AD-A147 102 ILIR TASK OF DIGITAL RECOIL TRAVEL MEASUREMENT SYSTEM (U) ARMY COMBAT SYSTEMS TEST ACTIVITY (PROV) ABERDEEN PROVING GROUND MD V A BETZOLD ET AL. JUL 84 1/1

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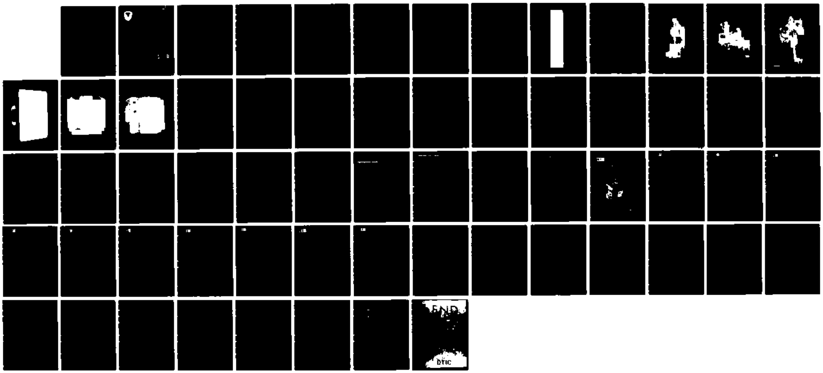

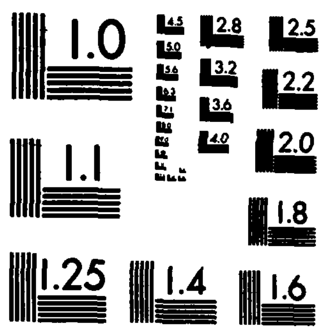
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AD NO.
FUNDING PROJECT NO. 1L161101A91A
TECOM PROJECT (TRMS) 7-CO-IL4-AP1-001
CSTA REPORT NO. CSTA-6045

FINAL REPORT

ILIR TASK

OF

DIGITAL RECOIL TRAVEL

MEASUREMENT SYSTEM

V. A. BETZOLD
C. L. FRANCIS

MEASUREMENTS AND ANALYSIS DIRECTORATE

US ARMY COMBAT SYSTEMS TEST ACTIVITY (PROVISIONAL)
ABERDEEN PROVING GROUND, MD 21005-5059

JULY 1984

Period Covered:
October 1982 to July 1984

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1. REPORT NUMBER: TECOM Project 7-CO-IL4-API-001	2. GOVT ACCESSION NO.: AD-A147 102
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): ILIR TASK OF DIGITAL RECOIL TRAVEL MEASUREMENT SYSTEM	5. TYPE OF REPORT & PERIOD COVERED: Final, October 1982 to July 1984
	6. PERFORMING ORG. REPORT NUMBER: CSTA-6045
7. AUTHOR(s): V. A. Betzold C. L. Francis	8. CONTRACT OR GRANT NUMBER(s): Not available
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Combat Systems Test Activity (Prov) STECS-MA-B Aberdeen Proving Ground, MD 21005-5059 (020)	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Not available
11. CONTROLLING OFFICE NAME AND ADDRESS: Commander, TECOM ATTN: DRSTE-AD-M Aberdeen Proving Ground, MD 21005-5055	12. REPORT DATE: July 1984
	13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): None	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: None

16. DISTRIBUTION STATEMENT (of this Report)

Distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

None

18. SUPPLEMENTARY NOTES

None

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Recoil travel
Ballistic Test Site Terminal
Incremental Optical Encoder
Recoil velocity

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A study was conducted to improve measurement of large caliber weapon recoil travel. Since the 1950s, a continuous rotation, single turn potentiometer driven by a rack and pinion gear has been used on a variety of weapons. Satisfactory data has been produced by this system, but the data records suffer from a number of problems caused by the potentiometer. Therefore, the potentiometer was replaced by a digital incremental optical shaft encoder.

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20. Circuitry was developed to interface the encoder output to a digital data acquisition system. Software was then written to process the data at the firing site, and provide a near real-time plot of recoil travel and velocity versus time. Originator supplied Keywords include: Ballistic Test Site Terminal, and Incremental Optical Encoder.

TABLE OF CONTENTS

(Page ii Blank)

FOREWORD

The US Army Combat Systems Test Activity (USACSTA (Prov)) (formerly Materiel Testing Directorate (MTD)), Aberdeen Proving Ground (APG), MD, conducted this investigation and prepared this report as part of an effort to improve the quality of ballistic measurements. Acknowledgement is given to Mr. Bryan Mitchell for fabrication and field testing of the Digital Recoil Travel Measurement System.

SECTION 1. SUMMARY

1.1 BACKGROUND

Measurement of weapon recoil travel versus time has been a standard ballistic measurement requirement for many years. Since the 1950s, a continuous rotation, single turn potentiometer driven by a rack and pinion gear has been used on a variety of large caliber weapons. A sample record obtained with this transducer is in Figure 1.1-1. Satisfactory data have been produced by this system, but the data records suffer from a number of problems:

a. When the potentiometer rotor crosses the gap between the ends of the stator element, an open circuit noise spike is generated.

b. The potentiometer noise output increases with wear.

c. The recording bandwidth must be high enough to capture the level change generated by crossing the gap in the stator. This is normally an order of magnitude higher than the actual motion bandwidth.

d. The record generated by the potentiometer cannot be read directly, but rather must be processed by a computer program which generates a displacement versus time record.

Problems a and b apply equally to analog or digital data acquisition systems. Problem c applies primarily to a digital system where limited memory is used rapidly by the higher sample rate needed to accurately reproduce the gap transition. Problem d applies primarily to an analog system as there is no way to perform the analysis at the test site whereas in a digital system the problem means additional processing time.

Providing the test director with an immediate indication of test results was generally not possible until recently, when the transition from analog to digital data acquisition facilities occurred. The new Ballistic Test Site Terminals (BTST) are digital data acquisition systems which provide the technician with a means to reduce data to engineering units in the field, with the prerequisite that he have a transducer which produces a usable signal and the software to interpret that signal.

The problems with the potentiometer output have been recognized for several years. A digital means of measuring recoil was attempted by J. G. Yeager as detailed in TECOM Report No. DPS-2363, 1967. Mr. Yeager discussed the results of development of an optical measurement system, in which a photoelectric transducer head and coded tape were used to produce a pulse output.

Considering the results achieved by this method and the advances in technology, additional investigation was considered necessary. Elimination of the rack and pinion concept is not of great benefit; after the initial investment in design and fabrication, they last indefinitely and require adjustment infrequently. Replacement of the potentiometer was considered to be the key to improving the measurement.

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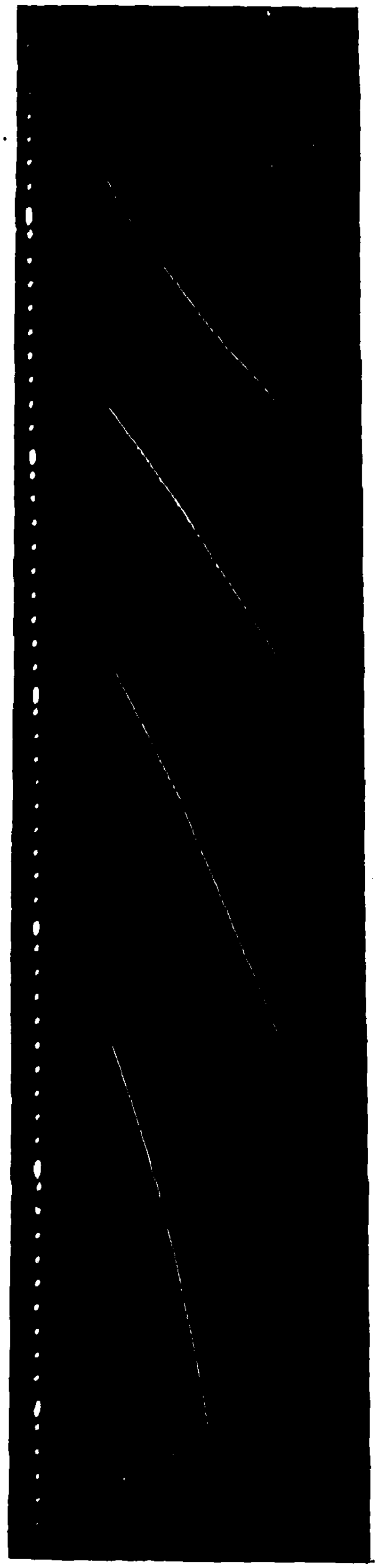


Figure 1.1-1. Recoil travel potentiometer output signal.

1.2 OBJECTIVES

The objectives of this project are to identify an improved recoil travel transducer, and to provide the test director with recoil travel versus time plots in near real time, at the test site.

1.3 SUMMARY OF PROCEDURES

An incremental shaft encoder (fig. 1.3-1, 1.3-2, and 1.3-3) was selected as a replacement for the continuous potentiometer. Circuitry was then developed (fig. 1.3-4, 1.3-5 and, 1.3-6) to interface pulses from the shaft encoder to a Hewlett Packard 1000 computer in the BTST. Finally, software was written to provide recoil distance traveled, a plot of recoil travel versus time, and a plot of recoil velocity versus time.

1.3 (Cont'd)

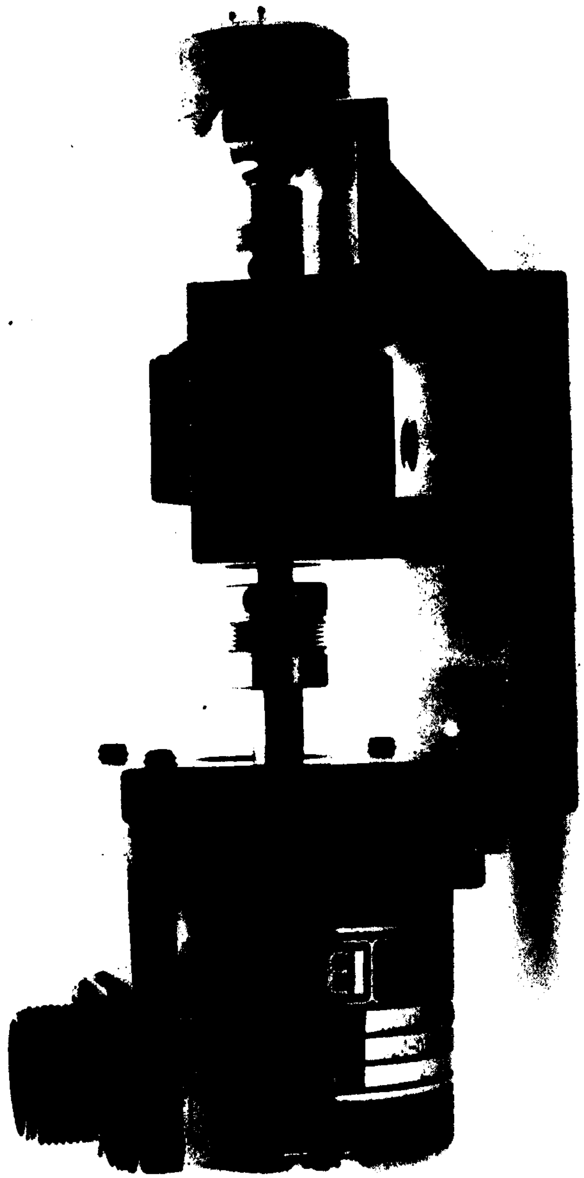


Figure 1.3-1. Incremental shaft encoder and pinion gear mount. (Note flexible shaft couplings.)

1.3 (Cont'd)

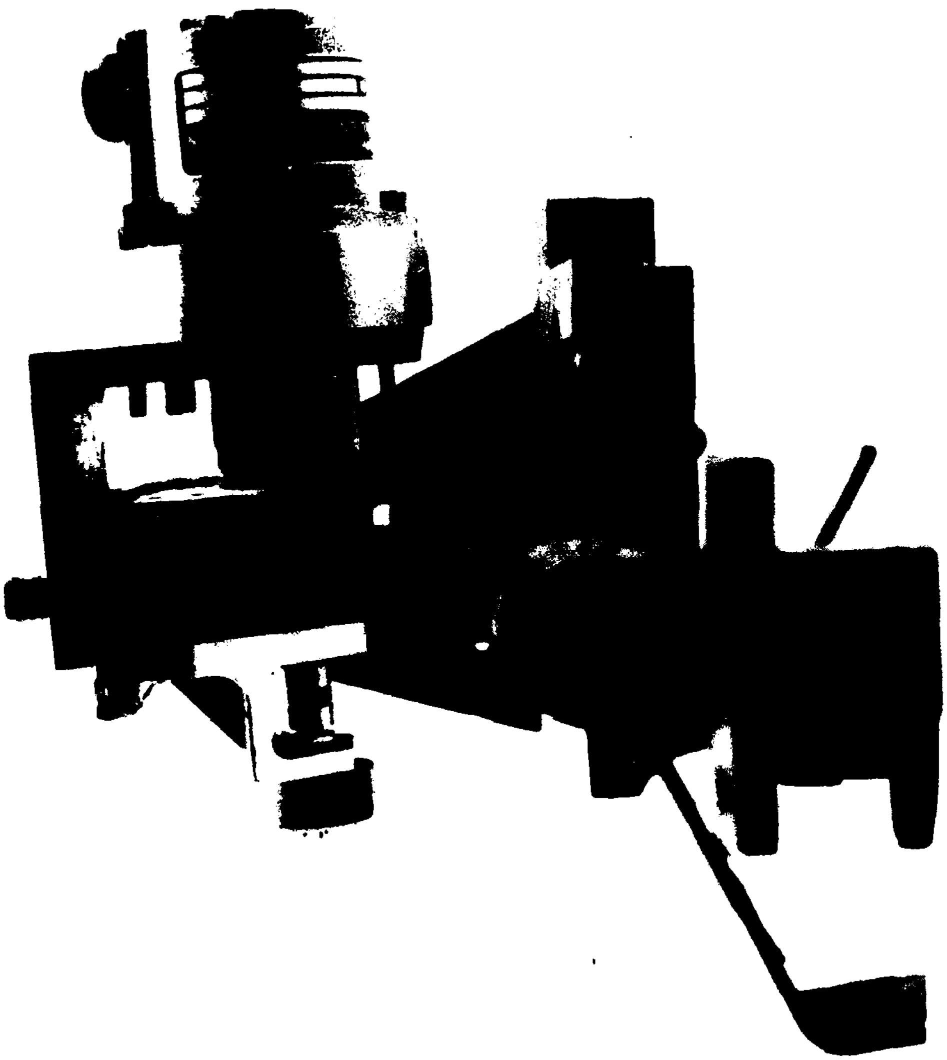


Figure 1.3-2. Incremental shaft encoder on 105-mm M68 recoil travel rack.

1.3 (Cont'd)

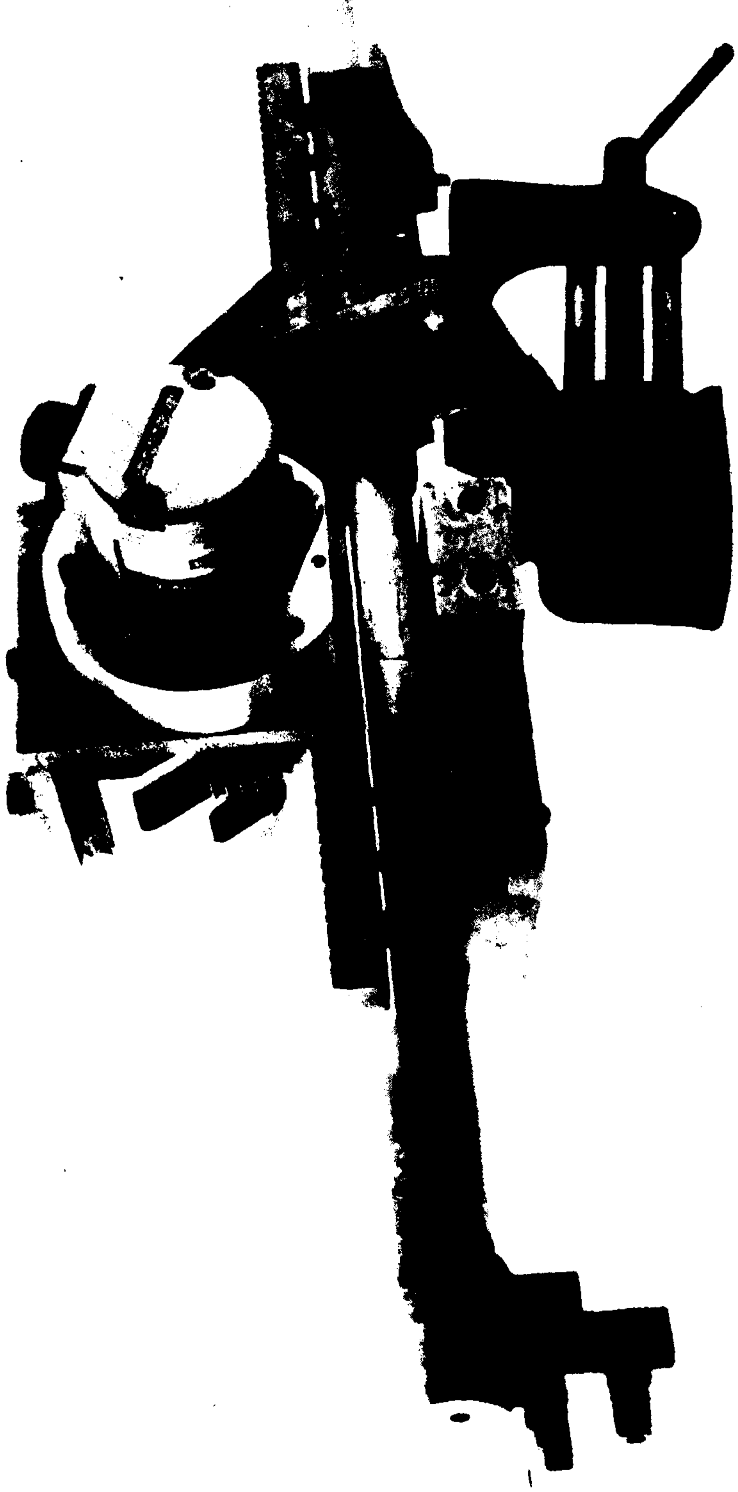


Figure 1.3-3. Incremental shaft encoder on 105-mm M68 recoil travel rack.

1.3 (Cont'd)

Figure 1.3-4. Recoil travel interface unit.

1.3 (Cont'd)

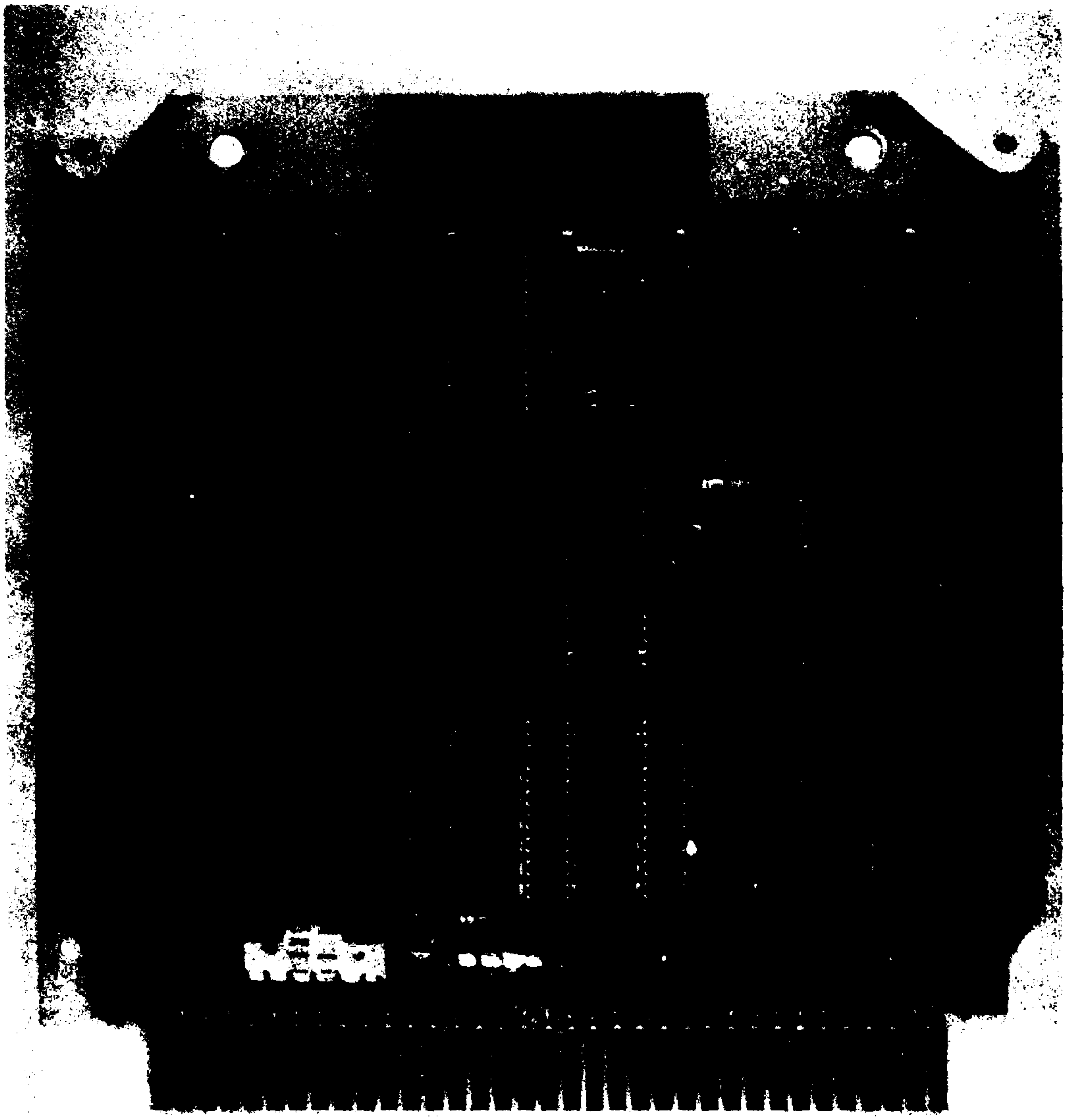


Figure 1.3-5. Recoil travel interface circuit card, component side.

1.3 (Cont'd)

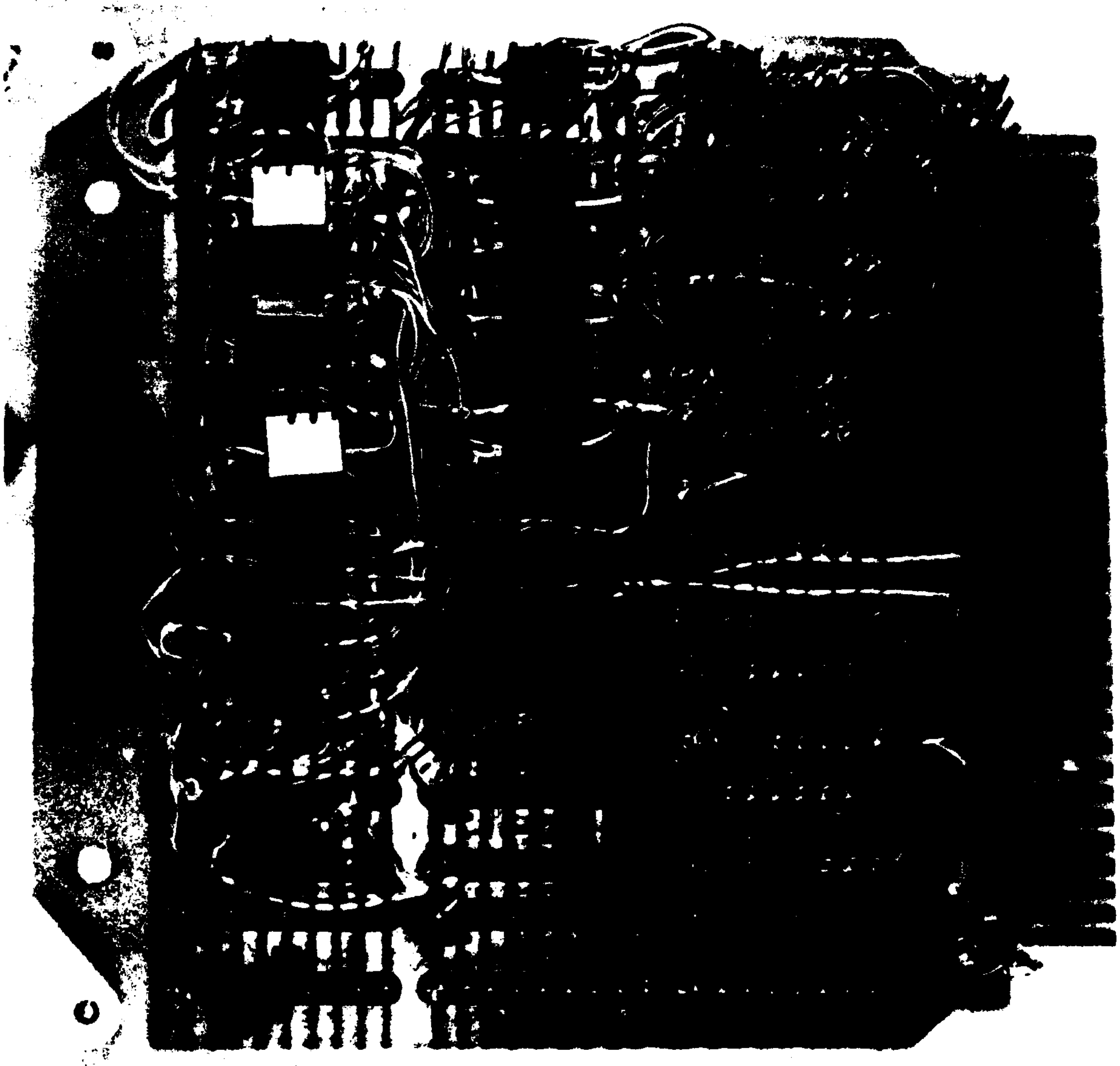


Figure 1.3-6. Recoil travel interface circuit card, wire wrap.

1.4 SUMMARY OF RESULTS

A typical record of recoil travel versus time is shown in Figure 1.4-1. Occasionally, data with obvious discontinuities is acquired, as in Figure 1.4-2. These discontinuities have been found to be the result of a misalinement of the rack and pinion gear. Figure 1.4-3 illustrates a failure to return to zero, which may be a misalined rack or a failure of the weapon to return to battery. When the technician encounters this situation, firing should be stopped and the problem discussed with the test director.

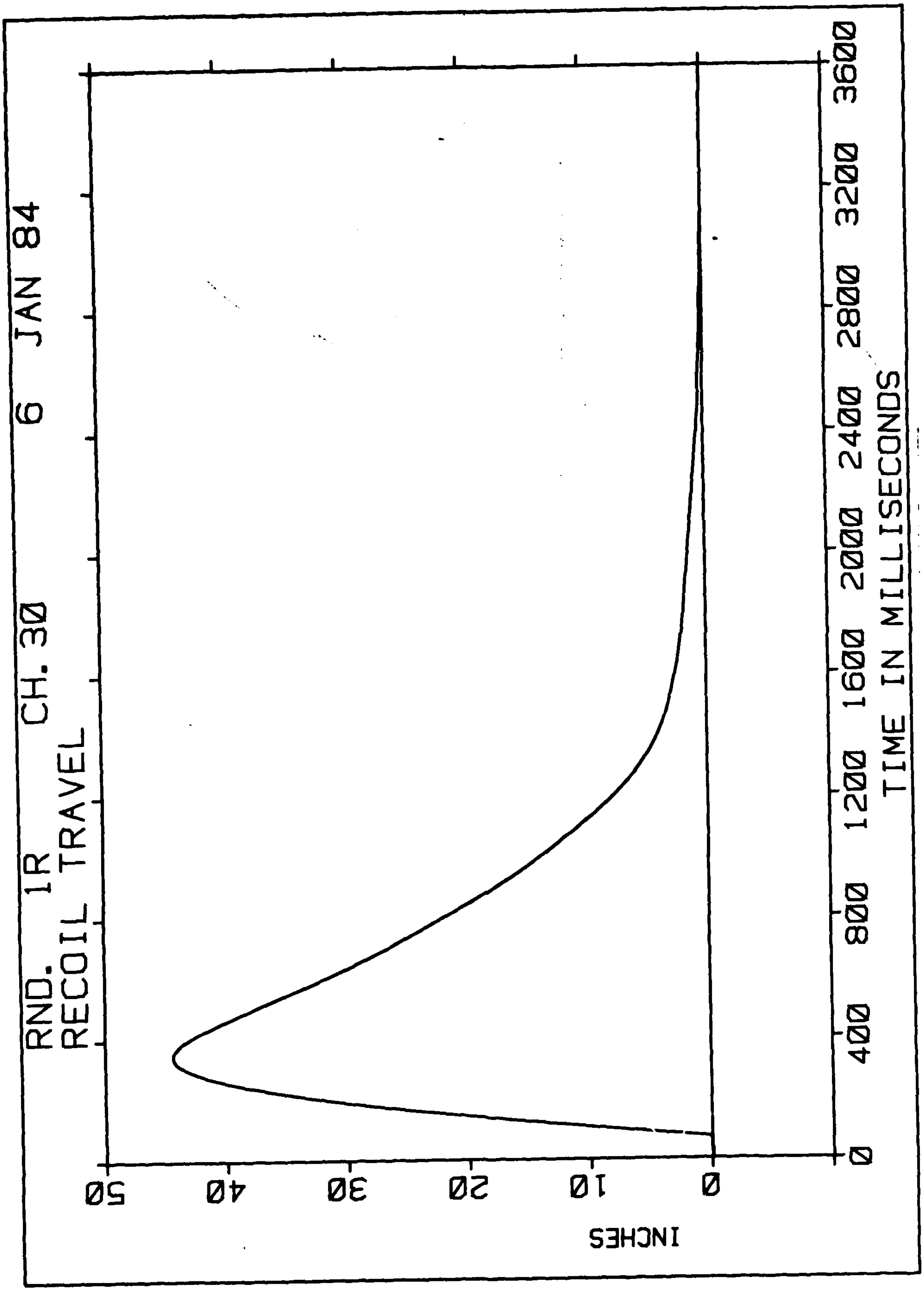


Figure 1.4-1. Recoil travel versus time.

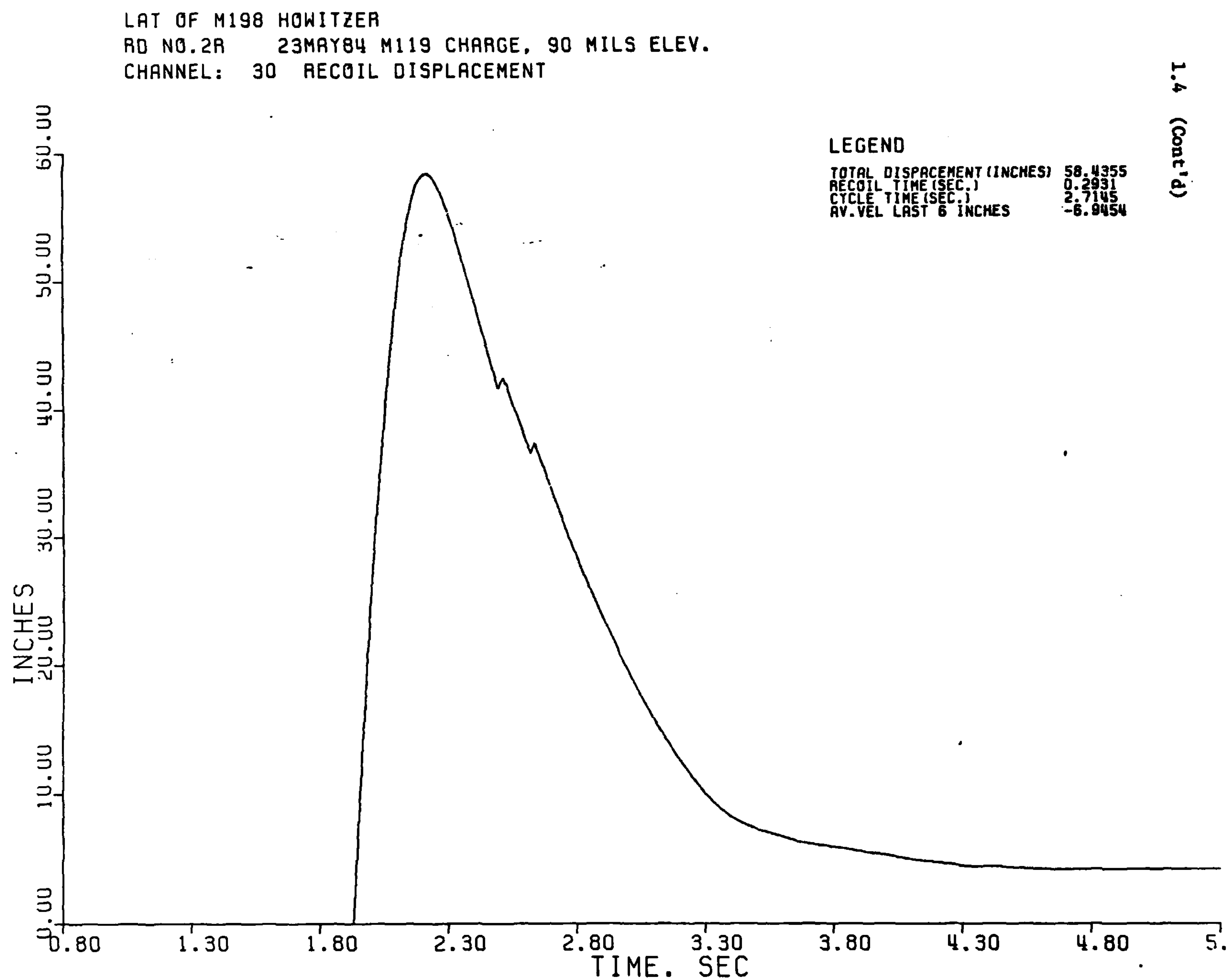


Figure 1.4-2. Recoil travel versus time plot demonstrating effect of misalined rack on weapon.

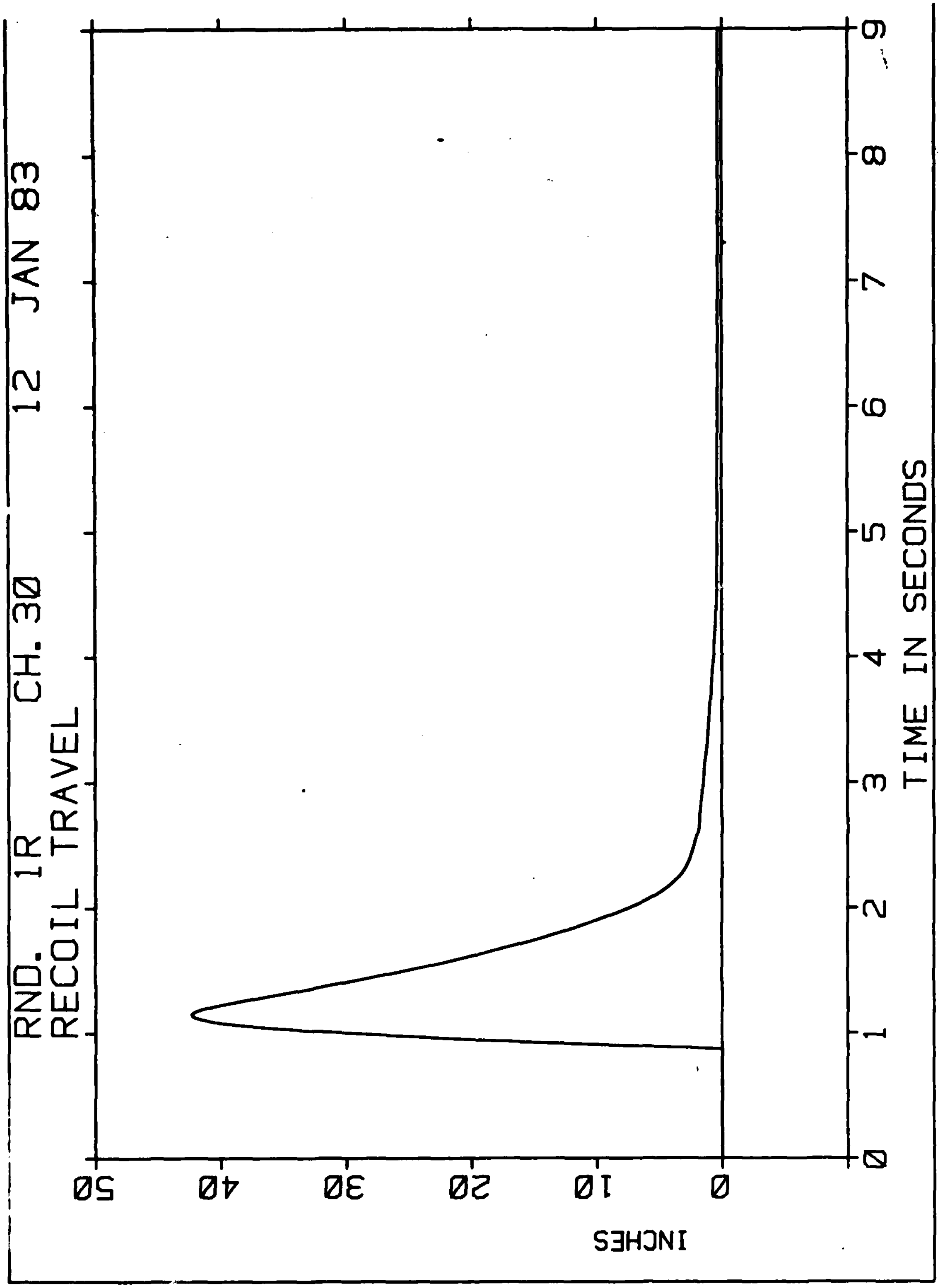


Figure 1.4-3. Recoil travel versus time plot, failure to return to battery.

1.5 ANALYSIS

The digital recoil travel system permits a more detailed analysis of recoil and counterrecoil than the potentiometer method. As a result, some anomalies in recoil travel records not previously observed are currently being investigated. These irregularities appear on displacement versus time records showing the curve passing through zero, indicating counterrecoil motion beyond the recoil start position as shown in Figure 1.5-1. This phenomenon may be the result of an incomplete return to battery on a previous shot(s), resulting in an apparent excessive counterrecoil distance on a successive shot(s) if the gun returns more fully toward battery. The cumulative effect of different recoil starting points must be considered during a test because there is no point of reference between a position on the gun and a numerical output from the incremental shaft encoder circuitry.

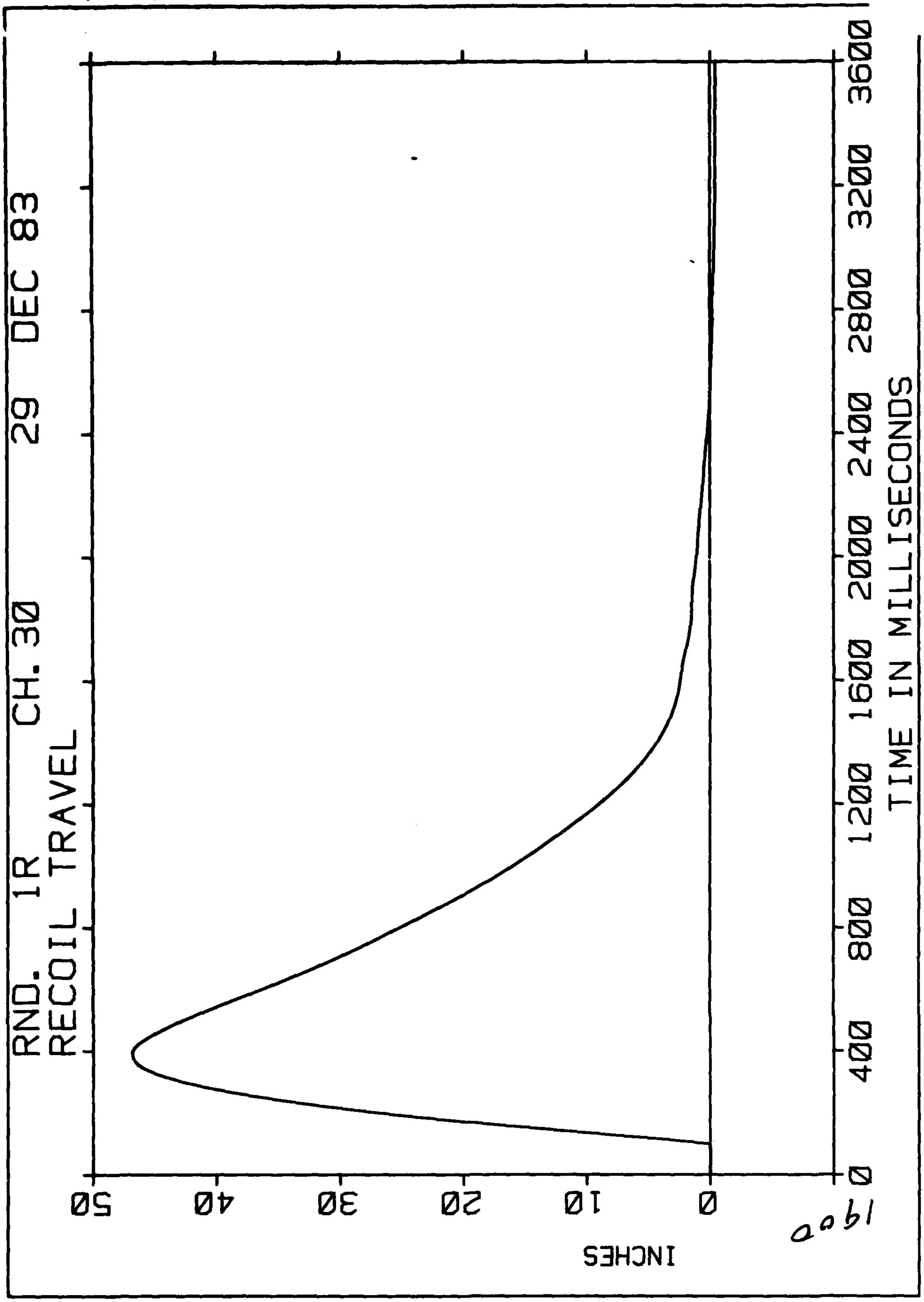


Figure 1.5-1. Recoil travel versus time plot, counterrecoil beyond starting position.

1.6 CONCLUSION

Digital recoil measurement is superior to analog recoil measurement in terms of transducer signal quality and speed of data reduction.

1.7 RECOMMENDATIONS

a. Whenever computer controlled test facilities are available, digital recoil measurements should be the preferred test method.

b. Additional digital recoil circuitry should be fabricated for BTSTs. It may be possible to incorporate the circuitry directly into the Adaptive Sampling Rate Digitizers in the BTSTs.

SECTION 2. GENERAL DISCUSSION OF SYSTEM DEVELOPMENT

2.1 TRANSDUCER SELECTION

An incremental, optical shaft encoder was selected as a digital alternative to a continuous potentiometer. A market search of available encoders produced a wide variety of available models. The design features of interest for this project were:

a. Rugged construction. The shock of weapon firing was expected to be a critical factor.

b. Physical size. A direct replacement of the potentiometer was desired. If an encoder of the proper size could be located, modifications to existing rack and pinion gears would be minimized.

c. Slew speed. During recoil, maximum speed of the pinion gear could cause encoder failure.

d. Pulses per revolution. Consideration of pinion gear diameter versus pulses per revolution was necessary to assure adequate resolution.

e. Electrical signal output. Several hundred feet of cable are typically used during a firing test. A line driver output was considered necessary.

f. Environmental specifications. A -51.1° C (-60° F) to 51.7° C (125° F) temperature range is demanded by some environmental temperature tests.

A BEI Electronics, Inc. heavy duty encoder, shown in Figures 1.3-1, -2, and -3, was selected to satisfy the system requirements. The specific part number ordered was H25D-SB-250-ABC-7830-SM18-5, which is interpretable when compared with the encoder specifications in Appendix B. Briefly, the encoder has the following characteristics.

a. 250 pulses per revolution.

b. Dual quadrature, complementary output channels.

c. 0.25 inch shaft diameter.

d. -40° C to 80° C temperature range.

e. Flat on encoder shaft 0.50 inch by 0.03 inch.

f. Incandescent encoder illumination.

This encoder has performed reliably through extensive 155-mm, 120-mm and 105-mm firing. Initially, an LED was preferred to the incandescent illumination, since durability was thought to be superior with an LED. However, the manufacturer recommended an incandescent lamp, and no failures have been experienced to this date.

2.1 (Cont'd)

Two pinion gear diameters are available for recoil tests, selected according to test specifications. The 7.446 inch and 5.108 inch diameters correspond to 0.0298 inch and 0.0204 inch per pulse, which is considered adequate resolution. Certain weapons will exceed the encoder slew speed specification when the smaller gear is used; however, the amount is not excessive and it is a transient condition.

A flexible shaft coupling (fig. 1.3-1) was added to the encoder to minimize axial and radial loading. The coupling selected is produced by Metal Bellows Corporation, model R3-856, PN 26046.

The -40° C temperature specification for the encoder is not adequate for all environmental chamber tests. The feasibility of applying a thermal element to the inside surface of the encoder is currently being investigated.

2.2 ELECTRONIC INTERFACE CIRCUITRY DESIGN

Pulses from the shaft encoder are not directly compatible with a computer. Interface hardware is required to detect direction of shaft rotation, increment or decrement a counter, and provide a latched signal to the computer interface circuit. A block diagram is shown in Figure 2.2-1.

A schematic drawing of the electronic interface circuitry is shown in Figure 2.2-2. Dual differential receiver U12 receives two output signals in quadrature from the encoder and provides TTL signals to D flip-flop U8. If U8-3 (clock) goes high while U8-2 (D input) is high, then U8-5 ($\overline{1Q}$ output) is high. These conditions exist while the weapon is recoiling. Since U7-2 is high, pulses from the encoder are applied to the B_1 input of one-shot U5. One-shot U5 then generates a 0.6 microsecond pulse at U5-4 ($\overline{1Q}$ output) for each pulse from the encoder. These pulses increment BCD counters U21, U22, U23, and U24.

During counterrecoil, U8-5 is low and U8-6 is high. This results in pulses being applied to the B_2 input of one-shot U5. One-shot U5 generates a 0.6 microsecond pulse at U5-12 ($\overline{2Q}$ output) for each pulse from the encoder. These pulses then decrement BCD counters U21, U22, U23, and U24.

Following the counter circuitry, 74LS174 latches U18, U19, and U20 ensure that the output data cannot change at the time of computer sampling. There are two examples of latch circuit operation shown in Figure 2.2-3. On the rising edge of the pulse generated by the shaft encoder, U7-3 (increment, recoil) or U7-6 (decrement, counterrecoil) triggers a 0.6 microsecond low pulse from U5-4 (increment) or U5-12 (decrement). The rising edge of an up or down pulse from the shaft encoder also produces a 1.2 microsecond low pulse from U3-4. The computer samples the counting circuit at an interval defined by a software cycle. Sampling is completed when DFLGA goes low, which produces a high pulse of 1.4 microsecond duration at U3-5. There are two requirements to assure proper sampling. First, approximately 20 nanoseconds must be allowed for the counter output to settle after changing count input. Second, approximately 20 nanoseconds must be allowed for the latch output to settle after changing the latch input. When reviewing the timing diagram, it is also important to note that the minimum time period expected between pulses from the encoder for the highest velocity recoil is approximately 100 microseconds. The computer sampling period is approximately 1 millisecond. There is no dependency between the varying rate of pulse output from the encoder and the fixed computer rate of sampling.

In the first timing example in Figure 2.2-3, the computer is signaled that the data input operation is complete on the negative edge of DFLGA. U3-5 then goes high for 1.4 microseconds. The latches are clocked once by U7-8 when U3-4 goes low, latching at the circuit output the most recent counter output. When the counter change does occur, U3-4 stays low for a short period so that the latch is not allowed to update until the counters have settled. U3-5 then goes low, and the latches are again updated, but with the new count.

In this example, since the computer is signaled that the data input operation is complete immediately before a counter change, two latch updates occur.

2.2 (Cont'd)

In the second example in Figure 2.2-3, only one latch update occurs, because the negative going DFLGA transition occurs after the counter change. Regardless of the manner in which the latch update occurs, the computer reads the latch output which was updated at the completion of the previous computer input operation. Latch updates only occur after the computer completes an input operation.

2.2 (Cont'd)

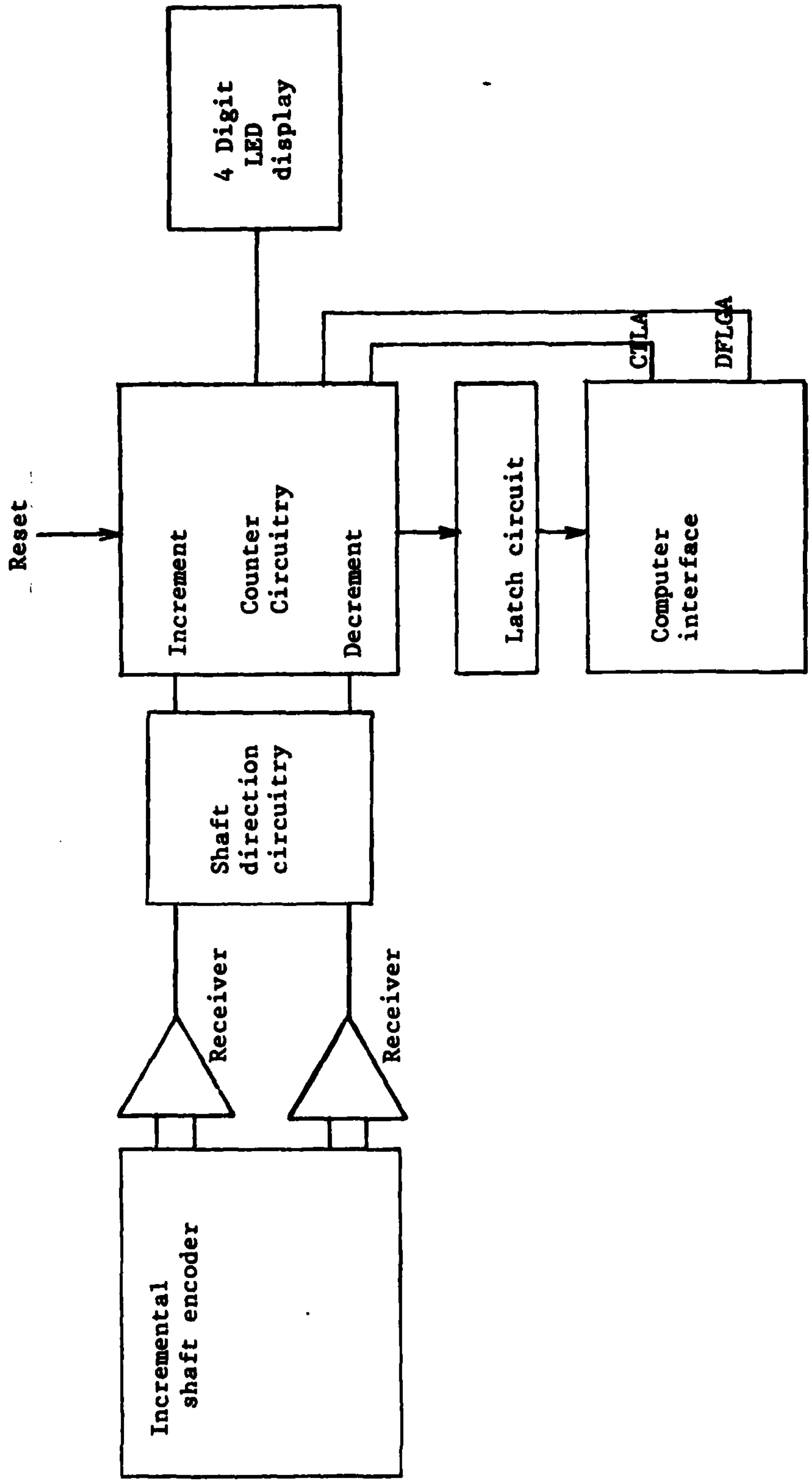
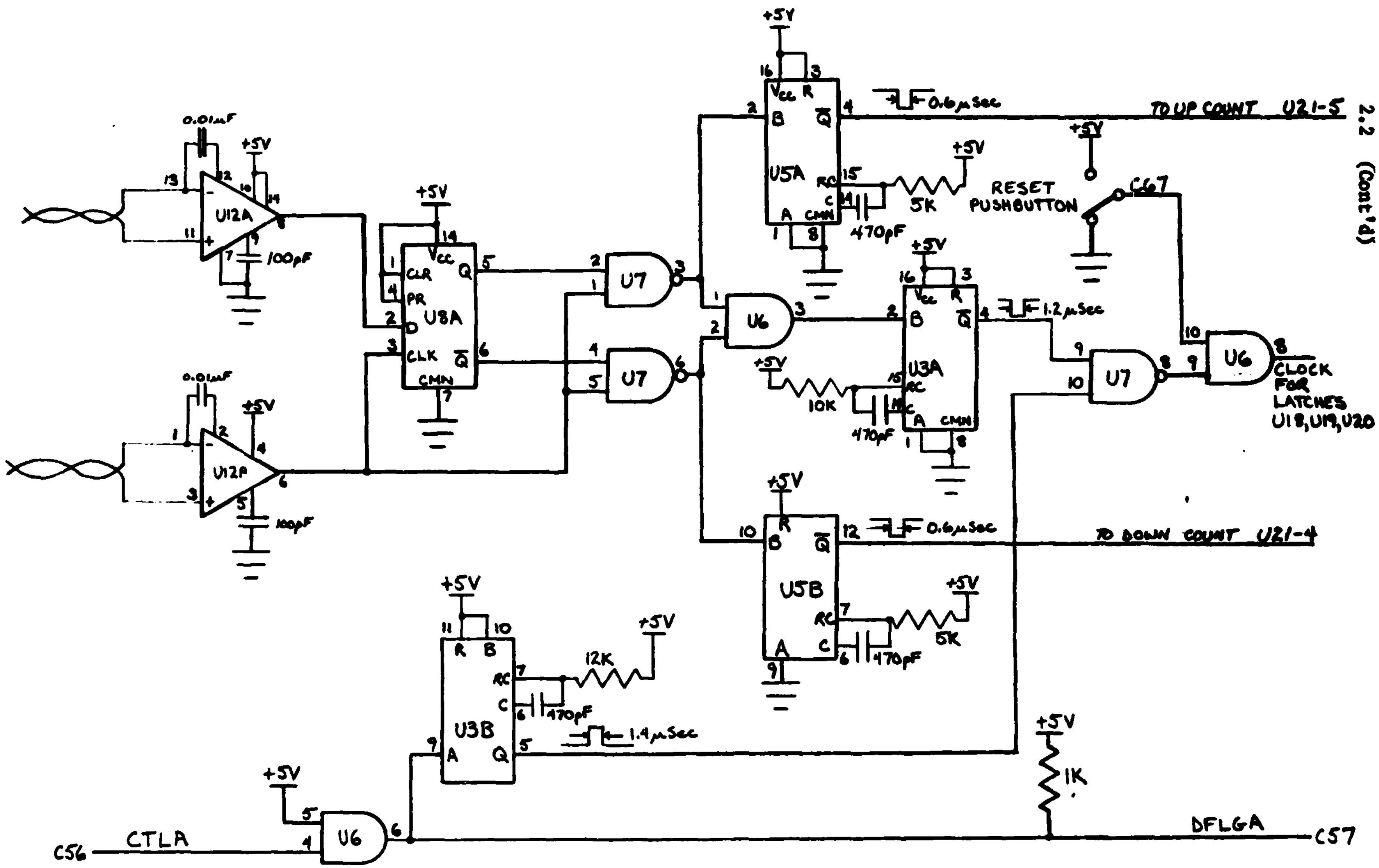


Figure 2.2-1. Recoil travel interface unit, block diagram.

2.2 (Cont'd)



U3,U5 - 74123
U6 - 7408
U7 - 5400
U8 - 5474
U12 - 8820

Figure 2.2-2.a. Interface unit circuit diagram.

2.2 (Cont'd)

U13,U14,U15,U16 - TIL 311
U21,U22,U23,U24 - 74192
U18,U19,U20 - 74LS174

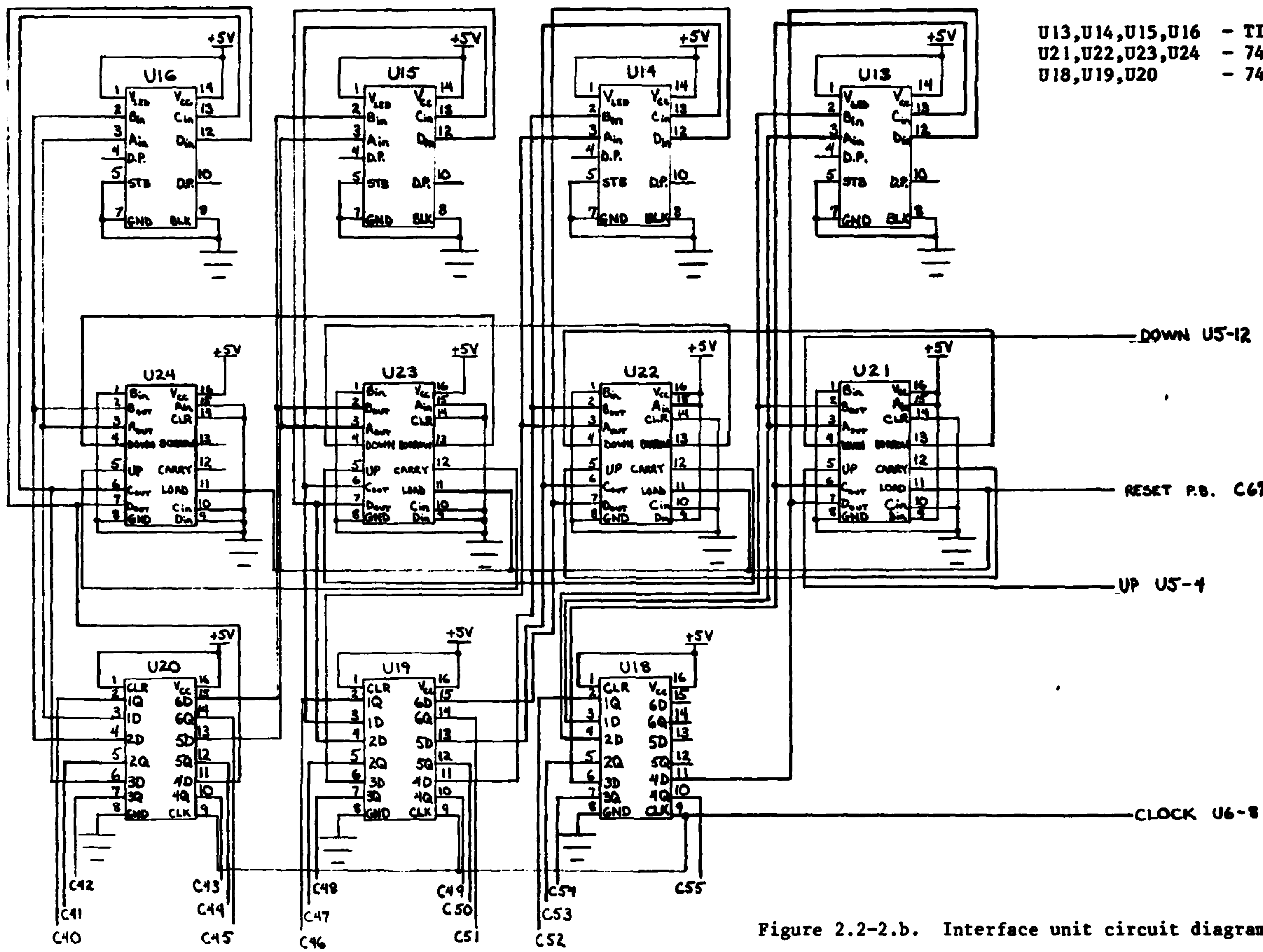


Figure 2.2-2.b. Interface unit circuit diagram.

2.2 (Cont'd)

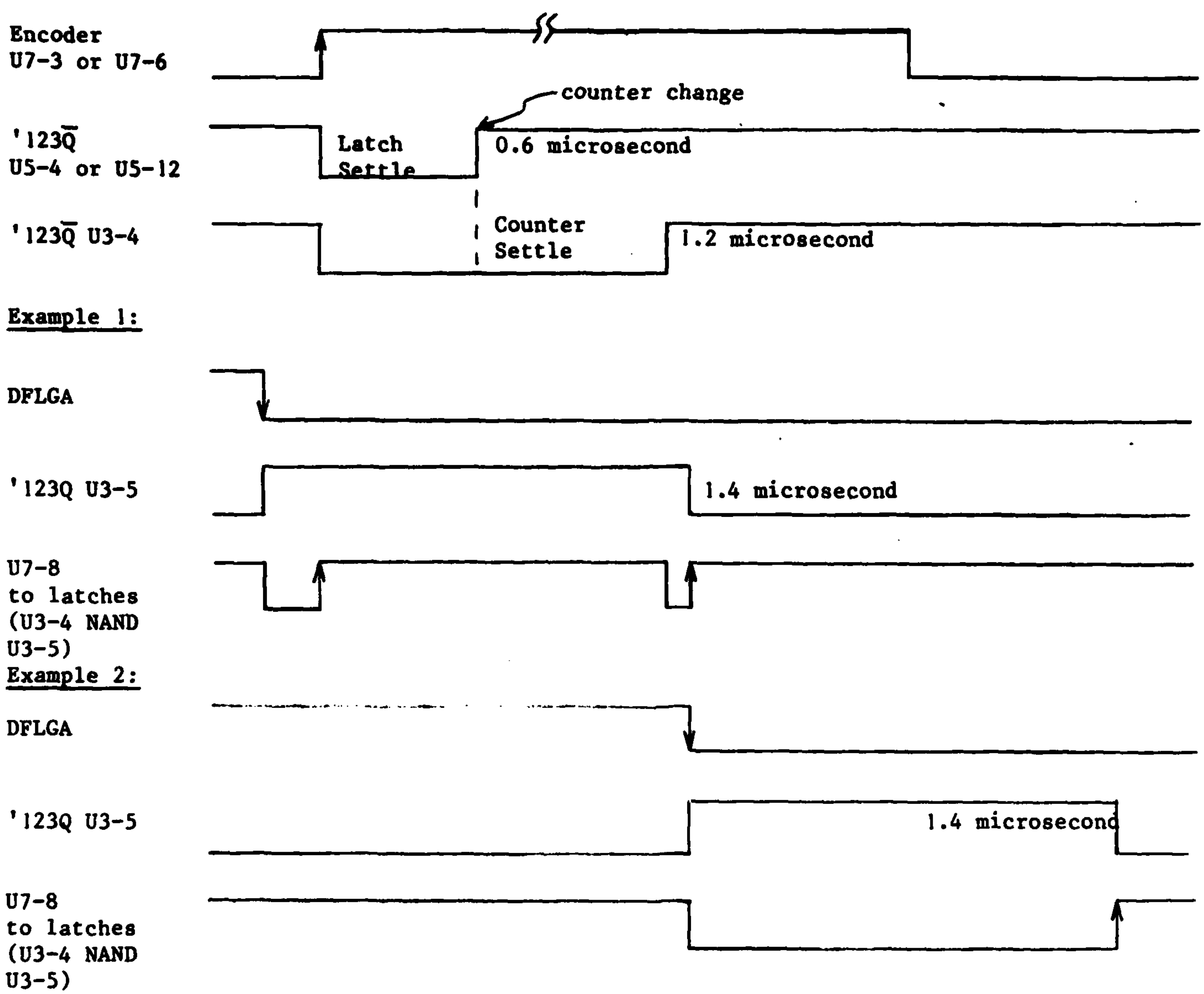


Figure 2.2-3. Interface unit timing diagram.

2.3 SOFTWARE DEVELOPMENT

The philosophy used in the software development was to take the data from the hardware circuitry and format it into a data file which is identical to that produced by a BTST. This format is described in detail in Appendix L of RDI Task Final Report of Research and Development of Software, Ballistic Test Site Terminal, C. L. Francis, Report APG-MT-5952, January 1984. The advantage of this technique is that all of the BTST software is available to plot and process the recoil travel data. The only disadvantage of this technique is that the hardware supports a range of 0 to 9999 counts but the BTST file format supports a range of -2048 to +2047. With the available rack and pinion gears and the anticipated weapon recoil ranges, this is not a problem as long as the reduced range is taken into account.

The software assigns channel 30 as the recoil travel channel. The labels, comments, and transducer gage factor are entered into this channel's parameter area. Since there is only one 32 channel BTST, this use of channel 30 generates no conflict with the other data acquisition channels. The data samples are stored in computer memory until the required number is obtained. Then the data samples are reformatted and written to disc in BTST data record format. In addition, a sample to sample difference is generated and stored as channel 31 to provide velocity versus time.

The software generated for this task consists of:

a. FORTRAN program RCOIL which:

(1) Obtains number of samples to be taken.

(2) Starts data acquisition on command.

(3) Provides options of saving or forgetting data.

b. HP 1000 assembly language routine READR which:

(1) Provides a synchronization pulse at the start of data acquisition cycle.

(2) Reads data from hardware using a software timing cycle and stores values in computer memory.

c. FORTRAN subroutine RTRAN which:

(1) Stores available documentation information on disc.

(2) Reformats data samples and stores on disc in BTST format as channel 30.

(3) Stores sample to sample differences as channel 31.

d. FORTRAN function JBCD which converts BCD data to 2's-complement binary data.

Listings of the software are contained in Appendix C.

2.4 FUTURE DEVELOPMENTS

2.4.1 Lower Temperature Range Expansion

Weapons are exposed to a variety of environmental conditions during developmental testing. The shaft encoder cited in this report is rated to -40° C (-40° F), and will operate properly for the majority of weapon tests conducted under cold temperature conditions. However, for testing conducted from -40° C to -53.9° C (-40° F to -65° F), addition of a heating element to the shaft encoder is planned. The element is expected to be a thin rubber mat, attached to the inner wall of the encoder. Current to the element will be controlled by a temperature sensor in the encoder, providing a feedback signal to circuitry in the BTST.

2.4.2 Integration into BTST

The standalone circuitry and software generated by this task provided an easy way to test the concept of using a digital shaft encoder to record recoil travel. Each BTST contains an Adaptive Sample Rate Digitizer (ASRD) which is described in detail in Appendix D of RDI Task Final Report of Research and Development of Software, Ballistic Test Site Terminal, C. L. Francis, Report APG-MT-5952, January 1984. If the analog-to-digital (A/D) converter board is removed from the ASRD and an appropriate interface card substituted, then the recoil travel channel can be recorded in the same manner as any other ballistic signal. By integrating the recoil travel into an ASRD channel, this data can now be synchronized with the other channels and all of the triggering and data compression features of an ASRD channel are available. The data word will be changed to 12 bit binary with a range of -2048 to +2047 instead of the current 16 bit BCD with a range of 0 to 9999. It should be possible to automatically reset the interface when an ASRD arm command is issued.

SECTION 3. APPENDICES

APPENDIX A - ILIR INVESTIGATION PROPOSAL AND AUTHORIZATION

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is TAGO.-

REFERENCE OR OFFICE SYMBOL	SUBJECT
STEAP-MT-M	FY84 ILIR Program

TO Chief, ~~M&A Division~~ FROM Chief, M&TM Division DATE 4 November 1983 CMT 1
G. Thomson/vh/2444

1. Authorization is hereby provided for the following ILIR Project (Encl 1):

TITLE/TRMS No. Digital Recoil Travel Measurement System/7-CO-IL4-AP1-001

2. This project has been assigned funding in the amount of $5000 under XO/WO 30595401-02.

3. The special instructions contained in Enclosure 2 are applicable to this ILIR project. Assistance on matters pertaining to this project can be obtained from George Thomson, ext. 2444/2734.

2 Encl
as

EDWARD V. SOMODY

DA FORM AUG 80 2496 PREVIOUS EDITIONS WILL BE USED ☆U.S. GOVERNMENT PRINTING OFFICE: 1982-372-711

DISPOSITION FORM

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REFERENCE OR OFFICE SYMBOL	SUBJECT
STEAP-MT-G	In-House Laboratory Independent Research (ILIR) Projects Proposals

XX THRU ~~C, Bal Meas Br~~ RSD FROM C, Fld Inst Sec DATE 18 Feb 83 CMT 1
Mr. Betzold/lv/2208

TO C, ~~M&A Div~~

Attached is an ILIR project proposal.

Victor A Betzold
VICTOR A. BETZOLD

1 Incl
as

STEAP-MT-G (18 Feb 83)

TO Chief, M&TM Div FROM Chief, M&A Div DATE 24 Feb 83 CMT 2
Mr. Fasig/kjz/4102

Recommend approval of this proposal.

J. W. FASIG

STEAP-MT-G

THRU ~~C, Bal Meas Br~~ RSD FROM C, Fld Inst Sec DATE 18 Oct 83 CMT 3
~~C, M&A Div~~
Mr. Betzold/lv/2208

TO C, M&TM Div

No funding has been received for this project. Completion of this project would vastly improve data acquisition for the LAT of the M198. The amount of $5,000 is requested for fabrication of hardware and field testing.

Victor A Betzold
VICTOR A. BETZOLD

1 Encl
nc

DA FORM AUG 80 2496 PREVIOUS EDITIONS WILL BE USED ★U.S. GOVERNMENT PRINTING OFFICE: 1982-372-711

ILIR TASK PROPOSAL

TASK TITLE: Digital Recoil Travel Measurement System

PRINCIPAL INVESTIGATOR: V. A. Betzold

FUNDS REQUIRED: $10,000

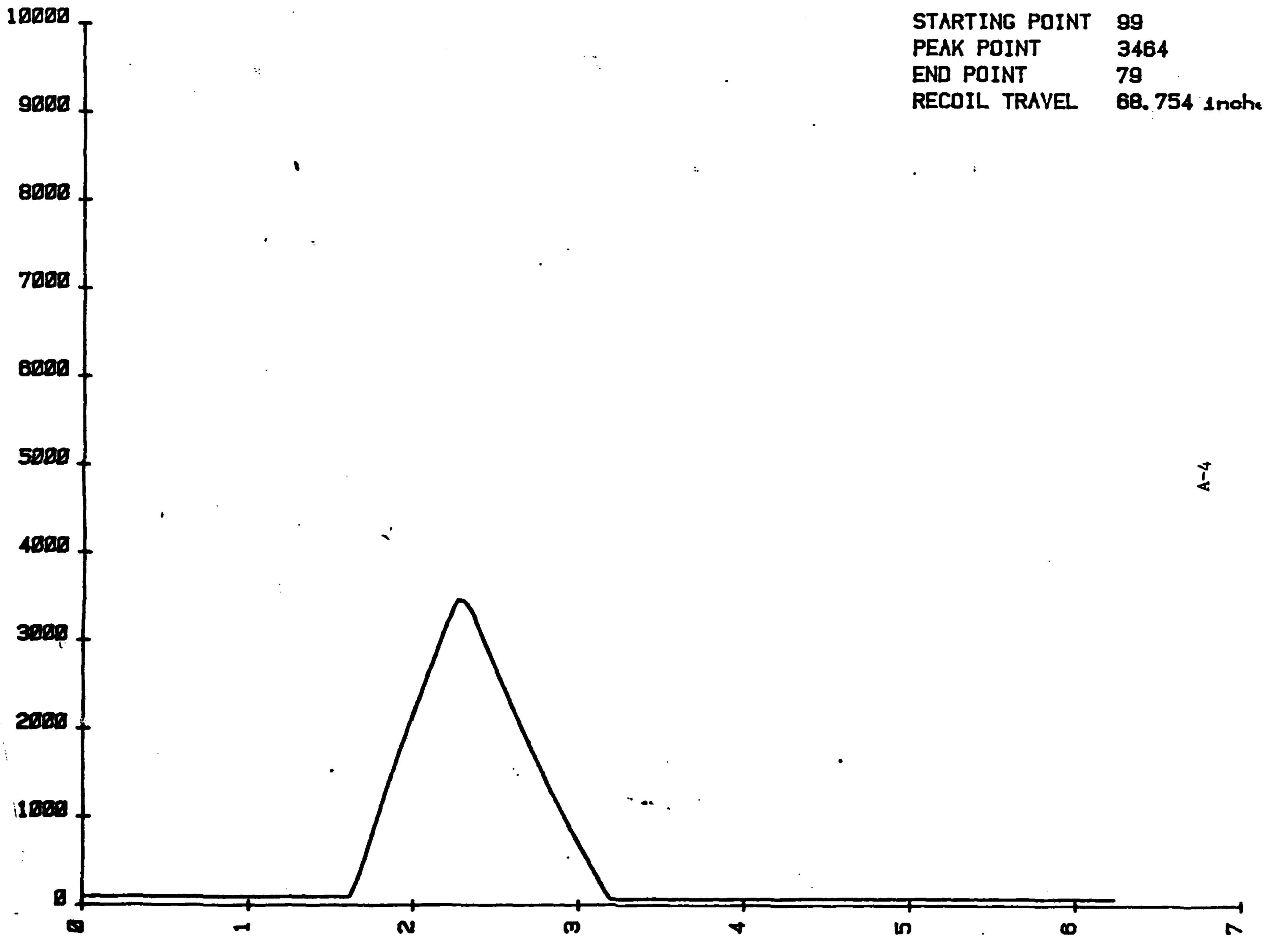
SCHEDULE:

TASK	COMPLETION (Time from start - months)
Hardware/Software Development	4
Field Testing	9
Complete Report	12

DESCRIPTION:

Recoil travel measurement of direct fire and artillery weapons is presently accomplished with analog potentiometers and analog recording facilities. The analog data is then processed at a later date by Analytical Branch. This data acquisition process contradicts the ADAPT concept: process the data on site to provide quality control and immediate feedback to the test director.

The Digital Recoil Travel Measurement System provides a direct interface to the ADAPT system. An incremental shaft encoder is used on the weapon in place of the potentiometers, and increments an up/down counter circuit. This circuit is interfaced to a desktop calculator or Ballistic Test Site Terminal computer, and plots of displacement vs time and velocity vs time can be generated at the test site. A sample plot of displacement vs time is attached. Commercial systems do not exist to meet this requirement.


STARTING POINT 99
PEAK POINT 3464
END POINT 79
RECOIL TRAVEL 68.754 inch
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
1
2
3
4
5
6
7

BEI Electronics, Inc.
Industrial Encoder
Division

7230 Hollister Avenue
Goleta, California 93117
(805) 968-0782

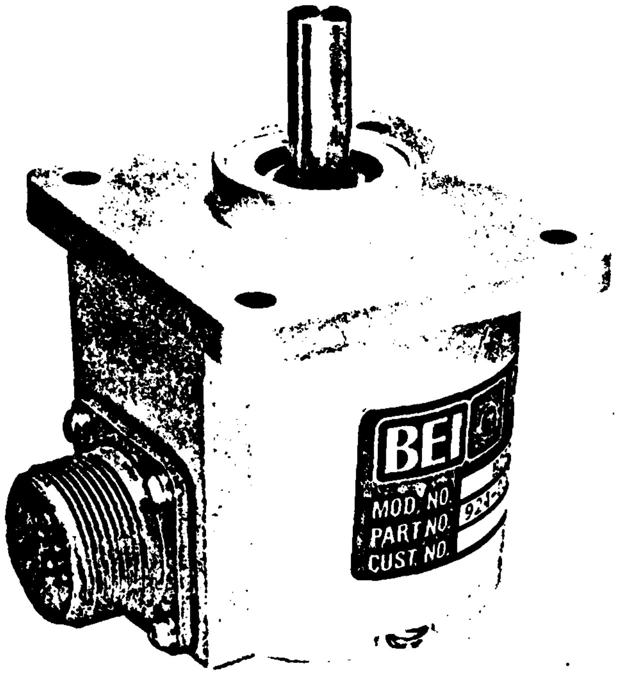
Specification

924 - 02002 - 001

General Specifications

Type H25

Incremental Optical Encoder



ACTUAL SIZE

924-02002-001 SHEET 1 OF 11

Notice: The design and specifications of the instruments and accessories illustrated and described in this publication are subject to improvement without notice.

REV	DESCRIPTION	DATE	
			PREP BY Doug McGuire 8/16/80
B	General Update	6/24/80	CHK Dale LaPlante
A	Paragraph 3.5, Change 36^0 to 27^0	1/23/80	APPD Jerry E. Jandt

REV

BEI Form 802A (7911)

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TITLE	NO.	
General Specifications Type H25 Incremental Optical Encoder	924-02002-001 Sht 2 of 11	Rev B

1.0 Scope: This specification describes the BEI Industrial Encoder Division Heavy Duty Type H25 Incremental Optical Encoder.

2.0 Mechanical Specifications

2.1	Dimensions	See Figures 2, 3 and 4
2.2	Shaft Diameter	Standard: .3747/.3745 Dia. Options: Available with stepped shaft .2497/.2495 Dia.
2.3	Optional Flat on Shaft	.50 long X .03 deep
2.4	Shaft Loading	Up to 40 lbs Axial and 35 lbs Radial
2.5	Shaft Runout	.0005 T.I.R.
2.6	Starting Torque at 25°C (Standard without shaft seal)	1.0 Oz. In. Max.
2.7	Starting Torque at 25°C (With optional sealed bearings)	1.5 Oz. In. Max.
2.8	Starting Torque at 25°C (With optional shaft seal)	5.0 Oz In. Max.
2.9	Bearings	Class ABEC 7
2.10	Shaft	416 Stainless Steel
2.11	Housing and Cover	Die Cast Aluminum
2.12	Bearing Life (mfg's specifications)	2×10^8 Revs at rated shaft loading. 5×10^{10} Revs at 10% of rated shaft loading.
2.13	Moment of Inertia	4.1×10^{-4} Oz. In. Sec.^{2}
2.14	Slew Speed	5000 RPM Max.
2.15	Weight	13 Oz. Typ.

TITLE	NO.	Rev
General Specifications Type H25 Incremental Optical Encoder	924-02002-001 Sht 3 of 11	B

3.0 Electrical Specifications

3.1	Code	Incremental
3.2	Cycles Per Shaft Turn	1 to 2540 on code disk
3.3	Supply Voltage	See Table I
3.4	Current Requirements	TTL 200 Ma Max,150 Ma Typ CMOS 150 Ma Max,125 Ma Typ
3.5	Output Format	2 Channels (A and B) in quadrature ± 27° electrical at 10 KHZ. See Figure I.
3.6	Output Format Options	Index & Complementary outputs are available
3.7	Output Options	See Table I

TABLE I

I.C. Number	Type	Feature	Optional Pull-up Resistor	Output	Supply Voltage ±5%
SN7404	T^2L	Totem Pole		16 MA/5V	+5VDC
SN7406	T^2L	Open Collector Hi Voltage	470 Ohms	40 MA/30V	+5VDC
SN74C04	CMOS				5 to 15VDC*
MC680	HTL	Totem Pole			15VDC
MC681	HTL	Open Collector	15K Ohms		15VDC
MC689	HTL	Open Collector Hi-Voltage	15K Ohms	20V	15VDC
DM8830	T^2L	Line Driver			5VDC
MM88C30	CMOS	Line Driver			5 to 15VDC*

*Specify actual voltage

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3.8	Illumination	Incandescent Lamp (40,000 hours life) or LED, optional
3.9	Frequency Response	50 KHZ
3.10	Frequency Response (Index)	20 KHZ

4.0 Environmental Specifications

4.1	Temperature	
	Operating	0 to 70°C Standard
	Storage	-25 to 90°C
4.2	Shock	50 G's for 11 MSEC duration
4.3	Vibration	5 to 2000 HZ @ 20 G's
4.4	Humidity	98% RH without condensation

5.0 Options (For the following option capability, consult factory for complete specifications)

5.1	Direction Sensing	Pulse Output X1, X2 or X4
5.2	Interpolation	Multiplied Square Wave Output X5
5.3	Dual Resolution	Selectable Output
5.4	Sinewave	Differential amplified outputs

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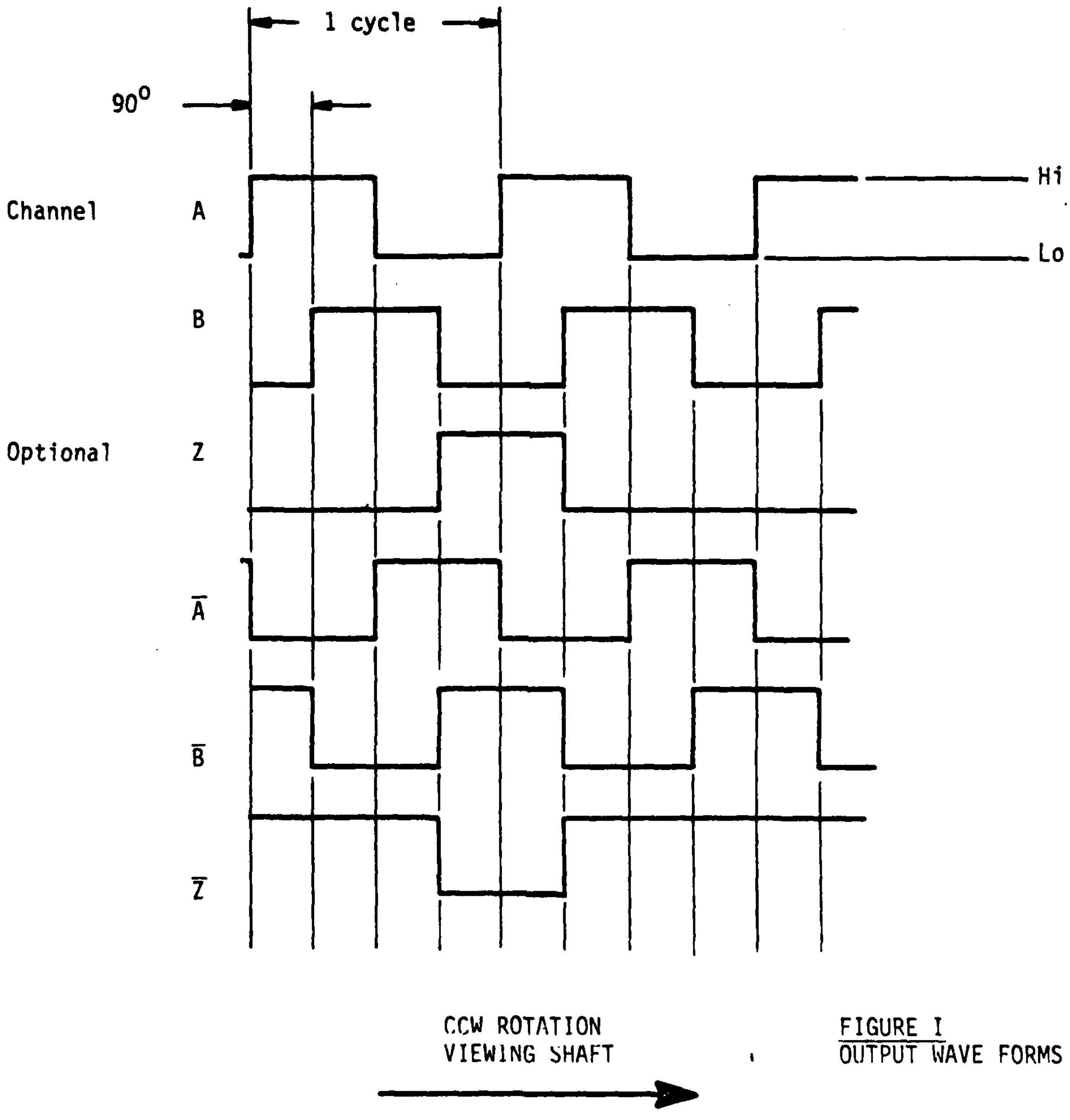

FIGURE I
OUTPUT WAVE FORMS

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GENERAL SPECIFICATIONS Type H25 Incremental Optical Encoder	924-02002-001 Sht 6 of 11	B

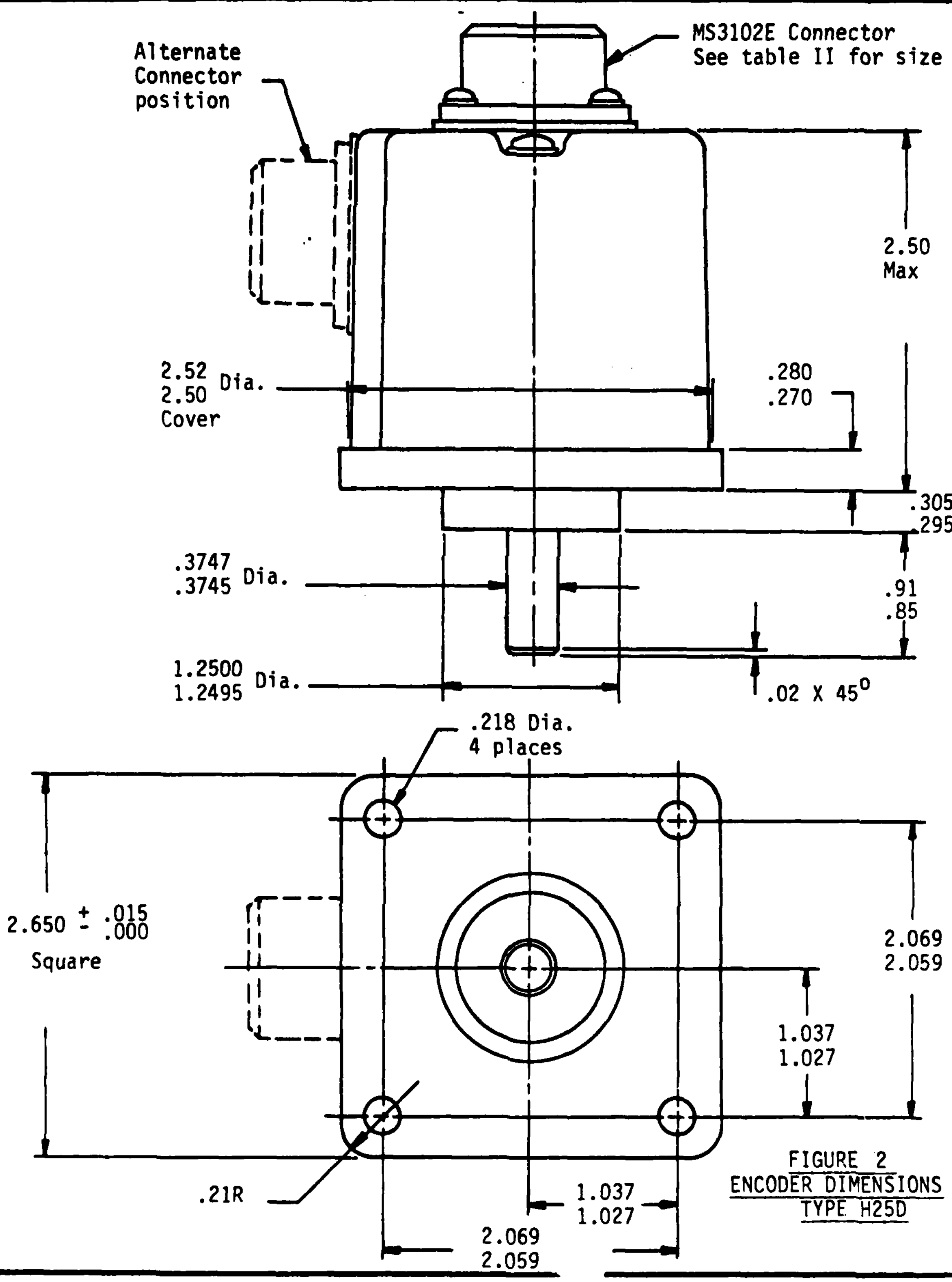

FIGURE 2
ENCODER DIMENSIONS
TYPE H25D

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General Specifications Type H25 Incremental Optical Encoder	924-02002-001 Sht 7 of 11	B

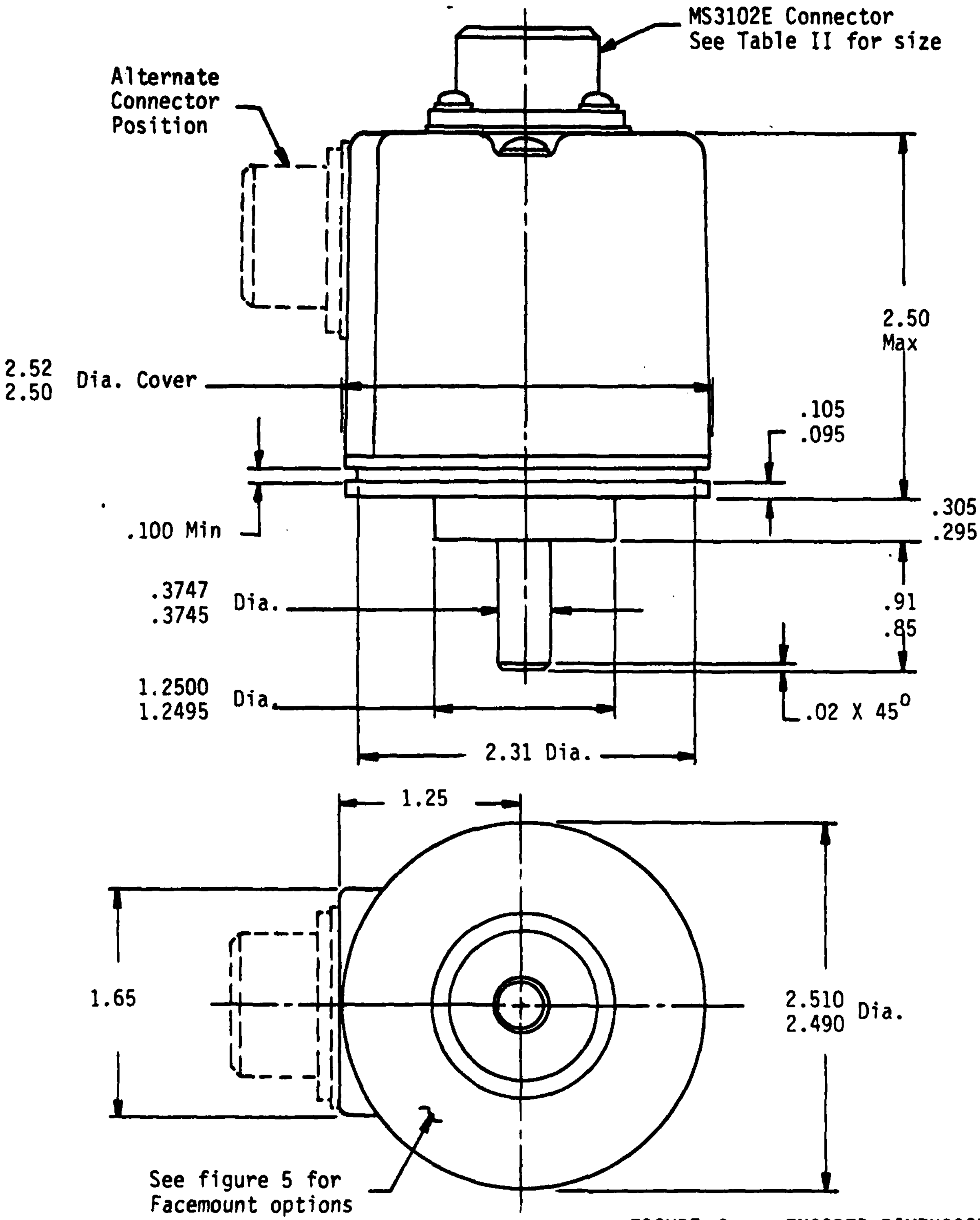

FIGURE 3 - ENCODER DIMENSIONS
TYPE H25E

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TITLE	NO.	Rev
General Specifications Type H25 Incremental Optical Encoder	924-02002-001 Sht 8 of 11	B

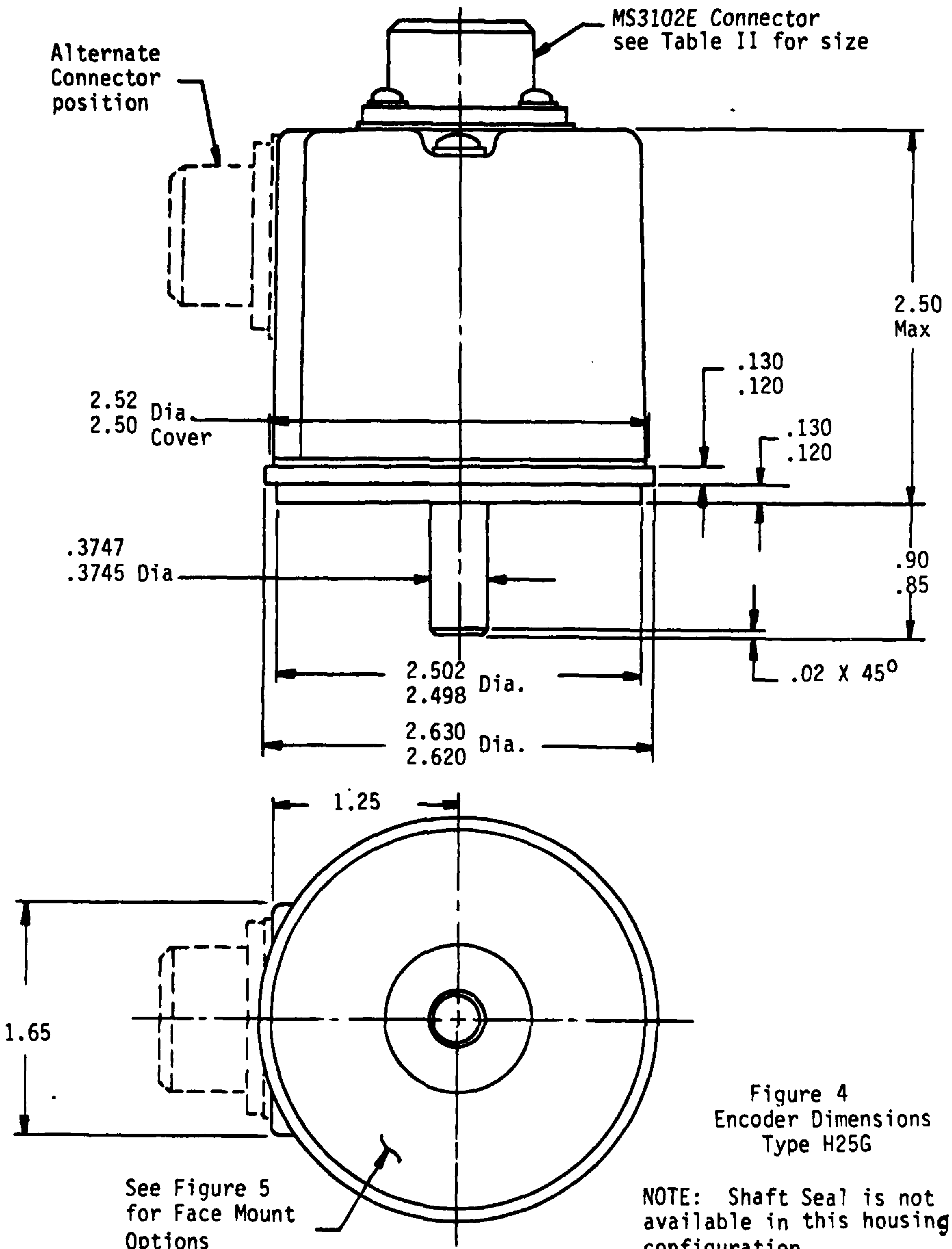
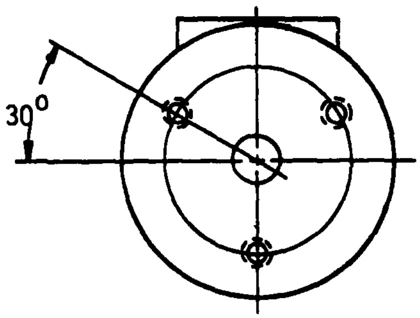


Figure 4
Encoder Dimensions
Type H25G

NOTE: Shaft Seal is not available in this housing configuration

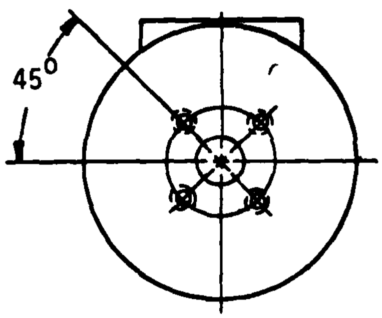
FIGURE 5

Face Mount Options



F1

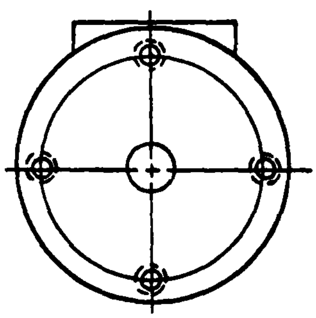
10-32 UNF-2B
.188 Min. Deep
3 places equally spaced on a
1.875 Dia. bolt circle.



F2

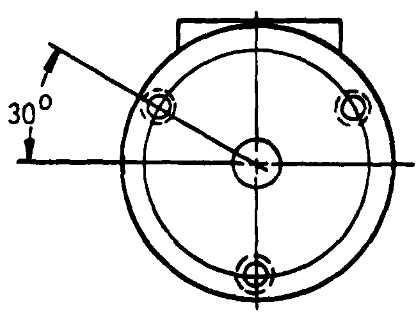
4-40UNC-2B
.250 Min. Deep
4 places equally spaced
on a 1.272 Dia. bolt circle
(.900 square, Ref)

Not available on H25D or H25E



F3

4-40UNC-2B
.250 Min. deep
4 places equally spaced
on a 2.000 Dia. bolt circle



F4

6.32UNC-2B
.250 Min. deep
3 holes equally spaced
on a 2.000 Dia. bolt circle

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TITLE	NO.	Rev
General Specifications Type H25 Incremental Optical Encoder	924-02002-001 Sht 10 of 11	B

TABLE II

STANDARD CONNECTOR TERMINATIONS

CONNECTOR	MS3102E-16S-1P			MS3102E-18-1P	
OUTPUT OPTION	CHANNELS A, B AND Z	CH. A & B WITH COMPLEMENTS	CH. A & Z WITH COMPLEMENTS	PIN	CH. A,B &Z WITH COMPLEMENTS
PIN: A	CH. A	A	A	A	A
B	CH. B	B	$\overline{A}$	B	B
C	CH. Z	$\overline{A}$	Z	C	Z
D	+V	+V	+V	D	+V
E	NO CONN.	$\overline{B}$	$\overline{Z}$	E	NO CONN.
F	GROUND	GROUND	GROUND	F	GROUND
G	CASE GROUND	CASE GROUND	CASE GROUND	G	CASE GROUND
				H	$\overline{A}$
				I	$\overline{B}$
				J	$\overline{Z}$

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TITLE	NO.	Rev
General Specifications Type H25 Incremental Optical Encoder	924-02002-001 Sht 11 of 11	B

6.0 Ordering Information: Encoder may be specified using the following model numbering system:

TYPE: — H

H = Heavy Duty

BASIC SIZE: — 25

25 = 2.500

HOUSING CONFIGURATION LETTER: — [ ]

D = Square Flange (Fig. 2)
E = 2.50 Dia Servo Mount (Fig. 3)
G = 2.62 Dia Servo Mount (Fig. 4)

FACE MOUNT OPTIONS (Fig. 5) — [ ]

F1, F2, F3, or F4
Blank = None

SHAFT SEAL CONFIGURATION: — [ ]

SS = Shaft Seal (Not available on H25G)
SB = Seal, Integral with Bearing
Blank = Shielded Bearing

CYCLES PER TURN: — [ ]

Enter Cycles:
500 = 500 cycles
2500 = 2500 cycles
Etc.

NO. OF CHANNELS — [ ]

A = Single Channel
AB = Dual Quadrature Channels
ABZ = Dual with Index
AZ = Single with Index

COMPLEMENTS: — [ ]

C = Complementary Outputs
Blank = None

OUTPUT I.C. — [ ]

7404, 7406, 8830 etc. (See Table I)
Followed by "R" = Pull-up Resistor

ILLUMINATION: — [ ]

Blank = Incandescent (Standard)
LED = Light Emitting Diode (Optional)

OUTPUT TERMINATION LOCATION: — [ ]

E = End
S = Side

OUTPUT TERMINATION: — [ ]

M16 = MS3102E16S-1P Connector
M18 = MS3102E18-1P Connector

S = Special Non-Standard Features specified on purchase order or customer's spec. — [ ]

Interface Unit Cannon Plug				Encoder Plug
Pin	Function	Pigtail	Cable	Pin
A	Output B	Brown	Brown	A
B	Output A	Red	Red	B
C	Output $\overline{B}$	Orange	Orange	C
D	V+	Yellow	Yellow	D
E	Output $\overline{A}$	Green	Green	E
F	V-	Blue	Blue	F
G	Sen +	White	White	D
H	Sen -	Black	Black	F
J	Case Ground	Shield	Shield	G

Interface Unit and Encoder Connector Terminations.

HEWLETT-PACKARD 1000 COMPUTER INTERFACE CABLE

Edge Connector Pin	D Connector Pin	Function
1	1	Bit 0
2	2	Bit 1
3	3	Bit 2
4	4	Bit 3
5	5	Bit 4
6	6	Bit 5
7	7	Bit 6
8	8	Bit 7
9	9	Bit 8
10	10	Bit 9
11	11	Bit 10
12	12	Bit 11
13	13	Bit 12
14	14	Bit 13
15	15	Bit 14
16	16	Bit 15
Z	22	Command
AA	23	Device Flag
BB	24	Ground

Hewlett-Packard 1000 Computer Interface Connector Terminations

****** T=00000 IS ON LU 08

```
FTN4
      PROGRAM RCOIL(),  REV A   2NOV83  CLF
C
C****************************************************************
C
C   THIS PROGRAM ALLOWS RECOIL TRAVEL DATA TO BE TAKEN USING A SHAFT
C   ENCODER, COUNTER CIRCUIT AND 12566B/C COMPUTER INTERFACE.  THE
C   PROGRAM USES OFF-LINE DRIVER PROGRAM READR TO TAKE THE SAMPLES
C   FROM THE COUNTER CIRCUIT AND STORE THEM IN COMPUTER MEMORY.  A
C   SOFTWARE TIMING LOOP IS USED TO MAKE MEASUREMENTS AT 1.28 MILLI-
C   SECOND INTERVALS.  THE BUFFER SIZE IS 1K-12K IN 1K INCREMENTS.
C   DATA ACQUISITION IS INITIATED UNDER OPERATOR CONTROL.  WHEN THE
C   BUFFER HAS BEEN FILLED THE DATA IS TRANSFERED TO DISC BY SBRTN
C   RTRAN.  RTRAN PLACES THE DATA IN AN ADCHK FORMAT III DATA FILE.
C   IN ADDITION THE VELOCITY IS CALCULATED BY DIFFERENCING THE
C   DISPLACEMENT DATA.
C
C   TO USE THE PROGRAM THE FOLLOWING STEPS SHOULD BE FOLLOWED:
C
C      1.  USING THE PA COMMAND MAKE APPROPRIATE ENTRIES FOR PARAMETERS
C             17 - GAGE FACTOR(DISTANCE/COUNT)
C             20 - UNITS
C             22 THRU 24 - TRANSDUCER DESCRIPTION
C             25 THRU 27 - PLOT LABELS & REMARKS
C          WHEN FINISHED, SET PARAMETER 1 (SELECTED) TO NO.
C
C      2.  AFTER COMPLETING LO & AR FOR THE ASRD CHANNELS, RU,RCOIL
C          ENTER THE DATA SIZE DESIRED.  WHEN READY TO TAKE DATA, HIT
C          CARRIAGE RETURN.  IF NECESSARY TO GET OUT TYPE  EX.
C
C      3.  WHEN DATA ACQUISITION IS COMPLETED, DETERMINE IF DATA IS TO
C          BE SAVED.
C
C   RU,RCOIL,INTRCTV LU(DFLT=1),DATA DISC LU(DFLT=19),
C                DATA START TRACK(DFLT=DIRECTORY)
C
C   REV A   28MAR83   CLF   ORIGINAL.
C             2NOV83   CLF   ADD CHECKS FOR EXIT & SAVING DATA.
C
C****************************************************************
C
      DIMENSION IPRM(5)
      COMMON IBUF(12288)
C ***** GET RUN TIME PARAMETERS
      CALL RMPAR(IPRM)
      LU=IPRM(1)
      IF(LU .EQ. 0)LU=1
      LUDK=IPRM(2)
      IF(LUDK .EQ. 0)LUDK=19
      IDTRK=IPRM(3)
      IF(IDTRK .EQ. 0)IDTRK=-1
C ***** GET OPERATOR ENTRIES
      WRITE(1,100)
  100 FORMAT("ENTER NO OF K-WORDS OF DATA TO TAKE:_")
      READ(1,*)NWORDS
      IF(NWORDS .LT. 1 .OR. NWORDS .GT. 12)GO TO 200
      NWORDS=NWORDS*1024
C ***** CHECK IF READY FOR DATA OR EXIT
      WRITE(LU,120)
  120 FORMAT(/"ENTER CARRIAGE RETURN TO TAKE DATA - EX TO TERMINATE:_")
      READ(LU,140)IANS
  140 FORMAT(A2)
      IF(IANS .EQ. 2HEX)GO TO 200
C ***** TAKE DATA
      CALL READR(IBUF,NWORDS)
C ***** CHECK IF DATA IS TO BE SAVED
  160 WRITE(LU,180)
  180 FORMAT(/"SAVE DATA IN MEMORY ON DISC(YE OR NO)?_")
      READ(LU,140)IANS
      IF(IANS .NE. 2HYE .AND. IANS .NE. 2HNO)GO TO 160
      IF(IANS .EQ. 2HNO)GO TO 200
C ***** WRITE DATA TO DISC
      CALL RTRAN(LU,LUDK,IDTRK,NWORDS)
C ***** DONE
  200 END
      END$
```

```
****** T=00000 IS ON LU 08

ASMB
      NAM READR   REV B  05JAN84  CLF
*
***************************************************************
*
*  THIS SUBROUTINE READS THE OPTICAL SHAFT ENCODER RECOIL TRAVEL
*  TRANSDUCER AND FILLS A BUFFER WITH THE READINGS.
*
*  A SOFTWARE TIMING LOOP IS USED TO GENERATE THE TIMING INTERVAL
*  FOR TAKING THE READINGS.  IT IS SET TO TAKE A READING EVERY
*  1280 MICROSECONDS(RATE 5 OF THE ASRD).
*
*  THE 12566B  12566C CARD MUST BE JUMPERED TO PROVIDE:
*      ------  ------
*    W1 = B        B        POSITIVE TRUE COMMAND
*    W2 = A        A        CLEAR DEVICE FF ON POSITIVE EDGE OF FLAG
*    W3 = A        A        STROBE DATA IN ON POSITIVE EDGE OF FLAG
*    W4 = DONT CARE
*    W5-
*     W8= IN      OUT       LATCH INPUTS ON FLAG
*    W9 = DONT CARE
*    W10=          B        12566B COMPATIBILITY
*    W11=         OUT       POSITIVE TRUE
*    W12=         IN        POSITIVE TRUE
*    W13=         OUT
*
*  REV B  05JAN84  CLF  ADD OUTPUT ON BIT 0 TO START EXTERNAL CHANNEL.
*  REV A  28MAR83  CLF  ORIGINAL.
*
***************************************************************
*
      ENT READR
      EXT $LIBR,$LIBX,.ENTR
*
***************************************************************
*
*  THE MICROCIRCUIT REGISTER SELECT CODE MUST
*  BE SET CORRECTLY BELOW FOR THIS SUBROUTINE TO WORK
MCKT  EQU 21B
*
***************************************************************
*
STOR  BSS 2
READR NOP
      JSB .ENTR
      DEF STOR
      LDA STOR       GET BUFFER ADDRESS
      STA IBUFA      SAVE ADDRESS
      LDA STOR+1,I   GET WORD COUNT
      CMA,INA        NEGATE COUNT
      STA COUNT      SAVE WORD COUNT
      JSB $LIBR      SHUT OFF INTERRUPTS
      NOP
*
***** OUTPUT A LOW TO BIT 0
*
      CLA            CLEAR A
      OTA MCKT       SEND TO MCKT CARD
*
*
***** START DATA ACQUISITION LOOP
*
LOOP  LDA DELAY      LOAD SOFTWARE DELAY LOOP VALUE
      STA DELWD      SAVE DELAY
      ISZ DELWD      INCREMENT DELWD
      JMP *-1        WAIT
      NOP            KILL 1 MICROSECOND
      STC MCKT,C     SET COMMAND & CLEAR FLAG
      SFS MCKT       CHECK IF DATA IS READY
      JMP *-1        IF NOT WAIT
      LIA MCKT       GET READING
      STA IBUFA,I    SAVE IT
      ISZ IBUFA      INCREMENT ADDRESS
      ISZ COUNT      INCREMENT COUNT
      JMP LOOP       CONTINUE IF NOT DONE
*
***** RESTORE A ONE TO BIT 0 OUTPUT REGISTER
*
```

```
      CLA             CLEAR A
      INA             SET A TO 1
      OTA MCKT        SEND TO MCKT CARD
*
***** DONE
*
      CLF MCKT        PREVENT ILL INT
      CLC MCKT        PREVENT ILL INT
      JSB $LIBX       TURN INT SYSTEM ON
      DEF *+1
      DEF *+1
      JMP READR,I
*
****** DEFINE CONSTANTS
*
IBUFA BSS 1
COUNT BSS 1
DELWD BSS 1
DELAY DEC -542
      END
```

```
****** T=00000 IS ON LU 08

FTN4
      FUNCTION JBCD(IWORD),  REV A  15SEP82  CLF
C
C***********************************************************************
C
C  THIS FUNCTION TAKES A FOUR DIGIT BINARY CODED DECIMAL(BCD) INPUT
C  AND RETURNS THE INTEGER VALUE OF THE FOUR BCD DIGITS.
C
C  INPUT ARGUMENT:  IWORD - 16 BIT INTEGER WORD CONTAINING FOUR BCD
C                           DIGITS.  IWORD IS NOT CHANGED. THE BCD
C                           FORMAT IS:
C                       BITS 15 ........................... 0
C
C                         / 8 4 2 1
C           BIT          <  0 0 0 0 8 4 2 1
C           WEIGHT       <  0 0 0 0 0 0 0 0 8 4 2 1
C                         \ 0 0 0 0 0 0 0 0 0 0 0 0 8 4 2 1
C
C  REV A  15SEP82  CLF  ORIGINAL
C
C***********************************************************************
C
      ISIGN=0
      IF(IWORD .LT. 0)ISIGN=1
      JBCD=IAND(IWORD,17B) + 10*(IAND(IWORD,360B)/16) +
     $  100*(IAND(IWORD,7400B)/256) + 1000*(IAND(IWORD,70000B)/4096)
     $  + 8000*ISIGN
      RETURN
      END
      END$
```

****** T=00000 IS ON LU 08

```
FTN4
      SUBROUTINE RTRAN(LU,LUDK,IDTRK,NWORDS),  REV A   2NOV83  CLF
C
C**********************************************************************
C
C         THIS SUBROUTINE TRANSFERS THE DATA STORED IN CPU MEMORY
C         BY SUBROUTINE READR TO DISC.  THE DATA IS STORED ON A BTST
C         DATA LU IN ADCHK FORMAT III AS CHANNEL 30.
C         IN ADDITION, THE VELOCITY IS CALCULATED FROM THE DATA IN
C         THE BUFFER AND STORED AS CHANNEL 31.
C
C    SUBROUTINE ARGUMENTS:
C
C      LU      - LOGICAL UNIT OF OPERATOR TERMINAL
C
C      LUDK    - DISC LU WHERE DATA IS TO BE STORED
C
C      IDTRK   - DISC TRACK WHERE DATA IS TO BE STORED
C                IF -1, DIRECTORY WILL BE USED TO FIND LOCATION
C
C      NWORDS - NUMBER OF WORDS OF DATA STORED IN MEMORY
C
C---------------------------------------------------------------------
C
C  The general sequence of the file is as follows:
C
C                       ROUND HEADER
C                       CHANNEL POINTERS
C                       FILE COMMENTS
C                       SPARE
C                       DOCUMENTATION INFORMATION FOR CHANNEL 30
C                       DOCUMENTATION INFORMATION FOR CHANNEL 31
C                       DATA WORDS FOR CHANNEL 30
C                       DATA WORDS FOR CHANNEL 31
C                       REMAINDER OF TRACK IS FILLED WITH ZEROES
C
C---------------------------------------------------------------------
C
C  ROUND HEADER FORMAT - SECTOR 0 OF DATA FILE:
C
C         Word          Contents
C         ----          --------
C         1 & 2         This is a floating point number which is a
C                       count of the number of words in the file in-
C                       cluding round header, channel pointers, channel
C                       doumentation and channel data.
C
C          3,4          Not used - set to 0.
C
C           5           ROUND HEADER information in ASCII format taken from
C         thru          sector 6 of track 1 of the data lu.  See program
C          64           HEADR for specific usage of these words.  This infor-
C                       can be read using the RH command of ADCHK.
C
C---------------------------------------------------------------------
C
C   CHANNEL POINTERS FORMAT - SECTOR 1 OF DATA FILE:
C
C     word    channel
C     ----    -------
C      1,2       0          The pointer contains a real word which is the
C      3,4       1          location of the start of the channel's data relat
C                           to the start of the data file.  If a channel i
C                           not selected its value is -1.0.  If the channel
C                           is selected but no data was taken, its value i
C    63,64      31
C
C---------------------------------------------------------------------
C
C   FILE COMMENTS - SECTOR 2 OF DATA FILE
C
C     This sector is filled with blanks by TRANS.  After the data file
C     is created, this sector can be used to record comments on the file.
C
C---------------------------------------------------------------------
C
C   SPARE - SECTOR 3 OF DATA FILE
C
```

```
C     This sector is filled with zeroes by TRANS.  It is available for
C     future expansion if necessary.
C
C---------------------------------------------------------------------------
C
C  CHANNEL DOCUMENTATION FORMAT - 4 SECTORS FOR EACH SELECTED CHANNEL:
C
C  sector    words     usage
C  ------   -------    ------------------------------------------
C    1,2     1-128     Setup parameters taken directly from track 0.
C                      TRANS makes no changes in any of these values.
C
C     3        1       Channel No.
C             2-22     Not used - set to 0.
C              23      Base rate.
C             24-34    Not used - set to 0.
C             35-36    Scale factor.
C              37      Baseline count (set to -4096 by TRANS).
C              38      Maximum count  (set to -4096 by TRANS).
C              39      Minimum count  (set to -4096 by TRANS).
C              40      Not used = 0.
C             41,42    Stop word number (set to 0 by TRANS).
C             43-64    Not used = 0.
C                                        NCI=NOT CURRENTLY IMPLEMENTED
C
C     4       1-64     Post event notes.  This area is set to ASCII
C                      blanks by TRANS for later use by the NO command
C                      of ADCHK.
C
C---------------------------------------------------------------------------
C
C  CHANNEL DATA WORDS FORMAT:
C
C     The first selected channels data words follow the notes sector.
C     The location is obtained from the channel pointers in sector
C     1 of the first track of the data file.  The number of words that
C     a channel can take varies from 1024-12288 in 1024 steps.
C
C     The data values in memory are in BCD format.  Function JBCD is
C     used to convert the values to integer and they are stored in the
C     data file on disc in integer format.  The memory values range from
C     0-9999 but are offset and limited to -2048 to 4047.  The rate is
C     added in to produce a data word format identical to a standard
C     ADCHK data word(FORMAT III).
C
C---------------------------------------------------------------------------
C
C  REV A  29MAR83   CLF   ORIGINAL.
C           2NOV83   CLF   MODIFY FOR FORMAT III TO GET ADDED RANGE.
C
C **************************************************************************
C
      DIMENSION MBUF(256),ICOUNT(2),ILBL(17),IUNITS(15)
C ***** THE DATA VALUES ARE PASSED INTO THIS SUBROUTINE THRU IBUF
      COMMON IBUF(12288)
      EQUIVALENCE (COUNT,ICOUNT(1))
      DATA IBLNK/2H  /,ICHAN/20/,IREAD/1/,IWRT/2/,IRATE/50000B/
      DATA ILBL/2HBE,2HCO,2HIL,2H V,2HEL,2HOC,2HIT,2HY ,2HDE,2HFL,2HEC
     *  2HD ,2HFR,2HOM,2H C,2HH ,2H3 /
      DATA IUNITS/2H F,2HER,2H S,2HEC,2HON,2HD ,9*2H  /,IBRATE/5/
C
C ***** CHECK IF DIRECTORY IS TO BE USED -- USE KDIR AS A SWITCH
C ***** TO INDICATE IF HEADER IS TO BE USED.
      KDIR=0
      IF(IDTRK .NE. -1)GO TO 110
      KDIR=1
C ***** READ DIRECTORY
      CALL EXEC(IREAD,LUDK,MBUF,256,1,0)
C ***** MBUF(2) HAS # OF DATA FILES IN DIRECTORY
C ***** CHECK FOR FULL DIRECTORY
      IF(MBUF(2) .LT. 127)GO TO 40
      WRITE(LU,20)
   20 FORMAT("DIRECTORY FULL -- TRANSFER NOT INITIATED")
      RETURN
C ***** CALCULATE START TRACK FOR TRANSFER
   40 NFILE=MBUF(2)
      ISTRK=MBUF(NFILE*2+1)+MBUF(NFILE*2+2)
      IDTRK=ISTRK
C ***** CHECK FOR FILLED DISC
      IF(LUDK .GE. 19 .AND. ISTRK .LT. 1017)GO TO 110
```

```
      IF(LUDK .EQ. 18 .AND. ISTRK .LT. 196)GO TO 120
      IF(LUDK .GE. 19)NLEFT=1023-ISTRK+1
      IF(LUDK .EQ. 18)NLEFT=202-ISTRK+1
      WRITE(LU,60)NLEFT
   60 FORMAT("ONLY ",I4," TRKS REMAIN--CONTINUE(Y OR N)?_")
      READ(LU,80)I
   80 FORMAT(A1)
      IF(I .NE. 1HY)RETURN
C ***** CHECK FOR INVALID TRACKS
  120 IF(IDTRK .GE. 2)GO TO 200
      WRITE(LU,140)
  140 FORMAT("TRACKS 0 & 1 ARE NOT VALID FOR TR COMMAND")
      RETURN
C
C ***** BEGIN TRANSFER PROCEDURE
C
  200 WRITE(LU,220)
  220 FORMAT("BEGIN TRANSFER.")
C ***** READ HEADER
      CALL EXEC(IREAD,LUDK,MBUF,64,1,6)
C ***** SET WORDS 1 & 2 TO TOTAL WORD COUNT
      COUNT=768.+FLOAT(NWORDS*2-1)
      MBUF(1)=ICOUNT(1)
      MBUF(2)=ICOUNT(2)
C ***** ZERO WORDS 3 & 4
      MBUF(3)=0
      MBUF(4)=0
C ***** SET FIRST 30 ADDRESSES STORED IN SECTOR 1 TO -1
      COUNT=-1.
      DO 260 I=1,31
      J=64+2*I
      MBUF(J-1)=ICOUNT(1)
      MBUF(J)=ICOUNT(2)
  260 CONTINUE
C ***** SET CHANNEL 30 ADDRESS TO 769
      COUNT=769.
      MBUF(125)=ICOUNT(1)
      MBUF(126)=ICOUNT(2)
C ***** SET CHANNEL 31 ADDRESS
      COUNT=COUNT+FLOAT(NWORDS)
      MBUF(127)=ICOUNT(1)
      MBUF(128)=ICOUNT(2)
C
C ***** INSERT DATA FILE NOTES SECTOR (ALL BLANKS)
C
      DO 280 J=129,192
  280 MBUF(J)=IBLNK
C
C ***** INSERT SPARE SECTOR FOR FUTURE EXPANSION (ALL ZEROES)
      DO 300 J=193,256
  300 MBUF(J)=0
C ***** WRITE FIRST FOUR SECTORS TO DISC
      CALL EXEC(IWRT,LUDK,MBUF,256,IDTRK,0)
C
C ***** INSERT CHANNEL DOCUMENTATION FOR RECOIL TRAVEL (CH 30)
C
C ***** GET CHANNEL SETUP PARAMETERS
      ISCTR=3*ICHAN
      CALL EXEC(IREAD,LUDK,MBUF,128,0,ISCTR)
C ***** SET CHANNEL 30 TO SELECTED
      MBUF(1)=131B
C ***** FILL CHANNEL LOG PARAMETERS
      MBUF(129)=ICHAN
      DO 320 J=2,64
  320 MBUF(128+J)=0
      MBUF(151)=IBRATE
C ***** GET SCALE FACTOR(=GAGE FACTOR)
      MBUF(163)=MBUF(17)
      MBUF(164)=MBUF(18)
      MBUF(165)=-4096
      MBUF(166)=-4096
      MBUF(167)=-4096
C ***** FILL NEXT SECTOR WITH BLANKS
      DO 340 J=193,256
  340 MBUF(J)=IBLNK
C ***** WRITE NEXT FOUR SECTORS TO DISC
      CALL EXEC(IWRT,LUDK,MBUF,256,IDTRK,4)
C
C ***** INSERT CHANNEL DOCUMENTATION FOR RECOIL VELOCITY (CH 31)
C
```

```
C ***** USE SAME VALUES AS CH 30 EXCEPT CHANGE PLOT LABELS AND SCALE FACTOR
C ***** CHANGE PLOT LABEL
      DO 360 I=37,53
  360 MBUF(I)=ILBL(I-36)
C ***** SET PLOT UNITS
      ICNT=1
      CALL LOOKS(MBUF(54),ICNT,15)
      IF(ICNT .GT. 9)ICNT=9
      DO 380 I=1,15-ICNT
  380 MBUF(53+ICNT+I)=IUNITS(I)
C ***** BLANK REMARKS
      DO 400 I=69,102
  400 MBUF(I)=IBLNK
C ***** SET CHANNEL NO
      MBUF(128)=ICHAN+1
      MBUF(129)=ICHAN+1
C ***** SET SCALE FACTOR
      ICOUNT(1)=MBUF(163)
      ICOUNT(2)=MBUF(164)
      COUNT=COUNT/0.00128
      MBUF(163)=ICOUNT(1)
      MBUF(164)=ICOUNT(2)
C ***** WRITE NEXT FOUR SECTORS TO DISC
      CALL EXEC(IWRT,LUDK,MBUF,256,IDTRK,8)
C
C ***** PROCESS DATA FROM MEMORY - CONVERT BCD TO INTEGER
C
      DO 500 I=1,NWORDS
      IBUF(I)=JBCD(IBUF(I))-2049
      IF(IBUF(I) .GT. 2047)IBUF(I)=2047
      IF(IBUF(I) .LT. -2048)IBUF(I)=-2048
      IF(IBUF(I) .LT. 0)IBUF(I)=IAND(IBUF(I),3777B)+4000B
      IBUF(I)=IBUF(I)+IRATE
  500 CONTINUE
C
C ***** TRANSFER DATA TO DISC
C
      ISCTR=12
      INDEX=1
      KAMT=5376
      IBAL=NWORDS
      ISWTCH=0
  520 IF(IBAL .LT. KAMT)KAMT=IBAL
      CALL EXEC(IWRT,LUDK,IBUF(INDEX),KAMT,IDTRK,ISCTR)
      IBAL=IBAL-KAMT
      IF(IBAL .EQ. 0)GO TO 540
      INDEX=INDEX+KAMT
      KAMT=6144
      IDTRK=IDTRK+1
      ISCTR=0
      GO TO 520
  540 IF(ISWTCH .EQ. 1)GO TO 700
C
C ***** PROCESS DATA TO GET VELOCITY
C
C ***** REMOVE RATE CODE AND CONVERT BACK TO INTEGER
      DO 620 I=1,NWORDS
  620 IBUF(I)=(IBUF(I)*16)/16
C ***** GENERATE DIFFERENCE AND CONVERT BACK TO ADCHK FORMAT
      DO 640 I=1,NWORDS-1
      IBUF(I)=IBUF(I+1)-IBUF(I)
      IF(IBUF(I) .GT. 2047)IBUF(I)=2047
      IF(IBUF(I) .LT. -2048)IBUF(I)=-2048
      IF(IBUF(I) .LT. 0)IBUF(I)=IAND(IBUF(I),3777B)+4000B
      IBUF(I)=IBUF(I)+IRATE
  640 CONTINUE
C ***** SET LAST WORD TO ZERO TO KEEP BUFFER SIZE IN 1K INCREMENTS
      IBUF(NWORDS)=0
C
C ***** SET UP TO TRANSFER DATA TO DISC
C
      ISCTR=KAMT/64+ISCTR
      IF(ISCTR .GT. 95)ISCTR=0
      INDEX=1
      IF(KAMT .EQ. 6144)IDTRK=IDTRK+1
      KAMT=6144-ISCTR*64
      IBAL=NWORDS
      ISWTCH=1
      GO TO 520
C
```

```
C ***** ZERO REMAINDER OF TRACK
C
  700 IF(KAMT .EQ. 6144)GO TO 800
      IBAL=6144-KAMT-64*ISCTR
      DO 720 I=1,IBAL
  720 IBUF(I)=0
      ISCTR=KAMT/64+ISCTR
      CALL EXEC(IWRT,LUDK,IBUF,IBAL,IDTRK,ISCTR)
C
C ***** TELL OPERATOR WHERE DATA WENT
C
  800 KAMT=IDTRK-ISTRK+1
      NWORDS=768+2*NWORDS-1
      WRITE(LU,820)NWORDS,LUDK,ISTRK,KAMT
  820 FORMAT(I5," WORDS TRANSFERRED TO DISK LU",I3," TRACK",I5/
     $  10X,I3," TOTAL TRACKS UTILIZED")
C ***** CHECK IF DIRECTORY WAS USED
      IF(KDIR .EQ. 0)RETURN
C
C ***** UPDATE THE DIRECTORY
C
C ***** READ EXISTING DIRECTORY
      CALL EXEC(IREAD,LUDK,MBUF,256,1,0)
C ***** MODIFY ENTRIES
      NFILE=NFILE+1
      MBUF(1)=ISTRK
      MBUF(2)=NFILE
      MBUF(NFILE*2+1)=ISTRK
      MBUF(NFILE*2+2)=KAMT
C ***** WRITE TO DIRECTORY
      CALL EXEC(IWRT,LUDK,MBUF,256,1,0)
      RETURN
      END
      END$
```

APPENDIX D - REFERENCES

1. Yeager, J. G., TECOM Report No. DPS-2363, 1967.

2. Francis, C. L., Final Report, RDI Task of Research and Development of Software, Ballistic Test Site Terminal, TECOM Project No. 5-CO-APO-DFW-203. US Army Aberdeen Proving Ground, Report APG-MT-5952, January 1984. (Distribution unlimited. AD 139 956.)

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