pins must protrude at least ⅛ inch but not more than ¾ inch. Ring seals and packings form an oiltight, gastight seal. The cylinder head group is constructed essentially the same as the piston group, with the outer section mounted solidly in the rear end of the recuperator cylinder. The piston rod passes through the cylinder head. Ring seals and packings prevent oil leaks, and the quantity of oil between the two sections of the cylinder head, like that between the two sections of the piston group, is determined by guide pins.

b. Counterrecoil buffer. The counterrecoil buffer is an oil-filled cylinder containing a spring-loaded piston and a piston rod. The buffer is mounted in the cradle below the cannon tube. The piston rod projects through the rear end of the cylinder and rests against a projection on the breech ring band when the weapon is in battery. When the weapon moves rearward in recoil, the piston and rod are released and the piston, driven by the spring, moves to the rear end of the cylinder; the piston rod is fully extended to the rear and stops its rearward movement, while the cannon tube and other recoiling parts move farther to the rear to complete the recoil cycle. During the last few inches of the counterrecoil cycle, the projection on the breech ring band comes in contact with the piston rod, forcing the rod and piston forward through the cylinder. The valve plate, now forced against the piston, forces oil through small metering passages in the valve plate. The restriction in the flow (buffing) of oil through passages to the rear side of the piston slows the cannon and causes it to ease into battery without excessive shock to the carriage.

c. *Replenisher.* The purpose of the replenisher is to allow for change in quantity of oil required by the recoil cylinders as the weapon cycles in recoil and counterrecoil and to allow for the expansion and contraction of the hydraulic fluid due to temperature changes. The replenisher also serves as an oil reserve for the counterrecoil buffer and the two recoil cylinders. The replenisher is mounted on the inner wall of the turret to the right of the cannon. The bladder in the accumulator is charged with nitrogen gas to a pressure of 7 to 8 pounds per square inch by direct support maintenance personnel. The using unit is authorized to add hydraulic fluid to the accumulator until the pressure gage has a reading of 17 pounds per square inch to 24 pounds per square inch. The hydraulic fluid in the recoil cylinders and the buffer is kept under pressure by the nitrogen gas in the partially compressed bladder. Hydraulic fluid OHT is the preferred fluid, but OHC may be used if OHT is not available.

d. *Variable recoil system.* The variable recoil system is composed of the two recoil cylinders and associated mechanical controls. The cylinders are mounted on the cradle, one to the upper left and the other to the lower right of the cannon tube. Each cylinder contains a piston assembly, an inner orifice, and an outer orifice. Each piston assembly consists of a piston, a piston tube (piston rod), and a plug. The plug is a bolt threaded on both ends. The plug is screwed into the breech end of the piston tube. A nut screwed onto the other end of the plug secures the piston assembly to the breech ring band of the cannon. The inner orifice is a shaft with four grooves, 36 inches long, cut lengthwise in its outside diameter. The outer orifice is a metal tube with two triangular-shaped slots (orifices), 24 inches long, cut into its side wall, one on each side of the tube. The wide ends of the slots are near the front end of the tube, with the points of the slots toward the rear end of the tube. The inner orifice is located in the hollow recoil piston tube (piston rod) and is supported by the front follower group, which serves as the front head of the recoil cylinder. The outer orifice is machined to fit into the front portion of the recoil cylinder and serves as the cylinder in which the recoil piston moves in recoil and counterrecoil. As the recoil piston moves to the rear during recoil, oil bypasses the piston by flowing through the slots in the outer orifice. At the same time, oil flows through four holes in the piston into and through the grooves in the inner orifice and thus ahead of the piston. At an angle of elevation of approximately 45° (plus or minus 3°), the inner orifice of each cylinder is mechanically rotated by meshed gears located at the front end of the cylinder so that the grooves in the orifice are no longer alined with the holes in the recoil piston. At angles of elevation above 45°, the only passages through which oil can bypass the piston are the triangular slots of the outer orifice; therefore, the length of recoil is limited to 24 inches At angles of elevation below 45°, the holes in the piston are alined with 36-inch-long grooves in the inner orifice, as well as with the slots in the outer orifice; therefore, recoil can continue for 36 inches. The gradual slowing down of the cannon results primarily from the increased throttling of oil as the piston moves rearward. The openings in the outer orifice through which oil can flow become narrower and finally disappear, and the grooves in the inner orifice gradually become more shallow, beginning at a point 24 inches in the recoil cycle, and finally disappear at a point equivalent to 36 inches of cannon recoil.

7-14. Maintenance of Recoil System

a. *Checking the replenisher.* The replenisher should be checked daily. Before firing the pressure gage should read 17 to 24 psi on the M109A1. On the M109A2/A3 the gage should be 17 to 24 psi. During firing the pressure gage should read 17 to 50 psi.

b. *Servicing the replenisher.* When the gage reading on the accumulator type of replenisher is less than 17 psi, the replenisher system must be serviced with hydraulic fluid OHT (or OHC if OHT is not available). If the pressure is greater than 50 psi, hydraulic fluid should be drained from the replenisher system until it is within tolerances.

(1) To replenish the fluid, remove the filler valve plug and gasket, install the M3 oil gun, filled with clean, new hydraulic fluid OHT, into the check/fill valve of the pressure gage/accumulator type, and pump the fluid into the replenisher until the pressure gage reads above 24 psi on the replenisher.

(2) Depress the tube to approximately -50 mils and loosen the right-hand bleed plug to bleed the accumulated air from the rear of the buffer. When *air-free fluid* continues to flow from the bleed cock or bleed plug, close the cock or tighten the plug.

(3) Elevate the tube to approximately +50 mils and loosen the left bleed plug to bleed the accumulated air from the front of the buffer. When *air-free fluid* continues to flow from the plug, tighten the plug.

(4) Elevate the weapon to approximately +180 mils and loosen the plug on the bleeder tee. When *air-free fluid* continues to flow from the plug, tighten the plug.

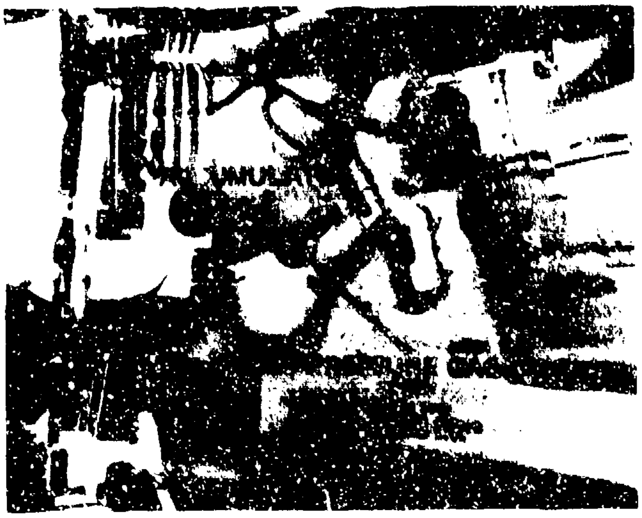


Figure 7-8. Pressure gage/accumulator type.

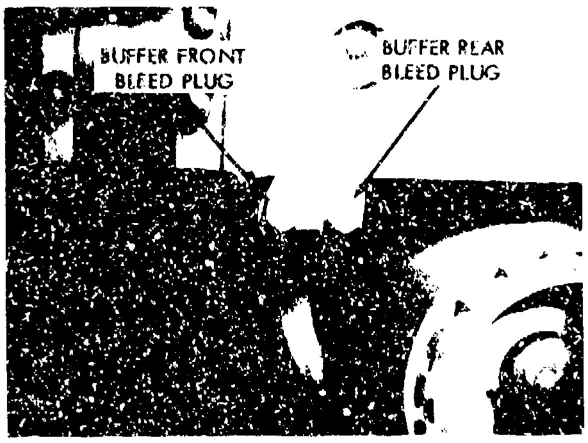


Figure 7-9. Buffer bleed plugs (M109A1/A2/A3).

Figure 7-10. Recoil cylinder bleeder tee plug.

(5) Open the replenisher bleed cock slightly to bleed off any accumulated air from the replenisher and, when *air-free fluid* continues to flow from the bleed cock, close the cock.

(6) Check the accumulator gage (fig 7-8) for a pressure reading of 17 to 24 psi.

(7) On the M109A1 if gage reads below 20 psi (on the M109A2/A3 below 17 psi), start over from step 1. If gage reads above 24 psi, bleed from any of the 4 places until gage reads below 21.

(8) If the check shows that the replenisher is low on fluid, add fluid to the correct operating range; if the check shows that the replenisher is overfilled, drain to the correct operating range.

(9) Rebleed the system if required and check for fluid leaks. Remove the M3 oil gun.

7-15. Malfunctions of the Recoil System

a. If the tube slams out of battery, the system is low on hydraulic oil or low on nitrogen.

b. If the tube slams into battery, the system is low on hydraulic oil or air is in the counterrecoil buffer.

c. If the tube is jerky in recoil action, air is in the recoil cylinder.

d. If the system leaks 3 drops or more in 5 minutes or less the weapon must be sent to support maintenance.

Section IV. ELECTRICAL AND HYDRAULIC SYSTEM

7-16. Electrical System

The 24-volt negatively grounded electrical system requires four 12-volt storage batteries. Direct current for charging the batteries and operating electrical units is furnished by a 100-ampere engine-driven alternator and a selenium-type rectifier. Current may also be supplied by an external source through a slave receptacle. On earlier models, the receptacle is located in the driver's compartment and the slave cable must be passed through the driver's hatch. On later models the receptacle has been repositioned and can be reached through the battery access door.

a. Contact boxes. The contact boxes pass the electrical power from the lower carriage to the turret. There are five contact boxes on the newer weapons and three on the older weapons.

b. Slip ring. The slip ring provides continuity of electrical circuits from hull to cab.

c. Cab power switch. The cab power switch is located on the gunner selector switch box at the gunner's station. This switch controls all electrical power to the cab with the exception of that for communications and lights.

d. Slave starting disabled vehicle.

WARNING: Do not allow personnel between vehicles during slave starting.

(1) Lock the brakes on both vehicles. (All accessories must be off.)

(2) On vehicles with serial numbers 1 through 1122 leave the MASTER switch in the OFF position. On vehicles with numbers 1123 and above, set the MASTER switch at the SLAVE position.

CAUTION: Polarity (plus-to-plus, minus-to-minus) and voltage (24 volts) must be the same in both vehicles.

(3) Start the engine of the vehicle supplying power and adjust the hand throttle lever to idle the engine at approximately 1,000 rpm.

(4) Connect the slave cable to the auxiliary power receptacle (fig 7-12) of each vehicle. The indicator lamp should light.

(5) Set the disabled vehicle engine STARTER switch at START.

(a) Serial numbers 1 through 1122. When the engine starts, turn the MASTER switch ON and set the idle to 650 rpm.

(b) Serial numbers 1123 and above. When the engine starts, set the idle to 650 rpm. Set and hold the MASTER switch at the SLAVE position. The indicator light should light, which means that the receiving vehicle batteries are connected to the generator system. Set the MASTER switch at the ON position; the indicator light should remain on. If it goes out, return the MASTER switch to the SLAVE position and hold a while longer.

(6) Disconnect the slave cable from both vehicles.

(7) Increase the disabled vehicle engine speed to 1,000 rpm to recharge the batteries. Check the battery indicator.

7-17. Components of Hydraulic Systems

a. Reservoir. The reservoir holds 11.25 quarts of oil, which may be pumped into the accumulator as it is needed to pressurize the system.

b. Power pack pump. The power pack, powered by a 5-horsepower electric motor, is located in the bottom of the reservoir. This pump pumps the oil out of the reservoir into the accumulator to pressurize the system.

c. Accumulator. The accumulator, a metal cylinder alongside the reservoir, has a free-floating piston in it. One end of the accumulator has a precharged nitrogen pressure of 500 to 550 psi. The accumulator allows the transfer of pressure to the system to serve the power traversing and elevating mechanisms and the rammer. It also serves the equilibrator.

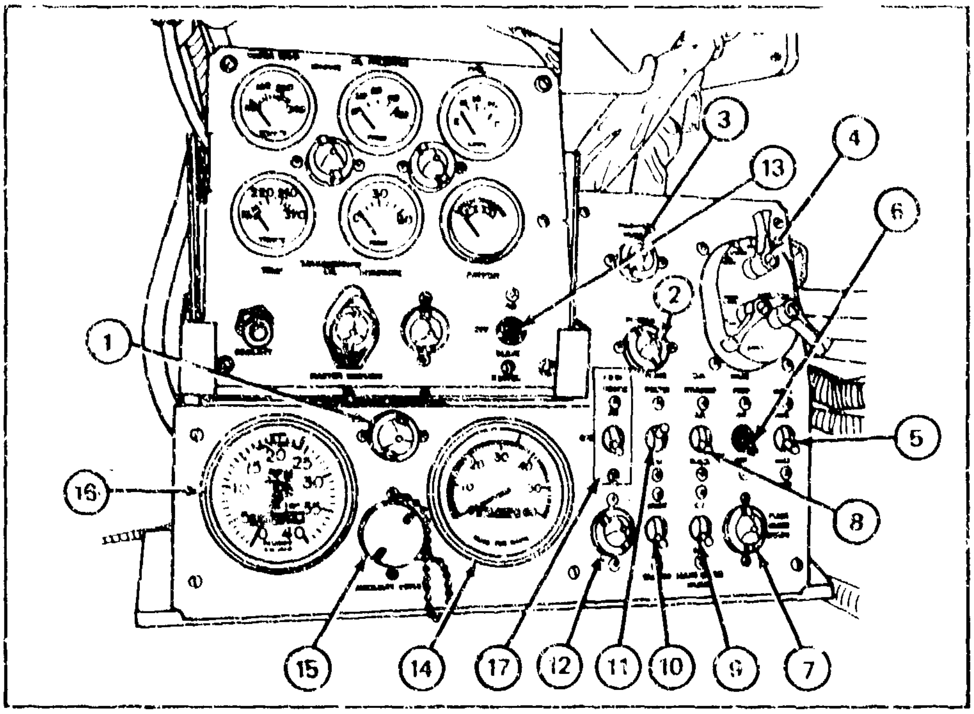
d. Pressure sensitivity switch. The pressure sensitivity switch is located at the base of the accumulator. It senses the pressure in the system and maintains the pressure between 925 and 1,225 psi. When the pressure drops below 925 psi, the pressure sensitivity switch turns on the 5-hp motor to activate the pump to return the pressure to operation limits. When the pressure reaches 1,225 psi, the switch shuts the motor off.

e. Safety relief valve. The safety relief valve opens when the pressure in the accumulator reaches between 1,600 and 3,100 psi. This action allows the hydraulic oil to flow back into the reservoir and prevents the seals in the hydraulic system from being damaged.

f. Accumulator pressure gage. The accumulator pressure gage, located in front of the accumulator, indicates the amount of nitrogen pressure during the zero pressure check.

g. Reservoir sight gage. The reservoir sight gage is located between the reservoir and the accumulator. It visually indicates the amount of oil in the reservoir.

h. Cab hydraulic system. The cab hydraulic system provides power for the operation of the cab traversing and howitzer elevating mechanisms and the rammer. Pressure within the system is supplied by a hydraulic pump powered by a 5-horsepower electric motor, which charges the accumulator. A power control handle is provided for use by the gunner in elevating and traversing the weapon. An elevation control handle is also provided for the assistant gunner; this control is operative when the gunner's elevation selector switch is depressed. In addition to the power controls, there are manual controls for elevating and traversing.



Item	Function
1—Indicator panel light	Indicates speedometer/odometer and tachometer/hour meter
2—Hi-beam indicator light	Illuminates if hi-beam headlights are "ON"
3—Parking brake indicator light	Illuminates if parking brake is "ON"
4—Vehicular light switch	Refer to figure 2-22
5—Fuel tank selector switch	To indicate fuel supply—refer to figure 2-16
6—Bilge pump switch	To control bilge pump (para 2-49)
7—Flame heater system light	Illuminates if flame heater system is "ON"
8—Blackout selector switch	Refer to figure 2-22
9—Flame heater master switch	To control flame heater (table 2-21)
10—Starter switch	To start engine
11—Flame heater switch	To start flame heater (table 2-21)
12—Master switch indicator light	Illuminates when master switch is "ON"
13—Master/slave switch	To control electrical power to vehicle
14—Speedometer/odometer	Indicates speed and registers vehicle mileage
15—Auxiliary outlet	To operate unattached accessories
16—Tachometer/hour meter	Indicates engine rpm and operating hours
17—Fuel primer	

Figure 7-11. Instrument panel.

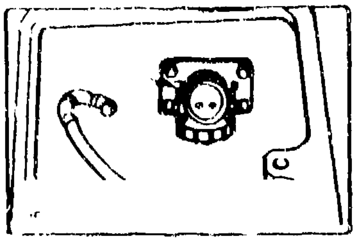


Figure 7-12. Auxiliary power receptacle.

7-18. Rammer

The rammer is an electrically activated, hydraulically operated system that aids in loading the cannon by thrusting the projectile into the chamber. The weapon-mounted rammer remain in alinement as the tube is elevated or depressed, and therefore permits ramming the projectile at any elevation between -53 mils and approximately 700 mils on the M109A1 only. The weapon-mounted rammer is supported in the stowed position to the lower left of the tube on the rammer shaft and needs only to be rotated about the rammer shaft into position behind the breech. The projectile is manually placed on the tray ahead of the cylinder. As the cylinder is swung back onto the tray, a switch is tripped, the rammer automatically extends, and the projectile is rammed into the chamber. As soon as the rammer retracts, it is folded into the stowed position. The principal components of the rammer are the cylinder, tray assembly, switches, timer, and solenoid valve.

a. Cylinder. The cylinder, when hydraulically activated, extends a telescoping ram, which slides the projectile into the chamber. At the completion of the ramming stroke, the ram is returned automatically.

b. Tray assembly. The tray assembly, a concave length of sheet metal, supports the projectile and guides the projectile into the chamber.

c. Switches. Three switches are provided for safe, automatic operation. The hinge switch makes the electrical operation of the rammer impossible when the rammer is in the stowed position. The tray and rollover switches provide for automatic operation. These switches must be depressed in sequence to activate the rammer. When the rammer is run through its normal cycle of operation, the switches will be depressed automatically and in proper sequence.

d. Timer. The timer, when activated by the switches in the base, closes an electrical circuit, which activates the solenoid for the period of time necessary for the complete extension of the cylinder ram and holds it in the extended position approximately .9 second.

CAUTION: Never "FULL POWER" actuator rammer control valve without having a projectile in the ram position. Actuating the rammer without the projectile in position will cause seal damage.

e. Solenoid valve. The solenoid, when activated by the timer, positions a spool within the valve, allowing hydraulic pressure to reach the cylinder and extend the ram. The spool returns to its normal position when the solenoid is inactivated, reversing the hydraulic pressure and thereby returning the ram into the cylinder. To prevent accidents, the crew must insure that the lead wire from the timer box to the solenoid is disconnected at the solenoid at all times except during live firing.

f. M109A2/A3 only. The rammer on the M109A2/A3 howitzer is manually actuated. The rammer actuator valve is mounted on the cab roof. Cannoneer number 1 pushes rammer actuator handle in. The valve handle will latch. Allow 4 seconds for proper seating of projectile, then release actuator.

7-19. Traverse

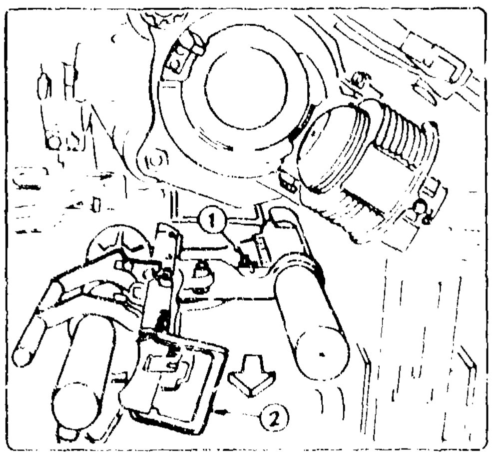
a. Type. The type of traverse is ring and race. The ring is attached to the hull (motor carriage) and does not move in traverse but supports the weight of the race, which is attached to, and moves, with the cab in traverse. Bearings between the ring and race provide ease of movement.

b. On-carriage traverse. The total amount of on-carriage traverse is 6,400 mils (360°).

7-20. Traversing Mechanism

a. Purpose. The traversing mechanism (fig 7-14) controls the movement of the weapon in azimuth.

b. Type. The traversing mechanism is of the hydraulic power type with a manual backup.



(1)—Lock indicator (2)—Main release handle

Figure 7-13. Weapon-mounted rammer (M109A1).

c. Flow of power. The traversing electrical circuit provides electrical control for the traversing hydraulic system. Actuation of the magnetic brake actuator releases the hydraulic motor magnetic brake. The power elevating and traversing control handle directs pressurized hydraulic oil to drive the traversing motor.

d. Traversing components.

(1) *Cab traverse lock.* The cab traverse (fig 7-15(1)) is located to the right of the gunner's control handle. A two-position lock, it locks the cab in place and relieves stress on the traversing mechanism.

(2) *Manual-power selection lever.* On the M109A1/A2/A3, the selector switch is on the gunner's selector switch box (fig 7-15(2)).

Note. With power off, always leave the lever in the manual position.

(3) *Hydraulic motor.* The hydraulic motor is located to the left of the manual traversing handwheel (fig 7-15(3)).

(4) The M109A1/A2/A3 has a no-back device built into the hydraulic motor that acts as a brake.

(5) *Manual traversing handwheel.* The manual traversing handwheel, located on the left of the gunner's power traverse control, enables the gunner to traverse manually (fig 7-15(3)).

(6) The handwheel moves the tube 10 mils in traverse per turn.

Note. The gunner must alert the crew prior to traversing.

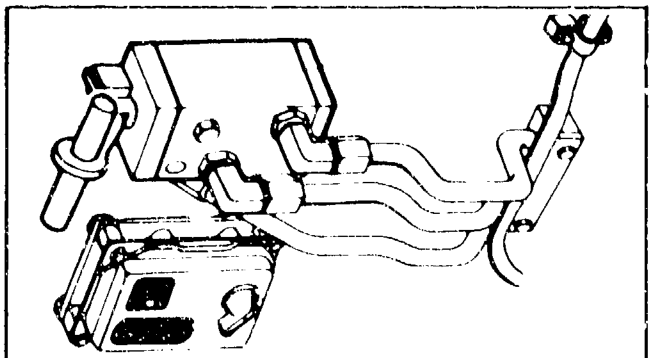


Figure 7-14. Operating rammer.

7-21. Elevation

The M109A1/A2/A3 howitzer has rear-mounted trunnions. The elevation mechanism is operated by hydraulic power. It permits elevation of the tube from -53 mils to +1,333 mils (-3° to +75°). A manual backup system is also provided.

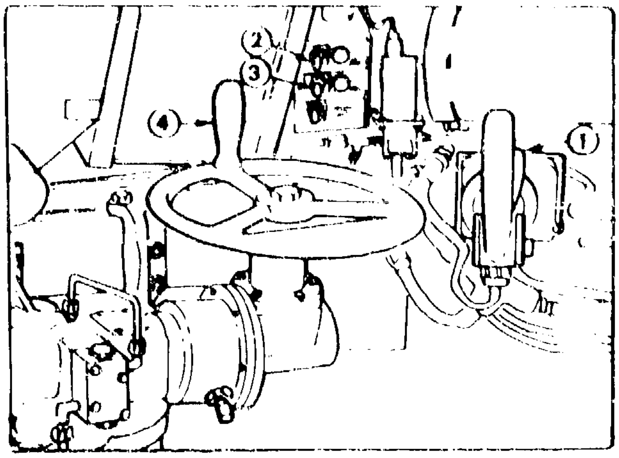


Figure 7-15. Elevating and traversing controls

7-22. Elevating Components

The gunner's and assistant gunner's controls are located at their respective stations.

a. Elevation selector switch. The elevation selector switch (fig 7-15(4)), located on the gunner's selector box, allows the gunner to choose whether he or the assistant gunner will elevate the weapon.

b. Equilibrated elevation cylinder. The equilibrated elevation cylinder, located on the cab ceiling, is to the left of the breech ring. The amount of oil which is pumped or drained from this cylinder causes the elevation cylinder piston to push or pull on the gun mount, which in turn causes the tube to be elevated or depressed.

c. Manual elevation accumulator. The manual elevation accumulator is the narrow cylinder located vertically along the right trunnion wall.

d. Manual elevation handpump. The manual elevation handpump, located at the assistant gunner's station, provides a manual backup in the event the power elevation mechanism becomes inoperable.

7-23. Maintenance of Elevation Mechanism

a. If the manual elevation accumulator is low on hydraulic oil—

(1) Lower the tube to the depression stop.

(2) Depress further (approximately 10 turns) with the manual elevating handpump.

b. Jerky motion of the elevation mechanism indicates emulsified oil. There are two methods of removing the emulsified oil.

7-24. Equilibrator

a. Type. The equilibrator (fig 7-16) is of the hydropneumatic type, in that both a fluid (hydro) and a gas (pneumatic) are employed in the system.

b. Purpose. The purpose of the equilibrator is to compensate for the preponderant weight of the muzzle (due to the rear-mounted trunnions) and to reduce the manual effort required to elevate the tube.

c. Components.

(1) *Equilibrated elevating cylinder.* The rear part of the elevating cylinder is located on the roof of the cab near the gunner's station. It is composed of a piston, a piston rod, seals, and a cylinder housing. The piston rod is attached to the howitzer mount. Hydraulic fluid under constant pressure from the hydraulic accumulator assembly forces the piston to exert a constant pull on the howitzer mount. This pull assists with the elevation or depression of the tube.

(2) *Accumulator.* On the M109A1/A2/A3, there are two accumulators located at the gunner's station. The primary one (fig 7-16(1)) is located below the handpump on the cab wall. The secondary one (fig 7-16(2)), which is smaller, is located above the handpump (fig 7-16(3)) on the cab wall.

(3) *Reservoir.* On the M109A1/A2/A3, the main reservoir provides hydraulic fluid to the accumulators through a pressurized line (fig 7-16(4)) or a free-flow line should the weapon be without power.

(4) *Handpump.* A handpump (fig 7-16(3)) is incorporated into the system to force the hydraulic fluid from the reservoir to a cross in the line leading from the accumulator to the cylinder. This permits adjustment of the equilibrator system to compensate for variations in the temperature. The handpump is located at the gunner's station on the left cab wall.

(5) On the M109A1/A2/A3 there two valves. The drain valve (painted red) allows the fluid to be completely drained out of the system. The second valve is the equilibrator valve knob, which allows fluid to be supplied to the equilibrators from the main accumulator. Variations in temperatures can affect elevating or depressing of the cannon. The equilibrator, which counterbalances the weight of the tube, must be adjusted if more effort is required to elevate than depress or vice versa. Take the following steps to compensate for differences.

7-25. Zero Pressure Check

a. The zero pressure check (fig 7-18) should be performed by qualified organizational maintenance personnel (artillery mechanics) quarterly or when troubleshooting the main accumulator and hydraulic system. The zero pressure check is not performed by the crew as a part of the daily or prefire preventive maintenance checks. However, in the event no artillery mechanic is available, it would become the responsibility of the chief of section and the crew.

b. The zero pressure check is two checks in one. The first indicates the amount of precharged nitrogen in the main accumulator. The second indicates if there is enough hydraulic oil in the main power pack reservoir.

c. If, after performing the before-operation and maintenance checks on the cab traversing, elevation, and rammer systems, they function sluggishly or unusually, it may be necessary to perform a zero pressure check. An example would be if the electric drive motor runs more often than usual to keep pressure built up for power operation of the traversing, elevation, and rammer systems.

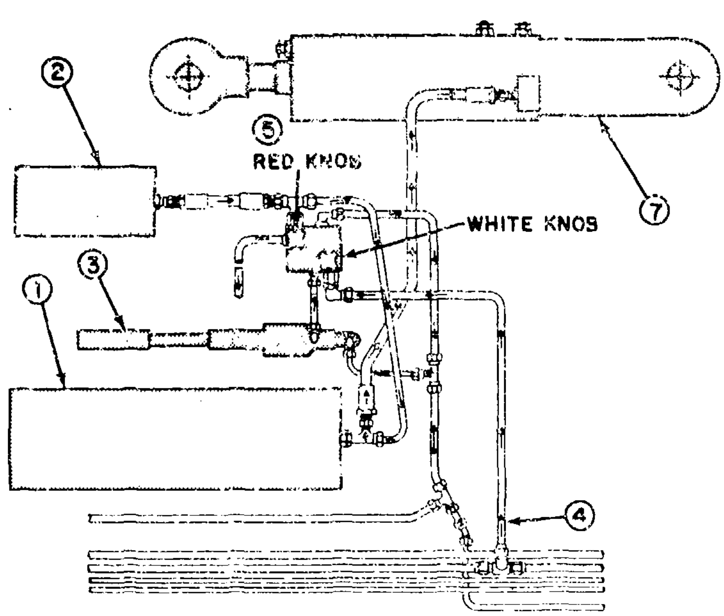


Figure 7-16. Components of the equilibrator system M109A1/A2/A3.

1. Using the gunner's quadrant, set the howitzer at +266 mils.
2. Using the manual elevation handpump (1), elevate and depress the howitzer tube to determine if it is as easy to elevate as it is to depress.
3. If no difference is detected, no adjustment is required.
4. If it is harder to elevate, increase equilibrator pressure with the handpump (2).
5. M109A1/A2/A3: If harder to depress, slowly open the system drain valve (4); place a clean container under the drain tube (5) and bleed off a small quantity of hydraulic oil.
6. Repeat step (2) and adjust the system with step (4) or (5) until no difference is detected.

Note. M109A1: With the MASTER switch and cab power switch turned on, the equilibrator valve knob open (turned left), and the system drain valve open, the complete hydraulic power pack will be pumped dry.

Note. M109A1/A2/A3: Equilibrating hydraulic oil comes from the power pack. Do not operate the system with low fluid levels.

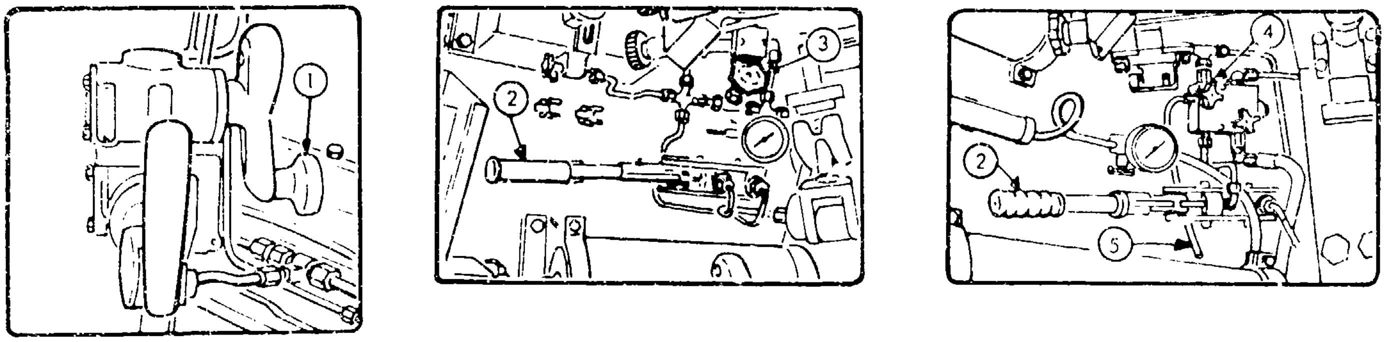


Figure 7-17. Adjustment of equilibrator.

Procedure:

1. Place the weapon on level ground, if possible.
2. Set the MASTER switch and cab power switch (1) to ON position to charge the system.
3. Observe the pressure gage (2) reading. Normal operating pressure is 925 to 1,225 psi.
4. Set the cab power switch and the MASTER switch to the OFF position.
5. Set the cab traversing lock handle (4) at the locked position or place the tube in travel lock.
6. On the M109A1/A2/A3, move the selector switch (5) to the manual position.
7. Disconnect the circuit connector (No 645) (3) located at the right rear of cab by the pressure gage.
8. Set the MASTER switch at the ON position.
9. Set the cab power switch (1) to the ON position.
10. Move the gunner's control handle (6) to the left or right.
11. Watch the pressure gage needle (7) as it drops from operating pressure until it flutters; then the needle will drop sharply to zero psi. The reading at which the needle fluttered is the amount of precharged nitrogen in the main accumulator. The normal precharged nitrogen pressure in the main accumulator is from 500 to 550 psi at 70°. (This psi will vary with temperature changes.)

Note. If the main accumulator nitrogen pressure is below 450 psi, notify organizational maintenance.

12. Set the cab power switch and the MASTER switch at the OFF position.
13. Observe the sight gage (8) on the main hydraulic reservoir. Oil appearing in the gage should be level with the mark on scale "full at zero pressure check."
14. If the oil is low, replenish by adding hydraulic oil.
15. To add hydraulic oil, remove the cab access plate (9) located on top right rear of cab, by removing four bolts (10).
16. Unscrew and remove the dipstick (11) from the top of the reservoir and note the reading on the dipstick.
17. Add hydraulic oil (MIL-L-6083) to the reservoir, if needed and check the level again with the dipstick. Oil should be level with the full mark on the dipstick.
18. Replace the dipstick in the hydraulic oil reservoir and tighten.
19. Replace the access plate and four bolts.

Figure 7-18. Zero pressure check.

20. Reconnect the circuit connector (No 645) 3 .
21. Set the MASTER switch to ON position. The main hydraulic system will then charge.
22. Set the cab power switch to the ON position
23. The needle will move from zero on the pressure gage and stop between 1,175 and 1,275 psi.

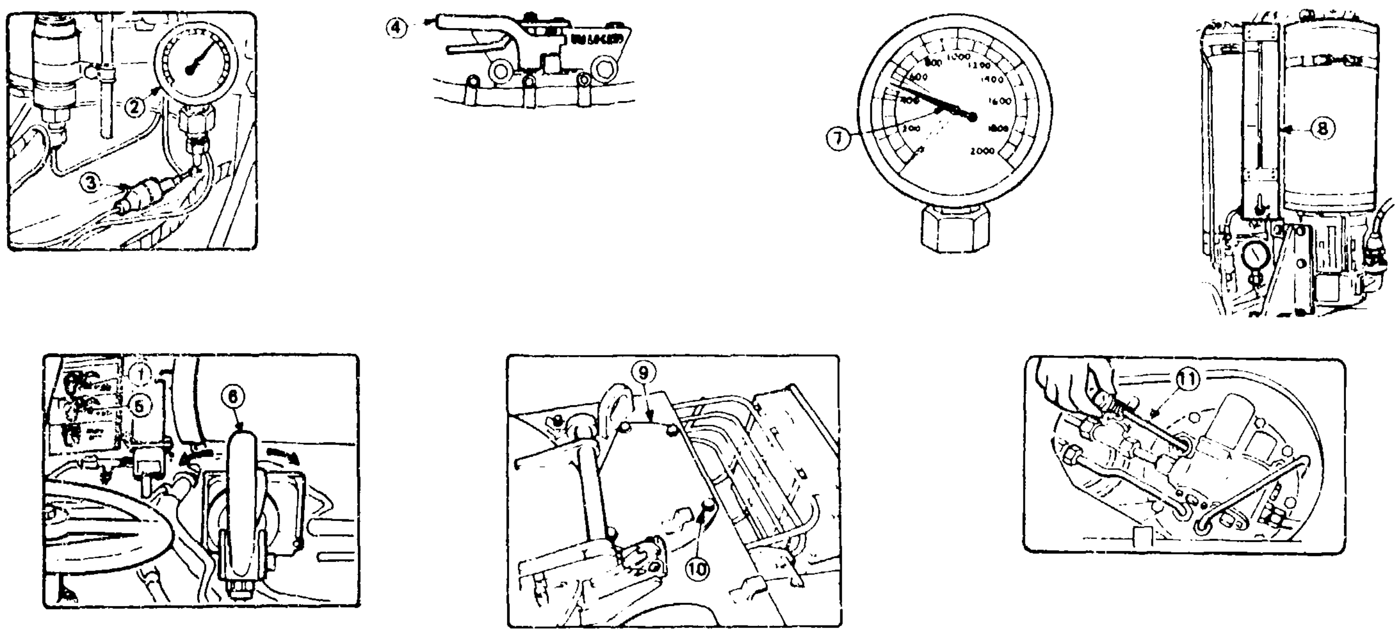


Figure 7-18. Zero pressure check—continued.

Section V. FIRE CONTROL EQUIPMENT

7-26. Panoramic Telescope M117

The panoramic telescope M117 (fig 7-19) is the basic instrument used in laying the weapon for direction. Unlike older series of panoramic telescopes, which have azimuth scales graduated from 0 to 3,200 mils, the M117 has an azimuth counter that permits readings from 0 to 6,400 mils. It is mounted directly on the telescope mount M145. It is a 4-power, fixed-focus telescope with a 10° field of view. It is equipped with a mechanical counter device. Included also is a reset counter, which can be set to show a reading of 3,200 mils when the telescope is alined with the aiming point. A gunner's aid counter mechanism is an integral part of the counter mechanism and permits special corrections for factors peculiar to the individual weapon and its emplacement to be entered. The 90° head prism, objective lens, reticle, and erector lens are included in a single assembly. This design eliminates relative movement between the reticle and the 90° head prism as the cab rotates.

7-27. Direct Fire Telescope M118C

The telescope M118C (fig 7-20) is mounted in the telescope mount M146 on a forward spherical seat and is retained at the opposite end by a kingpin. This instrument is a 4-power, fixed-focus telescope with a 10° field of view. The instrument contains two precollimated ballistic reticles that can be selectively placed in the field of view. The telescope eyepiece arm can be positioned to a convenient angle for viewing. The rim release lever prevents damage if the eyepiece arm is up and the tube is depressed. Two reticles are provided for use with the M118C telescope. Crewmen can rapidly interchange the reticles by rotating the reticle lever arm 180° right or left. Reticles and ammunition are correlated. The proper ammunition is identified in the upper portion of the field of view on each reticle.

7-28. Telescope Mount M146

The telescope mount M146, located to the right of the tube, forms an adjustable base to support the M118C direct fire telescope. The component parts are constructed primarily of stainless steel for strength and corrosion resistance.

a. Boresight knobs. Azimuth and elevation boresight knobs mounted on calibrated screws provide a means of adjusting the mount during boresighting. Telescope mount slip scales graduated in tenths of mils simplify the application of special ballistic corrections for factors peculiar to an individual weapon or its emplacement. Internal ratchets automatically lock the controls at any desired setting.

b. Cant correction. Crewmen achieve cant correction by rotating the entire telescope between the telescope ball supported at the forward end and the fixed telescope sleeve near the opposite end, thereby erecting the reticle pattern. A single tapered kingpin secures the telescope in the mount; the kingpin can be removed without the use of tools.

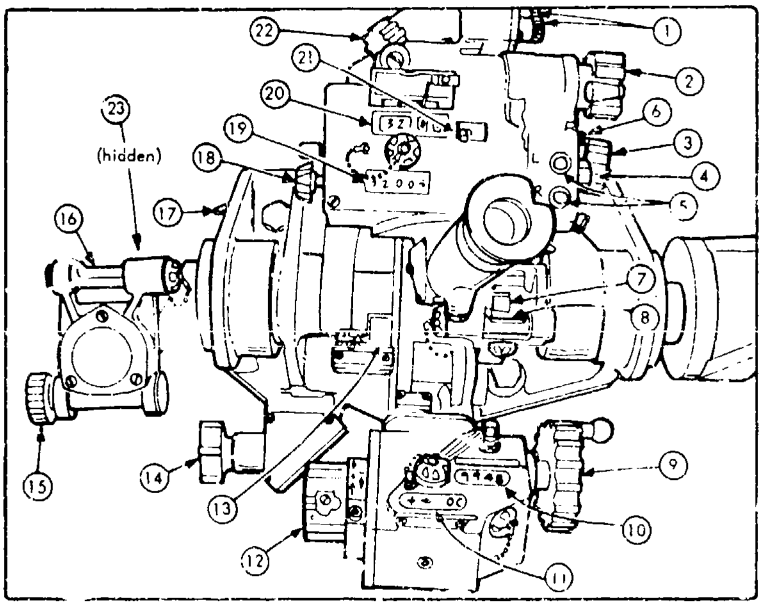
c. Cable assembly. A cable assembly conducts electricity from the vehicle power supply to the telescope for illuminating the reticles and level vial.

7-29. Elevation Quadrant M15

Elevation quadrant M15 (fig 7-21), mounted directly on the right-hand trunnion, is used for adjustment of the weapon in elevation when two men are laying the weapon. Elevation quadrant M15 is equipped with a mechanical mil counter for elevation readings. Correction counters are built in to permit quick, accurate insertion of elevation correction factors peculiar to the individual cannon and cannon emplacement. Quadrant seats are provided on the instrument to allow the use of gunner's quadrant M1A1 when fine elevation settings are required. A mounting bracket for the elevation quadrant is precisely machined and alined so that, when the instrument is installed, complex adjustments are unnecessary and only an accuracy check is required. The controls on the elevation quadrant are identical with corresponding controls on panoramic telescope mount M145.

7-30. Boresighting

a. Purpose. The purpose of boresighting is to insure accuracy in laying for elevation and



1 —Rheostat knobs: Turn to vary amount of light for lamps.
2 —Azimuth deflection knob: Turn to set azimuth reset counter and rotate telescope and to set azimuth counter.
3 —Cross-level knob: Turn to center cross-level vial (8).
4 —Gunner's aid knob: Turn to set gunner's aid counters (5).
5 —Gunner's aid counters: Used to set visual correction factor for individual weapon.
6 —Boresight detent shaft: Used in boresighting.
7 —Pitch-level vial.
8 —Cross level vial.
9 —Elevation handwheel. Turn to set elevation counter (10).
10 —Elevation counter: Shows quadrant.
11 —Correction counter: Registers correction value for individual weapon in mils.
12 —Elevation correction knob: Turn to set correction counter (11).

Figure 7-19. Telescope M117 and mount M145.

13 —Elevation level vial.
14 —Pitch knob: Turn to center pitch-level vial (7).
15 —Quadrant level knob: Turn to center quadrant cross-level vial (16).
16 —Quadrant cross-level vial.
17 —Toggle switch: Push up to turn on lamps.
18 —Reset knob: Push in and turn to reset the azimuth reset counter (19).
19 —Reset counter (3200-mil): Registers azimuth travel in mils.
20 —Azimuth counter (6400-mil): Registers azimuth travel in mils.
21 —Door release: Move to right to open azimuth counter door.
22 —Elevation knob: Turn to adjust reticle up or down 300 mils.
23 —Quadrant seat: Set gunner's quadrant here for fine elevation adjustment.

Figure 7-19. Telescope M117 and mount M145—continued.

direction. Boresighting is the process of alining the on-carriage sighting and fire control equipment so that the lines of sight of the telescopes are parallel to the axis of the bore. Boresighting is conducted before firing and, when necessary, during lulls in firing.

b. Methods of boresighting. In order of preference, the methods of boresighting are:

(1) M140 alignment device (M109A2/A3 only).

(2) Distant aiming point.

(3) Test target.

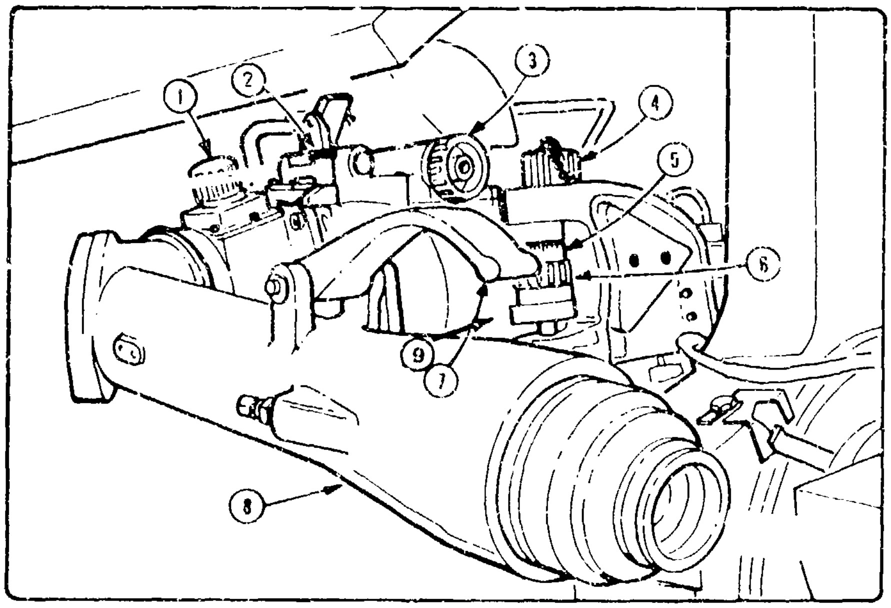
Note. For boresighting with the M140, see TM 9-2350-303-10N, pages 2-132 through 2-136.

c. Preparation for boresighting.

(1) Regardless of the method used, the trunnions should be as level as possible. Test target 0 mil. DAP boresighting trunnions 90 mils.

(2) The breech and muzzle boresights must be in their proper positions.

(3) All instruments and mounts must be positioned securely without free play.



1 —Light control knob
2 —Reticle detent knob
3 —Cant correction knob
4 —Kingpin knob (secures the direct fire scope in place)
5 —Elevation scale
6 —Elevation knob (boresight)
7 —Release lever
8 —Eyepiece arm
9 —Azimuth knob (boresight) not seen

Figure 7-20. Direct fire telescope.

d. Testing target method. To boresight, using the testing target method, follow the steps in (1) through (7) below.

(1) Level the trunnions to zero mils.

(2) Using the gunner's quadrant and adding algebraically any corrections determined by the end-for-end test to the embedded correction and stamped on the howitzer breech ring, set the tube to zero elevation.

(3) Turn all numeral counters and corrector scales to zero on both the panoramic telescope mount M145 and the elevation quadrant M15 and cross-level the bubbles.

(4) The elevation level bubbles in the vials on the elevation quadrant M15 and the telescope mount M145 should now be centered within plus or minus 0.5 mil. If they cannot be centered within this tolerance the mount M145 and/or the elevation quadrant M15 should be referred to authorized maintenance support personnel.

Note. A detailed orientation check of the elevation quadrant M15 can be found in figure 3-10, page 3-41 of TM 9-2350-217-10 if required.

(5) Place the testing target (fig 7-22) 50 to 100 meters in front of the howitzer tube and position the target so that the bore diagram is alined with the boresights.

(6) Place the panoramic telescope in the telescope mount M145 and—

(a) Check the gunner's aid to see that it has been set to zero and adjust the azimuth counter to read 3200.

(b) Check to see that the pitch and cross-level bubbles of the panoramic telescope mount M145 are centered.

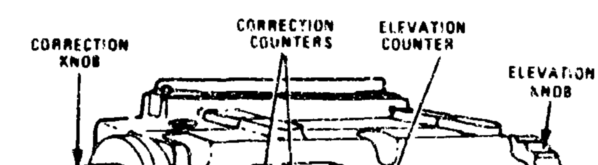


Figure 7-21. M15 elevation quadrant.

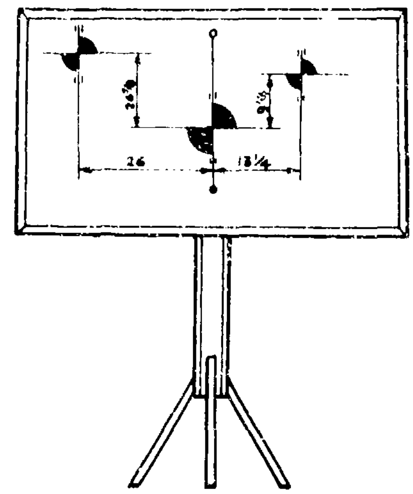


Figure 7-22. Boresight testing target for self-propelled howitzer M109A1/A2/A3.

(c) Take up the correct sight picture by alining the vertical and horizontal lines of the panoramic telescope reticle pattern to the left aiming diagram on the testing target by rotating the azimuth and elevation knobs, respectively.

(d) The azimuth counter should now read 3200. If it does not, fully depress the boresight adjustment shaft with a small screwdriver and rotate it until the azimuth counter reads 3200. The panoramic telescope is now boresighted for direction during indirect and direct fire.

CAUTION: To prevent extensive damage to the panoramic telescope M117, depress the boresight adjustment shaft fully before attempting to rotate it.

(7) To boresight the direct fire telescope—

(a) Center the cant level bubble by turning the cant correction knob.

(b) Rotate the azimuth and elevation boresight knobs on the direct fire telescope mount M146 until the correct sight picture is obtained on the right diagram.

(c) Set the telescope mount slip scales to elevation 4, azimuth 4 without moving the elevating or azimuth boresight knobs. The direct fire telescope is now boresighted for range during direct fire.

e. Distant aiming point method. A distant aiming point may be used for boresighting if a testing target is unavailable or if the tactical situation makes use of a testing target impractical. The aiming point selected should be a sharply defined point at least 1,500 meters from the howitzer and as near to howitzer zero elevation as possible. All steps prescribed for the testing target method (*d* above) apply in the distant aiming point method, except that, in the latter method, the boresights and the optical sights are alined on the same distant aiming point rather than on displaced points. Accurate leveling of the trunnions is not mandatory when a distant aiming point is used for boresighting. The trunnions should be within 90 mils of levels.

7-31. Fire Control Alinement Tests

The procedures for performing fire control alinement tests are contained in Reference Note WCXXFC, *Fire Control Alinement Tests for Self-Propelled 155-mm Howitzer M109A1/A2/A3, Self-Propelled 8-Inch Howitzer M110A2, Towed 105-mm Howitzer M102, and Towed 155-mm Howitzer M114 or M114A1/A2.*

Section VI. PRODUCT IMPROVEMENTS

7-32. The M109A2/M109A3

Improvements of the M109A1 have followed two separate tracks. The end result has been the same, however. The M109A2 originally began as the M109A1B which was manufactured specifically for foreign sales which was nothing more than a new M109A1 with all recent modifications. Afterwards, the decision was made to retain some of the M109A1B models and apply the midlife PIP items with the result being the M109A2. The M109A3 is an application of the same midlife PIP items to the M109A1 which has been in the field for quite some time and recalled for modifications.

a. Ammunition storage. One of the most noticeable changes resulting from PIP application appears in alteration to storage of ammunition. Ammunition capacity has been increased from 28 complete rounds to 36 by the addition of a projectile storage rack (fig 7-23). The rack is installed in the rear opening of the turret. It has been designed with three doors, two large doors which protect the projectiles and a small door which allows servicing of the howitzer with ammunition from the M548. The existing projectile rack inside the howitzer has been removed and replaced with a bracket which allows storage of 13 propellant containers. The rear door on the inside has been modified to allow storage of four metal fuze containers. In the past, servicing of air filters has been a problem due to the right front storage racks. Now, the racks are fitted with quick disconnects which facilitate easy removal of the racks when servicing the air filters.

b. Safety improvements. Crew handholds (fig 7-24) have been provided on the cab roof and side walls to reduce possibility of injury to the crew inside during movement. The handhold over the operating cam serves an additional function in that it provides a point to secure the cam during maintenance. Latches on the cab side doors (fig 7-25) have been improved to prevent accidental closing of the doors due to shock of firing. The equilibrator handpump (fig 7-26) has been moved to a location behind the panoramic telescope. A horizontal push-pull stroke is now possible without injury to crew members. The older stainless steel hydraulic lines running to various systems have been replaced with flexible hoses (fig 7-27) wherever possible. They should reduce the frequency of hydraulic line leaks. To reduce entry of rain water into the howitzer cab via the rotor assembly, a window shade type of cover (fig 7-28) has been installed on the exterior. Initially, however, the weather cover did not prevent entry of water at all angles of elevation which caused further improvement to be necessary.

c. Ballistic cover (fig 7-29). For some time many have believed that we could increase responsiveness if travel from one position to another could be accomplished with the panoramic telescope mounted. A ballistic cover with a plexiglas cover over the front has been installed to allow travel with the pantel mounted. Initially, the interior of the cover was painted the same color as the pantel making sighting of the pantel with aiming circle very difficult. To alleviate this problem the interior of the cover will be painted a different color. White has been considered but it does result in a significant signature which could be a tactical mistake.

d. Power-rammer (fig 7-30). The time delay sequencing of the loader-rammer has been removed and a simple push (ram)-pull (retract) control installed to replace the older system. Ramming is now a positive crewmember action. The chief advantage, however, is that ramming time has been reduced by approximately 50 percent.

e. Travel lock (fig 7-31). The travel lock has been installed with a set of springs at the pivot point to make it easier to raise and lower the travel lock. The springs also prevent the travel lock from falling and injuring the operator during engagement and disengagement.

f. Recoil mechanism (fig 7-32). The counterrecoil buffer has been redesigned to provide a more reliable system that reduces more of the shock of firing. The bleeder "T" on the front of the recoil mechanism is being designed such that tools are no longer necessary for servicing the recoil mechanism.

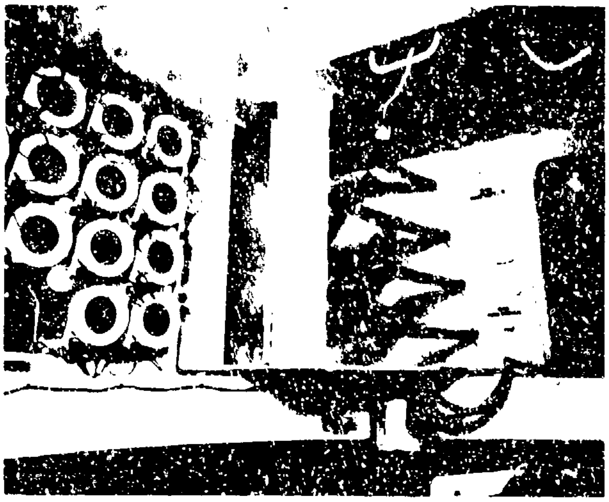


Figure 7-23. Ammunition storage.

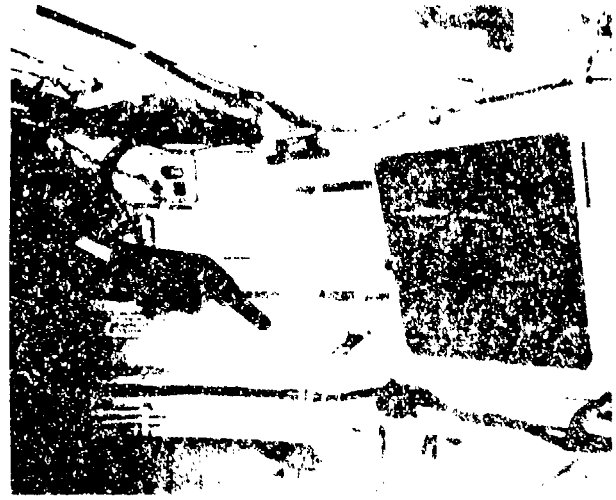


Figure 7-24. Crew handholds

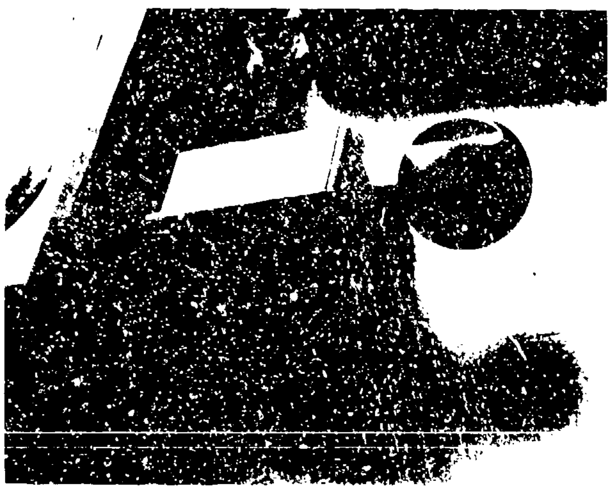


Figure 7-25. Latches—side door.

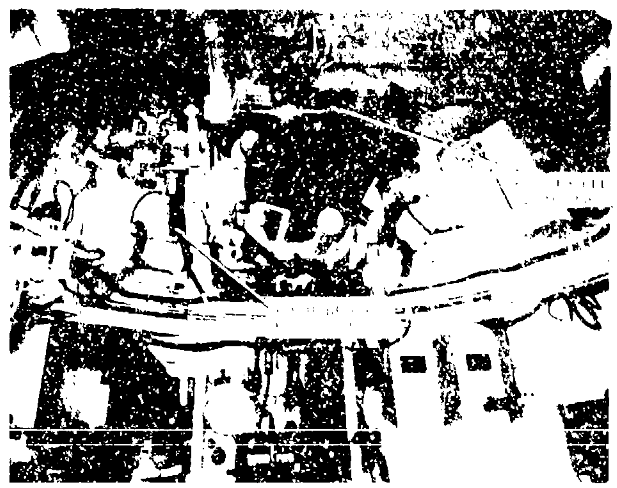


Figure 7-26. Equilibrator hand... up.

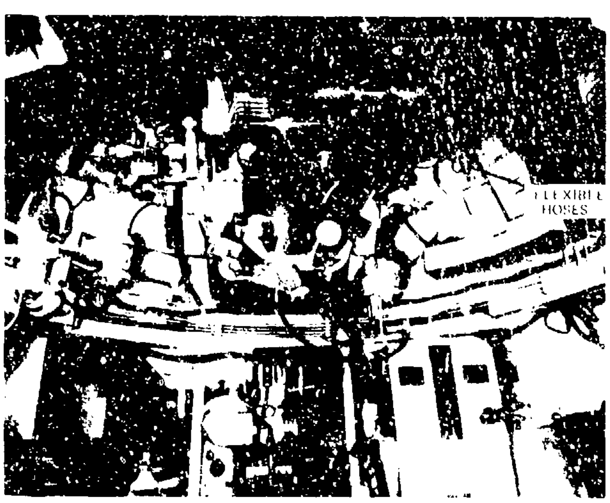


Figure 7-27. Flexible hoses.

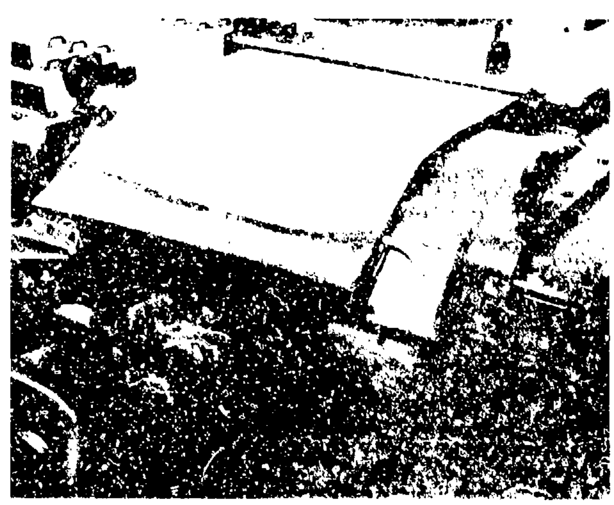


Figure 7-28. Window shade type cover

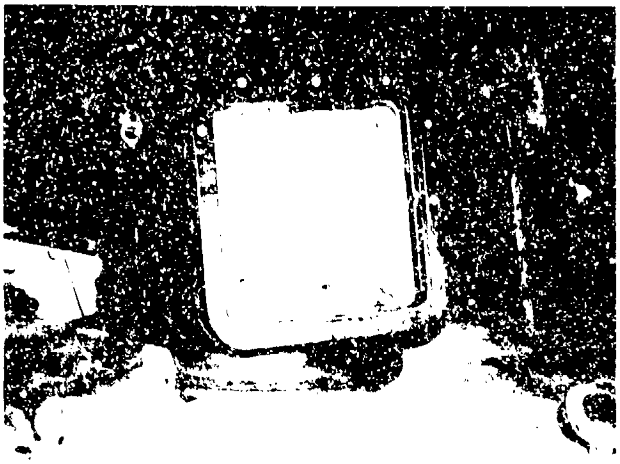


Figure 7-29. Ballistic cover.

Figure 7-30. Power-rammer.

Figure 7-31. Travel lock.

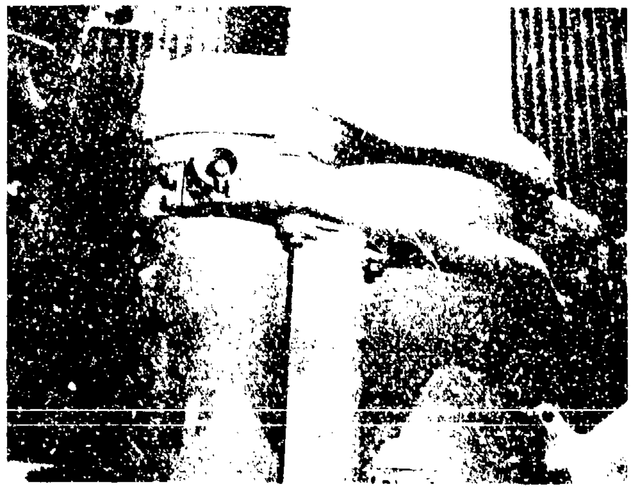


Figure 7-32. Recoil mechanism bleeder "T".

Figure 7-33. Driver's hatch.

Figure 7-34. Driver's instrument panel.

g. Driver's hatch (fig 7-33) and instrument panel. The driver's hatch on the M109/M109A1 provides access only after being opened from the inside. The new hatch allows the operator to open the hatch from the outside. The driver's instrument panel (fig 7-34) has been modified to provide mounting in the crew compartment of the howitzer for easier monitoring during firing. A shutdown alerting device in the form of a color coded temperature gage to indicate to the driver when the engine temperature is low enough to shut the engine down has been added to the instrument panel. Another alerting device to assist in proper maintenance of the engine is the aeration detector. This will provide the operator a positive indication when the coolant level is too low in the radiator.

h. Fuel pump. To increase the automotive life of the weapon, an electric fuel pump has been installed. Loss of injector assemblies and injector pumps has been attributed to air in the fuel filter system. With the new electric pump, however, any air in the fuel lines will be removed prior to the fuel going to the injector pump.

Section VII. SUMMARY

7-33. Review

This chapter was devoted to examining the major components of the M109A1/A2/A3. The characteristics, nomenclature, functioning and maintenance of the components of the weapon were discussed. The product improvements on the M109A2/M109A3 howitzer were depicted so that one can see what the weapon system will look like in the future. For more detailed information, see FM 6-88, TM 9-2350-217-10, TM 9-2350-217-20, and TM 9-2350-303-10N.

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CHAPTER 8

8-INCH HOWITZER, M110A2, SELF-PROPELLED

Section I. GENERAL

8-1. References

FM 6-94; TM 9-2350-304-10; TM 9-2350-304-20; and LO 9-2350-304-12.

8-2. Introduction

a. The 8-inch howitzer M110A2 is a highly mobile combat support weapon. A unique feature of these weapons is that they can be mounted interchangeably on a single vehicle. The interchange can be accomplished by support maintenance personnel in less than 2 hours. This greatly increases the versatility of general support artillery and permits a corresponding decrease in logistical support. A hydraulic suspension lockout system effectively harnesses the shock of firing and transmits the shock directly to the ground through the locked suspension system, thus making the vehicle an extremely stable firing platform.

b. The M110A2 is capable of attaining high speeds on average roads and of negotiating rough terrain, snow, and mud. A-vehicles add strategic mobility to general support artillery. The cruising range for the M110A2 is 325 miles.

c. The 8-inch howitzer (fig 8-1) mounted on the M110A2 retains the characteristics, accuracy, and reliability associated with early models of the 8-inch howitzer.

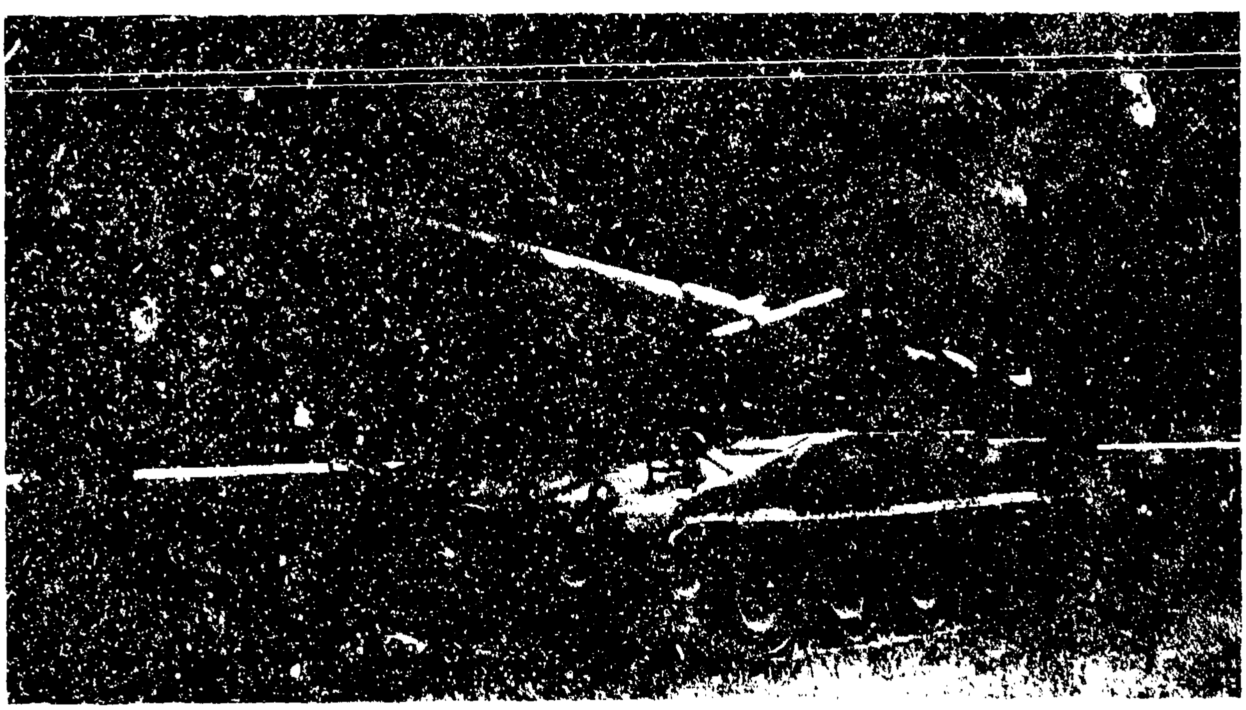


Figure 8-1. 8-inch self-propelled howitzer M110A2.

*Supersedes HB-8 WCXXWS, Dec 81.

Section II. CARRIAGE

8-3. Turret

The turret is mounted on a turret bearing assembly (base ring and race) in the rear center section of the vehicle hull. The basic structure consists of two trunnions that support the weapons mount and a circular base that is geared to the turret bearing through a traversing drive. The turret base and trunnions mount the weapon elevating and traversing mechanisms, the loader and rammer assembly, the gunner's seats, and the equipment stowage racks. The turret traversing and weapon elevating mechanisms are equipped for either power or manual operation.

Note. The hydraulic system and other components described in this chapter will be lubricated in accordance with LO 9-2350-304-12. Unit-level maintenance of the turret hydraulic and electrical systems is limited to cleaning, replenishment of oil in the hydraulic reservoir, replacement of filters in the hydraulic system, and adjustment or replacement of electrical switches.

8-4. Recoil Spade and Lockout System

a. Before the weapon is fired, the spade located at the rear of the vehicle (fig 8-2) must be lowered and must be emplaced firmly in the ground to minimize the rearward movement of the vehicle when the weapon is fired. If the spade is not properly emplaced and appreciable movement occurs when the weapon is fired, the spade and suspension systems could be damaged. The following procedures should be used to emplace the spade and to prevent damage to the weapon:

(1) Start the engine. Check the suspension lockout valve control handle (10, fig 8-3) to insure that the suspension system is in the UNLOCKED position.

CAUTION: Do not move the vehicle with the suspension system locked. Damage could result.

(2) Turn on the hydraulic pump power takeoff (PTO) clutch switch.

CAUTION: Insure that the hydraulic pump is turned on only when the engine is operating at idle speed (550-650 rpm). When the pump is in operation, the engine speed should not exceed 1,200 rpm except when the spade is being emplaced or raised.

Note. Raise the spade with the control handle to relieve pressure on the locks.

(3) Place the two spade cylinder locks (fig 8-4) in the UNLOCK position.

(4) Place the spade control lever (fig 8-5) in the LOWER position and increase the engine speed to lower the spade to the ground.

(5) Insure that the weapon tube is in the traveling position when the spade is being emplaced.

WARNING: Insure that the cradle is secured by the travel lock (fig 8-6) before attempting to move the vehicle

(6) Slowly move the vehicle backward until the spade is emplaced firmly in the ground. Insure that the spade does not jack up the rear of the vehicle. Also insure that all road wheels conform to the contour of the ground under the tracks.

CAUTION: Do not fire the weapon if the rear of the vehicle is jacked up by the spade or if all the road wheels are not on the ground. Damage to the spade and suspension systems could result.

(7) After the spade has been emplaced (fig 8-2), return the spade control lever to the neutral position, place the transmission shift lever in (N) neutral, and lock the vehicle brakes.

(8) Lock out the suspension system by placing the lockout valve control handle in the LOCKED position.

b. The following procedures should be used to raise the spade:

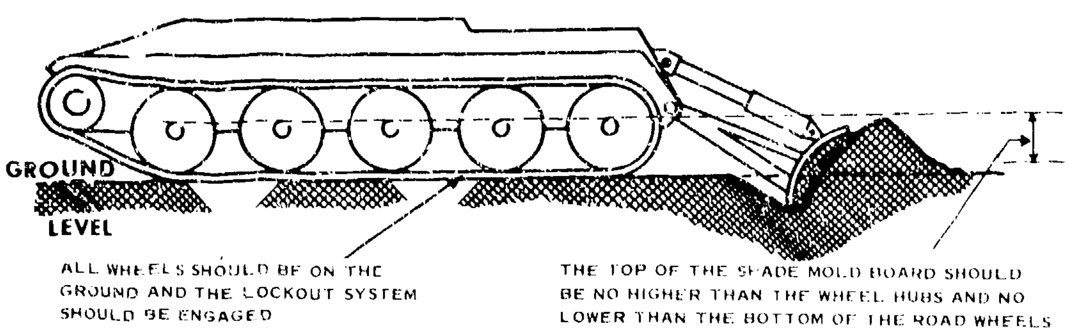
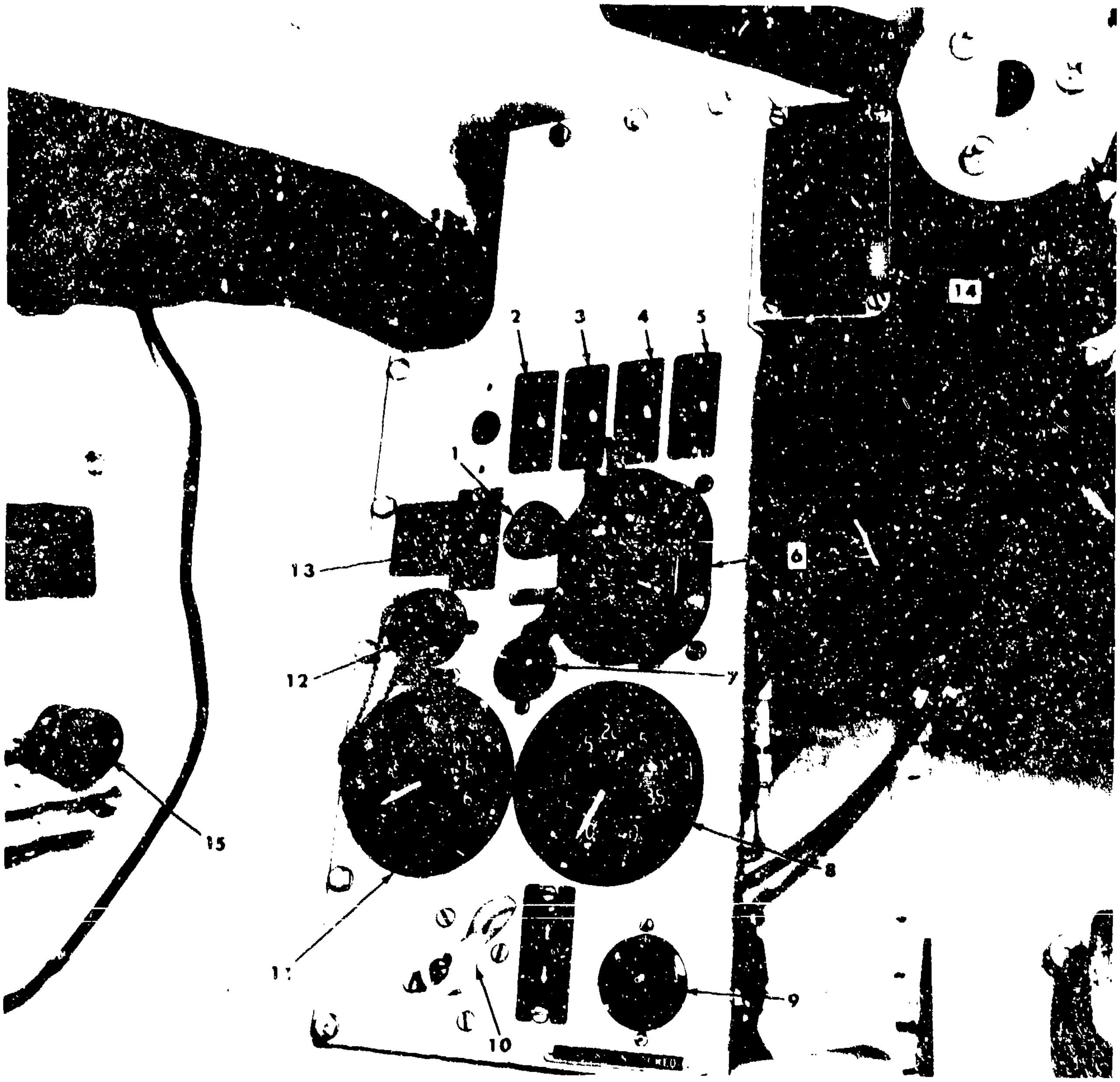


Figure 8-2. Recoil spade emplacement.



1—Starter switch
2—Infrared receiver switch
3—Infrared blackout (IR-BO) switch
4—Instrument panel switch
5—Vehicle master switch
6—Vehicle lights switch
7—Instrument panel light
8—Tachometer
9—Suspension-locked indicator light
10—Suspension lockout valve control handle
11—Speedometer
12—Utility outlet
13—Hydraulic pump power takeoff clutch switch
14—Engine air box heater switch panel
15—Driver's compartment light switch

Figure 8-3. Operator's compartment instrument and switch panel.

(1) Start the engine and turn on the hydraulic pump power takeoff switch (fig 8-3).

(2) Rotate the spade control lever to the RAISE position so that the hydraulic cylinders will lift the spade.

(3) When the spade is in the raised position, lock the recoil spade cylinder locks.

(4) Rotate the spade control lever to the neutral position.

c. Even though the spade is properly emplaced, the vehicle and spade have a tendency to creep rearward and to jack up the vehicle with successive firings. When this occurs, the spade must be reemplaced in accordance with the procedures in *a*(1) through (8) above.

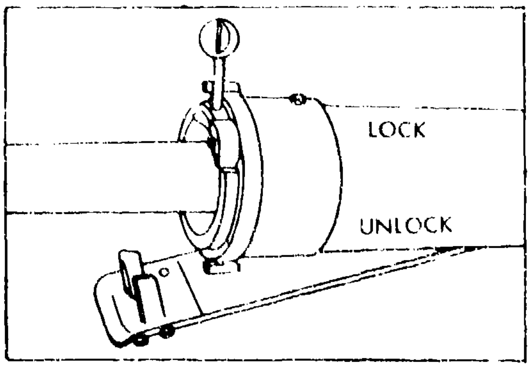


Figure 8-4. Recoil spade cylinder lock (shown locked).

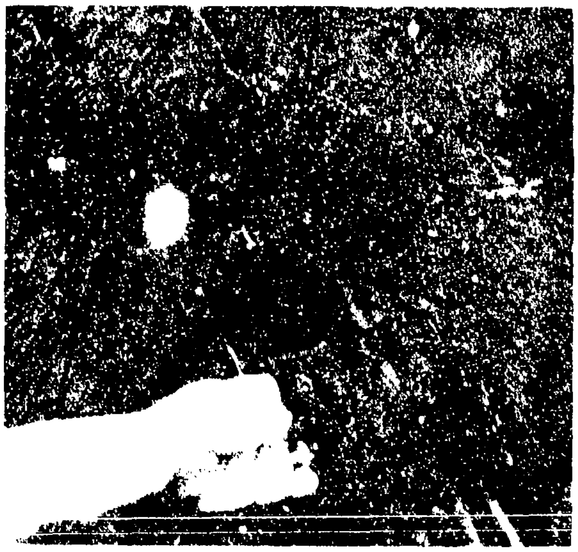


Figure 8-5. Recoil spade control.

d. The lockout system consists of lockout cylinders (adjustable shock absorbers), located on each side of the vehicle. The lockout system stabilizes the road wheels during firing. Lockout is accomplished by turning a control valve on the switch panel in the driver's compartment. Turning this control valve directs oil pressure to the lockout cylinders. It also causes a hydraulic pressure switch to turn on the lockout indicator lights, one of which is located on the switch panel in the driver's compartment and the other on the left trunnion wall.

Note. The lockout system should be exercised at least once each week.

8-5. Cradle, Travel Lock, and Retracting Control Valve Handle

a. Cradle. The cradle is mounted on the trunnion bearings of the top carriage. It houses the recoil, counterrecoil, and recuperator cylinders; and attached to the cradle is the replenisher cylinder. The trunnions form the fulcrum for the movement of the weapon in elevation. One end of each of the two equilibrators is secured to the cradle. The other end of each equilibrator is attached to the trunnion cap on the top carriage. A travel lock connection at the front end secures the cradle to the hull in the traveling position. The replenisher and the variable recoil cam assembly are attached to the cradle—the replenisher on the right and the variable recoil cam assembly on the left.

(1) *Purpose.* The travel lock is used to support the overhanging weight of the barrel and recoil mechanism in the traveling position, thus removing the strain from the elevating mechanism, which would otherwise be subjected to excessive wear.

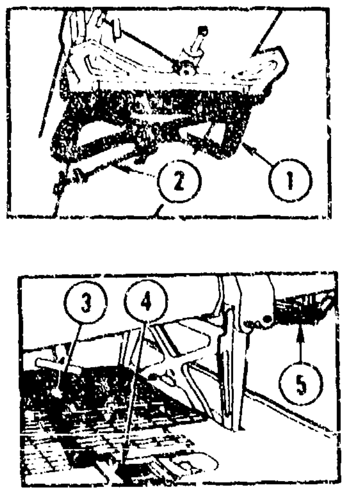


Figure 8-6. Travel lock and placing it in the traveling position.

(2) *New travel lock.* The 110A2 travel lock is newly constructed. The new travel lock is located near the front of the cradle on the under side (fig 8-6) and it consists of the long support which is used for travel. The short support is for shipping only. A lift latch is used to allow the control handle to be pushed either forward or to the rear so that the support will mate with the hull recess.

(2) *Placing the travel lock in the stowed position.*

(a) Release the travel lock control handle (fig 8-6) by lifting latch and pushing forward.

(b) Manually elevate the tube and guide the travel lock support out of the recesses.

(c) Lift the travel lock upward until it engages the catch on the lower surface of the cradle. The travel lock is now in the stowed, or firing, position.

(3) *Placing the travel lock in the traveling position.*

(a) Push support stow catch handle inward allowing long support to drop down into a vertical position.

(b) Use manual elevating handcrank and depress gun mount, meanwhile guiding support into mating hull recess.

(c) Lift latch and pull travel lock control handle to secure support to hull. Secure handle in locked position with latch.

Note. There is no adjustment of the new travel lock.

b. Retracting control valve handle. The heavy cannon tube is moved hydraulically in and out of battery by means of the retracting control valve handle (fig 8-7) located on the right rear of the cradle. The cannon tube should never be moved out of or into battery position by means of this retracting control valve handle unless the cradle is secured to the deck of the weapon by the travel lock (fig 8-6). Additional information on this handle and how it is used with the recoil mechanism is given in paragraph 8-9e.

WARNING: The travel lock must be in the traveling position (secured to the hull) whenever the retracting control valve handle is used to move the tube into or out of battery, whenever the self-propelled weapon is to be moved, or whenever a crew member is required to descend into the turret well. Otherwise, serious injury to personnel or damage to materiel may occur when the tube is being moved out of battery or when the self-propelled weapon is moved and the tube automatically elevates because of the sudden change of the tube pivot point.

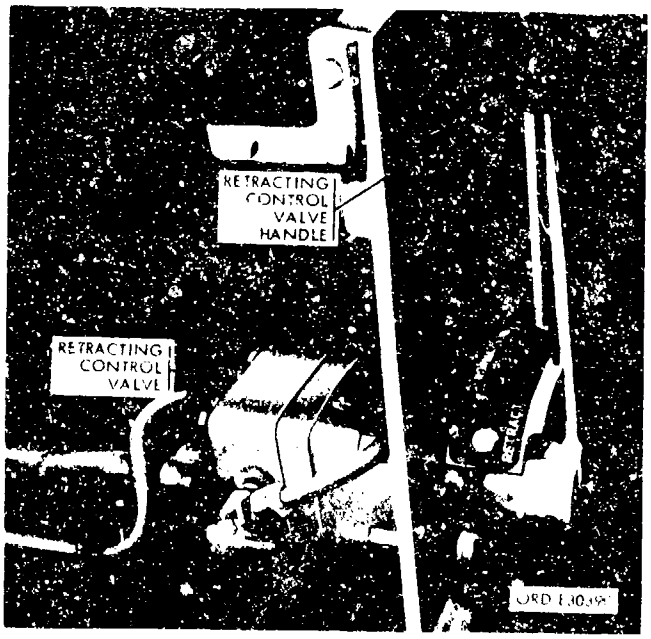


Figure 8-7. Retracting control valve handle.

8-6. Electrical and Hydraulic Systems

a. Electrical system. The vehicle is equipped with a 24-volt electrical system consisting of four 12-volt storage batteries; a 300-amp generator; a voltage regulator; a master relay; and miscellaneous relays, circuit breakers, switches, indicators, gages, sending units, and connecting wires and cables. An auxiliary power receptacle located in the fender on the left side of the hull provides a means of supplying electric power to or receiving electric power from another vehicle if required.

Note. When using external power (slaving) to start a vehicle, keep the master switch of the vehicle requiring external power in the OFF position until after the engine has started. This prevents damage to the voltage regulator and rectifier of the slave vehicle.

b. Hydraulic system. The hydraulic system supplies hydraulic power to operate various vehicle components (fig 8-8). Hydraulic oil pressure is provided by an electric motor-driven hydraulic pump, an engine-driven pump, or a hand-operated pump. The oil pressure is stabilized by an accumulator and is directed through lines and control valves to the suspension lockout cylinders, spade cylinders, turret traversing system, cannon elevating system, loader and rammer mechanism, and recoil mechanism. A 27-gallon tank housed in the right trunnion wall provides a reservoir for the system oil supply.

(1) *Electric-motor-driven hydraulic pump.* The electric-motor-driven hydraulic pump is mounted on the right side of the deck of the turret, over the hydraulic fluid reservoir. It includes a rotary pump, a direct current motor, and an adapter. The motor receives power from the four 12-volt storage batteries (hooked up in series parallel as the vehicle electrical supply system) and drives the pump. The pump, commonly referred to as the main pump, extends into the reservoir and is the primary source of providing the hydraulic pressure. The pump forces oil from the reservoir into the accumulator against the floating piston and causes the floating piston to move against the nitrogen gas pressure in the accumulator, thereby providing a source of stored energy within the limits of the pressure switches in the system. The switch for this pump is on the left trunnion wall.

(2) *Engine-driven pump.* The engine-driven pump, commonly referred to as the power takeoff (PTO) pump, is mounted at the front of the turret well. It is driven by the vehicle engine through the

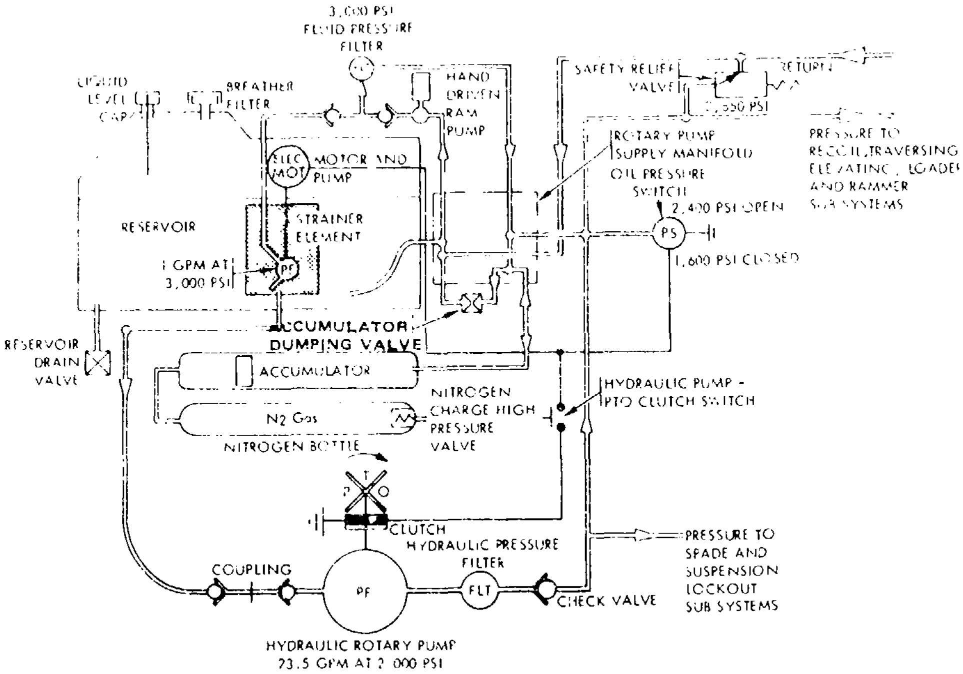


Figure 8-8. Hydraulic pressure system.

auxiliary drive. It is the secondary source of providing hydraulic pressure. The control switch for this pump is located on the instrument panel (13, fig 8-3).

(3) *Hand-operated pump.* The hydraulic hand-operated pump is located on a bracket at the right side of the turret. Manual operation of this pump will pump oil from the reservoir into the accumulator, thereby supplying pressurized fluid to the hydraulic system.

c. *Hydraulic fluid check.* The hydraulic system must be checked to insure that sufficient hydraulic fluid and the correct quantity of nitrogen gas are present in the system for operation. The hydraulic fluid is checked daily and before operation by the cannon crew. The nitrogen gas, the pressure limiting switch, and the high-pressure relief valve are checked during periodic maintenance service by organizational maintenance personnel. Normally, the *cannon crew* will make the inspections and checks in (1) and the *organizational maintenance personnel* will make the inspections and checks in (2).

(1) *Hydraulic fluid check.*

(a) Place the recoil spade in the raised-and-locked position, the tube in-battery and in travel lock, the loader-rammer in travel position and all switches off.

(b) Open the accumulator dumping valve slowly to allow the hydraulic fluid to flow back into the reservoir. The nitrogen gas will force the floating piston to the end of the accumulator; and when the piston bumps the end of the accumulator all of the hydraulic fluid will have been returned to the reservoir.

(c) Close the accumulator dumping valve when all of the hydraulic fluid has returned to the reservoir.

(d) Check the level of the hydraulic fluid in the reservoir. If the level of the fluid is below the ADD mark on the dipstick, add sufficient fluid to bring the level up to the FULL mark. If the level of the fluid is above the FULL mark, drain the excess fluid until the level drops to the FULL mark. If the fluid level is between the ADD and FULL mark, the system is operational.

(e) If the checks described in (2) below are to be performed by organizational maintenance personnel at this time, leave the master switch and the main oil pump switch off. If the checks are not to be performed at this time, turn on the master switch and the main oil pump switch to recharge the system.

Note. If batteries are weak, start the engine and place PTO pump switch to "ON" to recharge the system.

(2) *Pressure limiting switch, high-pressure relief valve, and nitrogen gas (zero) pressure) checks.* After the fluid checks in (1) above have been performed and while the system depressurizes, actuate the rammer controls to release residual pressure that may be in the system. Then proceed as follows:

(a) Remove the plug from the test station on the loader and rammer control valve and install the pressure gage.

(b) Repressurize the system by turning the master switch and electric-motor-driven hydraulic pump switch on and observe the pressure reading at which the electric-motor-driven hydraulic pump shuts off. The pump should shut off at 2,400 psi.

(c) Depress the override switch to reengage the electric-motor-driven hydraulic pump and observe the gage to determine the pressure at which the high-pressure relief valve opens. The valve should open at 2,850 psi, -50 psi.

(d) Operate the system and note the pressure at which the electric-motor-driven hydraulic pump automatically turns on. The pump should turn on at 1,600 psi.

(e) Turn off the master switch, open the accumulator dumping valve, and observe the pressure at which the pressure gage needle suddenly drops to zero. The needle should drop to zero when the gage reads between 1,100 and 1,330 psi.

(f) If the needle drops to zero when the gage reads between 1,100 and 1,330 psi, remove the pressure gage, replace the plug, and turn on the master switch and the electric-motor-driven hydraulic pump switch for normal operation.

Section III. RECOIL

8-7. Recoil Mechanism

The recoil mechanism employed on the 8-inch howitzer, self-propelled, is of the hydropneumatic, variable, independent type. An explanation of the nomenclature follows:

a. Hydro. Hydro means that a liquid is used, and this liquid is recoil oil. The recoil oil used in the recoil mechanism is one of three petroleum-based hydraulic fluids now in the supply system. The hydraulic fluids are commonly known as recoil oil OHT, OHA, or OHC. Because OHT provides more protection against corrosion, it is the preferred oil. The mixing of these oils is not recommended because this would tend to dilute the additives of one oil not contained in the other. A recoil mechanism containing a mixture of these oils should be drained and refilled with the preferred OHT as soon as it becomes available. All three oils are red in color and have an operational temperature range from -65° to 150° F.

b. Pneumatic. Pneumatic means that a gas is used. The gas is nitrogen, which is a relatively inactive gas that will not corrode metal.

c. Variable. Variable means that there is a mechanical way of varying the length of recoil. This prevents the breech mechanism from striking the turret deck when the weapon is fired at high angles of elevation. Under normal operating conditions, the maximum length of recoil can vary from 32 inches to 70½ inches.

d. Independent. Independent means that there is no liquid passage between the recoil cylinder and the counterrecoil or recuperator cylinders during normal recoil operation.

8-8. Purpose of the Recoil Mechanism

The purpose of the recoil mechanism is—

a. To stop the recoiling parts. The recoil portion of the recoil mechanism must absorb and control the rearward thrust of the weapon when fired without displacement of the carriage or excessive shock when the weapon is fired.

b. To return the recoiling parts. The recoil mechanism causes the recoiling parts to return to the in-battery position.

c. To prevent shock. The tube must be stopped in recoil and the recoiling parts must be returned to the in-battery position without excessive shock.

d. To hold the recoiling parts. The tube and other recoiling parts must be held in the in-battery position at all angles of elevation.

8-9. Components of the Recoil Mechanism

The recoil mechanism (fig 8-9) is mounted in the cradle. It is composed essentially of a recoil cylinder, a counterrecoil cylinder, a recuperator cylinder, a replenisher cylinder, a retracting control valve, a relief valve, and interconnecting tubing. The hydraulic oil for the *recoil mechanism is supplied by the vehicle hydraulic system.*

a. Recoil cylinder. The recoil cylinder is the large cylinder located beneath the tube. It houses the recoil pistonhead, which contains two ports, or openings, to permit the free passage of recoil oil. The recoil piston is mounted on the recoil piston rod, which extends through the recoil cylinder and is connected to the lower lug on the breech ring. When the weapon is fired, the piston and piston rod travel rearward with the tube during recoil. The piston and piston rod are drilled concentrically to provide a bore in which the recoil throttling rod functions during the recoil movement.

(1) A rotatable throttling rod is located within the piston rod and is attached to the packing head at the front end of the recoil cylinder. The throttling rod has two long and two short grooves of varying depth cut lengthwise in its surface. Recoil oil must flow through the grooves in the throttling rod in order to pass from one side of the recoil piston to the other. At least two of the four grooves must be alined with the two ports in the recoil piston in order to permit the flow of oil.

(2) A buffer rod and a buffer chamber are located within the recoil cylinder. The rear end of the throttling rod is smaller in diameter than the remainder of the rod and is provided with a throttling groove to form a spearhead buffer. The bore of the recoil piston rod is also smaller in diameter at the rear and forms a buffer chamber. Near the end of the counterrecoil movement, the spearhead buffer enters the chamber at the end of the recoil piston rod. The oil trapped in the buffer chamber escapes through the throttling groove and in doing so cushions the final movement of the tube as it returns to the in-battery position.

b. Replenisher. The replenisher is a small cylinder located on the right front side of the cradle. It is connected to the recoil cylinder by a metal tube. The replenisher contains the oil reserve for the recoil cylinder. The oil reserve and the oil in the recoil cylinder are held under constant pressure by an oiltight, spring-loaded piston. The purpose of the replenisher is to maintain the proper amount of recoil oil in the recoil cylinder at all times. It compensates for the contraction and expansion of oil due to temperature changes and changes in cylinder volume during recoil and counterrecoil. The operating position of the piston is automatically controlled by the use of a pressure relief valve.

c. Counterrecoil cylinder. The counterrecoil cylinder is the smallest of the three long cylinders. It contains a piston rod, a piston head, and recoil oil. The counterrecoil piston rod is connected to the lug on the breech ring and travels rearward with the tube during recoil. The pistonhead is fitted with an oiltight packing arrangement. When the pistonhead is drawn rearward, it forces the recoil oil in the counterrecoil cylinder toward the rear, through an oil passage in the counterrecoil and

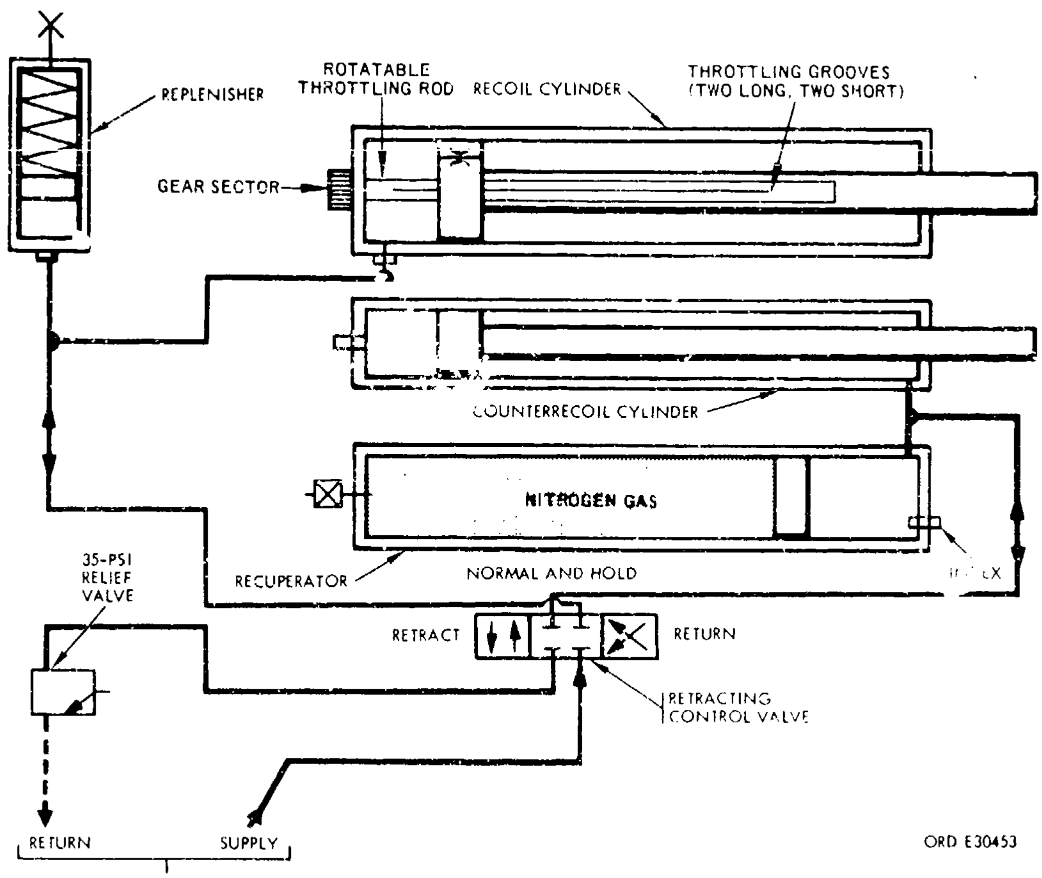


Figure 8-9. Components of the recoil mechanism.

recuperator cylinder head box, and into the recuperator. The counterrecoil respirator in the front end of the counterrecoil cylinder is equipped with a spring-loaded ball check valve. Its purpose is to release air and any oil which may have seeped past the pistonhead from in front of the counterrecoil pistonhead when the pistonhead is moved forward during counterrecoil.

d. Recuperator cylinder. The recuperator cylinder contains recoil oil, nitrogen gas, a floating piston, and the counterrecoil regulator assembly. The floating piston provides a movable oiltight and gastight seal. The piston moves forward during recoil and rearward during counterrecoil. The counterrecoil regulator valve assembly is housed in the rear end of the recuperator cylinder. The valve assembly permits a free flow of oil from the counterrecoil cylinder during recoil but regulates the flow of oil back into the counterrecoil cylinder during counterrecoil. A recuperator oil index is located at the rear end of the recuperator cylinder. This oil index indicates the presence of an oil reserve, which is necessary for the proper functioning of the recoil mechanism. When no oil reserve is present, the rear end of the floating piston presses on an oil index actuating rod, which actuates a gear, and the gear in turn moves the oil index. This action withdraws the rear end of the oil index into the outside face of the recuperator cylinder head. *The weapon should not be fired or elevated when the oil index has been withdrawn into the recuperator cylinder head, since no reserve is present.*

e. Retracting control valve. A three-position (RETRACT, NORMAL AND HOLD, and RETURN) detent valve (fig 8-7), located at the right rear of the cradle, actuates the recoil cylinder to retract the weapon tube into travel position and to connect the replenisher cylinder to the recoil cylinder during firing. Placing the retracting control valve handle in the RETRACT position actuates the recoil cylinder to retract the cannon tube into the travel position. Placing the retracting control valve handle in the RETURN position returns the cannon tube to battery and charges the recuperator cylinder. Placing the retracting control valve handle in the NORMAL AND HOLD position holds the cannon tube in the traveling or firing position.

WARNING: The retracting control valve handle should not be operated unless the travel lock is engaged in the traveling position (fig 8-7).

8-10. Recoil Cycle

a. Recoil cylinder. When the weapon is fired, the tube recoils on the recoil slides attached to the cradle. Since the recoil piston rod is connected to a lug on the bottom of the breech ring, it is drawn to the rear with the tube. As the recoil piston is drawn to the rear, the oil in its path is forced through two ports in the recoil piston and through the throttling grooves to the forward side of the piston. As the oil passes through the tapered throttling grooves, the flow of oil is gradually reduced and finally stopped. This throttling action absorbs the greatest portion of the recoil energy.

b. Counterrecoil and recuperator cylinders. When the weapon is fired, the counterrecoil piston, being connected to the breech ring, moves rearward with the tube. The oil in the counterrecoil cylinder is forced through an oil passage and into the recuperator regulator valve assembly by the counterrecoil pistonhead. The flow of oil under pressure opens a spring-loaded valve in the regulator valve assembly, permitting a free flow of oil against the floating piston. The floating piston, by moving forward, compresses the nitrogen gas. Thus, the throttling of oil in the recoil cylinder, the greatest compression of the nitrogen gas in the recuperator cylinder, and the friction of moving parts stop the tube in recoil.

8-11. Counterrecoil Cycle

a. Counterrecoil and recuperator cylinders.

(1) When the tube has fully recoiled and the force of recoil has been overcome, the flow of recoil oil is stopped and the spring-loaded regulator valve in the regulator assembly closes itself. The head of the regulator valve has two small openings, which are about 1/16 inch in diameter and permit a controlled flow of recoil oil back through the regulator assembly and into the counterrecoil cylinder.

(2) Since the floating piston is free to move, the energy stored in the compressed nitrogen gas reacts to displace the floating piston to its normal in-battery position. As the floating piston moves toward its in-battery position, it displaces the oil from the recuperator cylinder through two small openings in the regulator valve into the counterrecoil cylinder. The oil exerts pressure on the rear of the counterrecoil pistonhead, moving the counterrecoil piston to the forward position and thereby pulling the tube to the in-battery position.

b. Recoil cylinder. As the counterrecoil piston rod pulls the tube into battery, the recoil oil in front of the recoil piston flows through two ports in the piston and the exposed throttling grooves in the recoil throttling rod. Little throttling action is performed at this time in the recoil cylinder as compared to that performed in the recuperator cylinder; however, as the tube nears the in-battery position, it is slowed down and eased into battery by the spearhead buffer. The oil trapped in the buffer chamber must escape through the centrally-bored rotatable throttling rod. Thus, the final movement of the tube is cushioned as it returns to battery.

8-12. Variable Recoil Cam Assembly

a. The variable recoil cam assembly governs the rotation of the throttling rod in the recoil piston rod. An arc gear sector mounted on the forward end of the throttling rod is meshed with a similar gear sector mounted on the end of the variable recoil cam assembly. The tubular cam is machined with a spiral, or S-shaped, slot. A cam pin mounted on the camshaft rides in the spiral slot. The shaft is connected to the top carriage by the variable recoil connecting rod. As the tube is elevated or depressed, the connecting rod moves the shaft either forward or rearward, and, as it reaches certain positions, it causes the cam pin on the shaft to turn the cam and its gear sector, which in turn rotates the gear sector on the rotatable throttling rod located in the recoil cylinder, thereby determining the length of recoil.

b. As the tube is moved in elevation, the connecting rod of the variable assembly pulls the camshaft to the rear. This, in turn, pulls the cam pin straight to the rear in the groove of the cam. For the first 178 mils (approximately) of elevation, the cam pin does not rotate the cam, thereby allowing the weapon to recoil to the maximum length of 70½ inches. At elevation of 178 mils to 480 mils (approximately), the cam pin rides in the curved portion of the spiral slot and rotates the cam. This rotation, in turn, rotates the throttling rod within the recoil piston rod, and the two long grooves are moved partially out of line with the ports in the piston. This motion decreases the length of the oil passages and, hence, shortens the length of recoil to less than 70½ inches. At elevations above 480 mils, the two long grooves are completely out of line with the ports in the piston; therefore, at elevations between 480 mils and 1,156 mils, the maximum length of recoil can be only 32 inches because a greater throttling action is caused in the shorter grooves. As the tube is depressed, the opposite action occurs and the length of recoil is increased up to a maximum of 70½ inches at 178 mils or lower elevation.

Note. A recoil indicator attached to the right side of the cradle indicates the length of recoil.

8-13. Maintenance of the Recoil Mechanism

a. General.

(1) Examine the recoil mechanism for general condition and for loose or damaged parts. Examine the condition of the rail wipers; they must be in good condition to prevent dust or sand from entering the slides of the recoil mechanism. Notify organizational maintenance personnel if replacement is required. Check for dirt or rust on the slides. Remove rust; clean and lubricate surfaces.

(2) Check whether the recoil and counterrecoil piston rod nuts are in position and held with cotter pins. Tighten the nuts, if necessary, and replace the cotter pins.

(3) Exercise the weapon by placing the retracting control valve in RETRACT until the weapon moves out of battery approximately 54 inches. Place the retracting control valve in RETURN and recharge the recuperator cylinder as described in *b* below.

(4) When the weapon is fired, see that the air check valve in the counterrecoil front head is functioning properly and allowing the air trapped in the cylinder to escape. If the air check valve is not functioning properly, notify organizational maintenance personnel.

b. Recuperator oil index. The recuperator oil index, located under the cannon at the rear of the recuperator cylinder (fig 8-10) indicates the oil reserve in the recuperator. If the oil index protrudes beyond the face of the recuperator, it is good. The procedure for reestablishing the oil reserve for howitzer M110A2 is as follows:

(1) Place the tube in the in-battery position.

(2) Place the PTO clutch switch in the ON position with the engine running. Activate OVERRIDE position on the main oil pump switch to build-up the system to maximum pressure (2,800 psi).

(3) Place the retracting control valve handle in RETRACT position until the index pin on the recuperator moves *in*, then place the retracting control handle in the NORMAL AND HOLD position. (Omit this step when the pin is *in*.)

(4) Remove the plug from the replenisher and insert a clean improvised rod through the opening in the replenisher and against the piston. Note the depth of the piston.

(5) Assistant gunner will hold retracting control valve handle in return. After index pin has moved out, continue to hold handle in return for 3 seconds. If index pin does not come out, see note.

Note. If pin fails to move out, activate the override switch and repeat.

(6) Return the retracting control valve handle to NORMAL AND HOLD position.

(7) Release the oil pump motor switch from the OVERRIDE position.

(8) If the index pin does not move, notify organizational maintenance personnel.

(9) Check the piston movement in the replenisher by noticing the position of the improvised rod. If the rod has moved during step (5), the replenisher is operating normally.

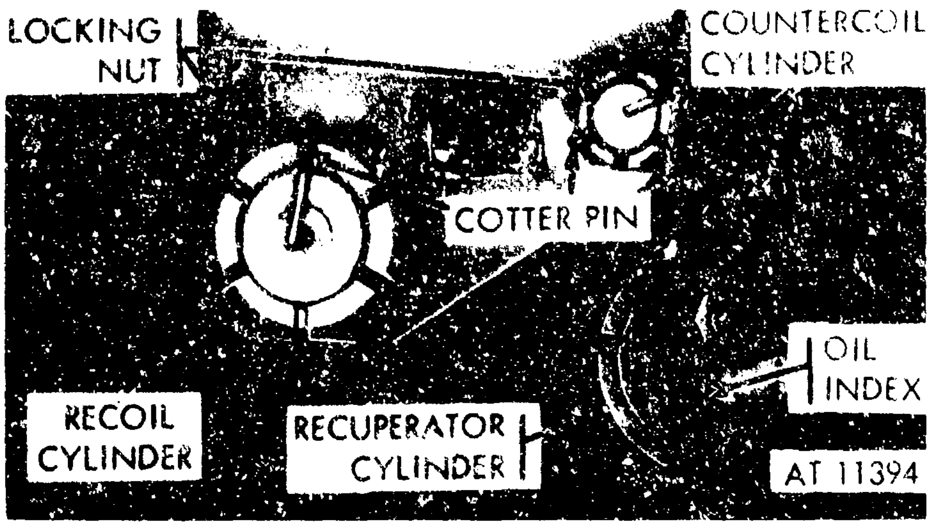


Figure 8-10. Recuperator oil index.

(10) Remove the rod and replace the plug in the replenisher.

CAUTION: Under no circumstances shall the index pin be tapped to insure that the index is operating freely. If the index pin fails to project beyond the face at the housing after following the above procedures, notify support maintenance personnel. If there is excessive leakage, notify organizational maintenance personnel. This procedure applies to the M110A2 (fig 8-10).

8-14. Equilibrators

a. Purpose. The purpose of the equilibrators is to compensate for the rear-mounted trunnions by making the tube as easy to elevate as it is to depress.

b. Type. The equilibrators are of the pneumatic lifter type.

c. Construction. One equilibrator is located on each side of the tube; each consists of two telescoping cylinders. The front end of each equilibrator is connected to the upper front part of the cradle; the rear end is connected to the adjusting screw mounted in the trunnion cap. Each equilibrator consists of a filling valve, a plunger and plunger head assembly, a case with two gland assemblies, and a plunger cover.

d. Functioning.

(1) The equilibrators are designed so that compressed gas works against the plunger head and the case gland. This gas pressure sets up tension which causes the opposite ends of the cylinders to be drawn together.

(2) The action of the equilibrators compensates for the muzzle preponderance by means of leverage applied from the trunnion caps to the cradle.

(3) Elevation of the tube causes the plunger and the case to telescope. This lengthens the interior pressure area and thereby reduces the pressure, since the maximum lift is required only at the lower angles of elevation.

(4) The equilibrators are interchangeable if modified by an index line cut on both sides of the case head. If they are not modified, a plate must be fastened to the equilibrator to indicate which is the left and which is the right.

Note. Temperature adjustment scales (0° to 110°) are located on both trunnion bearing caps (fig 8-12). The scales indicate the approximate position of the equilibrators for the prevailing temperature. The temperature adjustment scale can be read accurately only when the tube is on the depression stops.

e. Equilibrator adjustment procedure.

(1) Inspect the temperature scales to insure that both sides are reading the same.

(2) Using manual controls, unlock the travel lock.

(3) Elevate the tube to 560 mils.

(4) Elevate and depress the tube manually to see if it's as easy to elevate as it is to depress.

(5) If an adjustment is required, lower the tube to the depression stops.

(6) Turn the adjusting screw clockwise to make the tube easier to elevate and counterclockwise to make it easier to depress.

(7) *Adjust both equilibrators equally* in ¼-turn increments; then repeat steps (3) and (4) to insure the adjustment is correct.

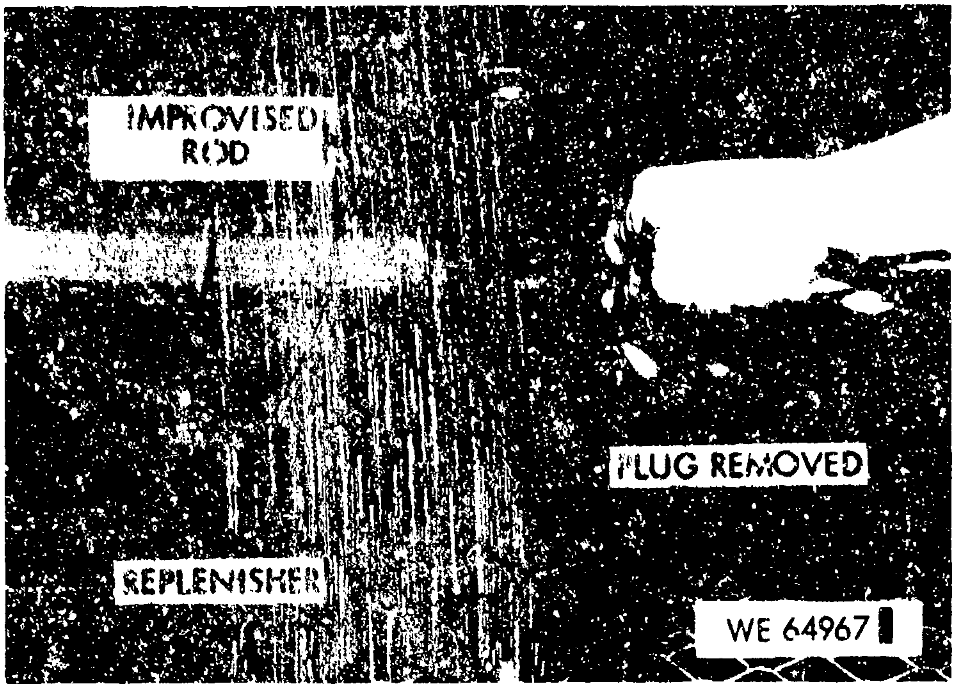


Figure 8-11. Checking replenisher.

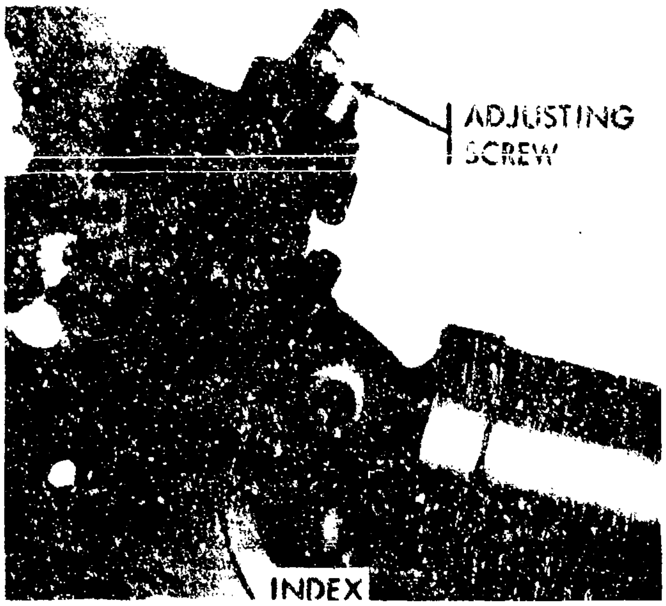


Figure 8-12. Temperature and adjustment scale.

8-15. Traversing and Elevating Controls

a. The traversing and elevating mechanisms on M110A2 are activated by squeezing an actuator-type switch on the control handles (fig 8-13). With either model, the switches should be depressed (squeezed) only when the tube is to be moved in traverse or elevation; repeated activation of the switches without moving the control handles, and thus the tube, causes excessive pressure in the drive motor assembly. This excessive pressure forces the seal inside the drive motor assembly away from its seat, which permits the hydraulic oil to leak from the traversing or elevating gear housing.

b. MWO 9-2300-216-30/19, dated 5 August 1969, authorized installation of the improved elevating and traversing control handle assemblies; therefore, all M110A2s should be equipped with the squeeze-type switches.

8-16. Traverse

The type of traverse is base ring and race. Bearings between the ring and race provide ease of movement.

a. On-carriage traverse. The total amount of on-carriage traverse is 1,066 mils—533 mils right and 533 mils left from the center of traverse.

b. Limiting feature. Position stops attached to the base ring limit the amount the weapon can be traversed.

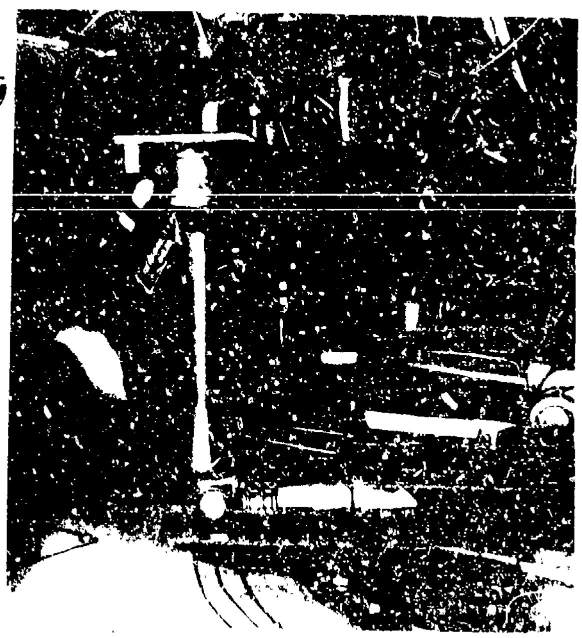
8-17. Traversing Mechanism

a. Purpose. The traversing mechanism controls the movement of the weapon in azimuth.

b. Type. The traversing mechanism is of the hydraulic power type with manual backup.

a. Squeeze actuator, move handle forward for traversing to right, rearward for traversing to left. Power elevating same as b.

b. Squeeze actuator, move handle rearward to elevate cannon, forward to depress cannon.



c. Turn hand crank (forward of left gunner's seat) clockwise to traverse cannon to right and counterclockwise to traverse cannon to left.

d. Turn hand crank (forward of right gunner's seat) clockwise to depress cannon. Turn counterclockwise to elevate cannon.

e. *CAUTION*: Never operate the manual controls when the power elevating or traversing systems are being used.

Figure 13. Turret traversing and cannon elevating control handles.

c. Flow of power. The traversing solenoid valve provides electrical control of the traversing hydraulic system. Squeezing the actuator (fig 8-13) energizes the traversing solenoid valve located on the left side of the turret, thereby sending pressurized hydraulic oil to the traversing control valve and releasing the traversing motor brake. Moving the traversing control handle actuates the traversing control valve, which directs pressurized oil to the traversing motor and causes the weapon to be traversed either to the left or right, depending upon the position of the handle.

d. Power traversing operation. The weapon is traversed by power in the following manner:

(1) Place master switch in "ON" position. Place main oil pump switch to "ON" position.

(2) Squeeze the actuator (or depress the trigger switch) to release the traversing motor brake.

(3) With the actuator squeezed (or the trigger switch depressed), traverse the tube to the desired direction. Push the traverse control forward to traverse to the right; pull the control to the rear to traverse to the left.

(4) Return the traverse control to the neutral position and then release the actuator (trigger switch).

CAUTION: Do not release the actuator (or trigger switch) until you have returned the control handle to the neutral position. Releasing the actuator (trigger switch) before returning the control handle to the neutral position may result in damage to the traversing mechanism.

e. Manual traversing operation. The manual traversing system (fig 8-13) is intended solely as a backup for the power system in case of power failure. To manually traverse the tube to the right (left), turn the handcrank clockwise (counterclockwise).

CAUTION: Do not operate the manual control when using the power traversing system; conversely, do not operate the power traversing controls when using the manual system. Simultaneous operation will damage the slip clutch.

8-18. Elevating Mechanism

a. Type. The elevating mechanism is of the arc and pinion type. It permits elevation of tube to +1,156 mils.

b. Limiting feature. The limits of elevation are governed by stops; one is located at the end of the elevating arc and the other is attached to the hull.

c. Flow of power. The elevating solenoid valve provides electrical control of the elevating hydraulic system. Squeezing the actuator (fig 8-13) energizes the elevating solenoid valve located on the side of the right trunnion, thereby sending pressurized hydraulic oil to the elevating control valve and releasing the elevating motor brake. Moving the elevation control handle actuates the elevating control valve, which directs pressurized oil to the elevating motor and causes the weapon to be elevated or depressed, depending upon the position of the handle.

d. Power elevating operation. The tube is elevated (depressed) by power in the following manner:

(1) Squeeze the actuator (or depress the trigger switch) to release the elevating motor brake.

(2) With the actuator squeezed (or trigger switch depressed), pull the control handle rearward to elevate the tube. (Move the control forward to depress the tube.)

(3) Return the elevation control handle to the neutral position and then release the actuator (trigger switch).

CAUTION: Do not release the actuator (or trigger switch) until you have returned the elevation control handle to the neutral position. Releasing the actuator (trigger switch) before returning the elevation control handle to the neutral position may result in damage to the elevating mechanism.

e. Manual elevating operation. The manual elevating system (fig 8-13) is intended solely as a backup for the power system in case of power failure. It is also used when the travel lock of the weapon is being engaged or disengaged. The manual elevating control (fig 8-13) is located forward of the right gunner's seat. To elevate the weapon, turn the handcrank counterclockwise.

CAUTION: Never attempt to operate the manual controls when the power elevation system is being used; conversely, never operate the power control when the manual system is being used.

8-19. Loader and Rammer

a. General. A hydraulically operated combination loader and rammer (fig 8-14 and 8-15) is provided to pick up a projectile from the rear or left side of the vehicle, place in position for ramming, and ram it into the chamber of the cannon. Hydraulic power for operation is obtained from the vehicle hydraulic system and is controlled by a three-valve loader and rammer power control. The loader and rammer consists essentially of a swing cylinder, a support arm, a loader arm and cylinders, and a rammer chain and cylinder. The swing cylinder attached to the support arms swings the loader and rammer into position for the loading and ramming operation. Two hydraulic lift cylinders attached to the loader arm raise and lower the projectile onto the rammer. A slide trough (fig 8-16) serves as an extension of the projectile loading tray to support the projectile between the loader and the cannon breech. It also serves as a tray for loading the powder bag. The rammer chain is actuated by a hydraulic cylinder with integral gear rack through a gear train and drive sprocket. The rammer chain consists of a headlink and pad and a semirigid roller chain. Handcranks are provided for rammer adjustment or removal of the rammer chain for maintenance.

b. Loader and rammer controls.

(1) The loader and rammer control valve handles (fig 8-16) are located on the rammer controls manifold, which in turn is secured to a bracket on the left trunnion support. Each handle operates a spring-loaded valve which returns the handle to its neutral position when the handle is released.

(2) The swing control valve handle operates a valve which actuates the swing cylinder to move the loader and rammer assembly into position for the loading and ramming operation.

(3) The loader control valve handle operates a valve which actuates hydraulic cylinders to load the projectile onto the loader and rammer assembly.

(4) The rammer control valve handle operates a valve which actuates a hydraulic cylinder. The hydraulic cylinder, in turn, operates the ramming chain, which rams the projectile into the chamber of the weapon.

(5) The rammer manual control handcranks mount on the ends of the rammer-head shaft for emergency operation if the hydraulic system fails. They are stowed in a bracket to the right of the rammer housing.

CAUTION: Under no circumstances should an attempt be made to ram a projectile into the tube until a visual inspection has been made to insure that the rammer piston rod rack is in its fully retracted position as shown in step 5, figure 8-17. The loader rammer assembly must be placed in the RAM position to make this visual inspection. If the rammer piston rod rack is not in its fully retracted position as shown in step 5, the rammer must be timed. To time the rammer, follow steps 1 through 5 as described and illustrated in figure 8-17.

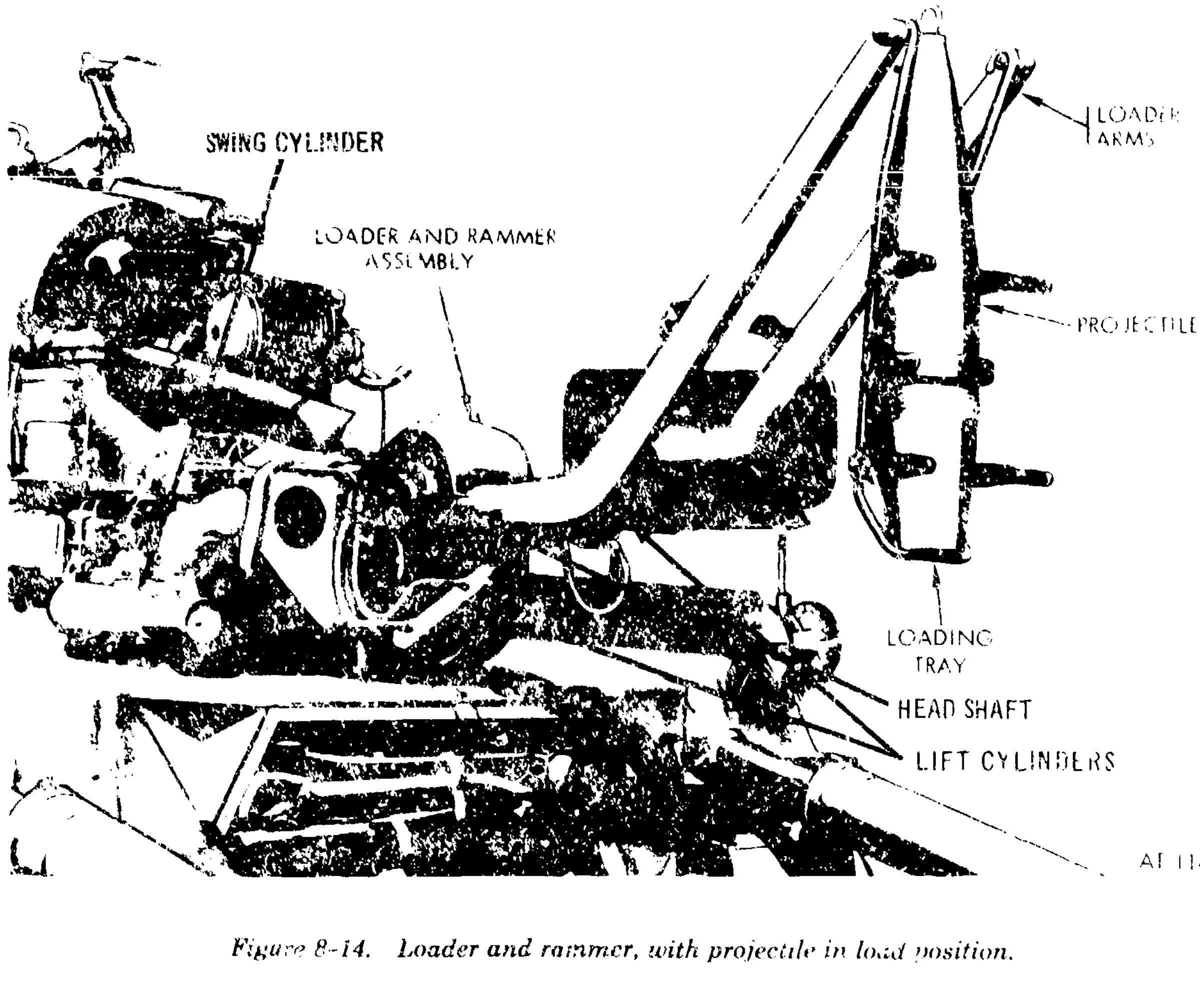


Figure 8-14. Loader and rammer, with projectile in load position.

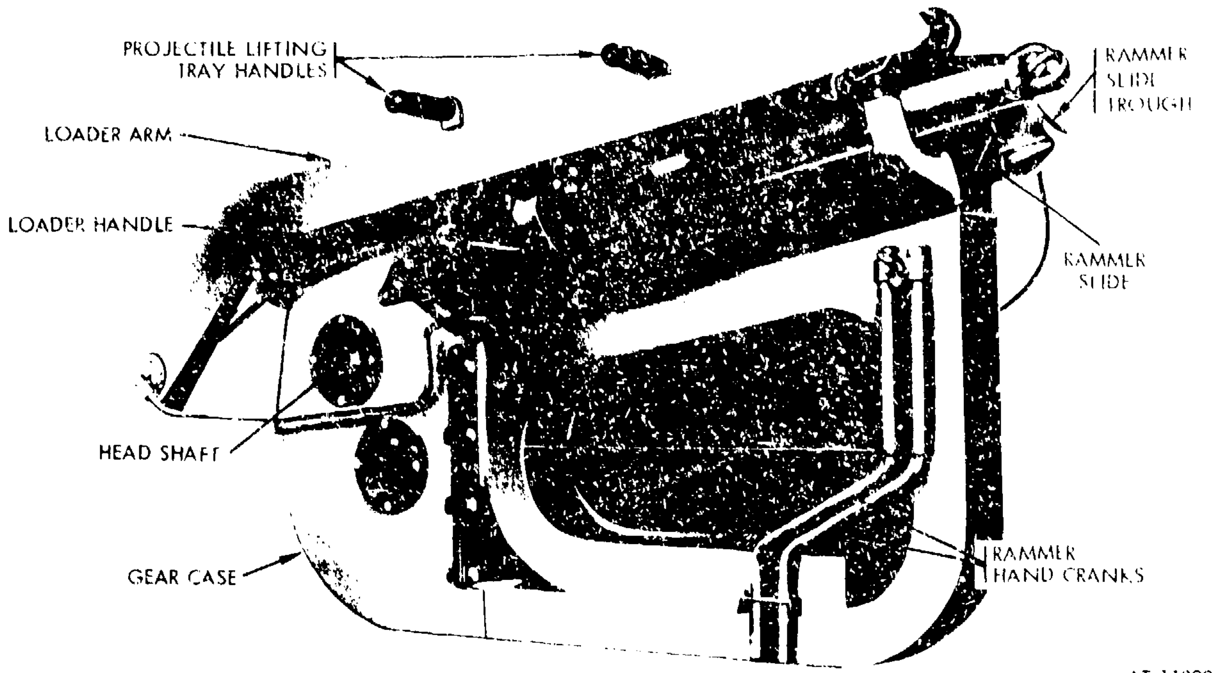


Figure 8-15. Loader and rammer, with projectile in slide trough.

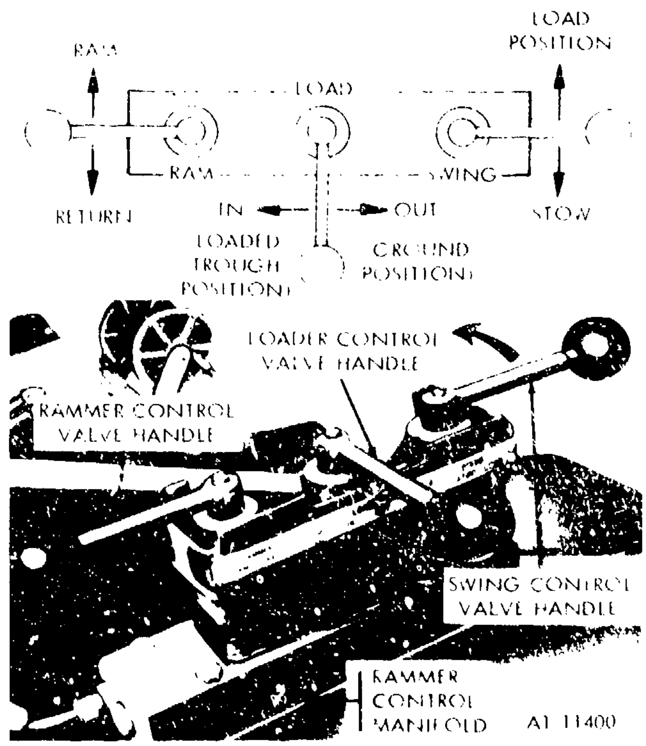
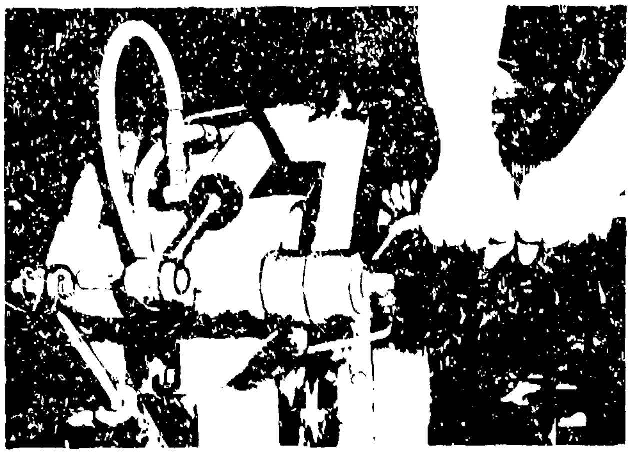
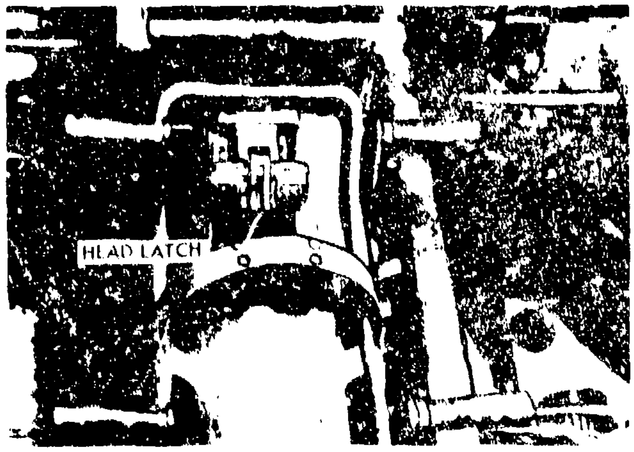


Figure 8-16. Loader and rammer controls.

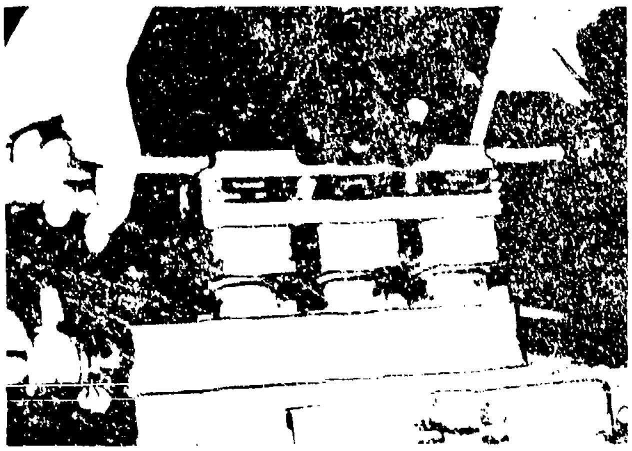


Step 1. Insert handcrank in right-hand rammer chain drive sprocket shaft.

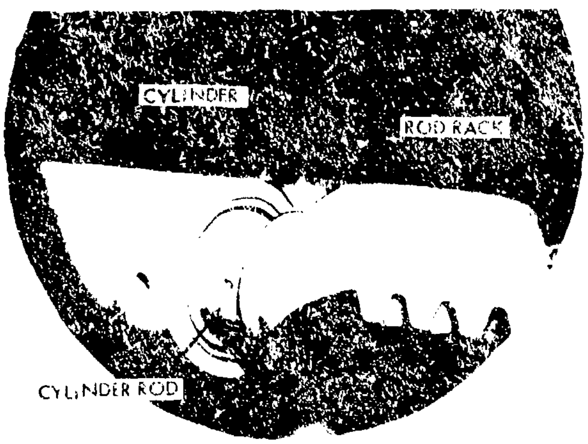


Step 2. Release rammer chain head latch *after* inserting crank on right side.

Step 3. Crank chain out approximately 3 feet as illustrated. Remove hand crank.



Step 4. Retract chain using hydraulic control. If the chain does not retract far enough to engage head latch, reinsert hand crank and wind up excess chain until head latch engages.



Step 5. As a final check, look through the hole on left side of loader-rammer. The hydraulic actuating cylinder rod should be fully retracted when the head latch is in its fully retracted and locked position. If cylinder rod, rod rack, and cylinder are not positioned as shown, repeat operation.

Note. Steps 1 through 5 are required for the old loader and rammer. The new M110A2 is self-timing and only step 5 is necessary.

Figure 8-17. Timing the loader and rammer.

c. Loading and ramming the projectile.

(1) Position the tube at the loading elevation by alining the elevation indicator arm with the index on the trunnion bearing cap.

Note. The loading elevation for each weapon must be determined by the using unit in accordance with TM 9-2350-304-10.

(2) Depress the breechblock operating lever catch and pull the operating lever rearward and downward. Swing the operating lever to the right to open the breechblock.

(3) Remove the lifting tray from the loader rammer assembly, release the stow position lock and position it for use in transporting the projectile from the loading area to the rear or left side of the vehicle. The loader and rammer assembly is now ready to operate.

(4) Move the swing control valve handle (fig 8-16) toward the right side of the vehicle and hold it in that position until the loader and rammer assembly is in the loading position. Loading may be accomplished from either the left or rear of the vehicle.

(5) Move the loader control valve handle (fig 8-16) to the OUT position and hold it in that position until the lifting arm is fully extended.

(6) Secure the loaded lifting tray to the lifting arm.

(7) Move the loader control valve handle to the IN position and hold it in that position until the tray and arm are fully seated in the ramming position on the loader rammer assembly.

(8) Move the swing control valve handle toward the right side of the vehicle and hold it in that position until the loader and rammer assembly stops in the RAM position. On the M110A2 make sure ram position lock is engaged.

(9) Slide the trough forward and engage the left trough handle in the notch of the trough lock. The rammer will not operate if the handle is not in the notch. The operator must insure that the projectile releases the headlink latch before the rammer control valve handle is placed in the RAM position (fig 8-17)

(10) Move the rammer control valve handle toward the right side of the vehicle and hold it in that position until the rammer chain stops and the projectile is rammed all the way "home" (*f* below). For the new loader rammer, move the rammer control valve handle up and forward until the pad of the chain reaches the breech recess and then release handle. The loader and rammer will then continue and return on its own.

(11) Move the rammer control valve handle toward the left side of the vehicle and hold it in that position until the rammer chain is fully retracted.

(12) Load the propelling charge by hand only; do not use the hydraulic rammer.

(13) Disengage the left trough handle from the locking notch and slide the trough to the rear. Make sure the ram position lock is disengaged before operating rammer.

(14) Stand forward of the swing cylinder and inboard of the rammer stop. Operate the swing control valve handle toward the left side of the vehicle and hold it in that position until the rammer stop arm comes to rest against the rammer stop. The rammer is now in the stowed position.

Note. The stowed position lock should be engaged.

(15) Close the breech by pulling the breechblock operating lever toward the breech; then push it to the vertical position.

d. Marking the rammer chain.

(1) Attach a measuring device, such as a measuring tape, to the rammer head.

(2) Manually crank out the rammer chain until there are 43.25 inches of chain extended from the face of the rammer head to the rear face of the breech ring.

(3) At that point on the rammer chain directly opposite the rear face of the breech ring, paint the chain link on the rammer chain white.

(4) Continue to manually crank out the rammer chain until there are 46.13 inches of chain extended from the face of the rammer head to the rear face of the breech ring.

(5) At that point on the rammer chain directly opposite the rear face of the breech ring, paint the chain link on the rammer chain a color other than white.

e. Manual operation. Ramming is accomplished manually by sufficient personnel assembling the cleaning staff section and operating the assembled staff sections to load the projectile into the powder chamber and the forcing cone of the tube. The projectile must be rammed with sufficient force to insure that the rotating band seats in the forcing cone and seals the front end of the powder chamber (forward obturation).

f. Maintenance and inspection.

(1) Position the weapon at the elevation for loading (approximately 150 mils) and open the breechblock.

(2) Move the loader and rammer assembly into the ramming position and move the loading trough forward into the breech chamber.

(3) Manually extend the rammer chain by means of the handcrank on the right side.

(4) Inspect the pad on the headlink and replace it if it is damaged.

(5) Inspect all cotter pins on both sides of the chain and replace any that are damaged.

(6) Inspect the loading trays and replace any damaged trays.

(7) Inspect the loading arm for bent or damaged members; if any member is bent or damaged, notify organizational maintenance personnel.

(8) Check for loose or missing bolts and tighten or replace as necessary.

(9) Inspect hydraulic connections and cylinders for leakage. If any leakage is found, notify organizational maintenance personnel. On the M110A2 stowed and ram position handle should be checked for cracks.

g. Depth of ram. Check the depth of the ram on the M110 series.

(1) When ramming the M106, M404, or M426, a proper depth of ram will be achieved when the white chain link is directly opposite the rear face of the breech ring (43.25 inches from front rammer head).

(2) For M422A1 and M424A1, the red chain link is directly opposite the rear face of the breech ring (46.13 inches from front of rammer head).

Section IV. BARREL AND BREECH ASSEMBLIES

8-20. Barrel Assembly

The principal parts of the barrel assembly are the tube and the breech ring.

a. Construction. The tube is made of the highest quality steel alloy. Bearings for support and alinement in the mount are provided by longitudinal rails attached to three hoops, shrunk on the tube. The rear half of the breech ring is lined with a breech ring bushing to accommodate a stepped-thread, interrupted-screw type of breechblock.

b. Exterior components. The exterior components are the integral and permanently affixed exterior features of the barrel assembly. Three short cylinders, or hoops, are shrunk onto the outside of the tube to provide additional strength and a means for attaching the longitudinal recoil slides and bearing strips. An extension on the underside of the breech ring forms a recoil lug which is used to connect the recoil mechanism to the breech ring. Another lug is constructed on the right side of the breech ring for attaching the breechblock carrier.

c. Interior components. The interior components of the bore, which are the same as those of other weapons that fire separate-loading ammunition, are described below in the order of their location, from breech to muzzle.

(1) The breech recess houses the breechblock when the breechblock is in the closed position.

(2) The gas-check seat is that part of the rear portion of the tube which is tapered to receive the split rings and gas-check pad in performing rearward obturation.

(3) The powder chamber is that portion of the tube from the rear face to the centering slope, formed to receive the propelling charge.

(4) The centering slope is the tapered portion forward of the powder chamber, designed to center the projectile in the bore during the loading operation.

(5) The forcing cone is the tapered portion of the rifling at the rear of the bore. It allows the rotating band of the projectile to be gradually engaged by the rifling.

(6) The main bore is the entire rifled portion of the tube.

(7) The counterbore is that portion of the muzzle end of the tube from which the lands have been removed to increase the diameter of the tube and thus decrease stress from firing.

d. Characteristics. The characteristics of the weapons are as follows:

		M110A2
(1) Caliber		8 inches
(2) Length of bore, calibers		40.5
(3) Number of lands and grooves (uniform right-hand twist)		64
		Projectiles
(4) Muzzle velocity, meters per second	M106	M650
(Maximum charge)	778 m/s	768 m/s
(5) Range, meters	22,900	24,400 rocket off 30,000 rocket on
(6) Maximum rate of fire for the first 3 minutes		1.5 rd per min
(7) Sustained rate of fire		1 rd per 2 min

e. Tube and breech life. Each round of ammunition fired through a cannon tube causes wear and erosion to the tube and results in a change in the dimensions of the bore. The extent of wear for most gun tubes and some howitzer tubes determines the remaining life of the tube. In

Table 8-1. Condemnation Criteria For Tubes and Breech Assemblies

Major Item	Cannon/	EFC Life of Tube	EFC Factor	Breech Life	Remarks
8-inch howitzer M110A2	M201A1	10,000 rds	Zone 9 = 1.0 Zone 7-8 = 0.7 Zone 1-6 = 0.25	Original and 4 tubes No retubing	

*Note. 0.135 in wear pullover gage measurement of 8.135.

addition to wear and erosion, each round produces metal fatigue, a process in which heat and expanding gases weaken the metal in the tube and reduce tube life. The method of determining the remaining life for these tubes is to convert rounds fired to equivalent full charge (EFC) rounds and subtract the EFC rounds fired from the remaining rounds authorized. The tube life and breech life for the 8-inch howitzer M110 and M110A1 are shown in table 8-1. The information in the table was extracted from TM 9-1000-202-10 and changes 1, 2, 3, 4, and 5 to TM 9-1000-202-35.

8-21. Barrel Maintenance

a. Cleaning.

(1) The tube should be cleaned with rifle bore cleaner (abbreviated on lubrication orders as (CR)) the day of firing and for 2 consecutive days after firing, making a total of at least three cleanings. After each cleaning, a coating of rifle bore cleaner should be left in the tube overnight. If the weapon is not to be fired within 24 hours after the third cleaning, it should be wiped dry, inspected, and lubricated with oil. Oil, lubricating, preservative, medium, should be used if the temperature is above 32°; oil, lubricating, preservative, special, should be used if the temperature is below 32° F.

(2) If the tube continues to sweat after the third cleaning, cleaning should be continued until the sweating stops.

(3) When the weapon is not being fired, the tube should be cleaned with rifle bore cleaner weekly and then wiped dry, inspected, and reoiled as in (1) above.

b. Cleaning solutions.

(1) *Rifle bore cleaner.* Rifle bore cleaner evaporates at 150° F. (If a hand can be placed on the tube without being burned, the tube is cool enough to clean.) Rifle bore cleaner is not a lubricant; but it will act as a rust inhibitor for 24 to 48 hours. Rifle bore cleaner should never be diluted.

(2) *Alternate solution.* If rifle bore cleaner is not available for cleaning, an alternate solution of ¼-pound castile or GI soap dissolved in a gallon of water may be used. Hot water is preferable because it will dissolve soap more readily. The tube should be cleaned while it is still hot so that the solution will wash the primer salts from the pores of the metal. The sequence for cleaning the tube with soap and hot water is the same as that for cleaning with rifle bore cleaner except that the tube must be rinsed, dried, inspected, and lubricated after each daily cleaning.

c. Lubricants.

(1) Oil, lubricating, preservative, medium, is used on all bearing surfaces if the temperature is above 32° F.

(2) Oil, lubricating, preservative, special, is used on all bearing surfaces if the temperature is below 32° F.

d. Reducing tube wear.

(1) Corrosion is a chemical decomposition of tube metal, caused by moisture being withdrawn from the air by hugroscopic primer salts deposited in the tube by firing. The tube should be cleaned with rifle bore cleaner immediately after firing and for 2 consecutive days thereafter, or until sweating ceases, to stop tube wear caused by corrosion.

(2) Erosion is the wearing away of the tube by the escape of propelling gases around the rotating band at the instant of firing (known as gas wash) and by friction. Erosion can be reduced by—

(a) Removing oil and other foreign matter from the tube before firing.

(b) Using the lowest charge commensurate with the mission.

(c) Using the lowest rate of fire commensurate with the mission.

(d) Letting the weapon rest 10 minutes per hour. (The rest periods should be used to clean and maintain the weapon.)

(e) Swabbing the tube with cold water during lulls in the firing.

(f) Insuring that all ammunition components are clean before loading.

8-22. Breech Ring and Breech Block

a. The tube (on the 8-inch howitzer) is screwed into an internal thread in the breech ring and is locked in place by a key and a screw. The inner portion of the breech ring forms the breech recess, which is divided into eight threaded and four plain sectors mating with those of the breechblock. Two leveling plates on the top surface of the breech ring are used as seats for the gunner's quadrant.

b. The breech ring forms a housing for the stepped-thread, interrupted-screw type of breechblock. The DeBang obturator device is employed on the breechblock to perform rearward obturation; that is, to prevent gases from escaping to the rear.

c. The percussion-type (continuous-pull) firing mechanism M35 is employed in the breechblock.

d. The breech life of each weapon is shown in table 8-1.

8-23. Counterbalance Assembly

a. The purpose of the counterbalance assembly is to hold the breechblock assembly in the open position at loading elevation and to facilitate closing the breech.

b. The counterbalance assembly is a cylinder with closed ends containing a relatively heavy compression spring. The spring is compressed between the head of the cylinder and the counterbalance piston, which is connected to the breechblock carrier hinge pin by its rod. The counterbalance is mounted to the breech ring by means of a counterbalance bracket secured to the forward right side of the breech ring.

8-24. Disassembly and Maintenance of the Breech Mechanism

Under no circumstances should an attempt be made to disassemble the breech mechanism with the breech partially or fully closed; because, when the breech is opened, the split rings and the gas check pad will drop into the threads of the breech recess. This could prevent the breech from opening and could damage the split rings.

a. Disassembly. To disassemble the breech mechanism (fig 8-19)—

(1) Remove the firing mechanism M35 by pressing in the firing mechanism and rotating it 70° in a clockwise direction. To remove the firing group block, pull the follower knob out and down into the disassembly position.

(2) Open the breech and place a spacer between the shoulder of the eye on the counterbalance piston rod and the counterbalance cylinder head. Then swing the carrier toward the closed position until the eye on the counterbalance piston rod can be lifted over the head of the pin on the hinge pin arm.

(3) With the breech open, remove the obturator spindle nut (use a 1⅜-inch socket).

(4) Remove the firing mechanism housing, spindle spring, and firing block.

(5) Slide the obturator assembly from the breechblock.

(6) Remove the control arc.

(7) Insert a section of the cleaning staff through the breechblock and remove the breechblock.

(8) Using a small drift, or punch, remove the spring pin from the crankshaft crank.

Note. The operating handle must be in the vertical position.

(9) Remove the crankshaft and operating handle as a unit.

(10) Remove the crosshead and the crankshaft crank.

(11) Remove the cotter pin from the bottom of the carrier hinge pin.

(12) Tap the hinge pin upward and remove.

Note. Do not drop the bearing, washer, or carrier.

(13) Remove the carrier and the thrust washer.

b. Maintenance. The breech mechanism is subject to contamination from powder residue, which works its way to and through the obturating parts. For this reason, disassemble the obturating parts and clean them in the same manner as prescribed for the barrel—the day of firing and for 2 consecutive days thereafter. Clean the breech mechanism, except the gas-check pad, with rifle bore cleaner. Remove all powder stains, rust, or burrs, using crocus cloth if necessary. Wipe the gas-check pad with a clean dry cloth or clean with hot soapy water. After cleaning and drying these parts, lubricate them as prescribed by LO 9-2300-216-12 (fig 8-19) before reassembling the breech mechanism.

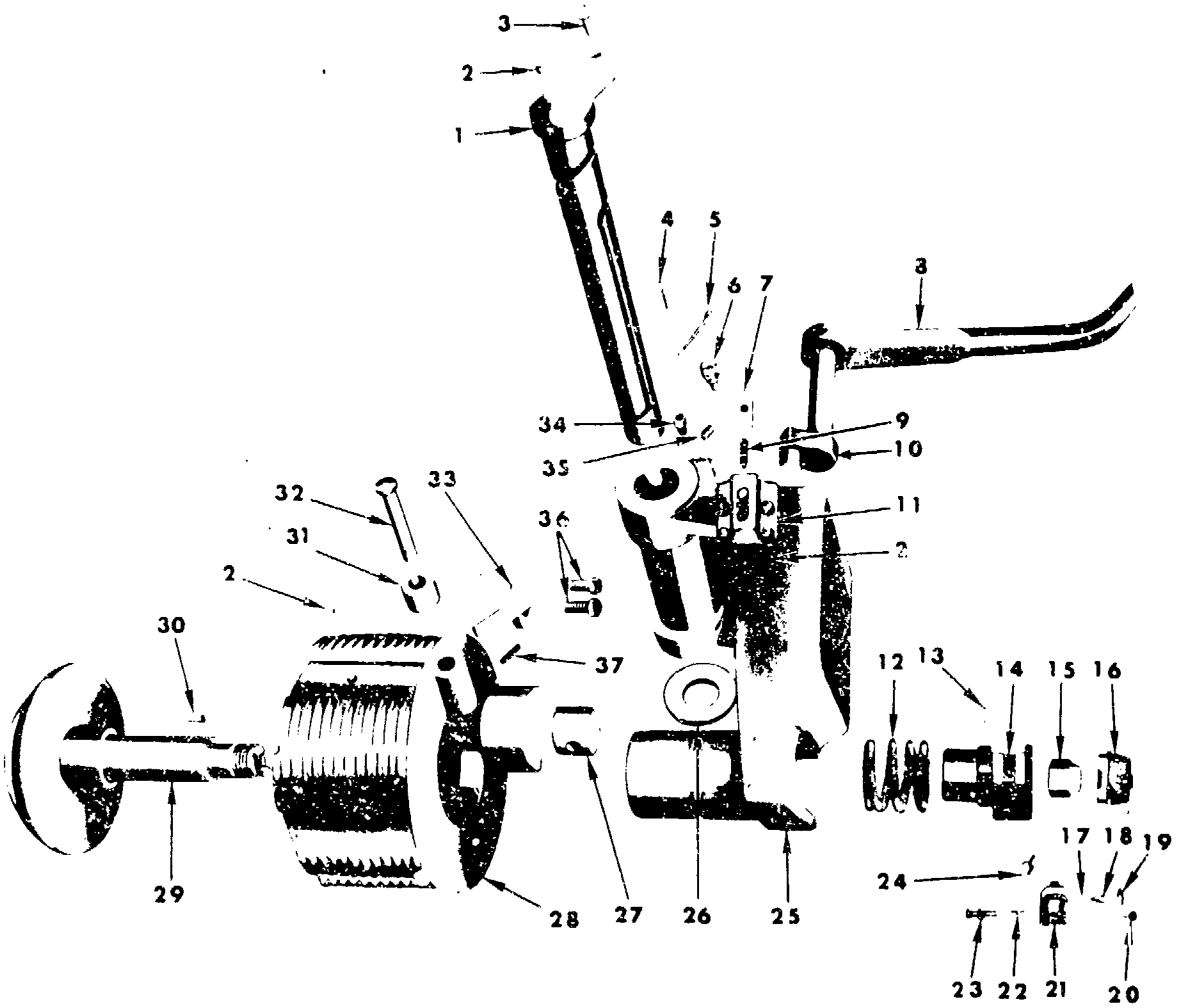
c. Assembly. Reassemble the breech mechanism in reverse order of disassembly.

8-25. Firing Mechanism M35 and Firing Mechanism Block Assembly

a. Firing mechanism. The firing mechanism M35, which is a percussion-type mechanism, is normally kept installed on the rear end of the obturator spindle and secured in the stepped recess of the breechblock carrier. The firing mechanism is operated manually by means of a lanyard.

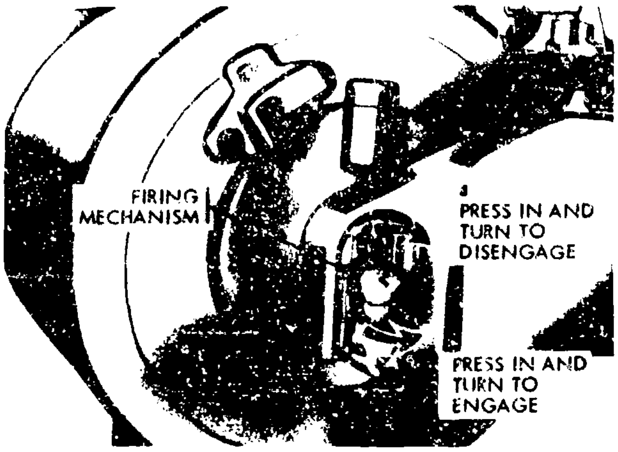
b. Removal, disassembly, and assembly of the firing mechanism. Figure 8-20 describes and illustrates the procedures for removal, disassembly, and assembly of the firing mechanism.

c. Maintenance. Maintenance of the firing mechanism M35 and the firing mechanism block consists of cleaning, lubricating, and replacing worn or damaged parts.

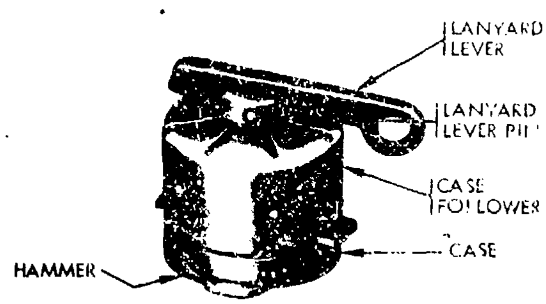


1—Hinge pin
2—Oil cup
3—Counterbalance piston rod end pin
4—Hinge pin key
5—Spring pin
6—Latch knob
7—Latch
8—Operating lever assembly
9—Latch spring
10—Crank
11—Latch bracket
12—Spindle spring
13—Extractor pin
14—Firing mechanism housing
15—Spindle nut
16—Firing mechanism
17—Spring
18—Firing pin
19—Firing pin retainer
20—Knob
21—Firing group lock
22—Spring
23—Block follower
24—Extractor
25—Breechblock carrier
26—Thrust washer
27—Crosshead
28—Breechblock
29—Obturator spindle assembly
30—Spindle key
31—Roller
32—Pivot pin
33—Control arc
34—Latch screw
35—Hinge key setscrew
36—Screws
37—Pin

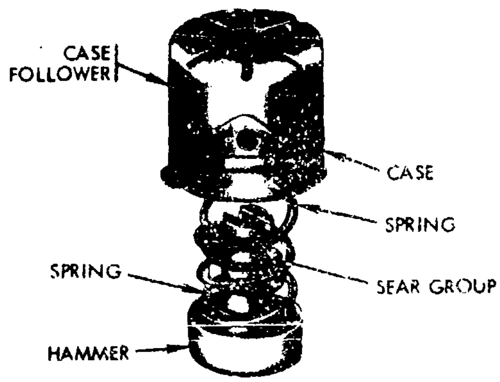
Figure 8-18. Breech and firing mechanism M35—exploded view.



a. Press in on firing mechanism with breech in extract or load position and turn mechanism 70° clockwise to disengage.



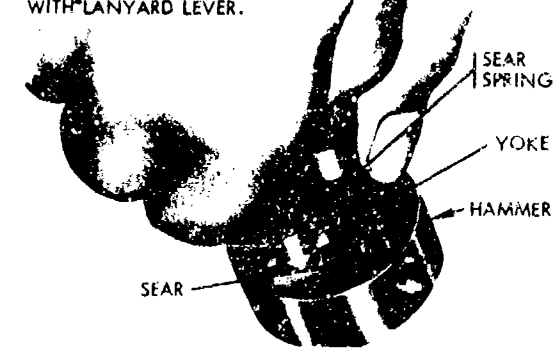
b. Place firing mechanism on solid surface. Place M18 fuse setter wrench over the case and follower and depress until pin can be removed from lanyard lever and yoke. Release spring tension slowly to prevent scattering of parts.



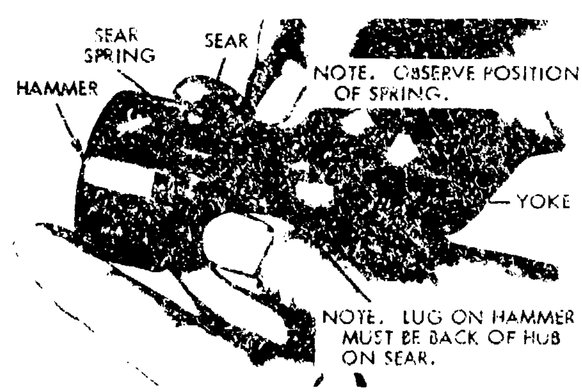
c. Remove case follower, case, and springs from hammer and sear group.

d. Remove sear hinge pin.

NOTE. PRESS DOWN ON SEAR WITH LANYARD LEVER.

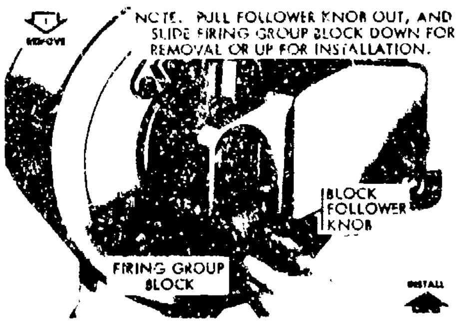


e. Separate hammer, sear hinge pin, sear spring, and yoke.

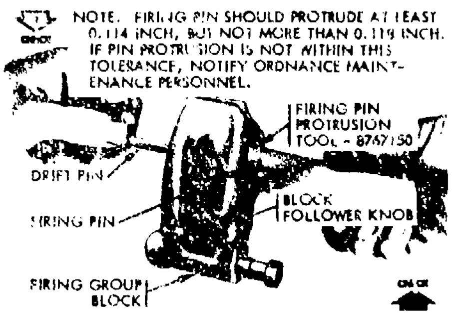


f. To assemble, insert hammer into bore of yoke, position sear spring on sear, and place sear with spring into slot in yoke. Engage ends of sear spring into two grooves above sear pin hole. Complete assembly by performing e through a.

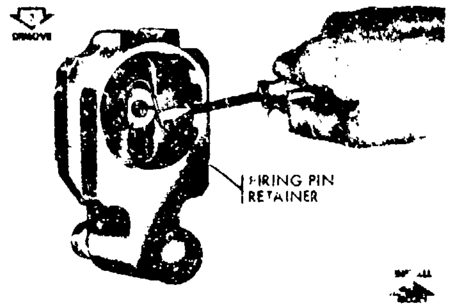
Figure 8-19. Removal, disassembly, and assembly of the firing mechanism M35.



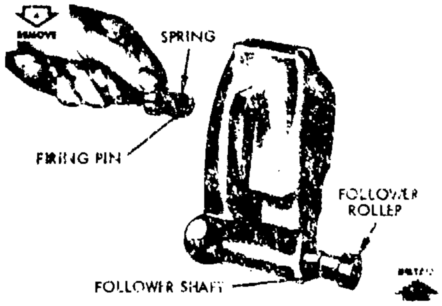
a. Firing group block.



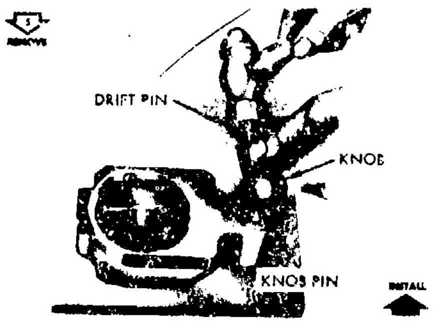
b. Firing pin protrusion.



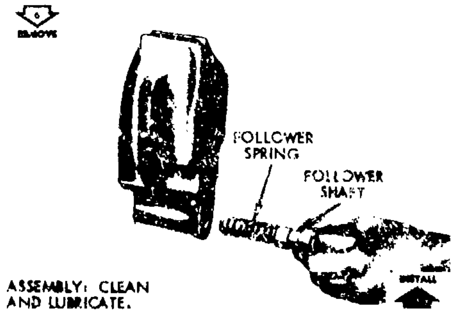
c. Firing pin retainer.



d. Firing pin and spring.



e. Knob pin and knob.



f. Follower shaft and follower spring

Figure 8-20. Disassembly and assembly of the firing mechanism block assembly.

d. Inspection of the firing mechanism. Check the firing mechanism for smooth and correct action of the moving parts. A weak or broken spring will reduce or hinder the essential snap and mechanical precision required for proper functioning. Examine the mechanism for corrosion. Powder fouling attracts moisture and hastens corrosion. Clean all exposed parts of the mechanism, wipe dry, and lubricate. For replacement of broken or worn parts, notify organizational maintenance personnel.

e. Disassembly and assembly of the firing mechanism block assembly. Figure 8-20 describes and illustrates the procedures for disassembly and assembly of the firing mechanism block assembly.

8-26. Definitions of Common Terms

a. Fire control instruments—Includes both on- and off-carriage instruments. On-carriage fire control instruments are those which are of built-in design or are placed on the weapon by the crew and which are used for laying the weapon in deflection and/or elevation. Such instruments as the panoramic telescope, range quadrant, elbow telescope, and gunner's quadrant are on-carriage equipment. The aiming circle, battery commander's telescope, and M2 compass are examples of off-carriage fire control instruments.

b. Trajectory—The curve traced by the center of gravity of the projectile in its flight from the muzzle of the weapon to the point of impact or the point of burst. The muzzle of the weapon is placed in the correct firing attitude (position) by setting appropriate horizontal and vertical data on the on-carriage fire control instruments and laying the weapon.

c. Reticle—A measuring scale or mark placed on the focus of an optical instrument. Some reticles have graduations which allow small deflection or range measurements to be made while the operator looks through the instrument.

d. Sighting—The process of directing a line of sight toward an aiming point.

e. Laying—The process of pointing the tube of a weapon in a given direction for a given range.

f. Indirect fire—Fire from a weapon which is laid by sighting on a point other than the target. Normally, the target and the weapon will not be intervisible.

g. Direct fire—Fire from a weapon which is laid by sighting directly on the target.

h. Cant—The tilting of the trunnions of the weapon out of the true horizontal plane. Cant causes the tube to travel out of the true horizontal plane in traverse and out of the true vertical plane in elevation. Cant is always present if the trunnions of a weapon are not level.

Section V. FIRE CONTROL EQUIPMENT

8-27. Gunner's Quadrant M1/M1A1/M2A2

a. The gunner's quadrant M1/M1A1/M2A2 (fig 8-21) is used on the 8-inch howitzer primarily during sight tests and adjustments. However, it may be used to lay the weapon for elevation if the elevation quadrant M15 or the elevation portion of the telescope mount M137 is inoperable. It may also be used to lay the weapon to the nearest tenth of a mil in elevation.

b. The gunner's quadrant consists of a frame with a graduated arc, an index arm, a micrometer knob and scale, a leveling bubble, and reference surfaces. The arc is graduated in 10-mil

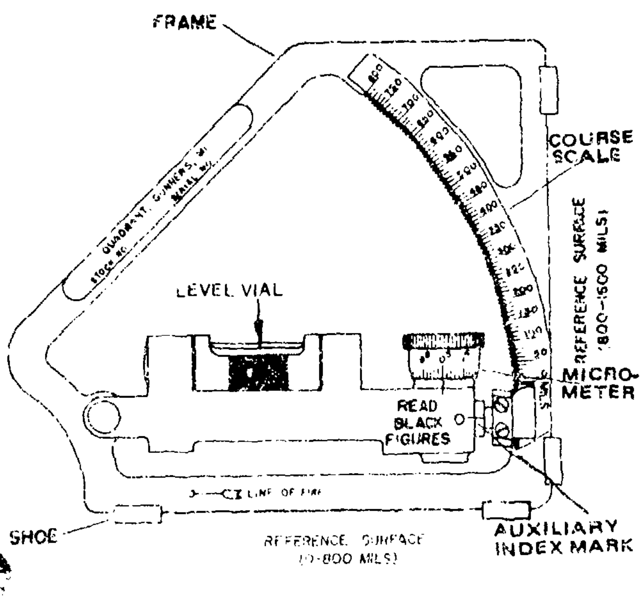


Figure 8-21. Gunner's quadrant M1.

increments from 0 to 800 mils on one side and from 800 to 1,600 mils on the other side. The teeth on the arc position the index plunger at the 10-mil graduations. The index micrometer scale is graduated in 0.2-mil increments from 0 to 10 mils. One complete revolution of the index micrometer knob raises or lowers the bubble 10 mils. The index micrometer scale on the M1 gunner's quadrant is numbered with black and red figures. The black figures are read for measuring an angle from 0 to 800 mils; the red figures, for measuring an angle from 800 to 1,600 mils. Two direction-of-fire arrows indicate the manner in which the gunner's quadrant is placed on the quadrant seats.

Note. The gunner's quadrant M1A1 differs from the M1 in the following respects: the M1A1 is provided with a micrometer mask to insure use of the correct scale, it has an indicator on the index arm, and the index mark on the micrometer is numbered 10 rather than 0.

c. Gunner's quadrant micrometer test. Gunner's quadrant micrometer test and end for end test must be conducted prior to using gunner's quadrant for any fire control alinement test.

(1) Set index at plus 10.

(2) Zero micrometer.

(3) Point line of fire arrow toward muzzle end.

(4) Depress/elevate tube to center bubble.

(5) Set index at zero.

(6) Set micrometer at 10.

(7) Point line of fire arrow toward muzzle end.

(8) Bubble should center.

(9) If bubble does not recenter, the micrometer is in error. The quadrant should be turned in to direct support maintenance for repair and no further test or adjustment made with the instrument.

d. End for end test. To test the gunner's quadrant for accuracy, perform the following end-for-end test before performing sight tests and adjustments.

(1) Zero the scales of the gunner's quadrant, place the gunner's quadrant on the quadrant seats on the breech ring, and level the tube.

(2) Reverse the quadrant (end-for-end) on the quadrant seats and check the bubble. If the bubble centers, the tube is level, the end-for-end test is complete, and the error in the gunner's quadrant is 0. However, if the bubble does not center then you must continue the end-for-end test and determine the sign (+ or -) and the amount of the correction for the error in the gunner's quadrant as described in (3) or (4).

(3) If the bubble does not center ((2) above), turn the micrometer knob and try to center the bubble.

(a) If the bubble centers when the micrometer knob is turned, read the block figures on the micrometer scale and divide the reading by 2. Set the results on the micrometer scale.

(b) Place the gunner's quadrant back on the qu[illegible] seats w[illegible]h the arrow pointed toward the [illegible], us[illegible] the elevating handwheel, level [illegible]be by centering the bubble.

(c) Reverse the gunner's quadrant (end-for-end) on the quadrant seats. The bubble should center. The reading on the gunner's quadrant is the amount of the positive (+) correction for the error in the gunner's quadrant, and the end-for-end test is complete.

(4) If the bubble does not center ((3)*(a)* above), move the gunner's quadrant arm down one graduation (10 [illegible]).

(a) Turn the micrometer knob until the bubble centers.

(b) Take the reading on the micrometer scale, add 10 to it, and divide the sum by 2. Place the results on the microm[illegible] scale.

(c) With the arm o[illegible] gunner's quadrant set at minus 10 and the results in *(b)* above set on the micrometer scale, place the gunner's quadrant back on the quadrant seats with the arrow pointed toward the muzzle and, using the elevating handwheel, level the tube by centering the bubble.

(d) Reverse the gunner's quadrant (end-for-end) on the quadrant seats. The bubble should center. If the bubble centers, subtract the reading on the micrometer scale from 10 to obtain the value of the correction for the error. This is known as the negative correction (-) for the error, and the end-for-end test is complete.

Note. If a correction (+ or -) for the error has been determined during the end-for-end test of the gunner's quadrant, it will be carried only during sight tests and adjustments and will not be applied to elevations in fire missions. However, if the correction for the error is more than 0.4 mil, the gunner's quadrant must be sent to the support unit at the earliest possible date for correction and adjustment.

8-28. Panoramic Telescope Mount M137

Telescope mount M137 (fig 8-22) provides an adjustable base for leveling the panoramic telescope M115. A mechanical four-digit decimal counter is used for registering elevation in place of the elevation scale and micrometer used on previous telescope mounts. A correction indicator is used for inserting relatively constant elevation corrections so that the elevation counter registers actual firing table elevation readings. Test and adjustments of the panoramic telescope mount are performed in the same manner as those of the elevation quadrant M15 (para 8-30). For details, see TM 9-2350-304-20.

8-29. Panoramic Telescope M115

Panoramic telescope M115 (fig 8-23) is a 4-power, fixed-focus telescope with a 10° field of view. It is mechanically similar to other panoramic telescopes now in service. It consists of a rotating head assembly, an azimuth worm housing assembly, a counter adapter assembly, a gunner's aid housing assembly, and an elbow assembly.

a. The primary purpose of the panoramic telescope is to lay the weapon for indirect fire. It allows the gunner to apply a specified change in direction (deflection) to the tube of the weapon by changing the line of sight of the telescope the same specified amount and then traversing back on the fixed aiming point. For example, to change the direction of the tube 200 mils to the right, the gunner refers the line of sight 200 mils to the left of the fixed aiming point and then traverses the tube until the line of sight of the telescope is back on the aiming point. This points the tube 200 mils right of its original direction.

b. The elevation knob, located at the top of the telescope rotating head enables the gunner to raise or lower the line of sight plus or minus 300 mils from center when rotated throughout its limits. A fine index and a coarse index indicate the level position. The fine index may be adjusted by loosening the three screws on the top of the elevation knob and then slipping the collar

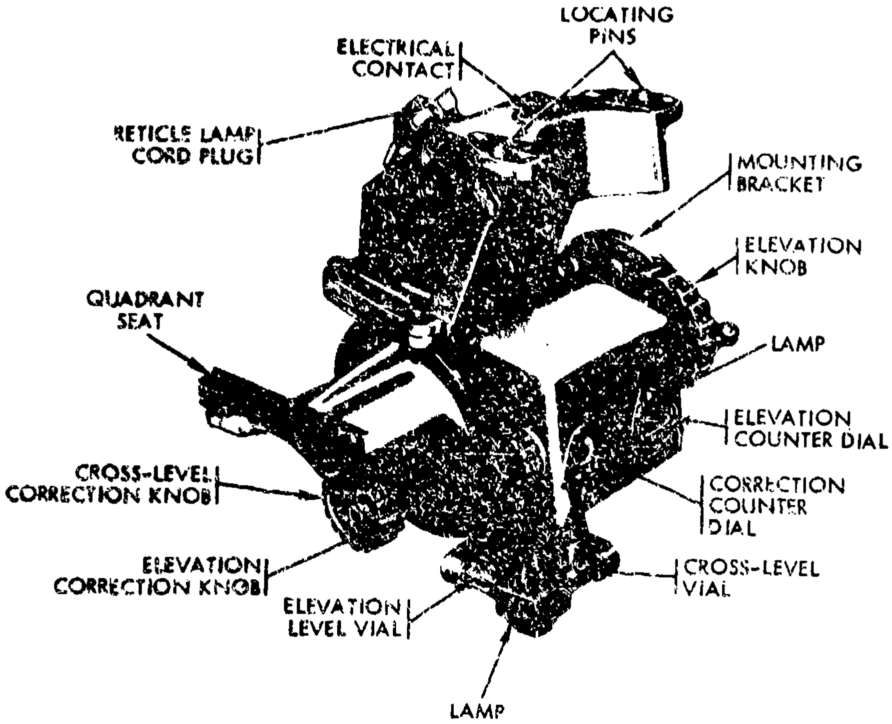


***Figure 8-22.** Panoramic telescope mount M137.*

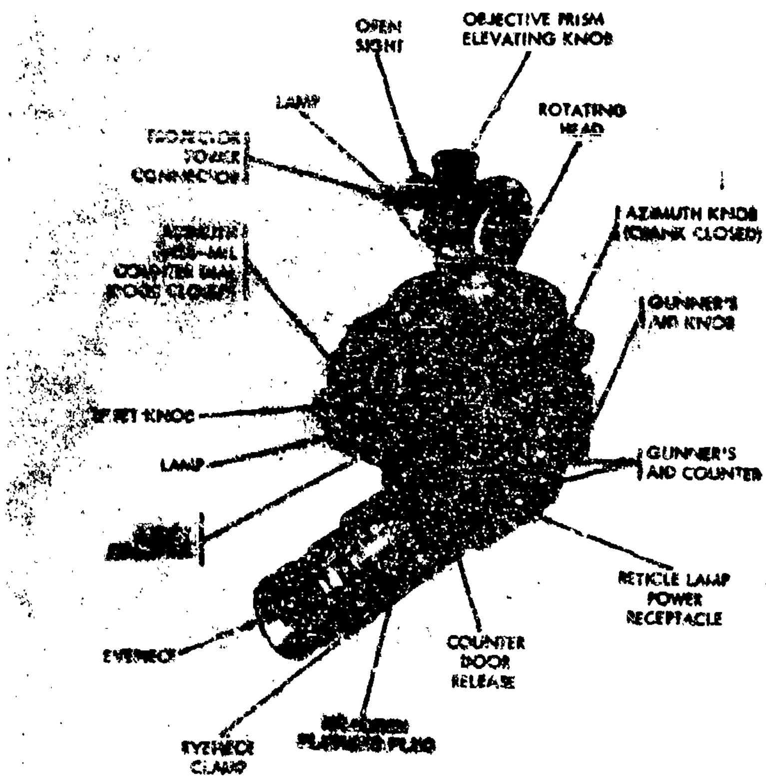


***Figure 8-23.** Panoramic telescope M115.*

containing the zero index into coincidence with the fixed index. The coarse index is adjusted by support personnel only. An open sight located on the right side of the rotating head is used for rough alinement with an aiming point.

8-30. Elevation Quadrant M15

a. Elevation quadrant M15. Elevation quadrant M15 (fig 8-24) is mounted directly on the right-hand trunnion and is used for adjustment of the weapon in elevation when two men are orienting the weapon. Elevation quadrant M15 is equipped with a mechanical mil counter for elevation readings. Gunner's aid counters are built in to permit quick, accurate insertion of elevation correction factors peculiar to the individual cannon and cannon emplacement. A quadrant seat is also provided on the instrument to allow the use of gunner's quadrant M1/M1A1 when fine elevation settings are required. A mounting bracket for the elevation quadrant is precisely machined and alined so that, when the instrument is installed, complex adjustments are unnecessary and only an accuracy check is required. The controls on the elevation quadrant are identical to corresponding controls on panoramic telescope mount M137.

b. Adjustment and tests for elevation quadrant M15. The adjustment and tests described in (1) through (6) below will be made whenever the elevation quadrant M15 is replaced or whenever a doubt exists concerning the accuracy of its mounting. These adjustments and tests are made after the trunnions and the weapon tube have been leveled as shown in figure 8-25.

(1) Check the mounting to make certain that the elevation quadrant is properly seated on the trunnion end plate key and is flush against the plate. Make certain that the capscrews have been tightened evenly during mounting.

(2) Zero the correction counter and elevation counter.

(3) Center the cross-level bubble with the cross-level knob and center the elevation bubble by elevating or depressing the tube.

(4) To test the elevation quadrant seats for accuracy, set the correction (if any) from the end-for-end test of the gunner's quadrant on the micrometer scale of the gunner's quadrant. Place the gunner's quadrant on the quadrant seats of the elevation quadrant M15 and check the bubble.

(a) If the gunner's quadrant bubble centers, there is no error in the elevation quadrant seats.

(b) If the bubble does not center, turn the micrometer knob of the gunner's quadrant until it does center. The reading on the micrometer must now agree within +0.2 mil of the reading set on the gunner's quadrant at the beginning of the test of the quadrant seats for accuracy. If it does not agree

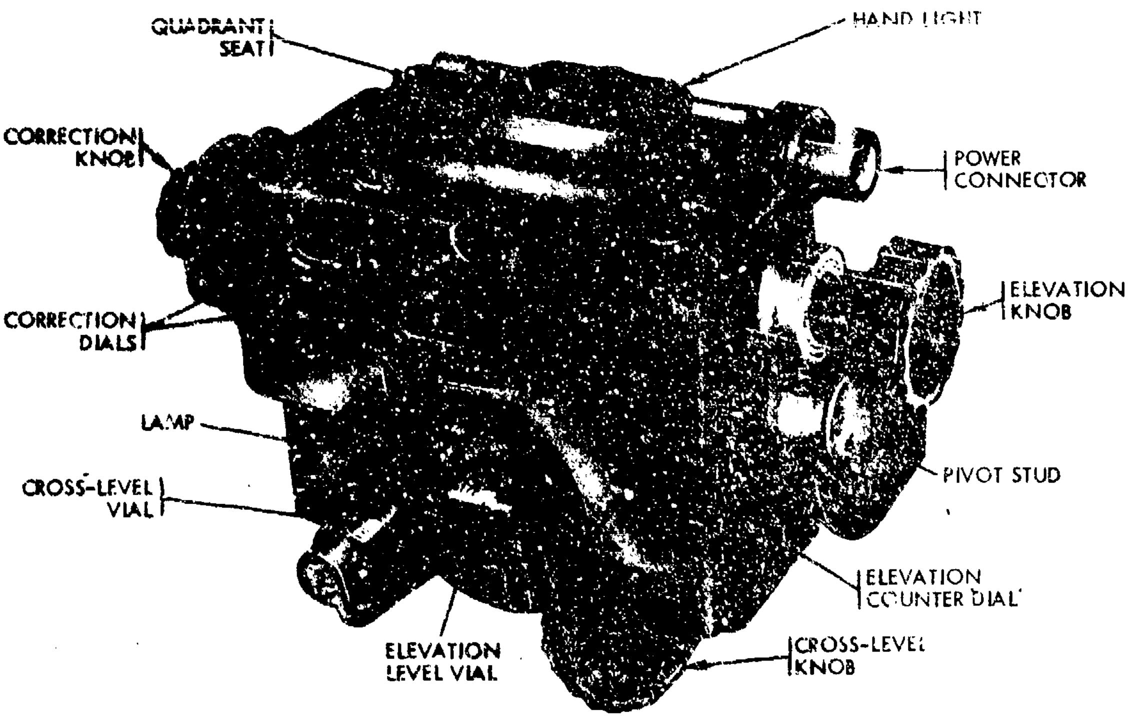


Figure 8-24. Elevation quadrant M15.

within +0.2 mil, the M15 elevation quadrant seats are out of tolerance and should be reported to the direct support maintenance personnel.

(5) To test for parallelism of the breech ring quadrant seats and elevation quadrant M15, add, algebraically, the correction determined by the end-for-end test of the gunner's quadrant and the corrections stamped in the breech ring of the weapon. Place the sum on a tested gunner's quadrant and place the gunner's quadrant on the quadrant seats of the breech ring.

(a) If the bubble of the gunner's quadrant centers, there is no error.

(b) If the bubble does not center, turn the gunner's quadrant micrometer knob until the bubble does center. The reading on the micrometer knob must now agree within +1.0 mil of the reading set on the gunner's quadrant at the beginning of the test for parallelism. If this reading agrees within +1.0 mil, the breech ring quadrant seats and the M15 elevation quadrant are within tolerances for parallelism. If the reading does not agree within +1.0 mil the M15 elevation quadrant is out of tolerance and should be referred to direct support maintenance for adjustment.

8-31. Elbow Telescope Mount M138

Telescope mount M138 (fig 8-26) mounts on elevation quadrant M15 and holds the elbow telescope M139. A lamp attached to a retractible lead on mount M138 provides illumination for the reticle pattern on telescope M139.

8-32. Elbow Telescopes M139

Elbow telescope M139 (fig 8-27) is used on the M110A2 howitzer. Both telescope mounts on telescope mount M138, which mounts on elevation quadrant M15. These telescopes are simple, fixed-focus, 3-power instruments. They are used in direct firing of the weapons. Illuminated reticle patterns are incorporated into the optical systems of the telescopes.

8-33. Care and Maintenance of Sighting and Laying Equipment

a. General care.

(1) Avoid rough handling.

(2) Disassemble the equipment only to the extent authorized in the technical manual pertaining to the weapon.

(3) Keep the equipment dry; never install covers when the equipment is damp or wet.

(4) When the equipment is not in use, keep it protected with the covers provided.

(5) If any instrument is not performing properly, send it to the maintenance support unit for repair.

(6) Do not paint instruments.

(7) Before using an instrument, remove all dust and grit from the contact surfaces.

(8) Wipe off all excess lubricant to prevent the accumulation of dust and grit.

b. Panoramic telescopes and telescopic sights.

(1) Remove dust or grit with a clean camel's-hair brush or lens tissue paper.

(2) Remove oil or grease from rubber eyeshields immediately.

c. Telescope mounts and elevation quadrant.

(1) Keep the level vials covered when not in use.

(2) Do not attempt to force a mechanism beyond its stop.

(3) Insure that lubrication is performed by maintenance support personnel periodically.

d. Gunner's quadrant.

(1) Do not burr, dent, or nick reference surfaces or the notched portion of the frame.

(2) Clean the arc frequently with a small brush or with a brush and drycleaning solvent.

(3) *Never* leave the gunner's quadrant on the weapon during firing.

e. Coated optical elements. The optics of some instruments are coated with a reflection reducing film of magnesium fluoride. Rub coated optics as little as possible. If such a coating is partly removed, *do not remove* the remainder, since any amount of coating will make the sights clearer.

Note. To replace telescopes or telescope mounts, refer to paragraph 2-64, TM 9-2350-304-20.

8-34. Boresighting

a. Definition and purpose. Boresighting is the process of alining the on-carriage sighting and fire control equipment so that the lines of the telescopes (optical axis) are parallel to the axis of the bore, and the mounts (that hold the telescopes) are in coincidence with the tube. The purpose of boresighting is to insure accuracy in laying the tube for elevation and direction. Boresighting is conducted by the section before firing and, when necessary, during lulls in firing. A tested gunner's quadrant (para 8-26) is the fire control instrument used to set the tube at the appropriate elevation and to test other sighting and laying equipment on the weapon.

b. Methods of boresighting. There are three methods of boresighting the heavy weapons. These methods are the testing target method and the distant aiming point (DAP) method. As a field expedient, the standard angle can be used to boresight the heavy weapons; however, if the standard angle is used to put the weapon in boresight, one of the more accurate methods of boresighting (testing target or distant aiming point) must be used at the first opportunity (lulls in firing) to verify that the weapon is in correct boresight. This chapter will describe the two methods of boresighting the heavy weapons. The procedures for establishing and using the standard angle check of boresighting can be found in FM 6-94.

c. *Six steps of boresighting.* Regardless of the method of boresighting performed, there are six basic steps that have to be considered by the chief of section in order to completely boresight the heavy weapons. These six basic steps involve the trunnions, tube, bubbles, elevation scales, target, and telescopes (panoramic and direct fire).

(1) *Trunnions.* The trunnions should be as level as possible when a heavy weapon is being boresighted. The simplest way to insure that the trunnions are level is to emplace the vehicle on level ground. If that is not possible, the method for leveling illustrated in figure 8-25 may be used or the tracks may be leveled by digging and filling under them. Tilt, corresponding to the cant in the weapon when the trunnions are not level, must be introduced in the telescope mount and the testing target when the testing target is used for boresighting. In no case should there be more than 90 mils of cant in the trunnions when using any boresighting method.

(2) *Tube.* The tube of the heavy weapon must be at zero elevation. Perform the end-for-end test of the gunner's quadrant (para 8-27). Add the correction (if any) determined from the end-for-end test to any correction embedded in the breech ring of the weapon. Set the sum on the micrometer of the gunner's quadrant and place the gunner's quadrant on the quadrant seats of the breech ring. Now, using the elevation handcrank, elevate or depress the tube until the bubble in the level vial of the gunner's quadrant is centered. This action places the axis of the tube at zero elevation.

(3) *Bubbles.* Turn all cross-leveling knobs and all elevation-leveling knobs on the mounts of the weapon until the bubbles center within the vials. The bubbles have been placed within coincidence with the axis of the tube without moving the tube.

(4) *Elevation scales.* When boresighting with the testing target and with all bubbles centered, then all elevation scales should read zero. Be sure that all correction scales have been set back to zero. If the scales read zero, then check the M15 elevation quadrant seats and the quadrant seats on the breech ring with a tested gunner's quadrant to see that they are parallel. This parallelism test must agree within 1 mil. The same test must be performed on the panoramic telescope mount M137. If the M15 elevation quadrant seats or the quadrant seats on the panoramic telescope mount M137 are not within 1 mil of parallelism with the quadrant seats on the breech ring, organizational maintenance personnel must be notified. If any of the elevation scales do not read zero, the elevation quadrant M15 and/or the panoramic telescope mount M137 must be checked in accordance with the instructions in paragraph 8-31.

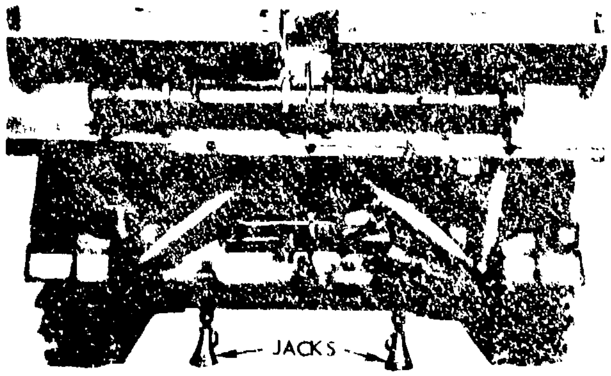
(5) *Targets.* Either of two targets—testing target or distant aiming point—may be used in boresighting the heavy weapons.

(a) Testing target. The testing target (fig 8-29) should be placed to the direct front of the weapon and at a distance between 50 and 100 meters from the weapon. The vertical and horizontal crosslines of the gun tube diagram on the testing target are brought into coincidence with the vertical and horizontal boresight cords of the weapon by moving the target (canting it if necessary) until coincidence is achieved. The maximum allowable cant of the trunnions (and the testing target) is 90 mils. The procedure for alining the vertical and horizontal crosslines of the telescopes and the vertical and horizontal crosslines of the target is described in (6) below.

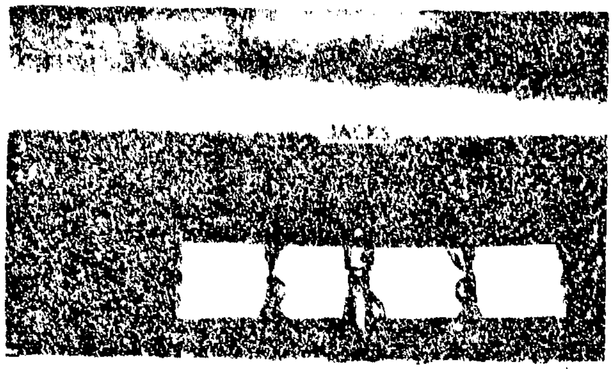
(b) Distant aiming point. The distant aiming point method of boresighting makes use of a definite aiming point at least 1,500 meters from the front of the tube. After the first four steps (para (1) through (4) above) have been completed, then the weapon can be traversed and elevated in order to place the crosshairs on the muzzle exactly on the distant aiming point (fig 8-28) and aline the optical axis of the telescopes with the same point of the distant aiming point as described in (6) below.

(6) *Telescopes.* The optical axis of each of the telescopes (panoramic and direct fire) must be placed parallel to the axis of the tube. This is done with each of the telescopes as follows:

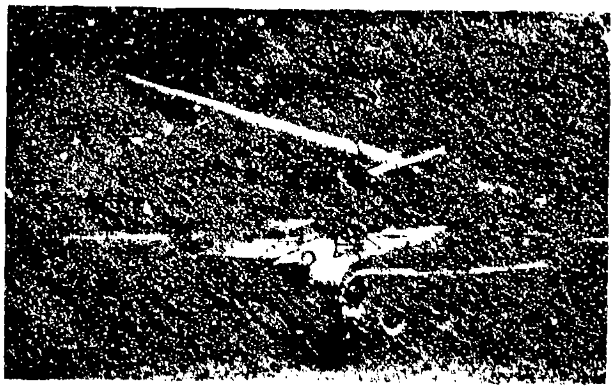
(a) Panoramic telescope M115. By rotating the azimuth knob, adjust the vertical line in the reticle of the panoramic telescope on the distant aiming point (fig 8-28) or on the testing target (fig 8-29), depending on the method of boresighting being used ((5) above). The azimuth counter should read 3200. If the azimuth counter does not read 3200, depress the boresight adjustment shaft (located under the azimuth knob), rotate the shaft until the azimuth counter reads 3200 and release the shaft. Check the reset counter by turning the reset counter knob and see if the reset counter will register 3200. If so, the panoramic telescope is boresighted for direction. Continue the adjustment of the panoramic telescope by adjusting the horizontal line of the panoramic telescope to the distant aiming point (or testing target diagram) by



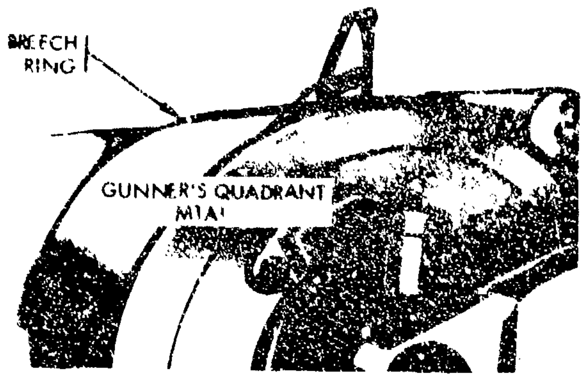
a. Position two mechanical jacks under rear of vehicle.



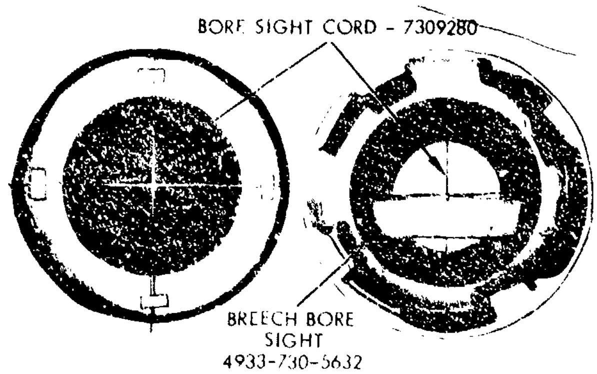
b. Position mechanical jack under front center of vehicle.



c. With fire control quadrant M15 elevation counter set to 0000, center and depress cannon to zero (0) degrees elevation as indicated on elevation level vial of the quadrant.



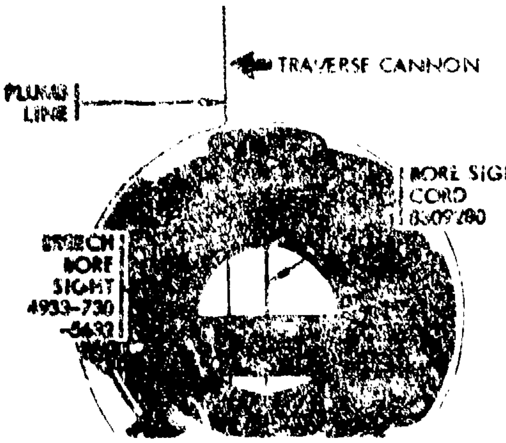
d. Calibrate gunner's quadrant M1A1 following procedures in TM 9-575. Adjust quadrant to 0-degree elevation and position on breech leveling surfaces. Adjust front jack to center quadrant bubble.



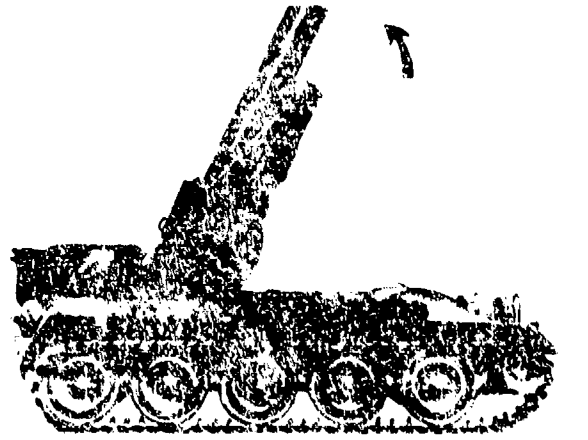
e. Tape bore sight cord to muzzle witness marks and install breech bore sight.

f. Hang plumb line in front of muzzle. Line must be long enough to be visible through barrel or tube with cannon at maximum elevation.

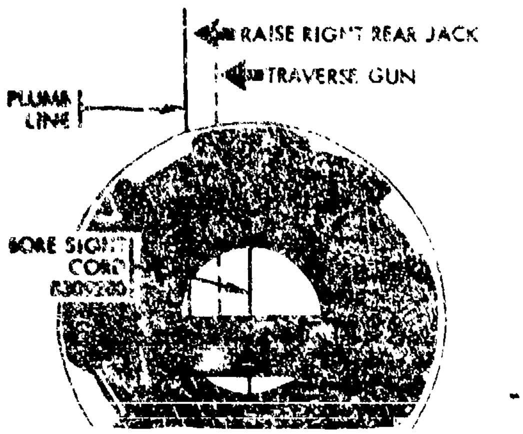
Figure 8-25. Cross-leveling cannon and trunnions.



g. Traverse cannon to aline vertical bore sight cord with plumb line

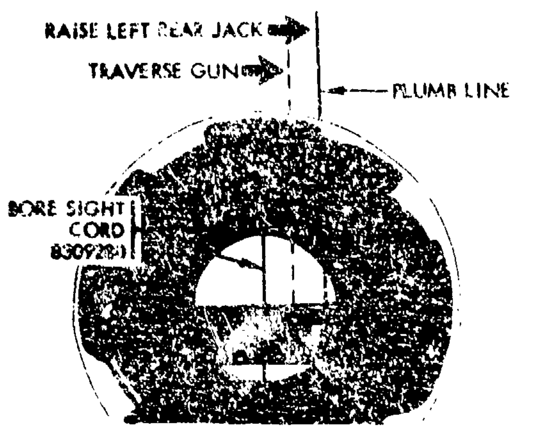


h. Elevate cannon to maximum elevation.



i. Observe plumb line with vertical bore sight cord alinement. Traverse half of error. Adjust rear jack to remove balance of error.

j. Depress cannon to 0-degree elevation.



k. Observe plumb line with vertical bore sight cord alinement. Traverse half of error. Adjust rear jack to remove balance of error.

l. Repeat steps h through k as necessary, checking alinement of plumb line and bore sight cord with cannon elevated alternately to 0 and to 65 degrees until all error is removed.

Figure 8-25. Cross-leveling cannon and trunnions—continued.

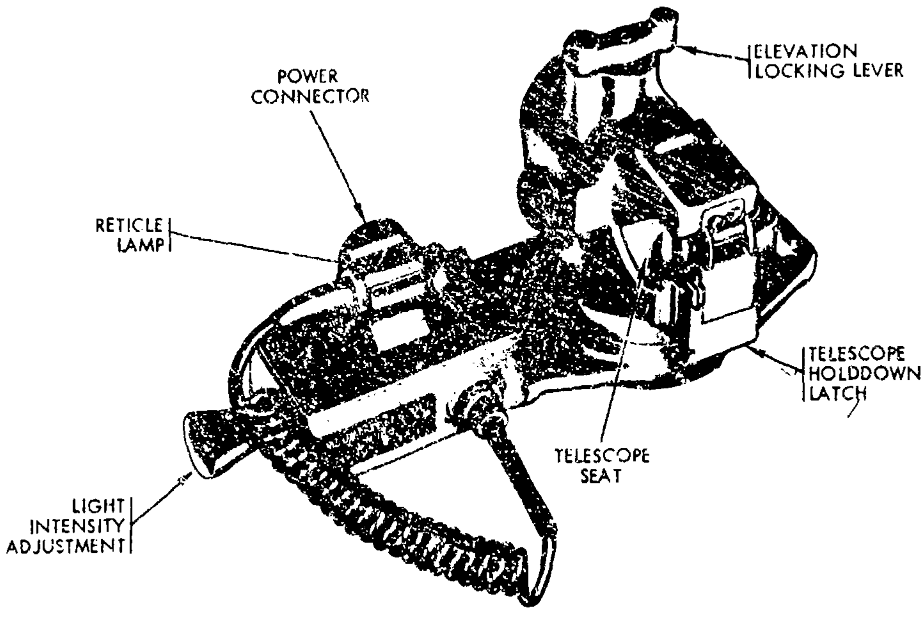


Figure 8-26. Elbow telescope mount M138.

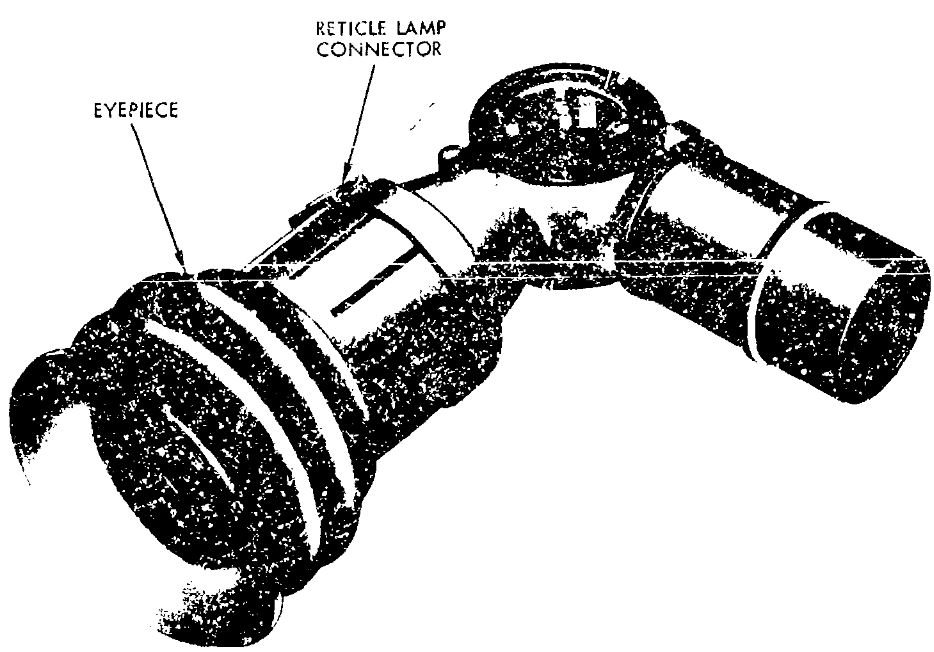


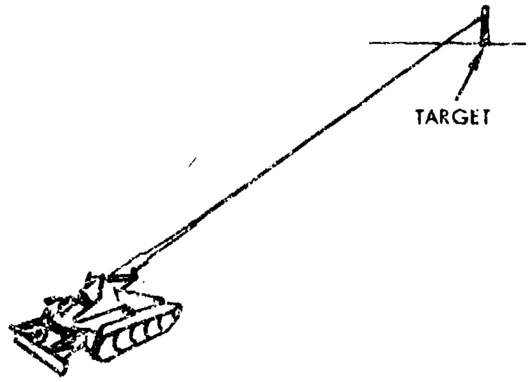
Figure 8-27. Elbow telescope M139.

means of the elevating knob on the telescope. If the fine indexes do not coincide, loosen the three screws on top of the elevating knob and slip the scales. Tighten the three screws and verify the adjustment.

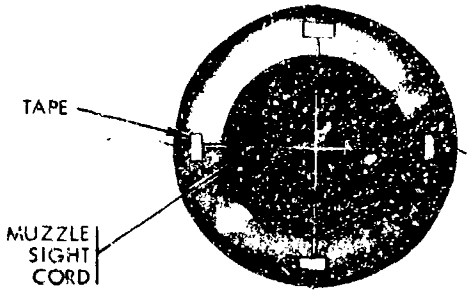
(b) *Elbow telescope M139.* The direct fire telescope can be adjusted to correct for errors in cant, elevation, and deflection by adjusting the reticle patterns to the distant aiming point or testing target as shown in e, f, and g, figure 8-27.

8-35. Special Safety Procedures (Misfire)

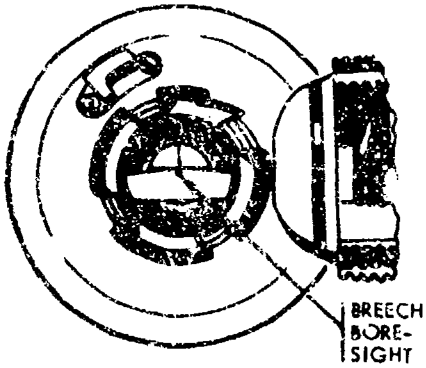
Malfunctions in the firing of artillery ammunition, such as misfires, hangfires and cookoffs, are defined and discussed in *a* through *c* below. When authorized and properly maintained ammunition is fired in properly maintained and operated weapons these malfunctions rarely occur. In order to avoid injury to personnel and damage to equipment, all personnel concerned must understand the nature of each malfunction



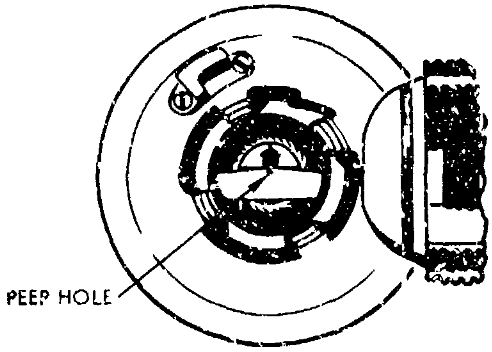
a. Position vehicle on flat, level ground. Select aiming point with well-defined vertical and horizontal axes at least 1,500 meters distant.



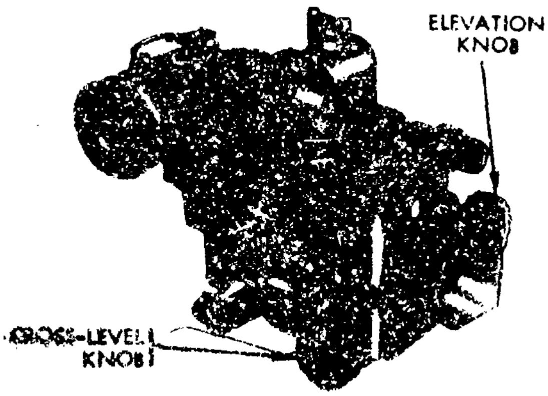
b. Tape muzzle sight cord to muzzle [illegible]ss marks.



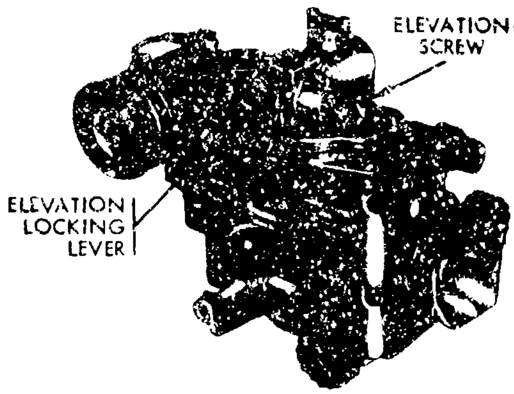
c. Install breech boresight in breech.



d. Aline muzzle crosshairs with horizontal and vertical axes of target while sighting through peep hole in breech boresight.

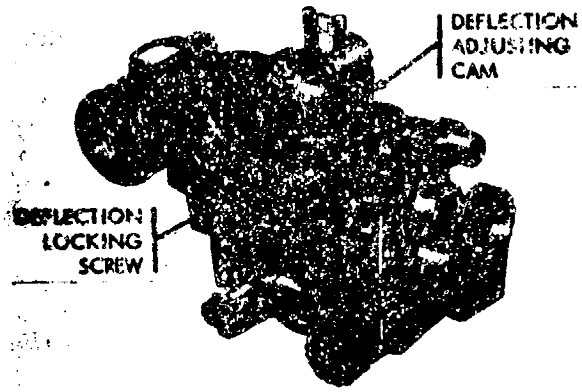


e. Adjust elevation and cross-level knobs until both level vial bubbles are centered on elevation quadrant M15.

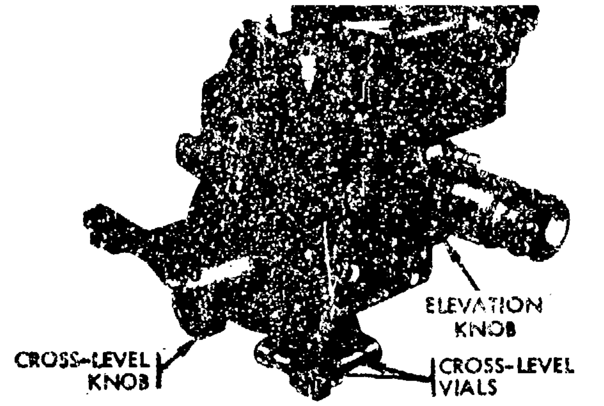


f. Turn elevation locking lever to release elevation screw on telescope mount M138. Rotate screw until horizontal crosshair of reticle of elbow telescope M139 is centered on target. Turn elevation locking lever to original position.

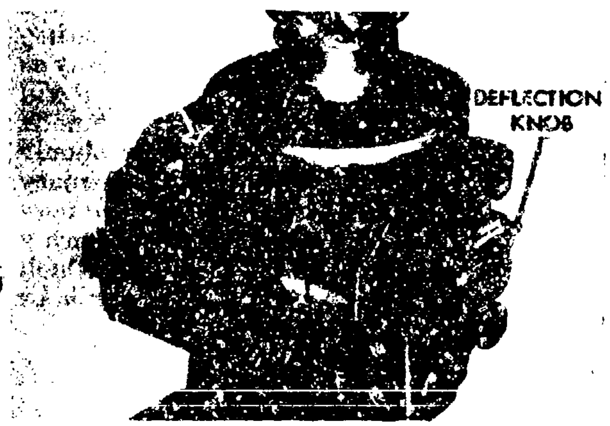
Figure 8-28. Boresighting.



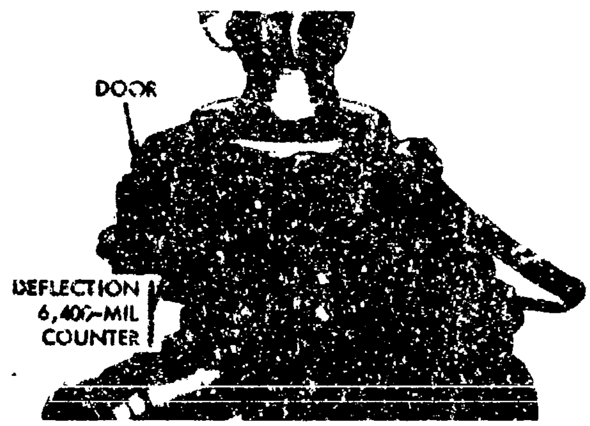
g. Loosen deflection locking screw and rotate deflection adjusting cam until vertical crosshair of reticle is superimposed on target. Tighten locking screw.



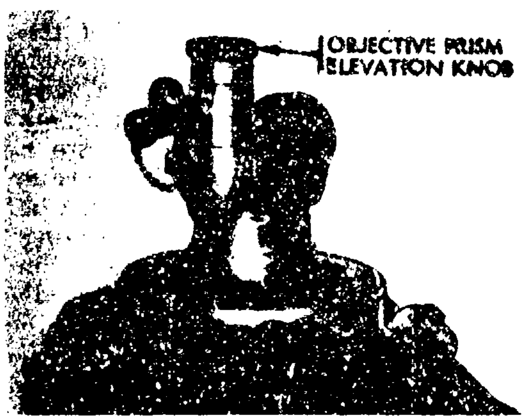
h. Adjust telescope mount M137 elevation and cross-level knobs until both cross-level vial bubbles are centered.



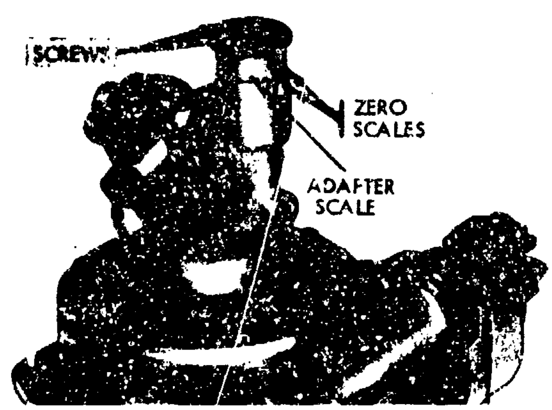
i. Rotate panoramic telescope M115 deflection knob until vertical crosshair of reticle is superimposed on target.



j. Open door of deflection 6,400-mil counter. Push in and rotate boresight adjustment shaft until counter registers 3,200 mils. Close door.



k. Rotate objective prism elevation knob until horizontal crosshair of reticle is superimposed on target.



l. Loosen three screws attaching objective prism elevation knob to adapter. Slip adapter scale, without moving knob, until zero scales coincide. Tighten screws.

Figure 8-28. Boresighting—continued.

and the proper preventive and corrective procedures. General procedures for removing chambered rounds associated with these malfunctions are described in paragraphs 8-36 and 8-37.

a. Misfire. A misfire is a complete failure to fire. It may be due to a faulty firing mechanism or a faulty element in the propelling charge explosive train. A misfire, in itself, is not dangerous, but, since it cannot be immediately distinguished from a delay in the functioning of the firing mechanism or from a hangfire (*b* below) it should be considered as a delayed firing until such possibility has been eliminated. Such delay in the functioning of the firing mechanism, for example, could result from the presence of foreign matter (such as grit, sand, frost, ice, or improper or excessive oil or grease), which might create, initially, a partial mechanical restraint. This restraint, after some indeterminate delay, is overcome as a result of the continued force applied by the spring, the firing pin then being driven into the primer in the normal manner.

b. Hangfire. A hangfire is a delay in the functioning of the propelling charge explosive train at the time of firing. In most cases, the delay, though unpredictable, ranges from a split second to several minutes. Thus, a hangfire cannot be distinguished immediately from a misfire (*a* above) and therein lies the principal danger—that of assuming that a failure of the weapon to fire immediately upon actuation of the firing mechanism is a misfire whereas, in fact, it may prove to be a hangfire. It is for this reason that the time intervals prescribed in paragraph 8-37 should be observed before the breech is opened after a failure to fire.

CAUTION: During the prescribed time intervals, the weapon will be kept trained on the target and all personnel will stand clear of the muzzle and the path of recoil.

c. Cookoff. A cookoff is a functioning of any or all of the explosive components of a round chambered in a very hot weapon, due to heat from the weapon. The primer and propelling charge, in that order, are, in general, more likely to cookoff than the projectile or the fuze. If the primer or the propelling charge should cookoff, the projectile may be propelled (fired) from the weapon with normal velocity even though no attempt was made to fire the primer by actuating the firing mechanism. In such a case, although there may be uncertainty as to whether or when the round will fire, the precautions to be observed are the same as those prescribed for a hangfire. However, should the bursting charge explosive train cookoff, injury to personnel and destruction of the weapon may result. To prevent heating to the point at which a cookoff may occur, a round of ammunition which has been loaded into a very hot weapon should be fired or removed within 5 minutes.

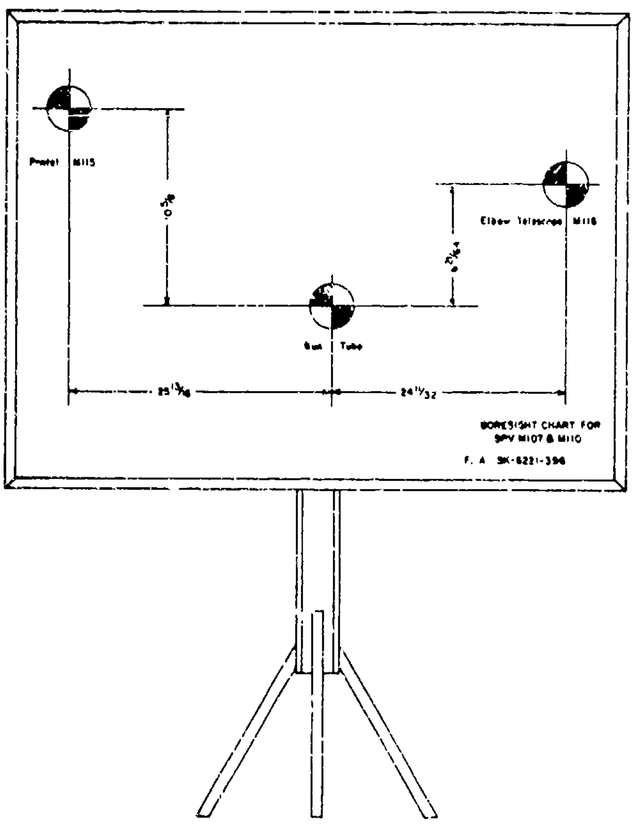


Figure 8-29. Testing target.

8-36. Loading Precautions

Certain precautions must be taken when firing artillery ammunition with a hot tube; therefore, the officer in charge of firing must determine when the tube is hot enough for the procedures and precautions to be applicable. Several factors which may cause a "hot" tube situation to exist are the ambient temperature, the temperature of the ammunition, the rate of fire or number of rounds fired within a specific period, and the charge being fired. In any event a "hot" tube situation exists when a combination of factors could cause a possible cookoff or exudation of the high explosive filler from a chambered round which cannot be fired immediately. If the person in charge of firing determines that a "hot" tube situation exists, the following loading precautions must be observed.

a. Do not chamber a round in the tube until immediately prior to firing.

b. Fire or remove from the weapon within 5 minutes a round that has been chambered in a hot tube.

c. If the round in a hot tube cannot be fired or removed within 5 minutes after loading and a *misfire is not involved*, take the following actions:

(1) Remove the primer.

(2) Evacuate all personnel to a safe distance.

(3) Leave the weapon laid on the target.

(4) Request explosive ordnance demolition personnel for assistance. Release the weapon to ordnance if required.

8-37. Misfire Procedures

a. Misfire procedures--cold tube. After a failure to fire (M110A2, all charges; actuate the firing mechanism two additional times in an attempt to fire. Wait 2 minutes from the last attempt to fire and then remove and inspect the primer.

(1) If the primer is not dented, the fault is in the firing mechanism. Repair the firing mechanism, insert a new M82 primer, and fire the weapon.

(2) If the primer is dented, the primer is at fault. Insert a new primer and fire the weapon.

(3) If the primer fired, the fault is in the propelling charge. Wait 10 minutes (5 minutes after removing the primer), open the breech, and remove and dispose of the defective propelling charge. Insert a new propelling charge and a new primer and fire the weapon.

b. Misfire procedures—hot tube. After a failure to fire all charges, actuate the firing mechanism two additional times in an attempt to fire. Wait 2 minutes from the last attempt to fire and then remove and inspect the primer.

(1) If the primer is not dented, the fault is in the firing mechanism. Repair the firing mechanism, insert a new M82 primer, and fire the weapon. If the round cannot be fired or removed within 5 minutes of chambering, follow the procedures outlined in paragraphs 8-36*c*(2) through (4).

(2) If the primer is dented but did not fire, the primer is at fault. Insert a new primer and fire the weapon if 5 minutes has not elapsed since the round was chambered. If 5 minutes has elapsed, follow the procedures outlined in paragraphs 8-36*c*(2) through (4).

Section VI. SUMMARY

8-38. Review

The 8-inch howitzer M110A2 is the current heavy weapon of the field artillery. This weapon can be interchangeably mounted on a self-propelling carriage that was designed specifically for field artillery purposes and that possesses flexibility, mobility, and stability to a degree never before attainable in heavy field artillery weapons. The entire operation of traversing, elevating, and loading the weapon is quickly and efficiently accomplished through the use of power equipment; however, the weapons can also be operated manually in the event of power failure.

U. S. ARMY
FIELD ARTILLERY SCHOOL
Weapons Department
Fort Sill, Oklahoma

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CHAPTER 9

14.5-MM FIELD ARILLERY TRAINER, M31

Section I. GENERAL

9-1. References

TM 9-6920-361-13.

9-2. Introduction

The purpose of this manual is to provide information on the use of the 14.5-mm field artillery trainer, M31 (fig 9-1) and the improved version of the trainer. The 14.5-mm trainer is a bolt action, single-shot, rifled barrel assembly designed to be fired from a tripod but improved to be fired through the bore of the howitzer as a subcaliber device. The improved version of the 14.5-mm trainer employs an adapter which permits mounting the barrel of the trainer concentrically inside the breech of the tube, thereby permitting the use of the on-carriage fire control equipment to deliver indirect fire. Unlike other artillery training devices, the M31 trainer fires a projectile to a maximum range of 730 meters. The projectile detonates and produces an audible report, a puff of smoke that is visible for 1,000 meters during daylight and a flash of light that is visible for several kilometers at night. The Gorman and Dynamic Training Boards stated an urgent requirement exists for an artillery unit training device which can provide realistic training for all components of the field artillery battery. To meet the requirement a program was initiated to develop an improved version of the 14.5-mm trainer. The improved version of the trainer permits the gunner and assistant gunner to respond to fire commands as though the primary weapon was being fired. A FADAC tape and graphical equipment for the 14.5-mm trainer allows realistic FDC training at battalion and battery. The purpose of fielding the M31 field artillery trainer is to provide a low cost, but still realistic trainer which will allow a field artillery unit to train all personnel involved in the delivery of fire, including gun crews, fire direction personnel, forward observers and survey crews. The trainer also allows realistic training in geographical areas where full scale artillery ranges are not available.

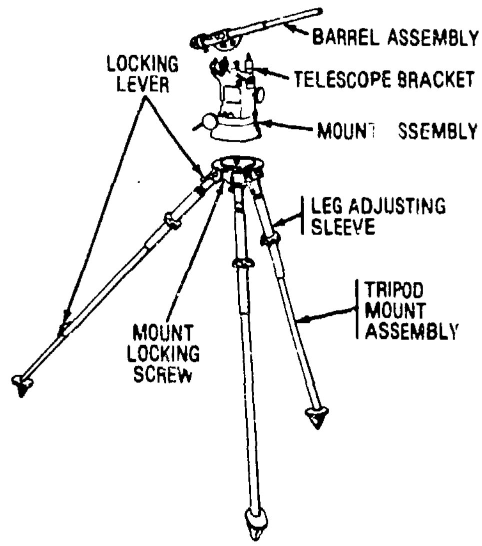


Figure 9-1. 14.5-mm Field Artillery Trainer, M31.

9-3. Composition of M31 Kits

a. In order to provide all field artillery units with the items required to fire the 14.5-mm trainer from the tripod or as a subcaliber device for the primary weapon, seven kits (A—H) have been prepared.

(1) Kit A c sists of the following:

(a) Six graphical firing tables.

(b) Six graphical site tables.

(c) Six tabular firing tables.

(d) Two M18 FADAC tapes (revision 5).

(e) Six users' manuals.

(f) Eight copies of TM 9-6920-361-13 w/change.

(g) Six copies of the safety regulation.

(h) Two safety tongs.

(i) One complete set of repair parts.

*Supersedes HB-9 WCXXWS, Dec 81.

(2) Kit B consists of two M31 trainers and two M12 series panoramic telescopic sights.

(3) Kit C consists of two M31 trainers and two telescope socket assemblies.

(4) Kit D consists of four 14.5-mm gun barrels with cleaning kit.

(5) Kit E consists of six adapters for the 105-mm howitzer M101A1.

(6) Kit F consists of six adapters for the 105-mm howitzer M102.

(7) Kit G consists of six adapters for the 155-mm howitzer M109A1/A2/A3 and four for the 8-inch howitzer M110A2.

(8) Kit H consists of six adapters for the 155-mm howitzer M114A1/A2.

b. Each field artillery battalion will draw three kits as indicated below:

Type Battalion	*Type Kits*
105-mm how M101A1	A, C, E
105-mm how M102	A, F telescope holder assy
155-mm how M114A1/A3	A, C, H
155-mm how M109A1	A, G telescope spt assy
8-inch how M110A2	A, G telescope holder assy

These kits will allow the battery to install a subcaliber device on each howitzer and train as a battery or, in the case of the light and medium battalions, three two-gun batteries can be employed during battalion operations. The heavy battalion can employ three one-gun batteries or two one-gun batteries and one two-gun battery to conduct battalion training.

9-4. Recommended Changes or Comments

Users of this handbook are encouraged to submit recommended changes or comments. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure complete understanding and evaluation. Comments should be forwarded direct to Commandant, US Army Field Artillery School, ATTN: ATSFA-PL-FM, Fort Sill, Oklahoma 73503.

Section II. PREPARATIONS

9-5. General

The degree of training benefits derived from the use of the trainer is in direct proportion to the preparation made by the using unit. In order to use the equipment provided in the training kits, the unit must construct a miniature range, develop a special map and teach personnel to use the special equipment.

9-6. Select a Range

a. When selecting an area for the M31 trainer range, consideration must be given to the safety requirements for indirect fire with the weapon. Dimensions of the surface danger zone are dependent on the nature of the firing and type of surface conditions present within the surface danger zone. Figure 9-2 shows a sample surface danger zone. TM 9-6920-361-13 and P and AR 385-63/MCO P3570.1 explain the procedures for constructing surface danger zones.

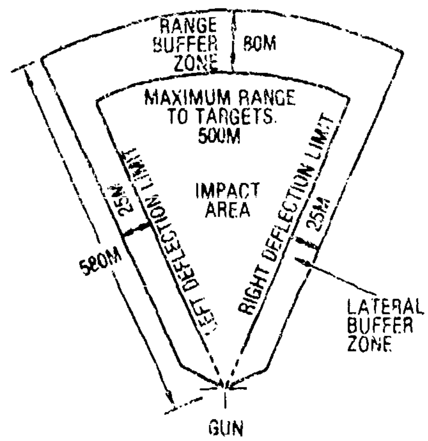


Figure 9-2. Surface danger zone.

b. The area should be fairly level to slightly rolling. Deep ditches or large mounds in the impact area will result in lost rounds. Tall grass or weeds over 6 inches high will also result in lost rounds. The grass and weeds should be cut or burned off prior to firing.

c. Type range. The types of ranges are, in order of priority, the permanent, semipermanent, and temporary. A description of each is discussed below.

(1) *Permanent range.* A permanent range is one which the user controls on a permanent basis and does not have to share the area with other training activities or operations. The targets, reference points, firing point markers, observation posts, and other manmade objects remain in place from month to month. Most military posts, where field artillery is stationed, have sufficient land to accommodate such a range.

(2) *Semipermanent.* A semipermanent range is one which must be shared with other training activities or operations, such as known distance rifle range, drill field, or temporary landing field. The targets, reference points, etc., must be removed after use and all reference stakes which mark the location of targets, firing points, etc.,

must be at or below ground level. The unit can use the range on a scheduled basis.

(3) *Temporary range.* A temporary range is one which the unit can use on a one-time basis (e.g., one day or weekend) and is normally private property, such as a meadow or wheat field after harvest or a pasture which is not being used for grazing.

9-7. Federal Aviation Authority Notification

Since the 14.5-mm trainer is used to conduct indirect fire and is classified as field artillery, the airspace in the firing area represents a hazard to low-flying aircraft. Therefore the 14.5-mm trainer range must be classified as a restricted area by the Federal Aviation Authority. The procedure for obtaining restricted classification of a range is contained in AR 95-50. The unit should contact the Department of the Army Regional Representation (appendix B, AR 95-50) for assistance when preparing a formal proposal. Military reservations are normally classified as restricted areas; therefore, the site for the range can be locally approved.

9-8. Construction of a Range

a. After the site for the range has been selected it should be examined by ground reconnaissance to determine the best position for observation posts and firing positions. The gun position should be almost on line with the observation posts so that the OPs do not interfere with the lateral safety limits. A sketch of typical battery and battalion position areas is shown at figure 9-3. If the area offers good observation from three or four sides, select several firing points/observation posts combinations to permit the unit to displace from position to position.

b. A plan for the target area should be drawn by the project officer and approved by the using unit commander. The plan need not be to scale; however, it should show the relative location of houses, roads, and other manmade objects to be built in the target area. A good plan will save many hours in organizing the work details and will allow several projects to be accomplished simultaneously. For example, if the plan shows four roads in the target area and the project officer has four work crews, he need only to stake the start point, road junctions, crossroads, and terminal point. The work crew will then be able to follow a simple sketch with minimum supervision from the project officer. As the roads are constructed, buildings can be built to represent farm houses, villages and towns along the roads. A house can be made of nine cinder blocks and a plywood roof. The house appears on the observer's map by military symbol. Such a structure is an excellent aid to the observer in locating targets that do not appear on the map. The house should not be used as a target.

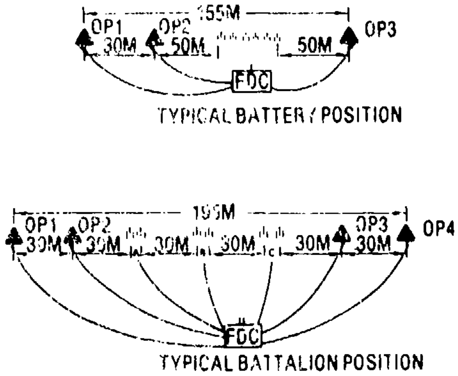


Figure 9-3. Typical battery and battalion positions.

9-9. Special Map

a. For permanent and semipermanent ranges a 1:5,000 scale map of the impact area should be constructed. Most training aids centers can "blow up" a portion of a 1:25,000 or 1:50,000 scale map five or ten times in order to make a 1:5,000 scale map. Shown in figure 9-4 is a type 1:5,000 scale map of 800 meters by 1,100 meters. The map shows the contour lines and terrain features shown on the original map. After the roads, buildings, and other terrain features (such as small mounds and orchards) have been positioned and accurately located by survey, they are included on the map. The map need not be in color if the terrain is fairly level and there are few contour lines; however, it should contain sufficient information on buildings, roads, orchards, etc., which will permit the observer to locate targets in relation to a known point that he can identify on the ground and on the map. The grid lines on the special map are 100 meters (1000 decimeters) apart which permits the observer to use the 1:50,000 scale observed fire (OF) fan and the coordinate scale he would normally use with the 1:50,000 map.

b. When labeling the grid lines on the special map, use the 100-meter value (see fig 9-4). For example, if you are preparing a map of the range which is located in the shaded square of a 1:50,000 map, you would label the grid lines of the special map as shown in figure 9-4, leaving off the 10,000-meter digit and adding the 100-meter digit.

c. Since a temporary range may be available to a unit for only 1 or 2 days, it is not practical to construct a map of the range; therefore, the unit may start the service practice by constructing an OF chart, then switching to a surveyed firing chart when survey is completed. The forward observer will be required to locate all targets using a shift from a known point method until survey has located his position and the OP is plotted on the firing chart. At that time, the forward observer can send polar coordinates in his call for fire (see FM 6-40 for methods of target location). Survey should

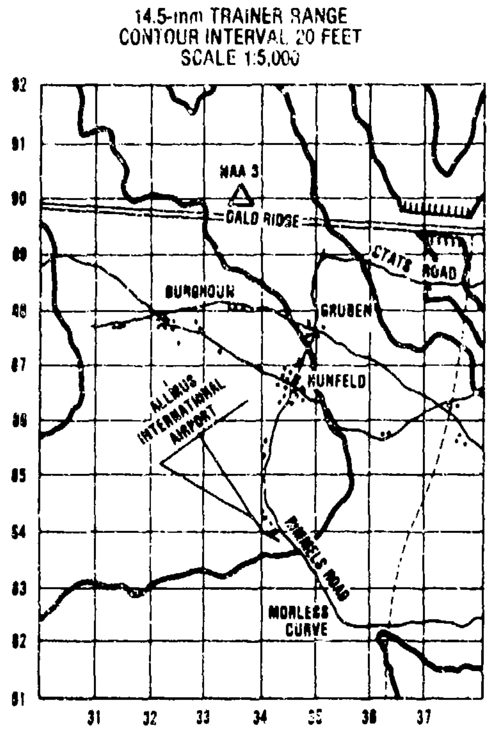


Figure 9-4. Example of a 14.5-mm range map.

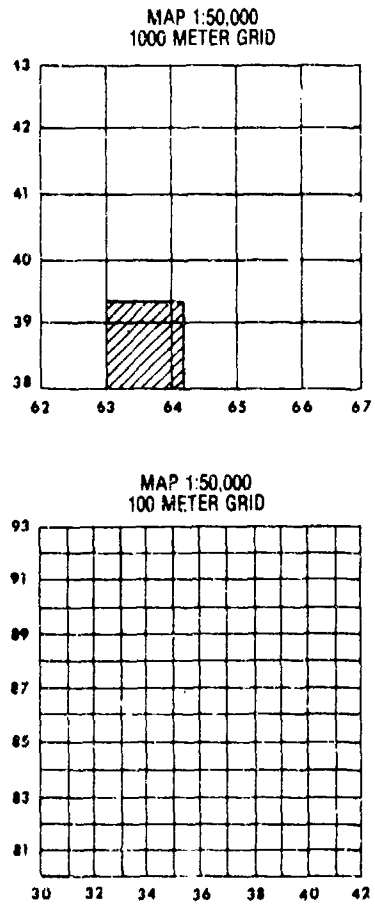


Figure 9-5. Labeling the special map.

start at the earliest opportunity and, if possible, be completed prior to the start of the service practice, negating the necessity of constructing an OF chart. The survey party can also provide the forward observer with a crude map of the area by drawing 500-meter grid lines between the 1000-meter lines on a 1:25,000 grid sheet, then labeling each grid line with its 100-meters (1000 decimeters) designation, plotting the critical points (reference points, buildings, etc.) on the grid sheet. The grid sheet will then become a 1:5,000 scale map with 1:50,000 grid lines. (See figure 9-6.)

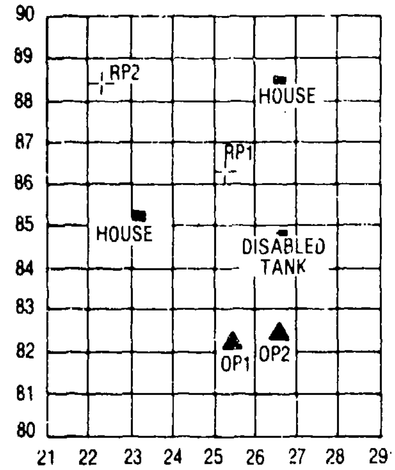


Figure 9-6. Special grid sheet map.

9-10. Survey Requirements

The battalion survey party must locate all critical points (buildings, road junctions, watertowers, etc.) to the nearest 1/10 meter with an accuracy of 1 in 500. This information will be required to construct the special map. All targets, firing points, reference points, and observation posts must also be located by survey to the same degree of accuracy. The firing point marker shown in figure 9-7 is used on a permanent range. It is a metal rod with a flat piece of metal 12″ × 6″ welded to it. A 3-foot piece of pipe driven in the ground 2½ feet serves as a holder for the firing point marker. Permanent communications can be installed between firing points, OPs and FDCs if the unit uses the same combination of OPs and gun positions. Reference points in the impact area are used by the officer in charge to identify targets to the observer. For example, FROM REFERENCE POINT THREE, GO RIGHT 35 MILS AND DOWN FROM THE SKYLINE ZERO MILS WILL PLACE YOU ON A SELF-PROPELLED GUN. A permanent reference point can be a piece of telephone pole 8-feet long with 3 feet in the ground. One-foot numbers on three sides permits all-round identification figure 9-8. On temporary ranges, portable reference points, such as a volleyball net pole, can be positioned in the impact

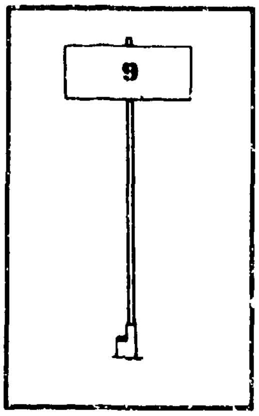


Figure 9-7. Firing point marker.

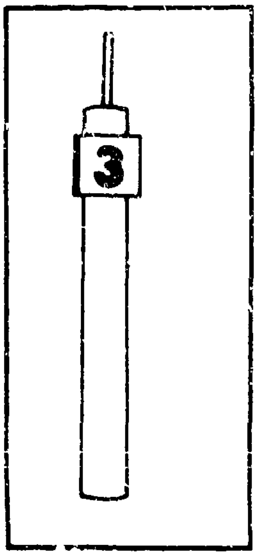


Figure 9-8. Permanent reference point.

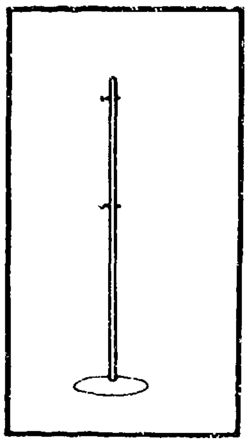


Figure 9-9. Temporary reference point.

area figure 9-9. Such a reference point need not be located by survey. The officer in charge should determine the azimuth to the reference point prior to the conduct of the service practice. The battalion survey party should provide the battalion S3 with a list of targets, firing points and OPs showing the coordinates of each to the nearest 0.1 meter. The list should also reflect the target number and description for ease of identification. A sample target list is shown below.

Tgt No.	*Coordinates (M)*		*Alt (M)*	*Description*
21	2168.1	3826.5	391	Self-propelled gun
22	2207.4	3794.6	389	Red 8-inch propellant container
23	2294.5	3788.2	392	Half-buried white auto tire

9-11. Firing Battery Procedures

a. When the 14.5-mm trainer is mounted on the primary weapon as a subcaliber device, the on-carriage fire control equipment, traversing and elevating mechanisms will be used by the crew to lay the weapon for direction and elevation. The chief of section, gunner and assistant gunner will perform their duties as though the primary weapon is being fired, except the breech is not opened and closed. Cannoneer number 1 will load the piece. During the conduct of an observed fire mission, realistic commands are announced to the section, i.e., BATTERY ADJUST, #3 1 ROUND AT MY COMMAND SHELL HE LOT XY CHARGE 3 FUZE QUICK DEFLECTION 3270, QUADRANT 335 1 ROUND TIME IN EFFECT. Each command will require the section to respond in much the same manner as though the primary weapon is being fired. The weapon can be serviced by a 4-man crew—a chief of section, gunner, assistant gunner and number 1 cannoneer.

b. The 14.5-mm projectile presents a burst about 1/10 the size of a 105-mm HE burst, consequently, when the bursts are more than 5 meters apart the observer has difficulty in spotting the center of the two bursts for range. Therefore, when positioning the weapons, the lateral distance between tubes should not exceed 5 meters, except in the case of heavy artillery when area adjustments are conducted with a single gun. Special corrections can be applied to fire for effect data if the weapons are more than 5 meters apart, but it is unrealistic to apply special corrections during the adjustment.

c. Boresighting procedures are contained in the instructions on installing the adapter and gun barrel.

d. During firing, the bore should be cleaned with the steel bore brush every 10 to 15 rounds to reduce the possibility of a muzzle burst. There is considerable buildup of cosmoline in the tube during firing and if it is not removed there is a loss in range and eventually the round will burst at the muzzle. It is not necessary to remove the 14.5-mm tube from the adapter for cleaning. Remove the bolt and swab the bore from the breech end of the tube. After firing has been completed and the adapter is removed, both the primary tube and 14.5-mm tube must be cleaned as though firing was done from both tubes. The adapters are cleaned using the same cleaning material as used for the tube and bolt.

e. A muzzle burst is currently considered a malfunction. In the event of a muzzle burst, the officer in charge of firing will follow the guidance contained in AR 75-1, which is basically to suspend firing immediately and notify the ammunition officer from which the unit drew the ammunition of the malfunction. The ammunition officer will provide the OIC with necessary guidance.

f. Although no overhead firing is permitted with the 14.5-mm trainer, the battery executive should compute the executive's minimum quadrant elevation and report it to the FDC. Crest clearance for the 14.5-mm trainer is 5 decimeters. Either the tabular or graphical solution is acceptable.

Section III. GUNNERY PROCEDURES

9-12. General

All information necessary to perform observer operations and to operate the fire direction center will be found in FM 6-40 and TM 9-6920-361-13 and P. It is important to consult these manuals since there are some unique procedures associated with the 14.5-mm trainer.

9-13. Observer Procedures

When the observer is provided a special map as previously discussed, normal observer procedures, to include the use of the OF fan, are used for determining the location of targets. The OT factor determined by the observer is based upon thousands of decimeters rather than thousands of meters. For example, an observer-target distance of 2,800 decimeters (280 meters) would result in an OT factor of 3. The observer corrects for deviation by multiplying the measured deviation by the OT factor and announcing his corrections to the nearest 10 decimeters, i.e., RIGHT 60. The bracketing method of adjusting for range is used by the observer. Caution should be exercised in establishing the range bracket; in many cases, the observer thinks his rounds are much closer to the target than they actually are. If the rounds are 30 meters (300 decimeters) short of the target the observer should announce ADD 400 in order to obtain a range bracket.

Section IV. AMMUNITION

9-14. General

a. The 14.5-mm trainer ammunition is classified as "fixed" ammunition and is ready for firing as it comes from the cardboard packing box. All rounds are identical in appearance except that the fuze designation, cartridge designation, charge designation and manufacturer's lot number are inscribed on the side of the cartridge case in black indelible ink. The cartridge size and manufacturer's identification are stamped on the base of the cartridge case as shown in figure 9-10. Three types of fuze action are available for use with the trainer.

(1) A point detonating (PD) fuze, M183, which produces a burst when the projectile strikes the ground or an object.

(2) A 3-second delay fuze M181 and a 6-second delay fuze M182 which produces airbursts when fired at a time of flight in excess of 3 seconds and 6 seconds respectively. The latter two fuzes are not "delay" as we think of them. They are factory-set time fuzes which do not have a point detonating element.

b. The projectile is coated with cosmoline under the cartridge case (see figure 9-10). Some of the cosmoline may appear on the projectile forward of the cartridge case. Unless the exposed cosmoline collects dust or dirt it should not be removed. The cartridge should be free of sand, dirt, moisture, frost, snow, ice or other foreign matter before loading. The round should not be removed from the cardboard box until the weapon is to be loaded in order to keep the ammunition clean.

c. The ammunition should be protected from the sun, rain, dust or other damaging element in order to maintain standard performance of the ammunition. Due to the low muzzle velocity (100 meters per second) a small increase or decrease from the standard will result in several decimeters in range dispersion.

d. When the fuze functions it causes the explosive to blow off the plastic base and the "burst" appears. Since there is no fragmentation, the projectile may ricochet some distance from the point of impact depending on the angle of impact and the condition of the ground.

9-15. Police of Duds

Due to the nonfragmentation of the projectile, it will appear that there are many "duds" in the impact area after firing. Such is not the case. A "dud" can be identified by having a black plastic cap on the base of the projectile. If it is necessary to move the dud for disposal by EOD personnel, use the 24-inch tongs provided in Kit A to handle the dud. Semipermanent and temporary ranges may require policing of all projectiles after firing is completed. A projectile should be treated as a dud until it can be determined that there is NO plastic cap attached to the base of the projectile. When picking up a dud with the tongs, position the projectile in the tongs so that the plastic cap is away from the body.

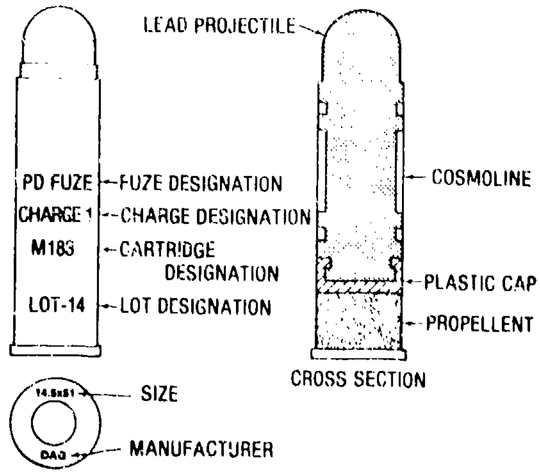
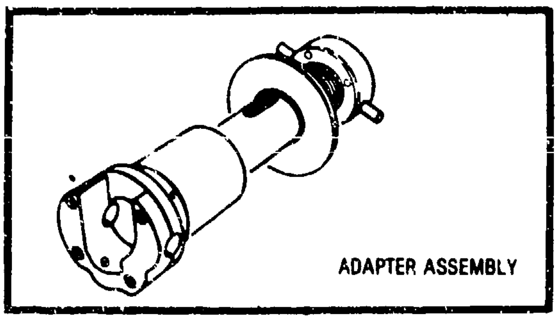


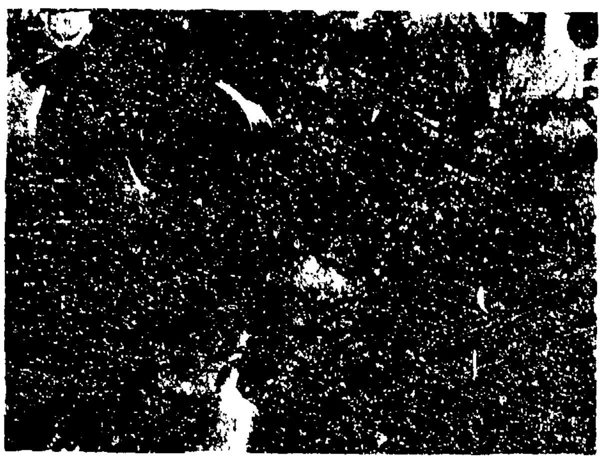
Figure 9-10. 14.5-mm trainer ammunition.

Section V. INSTALLATION

9-16. Installation Instruction for the M109A1/A2/A3/M110A2

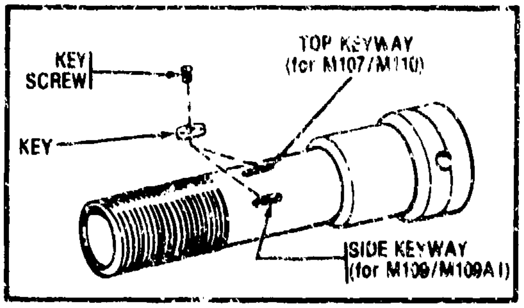
The 14.5-mm gun barrel is mounted in the breech of the M109A1/A2/A3 155-mm howitzers and the M110A2 8-inch howitzers as a subcaliber device. To mount the gun barrel and boresight the piece follow steps 1 through 14.

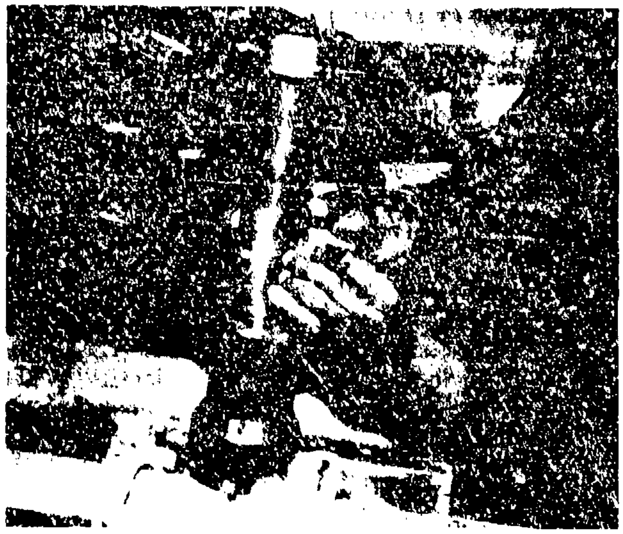




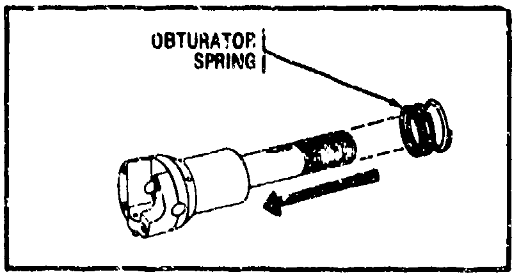
Step 1: Open the breech of the howitzer and remove the obturator group, obturator spring and firing mechanism housing assembly.

Step 2: Remove the adapter nut and washer.

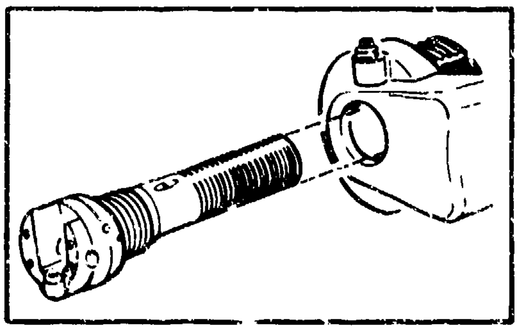




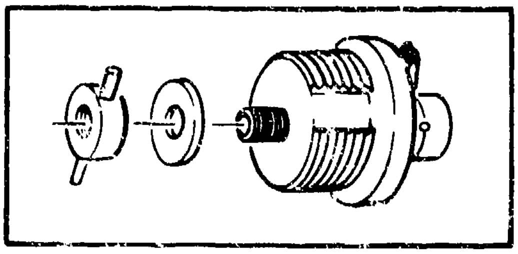
Step 3: Using the 7/64 allen wrench provided, attach the key in the appropriate keyway. The top keyway is for the M110A2 8-inch howitzer; the side keyway is for the M109A1/A2/A3 155-mm howitzers.

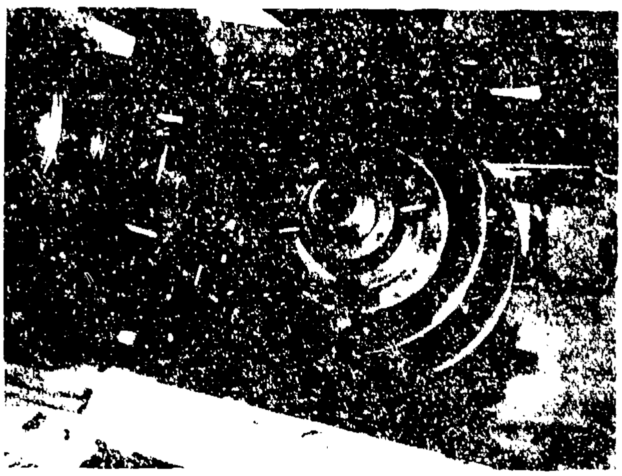


Step 4: Place the obturator spring over the adapter.

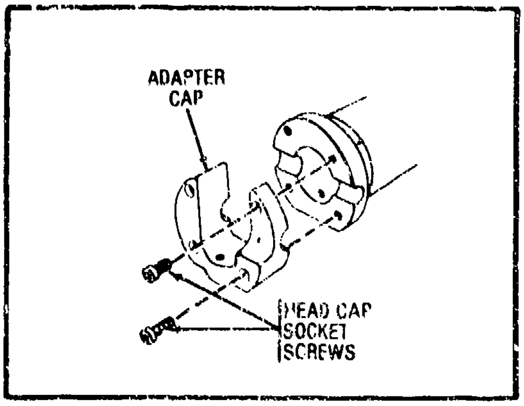


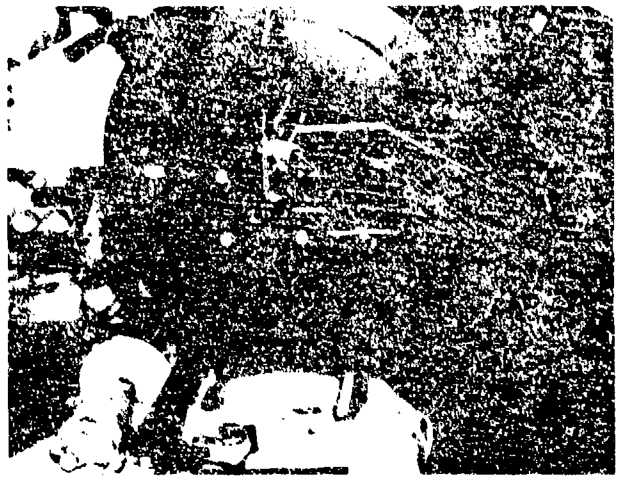
Step 5: Insert the adapter in the breechblock from rear to front.



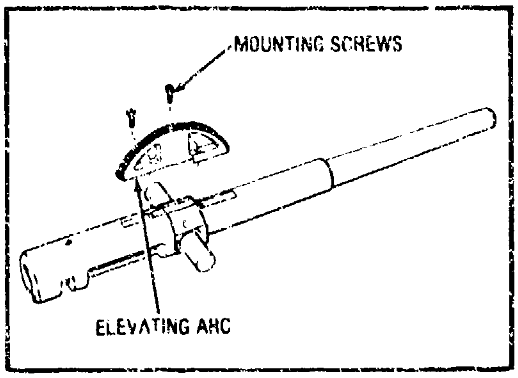


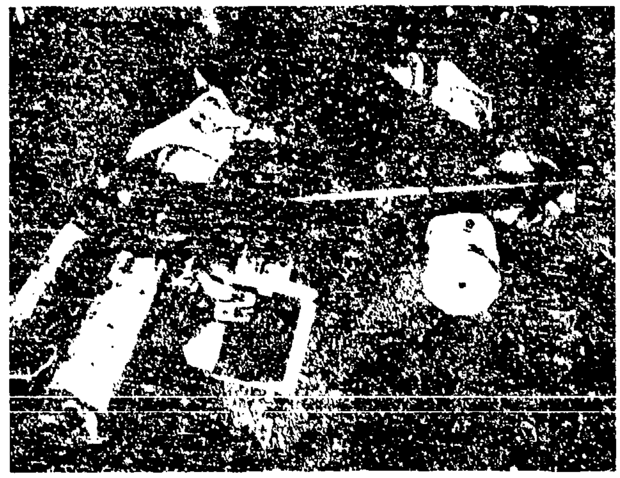
Step 6: Place the washer on the adapter; then tighten the nut until the spring is compressed; then loosen the nut two turns.



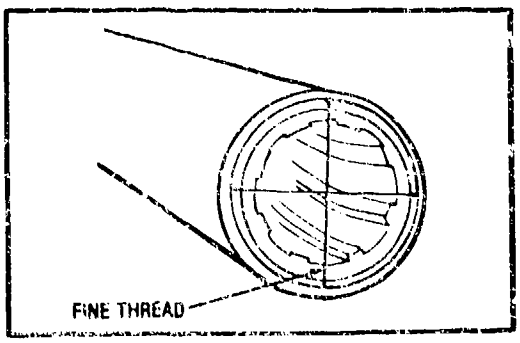


Step 7: Using a [illegible]-inch allen wrench from the mechanic's tool set, remove the four head cap socket screws.

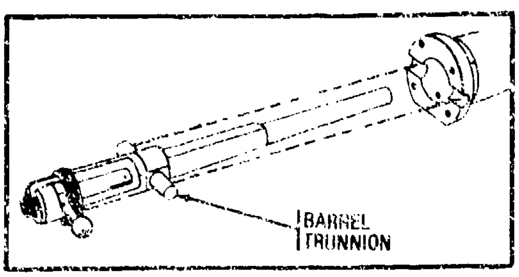




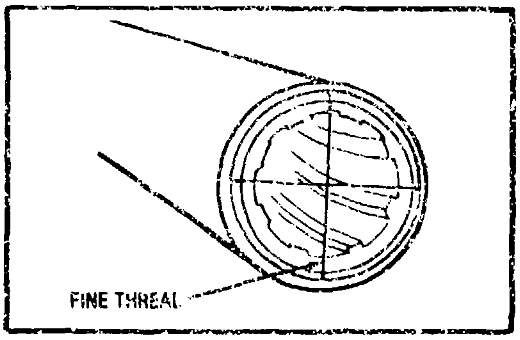
Step 8: Using a screwdriver, remove the elevating arc from the gun barrel.



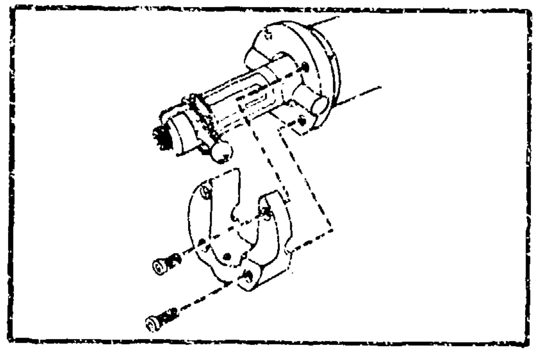
Step 9: Attach thread across the four witness marks on the end of the tube.



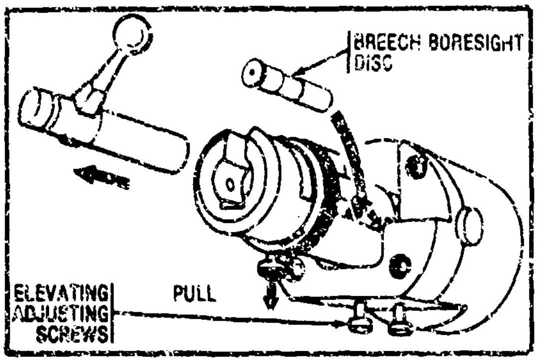
Step 10: Place the gun barrel in the adapter, muzzle first.



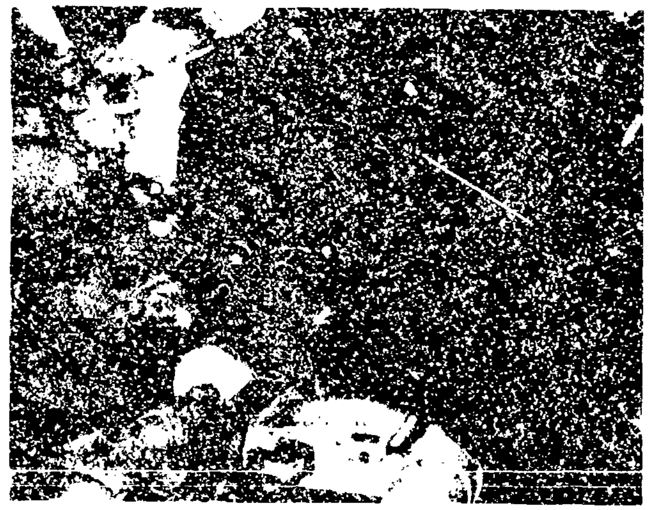
Step 11: Place boresight strings on the muzzle of the howitzer.

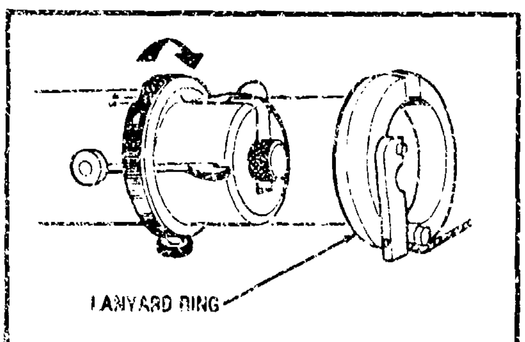


Step 12: Secure the adapter cap to the body but do not tighten the four screws until the gun barrel is near the center of the adapter.

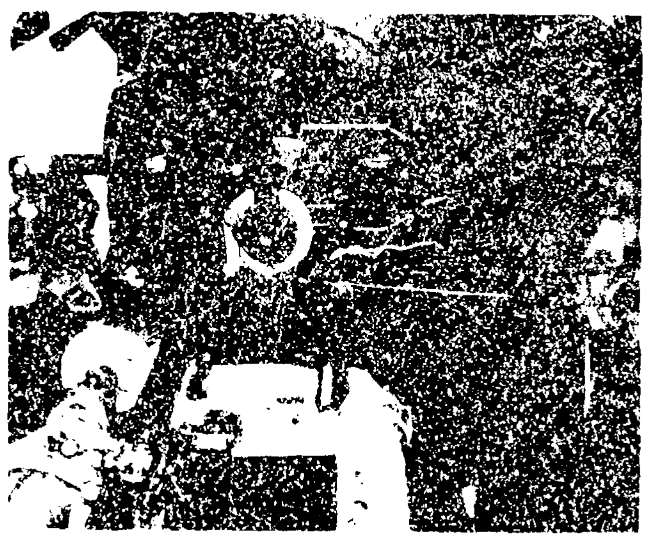


Step 13: Close the breech; remove the bolt by pulling down on the locking cap and pulling the bolt to the rear. Sighting through the breech boresight disc, aline the gun barrel horizontal crosshair boresight string with the horizontal crosshair string on the muzzle of the howitzer by tightening one of the elevating, adjusting screws. Boresight the 14.5-mm trainer using the distant aiming point method.



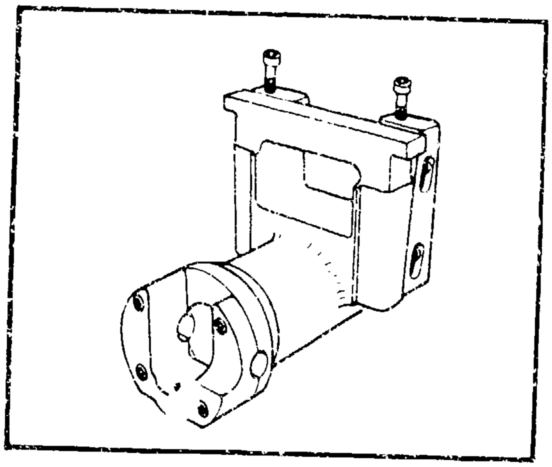


Step 14: Replace the bolt. Turn the safety ring to the "fire" position. Place the lanyard ring over the rear of the breech, matching the openings of the breech and the lanyard ring. The piece may be fired by pulling the lanyard from either side.

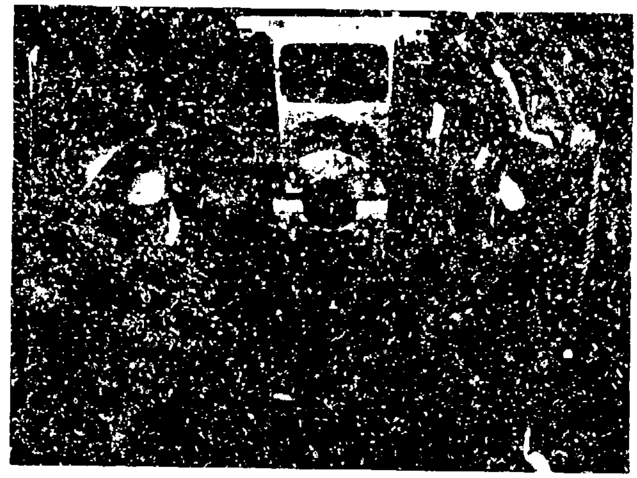


9-17. Installation Instruction for the M102 Howitzer

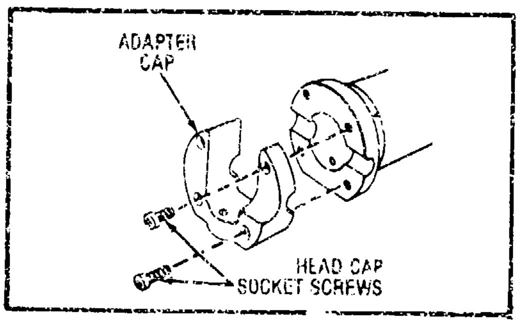
The 14.5-mm gun barrel is mounted in the breech of the M102 howitzer as a subcaliber device. To mount the gun barrel follow steps 1 through 8.



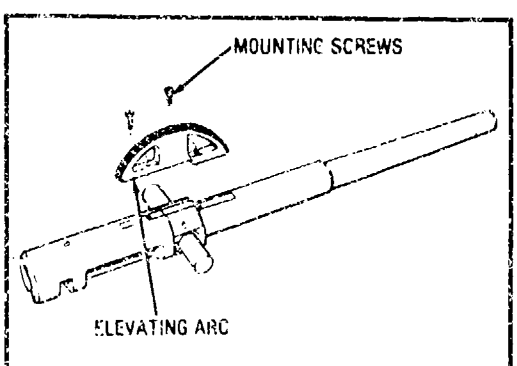
ADAPTER ASSEMBLY



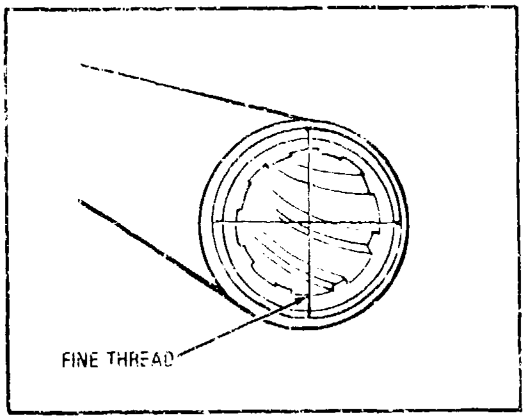
Step 1: Open the breech and place the adapter in the breech recess. The gib adjusting screws should be in the unscrewed position. Make sure the adapter rests against the breech ring; then tighten the gib screws.



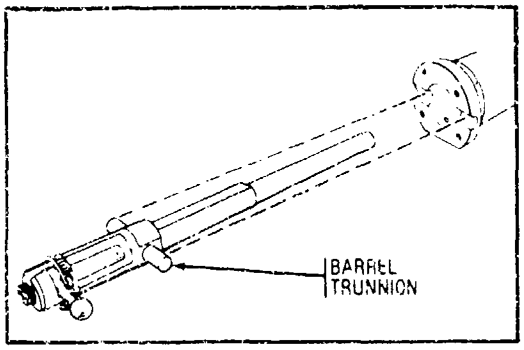
Step 2: Using a ¼-inch allen wrench from the mechanic's tool set, remove the four head cap socket screws.



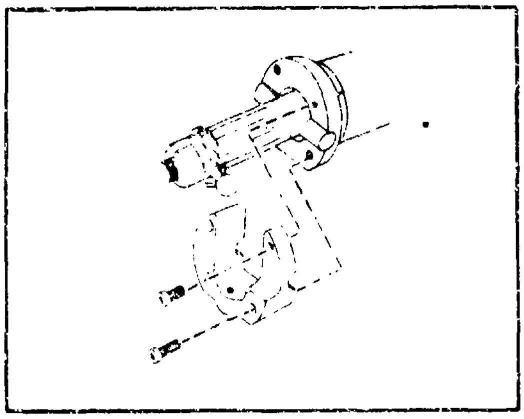
Step 3: Using a screwdriver, remove the elevating arc from the gun barrel.



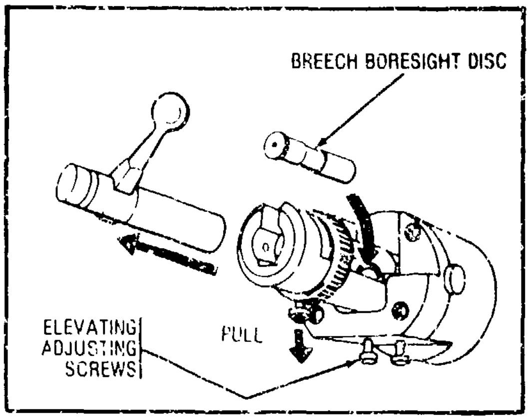
Step 4: Attach fine thread across the four witness marks on the end of the tube by using a rubber band. Also place boresight strings on the muzzle of the howitzer.



Step 5: Place the gun barrel in the adapter and engage the barrel trunnions with the adapter slots.



Step 6: Lock the barrel into position by securing the adapter cap to the body. Do not tighten the four screws yet.



Step 7: Boresight the 14.5-mm gun in the following sequence:

a. Remove the bolt and install the breech boresight disc.

b. Sight through the breech boresight disc and align the horizontal boresight string of the gun with the horizontal cross-hair string on the howitzer. To raise the barrel, tighten the front elevating adjusting screw. To lower the barrel, loosen the front screw and tighten the rear screws.

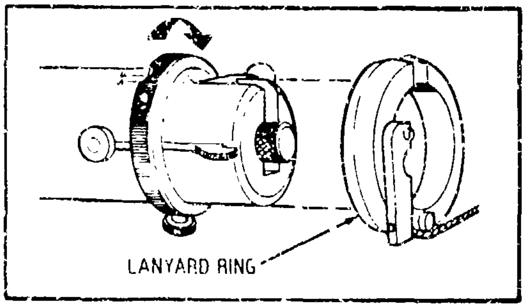
c. When the horizontal crosshairs are in alinement and the two elevating screws are tight, tighten the four head cap socket screws.

d. Remove the howitzer boresight strings.

e. Select a distant aiming point (DAP) at least 1,500 meters from the weapon. Sighting through the breech boresight disc aline the 14.5-mm barrel on the DAP.

f. Refer the panoramic sight to the distant aiming point. The reading should be 3,200 mils. If the reading is not 3200, adjust it to 3,200 mils.

g. Remove boresight disc and install breechbolt.



Step 8: Turn the safety ring to the "fire" position. Place the lanyard ring over the rear of the breech, matching the openings of breech and the lanyard ring.

9-18. How To Set-Up the 14.5-mm Trainer on Tripod

The 14.5-mm trainer has four major assemblies. The four assemblies are packed in their shipping/storage chest along with maintenance tools and equipment (figure 9-11). To set-up the trainer on tripod refer to figure 9-12 and perform steps 1 through 11.

The distant aiming point method of boresighting is used when the 14.5-mm trainer is mounted on the tripod. To boresight the trainer:

a. Center both mount bubbles.

b. Remove the bolt.

c. Install breech boresight disc. (The breech boresight disc is a fired cartridge case that has a 1/16-inch hole drilled in the center of the bore.)

d. Attach cross thread to the muzzle.

e. Sight the tube onto a distant aiming point (1,500 meters).

f. Aline panoramic telescope sight on the same distant aiming point using the tangent screws on the telescope mount.

g. Perform the end-for-end test of the gunner's quadrant. If the error exceeds 0.4 mils, it should not be used.

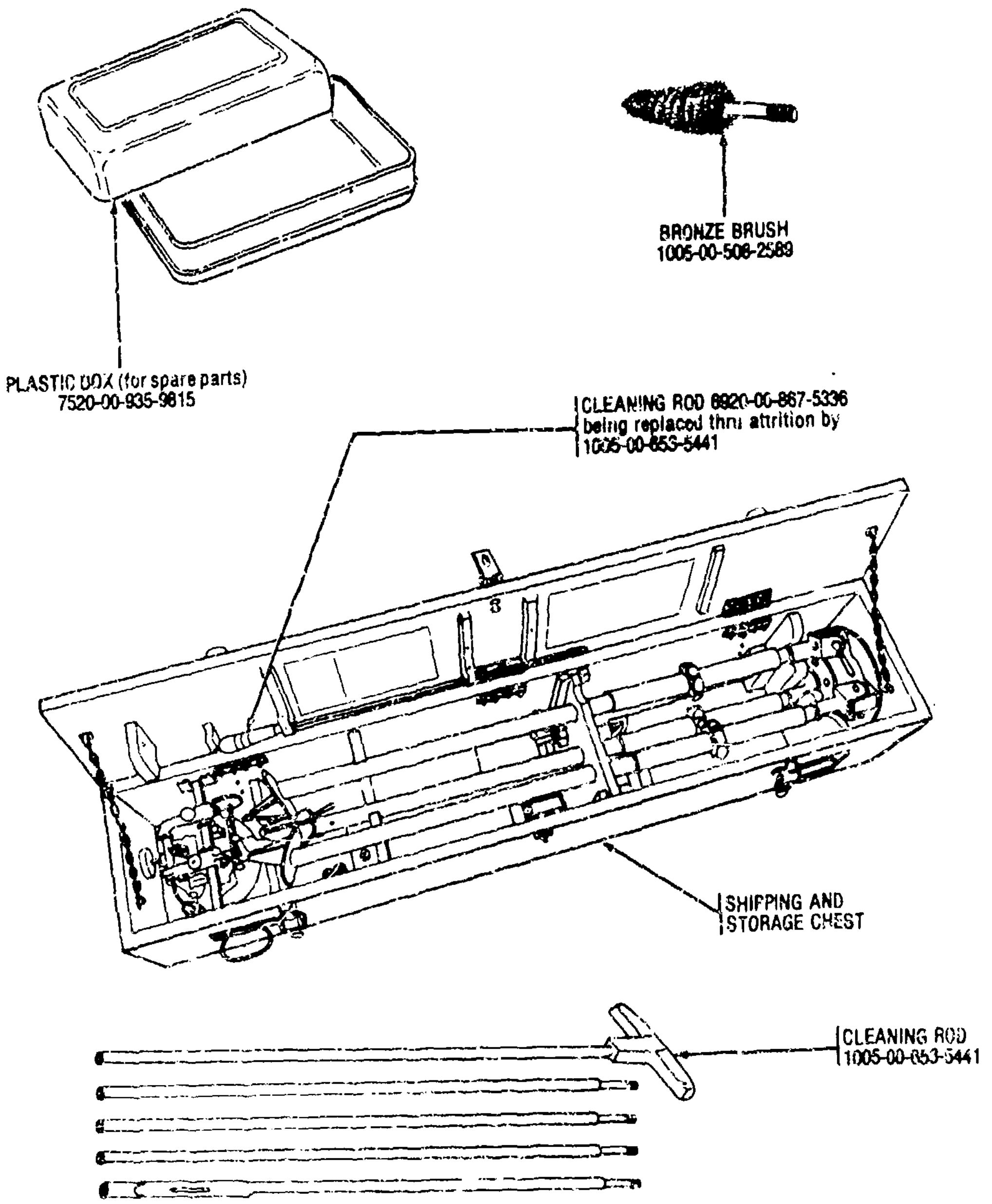


Figure 9-11. M31 trainer in chest.

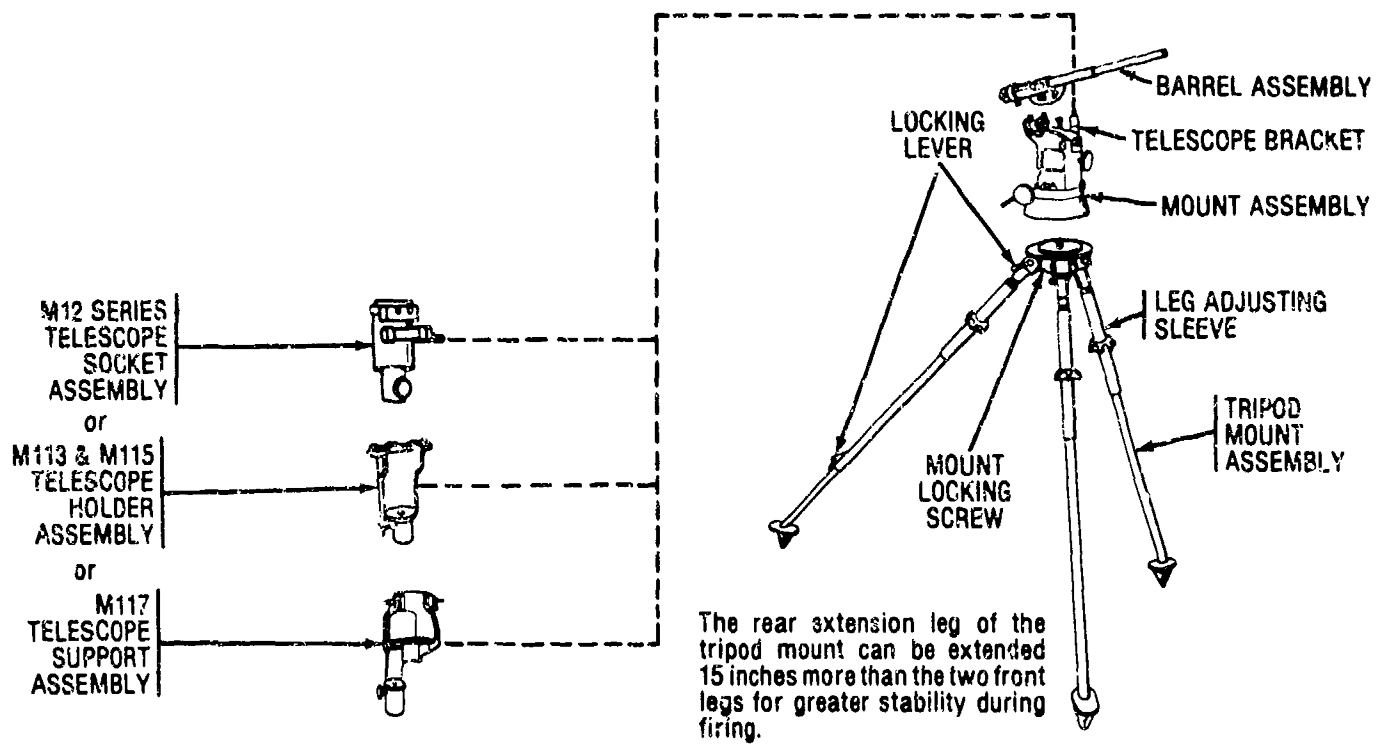


Figure 9-12. Mount and tripod assemblies.

Step 1: Remove the tripod assembly from the storage chest. (Note that one leg has a locking lever near the bottom. This leg is known as the rear leg.)

Step 2: With the rear leg pointing in a direction opposite to the direction of fire, spread the two front legs about 55 inches apart and lock them in place by turning the leg lock levers to the outward position.

Step 3: Unlock the locking lever at the bottom of the rear leg and extend the leg about 15 inches; then lock it in the extended position by tightening the lower locking lever.

Step 4: Place the rear leg in the ground so that the top of the tripod assembly is approximately level.

Step 5: Extend each leg until the yellow ring can be seen. (The yellow ring indicates the center of the threads; these are two red rings on each leg which indicates the rotating collar has reached the end of the threads. Do not turn the rotating collar beyond the red rings.)

Step 6: Remove the mount assembly and place it on top of the tripod assembly.

Step 7: Tighten the mount locking screw into the mount assembly; then open the trunnion caps.

Step 8: Remove the barrel from the chest and attach it to the mount assembly by placing the trunnions in the recesses; then lock the trunnion caps.

Step 9: Remove the telescope socket assembly from the chest; attach it to the mount assembly by tightening the telescope locking screw. (The socket assembly is designed to support the M12-series panoramic telescope sight.)

Step 10: Level the mount. There are two level vials on the mount. With the tube pointed in the approximate direction of fire, turn the traversing handwheel until one of the level vials is directly over the rear leg; this one will be known as the "cross level vial." The other level vial will be near the right front leg and will be known as the "horizontal level vial." The horizontal level vial bubble is centered by turning the rotating collar of the rear leg. The cross level vial bubble is centered by simultaneously turning the rotating collar of the two front legs either toward each other or away from each other.

Step 11: Place the M-12 series panoramic telescope sight into the telescope socket.

9-19. Firing the Trainer

a. Loading. Pull the breech bolt to the rear and make sure the bore and chamber are dry and free of dirt and foreign matter. Place safety in the safe position, insert a cartridge in the chamber, and close the bolt.

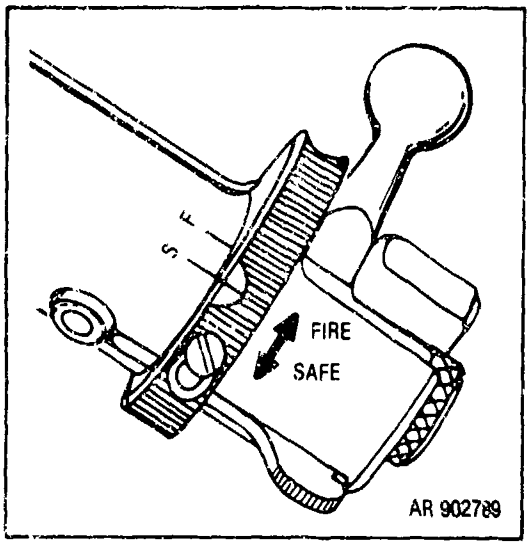


Figure 9-13. Operation of safety.

b. Firing. Rotate safety to fire position (fig 9-13). Depress the trigger by pulling the lanyard, or if the lanyard ring assembly is not installed, by placing the thumb on the trigger and the forefinger on the opposite side of the receiver to prevent lateral movement of the barrel when trigger is depressed.

c. Extraction. Pull the bolt to the rear to eject the cartridge case. If the case fails to extract, use the cleaning rod to remove it. If the adapter is installed in the breech recess of the major caliber weapon (e.g., 105-mm howitzer M102), it will have to be removed from the tube in order to push the cartridge case out with the cleaning rod. If the adapter is installed in place of the obturator spindle (e.g., 155-mm howitzer M114A1), it is only necessary to open the breechblock of the major caliber weapon.

d. Misfire, hangfire, and cookoff.

(1) *Misfire.* A misfire is a complete failure to fire and may be due to a faulty firing mechanism or faulty element in the propelling charge explosive train. A misfire in itself is not dangerous, but since it cannot be immediately distinguished from a delay in the functioning of the firing mechanism or from a hangfire, these possibilities should be considered until they have been eliminated. Such delay in the functioning of the firing mechanism could result from the presence of foreign matter such as sand, grit, frost, ice, or improper or excessive oil or grease. These conditions might create a partial mechanical restraint which, after some delay, is overcome as a result of the continued force applied by the spring, and the firing pin then driven into the primer in the normal manner. No cartridge should be left in a hot trainer or subcaliber device any longer than circumstances require because of the possibility of a cookoff.

(2) *Hangfire.* A hangfire (fig 9-14) is a delay in the functioning of a propelling charge at the time of firing. The amount of delay is unpredictable but, in most cases, will fall within the range of a split second to several minutes. A hangfire cannot immediately be distinguished from a misfire, and therefore, it may be mistaken for a misfire. In case of a misfire, perform the following steps in sequence:

(a) Keep the device trained on the target and all personnel clear of the muzzle.

(b) Before attempting to remove the cartridge from the trainer, personnel not required for the operation will be cleared from the vicinity.

(c) Inspect rear of bolt to determine if the firing pin has been released and is forward. (It will protrude from the rear of the bolt if the weapon is cocked.) If the firing pin has been released, wait 30 seconds and proceed with steps *(d)*, *(e)*, and *(f)*.

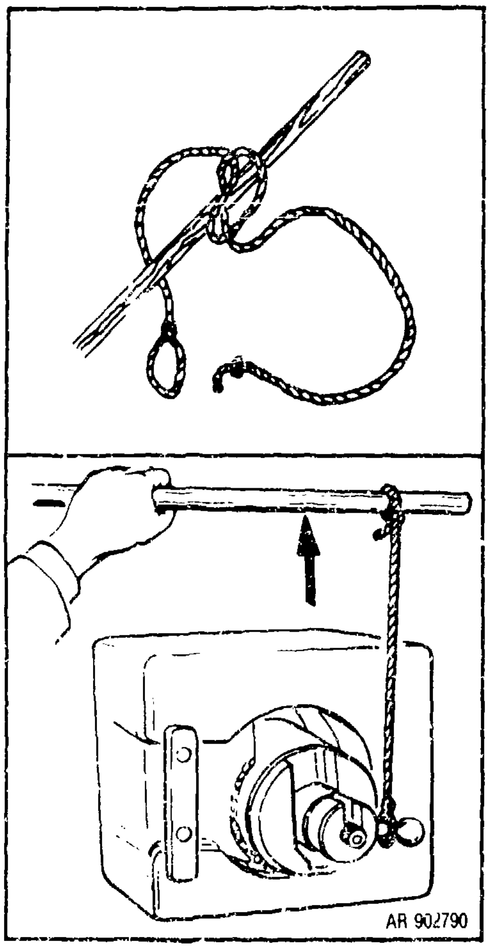


Figure 9-14. Hangfire device.

Note. You may have a hangfire. A hangfire cannot be distinguished from a misfire if the firing pin has been released. If the firing pin has not been released, you can immediately proceed to steps *(d)*, *(e)*, and *(f)*.

(d) Attach locally fabricated device to breech bolt lever.

(e) Pull bolt lever up, then to the rear and eject cartridge.

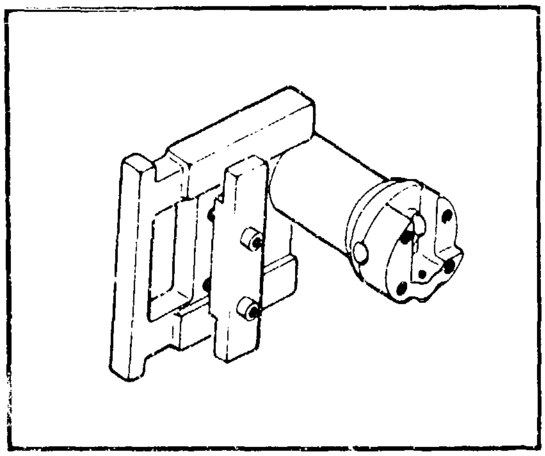
(f) Inspect the cartridge from a distance to determine if the cartridge or firing mechanism is at fault. If the primer is dented, dispose of the cartridge in accordance with local regulations for small arms ammunition. If primer is not dented, disassemble the bolt and repair as necessary.

(3) *Cookoff.* A cookoff is a functioning of any or all of the components of a cartridge chambered in a very hot trainer due to the heat from the trainer. If the cartridge propellant should cookoff, the projectile will be propelled from the trainer with normal velocity even though no attempt was made to fire the primer by actuating the firing mechanism. In such case, there may be uncertainty as to whether or when the cartridge will fire, and precautions should be observed (same as those prescribed for a hangfire). To prevent a cookoff, a cartridge which has been loaded into a very hot trainer should be fired immediately, or removed after a lapse of 5 seconds and within 10 seconds.

Section VI. SUMMARY

9-20. Adapter Assemblies for the M101A1 and M114A1/A2 Howitzer

Two additional adapter assemblies not discussed in this text are shown below (fig 9-15). For more information refer to TM 9-6920-361-13 and P.



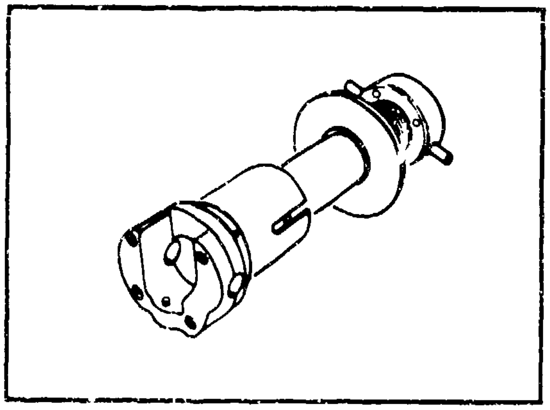


Figure 9-15. Adapter assemblies for the M101A1 and M114A1/A2 howitzers.

9-21. Review

The purpose of this chapter is to provide information on the use of the 14.5-mm field artillery trainer, M31. The preparation, installation, gunnery procedures, and ammunition of the trainer were discussed. The trainer allows for realistic training for gun crews, fire direction personnel, forward observers and survey crews at a low cost. For more detailed information, concerning the M31 trainer refer to TM 9-6920-361-13 and P and other applicable references as identified in this chapter.

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FIELD ARTILLERY SCHOOL
Weapons Department
Fort Sill, Oklahoma

CHAPTER 10

FIELD ARTILLERY DIRECT FIRE TRAINER

Section I. General

10-1. References

TM 9-6920-357-10-2.

10-2. Introduction

a. For the first time in the history of the Field Artillery, a direct fire trainer (fig 10-1) has been designed and built specifically for the artillery. Prior to the development of this field artillery direct fire trainer (ADFT) the howitzer section was totally dependent on the chief of section during dry fire training to tell them whether they hit the target or not. There was no realism in this type of training and very little if anything was gained. With the ADFT the section can actually see where their round would have landed and make actual corrections in order to achieve a hit on the target.

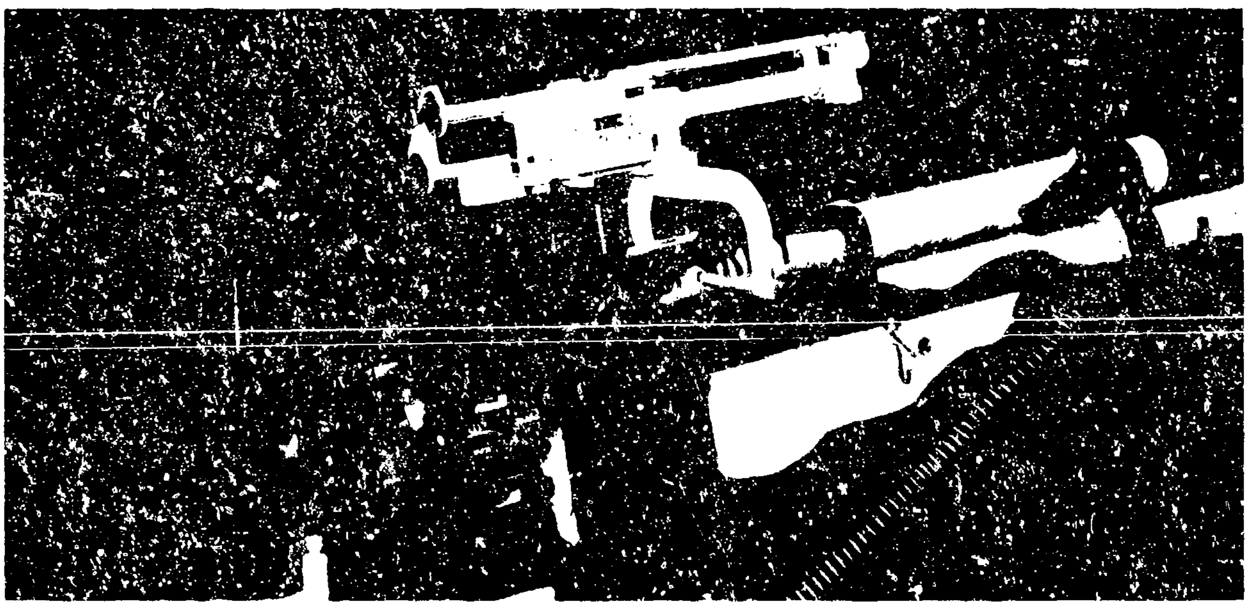

Figure 10-1. Field Artillery direct fire trainer.

b. The ADFT is a helium-neon gas-type laser, which produces a single, bright burst of intense red light when activated (fired). This visible red spot enables the crewmen to determine if a target hit was achieved and if not an adjusting point for the next round (beam of light) to be fired.

Note. (Caution) Eye damage can occur when the trainer is operated in the CONTINUOUS MODE. Staring into the laser output or at the laser light reflection from a mirror-like surface can be hazardous out to a range of 4 kilometers.

c. The laser beam is safe when the trainer is operated in the FLASH MODE.

d. The purpose of the ADFT is to provide an economical means of direct fire training for all members of a howitzer section. This training will allow them to become proficient in engaging any targets in the direct fire mode that come within the sections direct fire range capability.

10-3. General Characteristics

a. The ADFT uses the M55, Trainer, Laser Gunnery which was originally designed to be used

*Supersedes HB-10 WCXXWS, Dec 81.

on TANKS and ARMORED RECONNAISSANCE vehicles. Together they are used to train personnel in fire-adjustment and tracking operations while engaging both stationary and moving targets on a 1:10 (1/10) scale for range and speed (e.g., 40 to 160 meters represents 400 to 1600 meters) and (e.g., 0 to 2.5 mph represents 0 to 25 mph).

b. The ADFT and Laser can be mounted on the following weapons:

(1) 105-mm Howitzer M101A1.

(2) 105-mm Howitzer M102.

(3) 155-mm Howitzer M109A1/A2/A3.

(4) 155-mm Howitzer M114A1/A2.

(5) 155-mm Howitzer M198.

c. The ADFT and M55 Laser with all equipment (e.g., power distribution box, CA66 assemblies and targets) are packaged in two containers weighing a total of 441 pounds. The trainer requires 24 + 6 volts Direct Current. The optical system or the M55 is a fixed-focus type out to a range of 200 feet.

10-4. Components of the Target Board

a. The target board may be used in either a stationary or moving mode. It can be employed at distances between 40 to 160 meter (1/10 scale 400 to 1600 meters) from the Weapon/ADFT. The target board comes complete with mounting bracket to mount it in a ¼-ton trailer M416. The following items are included with the target board:

(1) Target mounting board.

(2) Target mounting board support assembly.

(3) Shipping container.

(4) Boresight target assembly (for appropriate weapon caliber).

(5) Target assembly moving.

(6) Target assembly stationary.

b. The M55 Laser must be boresighted with the weapon prior to operation. Boresighting procedures for the Laser and weapons are outlined in the appropriate TMs.

10-5. Controls and Indicators

The ADFT can be operated in either of two modes (fig 10-2) continuous or flash. The continuous mode is used primarily for boresighting the weapon or tracking a moving target. The flash mode is used when simulating firing. In either mode the TRIGGER ON and LASER ON indicator lamps illuminate as long as the gunner's firing lanyard switch is activated.

10-6. Mounting of the ADFT

The procedures for mounting the ADFT are covered in TM 9-6920-357-10-2. Procedures are basically the same for each weapon system; however, the TM should be reviewed prior to attempting to install the trainer on any weapon. The same mount assembly (C Clamp) is used on all weapons except the M114 which uses a special adapter assembly (bar). Power can be supplied from any vehicle that has a 24-volt DC system.

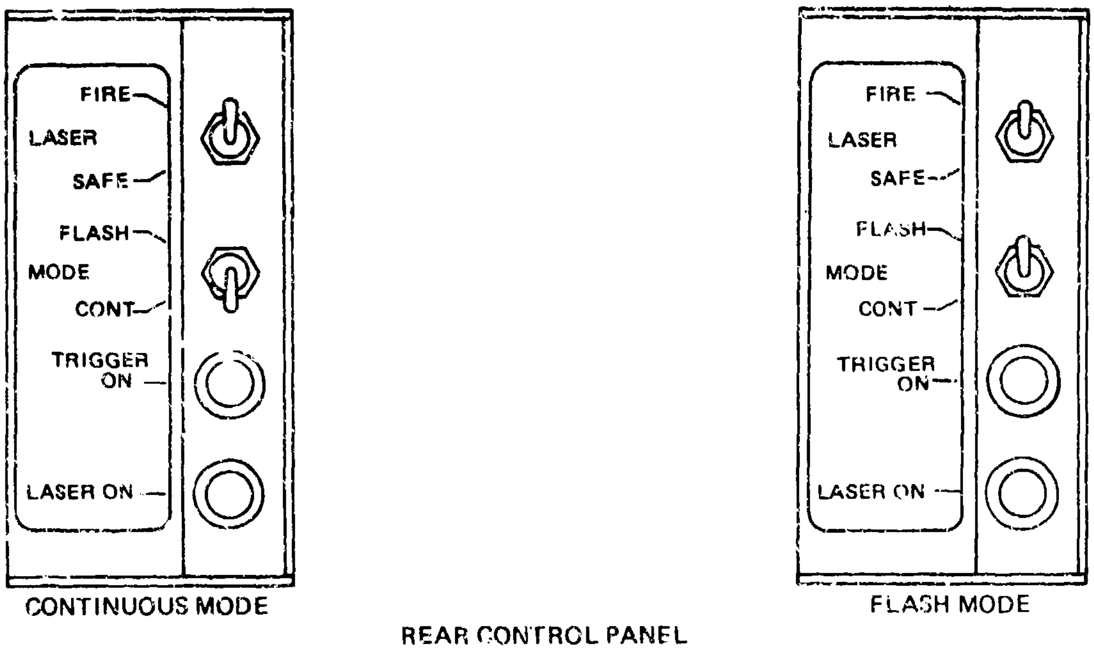

Figure 10-2. Rear control panel switch settings for mode of operation.

Section II. SUMMARY

10-7. Review

Although artillery batteries are normally associated with the delivery of timely and accurate indirect fires, there may come a time in every cannoneer's life that he is required to deliver direct fire for self protection. His ability to deliver this fire accurately will depend on the degree and quality of training that he has received. The ADFT provides us with the means to effectively train our cannoneers in direct fire procedure, without the expense normally associated with live fire training.

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CHAPTER 11
FIELD ARTILLERY AMMUNITION

Section I. GENERAL

11-1. References

a. TM 9-1300-200, *Ammunition, General.*

b. TM 9-1300-206, *Ammunition and Explosives Standards.*

c. TM 9-1300-214, *Military Explosives.*

d. TM 9-1300-251-20, *Organizational Maintenance Manual: Artillery Ammunition for Guns, Howitzers, Mortars, Recoilless Rifles, and 40-mm Grenade Launchers.*

e. TM 43-0001-28, *Artillery Ammunition for Guns, Howitzers, Mortars, and Recoilless Rifles.*

f. TM 43-0001-28-2, *Artillery Ammunition Cartridge/Projectile-Fuze and Propelling Charges Combination Charts.*

11-2. Introduction

Ammunition is artillery; the weapon is merely the means of projecting and directing the projectile to the target. For the artilleryman to achieve maximum efficiency from his ammunition, he must—

a. Know the characteristics of the explosive trains.

b. Know the capabilities and functions of ammunition.

c. Be able to identify and properly handle the various components of ammunition.

Section II. CLASSIFICATION OF AMMUNITION

11-3. Artillery Ammunition

a. Ammunition is that class of supplies usually containing a propellant and/or explosives or chemicals. It includes small-arms ammunition, artillery ammunition, mines, bombs, and other contrivances charged with propellants, explosives, pyrotechnics, initiating composition, or nuclear or chemical material.

b. The dividing line between artillery ammunition and small-arms ammunition is 37 millimeters (mm). Ammunition for weapons greater than 37-mm is considered artillery ammunition; ammunition for weapons of 36-mm or less is considered small-arms ammunition.

c. A complete round of artillery ammunition consists of four components—the primer, the propellant, the projectile, and the fuze. Activation of the primer, either by percussion (firing pin) or by electric current, ignites the propellant (powder charge). The rapid expansion of gases caused by the burning propellant propels the projectile from the tube toward the target or point of burst. Upon impact or at a predetermined time, the fuze initiates an explosive train in the projectile which causes the projectile to produce the desired effects.

WARNING: Do not fire an artillery round of any caliber without using the fuze authorized for that particular type of round. The firing of a round without a fuze or with a fuze unauthorized for that type of round could result in an inbore premature burst or some other hazardous condition that could cause serious injury to personnel and damage to equipment.

d. There are many technical manuals (TMs) available to assist you in learning about field artillery ammunition. Some of these manuals are listed below—

(1) TM 9-1300-200, *Ammunition, General*, contains information on the classification and identification of ammunition.

(2) TM 9-1300-206, *Ammunition and Explosives Standards*, contains specific information on the proper care, storage and handling, marking, preservation, and destruction of ammunition.

(3) TM 9-1300-214, *Military Explosives*, is a comprehensive manual on the history, development, characteristics, capabilities, and uses of standard military explosives.

(4) TM 9-1300-251-20, *Artillery Ammunition for Guns, Howitzers, Mortars, Recoilless Rifles, and 40-mm Grenade Launchers*, is one of a series of technical manuals on the service and maintenance of ammunition required to support organizational-level maintenance of artillery

*Supersedes HB-11 WCXXWS, Dec 81.

ammunition in calibers ranging from 37 millimeters through 8 inches. Artillery ammunition, as it is defined in this manual, includes conventional and improved conventional munitions for guns, howitzers, mortars, recoilless rifles, and 40-mm grenade launchers.

(5) TM 43-0001-28, *Artillery Ammunition*, contains specific information on all current types of artillery ammunition and their components.

(6) TM 43-0001-28-2, *Artillery Ammunition: Cartridge/Projectile-Fuze and Propelling Charges Combination Charts*, contains a comprehensive listing of authorized cartridge/projectile fuze and propelling charges combinations and interchangeability data for conventional ammunition. Table 11-5 of this chapter, which shows some of cartridge/projectile-fuze combinations for field artillery howitzers, is a modified extract of TM 43-0001-28-2.

e. In addition to the technical manuals listed above, a technical manual is published for each artillery weapon. This manual lists, among other things, the firing table to be used; describes the classification, identification, marking and packing, and type of ammunition available; and outlines the preparation of a complete round of ammunition for the weapon.

11-4. Classification of Ammunition According to Use

Ammunition is classified according to use as service, practice, blank, or drill ammunition. It also may be classified according to type of filler as explosive, chemical, or inert.

a. Service ammunition. Service ammunition is fired for effect in combat. Depending on the type of projectile, service ammunition may be high-explosive (HE), chemical (gas, smoke, or illuminating), canister, high-explosive plastic, antipersonnel (APERS) flechettes (darts), or improved conventional munitions (ICM) rounds.

b. Practice ammunition. Practice ammunition is fired in simulated combat and is used for training in direct fire procedures. The projectile in practice ammunition may have a small quantity of low-explosive filler to serve as a spotting charge, or it may be inert.

c. Blank ammunition. Blank ammunition is provided for light artillery weapons for such purposes as firing salutes and simulated fires. It has no projectile.

d. Drill ammunition. Drill (dummy) ammunition is used for training in handling and loading (service of the piece). It is completely inert.

11-5. Classification of Ammunition According to Type

Classification of ammunition according to type is based on the manner in which ammunition components are assembled for loading and firing; complete rounds of field artillery ammunition are known as either semifixed or separate-loading rounds.

a. Semifixed ammunition is characterized by an adjustable propelling charge. The propellant is divided into increments, or charges, and each increment of propellant is contained in a cloth bag. The increments, or charges, are tied together and are stored in the cartridge case, which is loosely fitted to the projectile. The howitzer crew adjusts the propelling charge by removing the projectile from the cartridge case, removing those increments not required, and returning the projectile to the cartridge case. The primer is an integral part of the cartridge case, and thus the complete round can be loaded into the weapon in one operation. Semifixed ammunition is used in 105-mm howitzers and may be issued fuzed or unfuzed.

Note. The high-explosive plastic tracer (HEP-T) round does not have an adjustable propelling charge, but it is considered semifixed ammunition. It is used against enemy tanks. The "-T" in the abbreviation indicates that the round is equipped with a tracer element to allow the gunner to correct his aim against enemy tanks.

b. Separate-loading ammunition has four separate components—primer, propellant, projectile, and fuze—and the components are issued separately. At the firing point, the eyebolt lifting plug is removed from the projectile, the fuze is installed, and the fuzed projectile is then loaded. The primer and propellant are loaded in two separate operations. Separate-loading ammunition is designed for use in large-caliber guns and howitzers, such as the 155-mm and 8-inch howitzers.

Section III. EXPLOSIVE TRAINS

11-6. Definition of Explosive Train

An explosive train is a designed arrangement of a series of explosives beginning with a small quantity of sensitive explosive and progressing through a relatively large quantity of comparatively insensitive, though powerful, explosive. There are two explosive trains in each conventional round of artillery ammunition—a propelling charge explosive train and a projectile explosive train (fig 11-1). A projectile reaches the target by the power obtained from the propelling charge explosive train; however, the function of the projectile in the target area depends on the type of filler in that projectile; that is, high-explosive, chemical, or antipersonnel filler. For example, a complete round of conventional high-explosive artillery ammunition contains two explosive trains—the propelling charge explosive train, which consists of a *primer*, an *igniter*, and a *propellant*, and the bursting charge explosive train (projectile explosive train), which consists of a *fuze*, a *booster*, and a *bursting charge*.

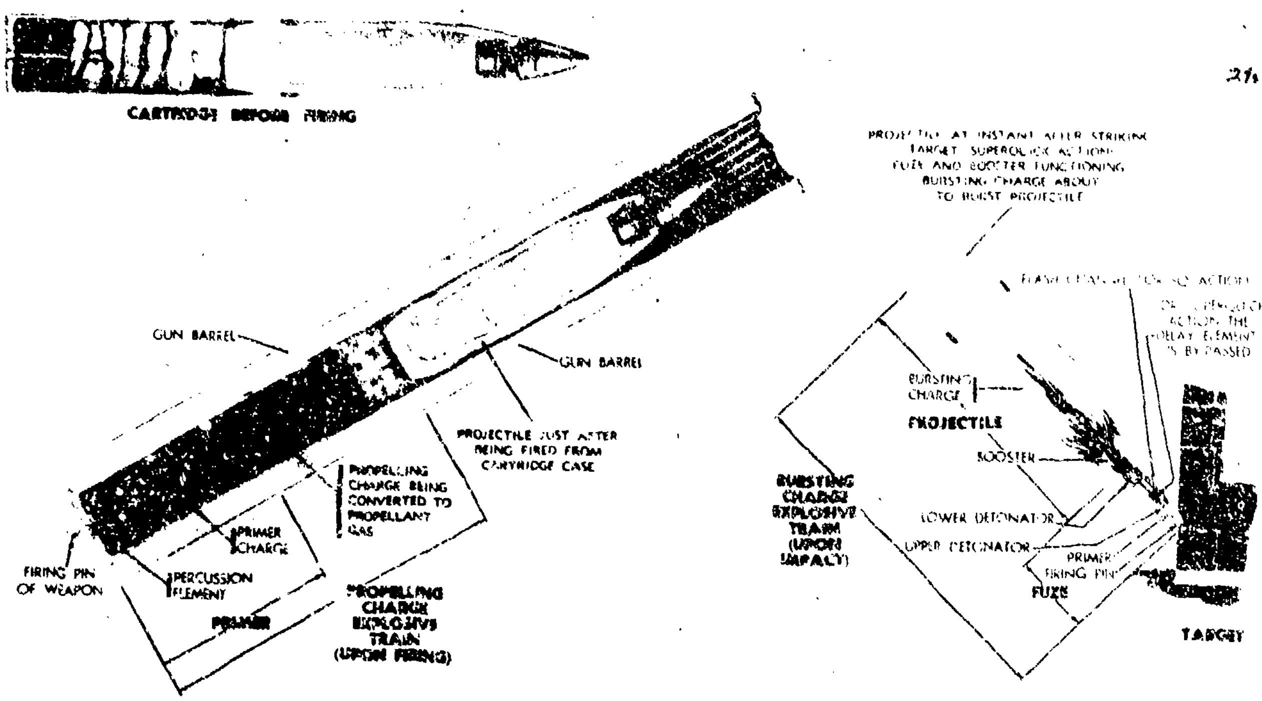


Figure 11-1. Two explosive trains in a high-explosive round.

11-7. Propelling Charge Explosive Train

a. Primers. The propelling charge explosive train is initiated by a small amount of a very sensitive explosive, such as fulminate of mercury, lead azide, or lead styphnate, used as the percussion element, or primer. The primer must be sensitive to shock, friction, spark, or flame and, therefore, they must be protected and separated from other components. The primer for semifixed ammunition is an integral part of the cartridge case and comes with the complete round and remains with it at all times. The primer for a round of separate-loading ammunition comes as a separate item of issue and it must be stored separately. This primer is not added to the complete round until the fuzed projectile has been rammed into the powder chamber, the powder charge added to the chamber, and the breechblock closed; then the primer is inserted into the firing mechanism and placed in position to fire the round.

b. Igniters. A charge of propellant in a powder chamber is ignited when the voids between the grains of powder and the perforations in the powder grains are filled with flaming gas and hot particles. For many years, this ignition action has been performed by the use of black powder, but, recently, the introduction of clean burning igniter (CBI) has been used in lieu of black powder. Black powder is very hygroscopic and subject to rapid deterioration on absorption of moisture; however, if it is kept dry, the powder will retain its explosive properties indefinitely. The controlled burning of the propellant inside the powder chamber is called deflagration.

(1) The igniter for a round of semifixed ammunition is an integral part of the primer. It consists of a perforated tube filled with black powder and permanently mounted in the cartridge case.

(2) The igniter for a round of separate-loading ammunition consists of a red pancake-shaped bag of either black powder or clean burning igniter (CBI). The igniter bag is sewn to the base charge of the propellant.

c. Propellants. A propellant undergoes autocombustion only on the surface; the burning progresses as though the powder grain (fig 11-2) consisted of very thin layers—each layer burning and igniting the next layer. Under conditions of constant pressure, the burning progresses through the powder at a steady linear rate peculiar to the composition of the powder being used. The mass rate of burning of a propellant charge is determined, to a great extent, by the physical form of the powder grain. Thus, through control of the form of the powder grain, the ballistic effect of a propellant charge is determined and kept within certain limits. Basically, the greater the capacity of the powder chamber of an artillery weapon, the greater the size of the powder grain that is used.

(1) *Forms of powder grain.* The forms of powder grain used in current field artillery cannons are the single-perforated and the multiperforated propellant powder grains (fig 11-2)

(a) Single-perforated grain. As the single-perforated powder grain burns, the outer surface decreases and the inner surface increases (fig 11-2). As a result of these two actions, the initial diameter of the perforation can be controlled so that the total burning surface remains nearly constant until the powder grain has been consumed. Such burning is called neutral burning.

(b) Multiperforated grain. When the multiperforated powder grain burns, the total surface area increases because the perforated grain burns from the inside and outside at the same time (fig 11-2). This type of burning is called progressive burning. When a multiperforated grain is not completely consumed, portions of the grain remain in the form of slivers and normally are ejected as such from the weapon.

(c) Usage. Both the single-perforated and the multiperforated powder grains are used in field artillery cannons to obtain the optimum muzzle velocity-chamber pressure ratio. Table 11-1 shows the exact design and composition of the green bag and white bag powder charges used for the 155-mm and 8-inch field artillery weapons.

(2) *Flashless-smokeless powder.* Smoke from propelling charges has long been a problem for artillerymen because it reveals the location of the gun position. Improvement in propellant compositions has largely reduced the smoke problem but has created the problem of increased muzzle flash, which reveals the location of the gun position at night. Whether a propelling charge is actually flashless and/or smokeless depends on a number of things—the weapon in which the charge is used, the type of ignition used, the wear on the tube of the weapon (tube wear), the temperature of the tube of the weapon, and the quantity and design of the propellant. Under standard conditions, flashless ammunition does not flash more than 5 percent of the time in weapons of average life; smokeless ammunition produces less than half the amount of smoke produced by ammunition not so designated. A complete round having both these characteristics is designated flashless-smokeless. Solvent is added to the finished powder grains to give the smokeless characteristic. A cooling agent is added to the propellant to cool the unburned gases below the kindling temperature and thereby reduce the flash.

(3) *Flash reducers.* Since it is necessary to use some propellants with a high rate of burning so that the muzzle velocity will not be impaired, flash reducers containing black powder and potassium sulfate are used to further reduce or to prevent flash. Flash reducers are used at night to reduce flash; they are also used during day and night firing with certain weapons to speed up the combustion of unburned propelling charge gases and thus prevent excessive muzzle blast. Table 11-1 contains special instructions on the use of flash reducers with certain propelling charges.

Figure 11-2. Forms of powder grain.

Table 11-1. Arrangement and Identification of Separate-Loading Propelling Charges for 155-mm and 8-Inch Howitzers

Weapon	Propelling Charge	Min Charge	Max Charge	Propellant configuration	Remarks
155-mm howitzer	M3A1 (Note 1)	1	5	Green bag. Base charge plus increments 2, 3, 4, and 5 are of single-perforated propellant.	A flash reducer pad is assembled on manufacture in front of increments 1, 4, and 5.
	M4A2 (Note 1)	3	7	White bag. Base charge plus increments 4, 5, 6, and 7 are of multiperforated propellant	Flash reducer pad is assembled on manufacture forward of increment 3.
	M119 and M119A1 (Note 2)	8	8	White bag. Base charge only. Charge 8 has a small circular igniter pad at the base, with an igniter core lengthwise through the center of the charge with benite ignition strands, a sheet of lead foil, a laced jacket, and a flash reducer pad at the end of the charge.	The basic difference between M119 and M119A1 is that the M119A1 has a donut-shaped flash reducer that precludes non-ignition of the rocket motor of the M549/M549A1 projectile.
	M119A2 (Note 2)	7	7	Red bag. Base charge only. Charge 7 has a large igniter pad sewn to the base; but no igniter core through center of the charge. Muzzle velocity of this charge is approximately the same (within 6 fps) as the M119 and M119A1 charges.	Flash reducer has been added to four longitudinal pouches affixed along the propelling charge 90° apart.
	M203A1 (Note 3)	8S	8S	White bag with a red jacket. Base charge only. Charge 8S has a central core black powder ignition train. Wear reducing additive, decoppering agent, and flash reducer material are included with the charge of M30A1 high energy, multiperforated propellant.	1. This new super charge cannot be used with the M712 COPPERHEAD (CLGP) or older, stockpiled projectiles: i.e., M107 HE round and family. 2. When fired with the M549A1 RAP round, a 30 km range is achieved with the M198 howitzer.
8-inch howitzer	M1	1	5	Green bag. Base charge plus increments 2, 3, 4, and 5 are of single-perforated propellant.	Flash reducer is not required.
	M2	5	7	White bag. Base charge plus increments 6 and 7 are of multiperforated propellant	Flash reducer M3 is to be used with this propellant and is a separate item of issue. One flash reducer pad is placed at the forward end of the propelling charge, under the propellant straps.
	M188 (Note 4)	8	8	White bag Base charge only. Charge 8 has an igniter core lengthwise through the center of the charge with ignition (benite) strands	This charge is to be used in the M110A2 SP howitzer (long tube) *only*; it has not been authorized to be fired in any short 8-inch howitzer tube
	M188A1 (Note 5)	8	9	White bag. Base charge (8) and increment 9. The charge has an igniter core lengthwise through the center of Charges 8 and 9 with ignition (benite) strands.	Do not fire Charge 9 in a long tube without the muzzle brake in place.

Notes

1. See TM 43-0001-28 or the technical manual for the 155-mm weapon for information on the older green bag powder charge M3, the older white bag powder charges M4 and M4A1, and the use of the M2 flash reducer with the white bag powder charges.

2. M119-series propelling charges (M119, M119A1, M119A2) are authorized for use in the long tubes M109A1, M109A2, and A3, and the M198 howitzers. NOT AUTHORIZED FOR USE IN *SHORT* 155-MM TUBES SUCH AS THE M114, M114A1, M114A2, OR THE M109 HOWITZERS.

3. M203A1 propelling charge authorized in the M198 weapon *only* at this time. THIS CHARGE NOT AUTHORIZED IN *SHORT* TUBES SUCH AS THE M114, M114A1, M114A2, M109, or the long tubes of the M109A1/A2/A3 howitzers.

4. Authorized in M110A2 cannons with M201 tubes only. NOT AUTHORIZED IN ANY *SHORT* TUBES.

5. Charge 9 authorized in M110A2 cannons with muzzle brake. THIS CHARGE NOT AUTHORIZED IN ANY 8-INCH *SHORT* TUBES.

d. Arrangement and identification of propelling charges. Field artillery cannon fire semifixed or separate-loading ammunition and the form in which the propelling charge is assembled depends upon the type of weapon in which it is to be fired.

(1) *Semifixed.* Most of the propelling charges for the 105-mm howitzers consist of the dual-granulation type charge, which consists of two increments of single-perforated grains (increments 1 and 2) and five increments of multiperforated grains (increments 3 through 7). Other types of 105-mm charges are used with the following projectiles—

(a) The antipersonnel cartridge with tracer (APERS-T), also referred to as the Beehive round, has only two powder increments in the cartridge case. These two increments consist of the base charge 6 and increment 7.

(b) The high-explosive rocket assisted cartridge (HE-RA) contains a five-increment white bag charge of dual-granulation propellant (increments 3 through 7).

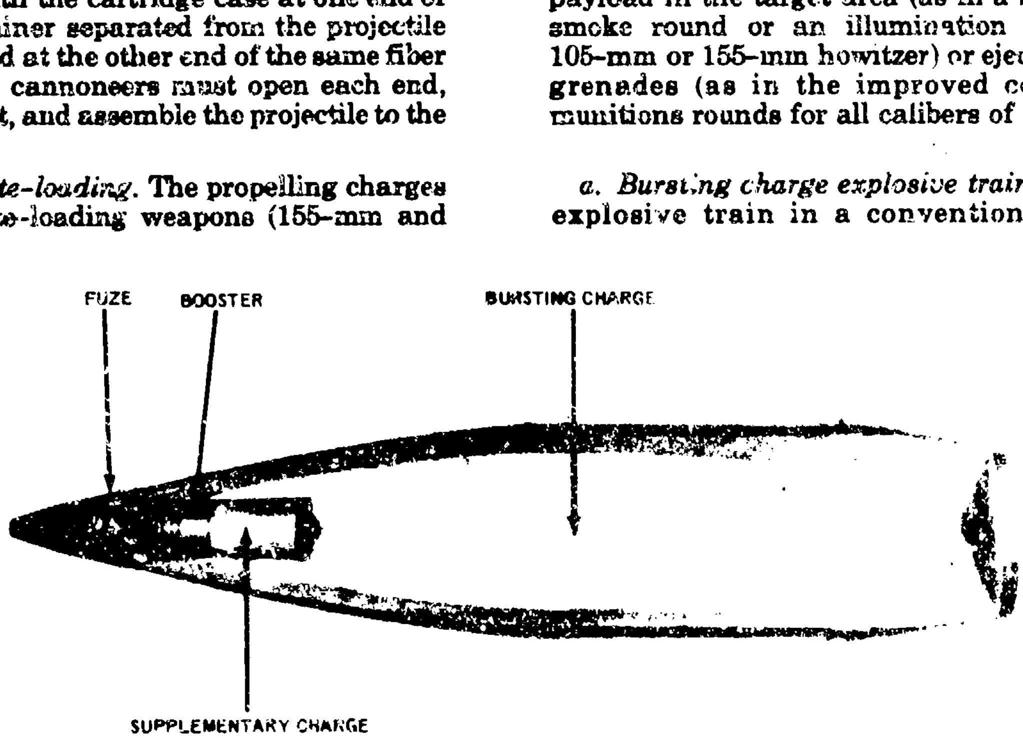
(c) The high-explosive antitank cartridge with tracer (HEAT-T), the high-explosive plastic cartridge with tracer (HEP-T), the target practice cartridge (TP), and the target practice cartridge with tracer (TP-T) contain a single, nonadjustable propellant charge. The M622 HEAT-T round is issued complete with the cartridge case crimped to the projectile; the other projectiles (HEP-T, TP and TP-T) come with the cartridge case at one end of the fiber container separated from the projectile which is located at the other end of the same fiber container. The cannoneers must open each end, remove, inspect, and assemble the projectile to the cartridge case.

(2) *Separate-loading.* The propelling charges for all separate-loading weapons (155-mm and 8-inch howitzers) consist of a base charge and a number of additional increments packed in either green bags (for inner zones) or white bags (for outer zones). A recent innovation in the 155-mm charges is the introduction of the M203A1 charge 8S that will have a red jacket on it to distinguish it from other high zone charges. The configuration and size of the powder grains (fig 11-2), which determines the force of the propelling charge, and the arrangement of the charge are designed to take advantage of the versatility of the weapon, assist in extending the life of the tube, and minimize the wasted propellant. The arrangement and identification of separate-loading propelling charges for 155-mm and 8-inch howitzers are shown in table 11-1.

11-8. Projectile Explosive Train

Every complete round fired to the target by the propelling charge explosive train also has a projectile explosive train to deliver the payload (filler) on to the target. There are many different types of fillers to include high-explosive, chemical, gas, smoke, illuminant, grenades, and antipersonnel fillers. The projectile explosive train is activated by a fuze. In some rounds, the fuze has a booster, which amplifies the action of the fuze so that the complete round is detonated (as in a conventional high-explosive round) or the burster tube is detonated (as in a chemical round, or white phosphorus round). In other rounds, the fuze starts the action and then the expelling charge ejects the payload in the target area (as in a base-ejection smoke round or an illumination round for a 105-mm or 155-mm howitzer) or ejects a series of grenades (as in the improved conventional munitions rounds for all calibers of howitzers).

a. Bursting charge explosive train. The second explosive train in a conventional round of



Note. The supplementary charge is removed when the long intrusion proximity (VT) fuze is used.

Figure 11-3. Bursting charge explosive train.

high-explosive ammunition is a bursting charge explosive train (fig 11-3). It consists of a fuze, a booster, and a bursting charge. The bursting charge is either trinitrotoluene (TNT) or composition B (comp B). When the booster amplifies the detonation of the fuze through the explosive in the booster, the bursting charge explodes with a high order of brisance and shatters its immediate surrounding area, which in this case is the projectile itself. The blast effect of the bursting charge and the fragmentation of the projectile send many small, ragged, sharp, irregularly shaped metal pieces flying all over the target area. The bursting charge of a high-explosive projectile requires a powerful explosive force for detonation. The standard high-explosive fillers currently in use are trinitrotoluene (TNT) and composition B. Comp B produces 40 percent more fragmentation than TNT when used in standard high-explosive rounds. Special HE fillers include composition A3 (comp A3), a high-explosive plastic, tritonal, a mixture of TNT and aluminum powder; tetryl; and tetrytol. The uses of these fillers are discussed below.

(1) *Trinitrotoluene and composition B.* Trinitrotoluene or composition B is used in standard high-explosive projectiles to produce fragmentation, to cause casualties and destroy material, or to destroy the enemy fortifications by concussion. Most standard high-explosive projectiles have a supplementary charge in the fuze cavity. The supplementary charge must be removed whenever one of the long intrusion proximity (VT) fuzes (M513, M514, or M728 series) is used; it must be left in place, or replaced, if an impact, mechanical time, or the new short intrusion proximity (VT) fuze M732 is used. In the late 1960s and early 1970s, a different type of HE round was developed to extend the range capability of the 105-mm, 155-mm, and 8-inch howitzers. This latest type of HE round is known as the high-explosive, rocket-assisted (HE-RA) projectile or simply as the rocket-assisted projectile (RAP). Rocket-assisted projectiles have high-fragmentation steel cases and are filled with composition B or TNT. This combination produces many more fragments that are scattered over a larger area when the projectile explosive train functions. Production of the HE-RA 105-mm projectile has been discontinued, but the HE-RA 155-mm projectile M549A1 and the 8-inch projectile M650 RAP are being produced. Some of the characteristics and capabilities of the 155-mm high-explosive RAP round are as follows:

(a) An integral rocket motor, positioned to the rear and in tandem with the projectile, contains a solid-grain propellant, an ignition delay assembly loaded with a pyrotechnic delay mixture, and an on-off selector cap. With the selector cap removed, the propellant gases ignite the pyrotechnic delay mixture, which burns for 7.6 seconds before igniting the rocket motor propellant, which burns for 3 seconds (fig 11-4).

(b) The M549/M549A1 RAP round may be fired in any 155-mm howitzer tube *except the M114A1 towed weapon.* The M549 projectile is filled with Composition B, and the M549A1 is filled with TNT.

(c) The RAP round will achieve a range of 19,400 meters when fired in the *M109* or *M114A2* howitzers. It will achieve a range of 23,500 meters when fired in the *M109A1* tube and with the M119A1 charge. The M549A1 RAP round fired in the *M198* tube with the M203 propelling charge will obtain a range of 30,000 meters.

(d) The firing of either the M549 or M549A1 RAP projectile has certain limitations for safety.

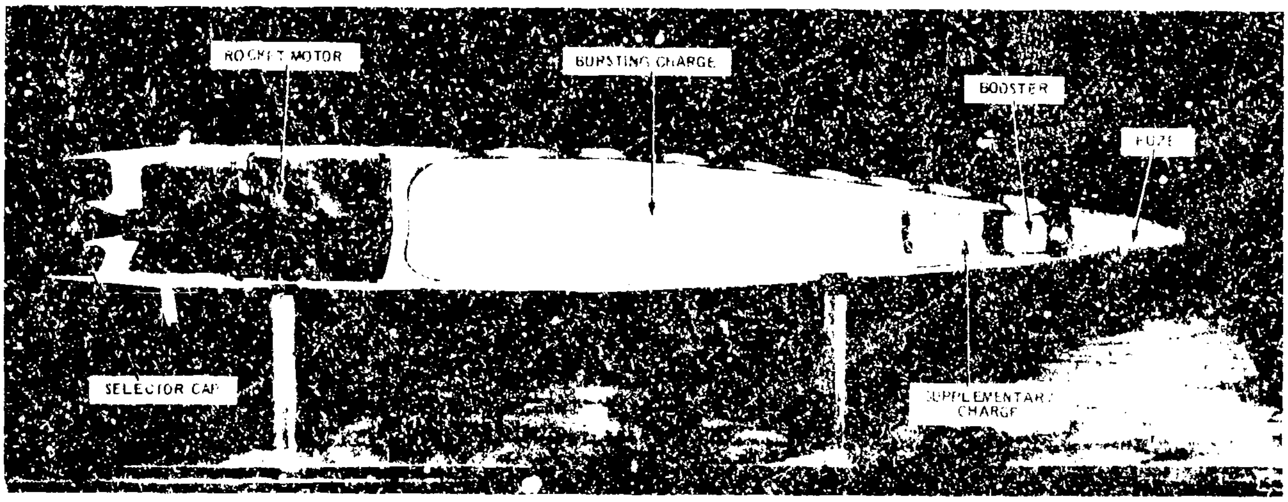


Figure 11-4. Projectile, 155-mm: HE-RA, M549/M549A1.

These limitations are found in TM 43-0001-28. Some of these limitations are as follows:

1. The M549/M549A1 cannot be fired if the obturating band is missing.

2. The M549/M549A1 will be fired rocket-on only (rocket-off cap removed). There are no firing tables for rocket-off firing of these projectiles.

3. The M549 model cannot be fired with the M203 propelling charge. Use of the M728 proximity fuze and the M549A1 projectile with the M203 propelling charge is prohibited—inbore premature may result. See the TM as listed in paragraph *(d)* above for other limitations on fuzes and propelling charge combinations.

(2) *Composition A3.* Composition A3 is used with the HEP-T antitank round M327. This round is a thin-walled, plasticized, high-explosive filled, base-detonating fuzed projectile that gives optimum penetration on slanted surfaces.

(3) *Tritonal.* Tritonal is a high-explosive filler consisting of TNT and aluminum powder and is used in the spotting round for the 8-inch howitzer.

b. Bursting tube explosive train. The second explosive train in a chemical round of gas or white phosphorus is a bursting tube explosive train (fig 11-5). It consists of a fuze, a booster, and a small burster tube filled with tetryl or tetrytol. This tube extends through the longitudinal axis of the projectile. The shell contains gas or white phosphorus filler. When the fuze functions, the booster so amplifies the shock wave that the burster tube breaks open the projectile; thus the chemicals escape from the interior of the projectile and spread throughout the target area. These rounds are available for 105-mm and 155-mm howitzers. The 8-inch howitzer does not have a white phosphorus round but has a gas-type round—the M426—that can be filled with either GB or VX (table 11-5).

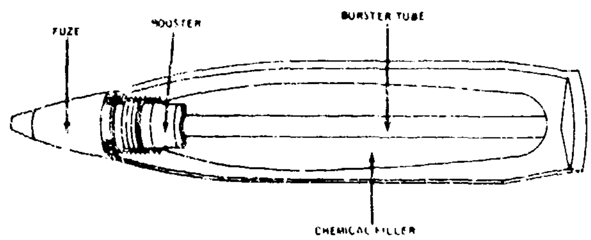


Figure 11-5. Bursting tube explosive train.

c. Expelling charge explosive train. The second explosive train in the antipersonnel, smoke, illumination, and the improved conventional munitions (ICM) rounds is an expelling charge explosive train. The term "antipersonnel" refers to items that have been designed to destroy or maim personnel or to destroy materiel or render it inoperable. There are three types of antipersonnel rounds used by the field artillery today—the flechette round, commonly called the Beehive round, and the two new types of ICM rounds. The antipersonnel (APERS) M546 round differs from the rest of these rounds in that its payload is ejected forward whereas the payloads of other rounds are ejected through the base of the projectile. In all these rounds the action starts with the fuze and culminates in the pressure of the burning expelling charge forcing the payload on to the target.

(1) *APERS M546 (flechette) round.* The APERS M546 flechette round, commonly referred to as the Beehive round (fig 11-6) is intended primarily for antipersonnel use at close and long ranges. It is effective against personnel in the open or in dense foliage. The projectile consists of a two-piece aluminum body, an aluminum fuze adapter, and a hollow steel base. The fuze adapter, which is threaded to the body, contains four radially oriented detonators, a flash tube, a relay, and an axially oriented detonator. A central steel flash tube extends from the projectile base to the detonator in the fuze adapter. The projectile body is loaded with 8,000 8-grain steel flechettes (darts). A mechanical time fuze is assembled to the projectile. On firing, the fuze starts to arm immediately and will function as set: either on leaving the cannon muzzle (called muzzle action (MA)) or at a preset time. When the fuze functions, the four radially oriented detonators, the smoke marker pellet, and the axially oriented detonator and relay in the fuze adapter are activated. The explosive force of the radially oriented detonators rips open the forward skin of the projectile ogive and the flechettes in the forward section of the projectile are dispersed by centrifugal force. At the same time, the axially oriented detonator and relay cause a flame to flash down the flash tube and ignite the base expelling charge. The pressure built up by the burning of the base expelling charge forces the flechettes and black marker dye in the rear of the projectile forward and out of the projectile.

WARNING: Firing Beehive rounds over the heads of exposed friendly troops is prohibited.

(2) *Illuminating round.* Illuminating rounds, which are available for 105-mm and 155-mm weapons only, are used for signaling or for illuminating a designated area. The projectile is made from a steel forging and is fitted with a soft metal rotating band, a pinned base plug, an expelling charge, and an illuminating canister and parachute assembly. The projectile is fitted with a mechanical time fuze. The 155-mm illuminating round has a primary expelling charge, a drogue parachute, a delay element in the main illuminant canister, a canister assembly

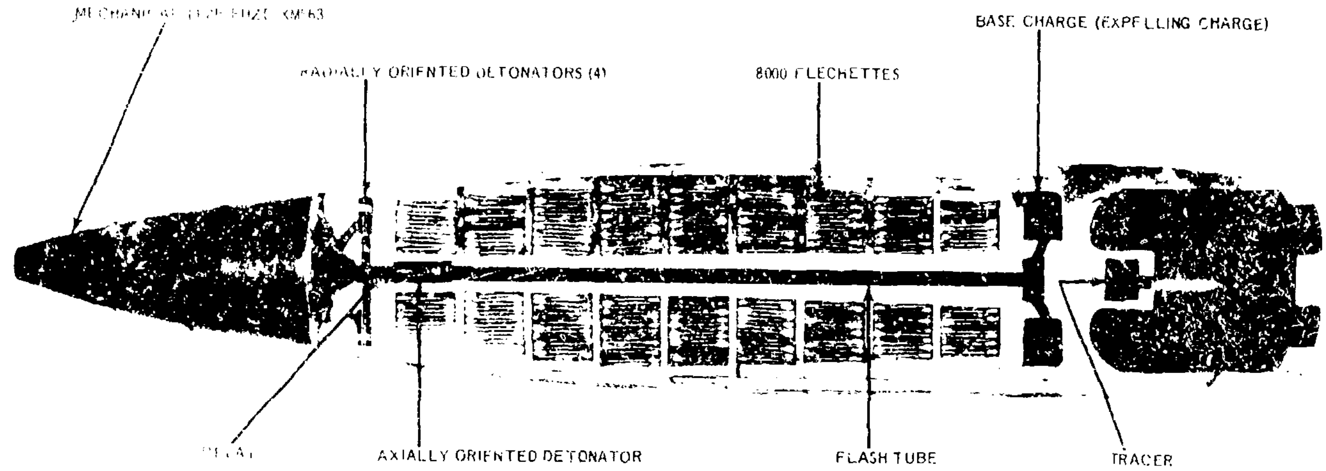


Figure 11-6. APERS M546 flechette (Beehive) round.

with antirotational brakes, and a main parachute. The 105-mm illuminating canister body has antirotational brakes but the round does not have a drogue parachute. When the fuze functions on either of the illuminating rounds, the expelling charge is ignited and the canister with parachute is ejected into the airstream. The antirotational brakes slow the spinning of the canister (the delay element ignites the main expelling charge of the 155-mm illuminant while the drogue chute slows the forward speed) and the main parachute lowers the burning illuminant to the ground. Characteristics of the illuminants are as follows:

Weapon	105-mm	155-mm
Projectile	M314A3	M485
Burning time	60 seconds	120 seconds
Candlepower	450,000	1,000,000
Rate of descent	30 feet per second	15 feet per second

(3) *Smoke round.* Smoke rounds, which are available for the 105-mm and 155-mm howitzers only, are used for screening, spotting, and signaling purposes. The base-ejection smoke round is similar in external configuration to the high-explosive rounds, and the projectile is fitted with a mechanical time fuze. The projectile is made from a hollow steel forging, which contains a black powder expelling charge, a steel baffle plate with a flash hole, three smoke canisters (105-mm) or four smoke canisters (155-mm) cardboard spacers, and a threaded steel base plug. The smoke canisters are steel encased, have a centrally located flash tube, and contain HC (white) smoke. The fuze ignites the expelling charge and concurrently ignites the smoke canisters and produces gases that blow out the base plug and eject the burning canisters into the airstream. The canisters emit smoke for a period of 40 to 90 seconds.

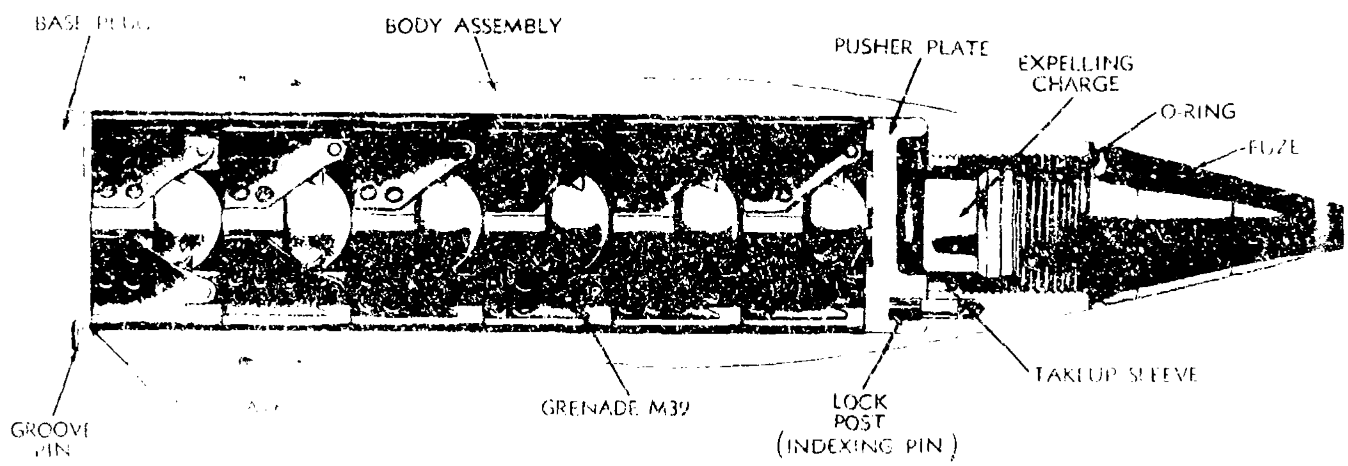


Figure 11-7. Improved conventional munitions (ICM) round.

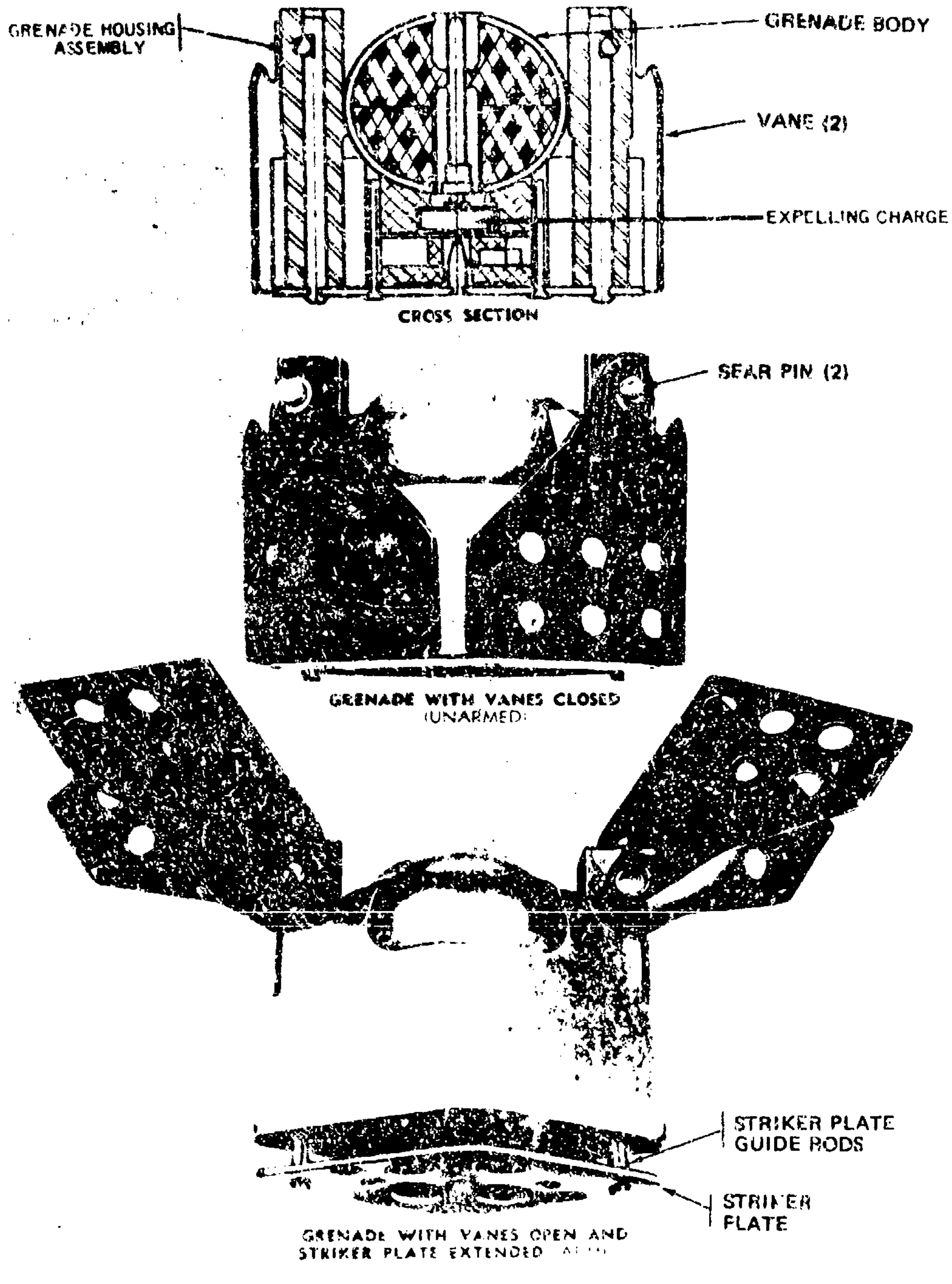


Figure 11-8. Improved conventional munitions grenade M39.

(4) *Improved conventional munitions rounds.* There are two types of ICM rounds available for field artillery howitzers; the old single-purpose antipersonnel round for the 105-mm, 155-mm, and 8-inch howitzers and the new dual-purpose antipersonnel-antimateriel round for the 155-mm and 8-inch howitzers. There is no antipersonnel-antimaterial round for the 105-mm howitzer. The basic difference between the new and old rounds is the type of grenade (antipersonnel-antimateriel) used as the filler for each type of projectile. In both cases, the projectile is merely the means of transporting the grenades to the target area; it is the grenades that do the work.

(a) *Antipersonnel round.* The grenade used in the antipersonnel round contains a steel ball filled with explosive; when the grenade strikes the target, it hurls the ball 5 or 6 feet into the air, where it detonates and scatters over the target area. The

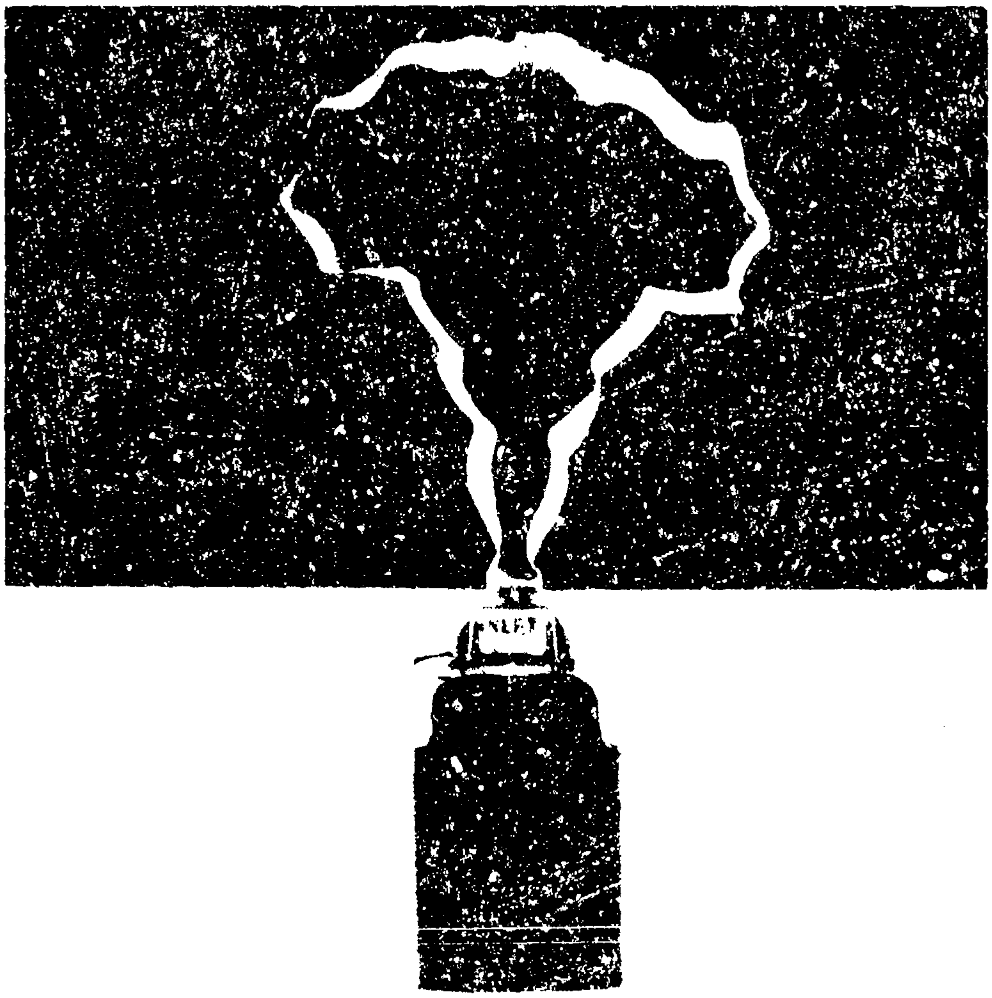


Figure 11-9. Improved conventional munitions grenade M42.

105-mm projectile contains 18 grenades M39 (fig 11-7). The 155-mm projectile contains 60 grenades (M43 series) and the 8-inch projectile contains 104 grenades M43. When the fuze on the projectile functions, it ignites the black powder expelling charge in the projectile. The burning black powder builds up pressure that forces all of the grenades out through the base of the projectile. Small vanes on each grenade flip upward and arm the grenade (fig 11-8). The vanes keep the armed grenade in a vertical position as it falls through the air so that the striker plate at the base of the grenade strikes the target area. This action causes the expelling charge in the grenade (fig 11-8) to hurl the steel ball 4 to 6 feet in the air and detonate the high explosive, which blows the metal ball to bits and scatters the fragments over the target area.

(b) *Antipersonnel-antimateriel round.* The grenade used in the antipersonnel-antimateriel round is the dual-purpose grenade (fig 11-9). This grenade has a high-explosive shaped charge and is equipped with a ribbon streamer which helps to arm the spinning grenade after it has been expelled from the projectile in a manner similar to that described in *(a)* above. The ribbon also keeps the grenade in a vertical plane as it falls to the target. Upon impact, the inertial weight drives the firing pin into the detonator initiating the explosive firing train. A shaped charge jet is expelled downward through the body of the grenade, while the rest of the grenade bursts into a large number of small fragments, expelled outward with high velocity. The jet is capable of penetrating approximately 2.75 inches of homogenous armor plate. The shaped charge is very effective against materiel or personnel. The M483 projectile for the 155-mm howitzer contains 88 shaped-charge grenades, and the M509 projectile for the 8-inch howitzer contains 180 grenades.

(5) *Family of scatterable mines (FASCAM)*

rounds. There are four base ejection type projectiles used in the 155-mm long tube cannons that are known as the FASCAM projectiles. All four of these projectiles are painted olive drab with yellow markings to include yellow triangles around the ogive of the projectile. Two of these projectiles contain 36 each antipersonnel mines, and 2 of them contain 9 each antitank mines. The yellow triangles have either a letter "L" or "S" painted inside the triangle. These markings identify the self-destruct time of the antipersonnel and antitank mines and are used by the cannoneers in selecting the right projectile to fire when artillery delivered mines are needed to deny or delay access to a particular area for a specific time period. The letter "L" signifies a long time (more than 24 hours) before self-destruction if not activated, and the "S" indicates a shorter period of time (less than 24 hours) before self-destruction. The actual times of "L" and "S" are classified, and the data can be found in TM 43-0001-28-1 (C).

(a) M692/M731 area denial artillery munitions. The M692 and M731 projectiles are known as the area denial artillery munitions, or ADAMs for a short title. These are antipersonnel rounds that contain submunitions used to deny the enemy use of certain areas for a period of time. This action is accomplished by firing the ADAM round so that the 36 submissiles are ejected over the target area. After each submissile comes to rest on the ground, 7 sensor trip lines will deploy up to 20 feet each from the mine. After another short time delay, to allow the munition to return to rest, the trip line sensor is activated causing the mine now to be completely armed. Disturbance of a trip line completes an electronic firing circuit. A thin layer of liquid propellant which by gravity rests under the kill mechanism is initiated, shattering the plastic munition body and projecting the spheroid kill mechanism upward. At a position 2 to 8 feet above the ground the kill mechanism detonates projecting approximately 600 1½-grain steel fragments in all directions. If the mine has not detonated or functioned within the factory set time (long or short self-destruct time) the mine will automatically self-destruct, thereby clearing the area.

(b) M718/M741 remotely activated antitank mine system. The M718 and M741 projectiles are of the remotely activated antitank mine system. These projectiles are used to deliver antitank mines in front of enemy armored forces to deny or delay access to a particular area for a specific time period (long or short time). They are called Remote Anti-Armor Mines System (RAAMS). Each projectile contains nine mines that can be expelled into the target area. The mines are scattered over an area and become armed within a few seconds after landing. Any metallic object, such as a tank, self-propelled vehicle, or other type unit, passing over the mines will cause them to activate and damage or destroy the equipment. If after a certain period of time these mines have not been activated they also provide a mechanism for self-destruction. Scattered among the mines are some that have an antidisturbance firing mechanism that can cause casualties if disturbed by enemy personnel attempting to clear the mined area.

Section IV. PROJECTILES AND THEIR MARKINGS

11-9. Exterior Components of an Artillery Projectile

Since the first projectile was manufactured, the demand for greater accuracy and greater range has influenced projectile design. Without definitely constructed shapes and exterior parts, there would be no standard ballistic characteristics for any group or type of projectiles. A lack of ballistic standardization would prevent the computation of firing tables. Modern projectiles are designed for maximum stability and minimum resistance to flight. The exterior components of an artillery projectile are shown in figure 11-10 and explained as follows:

a. Eyebolt lifting plugs and fuze well plugs. Separate-loading projectiles have an eye-bolt lifting plug (other types of projectiles have a metal hex-head or plastic closing plug) for lifting and to keep the fuze well clean, dry, and free of foreign matter and to protect the fuze well threads. The plug is removed and the appropriate fuze is inserted at the firing position. Some special-purpose semifixed projectiles are issued with the fuzes already assembled in the projectile.

b. Ogive. The ogive, which is the curved portion of a projectile between the fuze well and the bourrelet, streamlines the forward portion of the projectile. The curve of the ogive usually is the arc of a circle, the center of which is located in a line perpendicular to the axis of the projectile and the radius of which is generally 6 to 11 calibers.

c. Bourrelet. The bourrelet is an accurately machined surface that is slightly larger than the body and located immediately to the rear of the ogive. It centers the forward part of the projectile in the tube and bears on the lands of the tube. When the projectile travels through the bore, only the bourrelet and the rotating band of the projectile bear on the lands of the tube.

d. Body. The body is the cylindrical portion of the projectile between the bourrelet and the

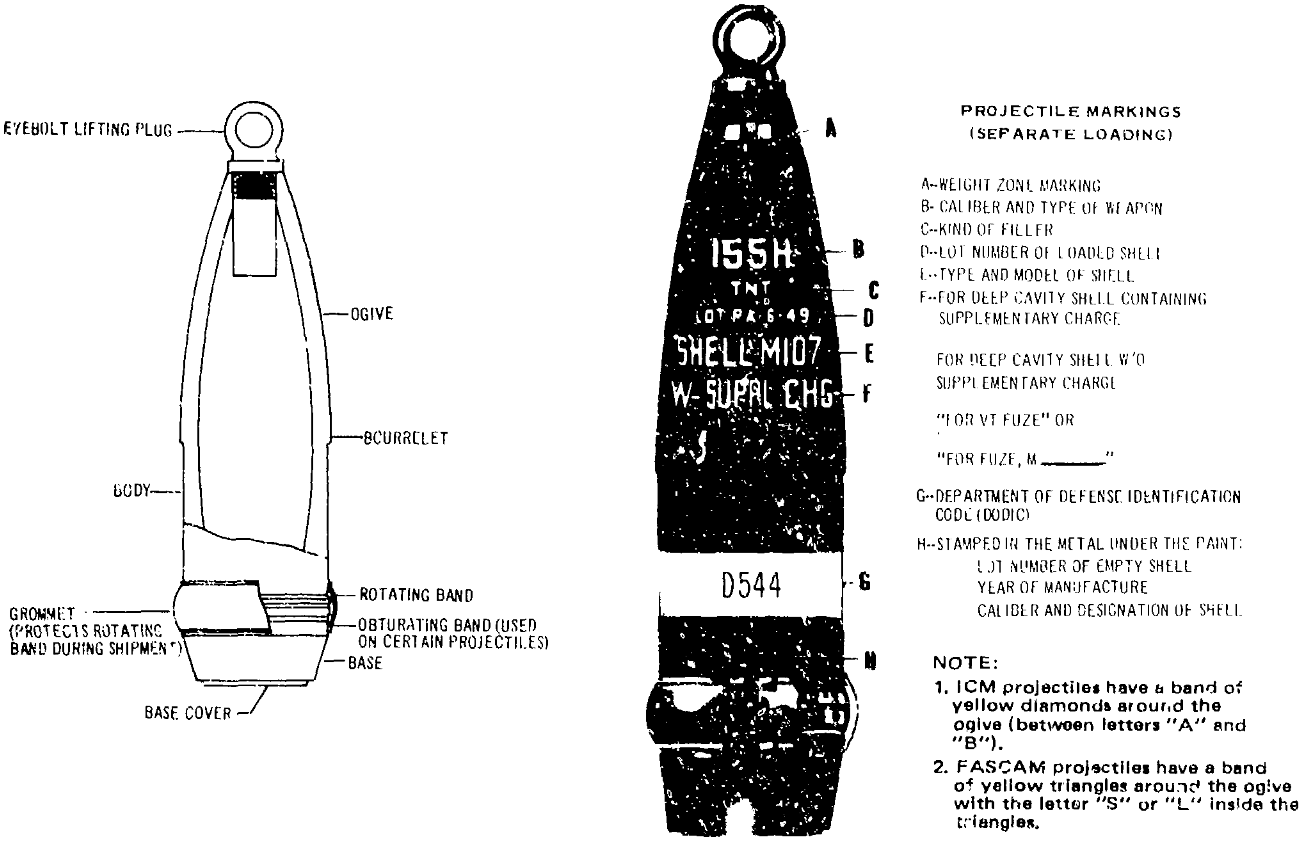


Figure 11-10. Exterior components and markings of projectile.

rotating band. It is machined to a smaller diameter than the bourrelet to reduce the projectile surface in contact with the lands of the bore. The body contains most of the projectile filler.

e. Rotating band. The rotating band is a cylindrical ring of comparatively soft metal that is pressed into a knurled, or roughened, groove near the base of the projectile. It mates with the forcing cone of the tube to eliminate gas wash and perform forward obturation. The rotating band, in conjunction with the rifling of the tube, imparts rotation to, and prevents the escape of propelling gases past, the moving projectile. A properly rammed separate-loading projectile is held in the tube at all angles of elevation by the wedging action of the rotating band against the forcing cone.

f. Obturating band. Some projectiles have a nylon obturating band below the rotating band to assist in forward obturation. Two examples of 155-mm projectiles with this type of a band are the illuminating and the high-explosive rocket-assisted rounds.

g. Base. The base is that portion of the projectile below the rotating band or obturating band. The most common type is known as the boattail base. This type of base streamlines the base of the projectile, gives added stability in flight, and minimizes deceleration by reducing the vacuum-forming eddy currents in the wake of the projectile as it passes through the atmosphere.

h. Base cover. The base cover is a metal cover that is crimped, caulked, or welded to the base of the projectile to prevent hot gases of the propelling charge from coming in contact with the explosive filler of the projectile through possible flaws in the metal of the base.

11-10. Projectile Painting and Marking

The *principal reason for painting a projectile is to prevent rust*, but painting is also used to identify the various types of ammunition.

a. Identification. The basic colors used for many years have been olive drab (OD) for high-explosive rounds, gray for chemical rounds, blue for practice rounds, and black for drill rounds. A system of contrasting color markings or bands in addition to the basic color has also been used to identify the particular type of high explosive or chemical used as a filler. Color coding of recent production projectiles is somewhat different (table 11-2). For example, illuminating and smoke rounds are no longer painted gray, the basic color for chemical shells. Illuminating rounds are now painted basically white or olive drab, and the smoke rounds are painted green. The basic color for dummy ammunition has been changed to bronze.

b. Weight. Variations in weight are inherent in the manufacture of projectiles. Since a high degree of accuracy is required in artillery firing, the data stenciled on the projectile (fig 11-10) must be compared with the data provided in the firing tables to obtain the proper ballistic corrections. The weight zone marking symbols for standard weight projectiles are as follows:

Caliber of projectile	*Standard weight zone*
105-mm	2 squares
155-mm, 8-inch	4 squares

c. Ammunition lot number. When ammunition is manufactured, an ammunition lot number is assigned in accordance with pertinent specifications. This lot number is an essential part of the ammunition marking. When the size of the item permits, this lot number is stamped or marked on the item itself and on all packing containers. The lot number is required for all purposes of record, including reports on the ammunition condition and functioning and on any accidents in which the ammunition is involved. All the components in any one lot are manufactured under conditions as nearly identical as practicable to insure uniform functioning. When semifixed ammunition is fired, successive rounds should be of the same lot number so that maximum accuracy is obtained. When separate-loading ammunition is fired, successive rounds should consist of projectiles of the same lot number, propelling charges of the same lot number, fuzes of the same lot number, and primers of the same lot number.

d. National stock numbers and Department of Defense ammunition code. National stock numbers (NSN) (for example, NSN 1320-00-529-7331) have replaced the old Federal stock numbers (FSN), the old ammunition identification codes (AIC), and ordnance stock numbers. Each item of supply has a different national stock number. The first four digits of a national stock number are always the Federal supply classification (FSC) class to which the item belongs. The next two digits identify the country of origin. Continental United States, for example, uses 00 and 01, whereas some of the other NATO countries use their assigned digits, such as 12 for Germany, 15 for Italy, and 21 for Canada to mention just a few of the NATO countries. The next seven digits constitute the national item identification number (NIIN). The dash between the third and fourth digits of the NIIN serves to reduce errors in transmitting. Each item has a different national item identification number. A Department of Defense identification code (DODIC) is added as a suffix to the national stock number; for example, 1320-00-529-7331 (D544). The Department of Defense ammunition code (DODAC) is an eight-character representation consisting of the four-character FSC code number and the DODIC, consisting of a letter and three digits. For example, 1320-D544, a typical DODAC, consists of FSC class 1320 and DODIC D544, which identifies a 155-mm high-explosive projectile M107, and the NSN 1320-00-529-7331 indicates that the projectiles are packed eight per wooden pallet. The same DODIC suffixed to more than one NSN indicates items that are interchangeable for issue and use.

Section V. PACKING, MARKING, CARE, AND STORAGE OF AMMUNITION

11-11. General Precautions

Tactical units must maintain a combat-ready status. To achieve this status, a unit or organization must maintain its basic load of ammunition in a serviceable and ready-to-fire condition; therefore, adequate inspection criteria must be established and all ammunition personnel must be made aware of their responsibilities. Normally, the quantity of ammunition in the basic load is reserved for emergencies and ammunition for normal expenditures is drawn from the ammunition supply point (ASP) at the available supply rate (ASR). The unit should rotate stocks in the basic load with ammunition drawn from the ASP to insure that all ammunition is inspected regularly and maintained in a serviceable condition. Expending ammunition in excess of the available supply rate normally requires approval of higher headquarters. In addition to being rotated, ammunition should be cared for, handled, and stored as outlined in the succeeding paragraphs of this section.

11-12. Ammunition Storage Precautions

a. Storage on vehicles. When the basic load is stored on vehicles and/or trailers, ammunition personnel must insure that—

(1) Wooden floor racks with a minimum height of 2 inches are placed on the bed of the vehicle.

(2) Drain plugs on all trailers are opened.

(3) The weight is distributed over the entire bed of the vehicle.

(4) The load does not exceed the bed height of the vehicle.

(5) The load is properly braced to prevent shifting during movement.

(6) Ridge poles are placed along the center of the bows and underneath the paulin of the vehicle to prevent the formation of water pockets.

(7) Paulin end curtains are utilized on the rear of all cargo-type motor vehicles.

Table 11-2. Painting and Marking of Ammunition

Ammunition	Painting and Marking of Ammunition of Earlier Manufacture	Painting and Marking of Ammunition of Recent Manufacture
HE	Olive drab w yellow marking	Olive drab w yellow marking
HEAT	Olive drab w yellow marking	Black w yellow marking.
HEP (over 40-mm)	Olive drab w yellow marking	Olive drab w black band and yellow marking.
Smoke (except WP or PWP	Gray w one yellow band and yellow marking.	Light green w black marking.
Smoke (WP or PWP)	Gray w one yellow band and yellow marking.	Light green w yellow band and light red marking.
Illuminating (semifixed)	Gray w one white band and white marking.	White w black marking.
Illuminating (separate-loading)	Gray w one white band and white marking.	Olive drab w white band and white marking.
Practice wo explosive filler	Blue or black w white marking	Blue w white marking.
Practice w high-explosive filler	Blue or black w white marking	Blue w yellow band and white marking.
Practice w low-explosive filler	Blue or black w white marking	Blue w brown band and white marking.
Chemical:		
Persistent toxic agent	Gray w two green bands and green marking.	Gray w two green bands and green marking. (One yellow band w explosive burster.)
Nonpersistent toxic agent	Gray w one green band and green marking	Gray w one green band and green marking. (One yellow band w explosive burster.)
Persistent irritant agent	Gray w two red bands and red marking.	Gray w two red bands and red markings. (One yellow band w explosive burster.)
Nonpersistent irritant agent	Gray w one red band and red marking.	Gray w one red band and red marking (One yellow band w explosive burster.)
G and V series agents	Gray w one green band for G series, two green bands for V series, and green marking.	Gray w three green bands and green marking. (One yellow band w explosive burster.)
AP w high-explosive filler	Black w yellow marking	Black w yellow marking.
APERS w flechettes	Black w white marking	Olive drab w yellow band, white marking and white diamonds.
AT mines, RAAM	None	Olive drab w yellow marking and yellow triangles w letters "S" or "L" in OD.
AP mines, ADAM	None	Olive drab w yellow marking and yellow triangles w letters "S" or "L" in OD.
Dummy	Black or blue w white marking	Bronze w white marking.

(8) Adequate ventilation is provided for in the loaded vehicle. The paulins should be raised periodically so that the ammunition on the vehicles can be aired.

b. Off-vehicle storage. In certain instances, part of the basic load may be stored on the ground or in buildings. Such ammunition should be earmarked for a specific vehicle and stacked by vehicle load. Operational plans must also provide for the time, personnel, and vehicles required to issue or move the ammunition.

(1) *Inside storage.*

(a) Dunnage should be high enough to allow a minimum airspace of 3 inches between the ammunition and the floor of the building.

(b) Stripping between boxes is desirable if the boxes are not cleated. Stripping should be no less than 1 inch thick and 2 inches wide. This allows better air circulation and makes the stacks more stable.

(c) Within each stack, items of the same type should be stacked together by lot number with the nomenclature facing outward and all boxes alined. This arrangement facilitates inventory and inspections.

(d) Stacks should be no closer than 6 inches to the wall and no closer than 18 inches to the ceiling.

(e) All items should be properly packaged and adequately marked.

(2) *Outside storage.*

(a) Dunnage should be high enough to provide a minimum of 6 inches between the stack and the ground.

(b) The procedures in (1)*(b)*, *(c)*, and *(e)* above apply to outside storage.

(c) Ammunition in outside storage will be protected by a canvas paulin, a wooden shed, or an A-frame. A minimum airspace of 18 inches should be maintained between the covering and ammunition to provide for proper ventilation.

11-13. Ammunition Storage in Artillery Emplacements

a. Firing batteries must be capable of moving within a few minutes of notification. Keeping ammunition loaded on vehicles and servicing the howitzers directly from the ammunition vehicle will help to keep your units mobile. This applies to

Follow these charts when you are combat loading your M548 ammunition vehicle with the 155-mm or 8-inch ammunition components.

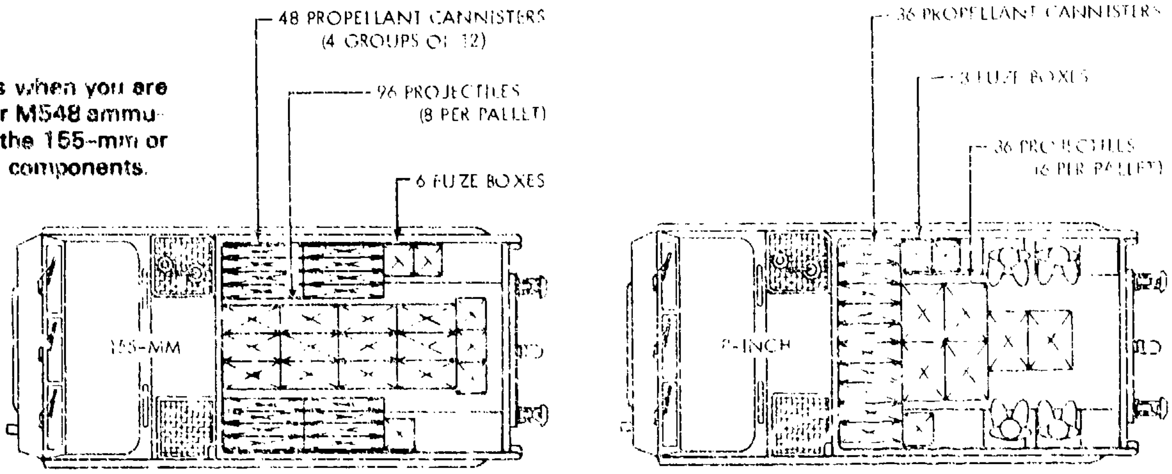


Figure 11-11. Combat loading charts of the M548 cargo carrier.

both towed and self-propelled artillery weapons. The ammunition vehicles then should be habitually associated with the howitzers. This means that when a howitzer receives a scheduled maintenance, so should the ammunition vehicle; convoys should be tactically configured so that ammunition vehicles follow their assigned howitzers; and, that if a howitzer is dug in or revetted, the ammunition vehicle is in the same revetment. An extract from TM 9-2350-247-10 of an ammunition combat loading chart of the M548 Cargo Carrier for the 155-mm or 8-inch howitzers is shown in figure 11-11. These charts are guides only, and the location of ammunition components may differ due to your combat mission.

b. Ammunition vehicles at the firing point will be placed so that the howitzer can still be serviced, but the possibility of ignition or detonation in case of an accident is minimized. Ammunition should be stored in a dry place and should be protected from the direct rays of the sun by tarpaulins or other covering. There should be ample circulation of air through and on all sides of the stacks. Erratic ranges and dangerous high pressure may result from overheated ammunition.

c. A suitable point should be designated and safety procedures should be established for the collection and disposition of unfired powder increments (see paragraph 11-17*b*).

WARNING: Smoking is always prohibited in the vicinity of explosives and ammunition.

11-14. Special Handling Precautions

a. Standard ammunition. Explosive ammunition must be handled with appropriate care at all times. Explosive elements, such as those in primers and fuzes, are sensitive to undue shock and high temperature. The general rules in (1) through (3) below as well as those in paragraph 11-13 should be observed in order to keep ammunition in a serviceable condition and ready for immediate use.

(1) Do not permit disassembly of components, such as fuzes and primers, without specific authorization. Any alteration of loaded ammunition, except by direction and under the supervision of the technical source concerned, is hazardous and must not be undertaken.

(2) Do not open sealed containers or remove protective or safety devices until just before use, except as required for inspection.

(3) Return ammunition prepared for firing but not fired to its original packing and mark it appropriately. Use such ammunition first in subsequent firings in order to keep stocks of previously opened containers at a minimum.

WARNING: Live ammunition will not be substituted for authorized drill ammunition for training purposes.

b. Beehive round. Special handling precautions and procedures for handling the Beehive round must be observed to prevent damage to the projectile. These special procedures are necessary because the projectile case is made of aluminum, except for the steel hollow base, and rough handling can cause extensive damage to the aluminum portion and thus render the projectile unserviceable. Damage to the Beehive projectile can be prevented by application of the procedures described in *a* above for standard ammunition and observation of the special precautions outlined in (1) through (5) below.

(1) Insure that all personnel are aware of the greater possibility of damage to Beehive rounds than to other types of ammunition. Since Beehive ammunition is reserved for special purposes, it may remain in the unit longer than other ammunition and thus may be handled many times before it is fired.

(2) Conduct frequent inspections to insure adequacy of storage, proper storage of Beehive

rounds in the basic load, and proper handling procedures.

(3) Do not allow the projectile to strike or be struck by sharp or heavy objects.

(4) Store (stow) Beehive ammunition separately from standard ammunition; however, if Beehive rounds must be stacked with standard ammunition, as may become necessary in certain tactical situations (e.g., airlift resupply), place the Beehive rounds on the top of the stack.

(5) Insure that adequate securing devices and protective materials are provided for rounds that have been removed from their containers for immediate firing and insure that cannon crews understand how to use these devices.

11-15. Packing and Marking

Ammunition is packed in special containers. These containers are clearly marked in accordance with pertinent Army regulations and specifications to show all essential information. Containers are designed to withstand normal conditions of handling, storage, and transportation and to comply with Interstate Commerce Commission regulations. Markings on containers include all information required for complete identification of the contents and for compliance with Interstate Commerce Commission regulations. For additional information, see TM 43-0001-28 and TM 9-1300-206.

11-16. Primers

Primers for semifixed ammunition are an integral part of the cartridge case; therefore, the storage requirements for propelling charges apply. The cartridge case should not be dropped, and the base of the case should not be set on a sharp object, which could cause the primer to ignite. Primers for separate-loading ammunition may be received packed with the propellant, in which case the primers will be stored with the propellant in the original containers. Separate-loading primers may be packed and issued separately, in which case they will be stored separately.

11-17. Propellants

a. Packing and storing. Propelling charges are packed in fiber containers or airtight metal storage cases for ease in handling and for protection from the elements. An igniter cap of cloth or paper protects the igniter end of the separate-loading propelling charges in shipment. The packing containers are marked so that all essential information may be seen without the seal being broken. Components of the propelling charge explosive train should be stored in their original, unopened containers until just prior to use in order to keep out moisture, which slows the burning rate of powder. Propelling charges should be checked carefully to insure that the proper number of increments is present.

b. Destruction. Unused powder increments should be burned, not buried. Burning will be accomplished by a two-man team supervised by an officer. The burning site will be at least 200 feet from other personnel and equipment. All powder charge increments to be destroyed should be placed in a single-layer row not more than 12 inches wide. The row of increments should be placed so that burning will progress toward the direction of the wind (into the wind). A train of combustible material (e.g., excelsior) approximately 25 feet long should be placed perpendicular to, and at the downwind end of, the row of increments. The combustible material should be lighted at the end farthest from the explosive by a member of the burning detail, who should be standing on the windward side of the train. Igniter powder (black powder) will be removed from the propelling charges and placed in a train not more than 2 inches wide at the upwind end of the row of increments to be destroyed.

WARNING: Propelling charges and igniter pads should be opened with a nonsparking knife to avoid premature ignition. Be sure to remove the igniting powder from the center core of certain propelling charges before burning; i.e., M119 or M188 series.

11-18. Projectiles

a. Semifixed projectiles. The projectile and propellant for semifixed rounds are placed in the same shipping container. The round is packed in a fiber container, which, in turn, is packed in a metal container or wooden box. For further protection, fuzed projectiles of 105-mm calibers may have U-shaped packing stops fitted into the fuze slots. These must be removed.

b. Separate-loading projectiles. Separate-loading projectiles do not require any outer packing; they are shipped unfuzed, with an eyebolt lifting plug in the nose and a grommet around the rotating band for protection. Palletizing the projectiles permits the employment of forklifts and other types of heavy materials handling equipment and thus reduces handling time and labor in shipping and storage.

c. Loose projectiles. Loose projectiles should always be loaded parallel to the sides of a vehicle and blocked so that they will not roll.

d. Ammunition storage. Ammunition storage in the field is the responsibility of the artilleryman. The three essential factors that govern storage of ammunition are *ventilation*, *cover*, and *drainage*. Components of ammunition are given priority of storage in order of their sensitivity. Chemical and white phosphorus projectiles should be given special attention. Chemical (gas) projectiles are stored downwind from the battery; white phosphorus projectiles are always stored on their bases because the phosphorus will melt at 110° F and run to the side (if the projectile is not upright) and thus cause erratic flight. If a round of white phosphorus starts to leak, it becomes a fire hazard and should be immersed in water. Projectiles of different lot numbers should be stored separately.

11-19. Fuzes

Fuzes are packed in individual fiber or hermetically sealed metal containers in a wooden box, with the exception of proximity (VT) and concrete-piercing fuzes, which are packed in sealed metal containers. When a round is being prepared for firing, two of the most important functions are fuzing and cutting the propelling charge. In fuzing, it is essential that the fuze be made fast to the projectile. Adjustable fuzes should be properly set and should be checked before firing. Any fuze that has been prepared for firing but has not been fired must be reset to the safe position before it is repacked in the original carton. Safety pins in the booster must be removed before the fuze and booster are seated in the projectile. Safety wires on fuzes must be removed before loading; if the fuze is not fired, the wires should be replaced. Only the proper fuze setter should be used.

Section VI. FUZES, FUZE WRENCHES, FUZE SETTERS, AND BOOSTERS

11-20. Forces That Act Upon a Fuze

A fuze is said to be armed when it is ready to detonate the projectile; that is, when all parts are in, or are free to move to, their proper positions so that the fuze may operate in its intended manner. Arming of fuzes is accomplished principally by inertia and centrifugal force. In some fuzes, both of these forces are used to actuate the safety devices; in others, only one force is used.

a. Inertia. Inertia is the property of matter by which any physical body (matter) persists in its state of rest or of uniform motion until acted upon by some external force. Inertia manifests itself in several ways.

(1) *Setback* occurs when the projectile accelerates on being fired. It may be used to advantage to lock safety devices or unlock them when required.

(2) *Creep*, a phenomenon that can cause malfunction, occurs as the projectile body decelerates in flight. It is taken into consideration in designing the fuze.

(3) *Setforward* occurs at impact or on sudden deceleration. This effect may be used to drive firing pins into primers or to drive primers against stationary firing pins.

b. Centrifugal force. Centrifugal force is that force which results from rotation of the projectile and fuze during flight. All objects within the fuze that are free to move will move away from the axis of rotation toward the outside of the fuze.

11-21. General Classification of Fuzes

a. An artillery fuze is classified according to its position on the projectile as—

(1) Base detonating (BD).

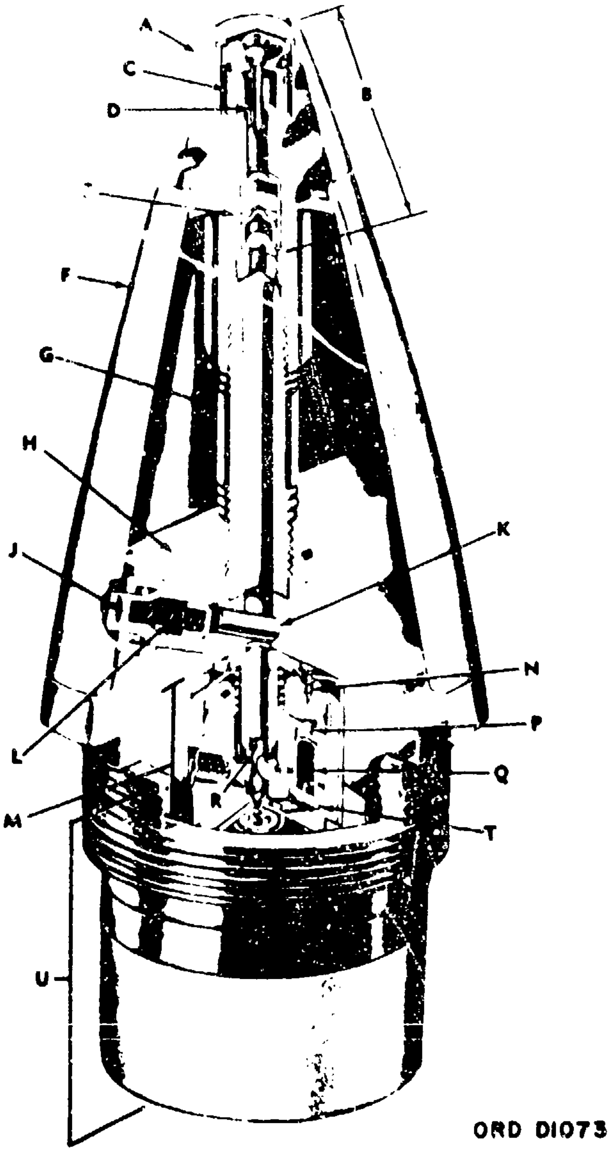
(2) Point detonating (PD).

b. Artillery fuzes are also classified according to the method of functioning as impact, mechanical time (MT), or proximity (VT) or as a combination of these. Combination fuzes, such as the superquick and delay or the time and superquick, are further classified as selective fuzes; i.e., the fuze may be set for either of the two available actions. A selective fuze set for the primary action should function on the alternate action if the primary arming element fails. This alternate functioning minimizes complete loss of effect on a target; it also provides a self-destruction capability and thereby prevents recovery of the rounds by enemy personnel. Setting a selective fuze for alternate functioning (e.g., setting a superquick and delay fuze for delay action or a mechanical time and superquick fuze for superquick action) in effect reduces the fuze to a single-action fuze and will result in a dud or low-order burst if the alternate arming element fails. Certain models of the proximity (VT) fuze incorporate a superquick element expressly for self-destruction purposes, whereas others are of the selective type.

11-22. Impact Fuzes

Impact fuzes are further classified according to the action initiated by the force of impact as superquick, delay, nondelay, or point initiation base detonation (PIBD).

a. Superquick. Superquick action is designed to cause the projectile to burst at the instant of impact with a solid object. Superquick action gives most of the effect above ground and leaves but a small crater. Heavy rain or hail may cause the superquick element of a fuze to function because the firing pin is mounted in the point of the fuze and will be driven into the primer upon impact with any solid object; therefore, a fuze should not be set for superquick action under such conditions. However, see paragraph (4) below for the new rain insensitive fuze M739. There are four impact, point-detonating fuzes that are basically similar in construction and have the superquick capability.



A—Head
B—Superquick element
C—Firing pin support
D—Firing pin (SQ)
E—Detonator M24
F—Ogive or windshield
G—Flashtube
H—Body
J—Setting sleeve
K—Interrupter
L—Interrupter spring
M—Delay plunger assembly M1
N—Firing pin (delay)
P—Primer M54
Q—Delay pellet
R—Plunger pin lock
S—Plunger pins
T—Relay M7 (delay element)
U—Booster M125A1

Figure 11-12. Impact fuze M557, selective type, superquick or delay.

(1) *M508 superquick fuze.* The M508 is a single-action impact fuze that requires no setting and gives a superquick action. It is basically the same as the M557 fuze ((2) below) but has no delay element. It incorporates a booster M125, and the booster rotor provides the bore safety. This fuze is used with burster-type chemical projectiles.

(2) *M557 selective fuze.* The M557 fuze (fig 11-12) is classified as a selective fuze because it offers a choice of superquick or delay action. The current production model has a black powder pellet that gives a delay of 0.05 second. This fuze is used with all HE projectiles. The M557 fuze is set by means of a slotted screwhead (selector sleeve) on the side of the fuze body (fig 11-12). Turning the slot to the vertical position (SQ) gives superquick action; turning it to the horizontal position (DELAY) gives a delay action. The position of this slot determines the action of the interrupter. If the selector is set for DELAY, the interrupter is locked into the flash channel and the superquick element cannot be armed. If the selector is set for SQ, the interrupter is moved out of the flash channel by centrifugal force. Therefore, the flash from the superquick detonator travels directly to the booster and superquick action results. If, for any reason, the superquick components fail to function, the delay plunger will move forward and cause the projectile to explode with delay action. Fuze M557 consists of—

(a) A superquick firing pin in the nose.

(b) A superquick detonator.

(c) A flash channel, extending from the superquick detonator to the booster.

(d) An interrupter in the flash channel, coupled with a selector sleeve.

(e) A delay action plunger in the base of the fuze, consisting of a fixed firing pin, a sliding detonator, and a black po... r pellet.

(f) A booster (M125A1).

(3) *M572 selective fuze.* The M572 fuze is essentially the same as the M557 fuze except that the nose of the M572 fuze has been filled with epoxy.

(4) *M739 selective fuze.* The M739 fuze (fig 11-13) is the latest improved version of the impact fuze. The new fuze has an aluminum-filled body. In addition, the new fuze has a rain insensitivity modification of the fuzing pin head, recessed ¾ inch into a ½-inch diameter sleeve, with four small crossbars installed at different depths and orientations inside this sleeve cavity. These crossbars cause raindrops that enter this sleeve to be atomized into small droplets. These droplets are thrown out of the cavity by centrifugal force and air pressure through four ⅛-inch-diameter radial holes located at the bottom of the sleeve. This

action makes the fuze less sensitive to rain so that it can be fired through heavy rainstorms without premature functioning of the round of ammunition. It will eventually replace both of the older, rain-sensitive, fuzes M557 and M572.

b. Nondelay. There are two types of nondelay fuzes—base-detonating and point-detonating. The BD fuzes are used in projectiles in which the location of the fuze on the point of the projectile would be impractical, as in the high-explosive plastic round. The nondelay point-detonating fuze is steel hardened to permit penetration of concrete emplacements without damage to the firing pin and booster assembly. The firing pin and detonator assembly of all nondelay fuzes are located within the fuze body and thus are protected from possible damage upon impact. The nondelay fuze depends on rapid deceleration of the projectile at impact for its action. Therefore, the nondelay fuze action is slightly slower than the superquick fuze action but is much faster than the delay fuze action. (The delay fuze incorporates a black powder pellet to control the duration of the delay.) There are two nondelay single-action fuzes.

(1) *M78 concrete-piercing, point-detonating, nondelay fuze.* The concrete-piercing, point-detonating M78 fuze is a single-action nondelay, impact, point-detonating, steel-hardened fuze with a white tip painted on the nose to distinguish it from the CP M78 delay fuze (*c* below). This nondelay fuze enables adjustment of fire on a fortification without the requirement for a fuze of different ballistic characteristics. A box of CP M78 fuzes contain 4 nondelay fuzes and 16 delay fuzes. The nondelay fuze has the same types of elements as the delay fuze (*c* below) except that it has no black powder delay pellet. The nondelay fuze is used in final adjustments during missions requiring concrete-piercing or rubble-clearing action. The M25 booster is used with the CP M78 fuze to insure complete detonation of the bursting charge.

(2) *M91 base-detonating nondelay fuze.* The BD M91 fuze is a single-action fuze with an integral booster charge and a tracer element. It is a base-detonating fuze for use with the 105-mm HEP-T projectile, and it is issued with the projectile. The tracer element is located in the conical base end of the fuze and has a burning time of 7.5 seconds.

c. Delay. A delay fuze is designed to allow the fuze and projectile to penetrate the target prior to the complete detonation of the bursting charge. This action requires a steel-hardened fuze to withstand this penetration. The concrete-piercing CP M78 delay PD fuze is a single-action, impact fuze that requires no setting and is capable of delay action only. An M25 booster is used with the CP M78 fuze to insure complete detonation of the bursting charge. The black powder delay element gives a delay of 0.025 second. This fuze and booster can be used to convert a high-explosive round to a concrete-piercing round, and are installed in the projectile by the cannoneer with a special fuze wrench, the M16 (fig 11-14).

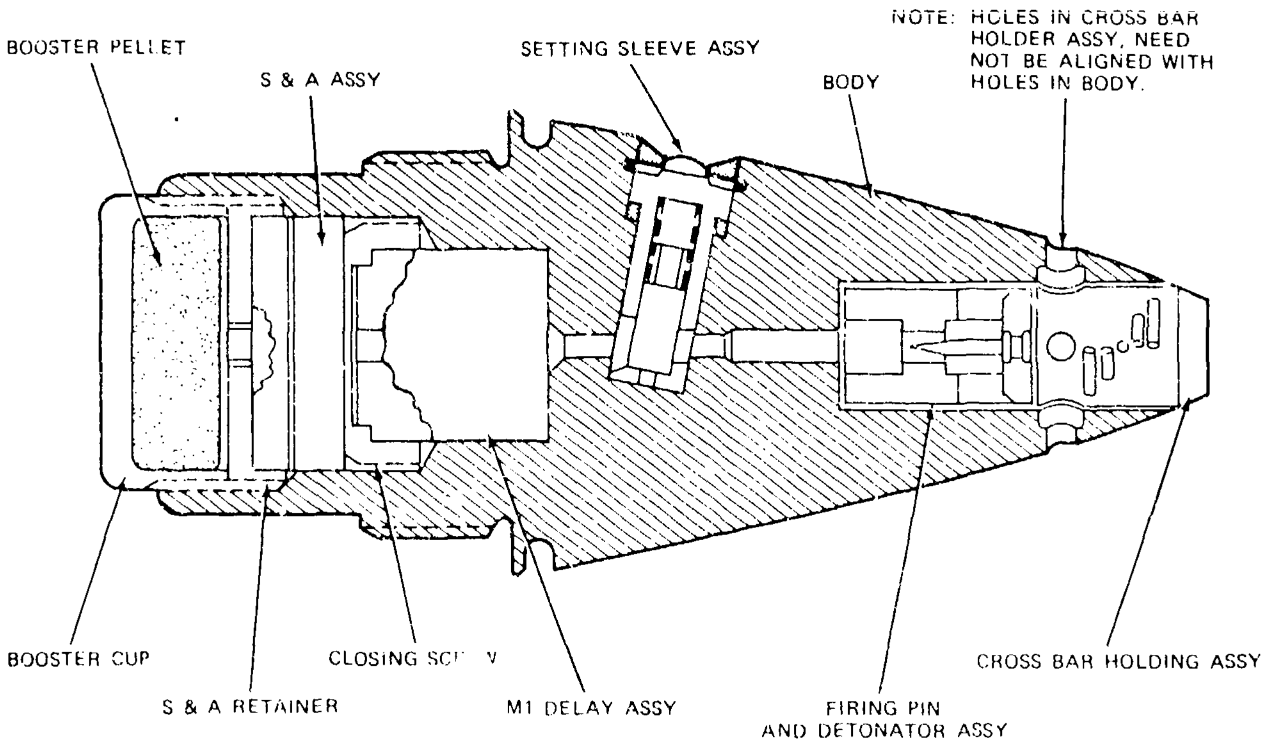


Figure 11-13. Impact point-detonating superquick and delay fuze M739.

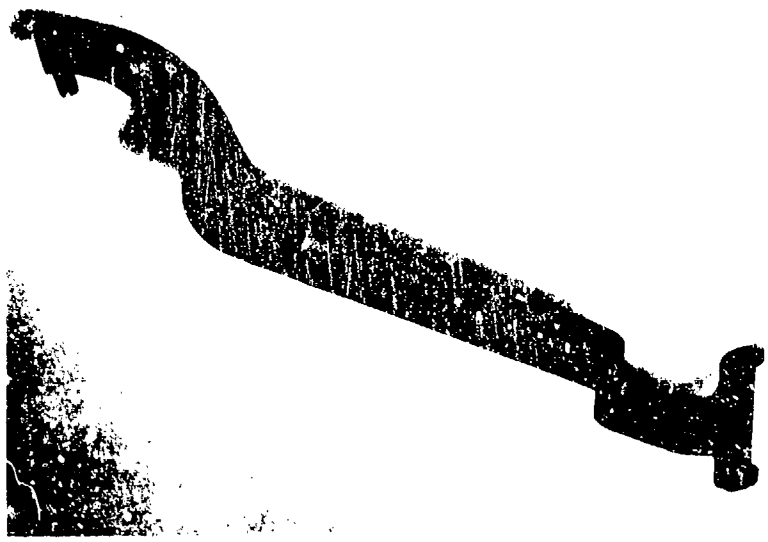


Figure 11-14. Fuze wrench M16.

d. Point initiating base-detonating. The point initiating, base-detonating (PIBD) fuze M509A1 is a special purpose fuze used with the M622 HEAT-T projectile in the 105-mm howitzer, to provide proper function of the round when it is fired in a direct role against enemy armored targets. A piezoelectric element retained in a nose cap is fitted to the threaded standoff spike assembly and is connected to the base-detonating fuze in the body. On impact, fuze functioning detonates the projectile and the cone collapses, creating a high-velocity, focused shock wave and a jet of metal particles that penetrate the target.

11-23. Mechanical Time and Proximity (VT) Fuzes

a. Mechanical time and proximity (VT) fuzes (fig 11-15), when installed and set properly, cause the projectile explosive train to function at the right time and place. This chapter contains information on the mechanical time (MT), mechanical time-superquick (MTSQ), and proximity (VT) fuzes being used in the field artillery at this time. It also discusses the fuze wrench to be used in installing each fuze, the fuze setter to be used in setting each type of fuze, the direction in which the time ring must be turned, and the number of times each fuze can be reset.

b. For many years field artillerymen the world over have used first the old powder train time fuzes (for example, the M54/M55) and then the mechanical time fuzes (such as the M501/M520, and later the M563, M564, and M565) to cause projectiles to function at a given time along the trajectory. They have also fired projectiles with both the old and the new proximity (VT) fuzes. The basic difference between the proximity (VT) fuzes is that the older fuze had no time ring for controlling the activation of the radio. The fuze broadcasted signals all along the trajectory, which, in many cases, resulted in early bursts. The later proximity (VT) fuze has a 100-second time ring for controlling the activation of the radio until the optimum time of 3 to 5 seconds before reaching the target. Today, all proximity (VT) fuzes have time rings, and they are known as proximity (VT) fuzes. The following information on both old and new time fuzes is provided to bring you up to date on what is available in the field. For information on all of the older time fuzes not covered in this chapter, see TM 43-0001-28, *Artillery Ammunition*.

11-24. M500/M501/M520 Mechanical Time-Superquick Fuzes

a. General. The M500/M501/M520 MTSQ fuzes are mechanical time-superquick fuzes that have two different firing pins, one for the time function and one for the impact function. The fuze will function on whichever action occurs first after the round has been fired and the fuze armed. These fuzes contain a mechanical time mechanism (just like the clockworks in your alarm clock or wristwatch). The time mechanisms are more reliable than the black powder rings in the old powder train time fuzes (M54/M55), and they can be set from 0 to 75 seconds, which is a significant improvement over the older time rings, which could be set from 0 to 25 seconds. The M500 fuze was replaced by the M520.

(1) *Early fuze wells.* Until 1962, the fuze wells of projectiles, into which the fuze bodies were screwed, were of two different sizes—one size for those fuzes that used boosters and a smaller size for those that did not require boosters.

(a) High-explosive and burster-type projectiles. The white phosphorus, gas, and

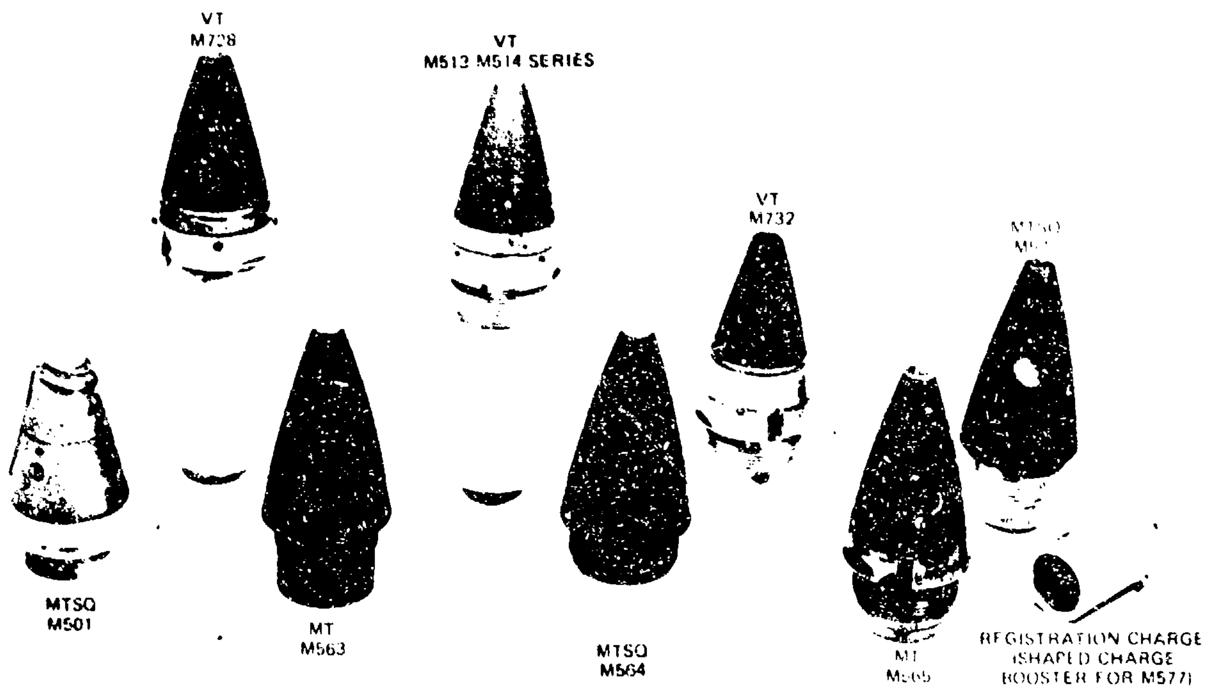


Figure 11-15. Time and proximity fuzes of the field artillery.

high-explosive projectiles had the larger fuze opening to accommodate the booster, which was screwed onto the base of the fuze and then screwed into the fuze well. These projectiles used the M500 fuze and, later, the improved version called the M520 fuze. In both cases, the field artilleryman received the fuzes and boosters already assembled and ready to be installed in the fuze well of the projectile.

(b) Base-ejection projectiles. All of the base-ejection projectiles, such as smoke, illuminating, had the smaller fuze opening and used the M501 fuze, which came without a booster. The M500 or M520 fuzes with boosters would not fit in this type of projectile because the fuze opening was too small.

(2) *Fuze wells of today.* Today, all of the fuze well openings in the projectiles have been standardized to the large size (1)*(a)* above, and the fuze bodies have been manufactured to fit the larger openings. However, there are still many projectiles of the base-ejection type (smoke and illuminating rounds) with the small fuze openings available, and for that reason the M501 fuze will have to stay in the inventory until all of the old stocks (of smoke and illuminating rounds) have been expended (*c* below).

b. M500/M520 MTSQ fuze. The M500 and M520 MTSQ fuzes are obsolete. Those still in existence are being converted to M501s by removal of the booster.

c. M501 MTSQ fuze. The M501 MTSQ fuze (fig 11-16) is still required for the base-ejection projectiles with the small fuze opening in the nose of the shell. You can recognize these old base-ejection smoke and illuminating rounds very easily. The smoke rounds are painted gray with yellow markings; the illuminating rounds are painted gray with white markings.

d. Installing the M501 fuze. Install the M501 fuze in the old smoke or illuminating projectile by removing the closing plug (or eyebolt lifting plug) from the projectile, inspecting the fuze well, placing the fuze in the fuze well of the projectile, and tightening the fuze by hand. Next, place the M18 fuze wrench (fig 11-17) correctly on the fuze so that you can turn the wrench counterclockwise about ¼ turn to loosen the fuze. Then with your hand on the handle of the wrench, turn the wrench sharply and firmly clockwise to tighten the fuze to the projectile. Do not use an extension on the fuze wrench. Be sure that there are no threads showing and that the fuze fits snug against the nose of the projectile.

WARNING: Do not fire an artillery round of any caliber without using the fuze authorized for

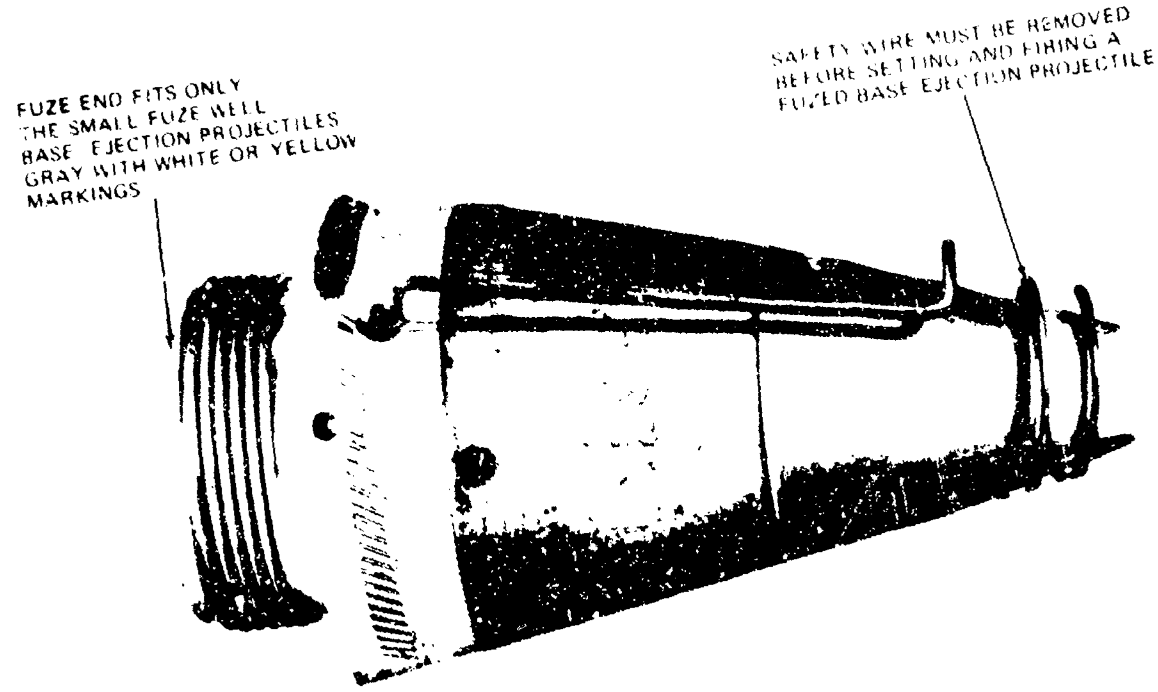


Figure 11-16. Fuze M501 mechanical time superquick.

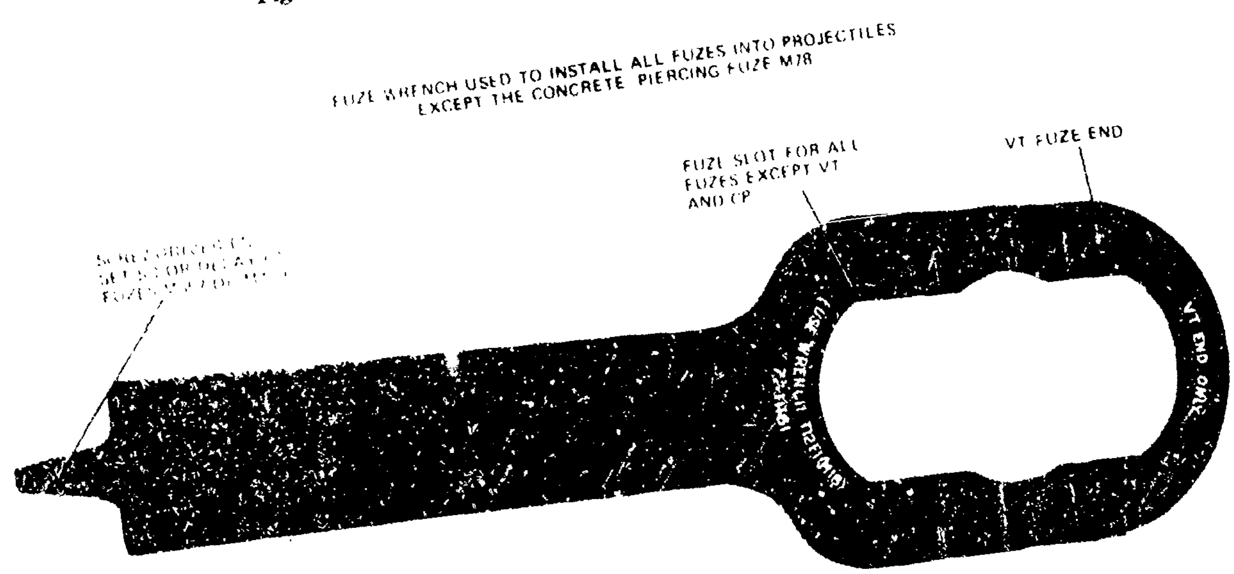


Figure 11-17. Fuze wrench M18.

that particular round. The firing of a round without a fuze or with a fuze that is not authorized for that type of round could result in an inbore burst or some other hazardous condition that could cause serious injury to personnel and damage to equipment.

e. Setting the M501 MTSQ fuze. The M501 MTSQ fuze can be set to the closest 1/10 second with the M26 precision fuze setter (fig 11-18) or to the closest ½ second with the M27 fuze setter (fig 11-19).

(1) *M26 precision fuze setter.* To use the M26 fuze setter, loosen the thumbscrew and set the time on the outer ring of the fuze setter. Set the time by turning the setting handle assembly and reading the time on the outer scale; interpolate between the .2 marks on the fuze setter. Remove the safety wire from the M501 fuze that is installed in the

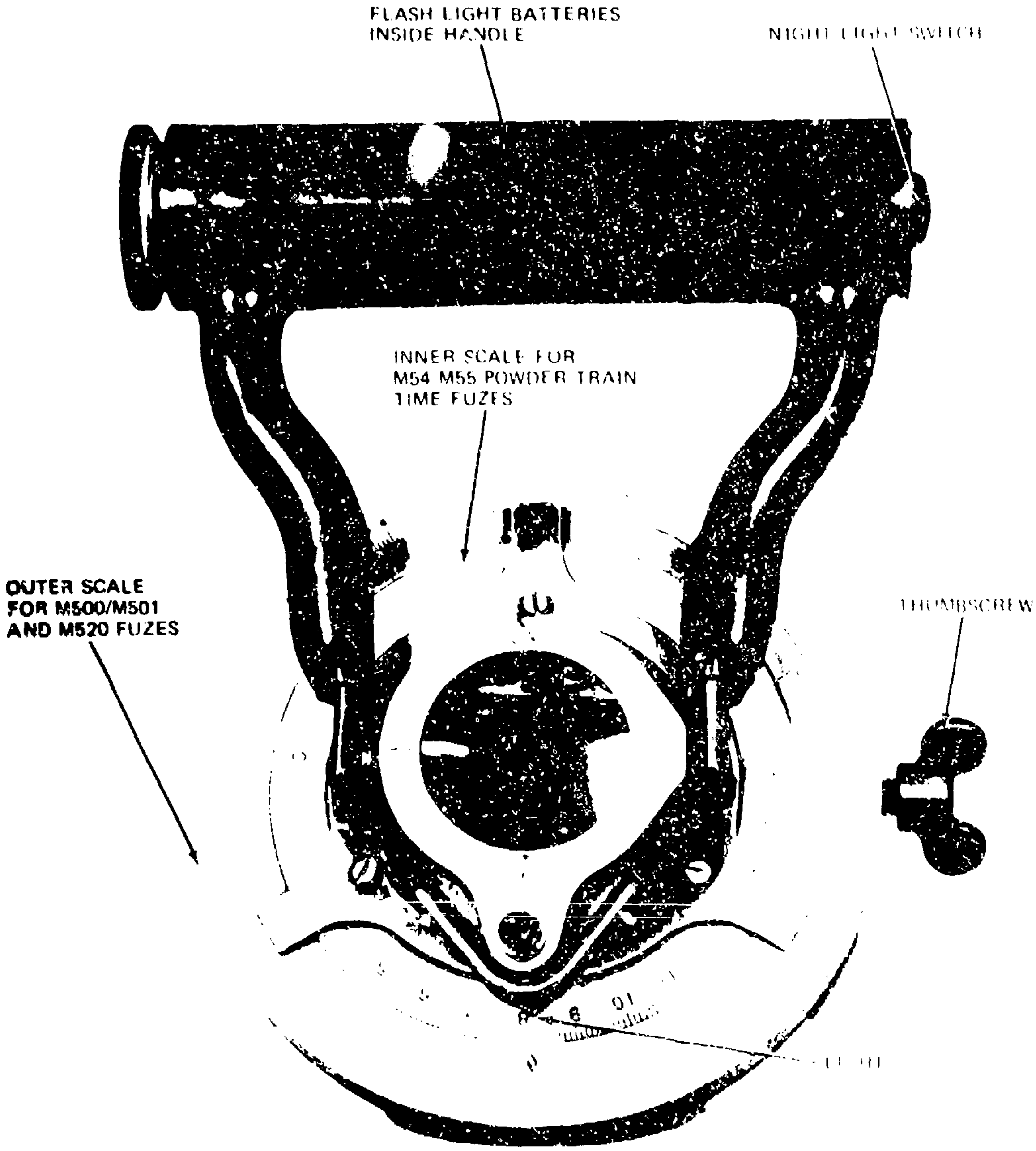


Figure 11-18. Fuze setter M26.

projectile. Place the fuze setter, with the correct time setting on it and with the thumbscrew tight so the scale will not slip, on the fuzed projectile. Seat the fuze setter onto the nose of the fuze, then lock the handle down on the scales, and rotate the setter in a counterclockwise direction until it stops and the pawl snaps into position. Next, raise the handle and remove the fuze setter. Be sure to check the setting on the fuze to insure that it is set correctly and that the fuze is still flush with the nose of the projectile. Sometimes the counterclockwise turning of the fuze setter loosens the fuze in the fuze well and leaves it loose on the projectile. A loosened fuze can cause an inbore explosion or other malfunction if fired in that condition. So if the fuze is loose, use the M18 fuze wrench to retighten the fuze so that it is again flush against the nose of the projectile. The M26 fuze setter is no longer issued and is being replaced by the M27 (fig 11-19).

(2) *M27 fuze setter.* Fuze setter M27 (fig 11-19) is a flat-handled wrench-type instrument with a cone-shaped portion, which consists of a bronze casting with a steel catch that is dovetailed and pinned to the casting, on the center of the

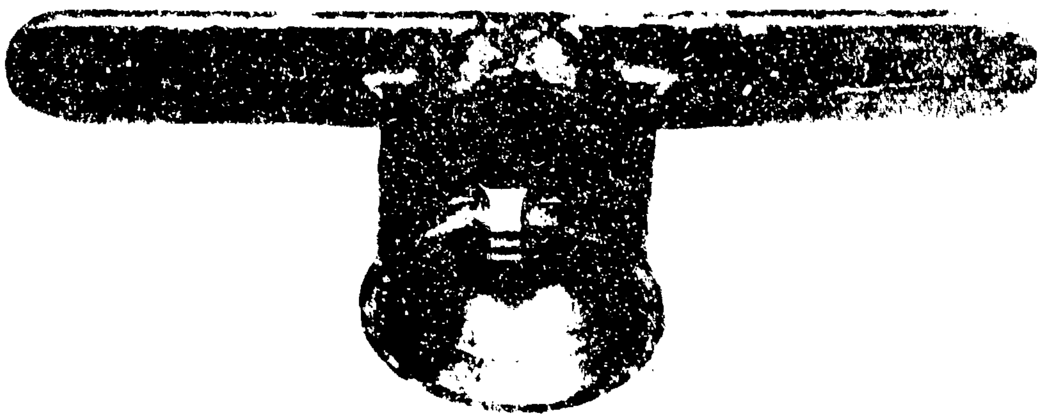


Figure 11-19 Fuze setter M27.

T-handle. The fuze setter has no scale. Obtain the desired setting by removing the wire from the fuze and placing the setter over the top of the fuze so that the steel catch engages the lug on the lower cap of the M501 fuze. Turn the fuze setter in a counterclockwise direction until the index mark on the cap points to the time desired on the time ring of the fuze. You can set the M501 fuze to the closest ½ second with this fuze setter. If you miss the setting, back up the index mark 1 or 2 seconds and then reset the index mark over the desired time setting.

(3) *Direction of setting M501 fuze.* When using the M26 fuze setter, always turn the fuze setter in a counterclockwise direction (toward increasing time), even when you are changing the time setting to a number that is lower than that you originally placed on the fuze. When using the M27 fuze setter, turn it counterclockwise also; but, if you miss the setting or want to change it to a lower one, you turn fuze setter M27 clockwise to at least 1 or 2 seconds below the desired setting and then approach the correct setting from lower to higher numbers. The purpose of going 1 or 2 seconds below the desired setting is to take up any lost motion in the mechanical time gear train that could adversely affect the airburst.

(4) *Setting the fuze to safe.* If you do not fire the M501 fuze, you must reset the fuze to safe and replace the safety wire on the nose of the fuze.

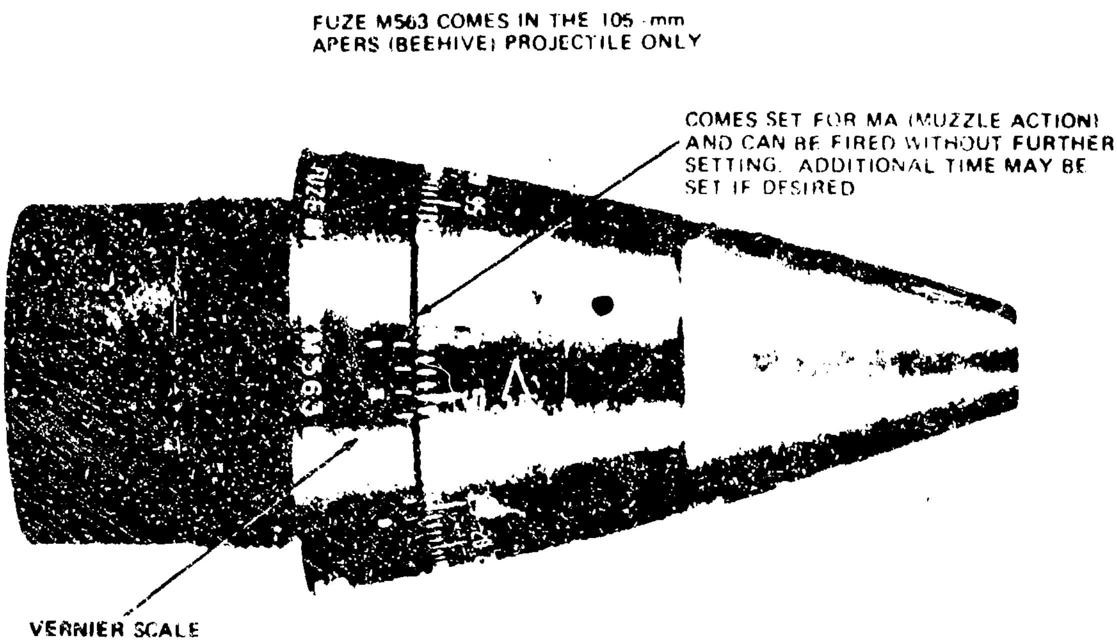


Figure 11-20. Fuze M563 mechanical time.

Using the M26 fuze setter, turn the dials of the fuze setter to S, place the setter over the nose of the fuze, and turn the setter counterclockwise until it stops. Remove the setter, check the setting on the fuze, and replace the safety wire. To set the fuze to safe with the M27 fuze setter, place the M27 fuze setter on the fuze, engage the steel catch in the lug on the lower cap, and turn the index mark counterclockwise until it is over the S setting on the fuze. Remove the setter, check the setting on the fuze, and replace the safety wire.

f. Number of times the M501 fuze can be set. The M501 has four small brass screws that hold the lower cap snug to the time ring on the fuze. Turning the index mark on the ring causes the screws to be worn. Therefore, the M501 fuze should not be set more than three times without the ammunition supply point surveillance team checking the torque of the screws to insure that they are snug enough to hold any settings put on the time ring. If you have an M501 fuze with a loose time ring, do not use it. Turn it back to your ammunition sergeant so that he can turn it back to the ammunition supply point, where personnel will retorque the time ring by tightening the four brass screws.

11-25. M563/M564/M565 Mechanical Time Fuzes

a. General. The M563, M564, and M565 mechanical time fuzes have 100-second time mechanisms and vernier scales, which are used in setting the fuzes to the closest 1/10 second. These fuzes have standard size fuze bodies and will replace the M501 and M520 MTSQ fuzes.

b. M563 mechanical time fuze. The M563 mechanical time fuze (fig 11-20) is a single-action fuze that comes set for muzzle action. The fuze can be set for any time of flight up to 100 seconds. The M563 mechanical time fuze was specifically developed for use with the 105-mm antipersonnel round, commonly called the Beehive round, and it is not used with any other projectile. It incorporates a time vernier scale similar to that of the M564 MTSQ fuze (*c* below) and is set for time in the same manner as that fuze (*f* below).

c. M564 mechanical time-superquick fuze. The M564 mechanical time-superquick fuze (fig 11-21) is intended for use with spin-stabilized burster projectiles in which mechanical time settings (from 2 to 100 seconds) or impact superquick functioning is desired. The M564 MTSQ fuze is designed to function either at a set time or upon impact, whichever occurs first after arming. However, the booster assembly prevents this fuze from arming for either action until the round has traveled a minimum distance of 200 feet from the weapon muzzle. The M564 fuze will replace the M520 fuze.

d. M565 mechanical time fuze. The M565 mechanical time fuze (fig 11-22) is similar to the M564 fuze but does not contain a booster or a superquick element. This fuze is set for mechanical time action just like the M564, and it must always be set for time. DO NOT USE THE M565 FUZE FOR IMPACT SUPERQUICK ACTION: THE RESULTS WILL BE A DUD EVERY TIME! Remember, use the M565 in the new base-ejection rounds with the larger fuze well, use the M501 in the older base-ejection rounds with the smaller fuze well, and use the M564 in the high-explosive and burster-type projectiles.

WARNING: Because of the standardization of the fuze well openings and the fuze bodies, it is possible to put either the M564 or the M565 in any of the new projectiles; *however*, improper results and malfunctions can occur if these fuzes are used incorrectly. KNOW WHICH FUZE GOES IN WHICH PROJECTILE!

e. Installing the M564 or M565 fuze. The M564 or M565 fuze is installed in the correct fuze well with the M18 fuze wrench (fig 11-17). Remove the closing plug (on 105-mm projectiles), or the eyebolt lifting plug (on separate-loading projectiles), inspect the fuze well, and then hand-tighten the M564 or M565 fuze in the appropriate projectile. Place the M18 fuze wrench on the fuze so that you can turn the wrench counterclockwise about ¼ turn to slightly loosen the fuze. Then with your hand on the handle of the wrench, turn the wrench sharply and firmly to tighten the fuze to the projectile. There should be no threads showing and the fuze should fit snugly against the nose of the projectile.

f. Setting the M563, M564, or M565 fuze. The M563, M564, and M565 fuzes do not require a precision fuze-setting instrument such as the M26 fuze setter. The time ring on each of these fuzes is set with a fuze setter and socket such as the M63 (fig 11-23) or a simple spanner fuze setter, open-wrench type, M34 (fig 11-24). Each fuze has a vernier scale (fig 11-25) that allows accurate 0.1-second settings to be made with either fuze setter. The *M563 fuze* is issued assembled to the 105-mm Beehive round and is used only with this special round. It comes set for muzzle action; however, it can be set for additional time depending upon the distance of the target from the weapon. The *M565 fuze* is used only with base-ejection rounds. It does not have a booster, nor is a booster used with it. *The M563 and M565 fuzes cannot be set for impact action, and they cannot be used with the burster-type high-explosive projectiles.* The *M564 fuze* is used with the burster-type high-explosive projectiles and can be fired for impact superquick or time action. The procedures for setting fuzes M563, M564, and M565 with fuze setter M63 and M34 are as follows:

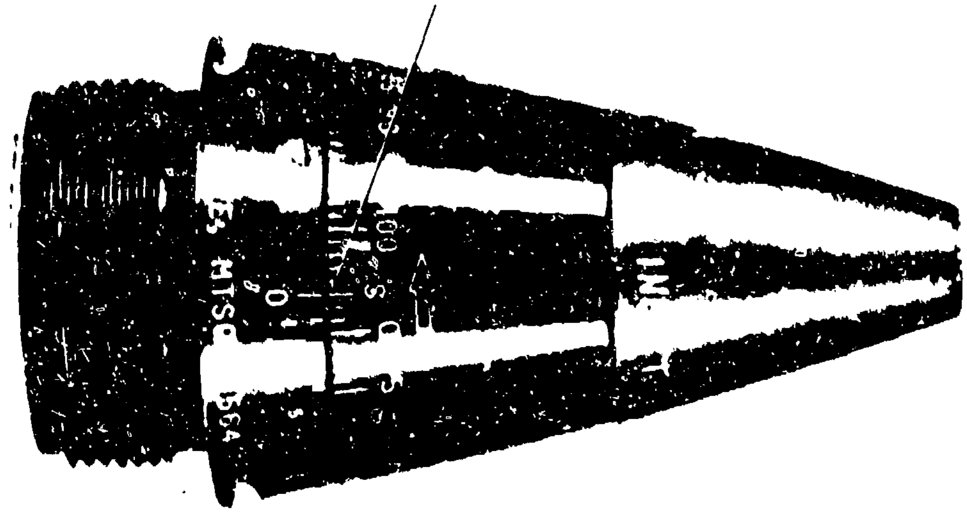


Figure 11-21. Fuze M564 mechanical time-superquick.

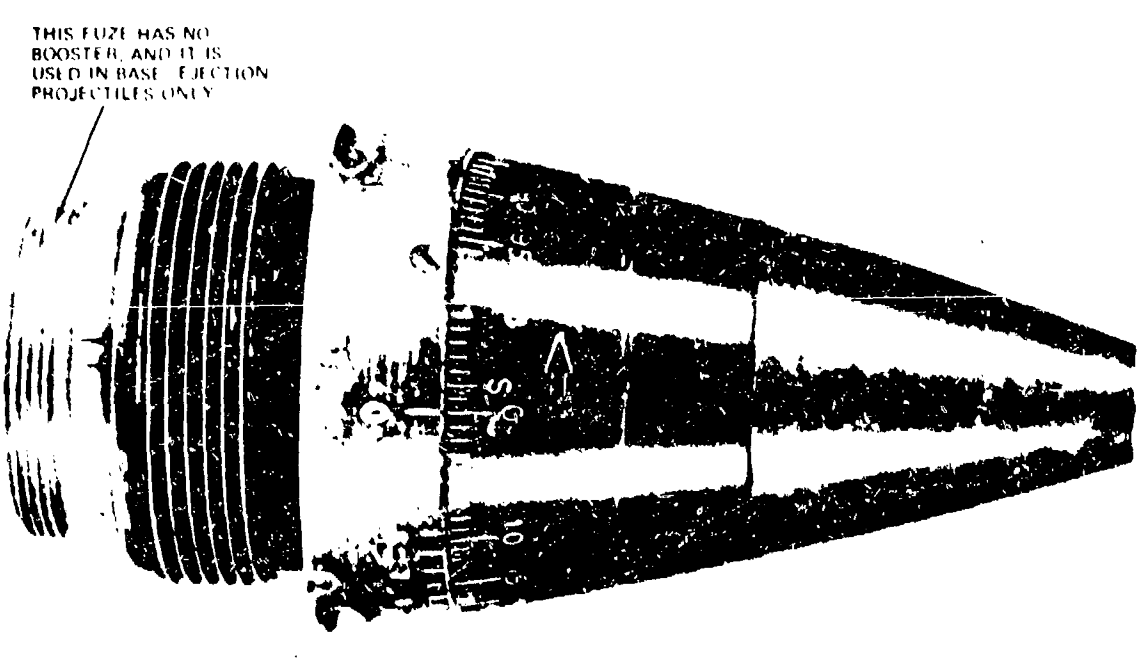


Figure 11-22. Fuze M565 mechanical time.

(1) *M63 fuze setter.* For making whole-second settings with fuze setter M63, place the setter over the fuze so that the socket engages the two lugs on the fuze cap. Turn the lower cap clockwise until the mark on the lower cap scale that represents the desired time setting is aligned with the 0 mark on the fuze body vernier scale (B, fig 11-25).

(a) Fractional second settings. For fractional second settings (in tenths of a second), turn the lower cap clockwise, in the direction of the arrow (A, fig 11-25) until the graduation for the desired whole second on the lower cap scale is alined with the 0 graduation on the vernier scale (B, fig 11-25). Observe on the lower cap scale the graduation immediately above and to the right of the graduation for the desired tenth of a second on the vernier scale. Continue to turn the lower cap until the observed graduation on the lower cap scale is alined with the graduation for the desired tenth of a second on the vernier scale (B and C, fig 11-25). For example, if the desired time setting is 5.5 seconds, turn the lower cap until the 5

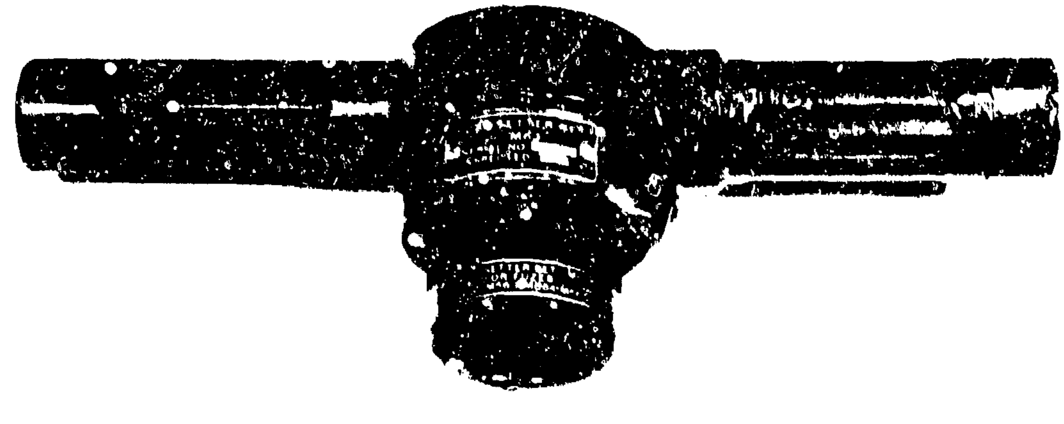


Figure 11-23. Fuze setter M63.

Figure 11-24. Fuze setter M34.

graduation on the lower cap scale (of 0 to 100 seconds) is alined with the 0 graduation on the vernier scale (fig 11-25). Observe that the 15 graduation on the lower cap scale is immediately above and to the right of the 5 graduation (the desired tenth of a second) on the vernier scale. Continue to turn the lower cap until the 15 graduation on the lower cap scale is alined with the 5 graduation on the vernier scale. The desired time of 5.5 seconds is now set on the fuze (C, fig 11-25).

(b) *Setting the fuze to safe.* If the fuzed projectile is prepared for firing but is not fired, place the M63 fuze setter back on the fuze and realine the S mark (MA on the M563 fuze) on the lower cap with the 0 mark on the fuze body by turning the fuze setter in a clockwise direction until the S (MA on M563) is alined over the 0. There is no safety wire to add to this fuze (as you do on the M501) because the holddown time lug is engaged inside the fuze automatically as the lower cap is turned to the S setting. *Never fire an M565 fuze without putting some time on the fuze so the holddown time lug will be unlocked.* Always turn the M63 fuze setter in a clockwise direction.

(2) *M34 fuze setter.* The M34 fuze setter (fig 11-24) is a simple spanner wrench-type setter with two small projections on the inside of the circle that fit into the lugs of the M563, M564, and M565 fuzes. To set any of these fuzes, always turn the M34 fuze setter in the direction of the arrow on the fuze (clockwise). The time setting or the safe setting is made on the vernier scale with this fuze setter in the same manner as with the M63 fuze setter ((1) above). However, if you miss the time setting, you can back up this fuze setter 1 or 2 seconds and then reset the fuze for the desired time. Be sure that the vernier scale is set to the correct tenth of a second.

g. *Number of times the M563, M564, or M565 fuze can be set.* The M563, M564, or M565 fuze can be set as many times as necessary in order to obtain the right setting. Unlike the M501 fuze, which has the four brass screws that become worn and lose torque when the cap is turned an excessive number of times, each of these fuzes has a wavered washer between the lower cap and the time ring that keeps the cap tight regardless of how many times it is turned.

h. *Direction of setting the M563, M564, or M565 fuze.* Always turn the fuze setter M34 or M63 clockwise, in the direction of increasing time, as

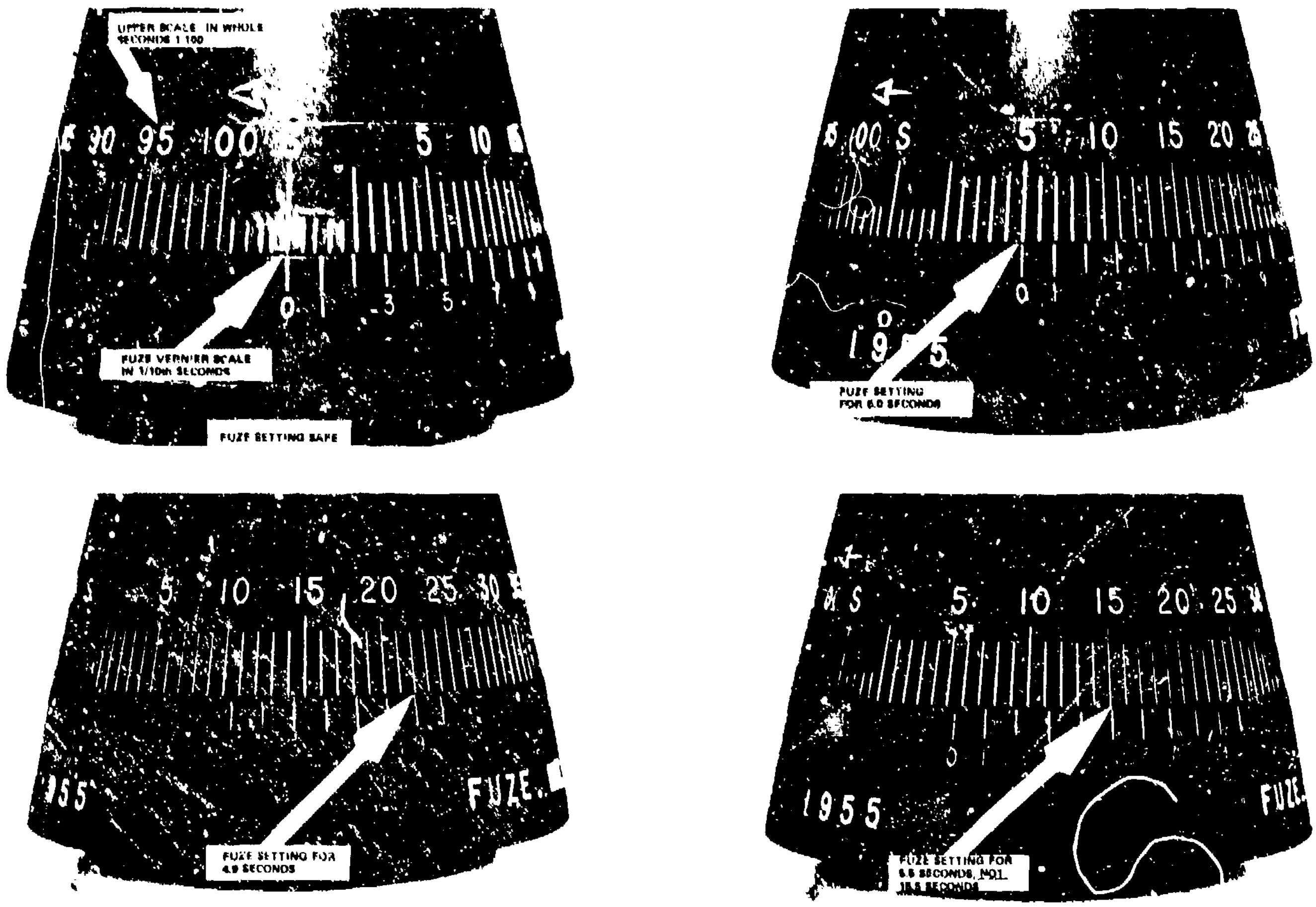


Figure 11-25. Vernier scale.

shown by the arrow on each of these fuzes. Remember that the M563 fuze is issued on the 105-mm antipersonnel projectile (Beehive) only and that it is already set for MA (muzzle action). This fuzed round can be fired without further setting, or time can be set on it if necessary to protect your firing position.

(1) *Setting the M564 fuze.* All settings on the M564 fuze are made in a clockwise direction. This fuze has two firing pins, one at the nose for impact action and one inside the fuze for mechanical time action. The time action cannot take place until you turn the time ring, which unlocks the safety lug and allows the clock mechanism to function after the round is fired so the projectile will be detonated along the trajectory. All time settings on the M564-type fuze are always backed up by the impact action. If the fuze does not function on the time setting, it will function on impact superquick action when it hits the target. If the M564 fuze is to be fired for impact superquick action only, then check the date of manufacture stamped on the fuze body, and follow either paragraph *(a)* or *(b)* below—

(a) M564 fuze made before 1970. Those fuzes made before 1970 must never be fired without a time setting being placed on the vernier scale, either for time or superquick action. The impact superquick setting for these early M564 fuzes (before 1970) is 90.0 seconds. *Do not fire these early fuzes on the "S" setting because premature bursts could occur!*

(b) M564 fuze made after 1970. A correction was made to those M564 fuzes manufactured in late 1969 so that the later fuzes can be fired as they come out of the can (set on "S") for superquick action. The date on these fuzes should read 1970 or a later date. *These later fuzes do not have to be set on 90.0 seconds for impact superquick action.*

(2) *Setting the M565 fuze.* All settings on the M565 fuze are made in a clockwise direction. This fuze has only *one* firing pin inside the fuze for mechanical time action. It cannot be set for impact action. In fact, a projectile fuzed with the M565 fuze will be a dud if it hits the ground before the set time on the vernier scale expires. It will also be a dud if the round does not go off on the time action. *Remember this fuze is used with the newer base-ejection rounds only*, and it is never fired in any burster-type high-explosive projectile.

11-26. M577/M582 Mechanical Time-Superquick Fuzes

a. General. The M577 and M582 mechanical time-superquick fuzes (fig 11-26) have 200-second time mechanisms, which are used in setting the fuzes to the closest 1/10 second. These newer fuzes will eventually replace the M564 and M565 mechanical time fuzes. The newer fuzes do not have vernier scales. Instead, each has three movable digital dials (similar in design and functioning to an odometer in a car) that can be viewed through a window on the body of the fuze. The dial closest to the nose of the fuze indicates hundreds of seconds. A nontime setting is indicated when the black triangle mark (◄) on this dial is under the hairline in the window. The next dial indicates tens of seconds, and the third dial indicates seconds. In addition, the third dial has a scale that indicates tenths of seconds. The desired setting is placed under the hairline in the window. The timing mechanism starts to operate upon simultaneous exposure to projectile spin and setback. When set for time function, the fuze starts its arming cycle approximately 3 seconds prior to the set time. Each fuze also has an impact superquick setting (*e*(1) below).

b. M577 MTSQ fuze. The M577 MTSQ fuze is in production and it is intended for use with a base-ejection projectile to expel the payload over the target area by mechanical time action. However, this fuze can be fitted with a special shaped-charge booster (fig 11-27) and used with the newer antipersonnel and antimateriel (ICM) projectiles M483 and M509 to make them blow up like conventional high-explosive rounds.

c. M582 MTSQ fuze. The M582 MTSQ fuze is not in production at this time, but is intended for use with spin-stabilized burster-type high-explosive projectiles when mechanical-time settings up to 200 seconds or impact superquick functioning is desired. This fuze will be shipped with its own booster assembled and should not be used in a base-ejection round. This fuze must never be fired without a setting placed on it; that is, a setting for impact action (*e*(1) below) or time action (*e*(2) below).

d. Installing the M577 or M582 fuze. Install the M577 or M582 fuze in the fuze well of the appropriate projectile by using the M18 fuze wrench (fig 11-17). Remove the closing plug (on 105-mm projectiles) or the eyebolt lifting plug (on separate-loading projectiles), inspect the fuze well, and then screw the M577 or M582 fuze in the appropriate projectile until it is handtight. Place the M18 fuze wrench on the fuze so that you can turn the wrench counterclockwise about ¼ turn. Tighten the fuze to the projectile with a sharp snap of the wrench in the clockwise direction. There should be no threads showing and the fuze should be seated firmly against the nose of the projectile. When the M577 fuze is to be fired with the 155-mm (M483) or 8-inch (M509) antipersonnel-antimateriel improved conventional munitions (ICM) round, some special preparation of the fuze may be required before it is installed. These special preparations are as follows:

(1) *Special assembly, registration mode.* A special shaped-charge booster (fig 11-27) is available for use with the M577 fuze and must be attached to the fuze for registering with the 155-mm (M483) or 8-inch (M509) ICM round. The expelling charge in the fuze well of the 155-mm projectile or the expelling charge in the 8-inch projectile must be removed before the M577 fuze with shaped-charge booster is installed in the projectile. This shaped-charge booster causes the ICM round to function in the same manner as a standard high-explosive round.

(2) *Special assembly FFE mode, 155-mm projectile M483.* To prepare this round for firing, remove the eyebolt lifting plug, inspect the fuze well, screw in fuze M577 with the M18 fuze wrench (*d* above), and set the correct time with the M35 fuze setter (*e* below). Then the 155-mm projectile M483 is ready to be loaded and fired for effect.

(3) *Special assembly, FFE mode, 8-inch projectile.* When the M577 fuze is used with the 8-inch (M509) antipersonnel-antimateriel ICM round for fire-for-effect action, the eyebolt lifting plug is removed, the fuze well inspected and the fuze is installed in the projectile (M509) in the same manner as described in (2) above.

(4) *Special instructions for installing the M582 fuze.* Never use the M582 fuze in any base-ejection round. Do not remove the booster that comes with the fuze. Always install the fuze and booster complete every time you use the M582 fuze in burster-type projectiles such as high-explosive, white phosphorus, and certain gas projectiles.

e. Setting the M577 or M582 fuze. The fuze setting key (which looks like a slotted screwhead on the nose of the fuze) controls the three dials in the fuze. This key is used for setting either the M577 or the M582 fuze after it has been screwed into the projectile. Place the M35 fuze setter (fig 11-28) over the nose of the fuze. With the palm of your hand pressing in on the top of the fuze setter (fig 11-29), rotate it counterclockwise so that the screwdriver-like blade in the cone of the fuze setter engages the slot in the top of the fuze. Set the appropriate numbers under the hairline visible through the window on the nose of the fuze.

(1) *Setting for impact action (◄ 98).* Rotate the fuze setter approximately ¼ turn in a counterclockwise direction to change from the shipping and storage setting ◄ 95 (fig 11-30) to a

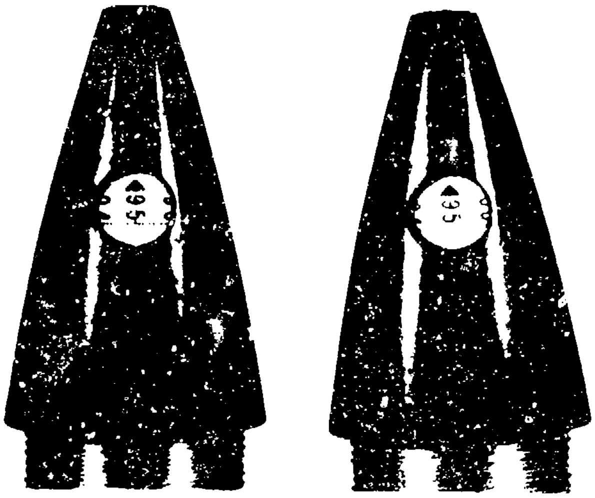


Figure 11-26. Fuzes M577/M582 mechanical time-superquick.

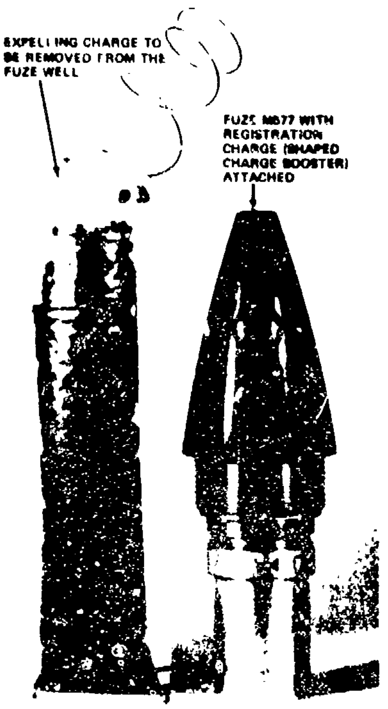


Figure 11-27. Fuze M577 prepared for registration mode with the 155-mm (M483) or 8-inch (M509) ICM projectile.

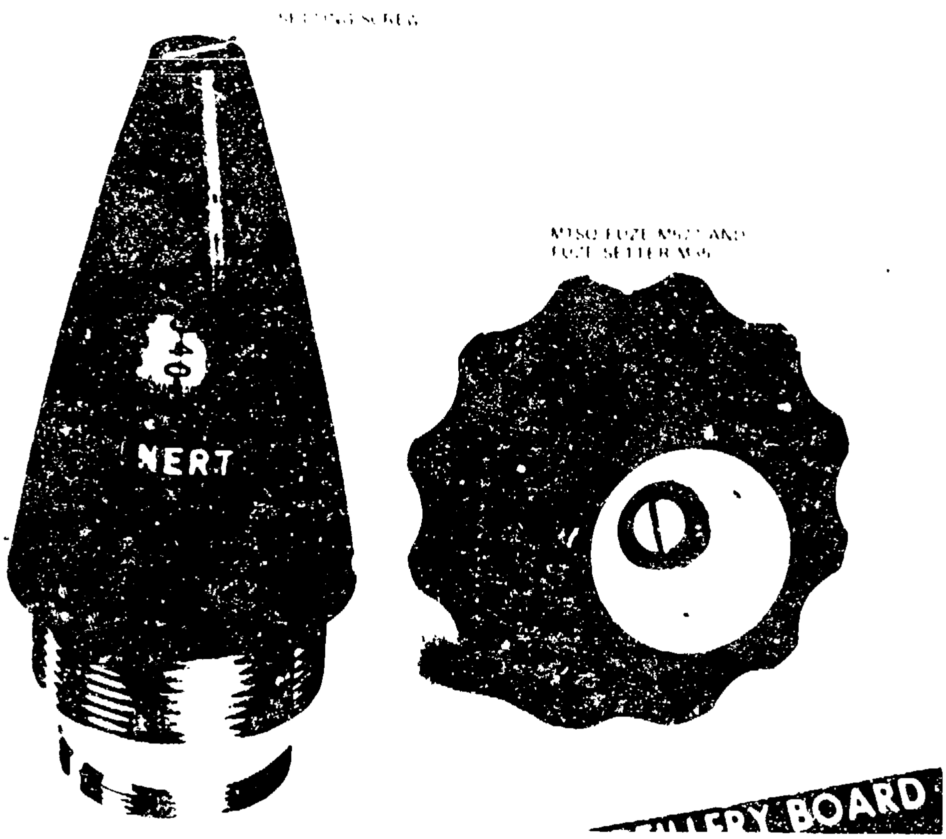


Figure 11-28. Fuze M577 and fuze setter M35.

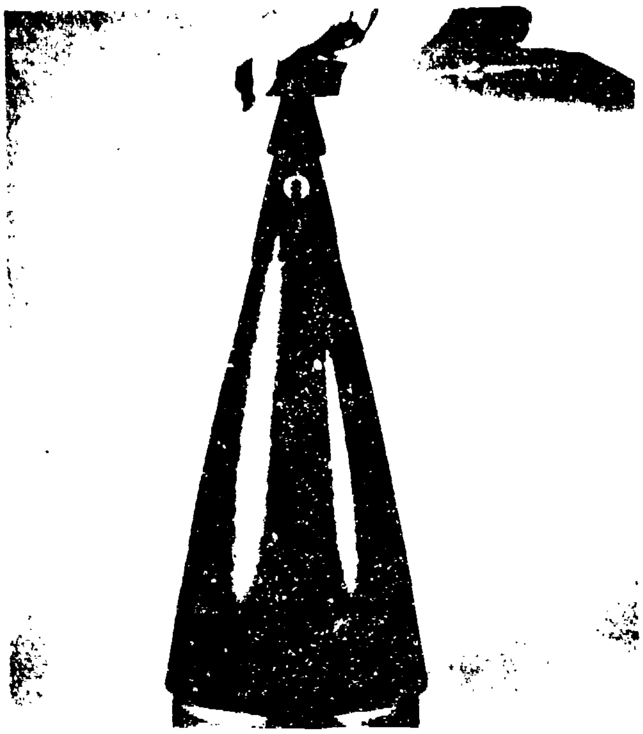


Figure 11-29. Operational view showing use of fuze setter M35 on MTSQ fuze M577 or M582.

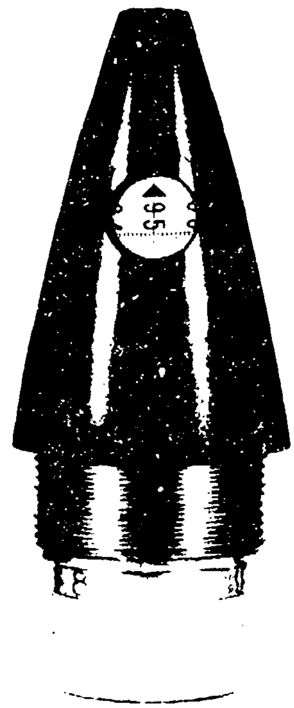


Figure 11-30. Shipping and storage setting of fuze M577 or M582.

setting of ◄ 98 (fig 11-31). At this fuze setting (◄ 98), either fuze M577 or fuze M582 will operate as a superquick point-detonating (PD) impact fuze and the round is ready for firing without additional action.

(2) *Setting for time airburst up to 200 seconds.* Rotate the M35 fuze setter approximately ½ turn in a counterclockwise direction to remove the shipping/storage and impact settings as well as the black triangle (◄). The black triangle indicates a nontime setting. Continue rotating the fuze setter counterclockwise past the zero time setting (000) until the desired time setting is reached. Each complete turn of the fuze setter moves the dials 10 seconds. Turning the fuze setter 20 complete turns moves the dials from 000 to 200 (fig 11-32). The dials cannot go beyond the 200 setting. In order to set the fuze back to a lower time setting, for impact, or to the shipping setting, you must turn the fuze setter in a clockwise direction. DO NOT TRY TO TURN THE FUZE SETTER BEYOND THE MECHANICAL STOPS AFTER 200 APPEARS ON THE DIALS IN THE WINDOW OR SET THE FUZE BELOW THE SHIPPING SETTING OF ◄ 95.5 TO ◄ 93.0 (*f* below). While reading the setting, apply slight torque to remove backlash.

(3) *Reducing setting for time airburst.* To reset either the M577 or the M582 fuze for a time interval less than the interval for which it was originally set, turn the fuze setter clockwise (as viewed from the nose of the projectile) to a setting that is at least 1 or 2 seconds less than the required setting. Then turn the fuze setter counterclockwise and set the fuze to the required time by lining up the appropriate number under the hairline.

f. Direction of setting the M577 or M582 fuze. You can set either the M577 or M582 fuze from the shipping and storage setting to the desired setting (PD or time) by rotating fuze setter M35 in a counterclockwise direction (fig 11-33). However, these fuzes *cannot* be set to the desired setting and then to the shipping and storage setting by the continuous rotation of the fuze setter in the counterclockwise direction. To change a time setting to an impact setting or a shipping and storage setting you must rotate the fuze setter in the clockwise direction.

g. Number of times the M577 and M582 fuzes can be set. The M577 and M582 fuzes can be set as many times as necessary to get the correct setting. If you miss the setting the first time, back the dials up 1 or 2 full seconds and reapproach the setting in the counterclockwise direction.

11-27. Proximity (VT) Fuzes

a. General. Each proximity (VT) fuze (fig 11-34) has a clock-like mechanism that is set to control the activation of the radio transmitter and receiver in the fuze. These fuzes may be set as many times

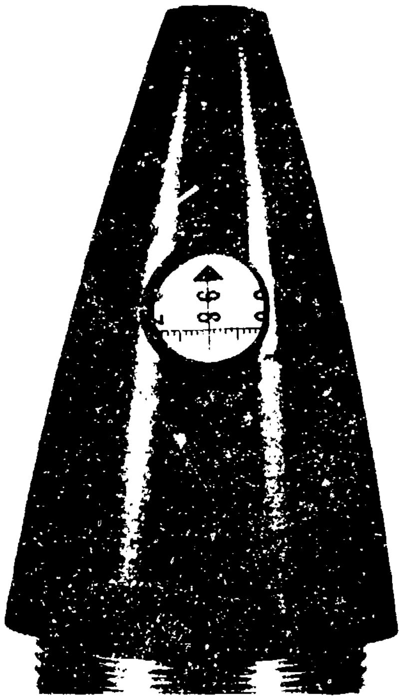


Figure 11-31. Superquick PD setting for fuze M577 or M582.

as necessary to get the right setting. The proximity (VT) fuze is essentially a combination radio transmitter and receiver. At a set time (from 5 to 100 seconds) after the projectile leaves the muzzle of the weapon, the radio is activated and begins sending out continuous waves toward the target. As the projectile approaches an object, the waves are reflected back to the fuze and are picked up by the receiving unit in the fuze. When the incoming waves reach a predetermined intensity, an electronic switch is thrown, and this action causes the fuze to function by starting the projectile explosive train. Impact superquick action can be expected if the appropriate time is set on the fuze and the proximity (VT) element fails to function.

b. M513 and M514 proximity (VT) fuzes. The M513 and M514 proximity (VT) fuzes are basically the same except that the sensitivity switch in the M513-series fuzes is set for a lower height of burst and is used only with the 105-mm projectiles. The M514-series fuzes are used with the 155-mm and 8-inch projectiles; however, they are being phased out and replaced by the M728 and M732 proximity (VT) fuzes.

Note. The impact elements of proximity fuzes M513, M513B1, M514, and M514B1 are not operable unless the fuzes are armed for proximity

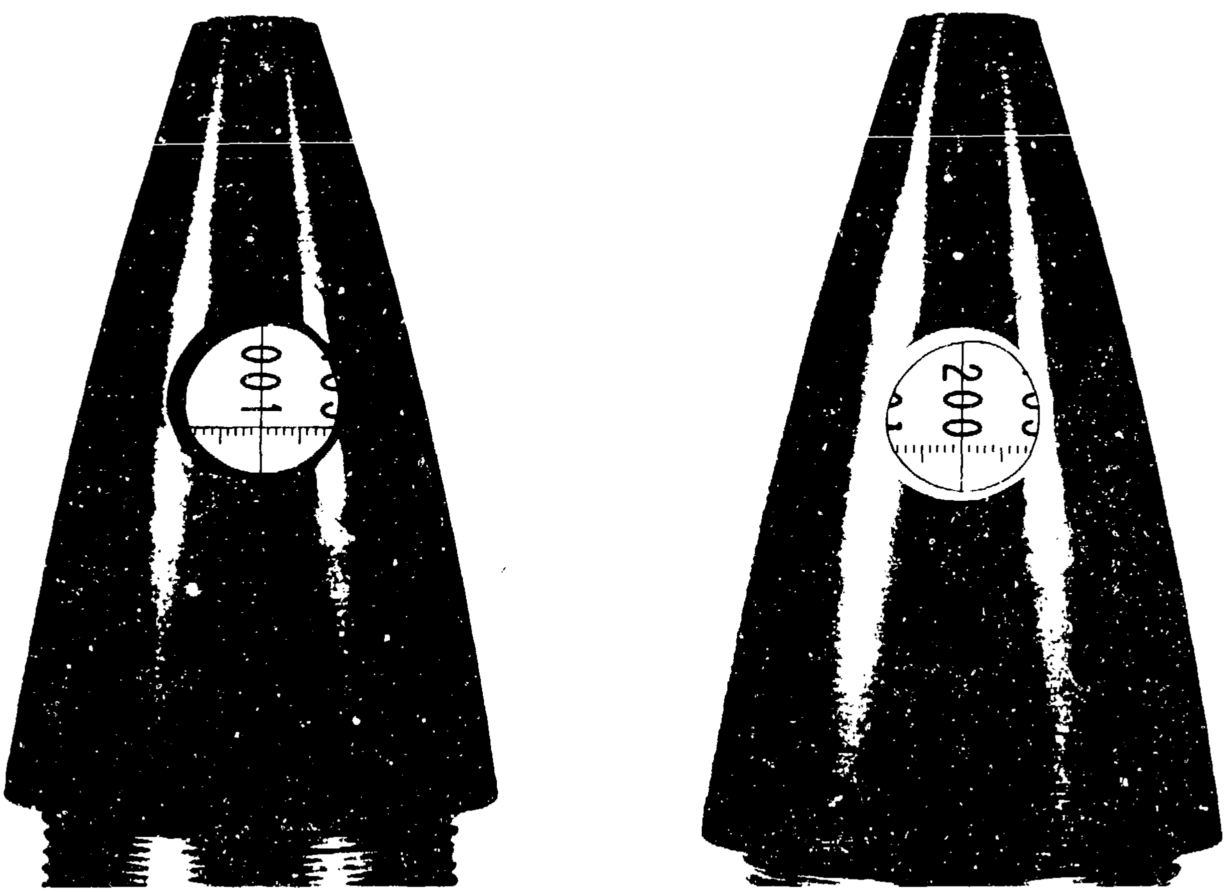
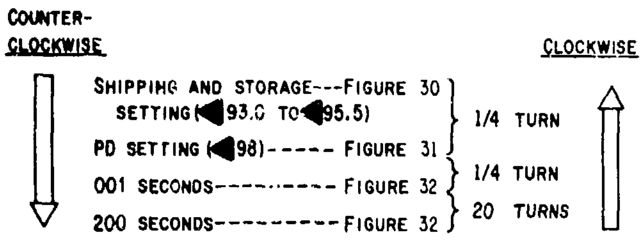


Figure 11-32. Start of time setting (001) and maximum time setting (200) of fuze M577 or M582.



CAUTION: Do not attempt to set these fuzes below ◀ 93.0 when setting them in the clockwise direction or above 200 seconds when setting them in the counterclockwise direction. The settings of 000 and 200 are not authorized service settings.

Figure 11-33. Direction of setting or resetting fuze M577 or M582.

action. If the fuzed projectile hits the target before the time set on the fuzes expires, the round will result in a dud. Later series of these fuzes, such as the M513A1, M513A2, and M514A1, have been improved with an impact superquick arming device which arms 2—3 seconds outside the muzzle of the cannon. See table 11-3 of this chapter for VT fuze restrictions for the proximity mode and the impact mode.

(1) *M513 and M513B1.* The M513 and M513B1 (VT) fuzes, used with 105-mm projectiles only, must always be set for proximity action because the impact electronic switch cannot be engaged *until* the proximity action is activated. If, after activation, the fuze does not function to produce an airburst, then it should go off on impact because the superquick element is armed when the proximity element starts broadcasting signals. *These fuzes cannot be set for impact action only.* They must be set for proximity action (see table 11-3).

(2) *M513A1 and M513A2.* The M513A1 and M513A2 fuzes are an improvement over the early M513 and M513B1 fuzes. One of the improvements is that the impact element arms 2 to 3 seconds outside the muzzle regardless of the time set for proximity action. Thus, if the fuzed projectile strikes the target before the time expires on the time mechanism, the result will be impact superquick action. If you want impact action only from these fuzes, set the fuze for 90 seconds (see table 11-3). YOU CANNOT SET THE M513 OR M513B1 FUZE IN THIS MANNER.

(a) Desensitizing cap M5 for M513-series fuzes. The purpose of the desensitizing fuze cap M5 (fig 11-35) is to lower the burst height of the HE 105-mm projectile fired with the M513-series artillery proximity fuze when rounds are fired over water and the burst heights are observed to exceed 50 feet. The effectiveness of the HE 105-mm projectile decreases significantly when bursts higher than 50 feet occur. The M5 cap applied to the M513-series fuze will reduce the burst height by a factor of about 4; for example, a burst height of 60 feet will be reduced to about 15 feet on the next round, and thus much better results are obtained with subsequent firing when the M5 cap is used.

(b) Restriction on use of M5 cap. DO NOT USE THIS CAP WITH ANY PROXIMITY FUZES EXCEPT THOSE OF THE M513 SERIES.

(3) *M514 and M514B1.* The M514 and M514B1 fuzes are similar to those discussed in (1) above and *cannot* be fired for impact action only. They must always be used for proximity action. These fuzes are used with some of the separate-loading projectiles for the 155-mm and 8-inch howitzers. They are *not* used with the projectiles for the 105-mm howitzer.

(4) *M514A1.* The M514A1 fuze is similar to those proximity fuzes discussed in (2) above in that it also has the impact element that is armed 2 to 3 seconds outside the muzzle regardless of the time set for proximity action. These fuzes are used with the 155-mm and 8-inch projectiles.

c. M728 (formerly M514A3 or M514A1E1). The M728 proximity fuze can be used with all calibers of field artillery projectiles and weapons. The only restriction is that it is not to be fired with charge 7 in the 105-mm projectile *except* in a combat emergency (table 11-3).

d. M732. The M732 fuze (fig 11-36) is the latest development in the proximity VT fuze family. It is a short-intrusion fuze of the same overall length as the standard impact or mechanical time fuze. The removal of the supplementary charge (fig 11-37) is not required; in fact, the charge must be left in the fuze well for proper functioning of this fuze. This new proximity fuze has a time ring that can be set from 2 to 150 seconds. The M732 fuze was classified standard A in February 1976, and will be used when all of the stockpiles of the M513, M514, and M728 series are exhausted.

e. Installing the proximity (VT) fuze. In order to accommodate the longer fuze bodies, all proximity (VT) fuzes except the M732 (*d* above) require a deeper fuze well cavity in the projectile (fig 11-37) than do the impact or MTSQ fuzes. Therefore, a part of each bursting charge has been placed in a small package that can be either left in the fuze well for shorter MTSQ and impact fuzes or removed to make room for the longer proximity fuzes. This small high-explosive package is called the supplementary charge. Always remove the supplementary charge when firing any of the M513, M514, or M728 series of proximity fuzes. BE SURE THE SUPPLEMENTARY CHARGE IS LEFT IN THE FUZE WELL, OR REPLACED IN THE FUZE WELL, IF THE FUZE COMMAND IS CHANGED FROM VT TO IMPACT OR MTSQ.

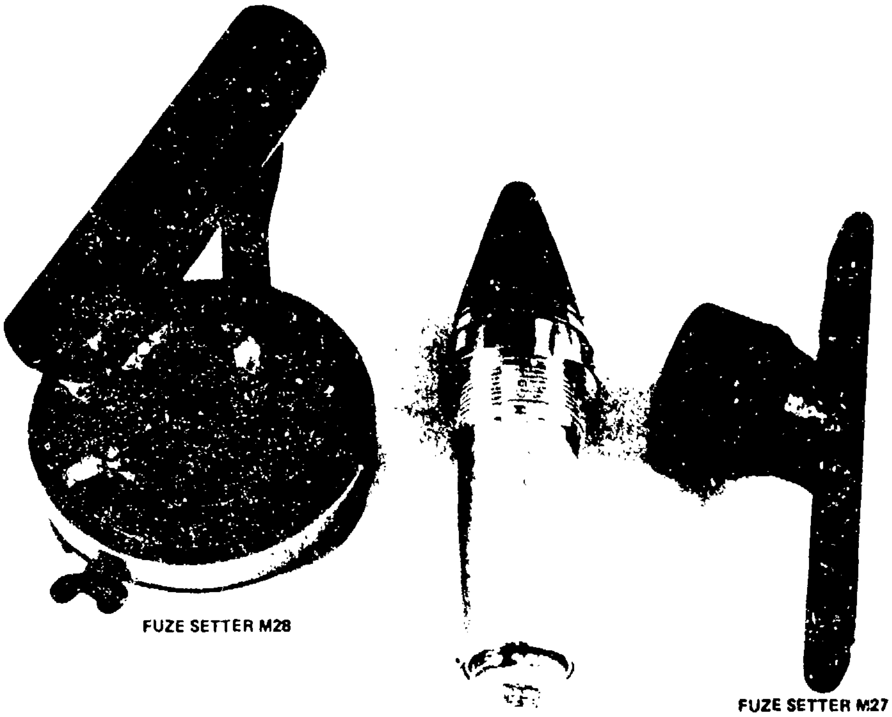


Figure 11-34. Fuze setters M27 and M28 and proximity VT fuze.

To prepare a projectile for a long intrusion proximity (VT) fuze, first remove the eyebolt lifting plug (on separate-loading projectiles) or the closing plug (on 105-mm projectiles). Remove the supplementary charge (fig 11-37) by its lifting loop and inspect the fuze well cavity. Next, place the proximity fuze (M513 series for 105-mm caliber projectiles, M514 series for all other caliber projectiles, and M728 series on any caliber projectile) into the fuze well and screw it down handtight. Then place the M18 fuze wrench (fig 11-17) on the fuze so that the VT portion of the fuze slot (the outer fitting on the wrench) is in the two grooves on the fuze. Turn the M18 fuze wrench counterclockwise about ¼ turn (to loosen the fuze) and then, with your hand on the handle, turn the wrench sharply and firmly clockwise to tighten the fuze to the projectile. There must be no threads showing, and the fuze must fit snug against the nose of the projectile. Because of the longer fuze body of the proximity fuze, occasionally it is impossible to tighten the proximity fuze so that it is snug to the nose of the projectile (fig 11-38). DO NOT FIRE THE FUZED PROJECTILE IN THIS CONDITION! REPLACE THE FUZE OR THE PROJECTILE. IF YOU REPLACE THE PROJECTILE, PUT THE SUPPLEMENTARY CHARGE BACK IN THE FIRST PROJECTILE AND FIRE IT WITH AN IMPACT OR MTSQ FUZE.

f. Setting the proximity (VT) fuze. Unlike the MTSQ fuzes, which must be set to the closest 1/10 second for correct time action, the proximity (VT) fuzes are set to the closest 1.0 second. The clock mechanism time ring on these fuzes merely delays

Figure 11-35. M5 desensitizing cap, M513 (VT) fuze, and capping device.

Table 11-3. Proximity (VT) Fuzes—Reliability

Weapon System	Proximity Action		Impact Action	
	Fuze model	Charge restriction	Fuze model	Charge restriction
105-mm howitzer	M513 (all series)	Charges 2 through 6; charge 7 only in a combat emergency (note 1).	M513A1 (T226E2) or M513A2 (T226E3)	Charges 4 through 6 *only*; for charge 7, see notes 1 and 2.
155-mm howitzer	M514, M514A1, and M514B1	Charge 3 green bag and above or charge 5 white bag and above.	M514A1 (T227E2)	Charge 4 green bag and above or charge 6 white bag and above (note 2).
8-inch howitzer	M514, M514A1, and M514B1	Charge 3 green bag and above or all white bag charges.	M514A1 (T227E2)	Charge 4 green bag and above or charge 6 white bag and above (note 2).
105-mm howitzer	M728 (formerly the M514A1E1 and the M514A3).	Charges 1 through 6; charge 7 *only* in a combat emergency (note 1).	M728 (formerly the M514A1E1 and the M514A3).	Charges 1 through 6; for charge 7, see notes 1 and 2.
155-mm howitzer 8-inch howitzer	M728 (formerly the M514A1E1 and the M514A3).	None None None	M728 (formerly the M514A1E1 and the M514A3).	None None None
All weapons	M732	None	M732	None

Notes.

1. All projectiles fired at charge 7 in the 105-mm howitzer will utilize impact fuze M557, MTSQ fuze M564, or other available authorized fuzes, *except* that under *emergency combat conditions* all the M513-series fuzes and the M728 fuze may be fired in the proximity mode at charge 7. *ONLY* the M513A1 M513A2, M728, and M732 fuzes may be used in the impact mode (note 2).

2. To achieve maximum reliability, set the M513A1, M513A2, M514A1, M728, and M732 fuzes for 90 seconds when impact PD action is desired. The M513, M513B1, M514, and M514B1 fuzes *cannot* be set for impact PD action only, because the proximity element must be armed before the impact element can become armed on these earlier model fuzes.

WARNING: All fuzes must be fully seated (no space between the shoulder of the fuze and projectile). Improper seating may result in premature functioning of fuzes.

the activation of the radio transmitter-receiver until the fuzed projectile gets close to the target. As the fuzed projectile approaches the target, the time setting activates the radio transmitter and causes it to broadcast a signal toward the target. The receiver is activated 2 seconds later and starts picking up the reflected signal. The fuze will not function on a weak reflected signal. But as the fuzed projectile approaches the target, the signal becomes stronger until it is strong enough to cause the VT fuze to activate the explosive train and detonate the projectile near the target. Most of these fuzes have a 100-second time ring on them for this purpose; however, the M732 short intrusion fuze has a time ring of 150 seconds. The early series of the M513, M513B1, M514, and M514B1 VT fuzes were designed so that if the radio was not activated, the electronic impact switch was not thrown and if a round hit the target before the time set on the time ring had expired, the result was always a dud. To prevent a round from becoming a dud with a VT fuze on it, the later M513 and M514 series of fuzes (with numbers ending in A1, A2, or A3) as well as the M728 and M732 VT fuzes were all designed so that the impact action on the VT-fuze projectile would always be armed 2 to 3 seconds outside the muzzle of the weapon when fired. Because of this latest change, these fuzes will function on either impact or time, whichever occurs first (see table 11-3).

(1) *Fuze setter M28.* Fuze setter M28 (fig 11-39) is similar to precision fuze setter M26 except that it has a 100-second time ring on its outer scale. The fuze setter must be turned in a clockwise direction to set the VT fuze. Place the time on the outer scale of the M28 fuze setter and lock the ring in place with the thumbscrew. Place the fuze setter on the nose of the fuze and rotate the setter in the clockwise direction until it stops. Then remove the setter. The setting on the fuze setter should be checked with the setting on the fuze to insure that they agree. Be sure that the fuze remains flush with the nose of the projectile; however, this is not normally a problem, because this fuze is set clockwise and does not tend to back out of the fuze well. Instead, the fuze tends to be tightened in the fuze well when the M28 fuze setter is turned clockwise to set the time. The M28 fuze setter is not used with the 150-second time ring of the M732 fuze and is no longer being issued, but is being replaced by the M27 (fig 11-19).

(2) *Fuze setter M27.* Fuze setter M27 (fig 11-19) can be used with the M501 MTSQ fuze and it

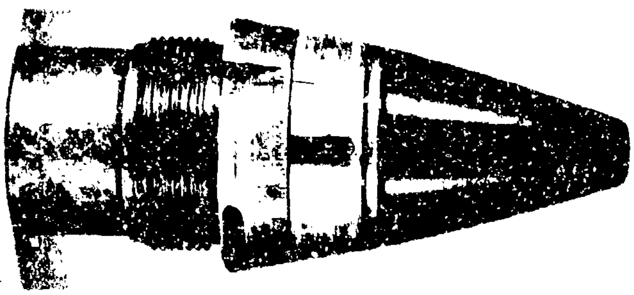


Figure 11-36. M732 proximity (VT) fuze.

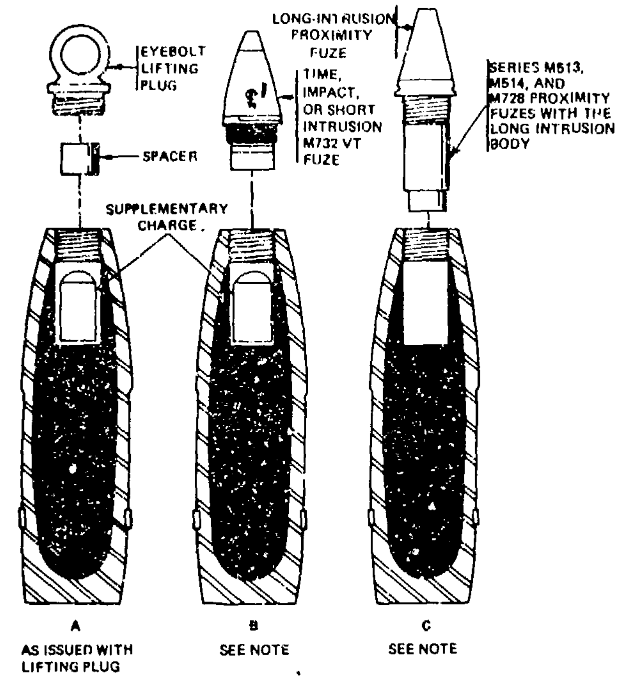
can also be used to set any of the time rings on the proximity (VT) fuzes. With this fuze setter you can turn the time rings on the VT fuzes in either direction as long as you take up any lost motion by turning the rings clockwise for the last few seconds on approaching the time to be set. You may turn these time rings as many times as necessary to get the correct time setting.

g. Direction of setting proximity (VT) fuzes. Rotate the M28 fuze setter in a clockwise direction (from lower to higher numbers). You can turn the M27 fuze setter in either direction. It is recommended that proximity (VT) fuzes always be set in a clockwise direction. If you miss the setting with the M27 fuze setter, back it up 1 or 2 seconds and approach the correct setting from lower to higher numbers. If the setting does not agree with the M28 fuze setter, recheck the setting on the outer scale of the setter, retighten the thumbscrew, and reset the time ring by turning the M28 fuze setter in a clockwise direction.

11-28. Weapon-Projectile-Propelling Charge Chart Compatibility and Authorized Fuze-Projectile Combination Chart

a. Table 11-4 lists information pertinent to the more common fuzes currently used with field artillery weapons. For additional detailed information, refer to TM 43-0001-28.

b. Table 11-5 is a modified extract of TM 43-0001-28-2 and is a comprehensive listing of the authorized cartridge/projectile-fuze combinations and interchangeability data for conventional ammuniton used with field artillery howitzers. Special instructions on the use of the



NOTE: The supplementary charge must be left in the projectile when firing a short-intrution fuze such as the mechanical time, VT (M732), or impact fuze (B above). The supplementary charge must be removed when firing a long-intrusion proximity (VT) fuze (C above).

Figure 11-37. Typical deep-cavity projectile with supplementary charge.

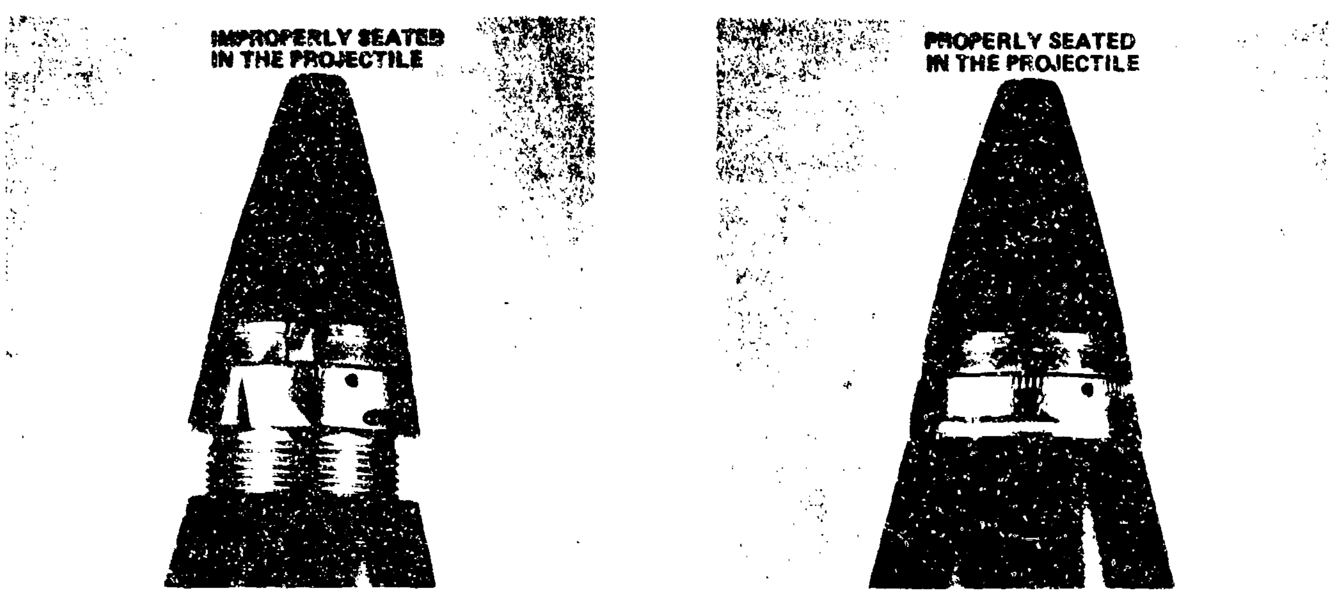


Figure 11-38. Improperly installed VT fuze on the left; properly installed VT fuze on the right.

Table 11-4. Fuze Information

Model and use	Type	Min/max settings and graduations	Minimum arming	Includes impact PD function	Can be set for PD only	Fuze should be set before firing	Setting means/ procedures	Response if fired as shipped	Special instructions
M557 Used with HE and burster-type projectiles	PD	None	61 meters	Yes (SQ or delay)	Yes (SQ or delay)	SQ--no, delay--yes	Screwdriver or M18 fuze wrench	PD (SQ)	1. Used with 105-mm, 155-mm, and 8-inch howitzers. 2. Early burst can be expected in heavy rain. 3. Can expect delay function if super-quick fails to detonate the projectile.
M563-series Used with the 105-mm Beehive round only	MTMA	0.5 to 100 seconds in 0.2-second increments	Time--0.5 second, MA--3 meters	No	No	MA--no, time--yes	Time--clockwise with fuze setter M34 or M63 MA--as shipped	Muzzle action at 3 meters	1. Do not fire over friendly troops. 2. Do not use for indirect fire.
M564 Used with HE and burster-type projectiles	MTSQ	2 to 100 seconds in 0.1-second increments	Time--2 seconds, PD--61 meters	Yes	No--early models Yes--later models (See note 3.)	Time--yes PD--early models--yes PD--later models--no (See note 3.)	Time--clockwise for all models; PD for early models--clockwise to 90 seconds with fuze setter M34 or M63. PD for later models--fire on "S" setting, but see note 3.	Early models--early bursts may occur. Later models--PD (SQ) (See note 3.)	1. Used with 105-mm, 155-mm, and 8-inch howitzers. 2. Early burst can be expected in heavy rain. 3. Point-detonating impact action can be expected if time action fails to detonate the projectile.
M565 Used with certain base-ejection projectiles	MT	2 to 100 seconds in 0.1-second increments	Time--2 seconds	Yes	No	Time--yes (no other setting possible)	Time--clockwise with fuze setter M34 or M63	Dud	1. Comes already assembled to certain base ejection 105-mm projectiles, such as illuminating or ICM rounds. 2. Issued for use in base-ejection 155-mm and 8-inch projectiles. 3. Must not be used with burster-type HE projectiles.
M572 Used with HE and burster projectiles	PD	None	61 meters	Yes (SQ or delay)	Yes (SQ or delay)	SQ--no, delay--yes	Screwdriver or M18 fuze wrench	PD (SQ)	1. Early burst can be expected in heavy rain. 2. Can expect delay function if super-quick fails to detonate the projectile.
M577 Used with certain base-ejection projectiles	MTSQ	1 to 200 seconds in 0.1-second increments	Time--0.15 to 2 seconds, PD--3 seconds	Yes, but not as backup to time setting	Yes	Yes	Time--counterclockwise, PD--counterclockwise to a setting of ◀98, with M35 fuze setter (all settings)	Dud	1. Used with all cargo-carrying projectiles of 105-mm, 155-mm, and 8-inch howitzers. 2. Special assembly of fuze required when fired in M483 or M509 projectiles for the registration mode.
M582 Used with burster HE projectiles	MTSQ	1 to 200 seconds in 0.2-second increments	Time--0.15 to 2 seconds, PD--3 seconds	Yes, but not as backup to time setting	Yes	Yes	Time--counterclockwise, PD--counterclockwise to a setting of ◀98, with M35 fuze setter (all settings)	Dud	1. Used with all burster-type HE projectiles of 105-mm, 155-mm, and 8-inch howitzers. 2. Not sensitive to rain.

Table 11-4. Fuze Information—Continued

Model and use	Type	Min/max settings and graduations	Minimum arming	Includes impact PD function	Can be set for PD only	Fuze should be set before firing	Setting means/ procedures	Response if fired as shipped	Special instructions
M739 Used with HE and burster-type projectiles	PD	None	61 meters	Yes (SQ or delay)	Yes (SQ or delay)	SQ--no, delay--yes	Screwdriver or M18 fuze wrench	PD (SQ)	1. Used with all calibers. 2. Not sensitive to rain. 3. Can expect delay function if superquick action fails to detonate the projectile.
M513 (T226) M513B1 (T226B1) M514 (T227) M514B1 (T227B1) Used with the cavitized HE projectile	VT	5 to 100 seconds in 1-second increments	Time--3 seconds, PD--arms with time set	Yes, for self-destruction if radio is activated and fails to function	No	Yes	Time--clockwise with fuze setter M27 or M28 (no other action available)	Dud (some rounds may give impact PD action if radio has been activated)	1. M513 is 0.5 pound heavier than other models. 2. None of these VT-series fuzes used for PD impact action.
M513A1 (T226E2) M513A2 (T226E3) M514A1 (T227E2) Used with the cavitized HE projectile	VT	5 to 100 seconds in 1-second increments	Time--3 seconds, PD--3 seconds after flight begins	Yes	Yes	Yes	Time--clockwise, PD--clockwise to 90 seconds, with fuze setter M27 or M28 (all settings) WARNING: If set on PD line, airburst may occur.	PD and VT armed from approximately 2 to 3 seconds after firing and throughout flight	1. Duds or prematures can be expected when fired with charges 1 and 2 of 155-mm and 8-inch howitzers. 2. Table 3 gives further instructions for insuring reliability in the proximity mode. 3. Table 3 gives further instructions for insuring reliability in the point-detonating mode (impact action).
M728 (M514A1E1 and/or M514A3) Used with the cavitized HE projectile	VT	5 to 100 seconds in 1-second increments	Time--3 seconds, PD--3 seconds after flight begins	Yes	Yes	Yes	Time--clockwise, PD--clockwise to 90 seconds, with fuze setter M27 or M28 (all settings)	PD armed from approximately 2 to 3 seconds after firing, VT armed 10 seconds after firing	1. Suitable for use with 105-mm, 155-mm, and 8-inch howitzers. 2. Proximity arming occurs approximately 3 to 5 seconds prior to set time. 3. Table 3 lists restrictions for use with 105-mm howitzers. 4. Height of burst of this VT fuze is much lower than the older VT fuzes; HOB is only 7 meters.
M732 Used with all HE projectiles	VT	5 to 150 seconds in 1-second increments	Time--3 seconds, PD--3 seconds after flight begins	Yes	Yes	Yes	Time--clockwise, PD--clockwise to 90 seconds, with fuze setter M27 or M28 (all settings)	PD armed from approximately 2 to 3 seconds after firing, VT armed 10 seconds after firing	1. Suitable for use with 105-mm, 155-mm, and 8-inch howitzers. 2. Proximity arming occurs approximately 3 to 5 seconds prior to set time. 3. Height of burst of this VT fuze is much lower than the older VT fuzes; HOB is only 7 meters.

Notes.
1. For additional information, refer to TM 43-0001-28.
2. Abbreviations used in this table are as follows: MT--mechanical time; MTMA--mechanical time, muzzle action; MTSQ--mechanical time, superquick; PD--point-detonating, impact action; and VT--proximity.
3. Those M564 fuzes stamped with the year 1969 or earlier, must always be set to 90.0 seconds for impact superquick action. The M564 fuzes stamped with the year 1970 or later, can be fired as they are unpacked from the fuze can (set on "S") for impact superquick action.

proximity or impact action of proximity (VT) fuzes are given in table 11-3. For special instructions and information on the older fuzes listed in table 11-5 and not discussed in this handbook, see TM 43-0001-28.

c. Appendix B to this handbook is a Field Artillery Ammunition Compatibility Chart by weapons and the deployment of current ammunition to Europe, Korea, and continental United States. This appendix is a general guide only and the appropriate technical manual (TM) should be consulted for operational employment of field artillery ammunition.

11-29. Boosters

A separate charge of somewhat greater sensitivity is provided to detonate the high-explosive filler of an artillery projectile. Because its function is to increase, or boost, the effectiveness of the explosive train, this charge is known as a booster (U, fig 11-12). This high explosive is usually tetryl. The function of a booster is twofold. Its primary function is to insure the proper detonation of the bursting charge and give a high-order detonation. It also serves as a means of providing mechanical bore safety, which is accomplished by a booster rotor. In most fuzes equipped with a superquick element (except electronic fuzes) a flash channel extends from the superquick detonator to the booster charge. Inserting a rotor above the booster charge and offsetting that portion of the flash channel prevents the flash from the superquick detonator from reaching the booster. If the rotor is eccentrically weighted and pivoted near its center, centrifugal forces will cause the rotor to turn. When the rotor has turned so that the heaviest portion is toward the outside of the fuze, the portion of the flash channel in the rotor will be alined with the remainder of the flash channel. By the time this alinement occurs, the projectile is well clear of the tube.

a. *M125-series boosters*. The M125-series boosters are received already assembled to those fuzes used in burster-type and high-explosive projectiles with the exception of the CP fuzes of the M78 series. The fuze-booster assembly is removed from the container, inspected, and seated in the fuze well of the projectile in one operation. Bore safety of the complete projectile and fuze is provided by the booster rotor, which holds the explosive train out of alinement with the firing pin until the round has been fired through the cannon tube. The setback force of the firing of the round and the rapid acceleration and centrifugal force applied to the round cause the rotor to be unlocked and move the explosive train in alinement with the firing pin. The earlier booster of this series reaches the armed position after the projectile has traveled between 150 to 300 feet from the muzzle, depending on the velocity and spin rate of the projectile. The later booster of this series, the M125A1, requires a minimum of 200 feet of projectile travel from the tube before reaching the armed position.

b. *M25 booster*. The M25 booster functions in the same manner as boosters of the M125 series; however, the M25 is used only on the CP fuzes of the M78 series and it must always be assembled in the fuze well of the high-explosive projectile instead of on the fuze. It cannot be assembled to the fuze because it does not fit on the fuze. The primary difference between the M25 booster and boosters of the M125 series is that the M25 has only three external threads whereas the M125 has nine. A cotter pin on the M25 holds the rotor assembly in place during shipping and handling. This cotter pin must be removed by the cannoneer before the booster is installed in the fuze well of the high-explosive round. After the booster has been installed, the CP fuze M78 is screwed tightly into the fuze well of the projectile on top of the booster. The M16 fuze wrench (fig 11-14) is used to assemble the booster and the CP fuze M78 in the fuze well of the HE projectile.

c. *Projectile spotting charge*. A special projectile spotting charge, that looks like a shaped-charge booster, has been developed that is screwed on to the MTSQ fuze M577 when the ICM projectile M483 or M509 is being prepared for firing in the registration mode (see para 11-26*d*(1) and fig 11-27). This projectile spotting charge is drawn

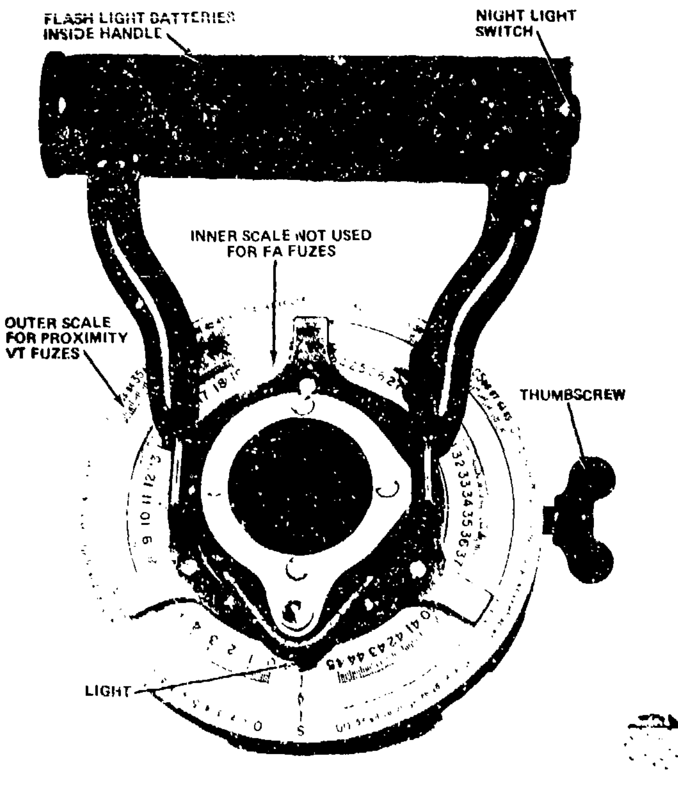


Figure 11-39. Fuze setter M28.

from the ammunition supply personnel as a separate item when firing either of these projectiles. This charge is not used with any other fuze or projectile.

Section VII. NEW AND EXPERIMENTAL AMMUNITION COMPONENTS

11-30. General

The principal of using four basic components to make up a complete round of ammunition is being put to good use in the new family of propelling charges, projectiles, and fuzes that are undergoing developmental tests and evaluation at this time. Not all of the items will be classified standard A, but many of them will be. This information is provided to keep field artillerymen abreast of the new items that may reach the field during the 1980s and early 1990s.

11-31. Propelling Charges

Developments under way at this time in the field of propelling charges are being conducted for the 155-mm and 8-inch howitzers. In all of these cases, the stress is on longer ranges for each caliber.

a. 155-mm propelling charges. There are two new propelling charges in production; one for use in the M109A1/A2/A3 self-propelled howitzers and both in the M108 towed 155-mm howitzer.

(1) *M119A2 propelling charge.* The M119A1 charge 8 has been redesigned by removing the center core igniter and changing the charge to 7 rather than 8. It is packed in a red bag to distinguish it from charge 7 WB series (see table 11-1). The muzzle velocity of this new charge is within 6 feet per second (6 fps) of the older

Table 11-5. Some Cartridge/Projectile-Fuze Combinations for Field Artillery Howitzers

WARNING: For limitations and special information on weapons, fuzes, projectiles or charges see the numbered notes at the bottom of this table as appropriate.

		FUZE (See Note 1)											
		PD			MT	MTSQ				PROX			
WEAPON	CARTRIDGE/PROJECTILE	M78 SERIES (CP)	M557	M739	M565	M501 SERIES	M564	M577	M582	M513 SERIES	M514 SERIES	M728	M732 (See Note 2)
105MM (See Note 3)	HE, M1 (Normal Cavity)	■	■	■			■		■				■
	HE, M1 (Deep Cavity)	■	■	■			■		■	P		P	■
155MM (See Note 4)	HE, M107 (Normal Cavity)	■	■	■			■		■				■
	HE, M107 (Deep Cavity)	■	■	■			■		■		P	P	■
	HE, M449 Series, ICM				■			■					
	HE, M483 Series, DP-ICM							■					
	FASCAM, M592/M731 ADAM							■					
	FASCAM, M718/M741 RAAMS							■					
	GB or VX, M121		■	■							P	P	■
	HE-RA, M549/M549A1 (See Note 5)		■	■								P	■
	ILLUM, M485 Series				■			■					
	SMOKE, WP, M110		■	■			■		■				
	GAS HD, M110		■	■			■		■				
	SMOKE, HC, M116 (old series)					■							
	SMOKE, HC M116A1 (new series)				■			■					
8-INCH	HE, M106 (Normal Cavity)	■	■	■			■		■				■
	HE, M106 (Deep Cavity)	■	■	■			■		■		P	P	■
	HE, M404 ICM				■			■					
	HE, M509, DP-ICM							■					
	HE-RA M650		■	■									■
	GB or VX M428		■	■							P	P	■

Key to Abbreviations and Symbols

■	as issued or compatible
ADAM	Area denial artillery munitions
APERS	Antipersonnel
BD	Base detonating
BE	Base ejection
CS	A tactical riot control agent
DP-ICM	Dual purpose improved conventional munition
FASCAM	Family of scatterable mines
GB	Nonpersistent toxic (casualty) nerve gas
H	Mustard gas
HC	Hexachloroethane (smoke)
HD	Distilled mustard gas
HE	High-explosive
HEAT	High-explosive anti-tank
HEP	High-explosive plastic
ICM	Improved conventional munitions
ILLUM	Illuminating
MOD	Modified
MT	Mechanical time
MTSQ	Mechanical time superquick
P	Requires removal of supplementary charge (if present)
PD	Point detonating
PIBD	Point initiating, base detonating
PROX	Proximity
RAAMS	Remote anti-armor mine systems
-T	With tracer
VX	Persistent toxic (casualty) nerve gas
WP	White phosphorus

NOTES:

1. For older fuze combination capability see TM 43-0001-28.
2. Do not remove the supplementary charge when firing the short-intrusion fuze M732.
3. All other 105mm rounds are issued complete with appropriate fuzes. These rounds are APERS M546, BE M84 series, GB M360, HE 444 ICM, Heat-T M622, HEP-T M327, ILLUM M314 series, WP Smoke, M60 and Gas H or HD M60
4. The 155mm towed howitzers M114/M114A1 are not authorized to fire the M483, M549, M692, M718, M731 or M741 series of new longer length family of projectiles, See TM 9-1020- 211-10 for limitations on propelling charges for M198 howitzer with certain 155mm projectiles.

For special limitations on fuze-projectile-propelling charge combinations see Appendix A of TM 43-10001-28.

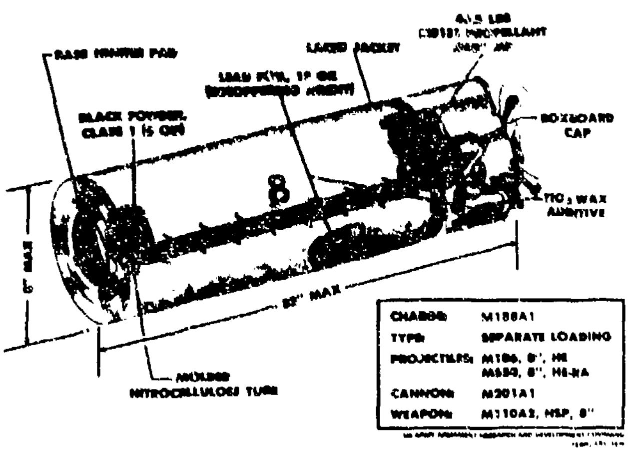


Figure 11-40. 8-inch propelling charge M188A1.

standard M119 and M119A1 WB series charge 8. No new firing tables will be required for this new Red Bag Charge 7, M119A2.

(2) *M203 propelling charge.* The M203 propelling charge has been designed for use in the M198 towed howitzer. It is classified as charge 8S and is a one-increment charge. This charge will fire the rocket-assisted projectile to a range of 30,000 meters. The test and development procedures for this charge have been completed for use in the M198 howitzer (see table 11-1).

b. 8-inch propelling charge. The M188A1 propelling charge (fig 11-40) is a two-increment powder charge (zones 8 and 9) for use in the long 8-inch tube on the M110A2 self-propelled howitzer. Early production models of the M188 charge, zone 8 (fig 11-41) were classified Standard for use in the M110A1 SP howitzer to fire a conventional projectile to a range of 20,600 meters. Additional tests were made on the long tube 8-inch howitzer to include adding a muzzle brake to the tube and adjustments to the recoil mechanism for the purpose of firing the M188A1 zone 9 (fig 11-40) with conventional ammunition to a range of 22,900 meters, and the M650 rocket-assisted projectile to approximately 30,000 meters. New production of M188A1 propelling charges will consist of zones 8 and 9. The M110A2 howitzer can fire the M188 zone 8. The M110A2 howitzer with muzzle brake can fire either zone 8 or 9 as appropriate, and all 8-inch M110A1 howitzers have been converted to M110A2 weapons.

11-32. Projectiles

There are many new designs of projectiles under consideration at this time, from a SADARM projectile to new ICM and chemical projectiles and to a cannon-launched laser-guided projectile. Most of these new projectile developments are for the 155-mm caliber; however, there are some new rounds being developed for the 105-mm and 8-inch weapons.

a. 105-mm projectile under development. The 105-mm projectiles under development at this time are—

(1) *M622 high-explosive antitank projectile.* The M622 high-explosive antitank projectile has been adapted from the M456 105-mm tank round which has a shaped-charge and is fin stabilized instead of spin stabilized. It is a special purpose round and comes complete with the cartridge case crimped to the projectile. It also has a special point-initiating base-detonating (PIBD) fuze screwed into the projectile. The round has been type classified for firing in all of the 105-mm howitzer tubes of the field artillery (fig 11-42) but is not in production at this time.

(2) *M314A3E1 illumination projectile.* The M314A3E1 illumination projectile is being improved to increase its reliability from 75 percent to 91 percent. Also, an attempt is being made to increase the total candlepower.

b. 155-mm projectile is under development. There are many new 155-mm projectiles under development that will include a new family of projectiles. Some of these new projectiles are being designed so that they will be ballistically similar.

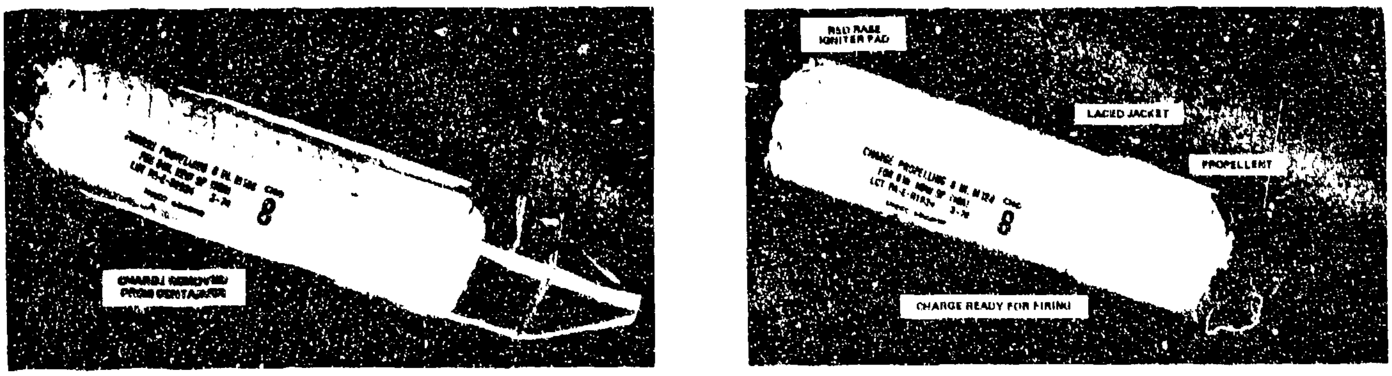


Figure 11-41. 8-inch propelling charge M188 zone 8

The exception to this is the M712 cannon-launched guided projectile COPPERHEAD which is an antitank projectile that will home-in on a reflected laser beam after it has been fired by the cannon crew (see paragraph (4) below).

(1) *M795 high-explosive projectile*. The M795 high-explosive projectile has been developed to replace the standard M107 HE shell for 155-mm weapons. It will provide increased effectiveness as well as 24 percent greater range capability than the M107. This increased range is obtained by achieving compatibility with the new top zone M203 propelling charge; whereas, the M107 is restricted from use with this new super charge. This new projectile will be made from high-fragmenting steel case for increased effectiveness. It will also be constructed so that it and the new family of 155-mm cargo carrying projectiles will be ballistically similar to the M483A2 projectile. This new 155-mm HE projectile will provide a low-cost registration round for the new family of 155-mm payload oriented ammunition. Production should start in FY 85.

(2) *M687 binary chemical projectile*. This new type of chemical round has been designed so that the chemicals are not premixed into a lethal dose, and that mixture will not take place until the round has been prepared and fired to the target. This projectile is shipped with one chemical canister inside the shell, and the other chemical canister is in a wooden box for ammunition supply point (ASP) storage. The ASP personnel will remove the base plate of the projectile, insert the second canister, and replace the base plate and issue to the field artillery units for firing. In a dire emergency the field artillery cannoneers may be required to remove the base plate, insert the canister and replace the base plate; therefore, a special wrench is provided with each pallet of rounds delivered to the cannon crew. A point detonating fuze is installed at the firing battery, the grommet is removed, and the round is ready for loading and firing. Set-back force punctures the two canisters inside the projectile, and spin force mixes the chemicals together, making the mixture lethal. When the round hits the target, the point detonating fuze will function, causing a bursting charge to blow open the projectile and scatter the chemical mixture over the target area.

(3) *M804 low cost indirect fire training round (LITR)*. The M804 LITR has been developed to provide a training round less expensive than the M107 HE projectile. It is constructed from a hollow M107 body and has been ballistically matched with steel-thickened walls. Smoke, which is generated by a chemical compound, is ejected through four holes drilled in the projectile just forward of the rotating band, and provides a visible signature upon impact. The firing tables used for the M107 HE projectile can be used with the M804 LITR. The M804 is prepared and fired

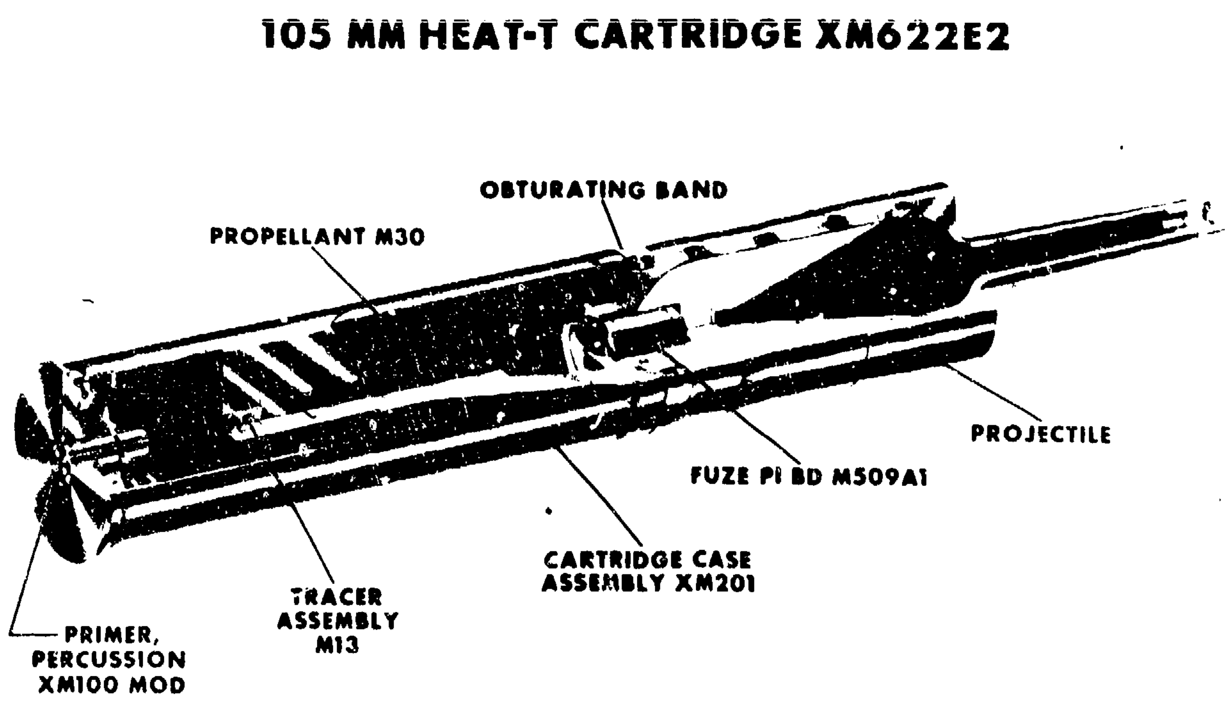


Figure 11-42. M622 high-explosive antitank projectile.

exactly like the M107 round with the impact fuze M557. The M804 LITR is ready for production and should be available in FY 83-84.

(4) *M712 cannon-launched guided projectile.* The M712 COPPERHEAD is a cannon-launched guided projectile (CLGP) antitank round that has the capability of homing in on its target after being fired by the cannon crew (fig 11-43). This round is loaded and fired the same as any other standard 155-mm projectile except that it is much longer (54 inches) and is fin-stabilized instead of spin-stabilized. The fins/wings, folded into recesses in the projectile, are extended in flight after the round clears the tube. The cannon crew will not have to install a fuze because the fuze is already assembled within the projectile. The cannoneers will have to set the fuze for time and a three-digit code. After firing the projectile, the forward observer must be directed to lase his target during the latter phase of the terminal portion of the trajectory so that the homing device, located in the plastic nose of this projectile, can pick up the reflected beam and home in on its target. This type of a round has been fired successfully at White Sands Proving Grounds. The tests at White Sands included a ground laser locator designator, a laser designator in a remotely piloted plane, and a laser designator operating from a helicopter.

(5) *M825 smoke projectile.* A new smoke projectile (fig 11-44) has been developed to provide increased obscuration effectiveness of two to three times that for the current smoke projectiles. A smoke screening obscuration time between 5 and 10 minutes has been obtained. This improved smoke projectile utilizes felt wedges impregnated with white phosphorus (WP) to facilitate rapid dissemination. Upon in-flight functioning of the M577 MTSQ fuze, an expulsion charge is ignited within the nose of the projectile causing base ejection and ignition of the smoke producing payload of the WP-felt pad wedges. These multiple sources fall to the target area in a large pattern and produce smoke for at least 5 minutes.

(6) *XM694E1 remotely monitored battlefield sensor system projectile.* The XM694E1 remotely monitored battlefield sensor system (REMBASS) projectile is an M483 family projectile which contains a single DT-570 seismic/acoustic sensor device. A set of fins that functions as brakes deploys to provide stability as the sensor device continues a ballistic flight until impact and implantation. This artillery delivered sensor is part of a complete sensor system that includes detection, discrimination, classification, and data collection.

(7) *XM864 extended range dual purpose, improved conventional munitions (ERDPICM).* The XM864 ERDPICM projectile will provide extended range by base bleed technology, and fill the void in ranges of the M483 DP-ICM and M549 HE RA projectiles. The range of the XM864 payload will be extended to approximately 23 kilometers in the SP M109 series howitzers, and to 26 kilometers in the M198 towed howitzers. The range will be enhanced approximately 20 to 30 percent through the use of pyrophoric granules in the base of the projectile. The granules are ignited after leaving the tube and create a positive overpressure behind the base of the projectile. This overpressure reduces the drag on the projectile as it passes through the atmosphere, thus enhancing its range without introducing the instabilities that are found in the M549 rocket-assisted projectile. The submunitions are base ejected in the same manner as the M483 DP-ICM projectile. The XM854 ERDPICM is in advanced development at this time.

(8) *XM867 expendable jammer (EXJAM).* The XM867 EXJAM will have six electronic countermeasure (ECM) transmitters packaged in the M483 cargo carrying type projectile, similar in

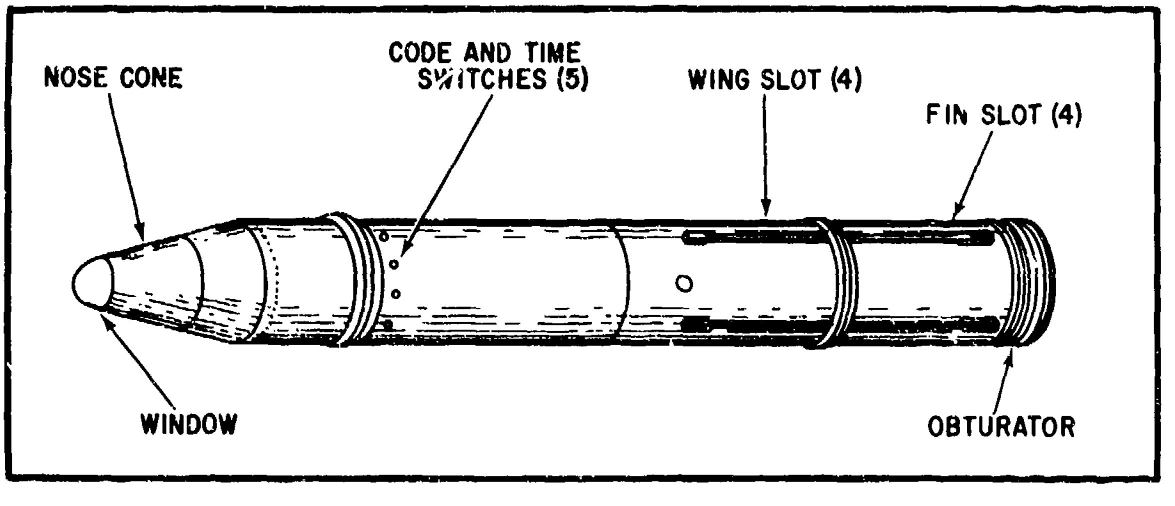


Figure 11-43. M712 Copperhead projectile.

concept to the FASCAM type artillery rounds. These expendable ECM jammers are designed to be low cost, gun rugged, and maintenance free. The ECM jammers will be expelled from the projectile in the target area and become active when they land on the ground. The XM867 EXJAM is currently in engineering development.

c. *8-inch projectiles under development.* The following projectiles are either under a development program or in production for use in the 8-inch SP howitzer. These projectiles are—

(1) *M650 rocket-assisted projectile.* Development of this 8-inch high-explosive rocket-assisted projectile (RAP) has been completed and is in production. This RAP round will increase the range of the new 8-inch self-propelled howitzer M110A2 to approximately 30,000 meters when fired with propelling charge M118A1, zone 9.

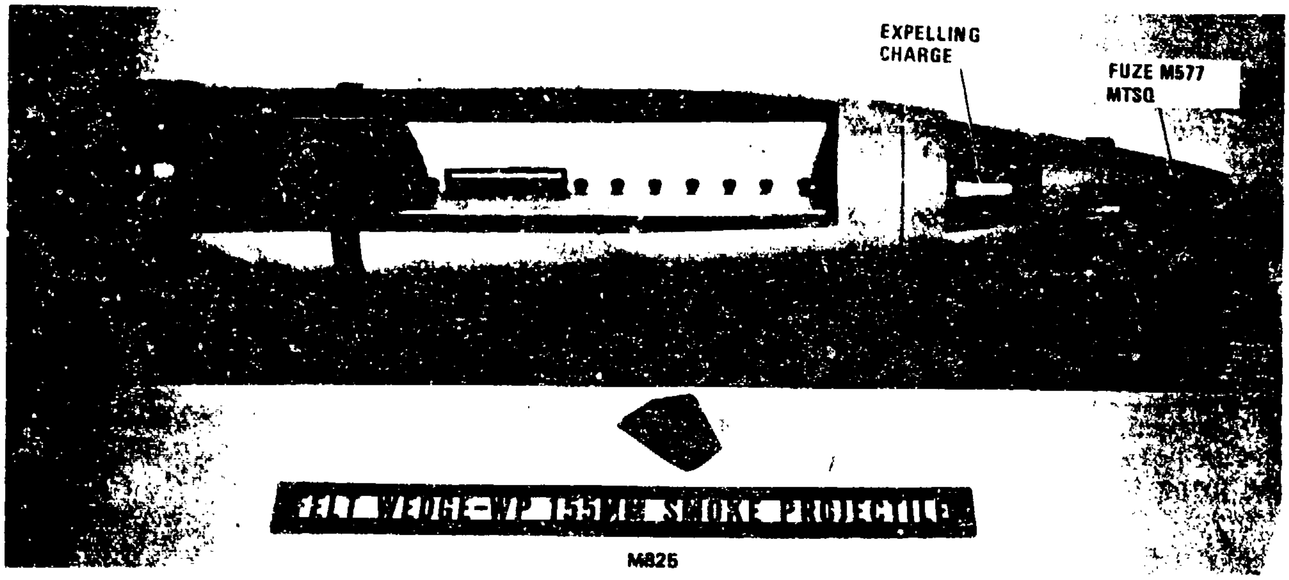


Figure 11-44. M825 felt wedge-WP 155-mm smoke projectile.

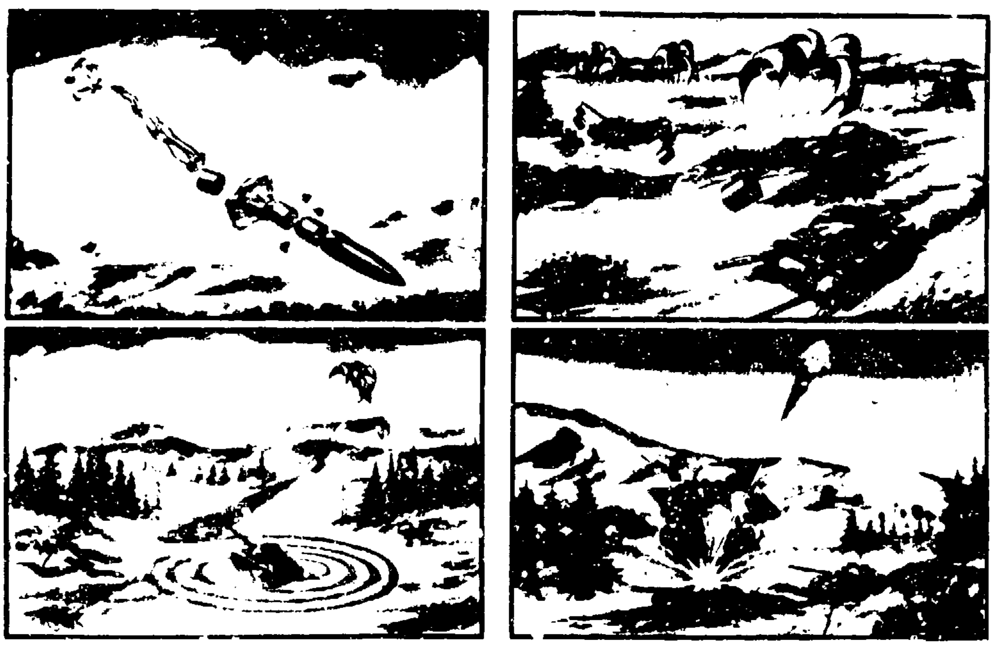


Figure 11-45. XM836 sense and destroy armor (SADARM) projectile.

(2) *XM836 sense and destroy armor (SADARM).* The XM836 SADARM system, as initially developed, will use a standard M509 8-inch projectile body to deliver multiple submunitions packaged within the projectile to an area above an armored concentration (fig 11-45). Each submunition contains an autonomous sensor for the detection of armored targets, a lethal mechanism capable of defeating the target at a long standoff, and a parachute for stabilizing and imparting a spin to the submunition while controlling the rate of descent of the submunition. This uniform spin and descent rate provides scan capability to the sensor. The SADARM approach is considered to be unique because it utilizes a self-contained sensing technique for target detection, and does not rely on a guidance and control subsystem to carry the lethal mechanism to the target. The sensor acts as a target activated fuze, evaluating and processing the inherent signature emanating from the target.

(3) *XM844 low cost indirect fire training round (LITR).* The XM844 LITR is being developed to provide a shootable training round for the 8-inch weapon that is less expensive than the M106 HE projectile. It will be constructed from a hollow M106 body and is to be a ballistic match so that the firing tables used with the M106 HE projectile can be used with the XM844 LITR. Smoke, which is generated by a chemical compound, will be ejected through holes drilled in the projectile just forward of the rotating band and will provide a visible signature upon impact. The XM844 will be prepared and fired exactly like the M106 round with the impact fuze M557. The XM844 is still in the developing and testing stage.

(4) *M845 dummy or drill projectile.* The M845 dummy projectile (completely inert) has been developed to facilitate training in the proper handling, loading, ramming, and extracting ammunition in the M110A2 self-propelled howitzer. The use of this inert projectile is intended to improve cannon crew proficiency in the proper operation and maintenance of the loader rammer system on the 8-inch self-propelled howitzers, in other than live fire situations. Effective training in proper loading and ramming can minimize or eliminate the problem of damaged M201 series cannon tubes. This projectile can be requisitioned by using NSN 1320-01-099-8515, DODIC D648 on the basis of one per howitzer. The M845 dummy projectile MUST NEVER BE FIRED, it is for training of cannon crews only. See TB 9-2350-304-10 for additional information on the maintenance, spare parts, and operating procedures of this projectile.

Section VIII. SUMMARY

11-33. Review

a. Rapid selection and assembly of the correct four major components of a complete round of field artillery ammunition—primer, propellant, projectile, and fuze—is necessary in order to load and fire a field artillery cannon one time, and produce the desired effect on the target within a matter of a few seconds. This means that field artillerymen must know their ammunition, how to select the proper components, inspect them, and prepare them for firing.

b. Classification of field artillery ammunition by type is based on the manner in which ammunition components are assembled for loading and firing. Complete rounds of field artillery ammunition are known as either *semifixed* or *separate-loading* rounds.

c. As field artillerymen, you must keep up with the changes in components so that you can comply with the fire commands, and select the right projectile (HE, ICM, SMOKE, WP, GAS, ILLUMINATION, new DP-ICM, etc.), cut the proper charge, select, install, and set the correct fuze (IMPACT, MTSQ, or VT) and load and fire the round so that it is on its way to the target area within a matter of a few seconds.

d. Ammunition is field artillery; the weapon is merely the means of delivering the round to the target! You need to know your ammunition components. Learn the different types of projectiles and their color codes and markings. Learn how to select and cut the correct powder charge and never, under any circumstances, fire a fuze that is loose on a projectile or one that has a loose time ring.

WARNING: Do not fire an artillery round of any caliber without using the fuze authorized for that particular type of round. The firing of a round without a fuze or with a fuze that is not authorized could result in an inbore burst or some other hazardous condition that could cause serious injury to personnel or damage to materiel.

L 223 Army—Fort Sill, Okla.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1983-673-321

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A GENERAL P
FIELD ARTIL

(NOTE: The appropriate TM should be used for operational use of ammunition.)

M198 HOWITZER (NOT IN USAREUR)

**** PROJECTILES	PROP CHARGES				MAXIMUM RANGE	FUZE ACTIONS	DEPLOYED		
	M3 SERIES	M4 SERIES	M119* SERIES	M203			USAREUR	KOREA	IN CONUS
M107 HE	YES, But Not Zones 1	YES	YES	NO	18,150	CP, PD, MTSQ, VT	YES	YES	YES
M549A1 RAP	NO	YES, but Zone 7 only	* YES, But Not M119	YES	30,000	PD	YES	YES	YES
M449 ICM	YES, But Not Zone 1	YES	YES	NO	18,100	MT	YES	YES	YES
M485 ILLUM	YES, But Not Zone 1	YES	YES But Degraded Reliability	NO	17,500	MT	YES	YES	YES
M483A1 DP-ICM	YES, But not Zones 1 or 2	YES	YES	NO	17,500	MT	YES	YES	YES
M692/M731 ADAM	YES, But not Zones 1 or 2	YES	YES	NO	17,500	MT	YES	NO	NO
M454 NUC	PROB COMPATIBLE USES SPECIAL PROP CHARGES				14,600	AIR BURST	CLASSIFIED		
M116A1HC	YES, But Not Zone 1	YES	YES	NO	18,150	MT	YES	YES	YES
M110 WP	YES, But Not Zone 1	YES	YES	NO	18,150	PD, MTSQ	YES	YES	YES
M687 BINARY	Not Zones 1 or 2	YES	YES	PROB COMP	TBD	PD, MTSQ	NO	NO	NO, Not in Production
M121 CHEMICAL	YES, But Not Zone 1	YES	YES	NO	18,150	PD, VT	YES	YES	YES
M796 HE	Not Zones 1 or 2	YES	YES	YES	22,400	PD, MTSQ, VT (M732 VT only)	NO	NO	NO, FY85
XM785 NUC	Not Zones 1 or 2	PROBABLY COMPATIBLE			30,100	AIR BURST	CLASSIFIED		
M825 SMOKE	Not Zones 1 or 2	PROBABLY COMPATIBLE			TBD	MT	NO	NO	NO, FY 84
M718/M741 RAAM	YES, But not Zones 1 or 2	YES	YES	NO	17,500	MT	YES	NO	NO
M712 COPPERHEAD	YES, But no requirement for zones 1 thru 3	YES	YES	NO	16,400	BD (Comes already	NO	NO	NO, RDF only FY 83-84
XM694/XM694E1	PROBABLY COMPATIBLE				TBD	MT	NO	NO	NO Unfunded
M804 PRACTICE	YES	YES, Zone 5 Max	PROB COMP	NO	9,700	PD	YES	YES	YES

M109A1 /A2/A3 SP HOWITZER

**** PROJECTILES	PROP CHARGES				MAXIMUM RANGE	FUZE ACTIONS	DEPLOYED		
	M3 SERIES	M4 SERIES	M119* SERIES	M203			USAREUR	KOREA	IN CONUS
M107 HE	YES, But Not Zone 1	YES	YES	NO	18,100	CP, PD, MTSQ, VT	YES	YES	YES
M549A1 RAP	NO	YES, But Zones 7 only	* YES, But Not M119	NO	23,500	PD	YES	YES	YES
M449 ICM	YES, But Not Zone 1	YES	YES	NO	18,100	MT	YES	YES	YES
M485 ILLUM	YES, But Not Zone 1	YES	YES, but Degraded Reliability	NO	17,500	MT	YES	YES	YES
M483A1 DP-ICM	YES, But Not Zones 1 or 2	YES	YES	NO	17,500	MT	YES	YES	YES
M692/M731 ADAM	Yes, But Not Zones 1 or 2	YES	YES	NO	17,500	MT	YES	NO	NO
M454 NUC	USES SPECIAL PROP CHARGES			NO	14,600	AIR BURST	CLASSIFIED		
M116A1 HC	YES, But Not Zone 1	YES	YES	NO	18,100	MT	YES	YES	YES
M110 WP	YES, But Not Zone 1	YES	YES	NO	18,100	PD, MTSQ	YES	YES	YES
M687 BINARY	YES, But Not Zones 1 or 2	YES	YES	NO	TBD	PD, MTSQ	NO	NO	NO, Not in production
M121 CHEMICAL	YES, But Not Zone 1	YES	YES	NO	18,100	PD, VT	YES	YES	YES
M796 HE	YES, But Not Zone 1 or 2	YES	PROB COMP	NO	TBD	CP, PD, MTSQ, VT, (M732 only)	NO	NO	NO, FY 85
XM785 NUC	PROBABLY COMPATIBLE, BUT NOT ZONES 1 or 2			NO	23,500	AIR BURST	CLASSIFIED		
M825 SMOKE	PROBABLY COMPATIBLE, BUT NOT ZONES 1 or 2			NO	TBD	MT	NO	NO	NO, FY 84
M718/M741 RAAM	YES, But Not Zones 1 or 2	YES	YES	NO	17,500	MT	YES	NO	NO
M712 COPPERHEAD	YES, but not requirement for zones 1 thru 3	YES**	YES ***	NO	16,400	BD (Comes Already Installed)	NO	NO	No, RDF only FY 83-84
XM694/XM694E1 REMBASS	PROBABLY COMPATIBLE			NO	TBD	MT	NO	NO	NO, Unfunded
M804 PRACTICE	YES But Not Zone 1	YES, Zone 5 Max	PROB COMP	NO	9,700	PD	YES	YES	YES

*M119 Series consist of M119 or M119A1 white bags, Zone 8's, and M119A2 red bag, Zone 7. CAUTION M119 propelling charge not authorized with any M549/M549A1 or any other rocket-assisted projectiles (RAP)

**M109A1 can shoot zones 4, 5, or 6. Can shoot Zone 7 in combat emergency only.

***M109A2 or M109A3 can shoot M712 projectile with M119A1 or M119A2 propelling charges to a range of 16,400 meters.

**** IAW TM's no firing at zone 1 with 155-mm long tubes because of "sticker" problems.

M114A1 HOWITZER (NOT IN USAREU

PROJECTILE	PROP CHARGES	
	M3 SERIES	M4 SERIE
M107 HE	YES	YES
M549A1 RAP	NOT COMP	
M449 ICM	YES	YES
M485 ILLUM	YES	YES
M483A1 DP ICM	NOT COMP	
M692/M731 ADAM	NOT COMP	
M454 NUC	USES SPECIAL PROP CHARGES	
M116A1 HC	YES	YES
M110 WP	YES	YES
M687 BINARY	NOT COMP	
M121 CHEMICAL	YES	YES
M795 HE	NOT COMP	
XM785 NUC	NOT COMP	
M825 SMOKE	NOT COMP	
M718/M741 RAAM	NOT COMP	
M712 COPPERHEAD	NO REQ FOR Z1 THRU Z3	
XM694 XM694E1 REMBASS	NOT COMP	
M804 PRACTICE	YES	Yes, Zon 5 Max

M114A2 HOWITZER (NOT IN USARE

PROJECTILES	PROP CHARGES	
	M3 SERIES	M4 SERI
M107 HE	YES	YES
M549A1 RAP	NO	YES, but Zone 7 only
M449 ICM	YES	YES
M485 ILLUM	YES	YES
M483A1 DP ICM	YES	YES
M692/M731 ADAM	YES	YES
M454 NUC	USES SPECIAL PROP CHARGES	
M116A1 HC	YES	YES
M110 WP	YES	YES
M687 BINARY	YES	YES
M121 CHEMICAL	YES	YES
M795 HE	PROB COMP	
XM785 NUC	PROB COMP	
M825 SMOKE	PROB COMP	
M718/M741 RAAM	YES	YES
M712 COPPERHEAD	NO REQ FOR Z1 THRU Z3	
XM694, XM694E1	PROB COMP	
M804 PRACTICE	YES	YES, Zo 5 Max

**155mm Propelling Charges

M3 series, green bag with zones 1 throug
M4 series, white bag with zones 3 throug
M119/M119A1, white bag with zone 8 o
M119A2, Red bag with zone 7 only
M203, Red bag with zone 8 super, used towed howitzer only.

Appendix B
A GENERAL PLANNING GUIDE FOR FIELD ARTILLERY AMMUNITION

al use of ammunition.)

FUZE ACTIONS	DEPLOYED USAREUR	KOREA	IN CONUS
CP, PD, MTSQ, VT	YES	YES	YES
PD	YES	YES	YES
MT	YES	YES	YES
MT	YES	YES	YES
MT	YES	YES	YES
MT	YES	NO	NO
AIR BURST	CLASSIFIED		
MT	YES	YES	YES
PD, MTSQ	YES	YES	YES
PD, MTSQ	NO	NO	NO, Not in Production
PD, VT	YES	YES	YES
PD, MTSQ, VT (M732 VT only)	NO	NO	NO, FY85
AIR BURST	CLASSIFIED		
MT	NO	NO	NO, FY 84
MT	YES	NO	NO
BD (Comes already	NO	NO	NO, RDF only FY 83–84
MT *	NO	NO	NO, Unfunded
PD	YES	YES	YES

FUZE ACTIONS	DEPLOYED USAREUR	KOREA	IN CONUS
CP, PD, MTSQ, VT	YES	YES	YES
PD	YES	YES	YES
MT	YES	YES	YES
MT	YES	YES	YES
MT	YES	YES	YES
MT	YES	NO	NO
AIR BURST	CLASSIFIED		
MT	YES	YES	YES
PD, MTSQ	YES	YES	YES
PD, MTSQ	NO	NO	NO, Not in production
PD, VT	YES	YES	YES
CP, PD, MTSQ, VT, (M732 only)	NO	NO	NO, FY 85
AIR BURST	CLASSIFIED		
MT	NO	NO	NO, FY 84
MT	YES	NO	NO
BD (Comes Already Installed)	NO	NO	No, RDF only FY 83–84
MT	NO	NO	NO, Unfunded
PD	YES	YES	YES

UTION: M119
(RAP).

o range of 16,400

M114A1 HOWITZER (NOT IN USAREUR)

PROJECTILE	PROP CHARGES M3 SERIES	M4 SERIES	MAXIMUM RANGE	FUZE ACTIONS	DEPLOYED USAREUR	KOREA	IN CONUS
M107 HE	YES	YES	14,600	CP, PD, MTSQ, VT	YES	YES	YES
M549A1 RAP	NOT COMP		NOT COMP				
M449 ICM	YES	YES	14,600	MT	YES	YES	YES
M485 ILLUM	YES	YES	13,600	MT	YES	YES	YES
M483A1 DP–ICM	NOT COMP		NOT COMP				
M692/M731 ADAM	NOT COMP		NOT COMP				
M454 NUC	USES SPECIAL PROP CHARGES		14,600	AIR BURST	CLASSIFIED		
M116A1 HC	YES	YES	14,600	MT	YES	YES	YES
M110 WP	YES	YES	14,600	PD, MTSQ	YES	YES	YES
M687 BINARY	NOT COMP		NOT COMP				
M121 CHEMICAL	YES	YES	14,600	PD, VT	YES	YES	YES
M795 HE	NOT COMP		NOT COMP				
XM785 NUC	NOT COMP		NOT COMP				
M825 SMOKE	NOT COMP		NOT COMP				
M718/M741 RAAM	NOT COMP		NOT COMP				
M712 COPPERHEAD	NO REQ FOR Z1 THRU Z3		TBD	BD (Comes already installed)	NO	NO	No, RDF only FY 83–84
XM694/XM694E1 REMBASS	NOT COMP		NOT COMP				
M804 PRACTICE	YES	YES, Zone 5 Max	9,700	PD	YES	YES	YES

M114A2 HOWITZER (NOT IN USAREUR)

PROJECTILES	PROP CHARGES M3 SERIES	M4 SERIES	MAXIMUM RANGE	FUZE ACTIONS	DEPLOYED USAREUR	KOREA	IN CONUS
M107 HE	YES	YES	14,600	CP, PD, MTSQ, VT	YES	YES	YES
M549A1 RAP	NO	YES, but Zone 7 only	19,300	PD	YES	YES	YES
M449 ICM	YES	YES	14,600	MT	YES	YES	YES
M485 ILLUM	YES	YES	13,600	MT	YES	YES	YES
M483A1 DP–ICM	YES	YES	14,500	MT	YES	YES	YES
M692/M731 ADAM	YES	YES	14,300	MT	YES	NO	NO
M454 NUC	USE SPECIAL PROP CHARGES		14,600	AIR BURST	CLASSIFIED		
M116A1 HC	YES	YES	14,600	MT	YES	YES	YES
M110 WP	YES	YES	14,600	PD, MTSQ	YES	YES	YES
M687 BINARY	YES	YES	TBD	PD, MTSQ	NO	NO	NO Not in Production
M121 CHEMICAL	YES	YES	14,600	PD, VT	YES	YES	YES
M795 HE	PROB COMP		TBD	CP, PD, MTSQ, VT (Only M732)	NO	NO	NO FY 85
XM785 NUC	PROB COMP		19,300	AIR BURST	CLASSIFIED		
M825 SMOKE	PROB COMP		TBD	MT	NO	NO	NO, FY 84
M718/M741 RAAM	YES	YES	14,300	MT	YES	NO	NO
M712 COPPERHEAD	NO REQ FOR Z1 THRU Z3		TBD	BD (Comes already installed)	NO	NO	NO, RDF only FY 83-84
XM694/XM694E1	PROB COMP		TBD	MT	NO	NO	NO, Unfunded
M804 PRACTICE	YES	YES, Zone 5 Max	9,700	PD	YES	YES	YES

155mm Propelling Charges

M3 series, green bag with zones 1 through 5
M4 series, white bag with zones 3 through 7
M119/M119A1, white bag with zone 8 only.
M119A2, Red bag with zone 7 only
M203, Red bag with zone 8 super, used in M198 towed howitzer only.

KEY TO FUZES

TYPE	CURRENT	REPLACEMENT	FUTURE
CP	[illegible]	[illegible]	[illegible]
PD	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
MT	[illegible]	[illegible]	[illegible]
MTSQ	[illegible]	[illegible]	[illegible]
VT	[illegible]	[illegible]	[illegible]

*M577 and M582 can be set for either MT or SQ action, but not for both.

8-INC

PRO
M106
M404
M422A
M424A
M426
M509
M753
M650
M650

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alle

8-in
M1
M2

105MM

APERS
GAS
GAS
GAS
HE, M
HE M
HE, M
HE, R
HEAT
HEP
ILLUM
SMOK
SMOK
NOT
some

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DEPLOYED		
USAREUR	KOREA	IN CONUS
[illegible]	YES	YES
[illegible]	YES	YES
[illegible]	YES	YES
CLASSIFIED		
[illegible]	YES	YES
[illegible]	YES	YES
[illegible]	YES	YES
[illegible]	NO	NO, RDF only FY 83-84
[illegible]	YES	YES

8-INCH HOWITZER M110A2

PROJECTILES	PROP CHARGES				MAXIMUM RANGE	FUZE ACTIONS	DEPLOYED		
	M1	M2	M188	M188A1			USAREUR	KOREA	IN CONUS
M106 HE	YES	YES	YES	YES	22,900	CP, PD, MTSQ VT	YES	YES	YES
M404 ICM	YES	YES	NO	NO	17,200	MT	YES	YES	YES
M422A1 NUC	USES SPECIAL PROPELLING CHG		YES	YES *	18,000	AIR BURST	CLASSIFIED		
M424A1 HES	USES SPECIAL PROPELLING CHG		YES	YES *	18,000	AIR BURST	CLASSIFIED		
M426 CHEMICAL	YES	YES	YES	YES	22,900	PD, VT	YES	YES	YES
M509 DP-ICM	YES	YES	YES	YES	22,700	MT	NO, FY 83-84		
M753 NUC	YES	YES	YES	YES	30,000	AIR BURST	CLASSIFIED		
M650 RAP Rocket ON	YES	YES	YES	YES	30,000	PD	YES	YES	NO
M650 RAP Rocket OFF	YES	YES	YES	YES	24,400	PD, MTSQ, VT (M732)	YES	YES	NO

*Zone 9 is not authorized for either the M422A1 or the M424A1 projectiles. During peace time, the M424A1 projectile may be fired with either M80 or Zone 8 of the M188 or M188A1 propelling charges in a new cannon tube. A new cannon tube is defined as one which has at least one-half of the tube life remaining.

8-inch Propelling Charges

M1 green bag, with zones 1 through 5.
M2 white bag, with zones 5 through 7.
M188 white bag with zones 8 only.
M188A1 white bag with zones 8 and 9

DEPLOYED		
USAREUR	KOREA	IN CONUS
[illegible]	YES	YES
[illegible]	YES	YES
[illegible]	YES	YES
[illegible]	YES	YES
[illegible]	YES	YES
[illegible]	NO	NO
CLASSIFIED		
[illegible]	YES	YES
[illegible]	YES	YES
NO	NO	NO Not in Production
[illegible]	YES	YES
NO	NO	NO, FY 86
CLASSIFIED		
NO	NO	NO, FY 84
YES	NO	NO
NO	NO	NO, RDF only FY 83-84
NO	NO	NO, unfunded
YES	YES	YES

105MM HOWITZERS M101A1 AND M102 TOWED

PROJECTILES	PROPELLING CHARGES	MAXIMUM RANGES		FUZE ACTIONS	DEPLOYED		
		M101A1	M102		USAREUR	KOREA	IN CONUS
APERS-T M546	SEE NOTE AT THE BOTTOM OF THIS CHART	11,600	12,400	Comes set for MA. Can be set to 100 Sec.	SOME OF THESE 105MM ROUNDS ARE IN ITALY WITH ONE BATTERY	YES	YES
GAS, GB M360		11,000	11,500	PD		YES	YES
GAS, H, HD M60		11,000	11,500	PD		YES	YES
GAS, Tac CS M629		11,000	11,500	MT		YES	YES
HE, M1 (Normal Cavity)		11,000	11,500	CP, PD, MTSQ, VT (M732)		YES	YES
HE, M1 (Deep Cavity)		11,000	11,500	CP, PD, MTSQ, VT		YES	YES
HE, M444 ICM		11,000	11,500	MT MODIFIED		YES	YES
HE RAP M548		14,500	15,100	PD, VT		NO	[illegible]
HEAT-T M622		DIRECT FIRE		PIBD		NO	[illegible]
HEP-T M327		DIRECT FIRE		BD		YES	YES
ILLUMINATION M314A3		11,000	11,500	MT		YES	YES
SMOKE, BE, HC M84		11,000	11,500	MT		YES	YES
SMOKE, WP M60		11,000	11,500	PD		YES	YES

NOTE Most 105mm rounds come complete with primer, propellant, projectile and fuze; [illegible] some lots of WP M60 that come w/o fuzes. CP, PD, MTSQ or VT fuzes as appropriate must be drawn [illegible]

KEY TO FUZES

TYPE	CURRENT	REPLACEMENT	FUTURE
[illegible]	M78 M78A1	None	None
[illegible]	M557 M572	M739 M739	None
[illegible] MT	M562	None	None
M[illegible]	M565	M577*	ET XM767
MTSQ	M564	M582*	ET XM767
	M513 M514	M728 M728	M732 M732

*M577 and M582 can be set for either MT or SQ action, but not for both.

KEY TO ABBREVIATIONS

ADAM	Area denial artillery munitions	IOC	[illegible]
apers	Antipersonnel	MA [illegible]	[illegible]
BD	Base detonating	MOD	[illegible]
BE	Base ejection	MT	[illegible]
CP	Concrete piercing	MTSQ	[illegible]
CS	A tactical riot control agent	PD	[illegible]
DP-ICM	Dual purpose improved conventional munition	[illegible]	[illegible]
ET	Electronic time fuze	[illegible]	[illegible]
FASCAM	Family of scatterable mines	[illegible]	[illegible]
GB	Nonpersistent toxic (casualty)	[illegible]	[illegible]
H	Mustard gas	[illegible]	[illegible]
HC	Hexachloroethane (smoke)		[illegible]
HD	Distilled mustard gas	[illegible]	[illegible]
HE	High-explosive	[illegible]	[illegible]
HEAT	High-explosive anti-tank	[illegible]	[illegible]
HEP	High explosive plastic	[illegible]	[illegible]
ICM	Improved conventional munitions	[illegible]	[illegible]
ILLUM	Illuminating		

The M804 Projectile (DODIC D513) [illegible]

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