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THE ORDNANCE SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

# ORDNANCE SCHOOL MANUAL

232

# ARTILLERY AMMUNITION

Claude E. Brown.

PREPARED BY

THE ORDNANCE SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

JULY 1941

NOTE

This publication is a temporary expedient pending the incorporation of the information contained herein in an approved War Department Manual.

THE ORDNANCE SCHOOL

Aberdeen Proving Ground, Maryland

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ERRATA

| PAGE NO. | PAR. NO. | |
|---|---|---|
| 28 | | Figures 6 (a) and 6 (b) - Show the primer head body (1) threaded into the brass case (11). |
| 83 | 6a. | Change last sentence to read - The shell is painted blue to identify the low explosive filler. |
| 84 | 9 | Change paragraph title to read - Blank ammunition. |
| | 13 | Change first sentence to read - The M38 has superseded the Mk. IV fuze. |
| 88 | | Figure 5. Change TETYRL to TETRYL |
| 90 | 35 | Change paragraph title to read - Types of ammunition. |
| 91 | 40 | Second line, change superceded to superseded. Fifth line, change M38A1E2 to M58. |
| | 42 | Change paragraph title to read - Base detonating fuze, M58. |
| | | Change second sentence to read - The modifications necessary to adapt this fuze for use on the M63 shell consisted of increasing the size of the booster and the diameter of the fuze body. |
| 100 | 6 | Second line, change chaptr to chapter. |
| 103 | 2 | Line 11, change onces to once. |
| 104 | 5d. | Change subparagraph to read - The shell, Mk. IX, has been superseded by the shell, M42. Stocks of shell, Mk. IX, will be issued until the supply is exhausted. |
| | 38 | Change last sentence to read - A detailed description of this fuze will be found in the chapter pertaining to fuzes. |
| | 39a. | Change last sentence to read - Further details are in the chapter pertaining to fuzes. |
| | 49 | Change third sentence to read - They are the same type of projectile as the shell, H.E., Mk. I, described in paragraph 37c. |
| | | Change last sentence to read - They are the same type as the shell, H.E., Model 1915, described in paragraph 37b. |

## TABLE OF CONTENTS

# CHAPTER I

# GENERAL



## SECTION I

## GENERAL

1. Round of artillery ammunition. - a. Generally, a "round of ammunition" consists of the projectile with all the components necessary to propel it from the piece and function it at the desired point. In general, these components are the primer, the propelling charge, the container (cartridge case or bags) for the propelling charge, the fuze, booster, and the projectile with its filler.

b. Since the firing of the first shot from a cannon, much time and effort have been expended in the improvement of these components with the result that, at present, the artillery of all modern armies is equipped with projectiles, fillers, and fuzes of scientific design, and powders with which to propel them with the proper velocity for required ranges.

2. Tactics and ammunition. - a. Artillery was first used mainly against fortifications for the purpose of breaching the walls for the passage of foot troops in the 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, in order to avoid neutralization by enemy small-arms fire and possible capture in the event of a repulse.

b. 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.

c. Following is a discussion of the development of the several components of artillery ammunition to meet the varying needs of the service.

## SECTION II

## DEVELOPMENT OF PROJECTILES

3. Early projectiles. The first projectiles fired from cannon were iron darts wrapped with leather, of a size to fit the bore. These continued in use even up to the sixteenth century, when they were replaced by spherical shot. One example was roughly rounded stone balls chosen because of their cheapness. Forged iron, bronze and lead balls were tried but expense prevented their general adoption. Further, as the heavy metal shot necessitated the use of a correspondingly large propelling charge too great a demand was made on the strength of the feeble pieces of the period. This frequently caused rupture of the cannon. Stone shot being about one third the weight of those of iron, the powder charge was reduced in proportion, thus effecting an additional economy. Both iron and stone shot occasionally were covered with lead, both to preserve the interior of the bore (by reducing the friction) and to afford a closer fit between the shot and the bore, thereby bettering the obturation (preventing the escape of the powder gases around the projectile) and thus increasing the muzzle velocity and range. Hollow projectiles filled with explosives or combustibles, and variations of canister, while not in general use, had made their appearance prior to this time.

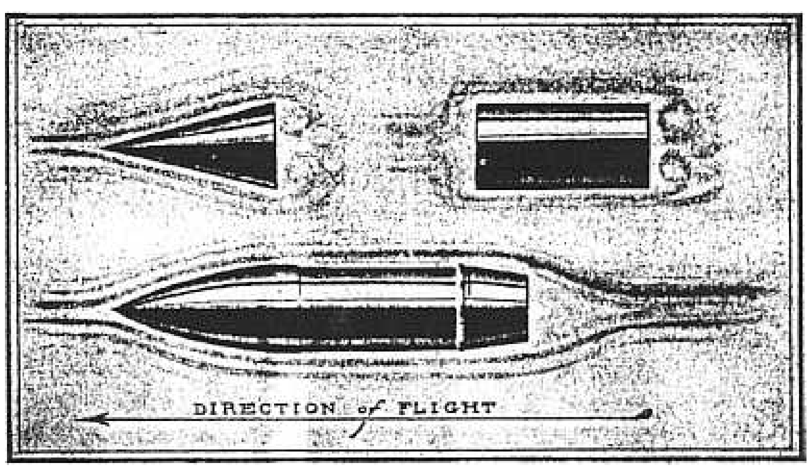



FIGURE 1. - Air currents caused by different shaped projectiles.

4. Shape (Fig. 1). - a. From the beginning the demand for greater and greater ranges has influenced the shape of the projectile. Towards the end of the sixteenth century cannon shot was made of cast iron and was spherical in form. The spherical projectile was inefficient ballistically, that is, 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 the air resistance and, by virtue of its shape, it presented a maximum surface to air resistance for its weight; nevertheless, the spherical form con-

cause 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.

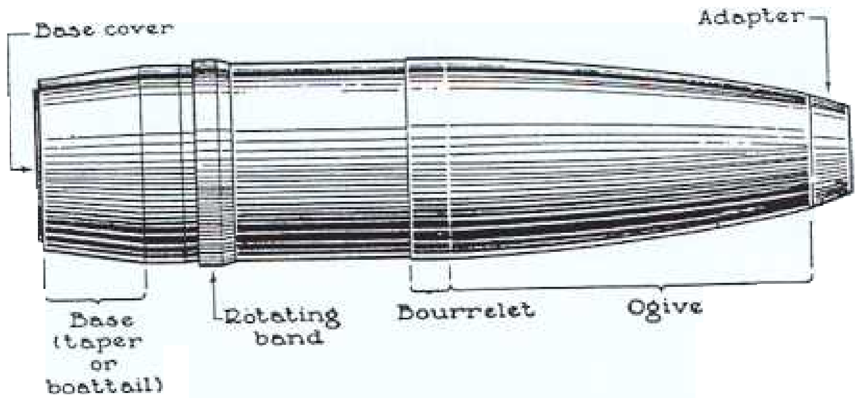



FIGURE 2. - A modern projectile

5. Exterior of modern projectiles (Fig. 2). 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. The cylindrical body usually is from one to two calibers long, and extends from the bourrelet (Par. 7) to the rotating band. The cylindrical surface in rear of the rotating band is coned slightly to form the boat-tail, with an inclination of from six to eight degrees to the axis of the projectile. The ogive describes an arc whose center lies on a line perpendicualr 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 ten or eleven calibers. Figure 2 shows the exterior of a modern artillery projectile.

6. Rotation. - a. "Rifling" consists of a number of spiral "grooves" in the surface of the bore of the gun. The spaces between the grooves are the "lands". The purpose of rifling is to rotate 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.

b. Early types of projectiles. The introduction of "rifling' brought about the use of elongated projectiles of increased weight. For projectiles used in rifled cannon, some device was necessary to cause the projectile to take the rifling. Several devices that were developed are shown in Figure 3.

(1) The studs on the projectile shown in Figure 3a were fitted into the grooves of the rifling as the projectile was inserted at the muzzle. In the Butler projectile, the part marked (x) was of brass and, on firing, was expanded outward into the rifling by the pressure of the powder gases.

(2) In the Hotchkiss projectile the parts (x) and (y) are of iron and are held apart by the ring of lead (z). The gas pressure acting on the part (y) forces the lead outward into the rifling.

(3) The bore of the Whitworth gun was a twisted prism of hexagonical cross section. The projectile was fashioned to fit the bore, its sides being provided with surfaces of a similar prism.

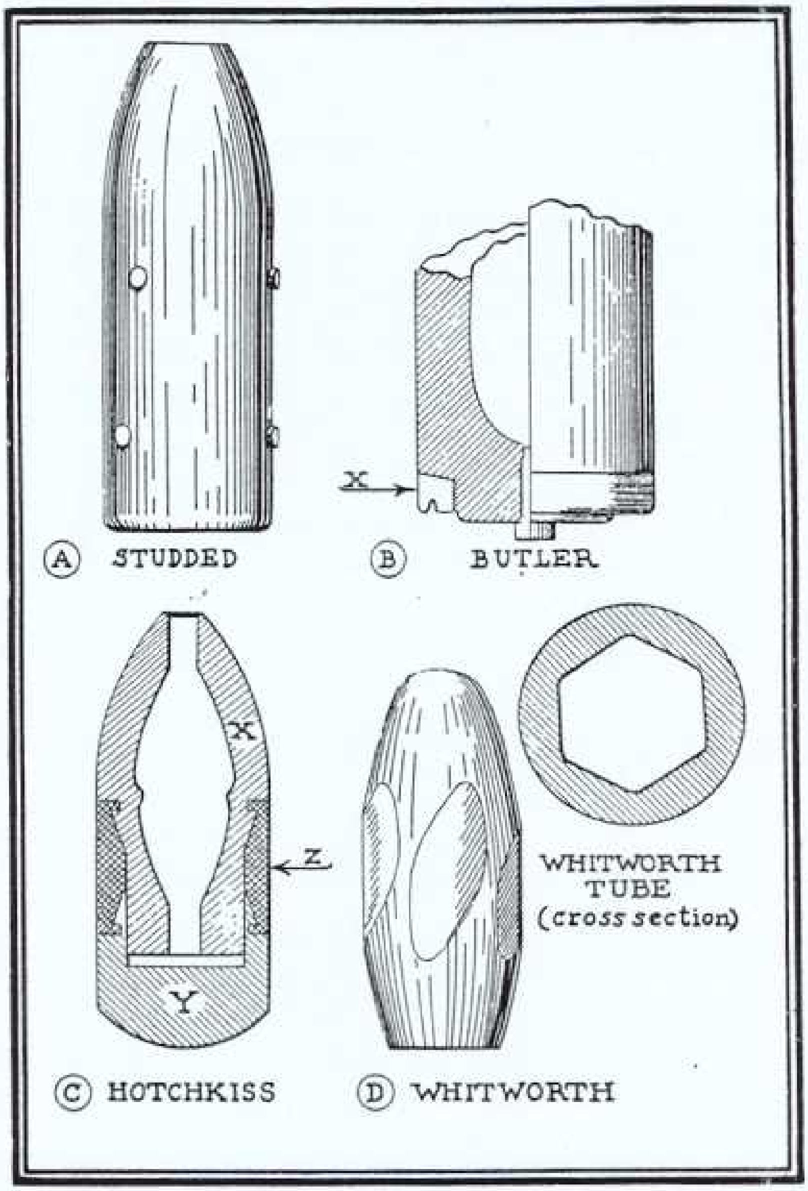



FIGURE 3. - Means of obtaining rotation, early projectiles.

c. Banding of modern projectiles (Figs. 4 and 5). (1) With the introduction of breech-loading cannon, the problem of giving rotation to the projectile was simplified. As previously explained, the raised portions between grooves were known as lands, and the caliber was the diameter between opposite lands. The bourrelet (Par. 7) of the projectile had the approximate diameter of the lands; at the rear of the projectile was a smooth band of soft metal which had the diameter of the grooves. The projectile was inserted into the smooth-surfaced chamber in rear of the rifled (grooved) portion of the bore. It then was rammed forward; the grooves partially engaged the soft metal of the rotating band sufficiently to hold the projectile in place while the tube was elevated. On the explosion of the propelling charge, the projectile moves forward and the lands cut their way through the rotating band, causing it to conform in sections to the rifling, thus giving to the projectile a rotary motion about its long axis.

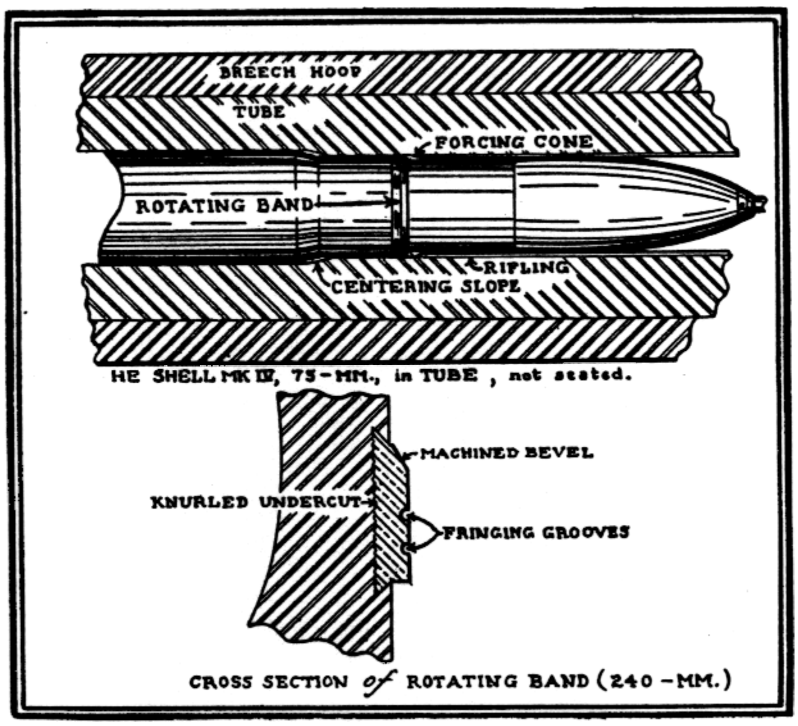



FIGURE 4. - Rotating band in gun chamber - projectile not seated.

(2) Since the band of a modern projectile completely fills the grooves, it prevents the escape of gas past the projectile, centers the projectile in the bore, and determines a fixed position of the projectile when rammed into the piece. The front surface of the band is machined to seat itself readily in the coned seat (forcing cone) at the origin of rifling.

(3) During firing, a small amount of the copper of the rotating band is forced back and 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 rotation combine to throw out this excess metal in a radical 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

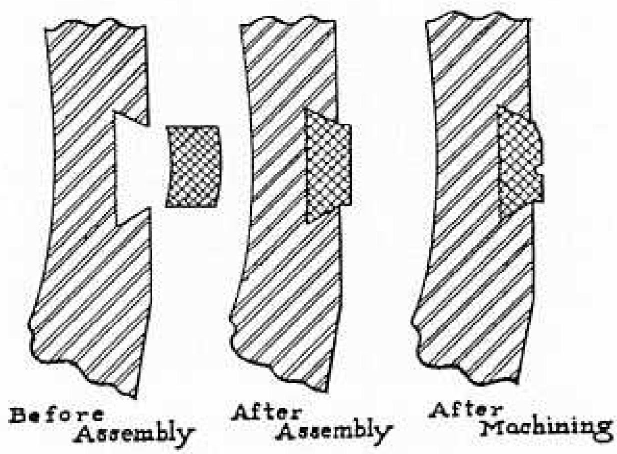



FIGURE 5. - Assembly of rotating band.

stability in flight, and causes decreased range and decreased accuracy. This fringing is obviated to a great extent by cutting grooves around and in the rear of the band.

(4) 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 muzt be hard enough to prevent it from stripping under the resistance met in rotating the projectile and avoid fouling the bore. Both copper and gilding metal seem to be favored as the best materials for rotating bands.

(5) Certain projectiles for the 155-mm. gun, M1918 (GPF), have two rotating bands, but generally there is only one rotating band on the projectile for all guns and howitzers.

7. <u>Bourrelet (Fig. 2)</u>. The forward bearing surface of the projectile is the "bourrelet", the purpose of which is to keep the projectile centered in the bore. It is about one sixth of a caliber in width, and is machined and polished to an accurate dimension slightly less than the diameter between the lands of the rifling. A clearance of .005 of an inch is prescribed for the bourrelet of the 75-mm. projectile. The bourrelet must fit closely to prevent wobbling but, of course, must not be tight enough to cause great friction or wear on the lands.

8. <u>Base cover (Fig. 6)</u>. Every projectile containing high explosive (except 37-mm.) is fitted with a base cover, which is designed to prevent the gas of the propelling charge from coming in contact with the explosive charge of the shell through possible defects in the base. Three types of base covers are in use, as follows;

<u>a</u>. The old type, common to all calibers, consisting of a

slightly dished brass plate covering a lead disc, the brass plate being crimped to the base of the projectile.

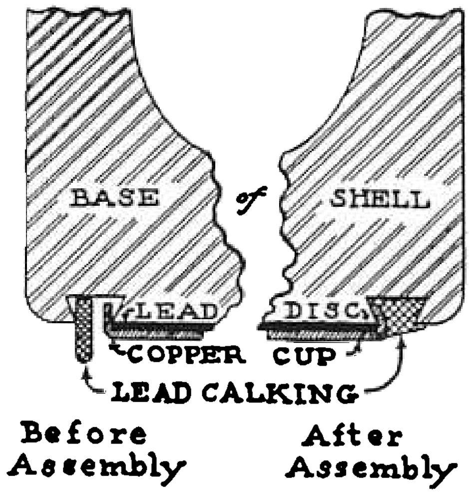



FIGURE 6. - Base cover assembly

b. The new type for small and medium calibers, having 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.

c. The new type for the larger calibers, consisting of a copper cup covering a lead disc, the copper cup being 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.

9. Projectile fillers. Classification. The modern projectiles fired by field artillery are classified according to the nature of the projectile, as shrapnel and shell. Following is a discussion of the development of the various types of projectiles, together with the purpose and action of each type.

a. 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.

b. Case shot (Fig. 7). (1) 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.

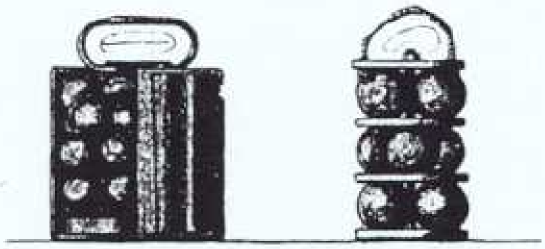



FIGURE 7. - Case shot and grape.

(2) 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 dislodgement 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 ranges owing to the wide pattern made by the spreading shot, but when the range exceeded five or six hundred yards there was practically no effect.

c. Grape (Fig. 7). A variation of case shot, known as grape, 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.

d. Explosive shell. (1) 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 gunpowder; the remaining space 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 regulating accurately 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 missles againct fortifications, and were used with some effect against personnel in the open.

(2) Modern shell, made of forged steel, are filled with high explosive, and upon reaching 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 to burst either above the ground--for effect against personnel; or to penetrate a short distance before explosion--for the purpose of destruction. Several high explosive fillers, such as TNT, amatol, and explosive D, are used.

e. Shrapnel. (1) 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.

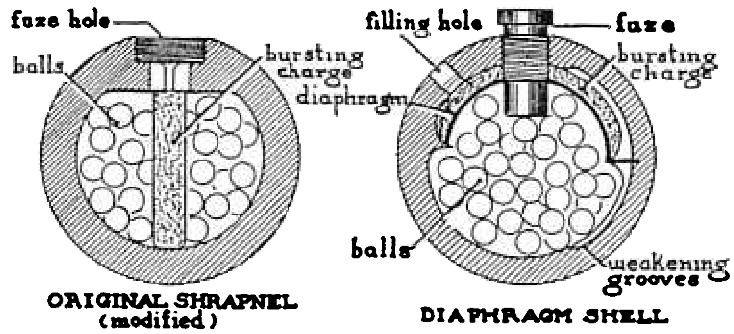



FIGURE 8. - Early shrapnel projectiles

(2) The original shrapnel (Fig. 8) was a spherical common 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 during flight; or a combination time and percussion 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.

f. Chemical shell. Chemical shell are a development of the World War, 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. No 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.

g. Incendiary shell. Since the earliest days of cannon, numerous means have been devised to project incendiary materials against enemy works. Perhaps the first effective incendiatry projectile fired from cannon was known as red-hot shot, developed about 1580. It consisted, in general, of a cast-iron shell filled with molten cast iron and immediately fired. On impact the shell broke, freeing the still molten iron and producing the desired effect. At present there is no projectile designed primarily to give incendiary effect, but certain projectiles now in use have this characteristic. Low-bursting shrapnel has some incendiary effect, as has white phosphorus (WP) smoke shell. Should any loading of incendiary material into projectiles be made in the future, it is likely that the material used would be Thermit (TH), 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.

## SECTION III

## DEVELOPMENT OF PROPELLANTS

10. 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 1600, and continued in use for more than 200 years.

11. Smokeless powder. Smokeless powder came into use about 1890, and quickly replaced black powder as the universal propellant for artillery. The first smokeless powder used in the United States service was nitroglycerine powder, which remained in use for small arms 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 is experienced with nitrocellulose powders. For this reason the latter are generally used in our service.

12. Rate of burning and granulation (Fig. 9). - a. Rapid development of gas pressure within the gun should be of such a progressive nature that the force exerted does not attain its maximum at the time of ignition (as would be the case if a high explosive in its usual form were used as a propellant), but rather attains it by a relatively gradual rise. Control of this pressure lies in the composition of the powder; form or shape of individual powder grains; and size or dimension of any particular form of grain. Granulation determines the area of the burning surface of the grain, which in turn controls the rate of combustion and through that, the pressure.

b. The best form of granulation from a ballistic point of view is; first, that which with the smallest weight of charge will impart to the projectile the prescribed muzzle velocity within the permitted limit of maximum pressure; second, that which will cause minimum erosion to the bore; and third, that which shows maximum regular-

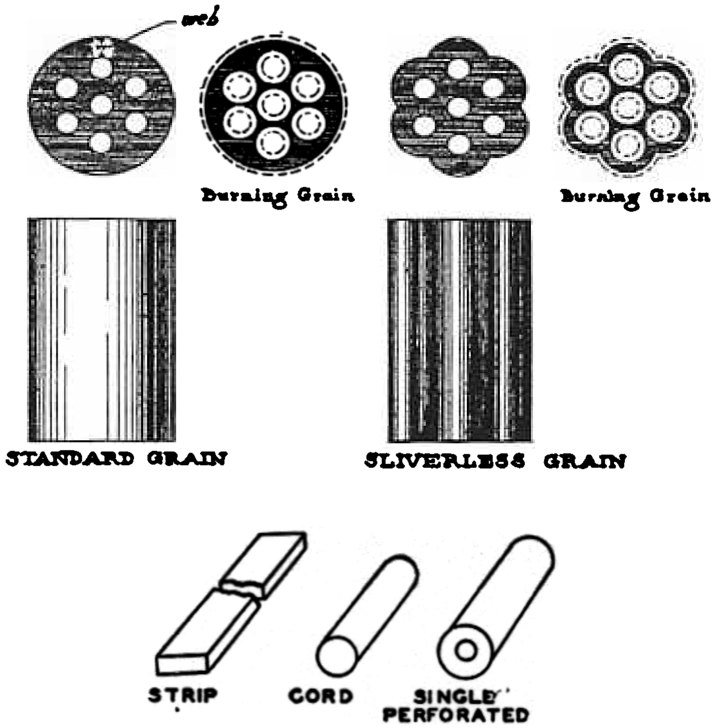



FIGURE 9. - Grains of powder

ity in ballistics. The grains burn uniformly from the surface and the rate of burning varies directly with the pressure; the greater the burning surface, the higher the pressure; all other things being equal. The shape of the grain is a direct factor in determining the total amount of burning surface of a given weight of powder.

13. FNH and NH powders for cannon. - a. Development. At the outbreak of the World War in 1914, the United States Army and Navy employed the same type of straight nitrocellulose powder that has been described above. After the experiences in the war, certain weaknesses in the standard propellent powder were recognized.

(1) Hygroscopicity. The standard nitrocellulose type of powder if exposed to the atmosphere is subject to change. The volatile solvent, ether-alcohol, used in the manufacture is not completely removed, the powder retaining from 3 to 7.5%, depending upon the size of the grain. In a warm atmosphere this residual solvent partially excapes and the rate of burning of the powder is increased. On the other hand, if the powder is exposed to a humid atmosphere, it absorbs moisture and the rate of burning is decreased. Thus, ballistic properties of the powder are appreciably affected by changes in atmospheric conditions to which the powder may be exposed.

(2) Flash. Another objection to the pyropowder was the

fact that when fired it produced a large, brilliant flash at the muzzle of the gun. This proved to be a serious objection during the World War owing to the great amount of night firing conducted, since the flash aided the enemy in locating positions of the guns. The need was recognized for a nonvolatile, nonhygroscopic, and flashless powder which would still retain the property of being substantially smokeless. Such a powder has been developed since the World War.

b. FNH and NH powder. (1) The FNH type of powder has been obtained by adding to the nitrocellulose inert or partially inert materials for the purpose of cooling the products of combustion and reducing the hygroscopicity of the powder. Such a powder may be flashless in certain weapons but not flashless in others. When flashlessness is not attained, the powder is designated as NH since flashlessness is dependent not only upon the composition of the powder, but upon relationship between quantity of powder used as a charge, the length of the bore of the gun, and the weight of the projectile, etc. While it might appear possible to obtain flashlessness in any weapon by merely increasing the amount of the flash-reducing agent in the powder composition, such a procedure may be impracticable either because of increased smoke or reduction in potential of the powder. While the present type of FNH powder has less strength than the standard pyrocellulose powder, it has sufficient strength to permit its use in all weapons without change in ballistic requirements.

(2) The manufacture of the FNH powder can be carried out in the same equipment and plant used for manufacture of the standard pyrocellulose powder. However, details of the processes for the two types of powder differ in many respects.

## SECTION IV

## PROPELLANT CONTAINERS

14. Classification. According to the method of assembly for transportation and for loading into the piece, ammunition is classified as "fixed", "semifixed", or "separate-loading" (unfixed). These classes of ammunition are shown in Figure 10.

a. Fixed ammunition comprises a cartridge case (which contains the propellant) whose base contains the primer, (Section V) and whose forward opening is crimped to the projectile so that the entire round is integral and all components are loaded into the gun in the same operation.

b. Semi-fixed ammunition 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 from it at the firing point for the purpose of varying the amount of the propelling bags, and, after the breechblock has been closed, to insert the primer. The base charge of the cartridge bags or the tying straps of the charge contain the igniter pad.

15. Cartridge cases. - a. Use. Where fixed or semi-fixed ammunition is used, a drawn brass cartridge case is supplied. This case has a profile and size to conform to the powder chamber of the cannon for which the case is intended. The head of the case is relatively thick and is provided with a flange for the purpose of mechanical extracting and for seating the round in the gun.

b. Function. In the center of the head is the primer seat, a circular hole into which the primer is seated by pressing to make a gas-tight joint. The wall or body of the case is relatively thin and of an outside diameter throughout its length just slightly less than the diameter of the powder chamber of the cannon. The primary function of the cartridge case is to hold the propelling charge, the primer and projectile, permitting the round to be loaded into the gun in one operation. Its secondary function is to block the pressure of the gas generated by the burning propellent charge. When the gun is fired, the case expands and the thin walls of the case fit themselves tightly against the surface of the loading chamber, thereby preventing the escape of the gas to the rear. This function of preventing the escape of propelling gas is known as "obturation". The action of the side walls and base of the metal cartridge case provides the means of accomplishing this function. The metal of the cartridge case, however, is springy enough so that, when the gas pressure is released, the cartridge case will contract, and can be extracted from the piece without difficulty.

16. Cartridge bags for separate-loading ammunition. - a. Cartridge bags are used with separate-loading ammunition. They form a suitable and convenient means of containing the propelling charge. Two classes of cloth are used in the manufacture of cartridge bags: "Cartridge bag cloth" and "cartridge igniter cloth".

b. Cartridge bag cloth is made of pure silk, wool, or mohair, but raw silk has been found to be the most practicable material. This cloth is used in the manufacture of all components of the bag, except those components containing the black igniting powder. It is necessary that the cartridge bag cloth have sufficient strength to withstand service conditions of handling; at the same time it must be consumed entirely during combustion of the propelling charge, as smoldering parts of it might cause the ignition of the next charge before the breech is closed, probably resulting in injury to members of the gun squad.

c. Cartridge-igniter cloth is made of pure silk, with properties similar to those of cartridge bag cloth, but is more closely woven to prevent the black ignition powder from sifting through. All igniter containers used with cartridge bags are manufactured from cartridge-igniter cloth. In order to avoid any possibility of error and to indicate clearly that they contain black powder, all igniter pads are now dyed red. In the older types that are not dyed red, the pads are stenciled, in black, with the word "igniter".

## SECTION V

## PRIMERS

17. - a. General. Primers for propelling charges are 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 semi-fixed 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 surface of the primer cavity, thus preventing the escape of propelling charge gases to the rear. The general classification of primers is based on the method of firing or initiating the ignition, as follows: Percussion; Friction; Electric; Combination percussion-electric; Igniting. The detailed description and functioning of these types are given in the section pertaining to primers, but figure 11 and the following descriptions will indicate the general characteristics of the various types.

b. The percussion primer is fired by means of a blow from the firing pin in the breech mechanism. Cartridge cases are in general fitted with this type. Percussion primers are made in several sizes for particular calibers of ammunition, the size referring more especially to the weight of the black powder charge; for example, a 49-grain primer contains an igniting charge of 49 grains of black powder. The primer known as a saluting primer is a percussion primer of special size.

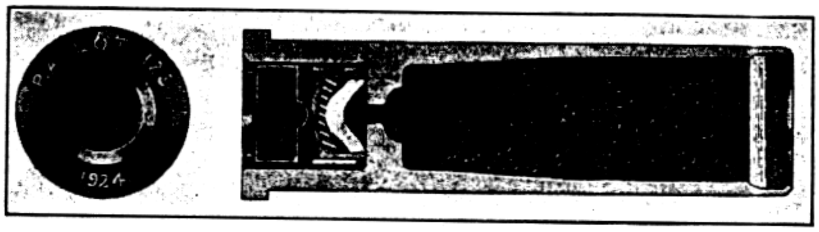
c. The friction primer, used only in seacoast cannon, is fired by the heat generated by pulling the serrated plug attached to the wire through the friction composition.

d. The electric primer is likewise used only in seacoast cannon. The primer composition is ignited by a wire heated by an electric current. In outward appearance the friction and electric primers are similar except that the wire of the electric primer is covered with black insulating material.

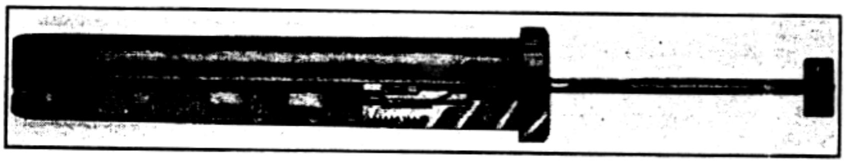
e. The combination percussion-electric primer may be fired either electrically or by the blow of a firing pin.

f. The igniting primer is used with subcaliber ammunition.

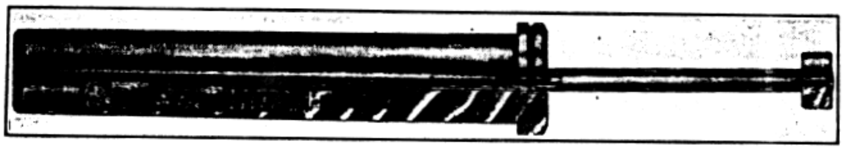
It has no initiating primer cap but is provided instead with a hole in a dummy percussion cap which allows the igniting flame from the service primer to fire the black powder charge in the igniting primer.



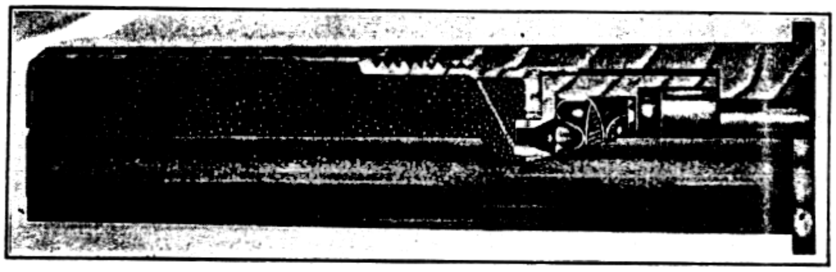
Year of loading　　　　Percussion primer



Friction primer



Electric primer



Combination percussion-electric primer

FIGURE 11. - Primers.

## SECTION VI

## DEVELOPMENT OF FUZES

18. Early fuzes. - a. A fuze is merely a 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 one 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 safety devices are not infallible.

b. 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.

c. Early attempts to produce percussion fuzes were unsuccessful, but the discovery of fulminate of mercury in 1799 finally afforded the means of attaining this object. Some 50 years elapsed however, befor 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.

19. World War types (Fig. 12). - a. Much ingenuity and labor have been expended in the effort to produce safe and accurate fuzes for all purposes. World War types of fuzes 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.

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

c. The double-banked type of combination time and percussion fuze used with shrapnel during the World War was satisfactory, however, there has been some improvement in the later types.

20. Post World War types. Most of the disadvantages enumerated above have been overcome in the recently developed fuzes. These are explained in detail in the section pertaining to fuzes.

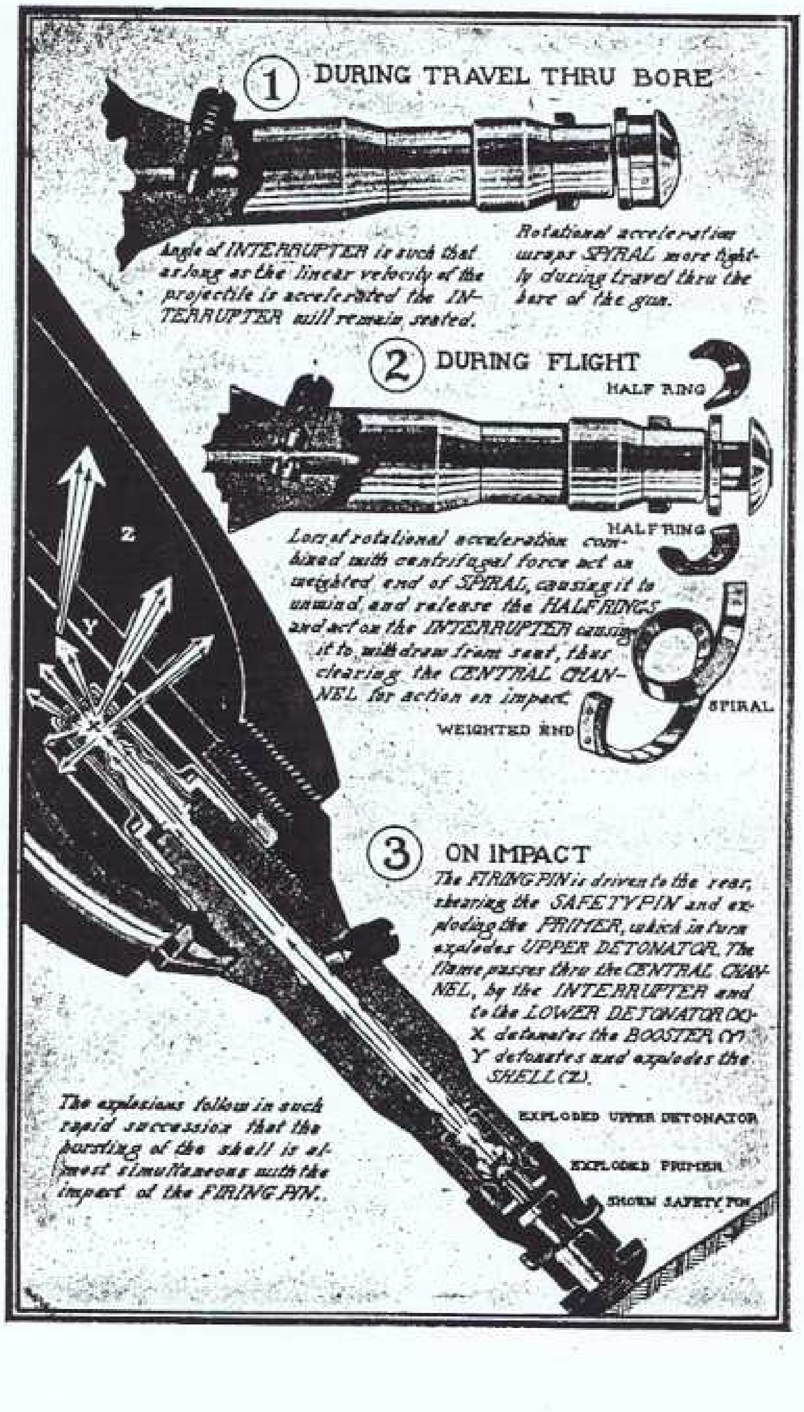
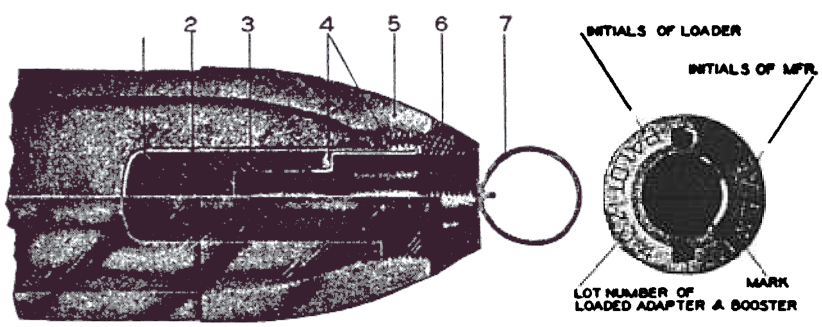



FIGURE 12. - Action of the Mark III (World War type) fuze.

## SECTION VII

## ADAPTERS AND BOOSTERS

21. - a. General. Some types of projectiles have a bushing screwed into the nose, known as the "adapter", to afford a recess tapped to receive the fuze. Attached to the adapter is the "booster casing", which contains the "booster". 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 augment the detonating wave and transmit it throughout the filler. This intermediary explosive is the booster. (See figure 13.) The inclination in the very latest types is to use a booster that is assembled directly to the pro-




1. Booster charge (tetryl).
2. Booster casing.
3. Fuse socket.
4. Felt washers.
5. Shell.
6. Adapter.
7. Adapter plug.

FIGURE 13. - Adapter and booster, Mk. III.

jectile, without the use of an adapter, the fuze, being screwed into the booster. Adapter boosters, boosters, or booster elements are used in all high explosive and chemical shell for all guns and howitzers. However, the term "booster" when applied to chemical shell is converted to "burster", as the function of this component in the chemical shell is to break up the shell and disperse the chemical filler. The burster charge is therefore greater than in the high explosive shell booster. The following methods are used to seal the chemical filler in chemical shell: provide the projectile and the adapter-booster or adapter with pipe threads; force the burster into the adapter to form a gas tight seal (in some of the older type projectiles that have been modified); or force the burster into the nose of the projectile itself (used in the later types of 105 and 155-mm. chemical projectiles).

# CHAPTER II

# PRIMERS

Section I. General
II. Percussion Primers
III. Friction Primers
IV. Electric Primers
V. Combination Electric and Percussion Primers
VI. Igniting Primers

## SECTION I

## GENERAL

1. General discussion. From the ammunition viewpoint, the word "primer" covers a large number of items of different uses and characteristics. All of these items have one thing in common: that is, they are used to initiate some action. The primers used to initiate the action of the propelling charge in artillery weapons are commonly referred to as "cannon primers". The cannon primers are composed of a metal body, a small pellet of a very sensitive composition to actually initiate the action, and a charge of black powder to amplify this action. The size of the primer, type, and model number of primer is usually included in the nomenclature. An example is the primer, percussion, 21-grain, Mk. IIA. Primers for assembly in fixed, semi-fixed, and blank ammunition are essentially manufacturing components and are not issued to the field, but those used with separate loading ammunition are issued separately, and loaded as a separate component at the time of firing the gun. See OFSB 3-2.

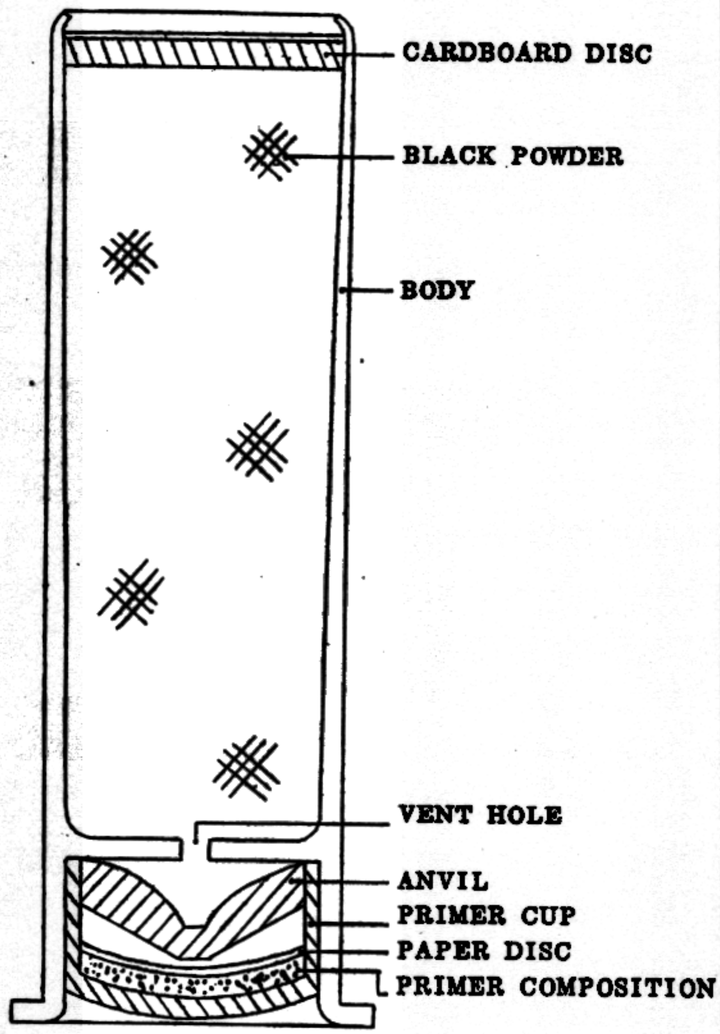
## SECTION II

## PERCUSSION PRIMERS

2. Primer, percussion, 20-grain, Mk. IIA1. - a. Description. This primer is obsolete. It was used in ammunition for the 37-mm. gun, M1916 until replaced by the M23. One of the reasons for discontinuing the use of this primer was the fact that obturation was sometimes destroyed by piercing the percussion element with the firing pin. Recent redesign of primers for fixed, semi-fixed, and blank ammunition was to prevent this malfunction. In the new design, a firing plug of soft metal eliminates direct contact of the firing pin with the primer cup as is the case in this model. See figure 1.

b. Action. Same as paragraph 5b.

3. Primer, percussion, 20-grain, M23. - a. General. The M23 primer is modified to the M23A1. The change being in the assembly of

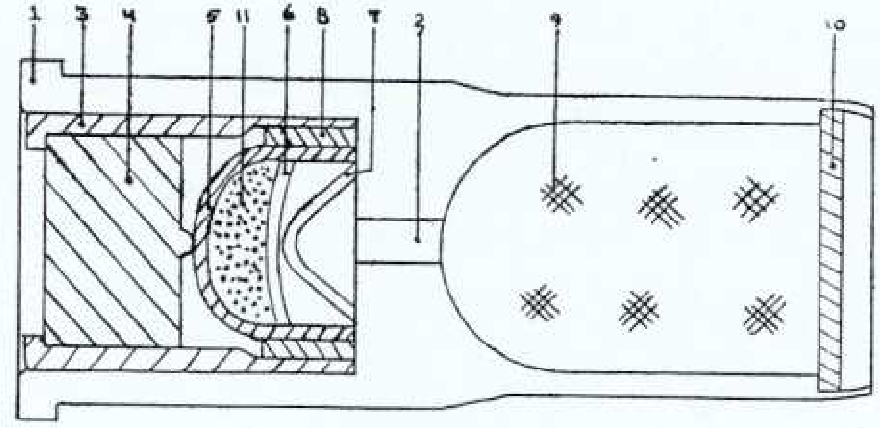



MK II A1

20-GRAIN PERCUSSION PRIMER

Figure 1

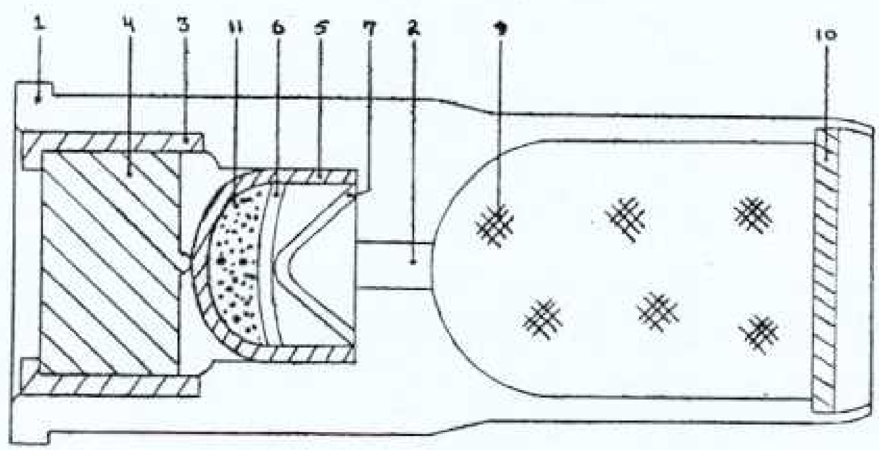
Figure 2 (a)




M23

1. Body
2. Flash hole
3. Sleeve
4. Plug
5. Primer cup
6. Paper disc
7. Anvil
8. Sleeve, primer cup
9. Black powder (20-grains)
10. Paper disc
11. Primer composition

Figure 2 (b)




M23A1

the firing plug (4) which was necessary because of frequent blow-backs. See figure 2(a). The older model may be still found in 37-mm. shell that were assembled before the modification.

4. Primer, percussion, 20-grain, M23A1. General. This primer is the standard for assembly in 37-mm. ammunition of all types, and in saluting ammunition for the 3" field gun. The illustration shows the firing plug (4) that is designed to receive the blow of the firing pin. The plug, being made of soft metal, does not penetrate the primer cup (5). Another function of the plug is to transmit the force of the blow to the primer cup over the apex of the anvil even if the primer is not in direct line with the firing pin. The old model, M23, must depend upon a firm seat of the plug against the shoulders of the sleeve (3) to prevent escape of gas. The M23A1 has eliminated the sleeve, primer cup (8), and reduced the length of the other sleeve. This causes the escaping gas to act against and expand the sleeve (3) at the forward end to more effectively seal the entire assembly. See figure 2 (b).

5. Primer, percussion, 21-grain, Mk. IIA. - a. Description. This is the primer used in all field guns using separate loading ammunition. The small charge of black powder contained in this primer is strong enough as the propelling charges have an igniting pad attached which serves to completely ignite the propellant. The functioning of all percussion primers is essentially the same. This one is explained in detail below, but the explanation may be applied to all, consideration being given to the small differences in design and assembly. See figure 3.

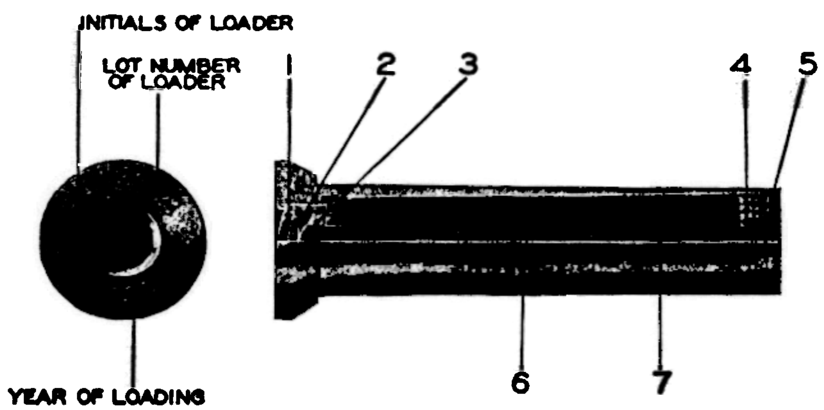



FIGURE 3. - 21-grain percussion primer, Mk. II-A.

1. Percussion cup.
2. Percussion composition.
3. Anvil.
4. Wax.
5. Shellac.
6. Case.
7. Black powder.

b. Action. When the firing pin strikes the percussion cup (1), it indents the cup and crushes the percussion composition (2) against the anvil (3), causing this composition to explode. The flame from the explosion of the percussion composition passes through a hole and ignites the powder charge (7) which, in turn, ignites the igniter of the propelling charge. The percussion composition (2) is sensitive and care must be taken that the cup (1) is not hit by any hard object. A blow simulating that of a firing pin attached to a 10 pound weight and dropped through a height of 3 inches may cause it to function.

c. Marking. Identification marks are stamped on the primer head as shown in the drawing.

d. Shipment. These primers are shipped packed in waterproof tin packing cans, 50 primers to each can, 48 of these cans (2400 primers) to a box. See SNL R-3. They are affected by moisture, and care should be taken that they are kept dry after the can has been opened. See paragraph 5, OFSB 3-3.

6. Primer, percussion, 49-grain, Mk. I. - a. Description. Many sizes and models of primers may be found assembled with 75-mm. ammunition, but this is the oldest, or first used. Primers containing 75, 100, or 150 grains of black powder are used instead at the present time. The size depending on the size of the propelling charge and the type of powder from which the propelling charge is made. The recent redesign of primers provides a uniform size of head so that a standard size primer hole could be used in all cartridge cases regardless of the primer used. See figure 4.

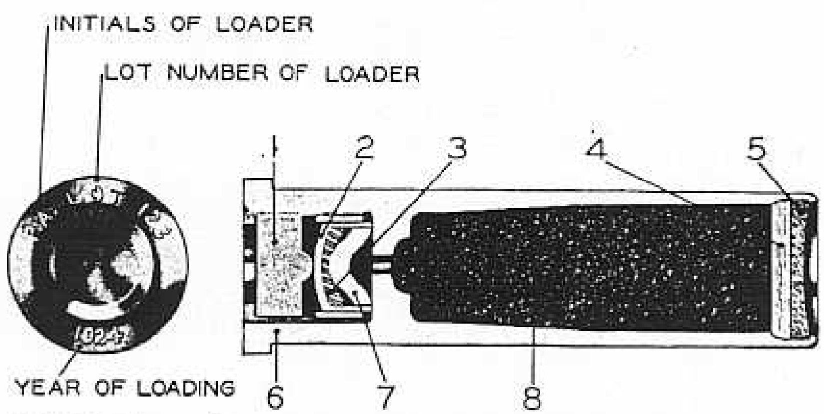



FIGURE 4. - 49-grain percussion primer, Mk. I.

1. Firing plug.
2. Cup.
3. Composition pellet.
4. End closing wad.
5. Shellac.
6. Body.
7. Anvil.
8. Black powder.

b. Action. Same as paragraph 5b except for the firing plug.

c. Marking. Identification marks are stamped on the primer head as shown in the drawing.

7. Primer, percussion, 75-grain, M22A1. - a. Description. These primers are assembled in H.E. shell using reduced and normal propelling charges, and Mk. II chemical shell only, for the 75-mm. field guns. They were originally made of sufficient length to accomodate 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 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; it also serves to support the black powder charge retaining cup. This primer, similar to all the other late models for fixed and semi-fixed ammunition, except the M23A1, employs the same head assembly to which is screwed a brass tubing body, closed at the outer end by a threaded brass plug. See figure 5.

b. Action. The firing pin of the gun strikes the firing plug with sufficient force to drive it forward and deform the primer cup. The percussion element charge is crushed against the anvil and explodes. The flame from this explosion passes forward and ignites the black powder charge. As the forward end of the body is fitted with a closing plug, the flame from the black powder charge flashes through the vents. Distribution of the flame in this manner results in uniform ignition of the propelling charge.

c. Marking. The initials of loader, lot number, year of loading, and model number are stamped on the head.

8. Primer, percussion, 100-grain, M1. - a. Description. This primer was adopted to supersede the 110-grain percussion primer for use in 3" AA ammunition, and the 49-grain percussion primer, Mk. I, for 75-mm. ammunition. The head is similar to that of the 20-grain, M23, in construction. This was modified to the M1A1 by changing the head assembly. The difference between the M1 and the M1B1 is in the design of the brass tube. The first is a drawn brass case that is open at one end, the other end slotted to receive a screwdriver. The latter is of brass tubing and closed on one end by a plug which is rolled crimped in place after being screwed in, and slotted to receive a screwdriver. Some manufacturers are prepared to make one type of tube, while others are prepared for the other. The method of manufacture of the tube does not affect the functioning of the primer. The M1B1 with the modified head becomes the M1B1A1. Cartridge cases for service ammunition for the 2.95", 75-mm., 105-mm. how., 3" AA guns, and blank ammunition for the 3" 15-Pdr., and 105-mm. how., will take either primer. Larger primers are now used in service ammunition for the anti-aircraft guns, and the 3" 15-Pdr. See figure 6(a).

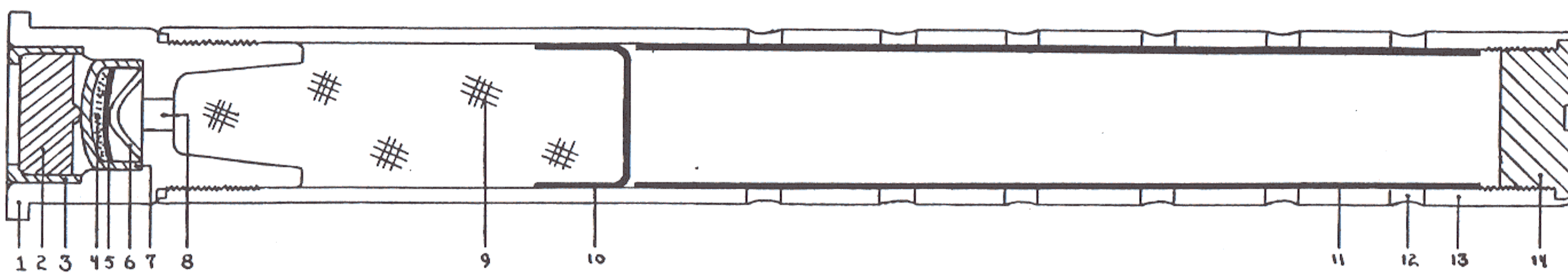
b. Action. Same as paragraph 7b.

c. Marking. Same as paragraph 7c.

9. Primer, percussion, 100-grain M1A1. See paragraph 8, and figure 6(b).

10. Primer, percussion, 100-grain M1B1. See paragraph 8, and figure 6(c).

1. Body, primer head
2. Plug
3. Sleeve
4. Primer composition
5. Paper disc
6. Anvil
7. Primer cup
8. Flash hole
9. Black powder (75-grains)
10. Paper cup
11. Paper liner
12. Vents
13. Tube, brass
14. Plug, brass

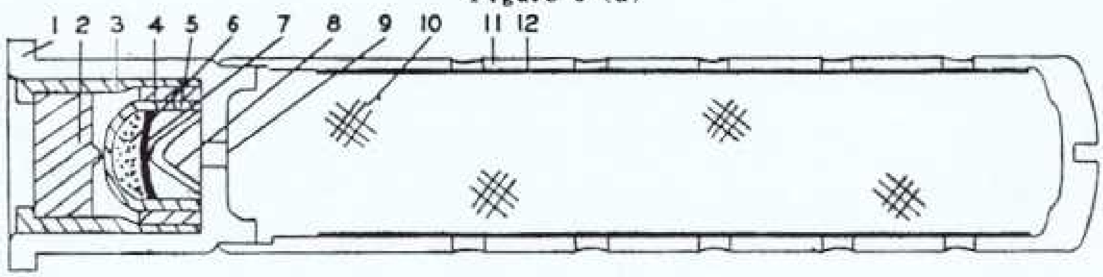



**M22A1**

**75-GRAIN PERCUSSION PRIMER**

Figure 5

Figure 6 (a)

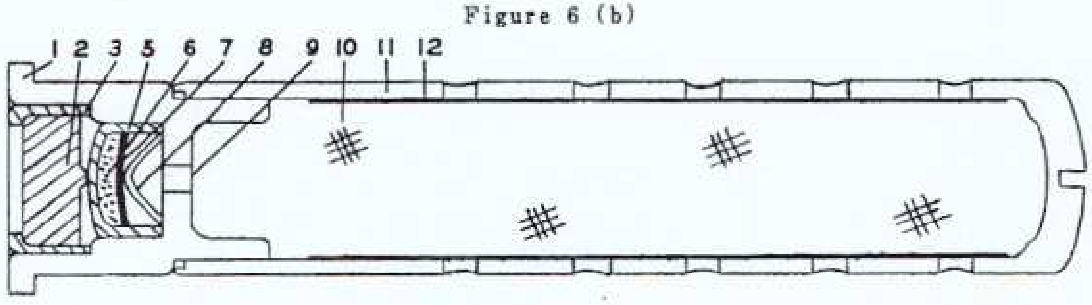



M1

100-GRAIN PERCUSSION PRIMER

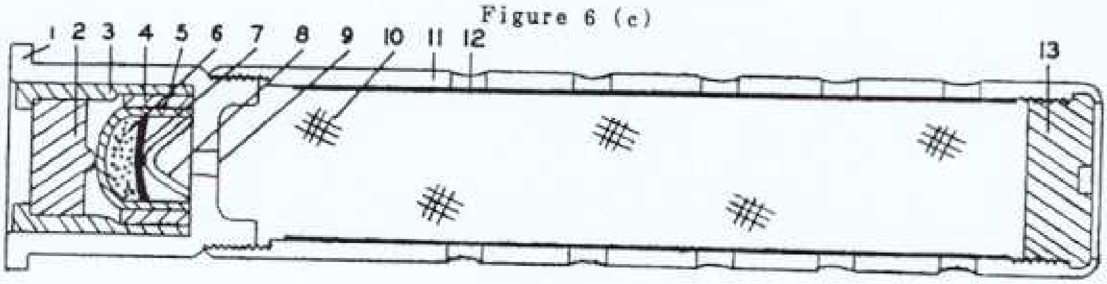
1. Body, primer head
2. Plug
3. Sleeve
4. Sleeve, primer cup
5. Primer cup
6. Primer composition
7. Paper disc
8. Anvil
9. Flash hole
10. Black powder (100-grains)
11. Case, brass
12. Paper liner

Figure 6 (b)




M1A1

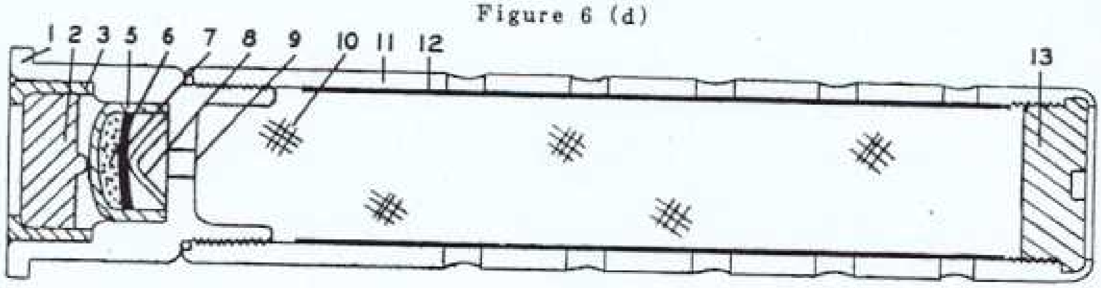
Figure 6 (c)




M1B1

1. Body, primer head
2. Plug
3. Sleeve
4. Sleeve, primer cup
5. Primer cup
6. Primer composition
7. Paper disc
8. Anvil
9. Flash hole
10. Black powder (100-grains)
11. Case, brass
12. Paper liner
13. Plug, closing

Figure 6 (d)




M1B1A1

11. Primer, percussion, 100-grain, M1B1A1. See paragraph 8, figure 6(d).

12. Primer, percussion, 110-grain. - a. Description. This primer is no longer standard for manufacture but will be found in service assembled in some 3" AA cartridge cases. It has never been assembled in ammunition for the 105-mm. AA gun. Being of smaller diameter than the 100-grain M1 primer, it will not fit cartridge cases drilled for the latter. The 110-grain primer is shown in the illustration with names of its principal parts. The body (8) is made from cartridge brass and contains a charge (4) of compressed black powder. The flash holes or vents (7) are drilled through the body and the powder charge after the latter has been pressed in. This results in considerable loss of powder, approximately 99 grains remaining in the finished primer. The charge is protected from moisture by a tin-foil wrapper (6) which covers the vents. The end closing wad (5) is crimped in place and shellacked. See figure 7.

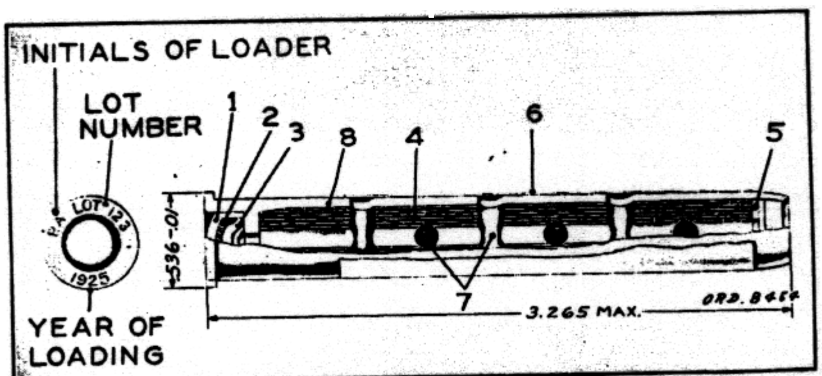



FIGURE 7. - Primer, percussion, 110-grain.

1. Primer cup.
2. Percussion charge.
3. Anvil.
4. Charge (compressed black powder).
5. Closing wad.
6. Tin-foil wrapper.
7. Vents.
8. Body.

b. Action. As the 110-grain percussion primer is not fitted with a firing plug, the primer cup (1) is indented by a direct blow from the firing pin of the gun. The percussion element charge (2) is crushed against the anvil (3) and explodes. The flame from this explosion passes forward and ignites the black powder charge (4) which in turn flashes through the vents (7) and the forward end of the primer, igniting the propelling charge in the cartridge case. The percussion element charge is sensitive and care must be exercised to protect it from shock at all times. A blow on the primer from a sharp object, simulating that of a firing pin, could explode a round of this ammunition with fatal consequences.

13. Primer, percussion, 150-grain, M31. - a. Description. Recently adopted super-charges of propellent powder for use with some rounds of high explosive shell in 75-mm. field guns require a primer of higher

black powder capacity than the M22A1, or the M1B1A1. The M31 primer is similar to the M22A1, with the exception that the tube must be without vents to such a distance from the head as to accommodate 150 grains of powder.

b. Action. Same as paragraph 7b.

c. Marking. Same as paragraph 7c.

14. Primer, percussion, 300-grain, M28A1. General. The appearance and functioning of this primer is identical with the 100-grain M1B1A1, except for the length of the tube which contains more powder. It is standard for assembly in ammunition for the 3" 15-Pdr., 3" AA, 90-mm. AA and 105-mm. AA guns, to supersede the 330-grain M21.

15. Primer, percussion, 330-grain, M21. General. This primer superseded the 100-grain, M1, and its modifications for use in all Anti-Aircraft ammunition, but has since given way to the 300-grain M28A1. The size and appearance is similar to the M28A1, but the head assembly is of the old type.

## SECTION III

## FRICTION PRIMERS

16. Primer, friction, M1914. - a. Description. The friction primer is designed to be fired by pulling a serrated plug through a friction composition. The friction primer is interchangeable with the electric primer, and is used for emergency use in case the electrical equipment fails. Another use for this primer is for drill purposes with dummy ammunition. They are listed, stored and issued under SNL P-6. See figure 8.

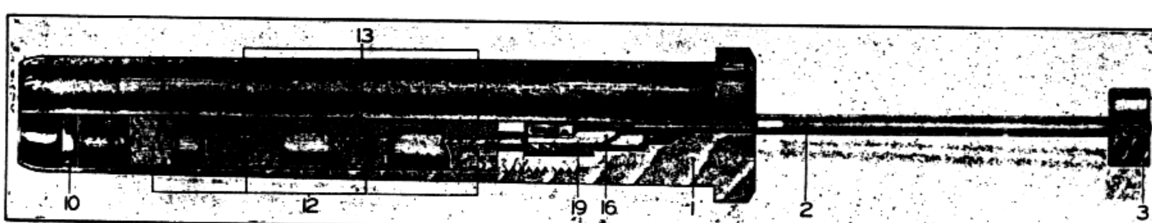



FIGURE 8. - Friction primer, M1914.

1. Body.
2. Wire.
3. Button.
10. Closing cup.
12. Black-powder pellets.
13. Loose black powder.
16. Gas check.
19. Friction composition.

b. Action. The assembled primer is inserted in the breech-block of the gun and is held in place by the slide. The firing leaf engages the button (3), which is threaded and riveted to the wire (2). When the lanyard, which is attached to the firing leaf, is pulled, the wire (2) draws the gas check (16), which is fitted with serrations or saw teeth, through the friction composition (19), causing it to explode. The flame from the explosion of this friction composition ignites the black powder charge in the primer, consisting of the black powder pellets (12) and the loose black powder (13). The mouth of the primer is closed by a thin brass cup (10), to seal the primer against the entrance of moisture. The primer is a close fit in its seat in the spindle of the breechblock and the walls of the primer body (1) are made thin so that they are expanded by the gas pressure against the primer seat, thus obturating the gas at this point. After the gas check (16) is pulled through the friction composition (19), it seats itself in the cone shaped recess in the primer body, thus preventing the escape of the powder gases through the primer. A pull of from 35 to 75 pounds is required to fire this primer. The lanyard should be pulled from a position as near the rear of the gun as possible. A strong, steady pull from one man, with as short a lanyard as practicable, should be used. Where a long lanyard is used, the slack causes the force to be applied slowly, increasing the chances for a misfire. If a primer can not be fired by one man, it should be rejected and another used. Two men pulling on a lanyard may injure the firing mechanism. When a primer is pulled and fails to fire, it should be removed from the gun and the wire should immediately be bent around the primer through an angle of about 180° to prevent its being used again. Instructions to the above effect are printed on the labels of the packing cans in which the primers are packed and they must be followed if the best results are desired. When the primer fails to fire it will be seen that the gas check (16), being then seated in its recess in the rear of the cavity in the primer body, the wire (2) will be free to move forward to its original position without moving the gas check (16) with it; there is some danger of firing the primer by reverse movement of the wire.

c. Marking. No distinguishing marks are machined on this primer body, as is the case with the electric primer. The base of the head is stamped as follows:

(1) Initials or symbol of loading plant.

(2) Lot number of the loaded primer.

(3) Year of loading.

d. Shipment. These primers are shipped packed in waterproof metal packing cans, containing 20 primers to the can, which in turn are packed in wooden packing boxes, 25 cans (500 primers) to the box. Primers are affected by moisture, and care should be taken that they are kept dry after the can has been opened.

SECTION IV

ELECTRIC PRIMERS

17. Primer, electric. - a. Description. Heavy artillery weapons installed in Harbor Defense emplacements are equipped with an electrical system which permits the use of electric primers. Until the recent development of the primer, electric, M30, the one described in this paragraph was the only one issued. They are listed, stored, and issued under SNL P-6. See figure 9.

b. Action. One end of the contact wire (11) is soldered to the contact plug (4), which is insulated from the body (1) by the plug insulator (5) and insulator (6), and attached to the wire (2), which is also insulated from the body by the paper insulation (15). Electrical contact is formed through the button (3) with the external circuit by means of clips attached to the firing mechanism of the gun. The back of the button is insulated by an insulated paper washer (26) shellacked to the button. The opposite end of the contact wire (11) is soldered to the contact sleeve (8), which is in electrical contact with the body (1). An electric current of sufficient intensity to heat the platinum contact wire (11) ignites the guncotton (14) and through this the primer charge, consisting of loose black powder (13) and black powder pellets (12). A maximum current of 1.1 amperes is required to fire this primer. The mouth of the primer is closed by a thin brass cup (10) to seal the primer against the entrance of moisture. The primer is a close fit in its seat in the spindle of the breechblock and the walls of the primer body (1) are made thin so that they are expanded by the gas pressue against the primer seat, thus obturating the gas at this point, and there is no escape for the gases through the primer itself.

c. Marking. A shallow groove is machined around the outside of the head of the primer body, which is a distinguishing feature of the electric primer. The base of the head is also stamped as follows:

(1) Initials or symbol of loading plant.

(2) Lot number of loaded primer.

(3) Year of loading.

d. Shipment. These primers are shipped packed in waterproof metal packing cans, containing 20 primers to the can, which in turn are packed in wooden packing boxes, 25 cans (500 primers) to the box.

18. Primer, electric, M30. - a. General. The electric primer is one designed to be fired by an electric current properly applied. Many instances have occured in which the primer discussed in the previous paragraph failed to fire. Examination of such primers has shown that the failure was due in most instances to the breaking of the deli-

cate bridge, or contact wire. Due to the method of assembly, this bridge wire could easily be broken during the assembly of the primer, and undoubtedly breakage occurred in some cases during subsequent trans-

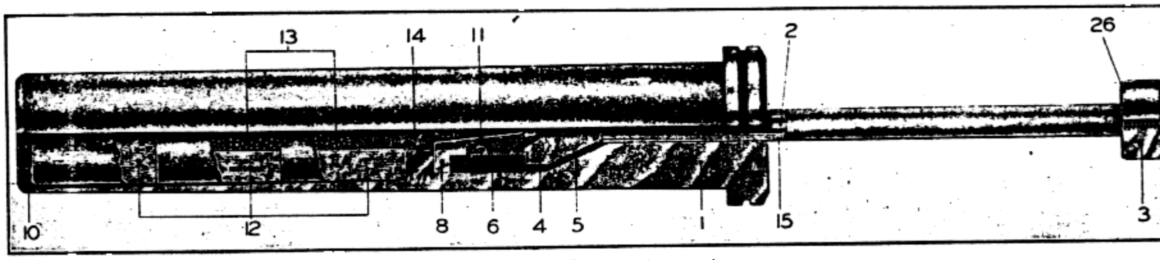



FIGURE 9. - Electric primer.

1. Body.
2. Wire.
3. Button.
4. Contact plug.
5. Plug insulator.
6. Insulator.
8. Contact sleeve.
10. Closing cup.
11. Contact wire.
12. Black-powder pellets.
13. Loose black powder.
14. Guncotton.
15. Paper insulation.
26. Paper washer.

portation. The M30 employs a unit bridge wire assembly which can be assembled completely, prior to insertion in the primer body, and difficulty due to breakage during assembly should be eliminated, at least to a very large extent, by this provision. In the older primer which functioned satisfactorily, subsequent difficulty was often encountered in removing the primer from the breechblock. This difficulty is believed to have been partly attributable to two causes: First, the primer body expanded and wedged itself into the spindle plug, this expansion being due to the pressure of the propelling charge gases against the conical contact plug inside the primer. Second, the deposit of slag between the primer body and spindle plug occurring when obturation was faulty. It is believed that the new electric primer eliminates the first mentioned cause for the difficulty by changing the conical contact plug to a cylindrical type contact plug. Investigations of the second cause for the difficulty indicate that the spindle plug in the breechblocks may have variations which contribute to faulty obturation. An electric primer testing set known as the Primer Tester, M1, has been designed and, after thorough tests by the using service, has been issued to all extablishments using electric primers. This primer tester, by means of a Wheatstone bridge circuit, will detect short circuits, open circuits, or high resistance in the primer prior to the attempted use of the primer is firing a round of ammunition. This primer tester, replacing make-shift methods sometimes used by the using service due to the lack of specially designed equipment, should result in a very great reduction in the number of misfires in experiments.

b. Marking. Same as 16c.

c. Shipment. Same as 16d.

## SECTION V

### COMBINATION ELECTRIC AND PERCUSSION PRIMERS

19. Primer, combination electric and percussion, Mk. XV Mod. 1. a. Description. There are Navy guns of 7" and 14" caliber on railway mounts, and of 16" caliber in Harbor Defense emplacements which require the combination primer. This primer is also of Navy design. This primer is listed, stored, and issued under SNL P-6. See figure 10.

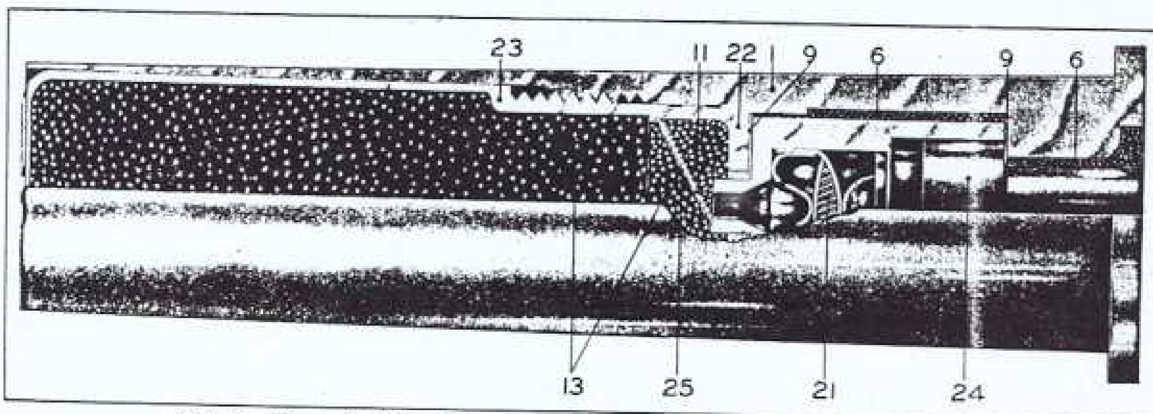



FIGURE 10. - Combination percussion-electric primer, Mk. XV M1.

1. Body.
6. Insulators.
9. Insulating washers.
11. Contact wire.
13. Loose black powder.
21. Primer cap.
22. Ignition cup.
23. Metallic seal.
24. Plunger.
25. Guncotton.

b. Action. When fired by percussion action, the striker, or firing pin in the breech mechanism of the gun, drives the plunger (24) into the primer cap (21), thus exploding it. The flame from this explosion passes into the ignition cup (22) and ignites the loose black powder (13), in the metallic seal (23). The charge in this primer is approximately 30 grains of loose black powder. The end of the metallic seal (23) is slotted, to permit the discharge of the hot gases and flame through the vent in the breechblock and against the igniter of the propelling charge. When fired electrically, electric contact is made on the plunger (24). When the circuit is closed, the resistance heats the platinum contact wire (11), firing the wisp of guncotton (25), which is wrapped around the contact wire (11) and ignites the loose black powder charge (13). The plunger and plunger cup are insulated from the primer body (1) by the insulators (6) and (9).

c. Shipment. These primers are shipped packed in waterproof metal packing cans, containing 24 primers to the can, which in turn are packed in wooden packing boxes, 42 cans (1008 primers) to the box. These primers are affected by moisture, and care should be taken that they are kept dry after the can has been opened.

## SECTION VI

## IGNITING PRIMERS

20. - a. General. Igniting primers are used in the cartridge cases of the subcaliber ammunition for use with the subcaliber guns of fixed and railway artillery not provided with percussion firing mechanisms. In exterior form and dimensions, an igniting primer is similar to a service primer. Its interior construction differs from the latter in that it contains no percussion, friction, or electric elements, and possesses a gas checking device. A friction, or electric primer must always be employed in conjunction with the igniting primer. This service primer is inserted in the same manner as when used for service firing. The flame from the service primer ignites the igniting primer, the flame from the latter igniting the subcaliber propelling charge. Igniting primers are made in two sizes, 20-grain, M25A1, and 100-grain, M24A2.

b. Identification. Generally, no distinguishing marks are machined on the primer bodies. The M25A1 primer is standard for assembly in 1.457" subcaliber ammunition for some weapons. As some 1.457" ammunition has a percussion primer, a red stripe $\frac{1}{4}$" wide is painted across the base of the cartridge case to denote an igniting primer. The head of the primer body is usually stamped as follows:

(1) Initials or symbol of loading plant.

(2) Lot number of loaded primer.

(3) Year of loading

# CHAPTER III

# FUZES



## SECTION I

## GENERAL

1. References. Proper nomenclature of fuzes is published in the following Ordnance Standard Nomenclature Lists: S.N.L. P-6 Fuzes, Primers, Blank Ammunition, and Miscellaneous Items For Harbor Defense, Heavy Field, and Railway Artillery. S.N.L. R-3 Service Fuzes and Primers for Pack, Light, and Medium Field Artillery.

2. Development. - a. A fuze is a mechanism or device by which the explosion of a projectile is governed so as to cause the explosion at a certain time or only under certain conditions. Fuzes as originally used in spherical projectiles were "time" or "concussion" fuzes. The oldest form of time fuze was a piece of "fuse" 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 and when burned down to the end 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.

b. In a concussion fuze, an inflammable composition was ignited on discharge of the gun and, on impact, by some contrivance, the flame was admitted to the burster charge. The contrivances used were glass tubes, zinc tubes which when heated by the burning powder inside would break off on impact, or plaster of paris tubes. Due to the fact that a spherical projectile would strike on any point of its surface, percussion fuzes did not operate satisfactorily, though tried in many forms. In one type three distinct double-ended plungers were used with their axis 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. On the introduction of rifled guns and elongated projectiles a great deal of the trouble with percussion fuzes was eliminated. As the projectile then struck point first the use of a plunger striking a cap, on impact, was made possible. The use of the rotation of the projectile to function additional safety features marked the further advancement in the design of fuzes. With the modern use of high explosives a further change was required in providing a detonating element and producing a delay feature.

3. Types. - a. Fuzes are grouped according to the assembled position in the projectile and action of functioning. The following types are now in use:

| Assembled in Point | | | Assembled in Base |
|---|---|---|---|
| Time | Combination | Impact | Impact |
| Powder<br>Mechanical | Time & Impact | Superquick, supersensitive, combination superquick-short delay, or delay only (limited use). | Non-delay<br>Short delay |

b. "Superquick" fuzes are designed to burst the shell promptly on impact and before it has penetrated. Very little crater effect will be obtained from this type. It is used where the target to be demolished is above the ground, such as wire and personnel.

c. "Supersensitive" fuzes are designed to burst the shell promptly on impact against a light target, such as an airplane wing.

d. "Delay" fuzes are designed to burst the shell shortly after impact. They are used where it is desired to obtain penetration and also against personnel. When used against personnel the round is fired so that a ricochet action is obtained.

e. "Time" fuzes are designed to burst the projectile at some predetermined time after the projectile leaves the cannon. They are used against personnel, aircraft and in barrages.

f. "Combination" fuzes combine two or more of the features such as "time and superquick".

4. Fuze design in general. - a. During the World War the application of science and engineering to the art of warfare reached such proportions that the system employed in fuzing our projectiles proved entirely inadequate to meet the requirements imposed on ammunition components. The history of fuze development shows a more or less regular progress, but much progress seems to have been made at the time the problems and new situation demanded improvements in functioning of the fuze. The development of fuzes has, since the World War, resolved itself into a problem requiring extensive study in order that our Ordnance program be complete.

b. Ammunition is of no value unless the projectile can be made to function at the time and place desired; hence a fuze must function with extreme exactness. A fuze is but a small part of a complete round of ammunition yet it requires a high degree of technical skill in its perfection and offers much difficulty in design.

c. Fuzes can be standardized only to the point where their efficiency is not impaired. The more action a fuze is required to perform, the greater its cost and delay in production. Since the actual life of a fuze in service is but a few seconds, a multi-purpose fuze would be required to perform more than required for an individual shot and would represent wasted effort. The standardization of fuze design must meet the requirements of supply, use and manufacture.

5. Technical requirements in fuze design. - a. The technical requirements which must be met in the design of a fuze are governed by the requirements of the using service. The caliber of the cannon in which a fuze is to be used may vary over a wide range with corresponding variations in muzzle velocity and pressure. The forces available for the design of a fuze are:

(1) Pressure of the propellent gases.

(2) Forces due to acceleration of the projectile (setback force).

(3) Centrifugal force, due to rotation of the projectile.

(4) Creep force, due to retardation of the projectile in flight.

(5) Impact force, due to the projectile striking the target.

These forces vary with the cannon in which the fuze is to be used and if the fuze is to be used in ammunition of several different calibers for the purpose of functioning under varied tactical requirements it is evident that the new development becomes quite involved.

b. The various stages in the development of a new fuze design, from the time the requirements are specified until final approval for manufacture and issue are as follows. The first step is to prepare a drawing board study and thereby determine the size limitations in the various shell for which the fuze will be used. To attain mass production the design must be based on the practical interchangeable manufacture of the components. It is highly desirable to develop a design, the components of which can be manufactured on punch press or automatic screw machines. The safety features of the fuze and the manner of loading and assembling the explosive train are very important considerations in a new design. The second step is to prepare detail drawings of the fuze which apparently meet the requirements. These working drawings must conform with the requirements of sound manufacturing methods whereby interchangeability of parts can be procured under mass production. This step involves a study of tolerances and manufacturing methods. The third step is the placing of an experimental order in the shop where the desired quantity, which is usually small, is manufactured and such changes in design recommended as may be found desirable from the manufacturing standpoint. The fourth step consists of design tests and service tests. The design tests are conducted at the experimental arsenal and the proving ground. The service tests are conducted by the using service. The fifth and final stage in the development of a design is its standardization by the Secretary of War.

6. Safety. All types of fuzes now in use are arranged with safety devices which tend to prevent functioning until after the fuze has been subjected to the forces in the cannon for which it was designed. In addition, the later types of fuzes have been designed to be detonator (bore) safe. A bore safe fuze is one in which all detonating elements are separated, by some form of interrupter, from the booster charge until the projectile has cleared the muzzle of the gun. This prevents premature action of the shell charge in the bore of the gun, due to malfunctioning of the more sensitive elements of the fuze.

## SECTION II

## DETONATING FUZES, BASE AND POINT

7. Base detonating fuze, M38 (Fig. 1). - a. General. This is a non-delay fuze with no means provided for partial or full bore safety (the detonating elements are not separated from the booster). This fuze was designed, primarily, to replace the old Mark IV base detonating fuze. When fired, using a propelling charge which resulted in chamber pressures greater than 18,500 pounds per square inch, the Mk. IV fuze frequently prematured. The weight of the M38 fuze is approximately 0.125 pounds

b. Function. (1) Action upon firing. The plunger through its inertia or setback forces the resistance ring over the shoulder on the firing pin down to the groove at the lower end of the firing pin. The dimensions of the resistance ring and the groove in the plunger are such that it causes locking of the plunger to the firing pin. The spring prevents forward movement of the integral assembly of the plunger and firing pin while in flight.

(2) Action at target. Upon impact the projectile is retarded and the integral assembly of the plunger and the firing pin moves forward functioning the detonator assembly which causes detonation of the tetryl booster pellet. This in turn functions the bursting charge in the projectile.

(3) Safety. The resistance ring in conjunction with the plunger prevents the firing pin from functioning the detonator assembly until after it has been fired from the weapon.

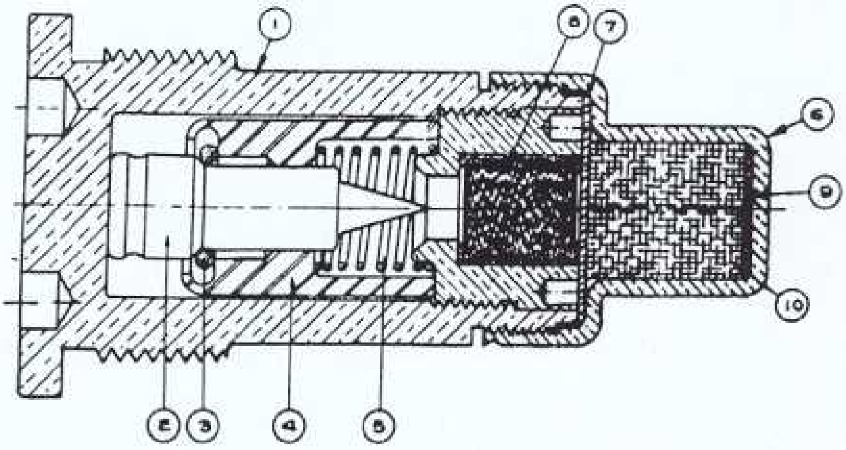



FIGURE 1. - Base detonating fuze, M38.

1 - BODY
2 - FIRING PIN
3 - RESISTANCE RING
4 - PLUNGER
5 - SPRING
6 - CLOSING CAP
7 - DISC
8 - DETONATOR ASSEMBLY
9 - CUSHIONING DISC
10 - BOOSTER PELLET

8. Base detonating fuze, M38A1. - a. General. This fuze is a modification of the base detonating fuze, M38. The detonator of the M38A1 contains a priming composition and lead azide, as compared with mercury fulminate used in the M38. A mechanical means of holding the detonator cup in the detonator plug is also a feature of the M38A1.

b. Function. The function of this fuze is exactly the same as explained for the M38 in paragraph 7a.

9. Fuze, base detonating, M58. - a. General. This fuze is a modification of the base detonating fuze, M38A1. Prior to standardization, it was known as fuze, base detonating, M38A1E2. The internal mechanism is identical to the M38A1, therefore, its operation is the same. The difference in these fuzes, M38A1 and M58 is in the diameter of the fuze body. The explosive cavity of the M63 H.E. shell, in which the M58 fuze 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 M38A1.

b. Functions. This fuze functions the same as the M38 fuze explained in paragraph 7a.

10. Base detonating fuze, Mk. V. - a. General. This fuze is used in high-explosive shell, where non-delay action is desired. This is a boresafe fuze, and loaded projectiles will be issued with the fuze assembled in place. Figure 2 shows this fuze and gives the names of the principal parts. Two types of these fuzes are in service, the medium

and major caliber types, the only difference being in the size of the head. For 14-inch high explosive shell the medium caliber type is used. Some armor-piercing projectiles may have major caliber base detonating fuzes, Mk. V temporarily assigned to them.

b. Function. (1) Action upon firing (Fig. 2). When the projectile is fired, no action takes place in the fuze while the projectile is in the gun. After the projectile has left the muzzle of the gun the percussion plunger (1) is armed by centrifugal force, in that the firing pin (2) is thus unlocked and revolved to the armed position.

(2) Action at target. On impact the percussion plunger is driven forward, overcoming the resistance of the restraining spring (3). The firing pin (2) strikes and explodes the percussion primer (4), which causes explosion of the detonator (5) consisting of about 12 grains of fulminate composition. This in turn detonates the booster charge (6), consisting of approximately 116 grains of TNT and tetryl. This in turn detonates the explosive charge in the projectile.

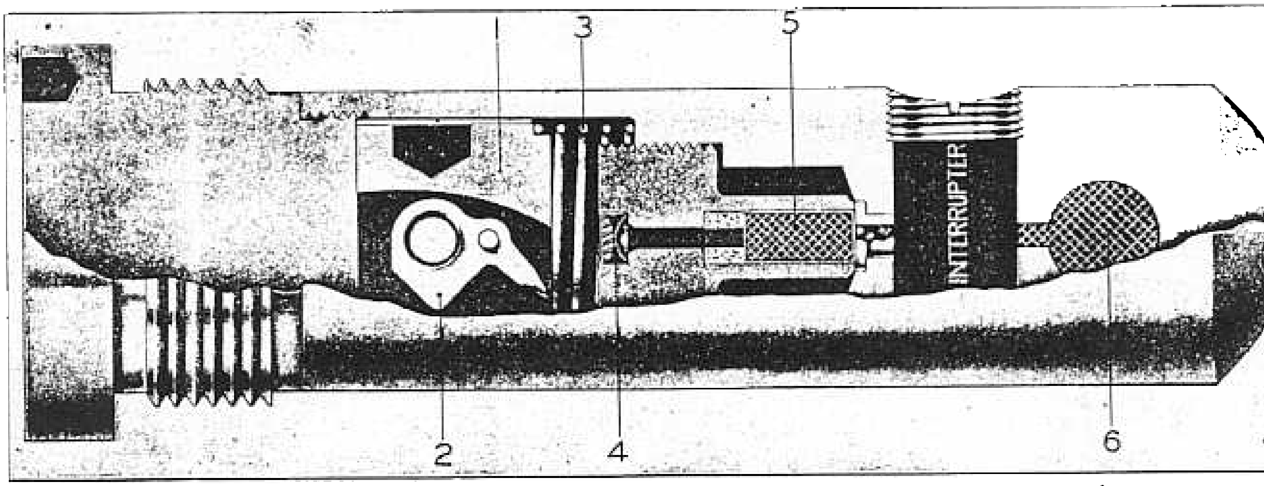



FIGURE 2. - Base detonating fuze, Mk. V (medium caliber).

1. Percussion plunger.
2. Firing pin.
3. Restraining spring.
4. Percussion primer.
5. Detonator.
6. Booster charge.

(3) Safety. The boresafe device consists of an "interrupter", which prevents any action of the primer (4) or detonator (5) from being transmitted to the booster charge (6) until the projectile has left the muzzle of the gun. The percussion plunger (1) arms at about 2,000 revolutions per minute. This fuze weighs approximately 3.27 pounds.

c. Marking. The exterior of this fuze is painted with black acid proof paint to prevent corrosion of the steel parts of the fuze and to prevent chemical action between the steel of the fuze and the explosive charge in the projectile. The head is stamped for iden-

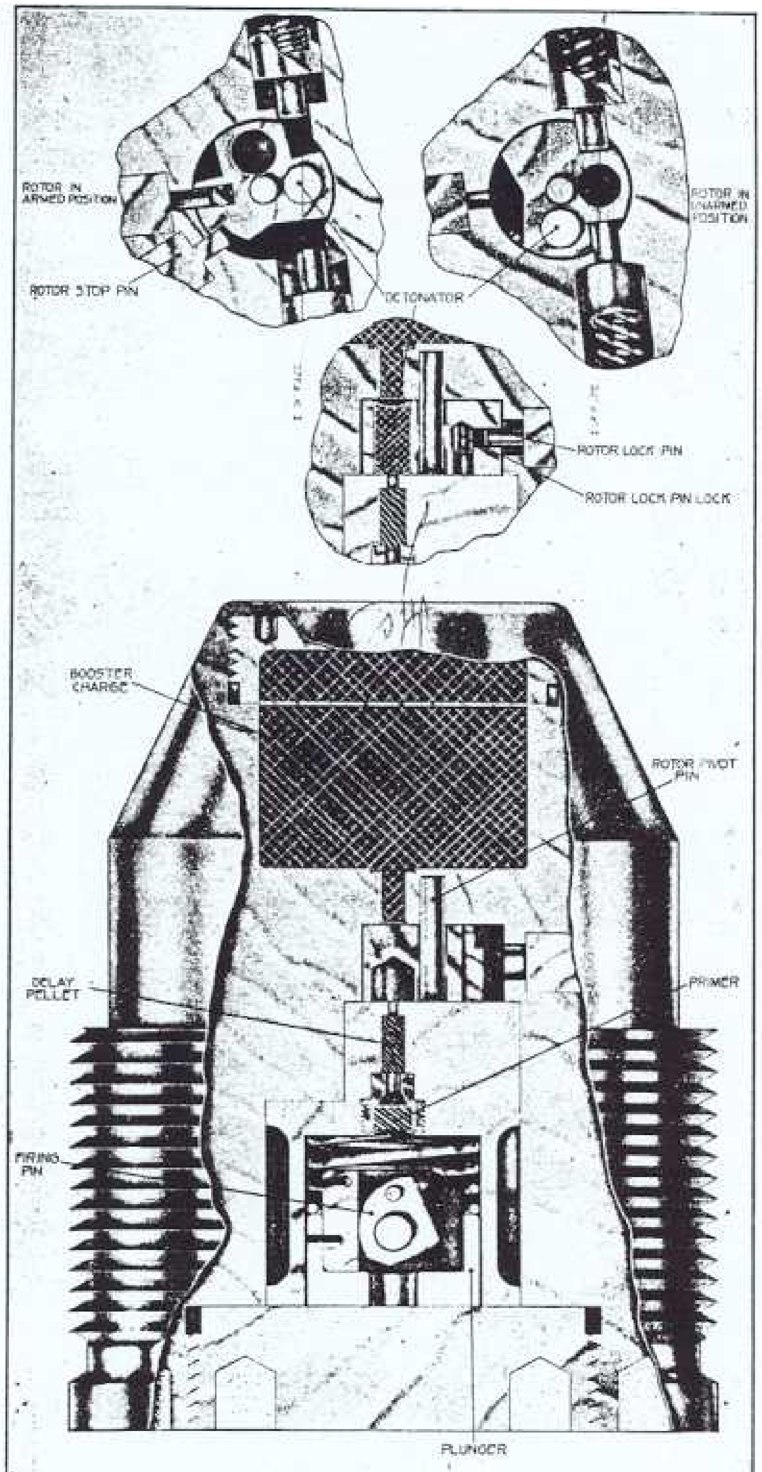



FIGURE 3. - Base detonating fuze, Mk. X.

tification as follows:

(1) BASE DETONATING FUZE.

(2) MARK V.

(3) NONDELAY.

(4) G for gun, H for howitzer, or M for mortar.

(5) MEDIUM for fuzes with small heads or MAJOR for fuzes with large heads.

(6) SEMPLE TYPE.

(7) The name of the manufacturer, lot number, and date of manufacture.

11. Base detonating fuze, Mk. X. - a. General. This is the standard fuze for armor-piercing projectiles, weight approximately 8 pounds, and will replace the major caliber base detonating fuzes, M1906, or Mk. V, now assigned to armor-piercing projectiles, pending receipt of this fuze. This is a boresafe fuze and future issues of loaded armor-piercing projectiles will have the fuze assembled in place. See figure 3.

b. Function. (1) Action upon firing (Fig. 3). When the projectile is fired, no action takes place in the fuze while the projectile is in the gun. After the projectile has left the muzzle of the gun, the fuze is armed through the action of centrifugal force. The firing pin in the plunger is normally held in the unarmed position by two pins and springs, which, under the action of centrifugal force, move outward, away from the axis of the fuze and unlock the firing pin, which, also due to centrifugal force, rotates to the armed position. The rotor, containing the detonator, is also held in the unarmed or safe position by two pins and springs, which release the rotor, due to centrifugal force, in a manner similar to the way the plunger is armed. Centrifugal force also rotates the rotor into the armed position. In the armed position of the rotor the rotor lock pin aligns with a hole provided in the fuze body and, due to centrifugal force, moves partly into this hole, thus locking the rotor in the armed position. The rotor lock pin lock is provided as an additional lock and moves into its position either due to air retardation or "creep" in the projectile or else on impact.

(2) Action at target. On impact the plunger overcomes the resistance of the restraining spring and the firing pin is driven into the primer, thus exploding it. This ignites the delay pellet, which burns a predetermined time and then explodes the detonator containing approximately 9 grains of fulminate of mercury, which detonates the booster charge, consisting of about 470 grains of tetryl, and in turn the explosive charge in the projectile

(3) Safety. The boresafe feature in this fuze is contained in the rotor, which carries the detonator out of alignment with

the delay pellet and booster until the projectile has left the muzzle of the gun, thereby preventing action of the booster and projectile charge due to premature action of the primer or detonator. The plunger and rotor of this fuze arm at 1,300 revolutions per minute, thus making the fuze suitable for use in gun, howitzer, or mortar projectiles.

c. Marking. The steel parts of this fuze are zinc plated as a rust preventive. That part of the fuze which may come in contact with the explosive charge of the projectile is painted with black acid proof paint to prevent chemical action between the metal of the fuze and the explosive in the projectile. The base of the fuze body is stamped for identification as follows:

1 BASE DETONATING FUZE, MK. X (name and mark number of fuze).

(2) Initials or symbol of manufacturer of the metal parts.

(3) Amount of delay (in seconds).

(4) Lot number of loaded fuze.

(5) Initials or symbol of loading plant.

(6) Month and year of loading.

d. Packing. These fuzes are normally shipped assembled in the loaded projectiles. When shipments of these fuzes are made to replace obsolete types of fuzes, they may be shipped in individual, hermetically sealed, metal or fiber containers, packed 20 to a wooden packing box.

12. Point detonating fuze, M56 (Fig. 4). - a. General. This fuze is a superquick point detonating fuze, designed for use on the high explosive shell, M54, for 37-mm. guns. This fuze is commonly referred to as "supersensitive", since it will detonate on impact against a double thickness of airplane fabric. This fuze differs from other point detonating fuzes in that it does not make use of a separate booster. The booster is made a part of the fuze, the booster explosive being contained in the lower body. Another feature of this fuze is the continuous train of explosive material from the primer to the booster, known as the lead.

b. Safety features. The firing pin is held away from the upper detonator by the shoulder of the firing pin resting in grooves cut in the two half blocks, which are held together by a flat spring wound around them. The slider, or interrupter, is held in the unarmed position by means of a resistance spring and the force of linear acceleration as it passes through the bore of the gun.

c. Function. (1) Action upon firing. Upon firing, all of the safety features remain in the unarmed position, due to linear acceleration, until after the projectile leaves the muzzle of the weapon. Upon leaving the muzzle of the gun, centrifugal force separates the two half blocks. This separation of the two half blocks forces the firing pin forward, due to the angle cut in the inner edge of the groove in the top of these blocks. The shoulder of the firing pin then moves back between the half blocks, causing the point of the firing pin to come in direct contact with the upper detonator assembly, which is the armed position. Centrifugal force also lines up the slider charge with the explosive train by compressing the coil spring.

(2) Action at target. Upon impact the nose of the head assembly is crushed, driving the point of the firing pin into the priming composition of the upper detonator assembly, functioning the upper detonator assembly and in turn the intermediate detonating charge, lead charge, slider charge, booster lead charge, and booster charge.

13. Point detonating fuze, M46 (Fig. 5). - a. General. The point-detonating fuze, M46 (PDF M46), is an instantaneous fuze manufactured by modifying the Mark III fuze, (World War type). Originally designed to overcome the disadvantages of the Mark III when used with 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.

b. Description. The conversion from Mark III to M46 consists of cutting off the forward end of the Mark 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 percussion 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, shaped like a largeheaded 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. A washer holds the firing pin in place, and a thin foil 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.

c. Safety features. The safety features of this fuze are:

(1) The centrifugal interrupter.

(2) The strength of the firing-pin support (cup), which is designed to resist the shock of discharge and the bumps and jars of handling and transport.

d. Action. 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 that, during flight, the interrupter is acted upon by centrifugal force as linear acceleration ceases and is thrown outward against the resistance of its spring, thus clearing the central 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. Flame and fragments from the resulting explosion pass down the central channel to the lower detonator, which in

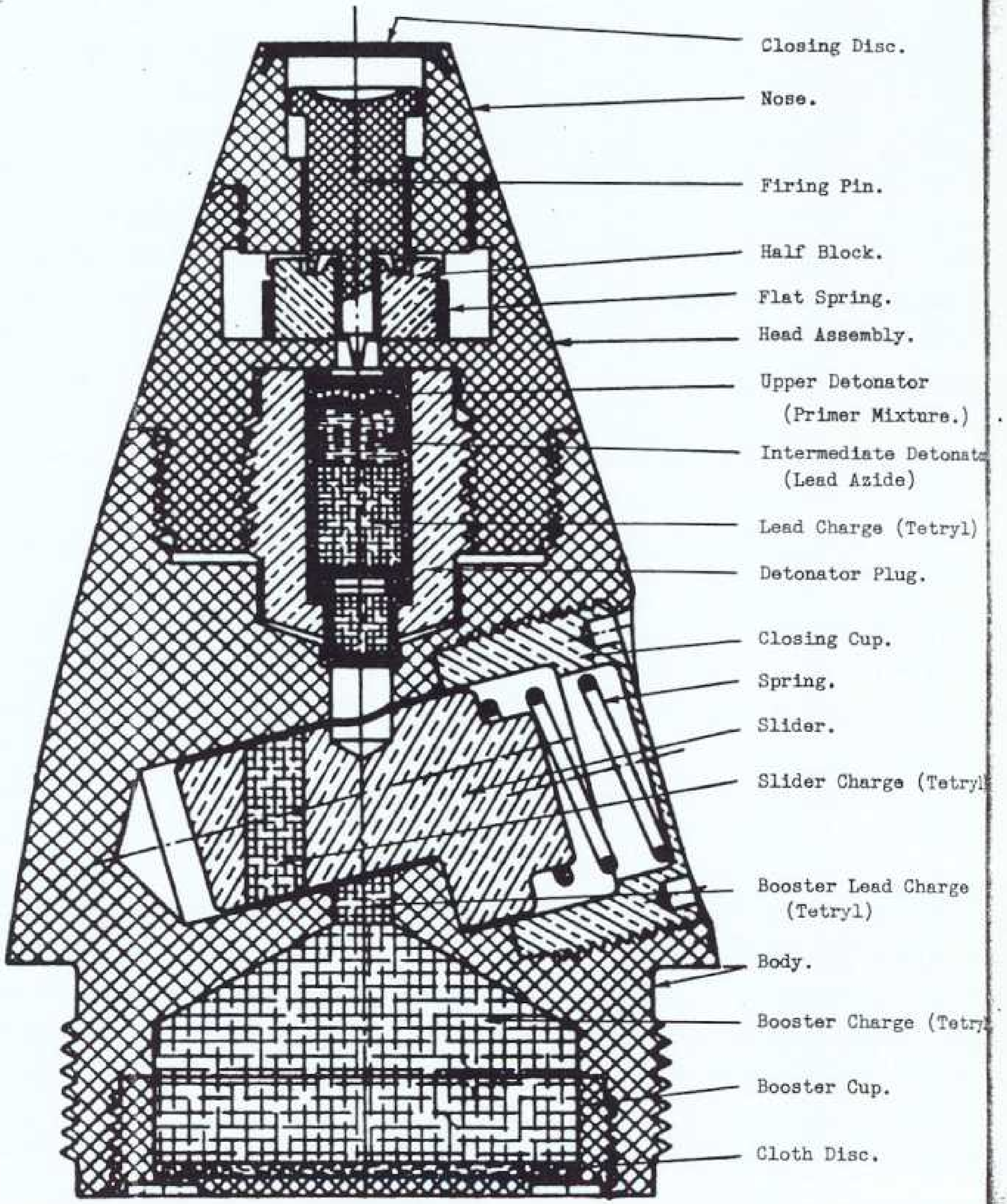
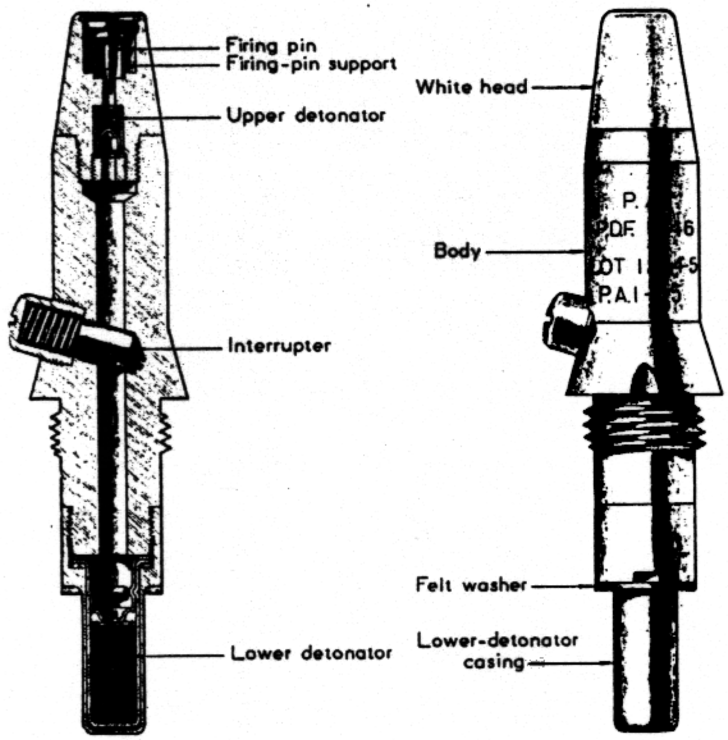
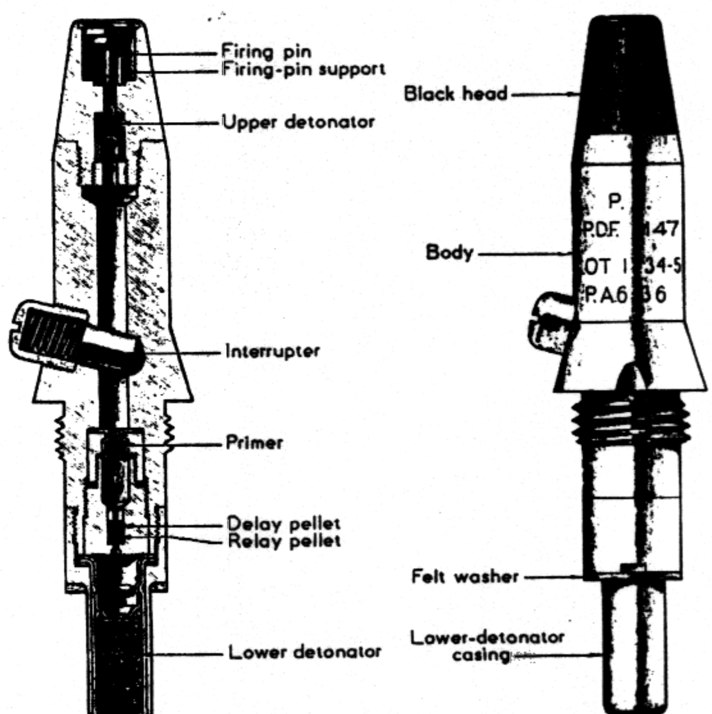



FIGURE 4. - Point-detonating fuze, M56.




Point-detonating fuze, M46 (instantaneous).




Point-detonating fuze, M47 (delay, .05-sec.).

FIGURE 5.

turn explodes 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.

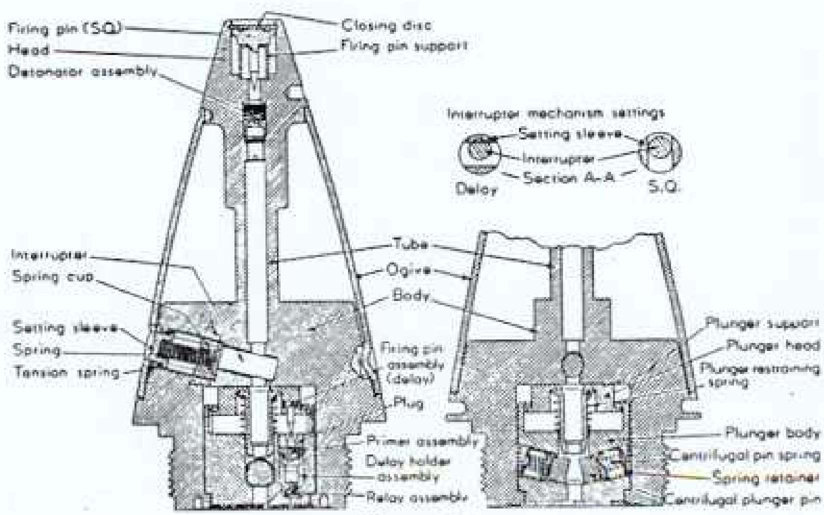
14. Point detonating fuze, M47 (Fig. 5). - a. General. The point detonating fuze, M47 (PDF M47), is a .05-second-delay fuze manufactured by modifying the Mark III fuze. This fuze is designed to serve as a companion fuze to the M46, the ballistic characteristics of the two fuzes being similar. (See the preceding paragraph).

b. Description. Externally this fuze is identical with the PDF M46 except for the marking. The stampings in the body of the fuze naturally differ with types and lots. In addition, the head of the M47 fuze is 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.

c. Safety features. The safety features are identical with those of the PDF M46.

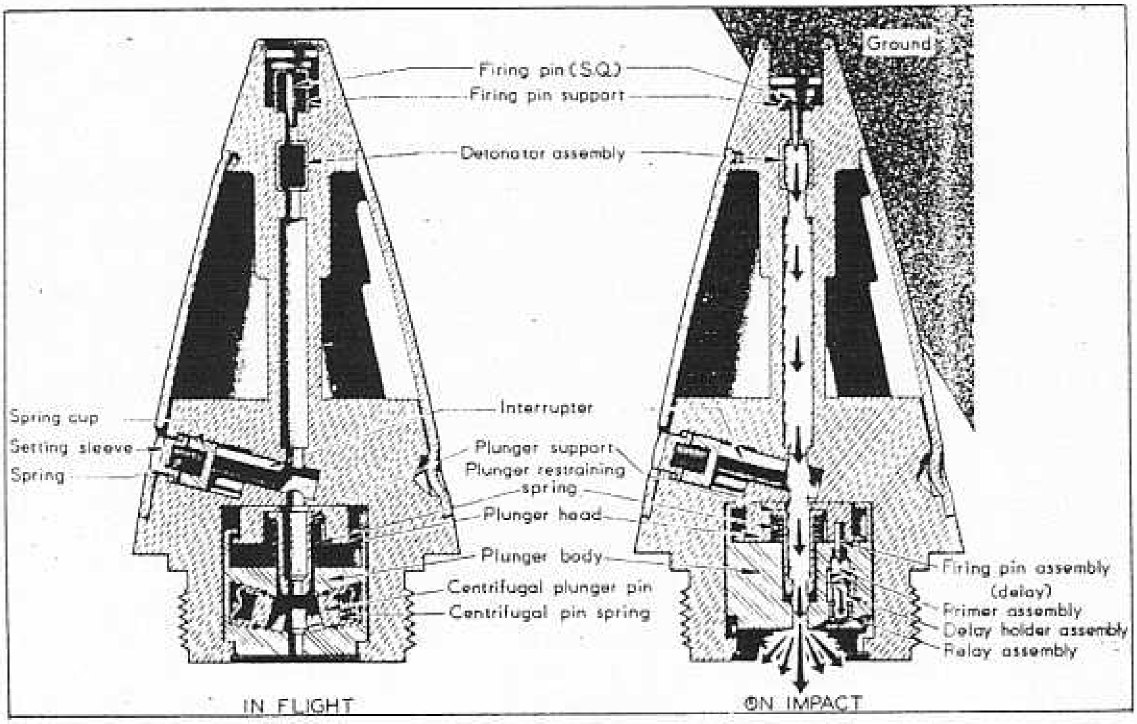
d. Action. During flight the interrupter is actuated. On impact the percussion mechanism in the head operates in the same manner as the M46 fuze. Flame and fragments from the explosion of the upper detonator pass down the central channel and set off the delay primer. The primer in turn sets off a delay pellet, which is constructed to burn for the desired length of time (.05-sec.). The flame of the delay pellet is converted into a detonation by the relay pellet, the flame and fragments of this detonation passing to and setting off the lower detonator.

15. Point detonating fuze, M48 (Fig. 6). - a. General. This is a selective superquick-delay point detonating fuze; that is, it may be set at will to give superquick functioning on impact or to function with .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. Boresafety is obtained in conjunction with the M20 booster.

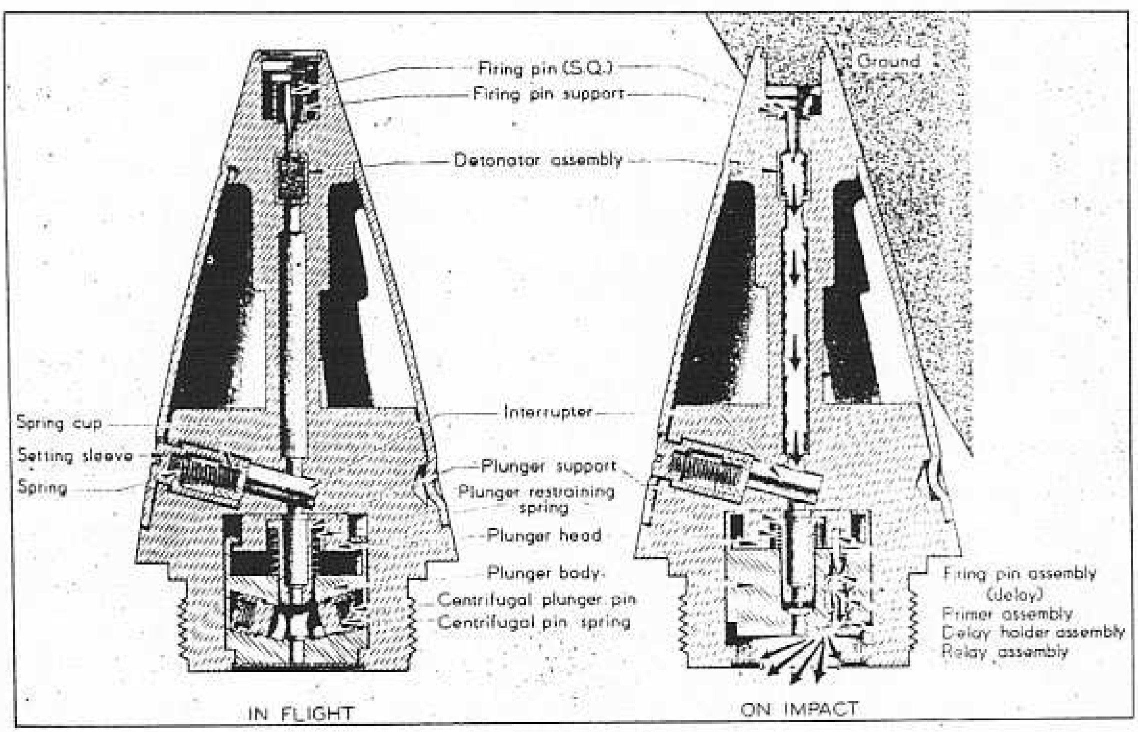



Nomenclature.

FIGURE 6. - Point detonating fuze, M48.




Superquick functioning.




Delay functioning.

FIGURE 7. - Point-detonating fuze, M48.

b. Description. (1) Major parts. The fuze consists of a head which carries the superquick element; a body which carries the delay element, setting device, and threads for 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 aluminum ogive which continues the contour of the projectile ogive; and a delay plunger assembly.

(2) Setting. As issued by the Ordnance Department this fuze is set for superquick action. It is readily set 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 aluminum 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, whereas, with a delay setting the superquick action is stopped at the interrupter. When 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 with 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 interuupter 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 transverse to 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 flight. A tension spring is placed between a shoulder of the setting sleeve and its retainer to prevent a change in the setting during firing or flight.

(3) Superquick element. Three major parts within the head comprise the superquick percussion 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 tin foil closing disc seals the open end of the cavity to exclude foreign matter.

(4) Delay element. The delay element is contained in the rear of the fuze body. A plunger support and plunger restraining spring prevent the plunger body, which carries the delay element, from contacting the plunger head, which carries the delay firing pin, during transportation and firing. Two centrifugal pins and 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. The delay explosive train consists of a primer which is actuated by the delay firing pin, a delay pellet which is adjusted so as to burn for .05-second, and a relay pellet which transforms the combustion of the delay pellet into a detonation.

c. Safety features. (1) Firing-pin support. The firing-pin support is so designed that it will not collapse under the force of setback but will collapse under the force of impact and supports the firing pin at a safe distance from the detonator assembly.

(2) Interrupter. The interrupter, while in the unarmed position closes the passage leading to the booster, preventing superquick action in the event the superquick detonator functions prematurely.

(3) Centrifugal pins and plunger support. 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.

(4) Plunger restraining spring. The plunger restraining spring prevents the delay firing pin from contacting the delay primer as a result of creep force during flight.

d. Superquick action (Fig. 7). 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 setback force resulting from the inclined axis) and the force of the interrupter 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. The explosive charge of this detonator initiates a detonating wave which is free to pass directly through the open flash hole 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.

e. Delay action (Fig. 7). 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 setback, the plunger support contacts the shoulders of the centrifugal pins, thus preventing the plunger head from contacting the plunger body. 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 arms when the projectile emerges about three feet from the muzzle. During flight the plunger head and plunger body are held apart by means of the restraining spring which surrounds the plunger support. On impact or retardation the plunger body is forced by inertia to move forward in the cavity of the fuze body, thus carrying the primer into contact with the delay firing pin and initiating the explosion of the delay assembly.

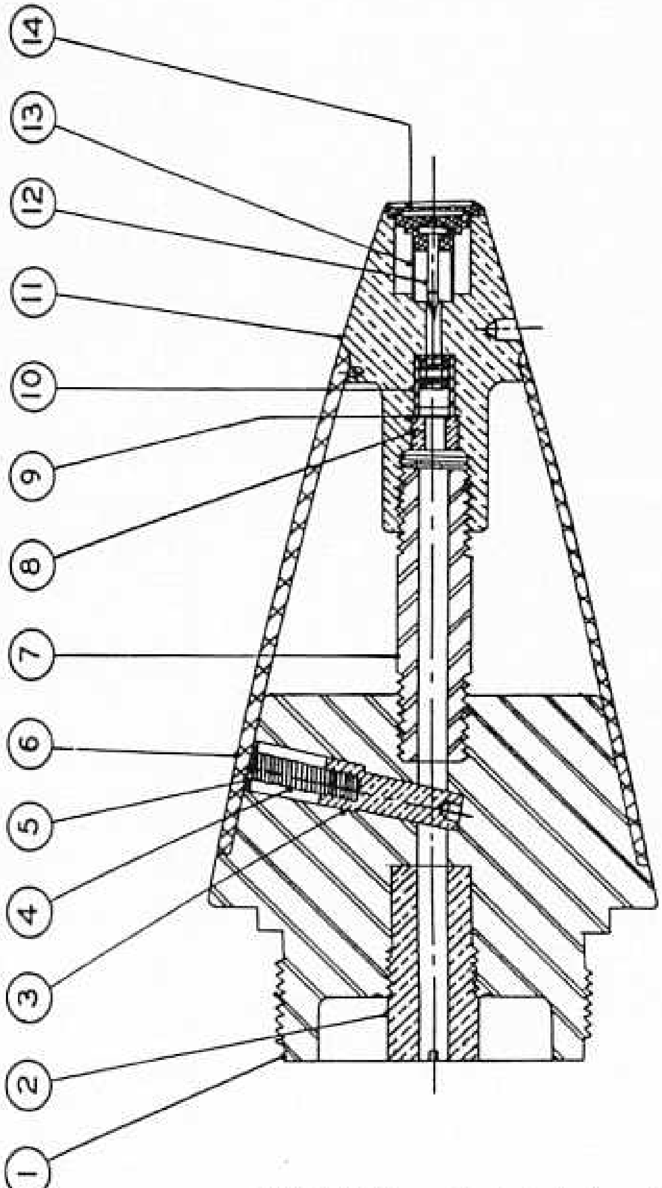
16. Point detonating fuze, M51. - a. General. This fuze is almost identical to the M48, (see par. 14), the difference being in the delay

firing mechanism. The delay plunger assembly of the M48 will not stay in (14) the armed position satisfactorily when fired from weapons which impart low rotational velocity to the projectile. For instance, the M48 will arm and remain armed during flight when fired from the 75-mm. gun due to high rotational velocity imparted to the projectile by the rifling in the bore, whereas, when fired from the 155-mm. howitzer the fuze will not remain armed due to low rotational velocity imparted to the projectile. This resulted in a modification of the M48 to include a mechanical device to hold the delay plunger armed during flight of the projectile when fired from these larger calibered weapons. The fuze so modified was designated M51. An explanation of this mechanical addition follows:

b. Function. The delay element is contained in the rear of the fuze body. A plunger support and plunger restraining spring prevent the plunger body, which carries the delay element, from contacting the plunger head, which carries the delay firing pin, during transportation and firing. Two centrifugal pins and 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. When centrifugal force overcomes linear acceleration the two centrifugal pins, move outward (in exactly the same manner as in the M48) leaving the way clear for the plunger body, that carries the delay element, to move forward on impact and strike the firing pin. In the larger caliber weapons, due to the low rotational velocity, the two centrifugal pins would tend to move back in their original position, leaving the delay plunger unarmed. The addition of a pivoted fork, weighted on one end to actuate on centrifugal force, to lock these centrifugal pins in the armed position, was placed in the M48 type fuze and redesignated M51. This fuze works in conjunction with the M21 (4) booster to obtain boresafety. See the section pertaining to boosters for a detailed description on this booster. (3)

17. Point detonating fuze, M57. - a. General. This fuze is a superquick point detonating fuze, with no delay element, designed primarily for use on chemical shell. This fuze is similar to the M48, (see paragraph 14 of this chapter) except that it contains no delay element or 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 and works in conjunction with the M22 booster.

b. Function (Fig. 8). As linear acceleration ceases, (this is after the round 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. The ex-

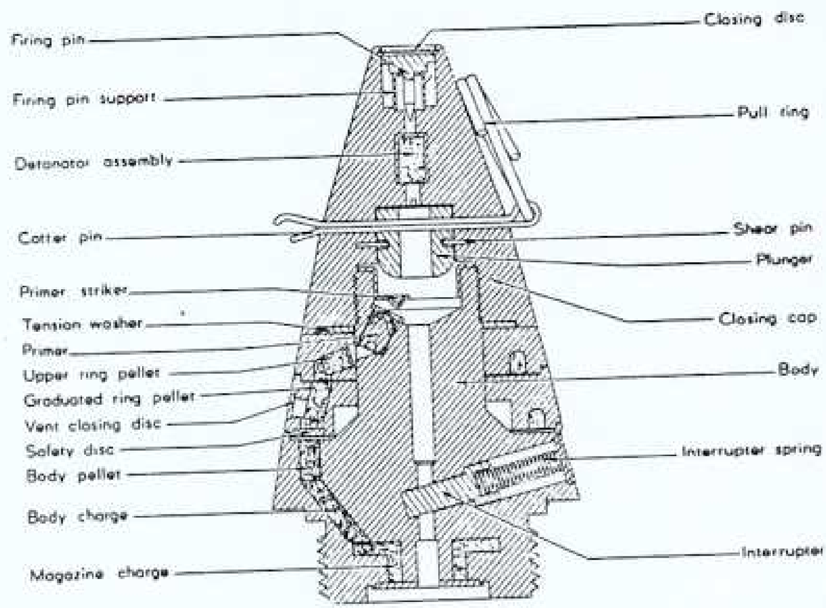



1. Body.
2. Body tube.
3. Interrupter.
4. Spring.
5. Interrupter closing disc.
6. Ogive.
7. Tube.
8. Detonator retainer screw.
9. Retainer washer.
10. Detonator assembly.
11. Head.
12. Firing pin assembly.
13. Firing pin support.
14. Closing disc.

FIGURE 8. - Point detonating fuze M57.

plosive charge of this detonator initiates a detonating wave which is free to pass directly through the open flash hole of the fuze to the booster. For details of this booster see the section pertaining to boosters.

18. Fuze, time and superquick, M54, (Fig. 9). - a. General. This is a combination superquick and 25-second powder-train time 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 M48 point detonating fuze. Boresafety is obtained in conjunction with the M20 booster.




Nomenclature.

FIGURE 9. - Fuze, time and superquick, M54.

b. Description. (1) Major parts. The fuze consists of a closing-cap assembly, which carries the superquick element and a concussion plunger for initiating the burning of the time train, and 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.

(2) Superquick element. The superquick element is identical to that of the point detonating fuze, M48, described in paragaph 14.

(3) Time element. The time element consists of an upper time train ring which is locked to the body of the fuze, a movable graduated time train ring, a pellet and body charge which connects the graduated-ring 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 thin foil disc. The graduated time-train ring is graduated from 0 to 25 seconds, the graduations from 1 to 25 being in divisions of 0.2 seconds. Directly above the primer there is an anvil-shaped striker. A concussion plunger is held in place above the striker by a cotter pin and two shear pins. The cotter pin extends through the plunger and closing-cap assembly and has a pull ring at its loop. The magazine charge is assembled into the base of the body.

c. Safety features. (1) Firing pin support. The firing pin support maintains the firing pin at a safe distance from the detonator. It is identical to that of the point-detonating fuze, M48.

(2) The interrupter. The interrupter, while in the unarmed position, closes the passage leading to the booster, preventing superquick action of the fuze in the event that the superquick detonator functions prematurely.

(3) Cotter pin. The cotter pin supports the plunger during transportation, thereby preventing accidental shearing of the shear pins and firing of the concussion primer. It must be removed prior to firing.

(4) Fuze set at safe. 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 graduated-ring powder train covers the body pellet. Under these conditions one or both time rings can burn completely without igniting the base charge in the fuze.

(5) Vent closing discs. The vent closing discs prevent premature ignition of powder trains by chamber gases. The pressure created by the 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 trains progress. These discs also serve to seal the powder trains against moisture.

(6) Safety disc. The safety disc is located at the ig-

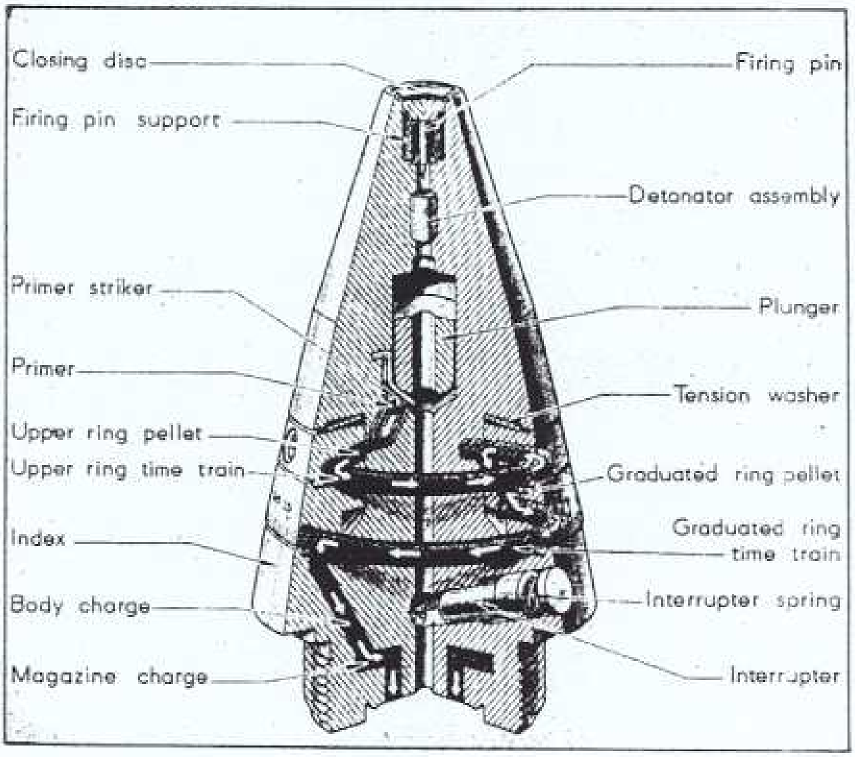
nition end of the graduated-ring time train. When the fuze is set at less than 0.4 seconds, the safety disc covers the body pellet and prevents its ignition by the graduated ring.

d. 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 seconds (for close-in defense) to 25 seconds are obtained by rotating the graduated time-train ring so that the desired reading in seconds or fractions of seconds coincides 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.

e. 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 the time of flight, the fuze will function on impact in exactly the same manner as the point detonating fuze, M57. (See figure 8.)

f. Time action (Figure 10). When the gun is fired, the setback 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, in turn, 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, which is accomplished 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 in turn 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.

19. Fuze, time and superquick, M55. This fuze is identical in every respect to the M54, explained in paragraph 17 and figures 9 & 10. When the M54 fuze is fitted to the M21 booster, for use in the modified Mark series of projectiles for the 155-mm. gun and howitzer and the M-series of projectiles of 155-mm. to 240-mm. inclusive, it is designated M55.




Time functioning.

FIGURE 10. - Fuze, time and superquick, M54.

## SECTION III

## POWDER TRAIN TIME FUZES

20. Fuzes, antiaircraft, 21-second, Mk. III, Mk. IIIA1, and Mk. IIIA2. - a. Description. (1) General. These are commonly known as powder train time fuzes and have been used almost exclusively with antiaircraft ammunition during and since the World War. The metal parts are made of brass and bronze and resemble in outward appearance the 21-second combination fuze, M1907M, used for shrapnel in 75-mm. field guns. They differ from this fuze, however, in that they contain no percussion element and will therefore not function on impact. These fuzes are protected against moisture by a waterproof cover which is removed and thrown away when the fuze is set for time. See figure 11.

(2) Fuze, antiaircraft, 21-second, Mk. III. Figure 11 shows a view of this fuze with the waterproof fuze cover (15) in place and the fuze set for zero time of burning. It also shows a sectional view of the fuze set at zero with the names of its principal parts. The heavy magazine charge (10) of black powder in this fuze (95 grains) pro-

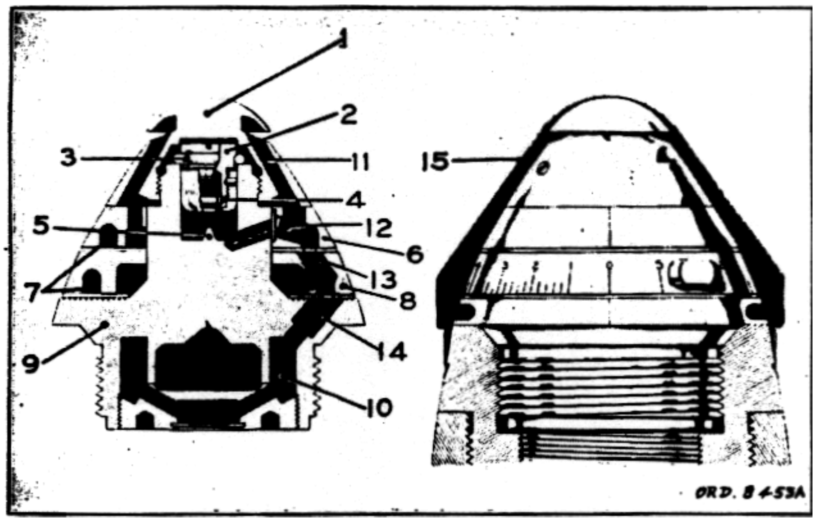



FIGURE 11. - Fuze, antiaircraft, 21-second, Mk. III.

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.

hibits its use in conjunction with the booster, M20. (See (4) below.) It is suitable for use with 3-inch antiaircraft shrapnel. Although it was superseded for manufacture by the fuze, Mk. IIIA1, existing stocks of the Mk. III fuze will be issued until the supply is exhausted. The fuze action is outlined in b. below.

(3) Fuze, antiaircraft, 21-second, Mk. IIIA1. This is a redesign of the antiaircraft fuze, Mk. III. The principal modification consists of strengthening the nose end of the fuze so that accidental striking of the end of the fuze against the breech of the gun will not function the fuze. The fuze, Mk. IIIA1, is similar in all other respects to the Mk. III and superseded the latter for manufacture. The fuze, Mk. IIIA1, is standard for use in all 3-inch antiaircraft shrapnel ammunition.

(4) Fuze, antiaircraft, 21-second, Mk. IIIA2. This is an antiaircraft time fuze, Mk. IIIA1, with the black powder magazine charge reduced in weight from 95 to 15 grains. This weight of charge is sufficient to actuate the Mk. X and the M20 boosters. The Mk. IIIA2 fuze is limited standard for use with all 3-inch antiaircraft high explosive shell.

b. Action. (1) Zero setting. These fuzes can be set and reset for any time from 0 to 21.2 seconds, the maximum setting; each graduation on the lower time train ring representing approximately 1/5 second of burning time. When the setting is at zero, as shown in figure 11, the action is as follows: When the gun is fired, the concussion plunger (2) will slip through the resistance ring (3) due to inertia or setback action in the projectile. The concussion primer (4) which is held in the concussion plunger, is thus fired by striking the firing pin (5). The flame from this primer passes through a hole in the fuze body and ignites the powder pellet (12) which is in the upper time train ring (6). The flame from this pellet (12) is transmitted to the ignition pellet (13) which is located in the lower or graduated time train ring (8). The flame from this pellet (13) ignites the ignition pellet (14) in the fuze body which in turn ignites the magazine charge (10). The flame from the magazine charge detonates the booster detonator in the shell or, in the case of 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 (4) to the magazine charge (10) by means of powder pellets. The powder train rings (7), which are responsible for the time feature, do not enter into this action. Attention is called to the fact that the time fuze when set at zero will cause the projectile to burst within 75 feet of the muzzle of the gun.

(2) <u>Time setting</u>. When a time setting is desired, 15 seconds, for instance, the action is somewhat different. The lower or graduated time train ring (8) 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 (2) is the same, and the flame reaches the powder pellet (12) as previously described. This powder pellet (12) ignites the powder train (7). The powder train (7) is machined 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 (13) in the lower or graduated time train ring (8) has been moved in setting the fuze, and it is necessary that the powder train (7) of the upper time train ring burn until this pellet is reached by the flame. Then with the ignition of the pellet (13), the powder train (7) in the lower or graduated time train will begin to burn. When the flame reaches ignition pellet (14) in the body (9), the action is as previously described for zero setting. The gasses from the burning of the powder train (7) escape to the atmosphere by means of the vents (11) in the closing cap (1).

(3) <u>Safe setting</u>. When the lower or graduated time train ring (8) is set so that the mark "S" is in line with the lines on the body and the upper time train ring, the fuze is said to be "safe". At this setting, the solid metal section of the upper time train ring is completely covering the ignition pellet (13) in the lower or graduated time train ring and the solid metal section of the lower time train ring is completely covering ignition pellet (14) in the fuze body which leads to the magazine charge. Set at safe the upper time train may burn out entirely in case of accidental firing of the concussion primer without the flame being able to reach the lower time train or the maga-

zine charge (10) and therefore the fuze would not function. These fuzes are always set "safe" for issue and if not used after making a setting they should be reset "safe" again before handling.

c. Care. Every precaution should be taken to keep moisture away from these fuzes. They are protected by waterproof covers and the powder trains (7) are covered with waxed paper, but short exposure in damp places will allow moisture to enter. A piece of felt cloth is on the underside of each powder train (7) which prevents the flame of the burning powder from creeping faster than it should. If these pieces of felt become wet, the powder will absorb some of the moisture which will greatly alter the time of burning. The waterproof fuze cover should not be removed before the ammunition is required for firing.

d. Test of condition. (1) Corrosion. Each fuze should be examined for indication of extreme exterior corrosion. If the fuze shows any appreciable stains around the time ring the entire round will be classed as "unserviceable"

(2) Frictional resistance of graduated time train ring. When the round is to be used with weapons equipped with continuous type of fuze setters, the fuze should be tested to determine the torque (twisting effort) necessary to turn the graduated time train. No fuze will be used when the torque required to turn the graduated time train ring is more than 60 inch-pounds.

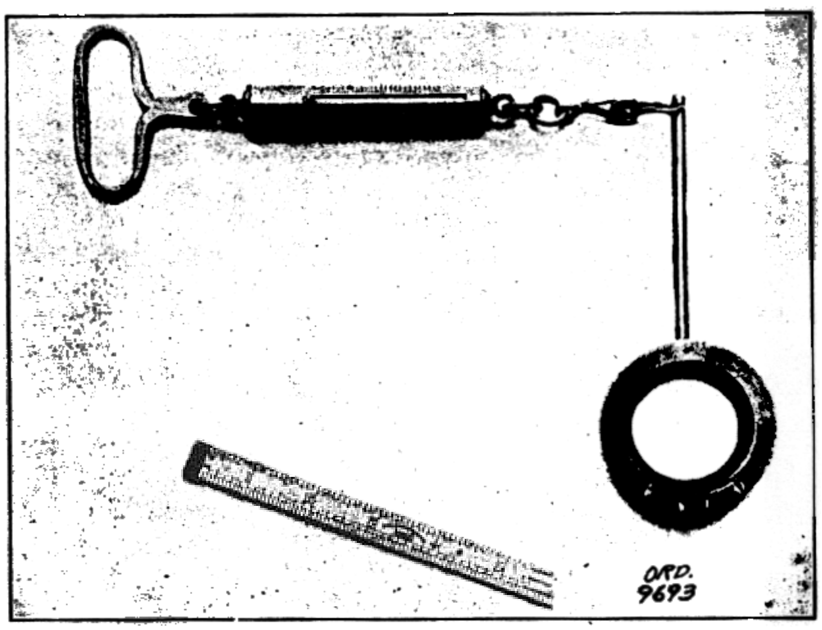



FIGURE 12. - Graduated time-train ring friction tester.

(a) Method of test. Place the ring spanner illustrated in figure 12 over the graduated time train ring so that it engages the rotating lug. Exercise the time train ring several times by hand. Apply pressure to the ring spanner through the spring balance scale and observe the reading on the scale required to move the graduated time train ring. With a stem 5 inches long, from the C/L of the ring spanner, each pound recorded on the scale equals 5 inch-pounds of setting torque. A reading on the scale of 12 pounds will therefore correspond to a setting torque of 60 inch-pounds. After testing, the fuzes should be reset to "S" (safe). This testing ring spanner should be improvised locally and available spring balance scales used. To obtain the desired reading, the scale must be attached to the stem of the spanner exactly 5 inches from the C/L of its ring, and the force of the scale exerted at a right angle to the stem of the spanner.

(3) The rounds to be used in fuze setters other than the continuous type need only be tested to see that the graduated time train rings are not sticking to such extent as to prevent the setting of the fuze.

(4) The sorting of fuzes and the tensioning tests should be done under the supervision of qualified ordnance personnel.

e. Marking. These fuzes may be identified by the following stamping which appears on the bevel edge of the body:

(1) Mark number of fuze (Mk. III, Mk. IIIA1, or Mk. IIIA2).

(2) Fuze lot number.

(3) Initials or symbol of manufacturer.

(4) Month and year of loading.

## SECTION IV

## COMBINATION FUZES

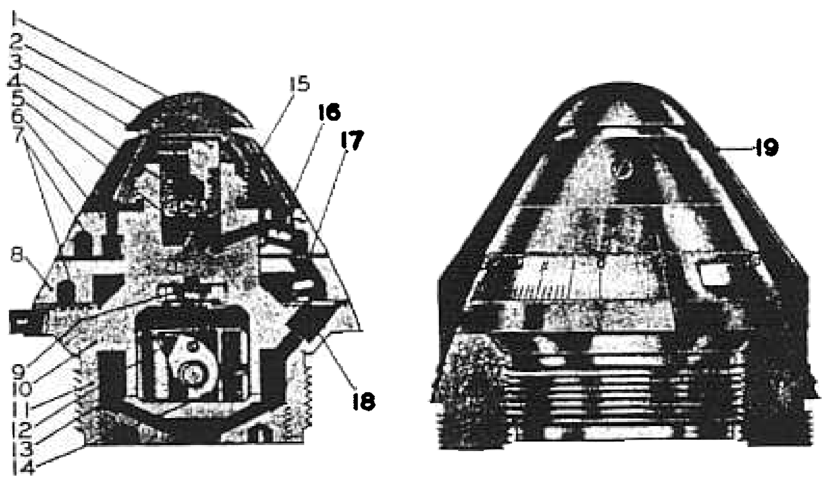
21. 21-second combination fuze, M1907M. - a. General description. (1) The 21-second combination fuze is used with shrapnel. It can be set and reset at any time from 0, for canister effect, to 21.2 seconds--the longest time that the fuze will burn after leaving the muzzle of the gun. It is made of brass and bronze and weighs 1.25 pounds.

(2) The fuze is always assembled to the shrapnel for shipment. It is protected by a waterproof cover which is removed and thrown away when the fuze is set for time of flight.

(3) This fuze does not have a 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" thus being derived from this double action feature. Figure 13 shows a view of the fuze with the waterproof cover (19) in place and the fuze set at safe. It also shows a sectional view of the fuze set at 0 with the names of the principal parts.

b. Canister action. (1) When the setting is at 0 for canister effect, the action is as follows: When the gun is fired, the concussion plunger (2) will slip through the resistance ring (3), due to inertia or the setback action in the projectile. The concussion primer (4), which is held in the concussion plunger, is thus fired by the firing pin (5). The flame from this primer (4) passes through a hole in the body and ignites the powder pellet (16), which is in the upper time-train ring (6). The flame from this pellet (16) is transmitted to the ignition pellet (17), which is located in the lower or graduated time-train ring (8). The flame from this pellet ignites the ignition pellet (18) of the body (11). The magazine charge (13) is exploded and the flame of same passes through the central tube of the shrapnel to the base charge.




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. Percussion primer.
10. Channel.
11. Body.
12. Percussion firing pin.
13. Magazine charge (black powder).
14. Percussion plunger.
15. Vents.
16. Powder pellet.
17. Powder pellet.
18. Powder pellet.
19. Waterproof cover.

FIGURE 13. - Adapter and booster, Mk. III.

(2) In the above action it is readily seen that when the fuze is set at 0, the action is merely a transmission of flame from the concussion primer (4) to the magazine charge (13) by means of powder pellets. The powder train (7), which is responsible for the time feature, does not enter into this action.

c. Time action. When the fuze is set for time, say 15 seconds, the action is somewhat different. The lower or graduated time-train ring (8) is moved 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 (2) is the same, and the flame reaches the powder pellet (16) as previously described. This powder pellet (16) ignites the powder train (7). The powder train (7) is machined in both 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 (17) of the lower or graduated time-train ring (8) has been moved in setting the fuze, and it is necessary that the powder train (7) of the upper time-train ring burn until this pellet is reached by the flame. Then, with the ignition of the pellet (17), the powder train (7) of the lower or graduated time-train ring will begin to burn. When the flame reaches ignition pellet (18) in the body (11) the action is as previously described. The gases from the powder train (7) escape to the atmosphere by means of the vents (15) in the closing cap (1).

d. Percussion action. The combination feature of this fuze is that it will function on impact. In the percussion plunger (14), the percussion firing pin (12) is armed by centrifugal force; that is, the firing pin is unlocked and revolves to the armed position so that on impact it will function the percussion primer (9). The flame from this primer passes through the channel (10) in the body to the magazine charge (13), thus firing the shrapnel.

e. General notes. (1) Every precaution should be taken to keep moisture away from this fuze. The fuze is protected by a waterproof cover and the powder trains (7) are covered with waxed paper, but short exposure in damp places will allow moisture to enter. A piece of felt cloth is on the underside of each powder train (7), which prevents the flame from creeping faster than it should. If these pieces of felt cloth get wet, the powder will absorb some of the moisture, which will greatly alter the time of burning.

(2) When the lower or graduated time-train ring (8) is set so that the mark "S" is in line with the marks on the body and the upper time-train ring, it is said to be "safe". At this setting, the solid metal section of the upper time-train ring is completely covering the ignition pellet (17) in the lower or graduated time-train ring and the solid metal section of the lower or graduated time-train ring is completely covering ignition pellet (18) in the body which connects with the magazine charge (13). It would be possible for both powder trains (7) to burn completely, but no flame would reach the ignition pellet (18) and, therefore, the shrapnel would not explode, except by percussion action. When firing shrapnel for percussion action, the fuze should be set at "S". These fuzes are always issued set "safe" and if not used after making a setting, they should be reset to "safe" again, before handling.

f. Marking. This type of fuze may be identified by the following stamping which appears on the bevel edge of the body:

1907M (model or mark number of fuze).

(2) Lot number.

(3) Initials or symbol of manufacturer.

Month and year of loading.

Practically this same stamping also appears on the waterproof cover.

22. 45-second combination fuze, M1907M. - a. General description. (1) The 45-second combination fuze is used with shrapnel. It can be set and reset at any time from 0, for canister effect, to 45.2 seconds--the longest time that the fuze will burn after firing. It is made of brass and bronze and weighs 2 pounds.

(2) Shrapnel may be found with this fuze assembled for shipment. It is protected from moisture by a waterproof cover which is removed and thrown away when the fuze is set for time of flight. Before setting the fuze, it is necessary to remove the safety wire at the top of the fuze. This safety wire is incorporated for safety in transportation, due to the low arming resistance of the concussion plunger.

(3) This fuze does not have a 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" thus being derived from this double action feature. Figure 14 shows a view of the fuze with the waterproof cover (19) in place and the fuze set at safe. It also shows a sectional view of the fuze set at 0, with the names of the principal parts.

b. Canister action. (1) When the setting is at 0 for canister effect, the action is as follows:

When the weapon is fired, the concussion plunger (2) will slip through the resistance ring (3), due to inertia or the setback action in the projectile. The concussion primer (4), which is held in the concussion plunger, is thus exploded by the firing pin (5). The flame from this primer (4) passes through a hole in the body and ignites the powder pellet (16), which is in the upper time train ring (6). The flame from this pellet (16) is transmitted to the ignition pellet (17), which is located in the lower or graduated time train ring (8). The flame from this pellet ignites the ignition pellet (18) of the body (11). The magazine charge (13) is exploded and the flame of same passes through the central tube of the shrapnel to the base charge.

(2) In the above action, it is readily seen that when the fuze is set at 0, the action is merely a transmission of flame from the concussion primer (4) to the magazine charge (13) by means of powder pellets. The powder train (7), which is responsible for the time feature, does not enter into this action.

c. Caution. Care should be taken in firing shrapnel with the fuze set at 0, when using zone 1 propelling charge, since the forward

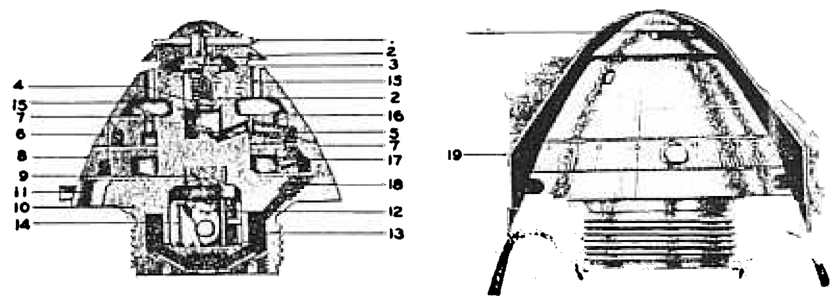



FIGURE 14. - 45-second combination fuze, M1907M.

1. Safety wire.
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. Percussion primer.
10. Channel.
11. Body.
12. Percussion firing pin.
13. Magazine charge (black powder).
14. Percussion plunger.
15. Vents.
16. Powder pellet.
17. Powder pellet.
18. Powder pellet.
19. Waterproof cover.

velocity of the shrapnel is not much greater than the rearward velocity of the shrapnel case when the shrapnel explodes and the shrapnel case may be thrown back close to the battery.

d. Time action. When the fuze is set for time, 15 seconds for instance, the action is somewhat different. The lower or graduated time train ring (8) is moved 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 (2) is the same, and the flame reaches the powder pellet (16), as previously described. This powder pellet (16) ignites the powder train (7). The powder train (7) is machined in both 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 (17) of the lower time train ring (8) has been moved in setting the fuze, and it is necessary that the powder train (7) of the upper time train ring, burn until this pellet is reached by the flame. Then, with the ignition of the pellet (17), the powder train (7) of the lower or graduated time train ring will begin to burn. When the flame reaches ignition pellet (18) in the body (11), the action is as previously described. The gases from the powder train (7) escape to the atmosphere by means of the vents (15).

e. Percussion action. The combination feature of this fuze is that it will function on impact. In the percussion plunger (14), the percussion firing pin (12) is armed by centrifugal force; that is, the firing pin is unlocked and revolves to the armed position, so that on impact it will function the percussion primer (9). The flame from this primer passes through the channel (10) in the body to the magazine charge (13), thus firing the shrapnel.

f. General notes. (1) Every precaution should be taken to keep moisture away from this fuze. The fuze is protected by a waterproof cover and the powder trains (7) are covered with waxed paper, but short exposure in damp places will allow moisture to enter. A piece of felt cloth is on the underside of each powder train (7), which prevents the flame from creeping faster than it should. If these pieces of felt cloth get wet, the powder will absorb some of the moisture, which will greatly alter the time of burning.

(2) When the lower or graduated time train ring (8) is set so that the mark "S" is in line with the marks on the body and the upper time train ring, it is said to be "safe". At this setting the solid metal section of the upper time train ring is completely covering the ignition pellet (17) in the lower or graduated time train ring and the solid metal section of the lower or graduated time train ring is completely covering ignition pellet (18) in the body which connects with the magazine charge (13). It would be possible for both powder trains (7) to burn completely, but no flame could reach the ignition pellet (18) and therefore the shrapnel would not explode, except by percussion action. When firing shrapnel for percussion action, the fuze should be set at "S". These fuzes are always issued set "safe", and if not used after making a setting they should be reset to "safe" again and the safety wire replaced before handling.

g. Marking. This type of fuze may be identified by the following stamping which appears on the bevel edge of the body:

1907M (model, or mark number of fuze).

Lot number.

Initials or symbol of manufacturer.

Month and year of loading.

(5) Some fuzes are also stamped with the drawing and revision numbers.

Practically this same stamping also appears on the waterproof cover.

## SECTION V

## MECHANICAL TIME FUZES

23. Mechanical time fuze, M43 (Figure 15). - a. 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", 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 the 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 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 atmospheric conditions, due to firing at various gun elevations.

(3) Ability to withstand long time storage without deterioration or loss in accuracy.

(4) Possible production advantage in that it can be manufactured by facilities not experienced in fuze work. Also, the procurement of materials does not present difficulty, such as that of fuze powder for the powder type of fuze.

b. Construction. The general construction of the fuze is shown on Figure 15. The shape of the fuze is designed for good ballistics, the contour being the same as that of other point fuzes of the latest types. The base is marked in 1/5 second graduations and may be adjusted from 1/5 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.

c. 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 of the 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 is created due to the rotation of the projectile in flight.

d. Timing (Fig. 16). The timing of the fuze is regulated by the angular distance through which the slot 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 the fuze is accomplished by turning the brass lower cap (1) with respect to the base. 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 setting the fuze, the timing disc rotates with the lower cap by means of the setting pin (2). However, the main driving pinion (5), 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 driving pinion to rotate the timing disc after it has been released from the setting pin (2).

e. Function. When fired, the acceleration force or set-back developed in the bore of the gun causes the hammers (3) on the cantilever spring to strike the protruding lug (4) on the timing disc, flattening it and releasing it from the setting pin (2). 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 set-back pin moving rearward. The firing arm is then free to rotate when the slot in the timing disc comes opposite the finger on the firing arm, thus releasing the firing pin safety plate and allowing the firing pin (7) to strike the primer (8) under the action of the spring (6). The firing arm and firing pin safety plate are both actuated by centrifugal force. Centrifugal force created by the rotation of the projectile in flight causes the safety lock to rotate and release the escapement. This safety lock is held in the locked position by a relatively soft flat spring. The movement is then free to run. The weighted gear segments in mesh with the main driving pinion (5) then drive the movement. The main driving pinion is connected by a train of gears to the escapement which governs its rate of rotation and thus the rate of rotation of the timing disc. When the slot in the timing disc reaches the finger of the firing arm, the fuze functions as explained previously. The magazine charge of the fuze consists of black powder (9) contained in a silk bag. The explosion of this black powder charge functions the M20 booster.

f. Additional data. Just prior to adopting the M43A1 fuze, (see next paragraph), some of the M43 fuzes were assembled with a spiral retaining wire fitted around the nose of the fuze. One end of the wire was inserted into the lower cap and into the setback pellet. This wire must be removed before inserting the round in the fuze setter.

24. Fuze, mechanical time, M43A1. This fuze is identical, in principal, with the M43. The "A1" designation was the result of minor modifications. A copper retaining ring was added to protect the timing disc, figure 16, against bulging or bending. The outside appearance remained the same at this time. Later, without changing the fuze number, the groove just above the lower cap, (1), figure 15, was eliminated, making the surface of the fuze smooth.

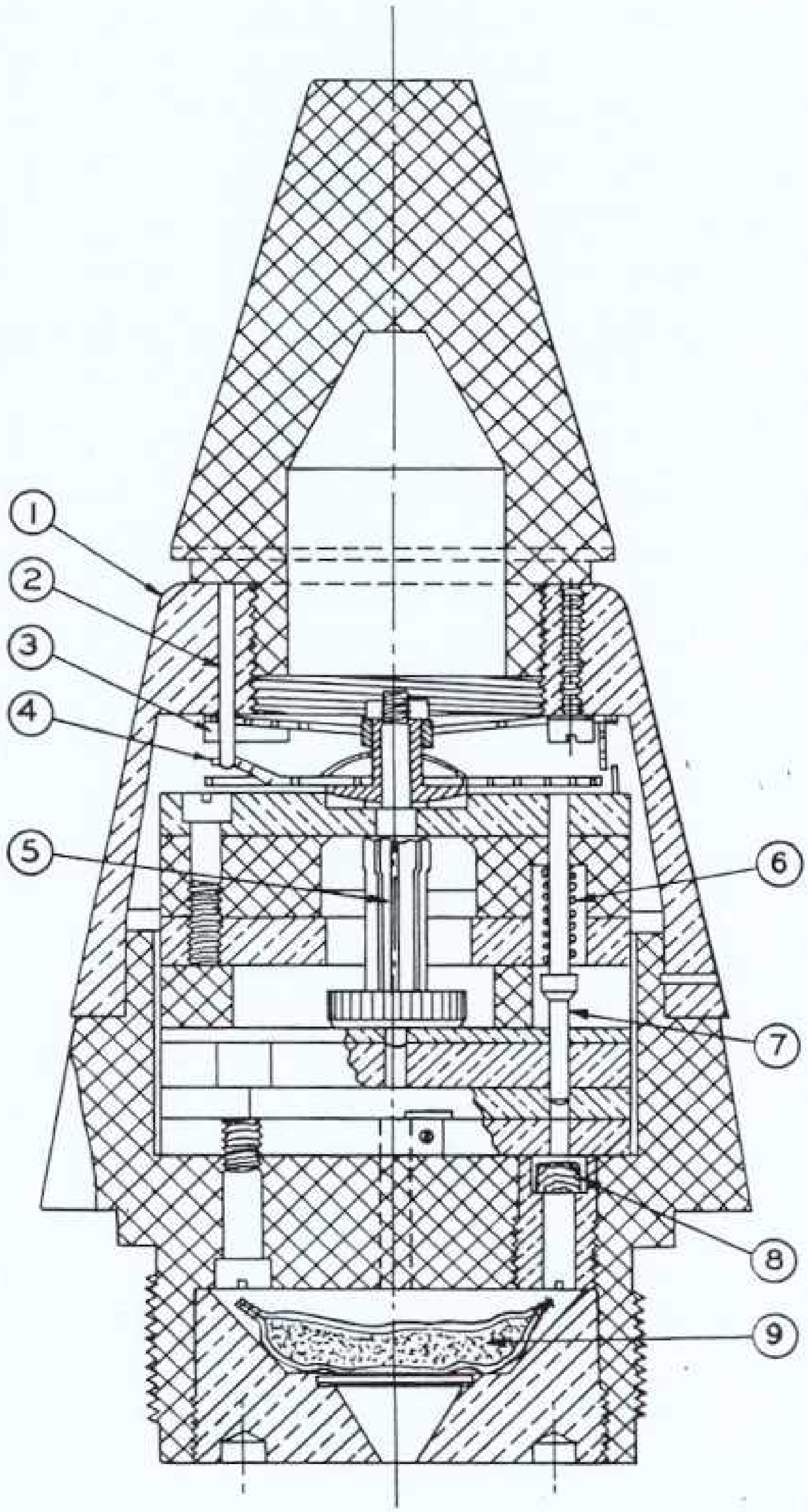



FIGURE 15. - Mechanical time fuze, M43.

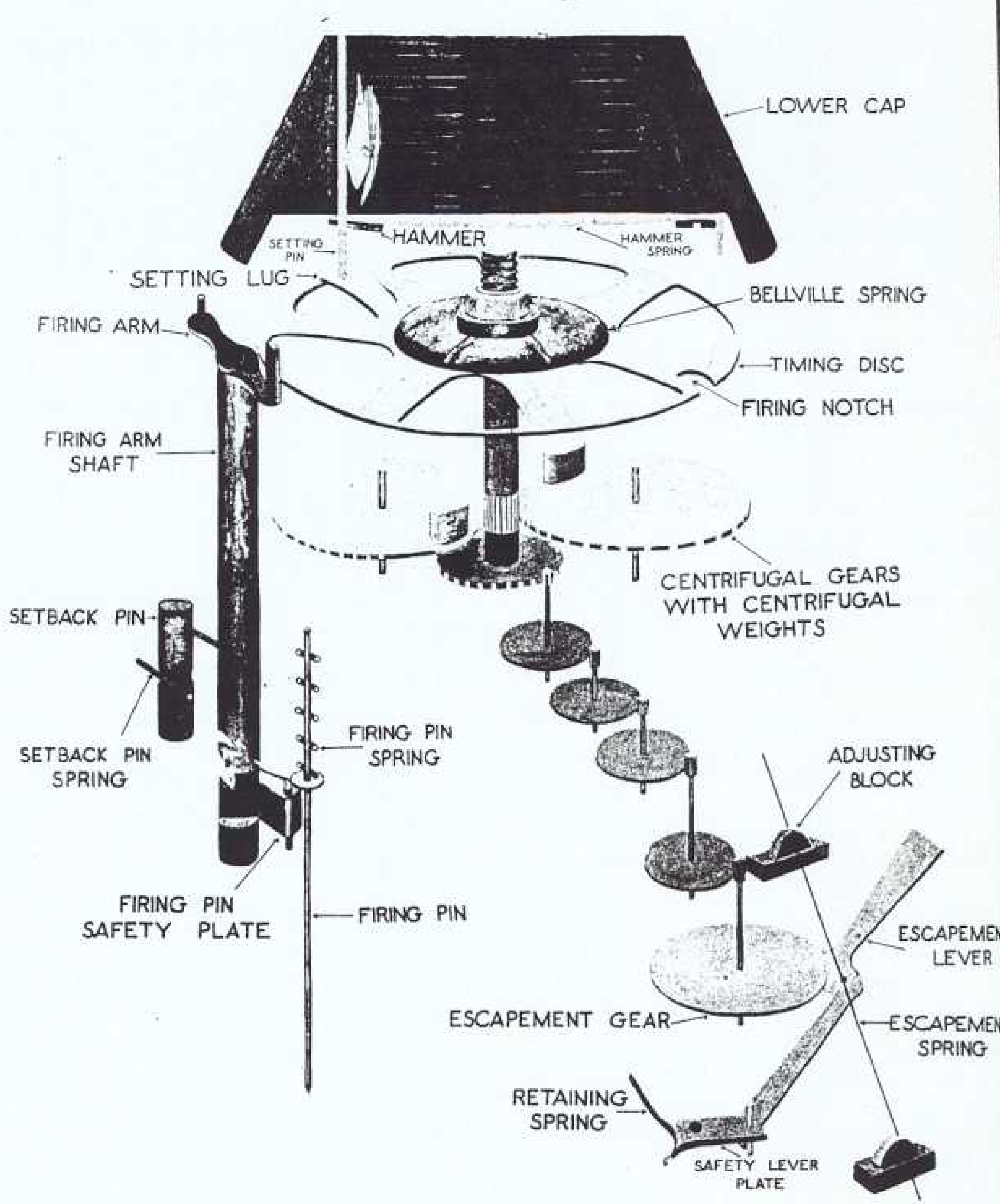



FIGURE 16. - Junghans-type, weight-driven fuze.

25. <u>Fuze, mechanical time, M2</u>. - <u>a</u>. <u>Description</u>. The action and design of this fuze are very similar to the mechanical time fuze, M43, described in the preceeding paragraph. The principal difference in these fuzes is that the fuze, M2, has a booster assembled to the lower portion of the fuze body. It also has a larger thread size than the fuze, M43, and is assembled to the 105-mm. shell, M38, without the use of an adapter. A set screw extends through the shell wall engaging the threaded portion of the fuze body, locking it in place. The booster of this fuze contains a bore-safe feature similar to the booster, M20, previously described. The fuze body is graduated for a time setting of from 1 to 30 seconds with 1/5-second subgraduation. A register line is scribed on the surface of the lower cap near one of the fuze setter slots. This line is set at the 15-second graduation during shipment and storage. For a time setting of more or less than 15 seconds the lower cap is turned in a clockwise direction as viewed from above.

<u>b</u>. <u>Use</u>. The mechanical time fuze, M2, has been superseded by the mechanical time fuze, M43, and the booster, M20. The mechanical time fuze, M2 will be used with the 105-mm. Antiarcraft shell, M38, until the supply is exhausted.

ESCAPEMENT LEVER

ESCAPEMENT SPRING

CHAPTER IV

ADAPTERS AND BOOSTERS



SECTION I

GENERAL

1. In general, an adapter is a bushing that fits into the nose of the shell and into which a fuze may be inserted. In general, a booster is a casing containing a charge of high explosive, which serves to boost the energy liberated by the fuze so as to insure detonation of the bursting charge in the shell. These assembled components are known as the adapter and booster.

SECTION II

ADAPTER & BOOSTER FOR HIGH EXPLOSIVE SHELL

2. General. In this assembly the booster casing extends well into the loaded shell. The detonation of the fuze is transmitted to the explosive charge in the booster. The booster, in turn, detonates the explosive charge of the shell. A booster contains a comparatively small amount of explosive (usually tetryl), which explodes with a high order of detonation. These types of adapters and boosters are all assembled into the shell for shipment. In the case of the new style 75-mm., shells for the gun, howitzer, pack howitzer and the 105-mm. howitzer which are the smaller sizes, the booster has the fuze assembled to it in the shell. In the larger sizes, whether new style or renovated old style shells, there is in place of the fuze a suitable plug to keep out all dirt and water. In the larger sizes of shell this plug has a ring and is used as a lifting plug in transportation. The nose plug also serves to reduce the possibilities of detonation when, in case of accident, other shells are detonating in the vicinity.

3. Types. - a. Adapter and booster, Mk. II-A. The adapter and booster, Mk. II-A, is used in the following high explosive shell:

(1) Shell, H.E., Mk. II, for 6" guns.

(2) Shell, H.E., Mk. I, for 8" guns.

(3) Shell, H.E., for 8" howitzers.

(4) Shell, H.E., Mk. III, for 240-mm. howitzers.

(5) Shell, H.E., Mk. IV, for 10" guns.

(6) Shell, H.E., Mk. X, for 12" guns.

(7) Shell, H.E., Mk. VI-A, and Mk. XI, for 12" mortars.

Figure 1 shows this adapter and booster and gives the names of the principal parts, together with the stamping identifications. A fuze socket protects the booster charge from moisture. As fuzes are never assembled in these shell, until just prior to firing, an eyebolt lifting plug is supplied which acts as a protection against the entrance of foreign substances, prevents injury to the fuze threads in the adapter and facilitates handling of the shell. This lifting plug is made of steel and a ring or eye is formed on one end, through which a hook or bar may be passed in handling the shell. Some shell may be received in which a die-cast white metal plug or a felt adapter plug is used, instead of the eyebolt lifting plug. The booster charge consists of approximately 4.4 ounces of tetryl. Some boosters are loaded with half tetryl and half T.N.T., the tetryl being placed around the fuze socket.

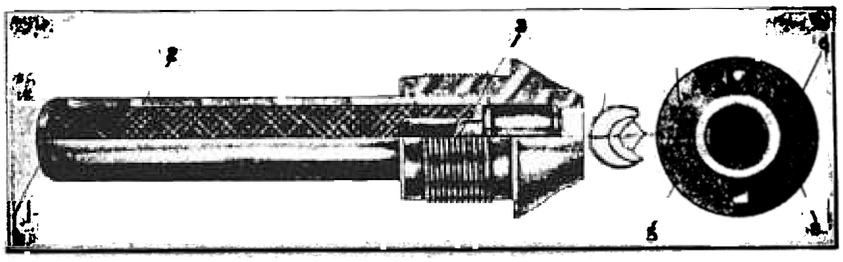


FIGURE 1. - Adapter and booster, Mk. II-A.

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.

b. Adapter and booster, Mk. III. The adapter and booster, Mk. III, is used in the following high explosive shell.

(1) Shell, H.E., Mk. I, for 2.95" mountain guns.

(2) Shell, H.E., Mk. I, for 75-mm. guns.

Figure 2 shows this adapter and booster and gives the names of the principal parts, together with the stamping identifications. 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 one ounce of tetryl. Some boosters are loaded with half tetryl and half T.N.T., the tetryl being placed around the fuze socket.

c. Adapter and booster, Mk. III-B. The adapter and booster, Mk. III-B, is used in the 75-mm. high explosive shell, Mk. IV. It is identical with the Mk. III, except that the diameter of the flange of the adapter is made smaller to fit the Mk. IV shell.

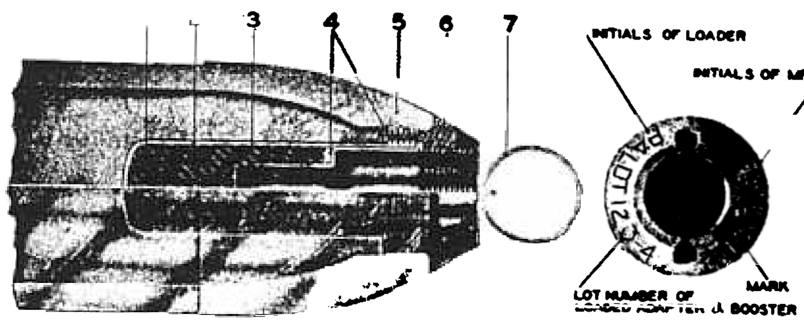



FIGURE 2. - Adapter and booster, Mk. III

1. Booster charge (tetryl).
2. Booster casing.
3. Fuze socket.
4. Felt washers.
5. Shell.
6. Adapter.
7. Adapter plug.

d. Adapter and booster, Mk. III-A. The adapter and booster, Mk. III-A, is used in the following high explosive shell:

Shell, H.E., Mk. III, for 155-mm. guns.

Shell, H.E., Mk. I, and Mk. IV, for 155-mm. howitzers.

Figure 3 shows this adapter and booster, and gives the names of the principal parts, together with the stamping identifications. A fuze socket protects the booster charge from moisture. As fuzes are never assembled in these shell, until just prior to firing a lifting plug is supplied, which acts as a protection against the entrance of foreign substances, prevents injury to the fuze seat threads in the adapter and facilitates handling of the shell. The lifting plug is made of steel and a ring or eye is formed on one end, through which a hook or bar may be passed in handling the shell. Some shell may be received in which a die-cast white metal plug or a felt adapter plug is used instead of the eye-bolt lifting plug. The booster charge consists of approximately one ounce of tetryl. Some boosters are loaded with half tetryl and half T.N.T., the tetryl being placed around the fuze socket.

e. Adapter and booster, Mk. III-AM2. The adapter and booster, Mk. III-AM2 is identical with the adapter and booster Mk. III-A, except that the recess in the adapter is larger. This is necessary so that the

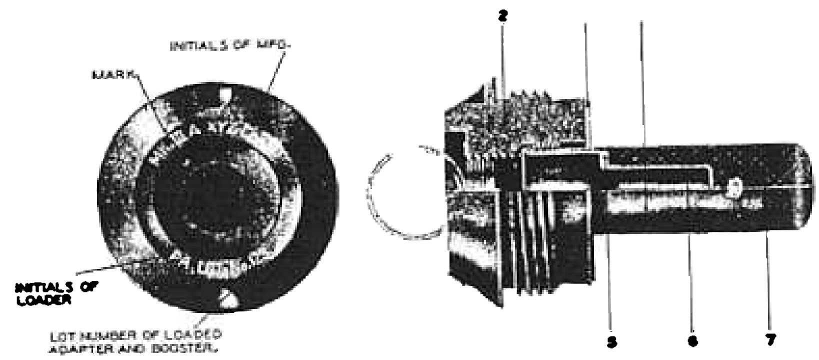



FIGURE 3. - Adapter and booster, Mk. III-A.

1. Adapter plug.
2. Adapter.
3. Felt washer.
4. Booster casing.
5. Felt washer.
6. Fuze socket.
7. Booster charge (tetryl).

adapter will receive the M46 or M47 fuze. The interrupter of these fuzes sits lower on the fuze body and would not seat properly in the Mk. III-A, adapter and booster.

## SECTION III

## ADAPTER AND BOOSTER FOR CHEMICAL SHELL

4. General. The function of the booster in a chemical shell is to break up the shell so that the contents may be released and scattered. The booster charge is therefore greater than in the high explosive shell booster. The adapter is provided with a pipe thread in order that the projectile may be made gas tight.

5. Types. - a. Adapter and booster, Mk. IV-B. The adapter and booster, Mk. IV-B is used in the 75-mm. chemical shell, Mk. II. Figure 4 shows this adapter and booster, and gives the names of the principal parts, together with the stamping identifications. Its function is to break up the shell so that the contents can escape. This component differs from that which is used in the high explosive shell in that the adapter and booster are made in one piece and the threads are tapered (pipe threads) instead of being straight, this type of thread and the one piece construction being necessary to make a gas-tight assembly. The joint made by the tapered threads is the only place where the gas can escape from the shell due to defective assembly. The booster charge consists of approximately 1¼ ounces of tetryl. Some boosters are loaded with half tetryl and half T.N.T., the tetryl being placed around the fuze socket.

b. Adapter and booster, Mk. VI-B. The adapter and booster,

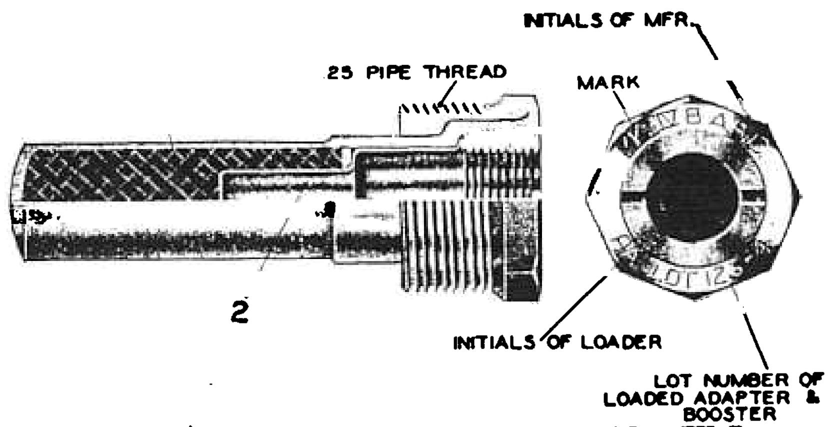



FIGURE 4. - Adapter and booster, Mk. IV-B.
1. Booster charge (tetryl). 2. Fuze socket.

Mk. VI-B is used in the following chemical shell:

(1) Shell, Chemical, Mk. VII, for 155-mm. guns.

(2) Shell, Chemical, Mk. II, for 155-mm. howitzers.

Figure 5 shows this adapter and booster, and gives the names of the principal parts, together with the stamping identifications. This component differs from that which is used in the high explosive shell in that the adapter and booster are made in one piece and the threads, by which it is assembled to the shell, are tapered or pipe threads, instead of being straight, this type of thread and the one piece construction being necessary to make a gas-tight assembly. The joint made by the tapered threads is the only place where the gas can escape from the shell due to defective assembly. Due to the facts, first, that quite a large booster charge is required to break up the chemical shell; and second, that the fuze alone would not dependably detonate this large booster charge, an auxiliary booster was found necessary. The auxiliary booster is exactly the same as the booster used in the Mk. III-A adapter and booster, the charge being approximately one ounce of tetryl. The charge of the main booster is approximately 9 ounces of T.N.T.

## SECTION IV

## BOOSTERS FOR ANTIAIRCRAFT AND OTHER HIGH EXPLOSIVE SHELL

6. General. The design of modern projectiles and fuzes, for both antiaircraft and field artillery guns, is such that no adapter is necessary. The booster is so designed that it takes the place of the adapter used in the older types of projectiles. The boosters described in this section provide a factor of safety in the handling and shipping

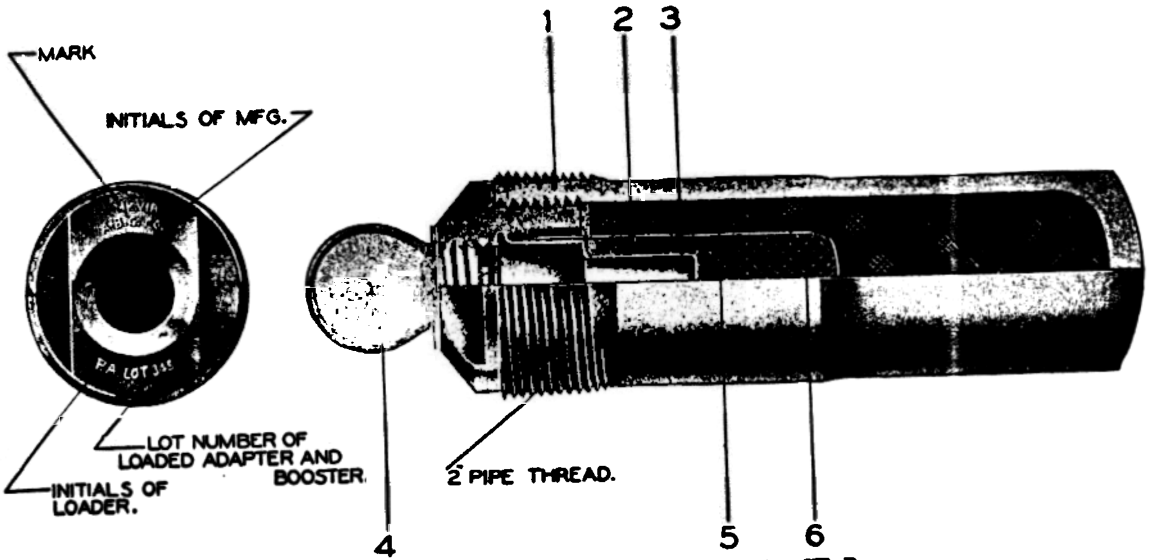



FIGURE 5. - Adapter and booster, Mk. VI-B.

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).

loaded ammunition to which the fuze is assembled.

7. <u>Types</u>. - a. <u>Antiaircraft booster, Mk. X</u>. The antiaircraft booster, Mk. X, will be found assembled in the 3" antiaircraft high explosive shell, Mk. I and Mk. IX. Figure 6 shows this booster in cross section, with the names of its principal parts. Practically all metal parts of this booster are made of brass. The interrupter (1) constitutes the boresafe device and this is operated by the centrifugal force of rotation. When the fuze has burned its predetermined time, the fuze magazine charge will explode and function the detonator (2) which contains about 12 grains of mercury fulminate. This detonates the booster charge (3). The booster charge in turn serves to detonate the explosive charge of the shell. The standard charge for the Mk. X booster consists of about 3/8 ounces of pressed tetryl.

b. <u>Booster, M20 (Fig. 7)</u>. (1) The booster, M20, is assembled in the following shell:

(a) Shell, H.E., M48, for 75-mm. guns.

(b) Shell, H.E., M48, M41, and M41A1, for 75-mm. howitzers.

(c) Shell, H.E., M42, for 3" S.C. guns.

(d) Shell, H.E., M42, for 3" AA guns.

(e) Shell, H.E., M58, for 90-mm. AA guns.

(f) Shell, H.E., M38A1 and T.P. M38A1, for 105-mm. AA. guns.

(g) Shell, H.E., M1, for 105-mm. howitzers.

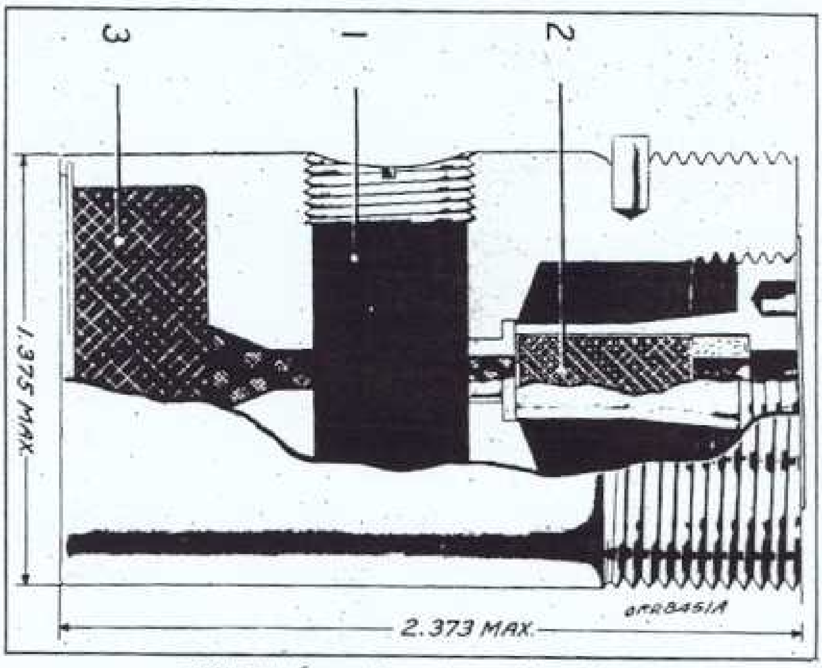



FIGURE 6. - Booster, Mk. X.

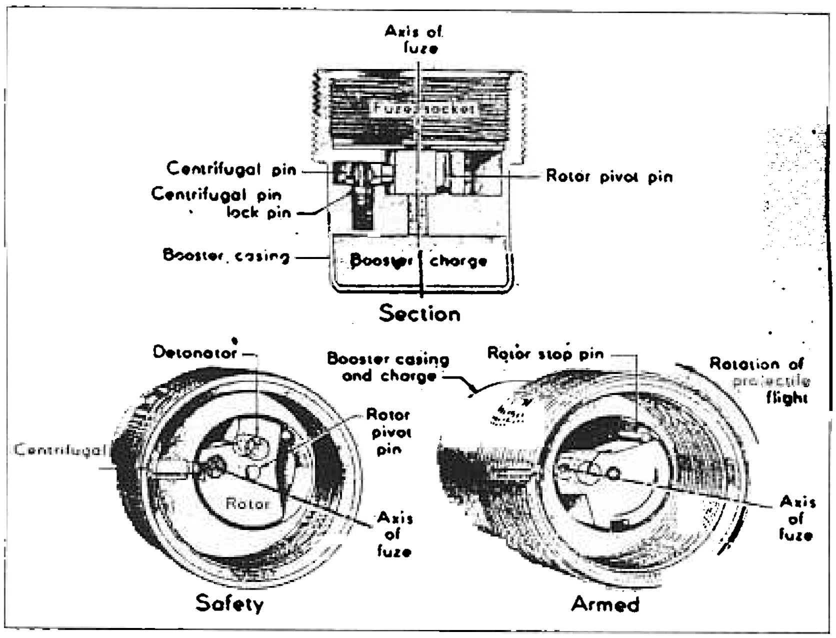
1. Interrupter. 2. Detonator. 3. Booster charge (tetryl).

(2) General. The combination of this booster and the M48 or M54 fuze is boresafe, since the rotor of the booster restrains its detonator out of line with the flash hole connecting the detonator of the fuze and with the booster closing cup charge and pellet until the projectile has cleared the muzzle of the weapon. The M20 booster is used in conjunction with standard contour, point detonating, and time fuzes to effect functioning of the later types of high explosive fixed and semifixed shell.

(3) Safety devices. The safety features of the M20 booster consist of a rotor, blocking the flash hole, held by the centrifugal pin and this pin is locked by the centrifugal pin lock pin.

(4) Functioning. On setback 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 the detonator. 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 three to five feet. In the armed position the booster detonator 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 <u>rotor lock pin</u> which is thrown outward by centrifugal force into the hole closed by the body plug. During flight the <u>rotor lock pin lock</u> moves by creep force behind the <u>rotor lock pin</u> (these locking features are not shown) and thereby restrains the latter from possibly moving inward. The explosives of the fuze are then free to set off successively the rotor detonator, the closing cup charge, the booster pellet, and the shell filler. When the booster is assembled to the M48 fuze, the booster detonator is functioned either by the superquick detonator assembly or by the relay charge of the delay element. When the booster is assembled to the M54 fuze, the booster detonator is functioned by the superquick detonator or by the flame from the black powder of the magazine charge.




② Operation.

FIGURE 7. - Booster, M20

<u>c</u>. <u>Booster, M21</u>. (1) The booster, M21, is assembled in the following shell:

(a) Shell, H.E., Mk. IIIA1, and M101, for 155-mm. guns.

(b) Shell, H.E., Mk. IA1, and M102, for 155-mm. howitzers

(c) Shell, H.E., M103, for 8" guns

(2) General. The booster, M21, is identical with the booster, M20, except that the centrifugal pin lock pin has been removed and a spring placed behind the centrifugal pin. The reason for this modification was that, when fired in the lower zones of these larger calibered weapons, the projectile did not have sufficient setback action to cause the lock pin to release the centrifugal pin.

d. Booster, M22. This booster may be substituted for the M20 and M21, for use on high explosive and chemical shell. It conforms in contour to the M20 and M21 boosters. The rotor has been omitted. A detonator of lead azide and tetryl is carried in the body leading to the booster charge. Due to the omission of the rotor, the booster is not boresafe.

## SECTION V

## BURSTERS FOR CHEMICAL SHELLS

8. General. - a. The old type adapter booster used in chemical shells have commonly been called bursters because their function was to burst the shell body and release the chemical filler. At the present time, however, there are in service several explosive charges which are properly named "Bursters". These new bursters are an improvement over the older types of boosters in that they extend through the entire length of the shell and completely rupture the entire body, whereas in the older types the nose of the shell was frequently blown away leaving the base intact, thus forming a cup in which a large part of the chemical filler might remain.

b. Description. The burster consists of two component parts: first the burster casing; and second the explosive charge. The burster casing is a steel tube, closed at one end and having a shouldered sleeve at the other end. The sleeve has a slight taper and when pressed into the seat, which is machined in the nose of the shell, forms a gas-tight seal preventing the escape of the chemical filler. The explosive charge is of tetryl pellets which are contained in a thin aluminum or cardboard tube. This explosive charge is inserted into the burster casing after the casing is pressed into the nose of the shell. If the shell are to be held in storage over a long period of time the burster charge will not be inserted into the shell until just prior to shipment.

9. Types. - a. Burster, M1. This burster is described in general in paragraph 8b above. It is used in conjunction with the M57 fuze and the M22 booster in the following shell:

(1) Shell, Chemical, Mk. IIA1, for 155-mm. howitzers.

(2) Shell, Chemical, Mk. VIIA1, for 155-mm. guns.

b. Burster, M5. This burster is described in general in paragraph 8b above. It is used in conjunction with the M57 fuze and the M22 booster in the following shells: (1) Shell, Chemical, M60, for 105-mm. Howitzers M1 and M2.