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DUST ENVIRONMENT LUBRICANT TEST



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Gun Weapon Systems Directorate
Naval Surface Warfare Center
Crane Division, Crane, Indiana

FINAL REPORT

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DUST ENVIRONMENT LUBRICANT TEST

Prepared by:



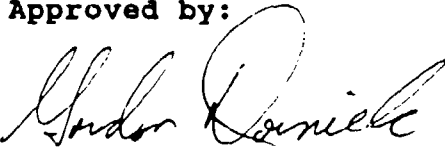
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Summary:

This report contains information about dust tests and a salt fog test conducted on various military and commercially available lubricants applied to M16A1 rifles and phosphate coated steel plates. Lubricants that were tested included synthetic and petroleum-based oils, greases and dry film lubricants. Testing was performed to determine which lubricants would give the best performance in environments of airborne dust and fine sand, high temperature and corrosive airborne salts.

Dust tests with exposure times of one hour, three hours, six hours, seven hours and eight hours were conducted with military and commercially available lubricants applied to M16A1 rifles. CLP provided the best overall performance, with one stoppage in five dust tests. VV-L-800 finished second with three stoppages in five dust tests. Other top finishers were Brand D with three stoppages in four dust tests, Brand C with seven stoppages in five dust tests, and Brand E with eight stoppages in five dust tests. The three top finishers were liquid lubricants. Although it appeared that more dust accumulated on the exposed exterior surfaces of bolt carriers with liquid lubricants than on bolt carriers with dry film lubricants, the liquid lubricants had more success overcoming friction caused by dust intrusion. The two top finishers, MIL-L-63460D CLP and VV-L-800C, are the lubricants currently specified in preventative maintenance documents for Navy small arms.

A 48-hour salt fog test was conducted on phosphated AISI 2020 steel plates coated with most of the lubricants that were in the dust test. Brand H, which is a molybdenum disulfide dry film lubricant, provided the most protection from corrosion, followed by MIL-L-63460D CLP. All other lubricants provided poor corrosion protection in this test.

The commercially available lubricants tested did not offer any significant benefits over lubricants currently being used by the Navy in environments of airborne dust, high temperature and corrosive salts. It is recommended that MIL-L-63460D CLP lubricant be used in these types of environments with Navy fleet small arms.

TABLE OF CONTENTS

Standard Form 298	ii
Summary	iv
TABLE OF CONTENTS	1
1 INTRODUCTION	2
1.1 BACKGROUND	2
1.2 OBJECTIVE	2
2 PROCEDURES	2
2.1 DUST TESTS	2
2.1.1 PREPARING THE RIFLES	2
2.1.2 PREPARING THE DUST CHAMBER	4
2.1.3 FIRING THE RIFLES	5
2.2 SALT FOG TEST	8
3 RESULTS	8
3.1 DUST TESTS	8
3.1.1 Brand A	10
3.1.2 Brand B	10
3.1.3 Brand C	11
3.1.4 Brand D	11
3.1.5 CLP	12
3.1.6 Brand E	12
3.1.7 Brand F	12
3.1.8 Brand G	13
3.1.9 Brand H	13
3.1.10 Graphite powder	13
3.1.11 Brand I	14
3.1.12 LSA	14
3.1.13 VV-L-800	15
3.1.14 Unlubricated	15
3.1.15 Brand J	15
3.2 SALT FOG TEST	17
4 CONCLUSIONS AND RECOMMENDATIONS	17

1 INTRODUCTION:**1.1 BACKGROUND:**

Several companies have developed lubricants over the past several years as alternatives to traditional gun oils. These lubricants have appeared in various forms, such as petroleum-based or synthetic oils and greases, and solid films containing graphite, silicone, fluoropolymers or molybdenum disulfide. The U.S. Navy has traditionally used MIL-L-63460D, Lubricant, Cleaner and Preservative for Weapons and Weapons Systems, more commonly known as CLP; VV-L-800C, Lubricating Oil, General Purpose, Preservative (Water Displacing, Low Temperature); MIL-L-46000C, Lubricant, Semi-Fluid (Automatic Weapons), more commonly known as LSA; and MIL-L-14107C, Lubricating Oil, Weapons, Low Temperature, more commonly known as LAW. Recent world events have generated questions as to whether lubricants currently used by the U.S. Navy are adequate for use in areas where there is excessive exposure to airborne dust and fine sand, high temperature, and corrosive airborne salts.

1.2 OBJECTIVE:

This report will provide information regarding the performance of various military and commercially available lubricants as applied to M16A1 rifles and phosphate coated steel plates. Performance was measured by conducting dust tests and salt fog tests utilizing MIL-STD-810E test equipment located at the Naval Surface Warfare Center, Crane Division (NAVSURFWARCEMDIV).

2 PROCEDURES:**2.1 DUST TESTS****2.1.1 PREPARING THE RIFLES:**

M16A1 rifles were randomly selected from two lots of Navy asset rifles that had never been fired. Each lubricant involved in testing was randomly assigned two rifles (one rifle from each lot) for the life of the test. Each rifle was also randomly assigned two 30-round magazines, which were labeled with the weapon's serial number, followed by the letter A or B to differentiate between the two magazines.

The rifles were then prepared for function testing. The rifles were degreased to remove all lubricants and preservatives. Increases in accuracy and velocity were claimed by some lubricant manufacturers. During function testing, accuracy and velocity were measured using nine of the lubricants. The rifle bores were

first swabbed and cleaned with MIL-C-372C rifle bore cleaner, wiped with dry patches and visually inspected. Bolt heads and cam pins were the only areas other than the bore that received any lubrication for the function test. These areas received a minimal amount of VV-L-800 oil to ensure proper function of the action during this function test.

Three ten shot groups were fired from the bench rest with each rifle. The velocity was recorded for each shot, and extreme spread was measured for all groups. Each rifle bore received it's assigned lubricant after these thirty rounds were fired. Two ten shot groups were fired through each rifle to wear in the lubricants, then ten three shot groups were fired. The rifles were allowed to cool for several hours, and ten more three shot groups were fired, followed by two ten shot groups. Velocity was recorded for each shot, and extreme spread was measured for all groups. For each rifle, velocity and extreme spread with and without the lubricant was compared. During this test, sixty-five rounds were fired from each magazine to test for proper function. Any observed malfunction that could not be pinpointed to the ammunition would be reason for disqualifying a rifle and the magazine that was used during the malfunction. This test was performed at the NAVSURFWARCENDIV Gun Weapon Systems Directorate's indoor range. Results of this test are recorded in NAVSURFWARCENDIV Test Report TR/2021/C91/558, titled "**Bore Lubricant Test**".

The rifles were carefully degreased to remove all traces of lubricants, and lubricated in preparation for dust testing. All weapons were lubricated in identical locations with the assigned lubricants, in accordance with TM 9-1005-249-10, Chapter 3, Section III, Operator's Manual for Rifle, 5.56mm M16A1, of February 1985. The areas that were lubricated were the upper receiver chamber including locking lugs, firing pin, firing pin recess in bolt assembly, bolt cam pin, firing pin retaining pin, bolt assembly cam pin hole, outer surfaces of bolt assembly, inner and outer surfaces of bolt carrier assembly, charging handle assembly and lower receiver spring and buffer assembly. The bore and lower receiver were not lubricated. The lower receiver was not lubricated due to the difficulty of applying some of the manufacturers lubricants in confined spaces. It was felt that the liquid lubricants would have an unfair advantage over the grease and some dry lubricants in permeating to the smallest spaces in the lower receiver, and that the test would not show a direct comparison of the performance of the lubricants. The bore was not lubricated since the limited number of rounds that would be fired in the test would not cause noticeable degradation to the barrel. There was also some concern that lubricants in the bore might result in dust clogging the bore. The bore was inspected as closely as possible before firing, but without disturbing the dust that accumulated on the rifle. External surfaces of the rifle and the internal

components of the magazines were not lubricated, as specified in TM 9-1005-249-10, Operator's Manual for Rifle, 5.56mm, M16 Rifle, 5.56mm, M16A1, Chapter 2, Section IV, paragraph 2-21 which specified that external surfaces of the rifles and internal components of the magazines were not to be lubricated in hot, dry, dusty and sandy areas. Rifles were lubricated by the same two personnel working in concert throughout the entire test to ensure that lubricating locations and the amount of lubricant used in those locations remained consistent. These personnel wore rubber surgical gloves which were changed after applying each lubricant. Hands were thoroughly washed between each application, due to the tendency that some lubricants permeate through rubber gloves. This ensured that only the particular lubricant assigned to the rifle was being applied throughout the life of the test, and that other lubricants were not contaminating the rifle.

2.1.2 PREPARING THE DUST CHAMBER:

The dust test was conducted at the NAVSURFWARCENDIV Building 2921 dust chamber. The chamber performs according to the specifications of MIL-STD-810E, Method 510.3 "Sand and Dust Test". The dust used in the test was silica flour. The average size of an individual dust particle was 140 microns, with a maximum size of 149 microns. The temperature in the chamber during testing was maintained at approximately 112°F. The dust flow rate was .65 gm dust/ft³. A wooden rack was built to hold a maximum of twelve rifles in the same horizontal orientation in the chamber, as shown in figure 1.

Before placing the rifles into the test chamber, dust protective caps were placed over the muzzles to avoid the possibility of blocking rifle bores with dust. One of the two ammunition magazines assigned to each rifle was used in the dust chamber for the life of the test. These empty magazines were attached to the rifles. All rifles were charged, the firing selector levers were placed in the SEMI position, and dry fired to release the firing pins. The bolt position was fully forward, engaging the locking lugs. Ejection port covers were left open, so that dust intrusion would be more pronounced during the tests.

Rifles were placed in the rack with muzzles pointing directly towards the fan, in the direction of oncoming silica flour. At the start of each test, rifles were randomly placed in each of the twelve positions in the rack. Once in the chamber, the rifles were carefully moved to four different locations in the rack during the course of the test, in four groups of three rifles, to receive the same amount of dust exposure. The test duration time was divided by four, and that was the time the rifles spent at a given location in the rack before being moved to a different location. For example, in the three-hour test, the sand and dust chamber was stopped every 45 minutes to rotate

the weapons to new locations. By direct observation, it appeared that the dust exposure was the same in each location in the rack, but the weapons were rotated to four different areas in the chamber for further assurance.

2.1.3 FIRING THE RIFLES:

After exposure to the dust for the specified time interval, the rifles were carefully removed from the dust chamber, loaded onto a gun rack, and transported to the NAVSURFWARCENDIV Gun Weapon Systems Directorate's outdoor small arms test range. The rifles were transported in a weapons van, going at extremely low speed, in order to minimize disturbance of accumulated dust.

As stated previously, one ammunition magazine was dedicated for use in the dust chamber. The other magazine assigned to each rifle was dedicated to shooting for the entire life of the test, and was not exposed to the dust chamber. These magazines were loaded with 30 rounds of M193 5.56mm ball ammunition. Rifles were selected in random order for the firing test. The shooter carefully transported each weapon to the shooting bench, removed the dust cap, removed the empty magazine used in the dust chamber, and attached the loaded magazine to the rifle. The bolt catch was then depressed to release the bolt and chamber a round. If the bolt did not engage the locking lugs, the forward assist was utilized. If the bolt carrier did not travel far enough to pick up a round and be in the area where the forward assist could be used, the shooter pulled back on the charging handle, and released it to chamber the first round. As a last resort, the shooter used the tip of his thumb in the bolt carrier recess to close the bolt. The shooter fired the rifle from the sitting position, resting his elbows on the table, with the rifle butt placed firmly on his right shoulder. For consistency, the same shooter was used for all of the dust tests. Approximately ten rounds were fired single shot with the firing selector in the SEMI position. The remainder of the magazine was fired with the selector in the AUTO position, three to five rounds per burst.

Testing on a given rifle could be suspended at any time by the test director, due to unsafe or extraordinary malfunctions. Results were recorded on data sheets and U-matic 3/4" videotape. As shown in figure 2, respirators and environmental protection suits were required during all phases of the dust test to limit exposure to silica flour. Prolonged unprotected inhalation of silica flour is known to cause a disease called Silicosis, which is related to Asbestosis.

In the first test, a duration of one hour dust exposure was chosen to get a benchmark measurement of dust accumulation, and to determine what type of effects the dust would start to have on the lubricants. Some lubricants experienced malfunctions resulting from this one-hour exposure. Exposure times were gradually increased to rate the effectiveness of each lubricant.

The first group of rifles went through one-hour, three-hour and six-hour dust test durations. Rifles were hand cleaned and degreased between each test. Lubricants were applied in accordance with TM 9-1005-249-10 before each test. Results were compiled for the one, three and six-hour tests. This set of tests was designated as Test Sequence #1.

Dust tests were then repeated with new rifles to see if there was a correlation with the results from the lubricants and the previous group. The most successful lubricants were chosen from the previous test, and the new rifles went through the same procedures of function testing and lubrication as the previous group. Results were recorded and compiled for seven and eight-hour tests. Rifles were hand cleaned and degreased between each test. Lubricants were applied in accordance with TM 9-1005-249-10 before each test. This set of tests was designated as Test Sequence #2.

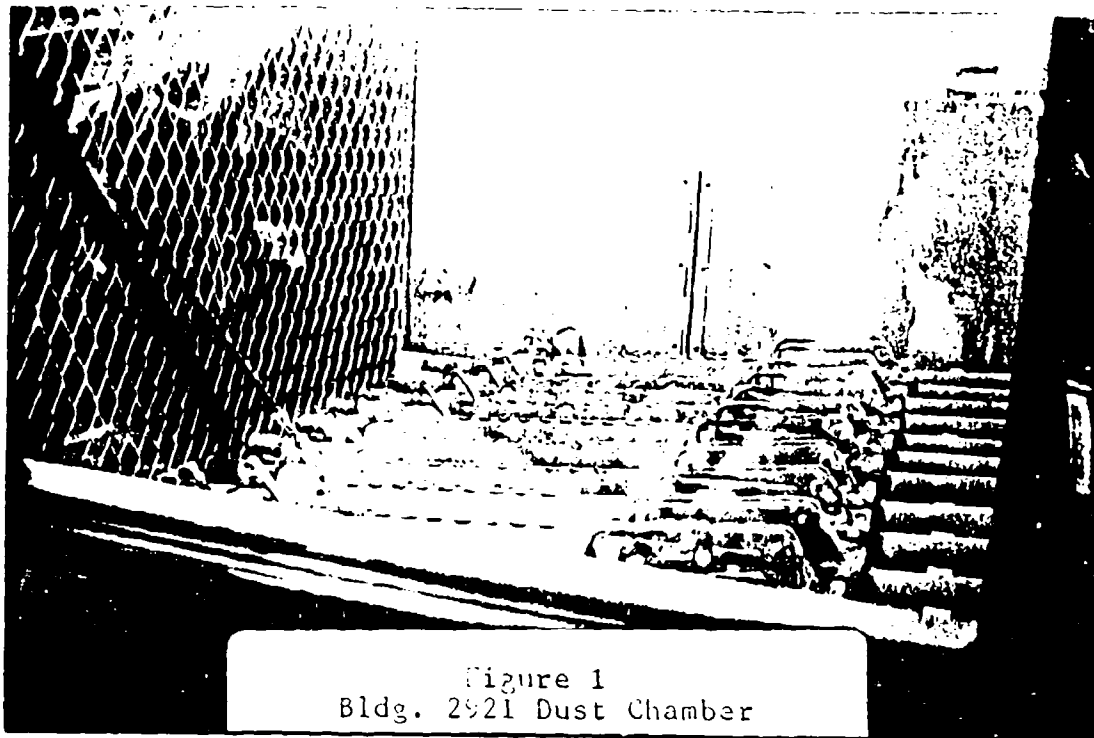


Figure 1
Bldg. 2921 Dust Chamber

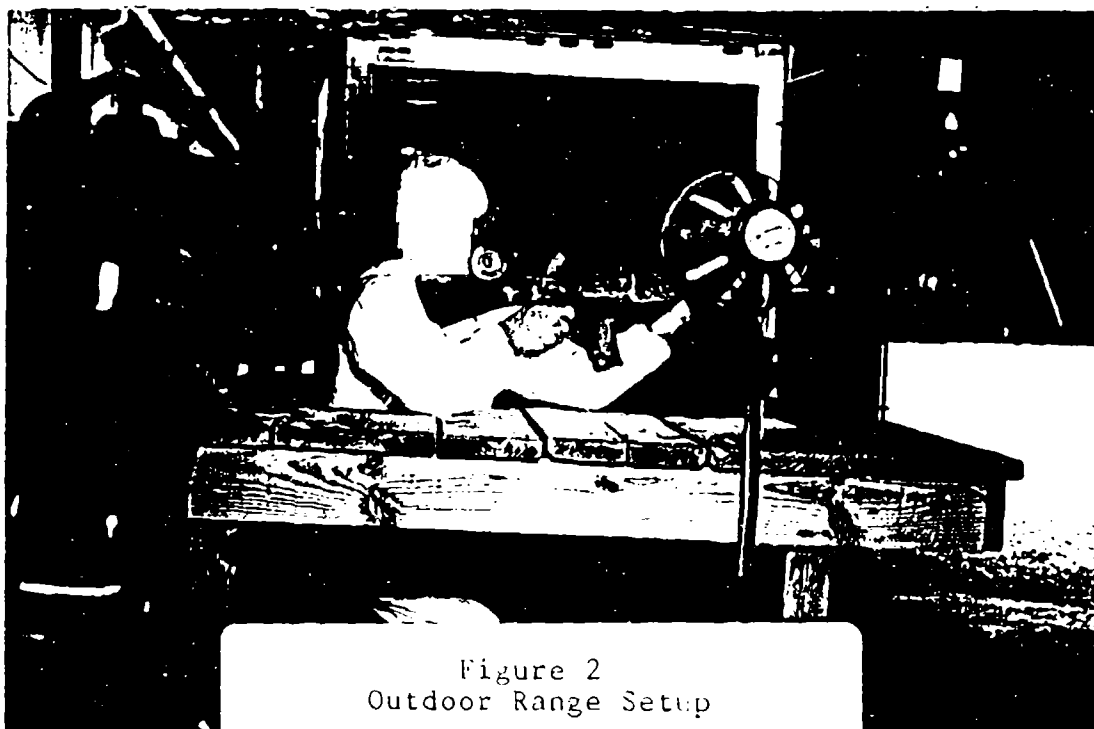


Figure 2
Outdoor Range Setup

2.2 SALT FOG TEST

The salt fog test was conducted at the NAVSURFWARCENDIV Building 2921 salt fog chamber. This chamber performs according to the specifications of MIL-STD-810E, Method 509.3, Procedure I "Salt Fog Test". During the test, the chamber was maintained at 95°F, with 5% salt concentration in the salt fog. The pH level was maintained at approximately 6.87. This test was conducted to compare lubricant protection from corrosion, using phosphate-coated steel plates. AISI 2020 steel plates were prepared, measuring 5.0" long x 3.0" wide x 0.125" thick. An identification number was stamped in the corner of each plate. The plates were phosphate-coated by NAVSURFWARCENDIV Gun Weapon Systems Directorate Overhaul and Repair Branch personnel. As shown in figure 3, a wooden rack was constructed to hold each plate tilted at a 15° angle to vertical, so that exposure to salt fog would be uniform for all specimens. The plates were then coated with the various lubricants on all sides and edges, and placed in the rack located in the salt fog chamber. One of the persons involved in lubricating the rifles in the dust test was assigned to lubricate all the plates in the salt fog test. This person wore rubber surgical gloves which were changed after applying each lubricant. Hands were thoroughly washed between each application, due to the tendency of some lubricants to permeate through rubber gloves. This ensured that only the particular lubricant assigned to plate was being applied, and that other lubricants were not contaminating the plate. The plates were subjected to a 24-hour cycle in the salt fog chamber, allowed to dry for 24 hours outside the chamber, then exposed to another 24-hour cycle in the chamber, followed by another 24-hour drying cycle. The results were recorded by medium format camera.

3 RESULTS:

3.1 DUST TESTS

The results of the dust tests are summarized in the test matrix shown in Table 1. The predominant malfunction that occurred was failure to feed the next round after firing due to the bolt carrier becoming mechanically stuck in the upper receiver as it was coming forward towards the breech. Malfunctions predominantly started after the first or second round was fired, in single shot mode, from the 30-round magazine. The failures to feed usually occurred until the bolt carrier overcame the friction caused by the silica flour. Sometimes the malfunctions occurred sequentially, but in some instances occurred with rounds successfully fired between malfunctions. Each time a rifle was fired, a cloud of silica flour was ejected from the upper receiver. Once the bolt carrier overcame the

friction caused by the remaining silica flour, the remainder of the rounds were usually fired without incident. Failure to feed the next round due to the bolt carrier stopping accounted for one hundred fifty-seven malfunctions. Failure to eject spent cartridge case malfunctions were only recorded four times during testing.

At the end of test sequence #1, only Brand D, CLP and VV-L-800 successfully fired all rounds without malfunction. Since all commercial vendors except for Brand D had experienced malfunctions after the six-hour test, test sequence #1 was concluded.

Test sequence #2 included the three lubricants that did not record any malfunctions in test sequence #1, seven other candidates from test sequence #1 and two new entries. New rifles were assigned to each of the lubricants. Lubricants were chosen by the success of performances in test sequence #1, with three exceptions. Brand I was retested because it previously failed so badly that the bolt and bolt carrier could not be moved forward to properly engage the locking lugs. Testing Brand I again would either correlate or disprove these previous results. A grease was received from Brand J Corporation as a late entry, and this was tested although it was known at the time that another test sequence was doubtful. A rifle without any lubrication was also added to the test as a baseline, and for informational purposes. After the test sequence #2 seven-hour test, lubricants that fired without a malfunction were placed in an eight-hour test. All lubricants recorded malfunctions in the eight-hour test. For test sequence #2, CLP had one malfunction, followed by VV-L-800 with three malfunctions, Brand C with four malfunctions and Brand E with five malfunctions.

CLP finished with the fewest malfunctions in overall testing. CLP recorded only one malfunction throughout five tests, a failure to feed after the second round was fired in the eight-hour test. VV-L-800 finished with three malfunctions in five dust tests. Other top finishers were Brand D with three malfunctions in four dust tests, Brand C with seven malfunctions in five dust tests and Brand E with eight malfunctions in five dust tests. CLP had more success than other lubricants in overcoming friction caused by the dust accumulation between the bolt carrier and the walls of the upper receiver. This resulted in fewer stoppages during the first few rounds fired, when the bolt carrier was prone to become stuck. The shooter reported that cycling of the rifles using CLP was especially smooth from the first rounds on through the end of the magazine.

In most of the cases where there were two or more consecutive malfunctions in thirty rounds, cycling would still feel sluggish for one or more rounds after the rifles successfully began firing. After enough dust was ejected from receivers, combined with lubricants eventually overcoming the friction caused by the dust that remained in the receiver, rifles

would begin shooting smoothly.

It was also noted that liquid lubricants were much easier to apply in confined spaces than greases and graphite powder. Dry film lubricants Brand H and Brand B were easy to apply because of the presence of liquid carriers.

Graphite powder was impossible to completely remove during cleaning and degreasing operations. Each time the powder was reapplied, there was an additive effect of applying lubricant over areas that already contained a thin film of graphite. This may help explain why graphite powder had a decrease in malfunctions from three and five in the one-hour and three-hour tests to one malfunction in the six hour test. Some of the manufacturers claimed their lubricants would become permanently bonded to the metal surfaces, but upon casual observation during cleaning this could not be substantiated.

Performance data including mean rounds between stoppages (MRBS) and a brief description of each lubricant involved in testing follows. MRBS was rounded up or down to the nearest whole number of rounds.

3.1.1 Brand A

Test Sequence #1: MRBS = 90/5 = 18

Test Sequence #2: MRBS = NA, was not tested

Company A produces three different forms of Brand A. Brand A, form 1 is a spray lubricant and cleaner, Brand A, form 2 is a liquid lubricant and preservative, and Brand A, form 3 is a grease. Brand A, form 2 was used in the dust test. Brand A, form 2 is composed of submicroscopic fluorocarbon particles suspended in a petroleum based carrier. In test sequence #1, rifle #1791564 fired without any malfunctions in the one-hour test, but recorded one malfunction in the three-hour test and four malfunctions in the six-hour test. This lubricant was not used on a rifle in test sequence #2 because Company A sent a new product called Brand B that was claimed to be superior to former Brand A products in sand and dust environments. This product is described below.

3.1.2 Brand B

Test Sequence #1: MRBS = 30/4 = 8

Test Sequence #2: MRBS = 30/5 = 6

Company A shipped this product to NAVSURFWARCENDIV after dust testing had begun. Brand B is available as a spray lubricant, cleaner and preservative, as an oil, and as a grease formulation. The spray was used in the dust test. Brand B spray is composed of submicroscopic fluoropolymer particles suspended in a chlorothene carrier which evaporates after application, and essentially is a dry film lubricant. Rifle #4804231 was assigned to Brand B during test sequence #1, and the lubricant was entered in six-hour test. The rifle had four malfunctions, the same number Brand A, form 2 had in the six-hour test. In test sequence #2, rifle #4866652 had five malfunctions in the seven-hour test.

3.1.3 Brand C

Test Sequence #1: MRBS = 90/3 = 30

Test Sequence #2: MRBS = 60/4 = 15

According to Company C, Brand C is a proprietary mixture of fluorocarbon and synthetic lubricating oils in a cream form. In the test sequence #1, rifle #1792800 fired without any malfunctions in the one-hour and three-hour tests, but did have three malfunctions in the six-hour test. In test sequence #2, rifle 1788975 fired without any malfunctions in the seven-hour test, but recorded four malfunctions in the eight-hour test.

3.1.4 Brand D

Test Sequence #1: MRBS = NA, all 90 rounds fired successfully

Test Sequence #2: MRBS = 30/3 = 10

No ingredient information was available for Company D, Brand D oil. It is advertised as an anti-friction liquid metal treatment, which offers a combination of mechanical, chemical, rust, corrosion, temperature and friction resistance properties. In test sequence #1, rifle #1795300 fired without any malfunctions in the one-hour, three-hour and six-hour tests. In test sequence #2, rifle #4878548 experienced three malfunctions in the seven-hour test.

3.1.5 CLP QPL-63460-13

Test Sequence #1: MRBS = NA, all 90 rounds fired successfully

Test Sequence #2: MRBS = 60/1 = 60

Qualified Products List QPL-63460-13 identifies several manufacturers of CLP, which is a cleaning, lubricating and preservative produced under Military Specification MIL-L-63460. The lubricant used in this test was CLP liquid. In test sequence #1, rifle #4783144 did not have any malfunctions in the one-hour, three-hour and six-hour tests. In test sequence #2, rifle #4813100 fired without any malfunctions in the seven-hour test, but recorded one malfunction in the eight-hour test.

3.1.6 Brand E

Test Sequence #1: MRBS = 90/3 = 30

Test Sequence #2: MRBS = 60/5 = 12

Company E produces Brand E, which is a liquid synthetic hydrocarbon derivative of proprietary composition, according to the Material Safety Data Sheet provided by the manufacturer. Company E states that this product forms a molecular bond with the surface of the metal. In test sequence #1, rifle #4785227 fired without any malfunctions in the one-hour test, but did have one malfunction in the three-hour test and two malfunctions in the six-hour test. In test sequence #2, rifle #5449207 fired without any malfunctions in the seven-hour test, but had five malfunctions in the eight-hour test.

3.1.7 Brand F

Test Sequence #1: MRBS = 90/11 = 8

Test Sequence #2: MRBS = 30/10 = 3

Company F produces Brand F Oil and Brand F Grease. Brand F Grease was used in the dust test. According to product literature, the grease contains proprietary "Brand F Particles" in a synthetic ester formula. In test sequence #1, rifle #4794117 did not have any malfunctions in the one-hour test, but did have five malfunctions in the three-hour test and six malfunctions in the six-hour test. In test sequence #2, rifle

#5452409 had ten malfunctions in the seven-hour test.

3.1.8 Brand G

Test Sequence #1: MRBS = 90/8 = 11

Test Sequence #2: MRBS = NA, was not tested

Company G produces Brand G, and states that the oil is a proprietary liquid formula of chemical and petroleum lubricants with microcrystalline corrosion preventatives. In test sequence #1, rifle #4794118 fired without any malfunctions in the one-hour test, but had four malfunctions in the three-hour test and four malfunctions in the six-hour test. Brand G did not participate in test sequence #2, due to the limitations of the dust test chamber, and the success of other liquid oil lubricants in test sequence #1.

3.1.9 Brand H

Test Sequence #1: MRBS = 90/10 = 9

Test Sequence #2: MRBS = 30/13 = 2

Company H manufactured the product that was used in testing. The company that presently manufactures the product is called Company X. Brand H is advertised as a dry film lubricant which contains molybdenum disulfide (MoS_2). In test sequence #1, rifle #4794187 fired without any malfunctions in the one-hour test, had six malfunctions in the three-hour test and four malfunctions in the six-hour test. In test sequence #2, rifle #4880973 had thirteen malfunctions in the seven-hour test.

3.1.10 Graphite powder

Test Sequence #1: MRBS = 90/9 = 10

Test Sequence #2: MRBS = 30/3 = 10

The graphite used on the rifles in this test was dry powder graphite. The powder is required to contain at least 95% graphitic carbon by weight, a maximum of 2.5% ash by weight and a maximum of 2.5% volatile compounds. The graphite particle is required to be less than 149 microns in size, and 88% of the particles were less than 74 microns in size. In test sequence

#1, rifle #4799958 had three malfunctions in the one-hour test, five malfunctions in the three-hour test and one malfunction in the six-hour test. In test sequence #2, rifle #776613 had three malfunctions in the seven-hour test.

3.1.11 Brand I

Test Sequence #1: MRBS = NA, disqualified

Test Sequence #2: MRBS = 30/30 = 1

Company I manufactures Brand I. Company Y is the United States distributor. This lubricant is a CFC aerosol propelled proprietary blend of corrosion inhibitors, petroleum distillates and mineral oil. Company I states that this product conforms to an Israeli Defense Forces standard that follows Military Specification MIL-C-23411A, Corrosion Preventive Compounds, Clear. MIL-C-23411A has been superseded by MIL-C-81309, Corrosion Preventive Compounds, Water Displacing, Ultra-Thin Film on 22 May 1980, and is currently in revision D. In test sequence #1, rifle #4799965 was removed from testing in the one-hour test before a shot could be fired. The shooter could not move the bolt carrier assembly forward enough by hand to properly engage the locking lugs. It appeared that the combination of the lubricant and the silica flour bound up the bolt carrier in the upper receiver. The same results occurred in the three-hour test, and the rifle was again removed from testing without any shots fired. In test sequence #2, rifle #1775437 did successfully engage the locking lugs, but malfunctioned on every round that was fired in the seven hour test. There were twenty-nine failures to feed, and one failure to eject, which resulted in a stovepiped cartridge case.

3.1.12 LSA

QPL-46000-10

Test Sequence #1: MRBS = 60/3 = 20

Test Sequence #2: MRBS = NA, was not tested

Qualified Products List QPL-46000-10 identifies several manufacturers of LSA, which is a semi-fluid lubricant for automatic weapons, produced under Military Specification MIL-L-46000C. The lubricant used in this test was manufactured by Company Z. In test sequence #1, rifle #4801203 fired without any malfunctions in the one-hour test, but had three malfunctions in the three-hour test. This lubricant was removed from further testing, since other lubricants currently in use by the military were showing better results.

3.1.13 VV-L-800

QPL-VV-L-800-17

Test Sequence #1: MRBS = NA, all 90 rounds fired successfully
Test Sequence #2: MRBS = 60/3 = 20

Qualified Products List QPL-VV-L-800-17 identifies several manufacturers of VV-L-800, which is a general purpose preservative liquid lubricating oil produced under Federal Specification VV-L-800C. The lubricant used in this test was contained in an aerosol propelled can. In test sequence #1, rifle #4802787 fired without any malfunctions in the one-hour, three-hour and six-hour tests. In test sequence #2, rifle #796911 fired without any malfunctions in the seven-hour test, but had three malfunctions in the eight-hour test.

3.1.14 Unlubricated

Test Sequence #1: MRBS = NA, was not tested
Test Sequence #2: MRBS = 30/6 = 5

An unlubricated rifle was placed in the test sequence #2 seven-hour test as a baseline to compare to the lubricated rifles. Rifle #4831774 had six malfunctions.

3.1.15 Brand J

Test Sequence #1: MRBS = NA, was not tested
Test Sequence #2: MRBS = 30/22 = 1

The product used in this test was advertised by Company J as L-1493 synthetic weapons lubricant in a grease form. No further information was available. This product was received as a late entry, and therefore was only entered in test sequence #2. In the seven-hour test, rifle #4804945 had twenty-two malfunctions.

Table 1

***** Dust Test Durations *****					
	Test Sequence #1			Test Sequence #2	
	** 1 Hour **	** 3 Hour **	** 6 Hour **	** 7 Hour **	** 8 Hour **
Lubricant	*****	*****	*****	*****	*****
Brand A	<u>1791564</u>	1791564 (1)	1791564 (4)	NA	NA
Brand B	NA	NA	4804231 (4)	4866652 (5)	NA
Brand C	<u>1792800</u>	<u>1792800</u>	1792800 (3)	<u>1788975</u>	1788975 (4)
Brand D	<u>1795300</u>	<u>1795300</u>	<u>1795300</u>	4878548 (3)	NA
CLP	<u>4783144</u>	<u>4783144</u>	<u>4813144</u>	<u>4813100</u>	4813100 (1)
Brand E	<u>4785227</u>	4785227 (1)	5227 (2)	<u>5449207</u>	5449207 (5)
Brand F	<u>4794117</u>	4794117 (5)	4794117 (6)	5452409 (10)	NA
Brand G	<u>4794118</u>	4794118 (4)	4794118 (4)	NA	NA
Brand H	<u>4794187</u>	4794187 (6)	4794187 (4)	4880973 (13)	NA
Graphite	4799958 (3)	4799958 (5)	4799958 (1)	776613 (3)	NA
Brand I	4799965 (*)	4799965 (*)	NA	1775437 (30)	NA
LSA	<u>4801203</u>	4801203 (3)	NA	NA	NA
VV-L-800	<u>4802787</u>	<u>4802787</u>	<u>4802787</u>	<u>796911</u>	796911 (3)
Unlubricated	NA	NA	NA	4831774 (6)	NA
Brand J	NA	NA	NA	4804945 (22)	NA

Chart Key

Bold and underlined rifle serial number - The rifle did not experience any malfunctions during the 30 round firing sequence.

Number in parenthesis (#) - The rifle recorded the number of malfunctions indicated in the parenthesis during the 30 round firing sequence.

Asterisk in parenthesis (*) - The rifle was removed from testing during the 30 round firing sequence because the bolt could not properly engage locking lugs due to friction caused by dust.

NA - Rifle with corresponding lubricant not included in test.

3.2 SALT FOG TEST

Results of the salt fog test were recorded by a medium format camera, and shown in figures 3 through 15. The plate which did not have any lubricants applied is noted in figure 3, because a more detailed picture was not available for this report.

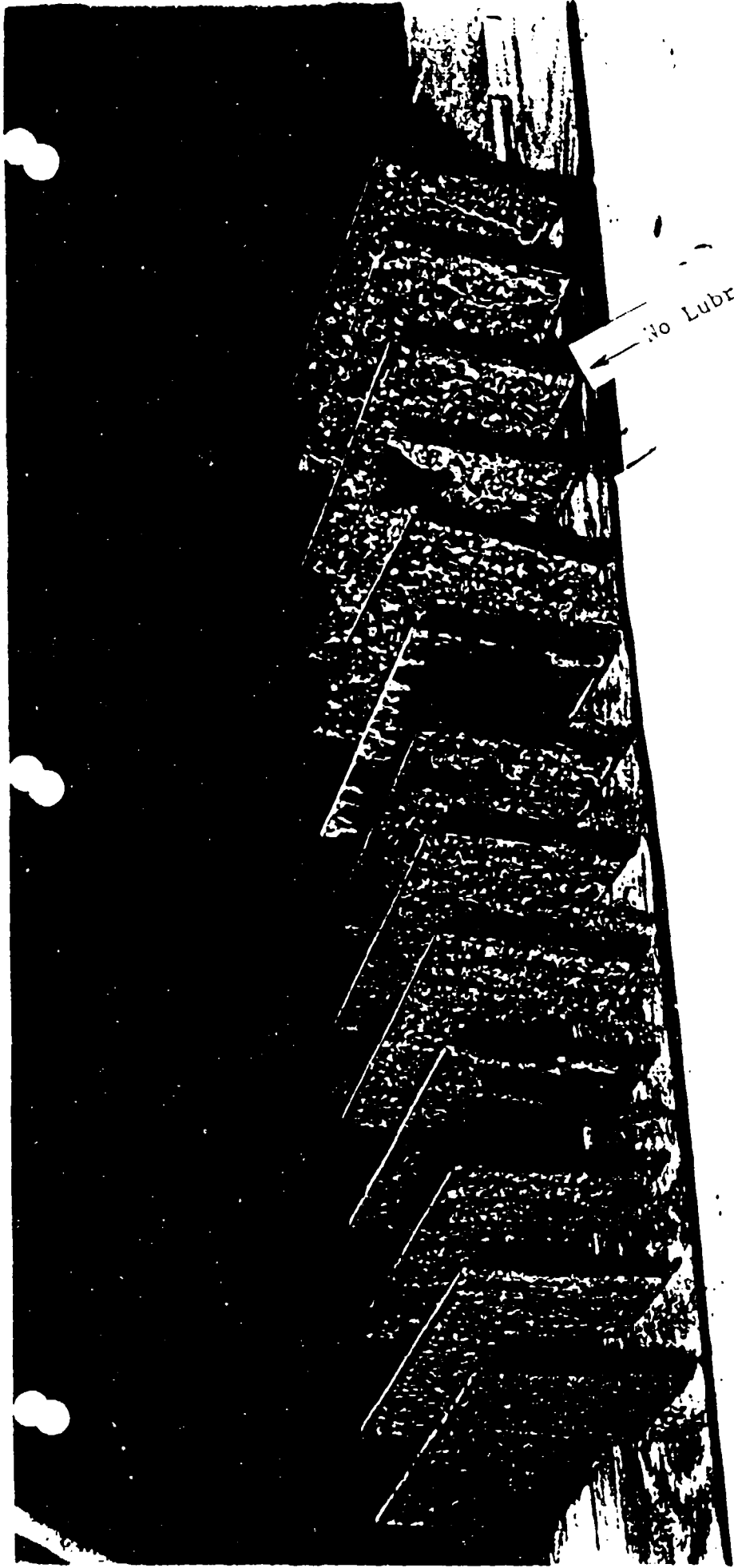
Lubricants which did the best job of limiting corrosion were Brand H and CLP. All other lubricants tested resulted in the formation of a significant amount of surface rust on the phosphate-coated AISI 2020 steel plates.

4 CONCLUSIONS AND RECOMMENDATIONS:

Based on the results of the dust tests and the salt fog test, the commercially available lubricants investigated did not offer any significant advantages when used on M16A1 rifles in an environment of excessive airborne dust, high temperatures and corrosive airborne salts, when compared to the lubricants currently used by the U.S. Navy.

Currently, the fleet uses Planned Maintenance Subsystem Maintenance Requirement Cards (MRC's) to lubricate small arms. MIL-L-63460D CLP is listed as the primary lubricant, with VV-L-800C oil as an alternate. Other lubricants have been substituted for unusual environments and mission specific applications, usually by Special Warfare groups. Lubricants that will not wash off the weapon during swimming operations, lubricants for surf zone (i.e. salt water and large crystal sand) or "no-muss no-fuss" lubricants for an emplaced sniper, etc. may be required. Ultimately, the lubricants used are based on prior use and confidence in the special application. However, for the fleet utilizing MRC cards, MIL-L-63460D CLP is an adequate lubricant for general purpose use in dusty, corrosive, high temperature environments.

REPRODUCED AT GOVERNMENT EXPENSE



48 hr. Salt Fog
Test Fixture

Figure 3

48-Hour Salt Fog Exposure
REPRODUCED AT GOVERNMENT EXPENSE

BRAND A
Type 3

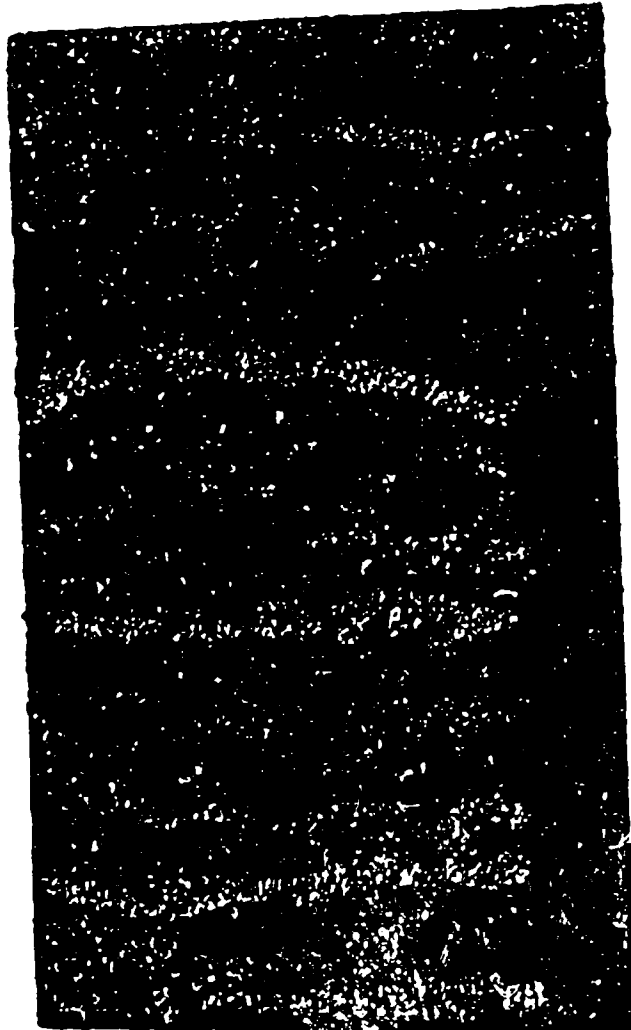


Figure 4

BRAND C

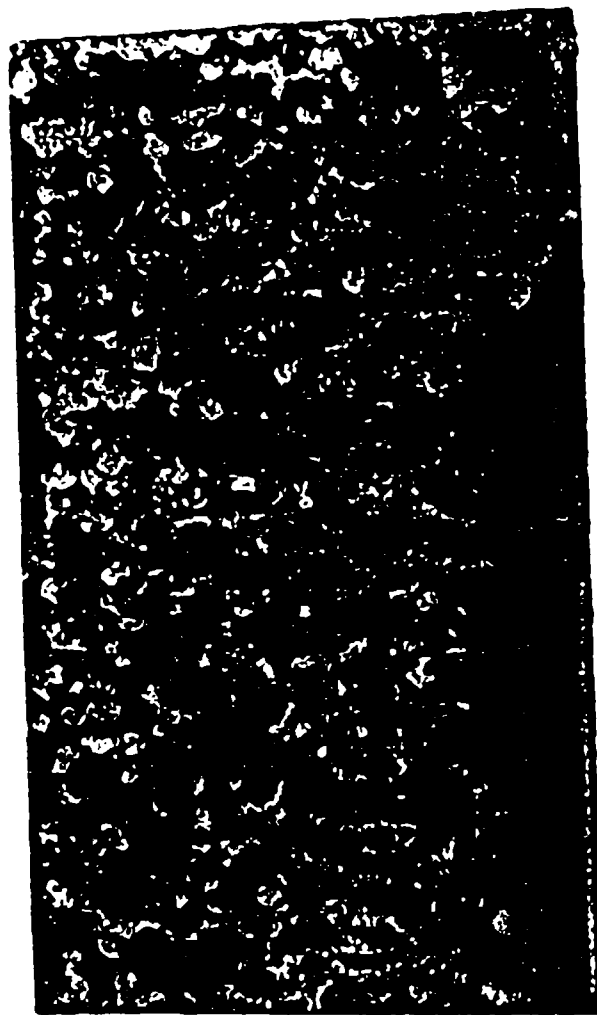


Figure 5

BRAND D

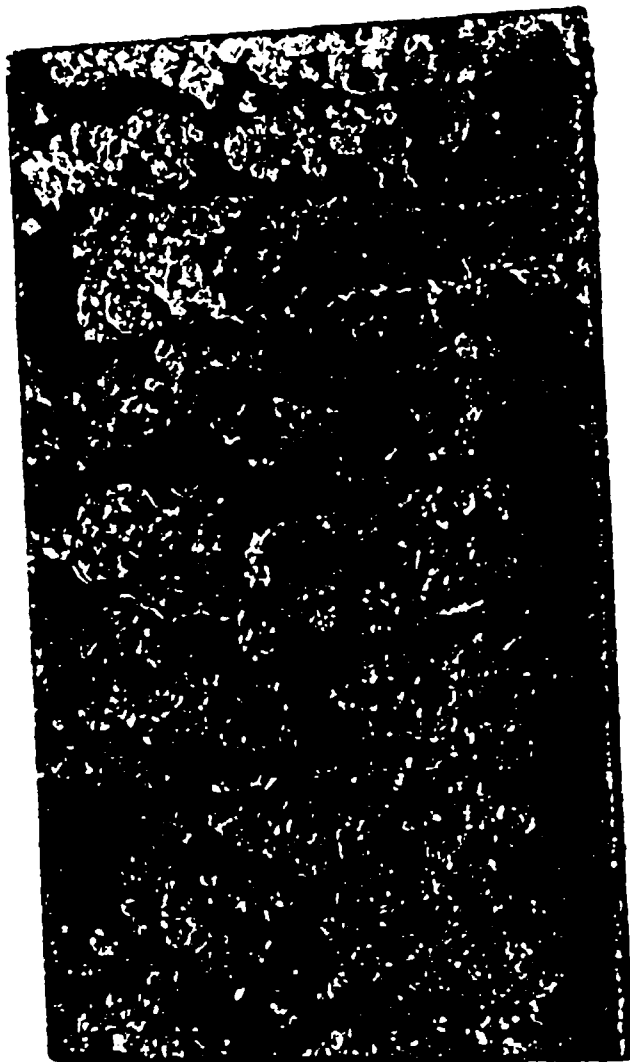


Figure 6

REPRODUCED AT GOVERNMENT EXPENSE

48 HOUR SALT FOG

MIL-L-63460
BREAK-FREE® CLP

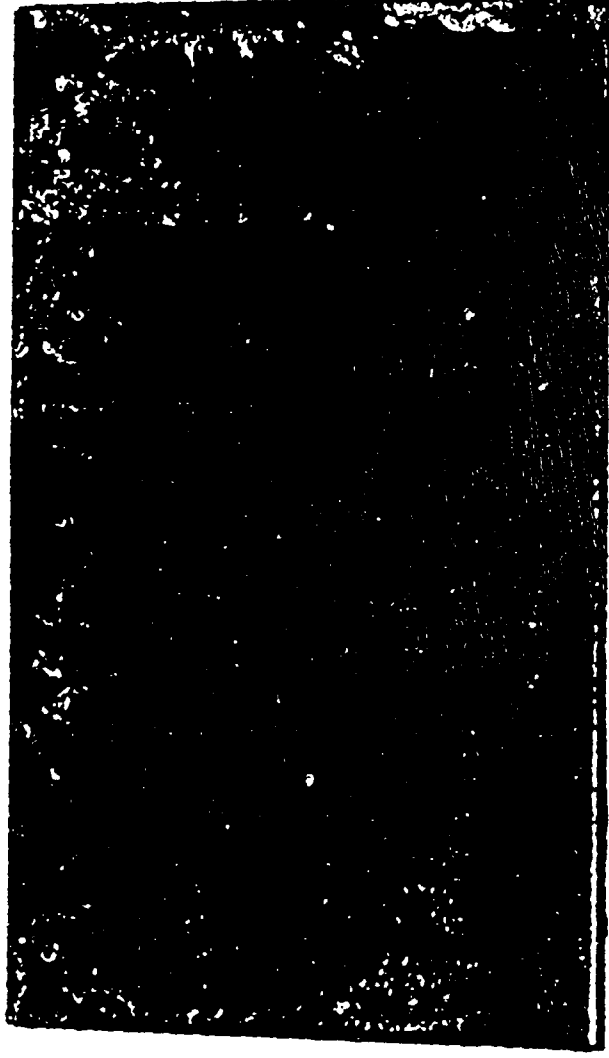


Figure 7

IN PROGRESS AT GOVERNMENT EXPENSE

BRAND E

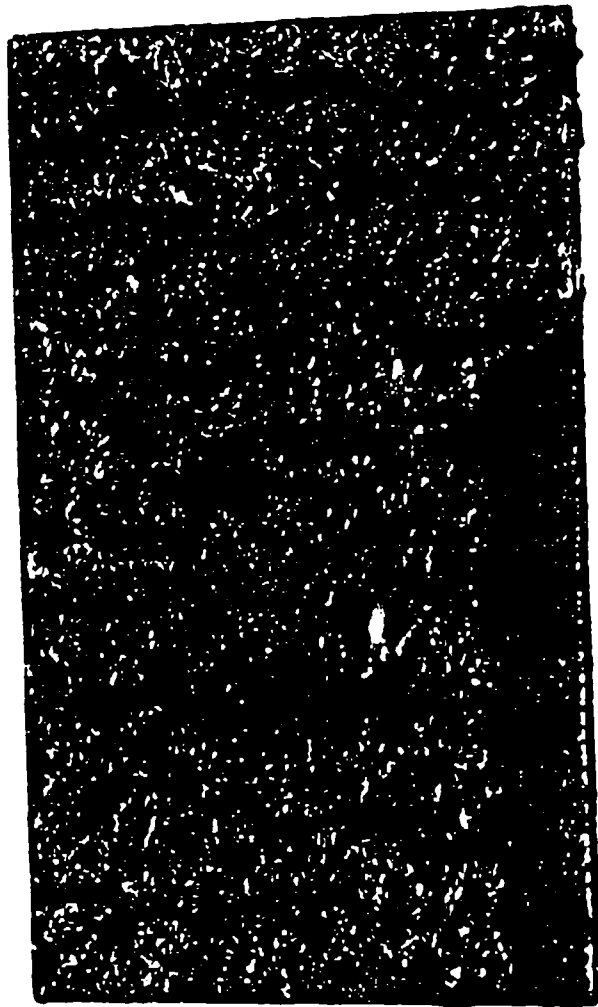


Figure 8

BRAND F



Figure 9

BRAND 6



Figure 10

BRAND H



Figure 11

REPRODUCED AT GOVERNMENT EXPENSE

48 HOUR SALT FOG

GRAPHITE POWDER



Figure 12

BRAND I



Figure 13

48 HOUR SALT FOG

MIL-L-46000

LSA

WEAPONS OIL, MEDIUM



Figure 14

48 HOUR SALT FOG

WV-L-800
LUBRICATING OIL, GENERAL PURPOSE



Figure 15

**END
FILMED**

DATE:

3-93

DTIC