ADVANCED FUZE & EXPLOSIVE ORDNANCE BULLETIN No. 6

1 JULY 1944

CONFIDENTIAL

This document is issued to the graduates of the Bomb Disposal School and the Advanced Fuze & Explosive Ordnance course by the Officer-in-Charge, Navy Bomb Disposal School, under authority of Bureau of Ordnance letter F41-6(L) dated 22 April 1944. It is for information and guidance only and is not a Bureau of Ordnance publication. This document shall be destroyed by burning when it has fulfilled its purpose.

TABLE OF CONTENTS

BOMBS

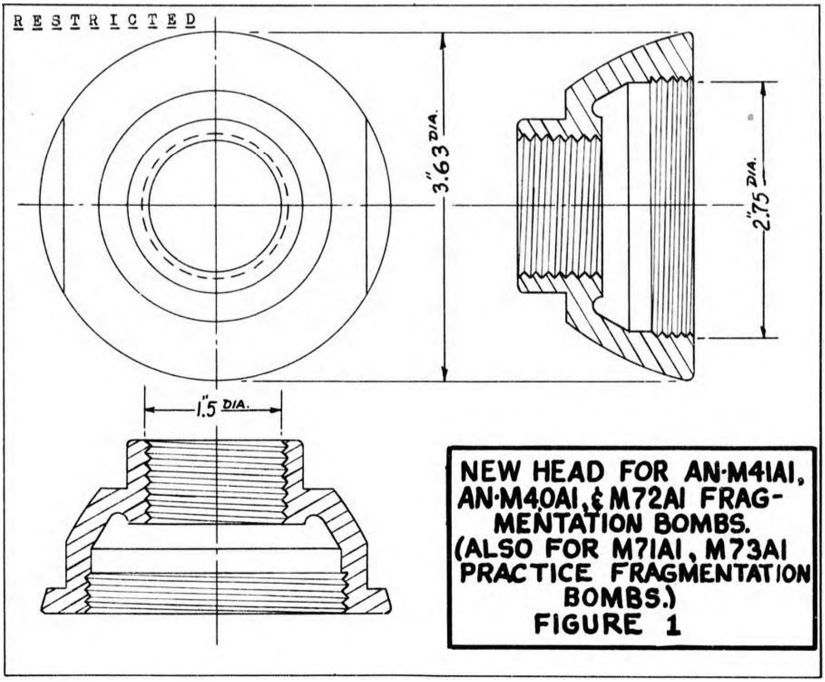
R E S T R I C T E D

CHANGE IN DESIGN OF 20 AND 23 LB. FRAGMENTATION BOMBS TO PERMIT SHIPMENT UNFUZED

Until recently the 20 lb. AN-M41 and the 23 lb. AN-M40 fragmentation bomb clusters have been shipped to the field complete with fuzes. In order to eliminate the disadvantages of stowing and handling fuzed bombs, minor changes in the nose of the bombs are now being made.

A 1/2 inch extension is being added to the heads of all 20 lb. and 23 lb. fragmentation bombs. (See Fig. 1) This extension will act as a seating surface for the bomb on the support plate of the AN-M1A2 Cluster Adapter.

The fuze vane lock plate on the AN-M1A2 Cluster Adapter will be modified to permit fuzing of bombs in the field without disassembling the cluster.



Cluster AN-M1A1 with modified adapter and modified bombs will be shipped unfuzed and without a metal liner. Fuzes will be placed in hermetically sealed cans and packed in the cluster box. Clusters will not be assembled at the loading plant with mixed lots of bombs, (modified or unmodified).

The AN-M4 cluster, with or without, modified bombs will be shipped unfuzed but with the metal liner, to protect parachute assemblies. The AN-M3 cluster adapter requires no modification for assembling of fuzes to bombs in the field. In this case too, the fuzes will be placed in hermetically sealed cans and packed in the cluster box.

Similarly, the following changes in bomb, cluster adapter and cluster designation will be effected.

(a) Fragmentation bombs (Modified)
AN-M40 changed to AN-M40A1
AN-M41 changed to AN-M41A1
M71 changed to M71A1 (Practice Bomb)
M72 changed to M72A1 (Vertical Suspension)
M73 changed to M73A1 (Practice Para-frag Bomb)

(b) Cluster Adapter, AN-M1A2 (Modified)
AN-M1A2 changed to AN-M1A3

(c) Cluster Adapter, AN-M3
No modifications; no change in designation

(d) Cluster, AN-M1A1
(1) With modified Cluster Adapter, AN-M1A3 and modified bombs, AN-M1A1: AN-M1A1 changed to AN-M1A2.

(2) With modified Cluster Adapter, AN-M1A3 and unmodified bombs, AN-M41: No change in designation; bombs to be fuzed when clustered at loading plant; packing box to retain metal liner.
(3) With unmodified Cluster Adapter, AN-M1A2 and modified bombs, AN-M41A1: No change in designation; bombs to be fuzed when clustered at loading plant; packing box to retain metal liner.
(4) Without any modifications of Adapter AN-M1A2 or bombs, AN-M41: No changes. Present requirements for clustering, fuzing, packing and designations to apply.

(e) Cluster, AN-M4
(1) With modified bombs, AN-M40A1 and Cluster Adapter, AN-M3, not fuzed, fuzes in hermetically sealed cans, packed in cluster box with metal liner: AN-M4 changed to AN-M4A1.
(2) With unmodified bombs, AN-M40 and Cluster Adapter, AN-M3, not fuzed, fuzes in hermetically sealed cans, packed in cluster box with metal liner: AN-M4 changed to AN-M4A1.

- - - - - - - - - - -

REFERENCE: (1) Ord. Com. Item #23225 (2) Ord. Dept. Drawing No. CGA2392

* * * * * *

R E S T R I C T E D

ALTERNATE DESIGN FOR AN-M81 260-LB. FRAGMENTATION BOMB

The AN-M81 260-lb. fragmentation bomb was first reported in AFEO Bulletin No. 1, page 11. The design of that bomb had the nose and tail pieces of cast steel screwed onto a central section of seamless steel tubing. A flat helical steel spring was wound around the steel tubing. The nose and tail pieces were partially cut through to afford greater fragmentation.

Fig. 2 shows an alternate design for the AN-M81. It is to be noted that the construction differs in that the flat helical steel spring is wound around the steel tubing for the entire length of the bomb. Fragmentation effect from this alternate design should be approximately the same, if not slightly greater, than that of the original design.

- - - - - - - - - - -

REFERENCE: Ord. Dept. Drawing No. 82-3-482

* * * * * *

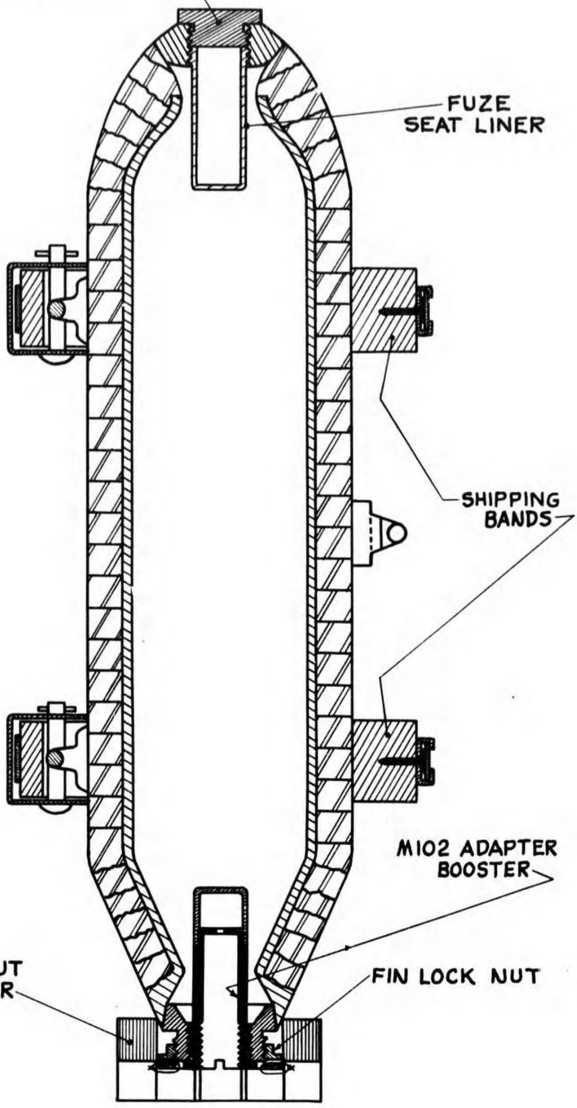


FIGURE 2

AN-M81 260 LB. FRAGMENTATION BOMB
(ALTERNATE DESIGN)

According to British Air Ministry Instruction No. 672, dated 29 April 1944, a skymarker bomb CHB Mk. I is carried on American aircraft in the European theater. The bomb, painted blue-grey with a yellow band around the body with markings stencilled in yellow, consists of the 100 lb. M47A1 incendiary case without the central tube. The nose and tail ends of the bomb are modified to receive special adapters. These adapters contain two grooved or notched bakelite discs centrally drilled to receive a detonator. The detonators are wired to a special electrical circuit on the aircraft. The bomb is filled with a liquid smoke compound.

Operation:

As the bomb is released and falls clear of the aircraft, the charging circuit is completed and the detonators function to break the bakelite diaphragms. The pressure of the air passing through the nose adapter forces the liquid filling through the tail adapter where, on contact with the air, dense white fumes are formed leaving a smoke trail as the bomb falls towards the ground.

- - - - - - - - - - -

REFERENCE: British Air Ministry Instruction No. 672, 29 April 1944.

R E S T R I C T E D

ASSIGNMENT OF NOMENCLATURE TO PARACHUTE UNITS ON 23-LB. FRAGMENTATION BOMBS

In the past the marking of the parachute units has been respectively, "Parachute Unit Assembly for 23-lb. AN-M4C Frag. Bomb and M71 Practice Bomb" and "Parachute Unit Assembly for 23-lb. Frag. Bomb and M73 Practice Bomb". When the components are assembled into complete rounds at loading plants the part of the marking that is not applicable is marked out.

The above marking did not present any particular difficulties as long as the complete rounds were marked AN-M40 and M72. However, with the advent of the A1 modification on the complete round and the possibility of further modifications, it appears that there will be some confusion unless the parachute unit marking is changed.

As a result, the parachute units for the fragmentation bombs have been assigned separate "M" numbers, omitting any reference in the parachute marking to the bomb for which the parachute is intended. This method seems feasible due to the following consideration now in progress:

1. Advent of A1 modification to the existing 20 lb. fragmentation bombs.
2. Contemplated modifications in existing parachute assemblages by enlarging the parachutes to permit release of fragmentation bombs at lower altitudes than now recommended. Tests are now being conducted to determine a suitable size parachute that will enable these bombs to be dropped from 50 ft. altitude.
3. Possible requirement of parachute assemblages for all types of present fragmentation and G. P. Bombs of the smaller sizes are also being tested.

Designations have accordingly been assigned as indicated below:

Parachute-Unit, M3 (For M40 and M71 Bombs)

Parachute-Unit, M4 (For M72 and M73 Bombs)

- - - - - - - - - - -

REFERENCE: Ordnance Committee Item No. 23717

* * * * * *

CONFIDENTIAL

AN MARK 230 MOD 4, AN MARK 229 MOD 3 HYDROSTATIC TAIL FUZES

Introduction:

The Bureau of Ordnance has received numerous reports concerning accidents involving the use of the Mark 229 and the AN Mark 230 fuzes when the bombs using these fuzes were released "safe". A typical report of this kind is quoted below from the Commanding Officer, Fleet Air Wing ONE, Headquarters Squadron, Fleet Air Command South Pacific, file number FP1-Hedron/F41, serial 0117, dated 28 March 1944:

> "VP-81, Black Cat Squadron, has been carrying four Mark 12 500-pound G. P. bombs on patrol missions in recent weeks. These bombs have been fuzed with the Mark 219 nose fuze set on "Instantaneous", and the Mark 229 Mod 2 hydrostatic tail fuze with a 25 ft. depth setting. While on a night patrol mission 23/24 March, one of the Black Cats encountered very rough weather and had to lighten the load in order to gain altitude and speed. The four Mark 12 bombs were dropped on "safe". All four bombs carried their respective arming wires away, indicating that no arming wires were held or pulled from the fuzes. Upon entering the water, three of the four bombs went off giving quite a jolt to the plane which was flying at 500 ft. altitude at the time of release. The PPC stated that from the characteristics known to him the bomb was evidently set off by the hydrostatic tail fuze. No fragmentation or surface flash of the bombs was present to indicate action of the nose fuze upon contact with the water."

The report also states that this situation occurred on several other occasions when flying at lower altitudes.

In a letter originating in Re2b, Bureau of Ordnance, file number FP12/F41 to Commander Air Munda, the Bureau states that it has also conducted tests in order to determine the cause for such accidental detonation. This letter states in effect that the arming mechanism housing carried away on the Mark 229 fuze on impact with water when the bomb is dropped from an altitude of approximately more than 1000 ft. After the arming mechanism housing breaks off the fuze, the detent retaining cup is carried away leaving the fuze fully armed even though the bomb was originally dropped "safe".

As a result of these accidents the Bureau has made changes in both the Mark 229 and the AN Mark 230 which are designated as Mark 229 Mod 3 and AN Mark 230 Mod 4.

Description:

The Mark 229 Mod 3 and the AN Mark 230 Mod 4 are the same as previous mods with the following exceptions:

(1) The fuze is sealed by a metal disc (See Fig. 3) to prevent entrance of the water at any point other than the regular water ports.

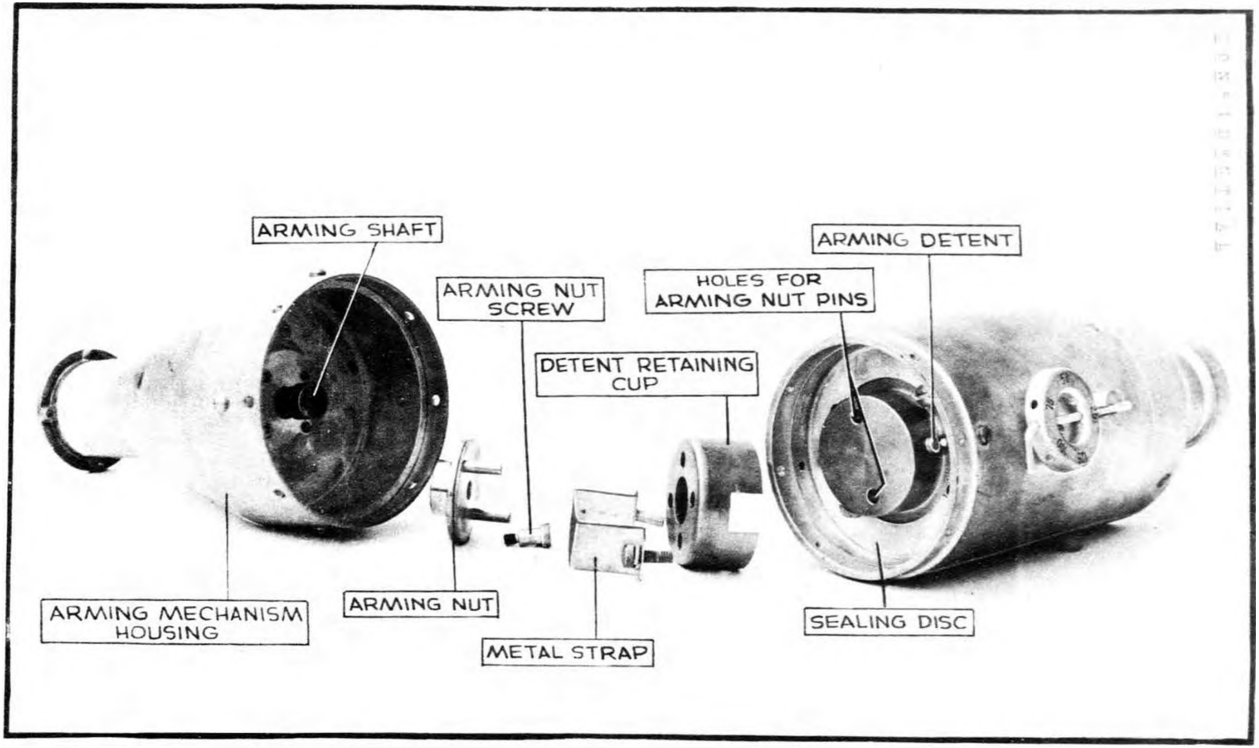


FIG. 3 AN-MK 230 MOD. 4 SHOWING MODIFIED ARMING MECHANISM

(2) The arming mechanism which frees the arming detents operates by rotation of the detent retaining cup rather than by raising it vertically. A metal strap is fitted over the cup. These additions (1) prevent arming of the fuze in case the tail cone or arming mechanism housing is torn off the fuze accidentally upon water entry, and (2) prevent the fuze from firing from hydro-dynamic pressures which are encountered in erratic movement of the bomb through the water or on re-entry after ricochet.

(3) The fuzes will also have a slight oval undercut above the fuze pocket threads to accomodate the new oval neoprene washer which has replaced the flat gasket formerly used. By using this neoprene washer, the holes for the safety rod located above the fuze threads, are now sealed from water entry.

Bombs in Which Used:

AN-MK 230 MOD 4		MK 229 MOD 3	
AN-M64	500 lb. G. P.	Mk 12-2	500 lb. G. P.
AN-M65	1000 lb. G.P.	Mk 13-2	1000 lb. G. P.
AN-M66	2000 lb. G. P.	Mk 38	650 lb. Depth Bomb
Mk 53	325 lb. Depth Bomb	Mk 49	700 lb. Depth Bomb
Mk 54	350 lb. Depth Bomb		

Although the AN-Mk 230 Mod 4 fuze will fit in the bombs in which the Mk 229 fuze is used, a space approximately 1⅞ long will be left between the standard Mk I auxiliary booster pellet and the booster of the AN-Mk 230 Mod 4. While it is not recommended that the AN-Mk 230 Mod 4 be used as a substitute for the regular Mk 229, the 1⅞ space may be partially eliminated by substituting two (2) Mk II auxiliary booster pellets in place of the standard Mk I pellet.

Operation:

While the hydrostatic element remains unchanged, the arming mechanism has been changed as seen in Fig. 3. Formerly (in the Mk 229 and AN-Mk 230) the rotation of the arming shaft caused the detent retaining cup to thread up vertically on the arming shaft and release the spring loaded detents from their engagement with the depth spring stem, thereby arming the fuze. In the Mark 229 Mod 3 and AN Mark 230 Mod 4 the detent retaining cup no longer rises, but rotates (Fig. 4 and 5). Rotation of the arming shaft first causes the arming nut assembly to rise (since it cannot turn because of the two pins which project into the detent carrier). When the two pins of the arming nut are fully clear of the detent carrier, the arming nut "washer" jams under the arming shaft preventing further rising. The arming shaft then turns the arming nut assembly, and, by means of the two pins, rotates the detent retaining cup approximately 85° until the two cutaway portions in the detent retaining cup align themselves opposite the detents (Fig. 5). The detents are then ejected freeing the depth spring stem and thereby arming the fuze. To limit the amount of water entering the slyphon bellows, the detents are prevented from jumping completely out of the detent carrier by the detent retaining pins which are fitted into the flange of the detent carrier.

The metal strap passes over the detent retaining cup preventing the removal of the cup from the detent carrier. Thus if the arming mechanism housing is broken off without rotation of the arming vanes, the fuze will not become armed.

After the bomb has submerged, water enters the fuze through two ports in the body sleeve only, since the use of the sealing cup above the detent carrier prevents water entry through the open end of the fuze in case the tail cone is broken off on impact.

Air Travel Required to ...

Air travel along the trajectory necessary to arm the fuze is 400' - 500'. The minimum altitudesof release to insure arming this fuze at various air speeds in horizontal bombing are:

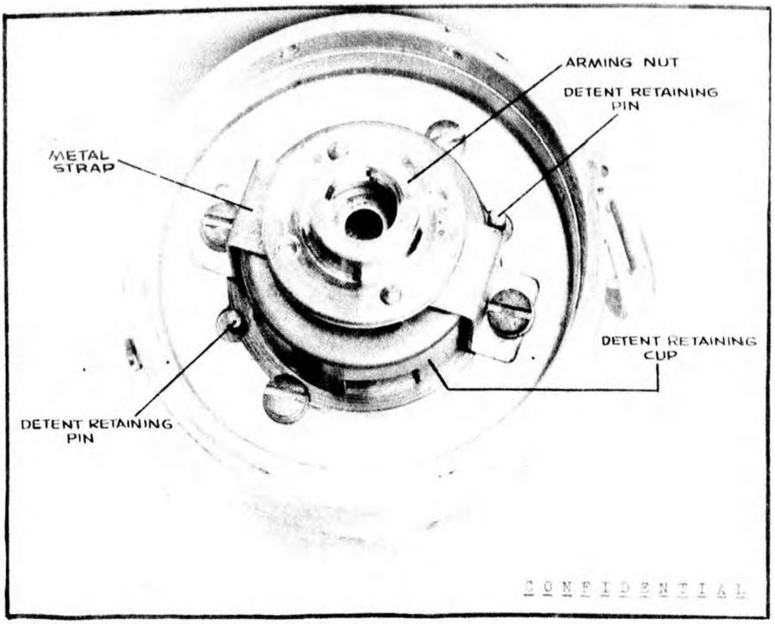


FIG. 4 AN-Mk 230 Mod 4. Unarmed position, arming nut flush with metal strap. Note position of cut-away for arming detents.

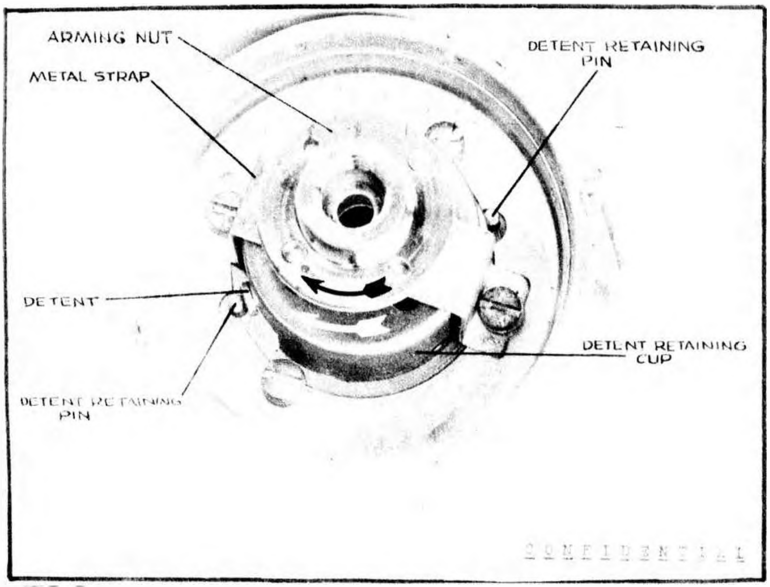


FIG. 5 AN-Mk 230 Mod 4. Armed position, arming nut has raised and pins in arming nut have turned detent retaining cup 85° to allow arming detents to jump out.

Air speed - knots	100	150	200	250
Alt. of release - feet	130	60	35	20

The above values for the minimum altitudes of release should not be confused with the minimum safe altitudes of release which depend upon other factors and not upon the air travel required to arm.

Packing and Marking (AN-Mk 230 Mod 4):

Fuze Container - One fuze is packed in a cylindrical metal container five and eleven-sixteenth inches maximum diameter and 16".05 maximum length. The weight of the fuze and container is 17.0 lb. The container is sealed, and is opened by a scored tear strip. The container is marked:

ONE HYDROSTATIC BOMB FUZE AN-MK 230 MOD 4, USN
LOT NO. YEAR OF MANUFACTURE
NAME OF MANUFACTURER
INSPECTOR

Fuze Container Crate - Four fuzes in fuze containers are packed in a metal fuze container crate approximately 11".56 x 11".56 x 16".54 high. The weight of the crate including the fuzes is approximately 74.5 lb. The top of the crate is marked:

4 HYDROSTATIC BOMB FUZES AN-MARK 230 MOD 4
LOT NO. NAME OF MANUFACTURER
YEAR OF MANUFACTURE
CONTRACT NO. INSPECTOR'S INITIALS
NET WEIGHT LBS. GROSS WEIGHT LBS.

General:

Safety features, handling, safety precautions, installation and servicing instructions are the same for the Mark 229 Mod 3 and the AN-Mark 230 Mod 4 as for previous mods.

- - - - - - - - - - -

C O N F I D E N T I A L

ACCIDENTAL EXPLOSIONS OF MK 229 AND AN-MARK 230 MOD 3 FUZES

The following is an excerpt of a report from Ensign J. R. Roach, Bomb Disposal Officer, dated 20 March 1944:

> "On May 10, R. E. Stewart, AOM1c, petty officer attached to this unit, was injured when the detonator of a Mk 229 fuze he was disassembling for instruction purposes exploded. Stewart suffered severe cuts on the face and hands and because possible injury to the right eye was feared he was taken by plane to Base Hospital #6 at Espiritu Santos. According to reports he is recovering satisfactorily with no permanent injury and will rejoin the unit early in June. . . . . detonation occurred upon the removal of the safety rod, following the removal of the booster . . . . ."

A report from the Bomb Disposal Officer, FIFTH Naval District, covers an accidental explosion which occurred during the routine disassembly of the explosive elements and firing assembly of an AN-Mark 230 Mod 3 bomb fuze. The fuze was being disassembled so that the booster could be inserted in a specially prepared fuze for static firing purposes.

The ordnance man disassembling the fuze stated that the explosion occurred when he attempted to unscrew the booster sleeve from

the fuze proper and that he had inspected the fuze externally prior to beginning disassembly and had ascertained that the shipping safety rod (See Fig. 6), was in place. He was unscrewing the booster sleeve with a 14" pipe wrench held in his right hand and was steadying the fuze in the vice with his left, and only about three to five threads of the booster sleeve remained in the fuze when explosion resulted. A portion of his right hand was blown off. The fuze and fragments are shown in Fig. 7.

Contrary to the above statements made by the ordnance man, it was the opinion of the Bomb Disposal Officer that the explosion did not occur as the booster sleeve was unscrewed. All evidence indicated that the booster sleeve had been successfully removed prior to the explosion and that the ordnance man had neglected to unscrew and remove the firing point from the base of the plunger housing and that he then removed the safety rod allowing the firing plunger to impinge upon the firing point and cause explosion of the detonator, lead-out, lead-in and relay charges.

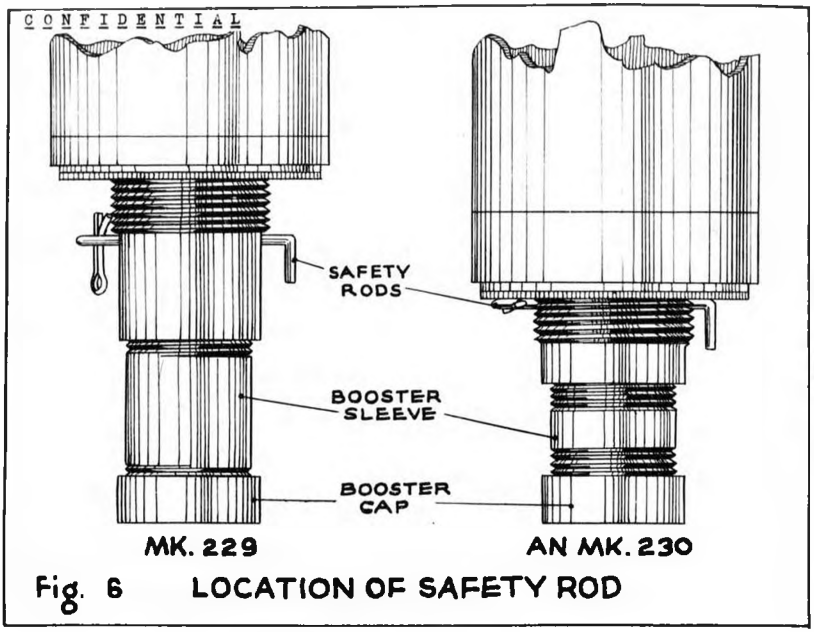


Fig. 6 LOCATION OF SAFETY ROD

The Bomb Disposal Officer in a subsequent letter recommends that the School "make sure that they (Instruction Department) are telling all our budding geniuses not (repeat) not to take out the booster sleeve of a Mark 229 or 230 type fuze without making certain that the safety rod is in position. If they do, it will fire . . . . . and you don't notice the holes for the safety rod either because there is a heavy rubber gasket around the booster sleeve that covers up the holes once the rod has been pulled out."

From the experience gained by the Bomb Disposal Officer in the above report, it cannot be impressed upon all hands too strongly that both the Mark 229 and the AN Mark 230 fuzes are potentially dangerous, especially when these fuzes must of necessity be disassembled. According to

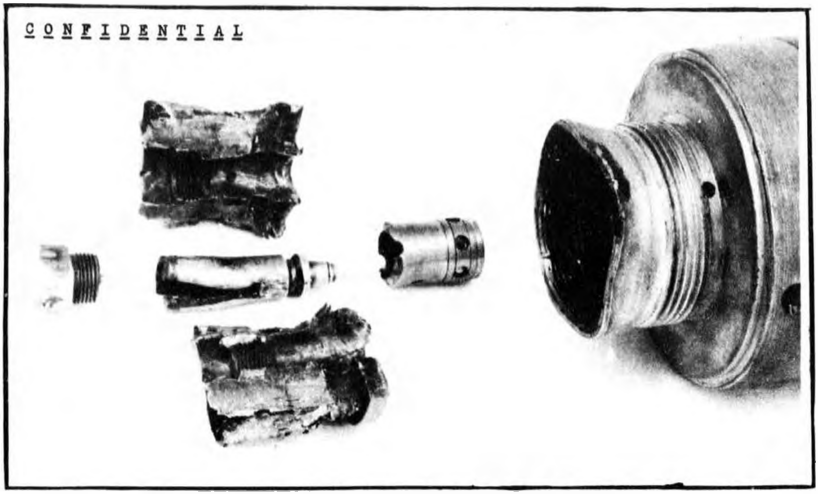


Fig. 7 . Fragments of accidental explosion of firing train (less booster) in AN-Mk 230. Booster was removed but firing point should have been unscrewed before safety rod was pulled out.

OP No. 988 "Bomb Fuzes", the only authorized disassembly operation is the removal of the delay arming mechanism sub-assembly. To remove this mechanism, perform the following operation in the order indicated:

"(1) Insert the safety rod to lock the firing plunger to the plunger housing, if this rod has been removed.

"(2) Remove machine screws holding arming mechanism housing to body sleeve and remove delay arming mechanism sub-assembly.

"(3) Unscrew detent retaining cup, from arming shaft.

"(4) Remove machine screws holding arming mechanism housing to gear carrier support. Remove gear carrier support by pulling on arming shaft."

In order to help overcome the hazardous condition of the fuzes, the Bureau of Ordnance has made arrangements to affix the following label on fuzes in current production:

"This is a loaded fuze and hence inherently dangerous. No disassembly or adjustment by other than Bomb Disposal or other specially trained personnel is authorized except as described in OP No. 988."

To repeat for emphasis: Never attempt to unscrew the booster unless the safety rod has been inserted so that the firing plunger is locked in place. Before pulling out safety rod, unscrew the firing point.

- - - - - - - - - - -

REFERENCE: (1) Letter of Bomb Disposal Officer, FIFTH Naval District ND5(32)/F41-6(3)/NT3-2 (Confidential) dated 5 June 1944.

(2) OP No. 988

* * * * * * *

MODIFICATIONS TO M123 SERIES LONG DELAY FUZES

New Glass Ampoule

The Army Air Forces recently sent out a dispatch to all air activities using the M123 series long delay tail fuzes requesting certain lots of the first 42,000 fuzes manufactured to be returned to continental United States. The reason for this action is the development of a new pyrex glass ampoule, which apparently is more resistant to shock and vibration than the older type which was made of ordinary glass.

Change in Anti-Withdrawal Device

Of the first 42,000 fuzes manufactured, approximately 3/4 of a turn was needed to function the booby trap. On later lots 1-1/2 turns is required which is deemed better in connection with anti-withdrawal action.

For purposes of replacing the ordinary glass ampoule with the pyrex glass type and modifying the ball locking device as above, the following fuze lots have been recalled;

M123 PAE 82, 83, 85, 86, 87, 101, 108, 109, 115, 118, 119, 120, 129

M124 PAE 27, 28, 30, 40, 41, 44, 46, 45, 52, 54, 58, 62, 80, 96, 99, 103, 107

M125 PAE 49, 50, 51, 63, 70, 72, 79, 81, 100, 106, 110, 111, 124, 125 126

Staking Body Extension to Body

As is undoubtedly well known by ordnance personnel working with the 123 Series fuzes, the arming mechanism involves a pinion gear which is carried (by rotation of the arming vane) in a circular path around the rims of two larger gears, one of which has 30 teeth and the other 29 teeth. The 30-tooth gear is attached through the arming stem which screws into the fuze to first break the ampoule and to later jam a steel collar against a rubber washer to seal the fuze. The 29-tooth gear is attached indirectly to the fuze body itself so that this gear does not normally rotate but provides the differential motion with respect to the 30-tooth gear which results in a 30 to 1 reduction in the overall mechanism.

According to recent reports, when the rotation of the arming stem is stopped at the completion of fuze's arming and sealing, the pinion gear generally continues to travel around its path grinding off the teeth on the two larger gears. There is enough occasional gear engagement or friction to cause a rather indeterminent torque which sometimes causes the arming stem to unscrew from the fuze and sometimes tends to cause the fuse to unscrew from the adapter booster. This action has been definitely observed in wind tunnel fuze arming tests and has been further corroborated by recovery of a fuze from a proving ground acceptance test in which the arming stem had unscrewed down far enough to break the ampoule and had subsequently unscrewed to the full extent permitted by the component dimensions and caused the fuze to fire prematurely, giving aerial burst.

In order to overcome this phenomena, when using fuzes already in the field other than those lots listed above, each fuse will be modified by pinning the body extension of the fuze to the body by the use of two steel shear pins which will prevent the separation of the two parts. (See Fig. 8). In the event an attempt is made to remove the fuze with a wrench or other bomb disposal methods, the shear pins will shear and cause the anti-withdrawal mechanism to function before the locking ball crushes. (While the pins will shear at 500 inch/lbs, the ball locking device requires a torque of 750 inch/lbs.)

Knurled pins, twist drills, and drill jigs needed for these field modifications will be supplied in the form of kits. Each kit contains instruction sheet, one drill jig, twelve drills and 1000 pins sufficient for modifying 500 fuzes. The pins are .65 inches long and .101 inches in diameter, with one end knurled 1/16 inch long. A number 38 drill is used. Briefly, the instruction sheet states that two holes,

.20 to .25 inches deep, are to be drilled into the body extension on the same level with the .1015 safety clip hole present in the fuze 180 degrees apart. The pins, with knurled ends up, are then pressed into place. As the end of the pin has the same radius as the surface of the fuze, the pin should be flush with the fuze surface. If not, the end of the pin should be filed flush. (See Fig. 8).

Current Production:

Fuzes which are being manufactured at present are staked at the factory. The first lots of pinned fuzes have shear pins fitted loosely in their holes and are held in place by a strip of transparent (Scotch) tape which is not to be removed. Later lots of the fuzes are assembled with press fitted knurled pins. These two types of pinned fuzes retain the M123 series designation and are suitably tagged.

C O N F I D E N T I A L

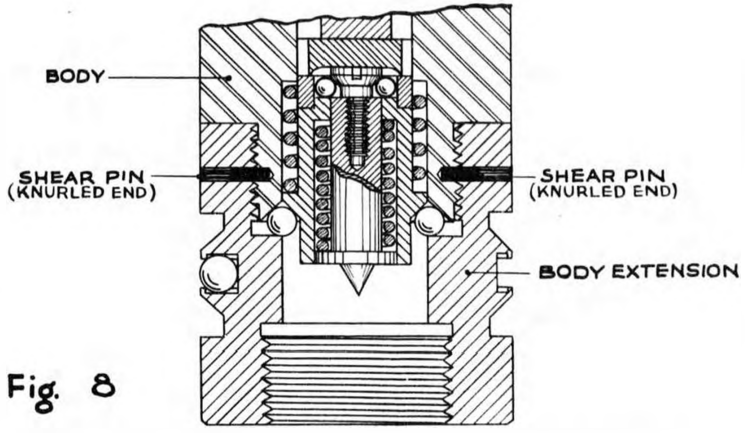


Fig. 8

MODIFIED M123 SERIES SHOWING BODY EXTENSION PINNED TO BODY

New Type Arming Vane:

Since the reduction gear arming mechanism has proven to be unsatisfactory, on future production commencing approximately August 1, a revision of the arming mechanism will be made. The reduction gears are to be eliminated and a direct drive arming mechanism is to be substituted using an eight bladed vane. The first modified fuzes will utilize the present type of stem cup and later production will have modified stem cup. Both types will have the eight bladed vane and are designated M123-A1 series.*

* Originally, the M123-A1 designation was reserved for the modified M123 series fuzes incorporating the copper sylphon bellows, similar to those used in the M132 series fuzes. However, the M123 series fuzes with sylphon bellows are still undergoing tests and it is not known what the exact designation of these fuzes will be when standardized.

Action by BuOrd:

The Bureau of Ordnance has recommended that sufficient kits be obtained from the Army to modify all the fuzes the Navy has on hand for current use. In a letter (Re2b) F51-6(1) dated 24 May, signed by G. F. Hussey, Jr., W. B. Moore, by direction, the Bureau states its future plans for the M123 series fuzes: "It is contemplated that this fuze (M123 series) will be withdrawn from use by naval forces at the earliest possible moment upon completion of development, manufacture and distribution of the Navy long delay fuze which is now being tested." When details on this new fuze are available, they will be published in the Bulletin.

* * * * * * * * * * *

R E S T R I C T E D

THE T56E1 (M136) MECHANICAL TIME NOSE FUZE

The T56E1, Fig. 9, shortly to be standardized as the M136, is a combination of the M111A2 mechanical time fuze and the AN-M103 nose fuze. The fuze is essentially the same as the M135 described in AFEO Bulletin No. 3, page 18*. The only difference between the two is that the T56E1 can be set for a delay of from 5 to 30.6 seconds, while the M135 has a setting range of from 5 to 92 seconds. The T56E1 was developed to provide greater accuracy, presupposing that a method can be devised for accurately measuring the altitude of release. Functioning can be expected to be accurate within plus or minus .3 seconds.

Description:

The mechanical time portion of the fuze contains the time graduations, the time set screw, the striker, safety block vane and arming pin. The time graduations range from 5 to 30.6 seconds, calibrated every .2 second and numbered chronologically from 1 to 30 seconds. Unlike the M135, no vernier scale is provided.

The striker stop, which is located between the striker and the safety collar, prevents the safety collar from falling out prematurely. The striker stop must not be removed from the fuze until the arming wire has been installed in the bomb rack.

The arming pin, which is held by a safety cotter pin during shipment and by the arming wire when installed in the bomb rack, starts the time mechanism at the moment the bomb is released and the arming wire is withdrawn from the fuze.

The body and booster portion of the fuze are a modified version of the AN-M103 fuze. The setting pin has been replaced by a spring loaded arming stem release pin. The arming stem release pin is held by a safety cotter pin during shipment and by the arming wire when its function is to hold down the arming stem.

Function:

Briefly, the fuze operates as indicated below after the arming wire is withdrawn:

(1) The vane lock is released and the vane starts to rotate.

---

* In AFEO Bulletin No. 3, page19, it is stated erroneously that the M135 will fire accurately to within .4 seconds. This figure should have been plus or minus one (1) second. It was further stated that the T56E1 would fire accurately to within .1 second. This is also incorrect, and as indicated above, will fire accurately to within plus or minus .3 second. The greater accuracy in the T56E1 is achieved by an improved clockwork mechanism.

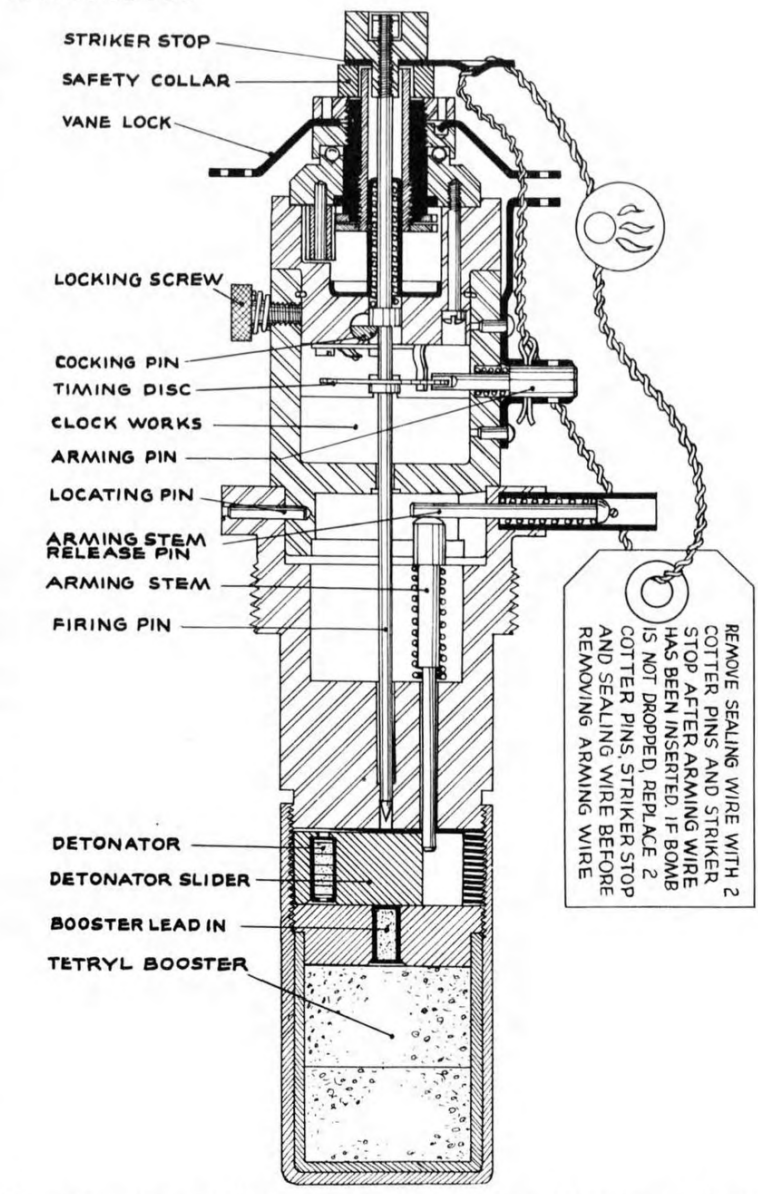


Fig. 9 T56 E1 (M136) MECHANICAL TIME NOSE FUZE

(2) The arming pin is ejected and the time mechanism starts to function.

(3) The arming stem release pin is ejected, allowing the arming stem to move upwards thereby permitting the detonator slider to move over into the armed position.

(4) After approximately 750 ft. of air travel the safety collar is released from the fuze and the time mechanism is then free to function according to the time set on the fuze. At the moment the time expires, the spring loaded firing pin is forced down to strike the primer and detonate the bomb.

The bomb may detonate if it strikes a target prior to completing the function of the time mechanism provided the arming wire has been withdrawn.

General:

The T56E1 can be used in any G. P. bomb in which the AN-M103 fuze will fit. Installation, stowage, and packing are the same as for the M135.

- - - - - - - - - - -

REFERENCE: Ordnance Department Drawing No. 73-8-215

* * * * * * * *

UNCLASSIFIED

M138 MECHANICAL TIME NOSE FUZE

(NOTE: On page 18, AFEO Bulletin No. 3 the M127 fuze was referred to as the former T39E1. This is in error as the M127 was originally the T39. A correction should be made accordingly.)

General:

The T39E1 has been standardized by the Army as the M138, mechanical time nose fuze. This fuze consists essentially of the metal parts assembly of the M111A2 mechanical time flare fuze with the booster and detonator components of the AN-M110A1 nose fuze. The only difference between the M127 and the M138 is the amount of tetryl in the booster cup. While the M127 has 18 grams, the M138 has only 7 grams, the balance of the space being taken up by an inert clay pellet.

The M138 was developed for use primarily in the E6R2 aimable incendiary cluster (See AFEO Bulletin No. 5, page 26). The Chemical Warfare service had originally planned to use the M127 in this cluster as well as in the M17A1. However, tests indicated that the M127 booster was too powerful when used in the E6R2 and damage to the incendiary bombs in the cluster resulted. The M138 was tested in the E6R2 cluster and pronounced satisfactory.

Setting:

Loosen the time set screw. Turn the time graduation scale until the necessary setting is opposite the index mark on the fuze body. The fuze may be set to function and open the cluster at any desired time from 5 to 92 seconds after release of the cluster from the aircraft. Tighten the time set screw.

Installation:

Precaution:

The M138 fuze when installed in the 500-lb. aimable incendiary cluster may function due to crushing if dropped from a distance of one to two feet. Therefore, the fuze should be assembled to the cluster only after the cluster is locked in place in the bomb rack.

UNCLASSIFIED

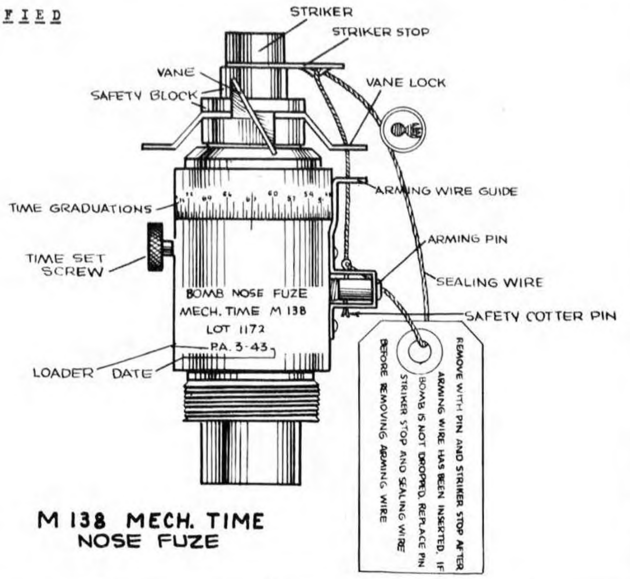


FIG. 10 M 138 MECH. TIME NOSE FUZE

a. Installing Arming Wire in Fuze. The arming wire should be inserted in the fuze before the fuze is screwed into the cluster. (Contrary to normal procedure, this is recommended by the Chemical Warfare Service because it is very difficult to thread the arming wire around the blunt nose of the cluster and then insert it through the arming wire holes of the fuze.)

(1) Thread the free end of the arming wire through the arming pin, the arming wire guide, and the vane tab.

(2) Adjust the arming wire to extend approximately 3 inches in front of the vane tab.

b. Fuzing Cluster.

(1) Remove the nose closing plug from the cluster and inspect the fuze cavity to see that it is clean.

(2) Screw the fuze into the fuze cavity and tighten handtight. Remove all kinks and burs from arming wire. Attach safety clip to arming wire to prevent it from being withdrawn from fuze.

(3) Check to see that the arming pin points in the same direction as the suspension lugs. If it does not, loosen the fuze and insert paper or cardboard shims between the fuze and the nose of the cluster so that when the fuze is hand-tightened the arming pin and suspension lugs point in the same direction.

(4) Uncoil the arming wire and connect the swivel loop of the arming wire to the bomb rack. Do not pass the arming wire through the front suspension lug.

(5) Check the time setting on the fuze to make sure it is correctly inserted in the fuze.

(6) Remove the sealing wire together with the striker stop and cotter pin attached to it. If the safety block falls out, no attempt will be made to use the fuze. It should be destroyed.

Shipping and Packing:

Fuzes are packed in individual metal containers, fifty per wooden box, which weigh 100 pounds.

- - - - - - - - - - -

REFERENCE: TB9-1980-21
Ordnance Committee Item No. 23768

* * * * * * * *

U N C L A S S I F I E D

T66 AND T67 NOSE FUZES

The T66 and T67 nose fuzes (in the process of being standardized as the M139 and M140 respectively) are similar to the standard AN-M103. The T66 will incorporate a .01 second delay while the T67 will have a .025 second delay. In order to distinguish these fuzes from the AN-M103, the vane cup will have a segment painted on it which corresponds to the present painting on the base of the M14 primer detonator. In each case the painted segment will be black, the T66 having a 1/8 and the T67 a 1/4 segment.

Both new fuzes will retain the standard instantaneous setting and functioning is the same as the AN-M103.

These fuzes were developed with a shorter delay than .1 second to provide companion fuzes for the AN-M100A2 series using M14 primer detonators with delays of .01 second or .025 second.

Both fuzes are currently being manufactured.

* * * * * * * *

R E S T R I C T E D

MARK 157 DELAY BASE FUZE FOR ROCKETS

The Mark 157 is a delay base detonating fuze primarily used for 5"0 aircraft rockets. It is essentially a base fuze, Mark 146, in which the shutter and firing pin have been changed to accomodate a delay detonator which includes a delay element of .02 seconds. In all other respects -- appearance, method of arming and functioning-- it is identical to the Mark 146 fuze (See page 19, AFEO Bulletin No. 2). The sensitivity of the Mark 157 base fuze is somewhat less than that of the Mark 146 fuze since the percussion type primer caps used in delay explosive trains are inherently less sensitive than the stab type primer caps in instantaneous detonators. Every effort is being made to increase the sensitivity of this fuze as much as possible.

- - - - - - - - - - -

REFERENCE: Buord Circular Letter AV-15-44

* * * * * * * *

MISCELLANEOUS

C O N F I D E N T I A L

AN-M103 NOSE FUZE RESTRICTED FOR CARRIER USE

Although malfunctioning of the AN-M103 nose fuze has been reported in the past, an accident recently occurred which in the future will restrict the use of this fuze aboard carriers. A plane returning with its bomb load lost one of its bombs due to a rough landing, with the result that one of the bombs having an AN-M103 nose fuze broke loose from its shackle and in tumbling over the deck detonated.

Because of this accident, the Bureau of Ordnance sent out confidential dispatch #292126. In this dispatch the Bureau recommends as an alternative fuzing arrangement the Mark 219 with the Mark 4 booster and an adapter. The AN-M103, however, is not completely restricted. The dispatch goes on to state that the AN-M103 is to be restricted only when it is expected that a flight will return with its bomb load to the carrier. If it is expected that the mission will be accomplished and that all bombs will definitely be released, the AN-M103 fuze may still be used.

* * * * * * * * * *

R E S T R I C T E D

PREMATURE ARMING OF MK 137 FUZE

1. During recent tests fuzes Mark 137, Mod 1 from lots 1-65 inclusive, were found frequently to arm in the launcher, when adjacent rocket charges were fired. To prevent this, the following instructions are to be followed by all personnel handling these fuze lots in service.

(a) Before each fuze is installed in the rocket, examine it to see if the arming vane is for any reason unscrewed enough so that the forward tips of the vanes extend out beyond the plane of the rim of the vane guard. If a fuze is found in this condition, it should be considered armed, the vanes should be taped so that they cannot be moved, and the fuze should be disposed of by lowering the fuze into deep water.

(b) After each fuze has been examined as in 1(a) and the vanes have been found to be below the rim of the vane guard, remove the safety wire and try to turn the vanes in a clockwise direction (when the fuze is viewed from the nose) to see if the vanes are locked by the vane locking pin. Do not turn the vanes more than one-half a turn. If the vanes can be turned, consider the fuze armed and dispose of it as in 1(a). If the vanes cannot be turned in the clockwise direction, try to turn them in the opposite direction; if the vanes cannot be turned, replace the safety wire and the fuze is safe for use. If the vanes can be turned counterclockwise, turn them one-half a turn and see that the vane locking pin snaps into the nearest hole in the vane hub. Then replace the safety wire and the fuze is safe for use.

2. The sealed metal containers in which these fuzes are shipped should not be opened for the sole purpose of checking the fuzes. Rather it should be done at the time the cans are opened preparatory to installing the fuze in the rocket body.

3. A summary of the Mark 137 fuze may be found in AFEO Bulletin No. 3, Page 28. It should be studied thoroughly before the above procedure is begun.

4. Should a fuze be found armed in a 4"5 Rocket Charge, do not attempt to remove the fuze but carefully tape the vanes so they cannot turn and dispose of the complete round by gently lowering into deep water.

5. IN ANY OPERATION INVOLVING FUZING, UNFUZING, ASSEMBLY, DISASSEMBLY, CLEANING, PAINTING, ET., OF ALL TYPES OF MUNITIONS, THE WORK SHALL BE ACCOMPLISHED IN THE MOST SUITABLE LOCATION, TAKING INTO ACCOUNT SAFE REMOVAL FROM OTHER EXPLOSIVES AND POSSIBLE DAMAGE TO VITAL INSTALLATIONS, AND SHALL INVOLVE EXPOSING THE SMALLEST NUMBER OF ROUNDS PRACTICABLE. ONLY THOSE PERSONS ACTUALLY ESSENTIAL FOR THE WORK SHALL BE IN THE VICINITY. THE IDEAL SITUATION WOULD BE THAT WHERE WORK WOULD BE PERFORMED ON ONLY ONE ROUND AT A TIME, IN A LOCATION ON DECK, REMOTE FROM ALL MAGAZINES, FROM READY STOWAGES, FROM OTHER SUPPLIES OF AMMUNITIONS OR EXPLOSIVES, AND FROM VITAL INSTALLATIONS.

- - - - - - - - - - -

REFERENCE: Bureau of Ordnance Circular Letter A10-44

* * * * * * *

C O N F I D E N T I A L

MODIFIED U. S. BOMBS FOR BRITISH AIRCRAFT

The following bombs, according to British Air Ministry instruction No. 673, dated 29 April 1944, have been modified for use on British aircraft:

1000 lb. G. P.	AN-M44 and AN-M65
500 lb. G. P.	AN-M43 and AN-M64
250 lb. G. P.	AN-M57

The bombs are similar to the standard types except that the tail units are of the drum type secured by the usual American type locking ring. Tail unit No. 55 Mk. I, measuring 18"5 x 18"8 is fitted to the 1000 lb. bombs and tail unit No. 54 Mk. I, measuring 14"0 x 14"2 to the 500 lb. bombs. The 250 lb. bomb has the normal American tail unit.

The bombs are fuzed with the appropriate American tail fuzes, but the pistol bomb nose D. A. No. 52 Mk. I, with a special exploder adapter is used in the nose.

* * * * * * * *

R E S T R I C T E D

FUZING AND UNFUZING OPERATIONS ON BOARD SHIP AND IN THE FIELD

Reference: (a) U. S. Navy Regulations 1920, Article 972 (18)
(b) U. S. Navy Regulations 1920, Article 972 (104)

1. Reference (a) prohibits the removal of fuzes from projectiles on board ship without explicit instructions from the Bureau of Ordnance. Prior to the present war, no occasion presented itself when it became necessary to issue such explicit instructions.

2. With the advent of the High Capacity Projectile, where provision was made for alternate fuzing with either a point detonating fuze, a time fuze, or a steel plug, it became necessary to authorize fuzing and unfuzing of these projectiles on board ship.

3. With the further advent of rocket-type ammunition and projector charges, it was again necessary to authorize fuzing and unfuzing on board ship. The explosive heads of 4"5 barrage rockets, and 7"2 rockets, and 7"2 projector charges, place these definitely in the bomb-type ammunition category. They are fuzed in a manner similar to bombs.

4. Reference (b) sets forth certain precautions as regards the fuzing of bombs.

5. (a) The following general prudential rule, which is dictated by common sense and the understanding that ammunition is, by its very nature, potentially destructive, is promulgated:

> IN ANY OPERATION INVOLVING FUZING, UNFUZING, ASSEMBLY DISASSEMBLY, CLEANING, PAINTING, ETC., OF ALL TYPES OF MUNITIONS, THE WORK SHALL BE ACCOMPLISHED IN THE MOST SUITABLE LOCATION, TAKING INTO ACCOUNT SAFE REMOVAL FROM OTHER EXPLOSIVES AND POSSIBLE DAMAGE TO VITAL INSTALLATIONS, AND SHALL INVOLVE EXPOSING THE SMALLEST NUMBER OF ROUNDS PRACTICABLE. ONLY THOSE PERSONS ACTUALLY ESSENTIAL FOR THE WORK SHALL BE IN THE VICINITY. THE IDEAL SITUATION WOULD BE THAT WHERE WORK WOULD BE PERFORMED ON ONLY ONE ROUND AT A TIME, IN A LOCATION ON DECK, REMOTE FROM ALL MAGAZINES, FROM READY STOWAGES, FROM OTHER SUPPLIES OF AMMUNITION OR EXPLOSIVES, AND FROM VITAL INSTALLATIONS.

(b) High Capacity gun projectiles are all fitted with auxiliary detonating fuzes in addition to nose fuzes. These auxiliary detonating fuzes provide an additional safety gate between fuze and filler, and the gate is not open without a high rate of spin. In view of this fact, authority is hereby granted to perform the work necessary in connection with the alternate nose fuzing of High Capacity gun projectiles in regular projectile handling spaces.

(c) The rule quoted in subparagraph (a) above is primarily for the guidance of "using" or "operating" personnel afloat and ashore. Naval Ammunition Depots and Magazines are operated in accordance with established depot procedures by skilled personnel.

- - - - - - - - - - -

REFERENCE: Bureau of Ordnance Circular Letter A16-44

* * * * * * * *

SUGGESTED READING

(NOTE: It is assumed that personnel in the field doing ordnance or directly related work are making an effort to keep themselves informed by reading all pertinent publications which are available to them. While the AFEO Bulletin is designed to keep personnel abreast of latest developments there are certain Ordnance Pamphlets, Circular Letters and other reading matter which for lack of time and space cannot be reprinted in the Bulletin. In order to notify interested individuals that such publications are available, the following "Suggested Reading" is included in this issue and will be a permanent section in subsequent Bulletins. "Suggested Reading" includes those items, which in the opinion of the School contain particularly important comments in the ordnance field.)

(1) BuOrd Circular Letter AV11-44 dated 5 May 1944 - "Torpex Loaded Munitions". (Restricted)

This circular letter contains a comprehensive study on the subject of Torpex, including its sensitivity to bullets and fragments, shock, and heat; sympathetic detonation and stability in stowage, etc.

(2) BuOrd Circular Letter A27-44 dated 17 April 1944 - "Return of Ammunition to Continental United States". (Restricted)

As the title of this letter implies, important details concerning the return of expended cartridge cases, brass scrap and other inert ammunition components is fully covered.

(3) BuOrd Circular Letter T6-44 - "Aircraft Torpedoes - Summary of Recent Information On". (Confidential)

This letter is intended to bring the service up to date in regard to recent developments in connection with current usage of aircraft torpedoes.

(4) Ordnance Pamphlet No. 1165 dated 12 April 1944 - " 3.5 Rocket Ammunition Assembly No. 10 and 3.5 Rocket Launcher Mark 1." (Confidential)

This Ordnance Pamphlet contains a description of an assembly and operating instructions for the rocket ammunition assembly No. 10 and 3.5 rocket launcher Mark 1. Assembly No. 10 consists of 3.25 rocket motor Mark 12, and the 3.5 rocket body Mark 10. The rocket body Mark 10 is loaded with rocket body load Mark 1, the load consisting of a quantity of tinfoil coated paper strips for use in connection with anti-radar. The launcher Mark 1 is a shipboard installation.

(5) Ordnance Pamphlet No. 1118 dated 28 January 1944 - "Instructions for Installation of Mines in Aircraft". (Restricted)

This publication contains instructions and illustrations covering the installation of mines Mark 12 Mod 1 and 4, Mark 13 and modifications, Mark 25, and AN Mark 26 Mod 1 in U. S. Army and Navy aircraft. These instructions are based on present designs, mines, aircraft bomb racks and shackles and similar equipment. They should, therefore, be generally applicable to most installations of mines in aircraft bomb and torpedo racks.

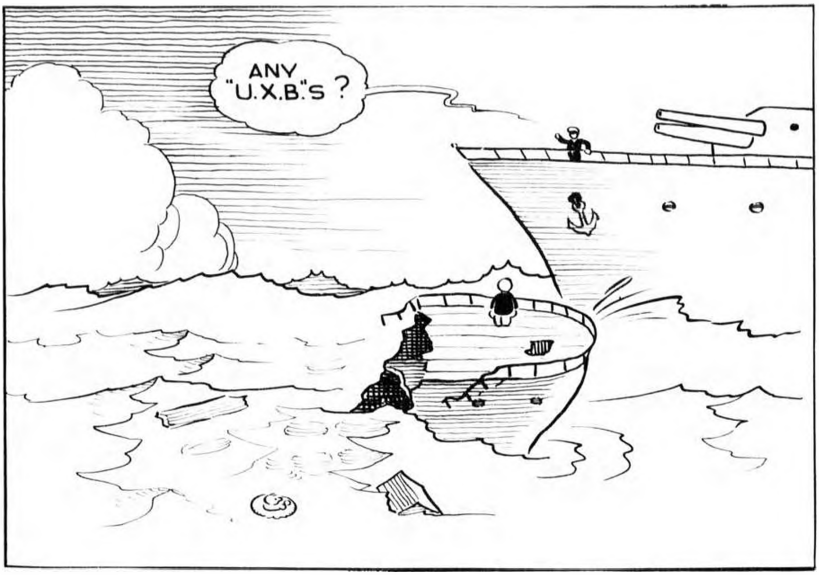
(6) Ord 677 dated October 1943 - "Mine Mark 35 - Description and Instructions for Use". (Confidential)

Ord 677 is a new publication which does not supersede any ordnance pamphlet now in use. This pamphlet contains a description of the Mark 35 mine and instructions for its assembly, testing and planting. It is a small vibration actuated land mine designed primarily for damaging railroad tracks and equipment. It may also be used in other locations subject to heavy vibrations, such as that caused by tanks, trucks or other heavy vehicles.

Briefly, the specifications for the Mark 35 mine are:

(a) Weight of assembled mine, 9 pounds.
(b) Weight of explosive charge, 5 pounds.
(c) Length of mine case, 14-5/8 inches.
(d) Diameter of mine case, 4-1/4 inches.

* * * * * * * *



C O N F I D E N T I A L

BOMBARDMENT OF PACIFIC ATOLLS

Recent operations have afforded an opportunity for Bureau representatives to study at first hand the general effect of various types of ammunition used in bombarding Jap shore installations on certain Pacific atolls. The following random generalizations based on Tarawa and Kwajalein observations are apparent:

(a) The Japs had sufficient heavy concrete shelters and underground retreats to provide general protection for the bulk of their personnel against bombardment with instantaneously fuzed ammunition.

(b) Due to the relatively small weight of filler in HC ammunition in comparison to the amount of filler in bombs, the degree of damage inflicted on non-concrete air field surfaces during a bombardment is not impressive. However, the damage done to parked planes and hangars is most impressive.

(c) It is difficult to set wooden structures on fire with naval gunfire. However, there are incendiary types of aircraft ammunition which are effective for this purpose.

(d) In the small pill boxes and machine gun emplacements observed at Kwajalein the concrete was of poor quality and a direct hit, even by 5" AA Common, resulted in lethal damage.

(e) 5" projectiles will detonate by base fuze action on direct impacts with palm tree trunks of about 8" and larger diameter. This results in air bursts which are especially hazardous to personnel who may be in fox holes or trenches.

(f) Although there was a complicated labyrinth of trenches around the periphery of Kwajalein Island, there were very few dead Japs in them, indicating that during prolonged bombardment they retired to covered shelters.

(g) The Japs made little attempt to conceal heavy gun emplacements (5"5 twins and larger) making them conspicuous from the air and hence especially vulnerable to bombing. Air reconnaissance readily revealed these emplacements so that they became easy targets for subsequent gunfire.

(h) By far the greater portion of Jap defensive positions were located within 50 yards of the shoreline, which condition was of interest in making out bombardment plans. Heavy concrete structures further inshore than this were usually air raid shelters, gun emplacement shelters, ammunition dumps, command posts, etc., which serve well as snipers' positions but were not intended as primary defensive positions.

(i) The damage done to a heavy concrete structure by a major caliber AP projectile, whether it detonates or not, is impressive.

The Bureau recommends that common type projectiles when available, or AP, rather than HC with steel nose plugs and non-delay base fuzes, should be used when heavy emplacements can be taken under direct fire. Conversely, HC should be used for general area bombardment with an adjusted percentage of steel nose plugs or nose detonating fuzes, depending on the nature of the target area. With the nose fuze instantaneous detonation can be expected on tree tops or very light structures. With the steel nose plug the slight inherent mechanical delay of the base fuze will control.

The Bureau feels that the destructive effect of steel nose plugged HC ammunition will be increased by adding a short delay element to the slight inherent delay mentioned above, (i.e. slight inherent mechanical delay of base fuzes in contrast to point detonating fuzes.) Accordingly all 8" to 16" HC ammunition will shortly be issued with base fuzes Mark 48 . . . . . Further it is expected that HC projectiles with base fuzes Mark 48 will probably be more effective than AP projectiles against the vast majority of targets.

The Mark 48 base detonating fuze is a member of the "20" series and is a Mark 39 fuze with a .01 second delay element added. The Mk 39 in turn was formerly designated the Mark 28S (S in this case standing for Special) and was marked by a green stripe. Thus the Mark 48 base detonating fuze is essentially a Mark 28 with weaker springs behind the detents and with an added .01 second delay element.

- - - - - - - - - - -

REFERENCE: Ordnance Information Bulletin No. 1-44, Paragraphs 140, 141, 142.

* * * * * * * *

C O N F I D E N T I A L

REPORT OF ACCIDENT USING THE AN-M1A1 FRAGMENTATION BOMB CLUSTER

According to a recent report, a TBF loaded with twelve AN-M1A1 clusters of fragmentation bombs was catapult launched and during the launching one cluster was thrown through the tunnel of the plane. The cluster came apart and the bombs scattered. The arming vane on one bomb was rotated by the air stream coming in through a broken bomb bay window. The other bombs were jettisoned. The bomb which had been partially armed exploded about 150 feet below the plane. The other four bombs detonated on impact with the water. The sixth bomb failed to detonate because of a bent arming vane. The cluster adapter was jettisoned and hence no inspection could be made of it.

The report states further that both the shackles and the suspension lugs were tested before takeoff and found to be in excellent condition. The officer submitting the report was under the impression that the bomb which detonated 150 feet below the plane was detonated by air pressure on the VT10A1 nose fuze and he recommended a stronger spring be installed in this fuze and also that a more careful inspection of the lugs be made, particularly during catapult launchings.

As a result of the above accident, the Bureau of Ordnance sent out dispatch #031815 dated 3 May, to ComFairSouth, as follows: ". . . . all AN-M1A1 clusters with M1A1 cluster adapters are hereby restricted. All clusters having M1A2 cluster adapters are satisfactory . . . . . request all unsatisfactory clusters be turned in to nearest Naval Ammunition Depot."

* * * * * * * * * *

C O N F I D E N T I A L

LIMITING ANGLES OF FALL FOR THE FUNCTIONING OF PROJECTILE FUZES

Recent firing tests at the Naval Proving Grounds, Dahlgren, have brought out the following conclusions with regard to the functioning of projectile fuzes on ground impact:

(a) Point detonating fuzes Marks 29 and 30 type, function consistently when assembled in their appropriate projectiles on soft dirt or sand at angles of impact of 8° or above. Variation of striking velocity between 1500 fs and 2000 fs does not affect performance.

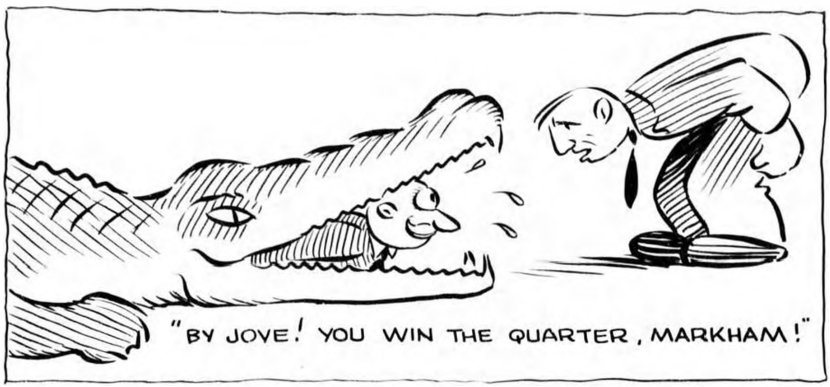
(b) The base detonating fuze Mark 39 in high capacity projectiles will function on soft sand at angles of impact down to 2° and striking velocities of about 1500 fs.

With regard to water impacts, projectile fuze behavior is known to be erratic due presumably to the random manner in which the projectile may strike the surface of waves. However, in general, at angles of fall of less than 12° to 13° consistent functioning at the first impact on water cannot be expected with point detonating or base detonating fuzes.

- - - - - - - - - - -

REFERENCE: Ordnance Information Bulletin No. 1-44, Paragraphs 143 and 144

* * * * * * *



PENETRATION OF ARMOR PIERCING AND SPECIAL COMMON PROJECTILES INTO REINFORCED CONCRETE

The Penetration Chart (Fig. 11) is a compilation of data received from a Dahlgren Report, No. 8-34, 24 December 1943.

It is based on Naval Proving Ground reports on reinforced concrete and all available data from the Army and the British performance of Armor Piercing and Common Projectiles against reinforced concrete of compressive strength of 5000 pounds per square inch. This reinforced concrete is the type likely to be encountered in fortifications. Somewhat greater penetration may be expected for reinforced concrete of the type normally used for structural purposes, the compressive strength of which is in the vicinity of 3500 pounds per square inch.

For a series of ranges, the chart gives the Angle of Fall and Striking Velocity (feet per second), both being taken from appropriate Range Tables, the thickness (feet) of reinforced concrete just completely penetrated (columns A and C) and the Depth of Penetration (feet) in massive slabs* (Columns B and D) at obliquities** of 0 degrees and 30 degrees. Also included in the chart are two additional tables, "Maximum Recorded Range" and "Sticking Limit". The Maximum Recorded Range column indicates the penetration data at the maximum ranges as listed in the above mentioned report from the Proving Grounds. The Sticking Limit column represents the minimum penetration (feet) wherein the projectile will probably stick in the target.

For Example: Taking a 14" Armor Piercing Projectile weighing 1500# and fired from a gun whose initial velocity is 2600 (feet per second), at a range of 30,000 yards --

(a) What thickness of reinforced concrete will be completely penetrated at (1) obliquity of 0 degrees; (2) obliquity of 30 degrees?

ANSWER: (1) 11 ft-6 in
(2) 8 ft-6 in

(b) What is the depth of penetration (feet) into a massive reinforced concrete slab, (1) obliquity of 0 degrees; (2) obliquity of 30 degrees?

ANSWER: (1) 8 ft
(2) 4 ft-6 in

(c) What is the minimum penetration (feet) into reinforced concrete wherein the projectile will probably stick in the slab?

ANSWER: 4 ft

The effect of the explosive in these projectiles toward increasing the penetration is negligible due to the small percentage of filler. The explosion can be expected to increase somewhat the size of the crater which for an inert projectile has a diameter of the order of 8 to 12 calibers. Both Armor Piercing and Common Projectiles will be effective against reinforced concrete at all striking velocities and obliquities obtained in service.

Armor Piercing and Common Projectiles are relatively ineffectual in producing craters in the ground and in removing earth or sand and log protective coverings from fortifications.

---

* See the table for a definition of "Massive Slabs".

** The Angle of Obliquity is the angle between the normal to the face of the target and the axis of the projectile at the point of impact.

Projectile	Total Weight	Range Table 0.2.30.
3"	13.0	861
4"	33.	178
5"	50.	185
5"	50.	183
5"	54.	551
6"	105.	560
6"	105.	563
6"	130	830
6"	130	834
8"	260	241
8"	260	22[illegible]
8"	335	80[illegible]
8"	335	85[illegible]
12"	870	16[illegible]
12"	870	16[illegible]
12"	1140	*
12"	1140	*
12"	1140	*
14"	1500	75[illegible]
14"	1500	74[illegible]
14"	1500	74[illegible]
16"	2240	72[illegible]
16"	2700	72[illegible]
16"	2240	72[illegible]
16"	2700	72[illegible]
16"	2700	72[illegible]

A Thickness

B Depth of
Massive S
pletely p
projectil
range of
striking
these con
under the
between *
depth of

* Based on
table.

AFEC Bulle[illegible]

CONFIDENTIAL

PENETRATION OF [illegible]R PIERCING AND COMMON PROJECTILES INTO REINFORCED CONCRETE

CONFIDENTIAL

FIG. 11

Projectile	Total Weight	Range Table O.P. No.	Initial Velocity	Range 2000 yds. E	Strik. Veloc.	Obliq. 0 deg. A	B	Obliq. 30 deg. C	D
3"	13.0	861	2700	1	2004	2	1½	1½	1
4"	33.	172	2500	1	1964	[illegible]	2	2½	1½
5"	50.	185	3150	1	2568	4½	3	3½	2
5"	50.	183	2300	1	1764	3	2	2½	1
5"	54.	551	2600	1	2141	4	3	3	1½
6"	105.	564	2800	1	2462	6½	4½	5	2½
6"	105.	563	2300	1	1986	5	3½	3½	2
6"	130	830	2500	1	2252	7	5	5	3
6"	130	832	2050	2	1812	5½	4	4	2
8"	260	243	2700	1	2476	10	8	7½	5½
8"	260	227	2300	1	2078	8	7	6	4
8"	335	807	2500	1	2325	11½	9	8½	5
8"	335	858	2000	2	1833	8½	6	6	4
12"	870	16[illegible]	2900	1	2694	19½	15	14½	8½
12"	870	169	2100	1	1917	12½	9½	9	5½
12"	1140	*	2500	1	2373	21½	16½	15½	9½
12"	1140	*	2300	1	2175	19	14½	14	8
12"	1140	*	1800	1	1687	13½	10	10	5½
14"	1500	752	2700	1	2551	25	19	16½	11
14"	1500	746	2600	1	2454	23½	18	17½	10½
14"	1500	754	1935	2	1828	15	11½	11½	6½
16"	2240	750	2520	1	2412	29½	23	22	13
16"	2700	770	2500	1	2409	36	26½	27½	15½
16"	2240	751	1935	2	1840	19	15	14½	8½
16"	2700	757	2300	1	2215	30½	23½	23	13½
16"	2700	758	1800	2	1727	21	16½	15½	9½

Projectile	Range 4000 yds. E	Strik. Veloc.	Obliq. 0 deg. A	B	Obliq. 30 deg. C	D	Range 6000 yds. E	Strik. Veloc.	Obliq. 0 deg. A	B	Obliq. 30 deg. C	D
3"	4	1409	1½	1	1	½	9	1045	1	½	1	½
4"	3	1525	2½	1½	2	1	8	1207	2	1	1½	½
5"	2	2068	3½	2½	2½	1½	4	1649	3	2	2	1
5"	4	1359	2½	1½	2	1	9	1106	2	1	1½	½
5"	3	1725	3	2	2½	1	6	1372	2½	1½	2	1
6"	2	2155	5½	4	4	2	4	1882	5	3	3½	2
6"	3	1713	4	3	3	1½	6	1460	3½	2½	2½	1½
6"	2	2019	6	4½	4½	2½	4	1799	5	4	4	2
6"	4	1592	4½	3	3½	2	7	1400	4	3	3	1½
8"	2	2267	9	8	6½	4½	3	2071	8	7	6	4
8"	3	1877	7	6	5	3½	5	1693	6	5	4½	3
8"	2	2156	10½	8	8	4½	4	1995	9½	7	7	4
8"	4	1679	7½	5½	5½	3	6	1535	7	5	5	3
12"	2	2500	17½	14	13	8	3	2318	15½	12½	12	7
12"	3	1753	11	8	8	4½	5	1608	10	7	7½	4
12"	2	2247	19½	15½	14½	8½	3	2124	18	14	13½	8
12"	2	2053	17	13	13	7½	4	1935	16	12	12	7
12"	4	1581	12	9	9	5	7	1481	11	8	8½	4½
14"	2	2409	22½	17½	17	10	3	2275	20½	16	15½	9
14"	2	2315	21	16½	16	9½	3	2134	19½	15	14½	8½
14"	4	1707	14	10½	10½	6	6	1603	13	9½	9½	5½
16"	2	2305	27½	21½	20	12	3	2200	25½	20	18½	11
16"	2	2322	33½	25	25½	14½	3	2237	31½	23½	23½	13½
16"	3	1749	18	14	13½	8	5	1662	17	13	12½	7½
16"	2	2131	28½	22	21½	13	4	2050	27	21	20	12
16"	4	1655	19½	15½	14½	8½	6	1586	18½	14½	14	8

Projectile	Range [illegible] E	Strik. Veloc.	A	B	C	D	Range 10,000 yds. E	Strik. Veloc.	Obliq. 0 deg. A	B	Obliq. 30 deg. C	D
3"	17	887	[illegible]	[illegible]	[illegible]	[illegible]	28	808	1	½	½	½
4"	14	1042	[illegible]	[illegible]	[illegible]	[illegible]	22	945	1½	1	1	½
5"	8	1[illegible]19	[illegible]	[illegible]	[illegible]	1	15	1107	2	1	1½	½
5"	16	987	[illegible]	[illegible]	[illegible]	[illegible]	25	912	[illegible]	1	1½	½
5"	11	1128	[illegible]	[illegible]	[illegible]	½	18	1003	2	1	1	½
6"	[illegible]	1647	[illegible]	[illegible]	[illegible]	1½	9	1447	3½	2	2½	1
6"	10	1291	[illegible]	[illegible]	[illegible]	1	14	1162	3	1½	2	1
6"	7	1600	[illegible]	[illegible]	3½	2	10	1428	4	3	3	1½
6"	11	1245	[illegible]	[illegible]	[illegible]	1½	16	1135	3	2	2½	1
8"	5	1890	[illegible]	[illegible]	5½	3½	7	1724	6½	5	5	3
8"	7	1527	[illegible]	[illegible]	4	2½	11	1366	5	4	3½	2
8"	5	1847	[illegible]	[illegible]	6½	3½	8	1708	7½	5½	6	3
8"	9	1408	[illegible]	[illegible]	5½	2½	13	1302	5½	4	4	2
12"	4	2150	14	11	10½	6½	5	1995	13	10	9½	5½
12"	8	1480	[illegible]	6	6½	3½	12	1369	8	5½	6	3
12"	5	2006	14½	12½	12½	7½	6	1893	15½	11½	11½	7
12"	[illegible]	1823	[illegible]	11	11	6½	8	1718	13½	10	10	6
12"	10	1392	10½	7½	7½	4	13	1314	9½	7	7	4
14"	4	2144	15	14½	14	8	6	2031	17½	13½	13	7½
14"	4	2063	18	13½	13½	8	6	1951	16½	12½	12½	7½
14"	8	1509	12	9	9	5	11	1426	11½	8½	8½	4½
16"	4	[illegible]	23½	16½	17	10½	6	2007	21½	17	16	10
16"	4	2154	[illegible]	22½	22	13	6	2074	27½	21½	20½	12½
16"	[illegible]	1579	16	12	11½	7	11	1501	15	11	11	6½
16"	5	1973	25½	20	19	11½	7	1900	24	19	18	11
16"	9	1522	17½	13½	13	7½	12	1460	17	12½	12½	7

Projectile	Range 15,000 yds. E	Strik. Veloc.	Obliq. 0 deg. A	B	Obliq. 30 deg. C	D	Range 20,000 yds. E	Strik. Veloc.	Obliq. 0 deg. A	B	Obliq. 30 deg. C	D
3"		-	-	-	-	-	-	-	-	-	-	-
4"		-	-	-	-	-	-	-	-	-	-	-
5"	31	967	1½	1	1½	½	50	1014	2	1	1½	½
5"		-	-	-	-	-	-	-	-	-	-	-
5"	40	950	2	1	1	½	-	-	-	-	-	-
6"	21	1131	3	2	2	1	37	1072	2½	1½	[illegible]	1
6"	30	1035	2½	1½	2	1	49	1085	2½	1½	[illegible]	1
6"	21	1154	3	2	2½	1	37	1102	3	2	2½	1
6"	32	1049	3	2	2½	1	54	1126	3	2	2½	1
8"	15	1391	5	4	4	2½	26	1197	4	3½	3	2
8"	22	1163	4	3	3	2	38	1121	4	3	3	2
8"	15	1415	6	4½	4½	2½	26	1248	5½	4	4	2
8"	26	1146	5	3	4	2	[illegible]	1145	5	3	4	2
12"	11	1671	10½	7½	7½	4½	18	1445	9	6	[illegible]	3½
12"	23	1185	7	4½	5	2½	39	1146	6½	4½	5	2½
12"	12	1651	13	9½	9½	5½	19	1482	11	8	8½	4½
12"	14	1502	11½	8	8½	5	33	1365	10	7	7½	4
12"	25	1189	8½	6	6½	3½	40	1184	8½	6	[illegible]	3½
14"	10	1766	15	11	11	6½	16	1611	13½	9½	10	5½
14"	11	1720	14½	10½	10½	6	17	1563	13	9	9½	5½
14"	21	1276	10½	7	7½	4	34	1221	10	6½	[illegible]	4
16"	10	1816	19	14½	14	8½	16	1629	16½	12½	12	7
16"	10	1892	23½	18½	17½	11	15	1740	21	16½	13½	9½
16"	19	1348	13½	9½	10	5½	31	1271	13	9	9½	5
16"	12	1733	22	16½	15½	9½	18	1604	19	14½	14	8½
16"	21	1337	15	11	11½	6½	33	1280	14½	10½	11	6

Projectile	Range 25,000 yds. E	Strik. Veloc.	Obliq. 0 deg. A	B	Obliq. 30 deg. C	D	Range 30,000 yds. E	Strik. Veloc.	Obliq. 0 deg. A	B	Obliq. 30 deg. C	D
3"	-	-	-	-	-	-	-	-	-	-	-	-
4"	-	-	-	-	-	-	-	-	-	-	-	-
5"	-	-	-	-	-	-	-	-	-	-	-	-
5"	-	-	-	-	-	-	-	-	-	-	-	-
5"	-	-	-	-	-	-	-	-	-	-	-	-
6"	[illegible]	1[illegible]6	2½	1½	2	1	-	-	-	-	-	-
6"	-	-	-	-	-	-	-	-	-	-	-	-
6"	[illegible]	1171	3	2	2½	1	-	-	-	-	-	-
6"	-	-	-	-	-	-	-	-	-	-	-	-
8"	40	1170	4	3	3	2	55	1250	4½	3½	3	2
8"	-	-	-	-	-	-	-	-	-	-	-	-
8"	39	1213	5	3½	4	2	55	1294	5½	4	4	2
8"	-	-	-	-	-	-	-	-	-	-	-	-
12"	28	1301	8	5	6	3½	39	1268	7½	5	5½	3
12"	-	-	-	-	-	-	-	-	-	-	-	-
12"	27	1383	10½	7½	7½	4	37	1353	10	7	7½	4
12"	31	1302	8½	7	7	4	46	1327	10	7	7½	4
12"	-	-	-	-	-	-	-	-	-	-	-	-
14"	23	1477	12½	8½	9	5	31	1435	11½	9	8½	4½
14"	25	1459	12	8½	9	5	34	1404	11½	8	8½	4½
14"	-	-	-	-	-	-	-	-	-	-	-	-
16"	24	1521	15½	11½	11½	6½	32	1472	15	11	11	6½
16"	21	1632	19½	15	14½	8½	28	1567	18½	14	14	8
16"	49	1312	13	9	10	5½	-	-	-	-	-	-
16"	25	1520	17½	13½	13	7½	34	1490	17	13	13	7½
16"	-	-	-	-	-	-	-	-	-	-	-	-

Projectile	Range 35,000 yds. E	Strik. Veloc.	Obliq. 0 deg. A	B	Obliq. 30 deg. C	D	Range 40,000 yds. E	Strik. Veloc.	Obliq. 0 deg. A	B	Obliq. 30 deg. C	D
3"	-	-	-	-	-	-	-	-	-	-	-	-
4"	-	-	-	-	-	-	-	-	-	-	-	-
5"	-	-	-	-	-	-	-	-	-	-	-	-
5"	-	-	-	-	-	-	-	-	-	-	-	-
5"	-	-	-	-	-	-	-	-	-	-	-	-
6"	-	-	-	-	-	-	-	-	-	-	-	-
6"	-	-	-	-	-	-	-	-	-	-	-	-
6"	-	-	-	-	-	-	-	-	-	-	-	-
6"	-	-	-	-	-	-	-	-	-	-	-	-
8"	-	-	-	-	-	-	-	-	-	-	-	-
8"	-	-	-	-	-	-	-	-	-	-	-	-
8"	-	-	-	-	-	-	-	-	-	-	-	-
8"	-	-	-	-	-	-	-	-	-	-	-	-
12"	-	-	-	-	-	-	-	-	-	-	-	-
12"	-	-	-	-	-	-	-	-	-	-	-	-
12"	49	1406	10½	7½	8	4½	-	-	-	-	-	-
12"	-	-	-	-	-	-	-	-	-	-	-	-
12"	-	-	-	-	-	-	-	-	-	-	-	-
14"	40	1434	11½	8	8½	4½	51	1507	12½	9	9	5
14"	44	1429	11½	[illegible]	8½	4½	-	-	-	-	-	-
14"	-	-	-	-	-	-	-	-	-	-	-	-
16"	41	1485	15	11	11	6½	52	1586	16	12	12	7
16"	36	1556	18	14	13½	8	45	1607	19	14½	14	8½
16"	-	-	-	-	-	-	-	-	-	-	-	-
16"	45	1528	17½	13½	13½	8	-	-	-	-	-	-
16"	-	-	-	-	-	-	-	-	-	-	-	-

Projectile	Maximum Recorded Range: Range	E	Strik. Veloc.	Obliq. 0 deg. A	B	Obliq. 30 deg. C	D	Sticking Limit **
3"	12,700	75	935	1	½	½	½	1
4"	14,700	49	924	1½	1	1	½	1
5"	22,600	62	1077	2	1	1½	½	1½
5"	12,600	40	888	2	1	1½	½	1½
5"	18,200	43	1030	2	1	1	½	1½
6"	27,500	62	1204	3	2	2	1	2
6"	21,260	59	1134	2½	1½	2	1	2
6"	26,040	59	1212	3½	2	2½	1	2
6"	20,100	56	1135	3	2	2½	1	2
8"	30,500	57	1268	4½	3½	3	2	2½
8"	24,300	54	1188	4	3	3	2	2½
8"	30,500	58	1325	5½	4	4	2	2½
8"	22,380	54	1210	5	3½	4	2	2½
12"	34,000	47	1303	8	5	6	3	3½
12"	21,000	42	1158	7	4½	5	2½	3½
12"	36,774	56	1482	11	8	8½	4½	3½
12"	32,011	56	1407	10½	7½	8	4½	3½
12"	22,316	52	1251	9	6½	7	3½	3½
14"	41,600	57	1599	13	9½	9½	5½	4
14"	39,100	56	1540	12½	9	9½	5	4
14"	24,445	53	1305	10½	7	8	4	4
16"	40,600	56	1625	16½	12½	12	7	4½
16"	42,345	[illegible]	1686	20	16	15	9	4½
16"	25,115	53	1336	13½	9½	10	5½	4½
16"	36,900	53	1600	19	14½	14	8½	4½
16"	23,930	51	1334	1[illegible]	11	11½	6½	4½

A Thickness of Concrete Slab (feet) completely penetrated at 0 degrees obliquity.

B Depth of Penetration (feet) into a Massive Slab at 0 degrees obliquity. A Massive Slab is one which is at least twice as thick as a slab that can be completely penetrated under given conditions of attack. For example: a 12 in. projectile weighing 1140 pounds with a Striking Velocity of 2124 ft/sec and a range of 6000 yards, will completely penetrate 18 ft. of reinforced concrete when striking the target at an obliquity angle of zero degrees. A Massive Slab under these conditions would be 36 ft. The depth of penetration into a Massive Slab under these conditions will be 14 ft. For intermediate slab thicknesses, i.e., between "Massive" thickness and thickness which can be completely penetrated, the depth of penetration will be between values shown for given conditions of attack.

* Based on Naval Proving Ground firings preliminary to establishment of range table.

C Thickness of Concrete Slab (feet) just completely penetrated at 30 degrees obliquity.

D Depth of penetration in Massive Slab (feet) at 30 degrees obliquity. "Massive Slab" see "B".

E Angle of Fall (degrees).   Striking Velocity is in feet/second.

** Sticking Limit: Depth (feet) beyond which the projectile will probably stick in slab. With less penetration, projectile will probably rebound.

NOTE: Because of the small percent of explosive filler, the effect of explosion toward increasing penetration is negligible although the crater can be expected to be increased somewhat.

NOTES:

Penetration Data is for concrete generally found in fortifications; i.e. compressive strength of 5000 pounds per square inch. Somewhat greater penetration may be expected in structural concrete, the compressive strength of which is about 3500 pounds per square inch.

No data is available to estimate penetration at obliquities greater than 30 degrees but values are certain to be considerably reduced and at obliquities greater than 50 degrees the projectiles will probably ricochet.

This chart is a compilation of data from Report No. 8-43, U. S. Naval Proving Ground, Dahlgren, Virginia.