UNCLASSIFIED

AD NUMBER
AD488428
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited. Document partially illegible.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; 19 JUL 1966. Other requests shall be referred to Naval Ordnance Laboratory, Explosives Research Department, Explosion Dynamics Division, White Oak, MD. Document partially illegible. This document contains export-controlled technical data.**
AUTHORITY
usnol ltr, 15 nov 1971

THIS PAGE IS UNCLASSIFIED

NOLTR 66-134

DEVELOPMENT OF THE MK 97 MOD 0 DELAY DETONATOR

19 JULY 1966

NOL

UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

NOLTR 66-134

DEVELOPMENT OF THE MK 97 MOD 0 DELAY DETONATOR

By

Vincent J. Menichelli

ABSTRACT: A nominal 0.3 second, flash-initiated, delay detonator has been developed for the AN-M173A1 Fuze. A limited number of detonators were subjected to standard Navy rough handling and surveillance tests. These tests were successfully met. An independent evaluation of the detonator confirmed the soundness of the detonator. The detonator is completely documented with drawings and specifications.

EXPLOSION DYNAMICS DIVISION
EXPLOSIONS RESEARCH DEPARTMENT
U. S. NAVAL ORDNANCE LABORATORY

NOLTR 66-134 19 July 1966

DEVELOPMENT OF THE MK 97 MOD 0 DELAY DETONATOR

This report discusses the design and development of a flash-initiated, delay detonator. The design of the detonator, the test program, and the test data are reported. The work was supported by "Fire Eye Fuzing", WepTask RM37-73066/W110-5H-03. The report will be of interest to fuze design engineers, explosive component designers, and explosive component users.

J. A. DARE
Captain, USN
Commander

C. J. ARONSON
By direction

CONTENTS

ILLUSTRATIONS

BLANK PAGE

INTRODUCTION

1. The multi-position fuze AN-M173A1 shown in Figure 1, is stockpiled by the Navy for use in fire bomb weapons. A number of safety and reliability deficiencies exist in this fuze which has necessitated a program to develop a new fuze and in the interim to modify the existing fuze with a "quick-fix" program. Numbered amongst its deficiencies are (a) an in-line explosive train, (b) easy arming by careless manipulation, (c) a detonator (the M31) which contains lead azide loaded into a copper alloy cup*[1], and (d) a primer (the M26) which was found to deteriorate on long term storage.

2. A program (Fire-Eye) to replace the AN-M173A1 Fuze with one which would meet current Navy safety and reliability criteria was established. In the interim, a quick-fix program (Fire-Eye Mother Hubbard) to modify and rework existing AN-M173A1 Fuzes began. The quick-fix "Fire-Eye Mother Hubbard" program would result in a modified AN-M173A1 Fuze. This modified fuze would have greater safety and reliability than the AN-M173A1 Fuze. The program involved making mechanical and explosive modifications to the AN-M173A1 Fuze. The explosive modifications consisted of replacing the M26 Primer with a more reliable primer (Mk 156 Mod 0 Primer) having good long term storage characteristics and replacing the M31 Detonator (instantaneous) with one which contains a short delay time (0.3 second). The delay time was required to allow the fire bomb fuel to disperse over a large area before fuel ignition occurred. This report covers the design and development of the delay detonator used to replace the M31 Detonator in the AN-M173A1 Fuze.

3. The requirements for the replacement detonator were that:

- (a) It meet standard Navy rough handling and surveillance tests normally conducted on such devices.
- (b) It be dimensioned so as to be retrofitted into existing AN-M173A1 Fuze hardware.
- (c) The sensitivity and output to be equal to or greater than that of the M31 Detonator.
- (d) The delay time to be 0.3 $\pm$0.1 second.

The explosive modifications to the AN-M173A1 Fuze are shown in Figure 2.

DETONATOR DESIGN

4. The external configuration of the detonator was dictated by the space available in the AN-M173A1 Fuze. Since this detonator was to be a direct replacement for the M31 Detonator, it was designed with

---

* References are on Page 6.

a threaded body so that it could be screwed into the existing fuze body. The detonator metallic parts (body, baffles, and sealing discs) were made of aluminum. Aluminum was chosen for its compatibility with lead azide, which was used as an explosive in the detonator. A-1A igniter composition (Mil-P-22264), an iron oxide/zirconium metal mixture, was chosen as the flash charge. The delay powder was manganese delay composition (Mil-M-21383). Slotted baffles were placed on both sides of the delay column to keep the delay column under compression during burning. This results in more reliable and uniform delay times [3]. The output or detonating explosives consist of lead azide and RDX. Aluminum discs were crimped at both ends of the delay detonator and an epoxy resin was applied to the crimped area to seal the component. The loaded detonator, designated Mk 97 Mod 0, is illustrated in Figure 3. The delay composition is loaded into the detonator first to eliminate the possibility of contaminating the walls of the detonator body with the more sensitive igniter composition and detonating explosives. This helps prevent instantaneous or short delay times. The adequacy of the output charge was based on its ability to initiate,high order, the tetryl booster in the modified AN-M173A1 Fuze.

TEST PROGRAM AND RESULTS

5. After the design of the detonator parts was completed and checked for dimensional compatibility with the fuze, a small number of detonators were loaded and tested for sensitivity, delay time, and output. The criterion for satisfactory sensitivity was that the detonator be initiated by the Mk 156 Mod 0 Primer (the primer to be used in the modified AN-M173A1 Fuze as a replacement for the M26 Primer) over a one-inch air gap. The delay column length based on the measured delay times was adjusted to yield the desired time of 0.3 $\pm$0.1 second. The base charge or output was established by firing the detonator against the tetryl booster in the modified AN-M173A1 Fuze and adjusting the weight until high order detonations were consistently obtained. Once the output of the detonator was satisfactory, the dent it produced in a steel witness block[4] was used as the criterion for proper output. A test fixture to obtain sensitivity, delay time, and output was designed and is shown in Figure 4.

6. At the completion of the above tests, the detonator design appeared reasonable so a lot of 184 detonators was fabricated for engineering design tests. The test schedule is given in Figure 5. After the detonators were conditioned, they were functioned in the test fixture (Figure 4) which is used in conjunction with the Mk 136 test set (ball drop machine). A two ounce ball was dropped from a height of six inches onto the firing pin to initiate the Mk 156 Mod 0 Primer.

7. Functioning, delay time, and output testing over the temperature range -90° to 165°F showed no significant shifts in delay time or output. The results of this testing are given on the following page:

	Delay Time (seconds)		
	165°F	RT	-90°F
N	25	25	25
$\bar{X}$	0.337	0.348	0.322
S	0.024	0.022	0.055
	Output - Depth of Dent (mils)		
N	7	5	2
$\bar{Y}$	22.0	23.1	23.0
S	1.75	1.2	-

N = Sample size
$\bar{X}$ = Mean delay time
S = Standard deviation
$\bar{Y}$ = Mean Depth of Dent

8. X-ray examination of the detonators after transportation and aircraft vibration showed no apparent changes in the internal or external structures. When functioned at room temperature in the test fixture, the following results were obtained:

	Delay Time (seconds)	
	Aircraft Vibration	Transportation Vibration
N	15	15
$\bar{X}$	0.332	0.335
S	0.024	0.015

9. Jolt and jumble testing had no significant effect upon the detonators and subsequent functioning in the test fixture gave the following results:

	Delay Time (seconds)	
	Jolt	Jumble
N	15	15
$\bar{X}$	0.342	0.340
S	0.011	0.014

10. The 40 foot drop test was modified to guide the detonators (in a fixture) to impact in a given position. The guided drop test was conducted in three positions, vertical, 45°, and horizontal. Some deformation of the detonators was noted after this test, but none initiated and they were capable of being fired afterwards in the test fixture. The results were as follows:

	Delay Time (seconds)		
	Vertical	45°	Horizontal
N	3	3	3
$\bar{X}$	0.337	0.332	0.376

11. A sequential test in which the detonators were subjected to vibration, jolt, jumble, and 40 foot guided drop gave the following results:

Delay Time (seconds)
N = 10
$\bar{X}$ = 0.320
S = 0.032

12. It was not certain whether or not this detonator could pass the temperature, humidity cycling test (Mil-Std-304) because the device does not have a hermetic seal. However, it was of interest to know just how long a period of time could be tolerated by the detonator in this environment. Therefore, samples were withdrawn from the conditioning test chamber after 7, 14, and 21 days. Functioning in the test fixture after withdrawl gave the following results:

	Delay Time (seconds)		
	7 Days	14 Days	21 Days
N	10	10	10
$\bar{X}$	0.333	0.350	0.357
S	0.008	0.019	0.021

The results of this test were very encouraging in that it indicated that although the device was not hermetically sealed, the epoxy resin seal was adequate and the surveillance characteristics of the detonator appeared to be good.

DISCUSSION

13. The nature of this development program required a quick-fix in the shortest possible time. There is always an element of risk in such a program due to the lack of time to contemplate the design and an insufficient test program to uncover any weaknesses that may exist in the device. Employed in the design of this device were the latest techniques and materials of pyrotechnic delay construction. Experience and engineering judgment resulted in a design which appears to have met the requirements imposed. The delay detonator is readily initiated from the Mk 156 Mod 0 Primer which will be used in the AN-M173A1 modified fuze. It is not known whether the manner in which the primer is used in the test fixture imposes a penalty on the initiation of the detonator. It appears to be a penalty when it is compared with the manner in which it is used in the fuze.

14. The output of the detonator was determined to be adequate by its ability to initiate the tetryl pellet in the fuze high order. This was further confirmed in field tests. The engineering tests conducted on the lot of 184 detonators yielded very little output data because of an error when the lot of detonators was loaded. The delay composition and igniter composition are loaded at a pressure of 30K psi. The lead azide and RDX are loaded at a pressure of 10K psi. During the loading of the detonators (184) the lead azide was inadvertently pressed at 30K psi. This loading pressure is approaching the "dead press" region for lead azide which can result in low order initiation. On the other hand, if the lead azide initiates high order, the detonation velocity and pressure will be greater at the higher densities; hence, an expected higher dent value. Consequently, the depth of dents observed in the steel witness blocks varied from no dent to 26 mils. Properly loaded detonators are known to give dents approximately 23 mils deep.

15. While the engineering tests were in progress, an independent group in the Laboratory was loading a lot of 3000 detonators for field testing and Laboratory evaluation. The hardware and tooling used were based on the preliminary drawings generated during the development program. No problems were encountered in the loading. Uniform delay times and output values were obtained on samples drawn at random while this lot of detonators was being fabricated.

16. The drawings and specifications for the detonator are finalized and are covered in LD-549737 and WS-6491 respectively. A portion of the 3000 detonators loaded by NOL was evaluated by an independent group. It was determined that the detonator was adequate for use in the modified fuze, that it could be properly retrofitted, and that the requirements of the drawings and specifications had been met.

17. Some of the engineering tests conducted, such as jolt, jumble, and 40-foot drop are safety tests. The criteria for passing these tests are that the items shall not initiate or become unsafe to handle or dispose of. It is not required that they function after these tests. The fact that they did meet the requirements of the test and functioned properly afterwards, is indicative of the ruggedness of the design.

18. Throughout the testing of this detonator (engineering, evaluation, and field) there was no known case of an instantaneous detonation or of a detonator dudding.

CONCLUSIONS

19. A delay detonator, the Mk 97 Mod 0, has been developed and has met the standard Navy rough handling and surveillance tests normally applied to such items. It has been demonstrated from laboratory and field testing, that the detonator is suitable for use in the modified AN-M173A1 Fuze.

REFERENCES

1. Encyclopedia of Explosives and Related Items, Volume 1, Picatinny Arsenal, Dover, New Jersey

2. The Journal of the JANAF Fuze Committee, "Some Aspects of Pyrotechnic Delays", Serial No. 22-0

3. NOLTR 63-256, "The Development of the Detonator, Delay WOX-60A", V. J. Menichelli, C. L. Scott, Nov. 1963

4. Mil-Std 316, "Detonator Output Measurement by the Steel Dent Test"

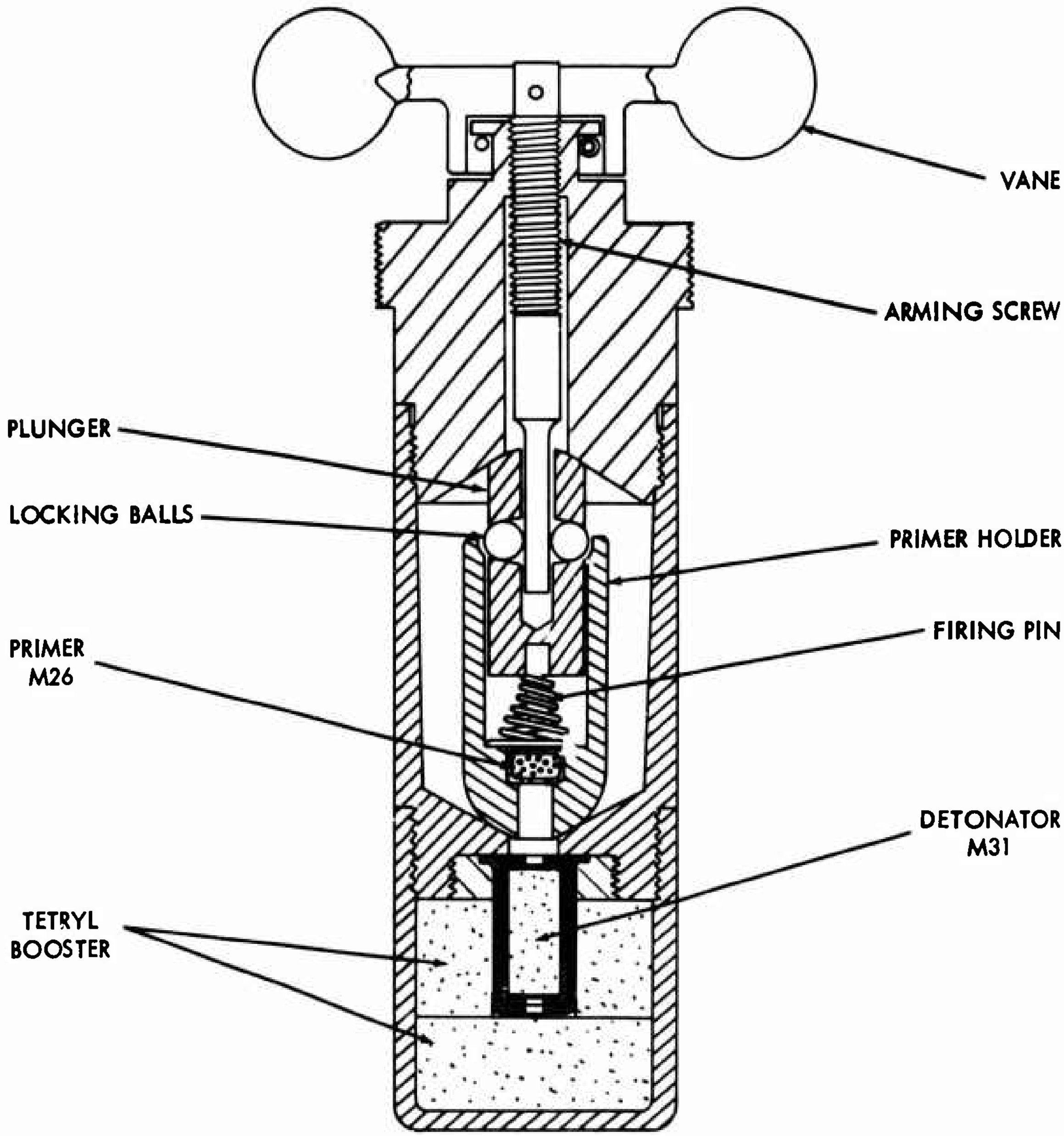

FIG. 1 MULTI-POSITION FUZE AN-M173A1

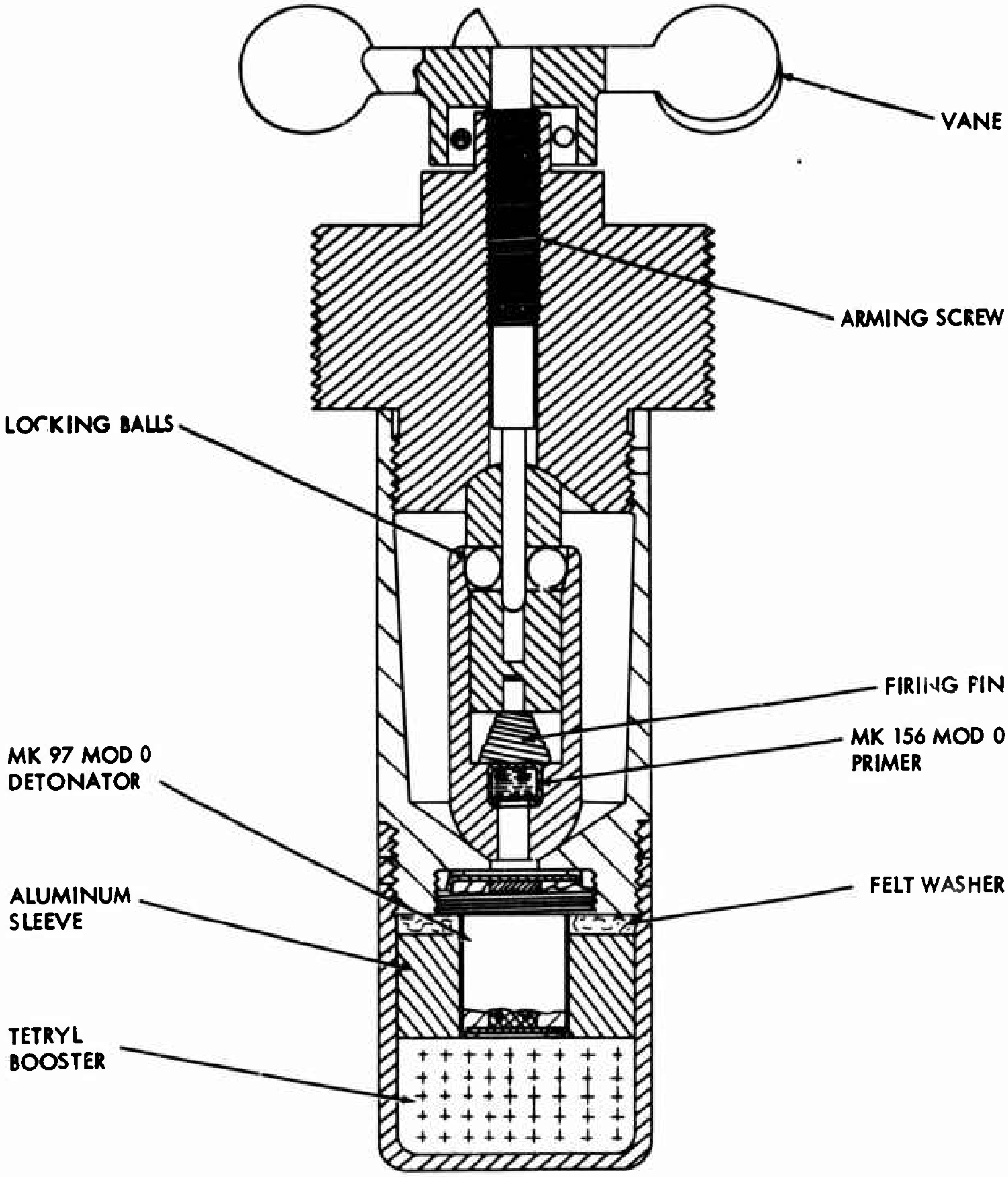

FIG. 2 EXPLOSIVELY MODIFIED AN-M173A1 FUZE

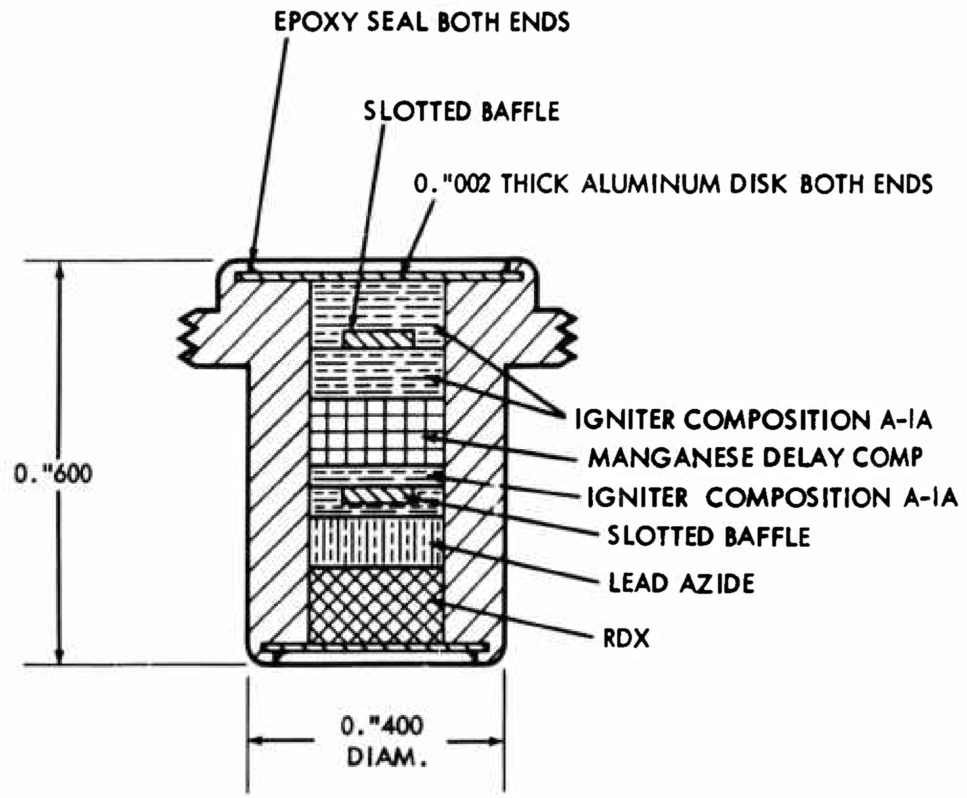

FIG. 3 DETONATOR, DELAY MK 97 MOD 0

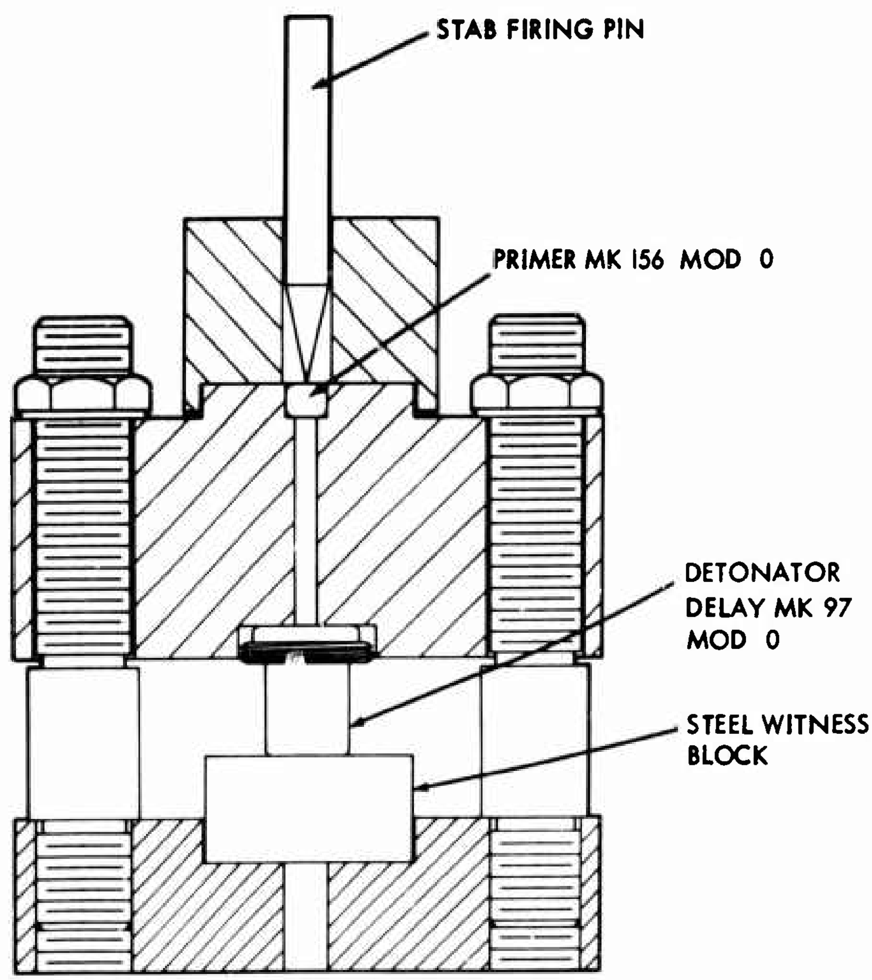

FIG. 4 FUNCTIONING, DELAY, AND OUTPUT TEST FIXTURE FOR THE MK 97 MOD 0 DELAY DETONATOR

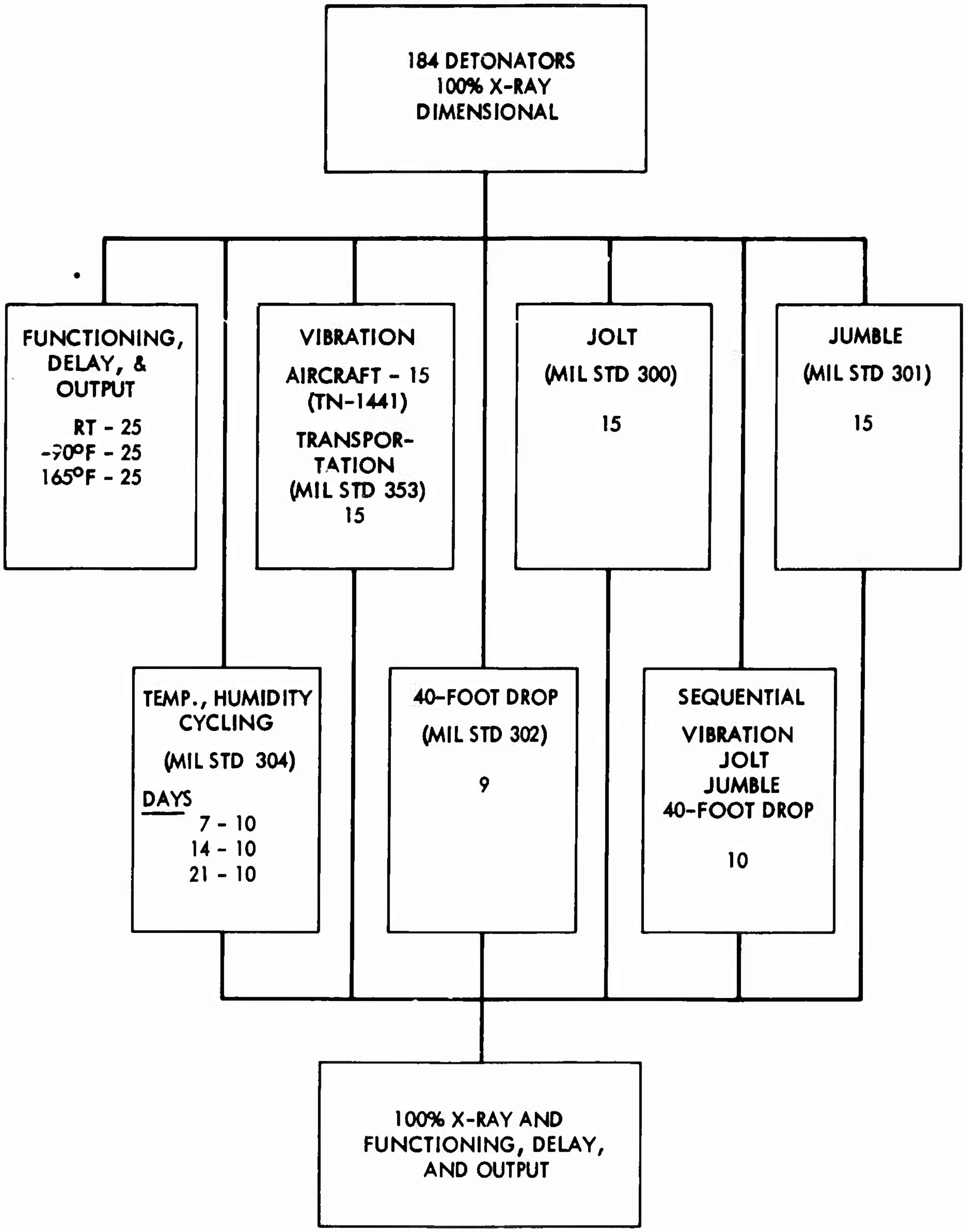

FIG. 5 ENGINEERING TEST SCHEDULE FOR THE MK 97 MOD 0 DELAY DETONATOR

BLANK PAGE

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Naval Ordnance Laboratory White Oak, Maryland	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

DEVELOPMENT OF THE MK 97 MOD 0 DELAY DETONATOR

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

FINAL

5. AUTHOR(S) (Last name, first name, initial)

MENICHELLI, Vincent J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
19 July 1966	13	4

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. WepTask RM37-73066/W110-5H-03	NOLTR 66-134
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	-

10. AVAILABILITY/LIMITATION NOTICES

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of NOL.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	NOSC

13. ABSTRACT

A nominal 0.3 second, flash-initiated, delay detonator has been developed for the AN-M173A1 Fuze. A limited number of detonators were subjected to standard Navy rough handling and surveillance tests. These tests were successfully met. An independent evaluation of the detonator confirmed the soundness of the detonator. The detonator is completely documented with drawings and specifications.

DD FORM 1 JAN 64 1473

UNCLASSIFIED
Security Classification

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Detonator Delay						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2*b*. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7*a*. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7*b*. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8*a*. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8*b*, 8*c*, & 8*d*. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9*a*. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9*b*. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through
_______________________________________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through
_______________________________________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through
_______________________________________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS), (S), (C), or (U)*

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.

UNCLASSIFIED
Security Classification