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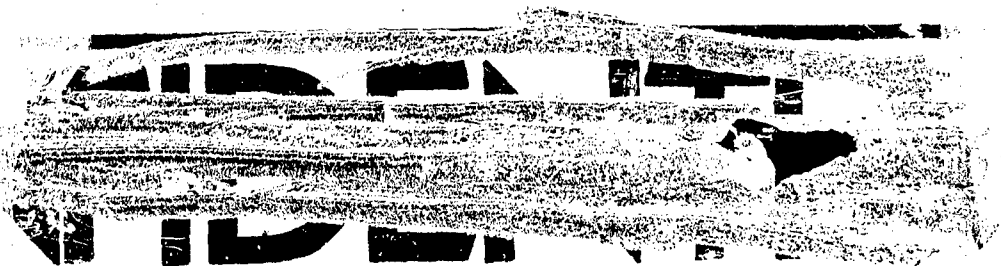
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U. S. NAVAL PROVING GROUND  
DAHLGREN, VIRGINIA

REPORT NO. 1090

INTERIOR BALLISTICS STUDIES

Partial Report

FOUNDATIONAL RESEARCH PROGRAMS

Partial Report

GENERAL INTERIOR BALLISTICS STUDIES

AN INSTRUMENT FOR THE STUDY OF THE  
INITIAL STAGES OF GUN RECOIL

Partial  
Report

Task  
Assignment MPG-Re5a-30-1-52

Report No. 34

Classification CONFIDENTIAL  
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AD 007214

An Instrument for the Study of the  
Initial Stages of Gun Recoil

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PART A

SYNOPSIS

1. This report describes the construction and operation of an instrument designed for the study of the initial stages of gun recoil.
2. On the basis of the results obtained with this instrument, it is concluded that:
  - a. An accurate time history of the first several thousandths inch of recoil motion can be obtained with this instrument.
  - b. Start of recoil can be determined to  $\pm 0.05$  millisecond.
  - c. The high degree of precision of measurement possible with this instrument should make it a useful tool in the study of the frictional forces of (1) the recoil mass, and (2) the projectile and bore surface during engraving of the projectile.

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Initial Stages of Gun Recoil

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PART B

INTRODUCTION

1. AUTHORITY:

The construction and test of the recoil strap described herein was performed incident to Interior Ballistics Studies authorized by Task Assignment No. NPG-Re5a-30-1-52 as established by reference (a). Since the instrument described promises to have wide applicability beyond the scope of the above task, certain phases of this analysis were supported by funds under the Naval Proving Ground program for Foundational Research.

2. REFERENCES:

- a. BUORD Test NP9-Re5a-RMS:cmj of 28 July 1951
- b. NPG Report No. 918 of 21 Feb 1952
- c. NPG Report No. 1004 of 25 Aug 1952

3. BACKGROUND:

In firings conducted on certain guns at the Naval Proving Ground, it was noted that breech pressure at the recorded start of recoil varied considerably from round to round under identical firing conditions. Since the pressure is changing rapidly in the region of start of recoil, this event could be displaced over a considerable pressure range by slight irregularity of operation of the recoil indicating device.

The instrument described in this report was developed primarily as a means of obtaining a more precise indication of recoil. In addition to performing this function, it provides adequate precision for the study of the initial stages of gun recoil, start of shot motion and the forces of engraving.

4. OBJECT OF TEST:

The object of the test was to develop and test an instrument for the study of the initial stages of gun recoil.

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PART C

DETAILS OF TEST

5. DESCRIPTION OF ITEM UNDER TEST:

The instrument described herein has been commonly referred to as the "recoil strap," the name originating from the fact that the essential component of this device is a steel band or strap. Assembled and exploded photographs of the device are included as Figures 1 and 2, respectively, of Appendix (A). Drawings of the strap and of several mounting brackets for installing it on different guns are enclosed as Figure 3 of Appendix (A).

A resistance strain gage is mounted on the steel band, which is clamped firmly at both ends. One clamp is bolted to a non-recoiling portion of the gun mount and the other to a section which recoils. Care must be exercised in mounting the instrument so that the steel band is parallel to the direction of recoil motion. After the band is clamped firmly at both ends, an initial stress is put on the strap by tightening the nut marked with an arrow in Figure 1 of Appendix (A). Normally, a stress producing approximately 0.5 ohm change in resistance in the 500 ohm strain gage is applied. This pre-stressing of the strap eliminates any possibility of slack in the strap before firing and permits measurement of slight forward motions of the guns preceding rearward motion. Such initial forward motion has been observed in the 3"/70 Type E Mod O Gun.

6. PROCEDURE:

The strain gage, mounted on the steel strap, is made one arm of a bridge circuit. The output of the bridge is fed into a hi-gain D. C. amplifier and the deflection of the oscilloscope beam is recorded by a drum camera. The recording technique is essentially the same as that of recording pressure versus time records as explained in reference (b).

By measuring the initial length of the steel strap, one can calculate and plot a displacement versus time curve of the recoil mass for the first several thousandths inch of recoil. Three such curves are shown in Figure 7, Appendix (C).

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## 7. RESULTS AND DISCUSSIONS:

The recoil strap has been used on three different guns to date. Oscillograms from 4 rounds fired in the 3"/70 Type E Mod O Gun, comparing the recoil strap with an oil-damped recoil switch, are shown in Figure 4 of Appendix (B). Two points are to be noted on these records:

- a. Start of recoil as indicated by the recoil strap occurs before the indication of the oil-damped switch.
- b. The strap records a slight forward motion of the gun preceding recoil. This is also evident in Figure 7 of Appendix (C).

When the instant of beginning of recoil in this gun, as determined by these two instruments, was correlated with breech pressure, it was observed that start of recoil as indicated by the strap, took place within a considerably narrower range of pressures than did start of recoil as indicated by the recoil switch. On 16 rounds fired in the 3"/70 Type E Mod O Gun, the breech pressure at start of recoil, as determined by the recoil strap, varied from 1650 to 2000 p.s.i. and averaged 1725 p.s.i. Start of recoil was considered here as the instant the gun began to move in recoil from the initial rest position. While different types of powders were used in the rounds, one type of projectile was used throughout the test. See reference (c). An accuracy of  $\pm 0.05$  milliseconds is obtained in determining the beginning of recoil by means of the recoil strap.

Sample records obtained with the recoil strap on two other guns are shown in Figure 5, Appendix (B). Note that these records show that the recoil masses in these two guns do not move forward initially as in the 3"/70 Type E Mod O Gun.

The possibility of using the recoil strap to obtain an indication of start of projectile motion was studied in the 3"/70 Type E Mod O Gun. In this study, the operation of the recoil strap was compared with an accelerometer located in the projectile. Two oscillogram records from these instruments are shown in Figure 6 of Appendix (B). The start of projectile motion, as measured by the projectile accelerometer, is indicated for each of 3 rounds in which the recoil displacement-time curves are plotted in Figure 7 of Appendix (C). The results from these rounds indicate that in this gun, start of projectile motion coincides with beginning of recoil of the gun as determined by the recoil strap within the accuracy of the instruments.

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The corresponding correlation in other guns has not yet been determined.

The possible applications which the recoil strap may have in studying (1) the frictional forces between projectile and bore surface during engraving and (2) the frictional forces involved in the initial movement of the recoil masses, are under investigation.

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

- J. MACATICIAN, Physicist, Armament Laboratories Division,  
Armament Department
- J. HENDERSON, Electronic Engineer,  
Armament Laboratories Division,  
Armament Department
- J. NANIGIAN, Physicist, Armament Laboratories Division,  
Armament Department

This report was prepared by:

- J. MACATICIAN, Physicist, Armament Laboratories Division,  
Armament Department
- J. NANIGIAN, Physicist, Armament Laboratories Division,  
Armament Department

This report was reviewed by:

- S. E. HEDDEN, Head, Interior Ballistics Branch,  
Armament Laboratories Division,  
Armament Department
- H. S. OVERMAN, Head, Armament Laboratories Division,  
Armament Department
- C. D. BERRY, Lieutenant, USN  
Machine Gun Battery Officer,  
Armament Department
- L. C. KLINGAMAN, Commander, USN, Armament Officer,  
Armament Department
- C. C. BRAUBLE, Director of Research, Ordnance Group

APPROVED: J. F. BYRNE  
Captain, USN  
Commander, Naval Proving Ground



E. A. RUCKNER  
Captain, USN  
Ordnance Officer  
By direction

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NPG REPORT NO. 1090

U. S. NAVAL PROVING GROUND  
DAHLGREN, VIRGINIA

Thirty-seventh Partial Report

on

Interior Ballistics Studies

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Ninth Partial Report

on

Foundational Research Programs

-----

Second Partial Report

on

General Interior Ballistics Studies

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An Instrument for the Study of the  
Initial Stages of Gun Recoil

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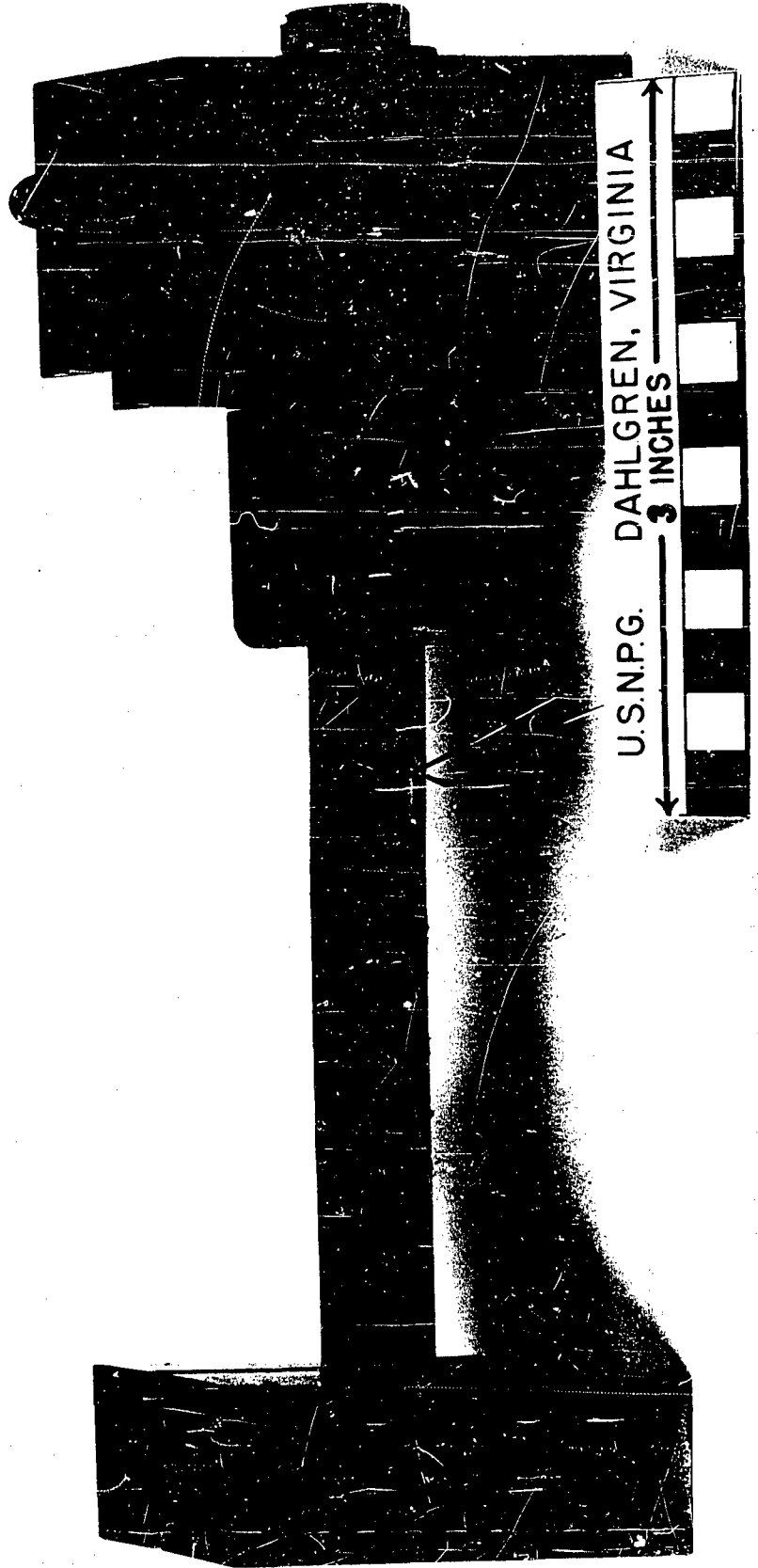
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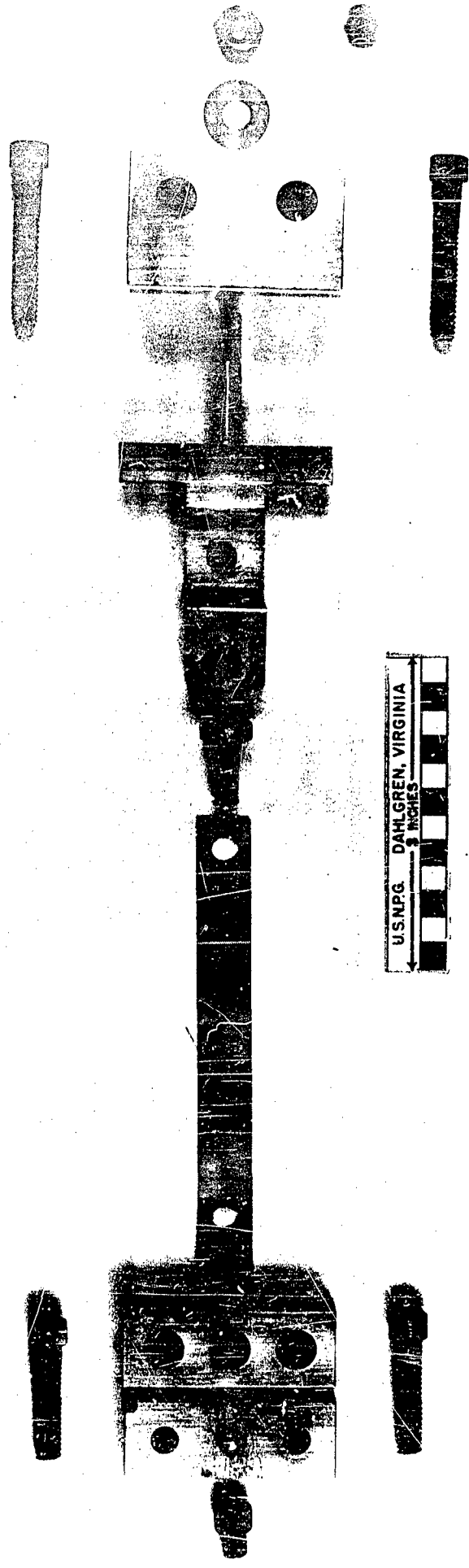
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NP9-44744

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Assembled View of Resistance Strain Gage  
Recoil Strap





U.S.N.P.G. DAHLGREN, VIRGINIA  
3 INCHES



Round 21

1 2 3

Close of Firing Key  
to Ejection-12.11 ms.

Round 22

1 2 3

Close of Firing Key  
to Ejection-12.10 ms.

Round 23

1 2 3

Close of Firing Key  
to Ejection-11.91 ms.

Round 24

1 2 3

Close of Firing Key  
to Ejection-11.96 ms.

NP9-50796

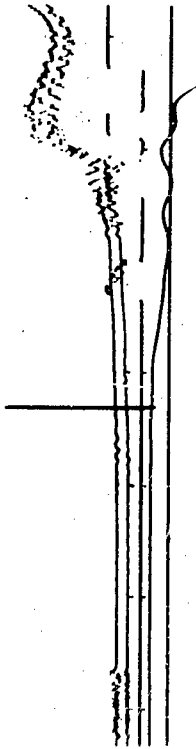
3"/70 TYPE E MOD 0  
RECOIL OSCILLOGRAMS

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- 1- Recoil Strap
- 2- Recoil Switch
- 3- Reference Line

Figure 4

Start of Recoil

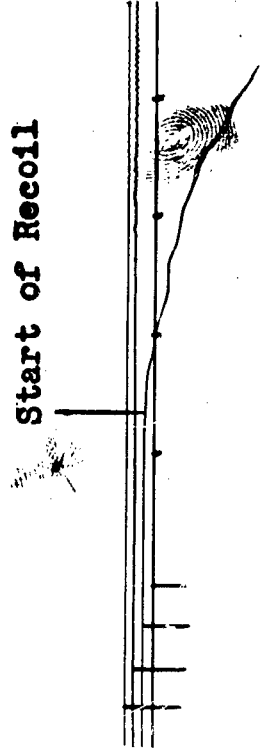


4"/3" Gun Type A Mod 0

Note:

Projectile - 4" pre-engraved test slug,  
Projectile weight - 15.0 lbs.

Start of Recoil



3."2 Gun Type B Mod 0

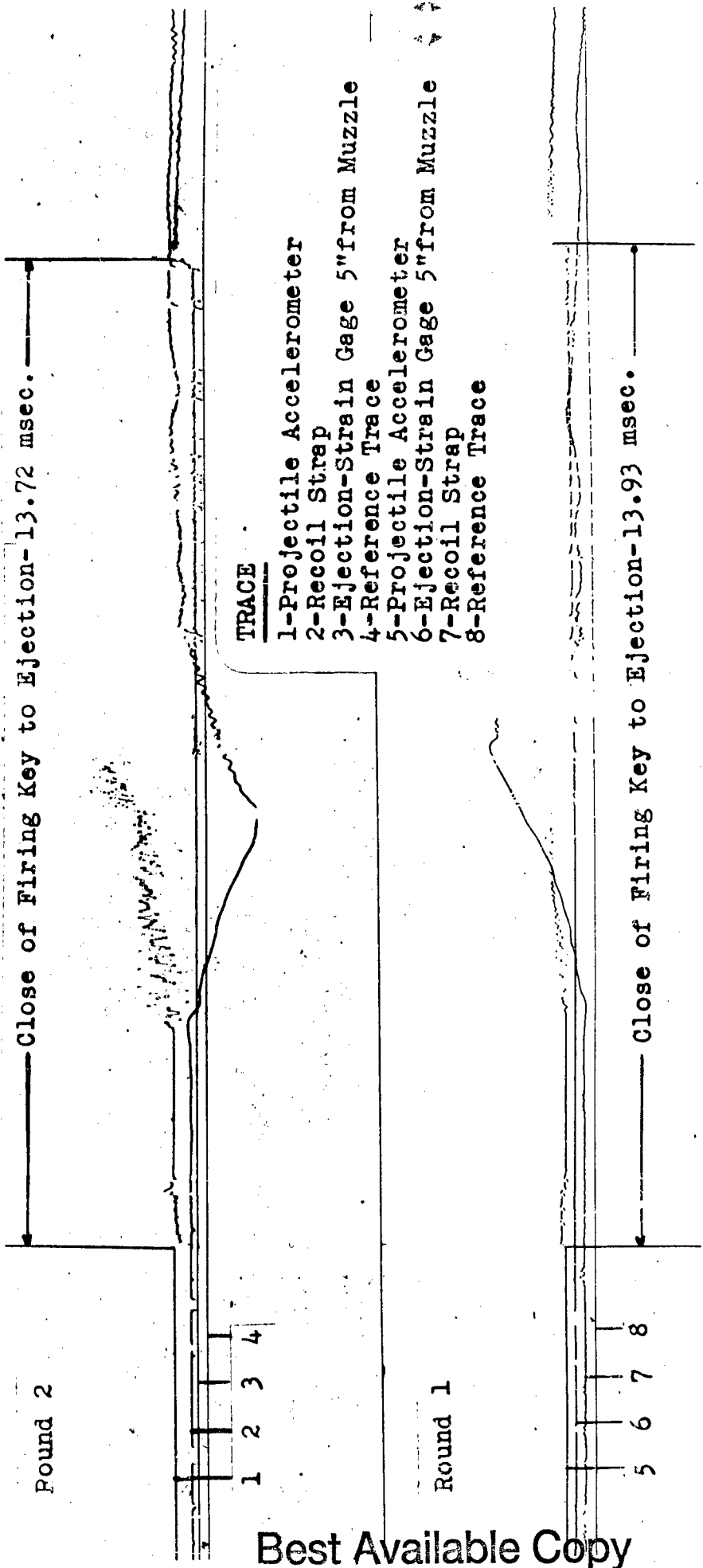
Note:

Barrel - smooth bore  
Projectile - fin-stabilized  
Projectile weight - 8.2 lbs (approx.)

Projectile Accelerometer and Recoil Strap Oscillograms

Powder Index: SPDN10114  
Charge Weight: 6.6 lbs.  
Projectile: Modified EX-11  
Projectile Weight: 12.6 lbs.

Copper Pressure: 12.2 t.s.i.  
Primer: XC-M11  
Case: EX-4



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Figure 6

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3" TO GUN TYPE E, MOD. O  
RECOIL TIME-DISPLACEMENT CURVES  
AUG - SEPT. 1952

NP9-50787

ROUND 1

ROUND 2

ROUND 3

LEGIBILITY POOR

INITIAL POSITION OF BUREAU

START OF PROJECTION

RO. 3  
RO. 2

RECOIL DISPLACEMENT-INCHES X 10<sup>-3</sup>