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NPG REPORT NO. 1158

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

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Date: AUG 21 1953

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Gunfire Tests of Vickers Incorporated  
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 three (3) inches in any one direction beyond the hole cut by the projectile) when subjected to a .50 caliber incendiary projectile impact.

2. Four (4) cylindrical piston-type accumulators with the following volumetric capacities were gunfire tested: two 50 cubic inch and two 200 cubic inch. The accumulators, charged with air and aircraft petroleum base hydraulic fluid, MIL-O-5606, were subjected to tumbled .50 caliber incendiary projectile impacts. The two 50 cubic inch accumulators, because of the exit of the projectile and/or the force of the escaping fluid and air, split along their longitudinal axis in excess of the specified requirements. The two 200 cubic inch accumulators satisfactorily resisted the projectile impacts and/or the force of the escaping fluid and air and remained intact.

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 were examined and found to have performed satisfactorily.

As an additional phase of the test, one 100 cubic inch accumulator was charged with air and non-inflammable Hydrolube hydraulic fluid H-2 and subjected to a non-tumbled .50 caliber incendiary projectile. This test was conducted to compare accumulators charged with Hydrolube with accumulators charged with aircraft petroleum base hydraulic fluid, MIL-O-5606. The accumulator resisted excessive tear but a piece of the cylinder wall 5/8-in. by 7/8-in. fragmented.

No flash fire occurred as was noted on the accumulators charged with aircraft petroleum base hydraulic fluid, MIL-O-5606.

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3. It is concluded that:

a. The 50 cubic inch accumulators failed to meet the specified requirements of Military Specification MIL-A-5498B.

b. The 200 cubic inch accumulators performed satisfactorily in accordance with the requirements of Military Specification MIL-A-5498B.

c. The 100 cubic inch accumulator charged with Hydrolube for comparison with accumulators charged with petroleum base hydraulic fluid failed to remain in one piece as required by Military Specification MIL-A-5498B.

d. 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 AE6233.2, established and authorized by reference (a).

2. REFERENCES:

- a. BU.AER ltr Aer-AE-621, Ser 72139, of 25 May 1953  
with BUORD First Endorsement of 3 June 1953
- b. Military Specification MIL-A-5498B

3. BACKGROUND:

Vickers Incorporated submitted to the Naval Proving Ground five cylindrical piston type accumulators for gunfire test.

4. OBJECT OF TEST:

As requested by reference (a), this gunfire test was 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 three 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 | 25 May 1953 |
| b. Date Material Received | 4 June 1953 |
| c. Date Commenced Test    | 5 June 1953 |
| d. Date Completed Test    | 5 June 1953 |

6. REPRESENTATIVES PRESENT:

Mr. S. E. Sanfilippo	Bureau of Aeronautics
Mr. E. H. Baker	Bureau of Aeronautics
Mr. R. Pagliarini	Naval Air Material Center - NAES Philadelphia, Pa.
Mr. D. T. Blair	Vickers Incorporated
Mr. R. Hallman	Vickers Incorporated
Mr. F. R. Straus	USAF - Wright Air Development Center Dayton, Ohio

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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 1,200 pounds per square inch and 3,000 pounds per square inch of hydraulic fluid pressure.

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

The air and fluid end caps and cylinder are constructed of X4130 molybdenum steel. Each side of the cylinder wall has been chrome plated to a thickness of 0.002-in. The piston is constructed of 17S-T aluminum alloy and is encircled by two "O" rings and two leather back-up rings. There is one drilled hole from the oil end of the piston to between the seats on the piston to prevent the piston from acting as a valve and to eliminate pressure build up between the seals. The hydraulic outlet boss is standard for a 1/2-in. 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 Vickers part number are directly and completely interchangeable with each other with respect to installation and performance.

8. DESCRIPTION OF TEST EQUIPMENT:

The following equipment was used in conducting this test:

- a. .50 caliber aircraft machine gun
- b. Standard .50 caliber incendiary ammunition
- c. Non-metallic tumble board
- d. Hydraulic fluid, aircraft petroleum base, MIL-O-5606
- e. Non-inflammable Hydrolube hydraulic fluid H-2
- f. Two Wollensak Fastax 16mm high speed

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9. PROCEDURE:

The subject test was conducted in general accordance with the requirements of paragraph 4. 5. 12 of reference (b) as requested by 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 three feet from the port. The accumulators were then charged with air to 1,200 psi and with hydraulic petroleum base fluid to 3,000 psi.

b. For the gunfire test, Marman clamps, which fitted over the fluid and air connection end bosses, were employed to support the accumulator vertically against the test supporting structure. The accumulators mounted with their longitudinal axis normal to the line of fire were subjected to tumbled .50 caliber incendiary projectile impacts.

c. In addition to the subject test, one 100 cubic inch accumulator was charged with air to 1,200 psi and with non-flammable Hydrolube hydraulic fluid H-2 to 3,000 psi and subjected to a non-tumbled .50 caliber incendiary projectile impact.

d. Two Wollensak Fastax 16mm high speed cameras were employed to photograph the projectile impacts.

e. Figure 1 is a view showing a 200 cubic inch accumulator mounted for the gunfire test.

10. RESULTS AND DISCUSSION:

a. Test of two 50 cubic inch accumulators:

The first 50 cubic inch accumulator tested was Model AA24320 Serial L-1278. The following damage occurred as a result of the projectile impact and/or the force of the escaping fluid and air: the piston was ejected; the entrance hole inflicted by the projectile was 3/4-in. by 1-3/4-in.; and the cylinder wall through which the projectile made its exit split along its longitudinal axis five inches, flowering the wall.

The second 50 cubic inch accumulator tested was Model AA24320 Serial L-1280. The following damage occurred as a result of the projectile impact and/or the force of the escaping fluid and air: the piston was ejected; the entrance hole inflicted by the projectile was 3/4-in. by 1-1/4-in.; and the cylinder wall through which the projectile made its exit split along its longitudinal axis 13-1/4-in..

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b. Test of two 200 cubic inch accumulators:

The two 200 cubic inch accumulators tested were Model No AA24350 Serial Nos. L-1277 and L-1279 respectively. The projectiles inflicted entrance holes of 3/4-in. by 2-in. and 1-1/8-in. by 1-3/8-in. in the two accumulators. The projectiles did not penetrate the opposite cylinder wall of the accumulators but there was a noticeable bulge in the wall of each. The piston of each accumulator was forced up to the entrance hole, where it jammed.

c. Figures 2 and 3 of Appendix (A) are views of the accumulators at the conclusion of the gunfire test. Figure 4 is a view of the accumulators disassembled.

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

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

f. As an additional phase of the test, one 100 cubic inch accumulator was charged with air and non-inflammable Hydrolube hydraulic fluid H-2 and subjected to a non-tumbled .50 caliber incendiary projectile impact. This test was conducted to compare accumulators charged with Hydrolube with those charged with aircraft petroleum base hydraulic fluid, MIL-O-5606. The projectile inflicted an entrance hole of 5/8-in. by 3/4-in. and an exit hole 1-1/2-in. by 7/8-in. in the cylinder wall of the accumulator. A piece of the cylinder wall, 5/8-in. by 7/8-in., fragmented.

g. Figures 5 and 6 of Appendix (A) are views of the accumulator at the conclusion of the gunfire test. Figure 7 is a view of the accumulator disassembled.

h. No flash fire occurred as was noted on the accumulators charged with aircraft petroleum base hydraulic fluid, MIL-O-5606.

i. 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 50 cubic inch accumulators failed to meet the specified requirements of Military Specification MIL-A-5498B.

b. The 200 cubic inch accumulators performed satisfactorily in accordance with the requirements of Military Specification MIL-A-5498B.

c. The 100 cubic inch accumulator charged with Hydrolube for comparison with accumulators charged with petroleum base hydraulic fluid failed to remain in one piece as required by Military Specification MIL-A-5498B.

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

PART E

DISPOSITION OF MATERIAL

12. The material used in this test will be disposed of as directed by reference (c).

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The tests upon which this report is based was conducted by:  
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Assistant Aircraft Damage Assessment Officer  
Aviation Ordnance Department

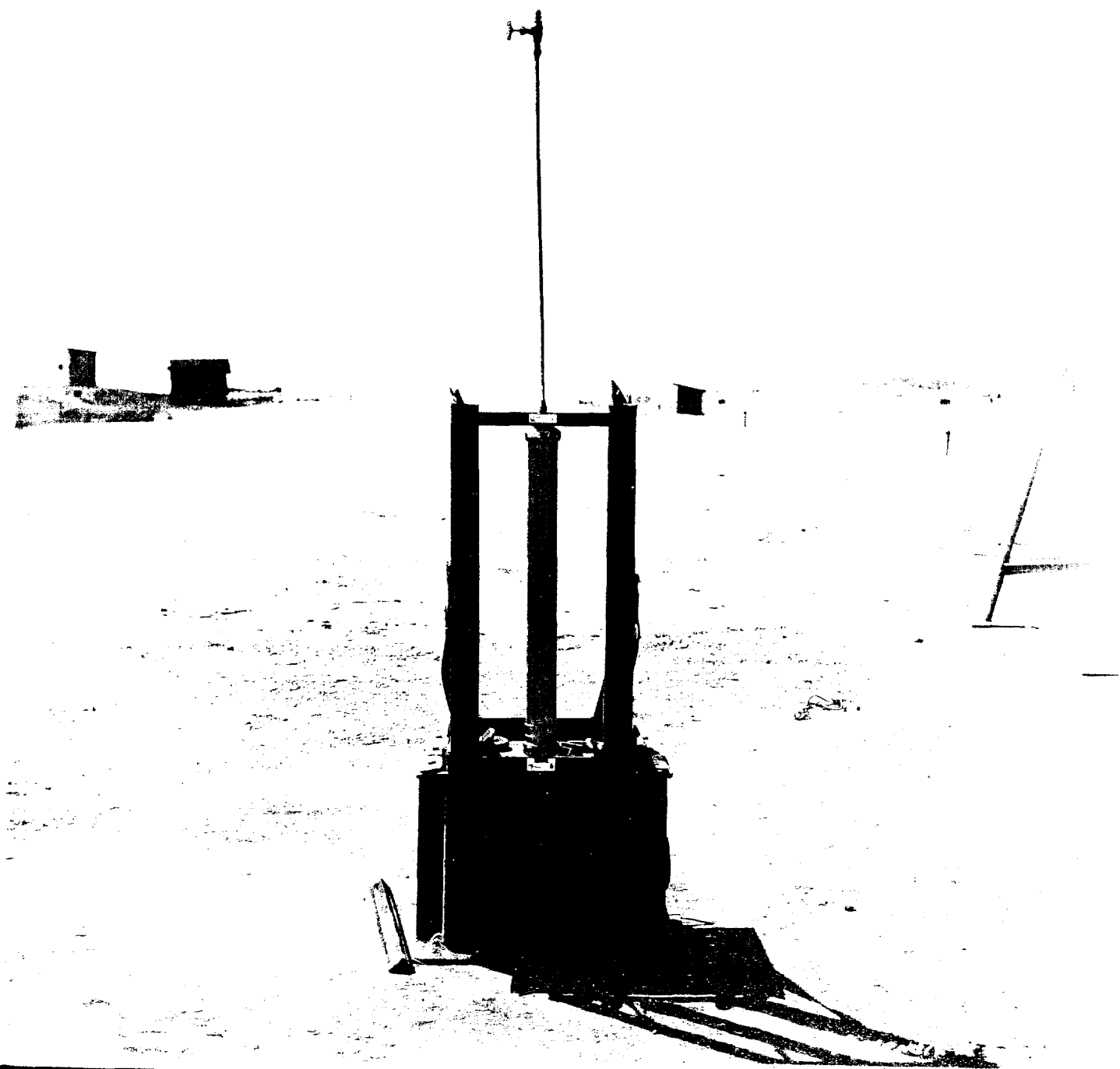
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Commander, Naval Proving Ground



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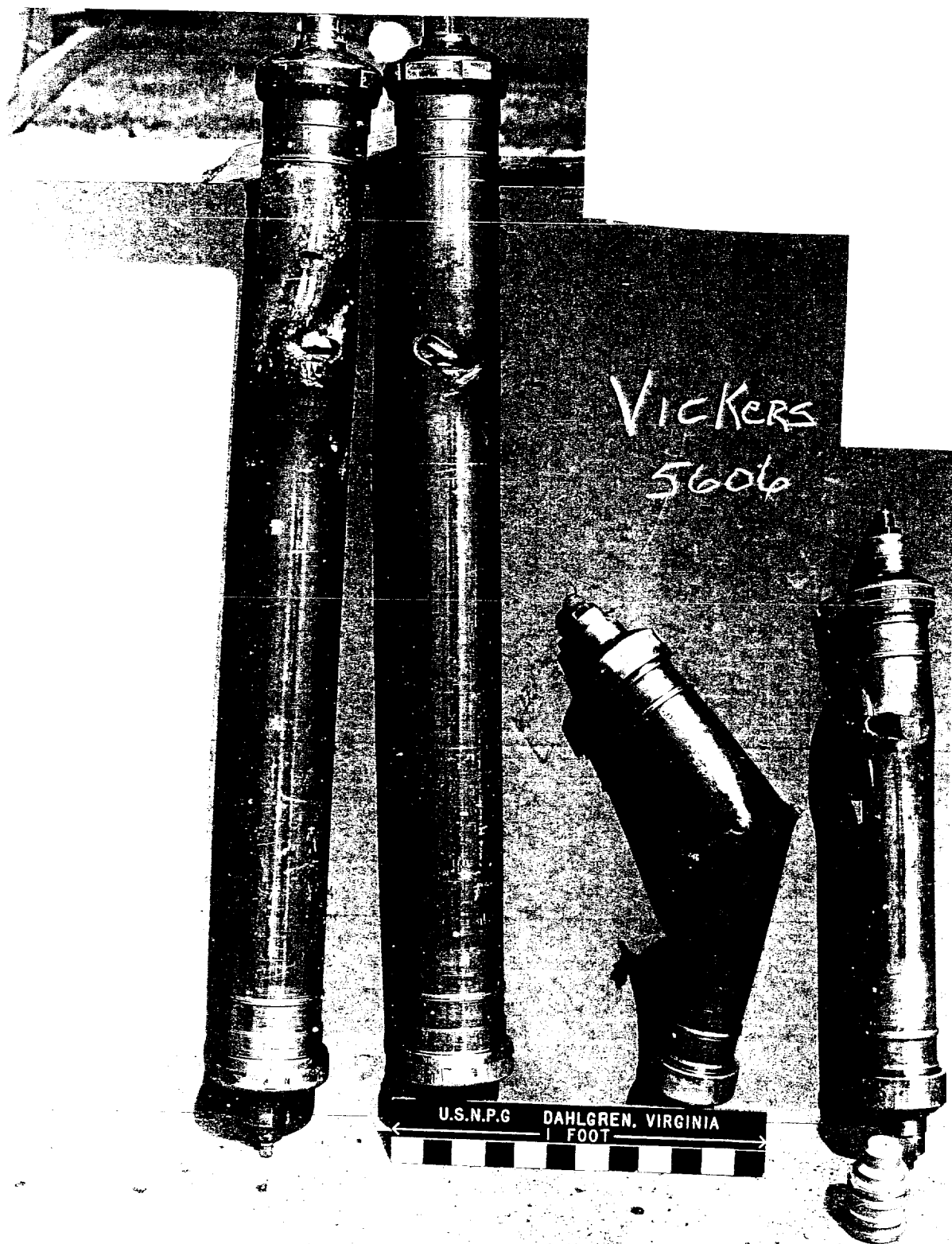
NP9-13560

5 June 1953

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Gunfire Test of Vickers Cylindrical Accumulators for Aircraft Hydraulic Systems.  
View showing 200 cubic inch accumulator mounted for Gunfire Test with .50 caliber incendiary projectile.

Figure 1



NP9-63561

5 June 1953

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Gunfire Test of Vickers Cylindrical Accumulators for Aircraft Hydraulic Systems. View showing entrance wall of 50 and 200 cubic inch accumulators after being attacked by .50 caliber incendiary projectiles. Accumulators were installed on and hydraulic aircraft systems from the 1940's.



NP9-63562

5 June 1952

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Gunfire Test of Vickers Cylindrical Accumulators for Aircraft Hydraulic Systems. View showing exit wall of 50 and 200 cubic inch accumulators after being attacked by .50 caliber incendiary projectiles. Accumulators were charged with air and hydraulic, aircraft petroleum base, MIL-O-5606, fluid.

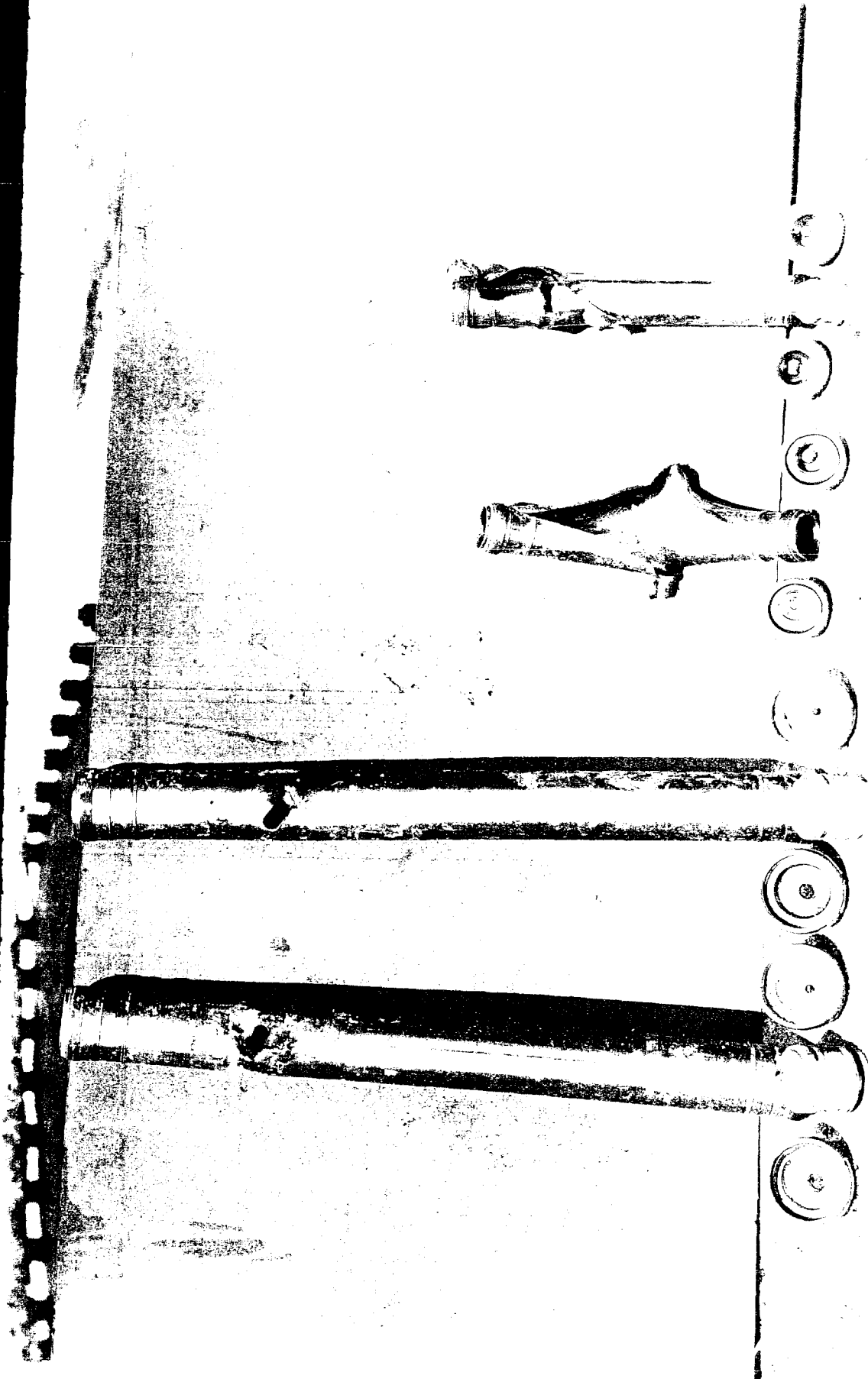
Figure 3

MP9-63563

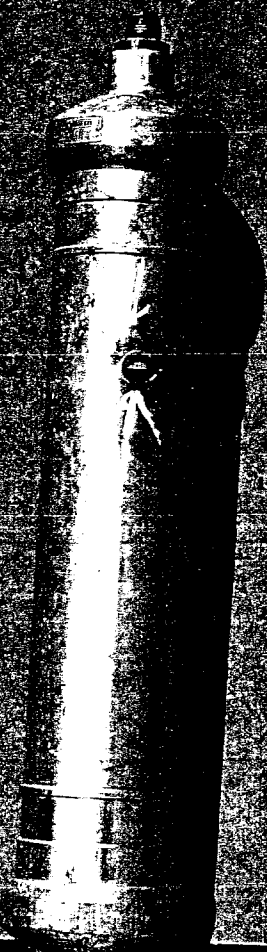
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Gunfire Test of Vickers Accumulators for Aircraft Hydraulic Systems. View showing  
50 and 200 cubic inch accumulators disassembled at conclusion of Gunfire Test with  
.50 caliber incendiary projectiles. Accumulators were charged with air and  
hydraulic, aircraft petroleum base, MIL-O-5606, fluid.

Figure 4



VICKERS  
Hydrokuba hydraulic



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NP-63564

5 June 1953

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Gunfire Test of Vickers Accumulators for Aircraft Hydraulic Systems. View showing entrance wall of 100 cubic inch accumulator after being attacked by a .50 caliber incendiary projectile. Accumulator was charged with air and Hydrokuba hydraulic fluid H-2.

Figure 5

*Hydraulic Accumulator*



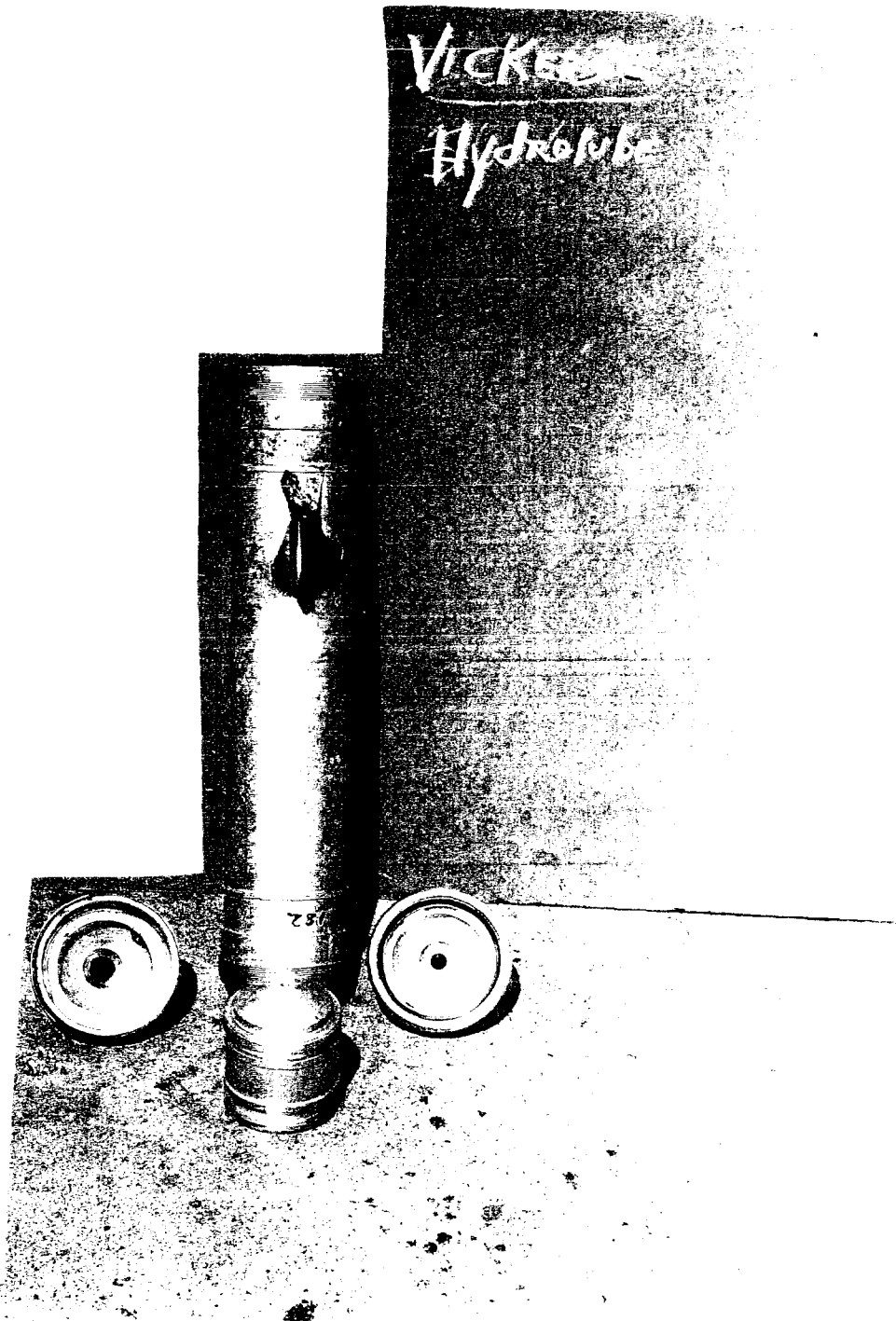
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89-63565

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Gunfire Test of Vickers Accumulator for Aircraft Hydraulic Systems. View showing exit wall of 100 cubic inch accumulator after being attacked by a .50 caliber incendiary projectile. Accumulator was charged with air and Hydrolube hydraulic fluid K-2.  
Figure 6



NP9-63566

5 June 1953

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Gunfire Test of Vickers Accumulator for Aircraft Hydraulic Systems. View showing 100 cubic inch accumulator disassembled at conclusion of Gunfire Test with .50 caliber incendiary projectile. Accumulator was charged with air and Hydrolube hydraulic fluid H-2.

Figure 7

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