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(6) DEVELOPMENT OF POINT-DETONATING FUZE, M535 (T177E3)

"PREPARED FOR THE U. S. ARMY MATERIEL COMMAND BY THE ARMY MATERIEL RESEARCH STAFF, UNIVERSITY OF PITTSBURGH, UNDER CONTRACT DA-36-034-AMC-3785(X)".

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The M535 is a point-detonating (PD) fuze that can be set, prior to firing, to function either with superquick (SQ) action or with an 0.05-second delay after impact. It is for all high-explosive (HE) artillery ammunition from 75 to 280 millimeters in caliber, except 75-mm and 90-mm antiaircraft ammunition; in addition, it is for use with 4.2-inch mortar ammunition and some 105-mm to 175-mm chemical shell. Its development was begun in 1945 as the T177 PD fuze, to replace the M51A5 PD fuze with the M21A4 booster. The design of the T177 was based on that of the M51A5. The M535 (and the fuzes of the T177 series) has the same contour and weight as the M51A5, but it possesses the advantage of being waterproof, contains an M18 detonator for faster functioning at the SQ setting, and has an M24 (T35E7) delayed-arming booster for increased safety. In addition, it is screwed directly into the nose of a projectile instead of being attached by matching threads on the booster, thereby minimizing the tendency at the delay setting to shear off on graze impact.

As originally designed, the T177 fuze had a Mk 22 booster. The first modification, the T177E1, was supplied with a T35 delayed-arming booster, and as improvements were made to the booster, which was developed separately, they were included in the T177 series of fuzes. The T177E2, for example, was similar to other fuzes of the T177 series, but it had a T35E1 booster. The T177E3 fuze, which was given final engineering tests in 1952 and user tests in 1953, used a T35E7 booster that armed at approximately 3,500 revolutions per minute. In

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10-54	TIR 6-10-7A1(1)	4.2-inch HE Shell, M329 (E85R7)
12-57	TIR 6-12-7A1(2)	120-mm HE Shell, M356 (T15E3)
7-57	TIR 6-12-7A2(1)	120-mm HE Shell, T275 Series
7-59	TIR 6-16-7A1(4)	175-mm HE Shell, T203 Series
12-58	TIR 6-16-8A1(2)	175-mm Chemical Shell, T204
11-58	TIR 6-19-7A1(1)	280-mm HE Shell, M124 (T122) Series
3-57	TIR 8-1-3	Development of Point-Detonating Fuzes for Artillery and Mortars
9-55	TIR 8-1-3A8	PD Fuze, M508 (T237E1)
10-57	TIR 8-1-3A11(1)	PD Fuze, T247 (M521)

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June 1959 the T177E3 fuze with the M124 (T35E7) booster was classified Standard A as the M535 PD fuze.

The M535 fuze contains an SQ impact element, a setting device for selecting SQ or delay action, a delay-plunger assembly for 0.05-second delay action, and a delayed-arming booster. The assembled fuze consists of the following parts:

1. An aluminum head, containing a firing pin and the M18 (SQ impact) detonator

2. A steel body, containing the setting device for SQ or delay action

3. A flash tube and a thin-walled ogive connecting the head with the body

4. An M1 delay-plunger assembly providing delayed functioning when selected, or when the SQ detonator fails to function

5. An M124 ball-rotor delayed-arming booster, containing an M19A2 (flash-initiated) detonator and the booster charge

A thin (0.010 inch) aluminum closing disk protects the blunt nose of the head. The base is screwed to the upper end of the flash tube, the lower end of which is screwed into the body. A thin steel ogive containing a small circular opening near its base gives the fuze a smooth contour from head to body.

The setting device can be adjusted through the opening in the ogive to select either SQ or delay action. The M1 delay-plunger assembly fits into the body's base, which has internal threads for attaching the M124 booster, and external ones for assembling the fuze to the nose of the projectile. The flash hole extending through the body from the flash tube to the delay-plunger assembly is blocked by the interrupting plunger of the setting device.

An interrupting plunger and its spring, positioned eccentrically in the setting sleeve, comprise the setting device. The head of the sleeve projects slightly beyond the opening in the ogive and has slots to enable it to be turned to either the delay setting or the SQ setting by a screw driver, coin, or any other object that will fit. The fuze is shipped with the setting slot aligned with the SQ marking. In this position, the setting sleeve will not interfere with the outward movement of the interrupting plunger to clear the flash path when the fuze is armed by centrifugal force. When the setting slot is turned 90 degrees and aligned with the delay marking, the sleeve is turned so that its eccentric bore prevents the plunger from moving outward under centrifugal force. On impact, the booster is then ac-

tuated only by the explosive elements of the M1 delay-plunger assembly.

This cylindrical delay-plunger assembly houses the delay-firing pin, plunger support, and plunger body. The body contains the delay element (primer, black-powder delay pellet, and relay), which is in line with the firing pin; held in the unarmed position by two spring-loaded pins, the delay element rests against a restraining spring around the hollow plunger support. The delay-plunger assembly has two flash holes, one extending through the plunger support and the plunger body to transmit the flash from the SQ detonator in the head of the fuze to the booster, and a second running from the delay element to the entrance of the flash hole in the booster.

A steel body, a lead cup of gilding metal, and an aluminum booster cup make up the M124 delayed-arming booster. The upper part of the booster's body is screwed into the body of the fuze, and its lower part is screwed into the booster cup. The lower part of the M1 delay-plunger assembly fits into a recess in the body; an M19A2 detonator mounted in a ball rotor below this recess is held out-of-line with the flash hole from the delay-plunger assembly and the other explosive elements of the booster by four detents. The lead charge below the ball rotor contains approximately 3 grains of tetryl; the booster charge is a 350-grain tetryl pellet.

The M535 PD fuze is assembled, transported, and stored in the unarmed condition. After the fuze has been assembled to a projectile, no further preparation is required for SQ action. If delay action is desired, the head of the setting sleeve must be turned 90 degrees to align the setting slot with the delay marking. Two of the three safety devices that keep the fuze unarmed — the interrupting plunger in the body of the fuze and the plunger pins in the delay-plunger assembly — function by centrifugal force to arm the fuze only after the projectile has left the muzzle. The third safety device — the rotor detents in the booster assembly — functions by centrifugal force immediately upon firing and frees the rotor before the projectile has left the muzzle. However, since the force of setback is sufficient to hold the rotor immobile while the projectile is in the bore of the weapon, the M124 booster does not become completely armed until after the projectile has left the muzzle. Because of this provision, the M535 fuze is bore-safe.

When the fuze is set for SQ action, centrifugal force on the interrupting plunger becomes sufficient to overcome the pressure of its spring after the projectile has left the muzzle; the plunger moves outward against its spring and unblocks the flash path from the M18 detonator in the head, thus arming the front part of the fuze. When the fuze is set for delay action, the setting sleeve prevents movement of the interrupting plunger, and the path of the flash from the M18 detonator remains blocked. Centrifugal force also becomes sufficient after the projectile has left the muzzle to depress the spring-loaded plunger pins that have maintained the delay plunger in the safe position. The plunger pins are locked in this position so that the plunger-delay assembly remains armed until the fuze strikes either the target or the ground.

Both centrifugal force and the force caused by deceleration operate to arm the booster. Although the rotor detents move outward under centrifugal force as a result of the rotation of the projectile, the detonator in the ball rotor is held in the unarmed position by the force of setback until the projectile begins to decelerate after it has left the muzzle; the rotor then turns spirally into a position in which the detonator is in line with the other elements of the explosive train. The distance from the muzzle at which the M124 booster becomes armed varies with the velocity of the projectile and the rate of spin. The minimum arming-delay distance, except for antiaircraft rounds, is approximately 40 to 100 feet. For antiaircraft rounds, the arming-delay distance was about 25 feet for 75-mm ammunition and about 50 feet for 90-mm ammunition, and it was for these reasons that Army Field Forces Board Number 4 (now US Army Air Defense Board) recommended that the fuze not be made standard for 75-mm and 90-mm antiaircraft ammunition.

PD FUZE, M535 (T177E3)

When the shell strikes, the firing pin in the head of the fuze is driven against the M18 detonator and the resulting flash travels along the flash tube and the flash hole in the body of the fuze. At the SQ setting, the flash path is unobstructed and the flash is transmitted through the flash hole along the axis of the delay-plunger assembly to the M19A2 detonator in the booster. At the delay setting, the flash hole in the body of the fuze remains blocked so that initiation of the M18 detonator on impact cannot set off the detonator in the booster; instead, after impact the M19A2 detonator will be fired by the delay element in the delay-plunger assembly.

Upon impact, including graze impact, inertia forces the body of the delay-plunger assembly to move forward and drive the delay elements against the delay-firing pin, thus producing a second flash 0.05 second after impact. This flash is transmitted through the canted hole in the delay-plunger assembly to fire the M19A2 detonator in the booster, provided that it has not previously been set off by

the flash from the M18 detonator. In normal functioning with the fuze set for SQ action, the flash from the M18 detonator will be transmitted to the detonator in the booster before the delay element has functioned; however, should SQ action fail, the M19A2 detonator will be set off by the delay elements. When the fuze is set for delay action, the flash from the M18 detonator is blocked, and the M19A2 detonator will be detonated only by the delay elements.

The flash from either the M18 detonator in the head of the fuze or the delay element in the delay-plunger assembly ignites the M19A2 detonator in the ball rotor, and the firing action is transmitted by the lead charge to the main booster charge, which then explodes the projectile.

The M535 PD fuze functions faster at the SQ setting than the M51A5, which it replaces, and it is also more sensitive when used in adverse weather conditions, such as in rain or in snow. In heavy-rain tests of early models of the T177E3 (M535) fuze, which had an 0.005-inch-thick aluminum closing disk, there were too many premature bursts. However, fire hoses were used in these tests to supply the simulated rain. It is now believed that the test conditions were unduly severe, and the results of the test have therefore been discounted.

PRINCIPAL CHARACTERISTICS

Model	M535 (T177E3)
Type	PD (SQ or delay)
Materials	
Head	aluminum
Flash tube	steel
Ogive	steel
Body	steel
Delay-plunger assembly	steel and brass
Booster assembly	aluminum and steel
Weight, with booster	2.15 lb
Length	
Over-all	5.95 in
Intrusion	2.21 in
Diameter	2.4 in
Thread size	2-12 UNS-1A
Arming	
Method	centrifugal force; force of deceleration
Centrifugal force required	3,500 rpm (approx)
Distance of arming delay	40-100 ft
Actuation	
Method	impact
Time of delay functioning	0.05 sec
Point detonator	
Type	stab
Model	M18

Delay element	
Charge	black powder
Model	M2
Booster	
Type	arming delay
Model	M124
Weight	0.63 lb
Explosive train	
Detonator	M19A2
Lead charge	3 grains of tetryl
Booster charge	350 grains of tetryl
Projectiles with which used	
75-mm HE shell	M48
76-mm HE shell	M42A1, M352A1
90-mm HE shell	M71
105-mm HE shell	M1
105-mm chemical (smoke and gas) shell	M60
4.2-inch HE shell	M329
120-mm HE shell	M356 (T15E3)
120-mm chemical (smoke) shell	T16E3
155-mm HE shell	M101, M107
155-mm chemical (smoke and gas) shell	M104, M110
175-mm HE shell	T203 series
175-mm chemical (smoke) shell	T204
8-inch HE shell	M106
280-mm HE shell	M124

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