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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 1136

BOMBS AND ASSOCIATED COMPONENTS

62nd Partial Report

TEST OF MK 77 MOD 0 BOMB (FIRE-750 LBS) WITH CANTED FINS

FINAL Report

Task Assignment NPG-Re3c-321-1-53

Copy No. ____

Classification RESTRICTED SECURITY INFORMATION

Test of Mk 77 Mod 0 Bomb (Fire-750 lbs.) with Canted Fins

PART A

SYNOPSIS

1. This is the final report on tests performed on the Mk 77 Mod 0 Bomb (Fire-750 lbs.) equipped with canted fins.

2. Tests were conducted on the bomb to determine:

   a. Fit on all applicable stations of available service type aircraft.

   b. Flight characteristics of bomb and plane combination.

   c. Separation characteristics in drops.

   d. Free flight stability.

   e. Time of fall.

   f. Spinning rate.

   g. Cratering characteristics.

   h. Functioning characteristics of fuzes.

   i. Approximate spread of bomb contents.

3. It was determined that:

   a. The bomb fits satisfactorily on wing and center stations of the F7F-3, the wing racks of the AD-2, and the port and starboard pylons of the F4U-5 provided that no more than 20 degrees of flaps are used.

   b. There is apparently no vibration in flight, and there is no appreciable deformation of the bomb other than a slight twisting between the sections at speeds up to 300 knots.

   c. The bomb separates cleanly when dropped from the F4U-5 and AD-2 aircraft.

   d. Flight stability is excellent.

e. Time of fall from 3500 feet and 250 knots indicated airspeed in horizontal flight is approximately 13.5 seconds. Time of fall from 3500 feet and 250 knots airspeed in a dive of approximately 60 degrees is nine (9) seconds.

f. The spin reached a maximum of 923 r.p.m. just prior to impact for the horizontal drops, and was approximately 600 r.p.m. for the diving drop just prior to impact.

g. The average dimensions of the craters were approximately five (5) feet deep by eight (8) feet in diameter.

h. One (1) of the two (2) fuzes recovered (tail fuze on drop number 3) did not arm although the arming wire had pulled free. The other fuze (nose fuze on the diving drop) had armed and would have fired.

i. Spread varied from 20 to 60 feet forward of the crater and was 10 to 20 feet wide respectively for the horizontal drops. The dive drop had a spread 60 feet long. At 30 feet ahead of the crater, the spread was 40 feet across. The shape of the spread resembled a diamond, with the sharp point at the crater.

4. Conclusions:

a. The bomb equipped with canted fins has a high rate of spin and excellent flight stability.

b. The tail fuze recovered did not arm either because of bomb spin or lack of air flow past the arming vanes in the recessed well.

5. Recommendations:

It is recommended that the effect of bomb spin on arming vanes of fuzes located along the centerline of the bomb be investigated. This spin acting in the same direction of rotation of the arming vanes' action in arming the fuze may prevent arming from taking place. It is further recommended that live drops be made to provide more definite information as to spread of the napalm gel since the inert mixture used is difficult to see and measure against earth.

Test of Mk 77 Mod 0 Bomb (Fire-750 lbs.) with Canted Fins

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PART B

INTRODUCTION

1. AUTHORITY:

Those tests were authorized by reference (a) and conducted under Task Assignment NPG-Re3c-321-1-53 established by reference (b).

2. REFERENCES:

a. BUORD Rest ltr Re3c-RJN:gg F41-6 of 24 Mar 1953
b. BUORD Conf ltr NP9 Re3c-BEK:mp Ser 42777 of 29 Jul 1952
c. NAVPROV ltr OVX:LHK:csc A11/3c321-1 Ser 30598 of 25 Feb 1953 to BUORD
d. PONECON between LT E. S. Houton, NPG, and Mr. R. E. Niederstrasser, BUORD, on 1 Apr 1953
e. NPG Report No. 838 of 28 Aug 1951

3. BACKGROUND:

In order to improve the spread of gel on medium altitude releases, attempts have been made to spin the fire bomb. Erratic results were obtained from attempting to spin the bomb by attaching tabs to the fins. These tests were reported in reference (c). The canted fins were developed in an effort to obtain more reliable spin and to improve the stability of the spinning bomb.

4. OBJECT OF TEST:

The object of the test is to determine the feasibility of spinning a fire bomb by means of canted fins to improve its overall effectiveness when dropped from 3500 feet in horizontal and dive altitudes.

5. PERIOD OF TEST:

a.	Date Project Letter	24 March 1953
b.	Date Material Received	24 March 1953
c.	Date Commenced Modifying Fins	1 April 1953
d.	Date Commenced Tests	16 April 1953
e.	Date Completed Tests	24 April 1953

6. REPRESENTATIVE PRESENT:

R. E. Niederstrasser — Bureau of Ordnance

Test of Mk 77 Mod 0 Bomb (Fire-750 lbs.) with Canted Fins

PART 2

DETAILS OF TEST

7. DESCRIPTION OF ITEM UNDER TEST:

The bomb tested was a standard Mk 77 Mod 0 Bomb (Fire-750 lbs.) inert loaded and equipped with inert M23 Igniters and inert M173 Fuzes and further equipped with modified canted fins instead of the standard fins or fins and shrouds. The nose and tail cones were not installed. The fins are manufactured of ST aluminum, 3/16 inch in thickness and 18 inches in length along the root chord. The fins were welded at an angle to an adapter which bolted to the bomb. The angle of fin to the fore and aft centerline of the bomb, and to the adapter, is about 10 degrees. Actual measurements are given in Table I. Reference (c) authorized the modification of the fins as follows: The fins were strengthened by bolting a 3/8 inch steel rod 1-1/2 inches down and in from the outboard after corner of two (2) adjacent fins, and bolting rods between the next two (2) fins as close as practical to the bolts used in the first two (2) fins. Figures 1 through 4 show the bomb before and after modification.

8. DESCRIPTION OF TEST EQUIPMENT:

a. The following aircraft were used: F7F-3, AD-2, and F4U-5.

b. A Mitchell chronograph camera equipped with a 40 inch lens.

9. PROCEDURE:

a. Assembling

The bombs were assembled without nose or tail cones, and the canted fins were modified. Inert M23 Igniters and inert M173 Fuzes were installed.

b. Fit Tests

The following aircraft were used for these tests: F7F-3, AD-2, and F4U-5. On the F7F-3 and AD-2 aircraft, the bomb was hung on the center rack and one (1) wing rack. (The center rack of the F7F-3 has been changed at this activity to a Mk 51 Mod 11 Rack. This is not standard equipment.) On the F4U-5, the bomb was hung on one (1) pylon rack. The landing flaps were actuated on all aircraft.

c. Flight Tests

One (1) bomb was loaded with water containing a small amount of fluorescent dye. The purpose of the dye was to give visual proof of any tendency of the bomb sections to separate or warp. This separation or warp might be caused by the canted fins twisting the after section of the bomb while the middle section was held rigid by the bomb rack and sway braces.

d. Aircraft Drop Tests

Four (4) bombs were inert loaded to weight with a dry mixture of granulated cork and Portland cement. Inert M23 Igniters and M173 Fuzes were installed. Three (3) bombs were dropped from the F4U-5 aircraft in horizontal flight at an altitude of about 3500 feet and 250 knots indicated airspeed. The fourth bomb was dropped from an AD-2 aircraft in a dive of 60° from 3500 feet and 250 knots indicated airspeed. Motion picture coverage of release, flight, and impact data was made with a Mitchell chronograph camera equipped with a 40 inch lens.

10. RESULTS AND DISCUSSION:

The modification of the Mk 77 Mod 0 Fire Bomb to take canted fins does not differ materially in fit or flight tests from the standard Mk 77 Mod 0 Fire Bomb as reported in reference (e). The canted fins and strengthening thereto do not cause additional interference on the aircraft on which fit tests were conducted. The F4U-5 cannot carry the bomb when more than 20 degrees of flaps are used. The bomb interferes with oil cooler door operation on the AD aircraft, and therefore cannot be carried operationally on the bomb ejector rack. Behavior of the modified bomb in flight tests was the same as that of the unmodified bomb. Results of fit and flight data are presented in Table II and Table III, respectively. The canted fins provide the Mk 77 Mod 0 Bomb with a very stable and smooth flight. The canted fins eliminate the erratic spin and instability heretofore encountered in attempting to make the fire bomb spin, but the results of this tests are inconclusive as to the effectiveness of increasing napalm spread. Drop data is given in Table IV. The tail fuze recovered from bomb number 3 was disassembled and showed that although the arming wire had pulled free, the fuze had failed to arm. A possibility exists that the fuze was not pre-armed by rotation of the arming vane one (1) full turn. Impact forces were high enough to jam the firing pin sleeve past the safe position and into a 3/4 fired position. Figures 7 through 11 show the fuze and relative positions of the firing pin and sleeve in the full safe position and as found.

PART D

CONCLUSIONS

11. Because of fit problems, the Mk 77 Mod 0 Fire Bomb with canted fins cannot be used by F4U squadrons operating at sea. The yaw and pitch of the bomb encountered in the drop made in the 60 degree dive and referred to in Table IV could have been caused by the aircraft being in a skid upon release of the bomb. Position of the cameras was such that the condition could neither be proved nor disproved by film assessment. Fuze arming action in the tail of the Mk 77 Mod 0 Fire Bomb is not positive. Air flow over the tail cone may be turbulent and of insufficient amount to cause the arming vane to rotate to the completely armed position. The effect of bomb spin on vane action may be such as to prevent arming. There does not appear to be any difference in the size of the crater made in horizontal drops from that made in a high angle release from the same altitude and airspeed. It was noted that most of the bomb and the nose fuze bounced out of the crater and landed approximately 20 feet ahead of the crater in the dive bombing drop. This effect might have been caused by spongy earth. The earth was soft and wet near the surface.

PART E

RECOMMENDATIONS

12. It is recommended that live drops be made to obtain accurate spread measurements in both horizontal and diving releases. It is further recommended that bomb spin effect on centerline mounted fuzes be investigated.

Test of Mk 77 Mod 0 Bomb (Fire-750 lbs.) with Canted Fins

The tests upon which this report is based were conducted by:
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Aviation Ordnance Department

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By direction

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NPG REPORT NO. 1136

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Sixty-Second Partial Report

on

Bombs and Associated Components

- - - - - - - - -

Final Report

on

Test of Mk 77 Mod 0 Bomb (Fire-750 lbs.) with Canted Fins

Project No.: NPG-R-3c-321-1-53
No. of Pages: 8

Date: JUN 8 - 1953

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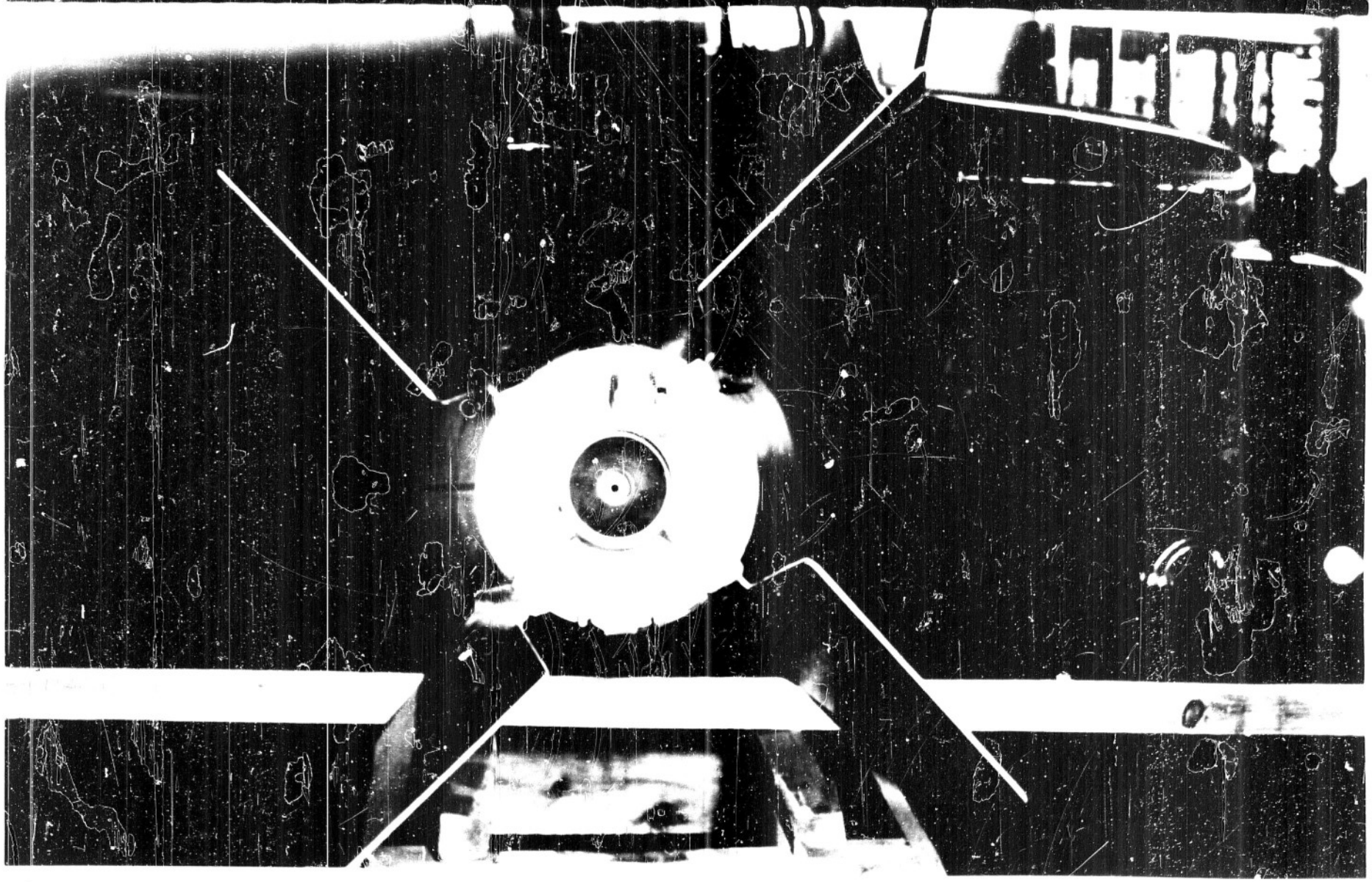
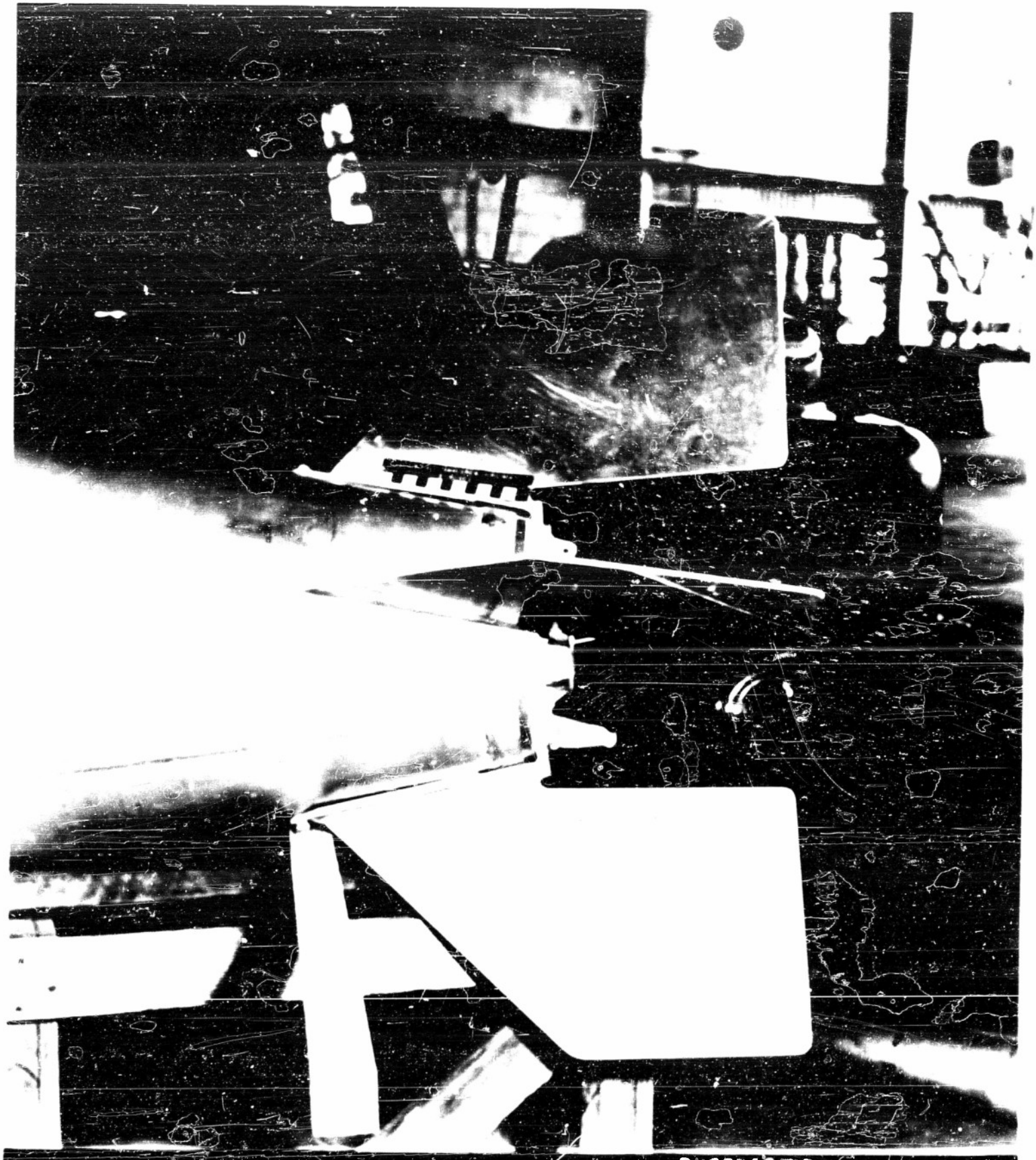
NP9-63004 2 April 1953 RESTRICTED SECURITY INFORMATION

Mk 77 Mod 0 Fire Bomb, equipped with canted fins before modification, rear view.

Figure 1





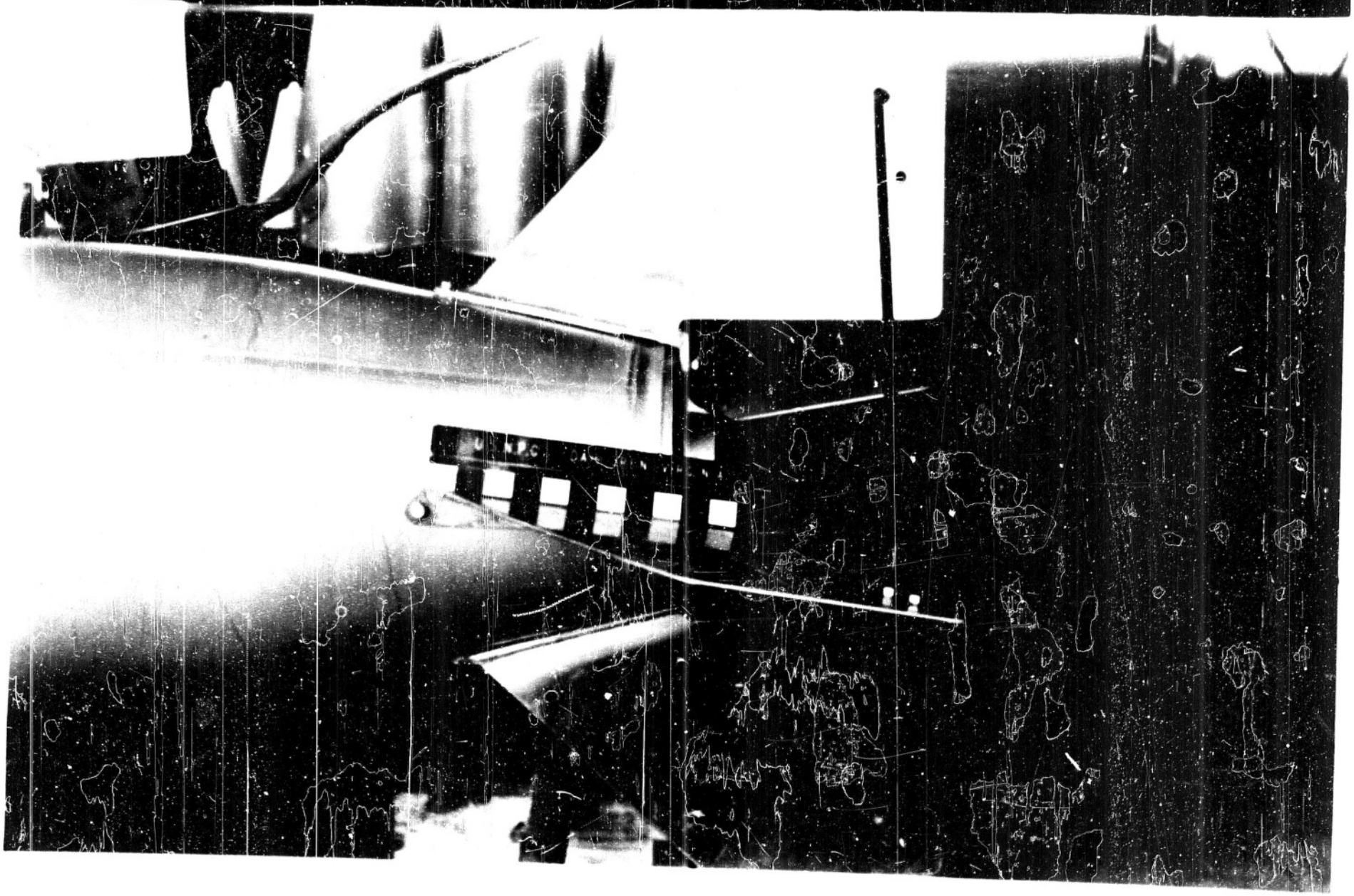
Mk 77 Mod 0 Fire Bomb equipped with canted fins before modification, side view.

Figure 2

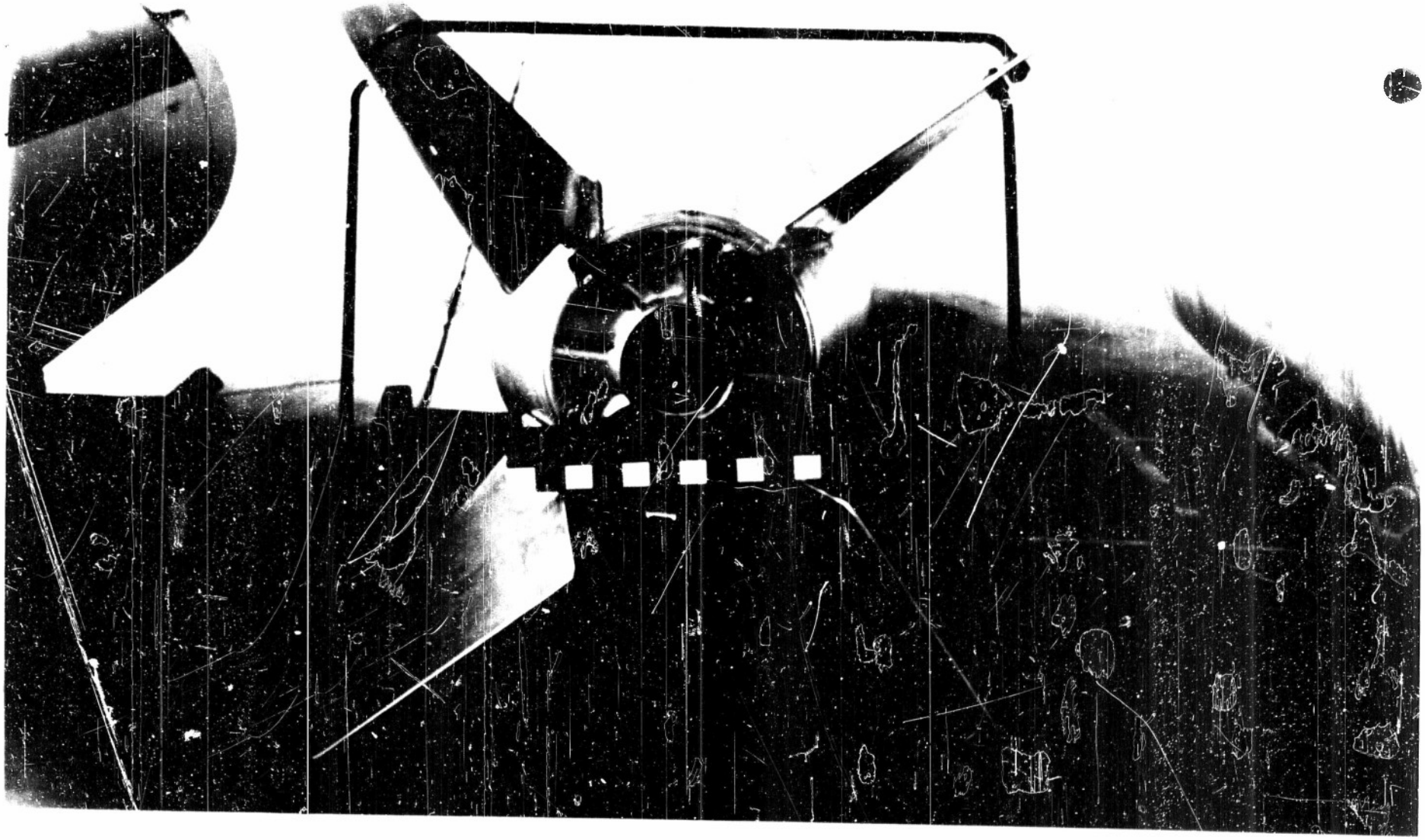
NP9-63136 7 April 1953 RESTRICTED SECURITY INFORMATION

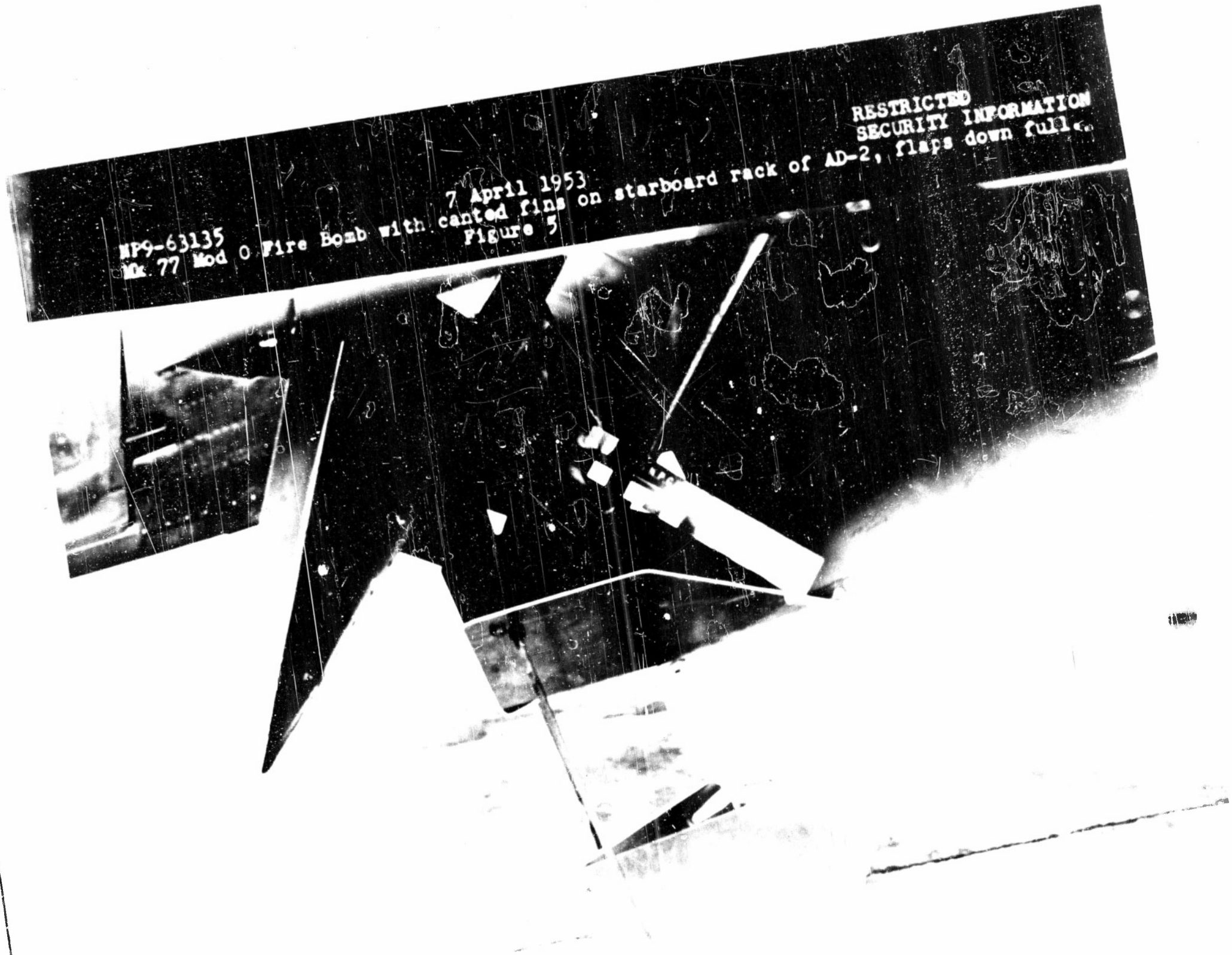
Mk 77 Mod 0 Fire Bomb equipped with canted fins, after modification, side view.

Figure 3



P9-63138 7 April 1953 RESTRICTED
Mk 77 Mod 0 Fire Bomb equipped with canted fins, after modification, rear view. SECURITY INFORMATION
Figure 4

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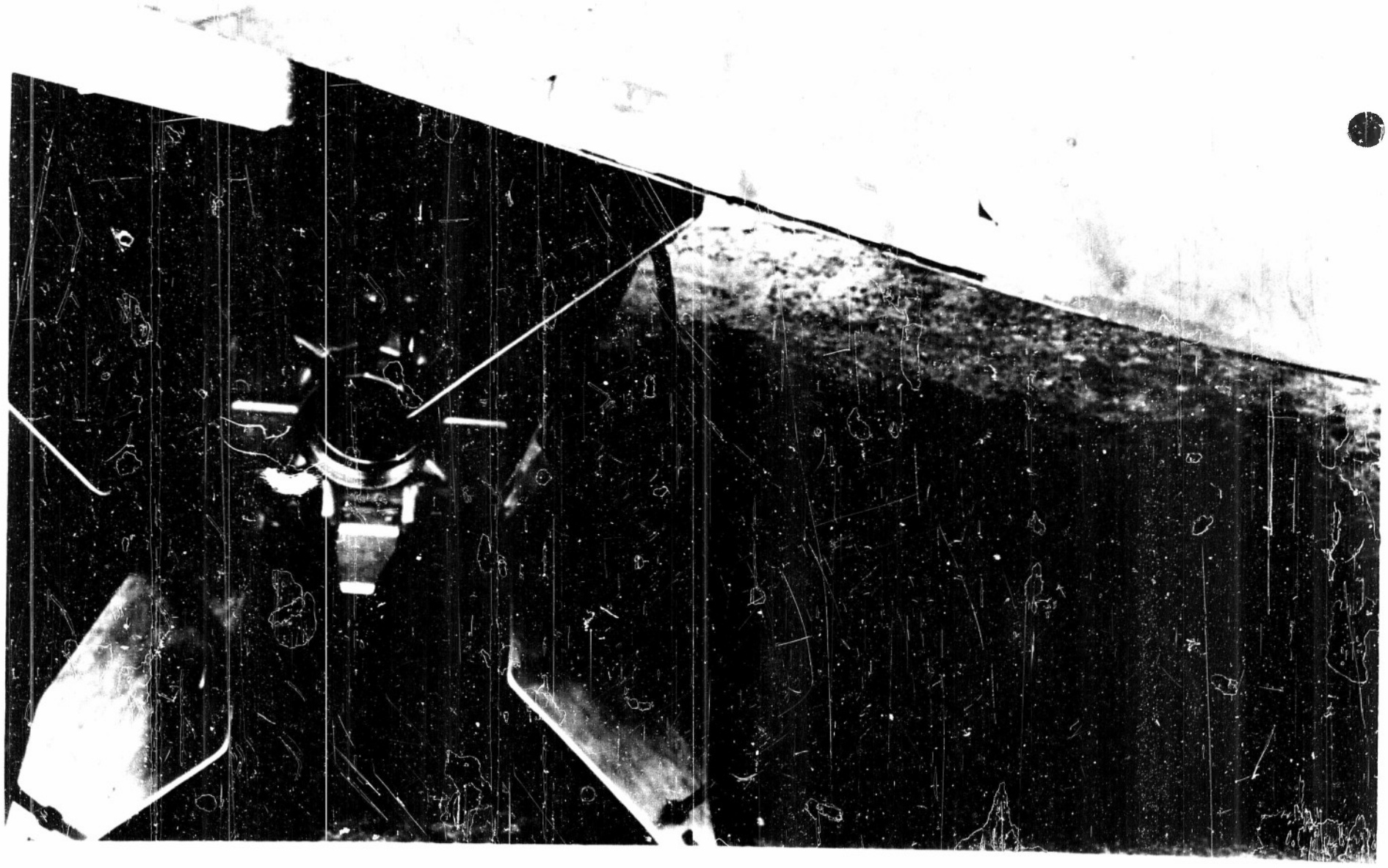
7 April 1953
NP9-63135
Mk 77 Mod 0 Fire Bomb with canted fins on starboard rack of AD-2, flaps down full.
Figure 5

NP9-63137 7 April 1953 RESTRICTED
SECURITY INFORMATION

Mk 77 Mod 0 Fire Bomb with canted fins on starboard pylon of F4U-5, flaps down 20°, bare clearance.

Figure 6



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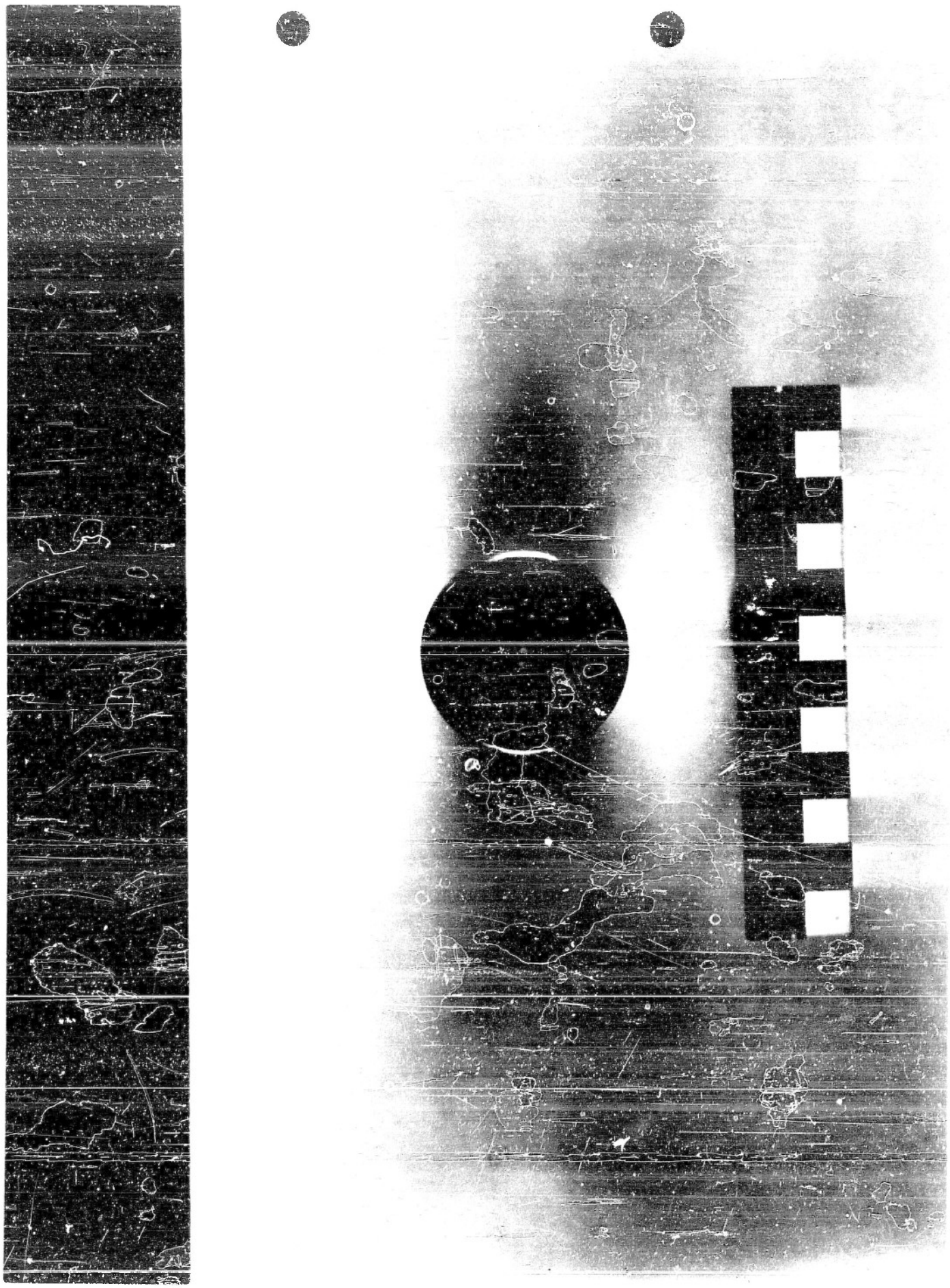

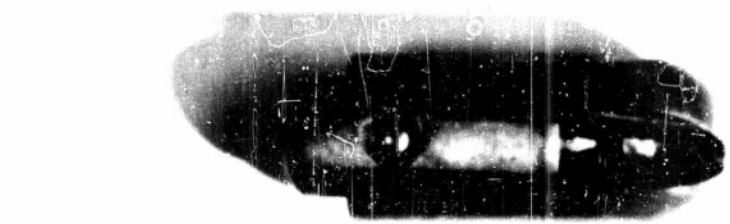

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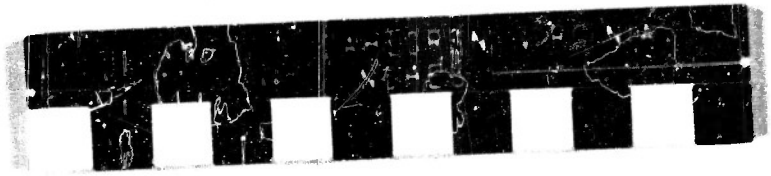

TABLE I

ANGLE OF FIN TO FORE AND AFT CENTERLINE OF BOMB

Drop No.	Top Right Fin	Top Left Fin	Bottom Left Fin	Bottom Right Fin
1	9°	9°	10°	11°
2	10°	8°	11°	9°
3	9°	13°	9°	11°
4	8°	8°	10°	11°

TABLE II

FIT TESTS ON AIRCRAFT

Type Aircraft	Station and Rack	Fit	Remarks
AD-2	Starboard Wing Mk 51-11	4-1/2 inches clearance from rod to flap. No interference between flap and fins.	Clearance Satisfactory
AD-2	Center Douglas Bomb Ejector	3 inch clearance between rod and fuselage. Oil cooler door opens only 1/4.	Interference between nose section of bomb and oil cooler door. Unsatisfactory.
F4U-5	Starboard pylon Mk 51-11	4 inch clearance between fin and deck. Flaps interfere at 20°.	Unsatisfactory at any time more than 20° flaps are needed.
F7F-3	Port Wing Mk 51-11	No interference and sufficient clearance.	Satisfactory.
F7F-3	Center Mk 51-11 (Not standard equipment)	1/2 inch clearance between rod and fuselage.	Satisfactory. Note that 14 inch suspension is not standard equipment for this station.

Test of Mk 77 Mod 0 Bomb (Fire-750 lbs.) with Canted Fins

TABLE III

FLIGHT TESTS ON AIRCRAFT

Type Aircraft	Time/Airspeed (min) / (kts)	Remarks
AD-2	30/200	Medium leak between aft and mid sections at bottom of bomb. Connecting rod nose nut opening commenced leaking.
AD-2	15/225	No leakage between aft and mid sections. Slight leakage between forward and mid sections along bottom of bomb.
AD-2	15/250	Slight leaks between aft, mid, and forward sections. Nose nut continued leaking.
AD-2	15/250	Slight leak between aft and mid section. Nose nut continued leaking.
F7F-3	8/300	Very slight leak at nose nut. All other leaks stopped.

Test of Mk 77 Mod 0 Bomb (Fire-750 lbs.) with Canted Fins

TABLE IV

DROP DATA

Drop No.	Type Aircraft	Date 1953	Release Alt(ft) / Airspeed (kts)	Time of Flight (sec)	Impact Spin Rate	Remarks
1	F4U-5	4/16	3500 ft/250 kts	13.5	923 rpm	Horizontal flight Excellent stability
2	F4U-5	4/17	3500 ft/250 kts	--	750 rpm	Horizontal flight Excellent stability
3	F4U-5	4/17	3200 ft/200 kts	13.5	750 rpm	Horizontal flight Excellent stability See Note #1
4	AD-2	4/24	3500 ft/250 kts	9	600 rpm	60° Dive - Slight yaw and pitch throughout flight.

NOTE 1: Aircraft pilot declared an emergency, and although originally scheduled as a diving drop, the bomb was released in horizontal flight as pilot returned to base.

Test of Mk 77 Mod 0 Bomb (Fire-750 lbs.) with Canted Fins

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