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Final Report  
on  
Gunfire Tests of Bendix Cylindrical  
Accumulators for Aircraft Hydraulic Systems

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Date: JUN 16 1953

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Gunfire Tests of Bendix Cylindrical  
Accumulators for Aircraft Hydraulic Systems

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PART A

SYNOPSIS

1. These tests were conducted to determine the ability of each piston-type accumulator to remain in one piece and the material of the cylinder to resist excessive tear (the size of the tear not to exceed 3 inches in any one direction beyond the hole cut by the projectile) when subjected to the impact of a standard .50 caliber incendiary projectile.
2. Six cylindrical piston-type accumulators with the following volumetric capacities were gunfire tested: Two 50 cubic inch, two 200 cubic inch, and two 400 cubic inch. With the exception of the second 400 cubic inch accumulator tested, the accumulators were mounted with their longitudinal axis normal to the line of fire and subjected to tumbled .50 caliber incendiary projectiles. The second 400 cubic inch accumulator tested was mounted with its longitudinal axis 20° away from the normal line of fire and was subjected to a non-tumbled round. Upon impact of the projectile and/or the force of the escaping fluid and air the following damage occurred to the accumulators: (1) the first 50 cubic inch accumulator tested split along its longitudinal axis 9-1/2 inches; split circumferentially from the entrance wound to the exit wound flowering the wall; a 1-1/4" x 2" section of the wall fragmented; the piston was ejected. (2) The second 50 cubic inch accumulator tested split circumferentially into two sections approximately 5 inches below the fluid end cap; the piston was ejected. (3) The cylinder of the first 200 cubic inch accumulator tested split for a total of 6-3/4 inches, the split extending 4-1/4 inches above the hole cut by the projectile and 2-1/2 inches below; split a distance of 6 inches along a circumference immediately below the lower reinforcing ring on the fluid end flowering the wall; the piston was ejected. (4) The cylinder of the second 200 cubic inch accumulator tested split along its longitudinal axis for a total of 14 inches, the split extending 4 inches above the hole cut by the projectile and 10 inches below; split a distance of 5 inches along a circumference immediately below the lower reinforcing ring on the fluid end flowering the wall; the piston was ejected. (5) The projectile inflicted a 1" x 1-1/8" hole in the cylinder wall of the first 400 cubic inch accumulator tested. (6) the projectile inflicted a 1" x 1" hole in the cylinder wall of the second 400 cubic inch accumulator tested.

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Upon entrance of the projectile into each accumulator a flash fire occurred.

At the conclusion of the gunfire test, the fluid and air end caps employed on the accumulators were examined and found to have performed satisfactorily.

3. It is concluded that:

a. The tears inflicted to the 50 and 200 cubic inch accumulators exceeded the limits specified in Military Specification MIL-A-5498B.

b. The 400 cubic inch accumulators performed satisfactorily in accordance with the requirements of Military Specification MIL-A-5498B.

c. The fluid and air end caps employed on the accumulators performed satisfactorily.

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PART B

INTRODUCTION

1. AUTHORITY:

This test was conducted under Bureau of Aeronautics Project TED No. NPG AE6233, established and authorized by reference (a).

2. REFERENCES:

- a. BUAER ltr Aer-AE-621, Ser 143180, of 9 Oct 1952 with BUORD 2nd End of 30 Oct 1952
- b. Military Specification MIL-A-5498B

3. BACKGROUND:

The Bendix Aircraft Corporation, Pacific Division, submitted to the Naval Proving Ground via the U. S. Naval Air Material Center (Naval Air Experimental Station) Philadelphia, Pennsylvania, six cylindrical piston-type accumulators for gunfire test.

4. OBJECT OF TEST:

As requested by reference (a), this gunfire test was conducted for the purpose of determining the ability of each piston-type accumulator to remain in one piece and the material of the cylinder to resist excessive tear (the size of the tear not to exceed 3 inches in any one direction beyond the hole cut by the projectile) when subjected to the impact of a standard .50 caliber incendiary projectile.

5. PERIOD OF TEST:

- |                           |               |
|---------------------------|---------------|
| a. Date of Project Letter | 9 Oct 1952    |
| b. Date Material Received | 9 April 1953  |
| c. Date Commenced Test    | 17 April 1953 |
| d. Date Completed Test    | 17 April 1953 |

6. REPRESENTATIVES PRESENT:

Mr. S. E. Sanfilippo	Bureau of Aeronautics
Mr. B. Hoof	Bendix Aircraft Corp.
Mr. D. Blackmore	Bendix Aircraft Corp.

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PART C

DETAILS OF TEST

7. DESCRIPTION OF ITEMS UNDER TEST:

a. The subject test specimens are identified as piston-type, class 3000 accumulators and are designed and constructed to operate with an air pre-charge of 1200 pounds per square inch and 3000 pounds per square inch of hydraulic fluid pressure. The following dimensions of each accumulator are included below:

<u>Volumetric Capacity</u> (Cubic Inches)	<u>Overall Length</u> (inches)	<u>Outer Diameter</u> (inches)
50	20-3/8	2-1/4
200	36-1/8	3-3/16
400	33-3/8	4-3/4

b. A brief description of the working parts of a Bendix piston-type accumulator is as follows:

The fluid and air end caps are constructed of 24S-T aluminum alloy and are held in place by a shear ring construction with an "O" ring seal. The cylinder shell is constructed of SAE 4130 molybdenum steel reinforced with three external rings at each end. The piston is constructed of 24S-T aluminum alloy and is encircled at each end by an "O" ring which acts as an equalizer support for the piston. One drilled passage in the piston permits the hydraulic fluid pressure to act upon the "O" ring and aids in minimizing air impregnation. The hydraulic outlet boss is standard for a 1/2" tube connection and the air valve boss is designed for use with an AN6287-1 air valve which was installed on accumulators used in this test.

c. All accumulator parts having the same Bendix part number are directly and completely interchangeable with each other with respect to installation and performance.

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8. DESCRIPTION OF TEST EQUIPMENT:

- a. Two Wollensak Fastax 16mm high speed cameras.
- b. .50 caliber aircraft machine gun.
- c. Standard .50 caliber incendiary ammunition.
- d. Non-metallic tumble board.
- e. Hydraulic petroleum base fluid - MIL-O-5606.

9. PROCEDURE:

The subject test was conducted in general accordance with the requirements of paragraph 4.5.12 of reference (b) and as outlined in enclosure (1) of reference (a). The details of the procedure are as follows:

a. To the oil port of each accumulator was fitted a length of steel tubing with a shut-off valve located 3 feet from the port. The accumulators were then charged with air to 1200 p.s.i. and with hydraulic petroleum base fluid to 3000 p.s.i.

b. For the gunfire test, Marman clamps which fitted over the fluid and air connection end bosses were employed to support the accumulators vertically against the test supporting structure. With the exception of the second 400 cubic inch accumulator tested, the accumulators were mounted with their longitudinal axis normal to the line of fire and subjected to tumbled .50 caliber incendiary projectile impacts. The second 400 cubic inch accumulator tested was mounted with its longitudinal axis 20° away from the normal line of fire and was subjected to a normal round.

c. Two Wollensak Fastax high speed cameras were employed to photograph the projectile impacts.

d. Figure 1 is a view showing a 50 cubic inch accumulator mounted for the gunfire test.

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## 10. RESULTS AND DISCUSSION:

a. Results of individual tests are given below:

<u>Volumetric Capacity</u>	<u>Projectile Type</u>	<u>Damage Resulting From Impact and/or Force of Escaping Fluid &amp; Air</u>
50 cubic inch	.50 Cal. Incen. (T)	The cylinder split 9-1/2" along the longitudinal axis and circumferentially from the entrance wound to the exit wound flowering the cylinder wall. A 1-1/4" x 2" section of the wall fragmented. The piston was ejected. (Refer to Figure 2)
50 cubic inch	.50 Cal. Incen. (T)	The cylinder split circumferentially into two sections approximately 5" below the fluid end cap. The piston was ejected. No fragmentation was noted. (Refer to Figure 3)
200 cubic inch	.50 Cal. Incen. (T)	The accumulator was propelled away from the test structure approximately 70 feet. The piston was ejected approximately 450 feet. The cylinder wall split along the longitudinal axis for a total of 6-3/4" - the split extending 4-1/4" above the entrance hole and 2-1/2" below the entrance hole. The cylinder wall split a distance of 6" along a circumference immediately below the lower reinforcing ring on the fluid end, flowering the cylinder wall. No fragmentation was noted. (Refer to Figure 4)
200 cubic inch	.50 Cal. Incen. (T)	The accumulator was propelled away from the test structure approximately 70 feet. The piston was ejected approximately 300 feet. The cylinder wall split along the longitudinal axis for a total of 14", the split extending 4" above the entrance hole and 10" below the entrance hole. The cylinder split a distance of 5" along a circumference immediately below the reinforcing ring on the fluid end, flowering the cylinder wall. No fragmentation was noted. (Refer to Figure 5)

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<u>Volumetric Capacity</u>	<u>Projectile Type</u>	<u>Damage Resulting From Impact and/or Force of Escaping Fluid &amp; Air</u>
400 cubic inch	.50 Cal. Incen. (T)	The projectile inflicted a 1" x 1-1/8" hole in the cylinder wall. No additional damage was noted. (Refer to Figure 6)
400 cubic inch	.50 Cal. Incen. (N)	The projectile inflicted a 1" x 1" hole in the cylinder wall. No additional damage was noted. (Refer to Figure 7)

b. Upon entrance of the projectile into each accumulator a flash fire occurred.

c. At the conclusion of the gunfire test, the fluid and air end caps employed on the accumulators were examined and found to have performed satisfactorily.

d. Figures 8, 9 and 10 are views showing the accumulators partially disassembled at the conclusion of the test.

e. Motion pictures of the gunfire test are contained in Appendix (B).

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PART D

CONCLUSIONS

11. It is concluded that:

a. The tears inflicted to the 50 and 200 cubic inch accumulators exceeded the limits specified in Military Specification MIL-A-5498B.

b. The 400 cubic inch accumulators performed satisfactorily in accordance with the requirements of Military Specification MIL-A-5498B.

c. The fluid and air end caps employed on the accumulators performed satisfactorily.

PART E

DISPOSITION OF MATERIAL

12. The materials used in these tests will be disposed of as directed by reference (a).

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The tests upon which this report is based was conducted by:

E. E. WIGINGTON, Lieutenant, USN  
Aircraft Damage Assessment Officer  
Aviation Ordnance Department

This report was prepared by:

H. P. BRANSCOME, Aircraft Damage Assessment Division  
Aviation Ordnance Department

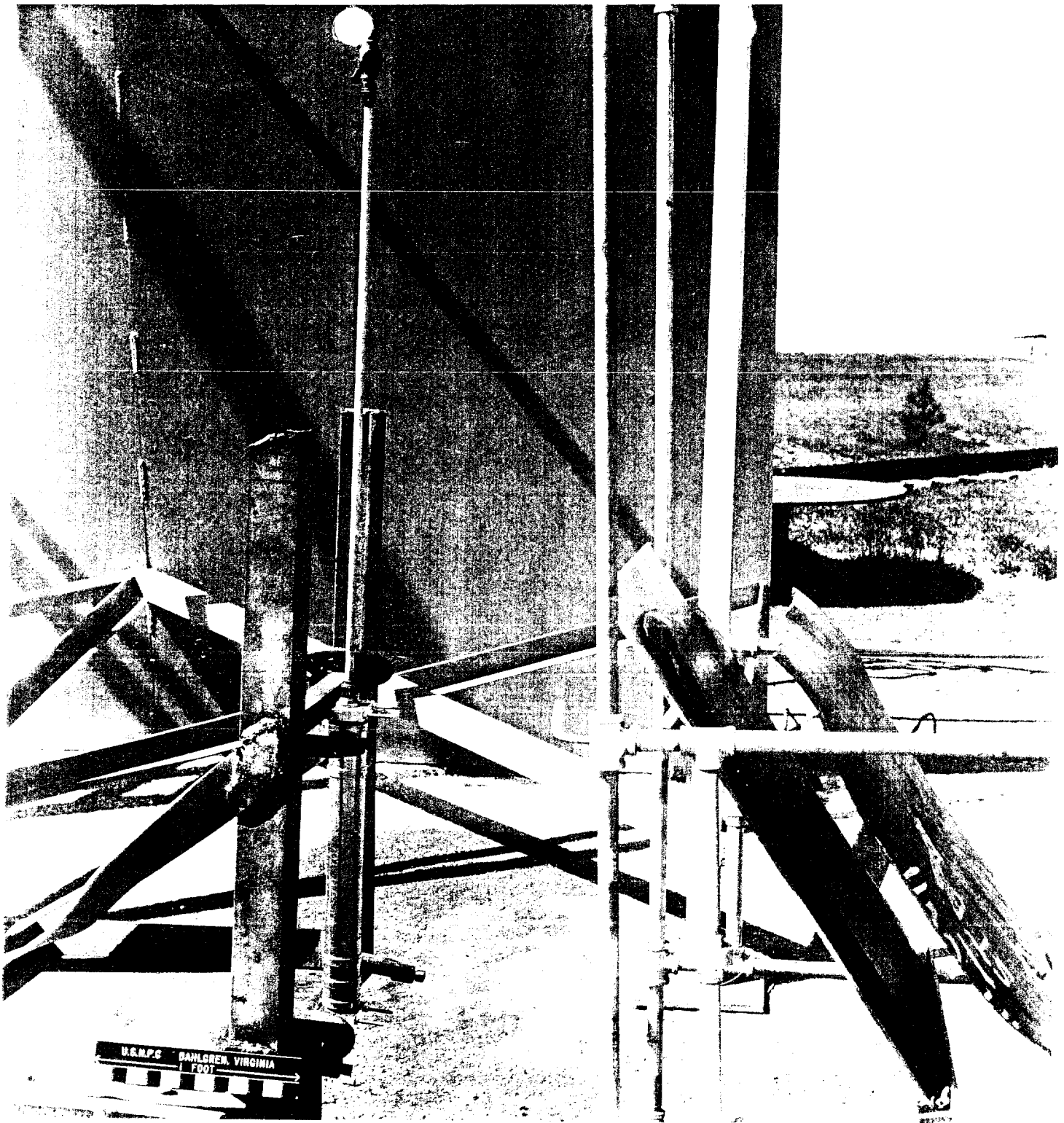
This report was reviewed by:

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Aircraft Damage Assessment Officer  
Aviation Ordnance Department  
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Captain, USN  
Commander, Naval Proving Ground



E. A. RUCKNER  
Captain, USN  
Ordnance Officer  
By direction



NP9-63242

17 April 1953

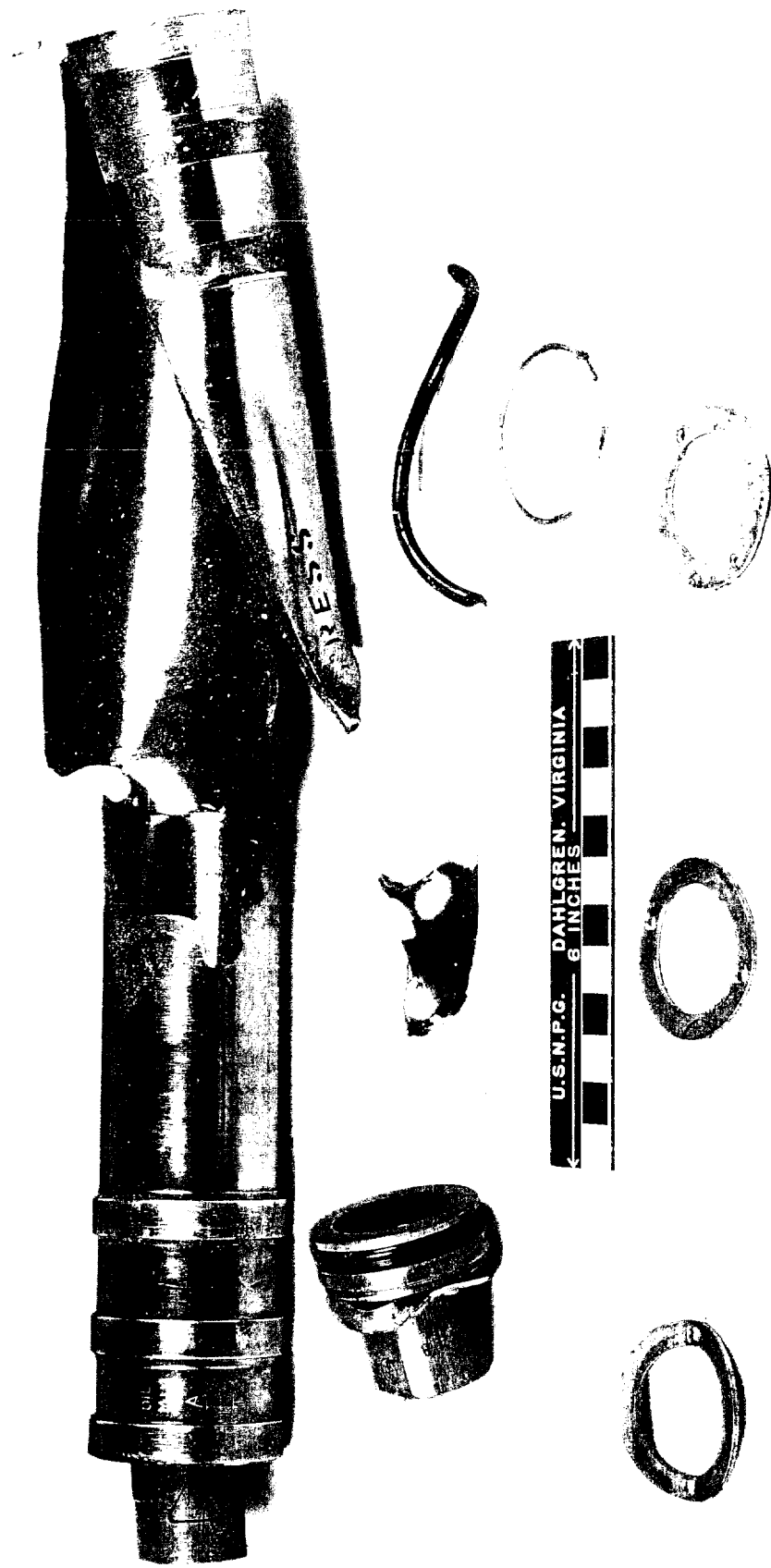
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Gunfire Test of Bendix Aviation Corp., Aircraft Hydraulic, Class 3000, Cylindrical with Piston Type Separator, Accumulators. View showing a 50 cubic inch accumulator mounted for gunfire test with standard .50 caliber incendiary

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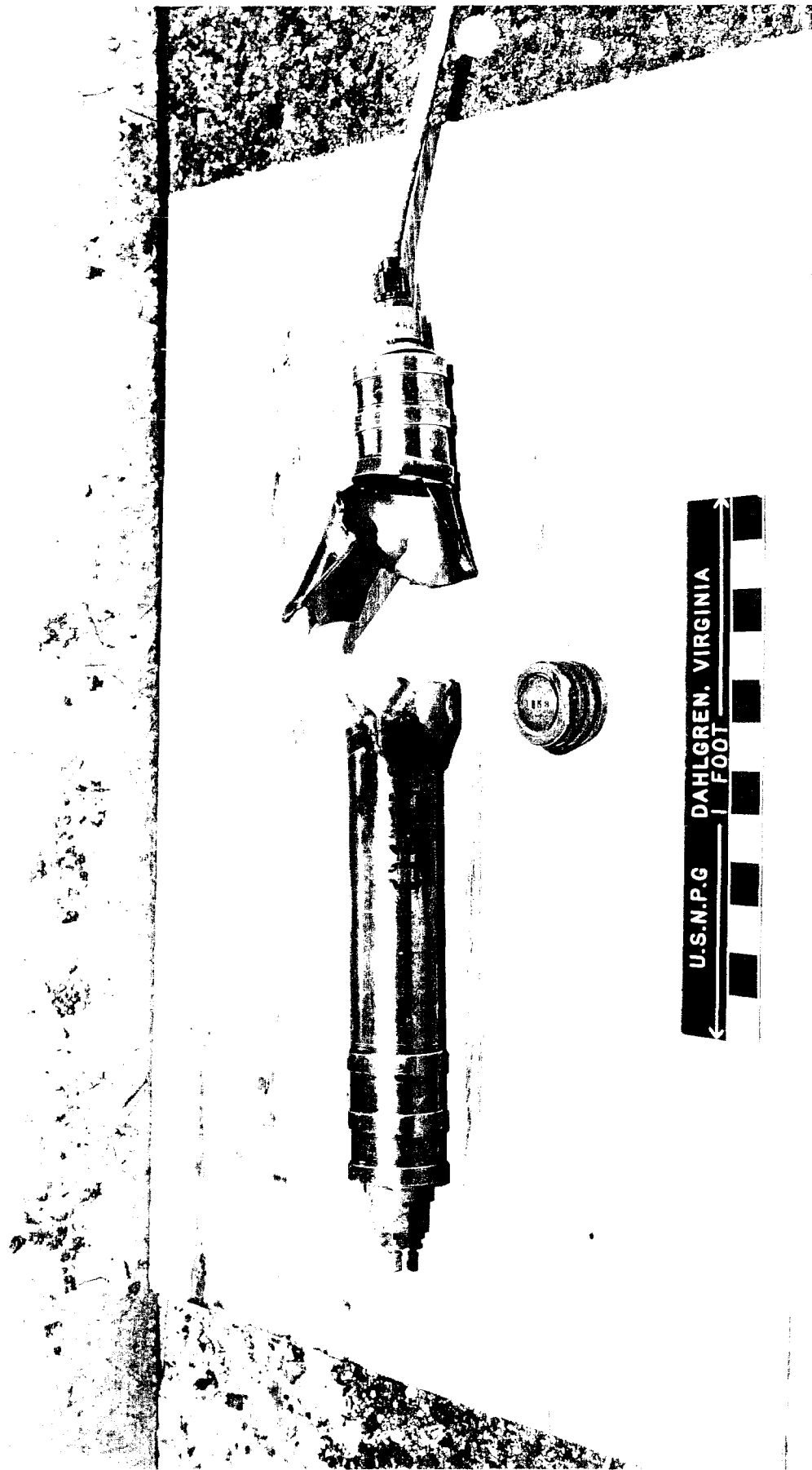
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Gunfire Test of Bendix Aviation Corp., Aircraft Hydraulic, Class 3000, Cylindrical with Piston Type Separator, Accumulators. View showing first 50 cubic inch accumulator after being attacked by a standard .50 caliber incendiary projectile. Figure 2



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Gunfire Test of Bendix Aviation Corp., Aircraft Hydraulic, Class 3000, Cylindrical  
with Piston Type Separator, Accumulators. View showing second 50 cubic inch  
accumulator after being attacked by a standard .50 caliber incendiary projectile.  
Figure 3



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Gunfire Test of Bendix Aviation Corp., Aircraft Hydraulic, Class 3000, Cylindrical  
with Piston Type Separator, Accumulators. View showing first 200 cubic inch  
accumulator after being attacked by a standard .50 caliber incendiary projectile.  
Figure 4

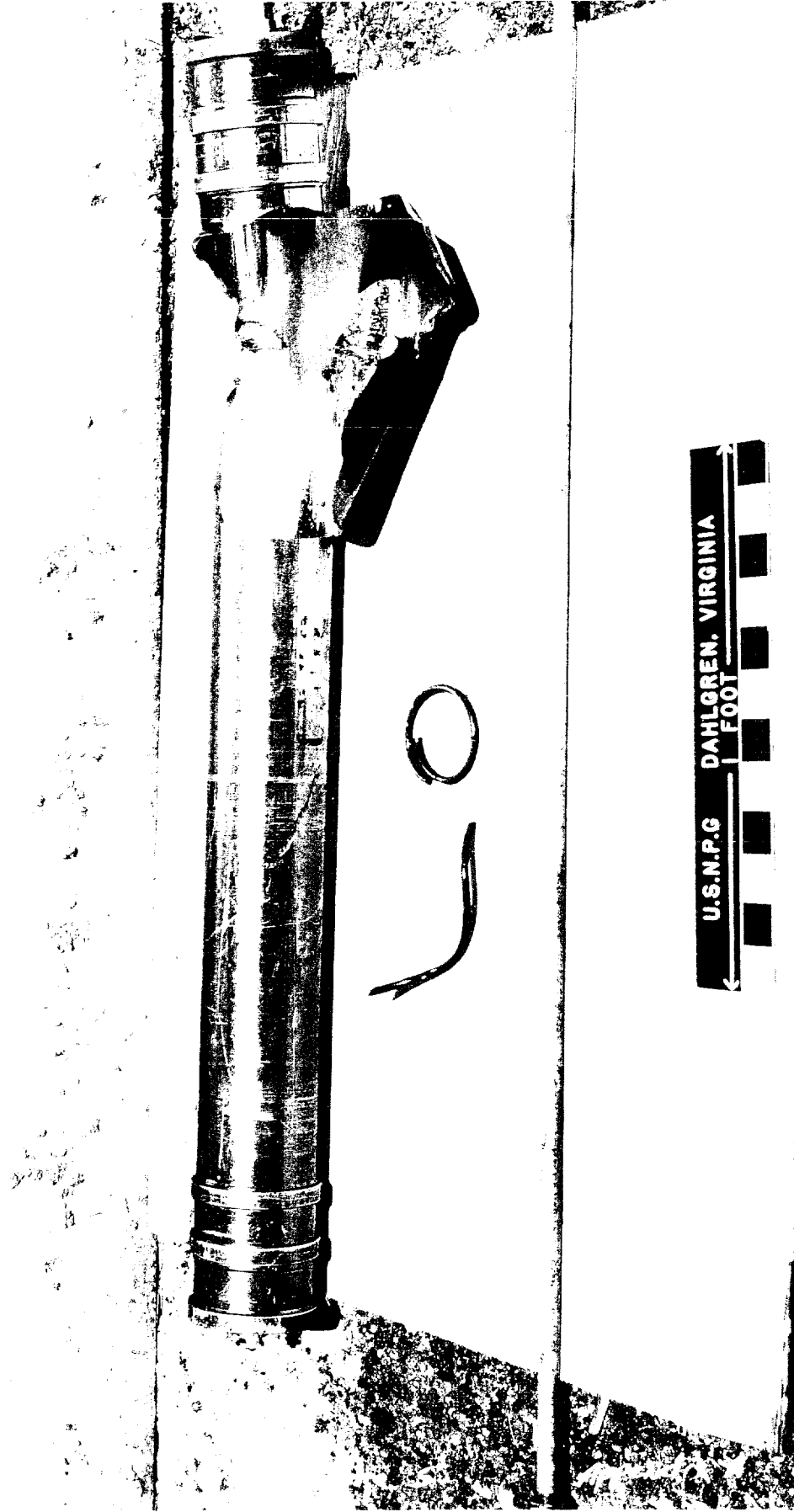


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Gunfire Test of Bendix Aviation Corp., Aircraft Hydraulic, Class 3000, Cylindrical with Piston Type Separator, Accumulators. View showing second 200 cubic inch accumulator after being attacked by a standard .50 caliber incendiary projectile.

Figure 5



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Gunfire Test of Bendix Aviation Corp., Aircraft Hydraulic, Class 3000, Cylindrical  
with Piston Type Separator, Accumulators. View showing first 400 cubic inch  
accumulator after being attacked by a standard .50 caliber incendiary projectile.  
Figure 6

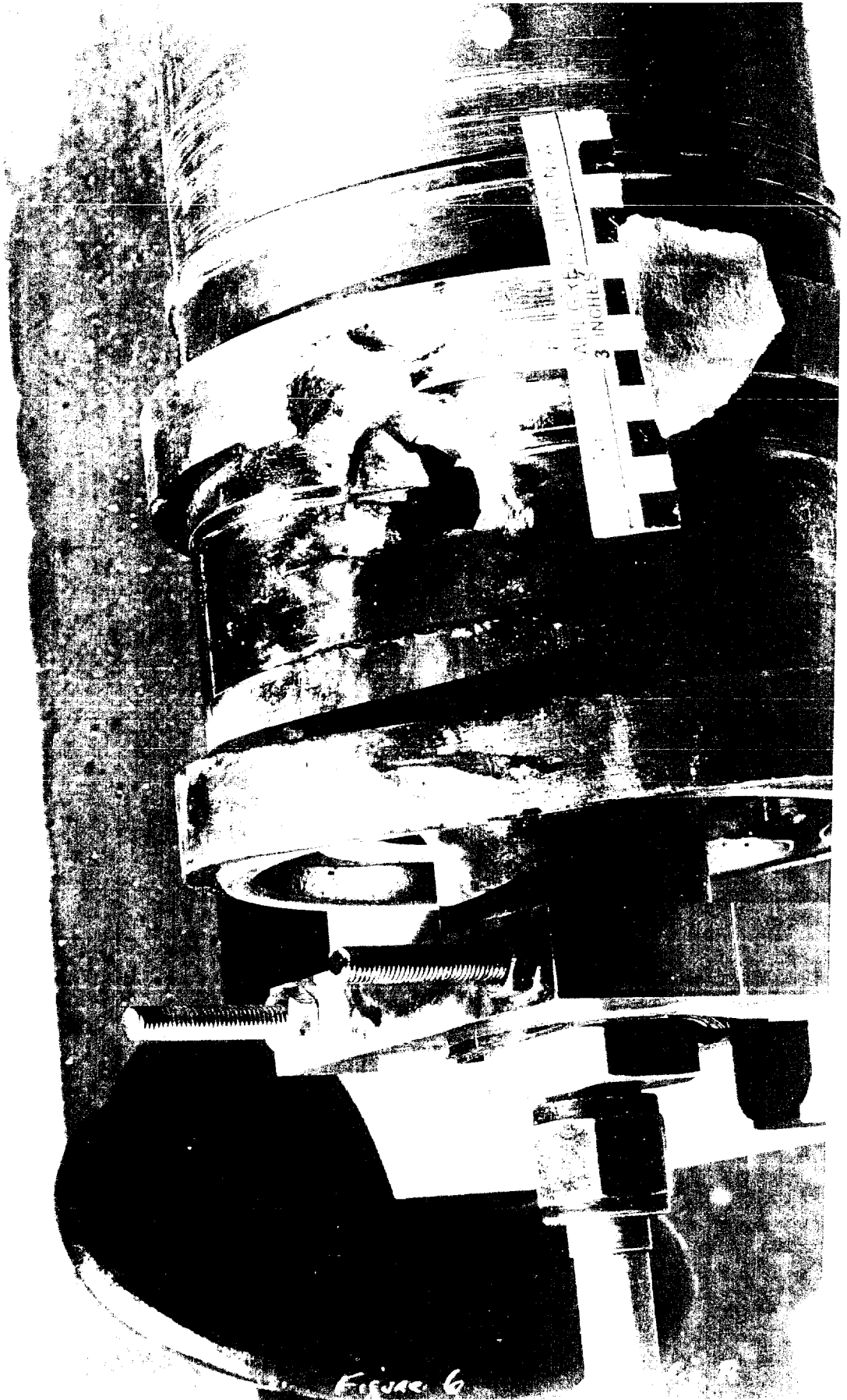


FIGURE 6

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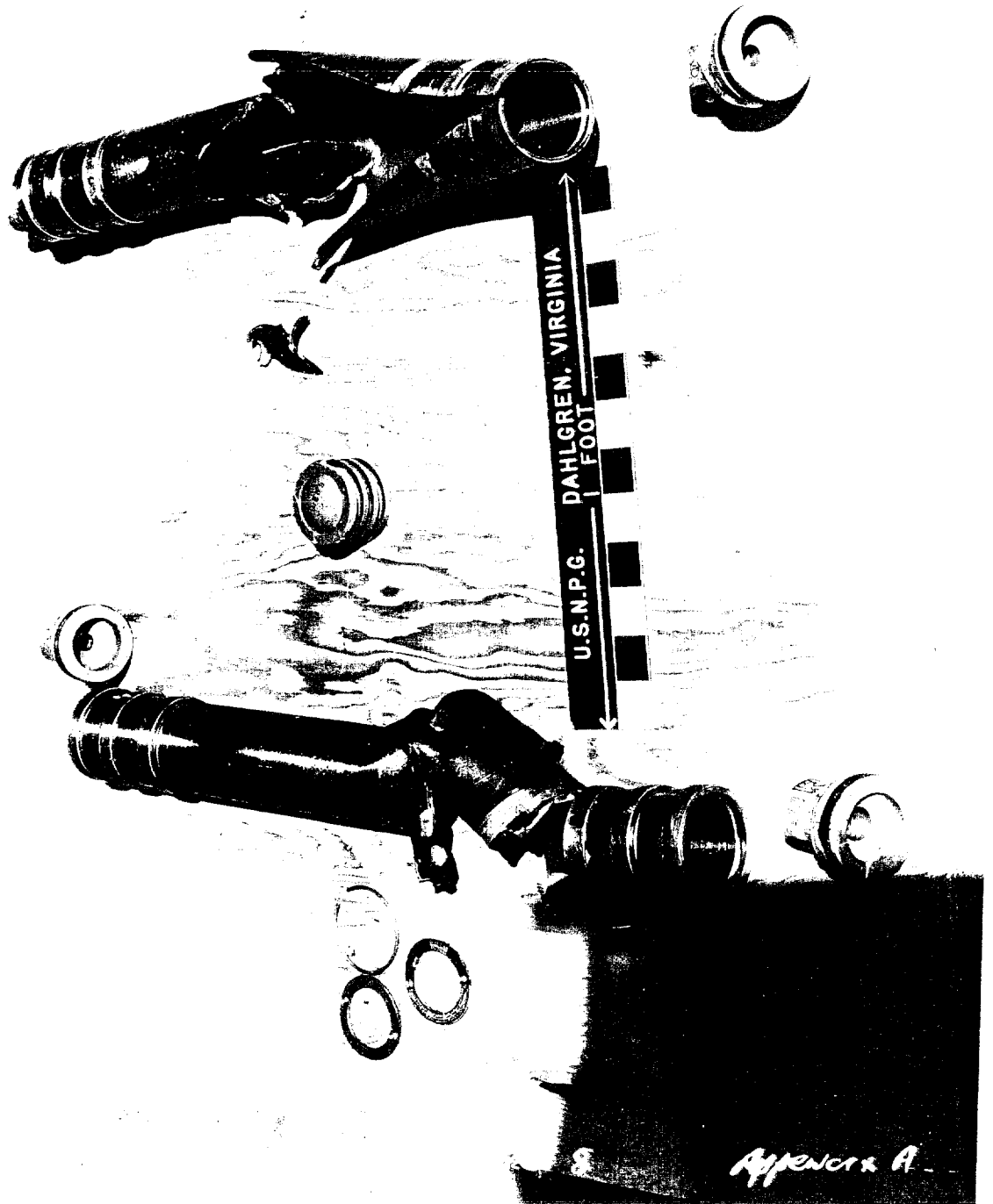
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Gunfire Test of Bendix Aviation Corp., Aircraft Hydraulic, Class 3000, Cylindrical  
with Piston Type Separator, Accumulators. View showing second 400 cubic inch  
accumulator after being attacked by a standard .50 caliber incendiary projectile.  
Figure 7



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Gunfire Test of Bendix Aviation Corp., Aircraft Hydraulic, Class 3000, Cylindrical with Piston Type Separator, Accumulators. View showing the partially disassembled 50 cubic inch accumulators at the conclusion of the gunfire test with standard .50 caliber incendiary ammunition. Figure 8



Appendix A

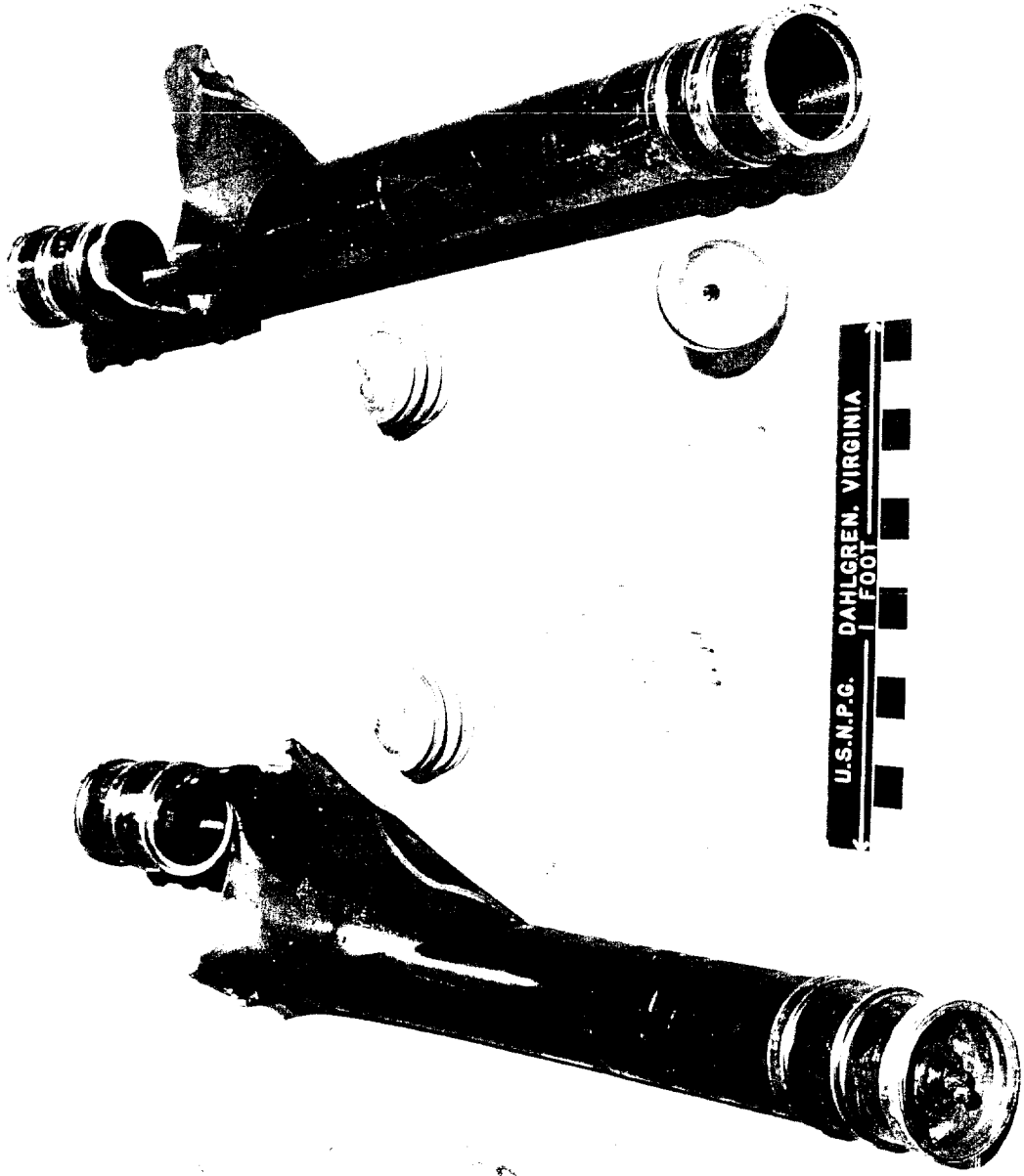
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Gunfire Test of Bendix Aviation Corp., Aircraft Hydraulic, Class 3000, Cylindrical  
with Piston Type Separator, Accumulators. View showing the partially disassembled  
20 cubic inch accumulators at the conclusion of the gunfire test with standard .50  
caliber incendiary ammunition.

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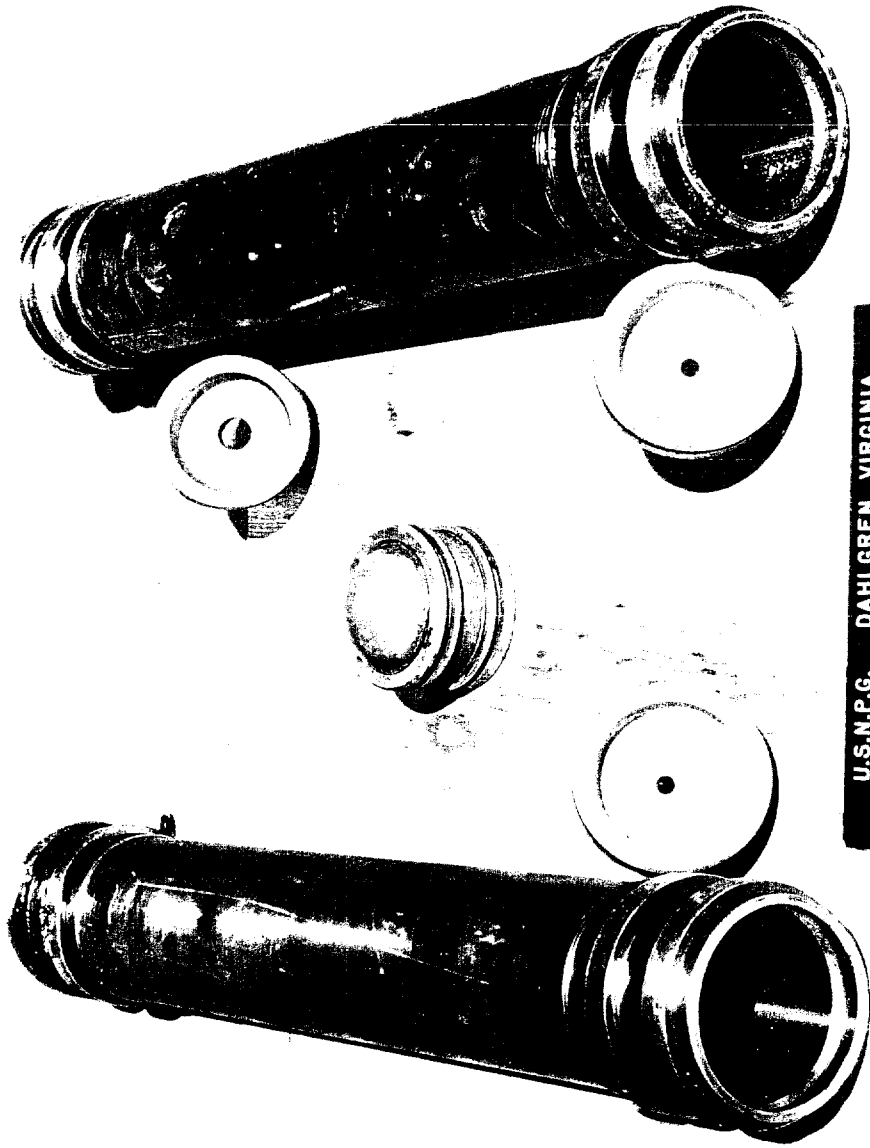
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Figure 9



MP-6325

Gunfire Test of Bendix Aviation Corporation Piston Type Separators with Piston Type Separators Accumulators at the conclusion of the gunfire test with standard .50 caliber incendiary ammunition. Figure 10



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