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Chapter 1

INTRODUCTION

Purpose

The purpose of this OP is to acquaint officers and men with the projectile fuzes of restricted classification now in general use, including their operation, performance characteristics, projectiles with which each is used, to explain the various forces encountered which affect fuze design, and to list basic fuze design requirements. VT fuzes are not included in this OP but are discussed in a confidential pamphlet, OP 1480 (Preliminary).

Definition

A projectile fuze is an explosive loaded device designed to detonate or ignite the explosive filler of its projectile with a high order detonation (or ignition) at the desired time or under the circumstances desired. There are three general classes of fuzes, depending on their location in the projectile, as follows:

Nose Fuzes
Base Fuzes
Auxiliary Detonating Fuzes

These are further subdivided as to type in the following paragraphs.

Nose Fuzes

Point Detonating Fuzes. Point detonating fuzes are designed to function on impact with the target. The fuze functions by detonating or igniting the burster charge of the projectile; or by igniting an incorporated auxiliary booster which detonates the burster charge.

Time Fuzes. Time fuzes are designed to burst the projectile at some predetermined time after the projectile leaves the gun. These fuzes contain a gear train and escapement mechanism which starts to run immediately after the inertia force of setback has ceased. After a predetermined and pre-set time interval, a firing pin fires a primer cap. The source of energy to drive the mechanism may be either coiled springs or centrifugal force acting upon driving weights.

Base Fuzes

Base Detonating Non-Delay Fuzes. Inertia plunger type impact fuzes which contain no actual delay element, but which do have a slight inherent mechanical delay.

Auxiliary Detonating Fuzes are always used in conjunction with nose fuzes for naval projectiles of 3-in. and larger caliber, with the exception of illuminating, WP, and certain chemical projectiles. They are interposed between the nose fuze and the bursting charge of the projectile and also act as a safety feature which prevents the projectile filler from detonating in case the nose fuze is actuated accidentally or at any time before the auxiliary detonating fuze is fully armed. In high capacity projectiles it is standard practice to substitute a steel nose plug for the nose fuze when greater penetration is desired, thereby relying largely on base fuze action. This takes advantage of the slight inherent mechanical delay of the non-delay base fuze if this type is installed. The auxiliary detonating fuze shall not be removed in this case.

Ignition and Detonating Fuzes

There are two different types of fuzes depending upon the method in which the burster charge is fired.

Ignition Fuzes. The operating mechanism of the ignition type fuzes acts to fire a black-powder magazine which may ignite the bursting charge of the projectile directly or function through an auxiliary detonating fuze, containing a detonating element. Examples of this type of fuze are found in the Fuzes Mks 18, 22, 25, etc.

Detonating Fuzes. A detonating fuze contains a high explosive detonating charge directly within its own body. Explosion of the projectile burster charge results directly from detonating fuze action. Examples of these fuzes are found in Fuzes Mks 19, 21, 28, etc.

Forces Used in Fuze Design

When a projectile is fired from a gun, several forces are brought into play which must be considered in fuze design. These are:

(a) Setback. The brief inertia force resulting from the acceleration of the projectile in the bore of the gun which tends to move all fuze parts toward the base.

(b) Angular Setback. For parts such as setting rings of time fuzes, the angular setback or inertia force created by the angular acceleration of the projectile in the bore is of primary importance. The weight of such parts must be determined so that the ratio of angular acceleration and setback will prevent slippage of the parts; otherwise, slippage might result in changing the time setting of the fuze.

(c) Centrifugal Force. The continuous force created by the rotation of the projectile which tends to move parts radially from the longitudinal axis of the projectile. This rotation is not constant but is a maximum just outside the bore and gradually decreases as the projectile travels along its trajectory. However, even at extreme ranges the rate of rotation is relatively high in comparison with the linear velocity of the projectile.

(d) Creep. The continuous inertia force resulting from the deceleration of the projectile caused by air resistance, which tends to move fuze parts not directly exposed to air resistance toward the nose of the projectile. This force is not constant but is a function of the velocity of the projectile and the density of the air reaching a maximum value just outside the bore and decreasing gradually as the projectile travels along its trajectory.

(e) Impact. The sudden inertia force which tends to make all movable parts in a base fuze move forward when the projectile strikes an object, or the shocking force from impact causing backward movement of a movable striker or striker extension in a nose or point detonating fuze.

(f) Friction. Fuze parts which are designed to have other than radial movement, i. e., axial movement (plunger) and rotation about the longitudinal axis (rotors), are subject to high frictional forces which act to restrain motion. The high frictional forces are in part the result of centrifugal forces acting on the parts, created by eccentricities of the axis of spin with the axis of the projectile or by virtue of their position relative to the axis of the projectile. Frictional forces acting on fuze parts also result when the force of setback commences.

(g) Forces Resulting from Yaw and Nutation of the Projectiles. These forces resulting from the unsteady flight of the projectile act only during the first part of the trajectory and are practically negligible thereafter. The unsteady flight gives rise to gyroscopic forces and also results in increasing creep over and above that which would be measured with steady flight. For most design purposes these forces are usually neglected—the measured creep force includes that added by the unsteady flight.

(h) Forces Due to Run-up in Worn Gun. In a worn gun, bore enlargement at the origin will prevent the projectile being seated when fired, thereby causing a certain amount of "run-up" before the projectile engages the rifling of the bore. Propellent gases cause the projectile to hit the lands of the rifling with considerable force, subjecting fuze parts to severe shock and strain. In the case of some nose fuzes, the force has been great enough to break the ogive from the fuze body and spill the detonator, with subsequent firing. A broken ogive may also cause firing of certain base fuzes through excessive deceleration at the muzzle. This factor in fuze design is under present study and experimentation.

(i) Pressure of Propellent Charge Gases. While a projectile is traveling down the bore of a gun, its base, and hence the exposed part of a base fuze, is acted upon by hot gases at very high pressure. This pressure may be utilized to actuate parts of the fuze in various manners. Actually, this force is not employed in any U. S. Naval fuzes but is used in some British base fuze designs, notably for a selective delay or non-delay feature.

In addition to these natural forces the fuze designer makes use of springs, clock mechanisms (either spring driven or actuated by centrifugal force), and the burning of powder trains. The latter device was formerly used in all anti-aircraft time fuzes, but these are now obsolete. (Except for U. S. Army fuzes.)

In order to give an idea of the magnitude of some of these forces which a fuze designer must consider, the following table is offered:

Caliber	Muzzle Velocity f/s	Max. Bore Pressure in New Guns	Maximum Setback Force**	Spin at Muzzle r.p.s.	Maximum Retardation in Flight* (Creep Force)
20-mm	2725	24 long tons/in²	96,566 g	1154	...
1.1″	2700	18 "	41,771 g	982	...
40-mm	2890	19.5 "	43, 215 g	734	...
3″/50	2700	17 "	20,627 g	338	11.4 g
4″/50	2900	17 "	14,505 g	272	7.1 g
5″/25 AAC	2175	17 "	13, 881 g	209	6.0 g
5″/38 AAC	2600	18 "	14, 344 g	208	7.2 g
5″/51 HC	3150	17 "	14,950 g	216	...
6″/47 AP	2500	18.5 "	9,012 g	200	3.5 g
8″/55 HC	2800	18 "	7,796 g	168	3.5 g
12″/50 HC	2620	17.5 "	4,717 g	105	2.0 g
14″/45 AP	2600	18 "	4,137 g	89	1.8 g
14″/50 HC	2830	18 "	4,867 g	96	2.4 g
16″/45 HC	2525	18 "	4,268 g	75	1.7 g
16″/50 HC	2690	18 "	4,268 g	81	1.7 g
16″/50 AP	2500	18 "	3,003 g	75	1.1 g

* The maximum retardation in flight occurs at the first instant the projectile is piercing still air; that is, at the instant the blast of propellent gases striking the base of the projectile has died down to zero value. This represents a distance from the muzzle varying appreciably with the caliber of the gun and probably runs from about 1½ ft. for 20-mm up to perhaps 30 ft. for 16-in. Before the projectile reaches this point, the fuze is fully armed.

** The unit "g" refers to gravity. That is, if a certain fuze part in a 20-mm projectile weighs one gram it is acted upon in the bore of the gun by a maximum acceleration force of 96,566 grams when the round is fired.

Explosives Used in Fuzes

Explosive materials used in fuzes must meet several basic requirements as follows:

(a) They must not be so sensitive that they are automatically initiated by the shock of firing or of impact. An exception to this is the 20-mm Fuze Mk 26 Mod 1, which contains a detonator designed to function by shock, or crushing action on impact.

(b) They must be compatible with other explosives, metals, or materials with which they are in contact. That is, such contact after long storage must not result in the chemical formation of supersensitive compounds or cause the original explosives to become desensitized. The explosives must resist deterioration due to age, moisture, and ammoniacal fumes.

(c) The explosive train in most fuzes consists of a primer cap, a detonator, and a booster in that sequence. The primer cap is acted upon first by a firing pin and hence, in itself, is the very heart of the fuze. This primer cap either sets off a detonator directly in the case of non-delay base fuzes, or a delay element in the case of delay base fuzes, which in turn sets off the detonator. To transmit the explosive shock wave from the detonator to the booster, since they are mounted in separate fuze parts, so called "lead-ins" and "lead-outs," consisting of explosive loaded channels are provided.

There is a type of detonator which does not need a primer cap to set it off but which is initiated directly by a stab-type firing pin which pierces the end of the detonator itself. This is commonly known as a primer detonator. This type is used in the Point

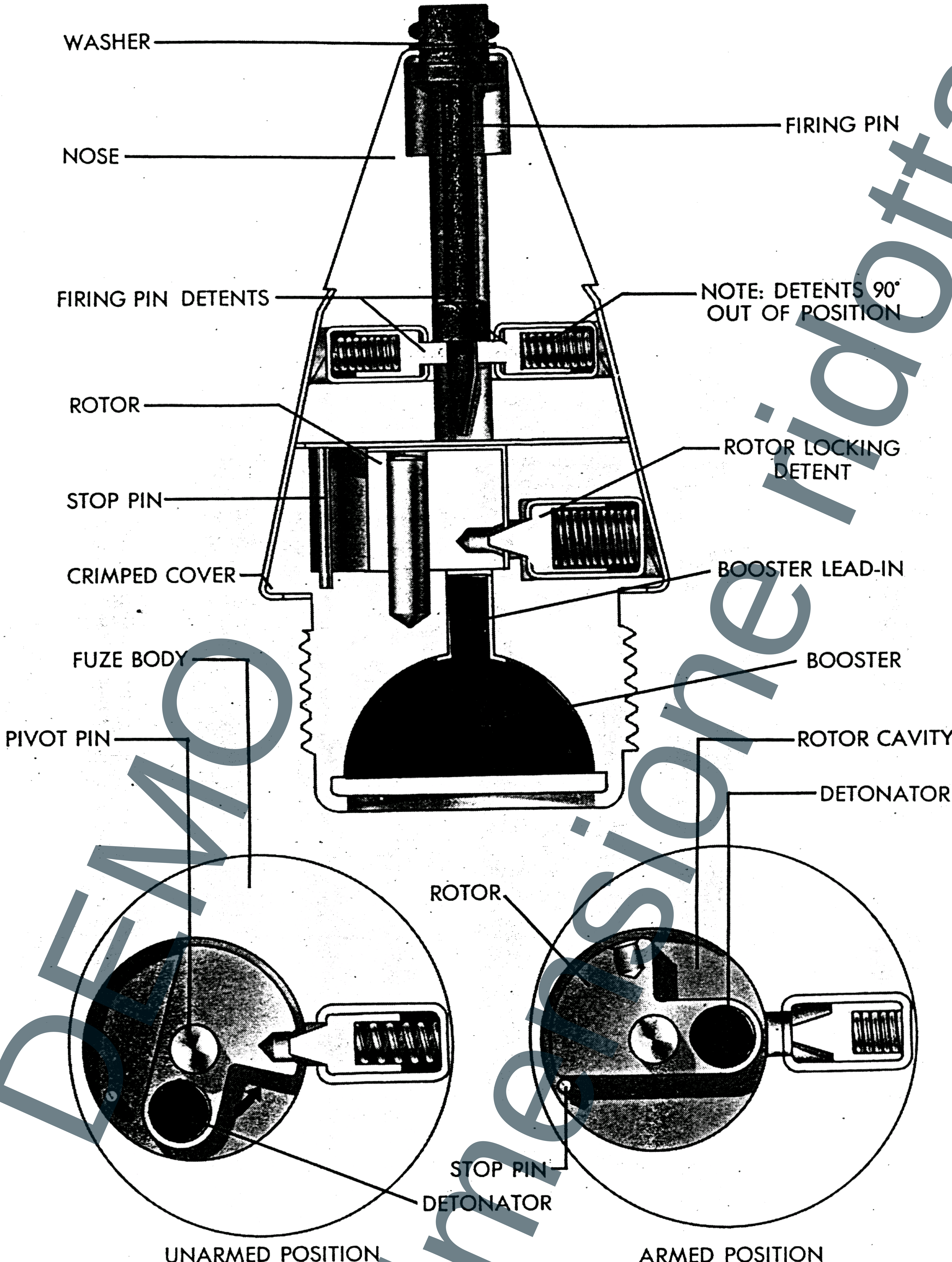

Figure 1.—Point Detonating Fuze Mk 12 Mods 2 and 3—Sectional View

Chapter 2

POINT DETONATING FUZE MARK 12 MODS 2 AND 3

General Data

Designation and Type

Point Detonating Fuze Mk 12 Mods 2 and 3

Projectile Used In

1.1-in. AA

Overall Dimensions and Weight

Length .... 2.125 in.
Body threads .... .875 in.-20NS-3RH
Weight .... 0.188 lbs.

Material

Nose .... aluminum
Base .... brass

Applicable OS 1001

General Arrangement Drawing No.

(Mod 2)—181781

Explosives Used

Fulminate of mercury* in detonator, tetryl in booster of both Mods

* A relatively few lots of Fuzes Mk 12 Mod 3 were loaded with lead azide detonators by one loading plant.

Description

This fuze is a sensitive fuze designed to burst the projectile with high order detonation on impact with materials offering appreciable resistance to penetration such as the wings or fuselage of aircraft, etc. The principal parts of the fuze are the nose and base secured together by a jacket which is crimped over at both ends. A thin disc is interposed between the nose and base. The nose contains the assembly of the firing pin detents and firing pin. The forward part of the firing pin protrudes from the nose through a thin washer, and is "eared" by a special tool to prevent its moving back against the detonator until impact. This was found necessary to prevent occasional prematures in the bore or close outside. The base contains the assembly of the rotor, rotor detent, detonator and booster.

Operation

The fuze becomes armed by centrifugal force set up by rotation of the projectile. The firing pin detents are thrown outward clear of the firing pin and the rotor detent is thrown outward clear of the rotor. The rotor thus released rotates about the rotor pivot until stopped by the rotor stop. The rotation of the rotor brings the detonator in the rotor in line wih the firing pin and booster lead. When the projecting head of the firing pin comes in contact with any object having an appreciable resistance to impact the firing pin "ears" are sheared and the pin stabs the detonator, exploding it, which in turn detonates the booster and the burster charge of the projectile.

Arming Spin

The firing pin detents arm at from 5000 to 7000 rpm. The rotor detent and hence the rotor arms at from 10,000 to 12,000 rpm in static tests. The muzzle spin of the projectile is about 58,920 rpm.

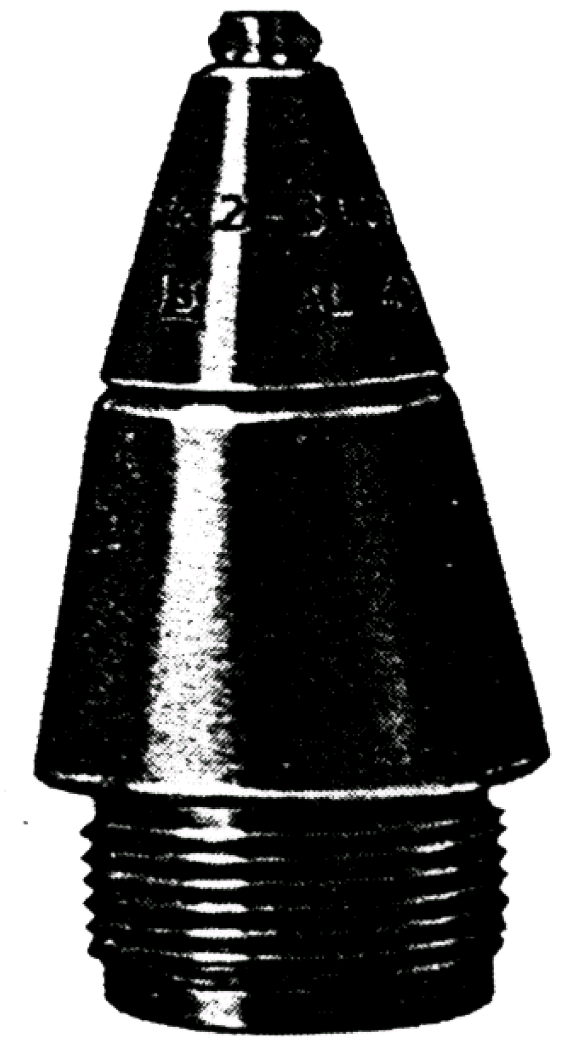

Figure 2.—Point Detonating Fuze Mk 12 Mods 2 and 3—Exterior View Full Size

Safety Features

Safety detent mechanism and rotor arm only by centrifugal force. Until fired from a gun, the detonator remains out of line with the firing pin. The acceleration and friction forces acting on the fuze while it is still in the barrel are such that the rotor does not actually snap into the armed position until just after it leaves the muzzle and the forward acceleration drops radically even though the projectile's spin while still in the barrel is far above that required to arm the fuze in a static fixture. This phenomenon thus acts as a bore safe feature.

Sensitivity Limits

These fuzes fired at service velocity will detonate consistently on 3/16-in. beaverboard or 0.032-in. dural but usually fail on 0.025-in. dural.

Acceptance Functioning Tests

Ten fuzes from each lot are tested by firing at service velocity against either (a) 0.045-in. thick dural plate or (b) 3/16-in. thick binder's board or cardboard. Under test (a) a minimum of 90% performance is required; under test (b) a minimum of 80% performance is required. Each fuze must cause a high order detonation of the projectile within four inches after contact with the plate or board. Failure of fuzes tested to meet percentages specified causes rejection of the lot.

Markings on Fuze

D.F. Mk 12-2 (or 3) ; Lot——
Manufacturer's initials; Inspector's initials;
Year and month of manufacture; Anchor stamp.

Remarks

The Fuze Mk 12 and Mods is no longer in production, having been superseded by the Point Detonating Fuze Mk 34 and Mods. The Fuze Mk 12 Mod 2 and Mod 3 differ only in the manufacturers of the inert parts. The Naval Gun Factory and the Pollack Manufacturing Company made parts for the Mod 2 and the Bohn Aluminum and Brass Corporation for the Mod 3. Fuzes of Mod 0 were never manufactured or issued. Fuzes of Mod 1 were manufactured by the Naval Gun Factory and were issued to vessels, but comparatively few were fired.

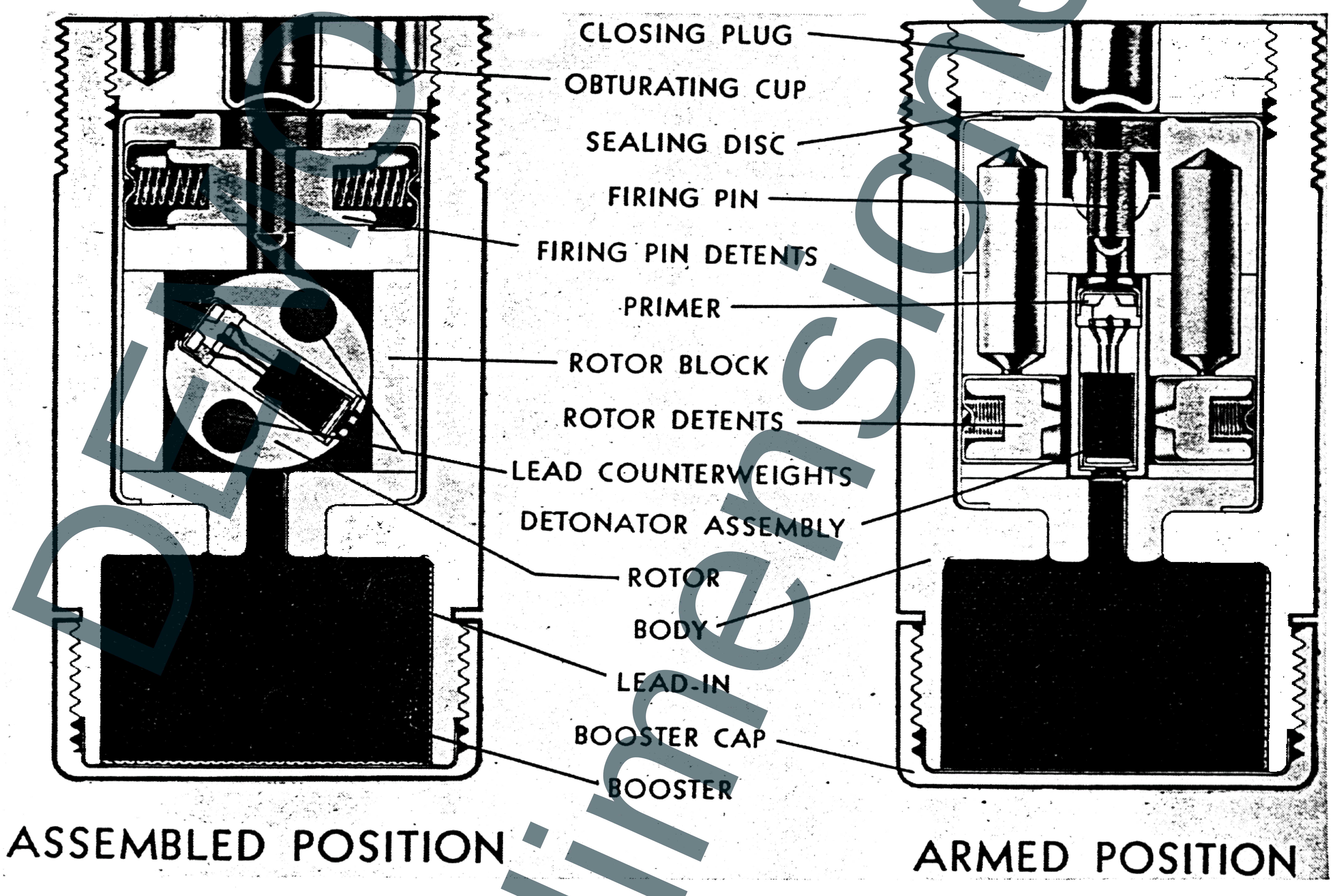

Figure 3.—Auxiliary Detonating Fuze Mk 17 Mod 0-7—Sectional View

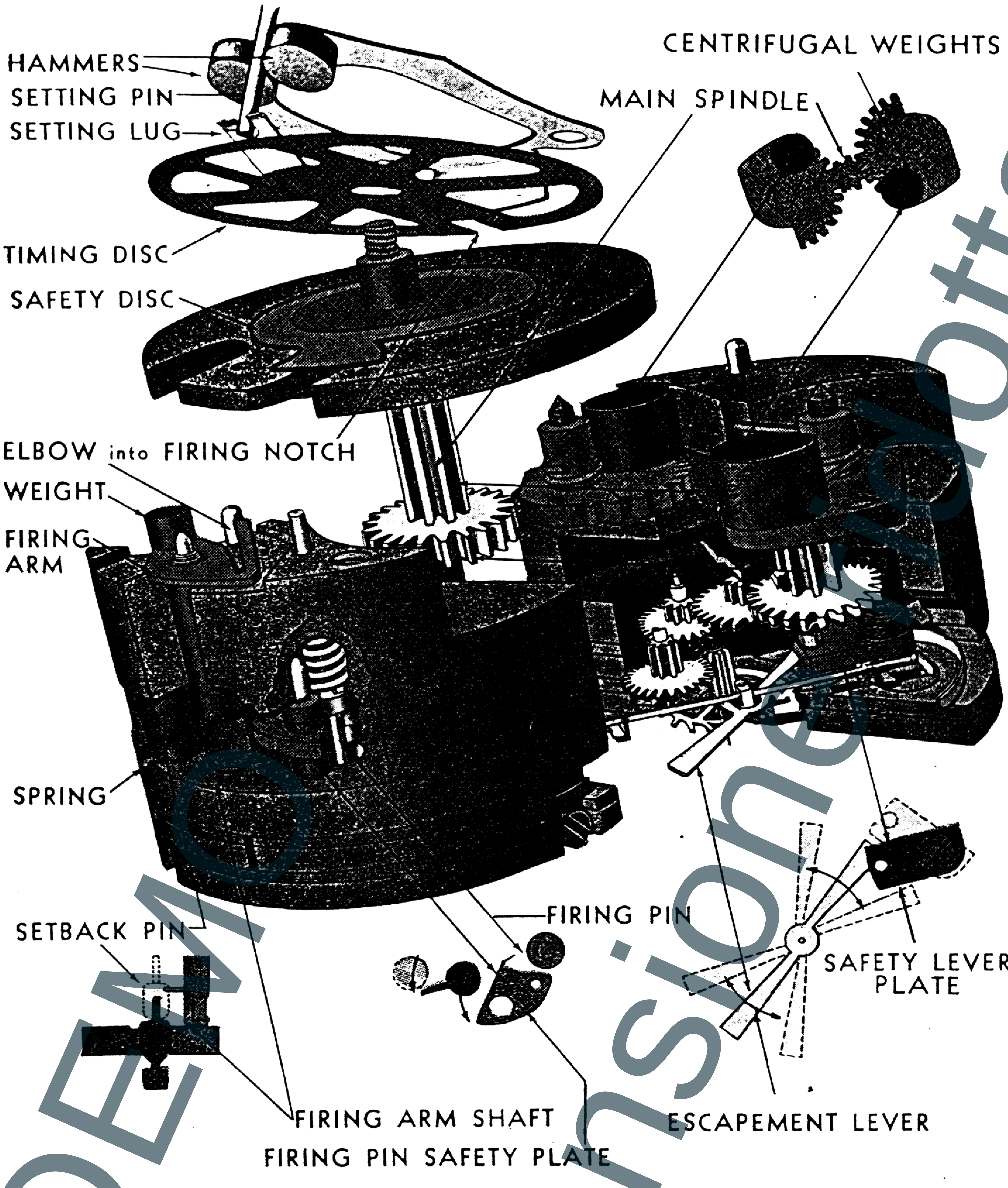

Figure 7.—Mechanical Time Fuze Mk 18—Exploded View

tion it could not release the firing arm and trip the firing pin.

(d) The timing disc is prevented from rotating by the setting pin, which passes between two prongs of a raised forked lug near the edge of the timing disc itself. This lug is bent down out of the way of the setting pin by the hammer in the upper cap when setback occurs.

Acceptance Functioning Tests

Sample fuzes from each production lot are fired at settings of 3, 10, 15, 20, 25, 30, and 40 seconds at various gun elevations. The actual mean time of flight and the dispersion obtained shall not differ from the setting by more than 0.08 seconds plus 0.005 times the setting.

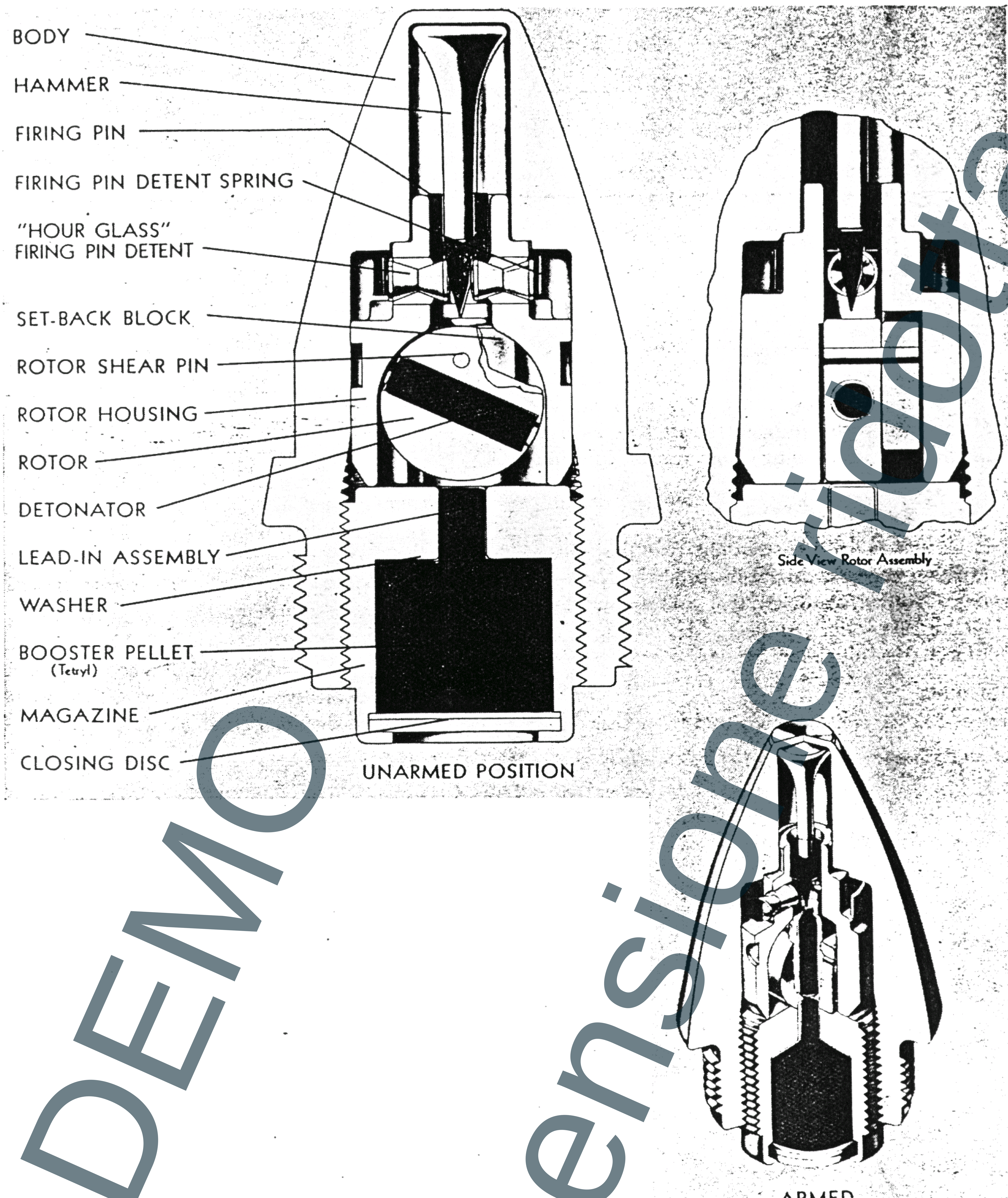

Figure 34.—Point Detonating Fuze Mk 34—Sectional View

Chapter 17

POINT DETONATING FUZE MARK 34

General Data

Designation and Type

Point Detonating Fuze Mk 34 Mod —

Projectiles Used In

1.1-in. AA

Overall Dimensions and Weight

Length .... 2.072 in.
Body threads .... 0.875-in.—20NS-1RH
Weight .... 82 ± 2 gm.

Material

Body .... Die-cast zinc alloy
Magazine .... Brass
Rotor housing .... Die-cast aluminum
Rotor .... Brass

Applicable OS 2870

General Arrangement Drawing No. .. 375643

Explosives Used

Lead azide primer mix, lead azide and tetryl in detonator
Tetryl in booster lead-in, and in booster magazine.

Description

The fuze consists essentially of a zinc alloy die-cast body, plastic hammer, firing pin with detents, rotor block, rotor, and magazine. The plastic hammer is located in the forward end of the nose. The after end of the hammer is supported in a hole in the stab-type firing pin, which is held safe by two detents with a spring similar to that used for Fuzes Mk 27. The rotor and rotor block firing pin holder combined, is a die casting located in the center of the body, and held in place by the magazine which screws into the after end of the fuze body.

Operation

The fuze is assembled in the unarmed position and remains so during transportation and storage. On firing the fuzed projectile from the gun, both centrifugal force and the force of setback act to free the firing pin and to permit rotor alignment of the detonator with firing pin and lead-in. The rotor with the detonator is assembled in the rotor block with the axis of the detonator at an angle of about 65 degrees from the axis of the fuze. The rotor is held in the unarmed position by means of slider block which is pinned to it by means of a copper shear wire. In this position the detonating element is safe; and if the detonator were to be exploded in this position, it would not detonate the booster. The force of setback drives the slider block down in the slot, shearing the copper shear wire, which leaves the rotor free to revolve to its armed position when setback ceases close outside the muzzle. Since the centrifugal force of the rotating projectile has released the firing pin detents, arming is now complete. Upon impact, the nose of the fuze receives a sharp blow which causes the plastic hammer to propel the firing pin. The firing pin stabs and fires the detonator, thereby initiating the explosive train of the booster lead-in, the booster, and the explosive filler of the projectile.

Figure 35.—Point Detonating Fuze Mk 34 Exterior View Full Size

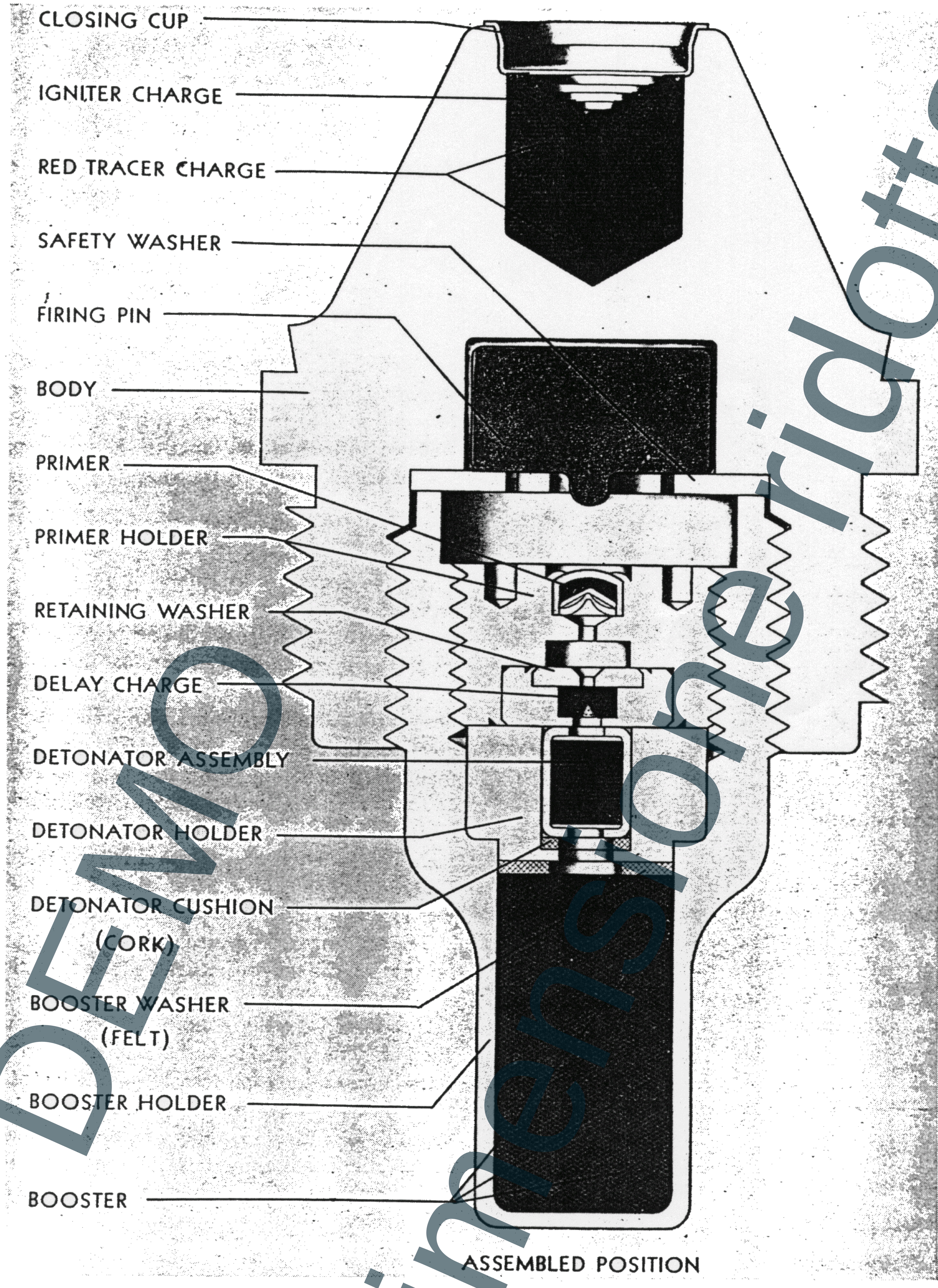

Figure 64.—Base Detonating Fuze M66A1—Sectional View

Chapter 33

BASE DETONATING FUZE M66A1

General Data

Designation and Type

Base Detonating Fuze M66A1

Projectile Used In

3″ AP Mk 29

Overall Dimensions and Weight

Length .... 3.458 in.
Thread length .... 0.70 in.
Body threads .... 1.65-in—10NS-1LH
Weight .... 1.0 lb.

Material

Detonator holder .... Steel
Body .... Chrome molybdenum steel
Firing pin .... Brass
Safety washer .... Steel
Booster holder ..... Chrome molybdenum steel
Primer holder .... Brass
Delay charge holder .... Brass

General Arrangement Drawing No.

73-2-178 (Army Ordnance)

Explosives Used

Primer (No. 26)—F.A. 70 mixture
Delay element—Black powder
Detonator (M17)—Lead azide and tetryl
Booster—Tetryl (five grams)

Description

The Fuze M66A1 contains no moving parts until impact occurs. That is, it is always armed in the technical sense. It consists essentially of a firing pin permanently in line with the primer and restrained from moving forward against the primer only by a steel safety washer which must be ruptured on impact to actuate the fuze. It contains a delay element of 0.016-second duration. The base of the fuze body contains an integral tracer which burns with a red flame.

Operation

No changes take place in the fuze on firing or during flight, since the only movable part is the brass firing pin and it is restrained by a steel safety washer. On relatively heavy impact, the retardation of the projectile causes the heavy firing pin to rupture the steel safety washer by its inertia and to continue forward until it impinges upon the primer. This in turn ignites the delay element which, after about 0.016 second, initiates the detonator, the fuze booster, and finally the projectile filler.

Arming Spin

None required. There are no centrifugal arming features.

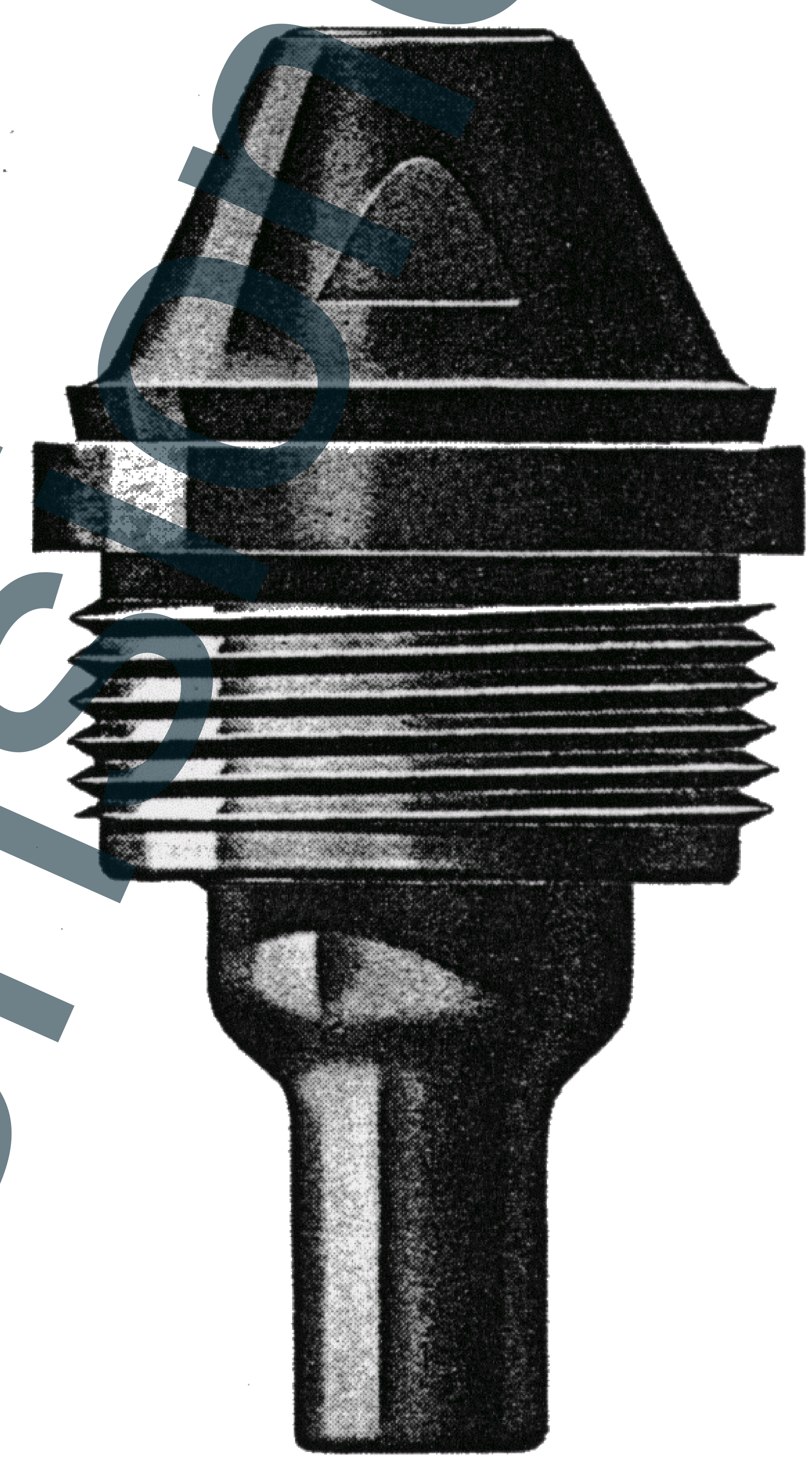

Figure 65.—Base Detonating Fuze M66A1 Exterior View Full Size

Safety Features

The only safety feature in the Fuze M66A1 is the steel safety washer which restrains the movable firing pin. This washer is of such strength that an assembled 3-in. AP round can be dropped in any attitude onto armor plate from a height of 40 feet without actuating or deranging the fuze.

Sensitivity Limits

The Fuze M66A1 in the 3-in. AP Projectile Mk 29 Mod 2 will function reliably on ½-in. STS plate at 20° obliquity and about 1400 f/s striking velocity. It will not function reliably on ⅜-in. mild steel plate. It will not function reliably on water or soft ground impacts.

Ballistic Acceptance Tests

Samples from each production lot are subjected to routine safety tests and to the following ballistic tests: Ten rounds from each lot are fired against 3-in. Class A or B plate at various velocities. Acceptance is based on 70% performance.

Markings on the Fuze

Around the flange of the body the following data are stamped: Lot No. —; Month and Year of Loading; FUZE, B.D., M66A1.

Remarks

The Fuze M66A1 is an Army fuze used primarily in anti-tank ammunition. It has been temporarily adopted for naval use pending the completion of the design, manufacture, and availability of a safer, more sensitive Navy fuze.

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