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DEVELOPMENT OF THE MK 38 MOD 0 CONTINUOUS ROD WARHEAD FOR THE SPARROW III AIR-TO-AIR MISSILE (C)

14 DECEMBER 1962

NOL

UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

DEVELOPMENT OF THE MK 38 MOD 0 CONTINUOUS ROD WARHEAD FOR THE SPARROW III AIR-TO-AIR MISSILE (C)

Prepared by:
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ABSTRACT: The Naval Ordnance Laboratory, White Oak, has developed a warhead for the SPARROW III air-to-air missile that will withstand the high temperature environment brought about by the aerodynamic heating due to carriage on high-speed aircraft. The development program was based on the continuous-rod kill mechanism and the use of a high-temperature resistant explosive, Diaminotrinitrobenzene-Plastic Bonded Explosive (DATB-PBX) now designated PBXN-4. As a result of the development program, the rod continuity produced by this warhead was at least 95% at a 25-foot radius with an average rod velocity in excess of 4000 ft/sec when initiated with a Mk 5 Mod 2 Safety and Arming Device.

U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

NOLTR 62-176

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This warhead development was conducted by the Naval Ordnance Laboratory, White Oak, under Bureau of Naval Weapons Task Assignment RM 37 23003/212 1/W020 A0 003. The purpose of this task was to develop a continuous-rod warhead, containing a high-temperature-resistant explosive, for the SPARROW III air-to-air missile. As a result of experience gained in the development of the Mk 11 and Mk 18 Warheads for SPARROW III this program represented a minimum development and evaluation effort.

The Prototype Production for Evaluation program was interrupted for six months due to a functional incompatibility between the warhead and the safety and arming device. The warhead was recommended for release to production on 29 December 1961. Details of the evaluation of the Warhead Md 38 Mod 0 will be reported in a separate Naval Ordnance Laboratory Technical Report.

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Captain, USN
Commander

J. H. Armstrong
J. H. ARMSTRONG
By direction

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INTRODUCTION

1. The Naval Ordnance Laboratory, White Oak, Maryland (NOL(WO)), has developed a warhead, the Mk 38 Mod 0, for the SPARROW III Guided Missile that will withstand the high temperature environment brought about by the aerodynamic heating due to carriage on high speed aircraft (Figure 1). This warhead will replace the earlier Mk 11 and Mk 18 Warheads which are temperature limited and which have placed some operational restrictions on current aircraft. The development program was based on the continuous-rod kill mechanism and the use of a high-temperature resistant explosive, Diaminotrinitrobenzene-Plastic Bonded Explosive (DATB-PBX) designated PBXN-4.

2. The Mk 38 Mod 0 Warhead (Figure 2) was designed for use on the SPARROW III XAAM-N-6b Air-to-Air Guided Missile based on the performance and design objectives (reference (a)) and the missile specification (reference (b)). The warhead can also be used on the -6 and -6a versions of the missile. It is 14 inches long by 8 inches in diameter and physically interchangeable with the Mk 11 Mod 0 and Mk 18 Mod 0 Warheads. The loaded weight of this warhead is about 65 pounds including 20 pounds of DATB-PBX which is 94% DATB and 6% nylon binder. The rod bundle, fabricated with 3/16-inch-square 1018 steel rod, was welded to the skin and end rings of the warhead for structural rigidity. The Mk 38 Mod 0 Warhead is compatible with the Mk 224 Shipping Container which was designed for the Mk 18 Mod 0 Warhead. Drawings of the empty and explosive loaded warheads appear in references (c) and (d) respectively. Descriptions and requirements are covered by references (e) and (f) respectively.

3. This report covers all of the program's development aspects, some of which took place during the Prototype Production for Evaluation (PPE) program because of short time scales allowed for completion of the task (reference (g)). The warhead was released to PPE in March 1961 by reference (h). Subsequent field tests revealed an incompatibility between the warhead and the initiating Mk 5 Mod 2 Safety and Arming (S&A) device. This incompatibility resulted in a degradation to warhead performance of about 5% and a six-month delay in resumption of the PPE program. The PPE program was resumed in November 1961 after the warhead - S&A device incompatibility had been resolved. The warhead was recommended for release to full production on 29 December 1961 by reference (i). Details of the evaluation of the Mk 38 Mod 0 Warhead will be reported in a separate document.

TERMINOLOGY

4. A variety of terms have been coined as a result of continuous-rod warhead technology. Definitions of these terms are presented in this section to aid in the interpretation of this report.

a. Arena. See firing-test arena.

b. Arena Radius. In a continuous-rod-warhead firing-test arena, the distance from the axis of the warhead to witness sheets.

c. Continuity of Cut. A performance rating which is obtained from examinations of the witness plates of a firing-test arena. This is normally expressed in percent as the ratio of cut (as measured on a horizontal projection) to the arena perimeter at a given radius.

$$\text{continuity of cut } \% = \frac{L}{S} \times 100$$

where

L = total length of horizontal projections of cuts through witness plates

S = total length of witness plates

d. Continuous-Rod. An expanding ring of interconnected rods.

e. Continuous-Rod Bundle. Layers of parallel and adjacent rods that are interconnected at the rod ends.

f. Continuous-Rod Warhead. A warhead containing a continuous-rod bundle with explosive inside the bundle. Upon detonation of the explosive, the continuous-rod bundle expands rapidly to form a continuous-rod hoop of expanding radius.

g. Cut-Off Tube. Tubular rings located at each end of the rod bundle to form a shaped charge upon detonation of the explosive charge. The shaped charge severs the joint between the rod bundle, skin, and warhead structure, thereby disengaging the rod bundle and skin from the structure.

h. Explosive Contour. The cross sectional profile of the explosive charge which is shaped so that upon detonation the energy or impulse is applied uniformly along the length of the rod bundle to propel the rods outward without breaking.

i. Firing Test. A method for evaluating the performance of a continuous-rod warhead by detonating the warhead and using instrumentation or devices suitable for obtaining the desired information.

j. Firing-Test Arena. An arrangement of witness plates, parts, and equipment for evaluating the performance of continuous-rod warheads; an arena consists of (1) a platform that holds the warhead, and (2) obstructions such as witness plates and airplane components positioned at various distances from the warhead.

k. Hinge Weld. The weld joint between adjacent rods that interconnects the ends of rods to form a continuous-rod bundle. The purpose of the hinge weld is to hold the rods together until the opening radius is attained.

l. Liner. Inert barrier between the explosive charge and rod bundle which determines the explosive contour.

m. Rod Pair. Two parallel and adjacent rods that are joined together at one end by a hinge weld.

n. Stitch Weld. A low-strength weld adjacent to a hinge weld made in a direction toward the midlength of a rod pair and usually a continuation of the hinge weld. Stitch welds are designed to absorb the energy of the opening rods by failing in a controlled and reproducible manner. This permits proper functioning of the hinge welds without failure.

o. Theoretical Maximum Opening Radius. The maximum radius ring formed by a fully-expanded continuous rod in which no breaks occur. The theoretical maximum opening radius is approximated by the following expression:

$$R_m \cdot \frac{SN}{2\pi}$$

where

R_m = theoretical maximum opening radius, ft.

S = length of single rod less two inches to compensate for the weld joint and bending, ft.

N = number of rods in warhead.

p. Witness Plates. Plates or sheets of metal which are placed along the perimeter of a firing-test arena facing the center of the arena to record continuity of a continuous rod during a firing test. If thin sheets up to 1/8-inch in thickness are used, rods usually cut through the sheets. If heavy steel plates are used, the rods hit the plate, but do not penetrate it, and marks on the plate record the data.

FEASIBILITY STUDY

5. A study was made in 1958 to demonstrate the feasibility of using a molded explosive charge in conjunction with a continuous-rod warhead. Three experimental models were fabricated and two were tested. These models consisted of a rod bundle, liner, center tube, skin, and end closures. The internal geometry, liner shape or explosive contour, was approximately the same as that of the H-6 loaded Mk 18 warhead. Only 29 rod pairs or about 90° of rod bundle was used. The remaining 270° of each warhead was a steel cylindrical shell. This design, known as a "stovepipe", was used despite its known disadvantages. A stovepipe did not simulate the full-scale model, but it was adequate for a feasibility study when cost was also considered. The

explosive charge consisted of PBXN-1 which is 66% RDX, 25% aluminum, and 9% nylon binder. The raw explosive was prepared by the Naval Weapons Station (NWS), Yorktown, Virginia, as a granular product and was sent to Picatinny Arsenal, Dover, New Jersey, to be pressed into solid cylindrical billets 7½ inches in diameter by 12 inches long. The billets were then machined by NOL(WO) to the proper contour for warhead assembly.

6. Three models were prepared and sent to the Naval Weapons Laboratory (NWL), Dahlgren, Virginia, to be tested. Two rounds were fired and yielded about 80% continuity. It was concluded that to use a plastic-bonded explosive for a continuous-rod warhead would require a development program to determine a suitable explosive contour. Reference (j) contained a proposal to develop a plastic-bonded explosive warhead for SPARROW III and reference (k) contained Bureau of Ordnance (now Bureau of Naval Weapons (BUWEPS)) approval of the proposed development program. DATB-PBX was chosen for use in the warhead development due to its higher temperature resistance and lower sensitivity than PBXN-1. Properties of DATB-PBX (PBXN-4) and PBXN-1 are compared in Table (1).

EXPLOSIVE CHARGE DEVELOPMENT

7. DATB, developed as a military explosive by NOL(WO), is a yellow, crystalline material with a melting point of 286°C (547°F) and a "cook-off" temperature between 310°C (590°F) and 320°C (608°F). It is extremely insensitive to rough handling. As measured by NOL(WO), DATB has a Bruceton impact sensitivity greater than 320 centimeters compared with 165 centimeters for cast TNT. Its theoretical maximum density (TMD) is 1.83 gms/cc. When pressed into solid form, pure DATB is generally brittle. In order to obtain satisfactory pressed charges, the use of a binder is required. References (l), (m), (n), (o) and (p) contain chemical, physical, and detonation properties of DATB.

8. Initial developmental explosive charges of DATB were fabricated with a phenolic binder. However, considerable difficulties were experienced in processing of this binder on full-scale charges, since the dwell times that were required in the pressing operation to produce acceptable charges were considered too long for production operations. To eliminate these problems it was decided to change the binder to nylon. DATB without a binder was considered for use in the warhead, but despite good performance achieved with one unit loaded with pure DATB, it was considered too difficult to machine the charges to contour. This difficulty was due to its brittleness and its tendency to crumble when exposed to a water coolant during the machining operations.

9. The DATB initially used in the development program was acquired in crystal form from the Holston Ordnance Works, Kingsport, Tennessee, and processed into molding powder by the Naval Propellant Plant (NPP), Indian Head, Maryland, by coating the crystals with a binder. Later in the program the crystals were coated by the manufacturer, eliminating NPP work.

NWS pressed the molding powder into billet form. The pressing operation for each billet was performed in two increments. This was necessary due to the bulk density of the molding powder and the limited stroke of the press. Considerable effort was expended at NWS in producing high-density nylon-bonded charges that were relatively free of cracks. The process that was developed for producing the charges used in the warhead developmental program follows:

a. The explosive powder was preheated to 120-125°C.

b. The preheated powder was pressed in a 7½-inch diameter die heated to 120-125°C at 20,000 psi pressure (400 tons total force) for 20-30 minutes.

c. The charges were ejected from the die and quickly placed in a temperature programmed oven to cool at a controlled rate of 2½-5°C per hour to room temperature. This slow cooling was necessary to prevent excessive cracking of the charge. The charges were then machined to contour at NOL(WO).

10. The machine-to-shape process, which was considered adaptable to production, was highly suitable for the development phase when the warhead liner-explosive interface was subject to experimental change readily accomplished by machining operations. However, after the dimensional freeze of the design, a process for pressing the explosive charge to the final shape was desirable. This process would increase the rate of production and promote savings in the following areas:

a. Equipment - The machine-to-shape process requires that expensive remotely controlled contour lathes be installed in production plants.

b. Time - The machining process is an expensive and time consuming operation.

c. Material - Approximately 13 pounds of explosive are removed from the explosive charge of each warhead during the machining. Most removed material can be reclaimed and reused, but this necessitates an added operation and all of the material is not recovered. The current cost of the explosive makes it imperative that the amount lost be kept at a minimum.

For these reasons, and based upon previous experience with the loading process associated with the Sidewinder IC Warhead, it was felt that the press-to-shape method for explosive charge fabrication in production should be investigated for the Mk 38 Warhead. Recognizing the advantages of eliminating the machining operations, NOL(WO) proposed by reference (q) a press-to-shape program.

11. The concept of the press-to-shape program provided for pressing the powdered explosive in a die which has the shape of the charge contour, including the hole in the center. The only machining operation to be performed after pressing is that of the charge length. No attempt was made at NWS to press to the exact length due to limitations of the die used. It is known from experience with the press-to-shape studies of the Sidewinder IC that lengths can be controlled within reasonable tolerances with proper control of pressure, die temperature and weight of powder introduced into the die. A number of Mk 38 Mod 0 Warheads loaded with charges which were pressed to shape were field tested and revealed no degradation to performance.

12. DATB-PBX charges were pressed at two pressure levels: 10,000 psi and 20,000 psi. Pressing at 10,000 psi was performed to determine the feasibility of pressing within the capacity of the 125-ton press at the Naval Ammunition Depot (NAD), Crane, Indiana. By investigating various temperatures and dwell times, charges with a density of 94-96% TMD and within the desired dimensional range were obtained for a particular batch of molding powder. However, subsequent pressing with molding powder of different particle sizes, which was procured from other sources, presented problems in that the density was not uniform throughout the charge. It has been determined that to obtain acceptable charges from this powder would require undesirably long dwell times. Therefore, in order to obtain acceptable charges at the 10,000 psi pressure level and with minimum dwell times, the particle size of the molding powder would have to be controlled. It has been demonstrated by a single field test that a warhead loaded with good-quality low-density charges performed as well as a warhead loaded with high-density charges.

13. The press-to-shape and the machine-to-shape process have been developed to such an extent that they have been approved for production based on the requirement for high density charges. Details of these processes are presented in reference (r). The DATB-PBX was recommended for release to production by reference (s), and was approved for service use as PBXN-4 by reference (t). Its description and requirements are covered in reference (u).

HARDWARE DEVELOPMENT

14. The hardware used in the warhead development was manufactured by the Symington Wayne Corporation, Fort Wayne, Indiana, and the Electronics Division of ACF Industries, Incorporated, Riverdale, Maryland, under fixed price contracts (references (v) and (w) respectively). Producibility of the end product was considered during all phases of the development. Various production techniques were discussed with the prototype manufacturers in the production engineering effort. Highlights of the warhead hardware development program included optimization of the liner configuration, elimination of the cut-off tube, increasing the length of the rod bundle, investigation of reducing the stitchweld length and investigating the use

of a plastic liner to replace the magnesium liner. These studies were primarily directed toward increasing the continuity and velocity of the rods and increasing the radius at which the rods retain a high degree of continuity.

15. The problem involved in optimizing the liner configuration for a continuous-rod warhead is to determine the relative importance of rod velocity and continuity for a particular target. It has been determined that by designing a liner for an increase in velocity, a decrease in rod continuity results, and, conversely, by designing for an increase in continuity, a decrease in velocity results. In order to obtain the configuration that would yield rod continuity which approached 100% and rod velocity which remained high, it was decided to deviate from basic continuous-rod warhead design convention. Liner shape studies in previous warhead development programs were based on a liner length equal to the rod length, varying only the contour radius and thickness. This criteria was abandoned during the Mk 38 Warhead development program in an effort to obtain higher rod velocity, yet maintain high continuity. The need for full length liners to prevent cast explosives from penetrating the rod bundle has been eliminated by the use of pressed PBX explosives. By varying the length as well as the radius and thickness of the liner, more flexibility was possible in determining the optimum shape. Twenty-four units were field tested in the liner shape study. The final liner design is shown in Figure 2. This shape permitted a 2½ pound explosive weight increase over the initial design, and consequently increased rod velocity by 400 ft/sec.

16. Liners molded from Diallyl Phthalate were investigated as replacement for the magnesium liners in an attempt to improve warhead performance. Very limited testing of warheads fitted with these liners resulted in an increase in continuity but showed a decrease in rod velocity. Due to this decrease in rod velocity and since these tests were not conducted until just prior to release to PPE, the Diallyl Phthalate liner was not incorporated into the warhead design. It was felt that an insufficient number of tests were performed and that with some additional effort the rod velocity could be increased so that optimum warhead performance would result.

17. The cut-off tube was incorporated into earlier continuous-rod warhead designs for SPARROW to form a shaped charge and free the rod bundle and skin from the warhead structure upon detonation. It was eliminated from the Mk 38 warhead design in an effort to increase the opening radius of the rod bundle and to simplify the warhead design. This study was inspired by the results of work performed on contract (reference (x)) by the Chamberlain Corporation, Waterloo, Iowa, in 1958 and reported in reference (y). This investigation indicated that the elimination of cut-off tubes did not have detrimental effects on warhead performance. Two EX-25 warheads tested with cut-off tubes yielded 94.4% and 82.8% continuity. The two warheads tested without cut-off tubes yielded 93.7% and 95.8% continuity. It was demonstrated by field tests in the early stages of the Mk 38 development program that cut-off tubes would not be required. Instead, the separation of the rod

bundle and skin from the warhead structure was accomplished by increasing the charge/mass ratio (explosive charge weight/inert parts weight) at the rod-case joint and by introducing a stress concentration area at the joint (see figure (2)) that would fail on detonation of the explosive but would survive all environmental requirements. The successful elimination of the cut-off tubes permitted a 3/8-inch increase in the length of the rod bundle. This resulted in a one-foot increase in the theoretical maximum opening radius of the rod bundle and therefore in an increase in effectiveness.

18. The rod bundle was fabricated with 3/16-inch square, aluminum-killed, 1018 steel rod with rounded corners. The hinge welds and stitch welds were made by the fusion welding technique (Tungsten-arc Inert Gas (TIg) without filler metal). The hinge welds were ½-inch long and were made on both sides of each rod pair. The stitch welds were one inch long and were made on one side of each rod pair. After welding of the rod bundle to the skin and end rings of the warhead, the assembly was stress-relieved for eight hours at 1200°F followed by slow furnace cooling. In an effort to simplify welding procedures and to minimize the time and cost required to fabricate a rod bundle, an investigation was made into the possible reduction or elimination of the stitch weld. This investigation was inspired by the results of field tests of four Mk II Mod O SPARROW III Warheads containing flash-butt welded rod mats fabricated by the Whirlpool Corporation, St. Joseph, Michigan, under contract (reference (z)). Two of the warheads fitted with rod bundles having no stitch welds yielded continuity as good as the two with rod bundles having one-inch stitch welds. In all four tests the continuity was greater than 96% (see reference (aa)). However, results of a limited number of Mk 38 Warhead field tests indicated that the stitch weld does contribute to increased continuity. Rod bundles having stitch welds one inch long yielded continuity about 5% higher than rod bundles having no stitch weld. It has been determined in other SPARROW III Warhead development programs that stitch welds longer than one inch have no appreciable effect on continuity. Information on the techniques and procedures for fabricating continuous-rod mats for warheads has been accumulated and prepared by Battelle Memorial Institute, Columbus, Ohio, on contract (reference (bb)) and is reported in reference (cc).

19. A redesign of the forward end closure to accommodate a contact fuze designed by the Naval Ordnance Laboratory (NOLC), Corona, California, took place during the development of the warhead without difficulty and with no detrimental effects on performance.

LOADING PROCEDURE DEVELOPMENT

20. The loading procedure used at the beginning of the program consisted of four steps.

a. The machined explosive charge halves were assembled into the magnesium liner using a pressure sensitive adhesive, Eastman Kodak 910 (cyanoacrylate adhesive) at the mating surface of the two charge halves.

b. The interior of the rod bundle in the warhead case was then coated with a polyester resin, Laminac 4116.

c. The liner-charge assembly was inserted into the warhead case.

d. The end closures were then attached.

Subsequent investigations resulted in a modification to the above method that provided better potting of the rod bundle. Studies of the effect of potting on performance of a continuous-rod warhead have indicated that potting reduces interaction between the individual rods and therefore tends to increase performance. The modified loading procedure consisted of the following:

a. The liner and the charge halves were assembled as above.

b. About one pound of polyester resin wqs then poured into the warhead case.

c. The liner-charge assembly was then pressed into the case under a load of about two tons.

d. The warhead end closures were attached.

The force applied to the liner-charge assembly forced the resin up and around the rod bundle, filling all voids and providing a moisture-proof seal. Details of the loading process can be found in reference (r). After loading, all of the warheads were inspected radiographically.

PERFORMANCE

21. The Mk 38 Mod 0 Warhead has a theoretical maximum opening radius of 30.5 feet. The initial development testing radius was 25 feet but was increased to 26 feet when the length of the rod bundle was increased due to elimination of the cut-off rings. The performance of the Mk 38 Warhead during the latter part of the development program consistently achieved a continuity of 98% with an average rod velocity in excess of 4,000 ft/sec. Initiation of these development warheads was accomplished by a simulated safety and arming (S&A) device (figure (3)) which was designed as a low cost simulation of the Mk 5 Mod 2 S&A Device. The Mk 5 Mod 2 S&A Device is the warhead initiating mechanism in the SPARROW III Missile. Drawings of the simulated S&A device appear in reference (dd) and drawings of the Mk 5 Mod 2 S&A Device appear in reference (ee).

22. During the PPE program, the testing radius was changed to 25 feet because of the requirements of the performance and design objectives (reference (a)) which call for a minimum continuity of 95% and a rod velocity of 4,000 ft/sec measured at a 25-foot radius. The warheads were initiated with Mk 5 Mod 2 S&A Devices. This was the first time a warhead evaluation

was performed using the actual S&A device. The firing tests produced rod continuities of about 93%, which indicated an apparent incompatibility between the warhead and S&A device. This incompatibility delayed continuation of the PPE program for six months. During this time several attempts were made to reconcile this incompatibility but without complete success. The S&A devices were modified to replace a standard lead with a shaped charge lead. The PPE program was continued and firing tests produced rod continuities of about 95% which is acceptable, but not the maximum experienced with the warhead. However, due to the urgent need for the warhead, it was decided to release it for use with the modified S&A device. Subsequently, a task (reference (ff)) was established to attempt to determine and understand the detonation phenomena between the warhead and S&A device in addition to other missile warhead explosive problems.

THERMAL VIBRATION TEST

23. During the development program a test was performed at NOL(WO) on the Mk 38 Warhead to simulate the extreme thermal and vibration environment of the SPARROW III XAAM-N-6b Guided Missile in carriage and launch from the F4H aircraft. It was felt that a complete and thorough over test of this type, conducted during the design phase, would be sufficient to demonstrate the adequacy of the warhead design so that testing of this nature would not be necessary in the PPE program.

24. The thermal test parameters were derived from the expected flight sequence as outlined in reference (b). From the specified environments at sea level and 45,000 feet, conditions were chosen that would produce the most severe thermal environment, determined by calculation, at the explosive-liner interface for any particular time. It was decided to simulate aircraft cruise and aircraft dash at sea level and missile launch at an altitude of 45,000 feet. Initial soak condition of 160°F was assumed for a MIL-STD 210 hot atmosphere. The heat input was achieved by a cylindrical radiant heating oven which was fitted with two banks of quartz lamps. Power to the oven was controlled by a rheostat to give the desired heating conditions. The vibration test parameters were determined to approach severe aircraft vibration at resonant frequencies of the test fixture (figure (4)) up to the load limit of the vibration exciter. The resonant frequency for the test fixture was 41 cps at an acceleration of one g. The vibration input was supplied by an MB Electronic Company C-10E Vibration Exciter. Thermal and vibration characteristics were recorded during the test by appropriate sensors.

25. The maximum skin temperature of 730°F was attained near the end of the missile launch condition at which time the explosive-liner interface temperature was 205°F. The maximum temperature at the explosive-liner interface was 250°F which occurred 2½ minutes after the end of the launch

condition. This was due to lag in the thermal input and would not actually occur since the missile would be expended during the launch phase. No structural damage occurred as a result of vibrating the warhead at resonance for the duration of the test and radiographs revealed no cracks or break-up of the DATB-PBX. After thorough examination of the warhead, it was ballistically tested at NWL. Results of the test compared favorably with those of a warhead tested previously with the same internal configuration. There was no degradation of the performance as a result of the heated vibration test. This test will be covered by the evaluation report which is under preparation.

SUMMARY

26. The Mk 38 Mod 0 Warhead development has been completed. The warhead was successfully evaluated in the PPE program and was recommended for release to production in December 1961. Major advantages of the Mk 38 Mod 0 Warhead over the previous SPARROW III Warheads (Mk 11 and Mk 18) include higher permissible operating temperatures which do not place operational restrictions on current aircraft, plus an increase in warhead effectiveness by increasing the opening radius as well as increasing the rod velocity and continuity. The rod continuity produced by this warhead is at least 95% at a 25-foot radius with an average rod velocity in excess of 4,000 ft/sec when initiated with a Mk 5 Mod 2 Safety and Arming Device. The Mk 38 Mod 0 Warhead is currently in production status by BUWEPS. NOL(WO) will transfer cognizance of this warhead to NWL on 1 January 1963.

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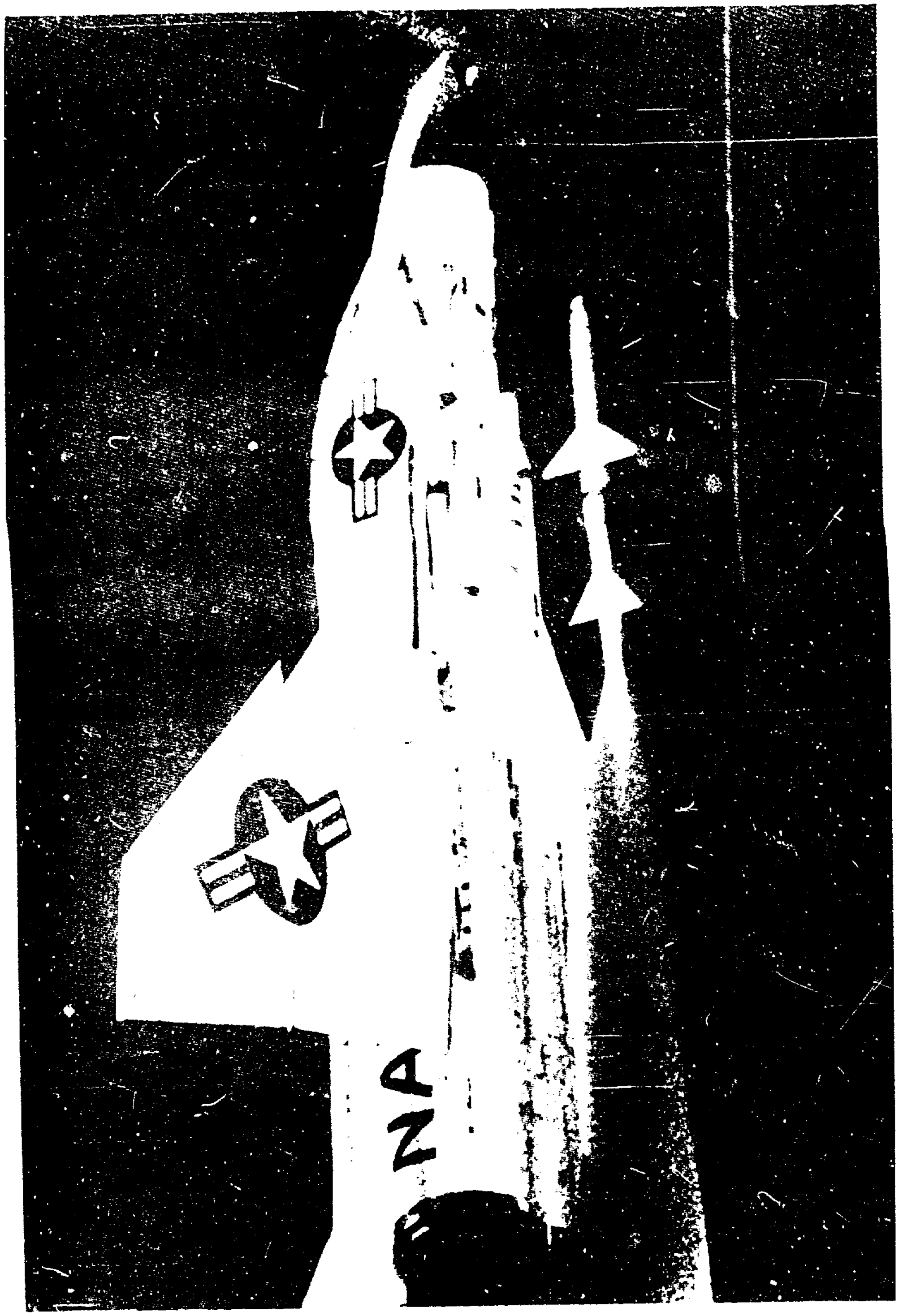

FIG. I SPARROW III MISSILE IN CARRIAGE AND LAUNCH BY F4H AIRCRAFT

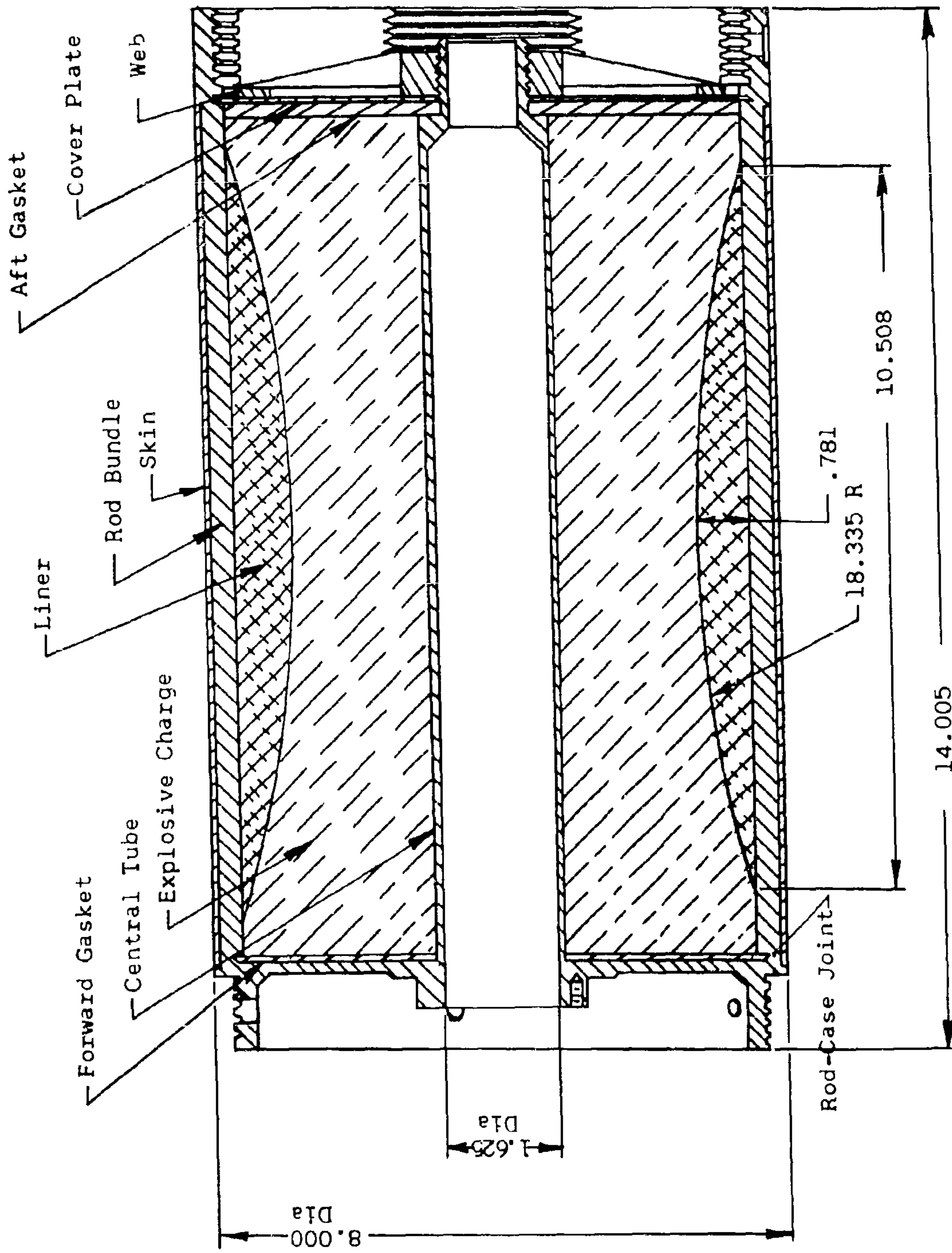

Fig.2 GUIDED MISSILE WARHEAD MK 38 MOD 0
BUWEPS DWG.2116970

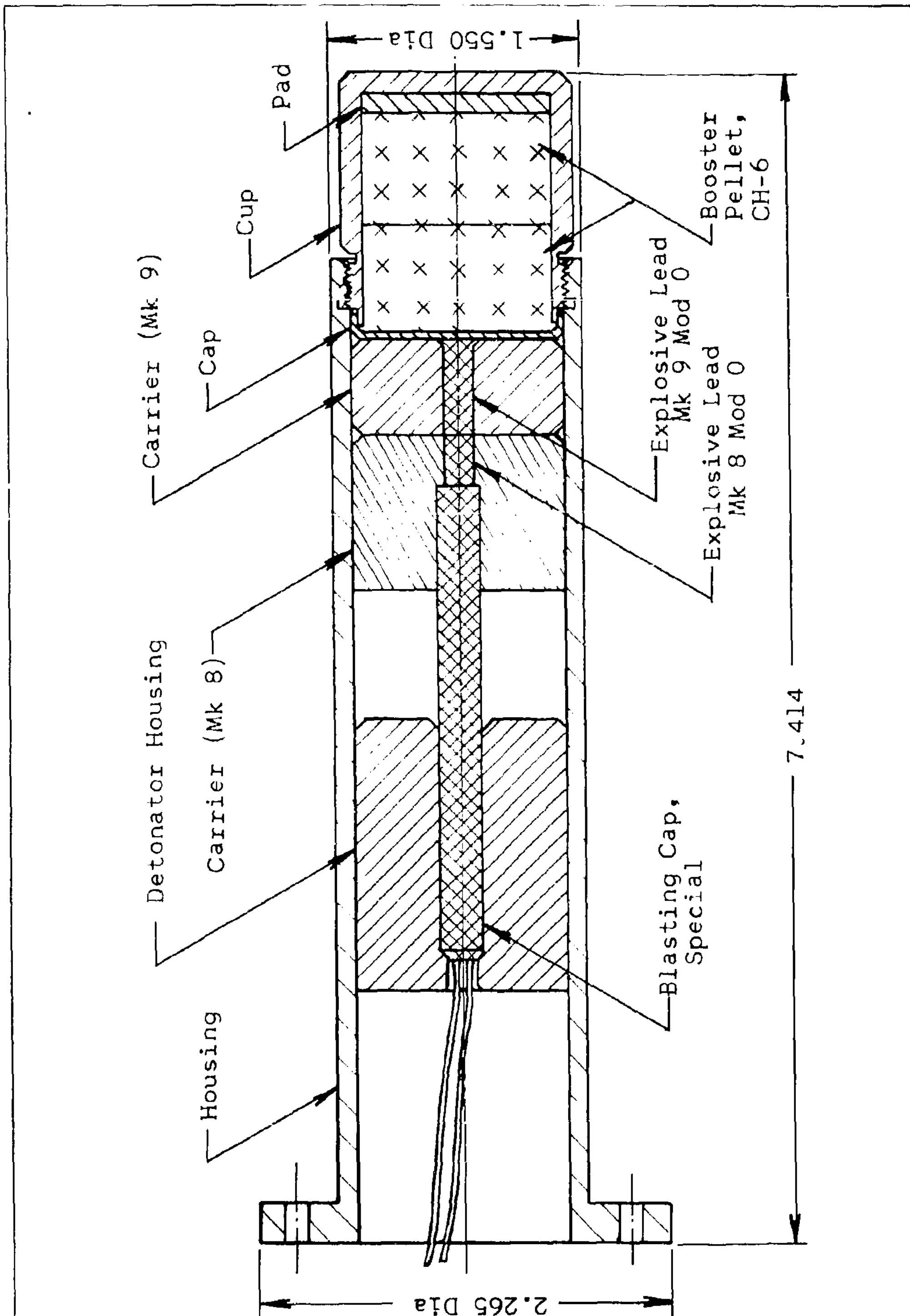

Fig.3 - SIMULATED SAFETY AND ARMING DEVICE
BUWEPS DWG. 2283671

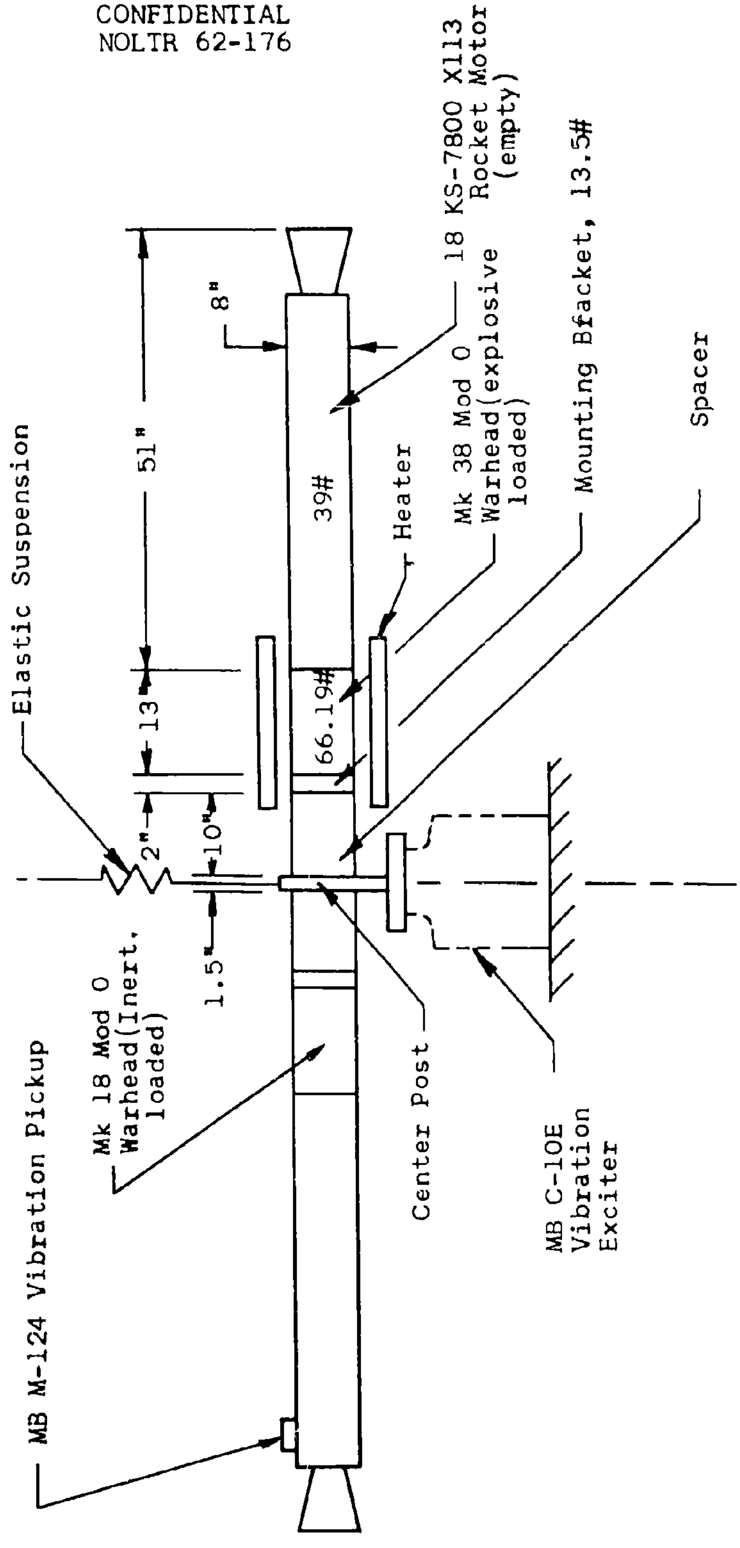

Fig. 4 THERMAL VIBRATION TEST ARRANGEMENT

TABLE I

PROPERTIES OF PBXN-1 and PBXN-4

	PBXN-1	PBXN-4
Composition	66% RDX 25% Aluminum 9% Nylon	94% DATB 6% Nylon
Density (TMD)	1.83 gm/cc	1.8 gm/cc
Compressive Strength	15,000 psi	8,450 psi
Detonation Velocity	7,850 m/sec	7,340 m/sec
Sensitivity (Bruceton)	50 cm (Max)	> 320 cm
Auto-Ignition Temperature	170-180°C (338-356°F)	310-320°C (590-608°F)
Useful Temperature Limit	150°C (300°F)	260°C(500°F)

REFERENCES

(a) NAVWEPS Report 7256 "Performance and Design Objectives EX 38 Warhead for the XAAM-N-6b (SPARROW III) Guided Missile (U)"

(b) BUWEPS (BuAer) SP-3006-0-5, Detail Specification for Model XAAM-N-6b Guided Missile SPARROW III Class AA (U), (Conf)

(c) BUWEPS (BUORD) LD 545885 and all drawings listed thereon for Warhead, Guided Missile, Mk 38 Mod 0, Empty

(d) BUWEPS (BUORD) LD 552961 and all drawings listed thereon for Warhead, Guided Missile, Mk 38 Mod 0, Explosive Loaded Assembly

(e) MILITARY SPECIFICATION MIL-W-23275(Wep), Warhead, Guided Missile, Mk 38 Mod 0 (Empty) (U)

(f) NAVWEPS OS 9889, Descriptions and Requirements for Warhead, Guided Missile, Mk 38 Mod 0, Explosive Loaded Assembly

(g) BUWEPS WEPTASK RM 3723 003/212 1/W020 AO 003 of 3 Aug 1960 to NOL(WO)

(h) NOL(WO) ltr KS:EHS:das 8810 Ser 0479 of 9 Mar 1961 to BUWEPS

(i) NOL(WO) ltr KS:WEP:mep 8810 Ser 03515 of 29 Dec 1961 to BUWEPS

(j) NOL(WO) Conf ltr KW:HCT:mgl X 11/7 Ser 02442 of 13 Nov 1958 to BUORD

(k) BUWEPS (BUORD) ltr ReWl-C-CCB:sjo X 11/1 Ser 011398 of 21 Nov 1958 to NOL(WO)

(l) NAVWEPS (NAVORD) Report 6016, "Heat Resistant Explosives II, 1, 3-Diamino-2, 4, 6 - Trinitrobenzene, DATB", K. G. Shipp and M. E. Hill, 31 Mar 1958

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(q) NOL(WO) ltr KS:WEP:brf 8810 Ser 02110 of 20 Jun 1961 to NWS.

(r) NAVWEPS OD 18798, Advisory Instructions for the Explosive Loading of Warhead, Guided Missile, Mk 38 Mod 0

(s) NOL(WO) ltr WE:CCM:plb Ser 01135 of 25 May 1961 to BUWEPS

(t) BUWEPS Notice 8811 of 24 Aug 1961

(u) NAVWEPS OS 12671, Descriptions and Requirements - DATB/PBX Explosive

(v) NOL(WO) Contract No. N 60921/5742 to Symington Wayne Corp.

(w) NOL(WO) Contract No. N 60921/6121 to ACF Industries, Inc.

(x) NOL(WO) Contract N 60921-4735 to Chamberlain Corp.

(y) Chamberlain Corp, Waterloo, Iowa; Report of Static Firing Test of Six Modified EX-25 Warheads, (Contract N 60921-4735) 6 Feb 1958

(z) NOL(WO) Contract N 60921-5134 to Whirlpool Corp.

(aa) NOL(WO) ltr KS:RFF:dbp Ser 01641 of 20 Jul 1959 to Battelle Memorial Institute

(bb) NAVORD Contract NOrd 18635 to Battelle Memorial Institute

(cc) Battelle Memorial Institute, Columbus, Ohio; Final Report on Continuous-Rod Fabricating Techniques for Warheads 1 Mar 1961 (Contract NOrd 18635)

(dd) BUWEPS (BUORD) LD 515962 and all drawings listed thereon for S&A Device (Simulated)

(ee) BUWEPS (BUORD) LD 521539 and all drawings listed thereon for S&A Device, Mk 5 Mod 2

(ff) BUWEPS WEPTASK RUME 3E 000/212 1/F008 10 004 of 25 Aug 1961 to NOL(WO)

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	DESCRIPTORS	CODES		DESCRIPTORS	CODES
SOURCE	NOL technical report	NOLTR	SECURITY CLASSIFICATION AND CODE COUNT	Confidential - 24	CØ24
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SUBJECT ANALYSIS OF REPORT

DESCRIPTORS	CODES	DESCRIPTORS	CODES	DESCRIPTORS	CODES
Mark	MARK	Aircraft	AIRC		
38 Mod 0	38MØ	Thermal	THMP		
Continuous-rod	CNTI	Vibration	VIBR		
Warhead	WARH	Plastic	PLAS		
Sparrow III	SPAR3	Bonded	BOND		
Air-to-Air	AIRA	Explosives	EXPL		
Guided	GUIE	Sparrow	SPAR		
Missile	MISL	Feasibility	FEAS		
Heat Resistant	HEAA	Diamino	DIAM		
Heat	HEAT	Trinitro	TRIT		
Aerodynamic Heating	AERY	Benzene	BENZ		
High Speed	HIGS	Loading	LOAI		

PRNC-NOL-5070/28 (5-62)

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 62-176)
DEVELOPMENT OF THE MK 38 MOD 0 CONTINUOUS ROD WARHEAD FOR THE SPARROW III AIR -TO-AIR MISSILE (C), by J. P. Talentino. 14 Dec. 1962. 18p. charts, tables. Task RM 37 23003/212 1/W02Q AO 003. CONFIDENTIAL

A warhead has been developed for the SPARROW III air-to-air missile that will withstand the aerodynamic heating due to carriage on high-speed aircraft. The development program was based on the continuous-rod kill mechanism and t he use of diaminotrinitrobenzene-plastic bonded explosive (DATB-PBX). The rod continuity produced by this warhead is at least 95% at a 25-foot radius with an average rod velocity in excess of 4000 ft/sec.

DOWNGRADED AT 3 YEAR INTERVALS: DECLASSIFIED AFTER 12 YEARS. DOD DIR 5200.10.

1. Missiles - Sparrow III
2. Missiles - Warheads
3. Warheads, Continuous - rod
4. Warheads - Explosives
5. Diaminotrinitrobenzene
6. Explosives, Plastic-bonded

I. Title
II. Talentino, James P.
III. Project

Abstract card is confidential.

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