AMOGUIDE

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WAR DEPARTMENT TECHNICAL MANUAL
TM 9-1904

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Ammunition Inspection Guide

WAR DEPARTMENT • **2 MARCH 1944*

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WAR DEPARTMENT
Washington 25, D. C., 2 March 1944

TM 9-1904, Ammunition Inspection Guide, is published for the information and guidance of all concerned.

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G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

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(For explanation of symbols, see FM 21-6.)

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INTRODUCTION

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Ammunition in General

GENERAL.

When venturing into any new field, one finds himself confronted with many new terms and materials to such an extent that he often becomes lost in a maze of confusion. It is, therefore, necessary to lay a foundation of information that will aid in interpreting the material which will follow.*

It is necessary for the ammunition inspector to have a wide and complete knowledge of all the types of ammunition that he will come in contact with in the line of duty, for he will be called on to pass judgment as to the safe conduct of various operations. To do this, he must know all the facts about the material in question. It might be well to point out that all ammunition is inherently dangerous, for its whole purpose of existence is to destroy or kill, but, if handled correctly and carefully, one need not be afraid to work with it. At all times, however, it must be given the fullest respect. A great portion of the accidents which do occur can be traced to some form of carelessness when the full measure of safety was not applied.

Nomenclature. In his daily duties the ammunition inspector will be called upon to discuss ammunition. Whether this discussion be written or oral, the proper use of terms or proper nomenclature is constantly required. All articles have specific names and designations which must be used at all times. The purpose of this is to insure that there will be no error in understanding, for some types of ammunition are so nearly alike that only by the use of proper terminology can they be distinguished. The habit of using proper nomenclature is one that should be formed from the beginning.

Model Designations. To distinguish a particular design, a model designation is assigned at the time the model is classified as an adopted type. This model designation becomes an essential part of the standard nomenclature and is included in the marking on the item.

Prior to World War I, the number of the year in which the design was adopted preceded by an "M" was used as the model designation; for example, M1906. From the World War until July 1, 1925, it was the practice to assign mark numbers. The word "Mark," abbreviated "Mk.," was followed by a roman numeral; for example, Shell, H.E., Mk. III. The first modification of a model was indicated by the addition of MI to the mark number, the second by MII, etc. The present

* This Technical Manual has been published in advance of complete technical review in order to provide a background for inspection of all types of ammunition.

system of model designation consists of the letter "M" followed by an arabic numeral. Modifications are indicated by adding the letter "A" and appropriate arabic numerals. Thus, M2A1 indicates the first modification of an item for which the original model designation was M2. In addition to the "A" modifications there are also "B" modifications. These may be either a change in the method of manufacture of an item, or a change in the material used. Examples of this are the M18B1 steel cartridge case and the M1B1A1 primer. Certain items standardized for use by both Army and Navy are designated by the letters "AN" preceding the model designation; for example, AN-M100A1, AN-Mk. 19, AN-Mk. IV. The two designations above, AN-M100A1 and AN-Mk. IV, indicate that the item is of Army design, while the designation AN-Mk. 19, indicates that the item is of Navy design. In recent years the Navy designations have been arabic numerals, previously they were roman numerals and some of these may still be found.

Classification by Standards.

Standard articles are those which are the most advanced and satisfactory, and have been adopted by the Secretary of War. They are preferred for procurement to meet supply demands.

Substitute standard articles are those which do not have completely satisfactory military characteristics, but are usable substitutes for standard articles. They are not normally in use, nor are they available for issue to meet supply demands. They may, however, be procured to supplement the supply of standard articles.

Limited standard articles are those which do not have as satisfactory military characteristics as standard articles, but are usable substitutes for standard articles. They are either in use or available for issue to meet supply demands.

Classification by Issue and Manufacture. In making use of the Standard Nomenclature Lists and Complete Round Charts, the status of the ammunition may be found marked as "S" or "S&M." In this instance, the "S" indicates that the item is standard for issue only and is no longer being manufactured. The "S&M" indicates that the item is standard for issue and is being manufactured.

Ammunition Lot Number. When ammunition is manufactured, a lot number, which becomes an essential part of the marking, is assigned in accordance with pertinent specifications. This lot number is stamped or marked on every item of ammunition unless the item is too small. A group of these lots which for both engineering and statistical reasons can be considered to be of the same standard of quality is called a grand lot. In addition to this lot number, there is assigned to each complete round of fixed and semifixed ammunition an *ammunition lot number* which serves to identify the conditions

under which the round was assembled and the components used in the assembly. This ammunition lot number is marked on every complete round of fixed and semifixed ammunition (except where the item is too small as in the case of small-arms ammunition) and on all packing containers. It is required for all purposes of record including reports on condition, functioning, and accidents in which the ammunition is involved. To provide for the most uniform functioning, all of the components in any one lot are manufactured under as nearly identical conditions as practicable. For example, in the case of fixed ammunition, all of the rounds in any one lot consist of:

1. Projectiles of one lot or grand lot (one type and one weight zone).

2. Fuzes of one lot or grand lot.

3. Primers of one lot or grand lot.

4. Propellent powder of one lot.

DEFINITIONS.

A few basic definitions are essential if one is to attain complete understanding of the material which is to follow.

Ammunition. Ammunition is defined as any or all materials used to charge weapons of war, including pyrotechnics in all of its forms.

There is one point in this definition that might not be clear. "Weapons of War" refers to not only guns, howitzers, mortars, and the like, but to airplanes and soldiers as well.

Caliber. Caliber is a term which has widespread use in the field of an ammunition inspector. Nearly all of the ammunition is measured in calibers. A caliber is the diameter of the bore of the weapon between opposite lands. While it is used as a unit of measure and is expressed in inches or millimeters, it has no unit in itself. Thus, if it is said that the barrel of a particular weapon is 30 calibers in length it does not mean that it is 30 inches or 30 millimeters long, but that its length is 30 times the diameter of its bore between opposite lands. To be of any use, caliber must refer to a specific weapon.

Lands. The lands in a weapon are the raised portions of the rifling of the weapon, and the spaces between the lands are called *grooves.*

Complete Round. A complete round of ammunition is made up of all the necessary components to a chain of events which will perform a desired function under the proper circumstances and at the proper time. For example, a complete round of a high-explosive shell would be made up of a projectile, an explosive filler, a fuze, a booster, a propelling charge, a cartridge case, and a primer. Here, all of these components are necessary to bring about the desired function of the shell and thus make up a complete round.

Small-arms and Artillery Ammunition. A most important dividing line in ammunition is that between small-arms and artillery ammunition. This dividing line is based on 0.60 inch. Small-arms ammunition is defined as ammunition fired in weapons whose bores are 0.60 inch or less in diameter, while artillery ammunition is defined as ammunition fired in weapons whose bore is over 0.60 inch in diameter. It is well to note that small-arms ammunition includes ammunition which is 0.60 inch in diameter, and that anything over 0.60 inch must be considered as artillery ammunition.

ARTILLERY AMMUNITION.

Tactics and Ammunition. Artillery was first used mainly against fortifications for the purpose of breaking down walls to allow the passage of foot troops in an attack. Because the hand weapons of the defending forces were crude and of short range, the cannon of the attacking force could be emplaced at close range. There was, therefore, no need for long-range fire, and artillery was put into position in front of the foot troops. With the development of shoulder weapons of increased range and accuracy, it became necessary for artillery to seek positions at greater distances from the opposing forces and in the rear of friendly troops who served to protect the artillery division.

These conditions called for greater range and power, which in turn necessitated improved projectiles and propellent powders. The assignment of special missions to artillery brought about the development of special ammunition with which to accomplish these missions.

Projectiles. A projectile is a missile, either solid or with an explosive, chemical, or inert filler, propelled from a weapon by the force of gases produced by a propelling charge.

Early projectiles fired from cannon were iron darts, wrapped with leather, of a size to fit the bore. These continued in use up to the sixteenth century, when they were replaced by spherical shot. One example of this shot was roughly rounded stone balls chosen because of their cheapness. Forged iron, bronze, and lead balls were tried, but expense prevented their general adoption.

Also, since heavy metal shot necessitated the use of a correspondingly large propelling charge, too great a strain was exerted on the feeble artillery pieces of the period. This frequently caused rupture of the cannon. Stone shot being about one-third the weight of iron, the powder charge was reduced in proportion, effecting an additional economy.

Both iron and stone shot occasionally were covered with lead to preserve the interior of the bore by reducing the friction, and to afford a closer fit between the shot and the bore, thereby improving the obturation, preventing the escape of gases, and increasing the muzzle velocity and range. Hollow projectiles filled with explosives or combustibles, and variations of canister appeared during the sixteenth century.

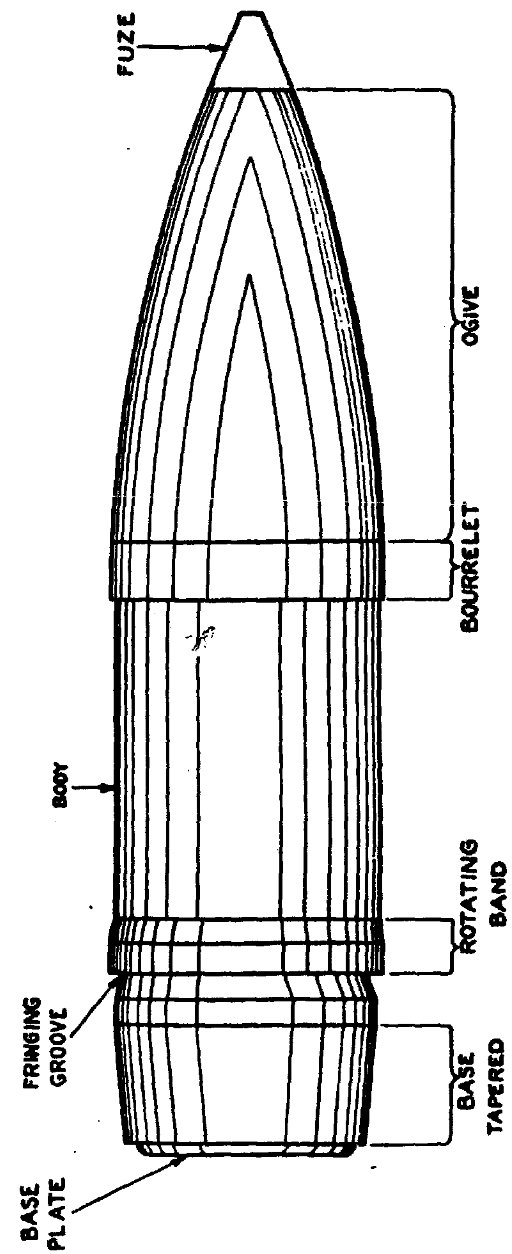

Figure 1 — Projectile

Shape. Since its inception, the demand for greater and greater range has influenced the shape of the projectile. Toward the end of the sixteenth century, cannon shot was made of cast iron and was spherical in form. The spherical projectile was inefficient ballistically, it was erratic in flight. Because of the crude methods of manufacture, a tight fit could not be obtained between the projectile and the bore of the cannon. Its rough surface increased air resistance and, by virtue of its shape, a maximum surface in proportion to its weight was effected by resistance. Nevertheless, the spherical form continued in use up to the advent of rifled cannon (about 1860), when projectiles were elongated to a cylindrical form with a pointed nose.

Factors affecting desired shape. The amount of air resistance depends upon the size, shape, and "presentation" of the projectile. Size is significant because of the greater number of air molecules to be displaced by movement of the larger projectile. Shape of the projectile has an important effect on the manner in which the molecules are shouldered aside. "Presentation" affects both the number of air molecules displaced and the manner in which they are pushed aside. A projectile of 2 feet in diameter displaces four times as many molecules as does a projectile of 1-foot diameter, since the area of the cross section of a projectile varies as the square of the diameter. A cone with a base diameter of 2 feet, since its greatest cross section is the same as a cylinder of the same diameter, displaces just as many molecules as does the cylinder, but because of its pointed shape, it effects the displacement more smoothly and consequently encounters less resistance.

Weight exercises a great effect on the power to overcome resistance. Thus, two cylinders of equal diameter and length composed of different materials, one twice as heavy as the other, would experience the same resistance to travel through the air. However, the heavier would possess double the ability of the lighter to overcome resistance.

Again, since length has little effect on resistance, a cylinder twice the length of the original one and composed of the same material, if solid, would be twice as heavy and would possess double the energy. In order that a cone may possess the same energy as a cylinder of equal diameter, it must be longer, since it otherwise would be of less weight. As the length of a projectile is limited by certain other considerations, the modern projectile represents a compromise, combining energy-producing effect by means of increased weight, and resistance-reducing effect by means of the pointed nose.

The air resistance is affected in a marked degree by the shape of the nose. It is found that in a shell in the usual form, the shape of the shoulders is more important than that of the actual point. This is explained by the fact that as air streams outward from the point to pass over the shoulders of the shell, it leaves a partial vacuum

near the point while the main air pressure comes near the shoulders. When a projectile with a radius of ogive of 5 or 6 calibers is used, the shape of the point becomes important in determining the direction of the air currents which flow over the shoulders.

The ideal shape for a projectile intended to travel through the air with the minimum resistance would be one of streamline profile and having a nose with an ogive curved for pushing aside the air molecules with the least disturbance. It would also have a tapered or conical ("boat-tailed") tail to eliminate vacuum-forming eddies in its wake. The flat, sawed-off bottom of the type of projectile in use prior to World War I is inefficient, because the partial vacuum formed behind the projectile during flight greatly retards it and causes unsteadiness in flight. For this reason modern projectiles are of the "boat-tailed" type.

Exterior of Modern Projectiles. Modern projectiles combine weight and form in the most practical way to secure a maximum of stability and a minimum of air resistance in flight.

Ogive. Starting with the point of the projectile and working toward the rear, the first portion encountered is the curved portion of the nose of the projectile. This is known as the ogive. The ogive describes an arc whose center lies on a plane perpendicular to the axis of the projectile, with a radius usually expressed in terms of caliber. This radius formerly was two calibers for all projectiles, but experiments have proved that a marked reduction in air resistance, resulting in greater range, can be obtained by increasing the radius of the ogive to as much as 10 or 11 calibers.

Bourrelet. Directly behind the ogive is a very carefully and accurately machined portion of the projectile, known as the bourrelet. It is this portion of the propectile which most nearly conforms to the bore of the weapon. In action, it acts as a forward bearing surface, and also helps to center the projectile in the bore of the weapon. The average bourrelet is about 1/6 of a caliber in width. By having only a small band such as the bourrelet for a bearing surface, the amount of resistance due to friction in the bore is greatly reduced as compared to the friction which would be produced if the whole body of the projectile were to contact the lands.

Body. The cylindrical portion of the projectile directly behind the bourrelet and extending to the rotating band is commonly called the body. This is slightly smaller in diameter than the bourrelet and is usually 1 to 2 calibers in length.

Rotating band. The purpose of the rotating band is to cause rotation of the projectile about its axis, in order to give it stability in flight. If the projectile did not rotate in flight, it would fly end over end or tumble; its flight would be irregular and inaccurate, and the range would be reduced. The rotating band, by engaging the lands

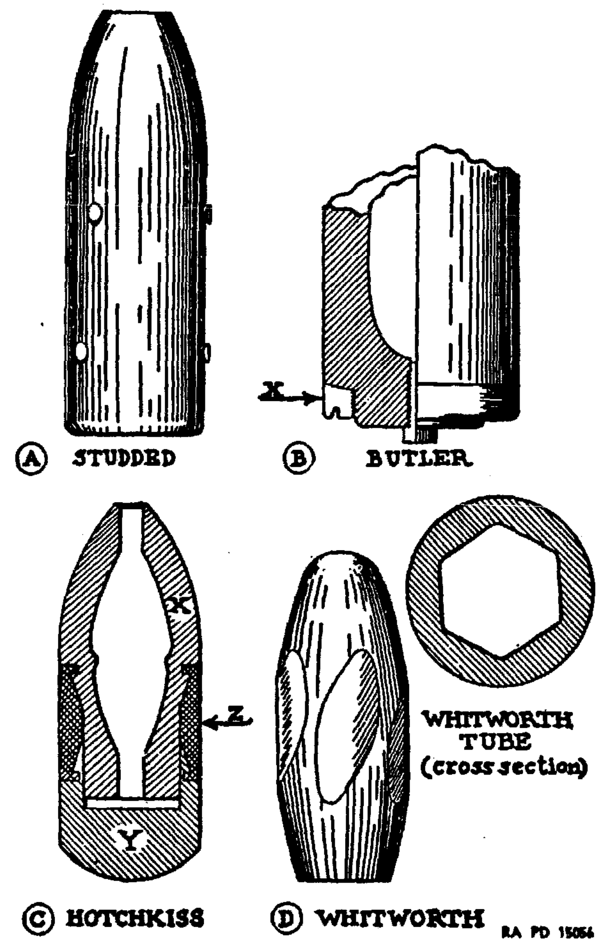

Figure 2 — Means of Obtaining Rotation, Early Projectiles

and grooves in the bore of the weapon, gives the projectile this rotation.

Before the advent of the rotating band, many devices were tried in order to obtain rotation. One means was to provide the projectile with a series of studs which were fitted into the grooves of the rifling as the projectile was inserted at the muzzle. This type of projectile was known as the "studded" type.

A second type of projectile was the "Butler" type. This projectile was fitted with a ring of brass at the rear of the projectile which

would expand when acted upon by the pressure of the gases from the propelling charge. This expansion caused the brass to fit into the grooves of the rifling and thus gave rotation to the projectile.

Another early type of projectile was the "Hotchkiss" type. This projectile was manufactured in three parts; the forward portion of steel, a rear portion also of steel, and the two held apart by a lead ring. When the round was fired, the rear portion forced against the lead ring which expanded into the grooves and thus gave rotation to the projectile.

A different method entirely was found in the "Whitworth" gun and projectile. In this model, the weapon was fitted with a hexagonal bore, twisted in the same manner as the rifling in the other types. The projectile was fashioned to fit the bore, its sides being provided with flattened surfaces of a similar pattern.

With the introduction of breech-loading cannon, the problem of giving rotation to the projectile was simplified. As previously explained, the raised portions between the grooves are known as the lands. The bourrelet of the projectile has the approximate diameter of the lands. At the rear of the projectile is a smooth band of soft metal which has the diameter of the grooves. The projectile is inserted into the smooth-surfaced chamber in the rear of the rifled portion of the bore, and then is rammed forward. The grooves engage the soft metal of the rotating band and hold the projectile in place while the tube is elevated. On the explosion of the propelling charge, the projectile moves forward and the lands cut into the rotating band, causing it to conform to the rifling. This gives the projectile a rotary motion about its long axis.

Since the band of a modern projectile completely fills the grooves, it prevents the escape of gas past the projectiles and centers the projectile in the bore. The front surface of the band is machined to seat itself readily in the coned seat at the origin of rifling. This coned seat is known as the forcing cone.

The metal of the rotating band must be soft enough to flow readily to fill the rifling grooves, and to prevent excessive wear of the lands. It must be hard enough to prevent stripping under the resistance met in rotating the projectile and to avoid fouling the bore. Both copper and gilding metal seem to be favored as the best metals for rotating bands.

Certain projectiles for the 155-mm gun have two rotating bands, but generally there is only one rotating band on each projectile for all guns and howitzers.

Fringing groove. During firing, a small amount of the copper of the rotating band is forced back behind the band and along the surface of the projectile in the rear of the band. The pressure of the released gas at the muzzle of the piece and the centrifugal force of

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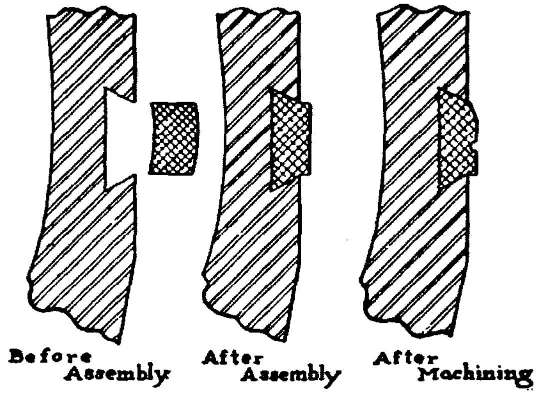

Figure 3 — Assembly of Rotating Band

rotation combine to throw out this excess metal in a radial direction, so that it becomes a fringe around the rear part of the band. When this fringe is excessive and irregular, it builds up air resistance, lessens the stability in flight, and causes decreased range and decreased accuracy. This fringing is eliminated to a great extent by cutting a fringing groove around and in the rear of the band.

Boat-tail. In order to reduce the vacuum forming eddies at the base of the projectile in flight, the base is tapered to an angle of from 6 to 8 degrees. These vacuum eddies, if present, tend to hold back the projectile and thus reduce the range.

Base plates. Artillery projectiles containing high explosives are fitted with base plates. These are designed to prevent the hot gas of the propelling charge from coming in contact with the explosive

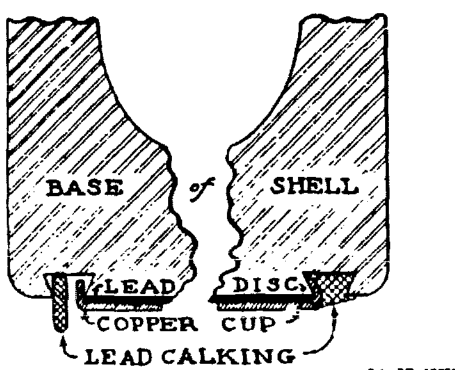

Figure 4 — Base Plate Assembly

INTRODUCTION

filler of the shell through possible defects in the base. Three types of base plates are in use.

The older type, common to all calibers, consists of a slightly dished brass plate covering a lead disc, the brass plate being crimped to the base of the projectile.

The new type, for small and medium calibers, has a disc of sheet brass or steel sweated to the base of the projectile with solder, or a steel disc welded to the base of the projectile.

For the larger calibers, the base plate assembly consists of a copper cup covering a lead disc. The copper cup is held in a dovetailed groove in the base of the projectile by means of a strip of lead calking wire, which is hammered down to fill the groove completely and to bend the flange of the copper cup. However, in large caliber projectiles that are not fitted with base fuzes, the steel disc is welded to the base.

Painting. All projectiles are painted primarily for the prevention of rust. The color of the paint, however, is varied for the different types of projectiles and thereby becomes a basic means for identification. The explanation of the color scheme is as follows:

1. Projectiles filled with high explosive, such as amatol, explosive D, TNT, etc., are painted olive drab and stenciled in yellow.

2. Shrapnel and low-explosive shells are painted red. This indicates that they contain a charge of low explosive.

3. Projectiles that are solid or filled with an inert filler are painted black.

4. Ammunition to be used for practice is painted blue. This painting holds even though the projectile may be solid or filled with a black powder (low-explosive) spotting charge.

5. Chemical shell are painted with a blue-gray base color, stenciled with a color which corresponds to its chemical classification, and have circumferential painted bands of the same color.

Projectile Fillers.

Solid shot. The earliest projectiles were spheres of solid metal and depended for their effect upon their weight and velocity, no attempt being made to produce effect by explosion at the target.

Case shot. The first departure from the solid type of projectile came with the advent of case shot. Case shot can be traced back to the early part of the fifteenth century; it retained its original form throughout the entire period of its use. It was intended for use at close quarters when a volley of small shot was required.

Case shot consisted of a cylindrical container of tin with a cast or sheet iron bottom and top plate. The container was filled with small round shot and the voids were packed with sawdust to prevent undue movement of the balls due to the shock of discharge. The shock of discharge disrupted the case, and the balls were scattered shortly after leaving the muzzle of the cannon. Case shot was very effective against troops at short range owing to the wide pattern made by the spreading shot, but when the range exceeded 500 or 600 yards, there was practically no effect.

Grapeshot. A variation of case shot, known as grapeshot, consisted generally of three tiers of cast iron balls separated by iron plates and held in place by an iron bolt which passed through the center of the plates. The effect of grapeshot was similar to that produced by case shot.

Explosive shell. Explosive shell do not appear to have been in general use before the middle of the sixteenth century. About that time, hollow balls of cast iron were fired from mortars. The balls were almost completely filled with gun powder; a small space was filled with a slow-burning composition. The slow-burning composition was ignited by the flash of discharge, and burned until the flame reached the bursting charge. As there was no way of accurately regulating the time of burning, some of the projectiles burst during flight, but many of them did not explode until a considerable time after they had struck the ground. With the development of more accurate fuzes, these projectiles became formidable missiles against fortifications, and were used with some effect against personnel in the open.

Modern shell, made of forged steel, are filled with high explosive, and upon burning a predetermined time, or upon impact, explode with terrific energy, breaking up the shell walls into several hundred fragments. Depending upon the fuze employed, they are designed either to burst in the air or promptly on impact, for effect against personnel, or to penetrate a short distance before explosion for the purpose of destruction.

Armor-piercing. Armor-piercing projectiles consist essentially of a steel shell to which is attached, usually by crimping, a steel armor-piercing cap, and to this cap is attached, by screw threads or crimping, a windshield for ballistic purposes. The projectile may be either filled with explosive D or may be inert. A very important part of the modern armor-piercing projectile is the cap. Against face-hardened armor, projectiles which would be useless without the cap are, with its assistance, able to penetrate in bursting condition. The cap is made of high-carbon chrome steel and heat treated so that the portion directly in front of the point of the projectile is very hard while the skirt is very tough. The period during which the cap performs its functions is so very short and the forces which act on it are so great that it is impossible to say exactly what takes place, but certain theories have been advanced and seem to be borne out by experiment. It is now generally accepted that the principal function of the cap is to place the armor under great stress, flaking the hardened

surface and destroying it, permitting the projectile body to reach the inner layers at an instant when they are already stressed in a favorable direction. The cap also lends lateral support to the point at the instant of impact, preventing a deformation which would result in disintegration of the projectile before perforation could be accomplished.

The cap also performs the valuable function of increasing the angle of obliquity at which penetration or perforation will take place, thus tending to avoid ricochet.

The function of the windshield is to increase the ballistic efficiency of the projectile by enabling it to overcome more readily the retarding effect of the atmosphere with a consequent increase in range. The windshield is made of brittle material and shatters on impact with the target.

The steel shell, or body, finally does the actual penetrating of the armour plate, and if loaded with an explosive filler, will explode after penetrating.

Shrapnel. The shrapnel projectile was developed during the latter part of the eighteenth century as a result of the lack of an effective projectile for use against troops in the open beyond the range of case shot.

The original shrapnel was a spherical shell filled with lead musket balls mixed with the bursting charge. With the advent of rifled guns, the form of the shrapnel projectile has changed, but its character has remained. Modern shrapnel cases are made of forged steel. The lead balls are contained in a matrix of smoke-producing compound and are separated from the base charge by a steel diaphragm. They are provided with a time fuze designed to cause the projectile to burst either during flight or on impact. Shrapnel is designed to carry the balls to a point over the heads of troops and, by the functioning of the fuze and base charge, to scatter the balls with increased velocity over a considerable area.

Chemical shell. Chemical shell are a development of World War I, resulting from the desire to transfer quantities of chemicals into enemy territory. Chemical projectiles are filled with chemical compounds designed to produce casualties, or with smoke-producing compositions for use in screening certain areas from view. Very little effect is produced by fragmentation, since the bursting charge is just sufficient to crack the projectile and scatter the chemical filler. In firing chemical shell, it is important that the shell burst before entering the ground, in order that the chemical be spread instead of being concentrated in and near the shell crater.

Fuzes.

Early fuzes. A fuze is a mechanical device to function the projectile at the time or place desired. Proper functioning of projectiles depends upon accurate and efficient fuzes.

It may be said that fuzes, from the start, have had more influence on the effectiveness of artillery than any other single item. Early explosive shell and shrapnel, more often than not, were wholly ineffective because of uncertain fuzes.

Early fuzes not only were inaccurate and uncertain of action, but also were dangerous to use. Many accidents resulted from prematures caused by defective fuzes. Even with the most modern fuzes in use today, a certain percentage of duds may be expected, and the safety devices are not infallible.

The first fuzes used were short iron or copper tubes filled with slow-burning composition and screwed into the fuze hole of the shell. The slow-burning composition was ignited by the flash of discharge and, when consumed, transmitted the flame to the bursting charge of the shell. There was, at first, no means of regulating the time of burning. Later, about the end of the seventeenth century, the fuze case was made of wood, so that by boring a hole through the outer casing into the composition, the fuze could be made to burn approximately for a given time before exploding the shell; or the fuze could be cut to the correct length for the same purpose.

Early attempts to produce percussion fuzes were unsuccessful, but the discovery of mercury fulminate in 1799 finally afforded the means of attaining this object. Some 50 years elapsed, however, before a satisfactory fuze was made. This was the Pettman fuze, in which a roughened ball covered with a detonating composition was released by the discharge of the piece. When the shell struck any object, the ball was thrown against the interior walls of the fuze, thereby exploding the composition and, consequently, the bursting charge of the shell.

World War I types. Much ingenuity and labor have been expended in the effort to produce safe and accurate fuzes for all purposes. World War I types were satisfactory, in general, for their purpose of detonating or exploding the bursting charge at the time and under the circumstances desired. However, safety devices were not sufficiently refined to insure complete safety against premature action in transportation and loading, and during travel through the bore of the piece.

Another serious disadvantage of World War I types of detonating fuzes was the fact that they could not be set at will for superquick or delay action. This necessitated a supply of all three types in the field.

Later types. Most of the disadvantages enumerated above have been overcome in the recently developed fuzes. These are explained in the chapters dealing with fuzes.

Adapters and Boosters. Since the small detonator contained in the fuze is not powerful enough to insure complete detonation of the shell filler, it is necessary to have a slightly larger quantity of high explosive, more sensitive than the shell filler, to amplify the detonating wave and insure the detonation of the filler. This intermediary filler is the booster. In recent years, boosters have been designed to be assembled directly to the projectile, the old "adapter-boosters" being discarded. The fuze is customarily screwed into the booster. Boosters are used in all high explosive and chemical shell for all guns and howitzers.

The old "adapter-boosters" consisted of an adapter and a booster which were held together as one piece. The adapter was designed to decrease the diameter of the nose of the shell so that the fuze could be screwed into place. The booster was simply a casing of high explosive.

The term "booster," when applied to chemical shell, is converted to "burster," as the function of this component is to break up the shell and disperse the chemical filler. The burster charge is therefore greater than in the high-explosive booster.

Propellants. A propellant is an explosive which, upon burning, propels the projectile from the tube of the gun. It is the final link in the low-explosive train.

Early propellants. The earliest propelling powder was black powder, of about the same composition as we know it today. In the sixteenth century, it was used in the form of a fine powder or dust, but owing to the difficulty of loading this fine dust into the muzzle of small arms, a granular form was developed about the year 1600, and continued in use for more than 200 years.

Smokeless powder. Smokeless powder came into use about 1890, and quickly replaced black powder as the universal propellant for artillery projectiles.

The first Army Ordnance experiments with smokeless powder were with nitrocellulose-nitroglycerine, or "double-base" powder, which type was used in small-arms ammunition until 1906.

The smokeless powder now used consists essentially of a gelatinized nitrocellulose in the form of short multiperforated grains. The United States and other countries have developed powders in the form of long tubes or flat ribbons and cords which usually contain a certain percentage of nitroglycerine.

Because of their hotter gases of combustion, nitroglycerine powders produce more erosion in the bore of the piece than nitrocellulose. For this reason, the latter are generally used as propellants.

A full discussion of smokeless powder will be found in the chapter covering low explosives.

Propellent Containers. According to the method of assembly for transportation and for loading into the piece, ammunition is classified as "fixed," "semifixed," or "separate-loading" (unfixed).

Fixed Ammunition. This type comprises a cartridge case (which contains the propellant) whose base contains the primer, and whose forward opening is crimped to the projectile so that the entire round is integral and all components are loaded into the weapon in one operation.

Semifixed Ammunition. This type differs from fixed ammunition in that, while the projectile and cartridge case are issued assembled and are loaded into the gun as a unit, the cartridge case is not permanently attached to the projectile, but may be removed at the firing point for the purpose of varying the amount of propelling charge as desired.

Separate-loading Ammunition. The distinguishing characteristic of separate-loading ammunition is that it requires two or more operations to be loaded into the breech of the gun. The propellant and primer are loaded separate from the projectile. The propellant is contained in either cartridge bags in definite quantities, or loosely in an uncrimped cartridge case. In the former instance, the amount of propelling charge may be varied as desired. The primer is generally inserted after the breechblock has been closed.

Primers. A primer is used to ignite the propelling charge of smokeless powder. The primer is loaded with a charge of black powder which, in ammunition for small calibers, is sufficient to ignite the propelling charge. In the larger calibers, additional ignition powder is required.

With fixed and semifixed ammunition, the primer is forced into the base of the cartridge case before loading the propelling charge.

With bag-loaded (separate-loading) charges the primer is inserted in the firing mechanism in the breech of the cannon. Primers for separate-loading ammunition are of the obturating type, in that the body of the primer is thin, so that, when the primer charge explodes, the primer will be expanded and pressed tightly against the inner surface of the primer cavity, thus preventing the escape of propelling charge gases to the rear.

Classification. The general classification of primers is based on the method of firing or initiating the ignition, as follows; percussion, friction, electric, combination percussion-electric, and igniting. The detailed description and functioning of these types will be taken up in the chapters covering the complete rounds.

Chapter 2
Safety

GENERAL.

In the line of duty as an ammunition inspector, the full meaning of safety must be kept in mind at all times. This is indicated by the fact that the "Ordnance *Safety* Manual" is the inspector's "Bible." No matter what the operation or procedure may be, the inspector's thought should always be, "Is it safe?"

There are several references where general safety regulations may be found, such as, The Ordnance Safety Manual, Safety Bulletins, TM 9-1900, and other manuals. However, while the regulations cover a wide field, there are times when it becomes necessary for an inspector to rely on his own judgment and common sense in arriving at a decision. For this reason, one should always keep an eye open for safety features and precautions while studying this text. Without some basic knowledge of the article being handled, common sense soon becomes little more than pure guess work. A study of accidents which have occurred in the handling, shipping, and storage of explosives and ammunition shows that in practically every instance where the cause could be determined, the accident has been due to circumstances which may be classed as avoidable.

There are two prime requisites which must be considered when determining a safe practice; safety for personnel, and safety for the ammunition. With respect to personnel, the inspector should be constantly on the alert to forestall any practice which might cause injury or death to any worker. With respect to ammunition, the inspector should see that it is handled, stored, and shipped in such a manner that no deterioration, damage, or destruction may result.

SAFETY REGULATIONS.

Personnel. All personnel handling ammunition should be impressed with the fact that their safety as well as that of others depends upon the intelligence and care exercised by themselves and their fellow workers.

The number of persons engaged in or around an operation should be kept at a minimum, but never should one person be allowed to carry on an operation of a hazardous nature.

Unauthorized persons should not be permitted to tamper with or disassemble any components. Serious accidents may result.

Safety shoes should be worn at any operation where explosive dust is present; particularly in the case of black powder or high-explosive operations. Safety shoes of the noninsulating type are mandatory for black powder operations.

Smoking must be absolutely prohibited in any magazine or magazine area, or around freight cars, motor trucks, or boats in which there are explosives or ammunition.

No portable lights other than approved electric lanterns and flashlights are to be used in magazines or around explosives and ammunition in freight cars, motor trucks, or boats.

Ammunition. Explosives and ammunition should be handled carefully. Containers should not be tumbled, dragged, thrown, or dropped on each other or on the floor.

All tools used when repairing, opening, or closing containers filled with explosives should be of nonferrous or nonsparking materials.

Explosives and ammunition should not be exposed to moisture or dampness or to the direct rays of the sun for any long period. If it is necessary to leave boxes temporarily outside of magazines or cars, they should be covered with a tarpaulin which is so placed that air can circulate freely through the pile.

If explosives spill or sift from a leaky container, all work must be stopped until the explosives have been swept up and removed and any remaining particles or dust have been neutralized with water.

When ammunition is to be stored, it must be stored in accordance with the current ordnance drawings in such a way that the piles are stable and cannot tip.

CONCLUSION.

The general precautions mentioned above are but an indication of the many rules and regulations to be followed. As additional material is discussed, safety regulations will be brought out and emphasized. In addition, every ammunition inspector should become familiar with the safety regulations as set forth in section II, page 5, of the Ordnance Safety Manual (O.O. Form No. 7224), and should govern his actions in the field accordingly. If all safety measures are applied and strictly observed, the number of accidents which occur can be reduced to a very small percentage of the present total.

SECTION II.

INTERPRETATION OF ORDNANCE DRAWINGS; USE AND CARE OF MEASURING TOOLS

Chapter 1

Information Topics

GENERAL.

Engineering Drawings. Engineering drawings were developed to portray an object of the inventor's mind in such a way as to enable someone other than himself to construct the item. Word descriptions proved entirely inadequate. Chinese, the language of Confucius, who said, "One picture is worth a thousand words" still uses line drawings of objects as letters of its alphabet.

Photographs were considered, but dismissed at once, for the simple reason that one cannot photograph what is in a person's mind. Thus, the only alternative was found to be line drawings. Through constant use they underwent considerable development until in the present day, carefully made line drawings, laid out according to certain simple, universally understood rules, act as our basis for transmitting precise information between various phases of production. It is a decided advantage, therefore, to anyone interested in almost any phase of production to understand these simple rules that he might be able to read the language of engineering drawings. Persons interested in the inspection and maintenance of manufactured items are certainly not an exception.

Reproduction of Engineering Drawings. There are many means of reproducing the original drawing. One of the most common is the blueprint, so called because of its blue background which results from a chemical action on exposure to light. It is made by exposing a piece of sensitized paper in contact with the tracing of the drawing to sunlight or electric light.

Other types of reproduction are blue line prints (blue lines on a white background), black line prints (black lines on a white background), and photostat prints. Photostats are commonly used in the Ordnance Department and consist of white lines on a dark background when taken directly from the tracing; brown lines on a white background when taken from the original photostat. They are made by taking a picture of the draftman's tracing with a large, specially designed camera.

Why Ammunition Inspectors Should Understand the Language of Mechanical Drawing. Some of the instances in which prints are of value to the ammunition inspector are as follows:

1. The construction of the buildings in which ammunition components are stored will show such factors as ventilation, floor load limits, floor finishing, and lightning rod equipment. The lay-out of the

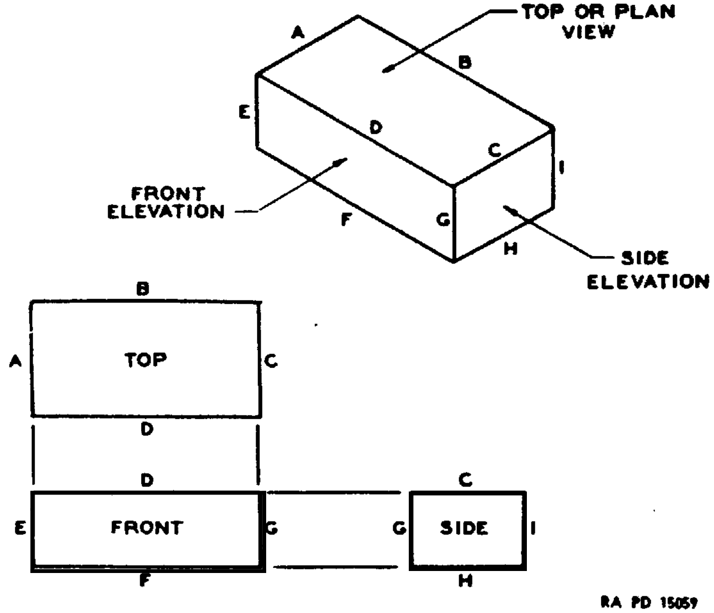

Figure 5 — Rectangular Block

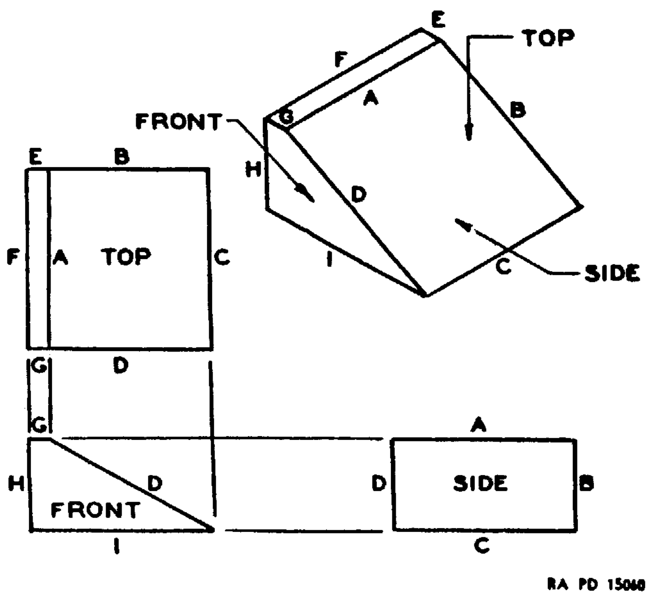

Figure 6 — Wedge

area, described as a general map, is used to determine what explosives and ammunition may be stored in a given magazine or building.

2. The approved methods of piling and stacking and the proper use of dunnage in storing ammunition and explosives are shown on ordnance drawings.

3. The loading and staying of explosives and ammunition for various means of transportation is described on ordnance drawings. Bureau of Explosives Pamphlets Nos. 6 and 6A are evidence of the wide use of drawings since they show the loading and staying in railroad cars.

4. Proper packing, stenciling, painting, and marking of ammunition components are illustrated with ordnance prints.

5. Ammunition components may be identified by looking through drawings of that particular class of ammunition.

6. Prints may be used to determine items for inspection by observing how the component is assembled, the importance of each part in the assembly, what explosive materials are contained, where they are located, under what circumstances the explosive train might be initiated and what parts are liable to damage due to rough handling or deterioration.

7. Drawings are used as guides in breaking down assembled components, such as fuzes, and in renovating and reconditioning ammunition and containers of ammunition components and explosives.

8. The ordnance drawings covering a particular component of ammunition are statements of authority as to how that component should be made, loaded, assembled, packed, marked, shipped, and stored.

INFORMATION TOPICS.

Description of an Object by Line Drawings. The shape of an object is outlined by using lines which represent edges. Only one face is viewed at a time; thus the complete drawing is made up of a number of outlines or views. Enough views are made to completely describe the object. Usually this takes three views, namely, top or plan view, front elevation, and side elevation (figs. 5 and 6). The top view is directly above the front elevation, and the side elevation is either to the right or left of and on the same level with the front elevation. If the object is so complex as to require a bottom view, it will be directly below the front elevation. Two views may be sufficient to show the exact shape of the object with the three dimensions; length, width, and thickness. However, it should be recognized that a three-view drawing is easier to read. Notice the letters on the objects (figs. 5 and 6) and check the corresponding edges on the different views which are also lettered.

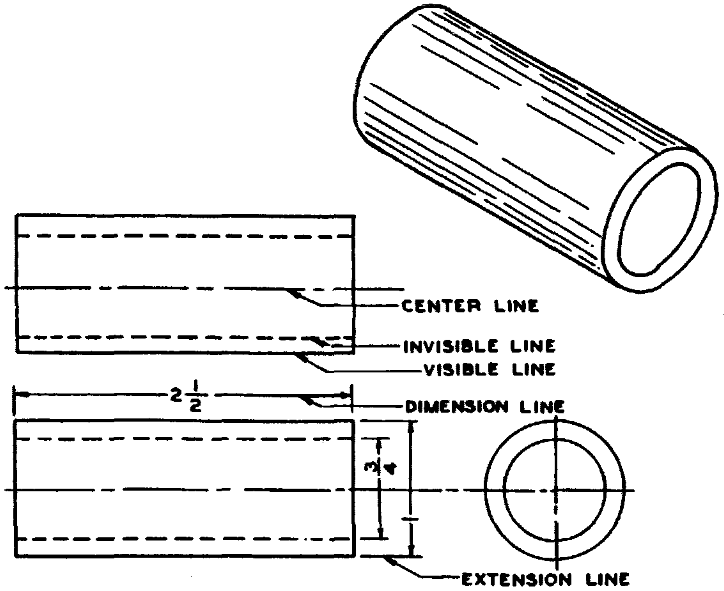

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Figure 7 — Tube

It will be noticed in figure 7 that the front and top views are the same. Therefore, the top view could have been eliminated. It is quite common to show only two views of a cylindrically shaped object.

In order to be sure that each part of an article, composed of two or more parts, will fit together and function as intended, an assembly drawing is made. This drawing is made before any of its parts are drawn and at this stage is called a lay-out drawing. The final assembly drawing is made after the parts are drawn and is used as a check on the assembled parts and to aid interested personnel in visualizing

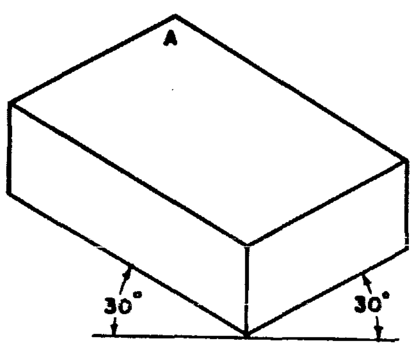

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Figure 8 — Block — Isometric

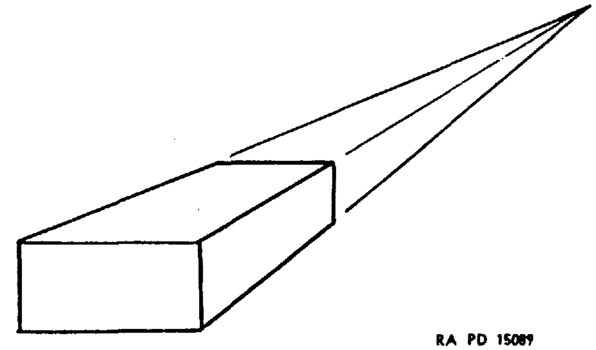

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Figure 9 — Block — Perspective

the article as a whole. The principles of mechanical drawing that are used in making detail drawings are also used in assembly drawings. However, when two parts adjoin one another, one line represents the two touching surfaces of each part.

Types of Lines Used in Engineering Drawing. Visible lines represent visible edges of objects and are shown by heavy full lines. (Figure 7 gives examples of all lines discussed in this paragraph.) Some of the edges of line drawings are invisible and are indicated by short dashes, somewhat lighter than visible lines. Lines running through the center of an object are indicated by long, uniform dashes separated by short dashes and are much finer than visible or invisible edges. Dimension lines are of approximately the same weight as center lines, and are drawn parallel to the direction of measurement and $\frac{1}{4}$ inch or more from the outline of the view. These lines are broken, usually near the center, for dimension figures, and are terminated at the extension lines by small arrowheads. Extension lines are full lines, comparable in weight to center lines, drawn at right angles to the dimension line at a point about $\frac{1}{32}$ inch from the outline and extended about $\frac{1}{8}$ inch past the dimension line.

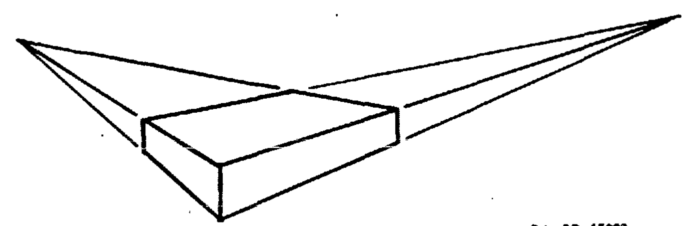

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Figure 10 — Block — Perspective

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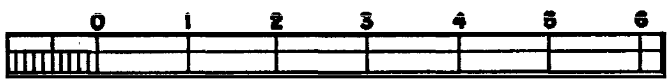
Isometric Drawings. An isometric drawing represents the object approximately as it appears to the eye. Its base lines are drawn at 30-degree angles. It is made up of parallel lines in their true lengths. Note that the block in figure 8 appears to be slightly distorted at the corner marked "A."

Perspective Drawings. The perspective drawing shows the object as it truly appears to the eye, and is drawn from one or more points outside of the drawing to a center or vertical line, measured from the horizontal plane (figs. 9 and 10).

Scales. Obviously objects cannot always be drawn to exact size. The draftsman therefore, must either reduce or enlarge all dimensions of the object to a size which will make a drawing easily read. The scale used is always shown on the drawing and may be expressed in several ways.

Examples: $\frac{2}{1}$ (size doubled)

1 in. =1 ft



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Measuring the dimensions from a drawing is called "scaling." It is seldom safe to scale a drawing for a dimension because the draftsman may change just a dimension in preference to changing a whole drawing. If it is necessary to find a dimension in this manner, the draftsman or some responsible person connected with the drawing should be consulted at once.

Dimensions and Notes.

1. Drawings are dimensioned the exact size of the piece, regardless of the scale of the drawing (fig. 11).

2. Only a minimum number of dimensions will be given. It is good practice for draftsmen to dimension an object so that it is not necessary for a workman to make any calculations. This is not always followed, however, so it is sometimes necessary to find a dimension by adding two or more dimensions or by subtracting one dimension from another (fig. 11).

3. Completely round elements such as holes are shown by diameter dimensions (fig. 11A). Elements that are partially round are shown by radii (fig. 11A). If the center of the radius lies outside the drawing a jog is made in the dimension line (fig. 11B).

4. Six kinds of holes commonly found on machine drawings are: Cored (left rough in the casting); drilled (drilled with a twist drill);

FIGURE 11A

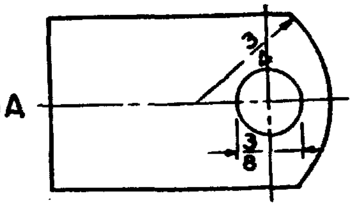


FIGURE 11B

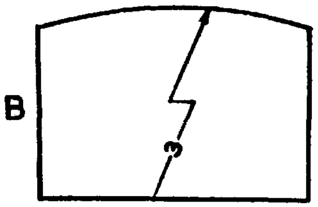
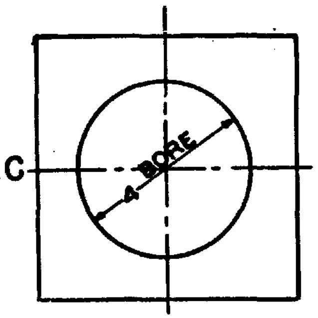


FIGURE 11C



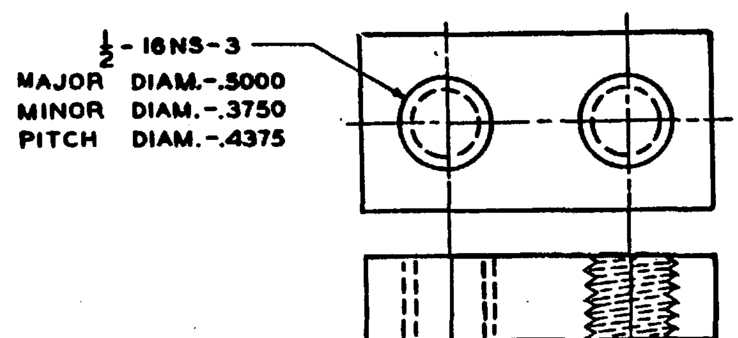


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FIGURE 11D

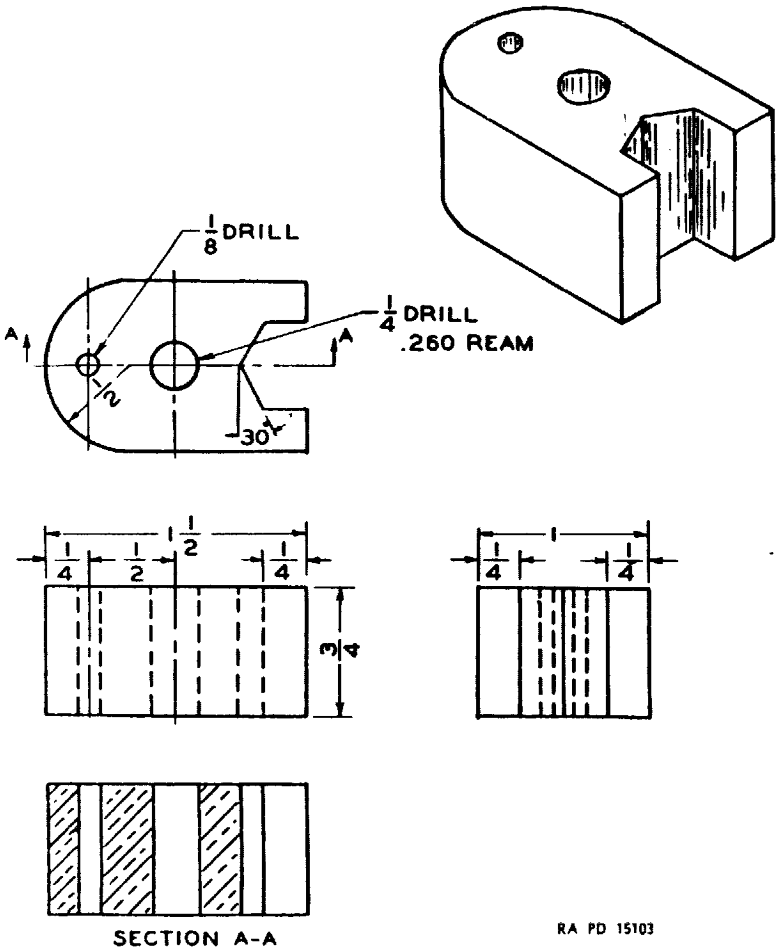

Figure 11 — Slider

reamed (reamed with a reamer, accurate); broached (broached with a broach, very accurate); bored (bored in a lathe or mill); tapped (threaded with a tap).

Cored, drilled, reamed, and broached holes are usually indicated as shown on figure 11. Bored holes are indicated as shown in figure 11C. Tapped holes are threaded holes. They are shown as indicated in figure 11D. The American National form of thread is adopted as the Ordnance Department standard. For technical data, dimensions, etc., consult the latest revision of the Report of the National Screw Thread Commission.

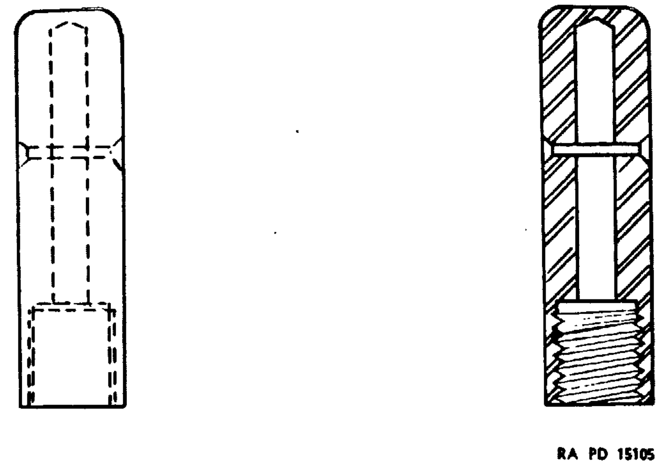

Figure 12 — Firing Mechanism Body

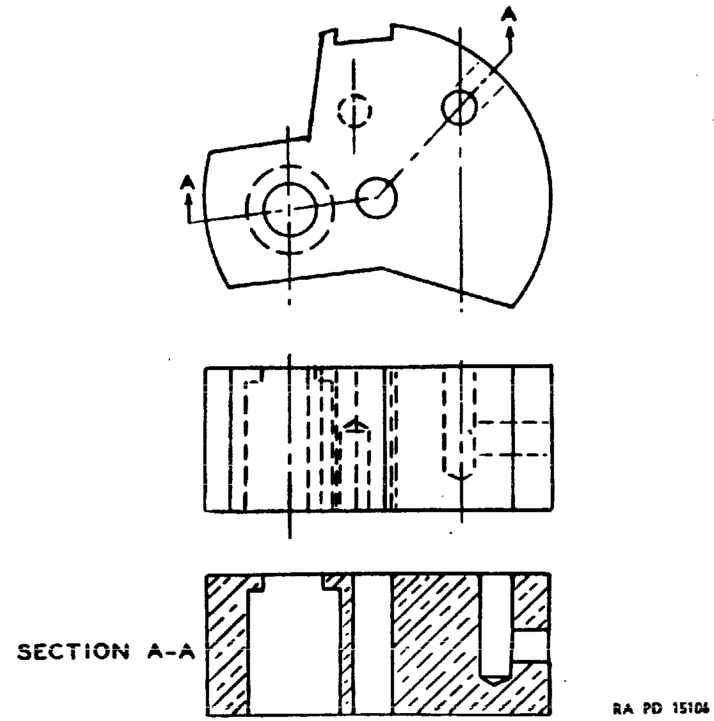

Figure 13 — Booster Rotor

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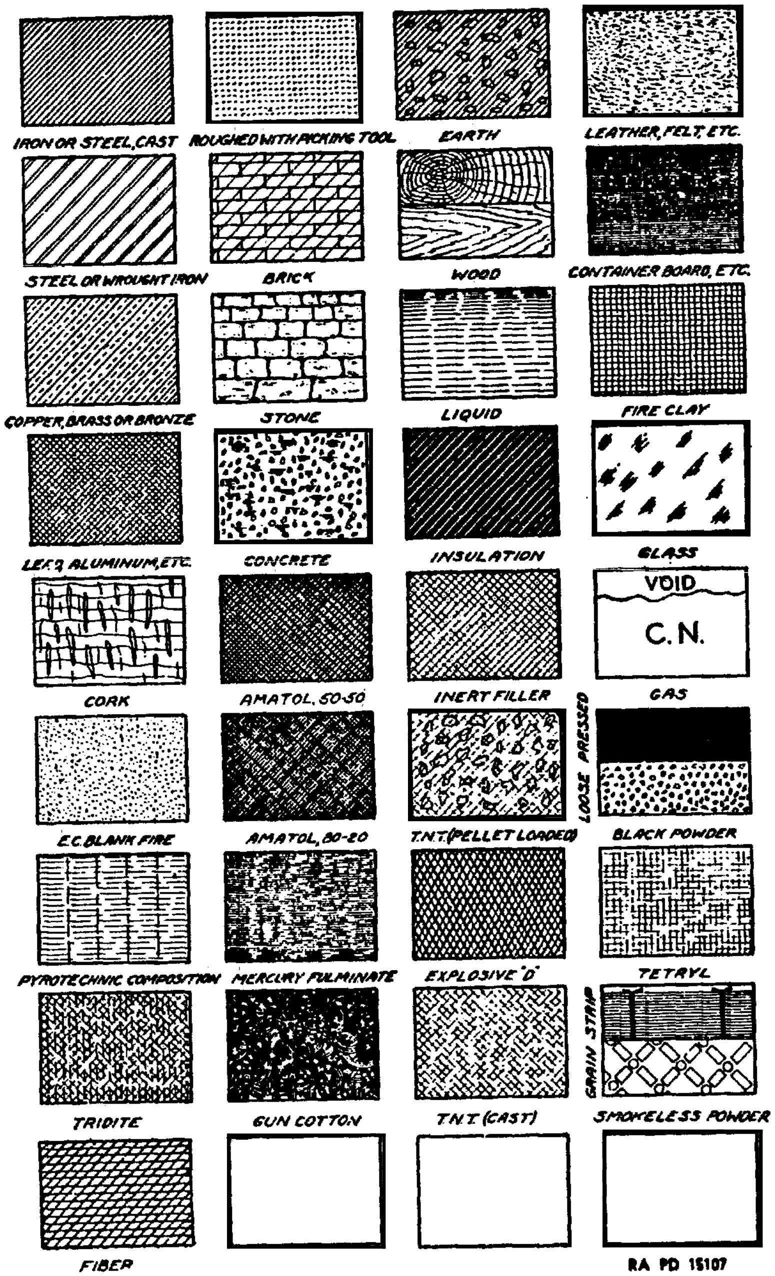

Figure 13A — Symbols for Ordnance Materials

5. Where accuracy is required, decimal dimensions are used.

Sections. The purpose of sectioning is to show the shape of cores, thickness of stock, interior mechanisms, and assembly. When a complex object is drawn, the number of invisible lines required may become confusing (figs. 11, 12, and 13). The object may be considered sawed in two on the plane indicated by the section lines A-A (figs. 11 and 13), and only the parts cut by the saw are sectioned. The sectioned parts are filled in with cross-hatching shown on "Symbols for Ordnance Materials." The section line may be passed through the important parts of the object it is desired to show, regardless of their position (section A-A, fig. 13). Invisible lines, back of the cutting plane, are not ordinarily shown in sectioning because their presence might make the section confusing and thus defeat its purpose. Sections taken through the width or diameter of objects are called cross sections, and those taken through the length are longitudinal sections.

Chapter 2

Regulations Covering Ordnance Drawings for Ammunition Division Materiel

GENERAL.

Classification, and Numbering.

Classification of drawings and model designations will be assigned by the keeper of the standard nomenclature record. Serial numbers of drawings will be assigned by the prints section.

All ammunition division tracings will be classified by giving each article a class and division number, as C12, Div. 107; C122, Div. 47; etc., and will be placed on "D" size sheets. The "D" size sheet is 40 by 24 inches.

Piece Marks. Each detail on every ordnance drawing will be given a piece mark. On ammunition division tracings, piece marks shall consist of the entire drawing number followed by a letter, viz., 73-3-116A, and these piece marks shall be placed immediately following and ordinarily on the same line with the name of the part. Piece marks should be lettered beginning at the upper-left-hand corner of the sheet across the top half, then the bottom half, from left to right. In any quarter of the drawing, the same process shall be followed. In case of one piece mark in the left half of the sheet, it shall be "A," then "B" upper right quarter, and "C" lower right quarter. In case of one piece mark in the right half of the sheet it shall be "B," and the left quarter "A," and the lower left quarter "C." Liquid parts and

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such articles as glue, shellac, solder, putty, wax, etc., shall not be given piece marks.

Titles. On detail tracings, the title will consist of the name of the component and under it the word "Details." On tracings of assembled views, the title of the article will be given followed by the word "Assembly."

Revision of Tracings. The revision number and date of revision will be indicated in the revision block. The piece mark of the part will be followed by the same number as indicated in the revision block; if part 115E is revised for the first time under the fourth revision of drawing 73-3-115, the new piece mark would be 115E4.

KINDS OF DRAWINGS.

General. Drawings of ammunition division material show either the details of the item or the assembly of items into more complete articles.

A set of drawings for an item may consist of one or more of the following series, including therein a list of parts, list of drawings, list of specifications, and list of components, etc.: detail drawings; component-assembly drawings; loading assembly drawings; complete-round assembly drawings; marking drawings, or packing, and marking drawings; and illustration drawings.

The title of each tracing will indicate the information included thereon, or as much thereof as is considered necessary.

The information to be placed on any one tracing and the arrangement thereon will depend on the item under consideration. Some tracings will contain only details; while others will contain details, an assembly or assemblies, list of parts, etc.

Detail Drawings. Details will sometimes be found on the same sheet with assemblies, while at other times the details will take up the standard size sheet of 40 by 24 inches. In the latter case, the tracing will be ruled into quarters, and ordinarily not more than four parts will be shown in any quarter. Beneath the detailing of each part will appear the following, in the order given:

Full name of part and piece mark.

Material as "Commercial brass, type I, composition "B," half hard.

Finish required, if any.

The detail drawing will show the assembly drawing number to which it pertains. In general, parts common to two or more items will be detailed only once and the drawing on which they appear will be listed on the assembly drawing of the item. An assembly complete within itself will not be redetailed for each round or item but will be treated as a component.

Example: Swivel loop, 82-3-135.

All artillery ammunition should be drawn pointing to the right. All bombs should be drawn pointing to the left.

Tolerances. Tolerances will be unilateral and will be expressed in one direction only.

Examples: 1.749 − 0.003 $\quad 1/8 - 1/32$

Bilateral tolerances may be used when dimensioning from center to center of holes, center to center of radii, and for size of angles.

Examples: 1.749 ± 0.003 $\quad 32^\circ\ 30'\ 0'' \quad \pm\ 0\ 32'\ 0''$

The basic dimension will be carried to the same number of decimal places as is required by the tolerance and vice versa.

Examples: 1.80 − 0.01
0.4000 − 0.0005
1.125 − 0.010
28.00 − 0.02

Component Assembly Drawings. Where appropriate, rope grommets, shipping bands for bombs, etc., will be shown on the assembly drawings. This component assembly drawing shall include besides the assembly: a complete list of drawings, and where there is room; a list of parts; a list of specifications; one or more details may be shown.

The title of this drawing shall consist of the name of the component or item and under it the words "Assembly," etc.

The list of drawings will indicate all drawings necessary for the manufacture of the component shown on the assembly. The drawings will be listed numerically and titles of all drawings will be indicated. At the end of this list of drawings covering the manufacture of the component, the assembly drawing of the packing box for the components, the drawing indicating the marking of the component, and the marking drawing of the packing box, etc., will be included.

The list of parts will cover only the parts of the component shown on the assembly and will include the following columns: line number; name of part; number required per component; piece mark; material; approximate unit weight; approximate gross weight of raw stock per 1,000 assemblies; remarks.

List of Specifications. If the drawing calls for a specification, the specification will be listed, and other specifications referred to therein will be listed if necessary for the manufacture or inspection of the article covered by the drawing. Then, in turn, all specifications referred to in these, which are necessary to the manufacture or inspection of the article, will be listed until the end of the chain. For explosive mixtures, the specification for each explosive entering the mixture will be listed. The following statement will appear with each list of specifications. "Specifications referred to in these specifications and not listed hereon, shall not apply."

Where space does not permit, the "List of parts" and "List of specifications" should be placed on supplementary drawings bearing the same number as the assembly drawing but followed by the letter "A" on the drawing showing "List of specifications," and by the letter "B" on the drawing showing the "List of parts." The "List of parts" and "List of specifications" may be placed on one drawing bearing the same number as the assembly drawing but followed by the letter "A." The title of the supplementary drawing shall consist of the component and under it "Assembly," "List of specifications," etc.

Loading-assembly Drawings. Loading drawings will show the loaded and assembled item ready for shipment by the loading plant. In addition to an assembled view of the item loaded, a "List of parts," "List of specifications," and a "List of drawings" will be included.

Complete-round Assembly Drawing. Assembly drawings for all fixed and semifixed ammunition (both fuzed and unfuzed complete rounds), hand and rifle grenades shipped fuzed or unfuzed, and pyrotechnics, should show the particular round or grenade in the "as-issued" state before packing. This complete round drawing should include, besides the assembly drawing, a list of components, etc. The title should consist of its name and under it the words "Assembly, etc." Drawings showing bombs in the "as-shipped" condition will be treated as loading drawings.

The "List of components, etc." will include not only the main component parts but such other materials as NRC compound, shell grease, etc., used in assembling the round, as well as the packing box and marking instructions. This list will have the following columns: line number; name of component; drawing number or piece mark; specification; approximate weight per unit assembly; approximate gross weight per 1,000 assemblies; remarks.

Marking Drawings or Packing and Marking Drawings. Packing and marking drawings are made for all packing boxes, containers, and crates. In addition to the proper marking for the box, container, or crate, there will be placed on this drawing a "List of parts," "List of specifications," and a "Table of weights" of the box plus the contents.

Bomb (Assembly, Complete) Drawings. For every bomb, there shall be prepared a drawing which will show the bomb with all components assembled thereto as dropped from the plane. This drawing will give the over-all length of the bomb, maximum diameter, center of gravity, position of suspension lugs with respect to each other and relative to the nose end of the bomb, the distance of the top surface

of the suspension lugs from the outside of the bomb body, and the maximum and minimum projected width of the fins. In the case of small fragmentation, and chemical bombs, the distance of the leading edge of the fin from the suspension lug will be given. A table listing the components with approximate weights and assembly drawings therefor will be shown. The drawings will bear the title "Bomb—assembly, complete" and will be placed in class 82, division 0.

Illustration Drawings. For each caliber of separate-loading ammunition an illustration drawing should show the complete round in the gun chamber. For each round of fixed and semifixed ammunition (except where covered by a complete round drawing) an illustration drawing should show the complete round including fuze. These drawings will indicate all important dimensions.

Other Drawings. There are other drawings used by renovation and surveillance not included in the above such as for small-arms ammunition and drawings for piling and stacking ammunition and explosives in magazines. However, if the inspector learns how to use the drawings described herein, he should have little trouble in interpreting others because practically the same principles are involved.

Chapter 3

Use and Care of Measuring Tools

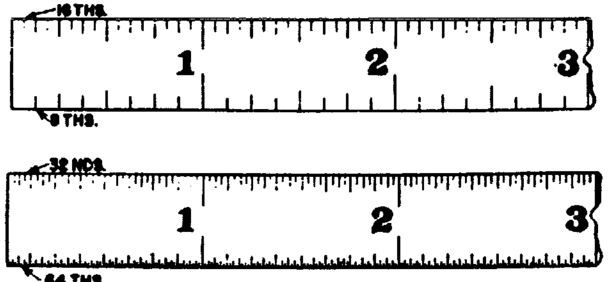
GENERAL.

The lives of troops and the accomplishment of their missions in bringing a war to a successful close are dependent on the quality of workmanship in their ammunition. For example, an imperfectly machined bourrelet on an artillery projectile will cause faulty ballistics which will result in the loss of the shell's effectiveness, and may endanger the lives of friendly troops.

Measuring tools are the inspector's means of checking ammunition components to insure that they are manufactured in such a way as to fulfill their purpose. The ability of the ammunition inspector to perform his duties in seeing that ammunition is furnished in a condition that will meet the requirements of the using arms is dependent, to a great extent, upon his knowledge of the use and care of measuring tools.

RULES.

The simplest measuring device is the rule. The mechanic's 6-inch flexible rule is most commonly used and the inspector should be able



RA PD 15109

Figure 14 — Two Sides of 6-inch Rule

to read it quickly and accurately. If the frequently used 6-inch rule is understood, the use of other types becomes merely a question of applying them to the work at hand. Ordinarily, the four available edges of a 6-inch rule are graduated in eighths and sixteenths of an inch on one side, and in thirty-seconds and sixty-fourths on the other. Figure 14 shows the two sides of such a rule. The following procedure is recommended for learning to read it: first, learn the eighths and sixteenths, then the thirty-seconds and sixty-fourths, and become thoroughly familiar with the readings shown in figures 14 to 18. Practice in reading measurements similar to the examples in figures 14 to 18 will soon enable the student to obtain accurate measurements very quickly with any type of rule. Other types of rules often used are narrow rules, hook rules, and slide caliper rules (fig. 17). The narrow rule is convenient on work where an ordinary rule is too wide: the hook rule is valuable for measuring inside dimensions where the hook is an advantage: the caliper rule is used for measuring outside diameters quickly. Figure 18 shows the usual methods of measuring work of several common shapes.

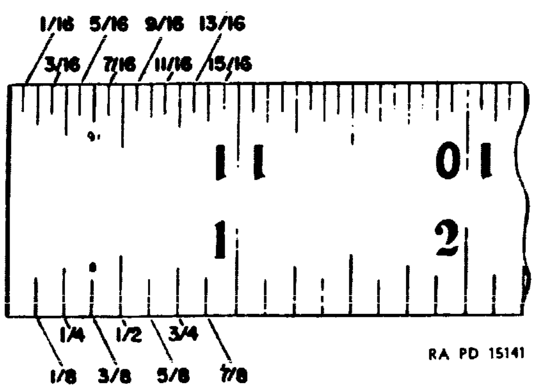


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Figure 15 — Readings on 6-inch Rule

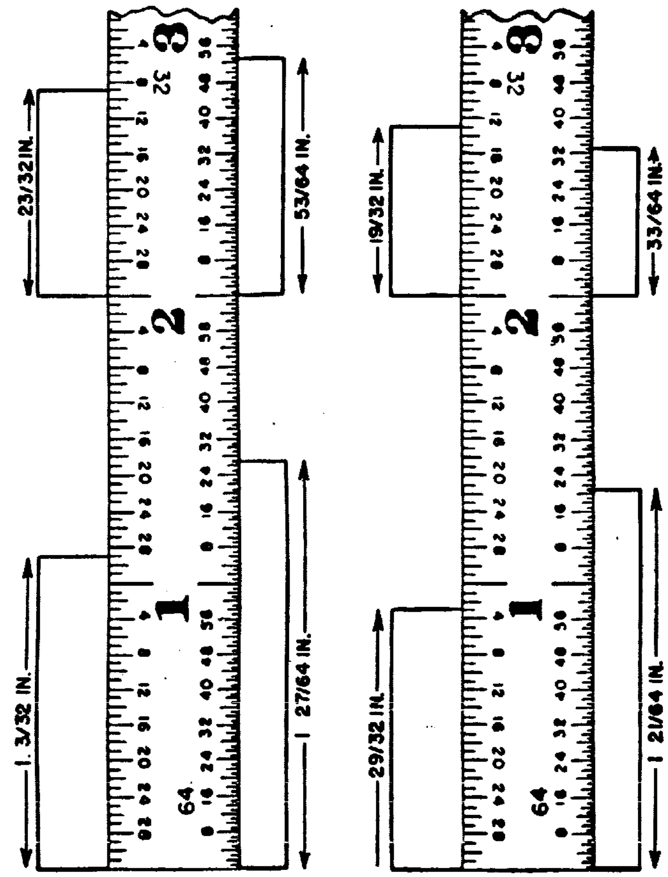

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Figure 16 — Practice Measurements on 6-inch Rule

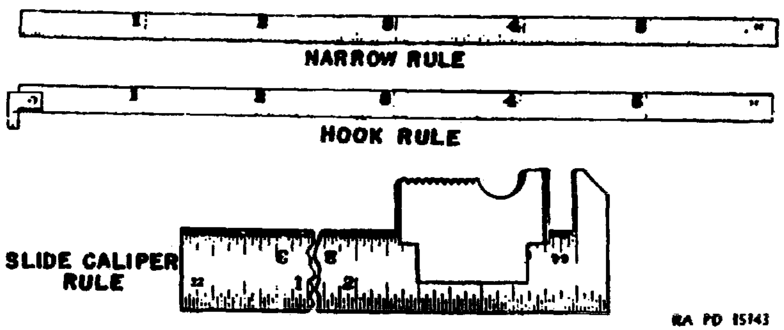


Figure 17 — Narrow, Hook, and Caliper Rules

SCRIBERS.

The scriber (fig. 19) is used for marking lines on metal, especially in connection with the use of a rule. Centers can be located with it by using it to draw two intersecting lines and marking the intersec-

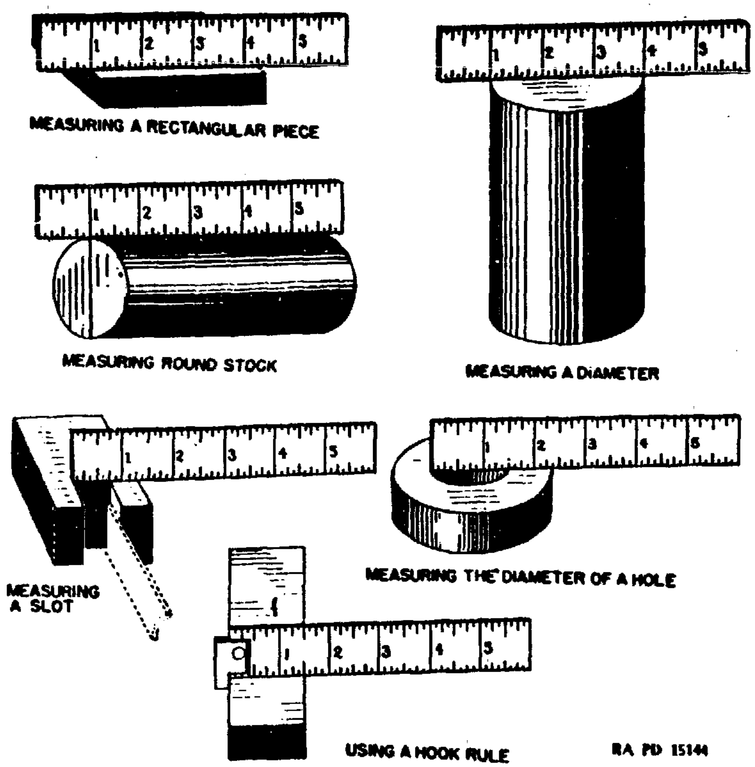


Figure 18 — Applications of 6-inch Rule

Figure 19 — Scriber

tion with a prick punch. The bent end is convenient for marking the inside of cylindrical objects or partially closed recesses. Keep the scriber sharp and use it like a pencil with only enough pressure to make a clear mark.

SQUARES.

Squares are used for measuring angles or locating and laying out centers on round work. Figure 20 shows the commonly used types. The solid square is convenient and accurate for measuring right angles only; the carpenter's steel square is used by carpenters for laying out woodwork and, quite often, by mechanics for lay-out jobs on large metal surfaces. The combination set is often used and familiarity with its numerous applications should be acquired. The illustration of combination set in figure 20 shows it equipped with a protractor head and a center head, as well as the stock 90-degree and 45-degree head. These accessories are readily removable, so that the one needed can be quickly attached to the blade. A number of common applications of the stock and center heads is shown in figure 21. The protractor head is used for measuring angles other than 45 or 90 degrees. Be sure that the blade and accessories of the combination set are kept clean, or inaccurate measurements may result; apply a small amount of oil to the blade occasionally with a rag to keep it from rusting.

CALIPERS.

General. Calipers are used for measuring diameters and distances, or comparing distances and sizes. The three common types are inside calipers, outside calipers, and hermaphrodite calipers, as shown in figure 22.

Outside Calipers. Outside calipers are used for measuring outside dimensions as, for example, the diameter of a piece of round stock (fig. 23). The caliper should first be set approximately to the diameter of the work; then, while held at right angles to the center line of the stock, adjusted until the points bear lightly on the surface of the work. Move the points back and forth slowly while adjusting them in order to get the "feel." When the adjustment has been made, the diameter can be read from a rule as shown in figure 23.

Inside Calipers. Inside calipers have curved legs for measuring inside diameters, such as the diameters of holes, the distance between

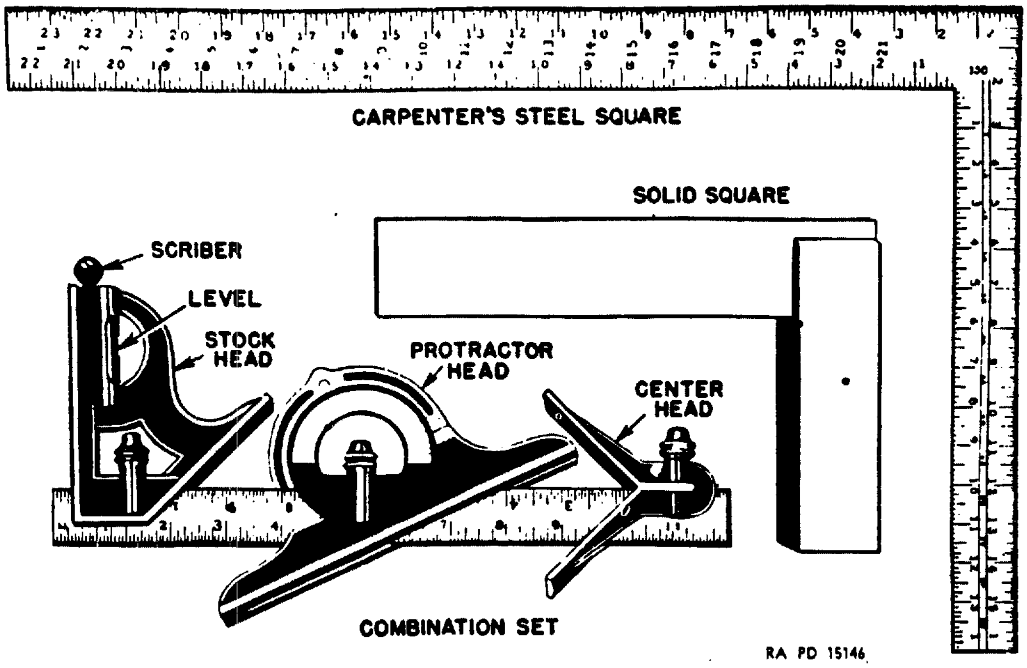


Figure 20 — Types of Squares

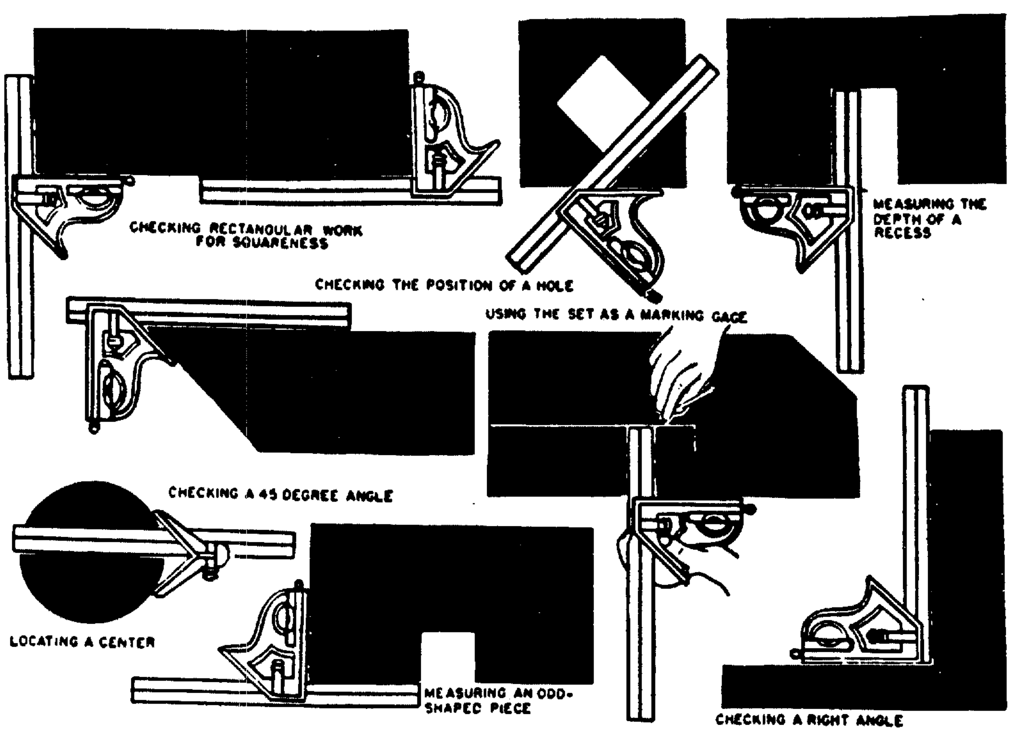


Figure 21 — Applications of Combination Set

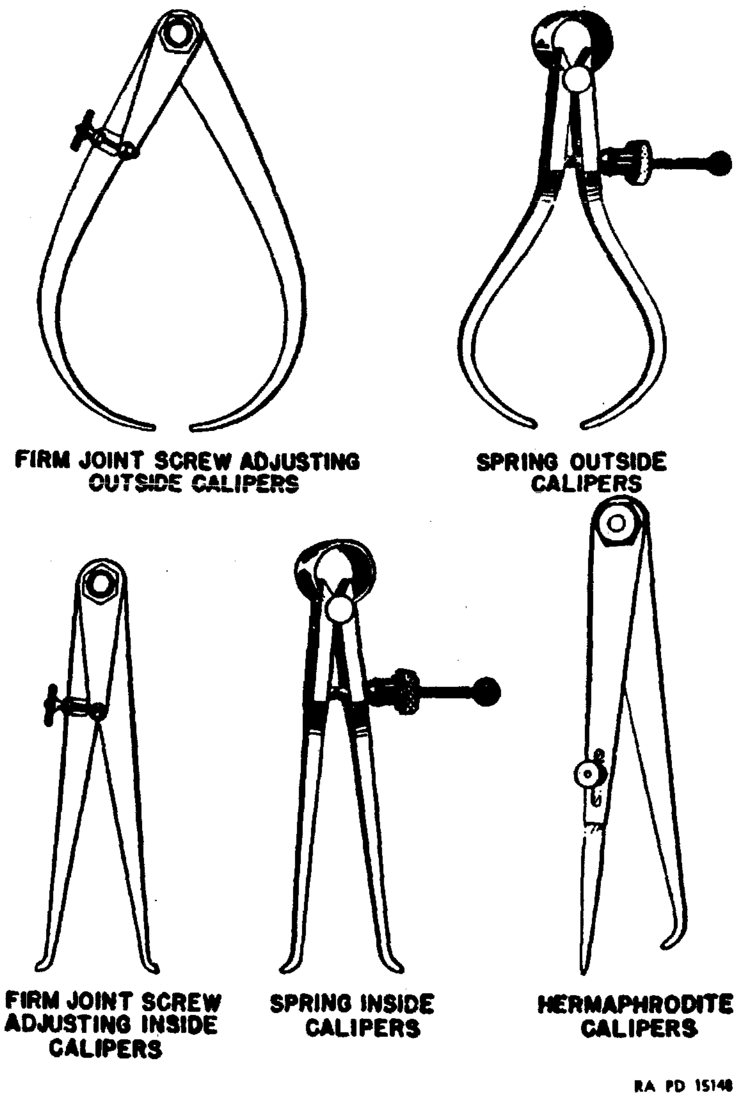


Figure 22 — Calipers

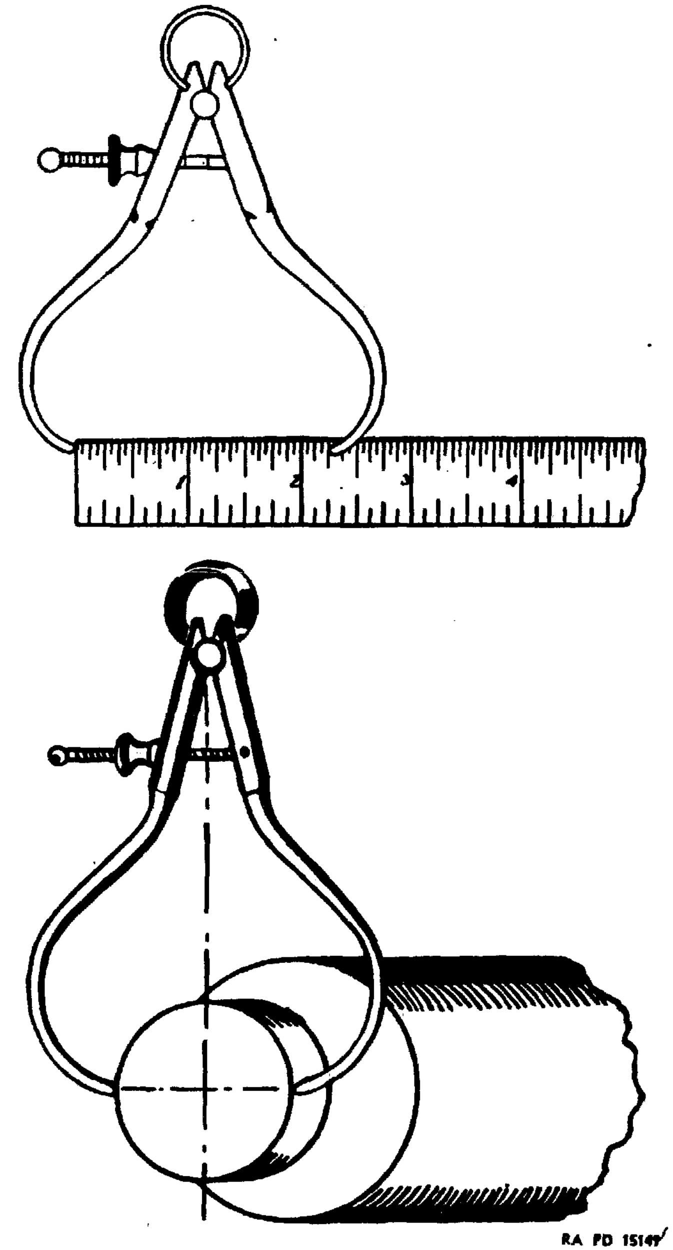
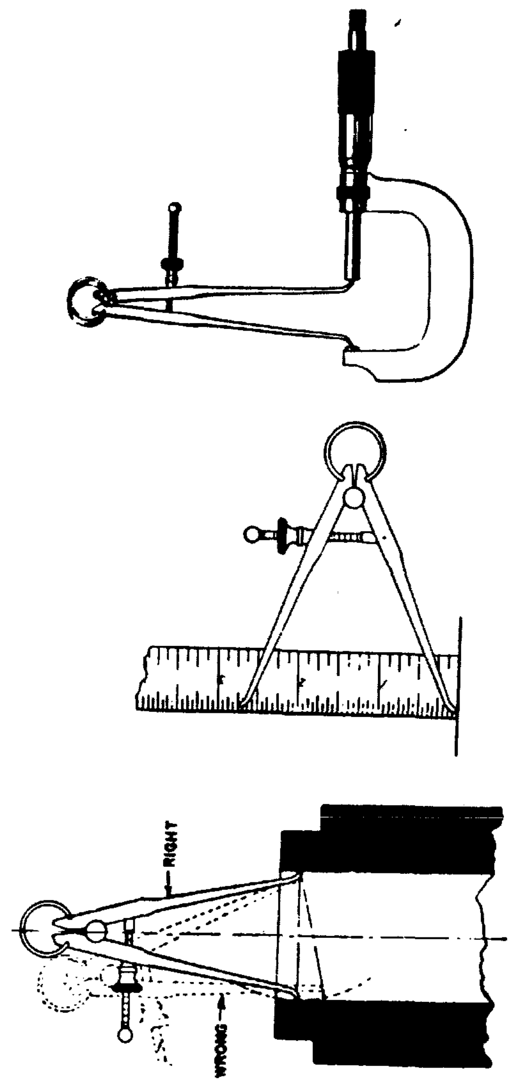


Figure 23 — Measuring Round Stock w/Outside Calipers



RA PD 15150

Figure 24 — Measuring a Diameter w/Inside Calipers

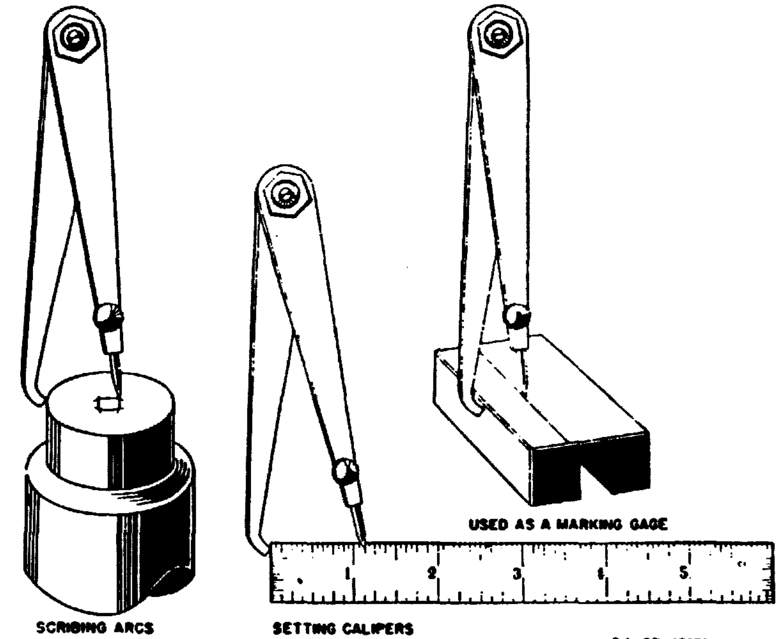


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Figure 25 — Three Uses of Hermaphrodite Calipers

two surfaces, the width of slots, and other similar jobs. To measure the inside diameter of a hole with inside calipers, first set them approximately to the size of the hole: then, holding one leg against the wall of the hole, adjust the other leg until it just touches the point exactly opposite, as shown in figure 24. The dimension can then be determined with a rule or a micrometer as shown. With practice, one can caliper a hole to an accuracy of one half-thousandth of an inch.

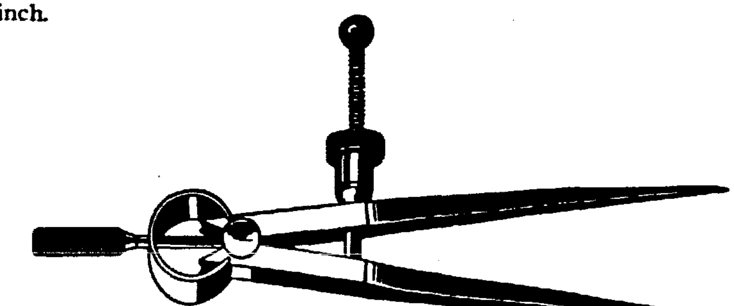

Figure 26 — Dividers RA PD 15152

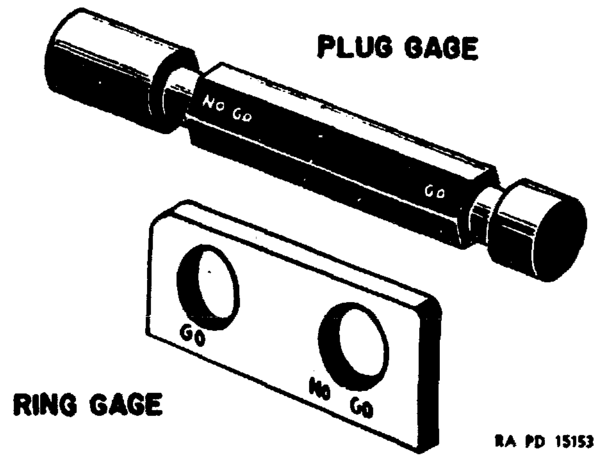

Figure 27 — Plug Gage and Ring Gage

Hermaphrodite Calipers. Hermaphrodite calipers are generally used to scribe arcs, or as a marking gage in lay-out work, as shown in figure 25. To adjust them to a rule, set the scriber leg slightly shorter than the curved leg; then with the curved leg against the end of the rule, adjust the scriber leg to the desired graduation on the rule. Hermaphrodite calipers should not be used for precision measurements.

DIVIDERS.

Dividers are tools for measuring distances between points, for transferring distances directly from a rule, or for scribing circles or parts of circles. Figure 26 shows a pair of dividers of a type commonly used. They are convenient for dividing spaces into equal parts or determining the dimensions of irregularly shaped work. Keep the

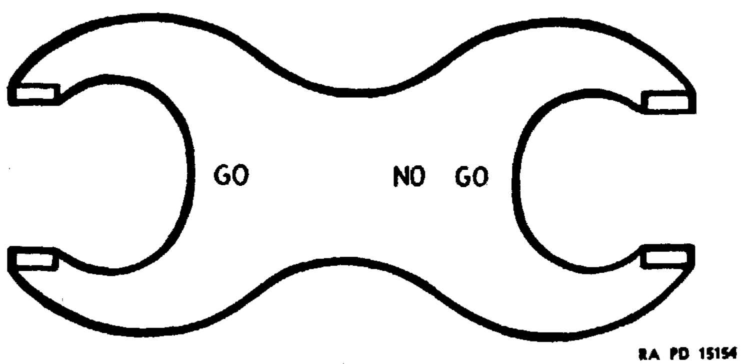

Figure 28 — Outside Caliper (snap) Gage

points of dividers sharp, and use only enough pressure on them to make a clear scribed mark on the work.

FIXED GAGES.

General. Gages are tools for measuring or transferring distances or dimensions, usually within one one-thousandth of an inch or less. They are made both adjustable and nonadjustable; this section deals only with gages which are nonadjustable or fixed. A fixed gage is made with extreme accuracy to some fixed standard of measurement or shape, so that when it is applied to a piece of work, the standard is transferred to the work. For example, if a mechanic wants to fix two surfaces, say six-thousandths of an inch apart, he will adjust them until a piece of metal known to be six-thousandths of an inch thick will just fit between them. Such a piece of metal would be a fixed gage. Fixed gages are generally made, either individually or in sets of two or more, for some specific operation, or for transferring some particular measurement, such as gaging thickness, threads, diameters, depths, and so on.

Types of Fixed Gages. A fixed gage can be obtained for practically any close measurement; thickness gages and screw thread gages are examples of fixed or nonadjustable gages. Plug gages and ring gages (fig. 27) are used in production work to check inside and outside dimensions for size and to see that finished parts are within the manufacturing tolerance. (Tolerance is the allowable variation in a dimension that is permissible without rejection of the finished part when inspected.) Fixed gages are usually made in pairs, either in one piece or two units. For instance, a plug gage generally has a "go" end, and a "no go" end. If the "go" end of such a gage will enter a finished hole and the "no go" will not, the hole is within the tolerance for which the gage was designed. If the "go" end of the gage will not enter the hole, the hole is too small. If the "no go" end of the gage, being slightly larger than the "go" end, does enter the hole, the hole is too large. Plug gages are used by the ammunition inspector for such purposes as checking the mouths of cartridge cases, size of primer holes, and so on. Plug thread gages and ring thread gages, are similar, except that they are threaded to check the accuracy of inside or outside threads. Outside caliper or snap gages (fig. 28), also used almost exclusively in production work, are for checking the dimensions of round or flat surfaced pieces; inside caliper gages (not illustrated) are used much as a plug gage for checking inside dimensions. The profile and alinement gage simulates the chamber of an artillery weapon and is used for gaging assembled artillery rounds to insure their fitting properly into the weapon. Flush pin gages are often used for measuring depths of booster cavities, etc.

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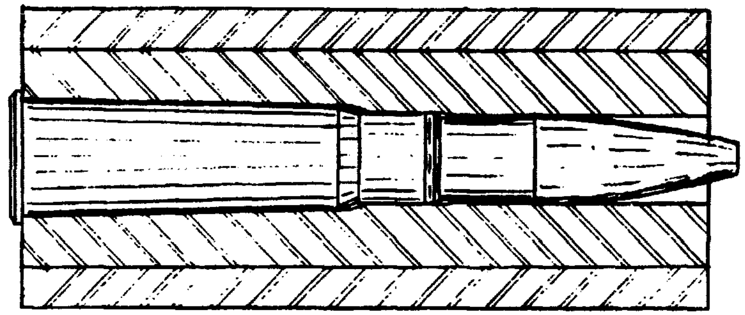

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Figure 29 — Profile and Alinement Gage

The flush pin gage consists of a pin which runs through a body as illustrated in figure 30. The upper surface of the body is divided into two parts, A and B. The opposite surface of the body rests on the top of the cavity whose depth is to be measured. When the top of the pin is flush with surface A, the other end of the pin is 3.61 inches from the lower part of the body or the top of the cavity. When the top of the pin is flush with surface B, this distance is 3.58 inches. Thus, if the depth of the cavity is to fall within the tolerance of 0.03 inch (3.61 — 3.58 = 0.03 inch), the pin must either be flush with surfaces A or B, or be between the two surfaces. In using the tool,

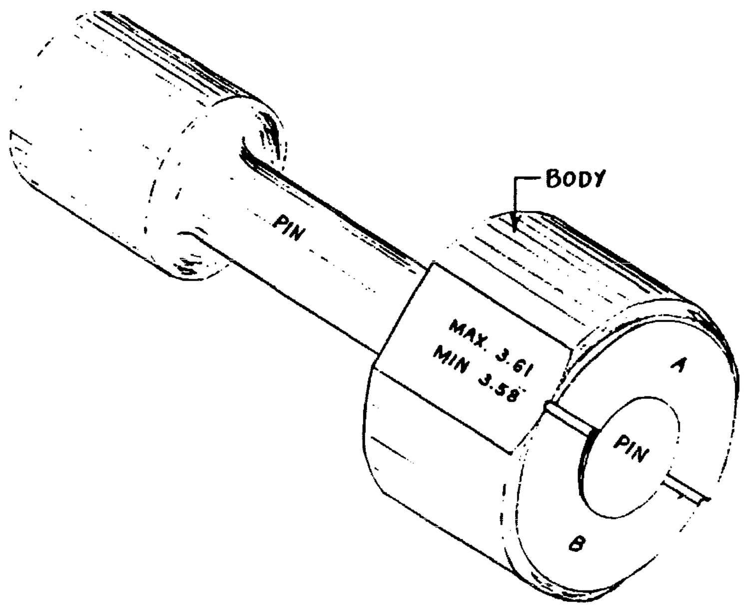

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Figure 30 — Flush Pin Gage

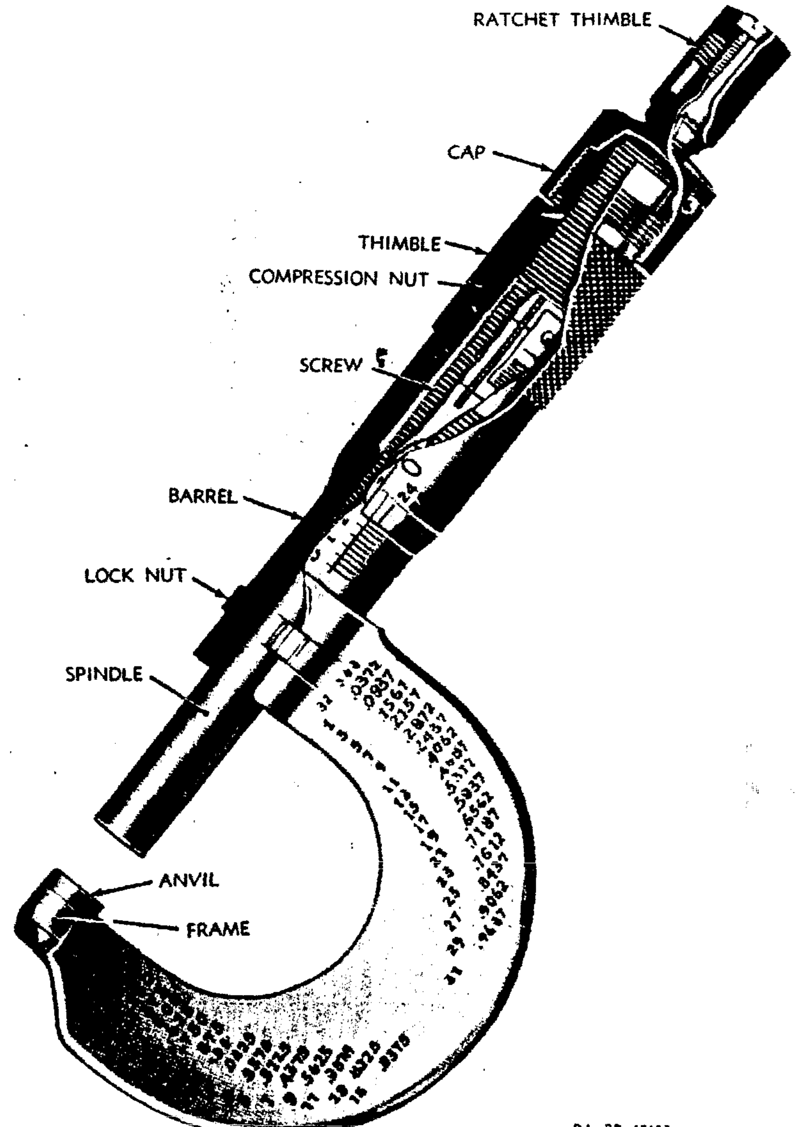

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Figure 31 — Outside Micrometer — Sectional View

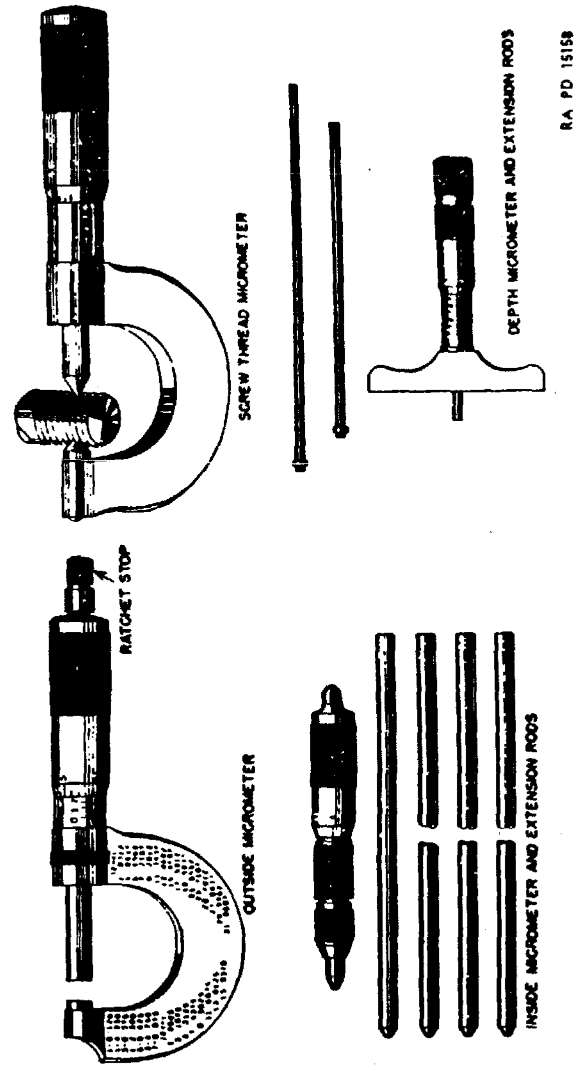


Figure 32 — Common Types of Micrometers

insert it into the cavity and check with the thumbnail for the proper position of the top of the pin.

Using Fixed Gages. All fixed gages are made for measuring some specific dimension. Handle them carefully; any strain imposed on them by forcing them over or into a piece of work or by dropping them can distort them enough to spoil their accuracy. See that their measuring surfaces, as well as the surfaces of the work, are clean and smooth; do not, under any circumstances, force a gage on any job. They are instruments of extreme precision; check them periodically with some standard to make sure that they have not changed in size because of wear or damage.

MICROMETER CALIPERS.

General. The micrometer is the most commonly used adjustable gage, and it is important that the inspector understand its mechanical principles, construction, use, and care. Figure 31 shows a 1-inch outside micrometer caliper with the various parts clearly indicated. Before making any attempt to use the tool, the user should become familiar with its nomenclature, especially the frame, anvil, spindle, barrel (or sleeve), screw, and thimble. Micrometers are generally intended to measure distances to one ten-thousandth of an inch; the measurement is usually expressed or written as a decimal, so the user should also know the method of writing and reading decimals.

Decimals. The decimal system is a method of expressing fractions and mixed numbers. For example, 2.000 inches written decimally indicates exactly 2 inches, accurate to within one-thousandth of an inch.

All figures to the left of the decimal point are whole numbers; all figures to the right of it indicate parts of whole numbers. Starting from the decimal point and moving to the right, the first digit indicates tenths; second, hundredths; third, thousandths; fourth, ten-thousandths; and so on. Thus, 2.3 is read two and three-tenths; 1.85 is read one and eighty-five hundredths; 4.071 is read four and seventy-one thousandths; 0.2318 is read twenty-three hundred eighteen ten-thousandths. (When there is no number to the left of the decimal point, the quantity indicated is less than one.)

Types of Micrometers. Three types of micrometers are commonly used: the outside micrometer, the inside micrometer, and the depth micrometer (fig. 32). The outside micrometer is used for measuring outside dimensions, such as the diameter of a piece of round stock. The screw thread micrometer is used to determine the pitch diameter of screws (fig. 32). The inside micrometer is used for measuring inside dimensions, as, for example, the inside diameter of a tube or hole, or the width of a recess. The depth micrometer is used for measuring the depth of holes or recesses.

Selecting Micrometers. All three types of micrometers are usually made so that the longest movement possible between the spindle and the anvil is 1 inch. This movement is called the "range." The frames of micrometers, however, are available in a wide variety of sizes, from 1 inch up to as large as 24 inches for special work. The range of the 1-inch micrometer is from 0 to 1 inch; in other words, it can be used on work where the part to be measured (between the spindle and the anvil) is 1 inch or less. The 2-inch micrometer has a range from 1 inch to 2 inches, and will measure only work between 1 and 2 inches thick; a 6-inch micrometer has a range from 5 to 6 inches, and will measure only work between 5 and 6 inches thick. It is necessary, therefore, that a person, in selecting a micrometer, first find the approximate size of the work to the nearest inch, and then select a micrometer that will fit it. For example, to find the exact diameter of a piece of round stock; if it is found, by using a rule, that the diameter is approximately 5¼ inches, a micrometer with a 5- to 6-inch range would be required to measure the exact diameter. Similarly, with inside and depth micrometers, rods of suitable lengths must be fitted into the tool to reach the desired dimension within an inch, after which the exact measurement is read by turning the thimble. The size of a micrometer is sometimes given as the size of the largest work it will measure and sometimes as its range.

Mechanics of Micrometer. The micrometer actually records the endwise travel of a screw during a whole turn or any part of a turn. The micrometer screw has a pitch of 40 threads to the inch; in other words, if the screw is turned 40 times, it will move the spindle exactly 1 inch either toward or away from the anvil. A clockwise turn moves the spindle toward the anvil: a counterclockwise turn moves the spindle away from the anvil. Therefore, by simple arithmetic, it is plain that a single turn of the screw moves the thimble $\frac{1}{40}$ or 0.025 of an inch (1.000 inch divided by 40 equals 0.025 inch).

READING MICROMETERS.

Thimble and Barrel Graduations. Remember that, if the sleeve of the micrometer is turned through one complete revolution, the micrometer opens or closes 0.025 inch. Hence, to change the opening 0.001 inch. the thimble should be turned to only one twenty-fifth of a revolution. To divide the inch into 1,000 parts by using the micrometer, therefore, the problem involved is to count the number of complete revolutions, plus any part of a revolution in twenty-fifths, that the sleeve makes to set the spindle and anvil exactly against the work being measured. For this purpose, the barrel and thimble of all micrometers are marked as shown in figure 33. The revolution line

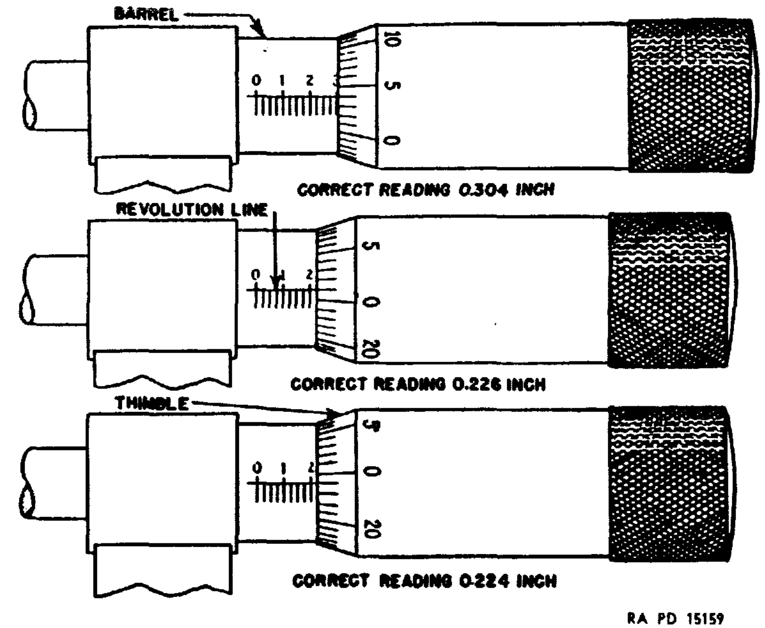


Figure 33 — Graduations of Micrometer

on the barrel should be understood first. It is graduated in lines 0.025 inch apart, so that each complete revolution of the thimble moves it exactly 0.025 inch along the barrel, or from one graduation to the next. Two complete revolutions move the thimble 0.050 inch, three revolutions 0.075 inch, and four revolutions 0.100 inch ($\frac{1}{10}$ inch). The numbers at every fourth graduation on the revolution line indicate, therefore, tenths of an inch (4 x 0.025 inch equals 0.100 inch). Assuming, for example, that the micrometer is closed and the screw is turned counterclockwise through four revolutions, the edge of the thimble would exactly coincide with the fourth graduation on the revolution line (marked 1) and the micrometer would be opened $\frac{1}{10}$ inch. If the edge of the thimble coincides with the next graduation on the barrel, five revolutions would have been made so the micrometer would be opened 0.125 inch (0.100 inch plus 0.025 inch). The graduations on the barrel are numbered from 0 to 10. The user should become thoroughly familiar with them before considering the graduations on the thimble.

The graduations on the barrel of the micrometer, as explained above, divide the inch into parts of twenty-five thousandths each; the graduations on the thimble further divide the inch into single thousandths, by indicating each twenty-fifth of a revolution of the thimble (complete revolution moves the thimble 0.025 inch which, when divided by 25, gives 0.001 inch). When the micrometer is closed, the edge of the thimble will coincide with 0 on the barrel, and 0 on the thimble will also coincide with the revolution line. As the thimble is turned, each time a graduation on the thimble passes the revolution line on the barrel, the micrometer opens 0.001 inch.

Procedure in Reading. With practice the inspector can read a micrometer correctly at a glance; however, in learning to do so, the following procedure is recommended; using pencil and paper, find the largest number on the revolution line between 0 and the edge of the thimble. Use the middle reading in figure 33 as an example; this figure is 2. Write it as 0.200 inch. Then add it to the number of unmarked graduations between this figure and the edge of the thimble, which in the example being used is 1, or 0.025 inch. Write this down under 0.200 inch, already written. At this point, if the 0 graduation on the thimble coincided with the revolution line, the reading would be complete, as follows:

0.200
0.025
———
0.225 inch, final reading

However, the 0 graduation on the thimble and the revolution line do not coincide, so it is necessary that the number of graduations between the 0 on the thimble and the revolution line be added to the 0.225-inch reading. In this example, there is one such graduation. Write this as 0.001 inch, and the complete addition is as follows:

0.200
0.025
0.001
———
0.226 inch, final reading

Therefore, in the example being used, the micrometer is open 0.226 inch. Using a similar procedure with the top reading in figure 33 the result works out as follows:

0.300 (largest number on revolution line between 0 and edge of thimble)
0.000 (number of unmarked graduations between this and edge of thimble)
0.004 (number of graduations on the thimble between 0 and the revolution line)
———
0.304 inch, final reading

Use the same procedure again with the bottom reading in figure 33. If the reading is taken correctly, the final answer will be 0.224. It should be noticed particularly in this last example, that the edge of the thimble appears to coincide with the 0.025 graduation on the barrel; but if this were true, the 0 line on the thimble would coincide

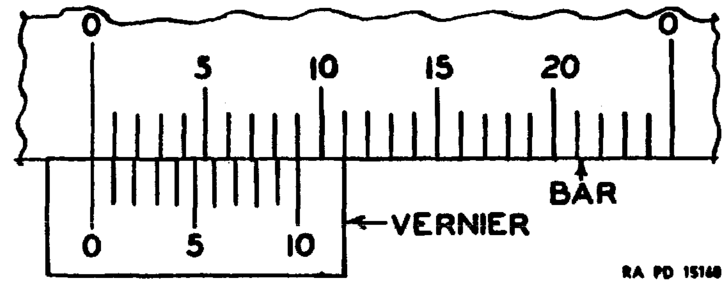


Figure 34 — Vernier Scale

with the revolution line, which it does not do. In other words, unless the 0 graduation on the thimble coincides with the revolution line, the third figure of the final reading cannot be 0.

THE VERNIER SCALE.

General. Operations are sometimes encountered where measurements in thousandths of an inch are not accurate enough. Most micrometers have a vernier scale on the barrel for reading measurements in ten-thousandths; no person should attempt to use this scale, however, until he has thoroughly mastered the reading in thousandths.

The fundamental idea behind the vernier scale is to divide a line of known length into equal parts, and to compare the length of those parts with those on a line the same length as the first one, but divided into one less part. Figure 34 shows the bar divided into 25 parts which would correspond to the divisions on a thimble of a micrometer caliper; each division represents 0.001 inch. The vernier scale is divided into ten parts and is exactly the same length as nine divisions on the bar. Consequently, each division on the vernier must be 0.0001 inch (0.001 ÷ 10 = 0.0001) smaller than the division on the bar in order to make ten divisions on the vernier equal nine divisions on the bar. In figure 34, 0 on the vernier coincides with 0 on the bar; the next graduation to the right on both vernier and bar will be 0.0001 inch apart; the second pair 0.0002 inch apart, and so on, until the graduations coincide again at 10 on the vernier. If the bar is moved so that its first division corresponds with the first division on the vernier, the zeros on vernier and bar will be 0.0001 inch apart. If the second divisions are made to coincide, the zeros will be 0.0002 inch apart, and so on. Thus, the number of the line on the vernier that coincides with a line on the bar will give the fractional reading of a division on the bar.

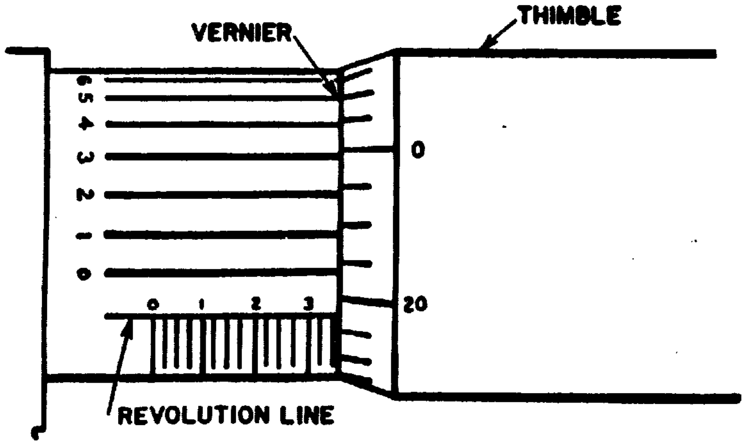


Figure 35 — Vernier Scale Applied to Micrometer

Vernier Scale Applied to Micrometer. Figure 35 shows how this principle is applied to the micrometer. The vernier consists of ten divisions marked on the barrel which equal in over-all dimension. nine divisions on the thimble. To obtain a correct reading in ten-thousandths in the example in figure 35. first find the reading in thousandths by the method described above, which in this case would give:

0.300 (largest number on revolution line between 0 and edge of thimble)
0.050 (number of unmarked graduations on the barrel between 3 and edge of thimble)
0.019 (number of graduations on the thimble between 0 and the revolution line)

0.369 inch, final reading

Now to read the vernier, find the vernier scale graduation that coincides with a graduation on the thimble. In this example, the figure is 5. Write this as 0.0005 inch, and add this to the reading in thousandths already obtained, and the result is:

0.369 (reading in thousandths)
0.0005 (vernier reading)

0.3695 inch. final reading in ten-thousandths

Figure 36 shows two further examples of the vernier scale applied to the micrometer. Following the procedure previously outlined, the example on the left is read thus:

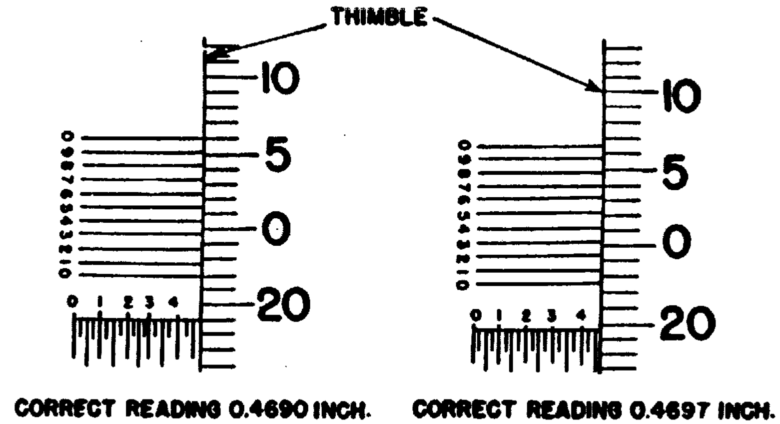


Figure 36 — Practice Readings of Vernier Micrometer

0.4000 (largest number on revolution line between 0 and edge of thimble)
0.0500 (number of unmarked graduations on barrel between 4 and edge of thimble)
0.0190 (number of graduations on thimble between 0 and revolution line)
0.0000 (number on vernier scale which coincides with a graduation on thimble)

0.4690 inch, final reading in ten-thousandths

Use the same method on the example on the right in figure 36. If the reading is taken correctly, the answer is 0.4697 inch.

Alternative Method for Reading Micrometer. A method of reading the micrometer may be defined in a few simple steps as follows:

1. Count the number of divisions on the revolution line between 0 and the edge of the thimble.

2. Multiply the above number by 0.025 inch.

3. Count the number of graduations on the thimble between 0 and the revolution line.

4, Multiply the above number by 0.025 inch.

5. Find the number of the line on the vernier scale that coincides with a division on the thimble.

6. Multiply the coinciding vernier scale line number by 0.0001 inch.

7. Add results of steps 2, 4, and 6. This sum is final correct reading.

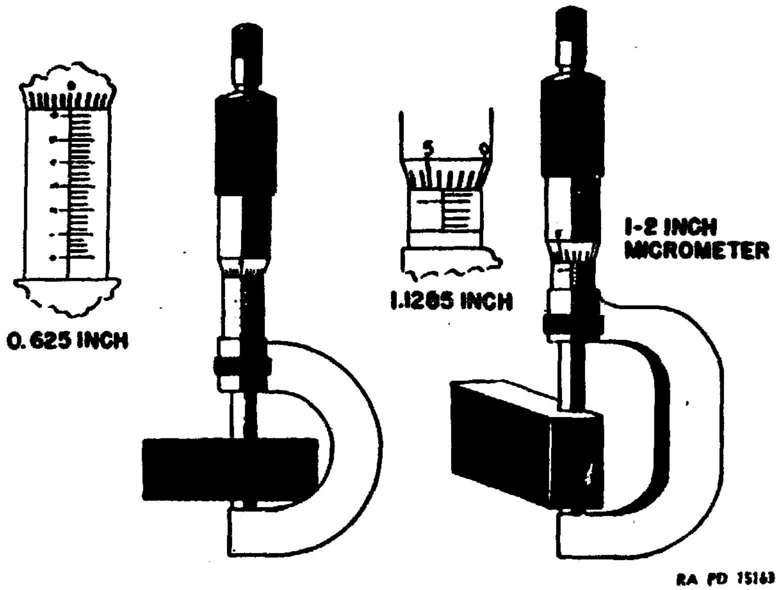


Figure 37 — Measuring Flat Surfaces With Micrometers

USING MICROMETERS.

Measuring Flat Surfaces. Figure 37 shows two uses of the outside micrometer in measuring the distance between two flat surfaces. The inspector should first of all select the right size micrometer for the work (in the first case a 0 to 1-inch size, as the work is less than 1 inch across). The micrometer should be opened far enough to slip

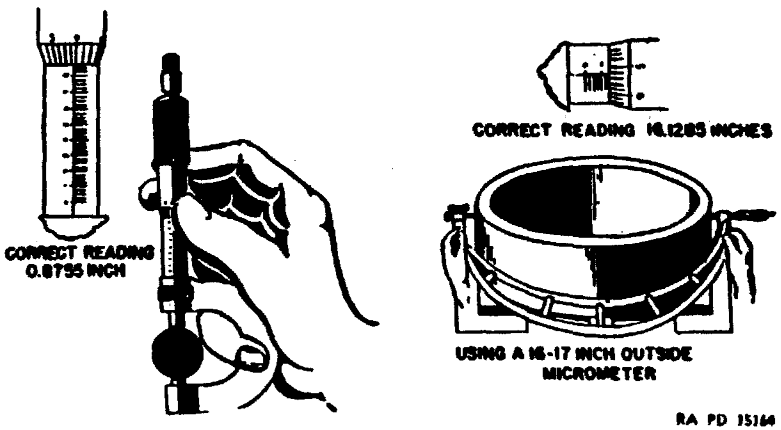


Figure 38 — Measuring Round Stock With Micrometers

over the work freely; then, the micrometer being held in the left hand, the thimble is turned clockwise until the spindle and the anvil lightly touch the work. A very light pressure only is required; if the tool is turned up too tight on the work, the frame will almost surely be sprung out of shape and the reading will be inaccurate. Most micrometers are equipped with a ratchet stop (fig. 32) on the end of the thimble which prevents the operator from closing the tool too tightly. This ratchet stop is so made that it will slip and click when a certain amount of pressure is applied to it, and so prevent the spindle from moving farther. If the micrometer being used is fitted with a ratchet stop, it is recommended that the operator make use of it to avoid damaging the micrometer. Take the reading of the micrometer while it is still on the work. Finally, open the micrometer and remove it from the work. The readings in figures 37 and 38 may be interpreted for further practice in reading the micrometer.

Measuring Round Surface. Figure 38 shows two operations in measuring the diameter of round stock. When the correct size micrometer is selected, the procedure is the same as in measuring across the flat surface. Care must be used to see that the work is measured at points exactly opposite each other; this can be done by sliding the micrometer back and forth across the piece until the right "feel" is obtained.

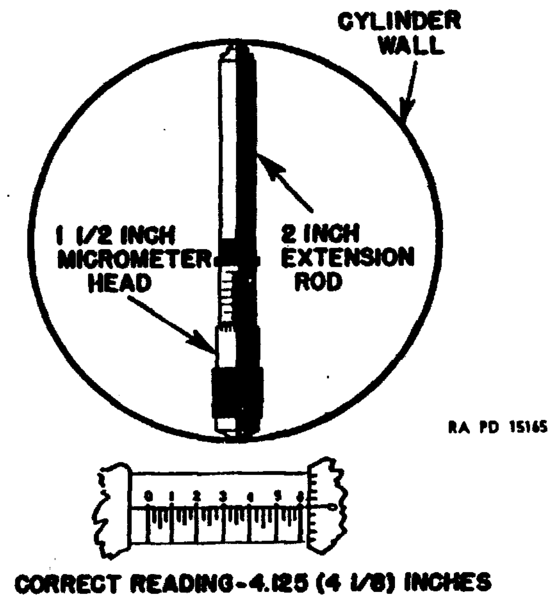


Figure 39 — Measuring Inside Diameters With Micrometers

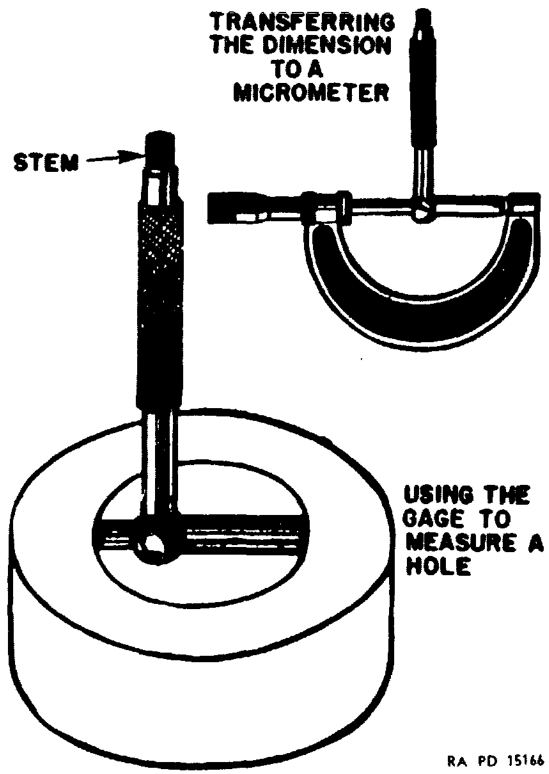


Figure 40 — Telescoping Gage

Measuring Inside Diameters. Figure 39 shows the correct position of an inside micrometer for taking the inside measurement of a round piece of work, such as the diameter of the mouth of a cartridge case. Proceed by first finding the approximate diameter with a rule; then select an extension rod of the proper length and attach it to the micrometer. The number of inches a rod will measure is stamped on each one. Be sure both the rod and the micrometer are thoroughly clean, that the rod is turned up the full distance possible, and that it is securely in place. Neglect of any of these precautions may result in an incorrect measurement. When the extension rod has been properly set, place the end of the rod against one side of the hole and turn the sleeve of the micrometer until the head barely touches the other side at a point exactly opposite. Then read the dimension while the micrometer is still in the work. Never let the micrometer bear heavily enough to hang in the work with the hand removed from it.

Another method commonly used for measuring smaller work, where an inside micrometer will not fit conveniently, is to use a tele-

scoping gage (fig. 40). The telescoping gage should be adjusted until it exactly touches points directly across from each other; it is then locked by turning the stem; then it is removed, and the dimension is measured with an outside micrometer. For very small holes, the type of inside micrometer shown in figure 41 is convenient; the illustration shows clearly its use and the correct method of reading the measurement obtained with it.

Measuring Depth of Recesses. Figure 42 shows the depth micrometer used to measure the depth of a hole. The inspector should first be sure that the surface of the work around the top of the hole is clean and smooth; any burs should be removed with a fine, smooth, flat file. With the base of the micrometer set firmly against the flat surface, as shown, turn the sleeve clockwise until the pin just touches the bottom of the hole. If the micrometer is equipped with a ratchet stop, it should be used. The measurement can then be read in the usual manner.

ADJUSTMENT OF MICROMETERS.

General. Micrometers often get out of adjustment, and should not be used until set back to their proper position. If the frame has been badly bent, it must be straightened before any adjustment is attempted; if it is sprung only 0.002 or 0.003 inch, the error can be compensated by the adjusting arrangements. The two adjustments possible on any micrometer are adjustment for wear of the screw and adjustment for position of the spindle.

Adjustment for Wear of Screw. Constant use of a micrometer will slightly wear the threads of the screw. In order to adjust the tool to compensate for this wear, proceed as follows:

1. Turn the thimble counterclockwise until the compression nut at the top of the hub can be reached with a spanner wrench provided with the tool.

2. Turn the compression nut a slight amount to the right and try the screw to see if it is tight.

3. If it is not tight, continue to turn the compression nut until the screw has a firm, easy "feel."

Adjustment for Position of Spindle. To compensate for wear on the end of the spindle of a micrometer, proceed as follows:

1. Loosen the cap with the wrench; this will make it possible to turn the thimble and the spindle independently of each other. Hold the spindle stationary and turn the thimble counterclockwise about one-fourth of a turn. Then let go of the spindle and turn the thimble to the correct 0 reading. Test this reading as follows:

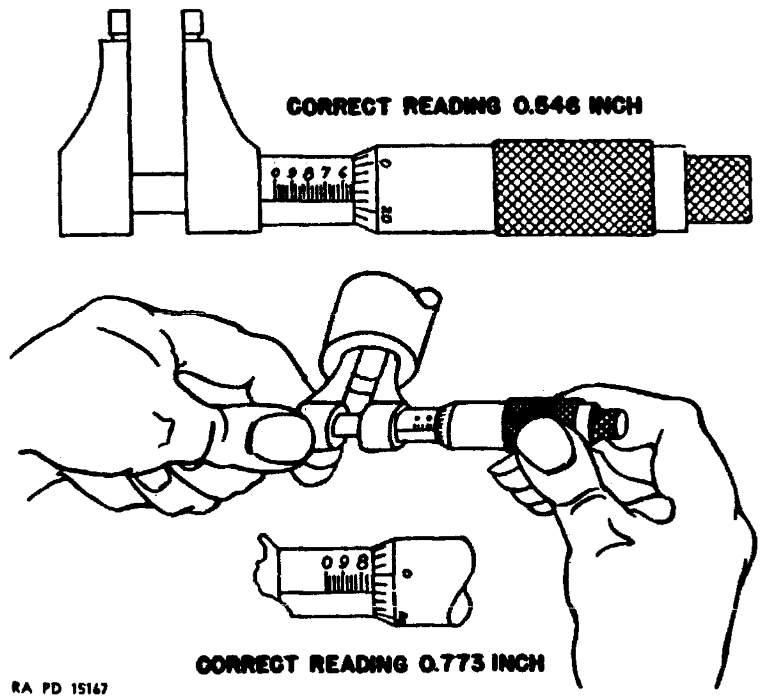


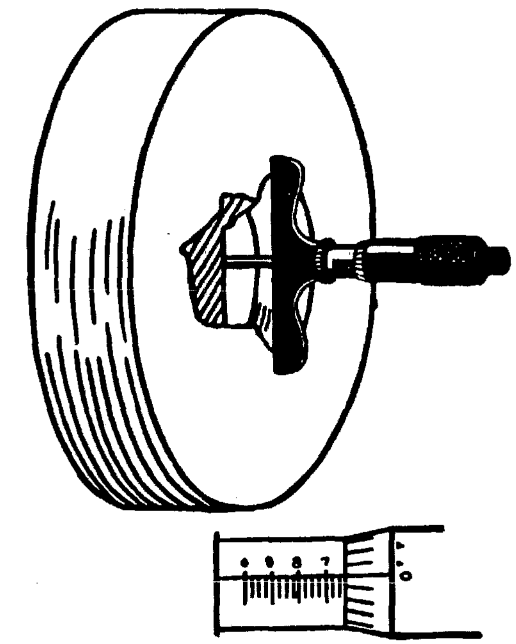
Figure 41 — Inside Micrometer for Small Holes

2. Let go of the thimble, and back the spindle away from the anvil with the fingers, then, again turning the thimble and letting go of the spindle, close the micrometer; if 0 on the edge of the thimble coincides with the revolution line, and the edge of the thimble coincides with the 0 graduation on the barrel, the micrometer is properly set. If not, continue adjusting until they do coincide, and tighten the cap.

3. To adjust a micrometer larger than a 1-inch size, the gage block must be used between the anvil and spindle to test for the correct 0 reading.

PRECAUTIONS IN THE USE OF A MICROMETER.

Normal use of the micrometer does not involve danger to the operator, but certain precautions should always be taken to prevent damage to the tool itself, since it is a delicate instrument. Most micrometers are ruined by being closed too tightly on the work. Only a very light pressure is needed to obtain an accurate measurement. If the micrometer has a ratchet stop, it should be used. It should never be dragged from the work; it should first be opened and then



CORRECT READING—LENGTH OF EXTENSION ROD PLUS 0.625 INCH.

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Figure 42 — Depth Micrometer

removed. The tool should never be swung back and forth by the thimble to secure the correct adjustment; always hold the frame stationary and adjust the micrometer by turning the thimble. Both the micrometer and the surfaces being measured must be clean to give accurate readings. In using large micrometers (24 to 36 inches), care is needed to see that the frames are not handled roughly, or sprung out of shape. When using the larger micrometers in cold weather, it is good practice to use a piece of cloth or waste between the hand and the frame, as the heat of the hand may expand the frame enough to cause a variation in the reading. The tool should not be laid where it will be dropped to the floor, or where it will pick up abrasive particles.

SECTION III.
EXPLOSIVES

Chapter 1
Introduction, Military Explosives

GENERAL.

When discussing any subject, it is necessary to build up a background and most particularly a vocabulary. This is especially true of the explosives used by the Ordnance Department, since people in widely scattered establishments must communicate with each other and use commonly understood terms in their communications. It is, therefore, necessary to know some fundamental definitions:

Explosive. A gaseous, liquid, or solid substance, or mixture of substances, which upon application of a blow to a small portion of its mass, or by a rise in temperature, is converted in a small space of time into other substances more stable, which are mainly gases or vapors, but may include solids. The chemical changes thus produced result in a sudden rise in temperature and pressure in the surrounding medium.

Upon analyzing this definition, it will be found that three essential characteristics are required in an explosive. These are namely:

1. Method of initiation; flame, spark, shock, or blow.

2. Rapidity of reaction; extremely rapid.

3. Results of reaction; rise in temperature and pressure in the surrounding medium.

Any substance to be properly termed an explosive must conform to all of the above points. For example, if a small amount of sodium chloride solution were poured from one test tube into silver nitrate solution in another test tube, a white precipitate would form with great rapidity. Even though one of the conditions (rapid reaction) was fulfilled, the others were not, and thus the mixture of substances would not be considered an explosive. Also, if a small amount of hydrochloric or nitric acid were poured into a small amount of sodium carbonate solution an effervescence would be noted. Even though two of the conditions were fulfilled (a formation of gases and thus pressure if confined, and a rapid reaction), the third was not, and thus the mixture of substances would not be considered an explosive. If, finally, a small amount of black powder is ignited, all of the required characteristics of an explosive as listed above will readily be observed.

All explosives, however, are not used by the military. A military explosive may be defined as "An explosive both suitable for and used for military purposes." As an example, let us consider dynamite

or even its mother substance, nitroglycerin. Both are commonly used in industrial fields, yet neither is suitable or used for military purposes, particularly not in ammunition.

HIGH EXPLOSIVES AND LOW EXPLOSIVES.

Military explosives are divided into a class of low explosives or high explosives. These two groups differ generally in three major characteristics; namely, method of initiation, rapidity of reaction, and results of reaction. A brief chart will best serve to visualize these differences.

	Low Explosives	High Explosives
Method of initiation	Flame or spark	Blow or shock
Rapidity of reaction	Slower, deflagration	Faster, detonation
Results of reaction	Displacement, power	Shattering, brisance

It must be remembered that the comparison above is general in nature. Exceptions to any one of the generalities may be found. For example, lead azide and mercury fulminate, both commonly classed as high explosives, may be, and many times in their military uses, are initiated by flame or spark. Black powder, on the other hand, is a low explosive but may be caused to detonate if ignited while confined. Normally however, high explosives and low explosives will each exhibit characteristics in line with the above chart. Variations in normal conditions, however, can be used to cause practically any desired change in the characteristics of any one substance.

Upon being ignited, low explosives will burn rapidly, but yet slower than the reaction of a high explosive. Rapid burning of this nature, rapid combustion, the same as the burning of paper or wood although much faster, is termed deflagration.

Deflagration is a comparatively slow transformation consisting of a rapid combustion.

Low explosives as a result of their deflagration exhibit a characteristic known as power.

Power may be defined as the ability of an explosive to displace its surrounding medium.

As an example, smokeless powder in the chamber of a gun, when ignited, does not burst the gun, but displaces its surrounding medium, the only movable portion of which is the projectile. A charge of TNT in the chamber of a gun however would burst the gun. TNT is a high explosive, smokeless powder a low. This gives an insight into the probable uses of low and high explosives. Low explosives are most commonly used as propellants, while high explosives are most commonly used as bursting charges in various components of ammunition.

High explosives are normally initiated by blow or shock, either produced by mechanical means or by the explosion of a preceding high explosive in the explosive train. The high-explosive filler of a projectile, for example, is initiated by the detonation of a booster which precedes it. The booster is functioned by the shock of a detonator in the fuze which precedes it. The detonator in the fuze is initiated, perhaps, by a blow from a firing pin. Upon being so initiated, the high explosive undergoes a very rapid reaction termed detonation.

Detonation is a very rapid transformation, not instantaneous, but starting at a given point and traveling in all directions away from that point with a high but measurable velocity.

The travel of the detonation is termed the wave of detonation or the detonating wave. Its rate may be so high as to exceed even 7,000 meters per second (approx. 23,000 ft per sec). It is this extreme rapidity that causes the results of the reaction of a high explosive to differ so greatly from the results of the reaction of a low explosive. The high explosive is so rapid in its transformation that the surrounding medium is shattered. This shattering is directly related to the rapidity of the reaction. It is termed brisance.

Brisance may be defined as the capacity of an explosive upon detonation to shatter its surrounding medium.

FURTHER REFERENCES:

TM 9-2900; FM 5-25; OS 9-18, Vol. I.

Chapter 2
Low Explosives

BLACK POWDER.

Historical. The origin of black powder has been attributed by various authorities to the Chinese, the Arabs, or the Hindus. It has been proven that alchemists of medieval days were familiar, to a certain extent, with the properties of mixtures of saltpeter, sulfur, and charcoal. References to black powder may be found in history as early as 1250 A.D. Progress and development led to use of black powder as a propellant until 1870 when it replaced all other devices in use for this purpose. Today, however, its use as a propellant has been discontinued, but it retains its utility in the form of spotting charges, delay elements, and safety fuse.

Manufacture. The manufacture of black powder is not technically complicated, since black powder is nothing more than a very intimate mechanical mixture of saltpeter, sulfur, and charcoal. However, because of the great sensitivity of black powder to initiation by practically any means, unusual precautions must be observed in its

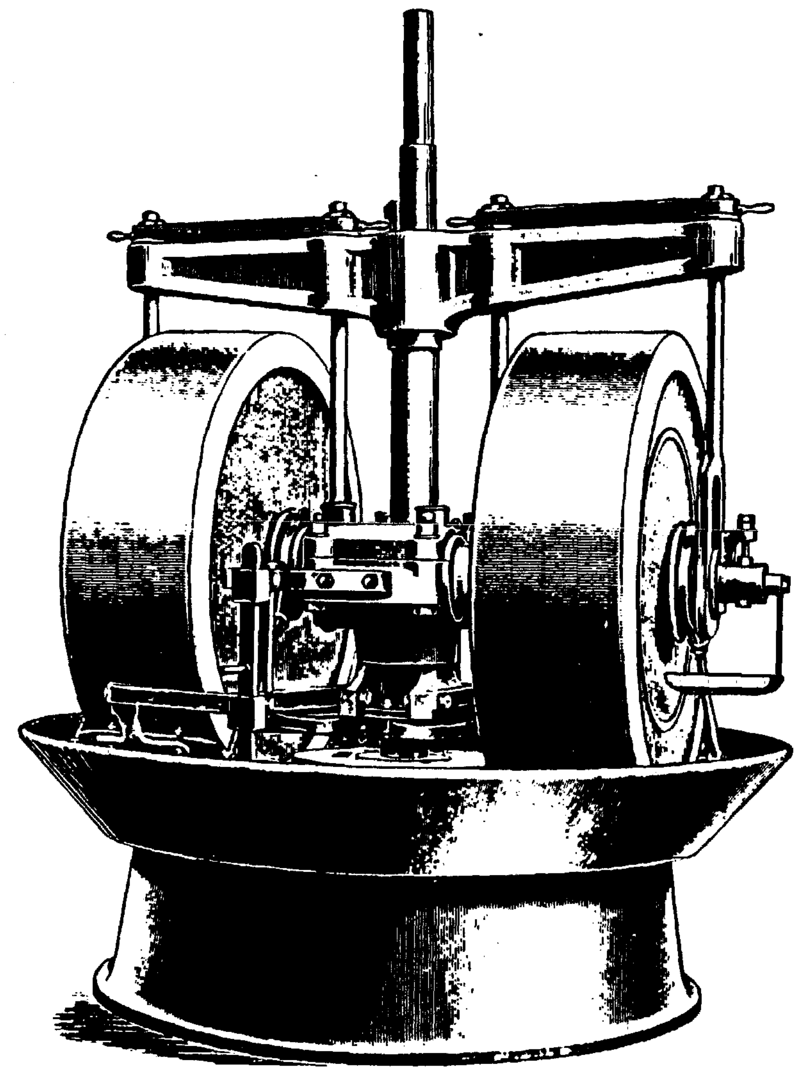


Figure 43 — Gruson Powder Mill

manufacture. A summary of the main steps in the manufacture of black powder follows:

Standard composition; 75 percent potassium or sodium nitrate, 15 percent charcoal, 10 percent sulfur.

Black powder made with potassium nitrate is known as Army black powder while black powder made with sodium nitrate is known as commercial or as sodium nitrate black powder. Sodium nitrate is commonly referred to as Chile saltpeter.

1. Pulverization and mixing. In the "wet" method of mixing, which is the most used method, the charcoal and sulfur, in the specified proportions, are pulverized in a ball mill. The ball mill is a device consisting of a revolving steel cylinder in which iron or steel balls do the crushing. The pulverized charcoal and sulfur are then stirred into a saturated solution of saltpeter at a temperature of about 130 C (265 F). The mass is then spread on a floor to cool, after which it is ready for incorporation. The lumps formed in the cooling are easily broken.

2. The edge-runner or wheel mills. After being mixed by the above method, the material is spread on the bed plate of a wheel mill. The wheel mill consists of two cast iron wheels, with nonsparking plows of phosphor-bronze. These wheels revolve on an axle, which in turn rotates about a central axis, the wheels rolling on the bed plate of the wheel mill. The wheels are in contact with the bed plate if it is wooden, but are suspended slightly above it if the bed plate is of cast iron. A safety device is included which consists of independent suspension of the wheels permitting an upward movement to prevent violent crushing of any possible lumps. The wheels weigh from 5 to 8 tons each. The plows are set in opposite directions, the plows on the inner wheel throwing the material to the outside, the plows on the outer wheel throwing the material to the inside. The process is carried on for about 3 hours at 10 rotations per minute. Water is added to maintain 3 to 4 percent water content (safety precaution). A wheel cake or clinker which forms must be broken before the next operation. The wheel mills thoroughly mix the ingredients, insuring a close mechanical contact between the ingredients.

3. Pressing. In order that the powder exhibit uniformity of ballistics, it is necessary that it be of uniform density. To achieve this uniform density, the mix from the edge-runner mills is placed on aluminum press plates which are then stacked on a small trolley. The trolley is then run over the bed plate of a vertical hydraulic press. A pressure of 1,200 pounds per square inch is applied and held for varying lengths of time. Cakes about ¾ inch thick by 24 inches square are the result. These cakes are broken with wooden tools and transported to the corning mills.

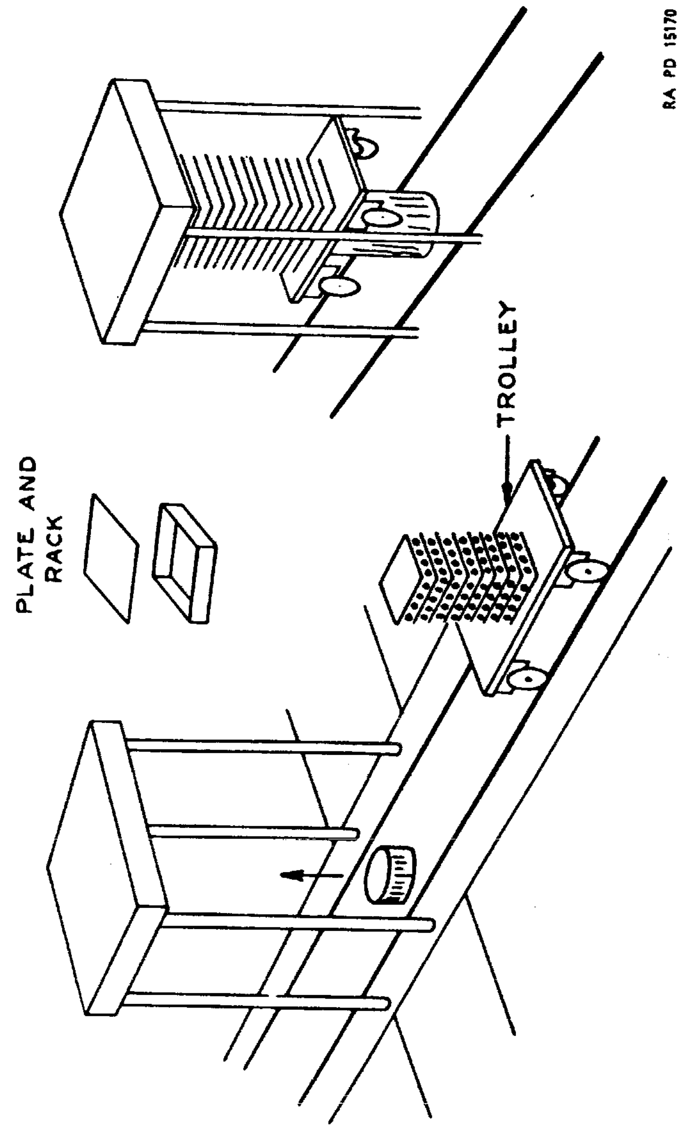


Figure 44 — Pressing Operation

4. The corning mills. The press cake is cracked or granulated in the corning mill by feeding the cake between crusher rolls. Mechanically-operated shaking screens separate the dust and coarse grains from the finished grains; the coarser lumps pass through successive crushing rolls, four sets of crushing rolls being the usual number per mill. The dust is generally passed back to the edge-runner mills but may also be used as meal black powder. The corning operation is considered the most hazardous of the various operations in the manufacture of black powder. Many devices, of which the following are typical, have been employed to reduce the loss of property and life in the corning mill to a minimum:

One of each set of crusher rolls is held by springs so that the roll may give, rather than violently crush extraordinarily hard lumps.

The broken press cake is fed to the corning mill by a conveyor which passes over the top of a steel barricade.

All personnel are excluded from the building during the operation.

5. Finishing. Rounding or polishing the grain is accomplished by tumbling in a revolving wooden cylinder. Drying is generally accomplished by forcing a current of warm air through the cylinder while the powder is being polished, or the powder may be removed from the cylinder and dried in stationary wooden trays. To glaze the grains, a small quantity of pulverized graphite is added to the powder while the powder is warm from the tumbling process and the process is continued for about a half hour. The drying and glazing process, when carried out on the single operation plan, requires approximately 8 hours.

Grades and Uses. Army black powder.

Composition: potassium nitrate, 75 percent; charcoal, 15 percent; sulfur, 10 percent.

Grade A.

Glazed.

No. 1. Igniting charges, certain primers, saluting charges.

No. 2. Unassigned.

No. 3. Special uses.

No. 4. Base charges for shrapnel, base charges for fuzes, primers, smoke-puff charges, bursting charges for practice projectiles, bursting charges for certain subcaliber shell, and spotting charges for practice bombs.

Unglazed.

No. 5. Pellets for primers and fuzes.

No. 6. Pellets for primers and fuzes.

Meal or fuze powder. Loading time train rings.

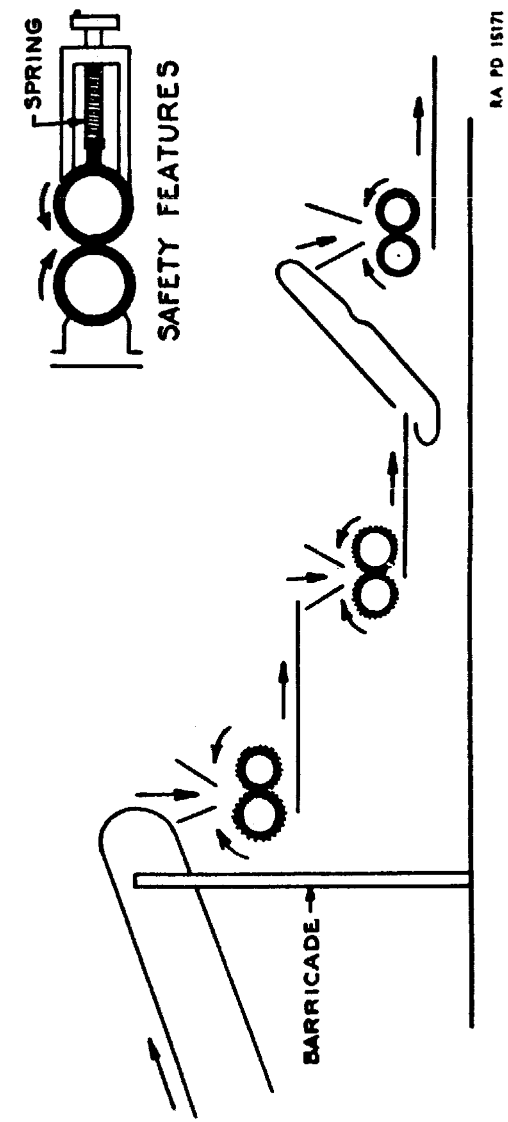


Figure 45 — The Corning Mills

Classes and Uses. Sodium nitrate black powder.

Composition: sodium nitrate, 75 percent; charcoal, 15 percent; sulfur, 10 percent.

Class A; saluting charges.

Class B; spotting charges for practice bombs.

Both the above grades are based on granulation, for Army black powder grade A, No. 1 is the coarsest granulation and meal or fuze powder the finest. For sodium nitrate powders, Class A is the coarser and Class B the finer.

The sodium nitrate black powder is more hygroscopic than the potassium nitrate black powder, and therefore is used where absolute dependability is not required.

Control of the Burning Rate of Black Powder.

To slow the rate.

1. Compress the powder into pellets, time train rings, or other devices.

2. Increase the charcoal content at the expense of the nitrate content.

3. Increase the sulfur content at the expense of the charcoal content. (Note—lessens the uniformity of the burning rate.)

4. Incorporate adulterants such as red or white clay. (Note—absorption of moisture acts as an adulterant.)

5. Substitute other nitrates for potassium nitrate. Barium nitrate is sometimes used for this purpose.

6. Substitute hardwood (oak) charcoal for softwood (willow or alder) charcoal.

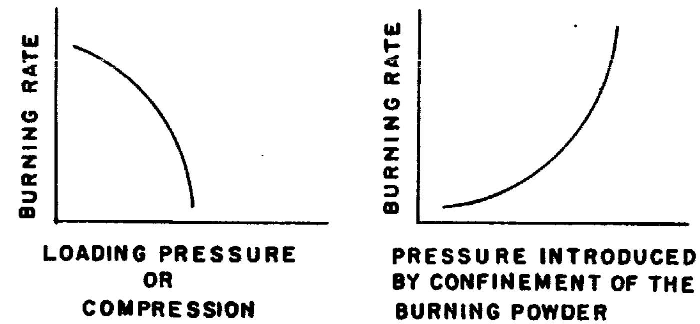
7. Substitute coal (powdered) for charcoal.

To speed the rate.

1. Confinement of burning black powder speeds the rate of burning. In some cases detonation may result. (Note—speed is not desired but must be considered.)

Comparison of effect of confinement and compression. By virtue of its method of manufacture black powder has a porous structure. Therefore, if the powder is compressed into pellet form, the porosity is lessened and the penetration of hot gases into the interior of the pellet is hampered, thus reducing the burning rate. On the other hand, if the powder is burned in confinement (or as a result of greater than atmospheric pressure), the penetration of hot gases into the interior

of the grain will be enhanced. This will result in a faster rate of burning and a quicker consumption of the grain.



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Reasons for Discontinuance of Use of Black Powder as a Propelling Charge.

1. Flash and smoke of discharge too great, revealing gun positions day and night.

2. Intense heat and violent pressure developed during discharge caused excessive erosion of the gun barrels.

3. Solid residue or ash left in the chamber after combustion proved dangerous to loading of succeeding charges, particularly in the case of separate loading ammunition.

4. Rate of burning difficult to control. Control of burning rate is essential for uniform ballistics.

5. Unstable in storage; it is hygroscopic. Absorbed water acts as an adulterant and slows the burning rate.

6. Dangerous to handle. Black powder is easily initiated by spark, flame, friction, and other means.

Products of Combustion of Black Powder.

Gaseous—44 percent Gaseous Products	percent by volume
CO_2—carbon dioxide	49.0
CO—carbon monoxide	12.5
N_2—nitrogen	33.0
H_2—hydrogen	2.0
CH_4—methane	0.4
H_2S—hydrogen sulfide	2.5
H_2O—water vapor	0.6

Solid—56 percent Solid Products	percent by weight
K_2CO_3—potassium carbonate	61.0
K_2SO_4—potassium sulfate	15.0
K_2S—potassium sulfide	14.5
S—sulfur	9.0
KCNS—potassium sulfocyanide	0.2
KNO_3—potassium nitrate	0.3

Uses of Black Powder.

1. Miners safety fuse which is composed of a core of compressed black powder enclosed in an insulated wrapping. It burns at a rate of 32 to 40 seconds per foot. It is recognizable by its smooth, white, outer wrapping.

2. Instantaneous blasting fuse which is a core of loose black powder enclosed in an insulated wrapping. No delay is imposed on the rate of burning. It is recognizable by its welted or braided red outer wrapping.

It is necessary, in order to achieve maximum safety, to burn an experimental length of about 1 foot of the fuse being used to determine its burning rate. One can easily see the danger or hazard coincident with mistaking instantaneous fuse for safety fuse.

It will also be noted that there are two spellings for the word fuse (fuze). By common practice in this country, the word "fuze" is applied to a mechanical device for producing explosion or detonation in artillery projectiles, bombs, or grenades, while the word "fuse" refers to the cord or casing filled with black powder or high explosive such as is used in blasting and mining work for setting off charges of explosive.

At the present time, any stocks of instantaneous fuse. not the property of the engineers, on hand in depot storage should be destroyed. Stocks which are engineer property should be marked with a red tag for issue only as directed by the Chief of Ordnance. Such issue will be for experimental purposes or to meet special situations.

Black Powder Charges. The assembly of blank ammunition for cannon and assembly of saluting charges will be conducted in accordance with special instructions furnished by the Chief of Ordnance.

Blank ammunition may be loaded with either:

1. Army black powder in bags.

2. Sodium nitrate black powder in bags.

3. Sodium nitrate black powder in pellet form.

Sodium nitrate black powder is available commercially and at a cost somewhat less than Army black powder, which contains potassium nitrate. Commercial sodium nitrate black powder pellets wrapped in cellophane are being used extensively. The pellet form of this powder greatly facilitates loading and reduces assembly hazards. Pellets are supplied in single and double units for reduced and full charges, respectively. Because sodium nitrate black powder is more hygroscopic than Army black powder, additional care is necessary in storing and handling, to prevent exposure to moisture.

Precautions similar to those applying to the assembly of other ammunition will be followed in assembling blank ammunition and saluting charges. Particular caution must be exercised because of the treacherous nature of black powder. The following general safety regulations will be complied with in the assembly of blank ammunition and saluting charges:

1. Black powder operations should be conducted in special buildings which will not be used for other purposes at the same time.

2. The floor of the building in which black powder is handled will be surfaced with suitable material.

3. Intraplant quantity-distance requirements for high explosives as given in the Ordnance Safety Manual will be followed.

4. Absolute cleanliness will be maintained at all times in and around each operation.

5. Noninsulating safety shoes will be worn by personnel in all assembly operations.

6. All equipment will be electrically grounded, and it should be determined by test that all parts of the equipment are effectively grounded.

7. Empty metal containers which have held black powder will be thoroughly washed inside with water before they are disposed of. Serious explosions have occurred with supposedly empty cans. Wooden containers will be destroyed by burning.

8. Safety tools only will be used in opening or closing containers or in handling black powder.

9. Processes should be so laid out as to bring about frequent grounding of operators.

Packing and Marking. The standard container for Army black powder is a metal keg of 25-pound capacity built in accordance with ordnance specifications, or a commercial drum of equal quality and capacity complying with Interstate Commerce Commission regulations.

Black powder in the form of igniting charges may be packed in airtight, metal-lined containers, complying with Interstate Commerce Commission regulations; but the amount of black powder packed in one container is limited to 50 pounds.

In addition to the marking prescribed by Interstate Commerce Commission regulations, the following identifying data should appear on Army black powder containers: ordnance contract number; manufacturer's name; plant symbols or key letter; name and grade of material; army lot number; net weight and gross weight.

Storage and Shipping. Ordnance drawings show the recommended method of piling black powder in metal containers. This method will be followed when new stocks are received or existing stocks are repiled.

Present ordnance drawings recommend storage of black powder metal containers with longitudinal seams on the side, with lip down so that moisture will drop off rather than run into the seam. This is in a pyramided stack. It is suggested, that since rusting occurs at points where the metal cans contact each other, that a pile built up with battens between each layer will afford better protection against moisture. The use of separators on the battens to prevent even a side contact of the cans may be found effective. It should be noted that this is a suggestion. There is no present authority for storage in this manner.

When black powder is shipped or received, each container will be inspected for holes, such as those made by nails, which are visible only upon close examination. Damaged containers will not be repaired; the contents will be transferred to new or serviceable containers.

Metal containers for export shipment will be crated. Usually two containers are packed in each crate.

Surveillance. Since black powder deteriorates with the absorption of moisture, and the cans in which it is stored are subject to rust, a thorough inspection of this material in storage will be made at least once each year. One or more containers from each lot will be opened at the time of the annual inspection, and if there is any doubt as to the serviceability of the powder, the Chief of Ordnance will be notified of the existing conditions.

Maintenance. Repainting of containers and repacking of black powder contained in damaged or unserviceable containers constitute the principal maintenance activities. Black powder containers are subject to condensation of moisture, which rusts metal drums or kegs, so repainting is necessary to keep containers serviceable. Repainting will not be done in a magazine in which explosives or ammunition are stored. It may be done in a nearby empty magazine, or in clear weather in the open at least 100 feet from the nearest magazine. The quantity of black powder at or near such operations will be limited to 100 pounds. The marking on repainted containers will be checked carefully to see that it is a facsimile of the old.

The metal caps on certain types of black powder containers deteriorate in storage. Replacement of these caps is allowed, but the same safety precautions as outlined above for repainting containers will be followed.

Operations such as the removal of black powder from containers and its transfer from unserviceable to serviceable drums will be conducted in strict compliance with applicable portions of the safety regulations for black powder charges, as described in the following paragraph.

Fires. Most black powder fires start from sparks, and ignition results in an explosion so quickly that no attempt can be made to fight the fire. Every effort will be made to prevent fire from reaching stores of black powder, but if this fails, fire-fighting forces will be withdrawn at least 800 feet from the fire, and will protect themselves

against an explosion by seeking any cover available, or by lying flat on the ground.

If an explosion should occur, every effort will be made to prevent flames from spreading to adjacent mazagines. Fire-fighting forces must be cautious in approaching a fire which may involve black powder to avoid being trapped or injured by an explosion.

Safety Precautions. Black powder is regarded as one of the worst known explosive hazards. When ignited unconfined, it burns with explosive violence, and will explode if ignited under even slight confinement. It can be ignited easily by very small sparks, heat, or friction.

Most explosions of black powder originate from sparks, and the safety rules contained in the following paragraphs will be strictly enforced and obeyed.

A container will not be opened in a magazine in which explosives or ammunition are stored. This will be done only in a room or building free from all other explosives or ammunition, or in suitable weather in the open at least 100 feet from the nearest magazine. The quantity at or near such an operation will be limited to 100 pounds.

Safety tools only will be used in opening or closing containers, or in other operations involving black powder.

Safety shoes will be worn in all rooms in which black powder is handled, and by all persons engaged in handling black powder; the wearing of nonconductive shoes such as rubber is prohibited.

If the handling of black powder is carried on over a concrete floor, the floor will be covered with a tarpaulin, or other suitable material.

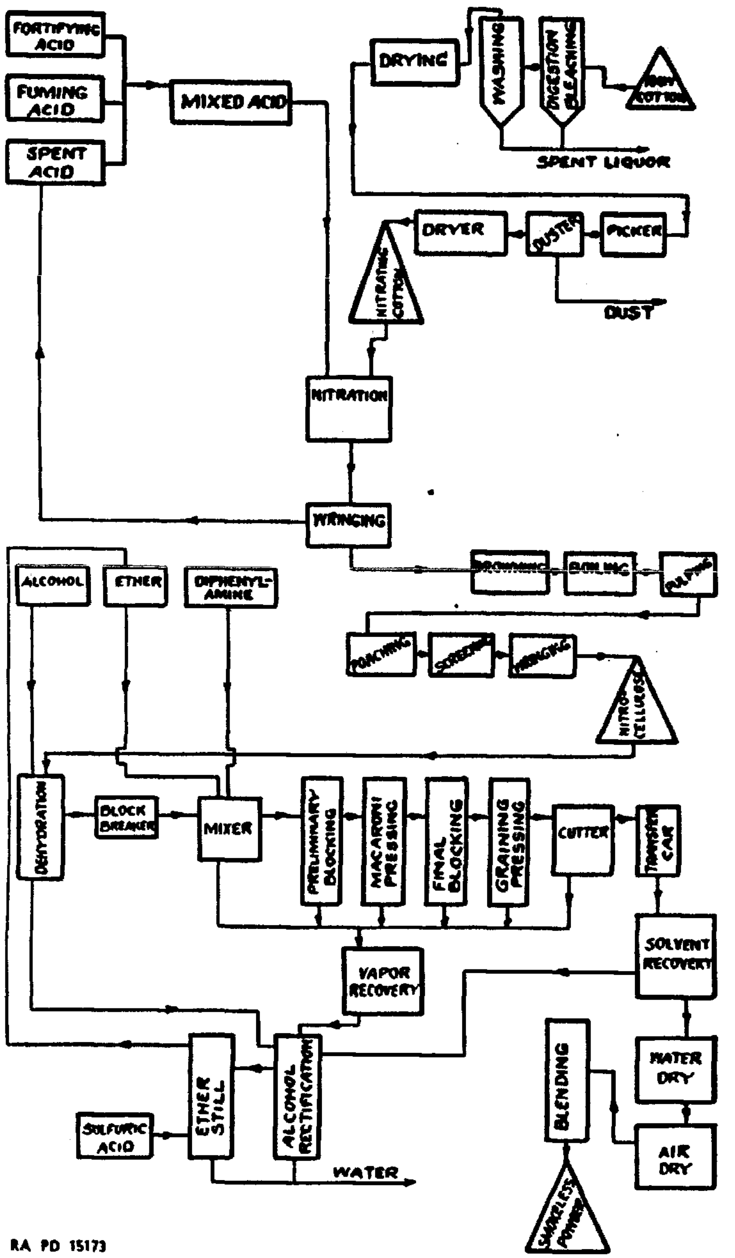
Loose black powder is extremely dangerous. Whenever it is necessary to handle loose black powder, not over 50 pounds of powder in open containers and 50 pounds in closed containers (100 pounds, total) will be permitted at or near such operations.

If black powder is spilled on benches or floors, all work will be stopped until the powder has been removed and the explosive hazard of any remaining dust or fine particles has been neutralized with water.

Rooms or buildings in which black powder is handled will be inspected frequently for the presence of black powder dust; and all such dust will be immediately removed with water.

SMOKELESS POWDER.

General. Smokeless Powder is considered in this chapter because of its succeeding black powder as a propellant. There are so many variations in the rate of burning of the various granulations and formulas of smokeless powder that it should be considered as a



RA PD 15173

Figure 46 — Flow Sheet — Manufacture of Smokeless Powder

class 2 explosive, except as noted under "Fires," below, with hazards largely limited to combustion with intense heat, rather than as a true low explosive.

In the latter part of the nineteenth century, smokeless powder of various forms was considered for use as a propellant. Its rapid development toward this end soon led to its replacing black powder for this use. At present, smokeless powder is the only propellant used. Its many advantages over black powder as a propellant include: accurately controlled burning rate; it is nonhygroscopic; it produces much less flash and smoke when fired; and it is much less hazardous in handling and storage.

Manufacture. The manufacture of smokeless powder may be considered as the result of eight major steps. These steps are best explained by the following outline:

I. PURIFICATION OF THE RAW COTTON.

A. Digestion. The purpose of this step is to remove the vegetable oils, resins, and other extraneous material in the cotton.

1. Cook. 6 hours, 2 percent caustic soda solution at 72 pounds per square inch pressure and 152 C temperature.

2. Wash. With water.

3. Bleach. A 2½ percent solution of. commercial bleach for as short a time as is necessary to decolorize. 36 C.

4. Excess bleach is destroyed with sulfuric acid.

5. Wash and dry.

B. Picking. If uniform nitration is to be obtained, it is essential that the cotton be of uniform low moisture content, or uniform physical condition, and free from lumps or other extraneous materials. The picking process and the drying process, which follows it, together achieve this uniformity of condition.

1. Picking machine. Cotton torn apart and fluffed by toothed rollers revolving at 1,000 revolutions per minute.

2. Air-blast. Cotton blown through flues and past baffles to the dry house. The baffles separate the fibers from the dust which settles into elbows or traps in the flues.

C. Dry House. Entering cotton contains about 8 percent of moisture. Treatment reduces this to about 0.5 percent.

1. Continuous drier. Cotton carried by conveyor through a long chamber heated to about 100 C. Weighted directly from belt into containers for transportation to dry house.

2. Chamber drier. An alternative method, more costly and less economical of time. The cotton is placed in long chambers which are tightly closed and heated to 105 C by a hot air blast. The time for a 2,500-pound charge is 24 hours. The end of the process is indicated by a laboratory test of the cotton showing a moisture content of less than 1 percent. Cotton transferred in fiber containers, carrying 32 pounds each, to the nitrating house.

II. NITRATION OF THE PURIFIED CELLULOSE.

A. **Systems Used.** DuPont mechanical dipper. Centrifugal. Thompson displacement. Pot.

1. The DuPont mechanical dipper process is the most frequently used because it is more economical of time, and also because the fumes are negligible.

The nitration. Four iron or stainless steel nitrators arranged for handling from a central point. Charge per nitrator is 1,500 pounds of mixed nitric and sulfuric acid and 32 pounds of cotton. The temperature of the acid is about 30 C. The cotton is drawn beneath the acid charge by vertically revolving paddles revolving at 60 revolutions per minute. Nitration continues for 24 minutes after which discharge valves in the bottom of each nitrator are opened dropping the nitro cotton and acid into centrifugal wringers below each nitrator.

The centrifugal wringer is a device, similar to a centrifuge, which rotates at first slowly at 300 revolutions per minute and later as fast as 1,100 revolutions per minute. This latter rate is held for 3½ minutes. The cotton is forked from the wringer into an immersion vessel below, from whence it is pumped or transferred by gravity to the boiling tub house. The heavier acid has been whirled off into catch basins where small residual amounts of nitrocotton are allowed to settle out.

III. PURIFICATION OF THE NITRATED CELLULOSE.

A. **The Preliminary Boiling.** The purpose of this step is to remove lower nitrated bodies and other impurities. The first boil lasts 16 hours, and is done in a solution of 0.1 to 0.3 percent sulfuric acid. Three neutral water changes are then made, the second and third coming at 8-hour intervals. The entire process consumes 40 hours.

B. **Pulping.** The purpose of this operation is to macerate the fibers of the nitro cotton in order to liberate free acid absorbed within the fiber. Also a finer state of division is obtained. The Jordan engine used in this process is a conical rotor in which are set broad bladed knives. These knives macerate the fibers as they are pushed through by a large volume of water. The desired degree of fineness is indicated by a clean break of a squeezed dry handful of material. Actual fineness is shown by laboratory test.

C. **Poaching.** The purpose of this process is to neutralize the acid liberated during the pulping process. It is similar to the preliminary

boiling except that it is carried out in a first water which is alkaline rather than acidic. The solution of first water is made up by dissolving 1 pound of SODA ASH (sodium carbonate) to a gallon of water. Seven and a half gallons of this solution are used to every 3,000 pounds of dry nitrocellulose. The other waters used are neutral and there are four rather than three changes. Ten cold water washes conclude the process.

D. **Tests.** At this stage of the process, various tests are performed on the nitrocellulose to indicate various properties which are of importance to later steps in the process. It is tested for:

1. Stability of the pyrocotton by KI test (potassium iodide and heat test at 134.5 C).

2. Percentage of nitrogen in the pyrocotton.

3. Solubility of the pyrocotton in the ether-alcohol mixture.

4. Degree of fineness.

5. Ash.

E. **Screening.** The purpose of this process is to remove any lumps or foreign materials. It is carried out in a Packer screen which is a brass plate having slits 0.025 inch wide. The pyrocotton is drawn through the slits by suction. Lumps are returned to the pulping process.

F. **Wringing.** The purpose of this process is to remove mechanically the larger amount of water present in the pyrocotton so that the dehydration with alcohol is accomplished with the minimum amount of water present. The wringer is a perforated brass basket lined with 24-mesh screen. This is revolved at 950 revolutions per minute for about 7 minutes. The moisture content will average 26 to 28 percent after this process.

IV. FORMATION OF THE COLLOID.

The purpose of this step is to put the nitrocellulose in a form in which its ballistics can be controlled.

A. **Dehydration.** The nitrocellulose as it leaves the previous step contains about 28 percent of moisture. The dehydration process removes this moisture and leaves in its place the required amount of alcohol solvent. The nitrocellulose is placed in a hydraulic press, and a pressure of 250 pounds per square inch is applied to squeeze out a portion of the excess moisture. One and a quarter pounds of alcohol per dry weight pound of nitrocellulose is then added under pressure and the pressure in the press is raised to 3,500 pounds per square inch. The first portion of alcohol combines with residual moisture and is forced out leaving a block practically free of moisture. The remaining portion is that amount of alcohol necessary as a solvent

AMMUNITION INSPECTION GUIDE

B. Breaking. The dehydrated block of nitrocellulose from the press is broken up to enhance the next process. The block is broken by being thrown against prongs and wire screens in a rotating drum. This produces small lumps which readily lend themselves to the mixing process.

C. Mixing. At this point, the ether necessary as a solvent for formation of the colloid is added. In solution with the ether is the diphenylamine necessary as the stabilizer. The finished powder will contain 0.9 to 1.10 percent diphenylamine. The mixing is accomplished in a water-cooled tank in which agitators rotate in opposite directions, thus kneading the material in the mixer. The ether is poured in rapidly to minimize evaporation, and the material is kept in closed containers from this point onward, for the same purpose.

D. Pressing. The mechanical action of three pressing operations completes the formation of the colloid.

1. The preliminary blocking press. Hydraulic press similar to the dehydrating press. The material is formed into a cylindrical block at 3,500-pound per square inch pressure.

2. The macaroni press. The block from the previous process is run through one 12-mesh-per-inch steel plate, two 24-mesh-per-inch steel screens, and one 36-mesh-per-inch steel screen at a pressure of 3,500 pounds per square inch.

3. The final blocking press. The material is again formed into a cylindrical block at a pressure of 3,500 pounds per square inch in a press similar to the preliminary blocking press. The colloid has now changed its appearance from a mass resembling light brown sugar to a dense, elastic, translucent brown or amber substance.

V. GRAINING AND CUTTING.

The granulation of the powder is one of the major factors in control of the burning rate. The block of colloid from the previous process is forced in horizontal or vertical hydraulic presses through steel dies. The press head may be equipped with 1 (16-in. gun powder) to 36 (small-arms powder) dies. The material issues from the press in strands which are led over pulleys to the cutters. The cutters are finely adjusted and control the length of the grain very closely.

VI. SOLVENT RECOVERY.

An excess of solvent is used to enhance formation of the colloid. The solvent recovery process removes the greater portion of this excess. The equipment used for this process varies but the cycle of operations is the same in all cases. Warm air is circulated through the powder in a closed chamber, and then passed over cold condenser coils where it loses the solvent it has picked up. The cycle is re-

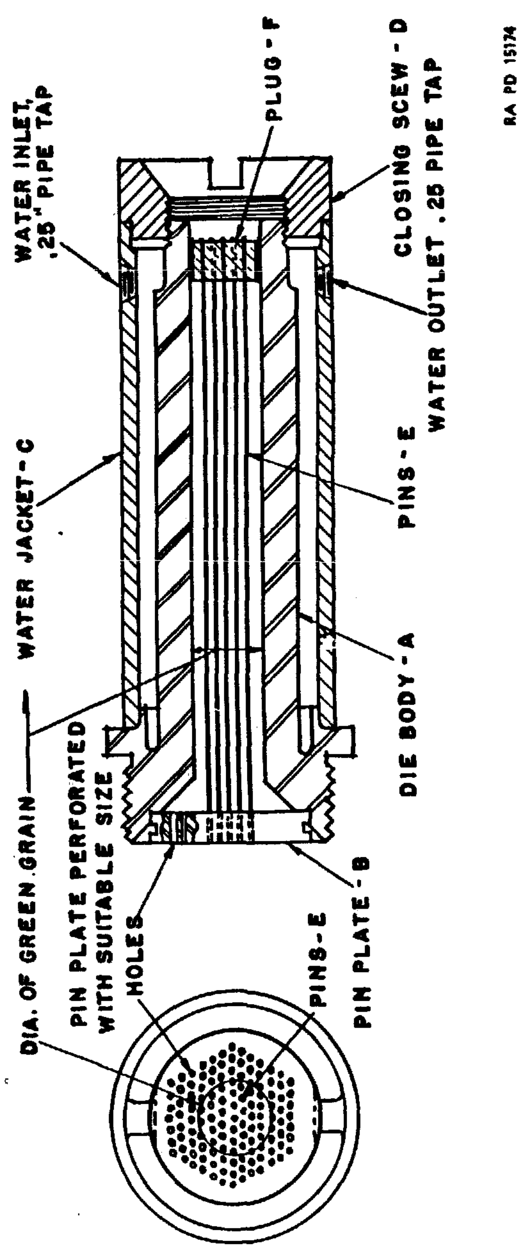


Figure 47 — Powder Die Assembly for Cylindrical Grains

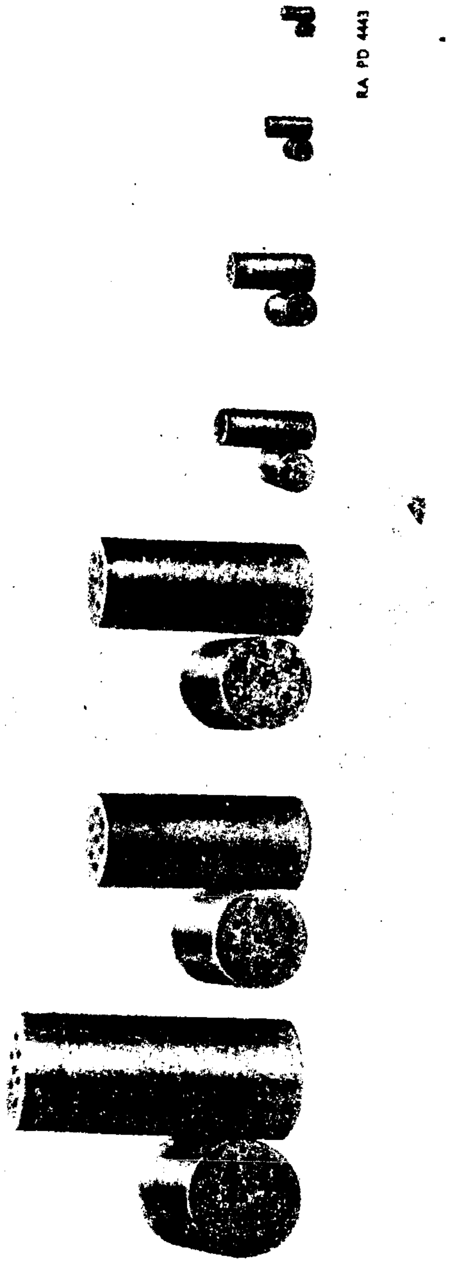


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Figure 48 — Typical Powder Grains

peated as long as necessary; large calibers requiring a greater length of time than smaller calibers. The rate of recovery is carefully controlled in order that an even removal of solvent will be obtained, and in order that shrinkage may be controlled.

VII. DRYING.

A certain amount of solvent is retained in the powder by specification as an additional factor in control of the burning rate. The drying process removes residual solvent to this point. It is more finely controlled than the solvent recovery process. Three processes are in use.

A. Air-dry. The most satisfactory from standpoint of stability. The powder is placed in bulk in narrow bins and subjected to heat. The time necessary to drive off the required amount of solvent, and the necessary temperature increases with larger calibers of powder. Laboratory test of samples indicates the end of the process. Control is essential since increase in percentage of retained volatiles reduces the rate of burning and the energy content of the powder. Thirty to 90 days are usually necessary.

B. Water-dry. The most satisfactory from the standpoint of time consumed. Warm water is circulated through the powder at a temperature of 25 C to 55 C. The powder after a few days of this treatment is air dried for another few days. The moisture content will, of course, be higher than that of air dried powders.

C. Continuous-dry. The powder is slowly run through a chute as warm air is passed through it. Baffles in the chute retard its progress. A shaking device controls the rate of progress. This process is most economical of time, and is also satisfactory from the standpoint of stability and fineness of control. 100,000 pounds of 75-mm powder may be dried by this system in 24 hours.

VIII. BLENDING.

In order to obtain uniformity of ballistics, lots of powder are thoroughly mixed or blended. This blending insures that all charges manufactured from a lot of powder will have similar ballistics. Lots range in size from 15,000 to 50,000 pounds for small arms and minor calibers to 100,000 pounds for larger calibers. The operation consists of transferring the powder by gravity from an upper to a lower bin. A baffle fans out the powder and insures proper mixing. A continuous cycle is the most recent development. Two buildings are placed 100 feet apart, each with upper and lower bins. Powder is transferred by conveyor belt from lower bins of one to upper bins of the other. Four complete cycles complete the blending. The powder is weighed into storage containers from the blending operation.

Disadvantage of Early Nitrocellulose Powders. The straight nitrocellulose or NC powders, if exposed to the atmosphere, were subject to change. Exposure to a humid atmosphere will cause absorption of water and a resultant reduction in the rate of burning and in energy. It will also cause deterioration of the powder by hydrolysis. As previously stated, the ether-alcohol solvent is not entirely removed, but is allowed to remain in percentages ranging from 3 to 7.5 percent for purpose of controlling ballistics. If the powder is exposed to a warm dry atmosphere, this residual solvent will escape with a resultant increase in the burning rate and energy of the powder. Ballistics will thus be affected.

Another objection to the NC powder was the large, brilliant muzzle flash produced upon firing. This flash aided the enemy in locating gun positions during night firing. The flash was caused by unburned propelling charge gases meeting the outside air at kindling temperature. Ignition and muzzle flash resulted.

Materials Added to FNH and NH Powders.

Diphenylamine (D.P.A.). This substance stabilizes the smokeless powder by combining with nitrous fumes given off as a result of deterioration. When nitrocellulose reacts with water, it hydrolyzes and reverts back to cellulose and free acid. The free acid is given off in the form of acidic gaseous oxides of nitrogen. The presence of these acidic fumes causes acceleration of the deterioration. The reaction builds up heat as it progresses until finally the kindling temperature of the nitrocellulose is reached and spontaneous ignition results. Diphenylamine by chemically combining with the acidic fumes prevents this acceleration of reaction as long as any of it remains present and uncombined. It thus prolongs the stable life of the powder.

Dibutylpthalate (D.B.T.). This substance is used as a cooling agent and as an inhibitor of hygroscopicity. It is an oily viscous liquid and is inert in the explosive sense. Since it is inert explosively, it cools the gases from the propelling charges below their kindling point and thus prevents muzzle flash when they reach the outside air. Since it is oily and viscous, it acts to sheer off water and thus overcomes the hygroscopic tendencies of the nitrocellulose. It is added during the mixing process of the formation of the colloid and replaces a portion of the volatile solvent necessary to the old NC powder. In this way, it reduces the percentage of volatile constituents present and thus the possibility of loss of volatile ingredients.

Dinitrotoluene (D.N.T.). This is used as a coat on certain small-arms powders to control the burning rate. Used as dinitrotoluene oil in larger calibers, it aids in reducing hygroscopicity. In reducing percentage of volatiles present, and being explosive in nature to a certain extent, it compensates, to a degree, for the loss in potential caused by incorporation of the explosively inert dibutylpthalate.

The terms FNH and NH are related to the caliber of weapons in which the powder is used. As weapons increase in caliber, the powder charge also increases, and at a rate in excess of the increase in length of gun barrel. In larger weapons, therefore, not enough D.B.T. can be added to cool unburned gases before they reach the muzzle of a comparatively shorter barrel, as related to the increase in weight of the charge. Generally speaking, FNH and NH powders have the same composition, the flashlessness depending upon the weapon in which the powder is used.

The potential of FNH and NH powders is somewhat lower than that of NC powders due to the addition of the inert cooling agent. However, it is not so much lower that the FNH and NH powders cannot be used in the same weapons as the NC powders without modification of the weapons.

Control of Burning Rate of Smokeless Powder. Three fundamental factors influence the burning rate of smokeless powder. These will best be considered individually:

1. Size and shape of grain. The rate of burning of a grain of powder is said to be degressive when the burning surface of the grain is reduced as the grain consumes itself. This results in the intensity of burning, and thus the amount of gases produced, lessening continually as the grain is consumed. Grains which exhibit a degressive rate of burning include strip, cord, and monoperforate types (fig. 49).

Conversely, the rate of burning is said to be progressive when the burning surface of the grain increases as the grain consumes itself. This results in the burning rate, and thus the amount of gases produced, increasing continually as the grain is consumed. Progressive burning is exhibited by multiperforate rosette or multiperforate cylindrical grains (fig. 49). It will be noted that perforated grains have either one or seven perforations. There are no intermediates.

When the multiperforate cylindrical grain burns, slivers which burn degressively are formed as the perforations enlarge through burning and meet the decreasing outer surface. In such weapons as the 12-inch seacoast mortars the barrel is not sufficiently long to allow complete burning of these slivers, and they are thus expelled from the muzzle in the unburned state. To reduce the amount of powder thus wasted, the sliverless grain was developed. This is commonly known as rosette (fig. 50).

2. The percentage of volatile and inert ingredients and retained moisture. The moisture retained in smokeless powder acts as an adulterant in the same way as it would in black powder. That is, it slows the burning rate and reduces the energy of the powder. The moisture reduces the energy of the powder and its rate of burning directly. For example, if a powder of 100 units of nitrocellulose has an energy

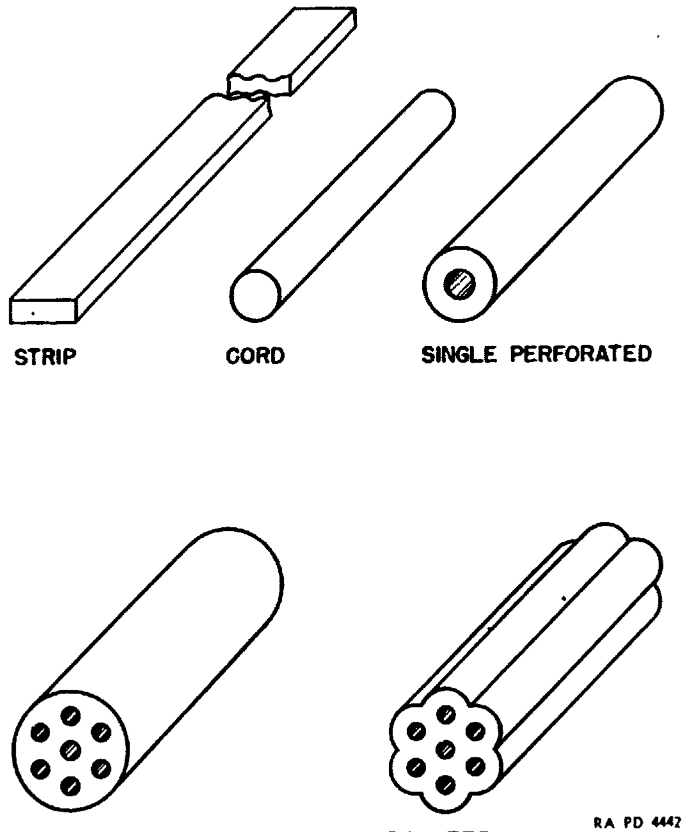

Figure 49 — Forms of Powder Grains

of 100, a powder of 99 units of nitrocellulose and one unit of moisture will have 99 units of energy.

Alcohol, ether, diphenylamine and other carbon and hydrogen compounds have a greater effect than does moisture because they utilize some of the energy of the powder to burn themselves. Their effect, if the effect of water is taken as one, would be as follows:

Water	1.0
Alcohol	2.5
Graphite	2.5
Diphenylamine	4.0

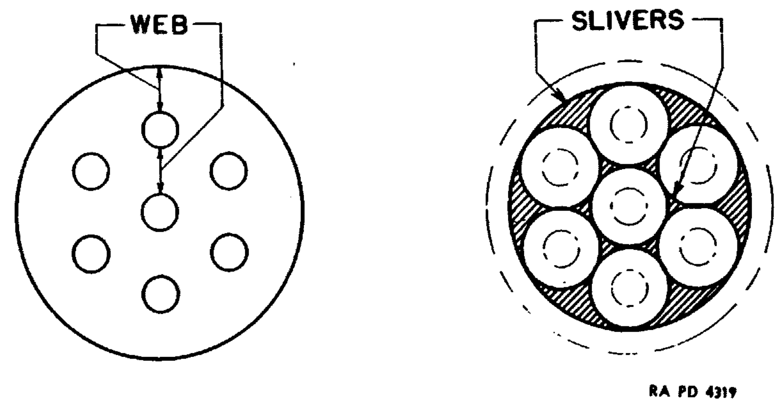

Figure 50 — Burning Grains

Other substances of like nature would influence the energy of powder in ratios corresponding to their carbon content and the readiness with which they will take part in the reaction.

3. The web average. The web of a powder grain is defined as the least burning thickness between parallel surfaces on a diameter. This factor is used as a control of the burning rate of multiperforate grains. As shown by the diagram (fig. 50), these grains will have two webs, an inner and an outer web. The web average is an average of these webs as shown. Powders having a thicker web are slower burning, and powders having a thinner web are faster burning.

Generally speaking, web thickness increases with caliber. However, shorter barreled weapons such as the howitzer and mortar will require thinner webs to achieve complete burning. Also, the larger the capacity of the powder chamber, the thicker the web of the grains.

Final Dimensions Factors in Design of Powder. Generally speaking, the weight of the projectile effects the design of powder since the heavier the projectile the thinner is the web required, consistent with the maximum chamber pressure.

Also, the greater the velocity desired the thicker is the web required, consistent with the maximum chamber pressure.

The maximum chamber pressure of any weapon is a constant. Therefore, an increase in weight of the projectile or an increase in velocity will require a slower burning powder, or in other words one of thicker web.

Causes of Deterioration in Smokeless Powder. Moisture causes hydrolysis of nitrocellulose with the evolution of nitrous fumes. Presence of fumes will cause acceleration of the deterioration, a building up of heat, and finally spontaneous ignition of the powder.

A specified percentage of volatile solvents and moisture is allowed to remain in the finished powder as a control of burning rate. Any change in this content will result in a change in ballistics, thereby making the powder useless from a ballistic standpoint.

Heat will accelerate any chemical reaction. Moisture and heat will, therefore, cause the powder to deteriorate more quickly than moisture alone.

Smokeless powder is kept in airtight containers. Fluctuating temperatures to extremes set up expansions and contractions which may cause leaks in the containers, and thus allow moisture to enter and volatiles to escape.

Packing and Marking. Smokeless powder is packed in accordance with the following general rules. Specific requirements for packing are covered in ordnance drawings, specifications, and directives.

The standard container for multiperforated nitrocellulose powders with web thickness of 0.019 inch and above is an all steel box of 110-pound capacity, constructed in accordance with ordnance drawings.

Standard containers for most double base powders, single perforated powders, and all powders with web thickness less than 0.019 inch are metal-lined wooden boxes, constructed in accordance with ordnance drawings.

For temporary storage, or transportation to loading plants, most powders may be packed in fiber containers in accordance with instructions issued by the Chief of Ordnance.

In addition to the marking required by Interstate Commerce Commission regulations, the following data should appear on smokeless powder containers: initials of the manufacturer whose formula is used; type of powder; manufacturer's initials; lot number; year of manufacture; caliber of gun for which intended; net weight.

Storage. The methods of piling bulk smokeless powder in boxes are shown on ordnance drawings. These drawings will be followed when new stock is piled, or existing stock rearranged.

Smokeless powder containers (bulk) are piled in double ranks, tops toward the aisles, and inclined at a 20-degree upward angle. This angle is to allow for insertion of methyl violet paper in container of powder undergoing inspection, without spilling of powder from the containers. Powder not as yet requiring inspection need not be stored at this angle. When restoring bulk powder containers which require inspection, a point should be made of keeping the methyl violet paper inserts uppermost.

The stability and useful life of smokeless powder are adversely affected if it is stored in a damp atmosphere or subjected to high temperatures. A combination of the two is particularly bad. Magazines for smokeless powder should be dry, and the ground around

them should be well drained. They should have a minimum variation in temperature and a free circulation of cool, dry air, except that a free circulation of air is not ordinarily required for smokeless powder stored in igloo magazines. Small-arms powders in bulk are stored in the same manner as cannon powders. As they may deteriorate more rapidly than cannon powders, the selection of proper storage magazines and the maintenance of good storage conditions are most important.

Smokeless powder in containers will not be exposed to the direct rays of the sun for any long period of time. Containers which cannot be placed promptly under cover will be covered with a tarpaulin placed so that air can circulate through the pile.

Rough handling of smokeless powder containers is prohibited, as seams may be opened in the containers or liners thus allowing air and moisture to enter the container, creating conditions which may seriously affect the life of the powder.

Surveillance. All bulk smokeless powder, except those lots manufactured within 15 years of date of inspection, will be inspected in accordance with the following procedure (see also, OFSB 3-13).

Each box will be opened. If the powder smells of nitrous fumes, or if the N/10 methyl violet paper has turned white, that box will immediately be segregated and subsequently be disposed of in accordance with regulations in OFSB 3-13. If neither of the above defects are found, a new dated N/10 methyl violet paper will be placed in the box, and the box returned to storage. If the amount of defective powder in any one lot equals 10 percent of the lot, the balance of the lot will be inspected thereafter at 6-month intervals.

Separate-loading propelling charges follow the same scheme except that inspection is not started until the powder has reached an age of 20 years from date of manufacture. Also the bags shall be removed from the cartridge-storage case for charges for 155-mm gun, 6-inch gun, 8-inch gun, 10-inch gun; 155-mm and 240-mm howitzers; and 12-inch mortars, and inspected for brown spots, odor of nitrous fumes, and general deterioration of the bag.

With charges for 12-inch, 14-inch, and 16-inch guns, the bags will not be removed unless the N/10 methyl violet paper shows signs of discoloration.

Segregated charges will be disposed of in accordance with regulations in OFSB 3-13. Satisfactory charges will be returned to storage with a new dated methyl violet insert.

Where the number of defective charges in any one lot reaches 10 percent, the balance of the lot will thereafter be inspected at 6-month intervals.

Maintenance. The principal maintenance activities are the repair of damaged containers and the replacement of defective covers and gaskets. Containers for bulk powder are not ordinarily air-tested in storage. They are substantially made and should not develop leaks after they have been filled and air-tested, unless they have been subjected to extremely rough handling.

Powder will not be stored or shipped in damaged containers. The outer or wood container usually can be repaired or replaced without removing the contents of the inner container. This work will be done in a suitable room or building, free from all other explosives or ammunition, or in clear weather, in the open, shaded from the sunlight at sufficient distance to comply with quantity-distance requirements, but in no case closer than 100 feet from any building containing explosives or ammunition. Safety tools will be used.

When the inner metal container is damaged, or when powder is to be repacked in new or serviceable containers, all repacking will be done in a suitable room or building, free from all other explosives or ammunition, where the powder will not be exposed to a damp atmosphere or the direct rays of the sun. Each container, in which powder is to be repacked, will be air-tested both before and after it is filled. This will be done with the air-testing apparatus used for testing the containers for separate-loading propelling charges, and using a special cover fitted with an air-test hole. The amount of powder at or near repacking operations will be limited to that in one open container and nine closed containers. The distance from nearby buildings containing explosives will be in accordance with the intraplant quantity-distance table, and in no case less than 100 feet. The inner metal container will not be repaired or soldered until precautions have been taken to insure that it contains no loose grains of powder or powder dust. Safety tools only will be used.

Fires. Careful study of the reports of several smokeless powder fires, which have occurred at ordnance establishments, shows that bulk powder in storage constitutes an unusual and severe fire hazard which in most cases can be confined to the building in which it originates. If a fire is discovered in a magazine, there is little chance that the building can be saved, and the efforts of the fire-fighting forces will be confined to protecting adjacent magazines. Because of the intense heat generated by burning smokeless powder, all fire-fighting equipment must be halted at least 200 yards from the fire, and all available cover utilized by the fire-fighting forces. A careful watch will be maintained for burning embers and grass fires in order to prevent the fire from spreading. If a fire occurs in a magazine or repacking room where employees are working, and involves only a small amount of loose powder (not more than 150 pounds), an effort should be made to control and prevent the spread of the fire.

NOTE: All types of smokeless powders, are class 2, except for the extremely fine flake powder of high nitroglycerine content used in

trench mortar ignition cartridges, which are class 9. In the case of the latter type, the powder will be stored as class 9 explosives as regards quantity-distance tables. Personnel engaged in combating fires involving this type powder will use the same precautions as for bulk high explosives.

EXPLOSION HAZARDS OF SMOKELESS POWDER.

When smokeless powder, other than the extremely fine flake powder, in bulk, of high nitroglycerine content as used in trench mortar ignition cartridges, is stored in magazines in containers or propelling charges, there is no evidence to indicate that fires will rise to any unusual hazards. Cases have been reported in which pressures sufficiently great to result in structural damage have occurred but which involved the burning or explosion of smokeless powder under circumstances not ordinarily encountered in the storage of the material in standard containers. It is known that pressures may develop when extremely fine bulk flake powder of high nitroglycerine content is burned under normal storage conditions; for this reason, powders of this type are considered class 9 explosives and are to be stored and handled as such. Normally, when other types of smokeless powders are burned under conditions encountered in storage, dangerous pressures do not develop. There is, however, evidence that explosions of nitrocellulose powders up to large grain sizes are capable of being propagated from box to box when initiated by the detonation of a high-explosive charge.

Safety Precautions. Smokeless powder exposed to extremely adverse conditions of moisture and temperature for a long period of time may ignite spontaneously. Care will be taken to protect powder from excessive temperature and moisture, as such conditions hasten decomposition. It always must be protected from the direct rays of the sun. If powder becomes wet or damp, or if there is any reason to suspect that it has been exposed to moisture, it will be segregated from other powder until it has been found satisfactory by stability tests. When leaking containers are discovered, an examination of the contents will be made for the odor of decomposing powder and the evolution of reddish fumes. If any such condition is observed, the powder will be segregated or disposed of in accordance with pertinent Ordnance Field Service Bulletins.

Powder will always be stored in containers, but should powder be spilled or powder dust accumulate, it will be removed immediately, as loose powder and powder dust are dangerous fire hazards. Dragging powder boxes over smokeless powder grains has been the cause of serious fires. Extreme care will be taken to guard against powder dropping into cracks and crevices or lodging in places where it may remain over a long period of time without being detected. It is believed that many fires have occurred from this cause.

In opening containers or repairing damaged boxes containing smokeless powder, safety tools will be used, and if powder is being repacked, the floor will be covered with tarpaulins, and safety shoes will be worn.

COMPOUND PROPELLANTS.

Ballistite. A double base compound propellant is a powder composed of nitrocellulose and nitroglycerine.

A single base compound propellant is a powder composed of nitrocellulose and other explosive factors.

Ballistite is our best example of a double-base powder. It is composed of: 60 percent nitrocellulose; 39 percent nitroglycerine; 0.75 percent diphenylamine; coating graphite.

It may be found in use as a propellant for trench-mortar ammunition and as a propellant for shotgun shells.

It is of satisfactory stability, the oily nitroglycerine content overcoming hygroscopic tendencies of the nitrocellulose.

E. C. Blank Powder. E. C. Blank powder is our best known single-based compound powder. It is composed of: 80.4 percent, nitrocellulose; 8.0 percent potassium nitrate; 8.0 percent barium nitrate; 3.0 percent starch; 0.6 percent diphenylamine.

It is used as a bursting charge for fragmentation hand grenades and as a filler for small-arms blank ammunition.

Storage. Compound propellants require similar precautions in storage and handling to those discussed for smokeless powder earlier in this chapter. They are not identical, however, and further study should be made before extensive handling of these powders.

FURTHER REFERENCES:

TM 9-2900; O.O. 7224, Ordnance Safety Manual.

Chapter 3

High Explosives

GENERAL.

When the entire field of high explosives is considered, the term "military high explosives" has a restricted application to a small number of substances. Those substances whose rate of decomposition is so rapid as to preclude their use as propellants, but which on the other hand bring about a very disruptive action are known as detonating substances, or more commonly as high explosives. The selec-

tion of various substances for use as a military high explosive are dependent on various factors.

Requirements for a Military High Explosive. The following factors must be considered in the selection of a substance for military use as a high explosive:

1. Availability of raw material. There are many high explosives which are excellent for use, but cannot be used for military purposes because the materials for their manufacture are not available in this country or from friendly neighbors. It is needless to mention that high explosives whose basic materials are available only in enemy territory are unsuitable for use as a military high explosive.

2. Cost of manufacture. Another factor to consider is the cost of manufacturing processes. The basic material may be available, but the machinery, the technical skill required in manufacture, and the danger involved may be so restrictive as to make the cost of its manufacture too expensive. An important point to note is the quantity of explosive desired for military use. That explosive which is used in great quantity must cost less than the explosive used in smaller quantities. For example, the TNT which is used in the greatest quantity as a military high explosive costs $0.14 to $0.25 a pound; tetryl which is used in smaller quantities as a military high explosive costs $0.60 to $1.00 a pound while mercury fulminate which is used in the least amount as a military high explosive costs $3.25 a pound.

3. Stability in storage. Military high explosives must not undergo decomposition in storage. Military high explosives manufactured today may be used years later, and therefore must be stored. High explosives which would deteriorate and be subject to change over a period of time not only under favorable conditions, but even under adverse conditions of storage, such as high temperature and humidity are not desirable for military use.

4. Hygroscopicity. A substance is defined as hygroscopic when it shows a tendency to absorb moisture. Such a characteristic, evidenced in a high explosive, indicates the possibility of this explosive to deteriorate in storage, or to corrode the casing in which it is inclosed.

5. Reaction with metals. High explosives for military use are usually loaded in metal shells, projectiles, and casings. A high explosive which reacts with metals will not only corrode its container, but in many instances will produce new, very sensitive explosive compounds: picric acid, for example, produces metallic picrates. These new compounds or high-explosive salts which are produced are much too dangerous to handle for military use.

6. Sensitivity to shock incident to loading, handling, and shipping. A high explosive used for military purposes must be loaded into the shell, handled, and shipped in large quantities. Many times it under-

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goes rough treatment during this procedure, treatment which will occur even with reasonable care in handling the explosive. A high explosive which will detonate under shocks which are unavoidable in its transit from the coarse high explosive to the firing point is decidedly not suitable for military purposes.

7. *Sensitivity to setback action in the weapon.* The force of setback that takes place in the barrel of the weapon illustrates a basic principal of physics. From Newton's law, it is known that objects at rest tend to stay at rest and that objects in motion tend to stay in motion. Setback is the force due to this fundamental principal of inertia. The shell with high-explosive filler and all its components are at rest when the shell is placed into the weapon. Suddenly the shell is propelled forward at a very high velocity. All components in that shell tend to fall back toward the base of the shell, and do so with terrific impact. Many high explosives under such conditions may explode. A high explosive for military use which is reasonably well loaded must not detonate in a weapon under such conditions.

8. *Brisance or shattering effect.* A very obvious requirement for a military high explosive is its ability to shatter its surrounding medium when properly initiated. A substance must have brisance or shattering effect to be considered suitable for a military high explosive.

9. *Suitability for its purpose.* Not all high explosives have the same brisance nor the same ability to be initiated by various external forces. A military high explosive on the basis of its characteristics is assigned to a certain use or purpose which is determined mainly by its brisance and sensitivity. It must be suitable for the requirements set forth for that purpose to be considered as suitable for military use. A further study of this point will be made in the chapter dealing with explosive trains.

It must be kept in mind that not all high explosives employed today for military use fulfil all the requirements desired, but several of the requirements are absolutely essential. Therefore, some disadvantages may be overcome in such a way that the military high explosive will meet the requirements deemed necessary for its use. For example, picric acid reacts with metals. This disadvantage can be overcome by painting the inside of the shell with a nonmetallic and acidproof paint. The requirements as listed, therefore, can be considered as those which depict the ideal military high explosive.

TRINITROTOLUENE (TNT).

General. Although trinitrotoluene was known as early as 1863, it was not suggested as an explosive until about 1890, and its importance from a military standpoint dates from 1904. Since that time, it has appeared as the principal constituent of many explosives, and has been used by itself under such various names as triton, trotyl,

tolite, trilite, trinol, tritolo, etc. It is commonly known in this country by the abbreviation TNT. The term trinitrotoluol, which is more generally used than trinitrotoluene, is less correct from the chemical point of view than the latter.

The importance of this explosive is based upon its relative safety in manufacture, loading, transportation, and storage, on the fact that it is not hygroscopic, on the lack of any tendency to form unstable compounds with metals, and upon its powerful, brisant, explosive properties.

Properties. *Color and solubility.* TNT usually resembles in appearance, light brown sugar, although in different grades of refinement or purity its color and appearance vary. When pure, it is a crystalline powder of very pale straw color. It dissolves readily in ether, acetone, alcohol, and various other solvents, but it is practically insoluble in water.

Classification. TNT is classified in U. S. Army Specifications into two grades designated as grade I, with a setting point of 80.2 C minimum, and grade II, with a setting point of 76.0 C minimum. Grade II is obtained directly by the nitrating process, while grade I must be prepared by recrystallization or by special chemical treatment of grade II material.

Safety precaution. Both grades of TNT are slightly toxic, and it is necessary that proper precaution be taken by those engaged in its manufacture or handling to avoid inhaling the vapors or dust from the molten or crystalline material. Good ventilation in manufacturing or shell loading plants is highly essential, and personal cleanliness should be enforced. All clothing should be changed upon the beginning and completion of work.

Stability. TNT is one of the most stable of high explosives, and when properly purified may be stored over long periods of time without alteration. It is quite insensitive to blows or friction, but can be detonated by severe impact between metal surfaces. When ignited by flame, it burns rapidly without explosion. Burning or rapid heating of large quantities especially in closed vessels may, however, cause violent detonation. It should therefore be melted in equipment so arranged that the maximum temperature of the melting unit cannot exceed 105 C.

Chemical action. While TNT has no tendency to form compounds with metals, thereby producing sensitive salts, it will react with alkalies such as sodium hydroxide or sodium carbonate to form unstable sodium salts which are quite sensitive. For this reason, the use of alkalies in purification of TNT is not permissible.

Detonation. TNT in crystalline form detonates readily under the influence of a No. 6 detonator (containing 1 gram of mercury fulminate). When compressed to a high density, it requires a No. 8

detonator (containing 2 grams of mercury fulminate), and when cast, it is necessary to employ a booster charge of pressed tetryl, or an explosive of similar high brisance, to insure complete detonation.

TNT may be classed as a "quick acting" explosive. It detonates at a rate varying from about 5,200 meters per second for loosely compressed material to nearly 7,000 meters per second for material cast or compressed to its maximum density.

Decomposition. The decomposition of TNT on explosion may be regarded as occurring according to one or both of the following reactions:

$$2C_6H_2(CH_3)\ (NO_2)_3 = 12\ CO + 2CH_4 + H_2 + 3N_2$$

or

$$2C_6H_2(CH_3)\ (NO_2)_3 = 12\ CO + 5H_2 + 3N_2 + 2C.$$

The deficiency in oxygen as indicated by both of these reactions is always apparent from the black smoke produced by the explosion of TNT. This deficiency of oxygen may be compensated for by addition of such substances as ammonium nitrate or sodium nitrate in various proportions, the resulting mixtures being designated as amatol and sodatol, respectively.

Manufacture. Manufacture of TNT involves the following processes:

1. Nitration of: toluene to mononitrotoluene; mononitrotoluene to dinitrotoluene; dinitrotoluene to trinitrotoluene.

2. Washing the finished product until free of acid.

3. Purification by remelting and chemical treatment or recrystallization.

4. Granulation, screening, and drying.

The detailed procedure involved in each of these steps will not be discussed here. It may be found in TM 9-2900, and other references indicated at the close of this chapter.

Uses. *Bursting charge.* Grade I TNT is slightly more expensive than grade II because it requires the additional purification. Grade I is used as the bursting charge for high-explosive shell, either alone or mixed with an equal weight of ammonium nitrate to form 50/50 amatol. (The TNT, in either case, being melted so that the shell is filled by a casting or pouring process.) Grade II is used only in 80/20 amatol, where it is mixed in the molten state with four times its weight of ammonium nitrate and filled into high-explosive shell by hand stemming or by means of a screw filling machine.

A charge of about 1¼ pounds of cast TNT in a 75-mm high-explosive shell weighing about 10 pounds breaks up the shell into approximately 400 fragments retained on a 4-mesh screen.

Other military uses for TNT are as a bursting charge for rifle grenades, airplane drop bombs, naval submarine mines, depth bombs, and as a constituent of propellent powder. In airplane bombs, it has

the disadvantage that penetration of the bomb by a rifle bullet may cause an explosion of the charge. This is also true of amatol, which is used extensively in drop bombs.

Demolitions. TNT is also used for military purposes in demolition work on bridges, railroads, etc., and for land mines placed under enemy trenches or fortifications. For demolition work carried on by the Corps of Engineers, the TNT is made up in the form of small, highly compressed blocks inclosed in a fiber container which protects them from crumbling in handling and renders them waterproof.

Airtight seal. TNT is used in conjunction with other explosives, such as amatol, to seal the amatol from moisture and to act as an efficient explosive to receive the detonating wave from the booster.

Blasting work. TNT has been demonstrated to be suitable for all kinds of blasting work where 40 or 60 percent dynamite is used and to give practically equal effects. It is well adapted for "adobe" shooting or "mud capping," terms applied to breaking up large rocks or boulders by means of a charge of high explosive placed on the rock and confined only by means of a shovelful of mud or wet earth thrown over it. Only quick-acting explosives can be successfully used for such work. Even in drill holes containing water, TNT gives excellent results because of the fact that it is insoluble in water. However, its use for blasting has been negligible because of the fact that it is expensive as compared with commercial dynamites.

Detonating fuse. "Cordeau Bickford," a trade designation for detonating fuse, consists of a flexible lead tube, smaller in diameter than a lead pencil, filled with TNT. It is quite extensively used in certain blasting operations, especially for insuring complete detonation of large charges of dynamite. The detonating fuse, being passed through the entire length of the charge and detonated at its external end by means of an ordinary blasting cap, transmits its high rate of detonation to the entire charge of dynamite.

AMMONIUM PICRATE (EXPLOSIVE D).

General. The use of ammonium picrate as an explosive was patented by Nobel in 1888 (Mosenthal, Jour. Soc. Chem. Ind., Vol. 18, p. 447, May, 1899), although even prior to that time Brugere made use of a mixture of ammonium picrate and sodium nitrate as a propellent explosive.

The importance of ammonium picrate as a military explosive is due entirely to its marked insensitiveness to shock and friction, which makes it well suited for use as a bursting charge in armor-piercing projectiles. From the standpoint of brisance, however, this explosive is inferior to TNT.

Properties.

Color and solubility. Ammonium picrate is soluble in water, crystallizing from its solution in orange-yellow needles darker in color than picric acid. It resembles picric acid in its bitter taste and property of dyeing the skin, clothing, etc., of those engaged in its manufacture or handling.

Hygroscopicity. It has a much greater tendency to absorb moisture than has picric acid, samples having been found to absorb over 5 percent by weight of water during storage for 1 month in an atmosphere saturated with moisture.

Chemical action. Like picric acid, ammonium picrate can react with metals to form metallic picrates, but it reacts with much less readiness than picric acid; in fact, when dry its action is almost negligible. Wet ammonium picrate reacts slowly, especially with copper or lead, to form picrates which are particularly sensitive and dangerous.

Heat action. Ammonium picrate does not melt on heating, but explodes when heated to a temperature of about 300 C. Small traces of metallic picrates may however lower this ignition temperature appreciably.

Sensitivity. Ammonium picrate is the least sensitive of all military explosives used as the bursting charge for shell. Its insensitiveness to shock accounts for it being given preference over TNT or amatol as the bursting charge for armor-piercing, base-fuzed shell. It is also more insensitive to detonation by means of mercury fulminate than is TNT. At a pressure of about 12,000 pounds per square inch the two explosives have the same densities, about 1.48.

Toxicity. Like TNT and picric acid, ammonium picrate liberates free carbon on explosion, giving a black smoke. The products of explosion, although more disagreeable in odor, are less poisonous than those from TNT and picric acid in that they contain less carbon monoxide.

Manufacture.

Process. The manufacture of ammonium picrate consists in the main of a simple neutralization of picric acid by means of ammonia either alone or in combination with ammonium carbonate. This process is not attended with any serious manufacturing difficulties or dangers, provided one excludes the possibility of leaking ammonia pipes.

Detailed presentation of the manufacturing methods may be found in references listed at the close of this chapter.

Use. As has been mentioned, ammonium picrate is used as the bursting charge for armor-piercing shell on account of its insensitiveness to shock which permits the shell to pass through the armor without exploding. Owing to the fact that it cannot be melted without decomposing, it must be loaded into the shell by pressing. The interior of the shell is covered with a suitable nonmetallic paint or

varnish. It has no commercial use as an explosive, although it enters into the composition of numerous patented blasting explosives which have not been used to any great extent.

Storage.

Regulations. Storage of ammonium picrate is governed by the same regulations as are applicable for the storage of TNT both as to type of magazine and rules for handling, and special regulations governing this particular explosive are not necessary.

Special precautions. Ammonium picrate which has been pressed at a shell-loading plant and removed from a shell is very much more sensitive to shock or blow than new material, and there are cases on record where serious accidents have happened in the loading of shell with ammonium picrate so treated. If it becomes necessary to store this material, special precautions should be observed to protect it against shock or fire, and it preferably should be stored in a building by itself.

Although less sensitive than TNT, ammonium picrate can be exploded by severe shock or friction, is highly inflammable, and when heated to a high temperature may detonate. It is therefore necessary that it be treated with proper care as a high explosive.

Magazines. Since it absorbs moisture, it should be stored in dry magazines and protected from dampness. Moisture, however, has no effect on ammonium picrate except to reduce its explosive strength and its sensitiveness to detonation.

Containers. Ammonium picrate is always stored in wooden containers because of the possibility of its forming metallic picrates in contact with metals, especially when moist.

PICRIC ACID.

General. Picric acid or trinitrophenol was first adopted as a military high-explosive by the French Government in 1886 under the name of melinite, and has since been used to a greater or less extent by almost all countries with or without addition of various materials intended to reduce its melting point. The British explosive designated as lyddite and the Japanese explosive schimose are both cast picric acid, and various names are given to other shell explosives the chief component of which is picric acid.

Properties.

Color and solubility. Picric acid is a lemon-yellow, crystalline solid, only slightly soluble in cold water but soluble in alcohol, benzene, and other organic solvents. A very small amount is, however, sufficient to color a large volume of water a distinct yellow color. It likewise stains the skin of workmen, colors clothing, hair, and everything else with which it comes in contact, and has an exceedingly persistent, disagreeable, bitter taste. Its property of coloring is utilized in the dye industry, and in fact, picric acid was long known as a dyestuff before its explosive nature was discovered. It has no tendency to absorb moisture from the air.

Heat action. Picric acid melts at a temperature of about 122 C when pure, and is usually required for explosive use to have a melting (or solidifying) point of at least 120 C.

Chemical action. Being an acid, it has the property of combining with ammonia and alkalies and with many of the metals, forming salts which are called picrates. Some of the picrates are much more sensitive than picric acid itself, and it is therefore necessary that formation of these picrates be avoided by keeping picric acid from direct contact with those metals with which it readily reacts.

Precautions. Picric acid is not as toxic as TNT and the chief danger in connection with its use is probably the fumes given off from the molten explosive in loading shell. While practically no trouble from poisoning results in manufacture or handling of picric acid, care must be taken, however, to avoid breathing the large amounts of picric acid dust that may arise in screening or packing the dry material.

Stability. Picric acid is entirely stable. It has no tendency to decompose at any temperatures which it might meet in storage. On sudden heating at temperatures much above its melting point (122 C) it may explode, although many cases are noted where considerable quantities of picric acid have burned without explosion. Presence of any trace of explosive that will detonate more readily such as metallic picrates may cause sudden detonation of burning picric acid.

Detonation. It has about the same sensitivity to shock or friction as TNT and is somewhat more readily detonated by means of a detonator. Picric acid is one of the most powerful of military explosives. Its high strength or concussive effect is due to its high rate of detonation which, for the cast or highly compressed explosive, is about 7,000 meters per second, slightly greater than that of TNT under the most favorable conditions. By both the Trauzl lead block test and the ballistic pendulum test, picric acid shows appreciably greater strength than TNT, being exceeded only by tetryl and TNA. The results of these methods of testing are confirmed by actual fragmentation tests of high-explosive shell where it is found that a larger number of shell fragments are produced from picric acid than from TNT at equal loading densities.

Use. The fact already noted that picric acid combines readily with some metals to form picrates which are unduly sensitive to friction, shock, or heat has been detrimental to the use of picric acid for military purposes in spite of the fact that it is a stronger explosive

than TNT. When a nonmetallic lining is used for the shell cavity as for instance, certain lacquers, varnishes, or paints, danger of formation of these salts is obviated to a great degree. Introduction of TNT as a military explosive has resulted in gradual abandonment of picric acid by practically every country except France where it was largely used during World War I. In the United States, it is used for conversion into "Explosive D" or ammonium picrate which is used in base-fuzed shell for seacoast cannon. Picric acid has also found use as a booster explosive and even as a substitute for part of the mercury fulminate charge in detonators.

Picric acid has been used extensively in the form of mixtures with other nitro compounds. Such mixtures, having a lower melting point than picric acid, can be melted and cast at temperatures below 100 C. The mixtures are more generally practicable because of the hazard involved in melting picric acid at the relatively high temperature required. Some of the compounds which have been used with picric acid are trinitrotoluene, trinitrocresol, trinitrobenzene, and the dinitro and mononitro derivatives of phenol, cresol, and naphthalene. Little, if any, change in brisance results from the addition of the trinitro compounds, but the addition of the mono and dinitro compounds causes a reduction in brisance in proportion to the amount added.

Storage. Rules governing storage of dry picric acid are the same as for TNT. Dimension of magazines should not exceed 42 by 26 feet. It is necessary that all dust accumulating from dry picric acid should be carefully removed from any point in or around the buildings, conveyors, or cars. Although dust originating from this source is not as dangerous as that from black powder, it is nevertheless a matter of record that serious explosions have been caused from this source. Safety shoes must be worn in every instance where picric acid is being handled.

NITROSTARCH EXPLOSIVES.

General. During World War I, certain explosives having nitrostarch as a base were used under the designations "Trojan grenade explosive," "Trojan trench-mortar shell explosive," and "Grenite." These explosives were frequently referred to as "nitrostarch," but it should be noted that pure nitrostarch was not used alone as a military explosive, the nearest approach to it for military purposes being grenite, which was about 95 percent nitrostarch, the balance being a binding material added for the purpose of granulating. The two Trojan explosives which were practically identical in composition contained approximately 25 percent nitrostarch with ammonium nitrate, sodium nitrate, and small amounts of materials added for the purpose of stabilizing, reducing sensitiveness and hygroscopicity, and neutralizing any possible acidity of other ingredients.

These nitrostarch explosives were used for the reason that at the time the United States entered the war a decided shortage of TNT was indicated and investigation showed nitrostarch explosives to be entirely suitable for trench warfare purposes and to offer the advantages of low cost and ample supply of raw materials, etc.

Properties.

Color and solubility. Nitrostarch is a white, finely divided material similar in appearance to ordinary powdered starch. When observed under the microscope, there is no appreciable difference between nitrated and unnitrated starch until the granules are treated with iodine, which colors the unnitrated starch blue but does not affect the nitrated product. Nitrostarch is insoluble in water and does not gelatinize or form a paste when heated with water, thereby differing from starch. The grade of nitrostarch ordinarily employed contains from 12.50 to 12.75 percent nitrogen; that prescribed for military purposes contains at least 12.80 percent. All nitrostarch is readily soluble in acetone, solubility in ether-alcohol in general increasing as the nitrogen content decreases. It has no great tendency to absorb moisture from the atmosphere beyond the amount of 1 to 2 percent.

Trojan grenade or trench-mortar shell explosive differed greatly in appearance and in certain of its properties from straight nitrostarch, being of grayish-black color and of about the consistency of ordinary brown sugar, having a slightly damp feel and tendency to pack under compression due to the small amount of mineral oil contained as an ingredient. This oil, besides decreasing the sensitiveness of the explosive to ignition and to shock or friction, helped to reduce its attraction for moisture, the mixture of ammonium nitrate and sodium nitrate which it contained being very hygroscopic. In spite of this coating of oil, the Trojan explosive when spread out in a thin layer in a damp atmosphere rapidly absorbed moisture to such extent that it became decidedly wet. Under ordinary working conditions, therefore, great care was taken in loading this explosive to avoid absorption of an undesirable amount of moisture.

Grenite, which was almost entirely pure nitrostarch with addition of a small amount of oil and a binding material, differed greatly in appearance from Trojan explosive, being in the form of small, white, hard granules which flowed freely without sticking together. Since it contained no ammonium nitrate or other hygroscopic materials, Grenite had no particular tendency to absorb moisture even in damp atmospheres.

Sensitivity. Pure dry nitrostarch is more sensitive to impact than TNT but less sensitive than dry guncotton or nitroglycerin. As mentioned above, it is highly inflammable and readily ignited by the slightest spark such as may result from friction, and like black

powder, burns with explosive violence. It is readily detonated by a mercury fulminate detonator.

Trojan explosive and Grenite were both much less sensitive than straight nitrostarch, being required to pass the pendulum friction test of the United States Bureau of Mines and the rifle bullet test when packed in pasteboard containers. In heavy metal containers, these explosives frequently ignited and burned when penetrated by a rifle bullet, and in rare instances exploded under this test. Trojan explosive was especially insensitive to ignition, being rather difficult to ignite with the flame of a match when spread out unconfined. When once ignited, however, especially in any quantity, it burned freely with a light-colored smoke.

Detonation. Nitrostarch explosives were readily detonated by mercury fulminate detonators, a No. 6 detonator containing 1 gram of fulminate composition, producing complete detonation unless the explosive had been rendered unduly insensitive by absorption of excessive moisture or by other cause.

Stability. Early attempts to manufacture nitrostarch resulted in production of material which was unstable, and numerous statements found in literature of explosives refer to nitrostarch as being unsatisfactory for use as an explosive because of sensitivity and instability. However, manufacturers in this country succeeded in placing on the market nitrostarch explosives which proved highly satisfactory in these respects and found considerable application as blasting explosives. Developments led to a product which met requirements prescribed for military explosives. However, the Trojan explosive if allowed to absorb undue quantities of moisture, especially in a warm atmosphere, tended to deteriorate, being quite similar to nitrocellulose in this respect.

Use.

Trojan explosive. The Trojan nitrostarch explosive was used as the bursting charge for hand grenades, rifle grenades, and trench-mortar shell. It was well adapted to such purposes, but was not considered for use as a bursting charge for high-explosive gun shell. Its physical consistency was such that it was loaded into grenades through the small filling hole by means of vibrating machines, the explosive being "jarred" into the grenade through small funnel openings. Trench-mortar shell were loaded by hand-stemming.

Grenite. Grenite was used only for grenades and was considered too sensitive for use as a trench-mortar shell explosive. Being granular and "free-running," it was readily loaded into the grenades through funnel openings, no attempt being made to pack it to a high density.

Nitrostarch. Nitrostarch has been considered for the manufacture of smokeless propellent powder and numerous attempts have been made to develop a satisfactory powder of this type, but the problem cannot as yet be considered solved.

Nitrostarch explosives, similar to Trojan grenade explosive, have been used for a considerable number of years as blasting explosives for use in mining, quarrying, and other engineering operations, and have met with considerable success as substitutes for the more expensive nitroglycerin explosives.

There has recently been adopted, after thorough investigation, a nitrostarch demolition explosive as a substitute for TNT. This explosive is somewhat similar to that used during the World War, but the formula has been modified by raising the nitrostarch content and the replacement of the ammonium nitrate with barium nitrate. It can be consolidated into blocks in the same manner as TNT, and in comparison tests it has been found that the TNT formula for computing small charges are directly applicable to the nitrostarch demolition explosive.

Storage. Storage of nitrostarch explosives, in general, is mainly a fire risk, that is, the danger accompanying storage is more one of fire than of explosion. However, burning may proceed at such a rate as to be almost explosive in nature, and the fact that nitrostarch can be exploded by impact should not be overlooked.

Magazines. Magazines should be kept at as low temperatures as possible in order to avoid as much as possible the tendency of nitrostarch to undergo decomposition on heating. A reasonably dry atmosphere in magazines is also essential for the Trojan explosive. This explosive was not suitable for storage in bulk in wooden containers because of its hygroscopicity. Even when loaded into grenades it tended to absorb moisture. Long contact of the explosive with the metal parts of the grenade, either iron, brass, or copper, resulted in corrosion.

Handling. There is no danger of poisoning of any kind connected with the handling of nitrostarch explosives.

TETRYL.

General. The high explosive commonly known as tetryl is trinitrophenylmethylnitramine. It is a derivative of benzene and is therefore in the same class of aromatic nitro compounds as TNT. Tetryl was first synthesized by Mertens in 1877. It did not acquire prominence as a military explosive until World War I when it was used as a booster explosive.

Properties.

Chemical and physical. Tetryl is a fine crystalline powder of a yellow color, practically insoluble in water but soluble in acetone, benzene, and other solvents. It is readily recrystallized and can therefore be obtained in very pure condition if desired. It melts when pure between 129 C and 130 C. Tetryl is poisonous when

taken internally, and precaution is necessary in its manufacture, especially regarding the dust encountered in handling and packing the dry material. It has a higher nitrogen content (24.4 percent) than any other military explosive. Tetryl is practically nonhygroscopic, absorbing less than 0.1 percent moisture when stored for several days in a saturated atmosphere.

Stability and sensitivity. Tetryl is stable at all temperatures which may be encountered in storage. When heated above its melting point, it undergoes gradual decomposition and explodes when exposed to a temperature of 260 C for 5 seconds. It is more sensitive to shock or friction than TNT, being of about the same order of sensitivity as picric acid. It is slightly more sensitive to detonation by means of mercury fulminate than TNT, and is readily exploded by penetration of a rifle bullet.

Detonation. Tetryl has been found to have a rate of detonation somewhat higher than the maximum rate obtained with TNT (7,000 meters per second). Strength tests such as the Trauzl lead block test show tetryl to be stronger than any other military high explosive, the average expansion produced in the lead block for the more common military high explosives being as follows: tetryl, 320 cubic centimeters; picric acid, 300 cubic centimeters; TNT, 260 cubic centimeters.

Use. *Charges.* The high-explosive strength and brisance of tetryl would seem to adapt it for use as a bursting charge, but its sensitivity to mechanical shock is such that if used as a shell filler it would not withstand shock of discharge of the gun. It is, however, sufficiently insensitive that when compressed into a booster it is perfectly safe. In this condition, it is readily detonated by the detonator in the fuze of the shell, and the violence of its detonation insures a high order of detonation of the bursting charge.

Tetryl has been adopted as a booster explosive. Formerly it was combined with TNT (grade I), the two explosives being usually loaded separately into the booster casing in the form of highly compressed pellets.

Detonator. It is also used in detonators for both military and commercial purposes as a base charge, the tetryl being pressed into the bottom of the detonator shell and then covered with a small priming charge of mercury fulminate, lead azide, or other initiator.

Storage and Handling. The same precautions should be observed in storage and handling of tetryl as in the case of other sensitive high explosives. It should be kept dry because moisture interferes with its effectiveness. It must be properly protected from bullet fire in brick or hollow tile magazines with iron doors and window shutters. Detonators, blasting caps, fuzes, dynamite, etc., must not be stored with tetryl. Rubber soled shoes should be worn in magazines and every precaution taken to prevent ignition or explosion from friction or blows due to rough handling.

MERCURY FULMINATE.

General. Mercury fulminate is one of the explosives used for bringing about detonation of high explosives. It detonates completely and with great violence on ignition by means of a flame such as the spit from a fuze or by means of an electrically heated wire. This fact, together with its property of initiating detonation of other explosives, makes it a most suitable detonator material.

Properties.

Color and solubility. Mercury fulminate is a heavy, crystalline solid, white when pure, but ordinarily of a faint brownish yellow or grayish tint. It has practically no tendency to absorb moisture from the atmosphere. It is only slightly soluble in water, 100 parts of water at 15.5 C (60 F) dissolving less than 0.01 part of fulminate, and may be kept in contact with water for long periods of time without undergoing change.

Size of crystals. Size of the crystals of mercury fulminate is an important factor, since it has been determined that very finely divided fulminate consisting mostly of fragments of crystals and usually containing an excessive amount of impurities is less efficient in detonating value and strength than larger crystals. In specifying the size of crystals desired, however, consideration has been given to the possibilities of controlling this feature in manufacture and also to the fact that there is some reason to believe that very large crystals of fulminate are more sensitive to friction or shock than smaller ones. As indicated below, U. S. Army specifications for mercury fulminate prescribe definite limits for the size of the crystals.

Impurities. Mercury fulminate is required by U. S. Army specifications to be at least 98 percent pure and the amounts of impurities which it may contain are strictly limited. The most objectionable impurities are:

Free metallic mercury, for the reason that it readily attacks copper or brass with which it may be in contact when loaded into fuzes, detonators, or primers, causing the metal to become brittle.

Acidity, which would cause deterioration of the explosive composition and corrosion of metal parts.

Insoluble material such as sand and grit, which might cause explosion of the dry fulminate in loading operations.

If improperly manufactured or incompletely washed, the fulminate may also contain various compounds of mercury which might produce decomposition and would certainly diminish explosive efficiency.

Stability. Mercury fulminate has been kept for long periods both dry and wet, and is believed to undergo practically no change when properly manufactured and stored. However, when stored either wet or dry at tropical temperature gradual deterioration takes place. It has been found that when stored at 35 C (95 F), mercury fulminate deteriorated to the point of malfunctioning in about 3 years and at 50 C (122 F) it deteriorated to practically the same degree in 10 months. It is never stored in quantity in dry condition except when loaded into detonators, fuzes, or primers for the reason that when dry it is readily detonated by friction or shock. Whereas, the great majority of high explosives will burn without detonating when ignited by a flame especially if a relatively small amount of the explosive is ignited, mercury fulminate is one of the so-called "primary" or "initiating" explosives which detonate completely on being heated to their ignition point by means of a flame or hot wire.

The presence of even small amounts of moisture in mercury fulminate greatly reduces its efficiency, and as little as 1 percent is said to cause failure to detonate. However, fulminate completely saturated with water may be detonated by detonation of dry fulminate in contact with it.

Sensitivity. By usual methods of determining ignition temperature, mercury fulminate detonates at a temperature of about 180 C (about 356 F), but under varying conditions detonation may result at much lower temperatures. Sensitivity to shock is much greater at elevated temperatures than under storage conditions.

When loaded into commercial detonators, mercury fulminate is usually compressed at pressures of about 3,000 pounds per square inch. In this condition, its explosive properties are not appreciably different from those of loosely compressed material. At greater densities obtained by higher pressures, there is a gradual reduction in sensitivity, until at such extreme pressures as 25,000 to 30,000 pounds per square inch fulminate entirely loses its property of detonating when ignited and will only burn. In this condition, it is referred to as "dead pressed." If, however, such highly pressed fulminate is initiated by loose fulminate or other initial detonating agent, it will detonate at even higher rates than are obtainable at low densities.

Although fulminate can be pressed under very high pressures without explosion, the presence of any particles of sand or grit is very dangerous in any pressing operation. Presses for loading are always carefully protected by heavy barricades, and no one is permitted to be near the press during operation.

The readiness with which dry mercury fulminate detonates from the effect of blows or friction is the chief reason for the fact that its transportation and storage in the dry state is not permitted. Tests with a special type of impact machine showed that mercury fulminate detonated from the blow of the falling weight dropped from a height of only 2 centimeters (about 0.8 inch), while TNT in the same apparatus required a drop of about 120 centimers (48 inches).

Detonation. For a number of years, mercury fulminate was considered to have special properties which made it an especially favorable initiating agent and numerous theories were advanced to account for its so-called "unique" properties. As a matter of fact, mercury fulminate has been used only because of its extreme sensitivity to flame or impact. In all other respects, mercury fulminate is inferior to other high-explosives such as TNT, tetryl, and picric acid as a detonating agent. For example, mercury fulminate has a rate of detonation of about 4,000 meters per second as compared with 6,800 meters per second for TNT under the same conditions. In the Trauzl lead block test, mercury fulminate produces an expansion of 213 cubic centimeters and TNT 260 cubic centimeters. The trend in military and commercial detonators for the past several years has been gradual replacement of the major portion of the fulminate charge with some high explosive to increase efficiency of the detonator, the fulminate being used only as a cover charge to initiate detonation of the high explosive forming the base charge in the detonator.

Use. Mercury fulminate is used only for the purpose of bringing about the detonation of other high explosives or the ignition of propellent explosives. In detonators for commercial or military use it may be used alone or mixed with from 10 to 20 percent of potassium chlorate. The usual grades of detonators contain from 15 to 30 grains of fulminate or its equivalent.

The ignition of propellent explosives, for example, smokeless or black powder in small arms cartridges, is effected by the flame from a primer or cap, the charge of which is usually a composition containing mercury fulminate mixed with other flame-producing materials such as potassium chlorate and antimony sulfide. The primer is initiated by impact of the firing pin.

Storage. Mercury fulminate is always stored thoroughly saturated with water.

When left in the barrels during storage, regular inspection must be made to insure that the barrels are kept always full of water and are not leaking.

Fulminate must not be stored with any other explosives for the reason that explosion of even a relatively small amount of dry fulminate may cause detonation of the wet material, effect of which might be to detonate any other high explosives stored in the same building.

In case of breakage, or other cause by which wet fulminate may be spilled on the floor, it must not be allowed to dry out before cleaning up. Dry fulminate is very sensitive to friction and must be

handled with extreme care. Spilled fulminate may be destroyed by washing floors, benches, etc., with a saturated solution of sodium thiosulfate (photographer's "hypo").

AMATOL.

General. Amatol is a mixture of ammonium nitrate and TNT. Due to the shortage of toluene during the early stages of World War I, the British Government developed this explosive and adopted it after exhaustive tests as a bursting charge for high-explosive shell. The United States Government shortly after its entrance into World War I and for similar reasons authorized its use as follows: 50/50 for shell from 75-mm up to and including 4.7 inches; 80/20 for shell from 4.7 inches up to and including 9.2 inches. The ingredients are mixed by weight. The first figure refers to ammonium nitrate, the second to TNT.

Properties. Amatol is hygroscopic, insensitive to friction, but can be detonated by severe impact. It has no tendency to form dangerous compounds with metals other than copper. It is more insensitive to explosion by initiators than TNT. 50/50 amatol has approximately the same rate of detonation and strength as TNT, but 80/20 amatol is slightly lower in rate of detonation and brisance. On detonation the ammonium nitrate oxidizes the excess carbon of the TNT with the result that 80/20 amatol produces a white smoke on detonation and 50/50 amatol produces a black smoke which is not as dark as that produced by straight TNT.

Manufacture. *50/50 amatol.*

Ammonium nitrate as received may contain some moisture and must be dried to a moisture content of not more than 0.25 percent. Caking may have occurred in barrels or drums in which it was shipped. To break up the lumps, it is often necessary to first run the material through a crusher, after which it is dried to the proper moisture content. After drying, the material is screened to remove any foreign material with which it may have become contaminated. It is now ready for addition to molten TNT. The speed of adding ammonium nitrate to TNT can be increased greatly if the ammonium nitrate can be added while it is still hot. It must be added at a rate so that no solidification of the molten TNT takes place in the melting kettle. Proportions for use in mixing 50/50 amatol range from 45 percent to 55 percent ammonium nitrate. This variation is permitted to take care of the various granulations, fine material requiring more TNT than coarse material. Temperature of the mixture when it is ready for pouring into the shell is 80 C to 85 C.

80/20 amatol. 80/20 amatol is a plastic mass resembling wet brown sugar and cannot be loaded by the casting method. The principal

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difficulty experienced with 80/20 amatol is to obtain ammonium nitrate which has proper granulation. With very fine material, plasticity of the mass is such that when loaded the density falls below the point desired, namely, not less than 1.38. With coarse material molten TNT is not completely absorbed, and a relatively large amount leaks out in the extruding operation which results in a charge of low density. It is, therefore, essential that granulation be such as to give a mixture which will not permit leaking of TNT and which will be sufficiently plastic to consolidate well from the extruder. It has been found that a mixture of coarse and fine material is the most suitable for this operation. Granulation requirements are through a No. 10 U. S. standard sieve not less than 99.0 percent; through a No. 10 on No. 35, 32 to 48 percent; through a No. 100, 15 to 30 percent.

Preparation of 80/20 amatol is conducted in a mixing kettle having a capacity of about 500 pounds of amatol. The correct amount of ammonium nitrate is added to the kettle and heated to the point where solidification of TNT will not occur. When the ammonium nitrate has been raised to at least 90 C, molten TNT is added, and the charge thoroughly mixed for 15 minutes. At the end of this time, it is transferred to the extruding machine from which it is forced into the shell by means of a screw working inside of a steel tube. This machine is counterweighted so that the material is forced into the shell under a definite pressure.

LEAD AZIDE.

General. Lead azide was first prepared and identified by Curtius in 1891, and in 1893 Will and Lenze began an investigation of lead azide as a military explosive. About 1910, commercial manufacture of lead azide was started abroad and has continued up to the present time. Since 1931 it has been produced commercially in this country. This commercial lead azide is free from needle crystals having a maximum dimension greater than 0.1 mm.

Properties. Lead azide (PbN_6) is an initiating compound used for bringing about detonation of high explosives. It is sensitive to flame but is too insensitive to be used alone where initiation is by impact of a firing pin. Lead azide is practically insoluble in water and its hygroscopicity at 30 C and 90 percent relative humidity is only 0.03 percent. It is not easily decomposed by heat as shown by surveillance tests where it has been stored for 15 months at 80 C without any noted impairment in sensitivity or brisance.

Storage. Lead azide is always stored thoroughly saturated with water. It is stored and handled in the same manner as mercury fulminate. Spilled lead azide may be destroyed by washing floors, benches, etc., with a solution of ammonium acetate.

PENTAERYTHRITE TETRANITRATE (PETN).

General. Pentaerythrite tetranitrate, commonly known as PETN, is derived from the nitration of pentaerythritol. PETN is considered by the Interstate Commerce Commission as an initiating agent. It must be packed wet with not less than 40 percent by weight of water in metal barrels, or wooden kegs, in which the material is packed in cloth or rubber bags.

Sensitivity. PETN is more sensitive than tetryl, but not as sensitive as mercury fulminate.

Uses. PETN is used in detonating cord, commercially known as Primacord. Primacord is a flexible, waterproof fabric tube $^{13}/_{64}$ inch (0.203 inch) in diameter with an explosive core of PETN; which has the velocity of detonation of about 20,300 feet per second. In this form, PETN is quite insensitive to shock, flame, or friction, and requires a cap to detonate it. It is now issued in 100-foot spools, is greenish yellow in color, and has a relatively rough waxy surface. These characteristics are not definitely dependable, however, for positive identification of present or future issues.

The extreme violence of a primacord explosion is sufficient to detonate high explosives in intimate contact with it. Hence, it is valuable for safe priming of charges in drill holes and for the simultaneous firing of a number of charges at some distance apart.

PETN has a second use in that it is used in conjunction with TNT to form pentolite, a bursting charge for certain types of ammunition.

TRIMONITE.

Trimonite, like amatol is specified as a substitute explosive for shell and bomb loading.

It is composed of 88 percent picric acid and 12 percent alphamononitronaphthalene. The reason for using 12 percent alphamononitronaphthalene is to obtain a mixture which can be melted in melting kettles using not more than 10-pound steam pressure. Picric acid melts at 120 C which prohibits its use as a casting explosive if low-pressure steam equipment is the only type available. However, by mixing 12 percent alphamononitronaphthalene with picric acid, the material becomes fluid at about 100 C and can be cast without any trouble.

Trimonite resembles 50/50 amatol in all its characteristics, with the single exception that it is likely to form sensitive compounds with metals. Provision must be made, therefore, that it will not come in contact with metal, such as zinc or lead. It has one advantage over TNT in that there is no danger of exudation.

In all tests conducted to date, no results have been obtained which would prohibit its use, and in case of an emergency it could be loaded with equipment available for the loading of TNT or 50/50 amatol.

TRIDITE.

Tridite consists of approximately 90 percent picric acid and 10 percent dinitrophenol. It was formerly specified as a substitute explosive for shell and bomb loading, but has been replaced as a substitute by trimonite. It has similar advantages to those of trimonite, and adaptability of these two explosives is almost identical, however, is more dangerous to load because of the toxicity of its fumes which accompany its melting.

TETRYTOL.

Tetrytol is a mixture of tetryl and molten TNT. As some of the tetryl goes into the solution, the mixture can be successfully cast with as high as 70 percent tetryl and 30 percent TNT by weight. The principal use and advantage of tetrytol is in loading boosters and bursters by the cast method. These items were previously loaded with dry tetryl which was pressed into pellets and then reconsolidated by pressing into the burster or booster casing. The mixture is agitated until ready for casting to prevent separation or precipitation. The use of tetrytol loaded into boosters and bursters has been approved except where the loaded item is plunged into or surrounded by a hot bursting charge, such as in the case of auxiliary boosters in general purpose bombs, where a remelt of the tetrytol might occur. The advantages of casting over the pellet reconsolidation, especially in long burster tubes, is tremendous from a standpoint of simplicity of operations, safety, and cost of equipment.

PENTOLITE.

Pentolite is a mixture of PETN and TNT. The 50/50 mixture results in a considerable increase in the brisance of TNT as measured by the rate of detonation. It is more sensitive to shock and friction than TNT, and where booster cavities have to be drilled, a mixture of 10 percent PETN and 90 percent TNT is used for the booster surround.

50/50 pentolite in the dry state is packed in the same manner as TNT. It is loaded by the casting method, 5 pounds of steam pressure on a steam jacketed open kettle being sufficient to melt the dry material. As the dry material melts, it must be constantly agitated to keep the PETN in suspension, as only a small portion of it goes into solution with the TNT. This agitation, usually by air-driven propellers or hand paddles, must be continued until the material is cast into the ammunition being loaded.

The stability of pentolite is not as favorable as that of straight TNT. Long periods of storage under high temperature may result in a separation of the material and the loss of its greatest effectiveness

as an explosive of high brisance. Every effort must be made to store it in a cool, dry place.

GENERAL SAFETY PRECAUTIONS PERTINENT TO HIGH EXPLOSIVES.

Safety shoes will be worn in repacking rooms or buildings, and whenever loose high explosives are handled. The wearing of safety shoes by personnel handling high explosives in boxes or other containers is at the discretion of the commanding officer, who should be guided in his decision by existing conditions. Boxes containing high explosives will be opened and repaired with safety tools. Containers will not be opened in a magazine in which explosives or ammunition are stored.

TABLE OF USES AND LOADING METHODS OF HIGH EXPLOSIVES

Explosive	Main Use	Method of Loading, If Any
TNT	Bursting charge	Casting or pouring
Amatol 50/50	Bursting charge	Casting or pouring
Amatol 80/20	Bursting charge	Extrusion
Picric Acid	Basis for making other explosives	
Explosive D	Bursting charge for A.P. shells	Tamped in increments
Trimonite	Bursting charge	Cast
Tridite	Bursting charge	Cast
Nitrostarch	Demolition work	Pressed
Tetryl	Booster	Pressed in pellets
Lead Azide	Detonator or initiator	Pressed
Mercury Fulminate	Detonator or initiator	Pressed
Tetrytol	Burster charge	Cast
Pentolite	Bursting charge	Cast
PETN	Detonating cord (Primacord)	Pressed

FURTHER REFERENCES: TM 9-2900; FM 5-25; Ordnance Safety Manual; Picatinny Test, Vol. II.

Chapter 4
Explosive Trains

GENERAL.

During the study of ammunition, there is usually much discussion, and confusion, over the subject of explosive trains. In reality, those

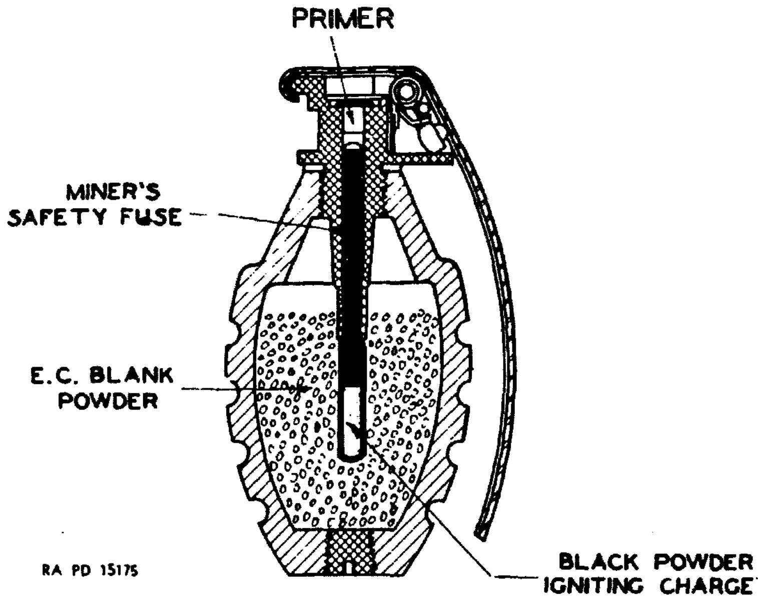

Figure 51 — Explosive Train Fragmentation Hand Grenade

explosive trains contained in ammunition are very simple; most of the confusion is a result of the numerous components which may be interposed in the basic train to gain the functioning desired from a particular train. An explosive train is nothing more than a series of explosions, the arrangement being such that control is gained over the explosions and the desired effect is accomplished.

Classes. There are numerous explosive trains found in ammunition, some of which are closely related and others which differ in many ways. Any of the explosive trains may, however, be roughly divided into one of the two general classes below:

I. PROPELLENT CHARGE EXPLOSIVE TRAINS.

A. Low-explosive Trains.

II. BURSTING CHARGE EXPLOSIVE TRAINS.

A. Low-explosive Trains.

B. High-explosive Trains.

In all explosive ammunition, one or both of the above trains will be found.

PROPELLENT CHARGE EXPLOSIVE TRAINS.

Small Arms. Propelling charge explosions are utilized to force the projectile from the weapon toward its target. A simple example

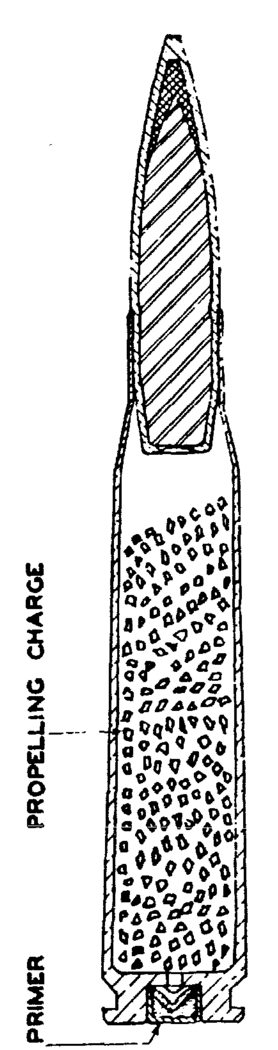

Figure 52 — Explosive Train Small-arms Cartridge

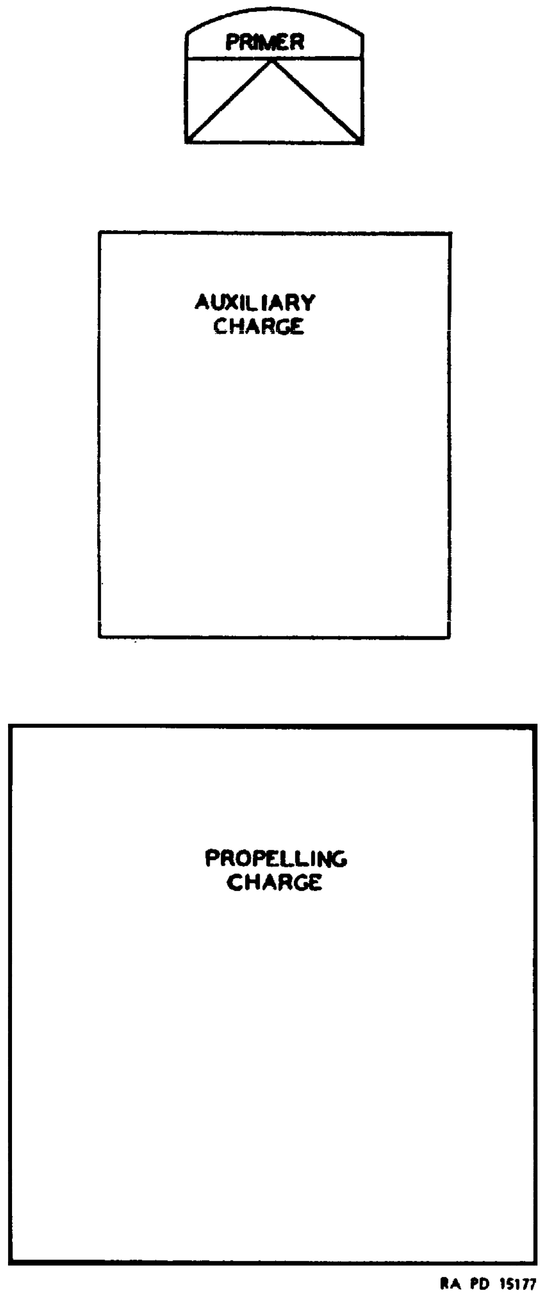

Figure 53 — Components Used in the Propelling Charge Explosive Train — Artillery Ammunition

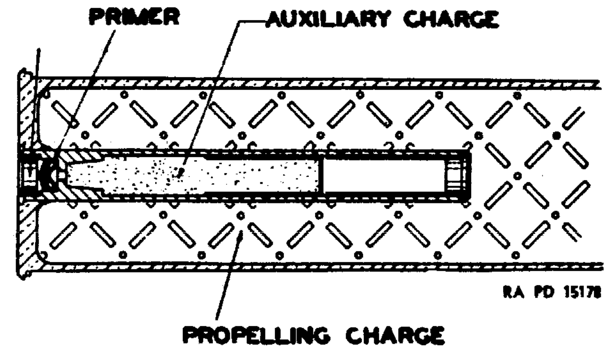

Figure 54 — Primer Showing Auxiliary Charge Contained in Primer Body

of this train is found in a round of small-arms ammunition (fig. 52). The components used in this train are a percussion primer and a propelling charge. The primer converts the mechanical energy received from the firing pin of the weapon into a flame. The flame passes

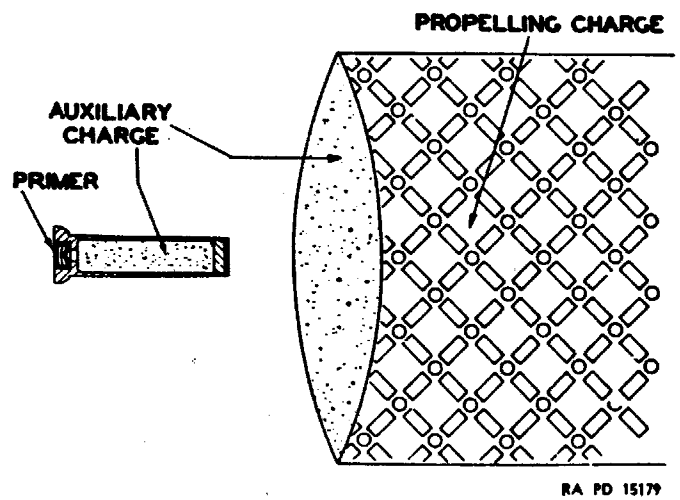

Figure 55 — Primer Showing Auxiliary Charge Divided Between Primer and Igniting Charge

through the vent leading to the powder chamber and ignites the propelling charge. The gases from the propelling charge explosion push the bullet out through the bore of the weapon. The train of explosions present in this series are the explosion of the primer and the explosion of the propelling charge.

Artillery. The propellent charge explosion of a round of artillery ammunition will show a slightly different train from the one in small-arms ammunition. In this train we have a primer and a propelling charge as illustrated (fig. 52), but in addition to these components, it is necessary to place an auxiliary charge of black powder between the primer and the propelling charge (fig. 53). The addition of the auxiliary charge is necessary because the small flame produced by the primer is not of sufficient intensity to properly initiate the large amount of propelling charge powder which is normally contained in a round of artillery ammunition.

The auxiliary charge may be contained in the body of the cannon primer, making an assembly of the primer and auxiliary charge (fig. 54), or it may be divided between the primer body and the igniter pad (fig. 55). In either case, its function is the same, the arrangement being such as to give the best ignition to the propelling charge. The series of explosions in this train are the explosion of the primer, auxiliary charge, and propellent charge.

BURSTING CHARGE EXPLOSIVE TRAINS.

General. Bursting charge explosive trains may be classified as high-explosive trains or as low-explosive trains. Shrapnel projectiles and fragmentation hand grenades are examples of those containing low-explosive trains. Rifle grenades, bombs, and artillery shell are examples of those containing high-explosive trains.

Low Explosive. In the case of shrapnel the components contained in the explosive train are a percussion primer, a powder time train of black powder, a magazine charge of black powder, and a base charge of black powder (fig. 56). The action is initiated by the firing pin within the fuze striking the primer, the flame thus set up is transmitted through the components named to the base charge. The explosion of the base charge forces the lead balls out of the body of the projectile.

The low-explosive train contained in the fragmentation hand grenade may be easily traced by reference to figure 51. The action of this train is started by a spring-driven firing pin striking the primer in the fuze. The flame from the primer is transmitted through a length of safety fuses to the black powder igniting charge at the end of the fuses. The explosion of the igniting charge initiates the action of the bursting charge of E. C. Blank Powder.

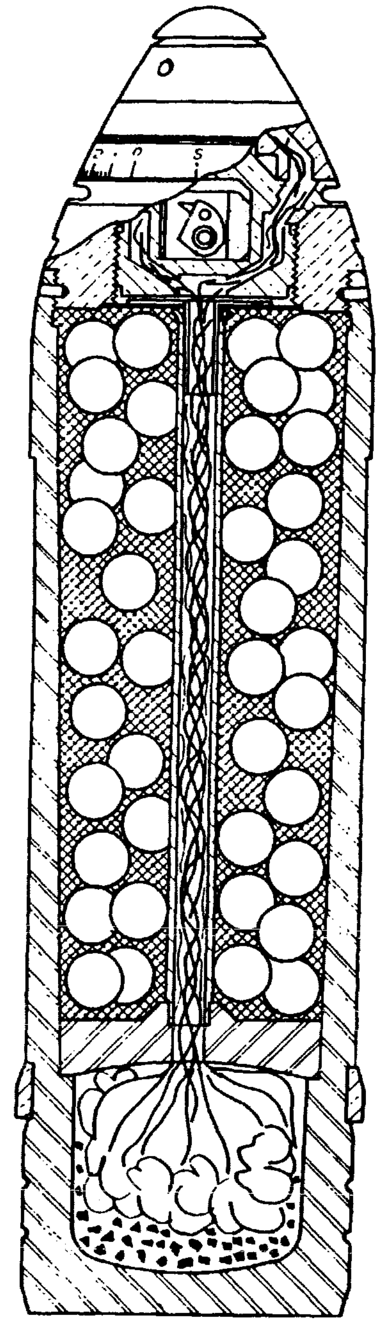

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Figure 56 — Explosive Train — Shrapnel Projectile

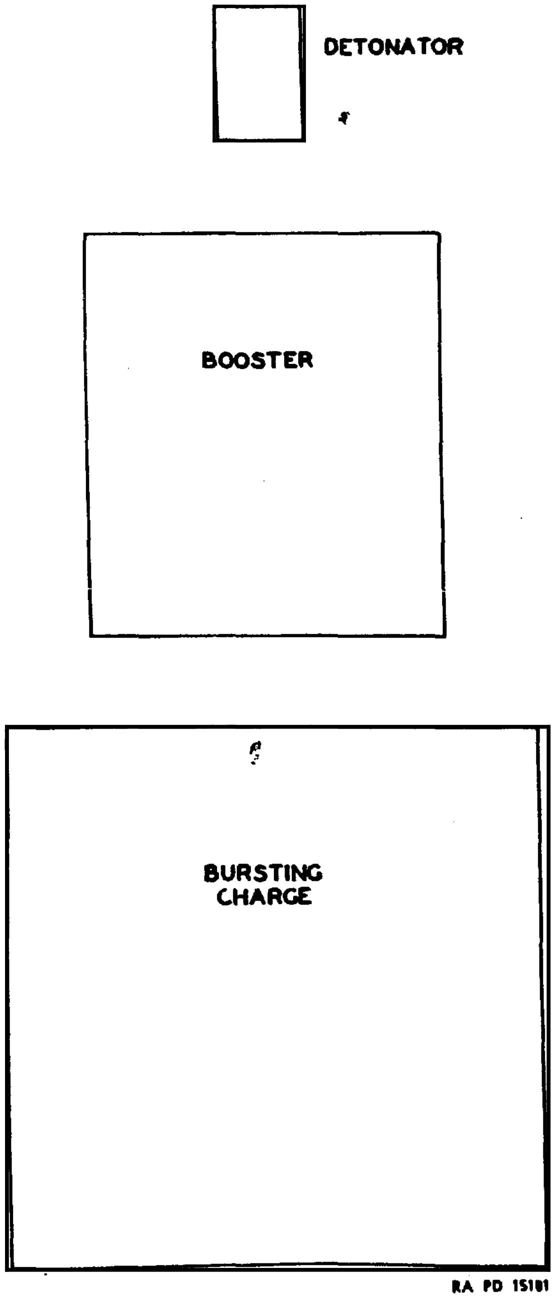

Figure 57 — Basic Chain of Components — High-explosive Train

EXPLOSIVES

High Explosive. High-explosive trains are very simple basically, but as the need for various actions arise the train becomes complicated. If we remember the basic chain of components which must be present in all high explosive trains, the picture will be clearer (fig. 57). The basic chain of components which must be present in all high-explosive trains used in ammunition are:

1. A detonator.

2. A booster.

3. A bursting charge.

The detonator sets up a high-explosive wave when initiated by the stab action of a firing pin or a flame. This detonation is so small and weak that it will not initiate a high order detonation in the bursting charge unless a booster is placed between the two. The booster picks up the small explosive wave from the detonator and amplifies it to such an extent that the bursting charge is properly initiated (fig. 58).

To gain the action necessary to control the time and place at which an explosive projectile will function, it is necessary to incorporate other components in the high-explosive train. The action desired may be a burst in the air, a burst instantly upon impact with the target, or a burst shortly after the projectile has penetrated the target. The components which may be used to give these various actions are a primer, a black powder delay pellet or train, an upper detonator, or any combination of these components arranged in such an order that the desired effect is gained. Regardless of the arrangement of the components the basic chain will remain the same, other components being placed in front of the basic chain.

THE HIGH-EXPLOSIVE TRAIN, COMPARISON OF THE BASIC STEPS

Step	Explosive	Cost Per Unit Weight	Amount Used	Sensitivity	Brisance
Detonator	Lead Azide or Mercury Fulminate	Most	Least	Most	Least
Booster	Tetryl	Intermediate	Intermediate	Intermediate	Most
Bursting Charge	TNT, Amatol, etc.	Least	Most	Least	Intermediate

The action for causing a projectile to burst in the air may be obtained by placing a primer, which is fired when the projectile leaves the weapon, and a black powder time train in front of the basic chain (fig. 59).

The primer is fired upon discharge from the weapon, thus igniting the time train rings. The time train rings burn for the length of time

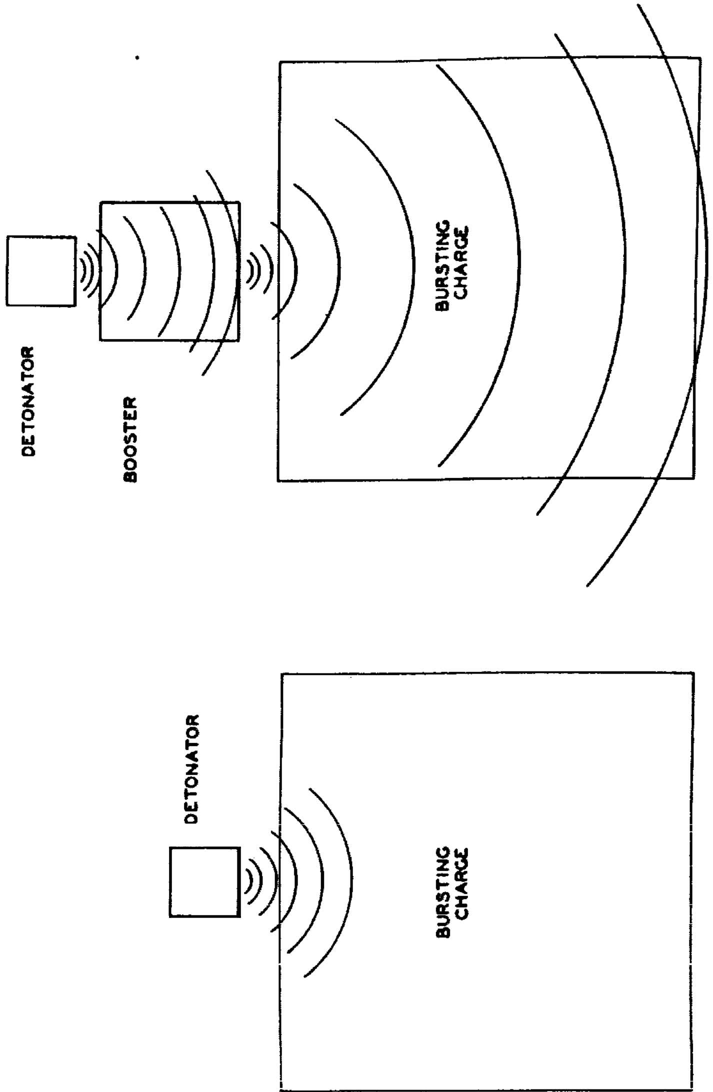

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Figure 58 — Detonator Wave Amplified by Use of Booster

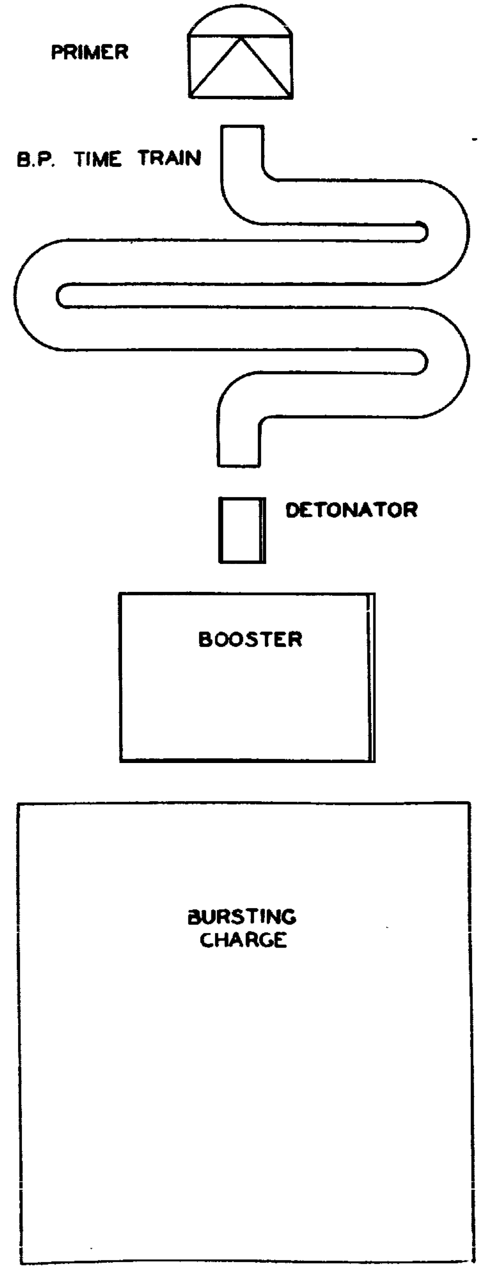

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Figure 59 — Arrangement of Components for Time Action

for which they were set previous to firing and then initiate the action of the detonator, booster, and bursting charge.

For bursting the projectile promptly upon impact with the target, a superquick or instantaneous action is necessary. This action is usually obtained by placing an upper detonator in the extreme front of the fuze and a lower detonator in the body near the booster charge (fig. 60). Upon impact with the target, the upper detonator is fired by the stab action of the firing pin which is set directly above it. The explosive wave thus started passes through the flash tube of the fuze to the lower detonator, to the booster, and in turn to the bursting charge. By placing an upper detonator in the extreme front of the fuze, the wave is started instantly upon impact and the mechanical problem of fuze design is greatly reduced.

To allow penetration of the target by the projectile, a delay action is necessary. This is obtained by placing a primer and a delay element ahead of the detonator (fig. 61). In some instances, this combination of primer and delay are inserted between an upper and a lower detonator. In such cases, the action starts off as a detonation, is converted into a flame by the primer, and into a detonation again by the lower detonator. In most cases, however, the action is started by the action of a firing pin on the primer without the use of an upper detonator.

It may be noticed that no mention has been made of mechanical actions utilized to effect bursting in the air. Action produced by mechanical means is not a part of the explosive train, hence only time action derived from explosive action is given.

Chemical Shell. A variation of the high-explosive train is found in chemical shell. In this train, there is no large bursting charge such as is found in high-explosive shell as it is only necessary to rupture the shell case and allow the chemical contents to escape. The actual bursting or rupturing of the shell is accomplished by the booster or an auxiliary booster charge. The boosters contained in chemical shells are usually larger than those contained in high-explosive shell of corresponding size. In chemical shell of more recent design, the shell body is ruptured by an added component called the burster. The components contained in the explosive train of the older type chemical shell are the detonator, usually upper and lower as superquick action is needed, and a booster.

The components used in the newer type chemical shell are the detonator, usually upper and lower, a booster, and a burster. The burster is a charge of tetryl which is contained in a thin aluminum case. This charge extends through the chemical filler to the base of the shell body. Upon functioning, a better rupturing effect is obtained than with the older type in which all of the explosive charge was concentrated in the nose of the shell.

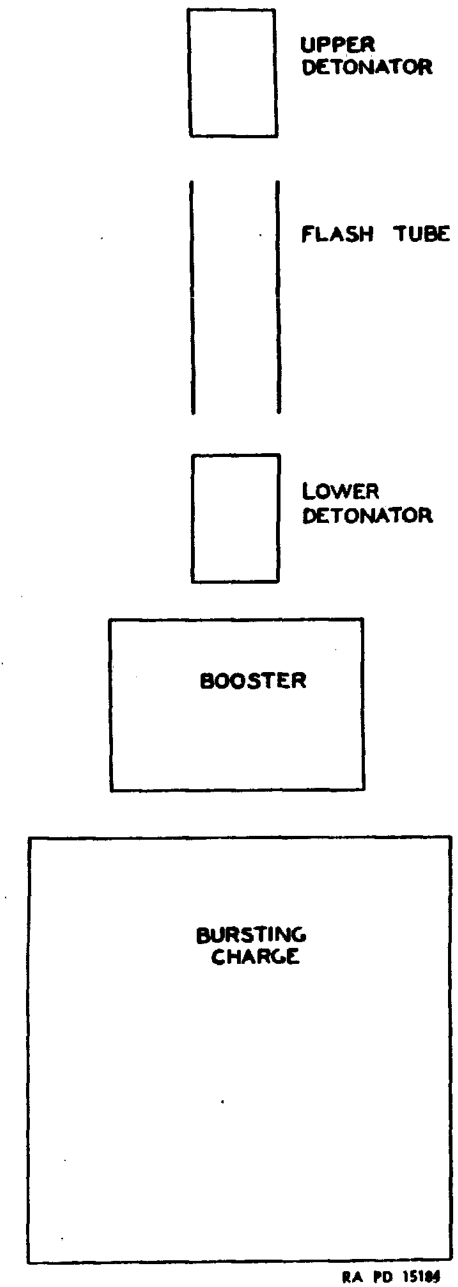

Figure 60 — Arrangement of Components for Superquick Action

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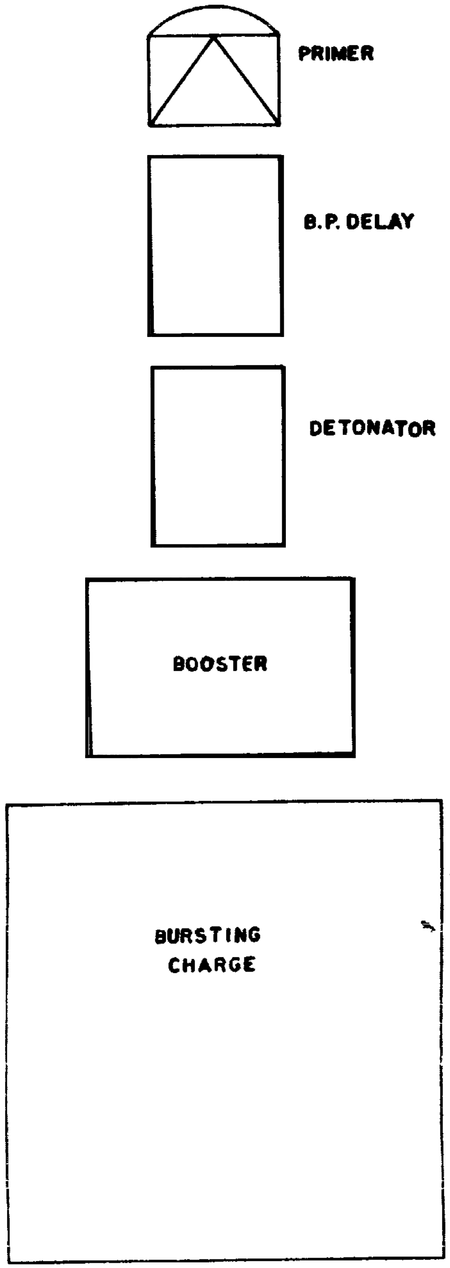


Figure 61 — Arrangement of Components for Delay Action

DUDS AND LOW ORDER DETONATIONS.

General. In considering the high-explosive bursting charge trains, it is taken for granted that the explosives would function properly. Occasionally, however, a dud or low order detonation may occur.

Duds. A dud is said to occur when a shell fails to explode. This condition is the result of a component which fails to function, or fails to completely function.

A dud can result from many causes which are often inherent in the high-explosive bursting train. Some of these can be listed as follows:

1. Improper initiation.

2. Deterioration of one component.

3. Poor contact between the steps of the train.

4. Omission of a component.

5. Foreign materials obstructing the function of a mechanical component which takes part in the action of the explosive train.

Low Order Detonation. A low order detonation is said to occur when the shell explodes incompletely. The detonation is in the nature of a burning instead of a shattering wave. It is well to note, in contradistinction to a dud, a low order detonation is the result of a component functioning completely but improperly. The detonating wave is slowed down.

A low order detonation in the high-explosive bursting train will result from the following causes:

1. Improper initiation.

2. Deterioration of one component.

3. Poor contact between the steps of the explosive train.

4. Low density of the shell filler.

5. Exudation.

A low order detonation can be detected in the following manner:

1. By the low report produced after the shell has exploded.

2. By the color of the smoke produced; for example:

Explosive	Color of Smoke for High Order Detonation	Color of Smoke for Low Order Detonation
TNT	Black	White
50/50 Amatol	Black	White
Explosive D	Black	Yellow
80/20 Amatol	White	White

3. Examination of shell body; unexploded fragments of explosive. The shell body may be split instead of properly shattered into efficient fragments.

CONCLUSION.

In conclusion, it may be well to reiterate that each and every element must function properly or the entire round of ammunition is lost. If a 5 cent primer fails to function, not only may a shell costing hundreds of dollars be wasted, but a life may be lost, or perhaps even the results of battle may be determined.

Chapter 5
Exudation

GENERAL.

Shortly after World War I, when large amounts of TNT and amatol loaded shell were stored, it was noticed that the TNT and 50/50 amatol loaded shell seemed to be undergoing some sort of deterioration evidenced by the emission of an oily, tarry material and, in some cases, a gas. Because of the large number of shells showing this deterioration, it was considered a serious problem and immediately an investigation was begun. As a result of that investigation, it was possible to arrive at conclusions as to the various causes for exudation, the remedies, and also the effect of exudation upon serviceability of the shell.

CAUSES.

The principal causes of exudation were found to be of two types, physical and chemical. These causes are:

1. The presence of impurities in the TNT as a result of manufacture.

2. The use of alcohol shellac in the booster cavity, and alcohol for cleaning threads in the nose of shell. Also, the occasional use of alcohol for recrystallizing TNT in the "purification" process.

3. The introduction of impurities by the ammonium nitrate used for amatols whose compositions are:

(50/50)—NH_4NO_3, 50 percent; TNT 50 percent by weight
(80/20)—NH_4NO_3, 80 percent; TNT 20 percent by weight

Impurities in TNT as a Result of Manufacture. The first cause, of manufacturing impurities, is a physical cause. The manufacture of TNT involves the reaction of toluene with nitric and sulfuric acids, to form trinitrotoluene. This reaction is controlled by the close control of temperatures and concentration of the acids.

However, even with the best possible control of conditions, it is still impossible to completely control side reactions, which are demonstrated below.

If A and B are the raw materials and C is the product desired,

$$A + B = C \text{ should be the reaction.}$$

However, in organic reactions, C is very often only one of several

possible products, so that while C may be the product preponderantly formed, another or several other products may be formed in small amounts, as indicated by

$$A + B = C \text{ (99 percent)}$$
$$D, E, \text{ (1 percent)}$$

Furthermore, it can be seen that if the materials A and B do not react completely, the final product will also have them in it, as an impurity, so that where we originally started to prepare pure C, we have ended up with a mixture of A, B, C, D, E, etc. down the alphabet.

Although these impurities are present in only small quantities, they still exert an appreciable influence on the properties of the final product.

In the case of TNT, the manufacturing impurities usually consist of incompletely reacted material such as dinitrotoluene, and the isomers of TNT, that is, those materials which have the same compositions, but in which the molecules are arranged in a different fashion.

Close control of conditions cuts those down to a minimum. However, during World War I, the grades of TNT used were of a low degree of purity as determined by melting point (or setting point) indicating sizable amounts of impurities.

To indicate the effect of these impurities, one can recall sprinkling salt on ice to lower the melting point, thus causing it to liquefy where ordinary water would be frozen. The DNT and isomers have the same affect on the TNT, that is, they lower the melting point. Chemically pure TNT melts at 80.75 C. Impure TNT may melt at as low a temperature as 76 C. In the center portion of the cast is the part that solidifies last, because the metal walls of the shell cool the outside rapidly.

For the reason indicated above, any impurities would tend to concentrate in the center core because they solidify at a lower temperature. In these areas, the impurities and TNT form low melting point mixtures, and if the shell should be exposed to elevated temperatures, even such as are reached in the southern parts of the United States, these low-melting point areas will liquefy and, due to expansion, will force their way out through the booster cavity. Note that this is a purely physical process; no gas is liberated and no reaction occurs. The remedy obviously is to use only high purity TNT. It has been found that TNT with setting point of 80.2 C or higher gave no exudation trouble.

Introduction of Alcohol Into the TNT. It will be noted that the cause of exudation discussed above creates no gas. Since gas is present in some cases, further investigation was made to determine its source. The gas liberated was found to be ethyl nitrite, which caused the investigators to suspect ethyl alcohol which was used for cleaning, and sometimes for "purification" of the TNT. By actual laboratory experiments, they were able to prove that TNT and alcohol react, and they prepared in this manner the same material that exuded from the shell. It will be noted that this is a chemical reaction.

To overcome this, the use of alcohol shellac for strengthening the booster cavity and alcohol for washing the threads on the nose, was discontinued, and acetone was substituted. Furthermore, the Army Specifications were revised to prohibit use of alcohol in recrystallization of TNT.

Introduction of Impurities by Ammonium Nitrate in Amatol. The third cause of exudation has been found in the case of the amatols. Ammonium nitrate as commonly prepared, is made from the ammonia that is liberated in the destructive distillation of coal. It is a byproduct, and contains as impurities many of the organic breakdown products such as pyridine. These had been found to act in a fashion similar to alcohol. The remedy is purification of the ammonium nitrate or the use of ammonium nitrate which is prepared in a different way, from pure products. The latter is a good deal more expensive, and purification of the byproduct NH_4NO_3 is usually practiced.

It was noted by the investigators, that 50/50 amatol exuded while 80/20 amatol showed only rare cases of exudation. This was because of the small amount of TNT and because the ammonium nitrate itself absorbed most of the exudate.

One final problem arose which was baffling for some time. Some samples of exudate showed red particles of an explosive compound which was found to contain iron. It was shown that when alcohol and TNT reacted in the presence of iron, this red material was formed. The iron came from corrosion of the shell case by the exudate in the case of TNT shell, or by moisture in the ammonium nitrate.

Several methods have been introduced to avoid this. One method is coating the shell inside with an acidproof paint. The other is controlling the moisture of the NH_4NO_3. Another is a TNT pour on top of the amatol, called a booster-surround. The purpose of this is to seal the hygroscopic ammonium nitrate from moisture.

EFFECTS OF EXUDATION.

Fire Hazard. Since the exudate from TNT shell carries TNT, and in some cases the explosive red iron compound with it, it is inadvisable to have it on the floor of a magazine. It is washed away with hot water as soon as it is found. Regulations require a monthly inspection of magazines containing shell and bombs, and one of the purposes of this inspection is to find exudation and have it cleaned up. Bulk TNT will not exude.

Corrosion of Shell. Since exudate is often acid in reaction, it corrodes the unprotected shell case and booster. When exudation is found, the booster is removed and the cavity is cleaned. It may be necessary to have this done regularly. Fortunately, however, this condition is unlikely to be found in modern ammunition so that it is only in war reserve ammunition that it may prevail.

Cavitation. Cavities in the filler are often another result of exudation. They may cause trouble in two ways. First, by desensitizing the booster or the surrounding charge; and, second, by lowering the density of loading, thereby decreasing the efficiency of the shell, somewhat. The exudate contains some TNT, but is very much less sensitive to detonation, so that the booster has a smaller chance of causing a high order detonation when initiated by a Mark III fuze, for example. However, it has been found that the M46 fuze which has what is called a "Horse Detonator" compensates both for desensitization of the booster and of the bursting charge, and gives consistently high order detonations with the worst exuding shell that can be found.

It was assumed at one time that cavitation was dangerous, since during setback a premature might occur because of the crushing of one piece of TNT against another, or against the shell wall, or pinching of TNT exudate in booster threads. This was tested in 75-mm and 155-mm shell in a very bad state of deterioration from exudation. They were fired at 12 percent excess pressure to make the worst possible combination of conditions. No prematures resulted either in the gun or along the trajectory. It was, therefore, concluded that for these two types of shell it was safe to use the exuding shell. The restriction on their use was therefore removed and they are cleaned with acetone and painted, when necessary, for morale. The issue of exuding shell is given priority for training purposes with a view to expending them.

Chapter 6

High-explosive Loading

GENERAL.

In the consideration of high-explosive loading, it is well to note that once a suitable bursting charge has been developed, the next important step is to load it into the projectile or bomb cavity at the proper density. Uniform density of loading is desired for the following reasons:

Low or nonuniform density of the charge in a shell will cause it to "set back" on being fired, and "set forward" on impact. This might possibly leave a void around the fuze or booster at the instant of functioning and result in a "dud" or "low order" detonation.

Voids or areas of low density within the explosive charge may cause a "dying out" of the detonating wave, resulting in the explosion of only a portion of the charge. This is also generally referred to as a "low order" detonation.

Internal stresses combined with frictional heat from "set back" on firing a high-explosive shell of low or nonuniform density is the cause of premature explosions of shells while still in the gun barrel (with resultant loss of life and materiel).

It may be said that practically all loading operations are made with a definite aim in view; to completely fill the shell and bomb cavities with high explosive to a predetermined satisfactory density in a safe and uniform manner.

TRINITROTOLUENE (TNT).

Melting. TNT is supplied to loading plants packed in paper-lined wooden boxes in the form of finely divided flakes or crystals. It varies in color from light yellow to buff. Grade I TNT has a minimum setting point of 80.2 C and Grade II has a minimum setting point of 76.0 C. NOTE: At the present time, Grade I TNT is being used exclusively in loading operations. It has been definitely determined that the exudation of oily liquids from shells and bombs loaded in the past was due principally to the residual impurities in Grade II TNT. The fact that TNT melts at a temperature less than the boiling point of water gives it a great advantage over most other high explosives since it facilitates its manipulation for shell filling permitting it to be melted in steam jacketed kettles or on low-pressure steam coils. The melt unit employs steam pressure not to exceed 5 pounds. To insure this, an 11 foot water column or "leg" (open at the top) is connected to the incoming steam line feeding the melt unit. Should the pressure at any time exceed 5 pounds, this water column will be blown out, releasing the incoming steam to the atmosphere. Prior to melting, flake or crystalline TNT is run through a ⅛-inch mesh sieve to remove all splinters, nails, lumps and extraneous material. The screen for flake TNT has oblong openings approximately ⅛ inch by ½ inch.

Another great advantage of TNT, is that it does not corrode the metal parts of ammunition or form sensitive compounds with metals over long periods of storage. Each shell or bomb, however, is carefully inspected for condition before loading. Interiors must be clean and free of rust, scale, chips, grease, etc. A coating of black acidproof paint is customary for all interiors, and this must be thoroughly dry before loading. NOTE: In some instances where shell are loaded with TNT immediately after shot blasting the interiors, this paint is omitted.

Precooling. TNT is loaded by means of the casting method; that is, it is poured directly into the shell or bomb cavity and allowed to solidify. The principal difficulty encountered in loading this material is to obtain a solid cast of uniform density. TNT when passing from the molten to the solid state contracts approximately 8 percent in volume, and it is necessary to take care of this contraction in some manner in order to overcome the cavities which will be produced by normal shrinkage of the charge. The first step to overcome this cavitation is to cool the molten TNT to between 79 C and 80.5 C, or to the point where fine crystals appear in the molten mass. This cooling process is done in large metal tubs provided for the purpose. As an additional precaution to remove foreign materials, the molten TNT is drawn off from the melt unit into the cooling tubs through a suitable 18-mesh brass or aluminum screen. Cooling is accelerated by mechanical agitation; by hand, with a wooden or aluminum paddle; or both. The molten TNT is stirred continuously during the cooling period. Mechanical agitation is recommended for preliminary cooling point as tubs can be set under hoods and fumes exhausted. (TNT fumes become very toxic over long periods of exposure.) As the molten mass approaches the proper temperature, it should be carefully observed in a good light to note the formation of the fine crystals which reflect the light much like tiny flakes of gold leaf. The trained eye of an experienced operator will be found entirely adequate to determine when the molten mass is ready for casting. In this manner, the amount of contraction which occurs in the shell is reduced nearly 50 percent. While this cooling reduces the amount of cavitation, it also reduces the cooling time required in the shell itself.

Pouring. Shells are filled either in one pour, or more than one pour, depending on their size and shape. The one-pour operation will be considered first and is described as follows:

Inspect the shell cavity to insure it is clean, evenly coated with black acidproof paint, and thoroughly dry.

Insert a suitable funnel and pour in the molten TNT, filling the funnel approximately three-quarters full.

The TNT first solidifies on the shell bottom and sides (fig. 62), and then forms a crust over the top surface of the liquid in the funnel. As the charge solidifies, contraction occurs causing the liquid in the funnel to recede into the shell, forming a cavity under the top crust in the funnel (fig. 63). No cavities will be formed in the shell charge, provided there is enough liquid TNT in the funnel to take care of all shrinkage in the shell charge, and provided the liquid TNT in the funnel is allowed to flow to all parts of the shell charge where shrinkage is taking place. A good example of this is shown in figure

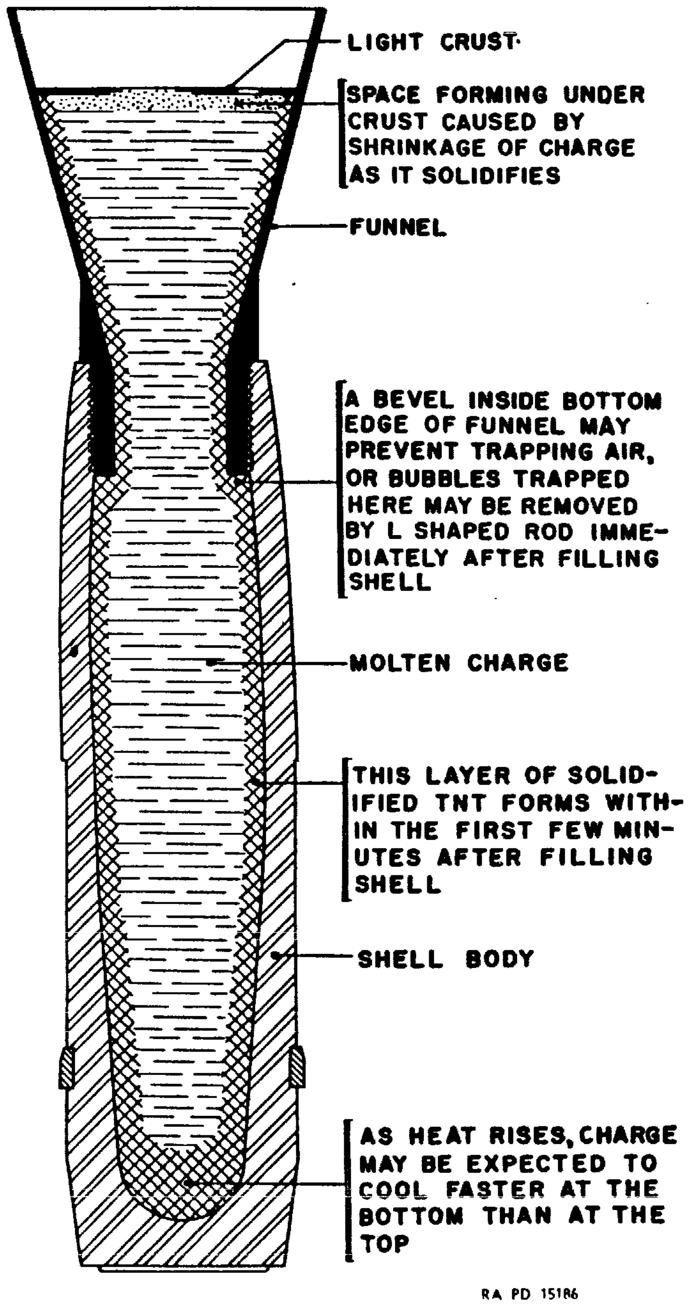


Figure 62 — Shell Immediately After Loading (One Pour)

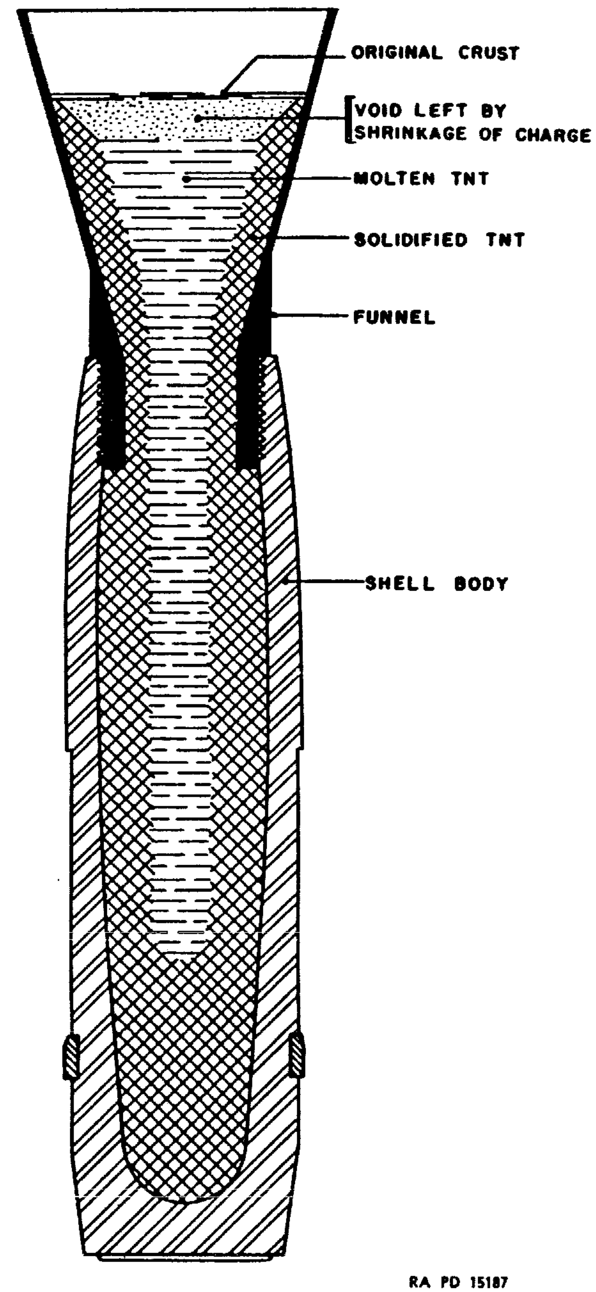


Figure 63 — TNT Solidifying in Shell (One Pour)

64. All cavities due to shrinkage have been formed in the funnel which is now loosened by a light tap and lifted out of the shell.

The principal cause of cavitation in the shell charge is illustrated by figures 65 and 66. In this case, cooling takes place more rapidly in the neck of the funnel than in the shell below and the TNT finally "freezes" solid at this point. The liquid TNT in the funnel can no longer flow into the shell and all further shrinkage that takes place below this point results in a central cavity or "pipe" in the shell charge. Three possible causes of this are:

The inside diameter of the funnel may be too small at the neck.

The funnel may be made of material that radiates heat too rapidly.

The outside circulation of cold air may be causing rapid cooling at this point.

This condition may be corrected by:

Redesigning the funnel to enlarge the inside diameter of the neck.

The use of approved plastic funnels which are relatively poor conductors of heat.

The insulation of shells and funnels by hoods, baffles, or other protection from drafts to prevent rapid cooling of the top portion of shell.

The size and shape of some of the larger shell is such that it is impracticable to obtain a suitable cast in one pour. When the opening in the nose is of considerably smaller diameter than the shell cavity, the TNT will freeze solid at this point long before the rest of the charge has had time to cool. This difficulty is overcome by partially filling the shell and allowing it to cool sufficiently before adding a second or final pour. The casting of a 155-mm H. E. shell is described as follows:

The shell is filled approximately two-thirds full and allowed to cool until a thin crust has formed. The crust is then cut into small pieces with a chisel pointed half-inch brass rod approximately 18 inches long. The crust is carefully cut away from the sides leaving a round hole with no projecting ledges. Trained operators continue cutting back the crust as it forms, carefully noting the condition of the molten mass. As the molten core in the center of the shell grows smaller in diameter, care must be exercised not to allow heavy or large pieces of crust to fall in and choke it up, as a cavity will form in the molten core below the choke point. When the center hole in the cast has reduced to about 1 inch in diameter, and the molten TNT has reached a consistency of thin mush, the second pour should be added by filling the shell to within approximately 2 inches from the top. As the second pour is added, care must be exercised to be sure there is no crust over the molten core of the first pour. An operator should precede the bucket man and cut the crust in each shell with a brass rod a few seconds before the second pour is added.

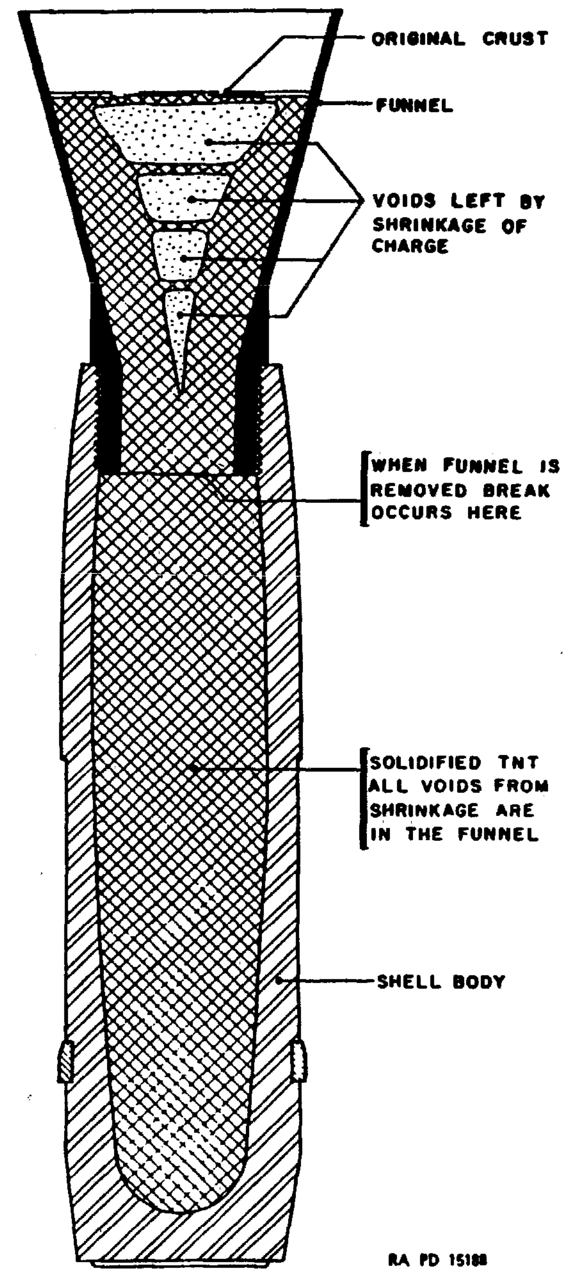
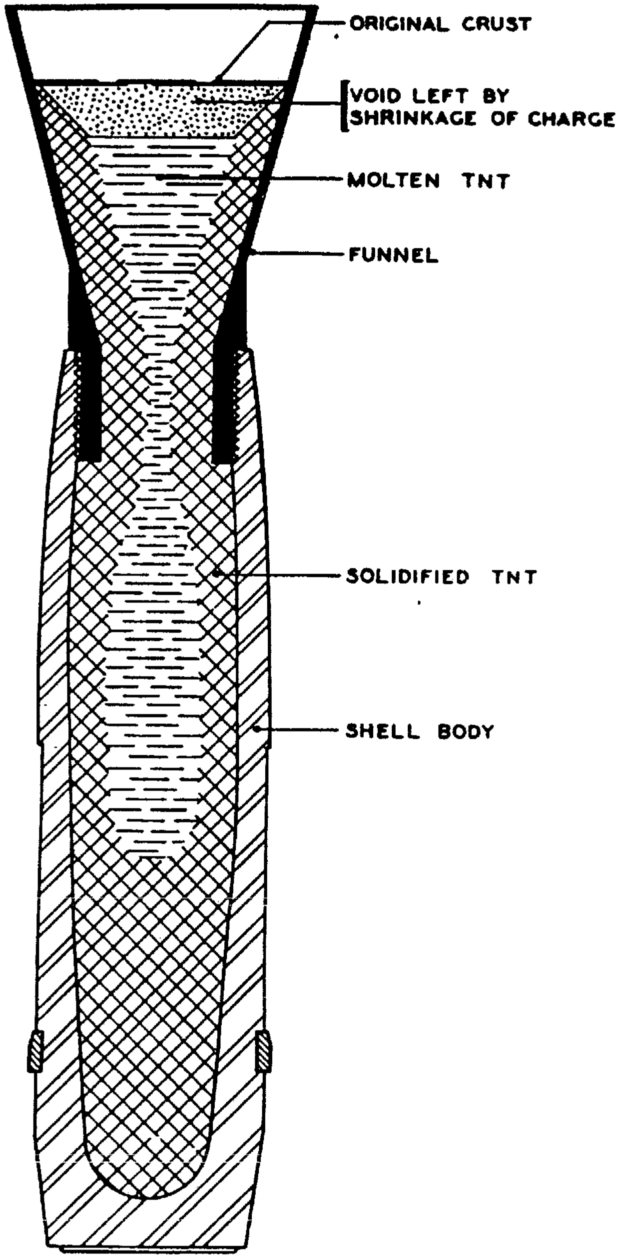
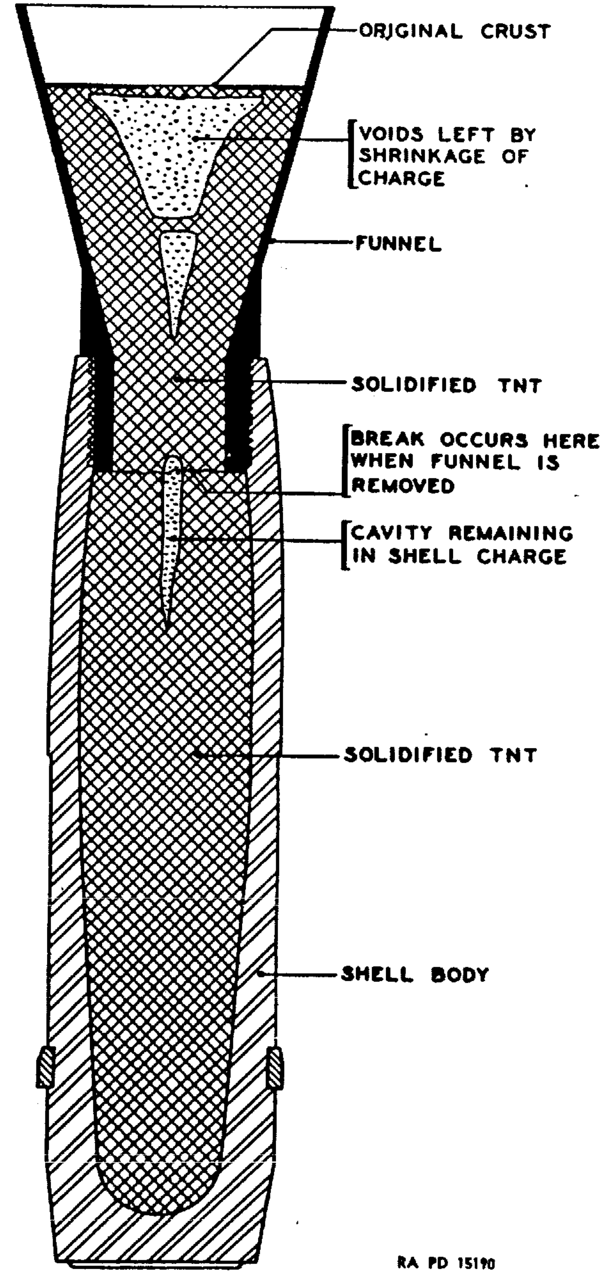


Figure 64 — Shell Properly Loaded — Cavity in Funnel



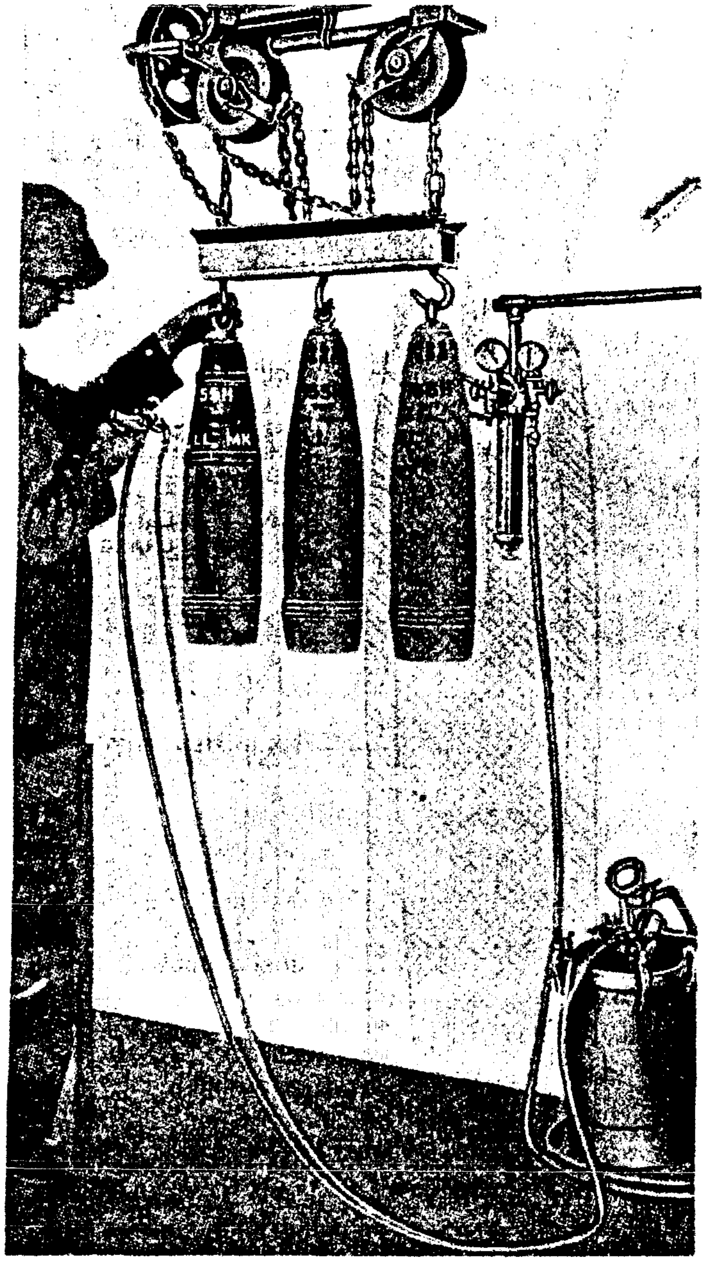
RA PD 15189

Figure 65 — Cavity Forming in Shell



RA PD 15190

Figure 66 — Shell Improperly Loaded — Cavity or Pipe Formed Near Neck of Shell



RA PD 15191

Figure 67 — Stenciling 155-mm Shells

Continue cutting the crust on the second pour in the same manner as described for the first. More care must be used as the molten core in the center is smaller now and can be more easily choked with dry chips falling into it. Keep it cut back and open in exactly the same manner as described for the first pour. Carefully watch the consistency of the molten mass as it will probably cool much faster than the first pour. When the central core has reduced to about 1 inch in diameter, and the molten TNT is the consistency of thin mush, the shells are ready to be topped off. This is done by inserting a large funnel to protect the threads and with enough volume to act as a riser. (If no other means of protecting the threads is used, this funnel remains in the shell during all previous operations.) The same care must be exercised in adding the top off pour as was used in adding the second pour to break up any crust on top of the molten core in the shell. An operator should precede the bucket man and cut the crust in each shell with a brass rod a few seconds before the top-off pour is added.

Fill the funnel approximately three-quarters full and allow to cool. If previous instructions have been followed, all shrinkage that takes place from now on in the shell will be filled from the reservoir of molten TNT in the riser and solid cast shell of uniform density will result. Common practice is to break the crust that forms on top of the funnel during the cooling period, but this is not necessary, and may even be harmful because if a a solid chip falls into and chokes the narrow molten central core, a cavity will form in the shell below the choked point.

Housekeeping. To assist in keeping the exterior of the shells and pouring room floor free of TNT, spilled during operations, a paper mat may be spread over the shells cutting openings for the insertion of each funnel. As an alternate, brass mats may be used with suitable openings for the nose of each shell. If a brass mat is used, it should be wiped very lightly with a half mixture of kerosene and paraffin oil to prevent the TNT from adhering to it. This liquid mixture is also excellent for treating pouring from floors and any metal or cement surface likely to become splashed with molten TNT, as it prevents the TNT from sticking. Rubber pouring buckets of soft latex have been found excellent for pouring TNT into shell as the bucket can be quickly collapsed by the operator as soon as it is empty (while still hot), causing the film of TNT adhering to the inside to flake off for reuse. Pouring funnels made of approved molded plastic material have also been found highly satisfactory. These are made to extend well into the shell nose protecting the threads during the casting period.

Drilling. Booster cavities are drilled, using a horizontal drill or other suitable means to produce a booster cavity which will conform

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to that shown on the loading drawing. A twist drill of high-speed steel has been found to be very satisfactory for this operation. Recommended maximum speed for horizontal drilling machines is 120 revolutions per minute. All explosive must be removed from the threads of shells, using a bronze pick while the shell is rotated on a rotating device. All loose particles of explosive must be removed from the booster cavity. This is usually accomplished by a vacuum unit approved for use in hazardous operations. All explosive must be removed from the exterior of the shell using a bronze scraper. Shells which have been carelessly loaded will usually have a cavity or pipe extending into the charge below the bottom of the booster cavity. This condition should be carefully watched for at this point in the operations, and such shell set aside pending decision of the inspector.

Determination of Specific Gravity. For the determination of specific gravity (density) of the charge, there shall be selected one empty bomb or shell from each 100 to be loaded. Each sample selected shall be marked so that it can be identified after loading. The test shall be accomplished as follows: Weigh each sample bomb or shell empty and then fill with water, making allowance for space occupied by fuze, booster, and weight of auxiliary boosters (if any). Weigh each water-filled sample, then empty, and throughly dry for loading. At the rate of 1 per 100, these samples will be loaded under conditions identical in all respects with those employed in loading other bombs or shells. After loading weigh each sample and calculate the specific gravity of the charge as follows:

$$\text{Specific Gravity} = \frac{W_t - W_e}{W_w - W_e}$$

W_e = weight of empty shell in pounds
W_w = weight of water-filled shell in pounds
W_t = weight of loaded shell in pounds

If the specific gravity complies with the requirements, the identification markings may be removed and the samples included in the lot. The specific gravity of the TNT charge shall not be less than 1.54. If the specific gravity falls below this requirement the 100 shells or bombs represented by the sample will be held pending final decision of the inspector as to the cause of the low density.

Splits. A visual examination of the charge is made as follows: The United States shall provide one or more empty shells or bombs of the type being loaded which shall be made into molds by halving longitudinally. These halves shall be held together with bands or other means and a gasket to prevent leaks while loading. From time to time at the discretion of the inspector, and especially at the beginning of loading operations, these split bombs or shells shall be filled under conditions identical in all respects employed during regular operations. After the charge has cooled, it is removed and examined

by the inspector to enable him to judge whether there is any objectionable cavitation or other defects. The molded charge is usually split longitudinally by sawing with an ordinary hand saw. If the conditions exhibited by the sectional charges are not satisfactory, steps shall be taken immediately to remedy the faults that have been disclosed. Additional valuable data may also be gained if water weight determination of density is taken on all splits as described above.

AMATOL.

General. Amatol is a mixture of TNT and ammonium nitrate. The percentage of each is determined by weight and may be mixed in proportions varying from 50/50 to 80/20, the latter figure in each case representing the percentage of TNT. Ammonium nitrate is a white crystalline material which when finely ground, resembles table salt in appearance. When pure and dry it melts at 170 C. (Compare this with TNT.) Its chief drawback is that it is very hygroscopic, quickly taking up moisture from the air. For this reason, amatol must be carefully sealed from the atmosphere. Unlike TNT, amatol has quite a corrosive effect on metals especially if moisture is present. The great value of ammonium nitrate is that it opens an enormous supply of an easily procurable and cheap material, practically nonexplosive by itself, which when mixed with as little as 20 percent of TNT provides an explosive practically of the same brisance as TNT alone. The available supplies of TNT can therefore provide a far larger quantity of high-explosive ammunition than would be possible without the use of ammonium nitrate. When mixed with various percentages of TNT, it will flow in the molten state and can be loaded by casting. When only 20 percent TNT is mixed with 80 percent nitrate (80/20), the mass is too stiff to pour and must be extruded or tamped while hot into the shell or bomb cavities.

Casting Method of Loading Amatol. When ammonium nitrate is received in hermetically sealed containers, it is fed directly into a sifter to screen it to the proper size. Lumps which fail to pass the screen are shoveled into a rotary nitrate cutter and thence back into the screen. The screened nitrate is placed in 50-pound covered buckets and taken to the mixing house and elevated to the third floor level. After carefully weighing, a charge of nitrate (approx. 800 lb) is placed in a steam jacketed rotary mixer known as a preheater where its temperature is raised to 82.1 C (180 F). This requires approximately 45 minutes.

In the meantime, a charge of TNT is being melted in a melt unit on the second floor (same as that used in TNT loading). The weight of this charge is such that when mixed with the charge of nitrate, the desired percentage of each will result. When all the TNT has melted, it is drawn off into a steam jacketed mixing kettle equipped with a mechanical agitator and kept at a temperautre of 85 C (184 F). The agitator is started and the operator opens a valve which allows the hot nitrate from the preheater on the third floor above to feed slowly into the molten kettle of TNT where it is thoroughly mixed and blended by the agitators. The dryness of the nitrate is essential, as with moist nitrate the amatol does not flow well or mix well, the moist nitrate crystals collecting together as lumps. Specifications require that ammonium nitrate contain not more than 0.25 percent moisture. After the entire charge of nitrate has been added, the blending and mixing in the kettle is allowed to continue until the entire charge appears to be fluid and no lumps of nitrate appear. For bombs which are to be loaded with approximately 60/40 amatol, it is desired that the amatol contain as high a percentage of ammonium nitrate as possible and still flow from the mixing kettle. This percentage depends on the fineness of the ammonium nitrate and may vary from 55 to 65 percent. The amount of ammonium nitrate used may vary from batch to batch and no attempt should be made to hold a uniform percentage. The amount used in each batch will be determined by the fluidity of the mix. The addition of ammonium nitrate to the molten TNT should stop at the point where the mixture will flow from the mixing kettle and at the point where the addition of more ammonium nitrate would prevent the mixture flowing from the mixing kettle.

From this point, the molten amatol is cast in the same manner as described for TNT, except for the fact that amatol is usually loaded with one pour, cooled until the central core is about ready to set up or has become "mushy," and topped off with TNT, using a riser as in the case of other TNT loading. This provides a TNT surround for the booster, seals the charge of amatol against moisture, and prevents corrosion of the booster case which would otherwise occur if it were in direct contact with the amatol. The interiors of all shells and bombs are given a coating of black acidproof paint prior to loading with amatol.

In the case of bombs which have both nose and tail fuzes, it is necessary to provide a TNT surround in both nose and tail to protect the fuze cavities from corrosion and seal the amatol charge against moisture. In loading a bomb through the tail opening, it is apparent that the TNT surround for the nose fuze must be poured in first. A separate melt unit is provided on the ground floor of the amatol mixing house to supply molten TNT for the purpose of casting TNT surrounds. The following operations are performed incident to loading a bomb with amatol by the casting method:

1. Remove nose plug and tail cap.

2. Inspect bomb interior and repaint if necessary.

3. Remove all grease from bomb and threads.

4. Insert fuze seat liner in nose of bomb sealing threads with animal glue.

5. Gauge fuze seat liner and insert nose plug.

6. Place bomb in loading rack. Insert auxiliary booster with special tool.

The bomb is now ready for TNT bottom pour to surround the nose fuze seat liner; the depth of this pour is shown on the loading drawings. TNT prepared in accordance with specifications is poured into the bomb to a depth somewhat above the joint between the fuze seat liner and auxiliary booster in accordance with the loading drawing, and allowed to cool. After the crust is formed, it is cut down with a brass rod every half hour, taking care not to disturb the core that forms around the auxiliary booster. When the molten charge becomes almost stiff, smooth off the surface with a rod by submerging any crust or chips and allow to set.

Amatol prepared in accordance with preceding paragraphs is drawn into a cooling tub and agitated with a paddle to cool it to a temperature of between 80 C and 85 C. (82 C or 179.6 F is recommended.) The molten amatol is then transferred into pouring buckets and poured into the bomb cavity to a depth as shown on the loading drawing. In loading smaller bombs, a funnel is used to avoid splashing. After the required charge is placed in the bombs, they are transferred to a cooling room where the crust is broken down and cut back in the manner described for TNT. When the amatol charge has become quite stiff and the molten central core has reduced to approximately 4½ inches in diameter, the TNT surround is poured as shown on the loading drawing.

If a tail auxiliary booster is required, it is inserted just prior to this pour and held in place with a special tool. In this case, the breaking down of the TNT crusts is done around this tool, taking care not to disturb the auxiliary booster until the charge around it has cooled. The booster cavity may be formed or drilled at the discretion of the contractor. In either case, a riser must be used for the last pour to eliminate cavitation due to shrinkage. The forming operations usually require the addition of two or three increments of molten TNT and several special tools are required. Complete instructions for forming of drilling operations may be obtained from the Chief of Ordnance.

After drilling or forming the booster cavity, threads should be thoroughly cleaned and freed from all explosive and foreign material. If chemical cleaner is used, no material other than acetone should be used. Care must be taken to prevent the acetone from soaking into the charge. Final assembly of the bomb should be completed as specified by the respective drawings.

Steps should be taken to reduce the waste of amatol scrap to the absolute minimum. Such scrap as is obtained from the cooling tubs and pouring pails can be utilized by puddling it into hot molten bomb castings while thin and friable scrap may be placed into the amatol mixing kettle after the TNT has been introduced and before the charge of ammonium nitrate is added so that remelt is obtained. In this latter instance, the granulation of the scrap should not exceed in size the clearance between the moving and stationary paddles of the amatol mixing kettle.

Density determination, selection of samples, and examination of the explosive charge by means of a split bomb will be carried out in the manner prescribed for TNT. The specific gravity of 50/50 amatol should not be less than 1.50.

Extrusion Method of Loading 80/20 Amatol. 80/20 amatol is a mixture of 80 percent ammonium nitrate and 20 perecent TNT. This material is not fluid enough to use the casting method and has to be handled by the extrusion method. The ammonium nitrate used for this work is prepared in the same manner as that for 50/50 amatol. From this point, the procedure changes for the 80/20 mixture. The ammoniun nitrate is first placed in the amatol mixing kettle and heated to approximately 95 C. The proper proportion of TNT is then added in the liquid state and the mixing continued for at least 15 minutes or until the entire mass has become plastic and of uniform composition. The mixed 80/20 is then transferred to the hopper of the extrusion machine. The hopper of this machine will hold approximately 250 pounds which is sufficient to load 16 155-mm shells. The hopper is steam heated so that the material is maintained in the plastic condition throughout the process. From the hopper, the material is fed into the shell by means of a steel screw operated inside of a steel tube. The shell is first placed on the carriage of the extrusion machine and allowed to run forward so that the end of the screw is within 2 to 4 inches of the base of the shell. At this point, a second trip action disengages the screw so that the shell can be removed from the carriage. A counter weight placed on the carriage of 200 pounds to 300 pounds maintains a steady pressure against the extruding amatol and thus solidifies the charge within the shell.

A number of difficulties arose during World War I in connection with the loading of 80/20 amatol. These difficulties were due to the type of ammonium nitrate which was furnished. If the ammonium nitrate is of fine granulation, low densities will be obtained due to insufficiency of the TNT to fill in the spaces between the crystals. If the crystals are too large, liquid TNT leaks from the extruder and also causes low density. For 2 years, Picatinny Arsenal investigated the loading of 80/20 amatol for the purpose of determining

the type of ammonium nitrate which should be used. The work on granulation has been completed and with a proper control of granulation, no difficulty is encountered with obtaining satisfactory density of the charge. The ammonium nitrate intended for use in the manufacture of 80/20 amatol is listed under specification 50-11-59 as "Class B." The granulations specified are those of commercial grade of ammonium nitrate used in the manufacture of dynamite and no increase in cost should arise.

Shells and bombs loaded with 80/20 amatol are topped off with TNT surround. Density determination, selection of samples, and examination of the explosive by means of a split will be carried out in the manner prescribed for TNT. The specific gravity of 80/20 amatol will be not less than 1.38.

TRIMONITE.

Trimonite is a mixture of 88 percent picric acid and 12 percent alphanitronaphthalene. This material is loaded by the casting method and is handled in the same manner as TNT. At the time of casting, the charge resembles 50/50 amatol more than it does TNT, due to the fact that all of the picric acid has not melted and is in suspension in the liquid. The casting temperature of trimonite is from 95 C to 105 C. Trimonite has practically the same explosive properties as 50/50 amatol. The cast charge has a density of not less than 1.60. Work at Picatinny Arsenal has shown it to be an excellent explosive for shell and bombs and the numerous tests at Aberdeen Proving Ground have failed to indicate a single item which would militate against its use as a shell and bomb filler. To date, however, it has not come into general use for loading high-explosive ammunition.

EXPLOSIVE D.

General. Explosive D (ammonium picrate) is supplied to loading plants in the form of finely divided crystals packed in paper lined wooden boxes. It varies in color from canary yellow to reddish brown. It does not melt on heating, but explodes when heated to a temperature of about 300 C. The only method of loading is to press it into the projectile cavity until the proper density is obtained. Ammonium picrate can react with metals to form metallic picrates but when dry, this action is almost negligible. Wet ammonium picrate reacts slowly, especially with copper or lead, to form picrates which are particularly sensitive and dangerous. Each projectile is carefully inspected before loading and interiors must be clean and well coated with black acid-proof paint, which has thoroughly dried, before loading. Explosive D is used as a bursting charge for armor-piercing projectiles on account of its insensitiveness to shock, which permits the projectile to penetrate the armor without exploding. It will absorb moisture from damp atmosphere and should be stored in dry magazines.

The Pressing Process. Projectiles are loaded with explosive D behind barricades with hydraulic equipment. The shell must be placed centrally under the ram of the press in order to make certain that the ram does not strike the side walls of the shell. The weight of the shell must not rest on the false ogive, armor-piercing cap, or windshield while pressing the charge, but must be supported at a point on the shell wall immediately forward of the bourrelet. This supporting ring must be machined of special steel to very close tolerance in order to prevent the projectiles from sticking in the support.

Explosive D is pressed into shell in increments of various sizes. Starting in the nose of the shell a small amount of explosive D is pressed with a ram of small diameter. The ram is then removed and a larger amount of explosive D added and pressed with a ram of larger diameter. As the height of the pressed charge rises, the diameter of the shell cavity (which is usually cone shaped) increases, and this allows an increase in the diameter of the ram used as well as an increase in each successive increment of explosive. When the cylindrical portion of the shell cavity is reached, the rammer diameter and explosive increment have reached their maximum size and remain constant until the shell is filled to the required height. Pressures required to obtain the desired density may vary from 7,000 to 20,000 pounds per square inch of pressing area of the ram, depending on numerous factors described in the following paragraphs. Pressure per square inch under the ram will be computed as follows:

$$\frac{P \times A}{A_1} = \text{Pounds per square inch under ram}$$

P = Pounds pressure per square inch in press cylinder (dial pressure)

A = Area of press cylinder in square inches

A_1 = Area of ram pressing surface in square inches

Experiments with all shapes of rams show that a flat ram is best. The diameter of the rammer face must be carefully determined. A properly designed ram reduces the danger of the operation by allowing excess explosive D not pressed by the ram to have free escape around the sides. This also produces more uniform densities; a larger ram gives high densities on the sides, a smaller ram gives high densities in the center. When loading is properly carried out, the major portion of the explosive is held firmly under the ram while the excess is given free escape around the sides without undergoing any compression. Relative motion of the particles of explosive D which are held firmly is negligible and the explosive D which escapes is still in proper condition for incorporation in the next increment. If, however, the clearance is too small (clearance area less than 16 percent of the cross section of the cavity, or ram not centrally located in the cavity), the escaping material will be compressed before it gets clear;

and will not be in satisfactory condition for repressing. It will also be noted that unless rams of small diameter are not made long enough, some explosive D may be compressed by the enlarged upper portion of the rammer shaft.

The amount of explosive for each increment and the size of ram and estimated pressure for each have been recorded from actual loading records and may be obtained from Picatinny Arsenal for a large number of projectiles of various sizes. Where records are not available, the rule for determining the size of the increment is that the height of the increment after pressing should not exceed the diameter of the ram by more than 25 percent. The diameter of the ram should be approximately 88 percent of the diameter of the cavity at the increment level after pressing. The pressure required to obtain the specified density varies with the granulation of the explosive and must be determined by actual test. Coarser grained explosive D is relatively easy to press to the required density while a fine, light, fluffy material is very hard to press. Granulation of the explosive is now controlled by current specifications that allow not more than 20 percent to pass a No. 100 U. S. standard sieve.

Setting Up the Loading Procedure. In preparation for the loading of shell, it is necessary to load the point increment into a projectile in strict accordance with the procedure so far outlined, and carefully note the following:

1. Weight of explosive.

2. Diameter of ram.

3. Maximum pressure applied and length of time the maximum pressure was held before releasing. It may be necessary to vary this time from 3 to 30 seconds.

4. Diameter of shell cavity at top of pressed increment.

5. Total length of pressed increment.

6. Condition of explosive remaining unpressed.

7. Centering of ram with respect to shell cavity.

CAUTION: Care must be exercised during experimental work to prevent the ram striking the shell cavity walls, especially on the first increment where the cavity diameter is small and tapers to a point.

The shell is removed from the press and the increment is carefully dug out by cutting it away from the side walls of the shell with a chisel-pointed brass rod. All large pieces are saved for determination of specific gravity by the mercury method. If uncompressed explosive is found in the bottom of the shell cavity, one or more of the following may be the cause and must be corrected: increment too large; ram too large in diameter; not enough pressure applied; or a combination of several causes. A properly pressed first increment will hold its shape to the point of the cavity and when care is used in cutting, a sample for density calculation can be obtained from the cavity point.

Corrections are made, and the above is repeated on several shells until a satisfactory increment of uniform density is obtained. The specific gravity of all samples is carefully recorded and charts to show a cross section of the cavity for each sample shell. Like procedure is followed for all increments. When satisfactory results are obtained, this procedure then becomes standard practice for loading the particular increment involved.

After samples are removed for density determination of the increment under development, samples are further cut out until the shell is entirely unloaded and the density of all previously loaded increments is checked. All results are checked against the points noted above, and a chart is prepared for each experimental shell. If the specific gravity runs higher than required, the possibility of increasing the size of the increment should be investigated with a view of reducing operating costs and increasing production. The use of more pressure than is required to obtain specified density should also be avoided. The foregoing procedure is continued until a standard practice has been developed for each increment. The height to which the last increment is pressed will be determined by a study of the drawing of the shell being loaded. Excess explosive to be cut away to allow seating of the base plug should be kept to a minimum.

The first projectile is loaded in accordance with the procedure so far outlined. Samples are taken for specific gravity in accordance with U. S. Army Specifications 50-15-1A. If the procedure has been correctly developed, the specific gravity throughout the charge should be satisfactory. If not, such corrections to the loading procedure as may be necessary are made. A good plan is to select several shells at intervals from the first day's production and remove samples for specific gravity to check operations. These results should definitely prove the quality of loading and if satisfactory, production should proceed. The shells used for all previous tests should be thoroughly cleaned, and the interiors should be recoated as required by the drawing.

Specific Gravity. The selection of sample shells for determination of specific gravity of the explosive charge should be made by the inspector in accordance with U. S. Army Specification 50-15-1A. The number selected varies from 1 for each 50 to 1 for each 1,000 shells loaded, depending upon the type and caliber of the shell. Samples for the determination of the specific gravity of the charge should be taken from each increment of loading and should be sufficient in number to represent all parts of the charge. The samples may be taken with a core drill or by using a metal bar of nonsparking material with a chisel point. Each of the samples of explosive should be cut to approximately a ¾-inch cube, and the specific gravity should be

determined on each sample by the mercury displacement method, as follows:

Clean the samples so as to leave no sharp corners, and weigh accurately on a laboratory balance. For determining the displacement, use an apparatus consisting of a glass beaker with ground top, a piece of glass of sufficient size to completely cover the top of the beaker, and a semihard rubber perforated plate, pierced at each corner with sharp pointed pins so that about ½ inch of pin protrudes from each side. Fill the beaker with clean mercury. Insert the rubber plate, and level off the mercury by pressing down with a flat glass until it is even with the top of the beaker. Place the sample beneath the prongs of the rubber plate, and level the mercury as before. Catch the excess mercury in a clean bowl. Weigh the mercury displaced, and calculate the specific gravity of the sample as follows:

$$\text{Specific gravity} = \frac{13.54\ W}{W_1}$$

W = weight of sample in grams

W_1 = weight of mercury displaced in grams.

For armor-piercing projectiles the specific gravity should not be less than 1.45 in all parts of the charge. For projectiles other than armor-piercing, the specific gravity should not be less than 1.35 in all parts of the charge.

After the last increment has been passed, the shell is removed to a convenient location for assembly of the base plug, fuze, and base cover. Excess explosive is removed from the projectile by means of a cutter having a contour the same as the inner face of the base plug. The amount of explosive removed should be such that the void between the inner face of the base plug and the explosive charge would not exceed 0.125 inch. Loose explosive left by the cutter should be removed by an approved vacuum unit and the threads thoroughly cleaned of all explosive dust. Waste explosives from drilling and thread cleaning operations must not be reclaimed but should be destroyed in accordance with safety regulations.

Base plugs are not interchangeable and both shell and plug must be cold stamped with a serial number before removing the plug to insure reassembly in the shell to which it belongs. NOTE: All base plugs and base fuzes are equipped with left-hand threads. The inner face of the plug must be coated with black acidproof paint and dusted lightly with flake graphite when thoroughly dry. A small quantity of the specified lubricant is applied to the threads of the base plug and the base plug is screwed into the projectile until it is properly seated flush with the base of the projectile. The plug is unscrewed one or two turns, and paraffin is poured through the fuze hole until it completely fills the void between the explosive charge and inner face of the plug.

The base plug is immediately tightened in the projectile and the paraffin is allowed to solidify.

A cutter having a contour which conforms to the contour of the fuze body is inserted through the fuze hole and the fuze cavity is drilled in the explosive charge. NOTE: Where a fuze seat liner is required, it must be inserted prior to final assembly of the base plug. The depth of this cavity should be such that when the fuze is assembled any void existing between the fuze and face of the explosive charge will not exceed 0.025 inch. All surfaces of the fuze coming in contact with the explosive must be coated with black acidproof paint. All loose explosives are removed from fuze cavity and fuze hole threads. A small quantity of approved lubricant is applied to the fuze threads before assembly. The fuze is screwed firmly in place until it seats flush with the base plug. In most cases the fuze comes to a positive stop against a shoulder in the fuze hole. Where a positive stop is not provided, the fuze is held in place with a locking pin. Wrench hole filling plugs are inserted as required. The calking groove is thoroughly cleaned and the base cover is assembled complete with lead disc. The projectiles are painted and marked as required by specifications and drawings.

In view of the fact that proper loading of projectiles depends absolutely on the size of the increment, the size of the ram, the pressure applied, and the granulation of the explosive, it can readily be seen that the explosive operators must follow instructions to the letter. The rate of application of the pressure and the time of holding the pressure on the explosive must be uniform, as disregard of these points alone can give a variation in density greater than allowed by specifications.

The foregoing information is to be used only as a guide where applicable to the various loading activities. Specific operations will be governed by the drawings, specifications, operation studies, standard practice sheets, and other instructions issued by the Chief of Ordnance.

TETRYL.

Tetryl has been recently adopted as a standard filler for small high-explosive shells. It is first blended with a small percentage of graphite or stearic acid and then pressed into pellet form (dry). These pellets are made to fit the inside diameter of the cavity to be filled. The correct number of these pellets are placed in the shell cavity and reconsolidated by a final pressing operation. Operators are always protected by a shield or barricade when pressing tetryl. To date, tetryl has been used principally as a filler for 20-mm and 37-mm high-explosive shells.

TETRYTOL.

This is a mixture of tetryl and molten TNT. As some of the tetryl goes into solution, the mixture can be successfully cast with as high

as 70 percent tetryl and 30 percent TNT by weight. The principal use and advantage of tetrytol is in loading boosters and bursters by the casting method. These items were previously loaded with dry tetryl which was pressed into pellets and then reconsolidated by pressing into the burster or booster casing. The mixture is agitated until ready for casting to prevent separation or settling. The use of tetrytol loaded boosters and bursters has been approved except where the loaded item is plunged into or surrounded by a hot bursting charge, such as (auxiliary boosters in demolition bombs) where a remelt of the tetrytol might occur. The advantages of casting over pellet reconsolidation, especially in long burster tubes, is tremendous from a standpoint of simplicity of operations, safety, and cost of equipment.

PENTOLITE.

This is a mixture of PETN and TNT. The 50/50 mixture results in a considerable increase in the brisance of TNT as measured by the rate of detonation. It is more sensitive to friction and shock than TNT and where booster cavities have to be drilled, a mixture of 10 percent PETN and 90 percent TNT is used for the booster surround.

50/50 pentolite is supplied in the dry state packed in the same manner as TNT. It is loaded by the casting method, 5-pound steam pressure on a steam jacketed open kettle being sufficient to melt the dry material. As the dry material melts, it must be constantly agitated to keep the PETN in suspension, since only a small portion of it goes into solution with the TNT. This agitation, usually by air driven propellers or hand paddles, must be continued until the material is cast into the ammunition being loaded.

The stability of pentolite is not as good as straight TNT. Long periods of storage under high temperature may result in a separation of the material and the loss of its greatest effectiveness as an explosive of high brisance. Every effort must be made to store it in a cool, dry place.

SECTION IV.

CHEMICAL WARFARE AGENTS

Chapter 1

Chemical Agents

INTRODUCTION.

General. Chemical agents are many times referred to as the weapons which can "shoot around corners," due to their ability to filter through small crevices and to settle in all recesses, thus seeking out their victims. A great many people feel that, because of this, chemical agents are too brutal and too inhuman to be used by a civilized nation. The facts from World War I prove otherwise. Of the 275,000 American casualties, more than one-fourth were caused by gas. Of the gas casualties, only about 2 percent died. Of those caused by other weapons nearly 25 percent died. In other words, the man wounded by gas had about twelve times the chance to live, in comparison with his fellow soldier suffering from the effects of the traditional weapon. Those who have opposed gas weapons on the basis of inhumanity have long since been halted by the facts.

No form of warfare is humane, for war is the negation of humanity. Before one concludes that gas warfare is too horrible for a civilized people to tolerate, he should compare gas casualties with the injuries resulting from high explosives, bullets, and bayonets. He should think of the torture that comes to the man who has been bayonetted, before death releases him, or to the man whose face has been shattered by a bullet which destroys eyes, nose, and jaw, yet fails to bring the release of death. He should also remember that most gas casualties can be avoided. Proper gas discipline and use of protective equipment can reduce to a very small percentage the number of men put out of action by chemical agents. A man in the open is helpless against the missile weapons, there is nothing he can do to avoid injury by bullets, flying pieces of metal, or shock of explosion. He can and should avoid injury by gas.

History. The idea of using chemical agents in warfare was not conceived as many believe in the days of World War I. History shows that the seed of chemical warfare has always been present in military thought. Only a proper combination of conditions was required to bring it to a vigorous life. The required conditions did not exist until the latter part of the nineteenth century, and the proper combination was not reached until the First World War.

The earliest recorded use of chemicals in military operations was at the siege of Plataea, 428 B.C., where the Spartans used gas as an offensive weapon against the Athenians. Wood, saturated with pitch

and sulfur, was burned under the walls of the city in order to create choking and poisonous fumes to assist the assault in subduing the defenders. This operation would have been most successful if a sudden rainstorm had not put out the fire. A similar operation at the siege of Delium, 5 years later, was a complete success.

Ancient chronicles report that about the year 360 B.C., the Greeks used suffocating and incendiary mixtures formed of various chemical substances easily ignited and hard to extinguish. They consisted of pitch, sulfur, tow, and resinous wood chips. This compound was put into pots which were thrown burning from besieged towns upon the "tortoise," the shelter under which the besiegers attempted to approach the walls. Later, incendiary arrows and other incendiary devices shot from catapaults came into use.

Greek fire was perhaps the most famous of all of the early means of chemical warfare. This compound was a powerful incendiary which produced suffocating fumes. Early writers state that it would ignite when brought in contact with the water and float and burn on the surface of the sea. The exact composition of Greek fire is not known. The process for its manufacture was kept a close secret for several hundred years. It must, however, have contained rosin, pitch, sulfur, naphtha or petroleum, quicklime, and perhaps also saltpeter. It was discharged from tubes in the bows of the ships.

At the siege of Petra, in the days of the Roman Empire, the Persians used vases filled with a fire compound of sulfur, asphalt, and naphtha. These were thrown into the city by mangonels, a military engine for hurling rocks and javelins. When they broke, the compound burst into flames which could not be extinguished and which gave off choking gases.

Smoke was successfully used in a river crossing by Charles XII of Sweden in 1701. Under cover of a thick cloud produced by burning damp straw, Charles was able to cross the Dvina and take position in the face of superior forces before the enemy learned what was happening.

During the siege of Sebastopol, 1855, Admiral Lord Dundonald submitted a plan for the use of sulfur gas for the reduction of the Russian forts. The English government admitted the plan was feasible, but would not permit putting it into execution. The use of sulfur was suggested at the siege of Charleston in the Civil War.

As a matter of fact, modern chemical warfare might just as well have started during the War Between the States in 1862 as during the World War in 1915. Only the failure of the War Department to grasp the golden opportunity offered prevented this. Not only was a practical scheme for using gas recommended, but the suggestion incorporated the use of the very gas that the Germans used so successfully at Ypres over 50 years later.

During World War I, the first gas attack of any consequence was the famous gas cloud attack at Ypres in April 1915. The chemical agent used in this attack was chlorine and the casualties numbered about 5,000 men. Although the element of surprise was perfect, the Germans failed to make the gains that were possible because they failed to realize the effect the attack had on the Allied morale.

Chlorine was followed by phosgene, also developed by the Germans, in an attack which took place on December 11, 1915. This attack was not successful because the Allies were ready for it.

Mustard followed next in line, being introduced by the Germans near Ypres on July 12 1917. This marked the first use of a chemical agent which would linger in one place for a great length of time and thus render that area unfit for use.

From this period in the First World War, chemical agents were developed in rapid succession by all nations, and new agents are still being experimented with and adopted for use today.

GENERAL.

Most people, when the words "chemical warfare" are mentioned, immediately think "poison gas." As a matter of fact, in the Chemical Warfare Service the agents are often referred to as "gases." The term "poison gas," however, is a misnomer. Most of the chemical combat substances are liquids and solids which are disseminated in the air by various methods. Some are contained in shells, or bombs, which explode and throw the liquid or solid agent into the air in drops or in fine particles. Some solids, are vaporized by heat within a container and pass into the air as a smoke. Others, generally liquids, are carried in tanks upon airplanes and released into the air to fall to the ground as droplets or as a fine mist. A few, those which enter readily into the gaseous state, can be released directly from cylinders, merely by opening a valve, and form a dense cloud which is carried by the wind.

Definition. Whether these materials are called chemical agents, combat chemicals, or poison gases, the terms all refer to any substance, useful in warfare, which by its ordinary and direct chemical action, produces either a powerful physiological effect, a screening smoke, or an incendiary action. Note the words "by direct chemical action." The active agent itself creates casualties directly. TNT, picric acid, smokeless powder, are all chemicals but they are useful in war because they propel shell fragments or bullets by their explosion. They exert their chemical effect indirectly and so are not spoken of as chemical agents.

Requirements. Of the many thousands of poisonous substances known to the chemist, the number that are important as agents of chemical warfare may almost be counted on the fingers. One may

point out very good reasons why there are so few effective combat chemicals. Not only must the warfare agent have irritant or toxic properties sufficient to irritate or cause casualties in extremely low concentrations, but it must also possess suitable physical characteristics and chemical properties, and meet rigid economic standards.

To find a material that will combine all requirements is practically impossible. There are 10 requirements which the ideal war gas must possess. To meet the ideal specifications, a chemical agent for our armed services must be:

1. Effective in small concentrations.

2. Unreactive, and not so easily neutralized or destroyed.

3. Easily manufactured in large quantities.

4. Composed of raw materials easily procurable on the North American continent or in the Western Hemisphere.

5. Cheap.

6. Easy to transport, compressible to a liquid.

7. Stable in storage and stable against shock of explosion.

8. Heavier than air.

9. Effective against all parts of the body; combination of lung, eye, skin, and nose irritant.

10. Odorless, tasteless, colorless; not easily detected.

All of these requirements obviously cannot be found in one chemical, they represent the ideal. Certain of them are essential. Every agent must combine at least the first five.

It is because of the necessity of meeting these requirements, especially the first three, that we have so few agents from which to choose.

Obviously, any agent to be useful must be effective in extremely small concentrations. It is necessary to understand how extremely small the concentrations of the really powerful chemical agents can be and still be effective. For example, one of the tear gases has a pronounced irritant effect at a concentration of eight ten-thousandths of an ounce (0.0008 ounces) in a thousand cubic feet of air. More than an ounce of this material can be held in the hand. Suppose an ounce of it is divided into 10,000 small parts. Then eight of these parts are put into a box 10 feet high, 10 feet long, 10 feet wide. This almost infinitely small quantity of tear gas inside the large box would cause much discomfort if one were in it for 3 minutes. It can thus be understood that by small concentrations of chemical agents, almost infinitesimal quantities are referred to quantities which can be disseminated in the air with little difficulty.

The most poisonous chemical that exists is valueless in warfare unless it can be manufactured quickly and in sufficient quantity. The chemical that is effective, cheap, and easily manufactured, is of little

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use if protection against it is easily obtained. Consequently, one quality of the ideal chemical agent is that it must not combine readily with other substances, so that it cannot be easily destroyed or removed. An unreactive chemical is sought, since the unreactive chemicals are more likely to pass through a gas mask without being filtered out.

Stability is important. The ideal agent should be stable in storage and also stable against the shock of explosion. Even if the agent were otherwise effective, it would not be used if it had a tendency to break down into its elements after storage for several weeks or several months, or if it would break down when fired in a shell. Lack of stability was one of the reasons why the very poisonous hydrogen cyanide, or hydrocyanic acid, proved to be a poor war gas. It was unstable in storage and also unstable to shock. Since the last war, suitable means have been found of stabilizing this poisonous material.

The chemical selected must not be too corrosive or it will destroy the container and itself. Several agents, which might otherwise be desirable, have to be used in glass-lined shells or containers because of their corrosive nature. The use of special linings or special containers complicates manufacture, is expensive, slows down production.

To be used on the battlefield, a gas must be heavier than air. Gases lighter than air rise and may have no effect on the man on the ground. They dissipate too rapidly. The fact that hydrogen cyanide is just a trifle lighter than air is another reason for its previous failure as a war gas.

An agent that will affect all parts of the body is far more useful than one which will affect only the lungs or the eyes or the skin. That is one reason why mustard gas is such an extremely valuable war material. If a man breathes it, he will become a dangerous casualty through the effects of the gas on his lungs. A very small amount in the surrounding atmosphere causes a powerful irritation on the eyes over a period of time. If a gas mask is worn, a man's lungs and eyes are protected. However, mustard gas is still effective even against a man wearing the gas mask, since it also affects the skin and causes serious burns.

Finally, the ideal war gas should be odorless, tasteless, and colorless. It would thus get in its deadly effect without the victim knowing it and making an effort to protect himself. No such toxic gas exists, with the possible exception of carbon monoxide which has neither color, odor, nor taste. However, although carbon monoxide is extremely poisonous, cheap, easily available, and stable; it is lighter than air and can not be compressed to liquid form. No method has ever been found that would permit its use in large quantities on the battlefield as a poison gas. Carbon monoxide, nevertheless, does cause deaths in battle because some of it is formed in every explosion. When

a high-explosive bomb or shell bursts in an inclosed space, men who escape the effects of the blast sometimes die from the effects of the carbon monoxide produced. This, however, is an incidental effect and carbon monoxide is not considered as an agent of chemical warfare.

Classification. Chemical agents are classified in various ways, depending upon who is doing the classifying, and in what phase of the subject the classifier is interested.

To obtain the color marking used on chemical ammunition, the classification according to tactical use is taken as the basis. The painting of chemical ammunition is as follows:

The round is painted a blue-grey base color to denote a chemical filler.

Then the round is marked with a band or bands and stencil, the color of which is based on the type of agent used as the filler.

Casualty agents	Green
Irritating or harassing agents	Red
Screening smoke agents	Yellow
Incendiary agents	Purple

The number of bands on a round depends upon the persistency of the agent used as a filler. By persistency is meant the time after dispersal of the agent that it will be effective in the area in which it was released. Agents which remain effective for over 10 minutes are termed persistent, while those which remain effective for less than 10 minutes are termed nonpersistent. Persistent agents are marked with two bands and nonpersistent agents are marked with one band.

According to their physiological effects, chemical agents are classified as lung irritants, vesicants, lacrimators, irritant smokes (sternutators), screening smokes, and incendiaries.

The lung irritants are those agents which when breathed cause irritation and inflammation of the bronchial tubes and lungs.

The vesicants are those agents readily absorbed through both the exterior and the interior parts of the human body, resulting in the production of inflammation, blisters, and general destruction of tissue.

Lacrimators are those agents which cause a copious flow of tears, and intense, although temporary, eye pain.

Irritant smokes, also called sternutators, are those agents which cause sneezing, coughing, lacrimation, headache, followed by nausea and temporary physical disability.

Screening smokes are those agents which when burned, hydrolyzed, or atomized, produce a dense obscuring smoke in air.

Incendiaries are those agents which are used primarily for setting fire to materiel.

AMMUNITION INSPECTION GUIDE

SYMBOL	NAME	CLASS	BANDS COLOR	LOADING	ODOR	TACTICAL CLASS	PHYSIOLOGICAL EFFECT
H	MUSTARD DICHLORETHYLSULFIDE	Gas	2 Green		Garlic Horseradish Mustard		Burns skin or membrane
L	LEWISITE CHLORVINYLDICHLORARSINE	Gas	2 Green		Geraniums		Irritates nasal passages. Later skin burns, poison.
ED	ETHYLDI-CHLORARSINE	Gas	2 Green		Biting Stinging		Causes blisters, sores
PS	CHLORPICRIN NITROCHLOROFORM	Gas	2 Green	+CG +CN	Flypaper Anise		Causes severe coughing, crying, lung edema
DP	DIPHOSGENE TRICHLORMETHYL CHLOROFORMATE	Gas	2 Green		Musty Hay Green Corn Ensilage		Causes coughing, breathing hurts, eyes water, toxic
CG	PHOSGENE CARBONYL CHLORIDE	Gas	1 Green		Musty Hay Green Corn Ensilage		Irritates lungs
CL	CHLORINE	Gas	1 Green	+ PS + CG	Highly Pungent		Intense immediate choking
CN *(CNS)	CHLORACETO-PHENONE	Gas (Solution)	1 Red (2 Red)		Apple blossoms		Makes eyes smart, shut tightly, tears flow. Temporary.
BBC	BROMBENZYL-CYANIDE	Gas	2 Red		Sour fruit		Eyes smart, shut, tears flow. Effect lasts some time.
DM	ADAMSITE DIPHENYLAMINE CHLORARSINE	Gas	1 Red	(+CN)	Coal Smoke		Causes sneezing, sick depressed feeling
PD	DIPHENYL-CHLORARSINE	Gas	1 Red		Shoe Polish		Causes sneezing, sick depressed feeling
HC	HC MIXTURE	Smoke	1 Yellow		Sharp-acrid		Harmless
FS	SULFUR TRIOXIDE IN CHLORSULFONIC ACID	Smoke	1 Yellow		Burning matches		Liquid burns skin if allowed to remain
FM	TITANIUM TETRACHLORIDE	Smoke	1 Yellow		Acrid		Harmless
WP	WHITE PHOSPHORUS	Smoke	1 Yellow		Burning matches		Burning pieces adhere to skin, clothing
†TH	THERMIT (THERMITE) IRON OXIDE AND ALUMINUM POWDER	Incendiary	1 Purple		Odorless		5000 degrees F. heat ignites materials

* CNS, A SOLUTION OF CN IN CHLOROFORM AND CHLORPICRIN, FREQUENTLY USED FOR SHELL FILLING

† THE FILLING OF A MAGNESIUM BOMB WHICH SERVES TO IGNITE THE METAL MAGNESIUM CASING

RA PD 27686

Explanatory Chart —Chemical Ammunition

CHEMICAL WARFARE AGENTS

PROTECTION	FIRST AID	COLOR & STATE		PERSISTENCE	TACTICAL USES
		LOADED	RELEASED		
	Remove clothing. Wash affected parts of body with soapy water. Irrigate eyes with 2% sodium bicarbonate solution	HEAVY DARK, OILY LIQUID	Liquid slowly evaporates	Open - 1 day Woods - 1 week to all winter	To neutralize areas Counter-battery Attack on Personnel
	Apply 3 to 5% solution hydrogen peroxide to skin; wash with soap and water. Irrigate eyes with water or 3% sodium bicarbonate solution	HEAVY DARK, OILY LIQUID	Liquid slowly evaporates	Open - 1 day Woods - 1 week	Similar to Mustard
	Apply 3 to 5% solution hydrogen peroxide to skin; wash with soap and water. Irrigate eyes with water or 3% sodium bicarbonate solution	CLEAR OILY LIQUID	Evaporates at medium rate.	1 hour	Counter-battery Preparation fire Harassing fire
	Wash eyes, keep quiet and warm. Do not rub eyes	YELLOW OILY LIQUID	Evaporates like water.	Open 6 hours Woods - 12 hours	Harassing and casualty fire
	Keep quiet and warm Give coffee as a stimulant	COLORLESS LIQUID	Evaporates like water.	30 minutes	Harassing and casualty fire
	Keep quiet and warm Give coffee as a stimulant	COLORLESS LIQUID	Colorless gas	10 to 30 minutes	Surprise attacks, projectiles Gas cloud release. For quick physical effect
	Keep quiet and warm Coffee as stimulant	YELLOW LIQUID	Yellow-green gas	10 minutes	Surprise attacks (cloud)
	Wash eyes with water or boric acid. Do not rub or bandage. Wash skin with 4% Na_2SO_3 in 50% Alcohol Solution	WHITE CRYSTALLINE POWDER	Cloud of small, solid particles	10 minutes	Training. Mob control. CNS used in counter-battery to force mask wear
	Wash eyes with boric acid Do not bandage	DARK BROWN OILY LIQUID	Slowly evaporates	Several days (weeks in winter)	To neutralize areas Counter-battery
	Remove to pure air and keep quiet. Breathe small amounts of chlorine	YELLOW-GREEN GRANULAR SOLID	Yellow smoke	10 minutes	Gas Cloud Attacks Mob control -
	Remove to pure air, keep quiet Sniff chlorine from bleaching powder bottle	WHITE CRYSTALLINE SOLID	Vapor or fine smoke	Summer 10 minutes	Harassing fire
NONE NEEDED	Produces no effect requiring treatment	GREY SOLID	White to grey smoke	While burning	To screen small operations in own lines and for training purposes
	Wash with Soda solution	CLEAR TO BROWN LIQUID	Dense white smoke	5 - 10 minutes	Airplane spray for screen on broad front -
NONE NEEDED	Produces no effect requiring treatment	YELLOWISH TO BROWN LIQUID	White smoke	10 minutes	Screening operations
NONE AVAILABLE	Wash with Copper Sulphate solution or immerse in water	PALE YELLOW SOLID	Burns to white smoke in air	10 minutes	To screen advancing troops Cause incendiary effects, losses Harass enemy observers -
COVER WITH EARTH, SAND	Treat for burn	METALLIC POWDER	White-hot metal	5 minutes	Destruction of Material -

RA PD 27691

Explanatory Chart —Chemical Ammunition

VESICANTS.

Mustard, H, Dichlorethylsulfide, $S(CH_2CH_2)_2Cl_2$.

Properties. When pure, mustard is a transparent, amber, oily liquid of 1.27 specific gravity, which boils with slight decomposition at 433.6 F, yielding a vapor 5.5 times as heavy as air.

Odor. It is almost odorless in ordinary field concentrations and in strong concentrations resembles horseradish or mustard.

Persistency. Because of its low volatility, mustard gas is very persistent in the field, varying from 1 day in the open and 1 week in the woods in summer, to several weeks both in the open and in the woods in winter. Its great persistency is the principal limitation on its use, as it cannot be used on the tactical offensive where friendly troops have to traverse or occupy the infected ground. However, by the same token, mustard is particularly adapted for use in the tactical defensive, to prevent the occupation by hostile troops of ground evacuated on withdrawal.

Physiological effect. Mustard is classified as a vesicant gas. At first it acts as a cell irritant, and finally as a cell poison. The first symptoms of mustard-gas poisoning appear in from 4 to 6 hours, but a latent period up to 24 hours may occur. The length of the latent period depends upon the concentration of the gas. The higher the concentration the shorter the interval of time between the exposure to the gas and the first symptoms arising as a result of mustard-gas poisoning.

The physiological action of mustard gas may be classified as local and general. The local action results in conjunctivitis or inflammation of the eyes; erythema of the skin, which may be followed by blistering or ulceration and inflammatory reaction of the nose, throat, trachea, and bronchii.

It is of interest that racial susceptibility to toxic action of mustard gas exists; the Caucasian is more susceptible than the Negro. There is also an individual susceptibility to the toxic action of mustard gas, particularly of the skin, and also of the respiratory tract.

Protection. Complete protective clothing plus the gas mask are required for protection against mustard gas. A discussion of the protective equipment follows at the end of the discussion of chemical agents.

First aid. To be effective, treatment must begin within a few minutes after exposure. Immediate prophylaxis is effective only up to 5 minutes after liquid contamination. It is of little value after exposure to vapor because, in this form, most of the agent has penetrated the skin before the person reports for treatment.

Contaminated clothing must be removed quickly, using proper precautions (mask, gas proof gloves, apron, protective ointment) to protect the attendant. Clothes must be placed in a covered metal container until decontaminated.

Great care must be taken in the removal of mustard from the skin; otherwise the agent will merely be spread. The steps are as follows:

1. Gently apply dry pads to absorb any mustard remaining on the skin.

2. Swab the area repeatedly with Protective Ointment M4, wiping the ointment off thoroughly after each application.

3. Scrub the contaminated area with soap and water.

4. Pat the area dry with a towel. *Do not rub.*

5. Burn or bury the materials contaminated during the procedure.

In the event that Protective Ointment M4 is not available, step 2, above, may be done with the application of sponges dampened with kerosene, CARBON TETRACHLORIDE, or alcohol. When following this procedure, the sponges should be damp with the solvent; if dripping wet, they may dissolve the agent and spread it as they run over the skin.

The eyes should be irrigated with a 2 percent solution of sodium bicarbonate. The solution should be run directly into the eyes with a rubber tube from an enema can or similar container. Petrolatum on the edges of the eyelids will prevent their sticking together.

If it is likely that mustard has entered the mouth or nose, the mouth and nasal passages should be rinsed and the throat gargled repeatedly with 2 percent solution of sodium bicarbonate. The patient should be kept quiet and warm to guard against bronchitis and bronchopneumonia.

If nausea and vomiting indicate that contaminated materials have been swallowed, the stomach should be washed out by repeated drinking of warm 2 percent solution of sodium bicarbonate. This will induce vomiting and wash out the irritant.

After decontamination, all persons with eye, nose, and throat burns, and with extensive skin burns should be hospitalized. Skin burns must be treated surgically as any severe extensive burn.

Lewisite, Chlorvinyldichlorarsine, $CHClCH\text{-}AsCl_2$.

Properties. Lewisite is an oily, colorless to light amber liquid, of 1.88 specific gravity, which boils at 374 F, yielding a dense vapor 7.1 times heavier than air. The freezing point of lewisite is 0 F.

Odor. Its odor faintly resembles that of geraniums.

Persistency. Lewisite is slightly less persistent than mustard. Under average conditions, in summer, it persists for 24 hours in the open, and from 2 to 3 days in woods. In winter it may last for a week or more.

Physiological effect. Physiologically, lewisite acts similarly to mustard gas and in addition is a systemic poison when absorbed into the body through the skin or lungs. It may, therefore, be classed as primarily a vesicant, secondarily a toxic lung injurant, and tertiarily a systemic poison when absorbed in the tissues. Lewisite is then both a general and local toxic of great strength. The effects of lewisite are visible much more quickly than those of mustard.

Protection. Complete protective clothing plus the gas mask are required for protection against lewisite. A discussion of the protective equipment follows the discussion of chemical agents.

First aid. Treatment must begin within 1 minute after exposure to liquid lewisite to be really effective. Contaminated clothing must be quickly removed with precautions to protect the attendant, and treatment should be started while the clothing is being removed.

The contaminated areas should be swabbed immediately and repeatedly with hydrogen peroxide. Solutions with 10 or even 20 percent available oxygen are best, but are somewhat unstable. The ordinary 2 percent solution available in drug stores will suffice. If hydrogen peroxide is not available, a solution of 10 percent sodium hydroxide in a 30 percent solution of glycerin in water, alternating with 70 percent alcohol, is the second choice. The glycerin protects the skin from the hydroxide. If no glycerin is available, 5 percent sodium hydroxide in water may be used. Lacking all of these, the solvents and technique described for liquid mustard must be used. Following treatment, the skin should be washed with soap and water and patted dry. All contaminated cloths or sponges must be burned or buried.

It is important that patients contaminated with lewisite come immediately under medical treatment. The doctor must open the blisters as soon as possible to prevent further absorption of arsenic. In opening the blisters, he must be careful to prevent infection and must remember that the blister fluid itself is capable of producing burns.

Liquid lewisite in the eyes is an emergency. The eyes must be rinsed immediately with 2 percent hydrogen peroxide. If that is not available, they must be irrigated with 2 percent solution of sodium bicarbonate. Delay may result in blindness.

Ethyldichlorarsine, ED, Ethyldichlorarsine, C_2H_5-$AsCl_2$.

Properties. Ethyldichlorarsine is a clear, somewhat oily liquid of 1.7 specific gravity, which boils at 312 F, yielding a vapor 6.5 times denser than air.

Odor. It has a stinging odor similar to that of pepper in the nose.

Persistency. Ethyldichlorarsine has a persistency of about 1 hour.

Physiological effect. Although ethyldichlorarsine is a fairly powerful sternutator and vesicant agent, its primary action on the body is as a lung injurant. Its first effect in low concentrations is a respiratory irritant. The effect upon the eyes and upper respiratory tract is evanescent, while that upon the lower respiratory tract leads to membranous tracheitis and pulmonary congestion, edema, and pneumonia. Arsenic is absorbed rapidly and leads to systemic poisoning, characterized by lowered temperature, toxic symptoms, anesthesia, and depression.

On short exposure (less than 5 minutes), ethyldichlorarsine is not a particularly efficient irritant for the human skin. On exposure greater than 5 minutes, however, positive burns appear which increase in severity with length of exposure. On the basis of rapidity of action, extent of rubefaction, swelling and edema, and time of healing, ethyldichlorarsine is about two-thirds as effective as mustard gas, but for vesication it is only about one-sixth as effective.

Protection. Complete protective clothing plus the gas mask are required for protection against ethyldichlorarsine. A discussion of the protective equipment follows at the end of the discussion of chemical agents.

First Aid. Immediate measures are the same as for lewisite. Nose irritation may be relieved by inhaling dilute chlorine from a small amount of bleaching powder in a wide-mouthed bottle or can. Repeated drinking of warm 2 percent sodium bicarbonate solution should be used for vomiting.

LUNG IRRITANTS.

Chlorpicrin, PS, Nitrochloroform, CCl_3NO_2.

Properties. Chlorpicrin is a colorless, oily liquid of 1.66 specific gravity, which boils at 231.5 F, giving off a vapor 5.6 times heavier than air.

Odor. Its odor is rather sweetish in nature resembling that of fly-paper or anise.

Persistency. Chlorpicrin has a persistency of about 6 hours in the open and 12 hours in the woods.

Physiological effect. It is a lethal compound which acts primarily as a lung injurant. In toxicity, it is intermediate between chlorine and phosgene.

In addition to its lung injurant effects, chlorpicrin is also a strong lacrimator, and has the additional advantage of being capable of penetrating gas mask canisters that are resistant to ordinary acid gases, such as chlorine and phosgene. The injurious effects of chlorpicrin also extend to the stomach and intestines, causing nausea, vomiting, colic, and diarrhea. These conditions are difficult to combat in the field and often persist for weeks so that even slight cases of chlorpicrin gassing frequently involves large casualty losses.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. Absolute rest and warmth are essential. The patient should be removed immediately to a pure atmosphere and made to lie down, kept at absolute rest, and kept warm with blankets. A person affected by lung irritants should always be moved on a litter or stretcher. He must never be allowed to walk. A light stimulant or hot coffee may be given. A glass of milk or cream, if available, will give marked relief from pharyngeal irritation, and the patient should be hospitalized. In cases of splashes of liquid on the skin, it should be washed off at once with alcoholic sodium sulphite, in order to prevent ulcerations. Skin scratches and abrasions exposed to chlorpicrin fumes or liquid develop a high degree of inflammation and easily become infected.

Diphosgene, DP, Trichlormethyl-chloroformate, $ClCOOC\text{-}Cl_3$.

Properties. Diphosgene is an oily liquid of specific gravity 1.65. It boils at 260.6 F, giving a dense whitish vapor 6.9 times heavier than air.

Odor. It has an acrid odor which strongly resembles that of musty hay, green corn, or ensilage.

Persistency. Diphosgene has a relatively short persistency of about 30 minutes on open ground.

Physiological effect. The toxicity of diphosgene is about the same as that of phosgene. In fact, it is probable that the toxicity of diphosgene is not a specific property of that compound, but is derived from the phosgene molecules into which it decomposes in the tissues of the body.

Diphosgene is somewhat lacrimatory and thus causes watering of the eyes, as well as coughing, and occasional vomiting.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. The first aid for this type of chemical agent is the same as that given for chlorpicrin above.

Phosgene, CG, Carbonyl Chloride, $COCl_2$.

Properties. At ordinary temperatures and pressure, phosgene is a colorless gas which condenses at 46.7 F, to a colorless liquid of 1.38 specific gravity. Above 46.7 F, phosgene immediately evaporates, although at a slower rate than chlorine, and gives off a transparent vapor, 3.5 times heavier than air.

Odor. It has an odor which strongly resembles that of musty hay, green corn, or ensilage.

Persistency. Because phosgene is a gas it is nonpersistent, remaining in the open for up to 10 minutes. It will, however, remain in low protected areas for as long as 30 minutes.

Physiological effect. The toxicity of phosgene is over 10 times that of chlorine. In high concentrations, which are often met in battle, one or two breaths may be fatal in a few hours. Phosgene appears to exert its physiological and toxic effects chiefly through the medium of its hydrolysis products, hydrochloric acid, and carbon dioxide. Its effects upon the upper air passages of the body, where moisture is relatively small, is therefore comparatively slight. With prolonged breathing, however, sufficient phosgene is decomposed in the bronchi and trachea to produce marked inflammation and corrosion. These effects reach their maximum in the alveoli where the air is saturated with water.

Unlike chlorine, phosgene produces but slight irritation of the sensory nerves in the upper air passages, so the men exposed to this gas are likely to inhale it more deeply than they would to equivalent concentrations of chlorine or other directly irritant vapors. For this reason, phosgene is very insidious in its action and men gassed with it often have little or no warning symptoms until too late to avoid serious poisoning.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. The first aid for this type of chemical agent is the same as that given for chlorpicrin above.

Chlorine, Cl, Chlorine, Cl_2.

Properties. At ordinary temperatures and pressures, chlorine is a greenish-yellow volatile gas. It is readily liquefied by moderate pressure at ordinary temperatures. When liquid, it has a specific gravity of 1.46 and when a gas it is 2.5 times heavier than air.

Odor. Chlorine has a highly pungent odor.

Persistency. Chlorine is a gas, and as such is nonpersistent. It remains at the point of dispersal for a short length of time, up to 10 minutes.

Physiological effect. Chlorine has a very irritating effect upon the membranes of the upper air passages. It causes violent coughing immediately if small amounts are breathed. It can also be lethal on continued exposure to the agent.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. The first aid for this type of chemical agent is the same as that given for chlorpicrin above.

LACRIMATORS.

Chloracetophenone, CN, Chloracetophenone, $C_6H_5CO\text{-}CH_2Cl$.

Properties. When pure, chloracetophenone consists of colorless crystals, of 1.3 specific gravity, which melt at 138 F, and boil at 476 F, yielding a vapor which is 5.2 times as heavy as air.

Odor. The odor of apple blossoms is characteristic of both the solid and the vapor.

Persistency. In the solid form, chloracetophenone is very persistent. However, in the vapor form, as usually released, it has a persistency of about 10 minutes. For this reason, it is classed as non-persistent.

Physiological effect. Chloracetophenone, being a lacrimator, has the effect of producing a copious flow of tears when breathed. In addition to its lacrimatory effect, chloracetophenone is a decided irritant to the upper respiratory passages. In higher concentrations, it is irritating to the skin, producing a burning and itching sensation especially on the moist parts of the body.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. The individual should be removed from the contaminated air and face the wind with the eyes open. If irritation is marked, the eyes may be irrigated with boric acid or a 2 percent solution of sodium bicarbonate. The eyes must not be rubbed or bandaged.

Skin irritation may be treated by sponging with a solution of 4 percent sodium sulfite in 50 percent alcohol. All symptoms usually disappear within 1 hour.

Brombenzylcyanide, BBC, Brombenzylcyanide, $C_6H_5CH\text{-}BrCN$.

Properties. Brombenzylcyanide is a yellow-white crystalline solid which melts at 77 F into a brownish oily liquid of 1.47 specific gravity, and boils at 437 F, giving off a vapor which is 6.6 times as heavy as air.

Odor. This substance has an odor similar to that of soured fruit.

Persistency. Its persistency in the open is 3 days; in woods, 7 days; and in the ground, from 15 to 30 days.

Physiological effect. Brombenzylcyanide produces a burning sensation of the mucous membranes and severe irritation and lacrimation of the eyes with acute pain in the forehead.

Protection. The service gas mask is adequate protection against this type of chemical agent.

First aid. The first aid for this agent is the same as that given for chloracetophenone above.

STERNUTATORS (IRRITANT SMOKES).

Adamsite, DM, Diphenylaminechlorarsine, $(C_6H_4)_2\text{-}NH\text{-}AsCl$.

Properties. The impure commercial product used in chemical warfare is a dark brownish-green crystalline mass which partially liquefies

at 320 F, but the major portion does not melt until a temperature of 374 F is reached. It has practically no vapor pressure or vapor density, as it distills into the air in the form of minute solid particles.

Odor. Adamsite has an odor which closely resembles that of coal smoke.

Persistency. The persistency of adamsite averages about 5 minutes in the open both in summer and in winter.

Physiological effect. It strongly irritates the eyes and mucous membranes of the nose and throat and causes violent sneezing and coughing. It then produces severe headaches, acute pains and tightness in the chest, and finally nausea and vomiting. The effects last for about 3 hours.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. Remove to pure air. Let the patient inhale dilute chlorine from a small amount of bleaching powder in a wide-mouthed bottle or can. Headache may be controlled with 10 to 15 grains of aspirin. There are no after effects and the person recovers within a few hours.

Severely exposed persons must be watched for suicidal tendencies. Continue to reassure them that their symptoms will be of brief duration and are not dangerous.

Diphenylchlorarsine, PD, Diphenylchlorarsine, $(C_6H_5)_2\text{-}AsCl$.

Properties. Diphenylchlorarsine is a white crystalline solid, of 1.4 specific gravity, which melts at 113 F. It boils with decomposition at 720 F. It has practically no vapor pressure or vapor density as it distills into the air in the form of minute solid particles.

Odor. The characteristic odor of diphenylchlorarsine is comparable to that of shoe polish.

Persistency. The persistency of diphenylchlorarsine is about 5 minutes in either summer or winter.

Physiological effect. The irritation begins in the nose, as a tickling sensation, followed by sneezing, with a flow of viscous mucus, similar to that which accompanies a bad cold. The irritation then spreads down into the throat and coughing and choking set in until finally the air passages and the lungs are also affected. Headache, especially in the forehead, increases in intensity until it becomes almost unbearable, and there is a feeling of pressure in the ears and pains in the jaws and teeth. These symptoms are accompanied by an oppressive pain in the chest, shortness of breath, and nausea which soon causes retching and vomiting. The victim has an unsteady gait, a feeling of vertigo, weakness in the legs, and a trembling all over the body.

Protection. The service gas mask will provide adequate protection against this type of chemical agent.

First aid. The first aid for diphenylchlorarsine is the same as that for adamsite given above.

SCREENING SMOKES.

HC Mixture, HC, Hexachlorethane-zinc, $Zn + C_2Cl_6$.

Properties. HC mixture is a combination of zinc dust, hexachlorethane, ammonium perchlorate, and ammonium chloride. When this material is burned, it yields zinc chloride which passes into the air in the form of a grayish-white smoke.

Odor. The odor of the smoke is rather acrid in nature.

Persistency. As the smoke is formed only as long as the particular round is burning, the persistency of the smoke will continue only as long as the burning continues.

Physiological effect. The zinc chloride smoke which is formed is harmless to personnel. Its use being to screen off operations from the enemy.

Protection. As the smoke has no harmful effects there is no protection required against this agent.

First aid. No first aid is needed as far as the smoke is concerned. If burns are produced from the burning agent, they should be treated as for any other burn.

Sulfur Trioxide in Chlorsulfonic Acid, FS, SO_3-SO_3HCl.

Properties. This mixture is a liquid of 1.91 specific gravity, which freeezes at —22 F. On contact with the air, it fumes vigorously and throws off dense white clouds composed of minute droplets of sulfurous, sulfuric, and hydrochloric acids.

Odor. The odor of this mixture is similar to that of burning matches.

Persistency. The persistency of this agent varies from 5 to 10 minutes.

Physiological effect. Although the smoke is harmless, it irritates the skin and throat. Spray in the eyes may cause serious burns.

Protection. Because of the irritation to the nose and throat, and the burns to the eyes, a gas mask is needed to prevent such action.

First aid. This consists of washing with large quantities of water. In the eyes, this should be followed by irrigation with a 2 percent solution of sodium bicarbonate.

Titanium Tetrachloride, FM, Titanium Tetrachloride, $TiCl_4$.

Properties. Titanium tetrachloride is a colorless, highly refractive liquid, of 1.7 specific gravity, which boils at 277 F and solidifies into white crystals at −9 F. It reacts vigorously with the moisture in the air, forming titanic acid hydrate and hydrochloric acid, with the evolution of dense white clouds of acrid smoke.

Odor. The smoke has an acrid odor.

Persistency. The persistency of this agent is approximately 10 minutes.

Physiological effect. On account of its hydrochloric acid content, titanium tetrachloride is acrid, but in ordinary field conditions it is not sufficiently irritating to the respiratory system as to cause coughing or other unpleasant physiological effects. The liquid may cause slight irritation to the skin due to its acidic nature.

Protection. No protection is needed against this agent.

First aid. The first aid for this agent is the same as that given for FS above.

White Phosphorus, WP, Yellow Phosphorus, P.

Properties. White phosphorus is a waxy solid, of 1.8 specific gravity, which melts at 111 F, and boils at 549 F. It is chemically very active and combines readily with oxygen in the air. Upon oxidation, the phosphorus becomes luminous and in a few minutes bursts into vigorous flames that can only be quenched by complete submersion in water.

Odor. The odor of phosphorus is similar to that of burning matches.

Persistency. The persistency of white phosphorus is about 10 minutes.

Physiological effect. While the vapors of white phosphorus are exceedingly toxic, these vapors are so quickly oxidized to phosphorus pentoxide and phosphoric acid as to be harmless to men and animals in ordinary field conditions.

In addition to its smoke value, phosphorus is of tactical importance because of its burning effect upon both personnel and material. In contact with the body, phosphorus produces burns that are slow and difficult to heal; the firing of phosphorus against personnel has a physiological value that greatly increases its tactical effectiveness. Against material, however, the incendiary effect of phosphorus is limited, as it only ignites readily combustible materials, so that here it is inferior to thermite and other primarily incendiary materials.

Protection. No protection is required against the smoke derived from white phosphorus. No satisfactory material has been found which will give protection against the burning particles of the material and still afford freedom of movement and comfort to the wearer under working conditions.

First aid. Keep the burn wet with water or wet cloths. This will stop the phosphorus from burning. Then apply large amounts of copper sulphate solution. Continue this treatment for three minutes. Remove the phosphorus particles (copper plated) by washing, or with forceps and treat the injury like an ordinary burn.

INCENDIARIES.

Thermite, TH, Thermite, 2Al-3FeO.

Properties. Thermite is an intimate mixture of iron oxide and finely powdered aluminum. It is in the form of a dark-gray granular mass. When ignited, it burns with great rapidity and the evolution of extreme heat, the iron oxide being reduced to boiling molten iron.

Odor. This material is odorless.

Persistency. The average thermite has a persistency of about 5 minutes.

Physiological effect. There is no physiological effect derived from thermite other than that of burns from the hot metal. If any of this material gets on skin or clothing, it will cause severe burns.

Protection. No protection is needed for personnel other than that of cover from the burning particles.

First aid. Burns received from the hot metal may be treated the same as ordinary burns.

PROTECTIVE EQUIPMENT.

Protective Clothing. Protective clothing is designed to protect the body against vesicant agents. There are two requirements which govern the kind of protective clothing needed. One requirement is to provide protection for certain personnel engaged in filling operations who might encounter large pools of the liquid or be subjected to sprays of the agent from broken pipes and vessels in case of accidents. The other is to provide protection for personnel required to handle contaminated equipment, engage in decontamination operations, or be protected from vapor or from airplane spray attacks. In the first consideration, a complete impermeable suit is required. It is not recommended for any use except in potentially dangerous situations where liquid mustard gas or lewisite in large quantities may likely be encountered. In the second situation, permeable protective clothing provides ample protection for all cases where vapor, absorbed mustard gas, or light spray of liquid gas is encountered.

Impermeable clothing. Impermeable suits are made of coated materials which will not allow liquid vesicants or vapors to pass through them. Since there is no circulation of air, the wearer perspires excessively and can wear this covering for only a relatively short time because of exhaustion. There is no satisfactory method of neutralizing liquid mustard gas on the garment, and accordingly it must be destroyed when excessively contaminated. A suit of impermeable clothing consists of a 1-piece working garment made of impermeable material with an attached hood of the same material. Under this suit, protective permeable underclothing and socks are worn. The foot covering consists of treated shoes over which the legs of the impermeable suit are buckled tightly. Boots of a type of rubber highly resistant to mustard gas or lewisite penetration can be substituted for the shoes, provided the trousers are pulled on over the boot leg. Highly resistant rubber gloves and a gas mask are likewise worn.

Permeable clothing. The permeable type of clothing consists of garments treated in such a manner that they afford reasonably safe protection against vesicant chemical agents in the form of vapor and small drops. The ordinary field uniform can be treated to provide considerable protection, yet permit much comfort and serviceability. However, specially designed garments add greater protection because of the necessity of covering completely all parts of the skin. Each suit includes one pair of socks, one pair of gloves, one pair of drawers, one undershirt, one hood and one 1-piece protective suit (coveralls). For protection of the feet, the wearer treats his footgear with impregnite issued for that purpose. It is sometimes advisable to include a nontreated set of underwear with the above treated outfit because of the allergy of some skins to the treated clothing. Protection of the hands is afforded by the chemically treated cotton gloves which may be supplemented by outer chemically resistant rubber gloves. For protection of the face, eyes, and lungs, a mask must also be worn.

Gas mask. The gas mask protects the wearer's eyes and respiratory tract from the chemical agents.

The principle of operation of the gas mask is based on air filtration. Air is drawn into the mask when the individual inhales, the mask being so constructed that the air must pass first through a canister containing a filtration system. This comprises a mechanical filter to prevent the entrance of smoke or dust, and a filter of charcoal and soda lime to absorb and neutralize toxic and irritating gases and vapors. After being purified, the air is drawn into the face piece, and after being inhaled and exhaled is expelled from the mask through an outlet valve. Gas masks, as issued, will give full protection against lung irritants, irritant smokes, and lacrimators in concentrations likely to be encountered. They will not protect against gases encountered in industry such as carbon monoxide and ammonia gas.

The service gas mask is the one that is commonly issued for the use of inspectors in the field. This type of mask will afford protection against all agents likely to be encountered under field conditions. A tube of antidim compound is included in the carrier, and if applied in a very thin film to both sides of the eyepiece, will assist in preventing fogging of moisture in the mask and from rain. The canister is carried in a carrier under the left arm and is connected to the face piece by a noncollapsible rubber hose. It must be remembered that, to be of any use, the gas mask must be correctly adjusted to the wearer. Any leaks around the face piece will prevent the mask from performing its proper function of preventing the entrance of the agent into the nasal passages.

FURTHER REFERENCES: O.O. 7224, Ordnance Safety Manual; FM 21-40, Defense Against Chemical Attack; Pamphlet No. 2, Chemical Warfare School, Edgewood Arsenal, Md.; Protection Against Gas, U.S. O.C.D., Washington, D. C.; Chemicals in War, Prentiss; Gas Warfare, Waitt.

SECTION V.

SMALL ARMS AND TRENCH WARFARE

Chapter 1

Small-arms Ammunition

GENERAL.

Small arms refers to those weapons normally accompanying foot troops (infantry). They include rifles, automatic rifles, pistols, and machine guns up to cal. .60 (0.60 inches diameter of bore) and also shotguns. Small-arms ammunition is defined as "amunition fired in weapons whose bore is 0.60 inches or less in diameter." In ordnance, small-arms ammunition is restricted to mean ammunition for those small arms used in military service. These are:

1. Cal. .50 machine guns.

2. Cal. .30 carbines, rifles, semiautomatic rifles, automatic rifles, and machine guns.

3. Cal. .22 pistols, rifles, and machine guns (for gallery practice).

4. Shotguns of 12-gage.

5. Cal. .45 automatic pistols, revolvers, and submachine guns.

6. Subcaliber tubes and adapters for artillery weapons which use ammunition of similar size and type.

Caliber and Gage. The caliber of a weapon is the diameter of the bore of the weapon between opposite lands, and in the instance of small arms, is expressed in inches unless millimeters are specifically mentioned. For example, cal. .30, means that the diameter of the bore of the weapon is 0.30 inches.

The gage of a shotgun refers to the number of lead balls of the diameter of the bore required to weigh 1 pound. For example, the diameter of the bore of a 12-gage shotgun is 0.785 inches, and it takes 12 lead balls of this diameter to weigh 1 pound.

Classification. Dependent on its purpose, small-arms ammunition is classified as follows:

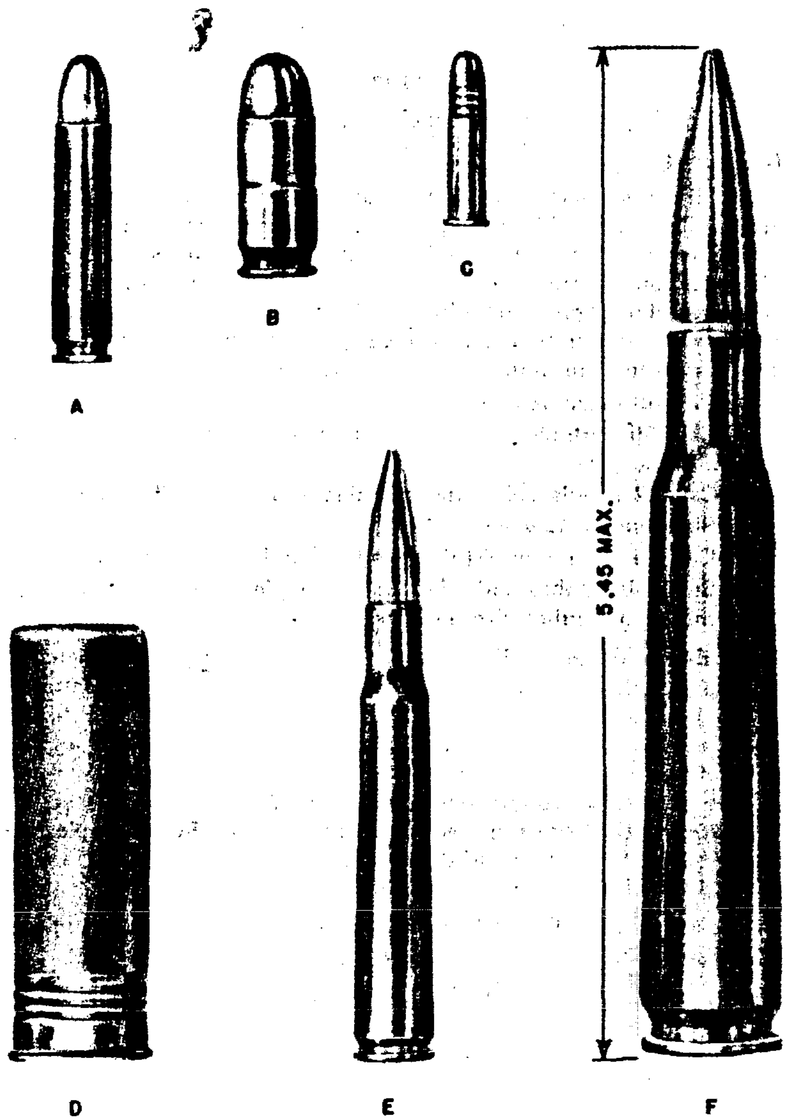
Ball. This type is effective against personnel or light materiel targets.

Armor-piercing. This type has a bullet containing a hardened steel core. It is intended for use against armored aircraft and vehicles, concrete shelters, and other bullet resisting targets.

Tracer. This type has a bullet containing a chemical composition which burns in flight. It is used for observation of fire, for incendiary purposes, and for signaling.

Incendiary. This type has a bullet containing a chemical composition. It is used to start fires.

Blank. This type contains no bullet. It is used for simulated fire, for signaling, and for salutes.



A–CARTRIDGE, CARBINE, CAL..30, M1
B–CARTRIDGE, BALL, CAL..45, M1911.
C–CARTRIDGE, BALL, CAL..22, LONG RIFLE
D–SHELL, SHOTGUN, 12-GAGE.
E–CARTRIDGE, BALL, CAL..30, M2
F–CARTRIDGE, BALL, CAL..50, M2

RA PD 4507

Figure 68 — Types of Small-arms Ammunition

Dummy. This type has no propelling charge or primer. It is used for training.

Gallery practice. This type has a reduced charge. It was formerly used for gallery practice, but is now standard for guard ammunition.

Guard. This type has a reduced propelling charge. It is used for guard purposes.

High-pressure test. This type has an augmented propelling charge. It is used only in proof-firing.

Rifle grenade. This type has no bullet. It is used with the rifle grenade.

Subcaliber. This type has a rimmed cartridge case. It is used in subcaliber tubes and mounts of cannon.

Shotgun shells. These are used for guard purposes, target practice, and hunting.

Complete Round. A complete round of small-arms ammunition is known as a cartridge, and is made up of the following components:

1. Cartridge case.

2. Primer.

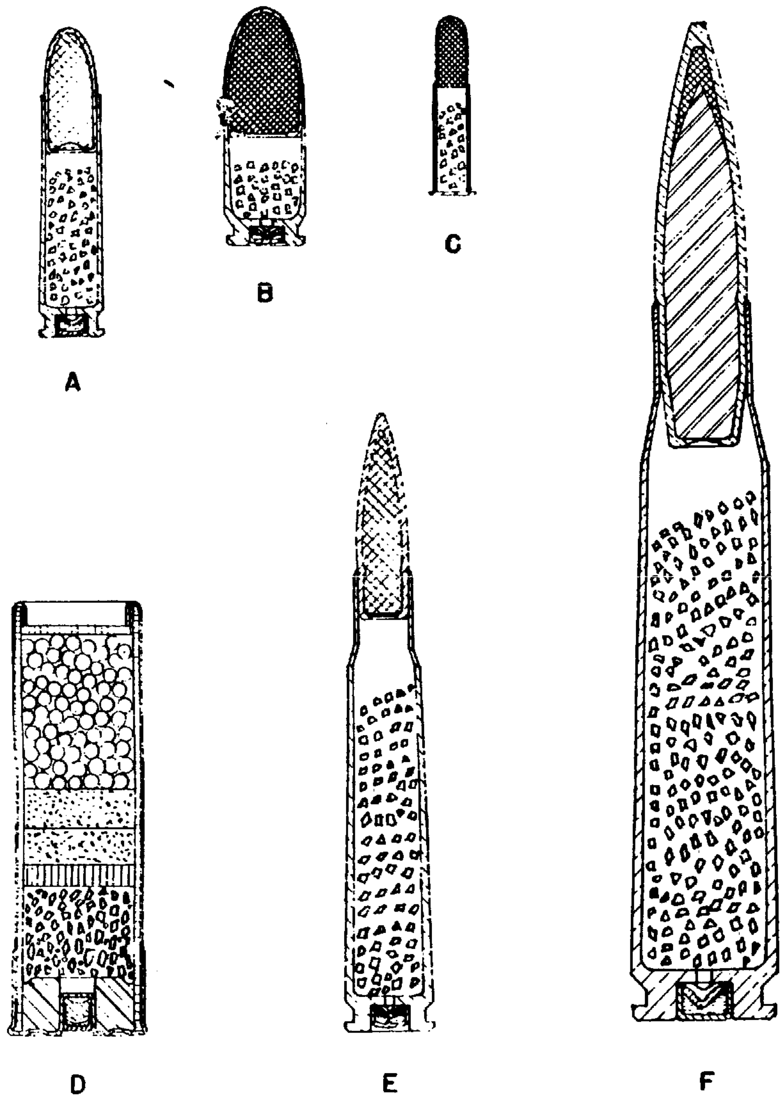
3. Propelling charge.

4. Bullet.

Cartridge Case. The cartridge case is the means whereby the other components are assembled into a unit. It also provides a waterproof container for the propelling charge. When the cartridge is fired, the thin brass is forced against the walls of the chamber by the pressure, thus preventing the escape of gases to the rear. This sealing process is known as obturation. The extraction groove on the case provides a means for extracting the fired cartridge case from the weapon.

Manufacture. The cartridge case is made from a circular disc of cartridge brass which is punched into the form of a cup and drawn through successive dies into shape. The closed end is pressed into shape to form the head which contains the primer pocket and vent. An extractor groove is machined in the side of the head to provide a grip for the mechanical extractor of the weapon. The case for pistol ammunition is cylindrical; that for carbine ammunition tapers slightly; that for rifle and machine gun ammunition tapers slightly from the head to the shoulder (approx. three-quarters of its length), then sharply at the shoulder to the cylindrical neck. After each punching or drawing operation, the case is annealed to remove strains.

Primer. The primer which is crimped into the primer pocket in the head of the cartridge case, consists of a soft metal cup, a priming or percussion composition, a disc of shellacked manila paper, and an anvil. A blow from the firing pin on the primer cup compresses the

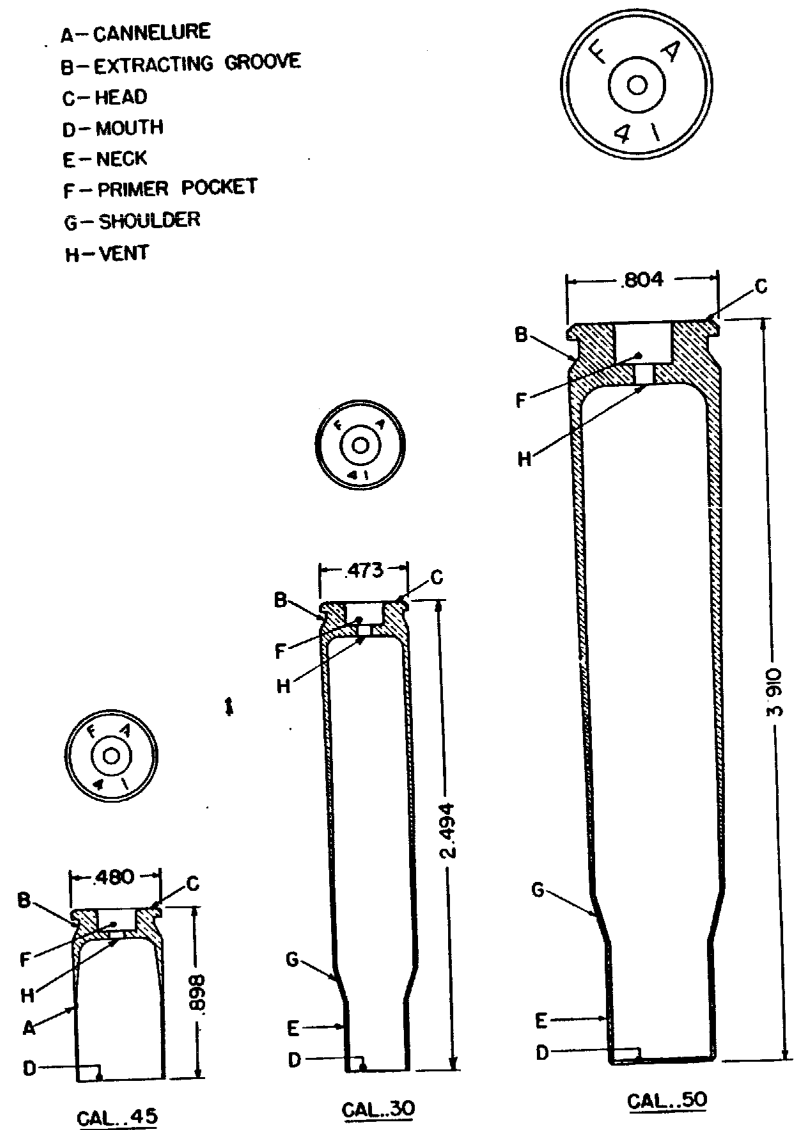


A CARTRIDGE, CARBINE, CAL. .30, MI.
B CARTRIDGE, BALL, CAL. .45, M1911.
C CARTRIDGE, BALL, CAL. .22, LONG RIFLE
D SHELL, SHOTGUN, 12 GAGE.
E CARTRIDGE, BALL, CAL. .30, M2
F CARTRIDGE, BALL, CAL. .50, M2

RA PD 4508

Figure 69 — Cartridges in Section

A—CANNELURE
B—EXTRACTING GROOVE
C—HEAD
D—MOUTH
E—NECK
F—PRIMER POCKET
G—SHOULDER
H—VENT



RA PD 4509

Figure 70 — Cartridge Cases in Section

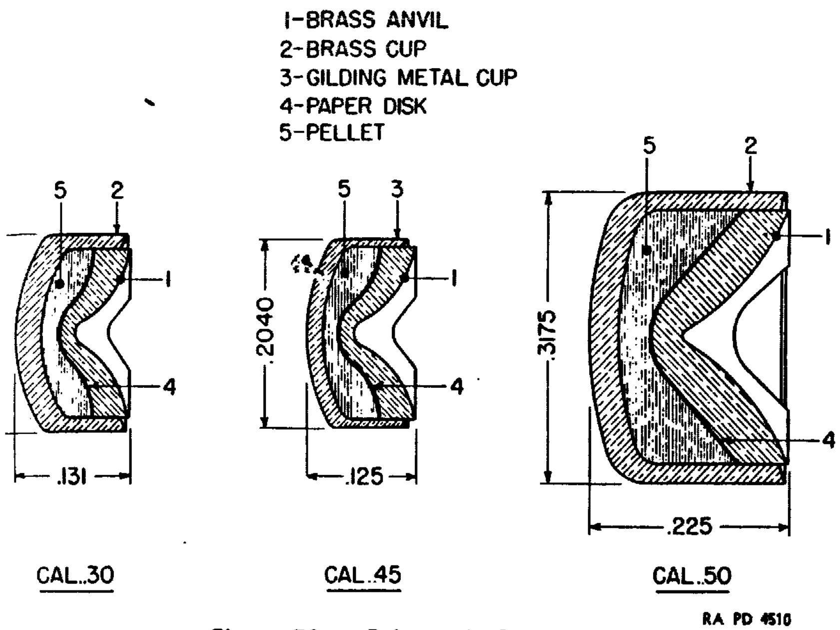


Figure 71 — Primers in Section

priming composition between the cup and the anvil, thereby producing a flame which passes through the vents in the anvil and cartridge case, and ignites the propelling charge of smokeless powder. The cup of the cal. .30 or cal. .50 primer is made of brass, whereas the cup of the cal. .45 is made of gilding metal because the lighter blow of the firing pins of pistols and revolvers necessitates a softer material. The priming composition is inserted into the cup and is held in place and protected from moisture and electrolytic action by the paper disc. The brass anvil is inserted last.

Recent primers of the noncorrosive, nonmercuric type are used in some cal. .45 cartridges and in the cal. .30 carbine cartridge. To function properly, primers must be free from such surface defects as folds, wrinkles, scratches, scales, or dents. Other primer defects are cocked, broken, or inverted anvils; scratched, torn, or dirty cups; and missing anvils, discs, or pellets.

Propelling Charge. The propelling charge consists of a quantity of smokeless powder. The weight of the charge is not a constant. It is adjusted for each powder lot to give the required velocity with pressure within the limits prescribed for the weapon in which it is fired. The powder charge is assembled loosely in the cartridge case.

Smokeless powder for small-arms ammunition is usually glazed with graphite to facilitate machine loading, and thus presents a black

polished appearance. Single perforated grains are usually used as small-arms propellants. Since the powder grains are small, they ignite more rapidly and burn more quickly than cannon powder. When abnormal temperatures prevail, small-arms powders are subject to rapid deterioration. Smokeless powder is not as sensitive to friction as black powder, but all precautions used in handling black powder should be observed for small-arms powders.

In general, there are two types of small-arms propellants; the single base nitrocellulose type and the double base type. The double base type is a mixture of nitrocellulose and nitroglycerine which burns more rapidly than the single base type.

Bullet. The bullet consists, in general, of a core covered by a gilding metal jacket. A cannelure is cut or rolled in the jacket to provide a recess into which the mouth of the case may be crimped at assembly.

The body of the bullet is cylindrical. The nose may be round, as in the cal. .45 bullet, or ogival (curved taper) as in all service rifle and machine gun bullets. The base may be "square" that is cylindrical, or "boat-tailed"; that is, having a conical taper.

Armor-piercing bullets contain a core of hardened steel. There may be point or base fillers of lead or aluminum filling the spaces between the steel core and jacket.

Bullets of ball cartridges usually contain a slug of antimony hardened lead except in the case of cal. .50, wherein the core is of soft steel in order to insure similar ballistic properties for ball and armor-piercing cartridges.

Tracer bullets contain a lead slug in the forward position, and a chemical composition in the rear.

Incendiary bullets contain an incendiary composition.

Special purpose bullets may vary in shape or composition. These will be described in the section on the particular cartridge.

Accessories.

Clips. Cal. .30 cartridges for use in the M1903 and M1917 Service Rifles, or for both rifle and machine gun use, are assembled in 5-round clips; those for the M1 Rifle are assembled in 8-round clips. In time of peace, the 8-round clips are nonexpendable items.

The 5-round clip consists of a body and spring, both of brass. Stop lugs on the exterior side of the body seat the clip in its slots in the receiver of the rifle. The top edges of the sides are folded inward, forming flanges which fit into the grooves in the cartridge case heads, holding the cartridge in place. The spring is provided with narrow tongues which, when the clip is filled, are pressed into the grooves of the outside cartridges, holding them securely in the clip.

The 8-round clip consists only of a case made of steel. It is indented near the base along the sides to form an inner rib which

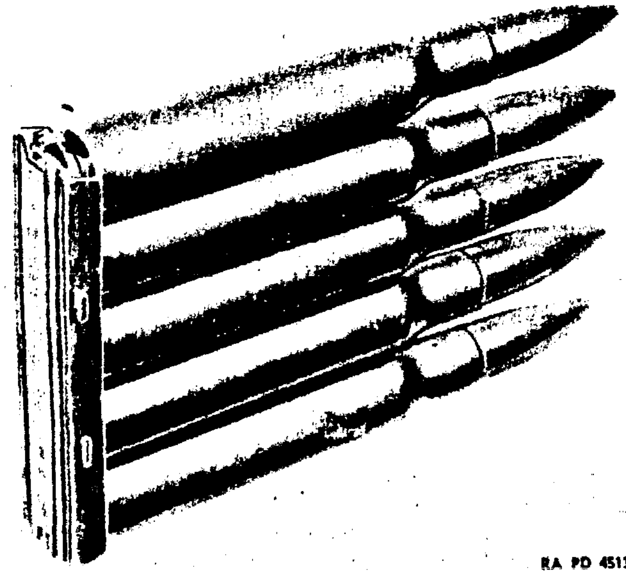


Figure 72 — 5-round Clip for Cal. .30 Cartridges

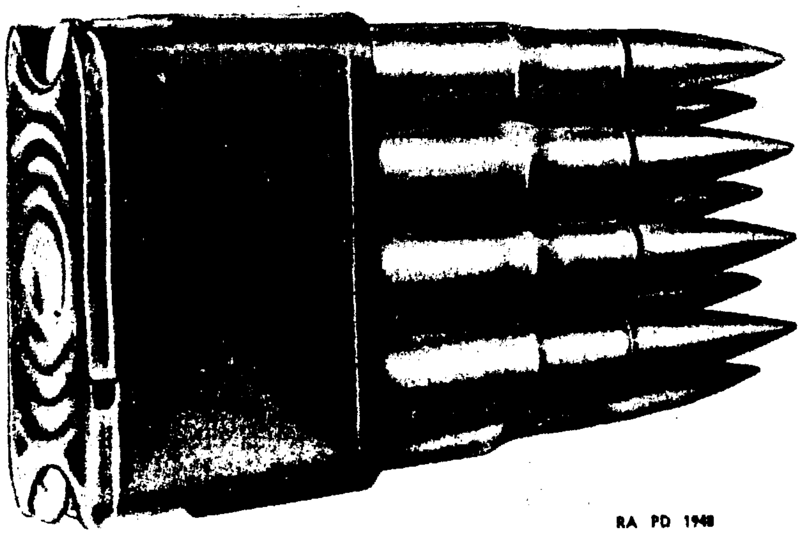


Figure 73 — 8-round Clip for Cal. .30 Cartridges

engages the extractor groove in the cartridges. The sides are inclined sufficiently to clamp the cartridges firmly in place. The cartridges are held firmly in two staggered rows. It is immaterial whether the

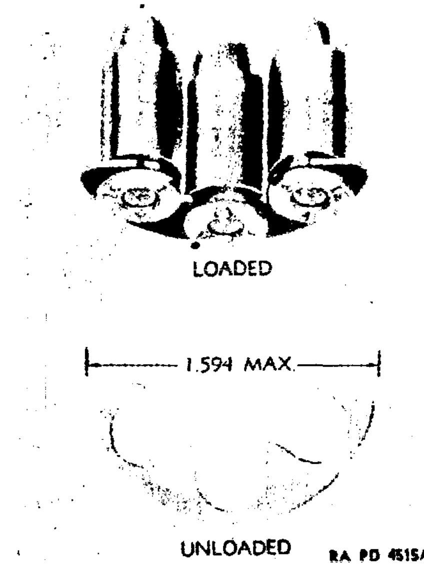


Figure 74 — Cartridge Clip for Cal. .45 Revolvers

uppermost cartridge of the loaded clip is on the left or right side of the clip as the follower slide of the gun adjusts itself for either loading. Experience in the field shows, however, that it is preferable to have the uppermost cartridge in the right side of the clip. The sides are curved at the ends to hold the cartridges securely in the clip.

Cal. .30 dummy cartridges were formerly assembled in a special clip. The present practice is to use the standard 5-round clip without tongues, marked for use with dummy cartridges. The Corrugated Dummy Cartridge, cal. .30, M1906 may be used for instruction in functioning when loaded into 8-round clips.

When used in the revolver, it is necessary to assemble the CARTRIDGE, ball, cal. .45, M1911, into clips. These clips are packed separately for assembly in the field. Each consists of a semicircular piece of steel with slots to hold the cartridge. Each clip holds three rounds.

Metallic belt links. For use in automatic weapons, cal. .30 and cal. .50 ammunition is issued in metallic link belts. These belts are assemblies of unit links, one for each cartridge. Each link has two loops fitting about one cartridge and a third loop fitting about one adjacent cartridge. Thus, each cartridge in a metallic link belt, except the cartridges on the ends, has two links attached to it. Each link is made from strip steel. A blank form is stamped from the strip and the blank is bent to form the circular loops. It is then heat-treated and

Figure 75—LINK, Metallic Belt, Cal. .30, M1 *Figure 76—LINK, Metallic Belt, Cal. .50, M2*

processed to prevent rusting. The links are manufactured to meet specified extraction tests from prescribed steel plugs made in the shape of cartridges. LINK, metallic belt, cal. .30, M1, must withstand an extraction pull of 5 to 10 pounds and LINK, metallic belt, cal. .50, M1, or M2, must withstand an extraction pull of 10 to 25 pounds.

GRADES OF SMALL-ARMS AMMUNITION.

Ammunition is manufactured to rigorous specifications and is inspected and tested thoroughly before acceptance. Since the various types of weapons; rifles, ground machine guns, aircraft machine guns, etc., have different requirements, production orders and specifications call for the classification of lots for use in specific weapons. Variations in manufacture may occur because of problems of mass production of ammunition. Considering variations from lot to lot and the different requirements for each type of weapon, grades are assigned to each lot of ammunition, in accordance with acceptance tests, to designate their use in the different types of weapons.

Current grades of all existing lots of small-arms ammunition are established by the Chief of Ordnance as a result of inspection and are published in OFSB 3-5. Grades are not marked on packing boxes or on slips inside the box. No lot other than that of grade appropriate for the weapon, as specified in the current publication of OFSB 3-5, will be fired.

The following grades have been established for cal. .30 and .50 ammunition as most appropriate for use in a specific type of weapon:

Aircraft machine gun .... AC
Aircraft machine gun or rifle .... AC or R

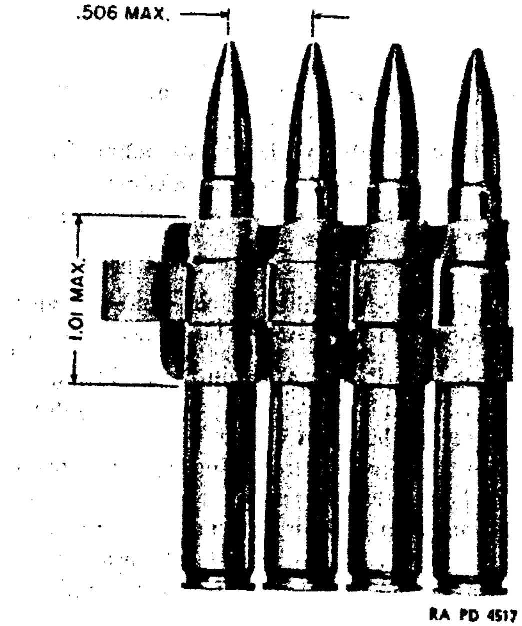


Figure 77 — Section of Cal. .30 Link Belt

Rifle .... R
Ground machine gun .... MG
Unserviceable (not to be issued or used) 3

Priority and Substitution. The following grades of cal. .30 and .50 ammunition may be used in the weapons specified below. They are listed in the order of priority of issue and use. Indicated substitutions may be made either by Field Service depots or in the field. No other substitutions should be allowed.

For cal. .30:

Grade AC; AC or R .... For aircraft machine guns
Grade AC; AC or R; MG; R .... For antiaircraft machine guns
Grade R; AC or R .... For rifles, semiautomatic and automatic
Grade MG; R; AC or R; AC .... For ground machine guns
Grade 3 .... Not to be issued or used

EXCEPTION: CARTRIDGE, tracer, cal. .30, M2, is for use in aircraft machine guns only.

For cal. .50:

Grade AC .... For aircraft machine guns
Grade AC; MG .... For antiaircraft machine guns
Grade MG; AC .... For ground machine guns
Grade 3 .... Not to be issued or used

EXCEPTION: CARTRIDGE, tracer, cal. .50, M2, is for use in aircraft machine guns only.

The following grades have been established for cal. .45 ammunition:

Grade 1. For cal. .45 revolvers, pistols, and submachine guns.

Grade 2. For cal. .45 pistols and submachine guns only. When available, this grade should be issued for these weapons in preference to grade 1.

Grade 3. Not to be issued or used.

For other calibers, the ammunition is considered serviceable unless specifically designated grade 3 (not to be issued or used).

Linked, Clipped, and Belted Ammunition. The grades of individual repacked lots of linked, belted, or clipped ammunition, cal. .30 and cal. .50, will not be listed in OFSB 3-5.

For the purpose of issuing and reporting repacked lots, their grades will be considered as follows:

All cal. .30 ammunition in 5- or 8-round clips will be grade R.

All cal. .30 ammunition in web belts will be grade MG.

All cal. .30 ammunition in linked belts will be grade AC.

All cal. .50 ammunition in linked belts will be grade AC.

All cal. .50 ammunition in linked belts with marking "Ground Machine Guns" on box will be grade MG.

All cal. .50 ammunition in linked belts in box, ammunition, cal. .50, M2 (steel) will be grade MG.

All cal. .50 ammunition in web belts will be grade MG.

Examples of Grading Considerations.

Grade 3. When ammunition becomes unserviceable due to some defects such as season crack, corrosion, or other defects, it is designated as grade 3.

Ammunition which has lost its identity is also considered as grade 3. However, unidentified ammunition will not be classified as unserviceable for this reason, until every effort has been made to establish its identity.

Grade 3 ammunition ordinarily will not be issued or used except in the instance of ammunition which is grade 3 because of loss of identity *only*. This ammunition may be issued for practice purposes in the *ground* machine gun only.

It should be kept in mind that in order to positively identify small-arms ammunition, the type, caliber, manufacturer, and lot number must always be known, and that every precaution should be made to maintain this information with a lot of ammunition in any and all operations where the ammunition may become separated from its original packing.

Some of the considerations taken in grading of ammunition are illustrated by the following examples:

Ammunition to be used in the bolt-action rifle requires that the average net extraction effort shall not exceed 15 pounds. This is essential for uniform and reliable action in a manually-operated weapon but is of lesser importance in automatic and semiautomatic weapons.

Ammunition for use in synchronized and remote controlled aircraft machine guns must be of selected uniformity and have a minimum variation in rate of ignition. These requirements are essential to insure continuous feeding during combat use of aircraft guns, where malfunctioning might result in destruction of propellers or might create other hazards.

Due to the rugged construction of the ground type of machine guns, the continuous control exercised by the operator, and the lower rate of fire, less stringent test limits are required. Ammunition that meets the general specifications for accuracy, pressure, dimensions, etc., is satisfactory.

Regrading. Ammunition in storage is periodically retested to insure that its characteristics have not changed. If changes have occurred, as shown by surveillance tests, the ammunition is regraded and the new grades published in OFSB 3-5.

Priority of Issue, Use and Sale. In order to provide a sequence for the issuance of small-arms ammunition, the following priorities of issue have been established:

1. Those lots marked with an asterisk in OFSB 3-5.

2. Lots containing less than 20,000 rounds.

3. Lots marked "Repacked-Liners Not Sealed."

4. Lowest or oldest numbered lots.

Following this rule, ammunition which has had the longest or least favorable storage will be issued first whenever practicable.

AMMUNITION, CAL. 30.

General. The ammunition described is designed for use in all standard rifles and machine guns of cal. .30. It includes cartridges of the following types: armor-piercing, ball, tracer, incendiary, blank, dummy, guard, rifle grenade, and high-pressure test.

Cartridges which differ in the type of cartridge case, such as subcaliber, cal. .30, and carbine, cal. .30, will be described separately.

CARTRIDGE, Ball, Cal. .30, M1906.

General. While the cal. .30, M1, and cal. 30, M2, Ball Ammunition have superseded the M1906 as standard items, the description of the latter is of value, in view of the stock of M1906 Ammunition that remains on hand.

Visual identification. This cartridge may be distinguished from the M1 and M2 Ball Rounds by the color of the jacket of the bullet, which is cupronickel and has a silvery appearance. Also, the numerals on the head of the cartridge case run from "21" downward.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet. The complete assembly weighs approximately 395 grains.

The bullet is pointed, having a square or cylindrical base, and the length of the bullet is approximately 1.085 inches. It has a jacket of cupronickel with a lead core hardened with antimony (97½ percent lead and 2½ percent antimony). The bullet is secured in the neck of the cartridge case by crimping the mouth into a cannelure on the bullet. The pull required to extract the bullet from the case is 75 pounds (minimum bullet pull).

External ballistics, maximum range (approx.) . . . . 3,450 yd
Average maximum pressure . . . . 52,000 lb per sq in.
Velocity:
  At 78 ft . . . . 2,640 ft per sec
  At 53 ft . . . . 2,660 ft per sec
  At muzzle . . . . 2,700 ft per sec
Muzzle energy . . . . 2,429 ft-lb

CARTRIDGE, Ball, Cal. .30, M1.

General. This cartridge is a limited standard item of issue and is used in the same weapons and for the same purposes as the CARTRIDGE, ball, cal. .30, M2.

Visual identification. This cartridge cannot be readily distinguished from the M2 Ball Cartridge of late manufacture except by weight and date.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet. The complete assembly weighs approximately 420 grains.

The bullet consists of two parts, a lead alloy core, composed of 90 percent lead and 10 percent antimony, and a gilding metal jacket. An alternative bullet having a gilding metal jacket and a core composed of 97½ percent lead and 2½ percent antimony may also be used. The base of either bullet has a 9-degree taper, called a boattail. The over-all length of the M1 Bullet is 1.32 inches, and that of [illegible] Alternative Bullet, 1.265 inches. The mouth of the cartridge [illegible]rimped into the knurled cannelure at assembly and a mini[illegible]l of 45 pounds is required to remove the bullet from the

External ballistics, maximum range (approx.) . . . . 5,500 yd
Average maximum pressure . . . . 48,000 lb per sq in.
Velocity:
  At 78 ft . . . . 2,600 ft per sec
  At 53 ft . . . . 2,620 ft per sec
  At muzzle . . . . 2,647 ft per sec
Muzzle energy . . . . 2,675 ft-lb

Accuracy. Average of mean radii of all targets at 500 yards, not greater than 4.5 inches; at 600 yards, 5.5 inches, when fired from a Mann accuracy weapon. Dispersions obtained from firings under service conditions at all ranges are published in firing tables for the weapons in which this ammunition is used.

CARTRIDGE, Ball, Cal. .30, M2.

General. This cartridge is a current standard item of issue and is used in machine guns and rifles against personnel and light materiel targets.

Visual identification. Cartridges of recent manufacture cannot be readily distinguished from the M1 Cartridges by visual inspection, although this can be done by weight and date. Cartridges manufactured prior to September 20, 1940, could be readily distinguished from the M1 Cartridges by their tin-coated, gilding metal bullet jackets.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet. The complete assembly weighs approximately 396 grains.

The bullet consists of two parts, a lead alloy core, composed of 90 percent lead and 10 percent antimony, and a gilding metal jacket. An alternative bullet having a gilding metal jacket, and a core composed of 97½ percent lead and 2½ percent antimony may also be used. The base of the bullet retains its cylindrical shape to the base line. The over-all length of the M2 Bullet is 1.125 inches, and that of the M2 Alternative Bullet is 1.103 inches. A minimum pull of 45 pounds is required to remove the bullet from the case.

External ballistics, maximum range (approx.) . . . . 3,500 yd
Average maximum pressure . . . . 50,000 lb per sq in.
Velocity:
  At 78 ft . . . . 2,740 ft per sec
  At 53 ft . . . . 2,755 ft per sec
  At muzzle . . . . 2,805 ft per sec

Accuracy (from accuracy rifle). Average of mean radii of all targets of 500 yards not greater than 6.5 inches; at 600 yards not greater than 7.5 inches.

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CARTRIDGE, Armor-piercing, Cal. .30, M2.

General. This cartridge is a current standard item of issue and is fired from machine guns and rifles. It is designed for use against armored aircraft, armored vehicles, concrete shelters, and similar bullet-resisting targets.

Visual identification. This cartridge may be identified by the additional cannelure and the blackened tip of the bullet.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet. The complete assembly weighs approximately 414 grains.

The bullet consists of four parts: a gilding metal jacket, a tungsten chrome steel core, a lead "T"-shot point filler, and a gilding metal base filler. The over-all length of this bullet is 1.370 inches and its point is blackened for a distance of approximately 9/32 inch. The base of the bullet is cylindrical down to the base line where it has a slightly beveled edge. The mouth of the case is crimped into the cut cannelure at assembly, and a minimum pull of 45 pounds is required to remove the bullet from the case.

External ballistics, maximum range (approx.)............3,500 yd
Average maximum pressure..................50,000 lb per sq in.

Velocity:
At 78 ft.................................2,715 ft per sec
At 53 ft.................................2,730 ft per sec
At muzzle ....2,775 ft per sec

Accuracy. Average of mean radii of all targets at 500 yards, not greater than 9.0 inches; at 600 yards not greater than 10.0 inches.

CARTRIDGE, Tracer, Cal. .30, M1.

General. This cartridge is a standard item of issue and is used in both machine guns and rifles. It is intended for use with either type of ammunition to show the gunner, by its trace, the path of the bullets. While tracer cartridges were primarily intended for machine gun use, there are cases wherein they can be advantageously used in rifles; for example, for signal and incendiary purposes, target designation, and range estimation.

Visual identification. The cartridge is readily identified by its characteristic red bullet point, red indicating the color of the trace.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet. The complete assembly weighs approximately 396 grains.

The bullet consists of four parts: a gilding metal jacket, a lead alloy slug, a tracer composition, and an igniter composition. The over-all length of this bullet is 1.45 inches and the point is painted red for a distance of approximately 5/16 inch. It has a square base which contains the igniter composition which is ignited by the propel-

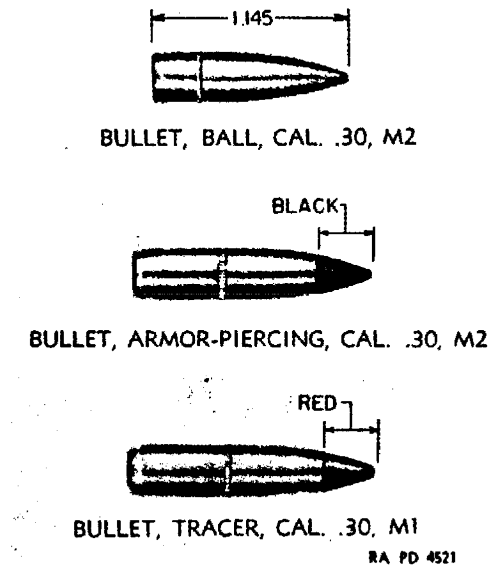


Figure 78a — Bullets, Cal. .30

ling charge when the cartridge is fired. The tracer composition burns with a bright red flame which enables the course of the bullet to be followed by the gunner. The mouth of the cartridge case is crimped into the knurled cannelure at assembly, and a minimum pull of 45 pounds is required to remove the bullet from the case.

Exterior ballistics, maximum range (approx.)............3,450 yd
Range of trace........trace begins at a distance not greater than 125 yd from the weapon, and bullets continue tracing to 750 yd from the weapon
Average maximum pressure..................50,000 lb per sq in.

Velocity:
At 78 ft.................................2,650 ft per sec
At muzzle ....2,715 ft per sec

Accuracy. Average of mean radii of all targets at 600 yards less than 15 inches.

Trajectory. This ammunition is designed so that the bullet's trajectory will cross the trajectory of Ball M2, and AP, M2 Ammunition of the same caliber at approximately 600 yards.

CARTRIDGE, Incendiary, Cal. .30, M1.

General. This cartridge is a standard item of issue for machine guns.

AMMUNITION INSPECTION GUIDE

A-BASE FILLER-GILDING METAL
B-COMPOSITION, IGNITER
C-COMPOSITION, TRACER
D-CORE-TUNGSTEN CHROME STEEL
E-JACKET-GILDING METAL
F-POINT FILLER-LEAD "T" SHOT.
G-SLUG-LEAD WITH ANTIMONY

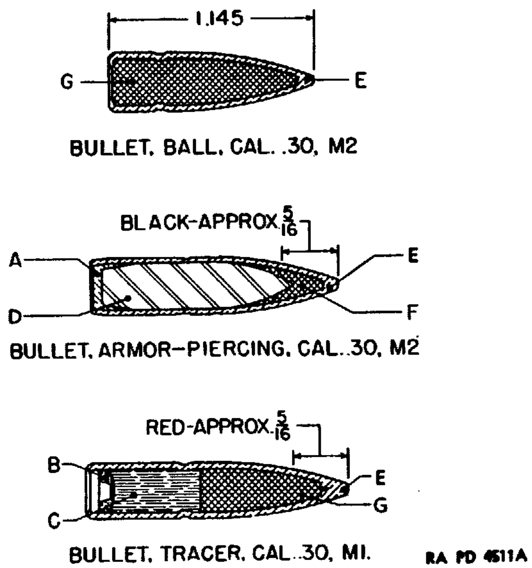


Figure 78b — Bullets, Cal. .30 — Sectioned

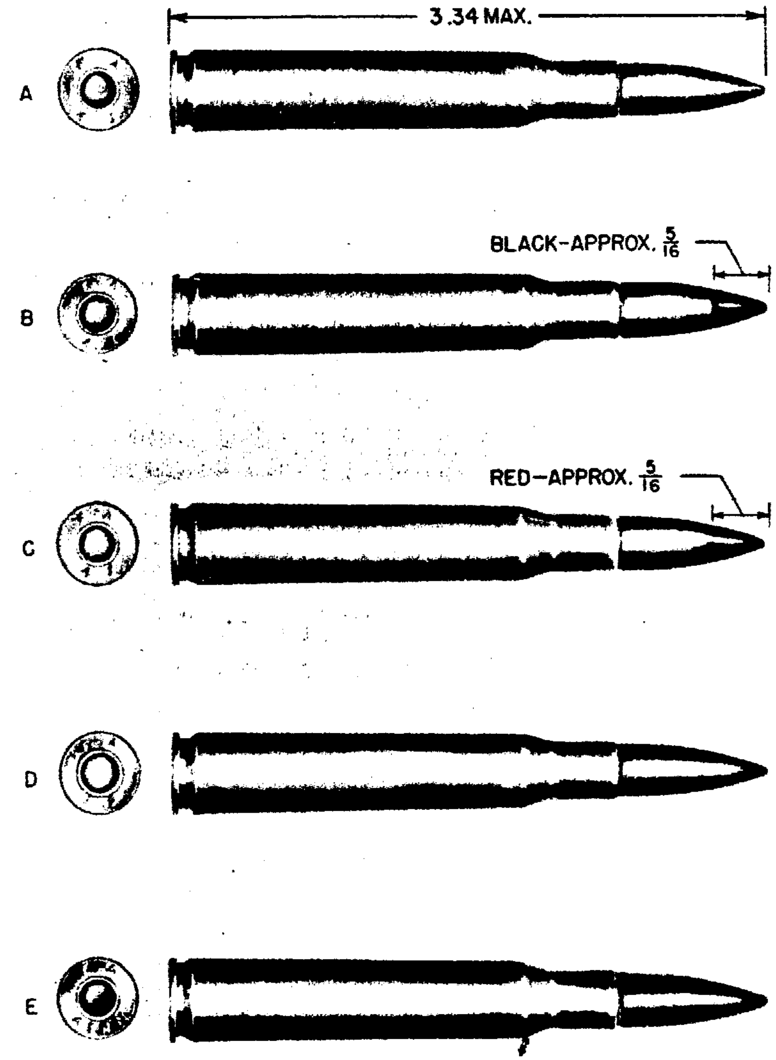
Visual identification. The cartridge resembles the CARTRIDGE, ball, cal. .30, M2, in outward appearance, but it may be identified by the light blue paint on the tip of the bullet.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet.

The bullet consists of four parts: a gilding metal jacket, a hollow steel cylindrical core, an incendiary composition, and a lead base filler. The mouth of the cartridge case is crimped into the knurled canneiure at assembly and a minimum pull of 45 pounds is required to remove the bullet from the case.

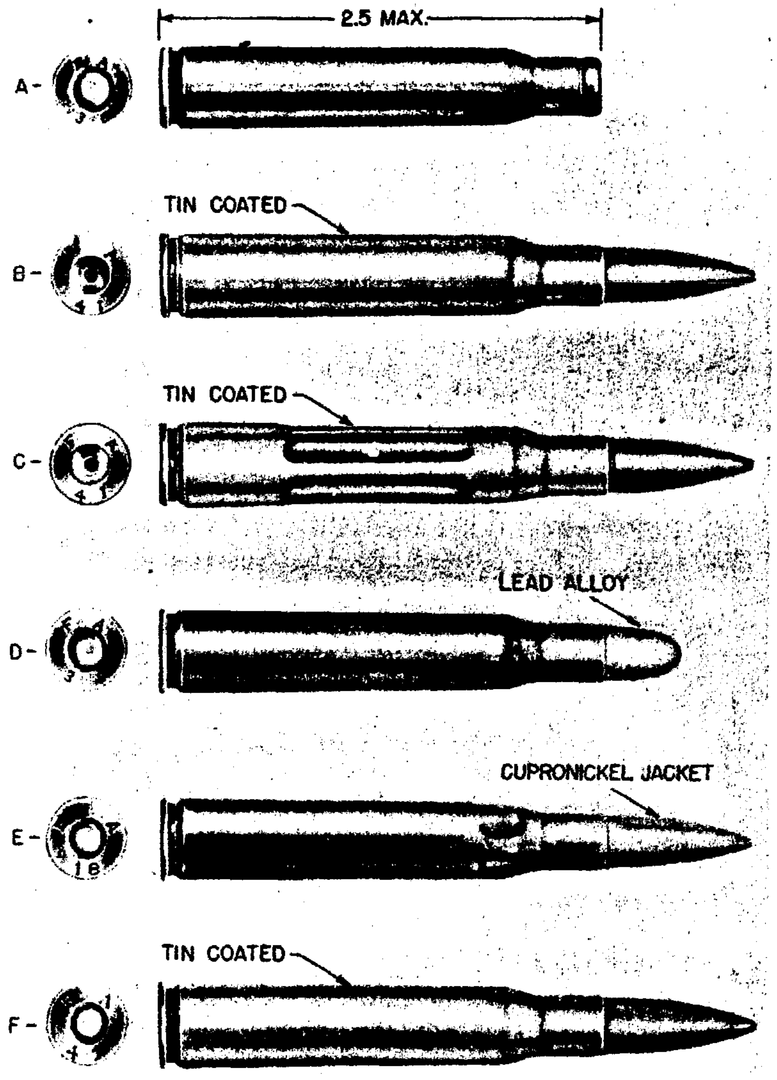
CARTRIDGE, Rifle Grenade, Cal. .30, M3.

General. This cartridge is used in cal. .30 Rifles, M1, M1903, M1903A1, and M1917, for discharging antitank rifle grenades. This



A—CARTRIDGE, ARMOR-PIERCING, CAL. .30, M2
B—CARTRIDGE, BALL, CAL. .30, M2
C—CARTRIDGE, TRACER, CAL. .30, M1
D—CARTRIDGE, BALL, CAL. .30, M1
E—CARTRIDGE, BALL, CAL. .30, M2, NATIONAL MATCH
RA PD 4522

Figure 79a — Cartridges, Cal. .30



A-CARTRIDGE, BLANK, CAL..30, M1909
B-CARTRIDGE, DUMMY, CAL..30, M2
C-CARTRIDGE, DUMMY, CAL..30, M1906
D-CARTRIDGE, GUARD, CAL..30, M1
E-CARTRIDGE, GUARD, CAL..30, M1906
F-CARTRIDGE. HIGH PRESSURE TEST. CAL..30. M1

RA PD 4523

Figure 79b — Cartridges, Cal. .30 — Continued

cartridge must not be used in lieu of the cal. .30, M1909 Blank Cartridge in automatic weapons, nor should it be fired in the direction of personnel.

Visual identification. This cartridge may be identified by the absence of a bullet and by the 5-petal rose crimp in the mouth of the case.

Components. The cartridge consists of a cartridge case, primer, and propelling charge, having no bullet. The complete assembly weighs approximately 246 grains.

The case is the same as the standard cal. .30 case except for a cannelure located about ¼ inch from the mouth. A wad is seated immediately above the cannelure after the propelling charge has been inserted. A drop of red lacquer is applied to the wad, and the mouth of the case is closed by crimping in the shape of a 5-leaf rosette. The cartridge is first loaded with a charge of 5 grains of black rifle powder, then with a progressive-burning small-arms powder.

Exterior ballistics. The cartridge, grenade, cal. .30, M3, is loaded to obtain a grenade velocity of 165 feet per second at 5.5 feet.

CARTRIDGE, Blank, Cal. .30, M1909.

General. This cartridge is a current standard item of issue and is used in the U. S. Rifles, M1903 and M1917, for simulated fire during maneuvers, for signaling purposes, and for firing salutes. It is also used in the machine guns and automatic rifles equipped with blank firing attachments, in order to operate these weapons for instructional purposes.

Visual identification. It is readily identified since it has no bullet, and furthermore, a cannelure is present in the neck of the cartridge case.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and a paper cup or wad of thin paper. Prior to January, 1925, a felt wad was used but was discontinued due to accidents caused by the clogging of gas escape holes in the blank firing attachment of machine guns and automatic rifles. The complete assembly weighs approximately 207 grains.

The cartridge case differs from the standard cal. .30 cartridge case described previously, only in that the neck has a cannelure and that the mouth is slightly rounded. Second class cartridge cases having small dents, scratches, or other minor defects may be used in the assembly of this ammunition.

The propelling charge for this cartridge differs from the standard cal. .30 propelling charge in that E. C. Blank Fire Powder is used in place of the standard smokeless powder.

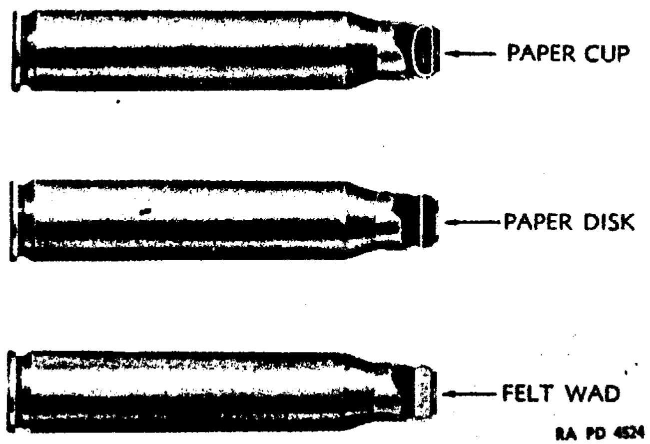


Figure 80 — Blank Cartridges — Necks in Section Showing Wads

The paper wad or cup is inserted in the neck against the cannelure and sealed in place with a few drops of shellac. The mouth of the case is roll-crimped to keep the wad in place.

CARTRIDGE, Gallery Practice, Cal. .30, M1919.

General. This cartridge is now superseded by the cal. .22 ball cartridge long rifle for gallery practice. Stocks on hand, however, are retained for guard purposes, for use when the supply of CARTRIDGE, guard, cal. .30, M1906, is exhausted. Cartridges of older manufacture are labeled cartridge, gallery practice, but new manufacture will be designated CARTRIDGE, guard, cal. .30, M1. This cartridge is described under that heading.

CARTRIDGE, Guard, Cal. .30, M1.

General. This cartridge was formerly the CARTRIDGE, gallery practice, cal. .30, M1919. It is now standard for guard purposes, and is used only in the cal. .30 rifle.

Visual identification. It is easily identified by its short, round nose, lead bullet.

Components. The cartridge consists of a cartridge case, primer, propelling charge and bullet. The complete assembly weighs approximately 346 grains.

The bullet is composed of a lead alloy and has a round nose and a cylindrical base. Its over-all length is approximately 0.815 inch and it has two knurled cannelures. A pull of not less than 45 pounds is required to remove the bullet from the case.

Exterior ballistics, maximum range (approx.) . . . . 2,500 yd
Average maximum pressure . . . . 15,000 lb per sq in.

Velocity:
At 53 ft . . . . 1,100 ft per sec
At muzzle . . . . 1,200 ft per sec
Muzzle energy . . . . 376 ft-lb

Accuracy. At 100 yards, the group diameter will be not greater than 6 inches.

CARTRIDGE, Guard, Cal. .30, M1906.

General. This cartridge is a limited standard item of issue and is used in the cal. .30 rifle for guard purposes. Second class bullets and cartridge cases may be used in the assembly of this cartridge.

Visual identification. This cartridge is readily identified by its six short corrugations, called flutes, just below the neck of the cartridge case.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet. The complete assembly weighs 355 grains.

The cartridge case is essentially the same as the cal. .30 case previously described, except that it has six short flutes or corrugations just below the neck.

The bullet consists of a cupronickel jacket encasing a lead alloy slug. It has a cylindrical base.

Exterior ballistics, maximum range (approx.) . . . . 2,000 yd
Average maximum pressure . . . . 15,000 lb per sq in.
Muzzle velocity . . . . 1,200 ft per sec
Muzzle energy . . . . 479 ft-lb

CARTRIDGE, Dummy, Cal. .30, M1906.

General. This cartridge is a current standard item of issue and is used for training personnel in the operation of loading and unloading rifles, and simulating rifle fire. Prior to January 15, 1940, this cartridge was assembled only with the M1906 Bullet. Since then, however, it has been permissible to also use either the M2 or M1 Ball Bullet.

Visual identification. There are six longitudinal corrugations on the tinned cartridge case. Before January 15, 1940, the cartridge case contained an inert primer and three holes, 0.125 inch in diameter, drilled through the case in alternate corrugations. Since that date, the cartridge has been assembled without a primer and the holes are omitted.

Components. The cartridge consists of a cartridge case and a bullet. The complete assembly weighs 339 grains when assembled with either the M2 or M1906 Bullet, and 363 grains when assembled with the M1 Ball Bullet. Second class components are used in the car-

Cartridge, Cal. .30	Status	Primer Cup	Cartridge Case	Ogive	Base	BULLET Jacket	Point Filler	Core	Base Filler	REMARKS
BALL M1	S	Brass	Brass	Pointed	Tapered	Gilding Metal		Lead Antimony		Cartridge case has numerals "25" and above on head
BALL M2	S&M	Brass	Brass	Pointed	Square	Gilding Metal		Lead Antimony		Cartridge case has numerals "38" and above on head (38-40 jacket tinned, 40-up not tinned)
TRACER M1	S&M	Brass	Brass	Pointed	Square	Gilding Metal	Lead Antimony	Tracer Mixture	Igniter Mixture	Tip of bullet painted red
ARMOR-PIERCING M2	S&M	Brass	Brass	Pointed	Square	Gilding Metal	Lead (T Shot)	Tungsten Chrome Steel	Gilding Metal	Tip of bullet painted black
INCENDIARY M1	S&M	Brass	Brass	Pointed	Square	Gilding Metal		Incendiary Mixture		Tip of bullet painted blue
RIFLE GRENADE M3	S&M	Brass	Brass							Mouth rose crimped
BLANK M1909	S&M	Brass	Brass							Mouth roll crimped
GALLERY PRACTICE M1919	S	Brass	Brass	Rounded	Square			Lead		
GUARD M1906	S	Brass	Brass (6 Flutes)	Pointed	Square	Cupronickel		Lead Antimony		
GUARD M1	S&M	Brass	Brass	Rounded	Square			Lead		
DUMMY CORR. M1906 (Prior to 1-15-40)	S	Brass	Brass (tinned) 6 Corrugations 3 Holes	Pointed	Square	Cupronickel		Lead Antimony		
DUMMY CORR. M1906 (After 1-15-40)	S&M		Brass (tinned) 6 Corrugations No Holes							May use M1906, M1, or M2 Bullets
DUMMY SLOTTED M1		Inert	Brass 1 Slot near head	Pointed	Tapered	Gilding Metal		Lead Antimony		Range dummy
DUMMY M2	S&M		Brass (tinned) No Slot	Pointed	Square	Gilding Metal		Lead Antimony		Used in inspection of weapons Not issued to troops
HIGH-PRESSURE TEST M1		Brass	Brass (tinned) "TEST" on head	Pointed	Square	Gilding Metal		Lead		Used to test for breech pressure Not issued to troops

tridge assembly. The cartridge case is essentially the cal. .30 case described previously, but is corrugated and tinned for identification purposes.

CARTRIDGE, Dummy, Cal. .30, M1.

General. This cartridge is a standard item of issue for use when assembled in clips with live ammunition on the range for detecting and correcting flinching and faulty trigger squeeze. The use of these cartridges in rifle practice requires that they be mixed with service cartridges without visual detection by personnel. They must therefore closely resemble the service cartridges with which they are mixed. The primers are inert and the cartridge cases do not contain a powder charge.

Visual identification. These cartridges are identified by a longitudinal slot, 0.06 inch wide, cut in the body of the case beginning at the extractor groove and continuing to a point approximately 0.687 inch from the head. The depth of this slot tapers from 0.03 inch at the extractor groove to 0.0 inch at the end farthest from the head of the case. When this ammunition is assembled in clips with service ammunition, the slot is hidden from view by turning it toward the adjoining cartridge.

Components. The cartridge consists of a cartridge case, inert primer, and bullet. The bullet may be either the M2 or M1 Ball Bullet depending on the type which is to be simulated. When using the M2 Ball Bullet, the complete assembly weighs approximately 340 grains. When using the M1 Ball Bullet, the complete assembly weighs approximately 364 grains. Second class components are generally used in the assembly of these cartridges.

CARTRIDGE, Dummy, Cal. .30, M2.

General. This cartridge is used only in the inspection of weapons and will not be issued to the service.

Visual identification. This cartridge is easily identified by its tinned brass cartridge case and the absence of a primer. It differs from the Dummy M1906 in not having corrugations in the case.

Components. The cartridge consists of a cartridge case, and bullet. Second class components may be used in the assembly of this cartridge. The complete assembly weighs approximately 341 grains.

The cartridge case is the same as the standard cal. .30 case except that it is tinned for identification purposes.

The bullet consists of a gilding metal jacket encasing a lead alloy core. It is a ball M2 Bullet, and prior to September 20, 1940, was tin-coated for further identification.

CARTRIDGE, High-pressure, Test, Cal. .30, M1. This cartridge is used for proof-firing rifles, automatic rifles, and machine guns. It is loaded with a powder charge sufficient to give a breech pressure of approximately 68,000 pounds per square inch. Due to this excessive pressure, and the consequent danger involved in firing, the guns under test are fired from a fixed rest under a hood by means of a mechanical firing device. This cartridge may be fired only by authorized personnel.

Visual identification. This cartridge is identified by its tinned cartridge case. Some models have the word "Test" stamped on the head.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet. The complete assembly weighs approximately 433 grains.

The cartridge case is the same as those used in the service cartridges and is further identified by being tinned.

The bullet consists of a gilding metal jacket encasing a hardened lead core, and has a cylindrical base. Its over-all length is 1.235 inches. The mouth of the case is crimped into the knurled cannelure at assembly and a pull of not less than 40 pounds is required to remove the bullet from the case.

AMMUNITION, CAL. .45.

General. The ammunition described in this discussion is designed for use in all standard revolvers, pistols, and submachine guns of cal. .45. It includes cartridges of the following types: ball, tracer, blank, dummy, and high-pressure test.

CARTRIDGE, Ball, Cal. .45, M1911.

General. This cartridge is a current standard item of issue and is used in the Automatic Pistol M1911 and M1911A1, the Colt Revolver M1917, the Smith and Wesson Revolver M1917, and the Thompson Submachine Gun M1928 and M1928A1 against personnel. To adapt it for use in the revolvers, it must be assembled in clips designed for this purpose.

Components. The cartridge consists of the cartridge case, primer, propelling charge, and the bullet. The complete assembly weighs approximately 327 grains.

The bullet has a round nose and a flat base. It consists of two parts, a gilding metal jacket and a slug of lead hardened with antimony. In early designs, bullet jackets were made of cupronickel and these have a silvery appearance. This was later changed to gilding metal which was given a thin tin wash which has a close resemblance to the cupronickel jacket. The practice of tinning the jackets has since been discontinued and the bullets of current design have the natural copper color of gilding metal. The over-all length of the bullet is 0.68 inch. The mouth of the case may be crimped to the bullet and a pull of approximately 40 pounds is required to remove the bullet from the case.

Exterior ballistics, maximum range:
In pistol .... 1,600 yd
In submachine gun .... 1,700 yd
Pressure .... 14,000 lb per sq in.
Velocity:
Pistol:
At 25.5 ft .... 820 ft per sec
At muzzle .... 825 ft per sec
Submachine gun:
At 25.5 ft .... 885 ft per sec
At muzzle .... 990 ft per sec
Muzzle energy:
In pistol .... 329 ft-lb
In submachine gun .... 383 ft-lb

CARTRIDGE, Tracer, Cal. .45, M1.

General. This cartridge was a standard item of issue for use in the Thompson Submachine Gun M1928A1 for observation of fire and incendiary purposes. It was also used for signal purposes in the automatic pistol. The M1 Cartridges have now been declared grade 3 and are not to be issued.

Visual identification. The cartridge is readily identified by its red tipped bullet, and the fact that the cartridge case has no cannelure.

Components. The cartridge consists of the cartridge case, primer, propelling charge, and bullet. The complete assembly weighs approximately 303 grains.

The bullet has a round nose and a cylindrical base. It consists of four parts: a gilding metal jacket, which is painted red for approximately $3/16$ inch from the tip; a slug of lead hardened with antimony in the forward portion of the jacket; a tracer mixture in the central portion; and an igniter mixture in the rear portion. The over-all length of the bullet is 0.857 inch. The case may be crimped to the bullet and a pull of approximately 40 pounds is required to extract the bullet from the case.

Exterior ballistics, average maximum pressure .... 18,000 lb per sq in.
Velocity, from submachine gun, at 25.5 ft .... 975 ft per sec
Range of trace .... 200 yd

Accuracy. Fires within a mean radius of 8 inches at 100 yards.

CARTRIDGE, Blank, Revolver, Cal. .45, M1.

General. This cartridge is a current standard item of issue for use in the Colt, and Smith and Wesson, cal. .45 Revolvers M1917. It is

used for signaling purposes, firing salutes, training cavalry horses, and in maneuvers where simulated fire is desired. It is fired from the revolver without the use of clips, as the cartridge case has a rim for extracting purposes.

Visual identification. This cartridge is identified by the absence of a bullet.

Components. The cartridge consists of the cartridge case, primer propelling charge, and a paper wad. The complete assembly weighs approximately 123 grains.

The cartridge case differs from the standard cal. .45 cartridge case in that it is heavier and has a rim for extracting purposes.

The paper wad, inserted over the powder charge, is sealed in with a coat of varnish, and the mouth of the case is roll crimped to a diameter of $5/16$ inch.

CARTRIDGE, Dummy, Cal. .45, M1921.

General. This cartridge is a current standard item of issue and is used for training personnel in the operation of loading and unloading revolvers and to simulate firing. It is also used as a range dummy cartridge in the automatic pistol. In this latter case, it is mixed with live ammunition in pistol magazines, the purpose being to detect and correct flinching and faulty trigger squeeze.

Visual identification. This cartridge is identified by its tinned case which either has no primer or has holes drilled in the side of the case.

Components. The cartridge consists of a cartridge case, and a bullet. The complete assembly weighs approximately 313 grains.

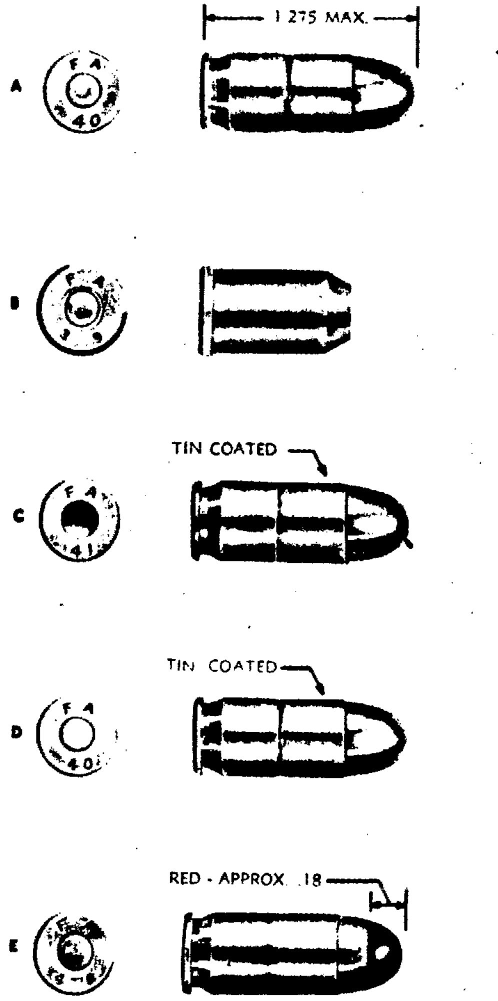
The case of the earlier design contained three $1/8$-inch holes drilled in the body of the case, equally distant from each other, and an inert primer. In later design, the holes and the inert primer are omitted. Both cases are tinned for further identification.

The bullet is the same as that in the CARTRIDGE, ball, M1911.

CARTRIDGE, High-pressure Test, Cal. .45, M1.

General. This cartridge is used for proof-firing cal. .45 weapons at the place of their manufacture. It contains a powder charge that will develop a breech pressure of approximately 20,000 pounds per square inch, this pressure being 4,000 pounds in excess of that required in cal. .45 service ammunition. Due to the danger involved in firing this cartridge, it should only be fired from a fixed rest under a hood, by means of a mechanical firing device, and only by authorized personnel.

Visual identification. It is readily identified by its tinned cartridge case.



A — CARTRIDGE, BALL, CAL. .45, M1911

B — CARTRIDGE, BLANK, REVOLVER, CAL. .45, M1

C — CARTRIDGE, DUMMY, CAL. .45, M1921

D — CARTRIDGE, HIGH PRESSURE TEST, CAL. .45, M1

E — CARTRIDGE, TRACER, CAL. .45, M1

RA PD 4525

Figure 81 — Cartridges, Cal. .45

Components. The cartridge consists of the cartridge case, primer, propelling charge, and bullet. The complete assembly weighs approximately 327 grains.

The bullet is the same as that in the CARTRIDGE, ball, M1911.

AMMUNITION, CAL. .50.

General. The ammunition described in this discussion is designed for use in all cal. .50 machine guns. It includes cartridges of the following types: ball, armor-piercing, tracer, incendiary, blank, dummy, and high-pressure test.

CARTRIDGE, Ball, Cal. .50, M2.

General. This cartridge is a standard cartridge for all cal. .50 machine guns.

Visual identification. This cartridge does not have any identification markings and the tip of the bullet is not painted.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet. The complete assembly weighs 1,800 grains.

The bullet consists of three parts; a gilding metal jacket, a soft steel core, and a point filler of lead hardened with antimony. The over-all length of the bullet is 2.29 inches. The base has a 9-degree taper, beginning at a point 0.386 inch from the base. The mouth of the case is crimped into the cannelure at assembly and a minimum pull of 100 pounds is required to extract the bullet from the case.

Exterior ballistics, maximum range (approx.) ....7,200 yd
Velocity:
At 78 ft.................................2,900 ft per sec
At muzzle ....2,935 ft per sec
Maximum pressure.......................52,000 lb per sq in.

Accuracy. At the time of acceptance, this ammunition will group within mean radii not greater than 8.0 inches at 500 yards, or 9.0 inches at 600 yards, when fired from an accuracy rifle held in a V-block.

CARTRIDGE, Armor-piercing, Cal. .50, M2.

General. This cartridge is a current standard item of issue for all cal. .50 machine guns. It is designed for use against armored aircraft, armored vehicles, concrete shelters, and similar bullet-resisting targets.

Visual identification. This cartridge may be identified by the blackened tip of the bullet.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet. The complete assembly weighs approximately 1,800 grains.

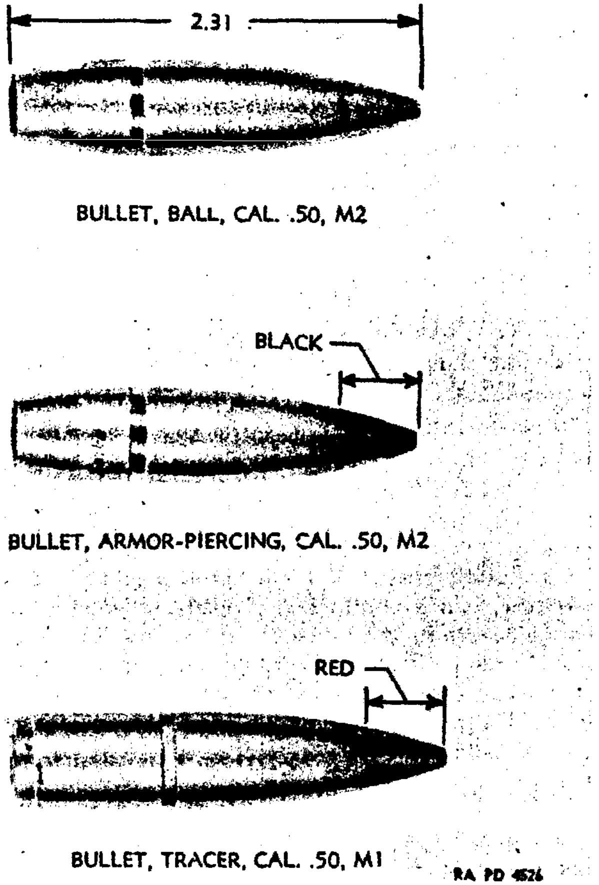


Figure 82a — Bullets, Cal. .50

The bullet consists of three parts: a gilding metal jacket; a tungsten-chrome steel core; and a point filler of lead hardened with antimony. The over-all length of the bullet is 2.29 inches and the point is blackened for approximately $^{9}/_{16}$ inch. The base has a 9-degree taper beginning 0.386 inch from the base. The mouth of the case is crimped into the cannelure at assembly, and a minimum pull of 100 pounds is required to extract the bullet from the case.

Exterior ballistics, maximum range (approx.) . . . . 7,200 yd
Maximum pressure . . . . 52,000 lb per sq in.
Velocity:
At 78 ft . . . . 2,900 ft per sec
At muzzle . . . . 2,935 ft per sec

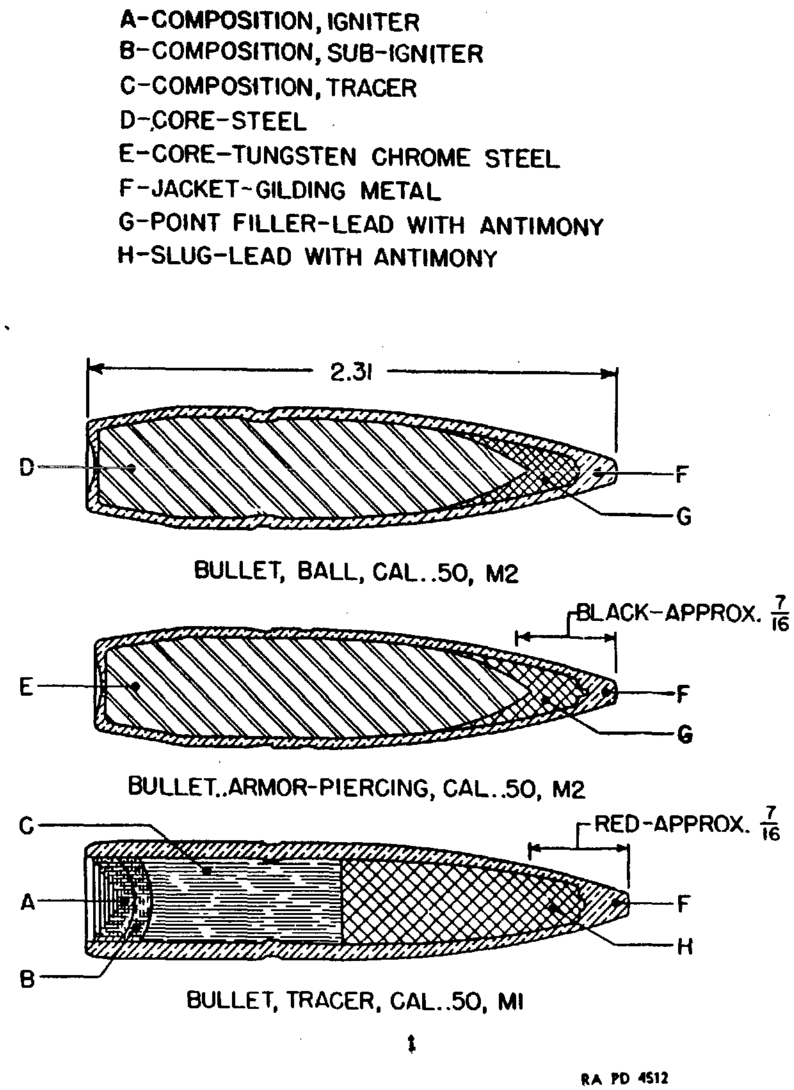
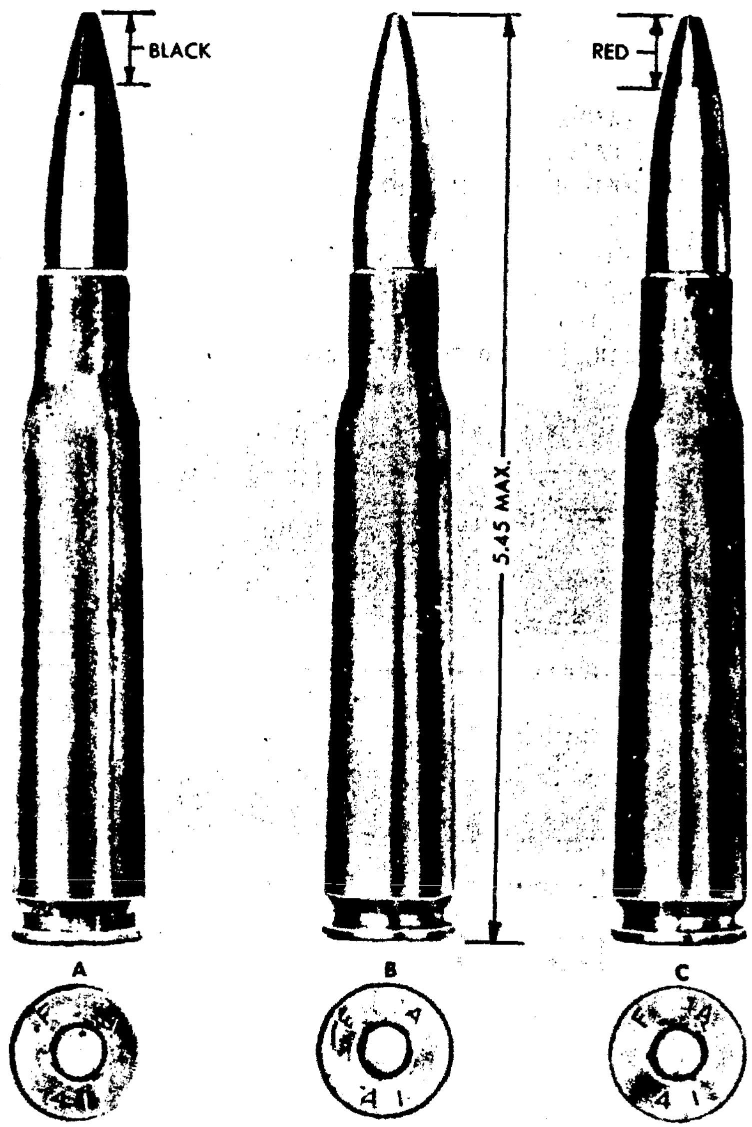


Figure 82b — Bullets, Cal. .50 — Sectioned



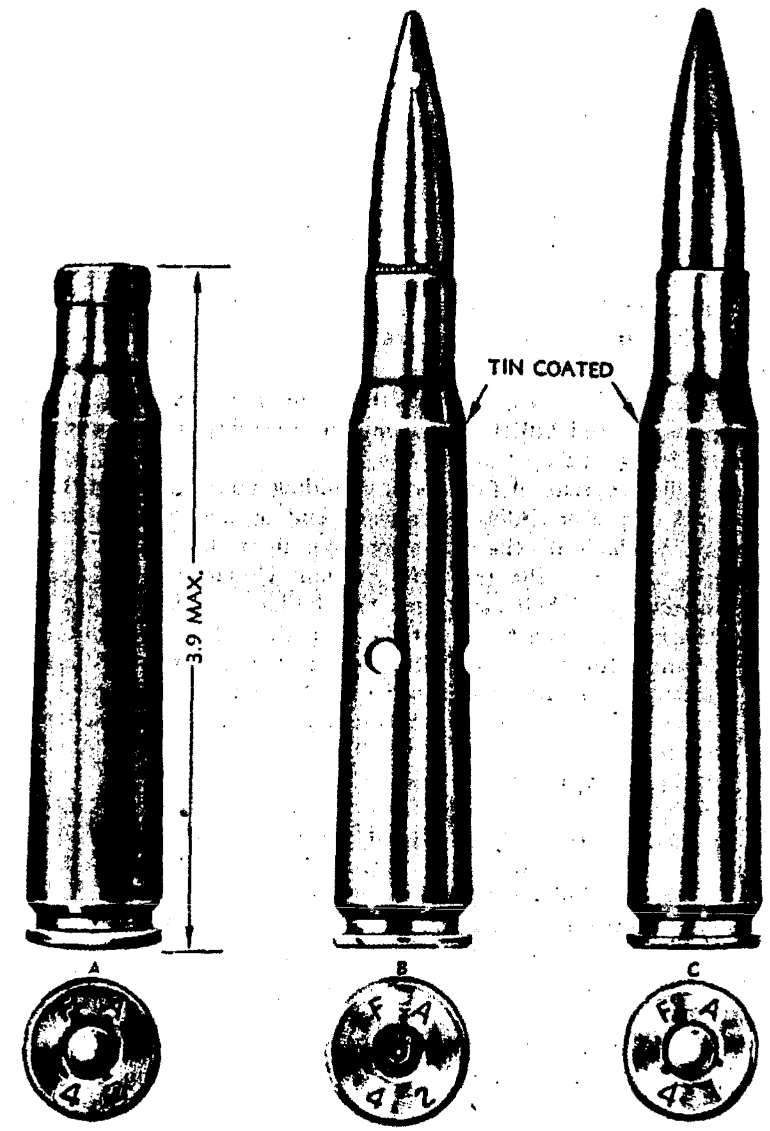
A—CARTRIDGE, ARMOR-PIERCING CAL. .50, M2

B—CARTRIDGE, BALL, CAL. .50, M2

C—CARTRIDGE, TRACER, CAL. .50, M1

RA PD 2117

Figure 83 — Cartridges, Cal. .50



A—CARTRIDGE, BLANK, CAL. .50, M1

B—CARTRIDGE, DUMMY, CAL. .50, M2

C—CARTRIDGE, HIGH PRESSURE TEST, CAL. .50, M1

RA PD 4530

Figure 84 — Cartridges, Cal. .50 — Continued

Accuracy. At the time of acceptance, this ammunition will group within a mean radius not greater than 8.0 inches at 500 yards, or 9.0 inches at 600 yards.

CARTRIDGE, Tracer, Cal. .50, M1.

General. The cartridge is standard for observation of fire in all cal. .50 machine guns. It may also serve as an incendiary against balloons and other readily inflammable targets. Care must be exercised in the use of this cartridge to guard against its igniting dry vegetation on the range.

Visual identification. This cartridge may be distinguished by the point of the bullet, which is painted red to indicate the color of the trace.

Components. The cartridge consists of cartridge case, primer, propelling charge, and bullet. The complete assembly weighs approximately 1,760 grains.

The bullet consists of five parts: a gilding metal jacket; a hardened lead slug which fills the forward end of the jacket; a tracer composition which fills the central portion; an igniter; and subigniter composition, which fills the rear portion. Unlike the bullets for armor-piercing and ball cartridges, this bullet is cylindrical to the base. The base is open to permit the propelling charge to ignite the tracer composition. The over-all length of the bullet is 2.4 inches. The mouth of the case is crimped into the cannelure at assembly, and a minimum pull of 100 pounds is required to extract the bullet from the case.

Exterior ballistics, maximum range:

Bullet .... 3,500 yd

Trace..... The trace begins at a distance not greater than 250 feet from the weapon; the range of the trace is about 1,600 yards.

Maximum pressure .... 52,000 lb per sq in.

Velocity:

At 78 ft.................................... 2,830 ft per sec

At muzzle .... 2,865 ft per sec

Accuracy. At the time of acceptance, this ammunition will group within a mean radii not greater than 20 inches at 600 yards.

CARTRIDGE, Incendiary, Cal. .50, M1.

General. This cartridge is a standard item of issue for use in cal. .50 machine guns.

Visual identification. The cartridge resembles the CARTRIDGE, ball, cal. .50, M2, in outward appearance, but it may be identified by the light-blue paint on the tip of the bullet.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet.

The bullet consists of four parts: a gilding metal jacket; a hollow steel cylindrical core; an incendiary composition; and a lead base filler. The mouth of the cartridge case is crimped into the knurled cannelure at assembly, and a minimum pull of 100 pounds is required to remove the bullet from the case.

Exterior ballistics—This information is not available at this time.

CARTRIDGE, Blank, Cal. .50, M1.

General. The CARTRIDGE, blank, cal. .50, M1, is a standard item of issue designed for use in cal. .50 machine guns with a blank firing attachment in order to operate the weapon for training purposes.

Visual identification. This cartridge is identified by the absence of a bullet.

Components. This cartridge consists of a cartridge case, primer, propelling charge, and wad.

The case has a slight annular groove about 1/4 inch from the mouth, which serves as a seat for the wad.

The wad is a disc punched out of strawboard sheet, 1/16 inch thick, and is lacquered on both sides before the blanking operation.

The powder charge consists of 43 grains of E. C. Blank Fire Powder. After loading, a heavy coat of lacquer is applied to the wad and the mouth is crimped.

CARTRIDGE, Dummy, Cal. .50, M2.

General. This cartridge is standard for use in all cal. .50 machine guns for training purposes. It may also be used for testing the mechanism of the gun.

Visual identification. This cartridge is distinguished from live ammunition by the cartridge case, which is tin-coated, has three holes drilled in the side and an empty primer pocket. It is distinguished from the CARTRIDGE, dummy, cal. .50, M1, by the bullet which is tin-coated.

Components. This cartridge consists of a cartridge case, and a bullet.

The cartridge case is identical with service cases except, as noted above, it is tin-coated and has three holes drilled about the midpoint.

The bullet consists of three parts: a tin-coated gilding metal jacket, a soft steel core, and a point filler of hardened lead. The mouth of the case is crimped into the cannelure at assembly, and a minimum pull of 100 pounds is required to extract the bullet from the case.

Cartridge Cal. .50	Status	Primer Cup	Cartridge Case	Ogive	Base
BALL M2	S&M	Brass	Brass	Pointed	Tapered
TRACER M1	S&M	Brass	Brass	Pointed	Square
ARMOR-PIERCING M2	S&M	Brass	Brass	Pointed	Tapered
INCENDIARY M1	S&M	Brass	Brass	Pointed	Tapered
DUMMY M2	S&M		Brass (tinned) 3 Holes	Pointed	Tapered
BLANK M1	S	Brass	Brass		
HIGH-PRESSURE TEST M1		Brass	Brass (tinned) "TEST" on head	Pointed	Square

Cartridge Cal. .45	Status	Primer Cup	Cartridge Case	Ogive	Base
BALL M1911	S&M	Gilding Metal	Brass	Rounded	Square
TRACER M1	S&M	Gilding Metal	Brass	Rounded	Square
DUMMY M1921	S&M	Inert None	3 Holes* No Holes*	Rounded	Square
BLANK M1	S&M	Gilding Metal	Brass Has extracting flange		
HIGH-PRESSURE TEST M1		Gilding Metal	Brass (tinned) "TEST" on head	Rounded	Square

BULLET				REMARKS
Jacket	Point Filler	Core	Base Filler	
Gilding Metal	Lead Antimony	Soft Steel		
Gilding Metal	Lead Antimony	Tracer Mixture	Igniter Subigniter	Tip of bullet painted red
Gilding Metal	Lead Antimony	Tungsten Chrome Steel		Tip of bullet painted black
Gilding Metal		Incendiary Mixture		Tip of bullet painted blue
Gilding Metal (tinned)	Lead Antimony	Soft Steel		
Gilding Metal		Lead Slug in two parts		Used to test for breech pressure Not issued to troops

BULLET				REMARKS
Jacket	Point Filler	Core	Base Filler	
Gilding Metal		Lead Antimony		Old jackets—cupronickel Next jackets—gilding metal—tinned Present jackets—gilding metal
Gilding Metal	Lead Antimony	Tracer Mixture	Igniter	Tip of bullet painted red Used in submachine gun
Gilding Metal		Lead Antimony		*Cartridge case is brass (tinned)
				Fired in revolvers only
Gilding Metal		Lead Antimony		Used to test for breech pressure Not issued to troops

CARTRIDGE, High-pressure Test, Cal. .50, M1.

General. The CARTRIDGE, high-pressure test, cal. .50, M1, is used for proof-firing cal. .50 machine guns at the place of manufacture. The cartridge is loaded with a powder charge sufficient to develop a breech pressure averaging 62,500 pounds per square inch for any 10 consecutive shots. Due to this excessive pressure and the danger involved in firing, the guns under test are fired from a fixed rest under a hood by means of a mechanical firing device. This cartridge should be fired only by authorized personnel.

Visual identification. This cartridge is distinguished from other cal. .50 cartridges by the tinned cartridge case. Dummy cartridges, which also have tinned cartridge cases, have holes drilled through the case.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet. The entire assembly weighs 1,980 grains.

The case is made of tinned cartridge brass; in other respects it is the same as the cases of other cartridges of this caliber.

The bullet consists of a gilding metal jacket and a core made up of two slugs, a front slug and a rear slug. The mouth of the case is crimped into the cannelure at assembly and a minimum pull of 100 pounds is required to extract the bullet from the case.

AMMUNITION, MISCELLANEOUS.

CARTRIDGE, Ball, Cal. .22, Long Rifle.

General. This cartridge has superseded the CARTRIDGE, cal. .30 gallery practice, M1919, and is used in the cal. .22 U. S. Rifles M1922, M1922MI, and M2, and in cal. .22 machine guns, machine-gun trainers, and pistols for gallery practice and training purposes.

Visual identification. Containers of this ammunition are marked by the manufacturer with the caliber, type, and such trade names as "Kleanbore," "Lubaloy," "Rustless," "Tackhole," "Copperhead," etc. Cal. .22 ammunition has the manufacturer's lot number stamped on the wooden packing box. This provides a means of identifying and reporting any ammunition of this type which may become defective.

Components. These cartridges are purchased by the Ordnance Department from several commercial manufacturers. They are all of the same general appearance, but differ slightly in the shape of bullet, powder used, and ballistic qualities. The cartridge, complete, weighs approximately 53 grains. It consists of cartridge case, priming composition, propelling charge, and bullet. The cartridge case is made of brass or gilding metal, and is of the rim-fire type; that is, the priming composition is spun into a circular recess inside the rim instead of being seated in the center of the case head as a separate component. A blow from the firing pin at any position on the rim

compresses the priming composition causing it to explode and ignite the powder charge. The priming composition and charge of smokeless powder may differ for each manufacturer. Cal. .22 long rifle ammunition contains a noncorrosive, nonmercuric primer composition. The type of powder used is usually marked on the containers, and the charge weighs approximately 1.7 grains. The bullet is made of lead. Bullets of different manufacture differ slightly in shape, but all weigh approximately 40 grains.

Exterior ballistics. Cal. .22 long rifle cartridges of different manufacture vary somewhat in velocity and pressure. The following data are approximate:

Maximum range, with the piece elevated at an angle
in order of 30 degrees . . . . 1,500 yd
Average muzzle velocity . . . . 1,100 ft per sec
Average pressure . . . . 16,000 lb per sq in.

CARTRIDGE, Subcaliber, Cal. .30.

General. The cal. .30 cartridge, subcaliber is designed for firing from the subcaliber tube of the 3-inch (15 pdr.) seacoast gun. Its use for subcaliber practice with other types of cannon has been discontinued. There are two types of cal. .30 subcaliber cartridges: the CARTRIDGE, subcaliber, cal. .30, M1925; and the cal. .30, subcaliber, cartridge old stock. Both types of cal. .30 subcaliber cartridges are limited standard; the old stock on hand is given priority of issue. Under no circumstances may the cal. .30, subcaliber, cartridge be used in other than "Krag" type rifle barrel chambers.

Visual identification. Subcaliber cartridges are distinguished from other cal. .30 types by the presence of an extracting rim on the cartridge case.

Components. This cartridge consists of cartridge case, primer, propelling charge, and bullet.

The cartridge case differs from that of other cal. .30 types, in that it has an extracting rim instead of a groove.

The primer is assembled in a monel metal primer cup in order that it may function without being punctured on the heavy blow of a gun firing pin, and still function properly on the light blow of a rifle firing pin.

The propelling charge consists of approximately 35 grains of pyro D. G. powder.

The bullet of the old style cartridge is cylindrical, with a round nose; the jacket is cupronickel; the filler, hardened lead. The bullet of the M1925 is boat-tailed and pointed; the jacket is gilding metal.

Exterior ballistics, maximum range . . . . 4,300 yd
Muzzle velocity . . . . 2,025 ft per sec
Average maximum pressure . . . . 40,000 lb per sq in.

CARTRIDGE, Carbine, Cal. .30, M1.

General. This cartridge is a current standard item of issue for use in the CARBINE, cal. .30, M1.

Visual identification. This cartridge can be readily identified by its characteristic shape.

Components. The cartridge consists of a cartridge case, primer, propelling charge, and bullet. The complete assembly weighs 195 grains. The cartridge case has a slight taper throughout its length. The bullet consists of two parts; a lead alloy core, and the jacket. The bullet weighs 110 grains.

Exterior ballistics, maximum pressure.........31,000 lb per sq in.

Velocity:

At 53 ft.................................1,900 ft per sec

At muzzle................................2,000 ft per sec

Accuracy. When test fired, it will group within a mean radius of 4 inches at 300 feet.

SHELL, Shotgun, 12-gage.

General. Shotgun shells are procured by the Ordnance Department from several manufacturers for use in 12-gage sporting and riot-type shotguns. They are intended for guard or combat use and for hunting or trap shooting.

Visual identification. Shells for guard and combat use have a brass head extending at least 1 inch along the case. Shells for sporting use have a head extending only ½ inch along the case.

Components. The shell consists of a case, a primer, several wads, a propelling charge, and a load of lead shot.

The case consists of a brass head and a paper case or shell body. In guard or combat shells, the head extends a distance of 1 inch along the case. (In some shells, the entire case is of brass.) In sporting shells, the head extends ½ inch. The head is reinforced by a base of compressed paper in which the primer pocket is formed. Some paper shells have a steel reinforcement, called the lining, under the brass head. The shell body is made of paper and waterproofed. The head is attached to the shell body by crimping.

The primer is a commercial type suitable for ignition of the smokeless powder used.

The size of the leadshot for each type is as follows:

Guard or combat..............................No. 00 buckshot
No. 4 chilled shot

Sporting ....No. 7½ chilled shot
No. 9 chilled shot

The arrangement of the wads (paper and felt) is shown in the illustration.

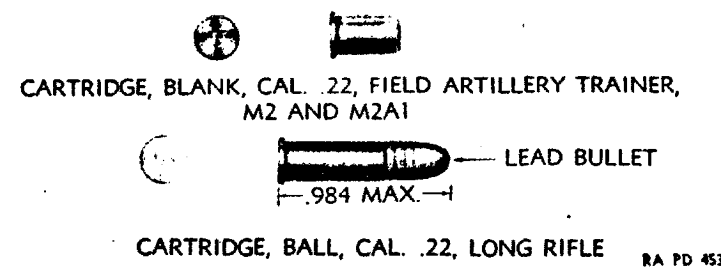


Figure 85a — Cartridges, Cal. .22

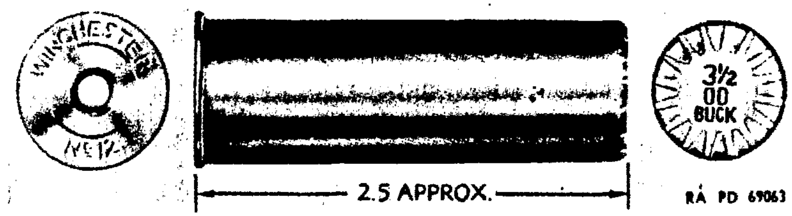


Figure 85b — SHELL, Shotgun, 12-gage

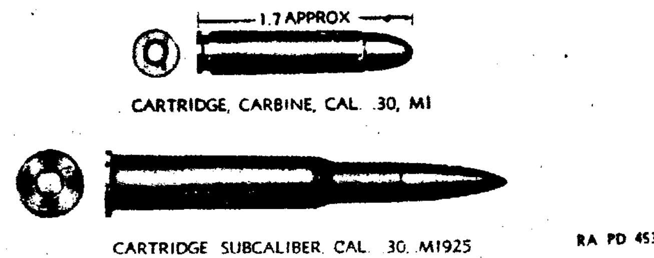


Figure 85c — Miscellaneous Cartridges

PACKING.

Packing Boxes. Standard wooden packing boxes are illustrated in figure 86. The outer wooden cover of the box is held in place by six wing nuts. Some boxes have watertight, metal liners. The cover of these liners is closed by soldering but can readily be torn or ripped off by use of a wire handle provided for this purpose.

Due to the current shortage of metal, other forms of liners are being used in place of the metal liners in some packing boxes. A liner made of paraffin-coated cardboard is used in some instances. This liner is but one-half the length of the metal liner, and two are required to a wooden packing box.

Another substitute for the metal liner is the use of packing envelopes. These are used for cal. .30 rounds, when linked in the 100-

round link belts. The envelope is made of paper with a metal foil liner. Twelve of these envelopes are used to a wooden packing box.

An all metal packing box is also used for some packings. This metal box holds one machine gun belt (250 rounds) and four of these boxes are packed in wire-bound crate.

Within Boxes—Cal. .30. For cal. .30, the following packings are found within the wooden packing box:

1. Cartons (20 rounds per carton).

2. Clips in cartons (5 rounds per clip, 4 clips per carton).

3. Clips in bandoleers (5 rounds per clip, 2 clips per pocket, 6 pockets per bandoleer; or 8 rounds per clip, 1 clip per pocket, 6 pockets per bandoleer).

4. Machine gun (web) belts (250-round belt).

5. Metallic link belts (100-round belt).

Within Boxes—Cal. .50. For cal. .50, the following packings are found within the wooden packing box:

1. Cartons (10 rounds per carton).

2. Metallic link belts (265 rounds per link belt).

Within Boxes—Cal. .45. For cal. .45, the following packings are found within the wooden packing box:

1. Cartons (20 rounds per carton).

2. Cartons (50 rounds per carton).

Within Boxes—Cal. .22. For cal. .22, the following packings are found within the wooden packing box:

1. Boxes within cartons (50 rounds per cardboard box, 10 boxes per carton, 20 cartons per wooden box).

MARKING.

General. The marking of small-arms packing boxes is divided into two groups: the older method; which covered cal. .30, cal. .45, and cal. .50 cartridges in all packings; and the modified method; which covers cal. .30 and cal. .50 cartridges when packed in clips, link belts, and web belts. In both methods, the boxes are painted chocolate brown and the stencil is in yellow.

Older Method. To provide a means of identification as to type and caliber, small-arms packing boxes were marked with color bands. On boxes for cal. .30 and cal. .45 cartridges, the band is painted vertically on the sides and horizontally on the ends. On boxes for cal. .50 cartridges, the bands are painted diagonally on ends and sides. Prior to 1933, the band was also painted across the top. Cal. .45 may be distinguished from cal. .30 by the size of the box (cal. .45 is

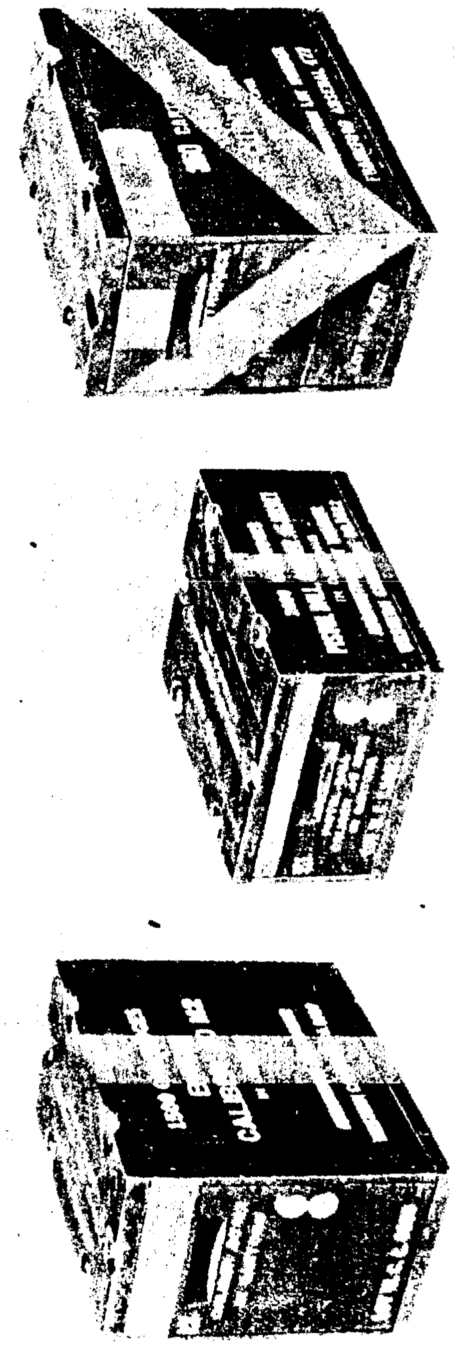


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Figure 86 — Color Band Marking for Small-arms Packing Boxes

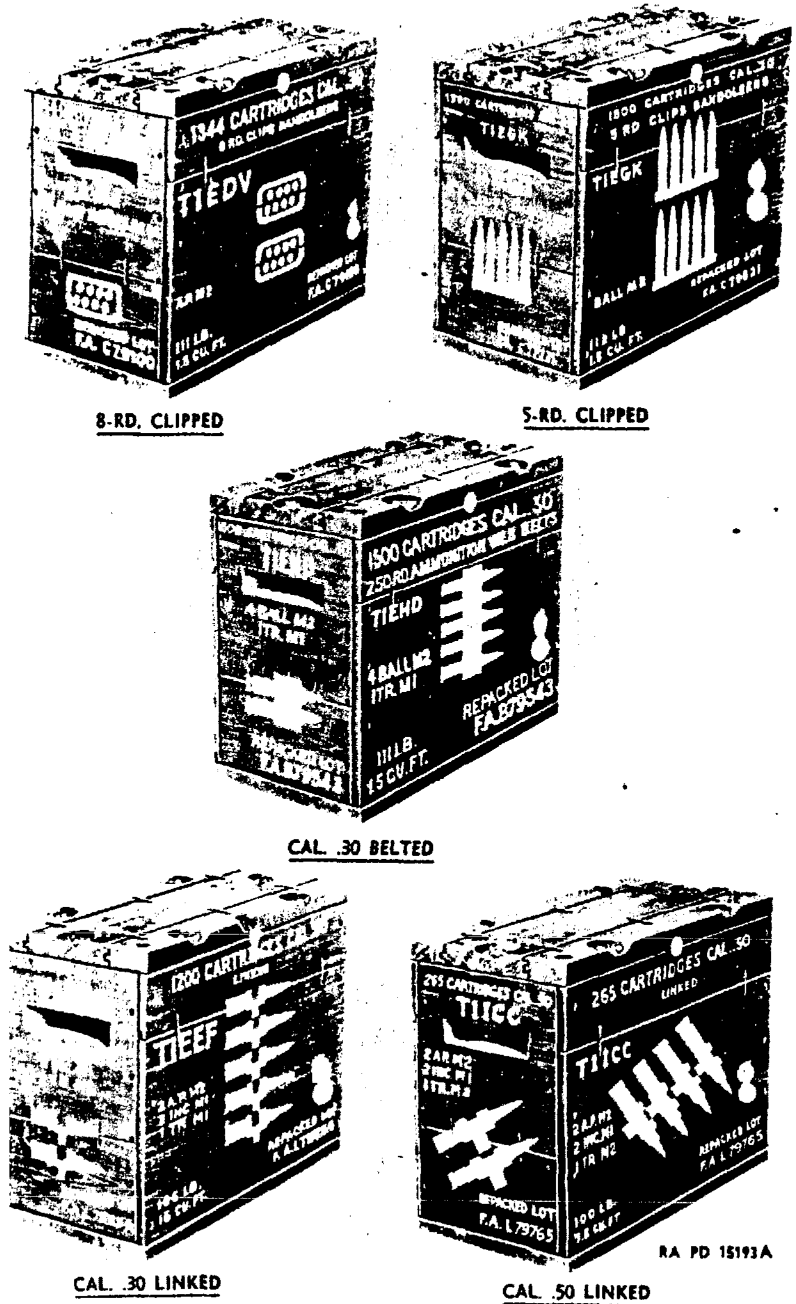

Figure 87 — Symbol Marking for Small-arms Packing Boxes

smaller) and by the band which is one-half the width, for cal. .45 of that used for cal. .30.

The following color bands were used for each type:

Type	Band
Ball	Red
Blank	Blue
Dummy	Green
Gallery practice	Brown
Guard	Orange
High-pressure test	Yellow
Armor-piercing	Blue on yellow
Tracer	Green on yellow
Incendiary	Red on yellow
Rifle grenade	2 Blue bands

While this method has been superseded by the modified method for certain packings (clips, link belts, and web belts), those boxes already marked with the bands will not be changed, and rounds which do not come under the provisions of the modified method continue to use the appropriate bands.

In addition to color bands, each box of ammunition is marked with complete information necessary for shipping, care, handling, and use.

Modified Method. In this method, symbols representing the method of packing within the box (clips, link belts, web belts) are stenciled on the box. These symbols are vertical, on the side and end, for cal. .30 ammunition, and diagonal, on the side and end, for cal. .50 ammunition. Color bands, formerly used to indicate the type of cartridges in the box, are replaced by markings stenciled on the box indicating the type, or types and ratio, of ammunition within the box, for example:

"4 BALL M2, 1 TR M1"

Aside from the changes noted above, the packing boxes are marked in the same manner as previously.

In view of the fact that both methods are now in service, it is to the ammunition inspector's advantage to be familiar with both methods.

SURVEILLANCE.

General. Surveillance includes, in part, the observation, inspection, investigation, and test of explosives and ammunition both in storage and in use. The Chief of Ordnance exercises general supervision over the surveillance of explosives and ammunition, prescribes the tests, and maintains the records of the condition of all lots in service and in storage.

Description of Tests. Tests to which small-arms ammunition is subjected for acceptance and, subsequently, for surveillance and grad-

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ing are visual examination; velocity test; pressure test; functioning and casualty tests in specified weapons; hang-fire test; bolt-lift test; accuracy test; tracer test; loading and unloading test. Some of these tests are described below.

Visual inspection. Examination of sample for season cracks, corrosion, or other visual defects.

Velocity test. Standard methods are used for conducting velocity tests. Screens are placed a definite distance apart and the velocity of the bullet is calculated from the time of flight in traveling from the first screen to the second. In the Boulenge test, the first screen is placed 3 feet from the gun muzzle and the second screen is placed 150 feet from the first. The velocity determined from the time of flight between the two screens is the velocity at 78 feet from the muzzle. A modification of the above test, where distance is not available, requires the screens to be spaced 100 feet apart, and the calculated velocity is the velocity at 53 feet from the muzzle of the gun. Other modifications of the test are to ascertain the velocities at the same average distance from the muzzle of the gun.

Pressure test. This test is conducted in a pressure barrel. The barrel has a small hole drilled in the side of the chamber into which is inserted a small piston. On firing the cartridge, the pressure of the gases forces the piston against a copper cylinder and compresses it. The amount of compression of the cylinder is the index of the pressure developed.

Hang-fire test. In this test, the cartridges are fired in a machine gun at a disc revolving at a prescribed speed. By means of a mechanical device the gun is synchronized with the disc; that is, the gun is mechanically timed to fire at a given point on the disc each time it makes a complete revolution. A small group of holes is produced on the disc, which must not exceed 15 degrees for grade AC ammunition, nor 28 degrees for other grades, when the disc speed is 1,800 revolutions per minute.

Machine gun functioning test. A number of cartridges are fired in a machine gun to determine the number of jams, ruptures, or other mechanical defects.

Rifle functioning tests. A number of rounds are fired in a rifle whose head space is specified.

Tracer test. Tracer ammunition is given a tracer test in which the ammunition is fired in a machine gun. The number of shots failing to trace the required distance and the number of muzzle bursts, blinds, or other erratics are recorded.

Defects found on visual examination. The following defects may be found in cartridges during examination:

Season crack. A split in the neck of the cartridge case. Working the metal in the drawing and tapering operations in the manufacture of the cartridge case produces internal stresses or strains due to distortion of the normal crystalline structure. This condition is further aggravated by the insertion of the bullet. Rearrangement of the crystalline structure leads to failure of the metal along definite longitudinal lines of least resistance. This is known as season cracking. Exposure to severe weathering conditions or certain reagents hastens the time of cracking. In order to prevent or decrease the tendency to season crack, a final anneal is applied to the neck of the cartridge case. This annealing allows the crystals to rearrange themselves in their natural state without the metal cracking. In reporting season crack in ammunition, care should be taken not to confuse this defect with that known as "split necks" which occur when the ammunition is fired.

Corrosion. There are varied stages of corrosion. The minor stages do not necessarily raise the surface of the metal, but are more in the nature of a harmless discoloration of the cartridge case. An examination of the case should indicate whether the corrosion has eaten into and weakened the metal to such an extent that it may cause rupture when the cartridge is fired. True discoloration is the blackening of the cartridge case, whereas corrosion adds other colors such as green, red, yellow, blue, and white. Corrosion in the advance stages, through some chemical action, appears to deposit a substance on the case which will interfere with chambering the cartridge. In reporting corrosion, the degree of corrosion should be described. Discoloration is really of minor importance since ammunition that is only discolored will function as well as good ammunition. Advanced corrosion, however, is a serious defect and ammunition thus affected should not be fired. The use of steel wool or other abrasives to remove corrosion from cartridge cases is prohibited.

Mouth pulled down. This defect would be attributed to the fact that the mouth of the cartridge case was not concentric, and when the bullet was seated it struck one side of the mouth of the cartridge case and shoved the metal down. This defect occurs much more frequently with a cartridge case whose mouth is annealed very soft, than with a cartridge case whose mouth has no, or a very slight, anneal. It is also possible that this defect may be caused by improper alinement of the bullet loading machine.

Shoulder bulge. A pucker in the metal of the cartridge case at the junction of the shoulder and body. This defect is generally caused by the metal at that point being either too thin or too soft. It is also caused by a maximum diameter bullet being seated in a cartridge case having a neck of minimum diameter.

Oil dent. A smooth-surfaced indent in the cartridge case generally in or near the shoulder or neck. This defect is caused by an excess of oil used in the tapering operation. Unless extremely large, so as to greatly increase the density of loading, thereby increasing the pressure, this defect is negligible.

Draw scratch. A longitudinal scratch, varying in degree, on the cartridge case. This defect is caused by grit or some other foreign material in the final draw die and is due to the improper washing of the material before reaching that operation. A cartridge having a deep draw scratch will probably open up on firing with a consequent loss in velocity. Also cartridge cases containing this defect will probably split in storage sooner than normal cartridge cases.

Split mouth. A split in the edge of the cartridge case. This defect is caused by the plugging operation.

Folded neck. Overlapping of metal in the neck of a cartridge case indicated by a longitudinal protuberance on the outside. This defect is caused by the metal in the neck of the cartridge case being thinner on one side than on the other and by insufficient annealing.

Scale. Inclusions of impurities in the metal which are sometimes hidden. If hidden, and not discovered by the inspectors, it often causes an irregular break in the cartridge case and loss of velocity due to the escape of gas when fired. This defect is inherent in the metal and is not caused by faulty manufacture. Scaly metal shortens the life of the cartridge-making tools considerably.

Indent and bur. These defects generally arise from rough handling of the cartridge cases during the process of manufacture. If cartridges with these defects chamber in the rifle, there is no danger in using them, unless the dent is so large that the density of loading is increased to such an extent that a dangerous pressure would result.

Crease. This is very similar to a fold, and generally occurs in the neck or shoulder of the cartridge case. It is caused by thin metal.

Thick head. The head of the cartridge case has a thickness of metal greater than the maximum allowed. This defect generally occurs during the adjustment of the head-trimming machine. It is also sometimes caused by a chip of metal getting on the push-in feed rod, thereby causing a cartridge case to be improperly chucked. Such a defect will probably give trouble in extraction, as the extractor is not able to function with an extremely large head.

Thin head. The head of the cartridge case has a thickness of metal less than the minimum allowed. This defect happens during the adjustment of the head-trimming machine. It will be the probable cause of the extractor failing to function because it pulls through the thin metal of the head and does not extract the case.

Round head. The head of the cartridge case which is beveled on the outer edge so that it is practically round. This defect is generally

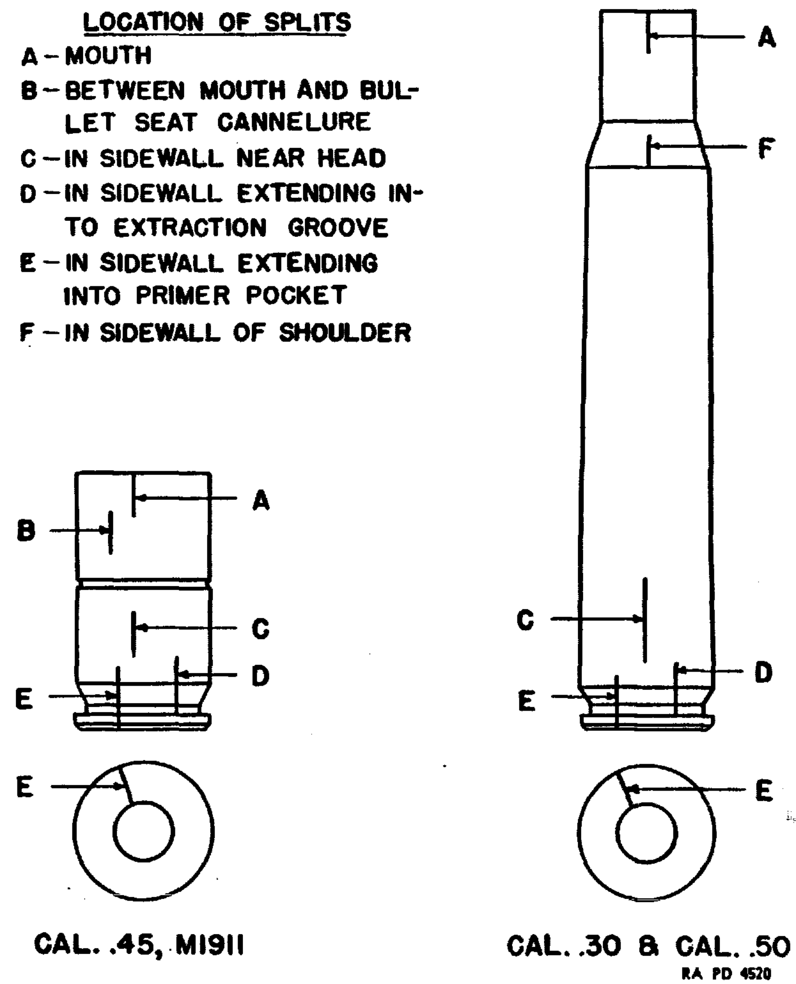


Figure 88 — Location of Splits in Cartridge Cases

found in a case which has been pocketed but not headed. It sometimes happens with a thin case which contains too little metal in the head to properly form it. This defect causes trouble in extraction. At times a thick-headed cartridge, on account of the bevel given it, has an appearance of a round head.

Split bullets (tracer ammunition). Longitudinal cracks in the bullet which often rupture the neck of the cartridge case. In most cases, this is due to impure tracer mixture which either has absorbed too much moisture or liberated free mercury which amalgamates with the metal of the bullet causing the split. This defect is very serious and when found should be immediately reported.

Defects Found After Firing.

Misfire (heavy blow). The primer shows an impression of the firing pin which indicates that a blow sufficiently hard to ignite a perfect primer has been delivered. Such a misfire as described indicates that the primer is defective. The defect may be from:

1. Thick metal in the base of the primer cup.

2. Thick primer pellet which cushions the blow.

3. No priming pellet in the primer.

4. No primer pellet mixture between the primer cup and anvil.

5. No anvil.

6. No vent hole.

7. Various combinations of these defects.

Misfire (light blow). The primer is so lightly marked by the impression of the firing pin that it indicates that the force of the blow struck was not sufficient to ignite the primer. This may be caused by:

1. A mechanical defect in the weapon.

2. A short or broken firing pin.

3. A weak firing pin spring.

4. The bolt of the weapon not completely locked.

5. Grease in the firing pin hole which cushions the blow of the firing pin.

6. Primer seated too deep in the primer pocket.

7. Improper angle of the shoulder of the cartridge case which allows the cartridge case to go forward.

Hangfire. Delayed ignition of the powder in the cartridge may be caused by a small or decomposed primer pellet, damp powder, or a light blow of the firing pin caused by dirt or a defect in the weapon. While a hangfire is a serious defect if the delay is long enough to permit the bolt to be opened before the powder burns completely, such a delay is rarely found in practice. Should a hangfire of several seconds delay occur, and the bolt be opened before the powder explodes, injury to the firer or damage to the weapon, or both, may result.

Pierced primer. Perforation of the primer cup by the firing pin. This may be caused by an imperfect pin or very thin metal in the base of the primer cup. There are various degrees of this perforation. A very small perforation will show, by means of a discoloration around the indent made by the firing pin, the escape of gas. The disc from a large perforation may be blown into the action of the gun with such an escape of gas as to lower the velocity of the bullet.

Primer leak. Gas generated by the explosion of the powder charge escapes between the walls of the primer cup and the primer pocket, causing discoloration around the primer and the head of the cartridge case. The discoloration may be slight, indicating a small primer leak; or heavy, indicating a large primer leak. The primer leak may be because of too small a primer, too large a primer hole, or excessive pressure generated by the propelling charge.

Blown primer. On firing the cartridge, the primer is blown completely from the pocket of the cartridge case. Although this is a serious defect, it is seldom encountered.

Primer set-back. Pressure developed by the explosion of the propellant charge forces the primer back against the face of the bolt. On examination, it will be seen that the primer protrudes above the head of the cartridge case. The set-back of the primer may be slight or heavy and is due to a defective bolt, cartridge, or excessive pressure.

Leak at back of case. The gas escapes into the action of the weapon. The discoloration due to this escape of gas is along the body of the cartridge case.

Failure of case to extract. This may be due to a poorly formed or weak extractor, or a defective cartridge.

Blowback. An escape of gas under pressure to the rear is commonly referred to as a blowback. Pierced primer, primer leak, blown primer, primer set-back, and ruptured cartridge, are known as blowbacks.

Split neck. The neck of the cartridge case splits in firing and is accompanied by an escape of gas. This should not be confused with a split neck due to season cracking which can be observed before firing.

Split body. A more or less regular longitudinal split in the body of the case which allows gas to escape, thereby reducing the velocity of the bullet. This defect is generally found in cartridge cases which have a deep draw scratch or in those which are made from defective brass.

CARE, HANDLING, AND PRESERVATION.

General. The provisions contained in this section are of a specific nature for small-arms ammunition only.

Care and Precautions in Handling.

Boxes. Small-arms ammunition, as compared with other types of ammunition, is not dangerous to handle. Care, however, must be observed to keep the boxes from becoming broken or damaged. All broken boxes must be repaired immediately. All markings should be transferred to the new parts of the box. The metal liner should be air-tested and sealed if equipment for this work is available.

Boxes should always be opened by breaking the seals and unscrewing the wing nuts. They should be opened carefully, as the wooden boxes are used as long as they are serviceable. If the cover of the metal liner sticks, it may be loosened by placing a piece of wood inside the handle so as to get a better grip. The metal liner is expendable but should be turned in for salvage.

Ammunition boxes should not be opened nor the metal liner broken until the ammunition is required for issue or use. Ammunition removed from the airtight container, particularly in damp climates may corrode, thereby causing the ammunition to become unserviceable.

Handling cartridges. After a box of ammunition has been opened and the cartridges removed, the primer should be protected from blows by sharp instruments as such a blow might explode the cartridges.

Ammunition should be protected from mud, sand, dirt, and water. If it gets wet or dirty, it should be wiped off at once. Verdigris or light corrosion should be wiped off. However, cartridges should not be polished to make them look better or brighter. The use of abrasives is forbidden. If a cartridge case becomes so corroded that a perceptible amount of metal is eaten away, it is dangerous to fire and should not be used.

The use of oil on cartridge cases is prohibited. Greasing or oiling cartridges used in machine guns and automatic arms cause the collection of dust and other abrasives which are injurious. Grease or oil on cartridge cases or on the walls of the chamber in nonautomatic rifles creates excessive and hazardous pressure on the rifle bolt. When there is oil on the cartridge case, there is no adhesion of the case to the chamber. When the case expands upon firing, the case slips back, and the bolt receives a greater rearward thrust. An apparent exception exists in the case of lead bullets. However, only the bullet is waxed or greased as issued.

Ammunition should not be exposed to the direct rays of the sun for any length of time. If the powder is heated, it is likely to cause excessive pressure when fired and will affect the performance of the ammunition.

Whenever cartridges are taken from cartons and loaded into belts or clips, the latter should be tagged or otherwise marked so that the ammunition may be identified as to lot number and manufacturer. Such identification is necessary to prevent otherwise serviceable ammunition from being placed in grade 3, because of loss of lot number.

Defective cartridges. Dented cartridges, cartridges with loose bullets, or otherwise defective rounds should not be issued. Lots having more than 5 percent of defective cartridges will be subjected to 100 percent inspection. Defective rounds will be culled out, the

serviceable rounds repacked, and a report made to the Chief of Ordnance. If 20 percent or more are defective, the lot is withdrawn from issue and held for disposition. Particular attention should be paid to incipient cracks which are not easily detected unless the thumb is pressed against the bullet, thus exposing the crack in the cartridge case. Defective cartridges will be considered as grade 3 ammunition.

No small-arms ammunition may be issued until it has been positively identified by ammunition lot number and grade, as published in the latest revision of OFSB 3-5.

Storage.

Piling by lot. Small-arms ammunition should be stored and piled according to type and ammunition lot number. Extreme care must be exercised to prevent the mixing of ammunition lots in one pile. When small-arms ammunition is received, issued, checked, stacked, or restacked, reliable personnel should be in charge and a check made of the ammunition lot number on each box.

Grade 3 ammunition. Whenever grade 3 ammunition is to be stored it should, if possible, be segregated and plainly marked with some sort of "issues prohibited" tags.

Protection. Whenever practicable, small-arms ammunition should be stored under cover. This applies particularly to tracer and shotgun ammunition. Tracer ammunition is subject to rapid deterioration if it becomes damp, and may even ignite spontaneously. Shotgun shells are not packed in waterproof metal-lined boxes except for overseas shipment.

Although small-arms ammunition is packed in boxes with metal liners, actual tests have shown that leaks in liners are developed in handling and shipping to the extent of 8 percent in newly packed ammunition, while in the older lots leaks have been found in as high as 70 percent of the liners. The leaks, though small, will admit moisture if the ammunition is exposed to the weather or extreme variations in temperature.

Should it become necessary to leave small-arms ammunition in the open, it should be raised on dunnage at least 6 inches from the ground and the pile should be covered with a double thickness of serviceable tarpaulin. Care must be exercised in using a tarpaulin to give the pile sufficient ventilation and to avoid the building-up of extreme temperature, especially in warm weather. Suitable trenches should be dug to prevent water flowing under the pile.

Tracer ammunition storage. If practicable, tracer ammunition should be stored separately from other ammunition.

High temperatures. Small-arms ammunition in storage should be protected from extreme heat to avoid decomposition of the propellent powder. The combination of high temperature and a damp atmosphere is particularly detrimental to the powder.

Opened boxes. When only a part of a box is used, the remaining ammunition should be protected against unauthorized handling and use by fastening the cover firmly in place. Such boxes should also be marked with a "light box" tag and be placed in a conspicuous place.

Fire hazard. If placed in a fire, small-arms ammunition does not explode violently. There are small individual explosions of each cartridge, the case flying in one direction and the bullet in another. In case of fire, it is advisable to keep personnel not engaged in fighting the fire at least 200 yards distant, and have them lie on the ground. It is unlikely that bullets and cases will fly over 200 yards.

FURTHER REFERENCES: OS 9-18, Vol. I, Ammunition General (Small Arms); O.O. 7224, Ordnance Safety Manual; TM 9-1990, Small-arms Ammunition; OFSB 3-5, Grades and Lot Numbers; SNL's, T-series TB 1990-1, Marking of Cartridge Packing Boxes.

Chapter 2

Hand Grenades

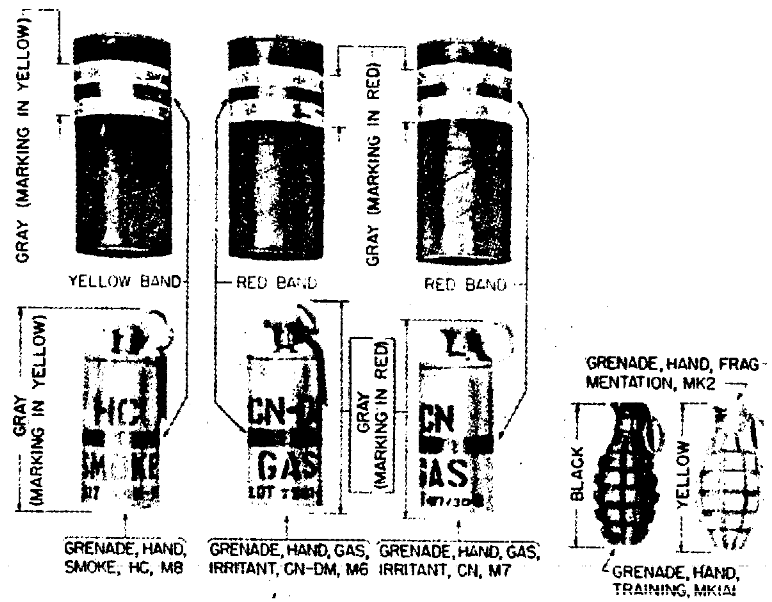
GENERAL.

Hand grenades form an important class of ammunition, especially for trench warfare. They are a convenient type of ammunition which, within certain limitations, enables the infantry to augment its primary weapons with a missile somewhat similar in action to a shell or bomb. Chemical hand grenades that produce clouds of irritant gases are also effective in dispersing mobs, quelling riots, etc.

Types. Hand grenades are divided into three general types, namely: explosive grenades containing a heavy charge of explosive, chemical grenades which contain a chemical filler, and training grenades developed for training in the use of grenades. At the present time, the Chemical Warfare Service handles all chemical hand grenades and there will be no discussion of this type.

GRENADE, HAND, FRAGMENTATION, MK. II, WITH HAND GRENADE IGNITING FUZE M10A2.

General. The Fragmentation Hand Grenade Mk. II, loaded with E. C. Blank smokeless powder and assembled with the Hand Grenade Igniting Fuze M10A2 is the standard for manufacture and issue. Its function is to cause casualties due to fragments of the grenade body. The grenade complete weighs approximately 20 ounces. This grenade, as issued, is shown in figure 90.



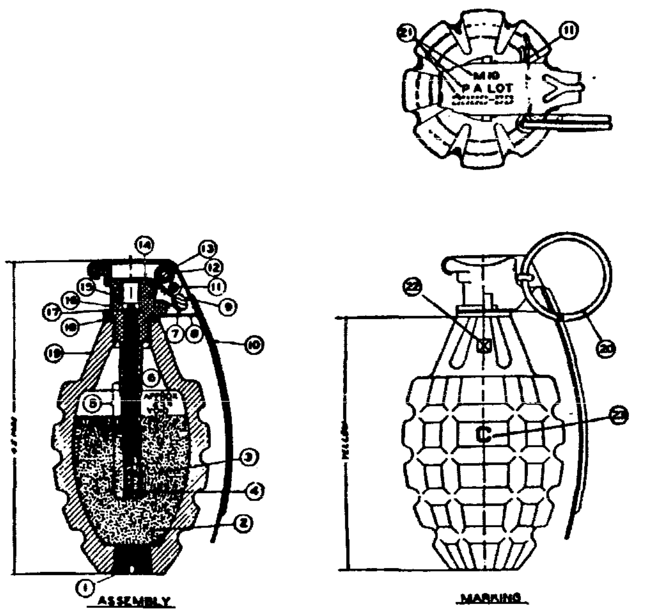
RA PD 4318

Figure 89 — Hand Grenades

Body. The Fragmentation Hand Grenade Body Mk. II, is made of cast iron. It is about the size and shape of a large lemon and is designed to fit comfortably in the hand. The outside surface is deeply serrated, horizontally and vertically, to assist in forming uniform fragments of effective size when the grenade explodes. The opening in the top is threaded for assembly of the fuze. The body weighs approximately 1 pound, empty.

Bursting Charge. The explosive filler or bursting charge consists of 0.74 ounce of E. C. Blank smokeless powder. This is a commercial type of semicolloided nitrocellulose, granulated into small shot-like grains. It is generally pink or yellow in color and is associated with the words "blank fire" in that its principal use has been for loading blank ammunition for small arms.

FUZE, Igniting, Hand Grenade, M10. This is a mechanical device assembled to the grenade body which functions the grenade at the time and under the circumstances desired. (For details, see figure 90.) The fuze body (16, fig. 90) is threaded and screwed into the opening in the top of the grenade body. A lever (10, fig. 90) covers the top of the fuze body, one end being bent over to hook under a protruding lip. The other end of lever extends downward and is curved to follow the contour of the grenade body. A cotter pin (11, fig. 90) with a ring (20, fig. 90) in the eye extends through



1. FILLING HOLE SCREW (DIE CAST).
2. BURSTING CHARGE (E.C. BLANK POWDER).
3. IGNITING CHARGE (BLACK POWDER).
4. CASE (COPPER).
5. COATED WITH N.R.C. COMPOUND.
6. TIME FUSE (COMMERCIAL).
7. STRIKER.
8. FUZE SEALER.
9. STRIKER POINT.
10. LEVER.
11. COTTER PIN.
12. HINGE PIN.
13. SPRING.
14. DISK (TIN FOIL).
15. PRIMER ASSEMBLY, MK. V.
16. FUZE BODY.
17. PRIMING CAP.
18. WASHER (COMPOSITION).
19. GRENADE BODY.
20. RING.
21. MODEL OF FUZE, MFG.'S INITIALS, AND FUZE LOT NUMBER STAMPED ON LEVER.
22. INSPECTOR'S STAMP.
23. GRENADE BODY MFG.'S INITIALS.

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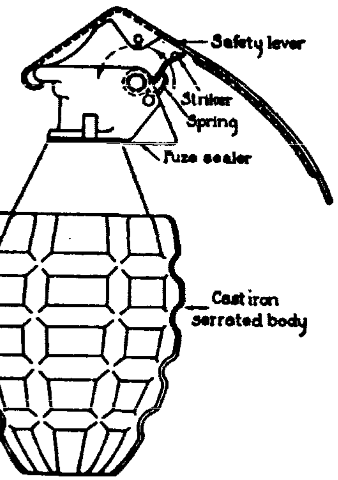
Figure 90 — GRENADE, Hand, Fragmentation, Mk. II, w Hand Grenade Igniting Fuze M10

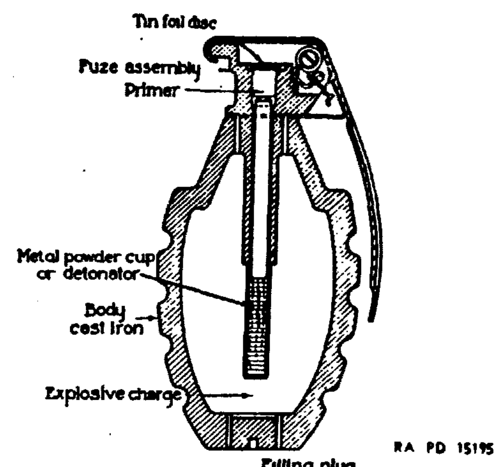
holes in the lever and fuze body, holding the lever and striker assembly (7, fig. 90) in place against the action of the spring (13, fig. 90). The primer (15, fig. 90) is of the center fire type and is known as the Mk. V. It contains a 0.4-grain charge of primer mixture in a cup inverted over an anvil. When the cotter pin (11, fig. 90) is removed and the lever (10, fig. 90) released, pressure from the spring (13, fig. 90) rotates the striker (7, fig. 90) around the hinge pin (12, fig. 90). The point of the striker impacts against the primer cup and explodes the primer charge by crushing it on the anvil. The flame from the primer charge flashes through the primer body and ignites a 2-inch piece of commercial time fuse (6, fig. 90). This burns for approximately 5 seconds while conducting the flame to the igniting charge (3, fig. 90) which then explodes and functions the grenade.



RA PD 15194

Figure 91 — GRENADE, Hand, Fragmentation, Mk. II

The igniting charge consists of 7 grains of loose black powder contained in a copper case (4, fig. 90). The open end of the case extends inside the stem of the fuze body and is crimped in place, the joint being waterproofed by an application of green colored N.R.C. compound. The primer end of the fuze is protected against the entrance of moisture by a tin foil disc (14, fig. 90) which is sealed in place with shellac varnish. Other components of the fuze are the fuze sealer



RA PD 15195

Figure 92 — Grenade — Section View

(8, fig. 90) and the composition washer (18, fig. 90). The fuze sealer is a piece of sheet metal which fits around the fuze body just above the threaded portion. Two projecting sides fit the triangular space between the fuze body and lever, thus preventing the entrance of mud, sand, or other foreign material into the firing mechanism. The composition washer serves as a gasket between the fuze and grenade body when the fuze is seated in place. Should the spring (13, fig. 90) lose its strength or become "set," failure of the fuze will result. It has been found necessary to replace old springs with new ones after long periods of storage. The complete fuze weighs approximately 3.22 ounces.

FUZE, Igniting, Hand Grenade, M10A1. The A1 modificiation of the FUZE, igniting, hand grenade, M10, consists of a redesign of the head of the fuze so that the fuze sealer washer is dispensed with and yet the striking mechanism is completely enclosed as before.

FUZE, Igniting, Hand Grenade, M10A2. The A2 modification of the FUZE, igniting, hand grenade, M10, consists of a change in the explosive train. The length of the Bickford fuse is shortened from 2 inches to $1\frac{5}{16}$ inches, and between it and the primer are two delay pellets of compressed black powder. The delay time remains 5 seconds, 2 seconds being obtained from the black powder pellet and 3 seconds from the shortened length of Bickford fuse. This modification was found necessary in order to prevent the primer flame from completely bypassing the Bickford fuse and igniting the igniting charge directly when small diameters of Bickford fuse were coincidentally associated with large inner diameters of the fuze stem.

Operation. The grenade is grasped in the throwing hand with the lever held firmly against the grenade body. The first finger of the free hand is inserted in the ring, gripping it firmly between the second and third joints of the finger. The cotter pin is withdrawn by pulling the ring. The grenade is then ready to be thrown. The thrower must take every precaution after the cotter pin has been withdrawn, not to release his grip on the lever until the grenade is thrown. The grenade is thrown with a full swing of the cocked arm as one would throw a ball. The instant the grenade is released, the striker forces the lever away and fires the primer as shown in figure 91. Five seconds later the action of the fuze causes the grenade to explode. The body bursts, forming many small fragments, some of which may fly over 200 yards. Personnel should be thoroughly familiar with the safety precautions in the following paragraphs before attempting to fire live fragmentation hand grenades.

Safety Precautions.

1. A live fragmentation hand grenade should never be thrown un-

less cover is at hand behind which the operator and friendly troops may secure shelter. Fragments may fly over 200 yards.

2. The grenade should not be armed by withdrawing the cotter pin unless the grenade is to be thrown at once. If the lever is accidentally released after the cotter pin is withdrawn, the striker will function immediately and the grenade will explode in approximately 5 seconds.

3. If the striker is accidentally allowed to function, the grenade should be thrown as far as possible and the thrower should seek shelter, but if none is near he should drop flat on the ground and lie prone.

4. If the grenade is accidentally dropped after the cotter pin has been removed, it should be picked up and thrown immediately; there is plenty of time if one does not hesitate. It will function in 4 or 5 seconds, but it can be thrown farther than one can run in that length of time. The operator should throw himself flat on the ground, as above, and warn others near him to do likewise.

5. It should never be assumed that one can guess when 5 seconds have elapsed, and allow the striker to function a moment or so before throwing the grenade. The material on the A2 modification of the fuze should bear out the wisdom of this precaution.

6. Live grenades that fail to fire (duds) should be handled very carefully in the manner prescribed in FM 23-30.

7. It should be kept in mind that the hand grenade is always loaded and cocked. It is always pointed at you. It is safe and effective when properly handled, but it is very dangerous when handled otherwise.

Painting and Marking. Loaded Fragmentation Hand Grenades Mk. II, are painted lustreless olive drab. The levers of the igniting fuzes are stamped with the fuze model, lot number of loaded fuze, and the fuze loader's initials.

Packing. Loaded and fuzed fragmentation hand grenades are packed in individual fiber containers, 25 grenades in containers per wooden packing box.

GRENADE, HAND, OFFENSIVE, MK. IIIA1, UNFUZED (ADAPTED FOR HAND GRENADE DETONATING FUZE, M6A2).

General. Because of its structure, which is such that there is no marked fragmentation, this grenade can be used more safely in the open than can fragmentation hand grenades. It is used for demolition.

Body. The body of this grenade is formed of laminated cartridge paper and is fitted with light sheet metal plates crimped to the ends of the body. In the center of the top, a threaded brass collar is crimped in place as an adapter for the FUZE, detonating, hand grenade, M6A2. The grenade is cylindrical in shape.

Filler. The filler of this grenade is a pressed charge of flake TNT.

FUZE, Detonating, Hand Grenade, M6A2. This fuze is similar in mechanical action to the FUZE, igniting, hand grenade, M10A2. It is provided with a 5-second delay.

Painting and Marking. The loaded grenade body is black in color. A yellow gummed paper sealer runs about the center of the body and is printed with the type, the model, the lot number, the date of loading, and the loader's initials.

Packing. The loaded offensive hand grenade and the FUZE, detonating, hand grenade, M6A2, are packed and shipped separately. The loaded grenade bodies are packed 24 per box or 50 per box. The fuzes are packed 25 per carton, 8 cartons (200 fuzes) and 1 wrench (for field assembly of fuze to grenade) per box.

GRENADE, HAND, TRAINING, MK. IA1.

General. The training hand grenade is made of cast iron and is approximately the same shape, size, and weight as a loaded Fragmentation Hand Grenade Mk. II. A projection is cast on the top and side to represent the fuze assembly. The A1 modification consists of the addition of a cotter pin and pull ring to a hole drilled in appropriate position through this projection. This more closely simulates the operations involved in the throwing of a fragmentation hand grenade. The training hand grenade is used for preliminary practice in grenade throwing.

Painting and Marking. This grenade is painted black; that being its only distinctive marking.

Packing. This grenade is packed 24 per box.

FURTHER REFERENCES: SNL S-4; OFSB 3-10; TM 9-1900, TM 9-1985; FM 23-30; O.O. 7224.

Chapter 3

Antipersonnel Mines and Booby Traps

GENERAL.

Antipersonnel mines are designed for effect against personnel and are laid to perform a definite tactical mission. Antipersonnel mine fields are used in antitank mine fields to give warning of enemy mine removal parties as well as for effect against such parties. They

surre. selves a. enemy, the

In many ca. personnel mine o. the purpose for which

Psychology of Use. Th. more important for their effe. than for the number of casualtie. ...er unexpectedly, and often when he ... s or busying himself with some routine tas. ...ld be planned by ingenious individuals who hav. ...ding of enemy psychology. The enemy should be for. ...es of confusing and frightful experiences to live in uncert. ...d dread. He should be given good cause to fear to advance into ... localities, to undertake new tasks, or to enter buildings or dugouts for shelter or rest. To this end, mines and traps should have infinite variety in their distribution and use, and should be particularly dangerous to those who attempt to locate or remove them.

Types. Two standard antipersonnel mines are provided; namely, the MINE, antipersonnel, M2, which in action is similar to a small trench mortar, projecting a shell about 6 feet into the air where it explodes, and the MINE, antipersonnel, M3, which is a fragmentation type. The complete round of either type consists of the mine itself, the firing device, and accessories such as trip wires which are necessary to the proper functioning of the mine.

In addition to the above types, fragmentation hand grenade, demolition blocks, and other adaptable ammunition items may be used as either antipersonnel mines or booby traps by their being fitted with standard firing devices.

FIRING DEVICES.

General. The following firing devices are manufactured especially for use with antipersonnel mines or booby traps: Pull Firing Device M1; Pressure Firing Device M1; Combination Firing Device M1; Release Firing Device M1.

These standard firing devices afford the following advantages over improvisations: established supply; speed of installation; dependability of mechanical functioning; resistance to weather; safety.

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A few of the many ways in which the above listed devices may be used are as follows:

1. To fire antipersonnel mines.

2. To protect antitank mine fields from enemy attempts to clear them.

3. To impede the advance of enemy troops.

4. To activate road mines.

5. To protect tactical barb wire from enemy attempts to cut the wire.

6. To set off booby traps in dwellings or other buildings which the enemy is likely to use.

7. To set off explosive charges instantaneously when electrical means are not available.

8. To prevent removal by the enemy of prepared demolition charges or delay action mines.

9. To prevent removal of railway equipment or other facilities abandoned to the enemy.

10. To cause demolition of bridges by vehicles crossing them.

11. To set off hand grenade antipersonnel mines.

12. To make the removal of other antipersonnel mines or vehicle mines in the vicinity more difficult.

These are only a few of the many and various ways in which these devices may be used. The actual number of uses is limited only by the ingenuity of the user. It is important to remember, however, that the entire installation must be well camouflaged or it will be discovered by the enemy. Standardization of location must be avoided so that the enemy will be forced to suspect everything and will fear to touch or move even the least suspicious object.

Pull Firing Device M1.

Description. The Pull Firing Device M1, is a nonelectrical mechanism, designed primarily for use with a trip wire, for firing mines or other explosive charges. A direct pull of from 3 to 5 pounds applied to the trip wire releases the firing pin, which is driven by the compression spring into a percussion cap fitted in the base. The percussion cap fires a nonelectric blasting cap, attached to the base, which in turn detonates the explosive charge. The device (fig. 93) measures approximately 4¾ inches long by ⅝ inch in diameter. It consists of a head, a housing tube, and a base. The head contains a release pin, a safety pin, and a loading spring. The housing tube contains the firing pin and the firing pin compression spring. The base contains a recess into which the percussion cap is placed, and a projection to which a nonelectric blasting cap is crimped when the device is loaded. The firing mechanism consists of a firing pin, a

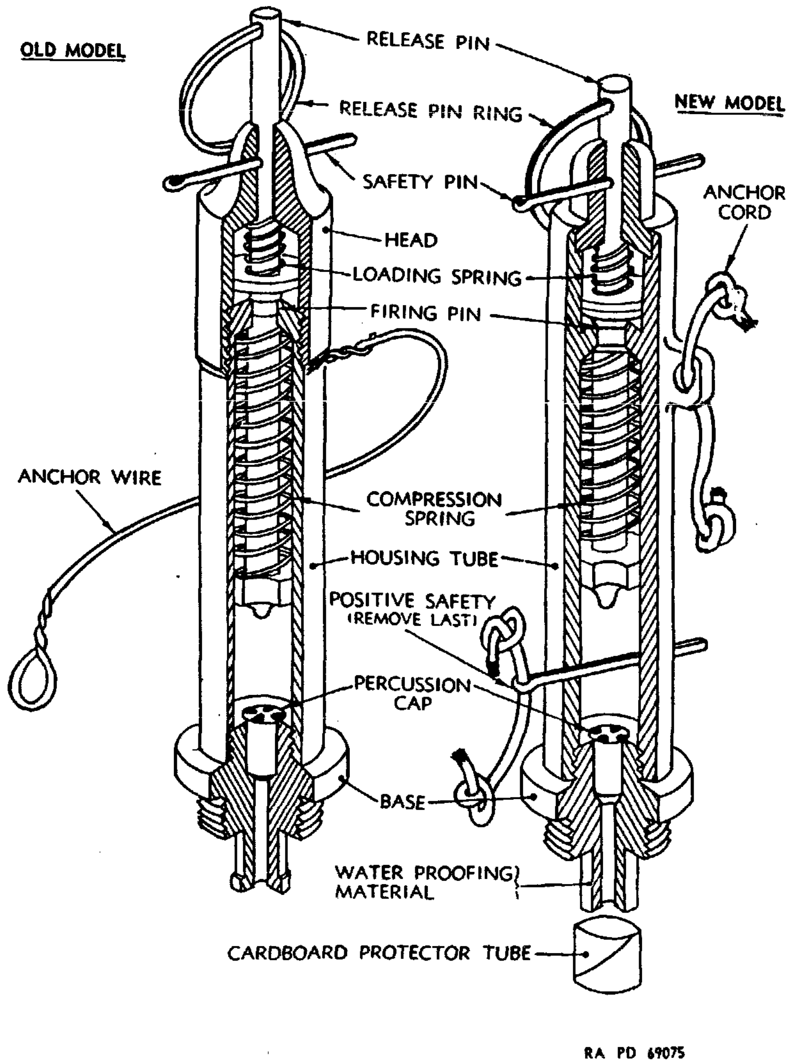

Figure 93 — Pull Firing Device M1

compression spring, a release pin assembly, and a loading spring. The split head of the firing pin is forced against pressure of the compression spring through a small opening or well, in the housing tube. The release pin enters into and expands the split head of the firing pin spindle against the sides of the well, thus preventing its return, although the striker is under pressure from the compression spring. The release pin is held in position by the loading spring. Holes in the main head and in the release pin allow insertion of a safety pin, thus preventing accidental movement of the release pin from firing the cap. A soldered joint is made between the main head and the housing tube, so that this part of the device cannot be taken apart. A short piece of flexible wire terminating in a loop is attached to the housing tube at this joint. This is to be used as an anchorage for the firing device. The ring on the release pin facilitates fastening the trip wire to the device.

Function. When the safety pin is removed, a pull of from 3 to 5 pounds applied through a distance of about $\frac{1}{32}$ of an inch is sufficient to overcome the resistance of the loading spring and cause the tapered end of the release pin to be withdrawn from within the split head of the firing pin. The split head of the spindle being no longer forced against the well, slips through under the influence of the compression spring. This forward movement of the firing pin continues until it strikes the head of the percussion cap contained in the base of the device. The percussion cap is thus fired and detonates the nonelectric cap crimped onto the base.

Packing. Pull firing devices are packed in boxes, each box containing five devices complete with percussion caps and two 80-foot spools of light trip wire. The box measures 4¾ by 4⅞ by 1⅝ inches. Each box weighs 1 pound 3 ounces.

Pressure Firing Device M1.

Description. The Pressure Firing Device M1 is a nonelectrical device designed to cause the detonation of antipersonnel mines or other explosive charges when the device is subjected to a pressure of 30 pounds or more. The device (fig. 94) is mounted on a rectangular base plate, measuring 2½ by 1½ inches and is composed of a barrel, head, and base. The barrel contains the firing mechanism. The head, permanently joined to the barrel, contains the trigger assembly. The base, which screws into the barrel, contains a recess into which a percussion cap fits and a projection over which a nonelectric blasting cap is crimped. (The base and percussion cap are identical with those used on the Pull Firing Device M1.) The firing mechanism consists of a striker assembly, a striker spring, a trigger assembly, and a trigger spring. The striker assembly consists of a round spindle with a turned down section of reduced diameter ⅜ of an inch from the

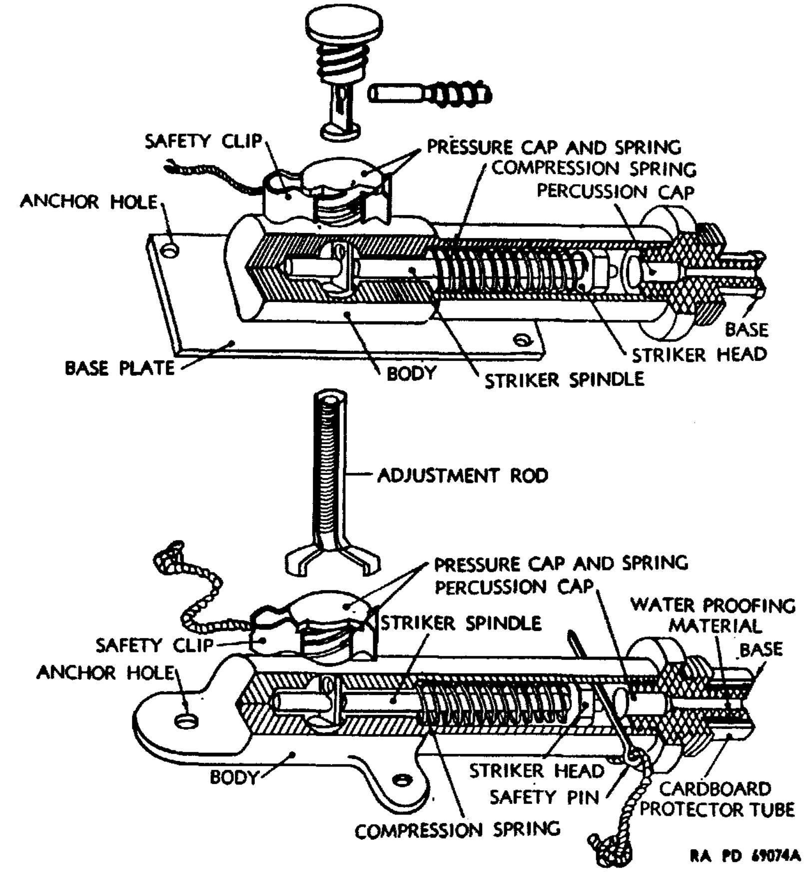

Figure 94 — Pressure Firing Device M1

end opposite the striker, the striker head, and a firing pin mounted on the striker head. The trigger unit consists of a large, flat head mounted on a trigger pin extending through the side and down into the barrel. The trigger pin has a pear-shaped hole in it. The small section of the spindle fits in the small end of the pear-shaped hole so that the striker spring is unable to cause a movement of the striker and firing pin. A safety clip extends around the trigger pin, between the barrel and the trigger head. No appreciable movement of the trigger pin against the action of the trigger spring is possible until the safety clip is removed.

Function. When the safety clip is removed, a force of from 25 to 35 pounds applied to the trigger head through a distance of $\frac{3}{16}$ of an inch is sufficient to overcome the resistance of the trigger spring and cause the trigger pin to move into the barrel, permitting the striker and firing pin to be driven forward and strike the percussion cap. The percussion cap detonates the nonelectric cap attached to the projection on the base.

Packing. These firing devices are packed in boxes containing five devices each, complete with percussion caps. A full box weighs 1 pound 14 ounces. It measures 4¾ by 5⅜ by 1⅝ inches.

Combination Firing Device M1.

Description. This firing device combines the principles of the Pull Firing Device M1 and those of the Pressure Firing Device M1 to give a firing device which may be set for either or both of the actions. This device is standard for use on the Antipersonnel Mines M2 and M3. It is a simple type firing mechanism containing a spring-loaded firing pin, and a percussion cap. It may be fired by means of a cord connected to the release pin ring, or by pressure applied to the pressure cap (fig. 97). A pressure of 20 to 40 pounds on the pressure cap or tension of 3 to 6 pounds on the release pin will cause release of the firing pin and detonation of the mine. It is packed with the mines with which it is used, along with the necessary accessories to proper function.

Release Firing Device M1.

Description. The Release Firing Device M1 is a nonelectrical firing device designed to operate when a restraining load is lifted from it. The device (fig. 95) measures 2⅞ by 1⅞ by 1⅞ inches, and consists of a cube-shaped body containing the lever, spring and firing pin, mounted on a nailing bracket. The end of the body is provided with a female connection to take the standard firing device base used on the Pull Firing Device M1 and on the Pressure Firing Device M1. The firing mechanism consists of the latch, spring lever, spring, and firing pin. When cocked, the device is restrained from firing as long as there is at least a 2-pound load on the top face of the latch. When the load is removed, the latch releases the spring lever which springs down and strikes the firing pin, firing the percussion cap. The latch normally is held in position by the safety pin which is so designed that it cannot be removed easily except when there is at least a 2-pound load on the top face of the latch. A nailing bracket is provided by a thin plate ¾ of an inch wide by 4 inches long, spot-welded to the bottom of the body. Two ¼-inch holes are provided on opposite sides of the device to permit the insertion of a nail or stiff wire to act as an auxiliary safety device by blocking the spring lever and preventing it from striking the firing pin.

Function. In order to remove the safety pin, a weight of at least 2 pounds must be applied to the exposed surface of the latch. After the safety pin in removed, the removal of the load on the latch automatically frees the spring lever which, propelled by the spring, swings

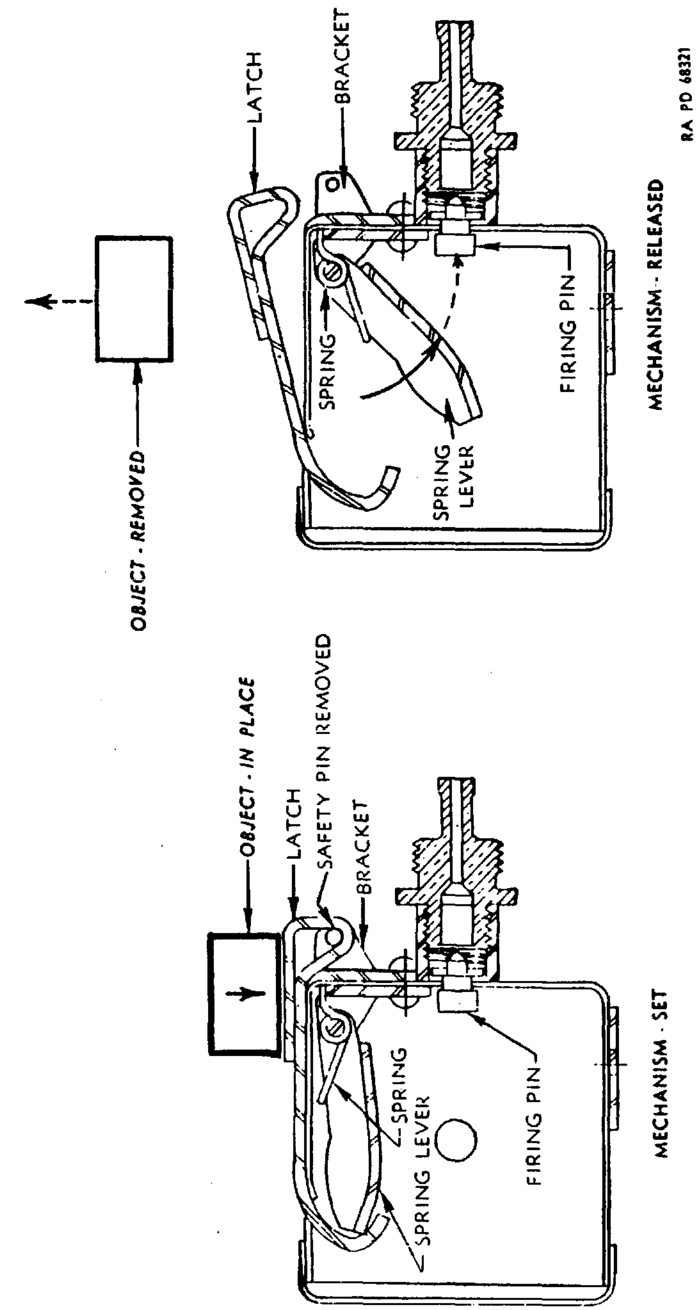

Figure 95 — Release Firing Device

through and strikes the firing pin at the end of its flight, firing the percussion cap which detonates the blasting cap crimped to the base.

Use. The principal uses of this device are to activate antitank mines, and to construct various types of booby traps.

Packing. Packed four per cardboard carton, with bases complete with percussion cap, unassembled but in the same carton.

ANTIPERSONNEL MINES.

General. An antipersonnel mine may consist of any of the following:

1. Standard Antipersonnel Mine M2 (bounding type).

2. Standard cast iron encased Antipersonnel Mine M3.

3. Improvised antipersonnel mine.

Principles of employment. The following principles should be observed in installing antipersonnel mines:

1. Concealment. They should be concealed carefully and camouflaged in order to make detection and removal difficult.

2. Terrain. They should be installed in likely avenues of enemy approach.

3. Tactical purpose. Antipersonnel mines are laid to reinforce antitank mine fields, barbed wire entanglements or other obstacles, and to establish antipersonnel mine fields to block hostile avenues of approach. Their purpose is not only to secure effect against personnel but also to give warning of their approach.

4. Change in methods. The utmost ingenuity should be exercised in varying the method of installing and camouflaging antipersonnel mines so as to keep the enemy in doubt as to what he may encounter.

5. Variety. Several different types of antipersonnel mines should be employed in any one locality.

MINE, Antipersonnel, M2.

General. MINE, antipersonnel, M2, (fig. 96) is similar to a small mortar, and projects a shell about 6 feet in the air, where it explodes. Designed for use against personnel, it has an effective radius of about 30 feet. The shell weighs approximately 3 pounds, of which 12 percent is high explosive. The shell fuze, which is ignited by the propelling charge, contains a delay element that delays detonation of the shell until it has attained the most effective height. This mine is fired by the action of a pull wire or a pressure cap.

Description. The mine (fig. 96) consists of a base plate to which a short length of thin-walled tubing is welded, and to which a ¼-inch pipe nipple is threaded. The cavity in the base plate contains the propelling charge, which consists of 20 grains of black powder assembled in a small bag. The mortar tube, containing the fuzed shell, is

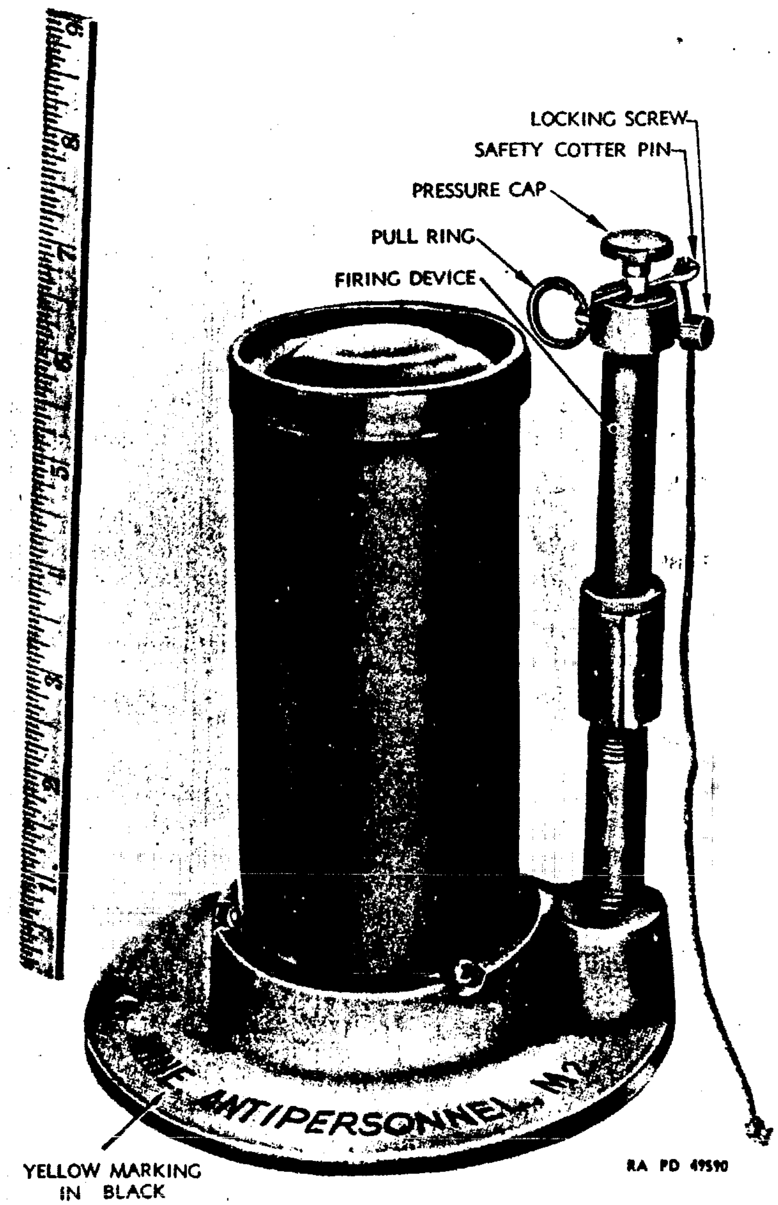

Figure 96 — MINE, Antipersonnel, M2, w/FUZE, Mine, Antipersonnel, M2, Complete

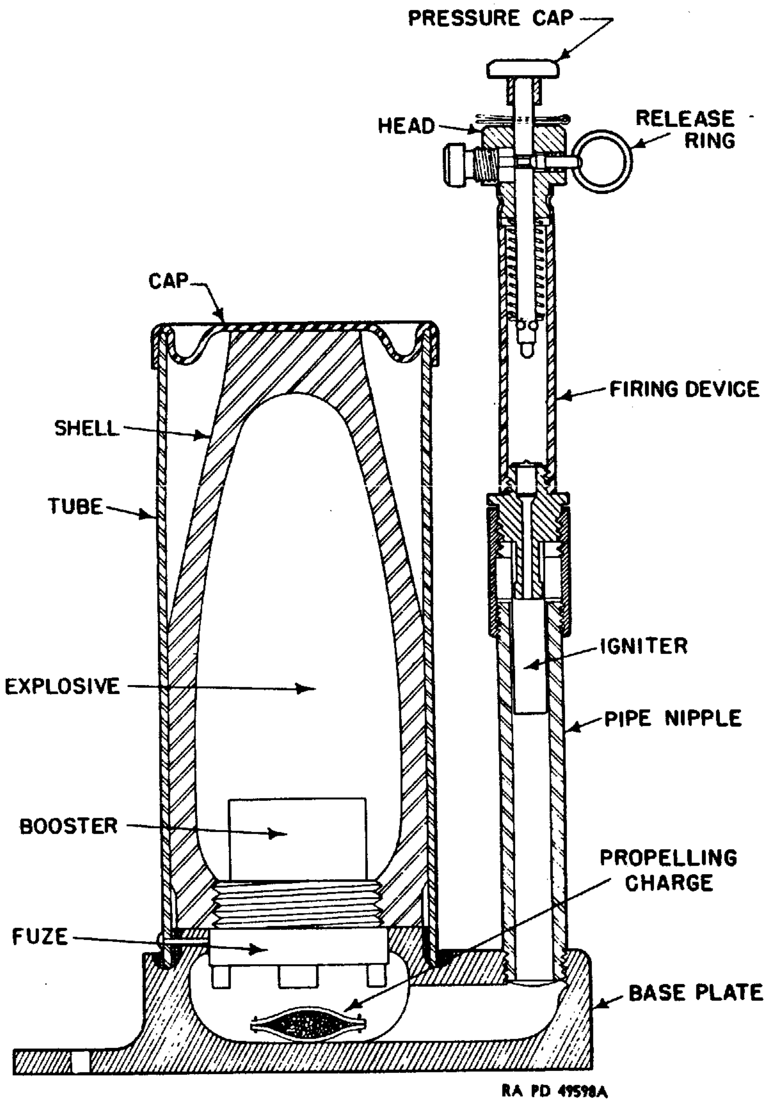

Figure 97 — MINE, Antipersonnel, M2A1, w/FUZE, Mine, Antipersonnel, M2, Complete

sealed with a metal cap. Attached to the pipe nipple is a coupling into which is fitted the primer and igniter assembly (the standard firing device base with a black powder igniter crimped in place). The primer is protected during handling and shipment by a metal cap. The firing pin assembly of the firing device is shipped separately in a tube, in the same box with the mine.

The firing device used with this mine is Combination Firing Device M1. (See previous description and figures.)

Function. When either by a 3- to 6-pound pull on the trip wire, or by a 20- to 40-pound pressure on the pressure cap the firing pin is released, it is driven by its compression spring into the percussion cap. This in turn ignites the igniter, the flame passing through the pipe nipple to the propelling charge of black powder in the base. The burning of the propelling charge ignites the fuze of the shell and propels the shell into the air. The delay in the fuze delays detonation of the shell until it has reached its most effective height (about 6 feet).

Painting and marking. The mine and the firing device are painted olive drab, lustreless, except for the flange of the mine base, which is painted yellow and embossed with the type and model of mine, the lot number, manufacturer's symbol, and date of loading.

Packing. The mine is packed one per corrugated paper carton. The carton contains the firing pin assembly in a fiber tube and 104 feet of wire. The wire is used for making tripping devices and is either olive drab or sand color. Ten such containers are packed in a wooden packing case, 32 by 13$^{3}/_{16}$ by 9$^{15}/_{32}$ inches in over-all dimension, and 93.4 pounds in weight.

MINE, Antipersonnel, M3.

General. The MINE, antipersonnel, M3, is a fragmentation type of land mine intended primarily for use against personnel. It consists of a cast iron block containing TNT and a firing device. It has an effective radius against personnel of 10 yards when fired at the surface of the ground. The effective radius is slightly increased when the mine is used several feet above ground level, and is decreased when the mine is buried in the ground. Fragments of the mine may be thrown more than 100 yards and suitable protection should be provided for friendly personnel within this radius.

Description. The MINE, antipersonnel, M3, is shown with principal dimensions in figure 98. It is a cast iron casing 3½ by 3½ by 5⅜ inches in over-all dimension. This casing is filled with a charge of $^{9}/_{10}$ of a pound of flaked TNT. In two opposite sides and one end, there are holes below which are fuze wells. Any one of these holes may be used. As shipped, the holes are closed with plastic plugs. In the end opposite the well is a filling hole which is closed with a disc.

The firing device used with this mine is the Combination Firing

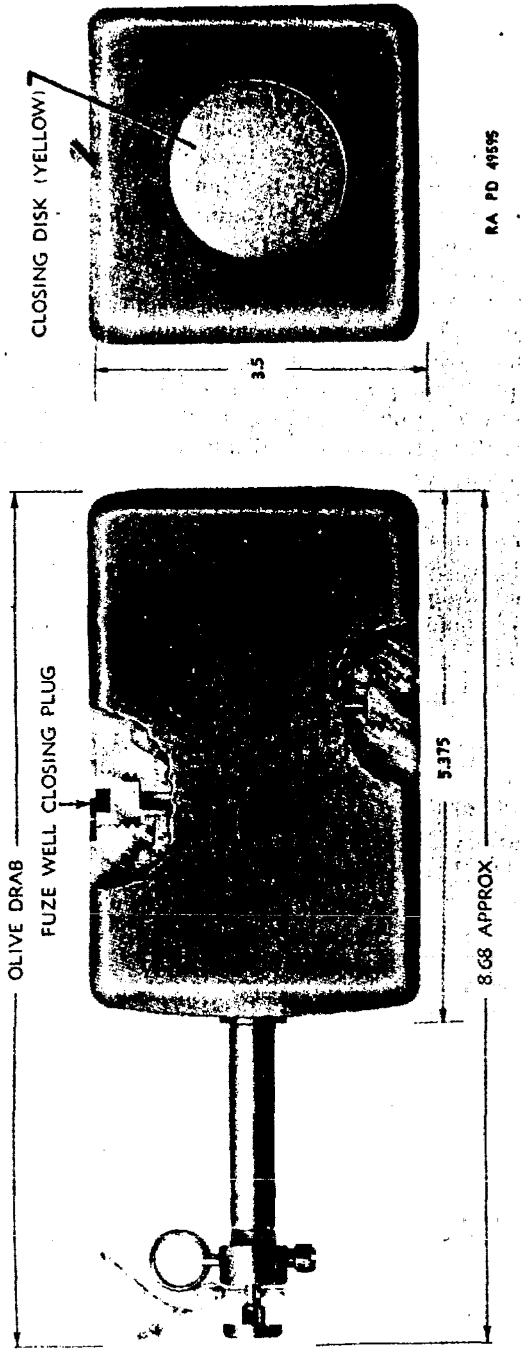

Figure 98 — MINE, Antipersonnel, M3

Device M1. (See previous description and figures.) In this instance, the firing device is provided with a special blasting cap (U. S. Army blasting cap, type A), which is crimped to the projection on the base of the firing device. The firing device complete with blasting cap is issued unassembled to the mine.

Function. When either by a 3- to 6-pound pull on the trip wire, or by a 20- to 40-pound pressure on the pressure cap the firing pin is released, it is then driven by its compression spring into the percussion cap. This in turn causes detonation of the blasting cap crimped to the base of the firing device and of the bursting charge of the mine. Fragments of the mine body will cover a 30-foot radius effectively.

Painting and marking. The mine body and the firing device are painted olive drab with the exception of the closing disc, which is yellow. The mine body is stenciled in black with type and model, lot number, and date of loading.

Packing. Six mines are packed in a wooden packing case, which also contains six firing devices. The firing devices are packed in sealed cylindrical fiber containers which, in turn, are packed in compartments in one end of the packing box. The dimensions of the packing box are $17\frac{7}{8}$ by $8\frac{11}{16}$ by $9\frac{1}{32}$ inches. As packed, the packing box weighs 72 pounds. Packed in the box is a small wrench which fits the square holes in the plastic plugs in the mine, and is used for unscrewing them prior to assembling the firing devices. Six coils of wire, for making tripping devices, are also packed in the box. Each of these coils is 104 feet in length. Some of the wires are olive drab and some are sand colored.

Improvised Devices.

General. The use of improvised devices as antipersonnel mines is limited only by the material at hand and by the ingenuity of the maker. Generally, these devices are not as effective as standard devices for reasons stated previously.

FURTHER REFERENCES: TM 9-1940; The Ordnance Sergeant, February 1943; SNL R-7.

Chapter 4

Rifle Grenades and Rockets

RIFLE GRENADES.

General. Rifle grenades fall into three general types: antitank grenades, practice antitank grenades, and fragmentation grenades. These types are designed to be fired from the cal. .30 rifle and the cal. .30 carbine. The various weapons used to project the rifle grenades require certain accessories.

The U. S. RIFLE, cal. .30, M1903, requires a launcher which is attached to the muzzle of the rifle, and the CARTRIDGE, rifle grenade, cal. .30, M3.

The U. S. RIFLE, cal. .30, M1903A1 and M1917, may also be used to project rifle grenades. In such cases, each of the above rifles requires a special sight and the M1917 Rifle also requires a special launcher, designed to fit this weapon in particular.

The cal. .30 carbine requires a special launcher and the CARTRIDGE, grenade, carbine, cal. .30, M6. No further information is available at the present time with regard to these accessories for the firing of rifle grenades from the carbine.

The original issue of antitank grenades to an individual soldier is made by means of a kit which contains, in addition to a supply of grenades and cartridge, the necessary auxiliary equipment for the rifle with which he is provided. Subsequent issues consist of only rifle grenades and cartridges until such time as replacement of the accessories becomes necessary.

GRENADE, Rifle, H.E., M9. This is the originally developed antitank grenade, and is now standard for issue only since an improved type has been developed. It has a sheet metal body and weighs 1.5 pounds. It will detonate upon impact, provided the surface struck and the angle of impact are such as to exert pressure on the projection on the nose of the grenade (fig. 99).

GRENADE, AT, M9A1. This grenade also has a sheet metal body, but weighs only 1.31 pounds. It is more sensitive than the M9 and may detonate upon impact with soft earth. However, for certainty of detonation, it should strike the target head-on, or nearly so. The grenade consists of two principal parts: the high explosive head, and the stabilizer tube and fin assembly (fig. 99). The head of the grenade is composed of the ogive, or forward rounded portion; and the body, or rear portion to which the ogive is crimped. The charge of the grenade is 50/50 cast pentolite with the exception of a 10/90 cast pentolite booster surround.

This type of charge is known by the name "shaped charged." The effect of such a shaped charge on armor plate is very unusual. It appears to focus the detonating wave against a small area of the plate. This focused and concentrated wave hits the plate with such terrific force that a roughly cylindrical hole is driven through it. The metal of the plate is raised to an incandescent heat and issues from the rear of the hole in the armor in the form of a cone-shaped spray whose angle of opening is approximately 90 degrees. This effect of the shaped charge is also known as the "Munroe effect," receiving this

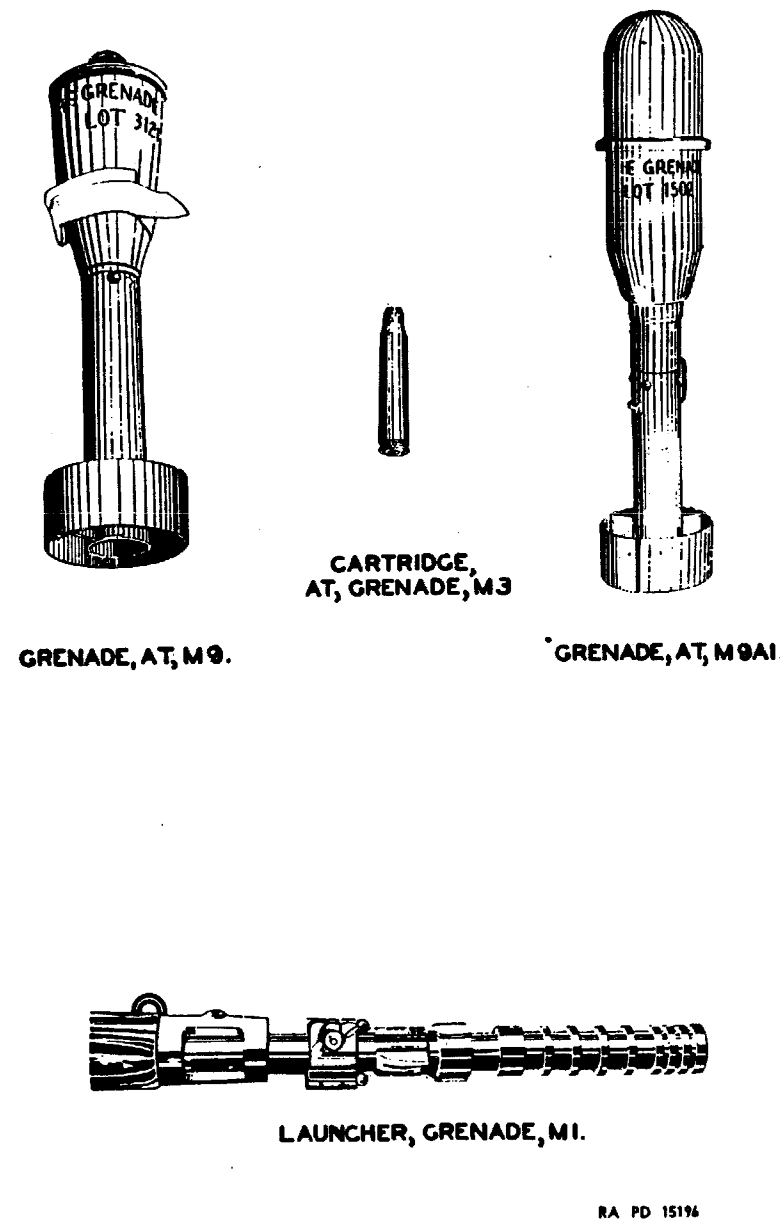

Figure 99 — Rifle Grenades and Launcher

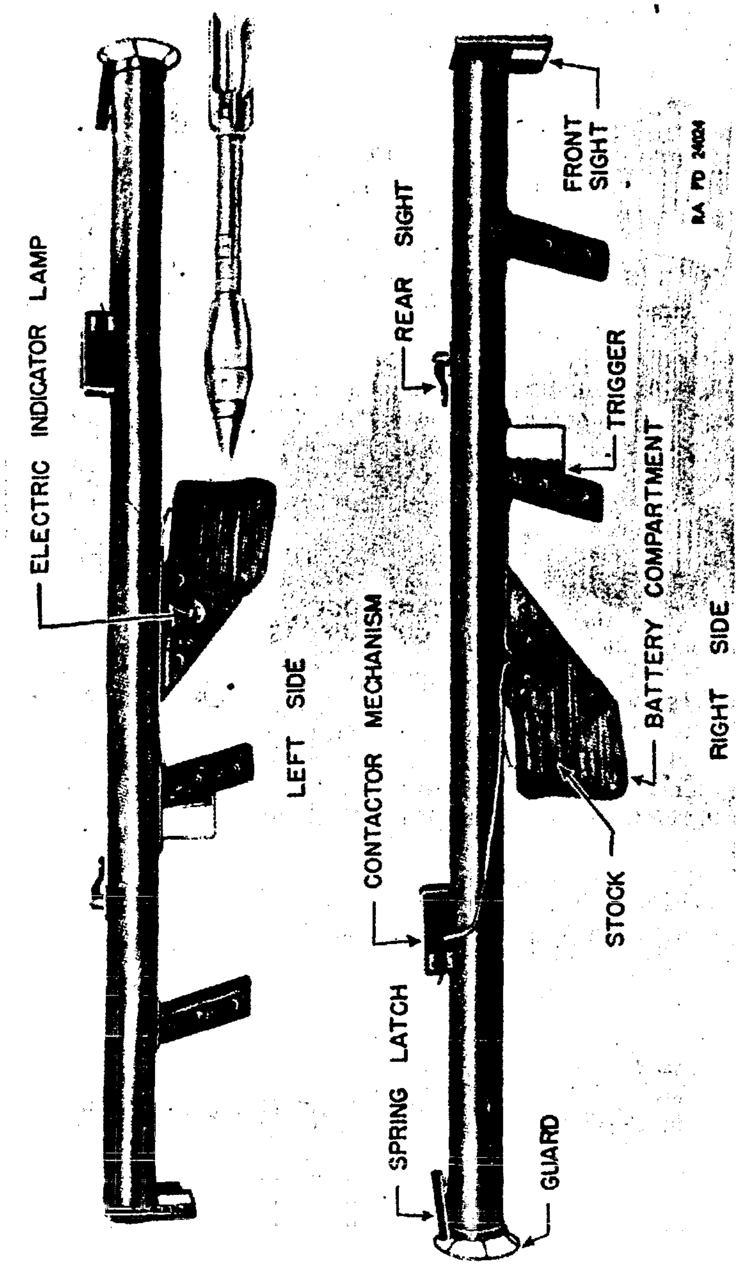

Figure 100 — Launcher, Rocket, AT, M1

name from that of the discoverer of the effect of shaping charges. Some figures substantiating the effect on armor plate will be presented in the sections dealing with antitank rockets.

The stabilizer assembly consists of these major parts: the fuze body, which contains the fuze parts and which threads into the union; the stabilizer tube, which attaches to the rear of the fuze body with four rivet-like pins; and the fin, which is spot-welded to the rear of the stabilizer tube.

The fuze is a simple impact firing device consisting of a spring restrained striker, which on impact strikes a detonator of priming mixture, lead azide, and tetryl, which in turn causes detonation of a booster of tetryl. The wave from the booster in turn detonates the bursting charge in the grenade body. The striker is held safe in storage by a safety pin which clips to the stabilizer tube and passes through the fuze body, at the same time engaging an annual groove in the striker. This safety pin must be removed prior to firing the grenade.

The stabilizer tube serves two purposes, an attachment for the fin, and a support for the grenade on the launcher. The tube is slipped over the end of the launcher. The fin, of course, stabilizes the flight of the grenade.

It should be noted that the penetration of the grenade is not achieved by its velocity, the initial velocity being in the vicinity of 150 feet per second, but entirely by the effect of the shaped charge.

GRENADES, AT, Practice, M11 and M11A1. These grenades are dummy (inert) grenades, similar in size, shape, and weight to the GRENADE, rifle, HE, M9, and the GRENADE, AT, M9A1, respectively. Each of these grenades consists of two parts, a head and a fin assembly. When damaged by repeated use, the fin assembly may be replaced. These grenades are used for target practice only.

CARTRIDGE, Rifle Grenade, Cal. .30, M3. This cartridge, used in discharging rifle grenades, is a special type of blank cartridge, recognizable by the rose crimp at its mouth. Only this cartridge must be used for this purpose. Neither ordinary blank ammunition nor ball ammunition may be used.

LAUNCHER, Grenade, M1. The launcher, on which the grenade is placed for firing, is an extension to the barrel of the rifle. A clamp with a wing nut is provided for attaching the launcher securely to the muzzle of the rifle. When the launcher is attached, the rifle may be employed for firing ball ammunition; however, the bayonet cannot be fixed. The rings and grooves on the launcher (fig. 99) act as gas checks, slowing down the escape of the propellent gases from the rifle grenade cartridge.

Recoil Pad. A rubber recoil pad is provided for protecting the rifle stock when the rifle is fired with butt resting against a hard sur-

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face. The pad also lessens the shock of recoil when the rifle is fired from the shoulder.

Painting and Marking. High explosive grenades are painted a lustreless olive drab and stenciled in yellow with the model and lot number. Practice grenades are painted black and stenciled in white with the model and lot numbers.

Packing. GRENADES, rifle, HE, M9, and AT, M9A1, are packed 1 per fiber container, 10 containers and 11 cartridges per box.

GRENADE, AT, practice, M11, is packed 1 grenade and 1 cartridge per fiber container, 50 containers per box.

GRENADE, AT, practice, M11A1, is packed 1 per fiber container, 50 containers per box.

CARTRIDGE, rifle grenade, cal. .30, M3, is packed 20 per carton, 100 cartons (2,000 rounds) per metal lined box.

GRENADE, Rifle, Fragmentation, Impact, M17.

General. The M17 Impact Fragmentation Rifle Grenade is an antipersonnel grenade for use in conjunction with standard grenade launchers, grenade cartridges, and cal. .30 rifles. The grenade is fired in a manner similar to the firing of the Antitank Grenade M9A1, except for the range determination. An impact type of fuze fires the grenade upon impact. The maximum range when fired from a grenade launcher on the M1917 or M1903 Rifles is about 220 yards.

Description. The grenade consists of a serrated cast iron body to which is fitted a tail assembly made up of a stabilizer tube and a fin assembly. An impact fuze is located in the forward end of the stabilizer tube. The firing pin is held in the unarmed position by a safety pin, which fits in an annular groove around it, through a hole in the fuze body, and clamps about the stabilizer tube. The safety pin and fuze is identical to that of the Antitank Grenade M9A1.

Function. The grenade is fired from a grenade launcher fitted to a cal. .30 rifle by using a standard rifle grenade cartridge (CARTRIDGE, rifle, grenade, cal. 30, M3). The safety pin must be removed before the grenade is fired. Upon impact, the fuze functions and detonates the grenade, provided the surface struck and the angle of impact are such as to exert pressure on the forward end of the grenade.

Packing and marking. The grenades are painted lustreless olive drab. Ten grenades in individual fiber containers and a carton of 11 rifle grenade cartridges are packed in a wooden packing box. Also included in the box are 3 launcher positioning clips for use in range determination.

ROCKETS.

ROCKETS, AT, 2.36-inch. The 2.36-inch AT rockets are launched from the LAUNCHER, rocket, AT, M1. The launcher is

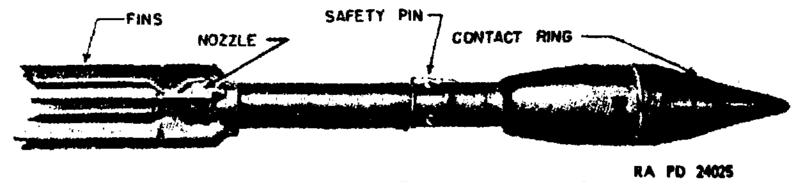


Figure 101 — ROCKET, AT, 2.36-inch, M6

an open tube approximately 54 inches long and 2.365 inches internal diameter, equipped with hand grips, stock, firing mechanism, and sights. The firing mechanism is electrical in nature, the ignition of the rocket propelling charge being accomplished by the current from a 2 dry-cell battery in the stock. The launcher may be fired from the shoulder. There is no recoil, since propulsion of the rocket is by jet action of the propelling gases. The range of the rockets ranges from 200 to 300 yards as an optimum, although longer ranges can be obtained. The muzzle velocity is about 300 feet per second. Two types of rocket are provided; namely, high-explosive and practice.

ROCKET, AT, 2.36-inch, M6 (fig. 101). This rocket is a high-explosive projectile for use against tanks. It is 21½ inches long and weighs 3½ pounds. The rocket consists of three principal parts: the high-explosive head, the stabilizer tube, and the fin assembly.

The head consists of metal parts which are similar in function to the parts of the AT grenade head. These parts are the ogive and the body. The bursting charge is similar, both in that it is a "hollow" or a "shaped charge," and also in its composition which is mainly 50/50 pentolite with a 10/90 pentolite booster surround. It is, however, a heavier charge, weighing approximately ½ pound.

The stabilizer tube consists of two principal parts: the fuze body, which threads into the union and contains the fuze mechanism, and the powder tube to which the fuze body is permanently joined, and which contains the propellent charge.

The fuze is similar in all its components to that of the AT grenade. It is, however, of heavier construction, as is the entire rocket, and contains heavier booster and detonator charges. The parts of the fuze are a spring restrained striker; a detonator of priming mixture, lead azide, and tetryl; and a booster of tetryl. The striker is held in the unarmed position prior to loading into the launcher, by a safety pin which engages an annular groove in the striker as it passes through opposed holes in the fuze body. The safety pin clips to the stabilizer tube and must be removed prior to firing of the rocket.

The powder tube or remainder of the stabilizer tube in this case serves as a housing for the propellent powder and an electric safety match or squib. The propellent powder is a monoperforated ballistite type formed into rather long grains. The electric safety match with an igniting charge of black powder is located at the upper end of the powder tube. Two contact wires pass down through the powder tube and out through the nozzle portion of the fin assembly.

The fin assembly consists of three parts: the nozzle, which is a venturi tube; the trap, which is a spider ring closing the nozzle opening above the venturi and holding the propellent powder in place; and finally, the fins themselves. The fins are six metal blades, each spot-welded to the outer surface of the nozzle at two points. Each blade is notched at a point opposite the lower extremity of the nozzle. These notches are unpainted and one of them serves as a contact for the electric safety match, one ignition wire being soldered to it. The other contact is made by means of an insulated (with a fiber strip) brass contact ring encircling the ogive. A brass connector strip runs from the end of the body to this ring. To the end of the connector strip is soldered the other ignition wire from the electric safety match. This ignition wire is taped to the stabilizer tube midway between fins and body.

Function. The safety pin is removed and the rocket inserted into the rear opening of the launcher. It is held in place by a safety catch. Firing is accomplished by establishing an electric circuit between rocket and launcher. This causes ignition of the electric safety match, the black powder ignites, and the propellent powder gases issue through the nozzle, the venturi serving to increase their velocity. This back blast serves to propel the rocket forward. There is no recoil and the back blast should not affect the firer since the powder is designed to be completely burned within the launcher. On impact with the target the striker, due to inertia, drives forward overcoming its restraining spring. It strikes and causes detonation of a detonator of priming mixture, lead azide, and tetryl, which in turn carries detonation of a tetryl booster, a 10/90 pentolite booster surround, and a 50/50 pentolite bursting charge.

Effect. The rocket has effect against various targets as follows:

1. Armor plate. Penetration slightly in excess of 3 inches of homogeneous steel armour plate at all ranges and at angles of impact as low as 60 degrees from normal. A hole, roughly cylindrical and about 1 inch in diameter, is blown through the plate, the force exerted by the detonation being of such high order that the metal of the armor plate is raised to a state of incandescence, and exits from the back of the plate in a spray of several hundred particles. Such a spray is cone-shaped with its angle of opening about 90 degrees. This spray exerts antipersonnel effect to a distance of 30 yards and usually causes explosion of ammunition it strikes.

2. Masonry. Penetration of brick walls and rock masonry not over 8 inches in thickness is accomplished with a burst having a powerful blast effect.

3. Structural steel. Shattering effect against cast steels and such materials as girders and railroad rails. Effect against a motor block causes extensive damage, in most cases irreparable.

4. Wood. Penetration of up to 9 inches of pine timber, caused by its blast action. Less than 1 inch of wood ordinarily will not cause detonation.

5. Water. Water will not cause detonation of the rocket bursting charge.

6. Soil. Impact with the ground will not ordinarily cause detonation except at ranges in excess of 300 yards. The trajectory is sufficiently flat to cause the rocket to ricochet at shorter ranges without detonating. At ranges from 300 yards to 650 yards, the extreme range, impact usually does cause detonation except in very soft soil such as mud. Bursts against the ground have much of the blast effect and all of the appearance of 75-mm H.E. shell. However, it will be under the most exceptional circumstances that this type of rocket will ever be employed against personnel in the open.

Uses. The primary use of the rocket is of course against tanks, it being highly effective against all known types of medium tanks. It, however, has secondary uses as follows:

1. Antitank mine. The rocket is placed, nose up, in a hole in the ground about 2 feet deep, properly placed to achieve the desired effect. It is fired electrically by attaching the ends of two wires to the rocket ignition wires, one to the brass contact ring on the ogive, the other to the fins. Ordinary twisted field telephone wire and the dry-cell battery from the launcher suffice for this purpose. The rocket may be placed in a road bed or set horizontally into the side of a cut or bank.

2. Demolition. The rocket may be used for destruction of railroad rails, structural steel, disabled armored vehicles, and various types of material. It may be placed in or near the object to be destroyed, allowance being made for about a foot of travel before impact. Ignition is accomplished as in the antitank mine use.

3. Booby traps. When used for this purpose, the rocket should be sited to strike a hard surface such as masonry or heavy timbers to obtain maximum effect of the blast. The ignition would be accomplished as above with a trip wire or similar device to make contact.

ROCKET, Practice, 2.36-inch, M7. This rocket is similar in shape, size, and weight to the high-explosive type. However, it is provided with only a propellent charge, the head being inert. No fuze is provided. The end of the stabilizer tube is extended to counter-weight the head and make the ballistics of this rocket similar to that of the H.E. type. A safety pin passes through the stabilizer tube

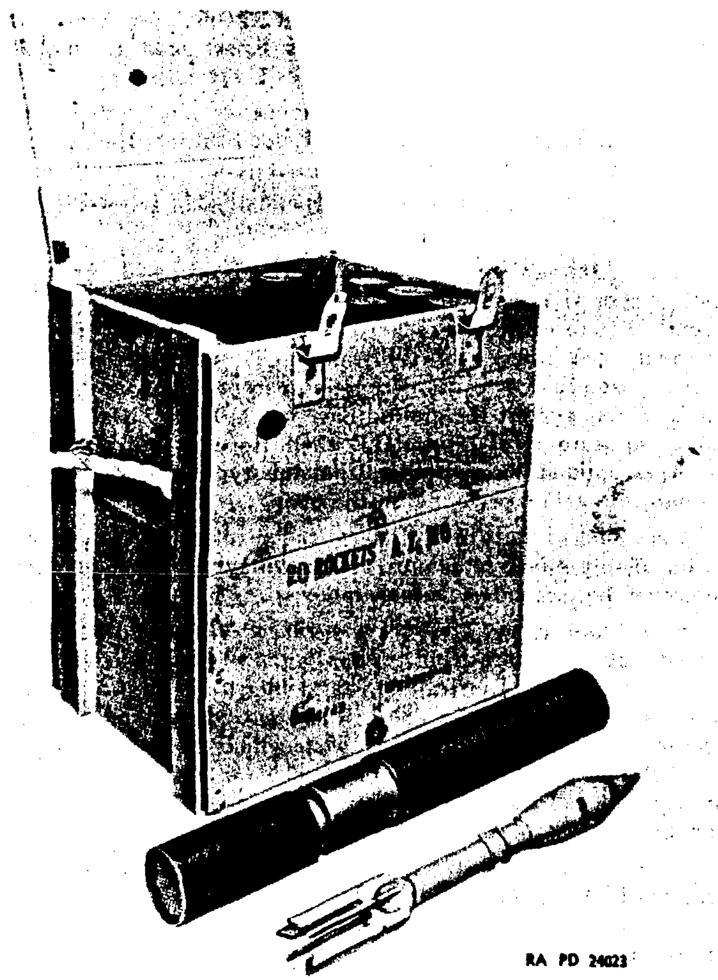


Figure 102 — Packing of ROCKET, AT, M6

at the upper end and in order to make the detail of firing this rocket similar to that necessary in the above H.E. type. Since there is no fuze, it naturally serves no useful function. In all other respects the rocket is similar to the H.E. type. It is used for target practice only.

Painting and Marking. The M6 Rockets (H.E. type) are painted a lustreless olive drab and stenciled in yellow, while the practice type (the M7) is painted black and stenciled in white. The stencil in each case includes the type, model, and lot number.

Packing. Each of the above types is packed 1 per fiber container, 20 containers (20 rockets) per box.

FURTHER REFERENCES: TM 9-294, TM 9-1900; FM 23-30; TC 104; SNL S-4, SNL S-9.

Chapter 5

Antitank Mines

GENERAL.

The antitank mine is an explosive device designed to be laid on the ground or planted flush with the surface for defense against armored cars and tanks. During the present war, with its great emphasis on armored vehicles, the antitank mine has become a very important device, being planted literally by the millions. Our mines are rather light and their effect is to severely damage or break the tread of a tank, stopping it, and leaving it open to the fire of other antitank weapons.

Foreign mines are in some cases heavy enough to breach the belly of a tank, as will our mines in isolated instances. Two types of mines are provided, high-explosive and practice.

MINE, ANTITANK, H.E., M1.

General. This complete round (fig. 103) consists of three parts: the loaded mine body, the fuze, and a spider which fits over the fuze to increase the effective size of its head.

The steel body is cylindrical, approximately 2¾ inches high and 7½ inches in diameter. The flanged rim around the top is notched in two places for assembling the spider. In the center of the top is the fuze cavity, approximately 2 inches in diameter and 2$\frac{5}{16}$ inches deep. A carrying ring is attached to the side of the mine. A filling hole, closed by a light, press-fit, metal cap is located near the outer edge of the top of the body. The complete body and fuze, with the spider, weighs approximately 10.4 pounds. The high-explosive filler weighs 6 pounds.

The spider consists of a ring and two cross members, each with a hook on either end, spot-welded together as shown in the illustration. The hooks engage the flange on the mine body and the center of the spider rests on the striker head of the fuze.

FUZE, Mine, Antitank, H.E., M1. This fuze which is used only in the H.E. mine contains its own booster. It consists (fig. 103) of a striker assembly and a body which houses the detonator and booster.

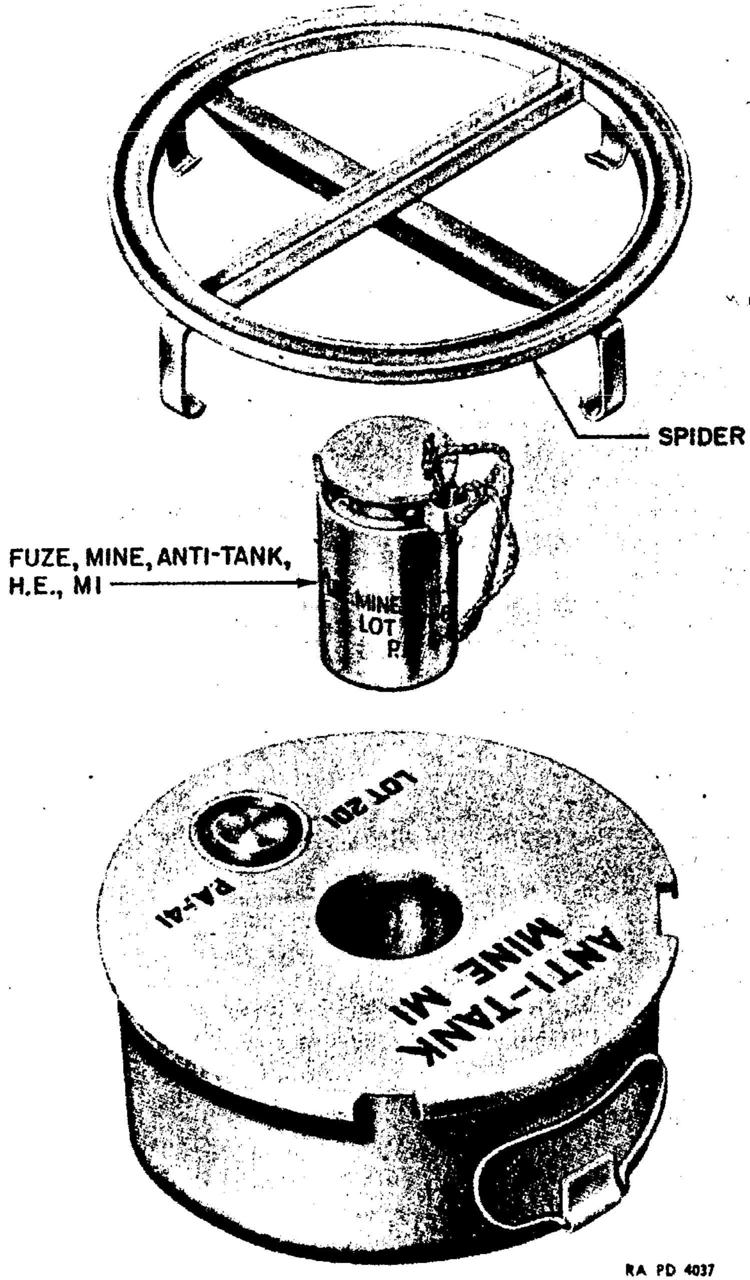


Figure 103 — MINE, Antitank, H.E., M1

The striker assembly, on the outer end of which is a 2-inch diameter head, protrudes approximately ⅜ inch beyond the body of the fuze. The firing mechanism, consisting of a firing pin and a compressed spring, is contained within the striker assembly. A collar, attached to the striker by shear pins, supports the firing pin in a cocked position by means of two steel locking balls. Each of these rests in a recess in the collar and is held in position by the shoulder of a similarly located recess in the striker. A detonator of priming mixture, lead azide, and tetryl is located in the fuze body directly beneath the firing pin. The lower part of the body contains the booster charge, which consists of a ring pellet and a full pellet of tetryl. The ring pellet encircles the lower end of the detonator. The striker head during shipping and handling is supported by a safety fork attached to it with a cord. On the outer surface of the fuze body are found two steel locking balls, each spring actuated, and each protruding slightly from the sides of the fuze body. These lock the fuze in the fuze cavity.

Assembly. The following steps are required to assemble the complete round:

1. Remove the spider from the bottom of the body.

2. Insert the fuze in the fuze cavity, pushing it down until it latches. When thus assembled, the upper surface of the fuze body is flush with the upper surface of the mine. Always be sure that the fuze cavity is clear of foreign material before inserting the fuze.

3. Assemble the spider by alining, but not engaging, two of its hooks with the two notches in the flange on the mine body. Engage the other two hooks beneath the flange. Next, press the first two hooks through the notches, then rotate the spider approximately one-eighth turn in either direction to secure the spider to the body.

4. Plant the mine, recording its location.

5. Withdraw the safety fork, thereby arming the fuze. The safety fork should be left beside the mine, attached to its cord, never between body and spider.

Function. A force of 500 pounds directly on the striker head or of 250 pounds on the rim of the spider is sufficient to force the striker inward, breaking the shear pins. The striker recesses become alined with the collar recesses and the locking balls are ejected from the collar by the force of the compressed spring of the firing pin. The firing pin spring also forces the firing pin down through the collar to strike a detonator of priming mixture, lead azide, and tetryl. The detonation of this detonator causes, in turn, detonation of a tetryl booster charge contained within the fuze, and of a TNT bursting charge contained in the mine body.

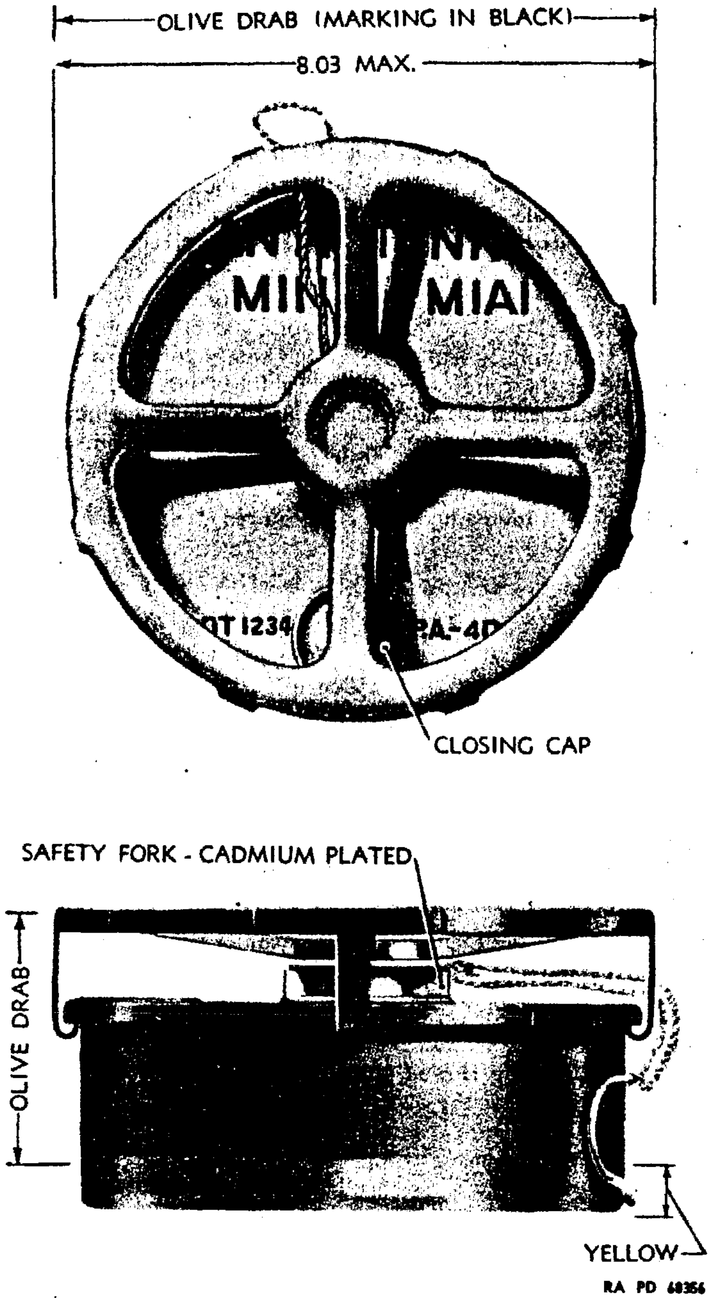


Figure 104 — MINE, Antitank, H.E., M1A1

MINE, ANTITANK, H.E., M1A1.

General. Because of disadvantages which appeared in the striking mechanism of the FUZE, mine, antitank, H.E., M1, a modification of this fuze was developed to derive the Fuze M1A1. This modification consisted of separating the striking mechanism and detonator from the booster, the booster being shipped assembled to the mine body. The fuze (striking mechanism and detonator) is shipped in a separate compartment of the same box in which the mine bodies are packed. The booster is held in a light steel cup which has five slightly outwardly flared steel fingers. These lock the booster in place beneath the flange at the top of the fuze cavity. The striking mechanism is similar to that of the M1 Fuze. The same detonator, within a detonator housing, protrudes from the base of it. The booster charge is of tetryl and consists of a ring pellet and solid pellet; the ring pellet once again accommodating the detonator.

The M1A1 Mine Body is similar to the M1 Mine Body except that the spider is formed from one piece of sheet steel rather than being composed of three members as formerly.

FUZE, Mine, Antitank, H.E., M1A2. The above described M1A1 Fuze has been modified further by the changing of its detonator to one more powerful. All other details are similar.

MINE, ANTITANK, H.E., M4.

In this round, the mine body differs only in that it is provided with an activator well which is capable of taking an engineer firing device with blasting cap. This enables planting of the mine in such a way that any attempt at removal will result in detonation.

FUZE and BOOSTER, Mine, Antitank, H.E., M4. The fuze differs in that a cricket spring which both supports the firing pin and propels it into the detonator, is substituted for the compressed spring and steel locking balls. This overcomes the obvious disadvantage of the cocked firing pin assembly formerly used. Also the detonator is housed within the fuze body, not protruding as formerly.

The booster differs from the M1A1 Booster only in that there is no ring pellet of tetryl, there being no necessity for it since the detonator does not protrude.

MINE, ANTITANK, NONMETALLIC, M5, WITH FUZE, CHEMICAL, MINE, ANTITANK, NONMETALLIC, M5.

The body of this mine is an inverted ceramic bowl, whose top is threaded for assembly of the chemical fuze. A masonite disc forms a container for the TNT bursting charge. Between this disc and a plate-like ceramic base a shock absorber ring of neoprene rubber is assembled. The entire assembly is contained within a hard paper shell

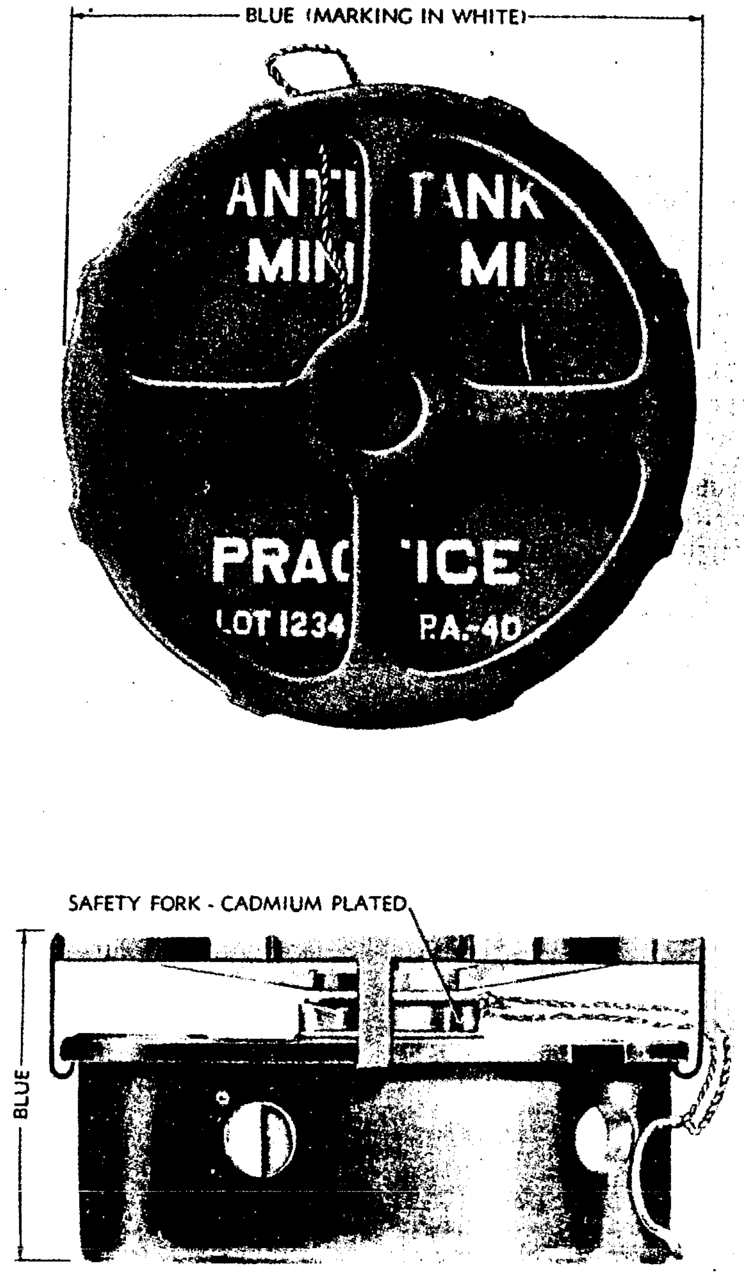


Figure 105 — MINE, Antitank, Practice, M1

which is separated from the ceramic parts by perforated asphalt cushions. This protective outer covering is held in place by nonstretch adhesive tape which allows compression action only. An activator well, in the base of the mine, accommodates engineer firing devices.

The fuze, as well as the body, has no metal parts other than a metal safety key which must be removed in order that the fuze can be inserted in the mine, and a metal safety ring which must be removed to arm the mine. The plastic fuze body contains a plastic firing pin which, under pressure, breaks an acid ampule. The acid sets off a priming mixture, which in turn causes detonation of a detonator, a tetryl booster, and the bursting charge of TNT.

This mine has two advantages over previous types:

1. It is nonmetallic and therefore not detectable by the detectors in use at the present time.

2. Due to its shock absorber ring, it is very insensitive to sympathetic detonation and therefore is resistant to attempts to clear paths through the mine fields with devices such as bangalore torpedoes.

MINE, ANTITANK, PRACTICE, M1, WITH FUZE, MINE ANTITANK, PRACTICE, M1.

The body of this mine is similar to that of the H.E. mine, differing only in that it is empty (no bursting charge). Also, it is provided with a cast iron former as a support to prevent crushing of the body. It has no filling hole. Five, equally spaced, 1-inch diameter holes may be found in the side of the mine body.

The FUZE, mine, antitank, practice, M1, is similar to the M1 H.E. Fuze except that a cal. .32 blank cartridge replaces the detonator and a smoke-puff charge of black powder and red phosphorus replaces the booster.

A FUZE, dummy (antitank mine), M1, is also provided. It is a plastic simulation of the service fuze and is provided with a removable safety fork. As its name indicates it is completely inert.

This mine can be used more than once by the provision of new fuzes and, when necessary, the replacement of bent or broken spiders.

MINE, ANTITANK, PRACTICE, M1B1.

This mine body differs from the previous mine body in that it may be sand-loaded to weight. A filling hole and filling hole cap are provided. Also, the body is without holes in the side. The cast iron former is of smaller diameter and is located centrally within the body. Four slotted openings are formed between it and the fuze cavity in the top of the mine body. The same fuzes as in the previous round are used with this practice mine.

PAINTING AND MARKING.

H.E. types are painted a lustreless olive drab with yellow base and black stencil. The H.E. fuze has a yellow striker head.

Practice types are painted blue and stenciled in white. The practice fuze has a red striker head.

PACKING.

Both types are packed in wooden boxes separated into six compartments by means of plywood separators. Five of these compartments contain mine bodies to the bottom of which are nested the spiders. In the case of the later (M1A1, etc.) H.E. types, the booster is assembled in the mine body. The sixth compartment contains five fuzes in a wooden separator.

The M5 Mines are packed four per box complete, no further data being available at the present time.

Chapter 6

Bangalore Torpedo

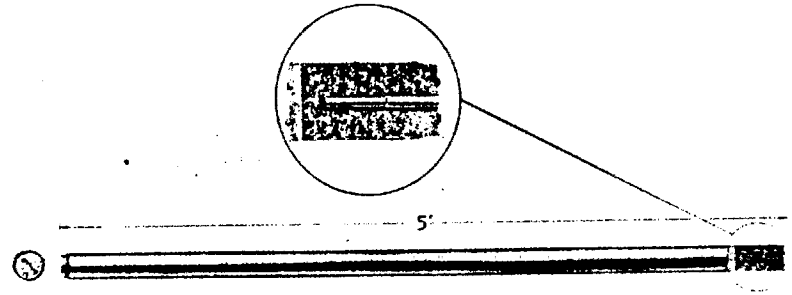
TORPEDO, BANGALORE, M1.

General. The bangalore torpedo is a tube or pipe filled with high explosive, primarily used for blasting an opening through wire entanglements or for clearing mine fields. In addition to these uses, it may also be used as an antitank mine, or antipersonnel mine. Because of its high percentage of explosive charge, it may also be used for demolition purposes.

Description. The TORPEDO, bangalore, M1, consists of a steel tube 5 feet in length and 2⅛ inches in diameter which is grooved and capped at each end. The tube is filled with amatol, with about 4 inches of TNT at each end. The weight of explosive charge is about 9 pounds. Each end of the tube is capped and contains a recess or well to accommodate a detonator or blasting cap. Nose sleeves which fit on the ends of the torpedo, and connecting sleeves for assembling the torpedoes in multiple lengths, are provided. The torpedoes and accessories are painted lusterless olive drab.

Detonator. Electric or nonelectric blasting caps may be used to detonate the torpedo. If commercial blasting caps are used, a No. 8, or stronger, blasting cap should be used.

A pull type detonator consisting of a blasting cap with an arrangement for detonating it by means of a pull wire loop may be used. A force of 15 pounds on the pull wire loop will cause detonation.



RA PD 49583

Figure 106a — TORPEDO, Bangalore, M1

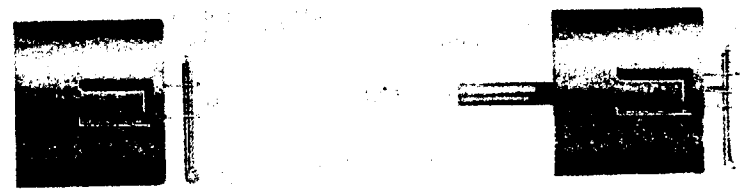


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Figure 106b — TORPEDO, Bangalore, M1 — Accessories

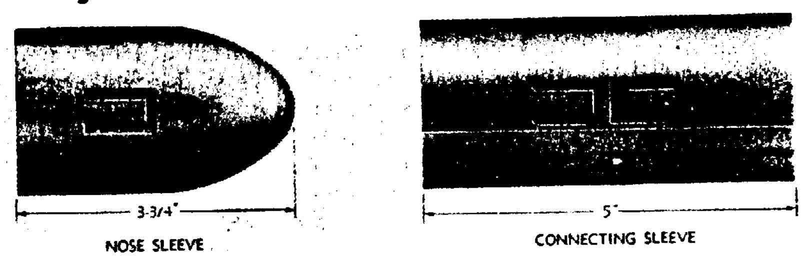

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Figure 106c — TORPEDO, Bangalore, M1 — Accessories

Nose Sleeve. This is a rounded point which fits over the end of a torpedo (fig. 106). It contains a single spring clip which holds it in place. It is used when multiple sections are assembled and pushed along the ground. The nose sleeve is provided for ease in installation and is not necessary for the proper functioning of the torpedo.

Connecting Sleeve. The connecting sleeve (fig. 106) is a short tube into which the ends of two torpedo tubes will fit and be held by three spring clips. It is used when assembling the torpedoes in multiple lengths.

Torpedo Cap. The torpedo cap (fig. 106) fits on the end of the torpedo and is locked in place by a spring clip. It is used to hold the detonator in place in the recess in the torpedo. When the pull wire detonator is used, the pull wire passes through the slot in the cap and a cotter pin is passed through the ears of the cap and the loop in the pull wire. The cotter pin then serves as a safety pin.

Detonator Wires. Hairpin wires are furnished to connect the loop of the pull wire detonator to a fixed object or pull cord.

Packing. TORPEDO, bangalore, M1, is packed 10 in a plywood box, which also contains 10 connecting sleeves, 20 torpedo caps, 20 detonator wires, 1 nose sleeve, and 20 detonators. The dimensions of the box in inches are 63⅜ by 15⅞ by 5⅜. As packed, the box weighs approximately 168 pounds.

Packed with each box of torpedoes is an instruction sheet which shows how the components are assembled and how the torpedo may be used as an antitank mine.

FURTHER REFERENCES: TM 9-1940; SNL R-7.

Chapter 7

Trench Mortar Ammunition

HISTORY.

Experience in World War I emphasized the need of more extensive and efficient artillery for the support of the land army. The infantry needed a weapon which would support it when it outdistanced its artillery forces. The artillery was merely able to give initial support. This resulted in terrific massacres of the infantry with the loss of what had been gained. Some attempts were made to increase the offensive power of the infantry by attaching field artillery batteries and guns. However, flat trajectory weapons did not supply the answer to the problem. The enemy dug in and the shells passed over the trenches or hills where they were located. In addition, a 550-yard minimum range of the artillery weapon and a 50-yard maximum range of the hand grenade produced a definite void.

The earliest form of the trench mortar weapon was a crude affair. It consisted of an arrangement of pipes and supports. Crude missiles were hurled at the enemy by propelling charges. At the time of entry into World War I, the United States did not number the trench mortar as one of its standard weapons. Britain, however, had adopted a standard 3-inch trench mortar weapon known as the Stokes Mortar. This weapon had a high angle of fire, short range, and short barrel. It was muzzle loaded and had a smooth bore. It fired a projectile weighing 11.7 pounds a maximum distance of 750 yards. This weapon at the time was the answer to a great need. It gave a decent range

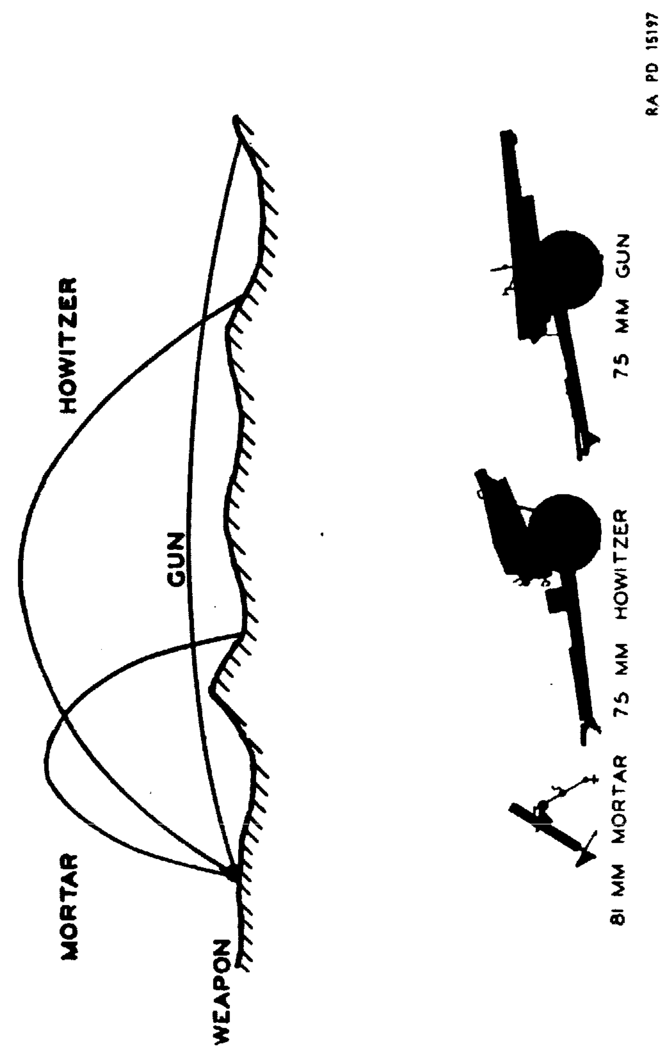

Figure 107 — Weapons and Trajectories

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and much better accuracy than the crude affair of pipes. The weapon served its purpose in that it supplied the needed support for the infantry that the artillery fire lacked, and it served to blast out machine gun nests, barbed wire entanglements and other obstructions. It also proved its efficiency by being a light weapon, firing a fairly heavy shell, being simple to manufacture and easy to carry.

Brief Comparison of Weapons. The classification of gun, howitzer, and mortar no longer conveys the precise meaning it once did. As formerly defined, a gun was a long, high-velocity weapon fired at elevations not exceeding 20 degrees; a howitzer of equal caliber was a shorter, lighter weapon, firing at higher elevations than the gun with less velocity, and at targets that could not be reached by direct force; the mortar was still a shorter weapon designed to fire at elevations up to 65 degrees and to give plunging fire on the targets. The distinction between gun and howitzer is less marked. The modern gun carriage permits firing at high elevations. For example, the 16-inch seacoast gun can be fired at elevations up to 65 degrees, and antiaircraft guns can fire up to 85 degrees. On the other hand, the increased ranges demanded of howitzers have necessitated longer, heavier weapons to produce the velocities required. The factors of weight and mobility, however, still justify provision of distinctive gun, howitzer, and mortar types of mobile artillery. Considering equal calibers, the gun will have the highest velocity, longest range, and least mobility.

Purpose of the Trench Mortar Weapon.

1. To tear down barbed wire entanglements.

2. To blast troops out of trenches.

3. To destroy obstructions.

4. To reach dead space behind hills.

3-INCH TRENCH MORTAR AMMUNITION.

General. The 3-inch trench mortar shell consists of a cylindrical steel casing, having a steel base and steel head screwed on at each end of the casing. The steel head serves to close the nose of the shell, and also seats the booster jacket and fuze. The steel base serves to close the tail end, and seats the cartridge container. Depending on the type of shell, the filler will either be TNT, WP, or inert filler with black powder to act as a spotting charge.

The booster jacket which is seated in the steel head consists of a 1-piece drawn steel cup with a supporting flange formed on one end. It serves to seat the booster charge consisting of mercury fulminate, tetryl, and TNT; or, in case of the practice shell, black powder. The fuze which screws into the head is known as the Mk. VI, all-ways percussion fuze. "All-ways," because this fuze is designed to

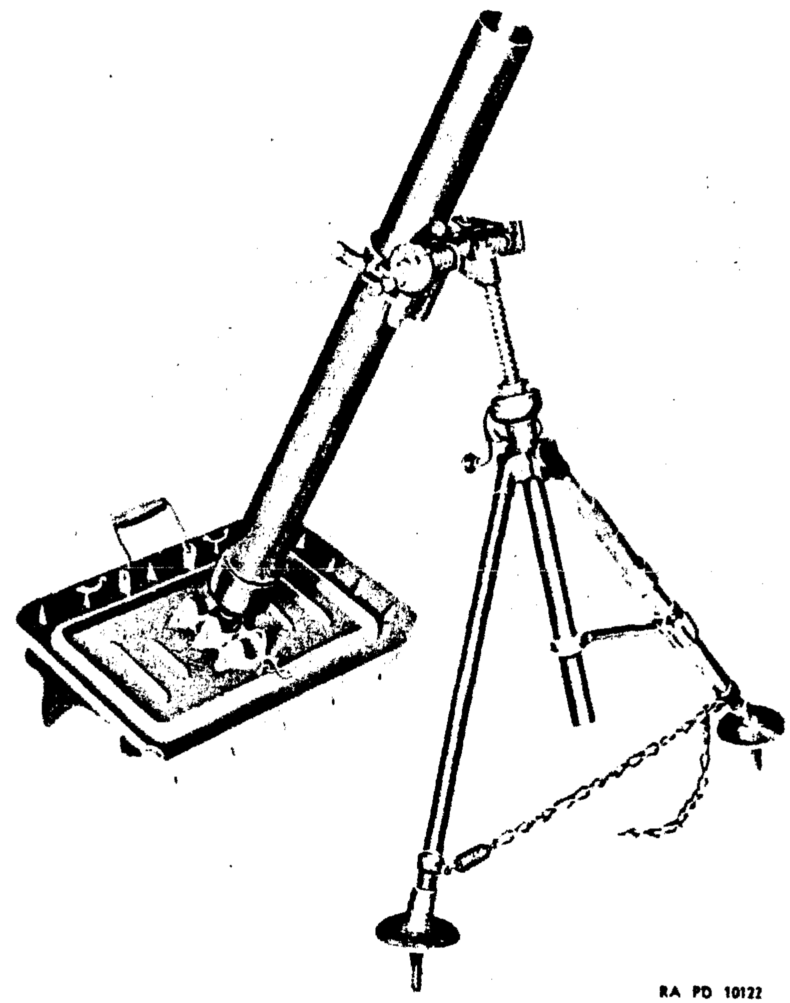

Figure 108 — 81-mm Mortar

function regardless of what position the shell may land, on nose, tail, or side. "Percussion," because this fuze has no detonating element in it and functions on impact action. This fuze must be used on 3-inch trench mortar shell because the shell is unstable in flight and may land in any position.

The cartridge container consists of a short, steel tube threaded at one end so as to screw on the steel base. The interior of the cartridge container is hollow, and into this cartridge container fits an ignition cartridge. Sixteen holes are drilled through the walls of the cartridge container to permit the escape of gases after the ignition cartridge is fired, and also to allow the ignition of powder rings which are placed around the outside of the cartridge container.

The propelling charge consists of two main units:

1. The ignition cartridge.

2. Powder rings.

The ignition cartridge. This is known as the Mk. I green cartridge and is similar in appearance to a blank shotgun shell. It consists of a cardboard cylinder, which has a brass base containing a primer. The rest of the ignition cartridge consists of 120 grains of loose ballistite sporting powder. The ignition cartridge fits into the cartridge container so that the primer fits flush with the end of the container, and when the shell is dropped into the weapon the primer strikes the firing pin of the trench mortar weapon. The flame produced from the primer ignites the ballistite powder which propels the shell a distance of 150 yards.

Powder rings. The powder rings consist of ring-shaped, silk cloth bags, each loaded with 100 grains of ballistite or 110 grains of MR No. 31 powder. The rings fit around the outside of the cartridge container and are ignited by the flame from the ignition cartridge. The shell may be fired by using the ignition cartridge alone, which permits a range of 150 yards, or may be fired by using the cartridge, and one, two, or three powder rings, depending upon the range desired. This permits four zones of fire, giving ranges of approximately 150 yards to approximately 750 yards. Zone 1 firing is conducted by using the cartridge only; zone 2, by using the cartridge and one powder ring; zone 3, by using the cartridge and two powder rings; and zone 4, by using the cartridge and three powder rings. The number of powder rings to be used is determined by the range desired. More than three powder rings are never used, as excessive pressure would be developed which might burst the mortar. Zone 4 is within the working pressure of the mortar, but use of this charge is recommended only in case of necessity.

Types of Ammunition: H.E. shell, chemical shell, and practice shell.

Class of Ammunition. *Semifixed.* Although all the ammunition is designed to be loaded into the weapon in one operation, provisions are made for adjusting the propelling charge at the point of fire.

Packing. The 3-inch trench mortar shell is sent to the field as unassembled, complete rounds. Three unassembled complete rounds are packed per wooden box, with one extra propelling charge (a total of 12 powder rings and 4 ignition cartridges).

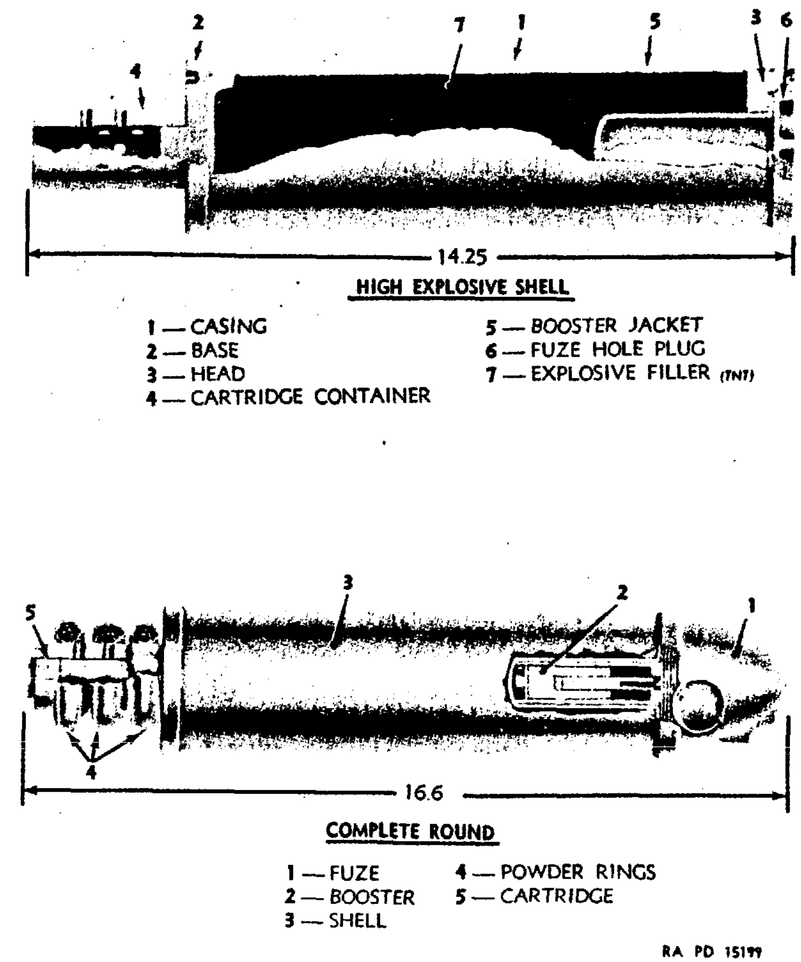

Figure 109 — 3-inch and 81-mm Trench Mortar Ammunition Mk. I

81-MM TRENCH MORTAR.

General. The first attempt to obtain more efficient trench mortar ammunition was with the development of the 75-mm smooth bore mortar in which the old 75-mm French type shell was modified by tapering the shell from the bourrelet back to the base, and fitting an aluminum fin in the base of the shell. The round was propelled by means of an ignition cartridge inserted in a short cartridge case, and with propelling increments inserted between the blades of the fin. The stability of the round was not satisfactory, and the development was abandoned. A streamlined projectile with fin assembly was then designed for the 3-inch trench mortar with poor results. Several attempts were made with shell of different contours, but proved unsatisfactory because proper stability was not obtained.

After World War I, there was an early trend away from the low powered, muzzle-loading Stokes mortar to breech and rifled mortars which were mounted on wheels. The muzzle velocity, the range, and the weight increased, but in so doing, the effectiveness of the trench mortar was decreased in that it lost its simplicity. The weapon became too cumbersome and unwieldly.

Meanwhile the Edgar Brandt Company worked on the 81-mm trench mortar which turned out to be simple in design, utilizing ammunition which was stable in flight and had a long range. In 1931 and 1932, tests conducted by the War Department proved that this mortar and ammunition were highly satisfactory. In 1932, manufacturing rights were purchased from Brandt Company. The weapon itself was a refinement of the 3-inch trench mortar, consisting mainly of a cross leveling mechanism, a better sight, and a heavier baseplate. For simplicity and effectiveness, this mortar proved a remarkable weapon.

Advantages of 81-mm over 3-inch Trench Mortar Ammunition.

1. The 81-mm ammunition is more stable in flight.

2. The 81-mm ammunition has a longer range.

3. The 81-mm ammunition comes to the firing line assembled, ready for use.

4. The 81-mm ammunition utilizes a point-detonating fuze.

Types of 81-mm Ammunition: High-explosive shell, chemical shell, practice shell, and training shell.

Class of Ammunition. 81-mm ammunition is classified as semi-fixed; although the ammunition is designed to be loaded into the weapon in one operation, provisions are made for adjusting the propelling charge at the point of fire.

Description. The ammunition itself is streamline in design. It has a stabilizer assembly in the rear of the shell to produce stability in flight and to seat the propelling charge. The stability adds to the range, velocity, and accuracy of the projectile, and causes the projectile to strike point first, allowing the use of a point detonating fuze. It comes assembled with fuze, propelling charge, and ignition cartridge in place. The only operation necessary before loading the shell into the weapon is to remove the round from its fiber container and then pull the cotter pin or safety wire from the fuze and drop shell into the weapon.

SHELL, H.E., M43. The shell was originally adapted as the light shell for the 81-mm mortar. It is designed for use against light targets such as machine gun nests, barbed wire entanglements and personnel in the open.

Shell body. The body of this shell is constructed of forged steel. It is tear-dropped in shape; that is, blunt nose and tapered tail. It has a bourrelet machined near the nose of the shell consisting of several annular grooves which serves to act as a forward bearing surface and a gas check. The action of the propelling charge gases expanding in the grooves and contracting to pass the raised portions tends to slow the gases and prevent their passing the bourrelet. The nose is machined and threaded to receive an adapter. The adapter is threaded and acts as a bushing for a bakelite fuze well cup and the fuze. The bakelite fuze well cup is fitted to the adapter before it is assembled to the shell body and prevents the entrance of foreign material into the fuze cavity prior to the assembly of the fuze to the round. The fuze used is the Point-detonating Fuze M45. This fuze has a selective element and can be set for either superquick or delay action. (For details, see pages 295 to 298.) To the rear of the bourrelet is a curved taper reducing the base of the shell to approximately 1½ inches. The base is closed and machined so as to receive a stabilizer assembly. The shell filler is 1.22 pounds of TNT. The total weight of completely assembled round is 7.05 pounds. Entire length of the fuzed shell is 13¼ inches.

Fin assembly. The fin assembly consists of a machined cartridge container to which are attached six stationary fins. One end is closed and threaded so as to be screwed on to the body of the shell. The other end is machined and hollow inside so as to receive the ignition cartridge. Several holes leading from the interior to the exterior periphery of the cartridge container serve to conduct the flames from the ignition cartridge to the propellent increments which are seated in the fins.

The ignition cartridge. The Ignition Cartridge M3, red, is similar in appearance to a shotgun shell; the head is of brass and contains the percussion primer; the body is of cardboard, red in color, and contains 120 grains of finely granulate double base powder. It is designed to fit into the hollow portion of the stabilizer assembly.

The propellent increments. The propellent increments are in the form of small half-round celluloid increments. These increments are often referred to as "chocolate drops" due to their similar shape. Each of these increments contains 100 grains of finely granulated double base powder.

A total of one ignition cartridge and a set of increments comprise the full propelling charge (720 grains of ballistite). The increments are held in the stabilizer assembly by small flanges on the fins and may be removed to adjust the propelling charge.

Zones of fire and range. This shell has seven zones of fire. The first zone of fire consists of the ignition cartridge. Zone seven consists of the ignition cartridge and six increments.

Zone one has a range of approximately 100 yards.

Zone seven has a range of approximately 3,300 yards.

Marking and packing. The shell body is painted olive drab lustreless with yellow stencil to indicate H.E. filler. The stenciling includes the following information: caliber of weapon, kind of filler, model number of shell, and ammunition lot number.

For storage, shipment, and issue this shell is packed as a complete assembled round with the fuze and propelling charge in place.

It is packed one round per individual fiber container, six containers per bundle. Weight of a full bundle is 59 pounds. It may also be packed one per individual fiber container, eight containers per wooden box. Weight of a full box is 91 pounds.

Individual fiber containers are sealed with adhesive tape. The color of the tape and stenciling indicate the type of the shell inside.

Metal plates are placed on the ends of each packing bundle. One plate gives the number of rounds contained in the bundle, the nomenclature of the rounds, the lot number, and initials of the loading plant. The plate at the opposite end gives the proper shipping name as listed in SNL R-4, the total weight of the loaded bundle, and cubic displacement.

Packing bundles are held together by a rod passing through the center of the bundle with a wing nut at the end. After assembling, each bundle is sealed with a wire and lead seal. If this seal has not been broken, the bundle may be considered as the original package, positively identified by the metal plates at the ends of the bundle and by the marking of the fiber container.

SHELL, H.E., M43A1. This shell was designed to replace SHELL, H.E., M43. It is standard for issue and manufacture (S & M), whereas the SHELL, H.E., M43, is standard for issue (S).

Shell body. The body, filler, adapter, and bakelite fuze well cup are exactly the same as in the M43. The fuze used is the Point-detonating Fuze M52, which has a superquick action. Due to the light

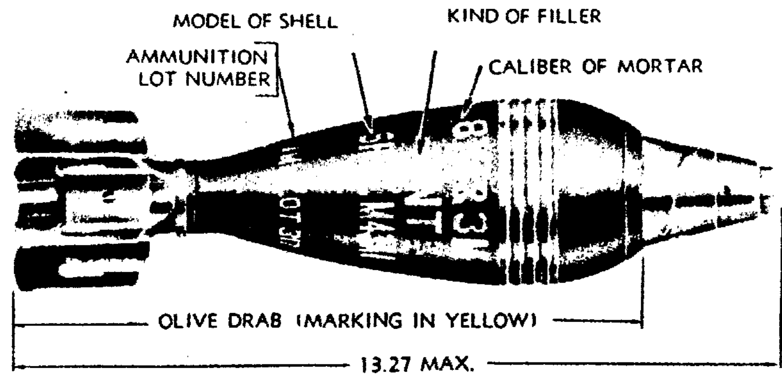

Figure 110a — SHELL, H.E., M43A1, 81-mm Mortar

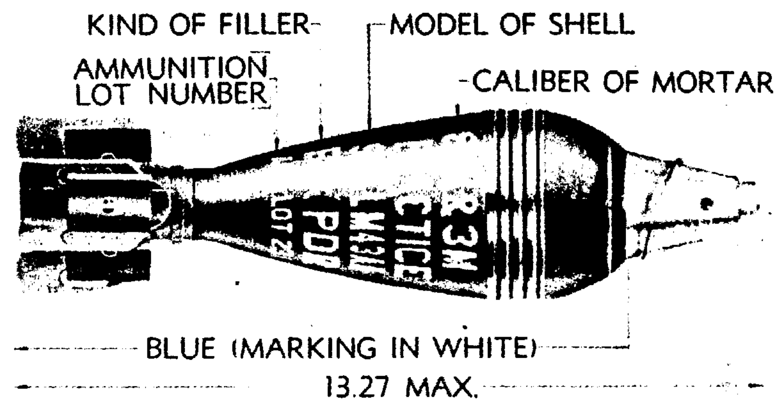

Figure 110b — SHELL, Practice, M43A1, 81-mm Mortar

weight and blunt nose of this shell, very little penetration can be obtained. This shell, as the M43, is designed, therefore, to produce fragments as its primary function against personnel in the open and against barbed wire entanglements. Fragments to be effective must be above ground. The use of a superquick fuze to burst the shell above ground is therefore mandatory. For details in the functioning of the M52 P.D. Fuze, see page 298 to 300.

Fin assembly. The fin assembly is similar to that previously described. It differs in that the flanges on the fins for holding the propellent increments are omitted, as they are not necessary with the newer type increments. Later models, without any change in designation, have the hollow end threaded in the inside so as to receive the new percussion primer.

AMMUNITION INSPECTION GUIDE

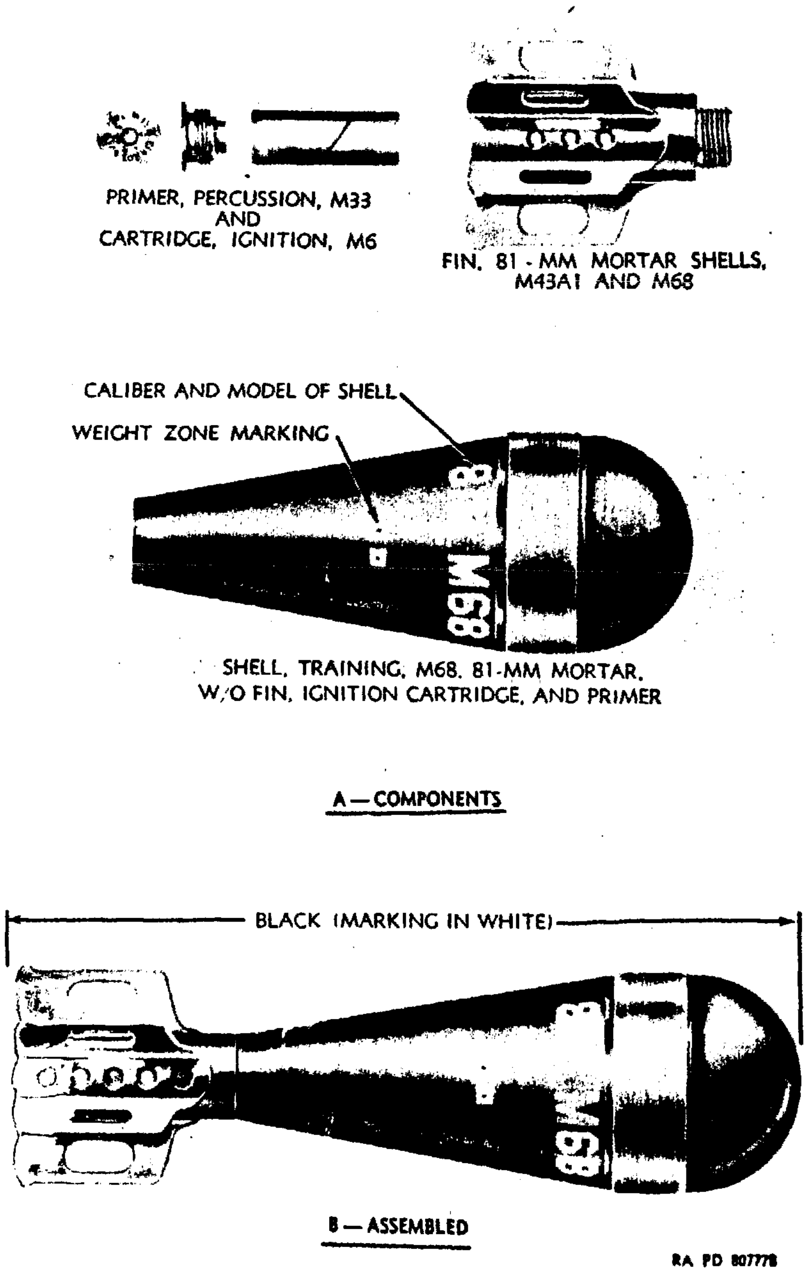

Figure 110c — SHELL, Training, M68, 81-mm Mortar

SMALL ARMS AND TRENCH WARFARE

Ignition cartridge. The Ignition Cartridge M6, red, consists of a cardboard container having approximately 120 grains of double base powder. It supersedes the M3 red and differs from it in that the percussion primer is no longer part of the ignition cartridge but a separate component.

The percussion primer. The Percussion Primer M33 is a relatively new component. The percussion primer is contained in an aluminum head and is threaded so as to screw into the end of the cartridge container after the ignition cartridge has been inserted. The advantage of this type of percussion primer and ignition cartridge is that the whole assembly will leave the mortar with the shell whereas the older type ignition cartridge would, due to the force of setback, at times leave its brass head in the trench mortar weapon, fouling the firing pin and possibly causing a misfire in subsequent rounds.

Propellent increments. The Propellent Increment M1 consists of square strips of double base powder sewn together to form increments. Passing thru these increments will be found holes to increase the burning surface. These sheets are thin and flexible and will not crumple or break as did the old celluloid containers of double base powder used with the M43 Shell. Each increment has 117 grains of double base powder. Occasionally one corner edge of an increment will be cut away (notched) so as to bring the charge to the desired weight and specification. The increments are held in the stabilizer assembly by being placed diagonally in the holes of the fins.

The percussion primer, ignition cartridge and six increments make up the full propelling charge of a total of 822 grains of powder. The increments may be removed to adjust the propelling charge.

Zone of fire and range. This shell has the same number of zones of fire and approximately the same range as described for SHELL, H.E., M43.

Marking and packing. The shell body is painted olive drab with yellow stencil. It is packed one per individual fiber container, six fiber containers per bundle, one bundle per wooden chocolate-stained crate for overseas shipment. The rounds are completely assembled, ready to fire.

SHELL, Practice, M43A1. SHELL, practice, M43A1, is similar to SHELL, H.E., M43A1. The shell body, components used, and packing are identical to the shell previously described. It differs in that the filler consists of 0.16 pound of black powder to act as a spotting charge, and 1.06 pounds of inert filler such as wax, talcum, or rosin which will not crack up in handling. The body is painted blue with white stencil to indicate a practice shell.

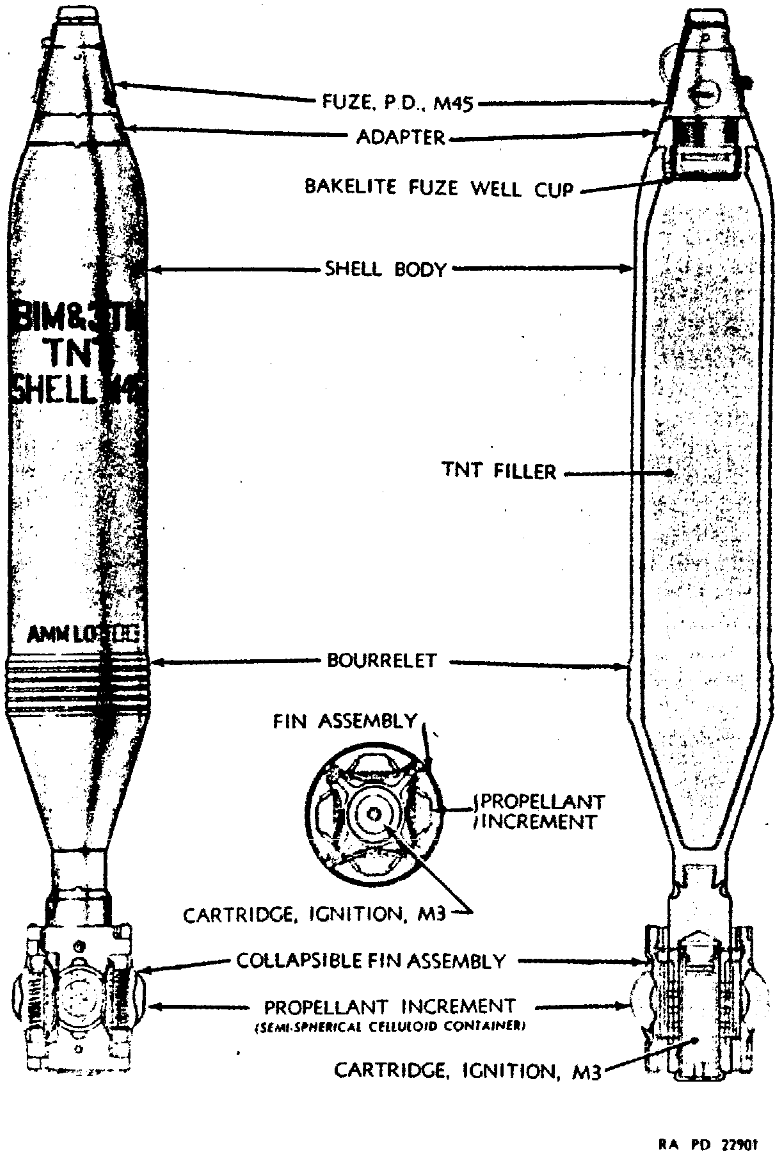

Figure 111 — SHELL, H.E., M45, 81-mm Mortar

SHELL, Practice, M44. This shell is used for practice firing in the 81-mm trench mortar weapon.

The body of the shell is made of cast iron and contains an inert filler. A small amount of black powder (0.20 pound) is placed below the fuze to give a spotting effect when the fuze functions. The body shape, size, and weight are identical to the M43 Shell. It has no adapter, however. The fuze screws directly into the nose of the shell.

The shell body is painted blue with white stencil and is packed in the same manner as SHELL, H.E. M43.

SHELL, H.E., M45. This shell is one of the early types adopted for use in the 81-mm mortar. At the present time, this shell is standard for issue but not standard for manufacture. The principal use of this shell is against dugouts, heavy barricades, and underground structures where a mining action is most effective.

Shell body. The body of this shell is constructed of forged steel. It is cylindrical in shape, having a tapered nose and tail. It has a bourrelet machined on the body near the tail which serves as a rear bearing surface and a gas check. There is no bourrelet at the front of the shell. The nose is threaded to receive an adapter.

The adapter is threaded to receive the fuze well cup and fuze. The use of an adapter bushing allows the shell to be loaded with less difficulty and also permits the use of the same fuze for the 81-mm and 60-mm shells. The fuze used is the P.D. M45 having a selective setting for either superquick or delay action. For details as to functioning of the M45 Fuze see pages 295 to 298. The base of the shell is closed and threaded so as to receive a stabilizer assembly. The shell filler is 4.48 pounds of TNT. The total weight of the completely assembled round is 15.10 pounds. The entire length of the shell is 23½ inches.

Fin assembly. The fin assembly consists of a machined cartridge container to which are attached collapsible fins. One end of the cartridge container is closed and threaded to be screwed on the body of the shell. The other end is machined and hollow inside to receive the ignition cartridge. Holes in the cartridge container act to lead the flame from the ignition cartridge to the propellent increments.

The propellent increments are held in place by the collapsible fins. The fins are always being forced into their open position by compressed springs. The fins are kept in position before firing by a small copper wire tied around them. The blast of the propelling charge shears the copper wire and permits the fins to open to a greater diameter than the shell body after it has cleared the muzzle of the weapon. This was designed to increase the stability of the shell by increasing the fin surface.

This type of fin assembly has not proved successful for several reasons:

During storage the springs which are always compressed will lose their tension or become set.

The fins, due to their size, are delicate and the blast of the propelling charge explosion will in many cases cause distortion.

Both of the above reasons tend to result in unstable flight and the purpose for which this stabilizer assembly was designed is defeated.

The ignition cartridge. The ignition cartridge is the M3 red previously described.

The propellent increments. The propellant is in the form of half-round celluloid increments previously described.

A total of one ignition cartridge and four increments comprise the full propelling charge of 520 grains of double base powder.

The propelling charge may be adjusted to vary the range.

Zones of fire and range. This shell has five zones of fire. The first zone of fire consists of the ignition cartridge itself. Zone five consists of ignition cartridge and four increments.

Zone one has a range of approximately 100 yards.

Zone five has a range of approximately 1,275 yards.

Marking and packing. The shell body is painted olive drab lustreless with yellow stencil to indicate H.E. filler.

The shell is packed as complete and assembled rounds for storage, shipment, and issue in the following manner:

One per individual fiber container, three rounds per bundle, or one per individual fiber container, four rounds per wooden box.

SHELL, H.E., M56. This shell was developed to replace the H.E. Shell M45 and is standard for issue and manufacture (S & M). It is used against dugouts, barricades, and underground structures where a mining action is desired. This shell is a much more effective one than the M45 due to the fact that it contains approximately 40 percent explosive filler as compared to 30 percent explosive filler of the M45. The greater the percentage of explosive filler, without sacrificing the penetrating ability of the shell body, the more effective is the shell when used for mining effect.

The shell body. The shell body is constructed of forged steel. It is long and cylindrical in shape with a tapered nose and tail. It has a bourrelet machined on the body near the base of the shell which acts as a rear bearing surface and a gas check. There are three raised portions around the shell near the nose to act as a forward bearing surface. The nose is machined and threaded to receive an adapter. The adapter is threaded to receive a fuze well cup and fuze. The fuze used is the M53 P.D. which has a delay in action on impact. For mining effect, penetration of the target produces the most effective

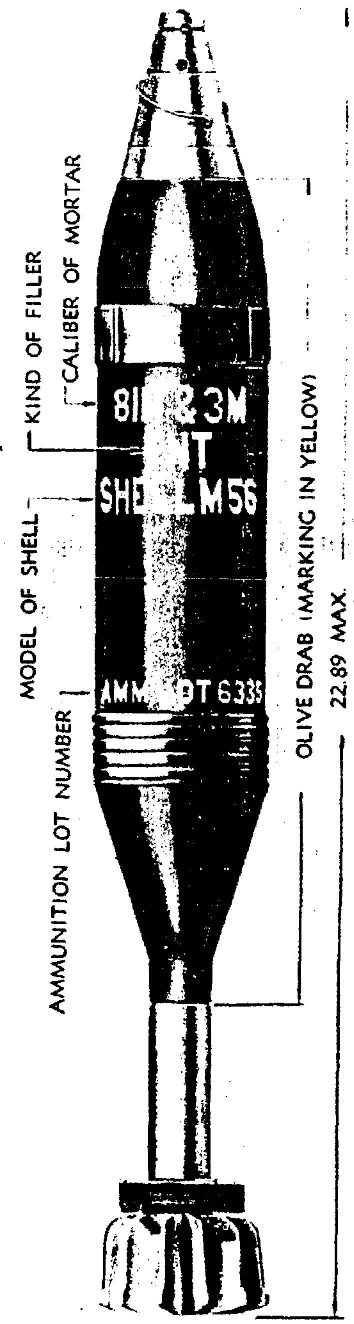

Figure 112 — SHELL, H.E., M56, 81-mm Mortar

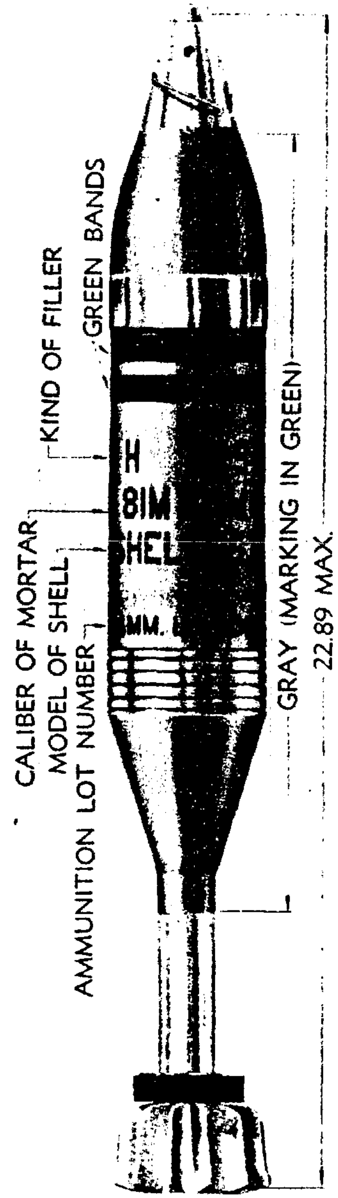

Figure 113 — SHELL, Gas, Persistent, H, M57, 81-mm Mortar

results. The use of a delay action fuze, therefore, to allow penetration is mandatory. For details of functioning of the M53 P.D. Fuze, see page 300 to 303. The base of the shell is closed, machined, and threaded to receive the stabilizer assembly. The shell filler consists of 4.31 pounds TNT. The weight of the completely assembled round is 10.77 pounds. The entire length of the shell with fuze assembled is 22.89 inches.

The fin assembly. The fin assembly consists of a long stem and cartridge container made of aluminum alloy. Having stationary fins formed at the open end of the cartridge container, the stem is closed and threaded so as to be screwed to the shell body. The cartridge container which is part of the same unit is hollow, machined, and threaded at the open end to receive the percussion primer. There are holes in the cartridge container near the fins so as to conduct the flames from the ignition cartridge to the propellent increments which fit around the cartridge container.

The ignition cartridge. The earlier shell of this model used the M3 Ignition Cartridge red. The later shell of the same model had the fin assembly threaded so as to receive the M6 Ignition Cartridge and percussion primer.

The percussion primer. The Percussion Primer M34 is of the same construction and shape as the M33 previously described except that it has a greater diameter.

The propellent increments. The Propellent Increment M2 is made up of thin square sheets of double base powder sewn together. A hole of the same diameter as the stem of the fin assembly is cut in the center of the increment and a slit runs to the outer edge so that the increments can be easily attached to the stem or removed to adjust the propelling charge. In the latest manufacture, however, the increments are held in place by a star shaped spring wire clip known as a propellent holder. Each increment has 205 grains of double base powder.

The percussion primer, ignition cartridge, and four increments comprise the field propelling charge; a total of 940 grains of powder.

Zone of fire and range. The shell has five zones of fire. The first zone of fire consists of the ignition cartridge and percussion primer; zone five consists of the ignition cartridge, percussion primer, and four propellent increments.

Zone one has a range of approximately 300 yards.

Zone five has a range of approximately 2,655 yards.

Marking and packing. The shell body is painted olive drab with yellow stencil. It is packed one per fiber container, three fiber containers per bundle, and one bundle per wooden crate for overseas shipment. The rounds are completely assembled ready for fire.

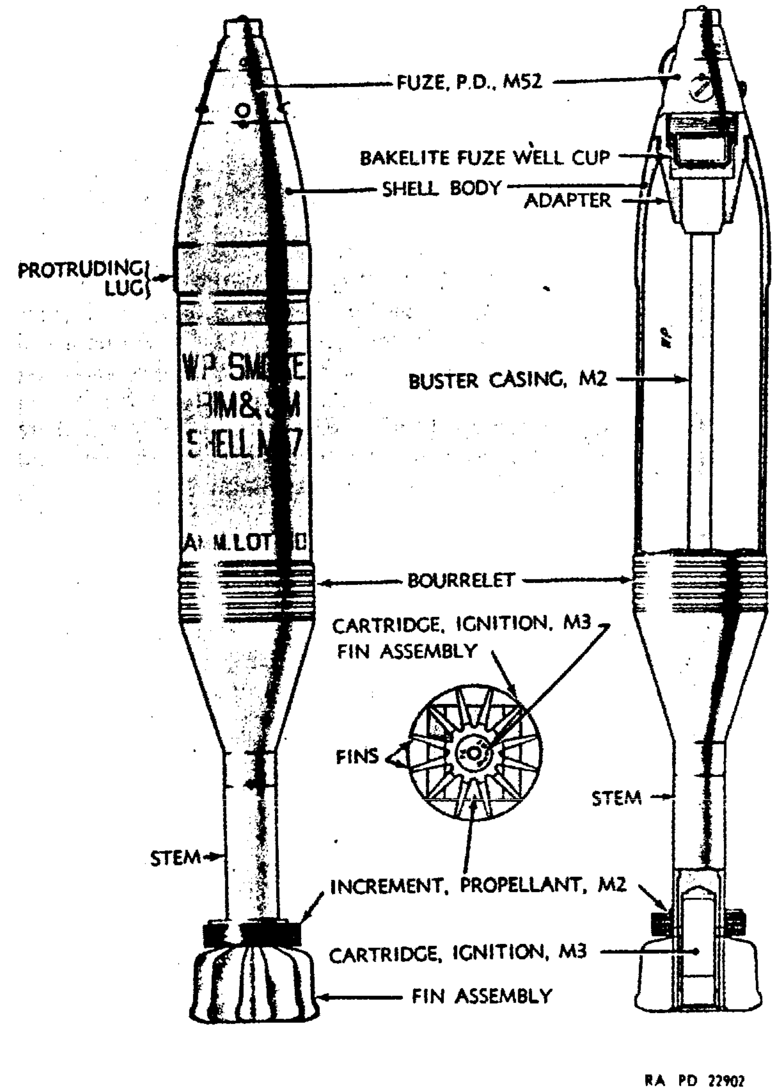

Figure 114 — SHELL, Chemical, M57, 81-mm Mortar

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SHELL, Chemical, M57. This shell is used for the placing of smoke screens and gas clouds with a secondary incendiary effect when WP is used as its chemical filler.

Shell body. In general construction, this shell body has the same outer characteristics as the High-explosive Shell M56. The nose of the shell is threaded to receive the type of adapter peculiar to chemical shell. The adapter is threaded internally to receive the Point-detonating Fuze M52 which has a superquick action. All chemical shell to produce efficient dispersion of filler must burst above ground. A superquick action fuze is therefore used to produce such action. For details, in function of the M52 P.D., see pages 298 to 300.

The chemical filler is loaded into the shell body, and then the burster casing is pressed in place. The head of the Burster Casing M2 is wider than the body of the burster casing and has a slight taper; when pressed into place in the adapter sleeve it forms a gas-tight seal and acts as a seat for the burster charge. A recess is machined in the base of the shell body internally so as to receive the end of the casing, preventing it from becoming loose due to the shock and jars incident to shipment. During the loading of the chemical filler and the pressing of the burster casing in place, there is no explosive charge present in the casing.

The Burster Charge M1 consists of tetryl pellets or tetrytol in a thin aluminum or cardboard cylinder. It is placed in the burster casing prior to the assembly of the fuze to the shell. This construction burster as compared to the old booster found in the 3-inch smoke shell is much more efficient. The explosive charge runs through the entire length of the shell and splits the shell from nose to tail upon function of the fuze, allowing for the dispersion of all the chemical filler in the shell. The old booster charge found in 3-inch smoke shell split the shell near the nose where the booster charge was located, and allowed a good deal of the chemical filler to remain in the base of the shell.

The fin assembly, ignition cartridge, propellent increments, and percussion primer are identical to those used with the High-explosive Shell M56.

Three chemical fillers are loaded at the present time; WP smoke, FS smoke, and H gas. The weight of the completely assembled round varies with the filler used. The weights of the various rounds are:

Filler	Weight of Filler (lb)	Weight of Completely Assembled Round (lb)
WP	4.04	11.50
FS	4.59	12.00
H	3.15	10.45

The total length of the shell with the fuze assembled is 22.89 inches.

Marking and packing. Shell loaded with WP and FS are painted a blue-gray base color with yellow stencil and one yellow band to indicate a nonpersistant screening smoke filler. Shell loaded with H are painted a blue-gray base color with green stencil and two green bands indicate a persistant toxic filler.

Packing is the same as for M56 High-explosive Shell.

SHELL, Training, M68. The shell is designed to give the mortar crew training in loading the weapons and practice in firing under conditions which will not permit firing in more than the first zone.

Shell body. The body of the shell is cast iron. It is similar in shape to the light H.E. 81-mm shell which is tear-drop with a blunt nose and tapered tail. It has a bourrelet on the body near the nose to act as a forward bearing surface and gas check. At the tail end is a recess which is threaded to receive a stabilizer assembly. The nose end is closed and rounded with no provisions made to receive a fuze. Its weight varies depending on its weight zone. Nine weight zones are used with a minimum of 9.50 pounds for weight zone one, and a maximum of 10.10 pounds for weight zone nine, weighed without fin assembly and ignition cartridge.

The fin assembly and propelling charge. The fin assembly is of the same construction and shape as previously described. It receives the Ignition Cartridge M3. Several ignition cartridges are provided with each round so that the shell can be fired more than one time. There are no propellent increments used because the shell is designed to be fired in the first zone only. The maximum range is 350 yards.

Marking and packing. The shell is painted black with white stencil. On the shell body may be found a number of white squares (one to nine) with a prick punch mark in the center of each to indicate the zone weight.

Information as to the packing of the shell is not available at the present time. However the complete round comes in separate units consisting of shell body, ignition cartridge, and fin assembly.

TRENCH MORTAR FUZES.

General. The fuzes used with the 81-mm and the 60-mm mortar ammunition are, except for the 60-mm illuminating shell, of the point-detonating type. The stability of the shell in flight allows the use of this type of fuze. The M45 Fuze, first used on the M43, M44 and M45 Shells, is a point-detonating fuze having a selective feature which allows the fuze to be set for either superquick or delay action as desired. The superquick action is used for effect against light

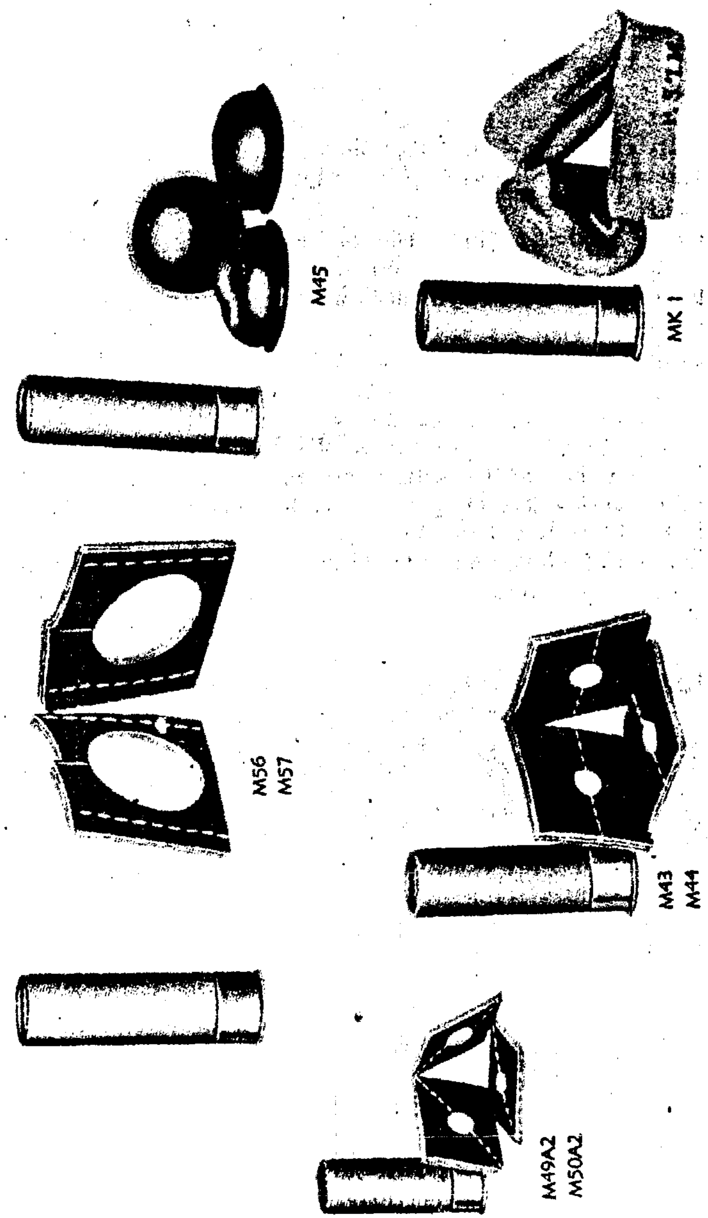

Figure 115 — Trench Mortar Propellants

targets above the ground where no penetration is necessary, and a fragmentation effect is desired such as against personnel and barbed wire entanglements. The delay action is used against heavy targets and underground structures where penetration is desired to produce the most effective mining and concussion results.

Recently it was decided that each shell could be classified as for use against light targets or as for use against heavy targets. Thus, a single action fuze could be definitely assigned to each shell according to its tactical use. All of the light shell (7 pounds or less) were classified for use against light targets, as very little penetration could be obtained due to their light weight and blunt construction. It is also to be noted that the percentage of explosive filler as compared to the percentage of metal components (approx. 17 percent) was designed to destroy the light shell so as to produce efficient fragments which can be effective only if distributed above ground. The M52 P.D. Superquick Fuze was also assigned to the Chemical Shell M57, as it is necessary to function the chemical shell above the ground to obtain the proper effects and dispersion to its chemical filler. All the heavy shell of the H.E. type were classified for use against heavy targets and for use where a mining effect was necessary. It is also to be noted here that the percentage of explosive filler as compared to the percentage of metal components (approx. 40 percent) was designed to produce an efficient mining or concussion result with heavy shell which would be most effective if allowed to penetrate its target and then explode. The M53 P.D. Delay Action Fuze was assigned to these shell.

The M45 P.D. Selective Fuze was declared limited standard (S). It was a waste of one element to use a selective fuze on trench mortar shell, because it was known before the shell ever reached the firing point what action fuze was desired. The M52 P.D. superquick and the M53 P.D. delay are standard for issue and manufacture (S & M). It is interesting to note that the subdivision of a selective fuze into two separate fuzes is in definite opposition to the trend in artillery fuze design where the tendency is to combine two fuzes into one selective or combination fuze. This is true because in artillery fuzes the action desired varies with the condition at the field of battle.

Rounds used with these fuzes may be considered boresafe. The detonating elements are positively separated from the booster until the projectile has left the bore of the mortar. The fuzes are assembled to their respective shell and stacked in place. They are, therefore, being stored, shipped, and issued as a permanent part of the complete round. Each fuze is stamped with its model number, manufacturer's initials, and lot number for positive identification. The M45 can be obtained in a practice type. It has a black powder charge in place of a tetryl booster charge, and is designated as a point practice

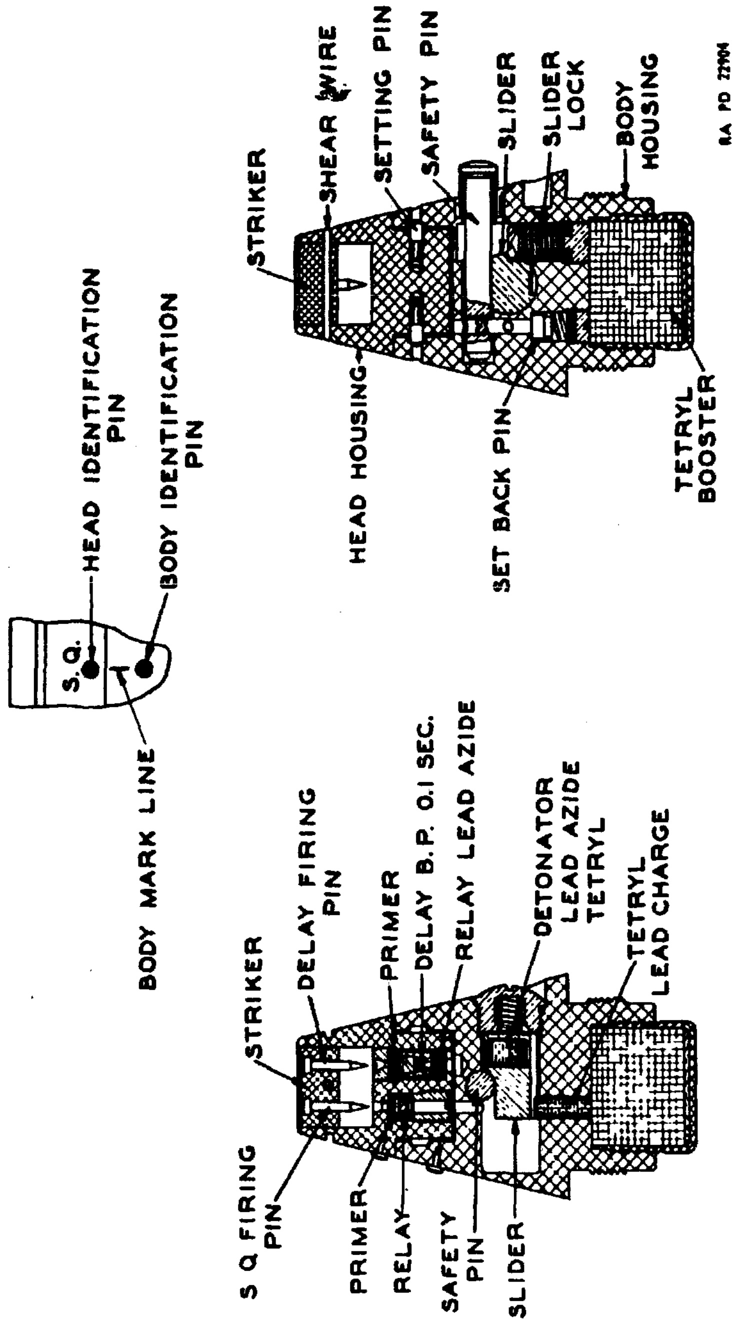

Figure 116 — FUZE, P.D., M45

fuze. The head is painted blue, and "Fuze, Point, M45, Practice" is stamped on the body.

Point-detonating Fuze M45.

Description. The M45 Point-detonating Fuze is a selective, superquick, and delay action fuze, used to effect functioning of SHELL, H.E. M45, fired from the 81-mm trench mortar. This shell and fuze are now limited standard. The superquick setting is used when it is desired to obtain fragmentation of the shell above the ground, whereas the delay setting is used for underground action. The fuze weighs approximately 0.52 pounds.

The fuze housing is made of aluminum. The head of the fuze fits into the body so as to be able to turn on the body housing. The head houses a comparatively short, but wide, striker which is flush with the nose. The striker has two firing pins and is held in place by a shear wire. Underneath the firing pins is a superquick element and a delay element. One element is directly in line with a flash hole to the body explosive charges, and the other element is in line with a dead flash hole depending on the setting. Located in the head are setting pins and setting pin springs which when in proper position for either delay or superquick setting will engage recesses in the body. On the external surface of the head are stamped "S.Q.," or "D," to indicate the setting. The body houses the slider, slider lock, safety pin, and set-back pin, with their respective springs. In the center and at the base of the body is an inverted brass cup known as a lead cup. It is held in place by crimping, and contains a tetryl lead pellet. The base of the body is internally threaded to receive a booster cup, which in turn houses a tetryl booster pellet. On the external surface of the body is a marked line and an identification pin which indicates the setting.

Setting. When set for superquick action the head is set so that the "S.Q." stamped thereon is in line with the line on the body. Identification pins are provided for setting at night. These pins are so located that for superquick setting the heads of the pins are directly in line and for delay setting, they are 180 degrees removed. Pressure applied on the setting pin by the setting pin springs forces them to engage in recesses in the body at the exact position of "S.Q.," and "D" so as to restrain the head in proper position.

Safety features. The M45 Fuze is boresafe. This is accomplished by assembling the detonator into a slider which in the armed position holds the detonator out of alinement with the explosive train. Arming of the slider in the bore of the mortar is prevented by a safety pin, the head of which bears against the bore, thereby retaining the slider in the safe position. To prevent arming of the set-back pin, which holds the safety pin in position, a cotter pin is utilized, preventing the set-back pin from moving rearward against its spring during handling.

Function when set for superquick action. The cotter pin is removed, freeing the set-back pin. The shell is dropped down the bore of the weapon. The force of set-back resulting from ignition of the propelling charge causes the set-back pin to move down against the set-back pin spring, freeing the safety pin. The safety pin, due to the action of the safety pin spring, is forced out of the fuze until its head comes in contact with the bore of the mortar. After emerging from the mortar the safety pin is completely ejected by its spring from the fuze. The slider is now free, and due to the action of the slider spring is forced into the armed position, thereby bringing its detonator in direct alinement with the explosive train. The slider also serves to close the hole left by the safety pin, so as to prevent the entrance of mud or dirt into the slider cavity which might interfere with the fuze functioning. The slider is locked in the armed position by a slider lock which is forced up into a recess in the slider by a slider lock spring.

Upon impact with the target the striker is forced inward, breaking the shear wire and carrying both firing pins into their respective elements. The superquick firing pin ignites a primer which in turn ignites a lead azide relay charge. The lead azide relay detonates, and sends a wave to the detonator charge of lead azide and tetryl in the slider. The wave from the detonator functions the lead charge of tetryl. The wave from the lead charge of tetryl detonates the booster of tetryl which amplifies the wave and sends it to the shell filler. Simultaneously with the above action, the delay firing pin functions its primer. If the superquick action functions properly, the delay action will proceed no farther. If the superquick fails to function, the primer will ignite a black powder pellet which will burn for 0.1 second. The flame from the black powder delay pellet in turn will set off a relay of lead azide which will detonate and carry a wave into a blank flash hole where it will be stopped and will proceed no farther.

Function on delay. The head must be turned so that the "D" stamped thereon is in line with the mark line on the body. By means of setting the head as described, the delay element is brought into alinement with the flash hole and the superquick primer is 180 degrees removed. The fuze function is exactly the same until action on impact.

Upon impact the striker is forced inward, breaking the shear wire, carrying both firing pins into their respective elements. The superquick firing pin ignites its primer which in turn sets off a relay of lead azide. The wave produced passes into a blank flash hole and proceeds no farther. Simultaneously with the above action, the delay firing pin functions its primer. The flash from the primer ignites a

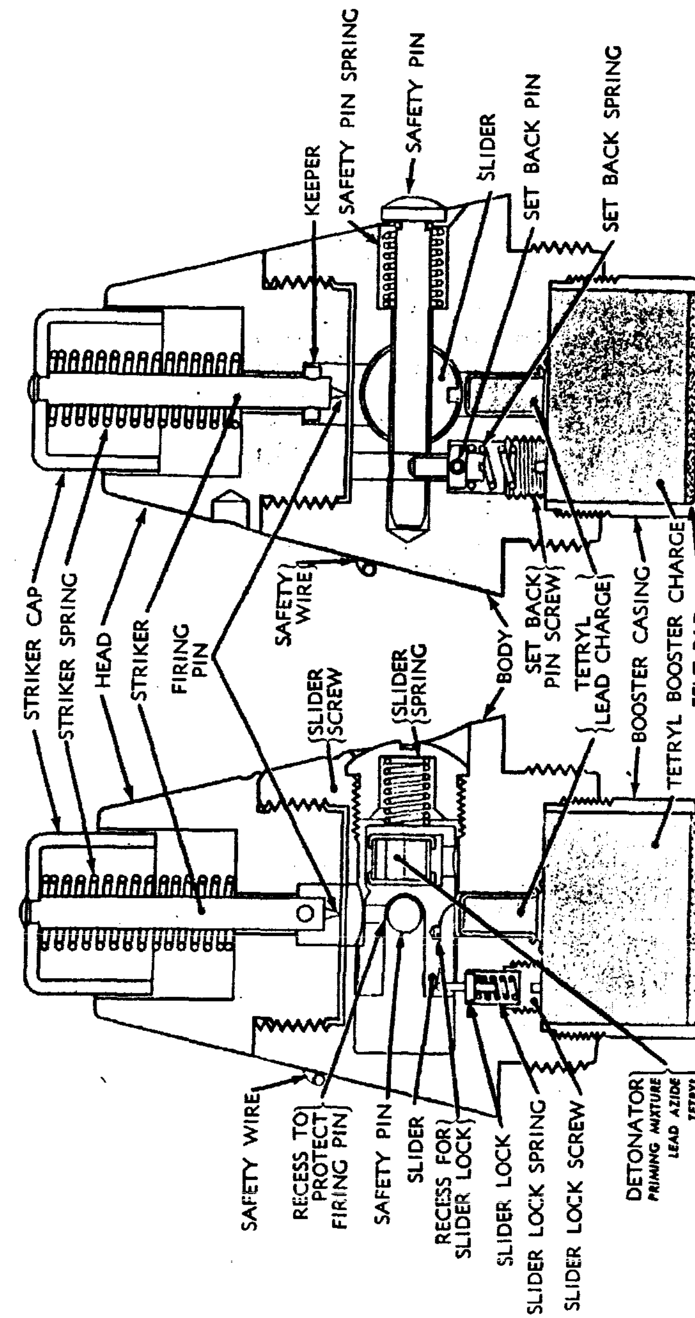

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Figure 117 — FUZE, P.D., M52

black powder delay pellet which burns for 0.1 second. The delay pellet ignites a relay of lead azide which detonates, and in turn sets off the detonator charge of lead azide and tetryl located in the slider. The wave from the detonator functions the lead charge of tetryl which detonates, and functions the booster of tetryl. The booster charge amplifies the wave and sends it to the shell filler.

Point-detonating Fuze M52.

Description. The M52 Fuze is a superquick fuze used to effect the functioning of rounds fired from the 81-mm and 60-mm mortars. It is normally used with light shell when fragmentation above the ground is desired. This fuze will fit any of the present "M" series of shell; however, it is only assembled in the following shell at present:

M43A1 H.E. for 81-mm T.M.	M57 Chemical for 81-mm T.M.
M43A1 Practice for 81-mm T.M.	M49A2 H.E. for 60-mm T.M.
M44 Practice for 81-mm T.M.	M50A2 Practice for 60-mm T.M.

The weight of the fuze is 0.45 pound.

The fuze housing is made of aluminum. The head of the fuze screws into the body. The head houses a long protruding striker and a compressed restraining spring. The striker and restraining spring are held in place by a keeper. The body houses the slider, slider lock, safety pin, and set-back pin, with their respective springs. In the center and at the base of the body is an inverted cup known as a lead cup. It is held in place by crimping and contains a tetryl lead pellet. The base of the body is internally threaded to receive a booster cup which in turn houses a tetryl booster pellet. The slider carries a detonator and a blank flash hole to receive and protect the firing pin from shocks due to handling and set-back action.

Safety features. The safety features correspond to the M45. The M52 Fuze is boresafe. This is accomplished by the assembling of the detonator into a slider which in the unarmed position holds the detonator out of alinement with the firing pin and the tetryl lead charge. Arming of the slider within the bore of the weapon is prevented by the safety pin, the head of which bears against the bore and retains the slider in the unarmed position. To prevent arming of the set-back pin, which holds the safety pin in position, a cotter pin (safety wire in later manufacture) is utilized.

Function. This fuze is armed in the same manner as the M45. The cotter pin or safety wire is removed to free the set-back pin. The shell is dropped down the bore of the weapon. The force of set-back resulting from ignition of the propelling charge causes the set-back pin to move rearward against its spring. This frees the safety pin.

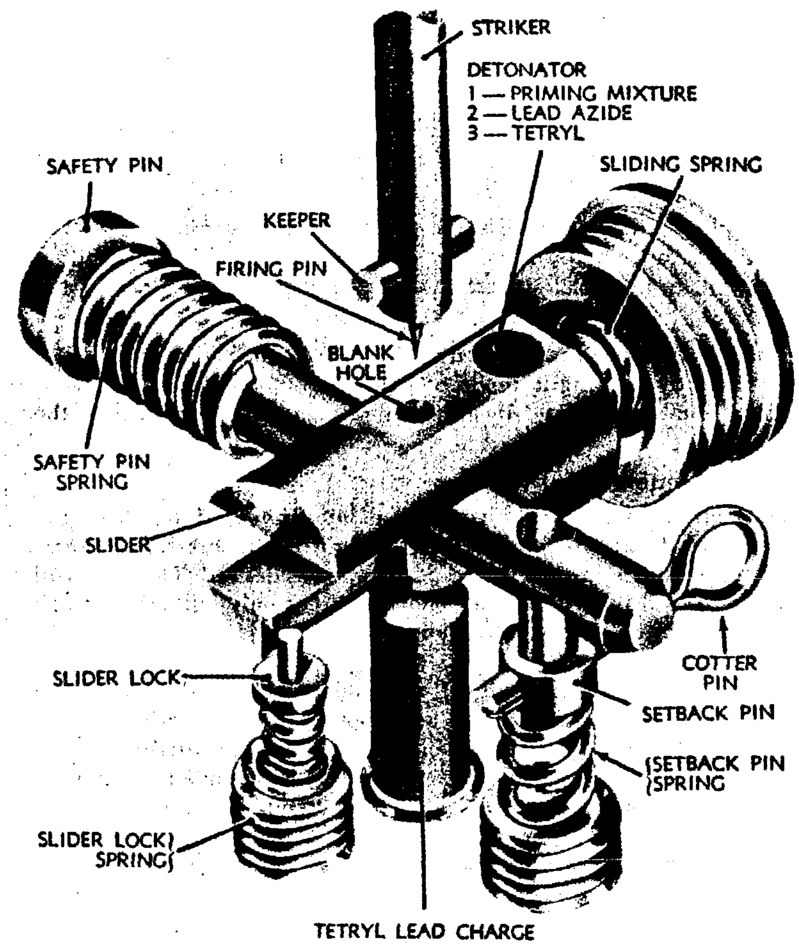

Figure 118 — Working Parts for FUZE, P.D., M52

The safety pin, due to the action of its spring, is forced out of the fuze until its head comes in contact with the bore of the mortar. After emerging from the mortar, the safety pin is completely ejected by its spring from the fuze. The slider is now free, and due to the action of the slider spring, is forced into the armed position, thereby bringing the detonator in direct alinement with the explosive train. The slider also serves to close the hole left by the safety pin, so as to prevent the entrance of mud or dirt into the slider cavity which might interfere with the fuze functioning. The slider is locked in the armed position by a slider lock which is forced into a recess in the slider by a slider lock spring.

Upon impact with the target, the striker is forced inward against its spring bringing the firing pin into the detonator charge of priming mixture, lead azide, and tetryl. The wave produced functions the lead charge of tetryl which in turn detonates the booster of tetryl. The booster charge amplifies the wave and sends it to the shell filler.

Point-detonating Fuze M52B1. This fuze differs from the M52 in that the body and head housing are made of bakelite instead of aluminum as the M52. In all other respects, it is identical to the M52 Fuze.

Point-detonating Fuze M52B2. This fuze differs from the M52 in that the body housing is made of bakelite, but the head housing is made of aluminum alloy. In all other respects, it is identical to the M52 Fuze.

Point-detonating Fuze M53.

Description. The M53 Fuze is a delay fuze used to effect the functioning of rounds fired from the 81-mm trench mortar. It is normally used with heavy shell where penetration is desired. This fuze will fit any of the "M" series of shell; however, it is only authorized to be assembled in the H.E. Shell M56 for 81-mm mortars. The weight of the fuze is 0.45 pound.

The fuze housing is made of aluminum. The head of the fuze screws into the fuze body. The head houses a comparatively short striker which is flush with the nose of the fuze. The striker is held in place by a shear wire. The head is internally threaded at the base to receive a delay assembly. The delay assembly houses a primer, delay pellet of black powder and a relay of lead azide. The body houses the slider, slider lock, safety pin, and set-back pin, with their respective springs. In the center and at the base of the body is an inverted brass cup known as a lead cup. It is held in place by crimping and contains a tetryl lead pellet. The base of the body is internally threaded to receive a booster cup which in turn houses a tetryl booster pellet.

Safety features. The safety features correspond to the M45 and M52 P.D. Fuzes previously described. The M53 is boresafe. This is accomplished by the assembling of the detonator into a slider which in the unarmed position holds the detonator out of alinement with the relay charge of lead azide and the lead charge of tetryl. Arming of the slider within the bore of the weapon is prevented by the safety pin, the head of which bears against the bore, thereby retaining the slider in the unarmed position. A set-back pin is used to hold the safety pin in position until set-back action occurs. To prevent arming of the set-back pin, a cotter pin (safety wire in later manufacture)

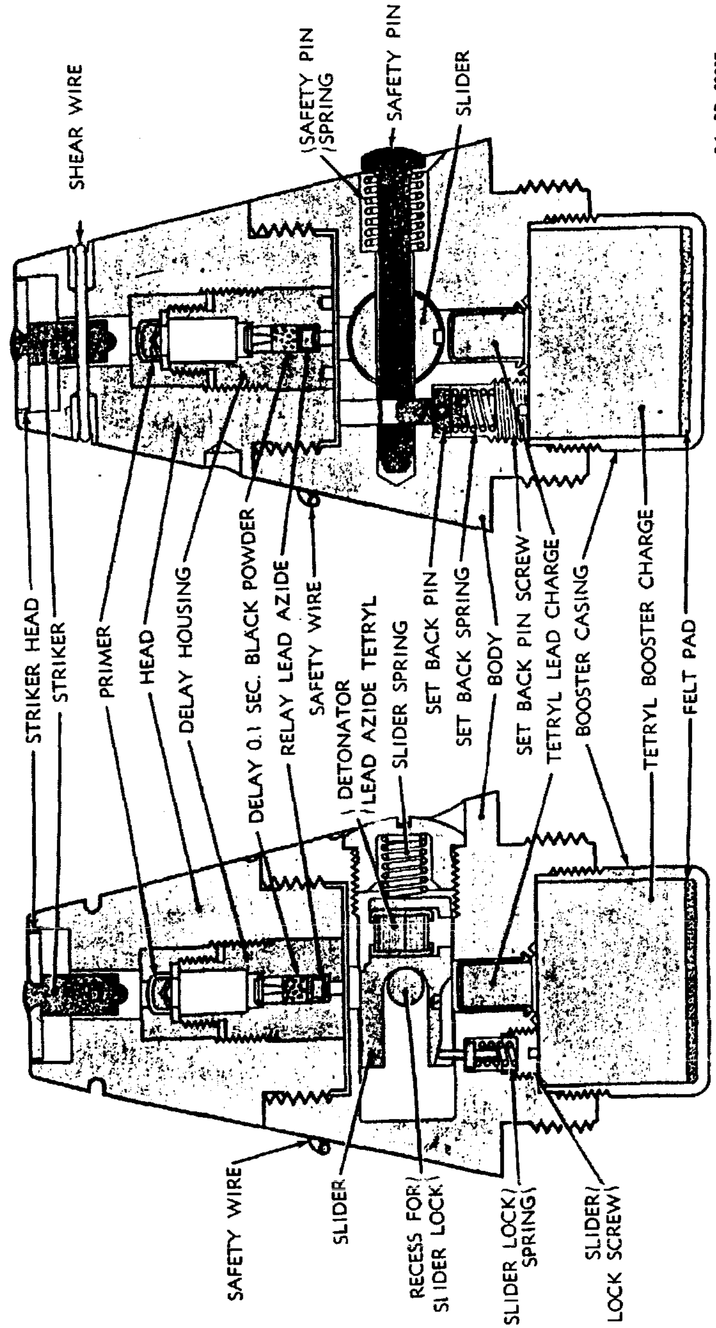

Figure 119 — FUZE, P.D., M53

COMPLETE ROUND CHART FOR 81-MM TRENCH MORTAR WEAPONS

Complete Round Designation	Filler	Fuze	Propellent Increment	Percussion Primer	Ignition Cartridge	Packing	Status
SHELL, H.E., M43	TNT	P.D. M45 or M52	400 grains (4 incr)	....	M3	Fuzed	S
SHELL, H.E., M43A1	TNT	P.D. M52	700 grains (6 incr—M1)	M33	M6	Fuzed	S & M
SHELL, practice, M43A1	Inert Mat'l B.P. Pellet	P.D. M52	700 grains (6 incr—M1)	M33	M6	Fuzed	S & M
SHELL, practice, M44	Inert Mat'l B.P. Pellet	P.D. M52	700 grains (6 incr—M1)	M33	M6	Fuzed	S & M
SHELL, H.E., M45	TNT	P.D. M45 or M53	400 grains (4 incr)	....	M3	Fuzed	S
SHELL, H.E., M56	TNT	P.D. M53	820 grains (4 incr—M2)	M34	M6	Fuzed	S & M
SHELL, chemical, M57	WP, FS, H	P.D. M52	820 grains (4 incr—M2)	M34	M6	Fuzed	S & M
SHELL, training, M68	....	....	....	....	M3	....	S & M

is utilized, preventing the set-back pin from moving rearward against its spring during handling.

Function. This fuze is armed in the same manner as the M45 and M52 P.D. Fuzes previously described. The cotter pin or safety wire is removed, freeing the set-back pin. The shell is dropped down the bore of the weapon. The force of set-back resulting from ignition of the propelling charge causes the set-back pin to move rearward against its spring, freeing the safety pin. The safety pin, due to the action of its spring, is forced out of the fuze until its head comes in contact with the bore of the mortar. After emerging from the mortar, the safety pin is completely ejected by its spring from the fuze. The slider is now free, and due to the action of the slider spring is forced into the armed position, thereby bringing the detonator in direct alinement with the explosive train. The slider also serves to close the hole left by the safety pin so as to prevent the entrance of mud or dirt into the slider cavity which might interfere with the fuze function. The slider is locked in the armed position by a slider lock which is forced up into a recess in the slider by a spring.

Upon impact with the target, the striker is forced inward against its shear wire, breaking it and bringing the firing pin of the striker into a primer. The flame from the primer ignites a black powder delay pellet which burns for 0.1 second. The pellet in turn ignites a relay of lead azide which detonates and in so doing sends a wave to the detonator of lead azide and tetryl. The detonator in turn functions the lead charge of tetryl which detonates the booster of tetryl. The booster charge amplifies the wave and sends it to the shell filler of TNT.

General Information. 81-mm ammunition can be used in 3-inch trench mortar weapons by making the following modifications:

1. The firing pin in the 3-inch trench mortar weapon must be lengthened. This modification will be found in the 3-inch Trench Mortar Mk. IA2. Therefore, the 81-mm mortar ammunition may be used only in the 3-inch Mk. IA2, and never in the 3-inch Trench Mortar Mk. I or Mk. IA1.

2. Maximum number of increments must be changed in the following manner:

Outer zone propelling charge must be reduced from six to four increments, for the M43A1 and M44 Shells.

Outer zone propelling charge must be reduced from four to three increments, for the M56 and M57 Shells.

The full charge of four increments may be used with the M45 shell.

The 3-inch trench mortar shell can be fired in an 81-mm weapon without any modifications being made.

Figure 120 — SHELL, H.E., M49A2

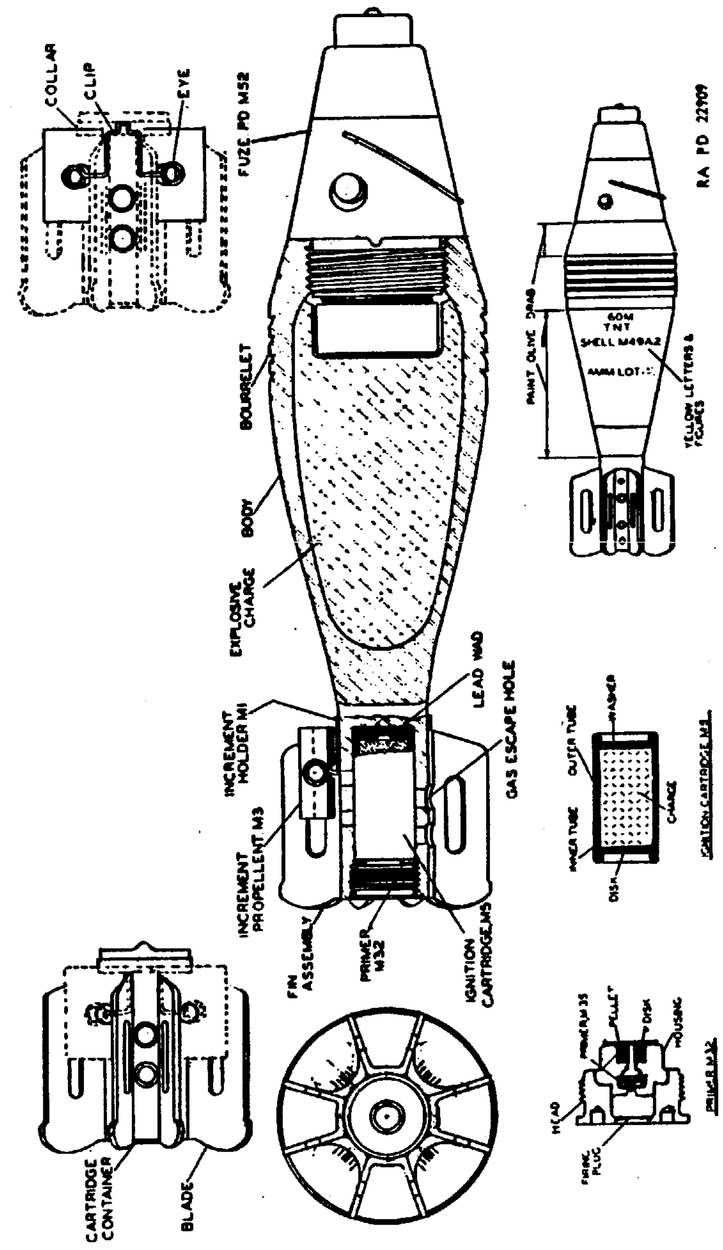

Figure 121 — SHELL, H.E., M49A2

60-MM TRENCH MORTAR.

General. For missions between ranges of usefulness of hand grenade and 81-mm trench mortar, the Ordnance Department initiated the development of a light 42-mm trench mortar.

Before a 42-mm trench mortar could be made, the Brandt Company furnished a 47-mm trench mortar which was suitable for infantry. The cavalry wanted something that had a greater maximum range than the 47-mm weapon. Consequently, a 60-mm trench mortar and ammunition for it was developed by the Brandt Company.

In 1938, the 60-mm trench mortar was adopted and the 47-mm trench mortar was rejected. The mobility of the weapon, due to its light weight, and the quantities of ammunition that can be carried, increased the fire power of the using arms in movement.

The general design of the 60-mm trench mortar shell is similar to the light shell for the 81-mm trench mortar. The method of firing is exactly the same. The color, marking, and stenciling are the same as for the 81-mm mortar ammunition of the same types. The class of ammunition used for the 60-mm mortar is once again semifixed. Four types of ammunition are at present provided for use in the 60-mm mortar: high-explosive shell, practice shell, training shell, and illuminating shell.

SHELL, H.E., M49A2. This is the present standard high-explosive shell for use in 60-mm trench mortar. It is used against light targets and personnel in the open.

Shell body. In shape, the body of this shell closely resembles the light shell for the 81-mm trench mortar; however, it is much smaller in size. Several methods of manufacturing the shell body are in practice at the present time, depending on the method best adapted to the individual manufacturer. The body may be of forged steel, cupped-rolled, plate-welded longitudinally, or a machined casting.

It is tear-dropped in shape, having a blunt nose and tapered tail. Near the nose end of the shell is a machined bourrelet which acts as a forward bearing surface and as a gas check. The nose is threaded to receive the fuze directly. The fuze used is the P.D. Fuze M52 which has a superquick action. Due to the light weight and blunt nose, very little penetration can be obtained. The shell is designed to produce fragments as the other light shells previously described. The tail end is closed and internally threaded to receive the stabilizer assembly. Earlier models of this shell had the stabilizer and body made from one piece with the fins attached. The shell filler is 0.34 pound of flake TNT. The weight of the round completely assembled is 2.94 pounds; the entire length of the shell with fuze attached is 9½ inches.

The fin assembly. The fin assembly consists of a machined cartridge container closed at one end with a threaded protrusion to screw into the shell body. It is hollow, with the other end threaded to receive an ignition cartridge and a percussion primer. A series of holes in the cartridge container serves to allow for the escape of gas, and to conduct the flame from the ignition cartridge to the propellent increments. Attached to the cartridge container are eight stationary fins in which may be seated the increments, or as recently changed, the increments are placed between the fins and held there by an increment holder.

The ignition cartridge. The ignition cartridge is the M5A1. It consists of a cardboard container having approximately 40 grains of double base powder. It supersedes the M5, and differs from it in that the number of grains of powder has been reduced from 47 to 40 grains. A hollow celluloid tube three-fourths inch long was also introduced at ignition end of cartridge. The M5 Ignition Cartridge produced erratic flight. Short ranges made it necessary for all members of the crew to be protected. With the M5A1, muzzle velocities have been reduced, but the maximum range obtained with all propellent increments and cartridges have not been reduced.

Previous to the M5 Ignition Cartridge, the M4 had been used. The M4 was a cardboard container having 47 grains of double base powder with a primer located in a brass base. It fitted snugly into the cartridge container and was disadvantageous in that set-back would cause residue of the M4 Ignition Cartridge to remain in the weapon.

The percussion primer. The Percussion Primer M32 is of the same construction and shape as the M33 previously described. It differs in that it has a narrow body diameter.

The propellent increments. The Propellent Increments M3 are made up of thin square sheets of double base powder sewn together. Each increment weighs approximately 35 grains. In the center of each increment is a hole which serves to increase the burning surface, and allows the increment to be held by the Propellent Increment Holder M1, by fitting into the wire loop of the increment holder. The corners, the sides, or edges may be notched to adjust the increment to the desired weight. The increments are held in place by seating in the fins diagonally, or recently by use of the Propellent Increment Holder M1. The Propellent Increment Holder M1 consists of a wire band seated around the stabilizer assembly near the body of the shell. Two thin wires bent in a V-shape, their ends in a circular loop, extend from the band down between the fins. On these loops are placed the increments by means of the holes in their center.

The percussion primer, ignition cartridge, and four increments comprise the full propelling charge; a total of 180 grains of powder.

Zones of fire and range. The shell has five zones of fire. The first zone of fire consists of the ignition cartridge and percussion primer. Zone five consists of the ignition cartridge, percussion primer, and four propellent increments.

Zone one has a range of approximately 100 yards.

Zone five has a range of approximately 1,935 yards.

Marking and packing. The shell body is painted olive drab with yellow stencil. The shell is shipped as a complete assembled round. One round is packed per individual fiber container, six individual fiber containers per large outer fiber container, three large outer containers (18 rounds) per bundle. One bundle per chocolate-stained wooden crate for overseas shipment.

SHELL, Practice, M50A2. SHELL, practice, M50A2, is similar to SHELL, H.E., M49A2. The shell body, components used, and packing are identical to the shell previously described. It differs in that its filler consists of 0.29 pound of inert material and 0.05 pound of a smoke producing pellet of black powder to act as a spotting charge. The body is painted blue with white stencil to indicate a practice shell.

SHELL, Training, M69. This shell is designed to give the mortar crew training in loading the weapon, and practice in firing under conditions which will not permit firing in more than the first zone.

Shell body. The body of the shell is cast iron. It is similar in shape to the 60-mm trench mortar shell and the M68 Training Shell for 81-mm mortar previously described. It is tear-dropped with a blunt nose and tapered tail. It has a bourrelet on the body near the nose to act as a forward bearing surface and gas check. At the tail end is a recess which is threaded to receive a stabilizer assembly. The nose end is closed and rounded with no provisions made to receive a fuze. Its weight varies depending on its weight zone. Seven weight zones are possible with a minimum of 3.83 pounds for weight zone one and a maximum of 4.07 pounds for weight zone seven without fin assembly and ignition cartridge.

The fin assembly and propelling charge. The fin assembly is of the same construction and shape as previously described. It receives the Ignition Cartridge M4. Several ignition cartridges are provided with each round so that the shell can be fired more than one time. There are no propellent increments used, for the shell is designed to be fired in the first zone only.

Marking and packing. The shell is painted black with white stencil. On the shell body will be found a number of white squares (one to seven) with a prick punch mark in the center of each to indicate the zone weight.

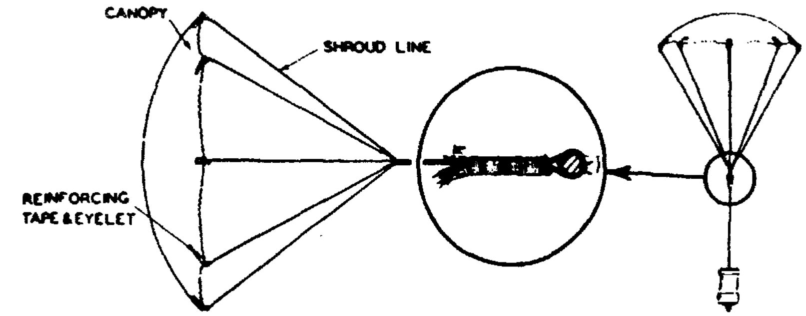

Figure 122a — SHELL, Illuminating, M83 — Parachute Assembly

Information as to the exact packing of the shell is not available at the present time. However, the complete round comes in separate units consisting of the shell body, ignition cartridge, and fin assembly.

SHELL, Illuminating, 60-mm, M83. The SHELL, illuminating, M83, was designed to provide a night light of relatively high candle power that could be fired from a standard infantry weapon. The SHELL, illuminating, M83, adequately fills the need, having 110,000 candle power, minimum, and burning for 25 seconds while drifting earthward on its parachute. The shell consists of the following components: fuze, body assembly, parachute assembly, illuminant assembly, fin assembly, propellant, and ignition cartridge.

Shell body. The body is constructed of a machined steel tube. It is cylindrical in shape with a tapered tail assembly and a nose assembly having its taper produced by the contour of the fuze. At the nose is a steel adapter spot welded and internally threaded so as to receive the Time Fuze M65. At the base of the cylindrical body is a coupling which serves to join the body to the tail assembly. The body is held to the coupling by means of four shear pins and Pettman cement. The tail assembly is held to the coupling by means of spot welding and Pettman cement,

The tail assembly consists of a cone to which is attached a fin adapter. The fin adapter is internally threaded to receive the fin assembly. The total weight of the shell completely assembled is approximately 3.8 pounds. Entire length of the fuzed shell is approximately 14.2 inches.

Parachute assembly. The parachute assembled in the illuminating shell is of sufficient size to permit the illuminant to burn 25 seconds while falling to the ground from a height of approximately 400 feet. The parachute assembly consists of a parachute canopy, tying cord, eight eyelets, eight shroud lines, reinforcing tape, and tying thread.

The parachute canopy is cut from Fortisian cloth, in the form of an octagon, having a width of 36 inches and pinked on the periphery. The canopy has a porosity of 225 cubic feet air per minute per square foot.

At each corner of the octagonal canopy, an eyelet is crimped into the cloth, the latter being first reinforced by sewing on a strip of cotton tape with nylon thread.

One end of each of the shroud lines is tied to an eyelet. The cords in each assembly are the same length, usually 31 inches. The lines are tied together with tying cord, at a point 27 inches distant from the eyelets.

The shrouds are run through the flare assembly loop and tied firmly back upon themselves with tying thread. The canopy is then folded according to specified directions and inserted in the parachute case.

After the illuminant assembly is inserted in the body tube, the suspension wire (to which the shroud lines are attached) is coiled in the bottom of the parachute case. The two hemicylindrical steel parachute spacers are fitted into the rear end of the body tube. They fit snugly against the inner wall of the tube and rest on the steel disc of the flare assembly. The two spacers form the cylindrical parachute case into which the chute is placed. The chute and the suspension wire are separated in the case by an onionskin paper separator.

Two chipboard parachute discs are forced into place against the walls of the spacers. A coupling disc is placed on the runs of the parachute spacers and the tail assembly is pressed into position, and the shear pins are inserted.

Illuminant assembly. The illuminant assembly is the functional part, the "heart" of the shell, and is carefully designed to insure its effectiveness. The assembly fits into the shell body, and its front face is in contact with the fuze. Its rear face is attached to the parachute assembly by means of a suspension wire. The illuminant assembly consists of a case, first fire charge, illuminant charge, priming charge, suspension wire, steel disc, quick match disc, top disc, plywood plug, quick match, top seal, spacer, quick match spacer, tying string, reinforcing band, and binding tape.

The quick match is in contact with the expelling charge of the fuze. The quick match leads through four alined holes in the steel quick match disc, hair felt quick match spacer, and top disc. The ends of the quick match, which is in two lengths, are exposed to the fuze; the middles, after passing through the four holes pass thru the priming charge.

The priming charge consists of a 0.055-ounce pellet of Army black powder that is located just above and in contact with the first fire charge. The first fire charge is 0.74-ounce pellet consisting of a mixture of 25 percent black powder and 75 percent illuminant com-

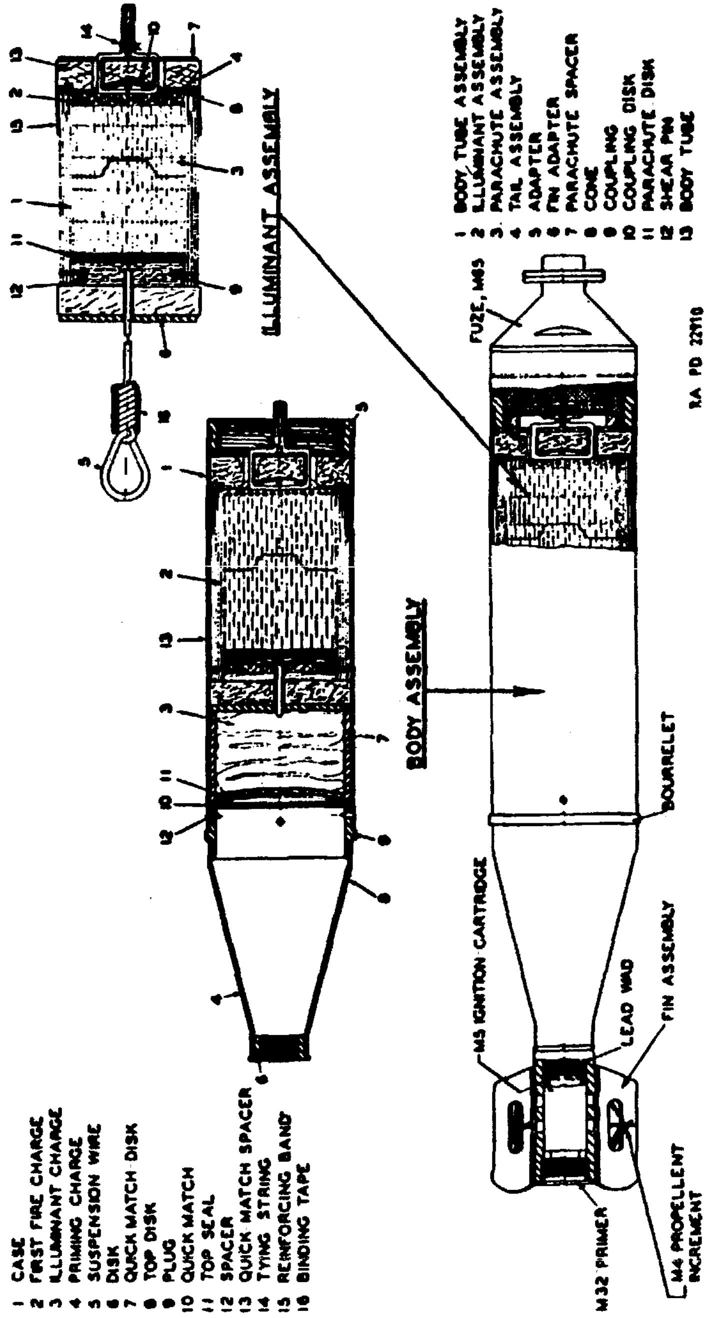

Figure 122b — SHELL, Illuminating, M83 — Body and Illuminant Assemblies position. Since the illuminant is difficult to ignite, the straight black powder priming charge and the partially black powder first fire charge are set up in series to insure ignition of the illuminant. The illuminant charge is just below the first fire charge and in contact with it.

The illuminant charge, which is pressed in two equal increments, weighs approximately 8.8 ounces, and has the following compositions:

	Percent
Barium nitrate	52.1
Sodium nitrate	10.4
Aluminum	26.0
Sodium oxalate	5.2
Sulfur	4.1
Castor oil	1.1
Linseed oil	1.1

The illuminant is ignited by the first fire composition and burns with a clear white light of 110,000 candle power, minimum, for 25 seconds minimum time. The illuminant (when the shell is in firing position) rests on a ⅛-inch thick top seal of fire clay. Just below the fire clay is a ⅜-inch thick plug of plywood, with a hole through its center.

All the components of the illuminant assembly mentioned previously with the exception of the quick match disc and a quick match spacer are within the illuminant case. The case is constructed of sheet box board ⅜ inch thick in the shape of a tube which will fit freely into the shell body. The quick match passes through four holes in the top disc. The disc serves as a cover for the case, after being glued and nailed into place. The fire clay top seal, illuminant, priming charge, and first fire charge are all shaped into discs to fit into the case. The quick match in passing through holes in the top disc and the quick match disc and spacer, anchors the latter two parts in place.

The suspension wire passes through the hole in the plywood plug, with the knotted end fitting flush in the pocket. The wire passes through alined holes in the hair felt spacer and steel disc. The steel disc forms the rest for the parachute spacer in the parachute case. The suspension wire from the surface of this disc to the end of the loop is approximately 11½ inches long. The loop is formed by wrapping the wire about itself and then binding with tape. The complete illuminant assembly slips freely into the shell case coming to rest against the fuze.

The top disc closing one end of the case is further sealed by the addition of a strip of crinoline that is pasted over the sides of the case and top disc.

The hair felt spacers serve to protect the illuminant charge against the sudden shocks of set-back and expulsion from the body tube. They

also assist in preventing the escape of expelling charge gases around the illuminant case.

Fin assembly. The fin assembly is the same as that assembled with the SHELL, H.E., M49A2.

Ignition cartridge. The ignition cartridge is the M5A1 previously described.

Primer. The primer is the M32 Percussion Primer previously described.

Propellent increments. The Propellent Increment M4 assembled with the illuminating shell are essentially the same as the Propellent Increment M3. The M4 Increments are composed of flake propellent powder, and each increment weighs 28 grains, which is less than the weight of the M3. Four increments are assembled with the illuminating shell, corners of the increments being wedged into the fin blade slots to hold them in place. An increment holder may be used with the illuminating shell to hold the propellent increments in place.

The percussion primer, ignition cartridge, and four increments comprise the full propelling charge; a total of 152 grains of powder.

Zone of fire and range. The shell is normally fired with the full complement of propellent increments. This fact and the fixed burning time of the fuze cause the shell to shear and the flare to commence to burn at a point at 800 yards range and 400 feet elevation. The parachute canopy controls the speed of descent so that the flare burns completely during its descent and no effect is lost by the flare burning on the ground.

Action. The cotter pin is removed from the fuze and the round is dropped down the bore of the mortar. The round is propelled from the mortar in the same manner as the H.E. shell, the propellent gases being confined by the bourrelet. Set-back causes the fuze to function in the manner described in pages 314 to 318. Ignition of the expelling charge in the fuze has two functions. First, to ignite the quick match; and second, to expel the flare assembly. The latter is accomplished by the expelling charge gases acting forcibly against the steel quick match disc. The shock caused by these gases is transmitted to the shear pins that hold the body tube to the tail assembling coupling. These pins are sheared and the flare assembly is expelled from the body tube. The tail assembly, the fuze, and the body tube fall free.

As the flare assembly (designation of the parachute assembly and the illuminant assembly together) is forced out of the case, the two parachute spacers fall free as do the coupling and parachute discs. The parachute spacers guide the ejection of the chute from the core, and when they fall free the parachute unfolds and checks the descent of the illuminant case. The flame from the expelling charge ignites the quick match, which in turn ignites the primer charge. As the quick

AMMUNITION INSPECTION GUIDE

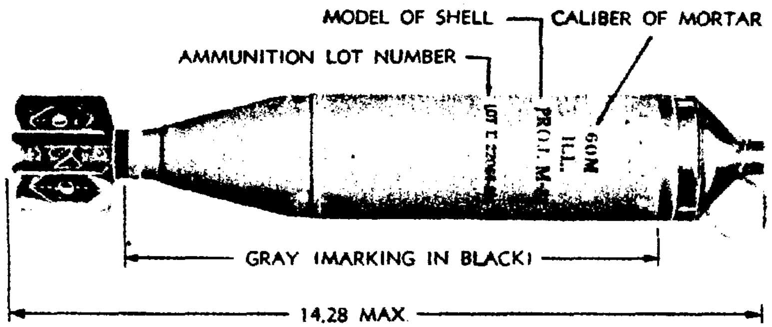

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Figure 122c — SHELL, Illuminating, M83 — Marking Diagram

match burns through the holes in the quick match disc, and the quick match spacer disintegrates, the two components fall free.

The primer charge ignites the first fire charge, and the latter ignites the illuminant charge. The burning of the illuminant ignites the illuminant case, but the case being in several thicknesses, burns at the same rate as the illuminant and is able to support the charge for its period of burning. The fire clay prevents the flame of the burning illuminant from igniting the shroud lines, during the period of descent.

Marking and packing. The shell body is painted gray with black stencil. The shell is shipped as a complete assembled round. One round is packed per individual fiber container, six individual fiber containers per large outer fiber container, three large outer containers (18 rounds) per bundle. One bundle per chocolate-stained wooden crate for overseas shipment.

FUZE, Time, (Fixed) M65. The Time Fuze (Fixed) M65 is assembled to the SHELL, illuminating, M83. It is a simple powder time-train fuze whose burning time is fixed. The fuze consists of a body assembly, a time train ring assembly, a head assembly, and a primer assembly.

Body assembly. The body is alumimum alloy die cast to the shape illustrated in figure 123. The upper projection is threaded to receive the head, and a recess is drilled to seat the primer. This recess narrows, and is met at right angles by a hole drilled through the walls of the time-train recess. The continuation of the primer recess and the hole which meets it, form the flash vent for the primer flame. The surface of the base on which the time-train may rest is cut with eight annular grooves. Glued to this grooved surface is a cloth washer. In the rear face of the body, a recess is formed for the expelling charge. The lower edge of this recess is threaded to receive the steel ex-

SMALL ARMS AND TRENCH WARFARE

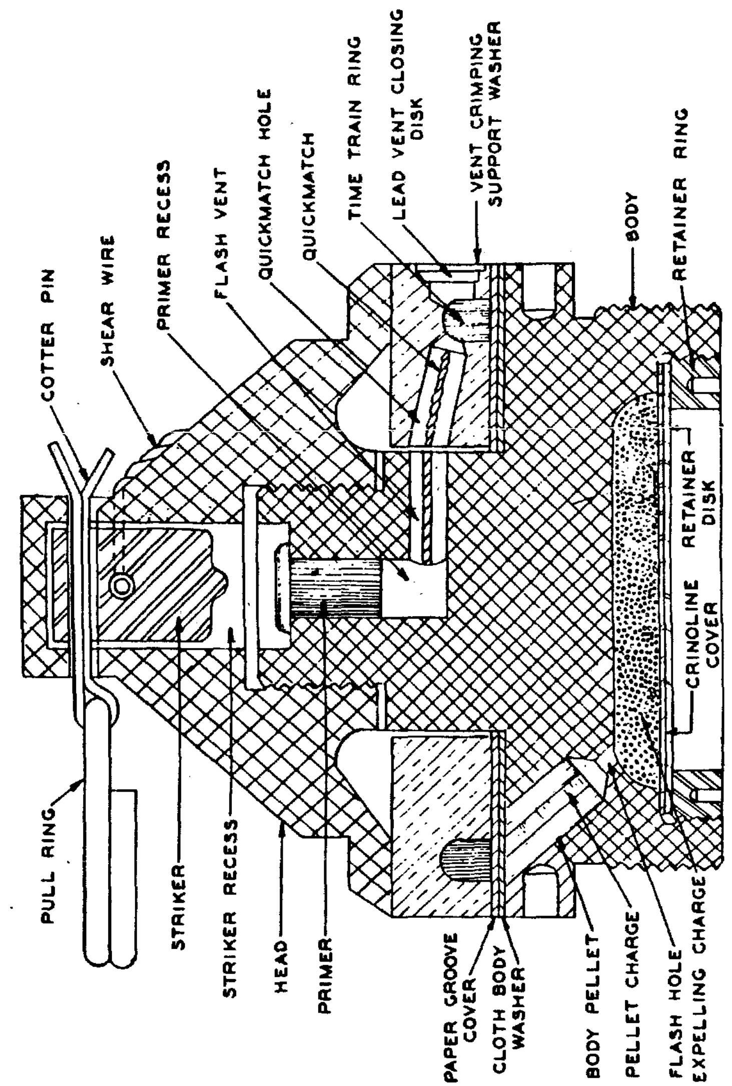

Figure 123 — FUZE, Time (Fixed), M65

pelling charge retainer-ring that holds the steel expelling charge retainer-disc and crinoline against the expelling charge. Leading from the surface of the time-train ring recess base to the expelling charge recess is a hole. It is drilled at a 45-degree angle to the surface of the time-train ring recess base. The upper or larger section houses the body pellet; the lower section is empty, and is the flash hole proper. A final hole is drilled normal to the surface of the time-train ring base. In this hole is seated a brass locating pin that fits into a hole in the time-train ring, thus properly locating the ring in the final assembly.

Time-train ring assembly. The time-train is essentially a large thick washer that fits over the upper projection of the body and rests on the fuze cloth-covered surface of the time-train ring recess base. The time ring is made of brass. In the lower surface of the ring is an annular groove interrupted by a brass plug. The black powder time-train ring (groove charge) is housed in this groove. Leading into the groove from the inner wall of the ring is a hole. This hole is a continuation of the primer flash vent in the head and houses a length of quick match. Drilled from the outer wall of the ring and meeting the annular groove at the ignition of the quick match hole and similar groove hole is another hole. This hole is closed by a lead vent closing disc and vent crimping support washer. The disc melts on ignition of time-train charge and permits the combustion gases to escape. An onionskin paper groove cover is shellacked to the lower surface of the ring.

Head assembly. The head made of aluminum alloy has two functions: first, to house the striker; second, to hold the time-train ring securely in place. The striker is housed in a recess in the top of the head. Passing through the head and striker, is a removable cotter pin and pull ring. Also passing through the striker and head is a shear wire. The inner recess of the head is threaded to receive the projection on the body. An outer flange rests on top of the time-train ring, and, when the head is tightened, holds the ring firmly in place.

Explosive components. A primer which is the standard Mk. V Primer is used in this fuze. In the flash vent of the time-train ring is housed a ¼-inch length of quick match that transmits the primer flame to the groove charge. The groove charge is approximately 60 grains of fuze powder, black powder of a very fine texture. It provides a time delay of approximately 14 seconds. The body pellet which leads from the ring to the expelling charge consists of approximately 5.2 grains of black pellet powder. The body pellet has a core, the pellet charge, which consists of approximately 0.02 grains of nitrocellulose. The expelling charge consists of 40 grains of black powder.

COMPLETE ROUND CHART FOR 60-MM TRENCH MORTAR WEAPONS

Complete Round Designation	Filler	Fuze	Propellent Increment	Percussion Primer	Ignition Cartridge	Packing	Status
SHELL, H.E., M49A2	TNT	P.D. M52	140 grains (4 incr—M3)	M32	M5A1	Fuzed	S & M
SHELL, practice, M50A2	Inert Mat'l B.P. Pellet	P.D. M52	140 grains (4 incr—M3)	M32	M5A1	Fuzed	S & M
SHELL, training, M69	....	....	....	....	M4	....	S & M
SHELL, illuminating, M83	Flare Composition	Time M65	112 grains (4 incr—M4)	M32	M5A1	Fuzed	S & M

Function. The cotter pin is removed prior to dropping the round down the bore of the mortar. The shear wire retains the striker in its normal position. The sudden forward motion of the round being fired causes the striker, through set-back, to shear the wire and move to the rear. The firing pin of the striker functions the primer. The flame from the primer ignites the quick match in the time-train ring flash hole. The quick match in turn ignites the time-train ring groove charge. The groove charge has a burning time of about 14 seconds. When the flame from the groove charge has completed its circle about the time-train ring, it ignites the body pellet of black powder and the pellet charge of nitrocellulose. This, in turn, ignites the expelling charge. The flame from the expelling charge passes to the rear through apertures in the expelling charge retainer disc. The fixed burning time of the fuze permits the round, fired with full increment charge, to be nearly at its optimum range and height when the fuze has completed its function.

Marking. On the circumferential flange just above the body threads of the fuze is stamped in small characters: "Time fuze, M65."

Packing. The fuze is packed assembled to the round.

Safety precautions. The cotter pin must only be removed immediately before the round is placed in the mortar.

FURTHER REFERENCES: TM 9-1900, Ammunition in General; OS 9-18, Ammunition in General; The Ordnance Sergeant; TR 1350-3A, 3-inch Trench Mortar Ammunition; FM 23-90 Basic Field Manual, 81-mm Mortar M1; SNL R-4 Parts 1 and 2; Complete Round Chart No. 5981; O.O. 7224, Ordnance Safety Manual Elements of Ordnance, Hayes; Ordnance Drawings; Picatinny Text, Vol. III; Ammunition for 60-mm and 81-mm Mortars, Savanna Section, Ordnance School.

SECTION VI.

ARTILLERY AMMUNITION

Chapter 1

Introduction to Artillery Fuzes

GENERAL.

An artillery fuze is a mechanism or device by which the explosion of a projectile is governed to cause the explosion at a certain time, or only under certain conditions.

Historical. Fuzes as originally used in spherical projectiles were "time" or "concussion" fuzes. The oldest form of time fuze was a piece of "fuze" or "slow match." This was followed by a wooden fuze forced into the opening in the shot containing a compressed black powder charge which was ignited by the blast of the gun. When burned down to the end it spit through an opening into the burster charge, and exploded the projectile. The wooden fuze was cut off or pierced along its length to fix the time of burning. In later developments, metal cases were substituted, but the principles involved were the same.

In a concussion fuze, an inflammable composition was ignited on discharge of the gun, and on impact the flame was admitted to the burster charge. The contrivances used were glass tubes, plaster of Paris tubes, or zinc tubes which when heated by the burning powder inside would break off on impact. Due to the fact that a spherical projectile would strike at any point on its surface, percussion (impact) fuzes did not operate satisfactorily, though tried in many forms.

The discovery of mercury fulminate in 1799 afforded a means of attaining a percussion fuze. Even so, early attempts to produce this type of fuze were unsuccessful. In one type developed during this period, three distinct double-ended plungers were used with their axes perpendicular to each other. The plunger whose axis was in line on impact, was arranged to strike a fulminate composition. The plungers were held in place during flight by copper shear wires. Some 50 years after the discovery of mercury fulminate, a fairly satisfactory percussion fuze was developed; this was the Pettman fuze. In this type, a roughened ball covered with a detonating composition was released by the discharge of the piece. When the shell struck any object, the ball was thrown against the interior walls of the fuze, thereby exploding the composition and, consequently, the bursting charge of the shell.

The introduction of rifled guns and elongated projectiles eliminated a great deal of the trouble with percussion fuzes. As the projectile then struck point foremost, the use of a plunger striking a cap on impact was made possible.

A further development of projectiles, the use of high-explosive bursting charges, made necessary the development of detonating fuzes and of delay action features. World War I fuzes of these types were satisfactory, in general, for the purpose of detonating or exploding the bursting charge at the time and under the circumstances desired; however, safety devices were not sufficiently refined to insure complete safety against premature action in transportation and loading, and during travel through the bore of the piece.

Another serious disadvantage of World War I types of detonating fuzes was the fact that they could not be set at will for super-quick or delay action. This necessitated carrying a supply of all types in the field.

Also, experiences during World War I indicated that science and engineering, as applied to the art of warfare, had advanced to such a degree that the system employed in fuzing our projectiles was inadequate to meet the requirements imposed on those same components. The changes made since the time of World War I have been mostly in the nature of improvement in safety features and of providing selectivity of action so that supply disadvantages have become eased.

CLASSIFICATION.

Fuzes are grouped according to the:

1. Assembled position in the projectile.

2. Action of functioning.

Following is a classification of those fuzes in use in present day artillery ammunition:

Assembled in Point.

Time Fuzes.
- Powder
- Mechanical

Combination Fuzes.
- Time and impact

Impact Fuzes.
- Superquick
- Supersensitive
- Instantaneous
- Delay
- Selective

Assembled in Base.

Impact.
- Nondelay
- Delay

DEFINITIONS.

The following is the definition of terms as applied to artillery fuzes:

Superquick, Instantaneous, and Nondelay. These fuze actions are designed to burst the shell promptly on impact and before it has penetrated. Very little crater effect will be obtained from these types. They are used where the target to be demolished is above the ground, such as wire and personnel.

NOTE: These actions differ from each other as follows:

1. Superquick is the fastest of the three actions.

2. Instantaneous is slightly slower in action than superquick, principally because of the several metal impedances which must be blown through by the elements of the explosive train.

3. Nondelay is the slowest of the three actions because the firing pin or striker is not acted upon directly on impact but is driven forward by its own inertia usually overcoming spring tension in its forward movement.

Supersensitive. This fuze action is designed to burst the shell promptly on impact against a light target, such as an airplane wing.

Delay. This fuze action is designed to burst the shell shortly after impact. It is used where it is desired to obtain penetration, and also against personnel. When used against personnel, the round is fired so that ricochet action is obtained. NOTE: In point delay actions, we generally find the delay present as a short delay of 0.05 seconds or as a long delay of 0.15 seconds. In base delay actions, we find the delay as both short and long delays, and also in other lengths. The length of the delay used is determined by the requirement imposed upon the fuze.

Time. This fuze action is designed to burst the shell at some predetermined time after the projectile leaves the cannon. It is used against personnel and aircraft, and in barrages. The time action may be obtained through a mechanical clock work mechanism as in modern fuzes, or through the burning of a black powder train.

Combination. This action as its name implies combines both a time action and an impact action (such as "time and superquick") in one and the same fuze.

Selective. This action as contrasted with the above, combines two or more impact actions (such as "superquick and short delay") in one and the same fuze.

FORCES AVAILABLE TO CAUSE ARTILLERY FUZE FUNCTION.

These following forces, their causes, and their effects are fundamental to the firing of any artillery weapon and the full trajectory of its projectiles.

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Chamber Pressure. This force results from the burning of the propelling charge and the confinement of the resultant gases in the chamber of the weapon. This force, of course, is responsible for the others which follow in that it causes movement of the projectile. (The fuzes discussed in this text do not use this force to directly cause some part of this action even though it is used directly by other countries.)

Set-back Force. This force results from the linear acceleration imparted to the projectile when the weapon is fired. It has the effect of causing objects within a fuze, which are free to move, to move toward the rear or base of the fuze. It persists throughout the travel of the projectile in the bore of the weapon.

Centrifugal Force. This force results from the rotation of the projectile during flight. It has the effect of causing objects within the fuze, which are free to move, to move away from the central axis of the fuze toward its periphery. This force, however, is not felt until the projectile has left the bore of the weapon, since frictional forces resulting from set-back force overcome it until that time.

Creep Force. This force results from the gradual retardation of the projectile due to air resistance encountered during flight. It has the effect of causing objects within the fuze, which are free to move, to move slowly (to creep) forward toward the nose or head of the fuze.

Impact Force. This force results from the sudden retardation of the projectile upon striking the target. It has the effect of causing objects within the fuze, which are free to move, to move violently forward toward the nose or head of the fuze. It may also act directly on one or more elements of the fuze.

SAFETY.

As previously stated, a major factor in the development of fuzes since World War I has been the addition and improvement of safety features. An important consideration in regard to safety in artillery fuzes is known as boresafety (detonator safety). Boresafety cannot be considered in regard to the fuze alone. All elements of the high-explosive train of a round must be considered.

Definition of Boresafety. A projectile may be said to be boresafe when all of its detonating elements are positively separated from the booster by some form of interruption while in the bore of the weapon.

SUMMARY.

Proper functioning of projectiles depends upon accurate and efficient fuzes. A fuze is but a small part of a complete round, yet the value of the round is lost unless the projectile can be made to function at the time and place desired. It may be said that fuzes, more than any other one item, have been responsible for the ever increasing effectiveness of artillery.

FURTHER REFERENCES: Picatinny Text, Vol. II; OS 9-18, Vol. II; OS 9-20, Vol. I.

Chapter 2

20-mm Ammunition

GENERAL.

The use of 20-mm ammunition against aircraft has been very significant in World War II. The Mk. II and Mk. IV Guns, commonly referred to as "Oerlikon guns," used for antiaircraft firing by the Navy have given outstanding performance and may be adopted by the Army. The present use of 20-mm ammunition by the Army is in Guns M1 and M2 which are mounted in aircraft. M1 and M2 Gun ammunition is also fired in the British Hispano gun mounted in aircraft. All 20-mm ammunition is of the fixed class, the cartridge case containing the propellant and primer is crimped rigidly to the projectile. The complete round is loaded into the weapon as a unit.

Weapons. The 20-mm M1, AN-M2, and Hispano guns are mounted for firing through the propeller hubs, or from fixed mounts in the wings of aircraft. They are capable of delivering fire at the rate of 600-700 rounds per minute. The guns are fed from either a 60-round drum-type magazine, or from disintegrating link belts similar to those used for machine gun ammunition.

Types of Ammunition. Types of ammunition authorized for use in the M1, AN-M2, and Hispano guns are:

H.E.-I (High-explosive-incendiary)
Ball AP-T (armor-piercing with tracer)

All types are standard for issue and manufacture.

CARTRIDGE, H.E.-I, MK. I.

Complete Round. The CARTRIDGE, H.E.-I, Mk. I, w/FUZE, percussion, D.A., No. 253 Mk. I /A/, was adopted from the British in 1941. Little modification has followed except in the redesign of the cartridge case and primer. The fuzed projectile remains the same as may be sensed from the adopted British nomenclature. (/A/ is the British symbol for shell used in aircraft mounted guns.) The car-

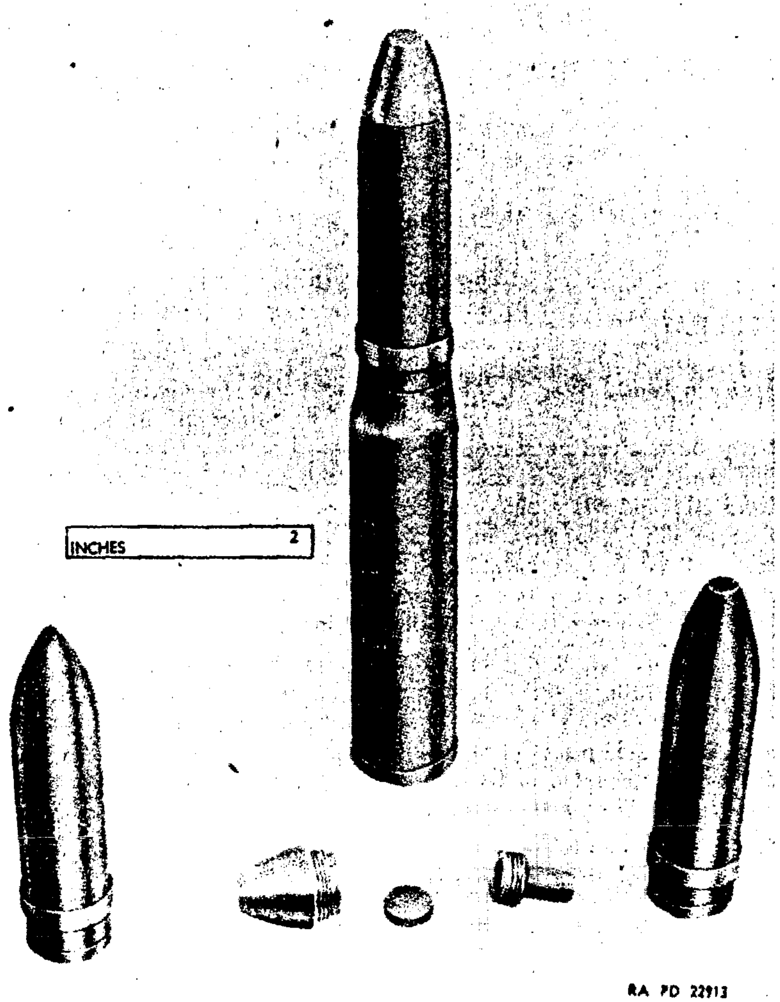

Figure 124 — Ammunition for 20-mm Guns M1, AN-M2, and British Hispano/A/ (Aircraft)

tridge is fired from aircraft guns against aircraft, primarily, although it may be directed against light ground targets and personnel. The complete round consists of the cartridge case, primer, propellant, and the projectile with its fuze and high-explosive-incendiary charge. It is 7.19 inches long, and weighs 0.57 pound.

Cartridge Cases. There are three cases used with this round:

Cartridge case M21A1. This is the standard cartridge case. It is made of cartridge brass and is very similar in appearance to cal. .50 small-arms cases.

Cartridge case M21A1B1. This case is "Substitute Standard." It is identical to the M21A1 except that it is made of steel and has a deeper extracting groove machined in the head. The "B1" designation on cartridge cases refers to steel as a substitute for cartridge brass.

Cartridge case M21. This case is "Limited Standard" and its manufacture has ceased. It differs from the M21A1 Case in that its primer recess is machined to receive the M37 (Berdan) Primer. In this type of primer, the anvil is not a component of the primer, but is a part of the cartridge case. The case also has two flash vents instead of the single vent found in the M21A1.

Primers. The PRIMER, percussion, M36, is standard for assembly in Cartridge Cases M21A1 and M21A1B1. It is the American type of primer with the anvil included. The primer consists of a brass primer cup, a strip brass anvil, a foiling paper cover, and a primer mixture of 2.1 grains. The primer is press fit into the cartridge case and is either staked with five equally spaced stab crimps, or is roll crimped in place.

The PRIMER, Berdan type, M37, is used with the M21 Cartridge Case. It differs from the American type primer in that it has no anvil. (The anvil is machined from the cartridge case.)

Propelling Charge. The standard propellant for the H.E.-I round is FNH (flashless and nonhygroscopic) powder, type II. Approximately 0.07 pound is poured loosely into the cartridge case.

Projectile. The projectile is made of cold-drawn steel and two recesses are machined into the body; one to receive a copper or gilding metal rotating band, the other is the cannelure into which the cartridge case is crimped. The cartridge case is crimped to the projectile with a minimum of four stab crimps or a continuous crimp. The thickness of the body at the base is only 0.15 inch, and to prevent a premature explosion a base cover is added. This cover is secured by a continuous resistance weld entirely around the edge. If the base cover were not used, there is a possibility that the propelling charge would initiate the explosive filler through flaws or cracks

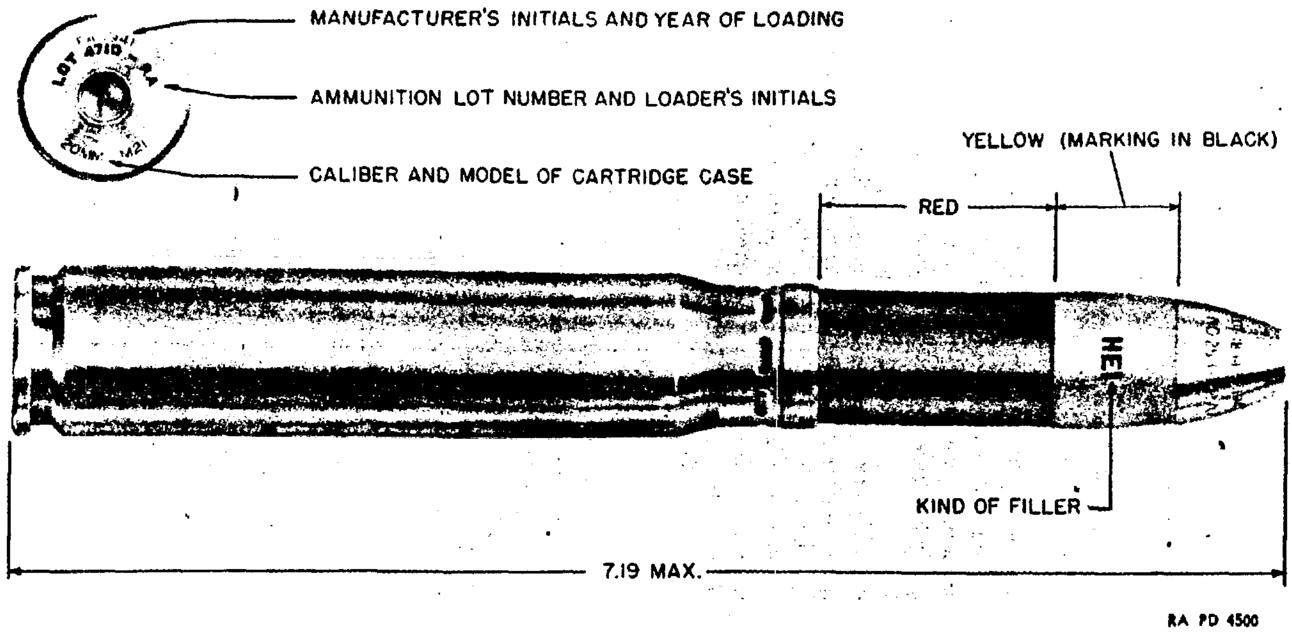

Figure 125 — 20-mm Cartridge, H.E.-I, Mk. I

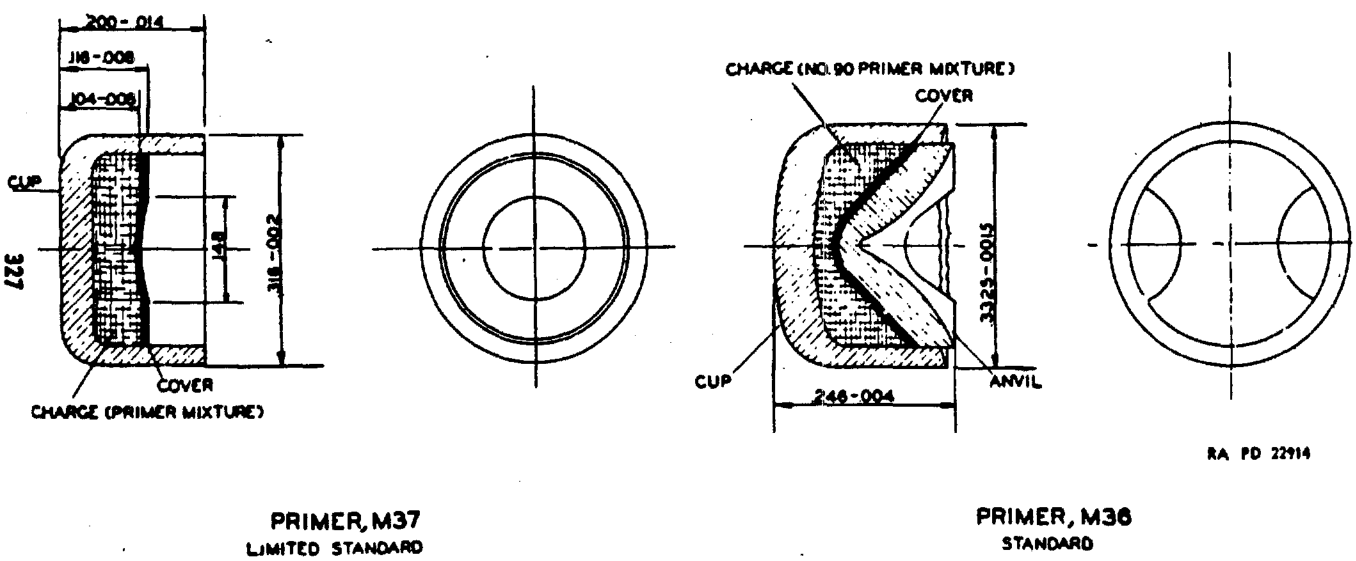

Figure 126 — 20-mm Primers

in the base of the shell. The projectile has a radius of ogive of 2.56 inches.

The filler for the projectile is high-explosive incendiary in nature, and weighs 175.2 grains. Details on the filler are classed as confidential at this time.

Fuze. The FUZE, percussion, D.A., No. 253 Mk. I /A/, is made of brass, and is streamlined to continue the ogive of the projectile. It is designed to function after the projectile has entered the plane, but before it penetrates the opposite wall. The projectile will thus burst inside of the cockpit of the plane, for example, where the fragments and incendiary bursting charge will be most effective. The fuze is not boresafe since there is no positive separation between the detonator and the booster. It is threaded into the projectile and secured with either three equally-spaced stab crimps or Pettman cement. Further details of the construction and function of the fuze are not available for publication at this time.

Identification. From the rearmost portion of the bourrelet forward, the surface of the projectile is painted yellow, with the letters "HEI," indicating the type of filler, stencilled in black. The remainder of the projectile, as far as the rotating band, is painted red.

CARTRIDGE, AP-T, M75.

Complete Round. This cartridge is used primarily from aircraft against the armored parts of other aircraft, and may also be used against lightly armored ground and sea-borne targets. The complete round is 7.22 inches long, and weighs 0.639 pound.

Cartridge Cases and Primers. M21A1, "Standard," M21A1B1, "Substitute Standard," or M21, "Limited Standard" cartridge cases with the appropriate primers may be used with this round (cartridge cases, page 325, and primers, page 325).

Propelling Charge. 0.066 pound of FNH powder, type II is poured loosely into the cartridge case.

Projectile. The projectile is machined from cold-drawn bar steel. A recess for seating the rotating band and a cannelure to receive the cartridge case crimps are cut into the projectile. The radius of ogive is 1.875 inches except for the very tip which is rounded giving it a blunted appearance. There is a cavity machined into the base to receive a tracer.

Tracer. The "T" in the nomenclature of this round stands for tracer mixture which is charged into the cavity in the base of the projectile. After the tracer charge is loaded, it is sealed by the assembly of a celluloid closing cup held in place by an adhesive compound.

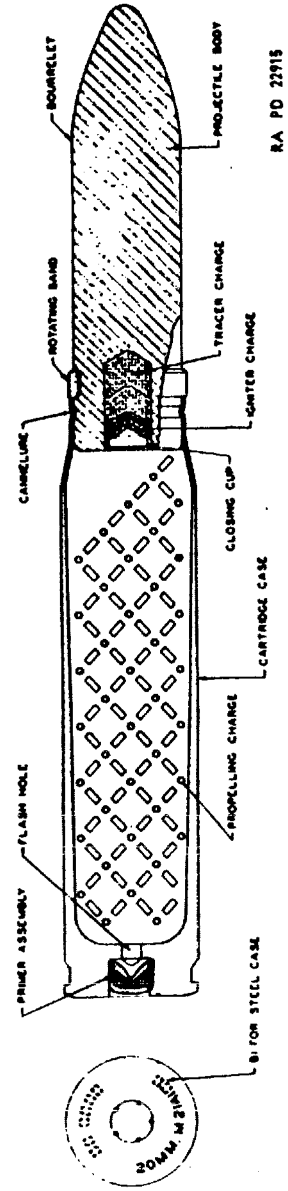

Figure 127 — 20-mm Cartridge, AP-T, M75

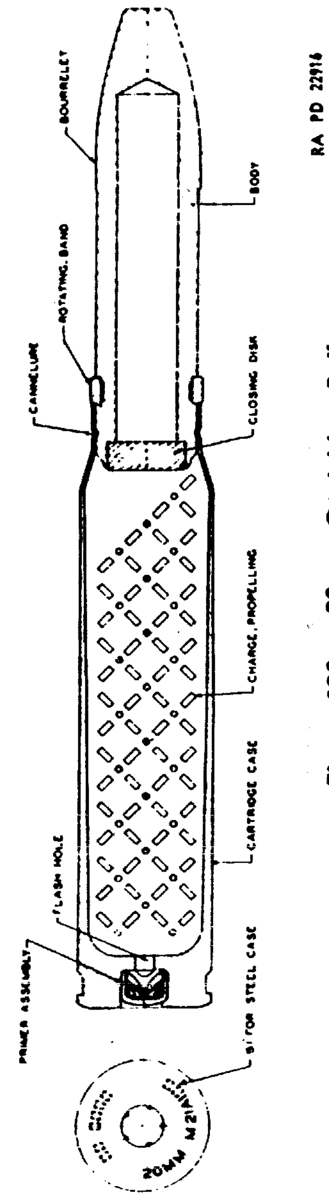

Figure 128 — 20-mm Cartridge, Ball

The heat from the propellant ignites the closing disc which in turn starts the tracer mixture burning.

The purpose of the tracer is to make a portion of the flight of the projectile visible so that the gunner may correct the line of fire and find the target.

Identification. The projectile is solid except for the tracer cavity, and the nose is slightly rounded. It is painted with black lacquer enamel excepting the rotating band which must remain clean.

CARTRIDGE, BALL.

Complete Round. The CARTRIDGE, ball, was designed to simulate the H.E.-I Mk. I for practice firing purposes. Since the projectile is cheap and easy to manufacture, its use for practice firing is economical. As indicated by the nomenclature, the round has lately been adopted for actual combat fire. The ballistics and effectiveness of the round in the field have warranted its manufacture and issue for combat. The complete round is 7.23 inches long and weighs 0.56 pound.

Cartridge Cases and Primers. M21A1, M21A1B1, or M21 Cartridge Cases with appropriate primers, are used (cartridge cases, page 325, and primers, page 325).

Propelling Charge. 0.07 pound of FNH powder is held loosely in the cartridge case.

Projectile. The projectile is machined from bar steel with a recess for a copper rotating band and a cannelure for securing the cartridge case. A cavity extending from the rear to about seven-eighths the length of the projectile brings it to the desired weight. A steel closing disc is fitted into the base. The nose of the projectile has an ogive radius of 2.56 inches. The nose appears to have been cut off squarely about 1/4 inch from the tip. No tracer is incorporated.

Identification. The entire projectile except for the rotating band is painted black. The cut-off nose and the lack of any identifying marking on the projectile body serves to differentiate between the ball and the AP round.

PACKING.

The three complete rounds for the 20-mm Automatic Guns, M1, AN-M2, and British Hispano /A/, are packed similarly. Ten rounds are packed in a heavy chipboard carton. The carton is in two parts, the cartridges are placed nose down in two vertical rows of five in the bottom part, and covered with the upper part, which is labeled and glued in place. Twelve of these cartons, making a total of 120 rounds, are placed in a metal-lined wooden box.

Detailed packing data may be obtained from ordnance drawings. The numbers of these drawings may be found under packing data for 20-mm ammunition in SNL R-1, Part 2.

FURTHER REFERENCES: OS 9-20, Vol. II; SNL R-1; Ordnance Drawings; Complete Round Chart No. 5981.

Chapter 3

37-mm Ammunition

GENERAL.

Types of 37-mm Guns. There are six different 37-mm guns in standard use, each one serves a specific purpose.

The 37-mm Gun M1916, while formerly used for infantry support as a field weapon, is now used primarily as subcaliber equipment for larger guns. Its only combat use is when firing the H.E. round, Mk.II, which is used as a substitute for armor-piercing shot.

The 37-mm Gun M1A2 is used for antiaircraft defense.

The 37-mm Guns M3 and M3A1 are mobile weapons for antitank use.

The 37-mm Automatic Gun M4 is mounted in aircraft.

The 37-mm Guns M5 and M6 are usually mounted in tanks.

Types of Ammunition. Each gun, except the M1916, is furnished a variety of types of ammunition so that the weapon may be fired against personnel, general targets, armor plate, or in target practice. Accordingly, there is a high-explosive, an armor-piercing and a target-practice round for each weapon except the M1916. The tank and antitank guns are also provided with canister ammunition.

Primers. The PRIMER, percussion, 20 grain, M23A2, is standard for all 37-mm rounds being manufactured at present. Primer M23A1 may be found in some rounds on hand for all guns, and some cartridge cases for the M1916 Field Gun ammunition may be primed with Primer Mk. IIA1.

PRIMER, percussion, 20-grain, Mk. IIA1. The Mk. IIA1 consists of a cartridge brass body machined with a slight taper for press-fitting into the cartridge case, a brass primer cup, a brass anvil, primer mixture, a foiling paper cover, and a charge of 20 grains of black powder sealed with a cardboard disc. The use of this primer was discontinued in 37-mm ammunition because the blow from the firing pin of the weapon was sufficient to puncture the primer cup. A part of the flame and gases from the priming mixture and primer charge were thus permitted to blow back through the primer cup instead of into the propelling charge.

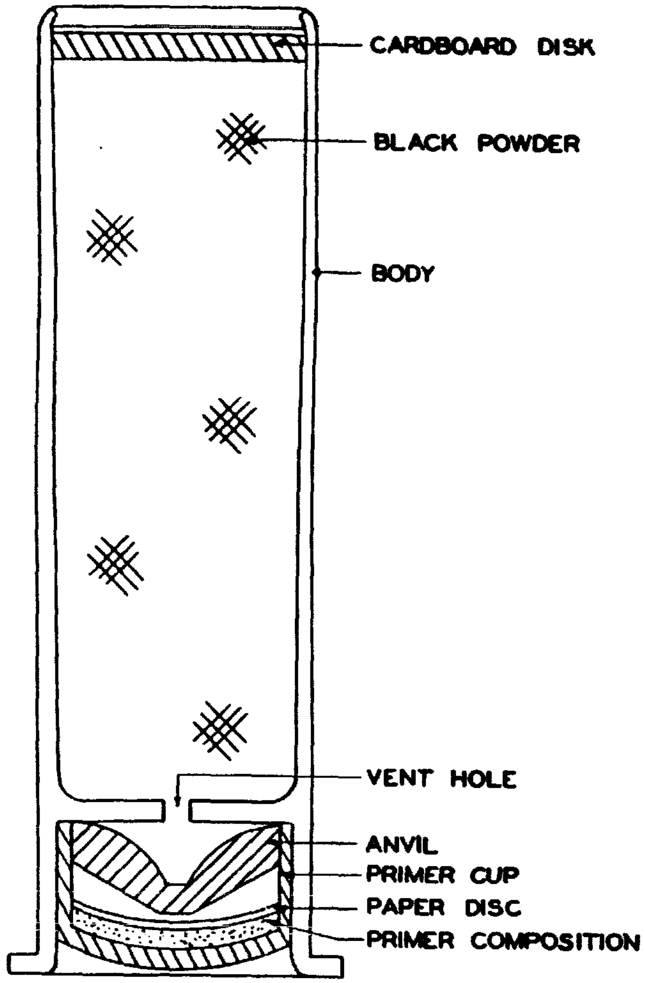

Figure 129 — 20-grain Percussion Primer Mk. IIA1

PRIMER, percussion, 20-grain, M23. This primer replaced the Mk. IIA1 for 37-mm weapons. The body is of entirely different design, being of greater diameter and of different shape. It is press-fit into the cartridge case as are all American made primers for fixed and semifixed ammunition. A soft metal auxiliary firing pin or firing plug was added to eliminate direct contact of the weapon firing pin with the primer cup. This assures that obturation (prevention of loss of gases) at the base will not be destroyed by piercing of the primer cup. A long rear sleeve extending from the bevel at the primer head

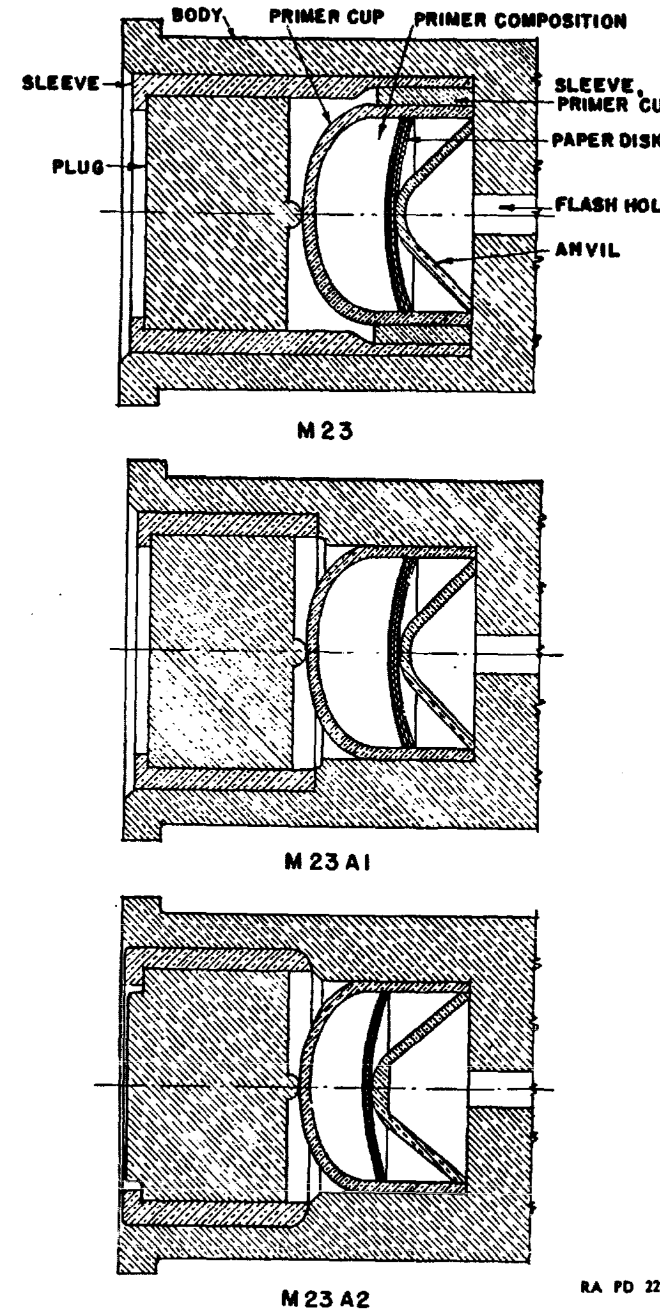

Figure 130 — Modifications of PRIMER, Percussion, 20-grain, M23

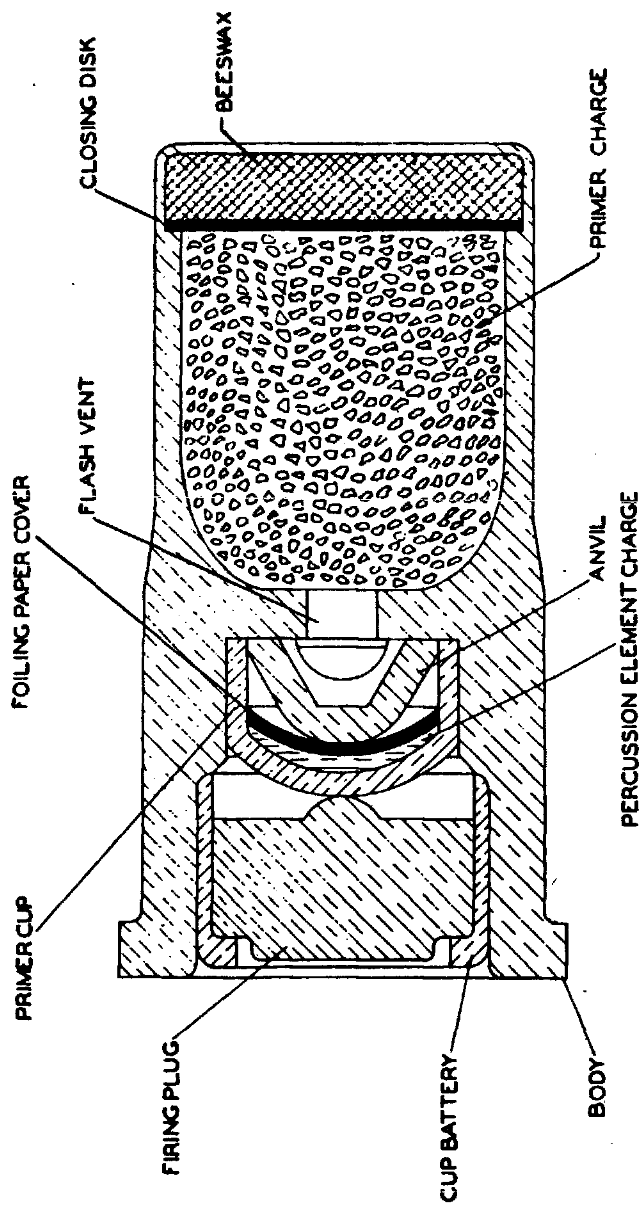

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Figure 131 — PRIMER, Percussion, M23A2

to the bottom of the cup cavity, and a shorter sleeve between this long sleeve and the primer cup were added to further aid obturation.

PRIMER, percussion, 20-grain, M23A1. The modification of the M23 to the M23A1 Primer consisted of shortening of the long rear sleeve and elimination of the primer cup sleeve. A rounded shoulder was also machined into the body between the rear sleeve and the primer cup cavity. These changes result in better obturation and insure the transmission of the force of the blow from the firing pin to the primer cup at a point just over the apex of the anvil, even if the primer is not in direct line with the firing pin.

PRIMER, percussion, 20-grain, M23A2. The A2 modification consists of a boss added to the firing plug which increases its thickness and reduces the number of misfires resulting from short firing pins. This primer is now standard for 37-mm ammunition.

When the firing pin of the gun strikes the firing plug of the primer, the blow is transmitted to the primer cup, indenting it and crushing the priming mixture against the anvil, causing the mixture to ignite. The flame from the explosion passes through the flash vent and ignites the black powder charge which in turn ignites the propellant.

Identification.

Cartridge cases. The best means of positively separating rounds for the various 37-mm guns is to compare their cartridge cases. The cartridge case for the M1916 Gun is the shortest of the lot with a length of 3.64 inches. The Aircraft Gun M4 requires a cartridge case 5.69 inches long. The Antiaircraft Weapon M1A2 and the Tank and Antitank Guns M3, M3A1, M5, and M6 all require cartridge cases 8.75 inches in length. The cartridge cases for the antiaircraft gun may be distinguished from those for the tank and antitank weapons by an extraction groove around the case just above the head. The antiaircraft gun has an automatic extractor device while the tank and antitank weapons are operated manually.

Projectiles. Differences in weapons also require variations in projectiles. For example, since the M4 (Aircraft) Gun is lighter than the M1A2 (Antiaircraft) Gun, the projectile of SHOT, AP, M80, is the same as the projectile of SHOT, AP, M74, only shorter and lighter in weight. Another instance is in the case of SHOT, A.P.C. (Armor-piercing-capped), M59, which is similar to SHOT, A.P.C. M51, except that the chambering mechanism of the M1A2 Gun requires that the windshield of the M51, for the M3, M3A1, M5 and M6 Guns, be omitted in the projectile for the antiaircraft gun.

Painting. In addition to being painted to prevent rust, all projectiles are colored to provide a ready means of identification as to type. The following color scheme applies to 37-mm projectiles as well as to artillery shell, in general, for the types included:

1. Black with white stencil. Armor-piercing, canister and drill (all inert).

2. Olive drab with yellow stencil. High-explosive.

3. Blue with white stencil. Practice.

4. Red with black stencil. Low-explosive.

Packing and Marking. Details of packing and marking will be most accurate if obtained from Standard Nomenclature Lists (SNL) R-1, Parts 1 and 2, and ordnance drawings. The numbers of complete round drawings will be found in SNL R-1, Part 2. Numbers of packing drawings will be found in SNL R-1, Part 2. Only very general details of packing and marking will be given in this text.

AMMUNITION FOR 37-MM GUN M1916.

General.

Weapon. With the introduction of armored vehicles during World War I, and the need for light supporting weapons for the infantry, it became necessary to develop a light field gun. As a result, the 37-mm Gun M1916, often referred to as the famous "one pounder," was adopted. Because of its low power, the gun is incapable of penetrating anything except very light armor plate (it will not penetrate 0.375 inch of good armor plate at 500 yards with the high-explosive shell), so today its use is limited. The weapon is used primarily as subcaliber equipment for larger guns, being standard for 75-mm, 155-mm guns and howitzers, and 105-mm howitzers. An oddity of this gun is that it is the only artillery piece in the service to have a left-hand twist of the lands and grooves.

Since the M1916 Gun is low powered as compared to other 37-mm guns, a smaller cartridge case and less propelling charge is used. A muzzle velocity of 1,276 feet per second is achieved with the high-explosive shell. The gun has no automatic feeding and extractor mechanism, but instead must be hand operated. The cartridge case, therefore, has only a flange for extraction and no groove as do most rounds for automatic weapons.

Types of ammunition. The age and success of the M1916 Gun resulted in the development of many types of rounds, as follows:

Type	Filler
Low-explosive	Black powder
Practice	Sand
High-explosive	TNT
Practice	Black powder
Canister	Lead balls
Blank	Black powder (old type) 10 Ga blank shotgun shell containing EC Blank powder (new type)
Drill	None

Only two rounds, H.E. Mk. II, and Practice Round Mk. IIA1 which stimulates the high-explosive round, are the standard for issue and manufacture. All other rounds are standard for issue only.

Cartridge cases. The Cartridge Case Mk. I, was the first used in the M1916 Field Gun. It is short as compared to other 37-mm cases, measuring 3.64 inches in length. The length of the neck and amount of shoulder is very slight, giving the case the appearance of a cylinder having almost straight sides and a flange at the base. The primer seat hole is of a size to receive only the Mk. IIA1, 20-grain, Percussion Primer.

To derive Cartridge Case Mk. IA1, the A1 modification of the Mk. I Cartridge Case consisted of reboring the primer seat hole of cartridge cases in the field to a larger diameter to receive the M23-series Primers.

The Mk. IA2 Cartridge Case is identical to the Mk. IA1 except that it is manufactured with a primer seat hole large enough to take the M23-series Primers.

SHELL, Fixed, L.E., Mk. I.

Complete round. The low-explosive round was the first ammunition adopted for the M1916 Gun. It was designed for use against personnel and light targets. It is now standard for issue only and is used for practice firing only.

Cartridge case and primer. This round will probably be found with the old Mk. I Cartridge Case primed with the Mk. IIA1 Primer, since its manufacture has been discontinued for some time (cartridge cases, page 337 and primers, page 331).

Propelling charge. Approximately 550 grains of FNH powder is poured loosely into the cartridge case. This is sufficient to give the projectile a muzzle velocity of 1,312 feet per second, a maximum range of 4,500 yards, and an effective range of 1,200 yards.

Projectile. The projectile is made of bar steel and is filled with .034 pound of black powder. It weighs approximately 1 pound. Since it is adapted for a base fuze, its nose is continued to a rounded point. The projectile is about 3.56 inches long and has a radius of ogive of approximately 2.25 calibers.

FUZE, base percussion, Mk. I. The construction of the Mk. I Fuze differs from the M38A1 Base-detonating Fuze (page 340) in that it has a shear pin rather than the plunger and resistance-ring arrangement. Also, as indicated by "percussion" in the nomenclature, it is an igniting fuze and its explosive train consists of priming mixture and black powder which ignites the black powder bursting charge. The M38A1 is a detonating fuze in which the explosive train consists of a detonator of priming mixture, lead azide and tetryl, and a booster of tetryl.

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Identification. The shell is painted red and stenciled in black (red indicates a low-explosive filler). Aside from the painting and marking, it can be positively identified as a round for the M1916 Gun by the length of its cartridge case (3.64 inches) which is more than 2 inches shorter than those for other 37-mm guns. The Low-explosive Round Mk. I may also be distinguished from the High-explosive Mk. II by its length. The Mk. II is .549 inch longer than the Mk. I. The Mk. I is 6.371 inches in length and weighs about 149 pounds.

SHELL, Fixed, Sand-loaded, Mk. I. The purpose of this round was to simulate the Low-explosive Mk. I, just discussed, for practice fire. The complete rounds are exactly the same except for the fact that the black powder and the live fuze of the low-explosive shell were replaced by sand and an inert fuze for practice work. The manufacturing and loading of the Sand-filled Projectile Mk. I have been discontinued, but, since a considerable number has been assembled for training purposes, they will be issued until the present supply is exhausted.

CANISTER, Fixed, M1.

Complete round. The Canister M1, was developed for the M1916 Gun. Its purpose was to spray personnel with lead balls at close range.

Cartridge cases and primers. Canister M1 will probably be found in the field assembled to Mk. IA1 Cartridge Case primed with M23A1 Primer. Some rounds may be found, however, with Mk. I Cartridge Cases and Mk. IIA1 Primers (cartridge cases, page 337, and primers, page 331).

Propelling charge. FNH powder contained loosely in the cartridge case.

Projectile. The canister is nothing more or less than a can filled with 38 lead balls. The case is provided with 3 longitudinal slots. A raised bead around the lower portion of the case stops the projectile from seating too far into the cartridge case. It should be noted that the projectile consists entirely of inert materials and does not require a fuze.

Function. When the gun is fired, the shock of discharge ruptures the case at the longitudinal slots, freeing the lead balls. The case bursts within 100 feet of the gun and the balls fan out into a cone-shaped pattern with a velocity almost equal to the muzzle velocity of the projectile which is about 1,276 feet per second. The penetration of wood, earth, or brick by the balls is very slight. The maximum effective range of canister against personnel is 75 yards.

Identification. The Canister M1 can be identified as a 37-mm M1916 Gun round by the length of the cartridge case. It may be

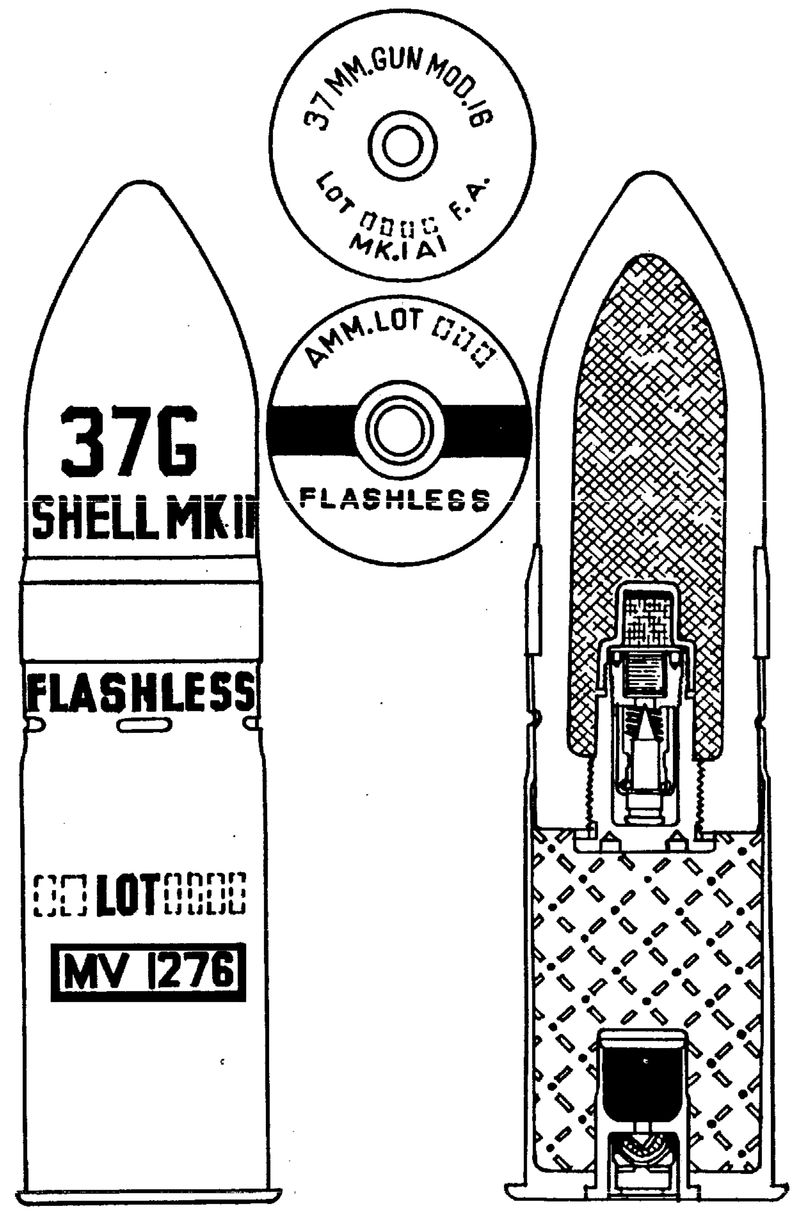

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Figure 132 — SHELL, H.E., Mk. II, for 37-mm Gun M1916

distinguished from other rounds by the can-like appearance of the projectile which is painted black (black painting indicates inert materiel).

SHELL, Fixed, H.E., Mk. II.

Complete round. The Mk. II High-explosive Shell is standard for issue and manufacture although it is not widely used for infantry support. It is only reasonably satisfactory as a substitute for armor-piercing shot against lightly armored targets since it will not penetrate .375 inch of good armor plate at 500 yards.

Cartridge cases and primers. The Mk. IA2 Cartridge Case with M23A2 Primer is standard for the high-explosive shell. However, older rounds may be found with the Mk. IA2 or Mk. IA1 Cartridge Case and M23A1 Primers, or possibly with Mk. I Cartridge Cases and Mk. IIA1 Primers (cartridge cases, page 337, and primers, page 331).

Propelling charge. Approximately 550 grains of FNH powder is poured loosely into the cartridge case.

Projectile. This shell is made of bar steel and has an explosive charge of 0.06 pounds of TNT. It is 4.45 inches long and has an ogive radius of 2.25 calibers. Since it is adapted for a base-detonating fuze, the nose is continued to a rounded point. The projectile is longer and has thinner walls than the low-explosive shell. The total weight of the projectile with fuze and bursting charge is about 1 pound.

FUZE, base-detonating, M38A1. The M38A1 Fuze is standard for the Mk. II Round. It is a typical nondelay fuze, being located in the base of the projectile and having no delay between the firing pin and the detonator. There is no positive separation between the detonating elements and the booster, so the fuze is not boresafe.

The fuze body is made of brass and forms a sleeve which contains the plunger assembly, restraining spring, and detonator assembly. A flange at the base prevents the fuze from being assembled flush with the base of the shell and provides enough thickness so that no base plate is required. The body has outside threads at the base for screwing into the projectile, outside threads at the top over which the closing cap is assembled, and inside threads at the top into which the detonator assembly holder is screwed. The plunger assembly consists of a firing pin, a resistance ring, and a sleeve. The sleeve is assembled over the resistance ring in such a manner that it will force the resistance ring over a shoulder and down into a groove at the base of the firing pin on set-back action. A restraining spring is interposed between the plunger assembly and detonator holder to restrain the firing pin during flight. The detonator holder containing the detonator assembly of priming mixture, lead azide, and tetryl is screwed into the fuze body directly over the firing pin. The closing cap con-

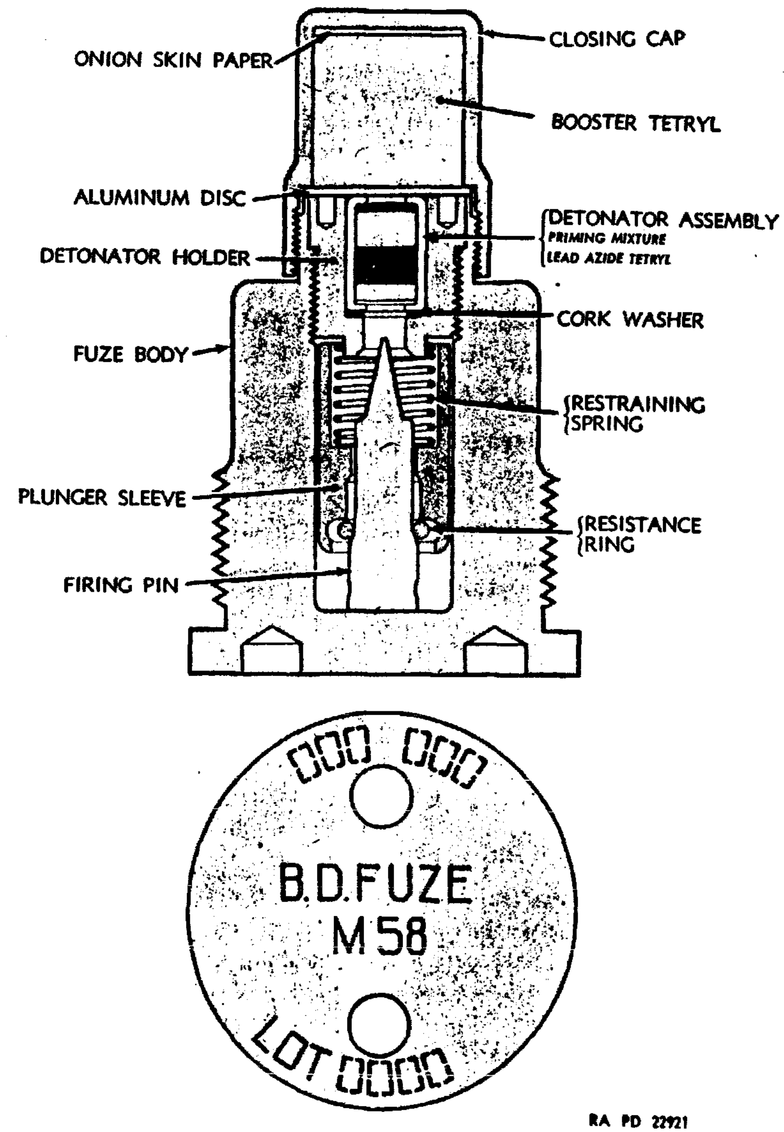

Figure 133 — FUZE, Base-detonating, M58

taining the booster pellet of tetryl then assembles over the outside threads at the top of the body. The booster pellet is separated from the detonator by a thin aluminum disc.

The function of the fuze begins when the projectile is propelled down the bore of the weapon. The set-back force caused by linear acceleration causes the plunger sleeve to force the resistance ring back over the shoulder into the groove at the base of the firing pin. This locks the plunger sleeve and firing pin together and leaves the point of the firing pin protruding far enough past the plunger sleeve head to penetrate the recess in the detonator holder and strike the priming mixture on impact. The plunger assembly is restrained from carrying the firing pin into the detonator during flight by a restraining spring. On impact, the firing pin is carried forward by inertia and initiates the explosive train of detonator consisting of priming mixture, lead azide and tetryl; booster of tetryl; and bursting charge of TNT.

FUZE, base detonating, M38. The M38 Fuze is limited standard for the High-explosive Mk. II Shell, having been replaced by its modification M38A1. The A1 modification was a change in the detonator assembly. The M38A1 contains priming mixture, lead azide, and tetryl in the detonator whereas the M38 Detonator is made up entirely of mercury fulminate. The M38 was designed, primarily, to replace the old Mk. IV Base-detonating Fuze which, when fired in conjunction with chamber pressures greater than 18,000 pounds per square inch, frequently prematured.

Identification. The complete round of SHELL, fixed, H.E., Mk. II, may be identified for the M1916 Gun by the length of the cartridge case (3.64 inches). The projectile is painted olive drab and is stenciled in yellow. (This painting and stenciling is common to ammunition loaded with high explosives.) Aside from painting and marking, the High-explosive Round Mk. II may be distinguished from the Low-explosive Round Mk. I by its length. The Mk. II is .549 inch longer than the Mk. I. The Complete Round Mk. II, is 6.92 inches long and weighs approximately 1.61 pounds.

SHELL, Fixed, Practice, Mk. II.

Complete round. This round was constructed to simulate the high-explosive shell for practice work. It is identical with the high-explosive round except that the bursting charge consists of 0.05 pound of black powder instead of 0.053 pound of TNT; and that FUZE, base-practice, M38 (a percussion type of fuze), is used instead of FUZE, base-detonating, M38A2. A percussion fuze is necessary to ignite the black powder charge. The Mk. II Practice Shell is standard for issue only, having been modified to Mk. IIA1.

The M38 Practice Fuze is similar to the M38A1. However, no booster is used so that the closing cap consists only of a threaded cup with a hole in the center which is closed with a paper disc. The

detonator assembly becomes an igniter assembly containing priming mixture and black powder.

The function of the two fuzes are the same until the force of impact when, in the practice M38, the firing pin strikes the priming mixture which ignites the black powder igniting charge. The flame from the igniting charge flashes through the paper covered hole in the closing cap and ignites the black powder filler of the practice shell.

Identification. The Mk. II Practice Shell can be identified as an M1916 Gun round by the length of the cartridge case (3.64 inches). It is painted blue with white stencil as is most practice ammunition. Aside from its painting and marking, it cannot be distingushed from the High-explosive Mk. II Round on visual inspection. The round would have to be broken down for complete identification if the painting and marking were obliterated.

SHELL, Fixed, Practice, Mk. IIA1. The A1 modification of the Mk. II Practice Shell was the addition of 15 percent colloidal graphite to the black powder charge. The Mk. II Practice Round could not be fired over personnel due to the possibility of premature explosion. The adding of colloidal graphite was for the purpose of eliminating this possibility of premature explosion of the bursting charge. The Mk. IIA1 is standard for issue and manufacture since it is widely used with subcaliber mounts.

CARTRIDGE, Drill, M5. Drill cartridges are used to train troops in handling ammunition and in loading and unloading weapons. The drill cartridge is entirely inert being assembled from inert components of 37-mm Gun M1916 ammunition. The drill round may be identified by holes drilled through the cartridge case and through the projectile to show that both are empty. The projectile is also painted black to show that it is inert.

Blank Ammunition.

Old type. Typical blank ammunition of the old type is made up of 37-mm Cartridge Case Mk. I, Mk. IA1 or Mk. IA2 with appropriate primer; a cylindrically-shaped charge of black powder inclosed in a silk bag or moistureproof cellophane bag with a hole in the center for fitting over the primer; a cardboard wad for holding the black powder charge in place; and a paper closing cup sealed with Pettman cement.

New type. The new type of blank ammunition for 37-mm guns consists of the appropriate cartridge case adapted at either end for a central tube which is of a size to seat a 10-gage blank shotgun shell. This 10-gage blank shell (correct nomenclature is Cartridge, blank, 10-gage) is fired when the firing pin of the weapon strikes its primer. The blank round for the M1916 Gun consists of the Adapter M1

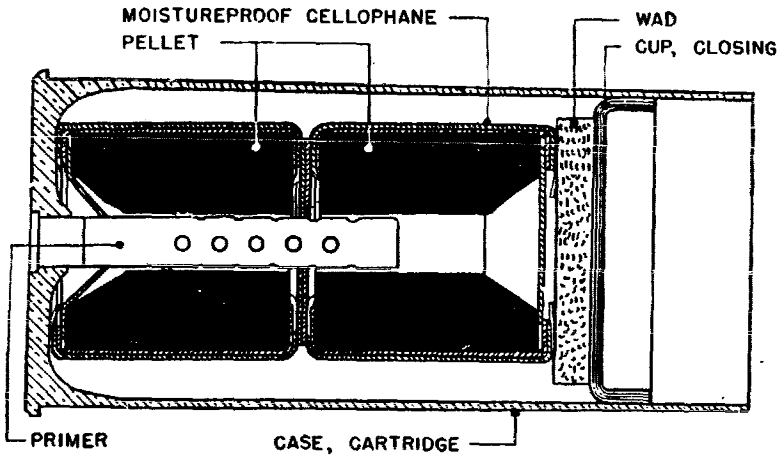

Figure 134 — Blank Ammunition (Typical)

(Mk. I, Mk. IA1 or Mk. IA2 Cartridge Case with tube for adaptation to 10-gage shotgun shell) and 10-gage blank cartridge.

Packing. Ammunition for the 37-mm Field Gun 1916 is packed as follows:

1. The Low-explosive Round Mk. I, the Sand-loaded Round Mk. I, and the drill cartridge are packed 60 rounds per wooden box without metal liner.

2. The Canister M1 is packed in two ways:

60 rounds per wooden box without metal liner

60 rounds per metal-lined wooden box

Ammunition for shipment to the tropics must be packed in boxes with metal liners.

3. The High-explosive Mk. II Shell and the Practice Shell Mk. II are packed in three ways:

60 rounds per wooden box without metal liner

60 rounds per wooden box with metal liner

1 round per fiber container, 40 containers (40 rounds) per wooden box

Ammunition for shipment to the tropics must be packed in boxes with metal liners.

4. The Practice Shell Mk. IIA1 is packed 1 round per fiber container, 40 containers (40 rounds) per wooden box.

5. The old type blank ammunition for 37-mm Gun M1916 is packed 100 rounds per wooden box.

6. The new type blank ammunition for 37-mm Gun M1916 is packed in a chest which contains 100 blank 10-gage cartridges, 10 M1 Adapters, and 1 ramrod, Subsequent shipments of blank cartridges are packed 25 per carton, 20 cartons (500 rounds) per wooden box.

AMMUNITION FOR 37-MM GUNS M3 AND M3A1 (ANTITANK) AND M5 AND M6 (TANK).

General.

Weapons. The slowly moving lightly armored vehicles of World War I were successfully combated by the 37-mm Gun M1916, but the high speed and improved armor plate of modern vehicles have made the M1916 Gun practically useless as a combat weapon. This situation resulted in the development of the much more powerful mobile 37-mm Antitank Guns M3 and M3A1, and the Tank Guns M5 and M6. The chambers of these new weapons are all the same size, and so they all use the same ammunition. Since the guns are more powerful than the M1916, a larger propelling charge is used. The cartridge case is, therefore, larger in diameter and longer (8.75 inches). These guns are manually operated; the ammunition is loaded and extracted by hand so no extracting groove is needed on the cartridge case. Present light tanks mount 37-mm guns, while certain medium tanks carry 37-mm weapons with 75-mm guns.

Types of ammunition. The following types of ammunition are used in the 37-mm tank and antitank guns:

Type	Filler
Canister	Steel balls in resinous material
High-explosive	TNT
Armor-piercing	None
Target-practice	None
Drill	None
Blank	Black powder

All ammunition discussed herein for the 37-mm tank and antitank guns is standard for issue and manufacture.

Cartridge Cases. The M16 Cartridge Case is "Standard" for all rounds of ammunition used in the 37-mm tank and antitank guns. It is made of cartridge brass and is 8.75 inches long. It has a flange at the base for extraction; no groove is needed since the guns are hand operated.

Cartridge Case M16B1 is "Substitute Standard." The only differences between it and the M16 are that the M16B1 is made of steel instead of cartridge brass, and has a slightly thinner primer seat. The length (8.75 inches) and the fact that these cartridge cases have an extracting flange only, positively identifies any 37-mm projectile to which they are attached for use in the tank and antitank guns.

Primers. The M23A2, 20-grain, Percussion Primer is standard. Some rounds may be on hand primed with the M23A1 (primers, page 331).

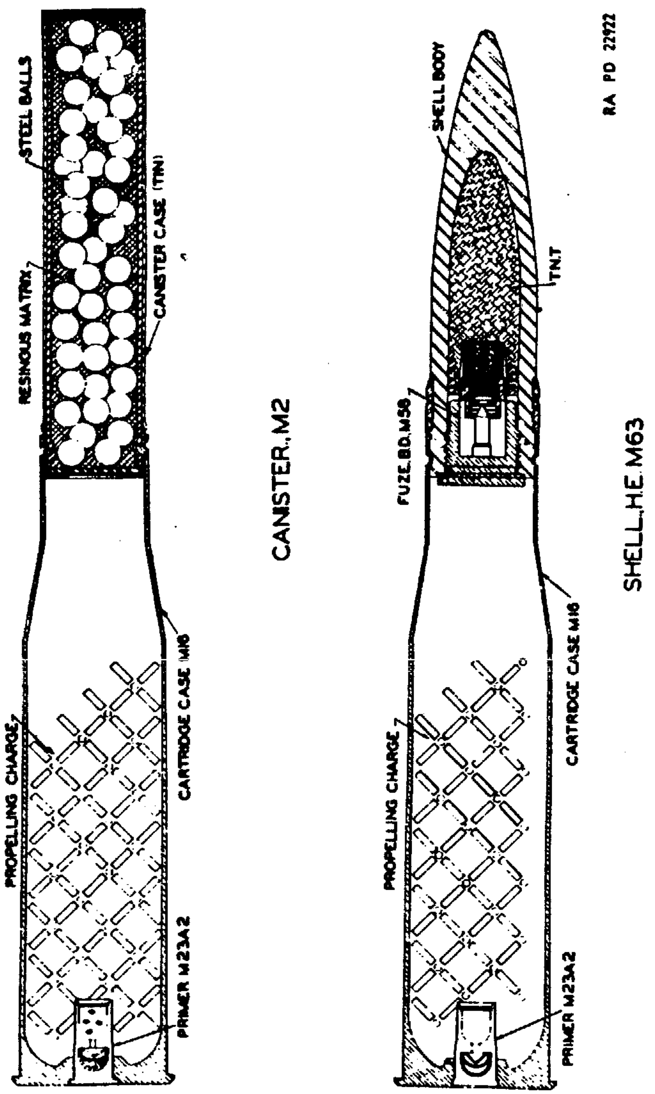

Figure 135 — Canister M2, and SHELL, H.E., M63, for 37-mm Guns M3, M3A1, M5, and M6

CANISTER, Fixed, M2.

Complete round. The canister is used in tank weapons to discourage personnel from approaching the tank.

Cartridge cases. M16 is "Standard," M16B1 is "Substitute Standard" (see cartridge cases, page 345).

Primer. M23A2, 20-grain, Percussion Primer, is "Standard." Some rounds may be on hand, primed with M23A1 (primers, page 331).

Propelling charge. .44 pound of FNH powder is poured loosely into the cartridge case. This imparts a muzzle velocity of 2,500 feet per second to the canister (slightly slower in the M5 Gun).

Projectile. The canister case is made of ordinary roofing tin, or ternplate. The filling consists of 122 steel balls, each approximately .375 inch in diameter, imbedded in a resinous material forming a matrix. A raised bead around the lower part of the case serves to seat it properly in the cartridge case. The function of the Canister M2 is the same as that for the Canister M1 for the M1916 Field Gun. Canister M2 is 6.50 inches long and weighs 1.94 pounds.

Identification. The length (8.75 inches) and extracting flange of the cartridge case identify the round for use in the M3 and M3A1 (antitank) and M5 and M6 (tank) Guns. The can-like appearance and black painting of the projectile identify it as canister. The complete round is 14.53 inches in length and weighs 3.31 pounds.

SHELL, Fixed, H.E., M63.

Complete round. The high-explosive shell for tank and antitank weapons is used against targets where the explosive feature of the shell will prove more destructive than armor-piercing shot. The round is shipped complete with fuze, as are all fixed artillery shell.

Cartridge cases. M16 Cartridge Case is "Standard," M16B1 is "Substitute Standard" (see cartridge cases, page 345).

Primer. The M23A2, 20-grain Percussion Primer is "Standard." Some rounds may be found primed with M23A1 (primers, page 331).

Propelling charge. Approximately 0.44 pound of FNH powder poured loosely into the cartridge case imparts a muzzle velocity of about 2,650 feet per second to the projectile.

Projectile. The High-explosive Shell M63 weighs 1.61 pounds loaded and fuzed, and measures 5.92 inches in length. The nose of the projectile has a long taper and extends to a rounded point since a base-detonating fuze is used. The ogive radius is 13 inches. The bursting charge consists of 0.085 pound of flaked TNT packed so as to completely surround the booster cavity.

Fuze, base-detonating, M58. The internal mechanisms and explosive contents of this fuze are identical to those of the M38A1 (page

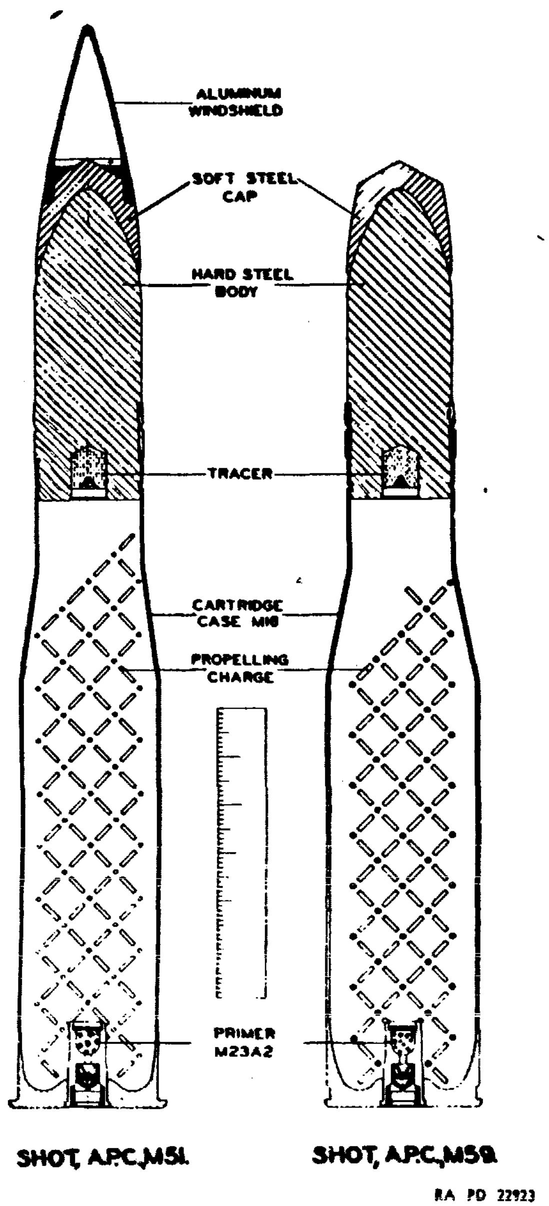

Figure 136 — SHOT, APC, M51 (M1A2 Guns), and SHOT, APC, M59 (M3, M3A1, M5, and M6 Guns)

340) therefore, its operation is the same. The differences in these fuzes lie in the fuze body. The explosive cavity of the M63 H.E. Shell, in which the M58 is used, is larger in diameter than the explosive cavity of the Mk. II H.E. Shell in which the M38A1 Fuze is used. Therefore, the body of the M58 is correspondingly greater in diameter than the body of the M38A1.

Identification. The M63 H.E. Round can be identified by the length of the cartridge case (8.75 inches) and the extracting flange. It is painted olive drab with yellow stencilling. Aside from the painting and marking, it may be distinguished from other tank and antitank rounds by its long, tapered nose. The AP and target-practice shot have smaller radii of ogive giving the appearance of a much blunter nose. If the shot is capped, the shape of the cap is peculiar. If the armor-piercing round is capped and has a windshield, the windshield may be distinguished because of the material used and because of the fact that it is screwed to the cap. The complete round of H.E. Shell M63 is 14.09 inches long, and weighs approximately 3.03 pounds.

SHOT, Fixed, A.P.C., M51 w/TRACER.

Complete round. This round has all of the features of an ideal armor-piercing shot, and is effective against all types of armor plate. The model number marked on the projectile may be either M51, M51B1 or M51B2; rounds so marked are identical in functioning, the B1 or B2 designations signifying only that the projectiles are manufacturing alternatives of the M51.

Cartridge cases. The Cartridge Case M16 is "Standard," M16B1 is "Substitute Standard" (cartridge cases, page 345).

Primers. M32A2, 20-grain, Percussion Primer is "Standard." Some rounds may be found primed with the M23A1 (primers, page 331).

Propelling charge. 8.1 ounces of FNH powder contained loosely in the cartridge case provides the projectile with a muzzle velocity of 2,900 feet per second.

Projectile. The projectile is made up of four parts:

1. The body is made of very hard steel and does the actual penetrating. It is solid except for a cavity in the base to contain the tracer.

2. The cap is made of soft steel and is sweated on the nose of the body. Its purpose is to reduce the possibility of ricochet and to serve as a cushion or guide for the body when it strikes the armor plate.

3. The windshield is a false ogive, made of an aluminum alloy, which is assembled to the cap with threads, and continues the nose of the projectile to a point. Its purpose is to streamline the projectile in flight, thus improving its ballistics.

4. The tracer is made up of red tracer composition, and igniting composition, and a celluloid cup which fits over the tracer charge and is sealed with adhesive compound. The tracer burns for about 2,000 yards of the flight of the projectile.

The term A.P.C. in the nomenclature of armor-piercing projectiles stands for armor-piercing, capped. The projectile weighs 1.92 pounds and is 6.36 inches long with the windshield and 4.63 inches long without the windshield.

Identification. The complete round may be identified for the M3 and M3A1 (antitank) and M5 and M6 (tank) Guns by the length (8.75 inches) and extracting flange of the cartridge case. It can be distinguished as the A.P.C. M51 Round by the aluminum windshield or, if the windshield is not assembled, by the threads on the armor-piercing cap. The complete round is 14.53 inches long and weighs 3.41 pounds. Since the projectile is inert, it is painted black and stenciled in white.

SHOT, T.P., M51 w/TRACER.

Target practice shot is for use in target practice and general field practice. The M51, T.P., Shot is listed as standard for issue and manufacture in SNL R-1. A T.P. Shot M51A1 is also listed in SNL R-1 and is standard for issue only. The A1 modification does not have a windshield.

Cartridge cases. Cartridge Case M16 is "Standard," M16B1 is "Substitute Standard" (cartridge cases, page 345).

Primer. M23A2, 20-grain, Percussion Primer is standard. Some primers designated M23A1 are on hand (primers, page 331).

Propelling charge. 6.6 ounces of FNH powder are poured loosely into the cartridge case.

Projectile. The projectile is the same as that for the APC, M51, Service Round except that the body and cap of the shot are made in one piece of steel that is not heat-treated. The Complete Round Chart carries the notation "Approximately 50,000 of unheat-treated shot in accordance with Drawing 75-1-73 have been manufactured for target practice purposes. Future requirements will be met by supplying the standard AP round in accordance with Drawing 75-1-70." However, SNL R-1, which is of a later date than the Complete Round Chart, lists T.P. M51A2 (Drawing 75-1-73) as standard for issue and manufacture. The T.P. M51A2 is similar to the T.P. M51 and also has a windshield.

Identification. Except for blue painting and white stencil, the T.P. M51 Round has the same appearance as the Service Round APC M51.

SHOT, Fixed, A.P., M74 w/TRACER.

Complete round. As indicated by the nomenclature, this round does not have an armor-piercing cap. It was designed because the manufacture requires fewer operations and less material and can be accomplished with greater speed. It is effective against homogeneous armor plate, but is likely to ricochet or be deflected on impact with face-hardened armor plate.

Cartridge cases. M16 is "Standard," M16A1 is "Substitute Standard" (cartridge cases, page 345).

Primer. The M23A2 Primer is "Standard" with this round. Some rounds may be on hand, primed with M23A1.

Propellant. Approximately 8.1 ounces of FNH powder, poured loosely into the cartridge case provides the projectile with a muzzle velocity of 2,600 feet per second.

Projectile. The Shot M74, is in the form of a solid steel slug, measuring 4.84 inches in length and weighing 1.92 pounds. It has a comparatively blunt nose, for the radius of ogive is 2.205 inches. A cavity is machined into the base for a tracer. This built-in tracer helps artillery crews to observe the fire of the weapon. The tracer assembly is the same as that described for the APC M51 Round (tracer, page 349). This M74 Shot is similar to the AP M80 Shot used in the 37-mm Antiaircraft Gun M1A2. The complete rounds differ in respect to cartridge cases and propelling charges.

Identification. The complete round may be identified for the tank and antitank guns by the length of the cartridge case (8.75 inches) and the extracting flange. It is distinguished as AP Shot M74 by the absence of an armor-piercing cap and the stubby appearance of the nose (ogive radius of 2.205 inches). The projectile is painted black and stenciled in white. The complete round is 13.01 inches long and weighs 3.34 pounds.

Blank ammunition. The old type blank ammunition for 37-mm Guns M3, M3A1, M5, and M6 is of the same type construction as that described for the M1916 Gun (blank ammunition, page 343). Of course, a M16 or M16B1 Cartridge Case would be used.

The new type blank round for the tank and antitank guns consists of an Adapter M2 and a 10-gage blank cartridge. The adapter is made up of an M16 Cartridge Case adapted for a central tube of a size to seat the 10-gage cartridge.

CARTRIDGE, Drill, M13. The drill round is made up of inert used components from service rounds. It is used to train personnel in the handling of ammunition and in loading and unloading weapons. It may be identified by a hole drilled through the cartridge case to show that it contains no propelling charge. If an inert H.E. projectile is used, it will also have a hole drilled completely through it.

Packing of Ammunition for Guns M3 and M3A1 (Antitank) and M5 and M6 (Tank). Ammunition for these weapons is packed as follows:

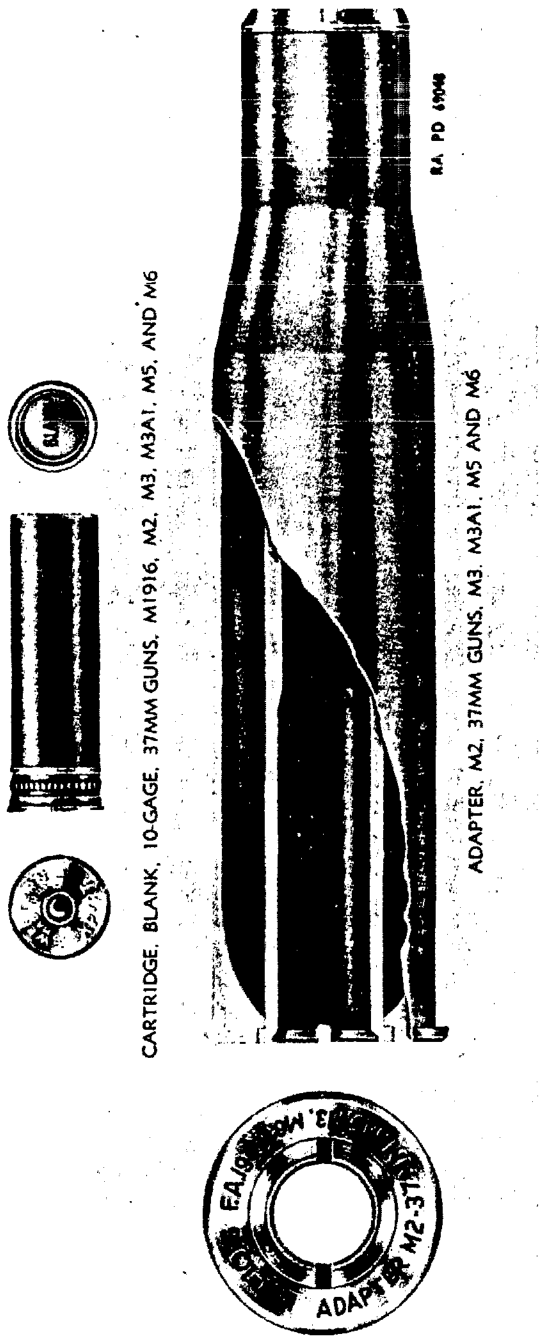

Figure 137 — Adapter and Blank Cartridge for 37-mm Gun

The canister, high-explosive, and drill rounds are packed 1 round per fiber container, 20 containers (20 rounds) per unlined wooden box.

The armor-piercing, armor-piercing capped, and target-practice rounds are packed in two ways:

1. 1 round per fiber container, 20 containers (20 rounds) per unlined wooden box.

2. 20 rounds per metal-lined wooden box.

Packing information on the old type blank ammunition for tank and antitank guns is not available at this time. The new type is packed in a chest containing 10 Adapters M2; 100, 10-gage blank cartridges; and 1 ramrod. Subsequent shipments of 25 to a carton, 20 cartons (500 cartridges) to a wooden box.

AMMUNITION FOR 37-MM AUTOMATIC GUN M1A2 (ANTIAIRCRAFT).

General.

Weapon. With the advent of aviation as a major factor in combat, it became necessary to develop a light, mobile, automatic antiaircraft weapon that would fire an explosive projectile. First, the 37-mm Automatic Gun M1A1, and later, the M1A2 were adopted to serve this purpose. The M1A2 is a fully automatic weapon. It is loaded automatically from a clip carrying 10 rounds. A cartridge case with an extracting groove in the base is required for ejection by the automatic extractor mechanism of the gun. The gun is mounted on a 4-wheeled trailer carriage capable of being towed 50 miles per hour on good roads. Antitank as well as antiaircraft firing is possible with this weapon.

Types of ammunition. There are three types of rounds used in the M1A2 antiaircraft gun:

Types	Filler
High-explosive	Tetryl
Armor-piercing	None
Practice	None

Cartridge cases. The Cartridge Case M17 is made of cartridge brass, and is the same size and shape as the M16 used in the 37-mm tank and antitank guns (page 345). The only difference in the two cases is that the M16 has an extracting flange while the M17 has an extracting groove located just above the head of the cartridge case.

The Cartridge Case M17B1 is "Substitute Standard." Except for being made of steel and having a slightly thinner head and primer seat, it is exactly the same as the M17 Cartridge Case.

Primer. The M23A2, 20-grain, Percussion Primer is "Standard" for all 37-mm antiaircraft ammunition. Some rounds may be found primed with M23A1 Primer (primers, page 331).

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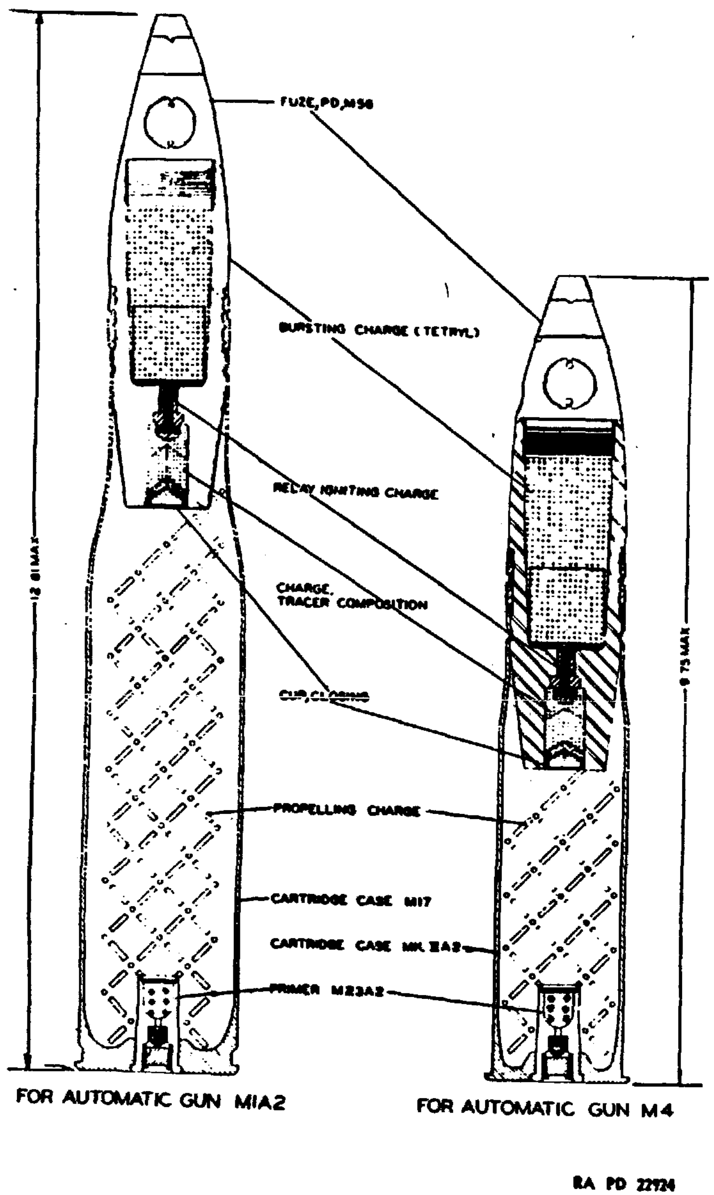

Figure 138 — SHELL, H.E., M54, for 37-mm Guns M1A2 and M4

SHELL, Fixed, H.E., M54 w/S.D. TRACER.

Complete round. The burst of the M54 High-explosive Shell is one of the best means known by the Army to discourage attack by enemy aircraft. The combination of a tetryl loaded shell and supersensitive fuze spells destruction for light material targets such as planes. The same projectile is used in the M4 (Aircraft) Gun against planes.

Cartridge Cases. The M17 Case is "Standard," the M17B1 is "Substitute Standard" (cartridge cases, page 353).

Primer. The M23A2 is "Standard." Some rounds on hand may be primed with the M23A1 (primers, page 331).

Propelling charge. A muzzle velocity of 2,600 feet per second is imparted to the projectile by 6 ounces of FNH powder.

Projectile. The Projectile M54, as fired, weighs 1.34 pounds and is about 5.9 inches long. It is the same projectile as the M54 fired from the M4 Aircraft Gun. The projectile consists of three components: the body with its bursting charge; the Point-detonating Fuze M56; and the shell-destroying tracer.

The body is machined from bar steel and is 4.13 inches long. Only 2.32 inches of the body itself protrudes from the cartridge case. The base of the projectile is very thick (over 1½ inches) and is tapered for streamlining purposes. The cavity for the shell-destroying tracer is machined into this heavy base. The bursting charge of 0.10 pound of tetryl is pressed into the body in two increments: a base pellet and a main charge.

The shell-destroying tracer assembly consists of a quantity of tracer composition, an ignited charge, a celluloid closing cup, a relay igniting charge and a relay pellet. The tracer charge is held in place by a celluloid cup sealed with adhesive compound. The celluloid cup transfers the flame from the propellant to the igniter charge of 20 grains of igniter composition. The igniter fires the red tracer composition which weighs 90 grains. When the tracer composition is almost completely burned, it initiates the relay igniting charge of 1.68 grains of black powder contained in a steel housing which screws into the tracer cavity just below the tetryl base pellet. This relay igniter carries the flame to the relay pellet of 23 grains of black powder which covers the entire base of the bursting charge cavity. The relay pellet is sufficient to effectively detonate the tetryl base pellet of the bursting charge, and finally the main bursting charge itself.

The maximum vertical range of the high-explosive shell is 6,200 yards and the maximum horizontal range is 8,875 yards. The tracer compound, however, burns out and ignites the black powder relay pellet after approximately 3,500 yards of vertical travel or 4,000 yards of horizontal travel, so the shell is destroyed before it reaches its maximum limit. This eliminates the possibility of the shell's

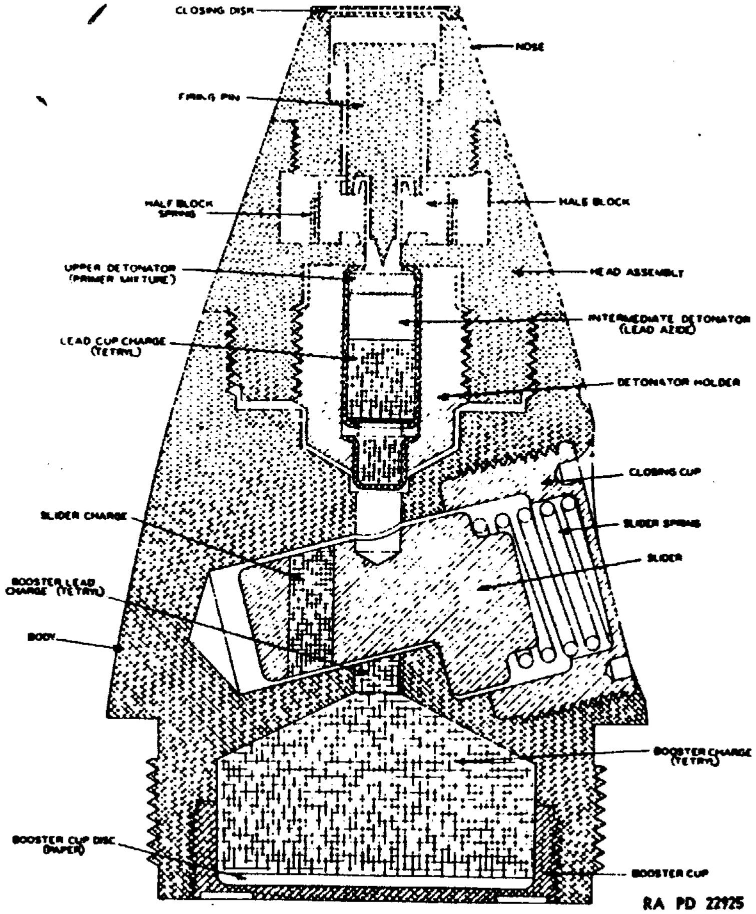

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Figure 139 — FUZE, P.D., M56

falling to the ground, detonating, and causing casualties among friendly troops.

FUZE, point-detonating, M56. Since the High-explosive Round M54 is required to function on impact with light materials such as those used in planes, a supersensitive fuze is needed. A supersensitive fuze is one which will detonate on very slight impact such as with a double thickness of airplane fabric. The M56 is both supersensitive and superquick because the firing pin is protected only by a very thin aluminum closing cup and rests, at the time of impact, right on the detonator which initiates an almost uninterrupted train of detonating explosives.

The body of the fuze is divided into three parts; the body loading assembly, the head assembly, and cap. The booster of tetryl is

pressed into a cavity in the lower part of the body, and is held in place by an aluminum closing cup which screws into the base of the fuze. The body loading assembly also contains an eccentrically weighted slider. The slider incorporates a charge of tetryl and is held in place, with its charge out of line with the rest of the explosive train, by a spring backed up by a cup-shaped brass retaining screw which assembles into the side of the fuze body. The detonator assembly consists of a brass detonator holder, which screws into the body loading assembly; a detonator of priming mixture, lead azide and tetryl, and a lead charge of tetryl. Semicircular, brass half blocks held together by a flat steel spring sit loosely in a cavity in the head assembly which screws over the detonator holder and into the body loading assembly. These half blocks have beveled notches which seat a rim on the firing pin. The firing pin fits into a cap closed with a very light aluminum cup. The cap containing the firing pin screws into the head assembly. All of the parts just described except the slider, the detonator holder, and the half blocks and their spring, are made of aluminum alloy.

The function of the fuze begins when the projectile has cleared the muzzle of the weapon and centrifugal force comes into play. The velocity with which the projectile rotates as it leaves the gun causes the eccentrically weighted slider to compress its spring and bring its tetryl charge into line with the explosive train. At the same time, the half blocks spread outward against their spring and the firing pin rides up the beveled notches. As the half blocks spread a sufficient distance apart, the firing pin comes gradually down between them and rests on the light aluminum closing disc of the detonator. When the projectile contacts the material of the target, the light aluminum closing cup in the cap is pushed in, and forces the firing pin into the priming mixture. The priming mixture initiates the explosive train of detonator, lead azide and tetryl, lead charge of tetryl, slider charge of tetryl, tetryl booster, and bursting charge of tetryl. These explosives are arranged in a practically uninterrupted train which gives the fuze superquick action.

Identification. The complete round of M54, H.E. Shell can be identified for the Antiaircraft Gun M1A2 by the extracting groove in the cartridge case. The presence of the M56 Fuze identifies the round as H.E. M54. The only other 37-mm round for the M1A2 Gun that has a fuze is the practice round. The fuze for the practice shell is a dummy made of cast aluminum. The M54 is painted olive drab and stenciled in yellow. The complete round is 12.81 inches long and weighs 2.62 pounds.

SHELL, Fixed, Practice, M55A1 w/TRACER.

Complete round. This round was designed to simulate the M54, H.E. Shell for practice firing.

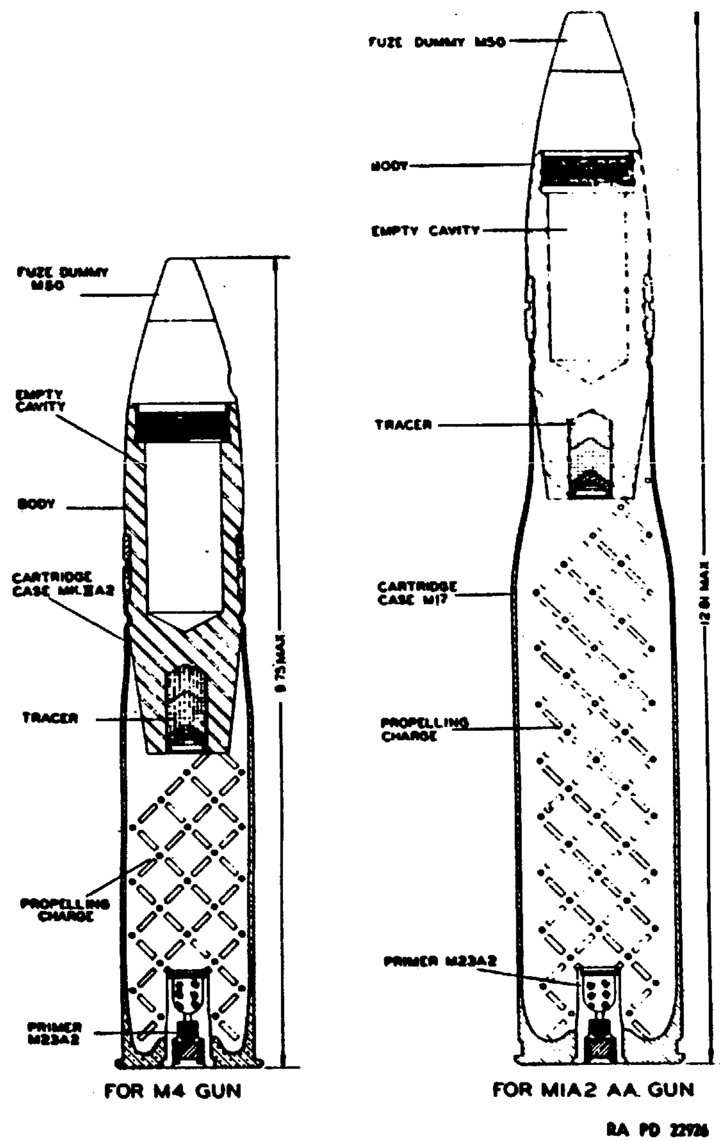


Figure 140 — SHELL, Practice, M55A1, for 37-mm Guns M4 and M1A2

Cartridge cases. M17 is "Standard," M17B1 is "Substitute Standard" (cartridge cases, page 353).

Primer. M23A2, 20-grain, Percussion Primer is "Standard." Some rounds may be found primed with M23A1 Primer (primers, page 331).

Propelling charge. The propelling charge consists of 6 ounces of FNH powder.

Projectile. The projectile is of the same length, weight, and contour as the H.E. Shell M54 (page 355). It is made up of three parts.

The body has no filler, but is made to the same size and weight as the high-explosive M54. A tracer cavity is machined into the base. Of course, since no filler is used, the tracer does not have shell-destroying qualities.

The tracer consists of red tracer composition and igniting compound closed into the tracer cavity with a celluloid cup which is sealed with adhesive compound.

The FUZE, dummy, M50, is entirely inert and is made in one piece of cast aluminum. It is of the same size, shape, and weight as the M56 Fuze.

Identification. The complete round can be identified for the M1A2, 37-mm Antiaircraft Gun by its size and the extracting groove in the cartridge case. Aside from the blue painting and white stenciling on the projectile, it may be distinguished as the Practice Round M55A1 by the Dummy Fuze M50. The complete round measures 12.81 inches in length and weighs 2.62 pounds.

SHOT, Fixed, A.P.C., M59 w/TRACER.

Complete round. This round is "Standard" for use against any type of armor plate. It is very similar to the SHOT, APC, M51, used in the 37-mm Antitank and Tank Guns M3, M3A1, M5, and M6. The main differences are in the cartridge cases and in the fact that the M59 Shot does not have a windshield to extend the ogive.

Cartridge cases. M17 is "Standard," M17B1 is "Substitute Standard" (cartridge cases, page 353).

Primer. M23A2, 20-grain, Percussion Primer is "Standard." Some rounds on hand may incorporate the M23A1 Primer (primers, page 331).

Propelling charge. A propelling charge of 0.31 pounds of FNH powder gives the projectile a muzzle velocity of 2,050 feet per second.

Projectile. Aside from the following differences, the projectile is the same as the SHOT, APC, M51, used in the Tank and Antitank Guns M3, M3A1, M5, and M6 (page 349).

The chambering of the Antiaircraft Gun M1A2 does not permit the use of a windshield.

The M59 Antiaircraft Round contains more tracer composition in the base (enough to burn 3,500 yards) than does the M51 Antitank Round.

The M59 Projectile is a trifle lighter than the M51.

Identification. The complete round may be identified for the antiaircraft group by the size and extracting groove of the cartridge case. The black painting with white stencil and the armor-piercing cap distinguishes it as SHOT, APC, M59. The complete round is 12.76 inches long and weighs 3.12 pounds.

SHOT, Fixed, A.P., M74 w/TRACER.

Complete round. As indicated by the nomenclature, this round does not include an armor-piercing cap. It was designed as "Substitute Standard" for SHOT, APC, M59. It does satisfactory work against homogeneous armor plate, but not against face hardened armor plate.

Cartridge cases. M17 and M17B1 are "Standard" and "Substitute Standard" respectively (cartridge cases, page 353).

Primer. M23A2, 20-grain, Percussion Primer is "Standard." Some rounds may still contain M23A1 Primer (primers, page 331).

Propelling charge. 4 ounces of FNH powder impact a muzzle velocity of 2,050 feet per second to the shot.

Projectile. The projectile is exactly the same as the M74 used for 37-mm Tank and Antitank Guns M5, M6, M3, and M3A1 (page 350).

Identification. The extracting groove on the cartridge case, and size of the round identify it as belonging to 37-mm antiaircraft group. The black painting with white stencil and the stubby nose (ogive radius of 2.205 inches) distinguish it as SHOT, AP, M74. The complete round is 13.01 inches long and weighs 3.07 pounds.

Packing of Ammunition for 37-mm Antiaircraft Gun M1A2. 37-mm antiaircraft ammunition is packed as follows:

The high-explosive and practice rounds are packed in two ways:

1. 1 round per fiber container, 25 containers (25 rounds) per wooden box.

2. 20 rounds per metal-lined wooden box.

The armor-piercing, and armor-piercing capped rounds are shipped 1 per fiber container, 25 containers (25 rounds) per wooden box.

AMMUNITION FOR 37-MM AUTOMATIC GUN M4 (AIRCRAFT).

Weapon. With the rapid advancement of aviation, the development of new techniques and purposes for aircraft, and the improvement of aviation armor, it was found necessary to design an aircraft weapon with a high-explosive round. The 37-mm Automatic Gun M4

was the answer to this necessity. It has a standard muzzle velocity of 2,000 feet per second. The ammunition is fed into the gun by a 5-round feeder, by a 15-round articulated-link belt housed in a magazine, or by a 37-mm Endless Belt M6 containing 30 rounds. A peculiarity of the weapon is that while it is automatic, the cartridge cases used with the ammunition have extracting flanges and no grooves.

Types of Ammunition. Types of ammunition used in the aircraft weapon are as follows:

Types	Filler
High-explosive	Tetryl
Armor-piercing	None
Practice	None

Cartridge Cases. The Mk. IIIA2 Cartridge Case is "Standard" for all ammunition used in the Aircraft Gun M4. It is made of cartridge brass and can be distinguished from all other 37-mm cartridge cases by its length (5.69 inches). The extracting mechanism of the weapon requires a cartridge case with a flange.

The Mk. IIIA2B1 Cartridge Case is "Substitute Standard." It differs from the Mk. IIIA2 only in that it is made of steel and has a slightly thinner head and primer seat.

Primer. The M23A2, 20-grain, Percussion Primer is "Standard" for all aircraft rounds. Some rounds may be on hand, primed with the M23A1 Primer.

Propelling Charges. The high-explosive and practice rounds require a propellant of 2.5 ounces of FNH powder. The armor-piercing round requires 2.3 ounces of FNH powder.

SHELL, Fixed, H.E., M54, w/TRACER. The projectile of this round is exactly the same as the M54, H.E., Shell for the Antiaircraft Gun M1A2 (page 355). The only differences in the complete rounds are in the cartridge case and propelling charge. The aircraft shell may be distinguished as such by its shorter cartridge case (5.69 inches) with its extracting flange. The complete round is 9.75 inches long and weighs 1.94 pounds.

SHELL, Fixed, Practice, M55A1, w/TRACER. This round is the same as the M55A1 Practice Shell for the Antiaircraft Gun M1A2 except for differences in the cartridge case and propelling charge (page 359). The aircraft round may be distinguished by the length (5.69 inches) and extracting flange of its cartridge case. The complete round is 9.75 inches long and weighs 1.94 pounds.

SHELL, Fixed, Armor-piercing, M80, w/TRACER. The M80 is very similar to the M74 Armor-piercing Shot which is fired from the

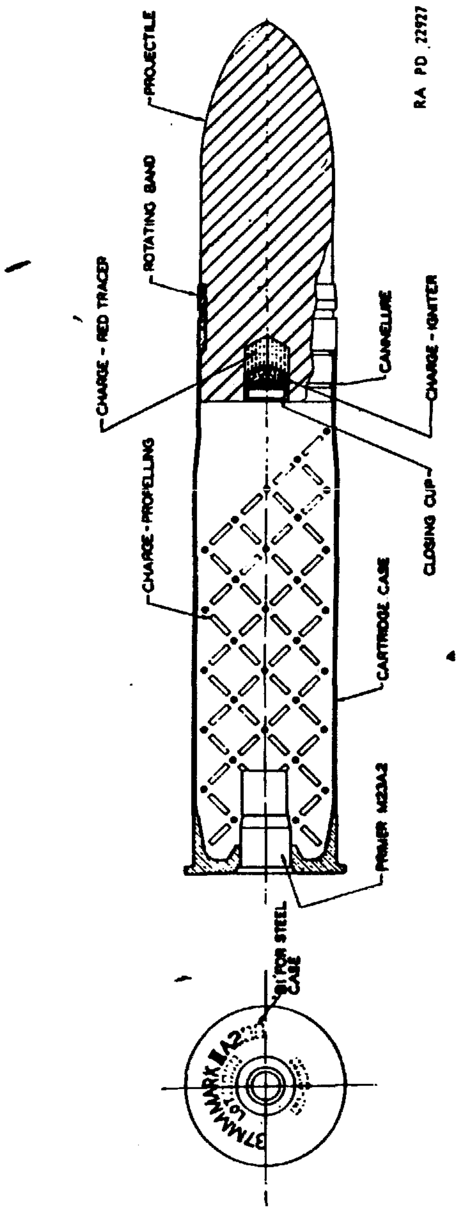


Figure 141 — SHOT, AP, M80, for 37-mm Gun M4

M1A2 antiaircraft gun (page 360). The main differences are in the cartridge case and propelling charge. The two projectiles are of similar construction, but the M80 is lighter in weight. This is accomplished by shortening the projectile. The M80 is 4.23 inches long and weighs 1.66 pounds, while the M74 is 4.84 inches long and weighs 1.92 pounds. The aircraft round also has a slightly greater radius of ogive (2.35 inches as compared to 2.205 inches). The Aircraft Round M80 may be distinguished as 37-mm ammunition by its size, and for the aircraft group by the length (5.69 inches) and flange of its cartridge case. The complete round is 9.34 inches long and weighs 2.25 pounds. The projectile is painted black with white stencil.

Packing of Ammunition for the 37-mm Aircraft Gun M4. This ammunition is packed as follows:

The high-explosive and practice rounds are packed in two ways:

1. 1 round per fiber container, 40 containers (40 rounds) per wooden box.

2. 20 rounds per metal-lined wooden box.

The armor-piercing shot is packed 1 round per fiber container, 40 containers (40 rounds) per wooden box.

FURTHER REFERENCES: SNL R-1, Parts 1 and 2; SNL R-5, Parts 1 and 2; Ordnance Drawings; OS 9-20.

Chapter 4

Ammunition for 40-mm Gun M1

GENERAL.

Weapon. The GUN, automatic, 40-mm, M1, is intended for duties intermediate between those of the high-altitude guns of the 3-inch and 90-mm class and the 37-mm antiaircraft weapon. It is very effective against dive bombers and low-flying aerial targets. With the armor-piercing ammunition it may also be effectively used against armored ground targets. Its rate of fire is 120 rounds per minute which is accomplished by feeding the ammunition into the weapon by means of a 4-round changer clip. These rounds may be fired continuously in rapid fire or a single shot at a time.

This weapon is sometimes called the Bofors gun, since it was developed by the Bofors Company of Sweden. It was adopted by the British and then by the United States Ordnance in 1941. The 40-mm M1 or "Bofors" gun is easily recognized by the funnel-shaped flash hider screwed on the forward end of the tube, which protects the gun operators from temporary blinding by the flash.

Class and Types. The 40-mm ammunition is of the fixed class and includes three types: high-explosive, practice, and armor-piercing.

Cartridge Cases.

CASE, cartridge, M25. The M25 Cartridge Case is "Standard" for ammunition of American design. This case is drawn from cartridge brass. It is 12.24 inches long and has a maximum weight of 1.94 pounds. An extracting groove is machined into the head of the case. The feeder mechanism of the M1 Gun requires that an annular groove be cut into the base. A tapered hole is machined through the head for press fitting the M23A2 Primer.

CASE, cartridge, M25B1. This case is "Substitute Standard" for 40-mm, American designed ammunition. Except for a few differences in the propelling charge cavity near the head, a thinner head, and being made of steel, it is the same as the M25 Brass Case. The differences in the head and material make the steel case approximately 0.25 pound lighter than the brass case.

CASE, cartridge, M22A1. The M22A1 is "Standard" for 40-mm ammunition of British design. It was developed from the Mk. I/L Cartridge Case which was redesigned to become the M22. The M22 Case was machined in the head to receive the British Percussion Primer, Mk. II/L/ which was assembled with threads into the cartridge case. The A1 modification of the M22 consisted of changing the head to seat the M23A2 American Primer. The M22A1 Cartridge Case differs only in very minor details from the M25.

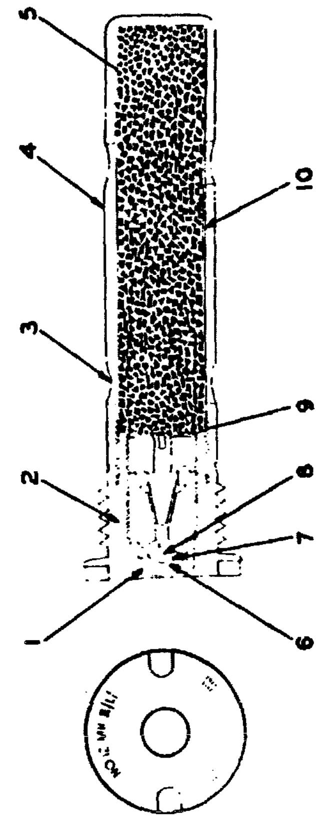
CASE, cartridge, M22A1B1. This case is "Substitute Standard" for 40-mm ammunition of British design. It differs from the M22A1 Brass Case in that the material is steel and the head is thinner. It weighs about 0.25 pound less than the brass case.

Primers.

PRIMER, percussion, 20-grain, M23A2. This primer is "Standard" for use in both American and British designed 40-mm ammunition. The primer and its development are described in the chapter dealing with 37-mm ammunition.

PRIMER, percussion, No. 12, Mk. II/L/. This primer may be found in some old rounds of British design. It is screwed and staked into the head of the old M22 or Mk. I/L/ Cartridge Case. The "L" in British nomenclature stands for land use. The Mk. II Primer consists of two parts, the head and the body.

The brass body contains the primer charge of 64 grains of black powder. It is in the shape of a tube closed at one end and tapped at the open end to receive the threads of the primer head. Several holes are drilled into the body to allow the flame from the primer charge to ignite the propellant. The primer charge is contained in a foiling-paper wrapping which lines the tube and prevents the powder from



1. PERCUSSION CUP
2. PERCUSSION HEAD
3. FLASH HOLE
4. PRIMER BODY
5. 64 GRAINS ARMY BLACK POWDER
6. 1.2 GRAINS #70 PRIMER MIXTURE
7. ONION SKIN PAPER
8. ANVIL
9. ONION SKIN PAPER
10. FOILING PAPER WRAPPER

RA PD 22928

Figure 142 — PRIMER, Percussion, No. 12, Mk. II/L/

spilling out through the holes. The charge is sealed at the open end with a disc of onionskin paper.

The primer head has outside threads at the top for screwing into the cartridge case and at the bottom for threading into the body. The primer cup is press-fit into the head from the forward end so as to leave a portion of the cup exposed to the firing pin of the weapon. The primer cup contains a priming mixture weighing 1.2 grains sealed with a paper disc. The anvil is threaded into the head behind the primer cup. A beveled gas-check plug fits loosely into a cavity in the anvil. A plug with a flash vent machined into it, threads into the head behind the anvil.

The function is the same as for the American type of percussion primer. The firing pin of the weapon indents the primer cup which crushes the primer composition against the anvil. The flame from the resulting explosion flashes through the vents and ignites the primer charge. The gas-check plug is pushed down by the gases from the primer composition and pushed up, closing the vent in the anvil, when the primer charge explodes.

CARTRIDGE, H.E.-T(SD), Mk. II.

General. This round was designed for use against aircraft but may also be used against other targets of opportunity. The nomenclature tells much of the story of the projectile since the "HE-T" indicates high-explosive filler with tracer and the "SD" refers to the tracer as shell-destroying. The complete round consists of a fuzed projectile complete with filler and tracer, a propelling charge, and a primed cartridge case.

Cartridge Cases. The M25 Brass Case is "Standard" for rounds of American design; the M25A1 Steel Case is "Substitute Standard." The M22A1 Brass Case is "Standard" with British rounds, the M22A1B1 Steel Case is "Substitute Standard."

Propelling Charge. A muzzle velocity of 2,960 feet per second is imparted to the projectile by 10.4 ounces of FNH smokeless powder poured loosely into the cartridge case.

Primer. The M23A2, 20-grain, Percussion Primer is "Standard" for all 40-mm rounds. PRIMER, percussion, No. 12, Mk. II/L/, may be found in some old rounds of British design.

Projectile. The Mk. II High-explosive Projectile is made up of a metal parts assembly, a filler, a shell-destroying tracer, and a point-detonating fuze. The projectile, loaded and fuzed, is a little over 7 inches long, the length varying slightly for different fuzes.

Metal parts assembly. This assembly consists of the shell body and the rotating band. The body is completely hollow. The cavity at the

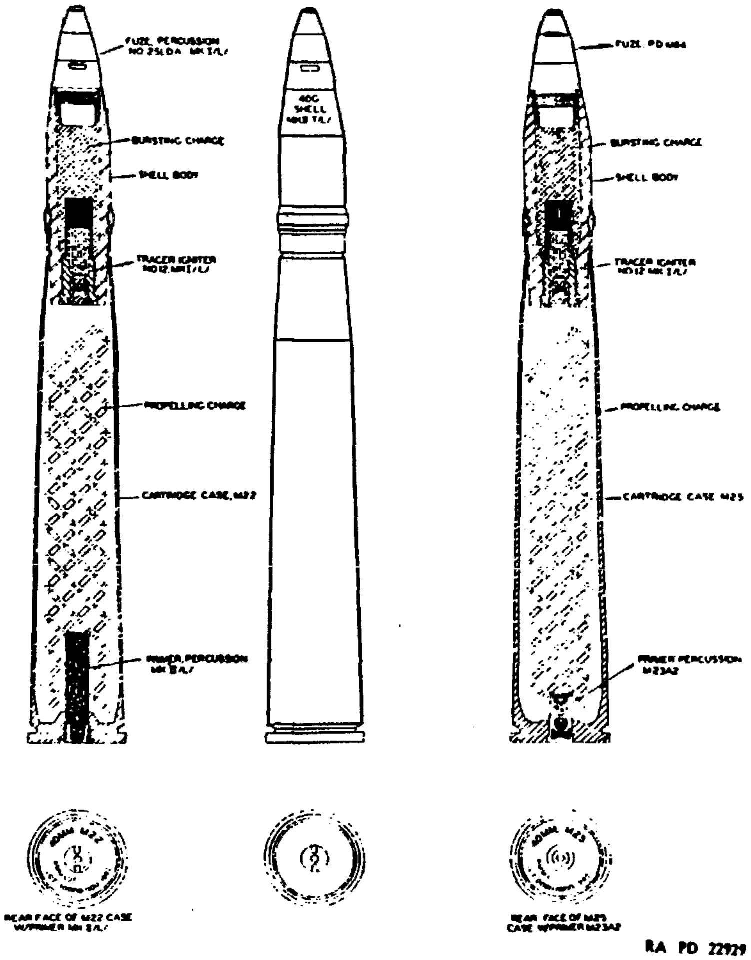


Figure 143 — Alternate Assemblies of Cartridge, H.E.-T (SD) 40-mm, Mk. II, T/L/

rear of the body is shaped and threaded to take the Tracer Igniter No. 12, Mk. I/L/. The nose end of the filler cavity is threaded to take Point-detonating Fuzes No. 251, Mk. 27 or M64A1. A knurled or ribbed recess 0.642 inch wide is machined into the body 1.745 inches above the base to receive a copper rotating band. A cannelure is cut into the shell about 0.5 inch behind the rotating band to receive the cartridge case crimps. The ogive of the projectile is tapered rather than curved. The taper is 7 degrees 15 minutes. The base is also cylindrically tapered to an angle of 7 degrees 45 minutes.

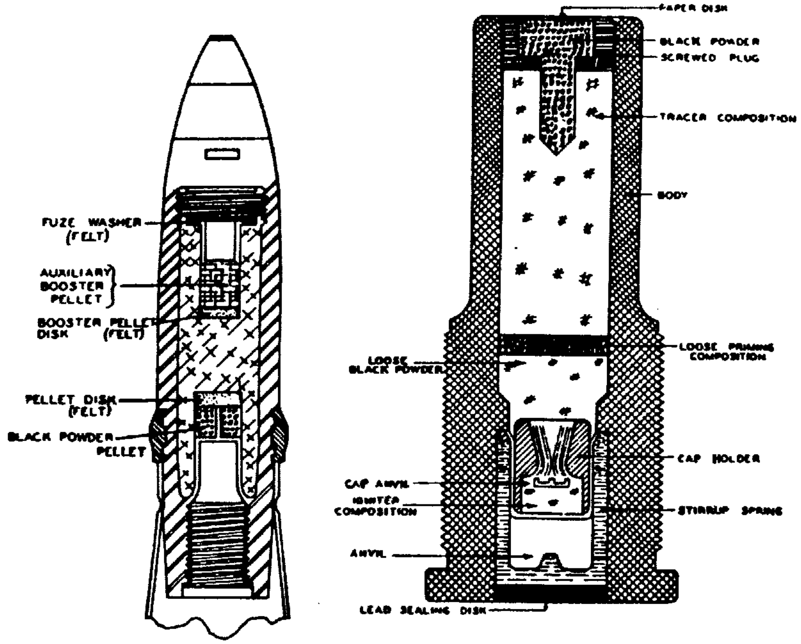


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Figure 144 — Tracer and Igniter, Shell No. 12, Mk. I/L/

Filler. The filler consists of 0.15 pound of TNT and 0.005 pound of black powder in the form of a pellet with a hole in the center. The filler of the American projectile is drilled out at the top to accommodate the booster of the fuze. This drilling leaves the fuze booster surrounded by TNT. The British filler is drilled deeper at the nose to accommodate an auxiliary booster pellet of tetryl. A cavity is also drilled into the TNT at the bottom leaving a surround. A felt disc fits into the top of this cavity. The black powder pellet is inserted behind this disc and is held in place by the tracer igniter assembly.

Tracer assembly. The proper nomenclature for the tracer assembly is "Tracer and Igniter, Shell, No. 12, Mk. I/L/ Internal," the British designation. The assembly is contained in a steel shell which threads into the base of the projectile so that only a paper disc separates the T-shaped relay igniter charge of loose black powder from the black powder pellet in the bursting charge. This relay igniter is surrounded by tracer composition which extends rearward to a layer of priming composition. Between the priming composition and the cap holder

which fits inside a stirrup spring is loose black powder. The cap holder assembly includes a cap anvil which fits over a vent leading to the loose black powder and igniter composition placed between the anvil and the stirrup spring. The stirrup spring rests on the shoulders of a cylindrically shaped anvil which is closed at the bottom. A protrusion in the bottom of the anvil acts much the same as a firing pin. The tracer and igniter assembly is sealed at the base with a lead sealing disc.

The function of the tracer and igniter assembly begins when the projectile starts down the bore of the weapon. Set back action causes the cap holder to move rearward and straighten out the stirrup spring which has retained it. The action carries the cap and stirrup spring onto the firing pin-like projection in the center of the anvil and crushes the igniting composition against the cap anvil. The flame from the resulting explosion fires the loose black powder which in turn ignites the priming composition. The back pressure from this loose black powder forces the mechanisms behind it out of the igniter body. The priming composition ignites the tracer composition. When the tracer composition has burned for approximately 7 seconds, it ignites the black powder relay igniter which carries the flame to the black powder pellet in the bursting charge and results in the destruction of the projectile.

There are three fuzes listed as standard for issue and manufacture for use with the Mk. II Projectile: the British FUZE, percussion, D.A., No. 251, Mk. I/L/, the Navy FUZE, P.D., Mk. 27, and the Army FUZE, P.D., M64A1.

FUZE, Percussion, D.A., No. 251, Mk. I/L/.

Description. The "D.A." in the nomenclature of this fuze is British for "direct action" which means about the same as the Army Ordnance term "superquick." The body of the fuze is made in three parts. The lower part is threaded on the outside for screwing into the nose of the Mk. II Projectile and is threaded on the inside to receive a relay assembly containing a charge of 2.3 grains of tetryl and a booster cup containing a tetryl pellet weighing 109.69 grains. A lead washer fits around the bottom of the protrusion on the relay holder. A thin brass cylinder fits over the upper end of the relay holder. Four tiny lugs at the top of this cylinder are bent over the rounded shoulder on the relay holder. Four tiny lugs at the bottom of the cylinder are bent out and up to retain a heavier brass arming sleeve. The arming sleeve is of sufficient length to protrude above the relay holder and retain two centrifugal blocks. These blocks form a positive separation between the relay charge and the detonating elements of the fuze making it boresafe. The detonator assembly fits in through the top of the lower part of the body and rests on the centrifugal blocks. The detonator charge consists of 0.93 grain of

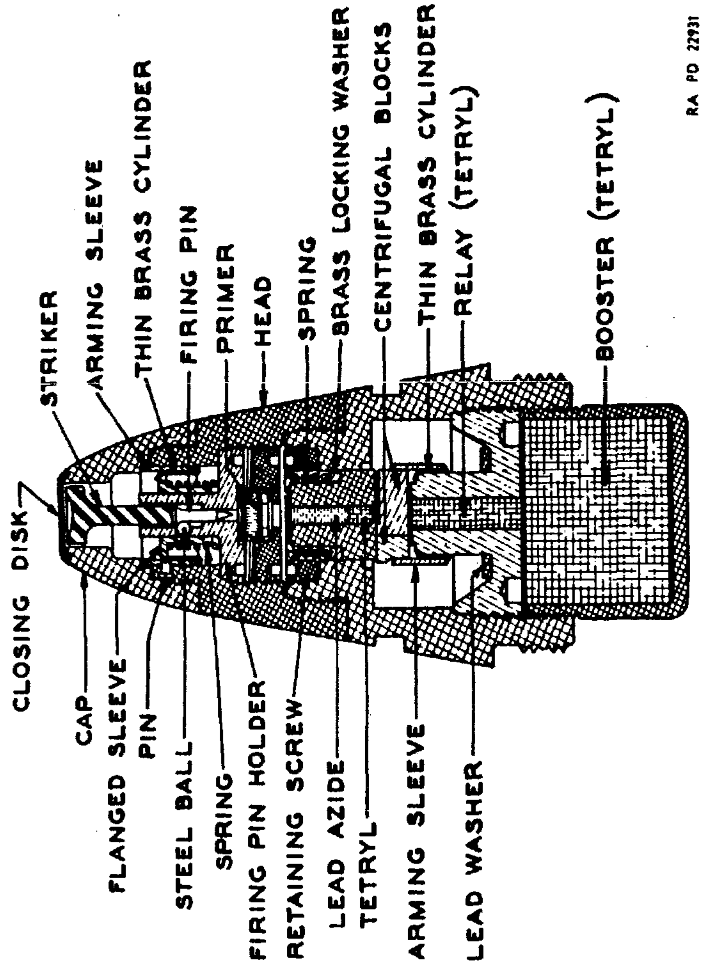

Figure 145 — FUZE, Percussion, D.A., No. 251, Mk. I/L/

lead azide over 0.15 grain of tetryl. A brass washer in two parts fits around the detonator holder just above the shoulder. This washer is backed up by a spring which is compressed and held in place by a retaining screw. The lower portion of the body is threaded on the outside at the top so that the second body part, the head, may be screwed over it.

The head is threaded on the inside at the rear to receive the firing pin sleeve and the primer assembly. The primer holder screws into the head behind the firing pin sleeve. The primer charge, of priming mixture weighs 1.9 grains and should be inserted into the primer holder so that the colored side is visible. A small hole in the firing pin holder seats a steel ball which engages the shoulder of the firing pin and keeps it from contacting the primer during shipment and handling. A sleeve, flanged at the top, fits around the firing pin holder and keeps the steel ball in place. A compressed spring fits around this sleeve and is held in place by the flange. A thin brass cylinder similar to that in the lower portion of the fuze has its upper lugs bent over the shoulder of the flange on the firing pin holder sleeve and keeps the spring from forcing it outward. The brass cylinder is in turn held down by an arming sleeve fitting into the lower lugs which are bent outward and upward. A small pin fitting into a slot in the arming sleeve insures proper movement. The arming sleeve cannot move outward because it engages a shoulder in the third portion of the body, the cap.

The cap is threaded on the inside at the bottom and screws over the head. It retains a nail-shaped, plastic firing pin striker. The lower end of the striker fits into the firing pin holder just over the firing pin. The cap is closed at the top with a thin metal disc.

Function. When the weapon is fired and the projectile starts down the bore of the weapon, set-back causes two actions to occur simultaneously. The arming sleeve around the centrifugal blocks and the relay assembly is forced rearward dragging the lugs of the thin brass cylinder off the shoulder of the relay assembly. The shock of this action is taken up by the lead washer which acts as a cushion. At the same time, the arming sleeve in the head of the fuze moves rearward and drags the lugs of the thin brass cylinder off the shoulders of the flange on the arming pin holder sleeve. As this flange is released, the spring forces the firing pin holder sleeve outward into the fuze cap. The steel ball then falls out of the firing pin holder and the firing pin moves inward and rests on the primer. Set-back action also causes the centrifugal blocks to be held more firmly in place.

As the projectile leaves the bore of the gun it has acquired a high rotational velocity. The resulting centrifugal force causes the centrifugal blocks, which are between the relay holder and the detonator holder, to move out into the recess in the lower body. When this

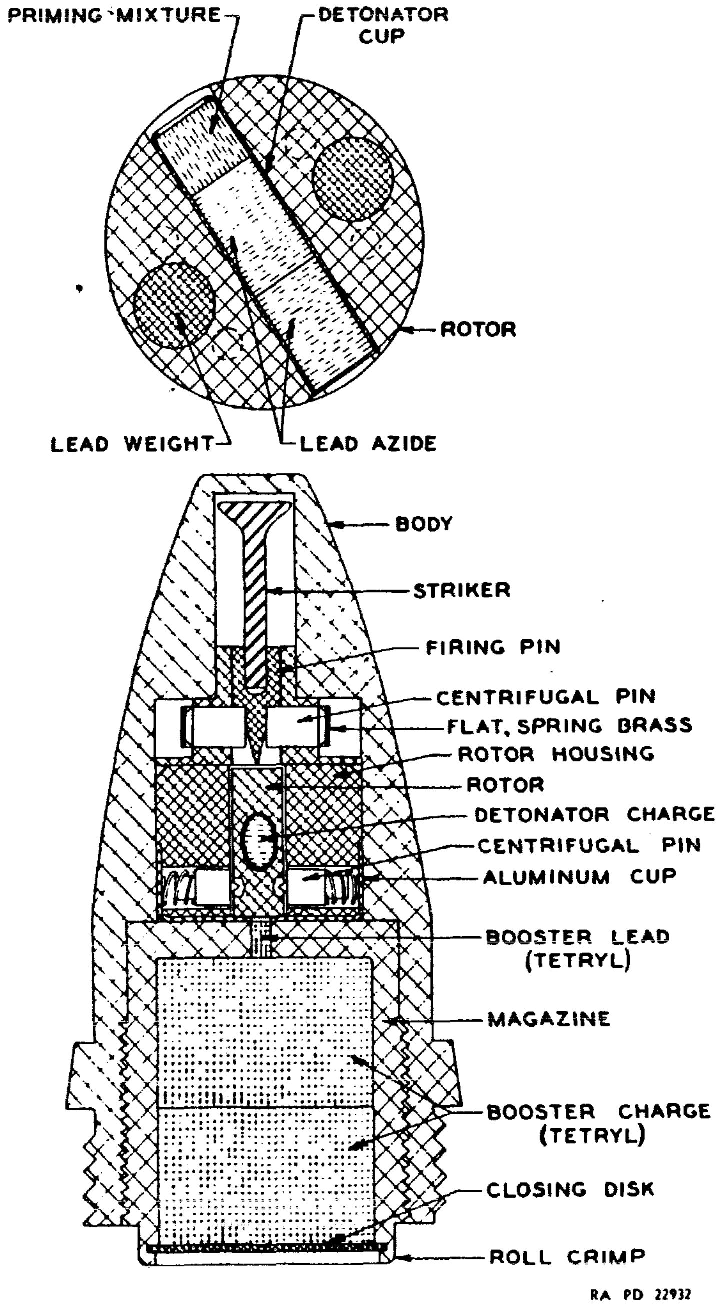

Figure 146 — FUZE, P.D., Mk. 27 (Navy)

occurs, the spring behind the detonator holder forces it rearward to close the space formerly occupied by the centrifugal blocks and bring the detonator charge immediately over the relay charge. The 2-sectioned washer around the detonator holder spreads into a recess in the lower body when the holder has moved sufficiently rearward. This locks the detonator firmly in place.

Impact with the target forces the thin metal disc and the nail-shaped firing pin striker inward. As the force is transmitted to the firing pin, it penetrates the primer. The resulting explosion functions the remainder of the explosive train consisting of the detonator charge of lead azide and tetryl, the relay of tetryl, the booster of tetryl, and finally the TNT bursting charge of the projectile.

FUZE, P.D., Mk. 27 (Navy).

Description. The body of the Mk. 27 Fuze is die-cast in one piece from aluminum-base alloy. It is threaded on the outside at the base to screw into the Mk. II or Mk. I High-explosive Projectiles and on the inside to receive a magazine or booster cup. The nose of the body is closed by leaving a thickness of 0.04 inch of the metal as a cover during casting.

A small cavity in the nose of the fuze seats a nail-shaped plastic firing pin striker. The lower part of the striker fits into the head of the firing pin which is cup-shaped. The firing pin holder is made in three diameters. The upper part with the smaller diameter fits into the striker cavity. The part of intermediate diameter is drilled transversely to seat two centrifugal pins which, in the unarmed position, prevent the firing pin from contacting the rotor detonator. A strip of spring brass is wrapped around this intermediate part and must be spread by the centrifugal pins before the firing pin is released. The part of largest diameter fits the larger cavity in the fuze and provides room for the centrifugal pins to spread.

The firing pin assembly is held in place by the rotor assembly which is fitted in behind it. The rotor housing is a solid cylinder of aluminum-base alloy. A rectangular cavity is cut into the center and goes completely through the length of the housing. The purpose of this cavity is to house the rotor. A hole is drilled completely through the housing at right angles to the rotor cavity. Centrifugal pins are inserted into this hole on either side of the rotor and are backed up by small springs. Small nipples on the end of the pins engage recesses in the rotor. The pins and springs are held in place by a thin aluminum cup which fits over the lower half of the housing. The aluminum cup has a flash hole in the center of the bottom.

The rotor is a flat circular disc with a hole drilled through its diameter to seat the detonator consisting of 0.03 gram of priming mixture over two pellets of lead azide, each weighing 0.054 gram.

Two lead weights are pressed into the rotor at opposite ends of a diameter which is at right angles with the detonator cavity. Recesses are machined into the rotor on each side to receive the nipples of the centrifugal arming pins.

The magazine is cup-shaped with heavy walls and bottom. It screws into the fuze body behind the rotor assembly so that only a small part is left protruding at the rear. A hole is drilled through the bottom of the cup to seat a booster lead charge of 0.020 gram of tetryl. The booster charge is made up of 5.40 grams of tetryl divided into two equal pellets. The open end of the magazine is closed with a disc held in place by a 360-degree crimp.

Function. The function of the Mk. 27 Fuze begins as it leaves the bore of the weapon. Centrifugal force causes both sets of centrifugal pins to move against their springs. The firing pin, thus released, moves inward and rests on the rotor. The rotor, which is then also free to move, alines its detonator with the firing pin because of the effect of centrifugal force upon the lead weights.

Impact with the target forces the firing pin into the priming composition. The resulting explosion initiates the remainder of the explosive train consisting of lead azide detonator, tetryl lead, booster of tetryl and the bursting charge of the Mk. II or Mk. I High-explosive Projectile.

FUZE, P.D. M64A1.

Description. The M64A1 Fuze body is a single piece, die-cast from an aluminum-base alloy. The body is threaded externally and internally at the base; the external threads screw into the nose of the Mk. II Projectile and the booster cup screws into the internal threads. A pellet of 112 grains of tetryl is contained in the booster.

The rotor assembly fits into a cavity ahead of the booster. The rotor housing, which is also a die-cast aluminum-base alloy is enclosed by a brass sleeve which fits snugly into the body cavity. The housing is in the shape of a solid cylindrical block with a rectangular cavity cut across its diameter to house the rotor. This cavity does not extend the full length of the block. Two holes are bored completely through the housing at right angles to the rectangular cavity. The upper hole is to seat two pins upon which the rotor pivots. These pins fit into circular recesses in the side of the rotor and are staked into place. The lower hole seats centrifugal pins on either side which also fits into circular recesses in the side of the rotor and hold it in position with the detonator out of line with the firing pin. A groove is cut around the circumference of the housing so that it passes through the centrifugal pinholes. A length of spring wire is wound around this groove and retains the centrifugal pins. Between 10,000 and 20,000 revc utions per minute are required for the centrifugal pins to

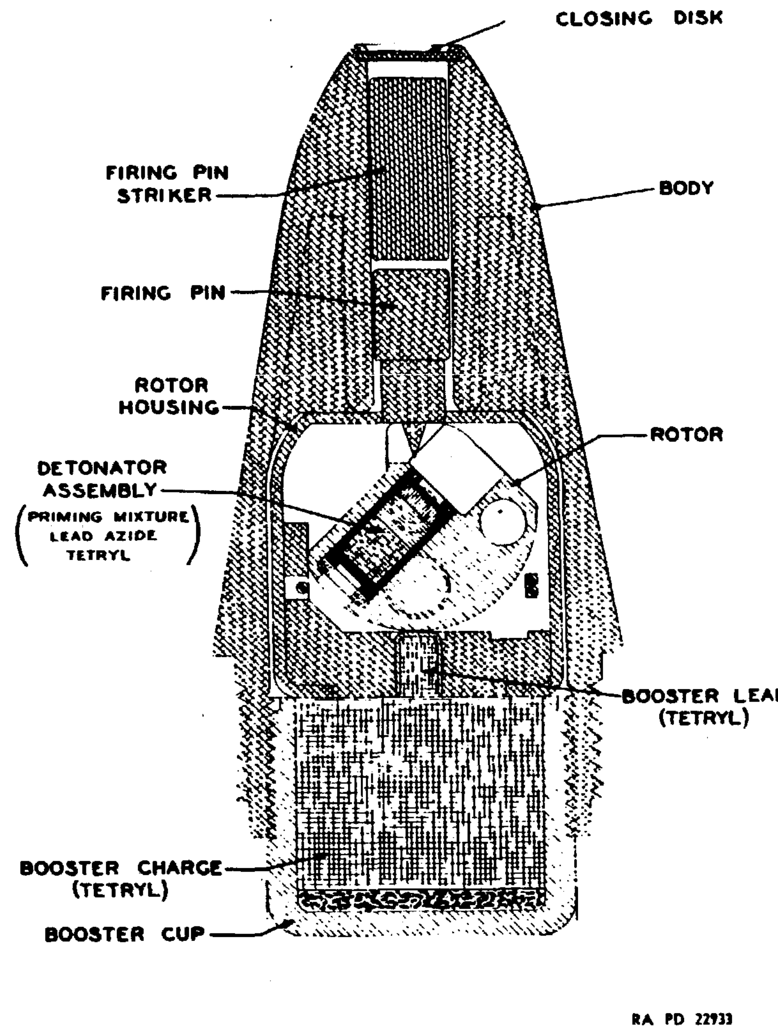

Figure 147 — FUZE, P.D., M64A1

spread this wire sufficiently to free the rotor. A hole is drilled through the bottom of the housing to the rotor cavity. A copper cup containing a booster lead charge of 1.67 grains of tetryl fits into this hole.

The brass rotor is centrifugally weighted and in the unarmed position holds its detonator of 0.72 grain of priming mixture, 2.39 grains of lead azide, and 1.08 grains of tetryl out of line with the firing pin. Since the detonator is thus physically separated from the booster charge, the fuze is regarded as boresafe. A notch is cut into the top of the rotor from the detonator cavity outward. The point of the firing pin rides this notch while the rotor is in the unarmed position.

The firing pin is made of aluminum alloy and fits into a small cavity in the nose of the fuze. A solid cylindrically shaped firing pin striker made of molded plastic fits into the cavity above the firing pin. The fuze body may be closed at the nose by leaving a thin thickness of the metal as a cover during casting, or by a closing disc.

A1 modifications. The M64A1 Fuze differs from the M64 in the following respects:

The firing pin striker in the M64 is nail-shaped. The M64A1 is a solid cylinder.

The firing pin of the M64 is hollowed out at the head to receive the end of the striker. The firing pin of the M64A1 has a head that contacts the full diameter of the striker.

In the M64 Fuzes, the rotor housing is contained directly in the fuze body. The base is threaded for screwing into the fuze body. The rotor housing for the M64A1 Fuze is contained in a brass sleeve which fits into the fuze body and the base is not threaded. It is held in place by the booster which is screwed in behind it.

There are other details of manufacture which differ in the two fuzes, but the fundamental differences are those outlined above.

Function. The function of the fuze begins as rotational velocity is imparted to it. Centrifugal force causes the centrifugal pins to move outward, spread the spring wire and free the rotor. The rotor, being eccentrically weighted, rights itself and brings the detonator into position so that the firing pin rests on the detonator just above the priming mixture.

Impact with the target crushes the nose of the fuze and forces the firing pin striker and firing pin inward. When the firing pin penetrates the detonator, the priming mixture explodes and initiates the remainder of the explosive train consisting of the detonator of lead azide and tetryl, the booster lead charge of tetryl, the tetryl booster, and finally the TNT bursting charge of the Mk. II Projectile.

Identification. The complete round is approximately 17.64 inches long and weighs about 4.64 pounds. The length and weight vary

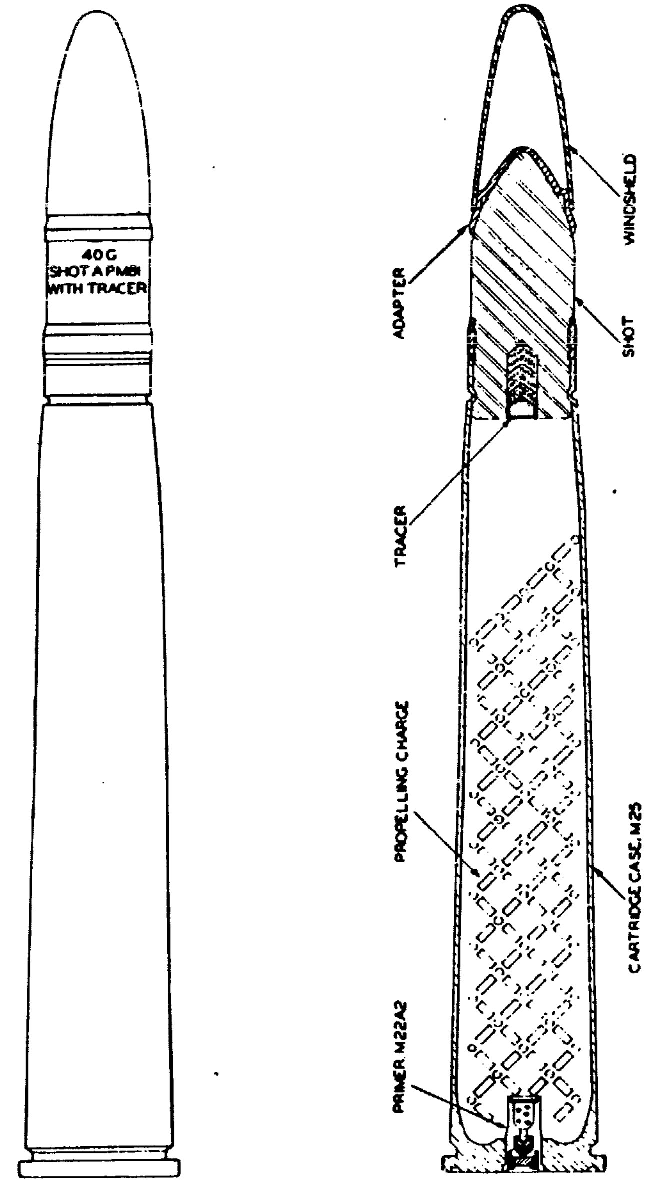

Figure 148 — Cartridge, AP-T, 40-mm, M81

slightly with the assembly of different fuzes. The No. 251, D.A., fuze may be recognized by the fact that its body is made up of three parts fitted together with threads. The M64A1 and Mk. 27 are similar in outward appearance but the nomenclature "Mk. 27" is stamped into the body of the Navy fuze. The Mk. 27 also has two notches cut into the body 180 degrees apart to fit a wrench. The Army projectile is painted olive drab and stenciled in yellow. The Navy system of painting is different.

CARTRIDGE, TP-T, T1.

This round was designed to simulate the 40-mm H.E. rounds for target practice. All components except the projectile and fuze are the same as those used in the service round. The projectile is inert except for a tracer in the base and is painted blue with white stencil to indicate practice use. The fuze used is the Dummy M69. This round is standard for issue only.

CARTRIDGE, AP-T, M81.

This complete round was designed for use against armored targets. It is peculiar as an armor-piercing projectile in that it has a windshield but no armor-piercing cap. The M81 is of American design and is standard for issue and manufacture.

Cartridge Cases. The M25 Case is "Standard"; the M25B1 Case is "Substitute Standard."

Propelling Charge. The propelling charge consists of 10.4 ounces of FNH powder held loosely in the cartridge case.

Primer. The M23A2, 20-grain, Percussion Primer is a standard component of the M81 Round. This primer is described in the chapter on 37-mm ammunition.

Projectile. The body of the projectile is machined from bar steel and is hardened to produce armor-piercing qualities. The ogive has a small radius and is continued to a point. A recess for a copper rotating band and a cannelure to receive the cartridge case crimps are machined into the body. The projectile is streamlined by the addition of a windshield which has a rounded nose. The windshield is soldered to a sheet metal adapter which is soldered and crimped to the nose of the body. A cavity is machined into the base of the body to receive the tracer assembly.

The tracer assembly is made up of tracer composition, igniting composition, and a clear celluloid cup. The cup is cemented and press-fit into the base of the projectile.

Identification. The complete round of the M81 Cartridge is 17.62 inches long and weighs 4.535 pounds. It is easily recognized by its

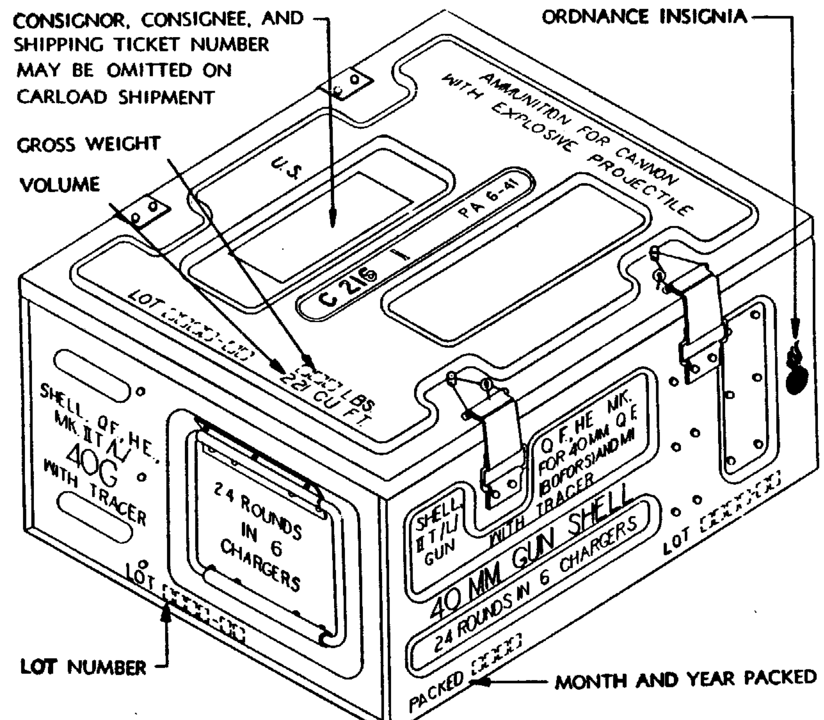

Figure 149 — Metal Packing Box for 40-mm Ammunition

size and the windshield and windshield adapter. Since it is inert, it is painted black and stenciled in white.

CARTRIDGE, AP-T, M81A1.

Information on the A1 modification of the M81 is not available at this time. Both the M81 and M81A1 Rounds are listed as standard for issue and manufacture.

OTHER SERVICE ROUNDS.

Complete rounds listed in SNL P-5 which are not discussed above and on which no detailed information is available at this time, are as follows:

CARTRIDGE, H.E., Mk. I (Navy), w/FUZE, P.D. Mk. 27

CARTRIDGE, H.E., Mk. I, L & P

CARTRIDGE, H.E., Mk. II, L & P

The term "L & P" in the above nomenclature is an abbreviation for "loaded and plugged."

PACKING.

CARTRIDGES, H.E.-T (SD), Mk. II; TP-T, T1; AP-T, M81 and AP-T, M81A1 may be packed either 1 round per fiber container, 24 containers (24 rounds) per box or 4 rounds per charger clip, 6 clips (24 rounds) per metal box. When CARTRIDGE, H.E.-T (SD), Mk. II, is fuzed with the Mk. 27 Navy Fuze, it may also be packed 4 rounds per charger clip, 4 clips (16 rounds) per metal box.

CARTRIDGES, H.E., Mk. I, L & P, and H.E., Mk. II, L & P, are packed 1 round per fiber container, 24 containers (24 rounds) per box.

CARTRIDGE, H.E., Mk. I (Navy), is packed 4 rounds per charger clip, 4 clips (16 rounds) per metal box.

FURTHER REFERENCES. OS 9-20; SNL P-5; SNL R-1; Ordnance Drawings.

Chapter 5

Ammunition for 57-mm Guns

GENERAL.

Weapons. The 57-mm Gun M1 is adapted from the British 2.24-inch (6-pounder) Gun Mk. III which has been successfully employed as an antitank weapon. The American gun differs in several respects from the British gun, but the same ammunition may be fired from either weapon. The gun is mounted on a split-trail carriage with rubber-tired wheels for high-speed transport, and is provided with armor-plate shields. The carriage is designed for 1-man control of elevating, traversing, and firing. The M1 Gun was known as the T2 Gun before standardization.

Class and Types. The 57-mm ammunition is of the fixed class. There are only two types of ammunition provided: the armor-piercing and the practice.

Cartridge Cases.

Case, cartridge, M23A2. This case, made of cartridge brass, is "Standard" for all rounds of 57-mm ammunition. The case is very long (17.40 in.), being approximately three-quarters the length of the complete round. It is provided with an extraction flange 0.20 inch thick. A primer seat to receive the M1B1A2 primer is machined into the head. The weight of the M23A2 Cartridge case is 3.9 pounds.

Case, cartridge, M23A2B1. As indicated by the B1 designation in the nomenclature, this case is made of steel. It is "Substitute Standard" for 57-mm ammunition. It differs from the M23A2 in that

it is lighter (weighs 3.6 pounds), has a thicker extracting flange, and a thinner primer seat.

COMPLETE ROUNDS.

General. All 57-mm rounds consist of a cartridge case with its propelling charge and primer, and a projectile firmly attached by crimps. These rounds and the 57-mm gun are very popular due to the terrific "punch" resulting from a large propelling charge and comparatively light projectile. All 57-mm rounds are standard for issue and manufacture.

CARTRIDGE, AP-T, M70.

Cartridge cases. The M23A2 Brass Case is "Standard"; M23A2B1 Steel Case is "Substitute Standard."

Primer. The M1B1A2, 100-grain percussion primer is standard for use in 57-mm ammunition (see Primer M1, and diagram in a later section).

Propelling charge. 2.25 pounds of FNH powder poured loosely into the cartridge case propels the projectile from the gun at a muzzle velocity of 2,800 feet per second.

Projectile. The M70 AP Projectile is a solid shot of hardened steel with a cavity machined into the base to receive a tracer. The ogive is continued to a point, and has a radius of 3.14 inches. A waved or knurled recess 0.79 inch wide is machined into the shot 1.01 inches above the base to receive a copper rotating band. A cannelure for receiving the crimps from the cartridge case is located 0.51 inch behind the rotating band.

The tracer charge consists of approximately 73 grains of red tracer composition in the form of 3 solid pellets and 20 grains of igniter charge in one pellet. The tracer charge is sealed into the tracer cavity with a clear celluloid cup cemented into place. The tracer burns for about 3 seconds. The projectile with tracer assembled weighs 6.37 pounds and is 6.81 inches long.

Identification. The complete round is 23.20 inches long and weighs about 12.64 pounds with the brass cartridge case. The size, length of cartridge case, stubby projectile, and black painting with white stencil identify the round as CARTRIDGE, AP-T, M70. On visual inspection the only difference between this round and the target practice round is the blue painting and white stenciling of the practice projectile, however, by examining the manufacturer's information just above the rotating band, it may be possible to distinguish between the two if the painting and stenciling is obliterated.

Cartridge, TP-T, M76. This round is used for practice firing. The only difference between it and the AP, M70 is that the projectile is made of mild steel which does not have the armor-piercing qualities of the steel in the AP projectile. All other characteristics of the two rounds, excepting the painting and marking, are the same. The target practice projectile is used because of ease of manufacture and economy.

CARTRIDGE, APC-T, M86. This is a new round. As indicated by the nomenclature it has an armor-piercing cap. A windshield is also added to decrease its wind resistance. Their features will distinguish it from the other 57-mm rounds.

PACKING.

Ammunition for 57-mm guns is packed as follows:

CARTRIDGE, AP-T, M70, is packed in three ways:

1. 1 round per fiber container, 3 containers (3 rounds) per bundle.
2. 1 round per fiber container, 4 containers (4 rounds) per box.
3. 6 rounds per metal box.

CARTRIDGE, TP-T, M76, and CARTRIDGE, APC-T, M86, are packed in two ways:

1. 1 round per fiber container, 3 containers (3 rounds) per bundle.
2. 1 round per fiber container, 4 containers (4 rounds) per box.

The bundled ammunition is put together in groups of three bundles (9 rounds), and crated for export shipment. This crate weighs approximately 171 pounds and displaces 3.5 cubic feet.

FURTHER REFERENCES: OS 9-20; SNL R-1; Ordnance Drawings.

Chapter 6

75-mm Gun Ammunition

GENERAL.

The 75-mm field guns are an adoption from the French. Previous to the present war, the field gun was the only 75-mm weapon. At the present time, due to war time development, we have three additional types. The four types of 75-mm guns are:

Field Guns M1897-16-17
Tank Guns M2, M3, T7
Antiaircraft Gun T6
Aircraft Gun M4

All of the 75-mm guns are provided with the fixed class of ammunition. Fixed ammunition is loaded into the weapon in one operation, the cartridge case being firmly crimped to the projectile so that there is no opportunity to adjust the propelling charge at the point

of fire. Three types of ammunition: H.E., chemical and AP, are provided for 75-mm guns.

The painting and marking of 75-mm gun ammunition corresponds to the standard color scheme which has already been presented. A possible additional marking, which may be found in the field, is a latter "S" stenciled just above the bourrelet. This indicates the presence of a smoke produced in the shell. These shell are dangerous and should be reported for destruction on ACR.

FUZES.

P.D. Fuze M46, Instantaneous. This fuze is an instantaneous fuze manufactured by modifying the Mk. III Fuze (World War I type). Originally designed to overcome the disadvantages of the Mk. III when used with the reduced charge, or in the low zones of howitzers, the M46 has very satisfactory results with all calibers of guns and howitzers. This fuze is not boresafe since the lower detonator is not positively separated from the booster.

Description. The conversion from Mk. III to M46 consists of cutting off the forward end of the Mk. III body and installing a new head assembly. The lower detonator housings are rebuilt, and more powerful detonators are installed at the time of conversion. The impact mechanism in the head of the fuze is identical to that found in the M48 and M54 Fuzes. A cavity in the forward end contains an aluminum firing pin which is shaped like a large-headed tack, and a gilding metal cup which acts as a support for the firing pin. In a socket below the point of the firing pin is the upper detonator of lead azide priming composition over lead azide. A washer holds the firing pin in place, and a tinfoil disc closes the open end of the cavity to exclude foreign matter. The head of this fuze is painted white to distinguish it from the similarly contoured M47 Fuze.

In the body of the fuze is contained the interrupter assembly consisting of an interrupter, an interrupter spring, and a cap which retains the mechanism within the fuze.

The lower end of the body is threaded to receive the lower detonator which is composed of lead azide over tetryl.

Safety features. The firing pin support is so designed that it will not collapse under the force of set-back but will collapse under the force of impact, and supports the firing pin at a safe distance from the upper detonator.

The interrupter, while in the unarmed position, closes the passage leading to the lower detonator preventing its function in the event the upper detonator functions prematurely.

Function. The fuze is ready to function when it is screwed home in the fuze socket of the projectile and seated with a fuze wrench. Its action is such that during flight the interrupter is acted on by centrifugal force as linear acceleration ceases, and is thrown out-

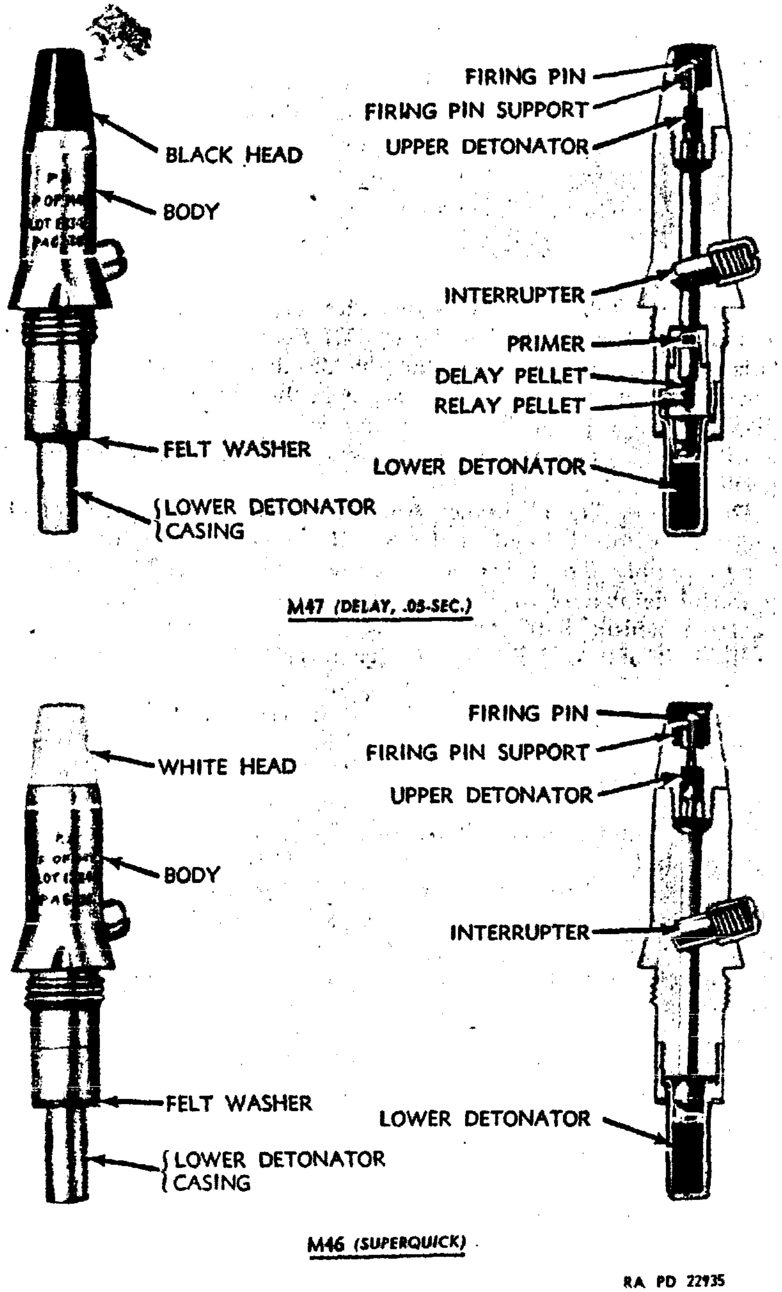

Figure 150 — FUZES, P.D., M46 and M47

ward against the resistance of its spring, thus clearing the central flash channel. No other parts are acted upon until impact. On impact, earth, water, or sand enters the cavity in the head and drives the firing pin inward. This action crushes the supporting cup and permits the point of the firing pin to strike the upper detonator, thus initiating a detonating wave. This detonating wave passes through the open channel to the lower detonator, which in turn detonates the booster and shell filler. Should the projectile strike a rock or other hard substance, the entire front portion of the head is crushed permitting the same functioning as described above.

P.D. Fuze M47, Short Delay. This fuze is a 0.05-second delay fuze manufactured by modifying the Mk. III Fuze. This fuze is designed to serve as a companion fuze to the M46, the ballistic characteristics of the two fuzes being similar.

Description. Externally, this fuze is identical with the P.D. Fuze M46 except for the marking. The stamping in the body of the fuze naturally differ with types and lots. In addition, the head of the M47 Fuze is painted black. The mechanisms of the two fuzes are alike except that, for the M47 Fuze, a delay element is inserted in the central channel at the rear of the body. This delay element consists of a primer striker, a primer, a delay pellet of compressed black powder designed to burn for 0.05 second, and a relay pellet of lead azide.

Safety features. The safety features are identical with those of the P.D. Fuze M46.

Function. The action of the fuze through impact with the target is similar to that of the M46 Fuze. The upper detonator of lead azide priming composition over lead azide upon being stabled by the firing pin initiates a detonating wave which passes down the central channel to the delay element located in the lower portion of the central channel. The force of the detonating wave crushes the primer which emits a nondisruptive flame, which in turn ignites the delay pellet of compressed black powder. This in turn burns for 0.05 second, at the end of that time igniting the relay pellet of lead azide which transforms the combustion into a detonation. This causes detonation of the lower detonator of lead azide and tetryl and of the booster to which the fuze is assembled.

Development of the Selective Fuze. It has been noted previously in relation to ammunition for the 81-mm trench mortar that, in that particular instance, a selective action was unnecessary and, in fact, uneconomical. The reason for the trend away from selectivity in the trench mortar fuzes is that the use to which each projectile is going to be put is known. Artillery ammunition presents a situation exactly opposed to that found in trench mortar ammunition. The artillery

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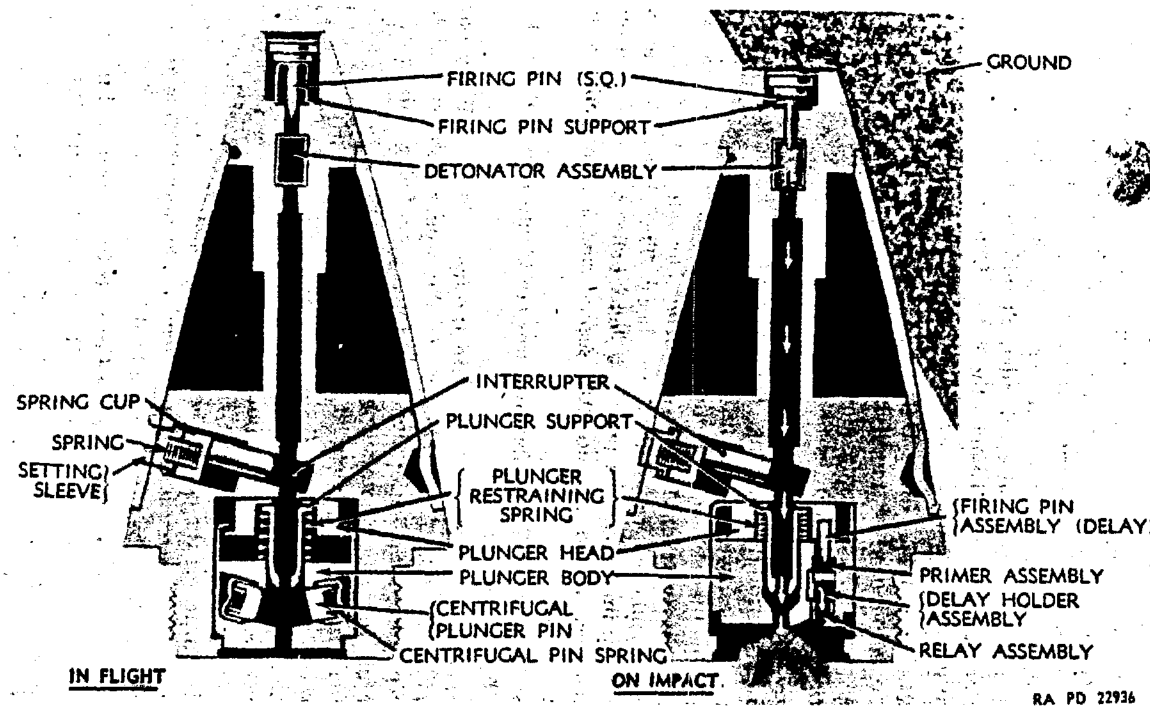


Figure 151 — FUZE, P.D., M48 — Superquick Functioning

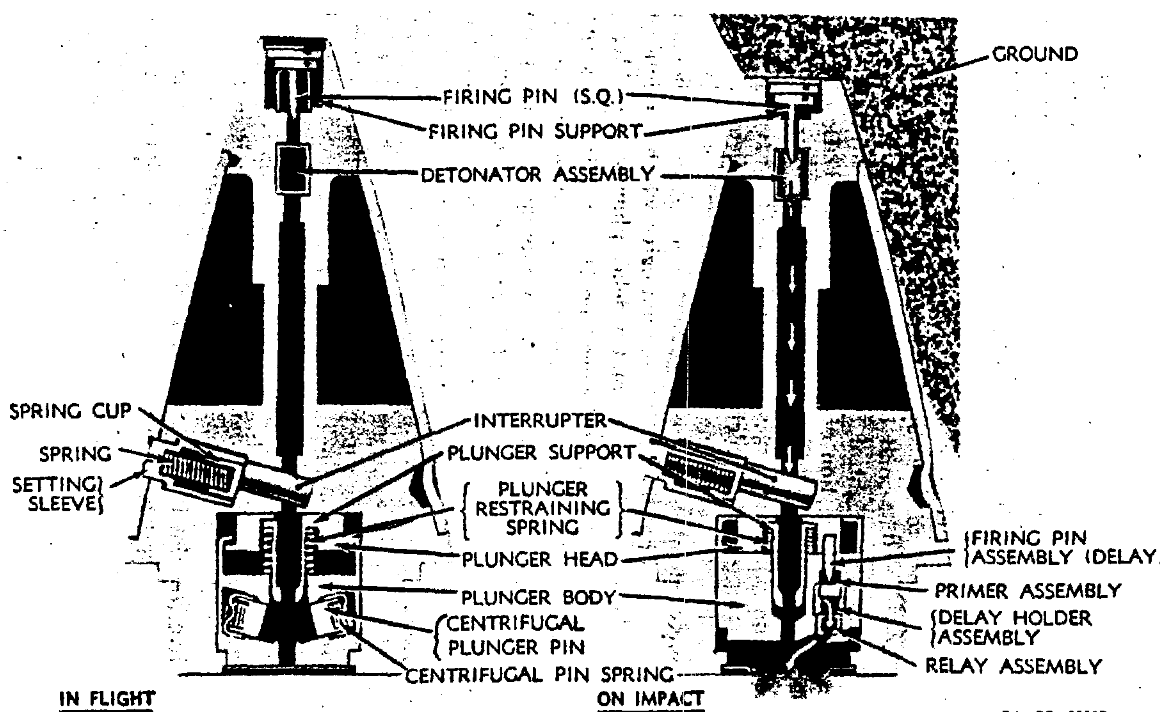


Figure 152 — FUZE, P.D., M48 — Delay Functioning

high-explosive shell is a multipurpose projectile, being capable with the proper fuzes of giving above ground bursts, or bursts after penetration has occurred. It is, therefore, desirable to have a selectivity of action in the fuzes for artillery H.E. shells.

The M46 and M47 P.D. Fuzes together gave this selectivity of action but presented a supply problem in that both had to be supplied for the one projectile, one of them, of course, being unused. For these reasons, it has been deemed advisable to develop a fuze with selective action for artillery high-explosive rounds.

P.D. Fuze M48, Selective, Superquick or Short Delay. This fuze may be set at will to give superquick functioning on impact, or to function with a 0.05-second delay after impact. It is of the new type with standard weight of 1.41 pounds, standard streamlined contour, and standard location of the center of gravity. Bore safety is obtained in conjunction with the M20 or M20A1 Boosters.

Description. The fuze consists of a head which carries the superquick element; a body which carries the delay element; setting device and threads assembling the fuze to the booster; a flash tube which forms a channel for the superquick detonation and holds the head in its proper position; an aluminium ogive which continues the contour of the projectile ogive; and a delay plunger assembly.

Setting. As issued by the Ordnance Department, this fuze is set for superquick action. It is readily set and reset for either superquick or delay action by a setting sleeve which for superquick action permits the interrupter to move to its armed position, or which for delay action retains the interrupter in its unarmed position during flight. The setting sleeve is a cylindrical piece of brass with a slotted head and a central hole slightly larger than the diameter of the spring. The cylindrical piece contains a wide slot into which is fitted the spring and cup. Both the superquick and delay elements function on impact but, with a superquick setting, the faster action operates before the delay action, while with a delay setting, the superquick action is stopped at the interrupter. Where superquick action is desired, the setting sleeve is turned so that the screwdriver slot is in line with "S. Q." stamped on the ogive (slot parallel to longitudinal axis of fuze). When the slot is in this position, the setting sleeve is turned so that only the spring cup is in contact with the interrupter, thus permitting centrifugal force to move the interrupter and spring cup outward against the action of the interrupter spring. For delay action, the screwdriver slot in the setting sleeve is turned so as to be in line with the word "DELAY" stamped on the ogive (slot parallel to transverse axis of fuze). In this position, one of the legs at either side of the slotted portion of the setting sleeve overlaps the eccentrically located interrupter. The interrupter is thus retained in its unarmed or safe position during firing or flight.

Superquick element. Three major parts within the head comprise the superquick impact mechanism of the fuze. A cavity in the forward end contains a firing pin, shaped like a large-headed tack, and a gilding metal cup which acts as a support for the firing pin. In a cavity below the point of the firing pin is the detonator assembly. A washer holds the firing pin in place and a tinfoil closing disc seals the open end of the cavity to exclude foreign matter.

Delay element. The delay element is contained in the rear of the fuze body. During transportation and firing, a plunger support and centrifugal pins prevent the plunger body, which carries the delay element, from contacting the plunger head, which carries the delay firing pin. The centrifugal pins and their springs are placed in the body, below the plunger support, in order to limit the possible movement of the plunger body until after the projectile has cleared the muzzle of the weapon. A plunger restraining spring coiled about the plunger support between the plunger head and the plunger body prevents these elements from contacting each other due to creep force during flight.

The delay-explosive train consists of a percussion primer which is actuated by the delay firing pin, a delay pellet of compressed black powder which is adjusted so as to burn for 0.05 second, and a relay pellet of lead azide which transforms the combustion of the delay pellet into a detonation.

Safety features. The firing pin support is so designed that it will not collapse under the force of set-back, but will collapse under the force of impact, and supports the firing pin at a safe distance from the detonator assembly.

The interrupter, while in its unarmed position, closes the passage leading to the booster, preventing superquick action in the event the superquick detonator functions prematurely.

The centrifugal pins in conjunction with the plunger support prevent the delay firing pin from contacting the delay primer until after the projectile has cleared the muzzle of the weapon.

The plunger restraining spring prevents the delay primer from contacting the delay firing pin as a result of creep force during flight.

Superquick action. When set for superquick action, the interrupter is permitted to move outward as soon as it may overcome the friction due to acceleration (the component of the set-back force resulting from the inclined axis) and the force of the restraining spring. This occurs after the projectile has emerged from the muzzle. On impact, earth, water, or sand ruptures the closing disc and forces the firing pin to the bottom of the cavity in the head. This action crushes the supporting cup and permits the point of the firing pin to penetrate the superquick detonator of lead azide priming mixture over lead azide.

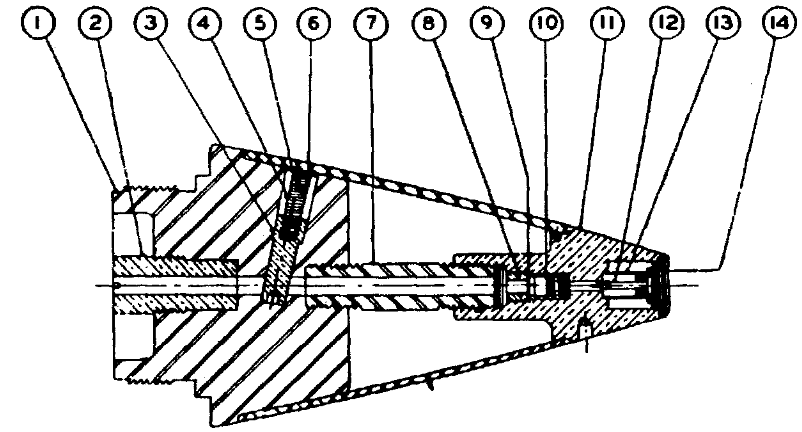
NOTE: Impact with a resistant target such as concrete or stone will crush the head of the fuze with the same final effect. This action initiates a detonating wave which is free to pass directly through the open flash channel of the fuze to the detonator of the booster, the latter being in the armed position. It should be remembered that the delay firing pin also functions the delay element but, since the fuze is set for superquick action, the detonator of the booster functions prior to the completion of burning of the delay pellet.

Delay action. This setting restrains the interrupter against outward movement in flight and, consequently, prevents the explosive wave of the superquick detonator from passing down the flash channel. On set-back, the plunger support contacts the shoulders of the centrifugal pins, thus preventing the plunger head and delay firing pin from contacting the plunger body and delay primer. Centrifugal force moves the two centrifugal pins to their outermost position, compressing the springs behind them as soon as linear acceleration has been overcome. The delay element is fully armed about 3 to 5 feet beyond the muzzle of the weapon. During flight, the plunger body and delay primer are prevented from contacting the plunger head and delay firing pin by means of the plunger restraining spring which surrounds the plunger support. On impact or retardation (ricochet), the plunger body is forced by inertia to move forward in the cavity of the fuze body, thus carrying the delay primer into contact with the delay firing pin. Flame from the primer ignites the delay pellet of compressed black powder which burns for 0.05 second and ignites a relay pellet of lead azide which transforms the combustion into a detonation which passes through an auxiliary flash channel into the main flash channel and thence to the detonator of the booster.

P.D. Fuze, M48A1, Selective, Superquick or Long Delay. The P.D. Fuze M48 has been found through combat experience to have two faults in its design. Firstly, the delay was not of sufficient length to allow for a high burst on ricochet. Shells fuzed with the M48 Fuze burst on ricochet at a height of about 3 feet, whereas a burst at a height of 8 to 10 feet is most desirable. Secondly the centrifugal pins in the delay plunger have been found in certain weapons with which the fuze is used to return to their unarmed position. This caused a shell fired for delay action to become a dud.

To overcome these disadvantages, a new design, the FUZE, P.D., M48A1, selective, superquick, or long delay, has been developed. This fuze differs from the M48 Fuze in that it contains the delay plunger assembly of the M51 Fuze and a 0.15-second delay pellet. The 0.15-second delay pellet is of sufficient length to delay detonation until the shell reaches a height of 8 to 10 feet on ricochet.

Point-detonating Fuze M57. This fuze is a superquick point-detonating fuze(with no delay element, designed primarily for use



1. BODY
2. BODY TUBE
3. INTERRUPTER
4. SPRING
5. INTERRUPTER CLOSING DISK
6. OGIVE
7. TUBE
8. DETONATOR RETAINER SCREW
9. RETAINER WASHER
10. DETONATOR ASSEMBLY
11. HEAD
12. FIRING PIN ASSEMBLY
13. FIRING PIN SUPPORT
14. CLOSING DISK

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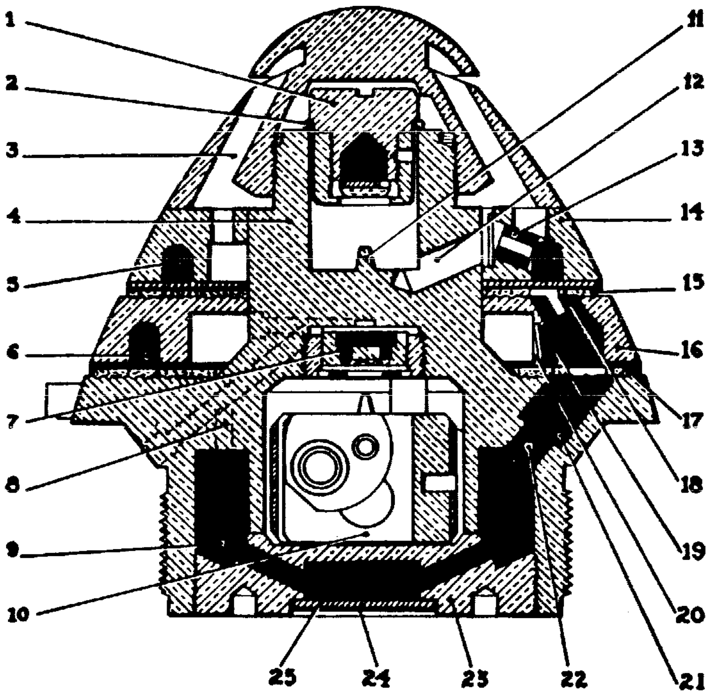
Figure 153 — FUZE, P.D., M57

on chemical shell. This fuze is similar to the M48, except that it contains no delay element and has no setting sleeve on the centrifugal interrupter. In firing chemical shell, it is important that the shell burst before entering the ground in order that the chemical be spread instead of concentrating in and near the shell crater. Due to the fact that the delay assembly of the M48 Fuze was not needed when firing chemical shell, it was decided to effect an economy by redesigning the M48 Fuze leaving out this assembly. This fuze as changed, is designated M57.



1. CONCUSSION PLUNGER.
2. CONCUSSION RESISTANCE RING, BRASS.
3. VENTS IN CLOSING CAP.
4. BODY, BRONZE.
5. UPPER TIME TRAIN, COMPRESSED POWDER.
6. LOWER TIME TRAIN, COMPRESSED POWDER.
7. PERCUSSION PRIMER.
8. VENTS LEADING FROM PERCUSSION PRIMER TO MAGAZINE.
9. POWDER MAGAZINE.
10. PERCUSSION PLUNGER.
11. FIRING PIN, BRASS.
12. VENT LEADING TO UPPER TIME TRAIN.
13. COMPRESSED POWDER PELLET.
14. UPPER TIME-TRAIN RING, TOBIN BRONZE.
15. WASHER FOR GRADUATED TIME-TRAIN RING, FELT CLOTH.
16. GRADUATED TIME-TRAIN RING, TOBIN BRONZE.
17. WASHER FOR BODY, FELT CLOTH.
18. COMPRESSED POWDER PELLET IN VENT LEADING TO LOWER TRAIN.
19. COMPRESSED POWDER PELLET IN LOWER TIME-TRAIN VENT.
20. BRASS DISC, CRIMPED IN PLACE.
21. COMPRESSED POWDER PELLET IN VENT LEADING TO MAGAZINE.
22. VENT LEADING TO MAGAZINE.
23. BOTTOM CLOSING SCREW, BRASS.
24. WASHER FOR CLOSING SCREW, BRASS.
25. WASHER FOR CLOSING SCREW, MUSLIN.

RA PD 22939

Figure 154 — FUZE, Combination, 21-second, M1907M

Function. As linear acceleration ceases (this is after the projectile has cleared the muzzle of the weapon), centrifugal force acts upon the interrupter causing it to move outward clearing the central flash channel. On impact, earth, water, or sand ruptures the closing disc and forces the firing pin to the bottom of the cavity in the head. This action crushes the supporting cup and permits the point of the firing pin to penetrate the superquick detonator of lead azide priming mixture over lead azide. This initiates a detonating wave which is free to pass directly through the open flash channel of the fuze to the booster or burster of the chemical shell.

21-second Combination Fuze M1907M. This fuze is used with shrapnel. Both shrapnel ammunition and this type of fuze are fast becoming obsolete. The discussion, therefore, will be limited to a general description. If further detail is desired, the time action of the fuze may be compared generally to that of the 25-second combination Fuze M54; and the impact action may be compared to that of the Mk. V or Mk. X Base-detonating Fuzes in so far as plunger and primer action are concerned.

This fuze can be set and reset at any time from 0, for canister effect (point blank burst approximately 75 feet from the muzzle), to 21.2 seconds, the longest time that the fuze will burn after leaving the weapon. It is made of brass and bronze, and weighs 1.25 pounds.

The fuze is issued set at safe and assembled to the shrapnel projectile. It is protected by a waterproof cover which is removed and thrown away when the fuze is set for time of flight.

The fuze has no detonating element, as it is designed to ignite the base charge of black powder in the shrapnel. If the time element of the fuze fails to function, or the setting is too long, the percussion element will cause the shrapnel to function upon impact. The term "combination" is derived from this double-action (time and impact) feature. Either burning of the time element or firing of the percussion element on impact will ignite a black powder magazine charge of the fuze. The flame from this charge will cause ignition of the black powder base charge of the shrapnel.

Further discussion of this fuze will be found in applicable references or by comparison of actions as outlined above.

Development of the Combination Fuze for the H.E. Round. Since shrapnel is fast becoming obsolete it might be thought that there would be no use for the combination fuze. The combination fuze, although somewhat modified (a detonator in place of the percussion element for impact action), is still, however, being used on H.E. rounds. The various uses which are possible for the combination fuze on H.E. round may be summarized as follows:

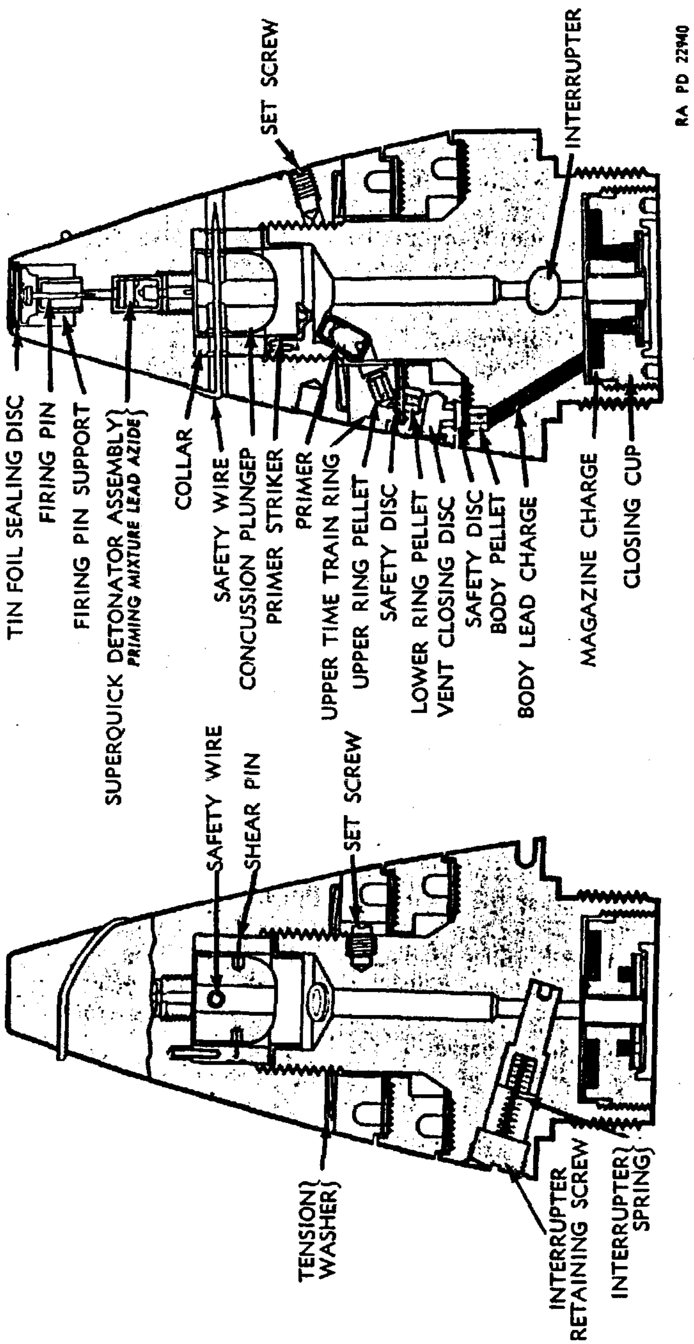


Figure 155 — FUZE, Combination, 25-second, T&SQ, M54

High burst ranging
Time fire for H.E. shell.

P.D. Fuze M54, 25-second, Time and Superquick. This fuze is a combination fuze which is used in conjunction with the M20 booster to effect the functioning of a shell after a predetermined lapse of time, or upon impact. It is of the new type, having a standard weight, contour, and center of gravity, so that its trajectory is the same as that of a similar round fuzed with the M48 Point-detonating Fuze. Boresafety is obtained in conjunction with the M20 Booster.

Description. The fuze consists of a closing cap assembly, which carries the superquick element; and a concussion (acting upon set-back) plunger for initiating the burning of the time train; a body which carries two brass time-train rings; an interrupter; and a black powder magazine charge. The rear portion of the body is threaded for assembly to the mating threads of the booster.

Superquick element. The superquick element is identical to that of the Point-detonating Fuze M48, previously described.

Time element. The time element consists of an upper time-train ring which is locked to the body of the fuze by a set screw which engages a slot in the inner surfaces of the ring, a movable graduated time-train ring, a pellet and body charge which connects the graduated ring time-train to the magazine charge, and the initiating device consisting of a concussion plunger, primer striker, and a primer.

The rings are held under compression by a cupped tension washer which is installed between the closing cap and the upper ring. Felt washers are glued to the upper surfaces of the graduated time-train ring and body. These washers serve to confine the flame and gases produced by the combustion of the time rings, and also to permit the graduated ring to be turned with uniform resistance and without mutilating the onion skin paper washers which are shellacked to the lower surfaces of the rings. On the lower face of each ring, a horseshoe-shaped slot is milled, and this slot is filled with compressed black powder. A graduated ring pellet connects one end of the train on the graduated ring to the upper time-train ring. An upper ring pellet connects one end of the upper ring to the initiating primer. On the exterior surface of each ring, there is a hole or vent which is closed by a tinfoil disc. The graduated time-train ring is graduated from 0 to 25 seconds, the graduation from 1 to 25 being in divisions of 0.2 second. Directly above the primer there is an anvil-shaped striker. A concussion plunger is held in place above the striker and within a collar by means of a safety wire and two shear pins. The collar has an alinement pin by which its position is maintained so that the safety wire, which terminates in a spiral about the closing cap nose, can extend through it, the plunger, and the closing cap.

The shear pins maintain the alinement of the plunger within the collar and support the plunger after the safety wire is withdrawn. The magazine charge is contained within the bottom closing disc which threads into the base of the body.

Safety features. The firing pin support maintains the firing pin at a safe distance from the superquick detonator until impact. It is identical to that of the P.D. Fuze M48.

The interrupter, while in the unarmed position, closes the passage leading from superquick detonator to booster preventing superquick action of the round in the event that the superquick detonator functions prematurely.

The safety wire supports the concussion plunger during transportation, storage, and handling, thereby preventing accidental shearing of the shear pins and firing of the concussion primer. It must be removed prior to firing.

When the fuze is set at safe, the metal between the ends of the time train in the upper ring covers the graduated ring pellet, and the metal between the ends of the time train in the graduated ring covers the body pellet. Under these conditions it is possible for one or both rings to burn completely without igniting the base charge in the fuze.

The vent closing discs prevent premature ignition of the powder trains by chamber gases. The pressure created by combustion gases, upon ignition of the powder trains, ruptures these discs, thereby providing vents (termed "exterior vents") for the gases generated as the burning of the time train progresses. These discs also serve to seal the powder trains against moisture.

Safety discs are located at the ignition end of both the upper and graduated ring time-train. When the fuze is set at less than 0.4 second, the safety disc of the upper ring covers the graduated ring pellet, and the safety disc of the graduated ring covers the body pellet, thereby preventing ignition of these pellets by the burning of the time-train rings. These features are necessary in order that a time burst of a H.E. projectile shall not occur too close to the gun position.

The shear pins perform the same function as the safety wire in that they support the concussion plunger during loading of the round into the weapon, and thereby prevent accidental firing of the concussion primer.

Setting. There is no selective setting provided for superquick action but, when desired, it is obtained by firing with the time-train set at safe ("S" on graduated ring opposite index line on body) or with a time of burning which is surely in excess of the time of flight. The manufacturer sets the time at safe, so that, if fired without any change of setting, a superquick impact burst results. Time settings from 0.4 second (for close-in defense) to 25 seconds are obtained by rotating

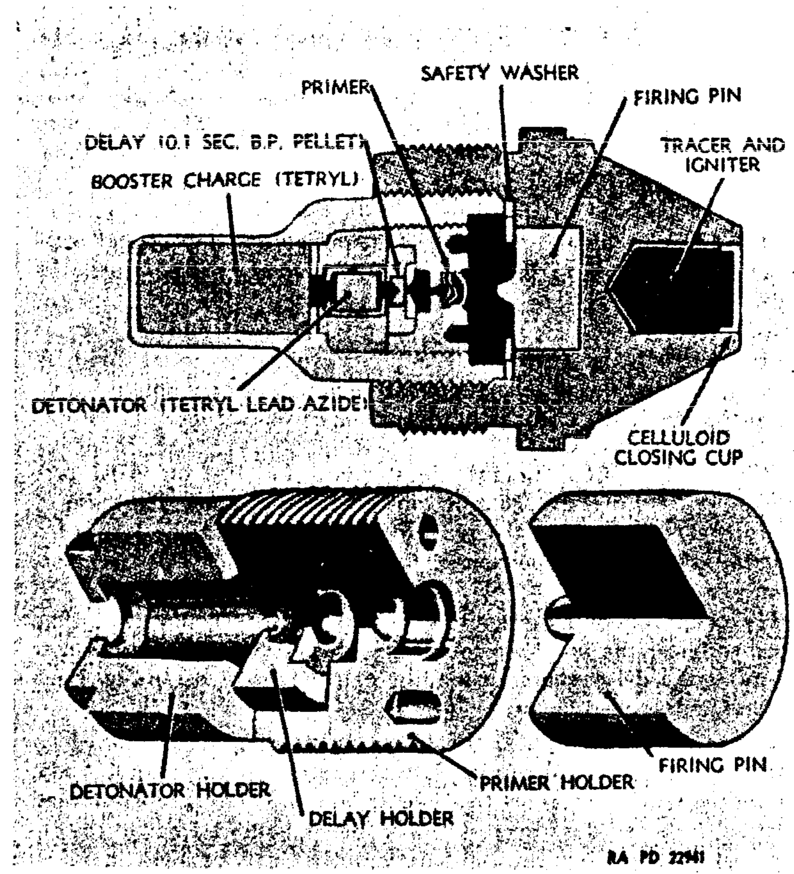


Figure 156 — FUZE, B.D., M66A1

the graduated time-train ring so that the desired reading in seconds or fraction of seconds coincide with the fixed setting line on the body. A shoulder is milled in the graduated time train ring between the ends of the scale, and another shoulder is milled in the body for turning the graduated ring in the fuze setter.

Superquick action. The nonsetting interrupter used with this fuze moves to its outward or armed position as soon as linear acceleration is overcome by centrifugal force. Provided the fuze is set on safe or with a time of burning in excess of time of flight, the fuze will function on impact in exactly the same manner as P.D. Fuze M57.

Time action. When the gun is fired, set-back force causes the concussion plunger to shear its shear pins and bend the primer striker against the primer. The primer, upon firing, ignites the upper ring pellet which ignites the powder of the upper time-train ring. The compressed powder in the upper time train ring burns at a relatively uniform rate, and the burning progresses to the point where the flame contacts and ignites the graduated ring pellet. The position of the graduated ring pellet is controlled by setting the graduated time-train ring before firing. The pellet of the graduated time train ring transmits the flame to the powder train of this ring. This powder train burns in a manner similar to that of the upper ring and communicates the flame to the body pellet. The body pellet ignites the body charge, which fires the magazine charge. As viewed from the forward end of the fuze, the upper ring burns in a counterclockwise direction and the graduated ring in a clockwise direction, so that increasing the setting of the graduated ring causes an approximately proportionate increase in the burning time of both rings.

FUZE, B.D. M66. This fuze is standard for use on APC projectiles for 75-mm guns, 76-mm guns, and 3-inch guns. The base of the fuze extends beyond the rear of the projectile, in the form of a boat tail, the rearmost portion of the fuze containing the tracer assembly.

The composition of the entire fuze may be broken down into five subassemblies: the body assembly, the booster assembly, the primer assembly, the delay charge assembly, and detonator assembly. Each of these is described below.

Description. The body of the fuze consists of a steel part which is threaded on the outside to fit into the base of the projectile body, and on the inside to receive the booster holder. It has a tapered head indented to house the tracer assembly and is hollowed out in the inside so that the firing pin and safety washer will be held in place when the booster holder is screwed into the body.

Tracer assembly. The tracer assembly in the rear of the fuze body consists of two pellets of tracer composition, one pellet of igniter composition, and a celluloid closing cup.

The tracer mixture is loaded into the cavity and pressed into place. The igniter composition is then pressed into place and the clear celluloid closing cup is inserted and secured by application of N.R.C. compound which has adhesive qualities.

Firing pin. The firing pin is a cylindrical brass plug with a small nipple on one face. It is a free fit in the hollow of the fuze body and is held in place by the safety washer until the fuze has been fired and the projectile impacted. The safety washer is a brass disc 1 inch in diameter, with a ½-inch hole in the center and eight 1/16-inch slots extending approximately ⅛ inch deep. These slots leave eight lips of brass to support the firing pin, but these lips are designed to

collapse upon impact. The inertia of the firing pin, when the travel of the projectile is abruptly halted, will carry the firing pin into contact with the primer assembly.

Booster holder assembly. The booster holder comprises the steel part which holds the primer, delay charge, detonator, and booster assemblies, and secures them to the body of the fuze. In short, it holds the explosive elements of the fuze in their proper relative positions.

Primer assembly. The primer is contained in a cavity in the rear face of the primer holder, a commercial brass cylinder which screws into the booster holder and which houses the delay charge holder assembly on its opposite face. The primer is of the same type as the one generally used in cal. .30 ammunition.

Delay charge assembly. The delay charge assembly is held on the other side of the primer holder and is connected to the primer by means of a flash channel. The flame from the primer passes down the flash channel, through a brass retaining washer, and into contact with the delay pellet of compressed black powder. When the delay charge has burned through, the flame again passes down a flash channel and into the detonator assembly.

Detonator assembly. The detonator holder is a steel cylinder which is designed to fit snugly into the booster holder and to be held in place when the primer holder is screwed down tightly. It is bored through the center with a hole that provides a snug fit for the detonator cup, which contains a charge of lead azide over tetryl.

Booster assembly. The last component of the explosive train is the booster charge. The detonating wave from the detonator passes through a flash channel and detonates the booster charge of tetryl.

Action. The M66 B.D. Fuze must be considered nonboresafe since there is no separation between detonator and booster. The restraining washer holds the firing pin from the primer until the projectile in which the fuze is being fired strikes a solid object so that its travel is abruptly halted. When the solid target is struck, the inertia of the firing pin causes it to continue in its course of flight. Thus it forces itself through the lips of the washer and into contact with the primer.

The flame from the primer ignites the delay pellet of compressed black powder which burns for 0.1 second. The flame from the delay ignites the lead azide of the detonator which detonates; the wave causes detonation of the tetryl in the detonator, the tetryl of the booster, and the explosive D of the bursting charge.

Modification. The A1 modification of the M66 Fuze consists of a strengthening of the body and an enlargement of the booster charge.

ADAPTER BOOSTERS AND BOOSTERS.

General. In general, an adapter is a bushing that fits into the nose of a shell and into which a fuze may be inserted. In general,

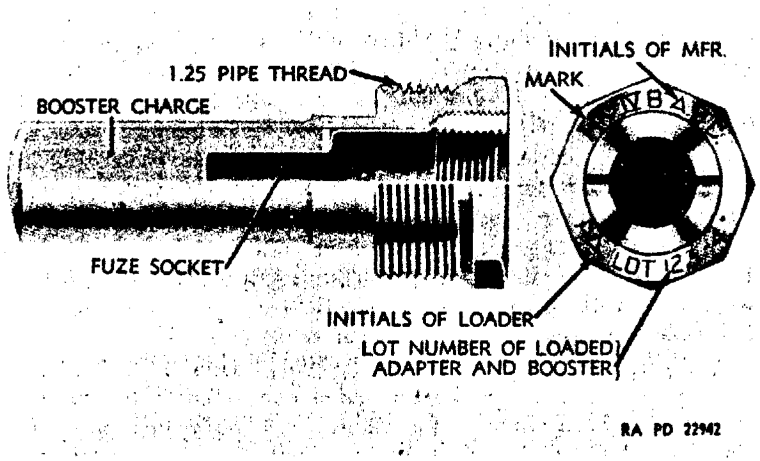
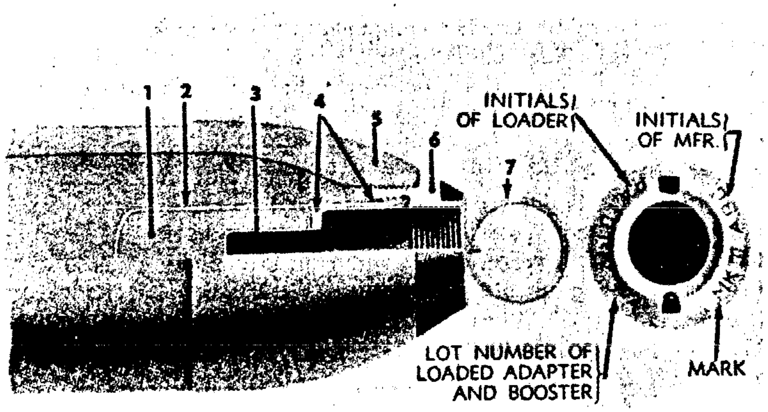


Figure 157 — Adapter Booster Mk. IVB

a booster is a casing containing a charge of high explosive which serves to amplify the detonating wave from the fuze so as to insure detonation of the bursting charge in the shell. These assembled components are known as the adapter and booster.



1 — BOOSTER CHARGE (TETRYL)
2 — BOOSTER CASING
3 — FUZE SOCKET
4 — FELT WASHERS
5 — NOSE OF SHELL
6 — ADAPTER
7 — CLOSING PLUG

Figure 158 — Adapter Booster Mk. III

The booster as used in projectiles of modern design and with fuzes of modern design requires no adapter, it being so designed that it takes the place of the adapter used with older types of projectiles and fuzes. These boosters also usually have a boresafe feature incorporated in their design which enables the handling and shipping of assembled complete rounds.

Adapter Booster Mk. III. The Adapter Booster Mk. III is used in the Mk. I, H.E. Shell for 75-mm guns. The illustration shows this adapter booster and gives the names of the principal parts. A fuze socket protects the booster charge from moisture. As fuzes are never assembled in these shell until the round is to be used, an adapter plug is supplied which acts as a protection against the entrance of foreign substances and prevents injury to the threads of the adapter. This adapter plug consists of a piece of felt thoroughly oiled and held in position between two metal plates by wire cleats. A ring is provided by which the plug may be removed. The booster charge consists of approximately 1 ounce of tetryl. Some boosters are loaded with half tetryl and half TNT, the tetryl being placed around the fuze socket.

Adapter Booster Mk. IVB. The Adapter Booster Mk. IVB is used in the 75-mm Chemical Shell Mk. II for 75-mm guns. In common with adapter boosters for chemical shell, its function is to break up the shell so that the contents may be released and scattered. The booster charge is therefore larger than that of the Mk. III Adapter Booster. The adapter is provided with a pipe thread in order that the projectile may be made gastight. The figure shows this adapter booster together with the names of its principal parts. It will be noted that the construction of the adapter booster casing is in one piece, which, with the pipe threading of the adapter, forms a gastight seal at the nose of the projectile. The joint made by the pipe threads is the only place where gas can escape from the shell due to defective assembly. The booster charge consists of approximately 1½ ounces of tetryl. Some boosters are loaded with half tetryl and half TNT, the tetryl being placed around the fuze socket.

Adapter Booster Mk. IVM1. The Adapter Booster Mk. IVM1 is a later form of the Mk. IV Adapter Booster. It differs from the Mk. IVB only in the configuration of adapter head which is hexagonal rather than octagonal as is that of the Mk. IVB. It is also used in the SHELL, chemical, Mk. II, for 75-mm guns.

Booster M20. The combination of this booster and the Fuzes M48, M48A1, or M54 is boresafe, since the rotor of the booster restrains its detonator out of line with the flash hole connecting the detonator of the fuzes with the closing cup charge of the booster, and positively interrupts the channel until the projectile has cleared the muzzle of

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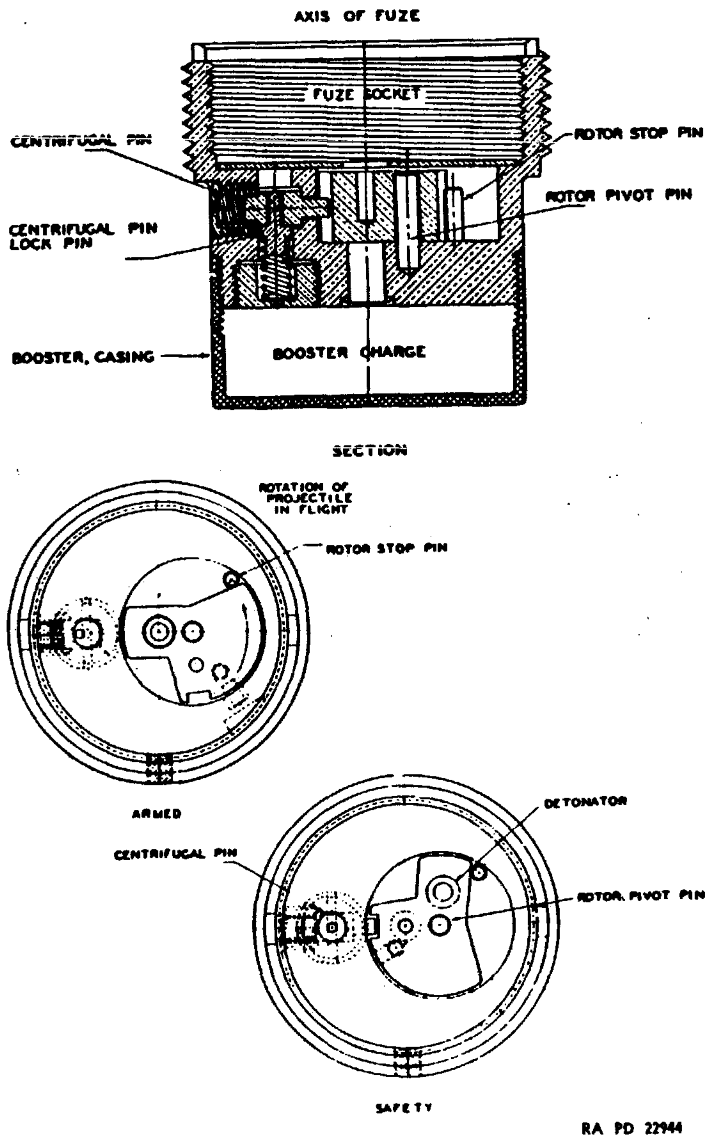


Figure 159 — Booster M20

the weapon. This booster is used in conjunction with standard contour fuzes in the SHELL, H.E., M48, for 75-mm guns.

Safety features. The safety features of the M20 Booster (see illustration) consist of a rotor blocking the flash hole, held by centrifugal pin and this pin being locked by the centrifugal pin lock pin.

Action. On set-back, the centrifugal pin lock pin moves rearward against the pressure of its spring, and it is then locked in its rearward position by centrifugal force which causes the end of the pin to engage the projection on the centrifugal pin screw. When centrifugal force is great enough to overcome the frictional forces resulting from acceleration, the centrifugal pin is thrown outward releasing the rotor which carries a detonator of lead azide over tetryl. The rotor, upon being released, moves by centrifugal force about its pivot until it strikes the rotor stop pin, this being the armed position. This action is completed when the projectile has cleared the muzzle by from 3 to 5 feet. In the armed position, the booster detonator (in the rotor) is in the center of the booster and thus in line with the flash channel of the fuze. To insure that the rotor will remain armed, it is locked in the armed position during the remainder of its flight by the rotor lock pin which is thrown outward by centrifugal force into the hole closed by the body plug. During flight the rotor lock pin lock moves by creep force behind the rotor lock pin and thereby restrains the latter from possibly moving inward. Both these locking devices are contained within the rotor, the lock pin in a recess drilled into the side of the rotor, and the lock pin lock in a recess which communicates with the recess for the lock pin drilled into the bottom of the rotor. Action of the fuze will now successively explode the rotor detonator of lead azide and tetryl, the closing cup charge of tetryl, and the booster pellet of tetryl.

Modification. The M20 Booster has been modified by enlarging of the flash hole in the rotor cover. The modified design is known as the Booster M20A1.

CARTRIDGE CASES.

Cartridge Case M18. This cartridge case is drawn brass, and is about 13.8 inches long. Assembled with a loaded primer, it weighs about 2.75 pounds. A projecting rim or flange is formed on the head of the cartridge case, and the extractor of the piece engages this rim to eject the case from the piece after firing. This rim or flange acts also as a stop for the round when it is loaded into the piece. The primer is fitted in the center of the base of the case and is forced into its seat by a press. The propelling charge is contained loosely in the case which is crimped to the projectile. The ammunition lot number of the complete round is stenciled across the base of the cartridge case.

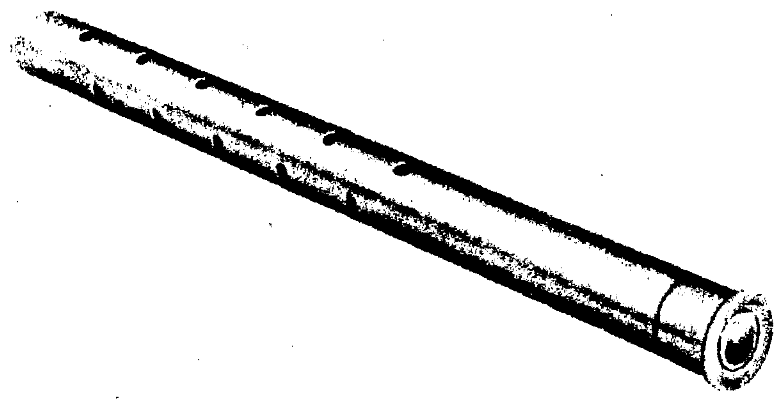


Figure 160 — Percussion Primer M22

Cartridge Case M18B1. This cartridge case is similar in all respects except the material from which it is made, to the Cartridge Case M18. It is made from drawn steel which is then copper plated.

PRIMERS.

Primer M22. This primer is one of the primers used with the reduced and normal charges for the 75-mm guns. It was originally designed to accommodate over 200 grains of black powder, but it was found that better performance could be obtained in some rounds with a primer of the same length, but with reduced charge. The reduced charge (fig. 161) is held in the end of the primer tube adjacent to the primer head by means of a cardboard cup. The empty portion of the tube is lined on the inside with a paper liner. The paper liner serves a dual purpose: first, to prevent the grains of propellent powder from entering the upper end of the primer tube; and second, it also serves to support the black powder charge retaining cup.

The head assembly of this primer is similar to that of the Primer M23, discussed in the chapter on 37-mm ammunition. To it is threaded a brass tubing body, closed at the outer end by a threaded brass plug. A 75-grain charge of black powder is contained in the lower end of this flash tube as described above.

Modification. This primer has been redesigned on three different occasions. The A1 modification is similar to that of the M23A1 Primer, consisting of a redesign of the primer head. (See chapter on 37-mm ammunition, page 331).

The A2 modification consists of a taper being introduced into the head of the primer beyond the flash hole and a resultant reduction

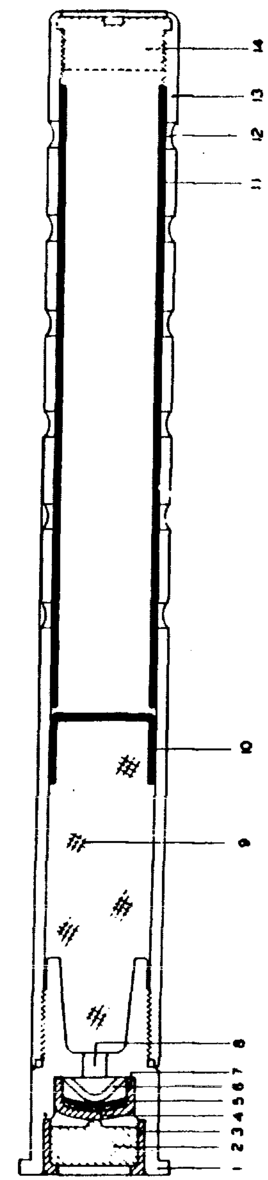
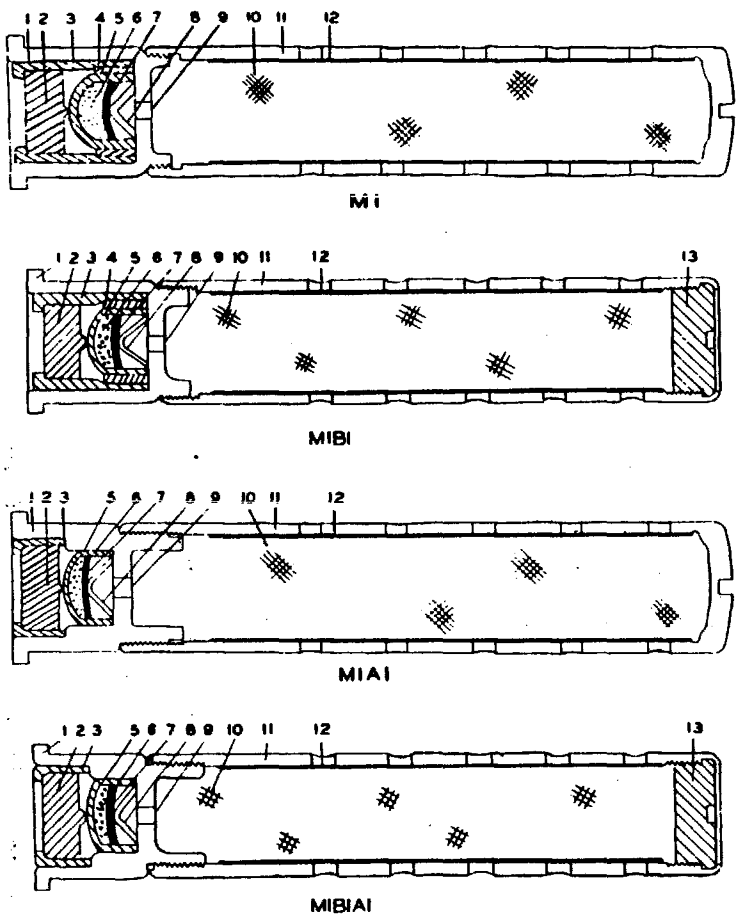


Figure 161 — PRIMER, Percussion, 75-grain, M22A1



1. BODY, PRIMER HEAD
2. PLUG
3. SLEEVE
4. SLEEVE, PRIMER CUP
5. PRIMER CUP
6. PRIMER COMPOSITION
7. PAPER DISK
8. ANVIL
9. FLASH HOLE
10. BLACK POWDER (100-GRAINS)
11. CASE, BRASS
12. PAPER LINER
13. PLUG, CLOSING

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Figure 162 — 100-grain Percussion Primers

of the auxiliary charge of black powder from 75 grains to 65 grains. This was done to eliminate wastage of the black powder in the auxiliary charge. Previous to this modification the powder in the periphery of the primer head immediately behind the flash hole was not ignited directly by the flame of the primer mixture (which could not reach it), but indirectly by flame from that part of the auxiliary charge ignited by the primer mixture.

The A3 modification of the primer is similar to that of the M23A2 Primer, consisting of a lengthening of the firing plug. (See chapter on 37-mm ammunition.) This Primer M22A3 is the present standard design.

Primer M1. This primer is used with the normal charge in the 75-mm gun shrapnel round. It is a 100-grain primer. The head is similar to that of the M22 (see above) Primer and the brass flash tube is a drawn brass case open at one end, the other end being slotted to receive a screwdriver (fig. 162).

Modification. This primer also has been modified on three different occasions. The B1 modification consists of a change in the flash tube. The redesigned tube is made of brass tubing closed at the one end by a threaded brass plug, roll-crimped in place. This change was made to aid procurement, some manufacturers being equipped for drawing operations and others for tubing operations.

The A1 modification is similar to that of the M22A1 Primer. (See above.)

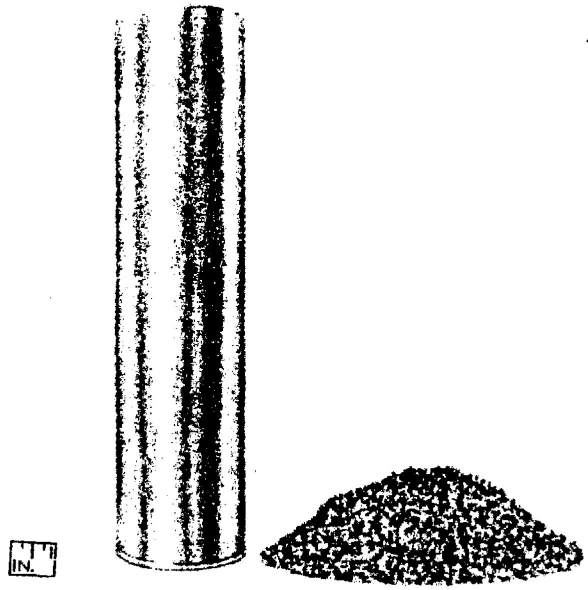
The A2 modification is similar to that of the M22A3 Primer. (See above.)

The present standard 100-grain primer is designated the M1B1A2.

Primer M31. This 150-grain primer is used with supercharged rounds for 75-mm guns, its higher capacity being necessary for efficient ignition of the larger amount of smokeless powder in the supercharge. The primer is entirely similar to the M22A1 Primer, except that the flash tube is without vents to such a distance from the head as is necessary to accommodate 150 grains of black powder. It is of later design than the M22 Primer which accounts for its having the later design of priming head, although it is unmodified.

PROPELLING CHARGES.

The propelling charges for 75-mm guns consist of FNH powder accurately weighed and poured loosely into the case. In order to afford a flexibility of fire, even though gun ammunition is fixed, three different weights of propelling charge are issued; a supercharge, a normal charge, and a reduced charge. The exact weight of charge in each case is determined by proving ground test of the powder lot to determine the weight required to give the desired muzzle velocity



RA PD 22948

Figure 163 — Propelling Charge for Fixed Ammunition

consistent with the allowable chamber pressure. The following table indicates the mean or average characteristics of these charges:

Charge	Weight of Charge (lb)	Muzzle Velocity (ft per sec)	Chamber Pressure (lb per sq in.)
Super	2.00	1,950	33,800
Normal	1.13	1,500	26,000
Reduced	0.56	950	8,500

The presence of these charges is indicated by the marking found on the cartridge case in the complete round. The reduced charge is indicated by two broad black bands on the side of the cartridge case, between which is stenciled the word "reduced" and by a black cross and the word "reduced" in black stencil on the base of the case. The normal charge is denoted by a black stencil consisting of a band, beneath which is the word "normal," on the side of the case, and a stripe and the word "normal" on the base of the case. The supercharge is evidenced by the word "super" stenciled in black on the side and base of the cartridge case. The marking for none of the charges indicates the weight, velocity, and pressure obtained from the charge. The data can be found on the ammunition data card for each lot. As previously stated, the ammunition lot number will be found stenciled in black on the base of the cartridge case in the complete round.

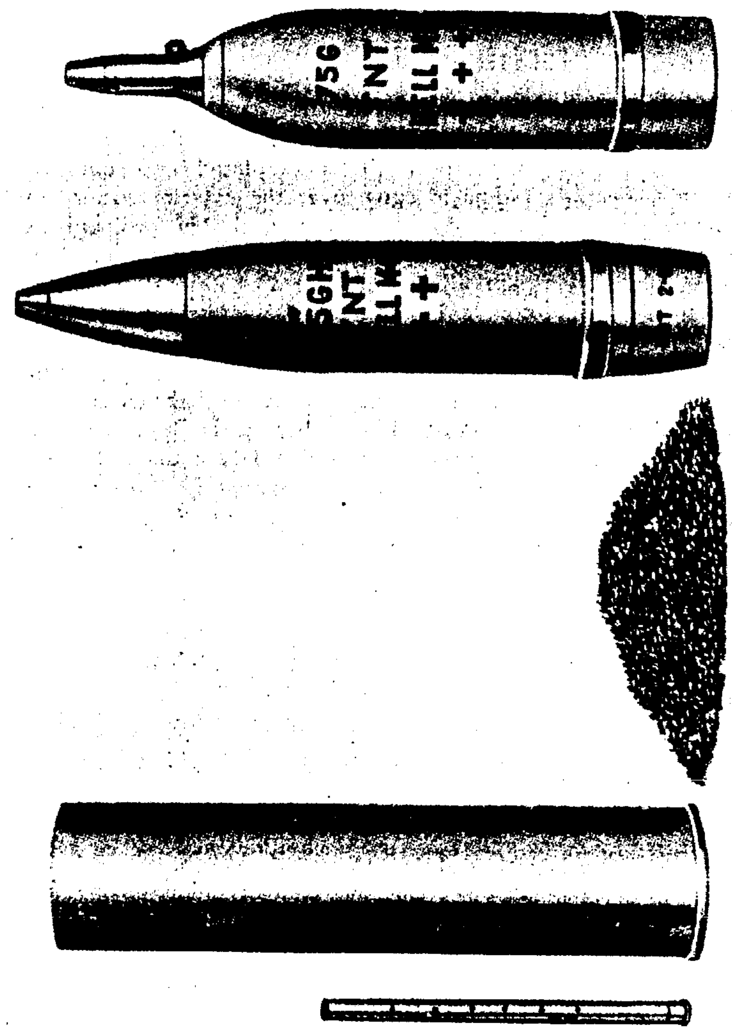


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Figure 164 — Components of a Complete Round of Fixed Ammunition

SHELL, H.E., M48.

General. This complete round as issued may be used against personnel, for demolition of above-ground targets such as barbed wire, for penetration effects against heavier targets, and in barrages. The mean or average weights of the complete round are: for the supercharge, 19.3 pounds; for the normal charge, 18.5 pounds; and for the reduced charge 18.0 pounds.

Projectile M48. This projectile is of the streamlined type with a 9-degree tapered or boat-tailed base and a 7.5-caliber radius of ogive. The streamlining of the projectile is completed by a continuation of the projectile's radius of ogive over the exterior surface of the standard contour fuzes with which it is used. The projectile is made of forged steel; it has a rotating band of gilding metal, a fringing groove, and a steel base cover spot welded to its base. It is also provided with a single groove, between the fringing groove and the boat-tail, for stab crimping of the cartridge case. The booster and fuze assemble directly to the nose of the shell, the booster being tightened in place by a set screw which passes through one side of the nose, and the fuze by staking into notches cut in the rim of the nose. The standard bursting charge consists of 1.49 pounds of TNT and is sufficient to break the shell into approximately 400 effective fragments. The mean weight of the loaded and fuzed projectile is 14.6 pounds. The actual weights, for uniformity of ballistics, are classified into weight zones which are indicated by yellow crosses stenciled below the bourrelet of the shell (fig. 165). The zones and their limiting weights in pounds are shown below.

	Light (+)	Normal (+ +)	Heavy (+ + +)
Minimum	14.22	14.52	14.82
Maximum	14.52	14.82	15.12

The projectile is painted a lusterless olive drab and is stenciled in yellow with the designation of weapon (75G), the designation of filler (TNT), and the complete round designation (Shell M48). In the complete round, the following listed components may be associated with this projectile:

Fuzes M48, M48A1 and M54.

Boosters M20 and M20A1.

Cartridge Cases M18 and M18B1.

Propelling Charges. Reduced, normal, super.

Primers M22A3 (or others of M22-series) and M31.

Guns. This round is provided with all charges for the field guns; with the normal and the supercharges and only the M48 and M48A1

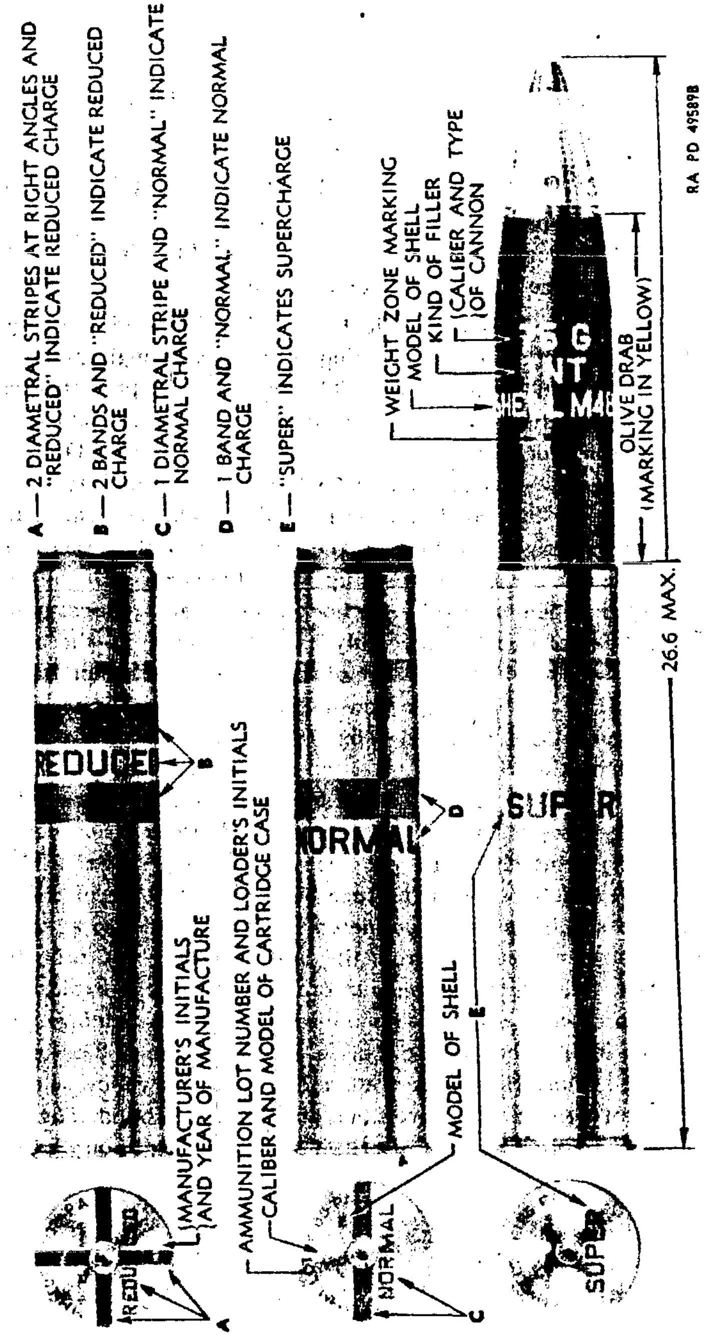

Figure 165 — SHELL, H.E., M48, for 75-mm Guns

Fuzes, for the tank guns; and with the supercharge and only the M54 Fuze for the antiaircraft guns.

NOTES: This round is standard for issue and for manufacture, and is issued fuzed.

PROJECTILE, APC, M61, W/B.D. FUZE, M66A1 AND TRACER.

General. This projectile, as its name indicates, is an armor-piercing round. The fact that it has a high-explosive filler is indicated by the inclusion of the fuze in the nomenclature.

Projectile M61. This projectile has a 7.5-caliber radius of ogive, a gilding metal rotating band, a fringing groove, a single groove for stab crimping, and a square base. The body of the projectile is of hardened forged steel. A cavity machined in the base contains the explosive filler which consists of 0.15 pound of explosive D. To the nose of the body is crimped and soldered an armor-piercing cap, which is centrally hardened and peripherally toughened. This armor-piercing cap is designed to take up the initial shock of impact, thereby protecting the body, and to set up favorable stresses in the plate, so as to enhance penetration by the body itself. It also reduces greatly the possibilities of ricochet on highly angled impacts. To the armor-piercing cap is threaded a die-cast aluminum windshield or ballistic cap. It is this cap which is responsible for the streamlining of the otherwise blunt-nosed projectile (fig. 166). The base of the projectile is closed by the M66A1 Base-detonating Fuze which contains its own booster. The fuze projects about 0.6 inch beyond the base of the projectile, the projecting end containing a red tracer. (See description of fuze.) A notch in the fuze body is so shaped that a dovetailed groove is left between the fuze body and the base of the projectile. Lead calking wire is hammered into this groove so as to seal the joint between fuze and projectile against seepage of propelling charge gases, thus protecting against prematuring of the explosive D filler. This projectile is not weight-zoned since the machining operations enable it to be brought to a close weight tolerance. The projectile is painted a lusterless olive drab, and stenciled in yellow with the designation of weapon, explosive filler, and complete round. The components associated with the projectile in the complete round are:

Fuzes M66 and M66A1.

Cartridge Cases M18 and M18B1.

Propelling Charge. The supercharge only, since the greater muzzle velocity afforded by this charge is a necessary factor in effective penetration of armor plate.

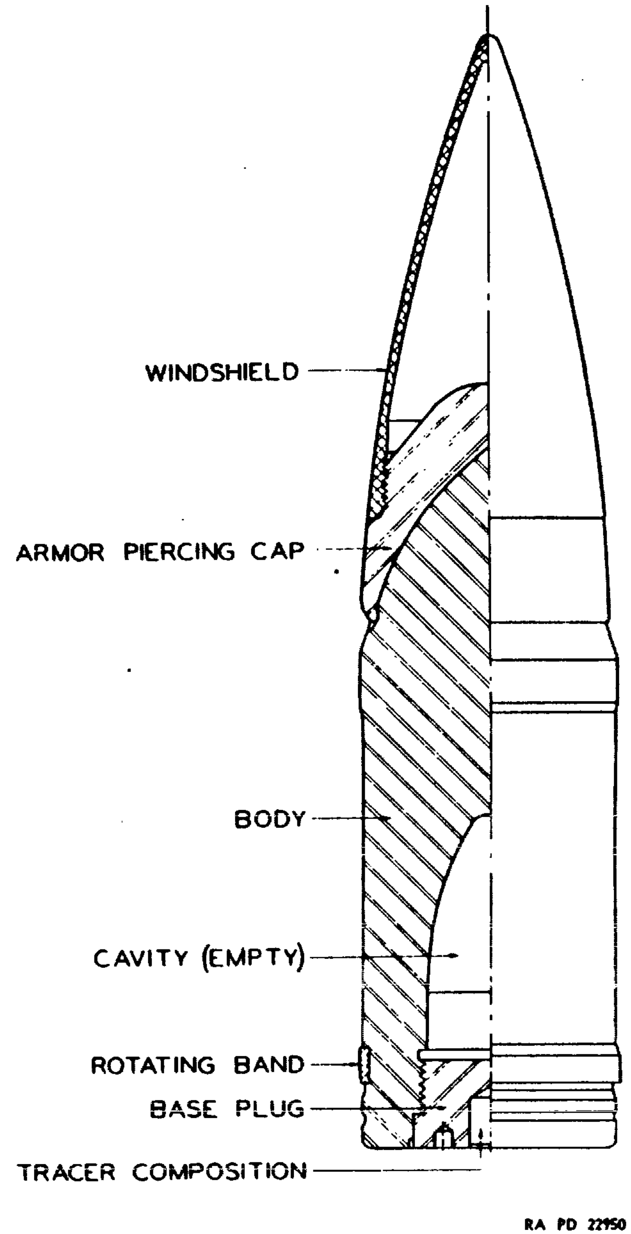

Figure 166 — PROJECTILE, APC, M61

Primer M32.

Guns. This round is provided as described above for all 75-mm guns.

NOTE: This round is standard for issue and for manufacture and is issued fuzed, even though it is not boresafe.

PROJECTILE, APC, M61.

General. This round, which is of an earlier design than the above round, is explosively inert. It will be noted that absence of mention of the fuze in the nomenclature discloses this fact.

Projectile, APC, M61, w/Tracer. This projectile is similar to that of the previous complete round except that it does not contain an explosive filler, and that the cavity in the base is closed by a steel base plug containing a tracer element similar to that of the M66A1 B.D. Fuze. The projectile is painted black and stenciled in white with the designation of the gun and of the complete round. The components associated with the projectile in the complete round are:

Cartridge Cases M18 and M18B1.

Propelling Charge, supercharge.

Primer M32.

Guns. This round is provided as described above for the 75-mm field, tank, and antiaircraft guns.

NOTE: This round is standard for issue only and is issued complete.

SHOT, AP, M72.

General. This round has been developed as a substitute for the two preceding rounds. Since it has no armor-piercing cap, it is not as efficient as the two preceding rounds as regards penetration. It does, however, fulfill the requirement of the using arms for armor-piercing ammunition. Manufacture of the more complex M61 Projectiles could not meet this requirement fully; therefore, the simpler round was developed.

Projectile M72. This projectile is a solid hardened steel shot with a small cavity in the base in which is incorporated a tracer element similar to that of the M66A1 B.D. Fuze and that of the M61 APC Projectile. It has a 1.5-caliber radius of ogive, a rotating band of gilding metal, a fringing groove, a single groove for stab crimping of the cartridge case to the projectile, and a boat-tail base with a 9-degree taper. The absence of the armor-piercing cap as stated above causes it to be of a lesser efficiency than the M61 APC Projectile, it

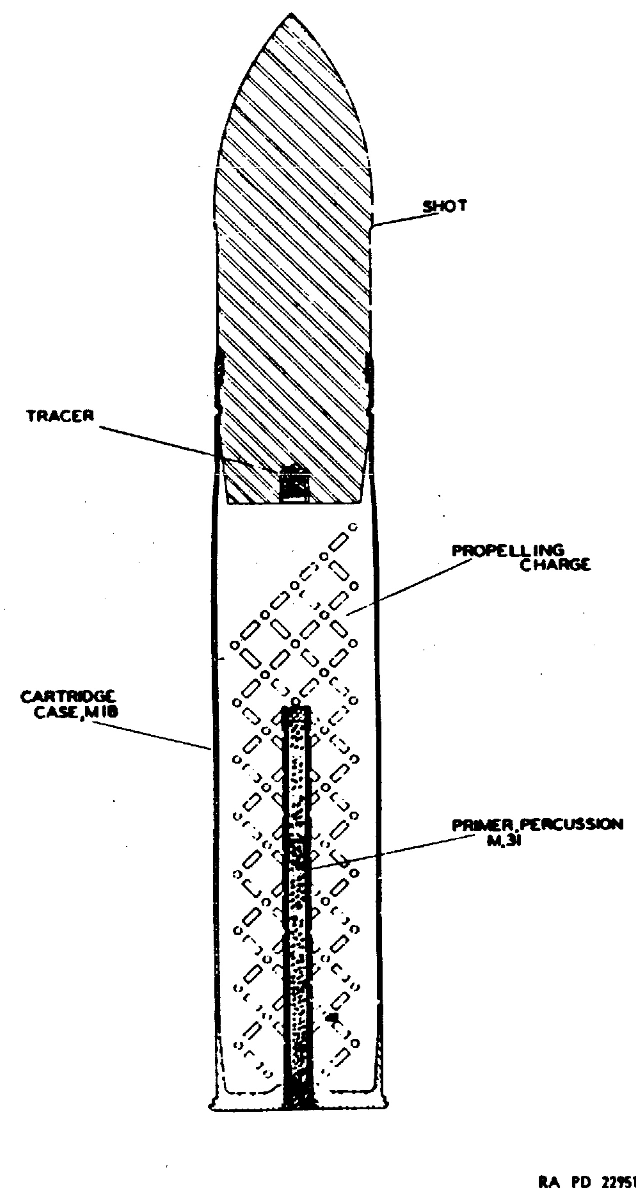

Figure 167 — SHOT, AP, M72, 75-mm

having a greater tendency to ricochet on angled impacts and no protection against breaking of the nose on impact.

The projectile is painted black and stenciled in white with designations of the weapon and the complete round. No weight zoning is necessary. The components of the complete round are:

Cartridge Cases M18 and M18B1.

Propelling Charge. A super charge of average weight of 1.90 pounds of FNH powder. This charge has similar characteristics to the previous supercharge of 2.00 pounds with this round.

Primer M32.

Guns. This round is provided, as described above, for all types of 75-mm guns.

NOTE: This round is standard for issue and for manufacture as long as a demand for it exists. If the armor-piercing requirements of the using arms can be satisfied with the more efficient M61 Projectile, this round will be standard for issue only. Its status at the present time can be described as substitute standard. It is issued complete.

SHELL, SMOKE, HC, BI, M89.

General. The complete round of SHELL, smoke, M89, differs in appearance from any round of ammunition previously described in this text. The complete round has the shape of a candle, for there is no ogive to improve ballistic properties, but only a blunt, perpendicular, slug-like stub (fig. 168). The complete round weighs 9.83 pounds and is approximately 20.25 inches in length. Because of its method of emitting smoke, the shell is termed a "base-emission" or "base-ignition" shell. This is abbreviated to "B.I." in the nomenclature.

Projectile M89. The Smoke Shell M89, with its squared off nose, resembles an ordinary tin can more than an artillery projectile. It is in the shape of a cylinder 7.49 inches long, and weighing 6.61 pounds, loaded. The shell consists of a tube and base which together constitute the body, and a charge of HC smoke.

Body. The body is made of cold drawn steel and consists of a number of components. First, there is the body itself. which forms the base of the shell, attached to which is the steel tube as an extension. The tube consists of welded steel tubing 0.065 inch thick and is approximately 5.25 inches long. This is closed at the end away from the base of the shell by a spacing disc of binder board and a steel closing disc, around which there is a 360-degree crimp of the end of the tube. This tube provides a light weight thin-wall structure to give maximum smoke capacity. Other standard high-velocity smoke shell weigh more, contain a lower percentage of smoke mixture, and

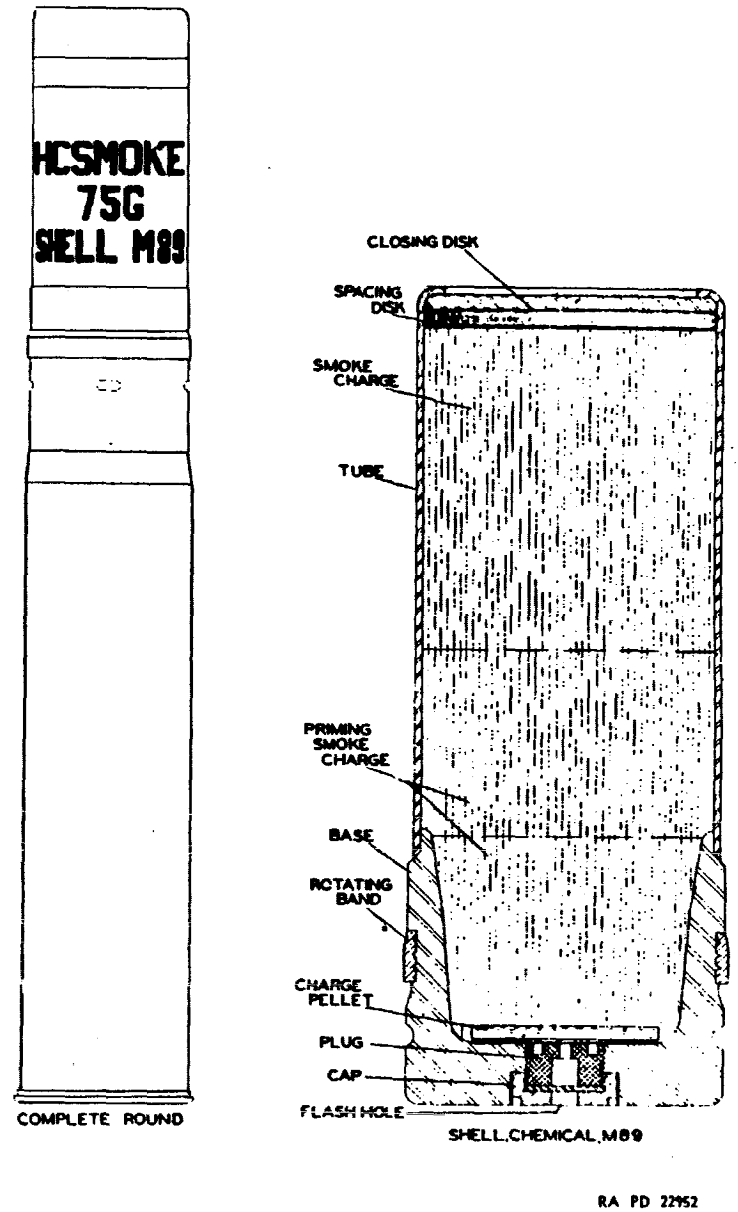

Figure 168 — SHELL, Smoke, M89, 75-mm (Base-emission Type)

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occupy more storage space in a tank than the base-emission type of shell.

Base. The base of the shell is in the shape of a cup. A large hole perforates the end, this hole being filled by a screwed-in, lead antimony alloy plug which contains a flash hole measuring 0.10 inch in diameter. The flash hole is covered by a thin flash hole disc of gilding metal, the disc being held in place by a steel cap which screws onto the lead alloy plug.

Charge. The HC charge is loaded into the shell in three steps. At the closed end of the tube the smoke charge of approximately 1.68 pounds of HC (hexachloroethane zinc mixture) is pressed into place. Behind that, the priming smoke charge of approximately 1.33 pounds of HC is loaded under pressure. Finally, a charge pellet of 0.017 pound of HC is inserted, followed by the plug and cap assembly.

Action. When the round is fired from the tank gun, the propelling charge bursts the gilding metal disc of the shell and ignites the charge pellet. This pellet burns slowly and almost imperceptibly until the shell has cleared the muzzle by a good distance. When the pellet is burned through, the priming smoke charge is ignited and smoke begins to billow from the tail of the shell. The increased pressure tends to blow the plug and cap assembly clear from the base and thus to allow more oxygen to enter to aid the burning of the chemical smoke.

The charge is designed to burn freely for approximately 2 minutes. Since the shell is not streamlined for best ballistic properties, it is apt to tumble and wobble once the original rotation imparted by the rifling of the gun on the rotating band of the projectile is lost. Modifications are being considered to increase the stability of the shell in flight.

The components associated with this shell in the complete round are:

Cartridge Case M18 or M18A1.

Primer M31A2 (150-grain).

Propelling Charge. The propelling charge of this round consists of 0.219 pound of FNH powder. This charge is poured loosely into the cartridge case. The small amount of powder used in this round is sufficient to give the smoke shell a velocity of approximately 850 feet per second and a range of between 1,500 and 2,000 yards when the gun is fired with an elevation of 12 degrees.

NOTE: This round is standard for issue and for manufacture (S & M) and is issued to the 75-mm Tank Guns M2, M3, and T7 only.

SHELL, H.E., Mk. I.

General. This complete round, which is not boresafe, weighs 16.5 pounds. It is no longer being manufactured, its present status being

as a limited standard substitute for the SHELL, H.E., M48, in 75-mm field guns.

Projectile Mk. I. This design of shell is an adaptation of the French, M1900, and represents the older type of shell in use before the streamlined shape was developed. It has a radius of ogive of 1.5 calibers, a copper rotating band, no fringing groove, two grooves behind the rotating band for stab crimping of the cartridge case to the projectile, a square base, and a base plate of brass covering a lead plate. The base plate is crimped to the base of the projectile. The nose does not take the fuzes directly but requires an adapter, to which is also fitted the booster. The bursting charge is 1.64 pounds of TNT. The weight zones and weight zone markings of this projectile are shown in the following table:

From		To		
Pounds	Ounces	Pounds	Ounces	Marking
10	11	11	0	L
11	0	11	5	+
11	5	11	11	+ +
11	11	12	0	+ + +
12	0	12	5	+ + + +

In common with the color scheme for marking of H.E. ammunition, the projectile is painted olive drab and stenciled in yellow with the designation of weapon, filler, complete round, and weight zone. The other components of this complete round are:

Fuzes M46 and M47.

Adapter Booster Mk. III.

Cartridge Case M18.

Propelling Charges. Normal, reduced.

Charge	Total Weight of Charge (lb)	Muzzle Velocity (ft per sec)	Chamber Pressure (lb per sq in.)
Normal	1.35	1,805	26,225
Reduced	.56	1,130	8,500

Primer. M22 series.

Guns. This round is provided for the 75-mm field gun only.

NOTE: This round is standard for issue only, and since it is not boresafe it is issued unfuzed.

SHELL, CHEMICAL, Mk. II.

General. This round also represents the older type of round in use before the streamlined type were developed. At the present time it is the only standard chemical shell for the 75-mm gun. It may be expected that a chemical round of the newer streamlined type (sim-

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Figure 169 — SHELL, Chemical, Mk. II

ilar to the M64 Chemical Round for 75-mm howitzers) will be developed in the near future. The loading of this round being carried out at the present time is from empty shell taken from World War I reserves.

Projectile Mk. II. This projectile varies from the H.E. Projectile Mk. I, only in that it is pipe-threaded in the nose and has no base plate. (Absence of the base plate is common to chemical shell of all calibers.) The purpose of the pipe threads in the nose of the shell is the insuring of a gastight seal in the joint between adapter booster and the nose of the projectile. The adapter booster in this projectile performs the function of bursting the shell. It is not entirely efficient in this respect, sometimes fragmenting only the upper half of the shell and leaving the lower half in the form of a cup which would carry a portion of the chemical filler into the ground undispersed. This projectile will be found provided with five different fillers: H—mustard, FS—chlorsulfonic acid and sulfur trioxide, WP—white phosphorus, FM—titanium tetrachloride, and NC—chlorpicrin. Present loadings are being made with the first three of these fillers while the latter two remain in storage from previous loadings. The projectile is weight-zoned in the same way as is the Mk. I H.E. Projectile. The marking of the projectile for the various fillers is shown in the following table. The base color of the chemical projectile, regardless of agent contained, is gray.

Chemical Filler	Marking on Shell	
	Present Color Scheme	Old Color Scheme
H—persistent gas	H—GAS and 2 bands (all in green)	3 red bands
NC—persistent gas	NC—GAS and 2 bands (all in green)	1 white, 1 red and 1 yellow band
FM—smoke	FM—SMOKE and 1 band (all in yellow)	2 yellow bands
FS—smoke	FS—SMOKE and 1 band (all in yellow)	None
WP—smoke	WP—SMOKE and 1 band (all in yellow)	1 yellow band

The above marking is in addition to the designations of weapon, complete round, and weight zones. The components used with this projectile in the complete round are as follows:

Fuze M46.

Adapter Boosters Mk. IVB and Mk. IV M1.

Cartridge Cases M18 and M18B1.

Propelling Charge. Normal (similar to normal charge in SHELL, H.E. Mk. I.)

Primers. M22 series.

Guns. This round is provided for the 75-mm field guns only.

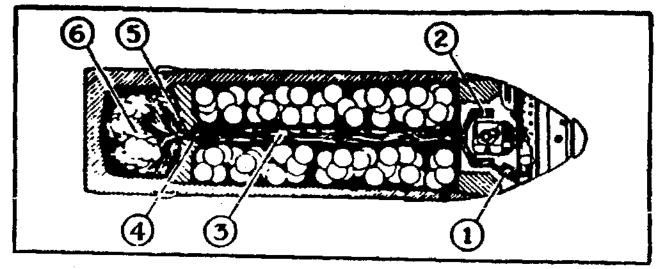
NOTE: This round is standard for issue and for manufacture (loading with the chemical fillers) with the H, WP, and FS fillers. With the NC and FM fillers it is standard for issue only. Since it is not boresafe it is issued unfuzed.

SHRAPNEL, Mk. I.

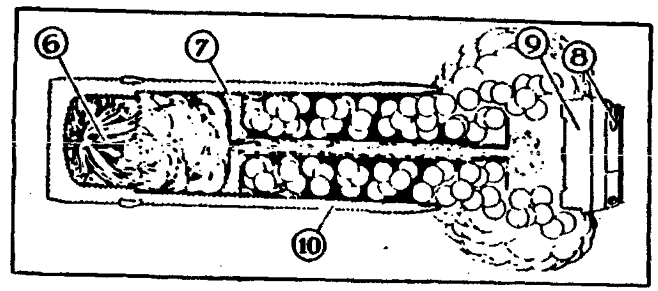
General. This round, an example of a very early type of artillery ammunition, having been developed in 1784 by Lieutenant Shrapnel, a British officer, is now fast becoming obsolete. Its use against troops in the open is being fulfilled at present by high-explosive shell which have been found to serve this same purpose more efficiently by reason of the large number of jagged steel fragments which they scatter in all directions at a high velocity. Shrapnel is now being used for training in the following rates of issue: 90 percent grade IIR for impact fire only; 10 percent grade I for high-burst ranging. Boxes of grade IIR shrapnel must be marked "FOR IMPACT FIRE ONLY" and, if the box is opened, the data card also must be marked in this manner. This must be done prior to issue of the ammunition.

PROJECTILE, Shrapnel, Mk. I. This projectile consists of a steel case, near the base of which a shoulder is formed on the interior surface. A base charge of 3 ounces of black powder is packed in the base of the projectile beneath a diaphragm of steel which rests on the shoulder. This diaphragm also supports a flash tube, the upper end of which is flared out into a smaller thin diaphragm. Between the two diaphragms is held a charge of melted resin which holds 270 lead balls suspended within it. These balls average 42 to the pound, the 270 totaling 6 pounds, 7 ounces. Above the lower diaphragm, the interior of the shrapnel case is gradually enlarged in diameter so that it tapers outward from base to head. The top of the case is closed by a steel head which fastens to the case with a fine thread, and which is adapted to the fuze with a coarse thread. The shrapnel is issued fuzed with the 21-second Combination Fuze M1907M, which is set at safe, and covered with a metallic moisture-proof cap.

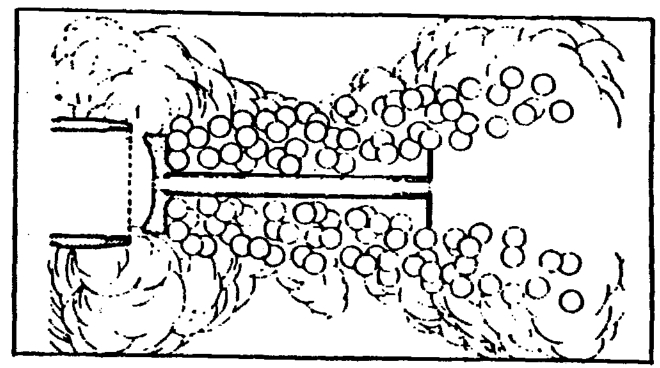
Function (fig. 170). The shrapnel projectile is actually a gun within a gun. The flame from the magazine charge (2) of the fuze (1) flashes down the central tube (3) and ignites the black powder base charge (6). In some shrapnel may be found a fiber cup (4) and cloth disc (5). The flash burns through these if they are present. Explosion of this charge forces the lower diaphragm (7), matrix and balls, and flash tube (3) upward, blowing off the fuze (8)



ACTION OF FLAME THROUGH CENTRAL TUBE AND IGNITION OF BASE CHARGE



ACTION OF BASE CHARGE AND FORMATION OF SMOKE BALL FROM MATRIX



ACTION OF BASE CHARGE COMPLETED.
SMOKE BALL AUGMENTED BY BASE CHARGE.
SHRAPNEL BALLS SPREADING TO FORM CONE.

RA PD 22954

Figure 170 — Action of Shrapnel at Time of Burst

COMPLETE ROUNDS FOR 75-MM GUNS

Complete Round	Projectile	Filler	Fuze	Booster	Cartridge Case	Propelling Charge	Primer	Status
Shell, H.E., M48	M48	TNT	M48	M20	M18	FNH Super	M31	S & M
			M48A1 M54	M20A1	M18B1	Normal Reduced	M22A1, A2, A3	
Projectile, APC, M61, W1 B.D. fuze, M66A1	M61	Explosive D	M66A1	....	M18 M18B1	FNH Super	M31	S & M
Projectile, APC, M61	M61	....	....	....	M18 M18B1	FNH Super	M31	S
Shot, AP, M72	M72	....	....	....	M18 M18B1	FNH Super	M31	S & M
Shell, smoke, HC, B.I., M89	M89	HC	....	....	M18 M18B1	FNH 0.219 lb.	M31A2	S & M
Shell, H.E., Mk. I	Mk. I	TNT	M46 M47	Mk. III	M18	FNH Normal Reduced	M22A1, A2, A3	S
Shell, chemical, Mk. II	Mk. II	HS, WP, FS	M46	Mk. IV MI	M18 M18B1	FNH Normal	M22A1, A2, A3	S & M
		NC, FM	M46	Mk. IV B	M18	Normal	M22A1, A2, A3	S
Shrapnel, Mk. I	Mk. I Shrapnel case	Lead balls B.P. base charge	M1907M	....	M18	FNH Normal	M1B1A1	S

and head (9) as a unit, the rupture occurring at the fine threads between the head and the case (10). The resin matrix is melted and ignited and the lead balls are ejected from the case in a whirling cone-shaped pattern due to the rotation of the projectile. They have a velocity of 350 feet per second in addition to the velocity of the projectile at the time of bursting. The shrapnel case recoils to the rear. The projectile is *not weight-zoned*, since it is possible to bring it exactly to weight by varying the number of lead balls added at the time of loading. It is painted red and stenciled in black with the designations of weapon, and complete round. The components associated with it in the complete round are:

Fuze M1907M.

Cartridge Case M18.

Propelling Charge. A normal charge of 1.69 pounds of powder which imparts a muzzle velocity of about 1,755 feet per second.

Primer M1B1A1.

Guns. This round is issued for the 75-mm field guns only.

NOTES: This round is standard for issue only and is issued fuzed.

PACKING.

The present standard packing for 75-mm gun rounds is one round per fiber container, three rounds in containers per bundle. Other packings which may be found in storage are:
One round per tin container, 9 rounds per box
One round per fiber container, 9 rounds per box
One round per tin container, 4 rounds per box
One round per fiber container, 4 rounds per box

Overseas Shipment. Bundle packing must be crated in 1-bundle crates which are stained chocolate brown and stenciled in the appropriate color marking for this type of round.

FURTHER REFERENCES: OS—9-20; OS—9-18; TM—9-1900; O.O. 7224, Ordnance Safety Manual; Complete Round Chart No. 5981; SNL R-1; SNL R-3.

Chapter 7

75-mm Howitzer Ammunition

GENERAL.

The 75-mm pack and field howitzers all take the same types of ammunition, namely, at the present time, H.E., A.T. shell, H.E. shell, and chemical shell. The tubes themselves of the 75-mm pack and field howitzers do not differ. The difference is in the carriages, the pack howitzer carriage breaking down into mule loads for operation over difficult terrains, and the field howitzer carriage being adapted to high-speed transportation. Other characteristics of the two weapons, such as elevation, traverse, etc., are also similar.

The ammunition provided for the 75-mm howitzer may with one exception, the H.E., AT shell which is fixed, be classified as semifixed. Semifixed ammunition is ammunition loaded in the weapon in one operation, but with the cartridge case loosely fitted to the projectile, permitting the adjustment of the propelling charge at the point of fire. The marking of the projectiles of 75-mm howitzer rounds conforms to the standard color scheme for identification of types of ammunition and will be discussed with the complete rounds.

Many of the components used in rounds for the 75-mm howitzer have been discussed in the section dealing with ammunition for the 75-mm guns. Only the components that vary will be discussed.

BURSTERS.

Burster M8. The M8 Burster is an aluminum tube filled with a cast charge of 70/30 tetrytol and covered at each end with a disc of onionskin paper glued in place.

Burster Casing M6. The Burster Casing M6 is a seamless steel tube closed at one end and fitted with a heavy flanged sleeve at the other. It is tested at 200 pounds per square inch pressure to insure its being gastight.

CARTRIDGE CASES.

Cartridge Case M5A1, Type I. This cartridge case, which is made of drawn brass, is about 10.70 inches in length. The A1 modification consisted of lengthening the case $\frac{3}{16}$ inch in order to keep complete round lengths proportional when the gun rotating band was adopted for howitzer shells. This case weighs approximately 2.45 pounds and is of the flange type for extraction.

Cartridge Case M5A1B, Type I. This cartridge case is similar in all respects to the M5A1 except that it is made from drawn steel and weighs approximately 2.18 pounds.

Cartridge Case M5A1, Type II. This cartridge case was necessitated by the adoption of the SHELL, H.E., AT, M66. The cartridge case is similar in all respects to the type I case with the exception of mouth diameter. The mouth of the type I case has a diameter of 2.938 inches whereas, for crimping to the projectiles, the mouth of the type II case is 2.913 inches in diameter. The B1 modification of the type II case, similarly to that of the type I case, consists of manufacture of the case from steel.

PROPELLING CHARGE.

The FNH propelling charge has a base section to which a small retainer assembly is attached. The retainer fits over the primer and locks the base charge to it. Three increments are each connected in sequence by means of a string to the base charge. The base and the first increment encircle the primer. The mean weight of the total charge is about a pound, the exact weight being determined by proving-ground test to secure a muzzle velocity of 1,250 feet per second at a pressure not exceeding the maximum allowable. The exact weight and velocity of each charge for a particular powder lot is found on the ammunition data card. The following table shows the characteristics of the charge:

Zone Charge	Components	Total Weight of Charge (oz)	Muzzle Velocity (ft per sec)	Pressure (lb per sq in.)
1	Base	6.7	700	4,500
2	Base and 1 increment	8.48	810	6,400
3	Base and 2 increments	10.75	950	9,300
4	Base and 3 increments	15.55	1250	21,500

SHELL, H.E., M48.

General. This complete round with the exception of cartridge case, primer, propelling charge, and marking is similar to the Gun Round M48.

Projectile M48. Similar to that discussed for 75-mm guns with the exception of the designation of weapon which will be "75 H." The components associated with the projectile are:

Fuzes M48, M48A1, and M54. Discussed in chapter on 75-mm ammunition.

Boosters M20 and M20A1. Discussed in chapter on 75-mm ammunition.

Cartridge Cases M5A1 and M5A1B1.

Propelling Charge. 4 zone, base and increment.

Primer M1B1A2. Discussed in chapter on 75-mm ammunition.

NOTE: This round is standard for issue and manufacture and is issued fuzed.

SHELL, H.E., M41A1.

General. This round is a substitute for the M48 H.E. Shell in the 75-mm howitzer. The projectile is made by cutting off the nose of

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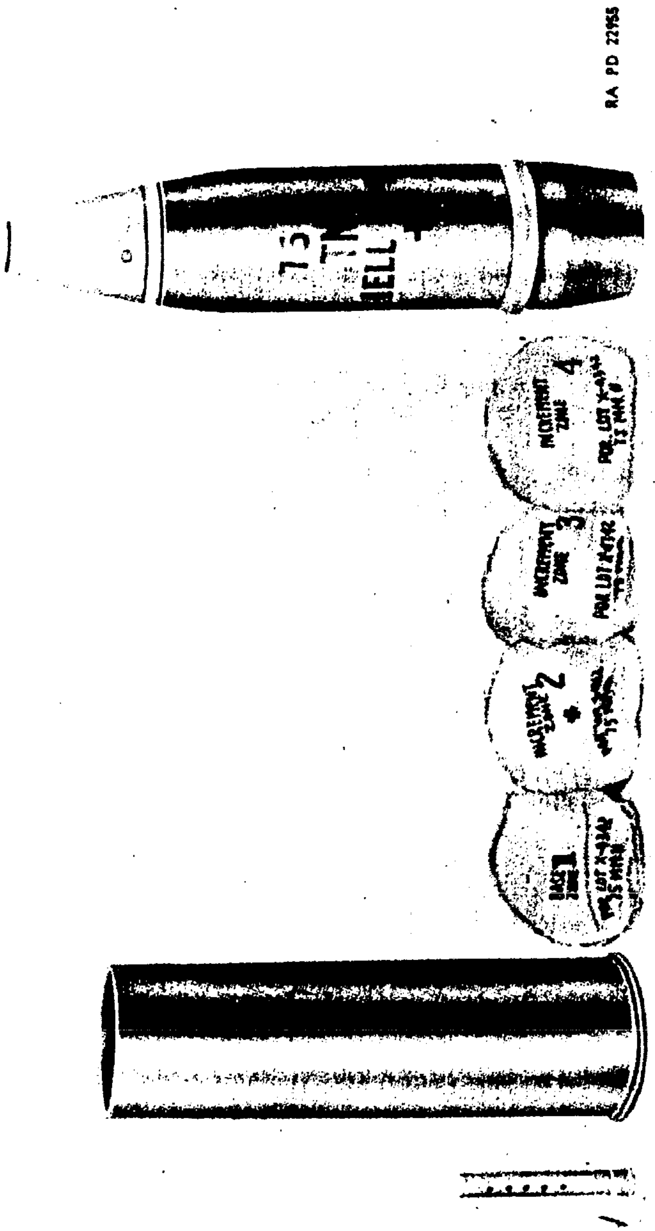

Figure 171 — Components of a Complete Round of Semifixed Ammunition (4 Zone Charges)

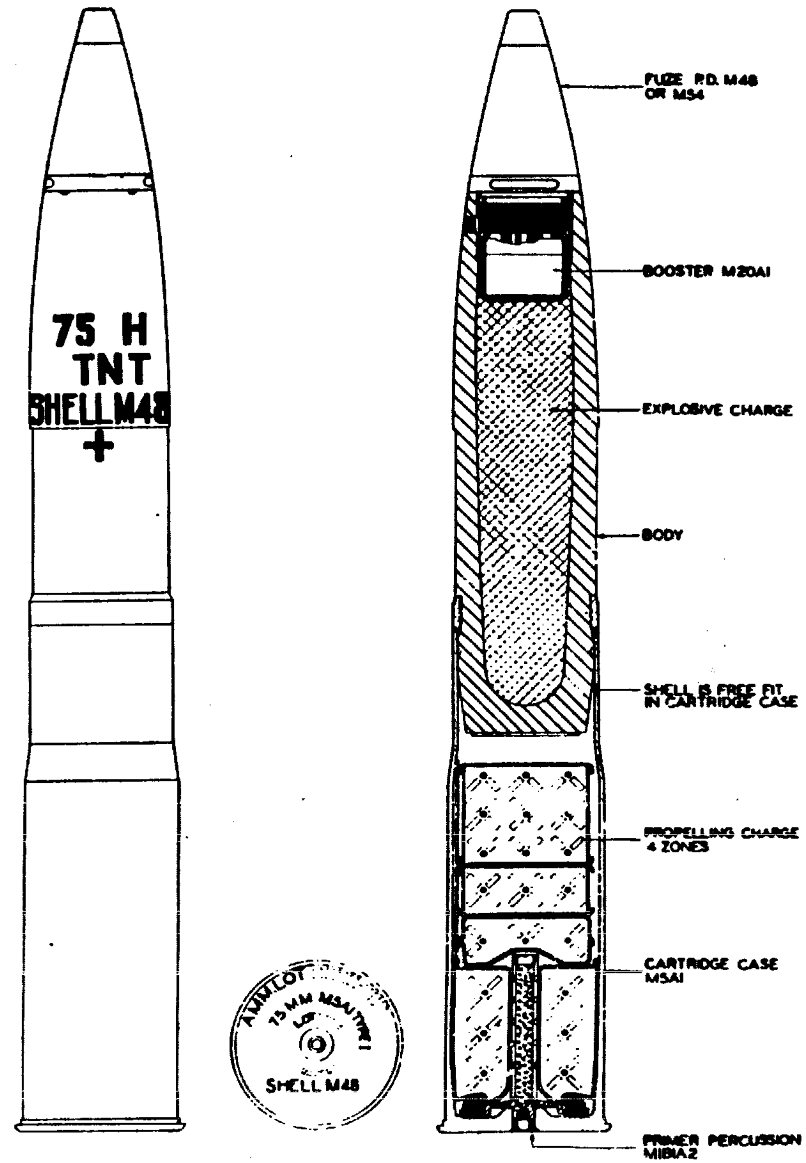

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Figure 172 — SHELL, Semifixed, H.E., M48

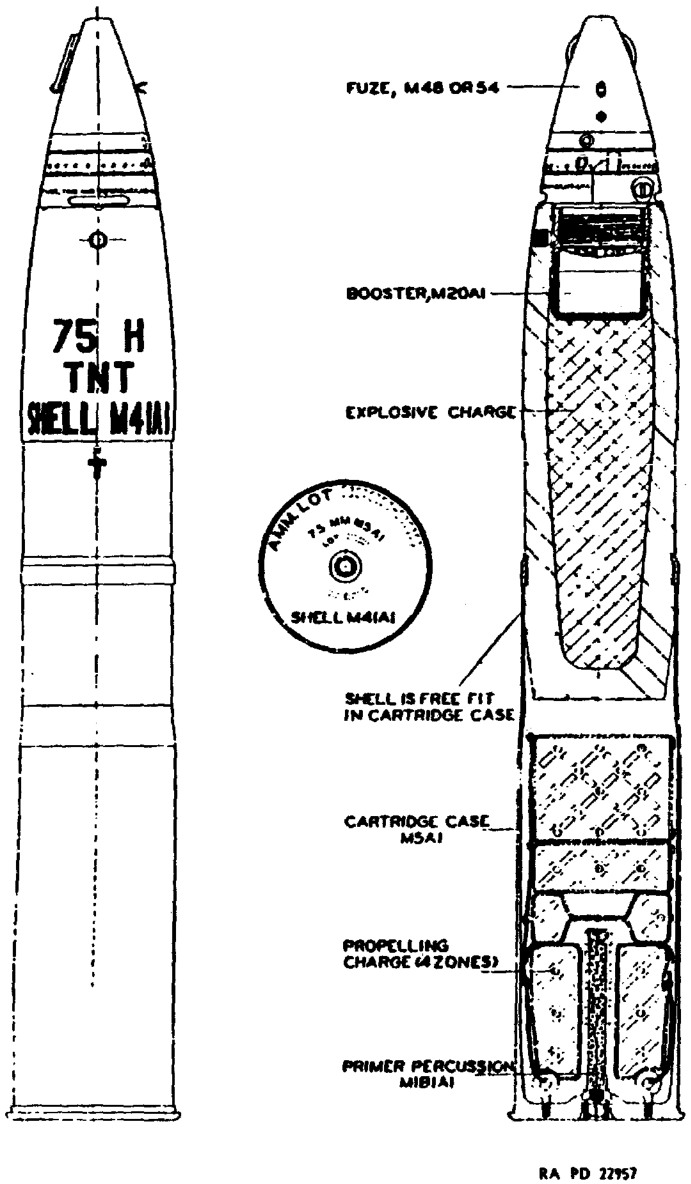

Figure 173 — SHELL, Semifixed, H.E., M41A1

the Mk. IV, H.E. Shell for 75-mm guns and rethreading it to take the new type standard contour fuzes and the M20 Booster. It is standard for manufacture and issue insofar as this modification procedure is concerned.

Projectile M41A1. This projectile is of the new type having an 11-caliber radius of ogive and a boat-tail base with a 9-degree taper. The rotating band is of copper and a steel base plate is soldered to the base. It is a low-capacity shell, one reason for its discontinuance as a gun round, having a bursting charge in the howitzer of 1.11 pounds of TNT. There are only two weight zones in this projectile. The markings of the projectile will be in yellow on an olive-drab base coat, and will include the designation of weapon, filler, complete round, and weight zone. The components associated with this projectile in the complete round are:

Fuzes M48, M48A1, and M54. Discussed in chapter on 75-mm gun ammunition.

Boosters M20 and M20A1. Discussed in chapter on 75-mm gun ammunition.

Cartridge Cases M5A1 and M5A1B1.

Propelling Charge. FNH 4 zone, base and increment.

Primer M1B1A2. Discussed in chapter on 75-mm gun ammunition.

SHELL, CHEMICAL, M64.

General. This round is a new type chemical round, the projectile being equipped with a full length burster. It disperses the chemical agents more efficiently than does the older type chemical round (see SHELL, chemical, Mk. II, in section on 75-mm guns) since the entire projectile is split open. It may be expected that a chemical shell of this type will also be standardized for the 75-mm guns in the near future.

Projectile M64. This projectile is similar to the H.E. Projectile M48 with the exception of an adapter for the burster casing in the nose, and the absence of a base plate. The burster casing is a press-fit in the adapter provided for it. The burster assembles within the burster casing. The standard fillers (chemical agents) for this shell are H, WP, and FS. The marking for these fillers will be similar to that for the same fillers in the SHELL, chemical, Mk. II. There are five weight zones in this projectile. The components associated with it in the complete round are:

Fuze M57. Discussed in chapter on 75-mm gun ammunition.

Burster M8.

Burster Casing M6.

Cartridge Casings M5A1 and M5A1B1.

Propelling Charge. FNH, 4 zone, base and increment.

Primer M1B1A2. Discussed in chapter on 75-mm gun ammunition.

NOTE: This round is standard for manufacture and issue and is issued fuzed. It is a boresafe round.

SHELL, FIXED, H.E., A.T., M66.

General. This round employs the "hollow charge effect" discussed in previous sections on rockets and rifle grenades. It is effective against either face-hardened or homogeneous armor plate and is designed for use against tanks.

Projectile M66. The M66 Projectile is composed of three major parts: namely, the ogive, the cone, and the body. The ogive has two purposes in this instance: first, to set up an effective distance between hollow charge and plate to be penetrated, and second, to streamline the round. It is a straight sided hollow cone which threads into the body and is maintained in position by three set screws which pass through the body.

The cone is held in position between the ogive and the shell body and is designed to form a hollow in the charge (the apex of the cone is to the rear, whereas the apex of the conical ogive is the front or nose of the projectile) which will provide the "hollow charge" or "Munroe effect."

The body or the rear position of the projectile is made of forged steel. It contains a cast charge of approximately 0.75 pound of 50/50 pentolite as a bursting charge. The base of the body is boat-tailed with an approximate 9-degree taper and is provided with a threaded opening to take the M62 B.D. Fuze.

The entire projectile is 15 inches long and weighs 13.1 pounds.

The components associated with this projectile in the complete round are:

Cartridge Case M5A1, Type II, or M5A1B1, Type II. The type II cases were especially designed for this round as it is the first fixed round in the howitzers. The only difference between type II and type I cartridge cases is in the mouth diameter; the mouth of the type II case tapers to a diameter of 2.913 inches, while the mouth of the type I case tapers to a mouth diameter of 2.938 inches. The type II case with its smaller diameter mouth is designed for crimping to the projectile.

Primer. 100-grain, M1B1A2.

Propelling Charge. 1.04 pounds of FNH powder poured loosely into the cartridge case. This charge gives the M66 Projectile a muzzle velocity of approximately 1,000 feet per second without exceeding

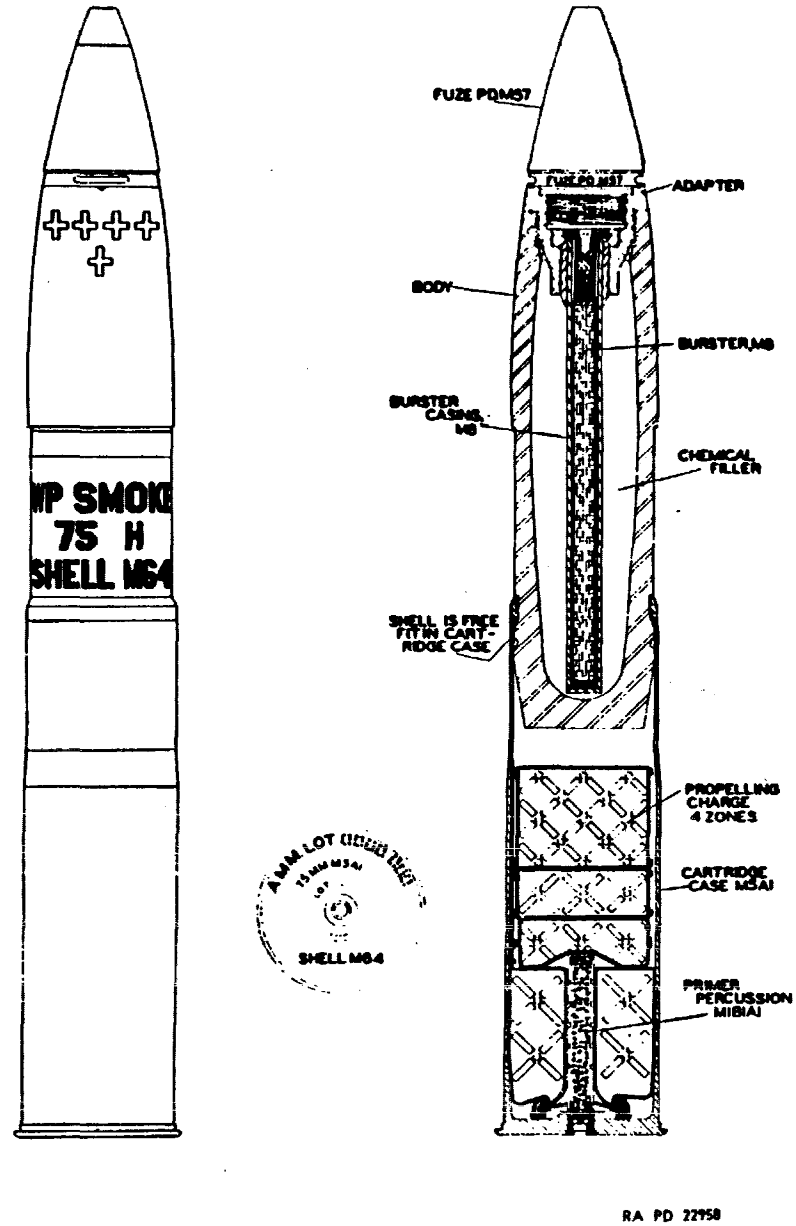

Figure 174 — SHELL, Semifixed, Smoke, WP, M64

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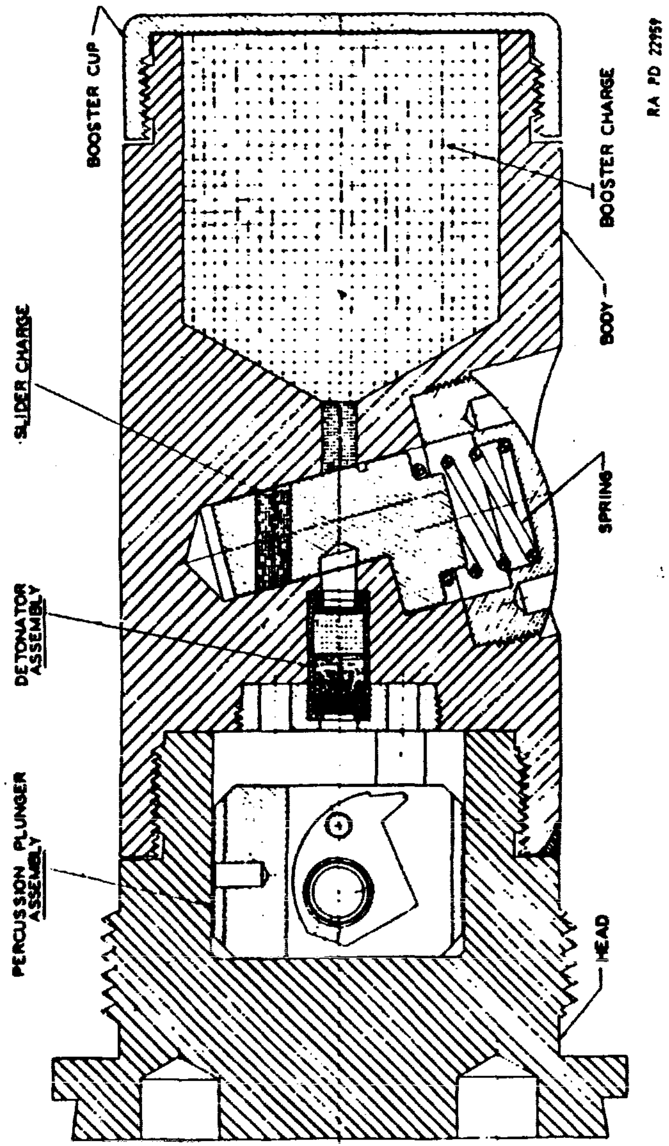


Figure 175 — FUZE, B.D., M62

the maximum allowable chamber pressure of 21,500 pounds per square inch. It must be remembered that in this round, velocity is not a factor in penetration, the penetration being accomplished by the hollow charge effect.

Fuze, Base-detonating, M62.

General. The M62 Fuze is a comparatively small device, measuring approximately 1.75 inches in diameter, and 3.5 inches in length. It is designed for use in the H.E., AT shell only.

Description (fig. 175). This fuze consists of two major parts, the head and the body. A recess within the head seats the percussion plunger. The body contains the explosive train which consists of a detonator of priming mixture, lead azide, and tetryl; a slider charge of tetryl; a booster lead charge of tetryl; and a booster charge of tetryl. The booster charge is held within the cavity in the upper end of the body by the booster cup. The body also houses a slider, slider spring, and retaining cap. This device causes the fuze to be boresafe by positively interrupting the explosive train and also by carrying a charge of tetryl out of alinement with the remainder of the explosive train in the unarmed or safe position.

Percussion Plunger Assembly. This assembly consists of a body, in a slotted portion of which is housed an eccentrically pivoted firing pin which is rotary in nature. The pin is held in a safe position by two centrifugal pins and springs. Two recesses, one on either side of the slot on the top of the body, house restraining springs and their caps.

Slider assembly. This assembly consists of an eccentric charge-carrying slider very similar in its shape to that of the M56 P.D. Fuze mentioned as a component of 37-mm ammunition, a slider spring, and a retaining cap. The slider is seated in the fuze body at an approximate 15-degree angle.

Function. The frictional forces resulting from linear acceleration prevent movement of centrifugally actuated parts while the projectile is in the bore of the weapon. When the projectile emerges from the weapon, however, centrifugal force cause arming of the percussion plunger and slider assemblies. The centrifugal pins which hold the rotary firing pin of the plunger assembly in an unarmed position are forced out into the plunger against their springs, thereby releasing the firing pin. The firing pin is rotated outward and upward into its armed position beneath the detonator by centrifugal force. Also, centrifugal force moves the slider outward to its armed position, alining the slider charge of tetryl with the remainder of the explosive train.

AMMUNITION FOR 75-MM PACK AND FIELD HOWITZERS

Complete Round	Projectile	Filler	Fuze	Booster	Cartridge Case	Propellant	Primer	Class	Issued	Standard
Shell, H.E., AT, M66	M66	50/50 Pentolite	M62 B.D.	....	M5A1 M5A1B1 Type II	FNH loose 1.04 lb.	M1B1A2	Fixed	Fuzed	S & M
Shell, H.E., M48	M48	TNT	M48 M48A1 M54	M20 M20A1	M5A1 M5A1B1 Type I	FNH 4 zones Base and increment	M1B1A2	Semifixed	Fuzed	S & M
Shell, H.E., M41A1	M41A1	TNT	M48 M48A1 M54	M20 M20A1	M5A1 M5A1B1 Type I	FNH 4 zones Base and increment	M1B1A2	Semifixed	Fuzed	S & M
Shell, chemical, M64	M64	H, FS, WP	M57	M8 Burster	M5A1 M5A1B1 Type I	FNH 4 zones Base and increment	M1B1A2	Semifixed	Fuzed	S & M

During flight, the plunger restraining springs overcome the tendency of the plunger to move forward due to creep force. They are, however, overcome by the weight of the plunger during its forward movement due to its own inertia at the moment of impact. The point of the firing pin stabs into the priming mixture which causes detonation of the lead azide and tetryl detonator charge, the slider charge of tetryl, the tetryl booster lead charge, and the booster charge of tetryl. The action is a nondelay action.

Safety features. The centrifugal pins hold the rotary firing pin in an unarmed or safe position during storage, handling, loading, and travel of the projectile through the bore of the weapon. They prevent chance shocks to the fuze during these times when driving the firing pin into the priming mixture.

The slider, prior to emergence of the projectile from the weapon, positively interrupts the flash channel between detonator and booster lead. It also carries a slider charge out of alinement with the remainder of the explosive train. It prevents prematures of the detonator prior to emergence of the projectile from the weapon from effecting the booster. It causes the fuze to be boresafe.

The plunger restraining springs prevent forward movement of the plunger due to creep force during flight. They prevent prematuring of the detonator by the firing pin during flight.

NOTE: This round is standard for issue and manufacture (S&M) and is issued to all 75-mm howitzers.

PACKING.

The present standard packing for 75-mm howitzer rounds is one round per fiber container, three rounds per bundle. They may also be found one round per fiber container, four rounds per box.

Overseas Shipment. Bundle packing must be crated in 1-bundle crates, which are stained chocolate brown and stenciled in the appropriate color marking for this type of round.

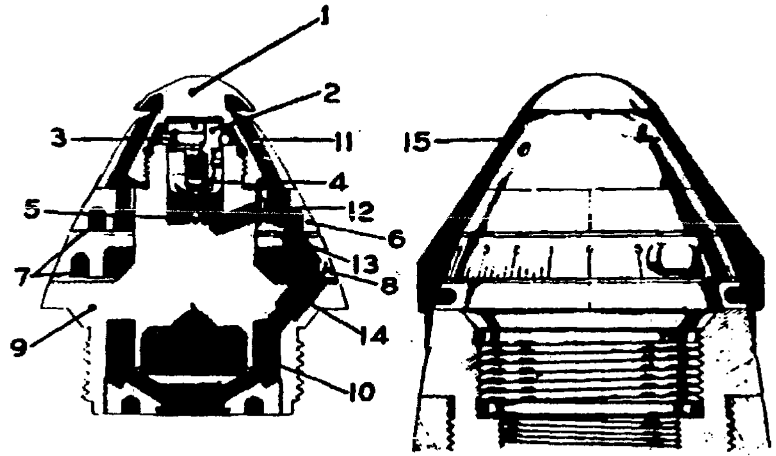
FURTHER REFERENCES: OS 9-20; OS 9-18; TM 9-1900; O.O. 7224, Ordnance Safety Manual; Complete Round Chart No. 5981; SNL R-1; SNL R-3.

Chapter 8

3-inch Ammunition

AMMUNITION FOR 3-INCH ANTIAIRCRAFT GUNS.

General. With the rapid development, since World War I, in the



1. CLOSING CAP.
2. CONCUSSION PLUNGER.
3. RESISTANCE RING.
4. CONCUSSION PRIMER.
5. CONCUSSION FIRING PIN.
6. UPPER TIME-TRAIN RING.
7. POWDER TRAIN.
8. LOWER OR GRADUATED TIME-TRAIN RING.
9. BODY.
10. MAGAZINE CHARGE (BLACK POWDER).
11. VENTS.
12. POWDER PELLET.
13. POWDER PELLET.
14. POWDER PELLET.
15. WATERPROOF COVER.

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Figure 176 — FUZE, Antiaircraft, 21-second, Mk. III

use of the airplane as a weapon of modern warfare it has become important that guns be developed to counteract this menace. The 3-inch antiaircraft guns were some of the first weapons designed to meet this need. The 3-inch AA guns are fired from two mounts: "fixed" and "mobile." The essential difference in the guns lies in the size of the powder chamber. The fixed mount guns have powder chambers that are longer and diametrically larger than the mobile mount guns; therefore, although the projectiles are interchangeable, the complete rounds are not because of the fact that the cartridge cases must be of different size and shape. The gun models that are fired from fixed mounts are the M1917 (all models), M1925MI, M1925MIA1, and the newer M2 and M4. Those fired from mobile mounts are the M1918 (all models) and the new M1 and M3.

All ammunition for 3-inch AA weapons is of the fixed class: that is, a cartridge case with its primer, propelling charge, and distance wad is firmly attached to a loaded and fuzed projectile.

Types of ammunition provided for 3-inch AA weapons are:

Shrapnel	Shot, A.P. (armor-piercing)
High-explosive	Shot, T.P. (target practice)
Projectile, A.P.C. (armor-piercing capped)	Drill
	Practice

FUZE, 21-second, AA, Mk. III. This fuze, a powder time-train type, with the A1 modifications, is standard for use in all 3-inch AA shrapnel ammunition. It is limited standard, with the A2 modification, for use with all 3-inch AA high-explosive shell. The Mk. III fuze is patterned after the M1907M Combination 21-second Fuze discussed in the chapter dealing with 75-mm ammunition components. Its only difference lies in the omission of the percussion plunger assembly in the base of the M1907M Fuze.

Description. This fuze is constructed of brass and consists of a concussion plunger assembly (with its resistance ring, primer, and plunger), a stationary firing pin in the head of the fuze body, two black powder time-train rings (the upper stationary and the lower movable and graduated in one-fifth seconds) and a magazine charge of loose black powder. Ignition pellets of black powder connect the primer to the upper time-train ring, the upper time-train ring to the lower time-train ring, and the lower time-train ring to the magazine charge. The time-train rings are separated from one another, and from the lower portion of the body by wax paper and felt washers. The fuze can be set and reset for any time from 0 to 21.2 seconds.

Function. When the setting is at zero, the action is as follows: When the gun is fired, the concussion plunger slides through the resistance ring due to inertia or set-back action in the projectile. The concussion primer which is held in the concussion plunger is thus fired by striking the firing pin. The flame from this primer passes through a hole in the fuze body and ignites the black powder pellet which is in the upper time-train ring. The flame from this primer is transmitted to the ignition pellet which is located in the lower or graduated time-train ring. The flame from this pellet ignites the ignition pellet in the fuze body which in turn ignites the magazine charge. The flame from the magazine charge ignites the booster detonator in the H.E. shell or, in the case of the shrapnel, flashes through the central tube and ignites the base charge. In the above action it is readily seen that, when the fuze is set at zero, the action is merely a transmission of flame from the concussion primer to the magazine charge by means of powder pellets. The powder train rings, which are responsible for the time feature, do not enter into this action even though they are ignited and completely burned.

When a time setting is desired, 15 seconds, for instance, the action is somewhat different. The lower time-train ring is turned counterclockwise until the 15 is in line with the lines on the body and the upper time-train ring. The action of the concussion plunger is the same, and the flame reaches the powder pellet as previously described. This powder pellet ignites the powder train. The powder train is placed in the upper and lower time-train rings in the shape of a horseshoe: that is, there is a solid section of metal at the beginning and end of the powder train. The ignition pellet in the lower time-train ring is moved in setting the fuze, and it is necessary that the powder train of the upper ring burns until this pellet is reached by the flame. Then with the ignition of the pellet, the powder train in the lower ring will begin to burn. When the flame reaches the ignition pellet in the body, the action is as previously described for zero setting. The gases from the burning of the powder train escape to the atmosphere by means of the vents in the closing cap.

When the lower ring is set so the mark "S" is in line with the lines on the body and the upper ring, the fuze is said to be "safe." At this setting, the solid metal section of the upper ring is completely covering the ignition pellet of the lower ring, and the solid section of the lower ring is completely covering the ignition pellet in the fuze body which leads to the magazine charge.

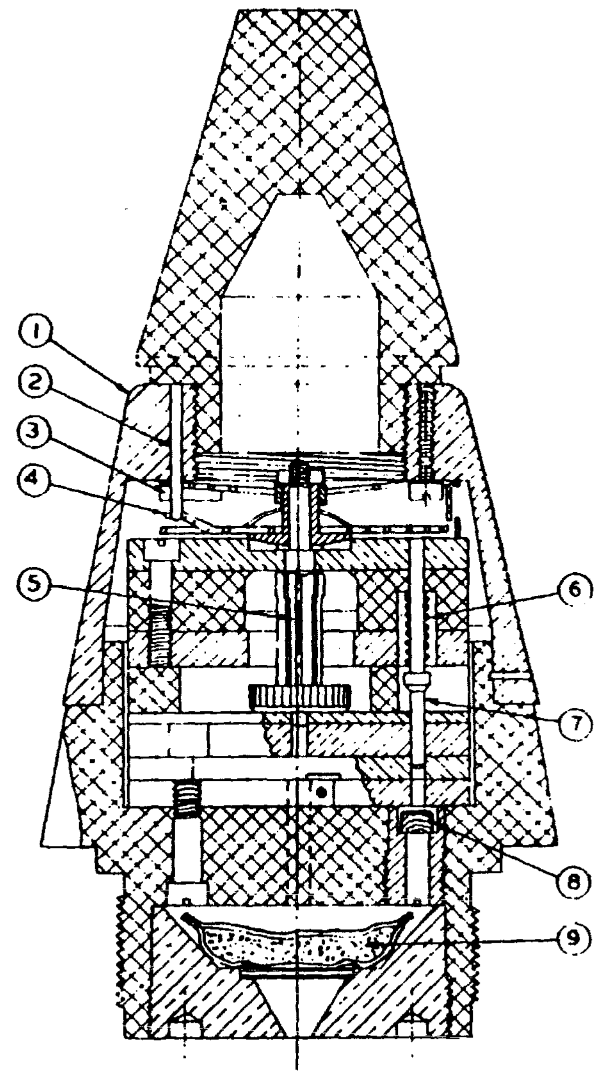
Moisture should be kept away from this fuze. The waxed paper, felt cloth discs, and the waterproof metal covers are all designed to prevent moisture from getting to the powder.

Modifications. Mk. III to Mk. IIIA1 consisted of strengthening the nose end of the fuze so the accidental striking of the point against the breech of the gun would not function the fuze.

Mk. IIIA1 to Mk. IIIA2 consisted of reducing the weight of the magazine charge from 95 to 15 grains, which is enough to function the Mk. X or the M20 Boosters which are used on H.E. antiaircraft rounds.

FUZE, Mechanical Time, M43.

General. This fuze is designed to initiate the functioning of the explosive charge of a projectile at a predetermined time after firing. It is standard for use on 3-inch, 90-mm, and 105-mm AA high-explosive shell ammunition. The time element of the fuze resembles a watch mechanism in general principles, differing from it in the following respects: Instead of being driven by a main spring, it is driven by a pair of weighted gear segments which are actuated by centrifugal force created by the rotation of the projectile in flight; its escapement differs from that of a watch, in that it beats at a very much higher frequency and makes use of a straight spring instead of the conventional spiral spring; also, the gears and pinions are much more rugged than those in a watch. The advantages of the



1. LOWER CAP, BRASS
2. SETTING PIN
3. HAMMERS
4. SETTING LUG
5. MAIN DRIVING PINION
6. FIRING PIN SPRING
7. FIRING PIN
8. PRIMER
9. MAGAZINE CHARGE

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Figure 177 — FUZE, Mechanical Time, M43

mechanical time fuze as compared with the powder train type of time fuze are:

1. Greater accuracy.

2. Calibration and accuracy are not affected by varying atmospheric conditions which result from firing at various gun elevations.

3. Ability to withstand long time storage without deterioration or loss in accuracy.

4. Possible production advantages, since manufacture does not require usual facilities necessary for explosive powder time-train fuzes.

Construction. The shape of this fuze is designed for good ballistics, the contour being streamlined as that of other modern point fuzes. The base is marked in ⅕-second graduations and may be adjusted from ⅕ to 30 seconds. Each full second graduation is numbered. The lower cap and base are provided with slots for the purpose of locking the fuze in the fuze setter and preventing its withdrawal until the fuze has received the proper setting.

Safety. The fuze contains three main safety devices which are armed by the action of firing the projectile from the gun. Two of them are under the force of set-back or linear acceleration, and one arms under the action of centrifugal force. These safety devices act respectively on the timing disc, the firing device, and the escapement movement. An inherent safety in the fuze is that no energy is available for running the movement and releasing the firing device until centrifugal force due to the rotation of the projectile in flight is created.

Timing. The timing of the fuze is regulated by the angular distance through which the firing notch in the timing disc must move to reach the finger of the firing arm. In setting the fuze, this angular distance is increased or decreased as the fuze setting is increased or decreased. Setting of the fuze is accomplished by turning the brass lower cap with respect to the body. The lower cap can be turned in either direction and through the zero and safety graduations. Turning this cap in a counterclockwise direction, as viewed from the point of the fuze, increases the fuze setting. When the fuze is being set, the timing disc rotates with the lower cap by means of the setting pin; however, the main driving pinion to which the timing disc is attached cannot move, because the gear train and escapement are locked by the centrifugal safety device. The friction washer which attaches the timing disc to the main driving pinion permits slippage to occur during the setting of the fuze, but the friction is sufficient for the main pinion to rotate timing disc after it has been released from the setting pin.

Function. When fired, the acceleration force or set-back developed in the bore of the gun causes the hammer on the cantilever spring to strike the protruding lug on the timing disc, flattening it and releasing it from the setting pin. The cantilever spring returns to its original position as soon as set-back ceases. Simultaneously, the set-back pin that locks the firing device is released. This is accomplished by the

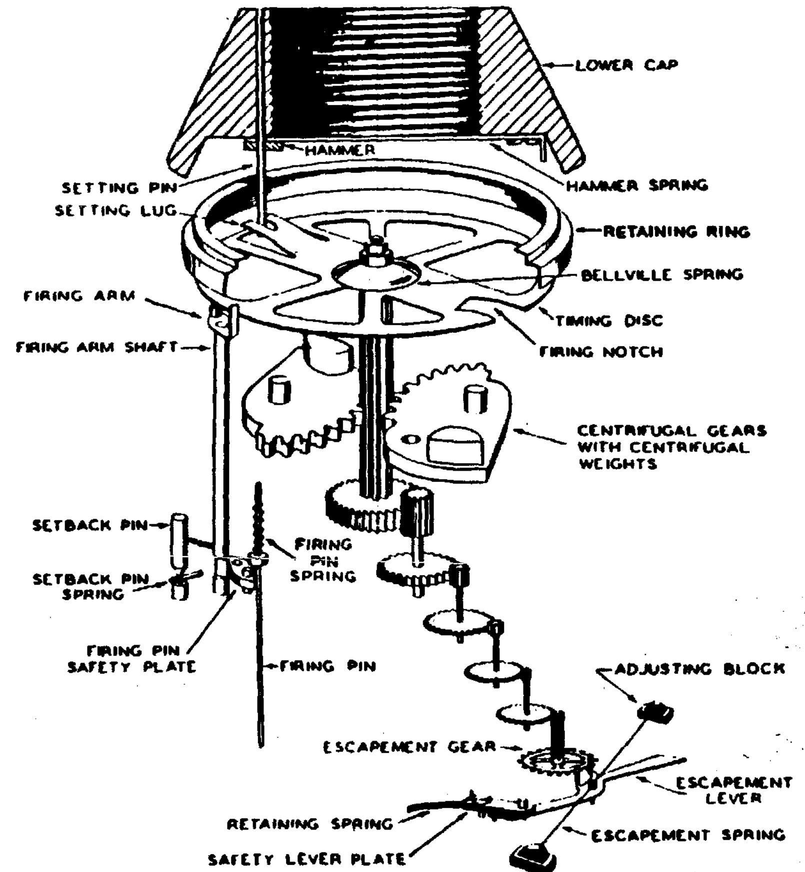

Figure 178 — Timing Mechanism of Mechanical Time Fuze

set-back pin moving rearward against the tension of a wishbone-shaped spring which in turn holds the set-back pellet in the rearmost portion of its recess. The firing arm is then free to rotate. Centrifugal force created by the rotation of the projectile in flight causes the safety lever plate or safety lock to rotate and release the escapement The safety lever plate is held in the locked position by a relatively soft flat spring. The movement is then free to run. The weighted gear segments mesh with the main driving pinion and drive the movement. The main driving pinion is connected by a train of gears to the escapement mechanism. Since the escapement lever is free to move, it is forced outward by each cog of the escapement gear, and then is thrown back by the escapement spring. The escapement mechanism thus controls the rate of rotation of the gears and, consequently, of the timing disc. As the action continues, the timing disc carrying the firing notch moves in a clockwise direction toward the firing arm finger. When the notch comes in line with the finger, centrifugal force causes the eccentrically weighted firing arm to move the finger into the firing notch. In so doing, it revolves the firing arm shaft and turns the notch in it into line with the firing pin safety plate. The firing pin safety plate being eccentrically weighted is now free to swing away from the firing pin shoulder. As it swings away it releases the firing pin which is driven by its compressed spring into a primer. The flame from the primer ignites the black powder magazine charge in the base of the fuze, completing the function.

Modifications. The M43 Fuze was modified to the M43A1 by the addition of a copper retaining ring designed to protect the timing disc against bulging or bending. Later, without changing the designation number, the groove just above the lower cap was eliminated, making the surface of the fuze smooth. The M43A1 was modified to the M43A2 by the addition of a metal leaf beneath the timing disc which prevents the functioning of the fuze until 1.67 seconds have elapsed. The A3 modification embodied several changes: Where the fuze parts had been cast, they were now machined; the frequency of the escapement was increased; and the manufacturer was changed from Bendix Aviation Corporation to Frankford Arsenal.

The M43A3B1 Fuze is the same as the M43A3, differing only in that it has laminated body parts. At the present time, there are fuzes of the M43-series being made with A4 and A5 modifications, but there is no information as to the nature of these changes available for publication.

Booster M20. Boosters M20 and M20A1 are used in the High-explosive Rounds M42 and M42A1 and are completely described in the chapter dealing with 75-mm ammunition.

Booster M23. Booster M23 is similar to the M20-series, and is used in the H.E. Mk. IX Round; however, there is no detailed information available at this time with regard to this booster.

Booster Mk. X. The Booster Mk. X will be found assembled in 3-inch AA High-explosive Shell Mk. I and Mk. IX. Practically all metal parts of this booster are made of brass. The split slider, which is similar to the split slider of the Mk. V B.D. Fuze, constitutes a bore-safe device and is armed by centrifugal force. When the fuze has burned its predetermined time, the magazine charge explodes, and functions the detonator of the booster which contains about 12 grains of mercury fulminate. This detonates the booster charge. The booster charge in turn serves to detonate the explosive charge of the shell. The standard booster charge is ⅜ ounce of pressed tetryl. Lead charges and slider charges are TNT.

Cartridge Cases for 3-inch AA Guns on Fixed Mounts.

Cartridge Case Mk. I and Mk. IA1. These cases have an over-all length of 27.15 inches, and are identical, except for the size of primer

seat. The Mk. I takes the older 110-grain percussion primer, while the Mk. IA1 takes the 100-grain, M1: the 330-grain, M21; or the 300-grain, M28A1. These two cases are used only on Mk. I Shrapnel to be fired in guns provided on fixed mounts.

Cartridge Cases Mk. IM1 and Mk. IM2. These cases have an over-all length of 26.7 inches, and are identical except for size of primer seat. The primers used are the same as those mentioned above for the Mk. I and Mk. IA1, respectively. The Mk. IM2 Case is the present standard for ammunition to be used in guns on fixed mounts, except for shrapnel which (due to its narrow rotating band) is provided with the longer Mk. IA1 Case.

Cartridge Cases for 3-inch AA Guns on Mobile Mounts.

Cartridge Cases Mk. II and Mk. IIA1. These cases have an over-all length of 23.65 inches, and are identical, except for the size of the primer seat. The primers used are the same as those used in the previously mentioned Mk. I and Mk. IA1, respectively. These two cases are used only with the Mk. I Shrapnel when fired from mobile mounted guns.

Cartridge Cases Mk. IIM1 and Mk. IIM2. These cases have an over-all length of 23.08 inches, and are identical except for the size of the primer seat. The primers are the same as those mentioned for the Mk. I and Mk. IA1 Cases, respectively. The Mk. IIM2 Case is the present standard for ammunition to be fired in mobile mounted guns, except for shrapnel which (due to its narrow rotating band) is provided with the longer Mk. IIA1 Case.

Propelling Charges and Distance Wads. The propelling charge used with 3-inch AA ammunition is, in all rounds, approximately 5 pounds of nonhygroscopic (NH) or flashless nonhygroscopic (FNH) smokeless powder held loosely in the cartridge case. In this connection, a cardboard distance wad is used to serve two purposes: It keeps the powder at a uniform density, thus insuring proper burning; and it also holds the powder firmly in intimate contact with the primer to insure efficient ignition. The distance wad consists of a wax-coated cardboard tube and two cardboard discs. This distance wad fills the space between the top of the powder in the cartridge case and the base of the projectile.

Primers. The primer which is standard for future manufacture of 3-inch AA ammunition is the 300-grain M28A2 which is identical in construction to the M1B1A2 described in the chapter dealing with 75-mm ammunition. The only difference lies in the fact that the M28 has 300 grains of powder while the M1-series has 100 grains.

SHRAPNEL, Fixed, Mk. I.

General. This round was developed during World War I and was used against aircraft at that time. At the present time, however, due to added armament on aircraft, shrapnel serves no effective service use, and has therefore been classified limited standard. The existing stocks are being used for target practice.

Projectile. The projectile for the Mk. I Round is of steel construction, with a radius of ogive of 7 calibers. The rotating band is of copper and is 0.55 inch wide. It retains its cylindrical shape from the rotating band to the base, and the projectile has no base plate. The base or expelling charge consists of 3 ounces of black powder which is separated from the lead balls in a matrix by means of a steel diaphragm that acts also as a support for the filling. The filling consists of 253 lead balls (hardened with antimony) held in a resin matrix. Each ball is approximately 0.5 inch in diameter and average weight is 42 balls to the pound. The shell also has a central flash tube that leads from the fuze to the base charge.

Components. The complete round consists of the Mk. I Projectile, fuzed with the 21-second Mk. IIIA1 Powder Time-train Fuze, and using the Mk. IA1 or the Mk. IIA1 Cartridge Case with a propelling charge of N. H. smokeless powder, distance wad, and M28A2 Primer.

Guns. The Mk. I Shrapnel Round can be used in all models of fixed or mobile mounted guns providing the cartridge case corresponds with the proper weapon.

SHELL, Fixed, H.E., Mk. IX.

General. In order to increase the life of the 3-inch AA gun, the twist of the rifling in all late models and relined or retubed guns was reduced to one turn in forty calibers. This change in rifling, however, caused the Mk. I High-explosive Shell to become unstable in flight, and it was therefore necessary to design a new H.E. shell. The shell designed to supersede the Mk. I is known as the Mk. IX.

Projectile. The Projectile, Mk. IX is of steel construction, and is shorter and lighter in weight than the Mk. I. It has a radius of ogive of 7 calibers, and it continues its cylindrical shape from the rotating band to the base. The rotating band is 1 inch wide. The filler is 0.91 pound of TNT. This shell has a steel base plate and an adapter. Varying projectile weights give rise to three zone weights; they vary from a minimum in zone 1 of 12 pounds, 7.75 ounces to a maximum in zone 3 of 12 pounds, 14.25 ounces.

Components. The complete round consists of the Mk. IX Projectile with its adapter, fuzed with the Mechanical Time Fuze M43A2, and using the Booster M23 or Mk. X. This loaded, boostered, and fuzed projectile is assembled to the Mk. IM2 or the Mk. IIM2 Cartridge Case with its propelling charge of NH smokeless powder, distance wad, and M28A2 Primer.

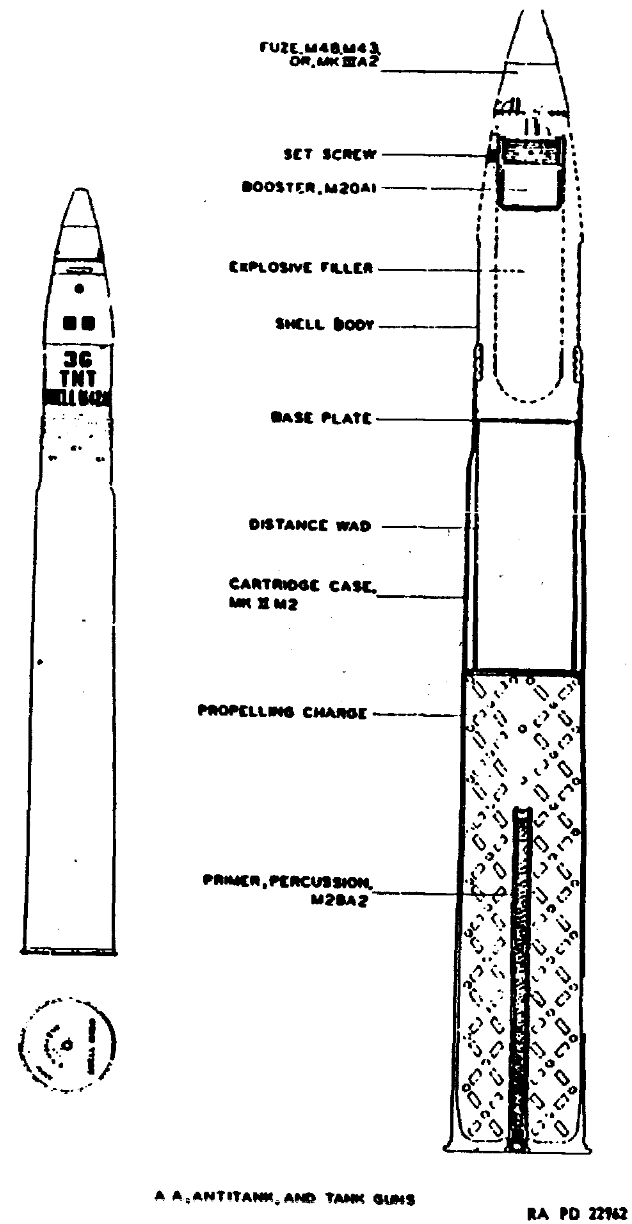

Figure 179 — SHELL, H.E., 3-Inch, M42A1

Guns. The Mk. IX H.E. Round can be used in all models of fixed or mobile mounted guns providing the cartridge case corresponds with the proper weapon.

SHELL, Fixed, H.E., M42.

General. This shell is essentially designed to replace the SHELL, H.E., Mk. IX, to take the M20 Booster directly without use of an adapter.

Projectile. The projectile is of 1-piece steel construction and has the same length and contour as the Mk. IX combined with its adapter. The nose is threaded to receive the M20 Booster. The radius of ogive, rotating band, and base plate are also identical to that of the Mk. IX H.E. Shell. The filler is 0.86 pound of TNT. The variation in shell weights gives three zone weights, similar to the Mk. IX. The M42 Projectile has been modified to the M42A1, and will be manufactured as such in the future. The modification consists of changing the inside cavity at the base of the projectile from a flat to a hemispherical contour.

Components. The complete round consists of the 42 Projectile loaded with TNT, having a bakelite cup in the nose to receive the M20-series Booster, and fuzed with the M.T. M43 Fuze (all models) or the 21-second Powder Time-train Fuze Mk. IIIA2. The above projectile is crimped to the Mk. IM2 or Mk. IIM2 Cartridge Case with its propelling charge of NH smokeless powder, distance wad, and the M28A2 Primer.

Guns. The M42 H.E. Round can be used in all models of fixed or mobile mounted guns, providing the cartridge case corresponds with the proper weapon.

SHOT, Fixed, A.P., M79, With Tracer.

General. As a direct outcome of World War II, some of the weapons designed originally for AA work entirely have been converted into dual-purpose weapons simply by adding rounds that serve an entirely different purpose. This is the case with regard to this armor-piercing round. The AA weapon can, with this type of ammunition, be used against tanks and armored vehicles as well as against aircraft. It should be noted at this point, however, that these new A.P. rounds are provided only for weapons on the mobile mount.

Projectile. The projectile consists of a heat-treated, hardened steel, solid shot which has a cavity in its base to hold the tracer element which is ignited by the propellent charge. The rotating band is of gilding metal, and is approximately 1 inch wide.

Components. The complete round consists of the Shot M79, with its tracer composition in the base, crimped firmly to the Mk. IIM2

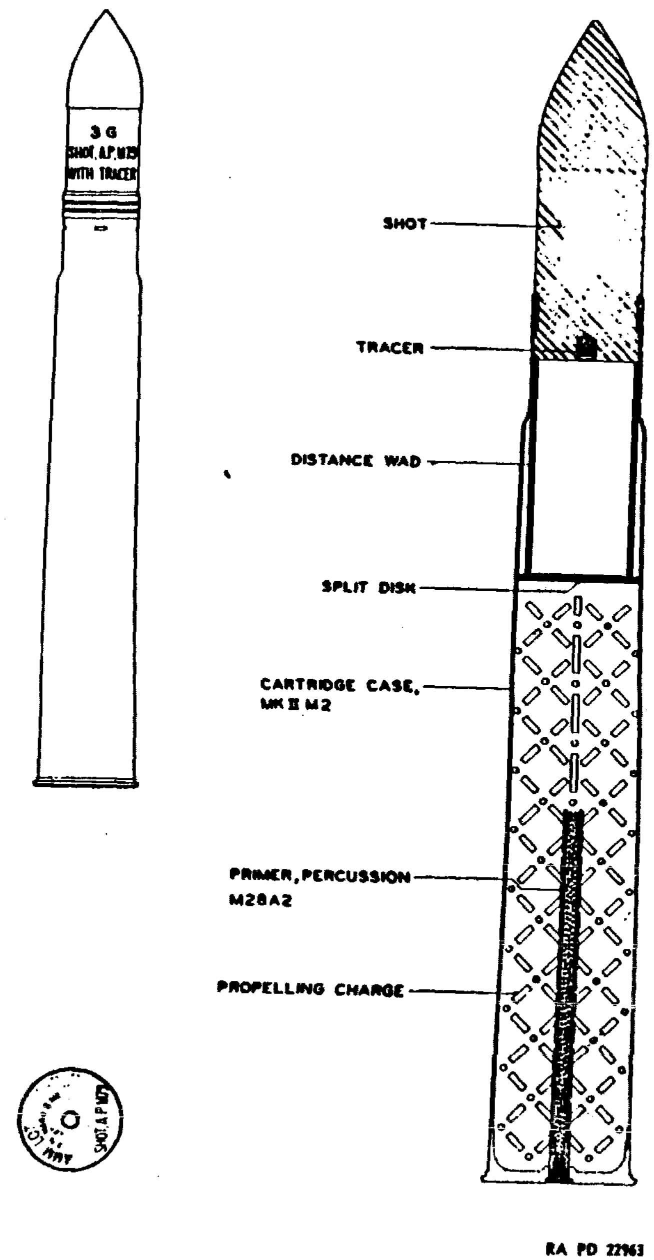

Figure 180 — SHOT, A.P., 3-inch, M79

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Cartridge Case containing 4.38 pounds of flashless nonhygroscopic (FNH) smokeless powder, a distance wad, and the Primer M28A2.

Guns. The SHOT, A.P., M79, can be used only in models of guns of the mobile mount.

SHOT, Fixed, T.P. (Target Practice) M85, With Tracer.

General. Simultaneously with the adoption of A.P. ammunition for AA weapons came the need for a practice round. The SHOT, T.P., M85, was designed to satisfy that need. To date, this projectile has not been manufactured.

Projectile. The projectile is the same as the one used on the A.P. M79 Round, but is probably of cast iron construction.

Composition. The complete round of SHOT, T.P., M85, has the same components as the SHOT, fixed, A.P., M79.

Guns. This round is used for target practice work in all guns on mobile mounts.

PROJECTILE, Fixed, A.P.C., M62, With FUZE, B.D., M66 or M66A1 and Tracer.

General. The Projectile A.P.C. M62 Round is the preferable service A.P. round. The Shot M79 is being made, however, since it can be manufactured much easier and faster than the PROJECTILE, A.P.C., M62. The need for A.P. ammunition has been immediate, and in order to satisfy this need the shot A.P. is being made on a larger scale than the projectile A.P.C. The SHOT, A.P., M79, is substitute standard, in that it will be manufactured only so long as the supply of PROJECTILE, A.P.C., M62, is not sufficient to the need for A.P. ammunition for the 3-inch weapon.

Projectile. The projectile consists of a heat-treated, hardened steel body which has a softer steel A.P. cap sweated on its forward end. The A.P. cap in turn is threaded to receive a cast aluminum windshield or false ogive. The body has a cavity for the high-explosive filler, and the base is threaded to receive a base-detonating fuze if a filler is used, or a base plug with tracer composition if no filler is used. Standard nomenclature informs whether or not a filler is used by specifying "With fuze and with tracer" if filler is present or simply "With tracer" if no filler is present.

Components. The complete round consists of the projectile A.P.C. with 0.17 pound of explosive D filler, and the Base-detonating Fuze M66 or M66A1. The above fuze is discussed fully in connection with 75-mm ammunition components. It has a boat-tail shaped base that protrudes from the rear of the projectile and contains the tracer composition. The projectile is crimped firmly to the Mk. IIM2 Cartridge

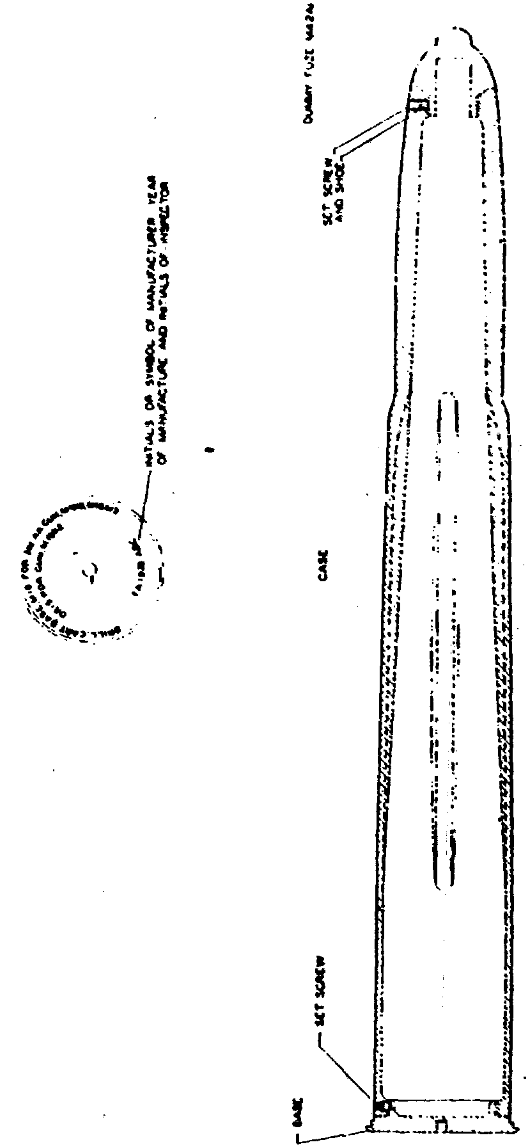

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Figure 181 — Drill Cartridge M10

Case which contains 4.62 pounds of FNH smokeless powder, a distance wad, and the M28A2 Primer.

Guns. This round is fired only from guns on mobile mounts.

CARTRIDGE, Drill, M9 and M10.

General. It has always been standard, logical training procedure to train gun crews in loading weapons and setting of the fuze on something other than service ammunition. The drill round is an outgrowth of this procedure.

Complete round. This round consists of a 1-piece hollow bronze casting (cartridge case and projectile) simulating service ammunition. The nose is threaded to receive 21-second M42 Dummy Fuze. The round has a base that is threaded and screwed in rear of the drill cartridge; this base receives the inert dummy primer. Both the fuze and base are held in place by means of set screws.

Guns. The M9 Drill Round is used in all models of guns on fixed mounts, while the M10 is used on mobile mounts.

AMMUNITION, Blank, M12 and M13.

General. Blank ammunition was designed to serve three purposes: firing salutes; firing the morning and evening guns; and firing in maneuvers. This ammunition is identical in construction to that provided for 75-mm guns.

Complete round. A complete round of blank ammunition utilizes a cut-down service cartridge case. This is accomplished by cutting the case down to proper length, and then reaming out the open end of the case and reducing the metal thickness. This cut-down case uses the M1B1A1, 100-grain, percussion primer and contains 1 pound of black powder in a fitted cloth bag. The charge is held in place by the insertion of a chipboard closing cup in the mouth of the case. On the bottom of the closing cup is cemented a 0.5-inch felt wad. This cup with its felt wad is sealed in the mouth of the case with Pettman cement and confines the charge of powder to produce loud report. Ordinarily, a sodium nitrate type powder is used; however, if potassium nitrate type is used, the felt wad is omitted as the report from the powder is loud enough without the use of the wad.

SHELL, Fixed, Practice, M42B2, With FUZE, T.M., M43 (All Modifications).

General. This round was designed for practice in AA fire, setting of the fuze, etc.

Projectile. The M42B2 Shell Body has an open base which is closed when a large steel base plug is screwed into place. In all other respects except for painting it is the same as the M42 Shell Body. It is painted blue with white stencil.

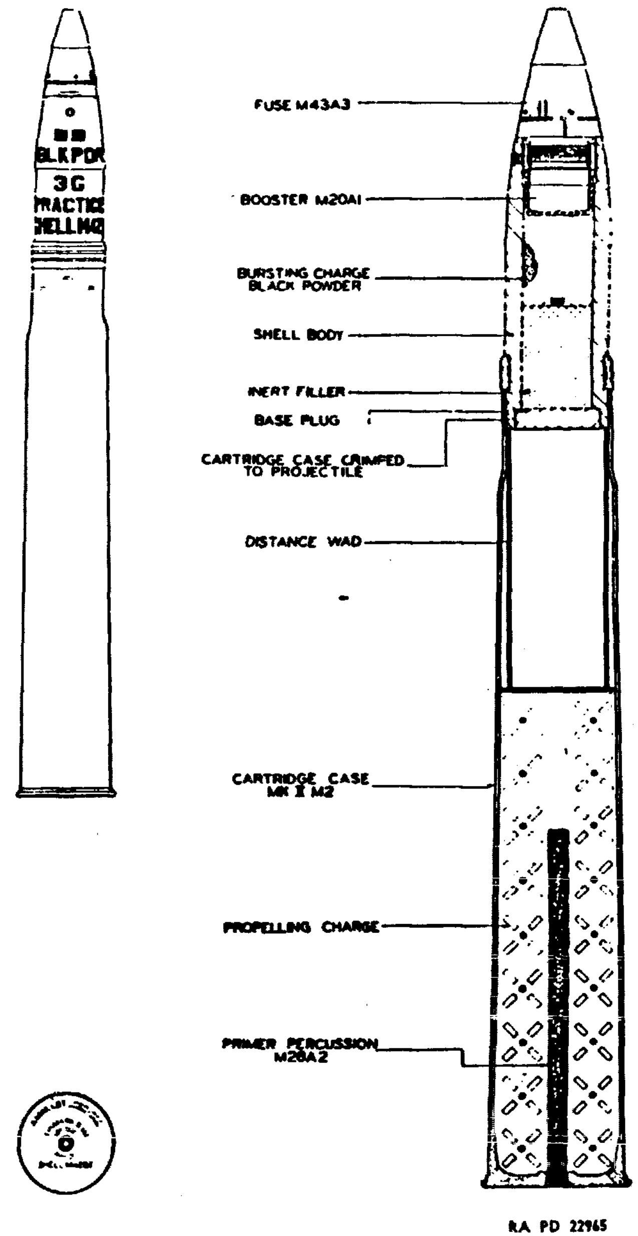

Figure 182 — SHELL, Practice, 3-inch, M42B2

Components. This complete round is sand-loaded with a black powder spotting charge, and has the M20-series of booster, the M.T. Fuze M43 (all modifications). The projectile is firmly attached to the Mk. IM2 or Mk. IIM2 Cartridge Case with its propelling charge of NH powder, distance wad, and the M28A2 Primer.

Guns. The M42B2 Practice Round can be used in all models of fixed and mobile mounted guns, providing the cartridge case corresponds with the proper weapon. The round for the fixed mount guns is the only one standard for future manufacture.

SHELL, Fixed, Smoke, HC, B.I., M88. This round is similar to the SHELL, smoke, HC, B.I., M89, discussed in the chapter dealing with ammunition for 75-mm weapons. Components required to make up a complete round are: Mk. IIM2 Cartridge Case, M28A2 Primer, and a reduced propelling charge of FNH powder. Use of this round is confined to mobile mount guns, as indicated by the fact that the complete round is provided with the Mk. IIM2 Cartridge Case.

Packing. Following is a list of the present standard packings of ammunition for 3-inch AA guns, fixed and mobile mounts:

SHOT, T.P., M85; SHRAPNEL, Mk.I; SHELL, H.E., Mk.IX; SHELL PRACTICE, M42B2; SHELL, H.E., M42; PROJECTILE, A.P.C., M62; SHOT, A.P., M79: 1 round per fiber container, 4 containers (4 rounds) per wooden nacking box.

CARTRIDGE, drill, M9 and M10: packed as required.

AMMUNITION, blank, M12 and M13: 1 round per fiber container, 20 containers (20 rounds) per wooden box.

AMMUNITION FOR 3-INCH SEACOAST GUNS.

General. 3-inch seacoast guns were designed to serve the general purpose of protecting important areas on sea frontiers. Naturally, these guns are fired from permanent emplacements in a fixed position; however, like 3-inch AA guns, they have two different sizes of powder chambers. The gun models that use 3-inch seacoast ammunition are the M1902MI which has a powder chamber of the same size as the mobile mounted 3-inch AA, and the M1903 whose powder chamber is the same as that of the fixed mount 3-inch AA guns. The projectiles in the 3-inch seacoast guns are interchangeable, but the cartridge cases are different.

Types of ammunition provided for the 3-inch seacoast weapons are:
High-explosive
Practice
Drill
Subcaliber

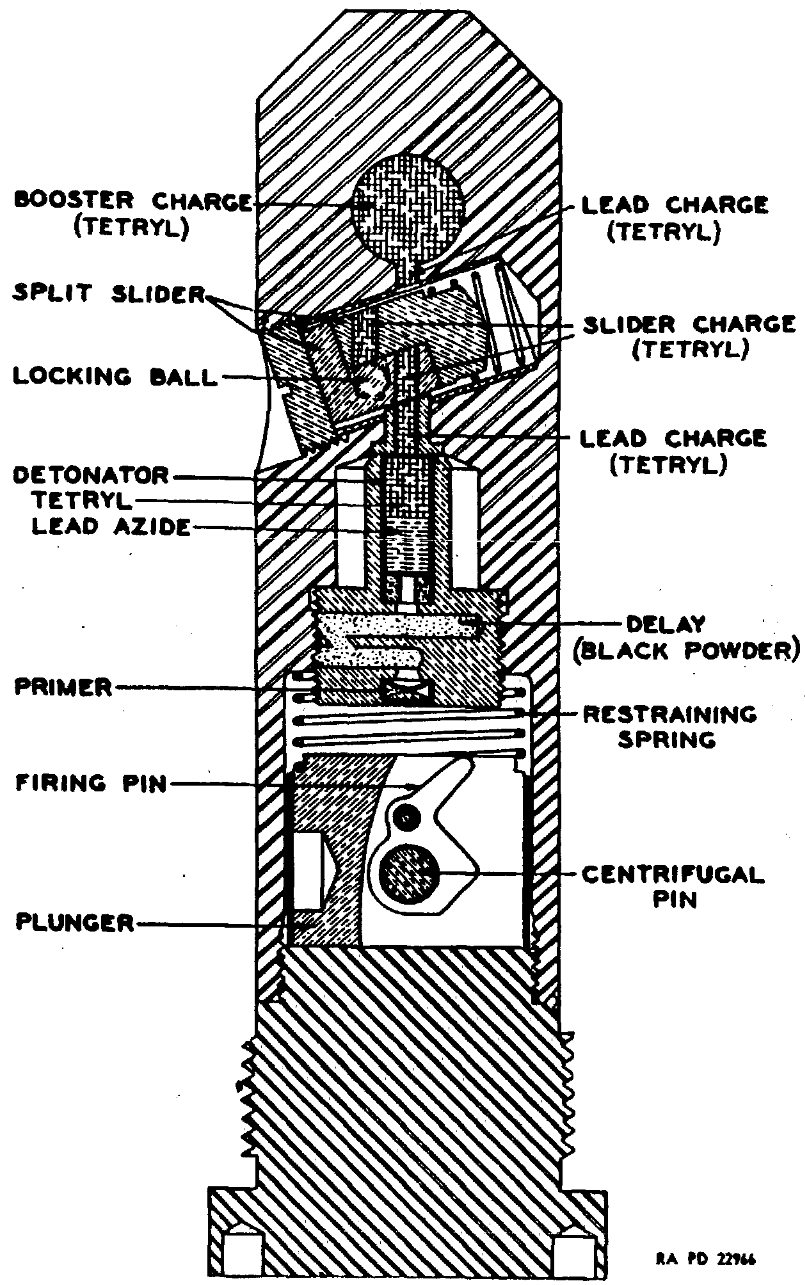

Figure 183 — FUZE, B.D., Mk. V

FUZE, Base-detonating, Mk. V (Medium Caliber). This fuze is used in the SHELL, H.E., M1915, in which nondelay action is required. The fuze, however, can be manufactured with a short delay of 0.05 second or a long delay of 0.15 second by merely adding a black powder pellet. It is a boresafe fuze, and loaded projectiles are issued with the fuze assembled in place.

Description. Illustration of the Mk. V Fuze presents a study of the fuze and its principal parts.

Action. When the gun is fired, no action takes place in the fuze while the projectile is in the weapon. After the projectile has left the muzzle of the gun, the centrifugal pins in the percussion plunger recede and the eccentrically weighted firing pin is swung into armed position by centrifugal force. Simultaneously with this arming of the percussion plunger by centrifugal force, the movable half of the split slider is forced outward against its spring, lining up the explosive train. A metal ball located in the stationary part of the slider drops into the space vacated by the movable part of the slider and prevents the fuze from disarming. On impact, the armed percussion plunger is driven forward, overcoming the resistance of the restraining spring. The firing pin strikes the percussion primer, creating a tiny flame which causes explosion of the detonator of lead azide and tetryl in the nondelay fuze, or ignites a delay train of black powder which burns for 0.05 second for the short delay, or 0.15 seconds for the long delay fuze. This in turn sets off a tetryl lead charge leading to the slider, and tetryl charges in the slider, which in turn function a tetryl lead charge leading from the slider. This, in turn, detonates the booster charge of tetryl. The explosive charge of the projectile is then detonated.

Safety. Bore safety is achieved by use of the split slider which prevents any action of the primer or detonator from being transmitted to the booster charge until the projectile has left the muzzle of the gun. The percussion plunger, also a safety feature, arms at a predetermined number of revolutions per minute. The restraining spring holds the firing pin off the primer and counteracts creep force.

FUZE, Point-detonating, M48 and M48A1. This fuze has been completely discussed in the chapter dealing with 75-mm gun ammunition.

Boosters M20 and M20A1. This booster, used in 3-inch seacoast H.E. shell, has been completely discussed in connection with 75-mm gun ammunition components.

Cartridge Cases. The cartridge cases used in conjunction with 3-inch seacoast ammunition are identical in every respect to those used on 3-inch AA rounds. They consist of the Mk. IA1, Mk. IIA1, Mk. IM2, and the Mk. IIM2.

Propelling Charges. 3-inch seacoast ammunition uses propelling charges of approximately 5 pounds of NH smokeless powder, and distance wads. Used in connection with the ROUND, shell, H.E., M1915, there is a black powder igniter pad placed on top of the propelling charge.

Primers. The primers used in complete rounds of 3-inch seacoast ammunition are identically the same as the primers used in 3-inch AA ammunition, namely, the M28A1, M28A2, and the M1B1A1.

SHELL, Fixed, H.E., M1915.

General. This round of ammunition is a based-fuzed high-explosive round used for armor-piercing work. The round is standard for issue only at the present time, due to the fact that it is ineffective as an A.P. round.

Projectile. The shell used in the M1915 H.E. Round is of forged steel construction. It has a rather blunt nose (radius of ogive of 2 calibers) and a square base. The filler is ½ pound of explosive D. A steel base plate is assembled by means of lead calking wire. The shell has a rotating band of approximately 0.55 inch.

Components. The completed round consists of the M1915 Shell with an explosive D filler and a Mk. V Base-detonating Fuze, the shell being firmly assembled to the Mk. IA1 or Mk. IIA1 Cartridge Case with its propelling charge of NH powder, igniter pad of black powder, a distance wad, and an M28A1 300-grain Percussion Primer.

Guns. This round is fired from the M1902MI (same chamber as mobile mount, 3-inch AA) and the M1903 (same chamber as fixed mount, 3-inch AA) Guns

SHELL, Fixed, H.E., M42.

General. This round replaces the M1915 H.E. Round. It is identical to the SHELL, fixed, H.E., for 3-inch AA guns, except for the fact that it is fuzed with the P.D. M48 Fuze rather than the M43 Mechanical Time Fuze. The complete round consists of the M42 Shell, M20 Booster, explosive filler of TNT, Mk. IM2 or Mk. IIM2 Cartridge Case, propelling charge of NH powder, distance wad, and the M28A1 Primer.

PROJECTILE, Fixed, Target Practice, Mk. VIIA1.

General. This round has been designed as the practice round for training gun crews operating 3-inch seacoast guns.

Projectile. The Mk. VIIA1 Projectile is of cast iron construction with no fuze, booster, or H.E. filler.

Components. The complete round consists of the Mk. IIA1 Projectile, attached to a Mk. IM2 or Mk. IIM2 Cartridge Case with NH propelling charge, distance wad, and M28A1 Primer.

Guns. This round is fired from the 3-inch Seacoast Guns M1902MI and M1903.

CARTRIDGE, Drill, M3 and M4.

Complete round. This round is essentially the same as the Drill Rounds M9 and M10, discussed in connection with 3-inch AA ammunition. They are standard for future issue and manufacture for 3-inch seacoast weapons. They consist of a 1-piece hollow bronze casting (cartridge case and projectile) simulating service ammunition. The nose has the M42A1 Dummy Fuze. A replaceable base is also provided to receive an inert primer.

AMMUNITION, Blank, M12 and M13.

General. These two rounds of blank ammunition are identical to the rounds provided for 3-inch AA, discussed previously in this chapter.

CARTRIDGE, Subcaliber.

General. The subcaliber cartridge consists of a cal. .30 rifle barrel mounted in a 1-piece bronze replica of a service round of 3-inch seacoast ammunition. The weight and dimensions of this round are similar to a service round. The base is grooved to receive two flat steel springs that eject the fired cal. .30 cartridge case. The 3-inch subcaliber cartridge is inserted and pushed home in the gun. The subcaliber cartridge, cal. .30, is then inserted in the chamber of the subcaliber barrel until its rim comes in contact with the extractor springs. The breech of the gun is then closed, the face of the breechblock coming in contact with the subcaliber cartridge, cal. .30, and forcing it to its proper seat. Ordinary cal. .30 cartridges cannot be used in subcaliber cartridges because their primer cups cannot withstand the heavy blow of the cannon firing pin. A special cal. .30 cartridge with a primer cup of monel metal has been adapted for this purpose, and requisitions for subcaliber ammunition should call for "subcaliber cartridge, caliber .30."

Packing. Following is a list of the present standard packings of ammunition for 3-inch seacoast guns:

SHELL, fixed, H.E., M42, and SHELL, fixed, target practice, Mk. VIIA1 are packed in individual fiber containers, four rounds per wooden box.

SHELL, H.E., M1915, is packed four rounds per wooden box.

CARTRIDGE, drill, M3 and M4 are packed as required.

AMMUNITION, blank, M12 and M13, one round per fiber container, 20 rounds per wooden box.

AMMUNITION FOR 3-INCH TANK AND ANTITANK GUNS.

General. The development of 3-inch tank and antitank guns is a result of the pronounced trend to armored tanks and vehicles in modern warfare. The M5 and M6 Guns are mounted on tank destroyers while the M7 is mounted in tanks. The fact that these weapons are all designed to be fired from mobile mounts indicates the use of ammunition with the Mk. IIM2 Cartridge Case used in other 3-inch mobile mounts.

Types of ammunition provided for the 3-inch Guns M5, M6, and M7 are:

Projectile, A.P.C. (armor-piercing, capped)
Shot, A.P. (armor-piercing)
High-explosive
Chemical, smoke (base ignition or base emission)

Components. Fuzes M66A1, M48, and M48A1 are used in this ammunition. They have been previously discussed in the chapter dealing with 75-mm gun ammunition. The Booster M20 was also described with 75-mm gun ammnuition. The Cartridge Case Mk. IIM2 and Primer M28A2 described earlier in this chapter are used in all rounds fired in 3-inch tank and antitank guns. The propelling charge is approximately 5 pounds of NH smokeless powder.

Complete Rounds. The following rounds are issued for use in 3-inch tank and antitank guns:

PROJECTILE, fixed, A.P.C., M62, with FUZE, B.D., M66 or M66A1, and tracer

PROJECTILE, fixed, A.P.C., M62, with tracer

SHOT, fixed, A.P., M79, with tracer

SHELL, fixed, H.E., M42 or M42A1, with FUZE, P.D., M48

SHELL, fixed, smoke, HC, B.I., M88

The first four rounds listed are identical to rounds of the same nomenclature provided for use in 3-inch AA guns on fixed mounts. The M42 H.E. Round is identical to the same round provided for use in the 3-inch Seacoast Gun M1902MI.

Packing. All rounds for 3-inch tank and antitank guns are packed in individual fiber containers, four rounds per wooden box.

AMMUNITION FOR 3-INCH FIELD GUNS.

General. Since the first World War, the 3-inch Field Guns M1902, M1904, and M1905 have been used only as saluting guns. Consequently, the only type of ammunition provided for these guns, is blank or saluting ammunition.

These blank rounds, of which there are four types, are practically the same. All four types use the Cartridge Case M10 which is made

COMPLETE ROUNDS FOR 3-INCH SEACOAST GUNS

Complete Round	Status	Projectile	Filler	Fuzes	Booster	Cartridge Case	Primer
Shell, H.E., M1915	S	M1915	Explosive "D"	Mk.V	....	Mk.IA1 Mk.IIA1	M28A1
Shell, H.E., M42A1	S&M	M42A1	TNT	M48	M20	Mk.IM2 Mk.IIM2	M28A1
Shell Practice, Mk.VIIA1	S&M	Mk.VIIA1 Cast Iron	Inert	....	....	Mk.IM2 Mk.IIM2	M28A1
Cartridge, Drill, M3 and M4	S&M	Cast Bronze	....	M42A1 Dummy	....	Cast Bronze	Inert
Ammunition, Blank M12 and M13	S&M	....	....	....	....	Cut-down Mk.IM2 Mk.IIM2	M1B1A1

COMPLETE ROUNDS FOR THE 3-INCH AA GUNS (FIXED AND MOBILE)

Complete Round	Status	Projectile	Filler	Fuze	Booster	Cartridge Case	Primer	Gun Mounts
Shrapnel, Mk.I	S	Mk.I	Lead balls, Bl. P. Base charge	Mk.IIIA1	....	Mk.IA1, Mk.IIA1	M28A1	Fixed mobile
Shell, H.E., Mk.IX	S	Mk.IX	TNT	M43 (all mod.)	M23	Mk.IM1, Mk.IIM1	M28A1	Fixed mobile
Shell, H.E., M42A1	S&M	M42A1	TNT	Mk.IIIA2 M43 (all mod.)	M20	Mk.IM2, Mk.IIM2	M28A1	Fixed mobile
Proj., A.P.C., M62, w/fuze, B.D., M66A1	S&M	M62	Explosive D	M66A1	....	Mk.IIM2	M28A2	Mobile
Proj., A.P.C., M62	S&M	M62	....	....	....	Mk.IIM2	M28A2	Mobile
Shot, A.P., M79	S&M	M79	....	....	....	Mk.IIM2	M28A2	Mobile
Shot, T.P., M85	S&M	M85	....	....	....	Mk.IIM2	M28A2	Mobile
Shell, prac., M42B2	S&M	M42B2	Sand	M43 (all mod.)	M20A1	Mk.IM2	M28A2	Fixed
Shell, prac., M42B2	S	M42B2	Sand	M43 (all mod.)	M20A1	Mk.IIM2	M28A2	Mobile
Cart., drill, M9 and M10	S&M	Cast bronze	....	M42A1 dummy	....	Cast bronze	Inert	Fixed mobile
Ammunition, blank, M12 and M13	S&M	....	....	....	....	Cut-down Mk.IM2 Mk.IIM2	M1B1A1	Fixed mobile

by cutting down a regular service cartridge case. The charge in each type is black powder, but each type uses a different weight charge. The standard for all purposes except firing salutes of international courtesy is a 6-ounce charge. A charge of 6.9 ounces, called a single pellet charge, is provided for use in lieu of the 6-ounce charge. A charge of 1 pound is provided for firing salutes of international courtesy, with a 13.8-ounce double pellet for use as an alternate.

Each round of blank ammunition is packed in an individual fiber container, and 10 rounds are packed in a wooden packing box.

In general, Blank Ammunition M10 for the 3-inch field gun is similar to the blank rounds discussed in connection with the 3-inch AA ammunition.

FURTHER REFERENCES: Complete Round Chart No. 5981; OS 9-20; OS 9-18; TR 1360-3A, 1370-A; OS 9-48.

Chapter 9

Ammunition for 90-mm Guns

GENERAL.

One of the most effective AA weapons used by the various arms today, is the 90-mm Gun M1. It is fired from a self-propelled mount as well as from the more common mobile mount. The self-propelled mount is used as a tank destroyer, and is moved about on half or full tracks by its own power. The mobile mount which can be used against tanks and aircraft is a towed carriage.

Types of ammunition provided for the 90-mm Gun M1 are:

High-explosive
Projectile, A.P.C.
Shot, A.P.
Practice
Drill

Fuzes. All fuzes used with complete rounds of 90-mm ammunition have been previously discussed.

P.D., M48, and M48A1, selective, time and super quick—Fully discussed with 75-mm gun ammunition.

B.D., M68—Identical in all respects to the FUZE, B.D., M66A1, discussed with 75-mm gun ammunition, except for the fact that the body of the M68 is larger.

Mechanical Time M43 (all modifications)—Fully discussed in the chapter dealing with 3-inch AA ammunition.

Boosters. All boosters are of the M20-series (M20, M20A1, etc.).

Cartridge Case. The case used on all 90-mm ammunition is the M19 or M19B1 (steel). This case is usually of drawn brass, and is about 23⅝ inches long. The case has an extracting flange on the head which acts to stop the round when it is loaded into the weapon, and also to eject the case after firing. The metal near the mouth of the case is comparatively thin and soft, so that the pressure of the propelling charge gases expands it tightly against the walls of the chamber, thus preventing the leakage of any gases past the cartridge case.

Propelling Charge. The propellent charge for 90-mm ammunition consists of approximately 7 pounds of NH smokeless powder poured loosely in the cartridge case.

Primer. The primer used in all complete rounds is the M28-series of 300-grain percussion type of cannon primer.

SHELL, FIXED, PRACTICE, M58.

General. This complete round was originally developed as the High-explosive Round M58. Due to the thin body walls, prematures resulted. As a result, the filler was washed out and a substitute filler of sand and a black powder spotting charge was substituted. The round, thus, has been designated a practice round.

Projectile. The projectile is of steel construction. It is streamlined, with a boat-tail base. The fuze continues the exterior streamline of the projectile. The shell has a steel base plate welded to its base.

Components. A complete round of M58 Practice Ammunition consists of the following: An M58 Projectile with 2.11 pounds of inert filler and 0.56 pound black powder spotting charge in pellet form; an M20 Booster and an M43A2 Fuze; and an M19 Cartridge Case with a propellent charge of NH smokeless powder.

Guns. This complete round is fired from all models of the M1 Guns.

SHELL, FIXED, H.E., M71.

General. The M71 Shell was developed to replace the M58. The walls are made thicker to overcome the premature factor. In all other respects (outwardly) the shell is identical to the M58.

Projectile. The M71 Shell is streamlined, with a boat-tail base and a steel base plate. The fuze continues the streamline of the projectile. It is of forged steel construction.

Components. The filler for this round is 2.04 pounds of cast TNT, which is detonated by the M20A1 Booster used in conjunction with the M43-series mechanical time fuze for AA work, and the P.D. M48 or M48A1 for firing against ground targets. The loaded and fuzed projectile is assembled to an M19 Cartridge Case containing approxi-

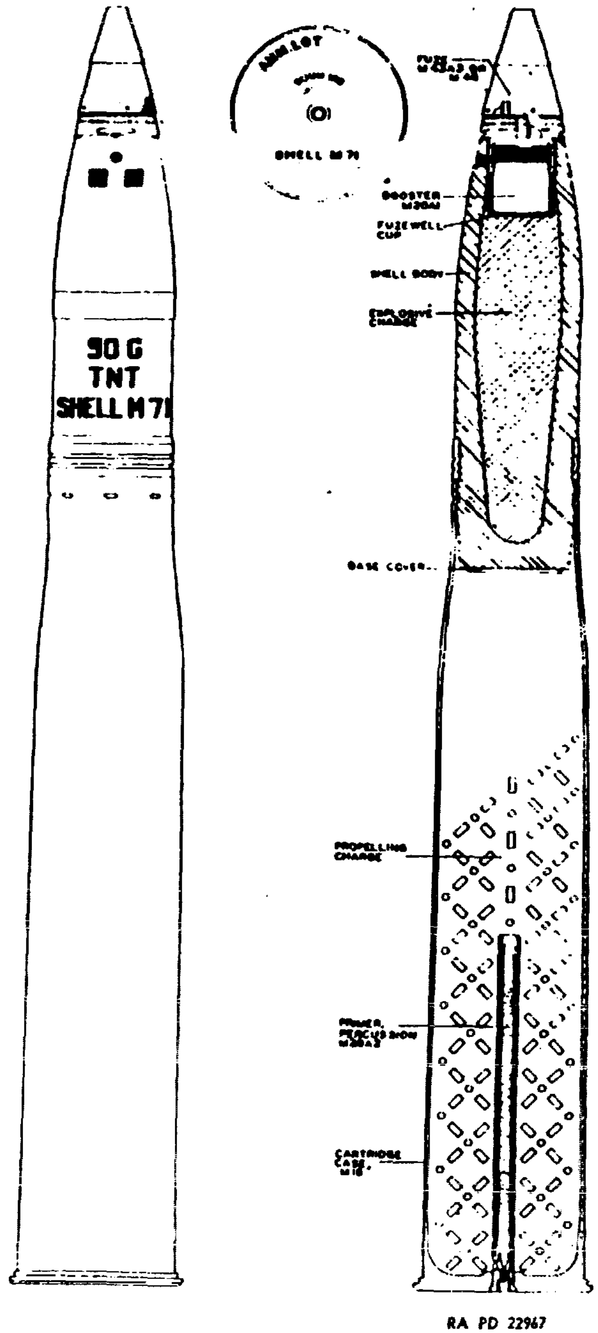

Figure 184 — SHELL, H.E., 90-mm, M71

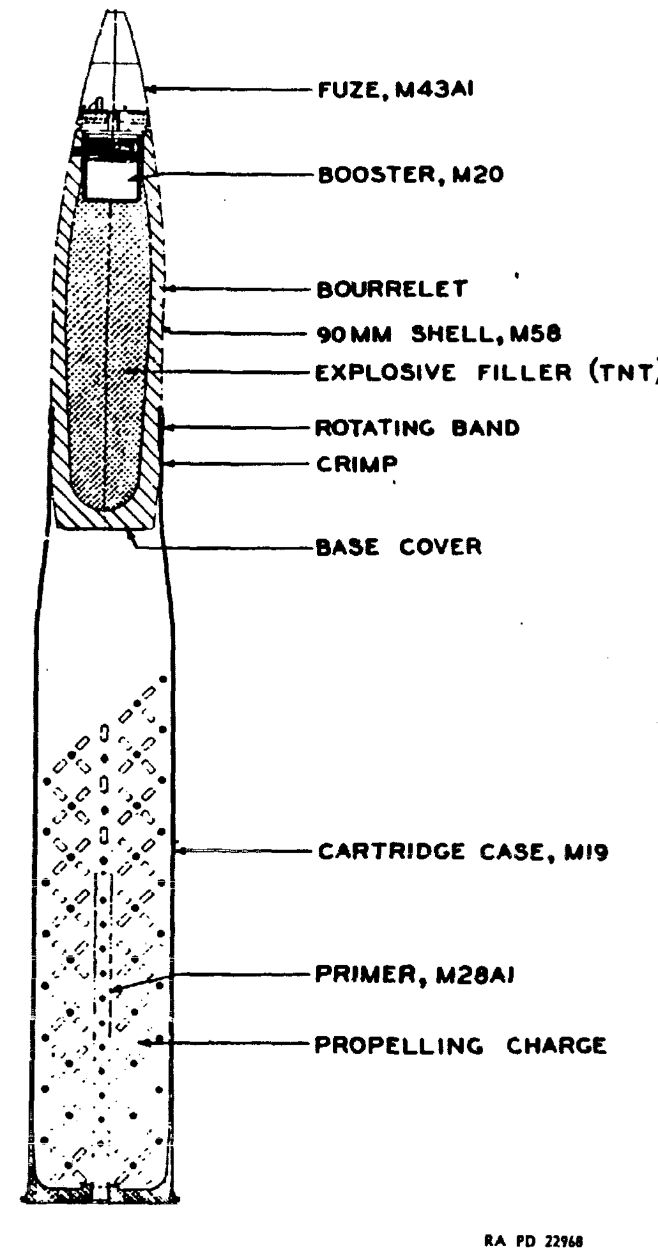

Figure 185 — SHELL, H.E., 90-mm, M58

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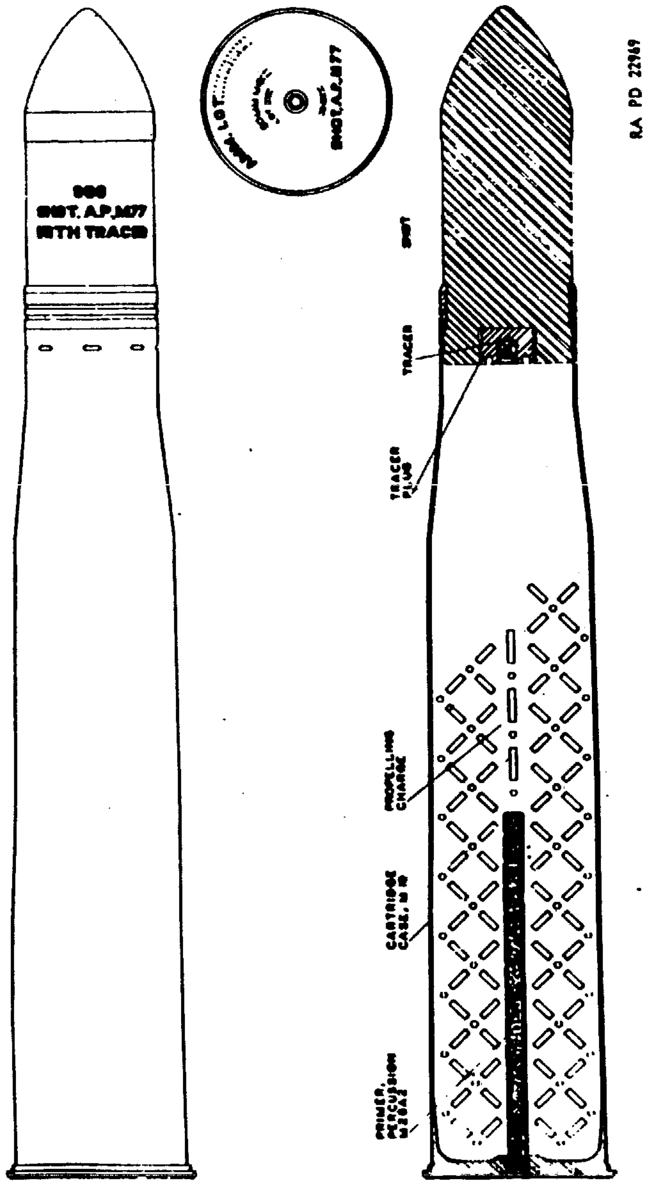

Figure 186 — SHOT, A.P., 90-mm, M77

mately 7 pounds of loose NH smokeless powder and an M28A1 or A2 Primer.

Gun. This round is fired from the 90-mm AA or AT Gun M1.

SHELL, FIXED, H.E., M58 (AMMANOL).

General. This round of ammunition was developed largely for testing purposes. It is identical in every way to the SHELL, H.E., M71, except for filler which consists of TNT, ammonium nitrate, and flaked aluminum. The aluminum gives a brilliant flash when the shell functions, and produces an incendiary effect against inflammable targets.

SHOT, FIXED, A.P., M77.

General. As the 90-mm Gun M1 can be used either against aircraft or tanks, the ammunition is adapted to both targets. The Shot M77 is provided for antitank use.

Projectile. The projectile consists of a heat-treated solid steel shot with no provision made for booster or fuze.

Components. The complete round consists of a SHOT, A.P., M77, firmly attached to an M19 Cartridge Case containing NH smokeless powder (approx. 7 lb) and an M28A1 or A2 Primer.

Gun. The 90-mm Gun M1 fires this round against tanks.

PROJECTILE, FIXED, A.P.C., M82.

General. This round is the more effective of the two armor-piercing rounds provided for the 90-mm gun when used against tanks.

Projectile. This round is the same as other A.P.C. rounds previously discussed, in that it has the heat-treated solid steel shot with an A.P. cap sweated on, and a false ogive or windshield screwed to this cap. Provisions are made for an explosive filler and base-detonating fuze.

Components. The complete round consists of the A.P.C. Projectile M82, with an explosive D filler and a B.D. Fuze M68. The M68 is similar to the B.D. M66, the only difference being in size. The M68 is larger than the M66. The fuze has a tracer composition in a boat-tail shaped portion that protrudes from the base of the projectile. The loaded and fuzed projectile is firmly crimped to the M19 Cartridge Case with its NH smokeless powder propellant and the M28A1 or A2 Primer.

Gun. This round is issued for firing in the M1 Gun when used against tanks.

COMPLETE ROUNDS FOR 90-MM GUNS

Complete Round	Status	Projectile	Filler	Fuze	Booster	Cartridge Case	Primer
Shell, Prac., M58	S	M58	Sand	Inert M43A2	Inert M20	M19	M28A1
Shell, H.E., M71	S&M	M71	TNT	M43A2 M48 M48A1	M20A1	M19	M28A1
Shell, H.E., M58	S	M71	Ammonal	M43	M20A1	M19	M28A1
Shot, A.P., M77	S&M	M77	....	....	....	M19	M28A1
Projectile, A.P.C., M82	S&M	M82	Exp. "D"	M68	....	M19	M28A1
Cartridge, Drill, M12	S&M	Cast Bronze	....	M44A2 Dummy	....	Cast Bronze	Inert

CARTRIDGE, DRILL, M12.

General. This round serves the same purpose and is of the same construction as other drill rounds already discussed. It is used to train troops in loading, and fuzing of ammunition. It is of 1-piece cast bronze construction that simulates a service round. The fuze used is the M44A2 Dummy Fuze, and an inert primer is also provided.

PACKING.

All rounds except the drill cartridge are packed one round per individual fiber container, and two or four rounds in containers per wooden box. The drill cartridge is packed as required. All rounds are shipped fuzed and boostered.

FURTHER REFERENCES: OS 9-20; Complete Round Chart.

Chapter 10

Ammunition for 105-mm Guns and Howitzers

AMMUNITION FOR 105-MM AA GUN M3.

General. The 105-mm AA Gun M3 is being replaced by other caliber AA guns that have proven to be more effective. It has been used for AA protection to harbor installations.

The types of ammunition provided for the 105-mm AA Gun M3, Pedestal Mount, are:
High-explosive
Practice
Drill

FUZE, M.T., M43 (All Modifications). This fuze has been discussed in conjunction with 3-inch AA ammunition components.

FUZE, M.T., M2. This fuze is similar to the M43, the only difference being the fact that it is a much larger fuze, and that it has a booster as an integral part of its make-up. Its function and parts are for all practical purposes the same.

Booster M20 (All Modifications). This booster is used on all 105-mm AA ammunition. It has been previously discussed in connection with 75-mm ammunition components.

Cartridge Case. The cartridge case used on 105-mm ammunition is the Brass Case M6. The M6 is 30.37 inches long, weighs 19.0 pounds, and is designed to seat the M28A2 Percussion Primer. It is fitted with a flange to contact the extractor lugs and to provide for ejecting the empty cartridge case after firing.

Propelling Charge. The powder used with rounds of 105-mm AA ammunition is 11 pounds of either FNH or NH smokeless powder. With this charge, there is a distance wad and an igniter of 5 ounces of Army black powder used.

Primers. The 300-grain Percussion Primer M28A2 is used on all rounds of ammunition for the 105-mm gun. This primer is the same as that introduced in the chapter dealing with 3-inch AA ammunition.

SHELL, Fixed, H.E., M38.

General. The M38 Round is at this time standard for issue only. This is due to the fact that it uses the older M2 Mechanical Time Fuze and an adapter rather than the M43 Fuze series. The M2 Fuze requires a nose opening of 2.2 inches, and has a booster embodied in its make-up.

Projectile. The M38 Projectile is streamlined in shape and is of forged steel construction. It is adapted to take a fuze that continues this streamline effect. The rotating band on the shell is 1.42 inches wide. A base plate of steel is found welded on the base. A cavity large enough to hold 4 pounds of TNT as a bursting charge is also provided.

Components. A complete round of H.E. M38 consists of a loaded and fuzed (M.T. M2 Fuze) projectile firmly attached to the M6 Cartridge Case with its propellant of NH or FNH powder, a distance wad, an igniter, and an M28A2 Percussion Primer.

Guns. The 105-mm AA Gun M3 on the Mount M1, fires this round of ammunition.

SHELL, Fixed, H.E., M38A1.

General. This high-explosive round is the same in every respect as the H.E. Round M38 discussed above, with one exception: The nose of the Projectile M38A1 is modified to receive an M43-series Mechanical Time Fuze in conjunction with the M20 Booster, while the M38 used the M2 M.T. Fuze.

The M38A1 Round may be found with an ammanol filler.

SHELL, Fixed, Practice, M38 and M38A1.

General. These two practice rounds differ from the high-explosive rounds in regard to filler only. The filler consists of 3.09 pounds of an inert filler made of lead oxide, paraffin, and barium carbonate accompanied by a black powder charge. This black powder charge is 8 ounces in the M38A1 Round, while it is only 5 ounces in the M38

Round. The components are the same as those in the high-explosive rounds.

CARTRIDGE, Drill, M8 (S) and M11 (S&M).

General. These drill rounds are similar in make-up to other drill rounds previously discussed, and they serve the same purpose. The T23 Dummy Fuze is used on the M11 Round while the M44A2 is used on the M8.

Packing. 105-mm AA gun ammunition is packed 1 round per fiber container, 2 rounds per box.

AMMUNITION FOR 105-MM HOWITZERS.

General. Three different types of howitzers are provided in the 105-mm caliber. Their difference lies in the function they are designed to perform, and in the carriage mount which equips them to fulfill that function. The light field howitzer, mounted on a split-trail type of carriage and towed behind a prime mover, is designed to meet the traditional demand of the artillery. It is designed to provide the infantry with necessary cover and support. The same weapon mounted on a full track chassis similar to that of the medium tank, will perform essentially the same job as the tank itself and, because of its lighter weight, it will have important advantages over the tank. These 105-mm howitzers are provided in two models: the "Limited Standard," M2, and the "Standard," M2A1, which are interchangeable and differ only slightly.

The third type is the recently developed, M3 Airborne Howitzer. It is naturally lighter, and complete rounds are not interchangeable between the M3 and the other howitzers.

All ammunition provided for the 105-mm howitzer is of the semi-fixed class.

Types of ammunition provided for the 105-mm howitzer are:

High-explosive
High-explosive, antitank (H.E., A.T.)
Chemical
Drill
Blank

Fuzes. Fuzes used may be listed as follows:

M48, P.D., selective, S.Q. and short delay
M54, combination, time and superquick
M57, P.D., superquick
M62, base-detonating

All of the above fuzes have been completely discussed with 75-mm gun ammunition components.

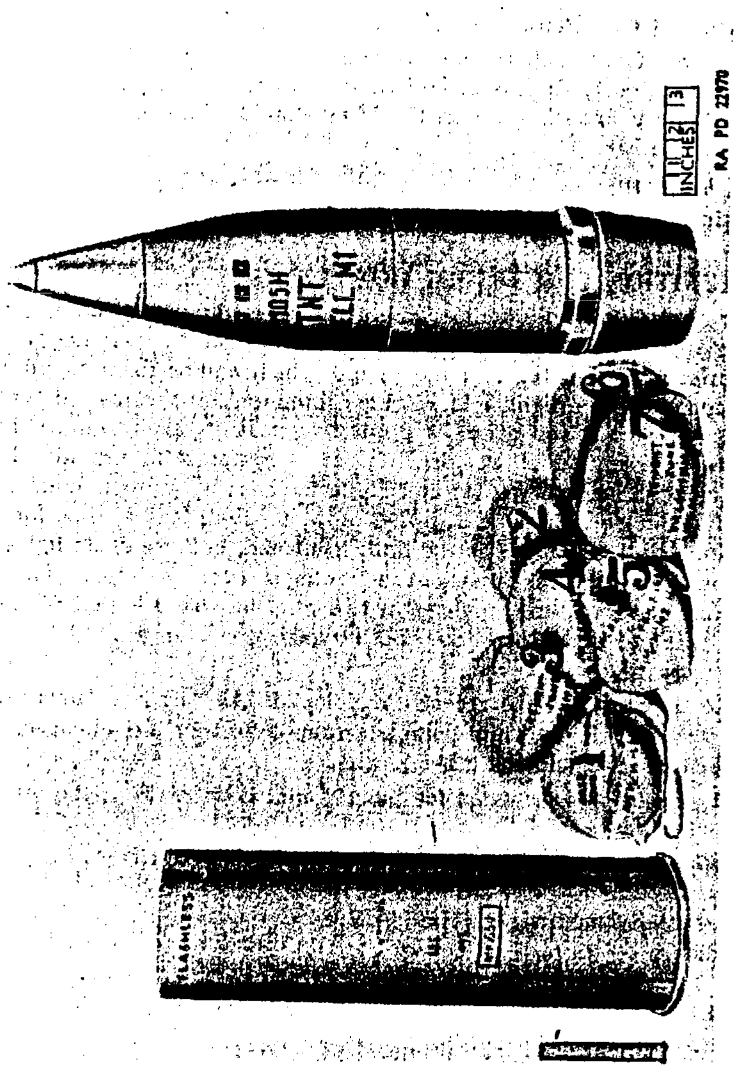

Figure 187 — Components of a Complete Round of Semifixed Ammunition (7 Zone Charges)

Boosters. The M20 (or M20A1) Booster is used in the H.E. rounds with the M48 or M54 Fuzes. The M22 is used in conjunction with the M5 Burster for the 105-mm Chemical Shell M60. The M22 is similar in size and outward shape. It differs in that a detonator of lead azide and tetryl is located in the body of the booster in line with the central flash channel of the fuze. As rounds assembled with this booster are not boresafe, the use of this booster will be restricted to chemical shell. The Burster M5 is similar to that in 75-mm chemical ammunition, except, naturally, for the fact that it is much larger. The burster charge is 1,331 grains of tetryl or tetrytol.

Cartridge Case. The standard case used with 105-mm howitzer ammunition is the M14, type I. This case is 14.64 inches long and weighs 5.9 pounds. It is made of brass. The type II case has a slightly smaller mouth, and was used in the ROUND H.E., AT, M67. M14 Cartridge Cases are designed to seat the M1B1A2 100-grain, Percussion Primer, and are found with and without screw eyes in the head to fasten the propelling charge. A retainer disc is used on cases that do not have screw eyes.

Propelling Charge. The smokeless powder used is FNH. It is inserted in seven increments, each in a cloth bag. Seven zones of fire result from the base and increment type of charge. The increments are of unequal weight and are, therefore, not interchangeable.

The propelling charge for rounds to be fired from the M3 Airborne Howitzer consists of a reduced charge which includes only a base and four increments, allowing five zones of fire. This difference makes the complete rounds for this weapon not interchangeable with those provided for other 105-mm howitzers.

The base charge (No. 1) and increment(No. 2)have a doughnut shape which enables the primer to fit up into the charge. When the retainer disc is used, it is sewn to the base charge and is then forced over the primer, holding the propelling charge firmly in the case.

Primer. 105-mm howitzer ammunition is provided with the M1B1A2 100-grain Percussion Primer exclusively. This primer is discussed in detail with 75-mm ammunition.

SHELL, Semifixed, H.E., M1.

General. The H.E. Shell M1 is issued to the using arms as a fuzed complete round, weighing 42.07 pounds.

Projectile. The M1 Projectile is of forged steel construction, streamlined in shape with a boat-tail base, and is adapted for a fuze that continues the contour. It has a steel base plate and a 0.81-inch rotating band of gilding metal. Provision is made for a 4.8-pound H.E. filler.

Components. A complete round of M1 H.E. Ammunition consists of a loaded and fuzed (M48 or M54 Fuze) projectile loosely attached

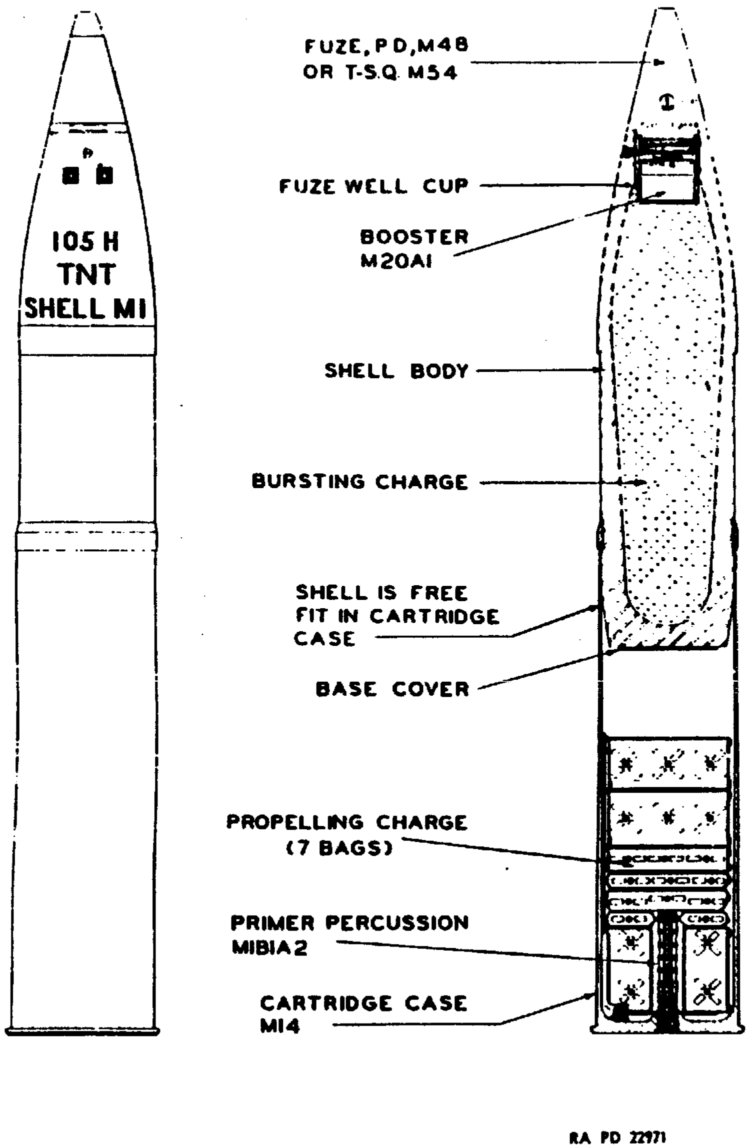

Figure 188 — **SHELL, H.E., 105-mm, M1**

to the M14 Cartridge Case with its 3-pound bag of propelling charge (7 zones) of FNH powder and an M1B1A2 Primer. If fired in the M3 Airborne Weapon, the reduced propelling charge will consist of a base and four increments.

SHELL, Semifixed, Chemical, M60.

General. There are three types of fillers for the Chemical Shell M60. These fillers are H (mustard), FS (smoke), and WP (smoke). Of the three fillers, only shell filled with H are classed as "Standard," the FS and WP filled shell being made "Substitute Standard" because of the standardization of the base-ejection type Smoke Shell M84.

Projectile. The M60 Projectile is of forged steel construction with the same general shape and size as the M1 H.E. Projectile. The body is actually 1 inch shorter, but the adapter that is necessary to hold the burster brings the length up to 19.33 inches, the same length as the M1. This projectile has no base plate. The rotating band, radius of ogive, and boat-tail base are the same in both rounds. The loaded weight of rounds varies with the filler: 37.77 pounds with H, 34.7 with WP, and 35.21 pounds with FS. The projectile has provisions for the M5 Burster which consists of the Burster Casing M5, and the Burster Charge M5.

Components. A complete round of M60 Chemical Ammunition consists of a loaded and fuzed (P.D. M57 Fuze with M22 Booster) projectile loosely attached to an M14 Cartridge Case with its propelling charge of seven increments of FNH powder and an M1B1A2 Primer. The Burster M5 consists of 1,331 grains of tetryl pressed in pellets. The fillers are found in the following quantities: H—3.17 pounds; WP—4.06 pounds; FS—4.61 pounds.

SHELL, Semifixed, Smoke, B.E., M84.

General. Two factors contributed to the adoption of the M84 base-ejection type of smoke shell in place of the M60 Smoke Shell. The first was the failure of the M60 to satisfy the requirements of the using arms for a screening smoke producer, and the second was the successful development and use of the base-ejection type by the British in their 25-pounder gun.

The general effect of the M60 Smoke Shell, with its superquick type of impact fuze and a burster charge of high explosive to disperse the chemical agent, is to create a large cloud of dense white smoke, most of which, due to the heat evolved, rises rapidly so that only a small percentage of the total remains to produce screening effect. This tendency to form a mushroom-shaped pillar of smoke is obviously unsatisfactory.

The British developed a base-ejection type of smoke shell similar to the ordinary star shell (illuminating projectile). It is fitted with

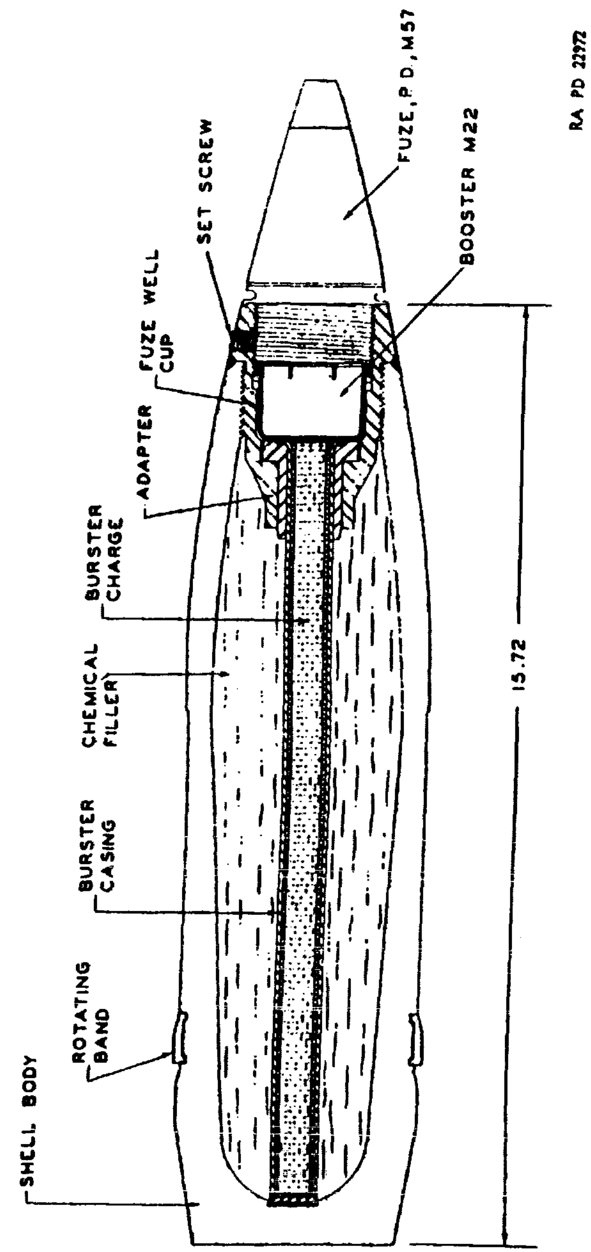

Figure 189 — SHELL, Chemical, 105-mm, M60

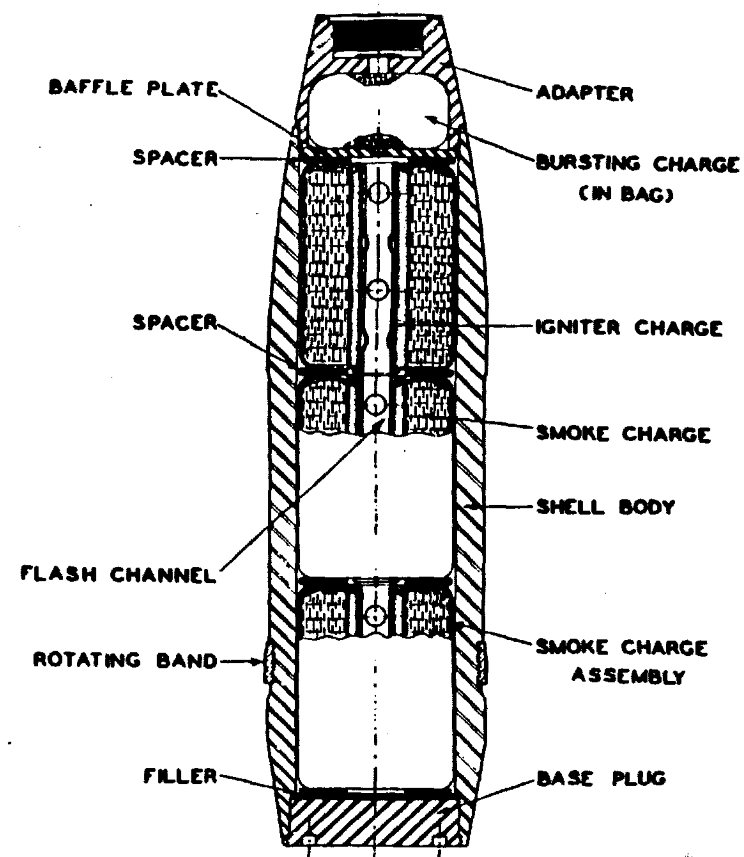

Figure 190 — SHELL, Smoke, B.E., 105-mm, M84

a time fuze and with a small black powder charge in the nose of the shell. The smoke elements are burning candles which are ejected from the base of the shell during its flight, through action of the time fuze. These candles continue burning for a period of over 1 minute after reaching the ground.

It is found that there is only negligible loss of accuracy in laying down a smoke screen when the time fuze is used, as in the M84, compared to when the superquick point-detonating fuze is used, as in the M60. When the candle units are ejected from the base of the shell, there is only a small loss in velocity and the units continue substantially along the trajectory, and fall only slightly short of the shell body. Thus, whether the burst is high in the air or close to the ground, the points of impact of the candles are not greatly affected.

Projectile. The B84 body is approximately 18.75 inches long and is of cold-drawn steel tubing. Its external contour is like that of the M60 and M1 Projectiles. The inside walls are left cylindrical. The base is closed by a steel base plug. This plug is screwed handtight and is held by three threads. A copper gasket of the same diameter fits in front of the plug to provide a moistureproof seal. The nose of the shell is extended 2 inches by an adapter which screws in handtight and is then staked. The adapter is made of cold-drawn steel and is threaded on the inside to receive the fuze. Just below the fuze, and connected to it by a short flash channel, is a charge of black powder (0.14 lb) in a bag of cotton cartridge cloth.

Below the burster charge is a steel baffle plate approximately 0.12 inch thick with a 0.10 inch hole in the center. This plate is designed to allow the flash from the burster charge to pass down the flash tube, and at the same time to be forced rearward by the burster charge detonation, thus expelling the smoke charge from the base of the shell. Behind the baffle plate is a spacer made of commercial binders board and measuring 0.09 inch in thickness. This spacer has a 1.1-inch hole in the center so that the flash tube will be clear.

Three smoke assemblies, separated from each other and from the base plug by spacers identical with the one described above, comprise the main charge of the shell. Each of these smoke assemblies is doughnut-shaped in that their containers have a hole down the center to allow clearance for the flash tube. The bottom and sides of the canister are made of a continuous sheet of steel. The top consists of a steel disc which is inserted after the canister is loaded and is held in place when the sides of the assembly are crimped over.

Each smoke assembly weighs approximately 2.50 pounds. The steel container holds the smoke charge which may be either HC mixture or a British composition. The British agent is considered "Standard" while the HC mixture (hexachlorethane-zinc mixture) is "Substitute Standard." Inside the smoke mixture, and surrounding the flash tube, is an igniting charge of igniting powder. The ignition charge is separated from the smoke charge by a layer of paper. The steel flash tube, extending from the baffle plate to the base plug, is perforated with vents in order to insure deflagration of the igniting charges in each of the smoke assemblies.

Functioning. When the round of ammunition is loaded into the gun, the Time-and-superquick Fuze M54 may be set to detonate for any time up to 25 seconds. When the desired time has elapsed and the fuze functions, the flash is picked up by the black-powder charge. The flame passes through the small vent in the baffle plate and sets off the igniter charge in each of the three smoke assemblies. Simultaneously the force of the explosion of the black powder charge forces the baffle plate toward the rear, and with it the three smoke assemblies and the base plug. Thus the entire charge is ejected from the base of the shell, and the three assemblies are left to land by themselves, like smoke candles.

Components. A complete round of 105-mm M84 Ammunition consists of a loaded and fuzed (FUZE, P.D., M54) projectile loosely attached to the M14 Type I Cartridge Case with its base and increment propelling charge of FNH powder and an M1B1A2 100-grain Primer.

SHELL, Semifixed. H.E., A.T., M67.

General. The H.E., AT Shell M67 is the exact counterpart of the 75-mm Shell M66. It is identical to the M66 in all respects except size and resembles other 105-mm howitzer ammunition in length and weight. This round of ammunition is designed for use against either face-hardened or homogeneous armor plate.

Projectile. The M67 Shell body is made of a steel forging and the base is fitted with a Base-detonating Fuze M62. The body is fitted with the same width and type of rotating band as other projectiles for these weapons. For details, note SHELL, H.E., A.T., M66, in the chapter dealing with 75-mm howitzer ammunition.

Components. A complete round of M67 H.E., A.T. Ammunition consists of a loaded and fuzed projectile assembled loosely to an M14 Cartridge Case with its propelling charge of approximately 3 pounds in one bag, and an M1B1A2 Primer. Originally, the round was designed as a fixed round, with a loose propelling charge of smokeless powder in an M14, Type II, Cartridge Case. The change back to semifixed class is to facilitate packing and shipping in accordance with existing standards. This round is adapted for firing from the M3 Airborne Howitzer.

CARTRIDGE, Drill, M14.

General. The Drill Cartridge M14 is a dummy round of ammunition for the use of gun crews in simulating the handling of service ammunition. The round is completely inert, but is so constructed that all of the functions normally required of a gun crew to prepare a round of service ammunition for firing may be practiced on it.

The over-all length of the Drill Cartridge M14, when the round is assembled, is 31.07 inches, and the weight is 41.35 pounds. The dummy shell and dummy cartridge case are designed to fit freely together, similar to semifixed service ammunition.

The Cartridge Case M14, usually used in 105-mm howitzer ammunition, is simulated by a dummy assembly 14.64 inches long. The

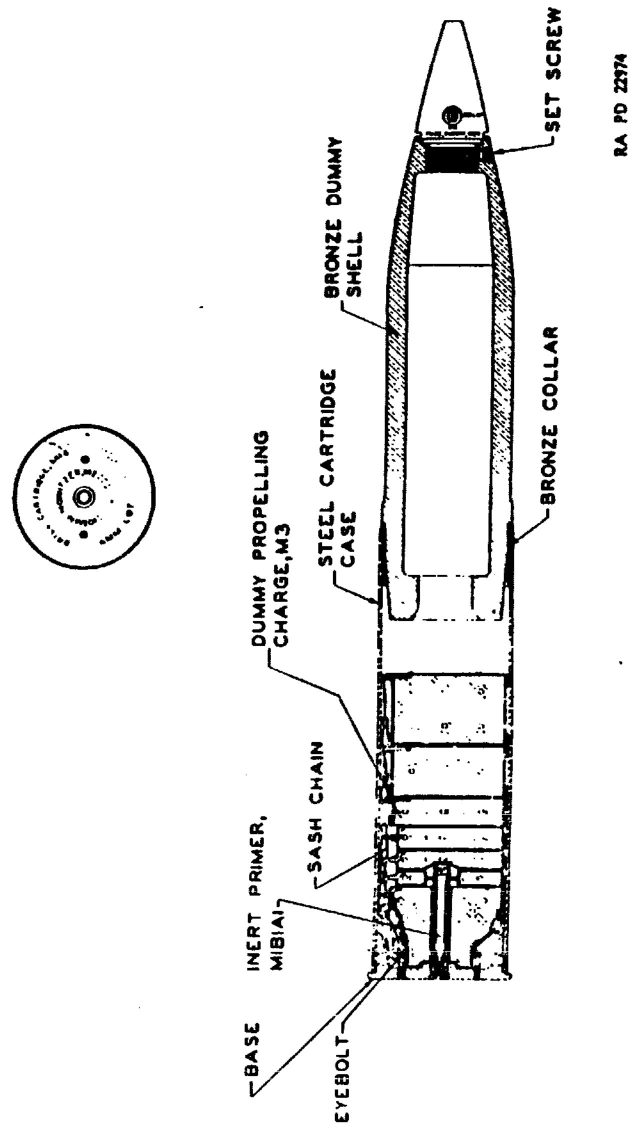

Figure 191 — *CARTRIDGE, Drill, 105-mm, M14*

assembly consists of a base which screws onto a tubular body, and a bronze collar to fit around the dummy shell when the round is assembled. The base is made of manganese bronze and has two steel eyebolts screwed into its face. The body is made from seamless steel tubing and is then given a cadmium plating. The body and the base are assembled by threads, and then held in place by two screws.

At the other end of the tubular body a collar is welded to the inside to provide form of sleeve for the projectile. The bronze collar is approximately 2 inches long, and extends a trifle beyond the end of the steel body. It is held in place by either 12 spot welds or by soldering with silver solder.

A sash chain made of coppered steel and 16 inches long is secured to the eye bolts in the base of the "cartridge case." After the chain is assembled, the eyes of the eye bolts are closed to prevent its slipping off. The other end of the chain bears a half-inch brass ring, which is later used to hold the zone 2 charge of the propellant

The DUMMY PRIMER, percussion, 100-grain, M1B1A1, is used in this inert round.

The propelling charge for the Dummy Round M14 is an inert assembly broken down into a base charge and six increments. Each of the increments corresponds in size and weight to its counterpart in service ammunition, the total weight of the propellant being approximately 3.10 pounds.

The base zone charge is assembled to the eye bolts in the base of the cartridge case by means of snaps which are first looped through rings on the flaps of the cartridge bag. The zone 2 charge is assembled to the brass ring on the end of the sash chain by means of a snap, which is connected to the cartridge bag by being looped through the same kind of ring. The zone 3 charge is snapped onto the ring on the flap of the zone 2 charge, and the other four increments are similarly attached to the next lower zone.

This arrangement of the sash chain and the snaps enables the gun crew to simulate the adjustment of the propelling charge for firing inner zones without necessitating the breaking and retying of twine for each drill problem. The 16-inch chain allows the six top powder bags to be removed from the case, the extra charges to be removed, and the required bags to be replaced without the expenditure of twine.

A cast bronze dummy shell is used to resemble the 105-mm service projectiles. This dummy has the same radius of ogive and the same boat-tail base as service missiles, and is cast with a flange to correspond to the rotating band generally seated on service projectiles. The dummy shell body is hollow and has an open base.

The nose of the shell body is threaded to fit either the M59 Dummy Fuze or an inert M54 Time-and-superquick Fuze. The M59 Fuze has the same contour as the M48 point-detonating, and is fitted with a

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setting pin so that the gun crew may practice fuze setting. The body of the dummy fuze is stamped with the letters "SQ" and "DELAY," and thus resembles the markings on the M48 Fuze. The setting pin is held under spring tension. If an inert M54 Fuze is used, it is made up of burned-out fuze parts, parts that have been condemned, or parts rejected by inspectors, of the regular service fuze. The time trains and concussion and percussion elements are omitted from the inert fuze. Both of these fuzes screw into the nose of the shell body and are held by lock screws which press against a brass shoe and are lightly staked in place. The shoe between the fuze threads and the screw preserves the threads of the fuze, so that it may be replaced if damaged.

Blank Ammunition. *General.* There is one standard round of blank ammunition for the 105-mm howitzer, a 2-pound charge. This cartridge is used for firing salutes and for simulating battle conditions.

The blank cartridge consists of an M15 Cartridge Case, a charge of black powder contained in a cotton bag, a percussion primer, and a closing cap assembly. Its over-all length is approximately 6 inches, and its weight is 6.23 pounds.

The Cartridge Case M15, can be made either by cutting down the M14 Case, or by original manufacture. It is made of brass and is approximately 6 inches long. It seats the PRIMER, percussion, 49-grain, Mk. II. The 2-pound charge of Army black powder is held in a 12-inch bag of cotton sheeting, the charge assembly being wrapped around the primer and held in place by the closing cup assembly. Next to the charge is a wad of hard hair felt ⅜ inch thick, which is secured to the under side of the pulpboard closing cup by cementing. The wad and the closing cup are then firmly cemented in place near the mouth of the cartridge case. An alternative charge of 1.5 pounds of a better grade of black powder is sometimes used, in which case the felt wad is omitted and the closing cup is brought into direct contact with the charge assembly.

Guns. All 105-mm howitzer ammunition with the 7-zone charge is fired from the M2 or M2A1 Weapon. The 5-zone charge for use in the M3 Howitzer has a quick-burning powder, and the rounds for the M2 and M2A1 Howitzers are not interchangeable with those for the M3 Howitzer.

Packing. SHELL, Semifixed, H.E., A.T., M67, is packed one round per fiber container, three rounds per bundle.

SHELL, semifixed, gas, persistent, H, M60, is packed one round per fiber container, two rounds per box; or one round per fiber container, three rounds per bundle.

SHELL, semifixed, smoke, HC, B.E., M84, is packed one round per fiber container, three rounds per bundle.

105-MM AA GUN AND HOWITZER COMPLETE ROUNDS

Complete Round	Status	Projectile	Filler	Fuze	Booster	Cartridge Case	Primer	Weapon	Class
Shell, H.E., M38	S	M38	TNT	M.T. M2	......	M6	M1B1A2	Gun	Fixed
Shell, H.E., M38A1	S&M	M38A1	TNT	M43 (all mod.)	M20	M6	M1B1A2	Gun	Fixed
Shell, Prac., M38	S	M38	Inert	M2	......	M6	M1B1A2	Gun	Fixed
Shell, Prac., M38A1	S&M	M38A1	Inert	M43 (all mod.)	M20	M6	M1B1A2	Gun	Fixed
Cart., Drill, M8	S	Cast Bronze	....	M44A2	......	Cast Bronze	Inert	Gun	....
Cart., Drill, M11	S&M	Cast Bronze	....	T23	......	Cast Bronze	Inert	Gun	....
Shell, H.E., M1	......	M1	TNT	M48 M54	M20	M14	M1B1A2	How.	Semifixed
Shell, Chem. B.E., M84	S&M	M84	H.C. Mixture	M54	......	M14	M1B1A2	How.	Semifixed
Shell, Chem., M60	S S S&M	M60	F.S. W.P. H.S.	M57	M22	M14	M1B1A2	How.	Semifixed
Shell, H.E., AT, M67	S&M	M67	50/50 Pentolite	M62	......	M14	M1B1A2	How.	Semifixed
Cart., Drill, M14	S&M	Cast Bronze	....	M59 Dummy M54 Inert	......	M14	Dummy M1B1A1	How.	Semifixed
Blank Ammunition	S&M	....	Black Powder	....	......	M15	Mk. II	How.	....

All other rounds are packed in fiber containers, two rounds per box, or three rounds per bundle.

The 105-mm howitzer container has been changed recently, due to damage done to cartridge cases in shipment when loosely assembled to the projectile. A container is now being used that opens at both ends, having a stop in the center. The projectile is placed in one end, fuze first, and the cartridge case with propelling charge and closing plug of cardboard is placed in the other end.

FURTHER REFERENCES: Complete Round Chart No. 5981; OS 9-20.

Chapter 11

Ammunition for 4.7-inch AA Guns

GENERAL.

The 4.7-inch AA Gun M1 on the 4.7-inch Gun Mount M1 is a new weapon designed for protection of large rear areas against fast-flying bombers at altitudes of approximately 30,000 feet. The maximum range varies from 50,000 to 60,000 feet. The mount is a trailer type, one load, two bogie portable unit designed for transport at low speeds over good roads. When emplacing the gun, the two bogies are removed and the four outriggers, which are connected to a heavy chassis, are lowered by hydraulic jacks to support the weight of the weapon. The breechblock is of the vertical sliding type which may be operated semiautomatically or manually. Ammunition is rammed home in the chamber by a power rammer which facilitates loading of the heavy round of ammunition. This ammunition is unique since it is the only existing round of separate loading ammunition that is provided with a cartridge case and is loaded into the gun in one operation.

Types of ammunition provided for the 4.7-inch AA gun include only high explosive.

Fuze. The FUZE, time, mechanical, M61, is "Standard" with this round of ammunition. It has a watch-like mechanism that can be set for any length of time up to 30 seconds. The M61 has a long ogive which continues the streamlining of the shell body and extends out 6.867 inches from the nose of the body. The fuze is shipped assembled to the M73 Shell. The function of the fuze is similar to that of the M43 Fuze used in 3-inch AA shell.

Booster. The M20A1 Booster is used on the M73 Round, and has been discussed with 75-mm gun ammunition.

Cartridge Case. The Brass Cartridge Case M24, weighs 24.70 pounds, and has an over-all length of 32.80 inches. It is fitted with a

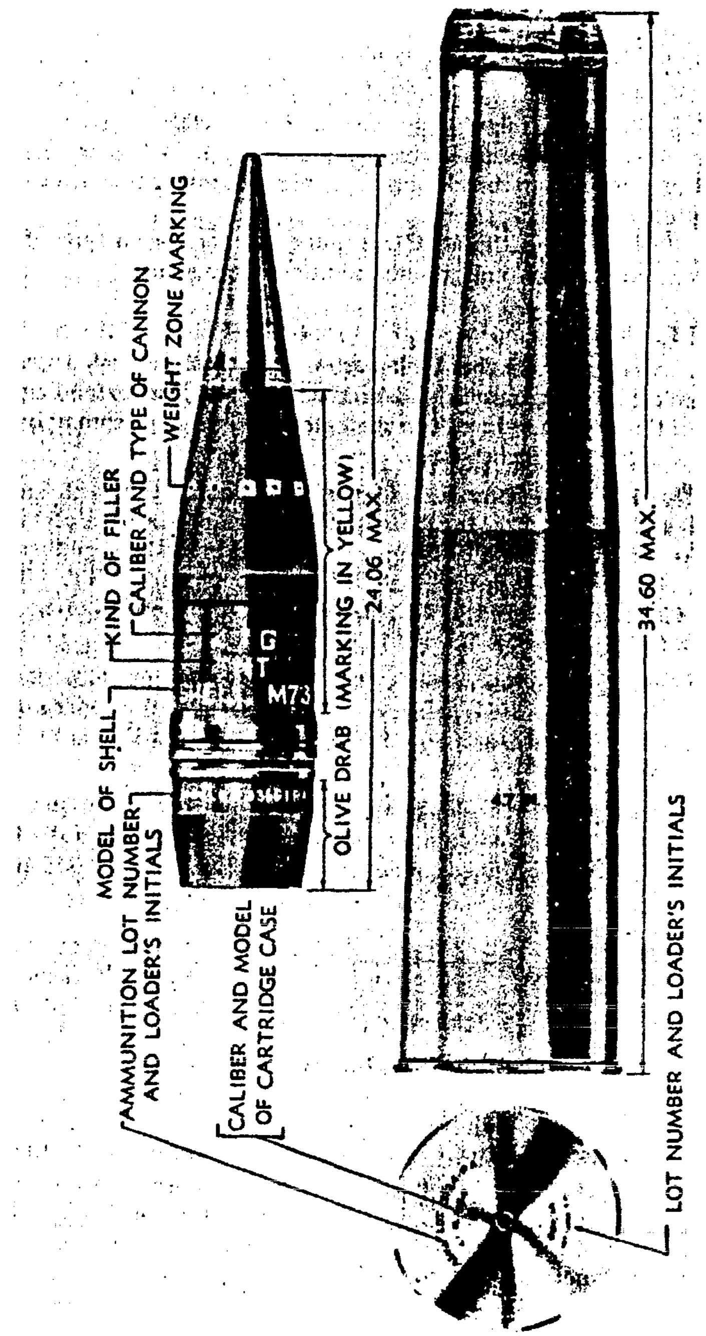

Figure 192 — SHELL, H.E., 4.7, M73

base rim to assist in extracting of the case after firing, and to trip the extractors in the breach so that the breechblock closes as the round is seated in the gun chamber. The diameter of the base is 7.55 inches.

Propelling Charge. This charge consists of loose NH powder contained in a brass cartridge case which is closed by a cork plug. An igniter of 8 ounces of Army black powder is placed around the primer to insure proper ignition.

Primer. The primer is the M1B1A2 100-grain percussion type of primer, discussed with 75-mm gun ammunition components.

SHELL, H.E., M73.

General. In this round the shell has a distinctive conical, long, graceful ogive beginning just ahead of the bourrelet and extending the length of the elongated fuze. The shell alone weighs approximately 50 pounds and is 24.06 inches long.

Projectile. The shell body is of forged steel construction with an ogival radius of 27.1 inches. It has a boat-tail base and a base plate of steel. The rotating band is 2.25 inches wide, and is made of gilding metal. The shell cavity is designed to hold 5.26 pounds of TNT, 4.8 pounds of 50/50 amatol and TNT surrounds, or 5.42 pounds of trimonite as a bursting charge.

Components. This round consists of a loaded projectile with the M20A1 Booster and the M61 Mechanical Time Fuze, and a separate Cartridge Case M24, with its cork closing plug, NH powder, igniter, and M1B1A2 Primer.

Packing. The propelling charge assembly is packed in an individual fiber container, two containers per wooden box. The fuzed shell is packed in an individual fiber container, two containers per wooden box.

Chapter 12
Ammunition for 4.5-inch Guns

GENERAL.

Weapon. The 4.5-inch Gun M1 on the 4.5-inch Gun Carriage M1 is a standard field weapon used for shelling targets within the ranges of 16,000 to 21,000 yards. Original American design called for a 4.7-inch gun, but the 4.5-inch caliber(approx. 114-mm)was standardized so that British and American guns could fire the same rounds of ammunition. The M1 Gun Carriage is of the split-trail type with pneumatic tires for high-speed transport.

Class. Since the 4.5-inch complete round is loaded into the gun in more than one operation, it is classed as separate loading ammunition.

NOTE: It should be understood that this text does not deal with all separate loading ammunition. Only 4.5-inch; 155-mm, which is the most widely used; 240-mm; and 14-inch ammunition are discussed. The 14-inch ammunition is representative of the larger calibers.

Type. Only the high-explosive type of ammunition is provided for use in 4.5-inch guns. The projectile is filled with TNT or substitutes, amatol or trimonite.

COMPLETE ROUND, SHELL, H.E., M65.

General. The complete round of 4.5-inch ammunition, as fired, consists of the fuzed projectile, a propelling charge, and a primer.

Projectile M65. The projectile is made up of a body or metal parts assembly, a bursting charge or filler, and a fuze with booster attached.

Metal parts assembly. The body has a streamlined shape that is characteristic of most modern artillery shell. The radius of ogive is 45.0 inches and the base is cylindrically tapered (7 deg 30 min). The length of the body is 18.90 inches excluding a 0.14-inch protrusion on the back and surrounding the base plate cavity. The purpose of this protrusion is to provide metal for a 360-degree crimp which secures a mild steel base plate 0.34 inch in thickness in a cavity in the base of the shell. This plate prevents the hot gases of the propelling charges from coming into contact with the bursting charge through possible defects in the base of the shell body. A knurled or grooved recess seats a 1.72-inches copper or gilding metal rotating band. The projectile is threaded at the nose to receive the fuze directly. When the body is made of cast steel it is designated as M65; when it is made of forged steel it is designated M65B1.

Bursting charges. As is the case with all filled projectiles, the interior of the shell is coated with acidproof black paint. The filler may be one of three high explosives. The most common and most desirable is 4.49 pounds of cast TNT. If TNT is not obtainable, 4.08 pounds of 50/50 amatol or 4.64 pounds of trimonite may be used. When the bursting charge is amatol, a 0.2 pound TNT booster surround is inserted between the booster and the filler to act as an auxiliary booster. Regardless of the bursting charge, a molded bakelite fuze well cup is screwed into the nose of the shell ahead of the booster to protect the booster from corrosive action by explosives.

Fuzes and boosters. P.D. Fuze M51 or M51A1, or FUZE, time, mechanical, M67, may be used with this round. See the following chapter for the description and function of these fuzes. The Booster M21, described in the following chapter, is shipped assembled to M51

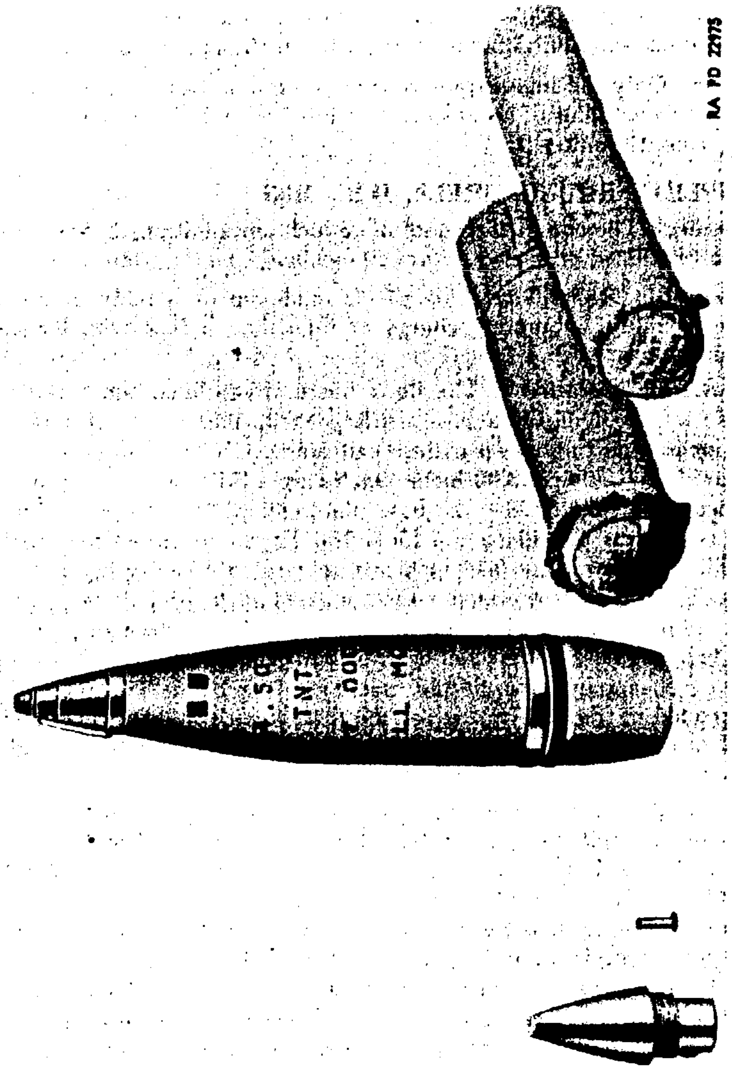

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Figure 193 — Components of Complete Round of SHELL, H.E., M65, 4.5-inch Gun

Fuze, and Booster M21A1, also described in the following chapter, is shipped assembled to M51A1 and M67 Fuzes.

Painting and marking. The painting and marking is according to the regular Army system. The base color is olive drab and the marking is yellow.

Weight zones. In the manufacture of artillery projectiles there are variations in weight due to the difference in densities of fillers and materials and the impossibility of machining shells as precisely as is desirable for accurate firing. Consequently, when the 4.5-inch Projectile M65 is loaded with explosive filler and fitted with a fuze well cup, it is weighed accurately, and its weight zone is marked on the nose of the shell so that appropriate ballistic corrections listed in firing tables may be applied. The weight zones are indicated by 0.5-inch yellow squares with a prick punch placed in the center of each square. By feeling these prick punches the gun crew may easily determine the weight zones at night. The weight zones are as follows:

Zone	Over (lb)	Up To and Including (lb)	Mark
1	52.11	52.61	⊡
2	52.61	53.11	⊡ ⊡
3	53.11	53.61	⊡ ⊡ ⊡

Propelling Charges. CHARGE, propelling, M7 (normal). The M7 Single section Class Propellant is the one most commonly used with 4.5-inch ammunition (page 505 for a description of a single-section charge). It weighs 6.5 pounds, is 22.8 inches long, produces a muzzle velocity of 1,820 feet per second, and gives the projectile a range of 16,300 yards. It is of the same length as the M8 Super Charge and is reduced in diameter accordingly. The weight of FNH powder varies according to lot. It is the same type of powder as is used in the 75-mm supercharged shell.

CHARGE, propelling M8 (super). The base and one increment of the super charge gives the 4.5-inch gun two zones of fire (the following chapter give a description of the base and increment type of charge). The base charge weighs 7 pounds, 7 ounces; the increment weighs 3 pounds, 9 ounces. The total charge is 4.9 inches in diameter, 22.8 inches long, and has a weight of 11 pounds. The base charge alone produces a muzzle velocity of 1,820 feet per second; using both base and increment, the muzzle velocity is increased to 2,275 feet per second. The projectile is fired to a maximum range of 21,000 yards, or over 10.5 miles. The FNH powder used is the same as that used in the 240-mm Howitzer M1.

CHARGE, dummy, M6. This charge is used for drill purposes and is of the base and increment type. It is 22.8 inches long, 4.9 inches in diameter, and weighs 11.917 pounds. Made of cotton duck, its weight is controlled by drilling a lengthwise hole in a circular piece of wood, filling the hole with lead, and inserting it in the base of the cartridge bag. The dummy igniter is also made of cotton duck, is filled with gravel, and dyed red. The igniter, base charge, and increment are each appropriately stenciled with the word "Dummy."

Igniter pad and protector. The igniter pad attached to the M7 Charge and the base of the M8 Charge is filled with approximately 5 ounces of Grade A-1 Army black powder. It can be distinguished from the rest of the charge by its red color and stenciling. To protect the igniter cap during handling and shipment, a protector cap made either of cloth or of paper and containing a felt pad in its base is used. It is secured to the base of the propelling charge by a draw string.

Primer. Mk. II or Mk. IIA 21-grain Percussion Primer is used to ignite the propelling charge (see page 509 for description). Mk. IIA1 Primer is restricted to use in 155-mm howitzers. All of these primers are standard for issue only. A new Primer, Mk. IIA3, 18-grain Percussion, is listed in SNL R-3; however, no information on this primer is available at this time.

Packing for Shipment and Storage. The components of a complete round of SHELL, H.E., M65, are prepared for shipment and storage as follows:

The projectile is shipped with eyebolt lifting plug to protect the fuze cavity and facilitate handling, and rope grommet protecting the rotating band from damage. The grommets are removed and the shell are stacked on their sides in storage.

The propelling charges are packed one per fiber container, three containers (three charges) per bundle. These bundles are crated for export shipment. The charges remain crated during storage, in emergency, to facilitate immediate shipment. In peacetime, the crates are removed when the charges are stored.

Fuzes and boosters are assembled together for shipment and storage. They are packed 1 fuze and booster per fiber container, 25 containers (25 fuzes and boosters) per box.

The primers are packed 50 primers per metal container, 48 containers (2,400 primers) per box.

FURTHER REFERENCES: SNL R-2 and R-3; Ordnance Drawings; OS 9-20; Complete Round Chart No. 5981.

Chapter 13

Ammunition for 155-mm Guns and Howitzers

GENERAL.

Weapons. The 155-mm weapons were developed during World War I. They are classed as mobile field artillery and their function is

to provide the fire power necessary to support other ground forces in combat. The 155-mm gun has been the standard heavy mobile artillery weapon of the United States Army since the first World War. It is a much more powerful weapon than the howitzer, having a greater muzzle velocity and range. The M1917-17A-18MI Guns fire the M101 H.E. Shell at a muzzle velocity of 2,410 feet per second to a maximum range of 20,100 yards, or approximately 11.5 miles. The new Guns M1 and M1A1 are still more powerful, firing the same projectile at a muzzle velocity of 2,800 feet per second to a maximum range of 25,400 yards, or about 14.5 miles. The 155-mm gun has been of great service in World War II, mounted on a tank chassis and being used as a tank destroyer.

The howitzers have shorter barrels and smaller powder chambers than the guns. Their purpose is to fire at intermediate ranges between the 155-mm gun and lighter artillery. The old M1917-17A1-18 Howitzer weapons fire the M102 H.E. Shell at a muzzle velocity of 1,476 feet per second to a maximum range of 12,775 yards with a full propelling charge. The new M1 Howitzer, fully charged, fires the M107 H.E. Shell at a muzzle velocity of 1,850 feet per second to a maximum range of 16,000 yards. The 155-mm howitzer was originally a French weapon, and most of the ammunition for the old 155-mm weapons was patterned from French designs.

Class. All 155-mm ammunition is of the separate loading class, meaning that it is loaded into the gun or howitzer in more than one operation. The general procedure for loading weapons with such ammunition is as follows:

The projectile is inserted into a weapon in such a manner that the rotating band fits tightly into the forcing cone of the bore of the weapon.

The propelling charge is placed in the powder chamber so that the igniter pad will take the flame from the primer. In larger guns, such as 14-inch, the propelling charge is divided into separate sections of a size that requires loading into the weapon one at a time. In this case, the placing of the propelling charge requires several operations.

The primer is finally inserted into the breech mechanism.

Types of Ammunition.

For 155-mm guns. The following types of ammunition are used in the guns:

Type	Filler
Low-explosive (shrapnel)	Black powder and lead balls in resinous material
High-explosive	TNT or substitutes
Practice	Sand
Chemical	H, FS, WP
Armor-piercing	Explosive D
Dummy	None

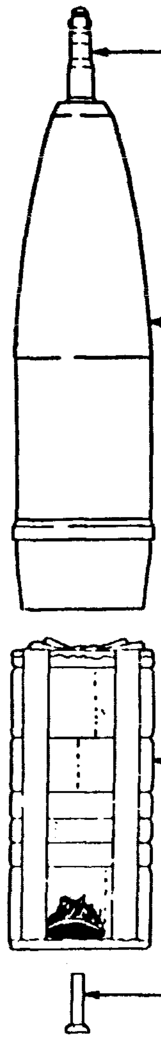


Figure 194 — Complete Round, Separate-loading Ammunition (155-mm Howitzer Shell)

For 155-mm howitzers. The same types of ammunition as those provided for guns are used in the howitzers, with the exceptions that HC and FM are added to the chemical fillers and that the armor-piercing round is omitted. The lower muzzle velocity of the howitzer as compared to the gun makes it unsatisfactory for armor-piercing work.

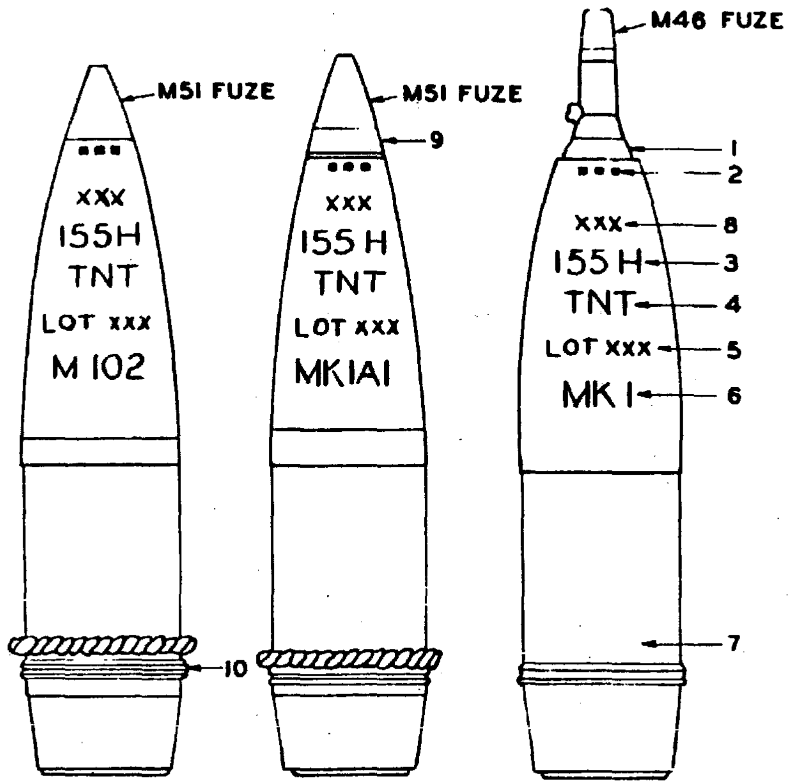
PROJECTILES.

Body. The bodies of all 155-mm projectiles except the dummy, armor-piercing, and base ejection are very similar in construction. They all have a radius of ogive of approximately 65 inches or 10 calibers, range from 22.84 inches to 23.80 inches in length, have tapered bases, are manufactured from forged steel, and are hollowed out to nearly their entire length to receive a filler of some type. The AP dummy and base ejection projectiles will be discussed under complete rounds since their construction is peculiar to the type.

Rotating Bands. The recesses for rotating bands machined into the bodies of the 155-mm projectiles vary in size depending on the weapon in which the projectile is used. The width of the rotating band varies directly as the power of the weapon. As the propelling charge gets larger, the rotating band must be wider to act as a gas check at the increased pressures. The Mk. and modified Mk. series gun shell have two rotating bands, each 0.602 inch in width and separated by a space of 0.5625 inch. These rotating bands are sufficient for the old M1917-17A1-18MI Guns, but do not suffice for the new M1 and M1A1 Guns. Therefore, Mk. and modified Mk. series gun shell cannot be used in the M1 and M1A1 weapons. The M-series gun projectiles are provided with a single rotating band 2.02 inches wide. The 2.02-inch rotating band is sufficient to withstand the pressure in both old and new guns so the M-series projectiles are interchangeable. Rotating bands for both gun and howitzer are made of gilding metal.

Mk., modified Mk., and M-series projectiles for the M1917-17A1-18 Howitzers have single rotating bands 0.602 inch in width. It is in the same position on the shell as the back rotating band on the Mk. and modified Mk. series gun shell which is of the same width. For this reason, Mk. and modified Mk. series shell for the old guns may be modified to old howitzers by simply trimming the front rotating band down even with the shell body. The new M1 Howitzer is much more powerful than the old howitzer, so a wider rotating band (1.02 inches) is required. The 0.602-inch band is not sufficient to withstand the pressures developed in the M1 weapon. On the other hand, the 1.02-inch band does not produce the desired ballistics in the M1917-17A1-18 Howitzer. Consequently, rounds for the old and new howitzers are not interchangeable.

AMMUNITION INSPECTION GUIDE



1. ADAPTER BOOSTER
2. WEIGHT ZONE MARKS
3. CALIBER AND TYPE OF CANNON
4. FILLER
5. LOT NUMBER OF FILLED SHELL
6. MK OR M NUMBER
7. MANUFACTURERS MARKINGS (STAMPED UNDER PAINT)
8. MEAN OR NORMAL WEIGHT OF SHELL (UNFUZED)
9. ADAPTER- TAKES NEW BOOSTERS
10. WIDER ROTATING BAND

RA PD 22977

Figure 195 — Marking and Comparison of Old and New 155-mm Explosive Shell

ARTILLERY AMMUNITION

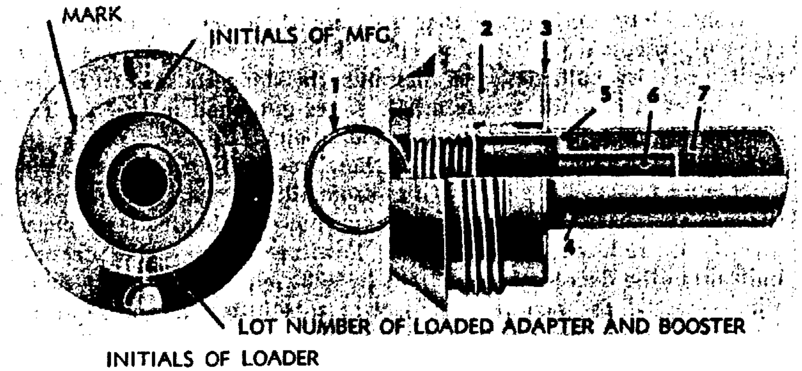
It should be understood that 155-mm shell are not to be interchanged except in the cases specified. Such interchange is certain to result in faulty ballistics, and may even be dangerous. For example, if an attempt is made to use a Mk. series gun shell in the howitzer, the front rotating band on the gun shell, being positioned farther forward than the rotating band of the howitzer, will engage the forcing cone so as to leave the base of the projectile protruding too far into the powder chamber. The space in the powder chamber will consequently be reduced, and when the howitzer is fired, the pressures built up in the decreased space may be sufficient to burst the weapon. Vice versa, if the howitzer shell were substituted for the gun, the rotating band, being positioned nearer the base would result in increased chamber space, reduce the pressure from the propellant and decrease the range.

Nose Fittings. The old Mk. series high-explosive and chemical shell are threaded in the nose to take adapter boosters. However, the nose of the Mk. series chemical shell is fitted with tapered pipe threads instead of standard threads in order to form a gastight seal when the adapter booster is screwed into place. These adapter boosters take the old M46 and M47 Fuzes. The modified Mk. and M-series H.E. shell are threaded in the nose to take the new M21 and M21A1 Boosters directly. The modified Mk. and M-series chemical shell are fitted with an adapter which is screwed into the nose threads and brazed with silver to form a gastight seal. An opening in the bottom of the adapter provides for press-fitting the burster casing. This adapter will receive the M21 or M21A1 Booster. In addition to the fittings just described for the modified Mk. and M-series chemical and H.E. shell, there is provided a bakelite fuze well cup which screws into the nose or adapter threads, as the case may be, and is cemented in place with N.R.C. compound.

Filler Cavities. A variation in the method of manufacture of the new M-series H.E. and chemical shell leaves filler cavities of some with flat bottoms and others with hemispherical bottoms. The shell with flat cavity bottoms are designated with just plain model numbers; for example, M101, while those with hemispherical cavity bottoms are given a B1 designation, example M101B1. In addition, both the modified Mk. and M-series chemical shell have a recess machined into the base to receive the burster well and hold it in place.

ADAPTER BOOSTERS AND BOOSTERS.

Adapter Booster Mk. IIIA. The Mk. IIIA is used in the Mk. series H.E. shell for both 155-mm gun and howitzer. It is made up of an adapter, a booster casing, and a fuze socket. The booster casing is threaded into the lower part of the adapter and contains a charge of either 1 ounce of tetryl or 0.50 ounce of tetryl and 0.50 ounce of



1 — ADAPTER PLUG
2 — ADAPTER
3 — FELT WASHER
4 — BOOSTER CASING
5 — FELT WASHER
6 — FUZE SOCKET
7 — BOOSTER CHARGE (TETRYL)

RA PD 22978

Figure 196 — Adapter Booster Mk. IIIA

TNT, the tetryl being placed around the fuze socket. The fuze socket is press-fit into the booster casing and is of a shape to receive the M46 Fuze. The adapter is threaded internally at the top to take the external threads of the M46 Fuze.

Adapter Booster Mk. IIIAMI. The M1 modification of the Mk. IIIA consisted of beveling the inside shoulder at the top of the adapter so that the Mk. III Fuze would screw in entirely. (The Mk. III Fuze was replaced by the M46.) The interruptor of the Mk. III Fuze was situated so as to contact the shoulder of the Mk. IIIA Adapter before the fuze was screwed all the way in.

Adapter Booster Mk. IIIAM2. The only difference between Adapter Boosters Mk. IIIAMI and Mk. IIIAM2 is that the shoulder of the Mk. IIIA Adapter was beveled in the field to become Mk. IIIAMI while the manufacture of the Mk. IIIAM2 included the beveled shoulder.

Booster M21. This booster is used in modified Mk. and M-series H.E. and chemical projectiles for 155-mm guns and howitzers. It is identical with Booster M20 used in 75-mm ammunition, except that the centrifugal pin lock pin is omitted, and a spring is placed behind the centrifugal pin. This change was necessary because the set-back action of the larger caliber weapons when fired in the lower zones of fire was not sufficient to cause the lock pin to release the centrifugal pin.

Booster M21A1. The A1 modification of the M21 Booster was the enlargement of the diameter of the flash hole from 0.125 to 0.25

inch. It was found that, with the smaller flash hole, the M21 Booster and the fuze assembled to it did not aline themselves perfectly.

Adapter Booster Mk. VIB. This booster is used with the old Mk. series chemical shell for 155-mm guns and howitzers. It is commonly called an adapter burster because its function is to burst the shell body and release the chemical filler. The Mk. VIB consists of an adapter and exterior booster casing made in one piece, an interior booster casing and a fuze socket. The exterior booster casing is threaded externally with tapered pipe threads to form a gastight seal when screwed into the nose of the projectile. This outside booster contains the main booster charge of 9 ounces of TNT. The main charge is detonated by the interior booster which fits inside the main charge and contains 1 ounce of tetryl. The fuze socket fits into the adapter and extends into the inner booster. It seats the M46 Fuze. The adapter booster is protected against injury to the threads and the entrance of foreign substances by an adapter plug.

Burster M6. The Burster M6 is used in conjunction with the Burster Casing M1. It is used in all modified Mk. and M-series chemical shell for 155-mm weapons. The Casing M1 is press-fit into the nose adapter and extends the full length of the chemical shell. It fits into a recess in the bottom of the filler cavity which prevents any movement of the burster. The Burster M6 is made up of 2,550 grains of tetryl in the form of 45 pellets contained in an aluminum alloy tube. The tube is 20.45 inches long, 0.745 inch in diameter, and 0.061 inch thick.

FUZES.

FUZE, P.D., M46. This fuze is used on Mk. series 155-mm H.E. and chemical shell. The M46 with explosives removed is also used in sand-loaded shell for practice firing. Its instantaneous action is required in the case of the chemical shell for above-ground bursting. The description and function of the M46 Fuze were previously discussed in the chapter on 75-mm ammunition.

FUZE, P.D., M47. This fuze is of the old type and has a delay of 0.05 second; therefore, it is used on high-explosive, Mk. series, 155-mm shell where the 0.05-second delay is desired. The inert M47 Fuze is also used on sand-loaded practice shell. The description and function of the M47 may be found in the chapter on 75-mm ammunition.

FUZE, P.D., M54. The M54 Combination Time and Superquick Fuze is used without a booster to ignite the black powder charge in base-ejection shell. Such shell are issued for both old and new 155-mm howitzers. The M54 Fuze is discussed in the chapter on 75-mm ammunition.

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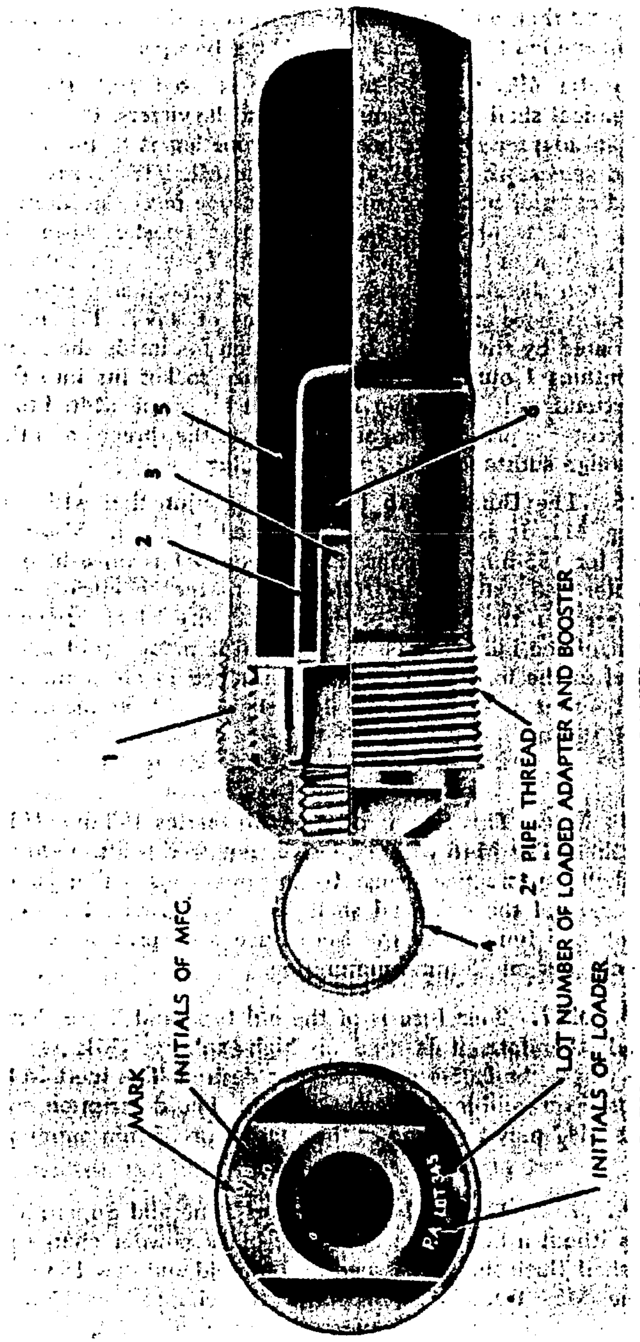

1 — EXTERIOR BOOSTER CASING
2 — INTERIOR BOOSTER CASING
3 — FUZE SOCKET
4 — ADAPTER PLUG
5 — BOOSTER CHARGE (TNT)
6 — AUXILIARY OR INTERIOR BOOSTER CHARGE (TETRYL)

Figure 197 — Adapter Booster Mk. VIB

ARTILLERY AMMUNITION

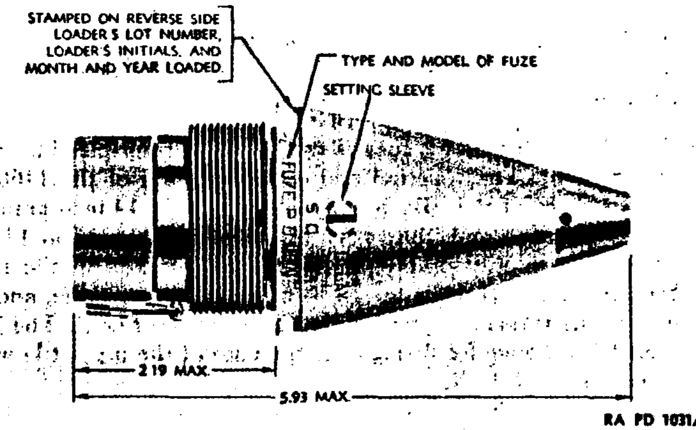

Figure 198 — FUZE, P.D., M51A1, w/BOOSTER M21A1

FUZE, P.D., M51. FUZE, M51, with BOOSTER, M21, is "Limited Standard" since it is superseded by the M51A1. It is used with all modified Mk. series and M-series, 155-mm, high-explosive and chemical shell except base ejection. It is identical with FUZE, P.D., M48, as discussed with 75-mm ammunition, except for the addition of an arming fork in the plunger assembly. The rotational velocity of major caliber projectiles is not sufficient, throughout their flight, to keep the plunger arming pins of the M48 Fuze in the receded position. As rotational velocity decreases the arming pins are forced, by their springs, back into the unarmed position sustaining the plunger support and thus prevent the primer from being driven onto the firing pin. To prevent this action a light, centrifugally weighted arming fork is pivoted in such a position as to swing its prongs between the arming pins when centrifugal force comes into play. The springs of the arming pins tend to push them back into place so that, as centrifugal force decreases, the pins contact the prongs of the fork and, while being held apart themselves, help to keep the fork in the armed position. There is enough room between the prongs of the fork for the plunger support to pass. The addition of the arming fork and use with the M21 instead of the M20 Booster resulted in changing the fuze nomenclature from M48 to M51.

FUZE, P.D., M51A1. When the M21 was changed to the M21A1 Booster, the A1 designation was also added to the fuze since the fuze and booster are shipped assembled to each other.

FUZES, Time and Superquick, M55 and M55A1. FUZE, time and superquick, M54, when assembled to the M21 Booster is designated M55. When the same fuze is assembled to the M21A1 it is designated M55A1. Fuzes M55 and M55A1 are used on modified

Mk. and M-series high-explosive shell for M1917-17A1-18 Howitzers. For description and function, see FUZE, time and superquick, M54, in the chapter on 75-mm gun ammunition.

FUZE, B.D., M60. This fuze is used in the armor-piercing round for 155-mm guns. The function and explosive train of the M60 are the same as those of the Mk. X, B.D. Fuze used in 14-inch ammunition (see description and illustration of Mk. X in chapter on 14-inch ammunition); the only difference in the two fuzes is in the body. The M60 has fewer threads for screwing into the projectile, and the diameter of the threads is greater than those of the Mk. X. The M60 body also has a flange for fitting over the base of the projectile which is omitted on the Mk. X.

Description. The M60 Fuze has a heavy steel body with a zinc plate as a rust-preventive. There is a cavity in the base into which is inserted the rotor assembly, the primer and delay assembly, the restraining spring, the plunger assembly, and a base plug, in the order given. The rotor assembly includes a brass rotor, a rotor charge of mercury fulminate and tetryl, a rotor lock pin, and a rotor lock pin lock. The primer and delay assembly fits in behind the rotor and contains a variable delay or no delay, and a percussion primer. The delay and primer holder is brass and has a sleeve extending rearward into which the restraining spring and plunger assembly fits. The plunger assembly consists of a sleeve, a plunger body, a firing pin, a pivot pin, and centrifugal pins backed up by springs. The firing pin is eccentrically weighted. Its point, in the unarmed position, is inside the plunger assembly. Two centrifugal pins, the heads of which engage recesses in the firing pin, hold it in the unarmed position. The sleeve fits around the plunger body and holds th ecentrifugal pins and their springs in place. The sleeve is held in position by a small pin. A heavy base plug screws into the fuze body behind the plunger assembly.

A cavity in the upper part of the fuze body is connected with a small hole to the rotor cavity. A lead charge of tetryl is pressed into this hole. A booster pellet of 278 grains of tetryl is pressed in over the lead charge. The upper cavity is closed with a hollow closing screw containing another booster pellet of 170 grains of tetryl. Centrifugal pins backed up by springs are inserted through diametrically opposed holes in the fuze body and are held in place by retaining screws. These pins are for the purpose of holding the rotor in the unarmed position. One of the rotor centrifugal pins is at an angle of 30 degrees. A small hole in the side of the slider cavity is backed up by a pin inserted through the side of the body and soldered in place. A rotor stop pin is also inserted through the fuze body and soldered in place.

Function. The function of the M60 Fuze begins with centrifugal force when the projectile leaves the bore of the weapon. The

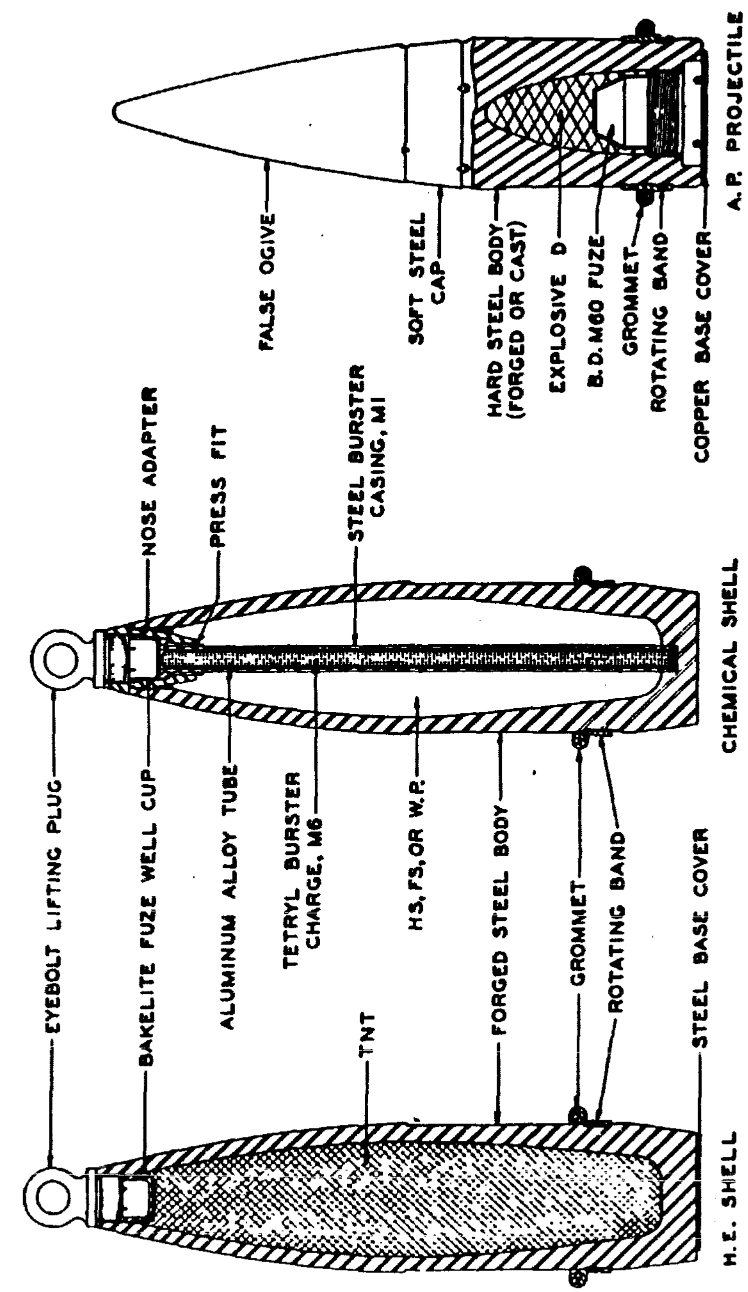

Figure 199 — Section of Modern 155-mm Projectiles

centrifugal pins holding the firing pin in place move outward against their springs. The eccentrically weighted firing pin, now being free, swings on its pivot to an upright position with the point protruding from the plunger assembly and in line with the primer. While these actions are taking place, the centrifugal pins in the upper part of the fuze spread against their springs and leave the rotor free to move. The rotor, being weighted off center, swings around its pivot until it contacts the rotor stop. At this instant the rotor lock pin, also acted upon by centrifugal force, moves partially outward into the recess in the fuze body and thus locks the rotor securely in place. The rotor lock pin lock, due to air retardation or "creep" in the projectile, moves in behind the rotor lock pin providing additional insurance that the rotor will remain armed. In this armed position the rotor detonator is in line with the rest of the explosive train.

On impact, the plunger compresses the restraining spring and carries the firing pin into the primer. The flash from the primer either ignites a variable delay of black powder or flashes through the hole to the detonator if no delay is present. The explosion of the mercury fulminate in the detonator, which is detonated by the primer flash or the burning delay, initiates the remainder of the explosive train of tetryl detonator pellet, tetryl lead charge, booster of tetryl, and shell bursting charge of explosive D.

FUZE, Time, Mechanical, M67. This time fuze is used on modified Mk. and M-series 155-mm projectiles when a time setting rather than impact with the target is desired. The action of the fuze is similar to the M43 with its modifications (see M43 Fuze, in chapter on 3-inch AA ammunition). The fundamental differences are as follows:

The centrifugal gears in the M67 are spring-driven and will, therefore, complete their part of the function without the aid of centrifugal force.

The escapement is so controlled that the time setting is from 0 to 75 seconds.

The escapement lever is released by a centrifugal plate which is backed up by the set-back pin. This is an added safety precaution against the accidental functioning of the fuze before it is fired from the weapon.

A safety pin is added under the set-back pin to insure its staying in position during handling, shipment, and storage.

BASE COVERS.

Two types of base covers may be found on 155-mm, H.E. shell. The old type of cover consists of a lead disc, a copper cover, and lead calking wire. The copper cover, with lead disc inside, fits into a groove machined into the base of the projectile and is secured by calking the lead wire into the remaining space in the groove. The new type con-

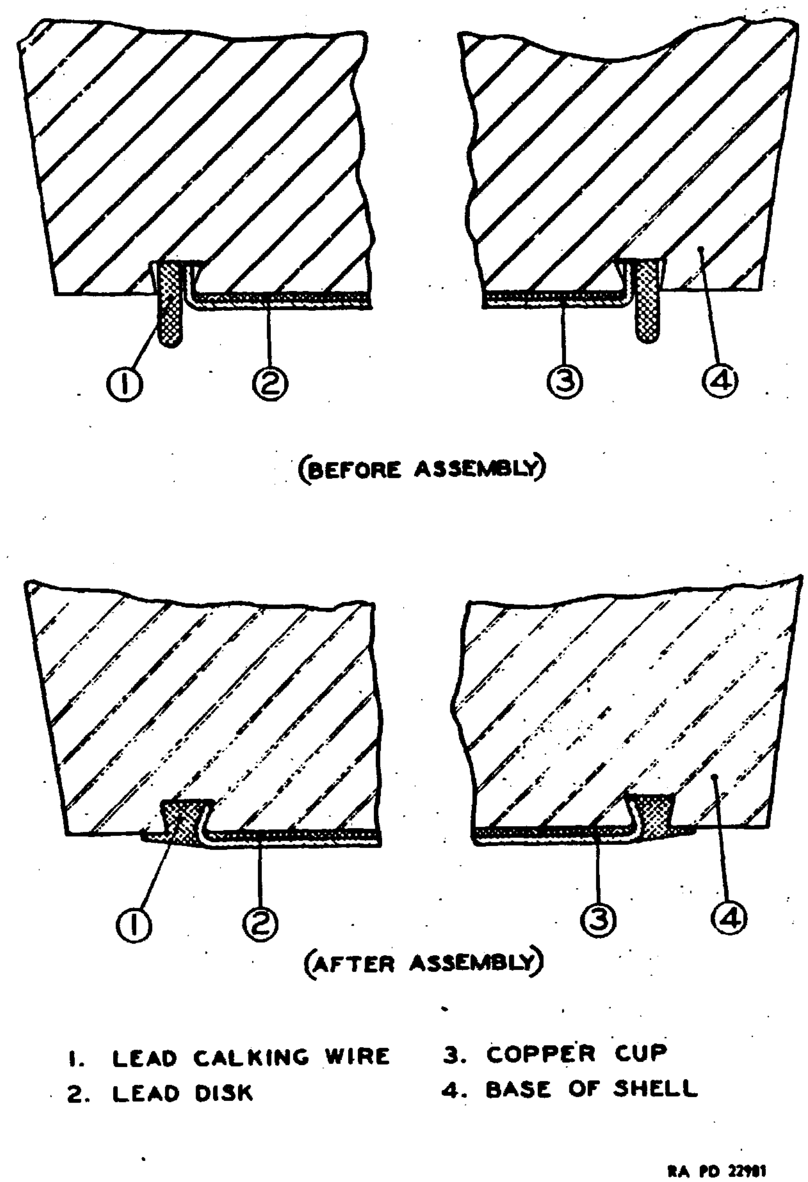

Figure 200 — Base Cover

sists of a thin steel cover, 0.031 inch (22 U.S.Ga.) in thickness, secured to the base with either a continuous overlapping spot weld or a seam weld around the entire edge of the cover.

The Mk. and modified Mk.-series H.E. projectiles in the field will be found with old type copper base covers. The Armor-piercing Projectile M112 also uses this cover after the M60 B.D. Fuze is inserted. M-series H.E. projectiles will usually be found with the new steel cover; however, the copper cover is an alternative in manufacture.

PAINTING AND MARKING.

The regular Army system of painting and marking is followed with 155-mm projectiles. The listing below shows painting and marking as to type:

Type	Painting and Marking
Low-explosive	Red with black stencil
High-explosive	Olive drab with yellow stencil
Practice	Blue with white stencil
Chemical	Blue gray with appropriate stencil and bands
Armor-piercing	Olive drab with yellow stencil
Dummy	Unpainted or black

WEIGHT ZONING.

All 155-mm H.E. and chemical projectiles are weight-zoned. The weights of the chemical projectiles, loaded and unfuzed, vary from 90.1 pounds to 100 pounds. High-explosive shell, loaded and unfuzed, vary in weight from 89 pounds to 95.6 pounds. Obviously, so much variation in weight would result in considerable variation in range. In order that the service may conveniently note these differences in weight, the shell are divided into 10 weight zones. Each particular lot number of ammunition contains only shell of one weight zone. The ballistic results are more uniform when firing shell from the same weight zone. The weight zone marks are yellow, 0.5-inch squares with a prick punch in the center for identification at night. These marks are in a straight line running at right angles to the axis and just below the nose of the shell. If more than five zone marks are required, the excess marks will be placed in another line immediately below the first five.

Variance in weight of projectiles may be caused by differences in manufacture, densities of metals, and densities of fillers. The first weight zone was between weights of 89 and 90.1 pounds. Projectiles within these weights were found to be too light to produce the desired results and were therefore rejected. This fact accounts for not finding projectiles with only one zone mark. High-explosive projectiles have a maximum weight of 95.6 pounds, which is in the sixth zone; therefore, high-explosive shell never bear more than 6

zone marks while chemical shell, with a maximum weight of 100 pounds, may have as many as 10 zone marks.

PROPELLING CHARGES.

General. Propelling charges for projectiles of all sizes are divided into two classes: the single section and the multisection.

Single section class. The single section is made up of the propellent powder in a single cartridge bag with an igniter pad sewn to the base. The cartridge bag cloth is made of raw silk or a substitute, such as wool, that will burn completely and leave very little ash. The igniter is made up of black powder contained in a pad of raw silk which is dyed red and stenciled in black. Old charges may have a white igniter pad stenciled in black. Its purpose is to ignite the base of the propellent uniformly and thus insure uniform and complete burning. The charge may or may not be putteed or wrapped with strips of raw silk to facilitate handling. Since black powder is very sensitive, a felt padded cloth or paper bag, called an igniter protector cap, is placed over the igniter and pulled tight with a draw string.

Multisection class. The multisection class consists of propelling charges divided into more than one cartridge bag. This class is divided into three types: the equally related type (sometimes referred to as aliquot parts type), the unequally related type, and the base and increment type. The equally related type consists of a propelling charge divided into separate cartridge bags of two or more equal parts. The igniter pad of all types is attached to one part known as the base charge and is covered with a protector cap.

The unequally related charge is divided into equal sections, one of which is further divided into two half sections. Each section is contained in an individual cartridge bag. The name of this type is derived from the fact that while the two half sections are not equal to the other sections, they are directly related. The advantage of such a propelling charge is in the additional zones of fire that may be obtained. For example, the Mk. I, unequally related charge, for 240-mm howitzers consists of four one-fifth and two one-tenth sections. The zones of fire that may be obtained are as follows:

Zone 1	Base section ($\frac{1}{5}$)
Zone 2	Base and one $\frac{1}{10}$ section
Zone 3	Base and one $\frac{1}{5}$ section
Zone 4	Base, one $\frac{1}{5}$ and one $\frac{1}{10}$ section
Zone 5	Base and two $\frac{1}{5}$ sections
Zone 6	Base, two $\frac{1}{5}$ sections, and one $\frac{1}{10}$ section
Zone 7	Base and three $\frac{1}{5}$ sections
Zone 8	Base, three $\frac{1}{5}$ sections, and one $\frac{1}{10}$ section
Zone 9	Full charge—four $\frac{1}{5}$ sections and two $\frac{1}{10}$ sections.

Such arrangement gives four more zones of fire than could have been obtained with five equally related sections.

The base and increment type of charge is made up just as the name implies. Any desired number of increments, parts of the full charge in individual cartridge bags, may be attached to the base charge. Each increment is stenciled with the zone of fire for which it is intended; for example, the old M1917-17A1-18, white bag, charge for 155-mm howitzers has seven zones of fire. The top increment is stenciled with "Zone 7" and, used with the previous five increments and base charge, gives the greatest range for that particular charge. The projectile may be fired into zone 6 by discarding the bag marked "Zone 7" and using the remainder of the charge. All multisection charges are assembled together with straps sewn to the base and tied above the last section.

The variation in ranges required makes the base and increment type of charges best suited to 155-mm weapons. The guns, having longest range, require two zones of fire. The howitzers fire to many varied ranges between the 155-mm gun and lighter artillery weapons. This wide variation of ranges requires a propelling charge that will fire into seven zones. It should be noted, also that the difference between old and new howitzers and guns necessitates changes in propelling charges. The new weapons have larger chambers that can stand greater pressures than those of the old.

Propelling Charge for 155-mm Guns M1917-17A1-18MI. The full charge of base and increment for the old 155-mm guns measures from 35 to 37 inches in length, has a maximum diameter of 5.8 inches, and weighs approximately 26.17 pounds. The base is filled with 19.125 pounds of NH smokeless powder. The increment contains 5.875 pounds of NH smokeless powder, making a total charge of 25 pounds. Both base and increment are putteed.

Propelling Charge for 155-mm Guns M1 and M1A1. The new M1 and M1A1 Guns have larger and stronger powder chambers than the old M1917-17A1-18MI models and therefore take a larger propelling charge. The charge for the new gun is made up in the same manner as the old M1917-17A1-18MI. The chief differences are in the diameters and weights of the charges; the charge for M1 and M1A1 Guns having a maximum diameter of 6.5 inches and weighing 32.24 pounds, whereas the old charge has a maximum diameter of 5.8 inches and weighs 26.17 pounds. The base of the M1 and M1A1 Charge contains 20.35 pounds of NH smokeless powder. The increment contains the balance of 10.35 pounds of powder, making a total of 30.70 pounds. Both the old and new charges are contained in white cartridge bags made of silk, wool, or mohair and are putteed.

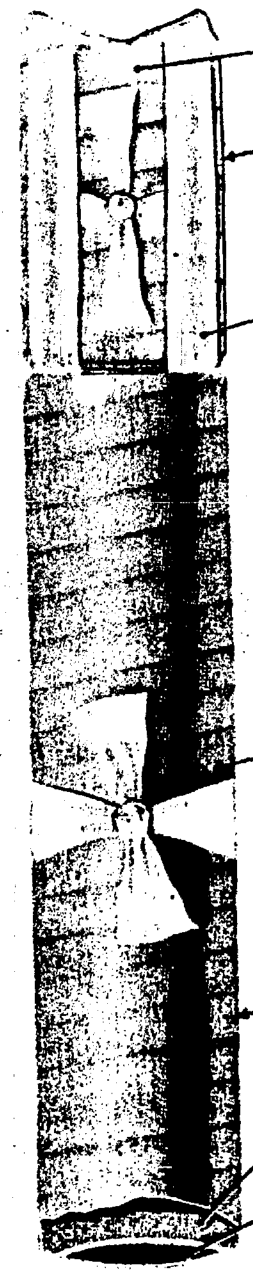

Figure 201 — 155-mm Gun Propelling Charge

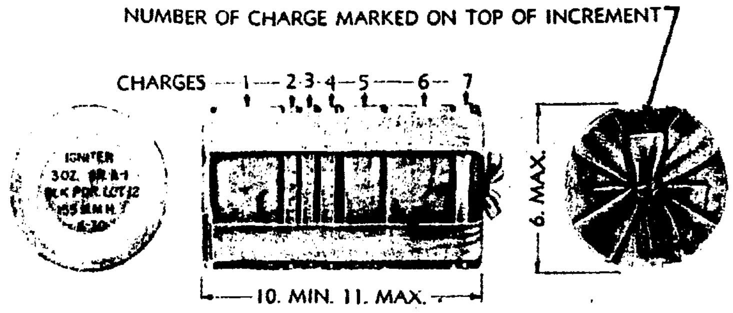

Figure 202a — Propelling Charges for 155-mm Howitzer M1917-17A1-18, White Bag

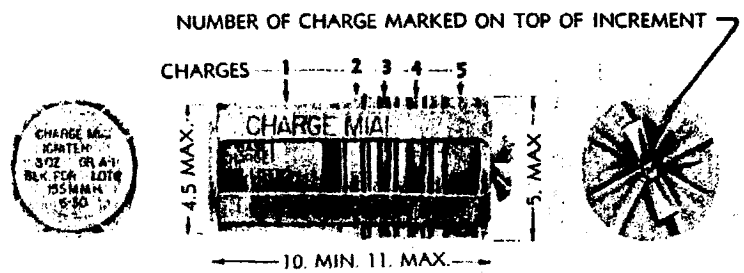

Figure 202b — Propelling Charges for 155-mm Howitzer M1917-17A1-18, Green Bag M1A1

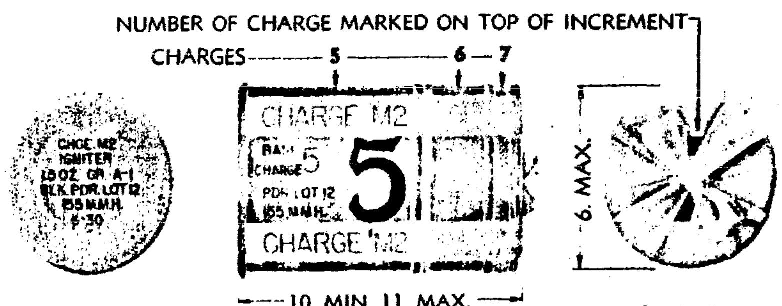

Figure 202c — Propelling Charges for 155-mm Howitzer M1917-17A1-18, White Bag M2

Propelling Charges for 155-mm Howitzers M1917-17A1-18.

First charge developed (white bag). As previously stated, all 155-mm howitzers fire in seven zones, and take base and increment propelling charges of seven sections (a base and six increments) or

the equivalent. Since howitzer charges are much smaller than those for the gun it is not necessary to puttee them for handling purposes. The first charge developed for the M1917-17A1-18 Howitzers is packed into white cartridge bags of base and six increments. The full charge is between 10 and 11 inches long, has a maximum diameter of 6 inches and weighs 8.64 pounds. The propellent is FNH smokeless powder as is true of all propellants used in 155-mm howitzers.

M1 (green bag). It was found that when using the base and 6-increment charge for firing in the lower zones, a large amount of powder was wasted, therefore, two new charges for the M1917-17A1-18 Howitzers were developed. One is designated as the M1 Charge and consists of the base charge and four increments, or the first five zones. It has a maximum diameter of 6 inches, is about 6 inches in length, and weighs approximately 3.93 pounds. The M1 Charge is contained in cartridge bags dyed green, and is designated as a "Green Bag" charge to distinguish it as the one used for the first 5 zones of fire in the howitzer.

M2 (white bag). Another charge was developed for firing in zones 5, 6, and 7, and is designated M2 (white bag) to distinguish it for firing in the outer zones. The M2 has powder ballistically equal to the first five zones of fire incorporated into one bag or base. Zones 6 and 7 in separate bags are strapped to this base charge. The M2 Charge being for the same weapons is about the same size and weight as the old propelling charge including all seven zones. With this arrangement, by using the M1 (green bag) Charge for firing in the inner zones, the zone 6 and 7 increments are not wasted.

M1A1 (green bag). The M1 (green bag) Charge did not prove satisfactory because of its length. Since it was only as long (6 in.) as its diameter, it would topple over in the chamber of the weapon exposing the side instead of the igniter pad to the flash from the primer. The result was poor ignition and irregular burning of the propelling charge. To remedy this disadvantage, the M1 was modified to M1A1 by changing the length to 10 inches and the diameter to about 4.5 inches. The weight remains the same; decreased diameter compensates for increased length.

Propelling Charges for 155-mm Howitzer M1. Propelling Charges M3 (green bag) and M4 (white bag) for the M1 Howitzer are made up in the same way as the M1A1 (green bag) and M2 (white bag) for the old M1917-17A1-18 Howitzers. The M3 is used for the five inner zones of fire and the M4 incorporates five zones in the base charge and has zones 6 and 7 detachable. Since the M1 Howitzer is more powerful than the old weapons, it requires more propellant. The M3 (green bag) Charge is between 14 and 15 inches in length, has a maximum diameter of 5 inches, and weighs 5.94 pounds. The M4 (white bag) Charge is between 19 and 21 inches in length, has a maximum diameter of 5.8 inches, and weighs 13.87 pounds.

PRIMERS.

General. The Mk. IIA1 21-grain Percussion Primer is standard for issue for 155-mm howitzers. PRIMERS, percussion, Mk. II and Mk. IIA, may be used in all 155-mm weapons, but should be reserved, where practicable, for issue for weapons other than 155-mm howitzers. Information on the primer that is standard for issue and manufacture for 155-mm weapons is not available at this time; however, a new, 18-grain percussion primer is listed in SNL R-3, part 1 which may be the one in question.

PRIMER, Percussion 21-grain Mk. IIA1. The Mk. IIA1 was derived through modification of the Mk. II and Mk. IIA 21-grain Percussion Primers. Information on the exact nature of these modifications is not available. The Mk. IIA1, while used for 155-mm and larger weapons up to 10 inches in caliber, is much smaller than primers used in fixed and semifixed ammunition larger than 37-mm. Separate loading ammunition requires a primer for the purpose of igniting only the igniter pad attached to the base of the propelling charge, while fixed and semifixed ammunition primers must ignite the propelling charge directly.

The body of the Mk. IIA1 21-grain Percussion Primer is 1.595 inches long and the diameter, except for the flange at the head, tapers from 0.356 inch at the head to 0.348 inch at the open end for press-fitting into the cartridge case. The primer body is made of cartridge brass. The percussion assembly consisting of anvil, paper disc, percussion compound, and percussion cup is inserted into the flanged head of the primer in the order given. The primer charge of 21 grains of Army black powder. Grade A4, glazed, is put in through the forward end of the primer and consolidated into a definite space by sealing it with onionskin paper, beeswax, and shellac. The beeswax must be a minimum of 0.11 inch in thickness.

Function. The primer is functioned by the firing pin in the breech mechanism. The firing pin indents the percussion cup and crushes the percussion composition against the anvil, causing the composition to explode. The flame from the percussion composition passes through vents in the anvil and a flash hole in the body to the primer charge. The heat and gasses from the primer charge melt the beeswax and consume the onionskin paper, allowing the flame from the primer charge to ignite the igniter pad attached to the base of the propelling charge.

PACKING FOR STORAGE AND SHIPMENT.

Projectiles. All 155-mm projectiles, except armor-piercing and shrapnel, are shipped uncrated. The Armor-piercing Round M112 is

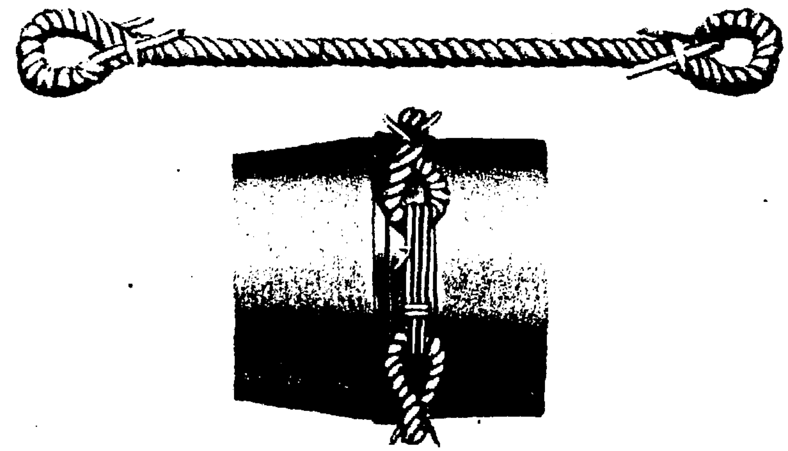

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Figure 203 — Rope Grommet

shipped one per box. The shrapnel is shipped two per box. All other projectiles are shipped fitted with grommets protecting the rotating bands and with eyebolt lifting plugs.

Eyebolt lifting plug. Plug screwed into fuze cavity for the following purposes: to keep foreign materials out of fuze cavity; to protect threads to which the fuze assembles; and to facilitate handling.

Grommets. The grommet may be one of three types: rope, rubber, or metal. The rope grommet is made of a length of rope splice-looped at either end and joined with heavy hemp twine. It is used on all Mk. and modified Mk. series 155-mm shell, and is fitted between the rotating bands on gun shell, and just above the rotating bands on howitzer shell. The rubber type grommet consists of a rubber strip backed by canvas. An eyelet is placed in either end through which heavy cord is threaded and tied. This grommet replaced rope on the M102 Shell but, due to the strategic value of rubber in World War II, it was not provided for other M-series shell. The rope on all M-series 155-mm shell, except the H.E. M102 Howitzer Shell was replaced by metal type grommets. The metal grommet has the same construction as the rubber grommet except that the rubber strip was replaced by steel. These grommets are placed on the rotating bands on the M-series shell. It is very important that all rotating bands be protected, because a damaged band may result in improper seating of the projectile in the bore of the weapon, and in poor obturation.

Propelling Charges. Propelling charges may be packed in metal cartridge storage cases or in new type fiber containers for shipment. If fiber containers are used, three are assembled into a clover-leaf

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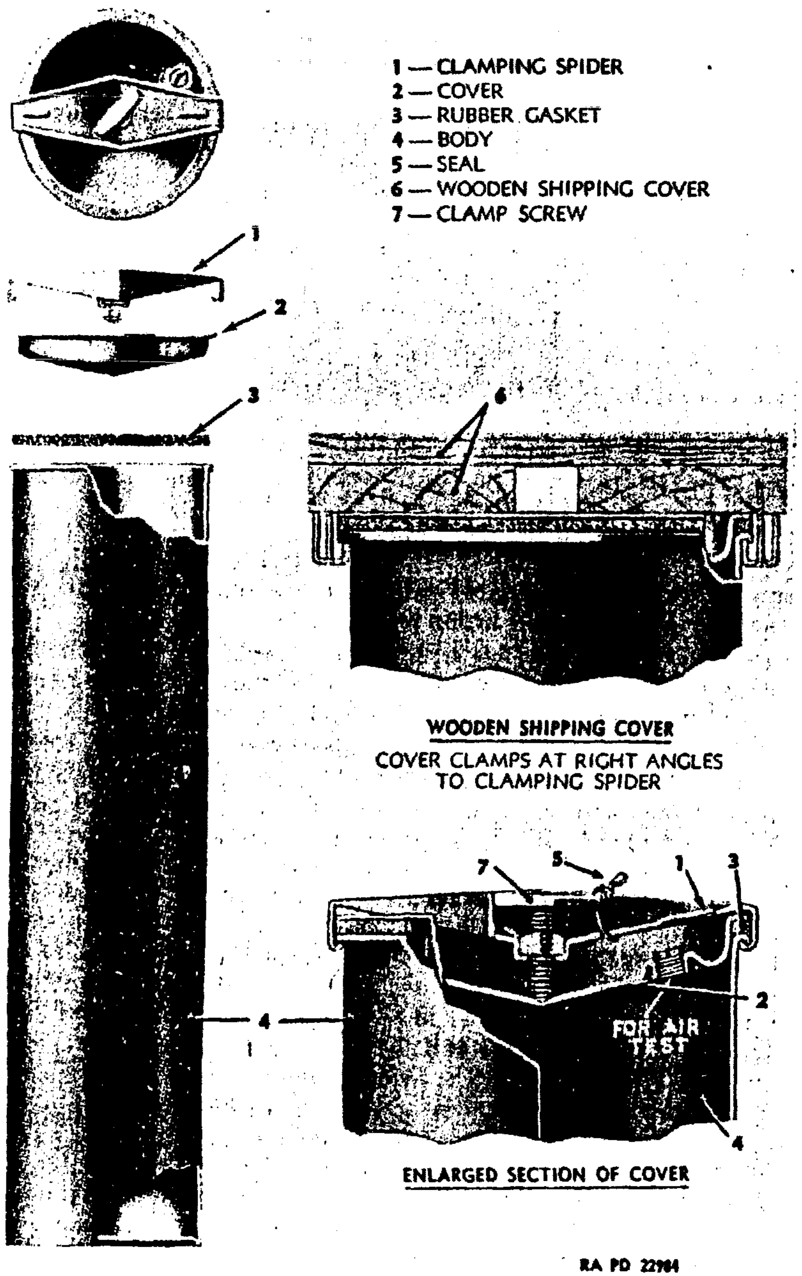

Figure 204 — Cartridge Storage Case

ARTILLERY AMMUNITION

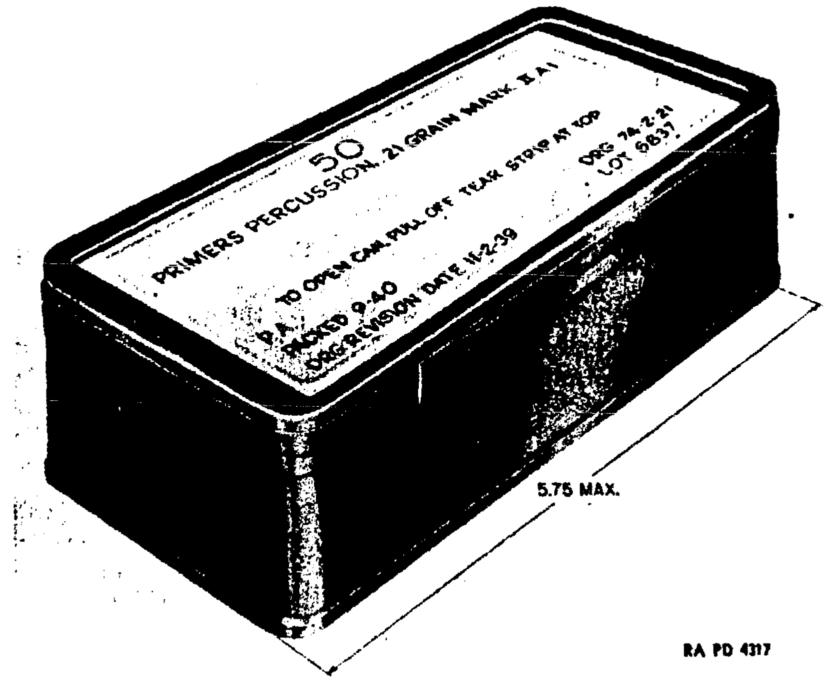

Figure 205 — Packing Can for 21-grain Percussion Primers Mk. II-A

bundle to facilitate handling, and conserve space. Export shipments require cartridge storage cases and clover-leaf bundles to be crated.

Primer. The 21- and 18-grain percussion primers are packed 50 to a metal container. Forty-eight of these metal containers are then packed in a box, making a total of 2,400 primers per box.

Fuzes. All 155-mm high-explosive and chemical shell are shipped unfuzed. Shrapnel is issued unfuzed for peacetime issue, but may be fuzed prior to issue in time of emergency. Fuzes that are shipped separate from projectiles are packed as follows:

FUZES, P.D., M46 and M47, are packed 50 per metal-lined box.

FUZES, P.D., M51, with M21 Booster attached and M51A1, with M21A1 Booster attached and FUZE, time, mechanical, M67, with M21A1 Booster attached are packed 1 per fiber container, 25 containers (25 fuzes) per box.

FUZE, P.D., M54, is packed 1 per fiber container, 50 containers (50 fuzes) per box.

FUZE, combination, 45-second, M1907M, is packed 1 per tin container, 50 containers (50 fuzes) per box.

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Storage. Boxed armor-piercing and shrapnel rounds remain in their boxes for storage and are stacked in block style. All other projectiles have their grommets removed for storage, and are stacked on their sides. In peacetime, export crates on propelling charge containers are removed before the charges are stored. In wartime, however, the crates are left on to facilitate immediate shipment. Primers and fuzes are stored in block form in their regular shipping containers.

COMPLETE ROUNDS FOR 155-MM GUNS M1917-17A1-18MI, AND M1A1.

General. The Mk. and modified Mk.-series 155-mm gun shell are used with the old models, M1917-17A1-18MI Guns, only. M-series gun shell may be used in both the old models, M1917-17A1-18MI Guns, and new models, M1 and M1A1 Guns. All of the M-series rounds are standard for both issue and manufacture, while the Mk. and modified Mk. series are standard for issue only.

SHELL, H.E., Mk. III. This was the first high-explosive round to be developed for 155-mm guns. The complete round, as fired, consists of the projectile fuzed either with P.D. M46 or M47 Fuze, the propelling charge for 155-mm Guns M1917-17A1-18MI, and either a Mk. II or Mk. IIA 21-grain Percussion Primer.

SHELL, H.E., Mk. IIIA1. The Mk. III Round was modified by adapting the nose of the projectile to take new fuzes and boosters. Complete round of Mk. IIIA1, as fired, consists of the following:

Projectile. The projectile fuzed with either the Selective Fuze M51 with Booster M21, or Fuze M51A1 with Booster M21A1; or FUZE, time, mechanical, M67, with Bootser M21A1.

Propelling charge. The propelling charge for 155-mm Guns M1917-17A1-18MI.

Primer. Mk. II or Mk. IIA 21-grain Percussion Primer.

SHELL, H.E., M101. This is the new high-explosive round for use in either old or new 155-mm guns. The complete round consists of the following:

Projectile. The projectile fuzed with either the Selective Fuze M51 with Booster M21, or M51A1 with Booster M21A1; or FUZE, time, mechanical, M67, with Booster M21A1.

Propelling charge. The propelling charge for M1917-17A1-18MI Guns or M1 and M1A1 Guns, depending on the weapon the round is to be fired in.

Primer. Mk. II or Mk. IIA 21-grain Percussion Primer.

SHELL, Chemical, Mk. VII. This shell was the original chemical shell developed for the American 155-mm guns. It may be filled with either [illegible] WP. Complete round, as fired, consists of the projectile

with M46 PD Fuze, the propelling charge for M1917-17A1-18MI Guns, and either a Mk. II or Mk. IIA 21-grain Percussion Primer.

SHELL, Chemical, Mk. VIIA1. The Projectile Mk. VII was modified to take new fuzes, adapters, and bursters. It may be filled with H, FS, or WP. The complete round consists of the following:

Projectile. The projectile fuzed with the Selective Fuze M51 with M21 Booster, or M51A1 with M21A1 Booster.

Propelling charge. The propelling charge for M1917-17A1-18MI 155-mm Guns.

Primer. Mk. II or Mk. IIA 21-grain Percussion Primer.

SHELL, Chemical, M104. The new chemical shell for old and new 155-mm guns may be filled with H, FS, or WP. The complete round consists of the following:

Projectile. The projectile fuzed with the Selective Fuze M51 with M21 Booster, or M51A1 with M21A1 Booster.

Propelling charge. The propelling charge for M1917-17A1-18MI or M1 and M1A1 Guns, depending on the weapon the round is to be fired in.

Primer. Mk. II or Mk. IIA 21-grain Percussion Primer.

SHELL, Empty, for Sand-loading, 95-lb, Mk. III. This round is used to simulate high-explosive and chemical shell for practice firing. The complete round consists of the following:

Projectile. An empty Mk. III High-explosive Projectile. The projectile is sand-loaded to service weight at the point of use. It is fuzed with an inert M46 or M47 Fuze.

Propelling charge. The propelling charge for M1917-17A1-18MI 155-mm Guns is furnished.

Primer. Mk. II or Mk. IIA 21-grain Percussion Primer is used.

PROJECTILE, AP, 100-lb, M112. This round was designed for armor-piercing work with old and new 155-mm guns. The complete round consists of the following:

Projectile. The projectile is filled with 1.44 pounds of explosive D, and fuzed with the B.D. Fuze M60. The projectile consists of a heavy steel body hollowed out to receive the filler and fuze, a steel adapter soldered and crimped to the nose of body and a steel windshield threaded to the adapter. The addition of the windshield continues the ogive which has a radius of approximately 65 inches. The base of the projectile is not tapered, and has a groove cut in it to receive a copper base cover after the M60 Fuze has been inserted. The fuze designation and lot number are stamped on the rotating band, and the appropriate delay is stenciled on the base cover. The projectile loaded and fuzed weighs 100 pounds. Since it contains a high explosive, the projectile is painted olive drab and stenciled in yellow.

Propelling charge. The propelling charge for M1917-17A1-18MI or M1 and M1A1 Guns, depending on the weapon the round is to be used in.

Primer. Mk. II or Mk. IIA 21-grain Percussion Primer.

Shrapnel Mk. I. The shrapnel is the only projectile that may be fired from either 155-mm guns or howitzers, however, its use is limited to the old M1917-17A1-18MI Guns and M1917-17A1-18 Howitzers for impact practice fire. Only in cases of extreme emergency would shrapnel be used for combat. The complete round, as fired, consists of the following:

Projectile. The projectile with the Combination 45-sec Fuze M1907M. Except for size, the 155-mm shrapnel projectile is the same as that described in 75-mm ammunition.

Propelling charge. The propelling charge for 155-mm Guns M1917-17A1-18MI.

Primer. Mk. II or Mk. IIA 21-grain Percussion Primer.

PROJECTILE, Dummy, 95-lb, Mk. I. In the larger caliber weapons, drill rounds are used to give personnel practice in loading and unloading weapons, and handling ammunition without the expense of actually firing the weapon. The components of such a round are entirely inert. The drill or dummy round for 155-mm guns consists of the following:

Projectile. The dummy projectile has approximately the same size, shape, and weight as the service rounds it simulates. The projectile is made up of a steel body, an inert fuze, a removable bronze band forming the bourrelet, a cast steel base on which is mounted a forged steel sliding ring, and a removable bronze band which is attached to the sliding ring and simulates the rotating band. Both the bronze bourrelet and rotating bands are secured with set screws so that they may be replaced when they become unserviceable. Bronze is used because it is soft as compared to steel, and protects the weapon. The cast steel base screws into the body and, with its handle and sliding ring, provides a means of extracting the projectile. There is always starting space between the sliding ring with its bronze rotating band and the base of the projectile for removal from the weapon.

Propelling charge. A dummy propelling charge is used to simulate the propelling charge used with the weapon concerned.

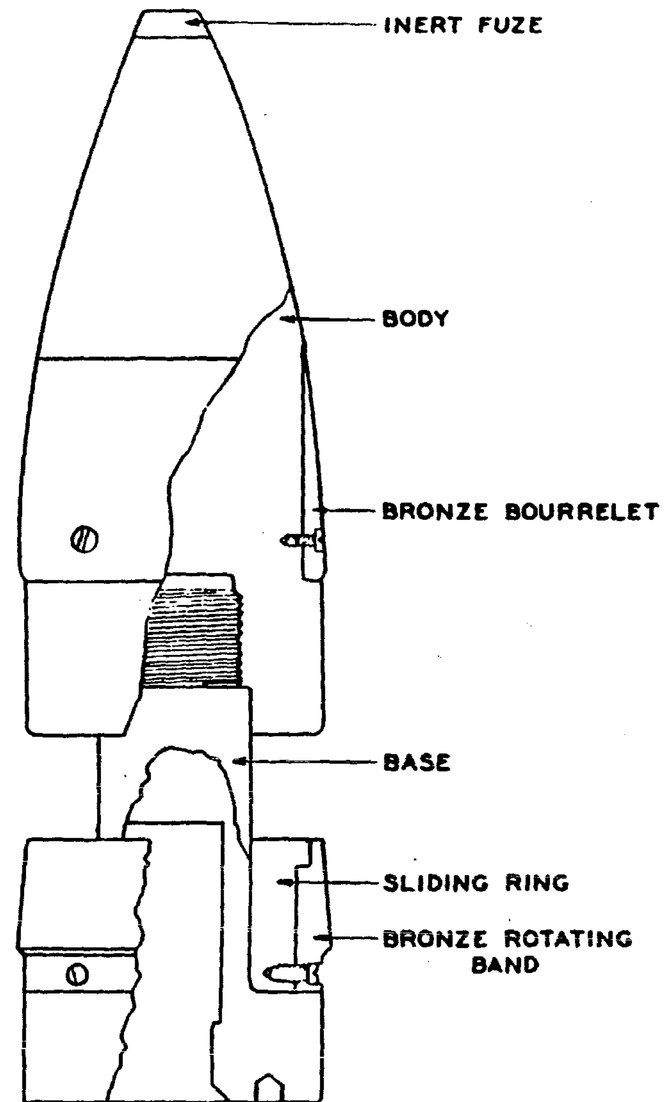


Figure 206 — PROJECTILE, Dummy, 95-pound, Mk. I

Primer. An inert Mk. II, Mk. IIA, or Mk. IIA1 21-grain Percussion Primer is used.

COMPLETE ROUNDS FOR 155-MM HOWITZERS M1917-17A1-18.

General. The width of the rotating band prevents interchangeability between old and new howitzer projectiles. All M-series projectiles for M1917-17A1-18 Howitzers are standard for issue and manufacture.

SHELL, H.E., Mk. I. This is the original shell designed for high-explosive work with the M1917-17A1-18 Howitzers. The complete round is made up of the following:

Projectile. The projectile with P.D. M46 or M47 Fuze. An unsuccessful attempt was made to make this projectile interchangeable between old guns and howitzers by increasing the width of the rotating band. The difference in position of the rotating band made the shell unsatisfactory for gun use, and the increased width made it unsatisfactory for howitzer use. The bands were therefore cut down to their original width. If Mk. I Rounds are found in the field with rotating bands exceeding a width of 0.602 inch, they should not be issued.

Propelling charges.

CHARGE, propelling, for 155-mm Howitzers M1917-17A1-18 (7 zones, adjustable).

CHARGE, propelling, M1A1 (green bag) (5 zones adjustable).

CHARGE, propelling, M2 (white bag) (zones 6 and 7 adjustable).

Primer. Mk. II, Mk. IIA, or Mk. IIA1 21-grain Percussion Primer.

SHELL, H.E., Mk. IA1. The Mk. I Projectile was modified in the nose to take new fuzes and boosters. The resulting Mk. IA1 Complete Round, as fired, consists of the following:

Projectile. The projectile with P.D. M51 or M55 Fuze with Booster M21, Fuze M51A1 or M55A1 with Booster M21A1.

Propelling charges.

CHARGE, propelling, for 155-mm Howitzers M1917-17A1-18 (7 zones, adjustable).

CHARGE, propelling, M1A1 (green bag) (5 zones adjustable).

CHARGE, propelling, M2 (white bag) (zones 6 and 7 adjustable).

Primer. Mk. II, Mk. IIA, or Mk. IIA1 21-grain Percussion Primer.

SHELL, H.E., Mk. IV. The complete round, as fired, is made up as follows:

Projectile. The projectile with P.D. M46 or M47 Fuze.

Propelling charges.

CHARGE, propelling, for 155-mm Howitzers M1917-17A1-18 (7 zones, adjustable).

CHARGE, propelling, M1A1 (green bag) (5 zones adjustable).

CHARGE, propelling, M2 (white bag) (zones 6 and 7 adjustable).

Primer. Mk. II, Mk. IIA, or Mk. IIA1 21-grain Percussion Primer.

SHELL, H.E., M102. This is the new shell manufactured to receive new fuzes and boosters. The complete round, as fired, consists of the following:

Projectile. The projectile with P.D. M51 or M55 Fuze with M21 Booster or M51A1 or M55A1 with M21A1 Booster.

Propelling charges.

CHARGE, propelling, for 155-mm Howitzers M1917-17A1-18 (7 zones, adjustable).

CHARGE, propelling, M1A1 (green bag) (5 zones adjustable).

CHARGE, propelling, M2 (white bag) (zones 6 and 7 adjustable).

Primer. Mk. II, Mk. IIA, or Mk. IIA1, 21-grain Percussion Primer.

SHELL, Chemical, Mk. II. This is the original chemical shell for use with M1917-17A1-18 Howitzers. It may be filled with H, FM, FS, or WP. The complete round, as fired, is made up as follows:

Projectile. The projectile with P.D., M46 Fuze.

Propelling charges.

CHARGE, propelling, for 155-mm Howitzers M1917-17A1-18 (7 zones, adjustable).

CHARGE, propelling, M1A1 (green bag) (5 zones, adjustable).

CHARGE, propelling, M2 (white bag) (zones 6 and 7, adjustable).

SHELL, Chemical, Mk. IIA1. The A1 modification of the Mk. II Chemical Shell was the change of the nose to take new adapters, fuzes, and boosters and the machining of a recess in the base to receive the shell-length burster. The Mk. IIA1 Shell may be filled with H, FS, or WP. There is also a Mk. IIA1 Mod. 1 Chemical Shell which is filled with H only. The "Mod. 1" change information is not available at this time. The complete round of Mk. IIA1, as fired, is made up as follows:

Projectile. The projectile with P.D. M51 Fuze with M21 Booster or M51A1 with Booster M21A1.

Propelling charges.

CHARGE, propelling, for 155-mm Howitzers M1917-17A1-18 (7 zones, adjustable).

CHARGE, propelling, M1A1 (green bag) (5 zones, adjustable).

CHARGE, propelling, M2 (white bag) (zones 6 and 7 adjustable).

Primer. Mk. II, Mk. IIA, or Mk. IIA1 21-grain Percussion Primer.

SHELL, Chemical, M105. This is a modern chemical shell for use with M1917-17A1-18 Howitzers. The components of a complete round are as follows:

Projectile. The projectile with P.D. M51 Fuze with M21 Booster or M51A1 Fuze with M21A1 Booster.

Propelling charges.

CHARGE, propelling, for M1917-17A1-18 Howitzers (7 zones, adjustable).

CHARGE, propelling, M1A1 (green bag) (5 zones, adjustable).

CHARGE, propelling, M2 (white bag) (zones 6 and 7 adjustable).

Primer. Mk. II, Mk. IIA, or Mk. IIA1 21-grain Percussion Primer.

SHELL, empty, for Sand-loading, 95-lb, Mk. I. This round is used to simulate high-explosive and chemical rounds for M1917-17A1-18 Howitzers for practice firing. The complete round, as fired, is made up as follows:

Projectile. The projectile with inert P.D. M46 or M47 Fuzes. The projectile is loaded with sand to service weight at the point of use.

Propelling charges.

CHARGE, propelling, for 155-mm Howitzers M1917-17A1-18 (7 zones, adjustable).

CHARGE, propelling, M1A1 (green bag) (5 zones, adjustable).

CHARGE, propelling, M2 (white bag) (zones 6 and 7 adjustable).

Primer. Mk. II, Mk. IIA, Mk. IIA1 21-grain Percussion Primer.

SHELL, Smoke, HC, B.E., M115. This shell, while in flight, ejects burning candles which fall only slightly short of the shell body, and produce an effective screening smoke. This is accomplished with the M54 Fuze which furnishes the time element and also will function on impact if the target is struck before the predetermined time has expired. The complete round, as fired, consists of the following:

Projectile. The projectile with M54 Combination Time and Superquick Fuze. The construction and function of this projectile are the same as for the M84 105-mm Howitzer Projectile (see discussion in chapter on 105-mm howitzer ammunition).

Propelling charge.

CHARGE, propelling, for 155-mm Howitzers M1917-17A1-18 (7 zones, adjustable).

CHARGE, propelling, M1A1 (green bag) (5 zones adjustable).

CHARGE, propelling, M2 (white bag) (zones 6 and 7 adjustable).

Primer. Mk. II, Mk. IIA, or Mk. IIA1 21-grain Percussion Primer.

SHRAPNEL, Mk. I. This round is used only for practice impact firing. The complete round is made up as follows:

Projectile. The projectile with M1907M 45-sec Combination Fuze. The projectile has the same construction and function as the shrapnel described in the chapter on 75-mm ammunition.

Propelling charges.

CHARGE, propelling, for 155-mm Howitzers M1917-17A1-18 (7 zones, adjustable).

CHARGE, propelling, M1A1 (green bag) (5 zones, adjustable).

CHARGE, propelling, M2 (white bag) (zones 6 and 7 adjustable).

Primer. Mk. II, Mk. IIA, or Mk. IIA1 21-grain Percussion Primer.

PROJECTILE, Dummy, 95-lb, Mk. I. The dummy or drill round is used to train troops in loading and unloading weapons and in handling ammunition. The complete round is made up as follows:

Projectile. The projectile with an inert fuze. The projectile is of the same type as that used for training with 155-mm guns except that the bronze band simulating the rotating band has a different over-all width.

Propelling charge. Dummy propelling charges to simulate service charges.

Primer. Inert Mk. II, Mk. IIA, or Mk. IIA1 21-grain Percussion Primer.

COMPLETE ROUNDS FOR 155-MM HOWITZER M1.

General. The M1 Howitzer is a new weapon, and all rounds used with it are standard for issue and manufacture. The rounds fired in the M1 Howitzer are not interchangeable with those fired in any other weapon.

SHELL, H.E., M107. The M107 is a new-type projectile designed for high-explosive work with the M1 Howitzer. The make-up of the complete round, as fired, is as follows:

Projectile. The projectile with P.D. M51 Fuze with M21 Booster, M51A1 Fuze with M21A1 Booster.

Propelling charges. Propelling Charges M3 (green bag) (5 zones of fire, adjustable) and M4 (white bag) (zones 6 and 7 adjustable).

Primer. Mk. II, Mk. IIA, or Mk. IIA1 21-grain Percussion Primer.

SHELL, Chemical, M110. The M110 Projectile may be filled with H, FS, or WP. The components of a complete round, as fired, are as follows:

Projectile. The projectile with P.D. Fuze M51 with M21 Booster or M51A1 with M21A1 Booster.

Propelling charges. Propelling Charges M3 (green bag) (5 zones of fire, adjustable) and M4 (white bag) (zones 6 and 7 adjustable).

Primer. Mk. II, Mk. IIA, or Mk. IIA1 21-grain Percussion Primer.

SHELL, Smoke, HC, B.E., M116. The purpose of this round is to screen enemy positions with smoke. Burning smoke candles are ejected from the projectile during flight which fall only slightly short of the shell. Components of a complete round, as fired, are as follows:

Projectile. The projectile with M54 Combination Time and Superquick Fuze. The construction and function are the same as for the M84 Projectile used with 105-mm howitzers.

Propelling charges. Propelling Charges M3 (green bag) (5 zones of fire, adjustable) and M4 (white bag) (zones 6 and 7 adjustable).

Primer. Mk. II, Mk. IIA, or Mk. IIA1 21-grain Percussion Primer.

FURTHER REFERENCES: SNL P-1, P-2, P-7, P-8, R-2, R-3, R-6; Complete Round Chart No. 5981; OS 9-20; Ordnance Drawings.

Chapter 14

Ammunition for 240-mm Howitzers

GENERAL.

Weapons. The 240-mm howitzers are mobile field weapons classed as heavy artillery. The old M1918-18A1-18MI-18MAI Howitzers are difficult to move and set up. Each breaks down into four 10-ton tractor loads. A pit 6 feet deep and 8 feet square must be dug to bury the base plate. The weapon fires the high-explosive projectile with a muzzle velocity of 1,700 feet per second to a maximum range of 16,400 yards, or over 9.5 miles.

The new M1 Howitzer was developed very recently, so that very little information about it is available. It is mounted on a mobile mount with pneumatic tires, and can be moved by one prime mover and set up in a much shorter space of time than the old howitzer.

Class. The complete rounds for 240-mm howitzers are classed as separate loading, since they are loaded into the weapon in more than one operation.

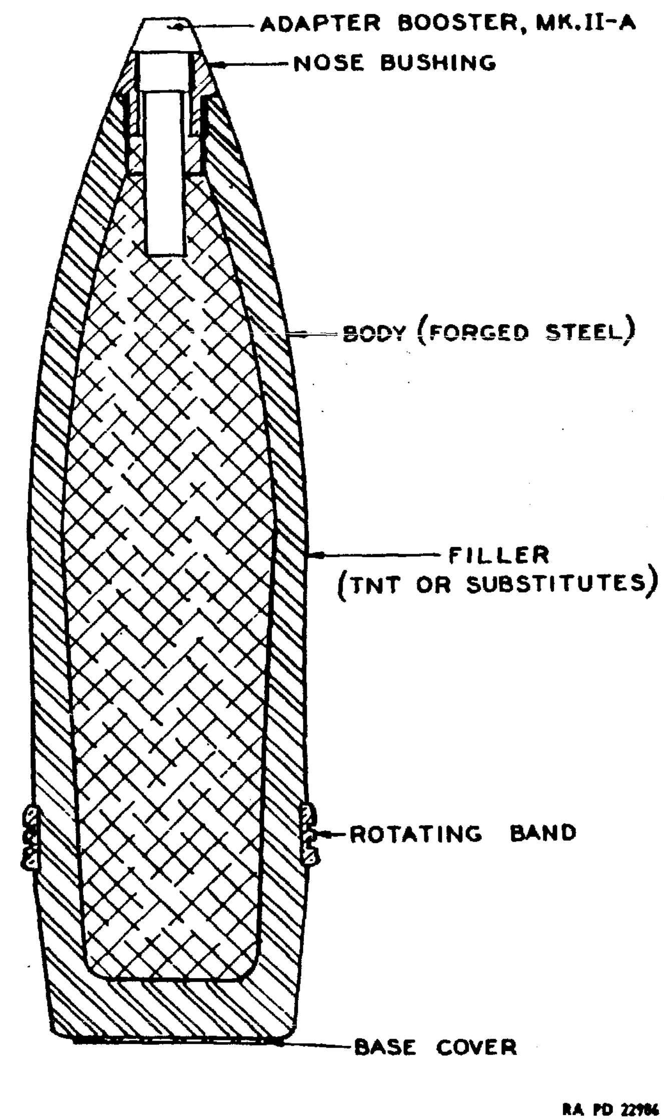


Figure 207 — 240-mm Projectile

Types. The three types of ammunition, classified as to filler, provided for 240-mm howitzers are as follows:

Type	Filler
High-explosive	TNT or substitutes
Practice	Sand
Dummy or drill	None

Painting and Marking. 240-mm projectiles follow the Army scheme of painting and marking as outlined below:

Types	Painting and Marking
High-explosive	Olive drab with yellow stencil
Practice	Blue with white stencil
Drill	Black or unpainted

COMPLETE ROUNDS FOR 240-MM HOWITZERS M1918-18A1-18MI-18MIA1.

Complete rounds of separate loading ammunition, as fired, consist of a fuzed projectile or shell, a propelling charge, and a primer. All rounds for 240-mm weapons are standard for issue and manufacture.

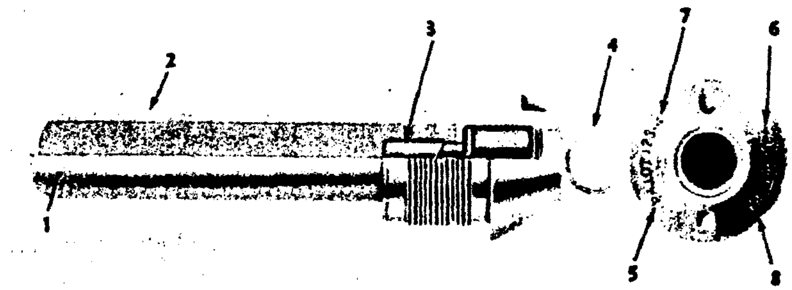
SHELL, H.E., Mk. III. This original shell was designed for use against personnel and structures. Despite the fact that it takes the old Fuzes M46,and M47, it is still listed for issue and manufacture in SNL P-1. The SHELL, H.E., Mk. III, consists of a metal parts assembly, a filler, an adapter booster, and a fuze.

Metal parts assembly. The Shell Body Mk. III is forged from forging steel. It has an ogive radius of 42.98 inches and the base has a cylindrical taper of 7 degrees. There is a circumferential groove machined into the base to receive a copper base plate. A recess 1.98 inches wide and with waved ribs on the bottom is machined into the shell to receive a copper or gilding metal rotating band. The filler cavity is threaded at the nose to take a bushing which continues the ogive, and reduces the size of the nose opening to take Adapter Booster Mk. IIA. The complete assembly is 32.64 inches long.

Filler. The filler or bursting charge is approximately 49 pounds of TNT or substitutes. The TNT is poured in liquid form into the nose and solidifies on cooling to a temperature below 80.2 C.

Adapter Booster Mk. IIA. The Mk. IIA has a wide use in major caliber shell. It is standard for the following: SHELL, H.E., Mk.II, for 6-inch guns; SHELL, H.E., Mk. I, for 8-inch guns and howitzers; SHELL, H.E., Mk. III, for 240-mm howitzers; SHELL, H.E., Mk. IV, for 10-inch guns; SHELL, H.E., Mk. X, for 12-inch guns; and SHELL, H.E., Mk. VIA, and Mk. XI, for 12-inch mortars.

The booster charge of about 4.4 ounces of tetryl is contained in a booster casing which is assembled with threads into the lower part of



1 — BOOSTER CHARGE (APPROX. 4 OZ. TETRYL)
2 — BOOSTER CASING
3 — FUZE SOCKET
4 — ADAPTER PLUG
5 — INITIALS OR SYMBOL OF LOADER
6 — INITIALS OR SYMBOL OF METAL PARTS MANUFACTURER
7 — LOT NUMBER OF LOADED ADAPTER AND BOOSTER
8 — MARK NUMBER

RA PD 22987

Figure 208 — Adapter Booster Mk. IIA

the adapter. A fuze socket of a shape to receive the lower part of the M46 or M47 Fuze is press-fit into the adapter and extends into the booster charge. Some boosters are charged with half tetryl and half TNT. In such case, the tetryl surrounds the fuze socket. The adapter has outside threads at the bottom for threading into the nose bushing of the shell. Inside threads at the top receive the exterior threads of the M46 or M47 Fuze.

Fuzes. P.D. M46 or M47 Fuzes are used with the Mk. III Round depending on whether instantaneous or short delay action is desired.

SHELL, H.E., Mk. IIIA1. The Mk. IIIA1 Shell is the same as the Mk. III except that the Mk. IIA Adapter Booster is eliminated and new fuzes and boosters are used. P.D. Fuze M51 with M21 Booster, or Fuze M51A1 with M21A1 Booster, or FUZE, time, mechanical, M67, with Booster M21A1 are assembled into the nose bushing. The outside threads of the M21 or M21A1 Booster are of a size to screw directly into the bushing threads. Fuzes M51, M51A1, and M67 are discussed in the chapter on 155-mm ammunition.

Shell, Empty, for Sand-loading, 345-pound, Mk. III. This shell consists of the metal parts assembly of the Mk. III High-explosive Shell, an inert Adapter Booster Mk. IIA, and an inert M46 or M47 Fuze. It is loaded to service weight with sand at the point of use.

Projectile, Dummy, 356-pound, Mk. I. This projectile, designed for training in loading and unloading weapons, is of the sliding ring type. Except for size, it is exactly the same as the dummy projectile used in 155-mm weapons.

Weight Zones. Due to differences in densities of fillers, high-explosive and chemical shell of medium and major calibers vary so much in weight that wide variations in range occur. To decrease inaccuracies in range, such shell are divided into weight zones, and marked so that these variations may be conveniently noted by the service. The Mk. III, High-explosive, 240-mm Shell vary in weight from 337 to 352 pounds. To obtain more uniform ballistic results these weights are divided into three zones as follows:

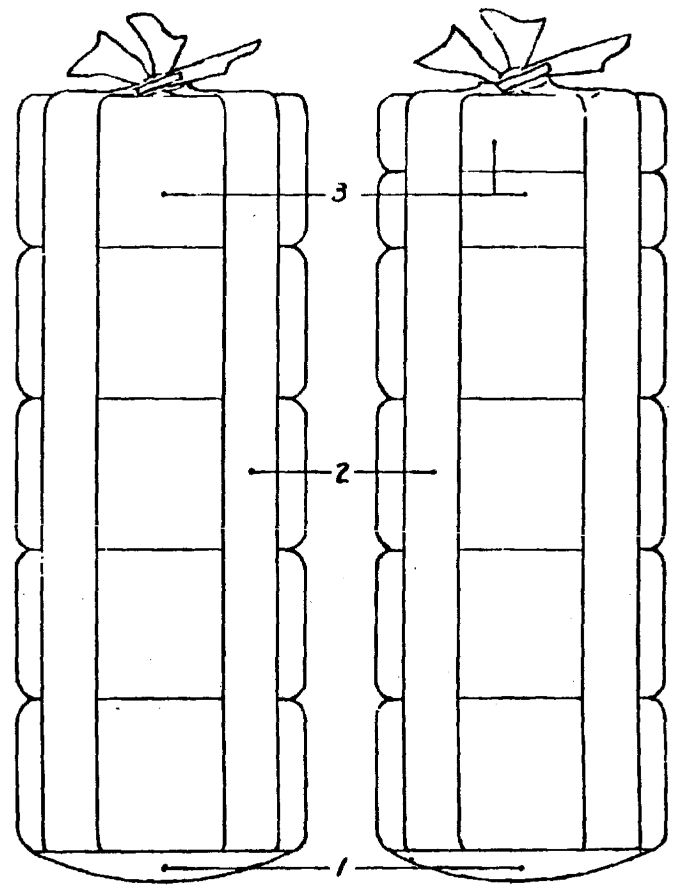
Zone	From (lb)	To and Including (lb)	Zone Marks
1	337	342	⊡
2	342	347	⊡ ⊡
3	347	352	⊡ ⊡ ⊡

The zone marks consist of ½-inch yellow squares with a prick punch in the center for identification at night. By feeling the pricks, the gun crew can determine the weight zone without seeing the squares. The squares are placed in a straight line running around and just below the nose of the shell. Each particular lot of ammunition contains shell of only 1-weight zone.

Propelling Charges. The multisection class of propelling charges is provided for 240-mm howitzers. (See chapter on 155-mm ammunition for general discussion on classes and types of propelling charges.) Two types of multisection charges are provided for M1918-18A1-18MI-18MIA1 240-mm Howitzers; the equally related and the unequally related types. Only the unequally related type filled with NH powder is standard for issue and manufacture. Some charges of both types are made up of the old pyro powder and must be inspected annually. The new NH powders, in propelling charges, need not be inspected until 20 years after the date of manufacture.

CHARGE, propelling, 4 one-fifth and 2 one-tenth section, Mk. I. The discussion of this charge and its zones of fire may be found in the general discussion of propelling charges in the chapter on 155-mm ammunition. The total charge assembled varies from 18.875 to 20.75 inches in length, has a maximum diameter of 9.025 inches, and weighs approximately 37.3 pounds. The total charge consists of an igniter pad sewn to the bottom one-fifth section; 3 additional one-fifth sections, and 2 one-tenth sections tied with straps to the bottom section; and an igniter protector cap fitted over the igniter pad and secured to the charge with a draw string.

CHARGES, propelling, 5 equal sections, Mk. I. The only difference between this charge and the 4 one-fifth and 2 one-tenth section charge



1. PRIMER PAD 2. TYING STRAPS

3. INCREMENTS

RA PD 22988

Figure 209 — Multisection Propelling Charge for 240-mm Howitzer M1918

is that the top section is not divided in half; in other words, it is made up of 5 one-fifth sections. The manufacture of this charge has been discontinued in favor of the unequally related charge because of its advantage of furnishing additional zones of fire.

CHARGE, propelling, dummy, 5 section (7½ pounds each). This charge is used to simulate charges used in both old and new 240-mm howitzers for practice in loading and unloading weapons. The charge consists of dummy powder grains of wood and lead in bags made of heavy canvas in order to withstand repeated handlings. An inert igniter pad is attached to the bottom bag. Igniter pads and bags are stenciled with the word "Dummy."

Primers. Mk. II or Mk. IIA 21-grain Percussion Primers are used in 240-mm rounds. (These are discussed in the chapter on 155-mm ammunition.) The Mk. IIA1 Primer is restricted for use in 155-mm howitzers. All of these primers are listed as standard for issue only in SNL R-3. A new, 18-grain Percussion Primer Mk. IIA3 is listed as standard for issue and manufacture, however, no information as to its use and construction is available at this time.

Packing for Shipment and Storage. The components of complete rounds for 240-mm Howitzers M1918-18A1-18MI-18MIA1 are packed as follows:

Projectile. The projectiles, except the dummy, are prepared for shipment with eyebolt lifting plugs protecting the fuze cavity, and grommets protecting the rotating band. (Lifting plugs and grommets are discussed in the chapter on 155-mm ammunition.) The dummy projectile is packed one per crate. In storage, the grommets are removed and the shell are stacked on their sides.

Fuzes and boosters. The new fuzes and boosters are shipped and stored assembled together. They are packed 1 per fiber container, 25 containers (25 fuzes and boosters) per box. The old M46 and M47 Fuzes are packed 50 per metal-lined box.

Propelling charges. The propelling charges are packed in two ways: 2 charges per cartridge storage case; 1 charge per fiber container, 3 containers (3 charges) per bundle.

The storage cases and bundles, often referred to as cloverleafs, are crated for export shipment. In emergency, these crates are not removed in storage to facilitate immediate shipment. In peacetime, the crates are removed to conserve space and reduce the fire hazard.

Primers. The Mk. II and Mk. IIA Primers are packed 50 per metal container, 48 containers (2,400 primers) per box.

COMPLETE ROUNDS FOR 240-MM HOWITZER M1.

General. Only two types of projectiles, high-explosive and dummy are used in the new M1 Howitzer to date. The dummy projectile is the same as that used in the old 240-mm howitzers.

SHELL, H.E., M114. This projectile is longer (approx. 38 in. as compared to 32.68 in.) and has a larger radius of ogive than the Mk. III for the old howitzers. A wider rotating band (about 2½ in.) is required to withstand the power of the new weapon. The base cover, usually steel, is secured with an overlapping spot, or continuous resistance weld entirely around its circumference. No bushing is used in the nose, since the nose is of a size to take new boosters.

Fuzes and boosters. FUZE, P.D., M51, with Booster M21 or Fuze M51A1 with Booster M21A1, or FUZE, time, mechanical, M67, with Booster M21A1 is assembled to the M114 Projectile at the time of use. These fuzes and boosters are discussed in the chapter on 155-mm ammunition.

CHARGE, propelling, base and 3 increments, NH powder. See the chapter on 155-mm ammunition for a general discussion on this type of multisection charge. This charge, with the exception of the dummy charge which was described under old 240-mm howitzer ammunition, is the only charge provided for the new M1 Howitzer. Information as to weight, size, etc., is not available at this time. However, the charge is more powerful than those used in the old howitzer and is therefore heavier.

Primers. The Mk. II or Mk. IIA 21-grain Percussion Primers initiate the propelling charge for 240-mm Howitzers M1. These primers together with the Mk. IIA1 are discussed with primers for 155-mm guns. A new, 18-grain Percussion Primer Mk. IIA3 is listed in SNL R-3, but information as to its use and construction is not available at this time.

Packing for shipment and storage. The packing of the components of a complete round is the same as for complete rounds of old 240-mm howitzers, except that old Fuzes M46 and M47 are eliminated, and that the base and increment propelling charge is packed only in cartridge storage cases.

FURTHER REFERENCES: SNL P-1, P-2, P-6, P-8; Complete Round Chart No. 5981; Ordnance Drawings; OS 9-20.

Chapter 15

Ammunition for 14-inch Guns

GENERAL.

The purpose of this chapter is to present 14-inch ammunition as a representative sample of ammunition used in the large guns. There are several different models of 14-inch guns in the service. These include M1907, M1907MI, M1909, M1910MI, and M1920MI-MII. They are used cainly on railroad mounts for coastal defense but may, in some cases, be used for land defense purposes with fixed mounts. With the rise of aviation as a major factor in warfare, a large portion of coastal defense has been taken over by aircraft.

In 14-inch, as well as in other separate loading ammunition, the complete round consists of a projectile, a propelling charge, and a primer.

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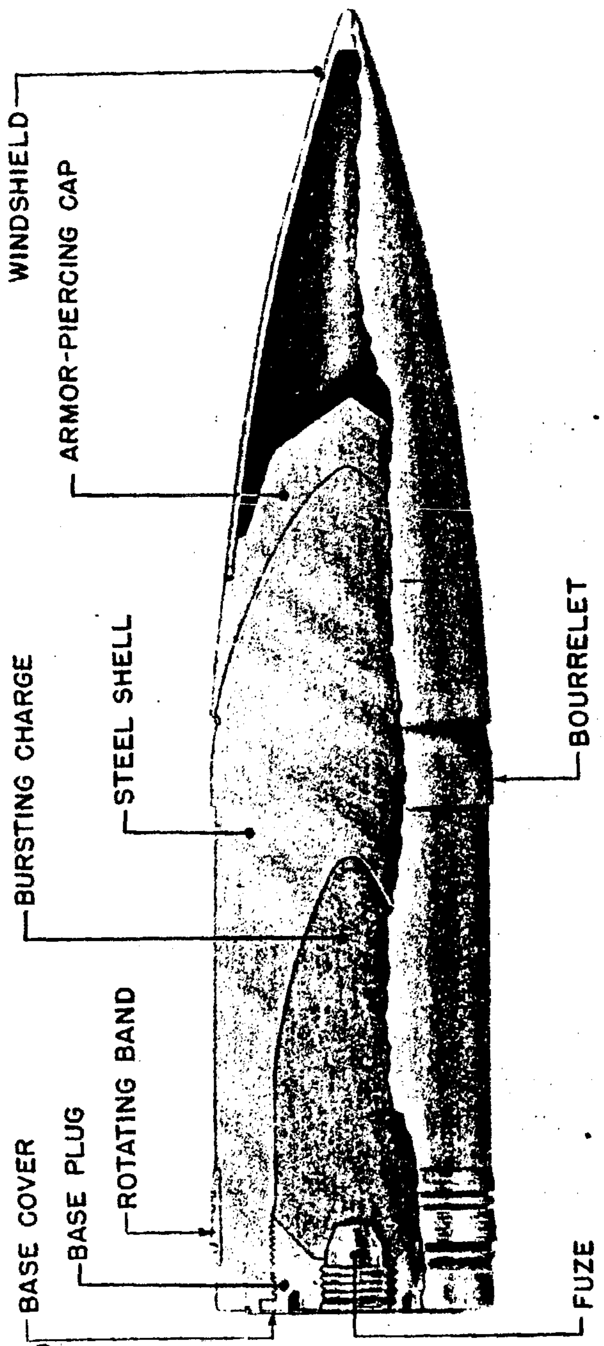
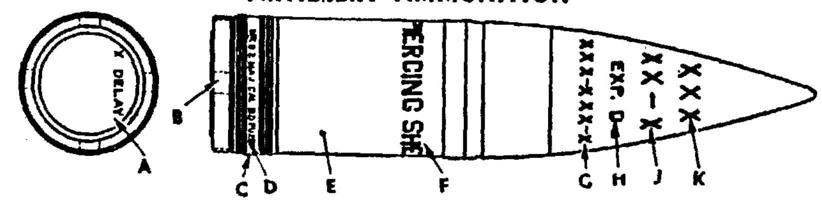


Figure 210 — Projectile, Armor-piercing

ARTILLERY AMMUNITION



(PROJECTILES PAINTED OLIVE DRAB, STENCILED IN YELLOW)

A — BASE COVER IS STENCILED WITH THE AMOUNT OF DELAY OF FUZE.
B — FOUR YELLOW STRIPES, 2 INCHES WIDE, INDICATE THAT THE FUZE HAS NOT BEEN ASSEMBLED IN THE PROJECTILE. THESE STRIPES ARE PAINTED OUT WITH OLIVE DRAB PAINT AFTER FUZE HAS BEEN ASSEMBLED.
C — THE AMMUNITION LOT NUMBER (G), IN ADDITION TO BEING PAINTED ON THE PROJECTILE, IS ALSO STAMPED ON THE ROTATING BAND ON THE OPPOSITE SIDE FROM FUZE STAMPING.
D — TYPE OF FUZE TO BE ASSEMBLED IN PROJECTILE AFTER PROJECTILE HAS BEEN FUZED. THE LOT NUMBER OF FUZE IS STAMPED ON IMMEDIATELY FOLLOWING THIS.
E — CALIBER AND TYPE OF CANNON, MARK NUMBER OF PROJECTILE, LOT NUMBER OF UNFILLED PROJECTILE INITIALS OR SYMBOL OF MACHINING PLANT, AND INSPECTOR'S STAMP (STAMPED ON PROJECTILE, UNDER PAINT).
F — TYPE OF PROJECTILE AND MARK NUMBER (LOCATION OF THIS STENCILING INDICATES CENTER OF GRAVITY OF LOADED AND FUZED PROJECTILE).
G — AMMUNITION LOT NUMBER OF FILLED PROJECTILE.
H — EXPLOSIVE FILLER.
J — CALIBER AND TYPE OF CANNON.
K — WEIGHT OF LOADED AND FUZED PROJECTILE (IN POUNDS).

RA PD 69067

Figure 211 — Marking for Armor-piercing and Deck-piercing Projectiles

PROJECTILES.

There are four types of projectiles used in 14-inch guns. Classified as to filler, they are as follows:

Type	Filler
Armor-piercing	Explosive D
High-explosive	Explosive D
Target-practice	None, or sand
Dummy	None

Armor-piercing Projectiles.

General. Since the primary function of 14-inch guns, in so far as the Army is concerned, is to protect coast lines, armor-piercing projectiles for the purpose of penetrating the armor plate of ships are most used. At one time armor-piercing projectiles were subclassified as "armor-piercing shot" and "armor-piercing shell." "Armor-piercing shot" applied to a projectile with relatively thick walls, and a correspondingly small-explosive charge. "Armor-piercing shell" applied to a projectile with thinner walls, and a correspondingly greater amount of filler. For example, M1909, 1,660-pound, "armor-piercing shot" contains a filler of 31.30 pounds of explosive D, while the M1909, 1,660-pound "armor-piercing shell" contains 88.3 pounds of the same filler. These terms have been discontinued in favor of the term "armor-piercing projectile." This accounts for the differences in nomenclature in 14-inch armor-piercing rounds. The modern design of armor-piercing projectile follows more closely the design of the old armor-piercing shot.

The armor-piercing projectiles in the service consist of a number of different models, varying in minor details, as manufactured by different contractors. For convenience, these are grouped into three divisions based on the three weights of projectiles in the service; namely, 1,400 pounds, 1,560 pounds and 1,660 pounds.

Metal parts assembly. The metal parts assembly consists mainly of a hard steel body, a soft steel cap crimped to the body, and a false ogive or windshield threaded to the cap. The body has a cavity machined into the base to receive the filler. This cavity is closed off with a heavy base plug which seats the fuze and screws into the body behind the filler. A recess approximately 4.66 inches wide and either knurled, waved, or scored at the bottom is machined into the body a few inches above the base to receive a copper rotating band. A circular groove is machined into the base to receive a copper base cover. The bases of the armor-piercing projectiles are not tapered. The assembly of the windshields give the projectiles a large radius of ogive (varies from approx. 98 to 126 in.). If fuzes are not assembled, a fuze hole plug threads into the base plug. The lengths of projectiles vary from a little over 4 feet to approximately 5 feet.

Filler. All 14-inch armor-piercing projectiles are filled with explosive D.

FUZE, B.D., Mk. X. The Base-detonating Fuze Mk. X, is used in all 14-inch armor-piercing projectiles. However, some A.P. shot and shell issued prior to January 1, 1943, may be fitted with earlier models of fuzes. The interior mechanism and function of the Mk. X is identical to that of the M60 Base-detonating Fuze used in 155-mm A.P. shell. The only difference in the two fuzes is the size of the outside body threads and the fact that the M60 body has a large flange at the base.

Fourteen-inch projectiles may be shipped and stored with or without fuzes. In order that the service may note whether or not the projectile is fuzed, four 2-inch black stripes, equally spaced and running parallel to the axis of the projectile, are painted from the base to the rotating band when the projectile is unfuzed. When the projectiles are fuzed, these black stripes are painted out with olive-drab paint. The nomenclature of the fuze is stamped on the rotating band. The time of the delay of the fuze is stenciled on the base cover.

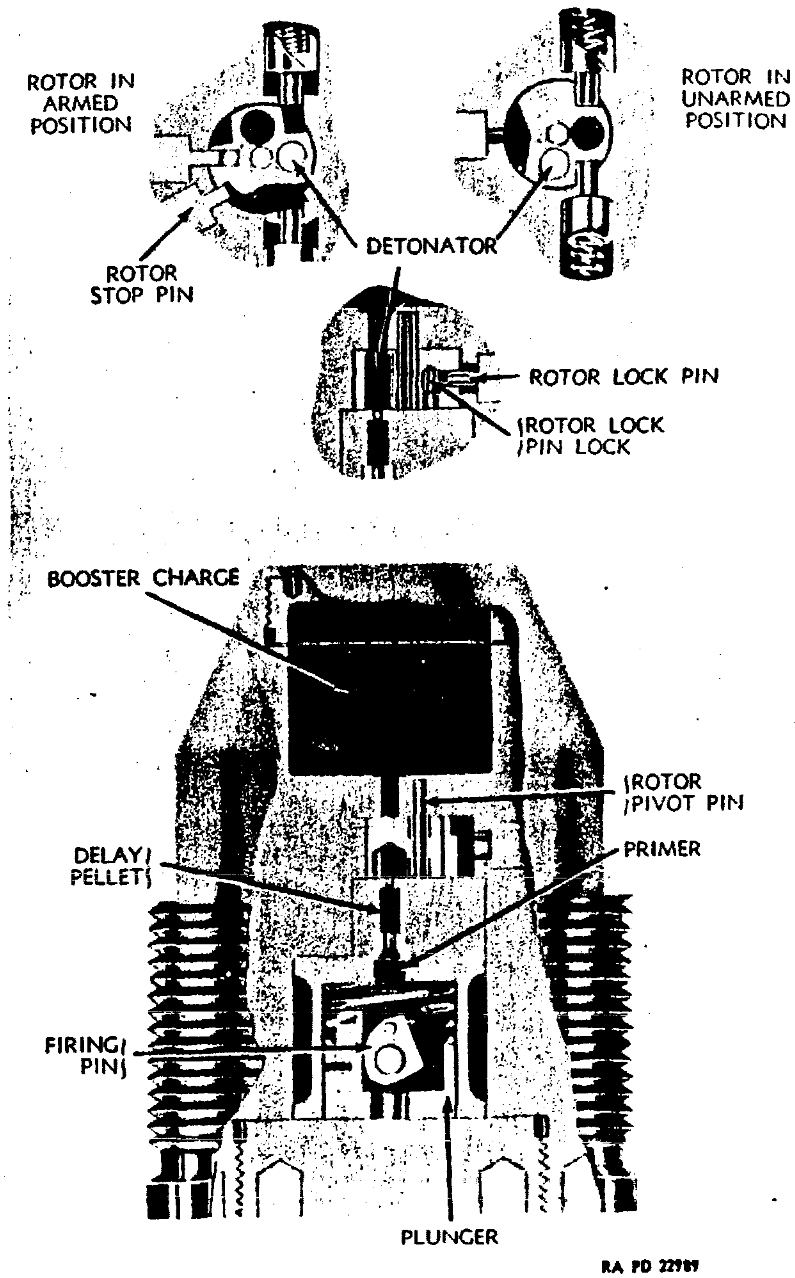
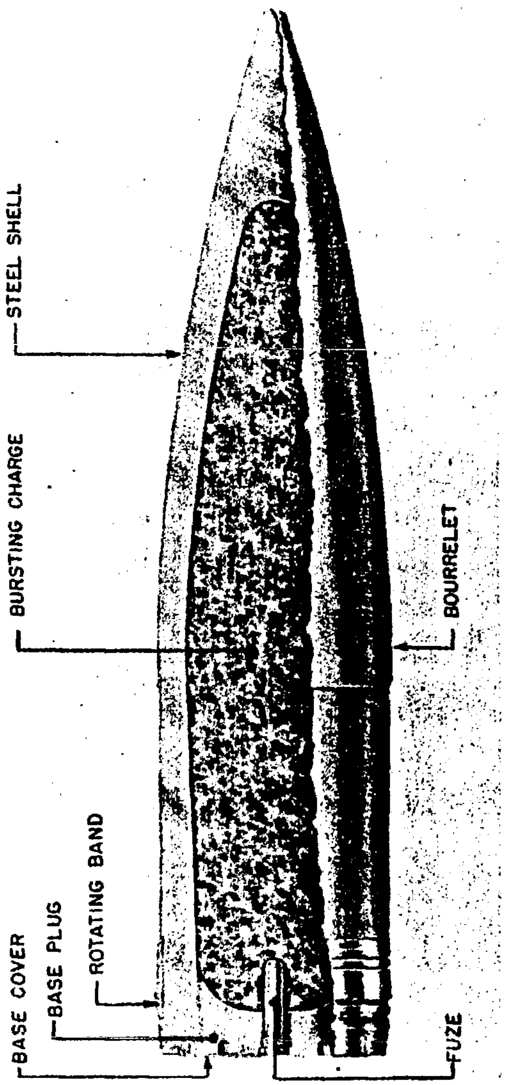


Figure 212 — FUZE, B.D., Mk. X



RA PD 5300

Figure 213 — Projectile, High-explosive

Service projectiles. The armor-piercing projectiles in use in the service are as follows:

PROJECTILE, A.P., 1,400-lb, Mk. VII, Mod. 6A1
PROJECTILE, A.P., 1,400-lb, Mk. VIII, Mod. 9A1
PROJECTILE, A.P., 1,560-lb, Mk. VI
PROJECTILE, A.P., 1,560-lb, Mk. VII
PROJECTILE, A.P., 1,560-lb, Mk. IX
PROJECTILE, A.P., 1,560-lb, Mk. X
SHELL, A.P., 1,660-lb, M1909
SHOT, A.P., 1,660-lb, M1909

Only one of these projectiles, the 1,560-pound Mk. VI is standard for both issue and manufacture. With the exception of the 1,660-pound Shot M1909, which is not used in the M1920MI-20MII Guns, any of the armor-piercing projectiles may be used in all models of 14-inch guns.

High-explosive Projectiles.

General. There is only one high-explosive projectile designed for use in 14-inch guns. It is used in the M1920 Guns only for demolition of targets which do not require an armor-piercing projectile. High-explosive projectiles have comparatively thin walls and a greater quantity of explosive filler than armor-piercing projectiles, and therefore cannot be used effectively against armor plate.

PROJECTILE, H.E., 1,200-lb Mk. XI. This projectile is standard for issue and manufacture, and is designated for use in M1920 Guns only.

The metal parts assembly consists of a forged steel body, a heavy forged steel base plug which screws into the rear of the filler cavity, a copper rotating band, and a copper base cover. The filler cavity extends from the base to within about 11 inches of the blunted nose of the body. The radius of ogive of 127.26 inches, and short cylindrical taper of 6 degrees at the base, streamline the projectile in flight. A recess, 4.65 inches wide and ribbed at the bottom, is machined into the body 2.25 inches above the base to receive the rotating band. The base plug seats the Mk. V Fuze and has a circular groove cut into its circumference to receive a copper base cover. The base cover is assembled after the base plug is screwed into the base of the shell. When the fuze is not shipped assembled to the projectile, a die cast shipping plug screws into its place.

The filler is approximately 167 pounds of explosive D. Even though the projectile is for demolition of targets other than armor plate, for best effect it must, on some occasions, do some penetrating before exploding. This fact accounts for the comparatively insensitive explosive D being used in place of TNT.

The B.D., Mk. V, Major Caliber Fuze is exactly the same as the B.D. Mk. V Medium Caliber Fuze (described and illustrated with

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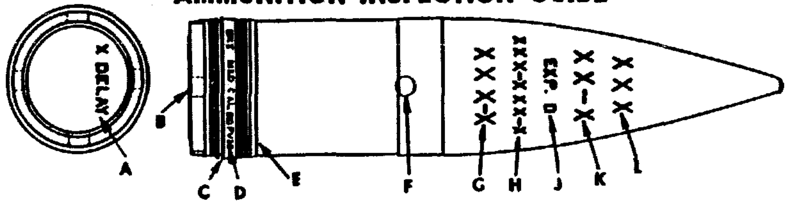


(FOR 10", 12", 14", AND 16" CANNON, PROJECTILE PAINTED OLIVE DRAB; STENCILED IN YELLOW)

A — BASE COVER IS STENCILED WITH THE AMOUNT OF DELAY OF FUZE.
B — FOUR YELLOW STRIPES, 2 INCHES WIDE, INDICATE THAT THE FUZE HAS BEEN ASSEMBLED IN THE PROJECTILE. THESE STRIPES ARE PAINTED OUT WITH OLIVE DRAB PAINT AFTER THE FUZE HAS BEEN ASSEMBLED.
C — THE AMMUNITION LOT NUMBER (H), IN ADDITION TO BEING PAINTED ON THE PROJECTILE, IS ALSO STAMPED ON THE ROTATING BAND ON THE OPPOSITE SIDE FROM THE FUZE STAMPING.
D — TYPE OF FUZE TO BE ASSEMBLED IN PROJECTILE. AFTER PROJECTILE HAS BEEN FUZED, LOT NUMBER OF FUZE IS STAMPED IMMEDIATELY FOLLOWING THIS.
E — CALIBER AND TYPE OF CANNON. MARK NUMBER OF PROJECTILE. LOT NUMBER OF UNFILLED PROJECTILE. INITIALS OR SYMBOL OF MACHINING PLANT AND INSPECTOR'S STAMP (STAMPED ON PROJECTILE UNDER PAINT).
F — LOCATION OF CENTER OF GRAVITY OF LOADED AND FUZED PROJECTILE.
G — MARK NUMBER OF PROJECTILE.
H — AMMUNITION LOT NUMBER OF FILLED PROJECTILE.
J — EXPLOSIVE FILLER.
K — CALIBER AND TYPE OF CANNON.
L — WEIGHT OF LOADED AND FUZED PROJECTILE (IN POUNDS).

NOTE:—HIGH EXPLOSIVE PROJECTILES FOR 10" AND 12" CANNON ADAPTED FOR POINT DENOTING FUZES ARE MARKED AS SHOWN ABOVE EXCEPT THAT (A), (B), (C) AND (D) ARE OMITTED AND (J) MAY BE "TNT", "AM 50-50", OR "AM 80-20" RA PD 69068

Figure 214 — Marking for High-explosive Projectiles—Base Fuzed

3-in. seacoast ammunition), except for the size of the head or base that assembles to the lower part of the fuze body. A larger head is required for screwing into the base plug of the 14-inch high-explosive shell.

Target-practice Projectiles.

General. Fourteen-inch projectiles for target practice are provided in two types; cast iron and sand-loaded. They are used to give personnel practice in loading and unloading weapons and in firing at a target.

Cast iron projectiles. The cast iron projectiles have the outside dimensions and features of a service round excepting, of course, the base covers which are not needed. The projectile is made in two parts: a solid, cast iron body with a cavity left in the nose to bring it to service weight, and a nose plug which threads into the cavity. These cast iron shell have the same center of gravity as the service rounds which together with like dimensions and weights, give practice and service projectiles practically the same flight characteristics.

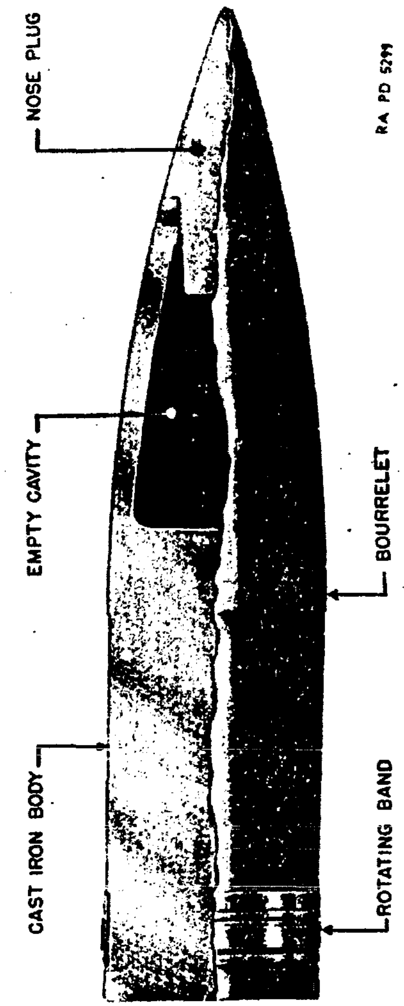
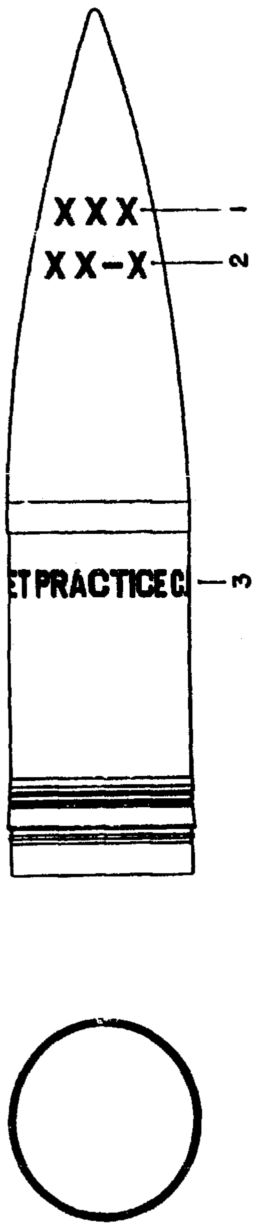


Figure 215 — Projectile, Target-practice



1. Weight of projectile (in pounds).
2. Caliber and type of cannon.
3. Type of projectile and mark number. (Location of this stenciling indicates center of gravity of projectile.)

Figure 216 — Marking for Target-practice Projectile

ORD 10565A

Sand-loaded projectiles. There are only two sand-loaded, target-practice, projectiles used in 14-inch guns; the 1,500-pound, Mk. IX, Mod. 2 and the 1,200-pound, Mk. XI, Mod. 2A1. The 1,200-pound target-practice projectiles are provided by loading empty High-explosive Projectiles, Mk. XI, Mod. 2A1, to the required weight with sand at the point of use. The fuze cavity is closed with a steel plug or dummy fuze. The 1,200-pound practice shell is used to simulate the 1,200-pound, high-explosive shell for practice purposes. The 1,400-pound, Mk. IX, Mod. 2, Empty Shell is made up in the same manner as the 1,200-pound projectile.

Service projectiles. The target practice projectiles used in the service are as follows:

SHELL, C.I., 1,400-lb, Mk. XIV
SHELL, C.I., 1,560-lb, Mk. XI
SHELL, C.I., 1,660-lb, M1909
SHELL, empty for sand-loading, 1,200-lb, Mk. XI, Mod. 2A1
SHELL, empty for sand-loading, 1,400-lb, Mk. IX, Mod. 2

The cast iron, Mk. XIV, and the sand-loaded, Mk. XI, Mod. 2A1, are standard for both issue and manufacture. The 1,400-pound, Mk. IX, Mod. 2, is to be substituted for cast iron, Mk. XIV, until the present supply is exhausted.

Dummy Projectiles. Dummy projectiles are designed to train troops in loading and unloading weapons without the expense and danger of actually firing the projectile from the gun. The 14-inch dummy projectiles are of the sliding ring type and, except for size, are very similar to the dummy projectile described in the chapter on 155-mm ammunition. Dummy projectiles for 14-inch guns are provided in two weights, as follows:

PROJECTILE, dummy, 1,560-lb, M4
PROJECTILE, dummy, 1,660-lb, Mk. I

Mk. I is standard for issue only; M4 is standard for both issue and manufacture.

Painting and marking. Fourteen-inch projectiles are painted and marked according to the regular Army system.

PROPELLING CHARGES.

General. Two classes of propelling charges were furnished for the 14-inch guns: the single section class, and the multisection class. The single section class is no longer standard for issue or manufacture. However, there may still be some in the field to destroy. The equally related type of multisection charge is used in 14-inch guns. (See chapter on 155-mm ammunition for a general discussion on classes and types of propelling charges.) Some equal section charges are "stacked" and some are not. The term "stacked" refers to charges

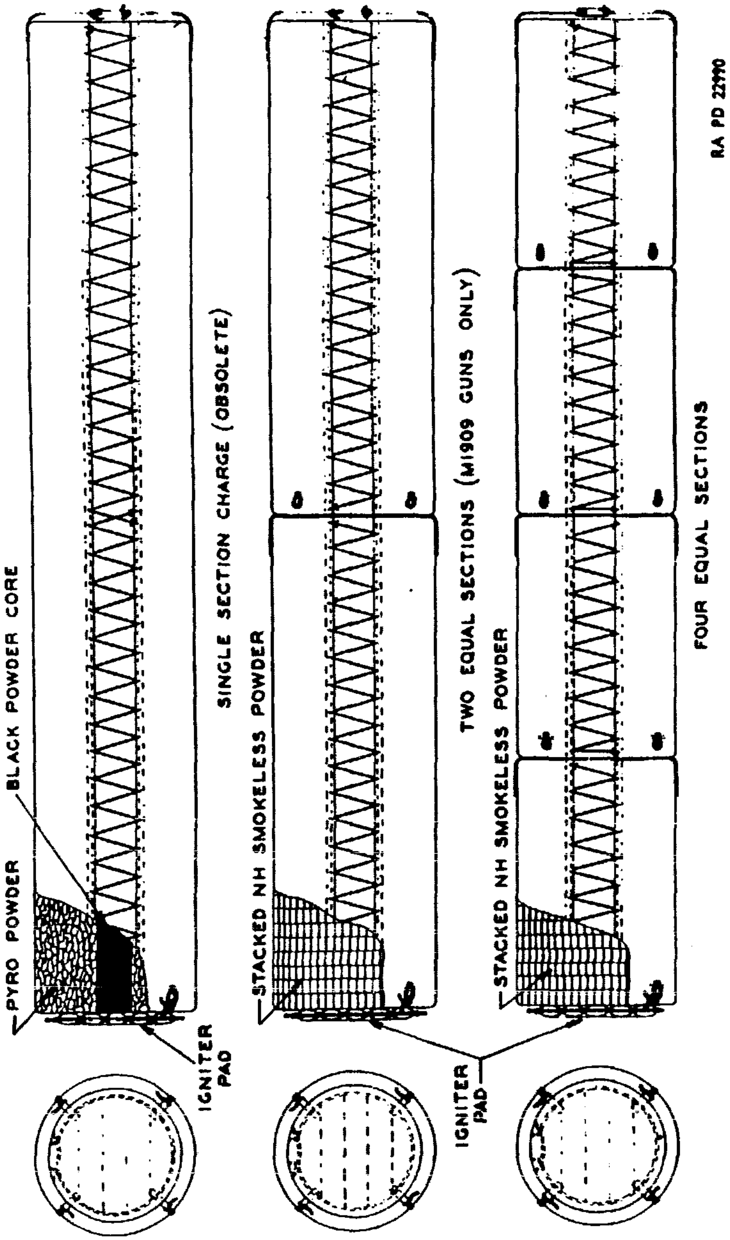


Figure 217 — Propelling Charges for 14-inch Guns

in which the powder grains are piled in orderly fashion, end to end, throughout the charge. In charges that are not stacked, the powder is just poured into the cartridge bags. Only propelling charges in which new NH smokeless powder is "stacked" are standard for issue and manufacture. The old charges filled with pyro powder must be inspected annually. The new NH powders in propelling charges must be inspected after 20 years have elapsed from the date of manufacture.

Single Section Charge. The single section charge is made up of one bag, having a central tube which passes longitudinally through the center of the bag. This tube is filled with approximately 72 ounces of black igniting powder. Approximately 14 ounces of black igniting powder is also quilted to each end of the bag. The bag is laced along both sides to make it more rigid.

Equally Related or Aliquot Parts Charges. The M1909 14-inch Gun takes a charge of two equal sections; all other 14-inch guns use charges made up of four equal sections. The size and weight of these charges varies with the guns they are to be used in. The weights vary from 320 pounds for M1907 Guns to 480 pounds for M1920 Guns. The sections are all made up in the same way, however. NH powder is stacked into a cartridge bag made of wool, silk, or mohair. The stacking of the grains of powder is accomplished with a form made especially for that purpose. The cartridge bags are laced along either side to make them more rigid. An igniter pad containing approximately 3 pounds is attached to one section of the charge with commercial brass safety pins during shipment and storage. When the charge is to be loaded into the gun, these safety pins are removed, and the igniter pad is attached to the base section by stitching in at least three places. An igniter protector cap is placed over the igniter pad and is secured to the charge with a draw string.

PRIMERS.

General. Electric primers are used to ignite the propelling charges for all 14-inch guns except the M1920MI and M1920MII. A friction primer is used as a substitute for the electric primer in case of emergency. M1920MI and M1920MII Guns use a combination electric and percussion primer for ignition of the propelling charge.

PRIMER, Electric, M30.

Description. This primer is initiated by heat resulting from the resistance offered by a platinum ignition wire to an electric current (fig. 219). A current of 1.1 amperes is required to fire the primer. It is usually supplied by a special hand-operated magneto which is considered safest for the work. The primer explosive train consists

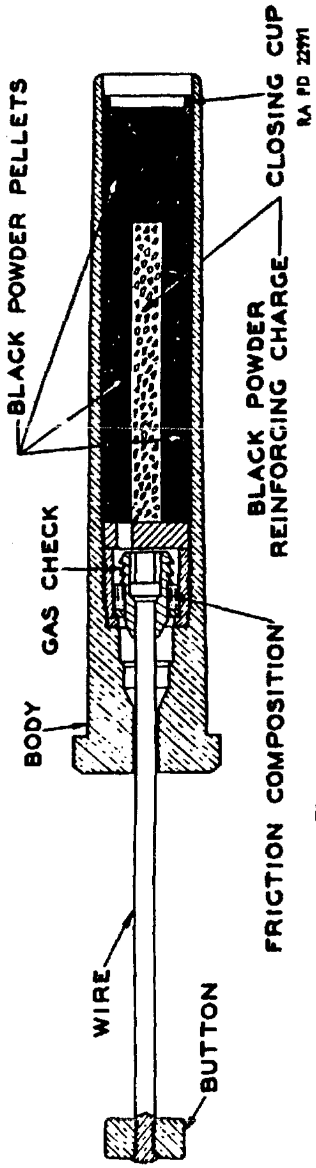


Figure 218 — PRIMER, Friction, M1914

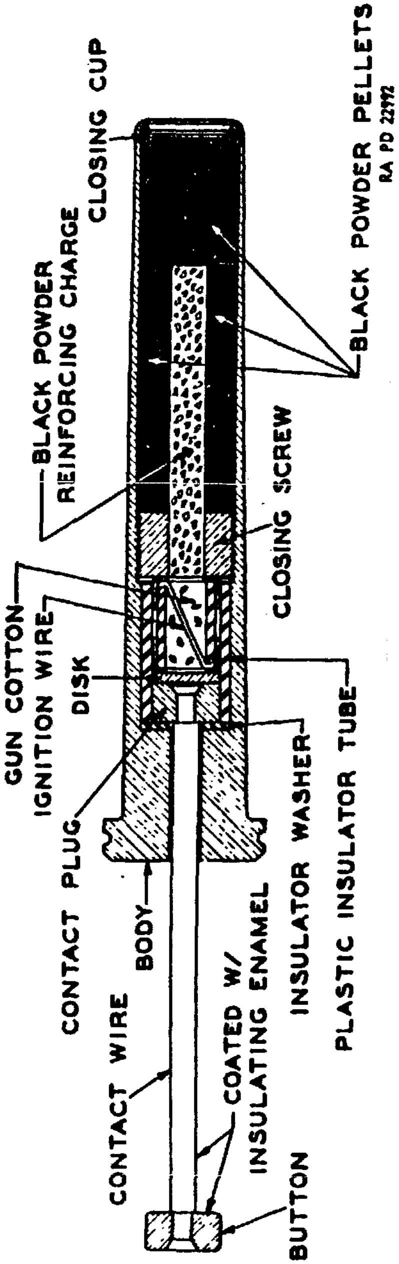


Figure 219 — PRIMER, Electric, M30

of guncotton wrapped around the platinum ignition wire; 3 grains of loose black powder over the guncotton and extending into a hollow black powder pellet weighing 13.39 grains; and a solid pellet of black powder weighing 22.80 grains. The primer is sealed at the forward end with shellac and a chipboard closing cup.

Function. One electrical contact is made with the button (fig. 219) and the other is made with the body, which, in contact with the firing mechanism of the gun, forms the ground. The electrical current therefore, flows through the system as follows:

1. From the magneto to the button.

2. From the button through the contact wire to the contact plug, which is insulated from the body by a plastic insulator tube and an insulator washer of fiber. The contact wire is insulated with insulating enamel.

3. From the contact plug, through the brass disc, to the rear gilding metal cap which is in contact with the platinum ignition wire. The gilding metal cap is insulated from the body by the outer insulator tube, and from the forward gilding metal cap by the inner plastic insulator tube.

4. Through the ignition wire to the forward gilding metal cap which contacts the closing screw.

5. Through the closing screw to the primer body and breech mechanism. The remaining connection on the magneto is attached to the firing mechanism.

At the point of the ignition wire in the circuit, the resistance offered to the flow of electricity results in enough heat to ignite the guncotton which initiates the primer explosive train.

PRIMER, Friction, M1914.

Description. The construction and explosive train of the friction primer is similar to that of the electric except that the explosives are initiated by a serrated gas check which is drawn through friction composition (fig. 218).

Function. The firing leaf of the gun engages the button, which is threaded and riveted to the wire. When the lanyard which is attached to the firing leaf is pulled, the wire draws the serrated gas check through the friction compound, causing it to explode. The resulting flame ignites the black powder reinforcing charge and pellets. The primer is a close fit in its seat in the spindle of the breechblock, and the walls of the primer body are made thin so that they are expanded by the gas pressure against the primer seat, thus making a gastight seal. After the gas check is pulled through the friction composition, it seats itself in the cone-shaped recess in the head of the primer body, thus preventing escape of the powder gases through the primer.

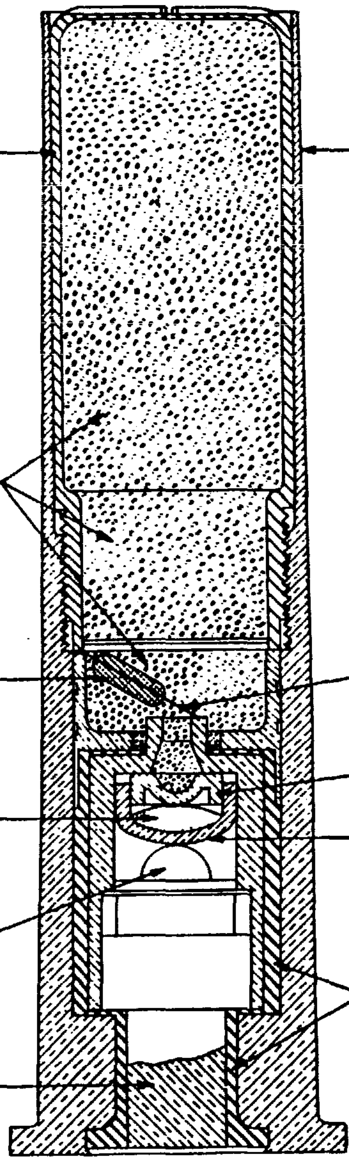


Figure 220 — PRIMER, Combination, Electric and Percussion, Mk. XV, Mod. 1

PRIMER, Combination, Electric and Percussion, Mk. XV, Mod. 1. The explosive train of this primer consists of priming mixture, a loose black powder reinforcing charge, and a main charge of approximately 30 grains of loose black powder. The explosive train may be initiated either by a blow on the firing plug or by heat generated by the resistance offered to an electric current by the ignition wire (fig. 220).

Function when initiated by a blow. When firing by percussion action, the striker, or firing pin in the breech mechanism of the gun drives the plunger or firing plug against the percussion cup. The percussion cup is dented inward, crushing the primer composition against the anvil, and exploding it. The resulting flame flashes through vents in the anvil and ignites the loose black powder reinforcing charge and main charge.

Function when initiated by electricity. One electrical connection is made to the firing plug and the other to the body. The current flows through the brass firing plug and sleeve and through the ignition wire to the body (fig. 220). The firing plug and sleeve are insulated from the body, thus preventing short circuiting. The ignition wire is wrapped with guncotton. The heat caused by the resistance of the ignition wire to the flow of electricity is sufficient to ignite the guncotton. The guncotton in turn ignites the loose black powder reinforcing and main charges.

PACKING.

The components of a complete round of 14-inch ammunition are packed as follows:

Projectiles. Armor-piercing, high-explosive, and dummy projectiles are packed one per crate. These crates are made of heavy lumber, and furnish protection to the rotating band, windshield, and cap. Target-practice projectiles may be shipped uncrated. Whether crated or uncrated, the rotating band is always protected by a rope grommet.

Fuzes. Ordinarily fuzes will be shipped assembled in the loaded projectiles, however, for replacement purposes, shipment of fuzes is made as follows: FUZES, B.D., Mk. V, are packed 1 per metal container, 25 containers (25 fuzes) per box.

FUZES, B.D., Mk. X, are packed 1 per metal container, 20 containers (20 fuzes) per box.

Propelling Charges. The 14-inch gun propelling charges are packed in cartridge storage cases, one half charge per case. An igniter pad is included in each case. Some of the older charges may be packed one full charge per cartridge storage case. These cases

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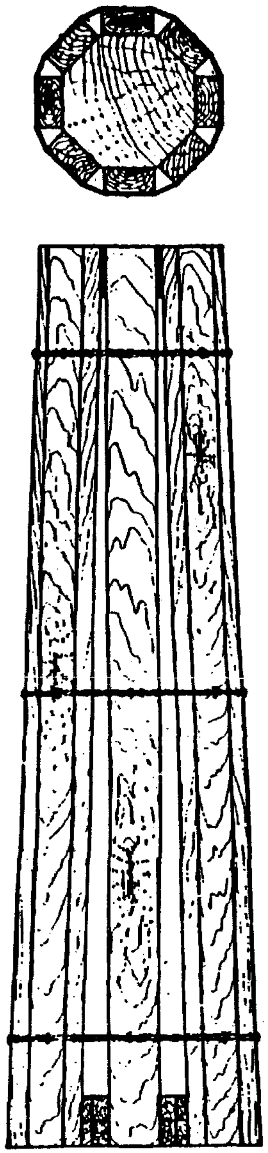

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Figure 221 — Crate for Shipping 14-inch Projectiles

are crated for export. Peacetime storage requires removal of export crates.

Primers. Primers used in 14-inch guns are packed as follows:

Electric and friction primers are packed 20 primers per metal container, 25 containers (500 primers) per box. Combination electric and percussion primers are packed 24 primers per metal container, 42 containers (1,008 primers) per box.

FURTHER REFERENCES: SNL P-3, P-4, P-7, and P-8; Complete Round Chart No. 5981; OS 9-20; Ordnance Drawings.

SECTION VII.

BOMBS FOR AIRCRAFT

Chapter 1

Introduction

DEVELOPMENT.

Improvised Bombs. The development of bombs depends on the previous development of aircraft. In the early part of the eighteenth century, long before man thought of using bombs, he perceived the playful idea of sending gaily colored bags of paper, buoyed up by hot air, into the sky. The military significance of this idea was not realized until 1794 in the battle of Maubeuge. The Austrians were surprised to see, hovering above the French lines, huge paper bags having two baskets. One basket contained hotcoal or charcoal to emit hot gases so as to keep the balloon aloft. In the other basket sat an observer to keep watch on all of the Austrian movements far beyond the range of vision of the average man.

In 1849 in a battle between the Austrians and Venetians, the Austrians found that the range of their batteries was too short to reach the city of Venice. When the wind was in the proper direction, blowing toward the city of Venice, the Austrians attached small bombs with time fuzes to paper balloons. The balloons were capable of lifting the bombs to altitudes of 30 feet, and drifted into the city. When well inside the city, the time fuzes exploded the bombs. Some bombs exploded in the canals of Venice. The material and physical damage which resulted was slight; however, the psychological effects were great.

In 1899, at the Hague Conference, an agreement was reached to prohibit the throwing of projectiles from balloons. In 1903, the Wright brothers invented the airplane. In 1907, the restrictions of the Hague Conference were removed.

By 1910, military authorities of all the major powers had begun experimenting with airplanes. The plane was regarded, however, as a more efficient means for gaining information in the field, and not so important for dropping explosives in enemy territory. The earliest recorded use of bombs dropped from planes was made in 1911 by the Italians in Tripoli. The Italians desired to drive the Arabs and Berbers from the strategic harbor of Tripoli. These early bombs were makeshift equipment dropped by hand over the side of a plane.

During the first few weeks of World War I, planes were used for observation purposes only. These planes had no guns nor bomb sights. It was customary during these few weeks for hostile aviators meeting over the lines to salute each other and then proceed to their respective missions. At the end of the first 3 months, however, all belligerents had organized squadrons to drop bombs. These bombs were crude artillery shells, such as 3-inch and 75-mm, equipped with fins and fuze. The planes had no sighting apparatus and no bomb racks. Bombers operated as free lancers, and accuracy depended on luck and judgment. A bomb which struck about ¼ mile from its target was considered fair aim.

By the end of World War I, bomb squadrons were of great importance, due to the vast improvement in planes, including speed, load capacity, bomb sights, and bomb racks. Also, there was a great improvement in bombs. Special purpose bombs such as incendiary, demolition, and fragmentation appeared. The size of the demolition bomb increased. During the war, the United States government manufactured large quantities of bombs. However, the United States forces in France were limited to bombs of British and French design. No bombs of American manufacture reached the front in time. Demolition bombs used at that time were 45-pound, 122-pound, and 230-pound. The fragmentation bombs used was the 25-pound British Cooper bomb.

Demolition Bombs. The demolition bomb as known today was developed during World War I. The demolition bomb as its name signifies was designed to produce a demolishing effect by producing a blast and mining result. It, therefore, carried the greatest percentage of filler possible.

The first demolition bombs made by the United States were the Mk. I series. These followed the streamlined tear-drop design of the French demolition bombs, and were manufactured in 25-, 50- and 100-pound sizes. None of these bombs saw service in World War I. The construction consisted of welding separate steel sections together by means of circumferential and longitudinal welds. The bombs contained approximately 50-percent explcsive filler. The fins were known as conical type fins. The fins were four in number, and extended over the rear one-third of the case. They were made from light sheet steel. The rear tip was welded to a cone which covered the fuze and completed the streamline contour of the case. The front tips were held to the bomb case by screws threaded into lugs which were welded on the case. A tail fuze of the arming pin type was employed. These bombs had many disadvantages, several of which can be listed as follows:

The body welds provided weak spots where the case might split open upon impact before proper penetration and detonation could be obtained.

The fins were not stable enough to produce satisfactory flight.

The fins had to be removed to fuze the bomb.

The fuze was armed immediately after withdrawal of the arming wire, and therefore could function while still in the bomb bay of the plane.

The small nose opening did not lend itself well to rapid and economical filling with explosive filler.

The method of manufacture of the bomb cases was long and costly.

In an attempt to remedy the faults of the Mk. I Bombs, a series of modifications and new bombs were developed. Some of the modifications included the elimination of the 25- and 50-pound bombs because they were too small for effective blast. Larger size bombs such as the 300-, 600-, 1,100-, and 2,000-pound demolition bombs were introduced. Nose and tail fuzes were included to decrease the chance of duds, and the fin assembly although still conical was made much more stable and permitted the tail fuze to be assembled without being removed. These modifications took place over a period of years, and later, some of the smaller weight demolition bombs had the tail assembly changed from conical to box type. All had a new nose fuze and tail fuze with appropriate adapter boosters included where necessary in a modernization program so as to incorporate some of the advantages in these bombs which the new M-series bombs at that time included. These bombs were known as the Mk. IMI, Mk. IMII, Mk. IMIII, Mk. IMIV, Mk. IMV, Mk. III, and Mk. IIIMI. The modification depended on the weight of the bombs. For example, the MI modification in the 100-pound bomb did not correspond to the MI modification in the 2,000-pound bomb.

A Mk. II series of bombs was later designed and tested at Aberdeen Proving Ground. This was known as a thick case bomb. These bombs were similar in construction to the 100-pound Mk. IMI Bomb in every respect, except that the cases were made of extremely heavy material, very much like our semiarmor-piercing bombs of today. The case was designed heavy enough to withstand proper penetration of any target so as to determine whether the use of flying fragments or blast had the greater effect. As a result of the test, this series was never standardized, for it was found that extremely heavy cases were not needed to withstand impact. Blast effect was found to be the significant factor in demolition bombs.

Later still, a Mk. III-series of bombs known as a thin case bomb was developed. Again the shape and construction was similar to the 100-pound Mk. IMI Bombs. The filler percentage was increased, however, to 55 percent. This series of bombs was found to be satisfactory and was included in the modernization program previously mentioned.

The forerunner of the M-series was the 2,000-pound Mk. I Bomb. About 1921, when the demolition bombs were undergoing development, it was decided that experiments with larger bombs were necessary. The result was the design and manufacture of test bombs 2,000-, 3,000-, and 4,000-pound bombs. The tests, as conducted, showed that the effects of 2,000- and 3,000-pound bombs were not sufficiently different to warrant the additional weight. As for the 4,000-pound

bomb, it was decided at that time that the destructive forces of the 4,000-pound bomb were too great for any man-made target, and a plane carrying two 2,000-pound bombs had twice as great a chance of hitting the target. The 4,000-pound bomb was, therefore, discarded. The final result was the 2,000-pound Mk. I Demolition Bomb.

The design of this bomb was revolutionary in so far as the shape of body and fin assembly were concerned. The 2,000-pound bomb was cylindrical in shape and allowed in later manufacture a 1-piece construction with no welding, casting, or other difficult procedure of manufacture. The fin was box shape in construction. This shape of bomb case and fin assembly, and the construction of bomb body was the forerunner of the M-series of demolition bombs and AN-M series of GP bombs.

TYPES OF BOMBS AND FILLERS.

Demolition. This group is composed of the following:

G.P. (general purpose) . . Filled with Amatol, TNT, or composition B
L.C. (light case bombs) . . . . Filled with amatol
S.A.P. (semiarmor-piercing) . . . . Filled with amatol
A.P. (armor-piercing) . . . . Filled with explosive D
D.B. (depth bomb) . . . . Filled with torpex or TNT

Fragmentation. Filled with TNT.

Chemical (Including Incendiary). Filled with HS, WP, or incendiary composition.

Practice.

Demolition. Filled with sand and black powder spotting charge.

Fragmentation. Filled with black powder spotting charge or pyrotechnic composition.

Drill and Gage. Inert or no filler.

PAINTING AND STENCILING.

General. Bombs are painted for prevention of rust, as a means for identification, and for camouflage. All bombs, except chemical, are painted olive drab, lusterless, base color, with black stencil for camouflage purposes.

Demolition. For identification purposes, GP, LC, AP, and depth bombs have three yellow bands to indicate high-explosive filler. One band, 1 inch wide, is located at each end of the bomb body, and one, one-fourth inch wide, is at the center of gravity.

Fragmentation. Fragmentation bombs have nose and tail caps painted yellow to indicate high-explosive filler.

Practice. Practice bombs, simulating GP bombs, have three blue bands instead of the yellow bands, whereas practice bombs, simulating fragmentation bombs, have the ends painted blue instead of yellow to indicate practice bomb filler. All practice bombs except the 100-pound M38A2 have "EMPTY" stenciled longitudinally in at least four places. When the spotting charge is added "EMPTY" is painted out. The 100-pound M38A2 is shipped separately from the spotting charge which is always added in the field. When practice bombs, which contain no spotting charge, are intended to be dropped in training, the fins and rear portions will be painted black.

Drill. Drill bombs have three black bands in place of yellow to indicate inert filler.

Chemical. Chemical bombs are painted with the same color scheme as other chemical ammunition. The base color of chemical bombs is blue gray with bands and stencil color to indicate type of filler and persistency of filler.

Marking. The following information is stenciled on the bomb body:

1. *Type.* "G.P.," "A.P.," "SAP.," "DEPTH," "FRAG.," "CHEM.," or "PRACTICE" whichever applies.

2. *Weight and mark or model of bomb.* For example, 100-pound, AN-M30.

3. *Kind of filler (if filled).* Example, "TNT," "AM 50-50," "CN GAS," "WP SMOKE," etc.

4. The word "EMPTY" is stenciled on unloaded bombs containing no explosive. At the time of loading, "EMPTY" is painted out with paint of the same color as that on the bomb body. The exception to this statement is the 100-pound M38A2, as previously explained.

5. Lot number of loaded bomb.

6. Initials of loading plant, and date loaded.

PACKING AND SHIPPING.

For the purpose of packing and shipping in general, bombs can be divided into three weights: under 100 pounds, 100 pounds, and over 100 pounds.

Bombs under 100 pounds in weight including fragmentation, chemical (incendiary) and practice fragmentation bombs are usually packed and shipped in clusters completely assembled, one cluster per metal-lined wooden box. The number of bombs in the cluster depends on the shape and size of the bombs and the size of cluster.

GP bombs weighing 100 pounds are packed and shipped in metal crates with fin attached and nose and tail shipping plugs threaded into the bomb body so as to close the nose and tail openings. Chemical bombs weighing 100 pounds are packed unfuzed, without burster, in wooden boxes.

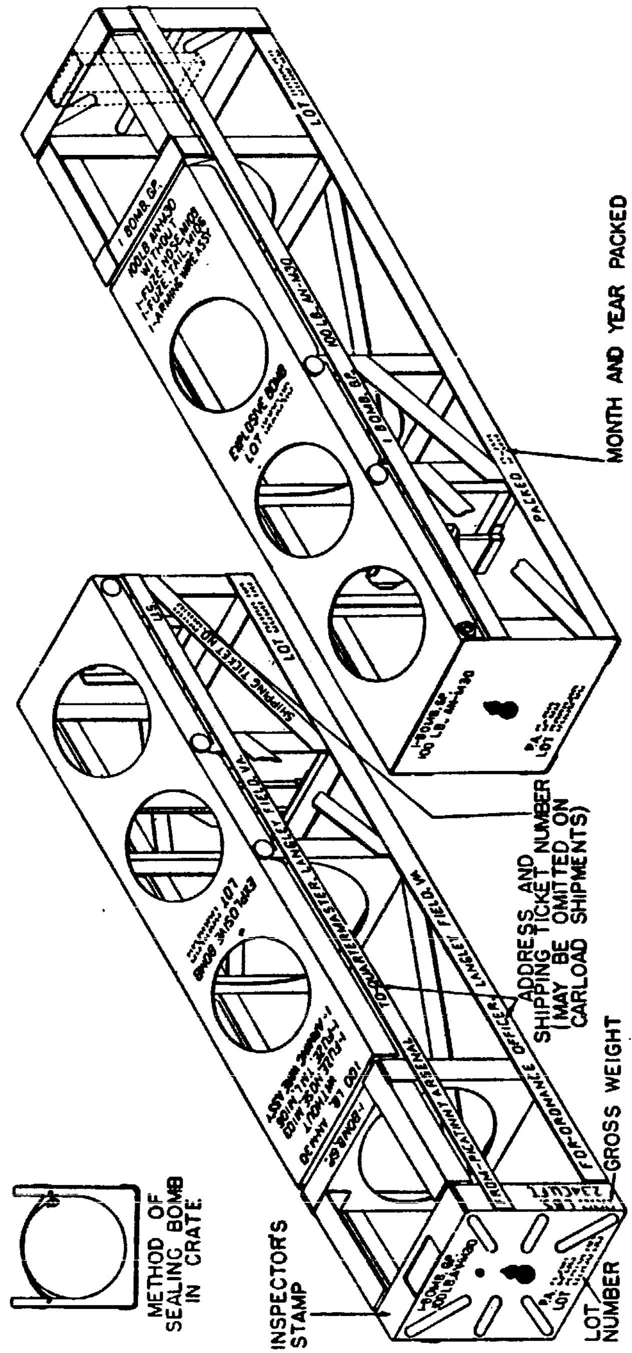

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Figure 222 — Packing Crate for 100-pound G.P. Bomb

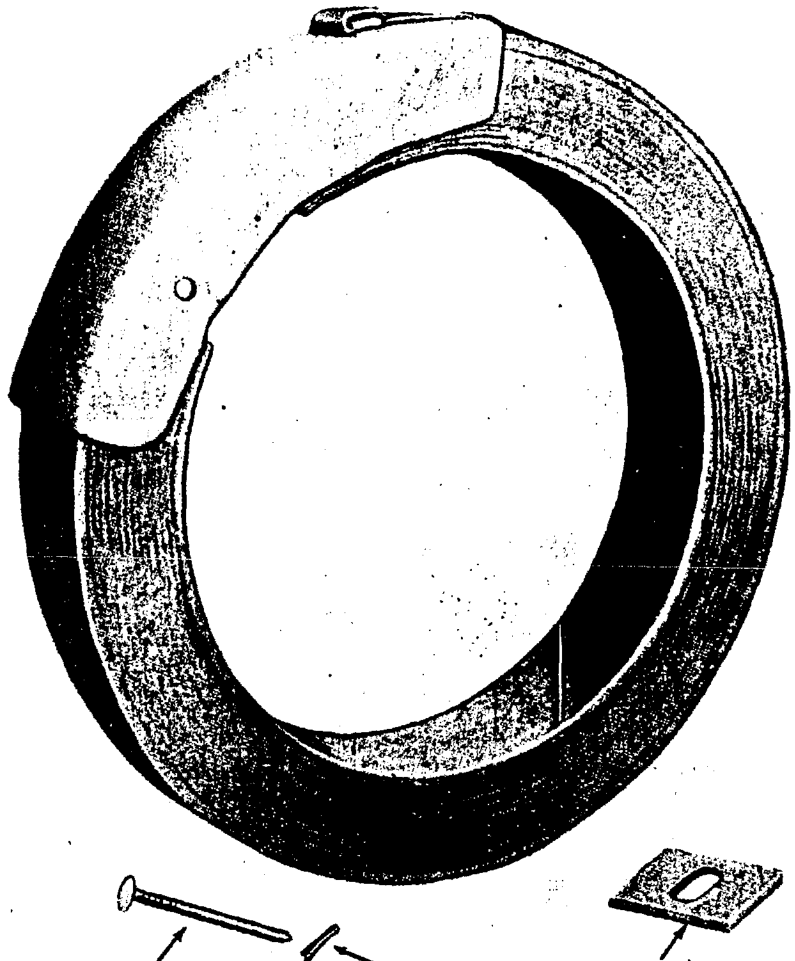

Figure 223 — Paper Shipping Band

Bombs weighing over 100 pounds such as GP, AP, SAP, LC, and depth bombs are packed in two parts. One part consists of the bomb body with shipping plugs to protect the nose and tail openings, if such are present. Shipping bands are channeled to fit over the suspension lugs around the circumference of the bomb. These bombs are provided with slots to attach slings, hooks, or any other means of handling. The shipping band protects the suspension lugs from damage and provides tracks for rolling the bomb on hard surfaces. Shipping bands are made of metal or, more recently, of layers of paper glued together.

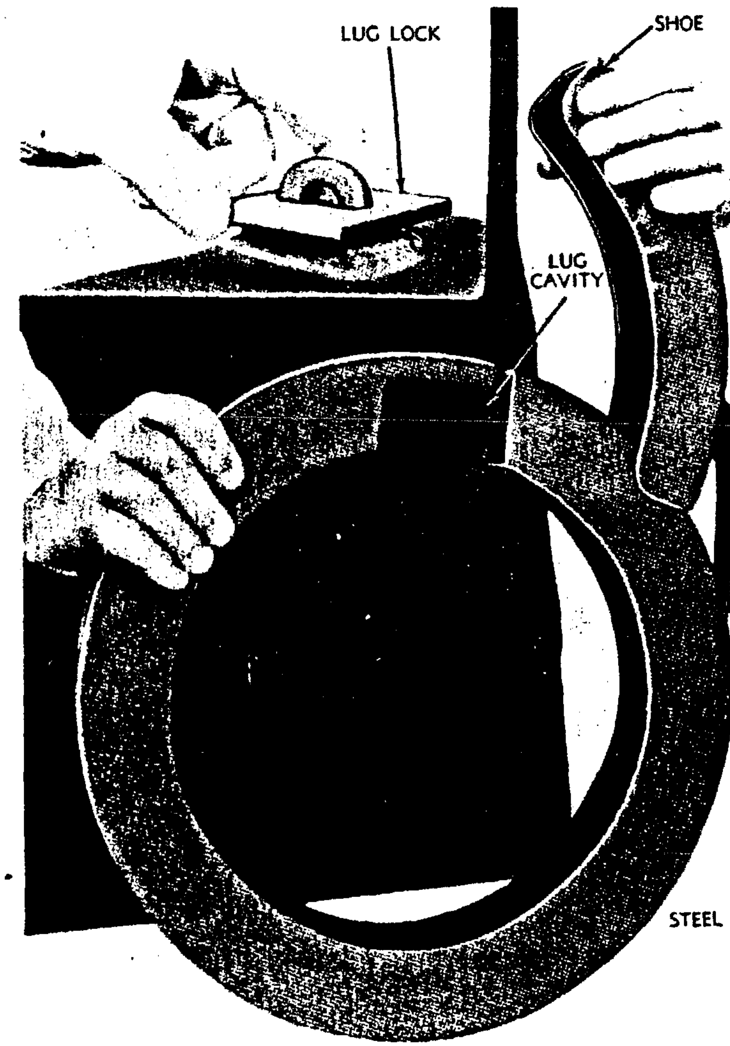

Figure 224 — Paper Shipping Band Showing Lug Cavity

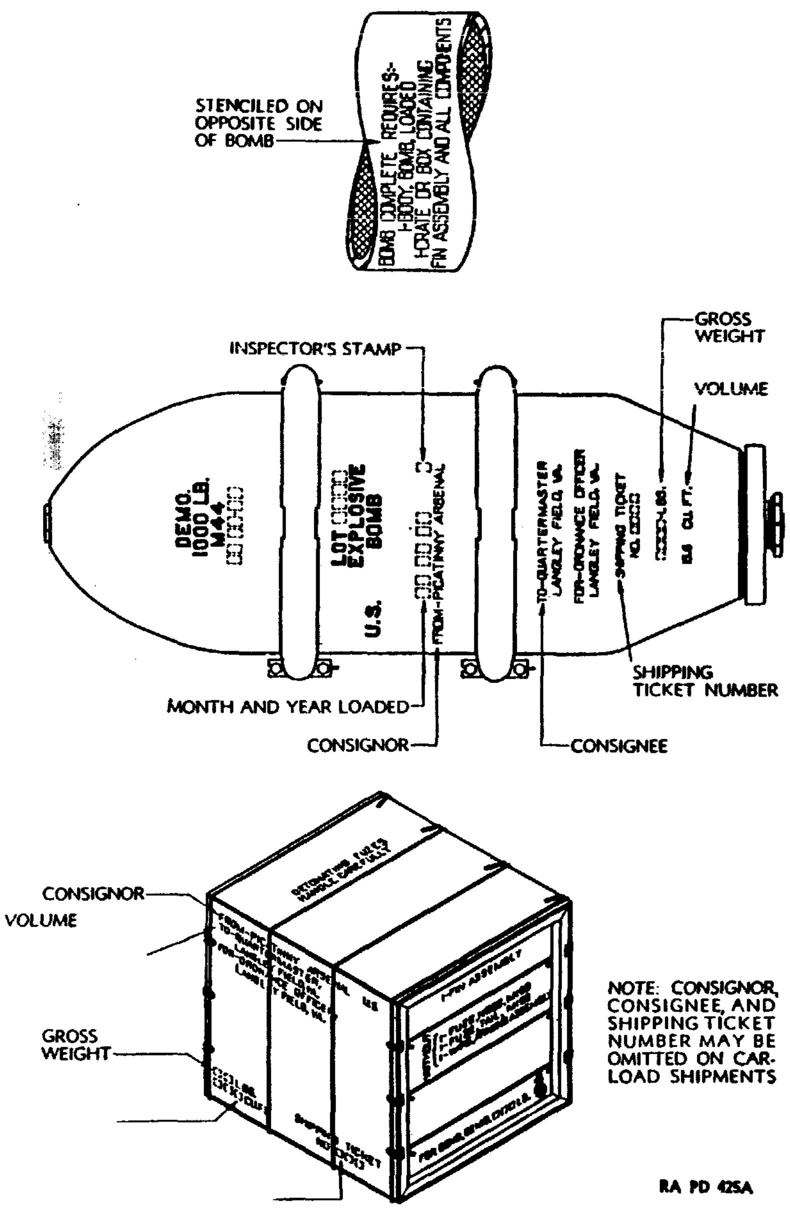

Figure 225 — BOMB, Demolition, 1,000-pound—as Shipped

The second unit of the packing of bombs over 100 pounds is the fin assembly which is packed in a metal crate. Metal is used for all AN bombs because Navy regulations will not permit wood aboard ships. The nose and tail fuze assembly and arming wire assembly will be shipped separately in bulk.

Components of unassembled rounds are never assembled until ready for use and when assembled, fuzes are threaded in handtight, never with the use of tools.

ARMING WIRE.

An arming wire is usually used with each complete round of bomb to provide a means whereby the fuzes are restrained from arming until such time as the bomb is released. At release, retention of the arming wire in the release mechanism of the plane arms the fuzes, while release of the arming wire with the bomb permits it to be dropped safe in friendly territory if the necessity arises.

Standard arming wire is of hard-drawn brass wire provided in either of two diameters, 0.036 and 0.064 inch, dependent upon the model of the bomb. To facilitate use, a swivel loop is attached at one end, or near the middle of the arming wire, dependent upon whether the bomb is fitted with one or two fuzes. A safety clip (phosphor bronze Fahnestock connector No. 3) is required for each type of arming vane type fuze. To aid in installing the smaller bombs in vertical bomb racks, if used, a serrated wire paper clip is furnished. At present, the tendency is to issue the arming wire, swivel loops, safety clips, and serrated wire paper clips unassembled in bulk. Standard arming wire assemblies have been found to be too short in some cases when alternate fuzes are used in bombs. Components in bulk consist of a 40-pound coil (approx. 3,300 ft) of 0.064-inch arming wire, 100 swivel loops, 100 Fahnestock connectors, and arming wire ferrules as required. The ferrules are included to aid in attaching swivel loops.

When assembled to the fuze, the protruding end of the arming wire should be adjusted to a length of approximately 2½ inches beyond the fuze; not less than 2 inches, nor more than 3 inches.

Arming wire assemblies are classified as type A and type B. Type A has the swivel loop at the end of the arming wire, whereas type B has the swivel loop situated near the middle. Type A will usually be found with bombs equipped with one fuze (an exception is the transverse hydrostatic fuze). Type B will usually be used with bombs equipped with two fuzes. Type A is supplied in sufficient length to provide for any method of suspension and therefore it may be necessary to cut off the excess length when certain methods of suspension are used.

FUZES.

General. Current designs of cylindrical GP and demolition bombs of the "AN" and M-series are equipped with both nose and tail fuzes.

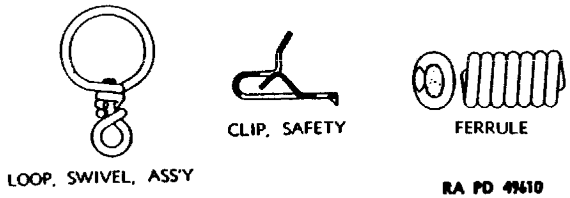

Figure 226a — Arming Wire Components

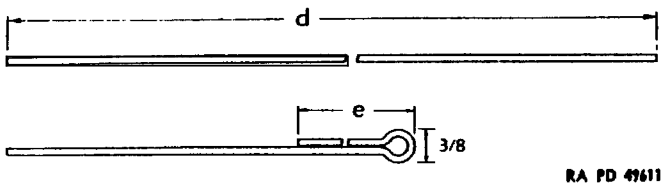

Figure 226b — Arming Wire Components—Continued

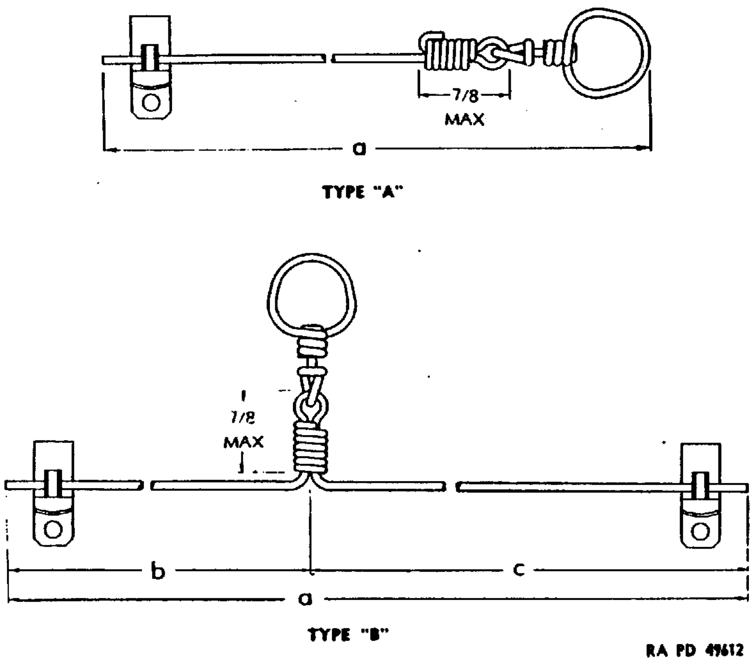

Figure 226c — Arming Wire Assemblies

Two fuzes are used, because it was found that 3 to 5 percent of fuzes fail to function and therefore 3 to 5 percent of the bombs would fall as duds. Two fuzes reduced the duds to 0.2 percent. Therefore, although two fuzes are not necessary for complete detonation of the

bomb, the extra fuze is an insurance that the bomb will function if one fuze fails.

The nose fuze is so designed that the primer, detonator, and booster are integral parts of the fuze. In the tail fuze, the primer detonator is a separable component, while the booster is assembled to the bomb at the time of manufacture in the form of an adapter booster. Most of the fuzes of earlier design were mechanical firing mechanisms containing no explosives.

An arming wire threaded through an eyelet in the arming pin, the vane strap, or the arming vane prevents initiation of the fuze action until such time as the arming wire is withdrawn.

Fragmentation and chemical bombs (excluding incendiary) are equipped with a nose fuze only. Practice bombs are equipped with a nose or tail fuze depending on the bomb.

SAP and AP bombs are designed for tail fuzes only, although SAP may also receive a nose fuze if so desired.

Depth bombs are provided with fuzes that run diametrically through the body or with nose or tail fuzes, depending on the target against which the bomb is used and on the size of the bomb.

Method of Arming. Fuzes are classified according to the method of arming in the following manner:

Arming vane type. This type is armed by means of two or more bladed vanes or propellers which begin revolving when the bomb is released from the plane. The vane is threaded directly to a striker. When the vane has revolved the same number of times as there are threads on the striker, the vane assembly falls free, arming the striker. This type of fuze arms immediately when it is dropped from the plane. It may be used for low-altitude demolition bombing. If it is used, a long delay in action is incorporated in the fuze, allowing the plane to escape after bomb impact, and also protecting the plane and pilot in case the bomb fuze should accidently strike another bomb or the plane fuselage after it has armed.

Arming vane type with mechanical delay. In this type, the vane is not directly threaded to the striker, but is meshed with reduction gears which control the freedom of the striker. The vane must make several hundred revolutions before the fuze is armed. This type of fuze provides a delay in arming and is used with bombs carrying high-explosive fillers, to prevent the fuze from accidently functioning near the plane if it should strike another bomb or the plane fuselage.

Arming pin type. This type is armed when the arming wire is withdrawn from the arming pin which holds the striker in place. This type of fuze arms immediately, and if used on bombs containing a high-explosive filler, it will be found to have a long delay on impact as previously explained.

Arming pin type with time delay. In this type, the fuze is armed by a black powder train. The arming wire, when withdrawn, allows the arming pin to be ejected by its spring. The arming pin frees a firing pin which starts a black powder train burning for a set time after which time the fuze is armed. This type fuze is used in bombs with high-explosive fillers for reasons previously explained.

Time. In this type, the fuze is armed either by the rotation of a vane assembly or ejection of an arming pin. This type is designed to function a predetermined number of seconds after release and is designed to be used against moving aircraft and for several types of pyrotechnics.

Any one of the above types may be designed for use in the nose or tail of the bomb. Nose fuzes, except time, function on impact by direct action; that is, the firing pin is driven into a primer at the instant the nose of the bomb strikes the target, whereas tail fuzes function by inertia. In tail fuzes, the plunger which carries the firing pin continues its forward motion as the bomb is retarded by the resistance of the target. Hence, the action of the nose fuze is slightly the faster.

Action on Impact. Fuzes can be classified according to the action on impact into three general classes:

Instantaneous and nondelay fuzes. Instantaneous and nondelay fuzes are used in demolition bombs to attain surface effect against targets which may be destroyed by the violence of the explosion. Nose fuzes which function immediately on impact are considered instantaneous acting fuzes, while tail fuzes which function immediately on impact are considered nondelay. The action of the tail fuze is slightly slower due to indirect action of impact causing inertia to act on the fuze as compared to the direct action on impact on the nose fuze. Instantaneous fuze action is also used for fragmentation and chemical bombs for above ground distribution of fragments and dispersion of chemical fillers.

Short delay fuzes. The greatest effect of any explosive is obtained when the charge is tamped. Similarly, the best effect of the demolition bomb against a resistant target is achieved if the bomb penetrates and then detonates within the target. For this reason, a great majority of targets against which demolition bombs are used will suffer maximum damage if the bombs are fuzed for delay action. The optimum delay is that which is long enough to allow the bomb to come to rest within the target. At present, the short delay fuzes vary from 0.01 of a second to 0.1 of a second delay in functioning after impact. The extent of the penetration will depend on the type of target, the bomb used, and the height from which it is dropped. In considering ship bombing, it is found that a short delay fuze is in most cases the optimum desired. Such fuzes would permit the

bomb to sink under the water a sufficient depth before exploding to exert maximum force against the armor plate near the bottom of the hull. Against submarines, a fuze which operates on water pressure is used. A short delay fuze would have slight effect if the submarine dived.

Long delay action fuzes. According to earlier regulations, planes could not drop bombs except from safe altitudes if these bombs were fuzed with instantaneous or short delay action fuzes for land bombing. Safe altitudes vary from a minimum of 1,500 feet for the dropping of a 100-pound bomb to the minimum of 4,000 feet for the dropping of a 4,000-pound bomb. For a plane to go below these safe altitudes is dangerous because the effects of concussion and fragments will be felt below such altitudes. It was found that in many cases such altitudes did not enable effective or any bombing. Particularly are such high altitudes not advisable or possible in such cases as the following:

1. Bad weather conditions where the target cannot be seen from high altitudes.

2. Where the climate is too cold to permit high-altitude bombing as in Alaska and Russia.

3. Where a good percentage of effective antiaircraft fire can be avoided by flying at low altitudes.

Long delay action fuzes from 4 seconds to 45 seconds have solved this problem by allowing the pilot to drop his bomb from low altitudes and move out of the effective danger area before the bomb explodes. As the tail fuze is usually the fuze designed for long delay, when such bombing is to be done and the type of bombing is not known until the target is reached, the nose fuze is made inoperative. The nose fuze can be made inoperative by removing the vane or by cutting the arming wire and wrapping it around the vane. If it is understood before the planes take off that the bombing is to be low altitude, both nose and tail fuze may be assembled to the bomb which provide for long delay.

Long delay fuzes of 4 to 5 seconds are found utilized for low-altitude sea bombing (masthead bombing). Such bombs are dropped near the side of a ship to allow for effective action below the water surface while long delay fuzes of 8 to 15 seconds are used for low-altitude land bombing (hedge hopping).

For special use, such as preventing immediate reuse of bombed areas and for moral effect, long delay fuzes which vary from one hour to several days may be found in use.

Fuze Nomenclature. Army fuzes will either be found with "Mk." and the appropriate mark number in Roman numerals or "M" with the appropriate M number in Arabic numerals. The Mk. series are the old fuzes and are obsolete. The M series of bomb fuzes will start at

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100 and at the present time can be found with numbers 100 to 126 inclusively. These fuzes may or may not be S&M. When these fuzes are interchangeable for Navy or Army use, the letters "AN—M" will precede the number to indicate the interchangeability and also that the fuze is Army design.

Navy fuzes were formerly found with the letters "Mk." and the appropriate mark number in Roman numerals. Later the letters "Mk." were followed by the appropriate mark number in Arabic numerals. For example, Fuze Mk. XXIV became Fuze Mk. 24. When these fuzes are interchangeable for Navy or Army use, the letter "AN—Mk." will precede the number to indicate the interchangeability, and also that the fuzes are Navy design. Recently, in order to avoid confusion in Navy fuzes, it was decided by the Navy to use the following system of numbering. All artillery fuzes were to be numbered from 1 to 99. All miscellaneous fuzes, such as used in torpedoes would be numbered from 100 to 199, whereas all bomb fuzes would be numbered from 200 to 299. For example Fuze Mk. XXIV which became Fuze Mk. 24, today should be changed to Mk. 224, and if it is also for Army use the fuze nomenclature should read AN-Mk. 224.

POWER AND EFFECT OF BOMBS.

Action and Effect of Explosives. The destructive effect of a bomb is in most cases due to the detonation of the high-explosive charge, and consequently it will be of interest to consider briefly some of the ways in which a high explosive acts.

In general, a high explosive consists of an unstable compound including nitrogen. The results of an explosion are to convert the whole of the explosive into gas. This may result in a volume of gas 10,000 times that of the explosive in solid or liquid form.

Thus, a bomb containing 10 pounds of explosive occupying $\frac{1}{10}$ cubic foot tends to produce 1,000 cubic feet of gas. At the bomb, the instantaneous pressure is momentarily of the same order as would be required to compress the gas back to solidity; about 10,000 atmospheres or 147,000 pounds per square inch. Fragments of a bomb may acquire velocities comparable to those of rifle bullets (nearly 3,000 ft per sec) and cause great impact effects.

There are two ways in which an explosive may act. If the bomb is exploded in the open, there is a blast effect accompanied by the dispersion of missiles which are fragments of the bomb case. If, on the other hand, the bomb is exploded deep in the earth or water, there is a lifting and heaving of the surrounding substance which is sometimes described as a mining effect.

A high explosive which is well tamped has about four and one half times the shattering effect that the same amount of explosive would have if it were exploded in contact with the same object, but in the open. Thus, if it required 10 pounds of TNT to breach a wall with

the explosive properly placed and tamped, it will require 45 pounds to produce the same effect if the explosive is simply lying against the wall. The same effect of tamping is obtained when a bomb explodes inside a building.

In 1941, a standard 500-pound demolition bomb was dropped from an altitude of 14,000 feet into a reinforced concrete slab 48 inches thick. The effect of the detonation was to pulverize and excavate the position of the slab immediately below the bomb and to shatter the remainder of the slab. The area excavated was 27 square feet and the area broken in the massive block was 400 square feet.

Against personnel, blast effectiveness is limited to very short distances. A hundred and ten feet is listed as the approximate maximum distance at which the blast of a 2,000-pound bomb is effective against personnel. A basis for this estimate was found in the explosion at Picatinny Arsenal, where a watchman received only slight injury when 775,000 tons of TNT detonated at a distance of 1,500 feet.

Fragmentation bombs are more dangerous than demolition bombs in the open. The fragments of the bomb, not the explosive charge, do the most damage when a bomb is detonated in the open. These bombs are intended for attack on troops, trucks, airplanes on the ground or in the air, and other light materiel and is designed to produce the most fragments possible.

HORIZONTAL DANGER RADIUS OF BOMB CASING FRAGMENTS

Bomb	Maximum Danger Radius of Fragments from Point of Detonation
100-lb, 300-lb, 600-lb, 1,100-lb	1,000 yd
2,000-lb	2,000 yd

BLAST EFFECT ON PERSONNEL

Bomb	Approximate Maximum Distance That Blast Is Effective on Personnel
100-lb	40 ft
300-lb	55 ft
600-lb	75 ft
1,100-lb	90 ft
2,000-lb	110 ft

TECHNIQUES OF BOMBING.

There are four methods of bombing used:

High-level Bombing or Horizontal Bombing. Planes travel at very high altitudes to drop their bombs on enemy targets. Very good bomb sights are essential in this type of bombing.

Dive Bombing. This is done at an angle of 70 to 75 degrees. It was developed by the United States government, but put into extensive use by the Germans.

Glide Bombing. Shallow dive bombing at an angle of 45 degrees or less for planes which cannot withstand the stress and strain involved in dive bombing techniques.

Low-level Skip or Hedge Hop Bombing. Bombs dropped from levels of 50 to 200 feet. Such bombs will ricochet; this is very effective against merchant shipping.

FURTHER REFERENCES: All references may be found at the close of this section.

Chapter 2

G.P. (General Purpose) Bombs

GENERAL.

With the design of the 2,000-pound Mk. I Bomb as cylindrical, a new innovation in American bomb development was initiated. A new series of bombs was developed and later standardized in 1939. This series of bombs was known as the M series.

The M series demolition bombs were cylindrical in shape with a box type tail assembly. The bomb body was made in one piece. This provided for four advantages over the Mk. series, namely:

The bomb case was stronger due to the absence of welds.

The bomb case was easier to manufacture and cheaper in cost.

The bomb itself was easier to load with explosive.

The shape of the bomb facilitated handling in the field. The M series of demolition bombs had the following nomenclature: 100-pound M30; 300-pound M31; 600-pound M32; 1,100-pound M33; 2,000-pound M34.

Shortly thereafter, the above series of demolition bombs were modified and several sizes of bombs were replaced by others. To make Army and Navy bombs interchangeable, a 500- and 1,000-pound demolition bomb were standardized and the 600- and 1,100-pound bombs were declared standard for issue only. To allow for Army, Navy, and British interchangeability of bombs, the 250-pound bomb was standardized and the 300-pound bomb which would not conveniently fit into British bomb racks was declared standard for issue only. In accordance with the above, all new bombs being manufactured had welded on their bomb bodies a single suspension lug at the center of gravity to allow for use in British single suspension racks and several of the Navy planes which carried single suspension racks.

Also the new bomb was improved by the substitution of the tail base plug instead of a rear closing cap to close the tail of the bomb. The lip of the rear closing cap would snag as the bomb penetrated the target pulling off the cap, fuze, and booster. This resulted in a low order detonation or dud. The tailbase plug screws into an internally threaded bomb body, overcoming this disadvantage.

To indicate these changes, a new nomenclature was utilized. All these new bombs were designed as AN to indicate Army and Navy use with the appropriate Arabic numerals preceded by a model or mark number to designate Army or Navy design respectively. The letters GP (general purpose) were added in place of demolition to conform with British nomenclature. The word "demolition" which had previously been restricted to what today is known as GP bombs received a new meaning to include all of the new bombs, which arose because of the complexities of modern warfare, such as general purpose, light case, semiarmor-piercing, armor-piercing, and depth bombs having a demolition effect. Because of their similarities, light case and the old demolition bombs are considered with general purpose bombs.

In considering a particular type of bomb, it is advisable to analyze one example of that type, for with slight variations the other bombs in that group are exactly the same. A typical example of GP bombs is the AN-M 500-pound bomb.

The early method of manufacture for GP bombs or their predecessor, the M-series, was made by swaging the end of a piece of seamless steel pipe to form the nose. The tail end was tapered down, using the same method. The shape of the bomb body was, therefore, cylindrical with tapered nose and tapered tail. Later, forging was also used; that is, a solid ingot of metal was forged into a cylinder with one end closed. The open end was tapered and trimmed, and the closed end was machined down to proper dimensions for the nose. As the demand for bombs increased, any case that could meet the requirements was accepted. This allowed for the use of welding, since techniques in welding have improved tremendously in recent years. Today, bomb cases will be found made of cast steel noses welded to seamless steel pipe, for example.

Dimensions of the Bomb Case. Regardless of the method of manufacture, a cross section of a bomb case will be essentially the same. The nose is relatively thick at the point where the fuze is attached, and it will taper gradually back through the ogive until the cylindrical side walls are reached. The cylindrical side walls are of uniform thickness and will continue through the tapering tail. That portion of the tail which is threaded internally for the tail base plug is thickened to make up for the loss of material through threading.

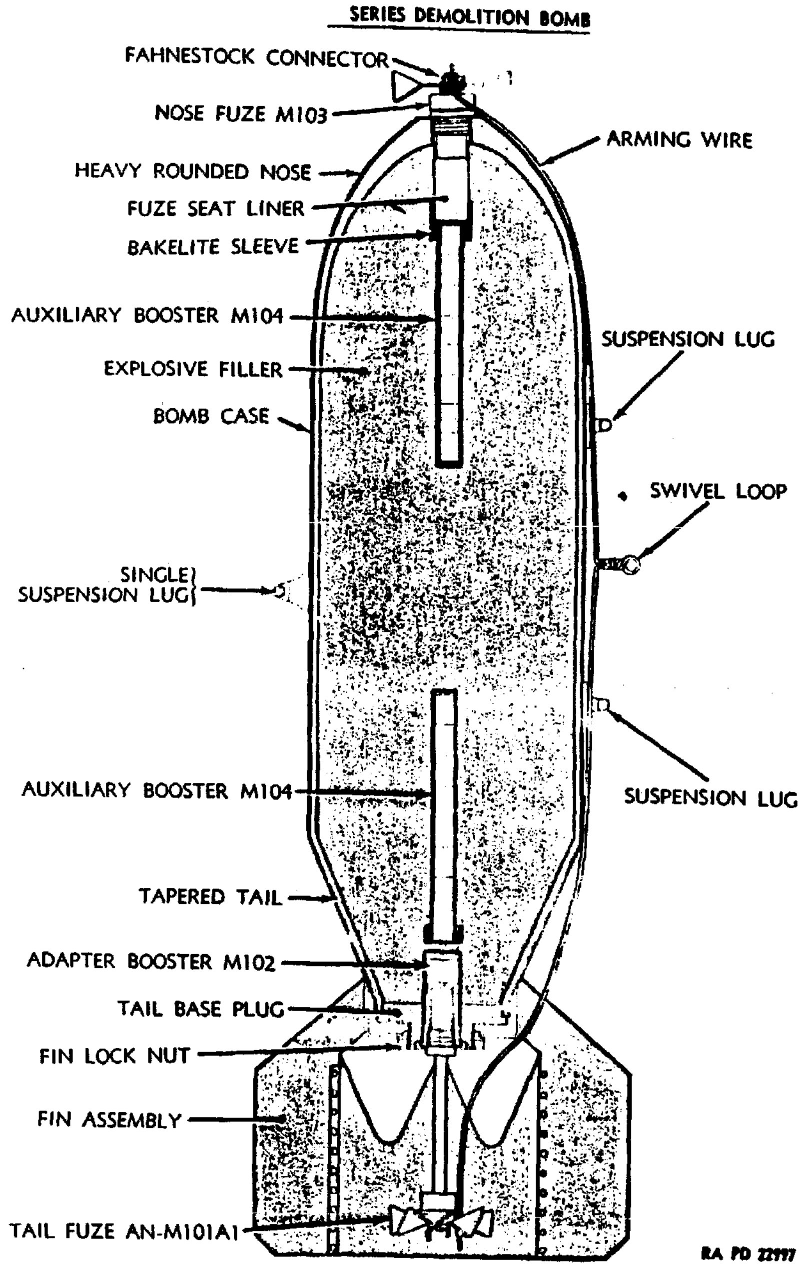

Figure 227 — BOMB, G.P., 500-pound, AN-M43

To illustrate, the minimum dimensions of the AN-M 500-pound GP bomb are as follows:

Bomb Case Section	Thickness in Inches
Nose	1.25
3 inches in back of nose	1.10
6 inches in back of nose	0.56
9 inches in back of nose	0.49
12.2 inches in back of nose	0.30
Side walls	0.30
Taper on tail	0.30
Portion of tail threaded for tail base plug	0.318

These figures can be considered typical, provided that they are, in any given case, proportioned to the size of the bomb.

Body Fittings. The nose of the bomb case is drilled and tapped for the fuze seat liner and nose fuze. The tail opening is threaded internally to receive an externally threaded base plug. This is a much more efficient construction than that employed in the past with rear closing cap. The rear closing cap is internally threaded so as to screw into an externally threaded bomb body. The lip produced in this type of construction has been found to catch as the bomb penetrates targets, pulling off the cap and tail fuze, and resulting in a low order detonation or a dud. The tail base plug is drilled and tapped in its center for the adapter booster. A collar is machined and threaded on the back side of the base plug for the fin locking ring which holds the fin in place and is internally threaded to receive an adapter booster. The adapter booster is internally threaded to receive the tail fuze. Welded to the bomb body are two Army suspension lugs, 14 inches apart, each 7 inches away from the center of gravity. A single suspension lug is welded to the opposite side of the bomb body at the center of gravity.

Construction of the Fin. The fins used on GP bombs are box type, and because of their structure they are very stable. The foundation of the fin assembly is a square metal box with top and botton open. One end of each side of the box ends in a vane, and is fastened to the end of another side of the box. These stabilizing vanes are at an angle of 135 degrees from the sides of the box. The ends of the vane extend beyond the end of the box, and are so cut that the extensions will bisect the angles of the box and meet in a common center. Fastened to these extensions is a shallow drawn cup or sleeve made to fit over the rear end of the bomb case. The sleeve conforms to the bomb case and fits snugly over the collar on the tail base plug. The fin locking ring or fin lock nut is threaded to the collar, jamming the base of the sleeve against the rear of the base plug and locking the fin assembly to the bomb case.

Painting. Until March 1942, all GP bombs were externally painted yellow with black stencil. Since March 1942, all bombs have been painted olive drab with black stencil. For identification, the bomb bodies have a 1-inch yellow band around the tail and nose and a ¼-inch yellow band around the center of gravity. Internally, all GP bombs are painted with acidproof black paint to prevent reaction of high-explosive filler with the metal bomb case.

Explosive Filler. The standard filler for the GP bomb is amatol in any of its percentages. Alternate fillers are TNT and composition B. When amatol is used, a TNT seal may or may not be used at the nose and tail openings. The TNT seal is advisable if the bomb is to be stored for long periods of time, because of the airtight seal it would form, preventing the ammonium nitrate in the amatol from reacting with the moisture in the air. The weight of 50/50 amatol in a 500-pound bomb is about 265 pounds, while for TNT loaded bombs the weight of TNT is about 280 pounds. In general, the explosive content is about 50 to 55 percent of the total weight of the GP bomb.

Fuze Seat Liner. The fuze seat liner is a steel cup which may be cadmium plated. It has a flange which is externally threaded so as to screw into the nose of the bomb body. The fuze seat liner serves to form a seat for the fuze when the latter is to be inserted into the bomb body, and also with the aid of a bakelite sleeve, it holds the nose auxiliary booster in line with the fuze while the bomb is being loaded. Recently, the construction of the fuze seat liner was changed from a 2-piece affair to a 1-piece design. It was found, in many cases, that the base of the fuze seat liner, which was a separate part, would allow the amatol filler to seep or run into the liner itself. The 1-piece construction helps to eliminate this condition. The outside of the fuze seat liner is painted acidproof black as in any metal component which comes into contact with explosive filler such as amatol.

Bakelite Sleeve. The bakelite sleeve is an open hollow bakelite cylinder with an internal shoulder so designed as to hold the auxiliary booster. The other end fits around the fuze seat liner. The position of the bomb in pouring, nose down, allows the bakelite sleeve in conjunction with the fuze seat liner to hold the auxiliary booster at the nose in place.

Boosters. An adapter booster is found in the tail of the bomb body only and is used to seat the tail fuze and amplify the detonating wave of the tail fuze detonator. All nose fuzes for GP bombs have the boosters incorporated in the fuze, for there is no adapter booster located at the nose of the bomb body. Correspondingly, all tail fuzes for bombs do not have boosters incorporated in the fuze because the bomb body has its own adapter booster.

Auxiliary Booster M104. The M104 Auxiliary Booster consists of a booster charge of tetryl (0.5 pound) in a bakelite casing 1 foot long. It is closed at the top with a felt disc, under a threaded bakelite cap. The cap of the booster casing rests on the shoulder of the bakelite sleeve as described previously. The M104 Auxiliary Booster is also found in the tail end of the bomb body. This is true of all GP bombs except the 100-pound GP bomb and the 4,000-pound LC bomb, each of which has one auxiliary booster only. The 100-pound GP bomb is too small to use two auxiliary boosters, so that the M104 is only found in the nose of the 100-pound bomb. The 4,000-pound bomb uses one large auxiliary booster which extends the entire length of the bomb. This auxiliary booster is the M111. It has approximately 3.4 pounds of tetryl and is 7 feet long. It is held in position at the nose in the same manner as described for the M104 Auxiliary Booster. For all other GP bombs, the M104 Auxiliary Booster is held in the tail by the amatol solidfying around the casing. Special equipment is utilized to form a cavity for the auxiliary booster and to hold it in place while the amatol solidifies. Such equipment is removed when the tail auxiliary booster is properly in place.

The use of auxiliary boosters is necessary to insure the high order detonation of the large quantity of comparatively insensitive bursting charge which is found in the GP bomb.

Adapter Booster M102. The M102 is threaded at the top with outside threads for screwing into the tail base plug. It is internally threaded to receive an Army tail fuze. At the bottom, the adapter is threaded to receive the booster casing which contains a charge of tetryl. A small closing cup located in the housing between the fuze cavity and booster charge is filled with tetryl and acts as a lead charge. The adapter booster is made of steel, and may be cadmium or zinc plated.

Adapter Booster M115. This recently adopted booster is similar to the M102 except that the diameter of the M115 is larger, making it possible to use the AN-Mk. 230 Navy Hydrostatic Tail Fuze. To reduce the diameter of the adapter to receive Army fuzes, a threaded sleeve is screwed into the M115 Adapter Booster. To make use of Navy fuzes, the sleeve must be removed with a special stud wrench having two studs which fit into two holes in the face of the sleeve. All GP bombs except the 500-pound AN-M64, the 1,000-pound AN-M65, and the 2,000-pound AN-M66 use the M102 Adapter Booster. The AN-M64, AN-M65, and AN-M66 use the M115 Adapter Booster, and are replacing GP bombs of like size.

Shipping Plugs. To close the nose and tail fuze cavities, shipping plugs are screwed into the nose threads and adapter booster threads. These plugs protect the threads and prevent entrance of dirt into the

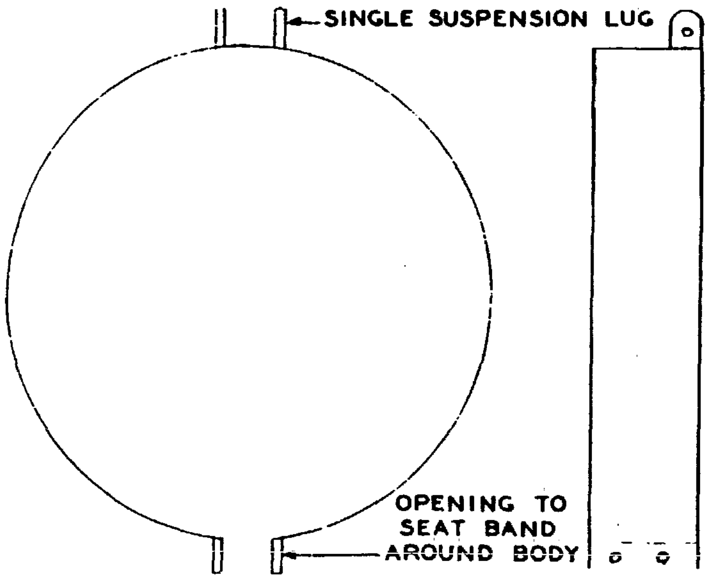

Figure 228 — Suspension Band

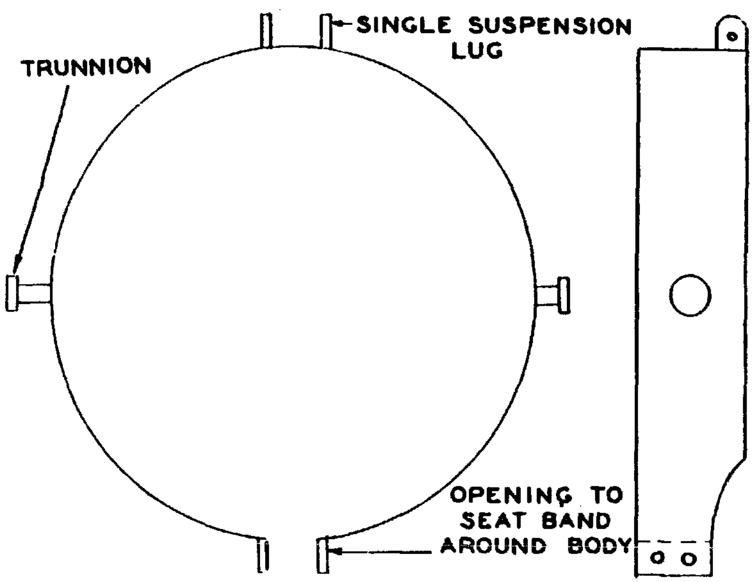

Figure 229 — Trunnion Band

fuze cavities. This is particularly necessary because bombs are never shipped with fuzes assembled.

Arming Wire. Type B arming wire is generally used for all GP bombs. This type has a diameter of 0.64 inch. The swivel loop is attached somewhat off center of the length of the wire with the longer end of the wire designed to be inserted in the tail fuze. As the standard bomb fuzes for GP bombs are of the arming vane type both at the nose and tail positions, two safety clips (phosphor-bronze Fahnestock connector No. 3) are required for the complete round.

Trunnion Band. Previously it had been mentioned that to adapt Army bombs for Navy use, a single suspension lug and a means of attaching bombs to special racks used in dive bombing had to be provided. To accomplish these necessities, the bombs were provided with trunnion bands. A trunnion band is merely a steel ring which can be placed around the circumference of the bomb and bolted together at the ends to secure it in place. Opposite the point where the band is bolted together, a single suspension lug is riveted and welded to the band. This single lug is for use in single suspension. Two pivot points or trunnions are provided on the same band for dive bombing racks. Each trunnion is 90 degrees from the suspension lug and the ends of the band. Thus, the trunnions are on the same plane and 180 degrees from each other on the band. They are riveted and welded in place. The trunnion band is bolted around the center of gravity of the bomb with the bolt on the same side of the bomb as the double suspension lugs. The trunnions fit into a yoke arrangement that lowers the bomb out of the propeller arc when it is released from the bomb shackle. Trunnion bands can be considered used for one or two of three purposes: to provide trunnions for dive bombing; to provide a third lug for single suspension; to provide a hoisting lug.

All trunnion bands serve to provide trunnions for dive bombing, and some trunnion bands serve for this purpose only. Others act to provide trunnions for dive bombing and also provide a third lug. The final group of trunnion bands acts to provide trunnions for dive bombing and a lug for hoisting. The M1 and M2 Trunnion Bands previously described act to provide trunnions for dive bombing and also furnish a single suspension lug, since the bomb for which they are provided has no lug for single suspension. The M1A1 acts to provide trunnions for dive bombing and a lug for hoisting.

Trunnion bands and the bombs they are used with are listed below:

M1; 500-pound M43 Demolition Bomb

M1A1; 500-pound AN-M43 and AN-M64 GP Bombs; also the 1,400-pound M63 AP Bombs

M2; 1,000-pound M44 Demolition Bomb

M2A1; 1,000-pound AN-M44 and AN-M65 GP Bombs

M3A1; 1,000-pound M52 and M52A1 AP Bombs; also the 900-pound M60 AP Bomb and 800-pound M61 Bomb
M4; 500-pound AN-M58 and AN-M58A1 SAP Bombs
M5; 1,000-pound AN-M59 SAP Bomb
M6; 600-pound M62, M62A1 and M62A2 AP Bombs

Suspension Bands. The 100-pound M30 Demolition Bomb uses a suspension band which is a steel band that fits around the bomb body. It provides the third lug which is attached to the band. The band is known as the M1, and adapts the bomb for single lug suspension racks for dive bombing purposes.

Suspension bands have one main purpose, and that is to provide an additional lug where desired. Some suspension bands provide besides the single lug, trunnions for dive bombing.

Hoisting Bands. These are bands which have one or two lugs for hoisting purposes only. They are used primarily by the Navy. Army hoisting bands are in the form of trunnion bands or suspension bands.

FUZE, Nose, M103 and AN-M103.

General. This is an arming vane type with mechanical delay in arming. It is used in all GP bombs, the M-series demolition bombs which preceded the GP series, the 4,000-pound LC bomb, and in the 650-pound depth bomb. It is used for high-altitude land bombardment, and also against water targets. Its action on impact is selective, instantaneous or 0.1 second delay. The length of this fuze is about 7 inches, and it weighs about 3.7 pounds. It is packed 1 per container, 25 containers per box. The vanes are packed separately in the same container.

Description. The selective action of this fuze is obtained by use of two firing systems, one for instantaneous action, the other for delay; both are contained in the upper part of the body. The detonator is mounted in a slider located below the firing pins, and is normally held out of firing position by the arming stem. In this "out of firing" position, the detonator communicates with a cavity into which the force of the explosion of the detonator could expand should the detonator function prematurely. In the arming of the fuze, the arming stem serves as a stop to limit the movement of the slider to the position appropriate for the required action, instantaneous or short delay, depending on the position of the setting pin. Delay arming is accomplished by interposing a reduction gear train between the arming vane and the arming screw to reduce the movement of the arming screw to 1 turn for approximately 65 revolutions of the arming vane. Arming discs between the striker and the body of the fuze prevent movement of the firing pin prior to arming. The detachable arming vane is held in position by a spring vane-holder ring.

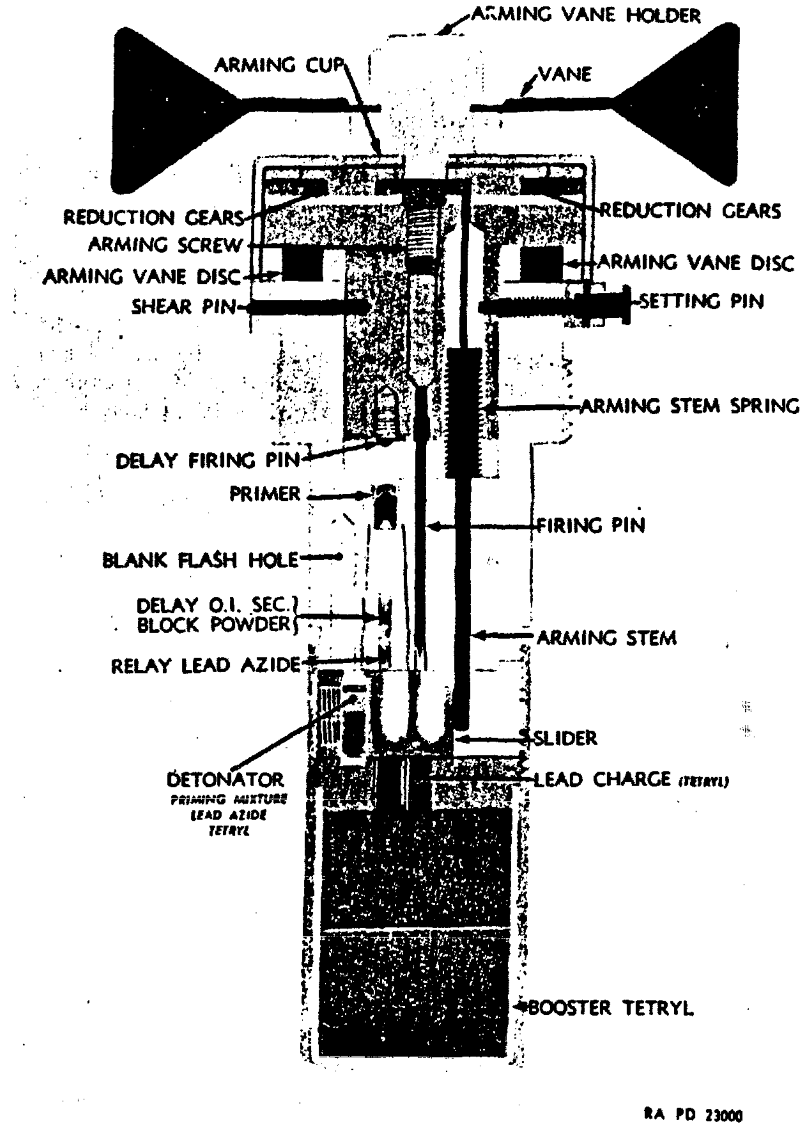

Figure 230 — FUZE, Bomb, M103 (Nose)

Eyelets in the vane strap which aline with corresponding eyelets attached to the vane cup are provided for the arming wire. The fuze may be set at will to instantaneous or 0.1 second short delay.

The reduction gear train consists of a drive gear which is directly connected to the arming vane. The drive gear rotates with the arming vane. The drive gear is in mesh with two eccentric gears. Upon the hubs of the eccentric gears rides an external gear. The external gear executes pure revolution about the axis of the drive gear and meshes with an internal gear, to which the arming screw is directly attached, at only one point on its circumference. The reduction achieved is 65 revolutions of the vane to 1 revolution of the arming screw.

Function when set for delay action. The bomb is dropped and the arming wire is retained in the plane. The arming vane is now free to be rotated by the air stream. The rotating arming vane, acting through the reduction gear train, slowly unscrews the arming screw which carries the vane cup with it. This movement of the vane cup uncovers the arming discs and permits them to be ejected by the flat U-spring. The striker is now held in place by a shear pin and the setting pin which acts as a secondary shear pin.

Simultaneously, this movement of the vane cup permits the arming stem, due to the action of the arming stem spring, to move partially out of the slider cavity until the shoulder of the arming stem comes into contact with the setting pin. When set for delay action, the setting pin is in the deep slot of the body and therefore protrudes into the arming stem cavity. The slider is now free, and due to the action of its spring it is forced to move toward the end of the slider cavity until its shoulder comes into contact with that part of the arming stem which still protrudes into the slider cavity. It is prevented from moving rearward by a slider lock which consists of a cupped spring which slips into a step-like cavity in the slider. It allows the slider to move forward but not backward. The slider is prevented, however, from moving forward by the arming stem. In this locked position, the detonator which is carried by the slider is directly in line with the delay explosive train. The instantaneous firing pin is now directly over a blank hole in the slider while the arming stem is over a second blank hole in the slider. This is to prevent these elements from interfering with action on impact, and also serves as additional locking elements after impact.

On impact, the striker is forced inward, breaking the shear pin and setting pin. The instantaneous firing pin and arming stem move into the blank holes in the slider. The delay firing pin strikes a primer. The flame from the primer ignites a black powder delay pellet which burns for 0.1 second. A relay of lead azide is initiated by the black powder flame. The detonating wave produced functions the detonator of priming mixture, lead azide, and tetryl. The detonator functions the lead charge of tetryl which detonates the booster of tetryl in the base of the fuze. The wave from the fuze detonates the auxiliary booster of tetryl in the bomb body and the explosive bursting charge.

Function set for instantaneous action. The bomb is dropped and the arming wire is retained in the plane. The arming vane is now free to be rotated by the air stream. The rotating arming vane, acting through the reduction gear train, slowly unscrews the arming screw which carries the vane cup with it. The movement of the vane cup uncovers the arming discs and permits them to be ejected by the flat U-spring. The striker is now held in place by a shear pin and the setting pin which acts as a secondary shear pin.

Simultaneously, this movement of the vane cup permits the arming stem, due to the action of its spring, to move up until its shoulder strikes the top of the striker body. The setting pin engaged in the shallow slot does not interfere with the movement of the arming stem. The slider cavity is now entirely free of the arming stem. The slider, due to the action of its spring, moves until it strikes the fuze housing. It is prevented from moving rearward by the slider lock. In this locked position, the detonator which is carried by the slider is directly underneath the instantaneous firing pin and over a second lead charge of tetryl. The arming stem is directly over the innermost blank hole in the slider and therefore does not interfere with action on impact but serves as an additional locking element after impact.

On impact, the striker is forced inward breaking the shear pin and setting pin. The arming stem moves into the blank hole in the slider. The instantaneous firing pin strikes the detonator of priming mixture, lead azide, and tetryl. The detonating wave produced functions the lead charge of tetryl which in turn detonates the booster of tetryl located in the base of the fuze.

Comparison between M103 and AN-M103. Normal arming of the M103 Bomb Fuze requires from 1,000 to 3,500 feet of air travel or 525 revolutions for delay action, 820 revolutions for instantaneous. Dive bombing and low-altitude bombing over water have produced bomb failures because the M103 Fuze was not completely armed at the time of impact. This fuze, when used for low-altitude water impact bombing, must be partially armed before dropping. Fuzes partially armed and set for instantaneous or delayed action will become completely armed at the time of impact when dropped from minimum combat altitudes.

The M103 Bomb Fuze may be partially armed by backing off the arming vane until ⅛ inch of the safety discs is exposed by the vane cup. This requires approximately 250 turns. Tolerance variations in manufacture and assembly of M103 Fuze may cause exposure of one-eighth inch of safety discs before making 250 turns of arming vane. Such a fuze is partially armed when one-eighth inch of safety discs is exposed. The arming vane must not be backed off more than 250 turns.

The Fuze AN-M103 arms within the minimum combat altitudes or within 435 to 935 feet of air travel or 220 revolutions for delay and 330 for instantaneous are required. An additional change was the modification of the arming vane to one somewhat smaller in diameter to make it more stable.

FUZE, Tail, AN-M101A1.

General. This is an arming vane type of fuze with mechanical delay. It is used in 500- and 600-pound GP bombs and M-series demolition bombs which preceded the GP series. 500-pound SAP bombs also utilize this fuze. It is used for high-altitude land bombardment and also against water targets. Its action on impact depends on the primer detonator used. It can vary from nondelay to 0.1 second delay. The arming time is approximately 720 revolutions of the arming vane. It is about 12 inches long, weighs about 2.9 pounds, and is packed 1 per container, 25 per box. The vanes are packed separately on spindles in the same box.

Description. This fuze is designed so that the delay time may be varied by changing the primer detonator. As shipped, the Primer Detonator M14 with 0.025-second delay is assembled to the fuze. This may be replaced in the field by use of the M14 Primer Detonator having a nondelay, a 0.01-second delay, or a 0.1-second delay by unscrewing the primer detonator, which appears as a knurled ring at the base of the fuze, and by screwing in the primer detonator assembly of the desired delay. The work is done by hand since the use of tools is neither necessary nor permitted. The length of the firing stem tube is 6.6 inches. Housed in the fuze body are the firing pin, primer, delay element, and detonator. The plunger is held in place by means of an arming stem which passes through the arming stem tube to the upper portion of the fuze. A cotter pin passes through the fuze housing and plunger at the point where the external threads are located for screwing the fuze into the adapter booster. This cotter pin must be removed therefore before the fuze can be assembled to the bomb.

Attached to the upper end of the arming stem is a cup in which is housed the delay arming mechanism. Delayed arming is obtained by a reduction gear train. Essentially, the reduction gear train consists of 3 gears. The idler gear is fixed to the bearing cup by means of a pinion called the idler pinion. The bearing cup is directly attached to the arming vane. The idler gear is in mesh with a stationary gear and a movable gear. The stationary gear has 29 teeth and is on a stationary gear carrier which is held to the stem cup by means of a

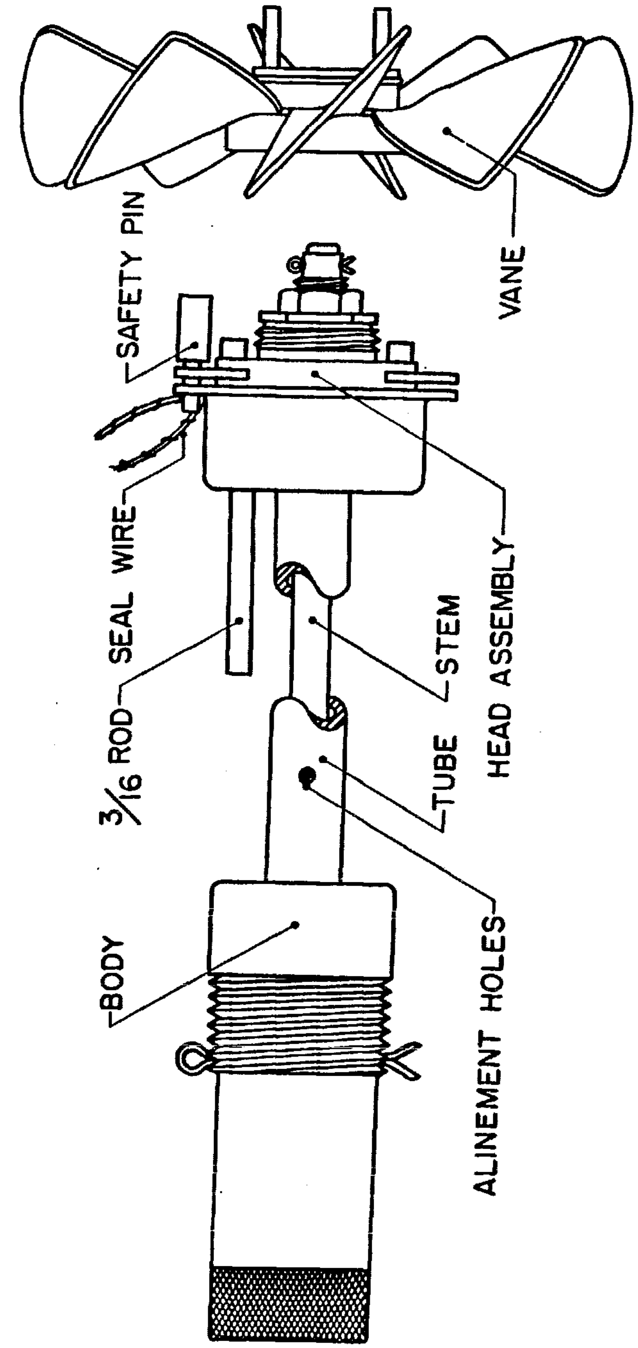

Figure 231 — FUZE, Bomb, AN-M100A1

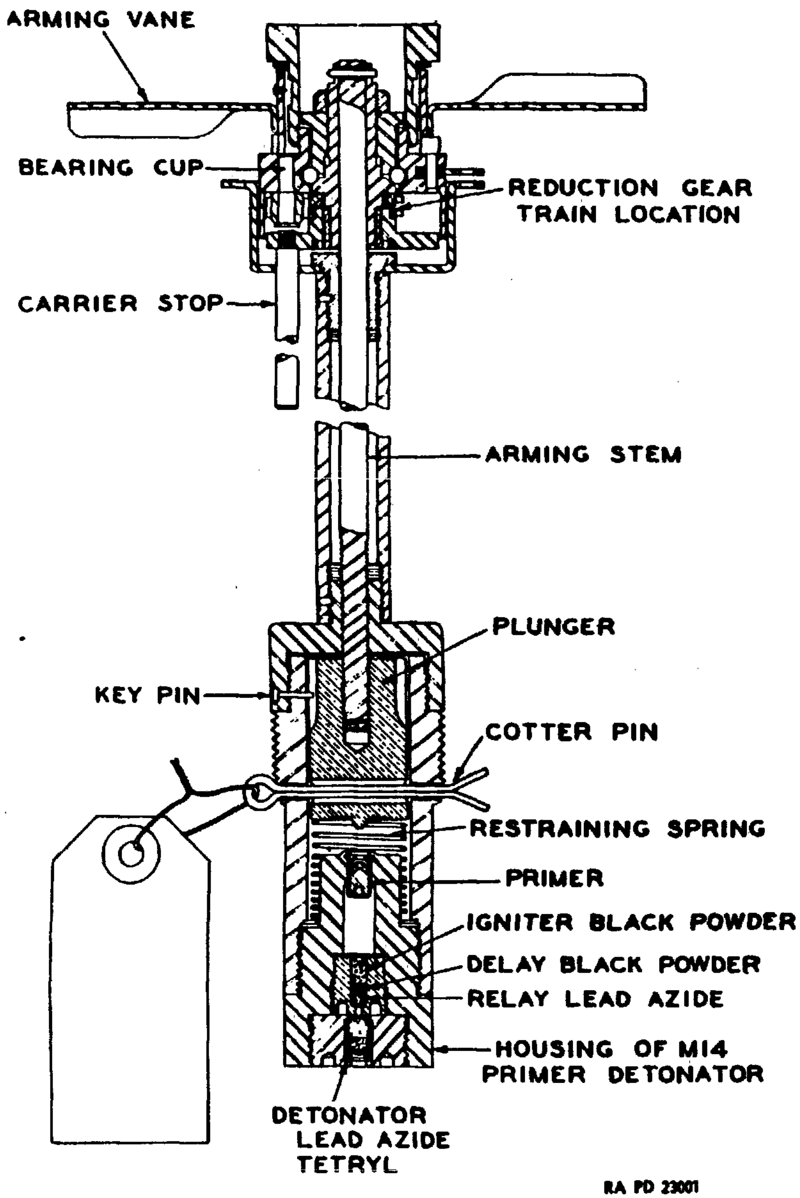

Figure 232 — FUZE, Bomb, AN-M101A2 (Tail)

carrier stop. This carrier stop will prevent any rotation of the stationary gear assembly. The movable gear has 30 teeth. Because of the differential number of teeth in the stationary and movable gears, the movable gear is caused to rotate 1 tooth for each turn of the idler gear about the 2 gears. This is 1 complete turn for 30 turns of the vane since the vane rotates the idler gear directly. The movable gear is attached to the arming stem. Consequently, as the movable gear rotates so does the arming stem. The stem turns $\frac{1}{13}$ of a thread for each turn of the vane or 1 complete thread for 30 turns of the vane.

Function. The bomb is dropped and the arming wire is retained in the plane, thereby permitting the arming vane to be rotated by the air stream. The rotating arming vane acting through the reduction gear train unscrews the stem from the plunger (approx. 720 revolutions), thereby arming the fuze. The plunger is now held away from the primer of the M14 Primer Detonator by a light coil restraining spring. After a total of approximately 1,260 revolutions, the entire arming vane, reduction gear train, and arming stem assembly is carried clear of the fuze by the air currents passing through the tail fin assembly. During this entire process of arming, a key pin prevents the rotation of the plunger as the arming stem unscrews.

Upon impact, the motion of the bomb is arrested and the plunger compresses the restraining spring causing the firing pin, which is milled into the end of the plunger, to strike the primer of the M14 Primer Detonator. The flame produced ignites a black powder igniter charge which in turn ignites the delay of black powder. This burns for the prescribed time and ignites a relay of lead azide. The detonating wave from the relay functions the detonator of lead azide and tetryl.

Primer Detonator M14 and M14A1. The Primer Detonator M14 or M14A1 screws into the base of the Tail Fuze AN-M100A1, AN-M101A1, AN-M102A1, AN-M100A2, AN-M101A2, or AN-M102A2. The primer detonator consists of a housing so threaded and machined as to receive a primer, delay, and detonator assembly. Around the outside of the housing will be found threads which are designed to screw into the base of any of the fuzes previously named. The base of the primer detonator is stamped with the appropriate delay and is painted to indicate the various delays as follows:

0.1-second delay....................Entire base is painted black
0.025-second delay ....¼ base is painted black
0.01-second delay ....⅛ base is painted black
Nondelay...........................Entire base is painted white

The primer detonator delay which comes assembled with the fuze

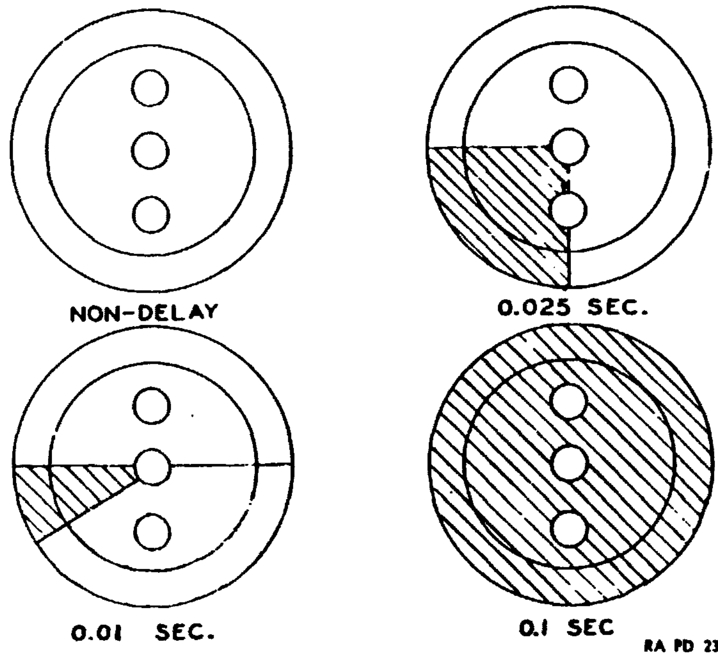

Figure 233 — Marking of M14 Primer Detonators

is at present the 0.025-second delay. The explosive train consists of the following elements in position as listed:

Delay Holder Assembly	Detonator Holder
Primer	Upper detonator lead azide
Igniter black powder	Lower detonator tetry
Delay black powder 0.025 sec	
Relay lead azide	

All other delays for the M14 or M14A1 Primer Detonator have the same explosive train elements with a difference, of course, in the delay pellet burning time, if any is present. The nondelay and 0.1-second delay primer detonator does not have an igniter charge of blacl wder.

FUZE, tail, AN-M100A1 and AN-M102A1. These fuzes are entirely the same as the AN-M101A1 described above in so far as function and description are concerned, differing only in the length of the arming stem tube in order that the arming vane will be properly positioned in the air stream. The arming stems are: 3.6 inches on the AN-M100A1: 6.6 inches on the AN-M101A1; and 10.6 inches on the AN-M102A1. Longer stems are necessary in larger bombs.

FUZES, Tail, M100, M101, and M102. These fuzes differ from the AN-M100A1, AN-M101A1, and AN-M102A1 only in that they

have a primer detonator of 0.1-second delay firmly attached. Delay cannot be changed.

FUZE, Tail, AN-M100A2, AN-M101A2, and AN-M102A2. Arming of fuzes listed above, having but the A1 modification, requires from 1,000 to 3,500 feet of air travel. Dive bombing and low-altitude bombing over water have produced bomb failures because the bomb fuzes were not completely armed at the time of impact. These fuzes, when used for low altitude water impact bombing, must be partially armed before using. Fuzes partially armed as described below will become completely armed at the time of impact when dropped from minimum combat altitudes.

To partially arm the AN-M101A1 or M101, or any others in the same series, one must measure the length of the 3/16-inch diameter rod (stationary gear carrier stop) extending beyond the cup. This length should be approximately 1.5 inches before partial arming. The vane is rotated clockwise approximately 350 turns. The rod is again measured. Its length should now be 0.4 inch less or approximately 1.1 inches. If the difference in measurement is greater or less than 0.4 inch, the vane may be rotated either clockwise or counterclockwise until the required difference of 0.4 inch is obtained.

Bomb Fuzes AN-M101A2, AN-M100A2, and AN-M102A2 are exactly the same as the A1 modification of the corresponding size, but do not require being partially armed. These fuzes arm within minimum combat altitudes. An additional change was the modification of the arming vane assembly from eight blades to four blades in order to make the assembly more stable.

FUZE, Tail, M113.

General. This is an arming vane type of fuze which is used in the 500- and 600-pound GP bombs and M-series demolition bombs. 500-pound SAP bombs also utilize this fuze. It is used for low-altitude land and sea bombing. Its action on impact depends on the action of the primer detonator used. The M16 Primer Detonator has two possible actions, a 4- to 5-second delay for low-altitude sea bombing, and an 8- to 11-second delay for low-altitude land bombing.

The arming time is about 18 turns of the arming vane or 100 feet of air travel. At speeds of 68 miles an hour, the fuze arms approximately 16 feet below the plane. At speeds of 136 miles per hour, the fuze. It has 4 blades, 0.5 inch wide and 5 inches long.

Description. This fuze is similar in outward appearance to Bomb Fuze AN-M101A2, except that it does not have the reduction gear assembly in the head and the cotter pin through the body. As shipped, the Primer Detonator M16, 8- to 11-second delay, is assembled to the fuze. This may be replaced in the field with Primer Detonator

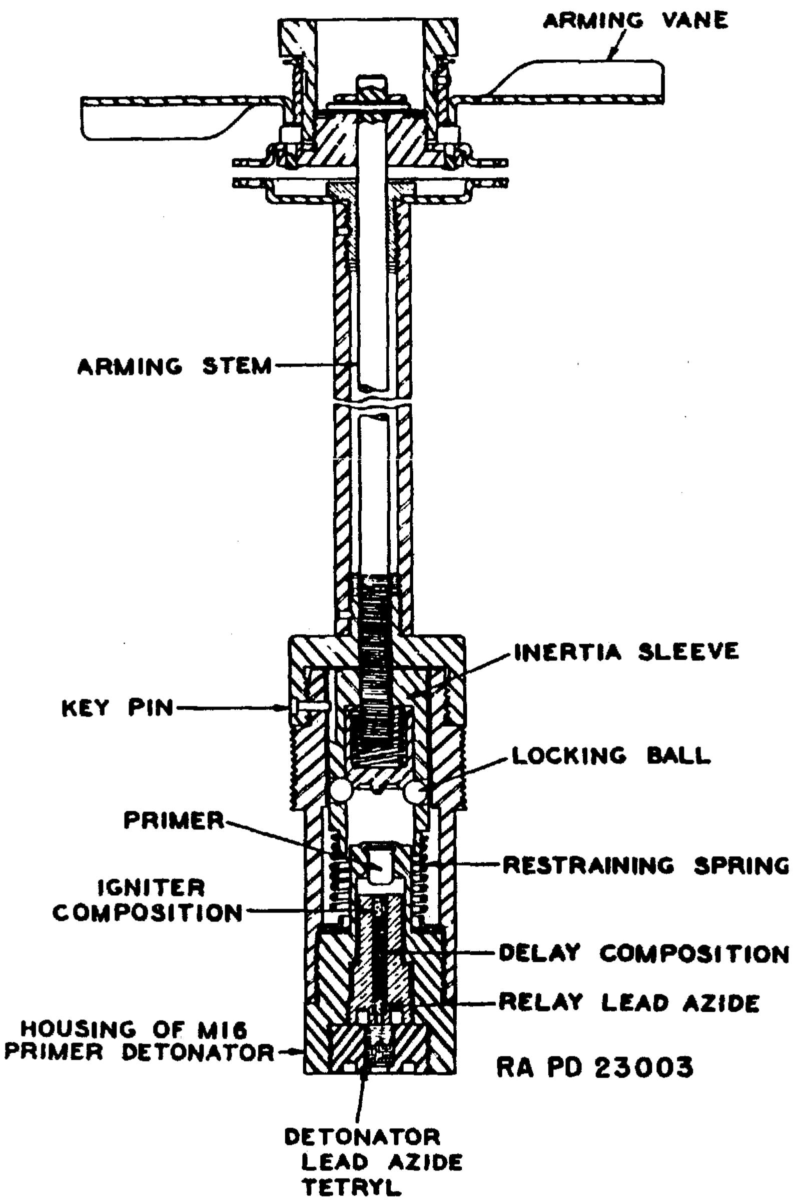

Figure 234 — FUZE, Bomb, M113 (Tail)

M16, 4- to 5-second delay, by unscrewing the primer detonator (which appears as a knurled and grooved member at the forward end of the fuze), and by screwing in the primer detonator assembly with the desired delay. The delay time is marked on the end of the detonator assembly. This replacement is done by hand. The use of tools is neither necessary nor permitted.

Housed in the fuze body, in addition to the detonator assembly, is the firing pin assembly. The firing pin assembly is of the cocked firing pin type. After arming, only a very light impact is necessary to cause detonation of the fuze; therefore, it is extremely sensitive to shock after the fuze is armed. The firing pin assembly is held in place (unarmed) by the threaded arming stem, which passes through the arming stem tube to the upper portion of the fuze. There is no gear reduction mechanism; the arming vane is directly connected to the arming stem which releases the firing pin assembly after approximately 18 turns of the vane. The vane is shipped unassembled to the fuze. It has 4 blades, 0.5 inch wide and 5 inches long.

This fuze is used for low-altitude demolition bombing as its special purpose. For that reason, it is instantaneous in arming and has a long delay action on impact. This long delay allows the plane to escape after the bomb strikes its target, or if it should accidentally strike another bomb while in flight after it has armed. For sea bombing, a 4- to 5-second delay primer detonator is used to allow the bomb to sink a sufficient depth underneath the water and then function near the side of the ship below the water line so as to produce effective damage.

With a direct arming vane type of fuze such as this, a special precaution must be taken to insure that a safety pin or arming wire is in place at all times to prevent any rotation of the vane and arming stem. If the arming stem has been rotated and unscrewed from the firing pin assembly (indicated by a gap between the eyelets in the stem cup and vane holder assembly of ½ inch or more), the fuze should be destroyed. One must not attempt to reengage the threads in the firing pin assembly. If the arming vane and arming stem have rotated, and the gap between eyelets is less than ½ inch, the primer detonator should be removed and the arming stem turned counterclockwise until tight and then turned clockwise three-quarters of a turn. The primer detonator may then be replaced. The arming stem should not be turned while the fuze is in a bomb.

Function. The bomb is dropped and the arming wire is retained in the plane. The arming vane is rotated by the air stream. The rotating arming vane directly connected to the arming stem, unscrews the arming stem from an inertia sleeve, arming the fuze. On impact, the force of inertia causes the inertia sleeve to move inward against a restraining spring. A pair of locking balls housed in the inertia sleeve, and supporting the firing pin, move with the sleeve until they fall into a recess in the fuze housing. The movement of the locking balls into the recess frees the firing pin which is forced into the primer of the M16 Primer Detonator by a compressed spring. The flame produced ignites a black powder igniter charge which in turn ignites a delay of black powder. This burns for 8 to 11 seconds or 4 to 5 seconds, and ignites a relay of lead azide. The wave from the relay functions the detonator of lead azide and tetryl.

Primer Detonator M16. The Primer Detonator M16 screws into the bases of the following Tail Fuzes M112, M113, M114, M115, M116, M117, and M122. The primer detonator consists of a housing so threaded and machined as to receive primer, delay, and detonator assemblies. Around the outside of the housing will be found threads which are designed to screw into the base of any of the fuzes previously mentioned. The M16 Primer Detonator in outward appearance resembles the M14 Primer Detonator. It can be distinguished from the M14 by an annular groove in the knurled part, the base of the M14 being completely knurled for facility in handling. The base is painted yellow with black stencil either 4 to 5 or 8 to 11 seconds, to indicate the time of delay. However, as an added safeguard, the two are so threaded and constructed that it is impossible to interchange the M14 and M16 Primer Detonators. The explosive train consists of the following elements in position as listed:

Primer
Igniter, black powder
Delay, black powder, 4 to 5 or 8 to 11 second
Delay, lead azide
Upper detonator, lead azide
Lower detonator, tetryl

FUZES, Tail, M112 and M114. These fuzes are entirely the same as the M113 described above as far as the description and function are concerned, except for the length of the arming stem fuze. The length of the stems varies so that the arming vane will be properly positioned in the air streams. The arming stems are: 9.6 inches on the M112; 12.6 inches on the M113; and 16.6 inches on the M114. Longer stems are necessary or larger bombs.

FUZES, Tail, M115, M116, and M117. The M115, M116, and M117 are Army fuzes designed for Navy use only. Navy planes leaving from aircraft carriers have found it extremely dangerous to carry bombs fuzed with the M112, M113, or M114 Fuzes because of landing hazards due to their almost instantaneous arming. The M115, M116, and M117 incorporate the reduction gear assembly and arming stem found in the A2 modifications of the AN-M100, AN-M101, and AN-M102 Fuzes. (These fuzes do not have to be partially armed for low-altitude water bombing.) Because of the low altitudes from

which the M115, M116, and M117 Fuzes are dropped, the base incorporates the firing mechanism of the M112, M113, and M114 Fuzes respectively, including the use of the M16 Primer Detonator, 4- to 5- or 8- to 11-second delay. These fuzes can therefore be classified as the arming vane type with mechanical delay with 4- to 5- or 8- to 11-second delay action on impact. The M115 corresponds to the M112 or AN-M100A2 Fuzes in size; the M116 corresponds to the M113 or AN-101A2 in size; the M117 corresponds to the M114 or AN-102A2 in size. The M115, M116, and M117 Fuzes are used in the same size bombs as the respective bomb fuzes to which they correspond.

FUZES, Nose, M118 and M119. These fuzes are of the arming vane type and are used in GP bombs and M-series demolition bombs from 100 to 2,000 pounds, inclusive. 500-pound and 1,000-pound SAP bombs also utilize these fuzes. They are used for low-altitude land and sea bombing. Their action on impact is as follows: M118, 4- to 5-second delay; M119, 8- to 11-second delay. The arming time is approximately 16 turns of the arming vane. This is normally accomplished in 80 to 100 feet of air travel.

Description. The M118 and M119 Bomb Fuzes are quick arming fuzes which may be used for extremely low-altitude bombing against unarmored or lightly armored targets. They contain delay elements which give a time delay of 4 to 5 seconds for the M118 Fuze and 8 to 11 seconds for the M119 Fuze to provide time for the plane to leave the effective area of the bomb blast. The delay element provides the only difference between the two models. The fuzes are intended for special tactical missions as auxiliary fuzes in bombs in which M112, M113, and M114 Tail Fuzes are used. They are similar in appearance to the M103 and AN-M103 Nose Bomb Fuzes, differing in that they do not have the reduction gear assembly in the head, nor do they have instantaneous elements. They are not detonator safe, for the explosive train is always in line whether the fuze is in the armed or unarmed position.

Rotation of the arming vane unscrews the arming screw from the striker, causing the vane cup to move forward and permitting the fuze to arm in a manner similar to the arming of the AN-M103 Fuze. Arming discs between the striker and body of the fuze prevent movement of the striker and firing pin prior to arming. The arming vane is held in position by a spring vane-holder ring. It is shipped unassembled to the fuze. Eyelets in the vane strap which aline with corresponding eyelets attached to the vane cup are provided for the arming wire.

Incorporated in each fuze is the explosive element consisting of primer, igniter, delay, relay, upper and lower detonator, lead charge, and booster charge. The tail fuzes used in conjunction with these nose fuzes may have primer detonators of either 4- to 5-second or

8- to 11-second delay. It is important to use the nose fuze of which the time delay corresponds with the time delay of the primer detonator used in the tail fuze.

Function. The bomb is released and the arming wire is retained in the plane. The arming vane is rotated by the air stream and since it is directly connected to the arming screw it turns the screw up and out of the striker. As the arming screw turns in the striker, it moves the vane cup forward and uncovers the arming discs which are then ejected by a spring. The fuze is now armed, the striker which carries the firing pin being prevented by a shear wire from moving inward.

Upon impact, the striker is forced inward causing the shear wire to be broken and the firing pin to strike the primer. The flame from the primer ignites an igniter of red lead and silicon which in turn functions the delay of lead chromate and silicon of either 4 to 5 seconds (M118 Fuze) of 8 to 11 seconds (M119 Fuze). The flame from the delay ignites a relay charge of lead azide which detonates and sends a wave to the detonator (upper and lower) of lead azide and tetryl. The wave is then carried to a lead charge of tetryl which in turn functions the booster of tetryl, which is a part of the fuze.

FUZE, Tail, M106. This fuze is of the arming pin type and is used in GP bombs and M-series demolition bombs from 100 to 2,000 pounds, inclusive. This fuze is standard for issue only, and was used for low-altitude land demolition bombing. On impact, it has a minimum delay of 45 seconds, and it arms instantaneously. It is 9.4 inches long and weighs 2.38 pounds. It is packed one per fiber container, 50 per box.

Description. The primer, delay element, and detonator are located in the body of the fuze. The delay of 45 seconds in this fuze is obtained by means of a coiled length of safety fuse incorporated in the explosive train between the primer and detonator. The striker is located in the tail end of the fuze and is restrained from moving by the arming pin. A restraining spring between the firing pin and primer prevents the striker, which incorporates the firing pin, from moving forward and resting on the primer after the arming pin has been ejected. The arming pin has two holes, the outer one for a cotter pin for shipment, the inner one, which is visible only when a slight pressure is exerted on the head of the arming pin, for the arming wire. The entire fuze is unpainted.

Function. The bomb is dropped and the arming wire is retained in the plane. The arming pin is ejected by the arming pin spring, arming the fuze. The striker which was held in place by the arming pin is now free and is prevented from resting upon the primer by a restraining spring.

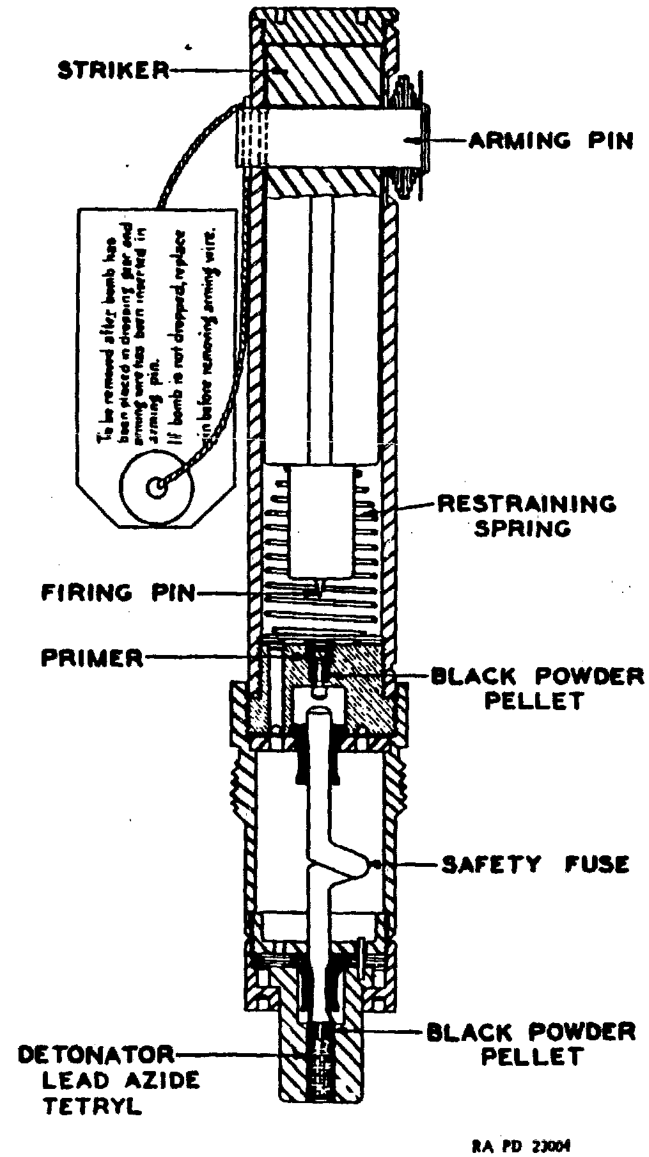

Figure 235 — FUZE, Bomb, M106A1 (Tail)

Upon impact, the force of inertia causes the striker to move inward against the spring driving the firing pin into the primer. The flame from the primer ignites a black powder pellet which insures ignition of the safety fuse. The safety fuse burns from 45 to 60 seconds, at the end of which time, it ignites a second black powder pellet which insures functioning of the detonator of lead azide and tetryl. Upon detonating, the detonator starts a shattering wave which functions the bomb.

Special features of the M106. The M106, besides insuring function of the bomb in the event that the nose fuze fails, is also a special purpose fuze. It is used for low-altitude land demolition bombing. When used for this purpose, the nose fuze is made inoperative by removal of the arming vane or by wrapping the arming wire around the vane, or by removing the nose fuze entirely. Because it is dropped from low altitudes, it arms instantaneously and has a long delay in action on impact to allow the pilot and plane to escape. From low altitudes, the force of inertia is not great. To insure the fuze's functioning, the M106 has a very heavy striker or plunger, a light restraining spring, and a very sensitive primer.

It was found in low-altitude bombing that the angle of impact of the bomb body was almost flat on its side. This tended to break the tail fuze at the point of entrance into the bomb case or rip it entirely out of the bomb body. This led to failure of the bomb to function. An improvement was made to overcome this difficulty. The M106 Fuze body was weakened by machining a groove somewhat above the external threads designed to screw into the bomb body. When the fuze does snap off, having this groove it will break at that point where the complete function will not be hindered.

M106A1. The A1 modification consists of reducing the action of impact from a minimum of 45 seconds to 8 to 11 seconds. In all other features, the fuze is entirely the same. The time of delay and the fuze model is indicated by black stencil on the side of the fuze housing, and the outer end of the body is painted white with the top painted green.

M106A2. For sea bombing, 8- to 11-second delay is too long. The A2 modification consists of reducing the action of impact from 8 to 11 seconds to 4 to 5 seconds. In all other features, the fuze is entirely the same as the M106 and M106A1. The time of delay and fuze model is indicated by black stencil on the side of the fuze housing and the outer end of the body is painted white with the top painted yellow.

The M106 with the A1 and A2 modifications is standard for issue only. The M112, M113, and M114 Fuzes as previously described were designed to replace the M106, M106A1, and M106A2 and were found much more satisfactory.

FUZE, Tail, M122.

General. This fuze is of the arming vane type with mechanical delay. In outward appearance and size, it resembles the M102 Bomb Fuze, having the same reduction gear train. It has, however, the cocked firing pin assembly of the M114 Bomb Fuze. It is a combination, therefore, of two fuzes previously discussed. The primer detonator is the M16 which has been previously described. It is used on a modified 2,000-pound GP bomb in conjunction with the M121 and M4 Destructor which destroys the control units of the bomb. No further information is available at the present time.

FUZE, Tail, M124.

General. This fuze is a very long delay fuze. It functions from 1 hour to 6 days after impact. It has an ampoule of acetone which is crushed by the arming stem. The acetone dissolves a celluloid collar which supports a firing pin. In size, it resembles the M101. It has incorporated in the fuze an antihandling device which will function the fuze if an attempt is made to unscrew it from the bomb body.

This fuze is used on the 500-pound GP bomb, all models; the 500-pound SAP bomb, and the 600-pound demolition bomb which preceded the GP bombs. It is designed to make immediate reparation of enemy targets that have been bombed extremely hazardous. It is further designed to provide a demoralizing effect since it will function if any attempt is made to remove it.

NOTES: Changes in fuze temperature will cause the average delay time to vary approximately as follows:

Temperature (Degrees F)	Average Time (6-hour Delay) (Hours)
110	1
75	2
45	4
40	6
25	12

The firing pin in the fuze is supported by a celluloid collar which may be damaged by exposure to high temperature. If the temperature exceeds 150 F (as indicated by solidification of powder in a green stoppered vial in the packing box), the fuze must not be used for low-altitude bombing. If the temperature exceeds 170 F (as indicated by solidification of powder in a red stoppered vial), the fuze must be destroyed.

Since the glass ampoule in this fuze may break on impact, with subsequent functioning, the fuze must be treated as though it cannot be dropped "safe."

Assembling the fuze to a bomb.

1. Remove adhesive tape and shipping plug from detonator end of fuze. In so doing the fuze should be held by body extension and not by body.

2. Insert holder closing disc (aluminum or copper); holder sealing washer (lead); and detonator holder assembly in lower end of fuze. These parts are packed in the wooden block inclosed with each fuze. Tighten detonator holder assembly with wrench. Since the purpose of the holder closing disc and sealing washer is to seal the detonator against the liquid contents of the fuze, considerable torque should be used to assure proper sealing of the detonator holder assembly. When properly assembled, the holder sealing washer will be flattened and deformed to a considerable extent. In making this assembly, special care should be taken that the crimp holding the extension ball in place is not damaged.

3. Remove thumb screw and ball clip. Ball should move freely in groove. After thumb screw has been removed, every effort should be made to handle fuze carefully since this fuze will fire if body extension is backed off approximately $\frac{3}{64}$ inch from the body.

4. After making sure ball will move freely in groove, screw fuze in bomb as far as possible. *Fuze must not be unscrewed during or after assembly to bomb since unscrewing will cause ball to seize in adapter and will cause fuze to fire.*

5. Arming wire should be inserted in place of arming block cotter pin before safety pin is removed. Fuze is to be inserted in bomb immediately before aircraft takes off. *Fuzed bombs must never be stored.*

FUZES, Tail, M123 and M125. These fuzes are exactly the same as the M124, differing only in the size of the arming stem tube and bombs for which they are adapted in the same manner as the M100, M101, and M102.

FUZE, Tail, Hydrostatic, AN-Mk. 230.

General. This is an arming vane type of fuze with a mechanical delay. Upon arming, detents (spring actuated pins) fly out so as to allow a bellows-like affair to expand under water pressure. It can function in various prechosen depths, and settings are made by a dial located on the exterior of the fuze body which operates a spindle inside the bomb fuze. The spindle varies the compression on the depth spring. By turning the dial, one of five settings can be obtained; namely, 25-, 50-, 75-, 125-, and 175-foot depths.

In operation, it is somewhat similar to the AN-Mk. 224 discussed later in the text except that water pressure forces the initiating explosive into a stationary firing pin. Only one system of bellows is used.

The fuze is used on 500-pound AN-M64 GP, 1,000-pound AN-M65 GP, and 2,000-pound AN-M66 GP Bombs in conjunction with the M115 Adapter Booster. When using this fuze, the sleeve in the M115 Adapter Booster must be removed so that the fuze can be screwed directly into the adapter booster.

Bombs fuzed with the AN-Mk. 230 Fuze are designed to be used against submarines.

Inspection of Bomb Components.

Bomb body. The bomb body should be inspected for proper painting and stenciling, rust spots, and for bent or broken areas. The shipping plugs should be removed from the fuze cavities and the cavities should be inspected for cleanliness and for worn or battered threads. The threads may be gaged for the purpose of insuring free entrance of the fuzes. The fin lock nut should be present and should be held in place securely, when the fin is unassembled, by cotter pins or wires.

Metal shipping bands, when present, should be inspected to insure that they are firmly attached and that the cotter pin which holds one of the main bolts in place has its ends spread apart wide enough so that it will not fall out. The nut holding the second bolt should be screwed on securely. Paper shipping bands, when present, should be inspected to make sure that they are firmly attached. The cotter pin which holds the retainer pin in position should be spread wide apart. The steel strip which holds the shoe around the paper band should be so tightened as to allow the shoe to fit securely over the paper band.

Suspension lugs should be checked for strength of welds to the bomb body and for any damage which might result in weakened lugs. They should be gaged by use of a bomb shackle to insure that they are the correct distance apart and in alinement with each other.

Fuzes. The container should be examined to insure that it is not damaged and is properly stenciled. The fuze should be free from any deterioration such as heavy rust or corrosion which might interfere with the proper function of the fuze and it should be free from any damage due to rough handling. Cotter pins should be checked for sufficient spread and for rust or corrosion which would make withdrawal difficult. All springs should be examined to make sure that rust, corrosion, or brittleness does not interfere with their proper function. In so far as possible, it should be ascertained that all visible safety components such as arming pins, safety blocks, cotter pins, and set screws are present. Fuze threads, external and internal, if present, should be examined to insure that they are not battered, rusted, worn or burred. Vanes should not be damaged nor distorted.

Arming wire assembly. This should be examined to insure that the wire is free from kinks, burs, or rough spots. The swivel loop

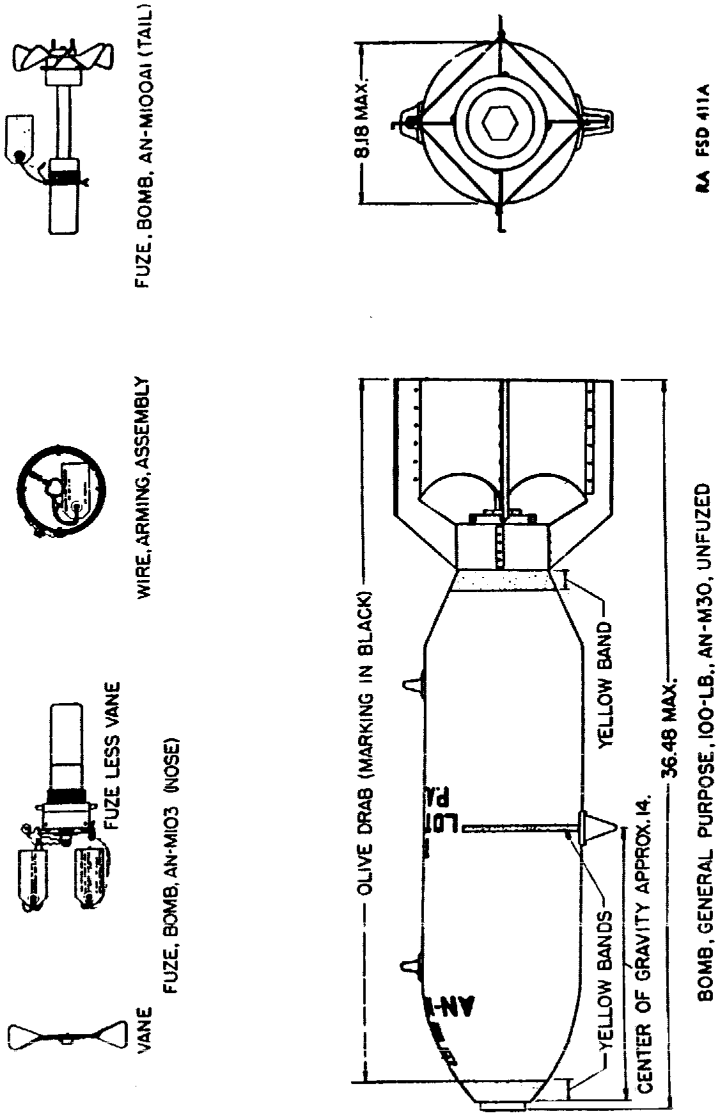

Figure 236 — BOMB, G.P., 100-pound Components, Complete Round

should be properly assembled and should be securely fastened. The arming wire must be checked for brittleness by gripping the ends and bending in a gentle loop, taking care not to produce kinks. The wire must be the proper type, thickness, length, and all additional components to make the assembly complete must be present. When assembled to the bomb, the arming wire should protrude from the fuze housing approximately 2½ inches.

Fin assembly. The fin assembly must be inspected for any distortion or damage. It should be properly welded and painted. If the fin assembly is attached to the bomb, it should be assembled securely and should be so alined that one blade will be in exact line with the suspension lugs, or at an angle of 45 degrees with the lugs. If the fin assembly is not attached to the bomb body, it should be in its proper metal crate. In the crate should be all the necessary components that travel with the fin for that particular assembly. The crate should be properly painted and stenciled.

Inspection Areas. An inspection such as the above in which the components are broken out of the packing should be carried on at a safe distance taking into consideration various factors in accordance with Ordnance Safety Manual regulations.

BOMB, GENERAL PURPOSE, 100-POUND, AN-M30.

General. The GP and M-series bombs of 100-pound weight have the same dimensions. The GP is distinguishable from the M-series by the fact that it has a base plug in the tail and a single suspension lug in addition to two Army lugs. The two Army lugs are 14 inches apart, each 7 inches away from the center of gravity. The single suspension lug is on the center of gravity 14 inches behind the nose.

Use. The 100-pound bomb is used on such targets as ammunition dumps, railway rolling stock, ordinary buildings, supply depots, grounded planes, and aircraft installations.

Description. The total length of this bomb is 38.5 inches, and the diameter is 8.2 inches. The weight of the case is 42.1 pounds and the fins weigh 3.5 pounds. The filler is either 53.3 pounds of 50/50 amatol or 56.6 pounds of TNT. The total weight of the bomb filled with amatol is 98 pounds, and if filled with TNT it weighs 100 pounds. Percentage of filler is approximately 49 percent.

Fuzes. The AN-M30 Bomb is fuzed in the nose with the AN-M103 Fuze and in the tail with the AN-M100A2 Fuze. Alternate fuzes that may be used as substitutes or for special purposes are the M103, M118, or M119 Nose Fuzes, and the M112, M100, M106, or its modifications, or the AN-M100A1 Tail Fuzes.

Complete Round Components. A complete round consists of the following components or an alternate if permissible:
Loaded AN-M30, GP, 100-pound Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M100A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, GENERAL PURPOSE, 250-POUND, AN-M57.

General. The 250-pound bomb replaced the 300 pound, and is preferred when available. The AN-M57 has a base plug in the tail, the single suspension lug, and the two Army suspension lugs. The Army lugs are 14 inches apart, each 7 inches from the center of gravity. The single suspension lug is on the center of gravity 17.7 inches behind the nose.

Use. Targets suitable for the 250-pound bomb are concentrations of railway rolling stock, rail terminals and buildings of similar construction, ammunition dumps, aircraft installations, seacraft such as submarines, transports, destroyers, etc.

Description. The total length of this bomb is 47.8 inches and the diameter is 10.9 inches. The weight of the case is 116. 6 pounds and the fins weigh 6.0 pounds. The filler is either 123.7 pounds of 50/50 amatol or 129 pounds of TNT. The total weight of the bomb filled with amatol is 240.9 pounds and if filled with TNT it weighs 262.3 pounds. Percentage of filler is approximately 49 percent.

Fuzes. The 250-pound Bomb AN-M57 is fuzed in the nose with the AN-M103 Fuze and in the tail with the AN-M100A2. Alternates or substitutes are exactly as those provided for the 100-pound AN-M30 Bomb described previously.

Complete Round Components. A complete round consists of the following listed components or permissible alternates:
Loaded AN-M57, GP, Bomb Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M100A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, GENERAL PURPOSE, 500-POUND, AN-M43 AND AN-M64.

General. The 500-pound bomb is made in three models: the M43, the AN-M43, and the AN-M64. The case and the fin can be considered the same for the three models; therefore, these bombs are considered under one heading because of their similarity in construction and use.

The identifying features of the M43 are the tail-base cap and two Army suspension lugs. This bomb is converted for Navy use by the M1 Trunnion Band which is shipped as an accessory. The AN-M43 has the same case as the M43, but is readily identifiable by the tail-base plug and the addition of the single suspension lug.

The AN-M64 is practically the same bomb as the AN-M43 having a tail-base plug. The internal threads are somewhat wider in diameter to receive the M115 Adapter Booster, which results in a slight change in the fin assembly. It also has two Army suspension lugs and the single lug. One distinguishing feature is the presence of a sleeve in the tail adapter booster for Army tail fuzes. The AN-M64, by utilizing the M115 Adapter Booster, makes it possible to use both Army and Navy tail fuzes. The diameter of the Navy fuze is greater than that of the Army fuze and therefore requires an adapter of larger dimensions. To reduce the diameter of the adapter to take the Army fuzes, a threaded sleeve is screwed into the M115 Adapter Booster. Bombs using the M115 Adapter Booster are shipped with the sleeve in place. To make use of the Navy fuze, the sleeve must be removed with a special stud wrench having two studs which fit into the two holes in the face of the sleeve.

Use. These bombs are intended for destructive effect against such targets as steel railway bridges, underground railways, seacraft such as light cruisers, concrete docks, medium size buildings, etc.

Description. The total length of these bombs is 59.2 inches, and the diameter is 14.2 inches. The case is 0.3 inch thick and weighs 210 pounds. The explosive filler is either 264.5 pounds of 50/50 amatol or 280 pounds of TNT. The total weight when filled with amatol is 494 pounds, and if filled with TNT the weight is 508 pounds.

Fuzes. The standard nose fuze used in these bombs is the AN-M103 and the tail fuze is the AN-M101A2. Alternates or substitutes are the M103, M118, or M119 Nose Fuzes and the M113, AN-M101A1, M101, M106 (all modifications), or the AN-Mk. 230 Hydrostatic Tail Fuzes.

Complete Round Components. A complete round consists of the following components or their substitutes:
Loaded M43, AN-M43, or AN-M64 Bomb Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M101A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, GENERAL PURPOSE, 1,000-POUND, AN-M44 AND AN-M65.

General. The 1,000-pound bomb is made in three models, the M44, the AN-M44, and the AN-M65. The bomb case and the fin can be considered the same for the three models; therefore, these bombs are considered under one heading because of their similarity in construction and use.

The M44 is identified by the tail-base cap and the two Army suspension lugs. It is converted to Navy use by the M2 Trunnion Band. The AN-M44 makes use of the same case as the M43 but is readily identifiable by the tail-base plug and the addition of the single suspension lug. The AN-M65 is distinguished from the AN-M44 by the sleeve in the M115 Adapter Booster. The M115 Adapter Booster is used to adapt both Army and Navy tail fuzes. The sleeve must be removed when Navy fuze is used. Detailed explanation of the M115 Adapter Booster is given under the AN-M64 500-pound Bomb.

Use. These bombs are intended for destructive effort aganst such targets as reinforced concrete bridges, steel railway bridges, piers, approach spans, etc.

Description. The total length of these bombs is 69.5 inches and the diameter is 18.8 inches. The case is 0.35 inch thick and weighs 399 pounds. The fins weigh 21.5 pounds. The filler is 536.6 pounds of 50/50 amatol or 566 pounds of TNT. The total weight is 939 pounds when loaded with amatol, and 967 pounds when loaded with TNT. Percentage of filler is 56 percent.

Fuzes. These bombs are fuzed with the AN-M103 Nose Fuze and the AN-M102A2 Tail Fuze. Alternate or substitute fuzes are the Nose Fuzes M103, M118, or M119, and Tail Fuzes AN-M102A1, M114, M106 (all modifications), M102, or the AN-Mk. 230 Hydrostatic Fuze.

Complete Round Components. A complete round includes the following components or any permissible alternates:
Loaded M44, AN-M44, AN-M65 Bomb Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, GENERAL PURPOSE, 2,000-POUND, AN-M34 AND AN-M66.

General. The 2,000-pound bomb is made in three models: the M34, the AN-M34, and the AN-M66. The bomb case and the fin

assembly can be considered the same for the three models; therefore, these bombs are considered under one heading because of their similarity in construction and use.

The M34 is identified by the tail-base cap and two Army suspension lugs. The suspension lugs are 30 inches apart. The AN-M34 has the additional single suspension lug and the tail-base plug. The single lug is on the center of gravity 33.5 inches behind the nose. The AN-M66 can be distinguished by the M115 Adapter Booster, used to adapt Navy fuzes to Army bombs.

Use. These bombs are intended for destructive effect against such massive structures as reinforced concrete bridges, dams, battleships, large skyscrapers, etc.

Description. These bombs are 92.9 inches long with a diameter of 23.3 inches. The case is 0.52 inch thick and weighs 942.5 pounds. The explosive filler is 1,014 pounds of 50/50 amatol or 1,117 pounds of TNT. The total weight is 2,045 pounds if filled with amatol, and 2,101 pounds if filled with TNT. Percentage of explosive filler is 54 percent.

Fuzes. These 2,000-pound bombs are fuzed in the nose with the AN-M103 Fuze, and in the tail with the AN-M102A2 Fuze. Alternates or substitutes for the nose are the M103, M118, or M119 Fuze. Alternate fuzes for the tail are the AN-M102A1, M106 (all modifications), M102, M114, or the AN-Mk. 230 hydrostatic.

Complete Round Components. A complete round consists of the following components or their alternates:
Loaded M34, AN-M34, AN-M66 Bomb Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, LIGHT CASE, 4,000-POUND, AN-M56.

General. This bomb is designated as a light case because it has an exceptionally thin metal case in order to allow for a high percentage of explosive filler. Because of the equipment required to carry and release this bomb, it has only two Army suspension lugs 30 inches apart. Contrary to the other modern bombs previously described, the tail end is closed with a rear closing cap instead of a tail-base plug. This is due to the fact that penetration is not

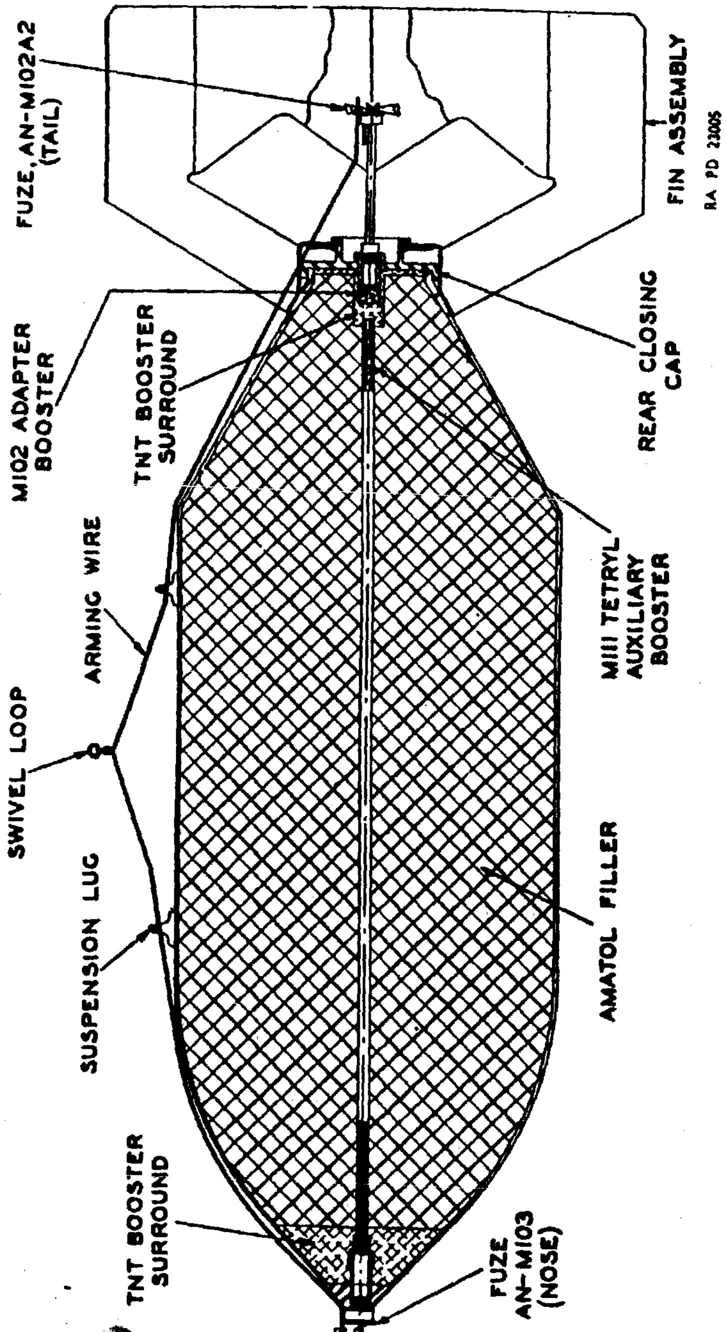

Figure 237 — BOMB, Light Case, 4,000-pound, AN-M56

desired. This is the largest bomb used by the U. S. forces today, although larger bombs may be forthcoming as the need arises.

Use. This bomb is intended for use against targets of large area such as villages, towns, and cities to produce a tremendous blast effect. It is familiarly termed a block buster.

Description. The total length of this bomb is 117.2 inches, and the diameter is 34.2 inches. The case is 0.38 inch thick and weighs 840.3 pounds. It is filled with either 3,240.6 pounds of 50/50 amatol, or 3,362 pounds of TNT. The total loaded weight is 4,087 pounds if filled with amatol, or 4,204 pounds if filled with TNT. Percentage of filler is 77.4 percent.

Fuzes. The L.C. 4,000-pound bomb is fuzed with the AN-M103 in the nose and the AN-M102A2 nondelay in the tail. Alternates are the M103 Nose Fuze and the AN-M102A1 Tail Fuze.

Complete Round Components. A complete round is made up of the following components:

Bomb Case AN-M56, loaded (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M102A2, nondelay (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, DEMOLITION, 300-POUND, M31.

General. The 300-pound M31 Bomb has been replaced by the 250-pound bomb, but it is still found in service. It is identified by the rear closing cap and it has only two Army suspension lugs 14 inches apart.

Use. It is used on the same targets as the 250-pound GP bomb previously described. These targets are concentrations of railway rolling stock, brick and concrete buildings, aircraft installations, supply depots, and unarmored seacraft.

Description. The length of the 300-pound demolition bomb is 51 inches and its diameter is 10.9 inches. The case is 0.2 inch thick and it weighs 124 pounds. The explosive filler consists of 135 pounds of 50/50 amatol, or 144 pounds of TNT. Total weight of the bomb is 263 pounds when loaded with 50/50 amatol, and 270 pounds when loaded with TNT. The percentage of explosive filler is 50 percent.

Fuzes. The 300-pound Bomb M31 is fuzed with the Nose Fuze AN-M103 and the Tail Fuze AN-M100A2. Alternate fuzes are the M103, M118, or M119 Nose Fuzes and the M112, M100, AN-M100A1, or M106 (all modifications) Tail Fuzes.

Complete Round Components. A complete round consists of the following components or their alternates:
Loaded M31 Bomb Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M100A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, DEMOLITION, 600-POUND, M32.

General. The 600-pound bomb has been superseded by the 500-pound GP bomb. It is identified by the presence of two Army lugs and a rear closing cap.

Use. It is used on the same targets as the 500-pound GP bombs previously described. These targets are light steel bridges, concrete docks, underground railways, medium sized buildings, light cruisers, seacraft, and railway terminals.

Description. This bomb has a total length of 61.9 inches and has a diameter of 15.2 inches. The case is 0.35 inch thick and weighs 265.5 pounds. It has an explosive filler of 319.3 pounds of 50/50 amatol, or 336 pounds of TNT. Total weight of the bomb filled with amatol is 586 pounds, and if filled with TNT, it weighs 603.5 pounds. The percentage of explosive filler is approximately 56 percent.

Fuzes. The nose fuze used in the 600-pound bomb is the AN-M103 and the tail fuze is the AN-M101A2. Permissible alternates are the M103, M118, and M119 Nose Fuzes as well as the M113, M101, AN-M101A1, and M106 (all modifications) Tail Fuzes.

Complete Round Components. A complete round consists of the following components or their permissible components:
Loaded M32 Bomb Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M101A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

BOMB, DEMOLITION, 1,100-POUND, M33.

General. The 1,100-pound bomb has been replaced by the 1,000-pound GP bomb, but it may still be found in service. It is identified by the rear closing cap and it has only two Army suspension lugs 14 inches apart.

Use. It is used on the same targets as the 1,000-pound GP bombs. These targets are reinforced concrete and heavy steel bridges, large reinforced buildings, light armored seacraft, reinforced docks, and warehouses.

COMPLETE ROUND CHART—GP BOMBS

Weight, Designation, and Status	Weight of Filler (Amatol)	Tail Auxiliary Booster	Tail Adapter Booster	Tail Fuze	Nose Fuze	Nose Auxiliary Booster
100 lb AN-M30 (S&M)	54.2 lb	None	M102	AN-M100A2(1)	AN-M103(2)	M104
250 lb AN-M57 (S&M)	123 lb	M104	M102	AN-M100A2(1)	AN-M103(2)	M104
500 lb AN-M43 (S)	266 lb	M104	M102	AN-M101A2(3)	AN-M103(2)	M104
500 lb AN-M64 (S&M)	264.5 lb	M104	M115	AN-M101A2(4)	AN-M103(2)	M104
1,000 lb AN-M44 (S)	538 lb	M104	M102	AN-M102A2(5)	AN-M103(2)	M104
1,000 lb AN-M65 (S&M)	536.6 lb	M104	M115	AN-M102A2(6)	AN-M103(2)	M104
2,000 lb AN-M34 (S)	1,077 lb	M104	M102	AN-M102A2(5)	AN-M103(2)	M104
2,000 lb AN-M66 (S&M)	1,014 lb	M104	M115	AN-M102A2(6)	AN-M103(2)	M104
4,000 lb AN-M56 L.C. (S&M)	3,245 lb	....	M102	AN-M102A2(7)	AN-M103(8)	M111(9)

(1) Fuze AN-M100A1, M100, M106 or modifications, M112, M115, or M123 may be substituted.
(2) Fuze M103, M118, M119, may be substituted.
(3) Fuze AN-M101A1, M101, M106 or modifications, M113, M116 or M124 may be substituted.
(4) Fuze AN-M101A1, M101, M106 or modifications, M113, M116, M124 or AN-Mk. 230 may be substituted.
(5) Fuze AN-M102A1, M102, M106 or modifications, M114, M117, or M125 may be substituted.
(6) Fuze AN-M102A1, M102, M106 or modifications, M114, M117, M125 or AN-Mk. 230 may be substituted.
(7) Fuze AN-M102A1 may be substituted.
(8) Fuze M103 may be substituted.
(9) Passes through entire length of bomb body from nose to tail.

FUZES USED IN GP BOMBS

Fuze Designation	Position in Bomb	Booster in Fuze	Bomb for Which It Is Adapted	Method of Arming	Primer Detonator	Action on Impact
M100	Tail	No	100 to 300 lb	Arming Vane w/mech. del.	None	0.1 sec del.
AN-M101A1	Tail	No	500 and 600 lb	Arming Vane w/mech. del.	M14 or M14A1	Nondelay to 0.1 sec del.
AN-M102A2	Tail	No	1,000 to 4,000 lb	Arming Vane w/mech. del.	M14 or M14A1	Nondelay to 0.1 sec del.
AN-M103	Nose	Yes	All GP Incl. 4,000 lb L.C.	Arming Vane w/mech. del.	None	Selective Inst., or 0.1
M106	Tail	No	All GP	Arming Pin	None	45 sec del.
M106A1	Tail	No	All GP	Arming Pin	None	8 to 11 sec del.
M106A2	Tail	No	All GP	Arming Pin	None	4 to 5 sec del.
M112	Tail	No	100 to 300 lb	Arming Vane	M16	4 to 5 sec or 8 to 11 sec del.
M113	Tail	No	500 and 600 lb	Arming Vane	M16	4 to 5 sec or 8 to 11 sec del.
M114	Tail	No	1,000 to 2,000 lb	Arming Vane	M16	4 to 5 sec or 8 to 11 sec del.
M115	Tail	No	100 to 300 lb	Arming Vane w/mech. del.	M16	4 to 5 sec or 8 to 11 sec del.
M116	Tail	No	500 and 600 lb	Arming Vane w/mech. del.	M16	4 to 5 sec or 8 to 11 sec del.
M117	Tail	No	1,000 to 2,000 lb	Arming Vane w/mech. del.	M16	4 to 5 sec or 8 to 11 sec del.
M118	Nose	Yes	All GP	Arming Vane	None	4 to 5 sec del.
M119	Nose	Yes	All GP	Arming Vane	None	8 to 11 sec del.
M121	Tail	No	Destructor	Arming Vane w/mech. del.	M27	Nondelay
M122	Tail	No	2,000 lb	Arming Vane w/mech. del.	M16	4 to 5 sec or 8 to 11 sec. del.
M123	Tail	No	100 to 300 lb	....	....	1 to 144 hr del.
M124	Tail	No	500 and 600 lb	....	....	1 to 144 hr del.
M125	Tail	No	1,000 to 2,000 lb	....	....	1 to 144 hr del.
AN-Mk. 230	Tail	No	500, 1,000, 2,000 lb	Arming Vane w/mech. del.	None	Water pressure

Description. This bomb has a total length of 71.1 inches and a diameter of 19.8 inches. The case is 0.43 inch thick and weighs 493.7 pounds. The filler is 588 pounds of 50/50 amatol, or 613 pounds of TNT. The total weight when filled with amatol is 1,083.4 pounds, and when filled with TNT, it weighs 1,113.4 pounds. The percentage of filler is approximately 54 percent.

Fuzes. Fuzes provided for this bomb are the AN-M103 Nose Fuze and the AN-M102A2 Tail Fuze. Alternate fuzes are the M103, M118, or M119 Nose Fuze with the M114, M102, AN-M102A1 or M106 (all modifications) Tail Fuzes.

Complete Round Components. A complete round consists of the following components or permissible alternates:
Loaded M33 Case (1)
Nose Fuze AN-M103 (1)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type B (1)
Fahnestock clips (2)

DESTRUCTOR M4.

General. The Destructor M4 is a detonating device for use in control unit boxes of certain planes to destroy their contents completely. It consists primarily of an explosive block of 2.5 pounds of tetrytol, an impact type of bomb tail fuze, and accessories for its assembly and mounting in the control unit.

Description. The main destructor assembly consists of an adapter into which the fuze fits, and of the explosive block mounted on a sheet metal support which is bent into the shape of an L. The adapter is welded in place on the short leg of the L. The explosive block is strapped in place on the other leg. The adapter and explosive block are connected by a length of detonating cord, which is crimped to the base of the adapter and extends to and through the center of the explosive block. A wood block having a channel to accommodate the detonator cord is fastened to the support and protects the detonator cord.

Complete Round Components. The Destructor M4 consists of the following components:
Main destructor assembly
Fuze Bomb M121 (tail) with vane assembly
Arming wire assembly
Fuze locking nut

FUZE, Tail, M121 for Destructor. This fuze is of the arming vane type with mechanical delay. It resembles in outward appearance and size, the M100 Bomb Fuze having the same reduction gear train as the M100. It has, however, the cocked firing pin assembly

of the M112 Bomb Fuze. It is a combination, therefore, of two fuzes previously discussed. The primer detonator it has incorporated in it, however, is the M27 Nondelay Primer Detonator which functions immediately on impact. It is used to function the M4 Destructor detonating device. On impact, the detonator in the fuze fires the detonator cord which detonates the explosive block of 2.5 pounds of tetrytol.

FURTHER REFERENCES: All references may be found at the close of this section.

Chapter 3

Semi-armor-piercing and Armor-piercing Bombs

GENERAL.

Semi-armor-piercing Bombs. Semi-armor-piercing (SAP) and armor-piercing (AP) bombs are designed to pierce the deck armor of battleships, heavy concrete structures, and similar highly resistant targets. SAP bombs have a heavy case of special steel and contain approximately 30 percent explosive. They are effective against all but the heaviest deck armor of modern battleships. SAP bombs are conventional in outline, resembling cylindrical GP bombs but being somewhat smaller in diameter and longer. The nose fuze seat liner is generally filled by a steel plug.

Armor-piercing Bombs. Armor-piercing bombs are designed to penetrate the heaviest deck armor, such as that used on the deck of a modern battleship. Unlike the rest of our modern demolition bombs, the armor-piercing bombs are filled with explosive D. This explosive is used because armor-piercing bombs are subject to great shock, and explosive D is very insensitive to shock. Armor-piercing bombs are designed to penetrate the target before function, and premature function due to a sensitive explosive is therefore undesirable.

Both the Navy and Army have a series of armor-piercing bombs. The Army bombs are converted 10-inch, 12-inch and 14-inch seacoast mortar deck-piercing or armor-piercing projectiles. The suspension lugs are attached to the body by means of suspension bands that surround the circumference of the shell and are bolted in place. A tail-base plug has been added to adapt the shell for tail adapter booster, fuze, and fin assembly. These bombs are standard for issue only.

The Navy bombs are made to be interchangeable for Army or Navy use. These bombs are standard for issue and manufacture.

Penetration and Terminal Velocity. GP bombs will penetrate three to four stories of ordinary buildings. SAP bombs will penetrate five to six stories of heavy construction or 2½ to 3 inches of armor plate. AP bombs are made to pierce 6 to 7 inches of armor plate.

The semiarmor-piercing bombs are capable of penetrating moderately armored decks from 12,000-foot altitude in horizontal bombing, or light armored decks in dive bombing from about 2,500-foot altitude. There is a small degree of underwater effect from near misses with the 1,000-pound size, but the effect is negligible with the 500-pound size.

The large armor-piercing bombs are capable of piercing the heaviest armor deck from about 12,000 feet in horizontal bombing, or moderate decks in dive bombing from about 2,500 feet.

In considering the terminal velocity of the above types of bombs, it was found that at 14,000 feet, planes traveling at 200 miles per hour dropped bombs producing the following maximum terminal velocities:

GP	SAP	AP
600-700 ft per sec	750-800 ft per sec	900-950 ft per sec

Armor-piercing Bomb Fuze, Nose AN-Mk. 228.

General. This fuze is designed to be used on armor-piercing bombs of Navy design such as the 1,600-pound AN-Mk. 1 and the 1,000-pound AN-Mk. 33. It is of the arming vane type with mechanical delay having a series of reduction gears to produce the desired delay in arming. It arms in 900 feet of air travel, and is designed to function on impact with a delay time of 0.08 second. One auxiliary booster of 180 grams is required to be used with this fuze. The auxiliary booster is found in the adapter booster fuze seat located in the bomb body. The fuze is packed one per can, four cans per crate.

BOMB, SEMI-ARMOR-PIERCING, 500-POUND, AN-M58.

General. This bomb is of the cylindrical type and has a box type fin. It contains approximately 154 pounds of high explosive and is adapted for both nose and tail fuzes, although the nose fuze seat liner contains a steel plug instead of a fuze. The tail-fuze cavity is kept free of foreign matter by means of an adapter plug. This bomb can be identified by the sharply pointed nose and pointed nose plug. It has two Army suspension lugs 14 inches apart and a single suspension lug at the center of gravity. It utilizes a tail-base plug as the GP bombs do.

Use. The 500-pound AN-M58 SAP Bomb is designed to pierce armor plate, reinforced concrete construction, and similar resistant targets.

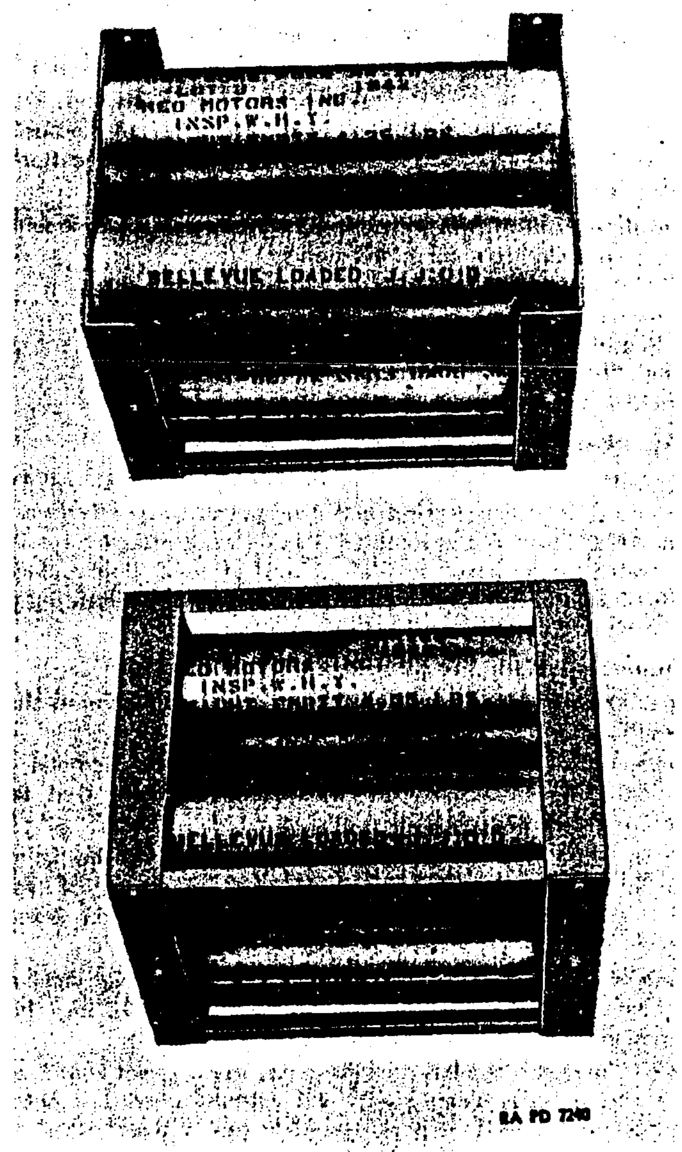

Figure 238 — FUZE, Bomb, AN-Mk. 28, Mod. 1—Packing

AMMUNITION INSPECTION GUIDE

Description. The total length of the 500-pound SAP bomb is 57.9 inches and the diameter is 11.9 inches. The case is 0.75 inch thick and weighs 310 pounds. It is filled with 154 pounds of 50/50 amatol, or 159 pounds of TNT. Total filled weight is 466.5 pounds if amatol is used, or 471.5 if TNT is used. The percentage of explosive filler is approximately 32 percent.

Fuzes. Standard fuzes used are, none in the nose and the AN-M101A2 in the tail. For special purposes or as substitutes, Alternate Fuzes M103, AN-M103, M118, and M119 are used in the nose while the AN-M101A1, M101, M113, and M106 (all modifications) are supplied for the tail.

Complete Round Components. The following components are provided to make up a complete round:

Bomb Case AN-M58, loaded (1)
Tail fuze AN-M101A2 (1)
Fin assembly (1)
Arming wire type A (1)
Fahnestock clip (1)

BOMB, SEMI-ARMOR-PIERCING, AN-M58A1.

General. This bomb was designed to replace the AN-M58 which was found to lack necessary penetrating power to be effective.

The AN-M58A1 is the same as the AN-M58 except for a heavier nose. Added to the nose was 27.5 pounds of steel. This replaced 5.5 pounds of amatol in order to give the bomb more penetrating power. This bomb is S & M. The AN-M58 is S.

Comparison With the 500-pound GP Bomb.

Use. The SAP bomb is used against more resistant targets than the GP bomb.

Shape. Both bombs are cylindrical; however, the diameter of the SAP bomb is much narrower (11.9 inches as compared to 14.2 inches) and the nose portion is more pointed.

Percentage of filler. Although the filler is the same, the percentage varies. The SAP carries approximately 30 to 33 percent of explosive filler, whereas the GP carries approximately 50 to 55 percent of explosive filler.

Bomb case. The SAP bomb case is made of special steel and is much heavier and thicker (0.75 in. as compared to 0.3 in.) than the corresponding GP bomb.

Fuzes. The SAP bomb, although it has the conventional fuze seat liner in the nose, is usually provided with no nose fuze but has a steel nose plug to aid in penetration. It can utilize a nose fuze in place of the steel plug. If it were to employ a nose fuze, this bomb could be effectively used as a large fragmentation bomb.

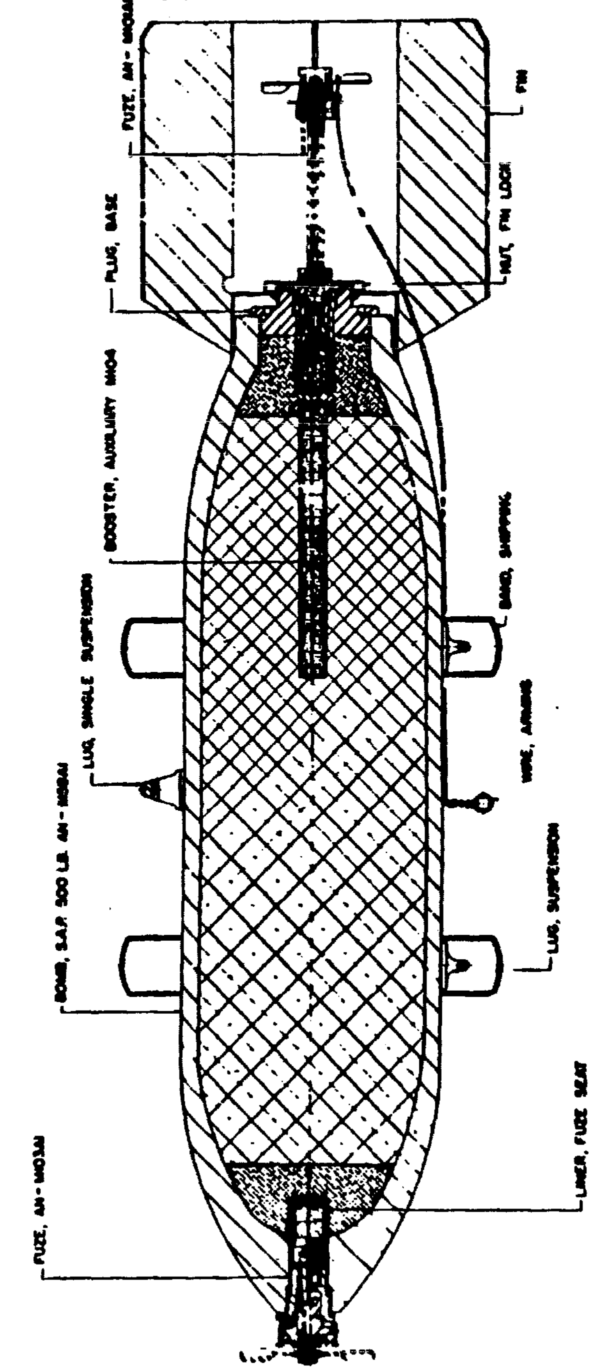

Figure 239 — 500-pound Bomb AN-M58A1—Sectionalized View

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Arming wire. As it usually employs only a tail fuze type A, arming wire 0.064 inch in diameter is shipped as a component of the complete round whereas the GP bomb utilizes a type B arming wire.

Auxiliary booster. The SAP bomb employs merely a tail auxiliary booster, whereas at the present time (although a change may be forthcoming) the GP bomb employs both a nose and tail auxiliary booster.

Other features. In all other features except size, the two bombs are alike. Both utilize a tail-base plug instead of a rear closing cap and a box type fin held firmly in place by a fin lock nut. The adapter booster in the SAP bomb is always the M102 whereas in the GP bombs either the M102 or the M115 Adapter Booster is employed, depending on the model of the bomb.

BOMB, SEMI-ARMOR-PIERCING, 1,000-POUND, AN-M59.

General. This bomb is similar except in size to the 500-pound SAP bomb previously described. It is cylindrical in shape and has a box type fin. It has approximately 307 pounds of high explosive and is adapted for both nose and tail fuze, although the nose fuze adapter (fuze seat liner) contains a steel plug instead of a fuze. The tail fuze cavity is kept free of foreign matter by an adapter plug or shipping plug. This is the largest bomb of the semiarmor-piercing type. It has the Army lugs 14 inches apart, one single suspension lug at the center of gravity, and a tail-base plug in the same manner as the GP bombs.

Use. This bomb is used against heavily reinforced buildings, docks, bridges, and seacraft.

Description. The total length of this bomb is 70.4 inches and the diameter is 15.1 inches. The case is 0.75 inch thick and weights 661 pounds. It is filled with 307 pounds of 50/50 amatol, or 318 pounds of TNT. The total loaded weight is 971 pounds with amatol, or 990 pounds with TNT filler. Percentage of filler is approximately 31 percent.

Fuzes. Fuzes provided for the 1,000-pound SAP bomb are the standard AN-M102A2 Tail Fuze with no nose fuze; however, alternates are the Nose Fuzes M103, AN-M103, M118, and M119, with Tail Fuzes AN-M102A1, M102, M114, and M106 (all modifications).

Complete Round Components. A complete round consists of the following components or their alternates:

Bomb Case AN-M59, loaded (1)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type A (1)
Fahnestock clip (1)

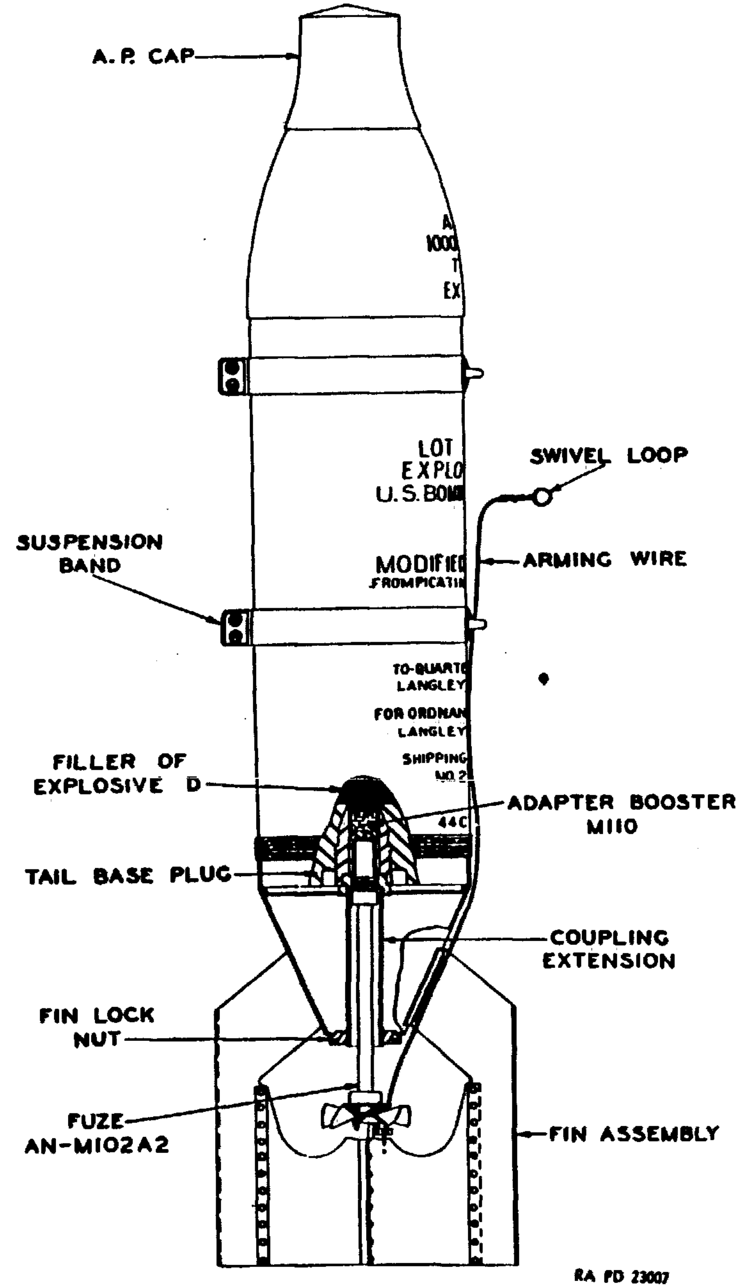

Figure 240 — BOMB, A.P., 1,000-pound, M52

BOMB, ARMOR-PIERCING, 1,000-POUND, M52.

General. The 1,000-pound armor-piercing bomb is a converted 12-inch mortar shell. The modifications included the removal of the base fuze and the incorporation of a tail-base plug which adapted the shell to receive a tail adapter booster, the M110, and a box type fin assembly by means of a coupling extension and fin lock nut. The fin lock nut holds the fin assembly around the bomb body in the same manner as described for the GP bombs, except that the threads to seat the fin lock nut are provided by the coupling extension.

Attached to the bomb body are two suspension bands which provide the lugs for double suspension. These bands fit around the circumference of the shell and are bolted in place. For dive bombing purposes, the Trunnion Band M3A1 was included in the complete round. The final addition was a type A arming wire assembly .064 inch in diameter for use in the tail fuze. This bomb can be identified by the blunt mild steel pellet on the nose.

Description. Total length of this bomb is 70.88 inches and the diameter is 12 inches. The case is 2.3 inches thick and weighs 983 pounds. It is filled with 58.35 pounds of explosive D, bringing the total weight to 1,077 pounds. Percentage of explosive filler in this bomb is 5.4 percent.

Fuzes. The bomb is fuzed with the Tail Fuze AN-M102A2. There is no nose fuze. Substitute fuzes are the AN-M102A1 and M102 Tail Fuzes.

Complete Round Components. A complete round consists of the following components or permissible substitutes:
Covered Mortar Shell M52, 1,000-pound, loaded (1)
Suspension bands (2)
Tail Fuze, AN-M102A2 (1)
Fin assembly (1)
Arming wire, type A (1)
Fahnestock clip (1)

The A1 Modification. The 1,000-pound AP Bomb M52A1 differs from the M52 only in that it has a new adapter booster which has a greater tetryl booster charge.

BOMB, ARMOR-PIERCING, 900-POUND, M60.

General. This bomb is a converted 12-inch mortar shell. Its modifications in general are the same as that previously described for the AP, 1,000-pound, M52 Bomb.

Description. Complete length of this bomb is 61.72 inches and the diameter is 12 inches. The case weighs 807.74 pounds and is filled with 43.34 pounds of explosive D to bring the total weight of the bomb to 899 pounds. Percentage of filler is approximately 5.5 percent.

Fuzes. The standard for this bomb is the AN-M102A2 Tail Fuze. Alternates are the AN-M102A1 and M102 Tail Fuzes.

Complete Round Components. A complete round consists of the following components or alternates:
Converted Mortar Shell M61, loaded (1)
Suspension bands (2)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type A (1)
Fahnestock clip (1)

BOMB, ARMOR-PIERCING, 800-POUND, M61.

General. The M61 Bomb is a converted 12-inch mortar shell. In general, the modifications involved are the same as those in the AP, 1,000-pound, M52 Bomb. It can be identified by its extremely blunt nose and threads for a windshield.

Description. Total length of this bomb is 58.72 inches and the diameter is 12 inches. Weight of the empty case is 787.28 pounds. The filler is 32.68 pounds of explosive D, bringing the weight of the complete round to 853 pounds. Percentage of filler is approximately 3.8 percent.

Fuzes. The standard fuze for this bomb is the Tail Fuze AN-M102A2 with the AN-M102A1 and M102 as alternates.

Complete Round Components. A complete round consists of the following components or permissible alternates:
Converted Mortar Shell M61, loaded (1)
Suspension bands (2)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type A (1)
Fahnestock clip (1)

BOMB, ARMOR-PIERCING, 600-POUND, M62.

General. This bomb is a converted 10-inch shell. Its modifications in general are the same as those previously described for the AP, 1,000-pound, M52 Bomb. It can be identified by the sharply tapering nose windshield.

Description. The total length of this bomb is 62.06 inches and its diameter is 10 inches. Weight of the empty case is 575 pounds. Filled with 33.61 pounds of explosive D, the complete round weighs 634 pounds. The percentage of filler is approximately 5.2 percent.

Fuzes. This bomb is fuzed with the AN-M102A2 Tail Fuze, and the AN-M102A1 and M102 are provided as alternates.

Complete Round Components. A complete round consists of the following components:
Converted AP Shell M62, loaded (1)
Suspension bands (2)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type A (1)
Fahnestock clip (1)

A1 and A2 Modifications. The 600-pound AP Bomb M62 used the M110 Adapter Booster. The M62A1 utilizes the M113 Adapter Booster, whereas the M62A2 incorporates the M114 Adapter Booster. In general, the bombs are the same in all other respects.

BOMB, ARMOR-PIERCING, 1,400-POUND, M63.

General. This bomb is a converted AP shell which weighs approximately 1,400 pounds. Its modifications in general correspond to those described for the AP, 1,000-pound, M52 Bomb.

Description. The total length of this bomb is 69.1 inches and the diameter is 14.0 inches. It is filled with 35 pounds of explosive D and weighs, 1,412 pounds. Percentage of explosive filler is approximately 2.5 percent.

Fuzes. The standard for this round is the Tail Fuze AN-M102A2. Alternates are the AN-M102A1 and the M102 Tail Fuzes.

Complete Round Components. The complete round consists of the following components:
Converted AP Shell M63, loaded (1)
Suspension bands (2)
Tail Fuze AN-M102A2 (1)
Fin assembly (1)
Arming wire, type A (1)
Fahnestock clip (1)

BOMB, ARMOR-PIERCING, 1,600-POUND, AN-MK. 1.

General. This bomb was designed by the Navy and is interchangeable between the Army and Navy. It is standard for issue and manufacture. It is cylindrical in shape and has a pointed nose, tapered tail, and box type fin assembly.

Uses. It is designed to penetrate the heaviest horizontal armor of combatant ships and detonate below deck. It should not be employed against unarmored or lightly armored craft, as the fuze delay may permit the bomb to pass completely through the ship before detonating. Due to the thickness of the walls of this bomb, the explosive cavity is small compared to that of GP bombs and it has

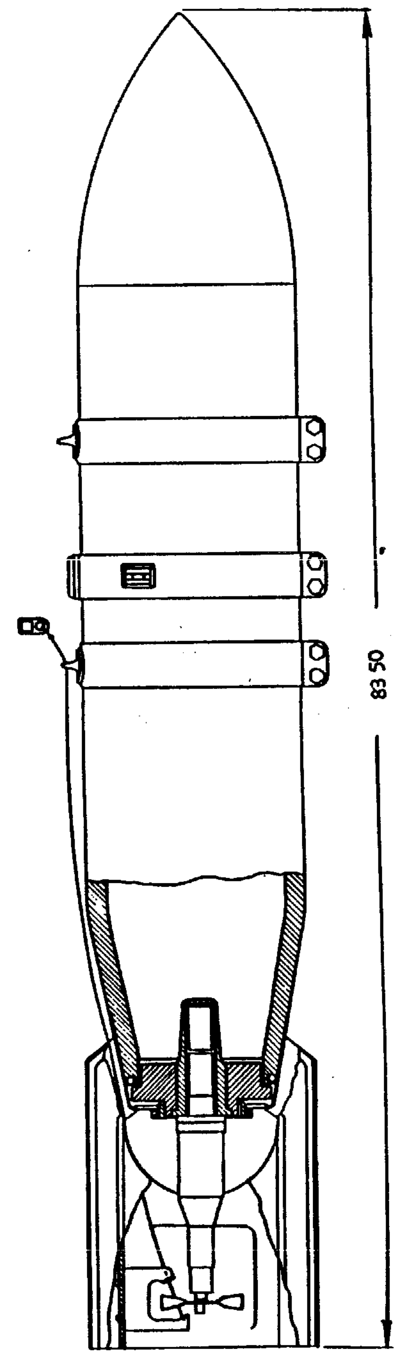

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Figure 241 — BOMB, A.P., 1,600-pound, Mk. 1, Complete Round

AMMUNITION INSPECTION GUIDE

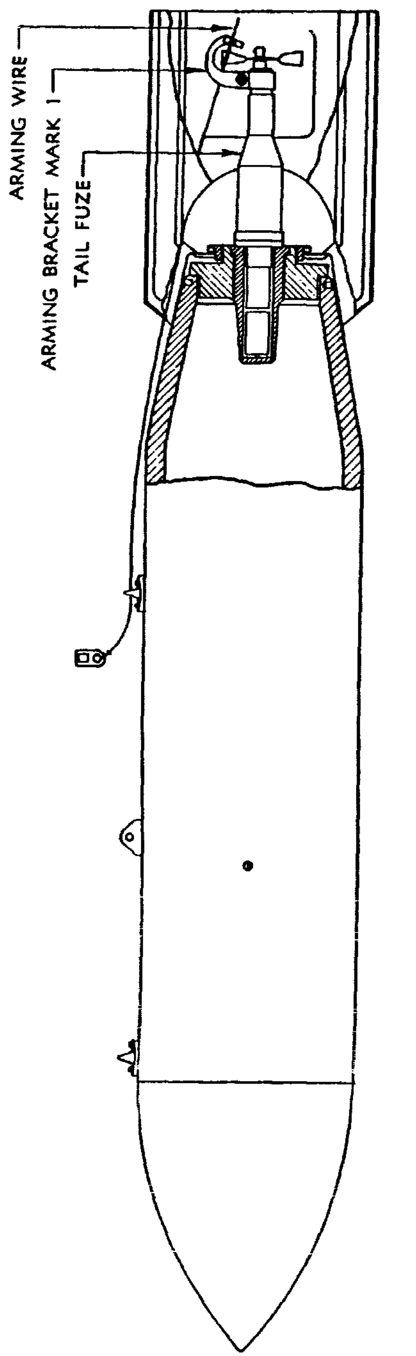


Figure 242 — BOMB, A.P., 1,600-pound, AN-Mk. 1, Complete Round

BOMBS FOR AIRCRAFT

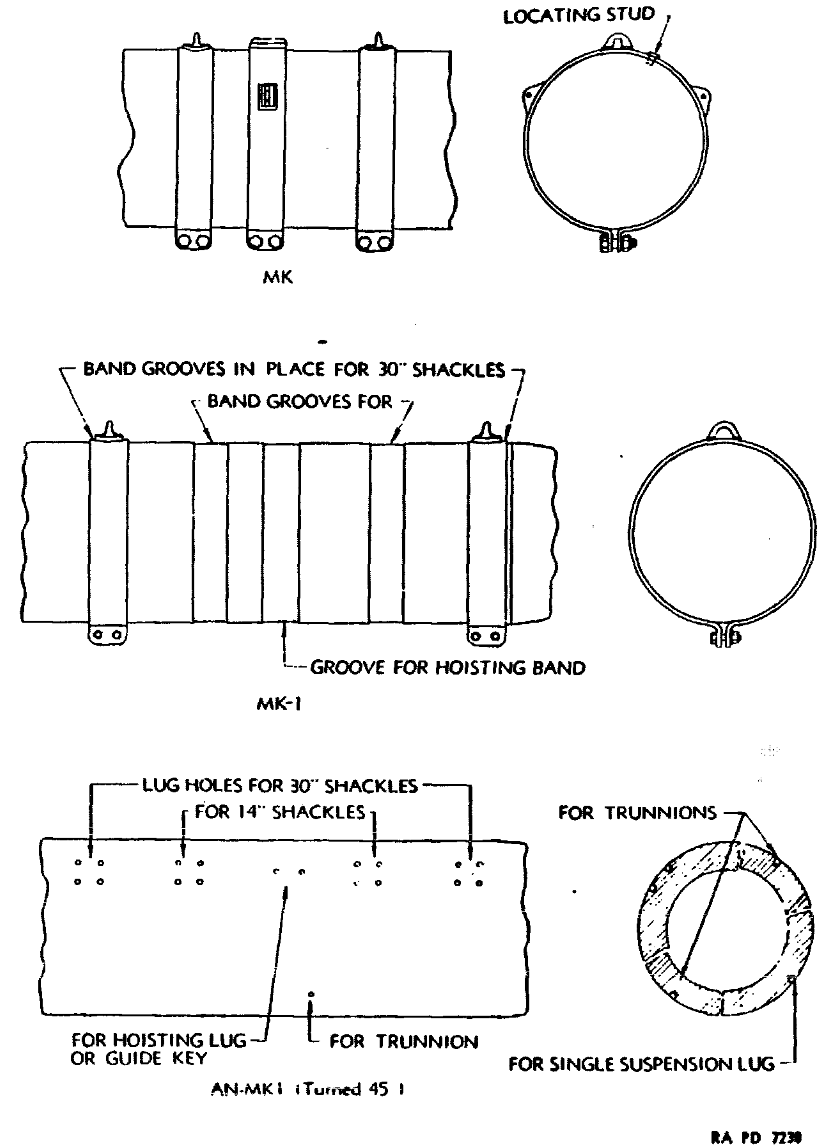


Figure 243 — Modifications of 1,600-pound A.P. Bomb

not as great an underwater effect for a near miss. It is adapted for tail fuze only.

Models. There are three modifications of this bomb which differ principally in the method of attachment of suspension accessories.

The Mark I has two suspension bands and one hoisting band, each of which is located by a stud on the inner surface of the band engaging a recess in the bomb body.

The Mark I or AN-Mk. I (early lot) has two suspension bands and one hoisting band, each of which is located by a shallow groove machined in the bomb case. (Five grooves are provided, the outer pair for locating the bands for 30-inch racks and the next pair to locate the bands for the 14-inch racks, the center groove for locating the hoisting band.)

The AN-Mk. I of current design has blind holes drilled and tapped in the bomb case. Suspension lugs, hoisting lugs and bolts, therefore, as well as trunnions, are packed in the fin crate for attachment as required. A guide key is also furnished for use when using torpedo sling suspension. The vane stop fork is not fitted to the tail of the AN-Mk. I Bomb; instead, an Arming Bracket Mk. I is attached to the fuze.

Suspension for dive bombing is provided by a combination hoisting and trunnion band for the Mk. I and Mk. I-Mod. 1. For the AN-Mk. I, the trunnions screw into the holes in the bomb case.

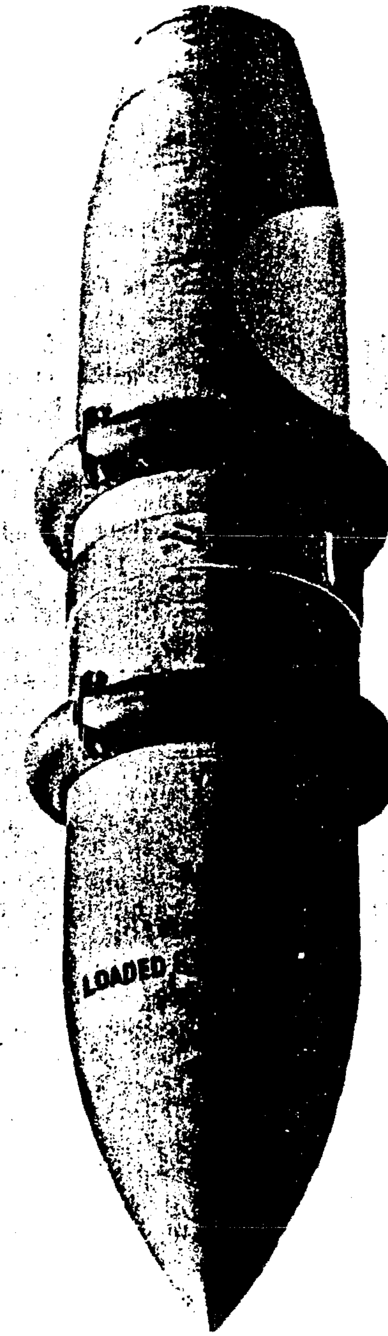
Description. The length of this bomb is 83.5 inches and the diameter is 14 inches. The total weight of this bomb when loaded with 228 pounds of explosive D is 1,613 pounds. Percentage of filler is 14.1 percent.

Fuzes. Fuzes provided for this bomb are the standard AN-Mk.228 Tail Fuze or its substitute, the AN-Mk.28 Mod. 1.

Complete Round Components. A complete round consists of the following components:

Bomb body, including:
- Filler
- Auxiliary booster
- Adapter
- Fin lock nut
- Suspension bands (or suspension lugs and bolts)
- Hoisting band (or hoisting lugs and bolts)

Arming Bracket, Mk. I (packed with fin assembly)
BOMB, Fuze, AN-Mk.228, Mod. 1 (tail)
Fin assembly
Trunnion band (or threaded trunnions, for dive bombing)
Arming, wire, assembly



RA PD 7237

Figure 244 — BOMB, A.P., 1,600-pound, Mk. 1, as Shipped

BOMB, ARMOR-PIERCING, 1,000-POUND, AN-Mk. 33.

General. This bomb is at the present time the latest armor-piercing bomb designed by the Navy for joint Army and Navy use. It is standard for issue and manufacture. It is cylindrical in shape and has a pointed nose, tapered tail, and box type fin assembly.

Uses. Similar to the 1,600-pound armor-piercing bomb, it is designed to penetrate heavy horizontal armor plate of combatant ships and to detonate below deck. It should not be employed against unarmored or lightly armored craft as the fuze delay may permit the bomb to pass completely through the ship before detonating. Due to the thickness of the walls of this bomb, the explosive cavity is small compared to that of the GP bombs and it has not as great an underwater effect in case of a near miss. It is adapted for a tail fuze only.

Bomb Body Description. The bomb body is of the same design as the 1,600-pound AN-Mk. I AP Bomb.

It is cylindrical in shape with a slightly tapered tail and a round nose ending in a sharp point. The nose portion of the bomb is solid, bringing the total weight of the empty bomb to between 800 and 825 pounds. The rear portion is threaded to receive a tail-base plug in the same manner and for the same purpose as that found in the GP bombs. Drilled and tapped in the bomb body are blind holes protected by shipping plugs threaded into these holes. Approximately 29 inches from the nose will be found four blind holes for the first of the double suspension lugs. When assembled, the shipping plugs are removed by means of a screwdriver and the suspension lug is then securely attached by means of four screws which are safety-wired in place. Fourteen inches from the first set of holes will be found a second set of four blind holes for the second suspension lug. Between these two sets of holes are two more blind holes for attachment of a hoisting lug. The body will also have two blind holes on opposite sides into which trunnions are threaded. Opposite the hoisting lug will be found the final series of holes to receive the single suspension lug or guide key. Guide keys are provided for longitudinal bracing of the bomb when suspended by slings in the torpedo position, for example in Navy TBD and TBF planes.

A box type fin assembly is provided which seats around a machined-down portion at the tail end of the body. It is held in place by a fin lock nut which screws around the tail-base plug. The fuze used is the AN-Mk.228. It utilizes an arming bracket over the fuze which alines with suspension lugs in the same manner as described for the 1,600-pound AP AN-Mk. I.

Description. Total length of this bomb is 73.0 inches and the diameter is 12.0 inches. Weight of the bomb complete with a filler of

COMPLETE ROUND CHART—SAP AND AP BOMBS

Type, Weight, Designation, and Status	Filler	Tail Auxiliary Booster	Tail Adapter Booster	Fuze (Tail)	Fuze (Nose)
Bomb, SAP, 500 lb, AN-M58 (S)	155 lb Amatol	M104	M102	AN-M101A2(1)	Steel Plug(2) Fuze Seat Liner
Bomb, SAP, 500 lb, AN-M58A1 (S&M)	150.4 lb Amatol	M104	M102	AN-M101A2(1)	Steel Plug(2) Fuze Seat Liner
Bomb, SAP, 1,000 lb, AN-M59 (S&M)	308 lb Amatol	M104	M102	AN-M102A2(3)	Steel Plug(2) Fuze Seat Liner
Bomb, AP, 1,000 lb, M52 (S)	58.35 lb Exp. D.	None	M110	AN-M102A2(4)	None
Bomb, AP, 900 lb, M60 (S)	43.34 lb Exp. D.	None	M110	AN-M102A2(4)	None
Bomb, AP, 800 lb, M61 (S)	32.68 lb Exp. D.	None	M110	AN-M102A2(4)	None
Bomb, AP, 600 lb, M6A2 (S)(5)	33.61 lb Exp. D.	None	M114	AN-M102A2(4)	None
Bomb, AP, 1,400 lb, M63 (S)	35 lb Exp. D.	None	M110	AN-M102A2(4)	None
Bomb, AP, 1,600 lb, AN-Mk. 1 (S&M)	228 lb Exp. D.	Navy 180 g	....	AN-Mk. 228	None
Bomb, AP, 1,000 lb, AN-Mk. 33 (S&M)	146 lb Exp. D.	Navy 180 g	....	AN-Mk. 228	None

(1) Fuze AN-M101A1, M101, M113 may be substituted.
(2) Fuze AN-M103, M118 or M119 may be used.
(3) Fuze AN-M102A1, M102, M114 may be substituted.
(4) Fuze AN-M102A1 or M102 may be used.
(5) M62 uses Adapter Booster M110; M62A1 uses Adapter Booster M113.

FUZES USED IN AP AND SAP BOMBS

Fuze Designation	Position in Bomb	Booster in Fuze?	Bomb for Which It Is Adapted	Method of Arming	Primer Detonator	Action on Impact
AN-M101A1	Tail	No	500 lb SAP	Arming Vane w/mech. del.	M14 or M14A1	Nondelay to 0.1 sec
AN-M102A2	Tail	No	600 to 1,400 lb AP	Arming Vane w/mech. del.	M14 or M14A1	Nondelay to 0.1 sec
AN-M103	Nose	Yes	All SAP	Arming Vane w/mech. del.	None	Selective, Inst. or 0.1 sec
M113	Tail	No	500 lb SAP	Arming Vane	M16	4 to 5 sec or 8 to 11 sec del.
M114	Tail	No	1,000 lb SAP	Arming Vane	M16	4 to 5 sec or 8 to 11 sec del.
M116	Tail	No	500 lb SAP	Arming Vane w/mech. del.	M16	4 to 5 sec or 8 to 11 sec del.
M117	Tail	No	1,000 lb SAP	Arming Vane w/mech. del.	M16	4 to 5 sec or 8 to 11 sec del.
M118	Nose	Yes	All SAP	Arming Vane	None	4 to 5 sec del.
M119	Nose	Yes	All SAP	Arming Vane	None	8 to 11 sec del.
M124	Tail	No	500 lb SAP	....	....	1 to 12 hr del.
M125	Tail	No	1,000 lb SAP	....	....	1 to 12 hr del.
AN-Mk. 228	Tail	....	1,000 and 1,600 lb AP	Arming Vane w/mech. del.	None	0.08 sec del.

146 pounds of explosive D is 1,004 pounds. Percentage of filler is approximately 14.5 percent.

Fuzes. The standard fuze for this bomb is the AN-Mk. 228 Tail Fuze. Alternate or substitute fuzes are the AN-Mk.28, Mod. 1 or the Mk. 28 Tail Fuze.

Complete Round Components. A complete round consists of the following components:
Bomb Case AN-Mk.33, 1,000-pound, loaded (1)
Tail Fuze, AN-Mk.228 (1)
Fin assembly (with lugs, keys, trunnions, and screws) (1)
Arming wire, type A (1)
Fahnestock clip (1)

FURTHER REFERENCES: A complete list of references dealing with bombs may be found at the close of the final chapter of this section.

Chapter 4

Depth Bombs

GENERAL.

Depth bombs were used by the Navy for a considerable length of time before their adoption by the Army. This is very natural, of course, since depth bombs are designed for use entirely against watercraft. After the introduction of the policy to make bombs interchangeable between the Army and Navy, the Army became concerned about depth bombs. Those designated as AN are very similar in operation and construction to one another.

Depth Bomb, FUZE, Transverse, Hydrostatic, AN-Mk. 224.

General. This fuze is designed to function in response to hydrostatic pressure at a predetermined depth. As issued, the fuze is set for a depth of 50 feet, but this setting may be changed for 25, 75, 100, or 125 feet. The fuze is installed in a transverse fuze cavity just forward of the bomb center.

Description. The fuze is issued in three subassemblies: pistol, booster, and booster extender. When assembled to the bomb, the fuze protrudes slightly on both sides and requires a section of arming wire for each end. Both sections of arming wire must be withdrawn in order to permit the fuze to operate.

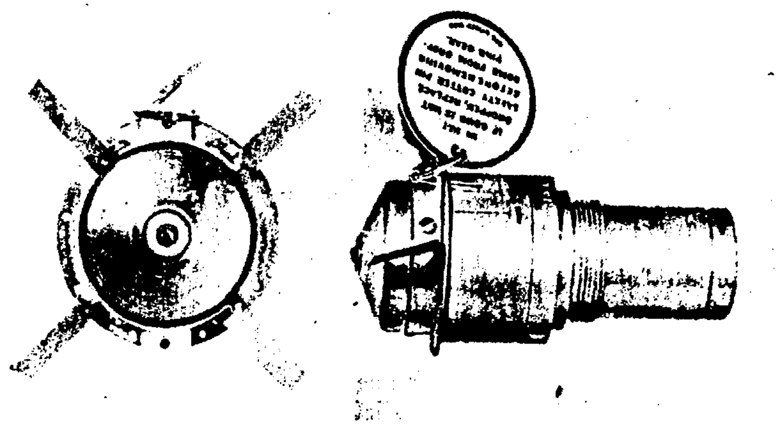


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Figure 245 — FUZE, Bomb, AN-Mk. 219

The fuze is approximately 3.6 inches in diameter and 16.6 inches in length when completely assembled. When inserted into the bomb body, the pistol assembly is bolted to one side of the bomb and the extender is bolted to the opposite side.

The explosive train for this fuze is interrupted by the primer assembly being held out of alinement with the detonator assembly and both of these assemblies being out of line with the firing pin and subbooster. The primer assembly is located in a sliding wedge which is under a spring load, with a similar sliding wedge containing the detonator assembly under a spring load in the opposite direction.

The booster extender assembly contains a bellow-shaped hydrostatic piston, an extender base, and extender pin. The extender pin, having a small groove milled in it, is held, by means of three locking

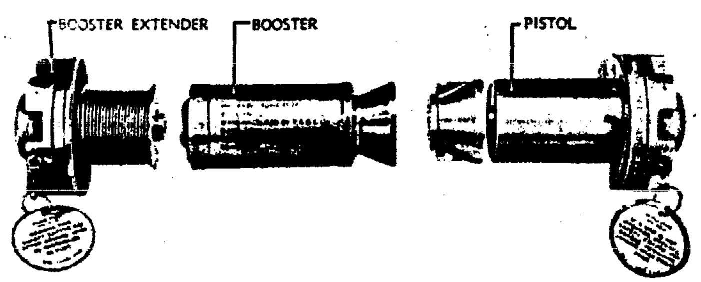

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Figure 246 — FUZE, Bomb, Hydrostatic, AN-Mk. 224

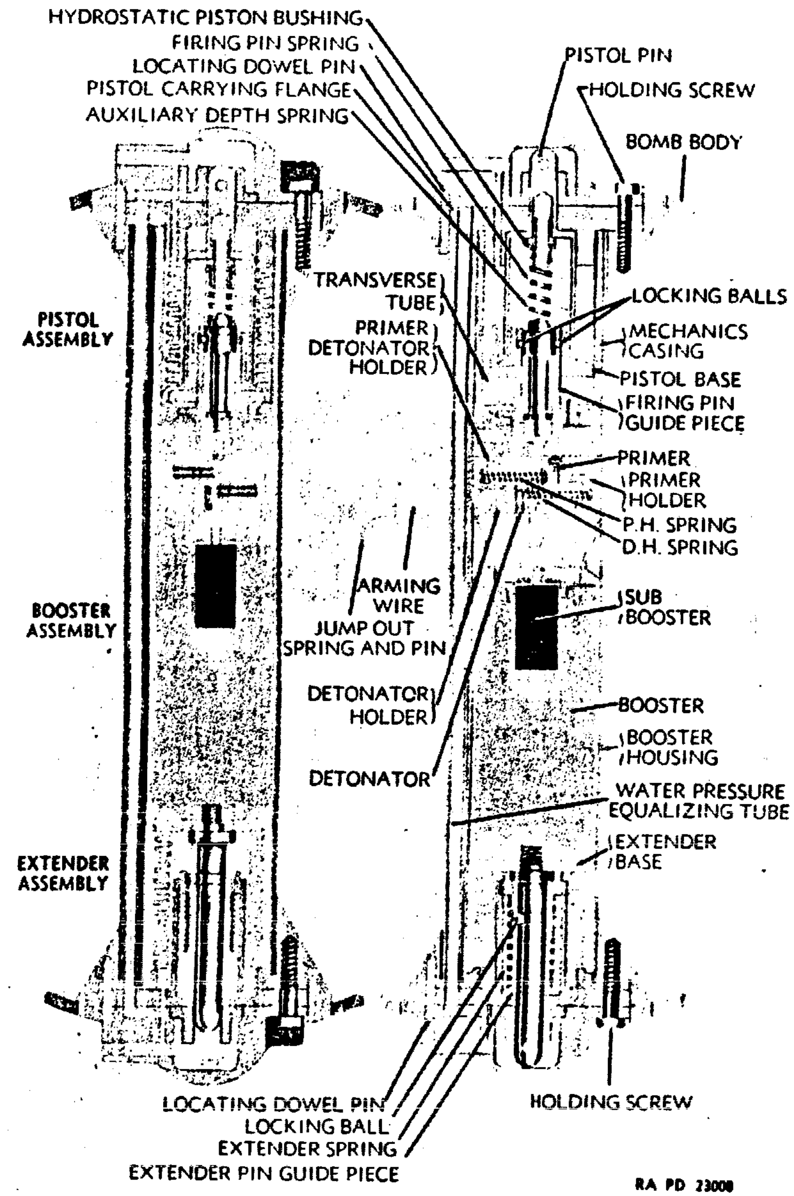

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Figure 247 — FUZE, Bomb, Hydrostatic, AN-Mk. 224—Transverse

balls which are 120 degrees apart, to an extender pin guide piece which has three corresponding holes to receive the locking balls and keeps the locking balls in position by means of a sleeve. Movement of the guide piece is counteracted by an extender spring which fits around the guide piece. An arming pin or jump-out pin prevents movement of the extender pin and, therefore, prevents movement of the booster extender assembly when the fuze is in the unarmed position.

The pistol assembly contains a hydrostatic piston which is also bellow shaped, a pistol base, and firing pin. The firing pin at its upper end has a small groove milled in it and is held, by means of two locking balls 180 degrees removed, to a firing pin guide piece which has two corresponding holes to receive the locking balls. The firing pin guide piece is covered by a sleeve which is part of the pistol base. Between the pistol base and the firing pin will be found a main spring and, if the depth setting so requires, an auxiliary spring, tending to counteract water pressure.

The pistol base at the top portion ends in a protrusion known as the pistol pin. Inserted into the pistol pin is an arming pin or jump-out pin which prevents the entire pistol assembly from operating when the fuze is in the unarmed position. The entire pistol assembly is encased in a mechanism casing which can be removed to change or add depth springs so as to vary the depth setting.

Function. The bomb is dropped and the arming wire is retained in the plane. The arming pins are ejected by their springs freeing the pistol pin and extender pin, and arming the fuze.

As the bomb sinks, water enters the inlets in the fuze and flows into the hydrostatic pistons and water pressure equalizing tube thus putting uniform pressure at opposite ends of the fuze. This pressure tends to force the pistol base and extender base toward the center of the fuze.

Considering the booster extender assembly, water pressure acts on a hydrostatic piston and extender base forcing the two, which are directly attached and therefore act as a unit, to move toward the center of the fuze (the piston merely expanding and acting as the water carrier). The extender pin, being directly attached to the extender base, carries with it the extender pin guide piece by means of three locking balls. The guide piece compresses the extender spring. The extender spring therefore counteracts the pressure created by the water and in so doing slows down the movement of the extender base. As this movement continues, the locking balls reach a recess in the sleeve, which is found between the guide piece and spring. The locking balls fall into this recess and free the extender pin from the guide piece and, therefore, from the extender spring. The water

pressure no longer being counteracted by the extender spring quickly drives the extender base and pin toward the center of the fuze. This occurs before a depth of 25 feet is reached.

The movement of the extender base serves to move the booster assembly to which the base is attached by threads toward the center of the fuze. The booster assembly at its lower end has a funnel-shaped opening which, as it moves toward the center of the fuze, forces the primer detonator holders to act against their springs bringing the primer and detonator into the armed position or in line with the firing pin. The booster assembly also carries the subbooster and booster charge into close position with the detonator so as to effectively receive the detonating wave.

Considering the pistol assembly, water pressure acting through a hydrostatic piston causes the pistol base with its sleeve to move toward the center of the fuze. In so doing, the pressure of the water is counteracted by a main firing pin depth spring and an auxiliary depth spring, if present. The greater the tension of the depth spring or springs, the more is the water pressure required to move the pistol base, with the sleeve, inward. As the sleeve moves inward, the two locking balls which hold the firing pin to the guide piece are almost uncovered. It is prevented from moving any farther by the mechanism casing. The firing pin guide piece due to the pressure produced by the water at the extender is forced toward the pistol end of the fuze. The locking balls are uncovered and fall into the recess of the pistol base and release the firing pin.

The firing pin is now driven by its compressed main spring into a primer which ignites. The flame from the primer ignites the detonator which starts a wave to function the subbooster. The subbooster of tetryl functions the booster.

Depth settings. There are five possible depth settings which may be obtained with this fuze, namely: 25, 50, 75, 100, and 125 feet. Unless otherwise marked, the fuze as issued will function at 50 feet. This may be changed by the insertions of the appropriate springs which are supplied in the can in which the fuze is packed. There are four springs supplied in all. Two of these are main springs, one being a 25-foot depth spring and the other a 50-foot depth spring. One or the other must be used, never both, in all depth settings because the width of these springs (½ inch) allows either one to fit over and around the firing pin. The two auxiliary springs give additional depth settings of 25 and 75 feet and must be used for depth settings over 50 feet. The diameter of these springs is ¾ inch so as to allow them to fit around the main springs. These auxiliary springs are too wide in diameter to fit over and around the firing pin, and must be used in conjunction with a main spring. The springs are painted different colors to differentiate between them. The depth settings and how each is obtained may be summarized in the following table:

Depth Setting	Main Spring	Auxiliary Spring	Color of Spring	Diameter of Spring
25 ft	25 ft	None	Yellow	½ in.
50 ft	50 ft	None	Black	½ in.
75 ft	50 ft	25 ft	Black (main) Green (aux.)	½ in. ¾ in.
100 ft	25 ft	75 ft	Yellow (main) Red (aux.)	½ in. ¾ in.
125 ft	50 ft	75 ft	Black (main) Red (aux.)	½ in. ¾ in.

Change of depth setting. To change depth settings of this fuze proceed as follows:

Unscrew primer detonator holder after forcing counterclockwise by hand to break staking.

Remove set screw in mechanism casing and unscrew casing from pistol carrying flange.

Remove guide piece, firing pin, and locking balls as a unit from hydrostatic piston bushing exposing the spring cavity.

For function at 25-foot depth, remove the black spring and substitute the yellow spring.

To function at 75-foot depth, leave the black spring in place and insert the larger green spring over it.

For function at 100-foot depth, remove the black spring and insert the small yellow spring, and over it, the larger red spring.

For 125-foot depth, use the black spring and the red spring.

Assemble firing pin and locking balls in guide piece and insert as a unit into the hydrostatic piston bushing, resting the firing pin on the 0.5-inch spring.

Assemble the mechanism casing to the pistol carrying flange, taking care that the guide pin enters the hole in the guide piece. Screw mechanism casing home and replace the set screw.

Reassemble primer and detonator holder to guide piece, taking care that end of firing pin is centered. Screw tightly home and stake by means of a suitable tool.

Mark pistol head to indicate depth setting. If the fuze is repacked, mark the packing can and data card as well.

Modifications. The late modification 1 fuze and the newer modification 2 fuze have certain differences as described below:

In an effort to make the fuzes watertight and to adapt them to

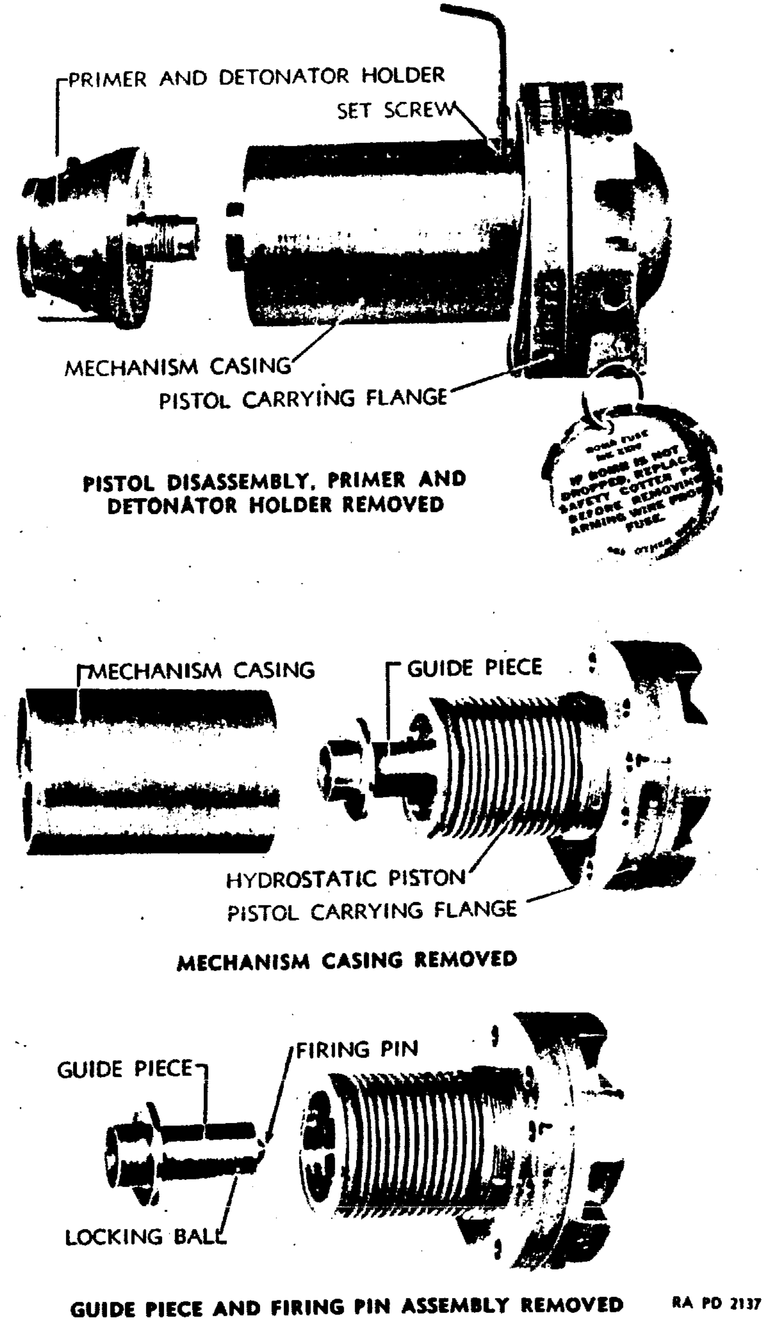

Figure 248 — Disassembly of Pistol for Insertion of Auxiliary Depth Spring, FUZE, AN-Mk. 224

a new type packing container, the design of the jump-out pin was altered so as to fit into the fuze body proper without the pin protruding from the circumference of the fuze.

All of the water ports leading into the fuze were eliminated except the jump-out pinhole which acts as the water port after the emission of the jump-out pin. This jump-out pin is designed with a rubberized extender washer-like affair near the outer end, which fits up against the surface of a shoulder in the jump-out pinhole making the fuze watertight.

Instead of two holes through the jump-out pin, there is now but one. This makes it only possible to insert either a cotter pin or an arming wire at one time. It is therefore necessary to apply pressure to the end of the jump-out pin in order to prevent it from flying out during the interval between the time the cotter pin is removed and the arming wire is inserted.

As an aid to accomplishing the withdrawal of the cotter pin and the insertion of the arming wire, a special tool is used which has been designed to hold the jump-out pin in place.

Packing. This fuze is packed as three subassemblies: pistol, booster, and booster extender are in a sealed metal container which contains auxiliary springs and 12 screws for attaching the fuze to the bomb. Four such containers are packed per metal crate or box.

Depth Bomb, FUZE, Transverse, Hydrostatic, AN-Mk. 234. The AN-Mk. 234 recently designed will replace the AN-Mk.224. This new fuze is designed to allow for depth settings which can be varied from the outside of the fuze without the necessity for disassembling the fuze and changing springs. This fuze will also utilize the special tool which is a modification of a screwdriver to hold the jump-out pin in place when the cotter pin is removed and the arming wire is inserted.

Depth Bomb, FUZE, Nose, AN-Mk. 219.

General. This fuze is an arming vane type with mechanical delay. It arms in 600 to 850 feet of air travel or about 6 seconds, and functions on impact with water or any denser medium with instantaneous action.

The fuze is shipped with an adapter so that when fuze and adapter are assembled, they will fit in the fuze cavity in the nose of the depth bomb.

Two booster pellets each containing 180 grams of TNT are shipped in place in the bomb in the booster cavity.

The fuze is packed one per metal container which is sealed by a soldered metal tear strip.

Use. This fuze is standard for Navy demolition bombs and in a special purpose fuze for the depth bomb when surface demolition or blast effect is desired with this bomb.

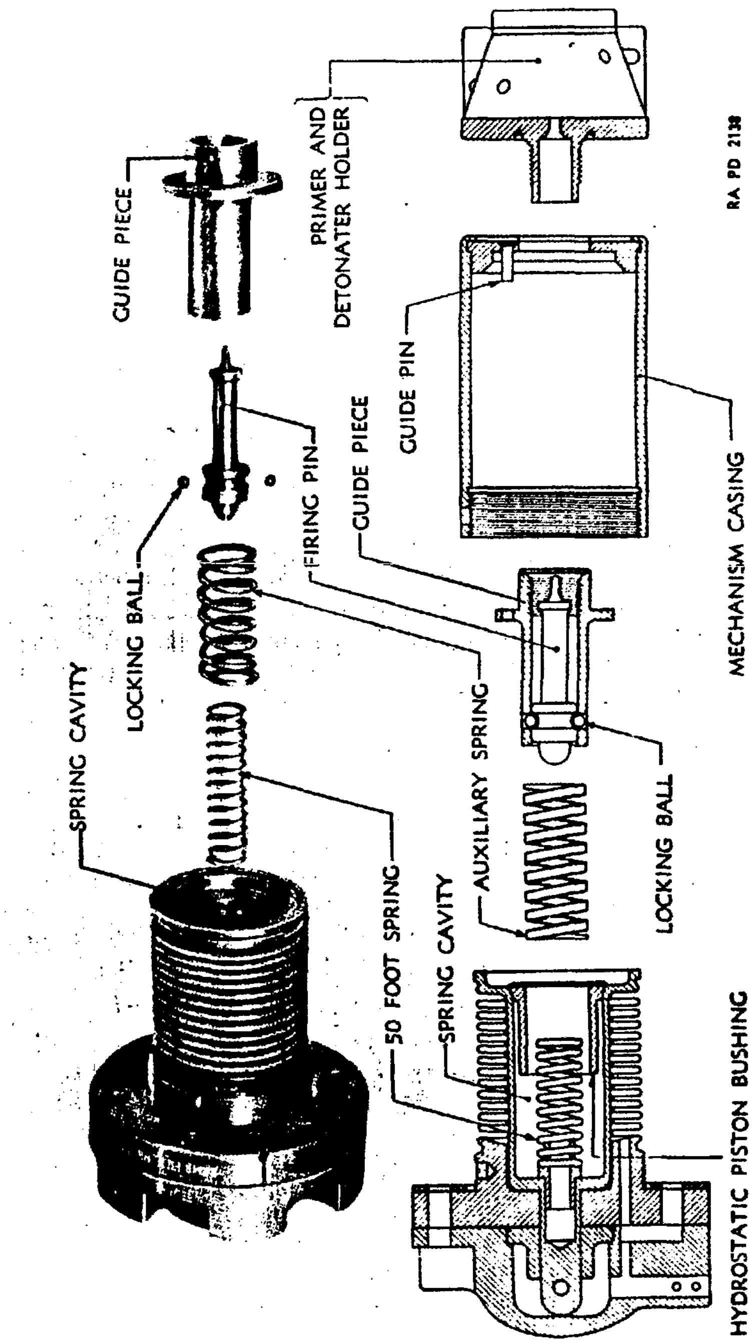

Figure 249 — FUZE, AN-Mk. 224, Reassembly of Pistol, With Auxiliary Depth Spring

Depth Bomb, FUZE, Nose, AN-Mk. 221.

General. This fuze is an arming vane type with mechanical delay. It arms in 800 to 1,100 feet of air travel and functions on impact with water or any denser medium with a delay of 0.01 second.

This fuze differs from the AN-Mk. 219 in the following main features:

A delay of 0.01 second is incorporated in the explosive train of the fuze.

The fuze body itself is threaded to be screwed into the fuze cavity of the depth bomb, consequently no adapter is used.

When this fuze is used, only one 180 gram TNT booster pellet is used in the fuze cavity, another must be removed before assembling of the fuze to the bomb.

Use. This fuze is standard for Navy domolition bombs and is a special purpose fuze for the depth bomb where blast effect is desired. For all normal usage, a hydrostatic fuze will function the depth bomb. Due to the fact that depth bombs are light case construction, the use of this fuze with its incorporated delay of 0.01 second is not recommended as the case may break before the fuze will function.

Models AN-Mk. 221 not antisubmarine. This includes AN-Mk. 221 and AN-Mk. 221M1 except lots 21, 22, 23 and AN-Mk. 221M3 and M4. These models are all the same being only slightly changed from the AN-Mk. 221 Fuze and are manufactured by different concerns. The AN-Mk. 221 will arm in approximately 850 feet air travel. All these fuzes will function, if dropped from 2,000 feet or higher, on impact with water.

Models AN-Mk. 221 antisubmarine. This includes AN-Mk. 221M1 lots 21, 22 and 23 and AN-Mk. 221M2. These fuzes were modified to be inoperative on water impact when released from less than 7,000 feet altitude. The AN-Mk. 22M1 are marked "A.S." fuzes if they are of the antisubmarine lots. All of the AN-Mk. 221M2 are built the same way, and therefore there is no need to mark these "A.S."

Depth Bomb, FUZE, Tail, Hydrostatic, AN-Mk. 229M1.

General. This is an arming vane type of fuze with mechanical delay. Upon arming, detents (spring actuated pins) fly out so as to allow the bellows to operate. It is a tail fuze and when armed it functions on water pressure. Depth setting is made by a dial located on the exterior of the fuze body which operates a long spindle in the interior of the bomb fuze. This varies the compression on the depth spring. By turning the dial, one of five settings can be obtained, namely: 25-, 50-, 75-, 125-, and 175-foot depths.

In operation, it is somewhat similar to the AN-Mk. 224 except that water pressure forces the initiating explosive into a stationary firing pin with only one system of bellows. The AN-Mk. 230 used on the

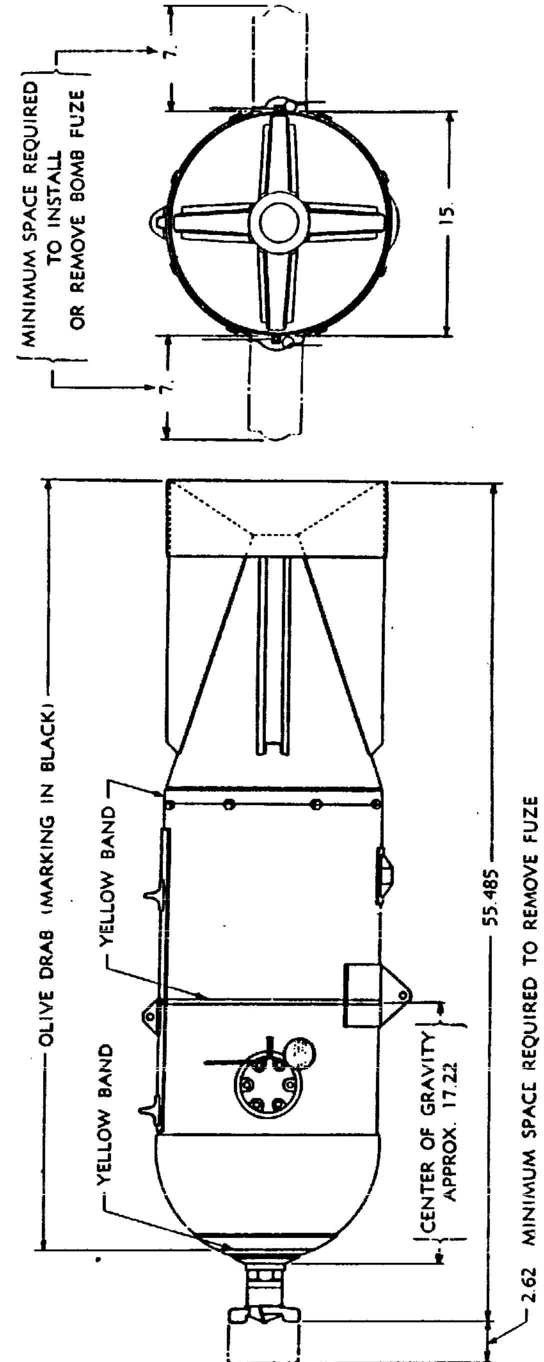

Figure 250 — BOMB, Depth, 325-pound, AN-Mk. 17

new GP bombs resembles this fuze; however, it is smaller in diameter and has different threads to fit the GP bombs.

Actually there are no AN-Mk. 229 (no mod.) Fuzes in service. Only the AN-Mk. 229 Mod. 1 Fuzes have been issued for service use.

BOMB, DEPTH, 325-POUND, AN-MK. 17M1.

General. This bomb is a light case bomb which is intended for use primarily against submarines but with special fuzing may be used for demolition effect on surface craft. It weighs 325 pounds of which 243 pounds or 75 percent is high-explosive filler.

Description of the Bomb Body. The body of the bomb is constructed from ${}^{1}/_{16}$-inch sheet metal with a well rounded nose and a flat recessed base. The nose end of the bomb is adapted to receive the adapter for the AN-Mk. 219 Fuze or the AN-Mk. 221 Fuze directly. These fuzes are used only when blast effect is desired.

Approximately 1 foot behind the nose of the bomb, a cavity passes through the bomb body from one side to the opposite side. This cavity is known as the transverse tube and serves as the housing for the AN-Mk. 224 Hydrostatic Fuze. The bomb is shipped unfuzed with suitable plugs and plates protecting the fuze cavities. These cavities are swabbed with gun slushing or rust-preventive compound and must be cleaned of this and other foreign matter before a fuze is assembled.

Welded to the top of the bomb body with the first lug approximately ½ inch behind the end of the ogive of the bomb and the second lug 14 inches further to the rear, are dual suspension lugs which permit the suspension of this depth bomb in the standard Army B-7 shackle.

A hoisting lug is approximately 6 inches behind the first lug and in line with both lugs. This hoisting lug is simply an L-shaped piece of metal with its base welded to the bomb body and along the long axis of the bomb. This lug protrudes from the body approximately 1 inch and it is designed to accommodate the hoisting hook of the Navy portable bomb hoist.

If the bomb is to be used in an Army bomber requiring the use of the B-7 shackle, then this L-shaped Navy hoisting lug must be gently pried to one side or it will interfere with the operation of the B-7 shackle. The lug may be bent to one side and out of alinement with the B-7 shackle by the insertion of a piece of drill rod into the hoisting hole and applying a bending force to the lug. Under no condition may a hammer or similar instrument be used to pound the lug to one side.

If this bomb is to be suspended from the belly of certain planes, the single suspension lug will be used. This lug is located 180 degrees away from the hoisting lug and at the approximate center of gravity

of the bomb. This lug is 4 inches wide and protrudes from the bomb body approximately 1.6 inches.

Approximately eight inches to the rear of the suspension lug is located a small metal protrusion which serves as a seat for the steadying forks of the Mk. XLI Bomb Rack. This metal protrusion is 3 inches wide and protrudes from the bomb body 0.7 of an inch.

Description of Tail Fin Assembly. Assembled to the rear of the bomb body by eight bolts is the tail fin assembly. The tail fin assembly consists of a frustum (bottom half) of a cone, 15 inches in diameter at the base, 4.35 inches in diameter at the top, and approximately 22 inches long. The base of the frustum has been drilled and tapped to receive eight bolts which pass through the body of the bomb and anchor the tail fin assembly to the bomb body.

Welded to the frustum are four U-shaped blades having the open ends of the U attached to and starting approximately five inches from the base of the frustum. The four fins are located 90 degrees from each other.

A band of metal, 5 inches wide and 15 inches in diameter, is welded to the rear end of the fin assembly. This band serves to protect the fin blades against warpage caused by impact with the water and also protects the blades against damage in handling and assembly.

Arming Wire. The arming wire assembly for use with the AN-Mk. 224 Hydrostatic Bomb Fuze is type B which consists of a swivel loop or arming plate to which are attached two lengths of wire each approximately 20 inches long.

The arming wire assembly for use with the AN-Mk. 219 or AN-Mk. 221 Nose Bomb Fuzes is type A which consists of a swivel loop or arming plate and a single wire approximately 22 inches long.

Altitude and Speed of Release. Tests show that this bomb will function if released from altitudes up to 5,000 feet. However, when dropped from high altitudes, the hydrostatic fuze will function at a greater depth than that for which it is set. The minimum altitude to provide safety from blast in horizontal bombing is 100 feet.

If speed and altitude at release are such as to produce an angle of impact flatter than 20 degrees from horizontal, a ricochet is probable and if flatter than 15 degrees a ricochet may be expected.

Flat Nose Attachments. As stated above, ricochets may be expected with the round nose 325-pound AN-Mk. 17M1 Depth Bomb. Also, it has been found that deflection to the right or left from the course intended may result. To remedy this situation, flat nose attachments are issued so as to enable the bombs to be modified in the field. The attachments will greatly reduce the tendency of the bombs to ricochet at low altitudes and high speed. The 325-pound bomb, when equipped with flat nose attachments, may be dropped

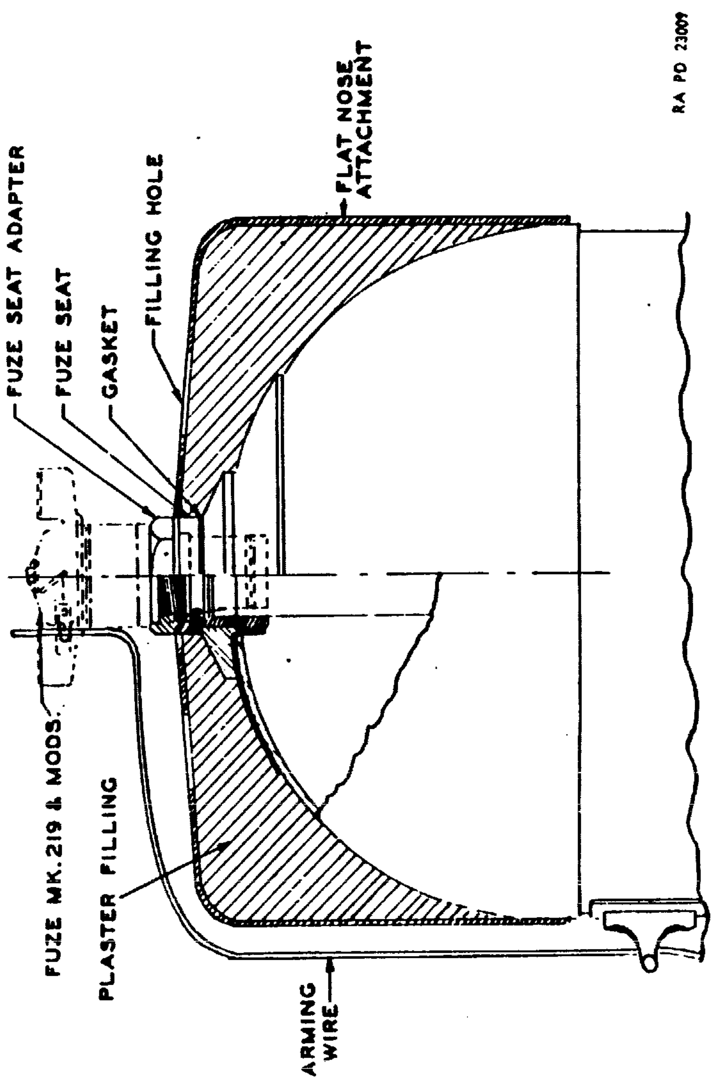

Figure 251 — Antiricochet Cap for 325-pound Depth Bomb AN-Mk. 17

at an altitude of 50 feet without appreciable danger or ricochet, provided the airspeed at release does not exceed 200 knots.

In general, the average horizontal component of the underwater travel to a depth of 25 feet will be between 30 and 40 feet, and the time of underwater travel to a depth of 25 feet will be between 2 and 4 seconds for the 325-pound depth bomb.

Tests have also shown that the depth bombs equipped with flat noses have considerably less tendency to deflect to the right or left of a normal course in underwater travel. Average deflections from the normal point of detonation (25-foot setting) are approximately 7 feet for the 325-pound depth bomb with a maximum of 15 feet occurring in some cases.

The air trajectories of the depth bomb will be slightly affected by the addition of the flat nose attachments. When aircraft bombs equipped with flat nose attachments are carried on external racks, some reduction in air speed due to increased drag of the flat noses will occur.

The flat nose attachment consists of a metal nose attachment which fits around the adapter of the Nose Fuze AN-Mk. 219 or the nose of the bomb itself. The metal attachment has openings in it to allow for the addition of a plaster filling which fills the space between it and the round nose of the bomb body. The entire bomb weight is increased by approximately 44 pounds, of which 34 pounds consist of the plaster filling and the other 10 pounds consist of the flat nose attachment.

Complete Round Description. The total length of this bomb is 52.48 inches and the diameter is 15 inches. The case is only 0.062 inch thick. The weight of the metal parts is 85 pounds while the TNT filler weighs 243 pounds. Total weight of this bomb is 325 pounds. Percentage of filler is approximately 75.8 percent.

Fuzes. This bomb is fuzed with the Transverse Fuze AN-Mk. 234. Substitute or alternate fuzes are the transverse AN-Mk. 224 or its modifications, or the Nose Fuze AN-Mk. 219 or AN-Mk. 221.

Complete Round Components. A complete round is made up of the following components:

BOMB, AN-Mk. 17M1, 325 lb (1)
Fin assembly (1)
Fuze, nose, or transverse (1)
Arming wire (1)

NEW 325- TO 350-POUND DEPTH BOMBS.

Following the development of 325-pound AN-Mk.17M1 Depth Bombs, a new series was issued. These new bombs differ only in the shape of the nose or in the kind of filler, or may differ in both of these ways. The difference in filler has caused an increased weight so that the bombs are described as 350-pound depth bombs. The flat nose as previously described was added to prevent ricochet. A summary of the bombs and the main differences are indicated in the following table.

Bomb Nomenclature	Shape of Nose	Bomb Racks	Filler
325 lb AN-Mk. 17M1	Round	External or Internal	TNT
325 lb AN-Mk. 17M1	Flat (special attachment)	Internal	TNT
325 lb AN-Mk. 41	Flat	Internal	TNT
350 lb AN-Mk. 44	Round	External or Internal	Torpex *
350 lb AN-Mk. 47	Flat	Internal	Torpex *

*44% cyclonite, 37% TNT, 18% powdered aluminum and 1% beeswax. Much more brisant than TNT.

BOMB, DEPTH, 650-POUND, AN-MK. 29.

General. The 650-pound depth bomb is used for undersea craft or surface vessels. It can be identified by the blunt nose, sheet metal case, and trunnion mounts, in addition to the double and single suspension lugs. The trunnion mounts are at the center of gravity and on opposite sides of the case 90 degrees from the double and single suspension lugs. The mounts are closed by a threaded plug. The trunnions are used to mount the depth charge on dive bomb suspension racks. When used with the AN-Mk. 224 Fuze, an extender is provided to make the fuze fit the longer transverse tube.

Description. Complete length of this bomb is 74.1 inches and the diameter is 17.07 inches. The bomb case is 0.125 inch thick. The metal parts of this bomb weigh 193 pounds while the explosive filler weighs 464 pounds. Total weight of this bomb is 657 pounds, 70.6 percent being explosive filler.

Fuzes. The standard fuzes provided for this bomb are the Tail Fuze AN-Mk.229M1 and the Transverse Fuze AN-Mk.234. Alternate fuzes are either nose or transverse. Those provided for the nose are the AN-Mk. 219, AN-Mk. 221, AN-M103, or M103. The alternate transverse fuze is the AN-Mk. 224 with its modifications. The M103 or AN-M103 must be equipped with special vane when used on flat-nose bombs. The standard vane will not cause the fuze to arm.

COMPLETE ROUNDS—DEPTH BOMBS

Weight and Designation	Filler	Fuze (Nose)	Fuze (Tail)	Fuze (Transverse)
325 lb AN-Mk. 17M1	243 lb TNT	AN-Mk. 219(1)	None	AN-Mk. 234(2)
325 lb AN-Mk. 41	TNT	AN-Mk. 219(1)	None	AN-Mk. 234(2)
350 lb AN-Mk. 44	TORPEX	AN-Mk. 219(1)	None	AN-Mk. 234(2)
350 lb AN-Mk. 47	TORPEX	AN-Mk. 219(1)	None	AN-Mk. 234(2)
650 lb AN-Mk. 29	464 lb TNT	AN-Mk. 219(3)	AN-Mk. 229	AN-Mk. 234(4)
650 lb AN-Mk. 37	TNT	AN-Mk. 219(3)	AN-Mk. 229	AN-Mk. 234(4)
650 lb AN-Mk. 38	TNT	AN-Mk. 219(3)	AN-Mk. 229	AN-Mk. 234(4)

(1) Fuze AN-Mk. 221 may be substituted. The adapter and one booster charge must be removed.
(2) Fuze AN-Mk. 224 or modifications may be substituted.
(3) Fuze AN-Mk. 221 or modifications or AN-M103 with special vane, may be substituted.
(4) Fuze AN-Mk. 224 or modifications may be substituted. An extender supplied with the bomb must be used when using the AN-Mk. 234 or AN-Mk. 224 in 650-pound depth bombs.

FUZES USED IN DEPTH BOMBS

Fuze Designation	Position In Bomb	Booster In Fuze	Bomb for Which It Is Adapted	Method of Arming	Primer Detonator	Action on Impact
AN-M103[1]	Nose	Yes	650 lb	Arming Vane w/mech. del.	None	Selective, Nondelay or 0.1
AN-Mk.219	Nose	No	All depth bombs	Arming Vane w/mech. del.	None	Instantaneous
AN-MK221	Nose	No	All depth bombs	Arming Vane w/mech. del.	None	0.01 sec del.
AN-Mk.224	Transverse	Yes	325, 350, 650 lb	Arming Pin	None	Acts on water pressure
AN-Mk.229	Tail	?	650 lb	Arming Vane w/mech del.	None	Acts on water pressure
AN-Mk.234	Transverse	Yes	325, 350, 650 lb	Acts on water pressure	None	Acts on water pressure

(1) Special vane must be used when AN-M103 is used with flat nose bombs. The standard vane will not arm the fuse on such bombs.

Complete Round Components. Components necessary to make a complete round of ammunition are the following:
BOMB, Mk. 29 650 lb, loaded (1)
Fin assembly (1)
Fuze, nose, transverse or tail (1)
Arming wire (1)

Comparison of 650-pound Depth Bombs.

Bomb Nomenclature	Shape of Nose	Shape of Base	Explosive Filler
650 lb AN-Mk. 29	Round	Round	TNT
650 lb AN-Mk. 37	Round	Flat	TNT
650 lb AN-Mk. 38	Flat	Flat	TNT
700 lb. AN-Mk. 49	Flat	Flat	Torpex

FURTHER REFERENCES: A complete list of references regarding bombs may be found at the close of this section.

Chapter 5

Fragmentation Bombs

GENERAL.

Early Types. At the close of World War I the U. S. government had two fragmentation bombs which were designated the 17-pound Mk.II and the 25-pound Mk.III.

The 17-pound Mk.II was a modification of rejected 3-inch and 75-mm shells. Attached to the shell to convert it to a bomb was a fin assembly, a lug for horizontal suspension, and an adapter to provide for fitting a suitable fuze to the body. The fuze used was the Mk.XI arming pin type with the Mk.III Primer Detonator.

The 25-pound Mk.III Bomb was a pear-shaped bomb known as the British Cooper bomb. The body was manufactured from malleable iron or semisteel. It was stabilized in flight by use of a fin assembly. It utilized the Mk.XII Time Fuze, which could be set from 0 to 30 seconds in intervals of 5 seconds, in conjunction with the Mk.II Primer and the Mk.IV Detonator.

Both bombs were intended for high-altitude bombing. Both bombs are now obsolete.

Modern Design. Fragmentation bombs are used for the purpose of producing destructive effect against personnel and light material targets. To accomplish this, the bombs are so designed as to break

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into a large number of effective fragments of uniform size. Although the blast will do damage at the point of impact, most of the effect is achieved by the bomb fragments. To facilitate fragments of uniform size, the bomb body is constructed of a series of rings assembled over a tubular sleeve. Recently, a spiral spring of square cross section has replaced the rings. The width and thickness of the ring or spring determines the width and the thickness of the fragments. Attempts to predetermine a third dimension, the length of the fragment, by notching each spring has not been successful. The design entailed too much machining to make large scale production feasible. Since the bombs depend entirely upon fragmentation to produce desired effects, the case or body is comparatively heavy while the explosive charge is just enough to rupture the case. The weight of the high explosive in these bombs is about 12 to 15 percent of the total weight of the bomb.

Fragmentation bombs are considerably smaller than demolition bombs, making it possible for a greater number to be carried by a plane. Some foreign countries have fragmentation bombs of even smaller size.

Tests.

The pit test. In determining the fragmentation efficiency of bombs at the proving ground, three types of tests are conducted. The pit test, the low panel test, and the silhouette test. In the pit test, the bomb is placed in a wooden box and buried in a sand pit of suitable size, and detonated statically. The sand is then screened and the fragments recovered on four sizes of mesh, the openings varying from 0.165 to 0.838 inch. These fragments are carefully weighed, screened, and classified, and a decision as to the effectiveness of the bomb is obtained. Any of these sizes is considered an effective fragment. However, the more fragments, the better the bomb is considered to be.

The low panel test. The low panels consist of four quadrants of panels, 12 inches wide, 5.75 feet high and 0.82 inch thick, of spruce lumber. Each panel represents the height and width of a man. Quadrants of panels are placed 10, 20, 30, and 40 meters from the center at which the bomb is fragmented statically. By substituting either the total number of perforations counted or the number of panels perforated at the several distances in a formula, a figure is obtained which represents relative fragmentation effectiveness in terms of casualties over a definite area and with a definite and uniform distribution of personnel over this area.

Silhouette test. The silhouette test consists in dropping a bomb on a field of silhouettes spaced 15 to 45 feet apart. The silhouettes are of the same dimensions as the low panels and represent the height

and width of a man. The bombs are dropped from altitudes between 2,000 and 4,000 feet. The perforations of silhouettes within radii of 10, 20, 30, and 40 meters from the point of impact are counted and used in a formula to obtain a figure of effectiveness. This test is identical with the low panel test except that the bombs are actually dropped and fragment on impact rather than being set off statically. This brings in the effect of the forward motion of the bomb, angle from vertical at which impact occurs, and any delay in functioning, thus giving a measure of the actual performance of the bomb.

Results of tests. The results of various tests seem to indicate that the ring or spring 0.44-inch square is the best. The number of fragments from the entire bomb will vary between 1,000 and 1,500, although many of these are relatively ineffective. To obtain the most effect, the bomb must be exploded while its axis is as nearly vertical as possible. This is because the side spray may be directed into the ground or harmlessly dissipated in the air if the bomb detonates while at any appreciable angle from the vertical.

If a stabilized bomb is released from minimum altitudes, it will not strike the ground in an upright position which is desirable.

As a result of tests, a means of assuring the escape of the plane from bomb fragments and a means of having the bomb nearly vertical at impact has been devised by replacing the fin assembly with a parachute assembly. A specially designed fuze is used to initiate function of fragmentation bombs with this parachute attachment.

Effect of Fragments. The fragments from a fragmentation bomb are projected with a velocity of over 4,000 feet per second. Fragments weighing approximately 0.3 ounce have been projected to a distance of 600 yards. The average fragment has about the same bulk as a cal. .30 bullet. The side spray of a fragmentation bomb (if detonated in a vertical position) is much more effective than that of a shell of equal weight.

FUZE, Bomb, Nose, M104.

General. This fuze is of the arming pin type with time delay. It arms approximately 2.5 seconds after the arming wire is withdrawn. Its action on impact is instantaneous because this action is necessary for effective dispersion of fragments. The M104 is used in the 23-pound M40 or the 23-pound M72 Fragmentation Bomb. It is packed 1 per container, 50 per box.

Description. A mushroom-shaped striker assembly extends approximately 0.5 inch beyond the nose of the fuze body. The firing pin, supported by a spring which keeps it in contact with the striker assembly, is housed within the body of the fuze. The booster encased in an aluminum cup protrudes from the base of the fuze. A time

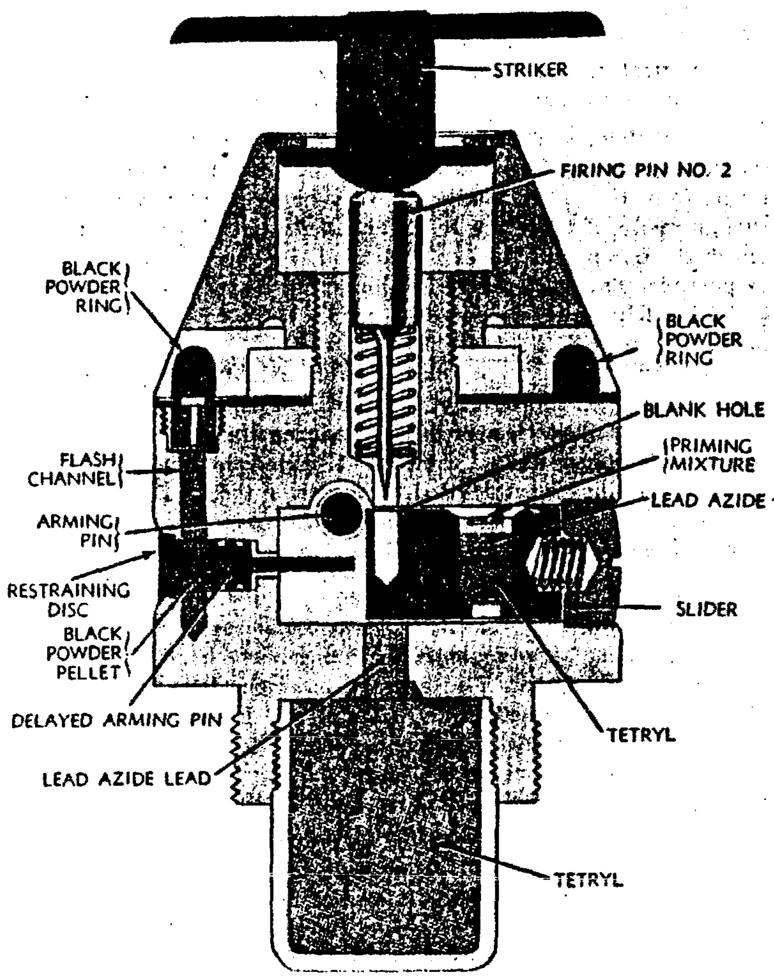


Figure 252 — FUZE, Bomb, M104 (Nose)

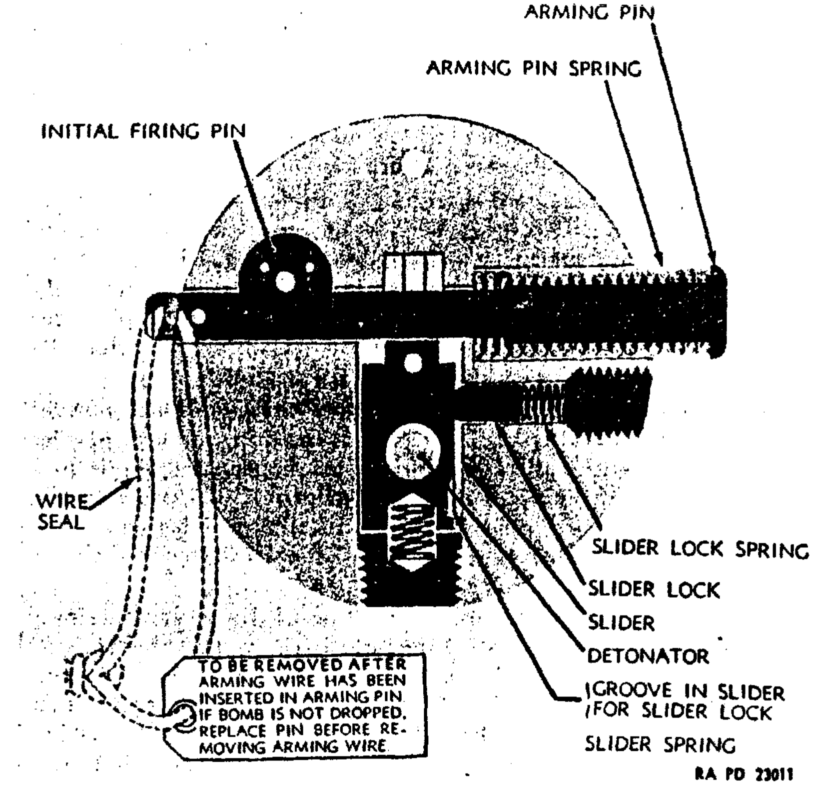


Figure 253 — FUZE, Bomb, M104 (Nose)—Cross Section

delay train located near the midpoint of the fuze provides for time delay in arming. The detonator is mounted in a slider located below the firing pin and is normally held out of the firing position by the arming pin which extends through the body of the fuze. Located in the slider is a blank hole for the protection of the firing pin when the fuze is in the unarmed position. In addition to the arming pin, a delayed arming plunger prevents the slider from moving to its firing position until the time delay train has burned through. When the time delay train has burned through, the delayed arming plunger is ejected and the slider moves to its armed position due to its spring. The time delay is initiated by an auxiliary firing pin which is driven forward by a compressed spring after the arming pin is ejected.

If armed, the fuze will function at any angle up to 13 degrees from the horizontal on striking the ground. If the fuze impacts the ground while the time train is still burning, it will not function on impact. If armed, the fuze will function on jarring and is exceedingly dangerous to handle.

Time delay is necessary because the parachute fragmentation bomb falls too slowly and from too low an altitude to use an arming vane with mechanical delay type of arming.

Function. The arming cord is withdrawn by the parachute, and the arming wire, which is tied to the arming cord, is withdrawn from the arming pin. The arming pin is ejected by its spring. Ejection of the initial arming pin leaves the slider held in the unarmed position only by the delayed arming pin. At the same time, the arming pin frees the cocked firing pin which is forced by its spring to strike the primer.

The flame from the primer ignites a loose charge of black powder which ignites the delay train. The gas from the burning black powder escapes from the fuze through vents in the upper part of the fuze body. The delay train burns for approximately 2.5 seconds and terminates in a small charge pellet of nitrocellulose. This ignites the body pellet which causes the explosion of a black powder charge around the delayed arming assembly.

The delayed arming assembly, consisting of a washer restraining disc and a plug, is forced out of the fuze body by the pressure created by the black powder. The slider, due to the action of its spring, is now free to move the delayed arming pin to the end of the fuze housing. In so doing, the slider brings the detonator directly underneath the firing pin, or into the armed position. The slider is locked in this position by a slider lock pin which rides in a groove in the side of the slider and fits into a cavity in the groove when the slider moves into the armed position.

Upon impact, the striker is forced inward causing the firing pin to move against its spring and strike the detonator. The detonator consisting of priming mixture, lead azide, and tetryl starts a shattering wave which functions a lead charge of lead azide. The lead charge in turn functions the booster charge of tetryl which is part of the fuze.

FUZE, Bomb, Nose, M109. There are but few differences between the M109 and the M104 described above.

The M104 is used on the parachute fragmentation bombs for low-altitude bombing. The M109 is used on the fin fragmentation bomb (20-lb M41) for medium low-altitude bombing (below 800 feet).

The M104 has a larger diameter striker head than the M109.

The M104 has the striker resting on the firing pin. The M109 has a striker spring cover and striker resistance spring underneath the cover to hold the striker in position. This is because the M109 has more wind pressure to counteract as it falls because of the height

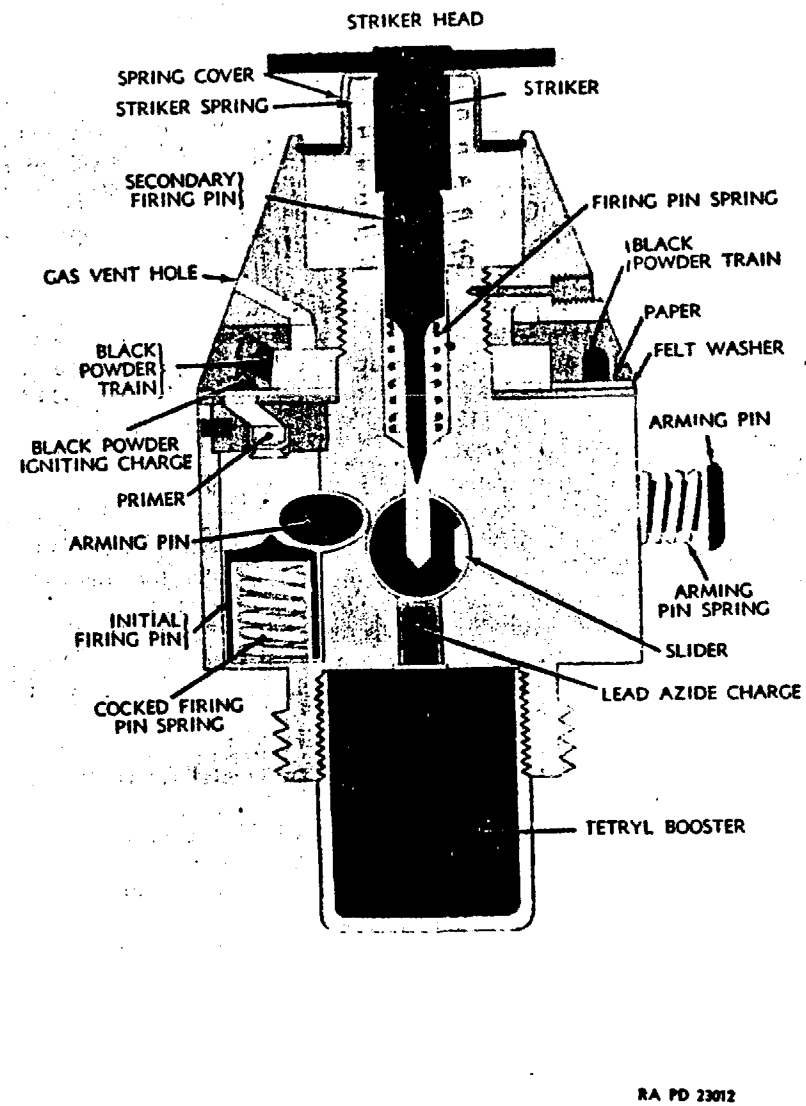


Figure 254 — FUZE, Bomb, M109 (Nose)

of fall and the speed of fall due to the absence of a parachute. The M109 might function before it struck if it did not incorporate this additional safety feature.

The M109 in all other features is similar to the M104. It is not generally used because the parachute fragmentation bomb is used for low-altitude bombing whereas the fin fragmentation bomb is usually used for high-altitude fragmentation bombing.

FUZE, Bomb, Nose, M120. Recently the M104 Fuze described above was replaced by the M120. The M120 is fundamentally the same fuze as the M104 except that its delay of 2.5 seconds in arming is produced by a mechanical time mechanism. It is more economical and easier to manufacture than the M104.

FUZE, Bomb, Nose, AN-M110A1.

General. This is an arming vane type of fuze with mechanical delay in arming. Its action on impact is instantaneous. The fuze is armed after approximately 340 revolutions of the vane. It is used in the 20-pound AN-M41 Fragmentation Bomb, the 20-pound M48 Practice Bomb, and the 115-pound M70 Chemical Bomb. It is packed 1 per container, 50 per box.

Description. The fuze is about 3.59 inches long and 2.30 inches of this length projects from the bomb when assembled. The vane is assembled to the fuze and has two tabs leading from it. These tabs have two holes which correspond to holes in a vane lock on the side of the body. These holes are to allow the fuze to be kept in the unarmed position until otherwise desired. The booster is encased in a metal cup which protrudes from the base of the fuze. On top of the booster cup is a metal disc with a small hole in the center to hold the detonator cup.

Above the detonator is the striker which is held away from the explosive element by a restraining spring and metal safety block. This unit is held in place by a small keeper.

The safety block is in the form of a ring with a section removed. This opening in the ring allows it to slip over the striker, but not over an arming sleeve which fits inside the safety block. When the vane revolves, the arming sleeve moves into the fuze housing by means of reduction gears, thereby freeing the safety block.

The reduction gears consist of a movable lower gear which is attached to the base of the arming sleeve. The arming sleeve is threaded into a ball race by means of 10 threads and so rotates with the arming vane. A stationary upper gear is attached to the ball race and, therefore, directly to the arming vane. Both gears are in mesh with an idler gear which is fixed loosely to a pin so that it can revolve around the axis of the pin.

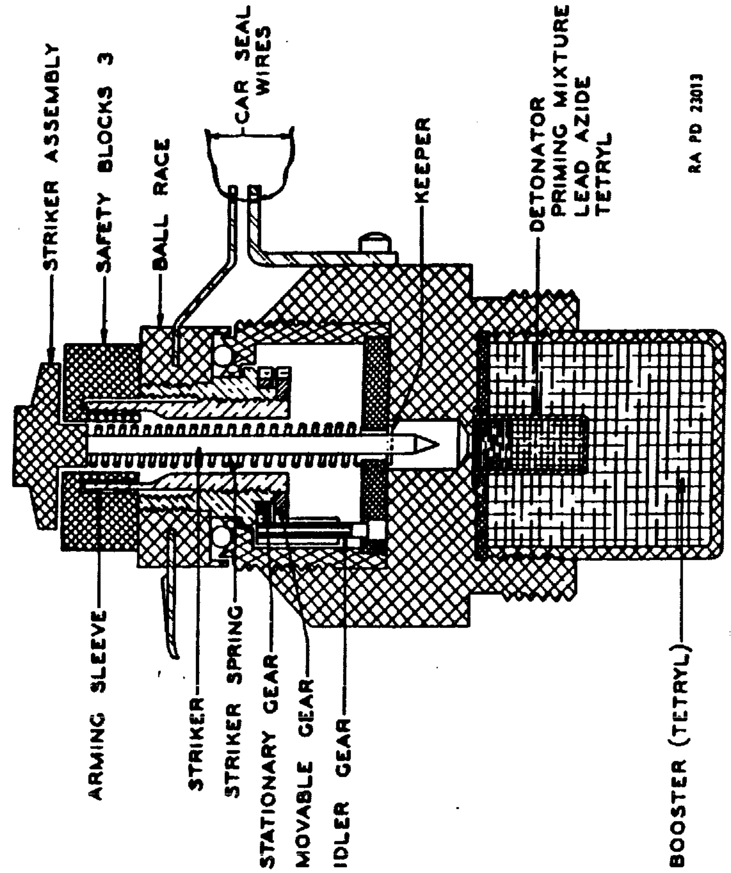


Figure 255 — FUZE, Bomb, M110 (Nose)

The movable gear has 34 teeth and the stationary gear has 33 teeth. Both gears turn with the arming vane. Both gears are in mesh with the idler gear and because of the differential in teeth, for every rotation of the arming vane the movable gear gains one tooth and the arming sleeve turns $1/34$ of a thread. For every 34 revolutions of the vane, the movable gear gains 1 complete turn and the arming sleeve turns 1 thread. As there are 10 threads to be turned before the arming sleeve moves completely into the fuze housing, 340 turns of the arming vane are required to arm the fuze.

Function. The cluster is dropped and the arming wire is retained in the plane. The cluster opens and the bombs fall free. The arming vane begins to rotate and, through a set of reduction gears, slowly moves the arming sleeve into the fuze housing. After approximately 340 revolutions of the arming vane, the sleeve moves completely into the fuze housing allowing the safety block to fall free, arming the fuze. The striker is now held away from the detonator only by a restraining spring.

Upon impact, the striker is forced inward against its spring causing the firing pin to strike the detonator of priming mixture, lead azide, and tetryl. The wave produced functions the booster of tetryl which is part of the fuze.

FUZE, Bomb, Nose, M110.

General. There are several differences between the M110 and the AN-M110A1 Fuzes, although the latter is the result of modifications made on the M110.

The AN-M110A1 is of much heavier construction, is larger in body shape although it has a smaller striker head. The vanes are smaller but wider and the entire body is treated with chromate solution to permit greater resistance to rust and corrosion. In general, it can be stated that the construction is much sturdier.

The AN-M110A1 has one safety block, split-ring shaped, and an arming sleeve which fits inside the safety block. The M110 had three safety blocks with inner recesses which slipped around an arming sleeve. If, as in certain cases, the arming sleeve was partially in the armed position, the safety blocks of some of the fuzes examined were found missing or almost off the arming sleeve. Such situations could and did result in serious accidents. All of the M110 fuzes were removed and were returned to the manufacturing plant for modification.

The AN-M110A1 has a reduction gear ratio which will allow the fuze to arm in 340 rotations of the arming vane, whereas the M110 has a ratio which allows the fuze to arm in 570 rotations of the arming vane.

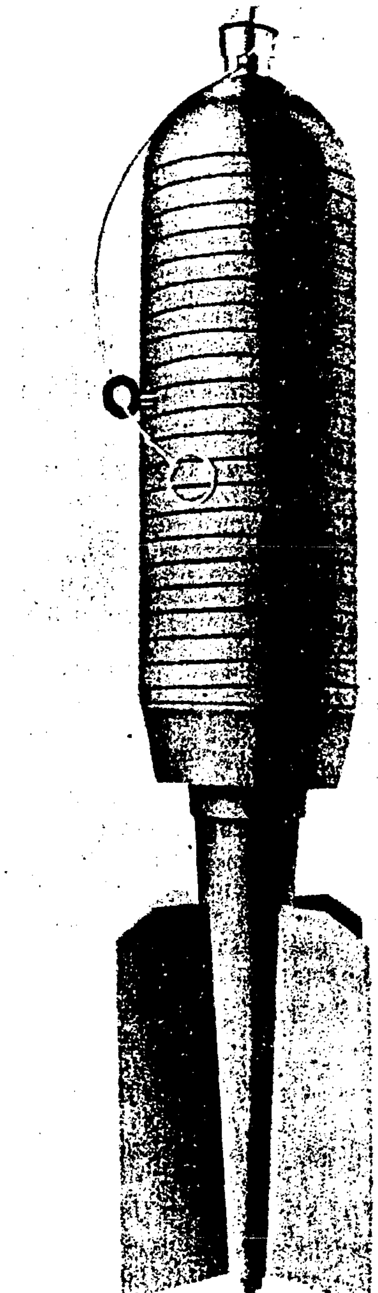


Figure 256 — 30-pound Fragmentation Bomb M5, With Mk. XIV Nose Fuze

BOMB, FRAGMENTATION, 30-POUND, M5.

General. This bomb was designed to have uniform effective fragments. It is standard for issue only, supplanted by a smaller bomb which is as effective and more economical. It is intended for high-altitude fragmentation bombing against such targets as personnel, motor convoys, planes on the ground, etc.

Bomb Body Description. The body consists of an inner steel sleeve which is threaded on both ends. Assembled over the sleeve is a series of steel rings which was cut from seamless steel tubing. The width and thickness of the individual rings determines the size of the fragments. A very even distribution of fragments of uniform size can be obtained. As an alternate to the rings, a closely wound helix bar of steel which is cheaper and just as effective is sometimes used.

The steel rings or helix bar of steel are held in place by two end adapter forgings which are screwed into the threads of the inner steel tube. The nose adapter is threaded to receive the M26 Adapter Booster. The M26 Adapter Booster in turn receives the Mk.IIB Primer Detonator and the Mk XIV Fuze. The tail adapter is closed and has a threaded protrusion to receive the fin assembly.

Two suspension lugs are provided, one welded to the bomb body for horizontal suspension and the other threaded to the fin assembly for vertical suspension.

The filler consists of 4.5 pounds of TNT, about 15 percent of the total weight of the bomb.

Fuze Mk. XIV. Brief mention can be made of this fuze as it is of relative unimportance today. It is the arming vane type, arming after several revolutions of the vane. The vane cup which moves up with the vane on arming frees a series of metal balls which permit the striker to be held off the fuze housing only by a shear wire.

The instantaneous primer detonator, the Mk.IIB, is a separate component consisting of primer, black powder, mercury fulminate, and tetryl. It is quite sensitive and dangerous to handle. On impact, the firing pin functions the primer detonator which in turn functions the M26 Tetryl Booster which functions the TNT charge in the bomb body.

The use of this fuze was dangerous because it armed so quickly and functions instantaneously on impact. If dropped singly, the fuze's arming so quickly may function the bomb directly beneath the plane due to accidental impact.

BOMB, FRAGMENTATION, 20-POUND, AN-M41.

General. This bomb is designed to replace the 30-pound M5 Fragmentation Bomb complete with stabilizing fins and fuze. It weighs 20 pounds and yields fragments equal to those of the 30-

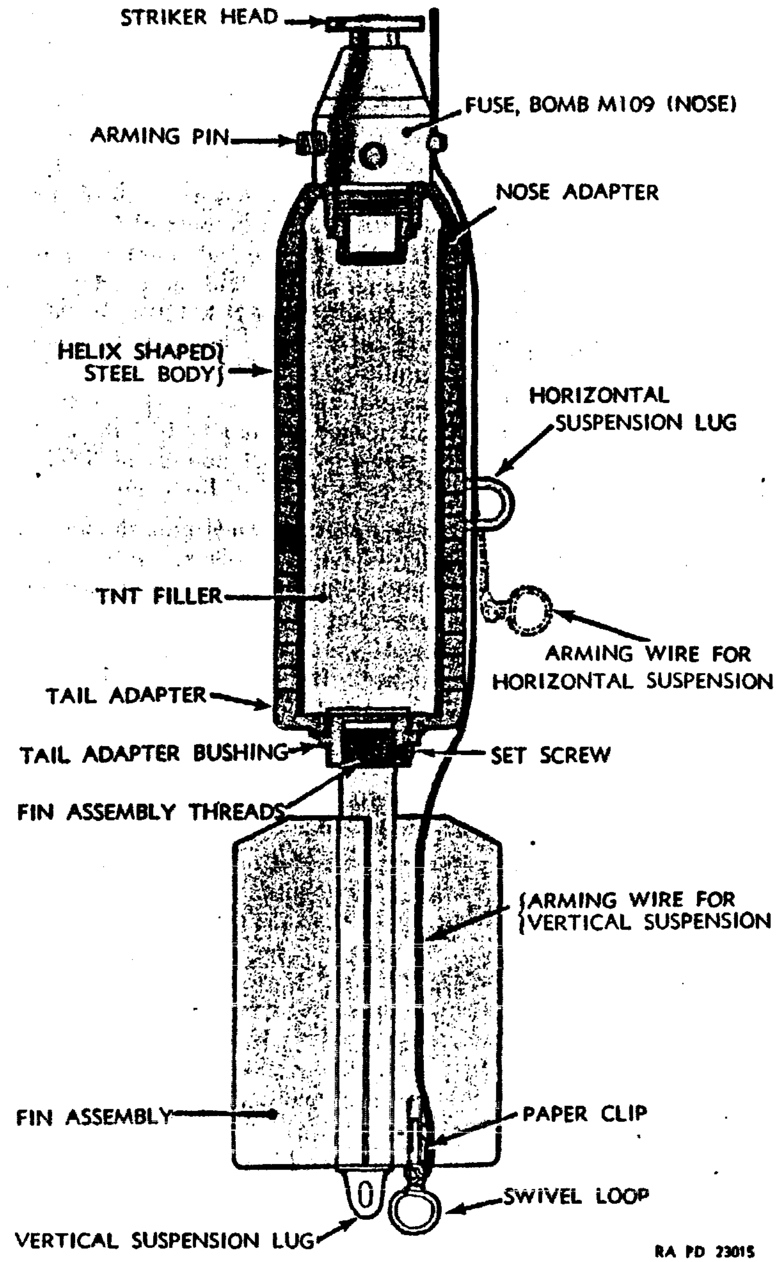


Figure 257 — BOMB, Fragmentation, 20-pound, M41

pound bomb in both size and destructive effectiveness. It is intended mainly for high-altitude and occasionally for medium low-altitude bombing, depending on the fuze, against such targets as personnel, motor convoys, planes on the ground, etc.

Bomb Body Description. The body consists of an inner tubular steel sleeve which is threaded on both ends. Assembled over the sleeve is a closely wound helix bar of steel whose width and thickness will determine the size of the fragments. A very even distribution of fragments of uniform effective size can be obtained.

The helix bar is held securely in place by two end adapter forgings screwed into the threads of the inner sleeve. The nose adapter is internally threaded to receive the Nose Fuze AN-M110A1 or M109 and a fuze well cup. The tail adapter is closed and has a threaded protrusion to receive the fin assembly.

Suspension lugs, one for horizontal suspension is welded on the bomb body, the other for vertical suspension is attached to the tail end of the assembly. The filler consists of 2.7 pounds of TNT or approximately 13½ percent of the total weight of the bomb.

Fin Assembly. The fin assembly consists of steel pipe threaded at one end to screw into the bushing of the rear adapter. It is held in place by a set screw when assembled. Attached to the pipe are four blades, and at the rear end a suspension lug is attached for vertical suspension.

When assembled to the bomb body, the fin is so assembled that one fin blade will be in line or at an angle of 45 degrees to the horizontal lug on the bomb body.

BOMB, FRAGMENTATION, 20-POUND, M42.

General. This bomb in construction is exactly the same as the 20-pound AN-M41 previously described. However, it is used against invading bombardment formations. For this purpose, the only change in the complete round is a change in the fuze from AN-M110A1 to the T7E1 which is a mechanical time and impact fuze.

This bomb is still in the experimental stage not in so far as the bomb body or fin assembly is concerned, for it has the standard body and fin assembly, but in so far as the fuze is concerned. The difficulty arises in timing the fuze so as to function the bomb near the proper place to produce effective fragments. At the present time, this model bomb is not included in the Standard Nomenclature Lists (January 1, 1943).

BOMB, FRAGMENTATION, 23-POUND, M40.

General. The Air Forces introduced a new tactical use for fragmentation bombs in which the bombing was to be done from very

low altitudes in order that the screening effect of trees and low hills might be used to hide the approach of attacking planes. Extensive tests were conducted; it was found that usually the plane was not far enough away to be out of the danger zone when the bomb exploded and also that the bomb would usually function in a horizontal position so that a loss of efficiency would occur. At times, the bomb failed to function at all.

It was evident, therefore, that two factors had to be considered. The bomb must be retarded so that the plane would have time to leave the danger zone of the fragments before the detonation occurred. Also, it must function while its long axis was perpendicular to the ground.

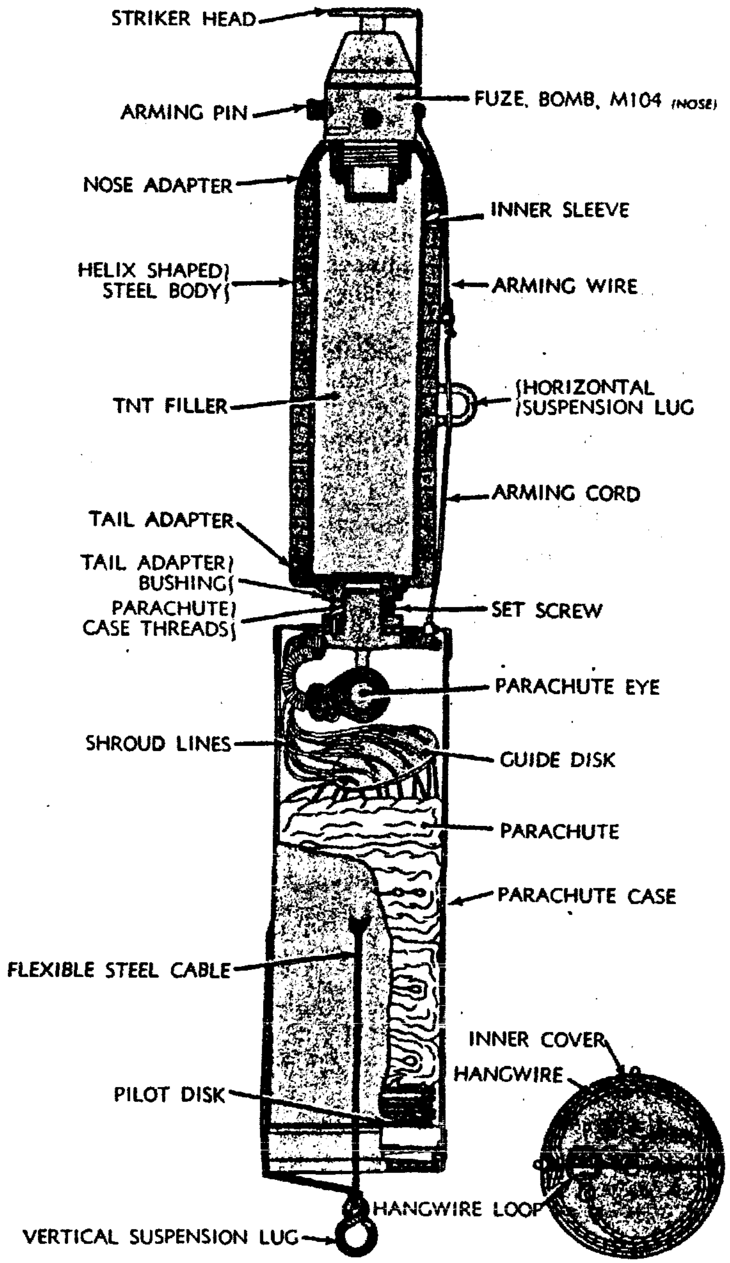
The most practical way to accomplish this was to equip the bomb with a small parachute housed within a case occupying little more space than the stabilizing fins of the high altitude bomb. The 23-pound M40 Bomb was thus developed. The parachute serves to retard the descent of the bomb for the required time and causes it to strike with its axis nearly vertical.

The use of a fuze with a semi-all ways percussion head and instantaneous action on impact insures function before the bomb loses its vertical position and even though it strikes the target at an angle while swinging, pendulum-like, from its parachute. A delay in arming incorporated in the fuze prevents premature detonation of the bomb due to malfunction of the parachute or collision during flight.

Bomb Body Description. This bomb uses the same body as the 20-pound AN-M41 and M42 Fragmentation Bombs. It is equipped with a parachute, however, in place of a fin assembly. The fin assembly is removed and the same bushing that receives the fin assembly now receives the parachute assembly. It is kept securely attached to the bomb body by a set screw in the same manner as is the fin assembly. It uses the M104 or M120 Nose Fuze. The additional weight of the bomb is produced by the parachute assembly.

Parachute Assembly Description. The parachute case is cylindrical in shape. It is made of sheet metal. Inside the parachute case are two cardboard pilot discs which are attached by means of silk cord to the top of the parachute. The parachute is made of mercerized cotton and airplane fabric and is 8 feet in diameter. It is attached to the parachute case by 12 silk shrouds which are tied to an eye in the base of the parachute case. Tied to the lower ends of the shroud lines is a silk cord known as the arming cord. It extends through an opening in the base of the parachute case and terminates in a short length of arming wire which is inserted in the arming pin of the fuze.

Earlier models of this bomb were designed to be dropped singly. Later without changing the model number of the bomb, the bomb



RA PD 23016

Figure 258 — BOMB, Fragmentation, 23-pound, M72

was modified to be dropped from clusters. The description of the above bomb is that of the later models.

Function of Parachute Assembly. The cluster is dropped and the arming wire is retained in the plane. The cluster opens and the outer cover is carried off the parachute case by the wind stream. The pilot discs are lifted out of the case by the air stream and in so doing withdraw the parachute from the case. As the parachute is filled with air, it retards the forward motion of the bomb and the arming cord is drawn into the parachute case and the arming wire is withdrawn from the arming pin of the fuze.

BOMB, FRAGMENTATION, 23-POUND, M72.

General. This bomb is the old 23-pound M40 Bomb used for single suspension only. The 23-pound M40 at one time was used for single suspension racks to be dropped unclustered. It was decided to change the 23-pound M40 in order to be able to drop these bombs from clusters. Without changing the model number, all of these bombs were modified to function from clusters. Included in the modification was the elimination of the outer cover and replacing it with the outer cover of the cluster, and the elimination of the inner cover, hangwire, and tear wire.

It was found that certain planes could not be adapted to receive the clustered parachute fragmentation bombs and could make effective use of parachute fragmentation bombs singly suspended. It was therefore decided to manufacture the old 23-pound M40 Parachute Fragmentation Bombs once again. However, to avoid confusion between the old and the new, the singly suspended parachute fragmentation bombs received the nomenclature "Bomb, Fragmentation, 23 pound M72."

Description. The body is the same as described for the 23-pound M40. The fuze used is the same, either the M104 or the M120 Nose Fuze. The parachute assembly in outward appearance is the same. It has attached to two points on the side, a flexible steel cable ending in a suspension loop above the case for vertical suspension.

The parachute assembly differs in the inside. After removing the outer cover, a flexible steel cable (hangwire) having a loop at one end and attached to an inner metal cover at the other end will be found. The loop on the cable is assembled to the bomb shackle in the same position as the arming wire. The inner cover which is held snugly in the parachute case has on its inner side a tear wire which is attached to the top pilot disc. From this point, both parachute assemblies are the same.

Function of Parachute Assembly. The bomb is dropped and the hangwire is retained in the plane. This pulls the inner cover from

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the parachute case. The inner cover, by means of the tear wire, pulls with it the top pilot disc. By means of a connecting cord, the top pilot disc withdraws the lower pilot disc and parachute. As the parachute is filled with air, it retards the forward motion of the bomb. The tear wire is torn, freeing the top pilot disc from the inner cover and thus severing any connection between the bomb and the plane. At the same time, the arming cord is sharply withdrawn from the arming pin of the fuze.

CLUSTER, FRAGMENTATION BOMB, M1 (100-POUND SIZE).

General. In order to provide for flexibility, fragmentation bombs are assembled into clusters. This serves for two definite advantages: the cluster may be installed in aircraft equipped with racks for large bombs; and clusters cover a large area more adequately than does the same number of bombs released singly.

The complete assembly consists of the following components:

Adapter Cluster M1
~~BOMB, fragmentation, 20-pound, M41 (6)~~
FUZE, bomb, M110 or AN-M110A1 (nose) (6)
Steel wires (4)
Cartridge M6
Firing mechanism M1
Wire, arming, type A

Adapter Cluster M1. The adapter cluster serves as the framework for holding the bombs together. It consists of two longitudinal steel tubes, a barrel, and separator. Welded to the separator and barrel are two nose and two fin supports for six bombs. Welded to the separator are two vane stops to prevent motion of the fuze vanes.

The barrel is hollow and is pierced with four holes through which four steel tie wires are threaded. The steel tie wires encircle the six bombs and hold them securely in place. One end of the barrel is closed with a steel plug. The other end seats a Cartridge M6 and is externally threaded to receive the M1 Firing Mechanism. Welded to the barrel are two loops 14 inches apart which act as double suspension lugs to fit into bomb racks that receive 100-pound bombs.

Firing Mechanism M1. The firing mechanism consists of a housing which contains a cocked firing pin. The lower portion is internally threaded to screw onto the barrel of the adapter cluster. The firing pin has two holes, one for a cotter pin and the lower one for the car seal wire which is replaced by the arming wire on assembly in the plane.

Cartridge M6. This consists of a primed cartridge case carrying a small propelling charge of 6 grains of black powder. The mouth of the cartridge case fits around a steel slug and the cartridge case is

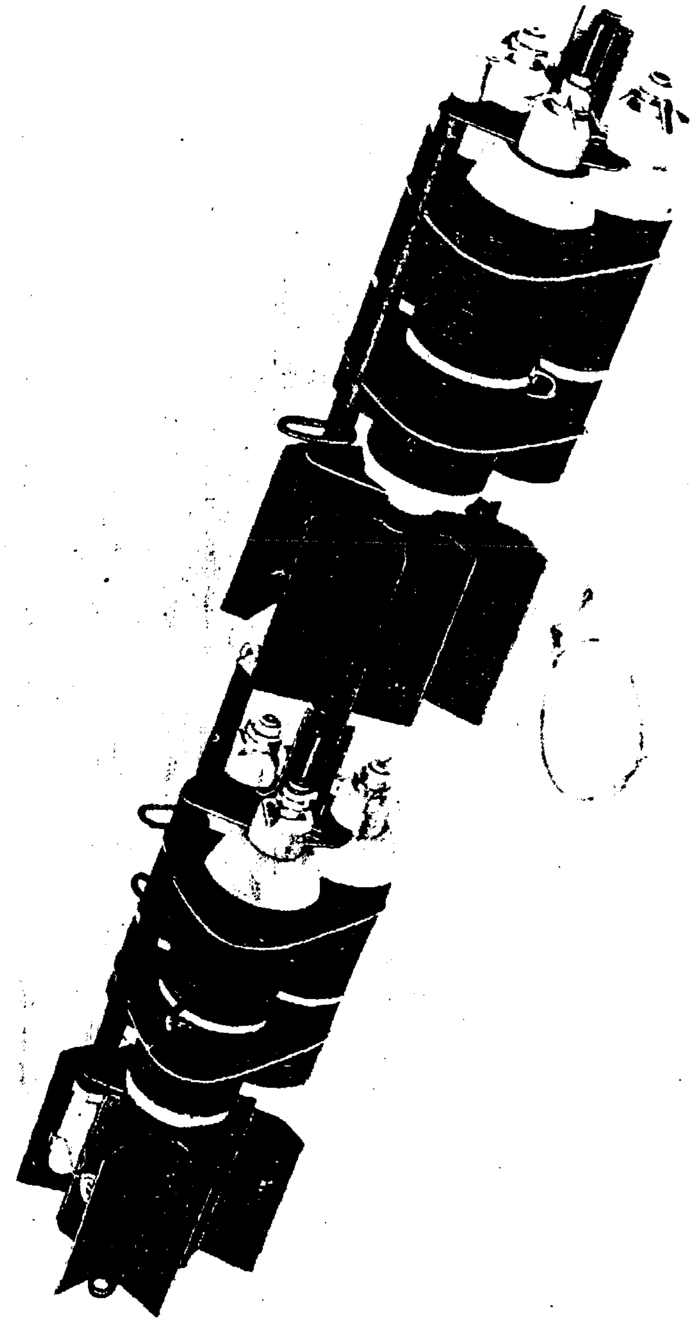

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Figure 259 — Fragmentation Bomb Cluster

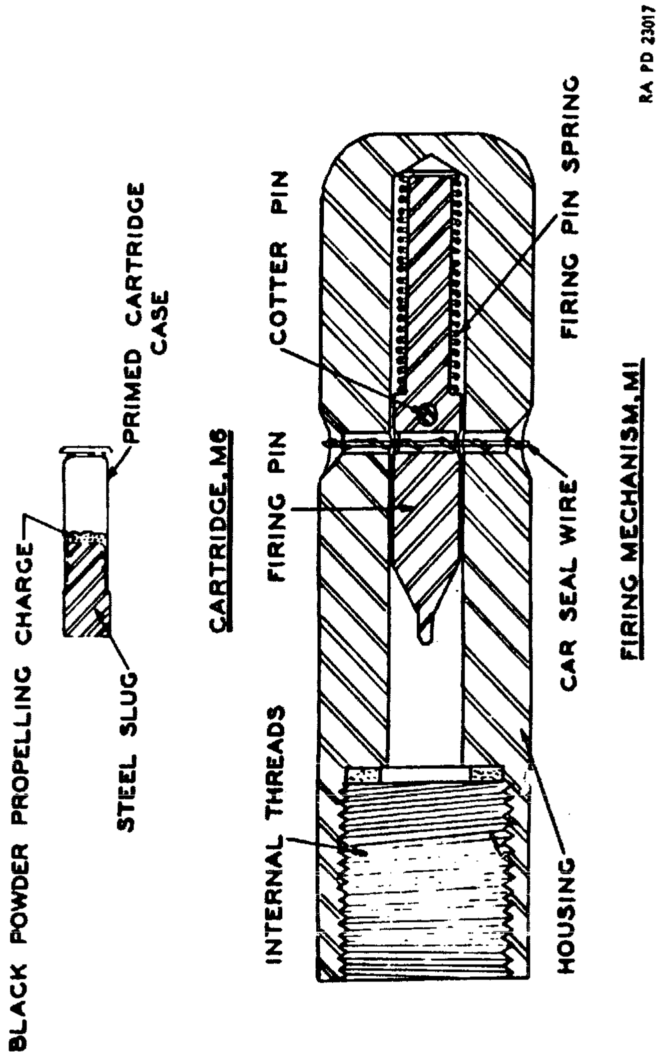


Figure 260 — Firing Mechanism and Cartridge for Fragmentation Bomb Cluster M1

held to the slug by crimping. The steel slug has sharp corners for severing the tie wires.

BOMB, Fragmentation, 20-pound, M41. In this fragmentation, cluster six 20-pound Fragmentation Bombs M41 are used. These bombs are fuzed with M110 Nose Fuze or AN-M110A1 Nose Fuze. The bombs are held in place by the four steel tie wires, resting on the adapter cluster by means of the nose and fin supports which allow for a snug fit.

Function. The fragmentation cluster is dropped and the arming wire is retained in the plane. This allows the firing pin due to the action of its compressed spring to strike the primer of the cartridge. The primer ignites the black powder propelling charge which propels the steel slug down the barrel of the adapter cluster. The slug, as it passes through the barrel, severs the four steel tie wires allowing the bombs to fall free and the vanes to begin to rotate. The steel slug terminates in a steel plug at the end of the barrel. Also at the end of the barrel is a large hole pierced in one side to allow for the escape of gas at that point.

If dropped safe, the arming wire is dropped with the cluster. The cartridge is not fired nor are the bombs released from the cluster. The vane stops restrain the fuzes from arming and the bombs do not function on impact.

CLUSTER, FRAGMENTATION, BOMB, M3 (100-POUND SIZE).

General. This cluster is similar to the M1 previously described. The components differ, but in function it is similar except in the incorporation of a delay cartridge of 5 seconds. This cartridge permits the cluster to drop for 5 seconds before opening. This delay is essential because the fuzes used with the fragmentation bombs in this cluster arm after several rotations of the arming vane. This delay permits the bombs to be well out of the range of the bomb fragments in the event that the bombs accidentally function in the air upon arming of the fuze.

The complete assembly consists of the following components:

Adapter Cluster M2
BOMB, fragmentation 30-pound, M5 (6)
FUZE, bomb, Mk.XIV (nose) (6)
Primer Detonators, Mk.IIB or Mk.IIC, instantaneous (6)
Steel wire (4)
Cartridge M7
Firing mechanism M1
Wire, arming, type A

Adapter Cluster M2. This adapter cluster is the same as the M1 previously described. Fundamentally, it differs only in size. It is larger for it receives the larger 30-pound fragmentation bomb instead of the smaller 20-pound fragmentation bomb. It is designed for 100-pound bomb racks.

Firing Mechanism M1. This is the same mechanism as previously described.

Cartridge M7. This consists of a primed cartridge case containing an igniter of black powder, a 5-second delay of black powder, a relay of black powder and a propelling charge of black powder. The mouth of the cartridge case fits around a steel slug and is held in place by crimping.

BOMB, Fragmentation, 30-pound, M5. In this fragmentation cluster, six 30-pound Fragmentation Bombs M5 are used. These bombs are fuzed with Mk.XIV Nose Fuzes using the Mk.IIB or Mk.IIC Instantaneous Primer Detonator. The bombs are held in place by four steel tie wires, resting on the adapter cluster by means of the nose and fin supports which allow for a snug fit.

Function. The fragmentation cluster is dropped and the arming wire is retained in the plane. This allows the firing pin due to the action of its compressed spring to strike the primer of the cartridge. The primer ignites a black powder igniter charge which ignites the delay of black powder that burns for 5 seconds. The delay of black powder ignites a relay charge of black powder and that initiates the propelling charge of black powder. The propellant sends the steel slug down the barrel of the cluster causing the slug to sever the four tie wires and to set the bombs free. The bombs fall free of the cluster and the vanes begin to rotate. The steel slug terminates in a steel plug at the end of the barrel. Also at the end of the barrel is a large hole pierced in one side to allow for the escape of gas at that point.

CLUSTER, FRAGMENTATION, BOMB, AN-M1A1 (100-POUND SIZE).

This cluster has been designed to replace M1 Fragmentation Bomb Cluster. It is simpler in construction and operation and utilizes a mechanical releasing device in place of a firing mechanism and cartridge to release the bombs from the cluster.

Components necessary to make a complete round:

Adapter Cluster AN-M1A1
BOMB, fragmentation, 20-pound AN-M41 (6)
FUZE, bomb, AN-M110A1 (nose), (6)
Steel, band (2)
Wire, arming, type B

Adapter Cluster AN-M1A1. This cluster consists of two longitudinal hollow steel tubes which can be described as a barrel and separator, the barrel being wider in diameter than the separator. Welded to

the barrel and separator are two nose supports and fin supports for six bombs. Welded to the separator are two vane stops to prevent motion of the fuze vanes. Passing through slits in the nose and fin supports near the separator are two flat pieces of spring steel formed in such a manner that when the bombs are pressed against them the resulting tension will force the bombs out of the cluster when the cluster opens.

Around the barrel will be found three suspension lugs, the outer two being 14 inches apart for double suspension, the inner one being exactly between the outer two at the center of gravity for single suspension. Any of these lugs can be removed from its extended position by withdrawing a cotter pin and bolt which holds them extended. The lugs will now be in such position that the bolt which formed the point for suspension will be in contact with the barrel.

Welded to the barrel approximately 5 inches from the outermost lugs are two clasp holders. Each clasp holder consists of two metal pieces, each piece having a hole at one end for a screw bolt of a steel band to fit through. The steel band has a clasp at its other end and will encircle the bombs, thereby holding them in place, so that the clasp will fit into the clasp holder. Four small holes pierced through the clasp holder at a point somewhat above the two main holes allow for the insertion of a common safety wire and arming wire.

As there are two clasp holders and two steel bands, the arming wire and safety wire pass through the two holders and when removed, the pressure of the bombs against the steel bands and the spring tension of the steel bands forces the bands with their clasps to spring open and free the bombs. The adapter cluster is designed for 100-pound bomb racks.

BOMB, Fragmentation, 20-pound AN-M41. This bomb is the same as the 20-pound M41, the AN merely being used to indicate that both services can utilize the bomb and cluster. The bombs, six in all, are held in place by the two steel bands which encircle the cluster. They rest on the adapter cluster by means of nose and fin supports which allow for a snug fit and are always being forced outward away from the cluster by the two flat spring steel pieces. The fuze used is the *AN-M110A1*.

Function. The cluster is dropped and the arming wire is retained in the plane. The clasps, which are now free, are sprung out of their holders by the pressure of the bombs against the steel bands and by the spring tension of the bands, freeing the bombs. The bombs are aided in their release from the adapter cluster by means of two flat spring steel pieces which eject them from the adapter. When the bombs are free from the cluster, the vanes begin to rotate and the fuze begins to arm.

CLUSTER, FRAGMENTATION BOMB, M4.

General. This cluster was designed to enable the dropping of parachute bombs from a cluster. The 23-pound Fragmentation Bombs M40 were all modified without change in nomenclature to enable them to be dropped from a cluster. Tests conducted at Aberdeen in October of 1942 proved that the cluster would function satisfactorily. However, a difference in position of cluster was noticeable in function. When the clusters were dropped with the nose end forward in the rack, 4 out of 36 bombs failed to function. When the clusters were dropped with the parachute end forward in the bomb rack, none of the 24 bombs tested failed to function.

Components necessary to make a complete assembly for this cluster are the following:

Adapter Cluster M3
BOMB, fragmentation, 23-pound M40 (3)
FUZE, bomb, M104 or M120 (nose) (3)
Steel, band (2)
Wire, arming, type B

Adapter Cluster M3. This adapter cluster is similar in construction to the AN-M1A1, although smaller. It consists of two longitudinal hollow tubes which can be described as a barrel and separator, the separator being smaller in diameter but about ½ foot longer than the barrel. Welded to both tubes is a rear end plate support for the parachute assembly, two parachute assembly supports, a support for the point of attachment of the parachute assembly and bomb body, and finally a bomb body support.

The barrel is the same in general construction and components as the adapter cluster barrel for the AN-M1A1. It has three lugs and two clasp holders attached in the same manner as previously described.

Attached to the parachute supports below the separator are two bolts. Around these bolts are coiled spring wires. Also attached to the bolts are partially cylindrical metal plates in which the three parachute assemblies are partially encased. The pressure of the parachute assemblies forces these plates against the coiled spring wire onto the parachute assembly supports. This causes the compressed springs to eject the parachute assemblies and, therefore, the bomb, when the cluster opens.

Two bolts are found protruding near the separator attached to the body supports. Around these bolts are spring coil wires against which the bomb body will press in order to rest on its support. These compressed springs will also aid in the ejection of the bomb body when the cluster opens.

COMPLETE ROUND CHART FOR FRAGMENTATION BOMBS

Weight, Designation and Status	Filler	Fuze (Nose)	Primer Detonator	Nose Adapter Booster	Tail Assembly
30 lb M5 (S)	4.51 lb TNT	Mk. XIV	Mk. IIC(1)	M26	Fin
20 lb AN-M41 (S&M)	2.7 lb TNT	AN-M110A1(2)	None	None	Fin
20 lb M42	2.7 lb TNT	T7E1	None	None	Fin
23 lb M40 (S&M)	2.7 lb TNT	M120(3)	None	None	Parachute
23 lb M72 (S&M)	2.7 lb TNT	M120(3)	None	None	Parachute

(1) Primer Detonator Mk. IIB may be found used.
(2) Fuze M109 or M110 may be found used.
(3) Fuze M104 may be substituted.

FUZES USED IN FRAGMENTATION BOMBS

Fuze Designation	Position In Bomb	Booster In Fuze	Bomb for Which It Is Adapted	Method of Arming	Primer Detonator	Action on Impact
M104	Nose	Yes	23 lb Parachute	Arming Pin w/time del.	None	Instantaneous
M109	Nose	Yes	20 lb Fin	Arming Pin w/time del.	None	Instantaneous
AN-M110A1	Nose	Yes	20 lb Fin	Arming Vane w/mech. del.	None	Instantaneous
M120	Nose	Yes	23 lb Parachute	Arming Pin w/mech. time del.	None	Instantaneous

Around the tail end of the parachute assembly and in contact with the rear end plate support will be found three covers in place of the outer covers of the parachute assemblies. These covers are the same in diameter, but differ in length. The longest is 4 inches; the next is 2 inches, and the smallest is ½ inch in length. These covers fall off the parachute assembly at different points in the bomb drop, the smallest freeing its parachute first, the longest freeing its parachute last, preventing the parachutes and bomb from interfering with each other.

The parachute fragmentation bombs are held in the adapter cluster by means of two steel bands and clasps in the same manner with the use of the same type arming wire and common safety wire as previously described.

BOMB, Fragmentation, 23-pound, M40. In this fragmentation cluster, three 23-pound Fragmentation Bombs M40 are used, the parachute fragmentation being much longer and heavier than the fin fragmentation bombs. These bombs are fuzed with the M104 Nose Fuze or the M120 and are held in place by two steel bands, resting on the adapter cluster by means of supports.

Function. The cluster is dropped and the arming wire is retained in the plane. The clasps, which are now free, are sprung out of their holders by the pressure of the bombs against the steel bands and the spring tension of the bands, freeing the bombs. The bombs are aided in their release from the adapter cluster by means of compressed springs which eject them from the adapter. When the bombs are free from the cluster, the outer covers fall off at different points in the bomb fall allowing the parachute discs to be exposed and the parachutes to open. The parachutes, as they open, pull the arming cord into the parachute case. The arming cord carries with it the arming wire which frees the arming pin allowing the fuze to arm.

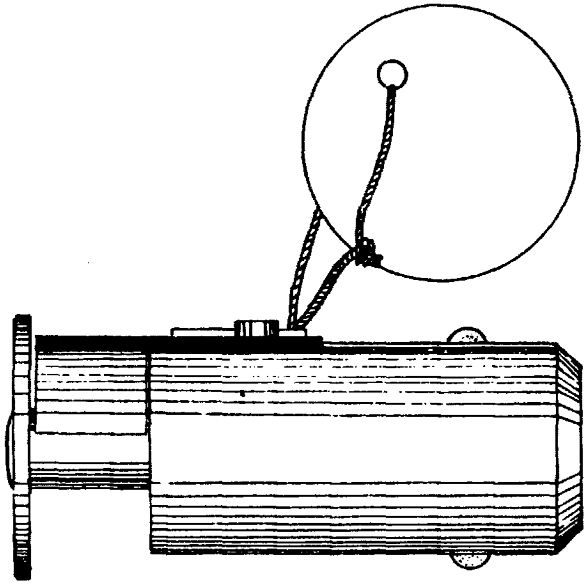
FURTHER REFERENCES: A complete list of bomb references can be found at the close of the final chapter in this section.

Chapter 6

Chemical Bombs

GENERAL.

Development. For several years after World War I, no attention was directed toward the development of chemical bombs except for demonstration purposes. For this use, a 50-pound Mk.I with a smoke filler of FM was used. The bomb was made from the 40-



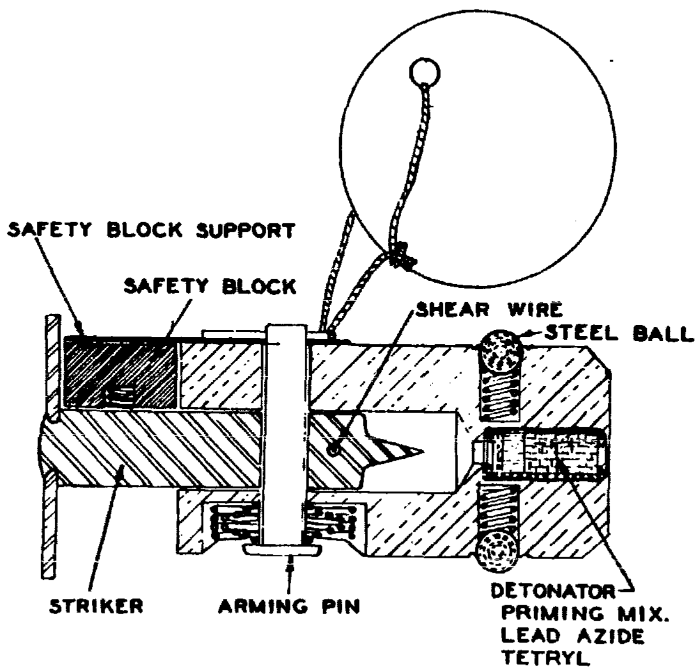


Figure 261 — FUZE, Bomb, M108 (Nose)

pound Mk.I incendiary which was streamlined in shape. A full length black powder burster with the Mk.XIV Fuze was provided.

With the trend toward the development of a chemical bomb being initiated, a general requirement that the bomb case must be strong enough to withstand "safe dropping" on normal soil from a height of 7,000 feet was decided upon.

This led to the development and standardization of the 30-pound M1 Chemical Bomb. This bomb was made by swaging a length of seamless steel tubing to a streamlined shape, fully closed at the tail end. A full length burster well was assembled to the nose end of the body by means of pipe threads which seal the bomb against leakage of the filler. The two authorized chemical loadings for the bomb were HS and WP. A full length burster of tetryl was used with both fillers. The bomb was functioned by the Mk.XIV Fuze, using the Mk.IIB Instantaneous Primer Detonator.

In 1934, the requirement that the chemical bomb must withstand safe dropping was eliminated. After much experimentation on thin case bombs, fuzed and unfuzed, the 30-pound M46 Chemical Bomb was standardized in 1940. This bomb was cylindrical in shape and was made of sheet metal. It was a great improvement over the old 30-pound M1 Chemical Bomb carrying much more filler (75 percent as compared to 30 percent) and gave a much more efficient distribution of the chemical filler. It incorporated the M108 Nose Fuze with a full length charge of tetryl known as the Burster M3. It was loaded with HS and WP.

Recent Developments. A 100-pound thin case bomb was standardized after the development of the 30-pound M46. This was designated as the 100-pound M47 Chemical Bomb. It had a filler of WP or incendiary oil. It utilized the M108 Nose Fuze with the M4 Burster of tetryl.

The 30-pound M46 in the meantime had undergone changes in its fin assembly to make it more stable in flight and body construction. It was modified so that its latest designation was 30-pound M46A2. However, because of the change in Air Force tactics, the tactical use of this bomb became quite limited. Fighter planes no longer had racks to fit this type of bomb. Experimental clusters of six bombs required as much room as a 500-pound demolition bomb and were deemed a great waste of space. Consequently, in 1942, all the 30-pound M46 Bombs with their modifications were declared obsolete and the 280,000 of these bombs found in the field were withdrawn and returned to Chemical Warfare Service for use as components in chemical land mines.

Chemical Bomb Nose Fuze M108.

General. This is an arming pin type of fuze with instantaneous arming action and instantaneous action on impact. It is possible to use this type of fuze on chemical bombs because this would cause no damage to a plane, were they to function immediately upon clearing the bomb bay. This, of course, is not the case with H.E. bombs. The M108 Fuze is used on the 100-pound Chemical Bomb M47 or its modifications. The fuze is packed 1 per container, 200 per box.

Description. This fuze has an over-all length of 2.66 inches. A striker assembly protrudes approximately ¾ inch beyond the nose of the fuze body. At the rear of the body are two spring-actuated steel balls diametrically opposed, which engage in the groove of the burster well adapter when the fuze is inserted in the nose of the bomb. This operation, performed solely by hand and without the use of force or tools requires no screwing. An arming pin with two transverse eyelets and positioned on a compressed spring, extends through both fuze body and striker shaft, thereby preventing movement of the striker. Also extending through both fuze body and striker is a shear wire. Incorporated as an integral part of the fuze is a detonator assembly.

As an added safety device for this fuze, a steel spring-loaded safety block is mounted between the striker head and fuze body. It is retained in place by a safety-block holder which is a thin metal plate fitting under the arming wire in the arming pin. It bears against the safety block and holds it in place. Upon fuzing, the arming wire is threaded through the inner eyelet and the cotter pin is removed.

The original M108 Fuze did not have the safety-block assembly. When used with the 100-pound chemical bomb, it was found to be quite dangerous because a drop of about 6 inches on a hard surface was sufficient to function the fuze despite the safety features. M108 Fuzes in the field without safety-block assemblies should be modified by inserting properly sized wooden blocks between the striker and fuze body and taping them securely in place. These blocks are removed only when the bomb is placed in the bomb rack.

Function. The bomb is dropped and the arming wire is retained in the plane. The arming pin is ejected from the fuze by its spring. At the same time, the safety-block holder, being free, is ejected by the safety-block spring. The striker is now held away from the detonator by a shear wire.

On impact, the striker is forced inward, shearing the shear wire and bringing the firing pin into the detonator. The detonator consisting of priming mixture, lead azide, and tetryl detonates and sends a wave to the burster charge of tetryl or black powder in the burster casing.

Chemical Bomb, FUZE, Nose, M126.

General. This is an arming vane type of fuze with mechanical delay in arming. It has instantaneous action on impact which is in all

cases necessary to provide for dispersion of chemical filler before any penetration can occur. It is used in the 100-pound Bombs M47A1 and M47A2 when dropped in clusters, and also in the 115-pound M70 Bomb.

Description. This fuze is similar to the AN-M110A1 with the elimination of the booster housing and booster charge, and with the incorporation of a detonator housing instead of a cup for the detonator charge. In all other respects, it is similar to the AN-M110A1 described in the chapter dealing with fragmentation bombs. It was designed to prevent the bomb from functioning too close to the plane. Especially is there a possibility of this if the bombs are to be dropped in clusters.

Function. In function it is similar to the AN-M110A1. Upon impact, however, the firing pin functions a detonator. The function in so far as the fuze is concerned ends at this point. In the AN-M110A1 a booster of tetryl which is part of the fuze is detonated by the detonator.

BOMB, CHEMICAL, 100-POUND, M47.

General. This bomb was developed to meet the requirements of the Air Forces for a chemical bomb for "bombardment" purposes. It is a thin case bomb whose design and construction is such as to provide maximum efficiency after release from the bomb bay of the plane.

Bomb Description. The body of this bomb is made of 1/32-inch sheet metal rolled and lap welded into a cylindrical shape 8 inches in diameter. The nose is hemispherical and welded to the body as is the box type tail fin assembly which forms the tail taper of the bomb body.

The over-all length is 45 inches excluding fuze, and the weight, after insertion of the burster well, is 20 pounds. The burster well is screwed into the bomb body by means of pipe threads to make a gastight seal at nose. It is held in place at the tail of the bomb body by an attached cone in the inner side of the fin assembly. It is internally threaded to receive a sleeve which has a groove in its lower portion to seat the fuze which is pressed in place. The pipe threads are coated with either white lead-in-oil, red lead-in-oil or varnish shellac before the burster is inserted to make a leaktight joint. The center of gravity is about 18.5 inches from the nose. Around the bomb body are two suspension bands 14 inches apart which provide suspension lugs for horizontal suspension. One blade of the fixed box type tail assembly is in line with the suspension lug.

It utilizes the Bomb Fuze M108 (Nose) in conjunction with the M4 Burster which has a charge of tetryl when used with a WP or

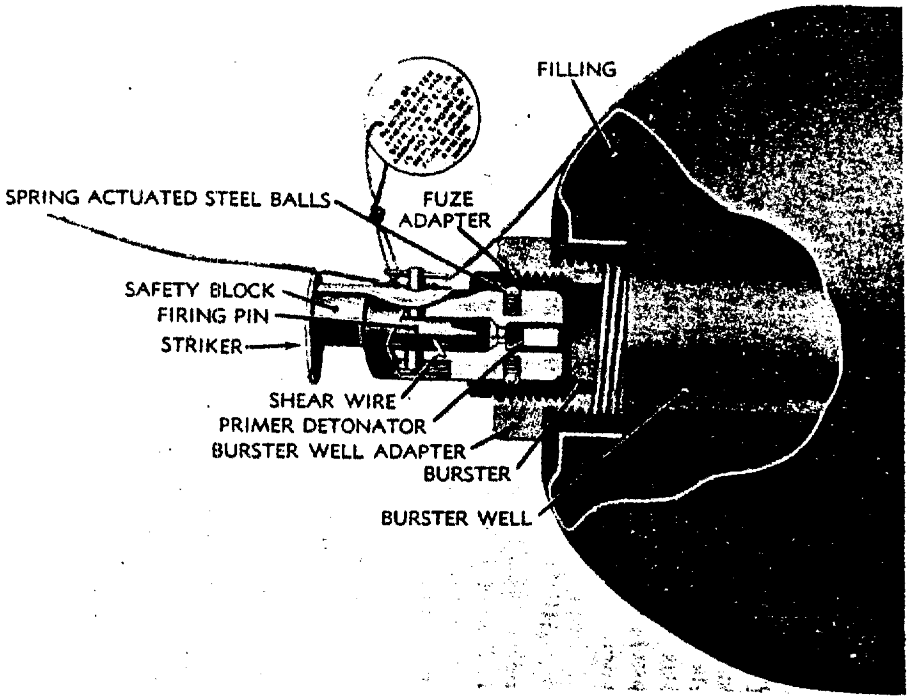


Figure 262 — Assembly of 100-pound Incendiary Bomb M47

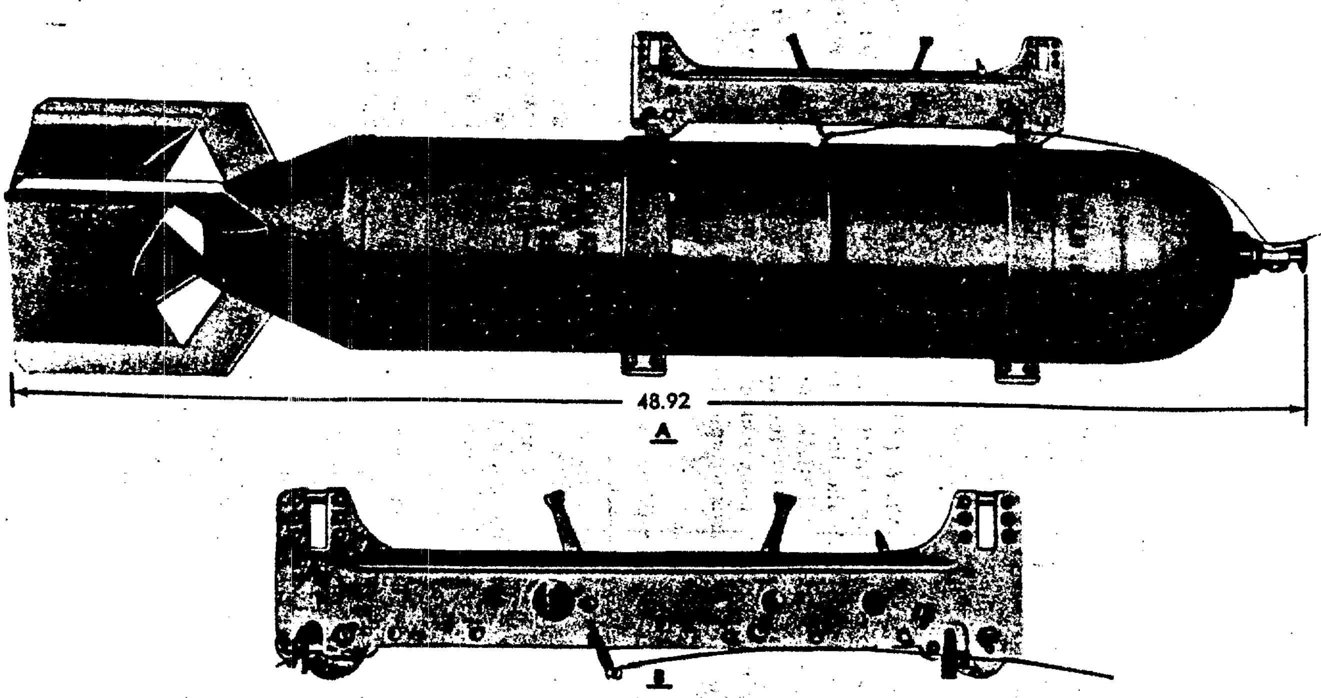


Figure 263 — Bomb Release Mechanism and 100-pound Incendiary Bomb M47 Attached

H filler. The H filler has been found to leak when loaded into this bomb and the M47A1, and is not to be loaded into the M47 or M47A1 Bombs at the present time. When loaded with H, the entire weight of the bomb is 93 pounds of which 73 pounds is H.

The bomb may be loaded with an incendiary filler of rubber and gasoline in the field. The base filling is gasoline supplemented by one of four different incendiary ingredients as follows:

1. LA-60. Consists of crude latex or sap in combination with caustic soda, cocoanut oil, and water.

2. Crepe rubber (CR). This is crude latex but is reduced to a solid by precipitation and kneading.

3. LA-100. This is crude latex dried until it is approximately 100 percent solid.

4. Smoked rubber sheets (SR). This is crude latex which has been dried over a smoky fire until it is approximately 100 percent solid.

When loaded with the incendiary filler the Fuze Bomb M108 (Nose) with a 1-pound black powder Burster Charge M7 is used. This burster charge bursts the bomb and scatters and ignites the filler. When filled, the body weighs 85 pounds of which 65 pounds is incendiary filler. This is a typical example of the scatter type of incendiary filler.

Painting. The bomb is painted as other chemical ammunition with a blue-gray base color. If loaded with H, it will have two green bands and will be stenciled in green. If loaded with WP, it will have one yellow band and will be stenciled in yellow. If loaded with incendiary filler, it will have one purple band and will be stenciled in purple. The stenciling for the incendiary bomb will indicate the type of rubber filling such as "incendiary oil, LA-60" or "incendiary oil SR."

Packing. This bomb is packed in a wooden box, one per box without fuze, arming wire or burster charge. Incendiary oils are loaded in the field into the empty bombs.

BOMB, CHEMICAL, 100-POUND, M47A1.

General. This bomb was designed to replace the 100-pound M47. The 100-pound M47 was found to have too thin a wall section, and in handling and storage, it developed leaks due to corrosion and rough treatment. Consequently, the wall thickness was increased from 1/32 inch to 1/16 inch, and the case was protected by coating inside with acidproof black.

Comparison. In design, it is similar to the 100-pound M47. It is, however, approximately 9 pounds heavier and weighs, when loaded with H, 102 pounds, of which 73 pounds is H. When loaded with

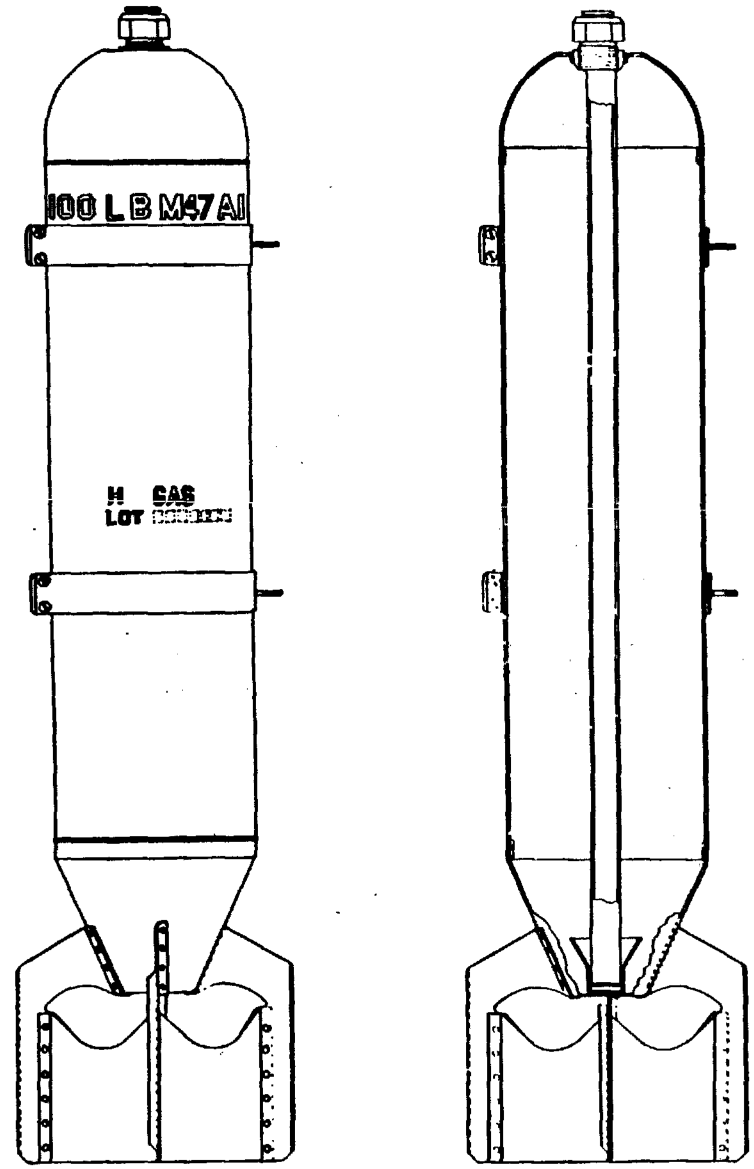


Figure 264 — Bomb, Chemical, 100-pound, M47A1

incendiary oil, it weighs 94 pounds, of which 65 pounds is incendiary oil.

In fillers, fuze, painting and packing, it is exactly the same as the 100-pound M47. It has a special inside coat of paint which provides a resistance of 100-pound pressure. However, H was still found to leak from the bomb case as with the previous bomb and is not to be loaded in empty 100-pound M47A1 Bomb Cases. The only standard fillers are WP or incendiary oils.

An additional fuze which may be found used with this chemical bomb is Fuze Bomb M126 (Nose).

BOMB, CHEMICAL, 100-POUND, M47A2.

General. This bomb was designed to be able to receive the chemical filler mustard (H) without leaking. It was coated on the inside with a special oil which proved in theoretical tests to be resistant to filler pressure having a resistance of 400-pound pressure.

Comparison. It does not differ from the 100-pound M47A1 in any appreciable way. It has the inside wall painted, however, with the special oil to make it resistant to H. It was found, however, that this bomb was also subject to leaking, but not to such an extent as its predecessors. H is still to be loaded into this bomb as a temporary emergency filler. Other fillers are WP and incendiary oils. The fuze is the Nose Bomb Fuze M108 or Fuze Bomb M126 (Nose). When the M126 Fuze is used, the special adapter for the M108 Fuze is removed, as the M126 Fuze can screw directly in the burster well. In all other components, the bomb is exactly the same.

BOMB, CHEMICAL, 115-POUND, M70.

General. This bomb was designed to receive a chemical filler of mustard (H) without any possibility of leaking. It is a thick case bomb as compared to the bombs which preceded it.

Comparison. In shape, construction, and weight, the bomb resembles the 100-pound general purpose bomb. It is somewhat longer, however. It is cylindrical, having a rounded nose and tapered tail. The body is constructed in one piece without any welds. At the base, however, a closed base plug which has a threaded protrusion is welded to the bomb body. The threaded protrusion receives a fin lock nut which seats the fin assembly snugly on the bomb. The nose of the bomb is unthreaded but receives a long burster which is press-fit into the nose to form a gastight seal.

Welded to the bomb body are three lugs. Two lugs 14 inches apart are provided for horizontal suspension, and a third lug on the opposite side at the center of gravity is provided for single suspension.

The burster casing receives a Burster Charge M10 and is threaded to receive Fuze Bomb M126 (Nose). The filler is at the present time H only.

FURTHER REFERENCES: A complete list of references may be found at the close of this section.

Chapter 7

Incendiary Bombs

GENERAL.

Definition. Incendiaries are combustible materials which are burned with intent to cause destruction of buildings, crops, food, ammunition, or materials of military importance.

Incendiaries dependent on their construction and manner of use are classified as intensive or scatter. The intensive type remains as a unit until consumed, thus confining its heat to a restricted area. The scatter type dispenses small fragments of its burning material usually by an explosive charge, thus starting simultaneously as many fires in as many different places as possible. Examples of the scatter type are the 100-pound gasoline rubber filled bomb and the 6-pound oil incendiary filled bomb. Some of the chemical bombs discussed in the preceding chapter are called a scatter type incendiary if the filler is of an incendiary nature. The M47 series of chemical bombs are an example.

Theory. For every incendiary bomb dropped, a fire is not started. The practice is to scatter the bombs over the heart of an entire city. The average city has 85 percent of its area devoted to parks, roads, valleys, back yards, and front yards, leaving 15 percent of the average city composed of some incendiary composition.

If a bomber carrying 2,000 of the small 2-pound incendiaries were to travel at a speed of 200 miles per hour dropping 20 bombs per second, the plane would travel 6 miles before it expended its cargo of incendiaries. Of 2,000 dropped, only 300 bombs will strike possible targets. One half of these will harmlessly ricochet off roofs or fail to find combustible roofs.

Thus it is obvious that for every 2,000 bombs dropped over the modern city, only 150 bombs will ignite targets; thus, only 7½ percent of those dropped will be effective.

Chemical Bomb, FUZE, Transverse, M1.

General. This fuze is used in the 6-pound Oil Incendiary AN-M69 and in the 10-pound WP incendiary AN-M67. It is threaded at one end so as to seat itself in threads located in the side of the bomb body near its nose portion.

Description. This fuze contains a safety plunger which is positioned on a spring so as to be partially ejected from the fuze housing when it is free or in the armed position. The ends of the safety plunger protrude from the fuze housing at the point where the threads are located. Passing through the fuze housing is a striker in the form of an E. The upper portion of the E-shaped striker is held in place by the end of the safety plunger in the unarmed position. The middle portion of the E-shaped striker is in the form of a firing pin and is directly over a primer. The lower portion of the E-shaped striker is resting against a spring which prevents the striker from moving down on the primer in the armed position before impact occurs.

Underneath the primer is a black powder spitter fuze which leads to a black powder booster charge located at the end of the fuze opposite the threads. The fuze should be inserted in the side of the bomb with the arrows which are located on the external surface of the fuze body pointing to the rear.

Function. The cluster is dropped and the arming wire is retained in the plane. The cluster opens and the bombs fall free. The safety plunger which had been imprisoned by intimate contact with the bomb next to it, is now free and is partially ejected by its spring from the fuze housing. The striker is now free but is restrained from striking the primer by a restraining spring.

On impact, the force of inertia causes the striker to move against its spring bringing the firing pin into the primer. The flame from the primer ignites a black powder spitter fuze which in turn sets off a black powder booster charge. The booster charge functions a charge of black powder and magnesium mixture which ruptures the bomb case, spreads the filler, and ignites it.

BOMB, INCENDIARY, OIL, 6-POUND, AN-M56.

General. This bomb is a relatively new bomb designed to be dropped from clusters to produce an incendiary effect. It is of the scatter type and is filled with an incendiary oil, the composition of which at the present time is unknown.

Bomb Description. The incendiary bomb is contained within a hexagonal light steel case 19.5 inches long and 2.9 inches wide. This outer case is divided into three compartments. The tail compartment contains 9.5 feet of 3-inch gauze which occupies 1.5 inches. In the main body of the bomb is loaded the oil emulsion filler. The **FUZE**, bomb, M1, occupies about 1.5 inches in the nose end and is separated from the filler by an impact diaphragm. The fuze should be inserted

in the side of the bomb with the arrows pointing to the rear. The bomb is designed to be packed in clusters.

Function. Upon release from the plane, the cluster breaks apart and the safety plunger of each bomb which was imprisoned by intimate contact with the bomb next to it, is free to move partially out under spring action. This arms the fuze. At the same time, the gauze streamer is forced out by air pressure and serves to stabilize the bomb in flight.

Upon impact, the striker moves down against its spring and strikes the primer. The flame ignites the spitter fuse which functions a black powder and magnesium mixture. The combined action of these charges ruptures the impact diaphragm and ignites the oil filler. The mixture is spread over an area of 100 yards. The oil emulsion which is known as IM or NP burns at a temperature of 700 C.

BOMB, INCENDIARY, WP, 10-POUND, AN-M67.

This bomb is identical to the AN-M69 described above in description and operation, but the filler is white phosphorus rather than incendiary oil.

BOMB, INCENDIARY, 4-POUND, AN-M50A1.

General. This magnesium type of incendiary bomb is patterned after the original German "Elektron" bomb but incorporates several distinct improvements including a blunt steel nose and a bigger stabilizing fin assembly. It is of the intensive type.

Description. This bomb measures 21.69 inches in length and 1.69 inches in width at the hexagonal cross section, with the center of gravity located 6.5 inches from the tip of the nose. The bomb consists essentially of a hexagonal blunt steel nose, a cored magnesium alloy body containing a first fire charge, and a thermate igniting composition, a striker unit with a safety plunger, and a hollow, hexagonal sheet steel tail approximately 8 inches long. The total weight of the AN-M50A1 Bomb is approximately 4 pounds, apportioned approximately as follows:

Magnesium alloy	1 lb 4 oz
Steel nose	1 lb 8 oz
Thermate igniting mixture	10 oz

The firing mechanism and tail assembly make up the balance of the weight.

Description. The striker is held away from a primer by the safety plunger which is actuated by a spring tending to eject the plunger partially out of the bomb body. It is prevented from doing so by being imprisoned in intimate contact with the bomb adjacent to it. In the armed position, the striker is held off the primer by a thin brass cross which rests on a firing pin holder.

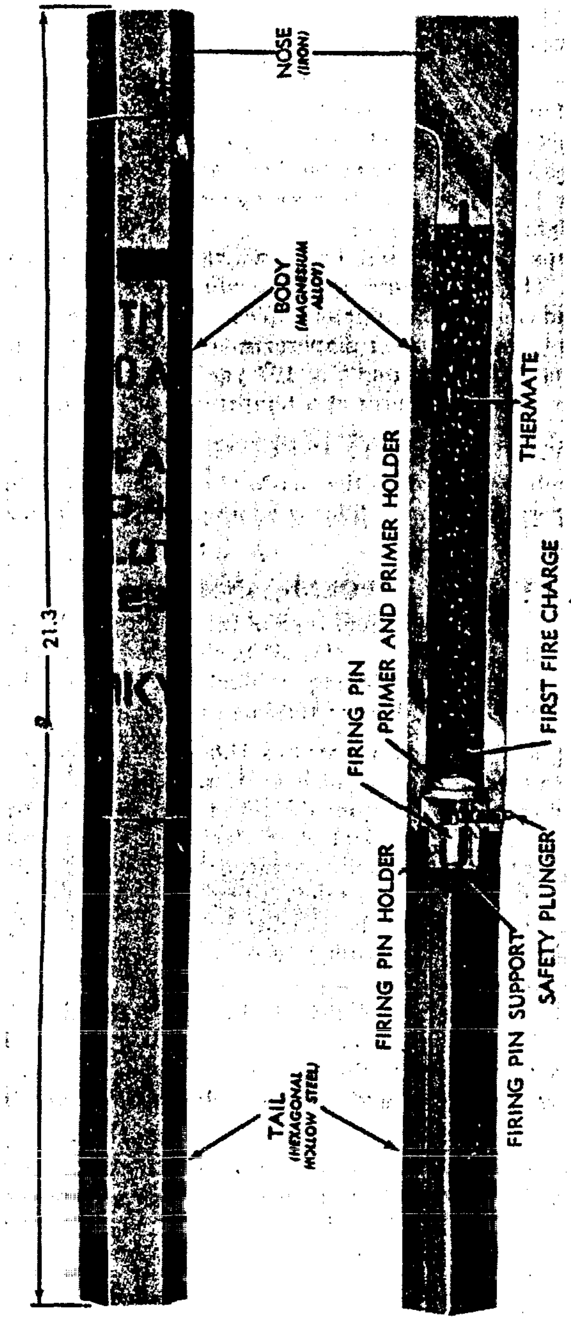


Figure 265 — BOMB, Incendiary, 4-pound, AN-M50A1

The design of the bomb is such as to set in motion the first of its functions immediately upon impact when released from a height of 50 feet or more above a target. Greater heights of release are always used, however, so that a maximum velocity consistent with a predetermined accuracy may be obtained, thus assuring to the bomb a maximum penetration upon impact.

Function. The cluster is dropped and the arming wire is retained in the plane. The cluster opens and the bombs fall free. The safety pin or plunger is now free and is partially ejected by its spring from the body of the bomb. The striker is now held in position by only the brass T-cross. The bomb is now armed. The hollow tail assembly and the heavy steel nose plug assure a vertical flight of the bomb in the air.

Upon impact, the force of inertia exerted upon the striker is sufficient to send it downward through the firing pin holder, pulling after it the thin brass cross. The consequent impact of the firing pin on the primer ignites the first fire charge. The fire charge ignites the thermate mixture and this ignites the magnesium alloy body. For a period of about 10 minutes, the body burns at an intense heat of 2,300 F to 2,500 F.

Painting and Stenciling. The bomb is painted a blue-gray base color with one purple band and purple stencil to indicate a nonpersistent incendiary. The lettering is in panel form surmounted by the band on the body of the bomb and gives the following information in two size letters as follows:

Purple band	——
Thermate	TH
Model number	AN-M50A1
Loader's initials or symbol	EA
Date of filling	10-41
Loader's lot number	Lot 123

Packing. These bombs are packed 34 to a cluster in a metal-lined wooden box. Larger cluster may be found having 62 and 128 bombs to the cluster.

BOMB, INCENDIARY, 4-POUND, AN-M50XA1.

This bomb is approximately equal in weight and is identical in measurement to the AN-M50A1 described above, and differs only in composition in that it contains a burster charge of 170 grains of black powder. The black powder burster charge is contained in a metal case near the nose of the bomb. The presence of the burster charge decreases the weight of the thermate igniting mixture by a slight amount.

The burster charge is incorporated to make hazardous an immediate approach to a burning bomb, thus discouraging attempts at extinguishing all 4-pound incendiaries. In this way, it increases the life span and burning efficiency of the standard Nonexplosive Incendiary AN-M50A1. The burster charged bomb may be said to "run interference" for the nonexplosive bomb. It explodes about 1½ minutes after the bomb is functioned. Approximately 20 percent of 4-pound magnesium alloy bombs in a cluster are of the AN-M50XA1 type.

BOMB, INCENDIARY, 2-POUND, AN-M52.

This bomb is similar to the AN-M50A1. It is shorter, 14.25 inches long, although it is the same width. It has no steel nose, nor does it have a long hollow tail assembly, although it has a short sheet metal tail approximately 5 inches long. In all other respects, except for the weight of the components, it is the same as the AN-M50A1. It is of the intensive type. The firing mechanism, the first fire charge, the thermate igniting composition, and the hexagonal magnesium case is the same. It is designed to be loaded so that 51 bombs may fit into 100-pound adapter clusters, 93 bombs into 250-pound adapter clusters and 192 bombs into 500-pound clusters. Upon function, the bomb burns at an approximate temperature of 2,400 F for a period of approximately 6 minutes.

BOMB, INCENDIARY, 4-POUND, AN-M54.

General. This bomb is similar to the 4-pound AN-M50A1 but it is designed to be used against much more resistant targets such as inflammables encased in metal as oil tanks. It burns at a much higher temperature and for a much shorter period of time. It is of the intensive type.

Description. Although within a fraction of an ounce of the same weight and of almost identical appearance, the AN-M54 differs considerably from the AN-M50A1 in its construction. The major difference is in its body, which is of tubular steel, and in the amount of thermate igniting mixtures. This allows for a much higher burning temperature although a much shorter time of burning.

There are also other differences in the weight and shape of the steel nose, in the design and operation of the firing mechanism, and in the weight and design of the tail. The striker, instead of being checked by a thin brass cross, is restrained by a 1¼-inch thin, wire spring attached to its nose. The spring has a pressure resistance equal to 25 ounces in weight.

The lengths of the two bombs are almost identical, and the diameter of the hexagonal noses and tails is almost the same. The center of gravity of this steel body bomb, however, is 6 inches from the tip of the nose, or ½ inch nearer the nose than in the magnesium type. Similar to the 4-pound magnesium bomb, the weight of this incendi-

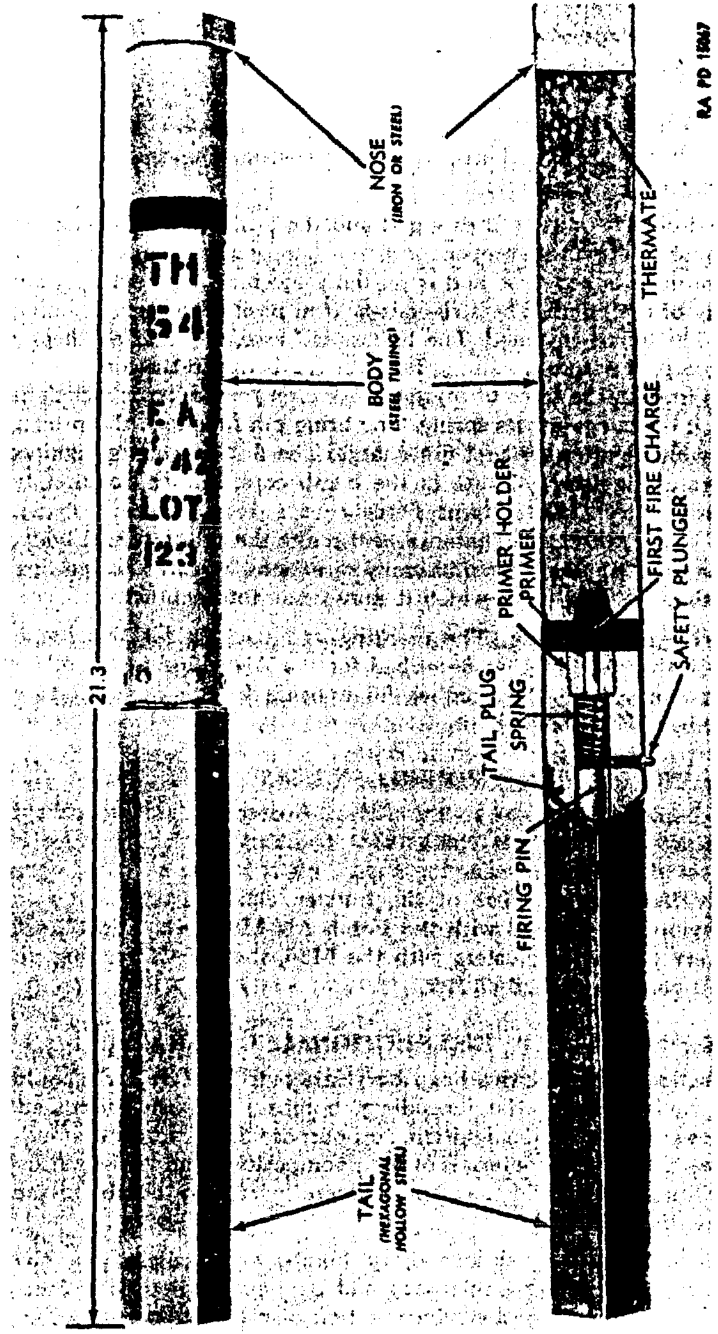


Figure 266 — BOMB, Incendiary, 4-pound, AN-M54

ary is approximately 4 pounds apportioned approximately as follows:

Steel body	1 lb 6 oz
Steel nose	10 oz
Thermate igniting mixture	1 lb 10 oz

The balance of the weight is distributed in the tail assembly and firing mechanism.

Function. The cluster is dropped and the arming wire is retained in the plane. The cluster opens and the bombs fall free. The safety pin or plunger is now free and is partially ejected by its spring from the body of the bomb. The striker is held in position by a restraining spring. The bomb is armed. The hollow tail assembly and the heavy steel nose plug assure a vertical flight of the bomb in the air.

Upon impact, the force of inertia exerted on the striker is sufficient to send it down against its spring. The firing pin functions the primer charge which ignites the first fire charge. The first fire charge ignites the thermate igniting mixture in the bomb core. For approximately 1 minute, the thermate burns fiercely at a temperature between 4,300 F and 4,400 F. This intense heat melts the tubular steel body, releasing molten metal to run in many directions, searing and igniting combustible material with which it may come into contact.

Marking and Packing. The marking and packing for this bomb is exactly the same as that described for the AN-M50A1, except for the fact that where the number 50 appears in the nomenclature the number 54 will replace it.

BOMB, INCENDIARY, 4-POUND, AN-M54X.

This bomb is identical to the AN-M54 described above except for the fact that a burster charge of 170 grains of black powder is incorporated in the core near the nose. This is similar to that in the AN-M50XA1. The purpose of the burster charge is the same as that previously described with the Bomb AN-M50XA1. The M54X Bombs are packed in clusters with the M54, the M54X making up about 20 percent of each cluster.

BOMBS, INCENDIARY, INSTRUCTIONAL, GENERAL.

Instructional incendiaries have no relation to aircraft and should not be confused with the incendiary bombs previously discussed. Their design, construction, ignition, and purpose differ from the standard types. Only in the materials of their composition and in the nature of their final function do they approximate incendiary bombs in the true sense of that term.

Purpose. Instructional incendiary bombs are designed for the purpose of demonstrating to troops and qualified civilians the functional time element and incendiary action of certain types of incen-

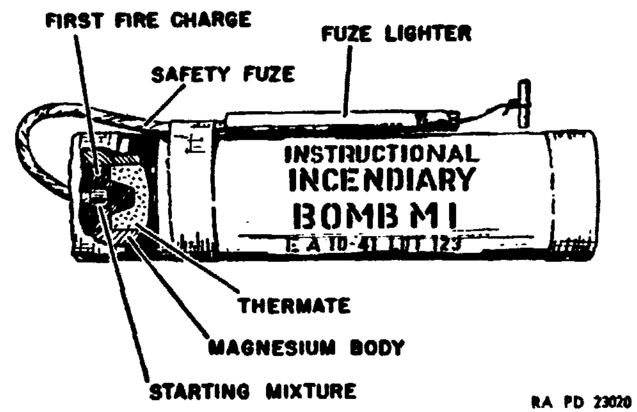


Figure 267 — Instructional Incendiary Bomb M1

diaries. When burning, they and the materials ignited by them provide opportunities for instruction in methods of control of burning magnesium and thermate bombs and the extinction of fires initiated by them.

Use. Since they are employed for training and educational purposes, instructional incendiary bombs are used at military and naval training centers and before civilian protective groups and agencies. Rather than being released from aircraft, dropped from stationary heights, propelled by mechanisms or discharged from weapons, they are hand-ignited and positioned by hand upon or near the material to be set afire. Their control is thus completely vested at all times in the hands of the instructor or demonstrator. For this reason, they may not properly be termed "practice" bombs as such classification is sometimes accorded to various other types of aircraft instructional bombs.

BOMB, INCENDIARY, INSTRUCTIONAL, M1.

General. This bomb simulates the magnesium type of incendiary bomb and is designed to give instructional methods in the handling of bombs whose basic composition is the magnesium body.

Description. This bomb, 2 inches in diameter and 9 inches in length, is cylindrical in appearance and is constructed of an extruded length of magnesium alloy tubing. One end is closed by a tin cap held in place by an 8-inch length of waterproof adhesive tape ¾ inch wide. The 1-inch diameter core is packed with the thermate igniting mixture to within ⅝ inch of its fuzing head. This remaining space is filled with the first fire charge to within ¼ inch of the end of the bomb, at which point a metal closing disc is inserted and secured by a second 8-inch strip of waterproof adhesive tape. All fillings are subjected to a pressure of 5,500 pounds per square inch.

Three holes perforate the closing disc, one in the center, and two ⅜ inch off the center. An 8-inch length of safety fuse, one end of which has been treated with a mixture of collodion and black powder and rests within a depression of the first fire charge, passes through the center hole, carries up and back and is taped to the bomb. After the installation of the fuse, the rim of the center hole is sealed with cement and coated with quick drying shellac. The off-center holes of ¼-inch diameter, serving as gas vents are covered with ¾-inch squares of waterproof adhesive tape and coated with varnish shellac. A pull wire fuse lighter is taped to the bomb but not assembled to the fuse.

Ignition. *After ¼ inch has been cut cleanly from its end, the fuse* is inserted in the fuse lighter with moderate pressure. The bomb is then held firmly in one hand with the thumb pressing the fuse lighter flat against the bomb body. With the other hand, the handle of the fuse lighter is pulled sharply away from the fuse which will burn for 30 seconds before igniting the first fire charge. The bomb will then burn for 5 minutes.

Safety Precautions. The following safety precautions should be observed when igniting instructional incendiary bombs:

Protect the hand holding the bomb with a heat-resisting glove or pad.

Point the fuze end of the bomb away from the face and body when pulling the fuze lighter.

Place the bomb in its predetermined incendiary position immediately after pulling the fuze lighter.

Stand at least 10 feet from the bomb after it has been placed in its incendiary position.

Remain in such position for at least 30 seconds after the bomb has ignited.

Marking and Packing. The instructional incendiary is marked with one band and lettering in purple lacquer enamel to indicate its type, the initial or symbol and lot number of the loader, and the date of filling.

Bombs are packed in cartons designed to contain four bombs each, and thence packed in wooden boxes designed to contain from six to eight such cartons. Packing cartons and shipping boxes are both marked in the same manner as the bomb body.

BOMB, INCENDIARY, INSTRUCTIONAL, M2.

General. This bomb simulates the thermate type of incendiary and is designed to give instructional methods in the handling

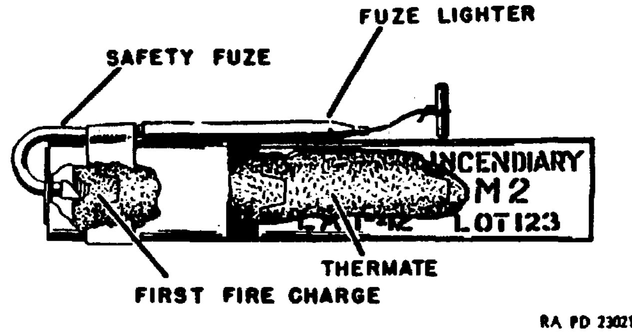


Figure 268 — Instructional Incendiary Bomb M2

of bombs whose basic composition is the thermate igniting mixture and steel body.

Description. Only in structional substances and in minor details does this thermate bomb differ especially from the foregoing magnesium type. It is 9 inches in length, but its body has a diameter of only 1½ inches and is constituted of steel tubing 0.04 inch thick. One end is closed by a tin plate, friction fitted and soldered, the other by a similarly soldered plate containing a center fuze hole and three vent holes equally spaced around the center. The body filling consists of thermate capped by a first fire charge. A 6-inch powder time-train fuse tipped with a collodion and black powder mixture is assembled in the same manner as in the M1 Bomb. The vent holes are taped; both they and the run of the fuze holes are treated with commercial liquid solder to insure waterproofing. A pull wire fuse lighter is taped to the bomb but not assembled to the fuse.

Ignition. This bomb is ignited in the same manner as the M1 previously described. The burning time for this bomb is 75 seconds, however.

Safety Precautions, Marking and Packing. The safety precautions, marking and packing described for the M1 Instructional Incendiary Bomb apply in the same manner to the M2 Instructional Incendiary Bomb.

CLUSTER ADAPTER T2.

General. All intensive incendiary bombs (except instructional) are designed to be released from clusters. The use of adapter clusters permits the bombs to be dropped effectively over a given area and also permits the use of the same bomb racks for demolition bombs. The Cluster Adapter T2 is described as a 100-pound adapter and is designed to be suspended in bomb racks which receive 100-pound

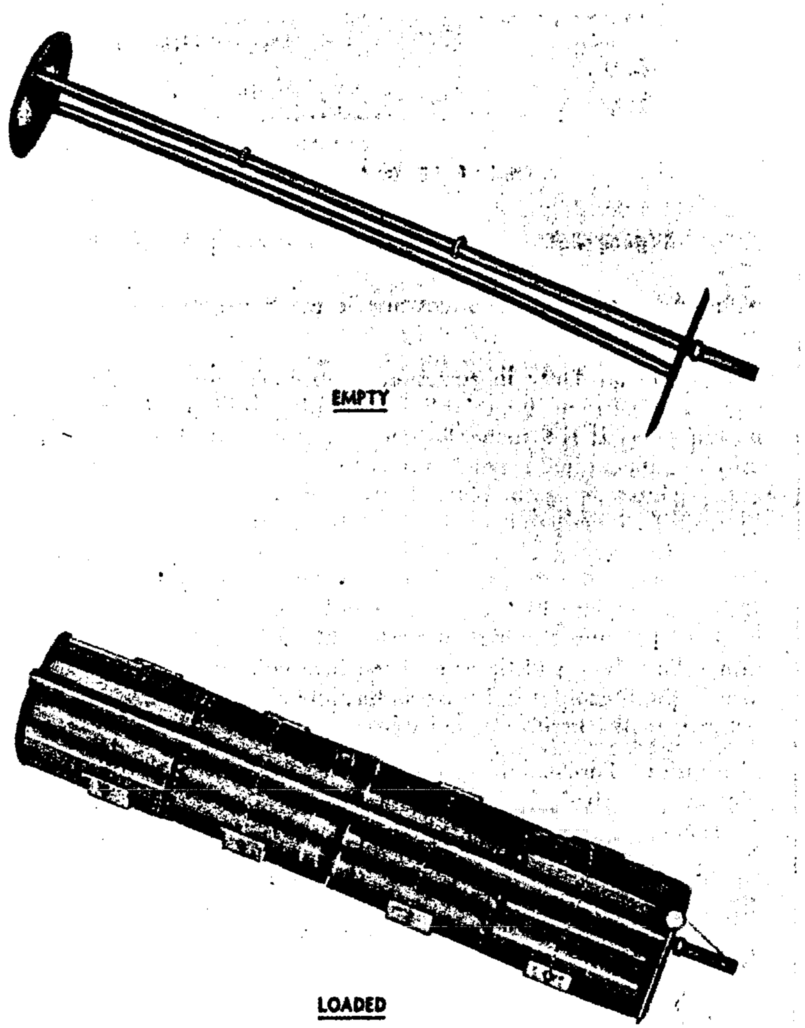


Figure 269 — Cluster Adapter T2 (Cartridge Type)

demolition bombs. It resembles the M1 Adapter Cluster used for fragmentation bombs.

Description. This adapter is composed of two thin steel end plates attached at right angles to two steel rods. The end plates are approximately 9 inches in diameter resembling a rounded shield or fat letter "U" closed at the top. One of the rods is 7/16-inch in diameter and is solid (separator), while the other is hollow with a ¾-inch outside diameter (barrel). The hollow rod, open at one end, is attached to the top centers of the end plates; the solid rod is attached to the bottom. A series of four small transverse holes in the hollow rod are at equal distances between the ends. At about one third the distance from each end is welded a steel suspension lug.

Long wires pass through the four series of holes in the hollow rod or barrel. These encircle a total of 34 bombs separated into two equal lots, and each bomb is positioned so that its safety pin or plunger is imprisoned against the adjacent bomb. A cluster adapter metal support plate of three angled sides, each side of which is the equivalent width of one of the hexagonal sides of the bomb nose and tail, is on each side of the cluster in such manner, that the adapter plate grips the sides of three bombs. There are four such plates for a full adapter load each plate being notched at its top and bottom. The wire through the barrel passes through the notches of the cluster plates and the ends are twisted together under the solid rod, thus insuring two fast, compact, and immobile clusters of 17 bombs each within the adapter.

Assembly. A special ball type cartridge similar to that used in fragmentation bomb clusters described previously is inserted into the open end of the hollow rod and the assembled firing mechanism is screwed on the barrel. The completed and loaded cluster adapter is then attached to the bomb shackle by means of the two suspension lugs welded around and to the hollow rod, and the arming wire is substituted for the safety pin in the firing mechanism. The plane is now serviced for incendiary flight.

Function. The cluster is dropped and the arming wire is retained in the plane. The compressed spring forces the firing pin into the primer of the cartridge. The propelling charge is ignited and propels the bullet through the barrel, cutting the four wires holding the two clusters to the adapter. The bombs tumble out. The bullet spends itself against the plug in the sealed end of the hollow rod. In a few seconds, the bombs right themselves and speed earthward nose first, the slip stream of the airplane and the backwash of the propeller having dispersed them. The cluster must open before the bomb can be armed, and the bombs must be dispersed for proper incendiary effect. In all operations, the adapter falls as a unit to the earth, empty or filled, as the case may be.

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Should it be necessary or desirable to rid the plane of its loaded cluster adapter unarmed, the arming wire is dropped with the incendiary cluster. This allows the cluster adapter with all of its bombs to fall as an intact unit.

Cluster Adapter Markings. It should be noted that the 4-pound incendiary bombs are not only manufactured as complete units in munitions plants, but are grouped in clusters as well, each cluster being "spotted" with its approximate 20 percent ratio of explosive or "X" bombs, and the finished cluster being properly loaded into the cluster adapter and secured as described.

The complete cluster is then packed in its metal-lined shipping box together with the arming wire. For this reason, it is necessary that proper information be shown upon each cluster adapter. Depending on the type of bomb, the following facts are stenciled in black upon the outside of one of the adapter end plates:

CLUSTER ADAPTER 100 LB. T2
FOR
34 INCENDIARY BOMBS
4 LB. AN-M50A1

CLUSTER ADAPTER AN-M3.

General. This cluster is designed to replace the Cluster Adapter T2. It is of the mechanical releasing type similar to the AN-M1A1 Adapter Cluster for fragmentation bombs.

Description. This cluster adapter is fundamentally similar to Cluster Adapter T2 described above, but is of noticeably different design and appearance. In place of the two parallel rods in the T2 Adapter, two parallel channelized bars of approximately $\frac{1}{16}$-inch sheet steel and 47.87 inches in length have been substituted. In addition, four $\frac{3}{4}$-inch thin sheet steel bands are substituted for the four cluster circumscribing wires, and three manipulative suspension lugs are set in a special affixed plate atop the upper bar to supersede the two welded lugs of the T2 Adapter in the same manner as the AN-M1A1 Cluster for fragmentation bombs.

The cartridge, and the four side support angle plates are not present. Four steel bands circumscribe the clusters, with band ends meeting above the top bar of the adapter, thus holding the bombs within the adapter frame. Each such function of ends is made fast by a common adapter length locking pin, which is assembled to the cluster adapter at the point of bomb manufacture. In the case of this cluster adapter, a 4-pronged arming wire is likewise assembled to the adapter at the point of bomb manufacture. The full adapter is attached to the bomb shackle by means of its suspension lugs. The last operation is the withdrawal of the common locking pin.

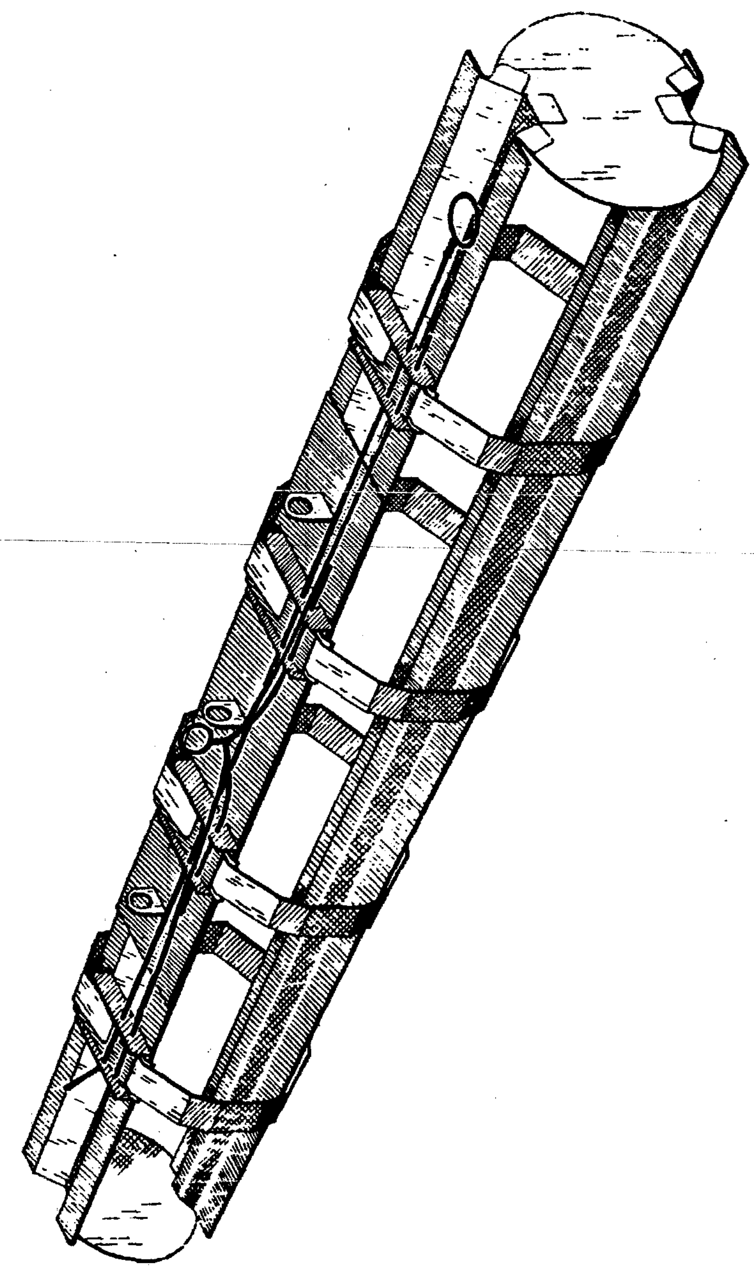

Figure 270 — ADAPTER, Cluster, 100-pound (Incendiary Bombs), M3

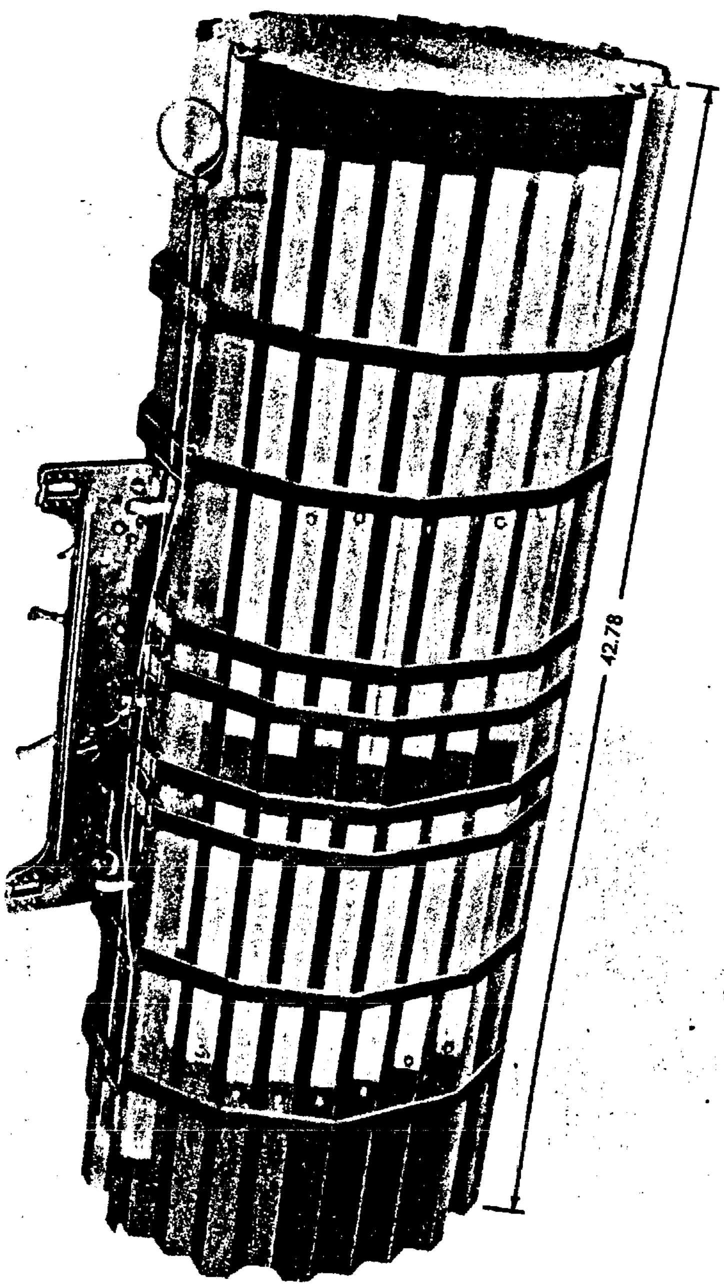

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Figure 271 — ADAPTER, Cluster, 100-pound (Incendiary Bombs), AN-M3

Function. The cluster is dropped and the arming wire is retained in the plane. The four prongs of arming wire release the steel bands which spring open and release the bombs. In a few seconds, the bombs right themselves and speed earthward, nose first, the slip stream of the plane and the backwash of the propeller having dispersed them. The bombs are now said to be armed. In this cluster adapter, the rods and end plates likewise fall apart and drop earthward.

Cluster Adapter Markings. In addition to the information described as stenciled upon one of the end plates of Cluster Adapter T2, the opposite end plate of Cluster Adapter AN-M3 will also bear the word "FRONT" for instruction in loading.

EXTINCTION OF AND CARE IN HANDLING INCENDIARY BOMBS.

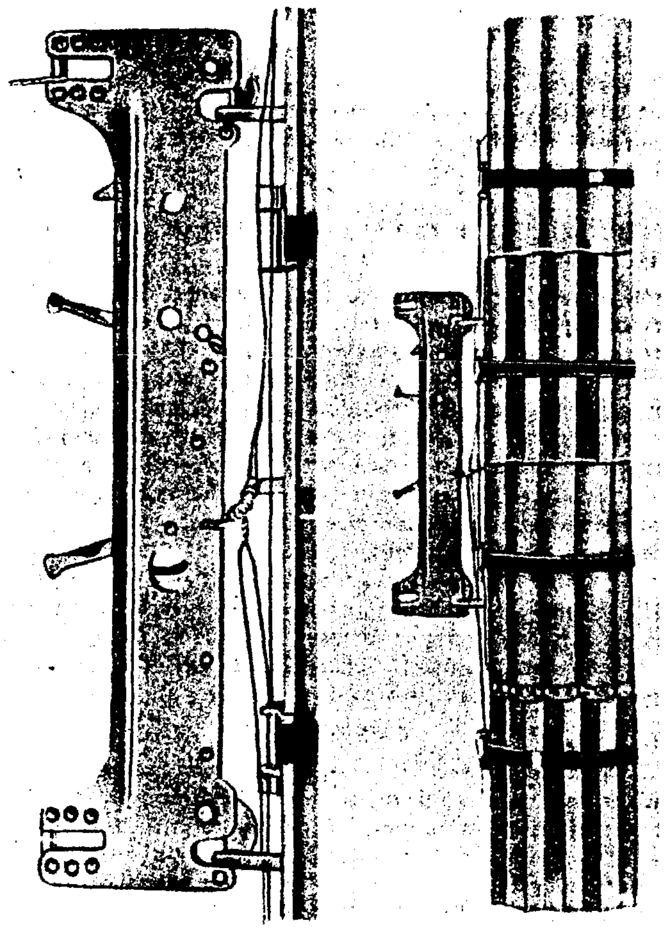
General. Incendiary bombs should be handled carefully. However, should one of the incendiaries described function when undesired, care, knowledge, and preparation is required to extinguish the bomb. It should be noted that the subsequent discussion applies only to the incendiaries discussed. Procedures to extinguish foreign incendiaries have recently changed to combat the new types found. These newer procedures are in sharp contrast to the procedure to be treated herein which is effective only for the incendiaries described previously.

In dealing with these incendiaries, efforts are aimed at control rather than extinguishment. Methods of control are described below, but in all instances one fundamental rule of conduct should be observed: Do not approach the bomb after its ignition until the expiration of 2 minutes. Both the spattering effect of the thermate igniting mixture and the burster charge explosion of the explosive bomb types are dangerous to personnel.

Control of AN-M50A1, AN-M50XA1, and AN-M52.

Water. In the use of water for control, care must be taken that no large amount such as a solid stream or a bucketful comes quickly into contact with the burning bomb. Should such occur, the resulting explosion will scatter burning fragments of magnesium over a considerable area. A fine water spray applied to the bomb will accelerate its burning rate and thus decrease the burning time.

Solids. Almost any powdered solid that is not of itself combustible is, to varying degrees, effective in controlling a burning magnesium bomb. Such substances, when thrown upon the bomb, decreases the amount of oxygen, thus causing the bomb to burn less violently. It may then be approached more closely and, if possible, moved to a less vulnerable place. This removal should be effected by means of a long-handled shovel, or some similar implement, and the bomb



RA PD 23023

Figure 272 — Bomb Release Assembly and Loaded Cluster Adapter M3, Attached

should be deposited in some receptacle, the bottom of which is lined with some noncombustible solid, preferably of a powdery nature. This fire resistant false bottom is more important, for without it the bomb might quickly burn through the vessel. Suggested solids include sand, commercial fire resistant powders, talc, ashes, and earth.

Chemicals. Chemical fire extinguishers are no more effective than water, and should be used with caution because of possible harmful physiological effects resulting from the reaction of burning magnesium and ingredients of certain extinguishers. Carbon tetrachloride, the filling of one type of extinguisher, gives off a vapor with anaesthetic properties similar to chloroform and is, therefore, dangerous in confined spaces. Accompanying this vapor may also be the toxic gas phosgene. Carbon dioxide, in contact with burning magnesium is broken down into carbon and deadly monoxide gas.

Control of AN-M54 and AN-M54X. These thermate and steel bombs burn at temperatures between 4,300 F and 4,400 F and cannot be smothered by water, sand, or other materials. This is true because the thermate mixture contains its own adequate supply of oxygen. The bomb simply must burn itself out, which it will do in not more than 2 minutes. Personnel should take pains to dispose of the molten iron produced during the thermate reaction.

Treatment of Burns From Incendiary Bombs. Particles of burning metal in contact with the skin should be removed at once. Should injury result from imbedded particles of magnesium bomb, relief may be obtained by application of petroleum jelly or some equivalent substance. But in no case should water be applied, as this will stimulate the burning rate of magnesium. For injury due to the thermate and steel bombs, flooding the affected surface with water will cool the molten iron and afford relief. Further treatment, once the metal has ceased burning, will be the same as that for any burn of like degree. Injury to eyes will require immediate medical or hospital treatment.

Care and Preservation. Extreme care should be exercised to insure that these bombs are stored in a dry place well removed from heat and fire. Rough handling is prohibited. If the airtight seal of the shipping containers is broken, the first fire charge of the bomb will absorb moisture which will radically interfere with ignition of the bomb. This is especially true of moisture-laden bombs loaded into a plane and carried aloft. The extreme low temperature of high altitude causes the first fire charge to freeze, thereby rendering the bombs completely useless for incendiary purposes.

FURTHER REFERENCES: A complete list of references dealing with bombs can be found at the close of this section.

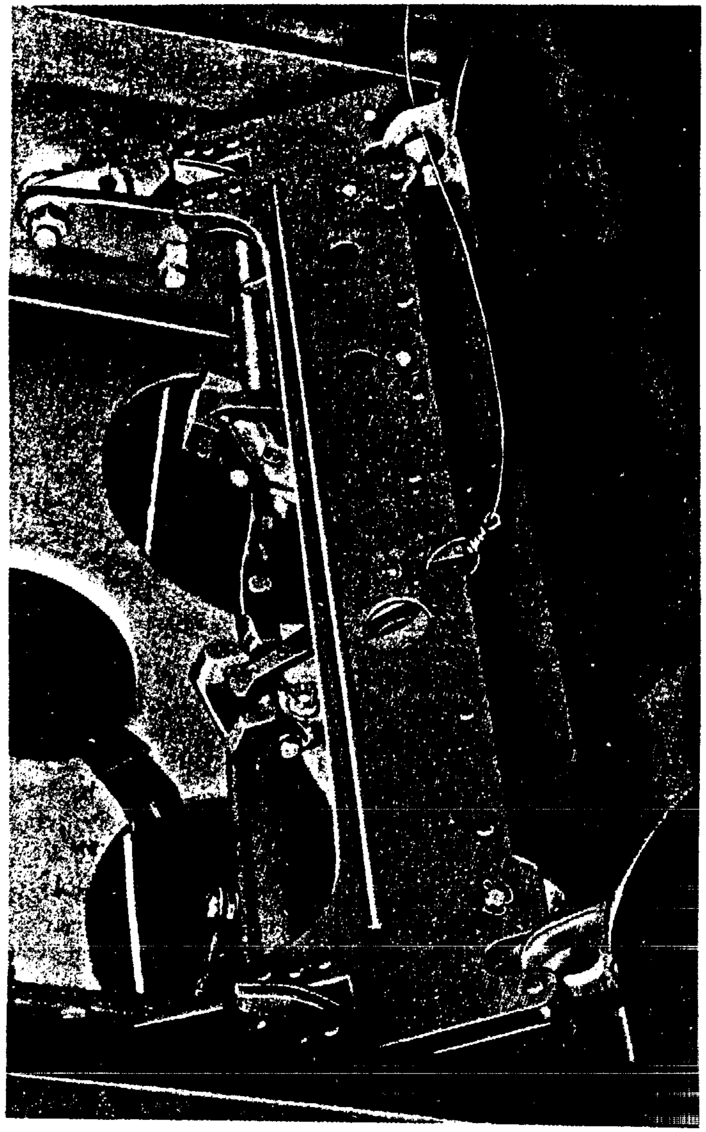


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Figure 273 — Loaded ADAPTER, Cluster, M3, Suspended in Airplane

Chapter 8

Practice and Drill Bombs

GENERAL.

Practice Bombs. Practice bombs are used during both peacetime and wartime. Their chief function is to enable Air Corps bombardiers to practice their marksmanship with bombs which resemble real bombs closely enough to assure that a hit with a practice bomb would be a hit with a real bomb. A secondary function is to give ordnance personnel practice in assembling, fuzing, and handling bombs.

Development. Practice bombs in contrast to other practice ammunition are not made by using the same case as the H.E. round and filling it with a spotting charge. Obviously it would be too expensive to drop large GP bombs, sand filled with a spotting charge and fuze added for practice. Therefore, the search for a cheap bomb was initiated.

The first real practice bomb used by the Army was water filled. This bomb had no spotting charge but depended entirely upon the resultant splash to inform the bombardier of his accuracy. This type was unsatisfactory for the following reasons:

The water froze at high altitudes.

The water moved and caused the bomb to waver in flight.

The splash could not be seen from high altitudes.

Another bomb was developed using sand and water as the filler. This gave the bomb added weight and prevented the water from swishing around during flight. To increase its visibility at the point of impact, a spotting charge was added in the tail end of the bomb. This was in the form of a smoke compound confined in a glass bottle. This compound on exposure to air immediately formed a cloud of smoke. However, it was found unsatisfactory because of the following:

The glass bottle burst at high altitudes.

The cap loosened under high pressure or temperatures.

The contents froze and broke the bottle at high altitudes.

In any of these cases, the plane became filled with smoke.

At this point, it was decided to use the empty bomb bodies of the Mark series from the first World War as practice bombs and at the same time to continue the search for a satisfactory cheap bomb. The Mark series used, consisted of bombs 17, 25, 40, 50, 100, and 300 pounds in weight. Sand, a spotting charge, a fuze (either nose or tail) and a primer detonator wherever necessary were added to the bomb body to make for a practice bomb.

Finally the 100-pound M38, later modified in several respects so as to become the M38A2, was developed as the standard practice bomb for demolition bombing. In the subsequent pages, the bombs

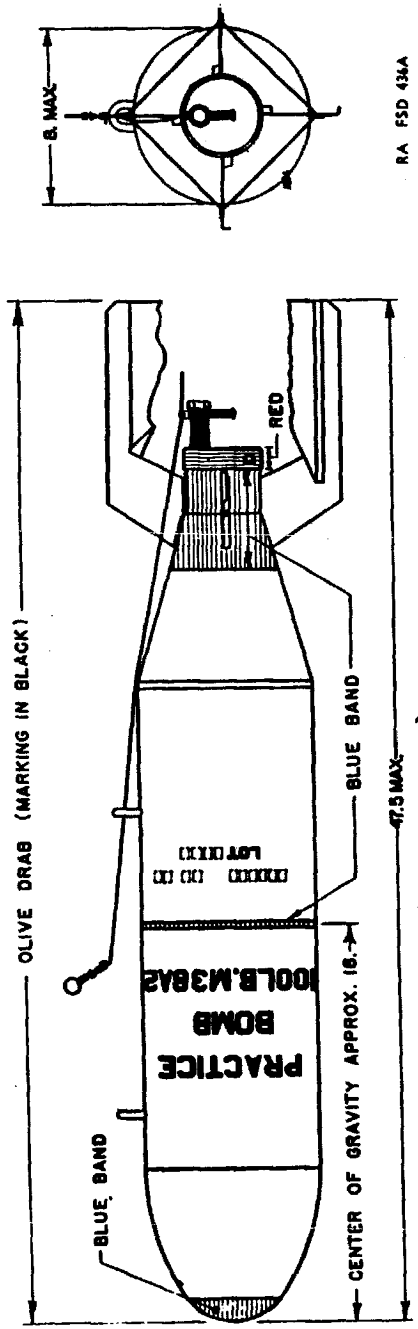

Figure 274 — BOMB, Practice, 100-pound, M38A2

discussed are those which are in use at the present time and were developed for practice in the use of specific types of service bombs.

Drill Bombs and Gage Bombs. Drill bombs are provided for training and practice in assembling, fuzing, handling, and loading on planes, and for the study of logistics. They are fitted with adapters to receive inert fuzes of standard models. Drill bombs are of the same size, shape, and weight as the corresponding service bombs. These bombs contain no explosive and are painted black or olive drab with black bands and are appropriately marked to distinguish them from explosive bombs.

Manufacturers of the various types of bombers and manufacturers of bomb racks are chiefly interested in gage bombs. These are either empty standard bombs or wooden forms used in the testing of planes for clearances, or in testing racks for capacity or proper function.

BOMB, PRACTICE, 100-POUND, M38A2.

General. This bomb is used to give practice in demolition bombing. It is a thin case bomb, easy to manufacture, cheap in cost, and accurate in use. The bomb case cannot be reused after it has once been dropped in practice.

Body Description. It is constructed of light sheet metal, approximately 22 gage. The body is formed by rolling a rectangular sheet of metal into the form of a cylinder 8 inches in diameter, and spot-welding the seam at 2-inch intervals. The rounded nose is pressed from the same metal, as is the tail which is formed in the shape of a cone. Inside of the smaller end of the conical tail section is welded the spotting charge receiver. It extends about 7 inches into the cone and projects about 2 inches out of the tail end. The inner end of this receiver is fitted with a shoulder which supports a thin metal cover which is inserted after sand loading to protect the spotting charge from the sand in the bomb. At the outer end of the receiver are two projecting ears which serve to lock the spotting charge in place.

The receiver may be equipped with a cover cap. This is sometimes removed because it tends to stick tightly and make insertion of the spotting charge difficult in the field. Since the bombs are protected from the elements by at least a tarpaulin, this procedure does not appreciably harm the bombs.

Two suspension lugs are bolted to the bomb body during fabrication. The tail portion ends in a box type tail fin which has one blade in line with the suspension lugs. The over-all length of the bomb body is 47¼ inches. When empty, the bomb body weighs approximately 14 pounds. When completely loaded with sand (approx. 80 lb) and spotting charge, the weight of the bomb is approximately 100 pounds. The cost of the empty bomb body is approximately $1.50. When

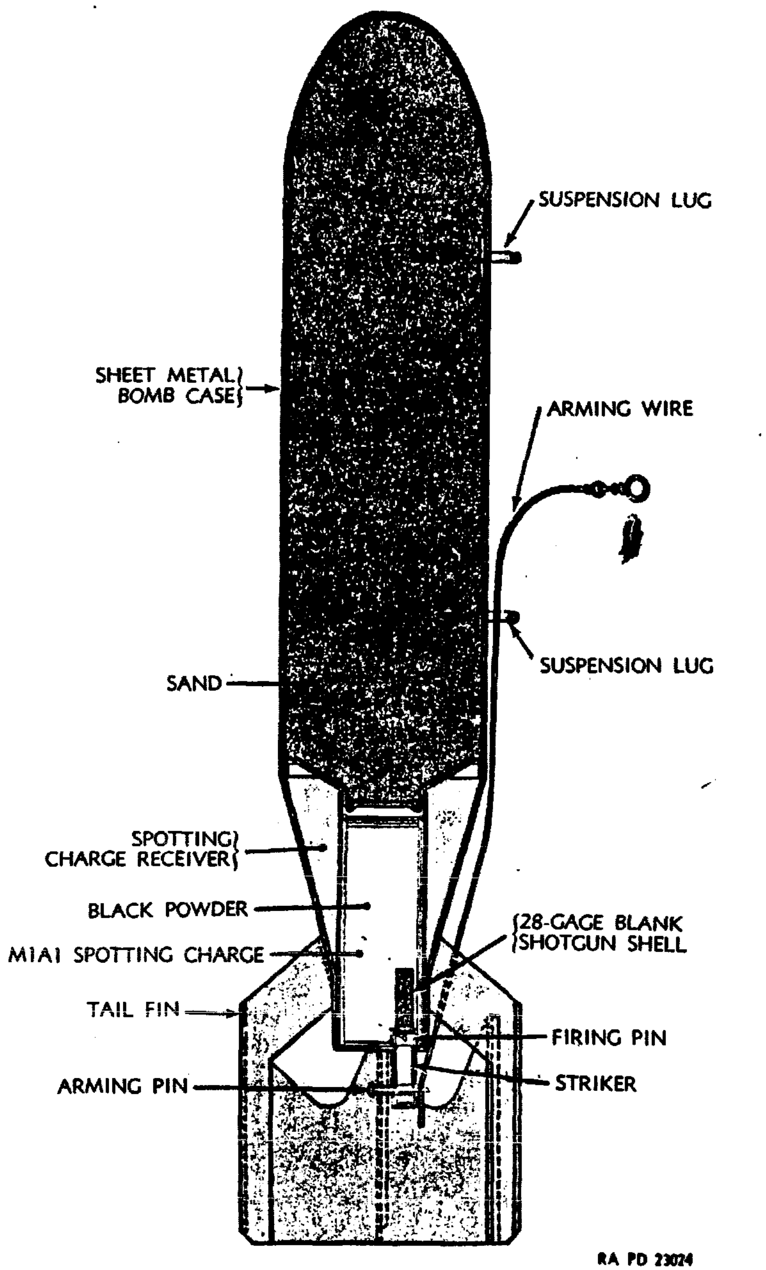

Figure 275 — BOMB, Practice, 100-pound, M38A2—Sectioned

completely loaded, the cost of the complete round is approximately $3.00. It receives the M1A1 Spotting Charge which houses both the spotting charge and firing mechanism. The Suspension Band M1 is provided for single suspension. The band is a separate component.

CHARGE, Spotting, M1A1. The M1A1 Spotting Charge is used to provide a charge and a firing mechanism. It is made from a large size tin can which has 3 pounds of black powder assembled loosely within. At the top of the can is a cover which has a hole in it for the insertion of a 28-gage blank shotgun shell and firing mechanism. The blank shotgun shell serves as a primer and igniting charge.

The firing mechanism consists of a fuze housing which has within it a striker held in position by an arming pin. Below the striker is a separate firing pin. The arming pin is always being forced outward by its spring but it is held in position by a cotter pin or arming wire located in one of the two eyelets in the small end of the arming pin. A small freely fitting sleeve is assembled over the end of the arming pin which is held in place by a cotter pin in the outer of the two holes. This sleeve makes the cotter pin more accessible and provides for proper arming wire resistance. It is important that this sleeve is always in place and that it is a loose fit on the arming pin. An inner hole through which the arming wire is threaded is exposed by a slight pressure on the head of the arming pin. The complete assembly is moistureproof and must not be disassembled under any circumstances. It is painted red with black stencil.

To assemble the spotting charge, about 80 pounds of sand is first added to the bomb. This requires filling to within ¼ inch of the receiver with sand. No water is ever to be added to the sand. The receiver cover disc is then inserted and the spotting charge is placed in the receiver so that the cotter pin is alined with the two suspension lugs. The two holes in the spotting charge cap are alined with the two ears projecting from the receiver sleeve. A slight force will cause the spotting charge cap holes and receiver ears to engage. A wooden tool is used to facilitate this action. This prevents longitudinal or rotational motion of the spotting charge in the receiver. The arming wire is placed through the inner hole of the arming pin after being threaded through the rear suspension lug. The arming wire is adjusted so as to protrude 2 to 3 inches beyond the arming pin. No safety clip is to be used.

Function. The bomb is dropped and the arming wire is retained in the plane. The arming pin ejected by its spring allows the striker to move down and come to rest on the firing pin.

On impact, the force of inertia causes the striker to move down against the firing pin. The firing pin strikes the primer of the 28-gage blank shotgun shell, igniting it. The flame produced ignites the igniting charge in the blank shotgun shell which in turn ignites the black

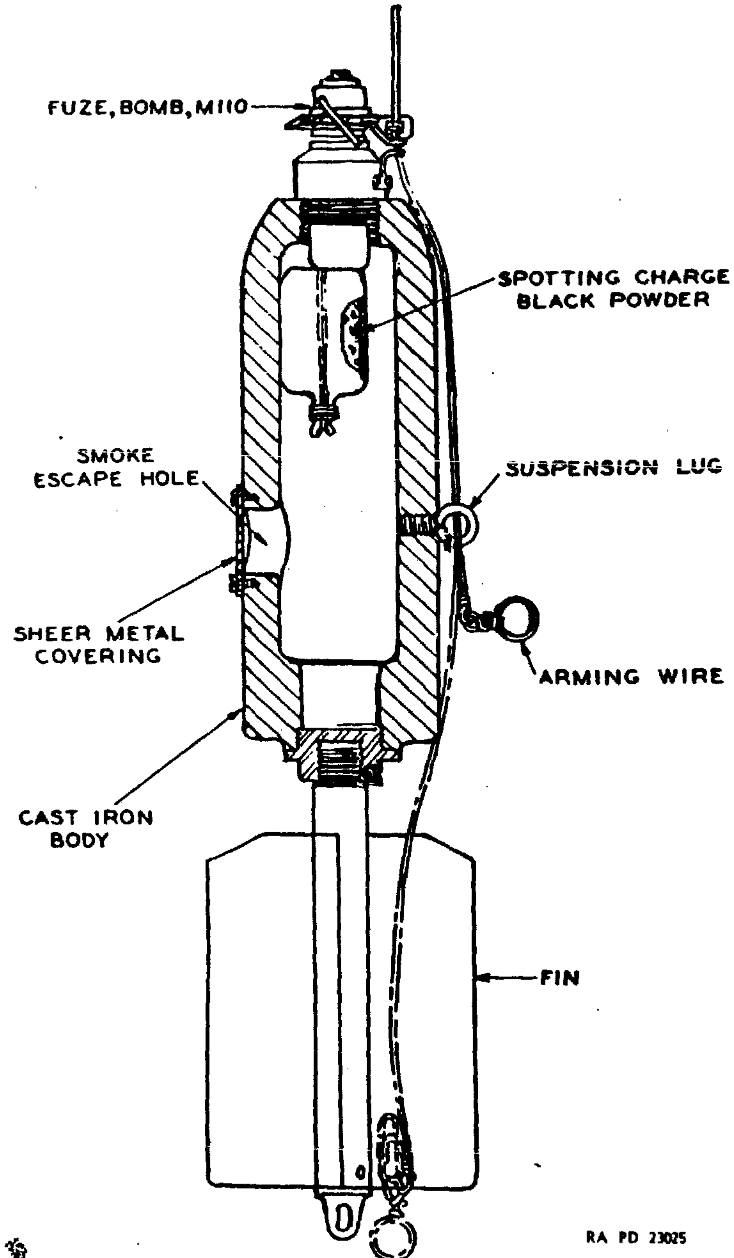

Figure 276 — BOMB, Practice, 20-pound, M48

powder spotting charge. The black powder produces a puff of white smoke at the point of impact to indicate where the bomb has struck. The bomb body is not reusable after dropping.

Packing. The bombs are packed 1 per cardboard container, empty. The spotting charges are packed 20 to the box. They are shipped separately.

Complete Round Components. Components necessary for a complete round consist of the following:

BOMB, practice, 100-pound, M38A2, less spotting charge
CHARGE, spotting, assembly M1A1, Practice Bomb, 100-pound, M38A2
Wire, arming, type A

BOMB, PRACTICE, 20-POUND, M48.

General. This bomb is designed to give practice in high-altitude fragmentation bombing. The bomb body may be reused after it has been dropped in practice unless it is badly damaged.

Description. The bomb body is cylindrical in shape and is made of heavy cast iron. To the rear of the bomb body, a hole in the side of the bomb, covered by a sheet metal disc is provided to allow for the escape of smoke. Opposite the hole on the other side of the bomb body is a lug for horizontal suspension. The nose is threaded to receive the M110 or the AN-M110A1 Bomb Nose Fuze. The body is hollow and receives a spotting charge of 0.13 pound of black powder. The rear of the bomb body is closed by means of a threaded cap. The cap is also threaded to receive the fin assembly. The fin assembly is bladed and the same as that of the 20-pound AN-M41 Fragmentation Bomb. Attached to the fin assembly is a lug for vertical suspension of the bomb. The fin is held securely to the threaded cap by means of a set screw. The over-all length is 21.7 inches. The total weight with spotting charge (no inert filler is used) is 20.5 pounds.

Function. In function, it acts exactly as the 20-pound AN-M41 High-altitude Fragmentation Bomb using the same fuze. The cluster is dropped and the arming wire is retained in the plane. The cluster opens and the bombs drop out. After several hundred revolutions of the vane, the fuze will arm. Upon impact, the fuze will function the black powder spotting charge. The smoke produced will blow out the metal disc and will show a white puff at the point of impact. The bomb body may be reused although the other components, fuze and spotting charge, must be replaced.

Packing. The bombs are packed in clusters, six bombs per cluster. Cluster Practice Bomb M2 is similar to the Fragmentation Bomb Cluster M1 except that six practice bombs replace the six fragmentation bombs. Cluster Practice Bomb M2A1 is similar to the Fragmentation Bomb Cluster AN-M1A1 with the same difference as described for the M1 and M2 Clusters.

Complete Round Components. A complete round consists of the following components:

BOMB, practice, 20-pound, M48, unfuzed without spotting charge assembly
CHARGE, spotting, assembly, PRACTICE BOMB, 20-pound, M48
FUZE, bomb, M110 or AN-M110A1 (nose)
Wire, arming, type A

BOMB, PRACTICE, 17-POUND, M37.

General. This bomb is designed to give practice in low-altitude parachute fragmentation bombing with or without the use of a fuze. The bomb is designed for reuse after it has been dropped.

Description. The bomb body is cylindrical in shape and is made of cast iron. Near the nose of the bomb body are two diametrically opposed holes leading into the bomb body. These holes allow for the escape of smoke from the spotting charge. At the center of gravity (6.13 inches from the nose) will be found a lug for horizontal suspension. The nose is threaded to receive the M104 Practice Bomb Nose Fuze or a closing plug. This fuze is similar to the M104 Fuze previously described except for the omission of the booster cup and charge of tetryl. The body is hollow and receives a spotting charge assembly weighing 0.75 pound. The rear of the bomb body is closed by means of a threaded cap. The cap is threaded to receive the same parachute assembly as the 20-pound M72 Fragmentation Bomb. Attached to the parachute case are wires which end in a lug for vertical suspension. The parachute case is held securely to the threaded cup by means of a set screw. The over-all length is 29.4 inches. The total weight with spotting charge (no inert filler is used) and fuze is 22.5 pounds.

Function. In function, it acts similarly to the 23-pound, M72, Low-altitude Parachute Fragmentation Bomb dropped without cluster. The bomb is dropped and the parachute opens arming the fuze. Upon impact, the firing pin initiates the detonator charge in the fuze (no booster) which in turn functions the spotting charge located at the rear of the bomb body. The smoke produced will blow out from the holes in the bomb body, producing a puff of smoke at the point of impact. The bomb body and parachute case may be reused although the other components, fuze and spotting charge, must be replaced.

NOTE: Since the parachute is ample for spotting purposes, the fuze and spotting charge are no longer used.

Packing. The bomb bodies, parachute units, fuzes, and smoke charges are shipped separately. The bomb bodies are packed four to a wooden box, whereas the parachute assembly is packed eight to a wooden box.

Complete Round Components. A complete round consists of the following components:

BOMB, practice, 17-pound, M37
PARACHUTE and CASE assembly for 17-pound Practice Bomb M37

BOMB, PRACTICE, 23-POUND, M71.

General. This bomb is designed to give practice in low-altitude parachute fragmentation bombing using an adapter cluster.

The bomb consists of the 23-pound M40 Bomb Case and parachute assembly. The bomb case is empty, and in place of a nose fuze, a nose plug is inserted. It is dropped from a cluster in the same manner as the 23-pound M40 Bomb. The open parachute lying on the ground after dropping provides a simple and efficient means of identifying where the bomb struck. All parts of this bomb are reusable.

It is packed in clusters, three bombs to the Adapter Cluster M3 previously described. The entire practice bomb cluster is designated as the M5 and differs from the M4 Fragmentation Bomb Cluster in that three practice parachute bombs replace the three fragmentation parachute bombs and no fuzes are used.

BOMB, PRACTICE, 23-POUND, M73.

General. This bomb is designed to give practice in low-altitude parachute fragmentation bombing, using bombs suspended singly.

This bomb consists of the 23-pound M72 Fragmentation Bomb Case and parachute assembly. The bomb case is empty, and in place of a nose fuze, a nose plug is inserted. It is dropped in the same manner as the 23-pound M72 or as the 17-pound M37 Practice Bomb. The open parachute lying on the ground after dropping provides a simple and efficient means of identifying where the bomb struck. All parts of this bomb are reusable.

BOMB, PRACTICE, 3-POUND, AN-MK. 5 MOD. 1.

General. This bomb is designed to give practice in low-altitude bombardment. It is particularly used for dive bombing practice on water or land. The bomb is rugged enough to allow for reuse after it has been dropped.

Body Description. The bomb body is streamlined or tear drop in shape, having a blunt nose and a tapered tail. It is made in one piece zinc alloy casting. An axial hole somewhat wider at the nose portion, extends through the bomb and is approximately 0.9 inch in

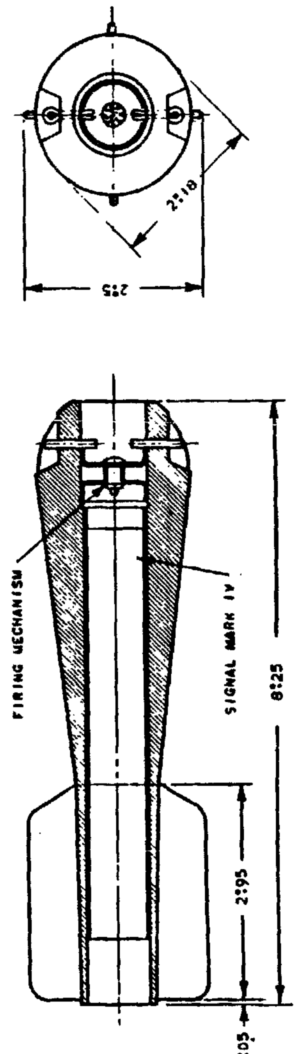

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Figure 277 — Practice Bomb Mk. V (Miniature—Navy)

diameter. A tail fin which consists of four blades is part of the body. There is no suspension lug on the bomb body. At the nose, a firing mechanism and blank shotgun shell is assembled to provide for a puff of white smoke. The entire length of the bomb body is about 8 inches. The total weight of the bomb body is approximately 2.7 pounds.

Firing Mechanism and Spotting Charge. The firing device consists of two shallow cups separated by a spacer. The firing pin extends through the bottom of one cup. The firing mechanism is held in place at the nose by a cotter pin which passes through holes in the bomb body above the firing pin and thereby prevents it from falling out through the nose and by a shoulder produced by the axial hole becoming smaller in diameter to prevent it from dropping out through the tail of the bomb body.

The Signal Cartridge AN-Mk. 4 consists of a long 10-gage blank shotgun shell 5.75 inches long containing an ejection charge and a pyrotechnic charge which burns above water after impact, forming a large puff of white smoke. To assemble the cartridge, it is only necessary to remove the cotter pin and firing pin assembly. The cartridge is then inserted. It is held by the flange on the brass base of the cartridge coming in contact with the shoulder of the bomb body. The firing pin assembly, having the firing pin directly above the primer of the cartridge, is replaced. The cotter pin is next inserted through holes in the nose of the bomb body to prevent the entire assembly from dropping out. No arming wire is used.

Function. The bomb is dropped, and on impact, the firing pin strikes the primer of the cartridge. The flame produced ignites the black powder which in turn expels a puff of white smoke through the tail of the bomb body to indicate the point of impact. The bomb body is reusable.

Packing. The bomb body and signal cartridge are shipped separately. The bomb bodies are shipped with the firing mechanism assembled to the bomb, 25 per crate. The signals are packed in a paper carton, 20 per carton, 20 cartons are packed per wooden box.

Complete Round Components. A complete round consists of the following components:

BOMB, practice, 3-pound, AN-Mk. 5 Mod. 1

BOMB, signal, practice, AN-Mk. 4

Comparison to Other Models. The AN-Mk. 5 Mod. 1 can be compared to a number of other miniature practice bombs as follows:

AN-Mk. 5. This bomb has a firing mechanism which is less sensitive.

M36. This bomb is the same as the AN-Mk. 5. It is made of a one piece die casting. It utilizes the M4 and M5 Blank 10-gage Shotgun Shell. The M4 has more powder and is used for high altitudes.

AN-Mk. 23. This bomb is 3 pounds in weight, made of cast iron.

AN-Mk. 43. This bomb is 4 pounds in weight, made of lead, and suited for glide and dive bombing. It conserves zinc.

FURTHER REFERENCES: Ordnance Drawings; TM 9-1980, Bombs for Aircraft; TM 3-330, Incendiary Bombs; OS 9-18, Ammunition, General; Ordnance Pamphlet No. 878; Ordnance Pamphlet No. 736; TM 9-1900, Ammunition in General; Pamphlet No. 2, Chemical Warfare; The Ordnance Sergeant; Complete Round Chart No. 5981; O.O. 7224, Ordnance Safety Manual; OS 9-49, Aircraft Depth Bomb Mk. XVII.

SECTION VIII.

MILITARY PYROTECHNICS

Chapter 1

Pyrotechnics

GENERAL.

Pyrotechnics are modifications of fireworks designed to produce a brilliant light for illumination, or to produce colored lights or smoke for signaling.

Some pyrotechnics were originally designed to be projected from or used on the ground; others to be released from or fired from aircraft. Accordingly they are classified as:

1. Ground types.

2. Aircraft types.

Further, pyrotechnics are classified according to the purpose for which they are intended:

1. Illumination.

2. Signaling.

Illumination may be necessary for:

1. Reconnaissance.

2. Observation.

3. Bombardment.

4. Landings.

Signaling may involve sending messages from aircraft to other aircraft, or to ground units. On the other hand, it may involve sending messages from ground troops to other ground troops, or to aircraft.

Pyrotechnic Flare Composition. In general, pyrotechnic compositions may be said to be mechanical mixtures of chemical compounds and elements. The action produced is an incandescence of the gases and of the small particles of solids carried by the gases. These substances, by virtue of their chemical composition, radiate much more light of the desired wave length than inert materials heated to the same temperature.

Chemical Characteristics. Since the composition is pressed into the form of candles, and burns progressively from one end to the other, oxygen of the air is not sufficient to support rapid combustion. Therefore, the mixture must contain an oxidizing agent for combustion, as well as a fuel. When subjected to pressure, the mixture must be sufficiently coherent to remain in compact form, so a binding agent is necessary. If the composition is to yield a colored flame, it may be necessary to include a color-intensifying compound. This compound must not affect the thermochemical reaction as a whole, but should influence the spectral distribution of the flame. In order to obtain the desired results, the burning rate must be kept within controllable limits. A retarding agent is needed for this purpose. Finally, as the composition must be protected against the absorption of moisture, a waterproofing agent is required. As some materials serve more than one purpose, each composition does not contain single ingredients serving each of the purposes mentioned.

The ingredients used in pyrotechnic flare compositions may be classified as fuels, oxidizing agents, color intensifiers, retardants, binding agents, and waterproofing agents. Typical ingredients in the classification are as follows:

1. Fuels. Provide combustible material: magnesium; aluminum; sulphur; asphalt; resinates of calcium, barium strontium, copper.

2. Oxidizing agents. Provide oxygen for combustion: perchlorates of potassium and ammonium; chlorates of potassium and barium; nitrates of potassium, barium, strontium, sodium; chromates of strontium and barium.

3. Color intensifiers. Add color to flame: chlorides of barium, strontium, copper; nitrates of strontium, sodium.

4. Retarding agents. Control burning rate: asphalt, paraffin, sulphur, resinates of metals.

5. Binding agents. Hold composition together: asphalt, paraffin, sulphur, resinates of metals.

From this tabulation, it is obvious that in some cases a single material will serve more than one purpose.

Factors Influencing Candlepower and Burning Rate.

1. Percentage compositions.

The addition of an ingredient may increase or decrease the candlepower and burning rate, depending on its chemical characteristics. For example:

Color-intensifying agents which are also oxidizing agents can be used to increase the candlepower and burning rate. Color intensifiers which are neither fuels nor oxidizing agents reduce the candlepower and burning rate while improving the color value.

2. Granulation of ingredients.

If a given composition is prepared from ingredients having certain granulations, and this is formed into a candle under a prescribed uploading pressure, combustion will take place at a controlled rate. This will result in definite pyrotechnic characteristics. It has been found that if the granulation of one or more ingredients is changed, the chemical reactions involved in the burning are retarded or accelerated, and the pyrotechnic values are affected. In general, decrease in size of particles increases the candlepower and increases the burning rate.

3. Density of loading (pressure)

It has also been found that the pressure under which a composition is formed into a candle affects the pyrotechnic characteristics. However, increased pressure brings about an increase in candlepower and a reduction in burning rate.

4. Diameter of candle (burning area).

Taking the same quantity of composition and forming, at constant pressure, candles of increasing diameters it has been found that an increase in diameter will cause an increase in candlepower and an increase in burning rate for the candle as a unit. This is naturally due to more exposed burning area.

Stability of Pyrotechnic Flare Compositions. The stability characteristics of pyrotechnic compositions as a class present a problem of major magnitude. This is due to the fact that ingredients, which in themselves may be quite stable, may prove extremely unstable when mixed with certain other materials.

Magnesium and aluminum are excellent fuels because each burns with a white light which is accompanied by the formation of a refractory oxide. Magnesium is superior to aluminum in these respects. However, each undergoes oxidation on exposure to air or moisture, magnesium being more easily oxidized than aluminum. In the case of aluminum, it appears that the thin film of oxide formed in early stages of oxidation acts as a protective coating. Magnesium, however, must be protected by a thin film of chemically inert material, such as paraffin.

Anhydrous strontium nitrate is hygroscopic, but normally stable. However, it has been found that when composition containing 40 percent strontium nitrate, 15 percent strontium chromate, 9 percent strontium chloride, 10 percent strontium resinate, 26 percent magnesium, coated, are subjected to storage at 50 C, there is no deterioration. However, at magazine temperatures there is a very definite deterioration within 9 months. Deterioration is accompanied by the formation of ammonia, indicating reduction of the nitrate by the magnesium. The reaction has been ascribed to temperature fluctuations, causing condensation of moisture or dehydration of the crystalline strontium chloride resulting in reaction between the nitrate and magnesium.

Slight volatility of a solid ingredient may cause the deterioration of a pyrotechnic composition.

Peroxides such as those of barium and strontium are oxidizing agents and color intensifiers. There is some evidence that, unless compositions containing these are protected from atmospheric moisture, this causes the reduction and hydration of the peroxide and consequent deterioration of the composition.

The stability of the newly developed pyrotechnic composition must, therefore, be established by storage at different temperatures with periodic tests. This is usually done by placing candles, in waterproofed paper cases, into a magazine subjected to climatic temperature variations. In some cases, the composition is also stored in an unpressed condition.

It is therefore important, in developing pyrotechnic compositions, to utilize ingredients which are nonhygroscopic, nonvolatile, nonoxidizing at ordinary temperatures, and nonreactive with other compounds in the presence of moisture.

Also from the preceding discussion, it is possible to determine the following factors which influence the deterioration of pyrotechnic compositions:

1. Moisture.

2. Continued high temperature.

3. Sudden fluctuations in temperature.

Visibility of Pyrotechnic Signals. The range of visibility of pyrotechnic flame signals is determined by:

1. Candlepower.

2. Color.

3. Weather (including time of day).

It is an accepted fact that the greater the candlepower (amount of light), the greater the range of visibility, all other factors being equal.

The color of the flame also determines its range of visibility in accordance with its color wave length. Colors with shorter wave lengths (red) are absorbed by air more quickly than those with longer wave lengths (green).

The presence of moisture in air has a notable effect in reducing the visibility of signals. In clear weather, a light can be seen farther than during rain, snow, fog, etc.

The amount of light present also influences the range of visibility. Light can be seen farther at night than during the day.

FLARE, AIRCRAFT, PARACHUTE, M8A1.

Use. For emergency night landings or for landings on fields with insufficient ground illumination.

Description. Burning time = 3 minutes; candlepower = 400,000; weight = 17 pounds; and dimensions = 25½ inches long by 4¼ inches diameter.

Methods of Release. From vertical flare launching tubes; horizontal flare racks; internal bomb racks; and from external bomb racks.

Composition.	Percent
Barium nitrate	33.7
Magnesium (linseed oil coat)	30.3
Aluminum	15.2
Sodium oxalate	18.8
Castor oil	1.0
Linseed oil	1.0

Construction.

Illuminant case. A convolute paper tube with 3/16-inch walls encased in a zinc sheath 0.14 inch thick. The composition is pressed into this at a pressure of 3,600 pounds per square inch.

Nonglare effect. This is produced by use of sodium oxalate. This gives flame a yellowish tinge which reduces glare and also reduces contrast between light and shadow. It does not blind the pilot in the plane.

Inner construction. A fire clay seal is pressed into the case through the opening in the bottom; this prevents the friction igniters from igniting the candle at the upper end. The flare composition is pressed in increments against the fire clay seal. A first fire charge, composed of 75 percent flare composition and 25 percent black powder, is pressed in against the flare composition. A primer disc follows in line. This is a perforated disc with the perforations filled with black powder priming paste. A closing cover closes the open end and is fastened over a metal end reinforcing ring. This cover is merely pressed on, but it must be tight enough so that it cannot work free in handling. It must, however, be loose enough so that it can be blown off when the composition begins to burn. An aluminum base block is secured to the upper end of the illuminant case above the fire clay seal. This base block holds the illuminant case to the parachute case. Within the base block are two friction igniters which contain:

1. A primer cup which holds the friction composition (potassium chlorate, charcoal, and a dextrine binder).

2. A friction wire made in the form of a loop, coated with red phosphorus and running through the friction composition.

3. A tear strip of aluminum which secures the friction wire to the base block and insures that a good pull is necessary before the friction wire is drawn through the igniter.

The base block also serves as an anchorage for the suspension cable—shock absorber assembly.

A paper tube (the quickmatch housing) runs through the illuminant and carries a double length of quickmatch from the igniters to the primer disc.

Parachute case. Zinc metal made the same as the outside of the illuminant case.

1. Shipping cover. A metallic cover sealed with tear strip.

2. Hangwire cover. A dish-shaped metal container for the hangwire.

3. Hangwire. A means of initiating function of the flare on release from the plane.

4. Coupling. Connects hangwire and tear wire. Also provides means for the release of the hangwire cover from the hangwire, thus preventing its pounding against the plane after release of the flare.

5. Tear wire, A thin copper wire with a breaking test of 26 pounds. It serves to pull out parachute and release flare from the hangwire.

6. Pull-out cord. A cord 15 feet long. It pulls parachute out of parachute case.

7. Pilot disc. A cardboard disc which serves to aid in pulling the parachute out of the case in the event of failure of the tear wire.

8. Parachute. Made of silk. Substitutes are being used in view of the shortage of silk. 15 feet in diameter.

9. Shrouds. Cotton cord 14 feet long with a breaking test of 100 pounds.

10. Metal spool. This spool provides a means of joining the shrouds to the suspension cable.

11. Suspension cable. Composed of metal wire. It prevents the flame of the flare from igniting the shroud lines.

12. Shock absorber. Made by running the suspension cable through copper tubing and then winding the assembly into the form of a spring. It lessens the load on the parachute at the instant it opens by absorbing the sudden shock of retardation of the fall.

Operation of the Flare. Before installing the flare in the plane, the tear strip is removed, thereby enabling removal of the shipping cover. If the flare is placed in the vertical launching tube, it may rest on the ignition end of the illuminant or may be supported by the suspension hook, depending on the type of device used. If the flare is installed on a horizontal rack, it is supported by the suspension bands.

The swivel loop of the hangwire is attached to the arming pawl of the releasing device. When the flare is released, the hangwire cover is removed by the resulting jerk on the hangwire, and, by means of the pull-out cord, the parachute is withdrawn from the parachute case. As the flare continues its descent the load, or weight, of the flare breaks the tear wire, the flare is free of the plane, and the parachute opens. When the hangwire cover is pulled out of the parachute case, a spring, which is U-shaped and which serves to hold the coupling in the hangwire cover, is ejected. This releases the hangwire cover from the coupling. When the tear wire breaks, this allows the hangwire cover to drop free of the hangwire, and thus avoids the possibility of the cover battering against the plane in the air stream. The load suddenly applied to the shock absorber by the opening of the parachute pulls the friction wires through the friction composition, creating a flame which starts the ignition train. This flame is picked up by the double length of quickmatch and is carried down through the quickmatch housing where it is transmitted to the primer disc. The black powder in the perforations of the primer disc is ignited, and in turn carries the flame to the first fire charge. The first fire charge amplifies the flame and ignites the flare composition. With the ignition of the flare composition, a pressure is produced which blows off the closing cover of the flare and the operation is complete.

The interval of time required for full ignition of the flare after release is from 3 to 5 seconds.

FLARE, AIRCRAFT, PARACHUTE, M24.

Use. At present, for training in night bombing. Also substitute standard for night observation and bombardment.

Description. Length = 37 inches; diameter = 8.1 inches; weight = 44 pounds; burning time = 3-3½ minutes; and candlepower = 1,000,000 nominal.

Method of Release. From horizontal suspension.

Construction. The body of the flare consists of a cylindrical case forward from terneplate, having one end permanently closed by a pressed metal cap. The other end is provided with a removable cover which consists of a steel disc 1/16-inch thick. To this disc is attached a light pressed metal cup which serves as a container for the hangwire. The disc is seated in an internal annular bead by three equally spaced indentations formed in the flare case. The hangwire assembly, which consists of a flexible steel cable 3/32-inch in diameter having a steel ring attached to the free end, is provided for the purpose of removing the cover assembly when the flare is released from a plane. The hangwire assembly is not permanently attached to the cover assembly, but is anchored to it by means of a soldered stop on the end of the steel cable. The stop is seated on the outer face of the disc, in the channel formed by the hangwire container and the wall of the flare case. The cable is then passed through a notch in the disc, then underneath the cover, and out through a notch in the opposite side. The channel between the hangwire container and the flare case is filled with a sealing compound to waterproof the end of the flare. A tubular stop, crimped to the hangwire, rests on the outer face of the disc at the point where the hangwire projects outward from the flare. A notched turned-over portion of the hangwire container bears against the top of the tubular stop for the purpose of preventing

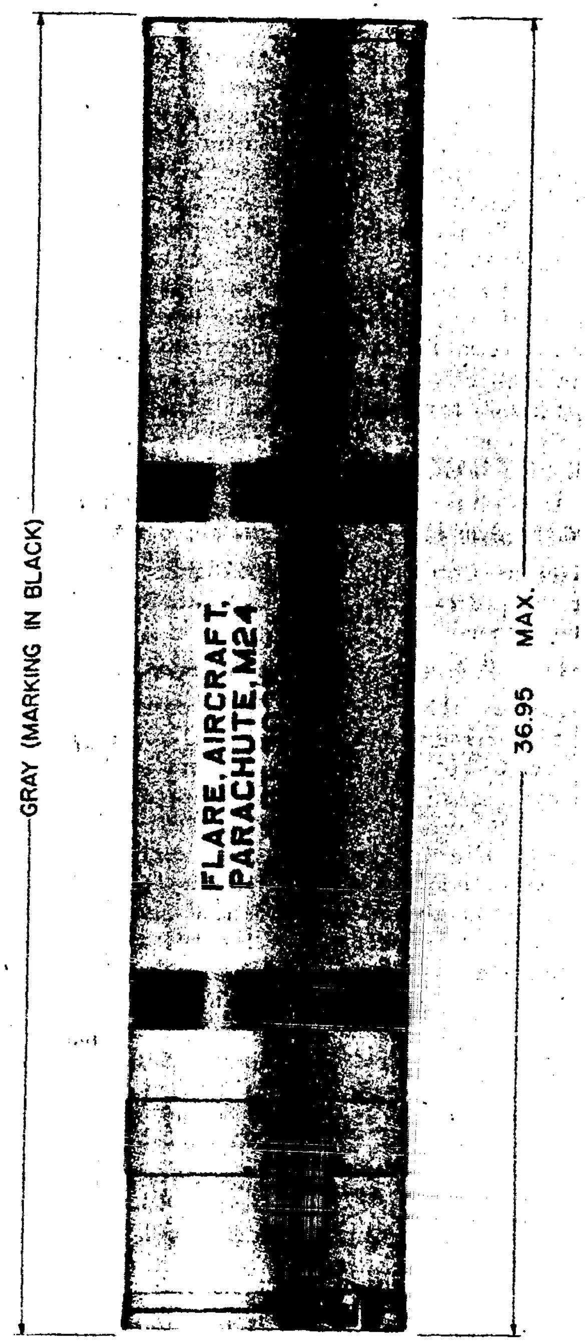


Figure 278 — FLARE, Aircraft, Parachute, M24

longitudinal movement of the hangwire. Movement of the hangwire would tend to fracture the sealing compound. A copper sealing wire is threaded through holes provided in opposite sides of the flare case, over the cover assembly. The ends of the sealing wire are twisted together over the center portion of the hangwire container. The twisted ends are embedded in a lead seal, stamped with the letters "P.A." The purpose of the seal is to indicate whether or not the flare has been tampered with. A tear wire which connects the hangwire to the parachute pull-out cord is attached to that portion of the hangwire extending underneath the cover assembly. A shipping cover is assembled to this end of the flare and is secured to the flare case with adhesive tape.

The illuminant assembly is of the same design as that used in the M8A1 Flare, with the exception that the illuminant case is 22½ inches in length, which is 6¾ inches longer than the illuminant for the M8A1 Flare. The base block igniter assembly and the shock absorber assembly are the same types as those used in the M8A1 Flare. The illuminant composition consists of the same ingredients as used in the M8A1 Flare composition, the proportions of which have been adjusted to give a candlepower of approximately 1,000,000.

A shade, 58 inches in diameter, made from asbestos cloth, is attached to the illuminant assembly in order to screen the glare of the burning composition from the bombardier sighting on a target illuminated by the flare. The shade assembly consists of eight arms made from ⅜-inch seamless steel tubing to which the asbestos cloth shade is attached. The arms are hinged to a spider, and each is actuated by a rat trap type coiled spring. The shade assembly is secured to the upper end of the illuminant assembly with the same screws which hold the base block in the illuminant assembly. The M8A1 Flare type Parachute is attached to the illuminant assembly. A pull-out cord, approximately 12 feet long and attached to the crown of the parachute, is connected to the hangwire with a copper tear wire. Suspension bands are furnished with the flare for suspension from standard horizontal bomb racks.

Operation. Before installing the flare in the plane, the adhesive tape is removed, thereby enabling removal of the shipping cover. The ring on the hangwire is attached to the arming pawl of the releasing device. When the flare is released, the cover assembly is removed by the resulting jerk on the hangwire. The parachute is then withdrawn from the flare case by the pull-out cord. As the flare continues its descent, the load, or weight, of the flare breaks the tear wire, the flare is free of the plane, and the parachute opens. Due to the retardation of the fall caused by the resistance of the parachute, the flare case is stripped from the illuminant and shade assembly. At the same time, the resultant jerk pulls the friction igniters through

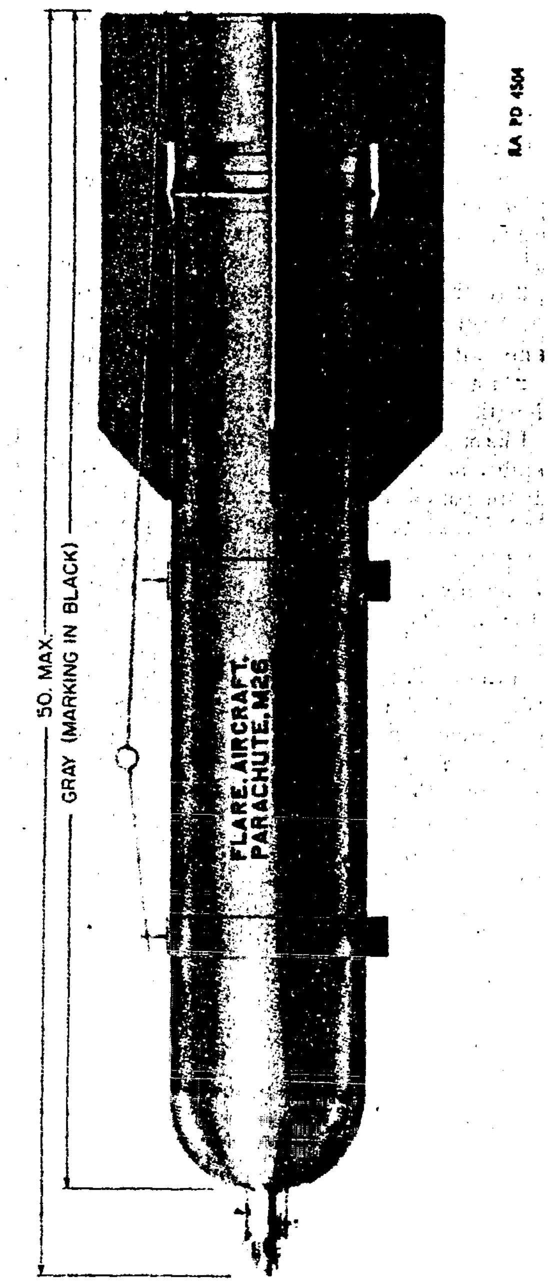


Figure 279 — FLARE, Aircraft, Parachute, M26

the friction composition, thus creating a flame which is picked up by the double length of quickmatch. The flame passes down through the quickmatch housing to the primer disc by means of the double length of quickmatch. The black powder paste in the perforations of the primer disc carries the flame to the first fire charge which in turn ignites the flare composition. When the flare composition is ignited, the pressure which builds up causes the end closing cover of the illuminant assembly to blow out, releasing the rib retainer which is attached to it, and thus allowing the springs to open the shade.

The full time for the complete ignition of the flare after release is approximately 2 seconds. Both the cover assembly and the flare case drop to the ground. The cover assembly is released from the hangwire assembly to avoid the possibility of the cover battering against the plane in the air stream.

FLARE, AIRCRAFT, PARACHUTE, M26.

Use. To provide illumination for night bombardment.

Description. Length = 50 inches; diameter = 8 inches; weight = 53 pounds; burning time = 3-3½ minutes; candlepower = 800,000; substitute composition = 575,000.

The flare is equipped with the M111 Mechanical Time Flare Fuze which permits the function of the flare at 3,000 feet when released from aircraft at any altitude between 5,500 and 25,000 feet. The flare may be released from a plane traveling at any speed up to 200 miles per hour.

Method of Release. From horizontal suspension.

Construction. The flare case is cylindrical with a rounded nose, has tail fins, and the body has two suspension lugs attached for horizontal suspension. A shipping cover with a handle closes the tail end of the body, and is sealed by a strip of tape.

The inner construction is similar to the M24 Flare with the addition of the stabilizing sleeve, and the aluminum disk assembly which is functioned by the pressure built up by the functioning of the fuze.

Installation. Unscrew the fuze hole plug, screw the fuze in by hand, and seat it by hand force. Set the fuze to the desired time by loosening the thumb screw, rotating the body of the fuze until the desired number of seconds is indicated opposite the marker, then tighten the thumbscrew.

The cover is removed from the base of the flare and the outer end of the arming wire hangwire assembly is drawn from the hangwire container, taking care not to pull out the attached end of the hangwire. The hangwire is brought around the vane stiffener to the suspension side of the flare, and the arming wire is threaded through first

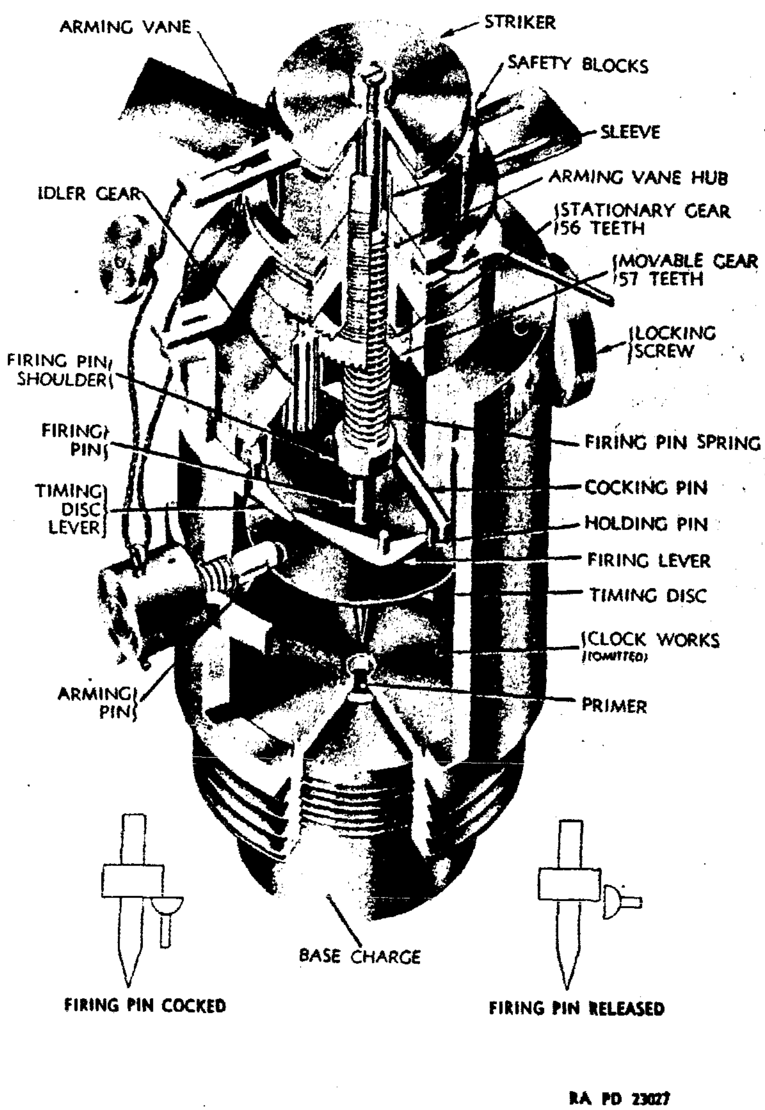


Figure 280 — FUZE, Flare, Mechanical Time, M111

the forward suspension lug, then the inner holes in the arming pin of the fuze, and finally through the inner holes in the vane stop. The flare is then installed in the plane and the ring of the arming wire hangwire assembly is attached to the arming pawl.

Operation. The flare may be released "safe" or "armed." If released "safe," it may function on impact. If released "armed," the following steps take place:

1. Movement downward withdraws the arming wire from the fuze allowing the vane to rotate to arm the fuze and, at the same time, allowing the arming pin to be ejected, thus starting the time mechanism.

2. When the flare has dropped the length of the hangwire, it breaks the seal wire, and pulls out the hangwire container which drops free. The tear wire, attached to the hangwire near its end, pulls out the tear-wire cord which, in turn, pulls out the stabilizing sleeve and its shrouds. A short length of cord attached to the shrouds removes the lock of the cover releasing cup.

3. When the flare has dropped this far, its momentum breaks the tear wire, allowing the flare to drop free. It is stabilized in flight by the fins and the sleeve. The arming vane on the fuze rotates to arm the fuze approximately 6 seconds after release.

4. At the time set, the fuze functions to push out the cover releasing cup. This releases the detachable cover to which the sleeve shrouds are attached, allowing the sleeve and cover assembly to separate from the flare and, by means of the parachute pull-out cord, to pull out the parachute.

5. The parachute opens and retards the fall of the flare with a jerk which:

Breaks the parachute pull-out cord, allowing the sleeve assembly to drop free.

Pulls the friction igniters through the friction composition, thus starting the ignition train of igniter, lead spitter fuze, quickmatch, primer, first fire, and candle. This is the same as the function of the M24, and reaches full ignition in approximately 9 seconds.

Pulls the flare assembly out of the case allowing the case to drop free.

6. As the candle ignites, it expels the rib retainer, as in the M24, allowing the rib springs to open the shade.

7. The flare burns for 3 to 3½ minutes with a light of 800,000 candlepower while dropping at an average speed of 11.6 feet per second.

FLARE, AIRCRAFT, PARACHUTE, M9.

Use. For reconnaissance. It is fired from Pyrotechnic Pistol M2 from a plane. It is not to be fired from a grounded plane.

AMMUNITION INSPECTION GUIDE

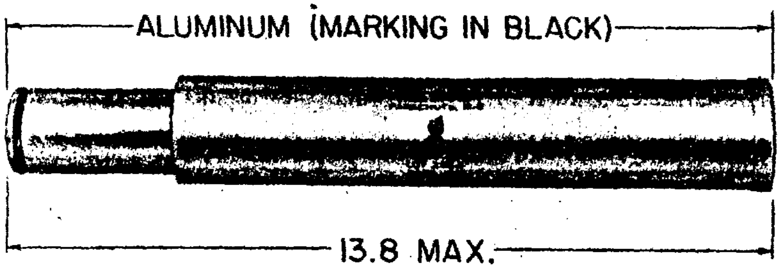


Figure 281 — FLARE, Aircraft, Parachute, M9

Description. Length = 13.8 inches; diameter = 2 inches; weight = 1.9 pounds; burning time = 1 minute; candlepower = 60,000.

Construction. The body of the flare is an extruded aluminum case, reduced at the base to fit into the detachable barrel, which is also of aluminum but of a smaller diameter than the flare case.

An expelling charge cup, containing black powder for the expelling charge, is attached to the inner wall at the base of the flare case. The fuse train (2½-sec del.) is housed in a metal flanged tube and is secured to the base of the expelling charge cup. The inner end of the fuse is in contact with the expelling charge, and the outward end is exposed to the flame of the propelling charge. The propelling charge is contained in the breech of the detachable barrel.

The illuminant charge is contained in the candle case. This case is closed at the upper end by the candle case cap which provides a means of attaching the parachute wire. A felt washer between the candle and the parachute acts to keep the flame of the expelling charge from igniting the parachute.

The upper end of the signal case is closed with a closing cap of aluminum which is pressed over the signal case.

A percussion primer is inserted into the lower end of the detachable barrel.

Operation. The flare is first locked in the pyrotechnic projector and is then initiated by a continuous pull on the trigger which fires the primer of the detachable barrel. This ignites the propelling charge, and projects the flare from the plane through a distance of approximately 80 feet, and at the same time ignites the delay train. After 2½ seconds, the delay train burns through, igniting the expelling charge. The gases of this charge expel the candle and the parachute. At the same time, the expelling charge ignites the igniter charge of the candle; thus, the first fire charge and finally the flare composition is fully ignited.

The flare burns for approximately 1 minute with a candlepower of 60,000.

MILITARY PYROTECHNICS

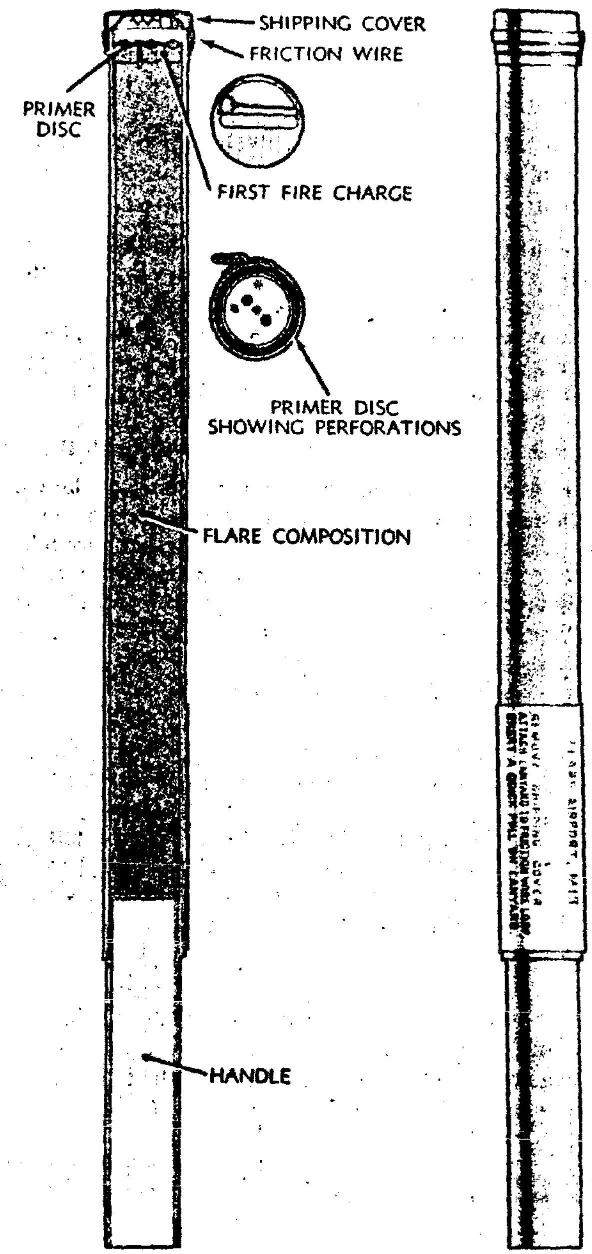


Figure 282 — FLARE, Airport, M13

FLARE, AIRPORT, M13.

Use. To provide illumination for night landings at emergency landing fields or in case of power failure at regular airports. It is operated from the ground.

Description. Length = 23 inches; diameter = 1¾ inches; burning time = 3 minutes; candlepower = 40,000.

Handle (hollow). Length = 7 inches; diameter = 1½ inches.

Construction. The body is composed of chip board with a chip board closing plug at the lower end held in place by the hollow handle.

The flare composition is pressed in on top of the plug, followed by a first fire charge, and finally by a primer disc. Perforations in the primer disc are filled with black powder priming paste.

The single friction igniter is held at the top of the primer disc in a metal cap with a raised hollow ridge running through the center.

Operation. After removing the shipping cover, a lanyard is attached to the ring on the end of the friction igniter. A quick jerk on the lanyard causes the friction igniter to be pulled through the friction composition thereby starting a flame. The flame ignites the black powder priming paste in the perforations of the primer disc, which ignites the first fire charge. The first fire charge ignites the flare composition, and the flare is fully ignited.

The flare burns for approximately 3 minutes with a candlepower of 40,000.

Before operating this flare, it must be fastened onto a support which may, in turn, be fastened onto a post or planted firmly into the ground.

When using a flare of this description, it must be borne in mind that pyrotechnics will drip in operation; consequently, care must be exercised that no inflammable material is present around the flare that might become ignited by the drippings.

Substitute Flare. Overage M8A1 Flares may be substituted for the M13. In so doing, all the components above the metal spool are removed and the lanyard is attached to the metal spool.

A sharp pull on the lanyard will cause the friction igniters to be pulled through the friction composition and then the ignition train runs its regular procedure of quickmatch, primer, first fire, and flare composition.

BOMB, PHOTOFLASH, M23A1.

Use. Aerial night photography.

Description. Length = 25.4 inches; diameter = 4¼ inches; weight = 10.5 pounds. Contents = 7¾ pounds flashlight powder;

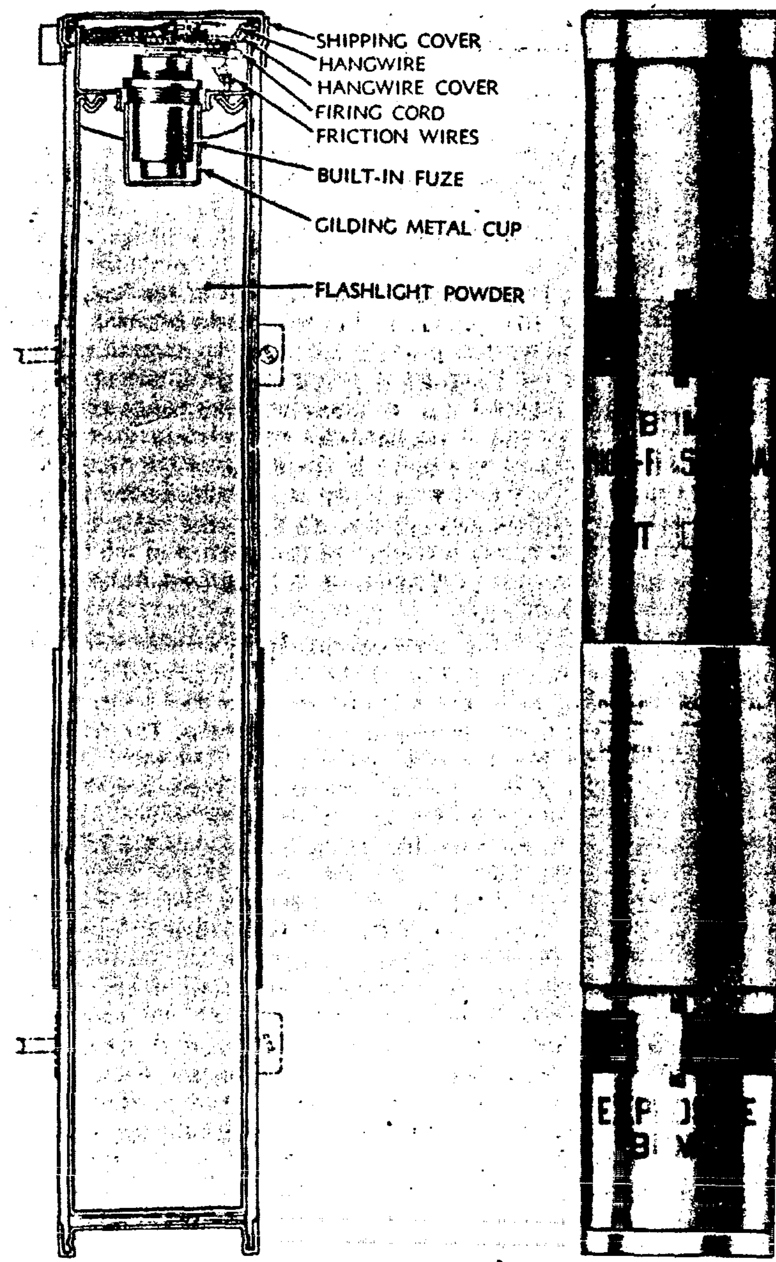


Figure 283 — BOMB, Photoflash, M23A1

maximum candlepower = 303,000,000; average candlepower = 84,840,000; total burning time = 0.16 second.

Construction. The case of the photoflash bomb is of laminated paper, sealed at the lower end with a metal closing cup. The flashlight powder is placed inside the bomb body and kept in place by a metal partition cup which is secured to the body by rivets. This cup accommodates the adapter for the fuze, and is a seat for the hangwire container. The hangwire container is provided with a flange which is notched on opposite sides. The partition cup is also provided with corresponding notches to accommodate the portions of the hangwire which project through the notches in the hangwire container. The hangwire is made from flexible steel aircraft cable 1/16 inch in diameter. The free end of the hangwire is provided with a swivel loop, the other end with a soldered stop. In assembling the hangwire container to the bomb, the end of the hangwire which is provided with the soldered stop is placed in a notch in the flange of the hangwire container. The hangwire then passes across the bottom of the hangwire container and projects outward through the other notch in the flange of the container. A ring is secured to that portion of the hangwire which passes underneath the container. A firing cord, which fires the fuze, is secured to this ring.

The design provides a delay of approximately 15 seconds from the release of the bomb to the ignition of the flashlight powder charge. The fuze consists of a body which houses an upper and lower time train ring assembly and two friction igniter assemblies. The friction wires are made from No. 1 braided picture wire. The ends of the friction wires, which project through the igniter cups, are coated with a red phosphorus paste. The igniter cups are loaded with a friction composition. At the outer face of the igniter cups, the friction wires are bent at right angles toward the center of the fuze, then twisted together. A thin aluminum disc, having a central hole, is pressed against the bent portions of the wire by the igniter retainer. The twisted ends of the wires project through the hole in the aluminum disc. The aluminum disc is a safety feature and, in operation, must tear or deform before the friction wires can fire the composition in the igniter cups. The coated ends of the igniter wires are formed in the shape of a helix, and in operation the helix must straighten out as the wires are drawn through the igniter cups, thus adding more resistance to the movement of the igniter wires. The twisted ends of the friction wires are run through a ring fastened to the firing cord and are attached to a staple secured to the partition cup.

Both time-train rings are loaded with compressed fuse powder, sealed with fire clay loaded into the fuze rings under pressure. The time trains of both rings burn both ways from the point of ignition

to a flash hole which is opposite the point of ignition. Thus, in effect, each time ring has two separate delay elements. A piece of quickmatch is used to ignite the upper time-train ring from the flame produced by the friction igniters. The flame from the upper ring is relayed to the lower ring by another piece of quickmatch. The time-train rings are separated by a spacer to facilitate venting. The lower ring contains a base charge which consists of 50 grains of grade A4 black powder. The ignition of this charge ignites the flashlight powder charge.

Operation. The outer cover is first removed; then the bomb is installed in the plane. The swivel loop on the end of the hangwire is secured to the arming pawl of the releasing device. When the bomb is released, the resulting jerk on the hangwire removes the hangwire container. As the bomb continues to fall, the friction igniters are fired by means of a jerk on the firing cord. The jerk removes the phosphorus coated ends of the friction wires from the igniter cups. The free ends of the friction wires slip through the ring on the firing cord and the bomb is free from the plane. The hangwire and firing cord remain attached to the releasing device. The hangwire container, which is not permanently attached to the hangwire, falls to the ground. The hangwire container is designed to automatically detach itself from the hangwire to prevent the container from battering the plane due to the force of the air stream. Because the twisted ends of the friction wires are secured to the partition cup, the wires remain with the bomb.

The flame from the friction igniters is picked up by the first length of quickmatch, and transmitted to the upper time-train ring. This ring burns in both directions around to the flash hole, where the flame is picked up by the second strip of quickmatch and carried to the lower time-train ring. This ring also burns in both directions to its flash hole where the flame passes through to ignite the black powder base charge. The blast from the base charge ruptures the adapter cup and ignites the flashlight powder charge. The time of delay of the fuze is 15 seconds.

The bomb burns for 0.16 second with a maximum candlepower of 303,000,000, and an average candlepower of 84,840,000.

BOMB, PHOTOFLASH, M46.

Use. For high-altitude night photography.

Description. Length = 45½ inches; diameter = 8 inches; weight = 51.9 pounds. Contents = 25 pounds flashlight powder; maximum candlepower = 1,000,000,000.

Construction. This photoflash bomb is equipped with the M111 Mechanical Time Flare Fuze which permits the function of the bomb

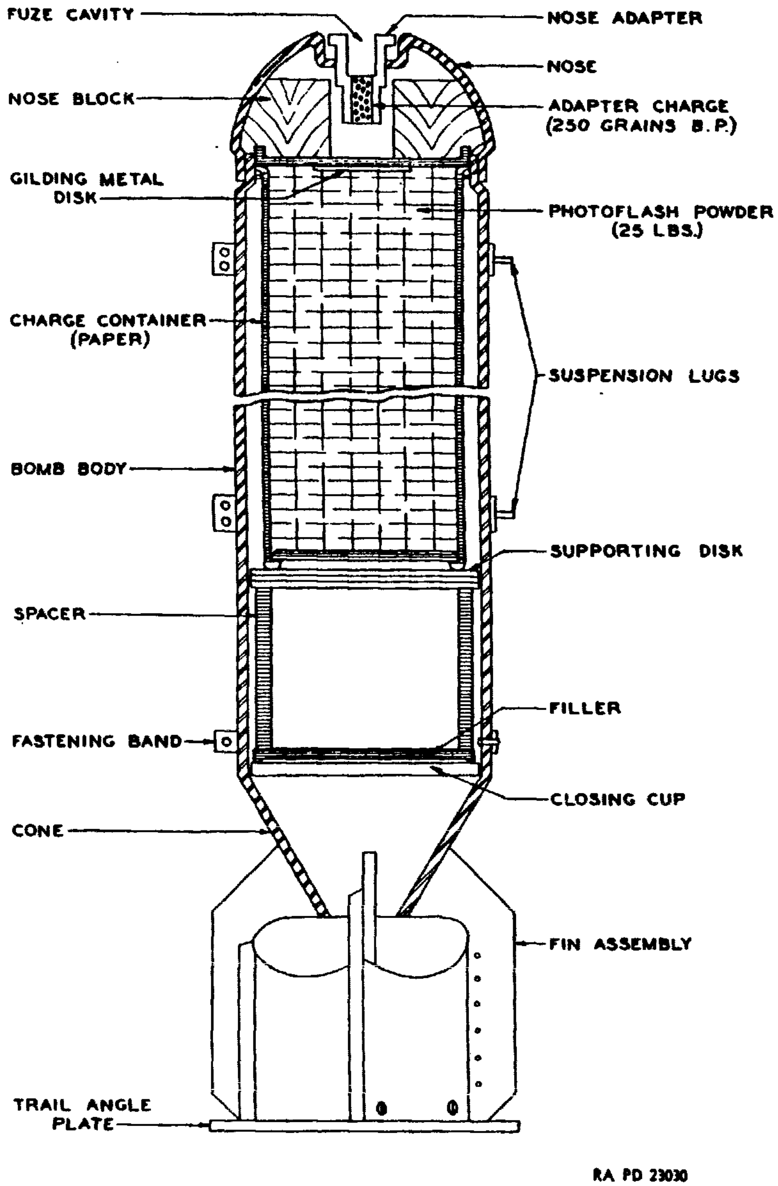


Figure 284 — BOMB, Photoflash, M46

at 3,000 feet when released from aircraft at any altitude up to 20,000 feet.

In appearance, the bomb resembles the 100-pound, M47 Chemical Bomb. It consists of a thin sheet steel cylindrical body to which a rounded nose and tail assembly are attached.

Into the nose section of the bomb is welded a steel nose adapter having a fuze cavity for the M111 Pyrotechnic Fuze, and containing in its base an explosive charge of 140 grains of black powder. Inside the bomb body, and directly below the adapter charge, is the cardboard container with 25 pounds of photographic flashlight powder. The top of this container is closed with a thin gilding metal disc, and the bottom is closed with crimped, sheet metal terneplate. This charge container is only 24 inches long and does not fill the entire bomb body. It rests on a plywood supporting disc which is held by a cardboard spacer in its proper place with respect to the strawboard filler and the sheet metal body closing cup.

The tail assembly is spot-welded together, and to the sheet metal cone section. The cone is attached to the rear end of the bomb body by means of three slotted grooves which lock around corresponding riveted lugs on the bomb body, and is held there by the fastening band. Attached across the back of the fin assembly is the flat trail angle plate, held by two ¼-inch carriage bolts running through the fins.

Operation. After proper fuzing and the insertion of the arming wire, the bomb is suspended in the bomb rack by use of a standard B-7 type shackle attached to the suspension lugs.

On release from the plane, the fuze arms in several seconds, and then functions at the predetermined time according to the altitude of the plane. When the fuze functions, the 70-grain black powder booster in the fuze sets off the 140-grain adapter charge in the bomb. The pressure set up by the adapter charge ruptures the gilding metal disc and ignites the flashlight powder charge.

TYPES OF SIGNALS.

General. Of the original class of aircraft signals, all except the SIGNAL, aircraft, red star, parachute, M11 have been reclassified as standard for issue only, while the M11 is still standard for issue and manufacture.

In January 1942, the Ordnance Department standardized a series of signals now referred to as the "Interim" type. This series consisted of six double star and three single star signals.

1. SIGNAL, aircraft, double star, Red-red, AN-M28.

2. SIGNAL, aircraft, double star, Yellow-yellow, AN-M29.

3. SIGNAL, aircraft, double star, Green-green, AN-M30.

4. SIGNAL, aircraft, double star, Red-yellow, AN-M31.

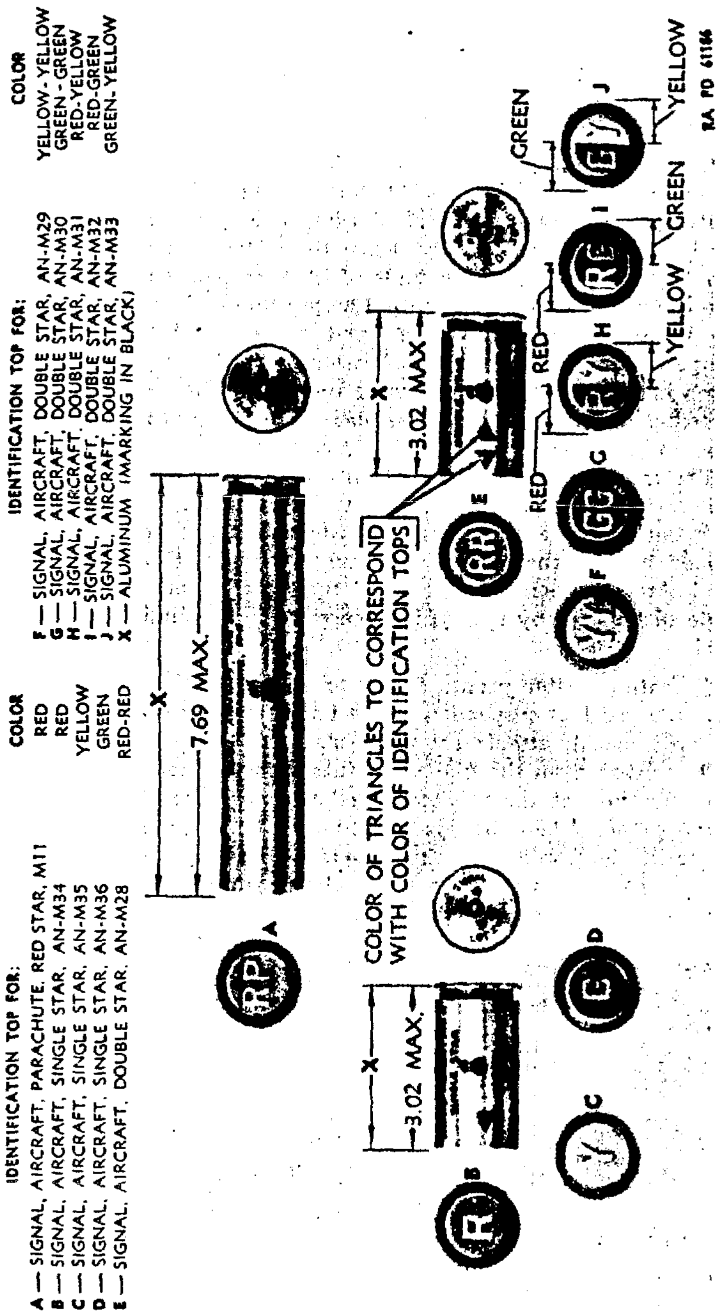


Figure 285 — Aircraft Signals

5. SIGNAL, aircraft, double star, Red-green, AN-M32.
6. SIGNAL, aircraft, double star, Green-yellow, AN-M33.
7. SIGNAL, aircraft, single star, Red, AN-M34.
8. SIGNAL, aircraft, single star, Yellow, AN-M35.
9. SIGNAL, aircraft, single star, Green, AN-M36.

These signals consisted of a star composition loaded in an aluminum cup and contained within an aluminum barrel, with dimensions of 3.02 by 1.56 inches. They were designed to be fired from the M2 Pyrotechnic Pistol. Each star composition burned for 7 seconds, with the candlepower depending upon the color of the star.

In April 1942, the "Interim" type signals were declared limited standard, and the "Final" type series signals were standardized to replace the "Interim" type.

The "Final" type signals closely resemble the British aircraft signals.

These signals are assembled in a shotgun type shell of cartridge paper with a brass head. The signal cartridge is 3.85 inches in length by 1.537 inches in diameter. They are designed for use in the breech loading PISTOL, pyrotechnic, AN-M8. Upon firing, the propelling charge ignites and projects either one or two freely falling stars, which burn from 7 to 13 seconds. The candlepower depends upon the color of the star.

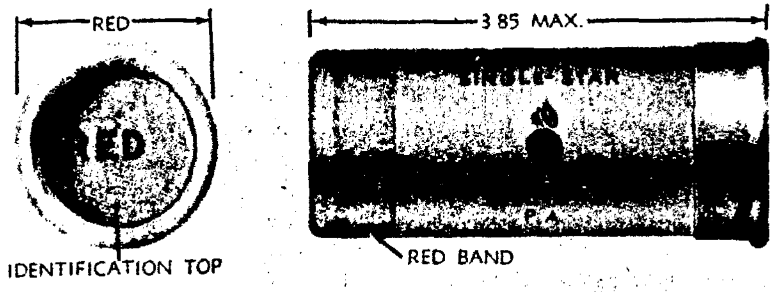
Included in the "Final" type series are also six double star and three single star signals.

1. SIGNAL, aircraft, double star, Red-red, AN-M37.
2. SIGNAL, aircraft, double star, Yellow-yellow, AN-M38.
3. SIGNAL, aircraft, double star, Green-green, AN-M39.
4. SIGNAL, aircraft, double star, Red-yellow, AN-M40.
5. SIGNAL, aircraft, double star, Red-green, AN-M41.
6. SIGNAL, aircraft, double star, Green-yellow, AN-M42.
7. SIGNAL, aircraft, single star, Red, AN-M43.
8. SIGNAL, aircraft, single star, Yellow, AN-M44.
9. SIGNAL, aircraft, single star, Green, AN-M45.

Color Identification.

Original type. The color of the star is shown on the closing or identification top of the outer case. In the one signal that is now standard, the top is painted red to illustrate the color of the star, and the top is also embossed with the letters "RP" to make identification possible at night. "R" signifies red, and "P" signifies parachute.

Interim type. In the "Interim" type of signal, the closing top is painted the same as in the original type. For the single stars, the top is a solid color of the same color as the star, and is embossed with a letter also corresponding to the color. In the double stars, the



RA PD 23031

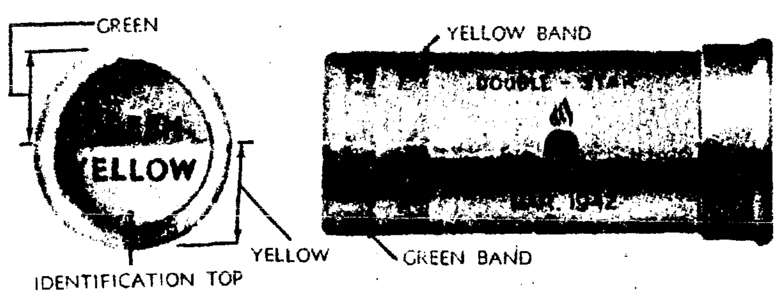
Figure 286 — SIGNAL, Aircraft, Single Star, AN-M43

top is painted to represent the color of the stars with each half taking the color of one of the stars; in addition, the letters which correspond to the colors are embossed in their proper colors.

In addition to the marking of the closing top, the barrel itself is marked with colored bands to represent the color of the star. In the single star signals, one band is used and is ½ inch wide. In the double star signals, two bands are used, each being ¼ inch wide and ¼ inch apart. Each band is the color of the star it represents.

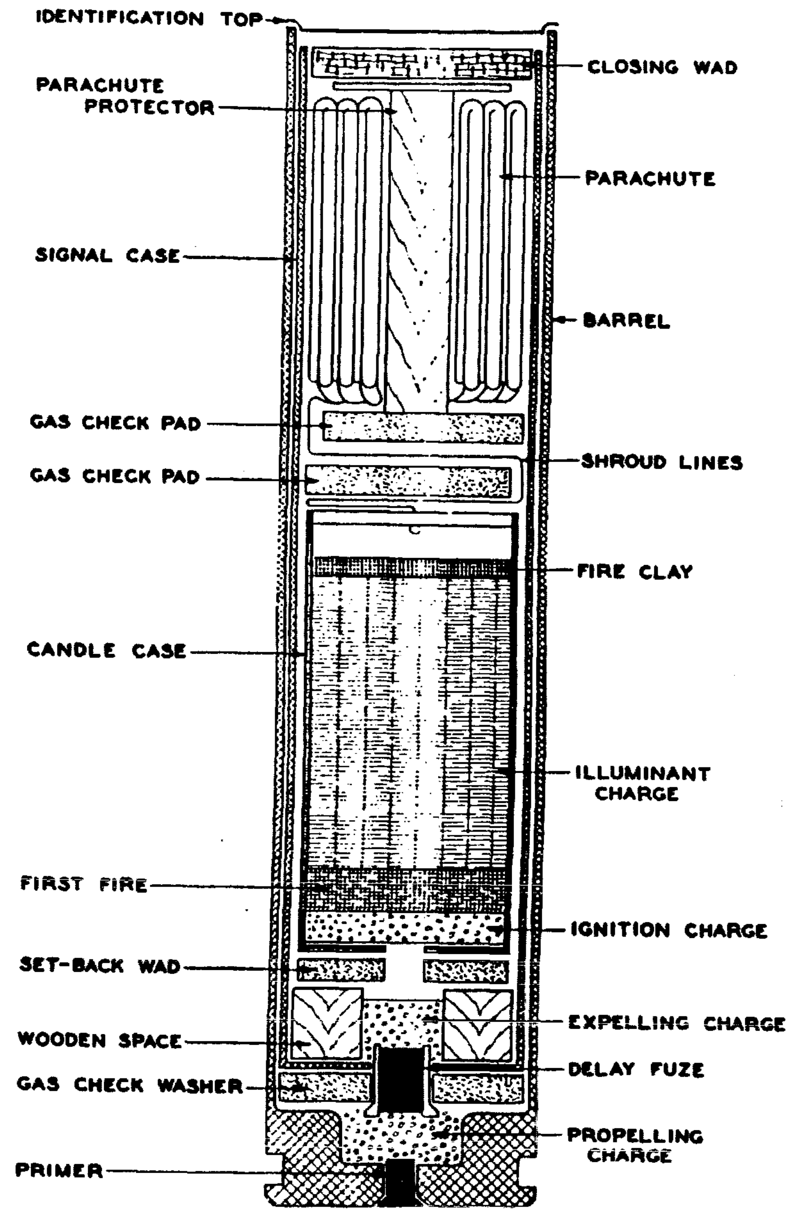
Final type. The "Final" type of signals is marked at the top in the same manner as the "Interim" type except that the word of the color is spelled out and is printed instead of being embossed. The barrels are marked in the same manner as the "Interim" type signals.

By means of these identification features it is possible to determine the type and color of the signal, even should the standard stenciling and nomenclature be obliterated.



RA PD 23032

Figure 287 — SIGNAL, Aircraft, Double Star, AN-M42



RA PD 23033

Figure 288 — SIGNAL, Aircraft, Red Star, Parachute, M11

SIGNAL, AIRCRAFT, RED STAR, PARACHUTE, M11.

Use. For signaling from aircraft to other aircraft, or from aircraft to ground units. Also used as a distress signal when fired from a grounded plane.

Description. Length = 8 inches; diameter = 1½ inches; weight = 9½ ounces; burning time = 30 seconds; candlepower = 30,000.

Construction. This signal is constructed with an outer case of aluminum, known as the barrel, which is closed at one end with a metallic closing cap. At the other end, which is permanently closed in manufacture, is a percussion primer. Also around the base is an annular groove which serves to lock the signal in the projector. Inside the barrel is a black powder propelling charge which is held in a recess in the base and in contact with the primer.

Within the barrel is the signal case which is also constructed of aluminum. At the base of the signal case is the exposed end of the fuse train and a gas-check washer. Inside the signal case, at the base, is a wood spacer enclosing the inner end of the fuse train and holding an expelling charge of black powder. Above the wood spacer is a set-back wad of black felt upon which the candle case rests. Directly on top of the candle case are a pair of felt gas check pads, and a parachute of either cloth or paper. This parachute is held around a wood spacer known as the parachute protector. The signal case is closed with a cork closing wad.

The candle case is of paper with the lower end open in the center to expose the ignition charge. Following the ignition charge is a first fire charge, and finally the signal composition itself. Above the signal composition is a fire clay seal which protects the shrouds from being ignited.

Operation. The signal is locked in the projector and the trigger is squeezed causing the firing pin to strike the percussion primer. The flame from the primer ignites the propelling charge of black powder which propels the signal case into the air and ignites the exposed end of the delay fuse. This fuse burns for 2½ seconds and then ignites the expelling charge. The gas-check washer at the base of the signal case prevents the escape of the gases around the signal case and thus insures the maximum efficiency of the propelling charge.

When the fuse ignites the expelling charge, the candle and parachute are expelled into the air, and the exposed ignition charge is ignited. The set-back wad between the wood spacer and the candle serves to prevent the candle from being crushed due to the force of set-back. The gas-check pads between the candle case and the parachute serve to prevent the escape of gases past the candle, protect the parachute from fire, and cushion the upward thrust on the parachute and the wooden parachute protector. The wooden parachute

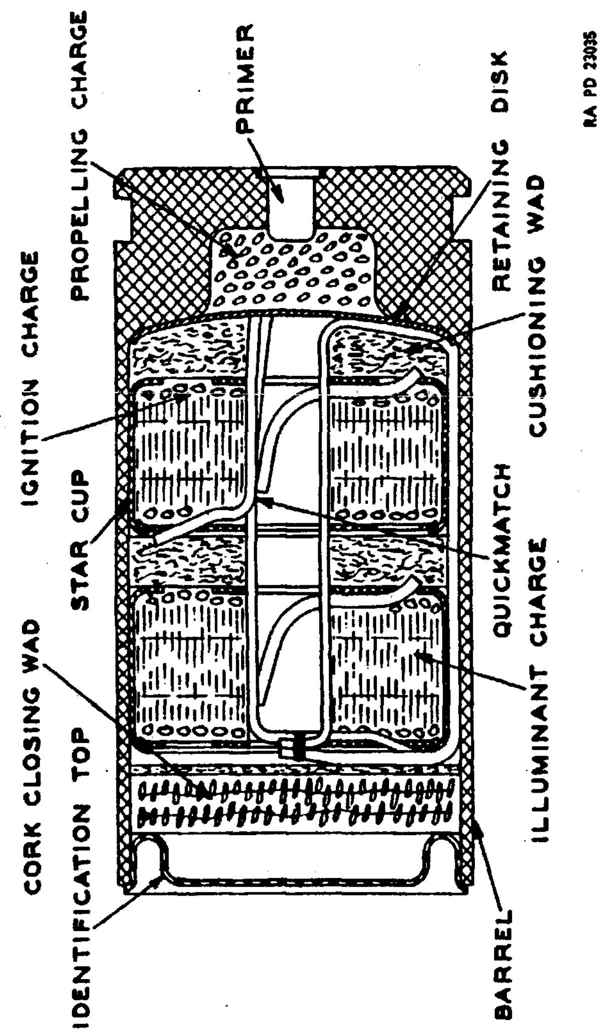


Figure 289 — SIGNAL, Aircraft, Double Star ("Interim") Type

protector pushes out the cork closing wad, and the parachute and candle follow.

With the ignition of the ignition charge which in turn ignites the first fire charge, the burning train is initiated. The first fire charge insures the ignition of the signal composition which burns for approximately 30 seconds with a candlepower of 30,000.

SIGNAL, AIRCRAFT, DOUBLE STAR, AN-M28 to AN-M33 ("INTERIM" TYPE).

Use. For signaling from aircraft to other aircraft or to ground units.

Description. Length = 3.02 inches; diameter = 1.56 inches; weight = 5 ounces; burning time = 7 seconds.

Construction. There are six of the signals, aircraft, double star, of the so-called "Interim" type. They are similar to each other, varying only in the color and candlepower of the stars. The assembly consists of a pair of stars housed in an aluminum barrel, tied together with a length of quickmatch, and separated from each other by a cushioning wad. The aluminum barrel is grooved at the base to fit in the M2 Pyrotechnic Pistol, and contains in its base a primer and a propelling charge of black powder. This is held in place by an onionskin retaining disc.

Each of the stars consists of an aluminum cup filled with illuminant charge which is coated, top and bottom, with a layer of black powder ignition charge. The top and bottoms of the star cups are perforated with six holes, in addition to the large central hole running entirely through the stars. Through these holes are threaded lengths of quickmatch which run from the ignition charge on the face of each star to the top of the propelling charge. The stars are held in the barrel by the cork closing wad and the identification top. This identification top is made from thin sheet metal and has two letters embossed into it which describe the color of the stars; it is painted correspondingly.

Operation. The signal is locked in the pyrotechnic pistol and the trigger is squeezed, causing the firing pin to hit the primer. The flame from the primer ignites the propelling charge, which ignites the quickmatch and propels the stars from the barrel. The quickmatch, in turn, ignites the ignition charges on the tops and bottoms of the stars, and these in turn cause the signal composition to become fully ignited.

The flaming stars fly through the air, burning for about 7 seconds each.

SIGNAL, AIRCRAFT, SINGLE STAR, AN-M34 TO AN-M36 ("INTERIM" TYPE).

Use. For signaling.

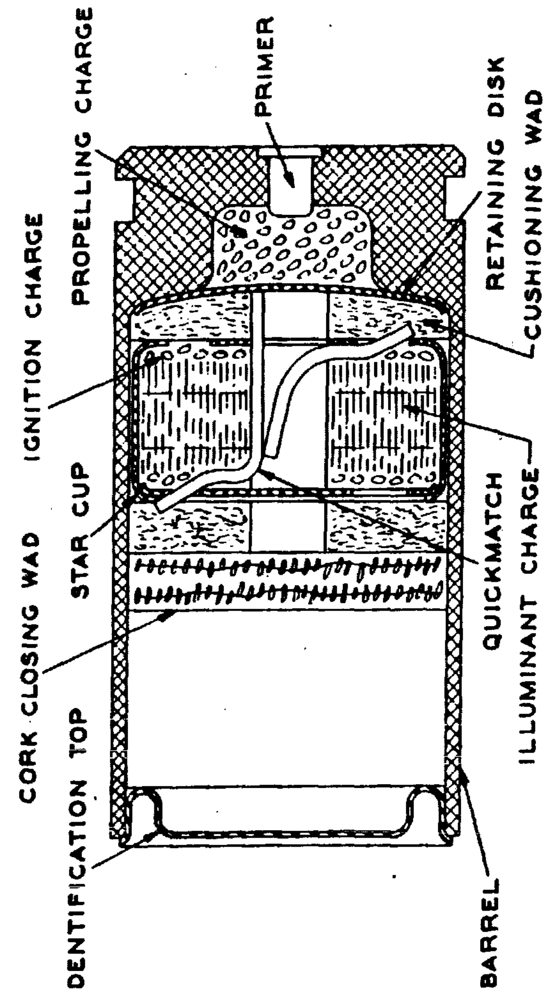


Figure 290 — SIGNAL, Aircraft, Single Star ("Interim" Type)

Description. Length = 3.02 inches; diameter = 1.56 inches; weight = 5 ounces; burning time = 7 seconds.

Construction. There are three of the signals, aircraft, single star of the so-called "Interim" type. They are similar to each other, varying only in the color and candlepower of the star. The assembly consists of a star housed in an aluminum barrel, protected by cushioning wads, and held in place by the cork closing wad. The star consists of an aluminum cup filled with illuminant charge which is coated, top and bottom, with black powder ignition charge. The top and bottom of the star cup are perforated with six holes in addition to the large central hole running entirely through the star. Through these holes are threaded lengths of quickmatch running from the ignition charge on the face of the star to the top of the propelling charge. The propelling charge consists of black powder and is housed in the barrel underneath the onionskin retaining disc in contact with the primer. The top of the barrel is closed with an identification top which is painted the same color as the signal, and which has a corresponding letter embossed in it.

Operation. The signal is locked in the pyrotechnic pistol and the trigger is squeezed, causing the firing pin to hit the primer. The flame from the primer ignites the propelling charge, which ignites the quickmatch and propels the star from the barrel. The quickmatch, in turn, ignites the ignition charges on the top and bottom of the star, and these in turn cause the signal composition to become fully ignited.

The flaming star flies through the air, burning for about 7 seconds with the candlepower depending upon the color of the star.

SIGNAL, AIRCRAFT, DOUBLE STAR, AN-M37 TO AN-M42 ("FINAL" TYPE).

Use. For signaling.

Description. Length = 3.85 inches; diameter = 1.537 inches; weight = 6.4 ounces; burning time = 7-13 seconds.

Construction. There are six of the signals, aircraft, double star, of the "Final" type. They are similar to each other, varying only in the color and candlepower of the stars. The assembly consists of two stars housed in a cardboard signal case, protected by cushioning wads, and tied together with quickmatch. Each star consists of an aluminum cup filled with illuminating charge which is coated, top and bottom, with black powder ignition charge. The top and bottom of each star cup are perforated with six holes, in addition to the large hole running entirely through the center of the stars; through these holes are threaded lengths of quickmatch running from the ignition charge on the faces of the stars to the top of the propelling

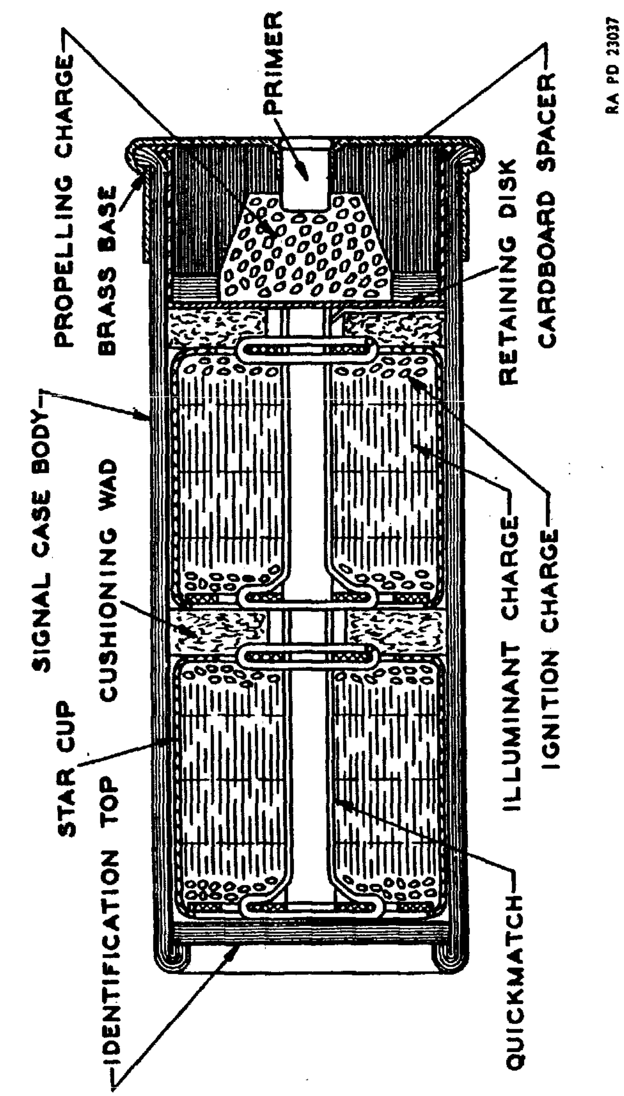


Figure 291 — SIGNAL, Aircraft, Double Star ("Final" Type)

charge. The propelling charge consists of black powder and is housed in a cardboard spacer inside the signal case underneath an onionskin retaining disc, and is in contact with the primer. The bottom of the signal case is reinforced by a thin brass base which provides a rim for seating the signal in a projector.

The top of the signal case is closed by a 360-degree, crimp-fastened, cardboard identification top which is colored correspondingly to the color of the signal.

Operation. The signal is inserted into the breech of the pyrotechnic pistol, and the trigger is squeezed, causing the firing pin to hit the primer. The flame from the primer ignites the propelling charge, which ignites the quickmatch and propels the stars from the signal case. The quickmatch, in turn, ignites the ignition charges on the tops and bottoms of the stars, and these cause the signal composition to become fully ignited.

The flaming stars fly through the air, burning for 7 to 13 seconds each, with the candlepower depending on the color of the star.

SIGNAL, AIRCRAFT, SINGLE STAR, AN-M43 TO AN-M45 ("FINAL" TYPE).

Use. For signaling from aircraft to other aircraft, or to ground units.

Description. Length = 3.85 inches; diameter = 1.537 inches; weight = 6.4 ounces; burning time = 7-13 seconds.

Construction. There are three of the signals, aircraft, single star of the "Final" type. They are similar to each other, varying only in the color and candlepower of the star. The assembly consists of a star housed in a cardboard signal case protected by cushioning wads, and held in place by a spacer and a spacer disc. The star consists of an aluminum cup filled with illuminant charge which is coated, top and bottom, with black powder ignition charge. The top and bottom of the star cup are perforated with six holes, in addition to the large central hole running entirely through the star; through these holes are threaded lengths of quickmatch running from the ignition charge on the face of the star to the top of the propelling charge. The propelling charge consists of black powder, and is housed in a cardboard spacer inside the signal case underneath an onionskin retaining disc, and is in contact with the primer. The bottom of the signal case is reinforced by a thin brass base which provides a rim for seating the signal in the projector. The top of the signal case is closed by a 360-degree, crimp-fastened cardboard identification top which is colored corresponding to the color of the signal.

Operation. The signal is inserted into the breech of the pyrotechnic pistol and the trigger is squeezed, causing the firing pin to

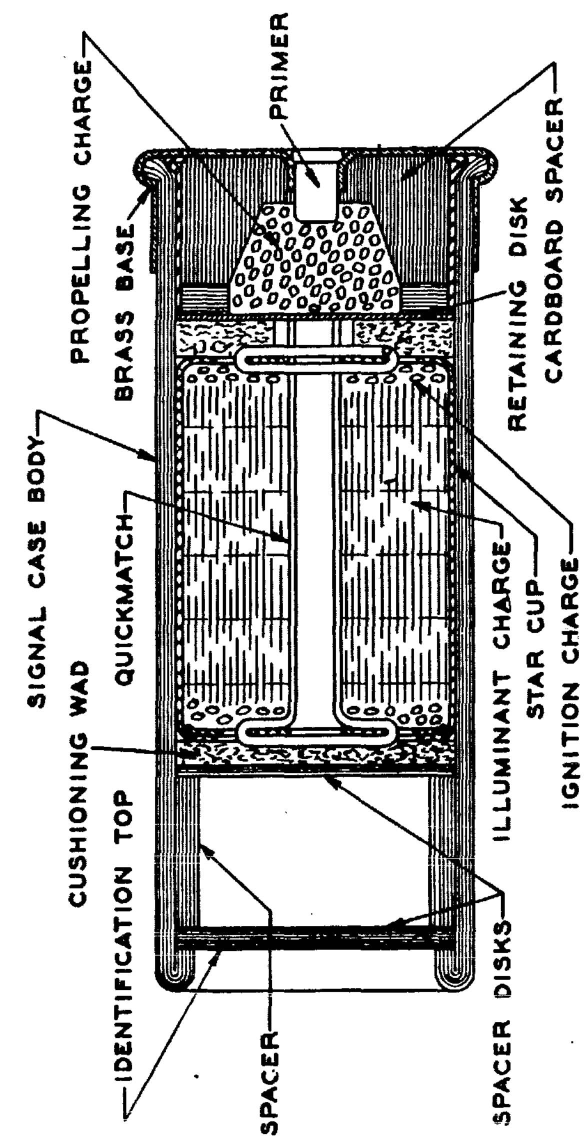


Figure 292 — SIGNAL, Aircraft, Single Star ("Final" Type)

strike the primer. The flame from the primer ignites the propelling charge which ignites the quickmatch, and propels the star from the signal case. The quickmatch, in turn, ignites the ignition charges on the top and bottom of the star, and these cause the signal composition to become fully ignited.

The flaming star flies through the air, burning for about 7 to 13 seconds, with the candlepower depending on the color of the star.

GROUND SIGNALS.

General. Ground signals are designed to be fired from the PROJECTOR, pyrotechnic, M1, M3, or M4. They are similar to the aircraft signals in construction, except that the signal case closing cap carries a tail and fin assembly to improve flight characteristics. The fin is marked by painting and embossing for identification purposes.

Operation is similar to that for the aircraft signals except that the signal case is projected from the fixed barrel of the projector instead of from an individual removable barrel as is the case with aircraft signals. The signal is fired by the impact of the signal primer with the firing pin of the projector. In the case of the PROJECTOR, pyrotechnic, M1, the firing pin is operated by a pull on the lanyard. In the case of the PROJECTOR, pyrotechnic, M3 or M4, the projector is struck smartly on the ground, thus driving the signal primer against a fixed firing pin.

SIGNAL, GROUND, WHITE STAR, PARACHUTE, M17.

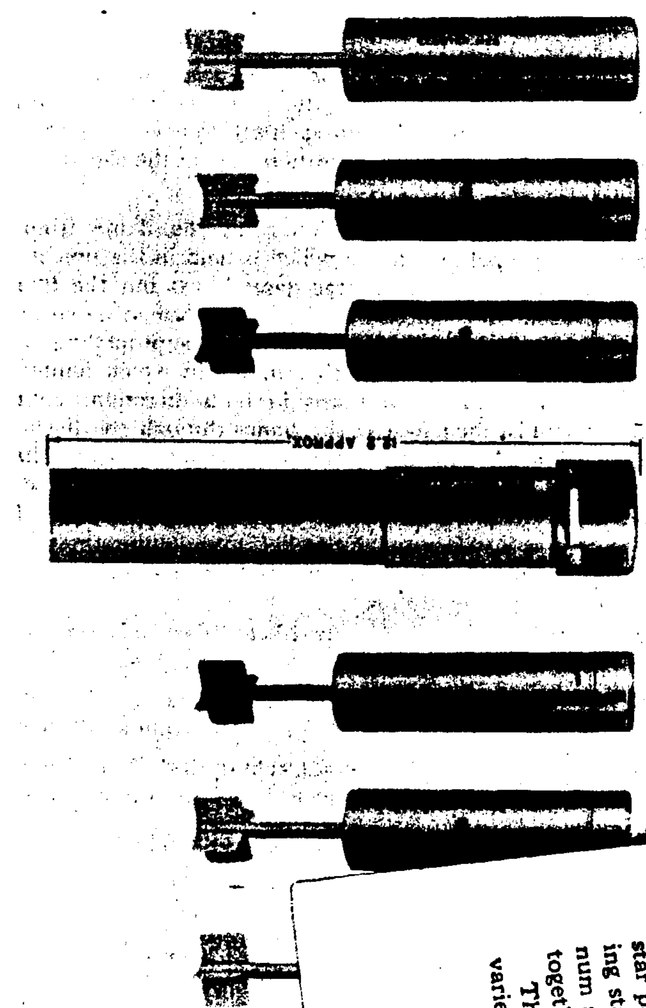
Use. For signaling from ground units to other ground troops, or to aircraft.

Description. Length = 9 inches; diameter = 1½ inches; candlepower = 20,000; burning time = 20 to 30 seconds.

Construction. The signal case is a drawn aluminum body closed at one end by a fuze housing which is attached by four crimps. This fuze housing is chambered to hold the propelling charge of Herco powder. A breech cap, which screws on the fuze housing, holds the propelling charge in place, and also provides a seat for the percussion primer.

The upper end of the fuze housing contains a circular time-train groove filled with black powder and covered with a fire clay seal except for the pellet of black powder which extends through the seal.

Inside the signal case, on the inner surface of the fuze housing, is an expelling charge of black powder connected to the fuze train by means of a flash hole in the fuze housing. This expelling charge is held in place by means of an onionskin retaining disc. Above the retaining disc is a set-back wad of black felt which is open in the center to allow the passage of the flame. Resting on the set-back wad



RA PD 4001

Figure 293 — Ground Signals and Projector

is the candle case which is covered by the gas-check washer of black felt. Over this may be found the parachute of cloth or paper; the wooden parachute protector around which the parachute is wound; the cardboard closing disc; and finally, the tail and fin assembly which closes the signal case.

The candle case itself is of cardboard, with the end nearest the expelling charge closed by means of an aluminum cap which is perforated. A strip of quickmatch is inserted into the cap. The ignition charge follows the quickmatch and is itself followed by the first fire charge and then the signal composition. Above the signal composition is a fire clay seal.

Operation. When the projector functions, the flame from the primer ignites the propelling charge which is held in the breech cap. The pressure of the propelling charge gases blows out the four recesses in the breech cap, and causes the signal case to move out of the projector. At the same time, the flame from the propelling charge ignites the black powder pellet of the time-train which ignites the time-train itself. The time-train burns in both directions giving a delay of 5½ seconds, then flashes the flame through the flash hole to the expelling charge. This delay allows the signal to reach a height of approximately 600 feet. When the expelling charge is ignited, the pressure of the gases forces the candle and parachute assembly from the signal case, and at the same time the flame ignites the strip of quickmatch. This ignites the ignition charge, then the first fire charge, and finally the signal composition.

The candle burns for approximately 20 to 30 seconds with a candlepower of 20,000 while suspended from the parachute.

NOTE: At about 100 feet, the signal flips over so that the tail and fin assembly act to stabilize the flight for the remaining 500 feet.

Other Ground Star Signals. In addition to the White Star Parachute Signal M17, the following are at present also standard for issue and manufacture:

SIGNAL, ground, white star, cluster, M18.
SIGNAL, ground, green star, parachute, M19.
SIGNAL, ground, green star, cluster, M20.
SIGNAL, ground, amber star, parachute, M21.
SIGNAL, ground, amber star, cluster, M22.

The cluster type signals function in the same manner as the single star parachute type with the exception that there are five freely falling stars that make up the cluster. These are each held in an aluminum star cup similar to those studied in the aircraft signals, and tied together with quickmatch.

The candlepower and burning rate for each of the above signals varies with the color of the star.

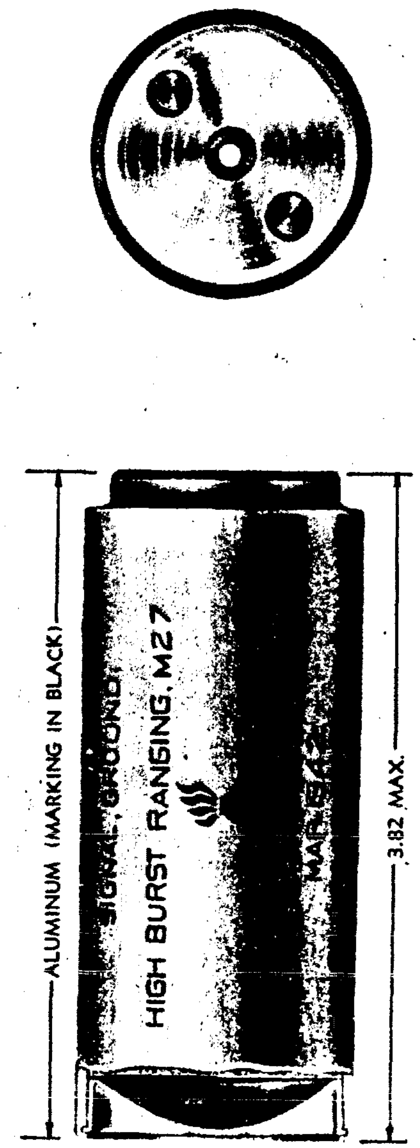


Figure 294 — SIGNAL, Ground, High Burst Ranging

MISCELLANEOUS PYROTECHNICS.

SIGNAL, Ground, High Burst Ranging, M27. This type of signal produces a smoke puff at the top of its rise and is used to simulate the high burst of artillery shell. It is fired from the M1A1 Projector and rises to an altitude of approximately 550 feet.

Further information is not available for publication at this time.

SIGNAL, Drift, Day, AN-Mk. I. This signal consists of a streamlined clay shell containing a metallic powder. When the signal is dropped in water the shell breaks, allowing the metallic powder to form a slick on the surface, which may be used as a reference point for air navigation.

The shell is a waterproof clay, 1/16 inch thick. The nose is of hemispherical shape, 3½ inches in diameter, and the body tapers over its 10-inch length to a blunt point. The cone of the tail has four clay fins formed integral with it, which tend to stabilize the flight of the signal. Because the clay shell is fragile, these signals should be handled with care to prevent their destruction.

SIGNAL, Drift, Night, AN-Mk. IV. This signal is torpedo-shaped and consists of a bronze hemispherical nose, a wood body tapered at the rear, and an aluminum alloy tail fin assembly. It is designed to float in water in a vertical position with the nose submerged. The wooden body is hollow and contains the first fire composition and the pyrotechnic pellet. The fuze functions when the signal strikes the water surface and ignites the first fire composition, which in turn ignites the pyrotechnic pellet. It burns out of the tail and projects a flame which may be used as a reference point for air navigation at night.

GRENADE, Hand, Smoke, HC, M8. While this round is discussed under its proper heading of grenades, it should be kept in mind that it has one use in the field of pyrotechnics in that it is issued to the Air Corps for use as an emergency distress signal.

HANDLING.

All pyrotechnics should be protected against moisture, continued high temperatures, and sudden fluctuations in temperature. If exposed to moisture they should be segregated until examination can be made to show if the pyrotechnic is still serviceable or if any dangerous conditions exist.

All pyrotechnics should be handled with care to prevent the possibility of functioning the friction igniters or of setting off the pyrotechnic compositions in cases such as the photoflash bomb. Care should also be exercised to prevent damage to the cases, especially in the instance of those fired from a projector, where a damaged

case might cause a round to become lodged in the bore of the projector.

It should be kept in mind at all times that photoflash powder is as hazardous as black powder.

STORAGE.

Pyrotechnics should be stored in a dry, well ventilated place, out of the direct rays of the sun, and should be protected against excessive or variable temperatures. Pyrotechnics should not be stored with other kinds of ammunition, except small-arms ammunition. When storage space is limited, pyrotechnics, except photoflash bombs, may be stored with burning type chemical ammunition (group D) provided the total quantity of pyrotechnic, chemical, and explosive material in the magazine does not exceed 1,000 pounds. Photoflash bombs may not be stored with other types of ammunition except under conditions of limited storage space when they may be stored in one magazine with small-arms ammunition, provided the total amount of explosives and flashlight powder does not exceed 1,000 pounds. Red and green light compositions may explode under certain conditions and hence should be stored separately if practical. Certain pyrotechnics deteriorate in storage and have an expiration date on the containers. Care should be taken to observe the directions for disposal of this material at the time indicated as prescribed in OFSB 3-9.

FIRE.

Pyrotechnics such as photoflash bombs and high burst ranging signals explode when heated, but most types burn with an intense heat and without serious explosions. Water should not be used to combat fires involving material containing magnesium.

FURTHER REFERENCES: OS 9-18, Volume 3; TM 9-1981; OFSB 3-9; SNL S-5; O.O. No. 7224; Ordnance Sergeant, September 1942 and December 1942.

SECTION IX.

DESTRUCTION OF UNUSABLE AMMUNITION AND EXPLOSIVES

Chapter 1

Introduction

UNUSABLE AMMUNITION.

The term "unusable" has replaced the term "unserviceable" with regard to destruction because it gives a better understanding of what materials are destroyed. Unserviceable ammunition and explosives are those that are in such a condition as to render them unfit for their intended purposes. Unusable components include those that are unfit for their intended purposes and cannot be used to advantage for any other purpose. Unusable ammunition or explosives may include the following:

Items of faulty manufacture. Materials which have failed to pass inspection.

Deteriorated materials. Deterioration has rendered them unsafe or ineffective.

Damaged components. Ammunition damaged beyond repair during manufacture, shipment or storage.

Obsolescent materials. Outdated ammunition or explosives which have been replaced by newer materials and which are made ineffective or detrimental by changes in methods of warfare.

Captured materials. The conversion of some captured ammunition for use by friendly troops is considered unfeasible.

Duds. Ammunition that has been properly initiated and has failed to function, but may function at any time.

SALVAGE.

Only ammunition or explosives that cannot be economically salvaged are destroyed. Salvage is a reclaiming rather than a destruction operation. For this reason, salvage operations will not be included in this chapter. It should also be recognized that during times of war certain materials, particularly metals, take on such strategic value as to become priceless. Under wartime conditions, cost would not be considered in the salvaging of such materials.

SAFETY.

The dangerous nature of explosives makes safety the major consideration in their destruction. They are made immeasurably more dangerous by deterioration because the sensitivity of such explosives

is usually increased. Safety must not be sacrificed for cost reduction and speed. There are cases on record of explosions which destroyed property worth much more from the standpoint of dollars and cents and the time necessary for replacement than could be saved through several years of relaxation of certain fundamental safety rules. This is to say nothing of lives that were lost and could not be replaced. Investigations of such explosions almost invariably bring out evidence indicating negligence or disregard of some safety precaution.

Every person engaged in an explosive operation should feel that it is his or her duty to see that pertinent safety regulations are enforced. There is a tendency among personnel to become less respectful of explosives upon observing that rough handling does not always result in an explosion. It should be remembered that explosives are fickle and when treated in certain disrespectful ways will respond violently. This fact, along with safety rules applicable to the item and operation, should always be pointed out to persons caught handling explosives carelessly.

The Ordnance Safety Manual and TM 9-1900 contain regulations for the safe handling of the various classes and types of ammunition and explosives. These rules, where applicable, will be observed in addition to the specific safety regulations presented in this chapter.

RESPONSIBILITY AND PROCEDURE.

General. Usually the ammunition inspector is given the responsiability for the disposition and actual destruction of unserviceable ammunition and explosives at ordnance establishments. Whenever ammunition or explosives are discovered to be unserviceable, the ammunition inspector will prepare and submit an Ammunition Condition Report (O.O. Form 7235) to the Office of Chief of Ordnance.

The Ammunition Condition Report (A.C.R.). This will include the following in the order given:

1. The number of the station the report is sent from in the block in upper left-hand corner.

2. The number assigned to the report for filing purposes in the block in the upper right-hand corner.

3. Complete standard nomenclature of the item in question.

4. The lot number assigned to the item.

5. The name of the station.

6. The date the report is written.

7. The quantity of components in the lot.

8. The number of components inspected.

9. The number of components found to be unserviceable.

10. A brief, concise, yet complete explanation of the reason or rea-

Station No. 465

AMMUNITION CONDITION REPORT

O. O. No. 10460

Item Shell, semi-fixed, gas, persistent, HS, M64, w/FUZE, P.D., M57, 75-mm how., M1 & M1A1 Lot No. E.A. 475-16

Station Delaware Ordnance Depot Date 5-16-42 Quantity in lot 5000

Number inspected 5000 Number found unserviceable 3

The unserviceability of the items covered by this report was not due to fault or neglect.

Reasons for unserviceability:

Three (3) rounds leaking slightly at nose from burster well casing. Recommend immediate local destruction.

Signature of Commanding Officer
(Signature)

FIRST ENDORSEMENT

Ordnance Office, ______ Date ______

(Signature)

SECOND ENDORSEMENT

SAMPLE

War Department, Ordnance Office, Date 5-20-42

Recommendation approved.

Signature of Ordnance Officer.
Ordnance Department, Assistant.

THIRD ENDORSEMENT

Delaware Ordnance Depot Date 5-25-42

1. It is advised that the above-authorized work has been completed, in accordance with the second indorsement.

Signature of Commanding Officer
(Signature)

O. O. Form 7885
Revised 1939

(SAMPLE)

RA PD 23038

Figure 295 — Condition Report—Obverse

INSTRUCTIONS

1. This form will be used for unserviceable ammunition, components, and explosives. Ammunition, components, and explosives will be considered unserviceable when they cannot be safely and effectively used for their intended purpose.

2. When ammunition becomes unserviceable by reason of fault or neglect, the statement to the contrary on reverse side will be lined out, and this report will be accompanied by a report of survey fixing responsibility.

3. Prepare a separate report for each lot involved, and forward in quadruplicate to the Chief of Ordnance, except that where the defects are common to several lots, a single Ammunition Condition Report will be used, enumerating by lot number the quantities involved. No letter of transmittal is required.

4. All information must be definite and complete, but as brief as possible. Do not list correspondence reference numbers in lieu of *full information; but make sure* that this report tells the whole story. Do not state that an item is "unserviceable" without adding why and to what extent. Quote test results when available. Modify descriptions of condition by indications of degree, such as "slight rust," "very heavy corrosion," "extreme exudation," etc.

5. Each report will be signed by or for the Commanding Officer or the station Ordnance Officer, and forwarded through the corps area or department Ordnance Officer, where applicable, for his recommendation.

6. Renovation plants will NOT use this form to report unserviceable ammunition or components resulting from renovation operations.

7. Instructions for disposition will be endorsed on the original report, which will be returned for the permanent files of the station. The Chief of Ordnance will be informed of completion of the authorized work by third endorsement on one copy of the report, thus closing the case.

8. When endorsement to this report orders the transfer of ammunition or ammunition components, two certified copies will be forwarded to the consignee with the shipping ticket.

9. See Section II, Circular No. 80, dated October 12, 1939, for use of this form as a property voucher.

THIS SPACE FOR CONTINUATION OF DESCRIPTION OF DEFECTS, AND FOR ORDNANCE OFFICE NOTES OR INSTRUCTIONS

RA PD 23039

Figure 296 — Condition Report—Reverse

sons for unserviceability.

11. Disposition may or may not be recommended. Such recommendation will facilitate the second indorsement, however. If recommendation for disposal is not made, the Office of the Chief of Ordnance will state the disposition and method in the second indorsement.

A sample of a completed Ammunition Condition Report is illustrated in figures 295 and 296. The person preparing the report should be sure to read the instructions shown on reverse.

When the basic A.C.R. is prepared as outlined above, it is sent to the Commanding Officer for his signature. It is then forwarded in quadruplicate to the Renovation and Surveillance Section, Office Chief of Ordnance. As many more copies as are required at the establishment will be made. The representative of the Chief of Ordnance will either state how the material is to be disposed of or will approve the ammunition inspector's recommendation for disposal by second indorsement. The first indorsement is used only in the case of Ports of Embarkation or Service Commands. After the second indorsement is made, the report is returned to the station and the material is disposed of as directed. The case is then closed by third indorsement stating that the work has been completed in accordance with the second indorsement and the form is returned to the Chief of Ordnance.

The only exception to this procedure is in the case of ammunition or explosives that are considered immediately dangerous to life and property. When this is true, the destruction may be authorized by the Commanding Officer of the establishment. The A.C.R. is then made out and the Office, Chief of Ordnance is advised in the basic report that the destruction has been completed.

METHODS OF DESTRUCTION.

Three general methods are authorized for the destruction of ammunition and explosives: detonation, also referred to as demolition or static firing; burning; and dumping at sea, establishments located near coasts may dump at sea. Burying or dumping into waste places, pits, wells, marshes, shallow streams or inland water ways is prohibited except as may be authorized under provisions of paragraphs 66a and 259d of the Ordnance Safety Manual for the disposition of black powder and chemical ammunition.

Chapter 2
Destruction by Detonation

GENERAL.

Ammunition components may be destroyed by initiating the explosive contained or by the force of explosion of explosive materials

placed in contact with the item. Components destroyed in such a manner are as follows:

Artillery projectiles
Aircraft bombs
Trench mortar shell
Antitank mines
Rockets
Offensive hand grenades
Rifle grenades
Fuzes, primers, detonators, boosters, and bursters
Photoflash bombs
Duds

One of two firing systems may be used to detonate the above items: the electric or the nonelectric systems.

THE NONELECTRIC FIRING SYSTEM.

The nonelectric firing system consists of a high explosive, a nonelectric blasting cap inserted into the explosive, and a length of miners' safety fuse inserted into the cap.

High Explosives. Detonation of ammunition components at ordnance establishments is accomplished with one of three explosives, TNT, nitrostarch, or dynamite. A fourth explosive, composition C, has been developed but information concerning it is not available at this time. However, it is of a plastic nature and may be molded to any shape.

Explosive, TNT, rectangular. TNT is issued in rectangular blocks, sometimes called "Triton" blocks, for destruction work. The blocks, as issued, weigh ½ pound and are 1¾ inches square by 3¼ inches long. Each block is incased in a cardboard container closed at both ends with lacquered tin. At one end is a cylindrical hole approximately 2⅛ inches deep to receive a blasting cap. This hole is covered with tissue paper. The blasting cap must not be forced through this paper; the paper should first be broken with a sharp piece of wood or similar instrument.

TNT blocks are "Standard" for destruction work because TNT most nearly fulfills the requirements of an ideal explosive for the task. It is comparatively insensitive in all forms. This characteristic makes a powerful detonating agent necessary. Fulminate of mercury will not positively detonate TNT so commercial blasting caps cannot be depended upon for its detonation. It may be positively detonated by special issue tetryl caps or detonating cord. TNT is insoluble in water and may be used for demolition work under water. A disadvantage is that explosion of TNT produces poisonous gases. However, these gases are so rapidly dissipated in open air that they are ren-

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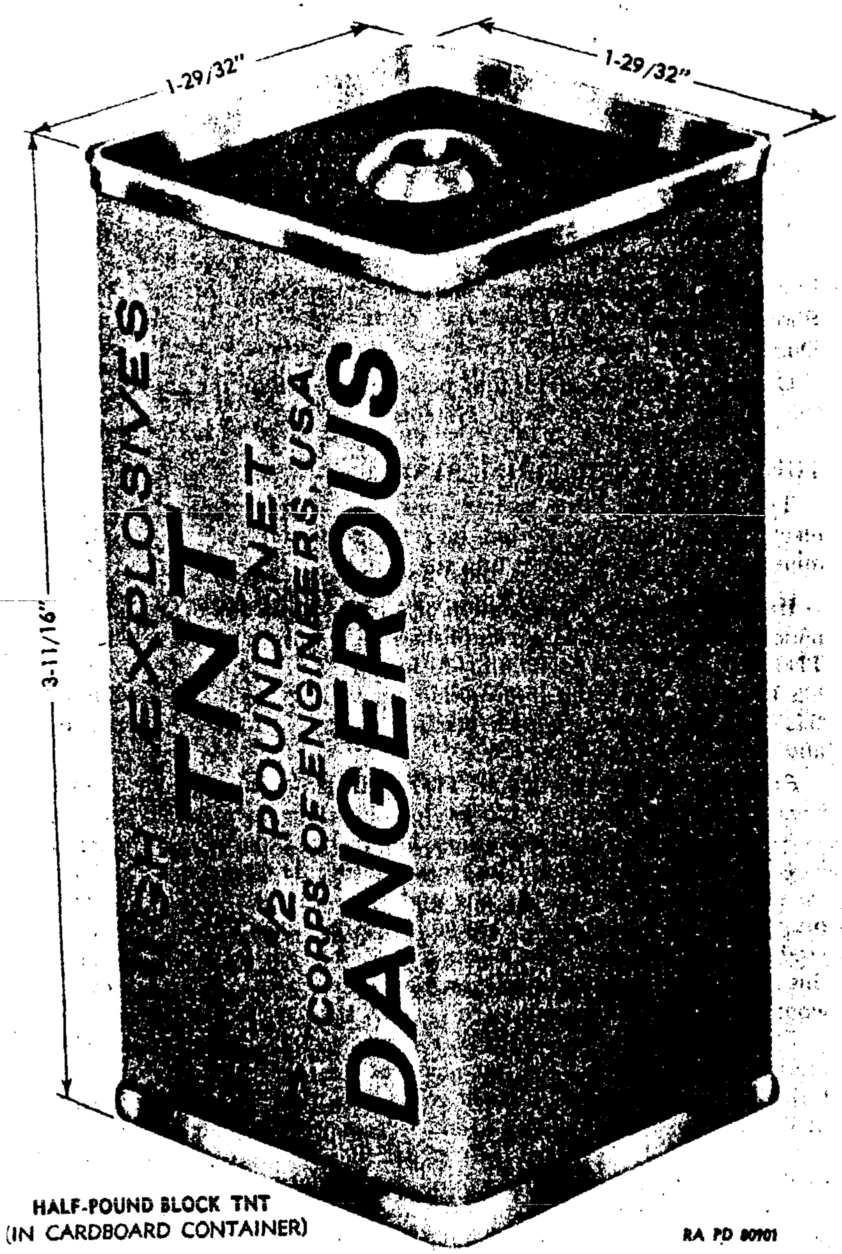


Figure 297 — Triton Block

dered harmless. The production of poisonous gases does prohibit the use of TNT in situations where the gases are confined.

Explosive, nitrostarch, rectangular. Nitrostarch is a substitute for TNT for destruction work. It is issued either in ½-pound blocks, 1.906 inches square by 3.062 inches long with a cap hole as in the TNT block; and in ¼-pound blocks, 1¼ inches square by 2½ inches long with a cap hole extending all the way through the length of the block. These blocks are wrapped in paraffin-treated paper. For convenience of handling and use, ¼-pound blocks are assembled into pound packages.

For practical purposes, the same methods and computations as for TNT are applicable. However, nitrostarch is somewhat more sensitive to friction, impact and flame or spark than TNT and consequently more care must be exercised in its use. The ¼-pound and ½-pound blocks *must not* be broken into smaller pieces.

Dynamite. Commercial straight dynamite consists of nitroglycerin absorbed in some porous material such as sawdust. The percent of the dynamite signifies the actual percent of nitroglycerin by weight. It is issued for destruction work in two types: dynamite, 40 percent (commercial) and dynamite, 50 to 60 percent (commercial). The 40 percent is issued on the basis of 1¼ pounds for each pound of TNT. The 50 to 60 percent is issued on an equal weight basis with TNT. Dynamite is usually packed in approximately ½-pound cartridges 1¼ inches in diameter by 8 inches long, of water-resistant-treated paper.

Dynamite is more sensitive than other high explosives and must be handled accordingly. Cases of dynamite should be stored right side up so that the cartridge will lie flat and will not stand on end. The cases should be turned every 30 days. The nitroglycerin has a tendency to shift to the under side and become concentrated and consequently much more dangerous.

Nonelectric Blasting Caps. Detonation of explosives such as TNT, nitrostarch, and dynamite is initiated by a small quantity of a more sensitive explosive contained in a cap. A No. 8 commercial blasting cap will detonate nitrostarch and dynamite. Special tetryl nonelectric or tetryl electric caps are necessary to insure detonation of TNT. Commercial blasting caps are numbered consecutively from 1 to 10, according to their strength, and contain, respectively, 0.3, 0.4, 0.54, 0.65, 0.80, 1.0, 1.5, 2.0, 2.5, and 3 grains of a mixture of 85 percent fulminate of mercury and 15 percent potassium chlorate. The special tetryl cap differs from the commercial cap in that its main charge is tetryl and is detonated by a small charge of fulminate of mercury and potassium chlorate.

The explosive charge of the cap is contained in a thin copper shell which is closed at the open end with a plug. The shell protrudes past the plug for assembly to miners' safety fuse by crimping.

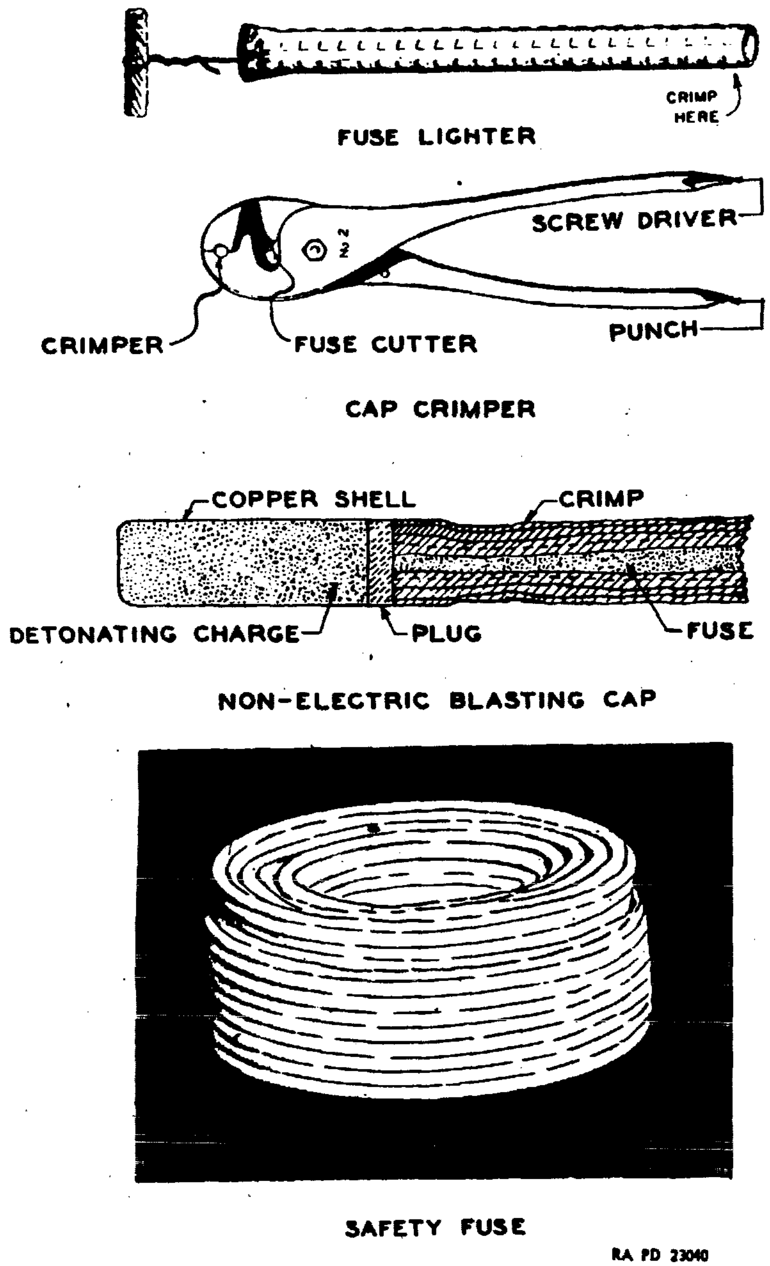


Figure 298 — Nonelectric Blasting Equipment

Safety precautions. The following safety precautions must be observed in the use of nonelectric blasting caps:

1. One person should be designated for the responsibility of taking care of the blasting caps during operations of destroying explosive components.

2. Blasting caps must not be stored or transported with high explosives.

3. Caps should not be left exposed to the direct rays of the sun.

4. Caps should not be carried in the pocket; there are special boxes made for the purpose.

5. Do not remove blasting caps from the box with a wire, a nail or similar instrument; use the fingers.

6. Do not use a weak cap. Use the prescribed cap or a more powerful one.

7. The cap should be held with the fingers by the open end. Subjecting the explosive to the heat of the hand should be avoided as much as possible. Heat increases the sensitivity of explosives.

8. Do not tap caps or attempt to disassemble them.

9. Do not hold the blasting cap in the hand while crimping. Place the cap on the fuse and holding the fuse in one hand crimp with the other. Hold the cap to one side, away from in front of the body while crimping. The crimp should be made at the extreme open end, opposite the explosive.

10. Do not crimp a cap with the teeth or a knife. Use the cap crimper.

11. Improvised methods of detonating blasting caps are prohibited.

Fuse, Blasting Time. This fuse is commonly called miners' safety fuse. It consists of a thin train of black powder tightly compressed and partially waterproofed in inner and outer wrappings. Safety fuse is manufactured in lengths of 50 feet and made into rolls. The exterior surface of the fuse is relatively smooth and is white or orange in color. These outward appearances cannot be depended upon for positive identification, however. The purpose of the fuse is to provide heat through the burning of the black powder to initiate nonelectric blasting caps and to provide enough time between the lighting of the fuse and the detonation of the cap to allow personnel to take cover. It burns at the rate of about 32 to 40 seconds per foot.

Safety precautions. The following precautions must be observed in the use and care of safety fuse:

1. The fuse should be stored in a cool, dry place free from oils, paints, gasoline, kerosene, distillates, and similar solvents that have a deteriorating effect on the fuse.

2. Care should be taken in handling not to twist the fuse or produce kinks, especially in cold weather. Such treatment will loosen the black powder and decrease the burning time.

3. Five or 6 inches should be cut from the end of the roll and discarded before using. The powder in the end is likely to have become damp or loose.

4. After 5 or 6 inches have been discarded, one foot must be cut from the roll and tested for burning time.

5. A length of fuse must be used that will give the person lighting it plenty of time to reach cover.

6. The fuse must square-cut. If an obliquely cut fuse is inserted into a blasting cap, it may double over the powder core and cause a misfire.

7. Do not twist the safety fuse into the cap and do not use force or violence. If the end of the fuse is flattened or too large, roll it between the thumb and finger.

Cord, Detonating (Primacord). The detonating cord, known commercially as primacord, is a flexible, waterproof fabric tube 0.203 inch in diameter with an explosive core of pentaerythritetetranitrate (PETN). It is used as a detonating agent for high explosives and may be initiated by an electric or nonelectric blasting cap. It may be used to provide a link between the blasting cap and the demolition block when safety fuse is used so that time need not be wasted by burning more fuse than is required. It is also valuable for the firing of a number of shots at some distance apart. PETN has a velocity of detonation of about 19,700 feet per second. It is comparatively insensitive to shock, flame, or friction. It is furnished in 100-foot lengths on wooden spools 7¼ inches long by 3¾ inches in diameter. The cord is greenish-yellow in color, and has a relatively rough, waxy surface.

Obsolete Fuses. There are two fuses formerly used for demolition work which are now obsolete. The first is called instantaneous fuse and consists of a core of loose black powder in a rough braided outer wrapping. Its burning time is 120 feet per second. It was used with miners' safety fuse to increase the length without making an appreciable increase in time. Issue of instantaneous fuse is prohibited, and if any is found it should be reported for destruction.

The second obsolete fuse is called cordeau detonant and consists of a core of TNT in a lead tube about the size of a lead pencil. This fuse has been discontinued for issue and manufacture. It has been replaced by primacord.

Miscellaneous Equipment.

Crimper, cap. The cap crimper resembles a pair of pliers in appearance. It is made of blued steel and is 7 inches long. A hole in

the nose of the crimper is of a diameter that will close the open end of a blasting cap firmly on miners' safety fuse and yet prohibit squeezing the fuse so tightly as to interfere with the burning of the powder train and cause a misfire.

Jackknife. A pocket knife with a sharp blade should be included in demolition equipment for the purpose of slitting safety fuse and cutting twine and tape.

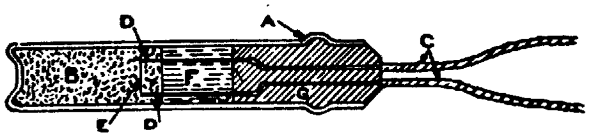
Tape and twine. Tape and twine are included in the equipment for such duties as assembling a number of explosive blocks together to form a charge, securing the blasting cap to the primer block, for wrapping splices and joints of time fuze, for securing a charge to a component and for securing blasting caps to detonating cord.

Safety matches. Safety matches of the wooden stick variety are used to ignite miners' safety fuse. Their care should be entrusted to one designated person as no other personnel is permitted to carry matches on explosives operations, and smoking is prohibited. The best method of lighting blasting time fuse with a match is to split the end of the fuse for about 1 inch so that the black powder is exposed, hold the match at right angles to the fuse with the head in the slit and draw the friction surface of the match box across it.

Lighter, fuse. The fuse lighter consists of a thin metal tube containing friction composition, a paper reinforcing tube, and a friction wire attached to a handle. The metal tube has sharp prongs on the inside pointing inward. When the fuse is inserted past these prongs, it will not pull out. Pulling the handle initiates a flame which is transferred to the safety fuse. Fuse lighters are also used in the construction of trap mines.

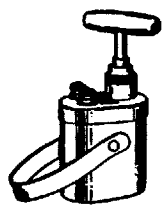
Preparation of Charges. When a number of demolition blocks are required for the destruction of ammunition components, best results will be obtained by placing the blocks in intimate contact with the item and placing one on top of the other. If three or four blocks are used, two will be placed close together on the wall of the component and the others will be placed on top of those two. If five or six are needed, there will be two layers of two blocks each with the fifth and sixth on top in a third tier. One of the top blocks, with blasting cap and fuse attached, will be inserted into the charge to act as a primer after the other blocks are in place. The blocks may be held in place by tamping moist earth lightly around them or by taping or tying them together and to the component to be destroyed. The fuse should be tied to the primer block about six inches above the blasting cap to prevent it from being pulled out.

Demolition explosives may be detonated with detonating cord by tying it tightly around the block. Further details on the assembly of charges may be obtained from the Engineer Field Manual, No. 5-25.

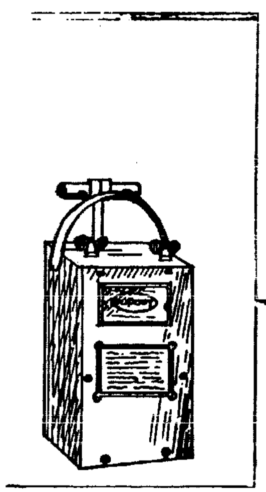


A. COPPER SHELL
B. DETONATING CHARGE
C. INSULATED LEAD WIRES
D. ENDS OF LEAD WIRES PROJECTING INTO CHARGE
E. PLATINUM WIRE BRIDGE
F. PLUG (ASPHALT)
G. FILLING MATERIAL (SULFUR)

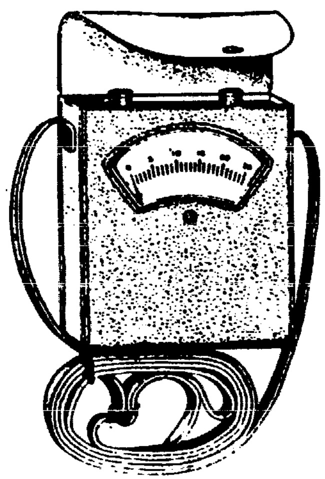
SECTION OF ELECTRIC CAP



10 CAP EXPLODER



30 CAP EXPLODER



GALVANOMETER

RA PD 23041

Figure 299 — Electric Blasting Equipment

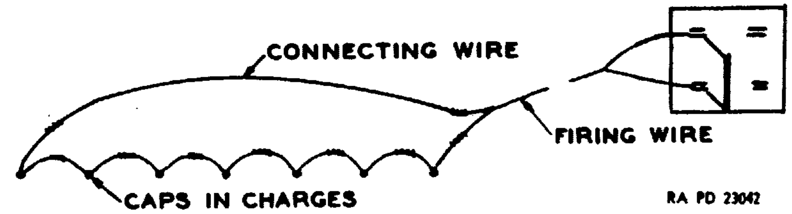


Figure 300 — Series Connection

THE ELECTRIC FIRING SYSTEM.

General. An electric firing system consists of a high explosive with an electric blasting cap inserted, a firing wire, and a magneto exploder or blasting machine.

High Explosives. The same explosives for destruction of ammunition are used in the electric system as are used in the nonelectric system.

Cap, blasting, electric. Electric blasting caps for demolition work may be either commercial or special tetryl caps. These caps contain the same explosives as the nonelectric cap and the commercial caps are numbered according to strength in the same way. Special tetryl caps are required positively to detonate TNT.

The explosive charge is contained in the bottom of a copper shell. An asphalt plug is inserted over the explosive and the remainder of the shell is filled with a sulphur filling material. Two 12-foot lead wires are inserted through and kept separated in the filling material and plug which are insulators. These wires extend into the explosive charge and are joined at the ends with a platinum wire or bridge. The lead wires are insulated from the cap outward. If the cap is of the special electric type, the explosive around the platinum wire is a mixture of mercury fulminate and potassium chlorate, and the balance is tetryl. When an electric current is induced through the lead wires, the resistance offered by the platinum bridge produces enough heat to initiate the mixture of mercury fulminate and potassium chlorate.

Safety precautions. The same safety precautions that apply to nonelectric caps also apply to electric caps with the exception of those that deal with the crimping and the holding of the cap in the hand. When using electric caps, the following should be added:

1. Hold the electric cap by the lead wires.

2. Do not pull on the wires of an electric cap.

3. The lead wires should be kept separated during connection to the firing wire to prevent short circuiting.

4. The ends of the lead wires and the ends of the firing wire should be scraped lightly with a knife blade before splicing to insure a good electrical connection.

5. If working on wet ground, the electrical splice between cap lead wires and firing wire should be held in an above ground position by bending the firing wire upward about a foot from the end and securing with mud. This will prevent short circuiting through the ground and consequent misfires.

6. The bared ends of the firing wire should be touched together before being spliced to the cap lead wires to get rid of any static electricity that may have accumulated.

Reel, Firing Wire. The firing wire is issued on a metal reel carrying 500 feet, the total weight of the reel and wire being about 30 pounds. The firing wire is made up of two No. 18 gage (B & S) copper wires, each insulated independently of the other, contained in a rubber cover. The inner end of the firing wire is attached to the reel and is always available for connection to the exploder. The other end is free to be unwound for connection to the charge. If one reel does not provide sufficient distance from the point of explosion for safe cover, two reels may be spliced together by connecting the free end of the wire from one reel to the inner end of the other.

Blasting Machines or Magneto Exploders. The blasting machine is used to generate the current for firing electric blasting caps. It consists essentially of a small portable dynamo or magneto. Blasting machines are issued in two sizes, the 10-cap and the 30-cap exploders.

The 10-cap exploder. This machine will initiate the detonation of 10 electric blasting caps with 12-foot copper wire leads connected in series. It has a possible overload of 100 percent. It is operated by a vigorous twist of the handle; the quicker the twist, the more current is developed. The exploder weighs approximately 5 pounds. If the voltage produced weakens through lack of use, the magneto may be revitalized by connecting the two posts with a short piece of copper wire or other conductor, and twisting the handle in a clockwise direction several times. The handle is easily removable, and for safety should be inserted in the exploder only when ready to fire and should be removed immediately after firing.

The 30-cap exploder. This exploder has a capacity of 30 electric caps with copper wire leads. It weighs about 25 pounds. This machine is operated by a hard downward thrust of the handle to the bottom of its travel.

Safety precautions. The following precautions should be observed in the use and care of the exploder:

1. The exploder should be assigned to the care of one responsible person who should keep it in sight during the whole destruction operation.

2. The firing wires should not be connected to the exploder until all personnel is under cover and the area is seen to be clear.

3. The exploder should not be operated half-heartedly.

4. In case of misfires, the handle of the exploder should be twisted several times to ascertain that enough current is being generated. If the charge still does not detonate, the exploder should be disconnected, revitalized, reconnected and tried again.

Miscellaneous Equipment.

Galvanometer. The galvanometer is an instrument used in demolition work to determine whether a blasting circuit is open or closed; that is, whether the circuit is in proper condition for the blast or, because of defective wiring or other reasons, will fail to transmit the electric current. The instrument is a magnetic device in which an electric current from a small chloride of silver dry cell moves a pointer across a scale. There are two posts conveniently located for connections. When the posts are connected in a closed circuit, the current flows through the galvanometer coil and causes the pointer to be deflected. The amount of deflection depends on the amount of resistance in the closed circuit and on the strength of the chloride of silver dry cell.

The galvanometer should be handled carefully and kept dry. It should be tested before using by placing a short piece of copper wire momentarily across its binding posts. If the needle does not swing freely across the scale, the battery cell is weak and should be replaced. A galvanometer circuit should never be closed over long periods of time because the strength of the chloride of silver dry cell would soon be exhausted.

To test a blasting circuit, touch the two ends of the inner reel firing wire to the two posts of the galvanometer. If the circuit is closed and has a low resistance, the needle will move freely across the scale. If the needle does not move, there is a break in the circuit. If the needle moves only slightly, there is a place of high resistance in the circuit such as a splice or partially broken wire. If the caps are placed in parallel, each cap must be tested individually. Each series in a series parallel circuit must also be tested individually.

Precautions applicable to the use of the galvanometer are as follows:

1. The proper chloride of silver dry cell must always be used, as other cells may have sufficient strength to detonate a cap.

2. All personnel should be under cover when the circuit is tested because it is possible that the caps may be set off by the small amount of galvanometer current.

Preparation of Charges. The only differences between nonelectric and electric charges is the use of an electric cap in the primer block and the electric system for the initiation of the cap. The cap may be secured in the block by looping the cap wires over the block instead of tying with string. A mud pack may serve the same pur-

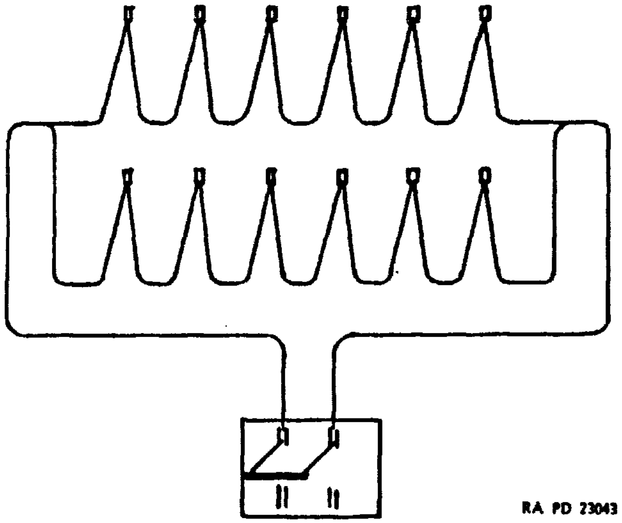


Figure 301 — Two Series Connected In Parallel

pose. A number of charges may be detonated simultaneously by connecting the lead wires of the blasting caps and the firing wire in series. A parallel circuit is rarely used because it necessitates testing each part of the circuit separately. A series parallel circuit is sometimes used, but the parallel connection must be made to the blasting machine since the circuit must be tested from cover. Detailed information of the assembly of charges is given in the Engineer Field Manual No. 5-25.

DESTRUCTION OF ARTILLERY SHELL.

General. The method of destruction of artillery shell varies somewhat with the filler and the construction.

However, the fundamental characteristics of the operation are the same and safety precautions vary only slightly. It should be understood that shell destruction refers only to the projectile. If fixed ammunition is to be destroyed, the cartridge case is removed from the projectile, the propelling charge is burned, the primer is fired and the primer body and cartridge case are salvaged. For better understanding of a destruction operation, it is best to take a specific case and compare other operations to it. The case cited in the following will be the destruction of 155-mm H.E. shell.

Destruction of SHELL, H.E., M107, Unfused, for 155-MM Howitzer M1. In the discussion of a sample destruction, it is best to assume that a number of shell are being destroyed and that, as yet, a site has not been selected for destruction work.

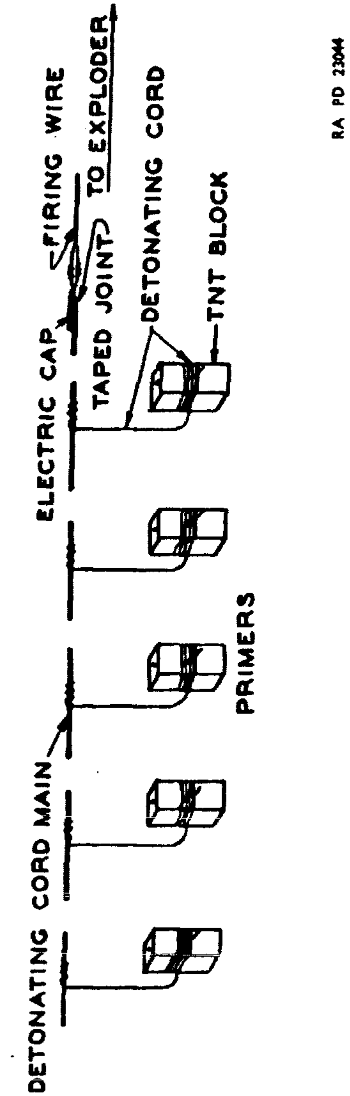


Figure 302 — Use of Detonating Cord

Selection of a demolition ground. The site used for the destruction of ammunition or explosives must be at a minimum distance of 800 yards from inhabited buildings, public railways, public highways, magazines, and operating buildings. (Definitions of these terms may be found in the Ordnance Safety Manual, section V.) Distances from 1½ to 3 miles are desirable. The area around the point of destruction must be cleared of dry grass, leaves, and other inflammable materials for a radius of 200 feet. Shell awaiting destruction will not be piled within 200 feet of the point of destruction and will be protected from grass fires, burning embers, and flying fragments. All dry grass, leaves, and other inflammable materials will be removed within a radius of 50 feet of the piles. Fire-fighting facilities for combatting grass fires should be maintained readily available if practicable.

If an area containing ravines or deep gullies is available, time and labor may be saved. In such case, the charge should be placed in a sharp bend that will block the flying fragments.

Shelter. A bombproof or barricade of sufficient strength to provide protection for personnel from flying fragments or missiles should be erected.

Personnel. The destruction of explosive material requires great care in every detail and should never be attempted by inexperienced or untrained personnel. Trainees must not take part in operations such as preparing charges and caring for blasting caps until they have first observed and been fully instructed on pertinent safety precautions on handling of equipment and explosives. The number of persons engaged in explosive operations should be consistent with the amount of work to be done; under no circumstances will one person be permitted to work alone. In addition to persons required for the work, guards or warning signs will be posted on all roads leading into the danger area to keep unauthorized personnel out during demolition operations.

Every person taking part in the destruction should be instructed as to his specific duties before the operations begin. If untrained personnel are present, pertinent safety precautions should be pointed out.

Transportation. The cargo portion of the truck carrying materials to the demolition grounds for destruction should be lined with boards or canvas. Signs should be displayed on each side and rear with the word "EXPLOSIVES" or a red flag 24 inches square marked with the word "DANGER" in white letters should be displayed. The explosive materials should be covered with a tarpaulin. The driver should be instructed to drive slowly and carefully, especially over rough roads. No more materials should be taken to the demolition grounds than can be destroyed in one day. Upon arriving at the grounds, the motor of the vehicle should be shut off while the ex-

plosive materials are being unloaded. The explosives should be covered with a tarpaulin before the motor is started and the truck is driven away.

Preparation of shell for destruction. If the number of shell that may be safely detonated at one time has not been previously determined, it may be found by starting with one shell and building up to a maximum number consistent with safety. This number will vary with conditions at different establishments. The number of shell to be detonated will be carried to the point of destruction and placed in a pit large enough to contain them. They will be piled together in intimate contact in pyramid fashion.

The charge of demolition blocks is placed on one of the top and center shell of the pile and either tied, taped, or packed in place with moist earth. The number of blocks required for the destruction may be found in the following table:

Caliber of Shell	Number of ½-pound TNT Blocks
20-mm, 37-mm, 40-mm	1
75-mm, 76-mm, 3-inch	2
90-mm, 105-mm, 4.5-inch 4.7-inch, 155-mm, 6-inch	3
8-inch, 240-mm	4
10-inch, 12-inch	5
14-inch, 16-inch	6

Never less than the number of blocks shown in the table should be used; it is better to use one more in the case of the larger calibers.

A nonelectric or electric blasting cap is inserted into one of the top blocks in the charge and is secured in place. If TNT blocks are used a special tetryl cap is required; if nitrostarch or dynamite is used, a No. 8 commercial cap or stronger is required. The cap lead wires or miners' safety fuse are laid so that the free ends will not be covered with earth and the shell are covered with three to four feet of dirt. Care should be taken that the earth cover does not include materials that will form dangerous missiles. Personnel should be instructed to pile the earth on the shell carefully so that the blasting cap and explosives will not be jarred. The earth should be piled so that it provides a 3- to 4-foot cover in all directions.

Destruction. If a nonelectric firing system is used, one man is left at the destruction point to light the fuse. The balance of personnel retire to the barricade and one specifically designated person, after making sure that the area is clear, gives the signal for lighting the fuse. The fuse is lighted and the lighter retires to the barricade.

If an electric firing system is used, the lead wires are connected to the firing wire and all personnel retire to the barricade where the other end of the firing wire is located. After the person in charge has made sure that the area is clear and that all personnel are inside of the barricade, the circuit is tested with a galvanometer. If the circuit is closed and has a low resistance, the firing wire is attached to the binding posts of the exploder and the charge is detonated.

The hole resulting from the explosion may be used for the destruction of the next shell, but care should be taken that it has cooled sufficiently. After each detonation, the area should be searched for unexploded materials and if any are found they should be included in the next blast.

Safety Precautions and Use of Equipment. The methods of use and the safety precautions connected with electric and nonelectric firing systems should be applied to any destruction operations in which they are used. .

Misfires. If a charge is initiated and does not explode, personnel should remain in shelter at least 30 minutes before investigating the failure. The charge should be uncovered very carefully so as not to disturb the blasting cap and another block should be primed with a new cap. This new primer is then exploded as before. Slight movement of the blasting cap that failed to function may result in an explosion. Heating caused by the electric current or flame from the fuse increases the sensitivity of the initiating explosive.

Shell Loaded With Explosive D. Shell loaded with explosive D must be destroyed one at a time. The filler is so insensitive that it will not detonate sympathetically. For the same reason, more demolition blocks are needed than for the destruction of shell loaded with TNT or amatol.

Shell Fitted With Adapter Boosters. Shell fitted with adapter boosters can be detonated without the use of demolition blocks by placing a special tetryl cap in the fuze cavity and sealing the opening with mud.

Chemical Shell. Shell with chemical fillers may be detonated as outlined in the destruction of 155-mm H.E. shell. The following precautions are added:

1. As chemical shell contain a comparatively small amount of exstroyed, water should be poured on the ammunition until no smoke should be double the number specified for high-explosive shell of equal caliber.

2. The chemical shell to be destroyed, excepting those filled with phosphorus, should be destroyed a single shell at a time, in a pit at least 6 feet deep. Phosphorus shell should be destroyed on top of the ground so that when the shell is split open, air will be available.

3. The point at which H shell are to be exploded should be chosen so that personnel can be excluded for a period of approximately 48 hours from the area 1 mile down wind from where the shell is to be

exploded. Also, personnel must be prevented from passing within a distance of 150 yards from the point of destruction for a period of about 2 weeks. When the charge has been set, the 6-foot pit is backfilled and the charge is exploded. The hole made by the blast should be filled with a mixture of dry bleach powder and earth. Place a permanent sign on the fill prohibiting digging. When shell containing persistent gases other than mustard are to be destroyed, specific instruction should be requested from the office of the Chief of Ordnance.

4. If leaking ammunition loaded with phosphorus is to be destroyed, water should be poured on the ammunition until no smoke is visible before the demolition blocks are placed for detonation.

5. Personnel engaged in the destruction of chemical ammunition will wear adequate protective equipment and clothing and will have necessary first aid supplies on hand.

Shrapnel.

Conventional method. The destruction of shrapnel cannot be accomplished by mass detonation as in the case of H.E. loaded shell. A shrapnel projectile with the time fuze removed may be destroyed by placing a blasting cap in the flash tube. The cap should be pushed down the tube carefully until it touches the bottom. The nose should be closed around the safety fuse or cap lead wires, as the case may be, with damp earth. If an electric system is used, the cap may be further secured by folding the lead wires back and taping them to the nose of the shell. When shrapnel is exploded in this manner, the projectile case recoils with a tremendous velocity and will escape from the pit unless backed up by a strong perpendicular surface.

Alternative method. The shrapnel is buried, base first, into the side of a 6-foot pit (large enough for operations described) for about three-quarters of its length and with the nose pointing slightly downward toward the bottom. A blasting cap is inserted into the flash channel as described in the conventional method. When the cap is initiated, the shrapnel case will be driven farther into the earth and the balls will be propelled into the bottom and opposite side of the pit. Several shrapnel may be detonated simultaneously by burying them in the sides of the pit and detonating them with electric blasting caps connected in series. Special tetryl caps are not required for detonating shrapnel because their only purpose is to initiate the black powder base charge.

DESTRUCTION OF AIRCRAFT BOMBS.

Compared With Destruction of Artillery Shell. Bombs may be destroyed in accordance with the instructions for the detonation of artillery shell. However, the following should be noted:

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1. Bombs contain much larger quantities of explosives by percent of total weight than artillery shell. The number detonated at one time must be reduced accordingly.

2. Bombs have thin walls and detonate so readily that fewer demolition blocks are required for their destruction.

3. Since bombs filled with high explosive are subject to mass detonation, they should be segregated into small piles at least 100 feet apart and at least 300 feet from the point of destruction. Protection must be provided that will shield the piles against fragments or missiles.

4. The destruction of bombs larger than 100 pounds will not be undertaken without specific instructions from the Office, Chief of Ordnance.

DESTRUCTION OF TRENCH MORTAR SHELL, ANTITANK MINES, AND ROCKETS.

These components have greater amounts of filler as compared to total weights than artillery shell so that fewer components should be destroyed at one time. Otherwise the destruction procedures are the same as for artillery shell. The part containing the propelling charge is removed from the rocket before it is detonated. Since these components have thinner walls than artillery shell, fewer demolition blocks are required for their destruction.

DESTRUCTION OF OFFENSIVE HAND GRENADES AND RIFLE GRENADES.

Grenades, up to a total of 40, should be packed in a box in intimate contact with each other and placed in a pit. Approximately 1 block for each 6 grenades is placed on top of the grenades. One of the top blocks in the pile should be fitted with a blasting cap. A lid should be placed over the box and the box should be covered with 3 or 4 feet of earth. Care should be taken not to pinch the safety fuse under the lid if safety fuze is used. All applicable safety precautions set forth in the discussions of the detonation of artillery shell and the nonelectric and electric firing systems will be observed.

DESTRUCTION OF FUZES, PRIMERS, DETONATORS, BOOSTERS, AND BURSTERS.

A small quantity of these components should be placed in a box of appropriate size in intimate contact. The box should be placed in a pit large enough to contain the box. One demolition block is fitted with a blasting cap and placed on top of the components. A lid should be placed on the box, and 3 or 4 feet of earth should be

provided as a cover. The charge should then be exploded in accordance with all applicable safety precautions set forth for destruction of artillery shell and use of electric and nonelectric equipment. It should be particularly noted that the quantity of explosive in these components, especially in the case of primers, is so large in proportion to the total weight of the unit that small quantities only should be exploded and then only with extreme caution.

DESTRUCTION OF PHOTOFLASH BOMBS.

Photoflash bombs may be treated as thin-walled artillery shell for destruction. Personnel should be instructed not to look in their direction when they are detonated as the flash is blinding.

DESTRUCTION OF DUDS.

General. Ammunition inspectors may sometimes be called on to destroy duds. Duds are marked where found with a red flag and then are reported. Amateurs should leave duds strictly alone because components that have been initiated and have failed to function are extremely dangerous to handle. They should not be moved but should be destroyed wherever found, if practicable. Should it be necessary to move a dud, great care should be taken not to cause movement of the internal parts. Such action may result in immediate explosion.

Detonation. The detonation of duds is carried out in the same manner as described for whichever type of component it happens to be. Added caution must be exercised in not jarring the dud in any way. If the dud is on a target range where shelter is not available, it is usually detonated, using a nonelectric firing system. A length of safety fuse that will give personnel time to get a safe distance away will be used. If the explosive content is large and facilities are available, a conveyance may be used to carry personnel to a safe distance.

DESTRUCTION OF OTHER COMPONENTS.

Components of the same nature of those discussed in this chapter but not included must not be destroyed without specific instruction from the Office, Chief of Ordnance. When exceptionally large quantities are to be destroyed, specific instructions will be requested from the Office, Chief of Ordnance.

FURTHER REFERENCES: A complete list of references with regard to disposal of unusable ammunition will be found at the end of this section.

Chapter 3
Destruction by Burning

GENERAL.

Types of Explosives and Ammunition Destroyed by Burning. The types of explosives and ammunition destroyed by burning are as follows:

Black powder
Smokeless powder
High explosives (TNT, tetryl, explosive D)
Pyrotechnics
Small-arms ammunition
Primers, fuzes, detonators, and boosters
Fragmentation grenades
Chemical ammunition filled with H

Selection and Preparation of Grounds. In choosing a burning ground, bad lands with gullies, etc., should be utilized. The burning ground should not be closer than ¼ mile to the nearest inhabited building, public railway, public highway, magazine, or operating building. (Definitions of these terms may be found in section V of the Ordnance Safety Manual.) Greater distances are desirable. All dry grass, leaves, or other inflammable materials must be cleared from around the point of destruction for a radius of 200 feet. Material awaiting destruction must be 200 feet from the point of destruction and the area around this material should be cleared of dry grass, leaves, and other inflammable materials for a radius of 50 feet.

Transportation. The cargo portion of the truck must be lined with boards or canvas and the material being transported must be covered with a tarpaulin. Signs on each side and rear with the word "EXPLOSIVES," or a red flag 24 inches square marked with the word "DANGER" in white letters must be displayed. The driver should be instructed to drive carefully, especially over rough roads. While the material is being unloaded at the burning grounds, the motor of the vehicle must be stopped. The explosive material must be covered with a tarpaulin while the motor is started and the truck drives away. No more than 1 day's supply will be taken to the burning ground.

Personnel. The destruction should be accomplished by trained personnel under the direction of a competent supervisor. Trainees will be fully instructed and will observe operations before taking part. Unauthorized personnel will not be permitted in the area while burning of explosives or chemicals is being accomplished. There should never be more than the required number of persons on the job, and never will there be less than two.

General Safety Regulations. The general safety regulations applicable to destruction by burning are as follows:

1. Facilities for fighting grass fires will be maintained readily available. When exceptionally large quantities of explosives are being burned, the fire department should be notified.

2. Unless otherwise specified, material to be burned will always be removed from containers as attempts to burn certain explosives under even slight confinement may result in detonation.

3. In repeated burning operations, care will be taken to guard against material being ignited from burning residue or heat retained in the ground. It is wise to select a new spot for each burning and not to reuse ground until 24 hours have elapsed.

4. Matches will be of the wooden stick safety variety and will be carried by one designated person only. Smoking will be strictly prohibited during burning operations.

5. When explosives in a train, pit, or trench are being ignited with inflammable material, all personnel except the person doing the lighting should retire to a safe distance. After lighting the material the lighter must also take cover.

6. If practicable, the ground at the point of destruction should be wet down with water at the close of each day's operation.

DESTRUCTION OF BLACK POWDER.

Containers. Black powder containers will be opened with tools of wood or nonsparking metals. The contents of only one container will be destroyed at a time. The emptied container will be thoroughly rinsed with water since serious explosions have occurred with supposedly empty black powder cans. The safest method of destroying black powder is to dump it into a stream or body of water since water dissolves the nitrates and renders the powder ineffective. If no suitable stream is available, it may be burned.

Burning. The powder must be removed from the container and spread out in a trail about 2 inches wide, care being taken that no part of the trail parallels another part within a distance of 10 feet. The ground over which the trail is laid must be free from cracks or other depressions in which the powder might be confined. A train of inflammable material, such as excelsior, at least 10 feet long and laid so that when it is ignited it will burn with the wind is used to ignite black powder. The ignition of black powder results in a flare or explosion so quickly that there is no chance to withdraw after the powder ignites.

There is some controversy over the position of the igniting train. Some persons believe that the powder should be ignited against the wind so that the train will burn more slowly and allow the person igniting it more time to get safely away. Others believe that if an igniting train 10 feet long is used and the powder train is properly laid upward, the igniter will have plenty of time to get away and in case of accidental ignition of the powder the wind will carry the sudden intense heat away from the trapped person. The latter, while recent, is very good reasoning.

BURNING OF SMOKELESS POWDER.

Bulk Smokeless Powder, Up To 500 Pounds. Quantities of less than 500 pounds of bulk smokeless powder may be burned safely if the powder is removed from the container and spread on the ground in a thin layer or train not over 3 or 4 inches thick. If the powder is transferred to a small-arms box, it will facilitate the spreading of the train. A train of inflammable material, or a very thin train of the powder itself, about 10 feet long and laid so that the lighter has the wind blowing toward him should be used to ignite the powder.

Bulk Smokeless Powder, Up To 5,000 Pounds. Quantities up to 5,000 pounds may be burned in a pit or trench if a train of inflammable material, at least 25 feet long and on the down-wind side, is used to ignite the powder. When such large quantities are burned, a shield, at least 200 feet away from the point of destruction, should be erected to protect personnel from the intense heat.

Propelling Charges. When separate loading propelling charges are to be destroyed, the smokeless powder will be removed from the bag at the burning ground by slitting the end opposite the igniter pad with a safety knife. The slit is enlarged by tearing and the smokeless powder is poured into a container which should be open only while receiving powder. This powder will be burned in accordance with the procedures for burning bulk smokeless powder.

The igniters and bags upon being emptied will be submerged immediately into a container of water. The igniter pad will be slit with a safety knife while being held under water and the black powder emptied. The igniter pads and cartridge bags will remain under water for a period of about 3 days, after which, they should be spread out into the open until thoroughly dry. When the igniters and bags are dry, they may be burned in a pit or trench taking care to limit the amount destroyed at one time to a safe number and to ignite them with an inflammable train. Bags and igniters awaiting destruction must be protected against accidental ignition.

BURNING OF HIGH EXPLOSIVES (TNT, TETRYL AND EXPLOSIVE "D").

High explosives such as TNT, tetryl, and explosive "D" will be destroyed by burning. A bed of excelsior should be prepared and the explosive should be spread on top of it in a thin layer, not over 3 or 4 inches thick. TNT box tops and wrapping paper may be substituted for excelsior as a bed. If the boxes are to be destroyed, they may be

placed along the sides of the bed. A train of inflammable material at least 10 feet long should be used to ignite the explosive from the down wind side. Personnel will retire to a safe distance so that the wind will blow the smoke and fumes away from them. The gases formed in the burning are poisonous.

If it becomes necessary to burn other high explosives such as fulminate of mercury, dynamite, picric acid, etc., special instructions will be requested from the office of the Chief of Ordnance.

BURNING OF PYROTECHNICS.

Pyrotechnics, Except Parachute Flares. Pyrotechnics, except parachute flares, will be destroyed in quantities consistent with safety in a trench about 4 feet deep. A quantity of excelsior, wood, or similar inflammable material sufficient to produce a good hot fire will be placed in the bottom of the trench. The pyrotechnics to be burned will be removed from their containers and placed on top of the inflammable material. A cover of heavy iron grating or wire mesh should be placed over the pit and staked down. The fire is lighted from the down-wind side with a train of inflammable material.

Parachute Flares. Parachute flares will be destroyed in the same manner as other pyrotechnics except that they will be placed on their ends atop the inflammable material with each flare separated by a distance of at least 4 feet. No cover is placed over the pit. It is imperative that personnel have good protective cover or withdraw to a safe distance since the flares are subject to detonation.

BURNING OF SMALL ARMS, PRIMERS, FUZES, DETONATORS, AND BOOSTERS.

The Pit and Chute Method. A pit which is approximately 6 feet square and 4 feet deep is dug. An inclined chute, such as a piece of 4-inch pipe, should be provided and should be placed so that one end is over the center of the pit and the other is behind a barricade. The end of the chute behind the barricade should be baffled and should be higher than a man's head. The chute may act as a rifle barrel for fragments flying from the pit. The pipe must be securely braced. A hot fire should be built in the pit and covered with sheet iron or other material suitable to confine flying fragments. Openings must be left for draft.

Components containing small amount of explosives such as small arms and 21-grain percussion primers may be fed through the pipe into the fire several at a time. This quantity may be properly limited by using a dipper. Fuzes, detonators, boosters, and large primers must be dropped into the pit one at a time and the explosion heard before another is dropped. If the small-arms ammunition does not sound like double machine guns when dropped into the pit, the operation should be discontinued. After 30 minutes, more fuel should be put on the fire and the operation continued.

Other containers may be substituted for the pit if they are strong enough to withstand the pressure of the explosions. An example is a square container of approximately ½-inch armor plate which is welded together. The container is set up on hollow cement building blocks and a good hot fire built under and around it. A heavy lid is put over the top and has small holes drilled in it to prevent its being blown off. The pipe runs through this lid. Holes may also be drilled around the top of the container to reduce pressures. Small holes about 2 inches apart may be drilled in the bottom. The container must be given ample time to become heated before any components are dropped in.

Burning in a Trench. Primers smaller than 100 grain may be burned in a trench approximately 2 feet deep, 1 foot wide, and of sufficient length to accommodate the number of primers to be burned at one time. A quantity of excelsior or similar combustible material sufficient to insure a good hot fire throughout its length should be placed in the bottom of the trench. The primers must be removed completely from their containers and placed on the combustible material before the fire is lighted. A piece of sheet metal should be placed over the trench to confine fragments. Sufficient space should remain uncovered at the ends to allow a draft through the trench. The combustible material is lighted with an inflammable train.

DESTRUCTION OF FRAGMENTATION GRENADES.

Grenades are destroyed by unscrewing the fuze from the body, emptying the EC blank powder into a barrel of water, and destroying the fuzes by the pit and chute method. The EC blank powder may be later spread out on the ground, allowed to dry, and burned in accordance with the procedures outlined for black powder. If the fuzes do not disassemble easily, the grenades should be destroyed with demolition blocks like offensive and rifle grenades.

DESTRUCTION OF CHEMICAL COMPONENTS FILLED WITH H.

General. When chemical ammunition containing mustard cannot be dumped at sea and a sufficiently isolated area is not available for static firing, it must be destroyed by one of the following methods. The precautions discussed in the chapter on storage of chemical ammunition will apply to the transporting and handling of the ammunition. Personnel will wear complete protective clothing and equipment. The appropriate first aid supplies must be on hand.

Burying. A small hole (about ¼ in.) is drilled into the void space of the component. A handful of waste or cloth wadding saturated with 5 percent bleaching powder solution should be held around the

point where the hole is being drilled to absorb any H vapor emitted when the drill pierces the component. The hole is then reamed or drilled to a diameter large enough to allow the mustard to be poured out. The H is then poured over a pile of loose earth and bleaching powder mixture in the bottom of a hole about 5 feet deep, dug at least 200 yards from well sites, streams, or bodies of water. Personnel must have the wind blowing away from them during this operation. The pile of loose earth and bleaching powder mixture in the bottom of the hole should consist of an intimate mixture of about 1 bushel of earth and 1 bushel of ordinary bleaching powder (35 percent chlorine). The emptied shell should be placed on top of the bleaching powder and the hole back filled to within a foot or so of the top. Then, approximately a barrel of water should be poured into the hole and the back filling completed. If HTH (bleaching powder containing 65 percent of available chlorine) is used instead of ordinary bleaching powder, only about one half as much is needed. A permanent sign should be placed on the fill prohibiting digging in the vicinity. The quantities given in this discussion are based on 155-mm shell which contain approximately 11 pounds of mustard. In cases where contents are greater or smaller, the amount of bleaching powder and earth must be changed accordingly.

Burning. A mustard component opened by drilling may also be destroyed by pouring the contents uniformly over a closely packed pile of wood containing about ¼ cord and laying the component on the top. The wood is then set on fire and personnel excluded from the down-wind area to a distance of 200 yards while the wood is burning. If the shell is heated to a red heat in this method of disposal, mustard adhering to the shell walls will be destroyed. If the shell contains a burster charge, the charge should be removed before the shell is placed on the wood. In emptying the shell, personnel should be placed so that the wind will blow the gas away from them. Drilling tools contaminated with mustard should be cleaned thoroughly by immersing in a 5 percent solution of bleaching powder for 10 or 15 minutes and then washing with water.

FURTHER REFERENCES: References will be found at the end of the last chapter in this section.

Chapter 4

Dumping at Sea

GENERAL.

The safest and easiest way to destroy unusable ammunition is to dump it at sea. The items disposed of in this manner must be of sufficient weight to sink to the ocean floor. Only at establishments located near a deep sea waterway is this method practicable. Port authorities must be consulted prior to taking explosive materials out to sea.

TRANSPORTATION.

Personnel supervising the loading of boats and barges should be familiar with Army Regulation No. 55-470. Unless a definite location for dumping is designated by the local port authorities, no explosive material should be thrown overboard within a distance of 10 miles from shore. An effort should be made to locate a deep place or a ledge sloping seaward. Instances are on record of heavy items of ammunition being washed ashore from almost incredible distances. During daytime transit, the boat or barge will display a red flag 4 feet square at least 10 feet above the top deck. At night, a red lantern is substituted for the flag. A competent man on board must be on the alert to signal approaching vessels of the cargo.

DUMPING.

All precautions relative to the safe handling of the various types of ammunition being destroyed will be carefully obeyed. All materials must be carefully removed from their packing before being dumped overboard. Great caution must be exercised to see that none of the items strike together or strike any part of the boat or barge.

FURTHER REFERENCES: The following references apply to all methods of destruction of unusable ammunition and explosives: FM 5-25, Engineer Field Manual; TM 9-1900, Ammunition General; O.O. 7224, Ordnance Safety Manual; SNL R-7; Training films; 5-270, Explosives and Demolition, TNT; 5-271, Explosives and Demolition, Nonelectric blasting equipment; 5-272, Explosives and Demolition, Electric blasting equipment, 9-2007, Destruction of Unusable Ammunition, Burning; 9-2008, Destruction of Unusable Ammunition, Detonation; 9-2009, Destruction of Unusable Ammunition, Dumping at sea; AR 55-470.

SECTION X.

MAGAZINE AREA

Chapter 1

Magazine Construction and Inspection

GENERAL. The end of World War I found this country with tremendous stocks of ammunition, powder, and bulk explosives. Proper storage facilities were not available for this quantity of material, and makeshift arrangements were found necessary. Among the early types of storage, wooden buildings, open sheds, and even outdoor storage with tarpaulin protection were resorted to. As might be expected, this type of storage proved unsatisfactory in many ways.

Exposure to excessive heat and moisture accelerated deterioration.

Nonfireproof construction permitted an exterior fire to destroy and explode the ammunition and explosives.

Lack of lightning protection caused a considerable hazard during thunderstorms.

Nonbulletproof construction permitted accidental shooting into magazine to set off some types of material so stored.

It is the purpose of this discussion to indicate the improvements made as evidenced by modern construction of magazines.

There are at present two distinct types of magazines: the above ground, and the underground or igloo. The tendency at new depots under construction is to make all magazines of the standard underground type.

ABOVE GROUND MAGAZINES.

Description. A typical modern above ground magazine has concrete foundation walls and piers. The walls are of hollow tile with or without a sand filler. The sand filler is for the purpose of preventing missiles from penetrating the hollow walls. The framework is of steel, and the floor is of concrete which may be covered with a sparkproof covering. A double pitched roof supported on steel trusses is used over a ceiling of corrugated asbestos with fireproof rock-wool insulation. The ceiling is attached to bottom chords of roof trusses.

It will be noted that the construction is fireproof. In addition, where the type of storage warrants it, the hollow tile walls are filled with sand to stop rifle bullets. This is especially important in storage of items such as black powder.

The use of hollow tile walls comes as the result of observations made at the scene of explosions in magazines. Often the radius and extent of the damage was spread by missiles formed from the bricks of which the magazines were constructed. The hollow tile construction is expected to pulverize under the force of an explosion, thus preventing large missiles from being formed.

The roof is of fairly light construction, thus permitting dissipation of part of the explosion force upward.

Adequate ventilation of the magazine is provided by roof, wall, and subfloor ventilators. Ventilators are either screened or baffled to prevent fire from entering the magazine from the outside. The air space above the ceiling and the ceiling insulation both serve to prevent heating up of the magazine from exposure to sun.

Water cannot readily enter the magazine (except through humidity in the air), thus making the construction essentially waterproof.

The lightning protection system on the magazine has two primary purposes. It provides a low resistance path for currents resulting from lightning which strikes the building directly. It also serves to prevent charging up of metal parts of the building as a result of induction which may occur when the lightning strikes nearby.

To accomplish these ends, an overhead lightning rod system is set up and, in addition, all metal parts such as doors and ventilators are connected to the grounding system. The grounding system enters the ground at several different points. In addition to lowering the resistance, this serves to prevent complete failure of the grounding system if one ground connection should fail or break. The ground connection itself, may consist of a metal pipe, copper plate or graphite rod extending down into the subsoil about 5 feet deep.

Sizes of magazines depend to a great extent upon what is being stored in them because maximum permissible quantities for each type are prescribed. Typical sizes are given in the following table to aid in comparison of various types.

Type	Storage	Size
Explosive magazine	Bulk explosives	27 ft 6 in. x 43 ft 4 in.
Smokeless powder magazine	Smokeless powder in boxes	37 ft 11 in. x 110 ft
Primer and fuze magazine	Primers, boosters, and fuzes	27 ft 6 in. x 43 ft 4 in.
Ammunition magazine	Fixed and separate loaded ammunition	51 ft 7 in. x 218 ft 8 in.
Warehouses	Nonexplosive material, as, small arms	Various sizes

The description given above is typical of recent construction. Deviation from the indicated characteristics may be expected at ordnance establishments having older types of magazines.

UNDERGROUND MAGAZINES.

General. The considerations of camouflage and still greater safety in storage have been taken into account in the construction of "igloos" or standard underground magazines.

The magazine is not really underground, but is built with the floor at ground level. However, a covering of earth over the top and sides constitutes the basis for the name.

Description. A typical igloo type magazine has reinforced concrete foundations, rear and front walls, and arched roof. It is this arched roof which is the basis for the name igloo. It has a built-in membrane waterproofing over the arch and rear wall. A layer of sand covered with a layer of soil is placed over the waterproofing. All metal parts are grounded, and ventilators are provided on doors, and at the rear of the magazine.

Gutters are provided beside each side wall which drain to the front of the magazine. A flutter valve which allows exit but not entrance, is provided at the drain end. The outermost extremity is closed by heavy screen to prevent entry of rodents, snakes, etc.

It is interesting to note that the concrete used is of a special type which will pulverize under the force of an explosion.

The entire arch roof as well as front and rear walls and floor are reinforced with 4-inch x 4-inch mesh, 0.20-inch diameter iron, while the sides of the arch contain ⅝-inch reinforcing.

All reinforcing is grounded by means of heavy copper wire extending about 5 feet into the ground.

This type of magazine offers excellent protection against missiles coming from outside the magazine and, for this reason, igloo magazines are considered barricaded with respect to missiles.

The mound of earth and sand around and over the magazine also serves to confine the missiles resulting from explosions in the magazine and tends to retard the missiles traveling through the side wall.

Typical sizes of these igloo magazines are 30 feet x 42 feet, 30 feet x 62 feet, and 30 feet x 82 feet.

REPAIR OF MAGAZINES.

When a magazine must be repaired in any way, a decision must be reached regarding disposition of the material in the magazine. Common sense would indicate that there is no blanket rule which can be used. The following regulations should determine the action taken:

Under normal conditions exterior repairs can be made to a magazine without removing the contents.

Interior repairs to a magazine may require removal of some materials and not of others. For example, if black powder, TNT, tetryl, or explosive "D" are in the magazine they should be removed for any type of interior repair. On the other hand, assembled ammunition such as fixed rounds packed in boxes need not be removed except in unusual cases.

All explosives and all ammunition must be removed from magazines in which repairs require the use of a blowtorch or soldering iron or the melting of asphalt.

Repair work should always be done under competent supervision and should be inspected after completion.

INSPECTION OF MAGAZINES.

General. In inspecting a magazine, it is important that special attention be given to the contents of the magazine, the magazine itself, the magazine and contents in relation to other magazines, to the rest of the post, and to the surrounding area. The summary given below is merely a rough outline of items which should be observed in each phase of the inspection.

The Contents of the Magazine. Listed below are the points which should be carefully checked in this inspection:

1. Are the mixed storage regulations being complied with?

2. Is the material separated by lots?

3. Is there sufficient aisle space?

4. Are there no blocked aisles?

5. Is the floor load too high?

6. Are all light boxes marked?

7. Are there any open boxes?

8. Is the material in stable piles?

9. Are piles separated by required safety distances where such are specified?

10. Are quantities of explosives in each pile within required limits?

11. Are total quantities in the magazine within required limits?

12. If there are detonating fuzes, is the number limited?

13. Has wooden dunnage been reduced to a minimum where required?

14. Is there any evidence of leakage from containers, or exudation?

15. Is the "housekeeping" inside the magazine satisfactory?

16. Are piles of ammunition properly grounded where this is possible?

The Magazine Itself. A thorough inspection should be made of the magazine itself to assure that all of the following points are satisfactory.

1. Are lightning rod ground connections secure?

2. Are the doors and ventilators in satisfactory condition? If made of metal are they properly grounded?

3. Is the lock in satisfactory condition?

4. Is the 50 foot fire break kept around the magazine?

5. Is there any loose wood or other inflammable material outside near the magazine?

6. Are there any leaks in the roof or breaks in the floor or walls?

7. Is there excessive condensation?

8. Is the area around the magazine properly drained?

9. Is the magazine suitable for the type of material in storage?

10. Is the magazine properly marked as required for chemical ammunition?

11. Is the auxiliary equipment required for a chemical magazine available? (For example, rubber gloves and barrel of water for WP ammunition.)

The Magazine in Relation to the Rest of the Post and Surrounding Area. One should make certain that the quantity of explosives in the magazine is within the quantity-distance limitations for the nearest magazine, public railway, public highway, inhabited buildings, or operating buildings. Any other unsafe conditions should be noted and recommendations should be made for action to be taken.

Chapter 2

Storage of Ammunition and Explosives

GENERAL.

Many different kinds of ammunition and explosives are required to meet the conditions of modern warfare. The diversity and the urgent nature of problems in the field of operations makes imperative the obtaining of any particular type of ammunition with the least possible delay. Therefore, ammunition components and explosives of all types are manufactured in excessive amounts and held in storage until they are needed by the using arms. This reservoir of ammunition must also be maintained in peacetime in the event of any emergency. In order to solve the problem of storage, depots have been established in various parts of the United States and outlying possessions.

It is the duty of personnel, including ammunition inspectors, connected with the handling, storage, and shipment of ammunition and explosives on the depot to see that pertinent regulations are enforced.

It is also their duty to obtain maximum protection against fire and explosions and to limit deterioration to the minimum.

Buildings which are of special construction and suited to the care and maintenance of ammunition components are designed for the sole purpose of storage. Explosives and ammunition in quantity may not be stored in the buildings which are used for other purposes. Neither may they be stored in the open without the approval of the Chief of Ordnance. All explosives and ammunition except small arms should be stored preferably in arch type earth-covered (igloo) magazines. Their use for storage is required in all future depot construction and is authorized, but not required, for operating storage areas in manufacturing and ammunition loading establishments. Ordnance depots and manufacturing arsenals which have the older type of magazines or which store only limited quantities of explosives and ammunition and cannot comply with regulations for future depot construction, must comply with the spirit of the regulations.

When an examination of the storage of ammunition and explosives within a storage area is made there are five main factors to be considered:

1. Mixed storage regulations.
2. Stacking or piling.
3. Fire hazard.
4. Safety regulations.
5. Quantity distance regulations.

MIXED STORAGE REGULATIONS.

General. In the early days of explosives manufacture, black powder was the only explosive used. As time went on, such explosives as smokeless powder, TNT, picric acid, amatol, and the more sensitive mercury fulminate and lead azide were developed for military use. Then too, the components in which these explosives were used became more and more varied, resulting in many different types of containers and packing for the components. The entrance of chemical ammunition into warfare further complicated the situation. Bitter experience in the form of serious explosions taught the lesson that these various types of components had to be stored and handled according to the hazards connected with them.

The fact became evident that explosive materials had to be separated in storage. This problem of separation was solved as far as Ordnance Depots were concerned by setting up a storage chart. This chart divides ammunition and explosives into groups for storage, each group showing similar hazards, as regards:

1. The results of an explosion. For example, black powder stored in or near a magazine containing H.E. shell would obviously be endangered by fragments if an explosion occurred.

2. The ease of deterioration. For example, smokeless powder is liable to spontaneous combustion due to deterioration. If this action did take place, materials stored with the smokeless powder would be destroyed.

3. The sensitivity of initiation. For example, mercury fulminate may be initiated by a slight shock or jar. Demolition bombs stored with mercury fulminate would be subjected to the same hazard.

4. The type of packing. For example, components packed in metal crates stored with components packed in wood crates would also be subjected to the additional fire hazard of wood crating.

5. Action in case of fire. Fire fighters would not attempt to put out a fire in a magazine containing black powder because of the extreme danger of explosion. Any materials stored in the same magazine would be lost in case of fire.

6. The quantity of explosives in each unit. For example, demolition bombs are regarded as extremely dangerous because of the large amount of explosives contained (30 to 75 percent of total weight). H.E. shell contain approximately 15 percent of explosive filler. They should not be subjected to additional hazard by storing them with GP bombs.

Deviation From Storage Chart. The only deviation from mixed storage regulations on the Ordnance Depot is in the case of temporary storage in shipping and receiving buildings. Subject to certain limitations, ammunition and explosives may be stored in accordance with the Shipping and Storage Chart of Explosives and Other Dangerous Articles. This chart is contained in the Interstate Commerce Commission Regulations for the transportation of explosives and other dangerous articles. Such storage will be in buildings specifically designated and used as packing or shipping buildings. The limitations under which storage according to ICC Regulations is permitted are as follows:

1. Incoming shipments will not be allowed to accumulate but must be distributed as soon as practicable after receipt.

2. Items for outgoing shipment will not be accumulated prior to receipt of orders covering each specific shipment.

3. Special rooms will be provided for the temporary storage of ammunition and explosives awaiting shipment, and for their preparation for shipment by assembling, crating, marking, etc. These rooms will be separated from each other and from offices and rooms in which inert operations such as the preparation of stencils, packing, and crating materials are performed by substantial dividing walls so constructed that they will act as fire walls.

4. Not more than three cars of ammunition or explosives, including both incoming and outgoing cars, will be permitted at a shipping or receiving building or at a building used for both shipping and receiving. In no case shall the total amount of explosives contained in cars and buildings combined exceed that authorized by the intra-

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The letter X at an intersection of a horizontal and vertical column shows that the item in the horizontal column may be stored with the item in the vertical column.

	A. Aluminum powder	Magnesium powder	B. Ammonium nitrate	DNT	C. Cyclonite	Pentolite	Tetryl	D. Cord detonating (primacord)	Explosive D	Picric Acid	TNT (bulk)	Demolition blocks	E. Lead azide (wet)	Mercury fulminate (wet)	PETN (wet)	F. Adapters, boosters, and bursters	Detonators, blasting, and percussion caps	Fuse, blasting, time	Fuzes, antitank mine	Fuze, anti-tank mine, practice, with smoke charge	Fuzes, detonating and time	Fuzes, grenade	Primers and primer detonators	G. Antitank mines, practice	Antipersonnel mines	Ball and A.P. ammunition, 20-mm	Blank ammunition for cannon	Bombs, fragmentation (in wood crates)	Bombs, practice, packed with spotting charge	Grenades, hand and AT—excepting training	H.E.I ammunition, 20-mm	Light mortar shell (81-mm and less)	Rockets, AT, AA, and artillery (including practice)	Separate loading shrapnel	Shell and shrapnel, fixed and semifixed	Small-arms ammunition	H. Bombs, demolition	Bombs, fragmentation (in metal crates)	Shell, H.E. Livens	Torpedo, bangalore	I. Pyrotechnics
A. Aluminum powder	X	X																																						
Magnesium powder	X	X																																						
B. Ammonium nitrate			X	X																																				
DNT			X	X																																				
C. Cyclonite					X	X	X																																	
Pentolite					X	X	X																																	
Tetryl					X	X	X																																	
D. Cord detonating (primacord)								X	X	X	X	X																												
Explosive D								X	X	X	X	X																												
Picric Acid								X	X	X	X	X																												
TNT (bulk)								X	X	X	X	X																												
Demolition blocks								X	X	X	X	X																												
E. Lead azide (wet)													X	X	X																									
Mercury fulminate (wet)													X	X	X																									
PETN (wet)													X	X	X																									
F. Adapters, boosters, and bursters																X	X	X	X	X	X	X			X										X					
Detonators, blasting, and percussion caps																X	X	X	X	X	X	X			X										X					
Fuse, blasting, time																X	X	X	X	X	X	X			X										X					
Fuzes, antitank mine																X	X	X	X	X	X	X			X										X					
Fuze, anti-tank mine, practice, with smoke charge																X	X	X	X	X	X	X			X										X					
Fuzes, detonating and time																X	X	X	X	X	X	X			X										X					
Fuzes, grenade																X	X	X	X	X	X	X			X										X					
Primers and primer detonators																X	X	X	X	X	X	X			X										X					
G. Antitank mines, practice																							X	X	X	X	X	X	X	X	X	X	X	X	X					
Antipersonnel mines																							X	X	X	X	X	X	X	X	X	X	X	X	X					
Ball and A.P. ammunition, 20-mm																X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X
Blank ammunition for cannon																							X	X	X	X	X	X	X	X	X	X	X	X	X					
Bombs, fragmentation (in wood crates)																							X	X	X	X	X	X	X	X	X	X	X	X	X					
Bombs, practice, packed with spotting charge																							X	X	X	X	X	X	X	X	X	X	X	X	X					
Grenades, hand and AT—excepting training																							X	X	X	X	X	X	X	X	X	X	X	X	X					
H.E.I ammunition, 20-mm																							X	X	X	X	X	X	X	X	X	X	X	X	X					
Light mortar shell (81-mm and less)																							X	X	X	X	X	X	X	X	X	X	X	X	X					
Rockets, AT, AA, and artillery (including practice)																							X	X	X	X	X	X	X	X	X	X	X	X	X					
Separate loading shrapnel																							X	X	X	X	X	X	X	X	X	X	X	X	X					
Shell and shrapnel, fixed and semifixed																							X	X	X	X	X	X	X	X	X	X	X	X	X					
Small-arms ammunition																X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X
H. Bombs, demolition																																				X	X	X	X	
Bombs, fragmentation (in metal crates)																																				X	X	X	X	
Shell, H.E. Livens																																				X	X	X	X	
Torpedo, bangalore																																				X	X	X	X	
I. Pyrotechnics																									X										X					X

Antitank mines, H.E.	STORED SEPARATELY
Black powder, bulk, saluting, spotting and smoke puff charges	
Bombs, photoflash	
Chemical amm. gr. A (persistent vesicants)	
Chemical amm. gr. B (toxic and smoke)	
Chemical amm. gr. C (phosphorus)	
Chemical amm. gr. D (burning)	
Chlorates, perchlorates, and peroxides	
Dynamite	
Flashlight powder	
Nitrocellulose	
Separate loading shell	
Smokeless powder, bulk or charges	
Tracer mixture	

STORAGE CHART FOR EXPLOSIVES AND AMMUNITION plant quantity-distance table for the distance to the nearest magazine or operating building.

5. These shipping and receiving buildings must also comply with prescribed safety distances with respect to inhabited buildings, public railways and public highways, based on the ammunition and explosives in buildings and cars combined.

Use of Storage Chart for Ammunition and Explosives. The X in the intersection of a horizontal row and a vertical column indicates that these items may be stored together. As one example, small arms may be stored with pyrotechnics. Where X appears in all of the intersections within a group, any or all of the items in a group may be stored together. For example, any or all of the items in group C may be stored in one magazine. Where X does not appear at the intersection of a row and a column, the two items may not be stored together in one magazine.

All of the materials within a group may be stored together and may not be stored with the materials in any other group. Such groups are lettered A through I. The only exception is in the case of small-arms ammunition (including 20-mm ball and armor-piercing ammunition) which may be stored with materials in groups F, G, and I. Items which must be stored alone in a magazine are listed at the bottom of the chart following the groups.

It should be noted that all components should be separated in storage except where the possibility of losing an entire stock of one item is decreased by dividing the stock into two or more magazines. For example, fuzes are limited to 50,000 of any one type to a magazine. The storage chart is to be used only in the case of such exceptions and where storage problems make it necessary to store more than one type of ammunition or explosive within a magazine. This is especially true at depots where small amounts of various types of ammunition are stored.

The storage chart does not list all ammunition components and explosives. Where items are not covered in the chart, it should be used as an indicator. Semi-armor-piercing bombs, for example, are not included. However, they are loaded with amatol as are general purpose or demolition bombs and are shipped and stored similarly. Therefore, presenting like hazards, the two types of bombs where the situation warrants such action may be stored together. Armor-piercing bombs are not included in the chart. They are loaded with explosive D and present the same hazards as artillery shell loaded with explosive D. Therefore, it may be assumed that the two items may be stored together in one magazine. Inert materials are not listed in the storage chart and should not be subjected to explosive hazards by storing them with loaded components. Neither should explosive materials be subjected to the additional fire hazards of inert compo-

nents packed in cardboard or wooden containers. These inert items should be stored preferably in weatherproof warehouses. If warehouses are not available, inert items may be stored in magazines, but not with explosive materials.

PILING AND STACKING.

General. Specific methods of piling or stacking of all types of ammunition are described on ordnance drawings. Before making an examination of any specific type of ammunition or explosives in storage, the inspector should read the drawing carefully to determine exactly how the item should be stored. There are certain rules to remember in addition to the information obtained from the drawings which apply to all types of storage. These are as follows:

1. Explosives or ammunition in piles will be separated by type and by lot.

2. Adequate dunnage will be used on the floor to protect the material in the pile from water and dampness.

3. Methods of piling or stacking will provide for good ventilation to all parts of the pile. Dunnage will be used as required.

4. Unless otherwise specified on ordnance drawings, aisles will be maintained so that units in the pile can be inspected, inventoried, and removed for shipment or surveillance tests.

5. Lids or opening ends of containers should face the aisles.

6. Partly filled boxes will be marked plainly and placed in conspicuous places on top of the piles containing the lots to which they belong.

7. Nomenclature on containers should be in such a position as to be easily read.

8. Inflammable material, such as dunnage and boxes, will be eliminated or reduced to an absolute minimum in magazines containing class 9 and class 10 materials (quantity-distance tables).

9. Quantity-distance requirements with regard to separation within magazines or other buildings will be observed carefully.

10. The piles or stacks of ammunition or explosives will be stable. Usually a level pile is a stable pile. Therefore, the stability of the pile may be checked by observing how straight the rows are horizontally and how straight the tiers are vertically.

Numbers of drawings of representative types of storage and information pertinent to inspection that may be obtained from the drawing will follow. This discussion will pertain mainly to storage in arch type earth-covered (igloo) magazines because their use for storage of all ammunition and explosives except small arms is required in future depot construction. All of the drawings referred to are for permanent storage. In wartime, when metal dunnage cannot be obtained, wood will be substituted and methods of stacking suitable to storage on wood will be used. Ways of stacking which deviate from those specified on ordnance drawings will conform in so far as possible, to the regulations contained herein. Such deviations should also provide for maximum storage and for maximum speed in getting components ready for shipment.

Bulk Black Powder Storage. Drawing 19-48-179 shows storage of black powder in metal containers (25 lb of explosive per container). The containers are stacked in double rows, pyramid fashion on floor dunnage only, running the length of the igloo. Aisles are maintained on all sides of the double rows and the tops of all cans are toward the aisles. Wooden floor dunnage is required because it is nonsparking. The detail indicating the proper position of the container seam in storage, shows it on the side, lip downward. This position is important because water will run over rather than into the seam and will drop off. The stops on the ends of the dunnage must be securely fastened in order to bear the weight of the pile. The maximum amount of explosive allowed is 250,000 pounds.

Bulk Smokeless Powder Storage. Storage for smokeless powder contained in the steel box in igloo magazines is shown on drawing 19-48-92. The boxes are stacked in double rows across the magazine and are held in place by steel dunnage made up of flat, angle, and channel irons. The floor dunnage is elevated on the aisle sides so that the containers lying on their sides are on a 20-degree angle with the lids to the aisles. The lid, which is off center in the can, should be uppermost so that methyl violet inspection may be made without spilling the powder. The containers being slanted inward make for a more stable pile and also permit any accumulated moisture to run off. Aisles are maintained on all sides of the double stacks except at the side walls of the magazine. A center aisle is left in order to give access to all containers. The boxes on the center aisle are stacked straight up in block form while those at the sides follow the contour of the magazine. No containers should touch the walls as condensation often occurs there and may result in rust and deteriorated powder.

Cloverleaf Bundle Storage. Many ammunition components and explosives are packed in fiber drums which are in turn assembled into a cloverleaf. Such items include fixed and semifixed artillery ammunition, trench mortar ammunition, separate loading propelling charges and rockets. Drawing 19-48-21 showing storage of 60-mm mortar shell in igloo magazines is typical of bundle storage.

The bundles are stacked in double rows on metal dunnage consisting of channels on the floor and angle iron supports on the center aisle. The bundles are stacked so that the tiers form a straight line perpendicular to the magazine at the center aisle and follow the contour of the magazine at the side walls. There is a single row in the extreme rear of the magazine, commonly called the back stack,

which is piled on floor dunnage only. The wing nuts on all packages should face the aisles and should be secured with an ordnance seal. Aisles are maintained between all double rows, at the center, in front, and between the last double row and the back stack. The bundles are nested together in the stack so that each bundle on the bottom tier rests on the dunnage and every other bundle is inverted.

Bundles Crated for Export. Due to conditions of war, it is deemed advisable to have all types of ammunition crated for export. Even propelling charges, which are stripped of wooden crating when placed in the magazine during peacetime, are stored crated in order to facilitate shipment to foreign theatres of operations. There is no occasion for inspection of long time storage under these conditions so the crates are stacked in intimate contact leaving only center and front aisles. Drawing 19-48-185, illustrating storage of 105-mm shell crated for export is typical of this type of storage. Every other crate is inverted and dunnage is used between each tier to give the pile stability. The crates are stacked solidly across the magazine from the back stack to the front aisle leaving aisle space in the center.

Box Storage. Ammunition or explosives packed in boxes are piled in block form following the contour of the igloo at the side walls. There may or may not be aisles between rows of boxes, depending upon the component. For instance, TNT is subject to sympathetic detonation and consequently is stacked solid on either side of a center aisle. If one box catches fire or explodes, all boxes in the magazine will be lost. Inspectors should be certain that boxes containing TNT or like explosives are stored with top side up so that the explosives will not sift out. Dunnage necessary for proper ventilation will depend upon the types of boxes. Storage of TNT is shown on drawing 19-48-55.

Storage of Separate Loaded Shell. Drawing 19-48-22 shows storage of separate loaded shell of 10 inches or less in caliber. There are no provisions made for inspection within the magazine. The piles consist of a back stack and double rows across the magazine leaving center and front aisles. The shell are stacked nose to nose and base to base leaving from 2 to 4 inches between noses. The shell in the back stack are piled with their noses to the wall. The dunnage consists of channels on the floor and bar steel between each tier with stops at the end to keep the shell from rolling. Care must be taken to keep the rotating bands from being injured by resting on the dunnage. Since the shell cannot be inspected during storage, a 100-percent inspection of base plates and at least a sample inspection of fuze cavities should be made before shipment. All unfuzed shell must be fitted with fuze hole plugs adjusted to hand tightness. All piles of separate loaded shell should be grounded for lightning protection.

Quantity-distance regulations are not observed in the igloo magazine, the shell are regarded as liable to mass detonation for quantity-distance purposes. Chemical shell are separated by aisle spaces however because they must be readily accessible to facilitate the handling of leakers. Separate loaded shell in the standard magazine are stacked in single rows, nose to nose, with aisle spaces which conform to quantity-distance. When the number of shell to be stored in a magazine is less than the quantity shown on ordnance drawings, quantity-distance separation between piles will be observed in the igloo and the number of shell in a pile in the standard magazine will be reduced rather than making an increase in the distance between piles.

Projectiles for fixed and semifixed ammunition, not assembled to or packed with cartridge cases and propelling charges, will be treated as separate loaded shell in regard to both piling or stacking and mixed storage.

Shell of Over 10 Inches in Caliber. Shell larger than 10 inches are stored on their bases on appropriate floor dunnage. Shell loaded with TNT or amatol must be separated by caliber distance. For example, shell of 12-inch caliber must be placed so that no shell will be within 12 inches from it. Shell loaded with explosive D may be stored in intimate contact.

The principles discussed above for storing separate loaded shell are based on the results of comprehensive tests at Aberdeen Proving Grounds. The following conclusions were reached as a result of these tests:

1. An explosion of shell loaded with TNT or amatol could be confined to one pile if ample distances were maintained between piles in a magazine.

2. Distance between piles at which an explosion would be transmitted increases with the number of shell in the pile in which the explosion originated.

3. All shell in the pile in which an explosion starts will explode. Piles should be reduced to the smallest practicable size if the effects of the explosion are to be limited.

4. Distances to be maintained between piles to prevent an explosion from being transmitted must be greater for shell fitted with die-cast white metal fuze hole plugs than for shell fitted with steel or iron fuze hole plugs.

5. It is practically impossible to explode a pile of shell loaded with explosive D. Explosions are usually of a very low order and limited to one shell.

6. Shell should be arranged in single piles, nose to nose or base to base. The lateral distance at which explosions are transmitted is several times greater than the nose to nose or base to base distance.

7. If piles are knocked down or disarranged by the explosion of one pile, or of an enemy bomb, or any similar occurrence, it is possible that a subsequent explosion will cause a mass detonation of the disarranged piles.

Bomb Storage. Chemical bombs are packed in boxes and follow the block form of storage with a back stack in the rear of the magazine and aisles between double rows. Aisles are also left in the center and in front. Armor-piercing bombs are stored similarly to separate loaded artillery shell filled with explosive D.

Demolition bombs (general purpose, semi-armor-piercing and depth bombs) and fragmentation bombs are subject to mass detonation and because of the large amount of explosive in each unit are regarded as one of the most hazardous types of ammunition. Safety can be obtained only by reducing the possibility of fire to an absolute minimum since no feasible way has been found of separating bombs or of barricading piles of bombs in a magazine to reduce the hazard of mass detonation. If igloo magazines are available, they should be used for storage of general purpose and semi-armor-piercing, depth, and fragmentation bombs. Wood dunnage will be used only in cases where metal dunnage cannot be obtained.

Drawing 19-48-1 is representative of storage of general purpose and semi-armor-piercing bombs from 250 to 2,000 pounds in weight. 100-pound bombs are stored as complete unassembled rounds in metal crates which are stored similar to boxed ammunition. Bombs larger than 100 pounds are stacked crosswise of the magazine in single rows leaving aisle space in the center and aisles between stacks. None of the bombs will be fuzed but will be fitted with shipping plugs screwed to hand tightness. These shipping plugs should be unscrewed, the fuze cavities inspected, and the plugs reassembled to hand tightness. The floor dunnage consists of channel irons and the dunnage between tiers is made up of I-beams. The shipping bands fit into the channel irons and I-beams. The above drawing shows shipping bands interlocked. Due to a change in the width of shipping bands, this practice is discontinued and the dunnage is made to fit the width of one band. The bombs are kept from rolling by placing iron wedges under the shipping bands at either end of the stack and backing them up with a piece of wood of appropriate length between the wedge and flat steel welded across the end of the channel or I-beam.

4,000-pound bombs are also stored on channels and I-beams, but the stacks consist of single rows, 2 bombs high on either side of the magazine (drawing 19-48-85). The noses of the bombs face the center aisle. Seven bombs are stored in the center aisle on the floor and 3 bombs are on the floor on each side of the center aisle in the front of the igloo. This storage just fits the 60-foot igloo with

77 bombs containing approximately 250,000 pounds of explosive which is the maximum permitted in the magazine.

FIRE HAZARDS.

Relative to Storage Within the Magazine. Magazines are constructed for the sole purpose of storing ammunition and explosives. Materials that are unnecessary, such as excess dunnage, trash, etc., are not to be permitted in the magazine. Materials crated for protection during shipment, such as propelling charges in wooden crates, must have the crates removed before they are stored because the wood is not necessary for protection during storage and constitutes an additional fire hazard. Extremely hazardous materials, such as general purpose and semi-armor-piercing bombs should be stored on metal dunnage if it can possibly be obtained. Black powder will not be stored on metal dunnage because of its sensitivity to sparks.

Any oil stains or exudate will be eliminated immediately. Materials subject to exudation, such as separate loaded artillery shell which are liable to exude on the floors, will never be stored in magazines floored with wood. Neither will chemical ammunition be stored on wooden floors.

There should be signs placed at the approaches to the magazines indicating the types of ammunition or explosives stored within, so that depot firemen will know what action to take in case of fire. In some cases, firemen will not attempt to extinguish the fire but will limit their efforts to preventing it from spreading. In other cases, depending on the components stored and the extent of the fire, they will attempt to extinguish the fire at its origin. If evidence of fire is detected by personnel in the area, they will turn in the fire alarm before making any investigation. Fire extinguishers, water barrels, buckets, and other auxiliary fire fighting equipment such as gunny sacks and brooms, at or near magazines, will be arranged in a neat and orderly manner and will be protected against undue deterioration. They will be placed uniformly in position where they are in plain sight and readily available. The inspector should make a periodic inspection of such equipment to see that it is in good order.

Fire Hazards With Regard to Storage Area Operations. Operations in the storage area will be accompanied by applicable fire-fighting equipment. Inspectors should examine fire extinguishers carefully to see that they are properly filled and in good working order. Any paints, oils, or solvents carried into a building in which explosives are stored should be kept in safety containers. Rags soaked with these liquids will not be allowed to accumulate. Safety tools will be used as designated in the Ordnance Safety Manual. Wood left from crating or loading must be removed at the close of the day's operation or as soon as possible thereafter. If a portable light

source is needed for the inspection of a magazine or other operations, it should be an explosion proof type of electric light.

Fire Hazards Relative to the Repair of Magazines. The following special regulations with regard to safety are particularly applicable to the repair of magazines:

1. All work will be done by careful, experienced workmen under competent supervision.

2. Safety tools will be used when indicated.

3. The floor in the immediate vicinity of the repair work will be swept carefully.

4. No work requiring soldering, the melting of asphalt, or the use of blowtorches will be done in a magazine containing explosives or ammunition.

5. No repairs will be made to the interior of a magazine containing bulk explosives such as black powder, TNT, tetryl or explosive D, until all explosives have been removed.

6. Magazines in which repair work has been done will be inspected by competent authority upon completion of the work.

7. When melting pots or any other heating apparatus, electrical or otherwise, are authorized by the commanding officer in any magazine or explosives area in connection with repair work on buildings, all such equipment should be kept at least 100 feet from any magazine or building containing explosives or ammunition and should be baffled or screened as necessary to prevent danger from sparks or flame.

The Fire Break. The area within a radius of 50 feet of the magazine is designated as the fire break. The vegetation within this area must be controlled to a height of not more than 10 inches. This space must also be free of all dry grass, leaves, rubbish, lumber, left-over dunnage, conveyors, etc.

SAFETY REGULATIONS.

Regulations for the safe manufacture, handling, shipment, and storage of any particular type of ammunition or explosives are contained in the Ordnance Safety Manual. The following are safety regulations that apply generally to the storage of ammunition and explosives:

1. Containers will be free from loose dirt and grit when stored. Dirty containers will not make a stable pile. Cleanliness runs hand in hand with safety.

2. Containers will not be opened or repaired in a magazine. This will be done in a building specifically set aside for this purpose or, in clear weather, in the open at sufficient distance to comply with intraplant quantity-distance tables (pages 802 to 806), but at least 100 feet from any building containing explosives.

3. Explosives and ammunition in damaged containers will not be stored in a magazine. Such containers will be repaired or the contents transferred to new or serviceable containers.

4. Open containers and containers with covers not securely fastened will not be allowed in magazines. Containers that have been opened will be closed again as effectively as is required upon manufacture or ordnance drawings.

5. Loose rounds or loose components will not be stored in the magazines.

6. The temperature in a magazine will be kept as even as possible. Sudden changes in temperature may damage airtight containers, or may result in excessive condensation of moisture in the air. If the temperature in a magazine exceeds 100 F for a period of more than 24 hours, the magazine will be cooled by wetting the exterior of the building with water or by opening the doors and ventilators after sunset and closing them in the morning. If these methods do not prove effective in lowering the temperature, the commanding officer will decide if the stores are to be removed to some other magazine, and will report such cases to the Chief of Ordnance. Maximum and minimum or recording thermometers are placed in representative magazines, and the records of the temperatures in those magazines are included in the monthly report of the ammunition inspector.

When temperature is controlled by opening the doors after sunset, effective measures will be taken to protect the stores against fires, and provision will be made for closing the doors in case of rain.

7. Two or more doors, when available, must be unlocked when personnel is working in a magazine in order that more than one means of escape will be available.

QUANTITY-DISTANCE REGULATIONS.

General. Storage areas, manufacturing and loading areas, administration buildings and other facilities at ordnance establishments, and such public installations as railroads, highways, and inhabited buildings bordering the depots must be separated from any point of which an explosion may occur by safe distances. These distances are dependent upon the type and quantity of the ammunition or explosives and upon the construction of the buildings in which they are stored. The ammunition or explosives within an area must also be separated by distances that will not permit explosions or fires to be propagated from one point to another.

The distances and maximum quantities set forth in this section are based on the following basic data:

1. Records of fires and explosions involving military explosives and ammunition.

2. Reports covering a comprehensive series of tests at Aberdeen Proving Ground.

3. The American Table of Distances, published by the Institute of Makers of Explosives, United States of America.

4. Chapter 87, Laws of 1925, State of New Jersey. Where, under quantity-distance, explosives and ammunition are grouped into classes, it is not meant or implied that the articles in a particular class are to be stored together, but merely that the hazards involved are similar for all articles in each group. The materials that may be stored together are designated in the storage chart on pages 786 and 787. The quantity-distance tables are based on three hazards: namely, fire, missile, and concussion. The table for a particular class of ammunition will be based on the hazard causing destruction at the greatest distance.

EXPLOSIVES HAZARDS AND QUANTITY-DISTANCE REQUIREMENTS.

Fire is the most common hazard incident to the manufacturing, processing, handling, and storage of ammunition, propellent powders, and other explosives. Except under unusual circumstances relating to methods of packing and heights of column for certain types and granulations (Ordnance Safety Manual, par. 94), smokeless powder is considered a fire hazard only. Consequently, in the smokeless powder tables (class 2) the quantities and distances shown are for fire protection only. Pyrotechnics, excepting flashlight powder and photoflash bombs, small-arms ammunition, and chemical ammunition are also considered fire hazards only, as regards quantities and distances. Most other items of ammunition and explosives may, as a result of fires, detonate and spread disaster to distances considerably in excess of fire-protection distances.

Missile hazards are introduced by explosions involving high-explosive shell or loaded ammunition components. Missiles may be projected either as pieces of broken shell cases or other components, or as complete projectiles which may and often do explode on impact or as a result of heating in burning explosives or other fires. Some of the worst disasters have resulted from high-explosive shell spreading explosions from building to building. Missile distances prescribed in the quantity-distance tables for classes 3, 4, 5, 6, and 7 are based upon tests made at Aberdeen Proving Ground. These distances do not take into account occasional missiles which may be thrown a mile or more. They are based upon the distance within which most missiles will fall.

Concussion effect which is produced by the detonation of explosives constitutes the commonest hazard associated with explosives. The distances given in the tables 8, 9, and 10 are expected to give protection against the concussion effect of explosions. They are identical with the American Table of Distances published by the

Institute of Makers of Explosives. Concussion hazards have been divided into three separate classes.

Structural damage to inhabited buildings. The distances shown in tables 8, 9, and 10 for inhabited buildings represent the distances at which buildings will be safe from substantial structural damage. Minor damage such as the breaking of window glass or the shaking down of plaster and possible damage from flying missiles is not considered as substantial structural damage. The term "substantial damage" is defined as follows: In stone or brick buildings, the serious weakening of or displacement of portions of supporting walls (i.e., foundations, side walls, or interior supports) and the breaking of rafters or other important roof supports or floor joists; in frame buildings, the serious weakening of or displacement of foundations, the breaking of any of the main supports in the side walls or interior supporting walls, and the breaking of any main supports of the roof or floors.

Structural damage to railroad equipment. The distances at which railroad cars are considered safe from the concussion effects of explosions have been fixed in the American Table of Distances at 60 percent of the inhabited building distance. These distances have been used in tables 8, 9, and 10. The use of the lesser distances was based on the following considerations: The lesser height and smaller area of railroad trains exposed to concussion, and the greater strength of railroad cars to resist concussion, as compared to buildings; and the fact that while a building is stationary and subject to any risk constantly, the presence of a train is only temporary.

Injury to persons on public highways. The public highway distances shown in tables 8, 9, and 10 were taken from the American Table of Distances. They represent the distances at which persons in the open are safe from the concussion effects of explosions. The cases tabulated by the Institute of Makers of Explosives did not conform to a fixed pattern, and in arriving at distances which would be safe and well beyond the distances at which injuries have actually occurred, public highway distances were fixed in the American Table of Distances at one-half the railroad distance or 30 percent of the inhabited building distances.

Explanation of terms used in quantity-distance.

Inhabited building. Any building customarily used as a habitation, church, schoolhouse, hospital, railroad station, or for other purposes of assembly; including general purpose buildings such as offices, barracks, shops, and power plants. Buildings pertaining to an explosives line or magazine area such as operating buildings, watchmen's shelters, field offices, and packing and shipping buildings are not considered as inhabited buildings. Lands outside of and adjacent to boundaries of military reservations will be considered as possible

sites for inhabited buildings. Watchmen's shelters, field offices, surveillance inspection buildings and bombproofs or shelters for personnel in the magazine area will not be located closer to magazines than the magazine to magazine distance for the quantity and classes of ammunition or explosives involved.

Public railway. Any steam, electric, or other railroad which carries passengers for hire.

Public highway. Any street, alley, road, or navigable stream. A navigable stream is one capable of extensive navigation by barges, tugboats, and other large vessels.

Nearest magazine. The nearest magazine containing explosives or ammunition. The amount of explosives or ammunition permitted in a magazine can sometimes be increased if the nearest magazines are filled with inert materials, thus greatly increasing the distance to the nearest magazine containing explosives or ammunition.

Measurements. Measurements for determining quantities of explosives will be made from the nearest point of the building containing explosives to the nearest point of the magazine, inhabited building, public railway, public highway, or channel of the navigable stream under consideration.

Operating building. Any structure in which operations pertaining to manufacture, processing, packing or shipping of explosives, or ammunition are performed.

Maximum permitted. The maximum quantity of explosives or ammunition permitted in any magazine. Maximum quantities are based on limiting losses of military stores as well as on quantity-distance considerations.

Sympathetic detonation. A sympathetic detonation is one which immediately follows as a direct result of an initial explosion. It may be the result of propagation, or it may be the result of missiles from the initial explosion. In any case, it is an explosion that so closely follows the initial explosion as to be indistinguishable from it. The magazine to magazine distances and the intraplant distances shown in this section for all classes of ammunition and high explosives are expected to give protection against propagation from explosions in adjoining buildings or magazines. It will be noted that these distances are in all cases substantially less than those required to protect inhabited buildings, against structural damage, and it is not expected that intraplant or magazine to magazine distances will give protection against structural damage.

Barricades. Whenever an explosives manufacturing building or magazine is effectively screened from another explosive manufacturing building or magazine, railroad or highway, either by natural features of the ground or by efficient artificial barricades of such height that any straight line drawn from the top of any side wall of the factory building or magazine to any part of the explosives plant building or building to be protected will pass through such intervening natural or artificial barricade, and any straight line drawn from the top of any side wall of the factory building or magazine to any point 12 feet above the center of the railroad or highway to be protected will pass through such intervening natural or artificial barricade, the applicable distance (except missile and smokeless powder distances) as prescribed by the quantity-distance table, and the intraplant quantity-distance table, and the distances separating magazines, may be reduced one-half.

When protected by barricades at the door end, approved, reinforced-concrete, arch-type, earth-covered (igloo) magazines are considered barricaded in all directions, and "barricaded distances" may be used as minimum safe distances in locating them with references to inhabited buildings, public railways, public highways, operating buildings, or other magazines. No other type of magazine is considered barricaded unless separate barricades are provided. Where concrete igloo magazines are not barricaded at the door end, "unbarricaded distances" will be used in locating them from structures and facilities which lie in front of the magazines and within the area bounded by lines drawn from the door and inclined by 30 degrees from a line drawn perpendicular to the front of the magazine.

A barricade used for the purpose of reducing safety distances must be constructed separate from the building it is to screen and must be located at a minimum distance of 4 feet from such a building. It may be either natural or artificial. If artificial, it should consist of earth or sand-fill with a minimum width of 3 feet at the top. Either one or both sides may be riveted, or supported by concrete, timber, or masonry walls. Barricades are authorized for use in reducing both intraplant distances and structural damage distances, but not for reducing missile distances. Approved reinforced-concrete, arch-type, earth-covered (igloo) magazines are considered barricaded with respect to missiles. Other types of magazines are not considered barricaded in any respect unless separate barricades are provided.

Flash barricades which are authorized for the purpose of preventing the spread of fires will not be used for the purpose of reducing safety distances.

Dividing walls. A definition of the words "within substantial dividing walls" with reference to intraplant distances between factory buildings is illustrated by the following example. If a building contains 4.000 pounds of explosives and is provided with a "substantial dividing wall," dividing the building into two rooms, one containing 3.000 pounds of explosives and the other 1.000 pounds, the distance between the room containing 3,000 pounds of explosives and the nearest operating factory building is based on the distance required for 3,000 pounds of explosives. To describe it otherwise, "a substantial dividing wall" would, in the event of a detonation of the larger quantity of explosives, prevent the sympathetic detonation of the lesser quantity of explosives in the adjoining room. The distance to the next building is governed by the 3,000 pound instead of the total of 4,000 pounds.

Substantial dividing walls used to separate buildings into individual rooms will not be added to existing buildings except by authority of the Chief of Ordnance. It is not expected that substantial dividing walls will materially limit structural damage. If all of the explosives on both sides of a substantial dividing wall are prevented from exploding en masse, the purpose for which the wall was provided has been accomplished, even though the wall may be demolished and structural damage in the plant may be severe. A substantial dividing wall must extend to the roof and to the side walls of the building or room which is divided into separate rooms. It must consist of concrete at least 12 inches thick, reinforced on both sides by rods at least ½ inch in diameter, located on maximum centers of 12 inches both vertically and horizontally. This paragraph should not be interpreted as discouraging the use of barricades of the bench or wing-wall type to cut down operating hazards; but for the purpose of establishing safety distances, such barricades should not be considered as dividing the explosives contained within the building or room into separate lots.

Classes and Quantity-distance Tables for Military Explosives and Ammunition. The explosive contents of ammunition and components are shown on ordnance drawings and in the complete round chart; but if these are not available, the information desired should be requested from the Chief of Ordnance. The quantities shown in the tables herein were computed in the following manner:

For smokeless powder, the quantity in pounds in the net weight of the powder in the boxes (bulk powder) or propelling charges.

For pyrotechnics, the quantity is the gross weight of the boxes and contents.

For fixed ammunition, the pounds of explosives are computed as follows:

If a magazine contains 200,000 pounds of 75-mm H.E. Shell M48, the amount of explosives in the magazine is 200,000 x 1.47 = 294,000 pounds. (1.47 pounds is the approximate weight of the high explosive in the shell.) The smokeless powder in the cartridge case is not classed as an explosive in this case and is not included in the computation.

For separate loading shell and bombs, the pounds of explosives are computed as follows: If a magazine contains 30,000 rounds of

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155-mm Howitzer Shell M102, the amount of explosives in the magazine is as follows: 30,000 x 15.56 = 466,800 pounds. (15.56 is the approximate weight of the high explosives in the shell.)

When military explosives and ammunition are not packed in accordance with the provisions of approved drawings and specifications, they will be stored in accordance with special instructions issued by the Chief of Ordnance. When military explosives and ammunition are packed in accordance with the requirements of approved drawings and specifications, and are stored in accordance with storage drawings, or as prescribed by the Ordnance Safety Manual, they are classified as indicated below, and will be stored in accordance with the quantity-distance tables shown.

Class 1. Small-arms ammunition, excepting 20-mm H.E.-I cartridge, fuzes without boosters, and antitank practice grenade. These materials are principally fire hazards. No limit is placed on the storage of small-arms ammunition, but the quantity limits imposed on class 3 material mentioned below apply also to mechanical time fuzes.

Class 2. Smokeless powder in containers[1], pyrotechnics, and chemical ammunition filled with phosphorus. These materials may become unsafe under extreme conditions of moisture and high temperature. They burn with intense heat.

CLASS 2 QUANTITY-DISTANCE TABLE

Quantity		Unbarricaded Distance[2] in Feet From Nearest			
Pounds Over	Pounds Not Over	Inhabited Building	Public Railway	Public Highway	Magazine[3]
100	1,000	75	75	75	50
1,000	5,000	115	115	115	75
5,000	10,000	150	150	150	100
10,000	20,000	190	190	190	125
20,000	30,000	215	215	215	145
30,000	40,000	235	235	235	155
40,000	50,000	250	250	250	165
50,000	60,000	260	260	260	175
60,000	70,000	270	270	270	185
70,000	80,000	280	280	280	190
80,000	90,000	295	295	295	195
90,000	100,000	300	300	300	200
100,000	200,000	375	375	375	250
200,000	300,000	450	450	450	300
300,000	400,000	525	525	525	350
400,000	500,000[4]	600	600	600	400

[1] Smokeless powder in containers is intended to mean any smokeless powder stored in boxes, powder cans, cartridge storage cases, or any container used for the storage of smokeless powder.
[2] Unbarricaded distances as shown always will be used when considering above-ground magazines in which smokeless powder is stored. One-half the above distances are authorized for separation of igloo type magazines containing smokeless powder.
[3] Distances shown are applicable to operations succeeding the graining operation in smokeless powder plants.
[4] Maximum quantity permitted in any one magazine.

Class 3. Point-detonating fuzes, minor caliber base-detonating fuzes, powder train and antitank-mine fuzes, packed separately in boxes; bomb fuzes, packed with fin assemblies; antitank mine, practice, with smoke charge. The amount of explosives in articles of this class, including the booster, varies from 30 to 500 grains, except in the case of bomb fuzes packed with fin assemblies, which contain a charge of approximately 1,000 grains. These fuzes usually explode progressively, not more than a box or two at a time. Pressures which would cause serious structural damage to adjacent magazines are not usually generated, and missiles are small and of light weight, usually falling within 300 feet. The quantity of fuzes stored in a single magazine will be kept to the minimum, consistent with available storage, capacity. The storage of more than 50,000 fuzes of any one model, or a total of more than 150,000 fuzes of all models in a single magazine will not be permitted except by specific authority of the Chief of Ordnance.

CLASS 3 QUANTITY-DISTANCE TABLE

Quantity, Pounds of Explosives (Not Over)	Unbarricaded Distance[1] in Feet From Nearest			
	Inhabited Building[2]	Public Railway[2]	Public Highway[2]	Magazine
10,000[3]	400	400	400	300

[1] These distances will not be reduced by barricades. One-half the above distances are authorized for concrete igloo magazines, except at the door end.
[2] Missile distance.
[3] Maximum permitted in any one magazine.

Class 4. When packed in accordance with ordnance drawings and specifications: Fixed and semifixed high-explosive shell (complete rounds); light mortar ammunition; hand and antitank grenades; shrapnel of all calibers (fuzed or unfuzed); blank ammunition for cannon; 20-mm H.E.-I cartridge; AT, AA, target, and practice rockets. Articles in this class usually explode progressively, only a few boxes at a time, many explosions of individual rounds being of a very low order. Pressures which would cause serious structural damage to adjacent magazines are not usually generated, and most missiles would fall within 600 feet.

CLASS 4 QUANTITY-DISTANCE TABLE

Quantity, Pounds of Explosives (Not Over)	Distance[1] in Feet From Nearest			
	Inhabited Building[2]	Public Railway[2]	Public Highway[2]	Magazine
500,000[3]	1,200	1,200	1,200	300

[1] These distances will not be reduced by barricades. One-half the above distances are authorized for concrete igloo magazines, except at the door end.
[2] Missile distance.
[3] Maximum permitted in any one magazine.

Class 5. Separate loading shell of all calibers, loaded with explosive D, fuzed or unfuzed; and shell loaded with explosive D, fuzed or unfuzed, not assembled to or packed with cartridge cases. These shell usually explode one at a time, and in practically all cases with low order. As only one shell should be involved in an explosion, the missiles are limited both as to number and range, and most missiles will fall within 1,200 feet.

CLASS 5 QUANTITY-DISTANCE TABLE

Quantity, Pounds of Explosives (Not Over)	Distance[1] in Feet From Nearest			
	Inhabited Building[2]	Public Railway[2]	Public Highway[2]	Magazine
650,000[3]	1,200	1,200	1,200	300

[1] These distances will not be reduced by barricades. One-half the above distances are authorized for concrete igloo magazines, except at the door end.
[2] Missile distance.
[3] Maximum permitted in any one magazine.

Class 6. Major and medium caliber base-detonating fuzes, bomb fuzes; and adapters and boosters for high-explosive shell, bursters for chemical shell, and for bombs, packed separately in boxes. The amount of explosives in single items of this class usually does not exceed ½ pound. They usually explode progressively, by piles. The number involved in any explosion is limited by making the piles small and separating them by prescribed distances determined by actual detonation tests. Structural damage caused by the pressure generated usually is limited to adjacent magazines and the missiles are light and usually fall within 600 feet. The quantity of fuzes stored in a single magazine will be kept to the minimum consistent with available storage capacity. The storage of more than 50,000 fuzes of any one model, or a total of more than 150,000 fuzes of all models in a single magazine will not be permitted except by specific authority of the Chief of Ordnance.

CLASS 6 QUANTITY-DISTANCE TABLE

Quantity, Pounds of Explosives (Not Over)	Unbarricaded Distance[1] in Feet From Nearest			
	Inhabited Building[2]	Public Railway[2]	Public Highway[2]	Magazine
100,000[3]	1,500	900	450	300

[1] These distances will not be reduced by barricades. For concrete igloo magazines (except at the door end), one-half the above distances are authorized. When items of this class are stored in igloo magazines (except when segregated into piles in accordance with drawing No. D-8361), the quantity and distance requirements prescribed for classes 9 and 10 will apply, except that no distances smaller than one-half the distances quoted in the above class 6 Quantity-distance Table are authorized.
[2] Missile distance.
[3] Maximum permitted in any one magazine.

Class 7. Separate-loading loaded shell of all calibers, fuzed or unfuzed, except those loaded with explosive D; and loaded shell except those loaded with explosive D, fuzed or unfuzed, not assembled to or packed with cartridge cases. Shell in this class usually explode

progressively by piles. The number involved in any one explosion is limited by making the piles small and separating them by prescribed distances which have been determined by actual detonation tests. Structural damage caused by the pressures generated is usually limited to adjacent buildings. Most missiles will fall within 1,500 feet.

CLASS 7 QUANTITY-DISTANCE TABLE

Quantity, Pounds of Explosives (Not Over)	Unbarricaded Distance[1] in Feet From Nearest			
	Inhabited Building[2]	Public Railway[2]	Public Highway[2]	Magazine
500,000[3]	1,800	1,800	1,800	300

[1] These distances will not be reduced by barricades. For concrete igloo magazines (except at the door end), one-half the above distances are authorized. When items of this class are stored in concrete igloo magazines (except when segregated into piles in accordance with drawing No. 19-48-12), the quantity and distance requirements prescribed for classes 9 and 10 will apply except that no distances less than one-half the distances quoted in the above class 7 Quantity-distance Table are authorized.
[2] Missile distance.
[3] Maximum permitted in any one magazine.

Class 8. Primers, detonators, primer-detonators for bombs, grenade fuzes, and blasting caps, packed in accordance with ordnance drawings and specifications. All in a magazine may explode at one time but as the total amount of explosives is limited, structural damage usually is limited to adjacent magazines. This class of ammunition forms light missiles which have a very limited range.

CLASS 8 QUANTITY-DISTANCE TABLE

Quantity, Pounds of Explosives (Not Over)	Unbarricaded Distance in Feet From Nearest			
	Inhabited Building[1]	Public Railway[1]	Public Highway[1]	Magazine
2,000	980	590	300	300
5,000	1,200	720	360	300
10,000	1,500	900	450	300
15,000	1,610	970	490	300
20,000[2]	1,740	1,040	520	300

[1] American Table of Distances, requirements for explosives in the form of blasting caps.
[2] Maximum permitted in any one magazine.

Class 9. Flashlight powder, demolition blocks, spotting charges, black powder, bulk priming explosives; bulk initiating explosives such as tetryl, and bulk high explosives such as TNT and explosive D. Priming explosives such as mercury fulminate and lead azide will be stored in accordance with special instructions to be issued by the Chief of Ordnance. In a fire, black powder usually explodes and TNT and explosive D usually burn, but may explode. Since these explosives are similar to commercial explosives on which the American Table of Distances was based, they are stored in accordance with this table.

CLASSES 9 AND 10 QUANTITY-DISTANCE TABLE

Quantity of Explosives		Unbarricaded Distance in Feet From Nearest			
Pounds Over	Pounds Not Over	Inhabited Building[1]	Public Railway[1]	Public Highway[1]	Magazine[2]
.....	500	720	430	220	140
500	1,000	1,020	610	310	180
1,000	1,500	1,060	640	320	210
1,500	2,000	1,200	720	360	230
2,000	3,000	1,300	780	390	260
3,000	4,000	1,420	850	420	280
4,000	5,000	1,500	900	450	300
5,000	6,000	1,560	940	470	300
6,000	7,000	1,610	970	490	300
7,000	8,000	1,660	1,000	500	300
8,000	9,000	1,700	1,020	510	300
9,000	10,000	1,740	1,040	520	300
10,000	15,000	1.780	1,070	530	300
15,000	20,000	1,950	1,170	580	300
20,000	25,000	2,110	1,270	630	300
25,000	30,000	2,260	1,360	680	300
30,000	35,000	2,410	1,450	720	300
35,000	40,000	2,550	1,530	760	300
40,000	45,000	2,680	1,610	800	300
45,000	50,000	2,800	1,680	840	300
50,000	55,000	2,920	1,750	880	400
55,000	60,000	3,030	1,820	910	400
60,000	65,000	3,130	1,880	940	400
65,000	70,000	3,220	1,940	970	400
70,000	75,000	3,310	1,990	1,000	400
75,000	80,000	3,390	2,040	1,020	400
80,000	85,000	3,460	2,080	1,040	400
85,000	90,000	3,520	2,120	1,060	400
90,000	95,000	3,580	2,150	1,080	400
95,000	100,000	3,630	2,180	1,090	400
100,000	125,000	3,670	2,200	1,100	800
125,000	150,000	3,800	2,280	1,140	800
150,000	175,000	3,930	2,360	1,180	800
175,000	200,000	4,060	2,440	1,220	800
200,000	225,000	4,190	2,520	1,260	800
225,000	250,000[3]	4,310	2,590	1,300	800

[1] American Table of Distances, requirements for bulk explosives.
[2] Magazine distances conforming with the requirements of basic magazine quantity-distance rule page 810 may be authorized in special cases.
[3] Maximum permitted in any one magazine.
a One-half the above distances are authorized for concrete igloo magazines, except at the the door end.
b Distances applicable to fragmentation bombs will not be less than those stated in class 4 Quantity-distance Table.

Class 10. Demolition bombs; fragmentation bombs; photoflash bombs; H.E. antitank mines; offensive hand grenade, bangalore torpedo; Livins H.E. shell. All in a magazine may explode. In this case, structural damage will be limited to the distances specified for inhabited buildings in the American Table of Distances for similar quantities of commercial bulk explosives, and most missiles will also fall within these distances. Quantities of class 10 explosives will be stored in accordance with the table for class 9 and 10.

Class 11. Chemical ammunition (except ammunition containing phosphorus). This ammunition is not considered an explosive hazard, and no limit has been placed on the storage of this material, except that storage must comply with the requirements presented in the chapter on storage of chemical ammunition.

Class 12. Explosives such as ammonium nitrate, DNT, and wet nitrocellulose. These materials are insensitive and can be detonated only by very strong initiation. When stored in an explosive area where there is a possibility that explosives may be projected into them, they will be stored in accordance with the regulations for class 9 explosives. When stored in an area with fire hazards only, and separated by inhabited building distances from areas containing explosives or ammunition, these materials may be stored in accordance with the regulations for smokeless powder.

Separation Within Magazines or Other Buildings. The quantity-distance tables for ammunition and ammunition components of classes 3, 4, 5, 6, and 7 are based on the assumption that on initiation, mass detonations will not occur, and that missile distances are the controlling consideration.

On initiation, ammunition of classes 3, 4, and 5 may be expected to explode progressively, a few boxes at a time, whether or not the piles are separated within the magazine.

Ammunition of class 6 stored in above-ground magazines, will be spaced in piles containing not over 5,000 pounds of explosives each, with the piles spaced a minimum of 2 feet apart. Otherwise, it must be assumed that, on initiation, the ammunition in the magazine will detonate en masse, and quantity-distance requirements including the maximum permitted in each magazine, will be those prescribed for classes 9 and 10. However, the limit per magazine will be 100,000 pounds, but not more than 50,000 fuzes of one model, nor a total of over 150,000 fuzes of all models will be stored in a single magazine.

Ammunition of class 7, stored in above-ground magazines, will be placed in piles containing not over 15,000 pounds of explosives each, and spaced in accordance with ordnance drawing 19-48-12. Otherwise, it will be assumed that, on initiation, all ammunition in the magazine will detonate en masse, and quantity-distance requirements including the maximum permitted in each magazine, will be those prescribed for classes 9 and 10.

When ammunition of classes 6 and 7 is stored in igloo magazines in accordance with ordnance drawings, aisle spacing is not sufficient to preclude mass detonation; therefore, quantity-distance requirements including the maximum permitted in each magazine will be those prescribed for classes 9 and 10.

Special Area Distances. In the lay-out of explosives manufacturing and ammunition loading plants, each operating line, storage area, and administrative area will constitute a separate group of buildings and facilities, so located that any group is separated from all the others by inhabited building distances. The distance to be used in each case will be the greater of the following: Inhabited building distances based on the missile hazards for the particular type of ammunition being loaded (tables for classes 3 to 8, inclusive); or inhabited building distances based on structural damage for the total amount of high explosives involved (table for classes 9 and 10).

Public railways which do not carry passengers will be permitted to pass not closer than 400 feet from magazines. However, they must be separated by railway distances from operating buildings.

In future construction, railroad classification yards designed to receive explosives or ammunition will be separated from inhabited buildings, administration areas, magazines containing explosives or ammunition, and operating buildings containing explosives or ammunition, by a minimum distance of 1,800 feet. However, this distance may be decreased to a minimum of 1,400 feet in the case of concrete igloo magazines.

New depot storage areas will be divided into blocks of not to exceed 100 igloo magazines each, the blocks to be separated by minimum distances of 1,400 feet. Each block will contain not more than 25,000,000 pounds of explosives. Storage areas will be separated from administration and other inhabited building areas by inhabited building distances based on the quantities and types of ammunition and explosives contained in the magazine.

Renovation plants and reconditioning plants must be located at inhabited building distances from magazine areas. However, the inhabited building distance governing the location of such plants may in some cases be based upon the amount of explosives in the renovation or reconditioning plant rather than upon the amount of explosives in magazines in the magazine area.

In arranging the storage of hazardous material in above-ground (not concrete igloo-type) magazines, the following general principles should be followed as guides for preventing the spread of damage throughout an entire area in case of fire or explosion in one part of the area:

1. Smokeless powder or other materials which may become hazardous if the buildings in which they are stored are damaged or demolished, or which may be ignited or exploded by burning or exploding missiles, should be stored at inhabited building distances from high explosives and ammunition magazines.

2. Bulk high explosives, general purpose, or semi-armor-piercing bombs, should be stored so they will be protected from missiles which may be thrown from ammunition magazines as a result of explosions. This principle requires a magazine in which bulk high

explosive is stored to be at missile distance from a magazine in which ammunition is stored.

Loaded Railroad Cars. Cars of loaded ammunition such as shell, complete rounds, smokeless powder in containers, or propelling charges in containers, if alongside an operating building, are considered as separate rooms of that building. The space in the car opposite the open doors will not be used for storage, except under the following conditions:

1. Where it is possible to spot the car so that its doors are opposite a blank wall with a minimum of 5 feet on either side of the car door to the doors or windows of the building, such cars may be fully loaded.

2. Where doors and windows in a building prevent the solution suggested above, the car door adjacent to the building may be closed. Thus a dividing wall is interposed and the car may be fully loaded through the opposite car door.

If more than one car is located at an operating building, a separation of at least 10 feet between cars is required.

If nearer than magazine distance to an operating building, motor trucks or railway cars containing classes 2, 9, or 10 ammunition and explosives will be considered as part of the building and not within separate substantial dividing walls unless such walls are interposed between car and building. Cars containing these materials will not be located beside buildings unless the amount in the car plus the amount within all separate rooms or bays not protected by dividing walls against propagation through influence by the car, is within the explosive limit bases on distances to adjacent buildings.

Cars or trucks containing ammunition or explosives will not be spotted between magazines or other buildings where they reduce effective safety distances and may act to transmit fires or explosions from building to building.

Railroad cars used for picking up or distributing shipments in a magazine area must be loaded in accordance with the storage table. pages 870 and 871. Except when the quantity involved is very small. trucks so used will be loaded in accordance with the storage table referred to. The use of the Interstate Commerce Commission loading table is restricted to cars spotted at shipping or receiving buildings or moving between the shipping and receiving buildings.

Intraplant Distances. All high explosives and black powder operating buildings must be located one from the other, and from other buildings on explosives plants in which persons are regularly employed; all service magazines will be located from buildings on explosives plants in which persons are regularly employed in conformity with the intraplant quantity-distance table.

If the hazards involved require dividing an operating line into separate buildings, such hazards are great enough to require the use of full intraplant distances between buildings unless effective separate barricades are provided, in which case these distances may be halved.

In cases in which it is impracticable, or undesirable from a production point of view, to separate operating buildings by prescribed safety distances, their separation by lesser distances may be approved by the commanding officer in special cases. Buildings so located will be considered as separate rooms within a single building, and the total

INTRAPLANT QUANTITY-DISTANCE TABLE[1]

Quantity of Explosives[2]		Unbarricaded Distance in Feet, Separate Building, or Within Substantial Dividing Walls
Pounds Over	Pounds Not Over	
......	50	60
50	100	80
100	200	100
200	300	120
300	400	130
400	500	140
500	750	160
750	1,000	180
1,000	1,500	210
1,500	2,000	230
2,000	3,000	260
3,000	4,000	280
4,000	5,000	300
5,000	6,000	320
6,000	7,000	340
7,000	8,000	360
8,000	9,000	380
9,000	10,000	400
10,000	12,500	420
12,500	15,000	450
15,000	17,500	470
17,500	20,000	490
20,000	25,000	530
25,000	30,000	560
30,000	35,000	590
35,000	40,000	620
40,000	45,000	640
45,000	50,000	660
50,000	55,000	680
55,000	60,000	700
60,000	65,000	720
65,000	70,000	740
70,000	75,000	770
75,000	80,000	780
80,000	85,000	790
85,000	90,000	800
90,000	95,000	820
95,000	100,000	830
100,000	125,000	900
125,000	150,000	950
150,000	175,000	1,000
175,000	200,000	1,050
200,000	225,000	1,100
225,000	250,000	1,150

[1] New Jersey State law for intraplant quantities and distances.
[2] Applies to high explosives or items loaded with high explosives.

amount of explosives contained in all buildings so located will not exceed the maximum authorized for a single building.

In operating lines of explosives manufacturing or ammunition loading plants, subbuildings in which persons are not regularly employed or which are visited only intermittently by operators may be placed adjacent to operating buildings without affecting the safety distances determined by the main operating building, provided the maximum amounts of explosives contained in each subbuilding are limited by its distance from the nearest main operating building in accordance with the intraplant quantity-distance table.

The maximum amount of explosives permitted in operating buildings or between substantial dividing walls as prescribed by the intraplant quantity-distance table is the top limit for the distance specified, and this limit must not be exceeded under any circumstances without the specific approval of the Chief of Ordnance. In many cases, the quantity specified will be excessive in view of conditions surrounding individual operations; therefore, it is mandatory that local limits be established at amounts no greater than those consistent with continuous and efficient operation. Local limits must specify the maximum number of specific units or items in addition to the quantity in pounds. In cases where the weight of items is too small, or where operations are changed too frequently to make it feasible to express the limits in units, the limits may be specified in pounds only. These limits must be posted in a conspicuous place in each room or building. If the operation is changed to another item of ammunition, the unit limits must be changed accordingly before operations may proceed.

Operations will be so arranged, and personnel will be utilized in such a manner that the least number of men consistent with continuous and efficient operation will be exposed to any one explosion hazard. Local limits for personnel will be established for each room, and will be posted in a conspicuous place in the room.

Basic Magazine Quantity-distance Rule. The laws of New Jersey (latest revision, ch. 27, Laws of 1941, March 28 1941) require a distance of 200 feet separation for magazines containing 5,000 to 25,000 pounds of explosives, plus 2⅔ feet additional distance for each 1,000 pounds of explosives in excess of 25,000 pounds. This rule is the basis for the table shown for quantity-distance classes 9 and 10, but for reasons of policy the latter table shows only three magazine distances for quantities varying from 5,000 to 250,000 pounds. This basic rule is restricted to intraplant use in locating service magazines from each other and to such other uses as may be authorized by the Chief of Ordnance in specific cases.

FURTHER REFERENCES: Ordnance storage drawings; Ordnance Safety Manual: TM 9-1900, Ammunition General.

Chapter 3

Storage of Chemical Ammunition

GENERAL.

The term "chemical ammunition" is used to designate a variety of forms of artillery shell, chemical mortar shell, Livens projector shell, bombs, grenades, candles, and containers which contain chemical agents.

Grouping of Fillings. For the purpose of storage, chemical ammunition is divided into four groups according to the nature of the fillings. These groups together with their fillings, are as follows:

C.W.S. Symbol	Name
Group A—Persistent Vesicants	
H	Mustard
L	Lewisite
ED	Ethyldichlorarsine
Group B—Toxic and Smoke	
PS	Chlorpicrin
DP	Diphosgene
CG	Phosgene
Cl	Chlorine
CN	Chloracetophenone
CA	Brombenzylcyanide
DM	Adamsite
DA	Diphenylchlorarsine
FS	Sulphur trioxide solution
FM	Titanium tetrachloride
Group C—Spontaneously Inflammable	
WP	White phosphorus
Group D—Incendiary and Readily Inflammable	
TH	Thermite
HC	Hexachlorethane mixtures
CN	CN burning mixture
DM	DM burning mixture
CN-DM	CN-DM burning mixture

CN and DM as listed in group B refers to these chemicals in bulk or as chemical filling in shell. In group D, the chemicals are mixed with small-grain smokeless powder as a filling for grenades.

General Rules. The general rules as to magazines and storage, as set forth in the preceding chapters must be followed with the exceptions and additions which apply specially to chemical ammunition.

Whenever possible, each kind of material must be stored separately. However, unless specifically prohibited, munitions of the same group may be stored together. Munitions of two or more groups of

fillings may not be stored together except upon the specific approval of the Chief of Ordnance.

Chemical ammunition must be stored in accordance with current ordnance drawings except for those lots for which special instructions are issued by the Chief of Ordnance.

Ammunition must be handled carefully. It must not be dropped or unnecessarily jarred. The same mechanical equipment for handling may be used as that used for high-explosive shell of the same size and weight.

In any temporary emergency necessitating storage outdoors overnight or for a longer period, chemical ammunition must be covered with a tarpaulin to protect it from the direct rays of the sun and from rainfall. Ammunition must be piled to permit free circulation of air.

The 1-ton containers should be stored, preferably under a shed or other open side protection, to allow handling with a crane. The shed should be of sufficient size to protect containers from rain. If stored in an open shelter, containers must be supported from the ground.

Chemical ammunition must be inspected at regular intervals, at least semiannually, to determine the condition of the paint or other rust-preventing covering. If deterioration is found, immediate corrective methods must be taken.

Report on Leaking Ammunition. Any chemical ammunition found to be damaged or leaking, must be reported immediately to the officer in charge of the magazines.

A report must be made to the Chief of Ordnance on all chemical ammunition found in a damaged or leaking condition. This report will include the following data:

1. Type and amount.

2. Lot number.

3. Date discovered.

4. Detailed information covering the nature of the leak, and whether it appeared to have been caused by defective material or improper handling or packing.

5. Disposition, or in the event that immediate disposition is not required, recommendations for such disposition.

A copy of this report must be forwarded direct to the Chief, Chemical Warfare Service.

Report of Injuries. Injury reports in duplicate prepared in accordance with existing regulations are forwarded promptly to the Chief of Ordnance, who will forward one copy to the Chief, Chemical Warfare Service.

Special Equipment. The extreme danger involved in working with chemical ammunition cannot be overemphasized. Because of this danger all personnel who work in magazines or buildings assigned to chemical storage must be provided with appropriate protective equipment.

Where special equipment is placed as called for under the special rules for the storage of the various groups of chemical ammunition, a list is posted showing the quantity of each item required. This special equipment must be replenished as required to maintain the full quantity in serviceable condition.

All required special equipment must be so marked as to preclude possible misapplication.

Special equipment should be inspected to note condition and compliance with rules at each regular inspection of the magazines for which the equipment is provided.

Protection of Personnel. Protective and first aid equipment must be provided for those employees handling defective or leaky chemical ammunition.

Protective equipment which has become unserviceable will be promptly replaced. The officer in charge of each establishment in which protective equipment is on hand will have this equipment inspected as often as is necessary to insure serviceability.

Personnel must wash their hands thoroughly with soap and water after handling chemical ammunition and particularly before eating.

Signs on Magazine Doors. There must be posted on the doors of all magazines containing chemical ammunition appropriate signs such as shown below:

Signs for group A chemical ammunition magazines. "This magazine contains chemical ammunition of group A (blistering agents). Complete protective equipment must be worn to avoid burns, if leaking ammunition is present."

Signs for group B chemical ammunition magazine. "This magazine contains chemical ammunition of group B (toxic and smoke agents). Mask must be worn if odor is present."

Signs for group C chemical ammunition magazines. "This magazine contains group C chemical ammunition (spontaneously inflammable). If fire breaks out, put on asbestos or heavy leather gloves and place burning component in water."

Signs for group D chemical ammunition magazines. "This magazine contains group D chemical ammunition (incendiary and readily inflammable). Don't use water on fires in this building."

GROUP A CHEMICAL AMMUNITION (PERSISTENT VESICANTS).

Description of Group A Fillings. Mustard (H) as filled in munitions is a liquid, dark brown to black in color, melting at 46 F to 50 F. Its odor is rather faint and somewhat like horseradish or garlic. Its

action is that of a vesicant or blistering agent. The liquid or vapor causes intense inflammation which may proceed to blistering of any skin or membrane with which it comes in contact. It causes reddening of the eyes, burning of the nose and throat, inflammation of the trachea and lungs, and burning or blistering of the skin. These symptoms develop 4 to 24 hours after exposure, thus giving no warning that a person is being burned. An extremely slight concentration will cause very severe burns. It can be detected by its odor in any concentration likely to produce burns. However, one rapidly becomes accustomed to the odor so that after a few minutes' exposure the smell is no longer noticed. When a dangerous concentration of mustard is detected, it is absolutely essential that all unprotected personnel leave the magazine at once. Any work done thereafter should be performed by men completely protected, wearing gas masks, protective clothing, protective gloves or mittens, and protective shoes or boots.

Lewisite (L) like mustard has strong vesicant properties and is a powerful lung irritant. Its vesicant action is not delayed, however, and the blisters differ in appearance from those produced by mustard. Lewisite, being an arsenous compound, has the additional property of entering and poisoning the blood stream. It is classed as a persistent agent, but is readily hydrolized by water. However, the hydrolysis product formed is itself a vesicant and very toxic, and contaminated areas will remain dangerous for a long time. Lewisite when pure is a colorless or slightly yellow liquid, but the product as usually prepared is a dark green oily liquid. It has a faint but unpleasant odor which resembles geraniums. The vapor causes a very disagreeable burning sensation in the nose and throat, and sometimes violent sneezing. This material is practically insoluble in water, but is readily soluble in absolute alcohol, benzene, kerosene, olive oil, liquid petrolatum, and other solvents. Woolen clothing gives some protection against L vapor. Wet wool absorbs more than dry wool, hydrolysing the L. Most closely woven rubberized fabrics, as well as leather and rubber, offer little resistance to penetration by liquid L. Lewisite is destroyed by an alcoholic solution of caustic soda. Chloride of lime may be used to destroy it in the field. L does not attack steel appreciably, and no special lining is necessary for shells.

Storage. Ammunition and components with group A filling may not be stored in magazines with wooden floors. They, preferably, should be stored in magazines with concrete floors. The floor should be treated with sodium silicate to render it nonabsorbent. The use of rubberoid or other such floor covering is prohibited. At all ordnance depots and storage points, ammunition of class A must be stored in fireproof magazines.

The slight odor of mustard or Lewisite in a magazine may not always indicate the presence of leaking ammunition. However, excessive concentration of fumes do indicate leaking ammunition.

Foremen, inspectors, or other authorized persons who are thoroughly familiar with work in magazines containing these agents must be present when a magazine is opened in order to determine whether or not the magazine contains leaking ammunition.

If it is decided that a magazine contains leaking ammunition, all personnel must put on protective clothing and equipment before they enter the magazine. All windows and doors of the magazine must be opened and a search conducted under the direct supervision of some responsible officer or foreman until the leaking ammunition is located.

Unboxed ammunition or containers filled with H (or L) must be handled only by personnel wearing protective gloves or mittens.

The officer in charge of the storage of munitions in this group will cause frequent inspections to be made to insure compliance with regulations and to ascertain if leaking ammunition is present.

Some unboxed shell now in storage are covered with cosmoline. These should not be set on readily combustible material such as wood because, in warm weather, this coating impregnates the wood, thereby increasing the fire hazard.

Special Equipment. The following protective equipment will be made available when men are working in magazines where this material is stored:

1. Service gas masks.

2. Protective clothing.

3. Protective footwear.

4. Protective gloves or mittens.

5. Commercial bleach or chloride of lime (calcium oxychloride containing not less than 35 percent chlorine). 100 pounds for each ton of H up to a total of 2 barrels of bleach should be supplied.

6. Iron tanks of such size as will readily contain the largest shell or container in storage.

7. First aid equipment to include: 20 tubes Protective Ointment M1 or M4; 3 dozen clean flannel, or cotton cloths, 1 square foot or equivalent; 1 pint of a solution consisting of 10 percent sodium hydroxide, 30 percent glycerin, and 60 percent water, to be labeled, "For Removal of Lewisite—External Use Only. Do not Use In Eyes"; one syringe, or douche cup; 1 nose cup; a supply of soap and water, a 1 percent sodium bicarbonate solution, a saturated solution of boric acid.

The sodium bicarbonate solution and the boric acid solution will freeze during the winter months. In this case, the requisite amounts of sodium bicarbonate or boric acid should be kept in a 1 pint bottle or jar; labeled and corked. To use, fill with water and shake thoroughly, after which it may be applied as directed.

First Aid. In case of exposure to any of the agents in group A, the proper first aid measures must be observed as set forth in the section covering the agents themselves. First aid must be prompt, however, for little can be done later than 20 to 30 minutes after exposure.

Leaking Ammunition. When leaking ammunition or components are located, they will be disposed of at the direction of the officer in charge.

At all times during the handling or disposal of leaking ammunition, adequate protective clothing and equipment will be worn by each person so engaged.

A leaking shell or component will be immersed in freshly prepared bleach solution and then removed down wind from the magazine area. The bleach solution should be prepared in iron tanks large enough to contain the shell in question. The solution is made up 3 pounds of chloride of lime to each gallon of water thoroughly mixed.

The methods for the final disposal of the leaking shell will be found in the section covering demolition.

Leaking Containers. The officer in charge of the magazine, or other responsible officer, will be notified whenever a shipping container is found to be leaking. He will take direct personal charge of removal.

In general, shipping containers are too large to immerse and handle like a leaking shell. Therefore, an attempt should be made to stop the leak by one of the methods set forth in the Ordnance Safety Manual.

Leaking containers will be disposed of, in general, by transferring the contents to a serviceable container. The transfer of contents will be done only by specially trained depot personnel after authorization from the Chief of Ordnance, or when in the opinion of the commanding officer of the depot immediate action is required. A leak which cannot be stopped should be considered as requiring immediate transfer of the contents of the container.

Removal of Spilled Material.

Mustard. If mustard from a leaking shell or container has contaminated the floor or other containers, it should be removed by washing thoroughly with freshly prepared bleach solution. If woodwork is stained, it should be removed and burned, as no simple treatment will remove mustard from wood.

After washing metal containers, shell, or concrete floor with bleach solution, dry bleach should be applied and allowed to remain for several days, after which it should be swept up and daily applications of alcoholic caustic made over a period of 2 weeks. If it is impracticable to use alcoholic caustic, freshly prepared bleach solution may be substituted.

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Alcoholic caustic should not be used without consideration of possible later danger from the contact of loose high explosives with caustic, which undoubtedly will remain in the floor.

The doors and windows of the magazine should remain open until the odor of mustard has disappeared. Complete protective equipment must be worn while conducting any of this work and at all times thereafter until the mustard and its odor have been removed from the magazine.

In the event that the above-described treatment does not remove all mustard from the floor, the treatment must be repeated. If repetition does not suffice, the only course available is to remove the contaminated portion of the floor and replace with new material. Protective clothing must be worn during such removal.

Lewisite. Decontamination for lewisite essentially parallels that for mustard. Like mustard gas, lewisite is almost immediately decomposed in the presence of alkalies such as caustic soda (5 percent solution) or ammonia, and by active oxydants, such as chloride of lime and the hypochlorites. While lewisite is readily decomposed with water, the reaction product is a vesicant solid that will cause severe burns upon contact with the body.

GROUP B CHEMICAL AMMUNITION (TOXICS, IRRITANTS, AND SMOKE).

Description of Group B Fillings. Phosgene (CG) is normally a colorless liquid. It boils at 47 F and has an odor resembling ensilage, or fresh-cut hay. On inhalation, it causes pulmonary edema, or an accumulation of water in the lungs, as a result of the irritant action of the chemical. The first symptoms noted in a strong concentration are a choking sensation and a feeling of constriction in the chest. However, the danger lies in the fact that low concentrations that are not particularly irritating may, after an interval of hours, produce serious symptoms, and even death. Among these symptoms are difficulty in breathing, rapid pulse, weakness, coughing with watery expectoration, and cyanosis (a blue color of the skin), caused by the inability of the lungs to oxygenate the blood.

The delayed action of phosgene makes it imperative that masks be worn whenever the odor is present. Further, because of its extremely rapid action in high concentrations, gas masks always must be readily available while working with shell or containers filled with phosgene.

Chlorpicrin (PS) is a colorless liquid boiling at 234 F. It has a sweet odor like sticky flypaper and causes irritation of the eyes with lacrimation and some irritation of the nose and throat. Its action is that of a lacrimator and suffocant. In a strong concentration, it is nauseating. The first effects are followed by pains in the chest, abdominal discomfort, and vomiting. The principal action, however, is

on the lungs (pulmonary edema). Prolonged exposure to very low concentrations may cause serious symptoms. Pulmonary edema does not develop until several hours after exposure to the gas.

The delayed effect of this agent necessitates the same availability of masks as prescribed for phosgene. A distinct odor and irritation of the eyes is noticed readily in any concentration which would be dangerous.

Brombenzylcyanide (CA) is a liquid, dark brown in color, which causes intense irritation of the eyes, followed by a prompt flow of tears. Lacrimation does not produce any permanent damage to the eyes, and this chemical has apparently no other effect on the system. Comfort of the worker will require wearing of the mask when in any concentration of this material.

Adamsite (DM) is a greenish-yellow to black solid melting at 383 F. It causes irritation in the nose and throat even in minute concentrations. Longer exposure causes tightness of the chest, sneezing, headache, coughing, intense nausea, and weakness. The symptoms increase in severity some time after exposure. The irritation produced by the smoke of this agent while burning is so intense that an intolerable concentration is reached long before it becomes dangerous to life. The effects may last for several hours, but no permanent injury is caused.

Diphenylchlorarsine (DA) is a solid varying in color from white to black which melts at 111 F. The crude material may be liquid in some cases. Its properties and action are the same as those of Adamsite.

Titanium Tetrachloride (FM) is a heavy, colorless liquid with a pungent odor. It can be readily detected by the large quantity of smoke produced when it leaks. It is used solely as a smoke-producing agent and has practically no toxic effects. Large quantities of the smoke produce a choking sensation and difficulty in breathing, requiring a gas mask for the comfort of the worker.

Chloracetophenone (CN) is a white to gray or black solid, melting at 138 F. It is a powerful lacrimator and has a somewhat fruity odor. Usually it is put in candles with smokeless powder to cause it to burn, or filled in liquid form in which CN is dissolved in suitable solvents. In solution, the odor of the solvent is usually discernible in addition to that of the chloracetophenone itself. In any case it is a strong lacrimator but does not cause permanent damage to the eyes. Its lacrimatory effects require the use of masks for the comfort of workers.

Chlorine (Cl) is a greenish-yellow liquid or gas boiling at 30 F. It has a pungent odor. The first effects produced by the inhalation of small proportions of chlorine is an active irritation of the upper respiratory passages, causing coughing and a sensation of suffocation which is extremely disagreeable. The odor of chlorine is very strong in any concentration that would cause irritation or symptoms of poisoning. When present in amount strong enough to cause irritation, masks should be worn and all personnel not so equipped should leave the vicinity.

Sulphur trioxide-chlorsulphonic acid mixture (FS) is a heavy mixture which fumes strongly in air, and decomposes above 68 F. It has an acid odor. It is used solely as a smoke-producing agent, and there is no evidence that it is harmful to man in concentrations normally attained in the field. Inhalation of concentrated fumes causes coughing and strangulation; a feeling of constriction around the chest, burning of the nose and throat, and hoarseness. When the mixture comes in contact with moisture, it forms hydrochloric acid and sulfuric acid, thus making it very corrosive to metals and to fabrics of various kinds. If applied directly to the skin, a burning sensation is felt at once and an acid burn follows.

Chloracetophenone-chloroform-chlorpicrin (CNS) is a solution of chloracetophenone, chlorpicrin, and chloroform. Its odor is somewhat like that of sticky flypaper. In strong solution, it may cause nausea in addition to severe lacrimation. An individual exposed to extremely high concentrations for a relatively short time may suffer serious effects such as pains in the chest, abdominal discomfort, vomiting, and an action upon the upper air passages and bronchial tubes similar to, but less than that of chlorine. Prolonged exposure, even to a very low concentration, may cause these effects. CNS has only a slight action on metals.

Chloracetophenone-benzol-carbon tetrachloride (CNB) is a solution of chloracetophenone in benzene and carbon tetrachloride. This solution should not be permitted to come in contact with the skin or eyes because of the considerable discomfort and possible injury that may result. It has no appreciable action on metals.

Storage. Ammunition and components with group B filling may not be stored in magazines with wooden floors. Preferably, they should be stored in magazines with concrete floors. The floor should be treated with sodium silicate to render it nonabsorbent. The use of rubberoid, or other such floor covering is prohibited. At all ordnance depots and storage points, munitions of group B must be stored in fireproof magazines.

Whenever a magazine containing group B chemical ammunition is opened, a foreman or other responsible person familiar with work in magazines containing this material must be present to determine whether munitions in the magazine are leaking. If it is decided that munitions in the magazine are leaking, masks must be worn and the doors and windows must be opened after which the leaking component should be located.

Masks should be readily available to all men working in these magazines. Unboxed shell and containers may be handled without

protective gloves unless contamination is noted. However, in some cases, a small amount of filling may be left on the outside of a shell during the filling of group B munitions. Protective gloves or mittens should be worn when handling contaminated material.

Special Equipment. The following protective equipment will be made available when men are working in magazines where this material is stored:

1. Service gas masks.

2. Protective gloves or mittens.

3. Stretchers or litters.

4. Woolen blankets.

5. Eight ounces of a mixture consisting of 4 ounces of pure grain alcohol (95 percent), and 4 ounces of chloroform, U.S.P., to which is added a few drops of ammonia.

6. One carboy of a saturated solution of sodium sulphite in pure grain alcohol (95 percent). This carboy must be kept sealed to prevent evaporation. This solution is for use in treating burns on the skin from liquid chlorpicrin and chloracetophenone.

One carboy of a saturated solution of sodium hydroxide (caustic soda) in pure grain alcohol (95 percent). This carboy must be kept sealed to prevent evaporation. This solution is for use in removing brombenzylcyanide from magazine floors or munitions, but is not to be used on personnel under any circumstances.

Leaking Ammunition. When leaking ammunition or components are located, they must be disposed of at the direction of the officer in charge.

A gas mask and protective gloves will be worn whenever handling leaking ammunition filled with group B material. Care should be observed that the leaking material does not come in contact with skin or clothing.

Pending final disposition, leaking ammunition will be removed from the magazine.

If the number of leaking shell or components is small, they should be disposed of by one of the methods described in the chapter on demolition. If a large number of shell is involved, the magazine should be ventilated, placed under guard, and the Chief of Ordnance notified by telephone or telegraph.

Leaking Containers. The officer in charge of the magazine will be notified whenever a shipping container is discovered to be leaking. He will inspect the container involved to determine proper disposition.

As soon as possible after discovery of a leaking container, and pending arrangements for its removal, attempt should be made to place the container in a position to prevent the contents from spilling on the floor or on other containers. If possible, this should be done by the man discovering the leak.

If the leak is stopped easily without allowing a large quantity of the filler to escape, the container may remain in the magazine. If the leak is not stopped promptly, the container must be transported downwind from the magazine area.

Containers in which the leaks have been stopped in such manner as, in the opinion of the magazine officer, renders them serviceable for continued storage may remain in the magazine. Containers which cannot be repaired satisfactorily with the facilities at hand will have the contents transferred to serviceable containers under the direct supervision of the magazine officer. The method of transferring contents will vary with existing conditions and the nature of the material.

Removal of Spilled Material. Gas masks and protective gloves must be worn when removing group B chemical fillings which have spilled.

Phosgene if spilled will, if left alone, quickly and completely evaporate. The addition of water will cause the phosgene to break down into other substances not harmful.

Chlorpicrin can be removed only with great difficulty, especially from woodwork. The most effective treatment is by means of scrubbing with a liberal application of alcoholic sodium sulphite solution.

Brombenzylcyanide is extremely difficult to remove from any surface which absorbs it. The liberal use of alcoholic caustic soda solution tends to reduce the nuisance caused by the presence of the lacrimatory material in a magazine. It should be noted that under many conditions the use of caustic soda in a magazine will be impossible because of the possible effect of the caustic on high explosives which might later be stored in this magazine, or on the bursting charge of chemical munitions.

Adamsite, if spilled, may be removed by first wetting thoroughly and then sweeping up with a broom. It should not be swept or handled in any way to cause dust formation.

Titanium tetrachloride can be removed easily by the application of large quantities of water.

Chloracetophenone can be removed best by scrubbing with soap and water, followed by liberal applications of alcoholic sulphite solution, or by the use of sulphite solution alone.

Chlorine can be removed by ventilation.

Sulphur trioxide-chlorsulfonic acid mixture can be removed by the application of large quantities of water.

GROUP C CHEMICAL AMMUNITION (SPONTANEOUSLY INFLAMMABLE).

Description of Group C Fillings. White phosphorus (WP) is a yellowish, translucent, wax-like substance, melting at 111 F. Its most

characteristic property is that of spontaneously igniting upon exposure to air, burning with an intensely hot flame, and giving off large volumes of white smoke. The fumes are not toxic except on exposure for a period of several months. Phosphorus is intensely poisonous when taken internally. Precautions should be taken to insure that none is taken into the body.

Storage. Chemical ammunition containing group C fillings must be stored in fireproof magazines with concrete floors. The preferred storage is in igloo magazines. It must be stored in accordance with current ordnance drawings, where applicable, except for those lots for which special instructions are issued by the Chief of Ordnance. In any case, ammunition containing white phosphorus must be stored in such a manner as to permit easy inspection.

The white phosphorus filling in ammunition or components becomes liquid at 111 F. At or above this temperature, defective ammunition may leak, and may catch fire, and in some cases (where a burster was in place) has been known to explode. Below 111 F the filling is solid, and shell will not leak. It is highly important, especially where this ammunition is stored on its side, that the temperature at which it is stored be kept below 111 F.

Special Equipment. There must be maintained at all times adjacent to each magazine in which group C chemical munitions are stored the following special equipment:

1. Heavy rubber gloves (gauntlet type).

2. Rubber boots.

3. Rubber aprons (ankle length) or leather blacksmiths' aprons.

4. A number of tubs, barrels, or tanks large enough to contain the storage unit. During the summer months, when fires are most likely in this type of ammunition, these tanks must be kept filled with water.

5. Two sponges and a pail or other vessel holding approximately 5 gallons.

6. A bathtub or similar container for first aid, and a means of heating water for use therein, must be maintained in some heated building as close as possible to the magazine of this group. Also a small number of gauze sponges should be maintained.

7. One bottle containing at least 1 gallon of 3 percent copper sulphate solution.

Leaking Ammunition. With leaking shell of this group, the great risk is that of fire. This can be combatted successfully only by prompt action. In general, the time elapsing from the time the fire is reported until the arrival of the fire department is sufficient to allow the fire to get beyond control.

A leaking shell or container of any type should be immersed immediately in one of the tubs provided at the magazine. The person discovering the leaking shell should put on rubber gloves and attempt to immerse it at once. In the event that this action is impracticable, the hose, if available, should be used with hydrant pressure. This is important, as a low-pressure stream of water will tend to smother the fire, whereas high pressure tends to scatter the fire over a large area, and thus greatly increases the difficulty of extinguishing it.

Rubber gloves will give protection against burns only, as they prevent contact of the phosphorus with the skin. Gloves are not effective when exposed to high temperatures, such as burning phosphorus. When burning phosphorus adheres to gloves, it can be extinguished by dipping the gloved hand in water.

When a single leaking shell has been discovered and immersed in water, it should be destroyed at a place where fragmentation will not be a hazard, smoke will not create a nuisance, and there is no dry vegetation which may be ignited.

Where the ammunition is packed in a container, and is fitted with either fuze or burster, the fire will be fought with water from outside the magazine. Defective shell must be removed if and when the fire is extinguished. If the leaking shell is removed, subsequent action will be taken to destroy it.

Removal of Spilled Phosphorus. Where phosphorus has leaked on the floor or other parts of a magazine and has been extinguished, a fire guard must be stationed within the building until it has been completely removed, as the drying up of the water will permit the phosphorus to ignite again.

Small amounts of phosphorus can be removed best by first scraping off as much as possible with an implement such as a putty knife and then removing the rest with a blowtorch or similar implement. This removal of phosphorous must not be attempted until all loaded ammunition has been removed.

After treatment the magazine should be kept under surveillance for at least 2 weeks, as fire may break out again. Portions of the floor containing deep cracks or crevices must be grouted with mortar before munitions are restored in the magazine.

GROUP D CHEMICAL AMMUNITION (INCENDIARY AND READILY INFLAMMABLE).

Description of Group D Fillings. Thermit (TH) is a mixture of iron, oxide, and aluminum. It is in the form of a dark-gray granular mass. When ignited, it burns with great rapidity and the evolution of extreme heat, the iron oxide being reduced to boiling molten iron.

Hexachlorethane mixture (HC) consists largely of hexachlorethane and zinc. It is a gray solid with a camphor-like odor. It burns rather slowly with the evolution of a dense cloud of smoke. The smoke produced is harmless and can be breathed without discomfort.

Incendiary bombs comprise a combustible body of magnesium metal, inside of which is an igniter composition such as thermit. When ignited, the body of the bomb burns with intense heat.

Chloracetophenone burning mixture (CN) is a mixture of CN and small grain smokeless powder. It is employed in hand grenades. It is most effective when distilled into the air by the heat of a burning composition.

Diphenylaminechlorarsine burning mixture (DM) is a mixture of DM and smokeless powder. Like CN, diphenylaminechlorarsine is most effective when disseminated as a smoke.

Burning mixture CN-DM is a mixture of chloracetophenone and diphenylaminechlorarsine with smokeless powder.

Storage. Chemical munitions containing fillings of group D may be stored in any dry, fireproof magazine.

Inspection and guard of ammunition of this type should be the same as that maintained for high-explosive shell.

Special Equipment. Unboxed ammunition containing group D material may be handled with special protective equipment. Some suitable equipment for fighting oil fires should be maintained at all times adjacent to magazines in which material of this class is stored.

Leaking Ammunition. In the event that containers of shell containing group D materials are discovered in a leaking condition they should be segregated. Instructions as to the disposition of such shell will be requested from the Chief of Ordnance.

Leaking munitions of this group may be destroyed, if necessary, by burning in the same manner as intended for service use, but in the case of bombs, statically, in an area where fire risk is negligible.

Removal of Spilled Material. In the event that components are broken open or leaking, the material should be swept up, removed from the building, and burned.

FIRES IN MAGAZINES CONTAINING CHEMICAL MUNITIONS.

Group A. If a fire breaks out in any building in which group A fillings are stored, all personnel should be removed from the downwind side of the magazine, as the vapors will undoubtedly be carried in the smoke as soon as the shell begins to open. If any large quantity of the material is likely to be released by such a fire, all possible means must be employed to notify inhabitants downwind from the fire. If possible, they should be moved to some locality other than downwind.

If it is impossible to move personnel, they should, as a last resort, take shelter in rooms not having a flue connection, and should stuff all openings to prevent ingress of the fumes. The danger zone for unprotected personnel during a fire must be estimated at the time by careful observation of smoke and presence of fumes.

Men fighting the fire should wear complete protective outfits. The attack on the fire should be made from the upwind side, if practicable; but, in any event, the fire must be extinguished at all costs.

The immediate area in which any shell have opened during a fire will undoubtedly be contaminated, and should be treated as such. Any shell which has been exposed to fire should be considered as dangerous and made the subject of special inspection to ascertain its condition.

Group B. If a fire breaks out in any building in which group B munitions are stored, all personnel should be removed from the down-wind side of the magazine. All personnel fighting the fire should wear gas masks.

The same precautions of notifying inhabitants down-wind from the fire should be taken as in group A. The danger to personnel down-wind is much less, however, than in the case of a fire involving group A fillings.

Any shell or container which has been exposed to fire should be considered dangerous and made the subject of special inspection to ascertain its condition. A report should be made to the Chief of Ordnance and instructions should be requested.

Group C. In the event of fire getting beyond control of the person discovering it, the following precautions, not generally necessary during ordinary fires, must be observed in order to attack the flames successfully.

Phosphorous once extinguished must either be immersed under water or must be continually sprayed to prevent the flames from breaking out anew.

Due to the great amount of smoke liberated, there is an extra hazard of men becoming lost in the magazine while attempting to fight the flames. Men with portable extinguishers should not be permitted in the magazine after a fire gains headway unless they are equipped with life lines, as they would have no hose line to follow back in order to escape from the magazine.

The fact that components becoming highly heated in a fire will explode with moderate violence, thus throwing the burning containers for some distance, tends to spread the fire rapidly.

As a high velocity stream of water tends to spread the fire, the lowest possible pressure stream consistent with possibility of approach should be used.

After a fire has been extinguished in a magazine, all adjacent shell and components must be considered dangerous and a report of the fire must be made immediately to the Chief of Ordnance.

Group D. The efforts of fire fighters should be confined to preventing the spread of the fire. Fire in a magazine containing group D material in any form should not be fought with water.

Unburned material in a magazine which has been partially destroyed by fire should be treated with the greatest caution, as HC mixture may absorb sufficient moisture to cause ignition with consequent recurrence of the fire.