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FM 17-12

DEPARTMENT OF THE ARMY FIELD MANUAL

TANK GUNNERY

DEPARTMENT OF THE ARMY • MAY 1957

FIELD MANUAL
No. 17–12

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *21 May 1957*

TANK GUNNERY

* This manual supersedes FM 17–12, 30 November 1950, including C 1, 13 November 1951, C 2, 16 June 1953, and C 3, 10 August 1954.

PART ONE

GENERAL

CHAPTER 1

INTRODUCTION

1. Purpose

The purpose of this manual is to—

a. Provide a general guide for tank gunnery training.

b. Treat in detail those elements of tank materiel and gunnery not covered in publications pertaining to specific models of tanks.

c. Outline principles, methods, and techniques which will insure full and effective use of tank weapons, both in training and in combat, under all foreseeable conditions.

d. Promote uniformity and high standards of training.

e. Provide a practical reference book for all echelons of command in learning, teaching, and supervising tank gunnery.

2. Scope

a. This manual contains five parts as follows:

(1) Part one outlines the purpose and scope of this manual.

(2) Part two presents general characteristics of tank armament, turrets, and controls applicable to all tanks. It also discusses tank gun ammunition and ballistics.

(3) Part three explains the fundamentals of tank gunnery, to include fire-control equipment, range determination, and tank gunnery principles applicable to all tanks.

(4) Part four covers conduct of fire. It presents in detail the principles, methods, and techniques of direct fire. It also discusses indirect fire.

(5) Part five covers tank gunnery training and testing of individual tank crewmen, sections, and platoons.

b. This manual is general in scope and covers only those principles, methods, techniques, training exercises, and proficiency tests applicable to all types and models of tanks. For details pertaining to any particular item of materiel, reference must be made to the specific publications for that tank.

c. The material presented herein is applicable without modifications to both atomic and nonatomic warfare.

PART TWO
MATERIEL

CHAPTER 2
CHARACTERISTICS OF TANK ARMAMENT, TURRETS, AND CONTROLS

Section I. INTRODUCTION

3. Background

The family of tanks includes three types—a light-gun tank, a medium-gun tank, and a heavy-gun tank. As the gun designation implies, these tanks are produced to fulfill certain roles according to their firepower capabilities. However, all tanks, regardless of type, have many common characteristics. The tank, being basically an offensive weapon, depends upon its mobility, armor-protected firepower, and shock action to accomplish its mission. Mobility refers to the ability of the tank to negotiate various types of terrain and to move rapidly from place to place on the battlefield. How well a tank moves over the ground depends largely upon its power plant, its suspension system, and its crew. Armor-protected firepower refers to the tank's ability to shoot rapidly and accurately in any direction with a multiplicity of weapons, at the same time furnishing adequate armor protection for the crewmen. The speed and accuracy of fire depend upon the turret and gun controls, the sights and fire-control instruments, and the skill of the tank crew. Shock action is obtained by properly employing mobility and armor-protected firepower.

4. Characteristics of Tanks

Regardless of the gun's size or the tank's mission, tanks have the common characteristics indicated in *a* through *k* below.

a. The crewmen stationed in the turret include the tank commander, who commands the tank, fires the turret- (or cupola-) mounted machine gun, and directs the actions of all the other crewmen; the gunner, who aims, fires, and adjusts the fire of the main gun and the coaxial machine gun(s); and one or more loaders, who load(s) the main gun and coaxial machine gun(s).

b. The turret, mounted on the turret ring, can be rotated by the gunner continuously and with variable speed in either direction by both manual and power controls. This permits firing in any direction without moving the tank. Slow or rapid traverse and immediate reversal of direction are possible. In addition, on some tanks, the tank commander is provided with a means for overriding the gunner's power control for rapid laying on targets.

c. The main gun is mounted on trunnions in the forward part of the turret. As the turret traverses, the gun traverses; but for elevation the gun must move independently of the turret. This is accomplished by use of a gunner's manual and/or power elevation system. As in traverse, the tank commander has, on some tanks, a means of overriding the gunner's power elevation controls.

d. At least one machine gun is mounted coaxially with the main gun and is aimed with the same direct-fire sights.

e. A turret- or cupola-mounted machine gun is provided for use by the tank commander against aerial and ground targets.

f. The main gun is fired either manually or electrically by the gunner, and electrically by the tank commander. It is provided with a manual safety to prevent accidental firing.

g. The main gun is normally mounted in a recoil mechanism. Some recoil mechanisms have one cylinder concentric with the gun tube; others are multiple-cylinder types which space the cylinders around the gun tube. This recoil mechanism limits the movement of the gun in recoil and returns the gun to the battery position.

h. The gun is aimed primarily by direct-fire sights but may also be laid by use of auxiliary fire-control instruments. Direct-fire sights are mounted for use by the gunner and tank commander.

i. The rear of the turret overhangs the turret support in order to balance the weight of the gun tube in the front of the turret. This assists traverse, particularly when the turret is not level. The space provided by the turret overhang is utilized for mounting the radios, ventilator, ammunition stowage racks, and miscellaneous equipment.

j. The turret can be locked in traverse by use of the turret lock. The gun can be locked in traverse and elevation by use of a gun traveling lock. These locks are designed to prevent damage to the traverse and elevation mechanism.

k. Ammunition for the main gun and machine guns is stowed so that some rounds are immediately available for loading. Other main gun ammunition may be stowed under the turret floor, in the turret overhang, in the sides of the hull, or in the forward part of the hull.

Section II. TANK GUNS AND GUN MOUNTS

5. General

Tank main guns vary in caliber but are fundamentally of the same design. They have the following common characteristics:

a. Mounted on a combination mount.

b. Consist of four main parts or assemblies—muzzle attachment, bore evacuator, tube, and breech mechanism.

c. Incorporate a breech which may be opened manually. The breech will close automatically at any time the extractors are tripped. During firing the breech will open automatically on counterrecoil and eject the empty case.

6. Combination Gun Mount

The combination gun mount consists of a gun shield and a cradle. The gun mount supports the main gun on trunnion bearings and provides attachments for the breech operating and firing mechanisms, the coaxial machine gun mount(s), the recoil guards, and in some cases a direct-fire telescope mount.

7. Recoil Mechanisms

Recoil mechanisms are of the hydrospring constant recoil distance type, designed to bring the gun to rest at the end of a predetermined recoil distance and to return the gun to battery position with a minimum of shock. This is accomplished by the controlled flow of hydraulic fluid and by the compression and expansion of spring(s)—hence, the designation hydrospring.

8. Main Gun

The main gun on a tank is a high-velocity, flat-trajectory weapon. It consists of four major parts—muzzle attachment, bore evacuator, gun tube, and breech mechanism. Muzzle attachments are provided to reduce obscuration. Bore evacuators are mounted on the gun tube to withdraw the smoke and gases from the tube at the muzzle. The tube is machined for attachment of the breech mechanism, bore evacuator, muzzle attachment, and in some cases the recoil piston.

9. Maintenance of Tank Guns

Maintenance of tank guns includes preventive maintenance services, inspections, and repair when necessary. Appropriate publications prescribe the services to be performed and by whom they will be performed. Generally the key to long tube life and proper functioning of the breech mechanism is proper cleaning after firing and proper inspection and lubrication during nonfiring periods. Abrasive compounds must not be

used on the interior of the tube. However, crocus cloth may be used to remove burrs from the breech mechanism and machined outer surfaces of the tube. Inspection, cleaning, and lubrication are prescribed to insure that no damage is done to the gun by rust or corrosion. Rifle bore cleaner is the authorized cleaning agent for use on tank guns. All unpainted surfaces are cleaned with rifle bore cleaner after firing and for three consecutive days thereafter. Rifle bore cleaner has a preservative agent which will prevent rust for periods up to 48 hours. This preservative will evaporate when applied to a hot tube; therefore, the gun tube should be cool enough to touch with the bare hand before cleaning. During periods when the gun is not being fired, the recoil system must be exercised. The frequency of exercise will be dependent upon climatic conditions. This exercise, accomplished by manually forcing the gun out of battery several times, inhibits the formation of rust on the unpainted surfaces of the gun tube, thereby preventing damage to the recoil cylinder when the gun is fired.

CHAPTER 3

TANK GUN AMMUNITION AND BALLISTICS

Section I. INTRODUCTION

10. General

Since the doctrine for employment of tank weapons is based on the theory of a fast first-round kill, it is essential to know and understand the ballistic performance of the different types of ammunition, which allow effective engagement of any enemy target which may be encountered.

11. Complete Round of Ammunition

Tank gun ammunition is classified as artillery ammunition. A complete round of ammunition is defined as one containing all the components necessary to load and fire the weapon one time. For tank gun ammunition these components are the projectile (which may include a fuze), the propellant, the primer, and the cartridge case (fig. 1).

Caution: Explosive ammunition, or components containing explosives *MUST* be handled with care at all times. The explosive elements in primers and fuzes are particularly sensitive to shock and high temperatures. Prescribed precautions for handling ammunition are stated in TM 9–1901 and TM 9–1900.

12. Fixed or Separated Complete Rounds

Either fixed or separated complete rounds are issued. In fixed rounds, all components are firmly contained by the cartridge case. In separated rounds, the projectile is separated from the cartridge case and the primer and propellant are sealed in the cartridge case. Tank gun ammunition is also classified according to the purpose for which the round is designed—armor-defeating, antipersonnel or antimateriel, and chemical.

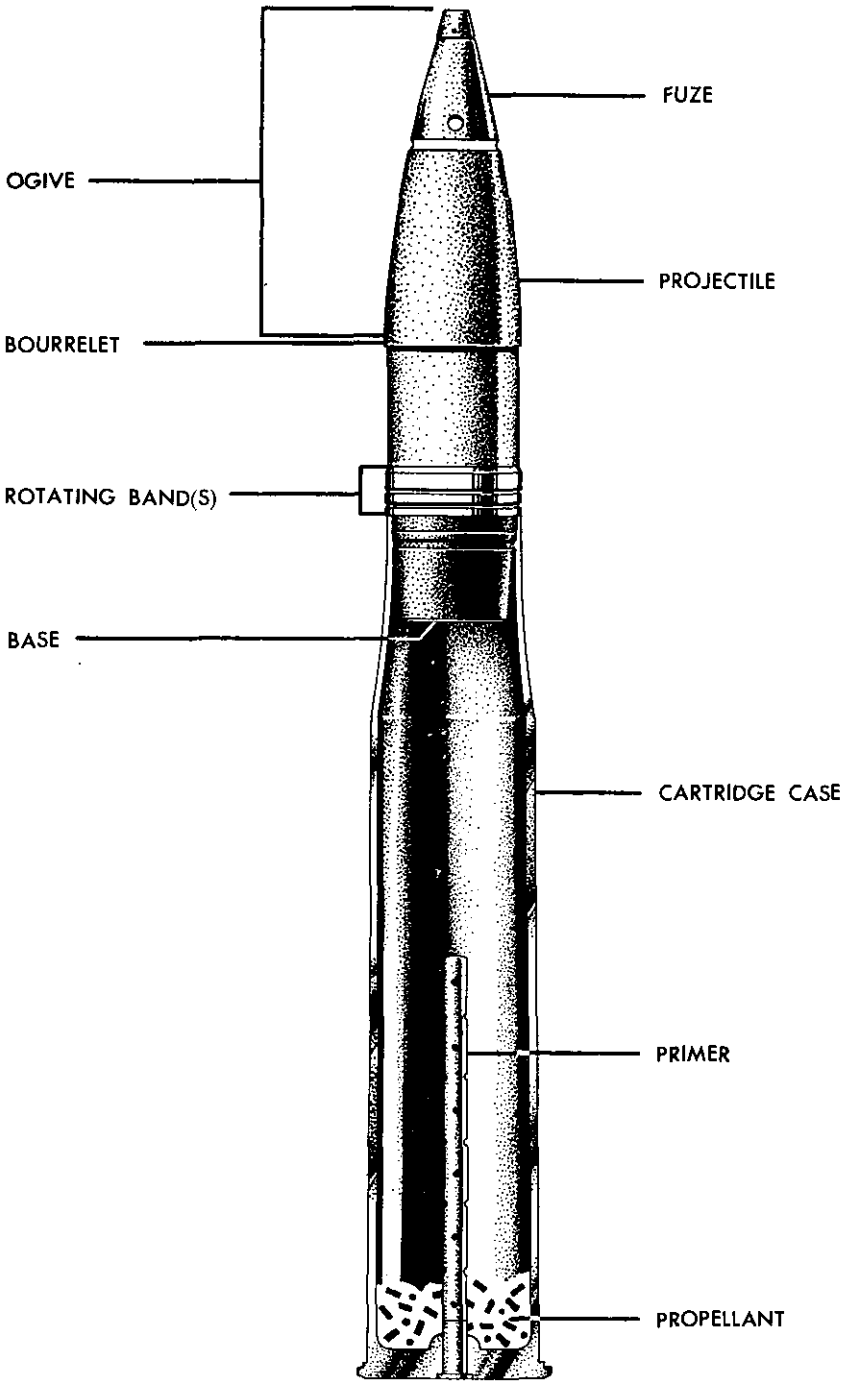


Figure 1. A complete round of tank gun ammunition.

Section II. PROJECTILES AND FUZES

13. General

Projectiles are classified as inert and filled. Inert projectiles contain no explosive filler and consist of metal slugs which obtain their effect by mass and velocity (kinetic energy). Filled projectiles contain either an explosive or a chemical filler. Filled projectiles are fused to detonate the explosive or to disseminate the chemical. Most standard tank gun projectiles contain a tracer element in the base.

14. Projectile Nomenclature

The forward portion of the projectile from the point to the area of largest projectile diameter is called the *ogive.* It includes the point detonating fuze or windshield. The ogive serves to streamline the projectile and provide better ballistic performance. To the rear of the ogive is the *bourrelet,* the area of largest projectile diameter. It is machined to fit snugly within the gun bore. The bourrelet forms the front bearing surface and centers the projectile while it moves forward in the gun tube. The *body* may contain a filler. The diameter of the body is slightly less than that of the bourrelet and *rotating band(s).* Rotating bands are fixed at the rear of the projectile. They form the rear bearing surface, sealing the propelling gases behind the projectile and imparting spin to the projectile as it begins its forward motion. Rotating bands are usually made of relatively soft metal. They are of sufficient diameter to squeeze into the grooves of the gun bore when the projectile first moves forward during firing. Because of the twist of the rifling, the rotating band causes the projectile to rotate. This rotation or spin continues during the time of flight of the projectile and provides stability. The *base* is that part of the projectile upon which the expanding propelling gases act to force the projectile forward. The base may also contain the tracer and base detonating fuze.

15. Armor-Defeating Projectiles

Armor-defeating projectiles achieve their effect by means of kinetic energy or chemical energy.

a. Kinetic energy projectiles (A, fig. 2) depend upon their velocity and mass to defeat armor. Kinetic energy projectiles are basically inert, but some types may contain a small explosive charge and a base detonating fuze to cause the projectile to break up after penetration of the armor. Kinetic energy projectiles include armor-piercing (shot), armor-piercing capped (APC), hyper-velocity armor-piercing (hyper-shot), and hyper-velocity armor-piercing discarding sabot (Sabot). Hyper-shot and Sabot projectiles are of lighter weight than solid shot and incorporate a core of tungsten carbide, a metal of extremely high density and hardness. Spaced armor arrangements and highly sloped armor reduce the effectiveness of hyper-shot type projectiles.

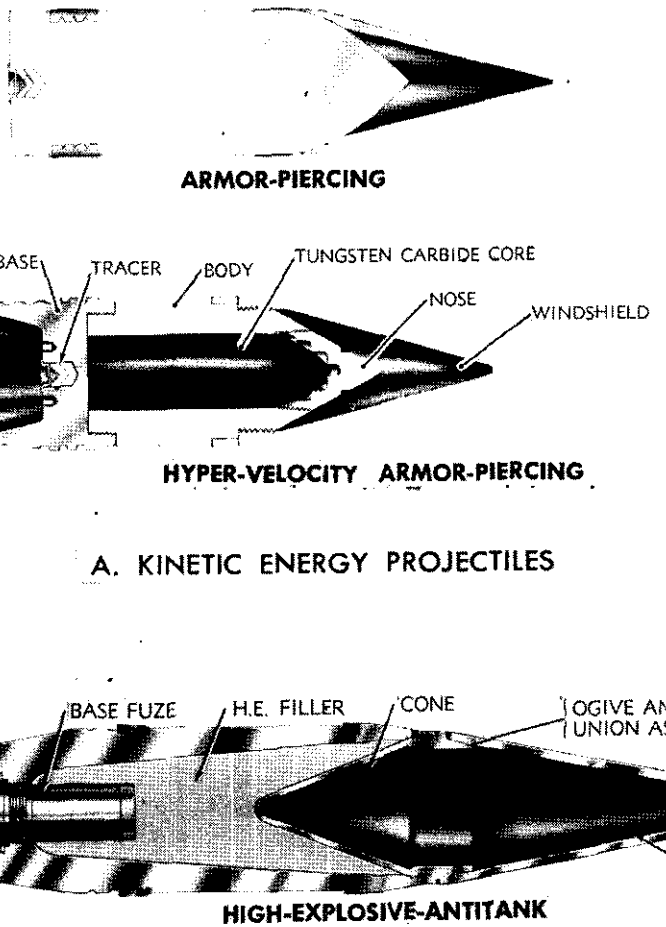


Figure 2. Armor-defeating projectiles.

b. Chemical energy projectiles (B, fig. 2) include high explosive antitank (HEAT) and high explosive plastic (HEP). Chemical energy projectiles have a given armor-defeating potential which is constant regardless of the range.

(1) Penetration by the HEAT projectile depends on utilization of the shaped charge principle. Detonation of the change causes formation of a supervelocity jet of flame and cone particles that can penetrate a considerable thickness of armor.

(2) Upon impact the plastic explosive of HEP mushrooms on the armor and detonates. This force transmits shock waves through the armor, causing large jagged spall fragments to be displaced from the back of the plate.

16. Antipersonnel and Antimateriel Projectiles

There are two types of projectiles in this category—high explosive (HE) and canister (fig. 3).

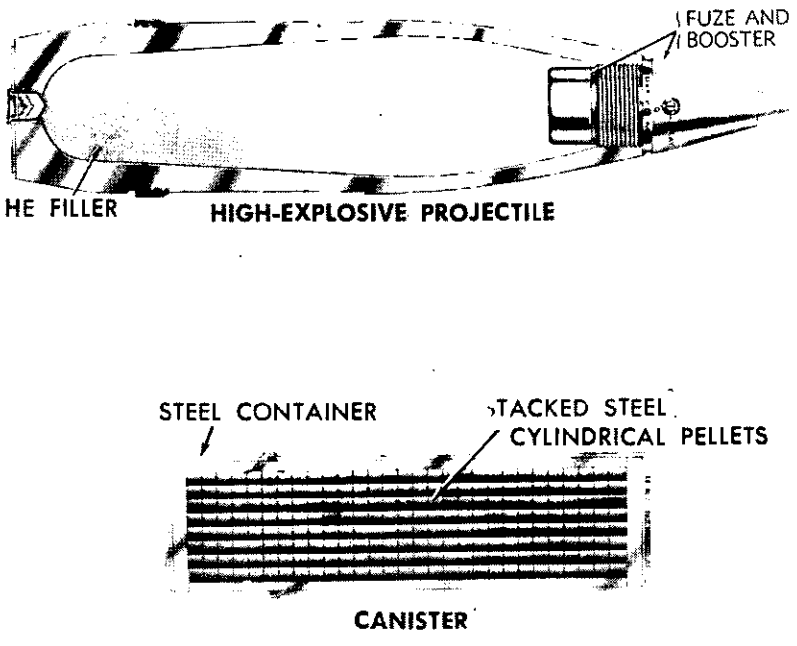


Figure 3. Antipersonnel and antimateriel projectiles.

a. High explosive projectiles are filled and fuzed. They consists of a steel body with a large cavity filled with a high explosive such as TNT or Composition B. The fuze is of the point detonating type and detonates either upon impact or as a result of time action. The fuze detonates the explosive filler, which causes fragmentation at the area of impact or detonation. High explosive projectiles are used against troops, thin-skinned vehicles, crew-served weapons, and light materiel.

b. Canister projectiles are cylindrical in shape and contain a large number of small steel pellets. As the projectile leaves the muzzle of the gun, centrifugal force ruptures the canister and discharges the pellets. Canister ammunition is used against concentrated troop formations at close range.

17. Chemical Projectiles

Although there are many types of chemical projectiles, the white phosphorus projectile (fig. 4) (WP or smoke) is the only type commonly fired from tanks. It is similar in construction to the high explosive projectile but contains a filler of white phosphorus which ignites on contact with air. It has a point detonating fuze which, upon impact, initiates a burster charge causing the projectile body to rupture. The white phosphorus, when scattered and exposed to the air, burns and produces a dense white smoke. This round is used to screen, to mark targets, and to produce casualty and incendiary effect.

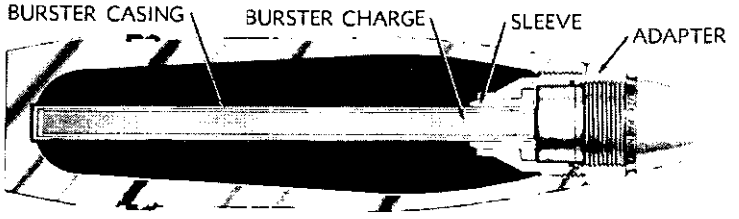


Figure 4. Chemical projectile.

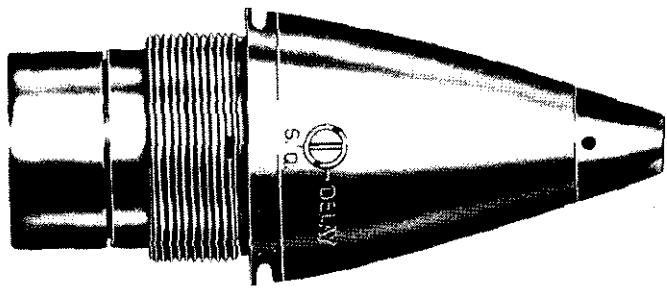
18. Fuzes

Fuzes are attached to filled projectiles to initiate detonation or action of the filler. Fuzes are classified, according to their location on the projectile, as point detonating or base detonating. They are also classified, according to their method of functioning, as time or impact. Impact fuzes are most common to tank gun ammunition, although time fuzes are available.

a. Point Detonating Fuzes—Impact Type. These fuzes (fig. 5) are fitted to the standard HE and WP projectiles. When the projectile is fired, the fuze remains unarmed until it has cleared the muzzle of the gun. For this reason they are called *boresafe* fuzes. On impact, the fuze initiates the detonation or action of the filler. Most point detonating fuzes of the impact type will provide superquick or delay action after impact. The complete round is issued with the fuze set at superquick (SQ); when the slot in the setting sleeve is rotated one quarter turn, the fuze will be set at delay and will initiate detonation a predetermined fraction of a second after impact. This delay permits ricochet action or penetration of light materiel prior to detonation. The high explosive projectile may be fitted with a concrete-piercing fuze when needed. This is a special point detonating fuze made of hardened steel. It provides added strength for the HE projectile, thus giving better penetration when used

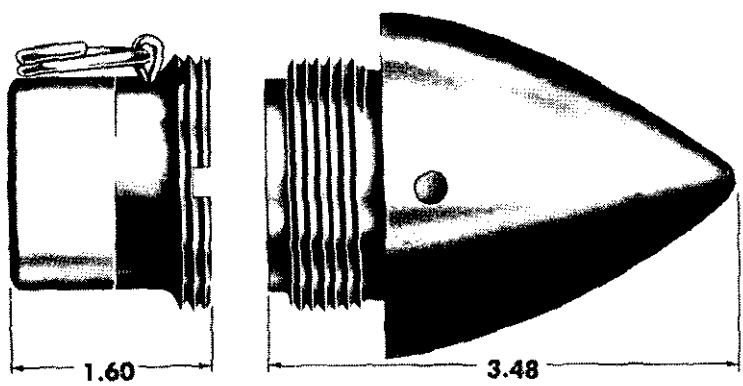
against concrete fortifications. It includes a predetermined delay action.

b. Base Detonating Fuzes—Impact Type. Some filled armor-defeating projectiles (APC filled, HEAT, and HEP) are fitted with a base detonating fuze. Extreme care must be exercised in handling rounds so fuzed, inasmuch as some fuzes are not boresafe (noninterrupted firing train) and function by inertia alone. A sharp blow applied to the point of the ogive may cause detonation whether the round has been fired or not.



STANDARD SUPERQUICK—DELAY FUZE

RA PD 104831



CONCRETE—PIERCING FUZE

RA PD 104830

Figure 5. Point detonating fuzes—impact type.

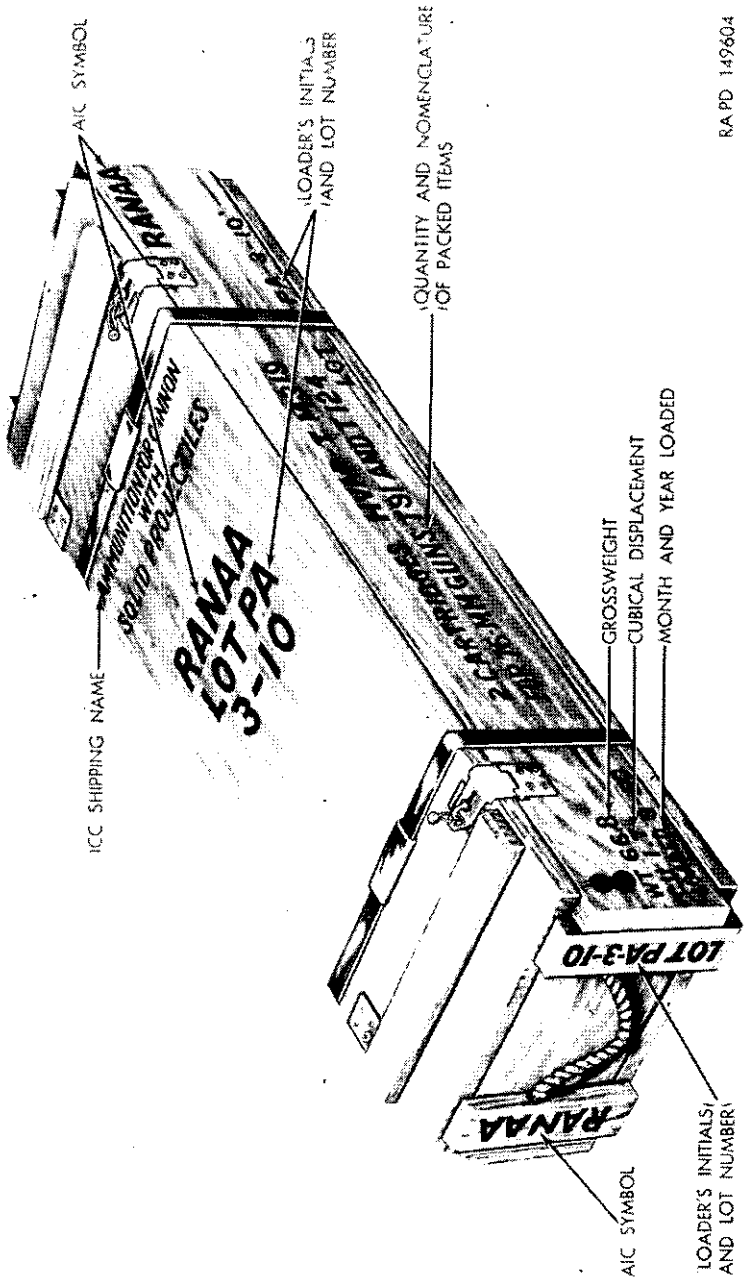


Figure 6. Typical two-round packing box.

19. Ammunition Lot Numbers

A lot number is stamped on the base of every complete round of tank gun ammunition and on all packing boxes and containers (fig. 6). It is required for all purposes of record, including reports on condition, functioning, and accidents in which ammunition is involved. To obtain the greatest accuracy in firing, successive rounds should be from the same ammunition lot whenever practicable.

20. Painting and Marking of Ammunition

Ammunition is painted primarily to prevent rust. A secondary purpose is to provide color for ease of identification.

Type of ammunition	*Color of projectile*
High explosive (any round containing high explosive).	Olive drab; marking in yellow
Armor-piercing (inert)	Black; marking in white
Canister	Black; marking in white
Chemical:	
WP (smoke)	Grey; one yellow band, marking in yellow
Illuminating	Grey; one white band, marking in white
Nonpersistent casualty gas	Grey; one green band, marking in green
Persistent casualty gas	Grey; two green bands, marking in green
Nonpersistent harassing gas	Grey; one red band, marking in red
Practice	Blue; marking in white
Dummy or Drill (inert)	Black; marking in white

Section III. MACHINE-GUN AMMUNITION

21. Cartridge Types, Caliber .30

a. Armor-Piercing Incendiary (API). Used against light armor and light materiel. At normal impact at 200 yards it will penetrate approximately ½ inch of homogeneous armor plate.

b. Armor-Piercing (AP). Same characteristics as API except without incendiary action.

c. Ball. Used against personnel and light materiel. At normal impact at 200 yards it will penetrate approximately ⅓ inch of homogeneous armor plate.

d. Tracer. Normal visible trace is 900 yards.

e. Frangible. Training ammunition. Bullet shatters on impact.

f. Blank. Used in training.

g. Test, High Pressure. Used for proof firing of rifles and machine guns. To be fired by authorized personnel only.

22. Cartridge Types, Caliber .50

a. Armor-Piercing Incendiary (API). Used against aircraft, light armor, concrete shelters, and similar bullet-resisting targets. At normal impact at 100 yards it will penetrate ⅞ inch of homogeneous armor plate.

b. Armor-Piercing Incendiary Tracer (API–I). Same as API but with the addition of a tracer element. Normal visible trace is 1,800 yards.

c. Ball. Used against personnel and light materiel.

d. Tracer. Range of visible trace varies from 1,800 to 2,450 yards.

23. Identification of Machine-Gun Ammunition Types

a. Color Identification.

Type of cartridge	*Color of tip of bullet*
Ball	Not painted
Armor-piercing	Black
Armor-piercing incendiary	Aluminum
Tracer (Cal .30)	Orange
Tracer (Cal .50)	Maroon
Armor-piercing incendiary tracer	Red and aluminum
Frangible	Green and white

b. Tinned Cartridge Case. A tinned cartridge case indicates high-pressure test cartridges only.

c. Drilled Holes in Case. Drilled holes in cartridge case indicate dummy cartridges.

Section IV. BALLISTICS

24. General

a. Ballistics is the science of the motion of projectiles. From the time a projectile leaves its starting place until it comes to rest, it passes through three phases—interior ballistics, exterior ballistics, and terminal ballistics.

b. For the most part, the crew cannot control the inherent ballistic characteristics of the gun-ammunition combination. However, the crew, by diligent application of correct tank gunnery techniques and approved cleaning, inspection, and maintenance procedures, can exploit the capabilities of the gun and ammunition.

25. Interior Ballistics

a. Interior ballistics concerns everything that takes place inside the gun tube. It deals with the temperature, volume, and pressure of the gases into which the propellant in the chamber of the gun is changed by combustion, and with the effect of the expansion of these gases upon the gun,

mount, and projectile. When the firing mechanism is actuated, the firing pin strikes the primer, initiating the burning of the propellant. The propellant burns gradually, producing a large volume of gas while the projectile is still in the tube. This gas expands, producing pressure in all directions in the chamber. The projectile moves forward, accelerating rapidly in the tube while the gun moves rearward in recoil. As the projectile moves forward, the rotating band is engraved by the rifling in the bore, sealing the propellant gases behind the projectile. Since the gun bore is rifled, the projectile spins as it travels forward. The gas pressure in the tube is still high when the projectile leaves the muzzle; this accounts for the large muzzle blast of tank guns. A study of interior ballistics permits the determination of all the factors which give a projectile its orientation, velocity, and rate of spin. Some of these factors are weight of charge, type and density of propellant, length of bore, and chamber volume. These factors determine the design of the gun and recoil system.

b. Interior ballistic performance is greatly affected by such factors as variations of powder temperature, tube wear, imperfect rotating bands, and extraneous matter in the gun bore. The crew can obtain the best and most consistent results by insuring that ammunition is not exposed to direct rays of the sun or other excessive heat, that gun tubes are cleaned before and after firing, and that ammunition is stowed in such a manner as to prevent damage.

26. Exterior Ballistics

a. Exterior ballistics is concerned with the path of a projectile from the time it leaves the gun until it strikes the target or bursts in the air at a desired point. The path of flight of the projectile is called the *trajectory*. This trajectory is the resultant of six major factors—

(1) Direction in which the gun is pointed.
(2) Projectile velocity.
(3) Drag on the projectile caused by the resistance of the air through which it passes.
(4) Drift of the projectile caused by its rotation in the air.
(5) Effect of wind.
(6) Force of gravity.

b. In order to overcome the force of gravity, the gun must be pointed above the line of sight to the target. The angle above the line of sight to which the gun must be elevated to cause a given projectile to strike a target at a given range is termed the *superelevation angle* (fig. 7). Generally, the lower the projectile velocity, the greater the superelevation angle required. High-velocity guns used in tanks need very little superelevation and are commonly referred to as *flat trajectory*. Tech-

nically, there is no flat trajectory; but tank gun projectiles fired at combat ranges describe a nearly flat trajectory.

c. The tank crew can compensate for many of the factors affecting the trajectory by selecting firing positions which are as level as possible, by careful sight adjustment, by accurate determination of range, and by correctly indexing ammunition.

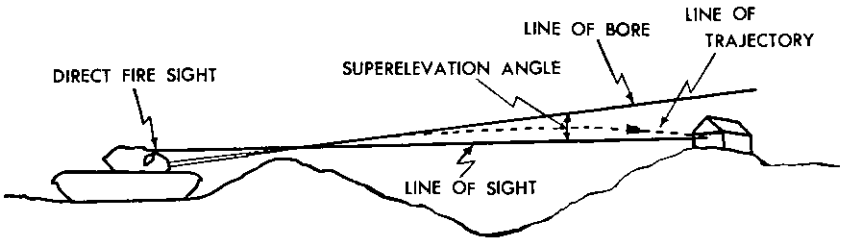


Figure 7. Superelevation angle.

27. Terminal Ballistics

Terminal ballistics is concerned with the effect of the projectile on the target. This effect is determined by the characteristics of the projectile, fuze, and target. Different projectiles produce varying target effects, such as—

a. Fragmentation.

b. Penetration (kinetic energy or chemical energy).

c. Incendiary.

d. Smoke.

The tank commander selects the type of ammunition which will produce the greatest "killing" effect on the target.

PART THREE

FUNDAMENTALS OF TANK GUNNERY

CHAPTER 4

TANK FIRE-CONTROL EQUIPMENT

Section I. INTRODUCTION

28. General

This chapter discusses the capabilities and limitations of fire-control equipment and how this equipment is adjusted and used in accurate and rapid target engagement. Since use of fire-control equipment must also include an understanding of angular measurements, the mil and mil relations as they apply to tank gunnery also are discussed.

29. Essentials of Good Gunnery

A thorough knowledge of fire-control equipment, its use, and its adjustment is essential to good gunnery. Fire-control equipment includes ranging and sighting equipment, which enables the gunner to see and aim at targets; auxiliary fire-control equipment, which permits the gunner to engage targets he cannot see; observation and vision devices, which allow tank crewmen to observe targets and adjust fire; and various other types of equipment which aid in laying tank guns.

Section II. THE MIL AND MIL RELATION

30. General

a. The *mil* is the basic unit of angular measurement used in tank gunnery, because of the precise calculations and adjustments required. Tank weapons may be laid for deflection and elevation by moving the gun right (or left) and up (or down) a specified number of mils. Tank fire-control equipment is graduated in mils to conform to the mil method of measurement. There are approximately 18 mils in one degree (1° equals 17.777778 mils).

b. The mil is a unit of angular measurement equal to 1/6,400th part of a circle (fig. 8). One mil, for tank gunnery purposes, subtends a width (or height) of 1 yard at a range of 1,000 yards (fig. 9). When the sides of a 1-mil angle are extended until they are 2,000 yards long, the width at the ends of the lines is 2 yards.

c. The relationship between the angle, the length of the sides of the angle, and the width between the sides remains constant. Figure 10 demonstrates this constant relation as the angle increases from 1 mil to 2 mils and the range increases from 1,000 yards to 2,000 yards.

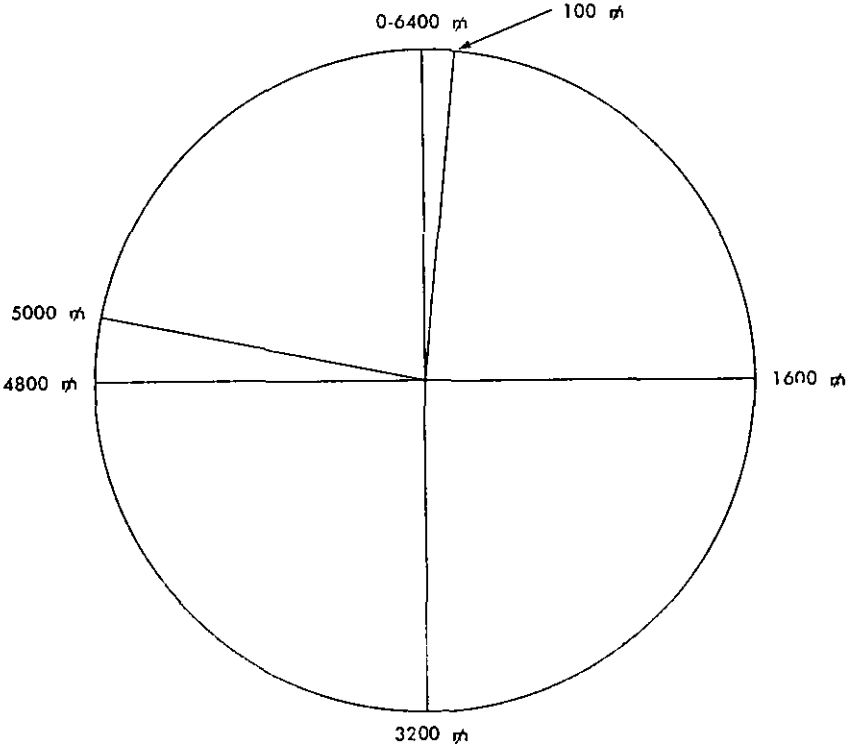


Figure 8. There are 6,400 mils in a circle.

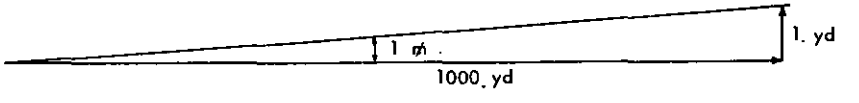


Figure 9. Mil relation at 1,000 yards.

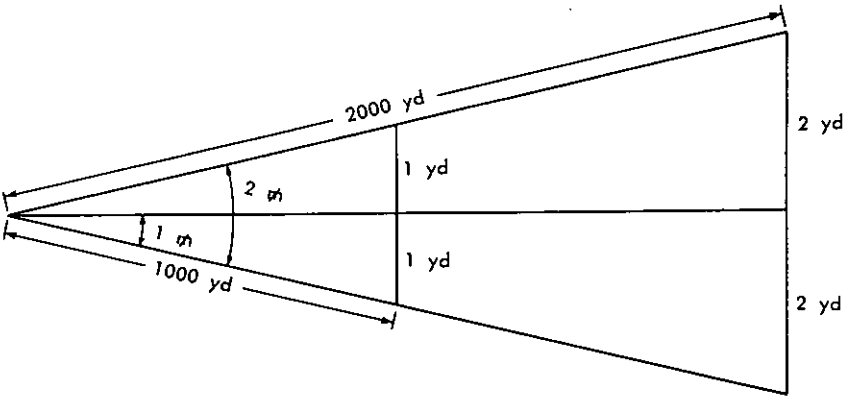
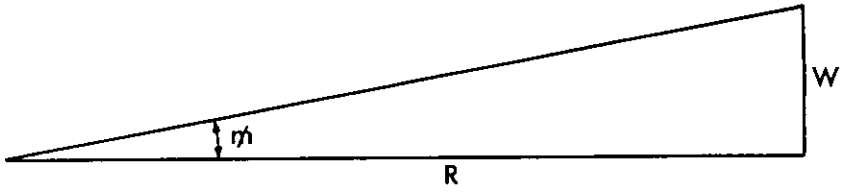


Figure 10. The mil relation is constant—
1 mil at 1,000 yards equals 1 yard.
1 mil at 2,000 yards equals 2 yards.
2 mils at 1,000 yards equals 2 yards.
2 mils at 2,000 yards equals 4 yards.

31. Mil Relation

a. The relationship between the size of the angle, the length of the sides, and the width between the ends of the sides is expressed as the *mil relation*, or: $\frac{W}{R\,m}$ (fig. 11).

W Width (or height) in yards.
R Range in thousands of yards.
m angle in mils.



W = WIDTH (OR HEIGHT) IN YARDS

R = RANGE IN THOUSANDS OF YARDS

m = ANGLE IN MILS

Figure 11. The mil relation.

b. Since the mil relation is constant, other linear units of measurement such as meters, feet, or inches may be substituted for yards in expressing

width (W) or range (R); however, the relation holds true only if both W and R are expressed in that same unit. For example, if the sides of a 1-mil angle are extended to 1,000 meters, the width between the ends of the sides is 1 meter.

c. The mil relation may be converted into a formula by removing the factor that is to be determined.

$$\text{Thus, } \frac{W}{R \text{ mil}} \text{ becomes } W = R \text{ x mil}$$

$$\text{or } R = \frac{W}{\text{mil}}$$

$$\text{or mil} = \frac{W}{R}.$$

As a memory aid, the word WORM may be used, meaning W over R x mil or $\frac{W}{R \text{ mil}}$.

32. Use of Mil Relation

a. The mil relation is used in tank gunnery to compute one of three elements—range, mil angle, or width. When two of the elements are known, the third may be determined. It should also be kept in mind that the mil relation holds true in either a horizontal or vertical plane (fig. 12). For angles less than 400 mils, the mil relation is accurate enough for use in computing firing data.

b. Determining Range.

(1) *General.* To determine range (R), the mil angle and the width must be known. Figure 13 illustrates a situation in which the tank commander at point A must determine the range to the target.

Remember:	Remove unknown:
$\frac{W}{R \text{ x mil}}$	$\frac{W}{? \text{ x mil}}$

(2) *Procedure.*

(*a*) It is known that the enemy tank is approximately 7 yards long (W).

(*b*) Using his binocular, the tank commander determines that the tank measures 10 mils (mil).

(*c*) By removing the R factor from the mil relation:

$\frac{W}{R \text{ x mil}}$ becomes $R = \frac{W}{\text{mil}}$

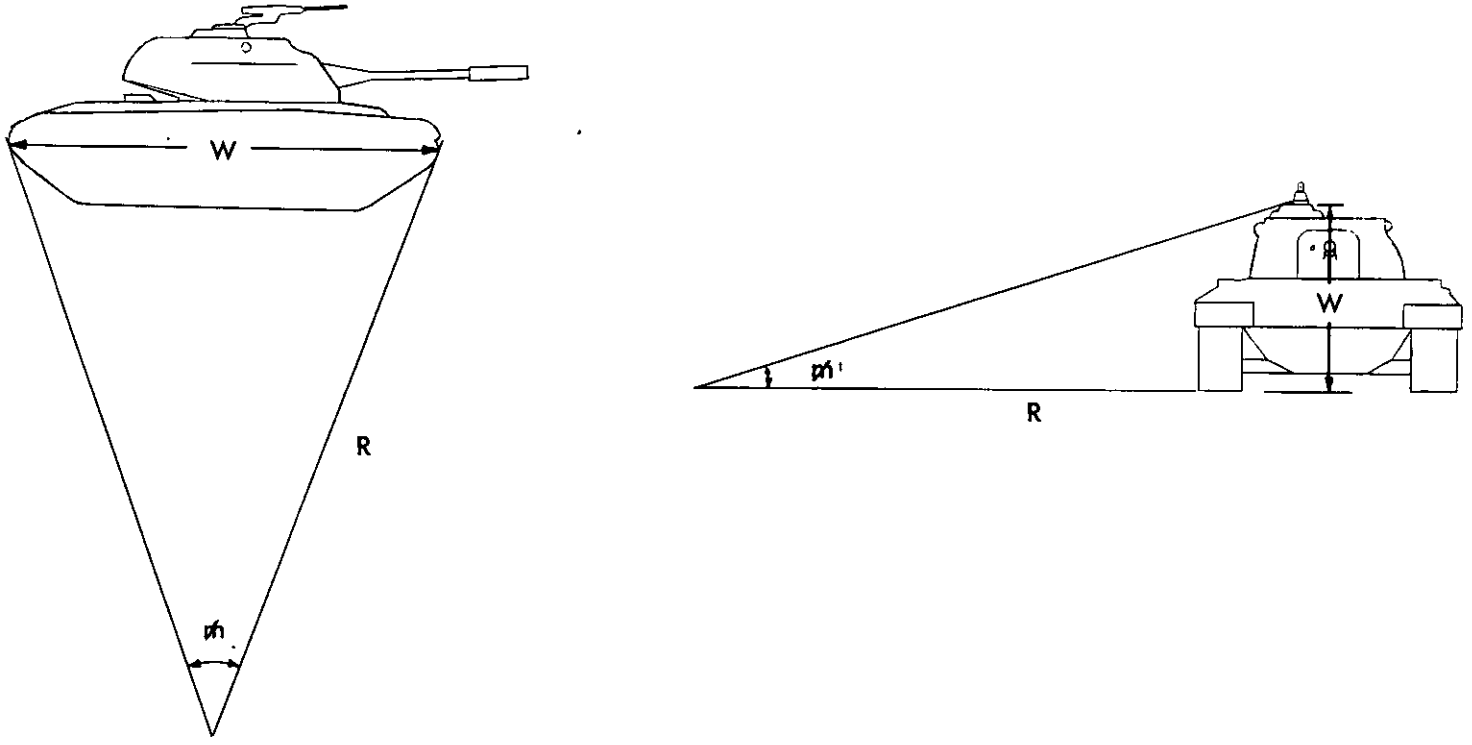


Figure 12. Mil relation is applicable in all planes.

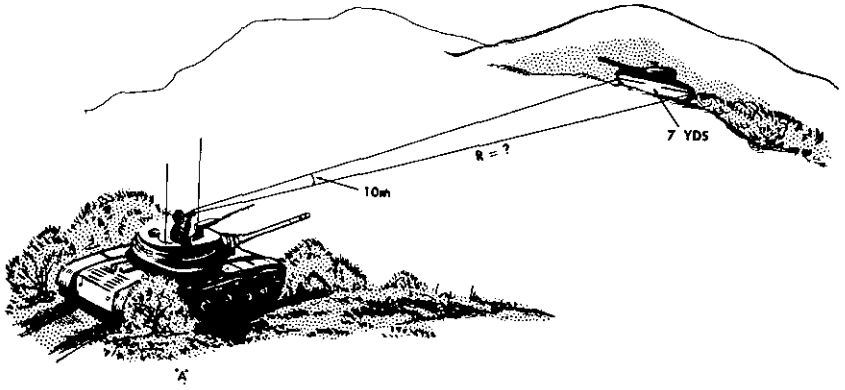


Figure 13. Determining range to a target.

(*d*) Substitute the two known values for W and ṁ and solve for R:

$$R = \frac{W}{\dot{m}} = \frac{7}{10} = .7.$$

(*e*) Since R is in thousands of yards, multiply the answer (.7) by 1,000: .7 x 1,000 = 700 yards, the range to the enemy tank.

c. Determining Mil Angle.

(1) *General.* It may be necessary to solve for the mil angle (ṁ) when determining the safety factor for friendly troops (minimum elevation), when determining angle of site, or when the mil angle cannot be measured directly with instruments. To determine the mil angle (ṁ), the range and width must be known. Figure 14 depicts a situation in which the tank commander at point A must determine the mil angle (ṁ) necessary to add a 5-yard safety factor to the top of the mask.

Remember—	Remove unknown—
$\frac{W}{R \times \dot{m}}$	$\frac{W}{R \times ?}$

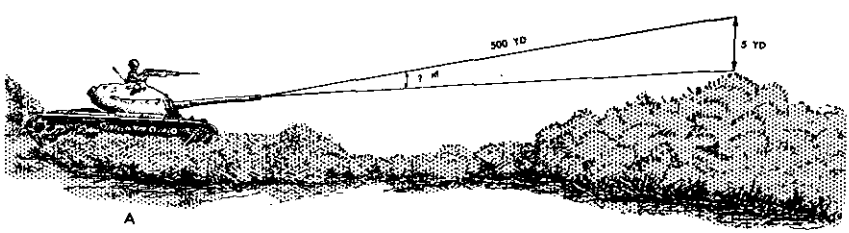


Figure 14. Determining mil angle.

(2) *Procedure.*

(*a*) Using the range finder or some other means of measurement, the tank commander determines that the range to the hill mask is 500 yards (R).

(*b*) The height above mask for troop safety is 5 yards (W).

(*c*) By removing the mil factor from the mil relation:

$$\frac{W}{R \times \text{mil}} \text{ becomes mil} = \frac{W}{R}$$

(*d*) Substitute the two known values for W and R and solve for mil:

$$\text{mil} = \frac{W}{R} = \frac{5}{.5} = 10 \text{ mils.}$$

d. Determining Width.

(1) *General.* It may be necessary to solve for width (W) when adjusting artillery fire, when adjusting tank fire from defilade, when determining clearance for bridges and underpasses, and when determining the difference in elevation between gun and target. To determine width using the mil relation, the mil angle and the range must be known. Figure 15 illustrates a situation in adjusting artillery fire. In order to correct for deviation, the tank commander at point A must determine the width (W) between the volley and his observer-target (OT) line.

Remember— $\frac{W}{R \times \text{mil}}$ Remove unknown— $\frac{?}{R \times \text{mil}}$

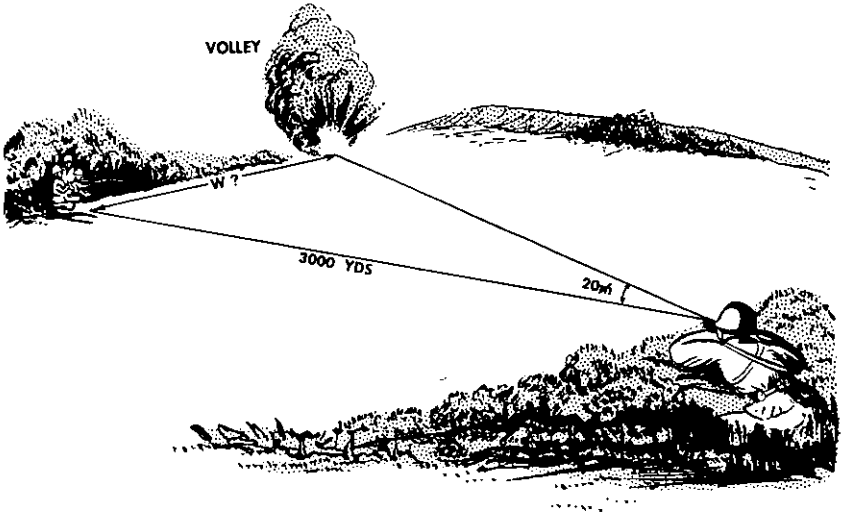


Figure 15. Determining width between target and volley.

(2) *Procedure.*

(*a*) The range from the observer to the target is 3,000 yards.

(*b*) Using his binocular, the observer determines that the angle between the OT line and the volley measures 20 mils (m).

(*c*) By removing the W factor from the mil relation—

$$\frac{W}{R \times m} \text{ becomes } W = R \times m.$$

(*d*) Substitute the two known values for R and m and solve for W. $W = R \times m = 3 \times 20 = 60$ yards, the width between the OT line and the volley.

33. Conversion Table

The following conversion table will be of assistance in using the mil relation. The first column of figures should be used for quick conversion; the second column for precise calculations.

To convert—	*Multiply number by—*		
yards to meters	.9	or	.914402
meters to yards	1.1	or	1.093611
kilometers to miles	.6	or	.621370
miles to kilometers	1.6	or	1.609347
feet to meters	.3	or	.304801
meters to feet	3.3	or	3.280833
mils to degrees	.06	or	.056250
degrees to mils	17.8	or	17.777778

Section III. BINOCULARS

34. General

Continuous evaluation of the terrain and actions of the enemy, through general observation, is a most important function of armor leaders. The binocular enables a tank commander to accomplish this observation. Tank crewmen use it for adjustment of fire, for locating targets, and for the measurement of small horizontal and vertical angles.

35. Description of Binocular

The binocular (fig. 16) is an optical instrument consisting of two telescopes hinged together for binocular vision. The reticle (fig. 17) in the left telescope has both horizontal and vertical scales. The horizontal scale is 100 mils wide, graduated in 10-mil intervals, with 50 mils right and 50 mils left of the center of the field of view. There are three vertical scales. Infantry use the vertical scale in the right half of the field of view in adjusting machine-gun fire; tankers use it only to denote the 30-mil mark on the right portion of the horizontal scale. The other vertical scales, one above the center and one above the left edge of the

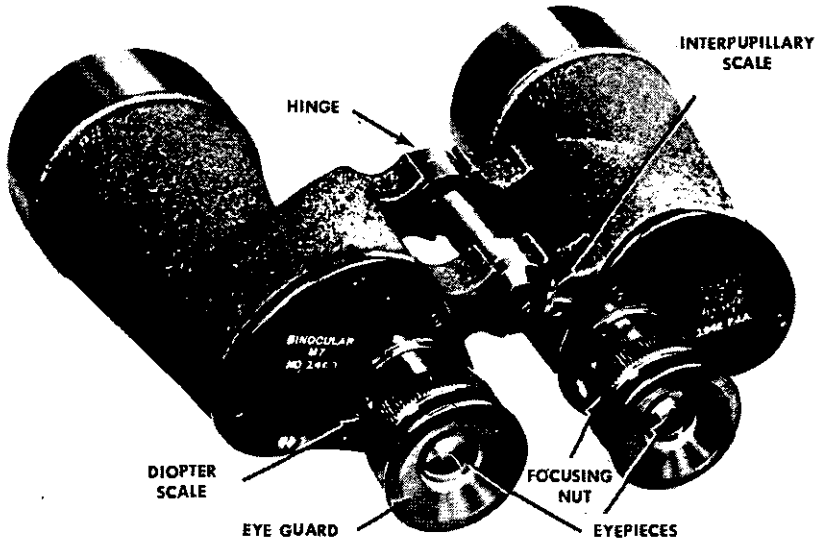


Figure 16. Binocular.

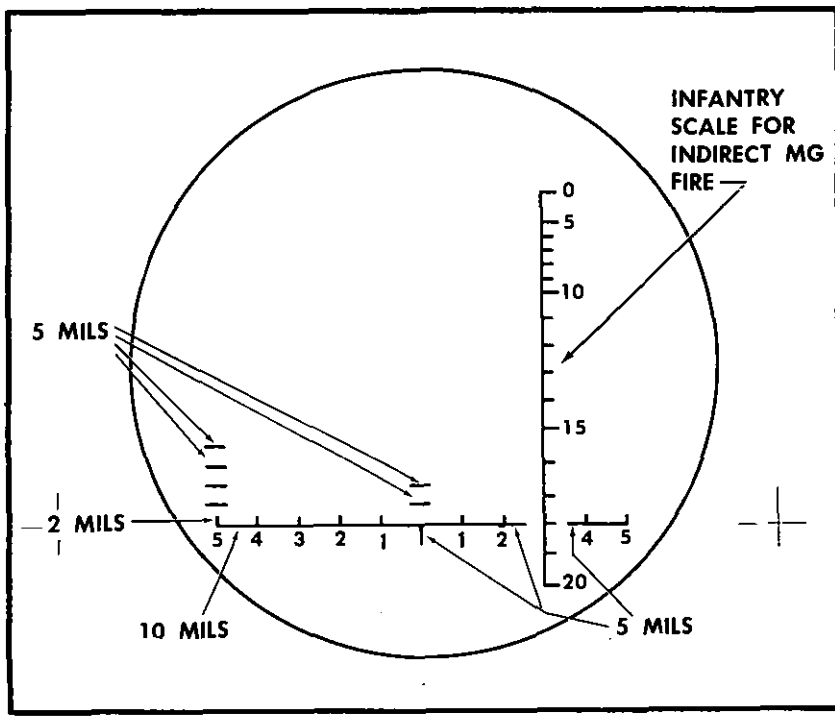


Figure 17. Binocular reticle.

horizontal scale, consist of short horizontal lines 5 mils long and spaced 5 mils apart vertically. These are for measurement of vertical angles.

36. Operation of Binocular

a. Setting Interpupillary Distance. To set the binocular so that the eyepieces are the same distance apart as the eyes, open the binocular at the hinge and look through the eyepiece at the sky; then close the binocular until the two circles appear as one sharply defined circle. Then note the reading on the interpupillary scale. This reading remains constant for any particular individual.

b. Focusing (Diopter Setting).

(1) Set both diopter scales at +4 and, with both eyes open, look through the eyepieces at a distant object.

(2) Cup the palm of one hand over the objective lens of one telescope and slowly turn the focusing nut of the other telescope until the object is clearly defined. Once the object becomes sharp, avoid any further turning of the focusing nut.

(3) Reset the scale at +4 and follow this procedure for the same telescope a second time. Use the greatest *plus* reading of the two trials.

(4) Repeat the procedure for the other telescope. It may be necessary to make a slight readjustment of the left eyepiece to define the reticle clearly.

(5) Note the diopter scale reading for each eyepiece for future use.

c. Observing.

(1) Holding the binocular with both hands, press the eyepieces lightly to the eyes (fig. 18).

(2) The thumbs should be bent and held at the side of the eye sockets to prevent light from entering the eyes from the sides. Do not look through the binocular any longer than necessary at one time.

(3) When observing from a moving vehicle, look at a specific area for a short period of time. To examine a wide area, observe sections of the terrain at a time. Do not attempt to observe more than the immediate field of view for each sighting.

d. Use of Reticle. The reticle appears superimposed on the observed area. It is used to measure horizontal and vertical angles. Accurate measurement, to the nearest mil, is of primary importance.

(1) Measuring horizontal angles (fig. 19). To measure the horizontal angle between two points, move the binocular so that both points are lined up along the horizontal scale. The number of mils between the two points is the horizontal angle. If the points are 50 mils or less apart, place the zero graduation on one point and then read the number of mils to the other. If the

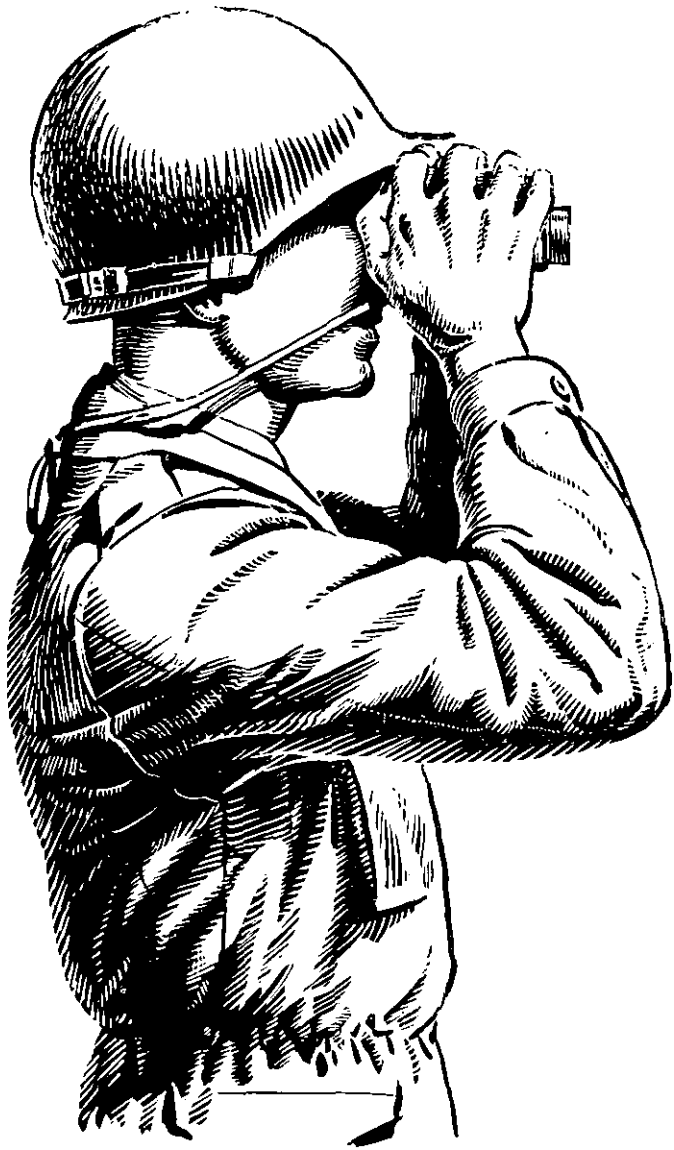


Figure 18. How to hold the binocular.

points are between 50 and 100 mils apart, place one end graduation on the point on that side and read the number of mils to the other point (remember that there are 50 mils between the end graduation and the zero graduation). If the points are more than 100 mils apart, select one or more points between them, make two or more measurements, and add them together. If one point does not appear exactly on a graduation, interpolate the number of mils less than 10.

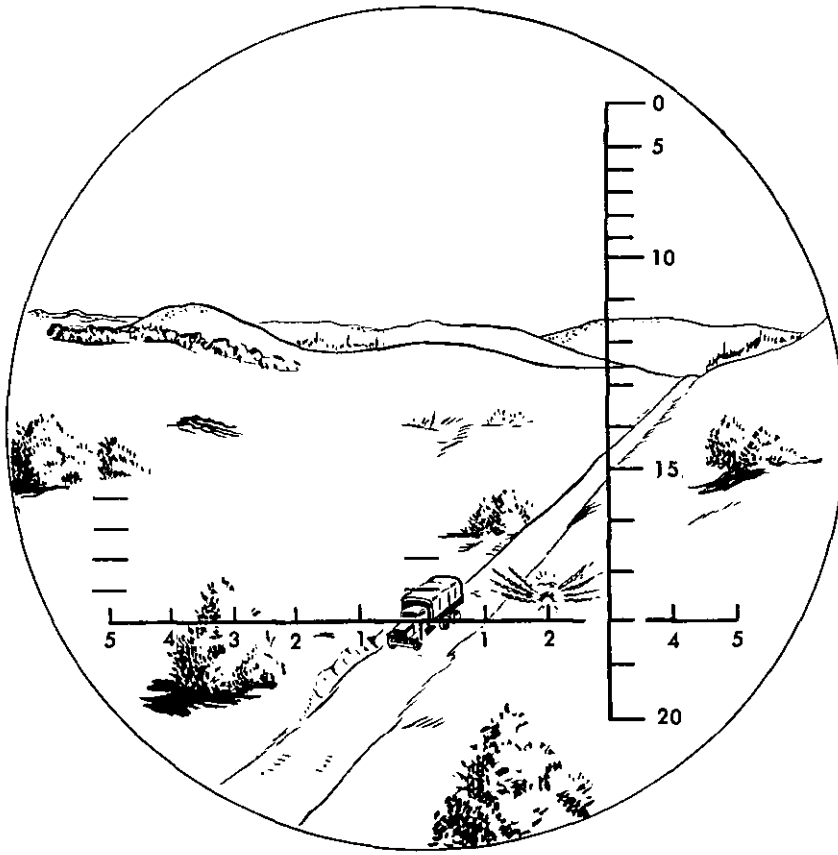


Figure 19. Measuring horizontal angle with binocular. The burst is 20 mils right of the truck.

(2) Measuring vertical angles (fig. 20). To measure the vertical angle between two points, move the binocular so that the bottom point is on either the zero or the left (50) graduation of the horizontal scale. The number of mils between the bottom and the upper points, as read on the vertical scale, is the vertical angle. Interpolate between the 5-mil graduations. To measure larger angles (over 20 mils), tilt the binocular sideways and use the horizontal scale.

37. Care and Preservation of Binoculars

a. Care. The binocular requires careful handling. It should be frequently inspected for moisture, dirt, fungus, grease, and damaged or titled reticles. Adjust the carrying strap so that the binocular will rest on the chest. In this position it is quickly available and is less likely to swing and strike against the turret or other parts of the tank. The binocular is kept in its carrying case when not in use.

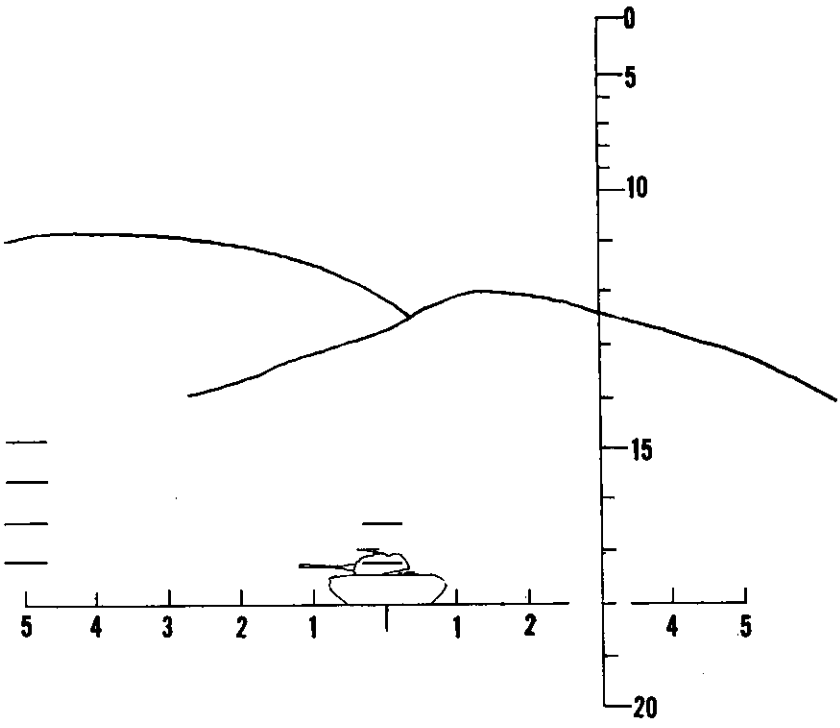


Figure 20. Measuring vertical angle with binocular. The height of the tank is 6 mils.

b. Cleaning and Preservation. Wipe the binocular dry immediately after use in wet weather. The lenses are made of soft glass and coated to reduce reflection. The only authorized lens cleaning materials are lens tissue, lens soap, and camel's-hair brush. Use saddle soap to preserve the leather.

c. Disassembly. The eyeguards may be removed to facilitate use of the binocular by personnel wearing glasses. Further disassembly will be performed by Ordnance personnel only.

Section IV. DIRECT-FIRE SIGHTS

38. General

a. Direct-fire sights are optical devices used to lay the gun for elevation and deflection when the target is visible through these sights. Direct-fire sights have the following characteristics:

(1) Move with the gun.

(2) Incorporate a gun-laying reticle.

(3) Have provision for boresighting (reticle movement).

(4) Provide reticle illumination.

b. Direct-fire sights are mounted for use by the tank commander and gunner. The gunner usually has two sighting systems, a primary and a secondary system. The tank commander's direct-fire sight is normally used to designate targets and to lay the gun for deflection. Types of direct-fire sights are telescopes, periscopes, and range finders.

39. Periscopes

Periscopes (fig. 21) normally provide two separate fields of view—one a magnified field with superimposed reticle for use as a direct-fire sight, the other a nonmagnified field for observation purposes.

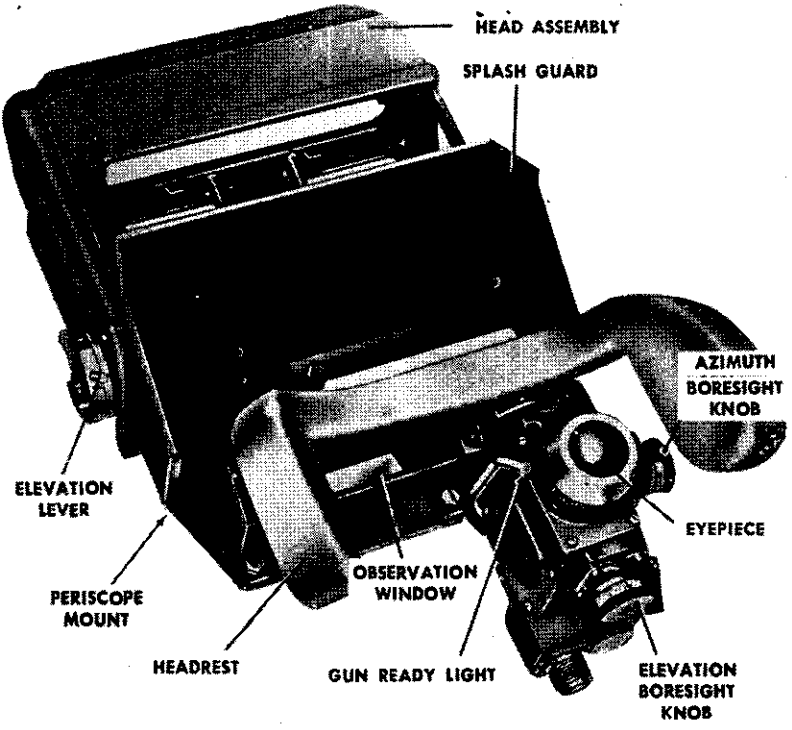


Figure 21. Periscope.

40. Telescopes

Telescopes (fig. 22) provide a magnified field of view with superimposed reticle. They are tubular in shape and fixed in a telescope mount which in turn is fixed to the combination gun mount.

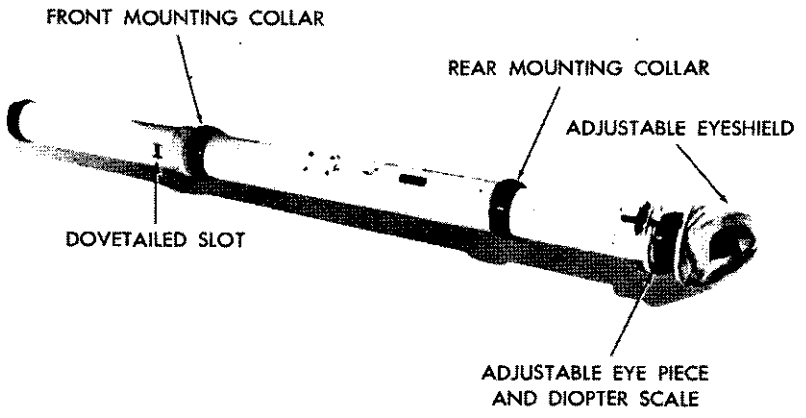


Figure 22. Telescope.

41. Range Finders

Some tanks are equipped with a range finding device (fig. 23) or instrument for use by the gunner or tank commander as a means for determining range and as a direct-fire sight.

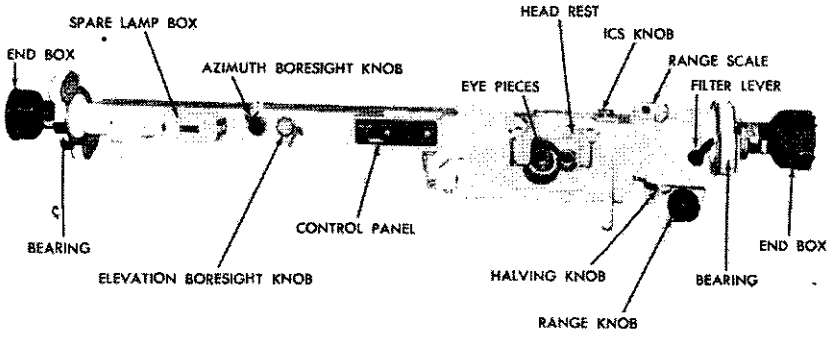


Figure 23. Range finder.

42. Direct-Fire Control Systems

Direct-fire control systems vary and are peculiar to the models and types of tanks. The systems may be either telescope sight mounted coaxially with the gun, range finder-computer-periscope with necessary linkage, periscope-ballistic unit and necessary linkage, or range finder alone. Figure 24 illustrates a representative direct-fire control system.

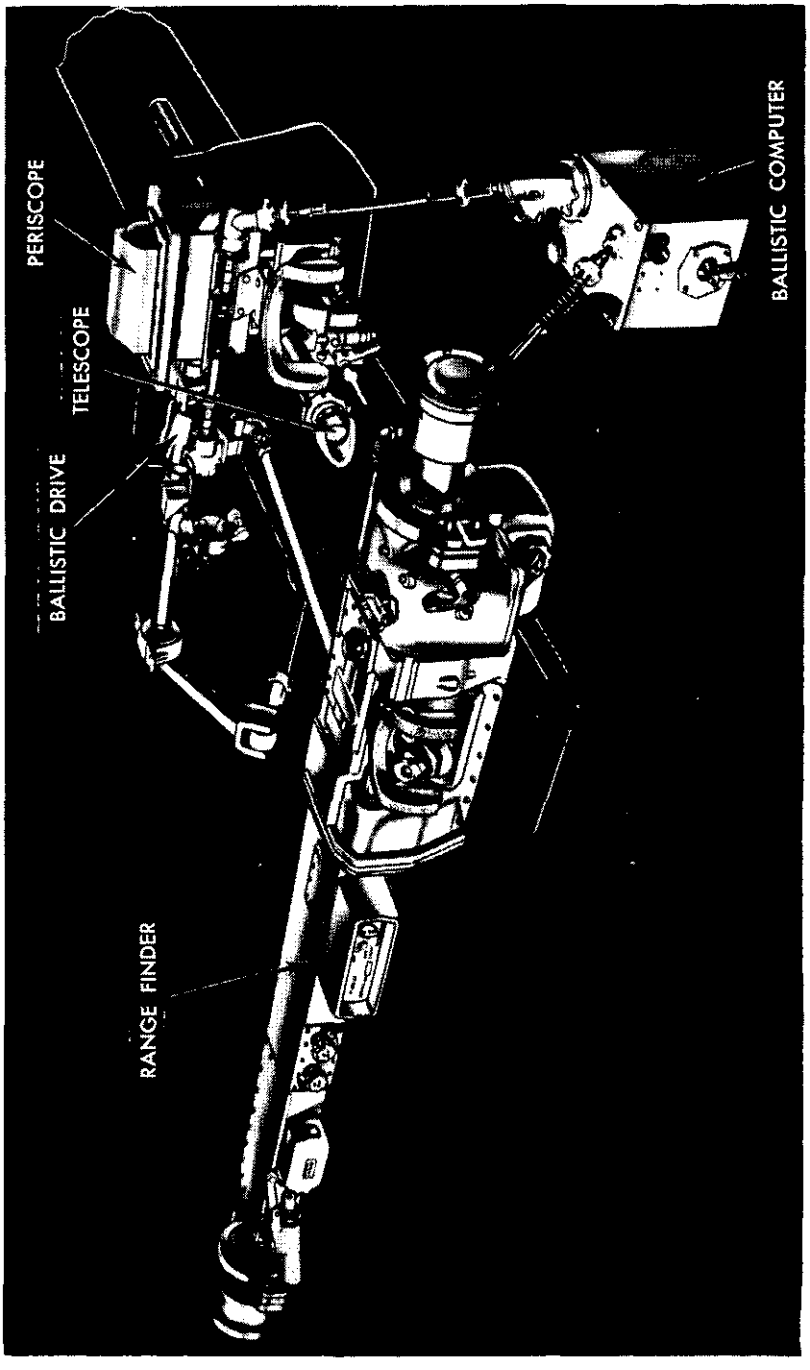


Figure 24. A representative direct-fire control system.

43. Sight Reticles

Sight reticles are of various types. In present use are the standard dash pattern and gun-lay reticles. The standard dash pattern reticle (fig. 25) is graduated for a particular ammunition type. The center of the boresight cross represents zero range and zero deflection and is used when boresighting. The gun-laying reticle (fig. 26) contained in other direct-fire sights can be used with any type of ammunition. The aiming cross in the center of the reticle is used to boresight and to fire the initial round at stationary targets. Both reticles incorporate vertical (range) lines and horizontal (lead) lines.

44. Direct Laying

Direct laying takes place when the tank gun is fired against targets which can be observed through the direct-fire sights. The sight reticle is used for direct laying of the gun. To lay the gun on a target, the gunner, by use of the power or manual controls, traverses and elevates

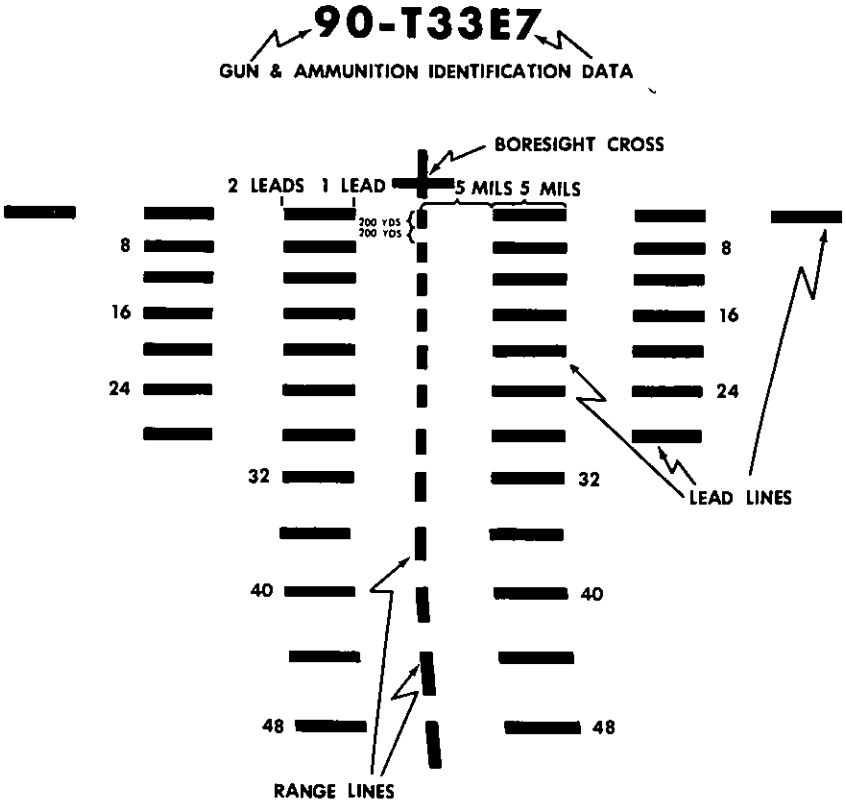


Figure 25. Standard dash pattern reticle.

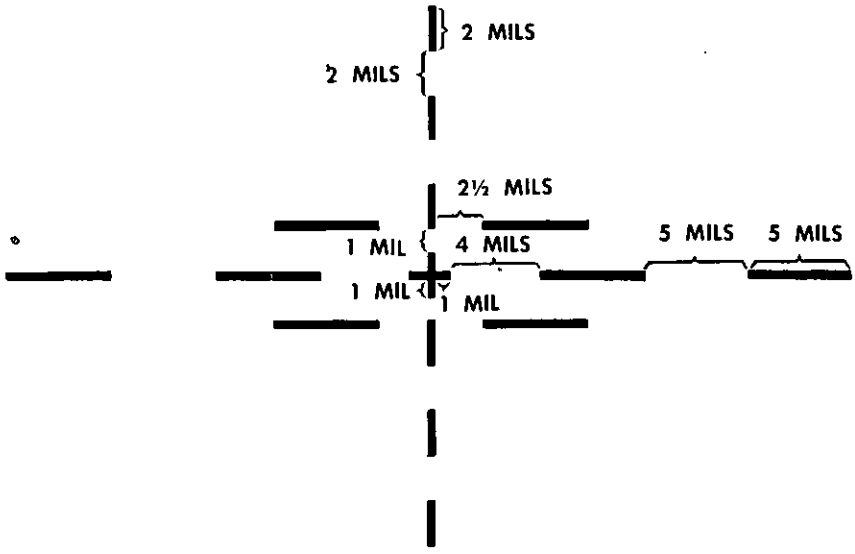


Figure 26. Gun-laying reticle.

until the proper point of the sight reticle is laid on the target. When traversing or elevating, he should make the last motion of the gun in the same direction each time. This eliminates lost motion.

Section V. SIGHT ADJUSTMENT

45. General

Accurate sight adjustment is fundamental in tank gunnery; it is impossible to fire accurately without it. It includes boresighting, zeroing, and verification of the zero.

46. Boresighting

Boresighting provides the basis for all sight adjustment. It is performed periodically to insure the greatest possible accuracy. Boresighting establishes a definite relationship between the axis of the gun bore and the lines of sight for all direct-fire sights. This is accomplished by alining the axis of the gun bore on a definite aiming point on a target at a prescribed range. Without disturbing the alinement of the gun, the aiming or boresight cross of the sights is moved to the same definite aiming point (fig. 27). For accuracy, the tank should be level to eliminate cant error (par. 49*b*) and superelevation must be removed from the sights.

47. Zeroing

Zeroing adjusts the sights so that the point of aim and the point of strike of the projectile coincide at a known range. It compensates for

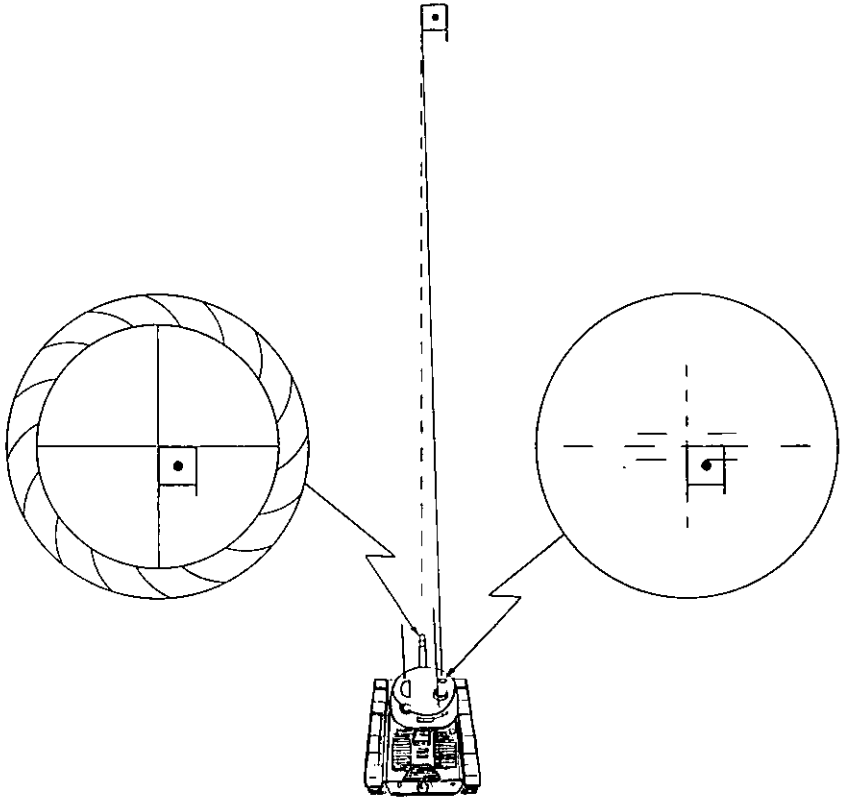


Figure 27. Boresighting.

certain variables which affect accuracy such as tube wear, jump, projectile drift, and climatic conditions. The steps in zeroing (fig. 28) are as follows:

a. Boresight.

b. Select a well-defined point in the target area at a range as near 1,500 yards as possible.

c. Determine the range to this target by the most accurate means available.

d. Using the known tank-to-target range, make a precise lay on the target.

e. Fire a clearly visible group of three rounds, using shot ammunition. Re-lay the gun after each round to obtain the same sight picture.

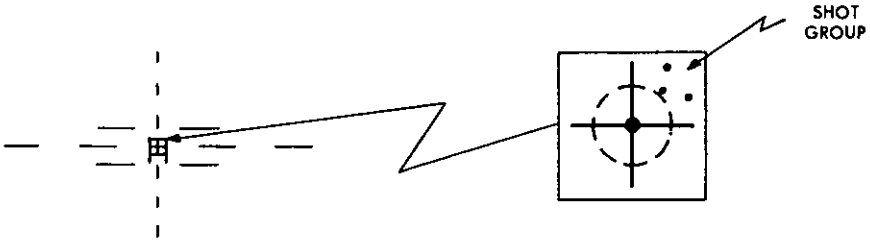
f. Lay the gun on the same aiming point. Then, without disturbing

the gun lay, move the aiming cross or appropriate range line to the center of the shot group.

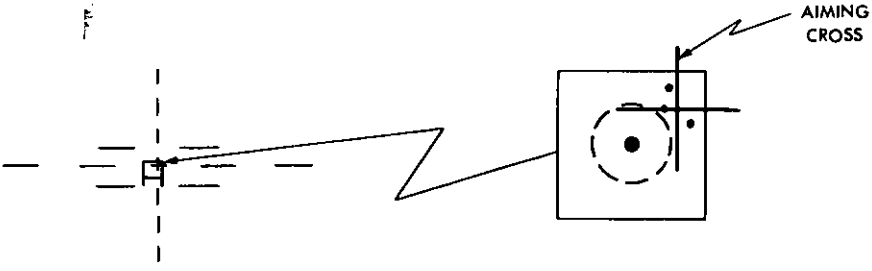
g. Use the manual controls to traverse and/or elevate the gun to lay the sight back on the aiming point.

h. Fire one or two check rounds. The check rounds should strike within a prescribed distance, for the particular gun, from the point of aim.

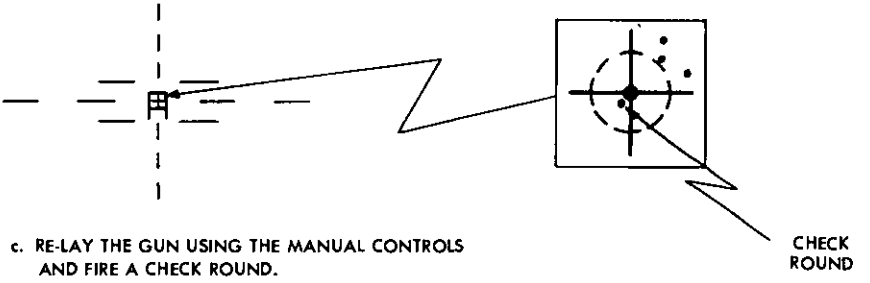
i. Record the zero settings. This is an established zero.



a. FIRE A THREE TO FIVE ROUND SHOT GROUP, USING THE CENTER OF THE TARGET AS AN AIMING POINT.



b. REFER THE AIMING CROSS TO THE CENTER OF THE SHOT GROUP USING THE BORESIGHT KNOBS.



c. RE-LAY THE GUN USING THE MANUAL CONTROLS AND FIRE A CHECK ROUND.

Figure 28. Zeroing.

48. Verification of Zero

Periodic checks of the gun zero are made by boresighting and indexing the established zero setting. A check round is then fired at a definite aiming point at a known tank-to-target range. If the projectile strikes within the prescribed distance of the aiming point, the zero is correct. If the projectile fails to strike within the prescribed distance, fire additional rounds and repeat the zeroing procedure.

49. Effects of Drift, Cant, and Parallax

The factors of drift, cant, and parallax cause a certain amount of error in firing. These errors are usually small at normal combat ranges and can be corrected in varying degrees by zeroing and adjusting fire.

a. Drift is the deviation of the projectile from the plane of fire. It is the result of the effects of rotation, air resistance, and gravity on the projectile. The rotation imparted to the projectile by the rifling of the bore causes the round to drift in the direction of the rotation. This is usually to the right, since most bores are rifled with a right-hand twist. Telescope sights correct for drift by use of offset range lines; however, periscope sights do not compensate. Proper zeroing results in full compensation for drift at the sight zeroing range and partial compensation at normal combat range. When firing is at long ranges, as in indirect fire, data from firing tables can be used to compensate for drift.

b. Cant is the inclination of the gun trunnions from the horizontal when the ground is not level. This causes increasing deflection and range error in the direction which the tank is canted, as the target range increases. The best way to avoid cant is proper selection of positions—on level ground whenever possible. When it is necessary to fire with cant, error may be avoided by taking a corrected sight picture (fig. 29) for the initial round.

c. Parallax is the apparent difference in the position of an object when it is viewed from two different points. In tank gunnery, parallax error is caused by a sight that is offset from the gun tube, such as a periscope. This error is correctible at the zeroing range; however, it is of small consequence at normal combat ranges. Parallax error is also caused by not positioning the eye to the sight in the same manner for each sight picture. This is correctible through training and proper adjustment of the headrest.

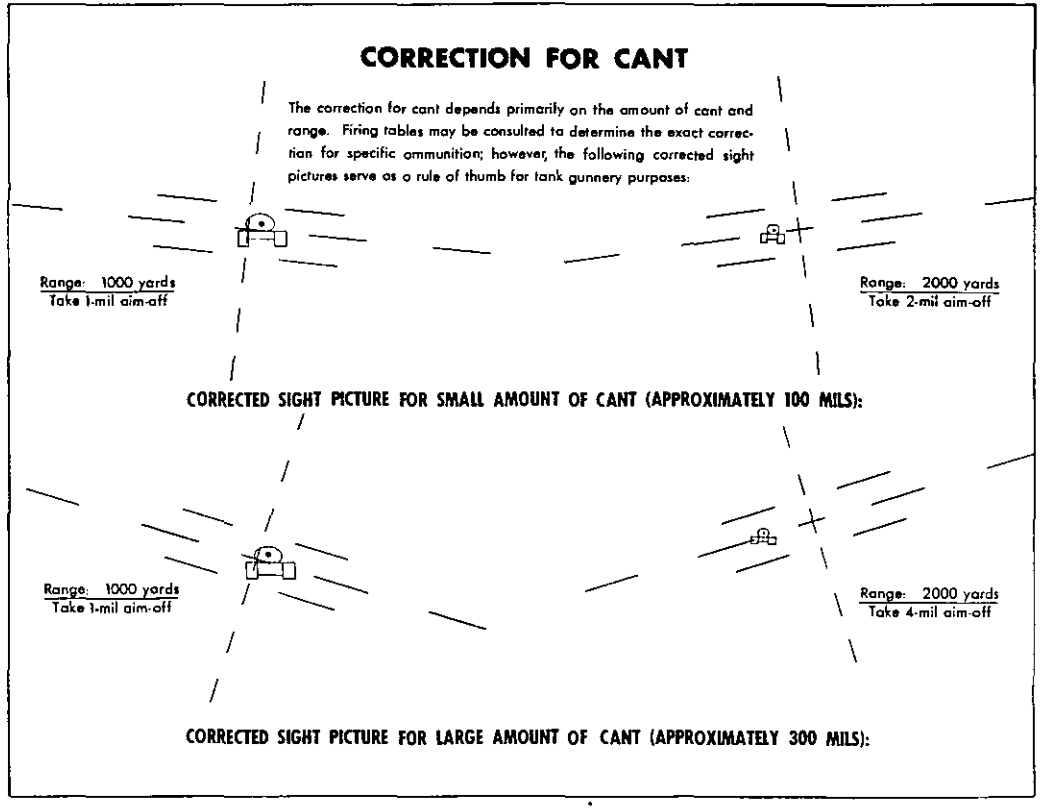


Figure 29. Corrected sight pictures for cant.

Section VI. TANK-MOUNTED AUXILIARY FIRE-CONTROL EQUIPMENT

50. General

Auxiliary fire-control instruments are used to lay the gun when the target cannot be engaged by use of the direct-fire sights. These auxiliary instruments include quadrants, azimuth indicators, aiming circles, and compasses.

51. Quadrants

Quadrants are used to measure the gun elevation angle. They may be mounted in the turret on the ballistic drive or gun mount, or carried in a case and set on the breech ring when in use (fig. 30). Whatever the type, all quadrants incorporate an elevation scale and index for coarse adjustment, a micrometer scale and index for fine adjustment, and a leveling vial to indicate true horizontal. All measurements are taken from the true horizontal; therefore the elevation scale and micrometer scale must be used in conjunction with the leveling vial. Quadrants are checked periodically to determine their accuracy. Inaccurate quadrants must be adjusted, repaired, or replaced.

52. Azimuth Indicators

a. Azimuth indicators (fig. 31) are used to lay the gun for direction and to measure horizontal angles. They are mounted on the turret ring gear in a position which permits them to be viewed by the gunner. There are two scales—an azimuth scale graduated in 100-mil increments and a micrometer scale graduated in 1-mil increments. There are three pointers —an azimuth pointer and a micrometer pointer, both of which are adjustable, and a directional pointer. The directional pointer indicates the amount of turret traverse measured from the front center of the tank hull and is nonadjustable. To use the azimuth indicator, lay the gun on a reference point or aiming point by use of the direct-fire sights or the gun tube. Push down the resetter knob and rotate it to move the azimuth and micrometer pointers to zero, then release it. Any subsequent turret rotation will be indicated on the azimuth and micrometer scales. For small shifts in deflection, rotate the gunner's aid to index the zero of its scale opposite the micrometer pointer, then traverse the turret in the desired direction until the micrometer pointer indicates the required deflection angle.

b. Azimuth indicators are checked periodically for accuracy. Since no error is allowable, inaccurate instruments will be sent to Ordnance for repair or replacement.

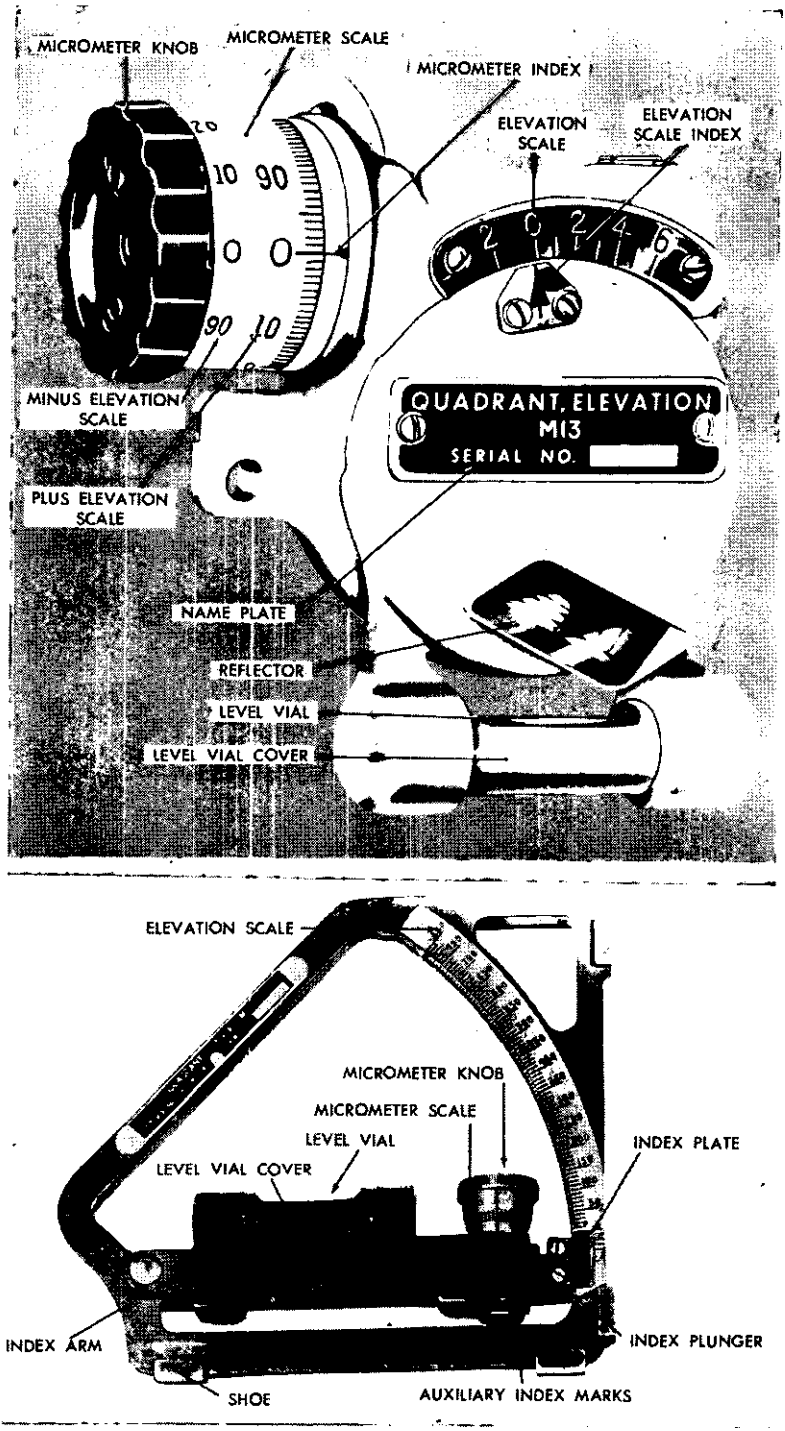


Figure 30. Two types of quadrants.

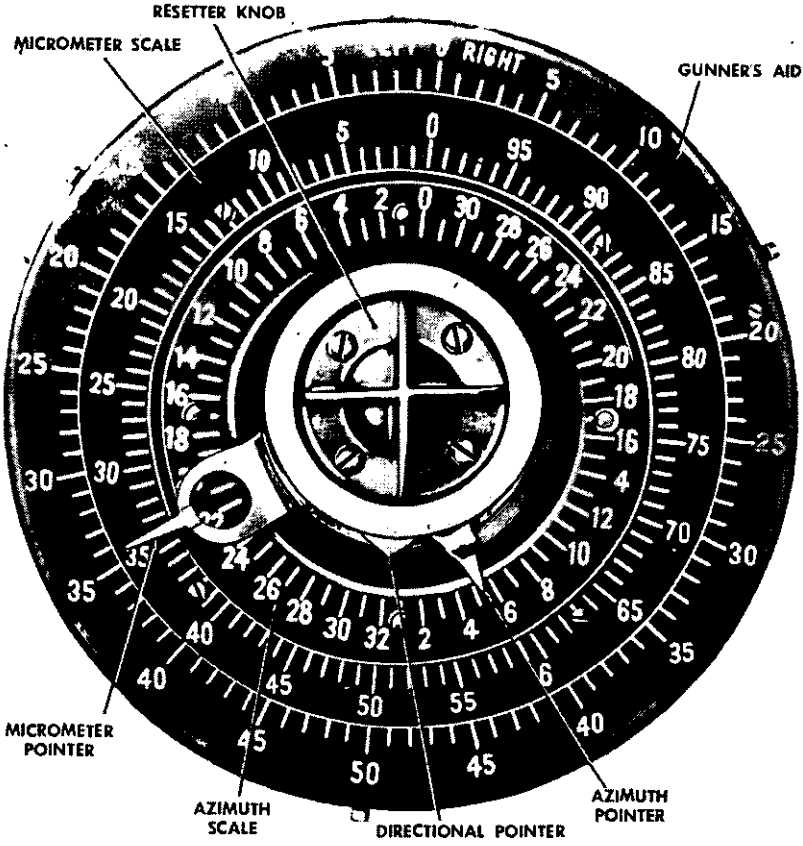


Figure 31. Azimuth indicator.

53. Indirect Laying

Indirect laying takes place when the tank gun is fired against targets which cannot be observed through the direct-fire sights.

a. To lay the gun for elevation, convert the range to a quadrant elevation, using a firing table, ballistic unit, or computer. Index the quadrant elevation on the quadrant, using the elevation and micrometer scales. For example, to lay the gun on a quadrant elevation of plus 135 mils, index plus 100 mils on the elevation scale and plus 35 on the micrometer scale; then move the gun until the bubble in the leveling vial is centered. Apply subsequent elevation corrections by adding or subtracting the number of mils to or from the initial elevation, setting the sum or difference on the elevation and/or micrometer scales, and centering the bubble in the leveling vial. If a subsequent elevation correction is given as a pure quadrant elevation, apply this setting to the elevation and micrometer scales and center the bubble.

b. To lay the gun for deflection, zero the azimuth indicator on a reference point. Then traverse the turret until the correct deflection reading is shown on the azimuth and micrometer scales of the azimuth indicator. Traversing the gun to the right moves the pointers clockwise; traversing to the left moves the pointers counterclockwise. The gunner's aid is used to make subsequent deflection shifts of 50 mils or less. After laying the gun for deflection initially, place the zero of the gunner's aid opposite the micrometer pointer. Small deflection shifts can now be made with reference to the zero of the gunner's aid. Do not set the micrometer pointer back to zero after each shift, but move the zero of the gunner's aid to a position opposite the pointer. To make subsequent shifts of more than 50 mils, add or subtract the subsequent shift to or from the initial deflection, and traverse until the azimuth and micrometer pointers indicate the correct reading.

54. Vision Devices

Although not used to directly control the fire of tank guns, vision devices are utilized for reconnaissance, observation, and adjustment of fire. Examples of vision devices are periscopes and the vision blocks in the cupola and driver's hatch.

Section VII. AIMING CIRCLE

55. General

The M2 aiming circle is an auxiliary fire-control instrument for measuring azimuths and angles of site and for general survey work. In tank gunnery, the aiming circle is used to lay tanks parallel and for the preparation of firing data.

56. Description of Aiming Circle

The M2 aiming circle (figs. 32 and 33) has four main parts—telescope assembly, compass assembly, azimuth mechanism, and leveling assembly. Accessory equipment includes a tripod, a back plate and canvas cover, an instrument light, a plumb bob assembly, a lamp holder and remover, and a cover for the aiming circle.

a. Telescope Assembly. This assembly consists of a 4-power, fixed-focus instrument with a leveling device. The telescope is pivoted above the compass box and may be moved through a vertical angle of −400 mils to +800 mils by turning the telescope elevating knob. The elevation scale is graduated every 100 mils from −4 to +8. The elevation micrometer scale is graduated in mils from 0 to 100 and is numbered every 10 mils. The telescope has a reticle (fig. 34) with vertical and horizontal mil scales; these scales are graduated in 5-mil increments, 85 mils in each direction from the center. The reticle can be illuminated for night use.

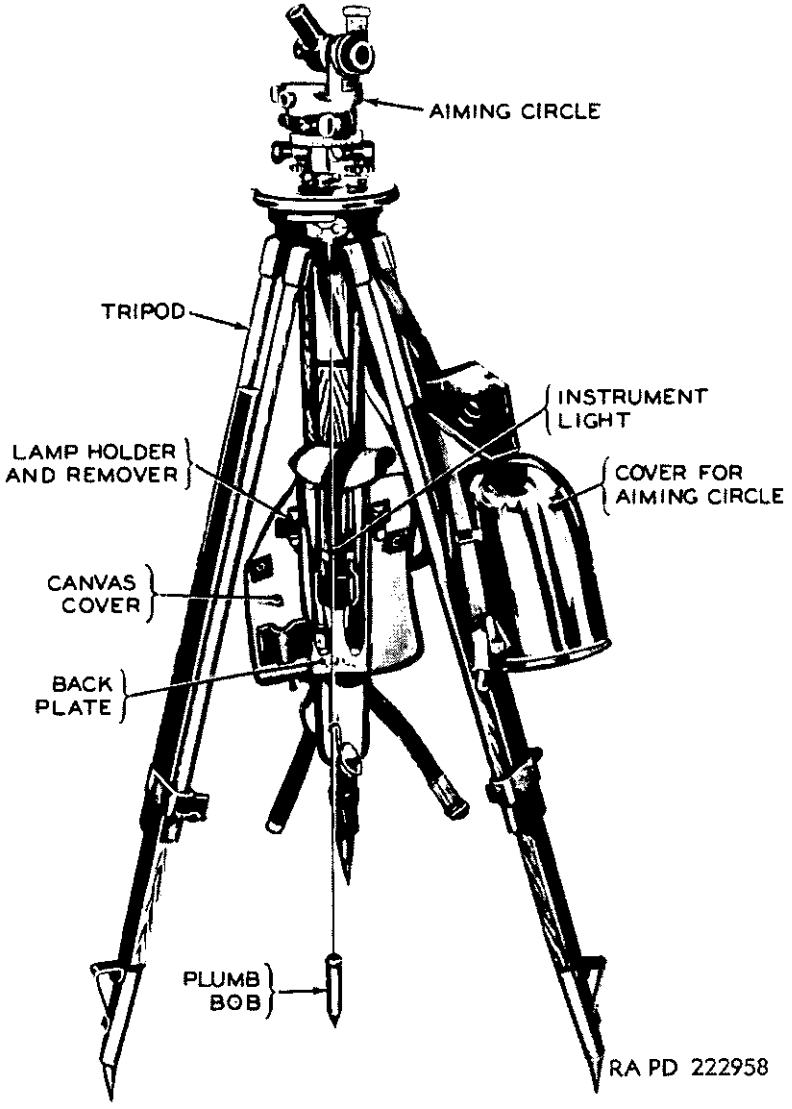


Figure 32. Aiming Circle, M2, with equipment.

b. Compass Assembly. The magnetic compass is located in the oblong recess in the top of the main housing. A rectangular glass reticle is located at one end of the compass recess. A magnifier which is set in the wall of the housing enables the observer to aline the end of the compass needle with the line of the reticle.

c. Azimuth Mechanism. The azimuth mechanism consists of an azimuth micrometer scale and an azimuth scale. The azimuth scale has two

scales which are graduated at 100-mil intervals and numbered every 200 mils. The upper scale is graduated from 0 to 6,400. The lower scale, graduated from 0 to 3,200, parallels the 3,200–6,400 upper graduations. The azimuth micrometer scale is located on the azimuth knob. It is graduated in mils and is numbered every 10 mils from 0 to 100. The azimuth knob (slow upper motion) is used for fine adjustments. A throwout lever is used for fast upper motion. Two orienting knobs control the slow lower motion. A throwout lever is provided for fast lower motion.

d. Leveling Assembly. The leveling assembly is provided for fine leveling adjustments. It consists of a base plate and three leveling screws.

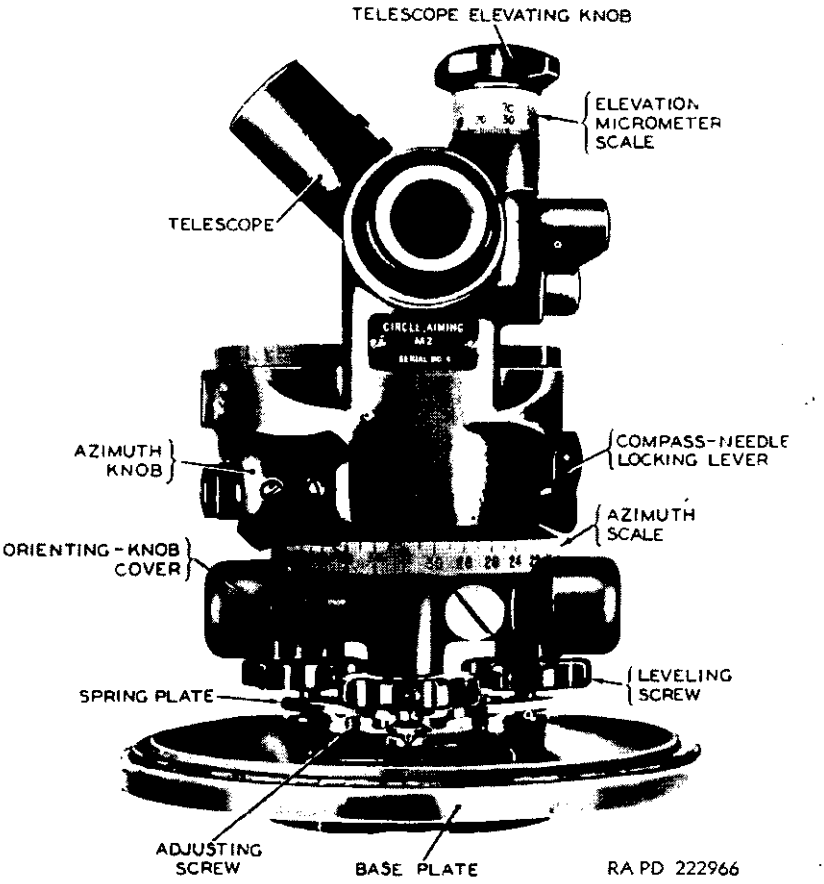


Figure 33. Aiming Circle, M2.

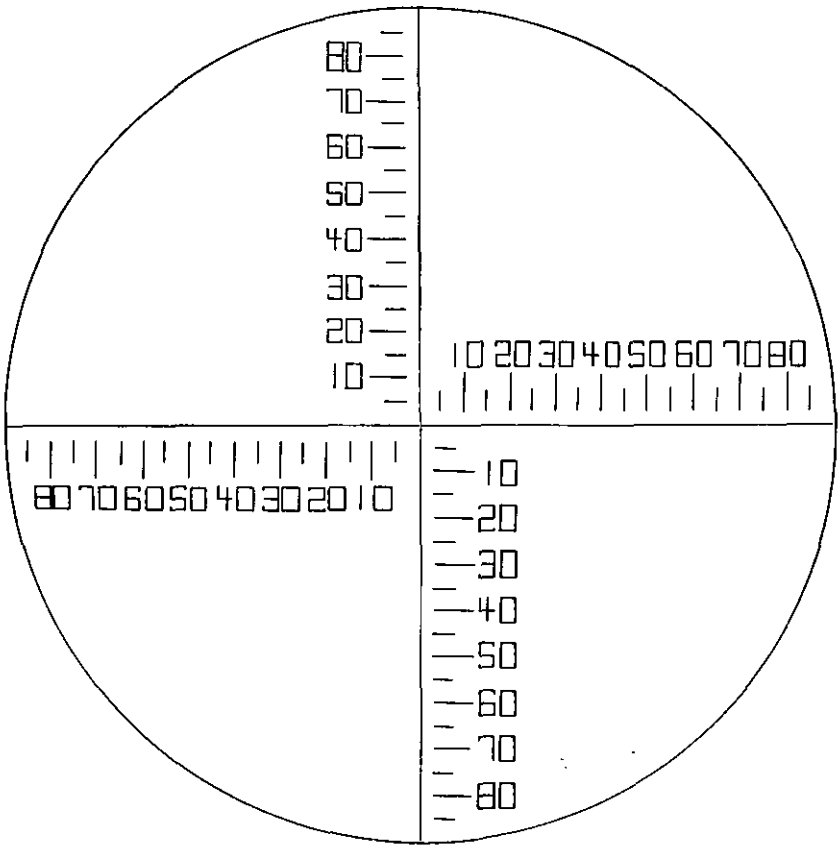


Figure 84. Telescope Reticle, Aiming Circle, M2.

57. Operation of Aiming Circle

a. Setting Up Aiming Circle.

(1) Unscrew the tripod head cover and unstrap the tripod legs. Loosen the leg clamp thumbscrews, and extend the lower legs to the desired length. Tighten the thumbscrews, and bed each leg firmly in the ground.

(2) Unsnap the aiming circle cover latches; remove the cover. Open the base plate cover assembly, and thread the tripod screw into the aiming circle until it is firmly seated. Check the circular level on the aiming circle, and readjust the tripod legs until the level is approximately centered.

(3) If the instrument is to be oriented with respect to a particular grid point, remove the plumb bob assembly from the canvas cover and hang it on the tripod hook. Adjust the position of the tripod legs until the plumb bob hangs directly over the grid point.

(4) Turn the aiming circle leveling screws until the circular level bubble is centered. Then rotate the aiming circle and, using the cylindrical level, make fine adjustments with the leveling screws at selected azimuth settings until the cylindrical level bubble remains centered throughout 6,400 mils of travel.

(5) With the aiming circle in a level position, turn the elevation scale and micrometer to zero. Note the position of the bubble in the level attached to the telescope body. It should be centered. If it is not, the instrument should be adjusted by Ordnance personnel.

b. Objects Affecting Operation of Aiming Circle. The aiming circle will not operate properly when it is too close to metallic objects, especially wires carrying electricity. Such metallic objects as steel helmets, small arms, and binoculars should be moved away from the instrument. For proper operation, the aiming circle should be set up at least the distance shown from the following objects:

High-tension power lines	150 yards
Tanks or other armored vehicles	75 yards
Trucks or telegraph wires	40 yards
Barbed wire	10 yards

58. General Uses of Aiming Circle

a. General. Compass instruments indicate direction with respect to magnetic north only; therefore, to use the aiming circle properly, it is necessary to know the following definitions and procedures:

(1) Magnetic north is the direction indicated by the magnetic needle of a compass.

(2) Grid north is the north direction of the grid line of a map or grid.

(3) Azimuth is a horizontal angle measured clockwise from a north direction.

(*a*) Grid azimuth is the clockwise angle from grid north to a definite point.

(*b*) Magnetic azimuth is the clockwise angle from magnetic north to a definite point.

(4) Declination constant (fig. 35) is the horizontal clockwise angle from grid north to magnetic north of a particular instrument; this will vary for different localities and for different instruments. Declination constant, therefore, is a combination of the grid-magnetic angle and the variation of the instrument.

(*a*) To declinate an instrument is to determine the declination constant of the instrument.

(*b*) To convert magnetic azimuths to grid azimuths, the declination constant must be applied to the compass reading.

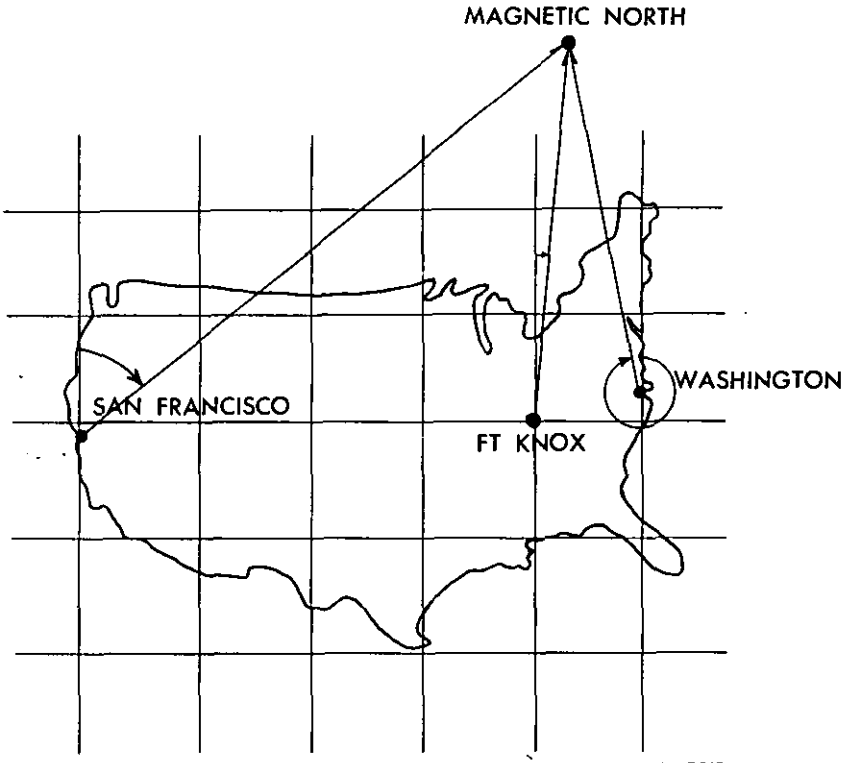


Figure 35. Declination constant.

b. Measuring Horizontal Angles.

(1) Set up and level the aiming circle.

(2) Zero the azimuth and micrometer scales.

(3) Using the lower motion, turn the head of the instrument to the general location of the point from which the angle is being measured.

(4) Sight through the telescope; using the slow lower motion, place the intersection of the horizontal and vertical lines of the reticle on the point from which the angle is being measured. (To eliminate lost motion, always make the last movement of the vertical line in the same direction.)

(5) With the upper motion, bring the vertical line of the reticle on the point to which the angle is being measured .

(6) The reading on the azimuth and micrometer scales is the angle between the points.

c. Measuring Vertical Angles.

(1) Small vertical angles.

(*a*) Level the instrument.

(*b*) Lay the intersection of the horizontal and vertical lines in the reticle on one point of the object to be measured.

(*c*) Read the angle to the other point by use of the vertical scale.

(2) Large vertical angles.

(*a*) Level the instrument.

(*b*) Turn the telescope elevating knob until the horizontal line of the reticle is on the lower object. Record the indicated reading.

(*c*) Turn the elevating knob until the horizontal line is on the upper object. Record the indicated reading.

(3) If both readings are plus or both minus, subtract, and the difference is the vertical angle. If one reading is plus and the other minus, add the two readings to get the vertical angle.

d. Measuring Angles of Site.

(1) Level the instrument.

(2) Lay the vertical line in the telescope reticle on the point to which you wish to measure the angle of site.

(3) Level the telescope by centering the bubble in the telescope assembly. Check to insure that the elevation micrometer scale is zeroed.

(4) Turn the telescope elevating knob until the horizontal line is on the object.

(5) Read the angle of site from the elevation scale and micrometer scale. If the reading is plus, the angle of site is plus; if the reading is minus, the angle of site is minus.

e. Measuring Magnetic Azimuths.

(1) Level the instrument.

(2) Zero the azimuth and micrometer scales.

(3) Release the magnetic needle.

(4) Look through the reticle of the magnetic needle magnifier; using the lower motion, aline the center vertical line with the base or large end of the magnetic needle.

(5) Lock the magnetic needle.

(6) Look through the telescope; using the upper motion, place the intersection of the horizontal and vertical lines on the point to which the azimuth is being measured.

(7) Read the angle from the azimuth and micrometer scales.

f. Measuring Grid Azimuth.

(1) Level the instrument.

(2) Set the declination constant on the azimuth and micrometer scales.

(3) Release the magnetic needle and center it, using the lower motion.

(4) Lock the magnetic needle.

(5) Look through the telescope; using the upper motion, place the intersection of the horizontal and vertical lines on the point to which the grid azimuth is being measured.

(6) Read the angle from the azimuth and micrometer scales.

59. Laying Tanks Parallel

When firing indirect, tanks are laid parallel; that is, regardless of the position of the tanks, all *gun tubes* are parallel. The purpose of this procedure is to insure coverage of the target area and to allow control of the fire of *all* tanks by a *single* command. Tankers may use any one of three methods to lay tanks parallel.

a. Tanks and Target Visible. When both the tanks and the target area are visible to the aiming circle operator, the following procedure may be employed (fig. 36):

(1) The operator levels the aiming circle and zeros the azimuth and micrometer scales. Using the lower motion, he sights on the target. He then commands AIMING POINT THIS INSTRUMENT, DIRECTION OF FIRE . . . (point).

(2) Each gunner sights through his gun tube on the telescope of the aiming circle and sets his azimuth indicator at zero.

(3) Using the upper motion, the operator lays the cross hairs of the telescope reticle on the center of the gun muzzle of Tank No. 1.

(4) The operator reads the lower azimuth scale and micrometer scale and announces the reading: for example, DEFLECTION NUMBER ONE, ONE THREE FOUR ZERO (reading must be taken from the lower scale so that it will be less than 3,200 mils). The process is repeated for each tank.

(5) Each gunner now traverses his turret until the azimuth indicator reading is the announced deflection. The tank guns are now laid parallel. Since the azimuth indicator is graduated into two 0–3200 parts, the gunner must know the direction of fire so that he can use the appropriate part of the scale.

(6) Gunners now zero their azimuth indictaors, and aiming stakes are set out for each tank.

b. Laying on Given Grid Azimuth. Upon receiving the command COMPASS . . . (the grid azimuth in mils), tanks are laid parallel on a grid azimuth as follows:

(1) The aiming circle operator subtracts the grid azimuth from the

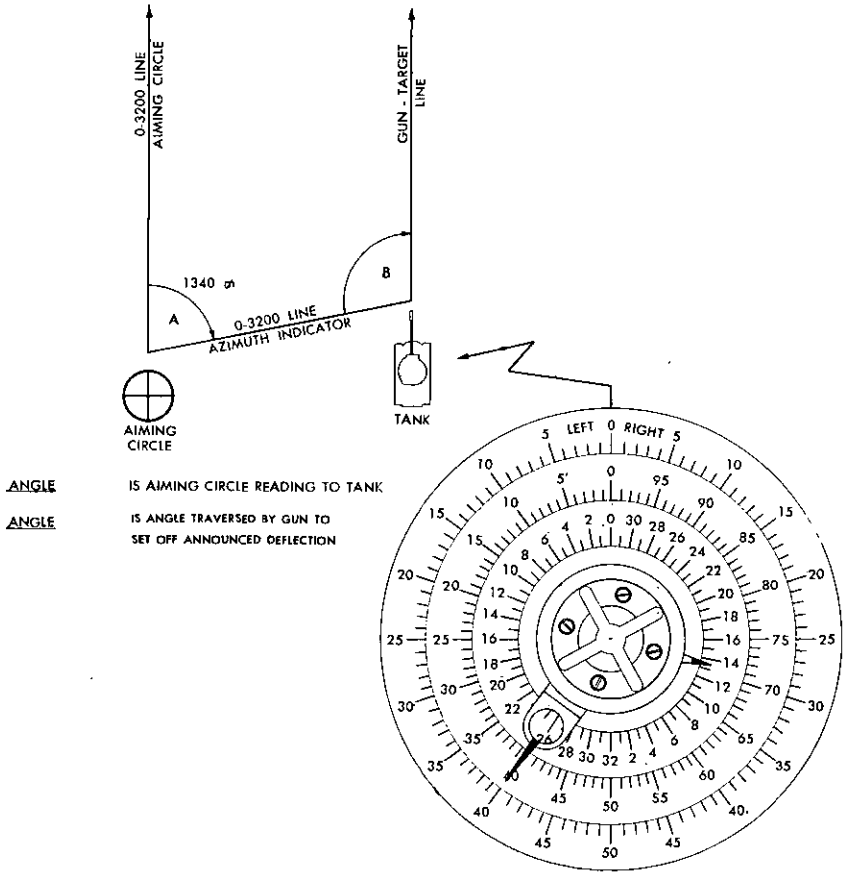


Figure 36. Laying tanks parallel when both tanks and target are visible to aiming circle operator.

declination constant of the instrument (6,400 mils is added to the declination constant if necessary).

(2) With the instrument level, the operator sets the result on the azimuth and micrometer scales. Using the lower motion, he centers the magnetic needle. (The 0–3,200 line of the aiming circle is now pointing along the given grid azimuth.)

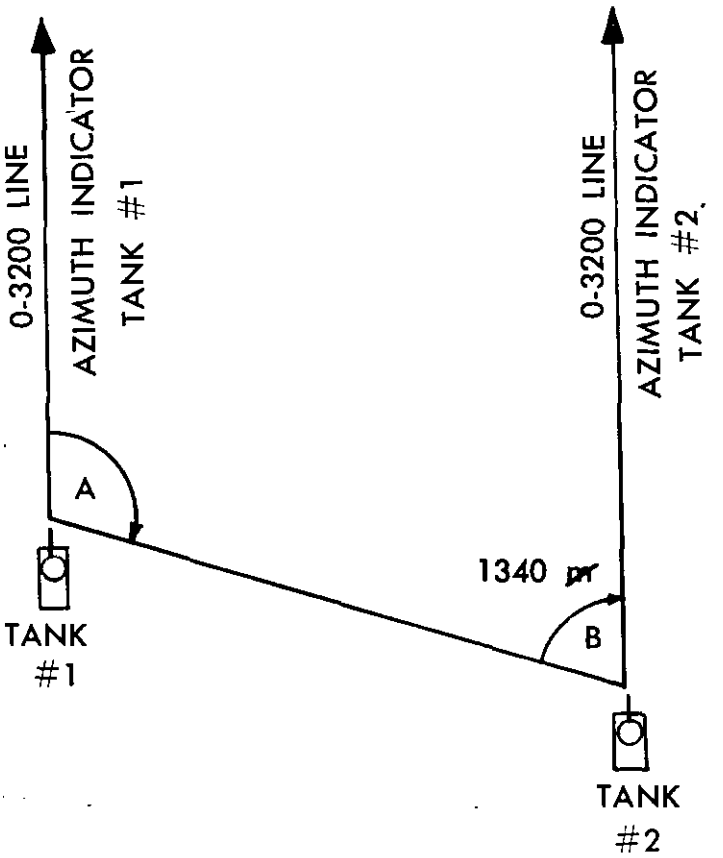
(3) The operator then commands AIMING POINT THIS INSTRUMENT, DIRECTION OF FIRE . . . (point). Tanks are then laid parallel by following the procedure outlined in *a*, above, (2) through (6).

c. Reciprocal Laying. If an aiming circle is not available, tanks may be laid parallel by reciprocal laying (fig. 37). Procedure is as follows:

(1) The center tank is alined on the target by use of aiming stakes. The gunner of the center tank then zeroes his azimuth indicator.

(2) On the command NUMBER TWO, LAY ON ME, the gunners of the center tank and the tank on the immediate right then traverse until both gun tubes are exactly alined. The loaders of each tank sight through the tubes to accomplish alinement.

(3) The gunner of the center tank announces his azimuth indicator reading and points in the direction of fire: for example, DE-



ANGLE A IS AZIMUTH INDICATOR READING TO TANK #2

ANGLE B IS MOVEMENT IN DIRECTION OF FIRE TO AZIMUTH INDICATOR READING OF ZERO

Figure 37. Reciprocal laying.

FLECTION NUMBER TWO, ONE THREE FOUR ZERO . . . DIRECTION OF FIRE . . .

(4) The gunner of the right tank indexes the announced reading on the azimuth indicator, using the scale *opposite* from the direction of fire. He then traverses in the prescribed direction until zero is indicated on the azimuth indicator. The right tank is now laid parallel to the direction of fire.

(5) The gunner of the center tank repeats the process to lay the left tank. The tanks thus laid then lay tanks on their flank in the same manner.

60. Declinating Aiming Circle

To declinate an aiming circle, a declinating station or point must first be established. This station is normally established by an artillery or engineer unit, by use of a transit. In the absence of an established declinating station, an instrument can be declinated for a particular locality on any line of known grid azimuth. After the line of known azimuth has been determined, declinate the aiming circle as follows:

a. Set up the aiming circle over one end of the line of known azimuth (which serves as a declinating station), and level the instrument carefully.

b. Set the azimuth and micrometer scales at zero, and center the needle with the lower motion.

c. With the upper motion, turn to the point of known grid azimuth and record the reading.

d. Repeat this process three times. Then subtract the average of these three readings from the known grid azimuth. (Add 6,400 mils to the known grid azimuth if the magnetic azimuth is greater.) The result is the declination constant for the instrument in that locality.

e. Accuracy can be increased by having more than one point of known grid azimuth visible from the declinating station. When more than one point is available, take the reading to each point, compute the difference, and use the average as a declination constant. An example of this procedure is illustrated in figure 38. The grid azimuth to point A is known to be 682 mils; the magnetic azimuth to point A is measured as 675 mils. Therefore, the difference between the grid azimuth and magnetic azimuth to point A is 7 mils. The grid azimuth to point B is known to be 2,136 mils, while the magnetic azimuth is measured as 2,130 mils, a difference of 6 mils. The grid azimuth to point C is known to be 5,418 mils, and the magnetic azimuth is measured as 5,410 mils; the difference here is 8 mils. The average difference is 7 mils (7 plus 6 plus 8 divided by 3), which is the declination constant of that aiming circle in that area.

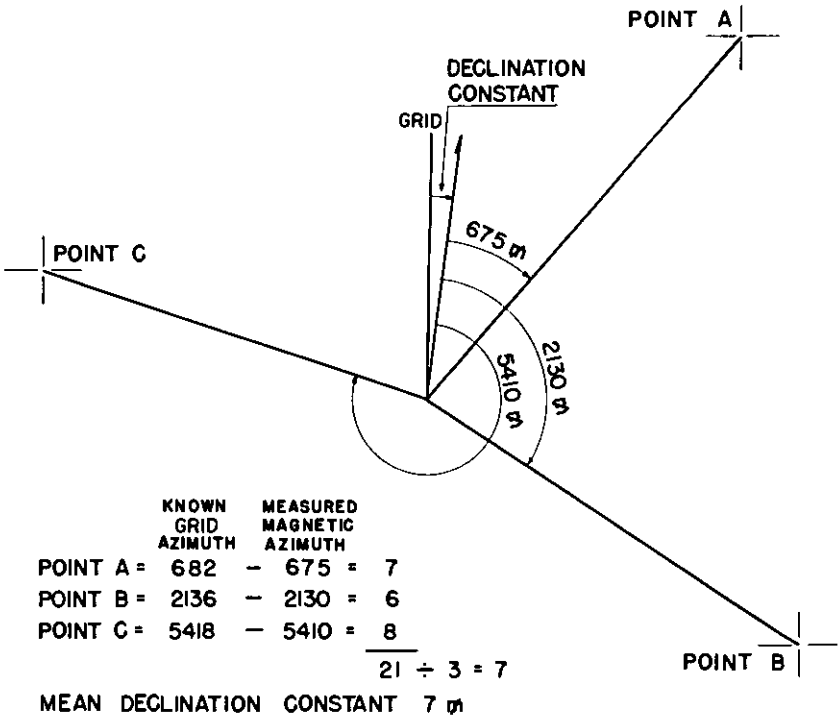


Figure 38. Declinating the aiming circle.

61. Care and Maintenance of Aiming Circle

a. Care of Aiming Circle. Proper care in handling the aiming circle will insure the best possible service.

(1) When the magnetic needle is not being used, lock it in place.

(2) Stops are provided on instruments to limit the travel of the moving parts. Do not attempt to force the rotation of any knob beyond its stop limit.

(3) Keep the instrument as clean and dry as possible. Keep equipment covered when it is not in use.

(4) Do not point the telescope directly at the sun unless a filter is used, as the heat of the focused rays may damage optical elements.

(5) To prevent excessive wear of threads and other damage to the instrument, do not tighten leveling, adjusting, and clamping screws beyond a snug contact.

b. Maintenance of Aiming Circle.

(1) Under normal operating conditions, clean the exposed metal surfaces of the tripod, and coat them with a thin preservative

oil. When using the instrument around salt water or extreme moisture, coat all unpainted metal surfaces with a lanolin-base lubricant.

(2) The aiming circle has coated optics. The coating reduces the amount of light reflected from the lens surfaces; this results in a corresponding increase in the amount of light transmitted through the lenses. Avoid excessive rubbing of the optics, because it will remove the coating. When cleaning the lenses of the telescope, use only the special issue lens soap, lens tissue, or other approved material.

(3) Ordnance is responsible for all repairs on instruments. Only Ordnance personnel should disassemble and repair the aiming circle.

Section VIII. COMPASS

62. General

The M2 compass (figs. 39 and 40) is used to determine azimuth or angle of site. The principal parts of this compass are the—

a. Compass body assembly.

b. Angle of site mechanism.

c. Magnetic needle and lifting mechanism.

d. Azimuth scale and adjuster.

e. Front and rear sights.

f. Carrying case.

63. Description of Compass

a. Compass Body Assembly.

(1) In the compass body, a circular glass window covers and keeps dust and moisture from the interior of the instrument, thus protecting the compass needle and angle of site mechanism.

(2) A hinge assembly keeps the compass cover parallel with the body when opened. A hole in the cover coincides with a small oval window in the mirror on the inside of the cover. A sighting line is etched across the face of the mirror.

b. Angle of Site Mechanism.

(1) The angle of site mechanism is attached to the bottom of the compass body. It consists of an actuating lever, located on the back of the compass body, and a leveling assembly with a tubular elevation level and a circular level. The instrument is leveled with the circular level to read azimuth and with the elevation level to read angles of site.

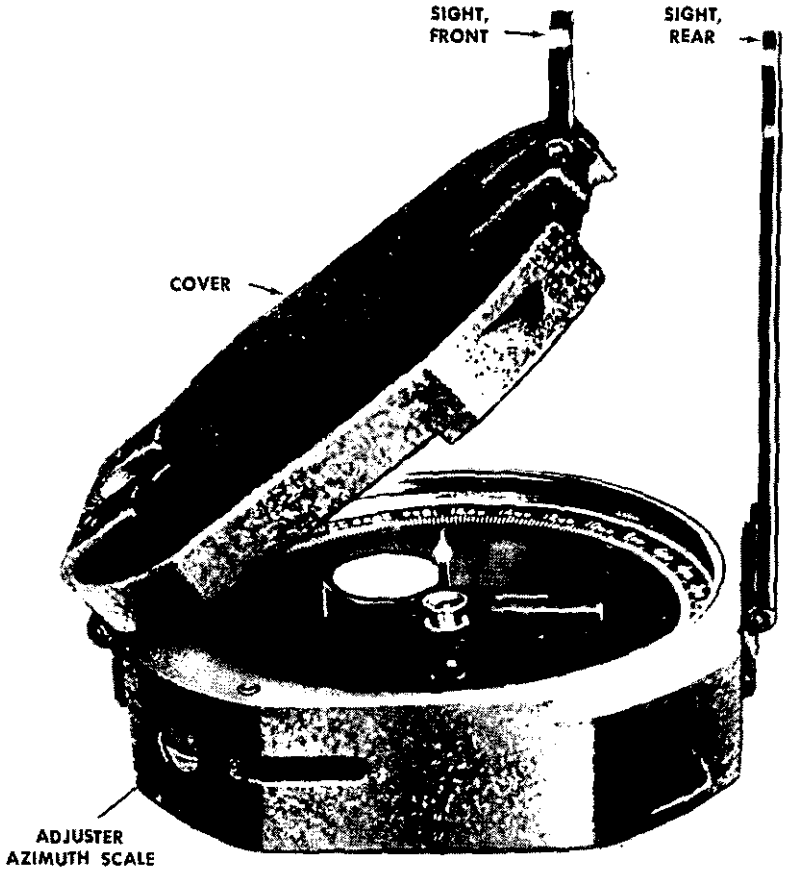


Figure 39. Compass, M2—side view.

(2) The elevation (angle of site) scale and the four points of the compass, represented by three letters and a star, are engraved on the inside bottom of the compass body. The letters E and W are reversed to facilitate reading direction through the mirror. The elevation scale is graduated in two directions; in each direction it is graduated from 0 to 1,200 mils in 20-mil increments and is numbered every 200 mils.

c. *Magnetic Needle and Lifting Mechanism.*

(1) The magnetic needle assembly consists of a magnetized needle and a jewel housing, which acts as a pivot. The north-seeking end of the needle is painted white. A thin piece of copper wire is wrapped around some needles to act as a counterbalance.

(2) A lifting pin projects slightly above the top rim of the compass body. The lower end of the pin engages the needle-lifting

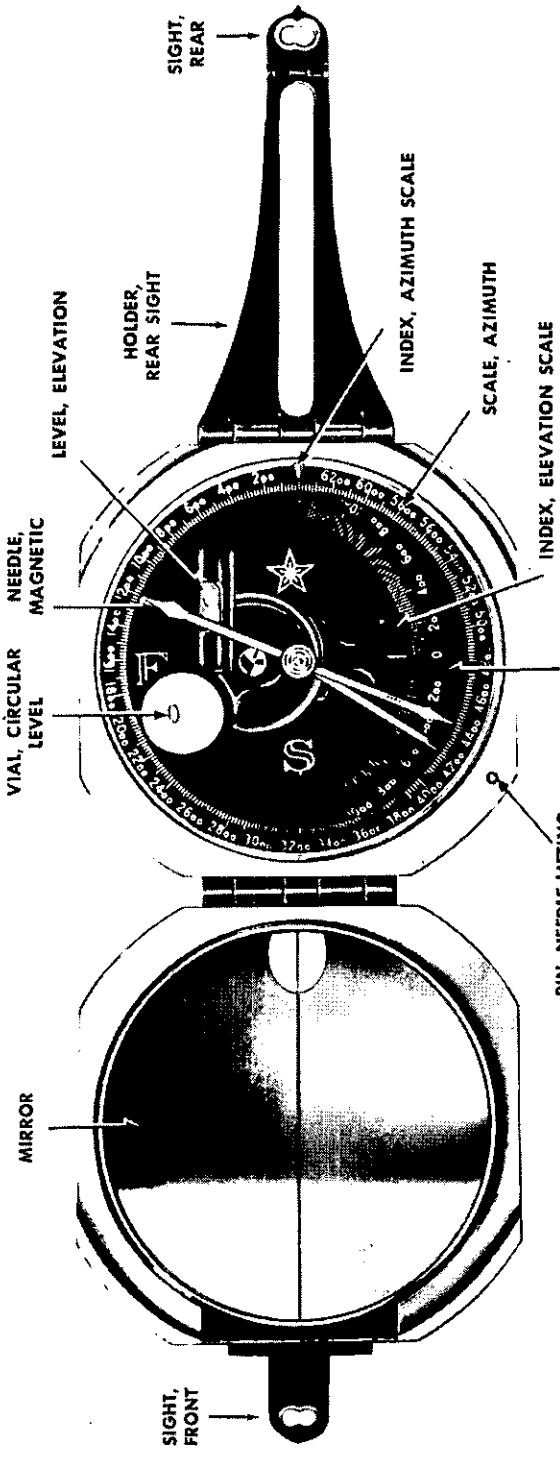


Figure 40. Compass, M2—top view.

lever. When the cover is closed, the magnetic needle is automatically lifted from its pivot and held firmly against the window of the compass.

d. Azimuth Scale and Adjuster.

(1) The azimuth scale is a circular dial geared to the azimuth scale adjuster. This permits the azimuth scale to be rotated approximately 900 mils in either direction. The azimuth index, a small metal pin, provides a means for orienting the azimuth scale to the magnetic declination.

(2) The azimuth scale is graduated clockwise in 20-mil increments, from 0 to 6,400, and is numbered at 200-mil intervals.

e. Front and Rear Sights. The front sight is hinged to the compass cover, so that it can be folded into its bracket when not in use. The rear sight is made in two parts, a rear sight and a holder. When the compass is not being used, the rear sight is folded across the compass body and the cover is closed over it.

f. Carrying Case. This case is made of leather and fits the general contour of the M2 compass. A loop on the back of the case permits its attachment to the user's belt.

64. Use of Compass

The M2 compass is an auxiliary fire-control instrument. It measures magnetic or grid azimuths, and angles of site.

a. Measuring Horizontal Angles.

(1) Using the compass sights, sight on the left extremity of the angle to be measured.

(2) Note the reading on the azimuth scale.

(3) Sight on the right extremity of the angle to be measured.

(4) Subtract the first reading from the second (adding 6,400 if necessary); the difference is the desired angle.

b. Measuring Magnetic Azimuths.

(1) Zero the azimuth scale by turning the azimuth scale adjuster.

(2) Place the instrument on a post, nonmetallic stake, or similar object (this is necessary only for very precise measurements), and center the bubble in the circular level.

(3) Looking through the sights, sight on the object.

(4) Read the azimuth under the black end of the magnetic needle. (Reading the white end of the needle would give the back azimuth.) Use interpolation to get angles of less than 20 mils. (When holding the compass in the hands, adjust the cover until the azimuth scale and the magnetic needle can be seen in the mirror.)

c. Measuring Grid Azimuths.

(1) Set the known declination constant on the azimuth scale by rotating the azimuth scale adjuster.

(2) Measure the azimuth as described in *b* above.

d. Measuring Angles of Site.

(1) Place the cover in such a position that when you sight through the rear sight and the aperture in the cover, you can see the bubble in the elevation level in the mirror. Turn the compass on its left side (with the elevation scale down).

(2) Sight on the point whose angle of site is to be measured.

(3) Rotate the level lever (located on the back of the compass body) until the bubble in the elevation level is centered.

(4) Read the angle on the elevation scale opposite the index mark.

e. Measuring Vertical Angles. To measure vertical angles, use the procedure described in *d* above to get two readings, one at each of the points between which the vertical angle is to be measured. The difference between these readings is the vertical angle between the points.

65. Care and Maintenance of Compass

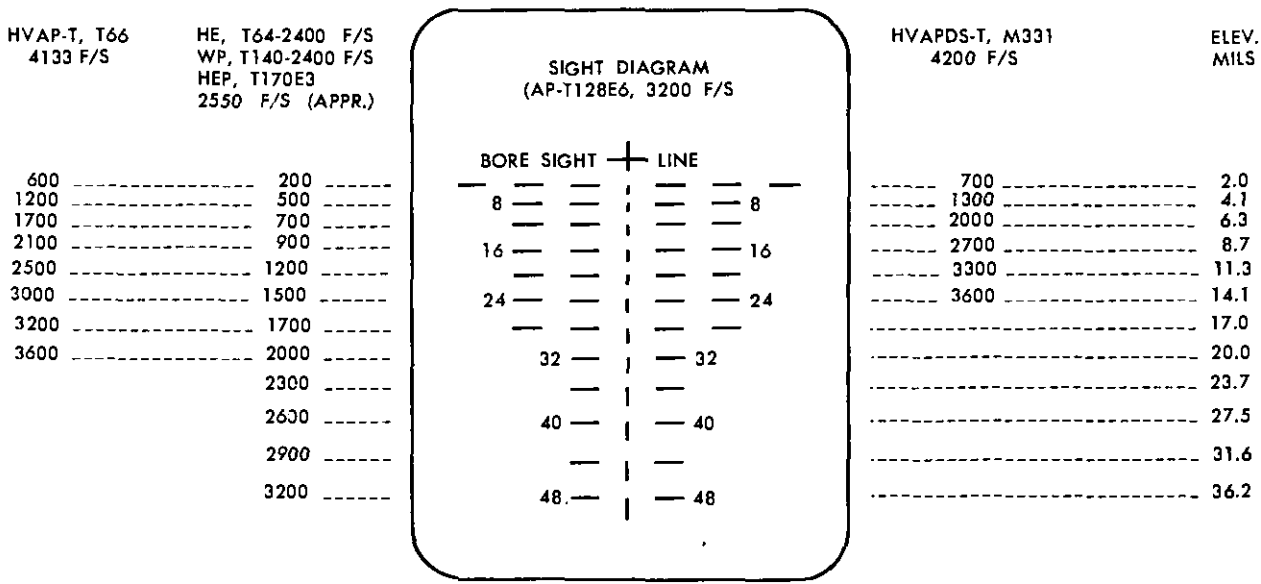
a. Handle the compass carefuly; avoid subjecting it to unnecessary shocks. Keep the compass in the carrying case when not in use. After using it in wet weather, wipe it dry before returning it to the carrying case. When the instrument is moved from one position to another or is not in use, the compass cover should be closed; this lifts the needle off its pivot and prevents injury to the pivot or jewel. Be very careful not to bend the sights or the cover hinge. Fold the rear sight so that it lies flat on the compass window before closing the cover; failure to take this precaution might result in a broken compass window.

b. This instrument requires no lubrication. Clean it with a camel's-hair brush, lens tissue paper, ethyl alcohol, and dry-cleaning solvent. Clean the metal parts with a clean cloth moistened with dry-cleaning solvent. Clean the glass parts with ethyl alcohol and clean lens paper. When cleaning the mirror, do not get alcohol on the edges of the mirror; it is set in putty, and alcohol might loosen this setting. Wipe all dust, oil, or other foreign substances off the carrying case, using a damp (not wet) sponge. Allow the leather to partially dry, then rub it vigorously with a soft dry cloth.

Section IX. MISCELLANEOUS FIRE-CONTROL EQUIPMENT

66. Aiming Data Chart

a. Inasmuch as the standard dash pattern type of gun-laying reticle is calibrated for one type of ammunition only, the gunner must compen-



TO USE CHART: GET ESTIMATED RANGE AND LOCATE IN COLUMN UNDER AMMUNITION BEING FIRED. READ SIGHT SETTING FROM SIGHT DIAGRAM. FOR PROJ. AP, T128E6, 3200F/S USE ESTIMATED RANGE AS SIGHT SETTING.

Figure 41. Aiming data chart.

sate for the difference in trajectory when he uses any other type of round. Normally, this correction is determined by use of the ballistic unit or computer. However, should these devices be inoperative, an aiming data chart similar to the one shown in figure 41 serves to indicate the range adjustment.

b. If aiming data charts are not available, gunners can prepare similar charts for any gun by comparing elevations as found in firing tables, ballistic units, and computers for the different types of ammunition. Aiming data charts are usually glued on the recoil guard of the gun.

67. Firing Tables (Tabular)

Firing tables are printed for each caliber of tank gun. They include data for firing all standard types of ammunition. There are two general types of tabular firing tables. The first of these is the unabridged or complete firing table, which includes all known data pertaining to a given gun-ammunition combination. The second is the abbreviated firing table, which includes only the data shown in figure 42. Of these two types, the abbreviated is more commonly used in preparation for and conduct of tank gun firing.

68. Graphical Firing Tables

a. Graphical firing tables are special type slide rules used in the preparation for and conduct of artillery fire, including tank gun fire. Each consists of one or more rules, on which are printed certain ballistic data, and an indicator.

b. For details of design and use of graphical firing tables, see TM 9–525.

69. Aiming Posts

Aiming posts are used as reference points in indirect fire. If necessary, they may be constructed from any straight wood or metal pole. During darkness or other conditions of poor visibility, a shielded flashlight may be taped or tied to the post for easy identification.

70. Observation Telescopes

Observation telescopes are optical instruments issued for the purpose of providing a greatly magnified field of view for detailed examination of targets or terrain. They are usually mounted on a tripod. Some have interchangeable eyepieces providing a selection of magnification from 10x to 30x. No reticle is provided in observation telescopes.

EXTRACT FROM FIRING TABLE

Shell, HE-T, T91
Fuze PD, M51A5

Muzzle Velocity, 2400 F/S

Range	Elevation	Elevation Change For 100 yd Range Change	Vertical Change For 100 yd Range Change	Vertical Probable Error	Drift
yd	mil	mil	ft	ft	ft
0	0.0	.8	0.0	0.0	0.0
100	0.8	.9	0.3	0.1	0.0
200	1.7	.9	0.5	0.1	0.0
300	2.6	.9	0.8	0.2	0.1
400	3.5	.9	1.1	0.2	0.1
500	4.4	.9	1.4	0.3	0.2
600	5.3	1.0	1.7	0.4	0.3
700	6.3	1.0	2.0	0.4	0.4
800	7.3	1.0	2.3	0.5	0.6
900	8.3	1.0	2.6	0.5	0.7
1000	9.3	1.0	3.0	0.6	0.9
1100	10.3	1.0	3.4	0.7	1.1
1200	11.4	1.1	3.7	0.7	1.4
1300	12.5	1.1	4.1	0.8	1.6
1400	13.6	1.1	4.5	0.8	1.9
1500	14.7	1.1	4.9	0.9	2.2
1600	15.8	1.1	5.3	1.0	2.6
1700	17.0	1.2	5.8	1.0	3.0
1800	18.2	1.2	6	1.1	3.4
1900	19.4	1.2	7	1.1	3.8
2000	20.6	1.2	7	1.2	4.3
2100	21.8	1.2	8	1.3	4.8
2200	23.1	1.3	8	1.3	5.4
2300	24.4	1.3	9	1.4	5.9
2400	25.7	1.3	9	1.4	6
2500	27.1	1.4	10	1.5	7
2600	28.5	1.4	11	1.6	8
2700	29.9	1.4	11	1.6	9
2800	31.3	1.5	12	1.7	10
2900	32.8	1.5	13	1.7	10
3000	34.3	1.5	14	1.8	11
3100	35.8	1.6	14	1.9	12
3200	37.4	1.6	15	1.9	13
3300	39.0	1.6	16	2.0	14
3400	40.7	1.7	17	2.0	16
3500	42.4	1.7	18	2.1	17

Figure 42. Tabular firing table (abbreviated).

CHAPTER 5

RANGE DETERMINATION

Section I. INTRODUCTION

71. General

The greatest potential cause of error in tank gunnery is range determination. When a tank crewman can determine range accurately, the probability of obtaining a target hit is greatly increased; speed and accuracy in firing the first round will produce the desired result.

72. Methods of Determining Range

The methods of determining range are—range finders, estimation by eye, binocular and mil relation, maps and photomaps, intersection, registration, and information from friendly troops. These methods have varying degrees of accuracy. The method used is dependent on the equipment or means available and the threat that the target presents. The best method in any given situation is the one which gives the most accurate range consistent with the amount of time available. When the range finder is available, it is the best and most accurate method of determining range; however, it is not mounted on all tanks, or it may become inoperative. Therefore, tank crewmen must become proficient in all methods of determining range.

Section II. METHODS OF RANGE DETERMINATION

73. Range Finders

On tanks so equipped, range finders are the primary method of range determination for tank crewmen. The value of the range finder lies in the increased probability of hits at ranges beyond 1,000 yards. The maximum time required for a trained operator to range on a target is five seconds or less. A tank crew can expect first-round hits on visible targets when the range has been determined by a range finder.

74. Estimation by Eye

Estimation by eye is the most rapid but least accurate method of determining range. This method requires a great deal of training. Training must be continuous to maintain the proficiency necessary to estimate

range by eye with any degree of accuracy. Accuracy is also greatly influenced by the distance to the target. As the range to the target increases, accuracy decreases at a very rapid rate. In estimating tank-to-target range, the tank crewman habitually employs some form of mental yardstick. This yardstick is in multiples of hundreds of yards (meters) to agree with the graduation on direct-fire sights. However, in order to apply this yardstick with maximum effectiveness, the crewman must be aware of certain factors which influence its application. These factors are *nature of the target, nature of the terrain,* and *light conditions.*

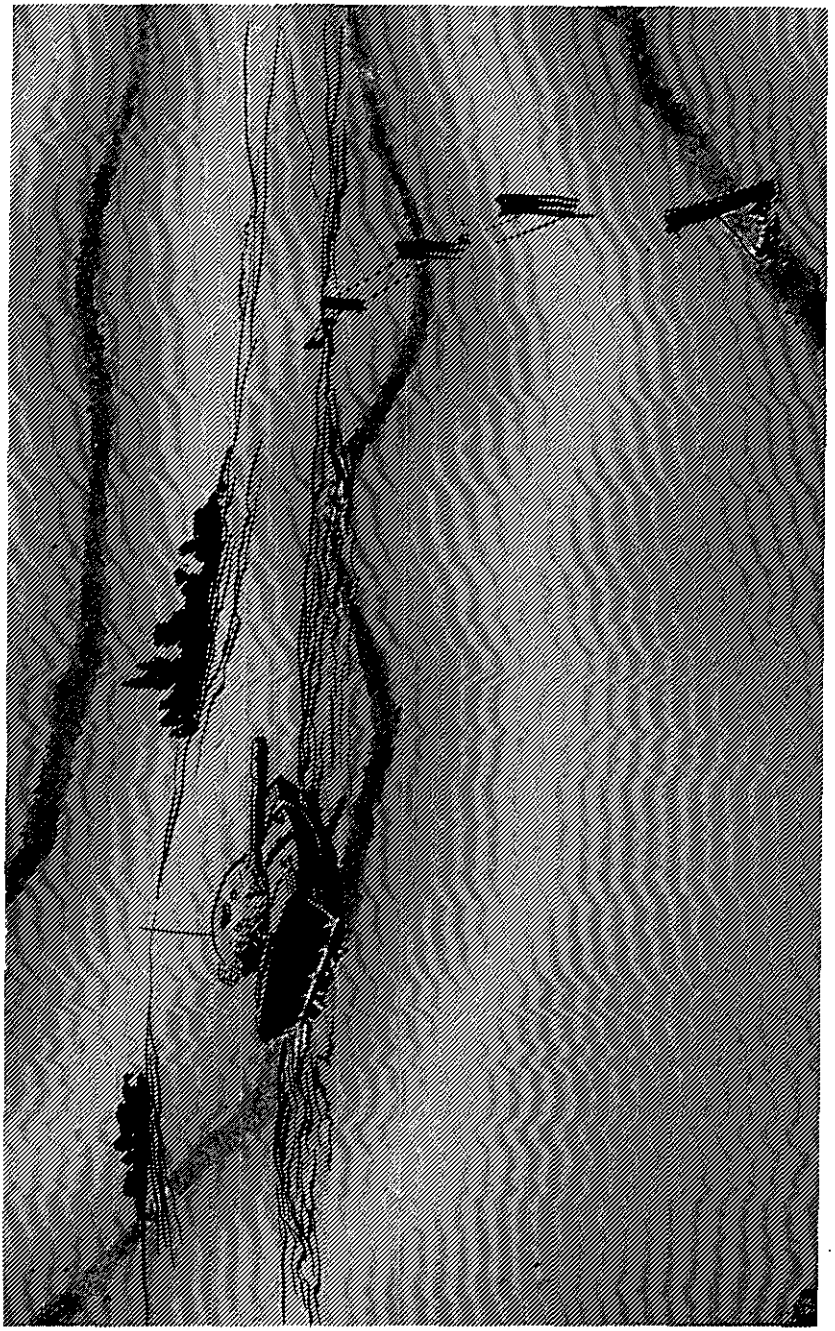
a. Nature of Target. A target of regular outline, such as a house or vehicle, appears to be closer than it actually is; while a target of irregular outline, such as a clump of trees or camouflaged position, appears to be more distant than it actually is. When the target is in contrast to the background, it appears nearer because the target outline is more clearly defined. If the target blends with the background, it appears farther away because it is more difficult to distinguish the target outline (fig. 43). The amount of target visible also affects the estimate. When the entire target is in view, it appears closer. When only part of the target is visible, it appears to be more distant (fig. 44).

b. Nature of Terrain. Since projectiles travel through the air from gun to target, the range to be estimated is the air-line distance and not the ground distance. The eye, however, tends to measure the ground distance. In figure 45, the distance between points A and B appears greater than the distance between points B and C because the eye has followed all the detail of the lines between A and B; actually, the distances are the same. In the field, the observer's eye unconsciously tends to follow the irregularities which vegetation and terrain conformation give to the ground line, thus resulting in overestimation of the range. Conversely, in observing over smooth terrain such as desert, water, or snow, or in any other situation where there is little to distract the eye, the tendency is to underestimate the range.

c. Light Conditions. The more clearly a target can be seen, the closer is appears. A target seen in the full light of the sun appears to be closer than the same target seen at dusk or dawn or through smoke, fog, or rain. The position of the sun with relation to the target also affects the *apparent* range. When the sun is behind the viewer, the target is in full light and easy to see and thus appears to be closer than it actually is. However, when the sun is behind the target and the viewer is looking into the sun, the target is more difficult to see and appears to be farther away.

75. Binocular and Mil Relation

The binocular and mil relation (pars. 30–36) are useful in deliberate range determination. To use this method, the width or height of the



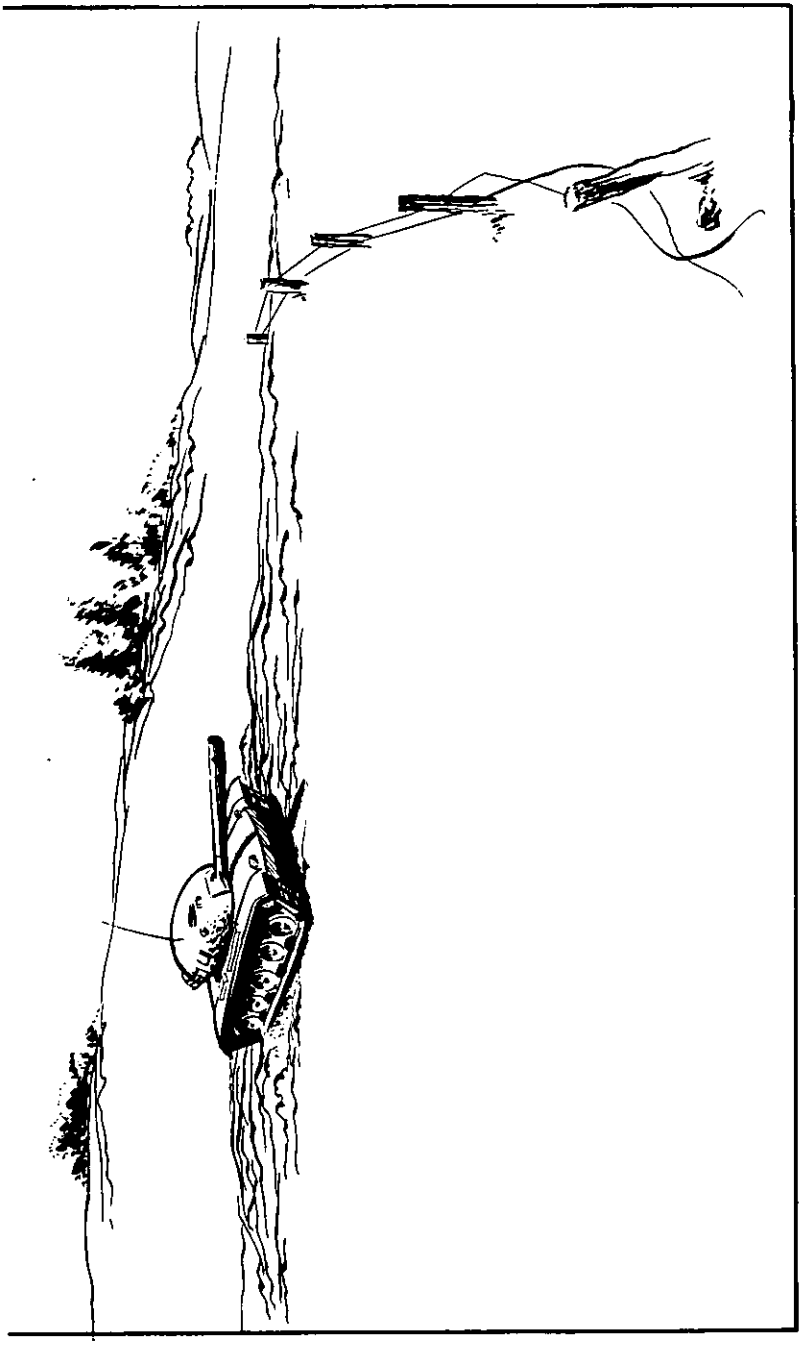


Figure 48. Clarity of outline affects estimation by eye.

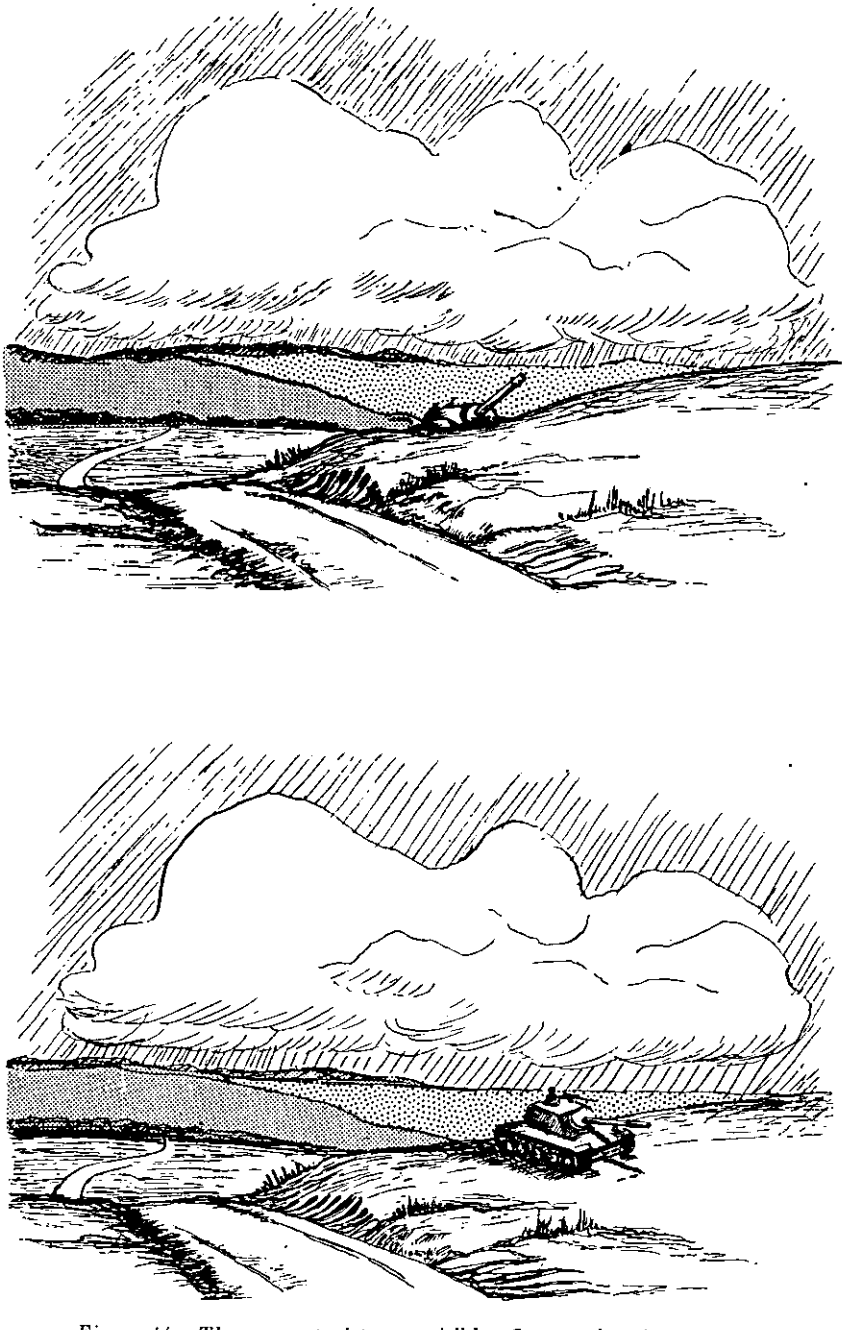


Figure 44. The amount of target visible affects estimation by eye.

target or objects in the vicinity of the target must be known. Measure the known width or height with the binocular mil scale, substitute the mil relation, and compute the range. Accuracy of this method depends on knowledge of target dimensions and the ability of the individual to make precise measurements with the binocular. The mil relation may be used in constructing a range determination chart as illustrated in figure 46.

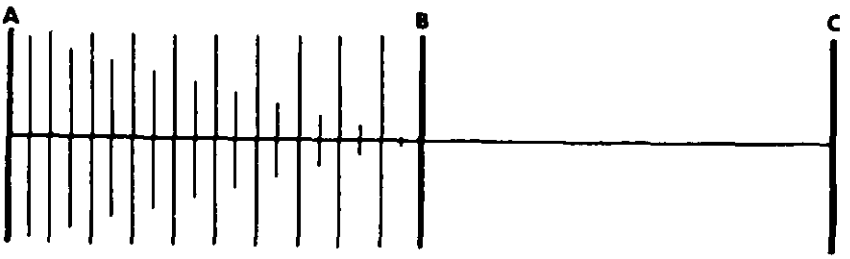


Figure 45. Measuring ground distance. Is line A-B longer than line B-C?

76. Maps and Photomaps

When a tank commander has located both his tank and the target on his map or photomap, he can measure the distance between them. He then applies this measured distance to the graphic scale on his map or photomap and obtains the range. The accuracy of this method depends on the ability of the individual to pinpoint both tank and target.

77. Intersection

When time and equipment are available, intersection is an accurate method of determining range (fig. 47). To use this method, establish a triangle using the target as the apex. Place an angle-measuring instrument at each end of the known base of the triangle. Measure the interior base angles. Subtract the sum of these two base angles from 3,200 mils. (The sum of the interior angles of a triangle is 3,200 mils.) Substitute known values in the mil relation and determine the range to the target.

78. Registration

The most accurate method of determining range, when firing a particular weapon, is registration by that weapon. This is accomplished by firing on a target until it is hit. However, it may not be practical to use this method, since it discloses the position of the weapon and may require an excessive expenditure of ammunition.

RANGE DETERMINATION CHART

MIL MEASUREMENT		1	2	3	4	5	6	7	8	9	10
Aggressor Medium Tank	LENGTH—19.7′	6600	3300	2200	1600	1300	1100	900	800	700	700
	WIDTH—9.8′	3300	1600	1100	800	700	500	500	400	400	300
Aggressor Heavy Tank	LENGTH—22′	7300	3700	2400	1800	1500	1200	1000	900	800	700
	WIDTH—10.1′	3700	1800	1200	900	700	600	500	500	400	400

NOTE: Above chart may be used to facilitate using mil formula as a means of determining range. This chart may be made readily accessible by placing it in a convenient location in the tank commander's cupola.

USE: 1. Measure mil angle of target with binocular.
2. Determine type of target.
3. Range to target to nearest 100 yards is found by the mil measurement.

Figure 46. A range determination chart.

79. Friendly Troops

Tank crewmen may obtain the range to a target from friendly troops. The information thus obtained is only as good as the method used by the friendly troops.

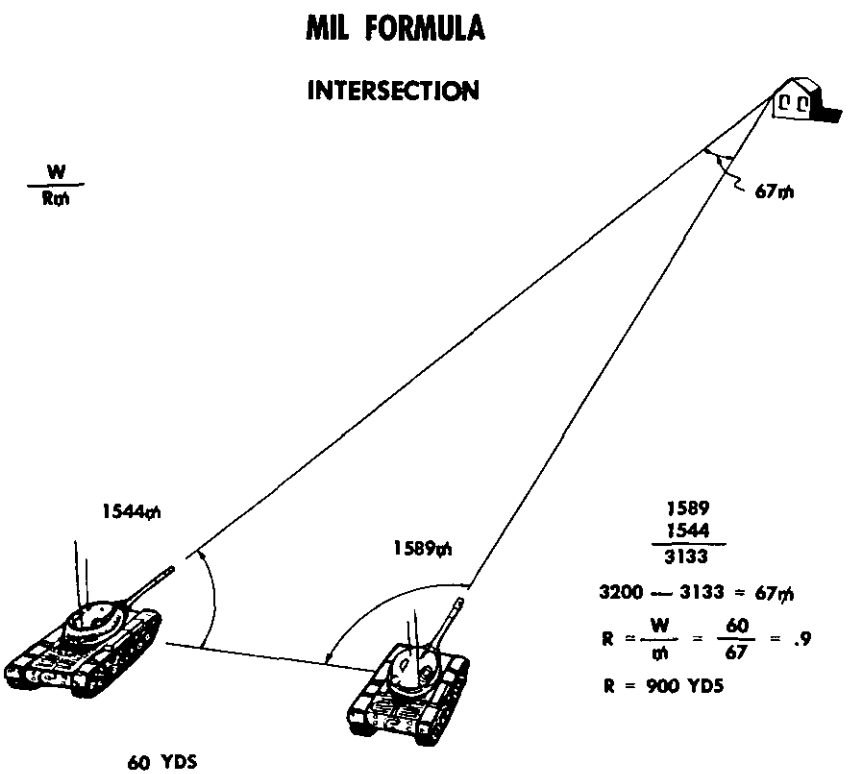


Figure 47. The intersection method of determining range.

PART FOUR

CONDUCT OF FIRE

CHAPTER 6

INTRODUCTION

80. Scope of Part Four

Part four explains the methods and techniques of conducting tank fire. Conduct of fire includes all elements of technique and method which enable the tank crew to place effective fire on the target.

81. General

The tank is an offensive weapon, possessing armor-protected firepower and a high degree of mobility. The ability of armor to rapidly concentrate devastating fire on the enemy while aggressively advancing on his position produces the shock action essential to success in battle.

82. Primary Role of Tank

The primary role of the tank is offensive combat; the basic mission is to close with and destroy the enemy. Tank units perform their basic mission by a penetration or envelopment of the enemy position followed by the exploitation and pursuit of the defeated enemy forces. In an overall defensive situation, tanks are used offensively as the counterattack force or mobile reserve. In either situation, the mission is accomplished by employing firepower and maneuver.

83. Firepower

Maximum firepower is obtained by concentrating the massed, coordinated direct fire of the entire tank unit. Direct fire is fire delivered on targets that can be observed through the direct-fire sights. It is the most effective method of firing tank guns because of the accuracy and rapidity with which enemy targets can be engaged, and should be employed in preference to indirect fire. Indirect fire is fire delivered on targets that cannot be observed through the direct-fire sights. This type of fire is not as effective as direct fire because it is neither as accurate nor as rapid, and the relatively flat trajectory of tank guns limits

engagement of close-in targets. Indirect fire is a primary function of artillery, not of tanks; however, tank crewmen receive training in indirect laying because it is a means of retaining the firepower of the tank unit when the tactical situation, terrain, or weather does not permit direct fire and maneuver.

84. Target Acquisition

a. Target acquisition includes both location and identification of an enemy target. Targets are broadly classified as *point* or *area*, according to their nature. A point target is one that consists of a particular object or structure, such as a tank, gun position, or bunker. An area target consists of a general location or area on which fire is to be delivered, such as a defensive position, an assembly area, or troops dispersed over an area.

b. Targets are further classified as *hard* or *soft*, according to the type ammunition necessary for destruction. Hard targets are those which cannot be defeated by small arms fire or the fragmentation effect of HE ammunition. The more common types of hard targets are armored vehicles, bunkers, and pillboxes. Soft targets are those which can be defeated by small arms fire and shell fragments, such as troops in the open, unarmored vehicles, and open gun positions.

c. Target acquisition is a duty of all crew members; however, it is primarily the responsibility of the tank commander. Acquisition should be rapid and accurate, so that the target can be quickly engaged with the correct ammunition. This is not an easy task, because enemy positions and weapons will often be concealed and camouflaged. Even when an enemy gun opens fire, the haze and noise of battle make target acquisition difficult. To assist the tank commander, each crewman is assigned a sector for observation. Tank crewmen should receive training in observation, target recognition, detecting camouflage, and distinguishing the differences between explosions and firing of weapons.

d. The tank crewman who first observes a target will alert the crew to its presence. The tank commander does this by issuing an initial fire command. Other crewmen designate a target by announcing TARGET, followed by the approximate range, direction, and description; for example: TARGET, 1,000, DIRECT FRONT, TANK. The gunner may designate the direction of a target by laying the gun, rather than by announcement. Should the tank commander desire to engage a target designated by another crewman, he will then issue a fire command.

85. Firing Positions

a. The ideal firing position is one which provides cover and level hardstanding. *Hull defilade* positions, where the hull is behind cover and the turret exposed, are employed for direct fire. Indirect fire is conducted

from positions affording full or *turret defilade.* Firing positions must be as level as possible in order to eliminate or reduce cant. In a static situation, selection and occupation of positions is deliberate. However, ideal firing positions are not always available in mobile situations. Rapid selection and immediate occupation of position is a crew effort requiring close teamwork between tank commander, driver, and gunner. Selection of the position is the tank commander's responsibility; however, a trained driver will constantly search for good positions so that he can move in immediately. When moving from turret to hull defilade, the driver is directed by the gunner. With the gun level, the gunner looks through his sight and halts the driver when the target area is just visible.

b. Although the machine guns may be fired effectively from a moving tank, shooting on the move with the main gun is extremely difficult and inaccurate. The tank gun will habitually be fired from stationary positions except in emergency situations, or unless the tank gun is stabilized.

86. Employment of Tank Weapons

The decision of whether to employ the tank gun or the machine guns is primarily based on considerations of target vulnerability and range. The tank gun is used to engage such hard targets as armor and fortifications, and soft targets which are beyond the effective range of the machine guns. The tank machine guns are employed against soft targets at close ranges, such as troops and thin-skinned vehicles. The tank gun has the greater destructive effect; however, machine guns have a greater volume of fire, give better area coverage, and can be more rapidly adjusted. The machine guns can be effectively fired from a moving tank and should be employed in the final assault of an objective because of their combined destructive, neutralization, and psychological effect against the defenders. In cases where either weapon could be used, the machine gun should be employed because of its greater volume of fire and the resulting conservation of tank gun ammunition for engagement of targets beyond the capabilities of machine gun ammunition.

CHAPTER 7

DIRECT FIRE

Section I. INTRODUCTION

87. General

Tanks employ direct fire whenever the target can be seen through the direct-fire sights. Direct laying is the most effective method of conducting tank fire; it affords the greatest accuracy and, consequently, maximum target destruction. This chapter discusses conduct of direct fire to include rapid engagement of enemy targets, initial and subsequent fire commands, adjustment of fire on stationary and moving targets, and special techniques of target destruction. The material contained in this chapter is applicable to all standard tanks.

88. Firing Duties

Effective tank fire is dependent on the skill and the coordinated action of the tank crew. The general firing duties performed by the individual members of the crew are listed below.

Tank commander .....Controls movement of the tank and actions of the crew; observes for and selects targets; gives initial fire commands and subsequent commands when necessary; lays tank guns for direction; ranges on targets (on tanks so equipped); supervises and assists gunner in adjusting fire; controls volume of fire; and fires turret-mounted machine gun.

Gunner .....Observes for targets; ranges on targets (on tanks so equipped); aims and fires the main gun and coaxial machine gun by use of direct and auxiliary fire-control equipment; adjusts fire of main gun and coaxial machine gun.

Loader .....Loads the main gun and coaxial machine gun; inspects, cleans, and stows ammunition; reduces stoppages and assists in the removal of misfires and reduction of other malfunctions.

Bow gunner .....Observes for targets; fires the bow machine gun (certain tanks do not have a bow gunner).

Driver .....Observes for targets; maneuvers and positions the tank for firing.

Section II. INITIAL FIRE COMMANDS

89. General

The initial fire command contains the necessary information to permit the crew to load, aim, and fire the tank weapons. The initial fire command is issued by the tank commander to his crew, and by the platoon leader to his platoon or a specific tank. Standard terminology, commonly referred to as "tankers' terminology," and sequence are used to achieve effectiveness and speed. The type of equipment used may allow omission, of certain elements of the command; however, the sequence of elements remains the same. For stationary targets, the initial fire command contains four, five, or six elements; for moving targets, five, six, or seven elements. Given below is an example of an initial fire command, showing sequence of elements and actions performed by the crew as each element is announced.

Element	*Example*	*Crew firing duties*
Alert	GUNNER	Entire crew is alerted. Gunner turns on turret power switch; loader unlocks manual safety, if necessary. Tank commander commences laying gun for direction, using power control.
Ammunition (and fuze, if necessary).	SHOT	Loader selects and loads announced ammunition, setting fuze if necessary, remains clear of recoil, and announces UP. Gunner turns on gun switch and indexes announced ammunition in computer or range finder. If using a ballistic unit or telescope, gunner notes announced ammunition and awaits next element of initial fire command.
Range (omitted when range finder is used as ranging instrument and is linked to sight, or if tank commander can index range).	ONE TWO HUNDRED	Tank commander may index range on range finder or announce range. If range is announced, gunner indexes range on computer, range finder, or ballistic unit, or uses telescopic sight.
Direction (normally omitted because tank commander lays for direction, using power controls and direct-fire sight).	TRAVERSE RIGHT—STEADY—ON	If direction is announced, gunner follows instructions of tank commander, who uses his direct-fire sight to insure that gunner lays on selected target.

Element	*Example*	*Crew firing duties*
Description	TANK	Upon hearing description and observing target in direct-fire sight, gunner announces IDENTIFIED. Tank commander then releases his control, and gunner positions the reticle so that he (or tank commander) can range on the target. After gunner ranges, he moves the gun to place the aiming cross of the direct-fire sight on the center of critical mass of the target. If the range finder is not used, gunner immediately places the aiming cross of the periscope or appropriate range line of the telescopic sight on the center of critical mass.
Lead (used only when engaging moving targets).	ONE LEAD	Gunner takes announced lead from center of critical mass of the target. Lead is maintained by tracking before, during, and after firing.
Command to fire	FIRE	After making final precise lay, gunner announces ON THE WAY, and fires. If tank commander uses the range finder, he does not command FIRE until he has completed ranging.

90. Alert Element

a. The alert is the first element of the initial fire command. It alerts the crew or unit to the presence of a target and designates the crewman or tank to fire.

b. Standard terminology is used for the alert. Examples are—

(1) GUNNER .....The gunner is alerted to fire.
(2) BOG .....The bow gunner is alerted to fire.
(3) GUNNER-BOG .....The gunner and bog are alerted to fire.
(4) PLATOON .....The platoon leader alerts his entire platoon.
(5) NUMBER THREE...The platoon leader alerts a specific tank.

Note. For reasons of security, the radio call sign for the entire platoon or for a specific tank may be substituted for PLATOON or NUMBER THREE.

91. Ammunition Element

a. The following common descriptive terms are used to announce the ammunition element:

Ammunition	*Term*	*Type targets normally engaged*
High explosive	HE	Troops, crew-served weapons, thin-skinned vehicles, bunkers, pillboxes.

Ammunition	*Term*	*Type targets normally engaged*
Armor-piercing (AP).	SHOT	Light and medium tanks.
Hyper-velocity armor-piercing (HVAP).	HYPER SHOT	Heavy tanks.
Hyper-velocity armor-piercing, discarding sabot (HVAP-DS).	SABOT	Heavy tanks.
High explosive antitank.	HEAT	Heavy tanks, bunkers, pillboxes.
Canister	CANISTER	Troops.
White phosphorus	SMOKE	For screening, incendiary, or casualty-producing effect.
Caliber .30 MG	CALIBER THIRTY	Same as HE at close range.

b. There are two types of fuzes for high explosive shells—a standard fuze with a setting sleeve for superquick or delayed detonation, and a concrete-piercing fuze. Both fuzes are interchangeable and either may be affixed to a round by the crew. The standard HE round is stowed in the tank with the fuze set on superquick (SQ). To obtain delay action, the tank commander announces HE DELAY, and the loader will turn the sleeve to setting DELAY. Concrete fuzes are issued for special purposes, either as part of a complete round or separately. Concrete fuze is called for as HE CONCRETE. If no fuze is mentioned, the loader loads HE with the superquick setting.

c. Upon hearing the ammunition element, the loader loads immediately, announcing UP. He continues to load the announced type of ammunition until a change in ammunition or CEASE FIRE is given.

92. Range Element

a. This element is omitted from the initial fire command when the tank commander or the gunner ranges on the target, or when the tank commander can physically index the range into the direct-fire control system. Whenever range must be announced, it will normally have been obtained by estimation and is usually announced to the nearest 100 yards. However, if the tank commander can accurately determine the range, he may announce it to the nearest 50 yards. Because the yard is the standard unit of measure for range, the words "range" and "yards" will not be included in the range element.

b. For clarity and standardization, all numbers (range, deflection, elevation) used in tank gunnery are announced as follows:

25 ..... TWO FIVE
100 ..... ONE HUNDRED
250 ..... TWO FIVE ZERO
1,800 ..... ONE EIGHT HUNDRED
3,000 ..... THREE THOUSAND
4,050 ..... FOUR ZERO FIVE ZERO

93. Direction Element

This element will normally be omitted in the initial fire command because the tank commander, whenever possible, lays the tank gun for direction, using his power control and direct-fire sight. He does this immediately while issuing the command. If the tank commander has no power, if he is otherwise engaged, or if a platoon leader is issuing an initial fire command to his unit or to a tank other than his own, it will be necessary to include this element. Examples of laying a single tank or tank unit for direction are listed in *a* through *d* below.

a. Traverse Right (Left)—Steady—On. As the tank commander commands TRAVERSE RIGHT (LEFT), the gunner traverses rapidly in the appropriate direction. As the gun approaches the target, STEADY is given, and the gunner slows his traverse. When the gun is laid on or near the target, the tank commander commands ON, and the gunner stops traversing. The tank commander should use his direct-fire sight to insure that the gunner lays on the selected target.

b. Reference Point and Deflection. To assist the gunner in locating the target, the tank commander may use a reference point and a shift in mils. The reference point must be one which the gunner can easily recognize. The tank commander measures, with his binocular, the deflection from the reference point, and announces the shift. For example, he commands REFERENCE POINT CROSS ROAD, RIGHT THREE ZERO. The gunner zeroes his azimuth indicator on the reference point, traverses right 30 mils, and looks for his target. Small shifts are made by using lead lines in the sight reticle.

c. General Direction. When the target is unmistakable, the tank commander may command DIRECT (LEFT OR RIGHT) FRONT or RIGHT (LEFT) FLANK. This method is normally used to direct a platoon, but may also be used to direct the gunner. Direct front is the direction in which the main gun tube is pointing, not necessarily the front of the tank.

d. Firing Gun. To lay the platoon for direction rapidly and accurately, or to identify an obscure target, the tank commander or platoon leader may fire his machine gun or main gun at the target. The direction element is then announced as WATCH MY TRACER (BURST). When the platoon leader's tank is not visible to all tanks or when other fire is being placed in the target area, it may be necessary for the platoon leader to combine methods, such as RIGHT FRONT, WATCH MY BURST.

94. Description Element

a. The description element is always announced so that the gunner can rapidly identify and lay on the target. To avoid misunderstanding, the

description must be clear and concise. Most of the targets encountered can be designated by using the following standard terminology:

Any tank or tank-like vehicle	TANK.
Any unarmored vehicle	TRUCK.
Personnel	TROOPS.
Any type of machine gun	MACHINE GUN.
Any antitank gun or artillery piece	ANTITANK.
Any building	HOUSE.
Any other target	Briefest term consistent with clarity.

b. If several targets are in view, the tank commander can specify the particular target by announcing FIRST TANK or LAST TRUCK or some other brief descriptive phrase. When a target is concealed, it is described as it appears to the gunner; for example, GREEN BUSH—ANTITANK or LEFT WINDOW—TROOPS.

c. When the gunner has positively identified the target, he will immediately announce IDENTIFIED, *not* waiting for the tank commander to finish the initial fire command. This is the signal for the tank commander to release his power controls. The gunner then takes over control of the gun, positions the reticle for ranging (on tanks equipped with range finders), and makes the final precise lay on the target.

95. Lead Element

The lead element is included in the initial fire command only when a moving target is engaged. Normally a moving target is initially engaged with one lead (5 mils) regardless of range or speed of the target. For a discussion of firing at moving targets, see paragraphs 109 through 114.

96. Command to Fire

The command to open fire is announced as FIRE. This command tells the gunner to fire when ready. If the tank commander is determining range by use of a range finder, he will not command FIRE until he has completed ranging. When the tank commander decides to open fire at a specific time, he will hold the command, commanding FIRE when ready. Before firing, the gunner announces ON THE WAY. During periods of training, the gunner will pause approximately one second between announcing ON THE WAY and firing. In combat, where rapid engagement of enemy targets is vital, there should be no pause. After firing, the gunner will continue to fire, without further command, until the tank commander commands CEASE FIRE or otherwise assumes direct control of the firing.

97. Repeating Initial Fire Command

a. When a crew member fails to hear or understand any part of an initial fire command, he announces the misunderstood element(s) as a

question. For example, he may ask AMMO?, DESCRIPTION?, or AMMO-RANGE?

b. When a crew member requests repetition of any part of the initial fire command, the tank commander repeats only the element(s) requested. For example, if the gunner or loader asks AMMO?, the tank commander repeats SHOT.

c. If the gunner asks DESCRIPTION?, he has failed to positively identify the target. To correct this, the tank commander will lay his aiming cross on the target and then repeat the description element.

98. Correcting Initial Fire Command

a. To correct an error in an initial fire command before giving the command FIRE, the tank commander announces CORRECTION and corrects the element in error. He then completes the command by announcing all elements after the corrected element.

Examples:

GUNNER
HE
TANK
CORRECTION
ANTITANK
FIRE.

GUNNER
SHOT
ONE SIX HUNDRED
ANTITANK
CORRECTION
HE
ONE SIX HUNDRED
ANTITANK
FIRE.

b. To correct an error after giving the command FIRE, before the gunner has executed it, the tank commander announces CORRECTION. He then corrects the incorrect element and again commands FIRE.

Example:

GUNNER
SHOT
ONE THOUSAND
TANK
FIRE.
CORRECTION
ONE TWO HUNDRED
FIRE.

c. The tank commander will not normally correct an eror in the ammunition element after the gun has been loaded; instead, he will allow the gunner to fire the chambered round, then will give a change in the ammunition as a subsequent fire command. Once the gunner has fired, any correction or change to any element will also be made by a subsequent fire command.

99. Subsequent Fire Commands

Any command to control firing issued after the initial fire command has been given is a subsequent fire command. The tank commander issues subsequent commands to change an element in the initial fire command or a previous subsequent command, to cease fire, and when it is necessary for him to employ the alternate method of adjustment. See paragraphs 105 through 108.

Section III. SENSINGS

100. General

A sensing is a mental notation of the round in relation to the target. Every round fired is sensed for deflection and range, by both the tank commander and gunner. A tracer round is sensed where the tracer strikes short of, passes, or hits the target; nontracer rounds are sensed at the point of burst. The strike or burst must be sensed immediately to avoid errors caused by drifting smoke or dust. The gunner uses his direct-fire sight as an aid in sensing, while the tank commander normally uses his binocular.

101. Deflection Sensings

Deflection sensings are mental notations of whether the round is on line with or to the side of the aiming point. These sensings are measured as so many mils left or right of the target and are not announced. For example, the tank commander or gunner might sense a round as *two left* or *line*. There should be little or no error in deflection.

102. Range Sensings

There are five range sensings—TARGET, OVER, SHORT, DOUBTFUL, and LOST. These sensings are mental; however, under certain circumstances they may be announced. If the gunner cannot observe his tracer or brust, he will announce LOST. This is the only sensing the gunner will announce. The tank commander will announce any pertinent range sensing when the gunner announces LOST or when the tank commander otherwise takes over adjustment of fire.

a. Target. In tank gunnery, a round is sensed as TARGET (fig. 48) when the round or shell fragments actually strike the target and cause it to change shape, move, disappear, or pieces to fly off it. When HE or shot strikes a metal object, there is usually a distinctive orange flash. A hit on any part of the target is sensed as TARGET; however, adjustment to a more vulnerable part may be required to obtain a *kill.*

b. Over. A round is sensed as OVER (fig. 49) when the burst appears beyond or the tracer passes above the target. A tracer round is sensed

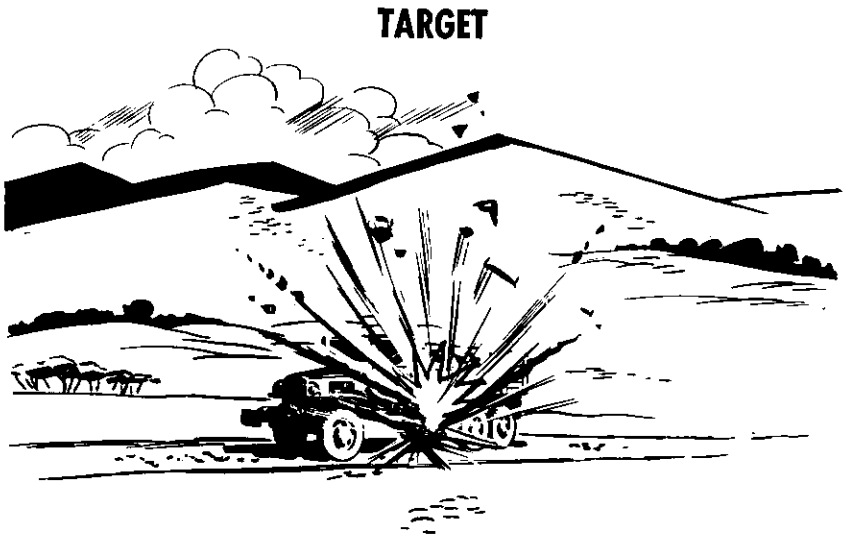


Figure 48. Sensing of TARGET.

at the exact point where it passes over the target; a nontracer round is sensed at the point of burst. Overs are also mentally sensed for deflection; for example, OVER, *three right.*

c. Short. A round is sensed as SHORT (fig. 50) when either the burst or strike is observed between the gun and the target. Both tracer and nontracer rounds are sensed at the point of burst or strike. The strike must be observed carefully and sensed immediately, since the target is sometimes temporarily obscured by smoke and dust. Shorts are also mentally sensed for deflection; for example SHORT, *line.*

d. Doubtful. A round is sensed as DOUBTFUL (fig. 51) when it appears to be correct for range but the tracer passes or the burst strikes left or right of the target. Since a deflection correction is normally sufficient to secure a target hit, no range change is made on a DOUBTFUL sensing. An example of this mental sensing is DOUBTFUL, *two right.*

e. Lost. A round is sensed as LOST (fig. 52) when the gunner or tank commander fails to observe the point of strike, burst, or tracer. The point of strike may not be visible due to obscuration, terrain, or failure of the round to detonate. Based on his terrain appreciation, the tank commander may be justified in making a range change if he feels that the round has been lost due to the terrain. This is the one sensing which must be announced by the gunner. It is announced so that the tank commander will know that the gunner cannot observe the point of strike. It is announced simply as LOST.

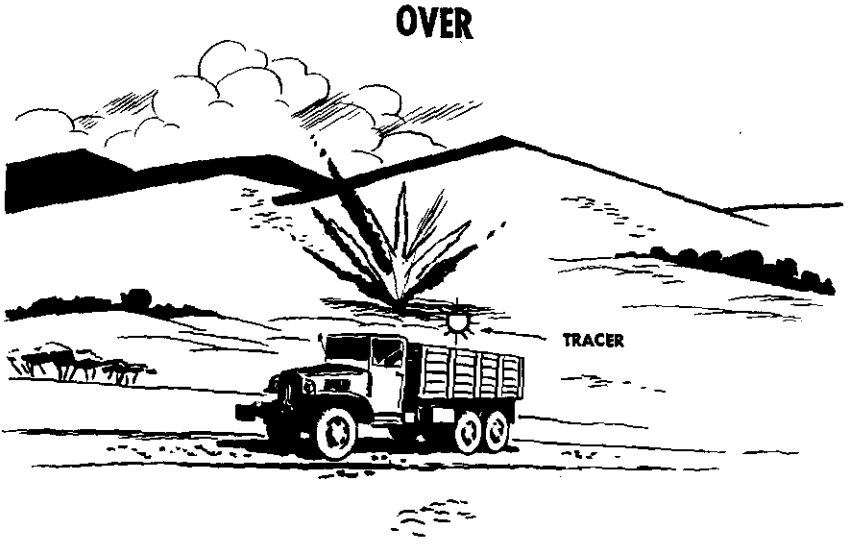


Figure 49. Sensing of OVER.

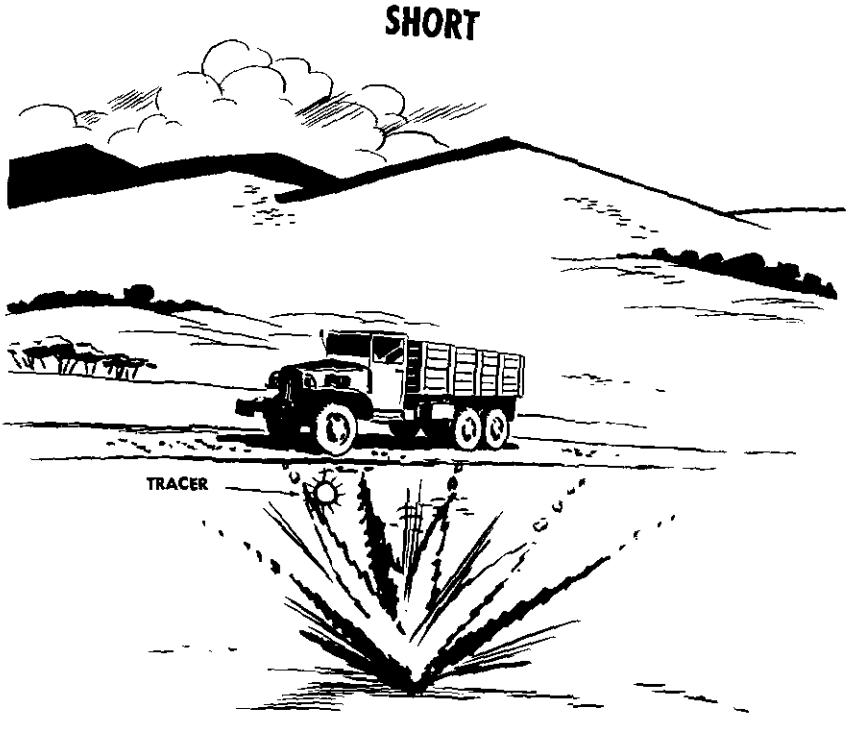
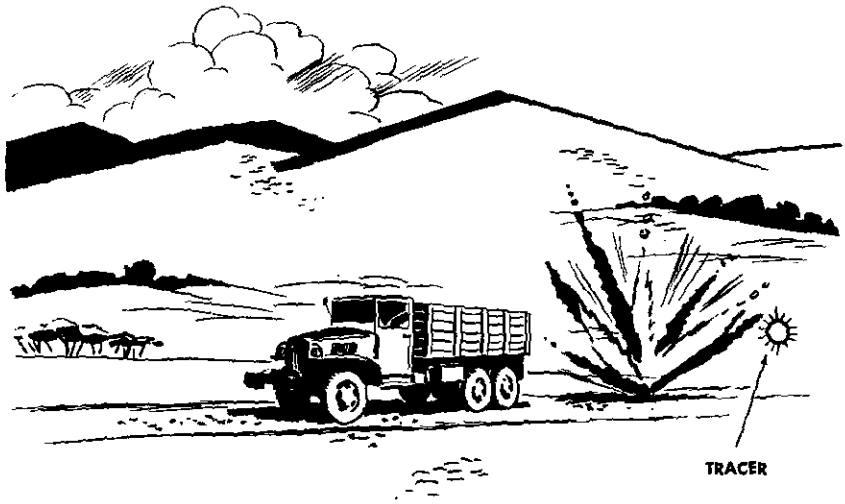


Figure 50. Sensing of SHORT.

DOUBTFUL

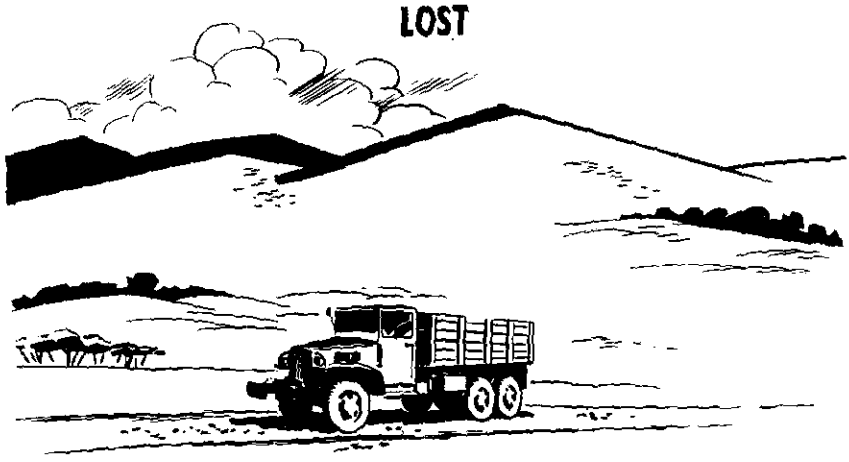


RANGE IS NEVER CHANGED

WITH SENSING OF DOUBTFUL.

Figure 51. Sensing of DOUBTFUL.

LOST



ROUND MAY BE LOST DUE TO:

1. **TERRAIN**
2. **OBSCURATION**
3. **FAILURE TO DETONATE (DUD)**

Figure 52. Sensing of LOST.

Section IV. ADJUSTMENT OF FIRE ON STATIONARY TARGETS

103. General

a. The ultimate goal in tank gunnery is a fast first-round kill. Due to the excellent fire-control equipment and the relatively flat trajectory of the tank gun, it is well within the capabilities of a well-trained crew to consistently achieve target destruction with a single round. Therefore, the standard for tank gunnery is a first-round kill. This standard, however, must be approached realistically. Such factors as crew skill and target nature will obviously affect achievement of this goal. If the target is not hit or is not hit in a vulnerable spot, it is necessary to adjust fire on the target rapidly so that maximum destruction is obtained with the minimum number of rounds. There are two methods of adjusting direct fire on a target. The primary method is applied by the gunner and is known as *burst-on-target.* The secondary method involves the tank commander and is known as the *alternate method.* With both methods, the gunner lays and fires the gun. The tank commander has firing controls and a direct-fire sight; however, he has so many responsibilities in connection with commanding his tank or unit that he should not fire the main gun except in an emergency situation.

b. Regardless of the method used, the adjusting or aiming point is the same. In tank gunnery, fire is adjusted on the *center of critical mass* of the target. This is defined as the center of the most vulnerable part of the target and is normally referred to in tank gunnery as the *center of mass.* On many targets, this will be the exact center; however, this does not always hold true. The center of mass will vary with the type of target and the angle at which it is engaged. For example, the heaviest armor of a tank is normally on the front slope plate and the turret. The most vulnerable parts of a tank are the sides and rear. Whenever possible, the gunner should aim at these parts rather than the turret or frontal armor. If only the front of an enemy tank is presented, then the center of mass is the turret ring. The purpose of aiming at or near the center of mass is to increase the probability of a target hit and kill. The relatively flat trajectory of tank guns will often allow a hit somewhere on the vertical surface of the target even if the determined range is not exactly correct.

104. Primary Method of Adjustment

a. The primary method of adjustment is *burst-on-target,* in which the gunner observes through his direct-fire sight and notes the point on the sight reticle where the burst or tracer appears in relation to the target. Without command from the tank commander, the gunner then moves that point of the sight reticle onto the center of mass of the target, announces ON THE WAY, and fires again. He continues to fire,

adjusting on the center of mass, until the tank commander commands CEASE FIRE. While the gunner makes the adjustment, the tank commander, acting as a silent observer, senses each round. The tank commander, by issuing subsequent fire commands, takes over the adjustment if he is not satisfied with the adjustment, if he wishes to cease fire, or when the gunner has announced LOST.

b. Accuracy of the burst-on-target method depends on the ability of the gunner to take consistently correct sight pictures and make precise sensings. The gunner first takes the correct sight picture on the center of mass. After firing, he immediately checks his lay and re-lays if necessary, so that the round appears on the sight reticle in proper relation to the target. After noting the exact point on the sight reticle where the burst or tracer appeared, he uses his gun controls to move that point, by the most direct route, onto the center of mass. Thus applied, burst-on-target provides an accurate, rapid means of obtaining second-round hits or of adjusting target hits to a more vulnerable part of the target.

c. Typical examples of this primary method of adjustment, showing gunner's application with the standard type sight reticles, appear in (1), (2), and (3) below.

(1) *Situation 1, gun-laying reticle; target, stationary tank.*

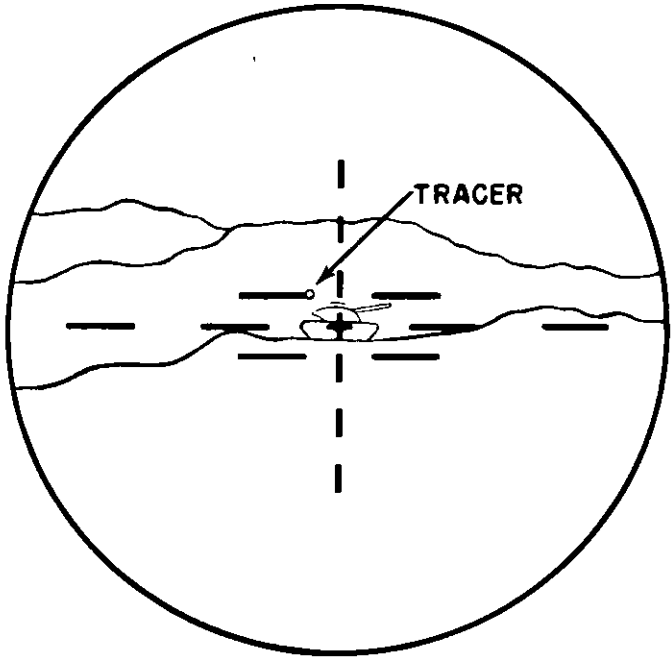


Figure 53. Situation 1, first round.

(*a*) After firing, the gunner immediately checked his lay. This round was over and to the left (fig. 53).

(*b*) The gunner mentally noted the point on the sight reticle where the tracer passed the target and, with the gun controls, moved that point to the center of mass of the target by moving the gun down and to the right. Without command, he fired again and obtained a target hit (fig. 54).

(2) *Situation 2, gun-laying reticle; target, antitank gun.*

(*a*) The gunner immediately checked his lay after firing and noted that the first round struck short of the target and on line with the center of mass (fig. 55).

(*b*) The gunner mentally noted the point on the sight reticle where the burst appeared and, with the gun controls, moved that point to the center of mass of the target. Without command, he fired the next round and obtained a target hit (fig. 56).

(3) *Situation 3, standard dash pattern reticle; target, stationary tank.*

(*a*) The tank commander issued the following initial fire command: GUNNER, SHOT, ONE THOUSAND, TANK, FIRE. After announcing IDENTIFIED, the gunner placed

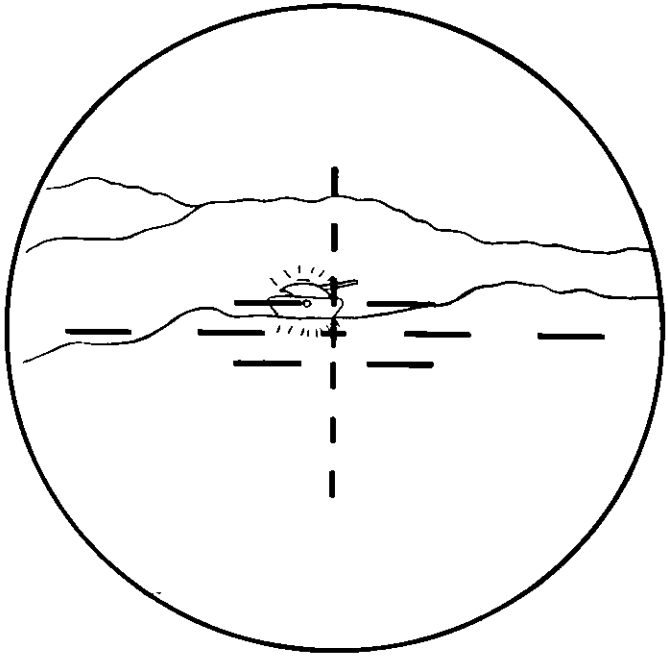


Figure 54. Situation 1, second-round hit.

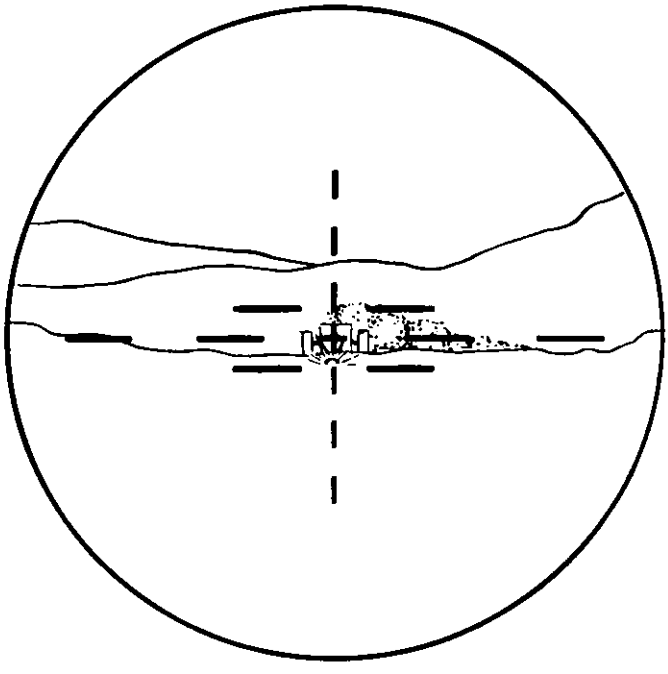


Figure 55. Situation 2, first round.

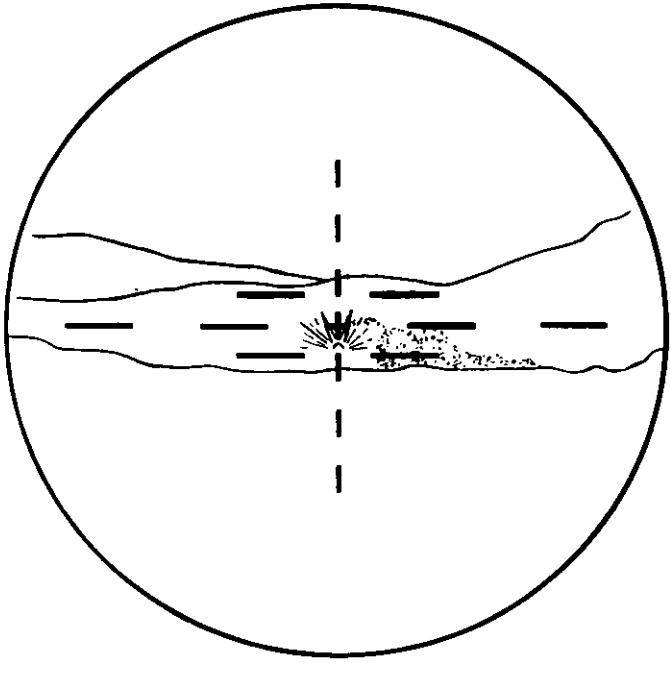


Figure 56. Situation 2, second-round hit.

the 1,000-yard range line on the center of mass of the target, announced ON THE WAY, and fired.

(*b*) The gunner immediately checked his lay after firing and noted that the first round hit the target to the left of the aiming point (fig. 57).

(*c*) The gunner mentally noted the point on the sight reticle where the strike appeared and, with the gun controls, moved that point to the center of mass. Since the tank commander remained silent, the gunner fired again and hit the center of the tank hull. The enemy tank burst into flames (fig. 58) and the tank commander announced TARGET, CEASE FIRE.

d. Although burst-on-target is the most accurate and rapid method of adjustment, there are certain conditions under which it cannot be effectively applied. When there is partial obscuration, or during firing over flat terrain at extreme ranges, burst-on-target is difficult to apply accurately. Also, if the gunner cannot observe the round, he cannot apply burst-on-target. In such cases, the alternate method of adjustment is used.

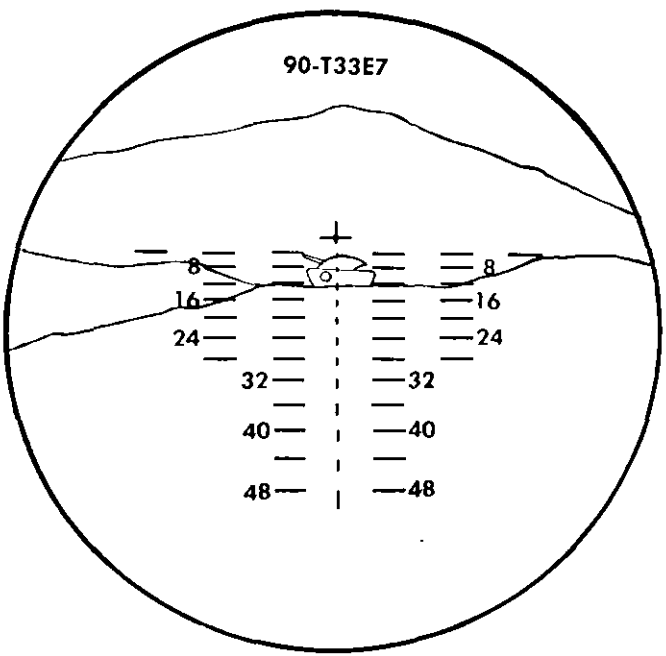


Figure 57. Situation 3, first-round hit.

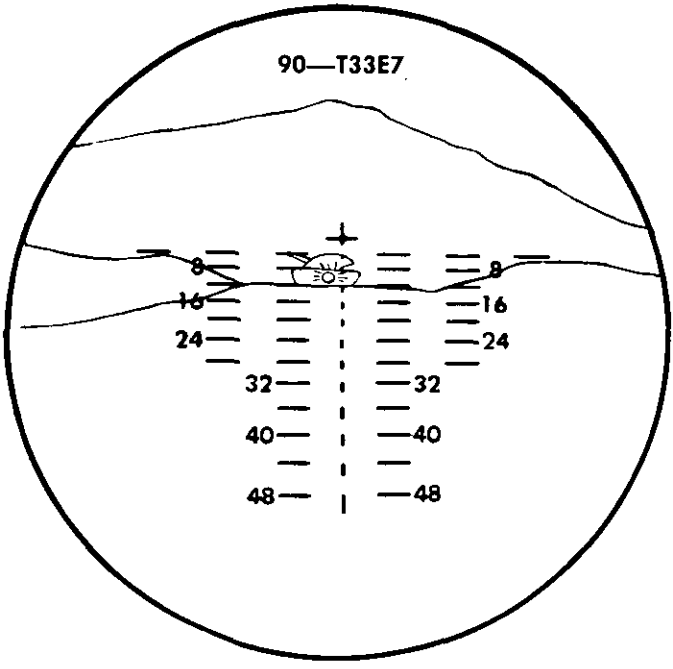


Figure 58. Situation 3, second-round kill.

105. Alternate Method of Adjustment

a. General. The alternate method of adjustment is the tank commander's means of adjusting fire when the primary method cannot be used or applied effectively. An announced sensing of LOST by the gunner indicates to the tank commander that he must take over from the gunner, since burst-on-target cannot be applied. The tank commander also employs the alternate method whenever it is obvious that the gunner is not adjusting properly or has made some other error, such as firing on the wrong target. The tank commander employs the alternate method by announcing his range sensing and issuing a subsequent fire command. The announced sensing is not part of the subsequent fire command, but will precede the command as a signal to the gunner that the tank commander is going to issue a subsequent fire command.

b. Subsequent Fire Command. The tank commander issues subsequent fire commands to change an element of a fire command, to cease fire, and to employ the alternate method of adjustment. When used in the alternate method, the subsequent fire command may consist of one, two, or three elements. If all elements are required, they are issued in the following sequence for firing at stationary targets: *deflection, range, command to fire.* Deflection and/or range corrections are omitted if not required; however, the command to fire is always given. Examples of typical announced sensings and subsequent fire commands are—

Sensing:	OVER	SHORT	DOUBTFUL	LOST	TARGET
Command:	RIGHT 2 DROP 200 FIRE.	ADD 400 FIRE.	LEFT 3 FIRE.	DROP 400 FIRE.	CEASE FIRE.

c. Deflection Corrections. The deflection element of the subsequent fire command is obtained from the tank commander's mental deflection sensing. The tank commander measures with his binocular the number of mils that the round passed or struck to the left or right of the center of mass of the target. He then commands the gunner to shift the measured number of mils in the opposite direction. For example, if the mental deflection sensing is *two left*, the announced deflection correction would be RIGHT TWO. If the round is sensed as *line*, the deflection element is merely omitted in the command. Since lateral dispersion is negligible with tank guns, there should be little or no error in deflection. A deflection error of more than three mils indicates improper sight picture, improper boresighting and zeroing, cant error, or failure to correctly identify the target.

d. Range Corrections. The range element of the subsequent fire command is based on the tank commander's announced range sensing. If the round is short, the tank commander *adds* range; if the round is over, he *drops* range. Range is changed for the initial adjusted round by use of the *standard range change*. The purpose of the standard range change is to obtain a target hit, to move the strike closer to the target so the gunner can observe the round and apply burst-on-target, or to provide a yardstick on the ground if the tank commander must continue to adjust. The standard range change applies only to the first adjusted round. Once an adjustment has been made (either by burst-on-target or by the alternate method) or a target hit obtained, the tank commander is no longer held to the standard range change, but may make any range change he feels is necessary to hit the center of mass. Range changes are normally made in multiples of 50 yards; if the necessary range change is less than 50 yards, the command is ADD (DROP) A HAIR. Use of the standard range change depends upon the conditions under which it is employed. These conditions are—

(1) When a range finder or other *accurate* means has been used to determine the initial range to the target (see note below), the standard range change is *200 yards* regardless of tank-to-target range. If the gunner fails to observe the first round, he announces LOST. The tank commander then announces his sensing and issues a subsequent fire command, making any necessary deflection change and adding or dropping 200 yards if there was a range error. If the next round does not destroy the

target, the gunner applies burst-on-target if possible. If this second round is also lost to the gunner, the tank commander continues with the adjustment, making necessary deflection and range changes to destroy the target.

Note. Accurate methods of range determination are range finder, registration, and intersection. Use of the mil relation to obtain range is only as accurate as the means of determining the mil angle and the width or height of the target. Maps are very accurate if both tank and target can be pinpointed. Range information from friendly troops may or may not be accurate, depending on the means used. Estimation by eye is rapid and effective, but not necessarily accurate.

(2) When the initial range to the target is estimated, the range change depends on the estimated range. If the estimated range is *1,500 yards or less,* the standard range change is 200 yards; if the estimated range is *over 1,500 yards,* the standard range change is 400 yards. The procedure for applying the standard range change is the same as in (1) above.

e. Large Range Error. If an extremely large error is made in the initial estimated range, the tank commander may announce a new range element—for example, RANGE TWO FOUR HUNDRED—or he may cease fire and then issue a new initial fire command to insure target identification as well as correct range.

f. Lost Rounds.

(1) Regardless of the means of determining range, if the gunner fails to observe a round *after* applying burst-on-target, the rule of the standard range change does not apply. The tank commander can make any deflection and range change that he feels is necessary to destroy the target.

(2) When the gunner fails to observe the round, he announces LOST. If the tank commander fails to observe the round, he also announces LOST and issues a subsequent fire command. Depending on the circumstances, he may not change the range, or he may give a range change to bring the next round to where it can be observed.

106. Application of Alternate Method

The tank commander bases his subsequent fire command on his sensing. The gunner applies the correction by use of his direct-fire sight.

He makes deflection corrections by use of the lead lines, moving the gun left or right the indicated number of mils. He makes range changes by use of the range lines, moving the gun up or down to change range by the indicated number of yards. Since the range lines of the sight reticle are graduated in mils, the value of C must be applied to convert the range change in yards to a mil change on the sight. For tank gunnery purposes, the C for 76-mm and 90-mm guns is 1 mil; that is, a 1-mil change in elevation will change the range 100 yards. For an example of application of the alternate method, see figure 59.

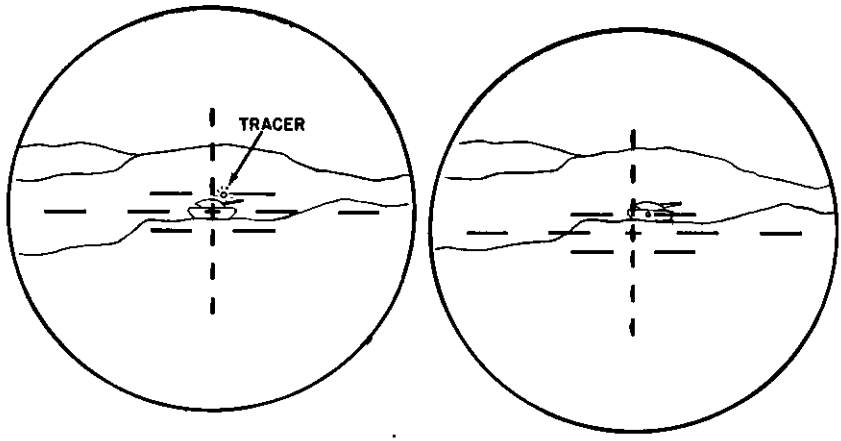


Figure 59. Application of alternate method. Tank commander mentally senses first round as OVER, two right; announces OVER, LEFT TWO, DROP TWO HUNDRED. Gunner applies correction by moving gun 2 mils left and 2 mils down.

107. Repeating and Correcting Subsequent Fire Commands

a. Repeating Commands. The procedure for repeating subsequent fire commands is the same as that for initial fire commands (par. 97), in that the crewman requests a repetition by announcing the element as a question and the tank commander repeats only that element requested. For example, if the gunner asks RANGE? the tank commander repeats ADD TWO HUNDRED.

b. Correcting Commands. To correct an error in a subsequent fire command, the tank commander announces CORRECTION and then issues a corrected command. The sensing is not repeated unless it was announced incorrectly.

Example:

Sensing:	OVER	DOUBTFUL	SHORT
Command:	RIGHT THREE	LEFT TWO	DROP FOUR HUNDRED
	ADD TWO HUNDRED	FIRE.	CORRECTION
	CORRECTION	CORRECTION	OVER
	RIGHT THREE	RIGHT TWO	DROP FOUR HUNDRED
	DROP TWO HUNDRED	FIRE.	FIRE.
	FIRE.		

c. Correcting Errors by Adjustment. If the gunner fires before an error in the initial or subsequent fire command is corrected, the correction is made by adjustment of fire. Errors in the deflection or range elements can be corrected by either burst-on-target or the alternate method. An extreme range error which would preclude use of burst-on-target or the standard range change can be corrected by a new range element. However, what appears to be a large range error may be failure to identify the target, or some other factor. In such cases it is best to cease fire and issue a new initial fire command.

108. Changing Ammunition (Fuze)

During firing, it may be necessary to designate a different type of ammunition or fuze. This may be due to an error in the ammunition element of the initial fire command or a change in the nature of the target. For example, if a round of shot has penetrated a pillbox or heavy masonry building and the tank commander desires to fire HE delay through the opening, he commands FIRE HE DELAY. The loader immediately loads, announcing HE DELAY UP. He will continue to load the new ammunition until he hears CEASE FIRE or another change. The gunner notes where the shot round appeared on his sight reticle with relation to the target. He then indexes HE in order to compensate for the difference in superelevation between shot and HE, re-lays with the same sight picture, and fires. The same procedure is used to change a fuze setting. For example, to change from fuze superquick to fuze delay, the tank commander commands FIRE HE DELAY. Normally, a chambered round will be fired even though a change in ammunition or fuze has been announced.

Section V. ADJUSTMENT OF FIRE ON MOVING TARGETS

109. Apparent Speed

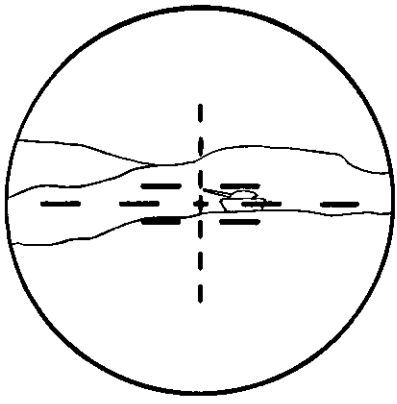
For tank gunnery purposes, a moving target is one which has apparent speed. Apparent speed (fig. 60) is defined as movement across the line of sight. Thus, targets which move across the line of sight, either at a right angle to the line of sight or on a diagonal, have apparent speed and are engaged as moving targets. On the other hand, targets which move directly toward or away from the tank have no apparent speed and are not engaged as moving targets. Targets moving with no apparent speed may require a slight elevation or depression of the tube to maintain the aiming cross on the center of mass, but otherwise are engaged in the same manner as stationary targets.

110. Leading

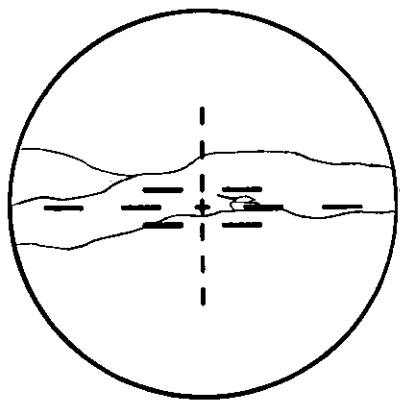
If the gunner fires a round with the gun aimed directly at a moving target, the target will move out of the path of the projectile, causing it

TANKS 1, 2, AND 3 ARE MOVING AT 10 M.P.H. TANK 1 HAS NO APPARENT SPEED. TANKS 2 AND 3 BOTH HAVE APPARENT SPEED, WITH TANK 3 HAVING THE GREATER

Figure 60. Apparent speed.



Moving target — range 1,000. Sight picture for one lead.



Same moving target — range 2,000. Sight picture for one lead. Target appears smaller due to greater range, but lead is the same.

Figure 61. Leading.

to miss the target. To compensate for this movement, the gun is aimed ahead of the target so that the projectile and target will meet. This technique is called *leading* (fig. 61). The gunner measures lead by use of the lead lines of his direct-fire sight. One lead equals 5 mils and is measured from the center of mass. Normally, moving targets are engaged initially with one lead, regardless of range or speed. Since the mil is a unit of angular measurement, range has no practical effect on lead. Speed does affect lead; however, one lead is sufficient for a hit on targets moving at battlefield speeds (1–15 MPH). Therefore the rule of thumb of taking one lead initially for all moving targets is a practical solution to a problem which would otherwise involve such considerations as speed, direction, range, ballistics, and human error.

111. Tracking

In order to maintain the proper lead, the gunner must cause the movement of the gun to keep pace with the movement of the target. This manipulation is called *tracking* and is a combination of traversing and changing elevation to maintain proper sight picture. In tracking, the gun should be traversed through and ahead of the center of mass until the proper lead is applied. The gunner tracks with a smooth, continuous motion, maintaining a constant sight picture before, during, and after firing so that a proper sensing and necessary adjustment can be made. He should not stop the movement of the gun as he fires, nor should he attempt to "ambush" the target (moving ahead of the target, stopping, and firing when the target reaches the proper lead on the sight reticle).

112. Initial Fire Command for Moving Targets

Initial fire commands are the same as those used for engaging stationary targets (pars. 89–98), with the addition that a lead element is announced just before the command to fire. Crew firing duties are also similar to those given for firing at stationary targets (par. 89); however, additional coordination is required between the tank commander and the gunner to insure continuous tracking of the target. The tank commander tracks the target while issuing his fire command until the gunner announces IDENTIFIED and takes over the controls. The gunner then tracks with no lead while ranging is accomplished (either by the tank commander or the gunner, depending on the type tank). On the command ONE LEAD, FIRE, the gunner takes one lead, continues to track, and fires. If range is announced or indexed by the tank commander, the elements of the command will be issued without pause; after identifying the target, the gunner will track, apply one lead, and fire. Depending on the situation and equipment used, the initial fire command may contain five, six, or seven elements. Examples are—

GUNNER	GUNNER	GUNNER
SHOT	HE	SHOT
TANK	ONE TWO HUNDRED	EIGHT HUNDRED
ONE LEAD	TRUCK	RIGHT FRONT
FIRE.	ONE LEAD	TANK
	FIRE.	ONE LEAD
		FIRE.

113. Primary Method of Adjustment, Moving Target

The primary method of adjustment for moving targets is burst-on-target, which is applied in a manner similar to burst-on-target for stationary targets (par. 104). The primary method will be used whenever the gunner can observe the rounds fired. The gunner fires while tracking with the correct lead and continues to track so that a proper sensing and necessary adjustment on the center of mass can be made. The gunner continues to fire without command until the tank commander gives CEASE FIRE. Typical examples of burst-on-target, showing gunner's application with the two standard type sight reticles, appear below.

a. Situation 1. Gun-laying reticle; target, moving tank.

(1) The gunner immediately checked his lay after firing. This round passed over and behind the moving target (fig. 62).

(2) The gunner mentally noted the point on the sight reticle where the tracer appeared and, with the turret controls, moved that point to the center of mass of the target. Without command, he fired again while tracking with the new sight picture, and obtained a target hit (fig. 63). Note that the gunner continued

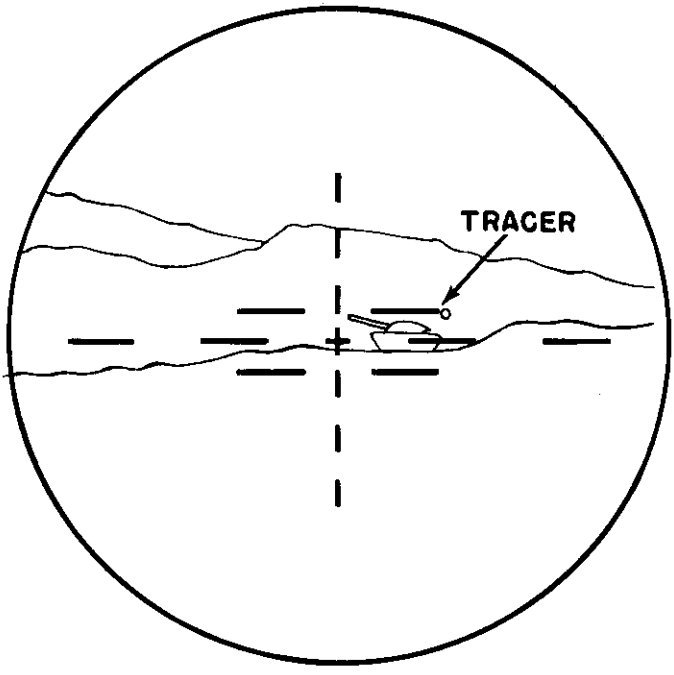


Figure 62. Situation 1, first round.

to track during the adjustment, increasing his lead to compensate for the apparent speed of the target.

b. Situation 2. Standard dash pattern reticle; target, moving tank.

(1) The gunner immediately checked his lay and noted that the round was correct for lead but over in range (fig. 64).

(2) The gunner mentally noted the point on the sight reticle where the tracer appeared over the target and, with the turret controls, moved that point to the center of mass. He fired again and obtained a target hit (fig. 65).

114. Alternate Method of Adjustment, Moving Target

a. General. The alternate method of adjustment is the tank commander's means of adjusting fire when the gunner cannot effectively apply burst-on-target. The conditions under which this method is applied are the same as those for stationary targets (par. 105).

b. Subsequent Fire Command. The tank commander employs the alternate method by announcing his range sensing and issuing a subsequent fire command. The announced sensing precedes the subsequent command. Range corrections are announced as prescribed for stationary targets, and the same standard range change rule applies. A lead correction is announced as a change in leads rather than in mils. For example, if a round passes 5 mils behind the center of mass of a target,

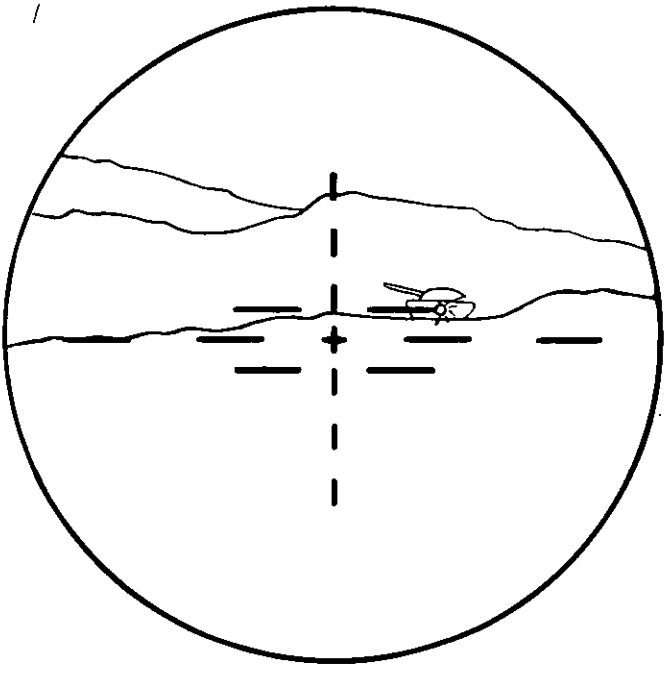


Figure 63. Situation 1, second-round hit.

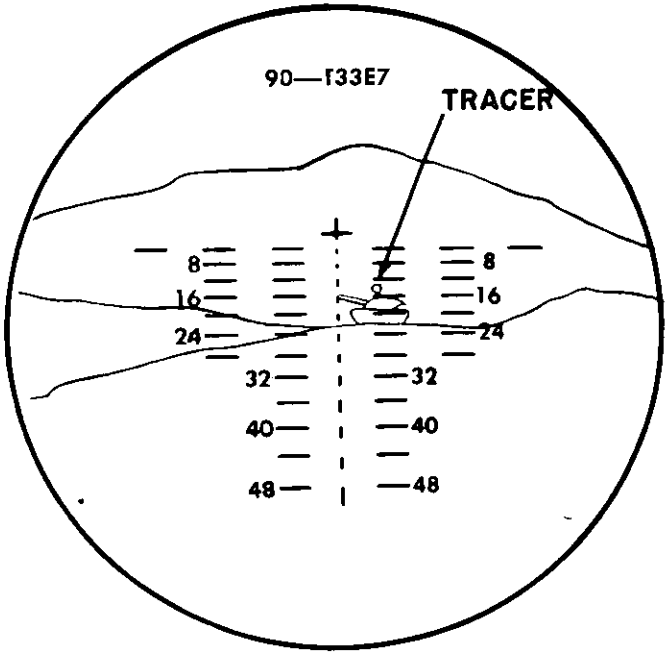


Figure 64. Situation 2, first round.

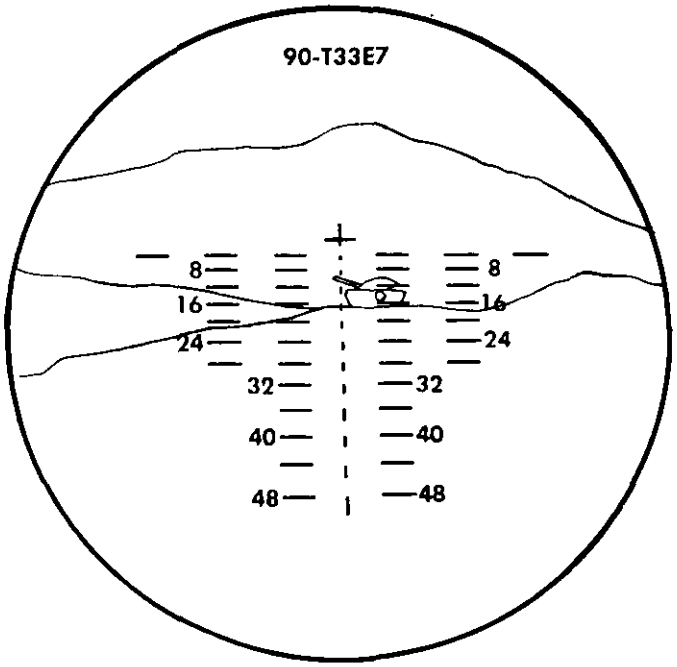


Figure 65. Situation 2, second-round hit.

the tank commander commands ONE MORE, and the gunner increases the lead accordingly. If the round passes 2½ mils in front of the center of mass, the tank commander commands ONE HALF LESS, and the gunner decreases the lead. ONE HALF is defined as half of one lead, or 2½ mils. The subsequent fire command may consist of one, two, or three elements. If all elements are required, they are issued in the following sequence: *range, lead, command to fire.* Examples of typical announced sensings and subsequent fire commands are—

Sensing:	OVER	SHORT	DOUBTFUL
Command:	DROP TWO HUNDRED	ADD FOUR HUNDRED	ONE MORE
	ONE HALF LESS	FIRE.	FIRE.
	FIRE.		

Section VI. FIRING TANK MACHINE GUNS

115. General

The tank machine gun is extremely flexible in that it can be fired effectively against a wide variety of targets from either a moving or stationary tank in offensive or defensive situations. The chief charac-

teristics of machine gun fire are dispersion and high rate and volume of fire. Volume of fire, area covered, and a killing zone from gun to target are gained and maintained by firing in bursts. Due to dispersion, the bullets of each burst do not follow the same trajectory, but scatter to form characteristic patterns in the air and on the ground. The vertical pattern is known as the *cone of fire*, and the pattern on the ground is the *beaten zone* (fig. 66). The cone of fire is oval in shape, while the beaten zone forms a long and narrow elliptical pattern (fig. 67). Thus the machine gun is a very effective weapon for engaging such soft or thin-skinned targets as troops, crew-served weapons, lightly constructed cover, and unarmored or lightly armored vehicles. While it has little destructive effect against tanks and fortifications, machine gun fire will cause tank crews to "button up" and other troops to take cover. Machine guns are effective against point targets; their dispersion and volume of fire make them ideal for engagement of area and moving targets.

116. Classes of Machine-Gun Fire

There are three general classifications of machine-gun fire (fig. 68); they are based on characteristics of the weapon, nature of the target, and the terrain within the sector of fire. All machine-gun fire will entail a combination of these three classifications, which can be further subdivided as follows:

a. Classes of Fire With Respect to Gun.

(1) *Fixed fire.* Fixed fire is fire delivered on a point or small area target. The depth of the beaten zone must be sufficient to include the target.

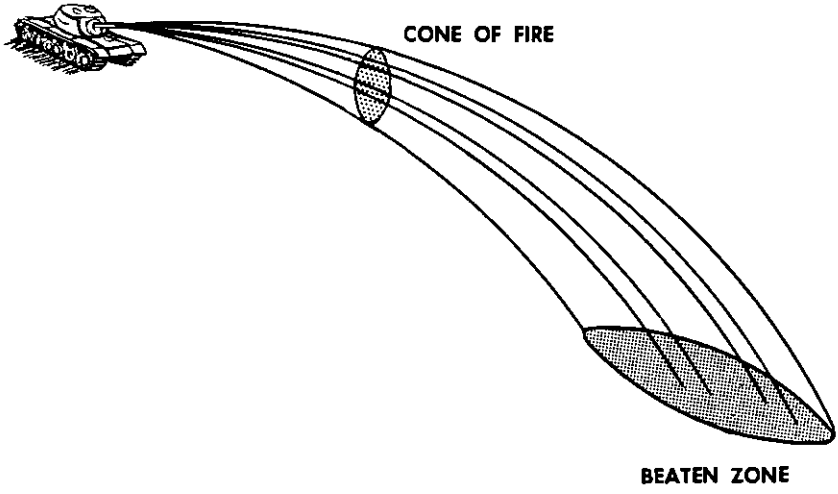


Figure 66. Cone of fire and beaten zone.

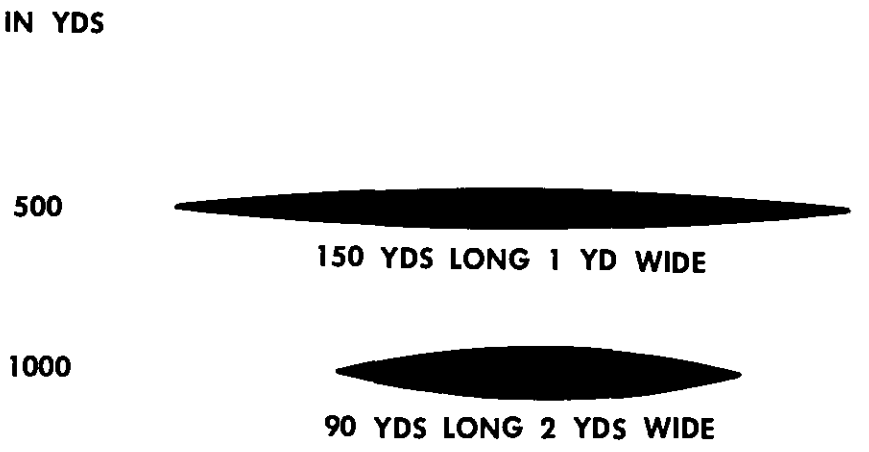


Figure 67. Approximate dimensions of beaten zones, caliber .30 machine gun.

(2) *Searching fire.* Searching fire is fire distributed in depth by successive range changes of the gun. It is used against targets too deep to be included in the beaten zone of fixed fire.

(3) *Traversing fire.* Traversing fire is fire distributed in width by successive changes in the direction of the gun. A burst of fire may be delivered after each change in direction, or a continuous burst may be fired while traversing through the target. *Traversing* and searching fire may be combined to engage targets of considerable width and depth.

b. Classes of Fire With Respect to Target.

(1) *Frontal fire.* Frontal fire is fire delivered at right angles to the front of a target.

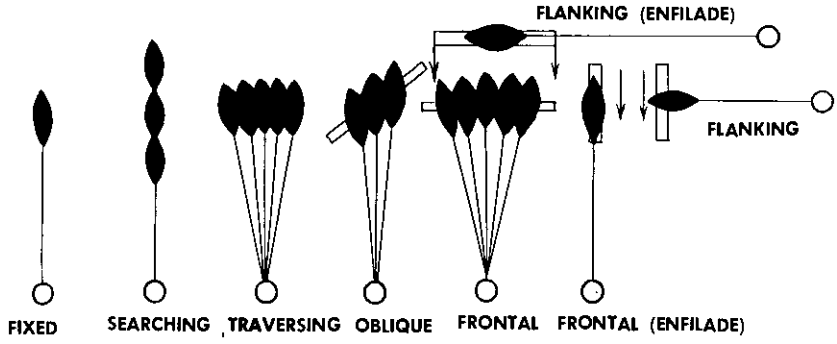
(2) *Flanking fire.* Flanking fire is fire delivered against the flank of a target.

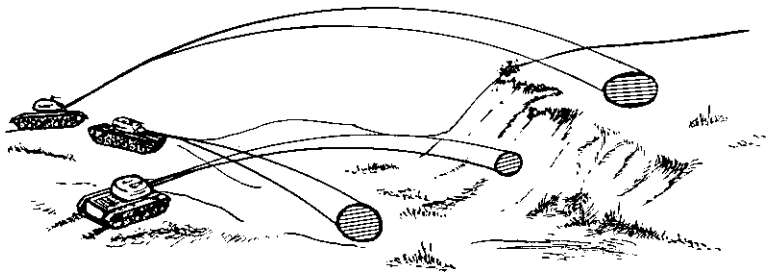
(3) *Oblique fire.* Oblique fire is fire delivered so that the long axis of the beaton zone is at an oblique to the long axis of the target.

(4) *Enfilade fire.* Enfilade fire is either frontal or flanking fire in which the long axis of the beaten zone coincides or approximately coincides with the long axis of the target.

c. Classes of Fire With Respect to Ground.

(1) *Plunging fire.* Plunging fire is that fire in which the angle of the cone of fire to the slope of the ground is such that the killing zone is practically confined to the beaten zone. Due to this angle the beaten zone is materially shortened. Plunging fire will occur when the gun is firing from high to low ground, into abruptly rising ground, or at long ranges.





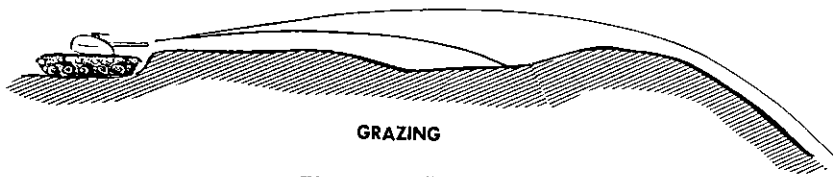


Figure 68. Classes of fire.

(2) *Grazing fire.* Grazing fire is that fire in which the center of the cone of fire does not rise above the height of a standing man. A gun fired over level or uniformly sloping ground will produce grazing fire at ranges up to 750 yards.

117. Tactical Employment of Machine Guns

The ideal situation for machine gun employment is when targets can be engaged from the flank by grazing, enfilade fire. However, in the selection of defensive positions, tanks are sited where they can best fire with the *main gun* on avenues of approach for enemy armor. Such a position may not offer the most effective class of machine-gun fire; however, the tanks are tied into the fire plan to augment the fires of the

ground mount machine guns, which will provide the grazing fire. In the offense, rapidly changing tactical situations dictate the method of employment. Tank machine guns are primarily offensive weapons and are normally employed against targets of opportunity. Their flexibility and high volume of fire make them very effective against surprise targets which must be rapidly engaged in mobile missions. In the attack, tanks supporting by fire normally employ the main gun. Maneuvering tanks use their main gun as they work toward the objective, but usually fire their machine guns in the assault.

118. Coaxial Machine Gun

Standard tanks have a caliber .30 machine gun mounted coaxially with the main gun. The same turret controls and fire-control equipment are used to fire both weapons. For this reason, the coaxial gun is capable of delivering accurate fire. Fire is adjusted by manipulating a continuous tracer stream into the target. Once fire has been placed in the target area, the gun is fired in bursts of 20 to 25 rounds, traversing and searching when necessary to obtain area coverage. Since tracer burnout occurs at approximately 900 yards, the coaxial machine gun is not normally fired at targets at greater ranges. Beyond the point of tracer burnout, the main gun should be used. The initial fire command is issued in the same sequence as for firing the main gun (par. 89). Range is announced mainly for identification purposes, since the coaxial machine gun is normally fired from the battlesight range (par. 128). When fire-control instruments which do not have a machine gun setting are being used, HE is indexed. An example of a typical fire command is as follows:

Alert	GUNNER
Ammunition	CALIBER THIRTY
Range	SIX HUNDRED
Direction	(omitted)
Description	TRUCK
Lead (if required)	ONE LEAD
Command to fire	FIRE.

119. Bow Gun

Some tanks have an additional caliber .30 machine gun mounted in the bow of the tank (right front of the hull). The bow gunner adjusts by firing in a continuous burst, manipulating the tracer stream into the target area. He then fires in bursts of 20 to 25 rounds, traversing and/or searching if necessary. The bow gun, because of the method of fire and the flexibility of the mount, must not be fired over the heads of friendly troops.

120. Turret-Mounted Machine Gun

The turret-mounted machine gun is employed by the tank commander against aircraft, lightly armored vehicles, and fortifications, as well as

the type targets normally engaged by other tank machine guns. No formal fire command is issued. Against aerial targets, the tank commander fires in a continuous burst as long as the aircraft is within range, moving the tracer stream into the target by leading and tracking. He adjusts on ground targets by firing in a continuous burst, manipulating the tracer stream into the target area. The turret-mounted gun (caliber .50) is fired in bursts of 10 to 20 rounds against ground targets. Tracer burnout for the caliber .50 machine gun occurs at approximately 1,800 yards.

Section VII. FIRING FROM A MOVING TANK

121. General

Firing the main gun from a moving tank is inaccurate and difficult, but it may become necessary in the final assault, when ambushed, or when surprised. Machine guns, however, can be effectively employed from moving tanks. The effectiveness of machine-gun fire is enhanced by the psychological factor of a moving tank firing on the objective.

122. Crew Teamwork When Firing on the Move

Successful firing from a moving tank requires crew coordination and teamwork. The driver must keep the tank steady and must warn the gunner of rough spots. He makes turns only when necessary and prevents the transmission from shifting during firing. The gunner must learn the feel of the tank and must counter its movement by manipulating the gun controls to maintain the steadiest possible sight picture. No attempts should be made to range on the target; guns are normally fired from battlesight (par. 128).

123. Firing Coaxial Machine Gun on the Move

Tanks maneuvering against the enemy should not stop to fire the coaxial machine gun unless the target is dangerous and good defilade is available. If caught in the open, tanks should continue to move toward the enemy, presenting their frontal armor to the enemy fire. Within effective range, the coaxial machine gun is the best weapon for engagement of soft targets from a moving tank. Fire is adjusted by observation of the tracer stream as in firing from a stationary tank. Aiming techniques vary with the direction of movement.

a. Firing to Front and Rear. When moving toward a target, the gunner adjusts fire to the near side of the target. He then allows the movement of the tank to move the fire through the target in depth while he traverses to cover the target width. When moving away from a target, he adjusts fire to the far side.

b. Firing to Side. When firing to the side from a moving tank, the gunner adjusts fire to the near side of the target. He then allows the

movement of the tank to move the fire through the target width while he elevates and depresses to cover the target depth.

124. Firing Bow Gun on the Move

The bow gun can be employed only in moving toward the target area. The technique of covering the target area is the same as when firing the coaxial machine gun to the front (par. 123).

125. Firing Turret-Mounted Machine Gun on the Move

The caliber .50 machine gun affords greater firepower at greater ranges; however, the accuracy of this fire is affected by the type of mount. Fire is adjusted as in firing from a stationary tank, and the technique of covering the target area is the same as for the coaxial machine gun (par. 123).

126. Firing Main Gun on the Move

In training, firing the main gun from a moving tank is prohibited, unless the gun is stabilized. However, under combat conditions, it may be fired in an emergency. Due to the inaccuracy of this fire, the purpose is neutralization rather than destruction. For this reason, HE is normally used against all targets. A certain amount of *aim-off* is required to compensate for the movement of the tank.

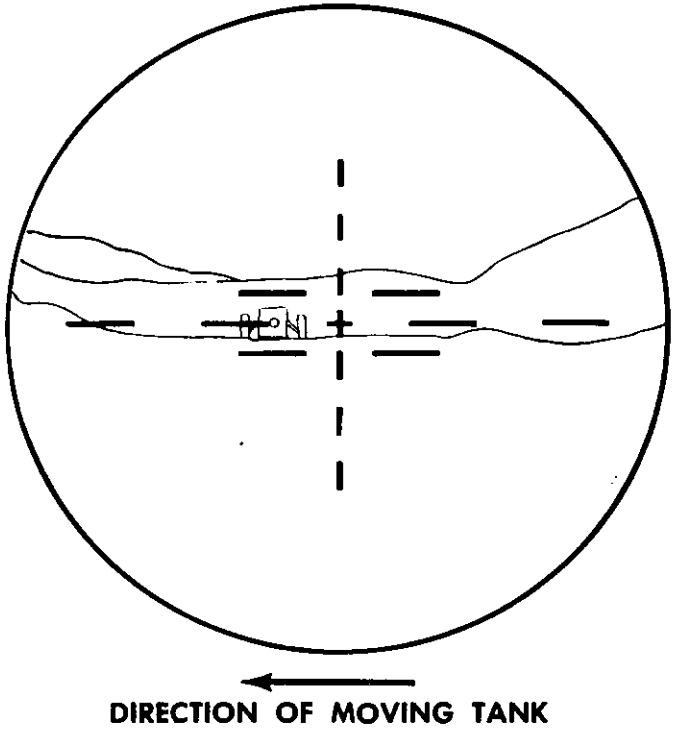


Figure 69. Reverse lead.

a. Firing to Front and Rear. When the tank is moving toward or away from a target, its pitching (up and down) motion will cause the gun to have greater vertical motion than lateral motion. As the gun moves upward, the gunner fires when the aiming cross passes the bottom of the target; as the gun moves downward, the gunner fires when the aiming cross passes the top of the target. This is known as vertical aim-off. The gunner adjusts fire by taking more aim-off if he is firing too late, less aim-off if he is firing too early.

b. Firing to Side. When the gunner is firing to the side from a moving tank, the forward and pitching motion of the tank will cause the gun to have greater lateral motion than vertical motion. The greatest lateral motion is in the direction of the tank's forward motion. This causes the gun to move through the target and gives a lateral motion to the projectile as it is fired. To compensate for this, the gunner fires with a reverse lead (5 mils) (fig. 69). He adjusts fire by taking more lead if he is firing too late; less lead if he is firing too early.

Section VIII. TECHNIQUES OF TARGET DESTRUCTION

127. General

A variety of weapons and methods of adjustment are required to destroy various types of targets. Since no two combat situations will be exactly alike, no single technique of engaging targets will fit every occasion. Because targets differ in importance, nature, size, location, and actions, tank crewmen—particularly the tank commander—must be quick to recognize these differences and shape their actions to fit the situation. As a result of combat experience, certain techniques of target destruction have been devised. These techniques are designed to obtain maximum target destruction in the minimum amount of time. They are based on a thorough knowledge of basic tank gunnery principles, vulnerability of targets, and the destructive capabilities of tank guns and ammunition.

128. Battlesight

Battlesight is a combination of a predetermined range setting and a specified type of ammunition. It is employed against dangerous surprise targets and rapidly fleeing targets. The range and ammunition will be determined by the unit commander as the most suitable combination for destruction of the most dangerous target expected to be encountered in the immediate battle area. Battlesight is incorporated into the unit SOP; however, it will vary according to available information of the enemy, terrain, and weather. The range can be determined by previous experience or reconnaissance. The ammunition selected normally depends on the probability of tank or antitank opposition. A *recommended* battlesight, which will give good overall performance, is a range of 800 yards

and armor-defeating ammunition. This range-ammunition combination gives a high hit probability up to 1,000 yards and should be employed when there is no specific information regarding enemy targets. Effective use of battlesight depends on speed and accurate laying, with the emphasis on speed. This means that both the main gun and machine guns are loaded. With guns loaded and sights set, a tank crew should "have the drop" on a dangerous target. The flat trajectory of the tank gun at a normal battlesight range should give a first-round hit; if not, the gunner will immediately apply burst-on-target and obtain a second-round kill. Should the target be at a range that is considerably in excess of the battlesight range, the tank commander will not employ battlesight. In employing battlesight, the following specific techniques are used:

a. Initial Fire Command. An example of a typical battlesight command is—

Alert	GUNNER
Ammunition and Range	BATTLESIGHT
Description	TANK
Lead (for moving target)	ONE LEAD
Command to fire	FIRE.

b. Actions and Adjustments. Since ammunition and range have been previously set into his sight, the gunner merely lays on the center of mass and fires on command. Adjustment of subsequent rounds and actions of the tank crew are otherwise in accordance with standard procedures. The loader will continue to load the battlesight ammunition rapidly until the tank commander gives CEASE FIRE or changes ammunition. Once a round has been chambered, it should be fired despite a subsequent change in ammunition, and the change made for the next round.

129. Firing by Tank Commander

Because of his command responsibilities, the tank commander will fire the main gun only in an emergency. By using his manual controls, the gunner can lay initially and make adjustments more precisely and quickly than the tank commander. However, in a situation where target recognition by the gunner is difficult, it may be necessary for the tank commander to take over the firing. For example, due to the position of the turret, the tank commander may be the only one to observe the flash of fire of a well-concealed antitank gun. The chances are remote that the gunner will be able to immediately identify the target, and the seconds lost in attempting to "talk" the gunner onto the target might result in destruction of the tank. The tank commander fires the initial round and continues to fire necessary subsequent rounds until the gunner can positively identify the target. Firing by the tank commander, particularly when burst-on-target is necessary, requires considerable skill and should

be attempted only when the gunner cannot immediately and effectively engage the target.

130. Ricochet Fire

High explosive ricochet fire (fig. 70) is fire delivered at a low angle of elevation, with the burst occurring close above the ground after the projectile has struck and bounced into the air. Ricochet fire with HE ammunition is obtained by changing the fuze setting from superquick to delay and firing short of the target. If the projectile strikes a relatively hard surface at a flat angle, the delay action of the fuze will cause an air burst. This fire is employed against dug-in troops and other targets with defilade but no overhead cover. The alternate method of adjustment is used to adjust the shell fragmentation effect on the ground into the target area. The tank commander is not held to the standard range change, but may make any range change he feels is necessary to obtain target effect. The gunner lays initially on a well-defined terrain feature approximately 50 yards short of and on line with the target. From this auxiliary aiming point, he makes necessary range and deflection changes. Since the gunner will be laying his aiming cross on this point, it cannot be a terrain feature which will interfere with the ricochet action of the projectile. If no such point exists, the gunner places the appropriate range line on the target, or uses any other auxiliary aiming point which will insure that the round strikes short and on line. Since ricochet fire is normally conducted in a deliberate manner, the tank commander informs the gunner of the method of fire prior to issuing the fire command and insures that the gunner has identified the aiming point before firing. Ricochet fire cannot be employed when the ground is soft or boggy, because the rounds will bury and explode, giving a mining effect.

131. Destruction of Armored Vehicles

Armored vehicles are those combat vehicles which cannot be penetrated by small arms fire. This class of vehicles includes tanks, armored self-propelled guns, armored infantry vehicles, armored utility vehicles, and heavy armored cars. The destruction of armored vehicles involves many factors, foremost of which are ammunition capabilities, range effect, and target vulnerability.

a. Ammunition Capabilities. The most common types of armor-defeating ammunition in present use are armor-piercing (AP or shot) and hyper-velocity armor-piercing (HVAP or hyper-shot). Due to its greater velocity and hardness, hyper-shot normally achieves greater penetration than shot. Therefore, medium tanks are engaged with shot, heavy tanks with hyper-shot. Another type of armor-defeating ammunition is high explosive antitank (HEAT), which blasts through armor and does not depend on velocity for penetration. Its penetration performance is usually greater than that of hyper-shot. Some effect against

RICOCHET FIRE

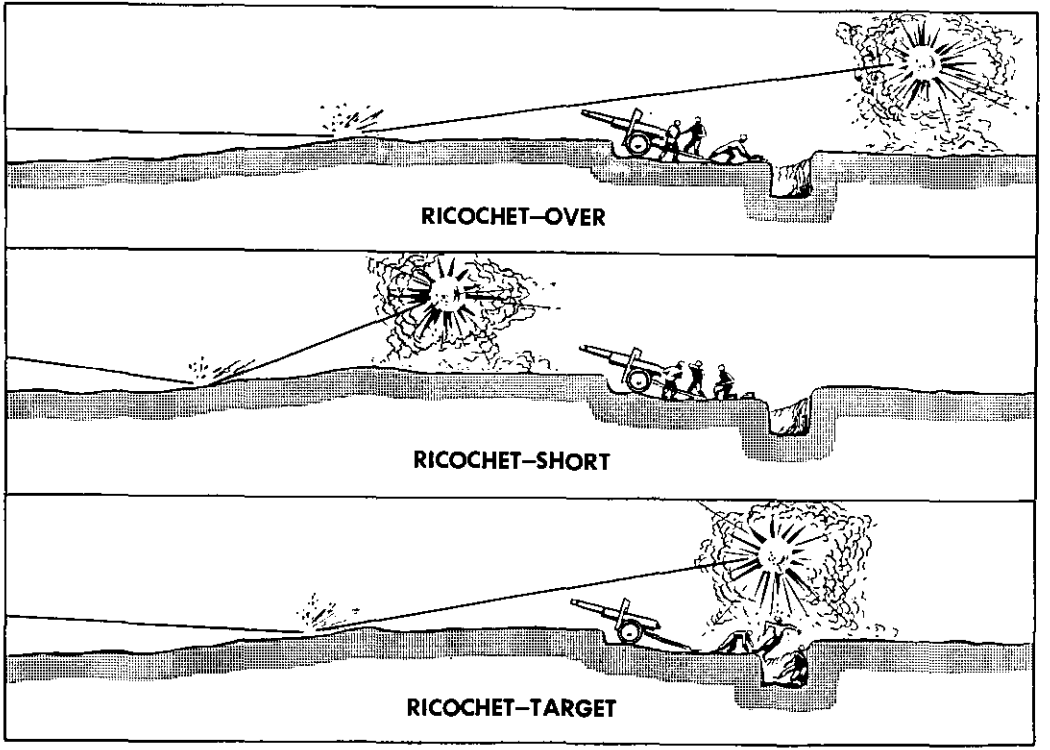


Figure 70. Ricochet fire.

armored vehicles can be obtained by HE and smoke; however, these projectiles are not armor-defeating. HE has some concussion effect against crews and is capable of damaging vehicular suspension systems. It is also effective against carriers and self-propelled guns with no overhead protection, and against crews dismounting from vehicles. Against armor, smoke is used for screening and possible incendiary effect.

b. Effect of Range. Regardless of the type of ammunition employed, range affects destruction of armor from the standpoint of accuracy. At close ranges, the determination of tank-to-target range is not difficult, and the relatively flat trajectory of the projectile compensates considerably for range errors. As the range increases, however, range determination becomes less accurate and the trajectory of the projectile becomes higher, thus decreasing the probability of a target hit. Adjustment also becomes difficult at longer ranges, due to decreased visibility. Additionally, range has a direct effect on kinetic energy projectiles. As the range increases, the penetration capability of shot and hyper-shot decreases proportionally. Range does not have this effect on chemical energy projectiles; HEAT has a penetration capability independent of range. Due to the many factors involved, it is not possible to set a maximum effective range for engaging armored vehicles. If a target is not immediately dangerous, it should be engaged at the closest possible range consistent with obtaining surprise. On the other hand, armored vehicles are engaged at long ranges if they are engaging the tank or attempting to flee. Also, when fighting a delaying action or engaged in a fire-support role, it may be necessary to engage enemy armor at extreme ranges.

c. Tank Vulnerability. The vulnerability of an armored vehicle depends on the *equivalent thickness* of its armor. Equivalent thickness is a combination of actual armor thickness, slope of the armor plate, and the angle of approach of the vehicle. Equivalent thickness becomes greater as the amount of slope increases and the angle of approach decreases, because there is more armor placed in the path of the projectile (fig. 71). Thus, a tank of given armor thickness with flat surfaces perpendicular to the line of fire is more vulnerable than a tank of the same thickness with sloped surfaces oblique to the line of fire. Tanks are built with sloped surfaces wherever possible and have the heaviest armor on the front of the hull and turret. The sides and rear of the turret have less armor, and the least amount is on the sides and rear of the hull. The sides and rear of the hull also have flatter surfaces and are accordingly the most vulnerable parts of a tank. Since no enemy will willingly present such a target, the center of mass will vary with the amount of target exposed and the angle at which it is engaged. Figure 72 shows the possible areas of penetration when a medium tank is being engaged with shot ammunition at a range of 1,000 yards. If it is possible to get a flank or rear shot at a tank, the center of mass is the center of the hull.

The center of mass of a tank engaged head-on is the turret ring. Vulnerability decreases considerably when tanks are in hull defilade positions. Although it is possible to penetrate the sides of a tank turret with shot, penetration of the front of the turret is less likely. Hyper-shot or HEAT should be employed against enemy tanks in hull defilade.

132. Destruction of Unarmored Vehicles

Unarmored vehicles are those vehicles which can be penetrated by small-arms fire. This class includes trucks, automobiles, and vehicles with light armor such as half-tracks, scout cars, and some light armored cars. Heavy armored cars cannot be penetrated by small-arms fire and should be treated as armored vehicles. If a doubt exists as to the classification of an armored car, armor-defeating ammunition should be used against it. Unarmored vehicles are vulnerable to all types of fire; however, their speed makes them difficult targets to hit. The caliber .50 machine gun is ideal for engaging light armored cars, and the coaxial machine gun is normally the best weapon for engaging other unarmored vehicles at ranges up to 900 yards. At greater ranges, caliber .50 or HE should be used. The value of the machine gun lies in its dispersion and large volume of fire. Moving targets at close ranges are easier to hit with machine-gun fire, and main gun ammunition is conserved for more dangerous targets. The aiming point varies with the type of target. Moving vehicles are immobilized by hitting the engine or driving compartment. This is also a good general rule for stationary vehicles; however, common sense will dictate certain exceptions. To increase the hit probability at long ranges, the aiming point is the center of the vehicle.

133. Firing at Dismounted Troops

Dismounted troops constitute an area target of varying depth, width, dispersion, and vulnerability.

a. Attacking infantry should be engaged with machine-gun fire whenever possible; however, the type of weapon and ammunition employed will depend primarily on the range and the actions of the enemy troops. Normally, HE is employed against troops at ranges in excess of 1,800 yards. At lesser ranges, the fire of the machine guns is added to that of the main gun. When firing the machine guns at troops in the open, the gunner should traverse and search through his assigned sector. When possible, he should employ grazing enfilade fire. Depending on the configuration of the ground, ricochet HE fire may be effective against troops advancing under cover. At very close ranges, canister is most effective against mass attacks. However, consideration must be given to the location of friendly troops before firing canister. When the attacking infantry begins the final assault, tanks will shift to the method of fire prescribed by the unit fire plan.

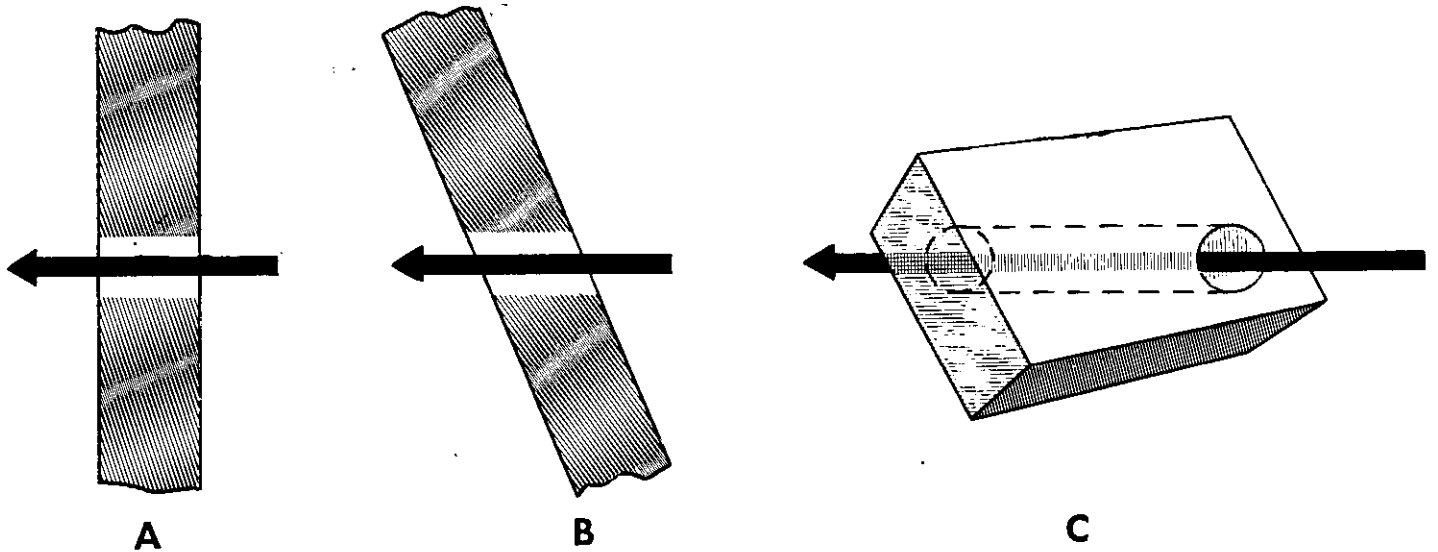


Figure 71. Equivalent thickness.

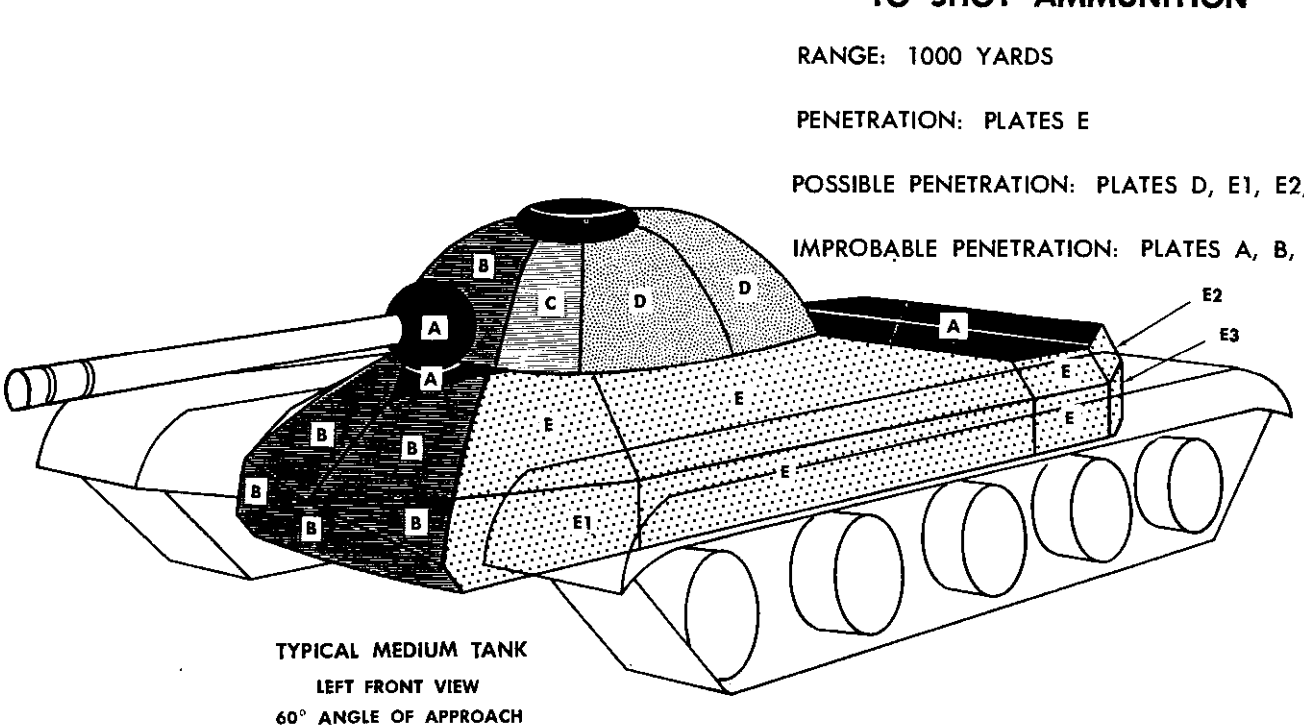


Figure 72. Tank vulnerability.

b. Assaulting tanks will usually employ the coaxial machine gun while moving, attempting to fire into trenches and other vulnerable parts of the enemy defense. Smoke can also be employed for incendiary, screening, and casualty-producing effect, depending on the location and construction of the enemy position.

134. Destruction of Crew-Served Weapons

This category of targets includes antitank guns, towed artillery, recoilless rifles, machine guns, and all other ground mount crew-served weapons. Engagement of crew-served weapons mounted in bunkers and pillboxes presents a different problem (par. 135). Crew-served weapons are sometimes encountered in hasty positions, but are usually placed in prepared positions with good cover and concealment. They present a small target with low silhouette. Normally, HE will be employed against these weapons; however, enemy positions with little or no cover may be engaged with machine guns when within effective range. Due to their dangerous nature and ability to achieve surprise, antitank guns may require engagement from battlesight. In fighting crew-served weapons, the crew is the primary target; destruction of the gun is of secondary importance. Often, both enemy gun and crew will be well dug in; in such cases, it may be necessary to employ ricochet fire using HE delay.

135. Engagement of Field Fortifications

Field fortifications are defensive positions constructed so that they afford good fields of fire and protection to the troops and weapons manning them. Such a position usually consists of a series of connecting, mutually supporting strongpoints. In addition to entrenchments and weapons emplacements, field fortifications include such positions with overhead cover as bunkers, pillboxes, and built-up areas. Fire alone will not defeat a well-fortified position; it is necessary to assault it. The following techniques of engaging specific types of fortifications will provide for the effective fire support vital to the successful attack of a strong position.

a. Open Entrenchments. Foxholes and trenches give protection against direct fire; however, they are vulnerable to air bursts. Tanks should employ ricochet fire, using HE delay. If the ground does not produce good ricochet effect, impact fire will neutralize much of the enemy's firepower, since he must expose himself to employ his weapons. At close ranges, machine guns may also be used to neutralize enemy firepower. Indiscriminate firing at trenches is wasteful of ammunition; therefore, fire should be placed into occupied sections of trench which may be exposed.

b. Open Weapons Emplacements. Open gun positions have some vertical surface and are therefore vulnerable to both impact and ricochet fire.

Impact fire is more accurate; however, a well-constructed emplacement may require ricochet fire. The range and the degree of protection afforded by the position will determine whether the main gun or the machine guns should be employed.

c. Bunkers and Pillboxes. Bunkers and pillboxes give good protection against all types of fire; however, they can be penetrated by attacking their structural weaknesses with the proper ammunition. The most vulnerable point on both bunkers and pillboxes is the aperture. A direct hit with HE at the aperture of a bunker will result in part of the force of the explosion being directed inside the bunker. The possibilities of achieving detonation inside a bunker are increased by employing HE delay. An HE projectile set on delay fuze may ricochet inside if it strikes near the aperture. If the angle of strike does not allow a ricochet, chances of penetration or damage to the structure are increased due to the delayed detonation. Concrete-piercing fuze is more effective than delay fuze and may be issued for this type of operation. Should HE prove ineffective, armor-defeating ammunition may be used. Shot will penetrate most log bunkers at normal ranges; however, more than one round may be necessary. Once penetration has been obtained by shot, HE or smoke can be fired through the opening with devastating effect. The technique of attacking pillboxes by fire is generally the same as for bunkers except that the additional strength of concrete prohibits use of HE delay for penetration purposes. The concrete-piercing fuze is designed to penetrate pillboxes, or to so weaken the structure that subsequent rounds of HE concrete will both penetrate and give a blast effect inside. Armor-defeating ammunition will achieve deeper penetration than HE concrete, but will not damage as much surface area or cause as much destruction on penetration. The choice of ammunition for engagement of bunkers and pillboxes depends primarily on ammunition availability and target vulnerability; however, employment of HE is preferred because of its greater casualty-producing effect and the resulting conservation of armor-defeating ammunition for use against armored vehicles.

d. Built-Up Areas. Built-up areas provide strong defensive positions and must be considered as excellent fortifications even when badly damaged or reduced to rubble by bombardment and cannon fire. Buildings, particularly those constructed of concrete or masonry, constitute strongpoints which normally must be reduced by a combined-arms attack. Tanks may encounter a wide variety of targets; however, the primary job is destruction of enemy tanks, troops, and weapons behind cover. Buildings and other structures are engaged in much the same

manner as bunkers and pillboxes. HE with superquick fuze should be fired through windows, doorways, shell holes, and other openings. HE delay will penetrate wood and other light structures; HE concrete or shot is required to penetrate concrete or masonry walls. In all cases, the desired effect is detonation inside the building; therefore, once penetration is effected, HE should be fired through the openings made: Smoke has a casualty-producing effect and is also effective against buildings, particularly those which will burn. Smoke fired into the ground floors produces rising fumes and smoke which force the occupants out. If the building is set afire, burning of supports will cause upper floors to collapse. Reduction of built-up areas produces rubble which, due to its thickness and irregular surfaces, forms a nearly impenetrable position. Troops barricaded behind such a strongpoint are effectively engaged by ricochet fire, using HE delay. Ricochet fire can also be used to "shoot around a corner" by banking HE delay off a wall (figs. 73 and 74). This type of fire can be adjusted with good effect on targets with no overhead cover. Shot and machine-gun fire can be ricocheted in the same manner; however, such fire is inaccurate and the effect is primarily psychological.

136. Special Uses of Tank Ammunition

In addition to the specific techniques of target destruction previously mentioned, there are a variety of special uses of main gun and machine gun ammunition which have proved effective in battle. Combat situations may arise where the following fire techniques could be effectively employed.

a. Use of HE. HE is a versatile type of ammunition in that it is employed in numerous ways against a wide variety of targets. The following special uses are in addition to those previously discussed.

(1) HE gives excellent fragmentation when fired into treetops over the heads of enemy troops. Superquick fuze is normally employed; however, if the trees are exceptionally tall or the troops are deep in the woods, delay fuze should be used.

(2) HE may be employed in the reduction of certain obstacles such as roadblocks and barbed wire. HE fire weakens the structure and explodes antipersonnel mines; however, it normally will not detonate buried mines. After an obstacle has been reduced by fire, it should be checked for booby traps and the immediate area probed for antitank mines. HE is not effective in clearing minefields. Clearance of extensive obstacles by fire is not practical because it requires too much ammunition.

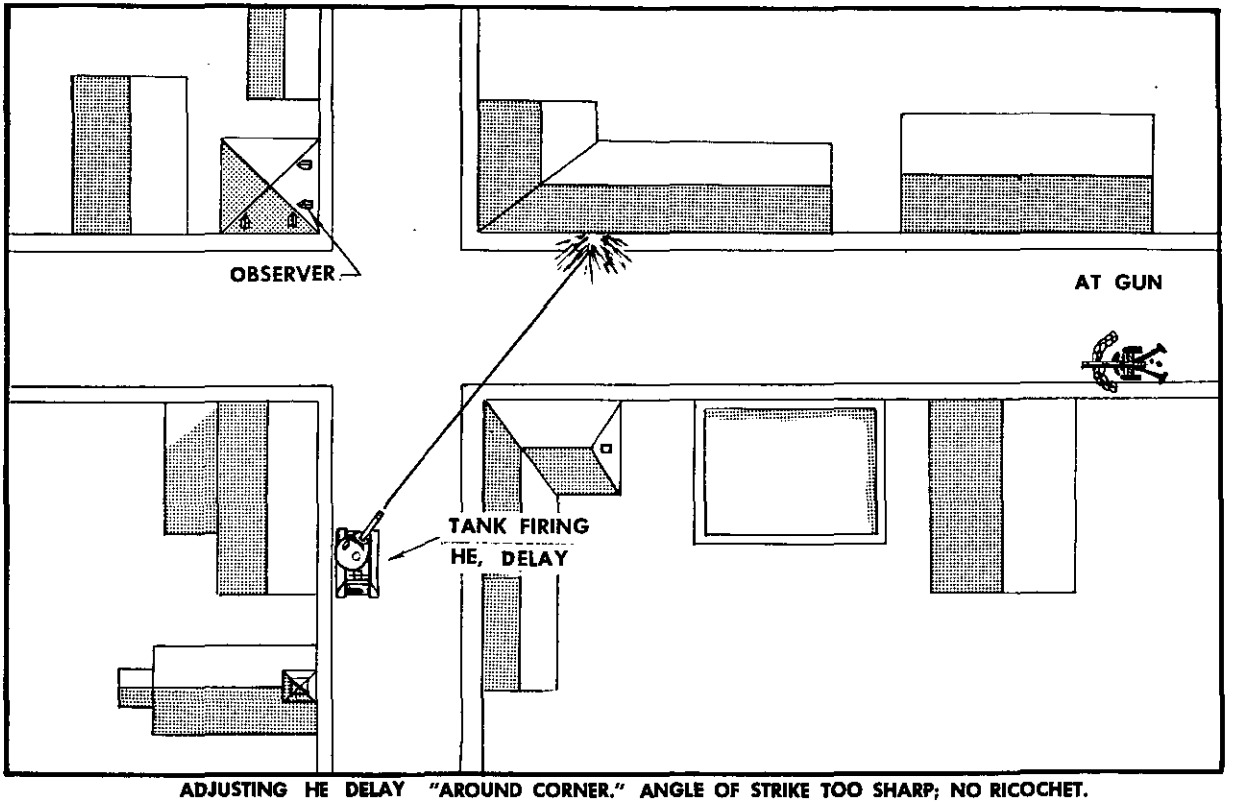


Figure 78. Shooting around corners—wrong.

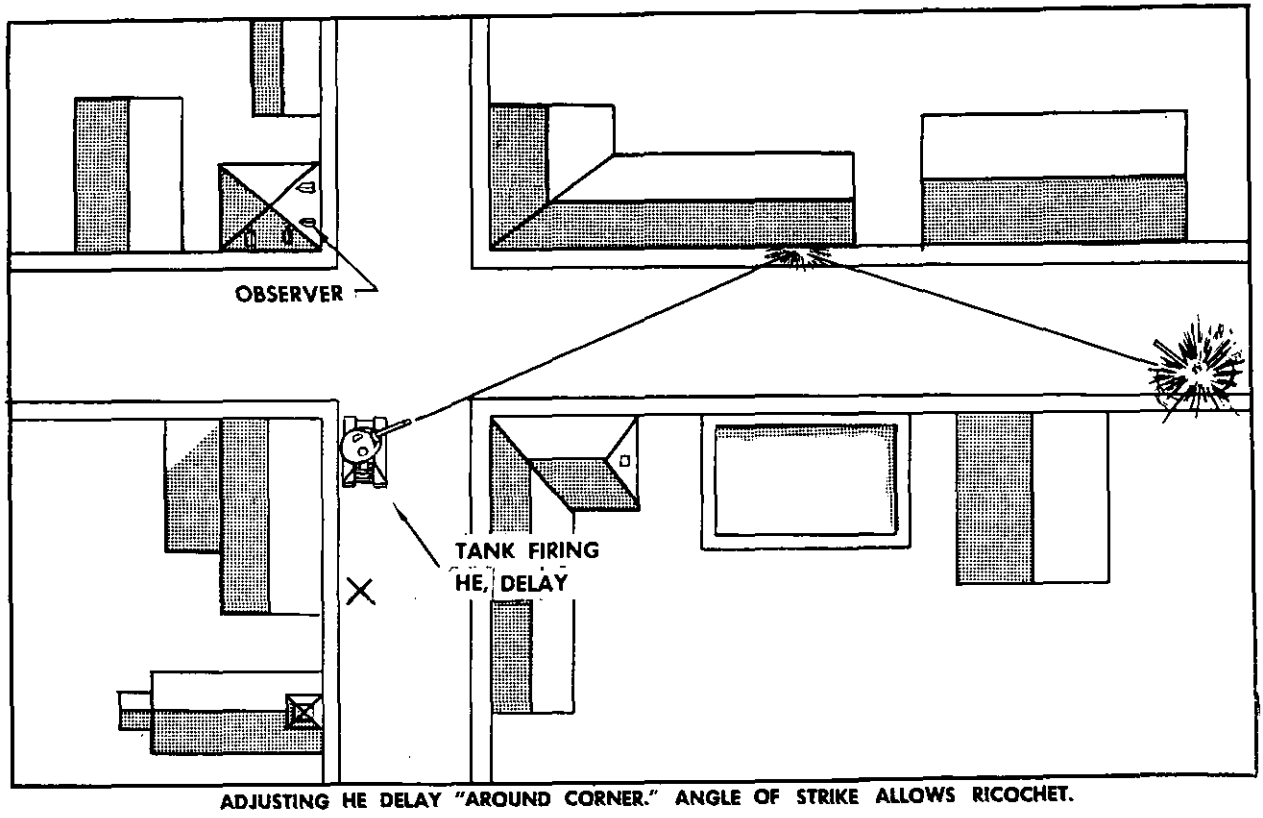


Figure 74. Shooting around corners—right.

(3) HE may be used in reconnaissance by fire of probable enemy positions beyond the effective range of the caliber .50 machine gun (1,800 yards). Such fire is confined to suspected locations in order to conserve ammunition.

b. Use of Armor-Defeating Ammunition. Armor-defeating ammunition is used only against hard targets such as tanks and fortifications which cannot be effectively engaged with HE.

c. Use of Smoke. Smoke is employed for screening, incendiary, and casualty-producing purposes. There are many combat situations where use of this round, particularly in conjunction with other ammunition, will produce excellent results.

(1) Screening serves the purpose of blinding the enemy, thus allowing greater freedom of movement of the friendly forces. Smoke may be placed in front of the enemy to screen the maneuver of attacking tanks or to cover their withdrawal. Due to the limited supply of smoke ammunition and the tendency of WP smoke to dissipate and rise rapidly, tanks should be employed for screening purposes only when other sources are not available. Tanks are capable of temporarily screening short movements of the tank platoon or company. The basic factors governing the employment of smoke are wind direction and velocity (fig. 75). With a wind from the flank, the screen is started to the windward side of the target so that it will drift into and in front of the enemy. With a tailwind, smoke should be placed just in front of the target; when firing into the wind, smoke should be placed on or behind the target. When the wind velocity is high, the rate of fire must be increased to maintain the screen. When firing into a strong headwind, caution must be exercised to prevent smoke from rolling back over friendly positions. Other effects on adjacent troops must also be considered.

(2) In addition to its incendiary effect on buildings and log fortifications, smoke is also effectively used in burning out enemy positions in woods and brush. The factors of wind direction and velocity which govern employment of smoke for screening also apply to its use for burning purposes. Precautions must be taken to avoid damage to friendly positions. HE should be employed in conjunction with smoke to destroy and harass enemy troops driven from cover by fires.

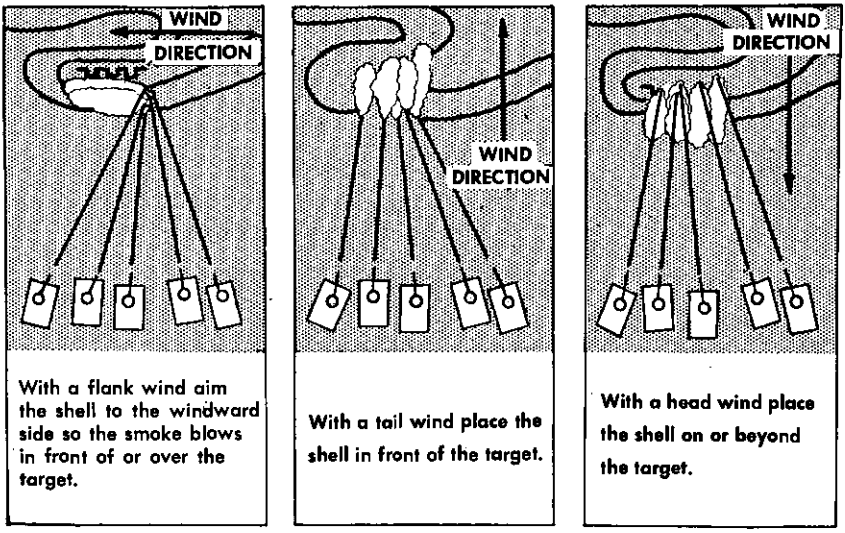


Figure 75. Screening with smoke.

(3) The casualty-producing effect of smoke is a direct result of its incendiary nature. Best results are obtained when smoke is fired into an enclosure, such as a bunker or the room of a building. It is also effective against troops in the open, because the burning phosphorus particles are scattered over a wide area. A single particle can cause severe burning because phosphorus sticks to the skin or clothing. Although smoke does not have the destructive capability of HE, it has a much greater psychological effect on troops.

(4) Smoke may also be used to mark targets.

d. Use of Machine-Gun Fire. Tanks carry a considerable amount of machine-gun ammunition. Main gun ammunition is conserved by employing the machine guns for many special purposes.

(1) Tank machine guns are well suited for reconnaissance by fire of suspected enemy positions and suspicious areas. The caliber .30 machine guns may be effectively employed up to ranges of 900 yards, the caliber .50 up to 1800 yards. API–T (incendiary) is particularly useful for this purpose.

(2) Machine gun fire may be used to designate targets.

(3) Incendiary and tracer ammunition will set fire to dry brush, grass, or wood.

(4) Machine guns should be used in conjunction with HE when engaging troops in the woods. Due to dispersion, machine gun fire will penetrate deeper into the woods with only partial deflection by trees and brush. The caliber .50 machine gun is particularly effective for this purpose.

Section IX. RANGE CARDS

137. General

A range card is a diagram or sketch of an area, showing the tank position, prominent terrain features, and probable targets, all in relation to their actual position on the ground. Range cards are an aid in firing day or night; they are used for identifying and laying accurate fire on plotted targets, laying accurate fire on targets of opportunity, firing at night or during periods of poor visibility, concentration of fire, and coordination of the defensive fires of a unit. Range cards must contain the following information for each target:

a. Target identification, to include a reference point.

b. Deflection (azimuth indicator reading).

c. Quadrant elevation (QE).

d. Range.

138. Target Designation

Both existing and probable targets are plotted on range cards. Probable targets or target areas include avenues of approach, defiles, obstacles, suspicious localities, and any other key terrain features where targets might appear. Targets are designated on a range card by conventional signs, symbols, or short, descriptive phrases. A unit number is assigned to each target so that it may be identified by all tanks. A legend, containing additional target information, may be placed on the range card.

139. Types of Range Cards

A good range card must be complete, simple, and easily read by all tank crewmen. Two of the more common types of range cards which meet this basic requirement are the *circular* and the *sketch* range cards.

a. Circular Range Card. The circular range card (fig. 76) represents the face of the azimuth indicator. It consists of three circles, used as range lines, and a deflection scale. The deflection scale is graduated in 100-mil increments in a manner similar to the azimuth indicator. Target data is recorded on the range card by drawing lines which correspond to

the actual range and deflection of each target. The target is designated by a numbered symbol placed at the end of the line. Since each line is positioned by interpolation, it is necessary to write the actual deflection, range, and quadrant elevation to the target. However, when the tank-to-target range is the same as one of the range lines, the range need not be written on the card. The value of this type range card lies in its ease of reading and direct application to fire-control instruments. Due to the limited space for recording targets close to each other, especially if a tank is assigned a narrow sector of fire, it may be necessary to use two or more range cards in order to accurately plot probable targets.

b. Sketch Range Card. The sketch range card (fig. 77) is a simple drawing of the assigned sector of fire of a particular tank. The drawing is schematic with only key terrain features, the reference point, and the tank position designated. Known and probable targets are circled and

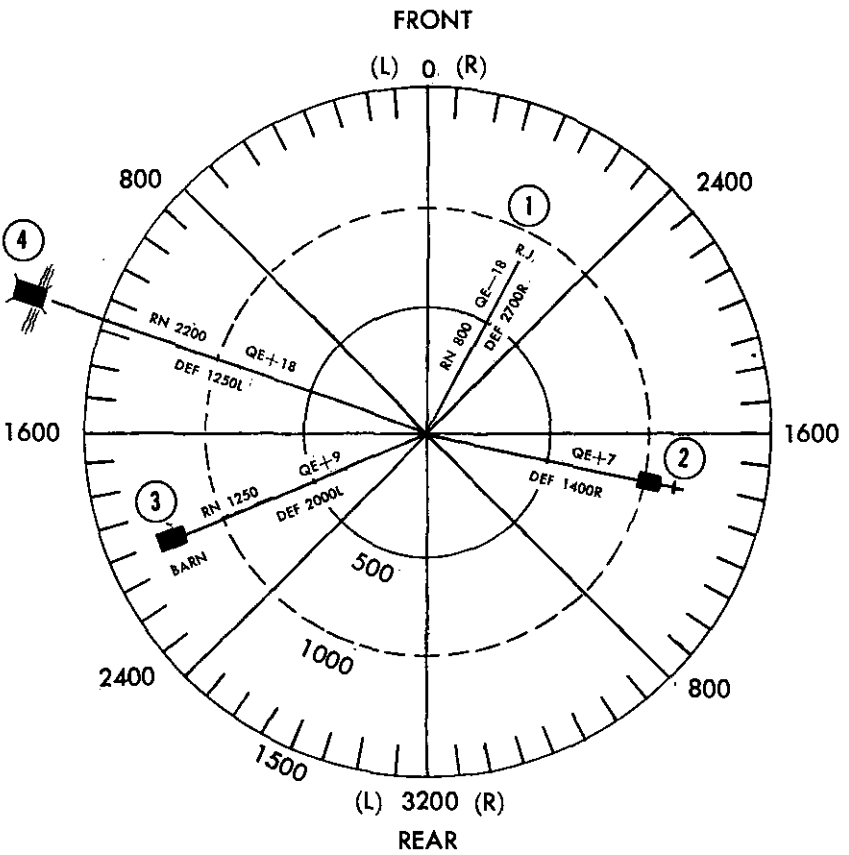


Figure 76. Circular range card.

numbered. Necessary firing data is plotted on a line extending from the tank position to each target. This type range card provides ample space for plotting targets; however, its value depends on the ability of tank crewmen to draw a simple, legible diagram.

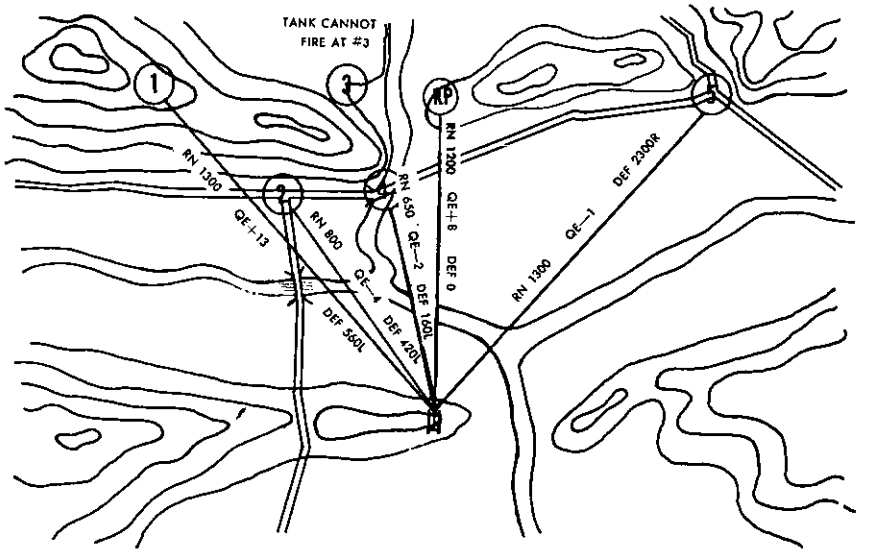


Figure 77. Sketch range card.

140. Obtaining Range Card Data

a. Tank in Position. When the tank is in the firing position, firing data is obtained by laying on the target and using the tankmounted fire-control equipment. Specific techniques will vary for different type tanks; however, the general method is the same.

(1) *Targets* are designated and numbered by the platoon leader or company commander. Additional targets for each tank may be selected by the tank commander, but these are identified by letters.

(2) *Deflection* is obtained by zeroing the azimuth indicator on the reference point and traversing to each target. The *actual* azimuth indicator reading is recorded.

(3) *Range* is obtained by ranging or by the most accurate method immediately available. If estimation is used initially, a more accurate range should be determined at the earliest opportunity.

(4) *Quadrant elevation* (QE) is obtained by indexing the range and HE ammunition into the direct-fire control system and laying on the center of the target with the direct-fire sight. Then the quadrant elevation is determined by centering the bubble of the elevation quadrant or gunner's quadrant.

b. Tank Not in Position. The tactical situation often makes it necessary for tanks to occupy firing positions at night. If a tank unit relieves

another, range cards are exchanged. However, if range cards are not available, they can be prepared by daylight reconnaissance parties, prior to moving tanks into position. Minimum equipment necessary is one aiming circle or M2 compass, and two aiming stakes per position. Additional equipment for physically preparing the position includes a shielded light for each aiming stake and white tape to mark the position. It is desirable to have two aiming circles if they are available. Upon arrival in the area, the reconnaissance party selects tank positions. To prepare a range card for a position, an aiming circle is set up to represent the center of the tank. Aiming stakes are used as a reference point. If possible, they are lined up at a right angle (1,600 *mils*) to the tank position. This alinement facilitates accurate positioning of the tank. Firing data is obtained as follows:

(1) *Targets* are designated in the same manner as for any other range card. They may be selected in advance by the unit commander or selected on the spot by the reconnaissance party.

(2) *Deflection* is obtained by laying on the reference point with the aiming circle, zeroing the scales, and measuring the angle to the target. The reading of the *lower* scale is subtracted from 3,200. This is the correct azimuth indicator reading for the tank.

(3) *Range* is obtained by intersection or some other accurate means.

(4) *Quadrant elevation* (QE) is obtained by combining elevation for range with angle of site. Elevation for range for HE ammunition is taken from a firing table or from the computer or ballistic unit of a tank. Angle of site is measured with the aiming circle or M2 compass, or determined from a map. The operator compensates for the difference in elevation between tank gun and instrument by sighting with the instrument on the bottom or near edge of the target.

141. Tactical Use of Range Cards

Range cards are used for a coordinated concentration of accurate fire on known enemy positions or probable enemy targets during day or night. The platoon leader coordinates his fire by designating tank positions and sectors of fire so that maximum target area is covered. By assigning a unit number to designated probable targets, the platoon leader is able to concentrate or shift the massed fire of his unit with a single command. A correct, predetermined range allows accurate direct fire during daylight on plotted targets, or targets of opportunity which appear near a plotted target. Firing at night or during periods of poor visibility is normally accomplished by applying the predetermined data to the auxiliary fire-control instruments. However, if illumination is available, the direct-fire sights are used. HE is employed against all

types of targets when firing under poor visibility conditions because of the fragmentation effect. Machine guns are also effective at night, particularly against enemy infantry.

Section X. FIRING AT NIGHT OR WITH POOR VISIBILITY

142. General

Tank crews must be capable of delivering effective fire on the enemy at night or during such conditions of poor visibility as dense fog, smoke, snow, or rain. When neither visibility nor illumination exists, it is necessary to fire from previously prepared range card data. However, when the target is visible, or when night illumination is available, direct-fire methods are employed. Whenever possible, fire is observed and adjusted. Effective fire during periods of poor visibility requires advance planning and coordination.

143. Preparation and Occupation of Night Firing Positions

Night relief of one tank unit by another normally involves direct exchange of position and range card by individual tanks. Such an operation requires detailed planning and coordination in order to be accomplished efficiently. Night movement into a position *not previously occupied* by another tank unit requires advance selection and preparation of night firing positions. Daylight reconnaissance parties establish liaison with front-line troops, select tank positions, and prepare the positions for night firing (par. 140*b*). Range cards are made for each tank, and positions are marked for night occupation. After the range card is completed, the position of the aiming circle or M2 compass is marked by a stake to represent the tank turret center. Two strips of white tape, intersecting at the position stakes, are laid out for use in guiding the tank into position. The longer tape marks the tank route, the shorter strip marks the tank position (fig. 78). The two aiming stakes used in preparing the range card are left in position as the reference point for the tank. Night lighting devices, such as covered flashlights or luminous markers, are placed on each stake so that the tank gun can be alined on the reference point. The position is now ready for occupation. After dark, each tank is moved into position by a dismounted guide. Light discipline must be observed. Interior lights in the tank are masked, and blackout lights are employed by both tank and guide. A piece of white tape or a white chalk mark on the front center of the tank hull is used in lining up the tank with the route-marking tape. The tube is traversed to the angle of the aiming stakes. The tank is then moved forward slowly until it is centered over the position stake. The loader, looking through the tube, alines the gun by giving necessary directions to the driver and gunner. The gunner then zeroes his azimuth indicator and

traverse to the target area. The tank is now properly positioned for night firing.

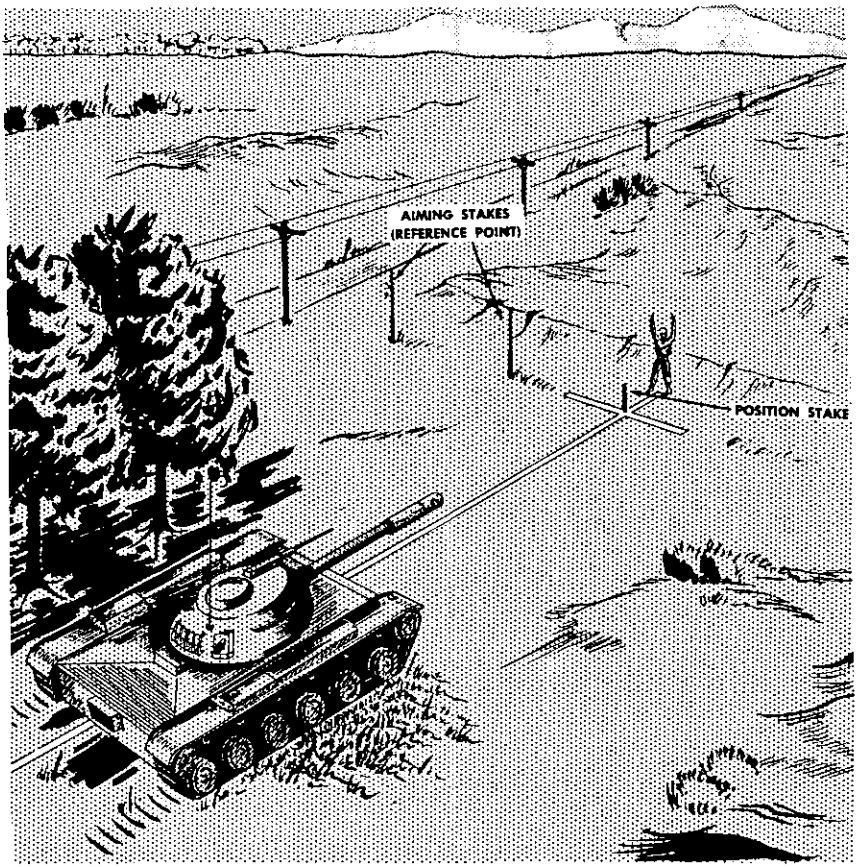


Figure 78. Night firing position.

144. Firing With Illumination

At night, bright moonlight or artificial illumination often provides sufficient visibility to allow target engagement by direct-fire methods. The gunner lays on the target with the direct-fire sight and fires, adjusting by burst-on-target or the alternate method. Fire commands are the same as for engaging any stationary or moving target during daylight. Artificial illumination is provided by searchlights, illuminating shells, flares, or fires in the target area. Fires may be started in the target area by firing smoke at such inflammable objects as brush, trees, or wooden buildings. Instrument lights are used to illuminate fire-control instruments, to include sight reticles. Before the target area is illuminated, adjacent friendly troops should be warned, so that their positions or activities are not exposed.

145. Firing With Poor Visibility

During firing at night with no illumination, or during daylight periods of poor visibility, HE ammunition is employed because of the fragmentation effect on the target when a direct hit is not obtained. Firing at night discloses the tank position and requires a considerable expenditure of ammunition to obtain effective results. The decision to fire is based on the importance of the target, the ammunition supply, and the possibilities of obtaining target effect.

a. Engagement of Plotted Targets. To fire on a previously plotted target, range card data is applied to the auxiliary fire-control instruments. The gunner lays for range by setting the indicated quadrant elevation on the elevation quadrant (or gunner's quadrant) and elevates or depresses the gun until the leveling bubble is centered. He lays the gun for direction by traversing right or left of the reference point to the prescribed azimuth indicator reading. Since the azimuth indicator has been zeroed on the reference point, it is not necessary to re-lay on the aiming stakes. Even when it is impossible to adjust fire by observation, target hits may be observed under certain conditions of poor visibility. For example, HE striking metal causes a distinctive orange flash and may have incendiary effect on some targets. When target effect is not visible, *area fire* is employed. To obtain area fire, the initial round is fired from range card data; subsequent rounds are fired 1 mil over, 1 mil short, 10 mils right, and 10 mils left of the first round. This pattern (fig. 79) gives good area coverage and should result in target destruction or damage.

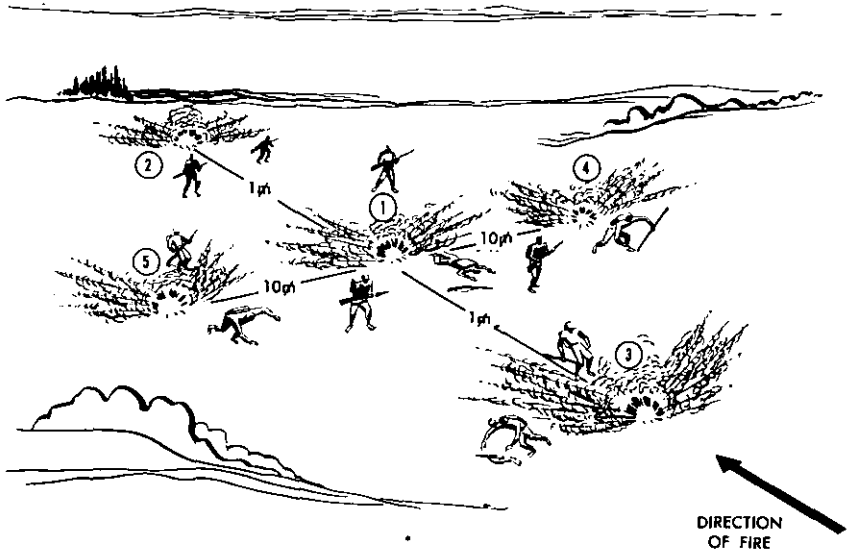


Figure 79. Area fire.

b. Engagement of Targets of Opportunity. Since targets of opportunity are not accurately located, firing on such targets during periods of poor visibility is more difficult than firing on plotted targets. The technique of fire depends on whether the target is located by sound or by flash. When a target is discovered by sound, the gun is laid in the approximate direction and the range estimated. Range card data to a nearby target may be used as a guide. To obtain the best possible area coverage, fire is adjusted by use of the area fire pattern. When the flash of an enemy gun is observed, the tank gun is laid on the flash and the range estimated. Fire is adjusted by area fire or by employing a second tank to observe. When two tanks are employed, each gunner lays his aiming cross on the flash—one to fire, the other to observe. To prevent distorted sensings, the tanks should not be more than 50 yards apart. The gunner or tank commander of the observing tank senses each round in relation to his aiming cross and gives a subsequent fire command to the gunner of the firing tank. For example, if the round appears below and 5 mils left of the aiming cross, the observer announces SHORT . . . RIGHT FIVE, ADD TWO HUNDRED, FIRE. Firing continues until target effect is observed or fire has been adjusted to the center of the observer's aiming cross. If fire has been adjusted without visible results, area fire may be employed to cover the target area.

146. Fire Commands for Firing With Poor Visibility

When direct-fire sights are used, the normal command for direct fire is issued. However, when auxiliary fire-control instruments are employed, range is announced as a quadrant elevation and direction as an azimuth indicator reading; for example—

Alert	GUNNER	GUNNER
Ammunition	HE	HE
Range	QUADRANT PLUS ONE SIX	QUADRANT MINUS SIX
Direction	DEFLECTION TWO FIVE FOUR SEVEN RIGHT	DEFLECTION FOUR THREE TWO LEFT
Description	ANTITANK	TROOPS
Command to fire	FIRE.	FIRE.

Note. When area fire is desired, the tank commander will announce AREA FIRE prior to issuing the fire command. When this is announced, the gunner fires the five-round pattern without further command.

Section XI. MASSED FIRE

147. General

The concentrated, massed fire of the tank platoon or company produces a far greater destructive effect than the uncoordinated fires of an

equal number of tanks. Maximum firepower is obtained by coordinating and controlling the fire of all weapons of the tank unit and its attached and supporting units. Coordination of fire is accomplished at all levels of tactical command by use of a fire plan; however, actual control of fire is conducted at the platoon or company level. The company commander coordinates fire by assigning sectors of responsibility to each platoon and by planning necessary supporting fires. He controls fire by issuing informal *fire orders* to one or more platoons to engage a target or area. Platoon leaders coordinate fire in the same manner as the company commander, but they control fire by *fire commands.* Authority to fire on targets of opportunity is normally delegated to platoon leaders; however, adjustment of fire is usually accomplished by the individual tank commanders or gunners. Because of the wide variety of situations that require massed fire, units should develop SOPs to incorporate specific techniques and procedures.

148. Massed Offensive Fires

Massed offensive fires are planned and coordinated initially; however, once the attack is rolling, tanks will also engage targets of opportunity. Tanks of the maneuvering element usually fire individually at targets as they appear; however, when feasible, the platoon leader concentrates the fire of the platoon or a section on a dangerous target. Tanks in support deliver massed fire in a more deliberate manner, but must be prepared to immediately shift to a new target.

149. Massed Defensive Fires

In a defensive situation, the fires of all available weapons are tied together to obtain maximum destruction. The tank company fire plan is used to coordinate the fires of the platoons. The platoon fire plan is based on the range cards of each tank.

150. Platoon Fire Commands

The platoon leader controls distribution and volume of fire by issuing initial and subsequent fire commands (figs. 80 and 81). Examples of typical initial fire commands follow.

Point Target

PLATOON
HE DELAY
MY RANGE ONE SIX HUNDRED
WATCH MY BURST
BUNKER
FIRE.

Area Target

PLATOON
HE
DIRECT FRONT
NUMBER TWO—RIGHT FRONT
NUMBER THREE—RIGHT FLANK
NUMBER FOUR—LEFT FRONT
NUMBER FIVE—LEFT FLANK
TROOPS
FIRE.

Ambush

PLATOON
SHOT
RIGHT FRONT
NUMBER FIVE—LEAD TANK
NUMBER FOUR—SECOND TANK
NUMBER TWO—FOURTH TANK
NUMBER THREE—LAST TANK
(PAUSE)
FIRE.

Night Firing

FIRST SECTION
ONE ROUND HE
TARGET NUMBER SIX
TROOPS
FIRE.

151. Actions of Individual Tanks in Massed Fire

Upon receiving a platoon fire command, each tank commander issues an initial fire command to his gunner. Unless specified otherwise, the platoon command also serves as the fire command for the platoon leader's gunner. Adjustment is conducted by each tank crew; however, when necessary, the platoon leader adjusts or shifts the fire of the platoon by issuing subsequent fire commands. When visibility is poor, the platoon leader controls the volume of fire by specifying AREA FIRE or the number of rounds. The command CEASE FIRE is also given by the platoon leader.

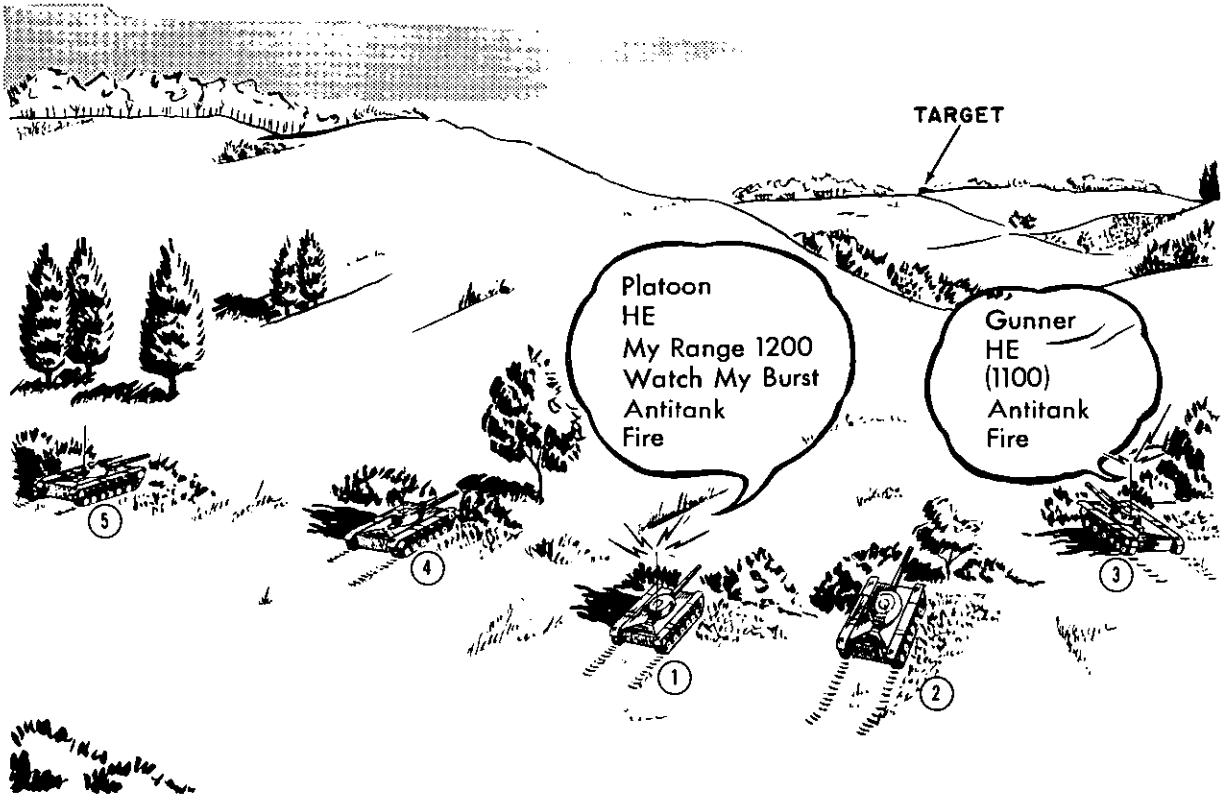


Figure 80. Engagement of point target by tank platoon.

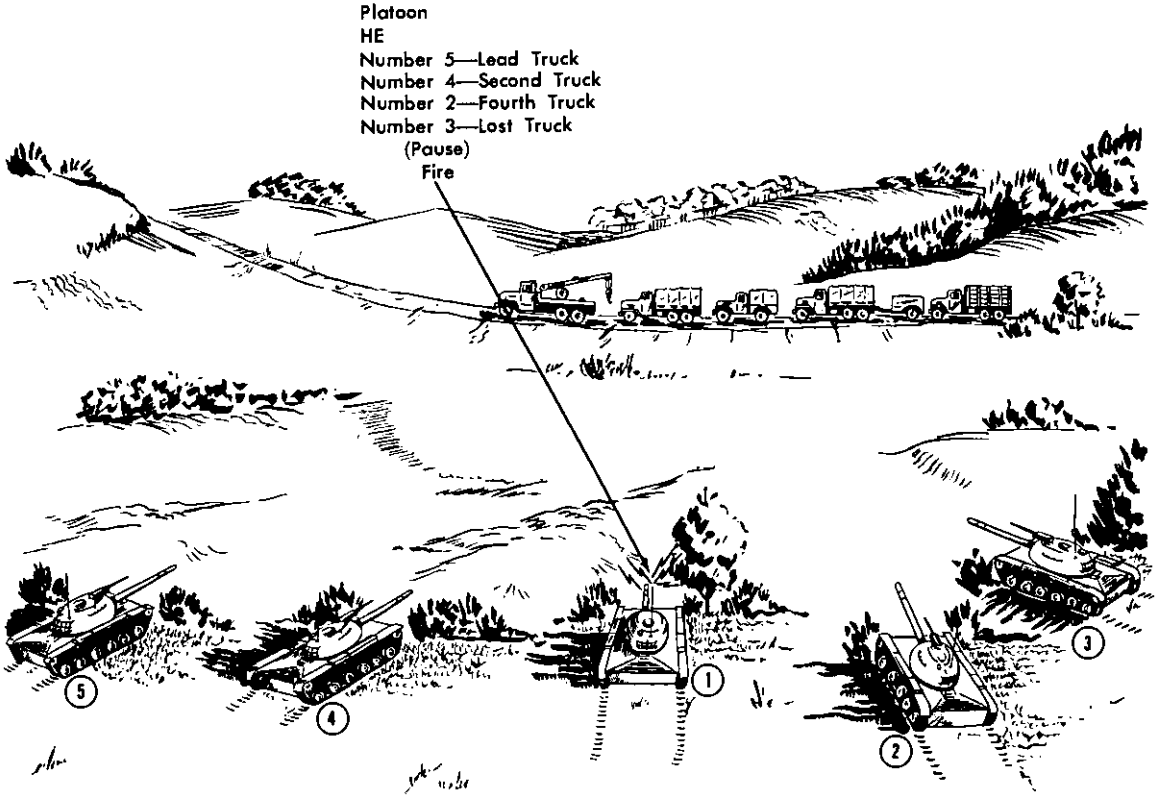


Figure 81. Ambush by tank platoon.

CHAPTER 8

SECONDARY FIRE MISSIONS

Section I. INTRODUCTION

152. General

Although is it not a primary role for tanks, under exceptional circumstances a decision may be made to employ tanks in an indirect-fire mission. This chapter discusses conduct of indirect fire of tanks in defilade, to include determination of minimum elevation and angle of site, initial and subsequent fire commands, and adjustment of fire. The material contained in this chapter is applicable to indirect fire of the single tank or tank unit, operating independently or in conjunction with artillery units.

153. Types of Indirect Fire

Indirect fire is fire delivered on targets that cannot be seen through the direct-fire sights. The types of indirect fire employed by tank units are:

a. Night Firing. Tanks employ indirect fire from direct-fire positions when firing at night or during other periods of poor visibility. Range cards are used in conducting this type of fire. This type of indirect fire is discussed in chapter 7.

b. Tanks in Defilade. The fire of a tank platoon or section is usually employed against area targets. Tanks are laid and fired as a unit; fire is adjusted by a single observer. Fire direction and control may be organic or in conjunction with artillery units. This chapter is primarily concerned with independent indirect fire of the tank platoon. The differences between this type of fire and indirect fire in conjunction with artillery are discussed in paragraphs 181 through 187.

c. Single Tank in Defilade. The fire of a single tank in a *turret* defilade position is usually employed against point targets. This is normally an expedient in a forward area where the tank cannot occupy a position for direct fire. Initial data is determined and fire is adjusted by the tank commander, who places himself where he can observe the target.

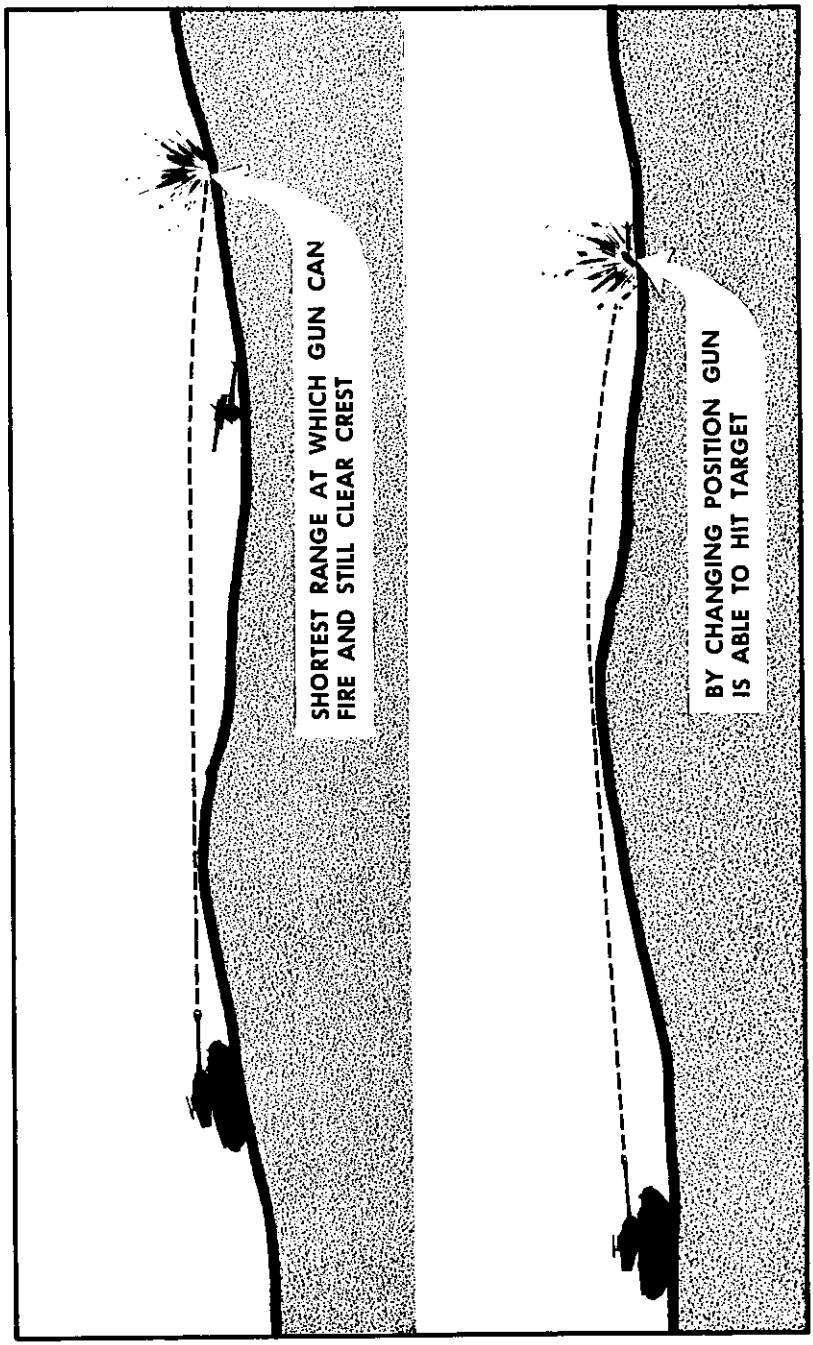


Figure 82. Placing tanks for indirect fire.

154. Firing Positions for Indirect Fire

a. In selecting a position for indirect fire, the commander of the tank unit considers the *immediate* mission, future *mobile* missions, and the *security* of his command. The following are characteristics of a good indirect firing position:

(1) It should be so located that tanks can fire on targets in the assigned sector. The position must be well forward, but not so near to a hill mask that close-in targets cannot be engaged (fig. 82).

(2) It should be so located that the tank unit has the ability to revert rapidly to its primary role of offensive combat. Multiple access routes, concealed if possible, are required to allow tanks to move without delay and to permit resupply.

(3) It should provide hardstanding with level ground.

(4) It should be behind a mask, so that tanks have full cover (turret defilade).

(5) It should permit 6,400-mil traverse, so that tanks can fire in any direction.

(6) It should enable easy communication between observer and tanks.

(7) It should be sufficiently large to allow proper dispersion of tanks.

b. When firing indirect, tanks are numbered from right to left. To occupy a firing position smoothly and promptly, the platoon leader's tank (No. 1) moves in on the right with each succeeding tank taking position to the left. Tanks are positioned approximately 35 yards apart. They should not be in a straight line, as this presents an easy target for air attack. Staggering the tanks help conceal the position and simplifies firing to the flanks (fig. 83).

c. The unit's basic load of ammunition should not be used in firing indirect. When such employment is contemplated, ammunition is stockpiled beforehand, so that the tanks are ready to fight with *full* ammunition racks. The commander must always be ready to commit his tanks in a mobile role if the situation permits.

155. Laying Tanks Parallel

Once tanks have been positioned, all gun tubes are laid parallel in the direction of fire, with an aiming circle or by reciprocal laying. This procedure insures area coverage and allows control of the fire of all tanks by a single command. When tanks are parallel, their fire falls in the target area in relation to their position on the ground. The fragmentation effect of an HE burst is nearly all to the sides, with little effect to the front and rear (fig. 84). This characteristic gives good area

coverage in width, and staggering of the tanks in position produces coverage in depth. Area coverage is obtained because the effective bursting area of 90-mm HE is approximately 40 yards in width and 7 yards in depth, and the tanks are positioned 35 yards apart and are staggered in depth (fig. 85). The observer can shift this fire to a new target area by issuing a single command, because all tanks are firing with the same quadrant elevation and deflection.

156. Minimum Elevation

a. General. Upon occupation of the position, the gunner of each tank will determine *minimum elevation.* Minimum elevation is the lowest elevation at which the gun can be fired and still clear the mask to the

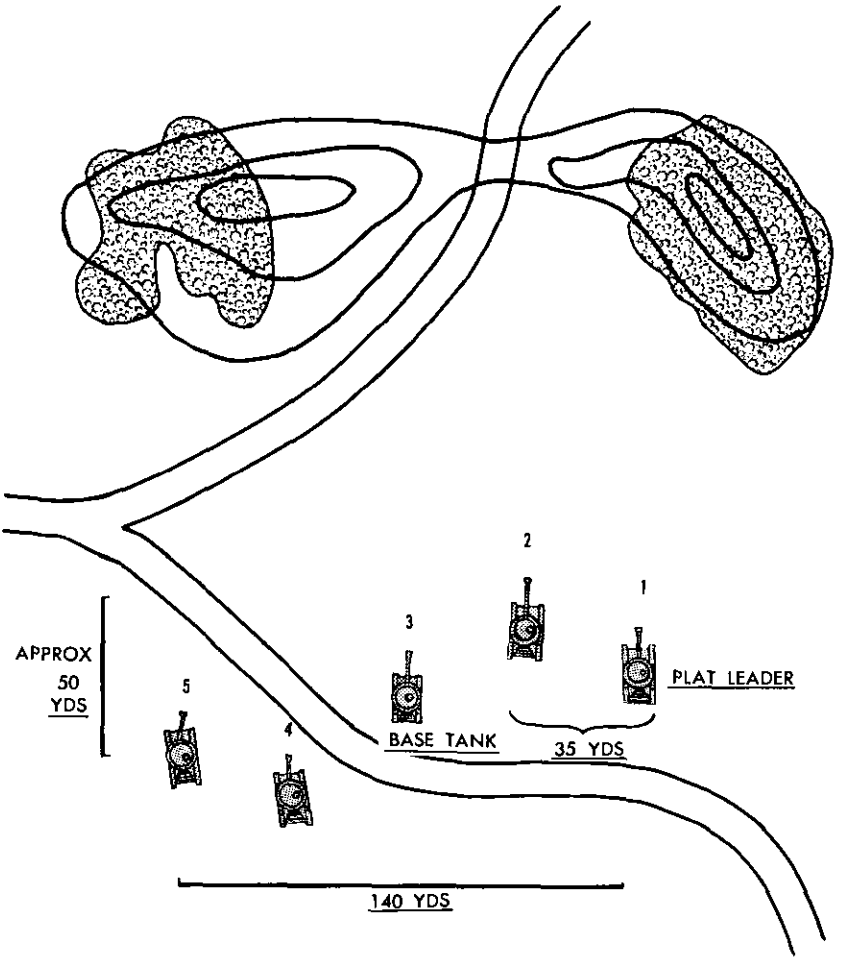


Figure 83. Platoon firing position.

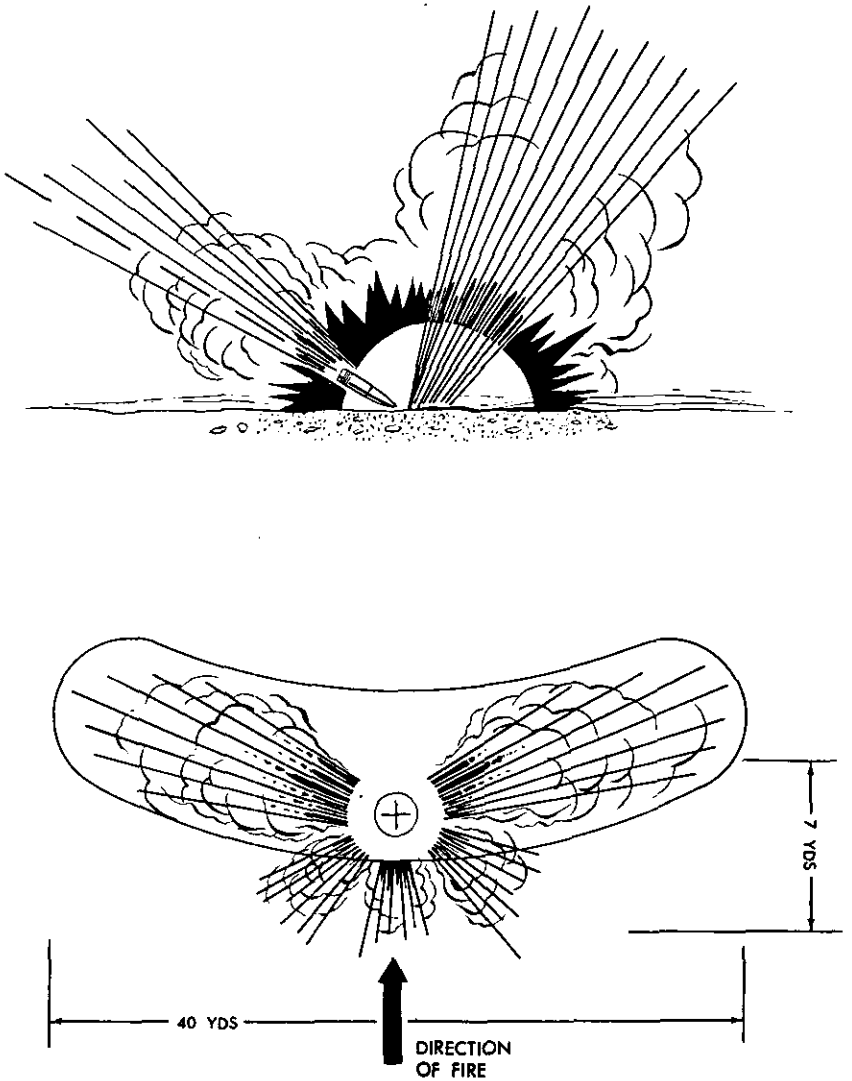


Figure 84. Fragmentation effect of HE burst.

front. Because this mask is often occupied by friendly troops, tanks are not permitted to fire *below* minimum elevation.

b. Determining Minimum Elevation.

(1) The gunner determines minimum elevation by combining the following factors:

(*a*) *Site to mask.* The vertical angle between the horizontal of the gun and the top of the mask is determined by sighting along the bottom of the tube and elevating the gun until the

line of sight clears the highest part of the mask (a, fig. 86). The gun elevation is measured with the gunner's quadrant and recorded as site to mask.

(*b*) *Elevation for range.* Elevation for range with HE ammunition is obtained by determining the range to the mask by the most accurate means available and finding the elevation for that range from a computer, ballistic unit, or firing table. This is added to the site to mask (b, fig. 86).

(*c*) *Twice C factor.* One C is the number of mils of elevation required to make a 100-yard horizontal range change (c, fig. 86). For tank gunnery purposes, the C, at normal ranges, is 1 mil. Therefore, two C's for the gun, or 2 mils, will ensure mask clearance (d, fig. 86). If the range to the mask is greater than 3,000 yards, consult a firing table for the C factor.

(*d*) *Troop safety factor.* If the mask is occupied or is to be occupied, the angle subtended by 5 yards at the range to the mask is added (e, fig. 86). This factor is obtained by using the mil relation to solve for *m*.

(2) The sum of the four factors, expressed in mils, is minimum elevation (f, fig. 86). If the sum is fractional, the next higher whole mil is used. Figure 87 is an example problem in determining minimum elevation.

c. Platoon Minimum Elevation. Each tank commander reports his minimum elevation to the platoon leader as soon as it is determined. The highest minimum elevation computed is the minimum elevation for all tanks. Each gunner records this figure for future reference. At any time during firing that the gunner receives a quadrant elevation or range change below this figure, he will cease fire and announce BELOW MINIMUM ELEVATION, UNSAFE TO FIRE.

157. Angle of Site

a. General. For indirect firing, the gun is elevated a certain number of mils for each range. However, with a gun laid at the correct elevation for a certain range, the projectile will hit a target at that range only when the target is at the same altitude as the gun. If the target is on higher ground than the gun, the projectile strikes short; if the target is lower than the gun, the projectile falls beyond the target (fig. 88). Therefore, in laying for range when there is a difference in altitude between gun and target, *angle of site* must be considered. Angle of site is the vertical angle between the horizontal of the gun and a line joining the gun and target. If the target is above the gun, the angle of site is plus; if the target is below the gun, the angle of site is minus. In direct fire, angle of site is included when the sight is laid directly on the target. In

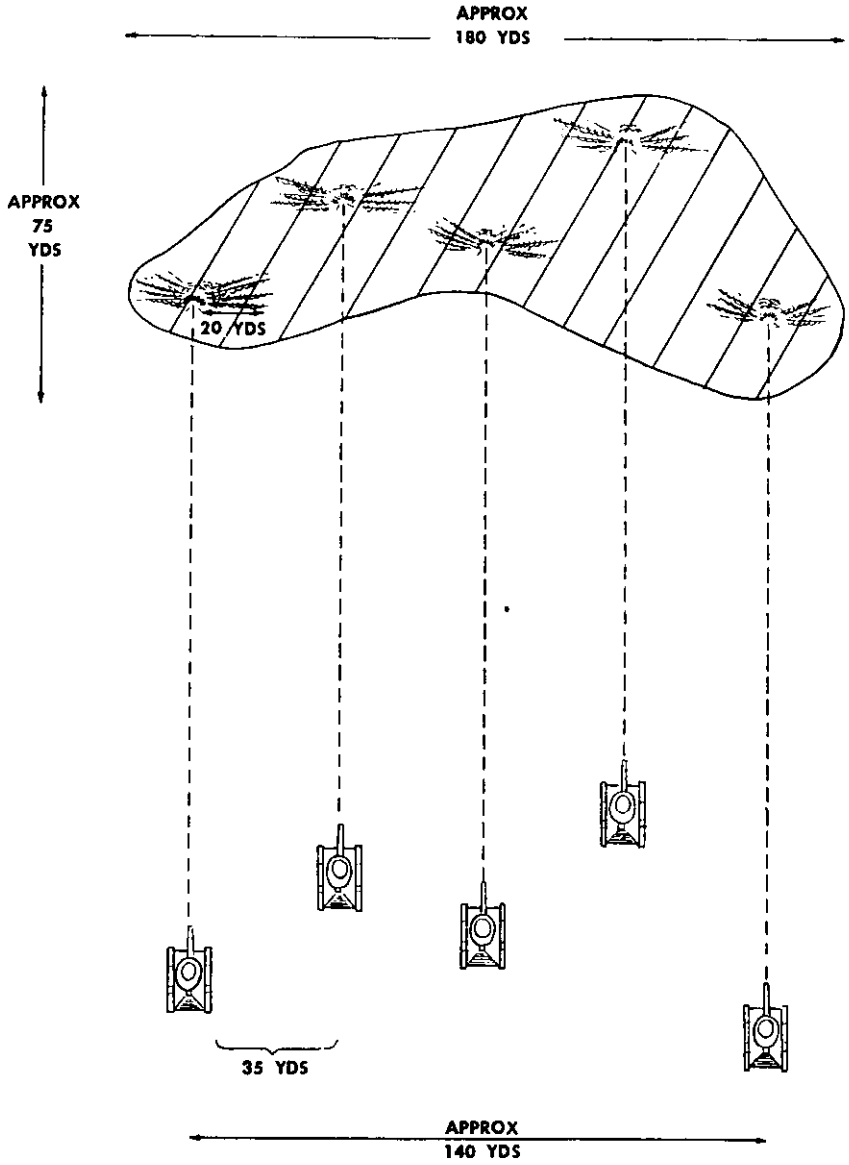


Figure 85. Obtaining area coverage.

indirect fire, where elevation is measured from the horizontal, angle of site is combined with elevation for range to obtain quadrant elevation (QE). A plus angle of site is added to the elevation for range, a minus angle of site is subtracted.

b. Determining Angle of Site.

(1) When the position of the observer is close to and at about the

same altitude as the firing position, one of the following methods may be used to determine angle of site:

(*a*) A point in the target area at approximately the same altitude as the firing position is selected. The vertical difference in mils between that point and the target is read from the binocular reticle. This method gives an *approximate* angle of site.

(*b*) An aiming circle can be used to measure angle of site directly. When the observer is above the firing position, he takes his reading from the top or far edge of the target.

(2) Angle of site may be computed by use of a map and the mil relation. This method is simple, does not require special equip-

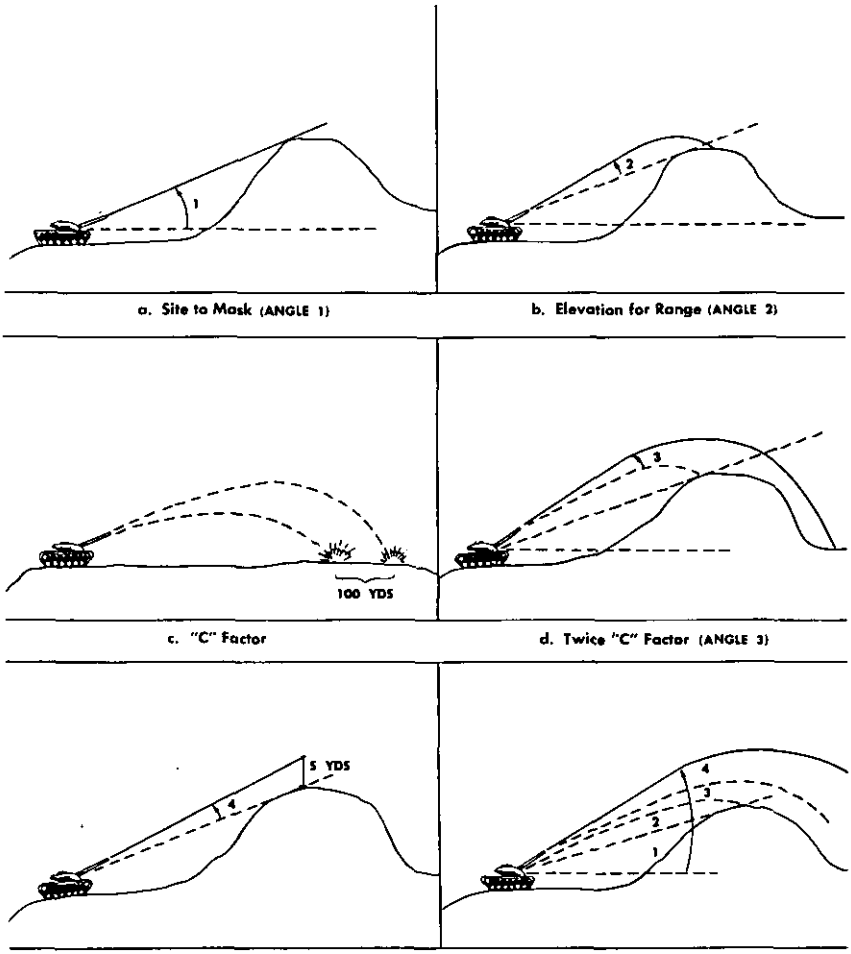
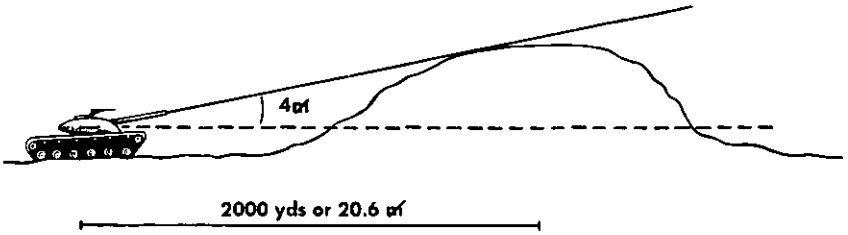


Figure 86. Steps in determining minimum elevation.



1. SITE TO MASK 4
2. ELEVATION FOR RANGE 20.6
3. 2 C's 2
4. TROOP SAFETY FACTOR 2.5

(M = $\frac{W}{R}$ = $\frac{5}{2}$ = 2.5) 29.1 OR MINIMUM ELEVATION = 30 mils

Figure 87. Minimum elevation problem.

ment or an OP near the firing position, and is accurate for tank gunnery purposes. Procedure is as follows:

(*a*) Firing position and target are plotted and range determined from the map scale. In figure 89, the range is 3000 yards.

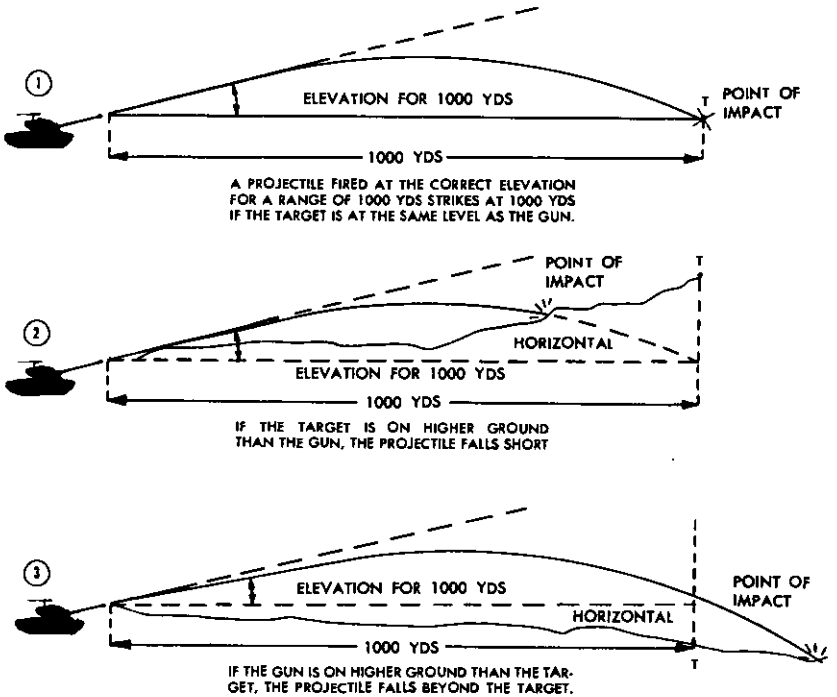
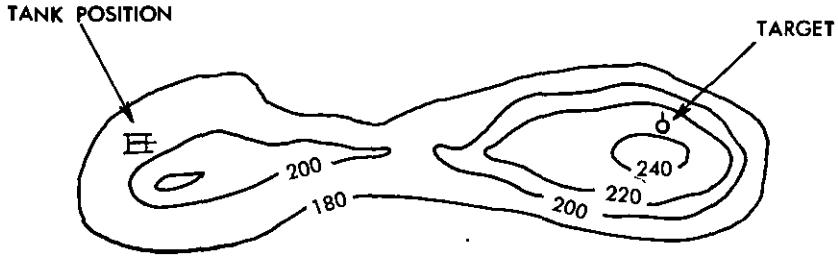


Figure 88. Effect of angle of site.

(*b*) Altitudes of both firing position and target are determined by interpolating between contour lines. The difference in altitude is obtained by subtracting the lower altitude from the higher. Range and the difference in altitude must both be expressed in the same unit of measure (yards, meters, etc.). In figure 89, the difference in altitude is 45 feet or 15 yards.

(*c*) By use of the mil relation, the difference in altitude (*W*) is divided by the range (*R*) to obtain angle of site (m). In figure 89, angle of site is +5 mils (target higher than firing position).

ANGLE OF SITE FROM A MAP



CONTOUR INTERVAL: 20 feet

RANGE TO TARGET:	3000	yards	(Determined from Map Scale)
ALTITUDE OF TARGET:	235	feet	
ALTITUDE OF TANK:	190	feet	
DIFFERENCE IN ALTITUDE:	45	feet or 15	yards

$$\frac{W}{Rm} \text{ or } m = \frac{15}{3} = 5$$

ANGLE OF SITE = +5 m

Figure 89. Determining angle of site from a map.

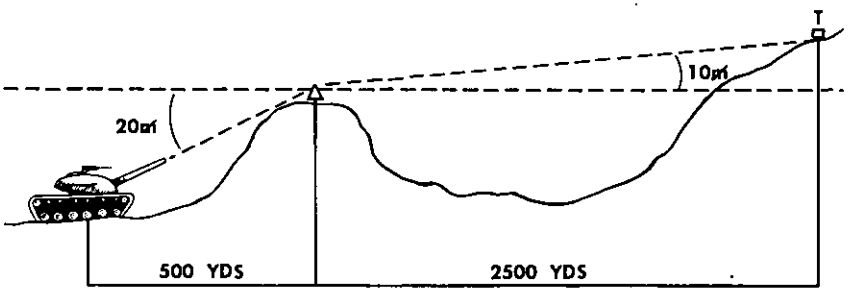
(3) An aiming circle (or M2 compass) may also be used in conjunction with the mil relation to determine angle of site. This method is somewhat time-consuming, but may be employed when the OP is not near the firing position and a map is not available. The observer selects a spot where he can sight on the firing position and the target, and proceeds in the following manner:

(*a*) *OP to T for W.* With an aiming circle, the observer measures the vertical angle from his position (OP) to the target (T). He then determines the range from OP to target by the most accurate means available. Using the mil relation, he multiplies the vertical angle (m) by the range (*R*) to obtain the difference in altitude (*W*) between OP and target. In figure 90, the difference in altitude is 25 yards.

(*b*) *OP to G for W.* Using the same method, the observer now computes the difference in altitude (*W*) between the OP and the firing position or gun (G). In figure 90, the difference in altitude is 10 yards.

(*c*) *G to T for W.* Using the results of these computations, the observer obtains the difference in altitude between gun and target by addition or subtraction. If both gun and target are below or above the OP, the lower altitude is subtracted from the higher. If one is below the OP and the other above, the two altitudes are added together. In figure 90, the difference in altitude between gun and target is 35 yards.

(*d*) *G to T for m.* Again using the mil relation, the observer determines angle of site (m) by dividing the difference in altitude between gun and target (*W*) by the total range from gun to target (*R*). In figure 90, m is 11.6; therefore, angle of site is +12 mils (target higher than firing position). When angle of site is fractional, it is announced to the nearest whole mil; when angle of site is added to or subtracted from elevation for range, fractions are not rounded off until the two figures have been combined.



1. OP TO T FOR W: W = RXM = 2.5X10 = 25 YDS
2. OP TO G FOR W: W = RXM = .5X20 = 10 YDS
3. DIFFERENCE IN ALTITUDE BETWEEN TANK AND TARGET = 35 YDS
4. G TO T FOR m: $m = \frac{W}{R} = \frac{35}{3} = 11.6 = +12m$

Figure 90. Determining angle of site by use of aiming circle and mil relation.

Section II. INDIRECT FIRE OF THE TANK PLATOON

158. Indirect Fire Missions

Two types of indirect fire missions are assigned to tank units—

a. Fire for Neutralization. This is fire designed to make an enemy's position untenable during the firing, and to cause casualties and damage which will reduce enemy combat efficiency. Area coverage is obtained by massing the fire of the unit. To conserve ammunition, adjustment is made by the center tank, or *base tank,* of the unit. The base tank of the tank platoon is tank No. 3. Commands are followed by all tanks of the platoon; when the adjustment is completed, the fire of the entire unit is placed on the target area.

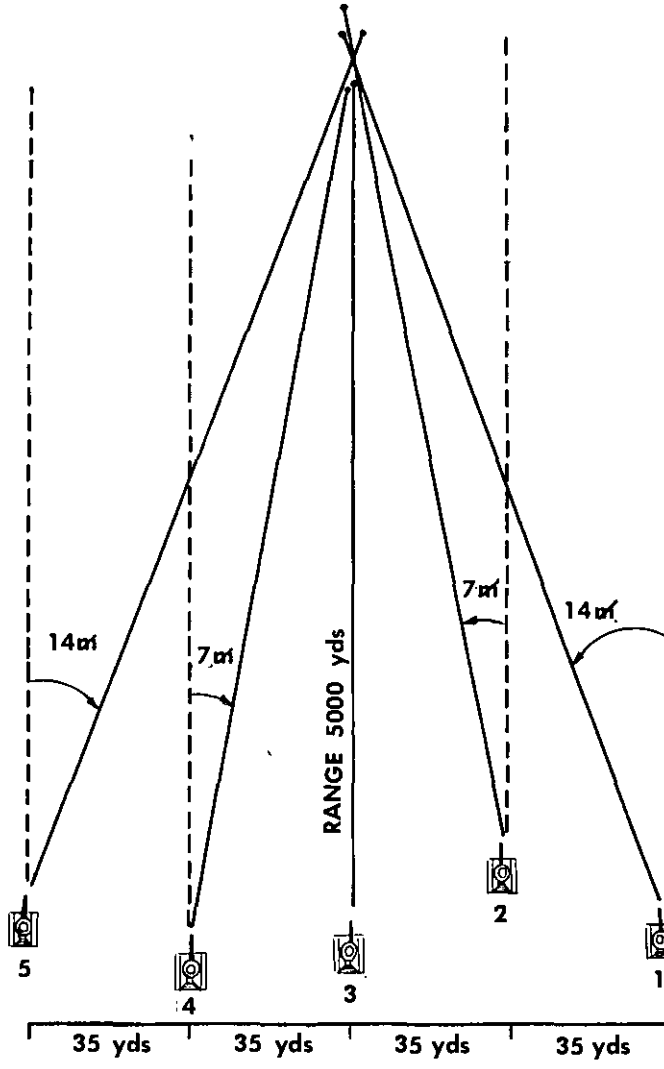
b. Fire for Destruction. This is fire designed to destroy a point target such as an antitank gun or building. Bunkers and pillboxes are not profitable targets because of the high ammunition expenditure required to achieve effect. Adjustment is made by a single tank. Other tanks of the platoon follow all commands so that additional fire may be placed on the target if necessary.

159. Sheaf

Distribution of fire depends on the *sheaf,* or plane of fire of two or more tanks. The width of a sheaf is the lateral distance between the flank bursts. Tanks employ two types of sheaf for indirect fire:

a. Normal (Parallel) Sheaf. A normal sheaf is one in which the planes of fire are parallel. Since tanks are normally positioned 35 yards apart, the width of a normal sheaf for a tank platoon is 140 yards. This type of sheaf is used for neutralization of area targets. Should the width of the target area be greater than the sheaf, the entire sheaf is shifted by a single command to all tanks.

b. Converged Sheaf. A converged sheaf is a special sheaf in which the planes of fire converge on the target. This type of sheaf is used for destruction of a point target. The sheaf of a tank platoon is usually converged on the base tank by use of the mil relation to determine the necessary shift for the other tanks. With tanks positioned the same distance apart in a parallel sheaf, only one mil relation computation is required. The amount of shift for the two interior tanks is the same; for the two flank tanks, the figure is doubled. In figure 91, the shift for No. 2 and No. 4 is *left 7* and *right 7* respectively; for No. 1 and No. 5, *left 14* and *right 14.*



$$M = \frac{W}{R} = \frac{35}{5} = 7$$

∴ #2 = LEFT 7

#4 = RIGHT 7

#1 = LEFT 14

Figure 91. Converged sheaf.

160. Organic Fire Control of Tank Platoon

a. The platoon is the basic firing unit of the tank company. Indirect fire of the tank platoon is controlled at the firing position by the fire control officer (FCO), who normally is the platoon leader. He is responsible for positioning tanks, laying guns parallel, and directing the fire of the platoon. Upon receiving the minimum elevation from each tank, he determines minimum elevation for the platoon. He also determines angles of site of prominent terrain features in the target area. When the altitude of the target area is reasonably constant, an average angle of site is determined. To save time during a fire mission, the fire control officer uses the average angle of site, or the angle of site to a terrain feature at approximately the same altitude as the target. Upon receiving an initial fire request or subsequent correction from the observer, the fire control officer directs fire by issuing necessary initial or subsequent fire commands to the tanks. The post of the fire control officer is where he can best control the fire of the platoon. Control is exercised by voice, wire, or radio. Wire should be provided to each tank to facilitate control and keep the radio net clear for communication with the observer and the company CP. Necessary fire-direction equipment for the fire control officer includes a map, a straightedge, and a firing table or graphical firing table (GFT). Not required, but very useful, are map pins and a ruler graduated to the map scale. The fire control officer requires one assistant. The assistant operates the radio or telephone and records platoon minimum elevation, angles of site, and each fire mission to include fire request, corrections, and all fire commands to the tanks. Every fire mission is assigned a concentration number for future reference. The computer's record, as described in FM 6–40, may be used as a guide for format of the recorder's log.

b. Since observers are not provided by tables of organization, it is necessary for the platoon leader to designate a qualified individual. The observer establishes his OP where he can observe the target area from a location on line, or nearly on line, with the center of the firing position and the center of the assigned sector of fire. This location is necessary because tank units do not have the equipment to employ artillery fire-direction methods. Consequently, it is necessary to adjust fire from, or in relation to, the *gun-target (GT) line.* A central location places the observer as close as possible to the line of fire, allowing him to make more accurate sensings than could be made from a position to either flank. Radio is the normal method of communication with the firing position; however, wire should be laid for sustained operations in a static situation. Fire-control equipment for the observer includes maps, binocular, M2 compass, and, when available, an observation telescope. The driver of the observer's vehicle acts as an assistant, and should be capable of taking over if the observer becomes a casualty. As an aid in

fire adjustment, the observer makes a rough terrain sketch of the assigned sector. The observer's sketch (fig. 92) is a schematic diagram of key terrain and the location of firing position, OP, and reference points. As concentrations are fired, they are plotted for future reference.

161. Determination of Initial Data for Indirect Fire

Targets are located in relation to a point known on the ground and/or a map by the observer and the fire control officer. The fire control officer determines data to engage a target by measuring the necessary shift in range and deflection on his firing chart (map). Known points may be a registration point, a previous concentration, or coordinates.

a. Registration Point. A registration (base) point is a known point in the approximate center of sector, used as a reference point for computing data. It is selected by the observer, and must be an easily distinguishable terrain feature which cannot move or be removed by fire. Whenever possible, the registration point should be identified on a map, so that its location can be plotted. Tanks should be registered on the registration point as soon as possible after moving into position. To register the tank platoon, the observer requests MARK CENTER OF SECTOR. Since tanks have been laid parallel in the direction of fire, only the base tank fires—with zero deflection, and a quadrant elevation for the range of the

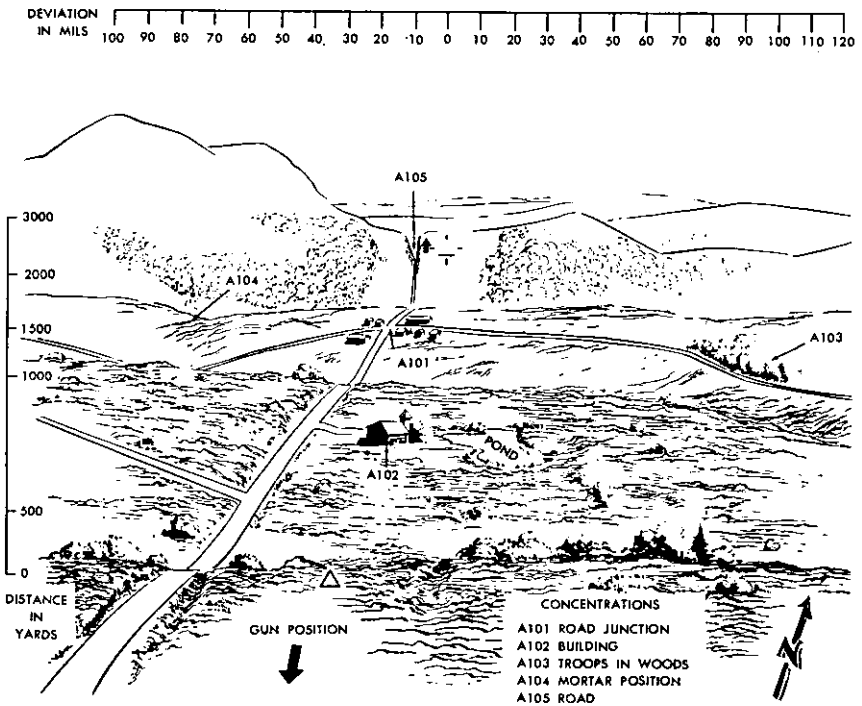


Figure 92. Observer's sketch.

approximate center of sector. *With all tanks following commands,* the fire of the base tank is adjusted until the registration point is hit or the closest possible adjustment has been made. On completion of the registration, all gunners zero their azimuth indicators without disturbing the lay of the guns. Tanks are now laid parallel in the registration point direction and will make all deflection shifts from this reference point. The adjusted quadrant elevation and zero deflection (6,400 mils) are entered in the recorder's log as *registration point data.* The fire control officer plots the firing position and the registration point on his firing chart, connecting the two points with the *registration point line.* If the registration point cannot be located by coordinates, the registration point line is plotted on the chart from firing data. This is done by drawing the registration point line from the firing position along the measured grid azimuth of the guns. By use of the map scale, the line is terminated at a point representing the known registration point range. This point is the *registration point location.* Initial data to engage a target located with reference to a registration point is determined in the following manner:

(1) The observer determines the necessary shift from registration point in yards, for both direction and range, and sends his fire request to the fire control officer.

(2) The fire control officer plots the target by measuring the shift on his chart. By inspection, he determines if angle of site must be considered.

(3) Range is determined by adding (subtracting) the range shift to the registration point range. Elevation for range is obtained from a graphical firing table or a firing table and is combined with angle of site to give the quadrant elevation. In figure 93, the quadrant elevation is 86 mils.

(4) Deflection is determined by converting the direction shift from yards to mils. This is done by using a graphical firing table or the mil relation. If a graphical firing table is not available, the mil relation can be used to prepare a conversion chart (fig. 94) prior to firing. Deflection is sent to the tanks as an azimuth indicator reading (if the target is right of registration point, the mil shift is subtracted from 3,200 mils; if the target is left of registration point, the mil shift is the azimuth indicator reading). In figure 93, deflection is *16 left.*

b. Concentrations. All fire missions are assigned concentration numbers by the fire control officer. After the mission is completed, the adjusted quadrant elevation and deflection are entered in the recorder's log to establish additional known points in the target area. Should a target appear closer to a previous concentration than to the registration point, the observer determines the shift from that concentration. Additionally, when there is renewed enemy activity in the area of

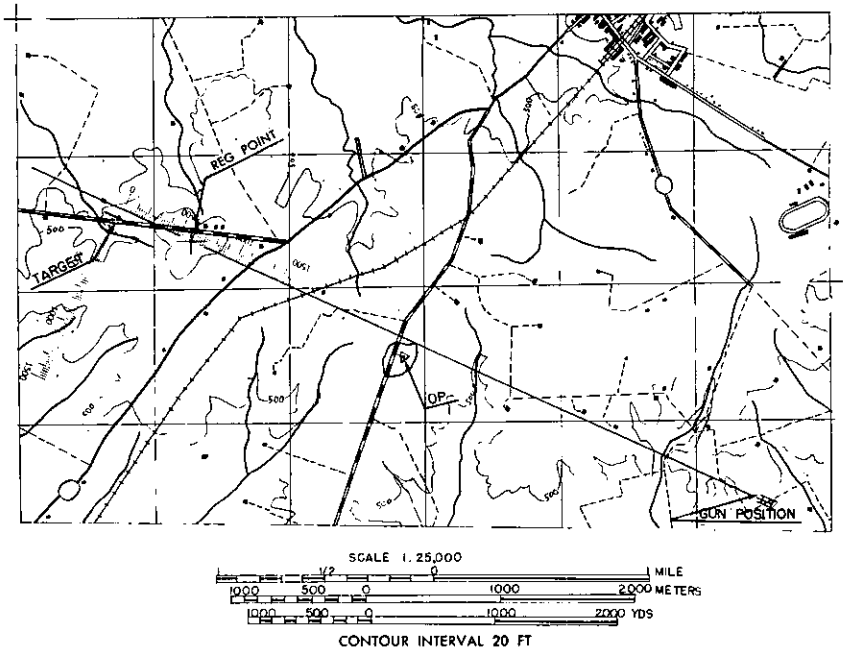


Figure 93. Determining initial data from registration point.

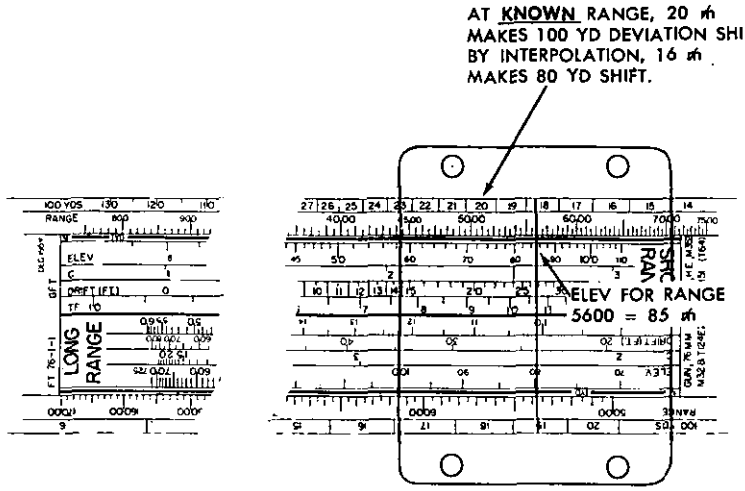
the concentration, the observer may request that the concentration be refired. The fire control officer uses the same procedure in determining firing data for a shift from a concentration as in shifting from registration point.

c. Grid Coordinates. When a target can be located on a map, its location may be sent by grid coordinates. This method is more accurate than computing a shift when the target is a considerable distance from a known point. Data to engage a target from map coordinates is determined as follows:

(1) The fire control officer plots on his chart the coordinates of the target, determining angle of site if necessary.

(2) Range is determined by measuring the distance between the plotted target and the firing position, converted to quadrant elevation by combining elevation for range and angle of site, and sent to tanks. In figure 95, QE is 83 mils.

(3) Deflection is determined by measuring from the coordinate to the registration point line. This deviation in yards is then converted to mils and sent to the tanks as an azimuth indicator reading. In figure 95, deflection is *3,010 right.*



OBSERVER'S SHIFT: ". . . . . From Registration Point, Left 80, Add 600 . . . . ."

PREVIOUSLY DETERMINED REGISTRATION POINT DATA:		INITIAL TARGET DATA DETERMINED BY FCO:		STEPS IN DETERMINING INITIAL TARGET DATA:
RANGE:	5000 yards	RANGE:	5600 yards	range shift combined with registration point range
ELEV :	71 mils	ELEV :	85 mils	taken from GFT
SITE :	+3 mils	SITE :	+1 mils	determined from map
QE :	74 mils	QE :	86 mils	site combined with elevation
DEFL :	6400 mils	DEFL :	16 LEFT	interpolated from GFT (use known range)

Figure 93—Continued.

DEVIATION—DEFLECTION CONVERSION CHART

To convert a deviation in yards to a mil deflection, the following chart is used:

RANGE	MIL SHIFT FOR DEVIATION OF:		
	100 YDS	50 YDS	20 YDS
2000	50 mils	25 mils	10 mils
2500	40 mils	20 mils	8 mils
3000	34 mils	17 mils	7 mils
3500	29 mils	15 mils	6 mils
4000	25 mils	13 mils	5 mils
4500	23 mils	11 mils	4 mils
5000	20 mils	10 mils	4 mils
5500	19 mils	9 mils	4 mils
6000	17 mils	8 mils	3 mils
7000	15 mils	7 mils	3 mils
8000	13 mils	6 mils	3 mils
9000	11 mils	6 mils	2 mils
10000	10 mils	5 mils	2 mils
11000	9 mils	5 mils	2 mils
12000	8 mils	4 mils	2 mils
13000	8 mils	4 mils	2 mils
14000	7 mils	4 mils	1 mils
15000	7 mils	3 mils	1 mils

Figure 94. Deflection-deviation conversion chart.

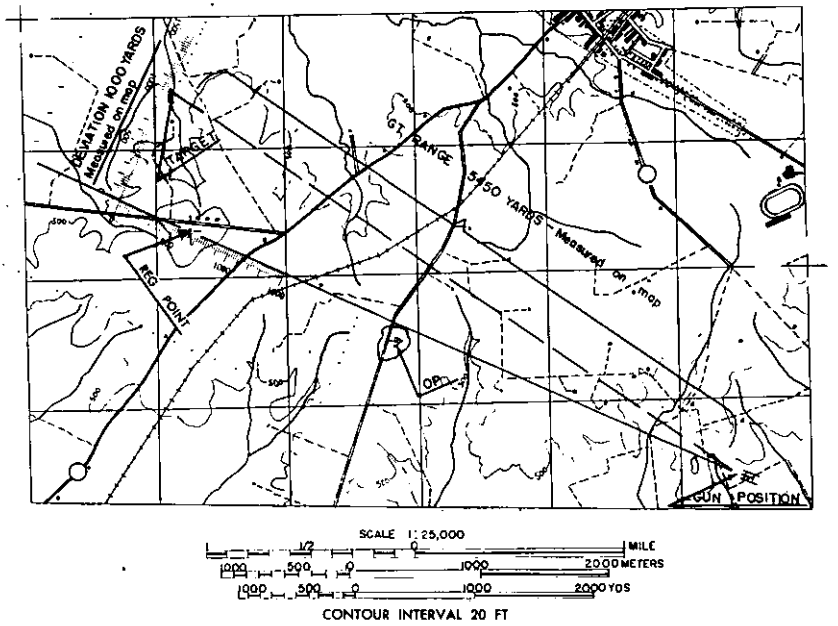
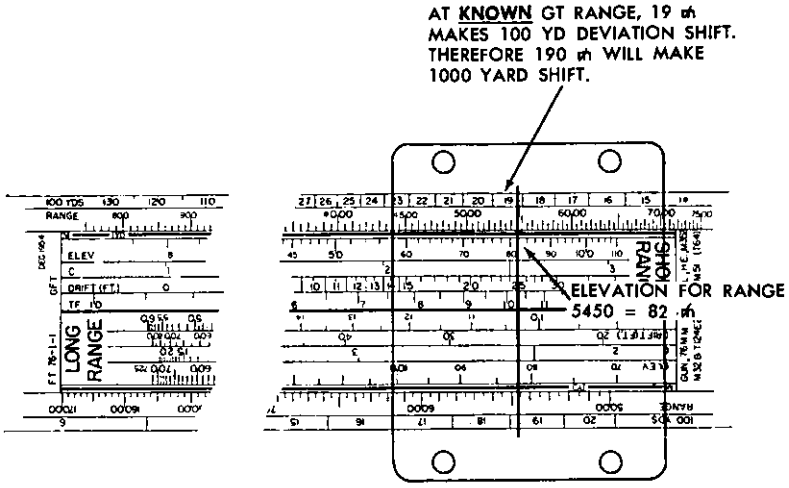


Figure 95. Determining initial data from coordinates.



OBSERVER'S COORDINATES: " . . . . . Coordinates 104913. . . . . "

PREVIOUSLY DETERMINED REGISTRATION POINT DATA:		INITIAL TARGET DATA DETERMINED BY FCO:		STEPS IN DETERMINING INITIAL TARGET DATA:
RANGE:	5000 yards	RANGE:	5450 yards	.....measured on map
ELEV :	71 ₥	ELEV :	82 ₥	.....taken from GFT
SITE :	+3 ₥	SITE :	+1 ₥	.....determined from map
QE :	74 ₥	QE :	83 ₥	.....site combined with elevation
DEFL :	6400 ₥	DEFL :	3010 RIGHT	.....deviation measured on maps; deflection taken from GFT (use known GT range)

Figure 95—Continued.

Section III. INITIAL FIRE REQUEST

162. General

To obtain fire on a target, the observer transmits an *initial fire request* to the fire control officer at the firing position. The initial fire request for tank indirect fire is the same as the request for artillery and other indirect-fire weapons except that the observer-target (OT) azimuth is not included. Since tank indirect fire is adjusted from the gun-target line, the observer-target azimuth is not a factor. Any observer who can communicate with the firing position can adjust tank fire; however, observers from other units must be informed to adjust from the gun-target line. Should an observer not know the general location of the firing position, the gun-target line can be established by a correction of ADD

(DROP) 400 after observation of the first round. The elements of the initial fire request are announced in the following sequence:

a. Identification of observer.
b. Warning.
c. Location of target.
d. Nature of target.
e. Unusual requirements (normally omitted).
f. Type of control.

163. Elements of Initial Fire Request

Announcement of the elements of the initial fire request is the same as outlined in FM 6–135 with the exception that the observer-target azimuth is omitted and the location of target is determined in a slightly different manner. These exceptions are due to the gun-target line method of adjustment. Target location for tank indirect fire is determined by one of the following methods:

a. Cordinates. When the observer can locate the target on his map, he may send six-digit coordinates; for example, COORDINATES 345,876. This is a rapid method of target location, and is usually more accurate than a large shift from a reference point.

b. Shift. The observe may locate the target by a shift from a reference point, such as the registration point or a previous concentration. The shift is given as a direction and range correction *in yards;* for example, FROM REGISTRATION POINT, RIGHT 80, ADD 600; or FROM CONCENTRATION CHARLIE 103, LEFT 100, DROP 400.

(1) *Direction.* When the observer is on or near the gun-target line, the direction correction is obtained by first measuring the deviation in mils from the reference point to the gun-target line. Then, by use of the mil relation, deviation (m) is multiplied by the distance from observer to reference point (R) to obtain the direction correction (W). The direction correction is sent to the nearest 10 yards. In figure 96, the correction is RIGHT 400. If the observer is not near the gun-target line, deviation cannot be measured accurately. In such cases, the direction correction is obtained by estimating the lateral distance between the reference point and the gun-target line. When the direction of the target is the same as that of the reference point, a direction correction is omitted from the fire request.

(2) *Range.* The range correction is determined by estimating the distance along the gun-target line to the target from a point where a perpendicular line from the reference point intersects the gun-target line. The range correction is sent to the nearest 100 yards. In figure 96, the range correction is ADD 600. If the range to reference point and target are estimated to be the same, the correction is announced as REPEAT RANGE.

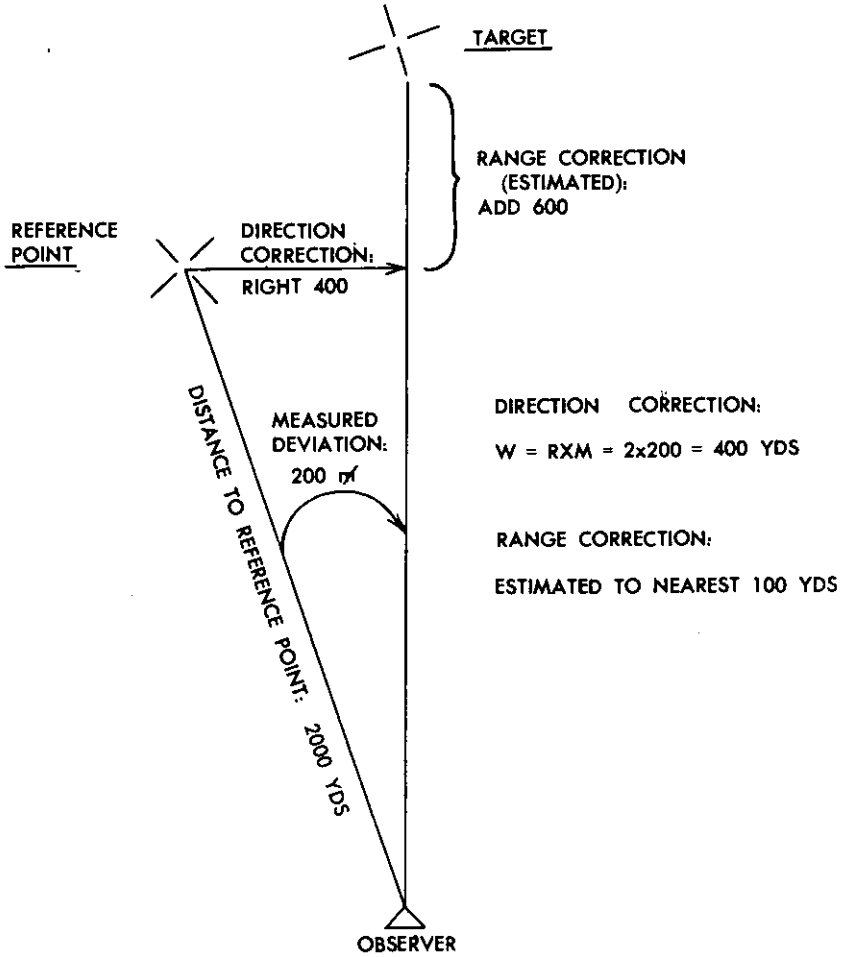


Figure 96. Target location by shift from reference point.

c. Marking Volley. When the observer does not know the location of reference points, he may request a marking round from which to shift to the target; for example, MARK REGISTRATION POINT or MARK CENTER OF SECTOR.

164. Examples of Initial Fire Request

THIS IS BRAVO 7
FIRE MISSION
(send your mission)
COORDINATES
987,456
INFANTRY COMPANY IN WOODS
WILL ADJUST.

THIS IS DELTA 5
FIRE MISSION
(send your mission)
FROM REGISTRATION POINT
RIGHT 60, ADD 400

ANTITANK
WILL ADJUST.

THIS IS TANGO 2
FIRE MISSION
(send your mission)
CONCENTRATION
101

BATTALION
ASSEMBLY AREA
FIRE FOR EFFECT.

Section IV. INITIAL FIRE COMMANDS FOR INDIRECT FIRE

165. General

Indirect fire of tanks is directed by fire commands from the fire control officer. The fire control officer bases his initial fire command on the initial fire request of the observer. The initial fire command for indirect fire consists of six elements and is issued in the same sequence as initial fire commands for direct fire (par. 89).

166. Alert Element, Indirect Fire Command

The alert element alerts the unit for the fire mission and designates the unit or tank to fire. When an adjustment is necessary, the base tank fires and the remainder of the unit follows commands. This is announced as PLATOON ADJUST, NUMBER 3. If no adjustment is necessary, the command is PLATOON or the number of the section or tank to fire (2D SECTION or NUMBER 2). The alert element also indicates whether *volley* or *salvo* fire will be employed.

a. Volley Fire. Volley fire is a specified number of rounds fired by each firing tank. Once the initial command to fire has been given, the indicated number of rounds are fired rapidly without further command. Unless otherwise specified, volley fire is the method employed.

b. Salvo Fire. Salvo fire is successive firing at a prescribed time interval by tanks in position. One salvo is one round fired by each firing tank. The command for salvo fire is PLATOON RIGHT (LEFT). On the command to fire, the right (left) flank tank of the unit opens fire, followed by each adjoining tank at two-second intervals. To vary the firing interval, it is necessary to specify the time; for example, PLATOON RIGHT, 5-SECOND INTERVAL.

167. Ammunition Element, Indirect Fire Command

The ammunition element is announced using standard direct-fire terminology for projectile and fuze. In addition, the number of rounds to be fired is announced; for example, 1 ROUND HE or 3 ROUNDS SMOKE. HE with superquick fuze is employed for most indirect fire targets.

168. Range Element, Indirect Fire Command

The range element is announced as a quadrant elevation to the nearest whole mil. Quadrant elevation is determined by combining the elevation for range and the angle of site. For example, an elevation for range of 123.4 mils and an angle of site of minus 3.7 mils are combined to give a quadrant elevation of 119.7 mils. This is announced as QUADRANT 120.

169. Direction Element, Indirect Fire Command

The direction element is announced as an azimuth indicator reading left or right of registration point (zero deflection). Thus, when a target is 124 mils left of registration point, direction is announced as DEFLECTION 124 LEFT; the same deviation to right of registration point is announced as DEFLECTION 3,076 RIGHT.

170. Description Element, Indirect Fire Command

The description element is announced to tank crews for information purposes and because this knowledge gives added incentive to tank crews. Standard tankers' terminology is used; for example, "infantry in the open" is announced as TROOPS.

171. Command to Fire, Indirect Fire Command

Tanks fire on the command FIRE, which is issued by the fire control officer. After the description element, the fire control officer withholds this command until the commanders of tanks to fire have signified readiness by raising their hands or announcing READY.

172. Examples of Initial Fire Command, Indirect Fire

PLATOON ADJUST	PLATOON	PLATOON RIGHT	NUMBER 2
NUMBER 3			
1 ROUND HE	2 ROUNDS HE	1 ROUND HE	3 ROUNDS HE DELAY
QUADRANT 116	QUADRANT 88	QUADRANT 120	QUADRANT 52
DEFLECTION 2,814 RIGHT	DEFLECTION 66 LEFT	DEFLECTION 1,234 LEFT	DEFLECTION 44 LEFT
TROOPS	TRUCKS	TROOPS	ANTITANK
FIRE.	FIRE.	FIRE.	FIRE.

173. Crew Firing Duties, Indirect Fire

In order to obtain speed in firing while retaining accuracy, tank crews perform firing duties in a logical sequence as the fire command is issued. Each element of the fire command requires specific action by the crew.

a. Alert. All tank crews designated to fire or adjust are alerted for the fire mission. Crewmen assume position and prepare to follow commands. Each element of the command is repeated by the tank commander.

b. Ammunition. All loaders select the designated ammunition, setting fuze if necessary. Only tank guns to fire are loaded; commanders of nonfiring tanks caution DO NOT LOAD prior to repeating type of ammunition. Loaders announce UP after loading.

c. Range. All gunners index the announced quadrant elevation on elevation quadrant, but do not center bubble at this time.

d. Direction. All gunners traverse manually in the indicated direction until the prescribed deflection is indexed on the azimuth indicator. On completion of traverse, each gunner manually elevates or depresses the gun until the elevation quadrant bubble is centered. The gun is now laid for range and direction.

e. Description. Gunners check azimuth indicator and elevation quadrant, turn on main gun switch (tanks to fire only), and announce READY to tank commander. Tank commanders then signify readiness by raising arms or announcing READY to the fire control officer.

f. Command to Fire. Upon receiving the ready signal from tanks to fire, the fire control officer commands FIRE. Gunners announce ON THE WAY and fire; the fire control officer sends ON THE WAY to the observer. After the initial round has been fired, the actions of the crews depend on the type fire specified in the initial command. When more than one volley has been ordered, the loader loads immediately after firing. The gunner checks his lay *after* loading, re-lays if necessary, and announces READY to the tank commander. All subsequent commands to fire are given by the tank commander; the crew continues to fire rapidly until the specified number of rounds have been expended. After firing the last volley or salvo, the loader stands by, but does not load. The gunner checks his lay, turns off the gun switch, and waits for a subsequent command.

Section V. ADJUSTMENT OF TANK INDIRECT FIRE

174. General

Indirect fire is adjusted to bring accurate massed fire on the target in the shortest possible time, thus obtaining maximum destructive effect before the enemy can take cover or move out of the fire. Fire is adjusted by *bracketing* the target. Bracketing means to inclose the target between bursts which are over and short for range. This bracket is then reduced until target effect is obtained. Indirect fire of tanks and artillery is adjusted, basically, in the same manner, with the exception that tank indirect fire is characterized by adjustment of a single tank with reference to the gun-target line while artillery is normally adjusted by two guns with reference to the observer-target line. The adjustment of tank indirect fire follows three cardinal principles:

a. Bring the burst to the gun-target line.

b. Inclose the target in a range bracket.

c. Split the bracket successively until the target has been hit or effect obtained.

175. Sensings, Indirect Fire

The observer mentally senses each burst for range and deviation. Indirect fire sensings are the same as those for direct fire (par. 100–102). When more than one gun is fired, the sensing is made from the center of the volley. Sensings are normally not announced, but are used as an aid in making subsequent corrections. The following range and deviation sensings are used for indirect fire.

Range sensings	*Deviation sensings*
TARGET.	
OVER.	(Mils) RIGHT, (mils) LEFT, LINE.
SHORT.	(Mils) RIGHT, (mils) LEFT, LINE.
DOUBTFUL.	(Mils) RIGHT, (mils) LEFT.
LOST.	

176. Subsequent Corrections, Indirect Fire

A subsequent correction is any necessary correction to the fire once an adjustment has started. Corrections are made in the following sequence: *deviation, range.*

a. Deviation Correction. Deviation corrections are made to bring the burst to the gun-target line. When the observer is on or near the gun-target line, he measures the deviation in mils from burst to adjusting point. Mil deviation is converted to yards by use of the mil relation ($W = R \times m$) in the same manner as in making a direction correction in the initial fire request. The R factor is the observer-target range expressed to the nearest 1,000 yards. Deviation corrections are announced to the nearest 10 yards. For example, with an observer-target range of 3,300 yards, the observer makes a deviation sensing in mils of 33 RIGHT. He multiples 33 mils by the R factor of 3; the deviation is 99 yards. This is announced as LEFT 100. When the observer is not near the gun-target line, he estimates the deviation correction in yards. A deviation correction of less than 20 yards is usually omitted from the subsequent correction.

b. Range Correction. Range corrections are made in hundreds of yards until the required correction is less than 100 yards. After the first positive range sensing, a range change is made by the observer announcing ADD (DROP) (so much), the amount of the range change being that required to hit the target or establish a bracket. Once established, the bracket is split until the target is inclosed in a 100-yard bracket. Under certain conditions it may be advisable to split the bracket proportionately, rather than in half. For example, after sending ADD 400, the observer notes that the next round is much closer to the target than the previous volley. In this case, he may send DROP 100 rather than DROP 200. A range correction is required for each subsequent correction. When a range change is not necessary, the observer announces REPEAT RANGE.

177. Type of Control

Type of control is announced after the subsequent correction when a change is necessary. A change in control is announced after the range correction.

a. Fire for Effect. Fire for effect is commenced at the center of a 100-yard bracket, or whenever the observer senses TARGET. This is announced as ADD (DROP) 50, FIRE FOR EFFECT, or REPEAT RANGE, FIRE FOR EFFECT.

b. Additional Fire. When the target requires additional fire, the observer announces REPEAT RANGE, REPEAT FIRE FOR EFFECT.

c. Shifting Fire for Effect. To obtain effect on large area targets or targets which have moved, the observer may shift the fire; for example, RIGHT 50, ADD 50, REPEAT FIRE FOR EFFECT.

178. Subsequent Fire Commands, Indirect Fire

a. Subsequent fire commands are issued to control firing after the initial fire command has been given. The fire control officer issues a subsequent command to change an element in the initial command, to cease fire, or to apply the observer's corrections during an adjustment. During an adjustment, the normal sequence of the command is *deflection, range, command to fire.* When deflection is unchanged, this element is omitted; however, range is repeated for each command, regardless of change. (The loader loads on this element.) Other elements of the initial fire command remain in effect, but are not repeated unless a change is to be made. In the following example, all tanks follow the commands; only the base tank fires:

Initial fire command	*Subsequent correction*	*Subsequent fire command*
PLATOON ADJUST NUMBER 3 1 ROUND HE QUADRANT 69 DEFLECTION 2,832 RIGHT TROOPS FIRE.	RIGHT 50 ADD 200.	DEFLECTION 2,822 RIGHT QUADRANT 74 FIRE.

b. Changes in tanks to fire, type of fire, number of rounds, and type ammunition are announced prior to the deflection (range) element. To fire for effect, or to make other changes in the initial command, the fire control officer announces the necessary elements in a subsequent fire command; for example: *Base tank has completed adjustment—*

To fire two platoon volleys in effect:	Base tank to fire three volleys:	Change of fuze and tank to fire:	To fire platoon salvo with smoke:
PLATOON	3 ROUNDS	NUMBER 4	PLATOON LEFT

2 ROUNDS	QUADRANT 71	3 ROUNDS HE DELAY	1 ROUND SMOKE
QUADRANT 71	FIRE.	DEFLECTION 2,815 RIGHT	QUADRANT 71
FIRE.			FIRE.
		QUADRANT 71 FIRE.	

179. Report by Observer

Upon completion of the mission, the observer announces END OF MISSION, and states the results. The fire control officer also announces END OF MISSION as the command for all tanks to return to zero deflection. Tubes are elevated for safety purposes. CEASE FIRE is the command to suspend firing pending further information; at this command, all tanks remain at the last announced deflection and quadrant elevation until a new command is issued.

180. Illustrative Example of Indirect Fire Mission

Figure 97 is an illustrative example of a fire mission by a tank platoon.

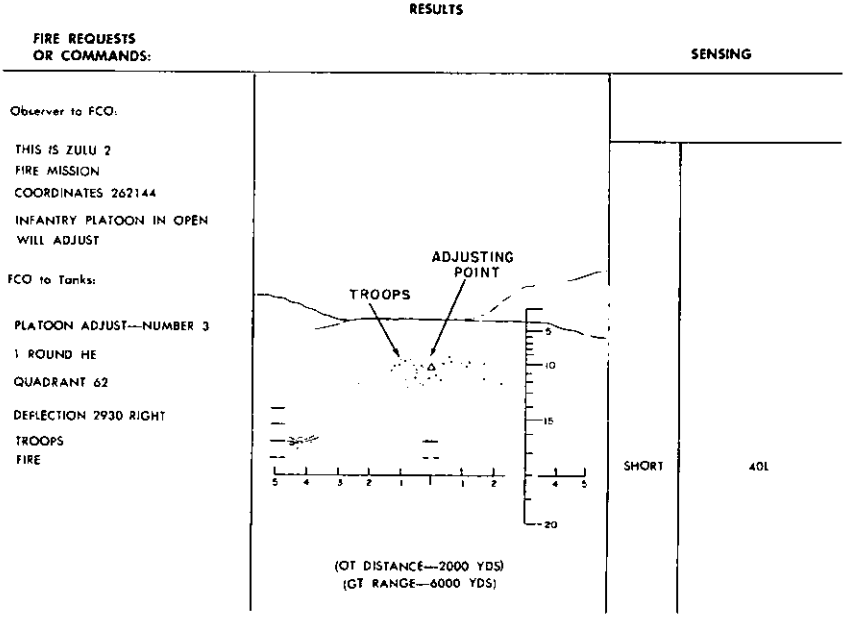
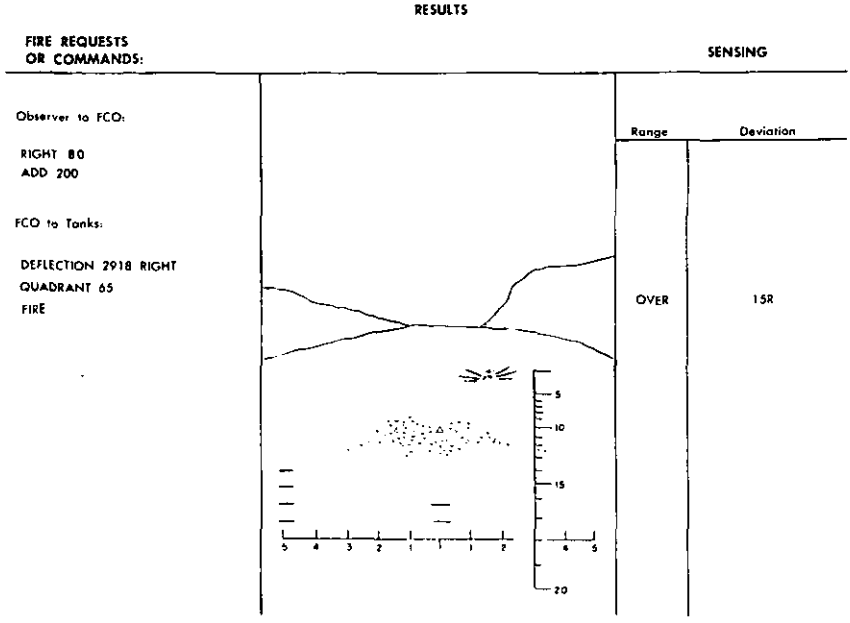


Figure 97. Indirect fire mission by tank platoon.



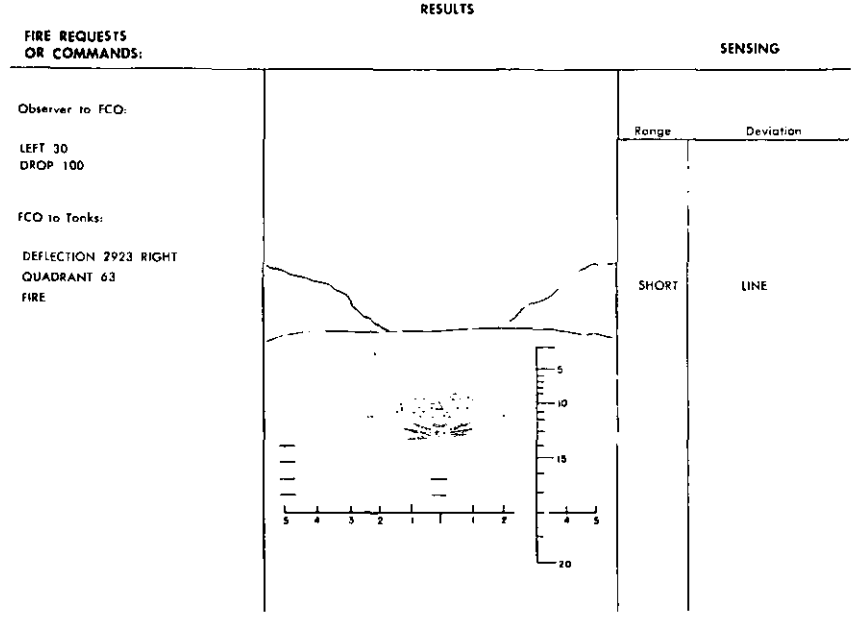


Figure 97—Continued.

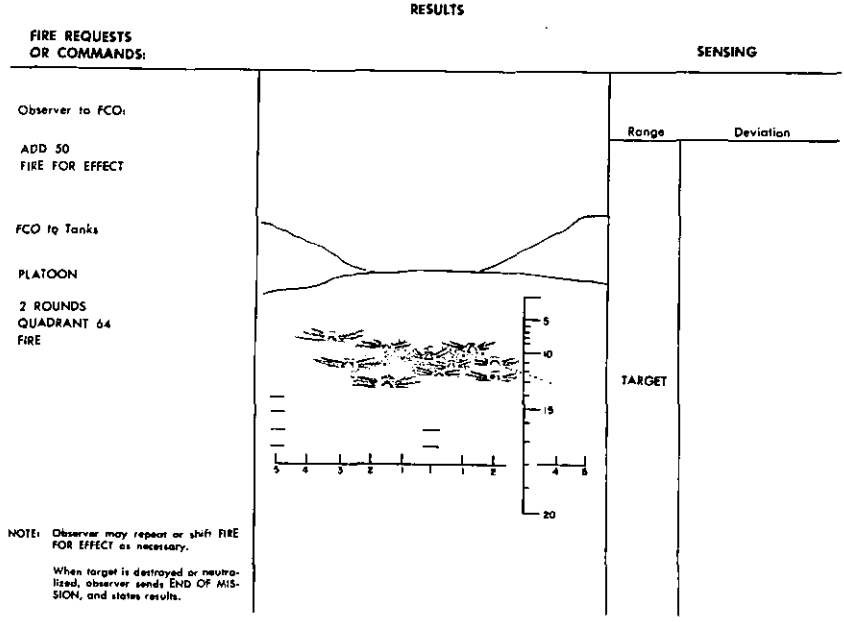


Figure 97—Continued.

Section VI. INDIRECT FIRE OF TANK PLATOON IN CONJUNCTION WITH ARTILLERY

181. General

a. When a decision is made to employ tanks in an indirect fire role, they may be employed in conjunction with artillery units. Tank platoons assigned such a mission remain under the command of their parent unit; however, their fire is directed and adjusted by artillery personnel.

b. When tank units are employed in conjunction with artillery, there are certain differences in procedures and techniques than when tanks are operating independently. These differences are resolved on the ground by the armor and artillery commanders. The major items for consideration are—

(1) Designation of general position areas.

(2) Air and ground observation.

(3) Necessary survey.

(4) Assignment of fire missions and preparation of firing data.

(5) Necessary communications to link tank unit with artillery fire direction center.

(6) Necessary training.

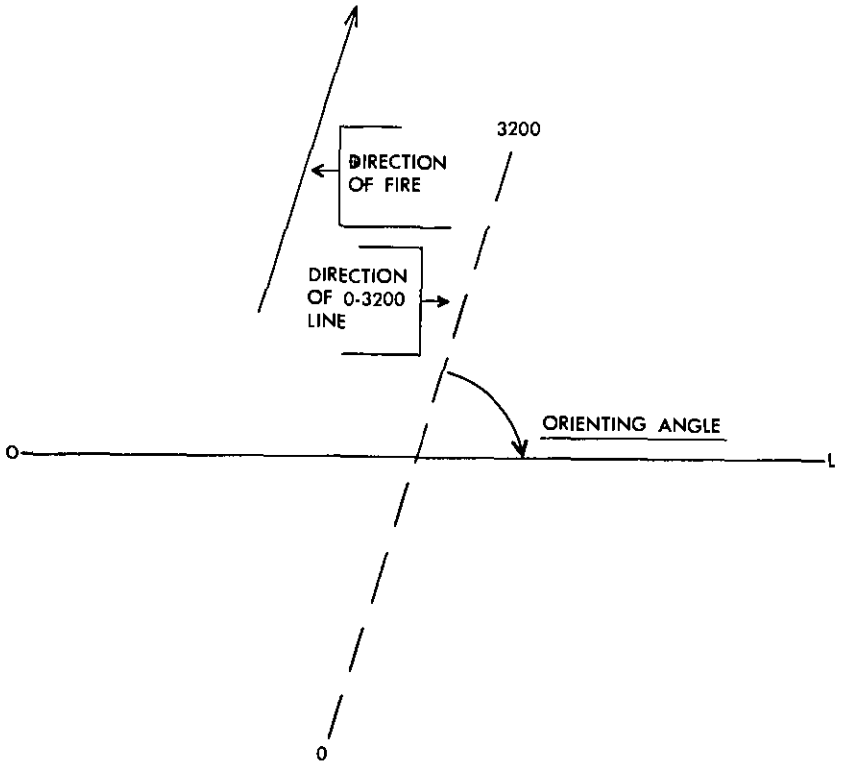


Figure 98. Laying tanks from orienting angle.

182. Laying Tank Guns From Orienting Angle

a. An orienting line is a line of known direction established on the ground in the position area, used as a reference line when laying guns for direction (fig. 98).

b. When tanks are employed in conjunction with artillery, the artillery unit is responsible for survey so that the tank unit can be tied in on the fire direction center charts. Survey personnel will establish the orienting line and the orienting station in the position area designated for the tank unit. Survey personnel will designate to the tank unit commander or his representative the location of the orienting station and stakes or points which mark the orienting line. The *orienting angle* will be furnished to the fire control officer by the survey party or the fire direction center. An orienting angle is a horizontal clockwise angle from the direction of fire to the orienting line. The following steps govern laying tanks parallel by orienting angle:

(1) Set up the aiming circle with the 0–3,200 line in the approximate direction of fire over the orienting station or other point on the orienting line where it can be seen from all tanks.

(2) The aiming circle operator sets the announced orienting angle on the azimuth and micrometer scales, using the upper motion.

(3) Using the lower motion, he sights along the orienting line. This places the 0–3,200 line in the direction of fire.

(4) The procedure outlined for laying tanks parallel on a given grid azimuth (par. 59) will govern laying tanks parallel in the direction of fire.

183. Referred Deflection

Referred deflection is the deflection indexed on the azimuth indicator after the tank has been laid for direction or registered on a base point. This referred deflection will be established as 2,800 or 2,600 by the FDC. This is standard artillery procedure and eliminates the necessity for announcing deflection as (so much) RIGHT (LEFT). Thus, with a referred deflection of 2,800, a shift of 60 mils to the right is announced as DEFLECTION 2,740; a shift of 33 left is announced as DEFLECTION 2,833.

184. Conduct of Fire

The artillery fire direction center receives, from an observer, necessary corrections to adjust fire on a target. The FDC then issues necessary data to the fire control officer of the tank unit, who converts this data into an initial fire command, or subsequent fire command, to the tanks.

185 Data From Fire Direction Center

Data from the fire direction center will contain all the information necessary for the fire control officer to direct the fire of his unit on the target or in the target area. This data will not be in the sequence in which it will be announced to the tanks. Data that will be received from the FDC is as follows:

a. Pieces to Follow Commands. This is the alert element, which signifies to the firing unit that a mission is pending and that all guns will follow all commands.

b. Projectile. This is the ammunition element, which dictates the type of ammunition to be employed in a particular mission; for example, HE (SMOKE).

c. Fuze. This element dictates the type fuze action to be employed in a particular mission (SUPERQUICK, DELAY, CONCRETE). If superquick fuze is desired, the fuze element is omitted.

d. Pieces to Fire. The command to fire all pieces is PLATOON (so many) ROUNDS. The command to fire a pair of tanks is RIGHT (LEFT), indicating the right (left) pair of tanks to fire. The command

to fire the center tank is CENTER. To fire any other single gun the command will be NUMBER (which gun).

e. Method of Fire. There are two methods of fire which can be employed—salvo and volley.

(1) *Salvo fire.* The command for a salvo (tanks firing with a time interval between guns) is RIGHT (LEFT), which indicates the flank from which pieces are to be fired successively.

(2) *Volley fire.* A volley may be fired by one or more tanks. The command for volley fire is (so many) ROUNDS.

f. Direction. To make a change in direction, a new deflection is commanded.

g. Quadrant Elevation. The command is QUADRANT (so much). Quadrant elevation is determined by combining elevation for range and angle of site.

186. Converting Fire-Direction Center Data to Fire Commands

a. The initial fire command to fire tanks in conjunction with artillery is the same as any tank indirect fire command. The fire control officer will receive necessary data from the FDC and must convert it to an initial fire command for the tanks; for example:

From FDC	*Command to tanks*
BATTERY ADJUST HE	PLATOON ADJUST, NUMBER 3 1 ROUND HE QUADRANT 130 DEFLECTION 2,740
CENTER 1 ROUND DEFLECTION 2,740 QUADRANT 130.	(TARGET DESCRIPTION) FIRE.

b. The above fire commands are those for an adjustment type mission. Should an adjustment not be necessary, the fire of the entire unit may be massed on a target by the following commands:

From FDC	*Command to tanks*
BATTERY ADJUST HE	PLATOON 3 ROUNDS HE QUADRANT 146 DEFLECTION 2,760
BATTERY 3 ROUNDS DEFLECTION 2,760 QUADRANT 146.	(TARGET DESCRIPTION) FIRE.

c. An artillery FDC does not normally announce a target description to the guns. It will be necessary for the fire control officer to request, in advance, that this element be included. The command to fire is also not given by the FDC unless the observer wishes to control the time of firing. In such cases, the FDC announces AT MY COMMAND, and at the appropriate time, FIRE.

d. Subsequent fire commands are issued to the tanks in the same sequence as any other subsequent command for tanks: *deflection, range, command to fire.* Example:

From FDC	*Command to tanks*
DEFLECTION 2,769	DEFLECTION 2,769
	QUADRANT 139
QUADRANT 139.	FIRE.

e. The deflection element may be omitted in the subsequent command when there is no change from the previous command; however, the range element is announced regardless of change. Other elements of the initial command are announced only when changed by FDC. In the following example, the platoon is to fire for effect after adjusting with the base tank:

From FDC	*Command to tanks*
BATTERY 2 ROUNDS	PLATOON
	2 ROUNDS
	QUADRANT 136
QUADRANT 136.	FIRE.

187. Prearranged Data Sheets

When the situation does not allow continuous or direct coordination and communication between the tank and artillery units, the artillery commander may assist the tank unit employed for indirect fire by the preparation of prearranged data sheets. These data sheets contain the necessary firing data to engage plotted targets. At specified times, the tank unit fires these prearranged missions, using the data furnished by the artillery. This fire may or may not be observed.

Section VII. SINGLE TANK IN DEFILADE

188. General

The tactical situation may sometimes require hasty indirect fire when the tank unit is employed in its primary offensive role. Under such conditions, a single tank may be employed from a turret defilade position against a point target which cannot be engaged by direct fire. The tank commander positions the tank, directs the gunner to determine minimum elevation, and then moves to an OP where he can observe the target and communicate with the tank. The tank commander should position himself on or near the gun-target line as close to the tank as possible.

189. Laying for Range

The tank commander determines range and angle of site by map or estimation. Range is announced in the initial fire command as a quadrant elevation or in yards plus or minus the angle of site; for example, QUADRANT 54 or 3,200 UP (DOWN) 5.

190. Laying for Direction

The tank may be laid on the target by any of the following methods:

a. Terrain permitting, the tank commander places himself on line between tank and target, commanding LAY ON ME. If the tank commander is behind the tank, he commands LAY ON ME, RIGHT (LEFT) 3,200. For safety purposes the loader does not load until the command to fire is given.

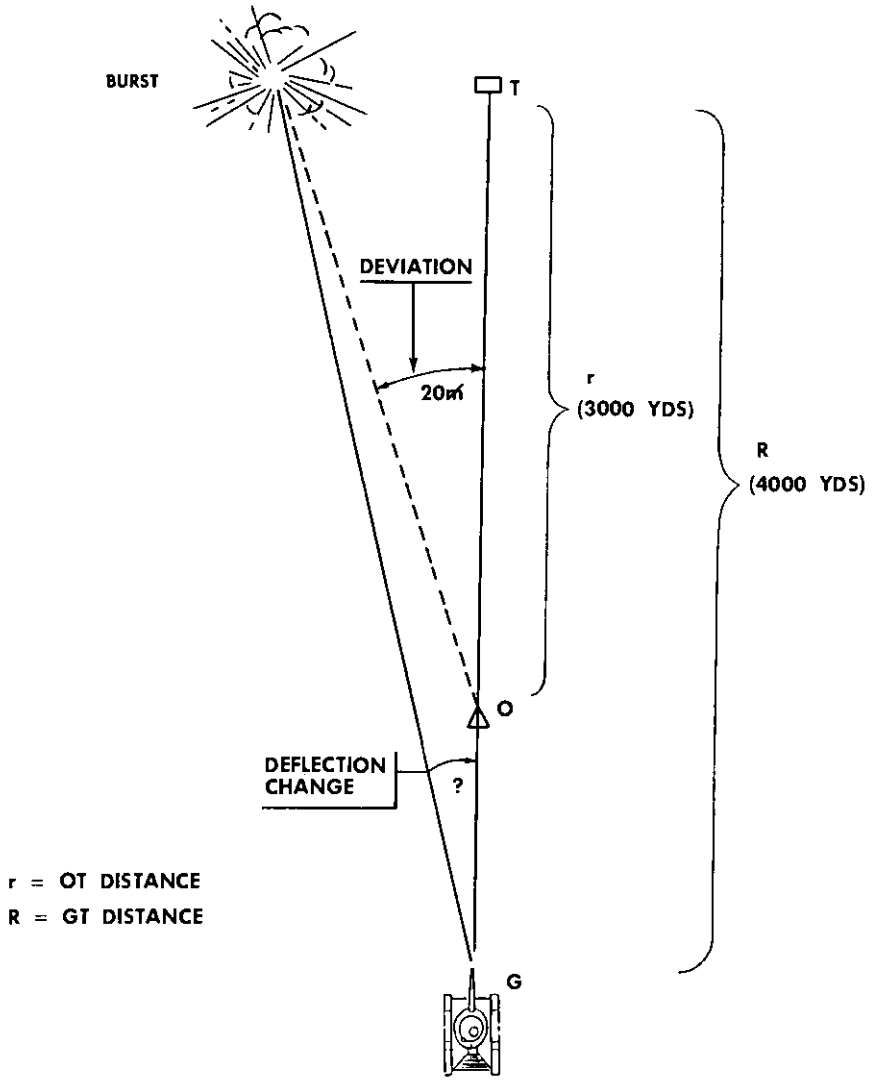
b. When the tank commander is not sufficiently close to the tank to employ the above method, he may command a shift in mils from a reference point. Since he is not positioned near the tank, his measured deviation from reference point to target is not the same as the deflection shift for the tank. The shift is determined by multiplying the measured deviation by the r/R factor (fig. 99). When applying the mil relation in this manner, r is observer-target distance in thousands of yards; R is gun-target range in thousands of yards.

c. Once a target has been successfully engaged, the gunner records the data on a range card. Each target engaged thus becomes an additional reference point.

191. Adjusting Fire, Single Tank in Defilade

Fire is adjusted in the same manner as in the alternate method for direct fire (par. 105) except that range changes are made to hit or bracket the target. The standard range change does not apply. When the tank commander is close to the tank, the deflection change is the measured deviation; when the difference in gun-target range and observer-target distance is more than 300 yards the r/R factor may be used. Range is announced in yards, deflection in mils. The gunner uses the azimuth indicator for deflection changes and the elevation quadrant for range changes. Since the C of 1 does not hold true at ranges of 3,000 yards and greater, the gunner should read the proper quadrant elevation from a firing table, computer, or ballistic unit. The following is an example of an adjustment on a point target by a single tank in defilade:

Initial fire command	*Sensings and subsequent commands*				
GUNNER	*1st Round*	*2d Round*	*3d Round*	*4th Round*	*5th Round*
HE	SHORT	OVER	SHORT	TARGET	TARGET
3,000 UP 3	LEFT 10	DROP 100	ADD 50	FIRE.	CEASE FIRE.
FROM REFERENCE	ADD 200	FIRE.	FIRE.		
POINT, RIGHT 30	FIRE.				
ANTITANK					
FIRE.					



$$\text{DEFLECTION CHANGE} = \frac{r}{R} \times \text{DEVIATION}$$

$$\text{DEFL} = \tfrac{3}{4} \times 20 = 15㎜$$

Figure 99. Converting measured deviation to deflection change.

PART FIVE

TRAINING AND TESTING

CHAPTER 9

INTRODUCTION

192. General

a. Every shot fired in range firing practice is of potential instructional value in producing well-trained tank crews. There are certain principles of learning, basic techniques, and standard methods which commanders should adhere to in order to efficiently accomplish the training mission. Training must be closely supervised and realistic, and must have as its objective the development of highly trained tank crewmen. To insure high standards of proficiency, certain tests and exercises are conducted to measure the ability of tank crewmen to apply and use the skills which have been taught during the training cycle.

b. Training in tank gunnery is directed toward producing well-trained tank crewmen capable of delivering accurate fire in order to destroy enemy armor, materiel, and personnel in combat. The tank crew must be able to function as a team; crew efficiency depends upon the skill and coordination of all its members. Each member of a crew should be trained in the duties of the other members, with the emphasis on gunner and tank commander duties, so that in the event one member of the crew becomes a casualty, the tank will still be effective.

c. Part five of this manual is designed to emphasize the importance of well-trained crews. The attainment of fire superiority depends directly on the ability of the men and how they use the tank weapons.

193. Sequence of Gunnery Training

a. To develop the qualities desired in efficient tank crews, training must be progressive with no distinct boundary between phases of instruction and drill. Rather, crewmen receive training in specific individual duties which are culminated in crew exercises. Continuous training is emphasized in all phases to perfect skills and techniques. Where weaknesses appear, the exercises are repeated. Safety precautions are stressed throughout gunnery training.

b. Gunnery skills and crew proficiency are developed through instruction and practice in the following:

(1) *Machine guns.* Machine gun mechanical training, to include assembly, disassembly, functioning, malfunctions, immediate action, headspace, timing, and installation in various type mounts.

(2) *Tank armament, controls, and equipment.* Familiarization with tank turrets, gun and turret controls, vision devices, fire-control equipment; sight adjustment and boresighting; preventive maintenance services.

(3) *Tank ammunition.* Identification; characteristics, capabilities, and use; handling and stowage.

(4) *Main gun.* Characteristics, nomenclature, disassembly, assembly, functioning, and malfunctions; care, cleaning, and lubrication; servicing recoil system.

(5) *Range determination.* The mil relation, use of the binocular, range estimation by eye, intersection, and practical work on range determination sites.

(6) *Range finder.* Characteristics, nomenclature, use, operation, inspection, maintenance, adjustment, ranging practice, computing internal correction system (ICS) settings, and testing proficiency.

(7) *Conduct of fire.* Classroom instruction on the initial fire command, firing duties, sensings, primary method of adjustment, alternate method of adjustment, firing main gun at stationary and moving targets, firing tank-mounted machine guns, use of battlesight, richochet fire, platoon fire commands; practical application on trainers or tanks; preliminary subcaliber firing; examination.

(8) *Crew drill and service of the piece.* Crew composition and control, organization and duties of the tank crew, crew firing duties, prepare-to-fire checks, boresighting and zeroing; safety precautions; use of signal flags; handling, stowing, and loading of ammunition for all guns; crew dismounted drill, mounting and dismounting the tank crew, closing and opening hatches, pep drill; unloading an unfired round or a misfire, removal of a stuck round, removal of a projectile, procedure to clear and secure guns; evacuation of wounded from a tank; destruction of equipment.

(9) *Gun drill.* Conducted in the form of nonfiring exercises or "dry-run" problems, with the crew working together in all phases of target acquisition, conduct of fire, and crew drill.

(10) *Subcaliber (coaxial machine gun) firing.* Preliminary training in zeroing the coaxial machine gun, correct sight picture and

accurate laying exercise, burst-on-target exercise, alternate method of adjustment; firing of subcaliber tables of the tank gunnery qualification course.

(11) *Service firing.* Zeroing main gun, firing at stationary and moving targets, adjustment of fire by burst-on-target and alternate method, firing from a range card, firing at night with and without illumination.

(12) *Firing tank machine guns.* Direct fire at stationary and moving targets from a stationary tank using the coaxial machine gun; firing from a moving tank with coaxial and bow machine guns; firing of turret-mounted caliber .50 machine gun at ground and aerial targets.

(13) *Practice and record firing, tank gunnery qualification courses.* Firing of subcaliber and service tables once for practice and once for record.

(14) *Crew and small unit firing exercises.* Firing at ground targets from a moving tank employing machine guns; tank crew proficiency exercise employing all tank weapons at various type targets; live-firing tank-infantry exercises.

(15) *Combat firing.* Normally fired to provide practice for units prior to actual combat operations; exercises should provide practice in all types of firing with all types of ammunition, under simulated battle conditions; various type moving, surprise, and camouflaged targets are used under both day and night conditions to provide realistic training. Organization of this type of firing is the responsibility of the unit commander. Because of variations in range facilities, target availability, mission of the unit, and other factors, no definite course or exercise can be outlined. The objective is to produce highly trained tank crews capable of hitting all types of targets under conditions which resemble those of actual combat.

c. In order to evaluate and obtain first-hand knowledge of training progress, commanders must have some means by which they can determine the relative proficiency and qualification of the tank crews. Although individuals or crews may have completed a training program, it cannot be assumed that they have attained the desired proficiency. No phase of training can be considered complete until personnel have been tested.

194. Methods of Testing Gunnery Training

a. Examination by Observation. Many aspects of gunnery training can be measured only by actual observation of the training or firing. For example, a tank commander who is able to write a correct fire command may not be able to give the command quickly and accurately dur-

ing a live-firing exercise. It is not enough to "look over" a phase of training where individuals are working; definite objectives must be sought. A checklist of important points should be followed to determine whether fundamentals are being taught and learned.

b. Oral Examination. This is a common form of testing and is normally used as an on-the-spot check of training. It can be used to test the effectiveness of the instructor and to determine whether the soldier understands the material being presented. Each oral question should have a specific purpose and emphasize one point.

c. Written Examination. This type of test or examination indirectly measures an individual's ability to apply gunnery skills. However, such tests are used to rapidly determine the knowledge gained over a wide area of subject matter.

d. Performance Type Test. Proficiency in tank gunnery training can best be determined by the performance type test. This type of test can be conducted on numerous phases of gunnery training by having the individual *do* what he has been *taught.* Characteristics of performance type tests include such factors as correct procedure, satisfactory results, and performance within a reasonable time limit. The *gunner's preliminary examination* is an example of a performance-type test. The *tank gunnery qualification course* is a performance test where the score determines relative proficiency of individuals. Additionally, the *tank crew proficiency course* tests and determines the overall efficiency of the crew. When any shortcomings are revealed by individual or crew tests, they must be promptly corrected by additional instruction and tests.

CHAPTER 10

NONFIRING EXERCISES

Section I. INTRODUCTION

195. General

Nonfiring exercises are designed to prepare tank crewmen for firing exercises. They are directed toward developing firing skills of the gunner and tank commander, as well as the teamwork of the entire crew. A thorough understanding of the operation and functioning of the tank turret and weapons is the first step in gunnery training. This is followed by classroom presentation and familiarization with crew duties and conduct-of-fire procedure for engaging targets.

196. Applicatory Nonfiring Exercises

Before any range firing can be attempted, applicatory nonfiring exercises are essential. Such exercises include individual training, crew training, range determination, range finder training, and target acquisition.

Section II. INDIVIDUAL TRAINING OF THE TANK GUN CREW

197. General

Success in battle depends upon close coordination within the tank crew. Conduct of fire depends primarily upon the skill and coordination of the loader, gunner, and tank commander, who make up the *tank gun crew*. The training of these three members is integrated after individual training. However, in all training, each crewman should master his individual duties before the crew works together as a team.

198. Training in Use of Direct-Fire Sights

One of the first steps in gunnery training is instruction in the use of the direct-fire sights. Use of the sights must be rapid and accurate when laying on a target and making adjustments. Each individual must know the use of the gun-laying reticle, aiming cross, lead lines, range lines, and mil measurements. Initial training is conducted in the classroom by the use of charts or slides. This instruction is followed with practical work on a trainer or tank.

a. Correct Sight Picture. The conduct-of-fire trainer (fig. 100) is an excellent training aid to teach crewmen the correct sight picture for direct laying and how to make range and deflection changes, set off lead, change the amount of lead, and make adjustments when using the primary or secondary sights. Another type of training device which may be easily constructed and used for this purpose is a target board and reticle (fig. 101).

b. Conduct-of-Fire Trainer. The conduct-of-fire trainer is used to apply direct-fire techniques and to introduce individual crew firing duties. Each crew member executes his assigned duties. Firing problems are conducted as follows:

(1) Tank commander issues appropriate initial fire command and lays on target.

(2) On hearing ammunition element, loader simulates loading and announces UP.

(3) Gunner simulates performing the duties required by the ammunition and range elements of the command.

(4) On identifying target, gunner announces IDENTIFIED and takes over gun controls.

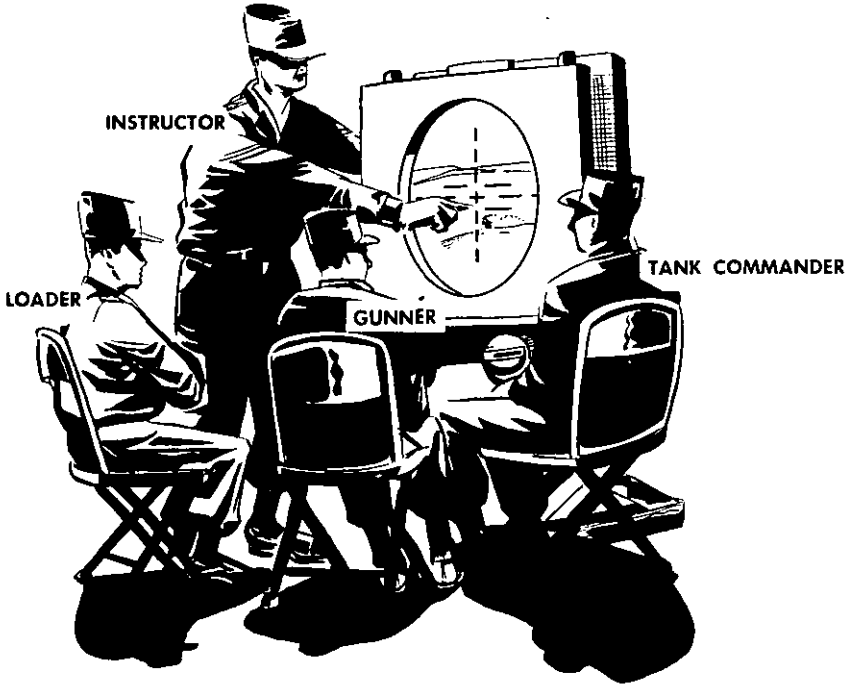


Figure 100. Conduct-of-fire trainer.

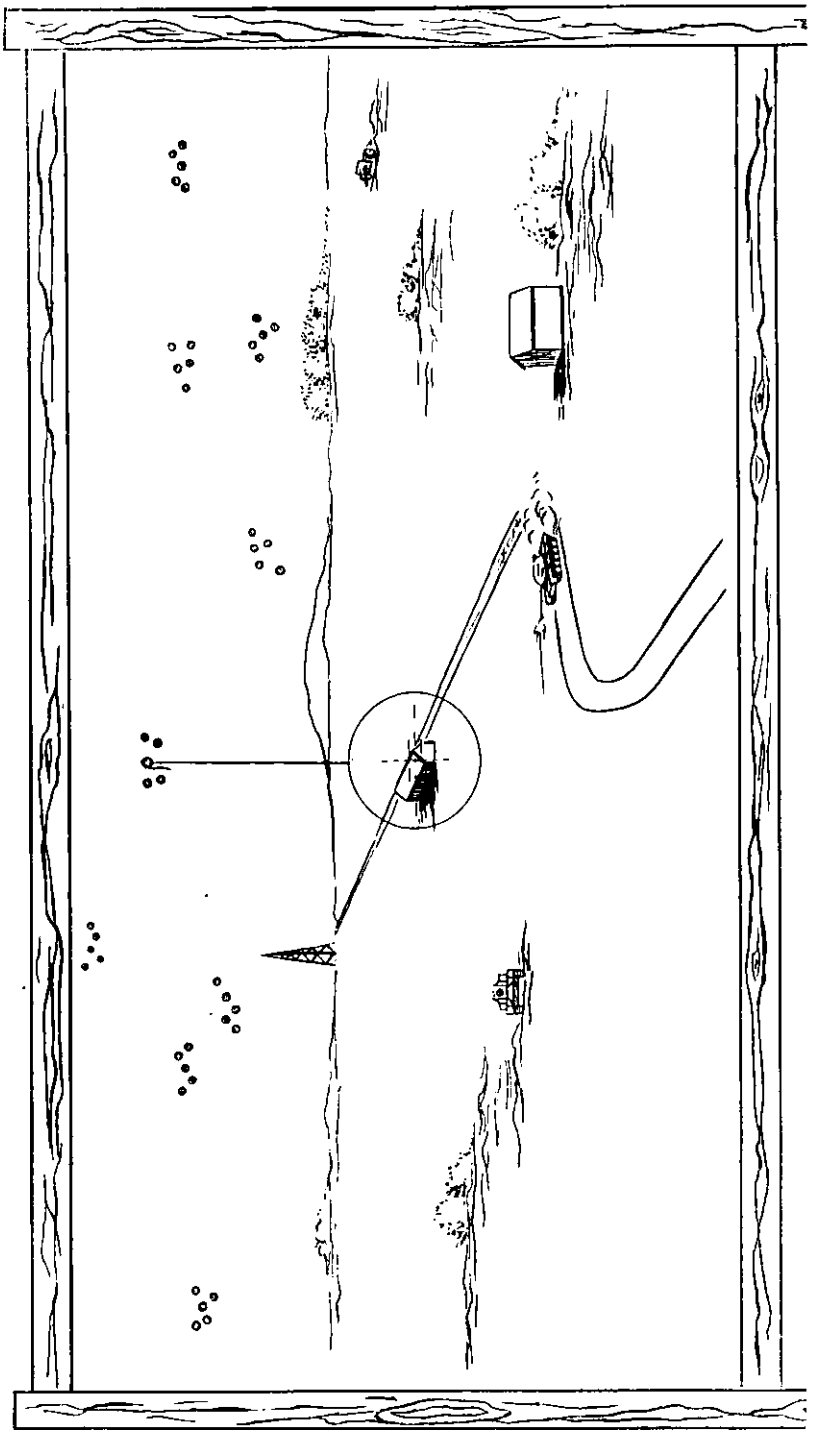


Figure 101. Target board and reticle.

(5) Gunner takes correct sight picture and announces ON THE WAY.

(6) Instructor flashes light to simulate burst or tracer.

(7) Gunner applies burst-on-target and again announces ON THE WAY.

(8) Problem continues until target is hit.

(9) Tank commander announces TARGET, CEASE FIRE.

(10) Instructor critiques problem.

Note to instructor: Place the light so that it is off target but within sight reticle. Insure that reticle can be traversed to target before commencing problem. If gunner fails to observe burst or fails to hit target within three rounds, require tank commander to announce sensing and issue subsequent fire command.

c. *Target Board and Reticle.*

(1) Silhouette targets, such as tanks and antitank guns, are drawn or pasted on a target board representing terrain. A clear piece of acetate is cut and placed in a circular frame. A gun-laying reticle is painted on the acetate to represent the gunner's sight reticle and field of view.

(2) The crewman places the reticle on the target in the proper position to represent initial laying, re-laying, applying burst-on-target, and making deflection and range changes. Following individual instruction, simulated crew firing exercises may be conducted.

d. Training on Tank. Further practical application of sight adjustment and direct laying is performed on a tank. The gunner simulates firing and adjusting on various targets. The instructor or tank commander supervises the gunner by observing through his direct-fire sight, which has been boresighted on the same target as the gunner's. Initially, accuracy is stressed. Speed is developed as training progresses.

199. Manipulation Exercises

Any exercise which gives the gunner practice in traversing and elevating the gun is called manipulation. These exercises must be practiced by the gunner throughout his gunnery training.

a. The *snakeboard* (fig. 102) is an effective aid to manipulation training. Lines, approximately 2 inches wide, are drawn on target cloth mounted between two standards or on the side of a building. The gunner tracks along the lines as accurately and rapidly as possible.

b. The next phase of manipulation training requires the gunner to rapidly lay on a series of stationary targets. This is a "dry run" of the manipulation table of the tank gunnery qualification course.

200. Tracking and Leading Exercises

a. Towed Card Exercise (fig. 103). A wire line is stretched between two supports at different heights. A card is suspended from the line by circular wire clips. The card is pulled along the line by a cord attached to the card. The gunner tracks the card during its movement. The speed of the moving card is alternately increased and decreased during its run.

b. Combat Tracking. Before firing at a moving target, the gunner performs dry-run tracking. A vehicle, or the moving target on a subcaliber or service range, may be used for this purpose. When a vehicle is used as a moving target, the speed and direction of the target should be varied. The gunner initially tracks with one lead. This lead is obtained by traversing through and ahead of the center of mass. The gunner simulates firing and adjusting by changing the range and lead as directed by the tank commander, who observes through his direct-fire sights. The gunner tracks with a smooth continuous motion, maintaining a constant sight picture before, during, and after firing. He does not stop traversing while he simulates firing. Whenever the situation permits,

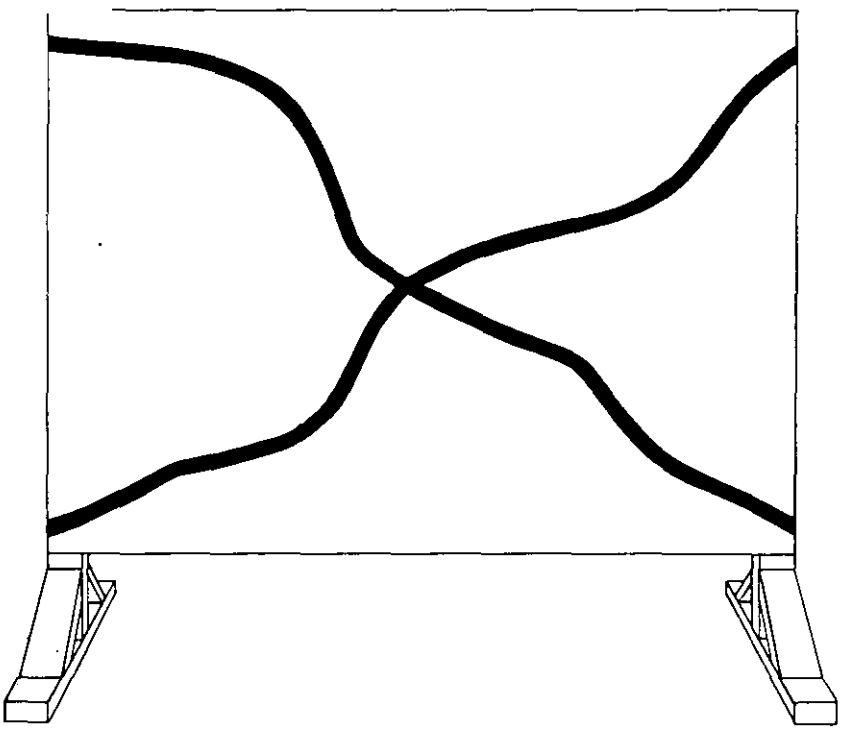


Figure 102. The snakeboard.

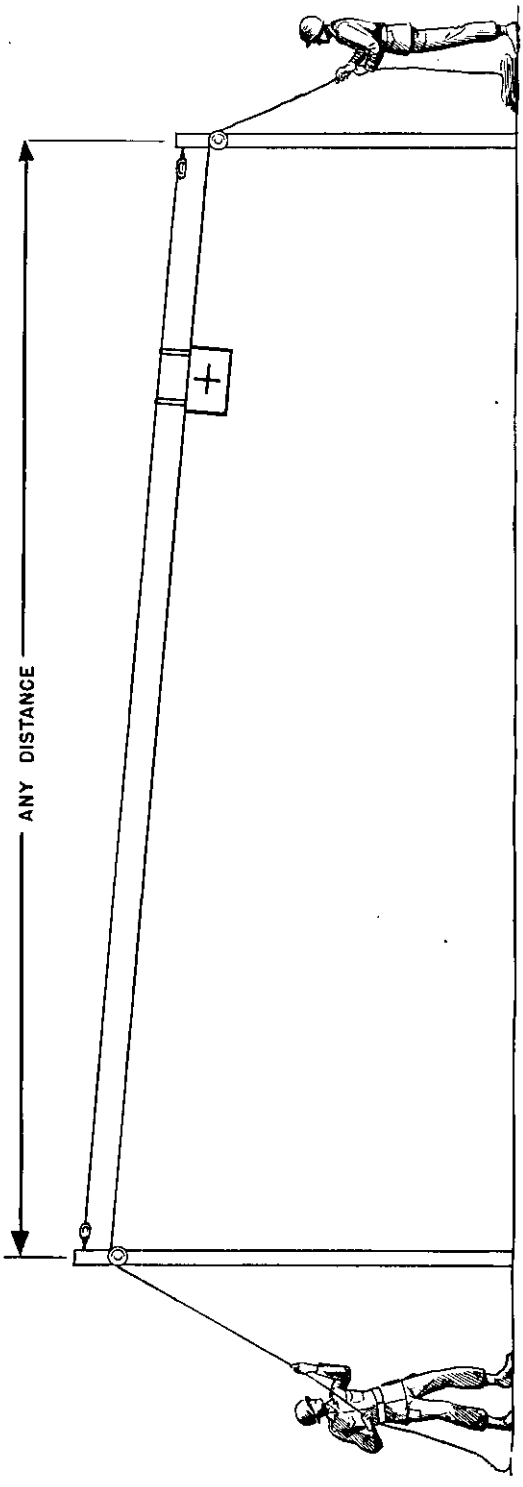


Figure 103. Towed card exercise.

gunners should practice tracking in conjunction with other training. Tanks positioned near a road or highway may use the normal vehicular traffic as moving targets.

201. Boresighting Exercise

Boresighting a tank gun is the process of alining the axis of the sights with that of the gun to converge on a boresight point. The prescribed steps for boresighting a particular tank gun should be followed closely and the exercise repeated until the gunner is able to make precise adjustments. To check the gunner's accuracy, the instructor selects a well-defined target point. The gunner alines the gun-laying reticle and the cross hairs of the tube on the aiming point, locks the boresight knobs, and notes the readings on the scales. The instructor then traverses the gun off the target, and unlocks and rotates the knobs to disturb the reading. The gunner then reboresights on the same target and readings are compared.

202. Zeroing Exercise

A dry-run exercise in zeroing will correct many of the errors which are common to gunners who have not had sufficient training. The zeroing procedure can be simulated by placing a target at the zeroing range. Several shot groups are painted on the target (fig. 104). The gunner simulates firing a shot group, refers his aiming cross to the center of one of the shot groups, and re-lays on the aiming point. Each time the exercise is completed, the gunner records the azimuth and elevation knob readings. To check the accuracy of the gunner, his results are compared with previously determined zero readings on the same shot group. Any variations in the reading can be directly associated to the gunner's ability to make an accurate lay.

203. Training in Use of Auxiliary Fire-Control Equipment

a. Before a range card exercise is fired, the gunner should have practice in obtaining data and in simulated firing from a range card. A setup similar to the subcaliber auxiliary fire-control table of the tank gunnery qualification course may be used. In testing the accuracy of the gunner, the tank commander verifies the azimuth indicator reading and uses the gunner's quadrant to check elevation.

b. Other appropriate exercises in the use of auxiliary fire-control instruments are: laying tanks parallel, determining minimum elevation, determining angle of site, and making deflection and range change.

NON FIRING ZEROING EXERCISE
TARGETS

(SHOT GROUP—3RDS)

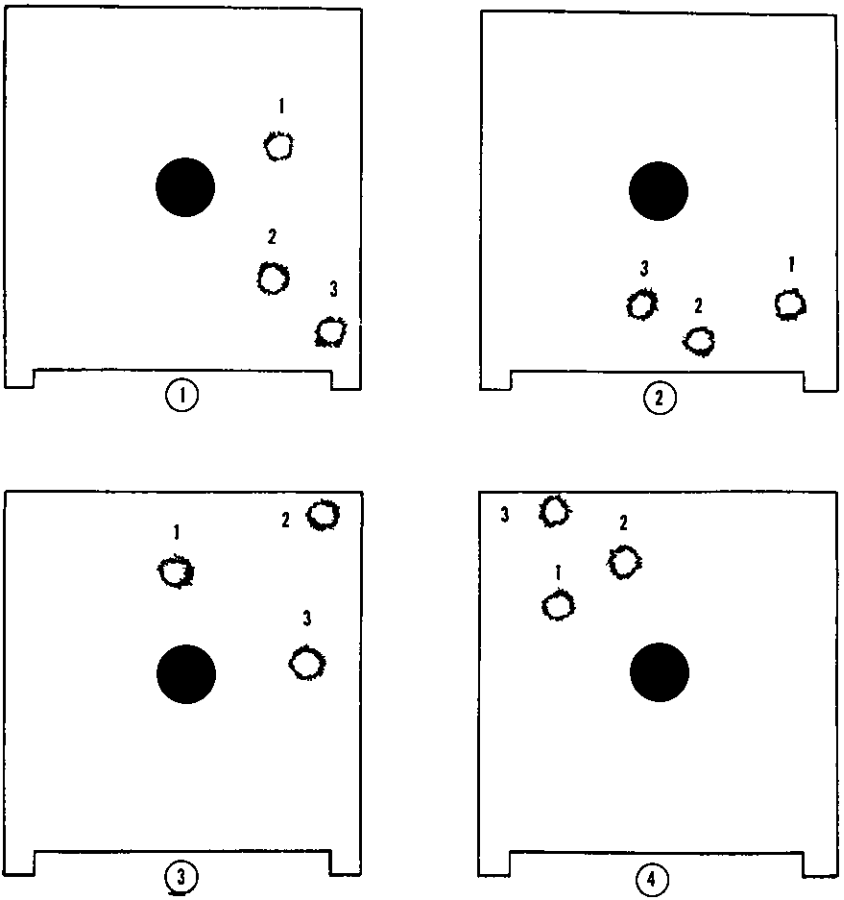


Figure 104. Zeroing target.

Section III. RANGE DETERMINATION TRAINING

204. General

Range determination training must be continuous, since skill in the estimation of range by eye can be attained only by constant practice. Initial training should be conducted utilizing range designation and range determination sites. As the individual acquires facility in the estimation of ranges on these sites, training should be conducted con-

currently with other field training. Regardless of the training techniques employed, normal terrain, including natural objects, should be used. As individual ability increases, more difficult objects such as camouflaged positions are introduced.

205. Range Designation Site

The range designation site (fig. 105) is employed in the initial stage of range determination training to assist the individual in acquiring the "mental yardstick" necessary to estimate ranges by eye. The site should, if possible, allow the placement of targets to a range of 3,500 yards. Signs marked 1, 2, 3, 4, and 8 are placed at ranges of 100, 200, 300, 400, and 800 yards from an observation point (800 yards is selected since it is normal battlesight range). Tanks, tank silhouettes to scale, or panels of appropriate size are placed at 500-yard intervals from 500 to 3,500 yards. Finally, the distances to prominent terrain features at greater ranges are determined. From the observation point, the crewman studies all of the marked ranges to get a mental picture of them. He then studies the tank silhouettes farther away, noting how the size tends to decrease as the range increases and the relationship between sizes at specific ranges. If suitable additional terrain exists at the range designation site, practical work may be given the individual by having him estimate ranges to targets in a different direction. While estimating, he refers to the laid-out site. Immediately after the range to a target has been estimated, the instructor announces the correct range.

206. Range Determination Site

a. After the individual has become accustomed to the measurement of range by use of the mental yardstick, his training should progress to the determination of ranges on a range determination site. On this site the student employs all techniques of range determination. This site may be established on any terrain having adequate fields of fire. The following steps are necessary to prepare the site for use:

(1) Accurate ranges are determined to prominent objects and terrain features.

(2) The height or width of each object and terrain feature is measured in feet or yards.

(3) The mil height or width of each object is determined by means of an aiming circle or other accurate method.

(4) If several similar objects exist in the target area, the azimuth to each target is measured as an aid to the instructor.

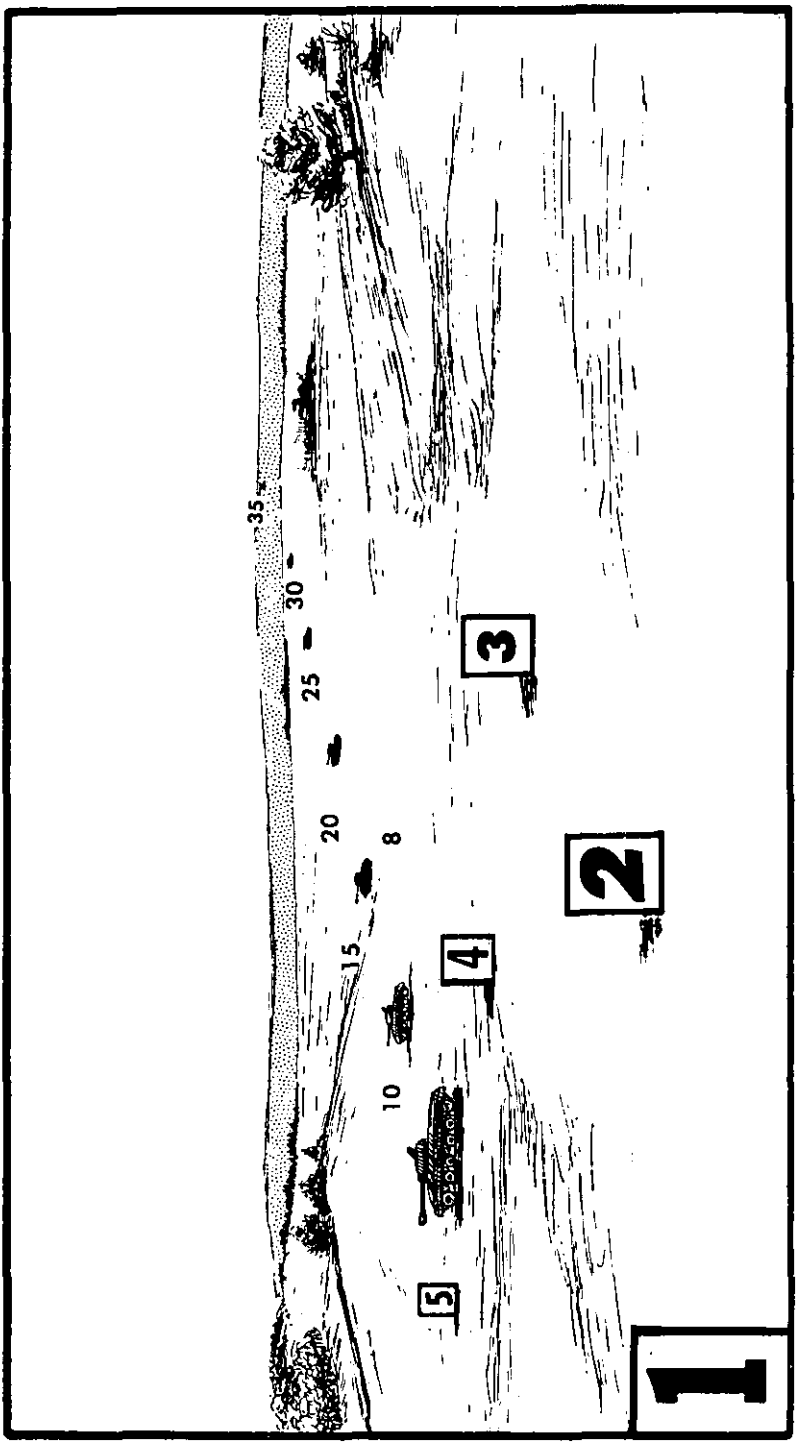


Figure 105. A range designation site.

b. A suggested method of employing the range estimation site is as follows:

(1) Point out targets one at a time, giving students time to estimate and record ranges.

(2) Have students make proper diopter and interpupillary settings on binoculars.

(3) Have all students measure the mil width or height of the same target by use of the binocular; when they finish, give them the width or height of the target in feet or yards.

(4) Announce the correct range for each target after estimation and mil relation computations have been made.

(5) Have students, working in groups, determine the range to several targets using the intersection method. (Aiming circles for this problem should be prepositioned by the instructor.)

207. Advanced Range Determination Training

When individuals have attained reasonable proficiency in determining range on the range determination site, camouflaged targets should be added and ranges thereto estimated and computed. From this point on, training is concurrent with field operations. Tank crewmen should utilize every existing opportunity to determine range; first estimating by eye, then checking their results against the known range obtained by other means.

Section IV. RANGE FINDER TRAINING

208. General

All training in tank gunnery is directed toward the main objective of a fast first-round kill. Since range determination is the greatest potential cause of error, the range finder is the key to success in combat. In range finder training, the standard is correct range within five seconds. This standard is achieved by the simultaneous development of speed and accuracy through constant and continuous ranging practice. Training and testing methods for both stereo and coincidence-type range finders are discussed in this section.

209. Training Areas and Equipment

a. Preliminary training in nomenclature, maintenance, adjustment, and operation is conducted in classrooms and motor parks. Ranging practice requires a target-ranging area, accessible to tanks, with ranges up to 3,500 yards. Targets should be placed at known ranges from 800 yards to the maximum visible range available. Panel targets are desirable for initial training; however, as proficiency increases, natural ter-

rain and field targets should be used. Targets should be in all available types of locations, such as on forward slopes, partially visible on reverse slopes, on the skyline, against contrasting background, and in both thick and sparse vegetation. Some targets should be partially camouflaged.

b. Training aids include graphic charts, training films, slide projectors, depth perception trainers, stereovision trainers, and plastic or wooden reticles. However, the best training aid is the range finder itself.

210. Steps in Range Finder Training

Range finder training should follow a logical sequence in order to make maximum use of training time. Because the bulk of training time is given to ranging practice, this instruction, in particular, should be closely supervised. The following steps in training are recommended:

a. Mechanical Training. Nomenclature, maintenance, and operation of the instrument and its components are taught as preliminary training.

b. Adjustment. A step-by-step procedure is employed to teach adjusting the range finder and placing it into operation.

c. Ranging Practice. Crewmen practice ranging on targets at varying ranges and locations. Each reading is recorded on ranging sheets. This training continues until crewmen are obtaining consistent, but not necessarily correct, rangings on all targets.

d. Determination of Internal Correction System (ICS) Setting. Once the crewman is ranging consistently within a spread of 200 yards, he is ready to determine his setting for the internal correction system (ICS) of the instrument. Spread is the difference between the highest and the lowest readings, and is computed on a basis of 20 rangings. The initial ICS setting is determined mechanically, and will allow the crewman to range more accurately.

e. Ranging With ICS Setting. The crewman practices ranging on targets with his initial setting set into the instrument. He should now be ranging closer to the target and reducing his spread.

f. Redetermination of Setting. After the crewman has reduced his spread to a maximum of 100 yards, he determines his ICS setting more closely. This is done by use of an ICS correction chart (fig. 106). He then makes additional practice rangings with the new setting. Accurate rangings should now be obtained.

g. Testing. When the crewman has obtained accuracy, he is tested. His results are checked by use of the graph shown in figure 107.

211. Range Finder Training Procedures and Techniques

a. Once tank crewmen have a thorough knowledge of nomenclature and operation of the range finder, they are taught how to maintain the instrument. Crew maintenance is limited to changing light bulbs and

TABLE

ICS CORRECTION FOR 1500 YARDS

(PLUS OR MINUS)	ICS UNITS M12	ICS UNITS M13
10	1	2
20	2	3
30	3	5
40	4	6
50	5	8
60	6	9
70	7	11
80	8	12
90	9	14
100	10	15
110	11	17
120	11	18
130	12	20
140	13	21
150	14	23

Figure 106. ICS correction chart.

cleaning of the exterior, to include outside lens. All other maintenance is restricted to higher echelon.

b. Since inability to use the range finder can usually be traced to improper adjustment, operators must master the step-by-step procedure of placing the instrument into operation. For stereo range finders, the interpupillary distance is one of the most critical adjustments. When a crewman cannot determine a sufficiently accurate interpupillary adjustment from a binocular, the instructor may use the following expedient:

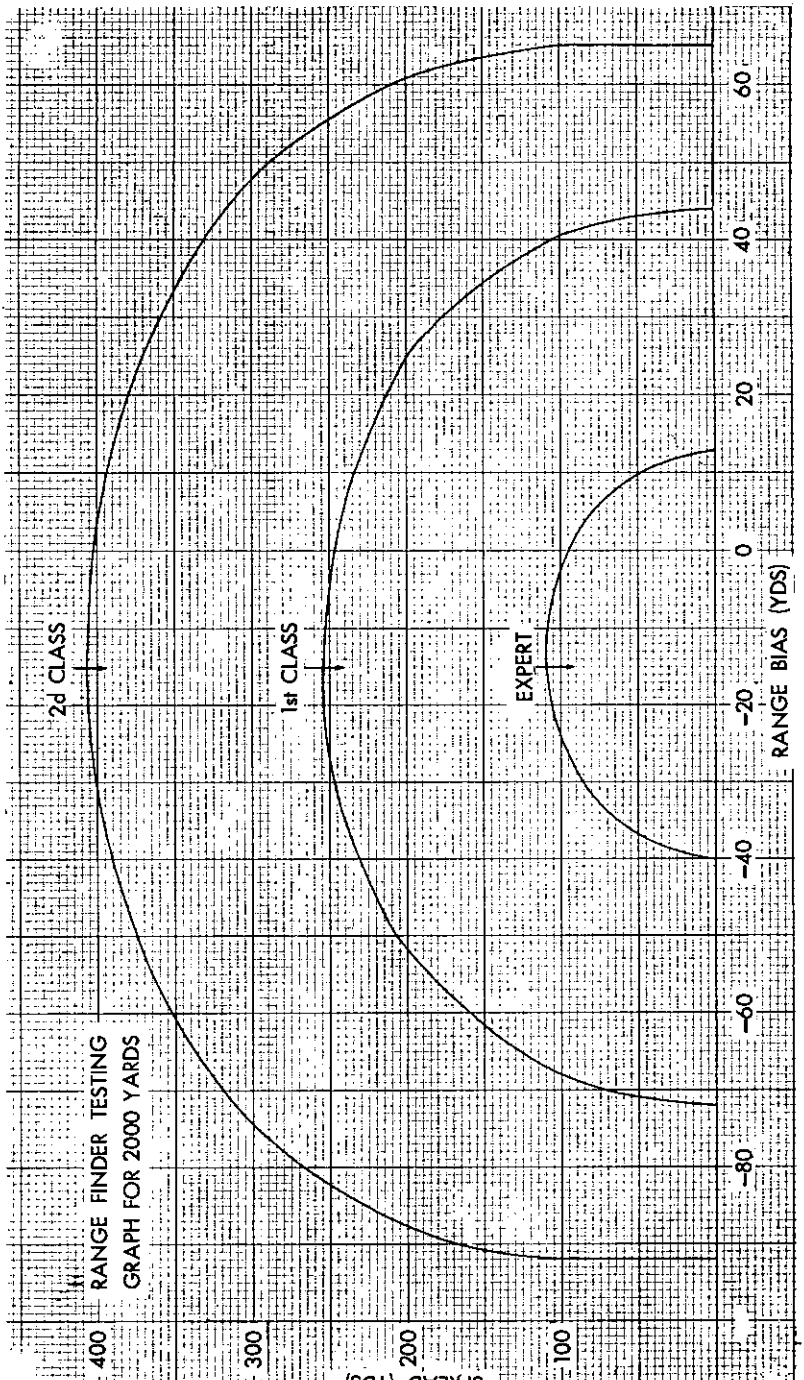


Figure 107. Range finder testing graph.

(1) He places himself underneath the range finder where he can observe the operator's eyes.

(2) With filters off, he will note two beams of light from the eyepieces shining on or near the operator's eyes.

(3) He then instructs the operator to narrow or widen the interpupillary distance with the adjusting knob, until the beams are centered in the operator's eyes.

c. During the first application phase of stereo range finder training, crewmen must be checked individually to insure that they can see the ranging reticle move in depth.

d. During early stages of training, men should not range for more than 20 to 30 minutes per hour, nor longer than 10 to 15 minutes at any one time. Best results are obtained when ranging practice is conducted in 4-hour blocks. Crewmen work in pairs; the second man reads and records the indicated range. Initially, the operator is allowed a maximum of 30 seconds for one ranging; this time is gradually reduced until he is ranging accurately within five seconds.

e. For initial ranging practice, the internal correction system (ICS) knob is set at 25. When the operator is ranging consistently with a spread of 200 yards, his initial ICS setting should be determined. This setting will decrease the average ranging error, but will not necessarily give him true ranges at this early stage. To determine his initial setting, the operator is assigned a target at a known range as near 1,500 yards as possible. He then performs the following:

(1) Indexes the known range on the range scale.

(2) Rotates the ICS knob, causing the following:

(*a*) *Stereo range finder.* The ranging reticle is moved in depth until the lower bar appears at the same range as the target.

(*b*) *Coincidence range finder.* Double target images are moved together until a single, sharp image is obtained.

(3) Then records the ICS scale reading.

(4) Repeats the procedure for at least ten readings.

(5) Determines the average reading, which is his initial ICS setting for *that* range finder.

f. With the initial ICS setting indexed into the range finder, the crewman makes additional practice rangings. He should now be ranging consistently closer to the target. The same range finder that was used to determine his setting should be used for subsequent ranging. If a different range finder is used, a new setting is determined; when this cannot be done immediately, the old setting is used temporarily.

g. The operator continues to make rangings, gradually building up proficiency. When his spread is 100 yards or less, he determines his

ICS setting more closely. If he is consistent, the operator can determine his setting more accurately by use of the ICS correction chart (fig. 106) than by mechanical means. This is done in the following manner:

(1) A representative block of 20 rangings made on a 1,500-yard target is obtained from a study of the crewman's ranging sheets.

(2) Range bias (average error) for the 1,500-yard target is obtained by determining the difference between the average range reading and the known range.

(3) If the operator's range was short of the target, he has a minus bias. Using the correction chart, he *adds* the corresponding number of ICS units to his setting.

(4) For a plus bias (when his range is beyond the target), the operator *subtracts* ICS units from his setting.

(5) Thus, a crewman with a bias of minus 50 for an M12 range finder would add 5 units to his setting; a crewman with a bias at plus 40 for an M13 range finder would subtract 6 units.

Note. Corrections are not computed for coincidence and other stereo range finders, but can be applied on a trial-and-error basis.

h. The corrected ICS setting is now checked by additional rangings at 1,500 yards. If necessary, this corrected setting is refined by making small corrections until the operator has determined his setting *for 1,500 yards* as closely as possible. In the absence of charts, refinements of settings can be made mechanically.

i. The best range for determining ICS settings is 1,500 yards; however, the same setting does not hold true at *all* ranges. For example, if a crewman has refined his setting to the point where he is making correct rangings at 1,500 yards, he should be overranging by about 50 yards on 2,000-yard targets. Since it is not practical to establish a setting for all ranges, a *final ICS setting* is established by subtracting 4 ICS units from the corrected setting. This revision will affect accuracy slightly at 1,500 yards, but will greatly improve it at 2,000 yards. Coincidence range finder operators do not make this correction.

j. When a crewman has obtained his *final ICS setting*, he is ready for testing. The number of rangings required to achieve this degree of proficiency varies with the ability of individuals. Some personnel will attain this status after a few hundred rangings; however, the average man requires 600 to 900 rangings with a coincidence range finder and 1,200 to 1,800 rangings with a stereo instrument before an accurate measure of his ability can be made.

212. Testing Range Finder Operators

The ideal testing site is one which is in a different location than the area for practice ranging; however, if this is not practicable, new targets may be erected in the practice ranging area. A minimum of six 7½x7½-

foot panels are placed at varying ranges from 1,000 to 2,500 yards. Two of these targets will be at accurately measured ranges of 1,500 and 2,000 yards. Using his final ICS setting, the operator makes 20 rangings on each of three targets, two of which will be the 1,500- and 2,000-yard panels. Each ranging commences from an indexed range of 800 yards in such a sequence that none of the rangings on any one target are consecutive. Every effort is made to prevent the operator from discovering the true range to the targets. All range scales on range finders or computers are covered or so positioned that the operator cannot read them. The testing officer or recorder notes and records each reading, reindexing 800 yards for the next ranging. At the completion of the test, the readings for all three targets are turned in to the unit commander. The tested crewman is not allowed to see his readings, but is informed of his *spread, bias,* and *classification* after computations are made. Operator proficiency is determined in the following manner:

a. The average range reading for each target is computed by adding all readings for that target and dividing by 20.

b. Range bias for each target is obtained by determining the difference between the average range reading and the known range for that target.

c. Range spread for each target is obtained by subtracting the smallest reading from the largest.

d. The values obtained in steps *b* and *c* above for the *2,000-yard target only* are applied to the graph shown in figure 107, in the following manner:

(1) Mark a point along the horizontal axis corresponding to the bias.

(2) Mark a point along the vertical axis corresponding to the spread.

(3) The intersection point of a vertical line from the bias scale and a horizontal line from the spread scale is then plotted.

e. If the intersection point falls within one of the three graph curves, the crewman is classified as *expert, first class,* or *second class.* If the point is outside the outer curve, the crewman is *unqualified.*

f. Bias and spread for the other targets cannot be accurately applied to the graph, but are computed as a check to determine if the operator is consistent at those ranges.

213. Improving Proficiency in Ranging

In addition to measuring proficiency, the testing graph is used to tell an individual how he may improve his ranging ability.

a. Spread. When an operator has too much spread, he is still making inconsistent rangings. The only way to develop consistency, or reduce spread, is through more ranging practice. However, additional practice

is not a sure cure, as all crewmen eventually reach the point of their maximum ability. Beyond this point, more ranging may not produce improvement, but it will enable the operator to maintain the proficiency that he has gained.

b. Bias. When an operator has excessive bias, but a good spread, his lack of accuracy can be traced to an improper ICS setting or an "off-day." To verify this, his rangings should be checked for at least two successive days. If he continues to range with the same error, his ICS setting can be corrected by the correction chart. However, if he is short one day and over the next, no correction is made.

214. Retesting Range Finder Operators

All crewmen below the *expert* classification should be retested. Personnel who achieved a good spread on their initial test may be retested within a few days; those who require additional practice to reduce spread should be retested at a later date.

Section V. TRAINING IN TARGET ACQUISITION

215. General

Target acquisition is a primary responsibility of the tank commander. Many times location and identification of targets is not an easy task, because enemy weapons and tanks are often well concealed and camouflaged. To assist the tank commander and to insure that all possible targets are quickly spotted, the other members of the crew are assigned sectors of responsibility most visible to them. Infantrymen will frequently point out targets to tankers. Once a target has been spotted and recognized, action is initiated to engage it with speed and accuracy. Target acquisition exercises can be of various types, the purpose being to give tank commanders and gunners practice in quickly locating and recognizing an enemy tank or weapon in position or when it fires. It is most beneficial when conducted under field tactical conditions. The area used for range finder practice could easily be adapted to this type of training.

216. Course Layout for Target Acquisition Training

Tank crews are positioned to observe an enemy area where various types of targets are emplaced (fig. 108). These targets are tanks, antitank guns, recoilless rifles, machine guns, and infantry. The weapons are positioned so as to indicate fire from different angles and at ranges of from 800 to 3,500 yards. Targets are camouflaged and placed in realistic tactical locations. Demolitions, simulators, and blank ammunition are used to simulate enemy fire. As training progresses, moving and surprise targets are introduced.

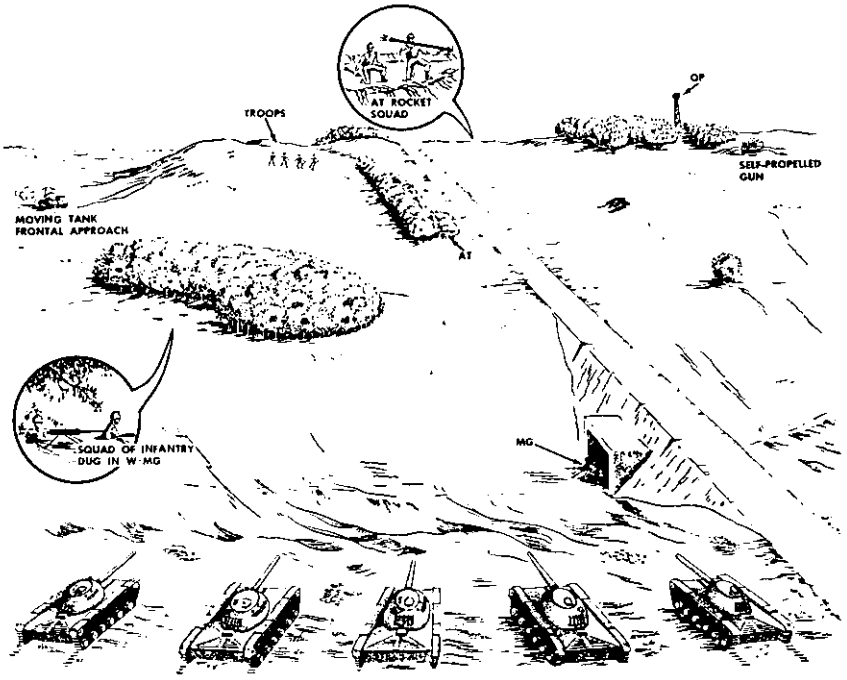


Figure 108. Target acquisition site.

217. Conduct of Target Acquisition Exercise

The members of the tank crew observe in assigned sectors. The enemy "fires" at varying intervals, and crews attempt to pinpoint the targets. As the "flash of the gun" is spotted, the tank commander issues an initial fire command. This fire command dictates the actions of the crew in a simulated firing exercise. To measure crew proficiency in this exercise, the following factors are considered: time elapsed before target is spotted, identification of target, ranging time, accuracy of lay, accuracy of determined range, and execution of crew firing duties.

CHAPTER 11

FIRING EXERCISES

Section I. INTRODUCTION

218. General

a. Tanks exist to shoot; and unless their tremendous firepower is brought to bear on the enemy, they assume a less important role. The tank is an effective fighting machine only when the crew is capable of delivering fire with speed and accuracy.

b. Firing exercises are designed to provide the tank crew with training in the destruction of enemy armor, troops, and equipment. These exercises are the culmination of gunnery training and are the most realistic type of training short of actual combat. Range firing exercises afford opportunities to apply by individual and collective efforts subject matter which was previously learned in the form of theoretical and nonfiring exercises. Participation in firing exercises also improves individual and crew skills.

219. Firing Skills

Individual and crew firing skills are developed by actual firing of subcaliber and service exercises in a logical sequence. These include—

a. Preliminary Subcaliber Exercises. These exercises are not scored or fired in any time limit but are designed to provide training in the basic fundamentals of gunnery. They may be conducted on outdoor or indoor ranges.

b. Subcaliber Firing Exercises. The purpose of the subcaliber tables is to test and train gunners, to develop speed and accuracy, and to instill confidence in the gunner's ability to use the direct-fire sights, the auxiliary fire control equipment, and the turret controls. They are outlined in the tank gunnery qualification course.

c. Service-Firing Exercises. These exercises are fired only after crewmen have successfully completed all subcaliber exercises. Service exercises provide practice in firing the main gun at various type targets and ranges, developing skill, speed, and accuracy in applying gunnery techniques and procedures. At the same time, personnel are mentally conditioned to the blast and recoil of the main armament. In addition, these

exercises provide realistic practice in gun and turret preventive-maintenance services, handling and stowage of ammunition, and safety precautions on and about tanks.

d. Crew-Firing Exercises. The purpose of these exercises is to develop speed, accuracy, and coordination by all members of the crew. Through the firing of combat-type exercises, the crew achieves the high standards of training and efficiency to prepare it for combat. Normally, the tank moves over a course where various surprise targets are placed which will require the tank commander to rapidly engage them with the proper type of ammunition.

Section II. PRELIMINARY SUBCALIBER FIRING EXERCISES

220. General

a. The purpose of this instruction is to school the individual crewman in the basic fundamentals of tank gunnery. This is accomplished by firing the coaxial machine-gun single shot at close ranges in order to teach gunners the application of firing techniques. These exercises must be mastered by crewmen before they go to the subcaliber tables in the tank gunnery qualification course. The exercises should be closely supervised and fired in the following sequence: zeroing of the coaxial machine gun, first-round hit exercise, primary method of adjustment, and alternate method of adjustment. Practice includes the use of the primary and secondary direct-fire sights. Tables XI, XII, XIII, and XIV of the standard familiarization course may be used for this purpose.

b. Aiming points (spotters) can be drawn on any type of target currently in use (fig. 109). They are placed at a distance of approximately 200 feet for outdoor firing and may be adapted for firing in indoor ranges at 1,000 inches.

c. Accomplishment of these exercises requires ammunition sufficient to permit firing each table twice with each sight.

221. Zeroing Exercise for Subcaliber Firing
(table XI)

a. In order to use the coaxial machine gun for subcaliber firing, it is necessary to converge the sights on a target; some sights cannot be converged at less than 200 feet, others will converge at 1,000 inches. The procedure for zeroing the machine gun is as follows:

(1) Loosen the cap screws which secure the front mounting bracket of the coaxial machine gun.

(2) Install the coaxial machine gun in its mount.

(3) Loosen the two socket-head screws that lock the elevation ad-

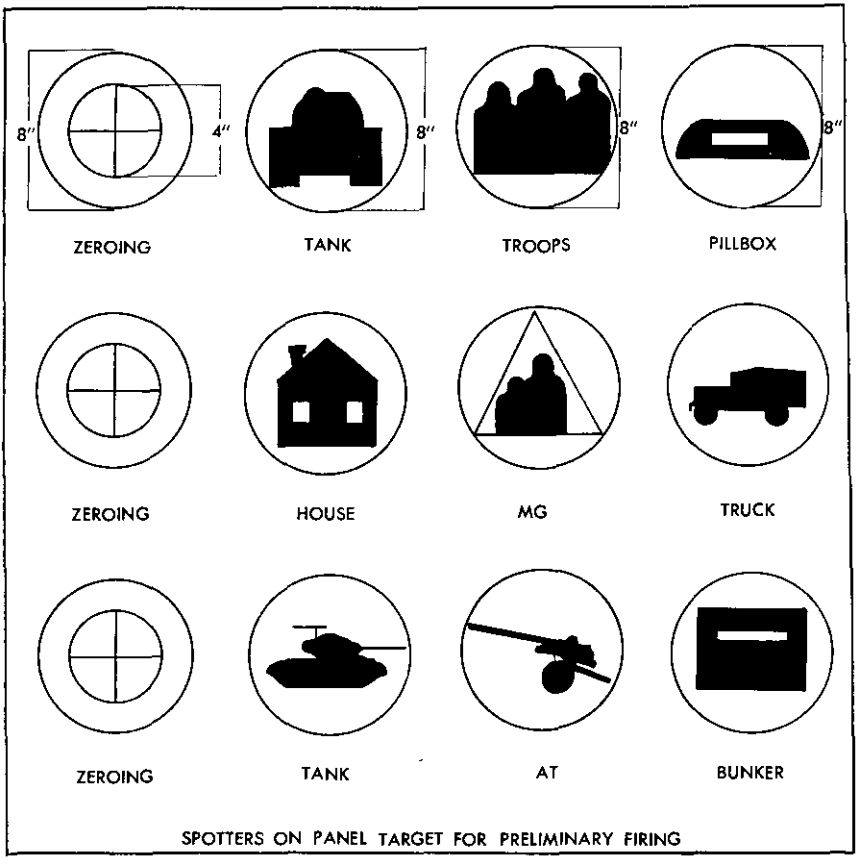


Figure 109. Spotters on panel target for preliminary firing.

justment and the socket-head screw that locks the traverse adjustment.

(4) Center the front barrel bearing of the machine gun in the aperture of the gun shield by use of the elevation adjustment.

(5) Traverse the receiver of the machine gun as far away from the line of sight as it will go.

(6) Grasp the barrel of the machine gun and pull it in the direction of the line of sight until the front barrel bearing touches the side of the aperture in the gun shield. Tighten the cap screws which secure the front mounting bracket of the machine gun. Tighten the socket-head screws which secure the elevating and traversing mechanism.

b. Boresight in the following manner:

(1) Remove back plate, bolt handle, and bolt from the machine gun.

(2) One person sights through the bore while another manipulates the turret and gun controls to lay on a definite point at the zeroing distance.

(3) Index appropriate ammunition and a range of 1,500.

(4) Unlock the elevation and azimuth boresight knobs and lay the aiming cross on the aiming point referred to in (2) above. Relock the knobs.

c. Zeroing is accomplished in the following manner:

(1) Lay on a definite aiming point.

(2) Fire three rounds single shot. Re-lay after each round.

(3) Without disturbing the lay of the gun, refer the sights to the center of the shot group by use of the elevation and azimuth boresight knobs.

(4) Fire one or more rounds to confirm the zero.

(5) If zeroing range is 1,000 inches, the check round should hit within 1 inch of the aiming point; if the range is 200 feet, it should hit within 2 inches.

(6) The zero obtained is used in exercises to follow, and must be accurate to obtain the desired results.

222. First-Round Hit Exercise

(table XII)

a. With an accurately zeroed coaxial machine gun, crewmen fire at various targets at varying ranges. The instructor, or crewman acting as tank commander, issues an initial fire command, and the gunner places the aiming cross or appropriate range line on the target. He then fires one round at each spotter. Initially, stress is placed on making an accurate, precise lay with the direct-fire sights. These exercises are not scored, but teach accuracy of lay, manipulation of turret controls, and correct sight picture. The area within which the round should hit must not be greater than the dispersion of the machine gun at that range. As a guide, squares or circles 2 inches in diameter are used for targets at 1,000 inches (fig. 110); 4 inches in diameter for targets at 200 feet (fig. 111).

b. A minimum of 10 rounds are fired with each sight. Accuracy, rather than speed, is stressed.

223. Primary Method of Adjustment Exercise

(table XIII)

a. This is a *burst-on-target* exercise; however, when the coaxial machine gun is being used at close ranges, the bullet hole in the target is used as the burst or tracer in its proper relation to the aiming point. Since the gun is zeroed, the instructor must induce a range error into

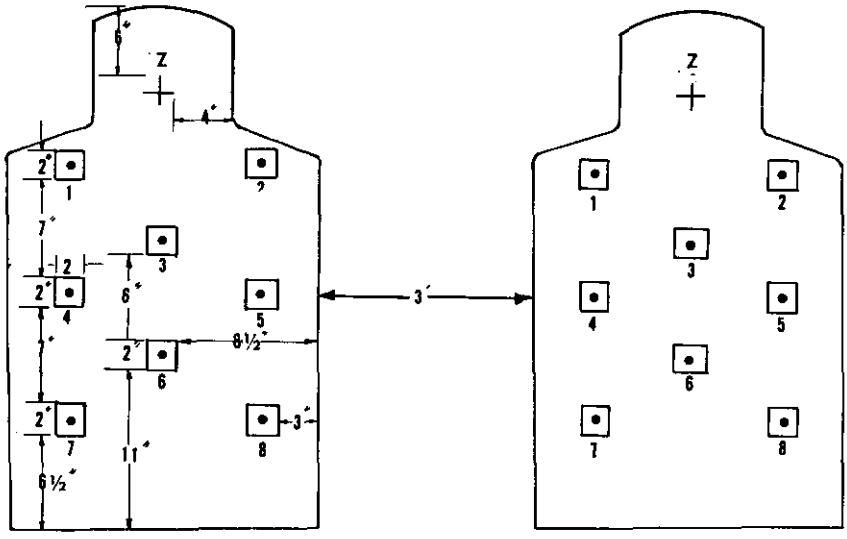


Figure 110. Targets for subcaliber 1,000-inch firing.

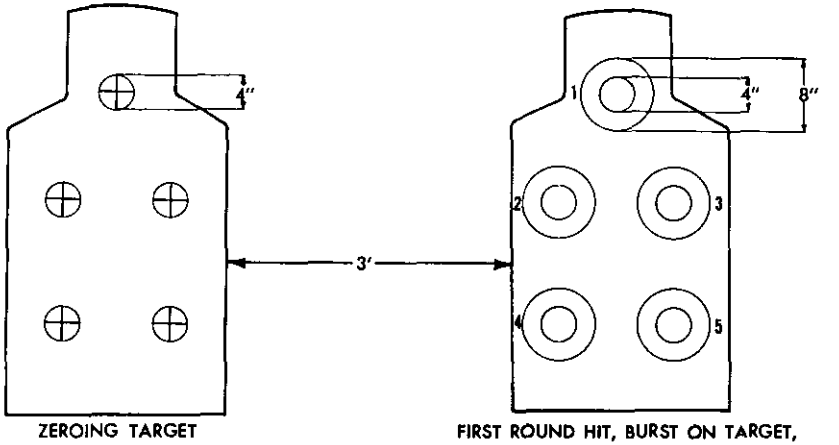


Figure 111. Targets for subcaliber 200-foot firing.

the sights and fire-control system, which will cause the gunner to miss with the first round.

b. The instructor issues an initial fire command requiring the gunner to engage a target. The gunner fires a round, notes the point on the reticle where the round hit in relation to the aiming point, applies burst-on-target, and fires a second round which should be a target hit. Induced range error should not exceed 200 yards. The tank commander announces

TARGET, CEASE FIRE, when a target hit is obtained. The gunner will not be allowed to fire more than three rounds at any one spotter. This exercise is practiced using the primary and secondary direct-fire sights.

224. Alternate Method of Adjustment Exercise

(table XIV)

The same procedure is used to throw off the gunner's established zero between problems as was described in the previous exercise (table XIII). The tank commander issues an initial fire command requiring the gunner to engage one of the numbered targets on the silhouette or panel. The instructor will cover the gunner's sight the moment the gunner announces ON THE WAY. Since the gunner will be unable to see the strike of the round, he will announce LOST. The tank commander, observing with binocular, announces his sensing and issues a subsequent fire command. The sight is then uncovered and the gunner applies the correction by using the sight reticle. When he has applied the correction, he fires, and the sight is again covered. This procedure is repeated for a third round if necessary. The gunner fires problems using both primary and secondary direct-fire sights.

Section III. GUNNERY QUALIFICATION

225. General

A qualified gunner is one who has fired a qualification course in tank gunnery and attained the prescribed standard score. The purpose of the tank gunnery qualification course is to provide a means of determining gunner proficiency; the course also serves as an adjunct to training. It is designed to test crewmen in the duties normally performed by the gunner. The complete examination for each type of weapon and tank is outlined in the field manual for the particular tank. It includes the gunner's preliminary examination, subcaliber firing exercises, and service firing exercises.

226. Gunner's Preliminary Examination

The gunner's preliminary examination is given to each member of the tank crew before he fires the qualification course. The examination includes materiel and simulated firing tests. A score of 80 percent or more is required before the crewman is permitted to fire the tables of the tank gunnery qualification course.

227. Subcaliber Tables

a. Firing on indoor and subcaliber ranges is an excellent means of attaining desired standards of training and preparing gunners for the

service qualification tables without subjecting them to the disturbance of the muzzle blast and shock of recoil. Training in this type of firing has a definite place in the sequence of gunnery instruction. It is not a substitute for, nor should it be supplanted by, service firing.

b. The subcaliber tables, as outlined in the field manual for each tank, are elementary in nature and are designed to prepare the crewman for similar exercises in the service firing tables. A satisfactory score on the subcaliber exercises (limited course) is indicative of the gunner's readiness for service firing (standard course).

228. Service Tables

a. The service ammunition tables (standard course) are fired only after the crewwman has successfully completed all subcaliber exercises. The first table fired is the zeroing exercise. The established zero is then used for subsequent firing. Service tables are fired once for practice and once for record. For active Army units, tank gunnery qualification is based on the score obtained on the service tables.

b. The method of scoring, ammunition allowances, and procedure for firing the service qualification tables (tables I through VIII) are outlined in the field manual for each of the current tanks (e.g., FM 17–78, 17–79, 17–80). Tables IX and X have been discontinued with existing equipment.

Section IV. STANDARD FAMILIARIZATION COURSE

229. General

a. Tank gunnery familiarization means that an individual has completed prescribed exercises for the tank weapons. The objective of a familiarization course is to give the individual sufficient training to enable him to fire any tank-mounted weapon.

b. This section outlines a standard familiarization course which includes preliminary instruction, preliminary subcaliber firing, and service firing.

230. Details of Familiarization Course

a. Preliminary Instruction. A minimum of 16 hours of preliminary instruction should be given to include—

(1) Weapons mechanical training.

(2) Turret familiarization.

(3) Conduct of fire.

(4) Crew drill and service of the piece.

b. Ammunition Required.

Cal .30 tracer (or ball)..... 30 rounds.
Cal .30 (4 ball to 1 tracer)..... 50 rounds.
Cal .50 (4 ball to 1 tracer)..... 50 rounds.
HE (for tank gun)..... 2 rounds.
Shot (for tank gun)..... 2 rounds.

c. Tables To Be Fired. Tables XI, XII, XIII, XIV, XV, XVI, and XVII are to be fired.

(1) No time limit or scoring is required for these exercises.

(2) Familiarization subcaliber firing (tables XI, XII, XIII, XIV) must be completed before familiarization service firing. (These tables are also described in pars. 220–224.)

(3) Familiarization service firing (table XV) and machine-gun firing (tables XVI, XVII) may be fired in any sequence.

Table XI
(Zeroing exercise)

Range	No. of rounds	Targets	Method
200 ft	5	Circles 4 inches in diameter drawn on E-type silhouettes or panels.	Fired single shot; re-lay on aiming point after each round. Fire 3- or 4-round shot group, refer sights, and fire a check round. Use primary sight.

Table XII
(First-round hit exercise)

Range	No. of rounds	Targets	Method
200 ft	5	4- and 8-inch circles drawn on a panel or silhouette target.	Fire one round at each of the five circular type spotters. Use primary sight.

Table XIII
(Burst-on-target)

Range	No. of rounds	Targets	Method
200 ft	10	4- and 8-inch circles drawn on a panel or silhouette target.	Fired single shot; two rounds at each target spotter. Induced 200-yard range error causes a miss for the initial round. Second round should be a target hit.

Table XIV
(Alternate method of adjustment)

Range	No. of rounds	Targets	Method
200 ft	10	4- and 8-inch circles drawn on a panel or silhouette target.	The gunner's sight is covered just prior to firing; unable to see the strike, the gunner applies the correction announced in the subsequent fire command and fires a second round. Two rounds are fired at each spotter.

Table XV
(Service firing)

Range	No. of rounds	Targets	Method
800–1,500 yds 800–1,500 yds	2 shot 2 HE	6×6-foot panel 3×5-foot panel	Fired at stationary targets from stationary tank. Burst-on-target is employed for subsequent rounds. Tank commander lays gun for direction and issues initial fire command.

Table XVI
(Coaxial and/or bow machine-gun firing)

Range	No. of rounds	Targets	Method
200–400 yds	50	Five E-type silhouettes 3 feet apart and staggered in depth.	Coaxial (or bow) gun firing from stationary tank at stationary targets 200 to 400 yards away. Fired in bursts of 20 to 25 rounds using prescribed method of adjustment.

Table XVII
(Caliber .50 machine-gun firing)

Range	No. of rounds	Targets	Method
500–700 yds	50	Five E-type silhouettes. Targets placed to resemble a crew in position behind a gun.	Turret-mounted caliber .50 machine-gun firing at stationary targets at a range of 500 to 700 yards. Fired in bursts of 10 to 20 rounds using prescribed method of adjustment.

Section V. CREW MOVING TANK EXERCISE (STATIONARY TARGET)

231. General

This is a crew firing exercise from a moving tank using the coaxial machine gun. It is considered as preliminary training of the tank crew and should be conducted prior to participation in tank crew proficiency and combat type courses.

Note. Where range facilities are limited, this exercise may be fired in lieu of the moving tank exercise outlined in tank field manuals, not as part of gunnery qualification but for crew training purposes. This course requires only 350 yards of runway.

232. Conduct of Moving Tank Exercise

a. Targets are four silhouettes representing troops, a 5 x 8-foot panel representing a truck, a 3 x 5-foot panel representing an antitank gun, and eight additional silhouettes representing troops (fig. 112).

b. Red flags will be placed on the edge of the runway, indicating each *commence firing* point. White flags will mark the *cease fire* points.

c. The terrain or runway should permit the tank to move at 5 to 8 miles per hour.

d. The ammunition will be belted 4 ball and 1 tracer.

e. Each crewman will make at least one run over the course.

f. The tank commander controls movement of the tank and firing by issuing the proper commands.

g. The machine gun is cleared at the end of the runway.

h. Separate runways may be set up and used concurrently, provided they are at least 30 yards apart.

i. Safety and control officers supervise movement and firing by radio and visual communication with each tank.

*Crew Moving Tank Exercise**
(Coaxial firing at stationary targets)

Range—yards	No. of rounds	Targets	Method
150	50	4 standing silhouettes to right front.	Tank commander commands DRIVER MOVE OUT, and issues fire command to engage troops. Tank fires on the move.
200–250	25	Truck (5 × 8-foot panel).	Tank commander issues fire command to engage truck target. Gunner fires one burst while tank is moving.

See footnote at end of table.

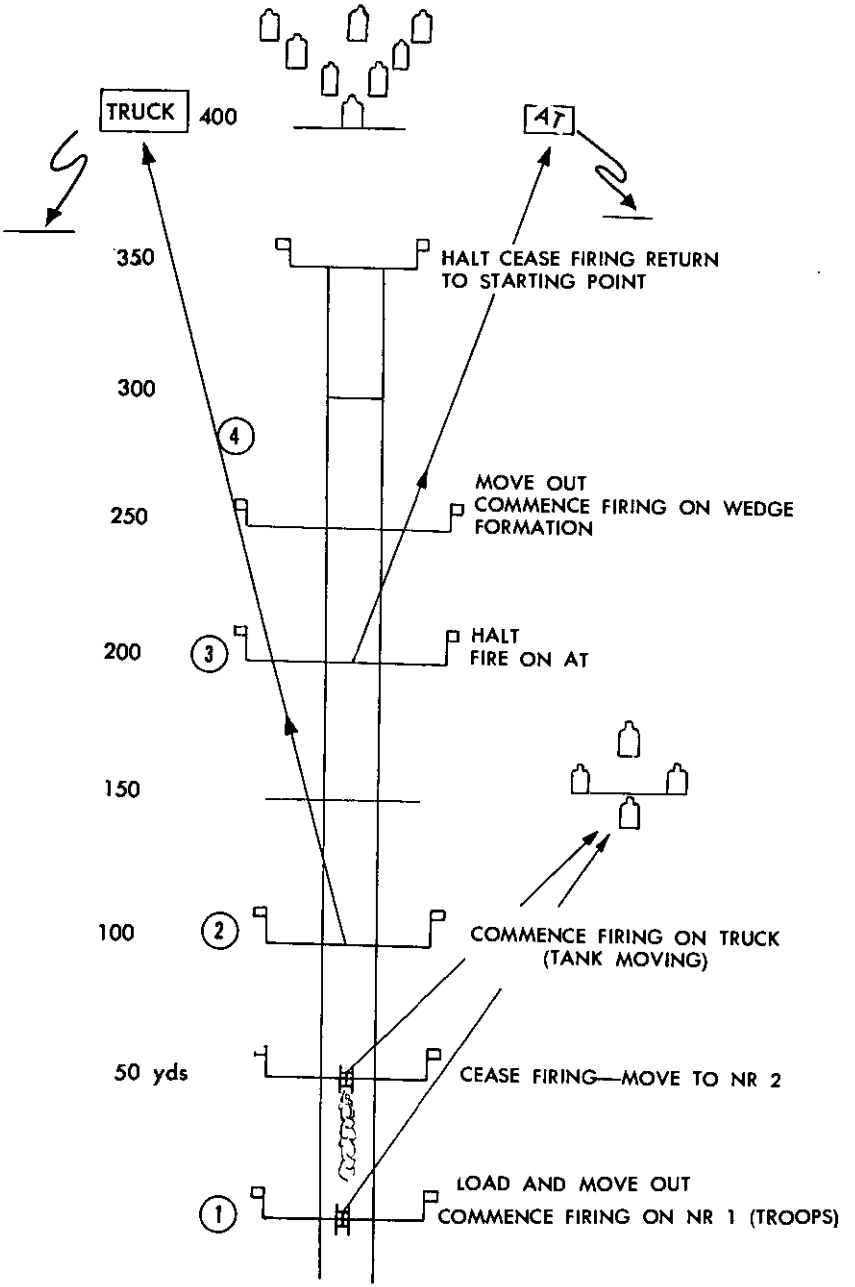


Figure 112. Course for crew moving tank exercise.

*Crew Moving Tank Exercise**—Continued

Range	No. of rounds	Targets	Method
150	25	AT gun (3 × 5-foot panel).	Tank commander says DRIVER STOP and issues fire command to engage AT gun. One burst is fired at panel with tank halted.
100–150	50	8 kneeling type silhouettes in wedge formation.	Tank moves remaining 50 yards on runway while firing at troops in wedge formation.

* SCORING: Possible 100 points: 2 points for the first hit on each silhouette target and 1 point for each additional hit, not to exceed 5 points per silhouette; 2 points for each hit on panel targets, not to exceed 20 points per target. Satisfactory score—70.

Section VI. CREW FIELD FIRING EXERCISES

233. General

a. Field firing begins with firing at stationary targets from a stationary tank and progresses to firing at surprise and moving targets from stationary and moving tanks. These exercises are a realistic approach toward combat-type firing.

b. Service field firing is the culmination of all previous gunnery training and is conducted after qualification and machine gun field firing. The objective is to train the crewmen in the proper selection of ammunition and to test their ability to fire upon any target that may face them on the battlefield, especially those whose direction and location are not known. Appropriate targets are constructed (fig. 113). Firing should progress from close to more distant targets and from plainly visible to partially visible targets. Gun simulators and moving and surprise targets should be utilized.

234. Conduct of Field Firing Exercise

a. Field service firing exercises may be of varying types. Figures 114 and 115 illustrate types of course layouts which are adaptable to existing range facilities. The number of targets and the length of the course may be increased, and different type targets may be used. The tank should move a minimum of 50 yards between firing problems. Dual runways may be established, using a common impact area (fig. 116).

b. The officer in charge of firing must brief each crew and maintain control. The briefing includes such information as:

(1) Explanation of the course and procedure.

(2) Targets to be engaged.

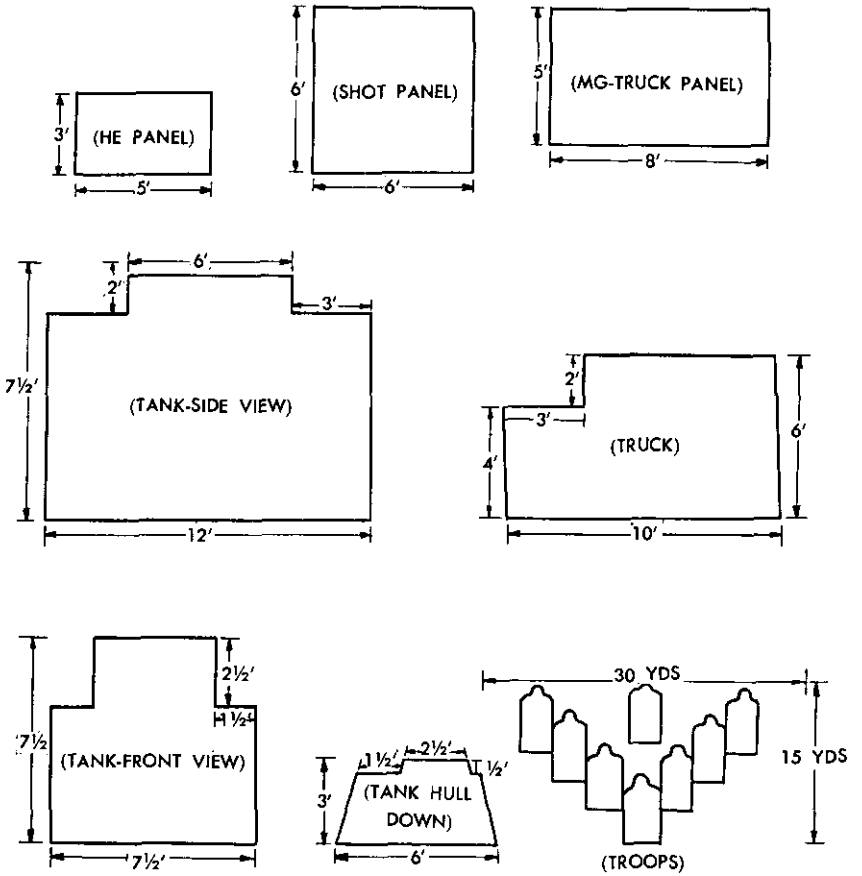


Figure 113. Targets for field firing exercises.

(3) If a first-round hit is not obtained, gunner will apply burst-on-target.

(4) Tank commander issues fire commands and traverses turret.

(5) Speed and accuracy are expected.

(6) Coaxial machine gun will be fired in bursts of 20 to 25 rounds, turret-mounted machine gun in bursts of 10 to 20 rounds.

(7) Gun must be pointed toward impact area within safety limits once the tank reaches the firing lane.

(8) Interphone and radio will be used at all times; radio check will be made with safety officer prior to moving onto the course.

(9) Driver control measures.

(10) Flag signals to be observed.

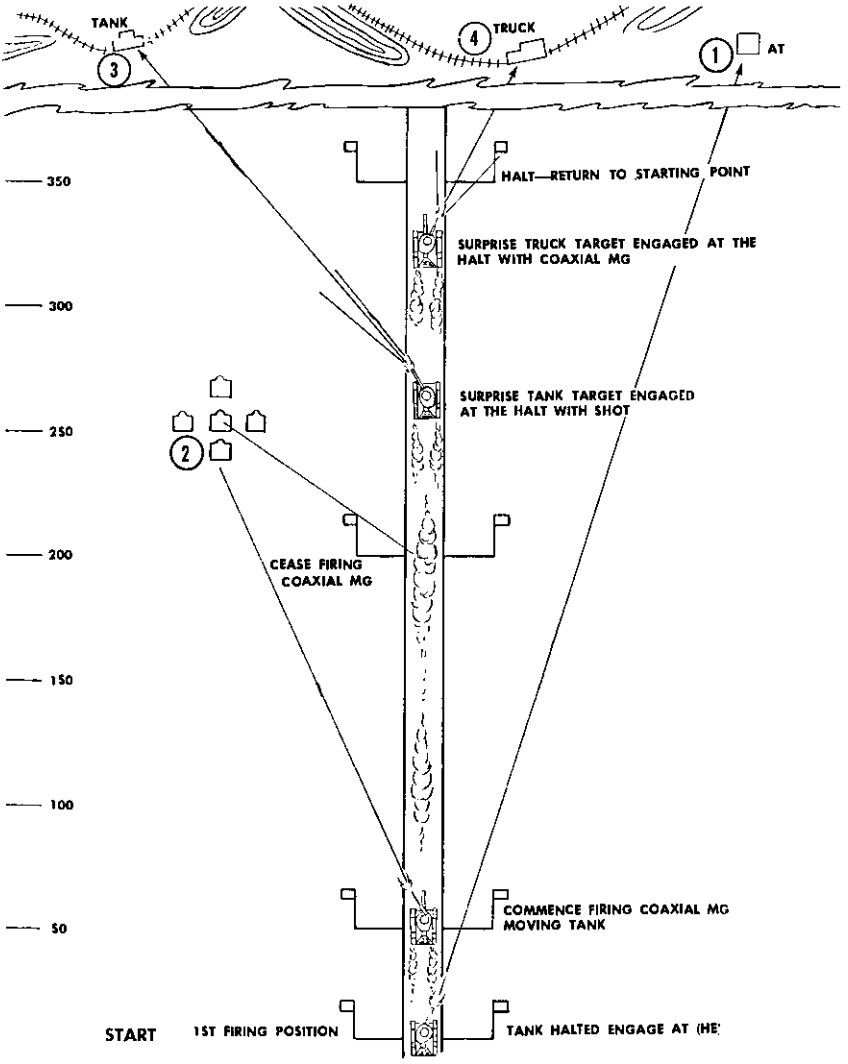


Figure 114. Crew field firing course A.

Crew Field Firing Exercise
(Course A)

Range—yards	No. of rounds	Targets	Method
1,200	2 HE	AT gun (3 × 5-foot panel).	Crew is briefed on the exercise. The tank moves over the course, halts, and fires on targets as they appear. All guns must be cleared before tank moves off the course.
200–250	75 Cal. .30	Troops (5 silhouette targets).	
800	2 shot	Moving tank (7½ × 12-foot panel).	
400	50 Cal. .50	Moving truck (5 × 8-foot panel).	

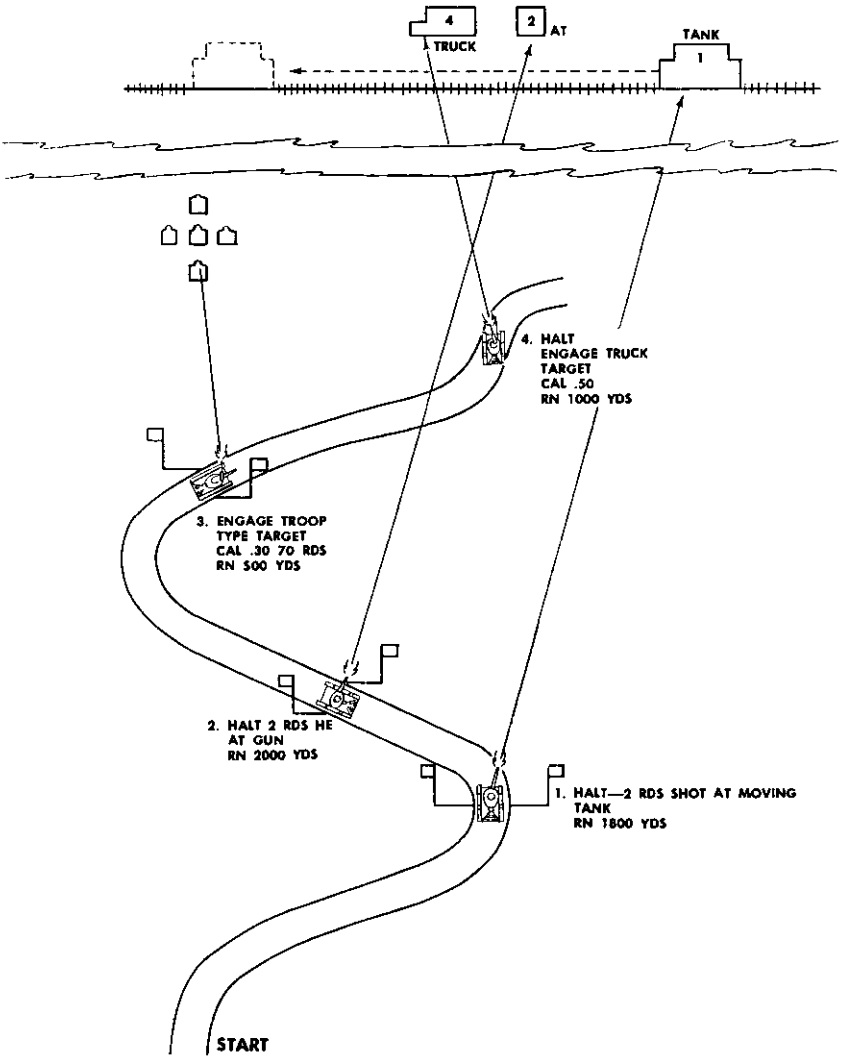


Figure 115. Crew field firing course B.

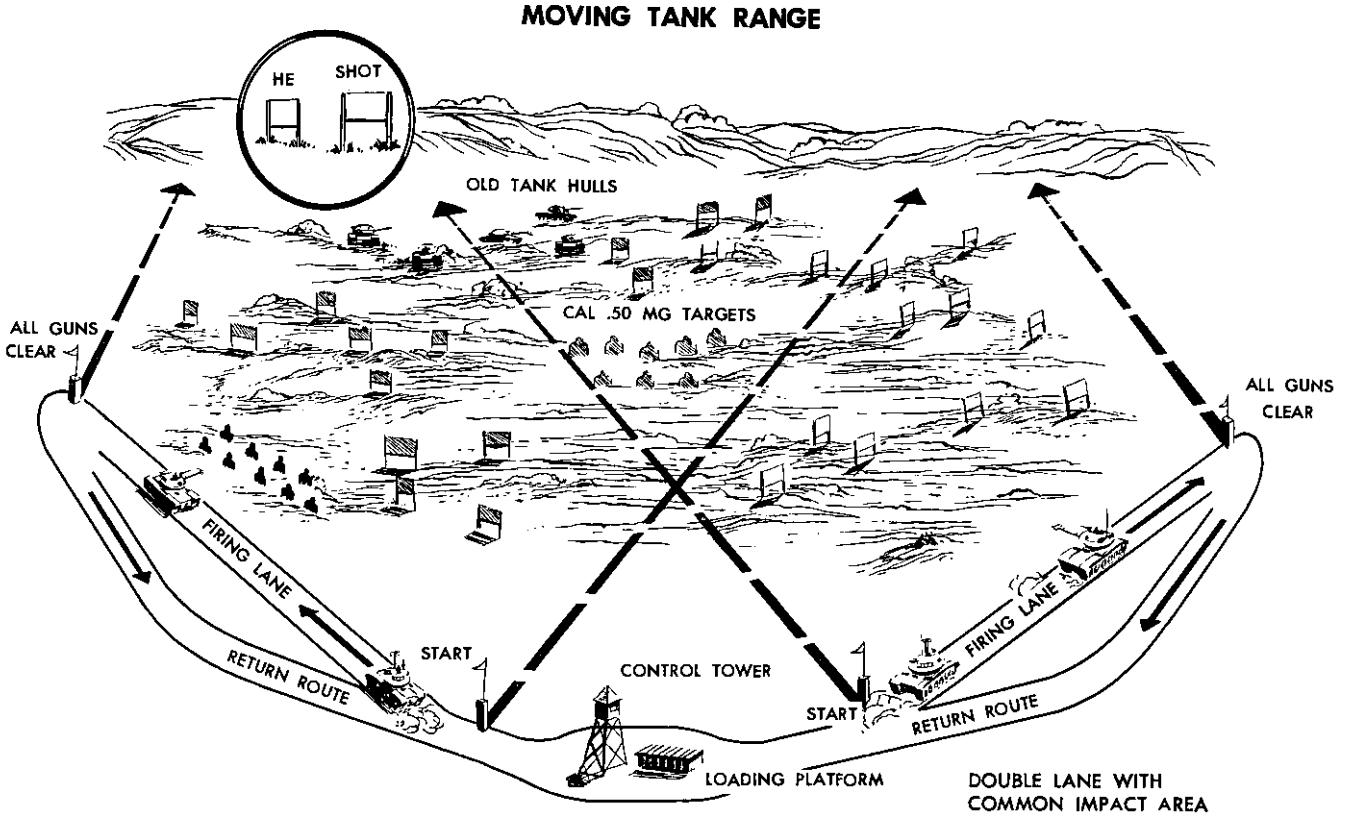


Figure 116. Dual runways with common impact area.

Crew Field Firing Exercise—Continued
(Course B)

Range—yards	No. of rounds	Targets	Method
1,800	2 shot	Tank (panel partially visible) or moving target.	Same as course A except targets are more realistic and at greater ranges.
2,000	2 HE	AT gun (simulate firing AT gun from bunker).	Stress accurate range determination and target recognition. Tank moves when firing the coaxial machine gun only.
500	75 Cal. .30	Troops (wedge formation of 5 silhouettes).	
1,000	50 Cal. .50	Truck (panel, stationary or moving, of a truck or a crew-served weapon in the open).	

Section VII. TANK CREW GUNNERY PROFICIENCY TEST

235. General

The following test is not a part of the tank gunnery qualification course, but may be given to determine the level of tank crew proficiency.

236. Description of Crew Proficiency Test

The tank crew proficiency test is used to emphasize the importance of establishing a high standard of proficiency, close crew coordination, and teamwork within the tank crew. It stresses the importance of engaging targets with the correct tank weapon and ammunition, thus insuring an adequate supply of ammunition for the continuance of the mission. This test requires the tank crew to engage, rapidly and accurately, a series of combat-type targets. The crew must employ all the tank-mounted weapons—the bow machine gun (where applicable), the coaxial machine gun, the turret-mounted machine gun (air and ground roles), and the main gun. In order to add realism to the test, the testing unit should draw up a general situation outlining the general mission of the tank crew, with special situations for each of the firing problems. To realize full benefit from the test, time must be accurately kept and targets positively scored.

237. Elements of Crew Proficiency Test

The crew is required to fire seven consecutive problems as one firing exercise. The sequence may be varied.

a. Coaxial machine gun exercise—moving tank. (Will be fired by the bow gunner if the tank is equipped with a bow machine gun.)

b. Coaxial machine gun exercise—moving tank.

c. Turret-mounted machine-gun exercise—air target.

d. Turret-mounted machine-gun exercise—ground target.

e. Service firing exercise—shot at moving target.

f. Coaxial machine gun exercise—moving target.

g. Service firing exercise—HE at stationary target.

238. Special Situations, Crew Proficiency Test

The following special situations apply as the tank moves out to fire the exercise (fig. 117):

a. The tank moves out from the assembly area (1). The tank commander notices several enemy infantrymen to his front. He commands the gunner (bog) to engage this target while continuing to move. When the gunner opens fire, the enemy infantrymen scatter. (If the tank is equipped with a bow machine gun, the command is given to the bow gunner.)

b. As the tank continues on its course, the tank commander notices an enemy machine-gun team on the side of a hill to his right front (2). He commands his gunner to take the target under fire with the coaxial machine gun while the tank is still moving. The enemy machine-gun team is destroyed.

c. As the tank moves down the course, the tank commander receives an air alert. He immediately prepares to engage an aerial target with the caliber .50 machine gun. An aerial target appears (3); the tank stops and the tank commander engages the target. The tank moves out.

d. The tank commander notices a friendly infantryman signaling him to stop (4). He stops his tank and joins the infantryman. The infantryman tells him there is an enemy gun crew going into position around the bend to his immediate front. The infantryman identifies the target with his rifle, using tracer ammunition. The tank commander identifies the target, returns to his tank, and cautiously moves out. As he rounds the bend he engages the target with the turret-mounted caliber .50 machine gun.

e. The tank moves on, and an enemy tank comes out of a draw to the front (5). The tank commander stops the tank and commands the gunner to engage the target with shot ammunition. The enemy tank is destroyed, so the tank commander orders a continuation of the mission.

f. Just as the tank moves out, a truck filled with enemy infantrymen appears in the same draw as the enemy tank (6). The tank commander commands the gunner to engage the target with the coaxial machine gun. The truck is hit and burns.

g. Again the tank moves out, and the tank commander sees a flash which appears to be an antitank gun firing at his tank (7). He stops the tank and commands the gunner to engage the target with HE ammu-

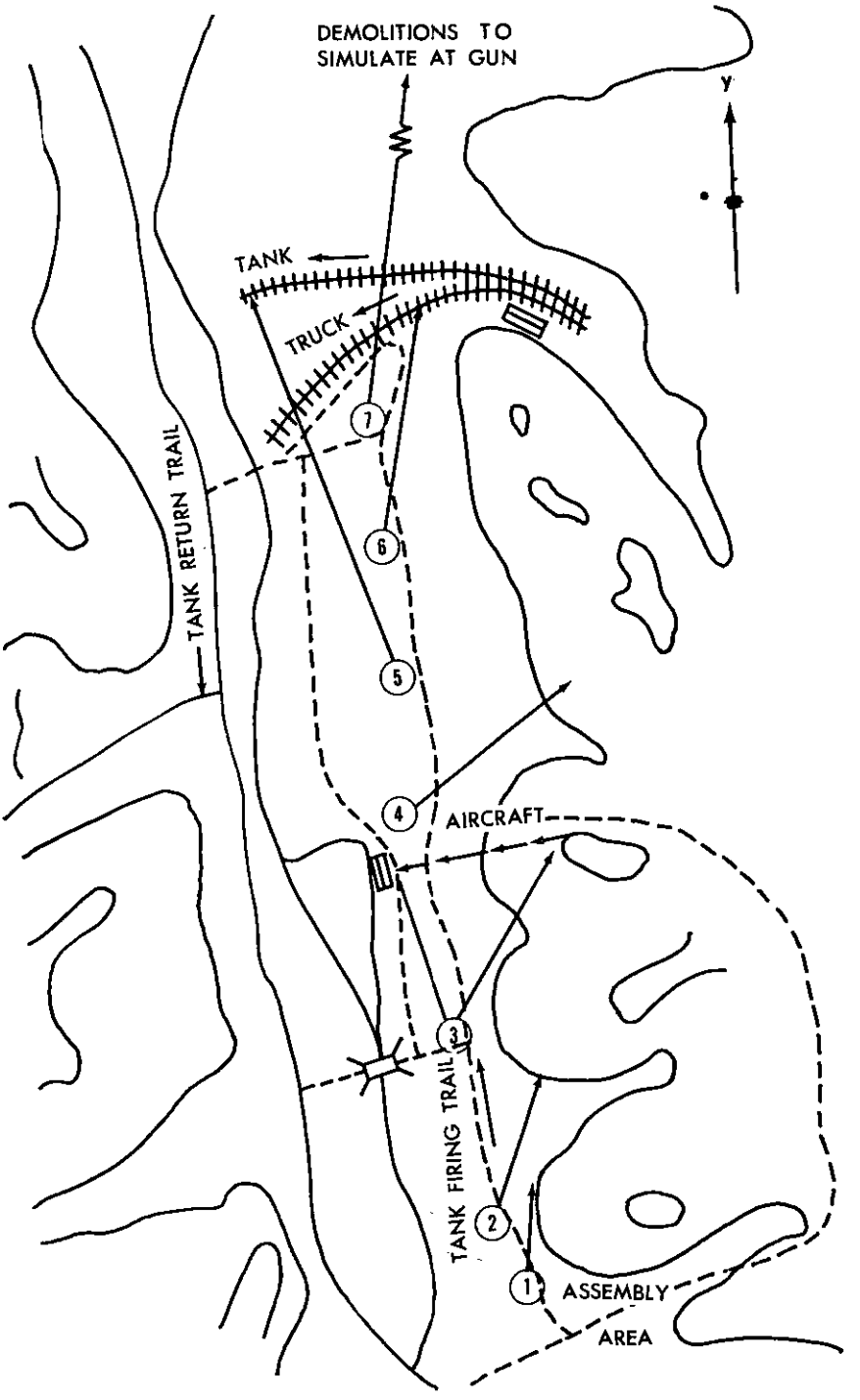


Figure 117. Course for tank crew gunnery proficiency test.

nition. The antitank gun is destroyed, and the tank commander continues the mission, thus completing the firing exercise.

239. Firing Exercises, Crew Proficiency Test

Note. All hatches except that of the tank commander will be closed during all firing.

a. Coaxial Machine-Gun Exercise—Moving Tank.

(1) *Nature of exercise.* The gunner will fire 75 rounds (4 ball to 1 tracer) of caliber .30 ammunition at stationary targets from a moving tank. (Tanks equipped with the bow machine gun will fire this exercise as a bow machine gun problem.)

(2) *Targets and range.*

(*a*) Targets will be E-type silhouette (not less than five) placed to represent troops so positioned as to be visible to the gunner (or bog). Targets should be placed within an area 15 yards deep by 5 yards wide.

(*b*) Targets will be placed at a range of 200 to 300 yards from the firing line and in line with the direction of tank movement.

(3) *Method of conducting exercise.*

(*a*) A testing officer will observe the firing from the rear deck of the tank.

(*b*) The tank moves forward along a road or trail with the coaxial machine gun half-loaded. As the tank reaches the firing line, the testing officer commands COMMENCE FIRING. The tank commander issues the initial fire command to the gunner, who opens fire and expends his entire belt in bursts of 20 to 25 rounds. The tank commander will throw a practice grenade in the target area as the tank passes. The tank commander commands CEASE FIRING upon reaching the *cease fire* point.

(*c*) The testing officer records the time from the command COMMENCE FIRING to the cessation of fire.

(*d*) After the firing ceases and the gun is cleared, a scoring crew will mark hits and record the score (par. 240).

b. Coaxial Machine-Gun Exercise—Moving Tank.

(1) *Nature of exercise.* The gunner will fire 75 rounds (4 ball to 1 tracer) at stationary targets from a moving tank.

(2) *Targets and range.*

(*a*) Targets will be E-type silhouettes (not less than five) placed to represent troops. Targets should be placed within an area 25 yards square.

(*b*) Targets will be placed at a range of 300 to 500 yards from the firing line and diagonal to the direction of tank movement.

(3) *Method of conducting exercise.*

(*a*) A testing officer will observe the firing from the rear deck of the tank.

(*b*) The tank moves forward toward the firing point with the coaxial machine gun half-loaded. As the tank reaches the firing point, the officer commands COMMENCE FIRING. The tank commander issues his initial fire command to the gunner and traverses the turret in the direction of the target. As soon as the gunner identifies the target, he takes over control of the turret and fires the problem.

(*c*) The testing officer records the time from the first element of the fire command to cessation of fire.

(*d*) After firing ceases and the gun is cleared, a scoring crew will mark hits and record the score.

c. Turret-Mounted Machine-Gun Exercise—Air Target.

(1) *Nature of exercise.* The tank commander will fire 50 rounds of caliber .50 tracer ammunition from the turret-mounted machine gun at an air target, from a tank that has been halted.

(2) *Targets and range.* The target is an aerial target, diving diagonally across the path of the tank at a range of about 300 yards. (Balloons may be used.)

(3) *Method of conducting exercise.*

(*a*) The testing officer indicates an air alert to the tank commander. The officer then gives a prearranged signal, and the target is released. When the target appears, the tank commander halts the tank and engages the target. He will fire in one continuous burst, adjusting his fire from the tracer stream.

(*b*) After firing ceases and the gun is cleared, a scoring crew or the testing officer will record the score.

d. Turret-Mounted Machine-Gun Exercise—Ground Target.

(1) *Nature of exercise.* The tank commander will fire 50 rounds of caliber .50 ammunition (4 ball to 1 tracer) from the turret-mounted machine gun at an area target. This is a problem in reconnaissance by fire.

(2) *Targets and range.*

(*a*) The target will be an area approximately 50 yards by 10 yards, so located as to represent a logical enemy position. A wooded area is most desirable.

(*b*) The target area should be at a range of 300 to 400 yards and located diagonally to the direction of tank movement.

(3) *Method of conducting exercise.*

(*a*) A testing officer will observe the firing from the rear deck of the tank.

(*b*) As the tank moves forward, an area of suspected enemy activity is pointed out to the tank commander, who engages the target with the caliber .50 turret-mounted machine gun. He will fire in bursts of 10 to 20 rounds.

(*c*) After firing ceases and the gun is cleared, a scoring crew will record the score.

e. Service Firing Exercise—Shot at Moving Target.

(1) *Nature of exercise.* The gunner will fire two rounds of shot ammunition at a moving panel from a tank that has been halted.

(2) *Targets and range.*

(*a*) The target will be a tank silhouette or a 6 x 6-foot shot panel painted OD to represent an armored vehicle. The target will be mounted on a moving rail car or a towed sled. It will travel perpendicular to the line of fire at a speed of 10 miles per hour and will be exposed for 300 yards.

(*b*) The range to the target will be 900 to 1,000 yards.

(3) *Method of conducting exercise.*

(*a*) A testing officer will observe the firing from the rear deck of the tank.

(*b*) The tank moves forward. As the tank approaches the firing point, the target appears. The tank commander halts the tank, issues the initial fire command, and traverses the turret in the direction of the target. As soon as the gunner identifies the target, he takes over the controls and engages the target.

(*c*) The officer records the time from the first element of the fire command to the cessation of fire.

(*d*) After the firing ceases and the gun is cleared, the target detail will record the score.

f. Coaxial Machine-Gun Exercise—Moving Target.

(1) *Nature of exercise.* The gunner will fire 75 rounds (4 ball to 1 tracer) at a moving panel target from a tank that has been halted.

(2) *Targets and range.*

(*a*) The target will be a truck silhouette mounted on a moving rail car or a towed sled. The target will be OD in color to represent a cargo-type vehicle. The speed of the target will be approximately 10 miles per hour. The target will travel perpendicular to the line of fire and will be exposed for 300 yards. (A 6 x 6-foot shot panel may be substituted for the truck silhouette.)

(*b*) The range to the target will be 400 to 500 yards.

(3) *Method of conducting exercise.*

(*a*) A testing officer will observe the firing from the rear deck of the tank.

(*b*) The tank moves forward with the coaxial machine gun half-loaded. As the tank approaches the firing point, the target appears. The tank commander halts the tank, issues the initial fire command, and lays the turret for direction. As soon as the gunner identifies the target, he takes over the turret controls and engages the target, firing in bursts of 20 to 25 rounds.

(*c*) The officer records the time from the first element of the initial fire command to the completion of the problem.

(*d*) After firing ceases and the gun is cleared, the target detail will record the score.

g. Service Firing Exercise—HE.

(1) *Nature of exercise.* The gunner will fire two rounds of HE ammunition at a simulated antitank target from a tank that has been halted.

(2) *Target and range.*

(*a*) The target will be a simulated antitank gun position. A 3 x 5-foot HE panel, painted to blend with the surrounding terrain, may be used.

(*b*) The target will be located at a range of 1,000 to 1,500 yards.

(3) *Method of conducting exercise.*

(*a*) A testing officer will observe the firing from the rear deck of the tank.

(*b*) The tank moves forward. As it approaches the firing point, a placed charge is set off in the vicinity of the target. The sound and flash bring the target to the attention of the tank commander, who halts his tank and issues the initial fire command while traversing the turret in the direction of the target. As soon as the gunner identifies the target, he takes over the controls and engages the target.

(*c*) The testing officer records the time from the first element of the fire command to cessation of fire.

(*d*) After completion of the problem, the testing officer will record the score.

240. Scoring Crew Proficiency Test

a. The total possible score for the crew test is 1,000 points. A score of 650 or higher gives a satisfactory rating. The individual exercises are scored according to the following table, which can be reproduced and used as a score card:

SCORING TABLE

DATE..... BN.....TK CMDR .....
CO.....GUNNER .....
CREW.....LOADER .....
BOG .....

Target No.	Rounds	Rounds used	Item	Possible	Points made	Total rating[1]
1-Bog or Coax	75		20 for each target hit up to five targets. 20 for opening fire in 10 seconds. 10 for initial fire command. 10 for proper method of fire.	140		[2]90
2-Coax	75		20 for each target hit up to five targets. 20 for opening fire in 15 seconds. 10 for initial fire command. 10 for proper method of fire.	140		[2]90
3-AA	50		60 for hitting the target. 25 for leading the target properly. 25 for getting fire into target area. 20 for proper method of fire.	130		[2]70
4-Cal. .50	50		10 for each target hit up to five targets. 50 for covering entire target area. 40 for proper method of fire.	140		[2]80
5-Tank	2		100 for hitting the target. 30 for opening fire in 20 seconds. 10 for initial fire command. 10 for proper tracking.	150		[2]110
6-Trk	75		10 for each target hit up to 10 hits. 20 for opening fire in 15 seconds.			

See footnote at end of table.

SCORING TABLE—Continued

Target No.	Rounds	Rounds used	Item	Possible	Points made	Total rating[1]
			10 for initial fire command. 10 for proper method of fire. 10 for proper tracking.	150		[2]100
7-AT	2		100 for getting effect in target area. 20 for opening fire in 20 seconds. 10 for initial fire command. 20 for completing fire in 45 seconds. ALSO: Cut 10 from total for each 5 seconds over 45 seconds.	150		[2]110
OVERALL				1000		[2]650

[1] Only satisfactory or unsatisfactory rating used.
[2] Score required for satisfactory rating.

b. Notes for Scoring Officer.

(1) Each target will be inspected for hits, and pasters will be placed over all holes.
(2) Tank commanders will identify all targets and will issue commands to crew members.
(3) Crew members who have been tested will not be allowed to serve in any capacity with another crew that is taking the tests.
(4) Each crew should fire its own tank. In any event, the crew will adjust the sights of the tank it uses for firing.
(5) Guns and tanks are assumed to be in perfect condition. Retests will not be given to those crews whose tanks or guns fail to function properly. Retests may be given to those crews whose firing is interfered with by circumstances beyond their control.
(6) Each problem will be critiqued upon completion.
(7) Scoring of the entire test will be accomplished as follows:
   (*a*) Each crew's scores for the seven parts of the test will be totaled. This total is the crew's test score.
   (*b*) The company score will be the average score of all crews tested in the company.
   (*c*) The battalion score will be the average score of all crews tested in the battalion.
   (*d*) A test score of less than 65 percent is unsatisfactory (see scoring table).

CHAPTER 12

ESTABLISHING AND CONDUCTING TANK FIRING RANGES

Section I. INTRODUCTION

241. General

a. Range firing is the type of training which most closely approximates the ultimate in combat—the destruction or annihilation of the enemy. Realistic training is achieved by the use of live ammunition on organized ranges. Tank ranges are of various types. Some are permamently established, such as those at armor training centers; others are used periodically. Range sites are designed for specific purposes, types of weapons, and particular firing exercises. All personnel in armored units will be concerned with range firing practice in some form or other, either as tank crewmen firing prescribed courses or as officers responsible for planning, supervising, or conducting range firing.

b. In order to accomplish the assigned mission, commanders must understand and comply with AR 385–63 and other appropriate Department of the Army directives, local range regulations (which govern all firing and use of local facilities), and provisions of appropriate field manuals which prescribe weapons firing.

242. Purpose

The purpose of this chapter is to—

a. Improve conduct and operation of tank ranges.

b. Establish procedures and provide guidance.

c. Supplement existing regulations by providing additional information and safety measures to be used in the conduct of tank gunnery ranges.

Section II. ESTABLISHING TANK FIRING RANGES

243. General

Range firing for tank crews is vital to their training. This training will be necessary wherever armored units are stationed. It is important that

adequate facilities be made available for all individual and crew firing exercises. The area required for establishing a range for firing tank guns will be dependent upon the caliber of weapon and the type of ammunition. This area should provide for direct firing at targets placed from 500 yards to 2,500 yards if possible. AR 385–63 prescribes the surface danger area diagram for all direct firing by tank weapons.

244. Range Safety Overlay

a. A range safety overlay (fig. 118) illustrates the safety limits required to fire a particular type of weapon and ammunition in a given area. It includes such information as—

(1) Date and time of fire.
(2) Type of weapon and ammunition.
(3) Moving or stationary vehicle.
(4) Moving or stationary target.
(5) Coordinates of firing point or line.
(6) Azimuth of right and left firing limits.
(7) Location of safety markers.
(8) Minimum range at which weapons can be fired.
(9) Maximum range at which weapons can be fired.
(10) Range of weapon at 15° elevation.
(11) Date of preparation.
(12) Preparing agency.
(13) Maps to be included with overlay.
(14) Responsibility for and location of roadblocks.

b. In the planning and establishing of a range, the following factors must be considered:

(1) Safety markers (barber poles) may be placed to provide a common impact area for all tanks on the firing line. To make maximum use of a narrow impact area, additional barber poles are placed so that tanks right of center on the firing line use the left inner marker and the right outer marker as their safety limits. Tanks left of center use the right inner marker and the left outer marker.

(2) To eliminate confusion, use black and yellow barber poles for inner markers and red and white barber poles for outer markers.

(3) When possible, barber poles should be placed at a range of 1,500 yards from the firing line so that they may be used for boresighting and for adjustment of internal correction system settings.

(4) When a range is first established, an air space request must be

OVERLAY: Tank Range Nr 5

MAPS: KENTUCKY, 1:25,000, FORT KNOX, PITTS POINT, COLESBURG and VINE GROVE.

ORGANIZATION TO FIRE: 757th Tank Battalion.

DATE AND TIME OF FIRING: 26 July 1956.

TYPE OF WEAPON AND AMMUNITION: Caliber .30 and caliber .50 MG—Ball and Tracer; 90-mm Gun—AP and HE.

Stationary vehicles firing at field targets, stationary panels, and moving targets.

FIRING POINT COORDINATES:

Left end—596101. Right end—597191

FIRING LIMITS:

Grid azimuth for left firing limit—1071m.

Grid azimuth for right firing limit—1507m.

- Inner safety marker (common impact area).
- Outer safety marker.

MINIMUM RANGE: 1000 inches for MG, 500 yards for tank gun.

MAXIMUM RANGE OF WEAPON: Range of weapon firing Cartridge AP-T, T33E7 at 15 degrees (267m)—12,800 yards.

MISCELLANEOUS:

Officer in charge of firing is responsible for raising and lowering range flag and manning road block as indicated.

PREPARED: 26 July 1956, S3, 757th Tank Battalion.

Signature: A. B. King

A. B. KING
Major, Armor
S3

Figure 118. Range safety overlay.

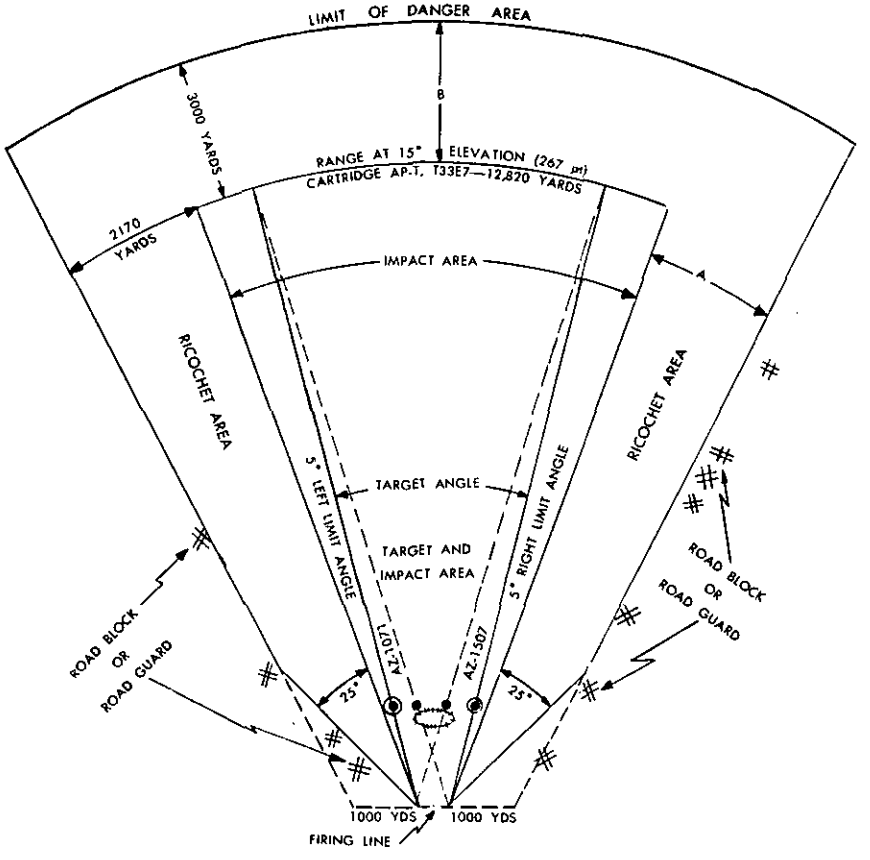


Figure 118—Continued.

forwarded through channels in order to prevent aircraft from flying over the range.

245. Subcaliber Ranges

Subcaliber exercises are fired at distances up to 200 feet. A single range site can be established to facilitate the firing of all subcaliber tables at one location. A target layout for subcaliber firing is shown in figure 119.

246. Combat Range

A combat range should be established to require high standards of proficiency similar to those demanded under combat conditions. It should be designed as a practical firing exercise to stress the coordination of fire of tank weapons on various type combat targets, and to cause the tank crew to operate as a fighting team. Figure 120 illustrates a type combat range layout, showing how both service ammunition and small arms safety fans are adapted to the terrain.

TARGET LAYOUT FOR SUBCALIBER EXERCISES GUNNERY QUALIFICATION COURSE, ON ONE RANGE

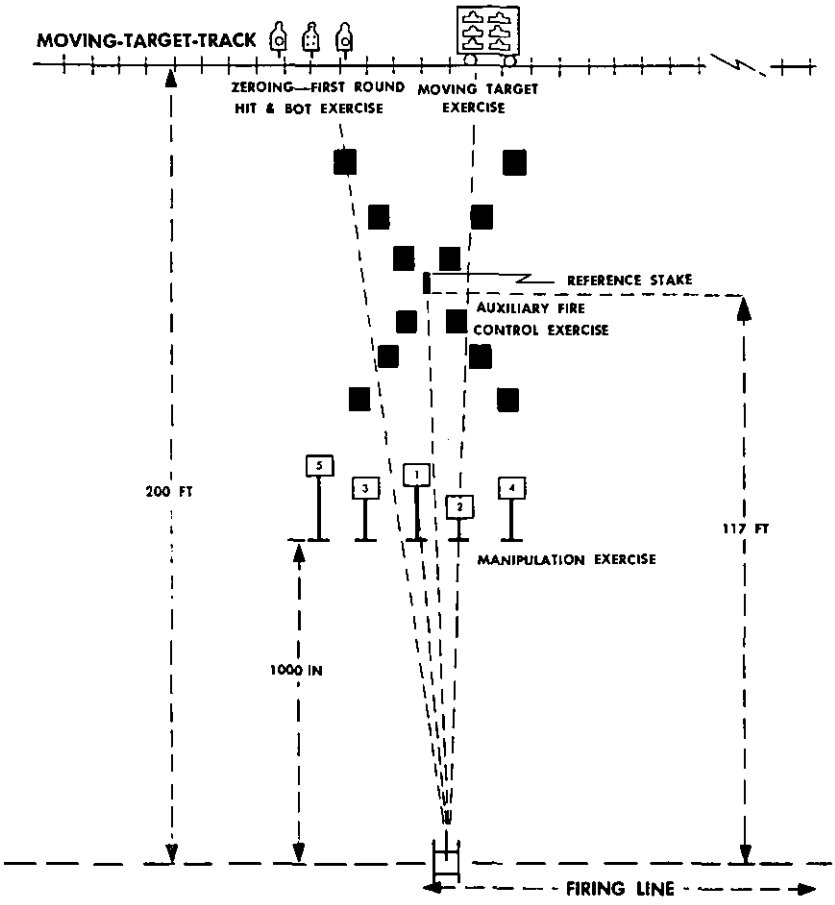


Figure 119. Target layout for subcaliber firing.

a. Assembly Area. Is selected in defilade and concealed from target No. 1.

b. Firing Position No. 1. Is selected as the tank exits from the woods, to permit engagement of a surprise target with main armament at approximately 1,000 to 1,200 yards range. The range safety overlay is constructed from this position.

c. Firing Position No. 2. Is selected as a hull defilade position on a ridge to permit engagement of a moving target with main armament at approximately 800 to 1,000 yards range. *Distance between position 1 and position 2 must be added to maximum range limit of the range safety overlay.*

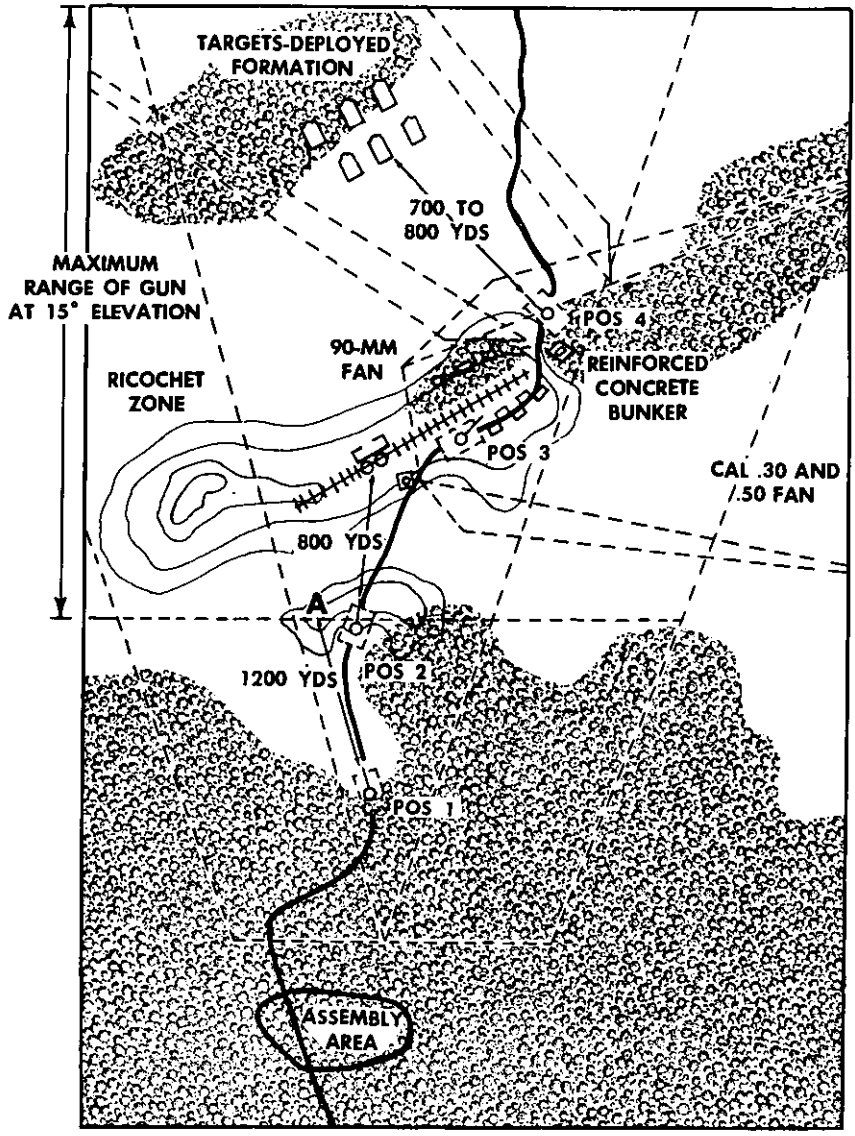


Figure 120. Combat range layout.

d. Firing Position No. 3. Is selected at the entrance to a mock village to permit engagement of surprise targets with the coaxial and turret-mounted machine guns (and bow gun, if tank is so equipped). The targets should appear from doorways, first-floor windows, and second-story windows. Caliber .50 and .30 machine-gun range safety overlays are established from this position.

e. Firing Position No. 4. Is selected as the tank exits from the village, to permit engagement of an area target with the tank machine guns at

approximately 700 to 1,200 yards range. It will be necessary to establish a machine-gun range safety overlay at this position if fire does not fall within the main armament range safety fan.

Section III. CONDUCTING TANK RANGE FIRING

247. General

Thorough planning and supervising are essential to all range firing exercises. The officer in charge of firing is responsible for all activities on the range. He is assisted by a safety officer, who has no duties other than insuring safety. They both must insure compliance with safety precautions prescribed in AR 385–63 and other pertinent directives. In order to take full advantage of the firing time allotted, the officer in charge of range firing should become familiar with his duties well in advance of the firing period.

248. Duties of Officer in Charge of Tank Range Firing

The officer in charge (OIC) performs certain duties before, during, and after range firing.

a. Before Range Firing.

(1) In his analysis of the training mission, the OIC should consider *what, who, when, where,* and *how* he will conduct firing.

(2) The OIC reconnoiters and checks the range area and facilities, to include firing points, target equipment, target area, target supplies, safety limits, safety markers, and roadblocks. Locations of all roadblocks are recorded.

(3) A range lesson plan is prepared by the OIC and serves as a guide and ready reference for general procedure to be followed. Lesson planning includes preparation of a check list to insure procurement and coordination of necessary personnel, equipment, and supplies, as well as establishment of the range.

(4) Final preparation includes a final check of range facilities, targets, communication facilities, ammunition, and all other coordinating activities.

b. During Range Firing.

(1) Upon arrival at the range, the OIC should conduct a briefing for his assistants and personnel to fire. This briefing is a statement of purpose, objectives, standards, procedure to be followed, and safety precautions to be observed. The briefing will also include an explanation and demonstration of proper methods of handling ammunition.

(2) Clearance to fire should be obtained after road guards are posted. The red range flag is raised in accordance with local regulations.

(3) Control of the firing is maintained by the officer in charge. This authority must not be delegated.

(4) At all times the OIC positions himself where he can supervise the operation of the range. He is responsible for all activities on the range.

(5) Accidents that occur are investigated and reported immediately. Other necessary action is taken according to the unit SOP and existing directives.

(6) Misfires and dented rounds will be removed from the tank and handled according to existing directives.

c. *After Firing Is Completed.*

(1) The OIC will supervise the care, handling, and turn-in of brass and unfired ammunition.

(2) All weapons are cleaned on the range under the supervision of the OIC.

(3) The post range office and unit operations section will be notified upon completion of the firing.

(4) Personnel will be inspected for live ammunition prior to departure from the range.

(5) The range and facilities are policed, and repaired if necessary, prior to departure from the range.

(6) A critique is conducted at the range site.

249. Checklist for Officer in Charge of Tank Range Firing

The following checklist may be used as a guide in preparing for and conducting range firing.

a. *References.*

(1) AR 385–63.

(2) Post range regulations.

(3) Unit range SOP.

(4) Current training directives.

(5) Appropriate weapons field manuals.

b. *Action Prior to Scheduled Day of Firing.*

(1) *Analysis of mission.*

(*a*) What is the mission?

(*b*) Who is involved?

(*c*) When is the firing to be conducted?

(*d*) Where is it to be conducted?

(*e*) How is the range firing to be conducted?

(2) *Tentative plan.* Make a tentative plan to include—
(*a*) Units to fire.
(*b*) Ammunition requirements.
(*c*) Transportation requirements.
(*d*) Supply.
(*e*) Training
(*f*) Assistants.

(3) *Reconnaissance of range.*
(*a*) Routes and condition of roads.
(*b*) Firing points and target equipment.
(*c*) Target area and target supply.
(*d*) Safety limits (check with range safety overlay).
(*e*) Mess area.
(*f*) Roadblocks and range flags.
(*g*) Communications.
(*h*) Concurrent training area.
(*i*) Arrangements for correction of deficiencies.

(4) *Lesson plan.*
(*a*) Objective of range firing.
(*b*) Standards required.
(*c*) Procedure and courses to be fired.
(*d*) Plan for movement to and from range.
(*e*) Schedule for firing and concurrent training.
(*f*) Equipment and personnel (safety officer, control officer, supply and mess personnel, turret mechanic, radio repairman, and others as required).
(*g*) Special instructions to participating units.
(*h*) References.

(5) *Preparing range.*
(*a*) Check firing schedule.
(*b*) Check training schedule.
(*c*) Check with local range officer.
(*d*) Insure that range deficiencies have been corrected.
(*e*) Coordinate with unit S3.
(*f*) Notify all personnel concerned.
(*g*) Conduct a briefing of assistants.
(*h*) Supervise placement of targets.
(*i*) Coordinate with supply, mess, and maintenance personnel.
(*j*) Insure presence of ambulance and qualified aid man.

c. Conduct of Range Firing.
(1) Give final briefing to assistants on the range.
(2) Brief personnel to fire.
(3) Orient and post road guards, and check roadblocks.

(4) Obtain clearance to fire.
(5) Raise range flag.
(6) Maintain rigid control of the firing at all times.
(7) Rotate personnel according to plan.
(8) Report and investigate all accidents immediately.
(9) If extension of time is required, obtain permission from post range officer to continue firing.

d. Action After Firing Is Completed.

(1) Supervise cleaning of weapons.
(2) Supervise the removal of machine guns.
(3) Turn in brass and ammunition.
(4) Report location of duds and misfires.
(5) Notify range office and unit S3 that firing is completed.
(6) Police range.
(7) Conduct critique.
(8) Submit necessary reports.

250. Communication and Control in Tank Range Firing

a. The type of control and means of communication employed by the post range officer are outlined in local range regulations. This control system is for the purpose of obtaining clearance, making reports, coordinating with other ranges, and ceasing fire. The range communication system allows immediate shutdown of all ranges in the event of an emergency.

b. The range OIC controls firing by use of radio, telephone, public address systems, and signal flags. Within the tank, control is exercised by use of the tank interphone system.

c. Signal flags are displayed on the control tower, or control point, and on all tanks during range firing. The display of flags on the control tower is the duty of the safety officer. On the tower, a red flag denotes permission to fire; a green flag denotes that the range is not clear for firing. The proper tank flag signals are:

(1) *Red flag.* Tank is carrying live ammunition and engaged in firing.
(2) *Green flag.* All tank guns are clear and tube is elevated. Any live ammunition in the tank is properly stowed.
(3) *Orange flag.* Tank is disabled or has a malfunction; used in conjunction with other flags.
(4) *Red and green flags.* Tank is preparing for firing or dryfiring exercise; all guns are clear, but not elevated.
(5) *Red and orange flags.* Tank has malfunction or misfire; gun is *not* clear.

(6) *Green and orange flags.* Tank has malfunction; all guns are clear.

(7) *Red, orange, and green flags.* Tank has completed firing, tube is elevated, all guns are clear.

251. Safety Precautions in Tank Range Firing

The officer in charge of firing is responsible for all safety measures. He is assisted by a safety officer, who will have no duties other than insuring safety.

a. The officer in charge, or the safety officer, should have radio communication with each tank in order to control the firing.

b. No gun will be loaded (or half loaded) until a command to do so has been given.

c. Before machine gun firing, the safety officer will ascertain that a cleaning rod and dry patch have been run through and removed from the muzzle end of each gun bore.

d. Prior to firing main guns, weapons record books must be checked to insure that there is sufficient tube life remaining for each tank. Rounds previously fired, plus those to be fired on the particular range, cannot exceed the estimated full service rounds (FSR) limit after last ordnance inspection.

e. Crew members must be cautioned to stay clear of the path of recoil.

f. When tanks are firing, the OIC will make certain that there are no trees or other obstructions in the line of fire that might cause an explosion of an HE shell at close range.

g. In emergencies, anyone may give the command CEASE FIRING. Firing will cease immediately, regardless of the source of command.

h. Whenever there is a cessation of fire, breechblocks will be open and machine-gun bolts will be held to the rear with T-blocks.

i. After machine guns are fired, and prior to dismounting or removing them from the tank, each gun will be inspected to see that it is unloaded. As part of this inspection, a cleaning rod will be passed through the muzzle end of the barrel of each gun and removed.

j. Tank guns must always be elevated after firing so that any accidental discharge of the guns resulting from failure to clear guns will go above personnel moving about in front of the tank. This procedure, however, does not eliminate the necessity for clearing the guns.

252. Duties of Safety Officer in Tank Range Firing

The duties of the safety officer are to insure that—

a. Safety limits are established on the ground and are understood by all personnel.

b. All gun tubes are free of dirt or obstruction prior to firing service ammunition.

c. Ammunition is handled correctly. When service ammunition is carried, the primer end will be up and covered with the palm of the hand.

d. Personnel mount and dismount from tanks correctly. If firing is being conducted from stationary positions, crews will mount and dismount over the right rear deck of the tanks.

e. Smoking is not permitted and fires are not built in the near vicinity of the tanks or ammunition.

f. The red flag is displayed at the control point before firing.

g. The officer in charge of firing is notified when it is safe to fire.

h. All range regulations are enforced.

i. No gun fires outside the lateral safety limits, above maximum elevation, or below minimum elevation, as prescribed by the range safety overlay.

j. The proper powder charge is used (if semifixed or separate loading ammunition is being used).

k. No gun is fired unless the range is clear.

l. No personnel are in the danger area, except as authorized in AR 385–63.

m. All personnel at the gun position are briefed and comply with the safety regulations.

n. Equipment for the safety officer includes—

(1) Copy of AR 385–63.
(2) An accurately declinated aiming circle.
(3) Range safety overlay and map.
(4) Copy of current local range regulations.
(5) Copy of current range memorandum, to include firing points.
(6) Copy of the appropriate firing tables.
(7) Binocular.

253. Safety Precautions Checklist for Tank Commander or Tank Instructor

The duties of the tank commander or instructor are to instruct, supervise, and insure compliance with the following:

a. General.

(1) No smoking is allowed near ammunition or tanks.
(2) No personnel will stand on top of turret.
(3) Personnel mount stationary tanks on a firing line from the right rear.
(4) Driver must be alerted when personnel are mounting the tank (on moving tank ranges).

(5) Misfires are reported to the OIC, who will take necessary action.
(6) Other safety precautions and proper operating procedures, as stated under *service of the piece* in the field manual for a specific type tank, are complied with.

b. Tank Commander's Position.
(1) Keep feet inside turret ring at all times.
(2) Keep entire body clear of recoil.
(3) Keep fingers off firing triggers.
(4) Be prepared to override gunner with power controls if he is committing an unsafe act.

c. Gunner's Position.
(1) Keep finger off the firing trigger until ready to fire.
(2) Keep body clear of recoil.
(3) Do not fire unless target is clearly identified.
(4) Do not announce ON THE WAY until after hearing the loader announce UP.
(5) Announce ON THE WAY and pause one second before firing.
(6) In case of misfire or stoppage, turn off firing switch and announce MISFIRE (STOPPAGE).

d. Loader's Position.
(1) Insure that ammunition is properly stowed and secured and that the primer is protected at all times.
(2) Keep clear of path of recoil.
(3) Insert T-block before announcing that machine gun is clear.
(4) Use asbestos gloves to handle hot brass.
(5) Do not throw empty brass out, unless area alongside of tank is clear.
(6) Use the extracting and ramming tool to close the breech, to chamber, or to remove a stuck round.

254. Suggested Arrangement and Handling of Ammunition and Containers for Stationary Tank Firing

a. Ammunition, boxes (with fiber containers), and brass are stacked as shown in figure 121.

b. Ammunition is laid on a tarp, fuze toward muzzle, and stacked no more than two layers high; front edge (toward muzzle) of the tarp is kept free so it can be folded back over ammunition and muzzle blast will not uncover ammunition.

c. Unpack at any one time only the ammunition necessary to fire one crew.

d. Fiber containers are put in boxes stacked five high. Salvageable material only will be placed in the fiber containers. Paper, tape, and small trash will be policed up.

e. Personnel will use wire cutters to cut wire on boxes. Remove containers from boxes, place cap end of container on the ground, and remove tape. Pull up on large portion of container and remove from round, holding the round steady with the other hand. Place left hand around nose (tapered portion) of round. Pick the round up, after upending it (primer end up), flip off the cap, and place hand over the primer. The round is then carried in this manner to the tarp.

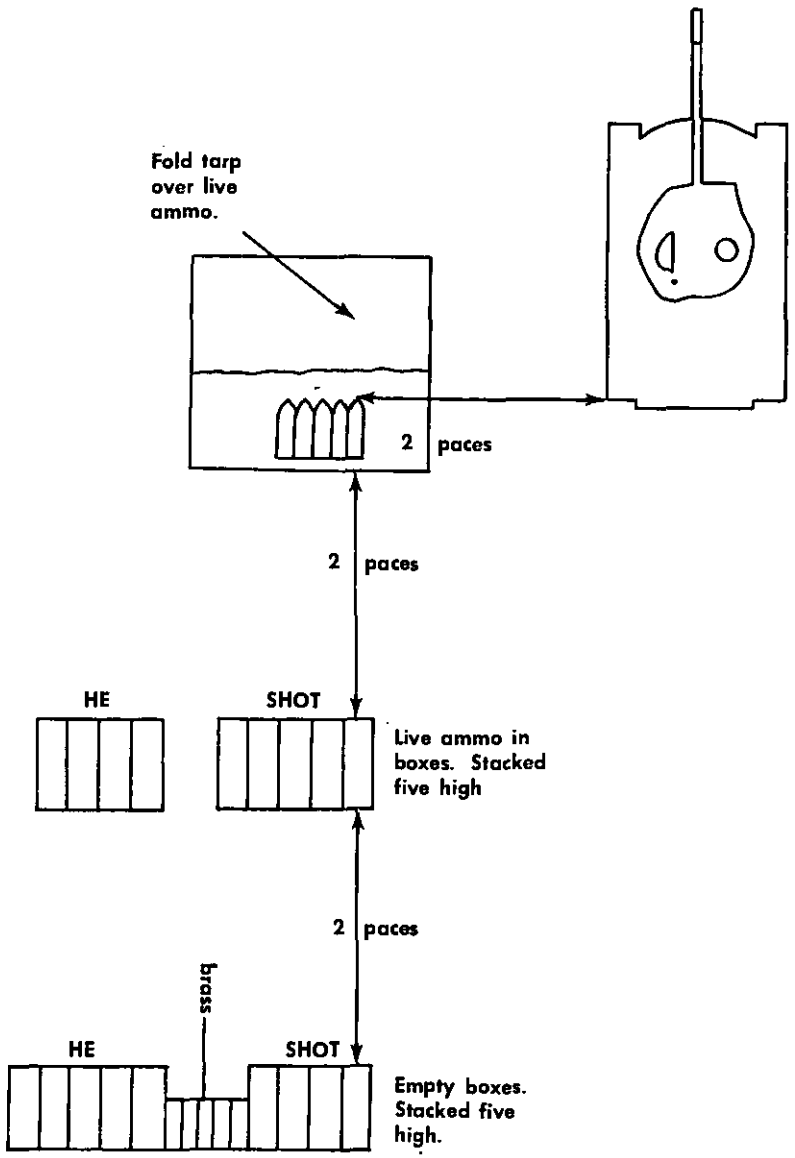


Figure 121. Arrangement of ammunition and containers for stationary firing.

APPENDIX I

REFERENCES

DA Pam 108–1	Index of Army Motion Pictures, Television Recordings, and Filmstrips.
DA Pam 310-series	Military Publications (indexes)
AR 385–63	Safety (Regulations for Firing Ammunition for Training Target Practice, and Combat).
SR 320–5–1	Dictionary of United States Army Terms
SR 320–50–1	Authorized Abbreviations
FM 6–40	Field Artillery Gunnery
FM 6–135	Adjustment of Artillery Fire by the Combat Soldier.
FM 17–32	Tank Platoon and Company
FM 17–33	Tank Battalion
FM 17–78	Tank, 90-mm Gun, M47
FM 17–79	Tank, 90-mm Gun, M48
FM 17–80	Tanks, 76-mm Gun, M41 and M41A1
FM 21–5	Military Training, Part One, Training Management.
FM 21–6	Techniques of Military Instruction
FM 21–30	Military Symbols.
FM 23–55	Browning Machine Guns, Caliber .30
FM 23–65	Browning Machine Guns, Caliber .50
TM 9–525	Graphical Firing Tables
TM 9–575	Auxiliary Sighting and Fire Control Equipment
TM 9–718A	90-mm Gun, Full-tracked Combat Tank, M47
TM 9–730	76-mm Gun Tank, M41 (TF41E1) and T41E2
TM 9–7012	90-mm Gun, Full-tracked Combat Tank, M48 and M48A1.
TM 9–1900	Ammunition, General
TM 9–1901	Artillery Ammunition
TM 9–1990	Small Arms Ammunition
TM 9–6166	Aiming Circle, M2
TM 11–284	Radio Sets; AN/GRC–3, –4, –5, –7, –8

INDEX

[AG 470.8 (15 Feb 57)]

By Order of *Wilber M. Brucker*, Secretary of the Army:

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Chief of Staff.

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OS Base Comd	Armor Tng Cen
Log Comd	USMA
MDW	Inf Sch
Armies	Armor Sch
Corps	PMST Sr Div Units
Inf Div	PMST Jr Div Units
Armd Div	PMST Mil Sch Div Units
Abn Div	Mil Dist

NG: State AG; units—same as Active Army.

USAR: Same as Active Army.

For explanation of abbreviations used, see SR 320–50–1.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1957—423275