3319

TECHNICAL REPORT BRL-TR-3319

BRL

AD-A248 454

TIME ZERO TRIGGERING SYSTEM

WALLACE H. CLAY
LAWRENCE W. BURKE, JR.
WILLIAM G. THOMPSON
JAMES B. HARMON

DTIC
ELECTE
APR 14 1992
S B D

MARCH 1992

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED.

92-09392

U.S. ARMY LABORATORY COMMAND

BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

92 4 13 011

NOTICES

Destroy this report when it is no longer needed. DO NOT return it to the originator.

Additional copies of this report may be obtained from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The use of trade names or manufacturers' names in this report does not constitute indorsement of any commercial product.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	March 1992	Final. Dec 85-Oct 90.

4. TITLE AND SUBTITLE

Time Zero Triggering System

5. FUNDING NUMBERS

PR: 1L162618AH80

6. AUTHOR(S)

Wallace H. Clay, Lawrence W. Burke, Jr., William G. Thompson, and James B. Harmon

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Ballistic Research Laboratory
ATTN: SLCBR-DD-T
Aberdeen Proving Ground, MD 21005-5066

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

BRL-TR-3319

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Muzzle radiography is one of a number of investigative tools that are used to study projectile behavior at or near the muzzle of the gun tube. These instrumentation systems require an accurate and reliable reference as a trigger for the instrumentation. Many weapon systems from small arms to tank guns produce a characteristic blast pressure signature when the projectile exits the gun. This report describes a triggering system developed at the Ballistic Research Laboratory (BRL) that uses this characteristic blast pressure signature to provide an accurate, reliable, and repeatable reference trigger for instrumentation.

14. SUBJECT TERMS

Pressure Signatures; Delay Circuit; Precursor; Pulse Amplitude; Threshold; Trigger Circuits

15. NUMBER OF PAGES 16

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

INTENTIONALLY LEFT BLANK.

TABLE OF CONTENTS

Accession For
NTIS GRA&I
DTIC TAB
Unannounced
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A-1

INTENTIONALLY LEFT BLANK.

LIST OF FIGURES

INTENTIONALLY LEFT BLANK.

ACKNOWLEDGMENTS

The authors would like to express their appreciation to Messrs. Jonah Faust and Eric Irwin for their efforts in the construction and testing of the Time-Zero boxes.

INTENTIONALLY LEFT BLANK.

1. INTRODUCTION

Muzzle radiography is an important investigative tool in the study of projectile behavior. X-ray instrumentation is used to study the structural integrity, the sabot separation, and the tip-off behavior of the projectile as it leaves the muzzle of the gun. The most important and most difficult aspect of near-muzzle radiography is obtaining a reliable trigger for the x-ray instrumentation. The trigger must be consistent from round to round and activated as close to the projectile muzzle exit as possible. This report describes a Time-Zero triggering system that combines a pressure transducer near the muzzle of the gun and a Ballistic Research Laboratory (BRL) designed electronic time delay instrument to provide accurate and consistent start pulses for near muzzle radiography. This is accomplished without altering the weapon and without interfering with the projectile. This system may be used with both small- and large-caliber weapon systems.

2. DISCUSSION OF PRIOR ART

Over the past 30 years, there have been numerous attempts to provide a reliable ballistic trigger. Described in the following are three primary techniques used to date:

(1) Delayed Electrical Firing Pulse. With this method, the relay that fired the gun also triggered the instrumentation. Safety requirements demanded that the trigger pulse be isolated electrically from the firing pulse to prevent accidental firing of the weapon. The isolation was accomplished with a parallel-operated relay. This method was inconsistent due to actuation of the relays and the variables associated with the burning rate of the gun powder.

(2) Muzzle Break Wire. A wire installed across the muzzle of the gun formed part of a make or break circuit. The exit of the projectile breaks the wire, and a trigger pulse is generated by an associated circuit. Large-caliber, high-velocity projectiles produce a precursor shock that would either stretch the wire or break it prematurely. The result is a wide and unpredictable range in trigger times.

(3) Muzzle Flash Detector. An infrared photo-detecting system detects the flash associated with the burning gun gases and triggers as the projectile exits the gun. The sensitivity of this system varies with ambient light level. A leaking projectile obturator would produce an early trigger.

Other methods include the use of pressure gages mounted near the muzzle end of the gun tube which requires a modification to the weapon or laser systems which detect the passage of the projectile through a laser beam as it exits the muzzle. Neither of these methods have provided a consistent triggering pulse to use with muzzle x-ray instrumentation.

In the study of the interaction between sabot separation and projectile flight behavior, it is required that a series of x-rays be taken in close proximity to the muzzle. Since near-muzzle film size is approximately 1.2 times the projectile length at higher velocities, this system could only tolerate a triggering error of approximately 25 μs. Furthermore, a triggering system was needed which would not alter the weapon nor interfere with the flight of the projectile. This system should trigger on the precursor shock to allow the study of the projectile exiting the muzzle or trigger on the propelling pressure shock so the near-muzzle flight/sabot separation could be studied. The methods described previously could not meet these requirements. Therefore, a highly accurate and reliable triggering system needed to be developed.

3. TIME-ZERO TRIGGERING SYSTEM

As stated previously, the Time-Zero triggering system consists of one pressure probe which incorporates a pressure transducer, a specialized electronic delay circuit, and a trigger generator designed to operate in conjunction with the pressure transducer.

3.1 Pressure Probe. A pressure gage is mounted in a probe just behind the muzzle end of the gun tube. This is illustrated in Figure 1. The probe is usually not mounted on the weapon but is placed on a tripod near the tube and is designed to pivot out and away from the recoiling gun tube to prevent damage.

The pressure probe is designed to measure the near-field blast pressures associated with the firing of the weapon. These blast pressures are characteristic signatures associated with the length of the gun tube and projectile velocity. Figure 2 shows a typical pressure probe voltage vs. time profile for a 25-mm projectile. As indicated in Figure 2, there are two voltage peaks associated with the blast profile. The first peak is produced by the precursor shock. The second pulse is produced by the main shock as the projectile exits the gun tube. As a rule, the second peak is larger in amplitude than the first; however, this is not always the case.

The pressure signature for a given weapon system is consistent and characteristic of the weapon system. Figure 3 shows a plot of precursor and main peak pressures as a function of velocity for a 120-mm weapon system. The time interval between the precursor shock and the main shock is a function of the length of the gun tube and the projectile velocity. An empirical relationship for the ratio of the time interval to the tube length and the projectile velocity is shown in Figure 4. For a given velocity, the time interval between pulses can be predicted by multiplying the corresponding value of the ratio by the tube length. The curve in Figure 4 was generated from actual test data using a variety of types and calibers of projectiles.

The voltage peak produced by the passage of the main shock past the pressure gage is the desirable trigger source. A problem arises when the precursor pulse is larger in amplitude than the main shock pulse. In addition, occasional noise in the system occurs between the two peaks which could produce a false trigger.

3.2 Time-Zero Instrument. A block diagram of the electronics is shown in Figure 5. The circuit generally works as follows. The output of the pressure transducer is connected to the input of the Time-Zero box and conditioned when necessary. The output of the signal conditioner is connected to two parallel threshold detection circuits. Initially, both channels are disabled until the operator manually enables channel 1. The detection of the precursor shock by channel 1 starts an internal time delay clock. The length of this delay is preset and is determined with the help of Figure 4. At the end of this preset delay time, channel 2 is enabled. Detection of the first threshold level after enabling produces an output pulse that is used for triggering an x-ray or other instrumentation. If threshold values and time delays are set correctly, this output pulse is in synchronization with the occurrence of the main blast pressure pulse.

The Time-Zero box features variable input gain and multiple output trigger pulses. Threshold detection levels are set from the front panel. An output pulse is provided at the preset time delay, which allows the unit to act as a straight delay generator. Other features include front panel clock rate selectability, display readouts of preset time delay, total interval time, and clock overflow indication. Time resolution varies from microseconds to milliseconds, depending upon the clock rate selected.

Figure 6 shows a photograph of the Time-Zero instrument that was designed and constructed at the BRL. This instrument takes advantage of the characteristic signatures observed at the pressure probe. The Time-Zero box is a specialized delay generator designed to produce an output trigger pulse in synchronization with the occurrence of the main shock pressure pulse. It works over a wide range of input signatures, even when the precursor shock is higher in amplitude than the main peak or when there is high-amplitude noise in the interval between the two peaks.

4. CONCLUSIONS

The Time-Zero triggering system described in this report has been tested and has been in operation at BRL ranges for several years. It has proven to be a very reliable and accurate method of obtaining trigger pulses for radiographic instrumentation and for other instrumentation systems as well. BRL has constructed and supplied Time-Zero instrumentation boxes for the Combat Systems Test Activity (CSTA), at Aberdeen Proving Ground, MD, and to the Sandia National Laboratories in Albuquerque, NM, for use in their test ranges.

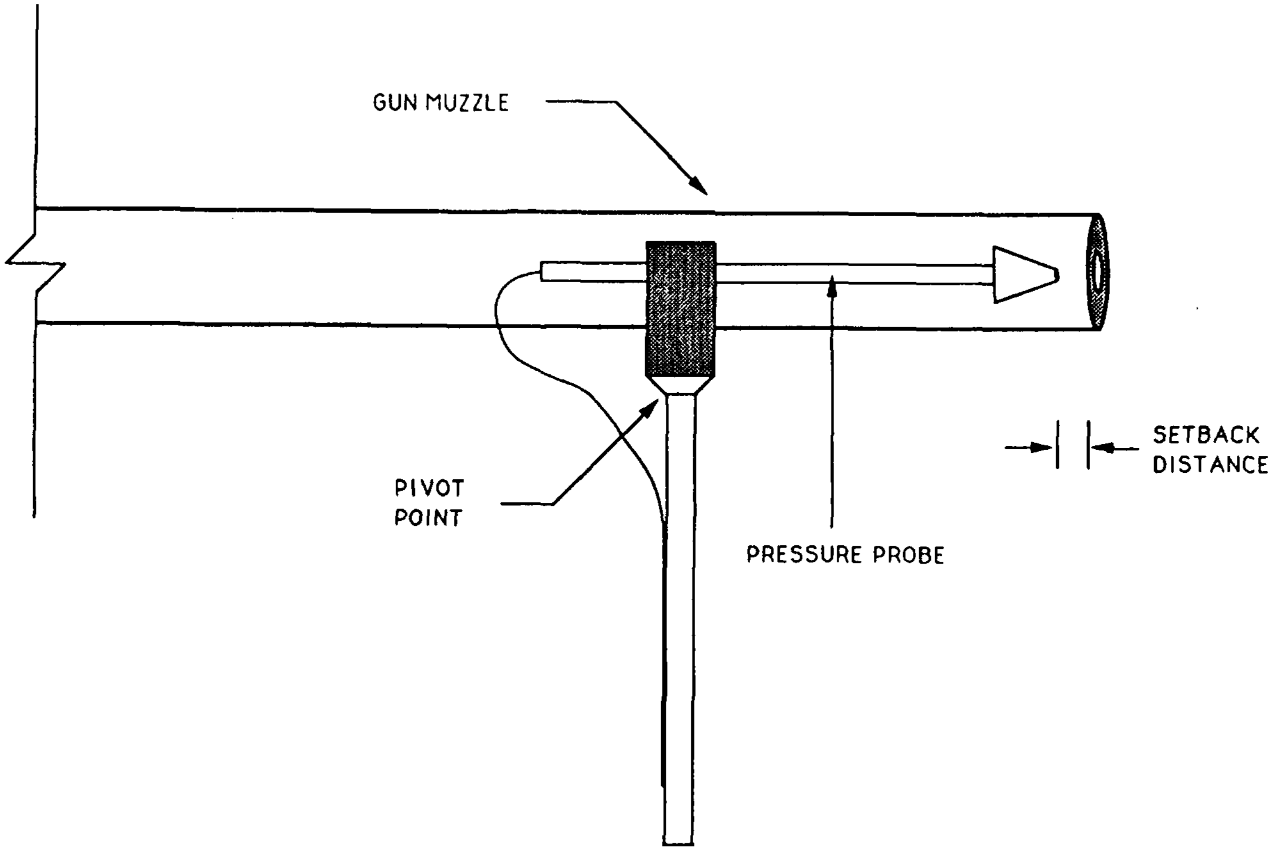

Figure 1. Mounting Location of Pressure Probe.

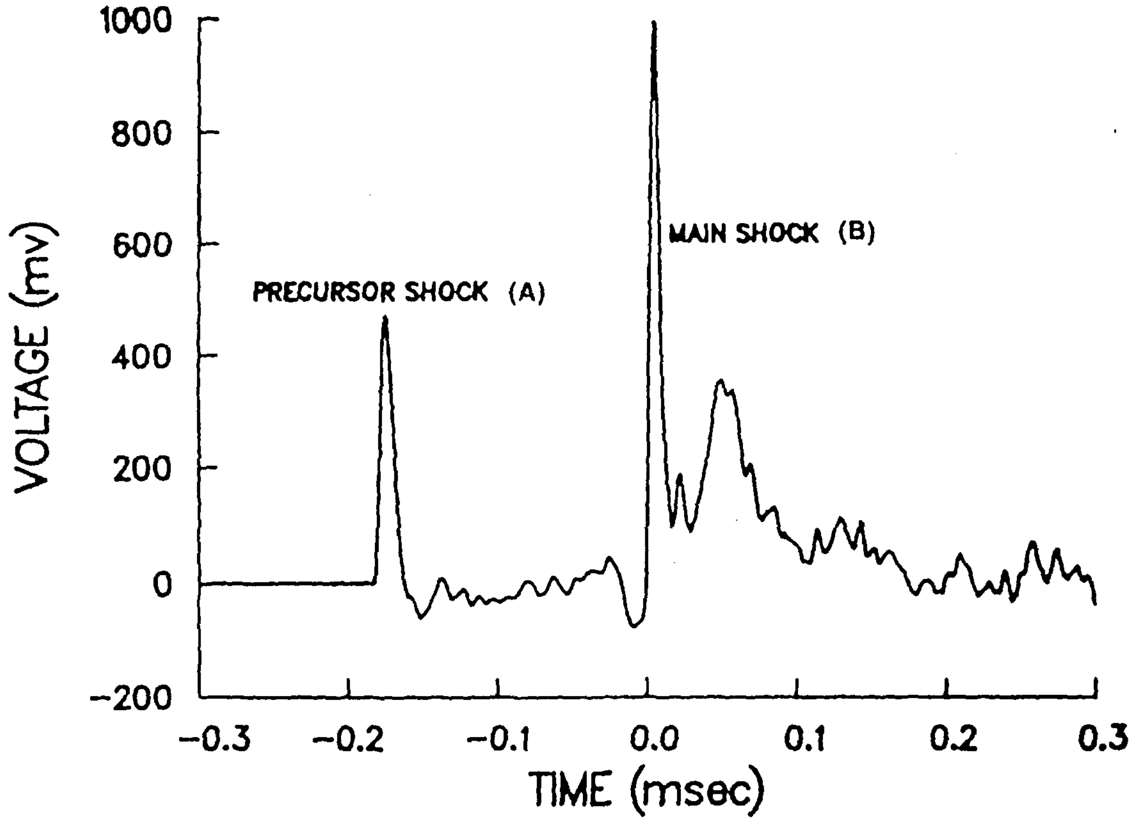

Figure 2. Typical 25-mm Muzzle Signature.

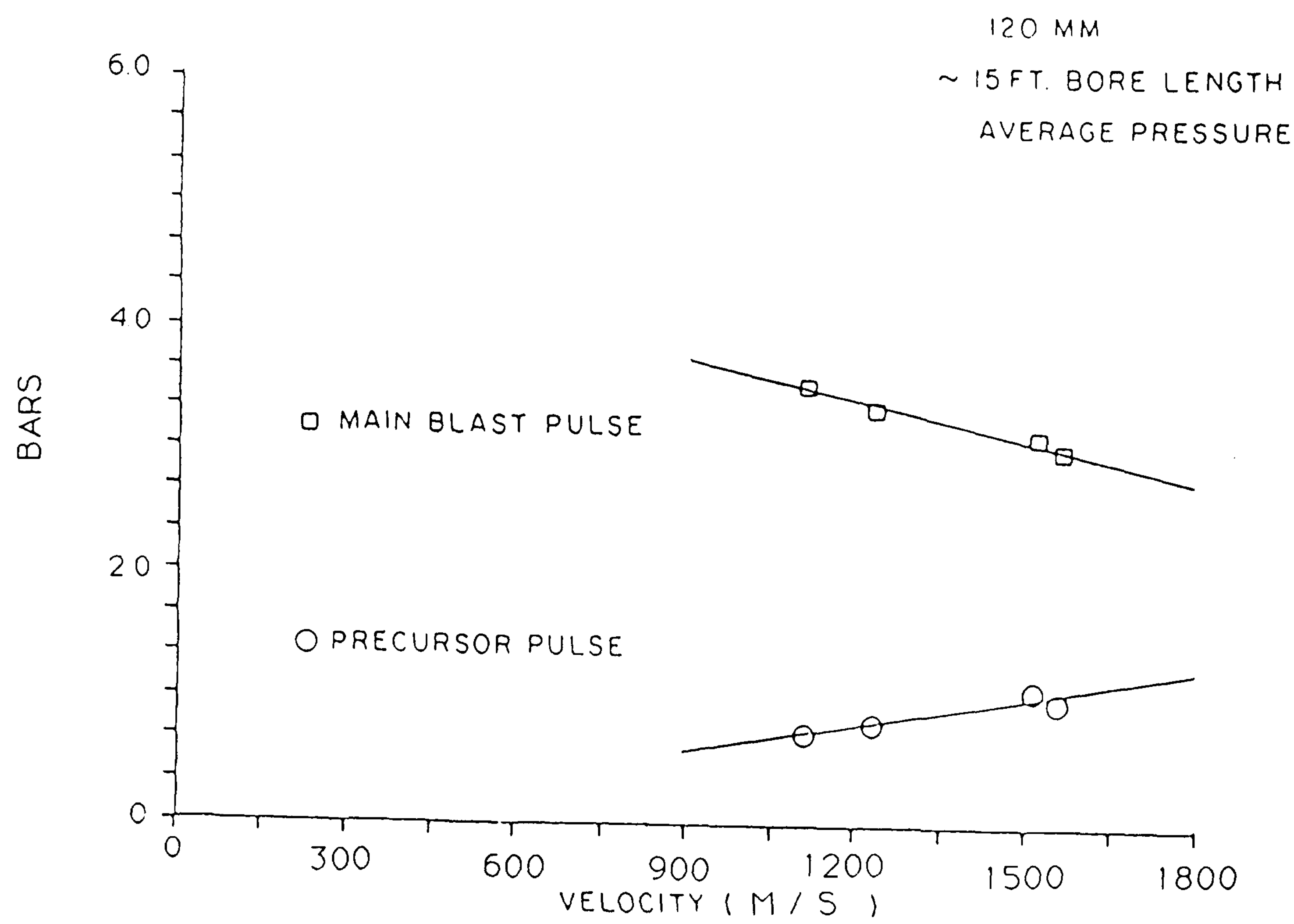

Figure 3 <u>*Pressure vs. Velocity for a 120-mm Weapon System.*</u>

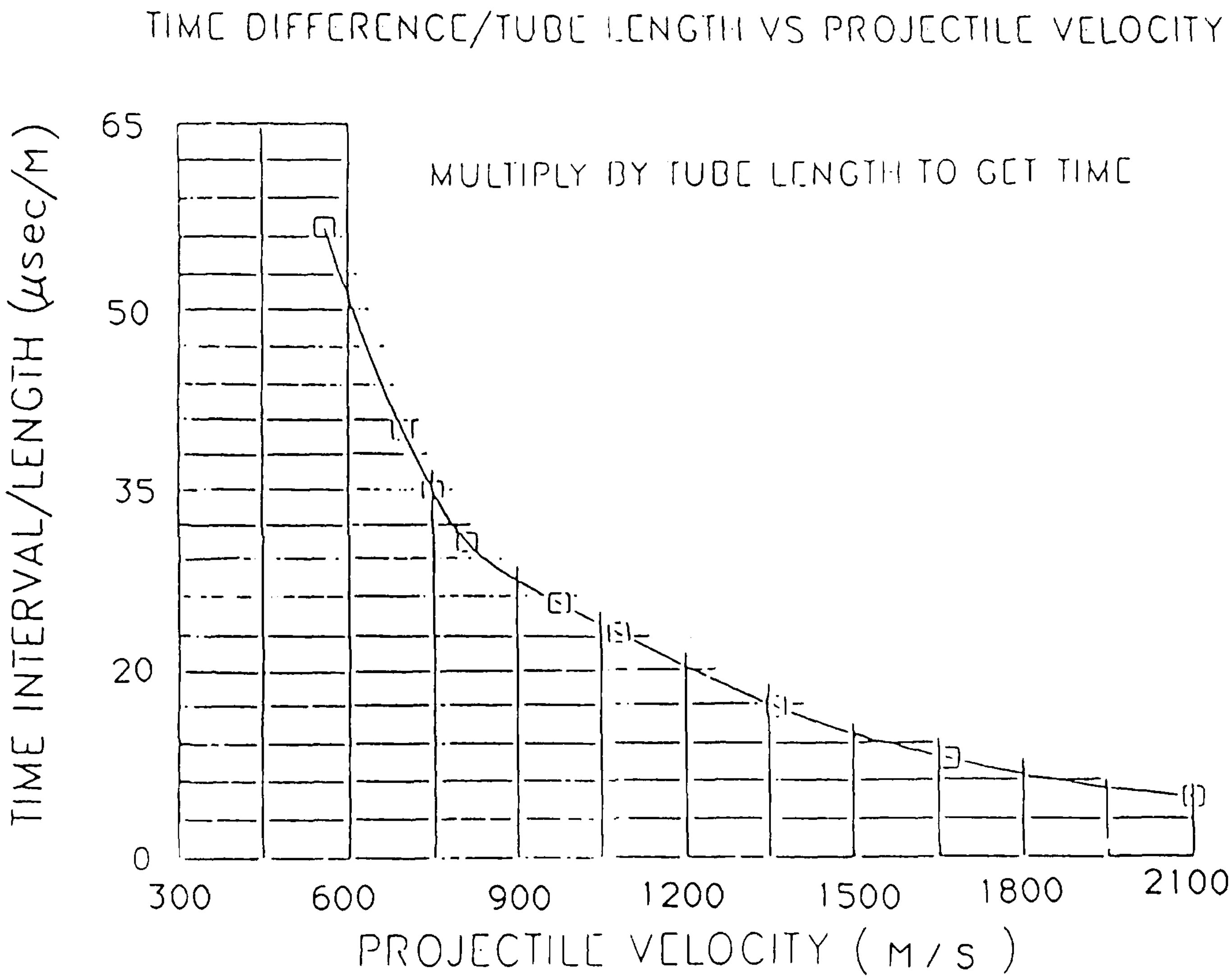

Figure 4 Pulse Separation Chart.

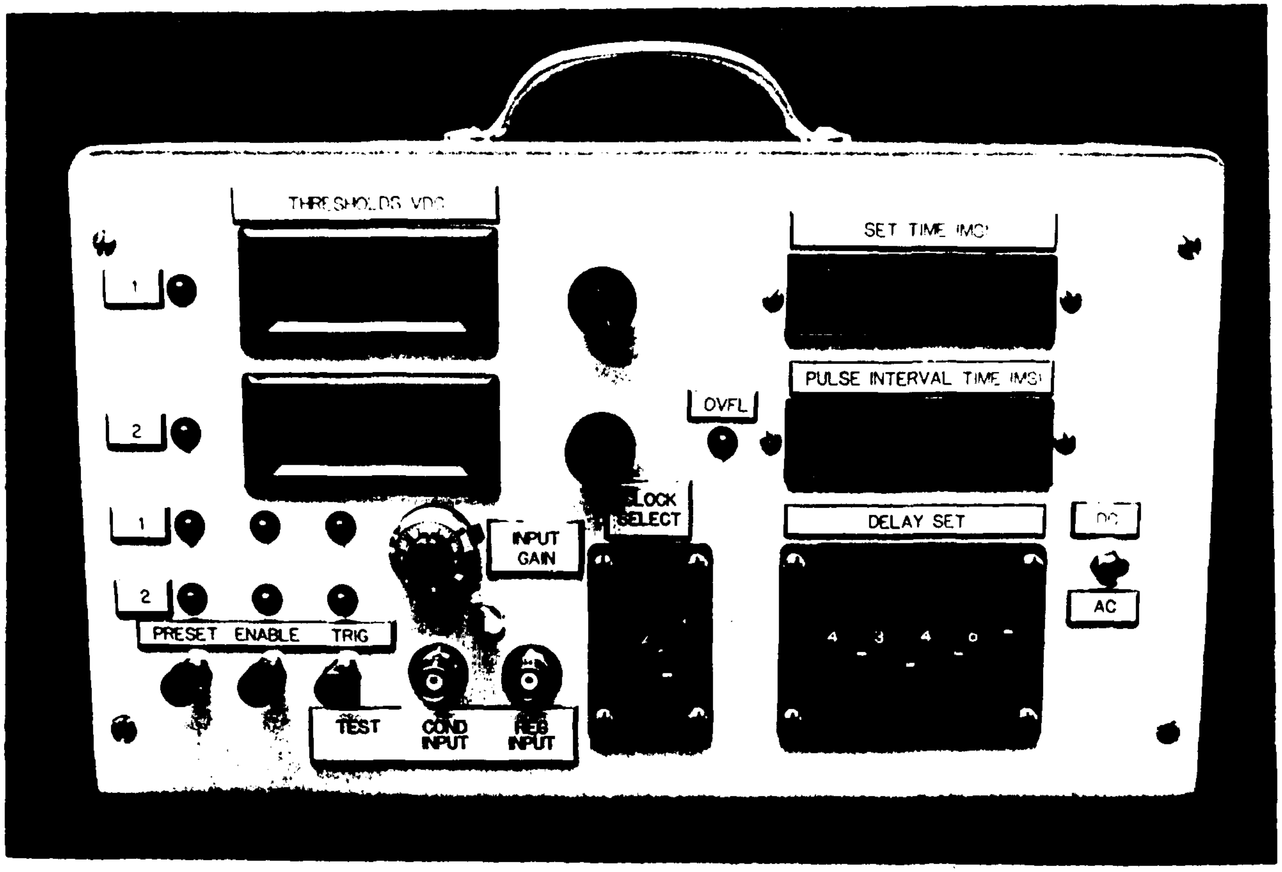

Figure 5. Time-Zero Box.

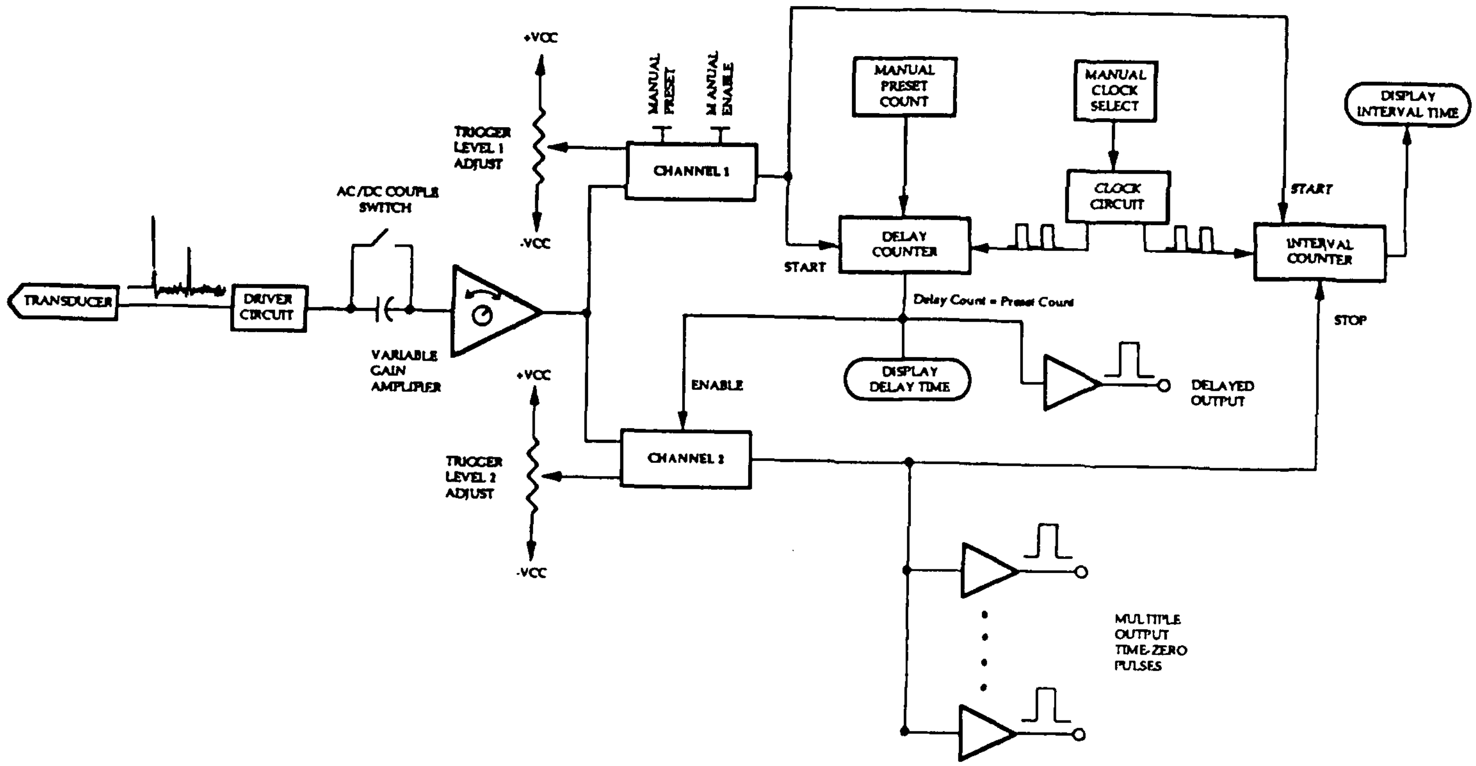

Figure 6. Block Diagram of Time-Zero Trigger System.

No. of Copies	Organization
2	Administrator Defense Technical Info Center ATTN: DTIC-DDA Cameron Station Alexandria, VA 22304-6145
1	Commander U.S. Army Materiel Command ATTN: AMCAM 5001 Eisenhower Ave. Alexandria, VA 22333-0001
1	Commander U.S. Army Laboratory Command ATTN: AMSLC-DL 2800 Powder Mill Rd. Adelphi, MD 20783-1145
2	Commander U.S. Army Armament Research, Development, and Engineering Center ATTN: SMCAR-IMI-I Picatinny Arsenal, NJ 07806-5000
2	Commander U.S. Army Armament Research, Development, and Engineering Center ATTN: SMCAR-TDC Picatinny Arsenal, NJ 07806-5000
1	Director Benet Weapons Laboratory U.S. Army Armament Research, Development, and Engineering Center ATTN: SMCAR-CCB-TL Watervliet, NY 12189-4050
(Unclass. only)1	Commander U.S. Army Armament, Munitions, and Chemical Command ATTN: AMSMC-IMF-L Rock Island, IL 61299-5000
1	Director U.S. Army Aviation Research and Technology Activity ATTN: SAVRT-R (Library) M/S 219-3 Ames Research Center Moffett Field, CA 94035-1000
1	Commander U.S. Army Missile Command ATTN: AMSMI-RD-CS-R (DOC) Redstone Arsenal, AL 35898-5010

No. of Copies	Organization
1	Commander U.S. Army Tank-Automotive Command ATTN: ASQNC-TAC-DIT (Technical Information Center) Warren, MI 48397-5000
1	Director U.S. Army TRADOC Analysis Command ATTN: ATRC-WSR White Sands Missile Range, NM 88002-5502
1	Commandant U.S. Army Field Artillery School ATTN: ATSF-CSI Ft. Sill, OK 73503-5000
2	Commandant U.S. Army Infantry School ATTN: ATZB-SC, System Safety Fort Benning, GA 31903-5000
(Class. only)1	Commandant U.S. Army Infantry School ATTN: ATSH-CD (Security Mgr.) Fort Benning, GA 31905-5660
(Unclass. only)1	Commandant U.S. Army Infantry School ATTN: ATSH-CD-CSO-OR Fort Benning, GA 31905-5660
1	Air Force Armament Laboratory ATTN: WL/MNOI Eglin AFB, FL 32542-5000
	Aberdeen Proving Ground
2	Dir, USAMSAA ATTN: AMXSY-D AMXSY-MP, H. Cohen
1	Cdr, USATECOM ATTN: AMSTE-TC
3	Cdr, CRDEC, AMCCOM ATTN: SMCCR-RSP-A SMCCR-MU SMCCR-MSI
1	Dir, VLAMO ATTN: AMSLC-VL-D
10	Dir, USABRL ATTN: SLCBR-DD-T

No. of Copies	Organization
1	Commander U.S. Army Yuma Proving Ground ATTN: STEYP-MT-I, Andrew E. Hooper Yuma Proving Ground, AZ 85365-9110
1	Sandia National Laboratories ATTN: Luis Abeyta P.O. Box 5800 Albuquerque, NM 87185
	<u>Aberdeen Proving Ground</u>
1	Dir, USACSTA ATTN: STECS-EN-BE-R Jeff Adams (Bldg. 451)

USER EVALUATION SHEET/CHANGE OF ADDRESS

This laboratory undertakes a continuing effort to improve the quality of the reports it publishes. Your comments/answers below will aid us in our efforts.

1. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which the report will be used.) ______

2. How, specifically, is the report being used? (Information source, design data, procedure, source of ideas, etc.) ______

3. Has the information in this report led to any quantitative savings as far as man-hours or dollars saved, operating costs avoided, or efficiencies achieved, etc? If so, please elaborate. ______

4. General Comments. What do you think should be changed to improve future reports? (Indicate changes to organization, technical content, format, etc.) ______

BRL Report Number BRL-TR-3319 Division Symbol ______

Check here if desire to be removed from distribution list. ____

Check here for address change. ____

Current address: Organization ______
Address ______

DEPARTMENT OF THE ARMY
Director
U.S. Army Ballistic Research Laboratory
ATTN: SLCBR-DD-T
Aberdeen Proving Ground, MD 21005-5066

OFFICIAL BUSINESS

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT No 0001, APG, MD

Postage will be paid by addressee.

Director
U.S. Army Ballistic Research Laboratory
ATTN: SLCBR-DD-T
Aberdeen Proving Ground, MD 21005-5066

END

FILMED

DATE: 4-92

DTIC

SUPPLEMENTARY

INFORMATION

DEPARTMENT OF THE ARMY
U.S. ARMY RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND 21005-5066

REPLY TO
THE ATTENTION OF

AMSRL-WT-W

Errata AD-A248 458

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Correction of BRL-TR-3319, Time Zero Triggering System, by Wallace H. Clay, Lawrence W. Burke, Jr., William G. Thompson, and James B. Harmon, dated March 1992

1. The purpose of this memorandum is to apprise the recipients of subject report of an error found in Figure 4 (Pulse Separation Chart), page 8. The scale for the plot shown is incorrect. It is requested that the attached corrected figure be used to replace the figure currently in subject report.

2. The U.S. Army Research Laboratory solicits input to improve the quality of reports it publishes. Comments or questions which contribute to that end should be submitted to the Director, U.S. Army Research Laboratory, ATTN: AMSRL-OP-AP-L, Aberdeen Proving Ground, MD 21005-5066.

FOR THE DIRECTOR:

Charles H. Murphy

CHARLES H. MURPHY
Chief
Weapons Concepts Division

Encl

DISTRIBUTION:

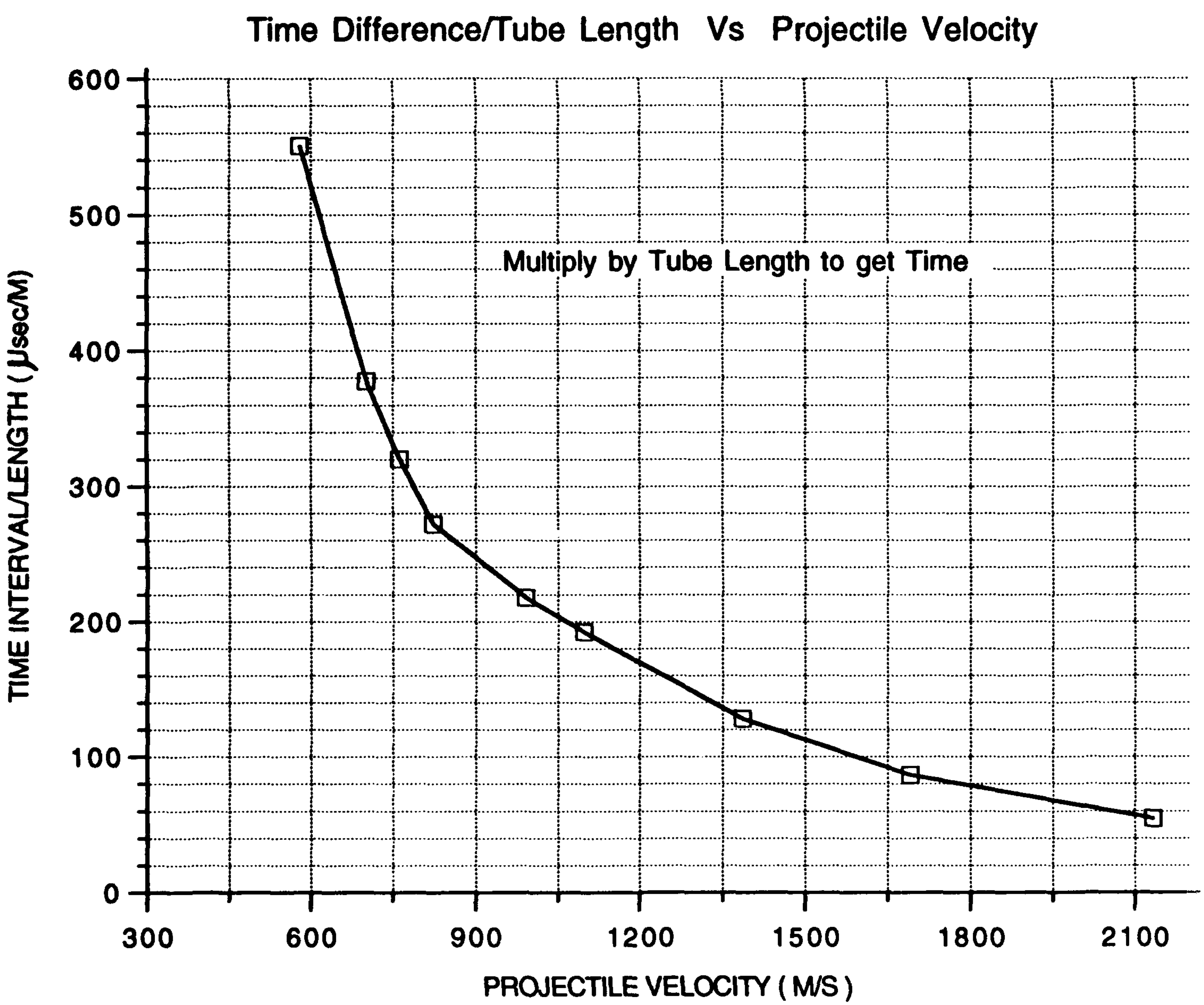

Figure 4 Pulse Separation Chart

END

FILMED

DATE: 9-94

DTIC