ADA024034

12

F.C.

COPY NO. 26

TECHNICAL REPORT 4858

FUNCTIONING TIMES AND SIMULTANEITY OF HOT BRIDGEWIRE DETONATORS XM100 AND T20E1

THOMAS McKIMM

D D C
MAY 7 1976

APRIL 1976

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

PICATINNY ARSENAL
DOVER, NEW JERSEY

The findings in this report are not to be construed as an official Department of the Army position.

DISPOSITION

Destroy this report when no longer needed. Do not return to the originator.

(14) PA-TR-4858

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

(7)

1. REPORT NUMBER: Technical Report 4858	2. GOVT ACCESSION NO.
	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): (6) Functioning Times and Simultaneity of Hot Bridgewire Detonators XM100 and T20E1.	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): (10) Thomas McKimm	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Ammunition Development & Engineering Directorate, Picatinny Arsenal, Dover, NJ 07801	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE: (11) April 1976
	13. NUMBER OF PAGES: 30
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): (12) 27p.	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited.

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

18. SUPPLEMENTARY NOTES

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

Electric detonator	XM100
Hot bridgewire	Simultaneity
T20E1	Functioning time

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

To determine the suitability of conventional hot bridgewire (HBW) detonators for use in multiple point-initiation warheads requiring precise firing times, detonators XM100 and T20E1 were tested using a capacitive discharge firing circuit with moderate voltage levels (100 volts maximum).

The T20E1 conventional HBW detonator can approach a functioning time of 2 microseconds with a simultaneity of approximately 0.4 microseconds. For conventional munitions with limited power sources, this HBW should be adequate.

The citation in this report of the names of commercial firms or commercially available products or services does not constitute official endorsement or approval of such commercial firms, products, or services by the US Government.

ACCESSION for
NTIS White Section
DDC Buff Section
UNANNOUNCED
JUSTIFICATION
BY
DISTRIBUTION/AVAILABILITY CODES
Dist. AVAIL. and/or SPECIAL
A

FOREWORD

The testing described in this report was performed by the Explosives Application Branch of the Ammunition Development and Engineering Directorate, Picatinny Arsenal. The author is particularly grateful to Mr. Fred Correll, who directed the test program.

TABLE OF CONTENTS

INTRODUCTION

A review of the open literature indicated that the conventional hot bridgewire (HBW) detonator could approach the exploding bridgewire (EBW) in functioning time with reasonable simultaneity. The ARC-211 detonator, developed by the Ballistic Research Laboratories, has a mean function time of 2.42 microseconds with a standard deviation of 0.045 microseconds (Ref 1). However, the firing circuit parameters, 6,000 volts on a 1-microfarad capacitor, are too high for consideration and cloud the initiation mechanism. The results of the literature search and conversation with personnel knowledgeable in the detonator field indicated that modifying the conventional HBW designs by removing the lead styphnate primer or spot charge and substituting RD 1333 lead azide for dextrinated lead azide would decrease the functioning time. While these explosives have desirable features, such as lead styphnate's ease of initiation and dextrinated lead azide's increased handling safety, both exhibit random reaction rates due to geometry, loading techniques, and lot-to-lot variations (Ref 2). Other areas that show promise for precision HBW are film bridges which allow better control of electrical and physical properties (Ref 3, 4, 5), and high loading pressures (greater than 30,000 psi) with RD 1333 lead azide (Ref 6). Multipoint-initiation warheads require precise firing times at each point. Exploding bridgewire (EBW) detonators have the precision times required. However, there are many problems associated with their use.

The literature survey showed a lack of published base line data. Consequently, the test procedure described in this report was designed to provide base line data for use in determining how good or bad the conventional HBW is with respect to simultaneity for reasonable voltage levels. The selection of 100 volts as a maximum was arbitrary, based on two judgments: that 100 volts is a reasonable limit for the switches and contacts typically used in safing and arming devices, and that a DC/DC step-up circuit of four- or six-to-one is compact and the power loss is not excessive.

The detonators selected for testing were the T20E1 and the XM100. The T20E1 (Fig 1) is a twin-lead ungrounded case design with a colloidal lead azide spot charge. The XM100 (or MICRODET) (Fig 2) is a single-pin grounded case design with a lead styphnate spot charge. The XM100 was selected over the M84/T77 primarily because it represents the smallest detonator package available at the present or anticipated for the near future.

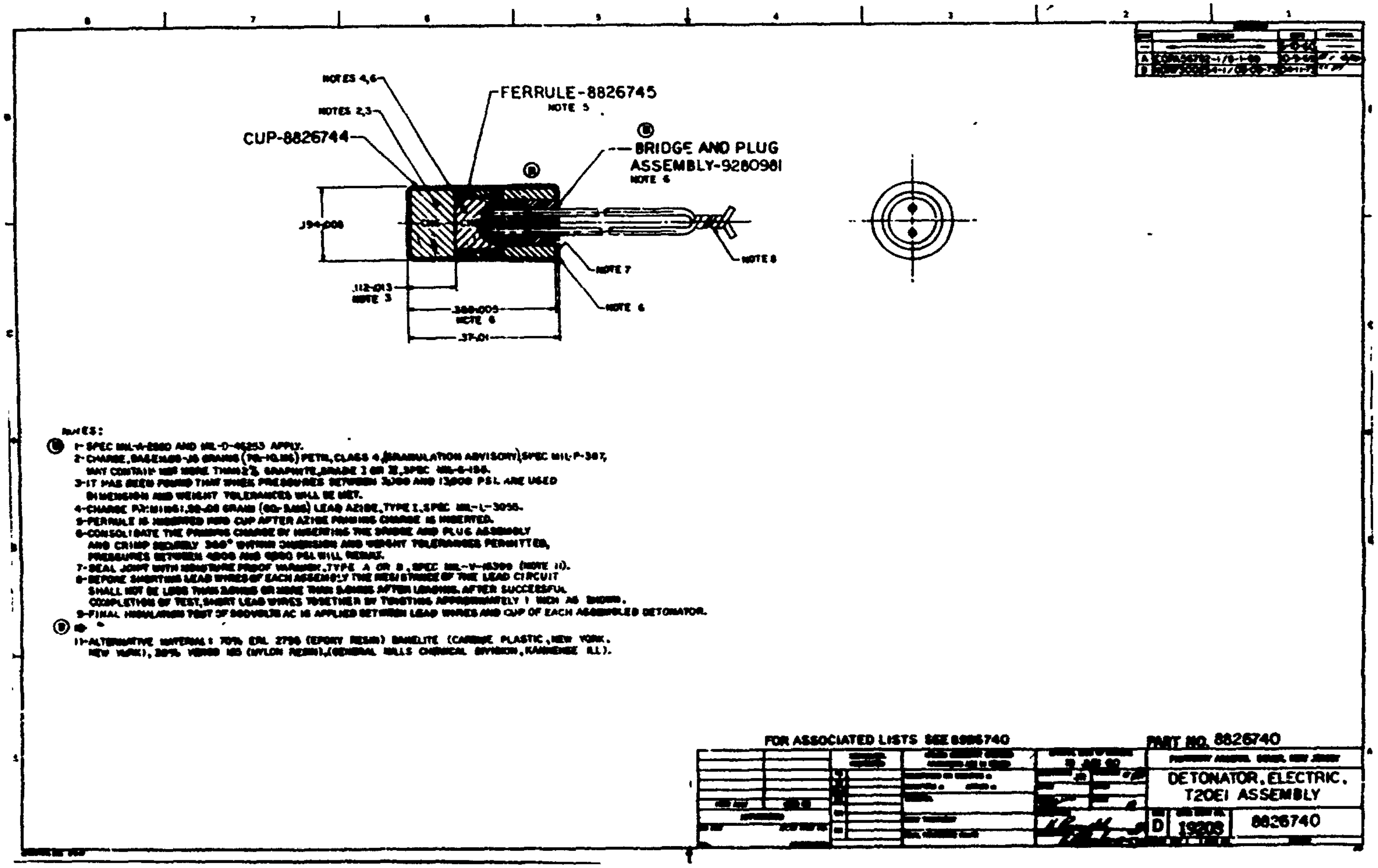

Fig 1 HBW detonator T20E1

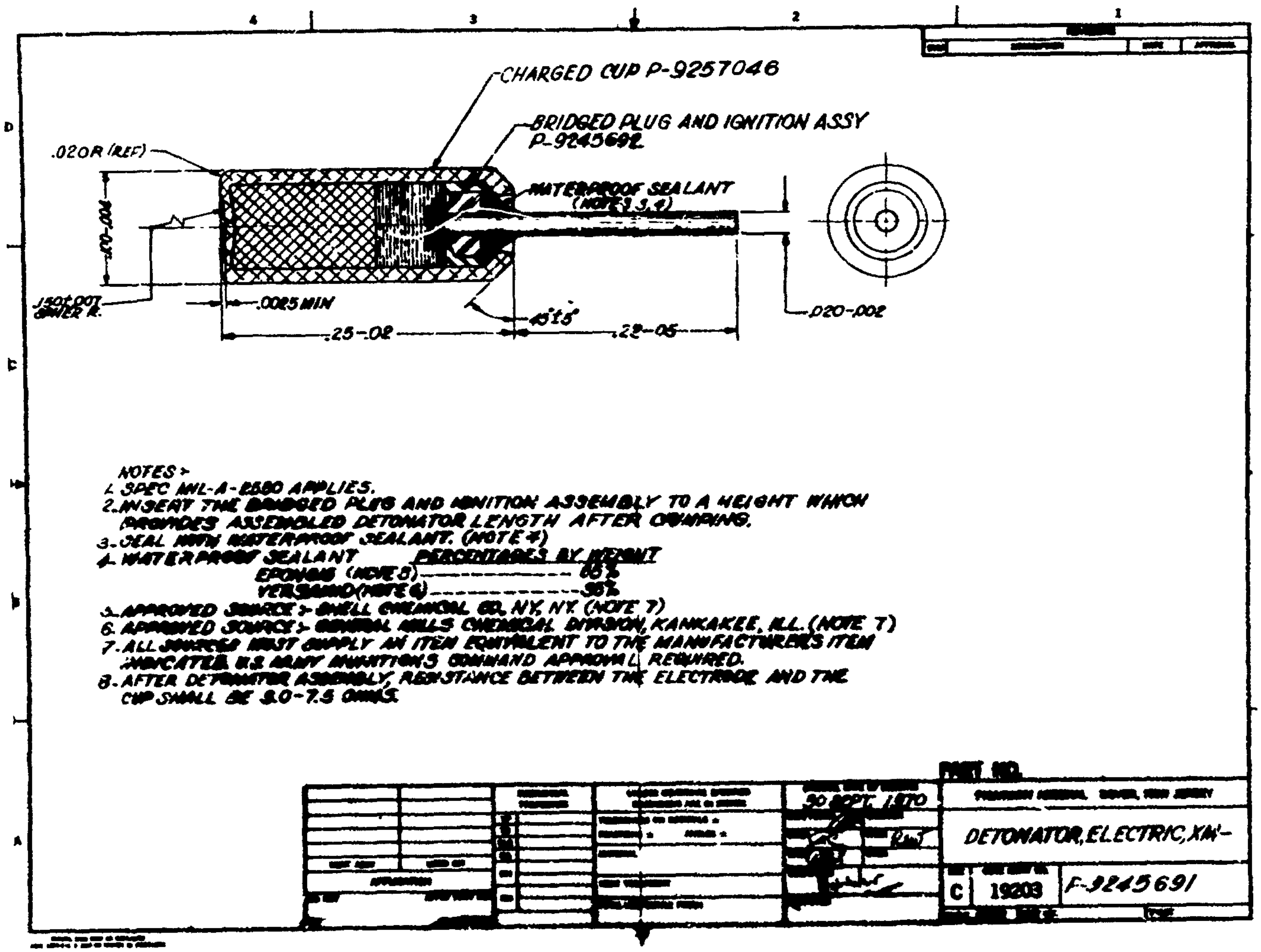

Fig 2 HBW detonator XM100

DISCUSSION

Test Method

The Franklin Institute Initiator Test Set (FILITS) with external capacitors was used to conduct the test. The original intent was to use tantalum capacitors as this would approach actual use conditions; however, the lead time (14 to 16 weeks) for tantalum capacitors with sufficient working voltage was prohibitive. For firing voltages of 50 volts or greater, Sprague Type 160P paper/film capacitors were used. These capacitors were connected in parallel as necessary to obtain the capacitance values required. This increased the internal resistance over that of a single capacitor of the correct value and affected the firing data by increasing the circuit RC time constant. The XM100 was fired using a 6.8 microfarad solid tantalum (MIL-SPEC-M-39003) at 25 volts.

An RCA 931A photo-detector was used to measure the functioning time from the application of the firing pulse to the first visible light. While other investigators prefer ionization probes, fiber optics, and framing photography to measure shockwave breakout, the photocell technique is the method used at Picatinny Arsenal. Some might argue with the absolute functioning time; however, the dispersion (simultaneity) is independent of the detection method used.

Test Results

A summary of the test data is presented in Table 1; the raw data sheets are attached as an Appendix. The functioning times of the XM100 at 25 and 50 volts were long, compared with the average. The XM100 detonator was developed for mine applications and most functioning time data was recorded at 1.6 volts on a 100-microfarad capacitor. The average functioning time under these conditions is 120 microseconds, but a few function in the 200 to 400 microsecond range. I attribute this scatter to the lead-styphnate spot charge and the off-center bridge location, especially in this small, 100-inch diameter, size. The functioning times for the XM100 stabilized at the 75-volt level.

The calculated mean and standard deviation for functioning times and bridgewire resistance are listed in Table 2. Since the sample size for each condition is small, a more precise labeling would be the sample mean and sample estimate of variance. The mean and standard deviation have been recalculated for the XM100 at 25 and 50 volts, excluding the long functioning times. The standard deviation gives an idea of the potential simultaneity for the detonator under these conditions. The values calculated are for a normal-probability distribution. In Table 3, the actual range of functioning times is compared to the 3-σ range calculated. The comparison indicates that a normal distribution is not a good choice for the XM100. The normal distribution mean and standard deviation for the XM100 at 25 and 50 volts indicate that the sample size was insufficient or that a skewed distribution would provide a better data fit. The T20E1 test data falls within the bounds of a normal distribution nicely. The T20E1 has the best performance in both functioning time (approximately 2 microseconds) and simultaneity (0.3 microsecond) between functioning time extremes. This is as expected, since the T20E1 has a colloidal lead-azide spot charge (Ref 7), and bridgewire resistance is lower and better controlled. This results in a higher current through the bridgewire; hence, a higher wire temperature. The longer, larger diameter bridgewire improves resistance control, and termination of the bridgewire at the header posts is easier. In Table 2, the bridgewire resistance is 1.72 to 3.03 ohms for the T20E1 and 2.82 to 6.04 ohms for the XM100.

The energy delivered to the bridgewire was calculated as an aide in analysis. This calculation is generalized in that the mean bridgewire resistance and mean functioning time were used. In addition, the firing circuit time constant neglected the resistance of the leads, the internal capacitor, and the firing switch.

The following equations were used:

$$E_a = \frac{1}{2} CV_1^2 \qquad (1)$$

$$V_r = V_1 e^{\frac{-t}{rc}} \qquad (2)$$

$$E_r = \frac{1}{2} CV_r^2 \qquad (3)$$

$$E_d = E_a - E_r \qquad (4)$$

The symbols used in the equations are as follows:

E_a - Energy available (ergs)

E_r - Energy remaining on capacitor (ergs)

E_d - Energy delivered to bridgewire (ergs)

V_I - Initial voltage (volts)

V_r - Remaining voltage (volts)

t mean function time (microseconds)

r - mean bridgewire resistance (ohms)

C - firing capacitor

This data is presented in Table 4. The energy delivered to the bridgewire did not indicate a clearcut trend for the XM100. It has been determined by others that capacitive discharge initiation (Ref 7) is significantly faster than constant-current initiation of HBW detonators. A primary factor in capacitive discharge initiation is the rate of energy delivery, which is controlled by the circuit time constant, increasing as the time constant decreases. The functioning time for the XM100 at 75 and 100 volts runs counter to this. The only plausible conclusion is that the 100-volt limit imposed is too low for the bridgewire resistance to reach the optimum energy-delivery rate. This is confirmed by another investigator's test with 230 volts giving a functioning time of 1 to 2 microseconds for the XM100. A 25% increase of energy delivered at 75 (versus 50) volts for the XM100 causes the long functioning times to stop. It is the rate of energy delivery that is the probable factor since the bridge plug assembly is only lightly pressed into the explosive column, and a gap may exist between the spot charge and the lead azide charge. On the other hand, the T20E1 is pressed into the primary charge with 4,000 to 6,000 psi pressure. This could cause poor thermal contact with the explosive and a greater loss of heat to the inert components of the detonator (Ref 7).

As indicated in Table 4, for the T20E1, an increase of approximately 25% in delivered energy results in the functioning time decreasing approximately 60%; however, the rate of energy delivery is increased by 225%. This indicates that the T20E1 should be tested further in the same voltage range with 0.5 to 1.5 microfarad capacitors. The supply of T20E1 detonators available was expended at these two data points. The original test plan included voltage and current traces at each point. This would have aided the analysis more than the data reflected in Table 4, but the equipment was inoperable during the test period.

CONCLUSIONS

A conventional HBW detonator can be used for multiple initiation of warheads if the functioning time requirements are not too severe. The T20E1 has a functioning time of approximately 2.0 microseconds with a simultaneity of 0.4 microseconds. However, an SCR was not used as the switching element of the firing circuit. A tactical firing circuit using an SCR would increase functioning time to the 5 microsecond range. The losses inherent in SCR's and tantulum capacitors do affect the simultaneity, but quantification is extremely difficult.

RECOMMENDATIONS

Investigating alternate developments for a precise functioning HBW is recommended, specifically:

1. Removing bridgewire spot charges and using RD 1333 or PVA lead azide at loading pressures greater than 30,000 psi. A control parameter of interest is the explosive granulation.

2. Investigating techniques for manufacturing film bridges and combining the parameters of the resulting bridges with the explosive development.

There is a need to know the effects of tactical firing circuit designs on HBW detonator functioning times. However, this should not be combined with the detonator development work, as the effects of the firing circuit could impair optimization of the internal detonator parameters.

Conventional HBW detonators should be considered a viable alternative to EBW system, especially in light of the present ambiguity of MIL STD 1316A regarding EBW's. The EBW's available do not use an approved explosive for in-line explosive trains. Therefore, the EBW would have to be used in a safing and arming device with the attendant cabling and switching problems associated with 2 to 4 kilovolts.

REFERENCES

1. Boyd C. Taylor, *All Electrostatic Insensitive Detonator for Precision Synchronization,* Ballistics Research Laboratories Memo Report 2096, Aberdeen Proving Ground, MD

2. R. A. Whiting, R. H. Stresau, J. N. Ayres, *Lot to Lot Variations in Explosive Properties and their Consequence in Explosive Component Development and Production,* Proceedings of the Explosives and Pyrotechnics Symposium, The Franklin Institute, Philadelphia, PA, 1967

3. J. M. Craig, et al, *Vacuum Deposited Thin Film Bridges in Electro-explosive Devices,* Proceedings of the Explosives and Pyrotechnics Symposium, The Franklin Institute, Philadelphia, PA, 1969

4. R. Stresau, R. Hillyer, D. Degner, *Fifty Millijoule Exploding Bridgewire Detonator Feasibility Study and Applied Research,* NAVWEPS Report 8841, Naval Ordnance Laboratory/Corona, Corona, CA, 1965

5. R. Stresau, *Electric Detonators for Navy Guided Missile Applications, Experimental Studies of Four Concepts,* Proceedings of the Explosives and Pyrotechnics Symposium, The Franklin Institute, Philadelphia, PA, 1967

6. R. Stresau, M. H. Rowe, *Observations of the Effects of Loading Density on the Initiation and Growth of Detonation of Azides,* NOL Technical Report 61-134, Naval Ordnance Laboratory/White Oak, Silver Spring, MD, 1961

7. H. S. Leopold, *Effect of Wire Temperature Upon Initiation Times of Four Primary Explosives,* NOL Technical Report 72-123, Naval Ordnance Laboratory/White Oak, Silver Spring, MD, 1972

Table 1

Test data summary

Detonator	Lct no.	Voltage (volts)	Capacitor (microfarads)	Quantity	Functioning time (microseconds)		
					average	long	short
XM100	AN190-5	25	6.8[a]	30	8.18	47.5	2.9
XM100	AN190-5	50	3.0[b]	54	6.99	33.7	2.5
XM100	AN190-5	75	1.0[c]	25	4.89	7.1	3.5
XM100	AN190-5	75	2.5[d]	25	4.88	7.4	3.3
XM100	AN190-5	100	1.0[c]	25	4.27	5.6	3.4
XM100	AN190-5	100	2.0[e]	25	4.00	5.3	3.3
T20E1	AAP 17	50	3.0[b]	18	5.40	6.3	4.7
T20E1	AAP 2	100	1.0[c]	25	2.04	2.2	1.9

[a] Solid tantalum polarized.
[b] Three 1.0-microfarad Sprague 160P.
[c] One 1.0-microfarad Sprague 160P.
[d] Two 1.0-microfarad Sprague 160P and one 1.5-microfarad Sprague 160P.
[e] Two 1.0-microfarad Sprague 160P.

Table 2

Calculated data

Detonator	Quantity	Voltage (volts)	Capacitance (microfarads)	Functioning Time (microseconds)		Resistance (ohms)		Measured range (ohms)
				$\overline{X}$	σ	$\overline{X}$	σ	
XM100	30	25	6.8	8.183	9.858	4.68	.67	3.56 - 5.87
XM100		25	6.8	5.14*	1.87*			
XM100	54	50	3.0	6.99	7.00	4.72	.74	2.82 - 6.04
XM100		50	3.0	4.76*	1.20*			
XM100	25	75	2.5	4.76	1.09	4.42	.46	3.73 - 5.46
XM100	25	75	1.0	4.88	.85	4.75	.54	3.51 - 5.76
XM100	25	100	1.0	4.27	.57	4.53	.63	3.64 - 5.81
XM100	25	100	2.0	4.03	.465	4.69	.65	3.61 - 5.93
T20E1	18	50	3.0	5.41	.315	2.14	.2	1.72 - 2.37
T20E1	25	100	1.0	2.04	.095	2.73	.17	2.33 - 3.03

* Long functioning times removed.

Table 3

Comparison of actual and calculated functioning times

Detonator	Voltage	Capacitor (microfarads)	Functioning time range (microseconds) test	calculated 3 σ
XM100	25	6.8	2.9/47.5	-21.4/37.76
XM100			2.9/8.9*	-0.47/10.75
XM100	50	3.0	2.5/33.7	-14.01/28.0
XM100			2.5/7.5*	1.16/9.36
XM100	75	2.5	3.3/7.4	1.49/8.03
XM100	75	1.0	3.5/7.1	2.33/7.43
XM100	100	1.0	3.4/5.6	2.54/6.0
XM100	100	2.0	3.3/5.3	2.74/5.43
T20E1	50	3.0	4.7/6.3	4.47/6.36
T20E1	100	1.0	1.9/2.2	1.78/2.32

*Long functioning times removed.

Table 4

Energy delivered to bridgewire

Detonator	Resistance (ohms)[a]	Capacitance (microfarads)	Voltage (volts)	Available energy	Time constant (microsecs)	Functioning time (microsecs)[b]	Energy delivered (ergs)[c]	
XM100	4.68	6.8	25	21,250	31.8	8.18	8,549	(5,870)[d]
XM100	4.72	3.0	50	37,500	14.16	6.99	23,528	(18,355)[d]
XM100	4.42	2.5	75	70,312	11.87	4.76	38,782	
XM100	4.75	1.0	75	28,125	4.42	4.88	25,034	
XM100	4.53	1.0	100	50,000	4.53	4.27	42,410	
XM100	4.69	2.0	100	100,000	9.38	4.03	57,653	
T20E1	2.14	3.0	50	37,500	6.42	5.41	28,231	
T20E1	2.73	1.0	100	50,000	2.73	2.04	38,782	

[a]Mean resistance for detonators tested.

[b]Resistance of leads; switch and capacitor neglected.

[c]Mean functioning time for detonators tested.

[d]Energy delivered values without long functioning times.

APPENDIX

RAW TEST DATA

Functioning time of XM100
and T20E1 detonators

Firing voltage	Capacitor (µfd)	Type of capacitor	Number tested	Functioning time (µ sec) average	long	short
		XM100 DETONATOR, LOT AAN 90-5				
25	6.8	Mallory solid tantulum	30	8.2	47.5	2.9
		Three-1 µfd in parallel				
50	3.0	Sprague Type 160P	54	6.8	33.7	2.5
75	1.0	Sprague Type 160P	25	4.9	7.1	3.5
		Two-1 µfd One-.5 µfd in parallel				
75	2.5	Sprague Type 160P	25	4.7	7.4	3.3
100	1.0	Sprague Type 160P	25	4.3	5.6	3.4
		Two-1 µfd				
100	2.0	Sprague Type 160P	25	4.0	5.3	3.3
		T20E1 DETONATOR, LOT AAP-17 AND LOT AAP-2				
		Three-1 µfd in parallel				
50	3.0	Sprague Type 160P	18	5.4	6.3	4.7
100	1.0	Sprague Type 160P	25	2.0	2.2	1.9

SARPA Form 1157 Dec 73 CALCULATION SHEET

PRECEDING PAGE BLANK-NOT FILMED

25/6/74
Starr
Lopes

XM100 detonator, Lot AAN-190-5
(6.8 µfd @ 25v)

Item no.	Resistance (ohms)		Function time (µsec)				
1	4.17		9.1				
2	3.77		5.6				
3	5.37		3.5				
4	4.89		3.9				
5	4.39		6.1				
6	5.54		8.5				
7	5.50		7.7				
8	4.15		6.4				
9	3.94		47.5				
10	5.52		32.3				
11	5.00		4.7				
12	4.34		5.2				
13	5.03		5.4				
14	3.81		26.9				
15	4.39		6.1				
16	5.03		4.1				
17	5.75		4.2				
18	4.99		7.9				
19	5.40		5.1				
20	4.40		3.5				
21	4.98		3.5				
22	4.11		3.7				
23	4.36		3.3				
24	3.72		2.9				
25	3.66		8.9				
26	4.80		3.6				
27	5.87		4.4				
28	4.93		4.8				
29	3.56		3.2				
30	4.91		3.5				

6/7/74
Starr
Lopes

XM100 detonator, Lot AAN-190-5
(3 μfd @ 50v)

Item no.	Resistance (ohms)	Function time (μsec)	Item no.	Resistance (ohms)	Function time (μsec)
1	4.73	3.9	28	3.69	6.9
2	2.82	3.2	29	4.29	4.4
3	4.05	3.0	30	5.51	4.7
4	4.24	2.8	31	4.63	4.9
5	4.07	3.1	32	5.59	6.2
6	3.67	2.5	33	3.94	4.1
7	4.73	2.8	34	5.90	3.3
8	4.80	3.0	35	4.51	5.0
9	4.10	4.9	36	4.32	4.0
10	5.71	29.9	37	5.55	5.4
11	5.41	missed	38	4.89	4.5
12	5.36	4.0	39	4.68	4.8
13	5.73	3.7	40	3.66	5.8
14	5.63	5.5	41	5.40	4.8
15	4.60	4.8	42	5.23	17.0
16	4.70	7.5	43	4.37	4.2
17	6.07	5.1	44	4.51	5.4
18	4.67	4.2	45	4.51	4.9
19	5.22	missed	46	4.74	4.4
20	5.57	5.7	47	3.62	4.1
21	4.56	7.3	48	5.85	3.8
22	4.31	4.8	49	3.83	4.4
23	5.13	4.3	50	4.45	5.3
24	5.94	5.4	51	4.22	32.8
25	4.21	26.6	52	4.28	33.7
26	5.26	2.7	53	5.81	6.2
27	3.74	4.1	54	4.06	4.7

6/7/74
Starr
Lopes

XM100 detonator, Lot AAN-190-5
(2.5 μfd @ 75v)

Item no.	Resistance (ohms)	Function time (μsec)
1	4.80	4.4
2	4.84	4.4
3	3.73	4.2
4	4.14	4.3
5	4.58	4.2
6	4.46	4.4
7	4.08	5.2
8	4.64	4.8
9	5.46	4.1
10	4.56	3.3
11	4.55	5.1
12	4.69	4.0
13	3.83	4.0
14	4.27	7.4
15	4.91	7.1
16	4.82	7.0
17	4.44	3.4
18	4.25	5.6
19	4.28	4.3
20	5.31	5.1
21	3.96	4.4
22	4.92	5.4
23	4.08	3.5
24	3.91	4.1
25	3.73	5.2

SARPA Form 1157 Dec 73 CALCULATION SHEET

6/6/74
Starr
Lopes

XM100 detonator, Lot AAN-190-5
(1 μfd @ 75v)

Item no.	Resistance (ohms)	Functiontime (μsec)				
1	4.82	5.3				
2	4.36	5.0				
3	5.14	5.0				
4	5.25	4.2				
5	4.72	7.1				
6	4.76	4.6				
7	4.35	4.4				
8	5.38	4.8				
9	4.62	4.3				
10	3.51	6.4				
11	5.04	5.0				
12	4.63	5.7				
13	5.25	4.6				
14	4.18	4.5				
15	4.34	4.1				
16	4.42	4.1				
17	4.81	3.5				
18	5.14	6.4				
19	5.45	4.8				
20	5.13	4.3				
21	3.92	4.0				
22	5.26	5.0				
23	3.94	5.0				
24	4.58	5.7				
25	5.76	4 1				

SARPA Form 1157 Dec 73 CALCULATION SHEET

6/6/74
Starr
Lopes

XM100 detonator, Lot AAN-190-5
(1 μfd @ 100v)

Item no.	Resistance (ohms)	Functiontime (μsec)				
1	5.63	4.4				
2	4.04	4.7				
3	5.09	3.5				
4	4.43	3.9				
5	5.35	4.3				
6	4.41	4.8				
7	4.37	4.5				
8	5.81	5.6				
9	4.23	3.8				
10	4.14	4.5				
11	4.04	4.3				
12	4.72	5.7				
13	4.35	4.8				
14	5.31	3.4				
15	3.64	4.0				
16	5.51	3.7				
17	4.14	3.8				
18	3.81	4.4				
19	4.53	4.6				
20	4.26	4.2				
21	4.28	3.5				
22	4.13	4.3				
23	5.24	3.9				
24	4.94	4.0				
25	3.78	4.1				

6/7/74
Lopes
Starr

XM100 detonator, Lot AAN-190-5
(2 μfd @ 100v)

Item no.	Resistance (ohms)	Functiontime (μsec)				
1	5.73	4.2				
2	4.54	4.5				
3	3.92	4.1				
4	4.45	4.5				
5	4.91	4.4				
6	4.54	5.3				
7	3.96	4.0				
8	5.34	3.3				
9	3.61	4.2				
10	4.92	4.6				
11	4.76	3.8				
12	4.18	3.8				
13	5.35	3.6				
14	4.72	4.3				
15	5.36	4.6				
16	5.62	4.2				
17	4.35	3.3				
18	4.54	4.0				
19	4.71	3.5				
20	5.08	3.7				
21	3.92	3.8				
22	5.08	3.6				
23	5.93	3.6				
24	3.54	3.9				
25	4.26	4.0				

SARPA Form 1157 Dec 73 CALCULATION SHEET

6/10/74
Starr

T20E1 detonator, Lot AAP 60-17
(3 μfd @ 50v)

Item no.	Resistance (ohms)	Function time (μsec)				
1	2.24	5.1				
2	2.32	5.3				
3	1.72	5.5				
4	2.00	5.2				
5	2.12	5.4				
6	2.20	5.4				
7	2.36	5.0				
8	2.08	5.5				
9	2.05	4.7				
10	2.15	5.4				
11	2.37	5.4				
12	1.83	5.7				
13	2.14	5.5				
14	2.16	5.4				
15	2.33	5.4				
16	2.36	5.4				
17	1.81	5.5				
18	2.27	6.3				

DARPA Form 1157 Dec 73 CALCULATION SHEET

6/10/74

T20E1 detonator, Lot AAP 60-2
(1 μfd @ 100v)

Item no.	Resistance (ohms)	Functiontime (μsec)
1	2.33	2.1
2	2.79	2.0
3	2.76	2.0
4	2.49	2.1
5	2.73	2.1
6	3.03	1.9
7	2.58	2.2
8	2.61	2.0
9	2.92	2.0
10	2.73	2.0
11	2.74	2.1
12	2.74	2.1
13	2.70	2.0
14	2.90	2.3
15	2.52	2.0
16	2.50	2.1
17	2.90	2.0
18	2.58	2.0
19	2.78	2.0
20	2.91	1.9
21	2.94	2.0
22	2.74	1.9
23	2.71	2.1
24	2.82	2.1
25	2.82	1.9

DISTRIBUTION LIST

	Copy No.
Commander US Army Development and Readiness Command 5001 Eisenhower Avenue ATTN: DARCOM-RD-W Alexandria, VA 22333	1
Commander US Army Armament Command ATTN: DRSAR-RDF Rock Island, IL 61201	2
Harry Diamond Laboratories 2800 Powder Mill Road ATTN: AMXDO-420, R. Keith Warner	3
AMXDO, Technical Library Adelphi, MD 20783	4
Commander Frankford Arsenal ATTN: K1000, Technical Library Philadelphia, PA 19137	5
Commander Edgewood Arsenal ATTN: SAREA-DE Edgewood, MD 21010	6
Commander Naval Weapons Center ATTN: Code 450, M. Brown	7
Code 753, Technical Library China Lake, CA 93555	8
Commander Naval Surface Weapons Center White Oak Laboratory ATTN: Code-WR-12, H. S. Leopold	9
Code-WX-21 Silver Spring, MD 20910	10

Commander Naval Surface Weapons Center Dahlgren Laboratory ATTN: Code WD, Library Dahlgren, VA 22448	11
Commander Pacific Missile Test Center ATTN: Technical Library Point Mugu, CA 93402	12
Armament Development and Test Center ATTN: ADA, Mr. D. Bednar Eglin AFB, FL 32542	13
Commander Picatinny Arsenal ATTN: SARPA-CO-T	14
SARPA-AD	15
SARPA-AD-F	16-17
SARPA-AD-F-E	18
SARPA-AD-E-P-4, R. L. Wagner	19
SARPA-TS-S Dover, NJ 07801	20-24
R. L. Stresau Laboratory Star Route Spooner, WI 54801	25
Defense Documentation Center Cameron Station Alexandria, VA 22314	26-37