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TECHNICAL REPORT 3086

INVESTIGATION
OF THE
CAUSE OF AN EXCESSIVE DUD RATE
OF
CARTRIDGE, 40 MM, HE: M406, LOT MA-10-3

WILLIAM CARLDON

COPY NO. 20 OF 40

JULY 1963

PICATINNY ARSENAL
DOVER, NEW JERSEY

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INVESTIGATION OF THE CAUSE
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EXCESSIVE DUD RATE
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CARTRIDGE, 40MM, HE: M406, LOT MA-10-3

BY

WILLIAM CARLDON

JULY 1963

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SECTION I

INTRODUCTION

The purpose of this investigation was to determine the cause of a reported excessive dud rate of Cartridge, 40MM, HE: M406, Lot No. MA-10-63, with M551 Fuze, Lot No. MHR-20-3 (Figure 1). The malfunction occurred 13 August 1962. During a training exercise of L Company, 3rd Battalion, 4th Marine Regiment, six rounds of 75 fired failed to function. Malfunction Investigation File (MIF) Number A-127-62 was assigned and was forwarded to Picatinny Arsenal by the U.S. Army Ammunition Procurement and Supply Agency.

Seven hundred twenty rounds of the affected lot were withdrawn from stock and shipped to Picatinny Arsenal for test firing to obtain duds for record and for teardown inspection of the recovered duds. Five hundred seventy-six rounds were fired at a range of 60 yards -- from an M79 Launcher mounted on a 57mm Gun Carriage -- into a target of fiberboard or "Celotex" (Figure 2). Twenty-four dud projectiles were recovered, disassembled, and components of the M551 Fuze were visually inspected for defects.

SECTION II

SUMMARY

During a firing exercise by L Company, 4th Marine Regiment, 6 rounds of 75 rounds fired failed to function. This is about double the rate allowed by acceptance criteria.

At the completion of a 576-round firing test at Picatinny Arsenal, 24 dud projectiles were recovered and disassembled to determine the cause of failure to fire. Appendix II gives detailed information on the teardown examination and the cause of the duds.

The number of duds per box of 72 ranged from one to seven and the overall dud rate of the 576 rounds fired was 4.34%. However, it was statistically determined that there is no significant difference between the dud rate of the test sample and the acceptance criteria (a maximum dud rate of 3.65%). It is also apparent that whatever difference exists between the dud rates in the acceptance tests and the dud rate in the firing test can be attributed to the fact that in acceptance tests the rounds are fired at a gravel target, whereas, in the firing test the rounds were fired at relatively soft targets.

The functioning of early lots of ammunition (including Lot MA-10-3) was adversely affected when the projectiles impacted into soft targets. In later lots, changes were made to the fuze to overcome the effect of soft targets.

SECTION III

CONCLUSION

Since it is apparent that the functioning of this lot of ammunition is affected by the type of target and since there is no significant difference between the dud rate of the test sample and rate allowed by the acceptance criteria, it is concluded that no deficiency exists in Lot MA-10-3.

SECTION IV

RECOMMENDATION

Since a deficiency is not evident in Lot No. MA-10-3, it is recommended that the lot be removed from suspension and be made available for field use.

SECTION V

STUDY

On 13 August 1962, during a training exercise of L Company of the 4th Marine Regiment, six of 75 HE 40mm M406 Cartridges fired failed to function. Malfunction Investigation File (MIF) Number A-127-62 was assigned and was forwarded to Picatinny Arsenal by the U.S. Army Ammunition Procurement and Supply Agency.

Seven hundred twenty rounds of the affected lot were withdrawn from stock and shipped to Picatinny Arsenal for test firing to obtain duds for record and for teardown inspection of the recovered duds. Five hundred seventy-six rounds were fired at a range of 60 yards -- from an M79 Launcher mounted on a 57mm Gun Carriage -- into a target of fiberboard or "Celotex". Twenty-four dud projectiles were recovered, disassembled, and components of the M551 Fuze were visually inspected for defects. Eight of the duds were found to be caused by unarmed fuzes (two due to failure of the Set Back Pin to retract and six due to re-entry of the Set Back Pin). Seven duds were found to have partially armed fuzes (due to bent or damaged verge and pinion dowels). Fuzes in the remaining nine duds were armed but failed to function. (Two of these fuzes had defective firing pins, and seven showed indentations of varying depths in the detonators.) Appendix II has detailed information on the M551 fuze examination.

Several changes were incorporated into the M551 Fuze after early production had begun, to correct the problems discussed. These changes included:

1. The Set Back Pin was redesigned and the Set Back Pin Spring was changed to a Set Back Retainer (Figures 3-5).
2. Additional mass was added to the hammerweights.
3. The upper and lower Plate Dowels were removed and incorporated on the Verge Shaft.

The ammunition involved was assembled with Fuze Lot No. MHR-20-3. This fuze lot was manufactured before incorporation of these listed changes. Therefore, it is expected that the number of duds resulting from the deficiencies encountered during this investigation will be considerably lower in later lots. As a matter of fact, in each lot of the last 70 lots tested for acceptance, the dud rate averaged approximately 1.9%.

APPENDICES

APPENDIX A

Firing Test
of
Cartridge 40mm, HE, M406, Lot MA-10-3

APPENDIX A

SUBJECT

Firing Test of Cartridge 40MM, HE, M406, Lot MA-10-3

OBJECT

To determine the percentage of duds obtained from a sample of 576 rounds.

TEST PROCEDURE

Five hundred seventy-six rounds were fired at a range of 60 yards into a target consisting of 8 to 12 layers of 1/2"-thick fiberboard or 1/2"-thick "Celotex". Initially, the rounds were fired into the fiberboard; however, when the supply was exhausted, the target was changed to "Celotex". These materials were used as targets to minimize damage to the duds and to facilitate recovery. All projectiles which failed to function were to be recovered for teardown and visual inspection of the fuzes.

TEST RESULTS

- (1) Twenty-five rounds failed to function; of these, 24 rounds were recovered. One round, penetrating a smouldering area of the target, failed to function. Smoke and flame around the impact point obscured the projectile, making recovery impossible. Therefore, the dud remained in position until all smouldering had ceased. The item was subsequently destroyed in place.
- (2) The number of duds encountered per box of 72 rounds ranged from one to seven.

DISCUSSION OF RESULTS

The acceptance criteria is that a 40mm Cartridge lot is acceptable when there are less than 12 duds (or a maximum dud rate of 3.65%) in a test sample of 300 rounds. The overall dud rate of the 576 rounds fired was 4.34%. However, it was statistically determined that there is no significant difference between the two rates.

In acceptance tests 300 rounds are fired at a hard target; whereas the 576 rounds test-fired during this investigation were fired at relatively soft targets. It is believed that seven of the duds failed to function because of the lower deceleration values experienced when the projectile impacted the soft target. If these duds were eliminated from the final results, the overall dud rate would be 2.85%.

Also, it was noted that the number of duds per box ranged from one to seven when "Celotex" was used for target material and from one to three when "fiberboard" was used. The resistance to penetration of the projectile by the fiberboard was greater than the "Celotex." Therefore it is concluded that the higher dud rates experienced with "Celotex" are a direct result of lower deceleration values on impact.

APPENDIX B

Teardown Examination
of
M551 Fuze

APPENDIX B

SUBJECT

Teardown examination of M551 Fuze.

OBJECT

To determine cause of failure.

PROCEDURE

Thirty minutes after impact of the 40mm M406 Projectile, the retriever proceeded to the target to recover the dud. The operator located the point of impact, and stripped away the layers of the target until the dud was accessible to the claw attachment of the retriever. Next, the projectile was removed from the target and placed into the armored dud transporter.

At the completion of the firing test, the transporter was towed to a remotely operated lathe. Here the dud retriever removed the projectile and placed the base end into the headstock collet of the lathe.

Subsequently, the ogive was removed with a parting tool, the fuze was gripped by the tailstock collet and unscrewed from the ball and skirt assembly.

With the booster held firmly by the headstock collet and the fuze body still held by the tailstock collet, part of the fuze cover was stripped away and the booster was separated from the fuze. After the major explosive components were removed, the fuzes were examined to determine if the rotors were in the ARMED, PARTIAL ARMED or UNARMED position. The fuzes were then placed behind a barricade. There, the remaining portion of the fuze covers were manually removed; the plates were pried apart with a sharp instrument, and each component visually inspected for defects.

(The recovery equipment and methods used are depicted by Figures 6-10).

TEST RESULTS

NUMBER OF DUDS	CONDITION	REMARKS
8	Unarmed	The Set Back Pin did not retract in two fuzes. The Set Back Pin re-entered in six fuzes.
7	Partially Armed	Bent or damaged verge and pinion dowels
9	Armed	Two fuzes had defective firing pins. There were indentations of varying depths in the detonators of seven fuzes.

DISCUSSION OF RESULTS

The causes for failure of 15 rounds to detonate were Set Back Pin re-entry or failure to retract and bent or damaged verge and pinion dowels. Another contributing factor to the dud rate of the test sample was the comparatively low deceleration of the projectile due to the softness of the target, as indicated by the seven fuzes whose detonators were impacted with insufficient energy to detonate.

Set Back Pin re-entry was due to failure of the Set Back Spring to lock the pin when it was fully retracted and prevent it from re-entering the hole in the upper spacer plate -- preventing movement of the rotor to the ARMED position.

Bent or damaged verge and pinion dowels inhibit the movement of the verge and pinion. This delays the rotor resulting in a dud due to an out-of-line detonator when the projectile impacts on the target.

The softness of the target reduced the deceleration of the projectile sufficiently in some cases to prevent the hammerweights from striking the firing pin with enough force to initiate the detonator.

Prior to this test, there was a history of failure due to Set Back Pin re-entry and bent or damaged verge or pinion dowels. The parts concerned

have been redesigned and the new designs have been incorporated into later models of the M551 Fuze. Also, mass has been added to the hammerweights so that enough energy would be imparted to the firing pin to initiate the detonator at lower deceleration values.

APPENDIX C

FIGURES

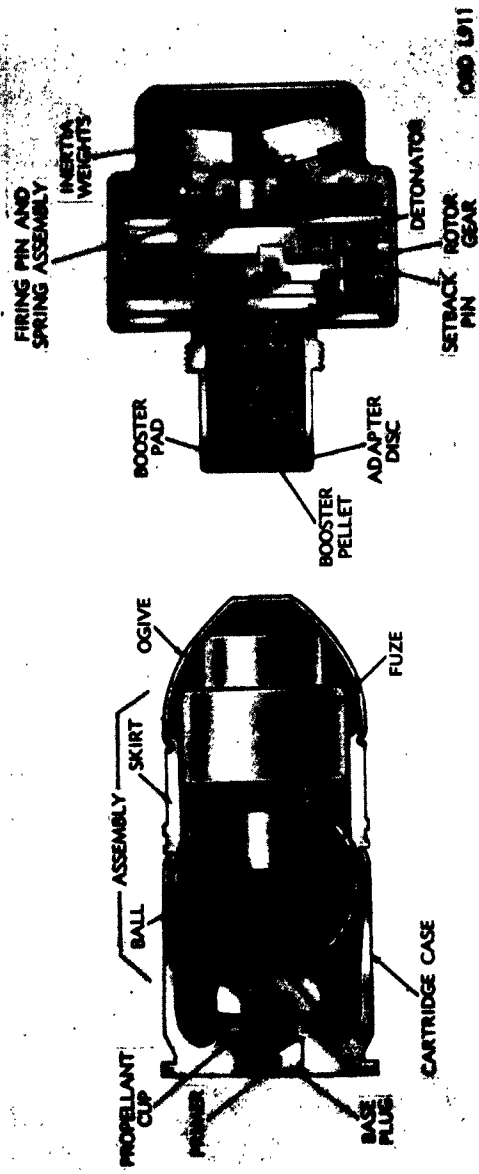
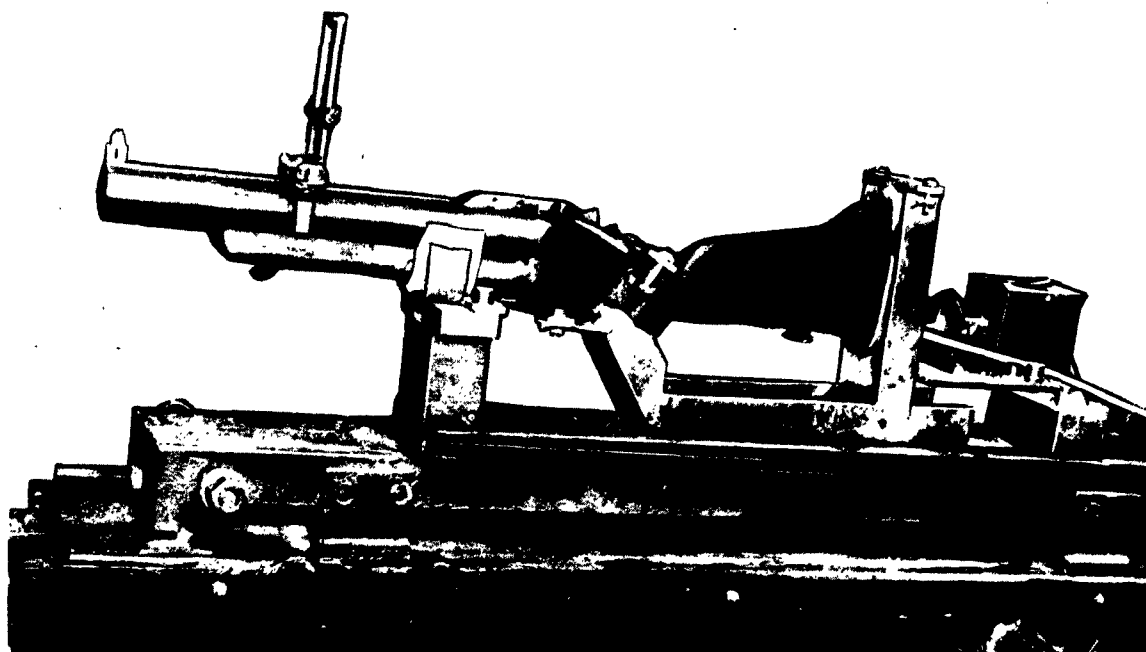
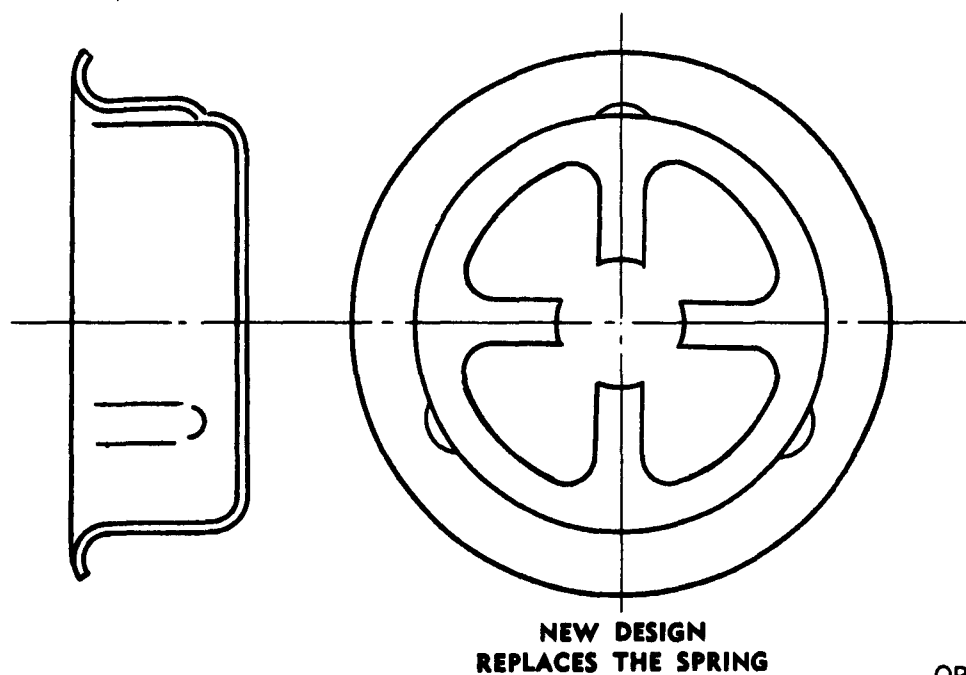
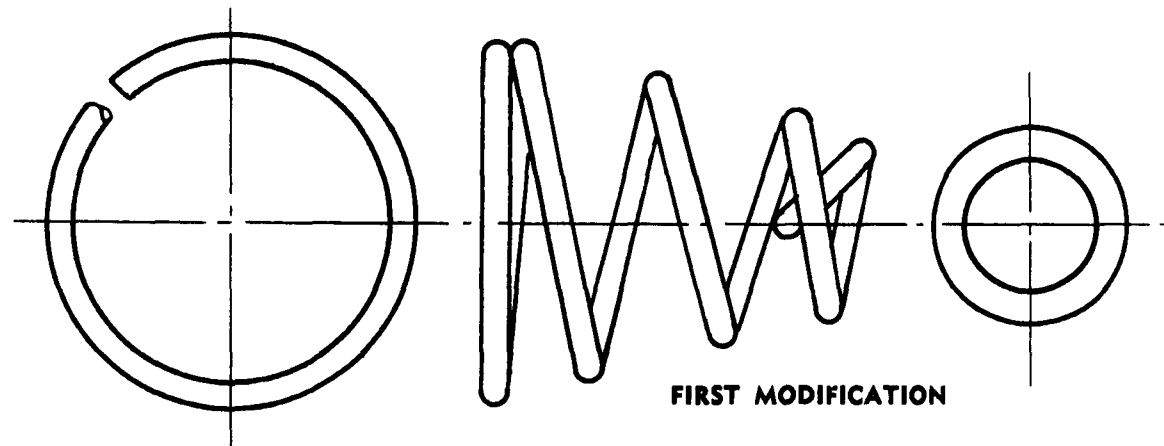
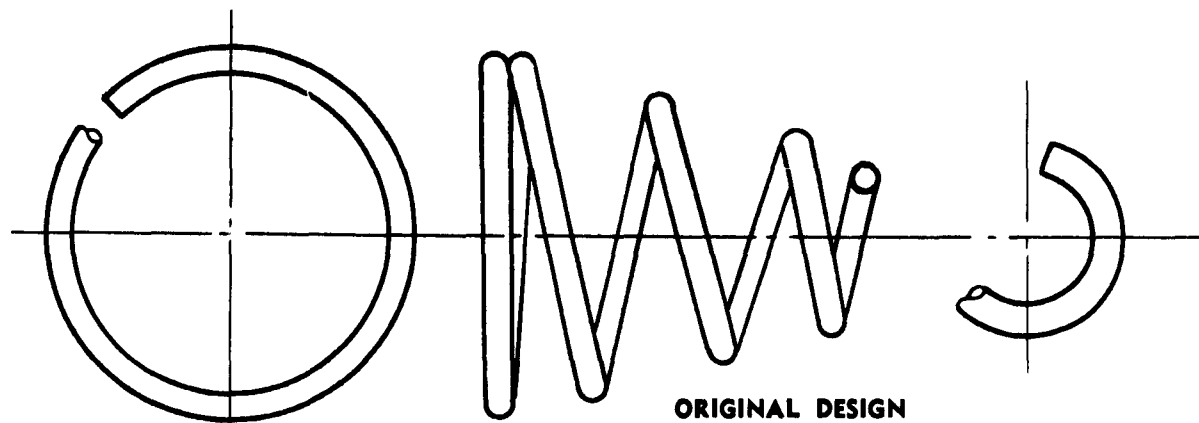


FIGURE 1. CROSS SECTION, CARTRIDGE 40MM HE, M406
CROSS SECTION FUZE PD M551



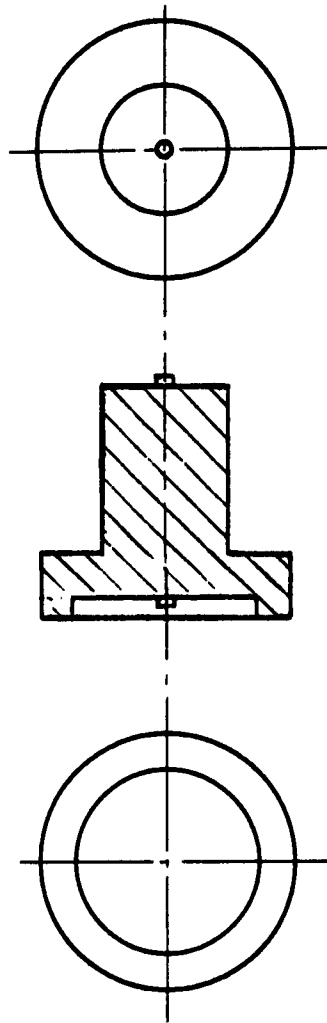
ORD L910

FIGURE 2. M79 LAUNCHER MOUNTED ON 57MM GUN CARRIAGE

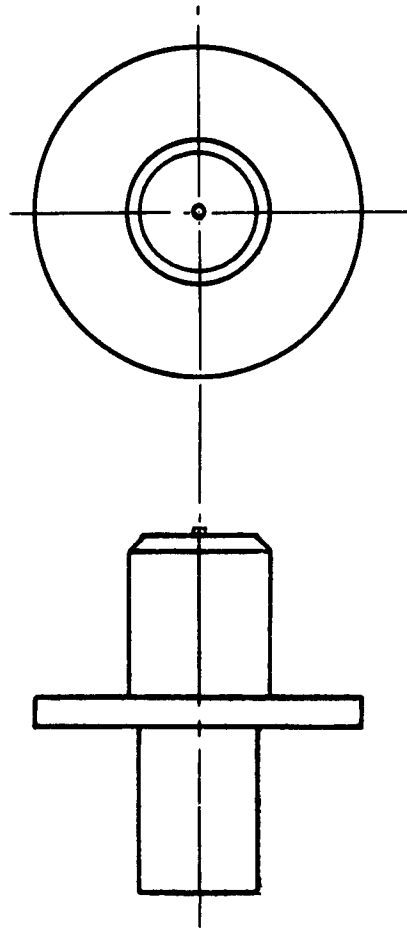


ORD L932

FIGURE 3. SET BACK PIN SPRING AND RETAINER



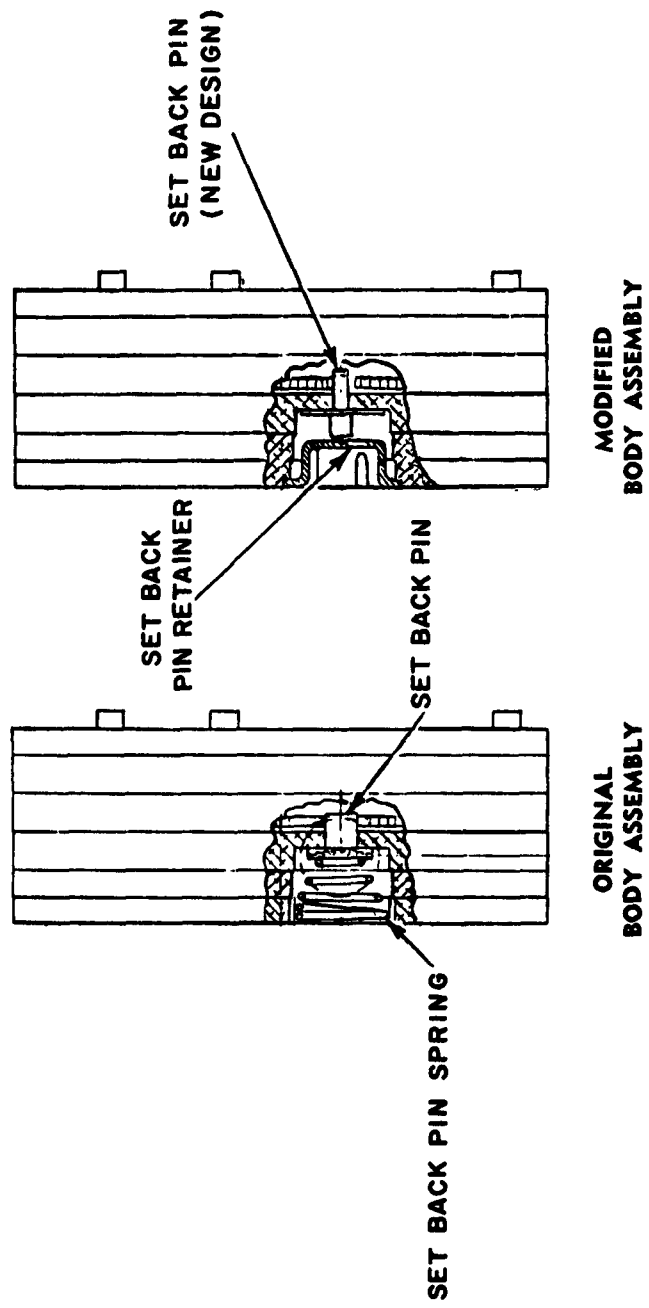
ORIGINAL DESIGN



NEW DESIGN

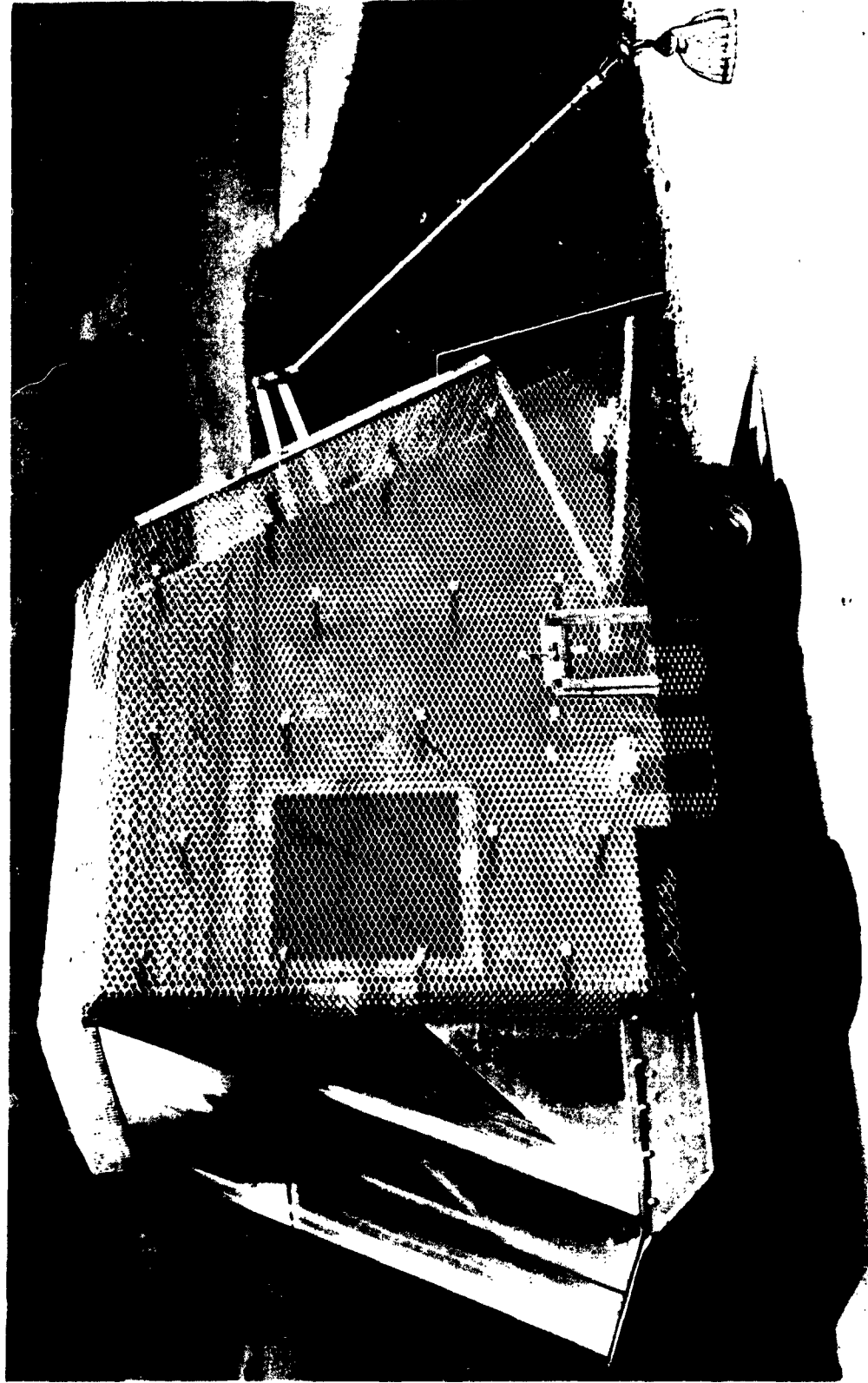
ORD L933

FIGURE 4. SET BACK PIN
-13-



ORD L931

FIGURE 5. BODY ASSEMBLY
-14-



ORD L881

FIGURE 6. DUD RETRIEVER-OVERALL VIEW
-15-

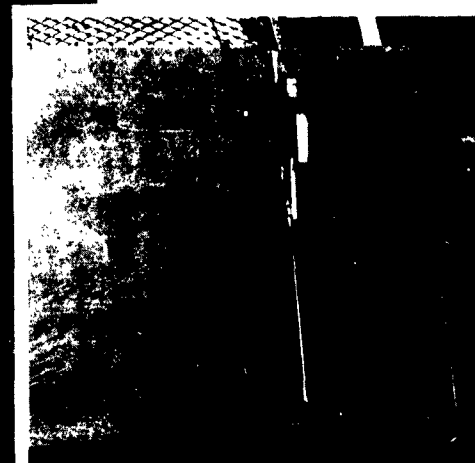
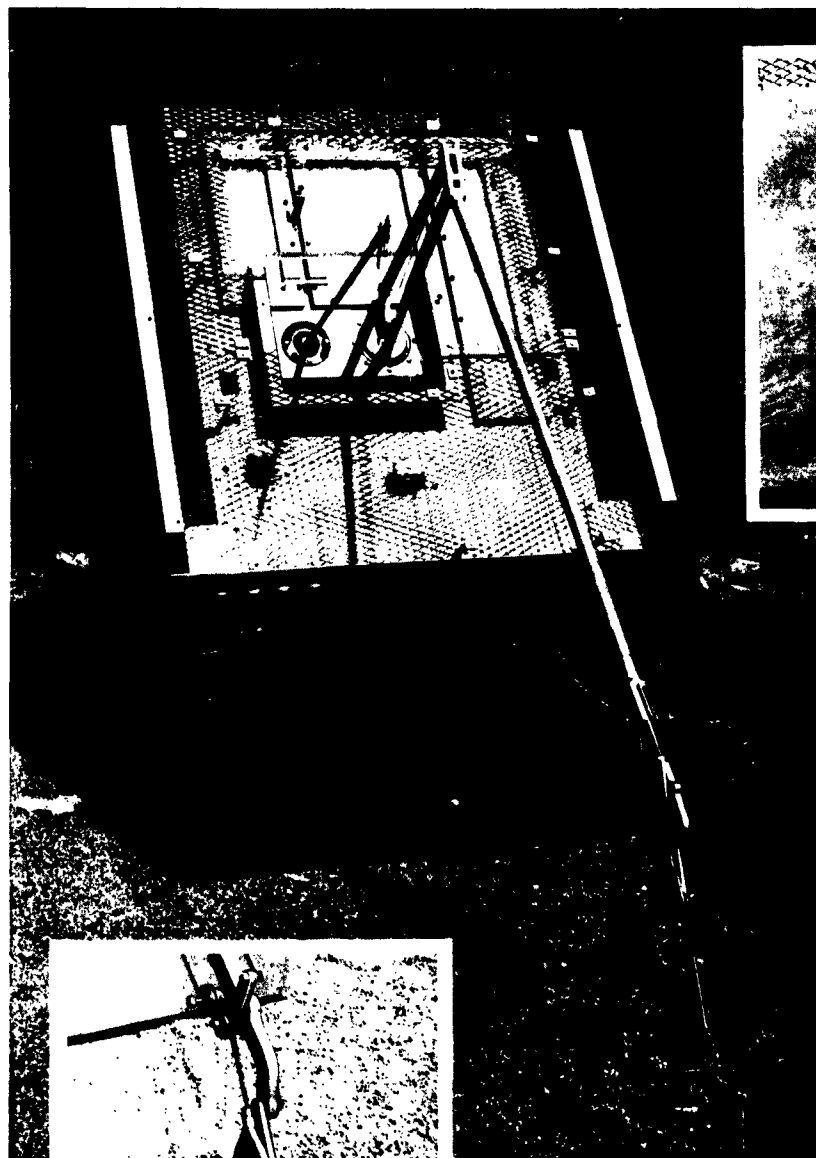


OVERALL VIEW
- COVER CLOSED

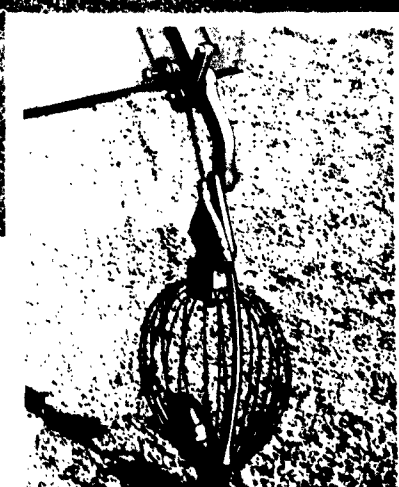


COVER OPENED
- DUD IN PLACE

FIGURE 7. DUD TRANSPORTER



**DETAILED VIEW
OF BASKET**

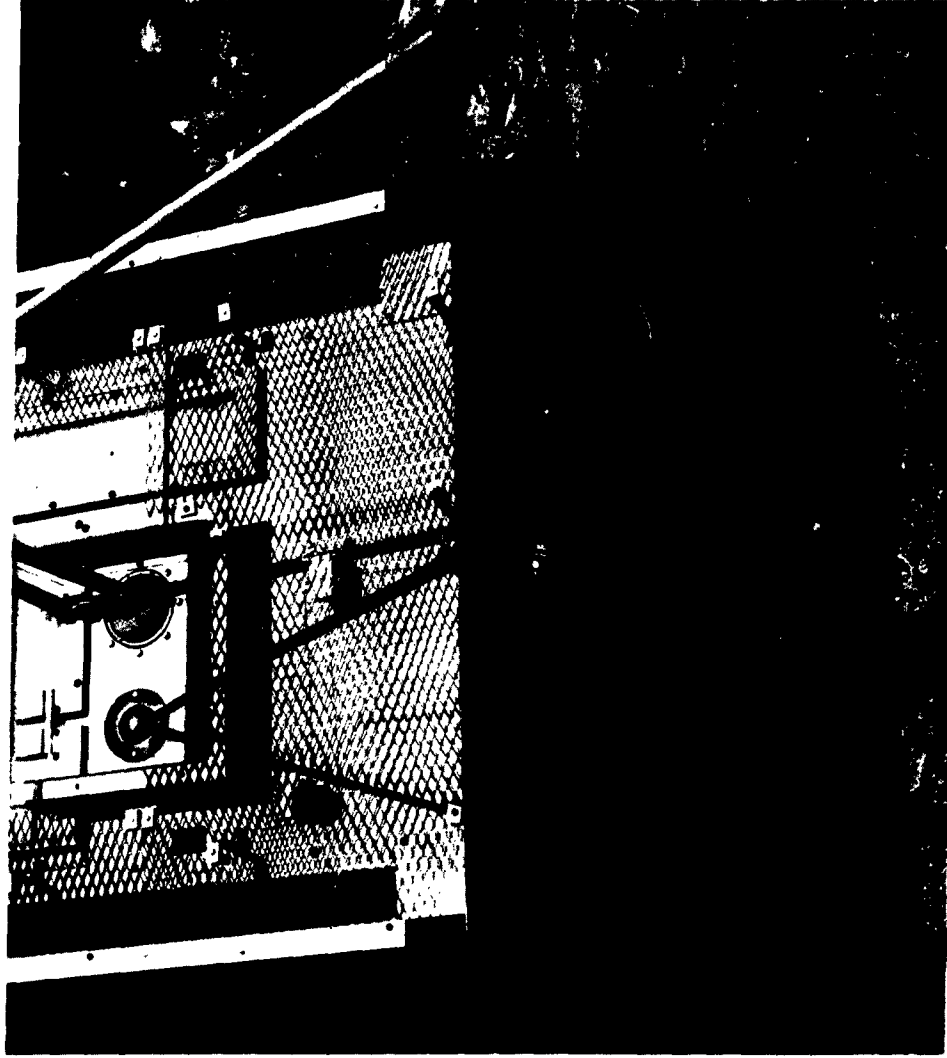


**DUD BEING
RAISED**

**BASKET
APPROACHING
DUD**

ORD L884

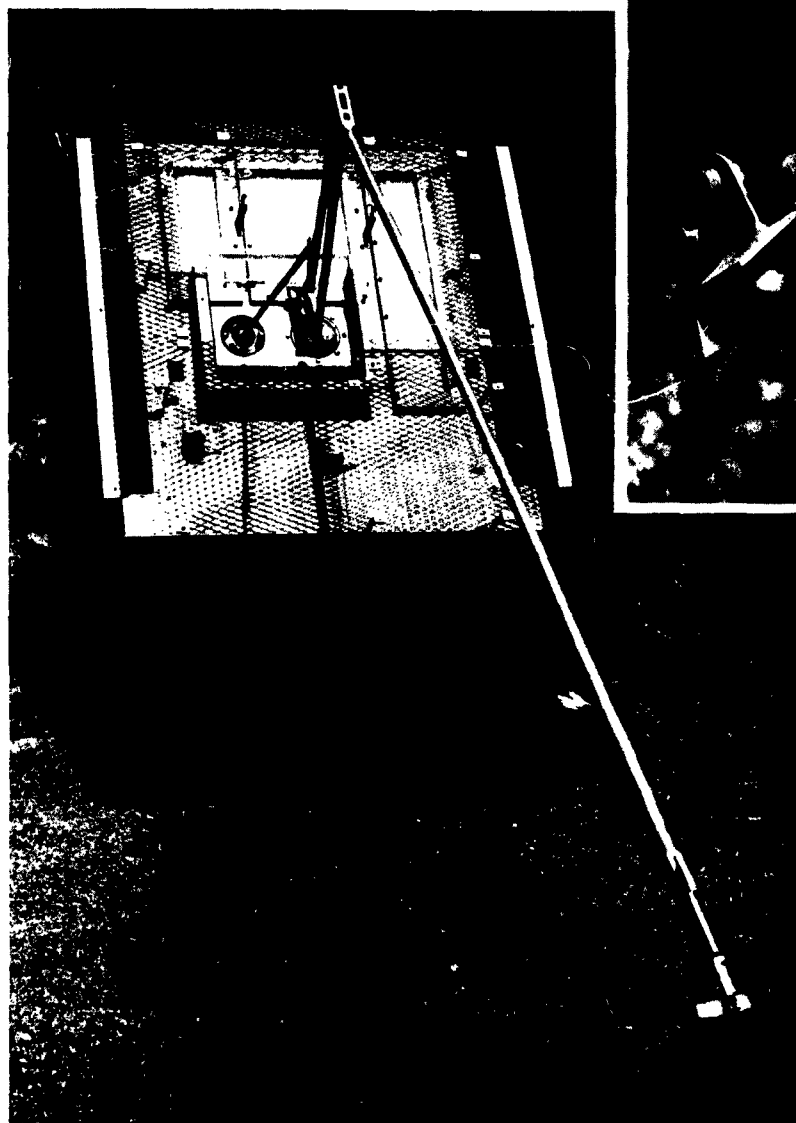
FIGURE 8. RETRIEVAL OF 40MM DUD WITH "BASKET" ATTACHMENT



**40-MM DUD RETRIEVED
WITH ARM NUMBER 2**

ORD L885

FIGURE 9. RETRIEVAL OF 40MM DUD WITH ARM NO. 2



VIEW SHOWING DETAILS
OF "FINGER" ATTACHMENT

APPROACHING DUD
WITH "FINGER"
ATTACHMENT

ORD L886

FIGURE 10. RETRIEVAL OF 40MM DUD WITH "FINGER" ATTACHMENT

ABSTRACT DATA

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Accession No. _____ AD _____

Picatinny Arsenal, Dover, New Jersey

INVESTIGATION OF THE CAUSE OF AN
EXCESSIVE DUD RATE OF CARTRIDGE,
40MM, HE: M406, LOT MA-10-3

William Carldon

Technical report 3086, July 1963

11 pp, appendices.

Unclassified report from the Applications
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and disassembled. Inspection of the fuzes
revealed eight unarmed, seven partially
armed; two with defective firing pins and
seven with indentations in their detonators.

The over-all dud rate of the 576 rounds was
4.34%. There is no significant difference
between the dud rate of the test sample and
the acceptance criteria.

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I. High explosive
cartridge -- Failure

I. Carldon, William
II. M406 Cartridge

UNITERMS

Malfunction

Failure

HE Cartridge

M406

40mm

M551

Fuze

Carldon, W.

Accession No. _____ AD
Picatinny Arsenal, Dover, New Jersey

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