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# 81MM MORTAR BASEPLATE M-3 PAD TEST

Stanley M. Jankowski, et al

Watervliet Arsenal
Watervliet, New York

August 1972

# TECHNICAL REPORT

WVT-7241

## 81MM MORTAR BASEPLATE M-3 PAD TEST





AUGUST 1972

**BENÉT WEAPONS LABORATORY**
**WATERVLIET ARSENAL**
**Watervliet, New York**

AMCMS No. 4410.16.0008

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13. ABSTRACT

Various organizations, including Viet Nam, have reported problems involving seizure of the socket to the baseplate. The testing program discussed in this report was initiated in an effort to solve this socket seizure problem. Three materials were tested: the previously standard Neoprene; the current standard Viblon; and Fluorglas. Testing of these materials included: static compression tests; soak tests; and pressure cycling tests. The compression tests showed Fluorglas capable of withstanding the grestest compressive load (20,000 psi) and possessing the lowest recovery rate (.001 in./hr.). Soak tests in various environments revealed that Fluorglas suffered no apparent expansions or softening in any of the five media tested. The other materials suffered varying degrees of damage. Most of the effort was spent in hydraulically pressure cycling the three materials, (cycling loads equivalent to impact loads during firing), while they were subjected to various foreign matter environments, i.e. dirt, sand, etc. The result of the three tests conducted was that Fluorglas seemed to hold up better in general than the other materials and was therefore recommended as a fix to the problem.

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| 81mm Mortar | | | | | | |
| M-3 Baseplate Pad | | | | | | |
| Test Equipment | | | | | | |
| Abrasion Testers | | | | | | |
| Test Chambers | | | | | | |
| Simulators | | | | | | |

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- 1 -

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BY

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AND

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Introduction

The 81MM Mortar baseplate M-3, currently employed, has a stepped pocket machined in it. A matching stepped socket fits into the baseplate pocket and rests on a pad and three annular rings. Currently, Viblon, coated with GAA grease, is used for the pad and ring material. The problem arose when reports were received that the socket could not be rotated relative to the baseplate, as is required for traversing the weapon, when using the previous standard Neoprene material for the rings and pad.

This problem, referred to as the socket seizure problem, was first detailed in PCR A082-W4, which was the result of a report from Ft. Benning. Reports from other sources, including Viet Nam, have also noted socket binding or seizure of the baseplate socket.

The current Viblon coated with GAA grease was released as an interim solution to PCR A082-W4.

The tactical result of these seizures had been an inability to rotate the mortar to accommodate large changes in direction of fire.

Examination of the components after such a seizure has shown that the pad and rings have experienced shredding and delamination. Foreign matter i.e., dirt, sand and water was found in the socket cavity and on the load bearing surfaces.

It was felt that the use of grease and oil such as would be used in the field as lubricants might also contribute to the deterioration or dimensional changes in the pad and rings.

As a result of this problem several avenues of investigation were undertaken. These ranged from a material change to redesign of the baseplate/socket interface area. Each of these approaches is reported elsewhere and is mentioned here solely for reference and information.

The purpose of the testing reported here was to investigate the three materials (Fluorglas, Viblon and Neoprene) presently available for use in the

M3 mortar baseplate. This investigation was limited to three areas: the load-deflection behavior of these materials under static load; the dimensional behavior of these materials when exposed to various environments for prolonged periods; and the behavior of these materials when cyclicly loaded while submerged in various environments.

## Test Procedures

### Static Compression Test:

Although some published data is available, it was felt necessary to check the behavior of these materials when subjected to a compressive load:

Fluorglas - approximate compressive strength 26,000 psi (published)
Viblon - ultimate compressive strength in excess of 10,000 psi (published)
Neoprene - unavailable - not normally provided.

The pad of each sample set was compressed on the 60,000 lb. tension tester. Load and deflection were recorded at various points. In addition to the three types of material under test, a pad from the standard Fabreeka set was tested. The recovery after load removal was also recorded. This data is shown in Figs. 1 a and 1 b.

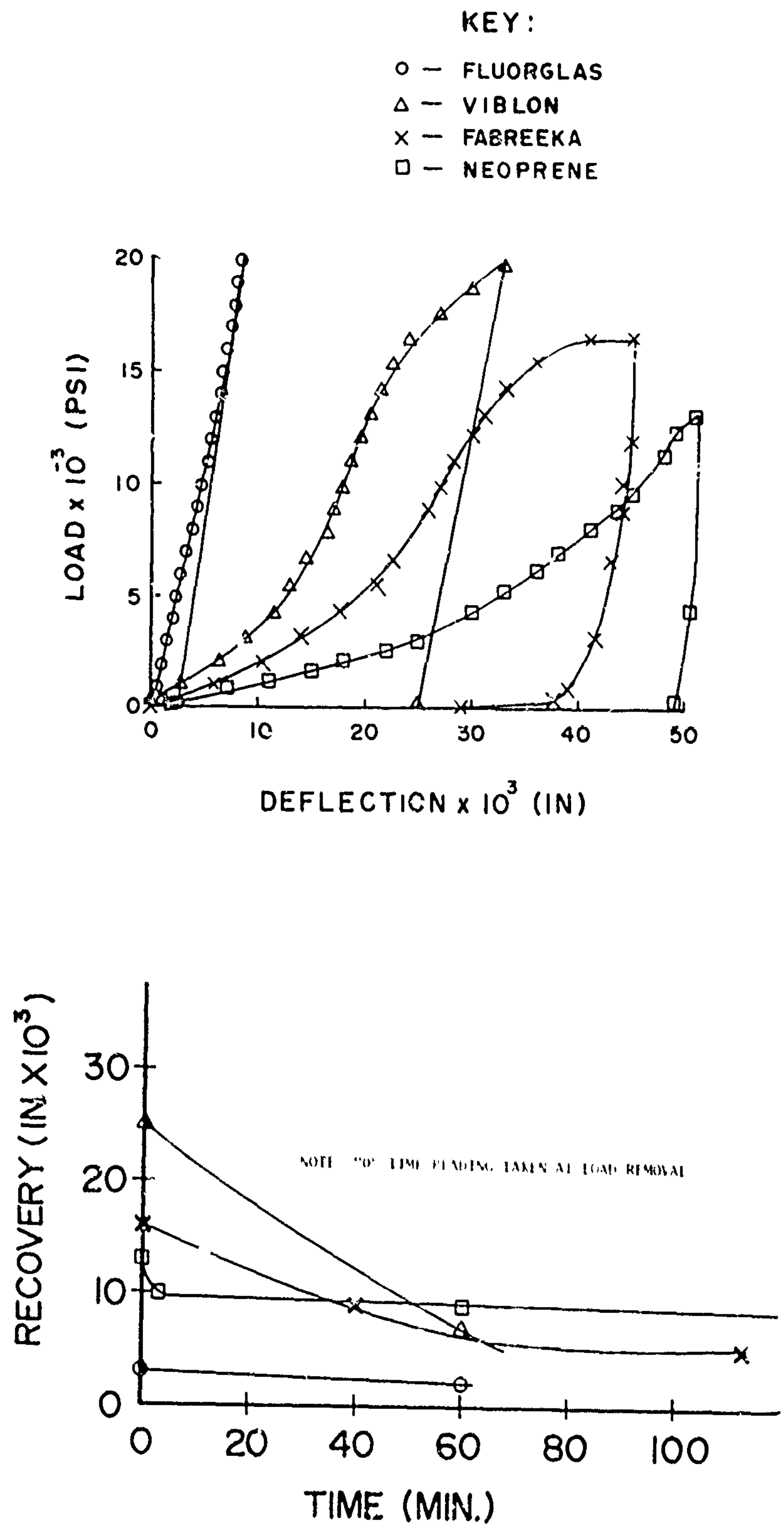
### Soak Test:

Sets of pads and rings were measured initially and then submerged in the following: water, salt water, GAA grease, SAE 30 oil and Mil-L-46000 lubricant. Measurements of each set were made at approximately 24 hr. intervals until the environment had little or no further dimensional affect (approx. 400 hrs) on the pads. The data obtained is shown in Figs. 2 a thru 2 e.

### Cycling Test: Operation of Test Apparatus

Each set of rings and pad was tested cyclically using the test fixture set-up shown in Fig. 3 a.

Hydraulic pressure was used to produce a load of 146,000 lb., which is equivalent to that from maximum firing pressure when multiplied by an impact factor of 2.




B

Figure 1. Pad Material Comparisons: Load Vs Deflection and Recovery Vs Time

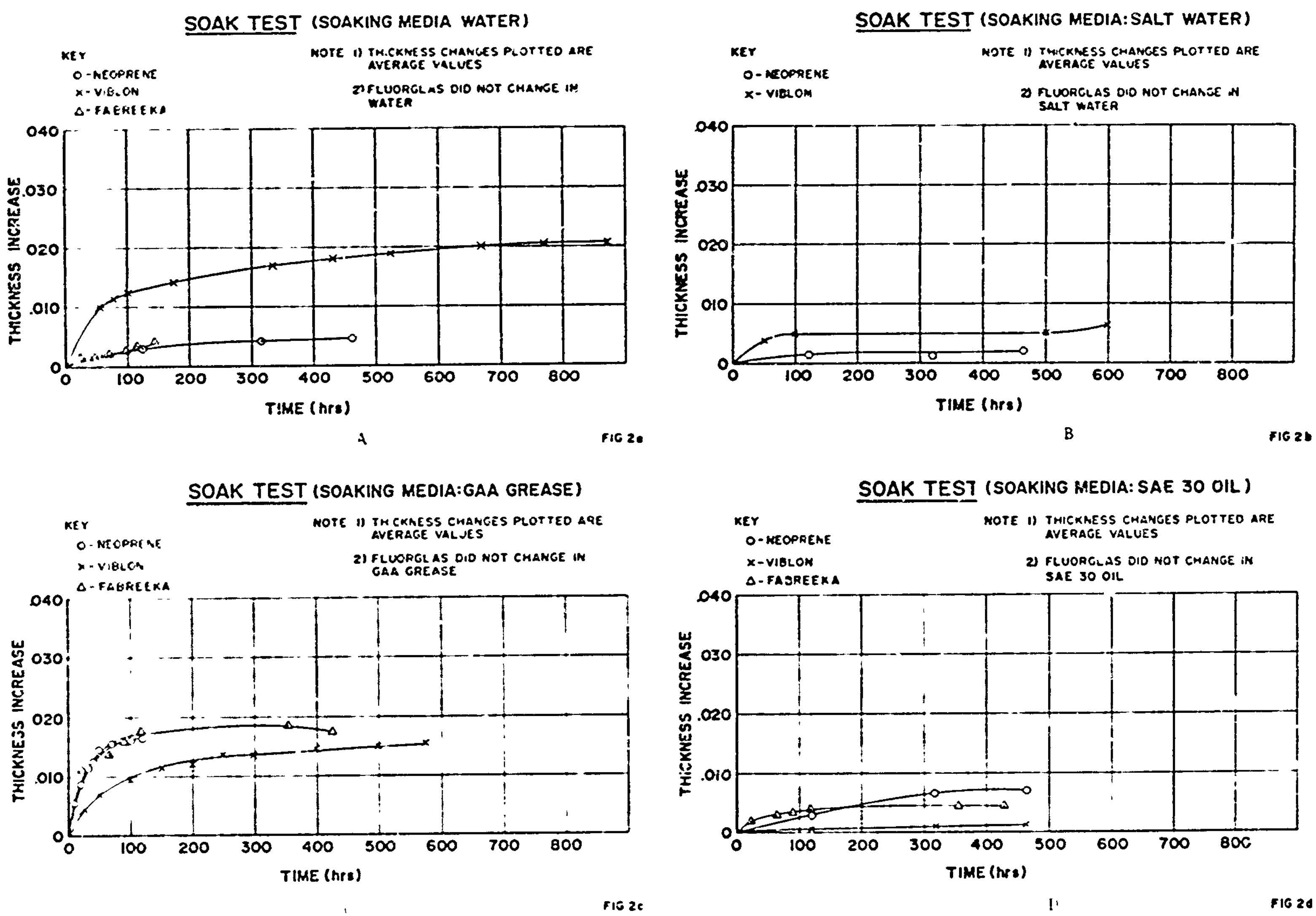
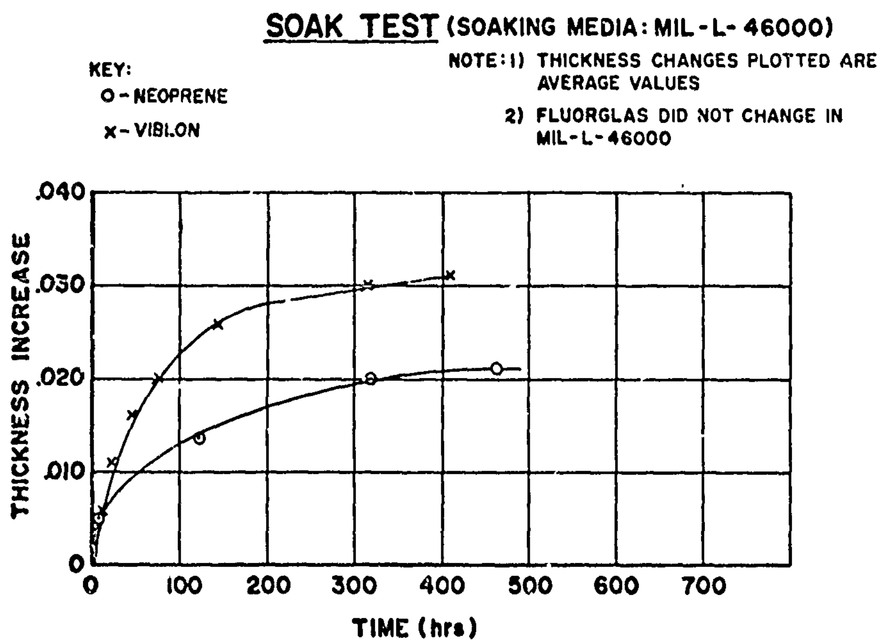


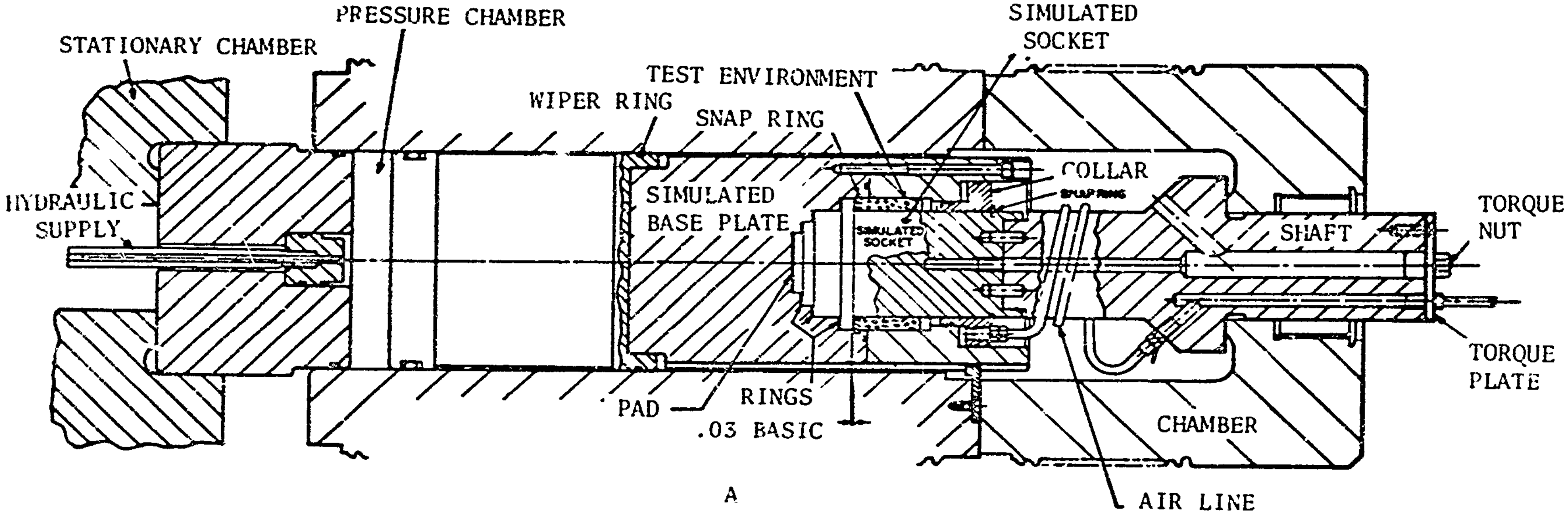

Figure 2. Soak Tests: Thickness Increase Vs Time




E

FIG. 2e

Figure 2. (continued)

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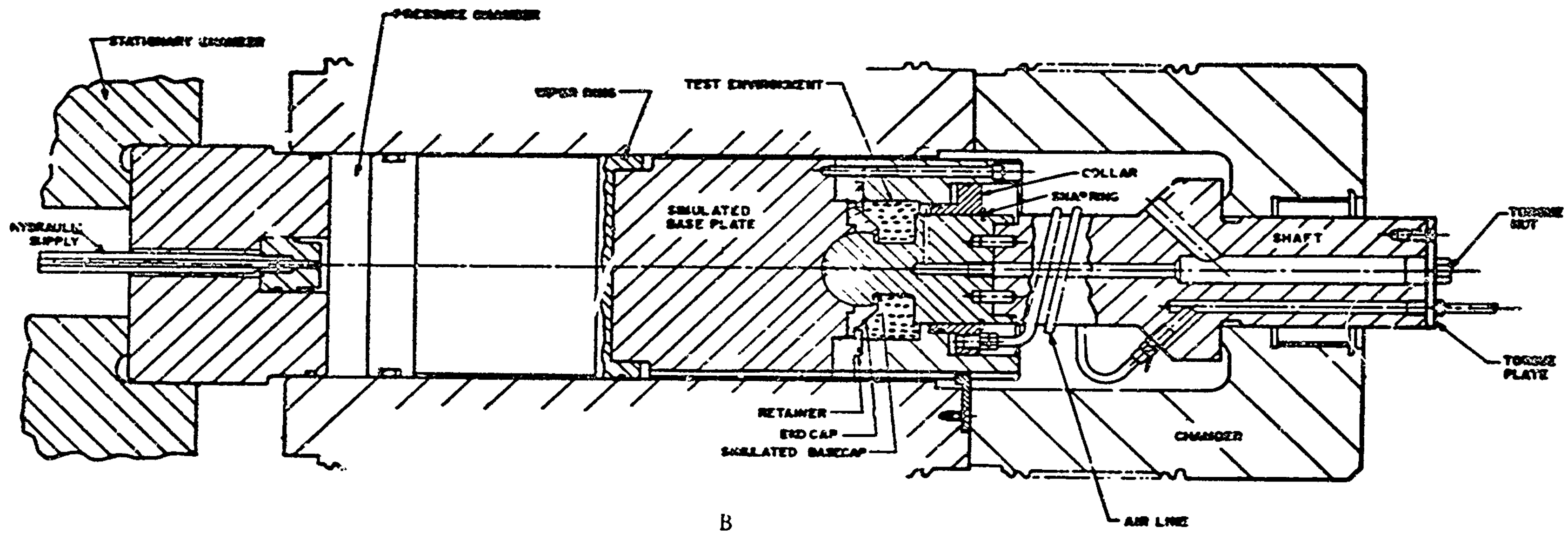
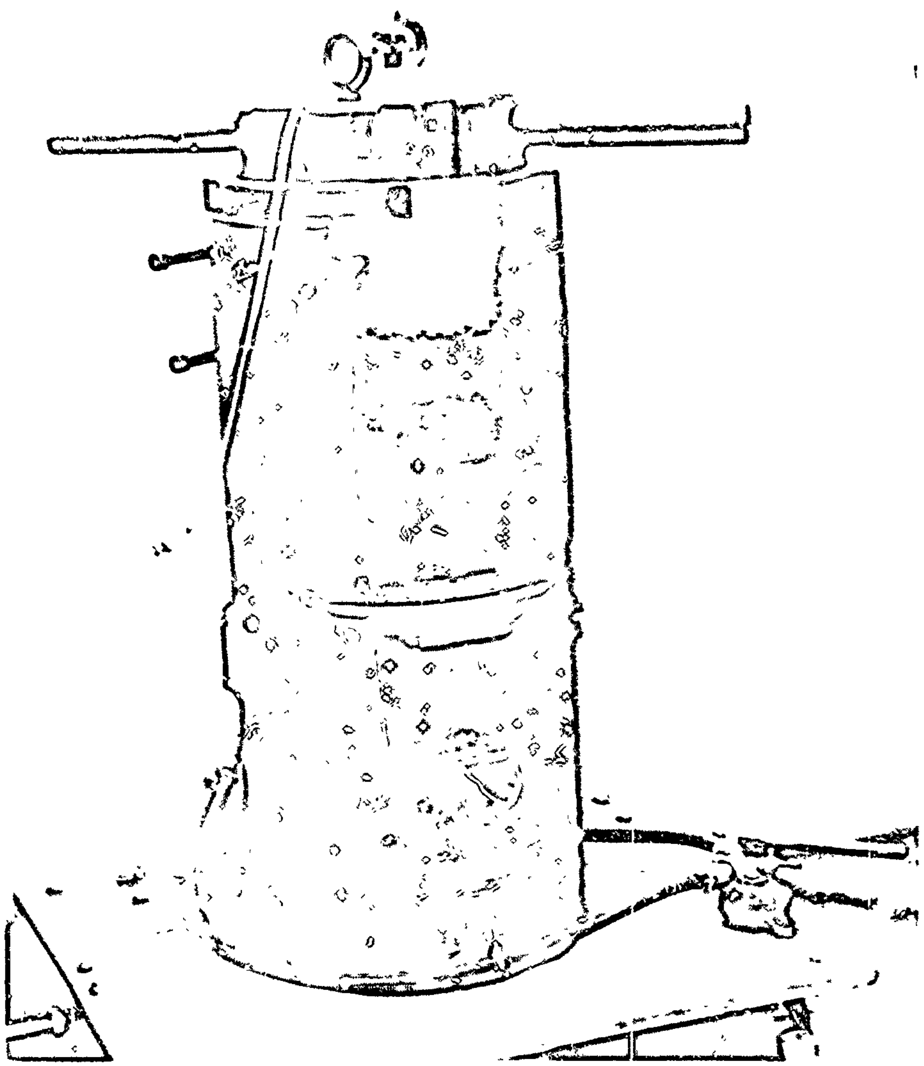



B

Figure 3. Pad Test Fixture Drawings and Photographs



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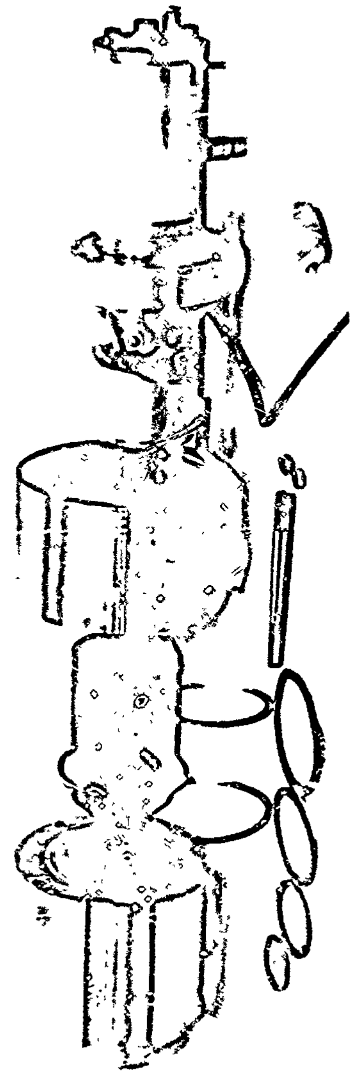


D- Interior

gure 3. (continued)

Strain gages were applied to the shaft and connected to a recorder in order to monitor the actual load.

An air source (90 psi) was permanently attached to assure that when hydraulic pressure was removed the rings and pad would be completely unloaded and no residual compression load would be present.

The hydraulic pressure was cycled at 4 cycles/min. and applied perpendicular to the plane of the rings and pad.

Each cycle took approx. 16.8 sec. and was divided as follows:

| | |
|---|---|
| rise time | 7.2 sec. |
| peak pressure | 2.0 " |
| fall time | .8 " |
| Dwell (no pressure) | 6.8 " |

The various foreign materials used as the test environment were retained around the ring and pad area by a well attached to the test fixture.

This method was applied to 46 sets of pads: 14 Neoprene , 19 Viblon and 13 Fluorglas. Torque required to rotate the simulated socket was measured with a torque wrench both clockwise and counter-clockwise. Fig. 4 a lists all of the cycling tests which were conducted; Fig. 4 b shows which of these runs may be compared. The comparisons which have been made are shown graphically Figs. 5 a1 - 5d8b.

In addition to cyclically testing the present pad configuration, three tests were made using a ball (spherical) socket and matching baseplate Fig. 3 b. Diameters of this ball and socket interface are the same as the present basecap and socket.

Discussion of Results:

Only a few of all the possible comparisons were tested. Many were eliminated in the interest of economy, based on the assumption that the more severe environments should be tested.

SUMMARY SHEET
(Cycling Test)

| RUN NO. | PAD MAT'L | SOCKET MAT'L | PRECONDITION OF MAT'L | TEST ENVIRO | CYCLES | RESULTS |
|---|---|---|---|---|---|---|
| 1 | Neoprene | Al. | None | None | 400 | Operable |
| 2 | Neoprene | " | None | None | 1000 | Operable |
| 3 | Neoprene | " | None | Mud | 550 | Operable |
| 4 | Viblon | " | Test Ass'y soaked in salt $H_2O$ | Mud | 1000 | Operable |
| 5 | Neoprene | " | Test Ass'y soaked in $H_2O$ | Mud | 1051 | Operable |
| 6 | Fluorglas | " | Salt $H_2O$ | Mud | 1001 | Operable Reusable |
| 7 | Fluorglas (.030 Champ) | " | None | Mud | 1001 | Operable Reusable |
| 8 | Neoprene | " | $H_2O$ | Mud | 1001 | Operable Reusable |
| 9 | Neoprene | " | None | Mud | 2001 | Operable |
| 10 | Neoprene | " | None | Wet Sand | 50 | Failed |
| 11 | Viblon | " | None | Wet Sand | 1000 | Failed Reusable |
| 12 | Fluorglas | " | None | Wet Sand | 250 | Failed Reusable |
| 13 | Viblon | " | None | Wet Sand | 300 | Failed Reusable |
| 14 | Viblon | " | 30 day soak in salt $H_2O$ | Mud & Sand | 1000 | Operable Reusable |
| 15 | Neoprene | " | None | Mud & Sand | 800 | Failed |
| 16 | Fluorglas | " | None | Mud & Sand | 1001 | Operable Reusable |
| 17 | Fluorglas (.030 Champ) | " | None | Dry Sand | 1001 | Operable Reusable |

A

Figure 4. Cycling Test Summary

| RUN NO. | PAD MAT'L | SOCKET MAT'L | PRECONDITION OF MAT'L | TEST ENVIRO | CYCLES | RESULTS |
|---|---|---|---|---|---|---|
| 18 | Fluorglas (.030 Champ) | Al. | None | Dry Fine Sand | 1001 | Operable Reusable |
| 19 | Fluorglas (.030 Champ) | " | None | Dry Coarse Sand | 1001 | Operable Reusable |
| 20* | Fluorglas (.030 Champ) | " | None | Wet Coarse Sand | 50 | Failed Reusable |
| 21* | Fluorglas (.030 Champ) | " | None | Wet Medium Sand | 500 | Failed Reusable |
| 22 | Viblon | Steel | None | Dry Coarse Sand | 1001 | Failed |
| 23 | Viblon | " | None | Dry Coarse Sand | 1001 | Operable Reusable |
| 24 | Viblon | " | None | Wet Coarse Sand | 59 | Failed Reusable |
| 25 | Neoprene | " | None | Dry Coarse Sand | 1001 | Operable |
| 26 | Neoprene | " | None | Wet coarse Sand | 900 | Failed |
| 27 | Fluorglas | " | None | Dry Coarse Sand | 1001 | Operable Reusable |
| 28 | Fluorglas | " | None | Dry Coarse Sand | 1001 | Operable Reusable |
| 29 | Neoprene | " | None | Dry Fine Sand | 1001 | Operable Reusable |
| 30 | Viblon | " | None | Dry Fine Sand | 1001 | Operable Reusable |
| 31 | Neoprene | " | None | Wet Medium Sand | 100 | Failed Reusable |
| 32 | Viblon | " | None | Dry | 1001 | Operable Reusable |
| 33 | Viblon | " | None | Wet Medium Sand | 1051 | Operable Reusable |
| 34 | Viblon | " | None | Mud | 1001 | Operable Reusable |

A (continued)

| RUN NO. | PAD MAT'L | SOCKET MAT'L | PRECONDITION OF MAT'L | TEST ENVIRO | CYCLES | RESULTS |
|---|---|---|---|---|---|---|
| 35 | Viblon | Steel | None | Wet Mixed Sand | 1001 | Operable Reusable |
| 36 | Viblon | " | Rings & Pad coated w/GAA grease | Wet Coarse Sand | 1001 | Operable Reusable |
| 37 | Fluorglas | " | " | Wet Coarse Sand | 300 | Failed Reusable |
| 38 | Viblon | " | Mil-L-46000 | Wet Mixed Sand | 600 | Failed |
| 39 | Viblon | " | GAA grease | Wet Mixed Sand | 1001 | Operable Reusable |
| 40 | Viblon | " | MIL-L-46000 | Wet Medium Sand | 50 | Failed |
| 41 | Neoprene | " | GAA grease | Dry Coarse Sand | 1001 | Operable |
| 42 | Viblon | " | GAA grease | Wet medium Sand | 1001 | Operable Reusable |
| 43 | Viblon | " | GAA grease | Dry Coarse Sand | 1001 | Operable |
| 44 | Viblon | " | MIL-L-46000 | Dry Coarse Sand | 1001 | Operable |
| 45 | Neoprene | " | MIL-L-46000 | Dry Coarse Sand | 200 | Failed |
| 46 | Fluorglas | Aluminum w/ ann. rings | None | Wet Coarse Sand | 1001 | Operable |
| 47 | | Spherical Steel ($R_c$-21) | None | Wet Coarse Sand | 50' | Failed Reusable |
| 48 | | " | None | Wet Coarse Sand | 1000 | Operable Failed |
| 49 | | " | None | Wet Fine Sand | 1000 | Operable Reusable |

NOTES:

* Runs 20 & 21 were conducted using same set of pads.

□ Socket could not be rotated with torque 50 ft. lbs. at No. of cycles indicated.

"Failed" means that the torque required to rotate the simulated socket exceeds 50 ft #

"Reusable" means that the pads after completion of test were still in good enough condition that, with cleaning, they could be reused.

4 (continued)

| ENVIRONMENT | MAT'L | PRE CONDITION | | | | |
|---|---|---|---|---|---|---|
| | | NONE | SALT $H_2O$ | $H_2O$ | GAA GREASE | MIL-L-46000 |
| DRY | N | RUNS 1,2 | | | | |
| | V | RUN 32 | | | | |
| | F | RUN 28 | | | | |
| MUD | N | RUN 3,9 | | RUN 5,8 | | |
| | V | RUN 34 | RUN 4 | | | |
| | F | RUN 7 | | RUN 6 | | |
| MUD & MIXED SAND | N | RUN 15 | | | | |
| | V | RUN 35 | RUN 14 | | | |
| | F | RUN 16 | | | | |
| MIXED SAND | N | RUN (10) | | | | |
| | V | RUN (11)(13) | | | RUN (39) | RUN (38) |
| | F | RUN (12) [17] | | | | |
| FINE SAND | N | RUN [29] | | | | |
| | V | RUN [30] | | | | |
| | F | RUN [18] | | | | |
| MEDIUM SAND | N | RUN (31) | | | | |
| | V | RUN (33) | | | RUN (42) | RUN (40) |
| | F | RUN (21) | | | | |
| COARSE SAND | N | RUN [25] (26) | | | RUN [41] | RUN [45] |
| | V | RUN [22] [23] (24) | | | RUN (36) [43] | RUN [44] |
| | F | RUN [illegible] 20 [27] (4[illegible]) | | | RUN (37) | |

( ) = WET ☐ = DRY

P

Figure 4. (continued)

Usually only one set was examined for each test condition, in the interest of economy. Where second runs were made, it was done because results from the first set were suspect.

Compression Test:

Each of the four materials tested were subjected to the maximum compressive load they could take without continuous extrusion at constant load. With each of the materials the load was recorded along with the resulting deflection at approximately 1000 psi increments.

The maximum compressive loads reached with these materials is as follows:

| | | |
|---|---|---|
| Fluorglas | - | 20,000 psi |
| Viblon | - | 20,000 psi |
| Fabreeka | - | 17,000 psi |
| Neoprene | - | 13,000 psi |

The results of the static compression test are shown on Fig. 1 a. As would be expected, Fluorglas is shown to be approximately 4 to 5 times less deformable than the previously used Neoprene. Viblon falls about in the middle. It should be pointed out that the Fabreeka pad material more closely approximates Viblon than either Neoprene or Fluorglas. After load removal the recovery of each material was noted as a function of time, the results of which are shown on Fig. 1 b.

For comparison, the average recovery rates were calculated and are listed.

| | | |
|---|---|---|
| Viblon | - | .018 in/hr |
| Fabreeka | - | .008 in/hr |
| Neoprene | - | .003 in/hr |
| Fluorglas | - | .001 in/hr |

As can be seen from Fig. 1 b , none of the materials tested have recovery rates rapid enough to recover completely between rounds. However, Fluorglas, since it possesses the lowest permanent set and remains essentially constant with time, offers the least effect on the weapon.

Soak Test:

During this test it was noticed that expansion due to absorption of environment was paralleled by softening of the material subjected to that environment.

The table below shows the relative severity (listed from most severe to least severe) of the environment on the material tested.

| Neoprene | Viblon | *Fabreeka |
|---|---|---|
| GAA grease | Mil-L-46000 | GAA grease |
| Mil-L-46000 | Water | Water |
| SAE 30 oil | GAA grease | SAE 30 oil |
| Water | Salt water | |
| Salt water | SAE 30 oil | |

*Fabreeka was not tested in Mil-L-46000 or salt water.

It was also noticed during this test that approximately 60% or more of the expansion and softening occurred in the first 100 hrs of soaking.

The most important result of this test, however, was that Fluorglas had no apparent expansion or softening in any of the five environments.

Cycle Test:

The plotted results of these tests are shown in Fig. 5a1 thru Fig. 5d8b.

In the beginning of this phase of testing, we had expected to find, in the mud environment, that the number of test cycles required and the number of rounds fired at A P G to achieve socket seizure would be approximately the same. This comparability was not obtained using mud mixed to the required specification. However, upon adding approximately 30% mixed sand the torque readings and seizures compared quite well with the APG firing data. The sand used for the cycling tests is identified in type and quantity on fig.6.

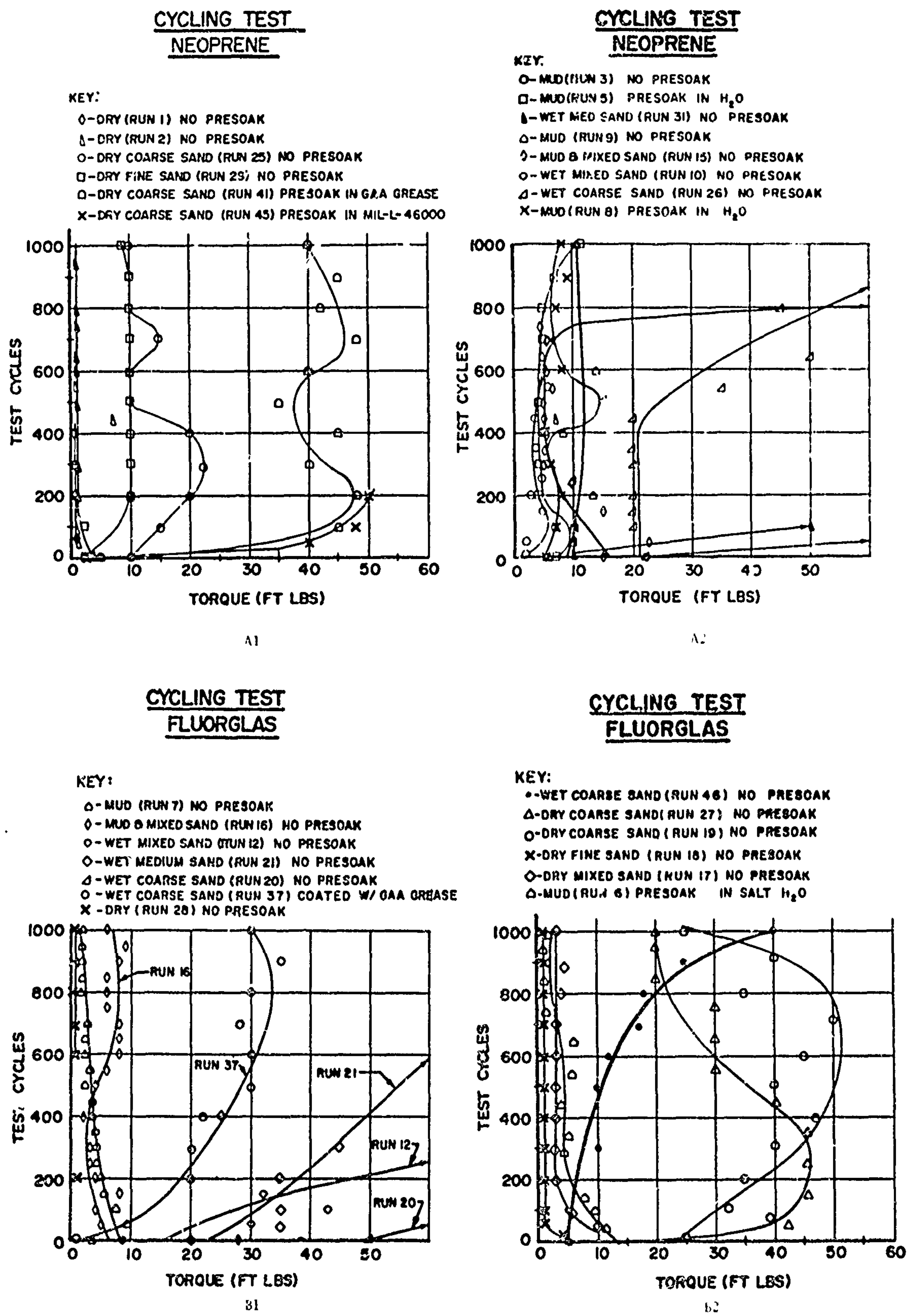
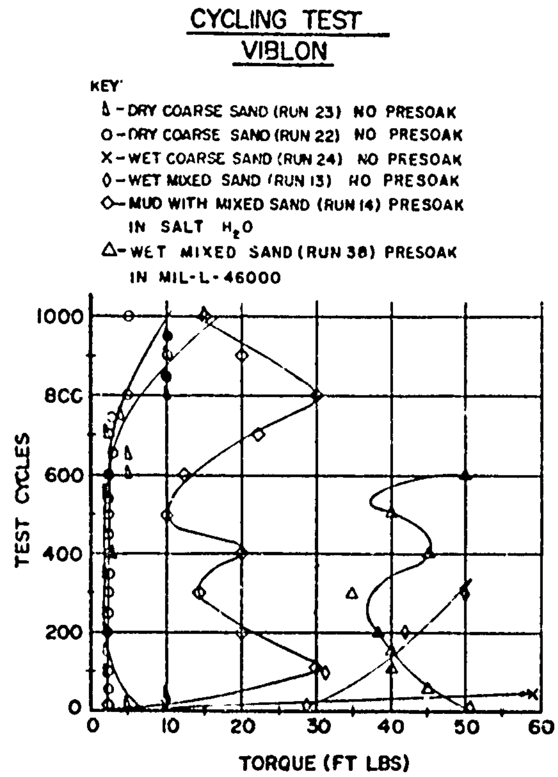
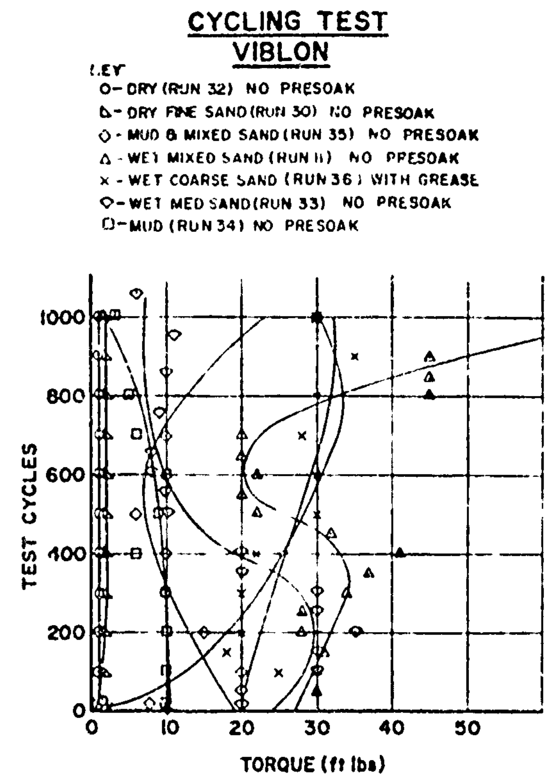



Figure 5. Cycling Tests: Materials and Conditions



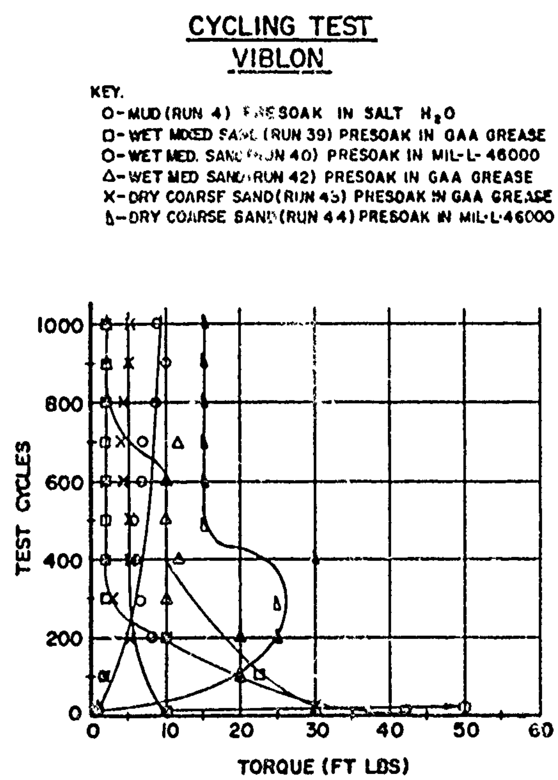
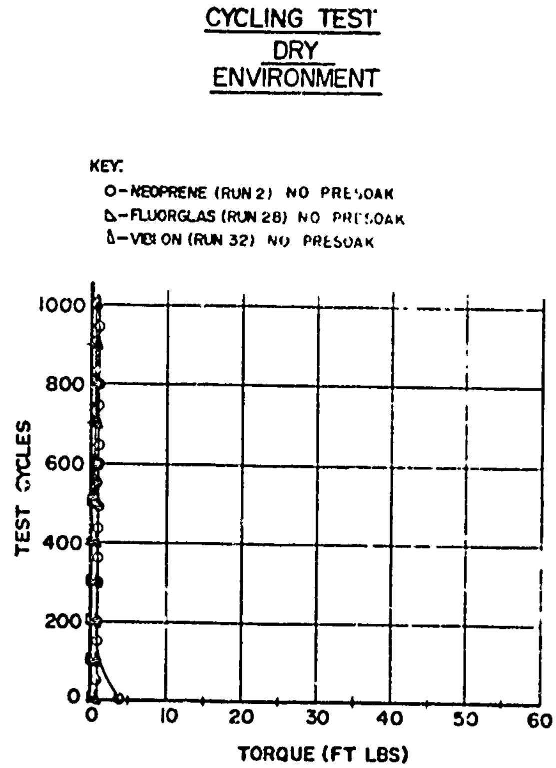
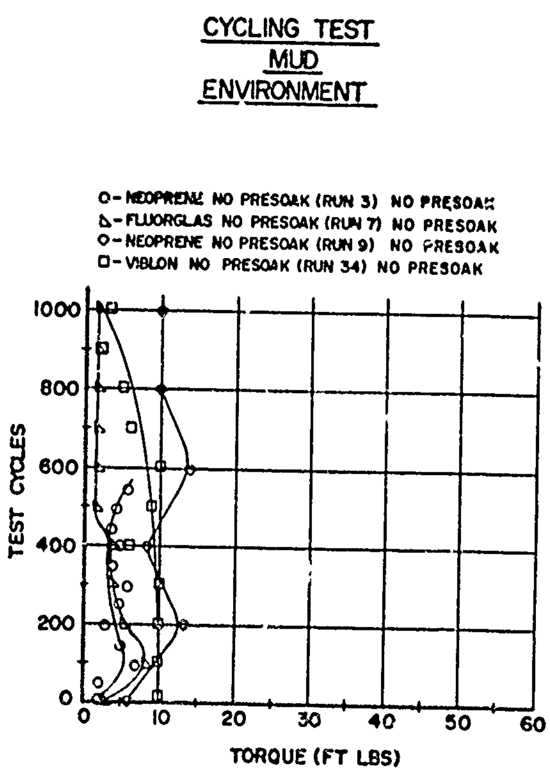




Figure 5. (continued)



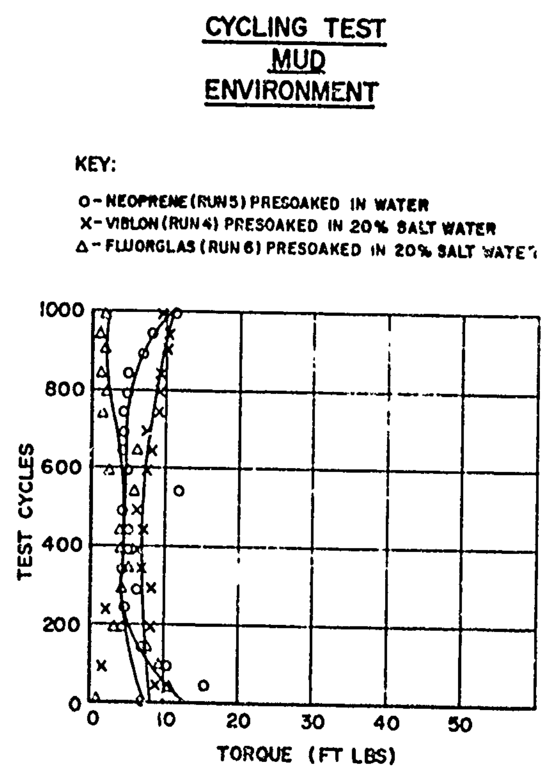
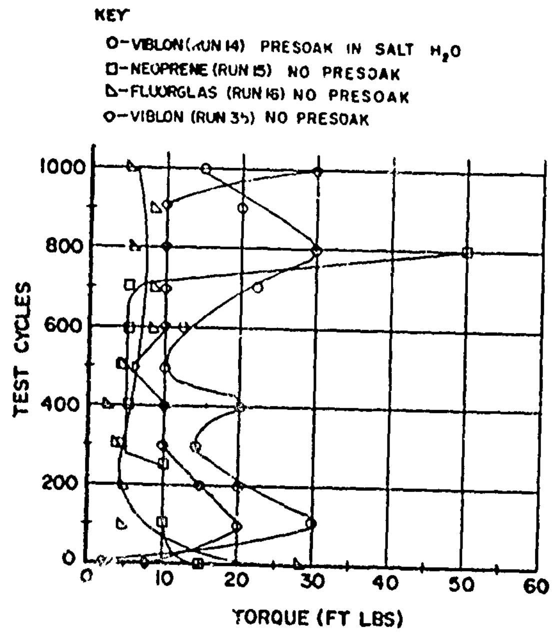
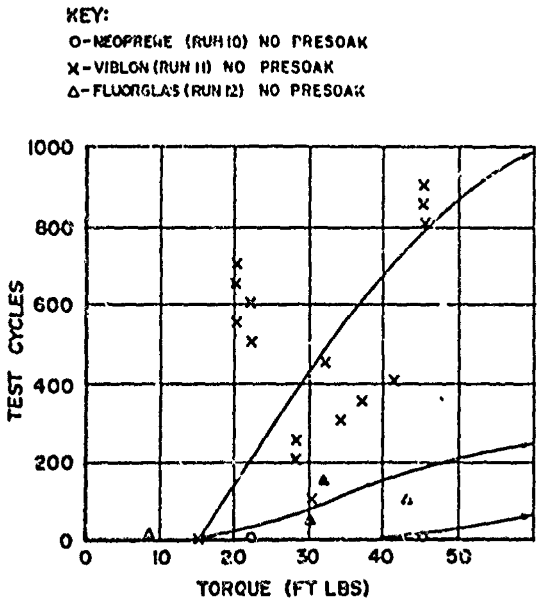




Figure 5. (continued)

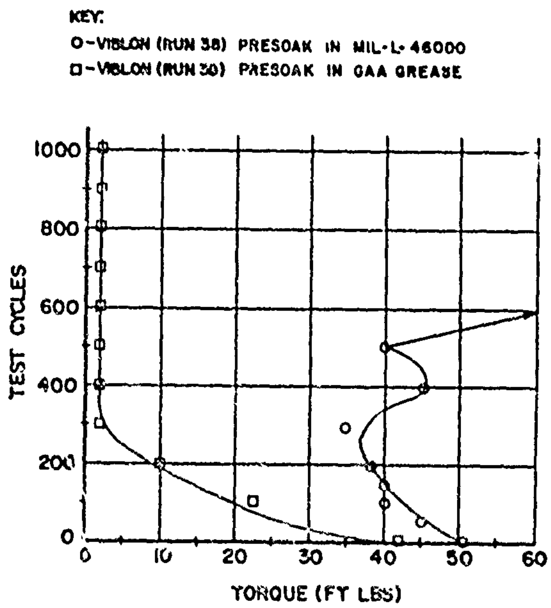
CYCLING TEST
MUD & SAND
ENVIRONMENT




CYCLING TEST
WET MIXED SAND
ENVIRONMENT




CYCLING TEST
WET MIXED SAND
ENVIRONMENT

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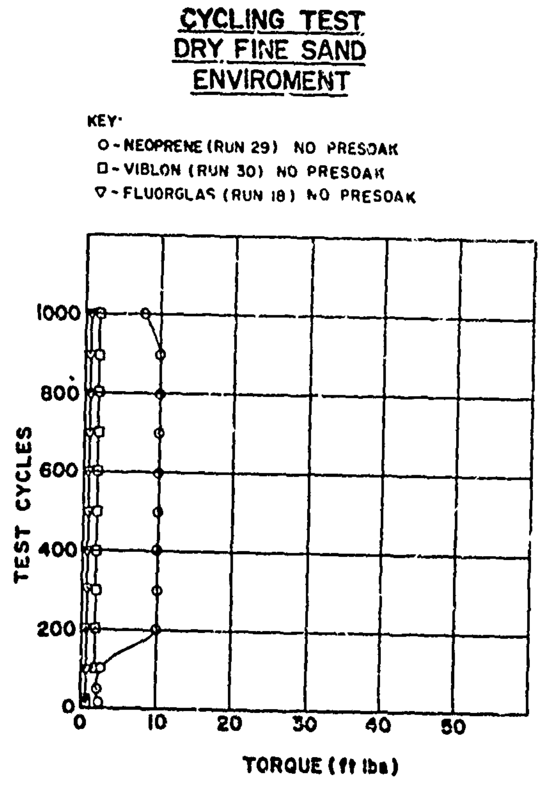


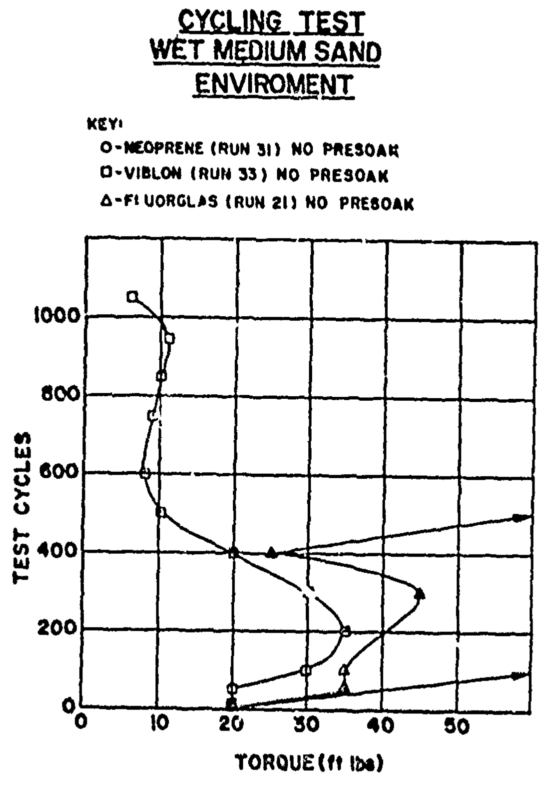


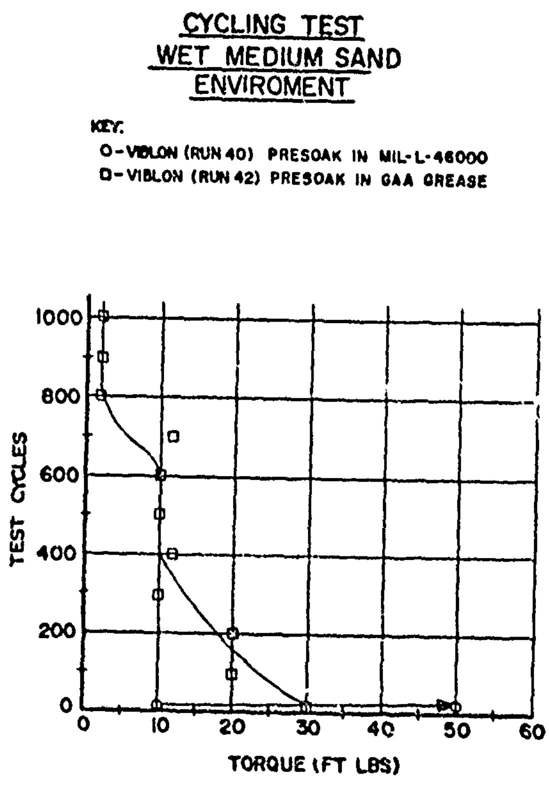


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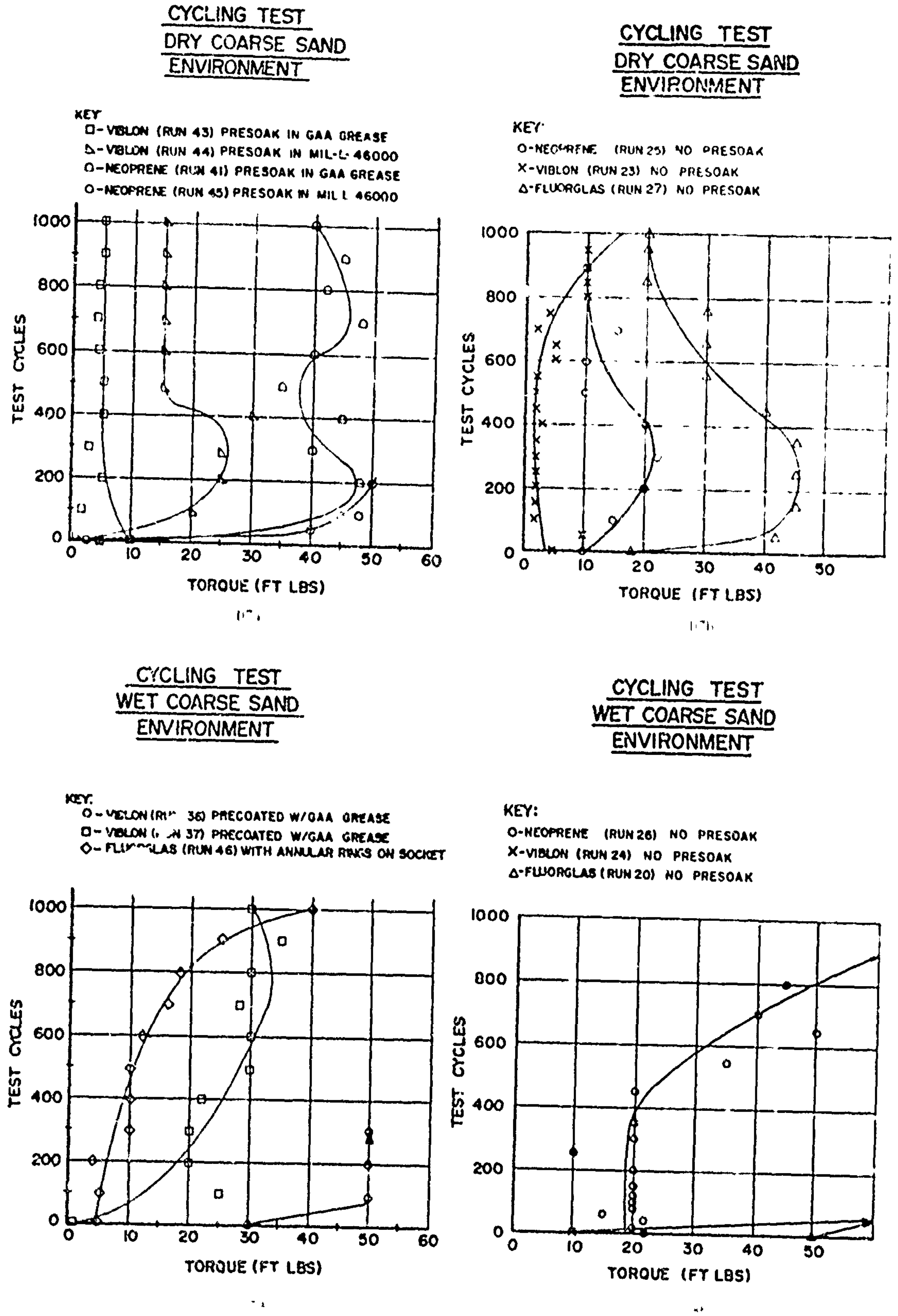



Figure 5. (continued)

## SAND IDENTIFICATION CHART

| | | |
|---|---|---|
| Coarse Sand | - | Sand, Placing, Dry, White<br>Granville No. 1<br>Approx. 60 Mesh<br>Stock No. 3428-47 |
| Medium Sand | - | Sand, Berkley Dry Float<br>Approx. 135 Mesh<br>Stock No. 3428-46 |
| Fine Sand | - | Flint Regular<br>Finer than 200 Mesh<br>Stock No. 5350-650-5620 |
| Mixed Sand | - | Approx. 1/3 each of<br>The three types above |
| Mud and Mixed Sand | - | Approx. 30% of mixed<br>sand added to the<br>Mud at time of test. |

Figure 6. Sand Types

In Figs. 5a, 5b, 5c the runs made with each material have been plotted; from this we can see that the most difficult environments were as follows:

| | | |
|---|---|---|
| Neoprene | - | Mud & mixed sand, wet mixed sand, wet coarse sand |
| Viblon | - | Wet coarse sand and wet mixed sand |
| Fluorglas | - | Wet coarse sand, wet mixed sand & wet med. sand |

The easiest environments were:

| | | |
|---|---|---|
| Neoprene | - | Dry |
| Viblon | - | Dry coarse sand, dry & dry fine sand |
| Fluorglas | - | Dry & dry fine sand |

Since there existed such a scattering of data in that the runs varied considerably, the data was also plotted for each environment tested, Figs. 5 d. As can be seen from these plots there is considerable overlap of data and particular trends are not easily discernable.

The nature of this type of failure - seizures due to foreign matter - is erratic and with only one sample generally being run for each condition the overlap and lack of consistency should be expected.

In testing the three materials in the three different sand granulation sizes it was found that, in general, as the granulation size increased, so did the torque required to rotate the socket. In one particular case using the coarse sand, it was impossible to determine if the pad and rings caused the seizure or if the large grains became wedged between the socket/baseplate interface and caused seizure.

Absolute values obtained in this test should not be used as indications of the exact amount of torque and/or life obtained while using these pads in the field. The primary reason for this being the rise time of the load during test was approximately seven (7) seconds - many hundreds of times slower that would be obtained during firing. The effects of the difference in use time is unknown at this time.

During soaking tests Fluorglas alone demonstrated it's ability to withstand the soaking environment without dimensional change, while Neoprene and Viblon both exhibited significant dimensional change.

When presoaked pads and rings were tested cyclically, there appeared to be a general increase in torque with those presoaked prior to cycling and those not presoaked. There has not been enough testing to isolate the effects of presoak.

Conclusions:

None of these materials completely solves the problem; we have degrees of improvement and each material will fail under certain conditions.

It was discovered that the physical appearance of the pad and rings was not related to seizure. Several sets were badly delaminated and shredded when they were removed, with no high torque measurements or seizure. Others, when removed after seizure, were found to look almost as good as new.

The grain size of the sand used was found to have an effect on the torque readings. Specifically, the larger the grain size used, the higher the torque readings.

During the compression tests it was found that Fluorglas was much more resistant to load than the other materials tested and also showed a much lower material set after load removal. Neoprene simply did not have enough structural strength and would delaminate under load.

The soak tests conducted showed Fluorglas was not dimensionally affected by any environment tested. Neoprene and Viblon, however, were affected dimensionally and, depending on the soaking environment, sometimes quite severely.

Of the sample pads cyclicly tested which had been presoaked it was noticed that both Neoprene and Viblon seemed to experience more fraying and delamination when presoaked than when they were not. Fluorglas did not appear to show much difference whether presoaked or not.

As a result of this testing it was found that three materials could be expected to last as follows:

Neoprene - in excess of 1000 cycles under most favorable conditions.
- less than 50 cycles under worst conditions.

Viblon - in excess of 1000 cycles under most favorable conditions.
- less than 50 cycles under worst conditions.

Fluorglas - in excess of 1000 cycles under most favorable conditions.
- less than 50 cycles under worst conditions.

On six of the tests made with Fluorglas the outside OD's were chamfered .030 in. The result of this chamfer was that it seemed to eliminate the "cupping" effect seen on other tests of the Fluorglas.

As far as torque readings were concerned the effect of this chamfer was undetermined.

The metal socket tested in the last three tests showed a generally lower torque level than any of the other materials and, even though it had undergone three separate tests, was still reusable.

<u>Recommendations</u>:

1. The current 10-15 in. lb maximum torque level required by TECOM is completely unrealistic. The socket can be rotated manually while offering a resisting torque of 50 in. lbs. manually and if the tube is used as a lever a torque of 90-100 ft. lbs. can be generated quite easily.

2. In any future testing, wet coarse sand should be used during the environment phase. This requirement should be incorporated in all future test directives for mortar baseplates.

3. Additional work to be accomplished in completing the investigation of the socket seizures problem is as follows:

a. Find the exact relation between laboratory cycles and firing. With this relationship established, materials could be tested in the laboratory without the high cost of firing. The relationship of foreign material penetration as related to firing shock is very important.

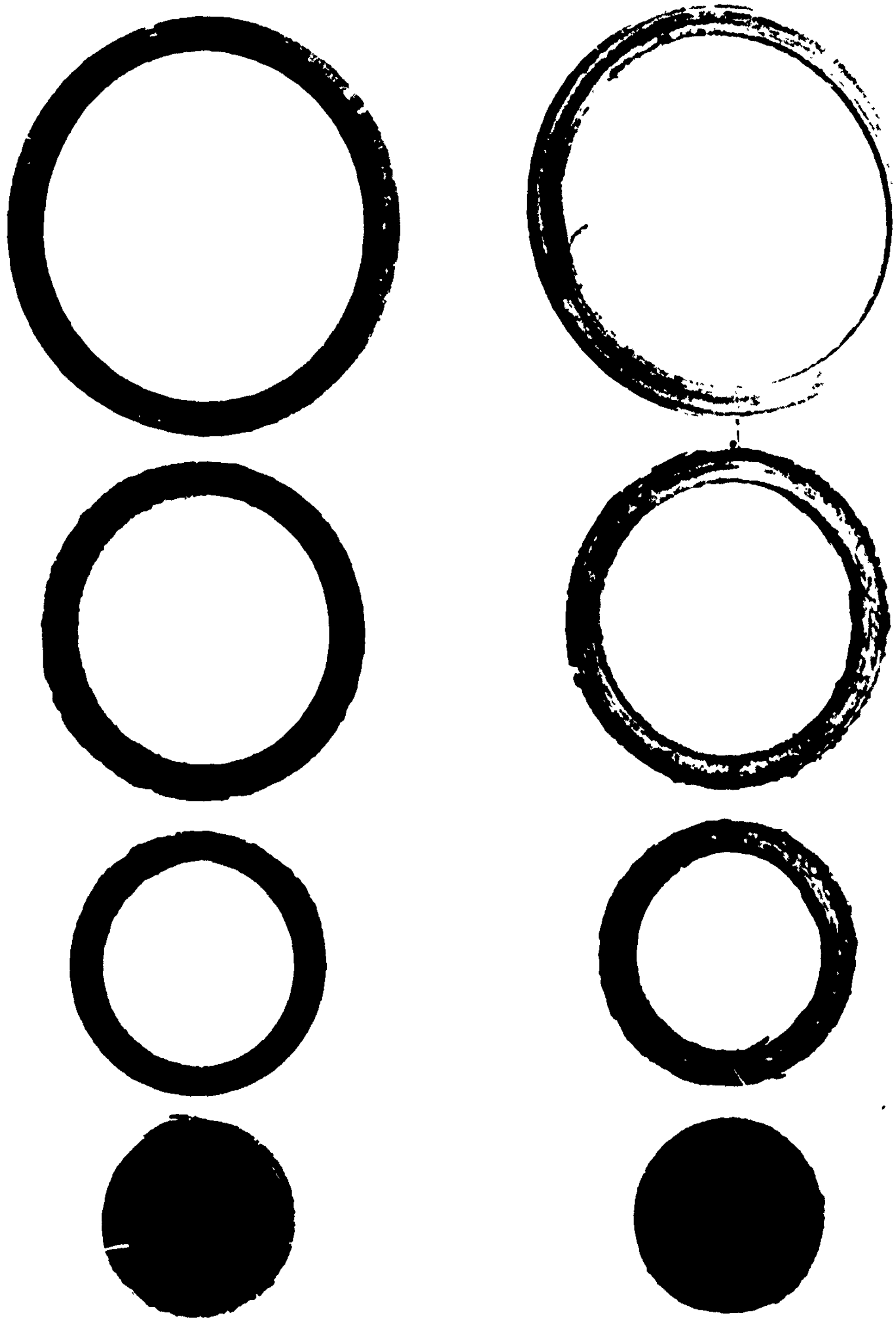
b. Increase the sample to five to insure accuracy of the results.

4. It is recommended that future consideration be given to a redesign of the socket/baseplate interface area aimed at eliminating the necessity of rings and pads.

5. It is recommended that the Fluorglas material coated with GAA grease should be used as a fix for the problem. This change over would be done on an attrition basis.

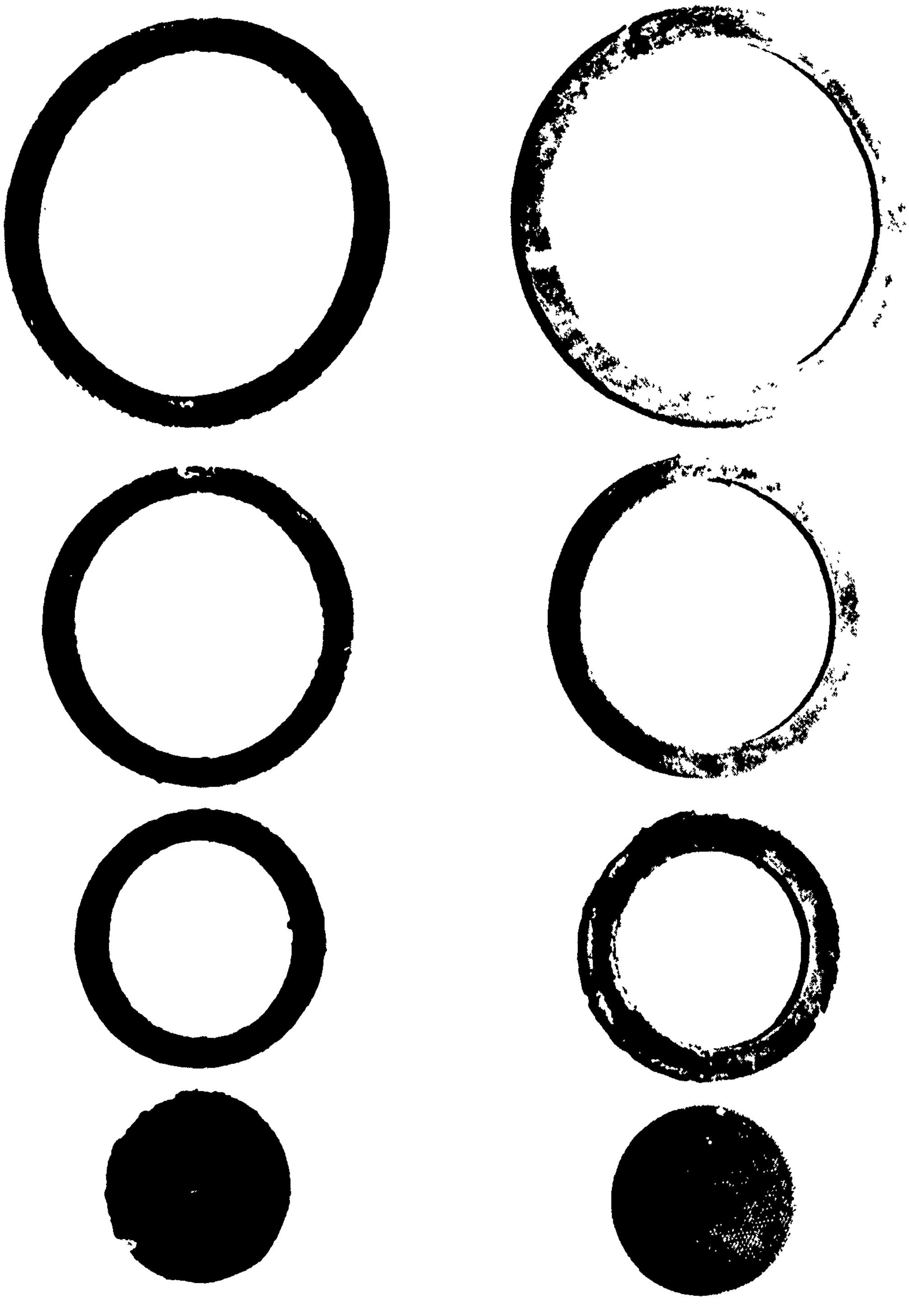
APPENDIX

Photographs of Test Pads and Rings; Runs 1-46



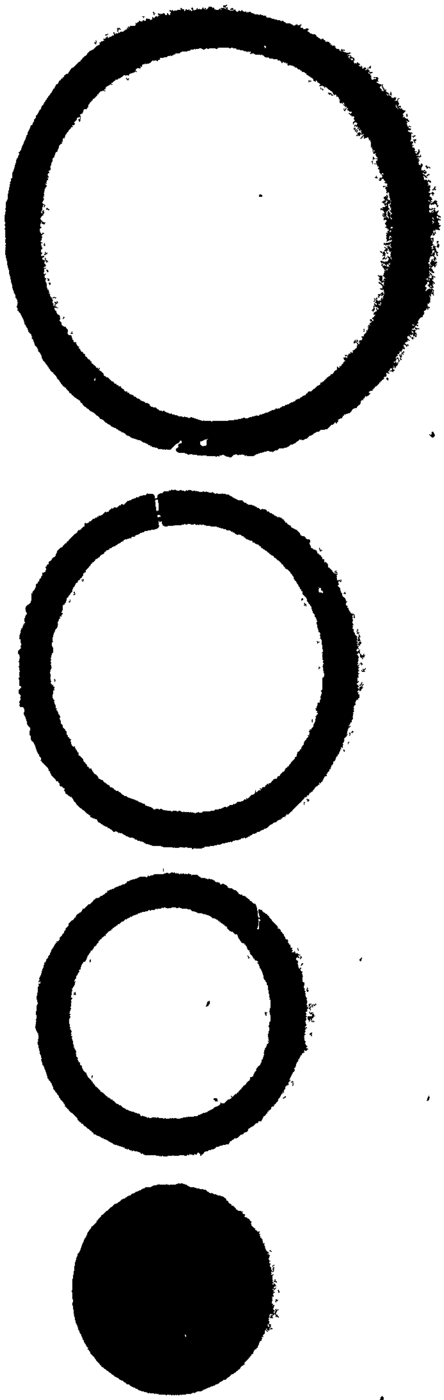
RUN 1
NEOPRENE
DRY
401 CYCLES

RUN 2
NEOPRENE
DRY
1000 CYCLES

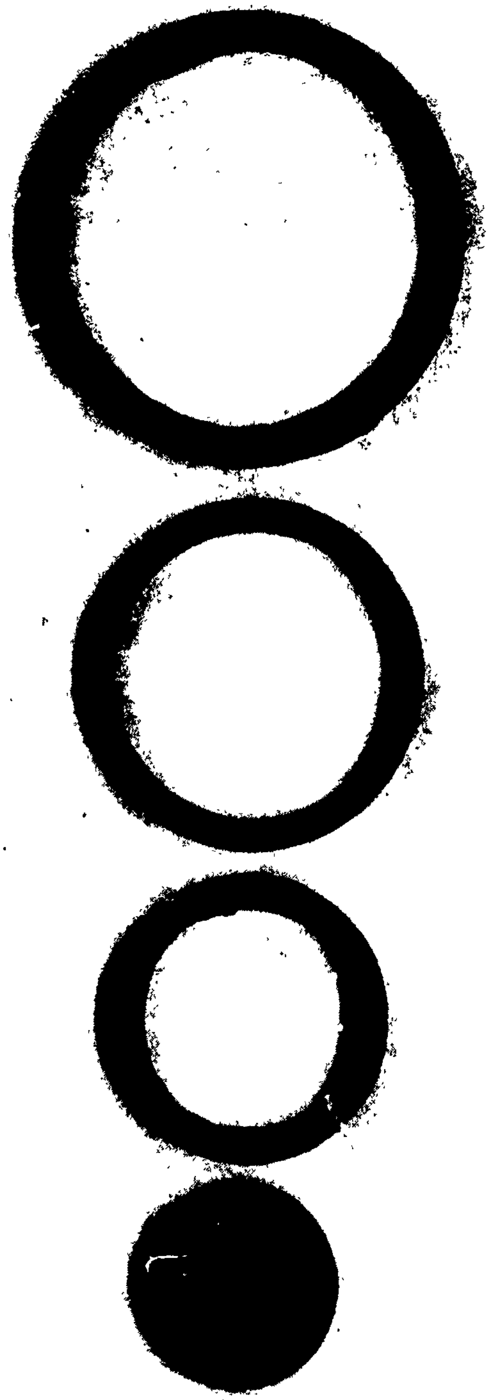


RUN 3
NEOPRENE
MUD
551 CYCLES

RUN 4
VIBLON (presoaked in salt water)
MUD
1001 CYCLES

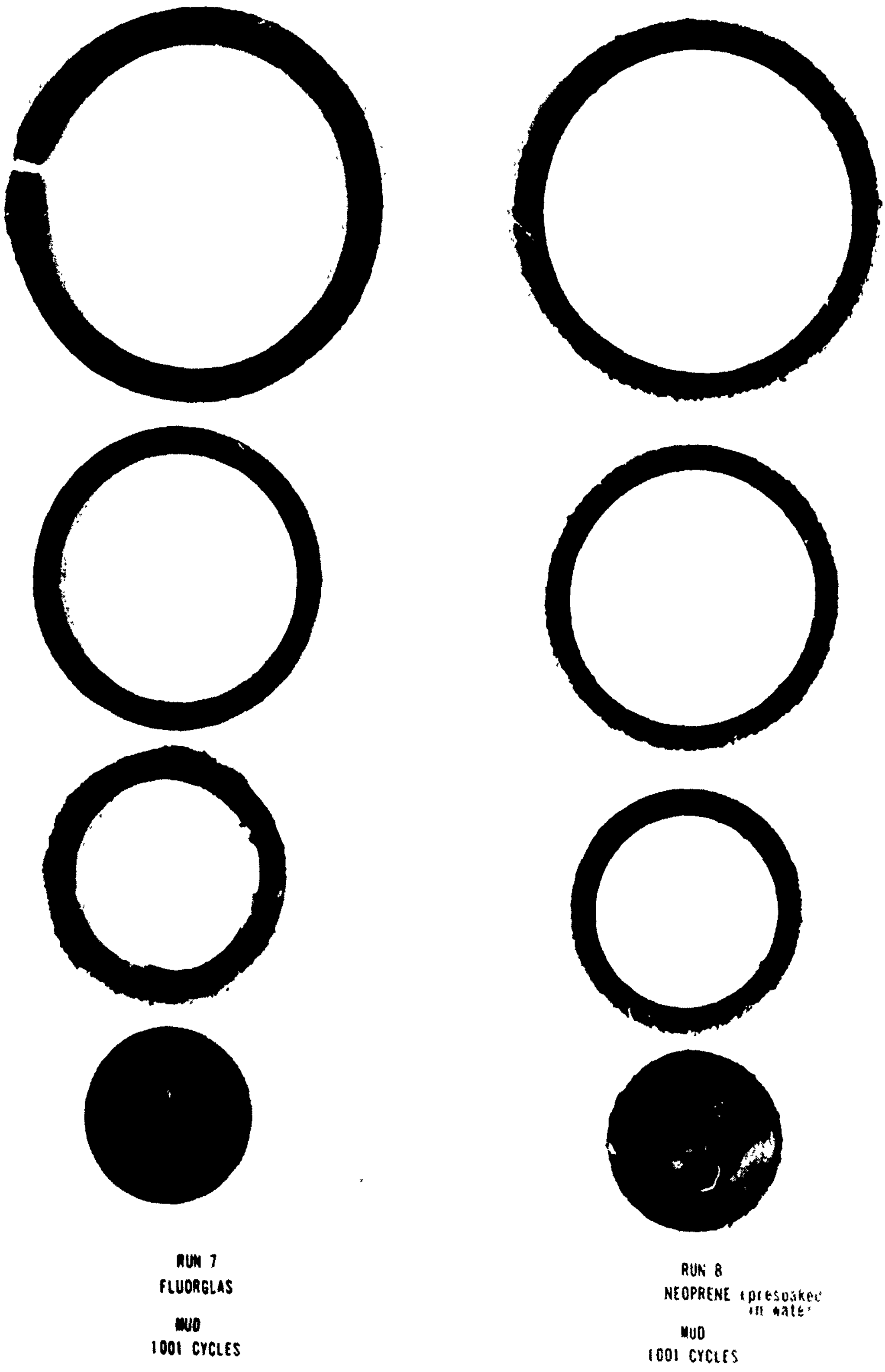


RUN 5
NEOPRENE (PRESOAKED IN WATER)
MUD
1051 CYCLES

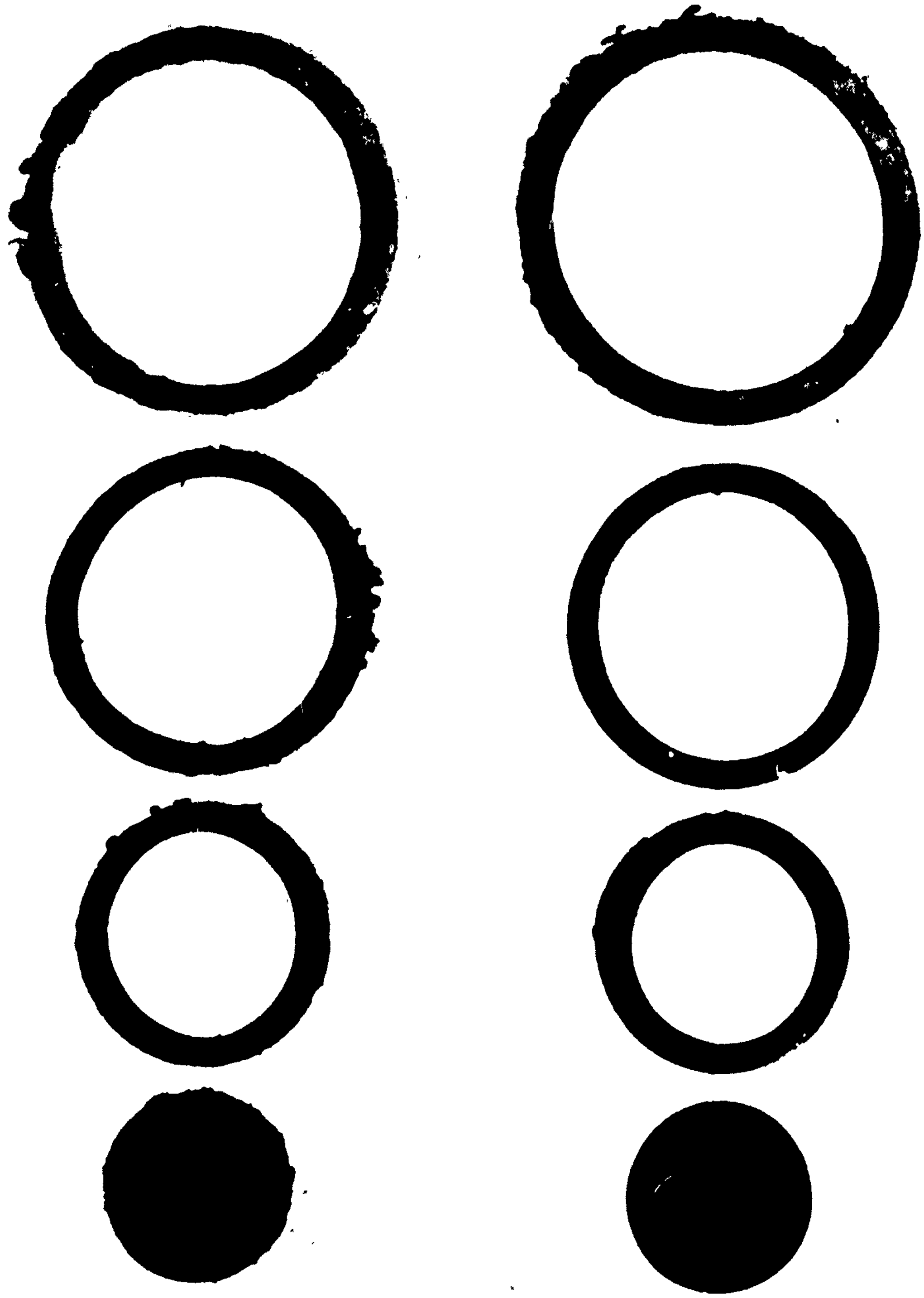


RUN 8
FLUOROGLAS (PRESOAKED IN SALT WATER)
MUD
1001 CYCLES

156-1-71

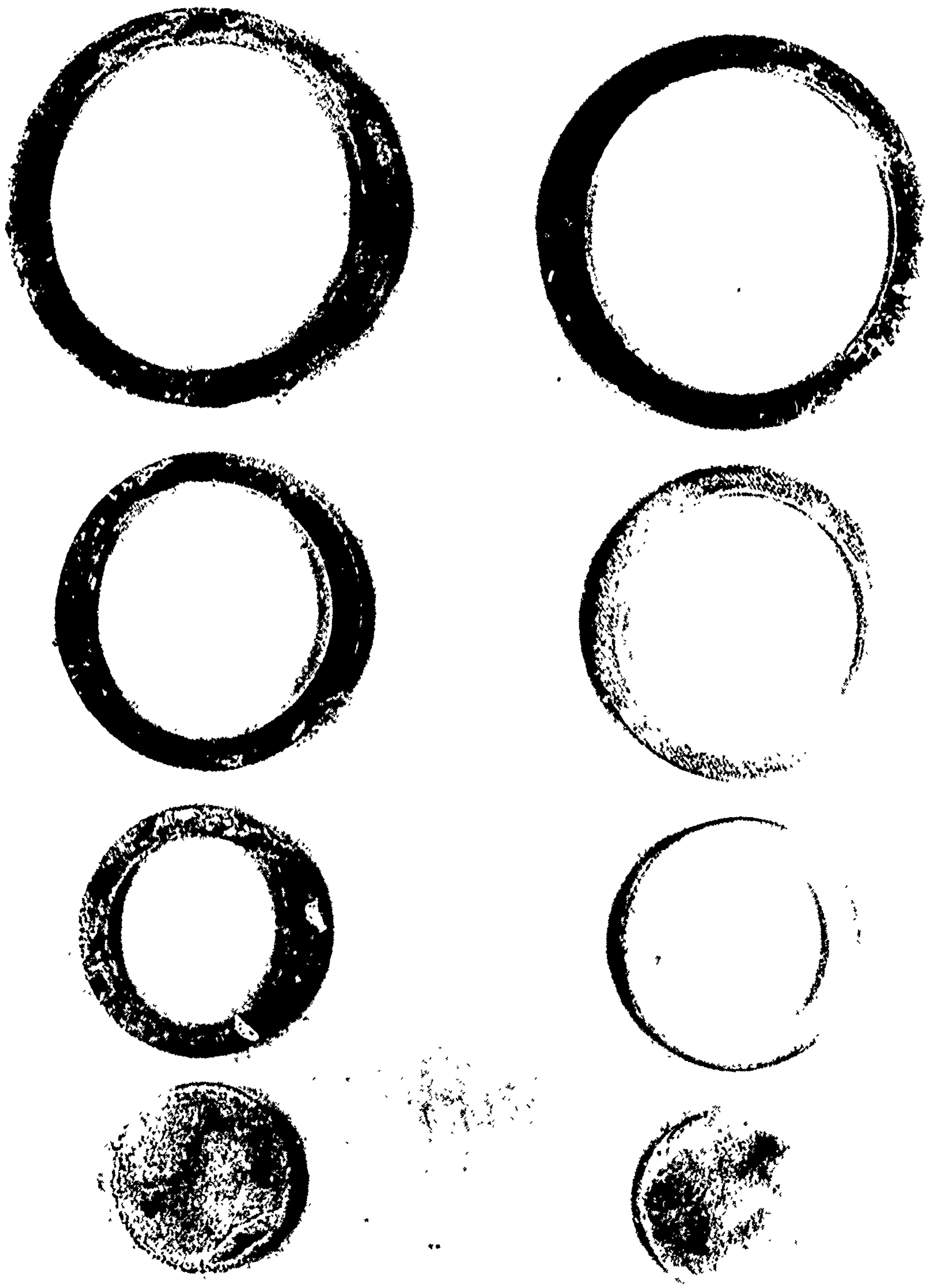

RUN 7
FLUORGLAS
MUD
1001 CYCLES
RUN 8
NEOPRENE (presoaked in water)
MUD
1001 CYCLES

156-16-71



RUN 9
NEOPRENE
MUD
2001 CYCLES

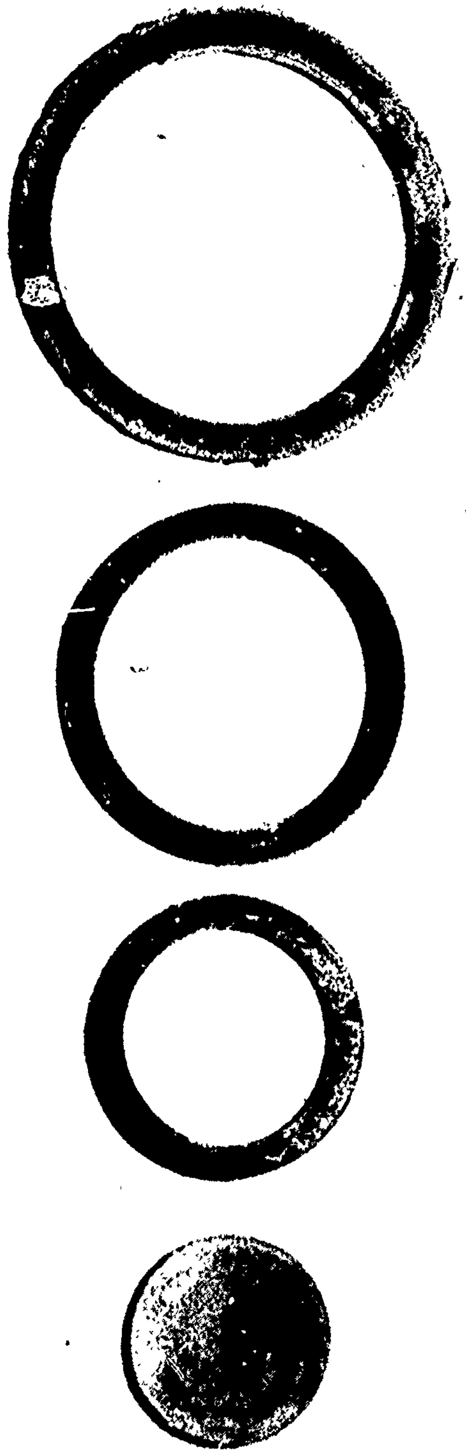
RUN 10
NEOPRENE
WET SAND (mixed)
50 CYCLES



RUN 11
VIBLON
WET SAND (mixed)
1000 CYCLES

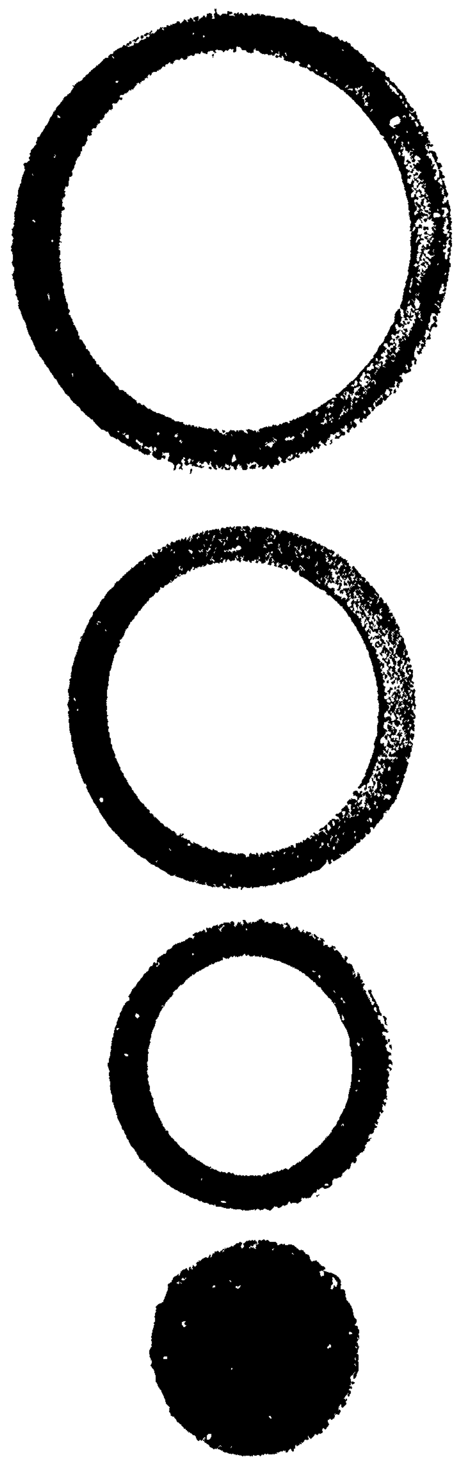
RUN 12
FLUORGLAS
WET SAND (mixed)
250 CYCLES

156-3-71



RUN 13
VIBLON

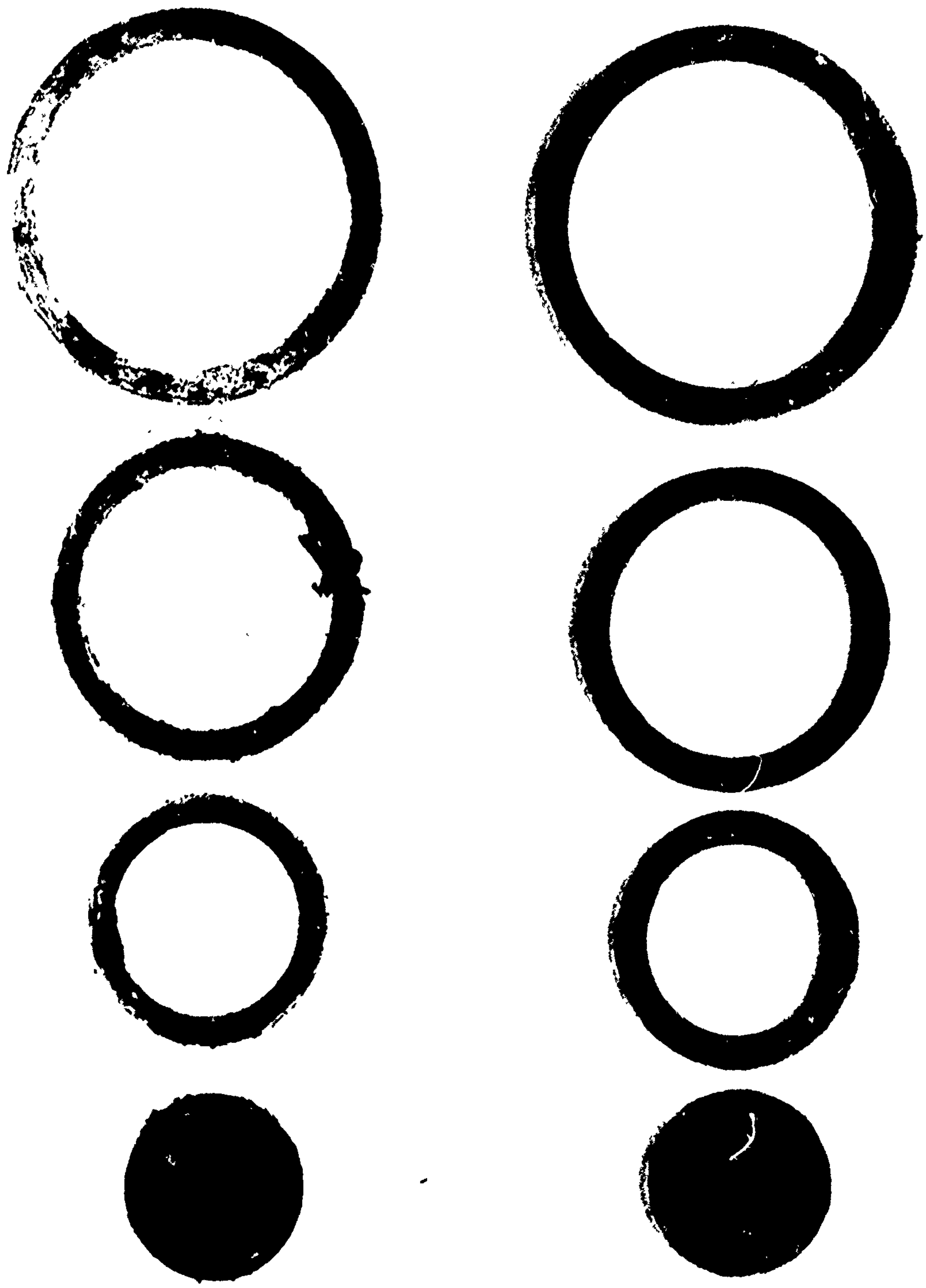
WET SAND (mixed)
250 CYCLES



RUN 14
VIBLON (presoaked in salt water)

MUD - SAND
1000 CYCLES

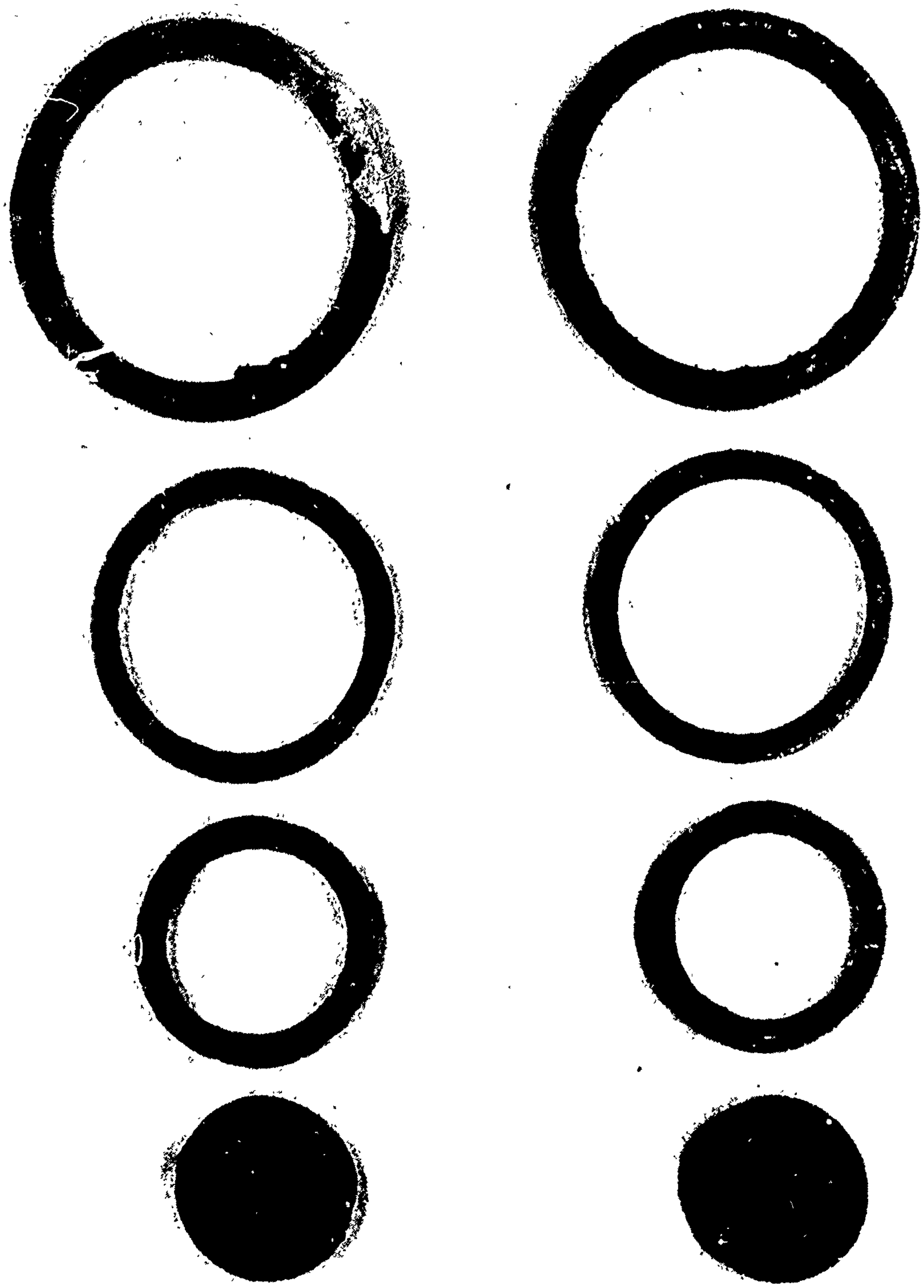
404-11-70



RUN 15
NEOPRENE
MUD + SAND
800 CYCLES

RUN 16
FLUORGLAS
MUD + SAND
1001 CYCLES

150-14-

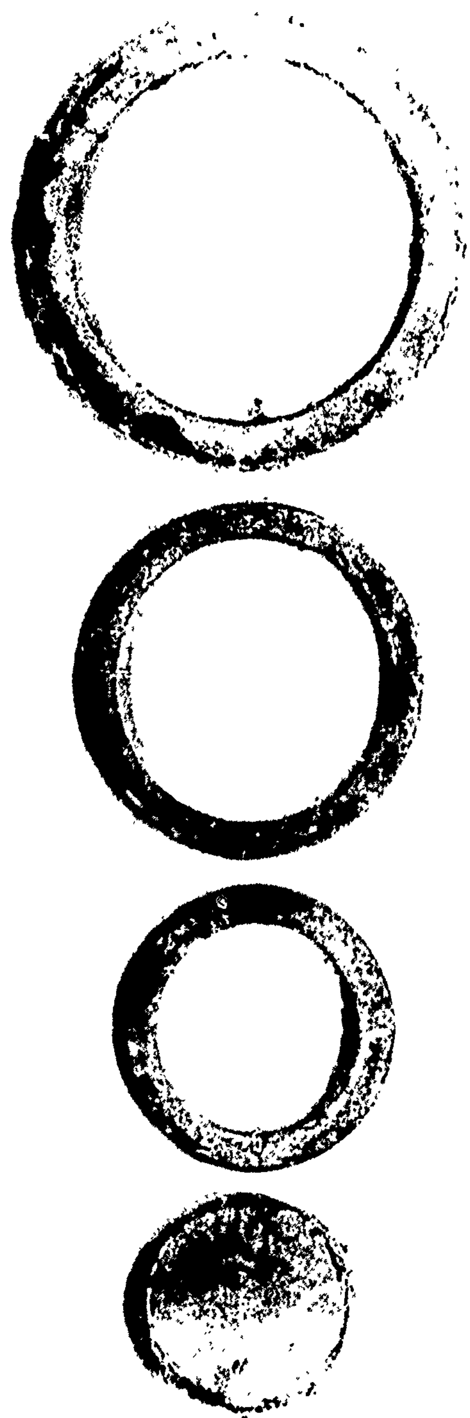


RUN 17
FLUORGLAS
DRY SAND (mixed)
1001 CYCLES

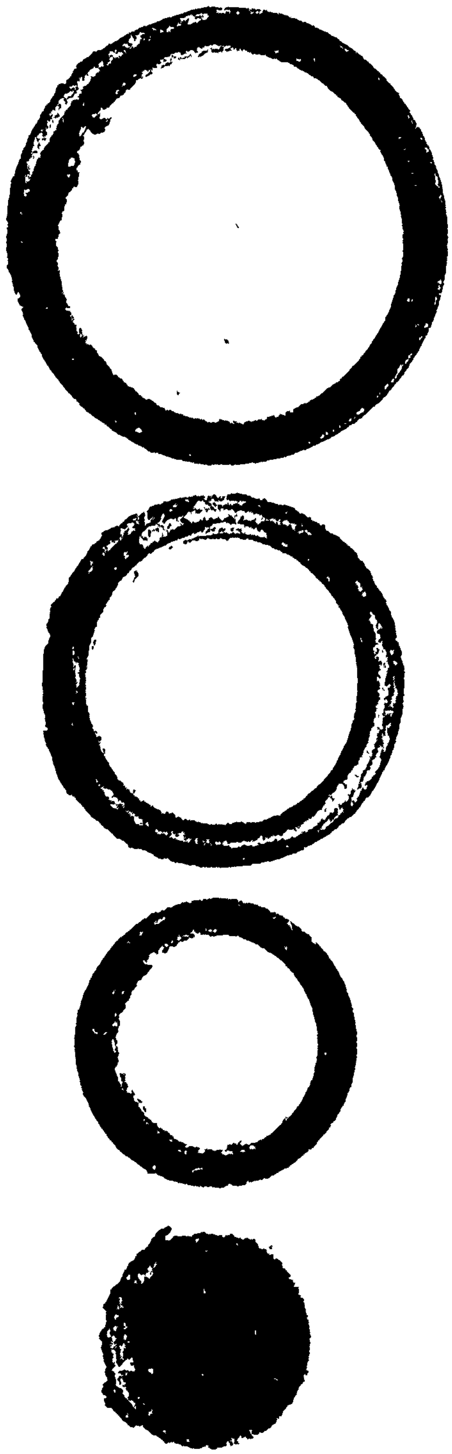
RUN 18
FLUORGLAS
DRY FINE SAND
1001 CYCLES

156-15-71

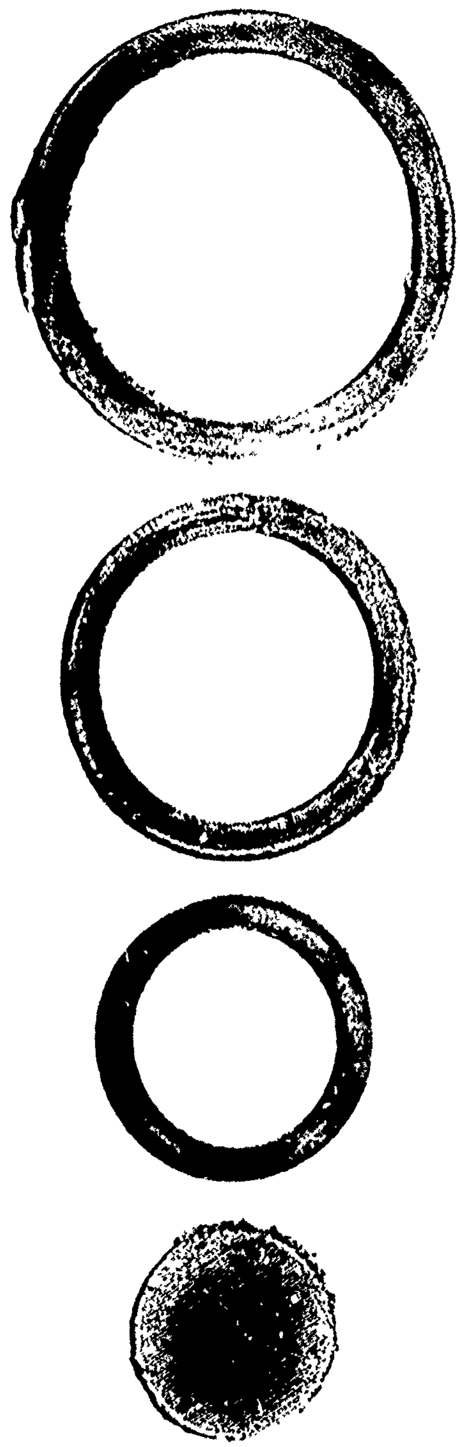
RUN 19
FLUORGLAS
DRY COARSE SAND
1001 CYCLES



RUN 20 & 21
FLUORGLAS
RUN 20 - WET COARSE SAND
RUN 21 - WET MEDIUM SAND
RUN 20 - 50 CYCLES
RUN 21 - 500 CYCLES

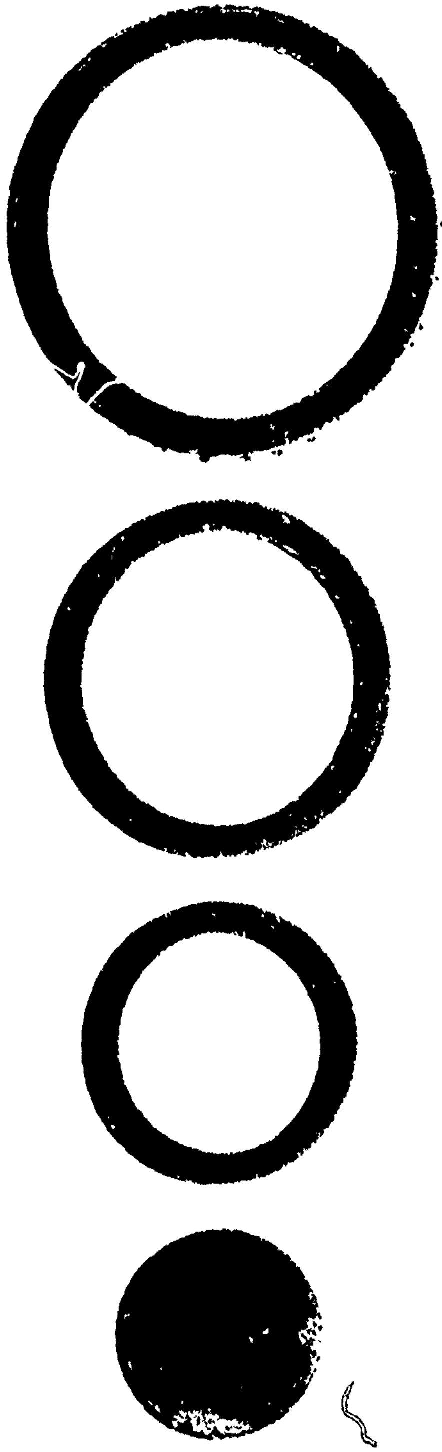


RUN 22
VIBLON
DRY COARSE SAND
1001 CYCLES



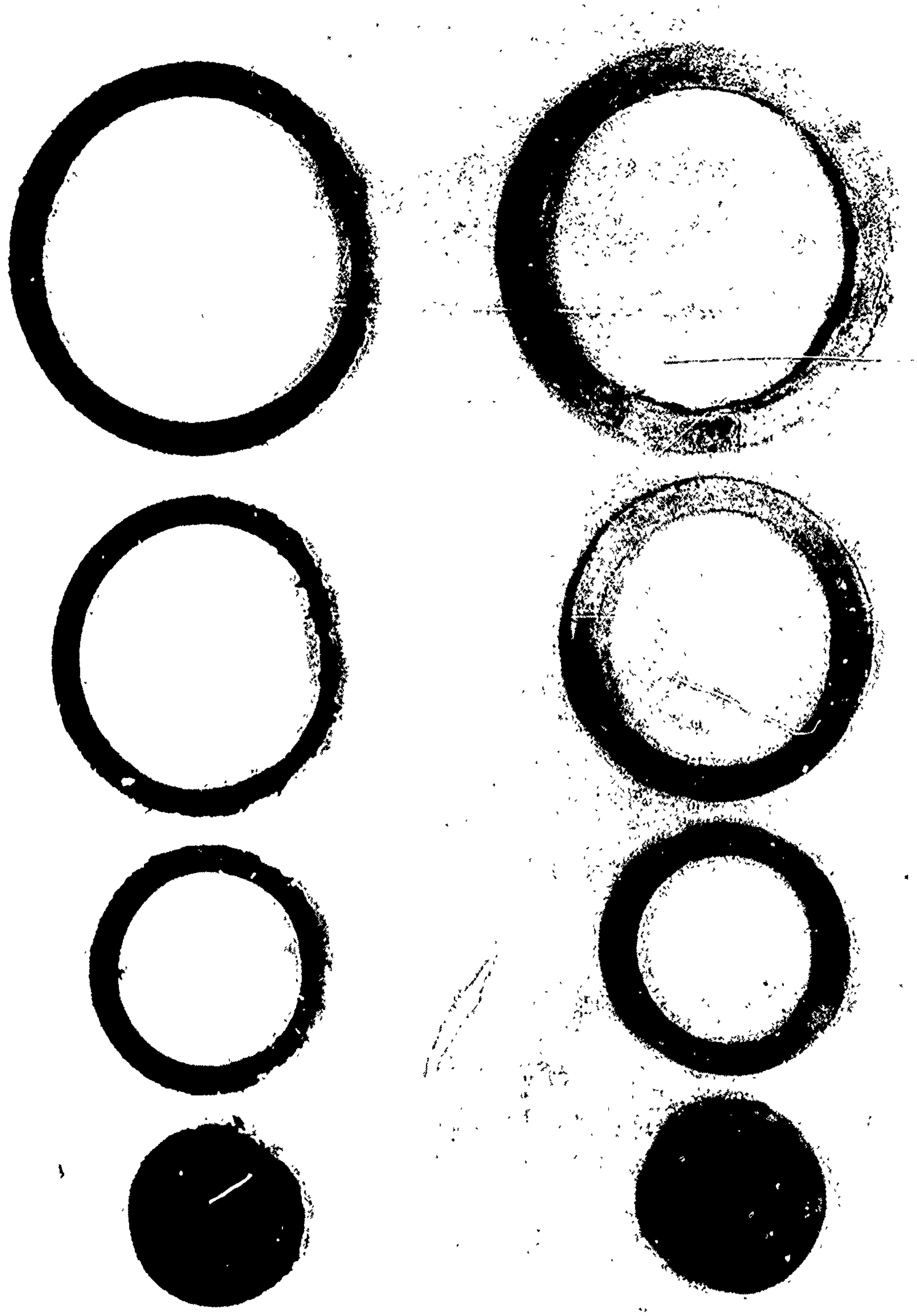
RUN 23
VIBLON
DRY COARSE SAND
1001 CYCLES

404-13-70



RUN 24
VIBLON
WET COARSE SAND
59 CYCLES

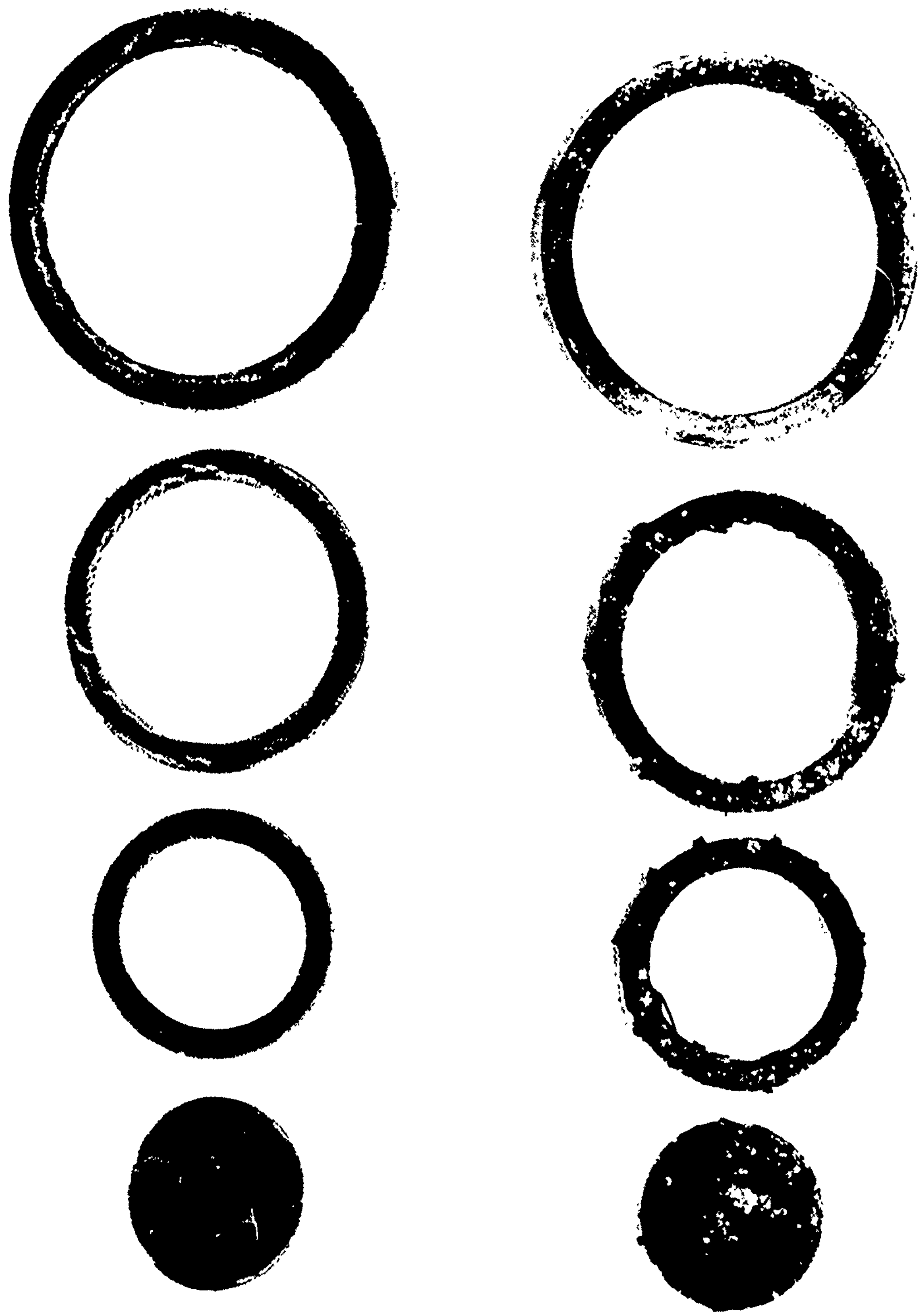
RUN 2[illegible]
NEOPRENE
DRY COARSE SAND
1001 CYCLES



RUN 26
NEOPRENE
WET COARSE SAND
900 CYCLES

RUN 27
FLUORGLAS
DRY COARSE SAND
1001 CYCLES

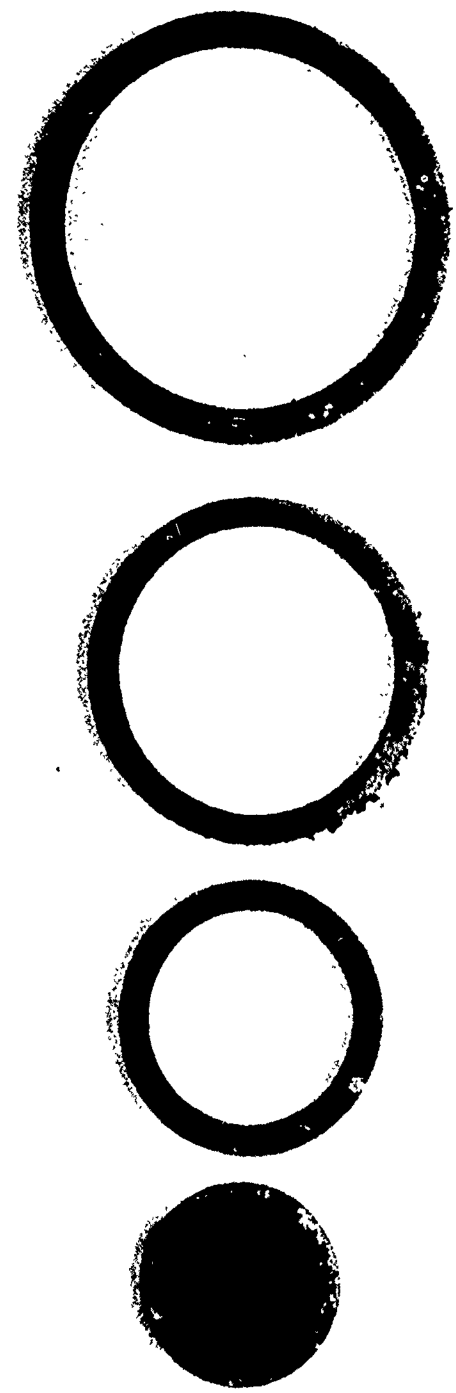
156-13-71



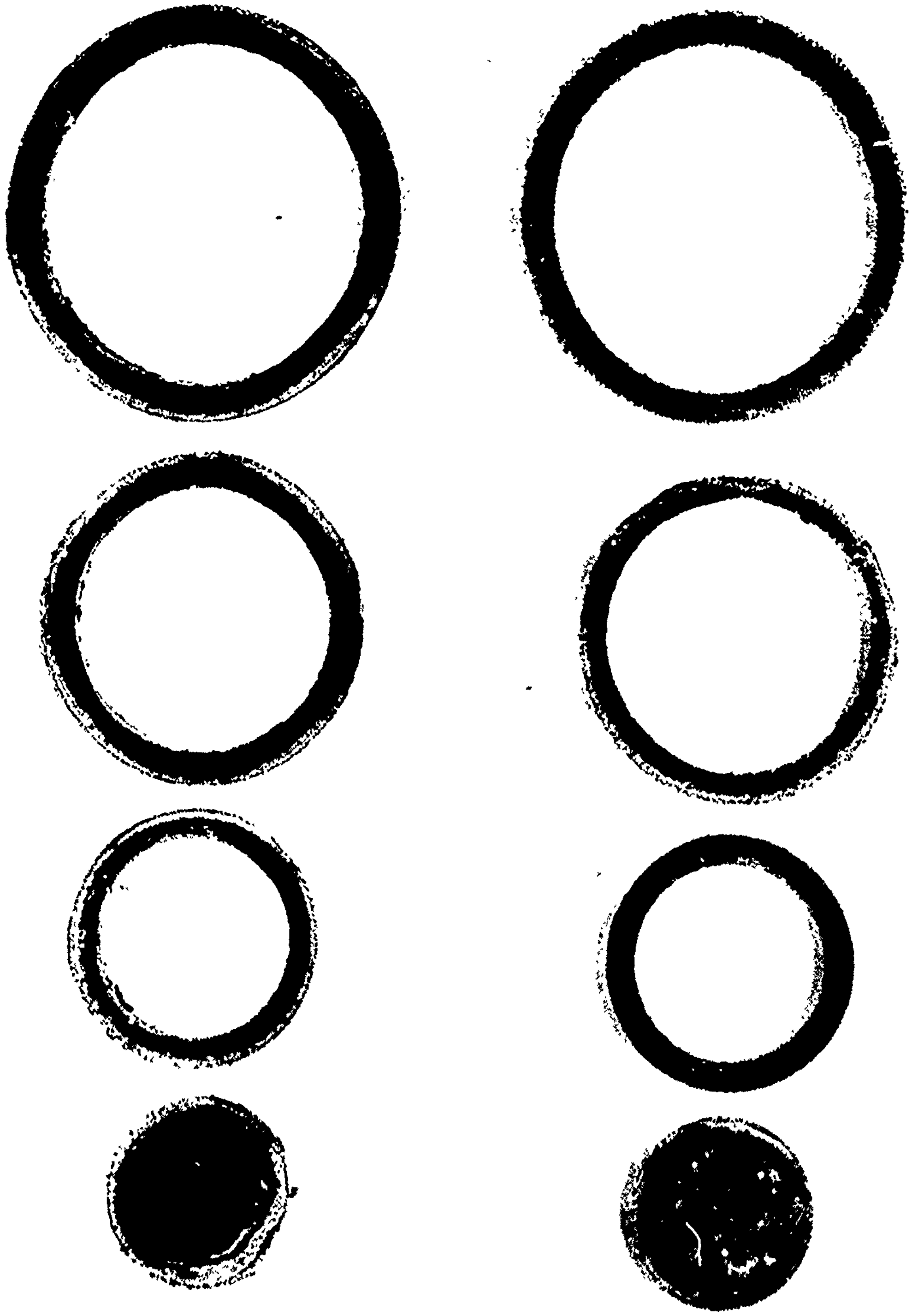
RUN 28
FLUORGLAS
DRY
1001 CYCLES

RUN 29
NEOPRENE
DRY FINE SAND
1001

RUN 30
VIBLON
DRY FINE SAND
1001 CYCLES

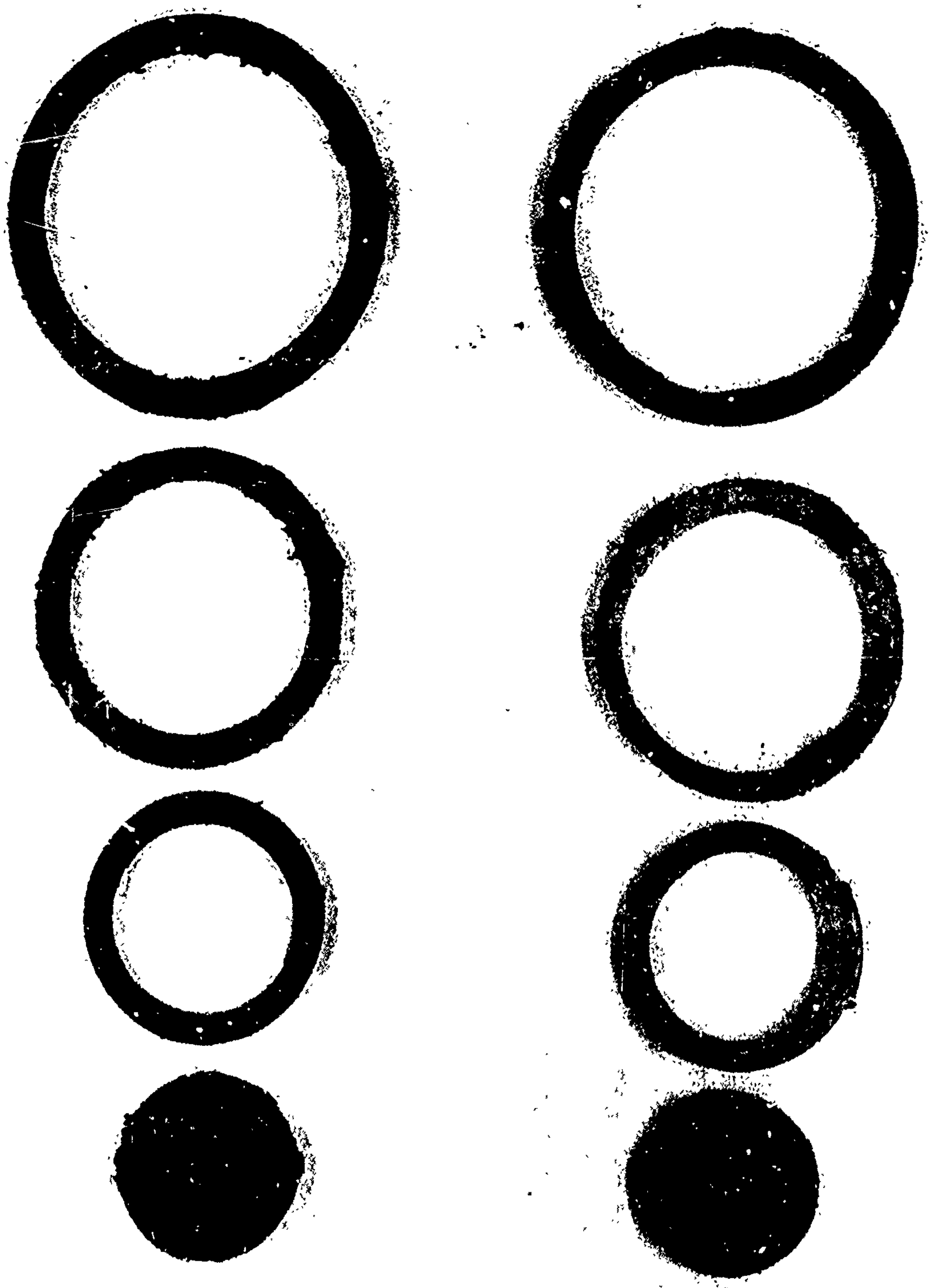


RUN 31
NEOPRENE
WET MEDIUM SAND
100 CYCLES



RUN 32
VIBLON
DRY
1001 CYCLES

RUN 33
VIBLON
WET MEDIUM SAND
1051 CYCLES

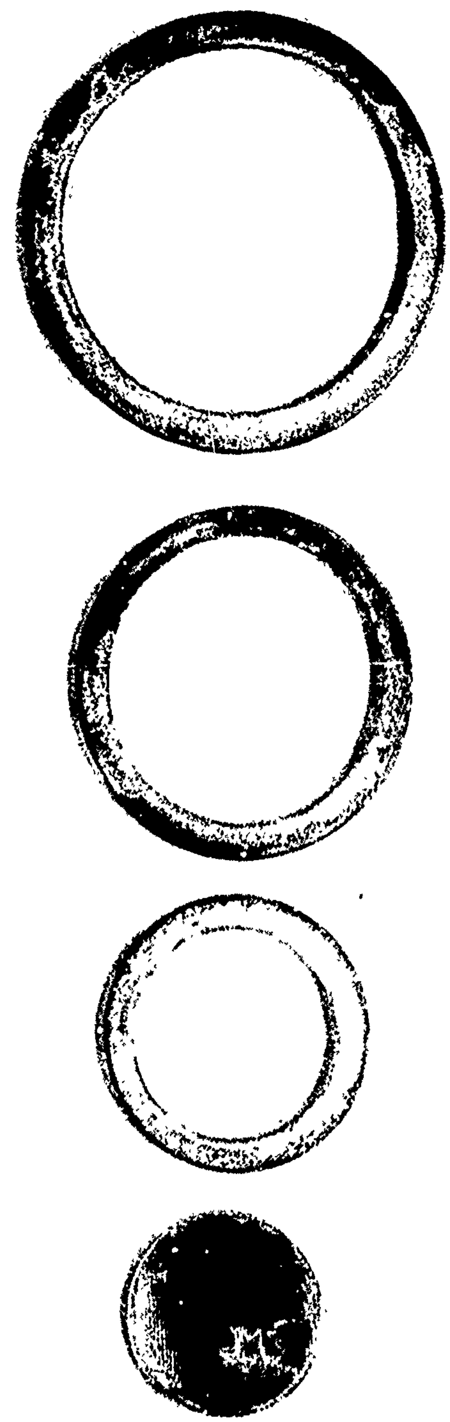


RUN 34
VIBLON
MUD
1001 CYCLES

RUN 35
VIBLON
MUD & MIXED SAND
1001 CYCLES

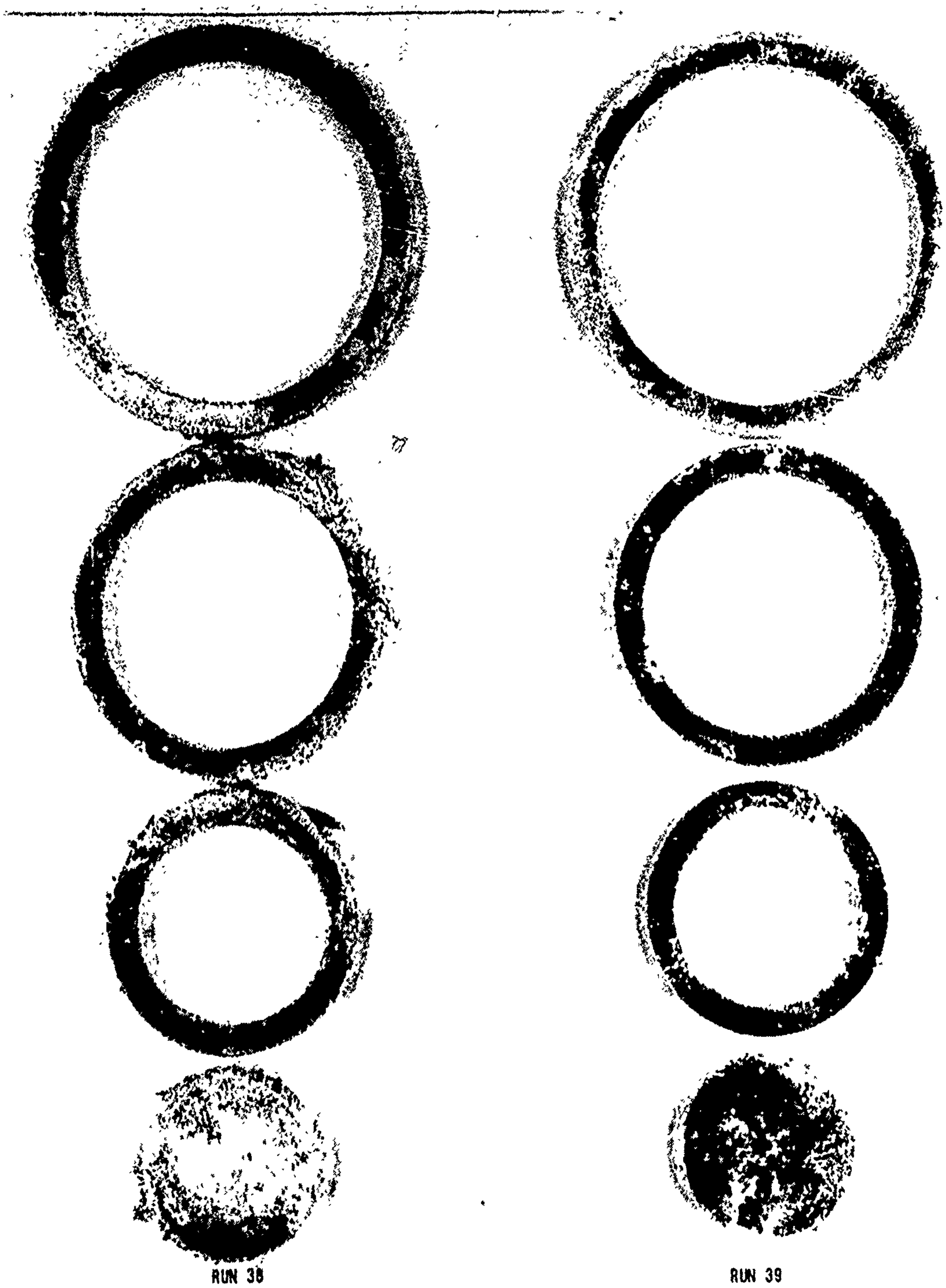
156-8-71

RUN 36
VIBLON (COATED
WITH GAA GREASE)
WET COARSE SAND
1001 CYCLES



RUN 37
FLUORGLAS

WET COARSE SAND
300 CYCLES

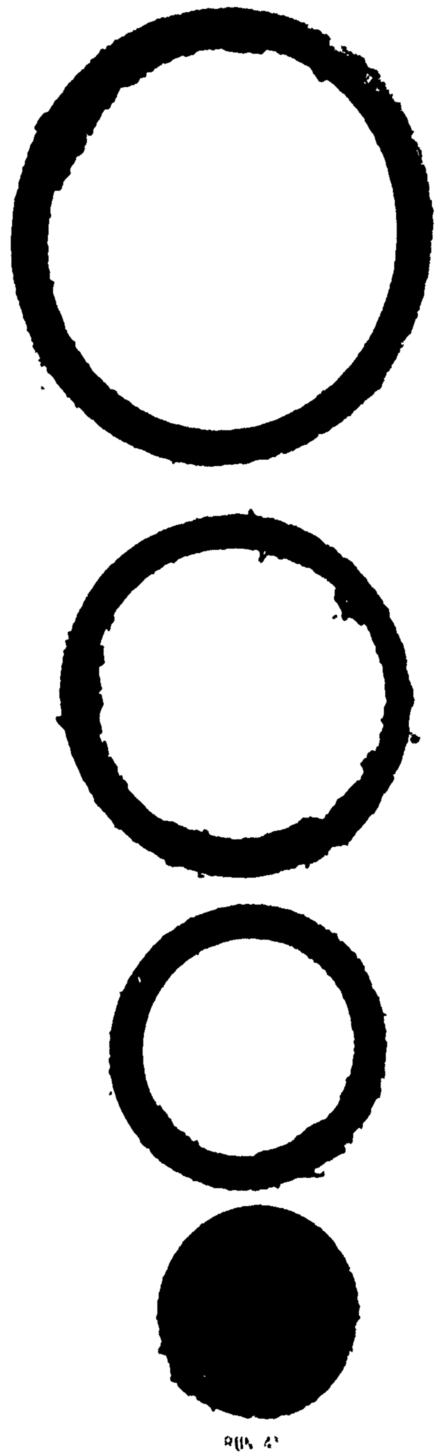


RUN 38
VIBLON (PRESOAKED
IN MIL-L-46000)
WET MIXED SAND
600 CYCLES

RUN 39
VIBLON (PRESOAKED
IN GAA GREASE)
WET MIXED SAND
1001 CYCLES

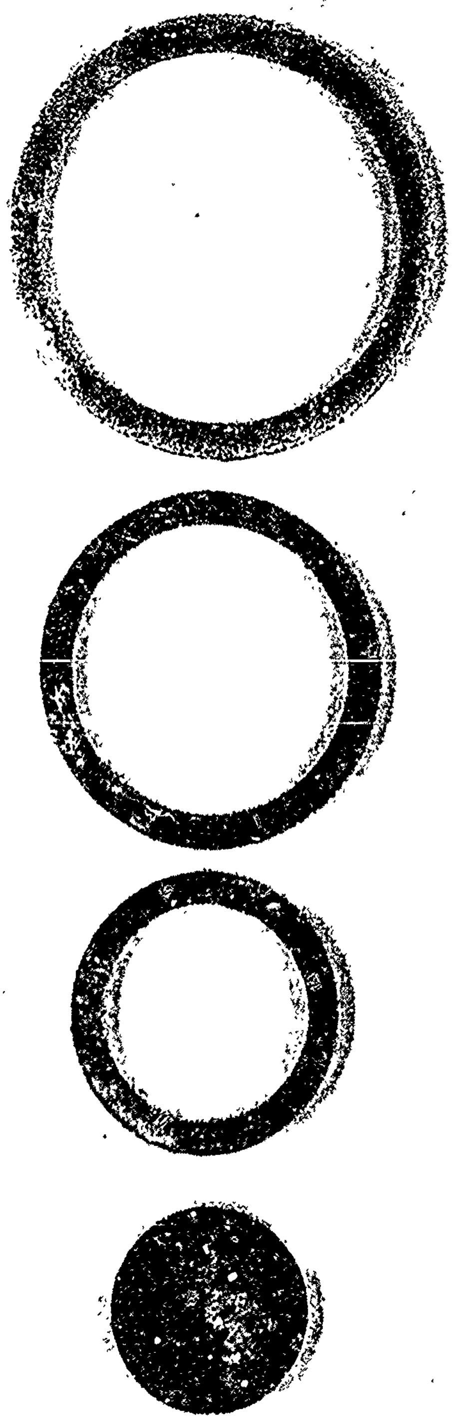
156-6-71

RUN 40
VIBLON PRESOAKED
IN MIL L 46000
WET MEDIUM SAND
50 CYCLES

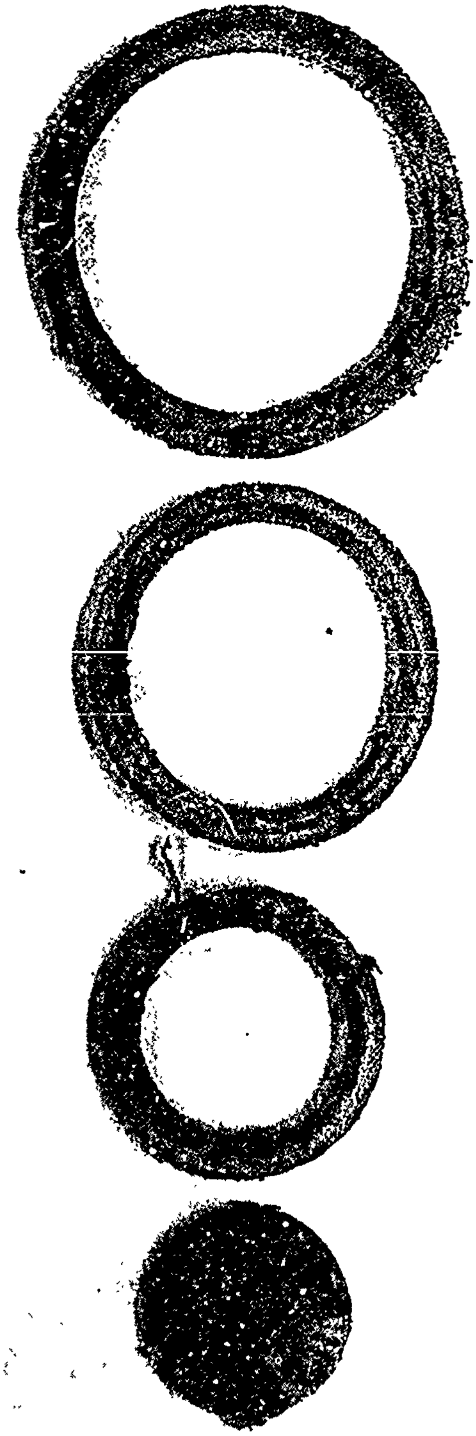


RUN 4[illegible]
NEOPRENE PRESOAKED
IN GAA GREASE
DRY COARSE SAND
[illegible]

156-4-[illegible]



RUN 42
VIBLON (PRESOAKED
IN GAA GREASE)
WET MEDIUM SAND
1001 CYCLES



RUN 43
VIBLON (PRESOAKED
IN GAA GREASE)
DRY COARSE SAND
1001 CYCLES

RUN 44
VIBLON (PRESOAKED
IN MIL L 46000)
DRY COARSE SAND
1001 CYCLES

RUN 45
NEOPRENE (PRESOAKED
IN MIL L 46000
DRY COARSE SAND
200 CYCLES

RUN 46
FLUOROGLAS (ANNULAR GROOVE SOCKET)
WET COARSE SAND
1001 CYCLES