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Project 3.8

EFFECTS OF AN ATOMIC DETONATION ON AIRCRAFT STRUCTURES ON THE GROUND

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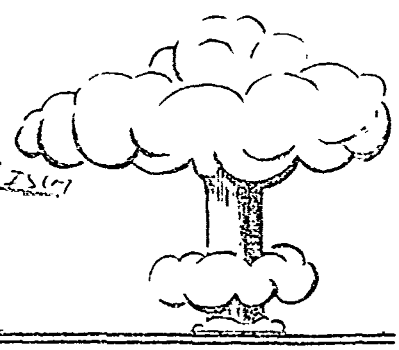

ARMED FORCES SPECIAL WEAPONS PROJECT
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OPERATION BUSTER

PROJECT 3.8

EFFECTS OF AN ATOMIC DETONATION ON AIRCRAFT STRUCTURES ON THE GROUND

By

JOHN E. GILROY
1st Lt., USAF

With Appendix

by

RALPH E. PETERS

Edited by

LLOYD J. BREIDENBACH

January 1952

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CONTENTS

ACKNOWLEDGMENTS iii

ILLUSTRATIONS vii

TABLES xi

ABSTRACT xii

CHAPTER 1 INTRODUCTION 1

1.1 General 1
1.2 Objective 1

CHAPTER 2 PROCEDURE 2

2.1 General 2
2.2 Location of Aircraft Relative to Ground Zero . 2
2.2.1 Location of B-17 for Dog Shot 2
2.2.2 Location of F-47 for Dog Shot 2
2.2.3 Location of B-17 for Easy Shot 2
2.2.4 Location of F-47 for Easy Shot 3
2.3 Instrumentation 3

CHAPTER 3 TEST RESULTS 7

3.1 Dog Shot 7
3.1.1 Fuselage Damage on B-17 7
3.1.2 Wing Damage on B-17 7
3.1.3 Empennage on B-17 7
3.1.4 Fuselage Damage on F-47 (Dog Shot) . . 27
3.1.5 Wing Damage on F-47 27
3.1.6 Empennage on F-47 27
3.1.7 Control Surfaces on F-47 27
3.2 Easy Shot 27
3.2.1 Fuselage Damage on B-17 (Easy Shot) . . 27
3.2.2 Wing Damage on B-17 (Easy Shot) 37
3.2.3 Empennage Damage B-17 (Easy Shot) . . . 37
3.2.4 Fuselage Damage on F-47 (Easy Shot) . . 37
3.2.5 Wing Damage on F-47 (Easy Shot) 37
3.2.6 Empennage Damage on F-47 (Easy Shot) . . 37

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CHAPTER 4 DISCUSSION 47

4.1 General 47
4.2 Dog Shot 47
4.3 Easy Shot 47

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS 49

5.1 Conclusions 49
5.1.1 Fighter Aircraft with Tail Toward Blast. 49
5.1.2 Bomber Aircraft with Side Toward Blast . 49
5.1.3 Bomber Aircraft with Nose Toward Blast . 49
5.2 Recommendations 49
5.2.1 More Comprehensive Program 49
5.2.2 Sufficient Aircraft 49
5.2.3 Early Assignment of Aircraft 50

APPENDIX A INSTRUMENTATION DETAILS 51

[redacted]

[redacted]

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[redacted]

ILLUSTRATIONS

CHAPTER 2 PROCEDURE

2.1 Method of Towing B-17 from Yucca Lake Strip to Area T-7 with Tail Wheel on Flat-Bed Trailer 4
2.2 Method of Towing B-17 Showing Tow Cable from Trailer and Attachment to Main Gear 5
2.3 Condition of F-47 Prior to Exposure to Dog Shot . . 6

CHAPTER 3 TEST RESULTS

3.1 Typical Failure of B-17 Fuselage in Radio Operator's Compartment 8
3.2 Permanent Set in Aft Fuselage of B-17 as a Result of Side Loading During Dog Shot 9
3.3 Severe Buckle in Right Side of Fuselage of B-17 Following Dog Shot 10
3.4 View Looking Aft Showing Critical Buckle in Fuselage and Buckle in Dorsal Fin 11
3.5 Skin Buckles on the Forward Portion of the B-17 Fuselage on the Side Toward the Blast 12
3.6 Skin Buckles and Broken Window on Nose Section of B-17 on Side Toward the Blast 13
3.7 Skin Buckles on Nose Section of B-17 on Side Toward the Blast 14
3.8 Deep Buckle in Fuselage in Radio Operator's Compartment. Frame Members were Also Buckled . . . 15
3.9 Skin Buckles on the Aft Portion of the B-17 Fuselage on the Side Toward the Blast 16
3.10 Interior View of Bomb Bay of B-17 Showing Buckle in Door and Also the Buckles in the Upper Portion of the Bulkhead as a Result of Dog Shot 17
3.11 Damage Incurred by Bomb-Bay Doors of B-17 on Dog Shot 18
3.12 Holes in Fuselage Produced by Waist Gun Window Fragments 19
3.13 Interior View of B-17 Cockpit Illustrating Thermal Damage to Fabric, Resulting from Dog Shot 20
3.14 Interior View of B-17 Cockpit Illustrating Thermal Damage to Fabric, Resulting from Dog Shot 21
3.15 Wing-to-Fuselage Fairing of B-17 Which was Torn Loose from the Fuselage Fasteners on Dog Shot . . . 22
3.16 Condition of Surface of Left Wing Panel after Dog Shot 23

[redacted]

[redacted]

[redacted]

3.17 View Showing Thermal and Blast Damage to Rudder Following Dog Shot 24
3.18 View Showing Thermal and Blast Damage to Dorsal Fin Following Dog Shot 25
3.19 View Showing Thermal and Blast Damage to Vertical Stabilizer Following Dog Shot 26
3.20 Typical F-47 Flap Hinge Bracket Broken on Dog Shot . 28
3.21 F-47 After Dog Shot with Damaged Control Surfaces Removed Prior to Easy Shot 29
3.22 General Condition of F-47 Fuselage After Dog Shot . 30
3.23 Overall View of B-17 Illustrating Crushing of Nose Section and General Condition of Aircraft After Easy Shot 31
3.24 General Condition of F-47 Following Easy Shot. Note the Complete Failure of the Left Wing 32
3.25 Additional Damage to B-17 Fuselage Including Crushed Superstructure Aft of Cockpit Incurred During Easy Shot 33
3.26 Exterior View of Damaged Bomb-Bay Doors of B-17 After Easy Shot 34
3.27 Interior View of Buckled Bomb-Bay Door Showing Failed Structural Member 35
3.28 Buckles in Nose Section of B-17 Following Easy Shot 36
3.29 Skin Buckles in B-17 Outer Wing Panels 38
3.30 Condition of Vertical Tail of B-17 After Easy Shot As Seen From the Left Side Previously Incident to the Blast on Dog Shot 39
3.31 Condition of Right Side of Vertical Tail and Dorsal Fin of B-17 After Easy Shot 40
3.32 Fuselage Failure Aft of Cockpit in F-47 as a Result of Easy Shot 41
3.33 Fuselage Failure Aft of Cockpit in F-47 as a Result of Easy Shot 42
3.34 Failure of Left Wing of F-47 as a Result of Easy Shot 43
3.35 Damage Sustained by Right Wing Panel of F-47 During Easy Shot. Ailerons and Flaps Were Removed Prior to This Shot 44
3.36 Damage Sustained by Right Wing Panel of F-47 During Easy Shot. Ailerons and Flaps Were Removed Prior to This Shot 45
3.37 Empennage Damage Sustained by F-47 on Easy Shot. The Rudder and Elevators had Been Removed Prior to This Shot 46

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CHAPTER 4 DISCUSSION

4.1 Location of Aircraft Relative to Ground Zero for Dog and Easy Shots 48

APPENDIX I INSTRUMENTATION DETAILS

A.1 Location of Instrumentation Chest In F-47 Cockpit After Removal of Control Stick, Rudder Pedals, and Instrument Panel. Chest Contains Accelerometer, Recording Oscillograph, Bridge Balance Unit, Battery, and Automatic Controls 53

A.2 Thin Skin Thermal Sensing Plate on F-47 Seat . . . 54
A.3 Condition of Ground Mounted Instrument Chest (Large Box) with Thin Skin Thermal Sensing Plate on Top. Small Chest Contains Photo Cell Triggering Mechanism for Starting Recording Systems . . 55
A.4 Pressure Sensing Orifice on F-47 Fuselage 56
A.5 Schematic Diagram Showing Location of Aircraft Instrumentation 61
A.6 Schematic Diagram of Ground Installation 62
A.7 Schematic Diagram Showing General Location of Instruments 63
A.8 Buster Tests, Aircraft Instrumentation, Pressure vs Time, Channel No. 6 64
A.9 Buster Tests, Aircraft Instrumentation, Vertical Acceleration vs Time, Channel No. 5 65
A.10 Buster Tests, Aircraft Instrumentation, Vertical Acceleration vs Time, Channel No. 5 66
A.11 Buster Tests, Aircraft Instrumentation, Vertical Acceleration vs Time, Channel No. 2 67
A.12 Buster Tests, Aircraft Instrumentation, Vertical Acceleration vs Time, Channel No. 2 68
A.13 Buster Tests, Aircraft Instrumentation, Radial Acceleration vs Time, Channel No. 4 69
A.14 Buster Tests, Aircraft Instrumentation, Radial Acceleration vs Time, Channel No. 4 70
A.15 Buster Tests, Aircraft Instrumentation, Temperature vs Time, Channel No. 1 71
A.16 Buster Tests, Ground Instrumentation, Pressure vs Time, Channel No. 6 72
A.17 Buster Tests, Ground Instrumentation, Vertical Acceleration vs Time, Channel No. 5 73
A.18 Buster Tests, Ground Instrumentation, Vertical Acceleration vs Time, Channel No. 5 74

[redacted]

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A.19 Buster Tests, Ground Instrumentation, Vertical Acceleration vs Time, Channel No. 2 75
A.20 Buster Tests, Ground Instrumentation, Vertical Acceleration vs Time, Channel No. 2 76
A.21 Buster Tests, Ground Instrumentation, Radial Acceleration vs Time, Channel No. 4 77
A.22 Buster Tests, Ground Instrumentation, Radial Acceleration vs Time, Channel No. 4 78
A.23 Buster Tests, Ground Instrumentation, Temperature vs Time, Channel No. 1 79

[redacted]

[redacted]

[redacted]
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TABLE

APPENDIX A INSTRUMENTATION DETAILS

A.I Tabulation of Instrumentation Results 30

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ABSTRACT

The objective of Project 3.8 is to determine the effects of an atomic detonation on parked aircraft with respect to structural damage.

The two aircraft allotted to this project were flown to Yucca Lake landing strip and then moved overland to the test location.

For Dog Shot, the fighter (F-47) was positioned with tail toward the blast at a ground range of 4,250 feet from the target ground zero. The bomber (B-17) was located with the left side toward the blast at a ground range of 6,310 feet from the target ground zero. Damage to the fighter from Dog Shot was confined primarily to the control surfaces, whereas damage to the bomber included a severe fuselage buckle aft of the wing, burning of the rudder fabric, and extensive local skin damage.

The aircraft were relocated for Easy Shot. The fighter was positioned with the tail toward the blast at a ground range of 2,675 feet. The bomber was placed with the nose toward ground zero at a range of 5,847 feet. The fighter was severely damaged, one wing failing completely. The bomber sustained additional damage to skin panels, and the bomb-bay doors were buckled inward.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Prior to Operation BUSTER very little data was available on the effects of an atomic detonation on aircraft parked on the ground although aircraft structural components were exposed on Operation CROSSROADS and on Operation GREENHOUSE. Information is required on the effects on complete aircraft parked on the ground to implement vulnerability studies.

1.2 OBJECTIVE

The objective of Project 3.8 is to determine the effects of an atomic detonation on parked aircraft with respect to structural damage from thermal and blast energy, and also to demonstrate the feasibility of cross-country movement of test aircraft from the Yucca Lake landing strip to the test location.

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CHAPTER 2

PROCEDURE

2.1 GENERAL

Since aircraft structures are designed to different load factors, at least two types of test vehicle are required, one in the bomber category and one in the fighter category. Whereas initially five four-engine bombers (B-17) and four single-engine fighters (three F-47 and one F-80) were requested, the project finalized with one B-17 and one F-47 assigned for test purposes. The aircraft were flown to the Yucca Lake landing strip and then were transported overland to the test positions.

2.2 LOCATION OF AIRCRAFT RELATIVE TO GROUND ZERO

The aircraft were placed at specific ranges from ground zero based on predicted overpressures for Dog Shot and then moved to new positions for Easy Shot. The method of towing the B-17 is shown in Fig. 2.1 and Fig. 2.2. The F-47 was carried on top of the flat-bed trailer with the main gear straddling the bed.

2.2.1 Location of B-17 for Dog Shot

Prior to Dog Shot, the B-17 was positioned on the natural terrain with the left side toward ground zero at a ground range of 6,310 feet on a true bearing of South 0° 57' West.

2.2.2 Location of F-47 for Dog Shot

The F-47 was placed at a ground range of 4,250 feet from the target ground zero on a true bearing of North 85° 58' East with the tail of the aircraft toward the blast. The condition of the F-47 as received is shown in Fig. 2.3.

2.2.3 Location of B-17 for Easy Shot

The B-17 was relocated for Easy Shot at a ground range of 5, 47 feet on a true bearing of South 7° 19' East and oriented with the nose toward ground zero.

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2.2.4 Location of F-47 for Easy Shot

The F-47 was relocated for Easy Shot at a ground range of 2,675 feet on a true bearing of 0 East and oriented with the tail toward ground zero.

2.3 INSTRUMENTATION

Instrumentation utilized on the project consisted of two oscillograph recorders, one mounted in the fighter cockpit and the other buried in the ground beside the aircraft. These instruments were employed to determine the feasibility of similar installations for future test programs. A more detailed discussion of the instrumentation is included in Appendix A.

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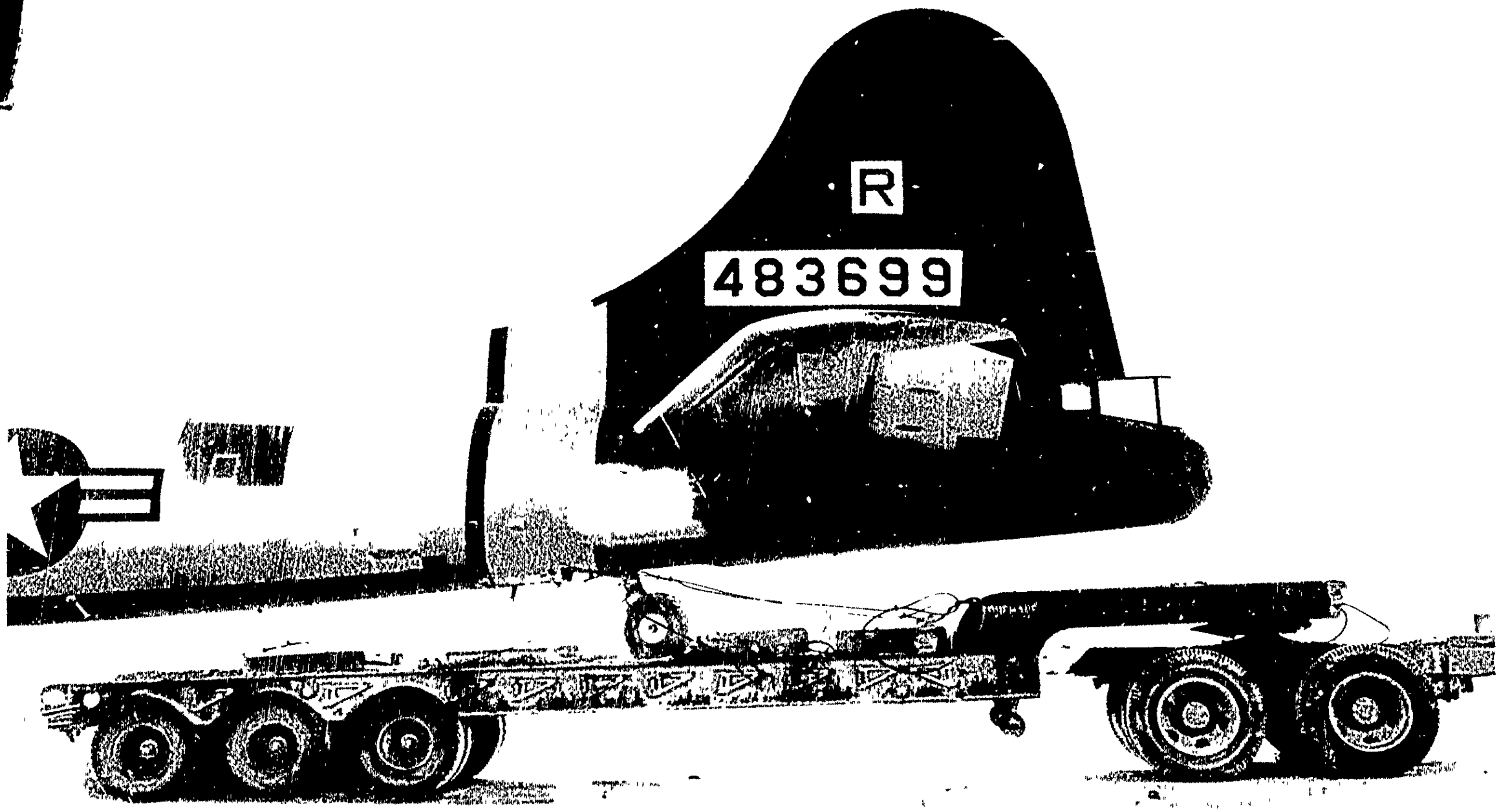

Fig. 2.1 Method of Towing B-17 from Yucca Lake Strip to Area T-7 with Tail Wheel on Flat-Bed Trailer

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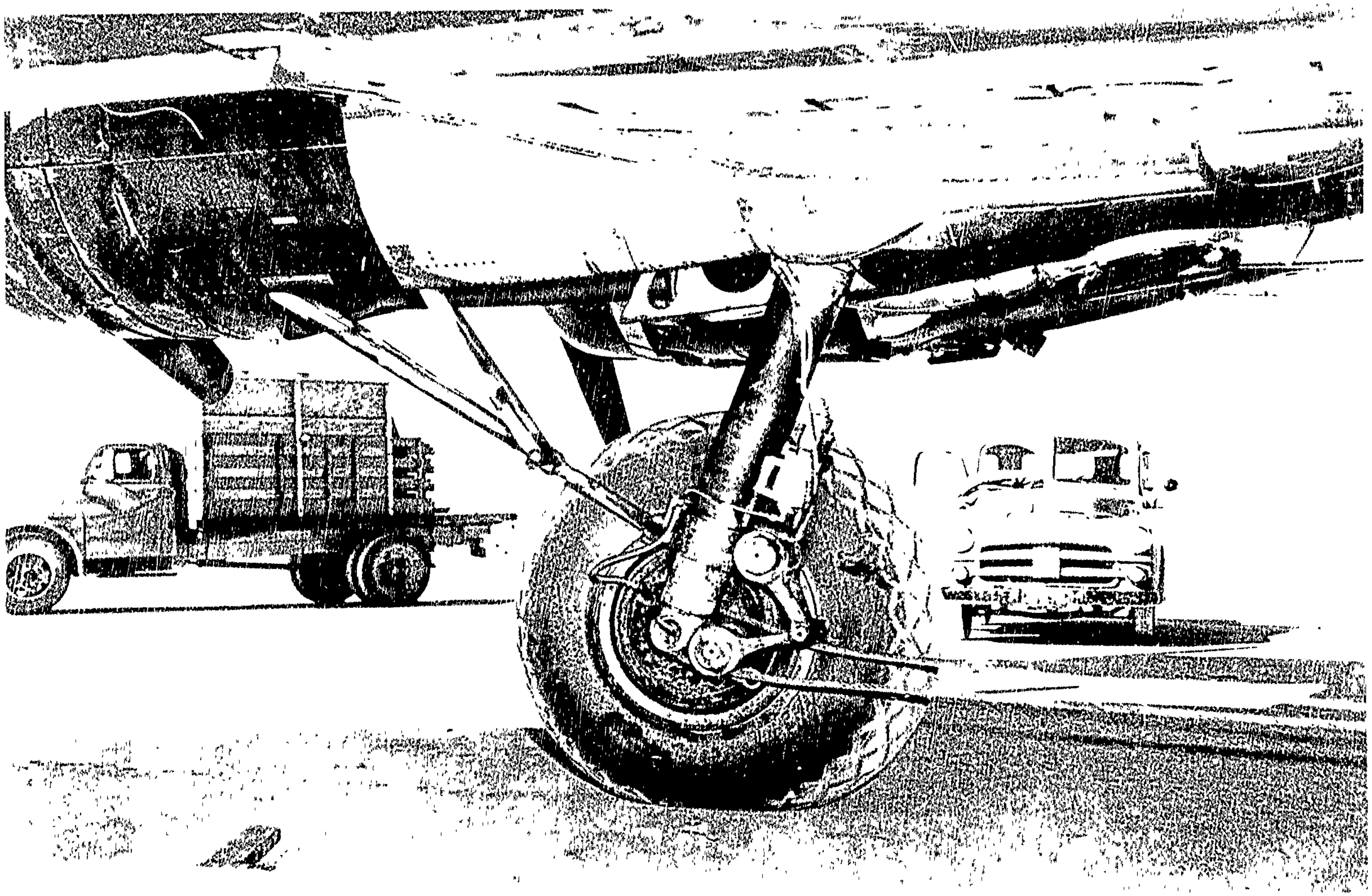

Fig. 2.2 Method of Towing B-17 Showing Tow Cable from Trailer and Attachment to Main Gear

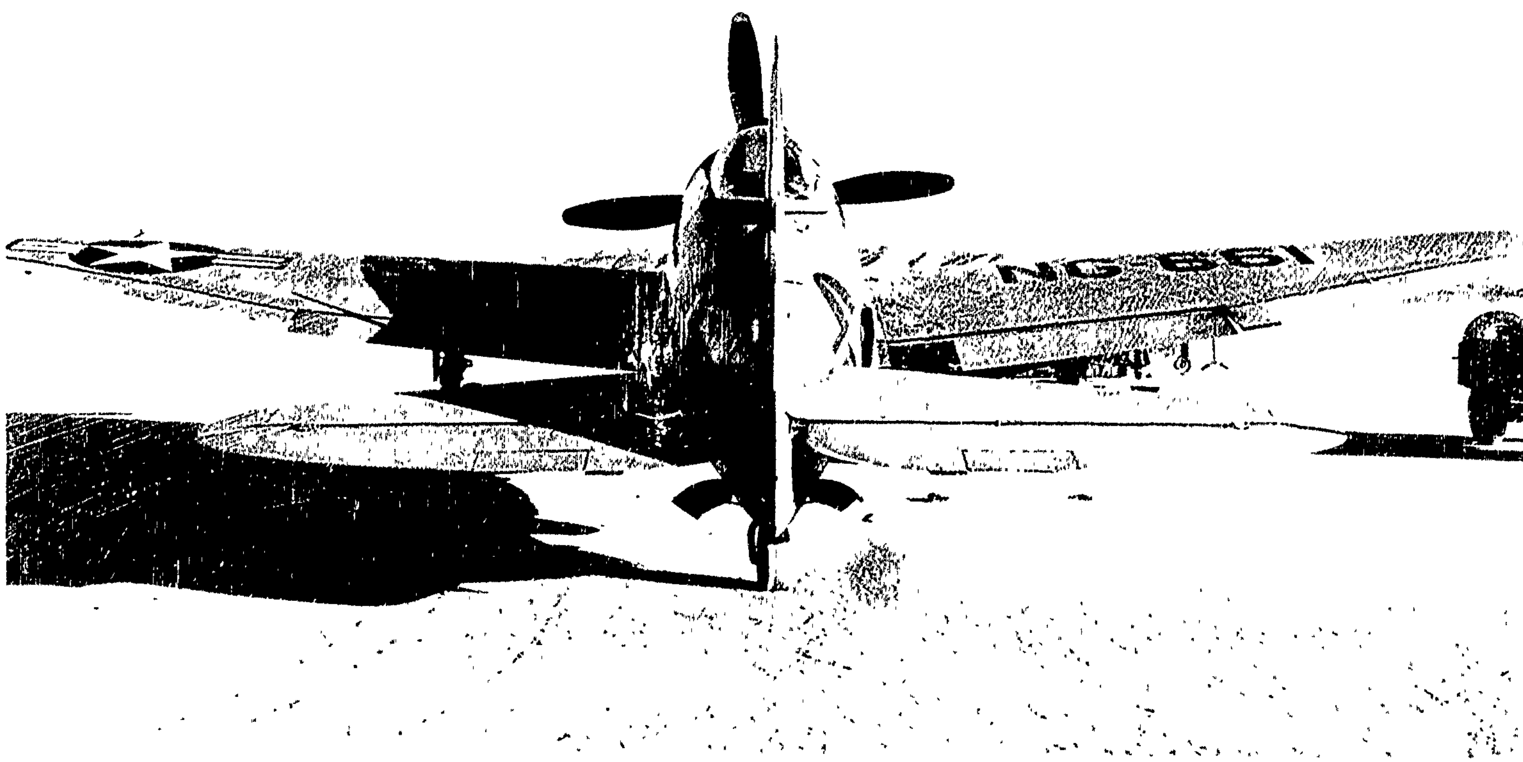

Fig. 2.3 Condition of F-47 Prior to Exposure to Dog Shot

CHAPTER 3

TEST RESULTS

3.1 DOG SHOT

The damage incurred by the B-17 as a result of the Dog Shot exposure was quite severe, the aircraft being rendered useless prior to extensive repairs including replacement of major components. The F-47 suffered loss of all the control surfaces and their attachment fittings.

3.1.1 Fuselage Damage on B-17

Due to the side-on orientation of the B-17, the fuselage was highly stressed in bending and in torsion produced by the load on the vertical tail, with a buckling failure occurring aft of the wing, in the radio operators compartment. Fig. 3.1 shows typical failure of stringers and frame members where broken on both sides of the fuselage. Fig. 3.2 shows the permanent set (clockwise) in the fuselage aft section, and Figs. 3.3 and 3.4 show details of buckled fuselage. Many of the skin panels were dished in on the side toward the blast as shown in Figs. 3.5 through 3.9. The bomb-bay doors were buckled inward, and some of the door stiffeners were ruptured. Figs. 3.10 and 3.11 show the external and interior views of the bomb-bay doors. A majority of the windows were broken and some of the acrylic fragments from the waist gun window on the left side were blown through the fuselage skin on the opposite side producing the results shown in Fig. 3.12. Paint was blistered or scorched where exposed to the incident thermal energy. Fabric in the cockpit was burned or charred. Although the fire did not propogate or reach a serious magnitude, the hazards of thermal ignition are apparent. Figs. 3.13 and 3.14 show some results of thermal damage in cockpit fabric.

3.1.2 Wing Damage on B-17

The B-17 wing appeared relatively free of damage except for the wing-to-fuselage fairing on the left side which tore loose from the rivets, as shown in Fig. 3.15. The condition of the left outer-wing panel is portrayed in Fig. 3.16.

3.1.3 Empennage

The dorsal fin, vertical stabilizer, and the rudder were severely damaged. The rudder fabric was completely burned except for the lower two panels. Dishing of the skin on the vertical fin and the dorsal fin was extensive. Paint was scorched and blistered with the red paint appearing more severely effected than the black paint in the same region. The combined effects of thermal and blast damage are shown in Figs. 3.17 through 3.19.

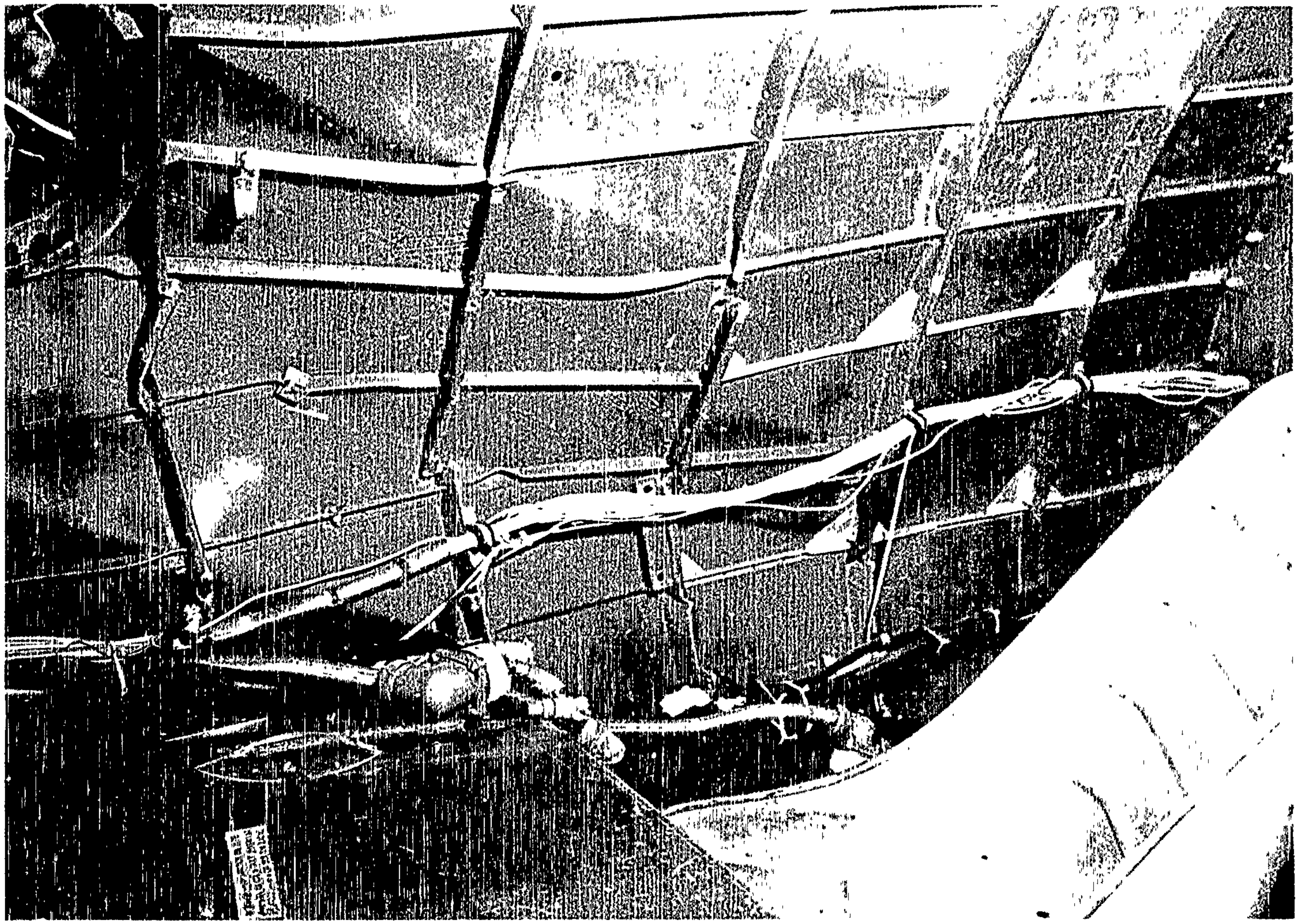

Fig. 3.1 Typical Failure of B-17 Fuselage in Radio Operator's Compartment

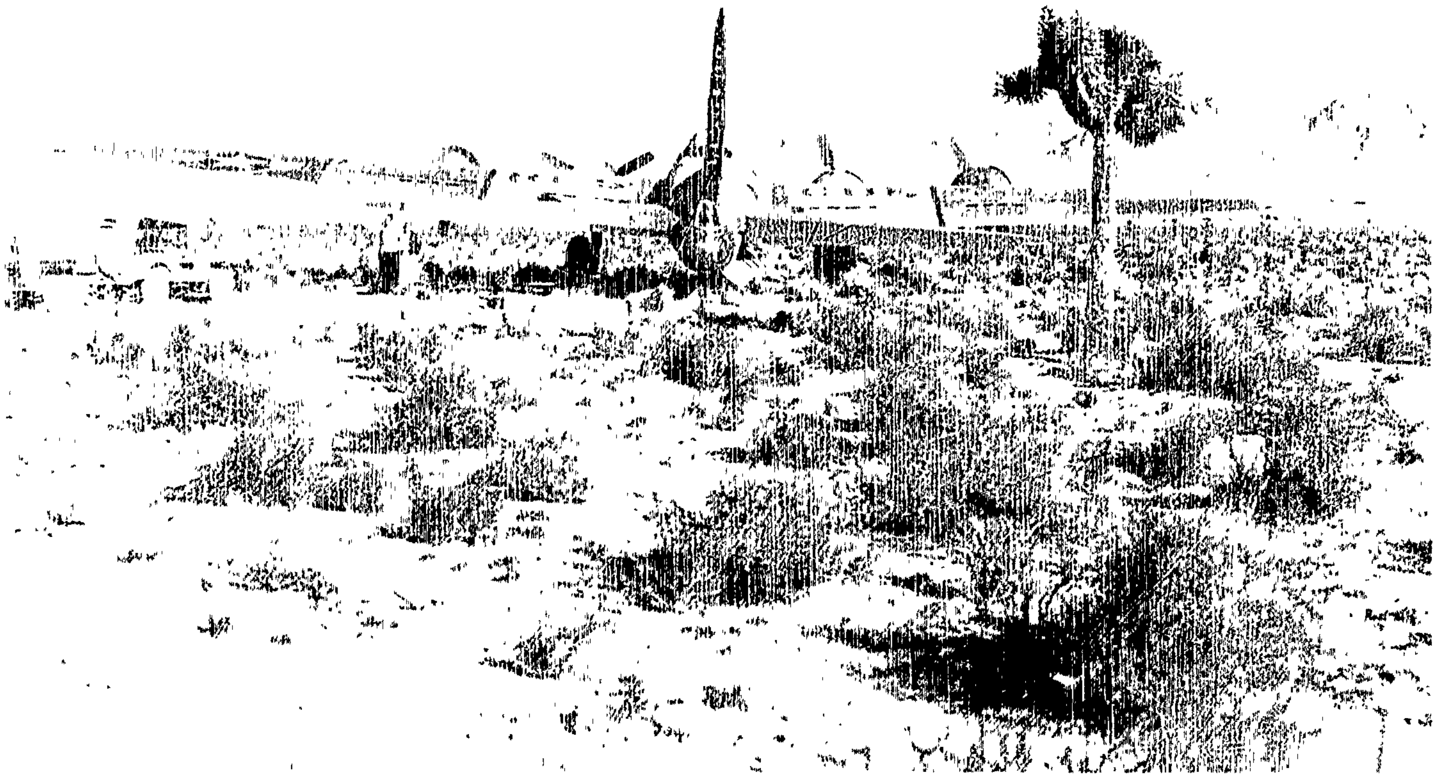

Fig. 3.2 Permanent Set in Aft Fuselage of B-17 as a Result of Side Loading During Dog Shot

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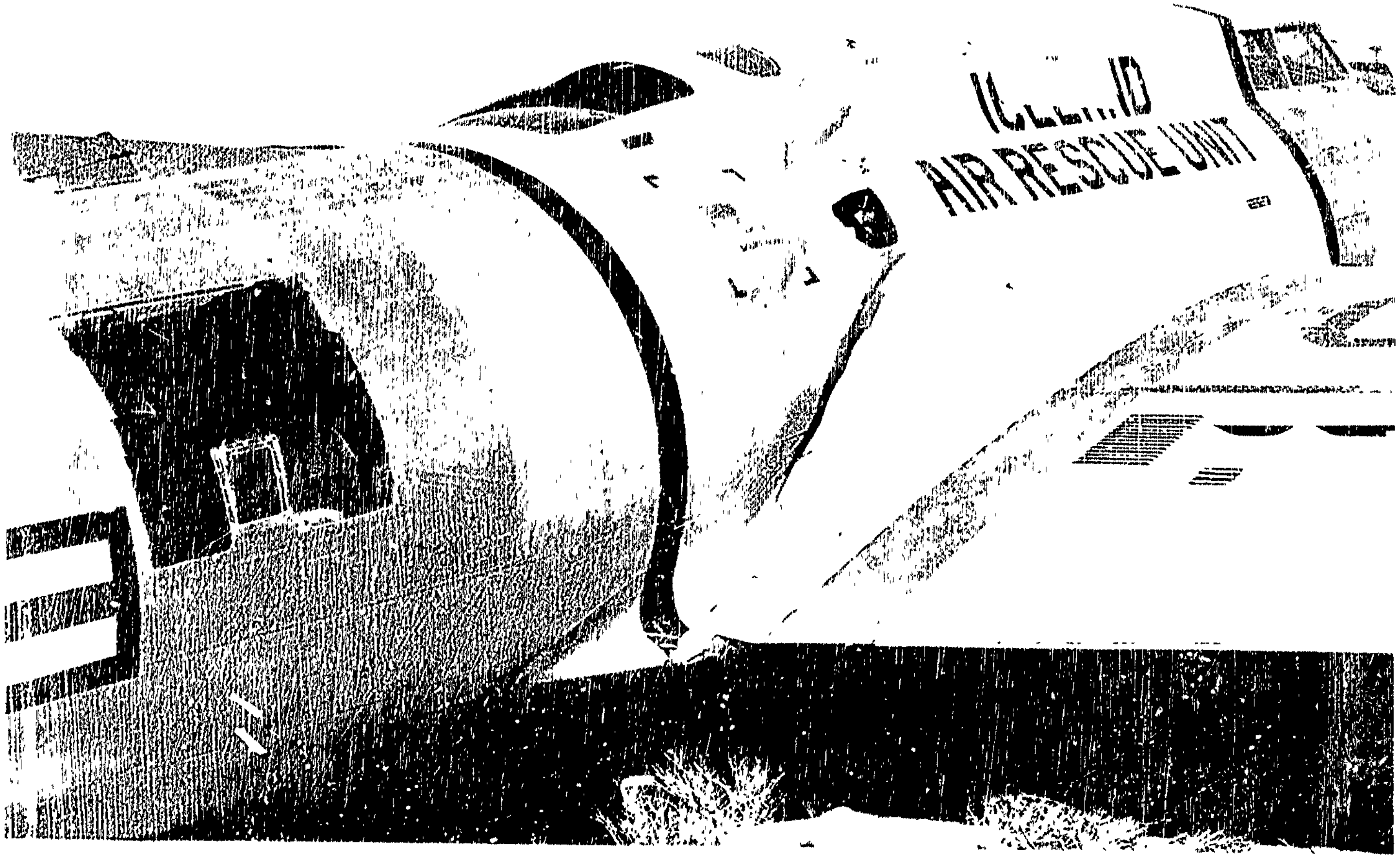

Fig. 3.3 Severe Buckle in Right Side of Fuselage of B-17 Following Dog Shot

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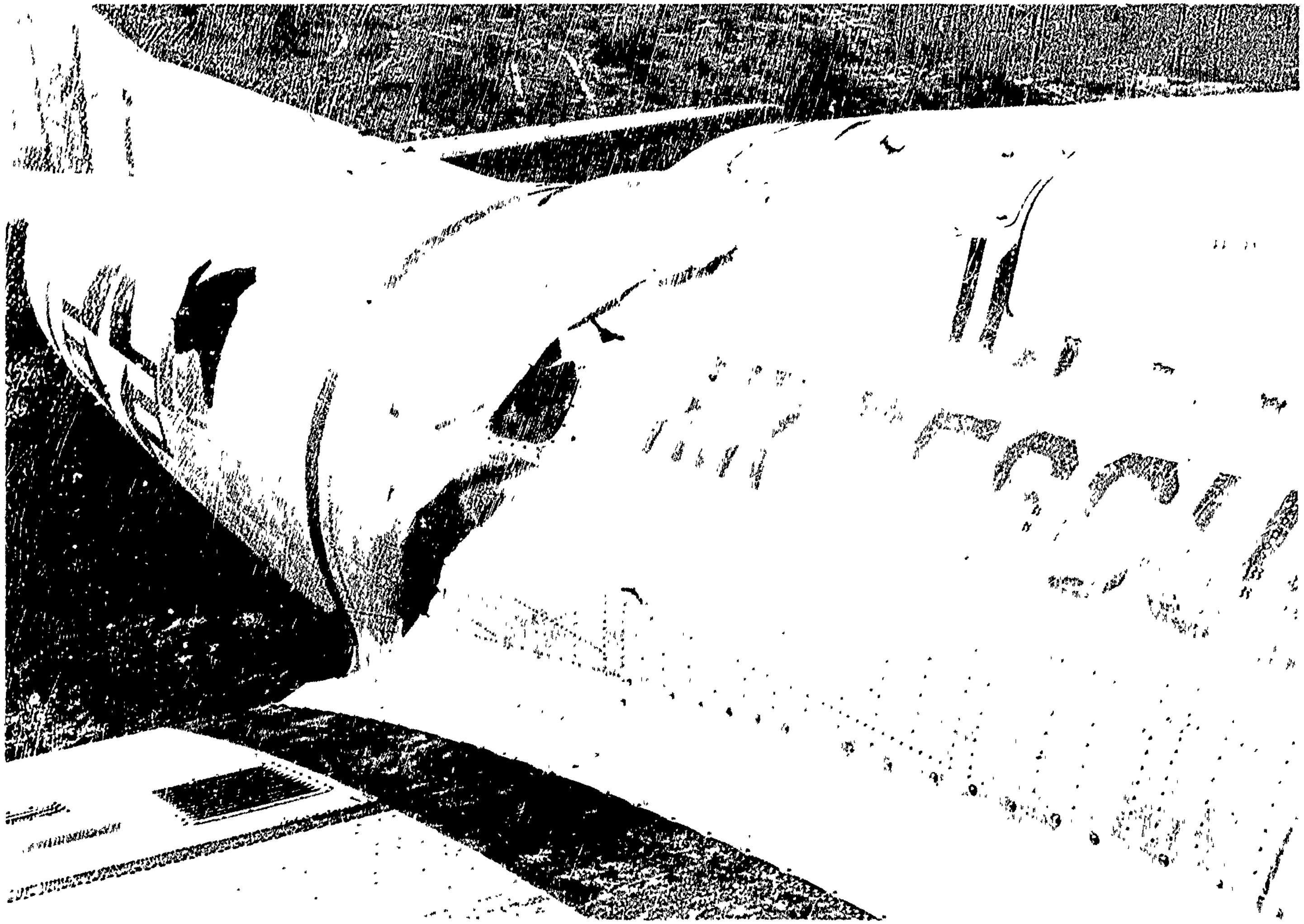

Fig. 3.4 View Looking Aft Showing Critical Buckle in Fuselage and Buckle in Dorsal Fin

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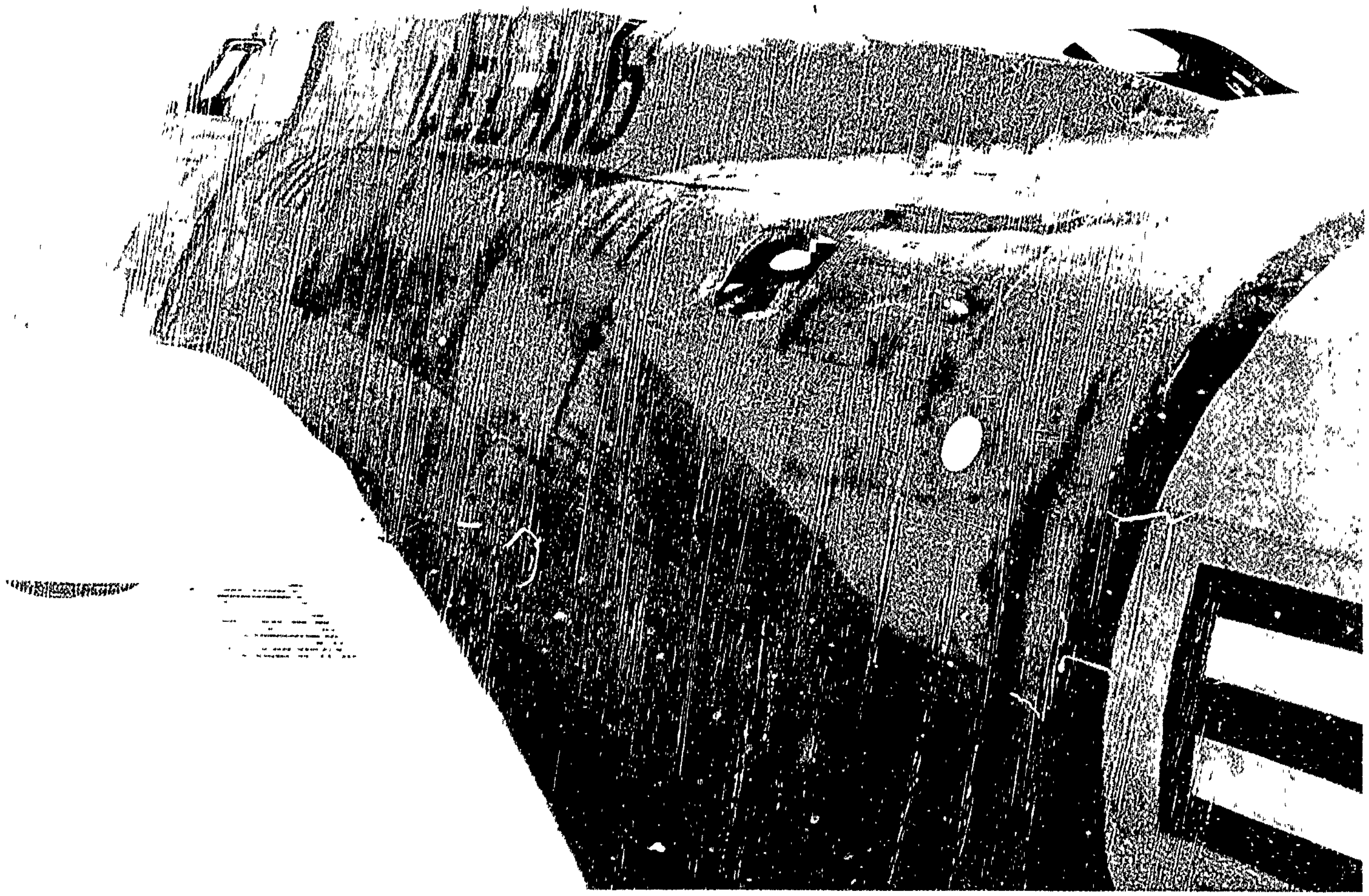

Fig. 3.5 Skin Buckles on the Forward Portion of the B-17 Fuselage on the Side Toward the Blast

Fig. 3.6 Skin Buckles and Broken Window on Nose Section of B-17 on the Side Toward the Blast

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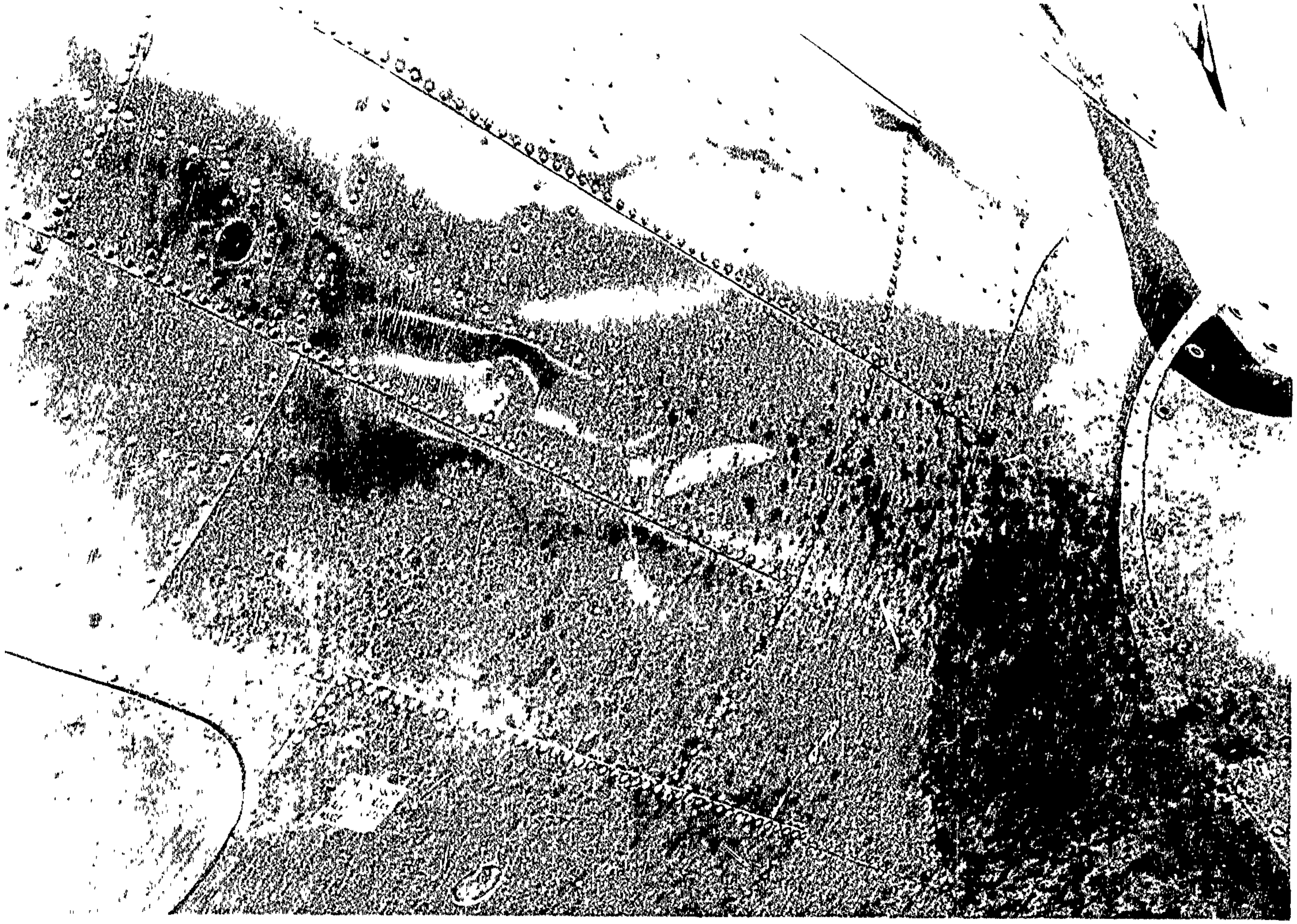

Fig. 3.7 Skin Buckles on Nose Section of B-17 on the Side Toward the Blast

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Fig. 3.8 Deep Buckle in Fuselage in Radio Operator's Compartment. Frame members were also buckled.

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Fig. 3.9 Skin Buckles on Aft Portion of the B-17 Fueslage on the Side Toward the Blast

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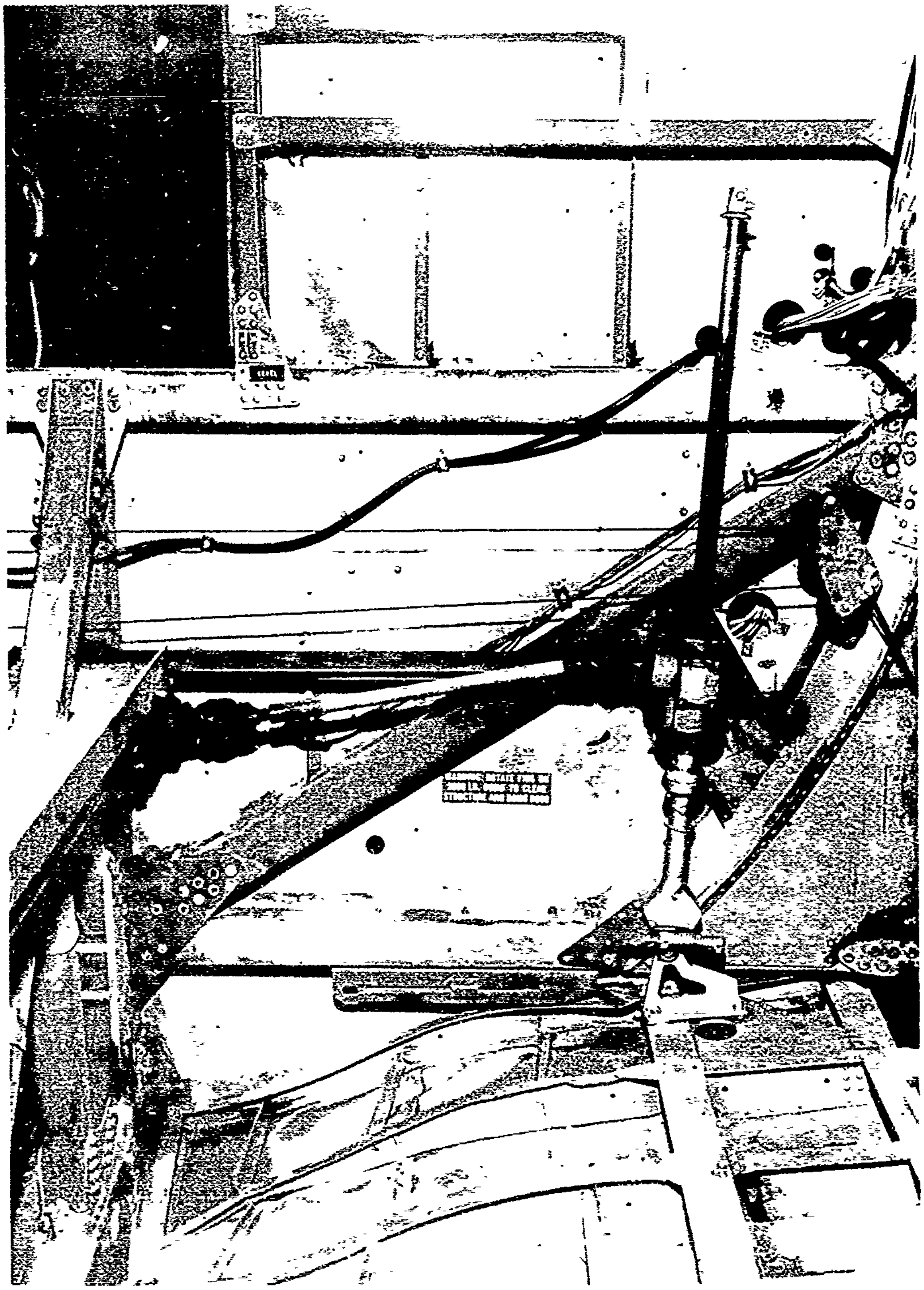

Fig. 3.10 Interior View of Bomb Bay of B-17 Showing Buckle in Door and Also the Buckles in the Upper Portion of the Bulkhead as a Result of Dog Shot

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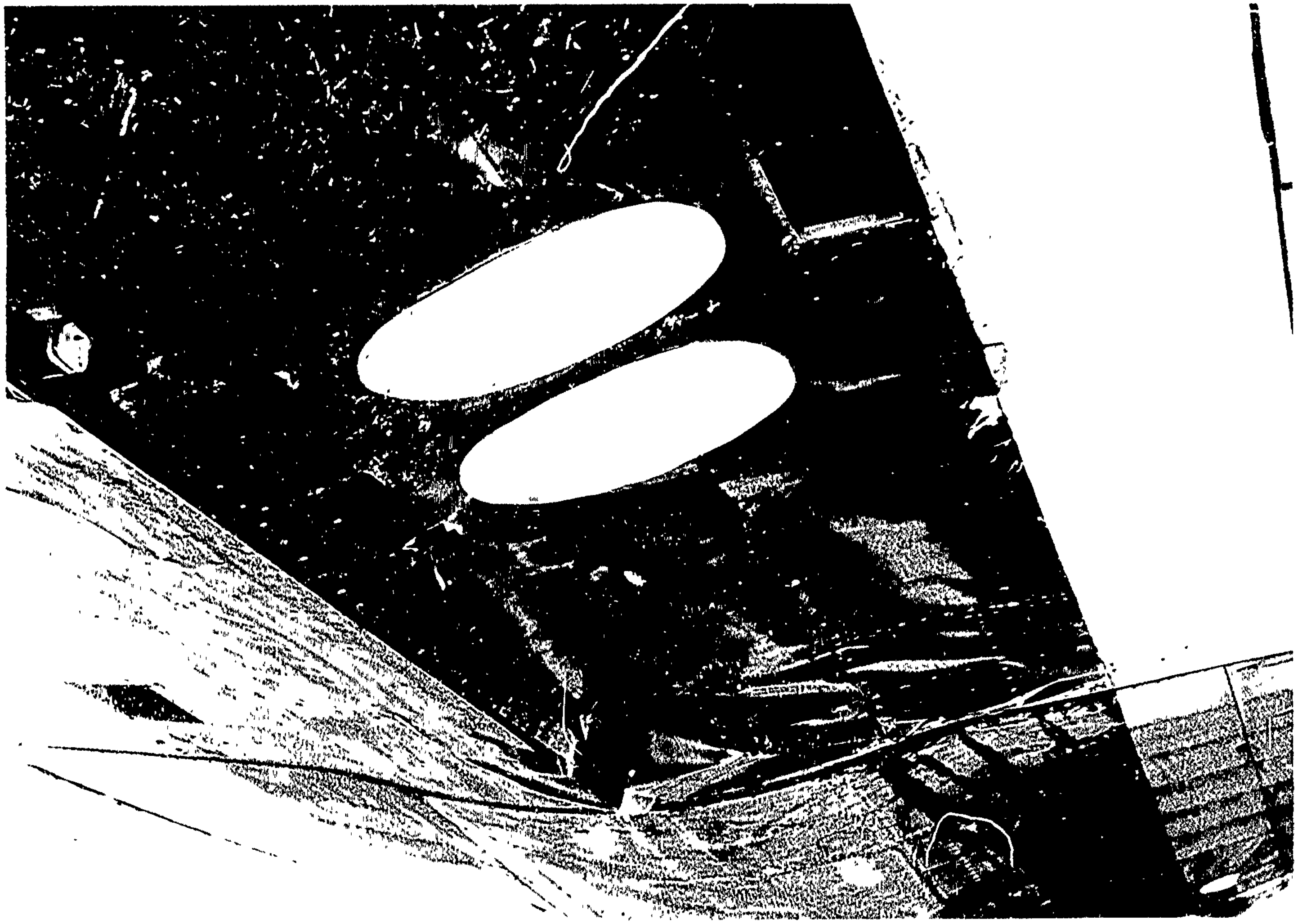

Fig. 3.11 Damage Incurred by Bomb-Bay Doors of B-17 on Dog Shot

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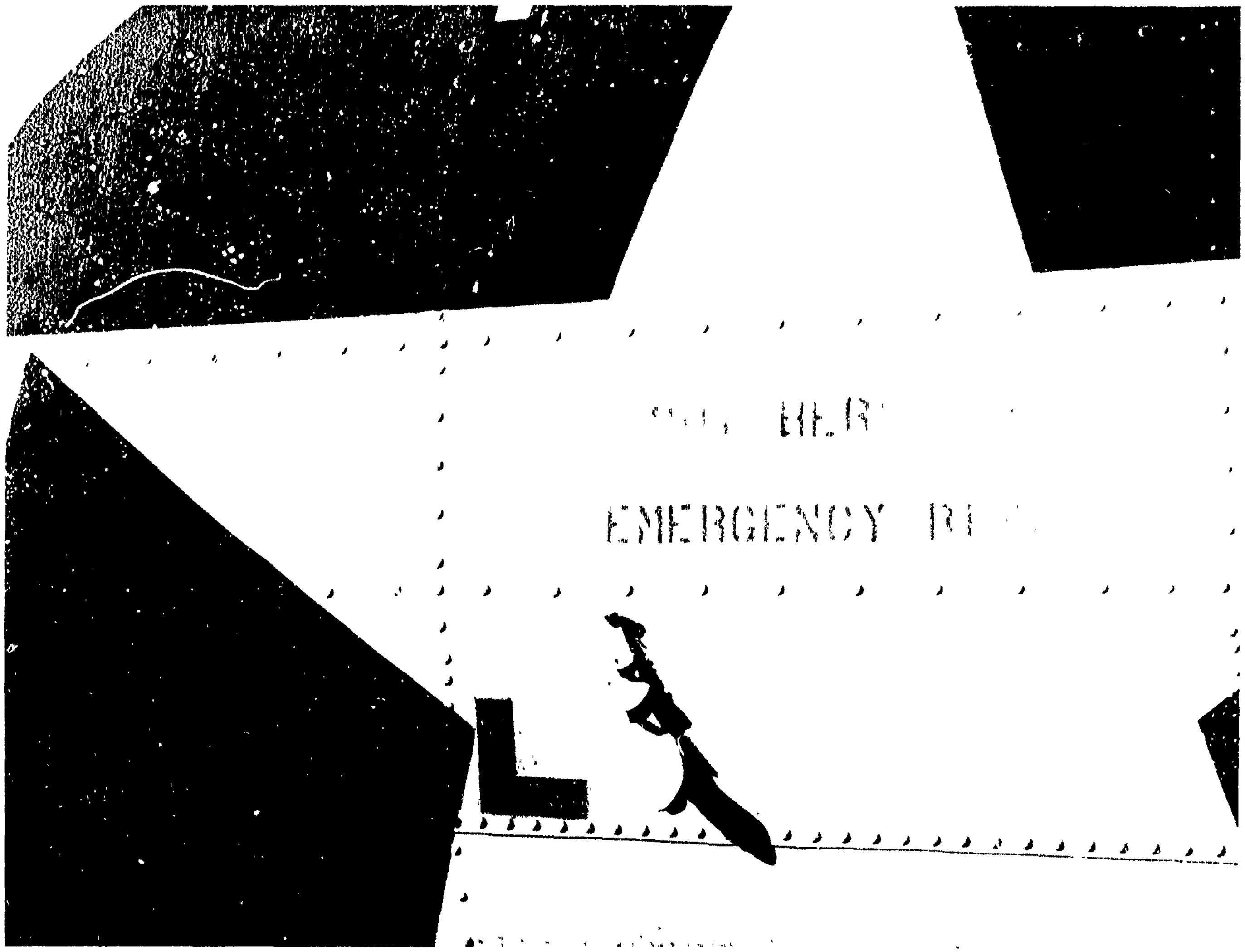

Fig. 3.12 Holes in Fuselage Produced by Waist-Gun Window Fragments

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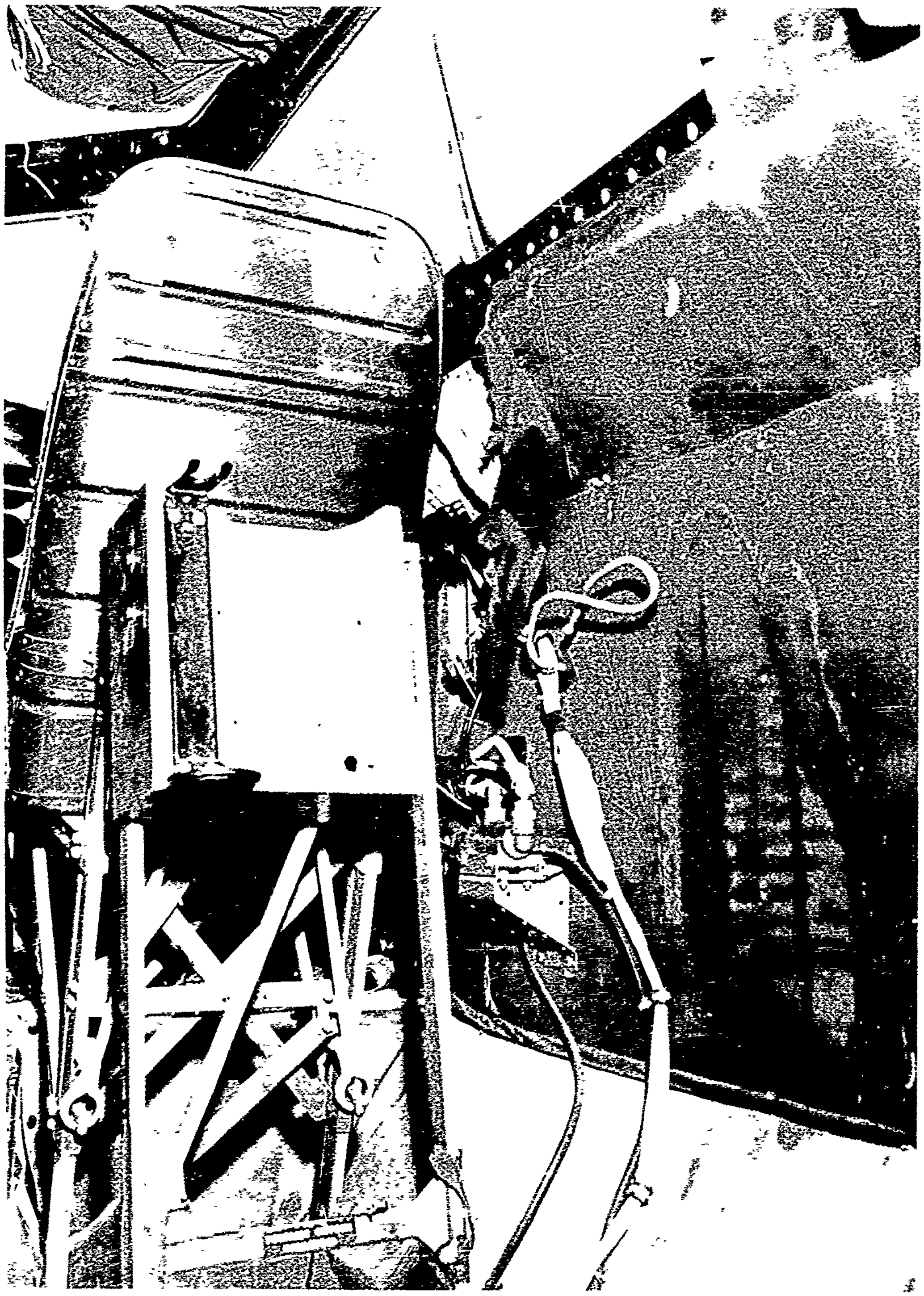

Fig. 3.13 Interior View of B-17 Cockpit Illustrating Thermal Damage to Fabric Resulting from Dog Shot

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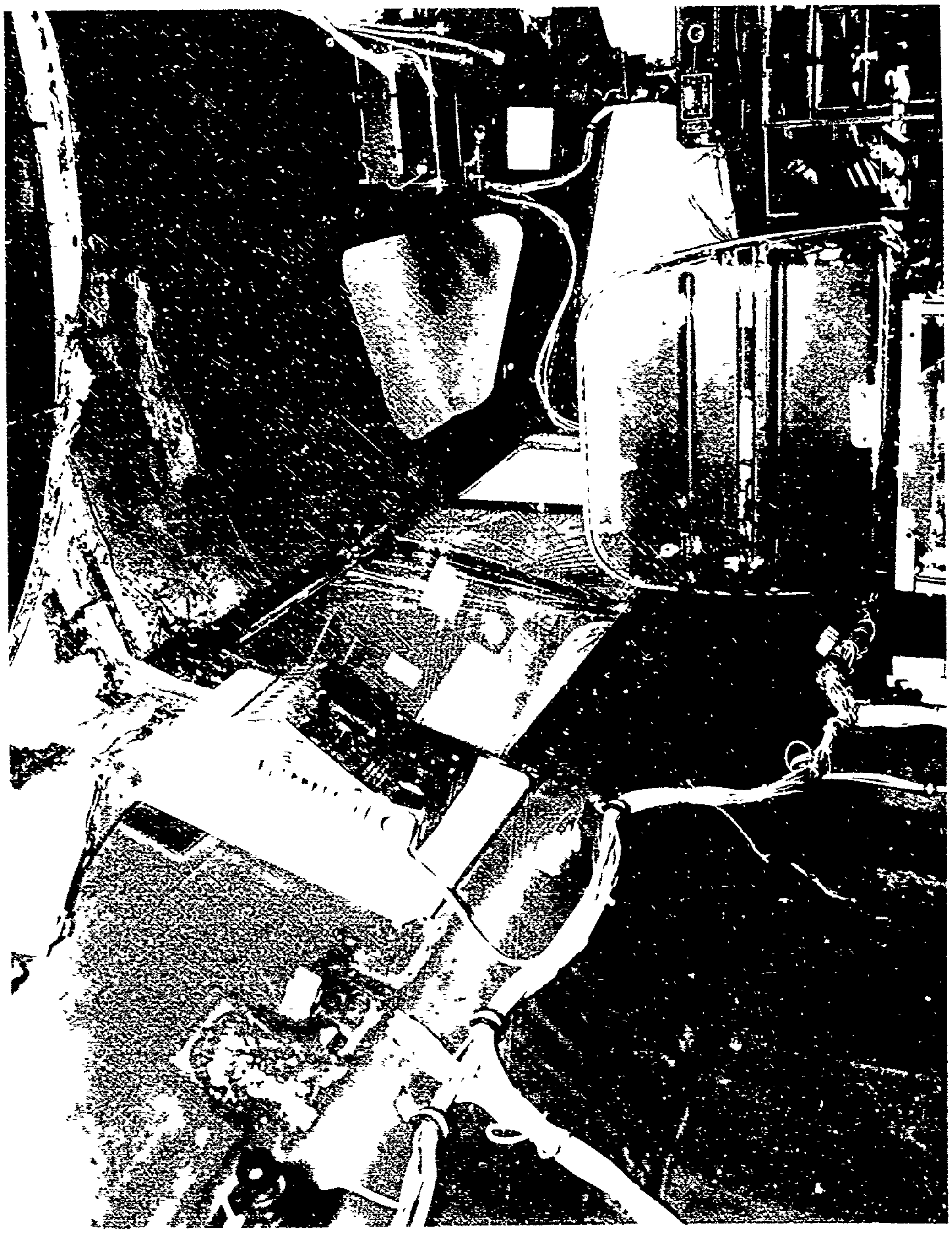

Fig. 3.14 Interior View of B-17 Cockpit Illustrating Thermal Damage to Fabric Resulting from Dog Shot

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Fig. 3.15 Wing-to-Fuselage Fairing of B-17 Which Was Torn Loose from the Fuselage Fasteners on Dog Shot

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Fig. 3.16 Condition of Surface of Left Wing Panel After Dog Shot

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Fig. 3.17 View Showing Thermal and Blast Damage to Rudder Following Dog Shot

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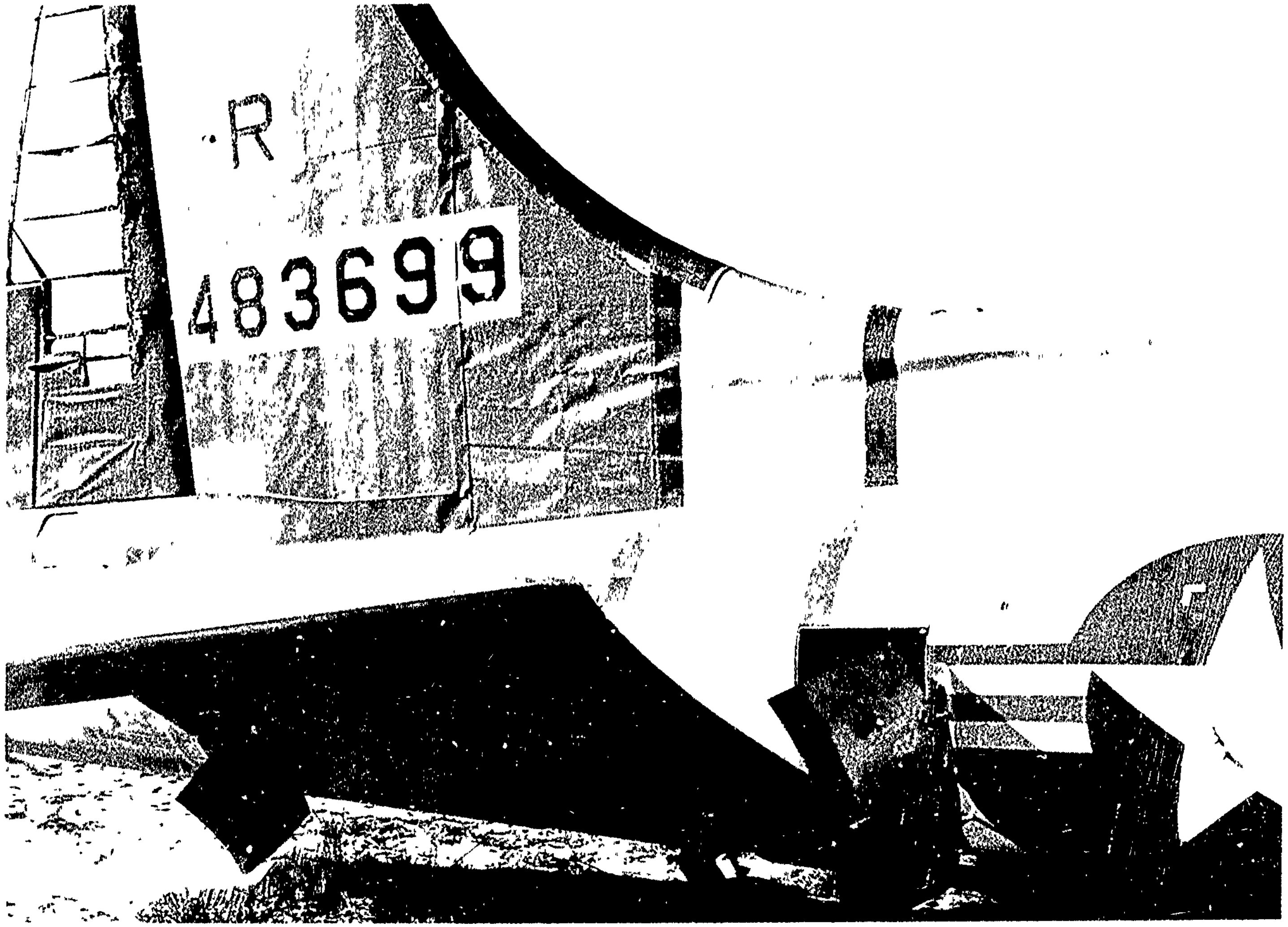

Fig. 3.18 View Showing Thermal and Blast Damage to Dorsal Fin Following Dog Shot

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Fig. 3.19 View Showing Thermal and Blast Damage to Vertical Stabilizer Following Dog Shot

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3.1.4 Fuselage Damage on F-47 (Dog Shot)

The F-47 was oriented favorably to reduce damage to the fuselage and no major damage was apparent. Only slight dishing of several skin panels was observed. The canopy was intact.

3.1.5 Wing Damage on F-47

The main-wing structure was not noticeably damaged, however, the ailerons and flaps together with their attaching brackets were rendered useless and would require replacement. See Fig. 3.20 for details of broken hinge brackets. The left aileron was found 120 feet "downwind" from the aircraft.

3.1.6 Empennage on F-47

The elevators and rudder were damaged beyond repair, however, the vertical and horizontal stabilizers were not substantially damaged.

3.1.7 Control Surfaces on F-47

The damaged control surfaces were removed from the aircraft in preparation for Easy Shot resulting in the configuration shown in Figs. 3.21 and 3.22.

3.2 EASY SHOT

Since both aircraft were damaged previously on Dog Shot, the results obtained after Easy Shot were accumulative. The orientation of the B-17 was changed to have the nose toward the blast but the F-47 was maintained with the tail toward ground zero. The damage to the B-17 included dishing in of the unsupported skin panels, caving in bomb-bay doors, and thermal and pressure damage to the "chin" radome. The damage to the F-47 was extensive, the fuselage and one wing being broken. The general condition of the B-17 is shown in Fig. 3.23, and that of the F-47 in Fig. 3.24.

3.2.1 Fuselage Damage on B-17 (Easy Shot)

The fuselage damage incurred by the B-17 during Dog Shot was made progressively worse by Easy Shot. The fuselage superstructure aft of the cockpit was crushed as may be seen in Fig. 3.25. The bomb-bay doors were blown into the bomb bay, one of the heavier structural members of the door being completely ruptured. Details of the damage are shown in Figs. 3.26 and 3.27. The wing-to-fuselage fairing received additional damage. The left side of the nose was caved in and the escape hatch buckled inward. Details of this section are shown in Fig. 3.28.

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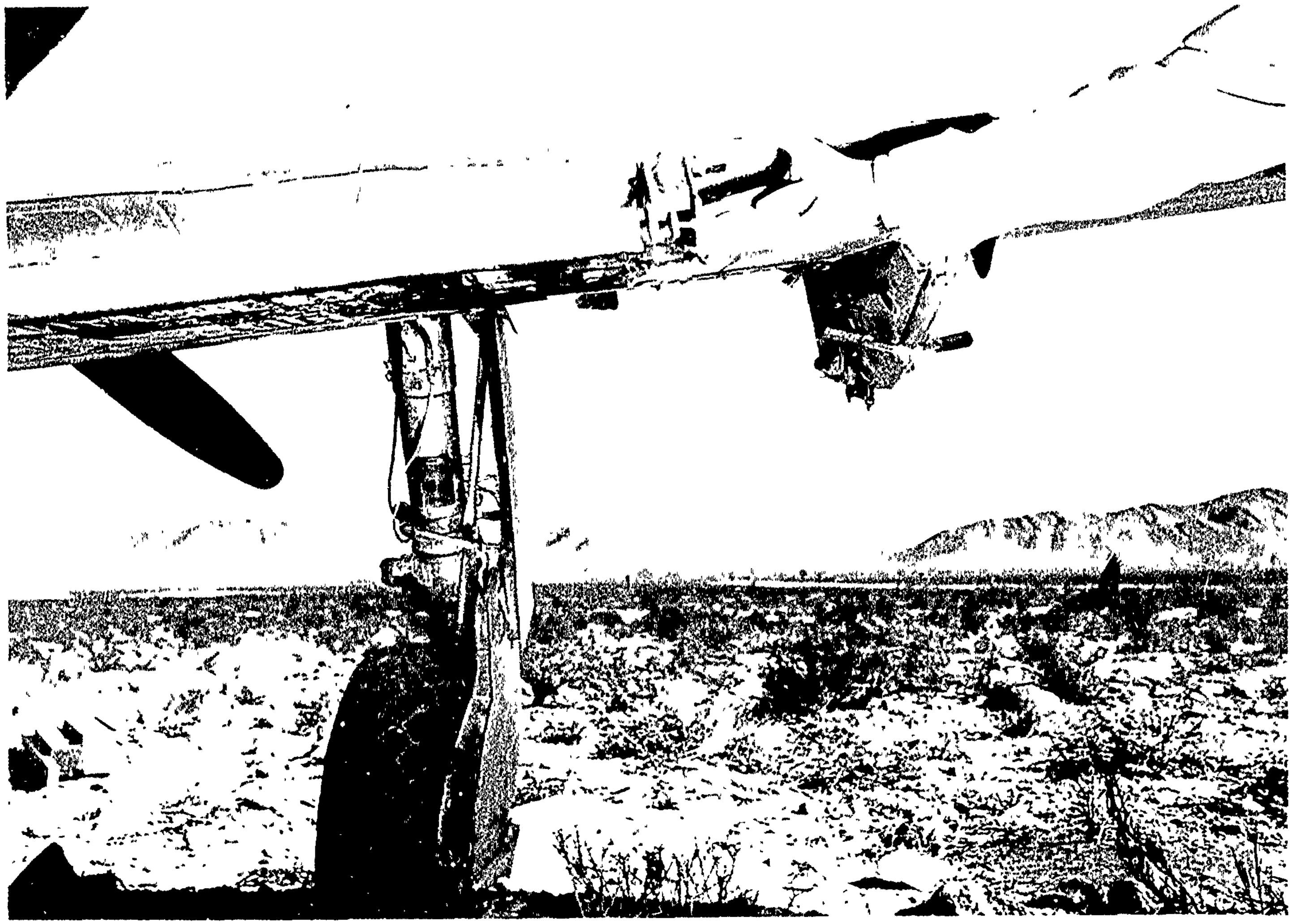

Fig. 3.20 Typical F-47 Flap Hinge Bracket Broken on Dog Shot

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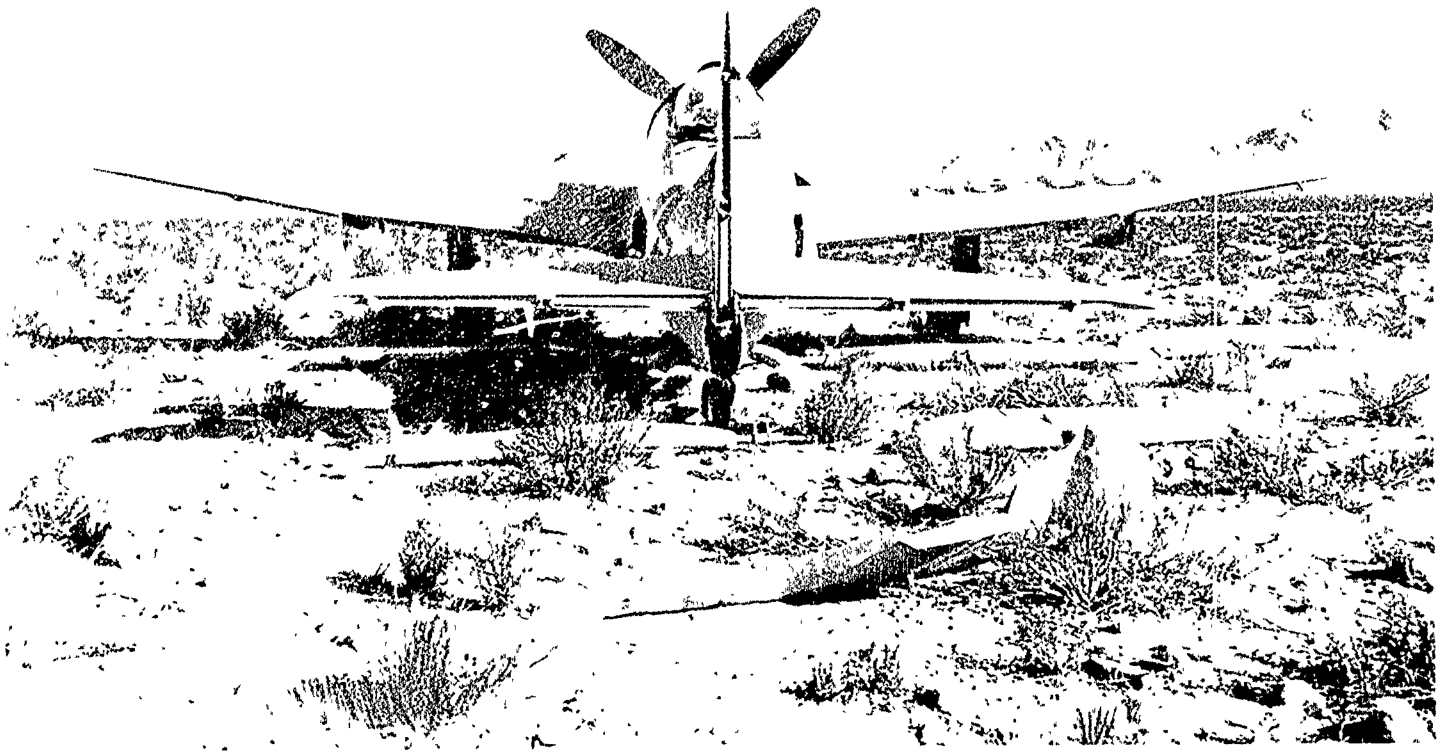

Fig. 3.21 F-47 After Dog Shot with Damaged Control Surfaces Removed Prior to Easy Shot

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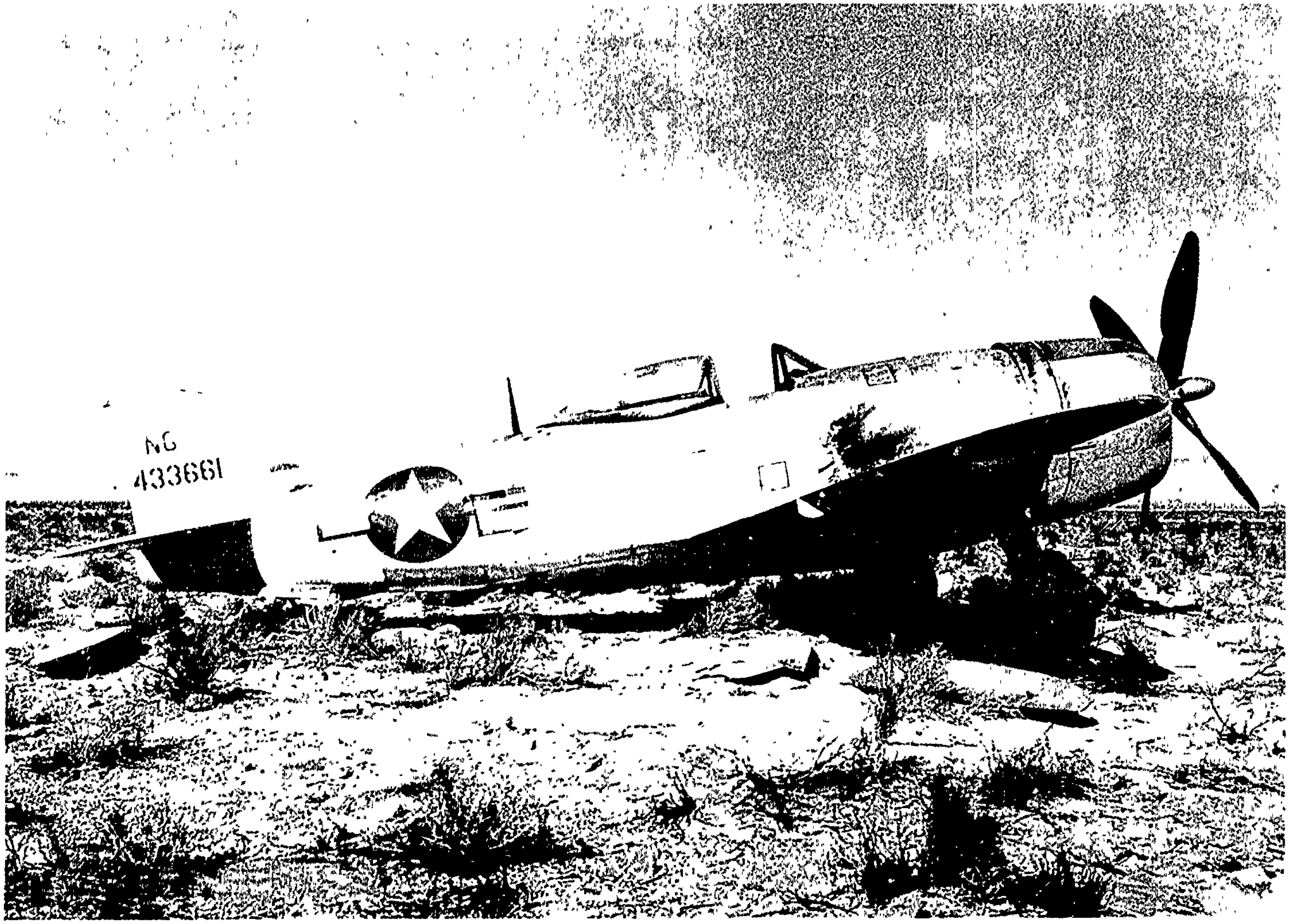

Fig. 3.22 General Condition of F-47 Fuselage After Dog Shot

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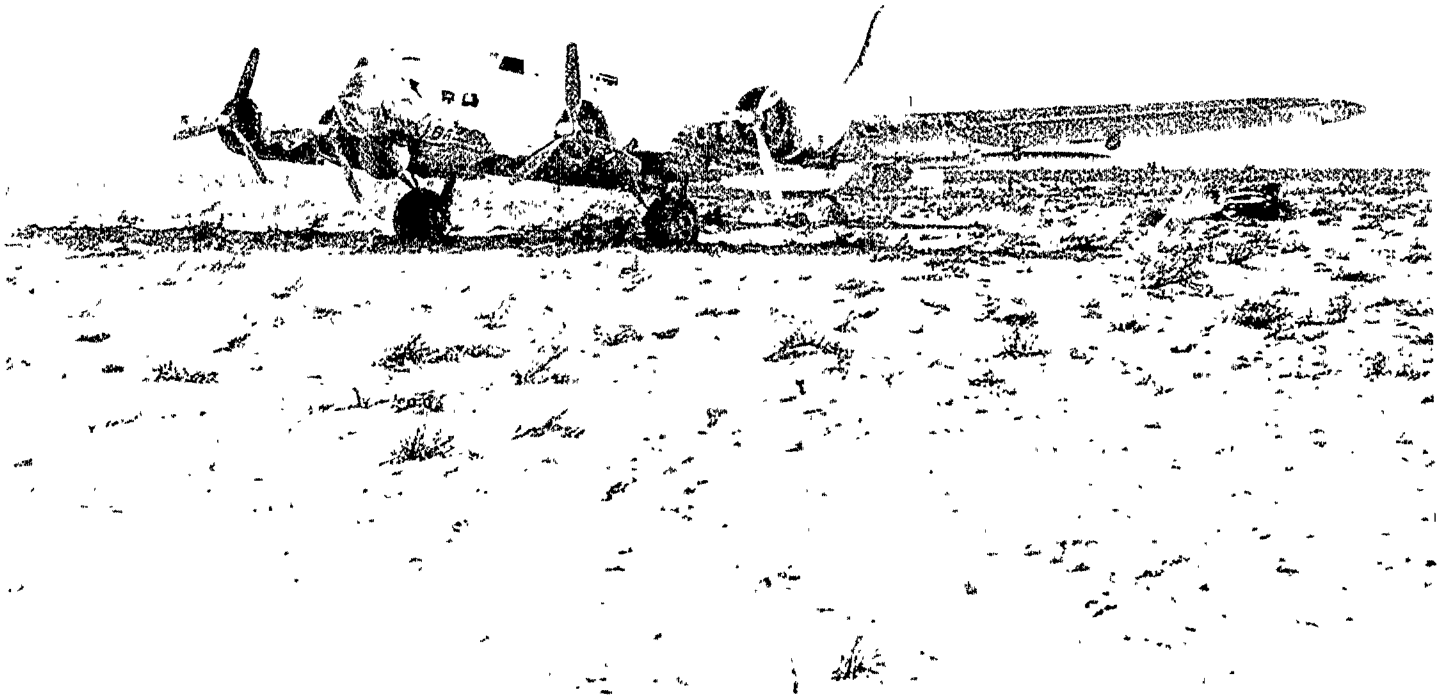

Fig. 3.23 Overall View of B-17 Illustrating Crushing of Nose Section and General Condition of Aircraft After Easy Shot

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Fig. 3.24 General Condition of F-47 Following Easy Shot. Note the complete failure of the left wing.

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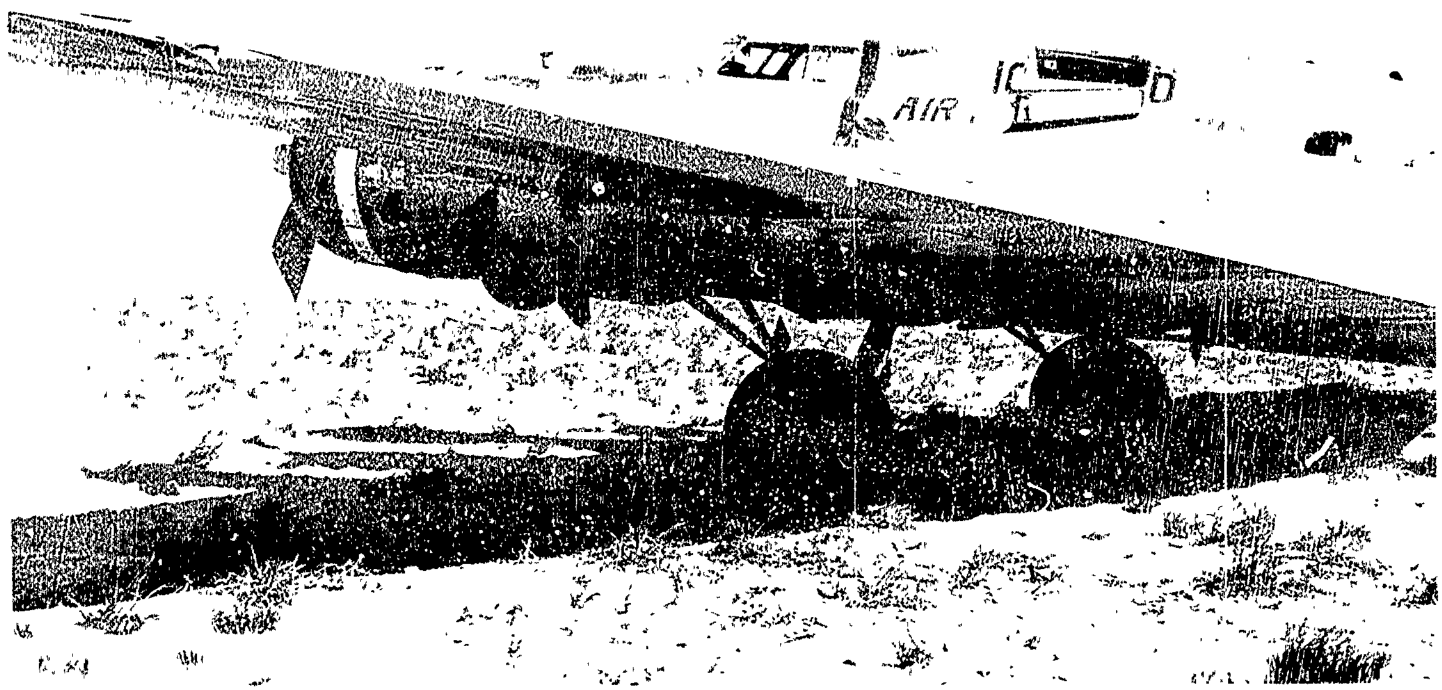

Fig. 3.25 Additional Damage to B-17 Fuselage Including Crushed Superstructure Aft of Cockpit Incurred During Easy Shot

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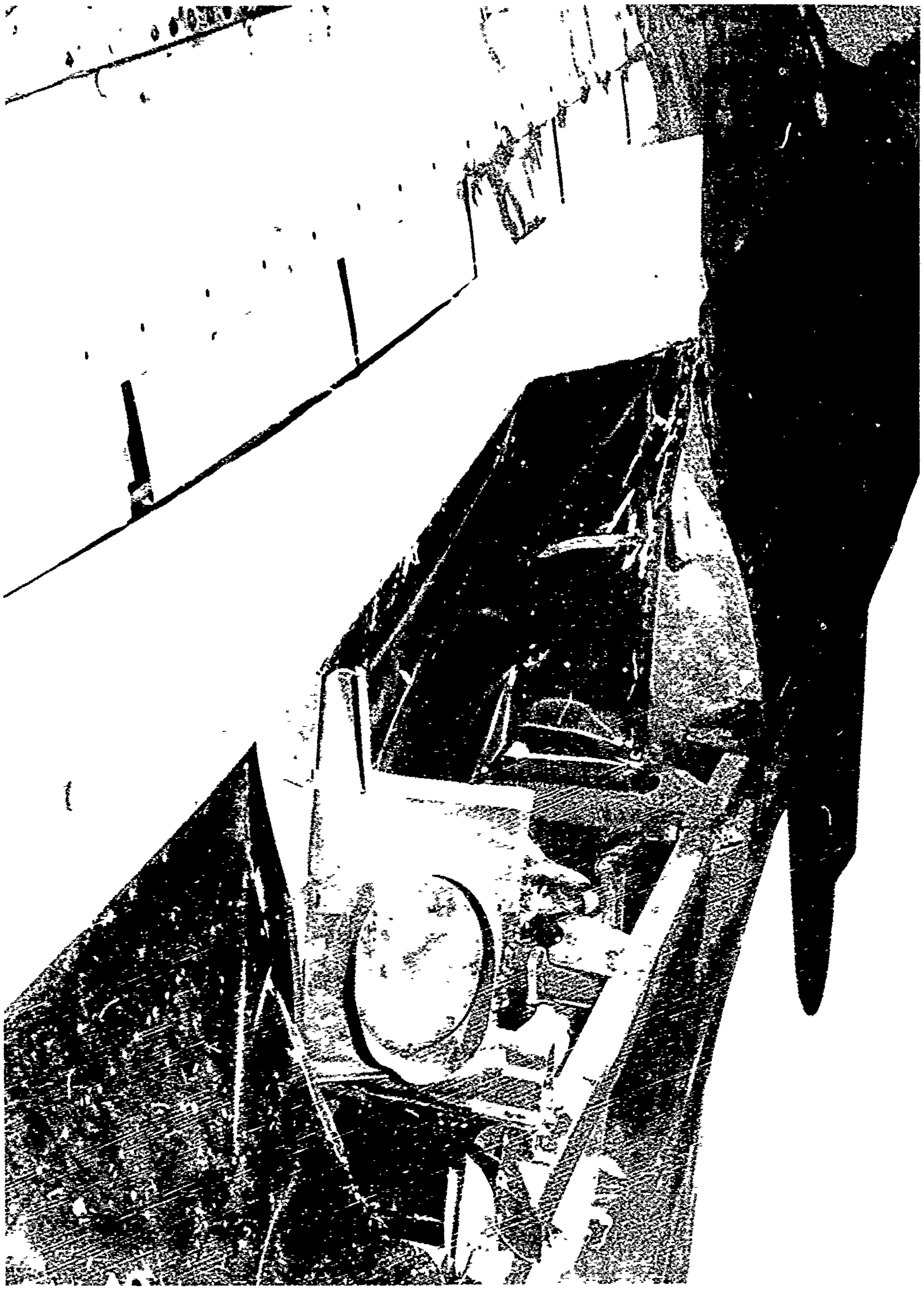

Fig. 3.26 Exterior View of Damaged Bomb-Bay Doors of B-17 After Easy Shot

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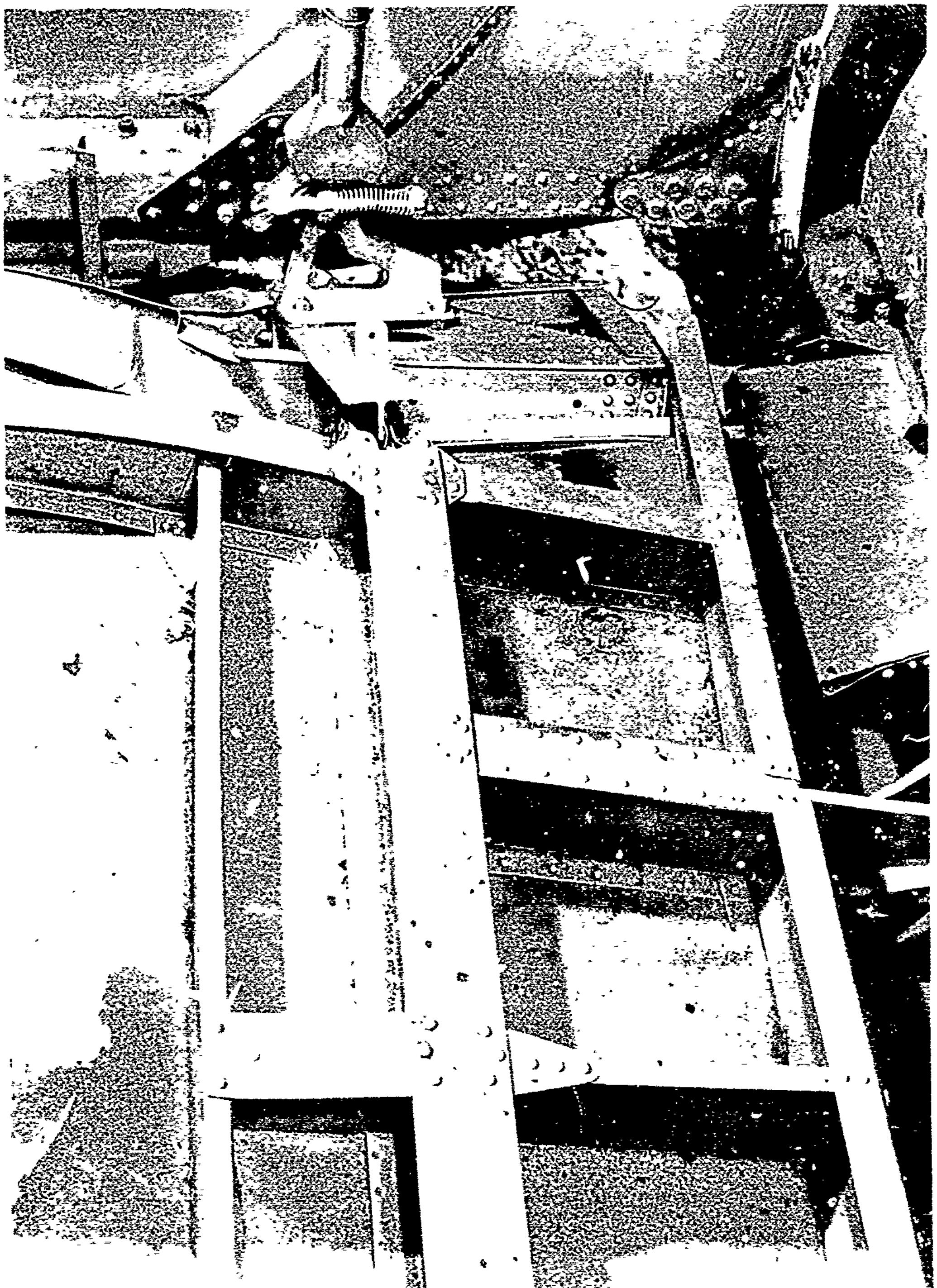

Fig. 3.27 Interior View of Buckled Bomb-Bay Door Showing Failed Structural Member

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Fig. 3.28 Buckles in Nose Section of B-17 Following Easy Shot

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3.2.2 Wing Damage on B-17 (Easy Shot)

Large areas of the wing skin were dished in as shown in Fig. 3.29. All small access doors were found open along the lower surface of the wing.

3.2.3 Empennage Damage B-17 (Easy Shot)

The elevator fabric was ruptured at several places. The dorsal fin and vertical stabilizer were crushed to a greater extent than on Dog Shot. Figs. 3.30 and 3.31 indicate the condition of the vertical tail following Easy Shot.

3.2.4 Fuselage Damage on F-47 (Easy Shot)

The fuselage of the F-47 sustained a structural failure aft of the cockpit. A portion of this failure is shown in Figs. 3.32 and 3.33. It appeared that considerable sand blasting had damaged one side of the fuselage. The canopy was destroyed. The propeller had the blades bent, probably due to contact with the ground during the blast phase.

3.2.5 Wing Damage on F-47 (Easy Shot)

The left wing panel was completely failed. Details of the failure are shown in Fig. 3.34. Sand-blasting effects were also evident. The skin over substantial areas of the upper surface of the outer-wing sections was missing. Figs. 3.35 and 3.36 portray the general condition of the right outer-wing panel. The gun-bay door was buckled. Sand-blast effects were more severe on the right hand wing, but the structural frame was practically intact.

3.2.6 Empennage Damage on F-47 (Easy Shot)

The skin on the upper surface of the horizontal stabilizer was removed by the thermal and blast effects except for small sections of skin immediately over the structural frame. The skin on the vertical stabilizer was essentially intact but showed the effects of some sand and debris blasting, however, the vertical tail was failed at the root section. The damaged tail section is shown in Fig. 3.37.

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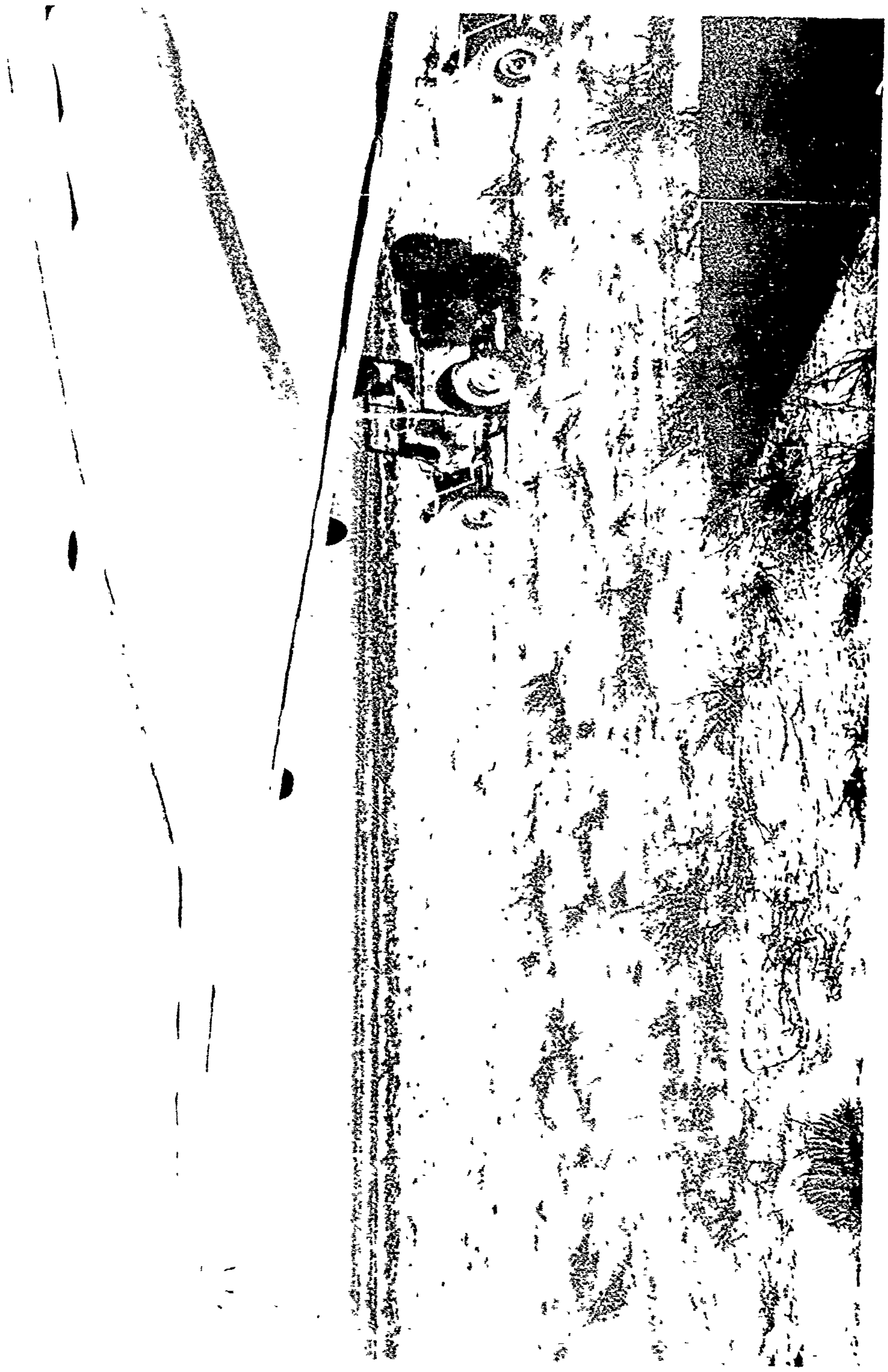

Fig. 3.29 Skin Buckles in B-17 Outer Wing Panels

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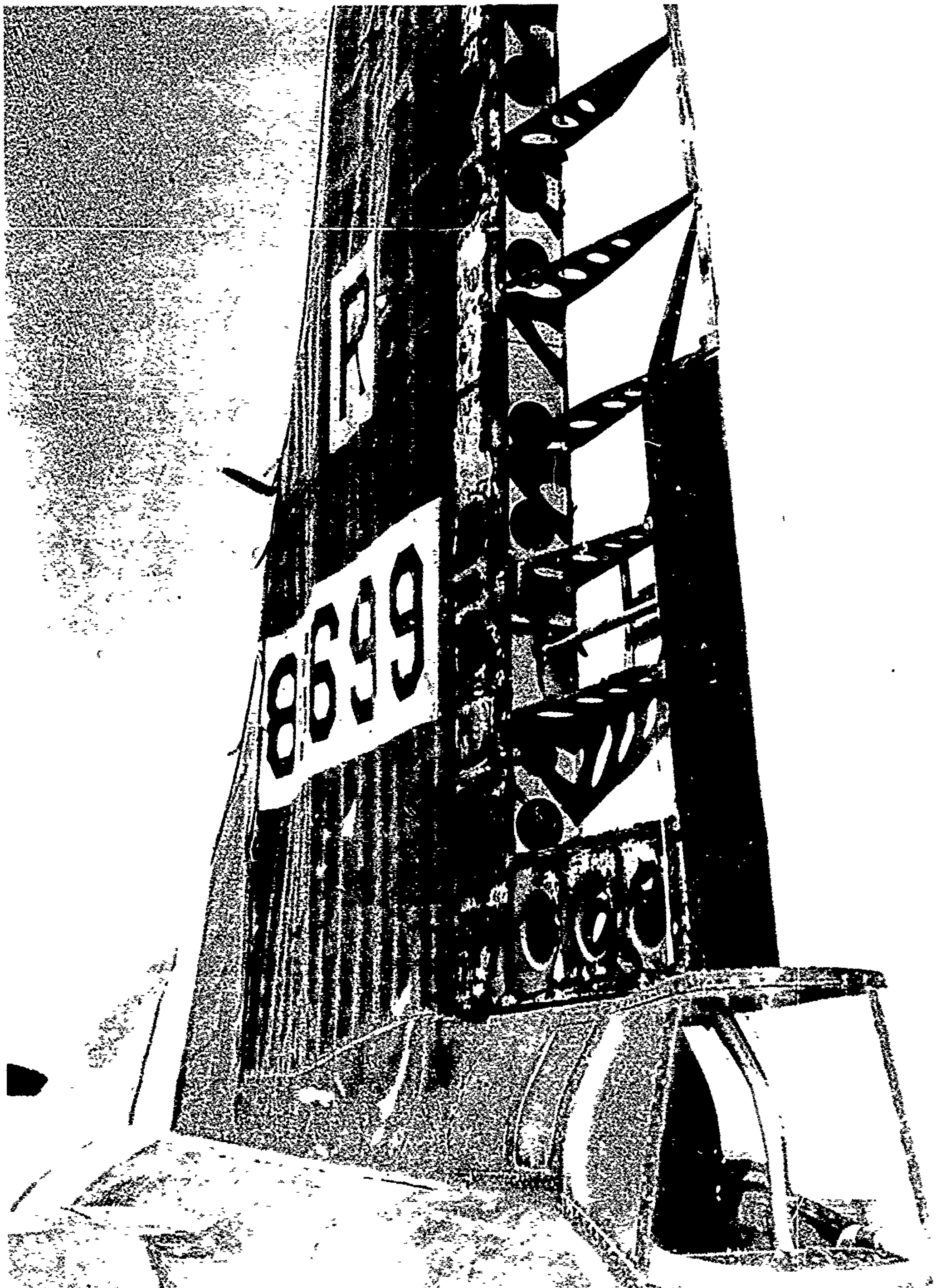

Fig. 3.30 Condition of Vertical Tail of B-17 After Easy Shot as Seen from the Left Side Previously Incident to the Blast on Dog Shot

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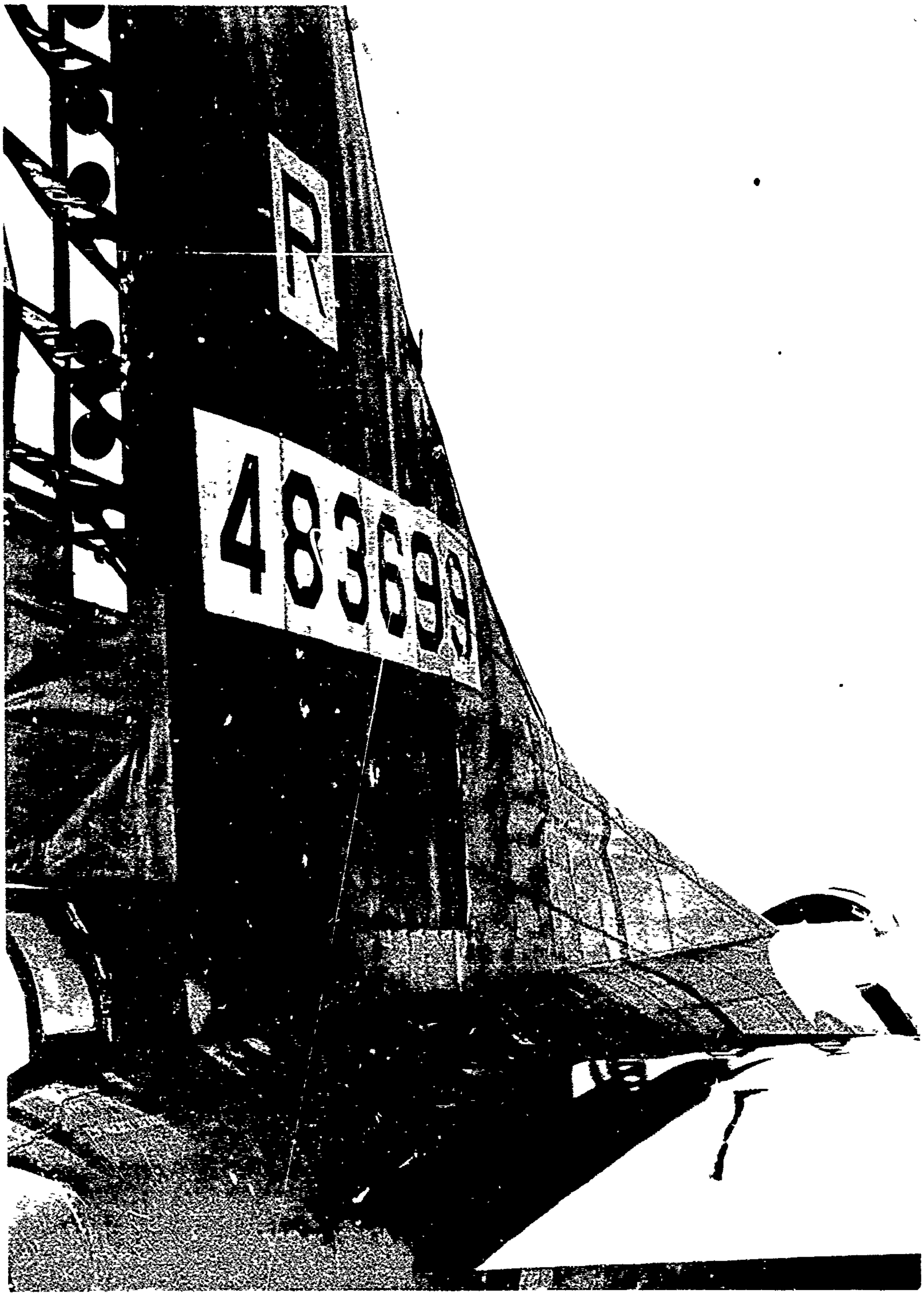

Fig. 3.31 Condition of Right Side of Vertical Tail and Dorsal Fin of B-17 After Easy Shot

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Fig. 3.32 Fuselage Failure Aft of Cockpit in F-47 as a Result of Easy Shot

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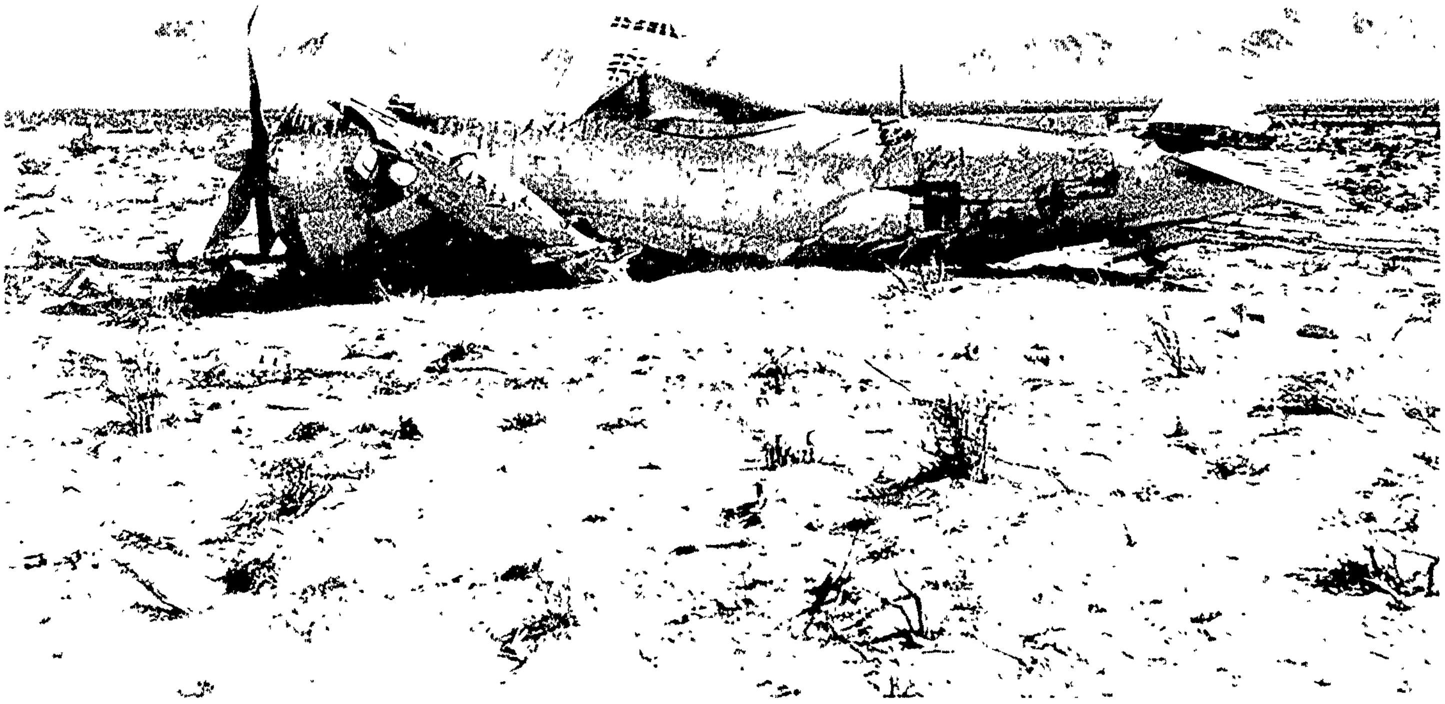

Fig. 3.33 Fuselage Failure Aft of Cockpit in F-47 as a Result of Easy Shot

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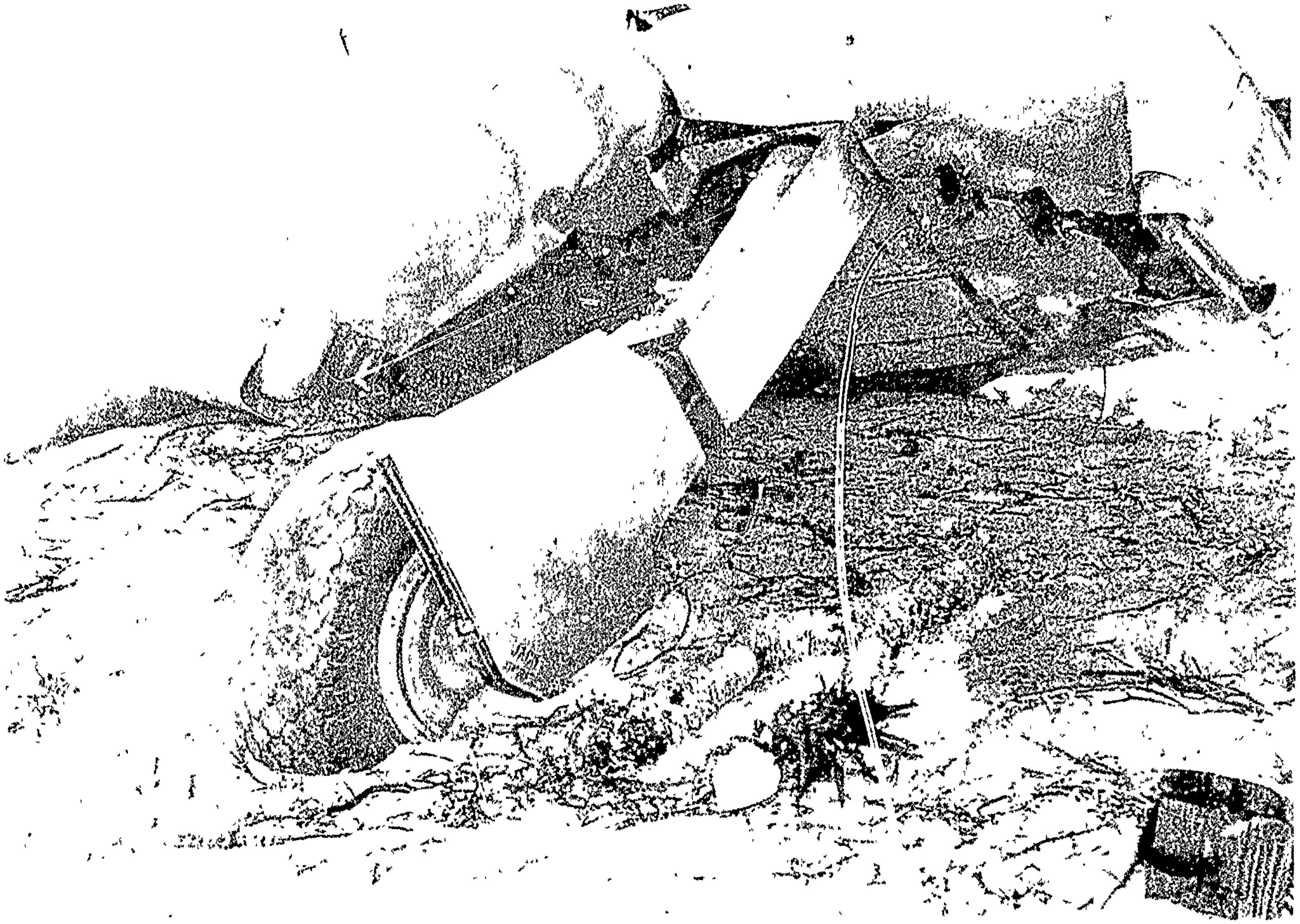

Fig. 3.34 Failure of Left Wing of F-47 as a Result of Easy Shot

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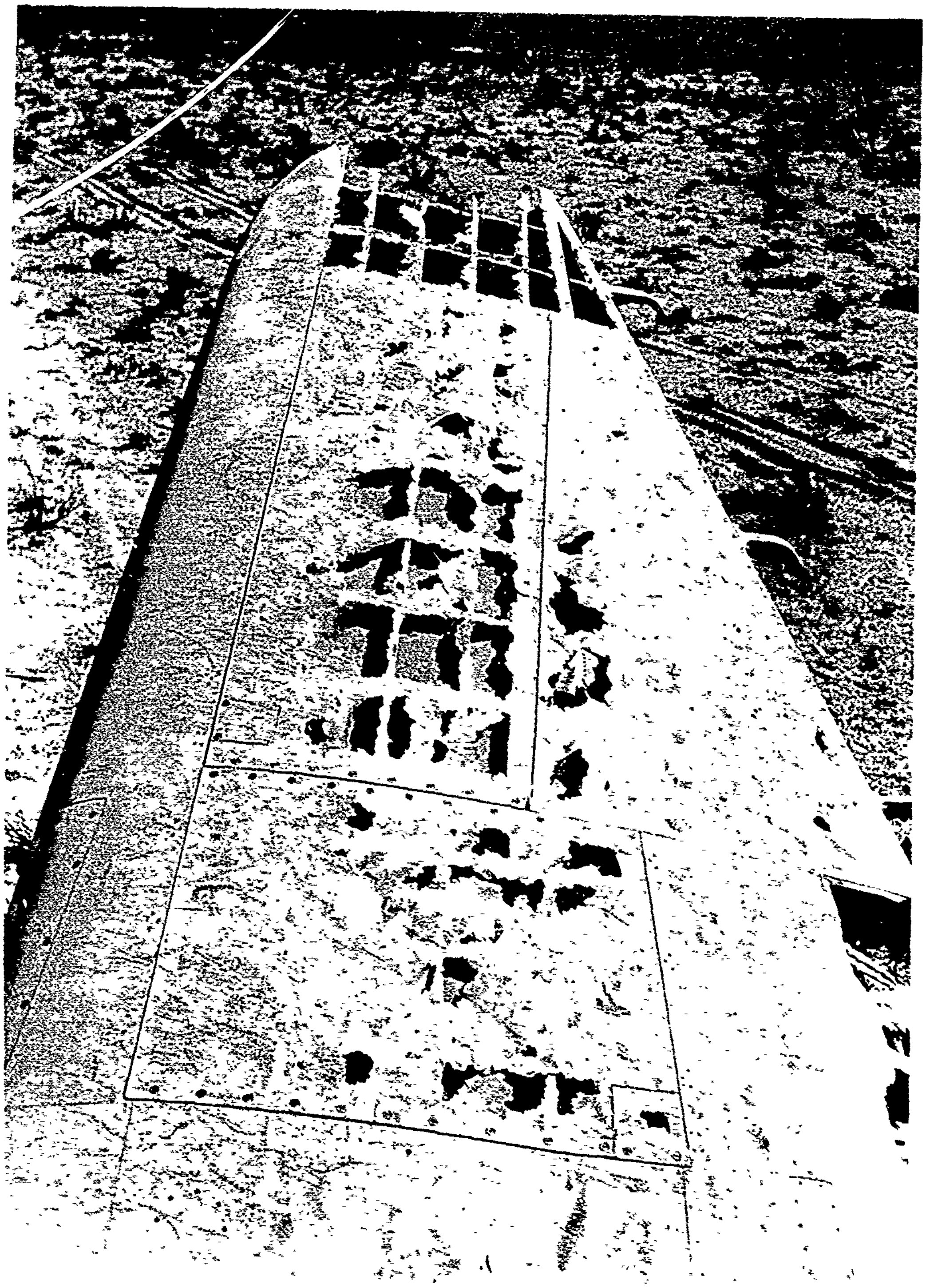

Fig. 3.35 Damage Sustained by Right Wing Panel of F-47 During Easy Shot. Ailerons and flaps were removed prior to this shot.

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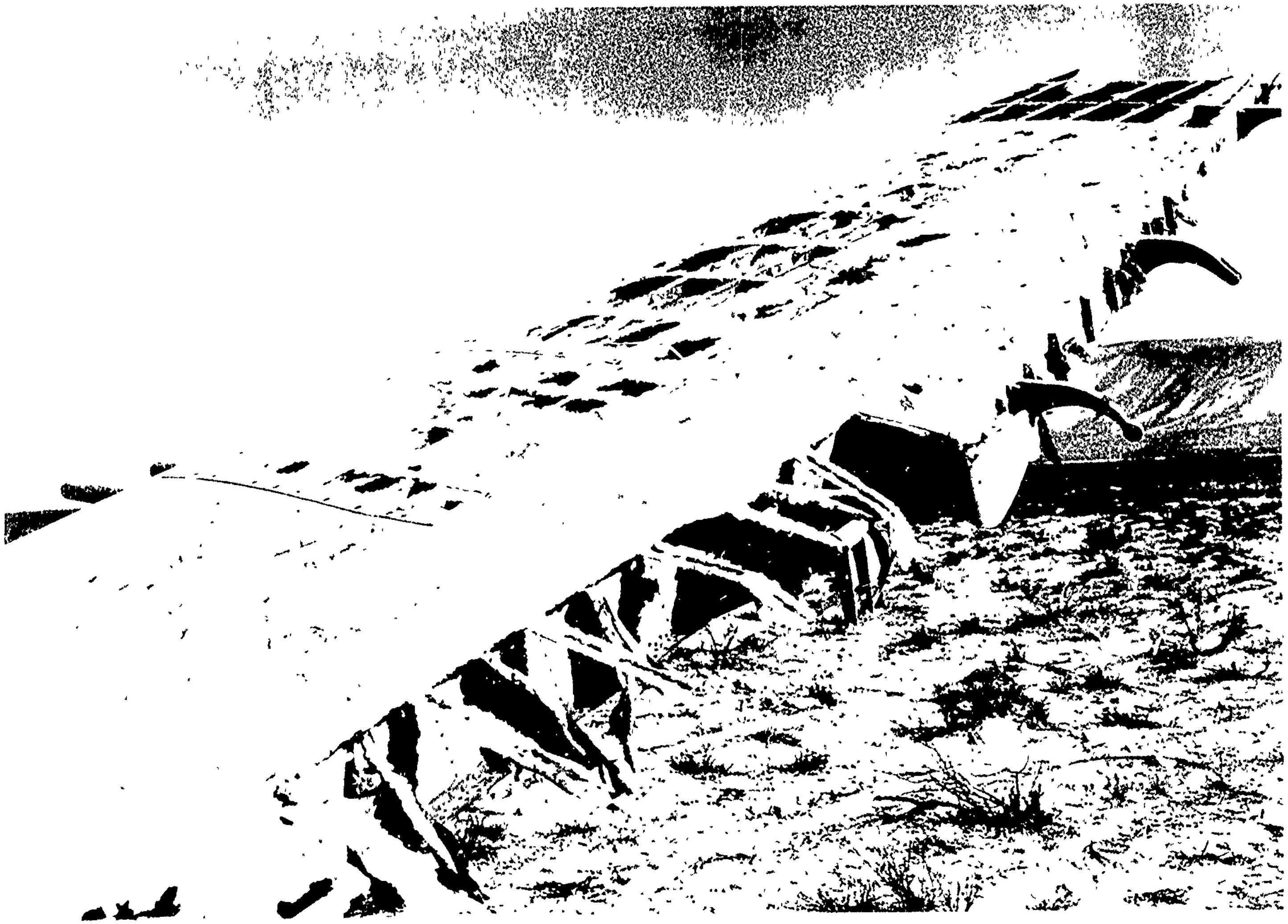

Fig. 3.36 Damage Sustained by Right Wing Panel of F-47 During Easy Shot. Ailerons and flaps were removed prior to this shot.

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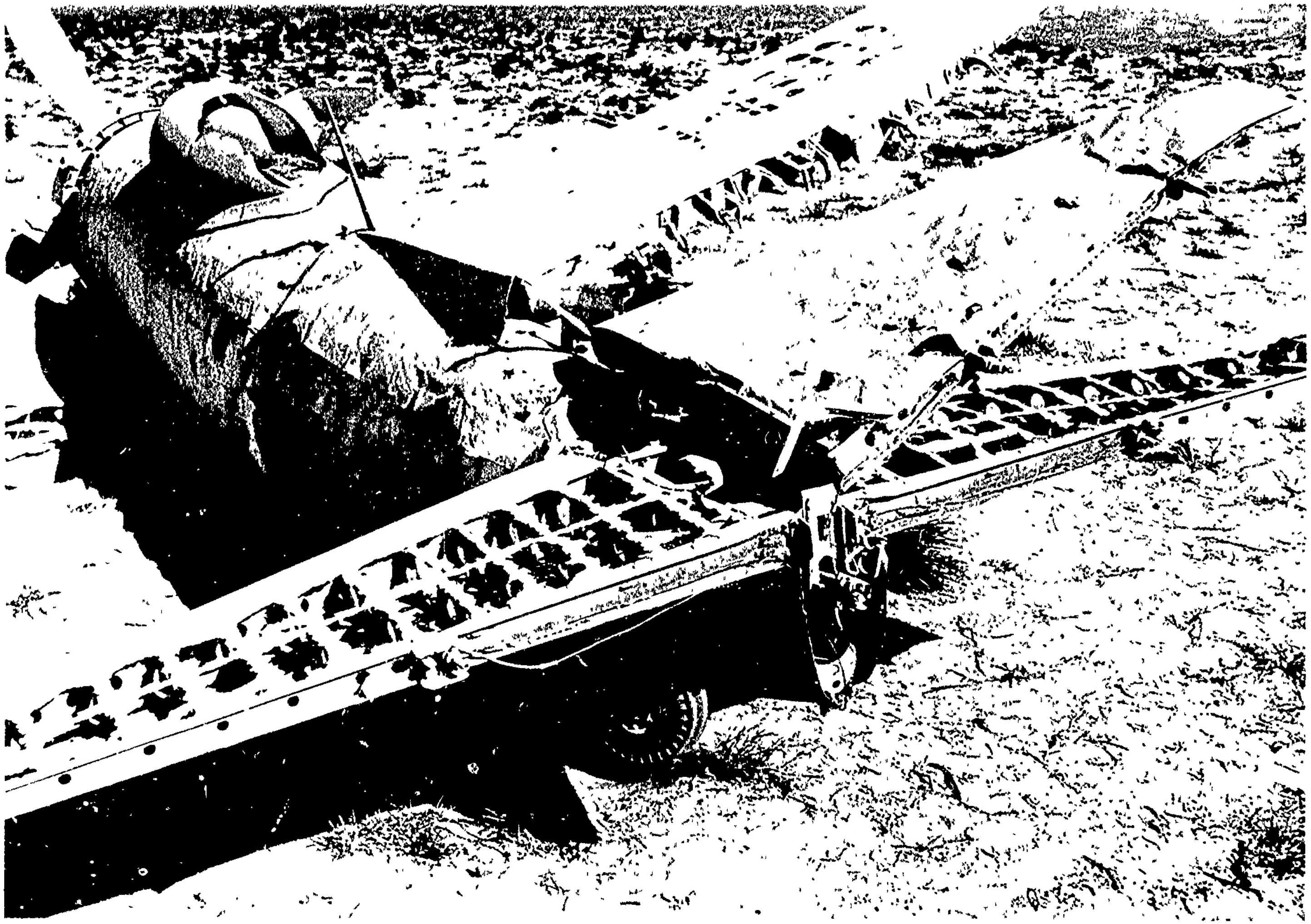

Fig. 3.37 Empennage Damage Sustained by F-47 on Easy Shot. The rudder and elevators had been removed prior to this shot.

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CHAPTER 4

DISCUSSION

4.1 GENERAL

The aircraft were positioned at specific ranges determined by the estimated overpressures, the B-17 at 3 psi and the F-47 at 6 psi. The data available prior to the BUSTER operation indicated that for a 25 KT bomb an overpressure of 3 psi would be realized at approximately 6,300 feet and 6 psi would be realized in the vicinity of 4,250 feet. The aircraft were positioned accordingly, as shown in Fig. 4.1.

4.2 DOG SHOT

Results of Project 3.8 instrumentation indicated that an overpressure of 4.9 psi was experienced by the F-47 at 4,250 feet. Overpressure data was not obtained from other agencies for Dog Shot reportedly due to malfunction of equipment, hence no correlation is possible. Overpressures were not measured at the B-17 but it is estimated that at 6,300 feet the peak overpressure was about 3.1 psi. Details of Project 3.8 instrumentation procedures and results are included in Appendix A. Both aircraft sustained sufficient damage to prevent flight missions prior to making repairs.

4.3 EASY SHOT

On Easy Shot, the F-47 at 2,675 feet from ground zero was subjected to about 7.7 psi and the B-17 at 5,847 feet sustained a peak overpressure of about 4.1 psi according to data supplied from other agencies. The Project 3.8 instrumentation data was not obtained on Easy Shot due to failure of lamp filaments in the recording oscillographs. The F-47 was destroyed with complete failure of the left wing, a severe failure of the fuselage near the mid-section, and a failure at the base of the vertical stabilizer in addition to extensive local skin and frame damage. The B-17 was oriented nose in which is a favorable position to reduce damage to most of the structure with the exception of the bomb-bay doors, however, local skin buckles were produced over the entire airframe during Easy Shot. The opening of all the small inspection doors on the wing was previously experienced at a considerably lower overpressure on Operation GREENHOUSE, as was the sensitivity of bomb-bay doors to damage at low overpressure. The locations of the aircraft relative to ground zero for Dog and Easy Shots are shown in Fig. 4.1.

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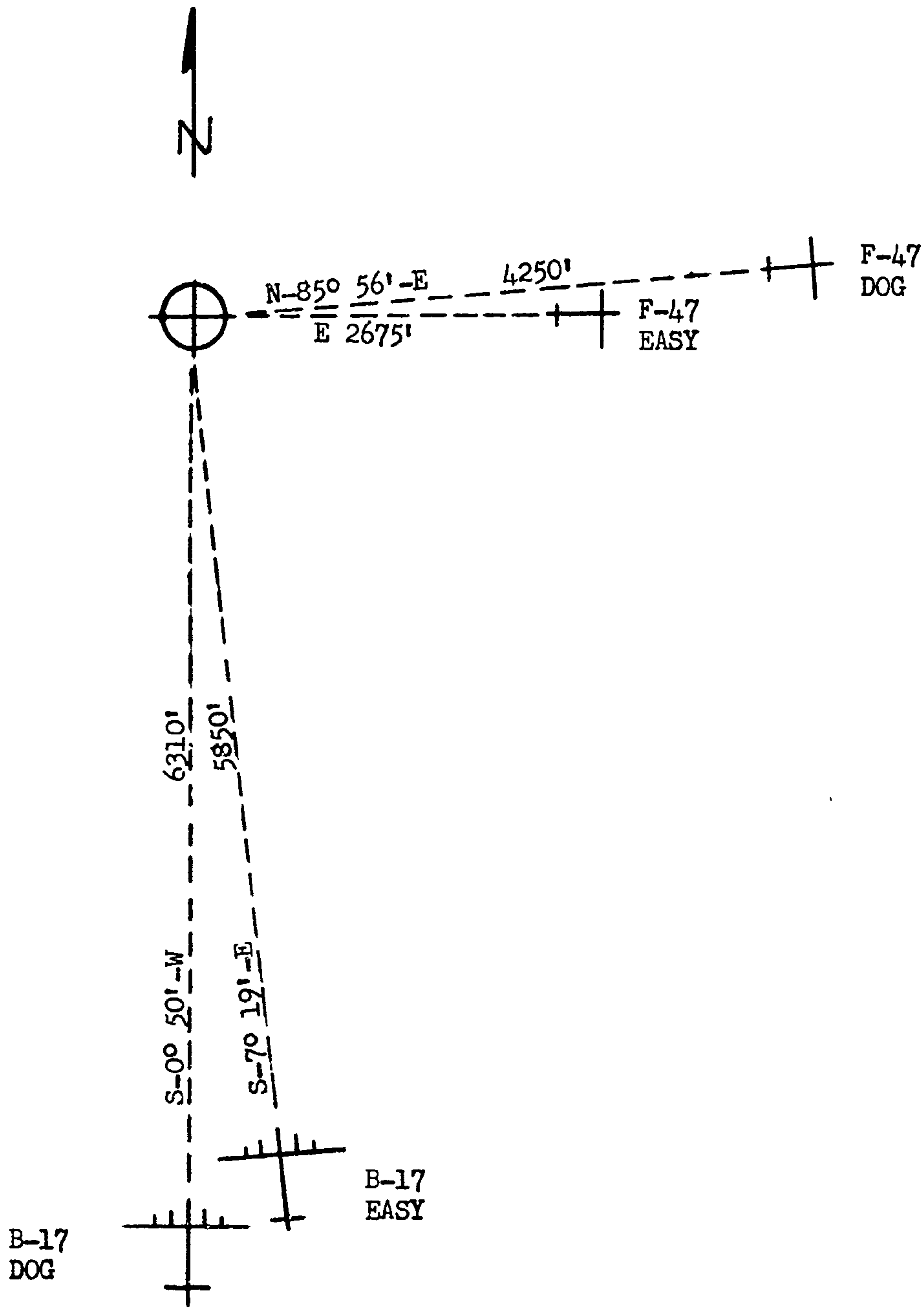

Fig. 4.1 Location of Aircraft Relative to Ground Zero for Dog and Easy Shots

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CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The following conclusions are based upon singular data as obtained from one fighter-type and one bomber-type aircraft.

5.1.1 Fighter Aircraft with Tail Toward Blast

Fighter aircraft, as represented by the F-47, exposed directly to an atomic detonation with the tail toward the blast will be rendered unflyable in overpressure regions of 4.9 psi or higher.

5.1.2 Bomber Aircraft with Side Toward Blast

Bomber aircraft, as represented by the B-17, exposed directly to an atomic detonation with the side toward the blast will be severely damaged and rendered unsafe for flight in overpressure regions of 3.1 or higher.

5.1.3 Bomber Aircraft with Nose Toward Blast

Bomber aircraft (B-17 type) oriented with the nose toward the blast will sustain skin buckles and some frame buckles at over-pressures of 4.1 psi or higher.

5.2 RECOMMENDATIONS

5.2.1 More Comprehensive Program

It is recommended that a more comprehensive program be initiated to determine on a statistical basis the vulnerability of parked aircraft to an atomic detonation.

5.2.2 Sufficient Aircraft

It is recommended that sufficient aircraft be allocated to the parked-aircraft-vulnerability program to investigate several parameters simultaneously, these parameters to include several peak overpressures, various aircraft orientations, and the effect of passive-defense measures.

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5.2.3 Early Assignment of Aircraft

It is recommended that the aircraft for any future program be assigned at the earliest possible date to permit adequate planning and instrumentation work.

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APPENDIX A

OSCILLOGRAPHIC-TYPE RECORDING IN THE PRESENCE OF ATOMIC EXPLOSIONS (UNCLASSIFIED)

A.1 PURPOSE

To study the feasibility of using oscillographic-type recording instrumentation for obtaining data on aircraft structures and structural components in the vicinity of atomic explosions and to measure certain kinetic effects on an F-47 aircraft.

A.2 FACTUAL DATA

The information reported herein was obtained from Dog and Easy shots Operations BUSTER as part of Project 5.8. The sensing and recording of the required information was accomplished by using resistance type acceleration, pressure, and temperature transmitters, multi-channel Heiland oscillograph, Nosker bridge balance units, and appropriate connecting circuits. Variations in the quantities to be measured affected the gages and produced a proportional electrical unbalance in the bridge circuit of the gage. The amount of unbalance of each gage bridge circuit was measured by the deflection of a D'Arsonval type galvanometer connected across the output terminals of the circuit. The deflection of each galvanometer was recorded simultaneously on moving photo-senstivie paper by the camera section of the oscillograph. Timing marks every one hundredth (0.01) second were also photographed on the edge of the paper to provide a time reference for the recorded data.

The component parts of the system were calibrated by subjecting the gages to representative values of their specific functions while the gages were properly connected through the balancing controls of the oscillograph. The oscillograph trace deflections were then compared to the corresponding applied leads to obtain a calibration factor based on the amount of applied loads required per inch of trace deflection. This was accomplished for each gage-galvanometer combination used on the test.

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For the purpose of this study it was necessary to prepare instrumentation for two installations. The first, an installation in the cockpit of an F-47, was used to sense and record local pressure, temperature and accelerations, with the aircraft on the ground during the tests (See Fig. A.1, A.2, and A.3). The second, an installation in the ground, was used to sense and record similar local data (See Fig. A.4). The oscillograph, oscillograph battery and the bridge balance unit used in each installation referred to above were shock mounted in a steel box in order to prevent damage from accelerations resulting from the test explosion. In each installation two Statham accelerometers were used to measure the vertical acceleration during the test, one accelerometer was mounted on the oscillograph and a second was mounted on the steel box. A third Statham accelerometer was used to measure e horizontal radial acceleration, or acceleration which occurs along a radius through ground zero for the test.

Aluminum sheets (.020-24ST) with the upper surface finished a dull black and a transonic temperature transmitter fixed to the underside were used to measure the temperatures during the tests. Pressure transmitters which had a fifteen (15) pound per square inch range were used to measure the test pressures.

Due to the different requirements of the two installations, the location of the temperature plates and the pressure pick-ups relative to the oscillograph were different. The exact location of these sensing units are covered in paragraphs 10 and 12.

The galvanometer deflection for any given bridge unbalance is directly proportional to the bridge voltage, therefore the voltage of each bridge balance unit was recorded during the test.

In order to actuate the instrumentation at the exact time the test started two Edgerton, Germeshausen and Gier, Type A-2 Blue Boxes were used. The type A-2 Blue Box contains a 929 photo-tube (V 101) with a 4.7 megohm cathode load resistor which is coupled with a 2D21 gas-filled thyratron (V 102). The thyratron is normally non-conducting but is energized by an abrupt rising, light pulse of sufficient intensity which strikes the cathode of the 929 photo-tube. The relay closes within two (2) milliseconds after the light pulse and remains closed until after the reset button is manually pressed. The power was supplied to the Blue Box by a 115 volt, AC, four hundred (400) cycle inverter.

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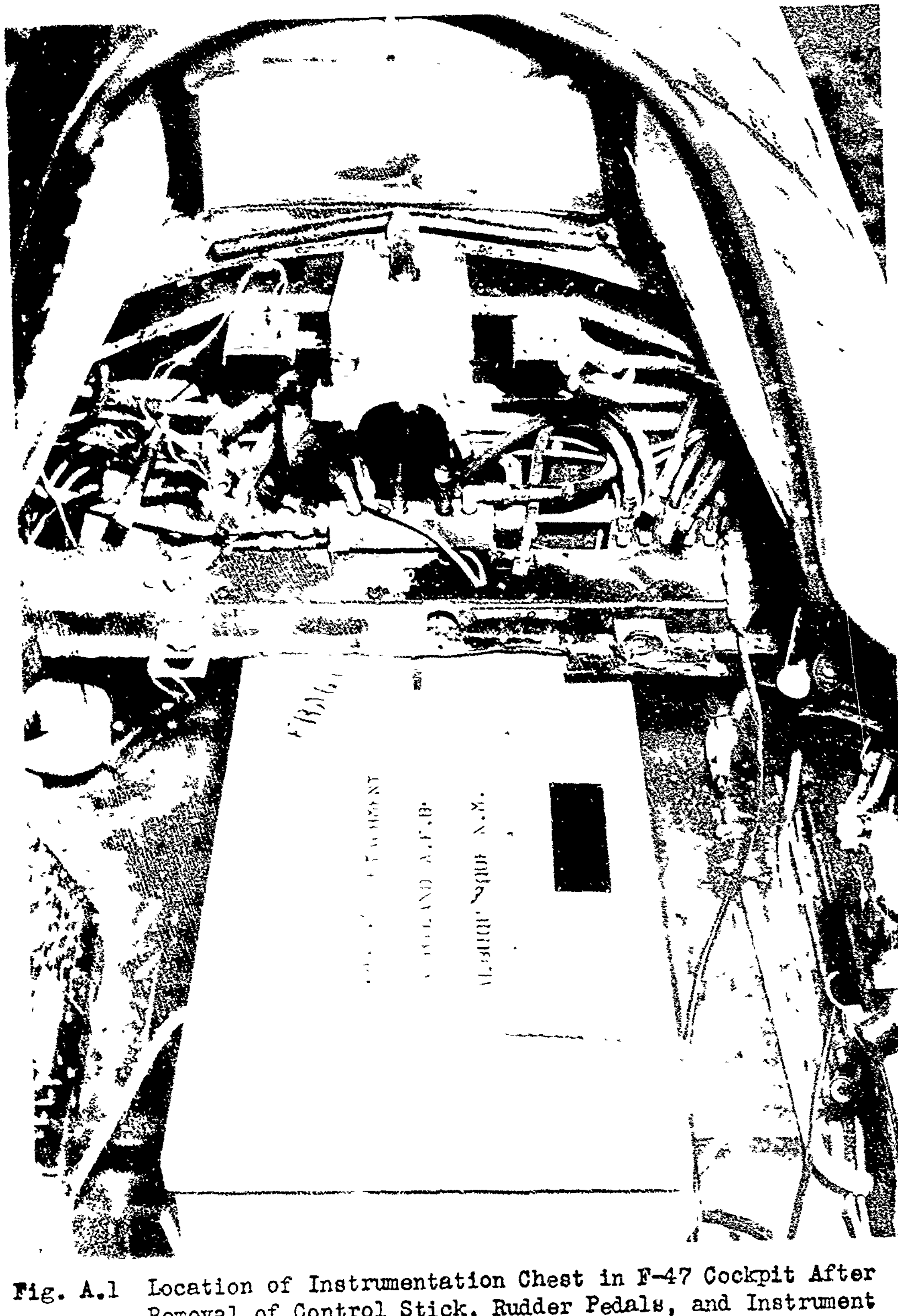

Fig. A.1 Location of Instrumentation Chest in F-47 Cockpit After Removal of Control Stick, Rudder Pedals, and Instrument Panel. Chest contains accelerometer, recording oscillograph, bridge balance unit, battery, and automatic controls.

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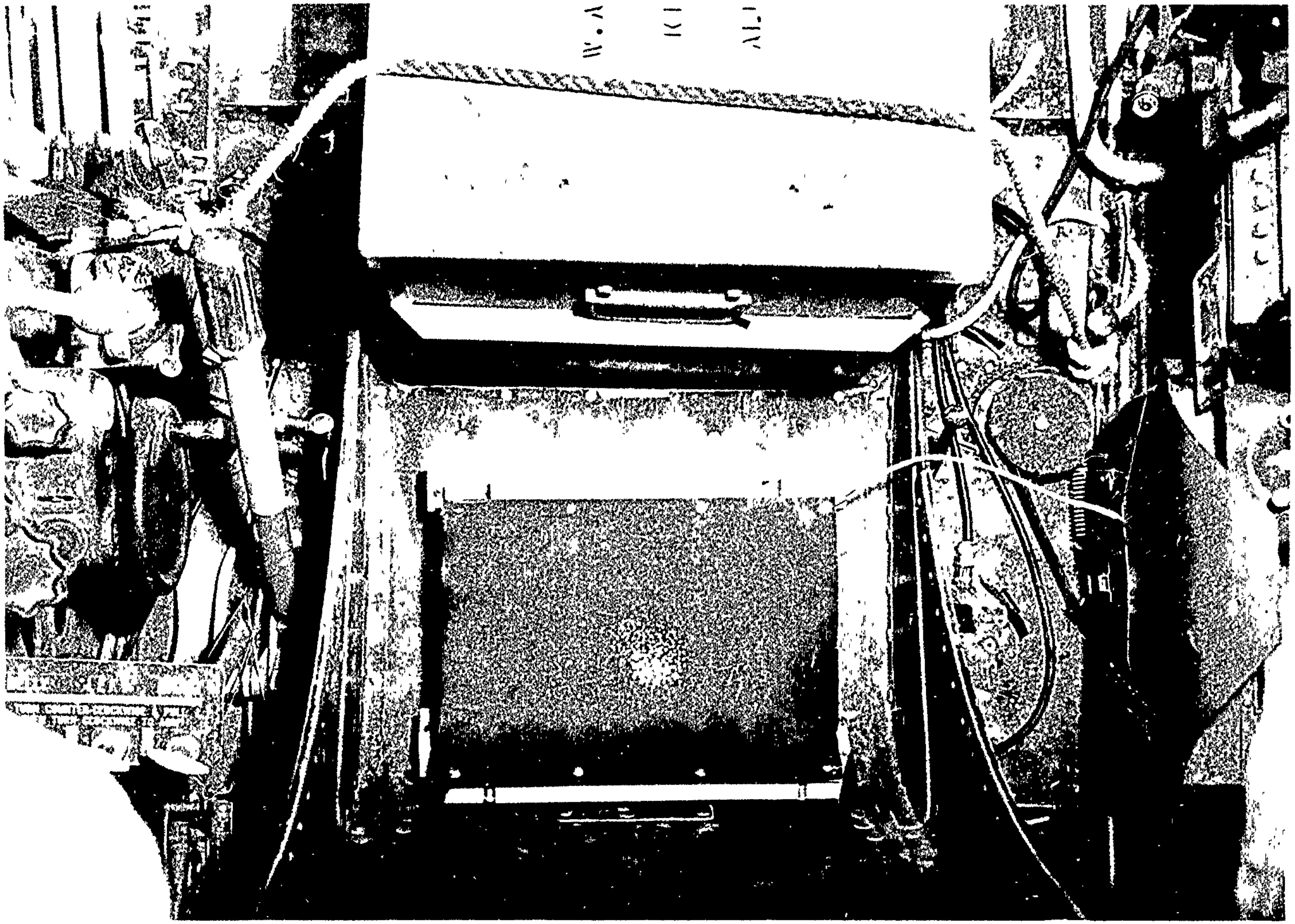

Fig. A.2 Thin Skin Thermal Sensing Plate on F-47 Seat

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Fig. A.3 Condition of Ground Mounted Instrument Chest (Large Box) with Thin Skin Thermal Sensing Plate on Top. Small chest contains photo cell triggering mechanism for starting recording systems.

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Fig. A.4 Pressure Sensing Orifice on F-47 Fuselage

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It was necessary to provide a warm up period for the bridge balance units and the Blue Boxes. This was accomplished in each installation by using a 24 Volt timer switch which was operated by a standard aircraft battery. At approximately H - 12 hours the clock for the timer switch was started, and the timer switch was set to trip the Blue Box warm-up relays and turn on the bridge voltages thirty minutes before H hour. The light output of the test explosion actuated the Blue Box which started the recording mechanism.

At the Nevada test site the rudder controls, suit heater, control stick and supporting castings, instrument panel and all adjoining panels were removed from the cockpit of the F-47 Serial No. 44-2566. This was necessary for the purpose of installing the instrumentation in the aircraft. The steel box containing the oscillograph, oscillograph battery and bridge balance unit was secured immediately forward of the pilots seat on the cockpit floor Fig. A.1. It was located in such a way that the longitudinal **axis** or the optical axis of the oscillograph paralleled the longitudinal axis of the aircraft. Positioning the oscillograph in such a manner was necessary in order to have minimum side accelerations acting on the galvanometers during the tests. The temperature panel was located four (4) inches above the bottom of the pilots' seat, parallel to the ground. The pressure transmitter for this installation was located on the right side of the fuselage just ahead of pilots compartment, Fig. A.5. The Blue Box timing switch inverter and battery were buried in the ground next to the aircraft figure A.7, and the Blue Box window was directed at the initial point of the test or the point at which the weapon was detonated.

The connection cable from the Blue Box to the Aircraft instrumentation was long enough to allow for a thirty (30) foot movement of the aircraft. In order to prevent the insulation from burning off of the cable due to the initial radiant heat of the explosion, all lead-in wires were protected by either being buried in the ground or wrapped with aluminum foil.

The steel box, containing the oscillograph, and the component parts for the second installation was buried in the ground ten (10) feet off the right wing tip of the F-47 aircraft, figure A.7. The top of the box was exposed and at ground level with the longitudinal axis of the oscillograph along a radius through ground zero, or the ground point directly below the initial point of the test. The temperature panel was mounted on the exposed surface of the box

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furthest from the ground zero, and the source for the pressure transmitter was located on the exposed surface of the box closest to ground zero. For this installation the Blue Box, timer switch, inverter and battery were placed five (5) feet from the oscillograph box with the Blue Box window directed at the initial point of the test, Figure A.6. All connecting wires in this installation were buried to prevent heat damage to the insulation.

During the test no additional precautions were taken to prevent any radiation from affecting the photo-sensitive paper used for recording. Shielding with lead sheet or concrete were purposely omitted so that the radiation effects could be studied.

Due to the operational limitations it was necessary to install all instrumentation approximately twelve (12) hours before H hour. At this time the final operational check of the instrumentation was made and a zero record was taken for the test.

The first of the two (2) atomic explosions during which measurments were taken, was a 20.9 KT weapon. For this test the aircraft and ground instrumentation were four thousand, two hundred and fifty (4250) feet from ground zero. This distance was theoretically selected to give a six (6) pound per square inch over-pressure.

The peak values recorded for this test for all measured quantities are listed below for each of the installations

Quantities	Aircraft Inst. Value	Ground Inst. Value	Response of Pick-up
Overpressure (psi)	4.92	4.82	Good
Vertical Acc.Box (G)	5.2 to-8	9 to-22.75	Fair
Vertical Acc.Osc. (G)	7.9 to-2.4	3.9 to-.85	Fair
Radial Acc. Box (G)	3.4 to-2.9	.44 to-.28	Fair
Temperatures ('F)	92°	220	Good

The figure numbers above refer to graphs on which the input and response are plotted versus time.

The ground shock had no apparent influence upon the galvanometer response; however, the air shock had a definite effect upon the galvanometer recording. The galvanometer response to air shock could not be separated from the actual accelerations encountered, and there is possibly a fourteen percent (14%) error at the peak

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reading for the pressure recorded on the aircraft. From the pressure time plot, Figure A.8, it is noted that there is an abrupt change in the slope at four (4) pound per square inch and at four and two tenths (4.2) pounds per square inch on the increasing portion of the curve and a similar change at the same values on the decreasing portion. These changes of slope give evidence to the possibility that air shock could be responsible for this final peak. The ground installation does not show a similar condition for the pressure record. The reason for this is undetermined.

The temperature measurement for the ground installation showed good response and the effect of air shock could be separated from the actual temperature successfully. The temperature recorded in the aircraft was of much smaller magnitude than that of the ground installation because of shielding from the direct radiation of the weapon. The ground installation temperature record showed a lag to the first peak of one (1.0) second and a lag to the second and largest peak of two and sixty five hundredth (2.65) seconds, Figure A.25.

The radiation eminating from the test explosion was also of definite concern for its effect upon the photo-sensitive paper, caused a considerable fogging or graying. The radiation effects of the first test did not seriously impair accurate reading and interpretation of the record.

The test explosion had no physical effect upon the instrumentation itself except that the filter windows of the Blue Boxes were broken. This damage did not effect normal operation and the Blue Boxes were used successfully on the last test.

The second of the two (2) atomic test explosions during which measurements were taken was a 31.25 KT weapon and for this test the aircraft and ground instrumentation was two thousand, six hundred and seventy five (2675) feet from ground zero. This position was selected theoretically to give a fifteen (15) pound per square inch overpressure.

The galvanometer lamp in each installation burned out at some undetermined time after a zero record was taken, so no information was acquired other than radiation effects. Since there were no traces on the exposed record it is not possible to determine whether the amount of fogging obtained was severe enough to seriously impair reading and interpretation.

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During this test the extreme heat melted approximately half of the temperature plate of the ground installation, other than this no other physical damage was done.

All the results of the test and some of the specific recommendations are found in tabular form in Table I.

A.3 CONCLUSIONS:

The radiation emitted from the test weapon had very definite effect on the photo-sensitive paper used in the recording oscillograph. It caused considerable fogging or graying and caused difficulty in reading end interpretation.

The galvanometers showed a noticeable response to air shock, which had a definite effect upon the acceleration readings and it could not be separated from the actual test accelerations. There is a possible error at the peak pressure readings for the aircraft instrumentation. The temperature readings could be faired through the galvanometer response and good response was obtained from the temperature pick-ups.

The radiant heat accompanying Easy Shot was sufficient to melt approximately half of the temperature plate of the ground installation.

A.4 RECOMMENDATIONS:

It is recommended that:

The oscillographic-type instrumentation as described be considered for use under conditions of the first range and KT combination or similar combinations emitting equal radiation.

Lead shielding be used, or the recording instrumentation be placed in a concrete black house when the instrumentation is operated at a shorter range.

Future tests be conducted to determine response of galvanometer to rapid pressure and temperature changes, in order to determine transient effects on the recorded data.

All recording instrumentation should be surrounded by sound proof, shock absorbing material, in a box which is securely fixed to the ground. Lead masses should be used to deaden the vibrations of flat surfaces and accelerometers.

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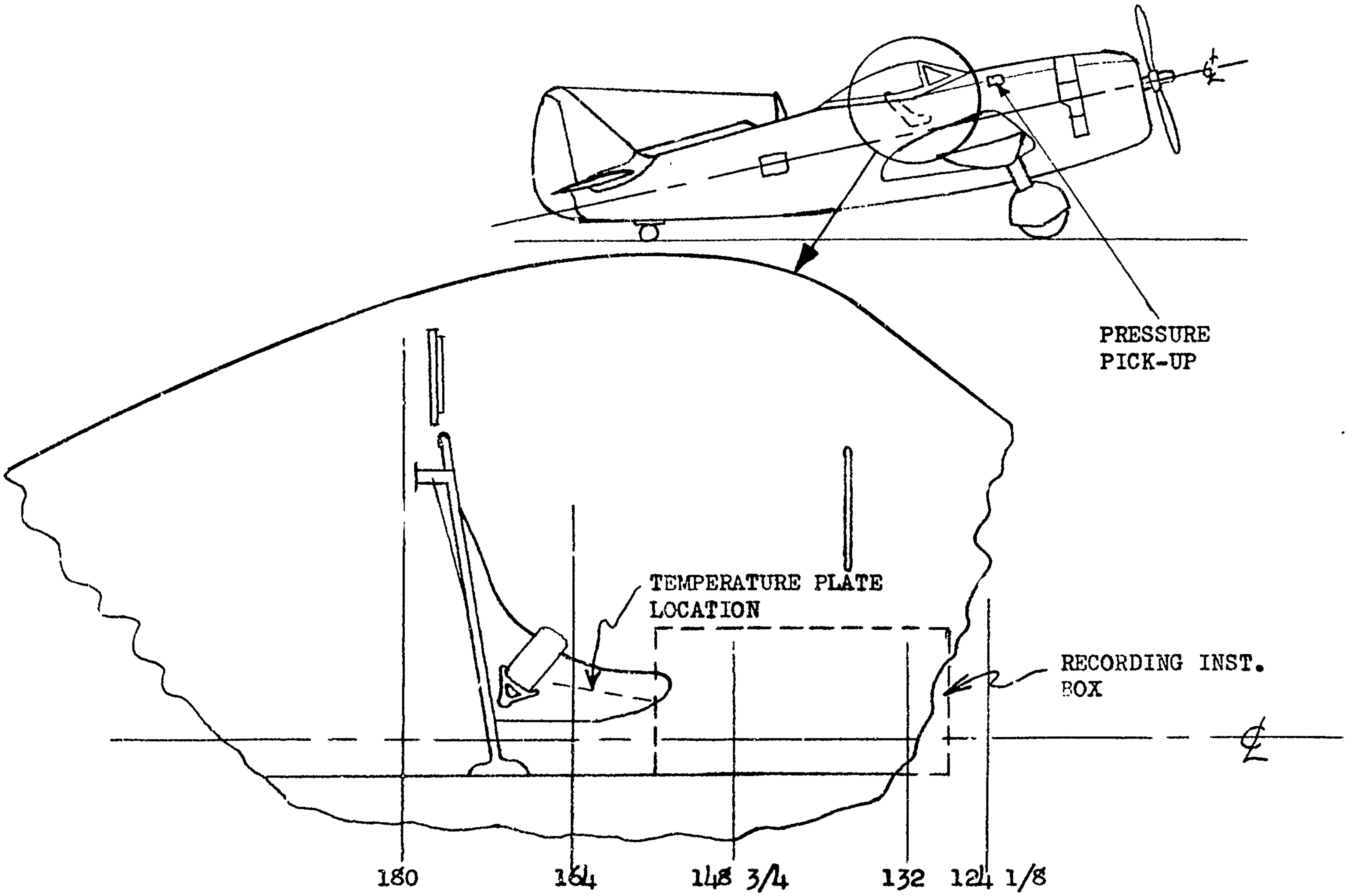
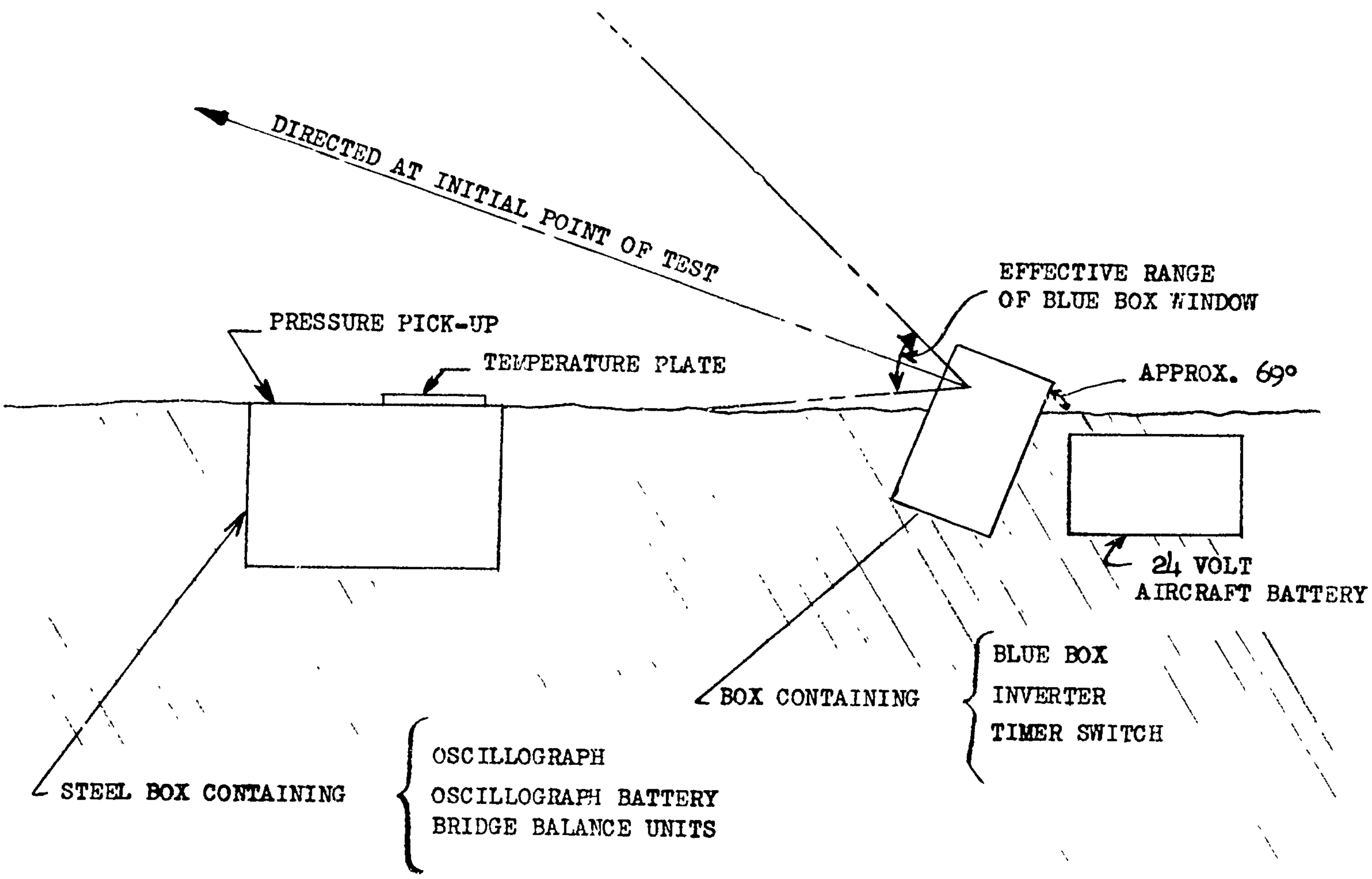


Fig. A.5 Schematic Diagram Showing Location of Aircraft Instrumentation



NOTE: ALL CONNECTING WIRES IN THIS INSTALLATION WERE ROUTED BELOW GROUND LEVEL.

Fig. A.6 Schematic Diagram of Ground Installation

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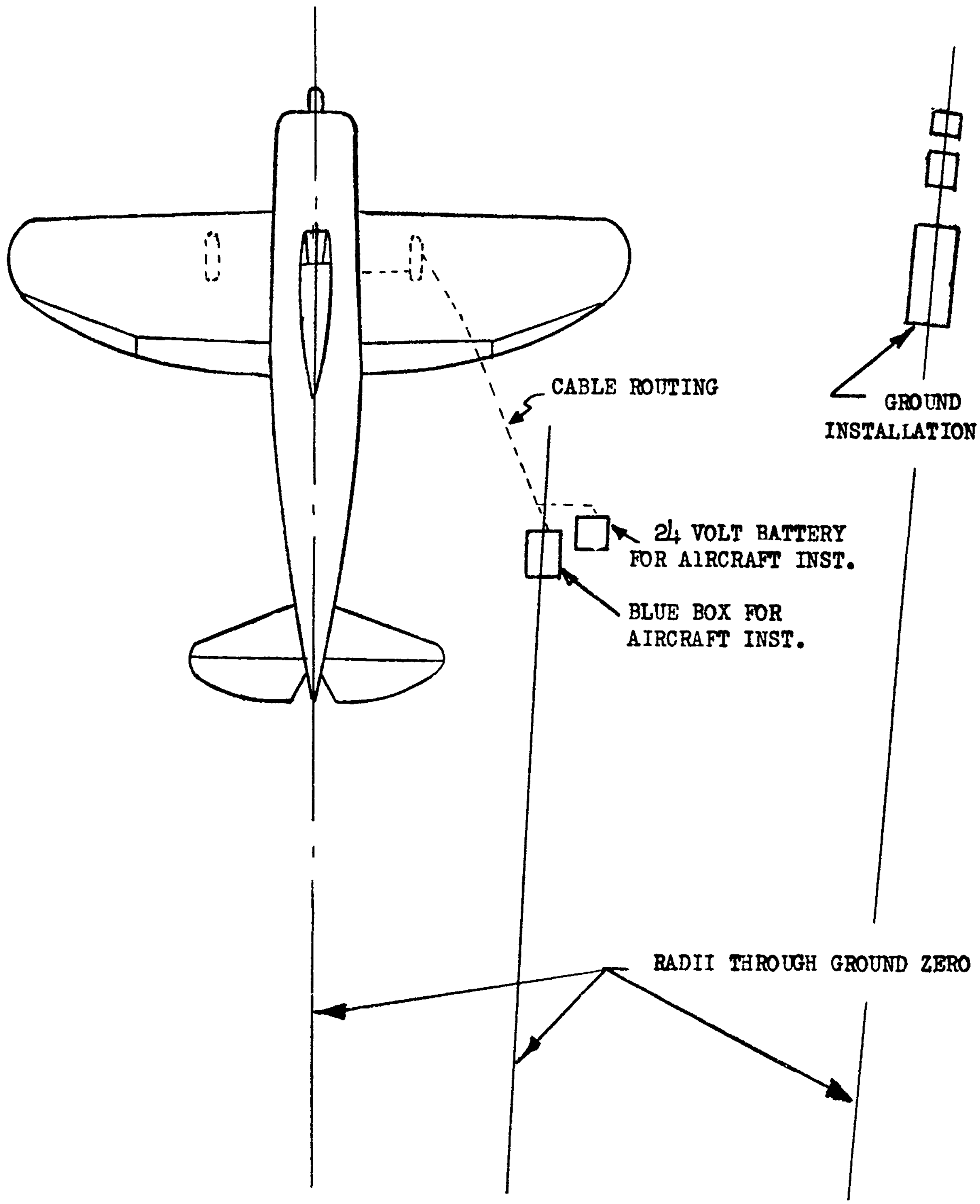

Fig. A.7 Schematic Diagram Showing General Location of Instruments

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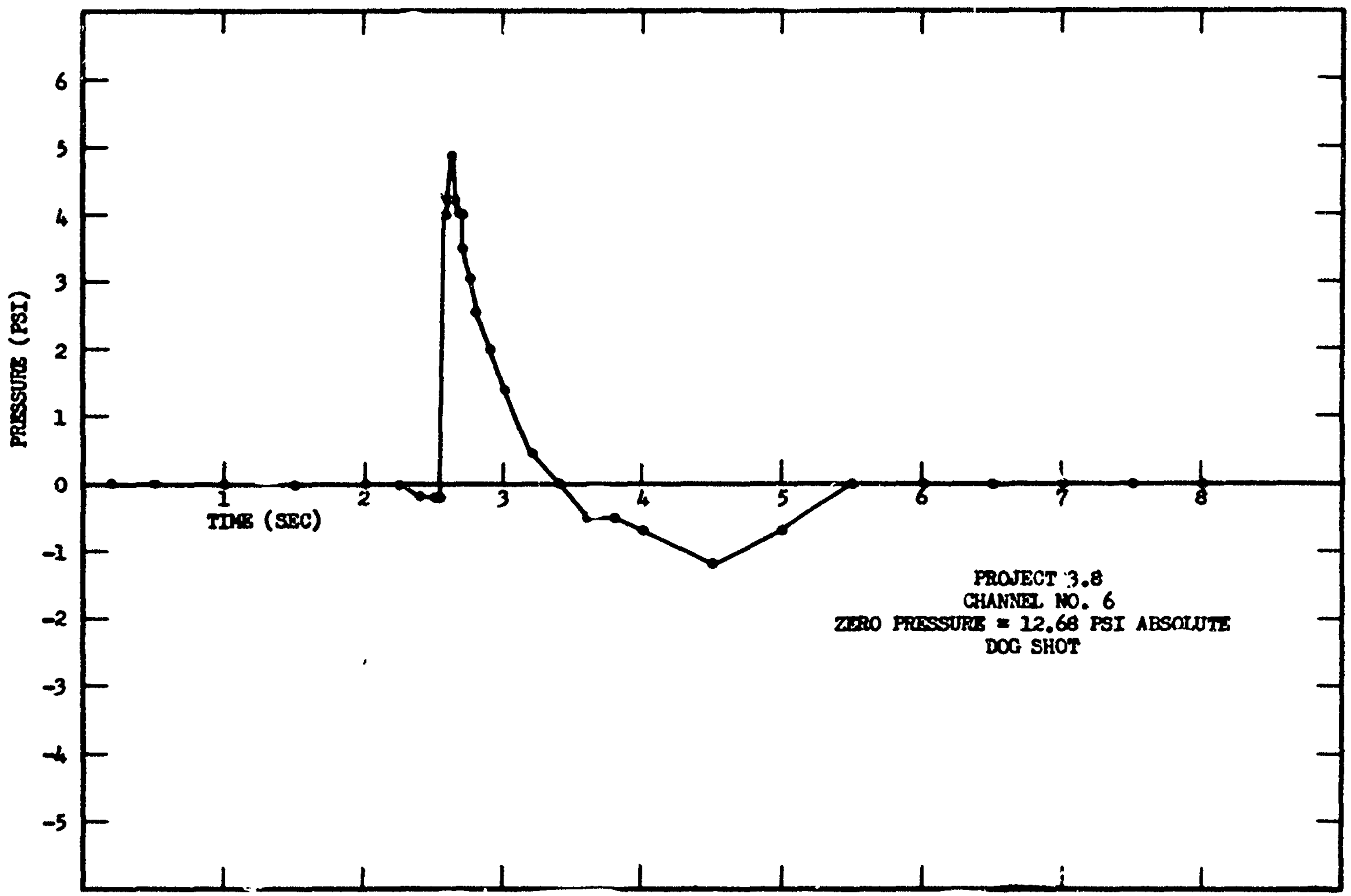

Fig. A.8 Aircraft Instrumentation Pressure vs. Time

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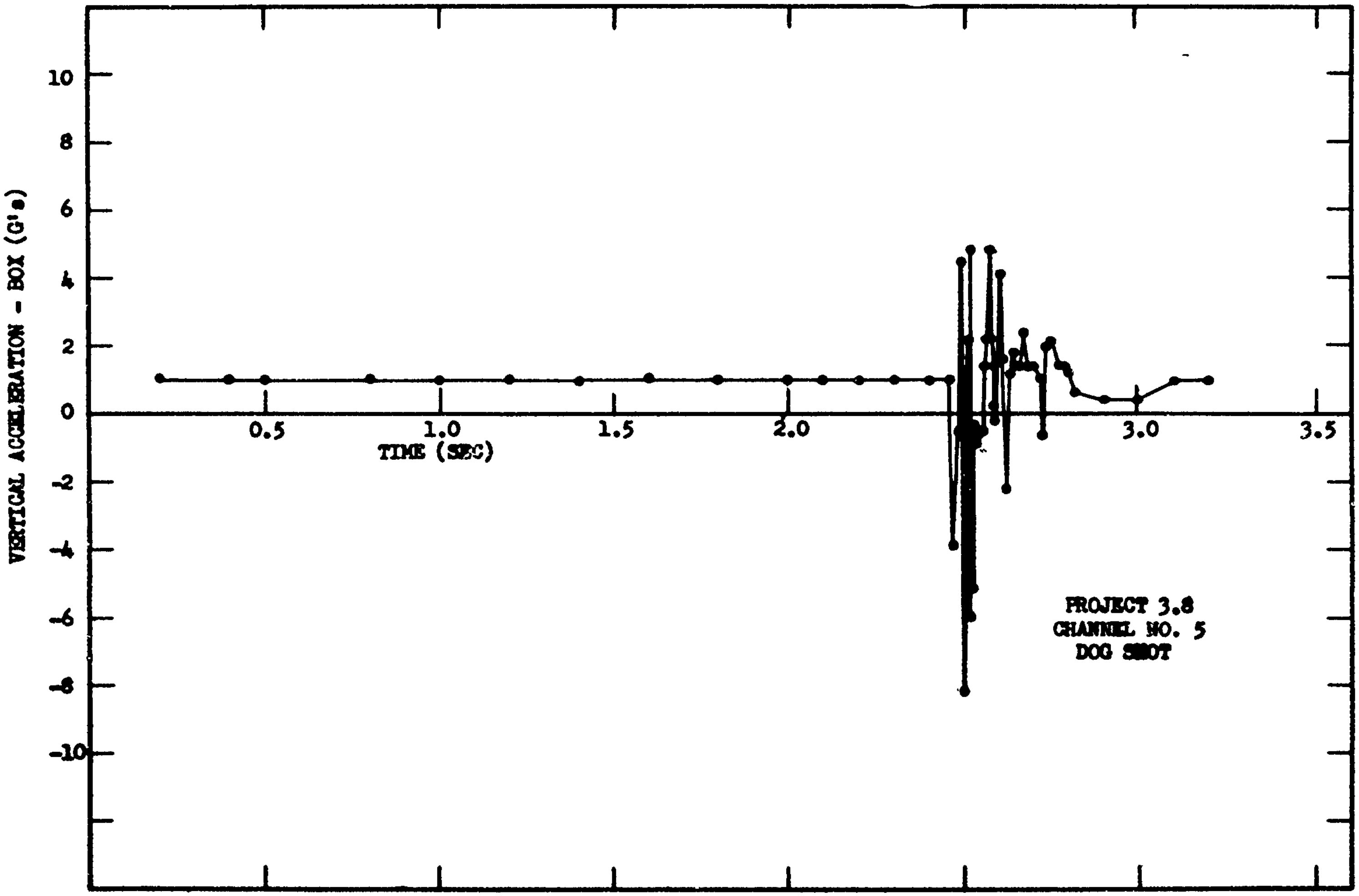

Fig. A.9 Aircraft Instrumentation Vertical Acceleration vs. Time

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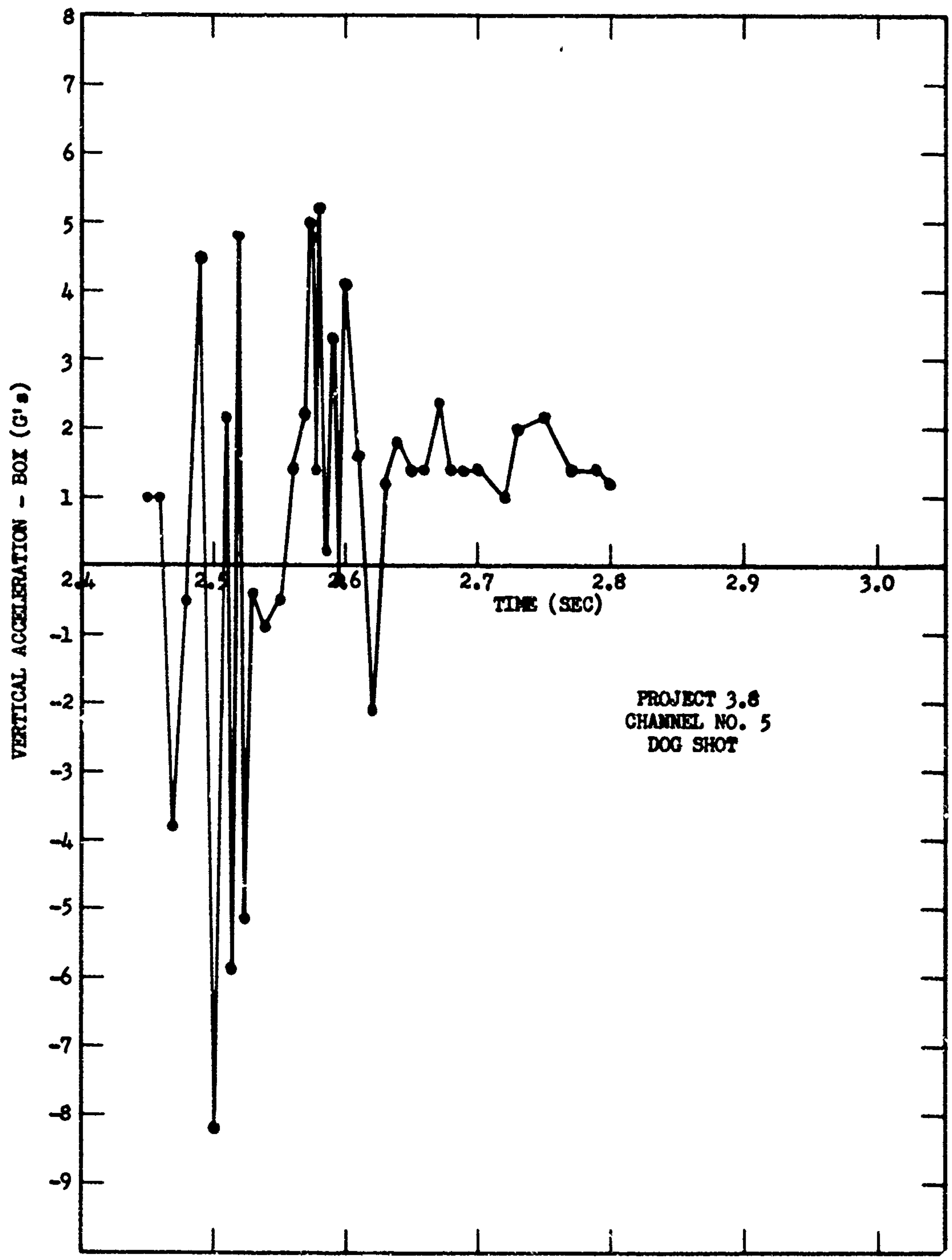

Fig. A.10 Aircraft Instrumentation Vertical Acceleration vs. Time

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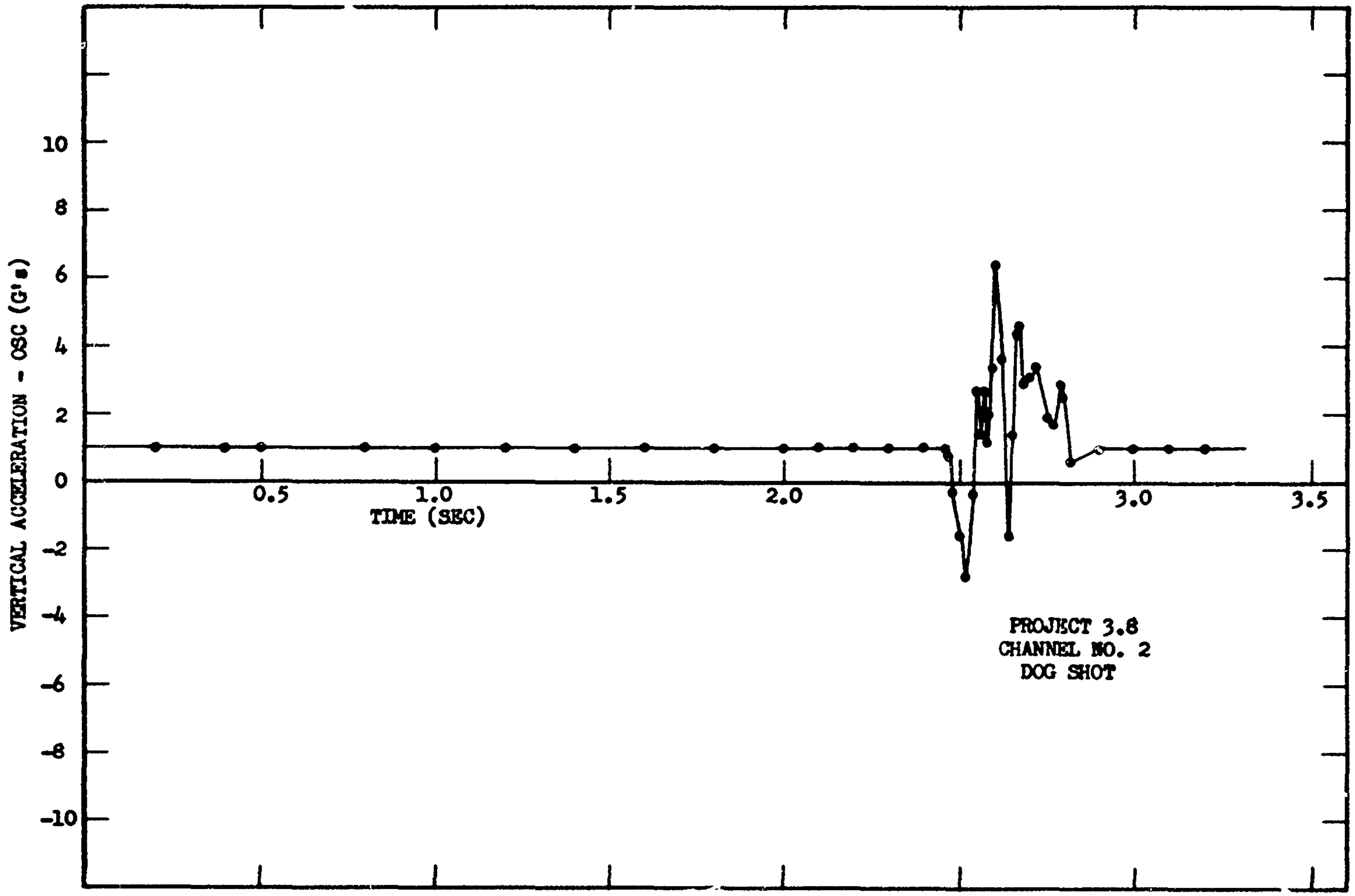

Fig. A.11 Aircraft Instrumentation Vertical Acceleration vs. Time

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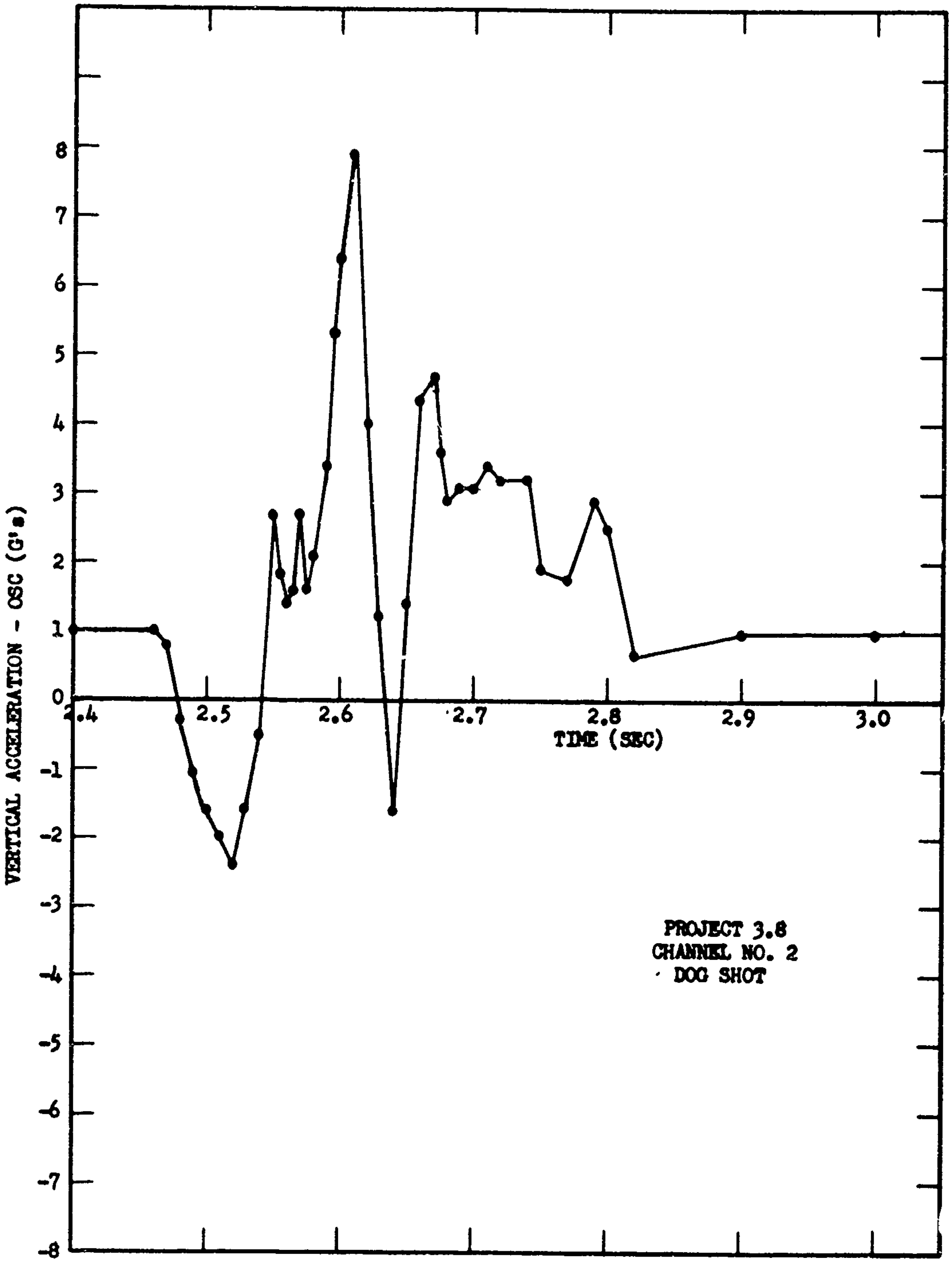

Fig. A.12 Aircraft Instrumentation Vertical Acceleration vs. Time

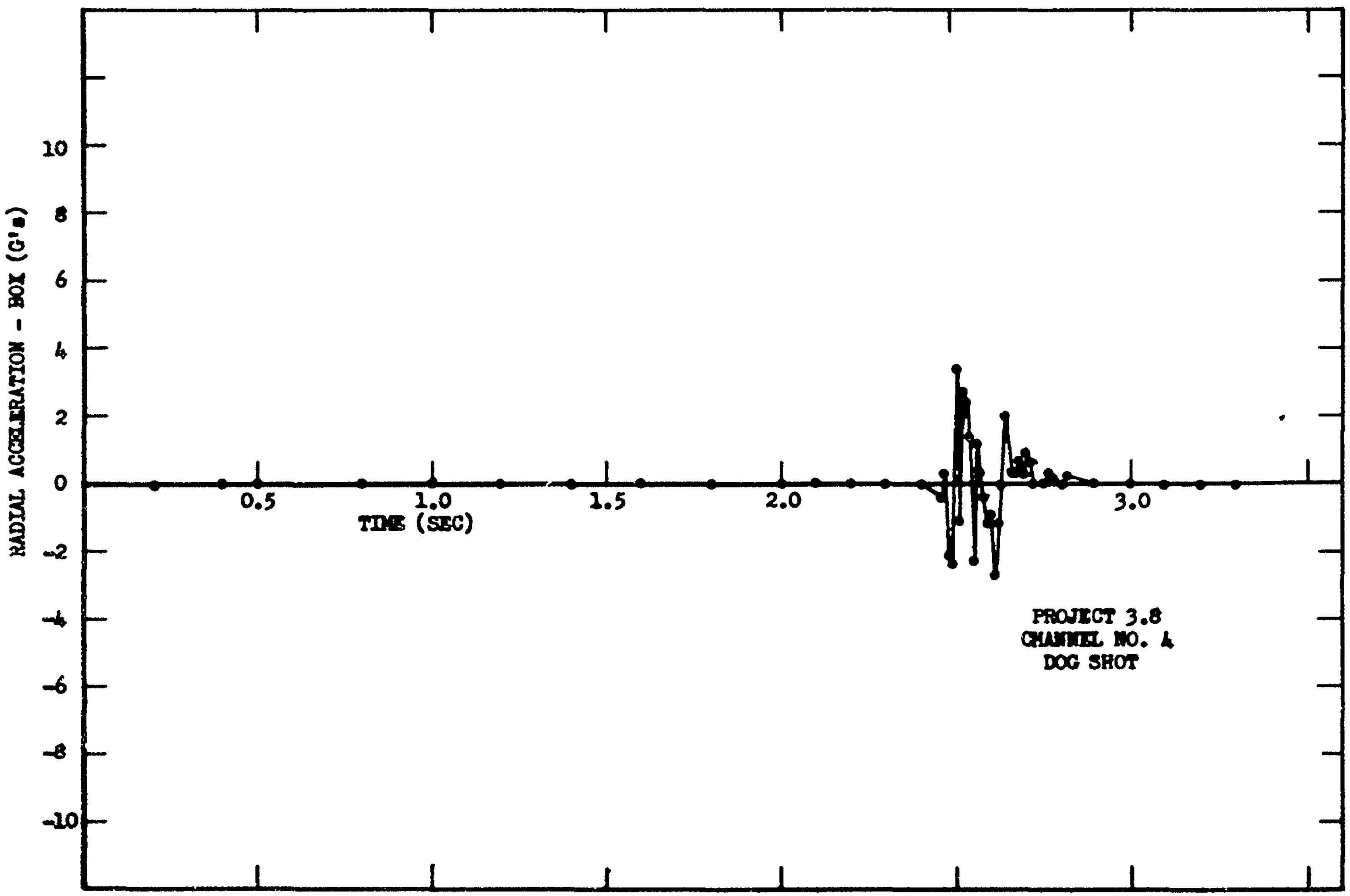

Fig. A.13 Aircraft Instrumentation Radial Acceleration vs. Time

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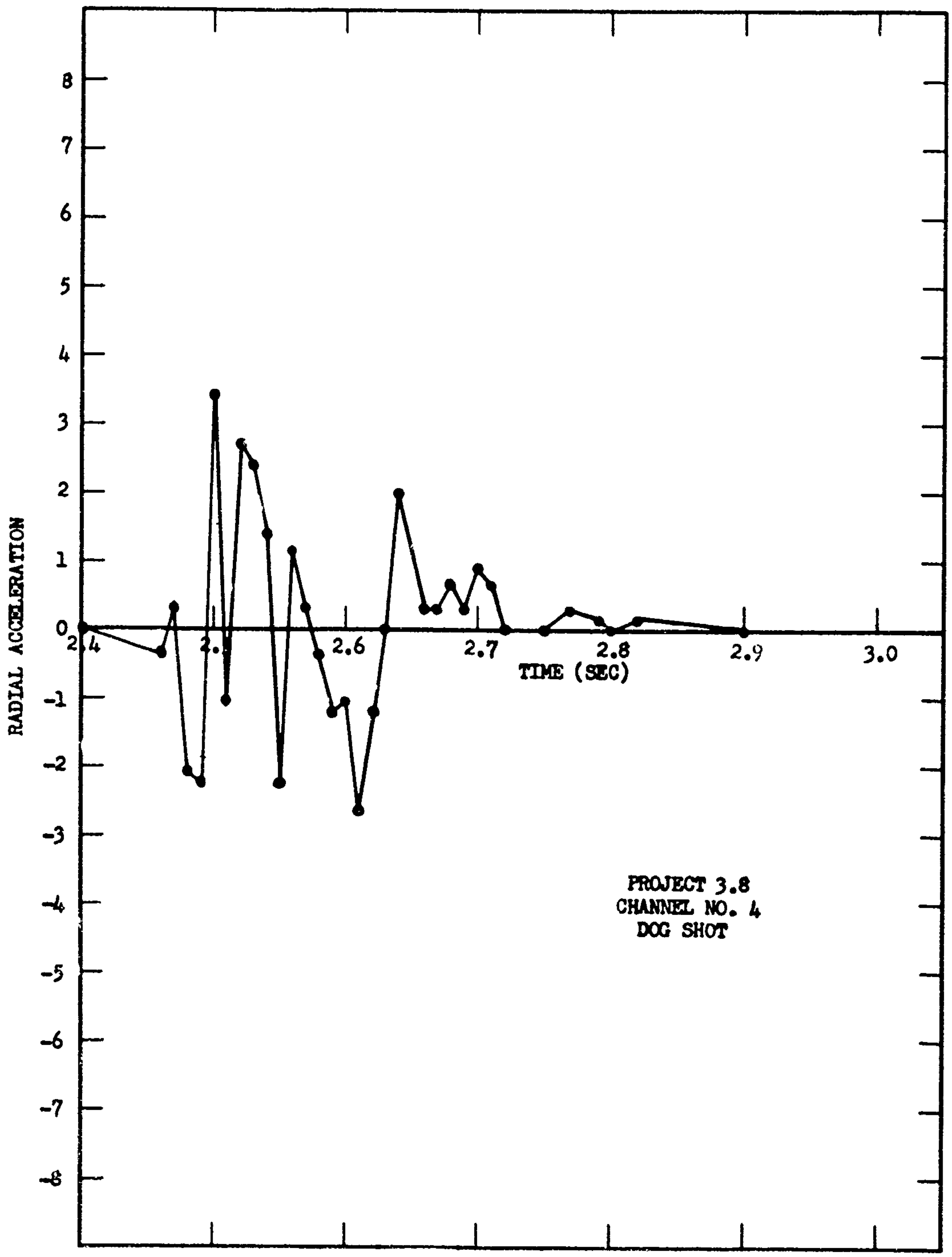

Fig. A.14 Aircraft Instrumentation Radial Acceleration vs. Time

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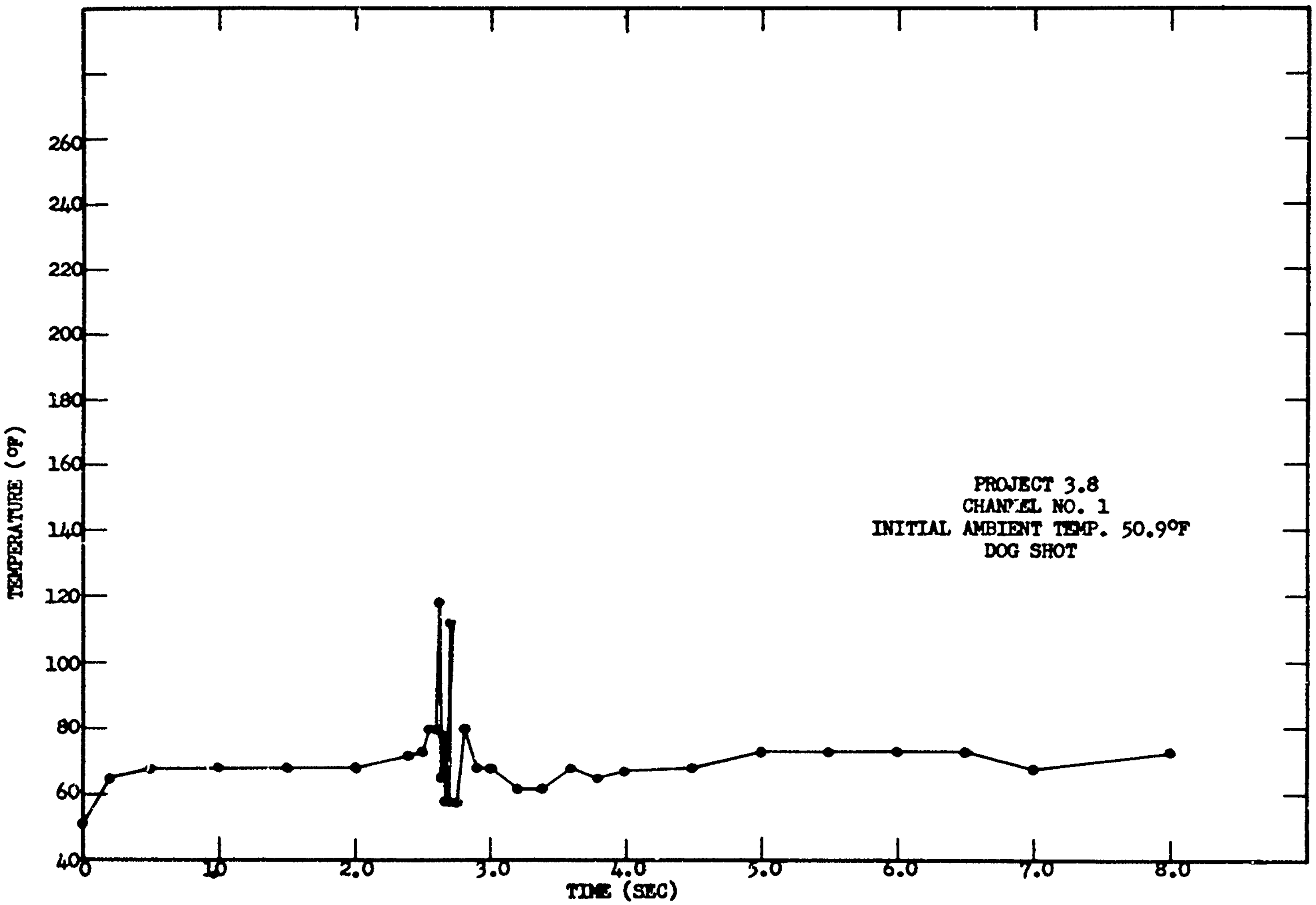

Fig. A.15 Aircraft Instrumentation Temperature vs Time

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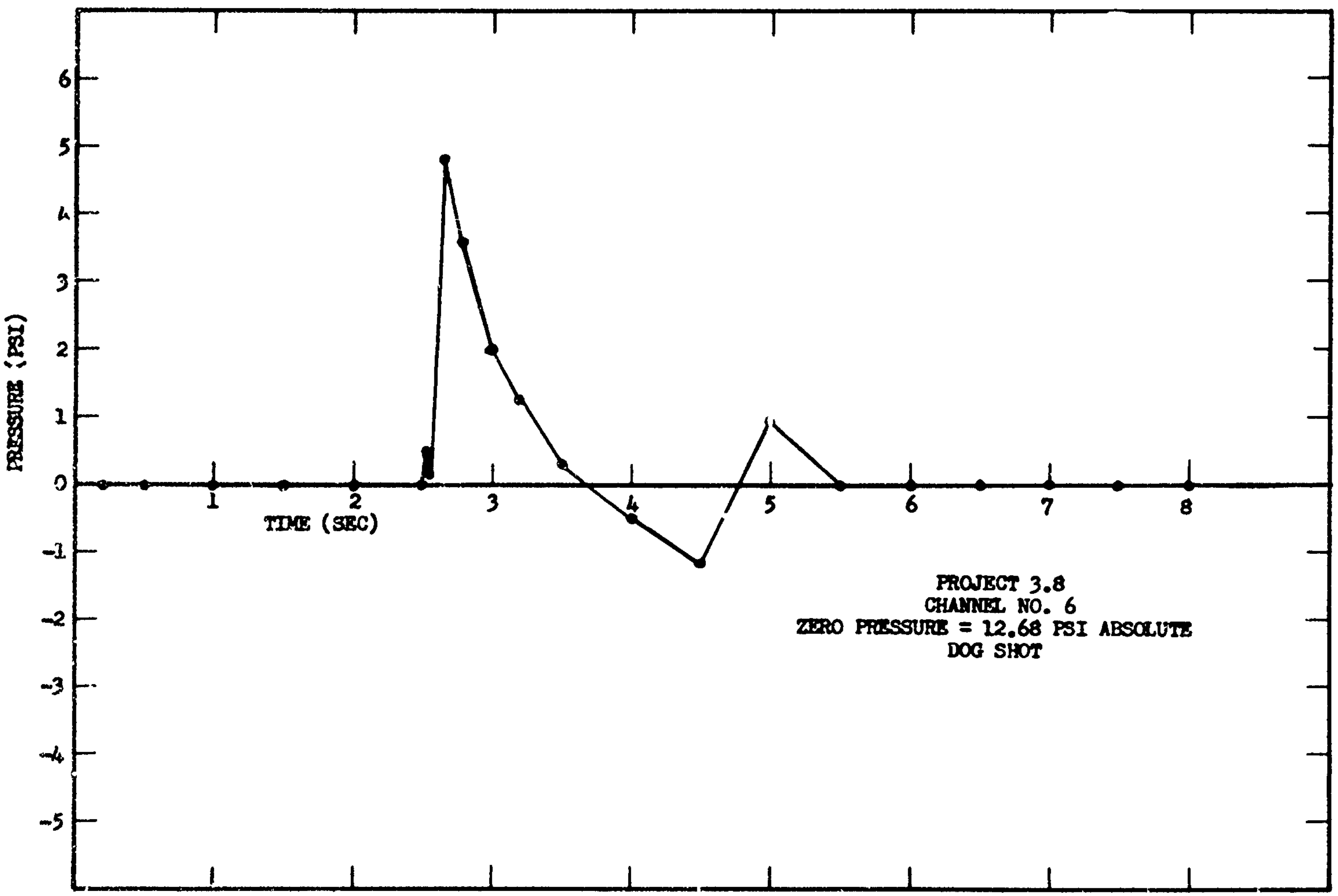

Fig. A.16 Ground Instrumentation Pressure vs. Time

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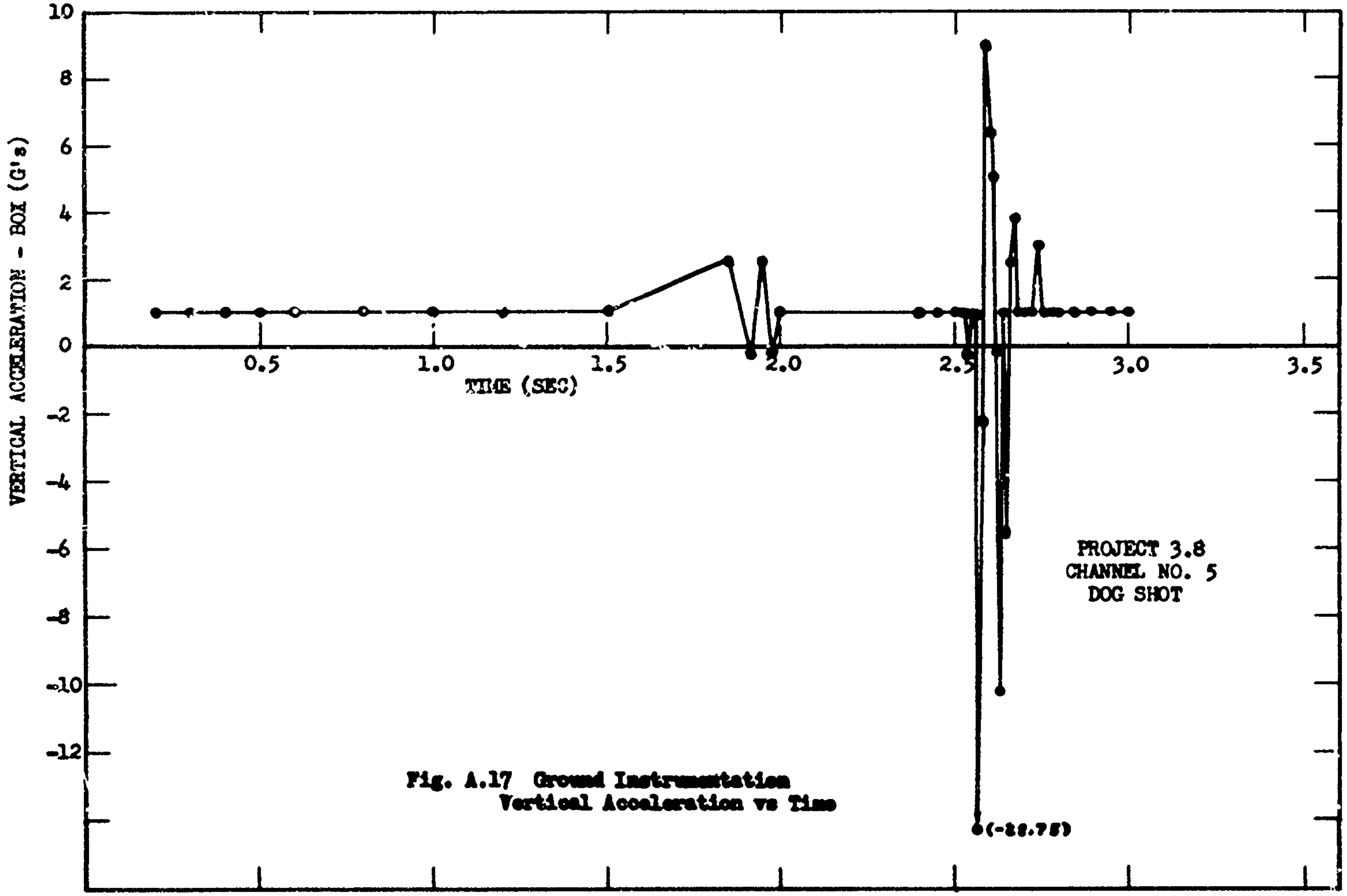

Fig. A.17 Ground Instrumentation Vertical Acceleration vs. Time

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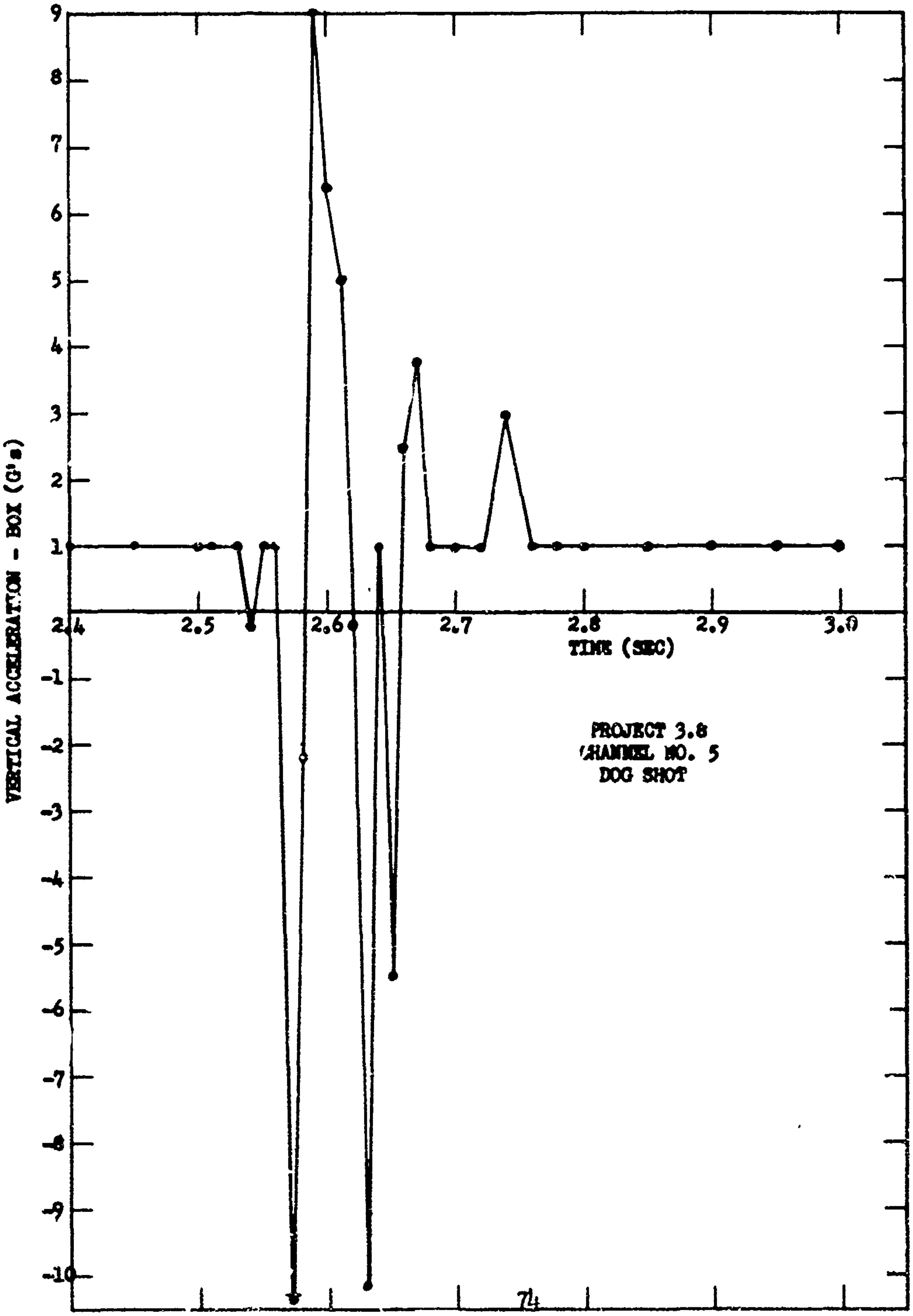

Fig. A.18 Ground Instrumentation Vertical Acceleration vs. Time

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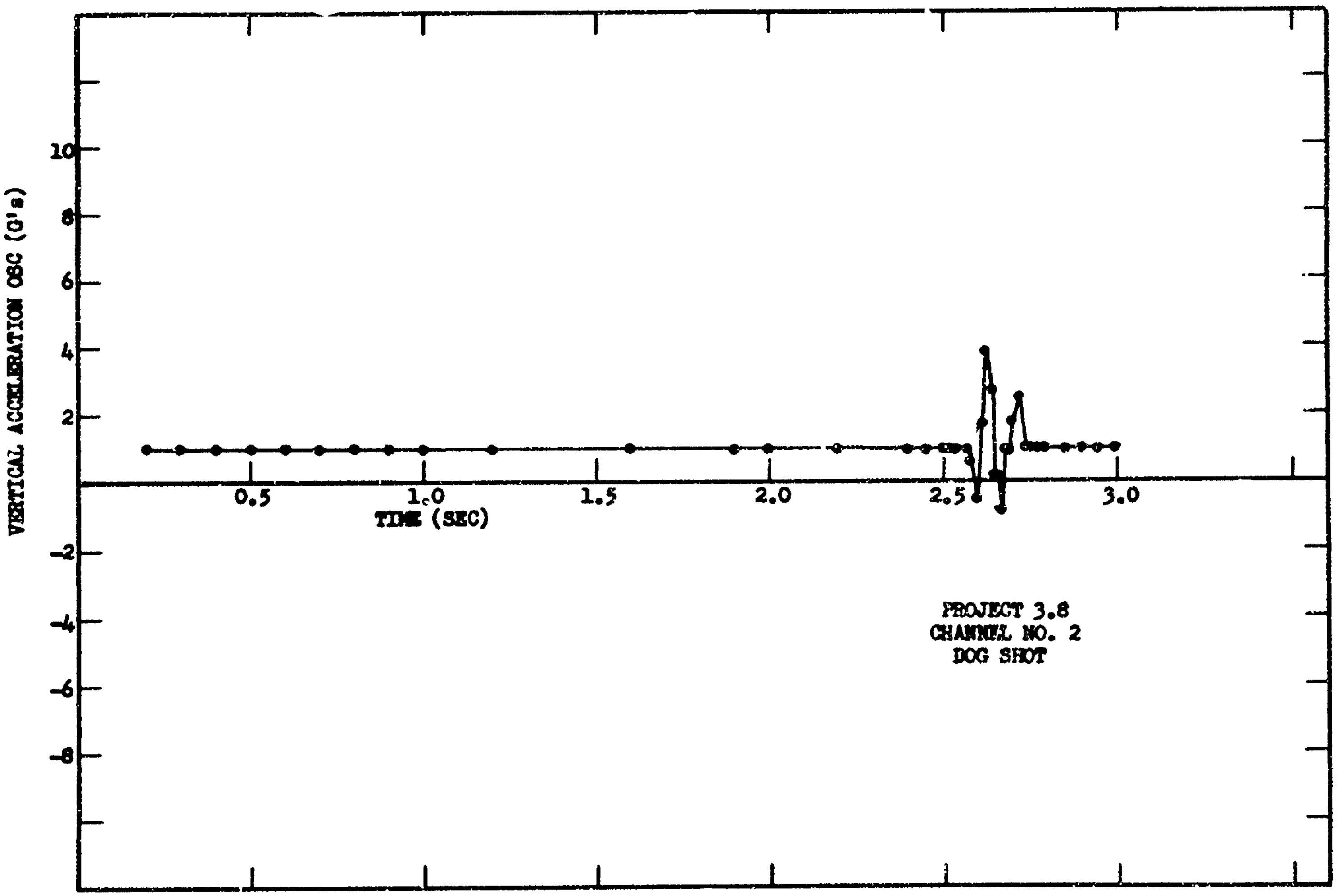

Fig. A.19 Ground Instrumentation Vertical Acceleration vs. Time

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[redacted]

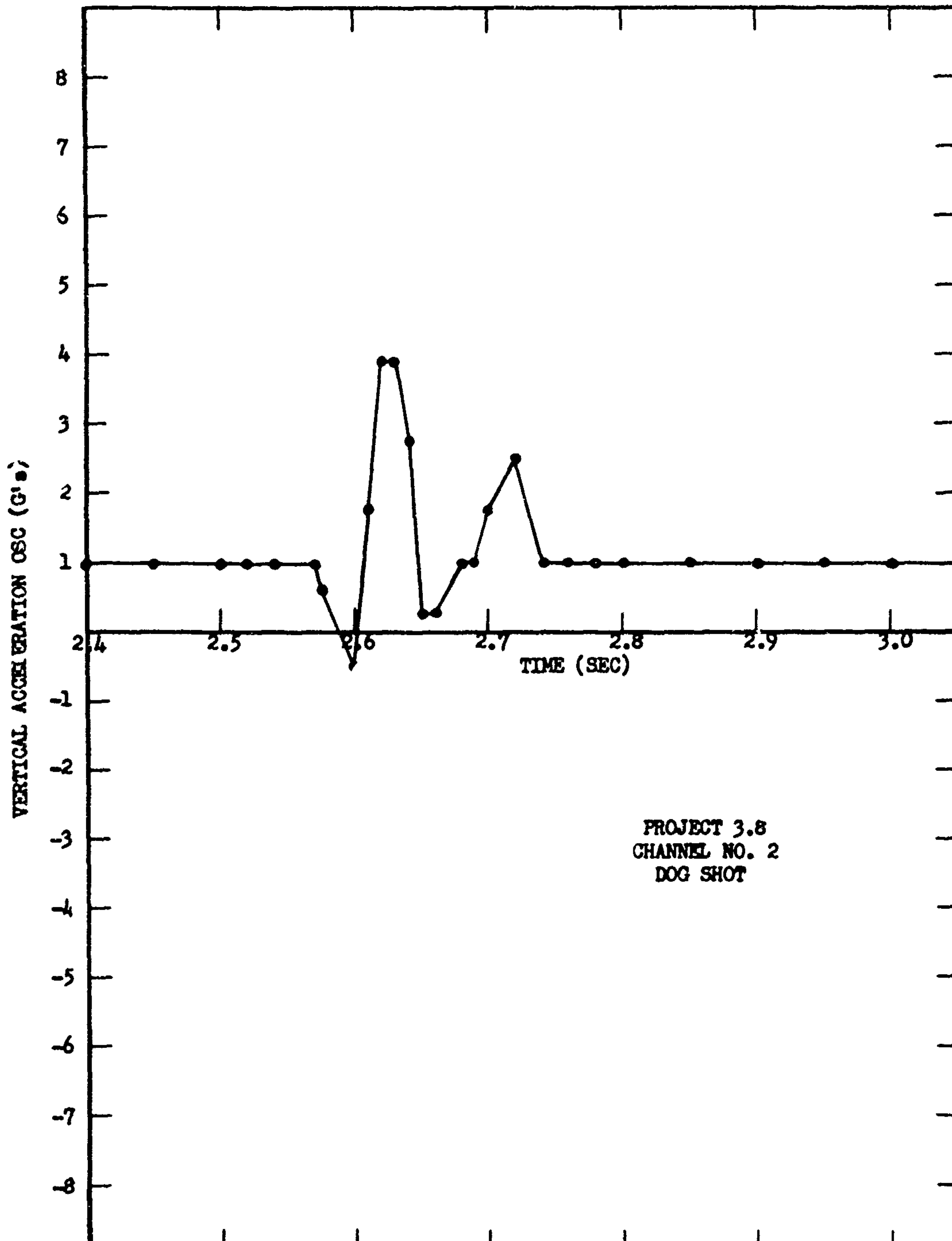

Fig. A.20 Ground Instrumentation Vertical Acceleration vs. Time

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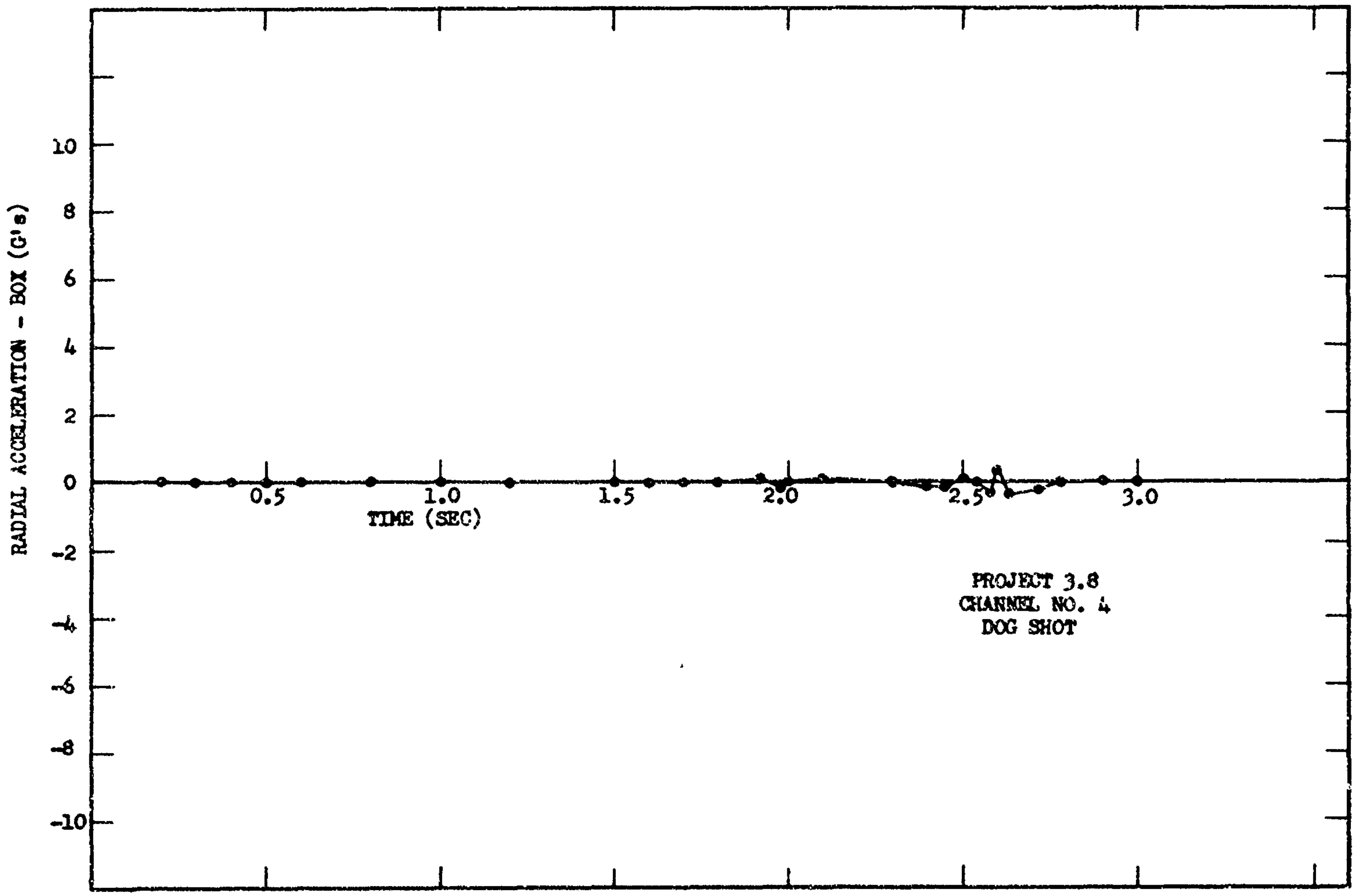

Fig. A.21 Ground Instrumentation Radial Acceleration vs. Time

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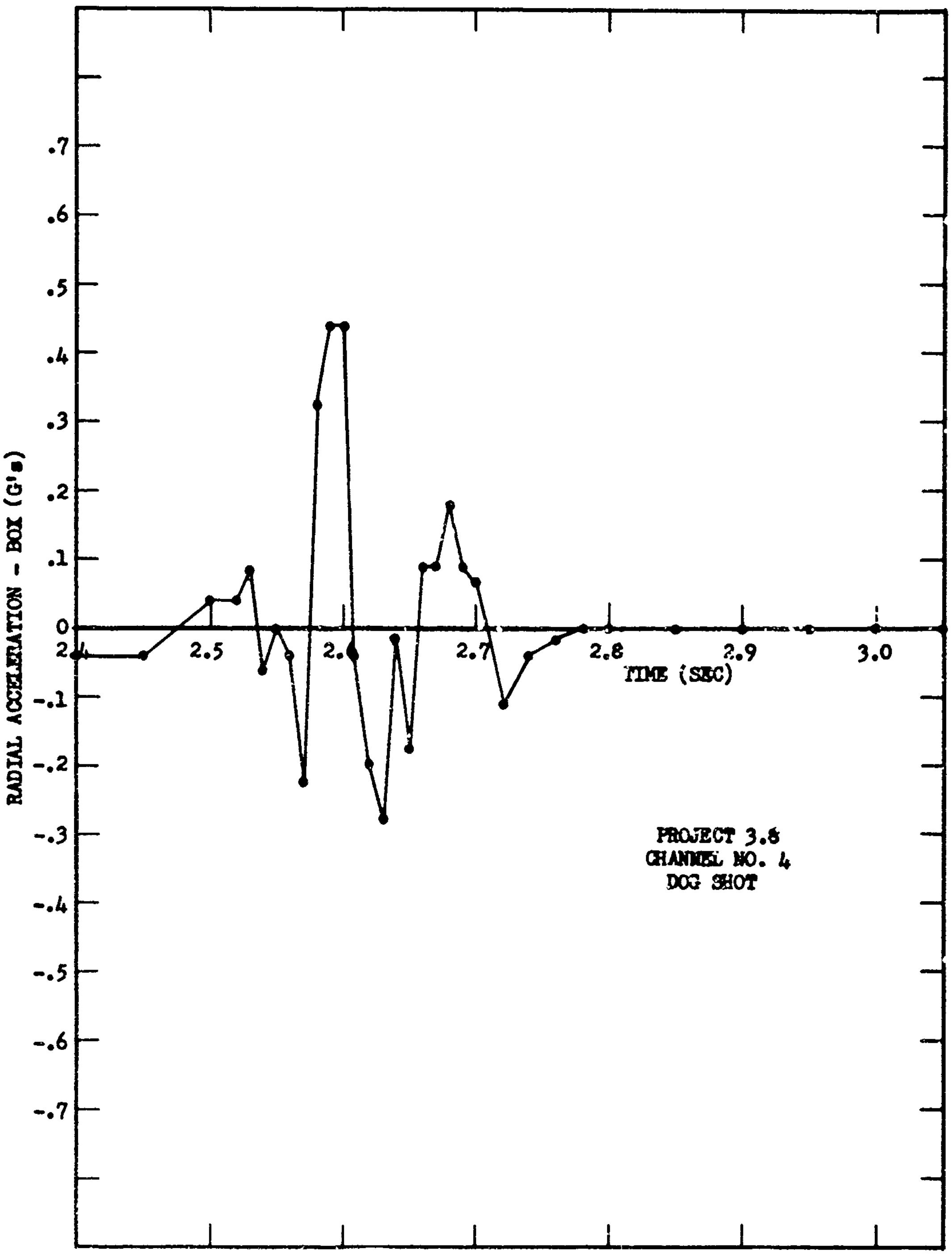

Fig. A.22 Ground Instrumentation Radial Acceleration vs. Time

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[redacted]

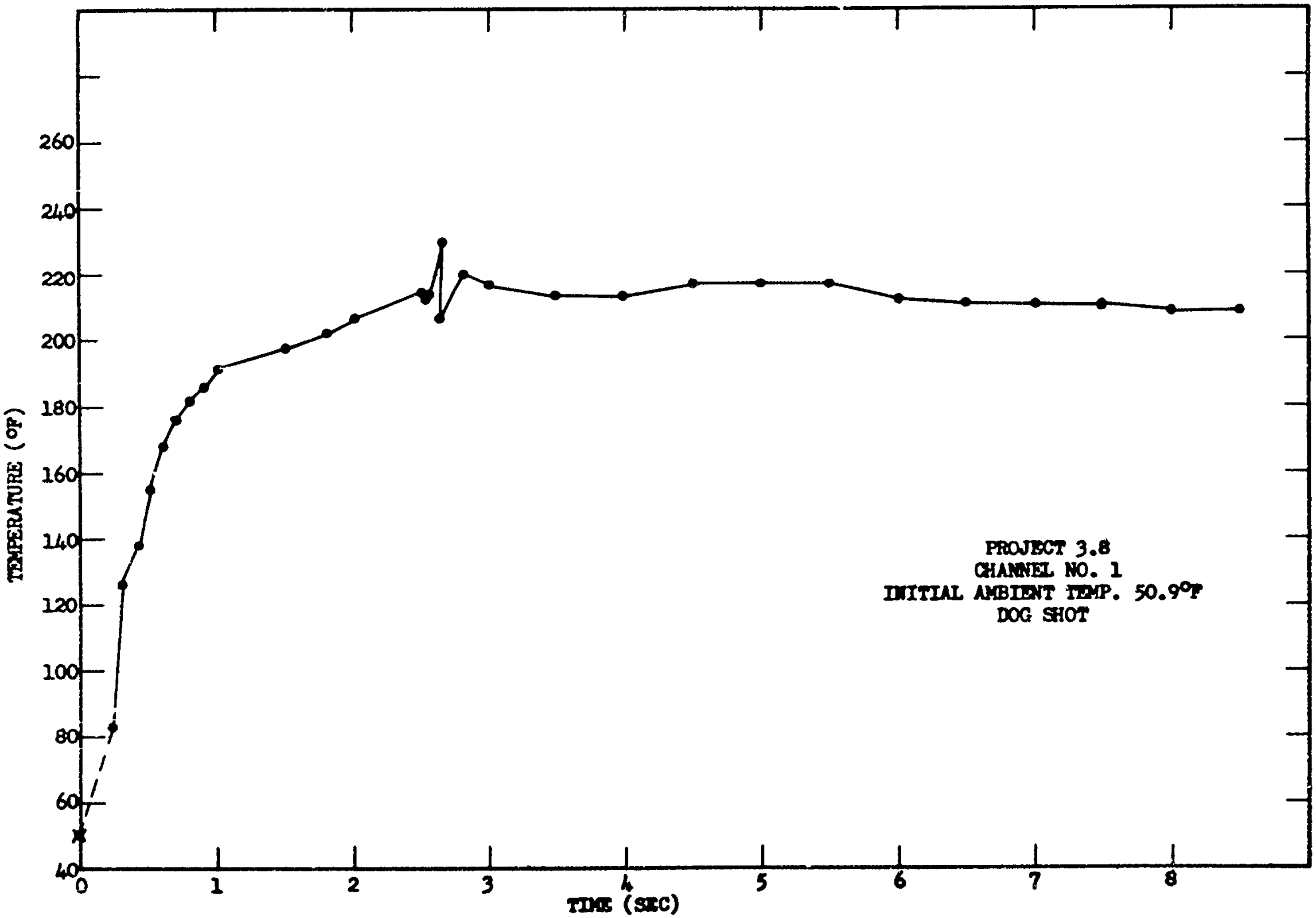

Fig. A.23 Ground Instrumentation Temperature vs. Time

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TABLE A.I

Tabulation of Results and Some Conclusions

	Paper Exposure	Galvanometer Response to Ground Shock	Galvanometer Response to Air Shock	Accelerometer Response	Pressure Response	Temperature Response*	Correction for Exposure	Correction for Ground Acceleration	Correction for Air Acceleration
Dog Shot 20.9 KT Ground Range 4240 Slant Range 4350	Fogged but readable	None	Noticeable, definite effect on acceleration readings, these effects could no; be separated fr a actual accelerations. Possibly 14% error at peak reading of pressure on aircraft	Possibly as high as 8'G's on oscillograph in the aircraft and possibly as high as 4 G's on oscillograph in ground	Good over pressure 5 psi	Record good lag to 1st peak 1. sec. To second 2.65 sec. (Major peak)	Use under conditions of first range. Wrap installation with lead foil. Concrete block house will offer additional protection	None required	Rigid mountings of box to ground surrounding box with sound shock absorbing material deaden flat surfaces and accelerometers with lead plate Lead serves a dual purpose. Also adds protection from radiation effects
Easy Shot 31.25 Ground Range 2675 Slant Range 2980	Fogged badly. May have been readable if galvanometer light had not burned out			All other effects unknown					

*Temperature readings could be faired through galvanometer response

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