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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 1134

EFFECT OF SOIL BARRIERS
ON
SHAPED CHARGE PENETRATION

FINAL Report

Copy No. 8

Task

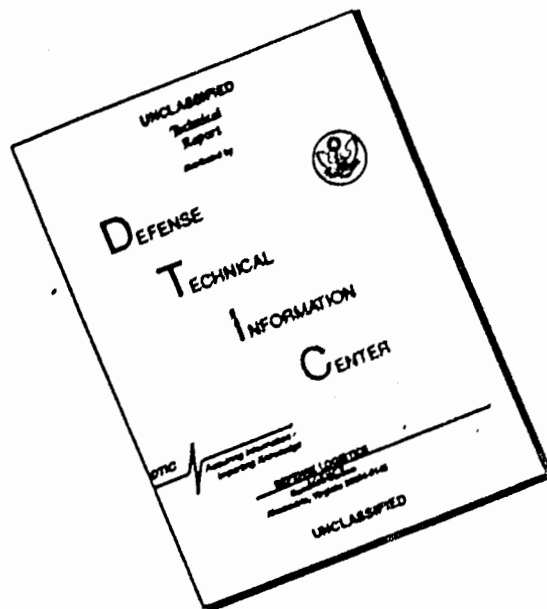
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Effect of Soil Barriers on Shaped Charge Penetration

PART A

SYNOPSIS

1. This test was conducted to determine the effect of dry and wet soil barriers (sand, loam, and clay) on shaped charge jet penetration. The 5" Rocket Head Mk 25, Composition B loaded, was used as the jet producer. After the jet passed through the soil barrier, it impinged upon a plate of armor steel. The residual penetration of the steel was measured in each case.

2. a. The minimum residual penetrations for the various soil barriers tested are as follows:

| <u>Soil</u> | <u>Condition</u> | <u>Barrier</u> | <u>Minimum Residual Penetration</u> |
|---------------------|------------------|----------------|---|
| Sand, loam, or clay | dry | 4' | 2" |
| Sand, loam, or clay | wet | 4' | 1" |
| Sand, loam, or clay | dry or wet | *3-1/2' | 2" |
| Sand or loam | dry | 3' | 3" |
| Sand, loam, or clay | wet | 3' | 2-1/2" |
| Sand, loam, or clay | dry | 2' | 4" |
| Sand or loam | dry | 2' | 5-1/2" |
| Sand, loam, or clay | wet | 2' | 4" |

* Interpolated from test results.

b. Varying soil had little effect on the amount of shaped charge penetration. Clay and wet soil barriers offered slightly more resistance to the shaped charge jet thereby reducing the amount of armor penetration.

Effect of Soil Barriers on Shaped Charge Penetration

TABLE OF CONTENTS

| | <u>Page</u> |
|---|----------------------|
| SYNOPSIS | 1 |
| TABLE OF CONTENTS | 2 |
| AUTHORITY | 3 |
| REFERENCES | 3 |
| BACKGROUND | 3 |
| OBJECT OF TEST | 3 |
| PERIOD OF TEST | 3 |
| REPRESENTATIVES PRESENT | 4 |
| DESCRIPTION OF ITEMS UNDER TEST | 4 |
| PROCEDURE | 4 |
| RESULTS AND DISCUSSION | 5 |
| CONCLUSIONS | 5 |
| APPENDIX A - FIELD TEST SET UP | .FIGURE 1 |
| APPENDIX B - PLATE AND SLUGS AFTER FIRING, PHOTOGRAPHS | .FIGURES 2-3 (Incl) |
| APPENDIX C - PLOTS, PENETRATION VERSUS DEPTHS | .FIGURES 9-10 (Incl) |
| APPENDIX D - FIELD DATA | .TABLES I-II (Incl) |
| APPENDIX E - DISTRIBUTION | .1-2 (Incl) |

Effect of Soil Barriers on Shaped Charge Penetration
-----PART BINTRODUCTION

1. AUTHORITY:

This test was authorized by reference (a).

2. REFERENCES:

- a. BUCRD Conf ltr S7c-1 Re2c-JSM:rjb Ser 48219 of
25 November 1952
- b. NAVORD Conf Report 2487 of 27 June 1952

3. BACKGROUND:

a. Shaped charges as anti-tank mines were developed during World War II. The Office of Naval Research is pursuing the use and application of these charges by investigating the effects of soil on various types of charges.

b. Reference (b) reported the effect of soil barriers on 1 1/2" and 3 1/2" diameter shaped charges. Reference (a) requested that tests be conducted with the 5" Rocket Head Mk 25 shaped charges for the Office of Naval Research and Headquarters, Marine Corps. The Naval Ordnance Test Station is conducting similar tests with different shaped charges.

4. OBJECT OF TEST:

This test was conducted to determine the effect of dry and wet soil barriers (sand, loam, and clay) on shaped charge jet penetration. The 5" Rocket Head Mk 25, Composition B loaded, was used as the jet producer.

5. PERIOD OF TEST:

- | | |
|-------------------------------------|------------------|
| a. Date Project Letter | 25 November 1952 |
| b. Date Necessary Material Received | 1 December 1952 |
| c. Date Commenced Test | 26 January 1953 |
| d. Test Completed | 3 April 1953 |

Effect of Soil Barriers on Shaped Charge Penetration

6. REPRESENTATIVES PRESENT:

This test was witnessed in part by LCDR R. G. Gibson and LT J. E. Peterson representing the Office of Naval Research.

PART CDETAILS OF TEST

7. DESCRIPTION OF ITEMS UNDER TEST:

a. 5" Rocket Head Mk 25 Mod 1, loaded with 16.0 lbs. of Composition B, Head Lot No. 71, Ammunition Lot RHCZ-6-HA-52, assembled with Mk 149 nose fuze modified for static detonation, and total assembled weight of 51.3±0.6 lbs. This head contains a copper cone.

b. 4-1/4" thick Class B armor plate.

| c. <u>Soil Barriers</u> | <u>% Water</u> | | | <u>Average</u> |
|-------------------------|------------------|-----------|-----------|----------------|
| | <u>Sample #1</u> | <u>#2</u> | <u>#3</u> | |
| (1) Dry Sand - | 0.08 | 0.10 | 0.09 | 0.09 |
| (2) Dry Loam - | 2.80 | 2.43 | 2.35 | 2.53 |
| (3) Dry Clay - | 2.05 | 1.69 | 1.91 | 1.88 |
| (4) Wet Sand - | 18.54 | 18.09 | 20.06 | 18.89 |
| (5) Wet Loam - | 32.37 | 29.94 | 27.92 | 30.08 |
| (6) Wet Clay - | 23.57 | 31.74 | 26.50 | 27.27 |

8. PROCEDURE:

The test set up is shown in Figure 1. After a 12" diameter hole was dug for the desired soil depth the rocket head was lowered base-down into the hole. The hole was then filled with loose soil. Either one (1) or two (2) thicknesses of 4-1/4" plate was placed over the expected jet exit on 12" high wooden blocks. During the filling of the hole with soil, a water hose saturated the soil if a wet soil condition was desired. The dry soil used was dried on a heated plate one (1) week before the test. Jet penetration was measured by a thin wire prober. The recorded penetrations are not the maximum since some jet material usually remained in the plate.

Effect of Soil Barriers on Shaped Charge Penetration

9. RESULTS AND DISCUSSION:

The detailed field data are listed in Tables I and II. The plate penetrations are shown in Figures 2 to 7, inclusive. Typical jet slugs are shown in Figure 8. The average penetrations for dry and wet soils were plotted and are shown in Figures 9 and 10. The averaged data are summarized as follows:

| Soil Type | Plate Penetration (Inches) | | | | | |
|-----------|----------------------------|--------|---------|-------|---------|--------|
| | 2' Soil | | 3' Soil | | 4' Soil | |
| | dry | wet | dry | wet | dry | wet |
| Sand | 5-5/8 | 4-5/16 | 3-1/8 | 2-3/4 | 2-11/16 | 1-7/8 |
| Loam | 6-1/4 | 4-7/8 | 3-3/4 | 3-1/4 | 2-11/16 | 1-5/16 |
| Clay | 4-1/4 | 4-9/16 | 2-3/8 | 2-5/8 | 3-1/16 | 1-5/8 |

At the 2' and 3' soil barrier depths, the loam soil appeared to offer the least resistance to the shaped charge jet. A wet soil condition generally can be expected to reduce the plate thickness penetrated. At 4' barrier depths, the variation of soil did not result in any significant plate penetration differences.

PART DCONCLUSIONS

10. a. The minimum residual penetrations for the various soil barriers tested are as follows:

| <u>Soil</u> | <u>Condition</u> | <u>Barrier</u> | <u>Minimum Residual Penetration</u> |
|---------------------|------------------|----------------|-------------------------------------|
| Sand, loam, or clay | dry | 4' | 2" |
| Sand, loam, or clay | wet | 4' | 1" |
| Sand, loam, or clay | dry or wet | *3-1/2' | 2" |
| Sand or loam | dry | 3' | 3" |
| Sand, loam or clay | wet | 3' | 2-1/2" |
| Sand, loam or clay | dry | 2' | 4" |
| Sand or loam | dry | 2' | 5-1/2" |
| Sand, loam, or clay | wet | 2' | 4" |

* Interpolated from test results.

Effect of Soil Barriers on Shaped Charge Penetration


b. Varying soil had little effect on the amount of shaped charge penetration. Clay and wet soil barriers offered slightly more resistance to the shaped charge jet thereby reducing the amount of armor penetration.

The tests upon which this report is based were conducted by:
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By direction

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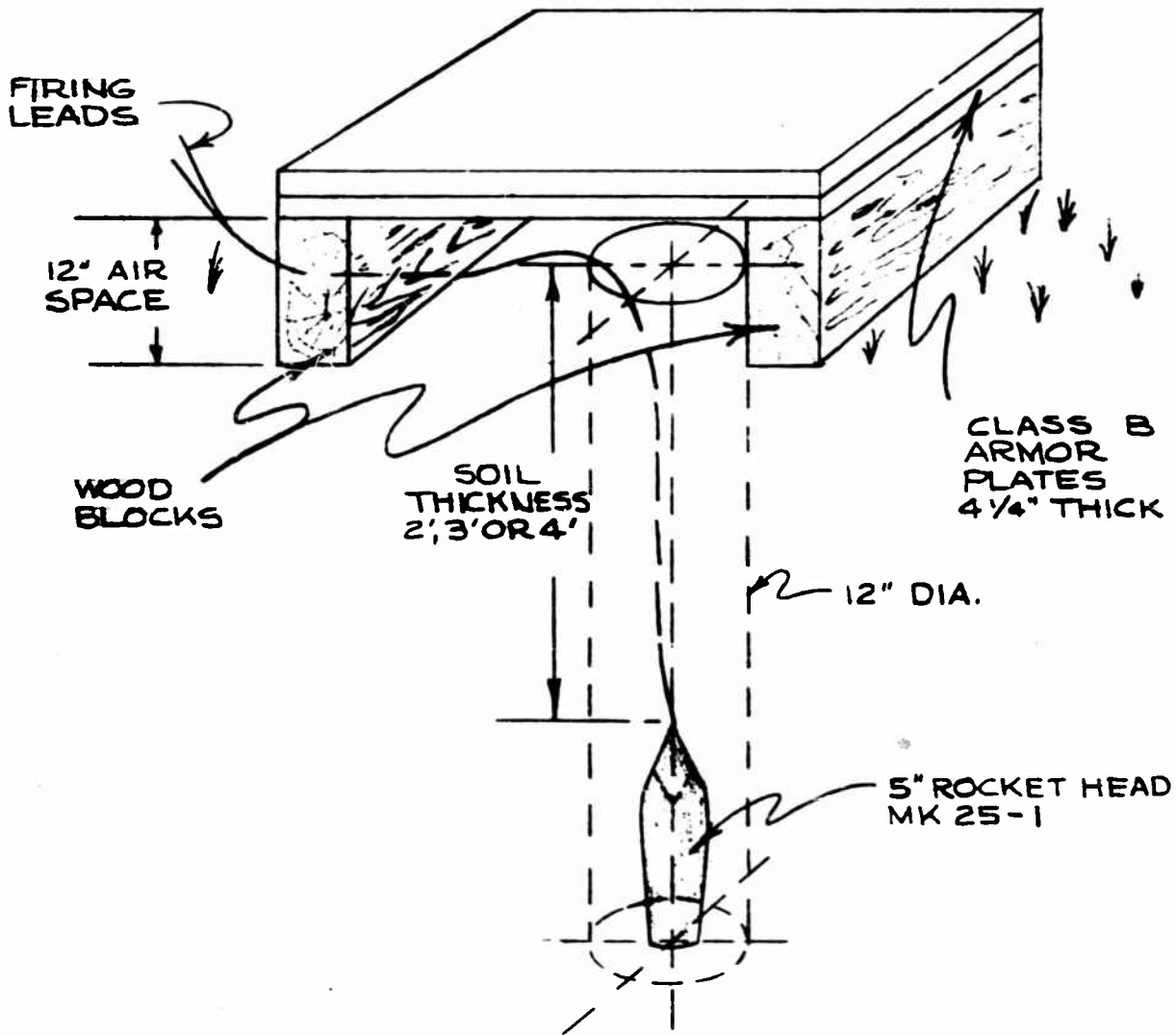
Final Report
on
Effect of Soil Barriers on Shaped Charge Penetration

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SOIL BARRIER TEST



FIELD TEST SET UP

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FIGURE 1

APPENDIX A

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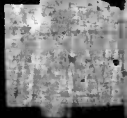
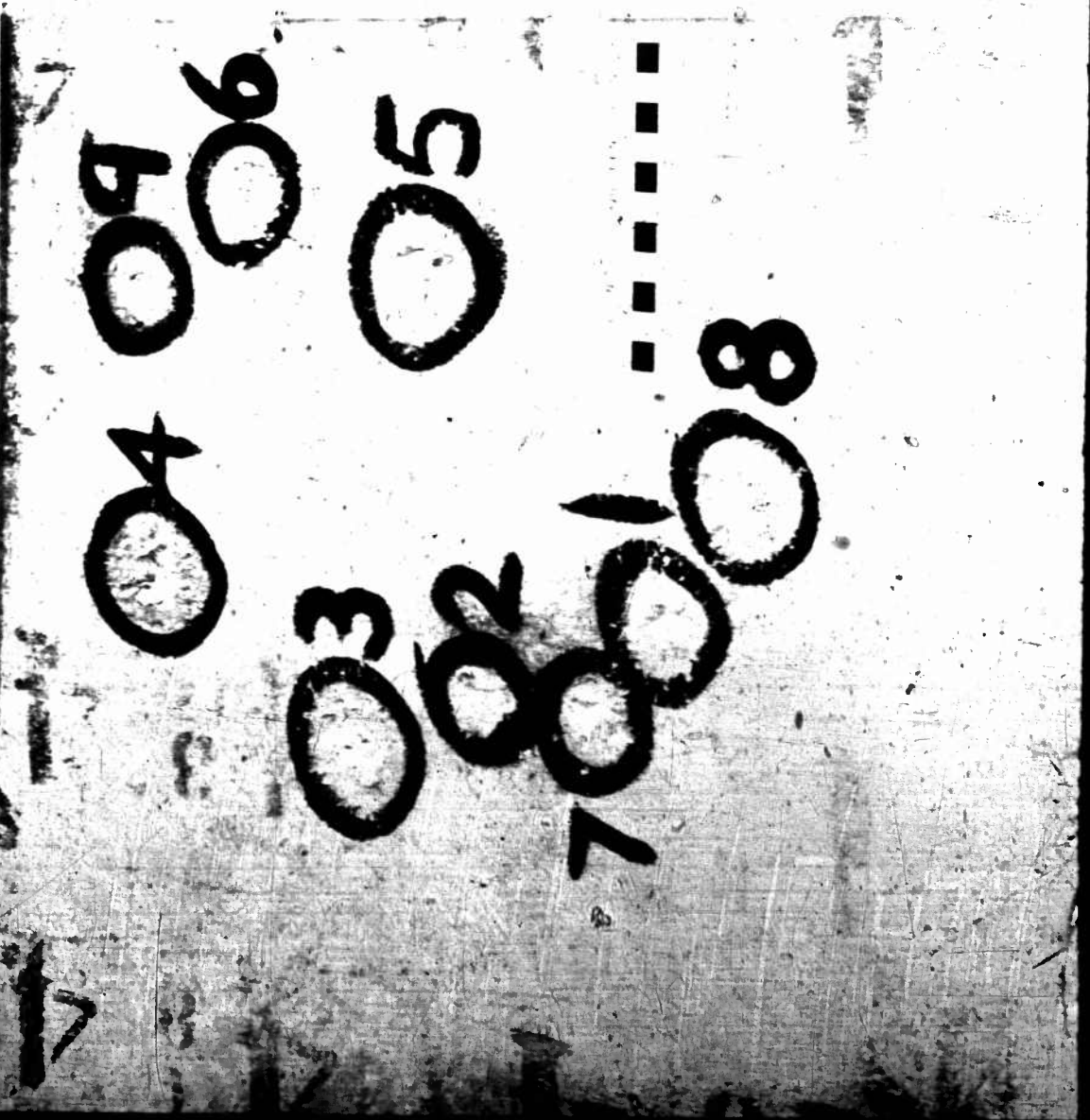
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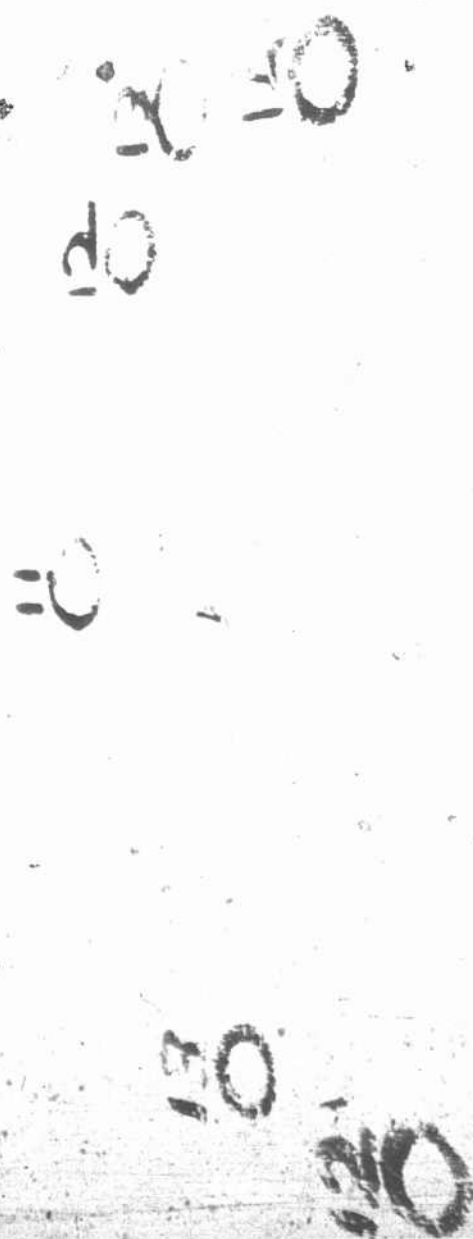
NP9-63033

18 February 1953

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5" Rocket Head Mk 25-1 shaped charge impacts on armor plate after penetrating dry soil barriers.

FIGURE 3



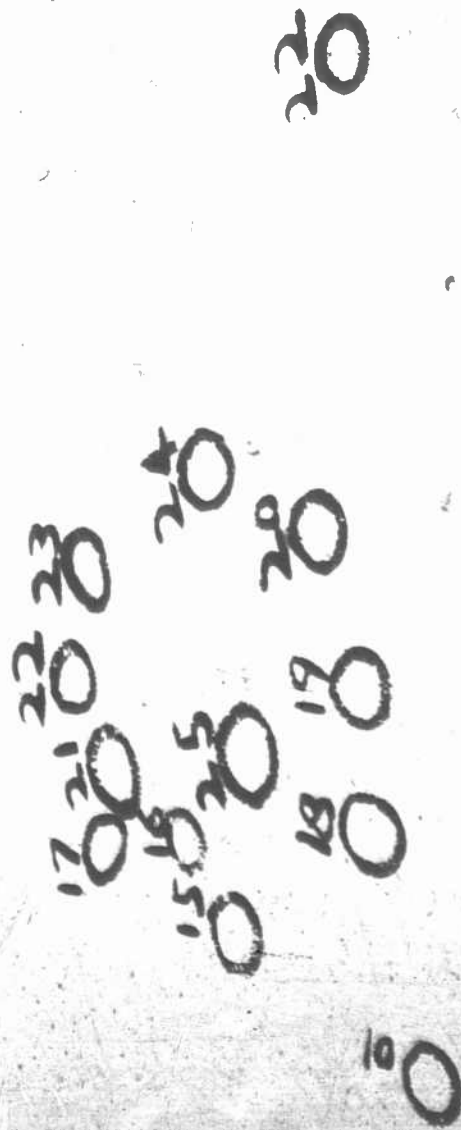
MP9-63034

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5" Rocket Head Mk 25-1 shaped charge impacts on armor plate after penetrating dry soil barriers.

FIGURE 4



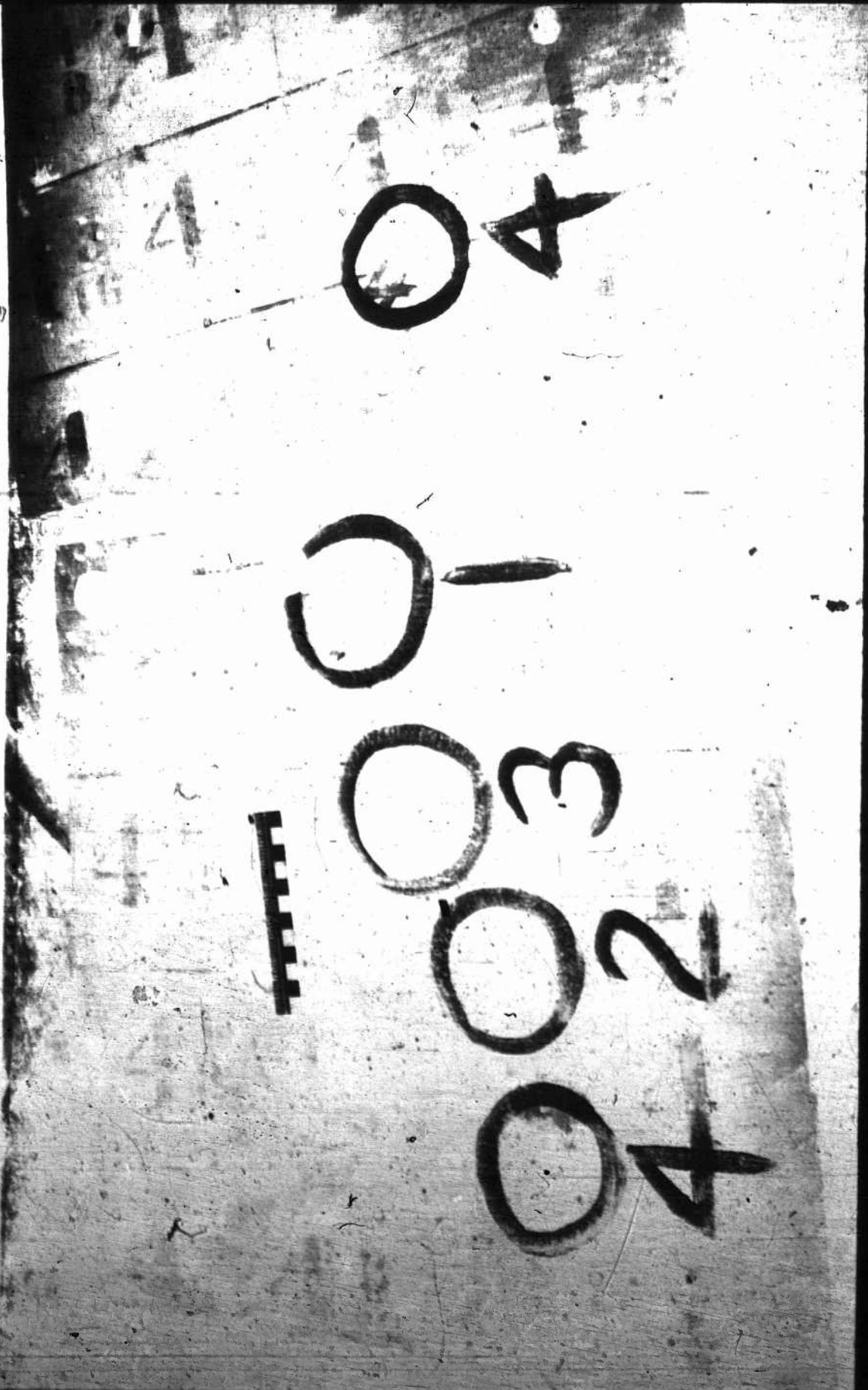
MP-63035

26 January 1953

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5" Rocket Head Mk 25-1 shaped charge impacts on armor plate after penetrating wet soil -
barriers.

Plate 5



NP9-63036

28 January 1953

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5" Rocket Head Mk 25-1 shaped charge impacts on armor plate after penetrating wet soil barriers.

FIGURE 6



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809
805

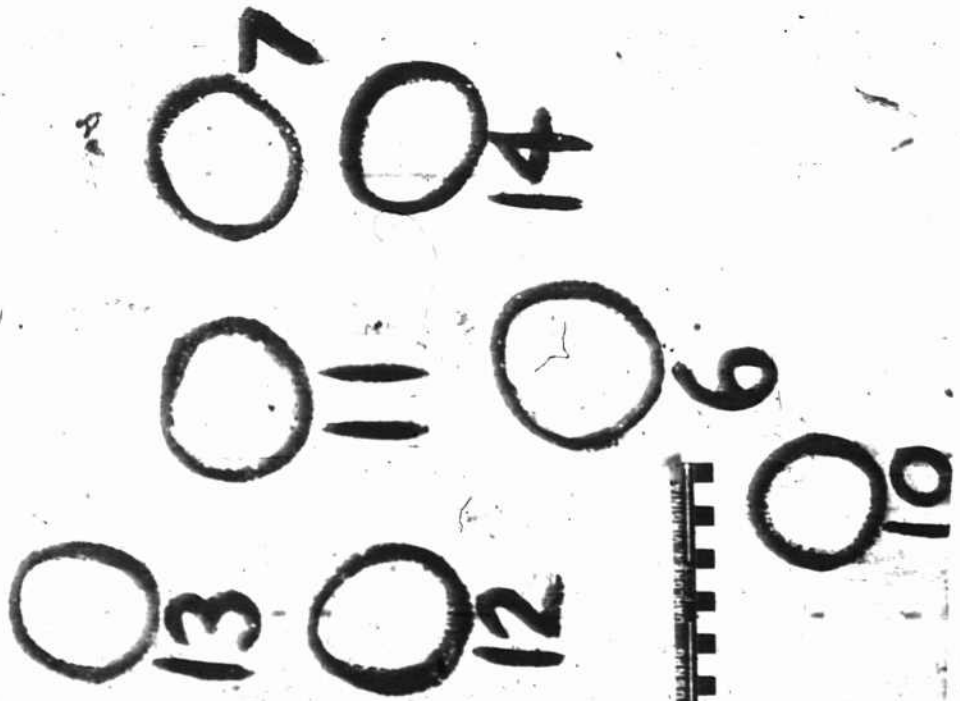
1199-63037

29 January 1963

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50 Rocket Head 1k 25-1 shaped charges in post to be arms of 1st 40. After penetration of war soil barriers.

Table 1



179-9038

19 February 1953

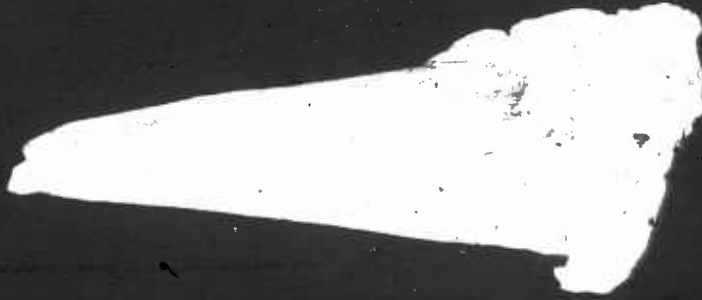
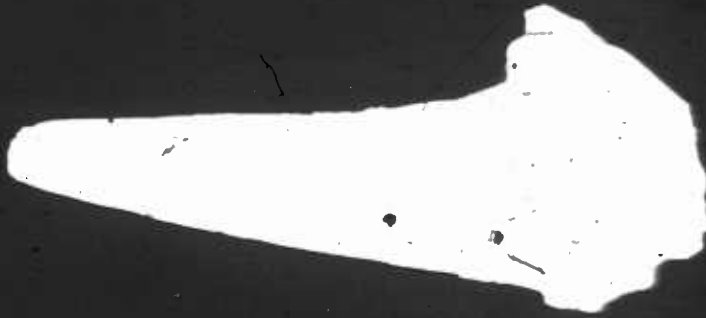
Sample copper jet slugs recovered after crash. One slug 1.14 inches long. 500 rocket heads 1 K 135 Rod 1.

Page 6

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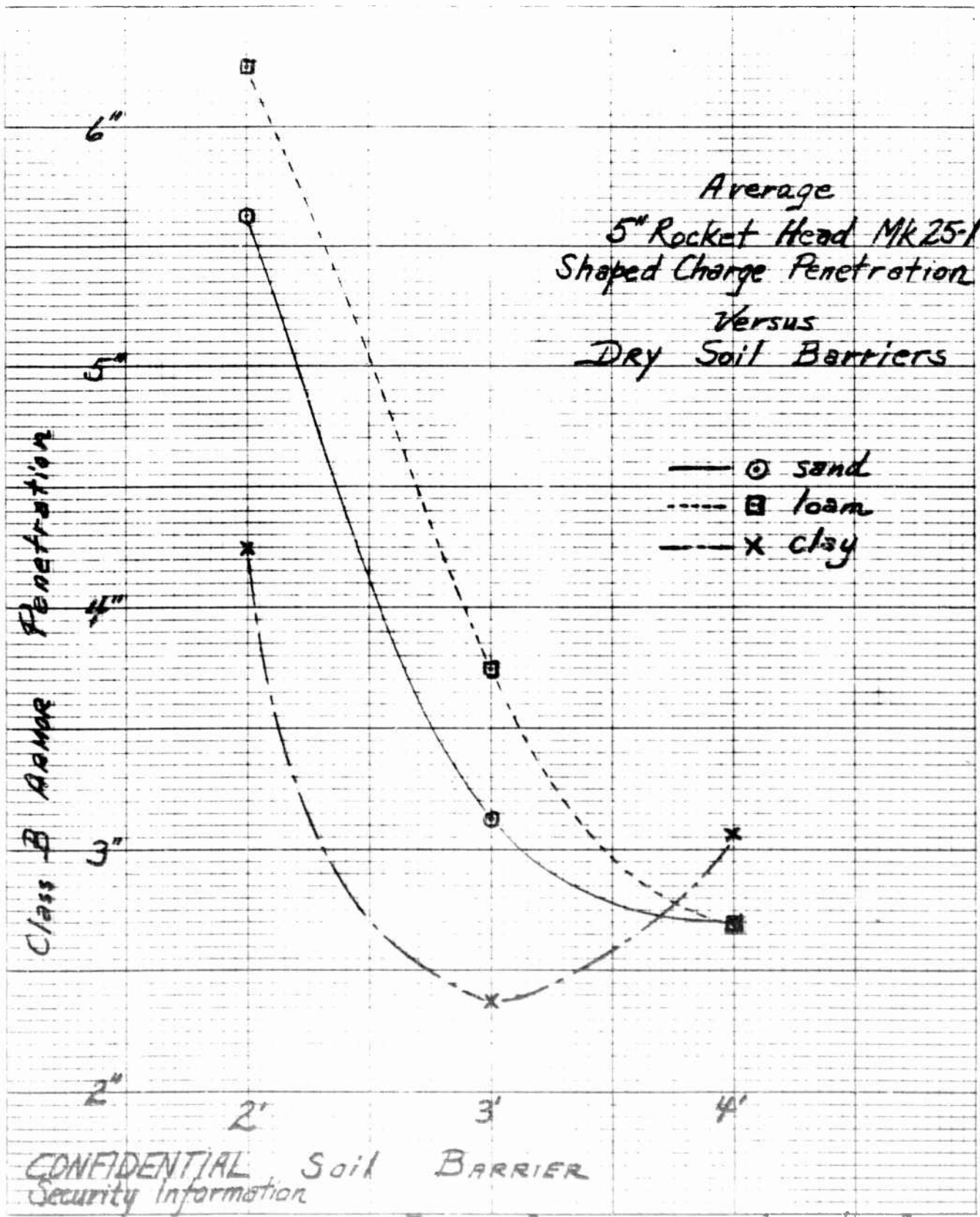
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Figure 9

Appendix C

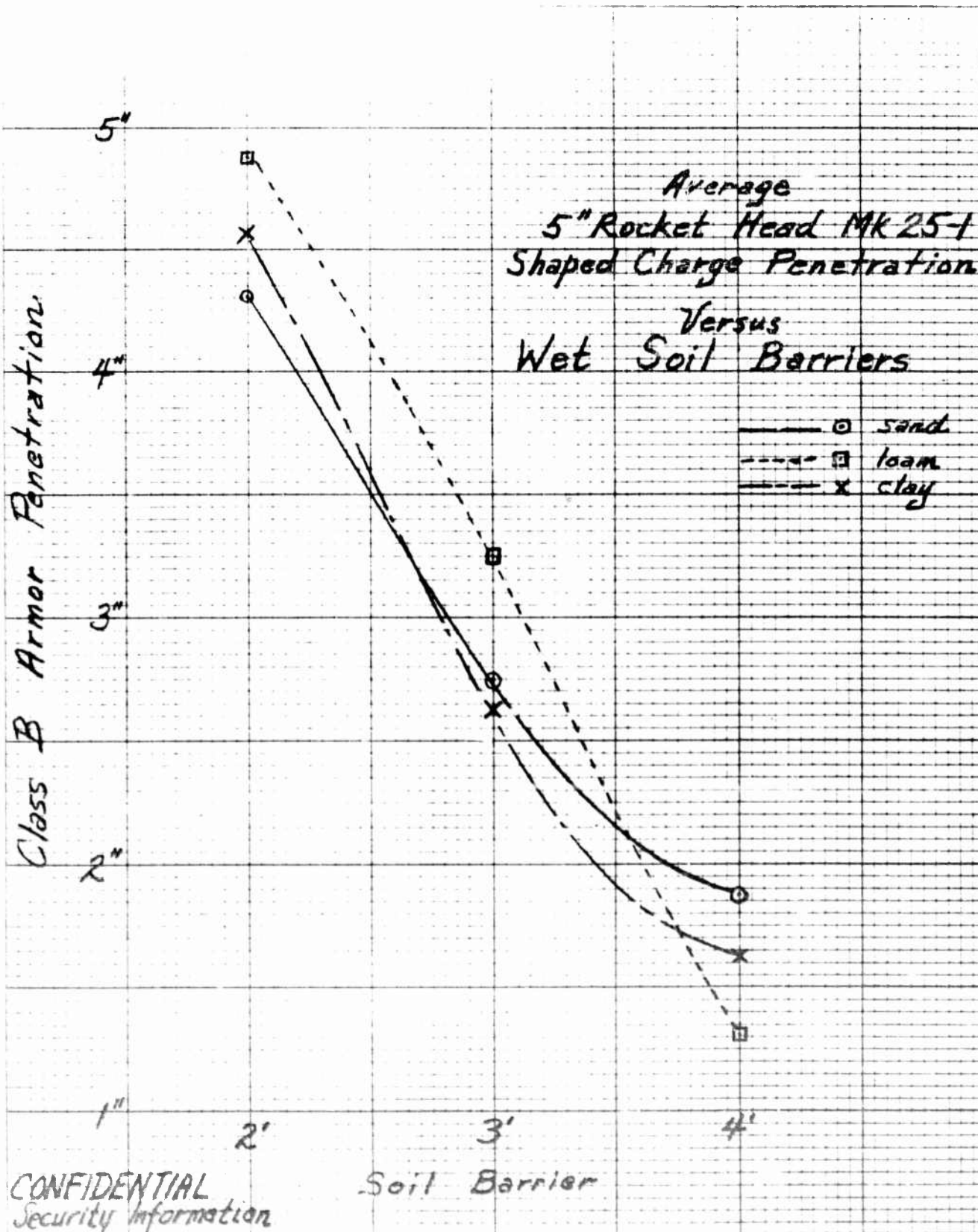


Figure 10

Appendix C

Effect of Soil Barriers on Shaped Charge Penetration

TABLE I

Shaped Charge: 5" Rocket Head Mk 25-1

Soil Condition: Dry

| <u>Rd. No.</u> | <u>Soil Barrier (feet)</u> | <u>Soil</u> | <u>Penetration (inches)</u> |
|----------------|--------------------------------|-------------|---------------------------------|
| 1 | 3 | clay | 1-3/4 |
| 2 | 3 | " | 1-3/4 |
| 3 | 4 | " | 2-9/16 |
| 4 | 4 | " | 2-1/2 |
| 5 | 3 | " | 2-1/4 |
| 6 | 2 | " | 4-3/4 |
| 7 | 2 | " | 4-1/8 |
| 8 | 3 | " | 4-1/4 + |
| 9 | 3 | " | 1-7/8 |
| 10 | 4 | sand | 2-7/8 |
| 11 | 3 | " | 2-1/4 |
| 12 | 2 | " | 6-1/16 |
| 13 | 2 | " | 5-3/16 |
| 14 | 3 | " | 4-1/4 + |
| 15 | 3 | " | *1-1/8 |
| 16 | 3 | " | 2-13/16 |
| 17 | 3 | " | 3-1/4 |
| 18 | 3 | loam | 4-1/4 + |
| 19 | 3 | " | * 13/16 |
| 20 | 3 | " | 3-9/16 |
| 21 | 3 | " | 2-5/8 |
| 22 | 2 | " | 6-15/16 |
| 23 | 2 | " | 5-1/2 |
| 24 | 3 | " | 4-1/4 + |
| 25 | 4 | " | 2-11/16 |
| 26 | 4 | sand | 2-1/2 |
| 27 | 4 | loam | *1-1/2 |
| 28 | 4 | clay | 3-5/8 |
| 29 | 4 | " | 3-5/8 |

+ indicates complete penetration of a 4-1/4" plate.

* penetration was greater than amount shown, part of cone stuck in plate. These values were not used in averaging.

Effect of Soil Barriers on Shaped Charge Penetration
-----TABLE II

Shaped Charge: 5" Rocket Head Mk 25-1

Soil Condition: wet

| <u>Rd. No.</u> | <u>Soil Barrier (feet)</u> | <u>Soil</u> | <u>Penetration (inches)</u> |
|----------------|--------------------------------|-------------|---------------------------------|
| 1 | 4 | sand | 1-7/8 |
| 2 | 3 | " | 4-1/16 |
| 3 | 3 | " | 3-1/16 |
| 4 | 2 | " | 4-5/16 |
| 5 | 3 | " | 9/16 |
| 6 | 4 | clay | 2-3/16 |
| 7 | 4 | loam | 2-5/16 |
| 8 | 3 | sand | 2-9/16 |
| 9 | 3 | " | 3-3/8 |
| 10 | 3 | clay | 1-7/8 |
| 11 | 3 | " | 1-1/2 |
| 12 | 3 | loam | 2-3/4 |
| 13 | 3 | " | 3-1/4 |
| 14 | 2 | clay | 4-5/8 |
| 15 | 4 | loam | 3/4 |
| 16 | 3 | " | 4 |
| 17 | 3 | " | 3-1/16 |
| 18 | 4 | " | 7/8 |
| 19 | 2 | " | 4 |
| 20 | 4 | clay | 1 |
| 21 | 2 | " | 4-1/2 |
| 22 | 3 | " | 3-1/4 |
| 23 | 3 | " | 2-3/4 |
| 24 | 2 | loam | 5-3/4 |