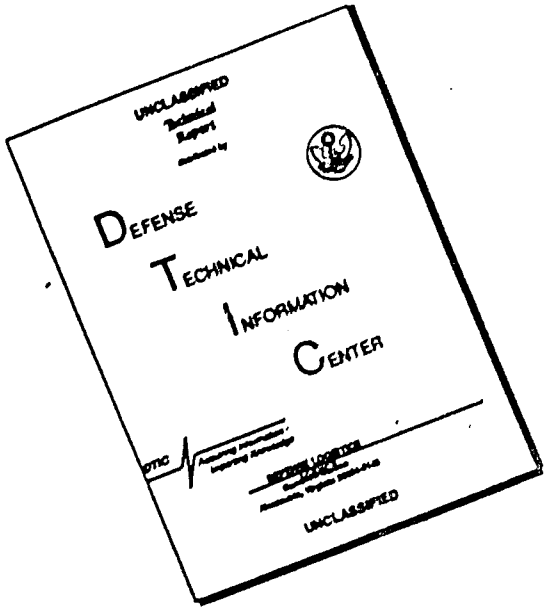
# DISCLAIMER NOTICE




THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

62-4-4



Report HTC-62-39

# THE HIPEG SYSTEM

(20mm Aircraft Gun Mk 11 and Gun Pod EX 1)

Progress Report for May 1962





HUGHES TOOL COMPANY · AIRCRAFT DIVISION
Culver City, California

Report HTC-62-39

# THE HIPEG SYSTEM

(20mm Aircraft Gun Mk 11 and Gun Pod EX 1)

Progress Report for May 1962

Prepared under Navy, Bureau of Naval Weapons
Contract NOrd 19180-C



HUGHES TOOL COMPANY -- AIRCRAFT DIVISION
Culver City, California

## LIST OF ILLUSTRATIONS


| Figure | | Page |
|---|---|---|
| 1 | Rammer Instrumentation | 4 |
| 2. | Instrumentation used in Reliability Test of Gun Pod | 5 |
| 3. | Oscillogram Showing Sear-Link Bounce | 6 |
| 4. | Ejection Gas Tube Redesign | 10 |
| 5. | Liquid Spring Buffer for Loader Rammer | 12 |
| 6. | Rammer Test Fixture | 13 |
| 7. | Oscillogram of Ram-Time-Displacement on Test Fixture | 14 |

## INTRODUCTION

Approximately 16,000 rounds were fired during May from the Mk 4 pod and its Mk 11 gun in the Reliability Test Program. The total rounds fired to date on the current program include 50,000 of Reliability Test and 22,000 of R & D, for a total of 72,000.

The number of rounds on specific pieces is becoming significant. Over 35,000 rounds have been fired on one gun, and the condition of the basic components shows no indication of approaching life termination. The low voltage switch on this same gun has been and is continuing to function satisfactorily (previous design had a part life of 3000 rounds). As stated in the last report, one loader has been used for over 25,000 rounds. One pod has been used in tests for over 70,000 rounds of firing if test work prior to the present reliability program is included.

Stoppages did occur during the month, and corrective action is underway as described later. R & D work was continued with tests of a liquid spring buffer, and a rammer latch to prevent sear link bounce. New barrels without barrel caps were also introduced into the program.

Some APT ammunition was fired during the report period, and it was found some Range bunker modifications were necessary to accommodate large scale firing of this type of ammunition. A steel roof was required over the sand butt to protect the ceiling from APT ricochets. The steel roof installation was made during May, and while the Range was inoperative the pods

were inspected in detail and some brackets and rivets were replaced. It was also noted that the profile of the APT ammunition was different from the target practice ammunition previously used, and some loader modifications were necessary for clearance.

## RELIABILITY TEST PROGRAM

During May, 17 pod loads were fired with the red pod and nine with the green, for a total of 16,000 rounds. Of the 17 red pod loads, seven fired out 100%.

There were a total of 29 stoppages from all causes. Seven of these were the result of non-gun system failures and eight were caused by minor parts breakages or by the failure of experimental parts. The remaining stoppages were primarily the result of ram failures and these are being attacked as indicated in following paragraphs.

The stoppage rate for the month, excluding personnel and manufacturing errors, was 730 rounds per stoppage. The over-all rate was 550 rounds per stoppage.

Six of the last 10 pod loads in the red pod fired out 100%. The stoppage rate during these 10 pod loads was 1250 rounds per stoppage, with six stoppages, two of which were the result of manufacturing errors.

As stated above, primary emphasis has been placed on the ram problem and establishing a means to its solution. As a first step the rams were instrumented so that time displacement traces could be recorded together with ram

pressure and the other instrumentation normally taken (recoil and firing voltages). The same type of potentiometer used in recoil time displacement recordings was mounted on the loader as shown in Figure 1. The pot-sweep was attached to the ram and the traces of Figure 2 were recorded. Initial instrumentation life was short because of the 4000 G's applied to it. As a result the instrumentation was not always recording properly by the time failures were encountered. The sweep-pod configuration is being improved for the application.

One recording was made (Figure 3) that shows that the sear link bounced out of engagement. The sear did have a mouse-trap spring which shows that the spring was inadequate and was not preventing sear link bounce. A sear latch is being tested on the R & D gun that will prevent sear bounce by latch action. The latch operates in the following manner: As the sear link cams over the sear, the sear link rotates the latch out of the way. When the sear link moves into the sear position, the latch rotates and positions itself under the link. An over-center lock is established by this latch and the sear link cannot bounce out of engagement.

The latch principle is the same as that used to eliminate pawl bounce in the 30mm Mk 1 feeder. High-speed movies have been taken of the rammer latch during gun firing and performance is as designed. There is no latch bounce and good locking action is provided.

Present plans call for continued testing to verify these initial results

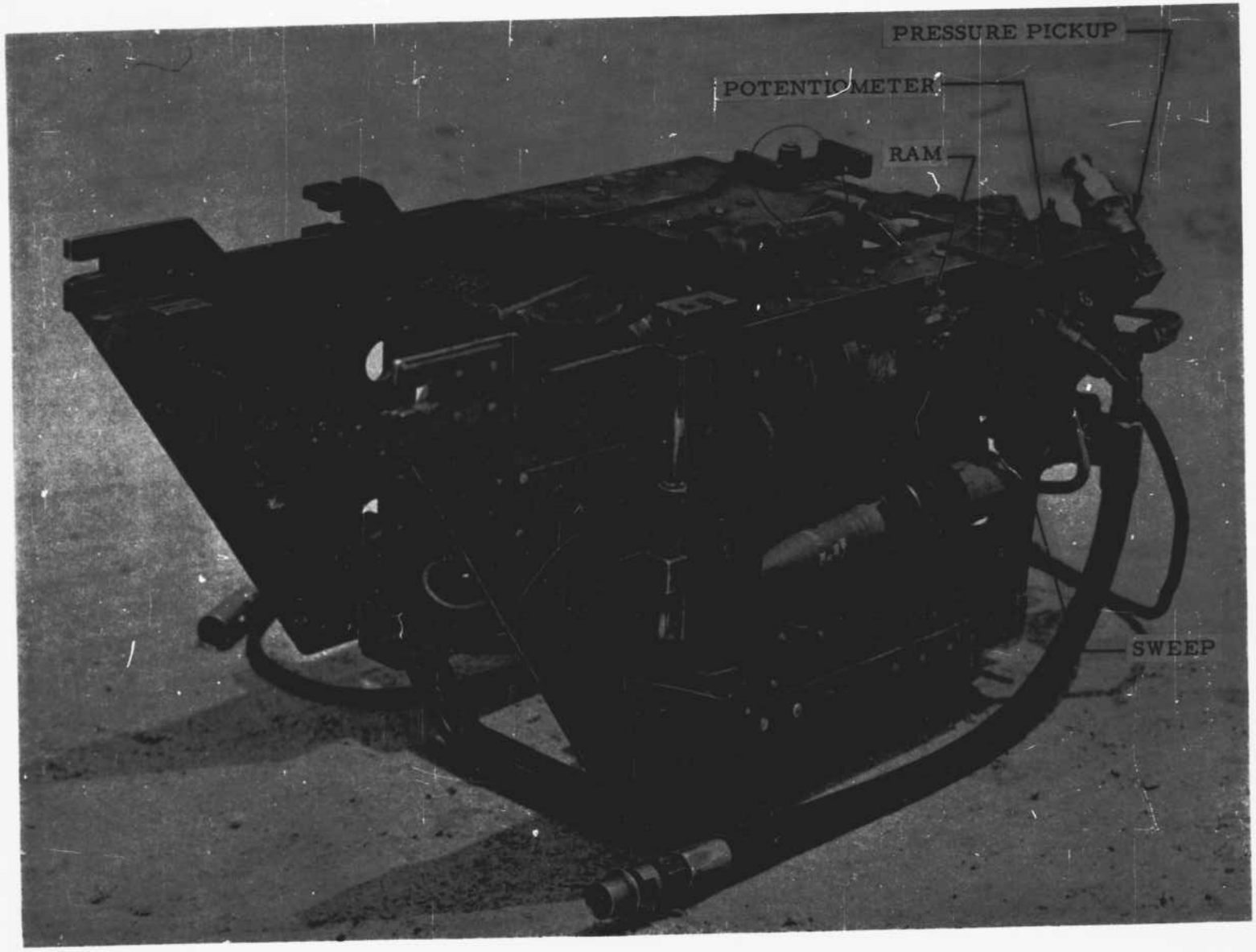



Figure 1. Rammer Instrumentation

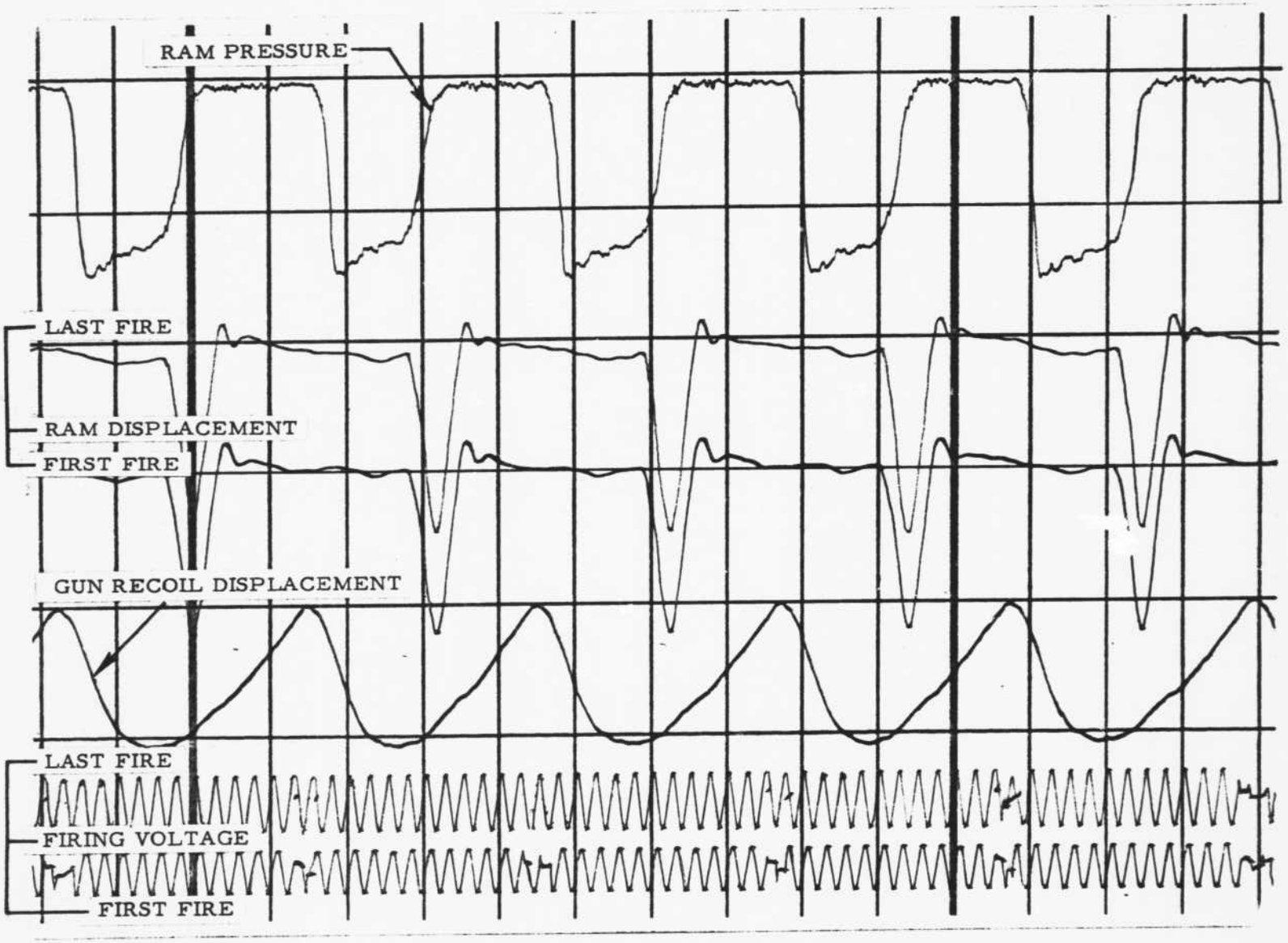



Figure 2. Instrumentation Used in Reliability Test of Gun Pod

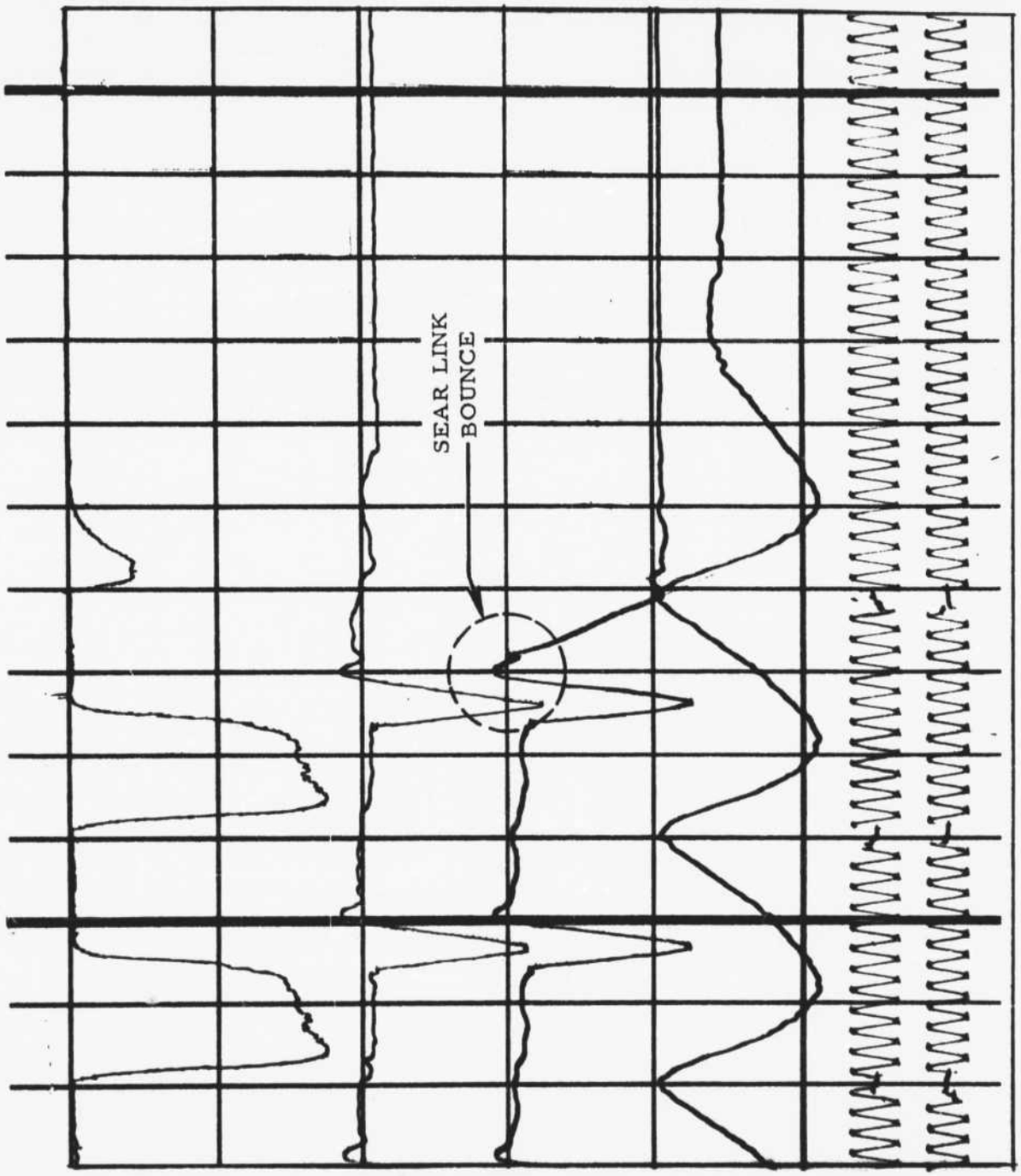



Figure 3. Oscillogram Showing Sear-Link Bounce

and to establish if causes other than sear link bounce may be contributing. In the interim, latch hardware will be made for the Reliability Test guns.

## DESCRIPTION OF STOPPAGES

A summary of the stoppages is as follows:

### Non-Gun System Stoppages

| | |
|---|---|
| Manufacturing errors | 6 |
| Personnel errors | 1 |
| | 7 |

### Gun System Stoppages

| | |
|---|---|
| Loader | 16 |
| Link | 0 |
| Electrical | 0 |
| Gun Mechanism | 6 |
| Pod | 0 |
| | 22 |

Total from all causes.....29

A more detailed summary of stoppage causes is included in Appendix A. A summary of results for each of the two pods under Reliability Test is in Appendices B and C.

### Manufacturing Errors

A total of six stoppages was recorded during May that were caused by Manufacturing errors. Of the six, five were caused by rivets in the ammunition link. As reported last month, more rigorous inspection was initiated to circumvent the problem. It is anticipated that the problem will disappear when the later link lots reach the Firing Range that have received this inspection.

The other Manufacturing error that resulted in a stoppage was caused by a faulty lug on an ammunition link. The flange was machined too thin, and the belt pulled apart. The problem is being watched, and if it continues to occur it may mean that 100% pull tests will be required during link manufacture.

Personnel Errors

Only one stoppage occurred during the month that was caused by a personnel error. The stoppage was the result of not tightening a gas tube nut after standard maintenance. Personnel errors have become fewer. As maintenance becomes less, and more routine, it is anticipated that the occurrence of personnel errors will become less.

Loader

Of the 16 loader stoppages recorded, 12 had to do with ramming. Ten of these were failures to resear and two were failures to ram deep enough. As stated earlier, the resear problem is being attacked with more instrumentation. Part of the problem has now been definitely proved as being caused by sear link bounce. Some of the failures to resear may also be caused by rammer contamination, which in turn would result in energy loss. It appears that the sear link bounce can be corrected by the rammer latch now under test.

A correction of the contamination problem is being investigated by studies of different surface applications to the ram and rammer piston. In those cases where the rounds were not rammed deep enough, there was low ram pressure. It is planned to study the variables that affect ram pressure.

Of the remaining four stoppages, two were caused by minor parts breakage and two were ejection stoppages. The two parts that failed were (1) the aluminum rivets attaching the ammunition guide bracket and (2) an oscillating guide pin that failed at the cotter pin hole. The aluminum rivets were replaced by steel and the cotter pin hole will be removed in future parts and the pin locked in place by a clip rather than with a cotter pin.

Gun Mechanism

All the failures in the gun mechanism were due to broken parts. Of the six recorded, three were caused by barrel cap failures. New barrels are being supplied without barrel caps, which will eliminate this type of failure. One barrel cap failed explosively and caused pod and gun damage. A micro-analysis of the part showed that the rapid heating and cooling of the barrel caused heat treat type stresses which resulted in cracks. This type of cracking is not predictable and failure can result any time. Barrel caps of Hayes 25 material were tried. There was no problem with heat treat type stresses with this material, but erosion was high. The rear face of the cap eroded and caused two stoppages.

Two stoppages were the result of broken elbows at the booster block. A new design has been made, which will reduce the stress level by 4 times.

One stoppage was the result of a broken gas ejection tube. The flange at the upstream end of the tube parted from the basic tube. The part was redesigned and the new and old parts are compared in Figure 4. The flange was made stronger and the welded joint moved downstream.

Pod

There were no stoppages during the month attributable to the pod.

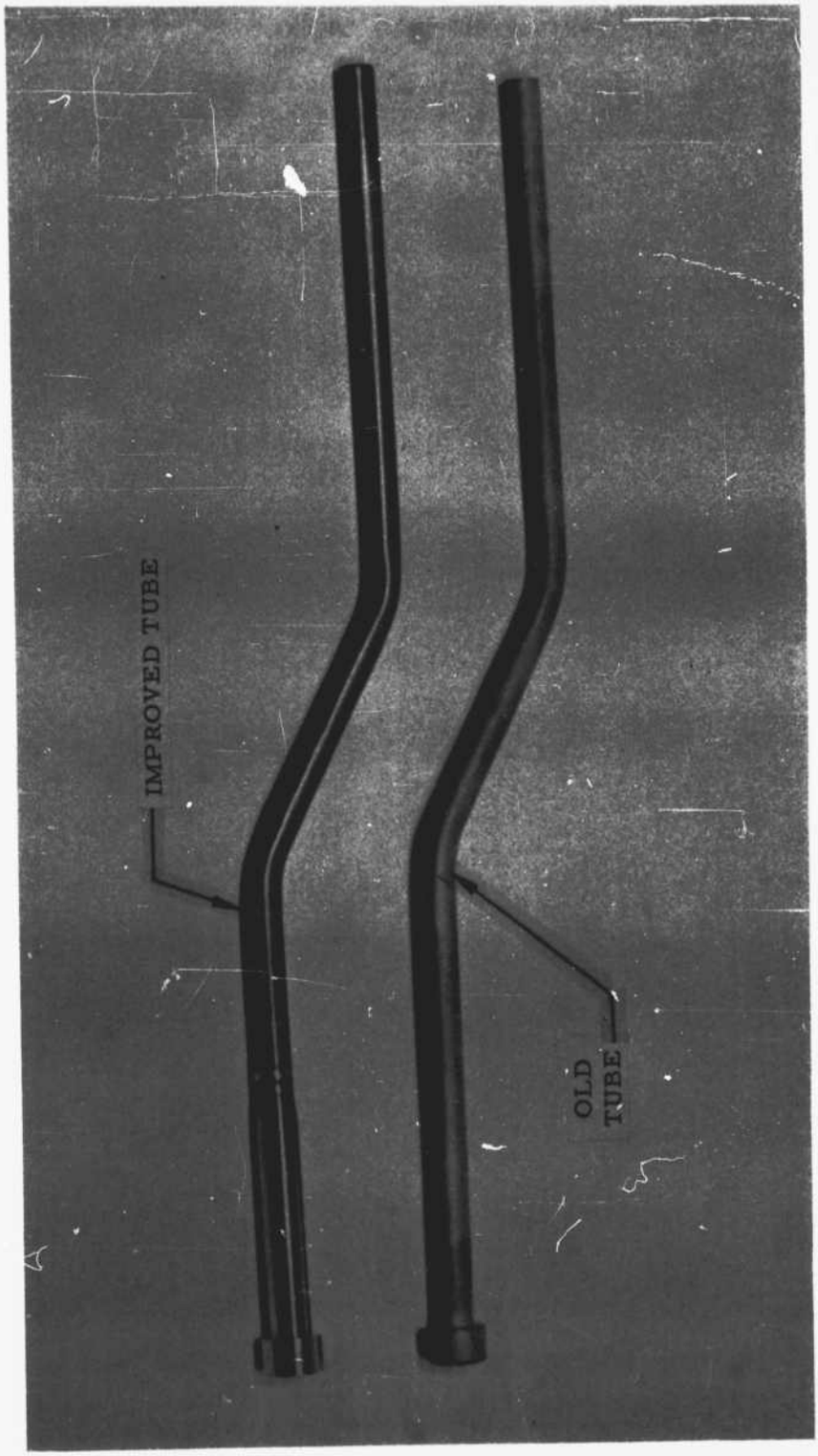



Figure 4. Ejection Gas Tube Redesign

## LIQUID SPRING TESTS

The liquid spring buffer (Figure 5) for the loader rammer was mounted in the test fixture as shown in Figure 6. Approximately 1000 cycles were applied, and land photographs of oscilloscope traces were recorded as shown in Figure 7. The data collected indicates that the liquid spring buffer as installed has a 60% efficiency. This is 10% lower than that recorded with the pneumatic buffer. The additional loss is partially due to the heavier piston in the liquid spring. Assuming that satisfactory function can be achieved with this spring, the advantages of it outweigh the 10% loss in efficiency.

One of the springs was placed in a low temperature chamber for 24 hours. The low temperature of -65° did not induce a seal leak. No dynamic tests at this temperature have been performed as yet.

The next step in the liquid spring tests is to mount the springs on loaders of firing guns. One spring will be mounted on a reliability gun and the other on the R&D weapon.

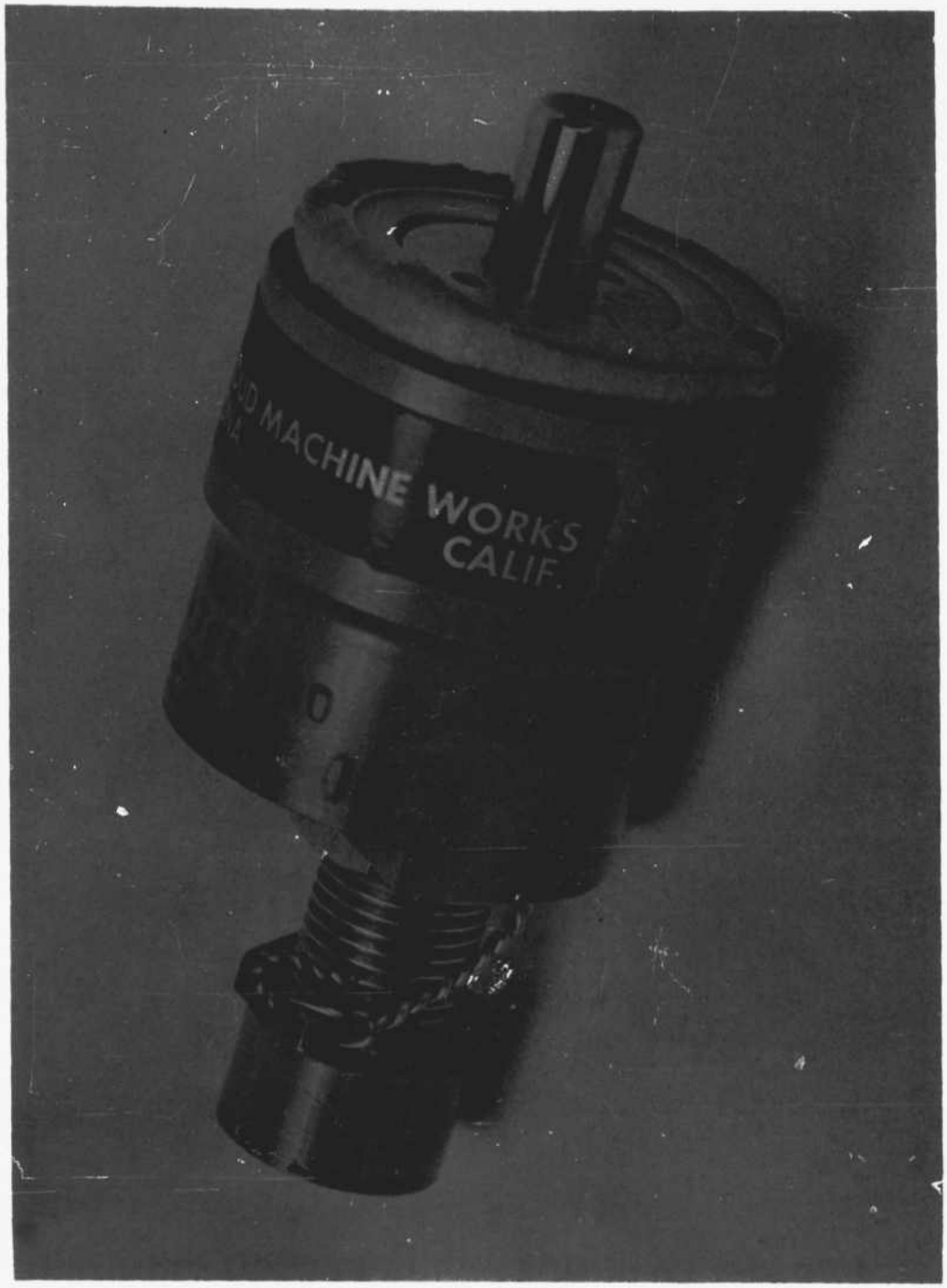



Figure 5. Liquid Spring Buffer for Loader Rammer

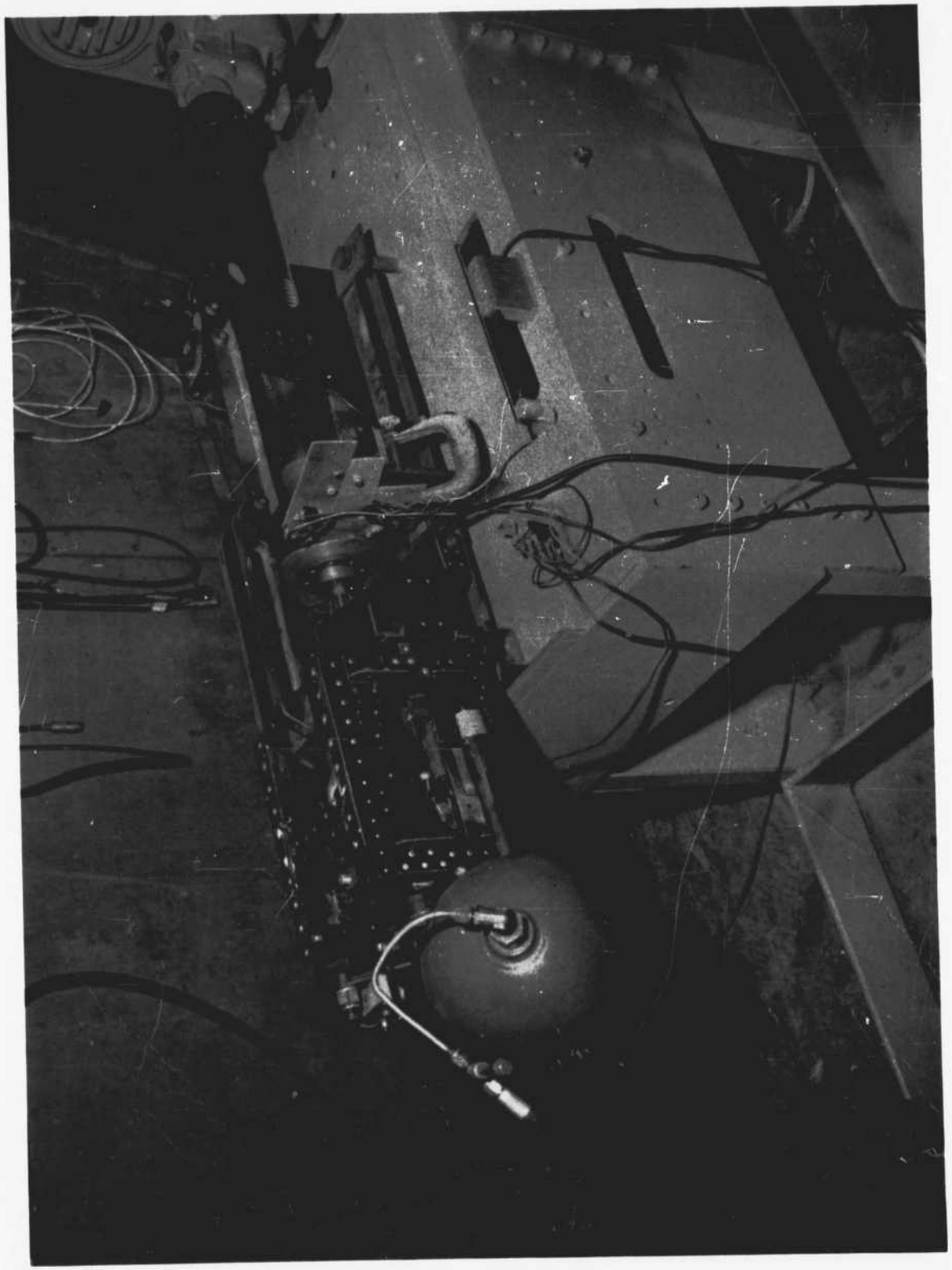


Figure 6. Rammer Test Fixture

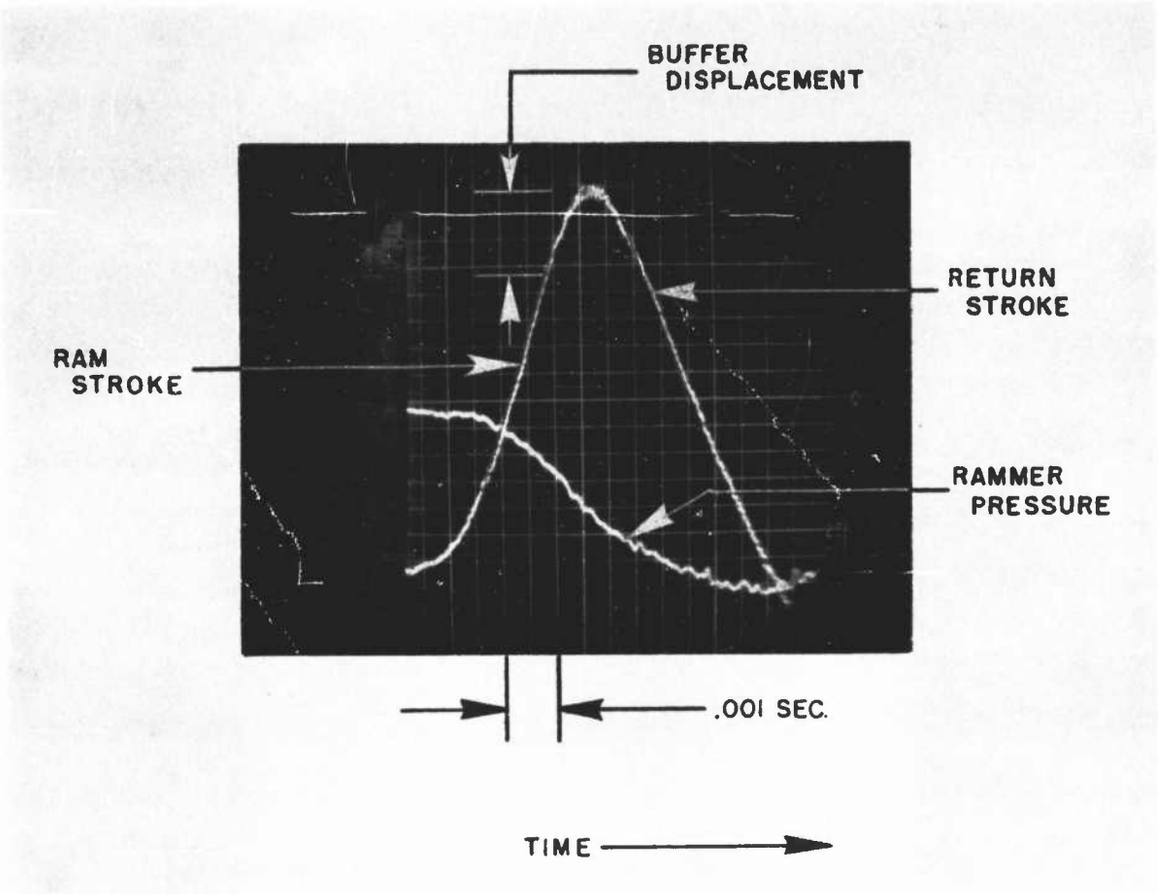



Figure 7. Oscillogram of Ram Time-Displacement on Test Fixture

# APPENDIX A

## STOPPAGE SUMMARY - BOTH PODS

## STOPPAGE SUMMARY

## FOR MONTH OF MAY 1962

| TYPE OF STOPPAGE | NUMBER OF STOPPAGES | | |
|---|---|---|---|
| | GREEN POD (6) | RED POD (4) | TOTAL |
| MANUFACTURING ERRORS | | | |
| 1. Short rivet in link | 2 | 3 | 5 |
| 2. Faulty lug in link | 0 | 1 | 1 |
| Sub-total | 2 | 4 | 6 |
| INSTRUMENTATION | 0 | 0 | 0 |
| AMMUNITION | 0 | 0 | 0 |
| PERSONNEL ERRORS | | | |
| 1. Gas tube not tightened | 1 | 0 | 1 |
| Sub-total | 1 | 0 | 1 |
| LOADER | | | |
| 1. Failed to resear | 5 | 5 | 10 |
| 2. Failed to ram deep enough | 1 | 1 | 2 |
| 3. Case went thru link | 0 | 1 | 1 |
| 4 Case hit link | 0 | 1 | 1 |
| 5. Broken ammo guide | 1 | 0 | 1 |
| 6. Broken pin - Oscillating Guide | 1 | 0 | 1 |
| Sub-total | 8 | 8 | 16 |
| LINK | 0 | 0 | 0 |
| ELECTRICAL | 0 | 0 | 0 |
| GUN MECHANISM | | | |
| 1. Eroded barrel cap (Haines metal) | 2 | 0 | 2 |
| 2. Barrel cap explosion | 1 | 0 | 1 |
| 3. Broken elbow - ram gas tube | 1 | 1 | 2 |
| 4. Broken gas eject tube | 0 | 1 | 1 |
| Sub-total | 4 | 2 | 6 |
| POD | 0 | 0 | 0 |
| TOTAL | 15 | 14 | 29 |
| Rounds fired during May | 4,614 | 11,421 | 16,035 |
| Rounds fired prior to May | 15,360 | 18,576 | 33,936 |
| Total rounds fired to June 1 | 19,974 | 29,997 | 49,971 |

# APPENDIX B

## STOPPAGE SUMMARY - POD #4

## STOPPAGE SUMMARY

FOR POD NO. 4

| Pod-full No. | Stop-page No. | Rounds Since Stoppage | Stoppage | Gun & Ldr. No. |
|---|---|---|---|---|
| 28 | 42 | 593 | Mfg. Error. Short rivet in link. | |
| | 43 | 299 | Mfg. Error. Short rivet in link. | |
| 29 | 44 | 697 | Loader. Failed to resear. | |
| 30 | 45 | 700 | Loader. Failed to resear. | |
| 31 | 46 | 739 | Loader. Failed to resear. | |
| (One-Piece Barrels Installed) | | | | |
| 32 | -- | -- | 100% Fire-out. | |
| 33 | 47 | 1151 | Loader. Failed to resear. | |
| | 48 | 513 | Loader. Failed to ram deep enough - low pressure. | |
| | 49 | 21 | Gun Mech. Broken gas eject tube. | |
| 34 | -- | -- | 100% fire-out. | |
| (Ram Position Indicators Installed) | | | | |
| 35 | | | 100% fire-out. | |
| 36 | 50 | 2172 | Mfg. Error. Faulty lug on link. | |
| 37 | -- | -- | 100% fire-out. | |
| 38 | 51 | 941 | Loader. Failed to resear. APT ammo bound on J Guide. | |

## STOPPAGE SUMMARY

FOR POD NO. 4

| Pod-full No. | Stop-page No. | Rounds Since Stoppage | Stoppage | Gun & Ldr. No. |
|---|---|---|---|---|
| (Anti-Declutch Bracket Installed) | | | | |
| 38 | 52 | 429 | Gun Mech. Broken elbow - ram gas tube. | |
| 39 | 53 | 161 | Loader. Case went thru link. | |
| | 54 | 237 | Mfg. Error. Short rivet in link. | |
| 40 | -- | -- | 100% fire-out. | |
| (Teflon ammunition) | | | | |
| 41 | 55 | 1030 | Loader. Case did not can up in link. | |
| 42 | -- | -- | 100% fire-out. | |
| 43 | -- | -- | 100% fire-out. | |
| | | | | |
| | | | | |
| | | | Total rounds fired: 29,997<br>Rounds prior to May: 18,576 | |
| | | | Rounds fired during May: 11,421 | |
| | | | | |
| | | | | |
| | | | | |

# APPENDIX C

## STOPPAGE SUMMARY - POD #6

## STOPPAGE SUMMARY

FOR POD NO. 6

| Pod-full No. | Stop-page No. | Rounds Since Stoppage | Stoppage | Gun & Ldr. No. |
|---|---|---|---|---|
| 23 | 37 | 29 | Gun Mech. Eroded barrel cap. Haines metal | |
| | 38 | 31 | Gun Mech. Same as #37. | |
| 24 | 39 | 137 | Mfg. Error. Short rivet in link. | |
| | 40 | 63 | Gun Mech. Barrel cap exploded. | |
| | 41 | 261 | Gun Mech. Broken elbow - ram gas tube. | |
| 25 | 42 | 527 | Loader. Failed to ram deep enough - low pressure. | |
| (One-Piece Barrels Installed) | | | | |
| 26 | 43 | 430 | Mfg. Error. Short rivet in link. | |
| 27 | 44 | 819 | Loader. Failed to resear. | |
| | 45 | 83 | Loader. Broken ammo. guide. | |
| | 46 | 213 | Loader. Failed to resear. | |
| 28 | 47 | 105 | Personnel Error. Gas tube not tightened. | |
| 29 | 48 | 205 | Loader. Failed to resear. | |
| (Ram Position Indicators Installed) | | | | |
| | 49 | 475 | Loader. Failed to resear. | |
| 30 | 50 | 253 | Loader. Broken pin in oscillating guide. | |

## STOPPAGE SUMMARY

FOR POD NO. 6

| Pod-full No. | Stop-page No. | Rounds Since Stoppage | Stoppage | Gun & Ldr. No. |
|---|---|---|---|---|
| (Teflon Ammunition) | | | | |
| 30 | 51 | 293 | Loader. Failed to resear. | |
| | | | | |
| | | | Total rounds fired: 19,974<br>Rounds fired prior to May: 15,360 | |
| | | | Rounds fired during May 4,614 | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

DISTRIBUTION LIST

| Addressee | No. of Copies |
|---|---|
| Chief, Bureau of Naval Weapons<br>Department of the Navy<br>Washington 25, D. C.<br>Attention: Code RMMO-45 | 1 |
| Code RAAV-54 | 1 |
| Commander<br>U. S. Naval Weapons Laboratory<br>Dahlgren, Virginia<br>Attention: Code WWE | 1 |
| Bureau of Naval Weapons Representative, Inglewood<br>North American Aviation, Inc.<br>Los Angeles 9, California | 1 |
| Office, Chief of Ordnance<br>Department of the Army<br>Washington, D. C.<br>Attention: ORDTS | 1 |
| Commanding Officer<br>Springfield Armory<br>Springfield 1, Massachusetts<br>Attention: Res. & Dev. Project Control | 1 |
| Headquarters, U. S. Air Force<br>Washington 25, D. C.<br>Attention: AFDRD-CC/1 | 1 |
| Commander (ACRG)<br>Air Force Armament Center<br>Eglin Air Force Base, Florida | 1 |
| Armour Research Foundation<br>35 West 33rd Street<br>Technology Center<br>Chicago, Illinois<br>Attention: Mr. W. Babco | 1 |

DISTRIBUTION LIST (continued)

| Addressee | No. of Copies |
|---|---|
| Westinghouse Electric Corporation, Air Arm Division<br>Friendship International Airport<br>Baltimore, Maryland<br>Via: BuWeps Representative, Glenn L. Martin Company<br>Baltimore 3, Maryland | 1 |
| Grumman Aircraft Engineering Corporation<br>Bethpage, Long Island, New York<br>Attention: Mr. Thomas Fessenden | 1 |
| Sikorsky Aircraft Division<br>United Aircraft Corporation<br>Stratford, Connecticut<br>Attention: Mr. R. J. Tynan | 1 |
| Chance Vought Aircraft, Inc.<br>Box 5907, Dallas, Texas<br>Attention: Mr. H. R. Jordan | 1 |
| Douglas Aircraft Company, Inc.<br>El Segundo Division<br>827 Lapham Street<br>El Segundo, California<br>Attention: Mr. R. H. Cocks<br>ASW Armament Section, B-250 | 1 |
| Equipment Board<br>Marine Corps Schools<br>Quantico, Virginia | 1 |
| Headquarters Marine Corps, Code AAP<br>Div. of Aviation, Aircraft Programming Section<br>Washington 25, D. C. | 1 |
| Commander, Naval Air Test Center<br>Patuxent River, Maryland<br>Attention: Mr. A. Adams<br>Weapons System Test | 1 |

DISTRIBUTION LIST (continued)

| Addressee | No. of Copies |
|---|---|
| Department of the Army<br>Washington 25, D. C.<br>Attention: Chief of Transportation<br>Rm 1846 - Pentagon | 1 |
| Dr. R. S. Titchen, OP-03EG<br>Office of the Chief of Naval Operations<br>Room 4A714, Pentagon<br>Washington 25, D. C. | 1 |
| Commanding Officer<br>Attn: Purchasing Officer, ORDBB-PC<br>Picatinny Arsenal<br>Dover, New Jersey | 1 |
| ASTIA<br>Arlington Hall Station<br>Arlington 12, Virginia | 10 |
| U. S. Navy Liaison Officer<br>Headquarters, Air Force Systems Command<br>U.S. Air Force<br>Andrews Air Force Base<br>Washington 25, D. C.<br>Attention - Capt. R. Kolakowski | 1 |