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ED-39
Build Packaging

December 10, 1956

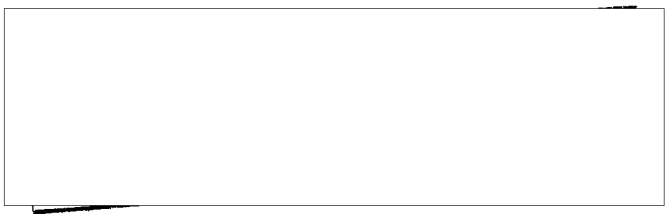
F I N A L R E P O R T

ON

HOT DIP PACKAGING

1210-C-2

Contract No. RD-88
Task No. 2



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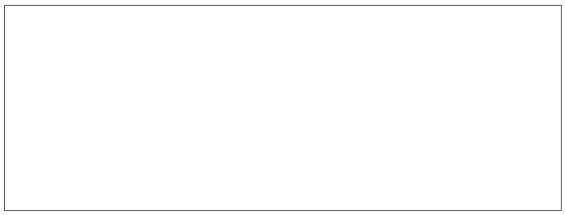

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Introduction

The use of plastic, such as that defined under JAN-C-149, Type II, to act as a protective barrier for hardware and machine parts has proven quite successful even when these items are stored for long periods of time. The method of obtaining a barrier coating is to immerse the item in a plastic bath which is at a temperature of approximately 325 Deg. F. For the purposes of this investigation cellulose acetate butyrate was used.

This method of protection was extended to incendiary and explosive items. It was possible that when these were immersed in plastic such effects as decomposition of components, activation of the item, or plastic flowing into the openings of the package could occur and render the item useless. All of these effects were determined by means of a long term immersion in the hot plastic. These units were then subjected to physical examination and then functioning tests. The results of these long term dips are given in the following pages.

Purpose

The scope of this program may be divided into the following phases:

I. The temperature and time duration of exposure, to which a packaged item would be subjected, was determined. The units were contained in the standard packaging configuration and dipped by the standard hot dip procedure. The

safety of the operation over an extended period was established should one of the items become wedged or dropped into the tank.

II. From the data obtained in Phase I, and from information contained in the literature, it was established that the standard package for the items under consideration provides sufficient protection against thermal damage during the normal dipping operation.

III. Plastic coatings for the packaged items were prepared and placed in storage for later evaluation.

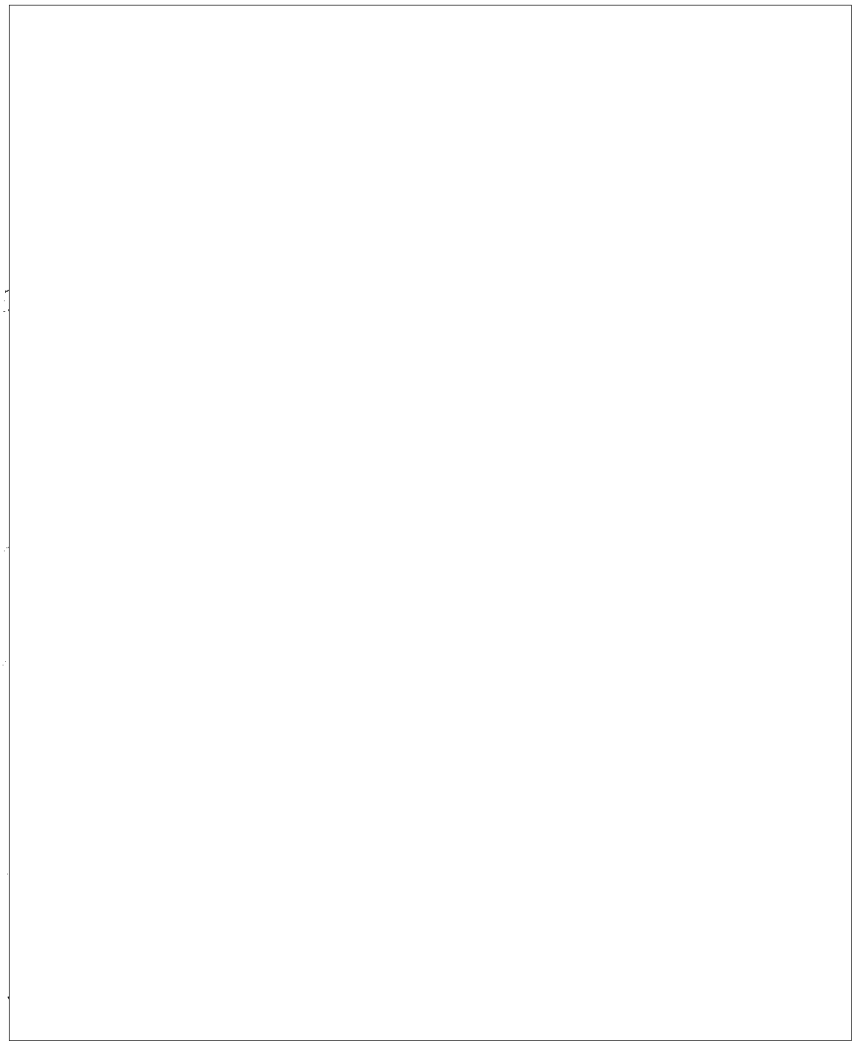
IV. Units, which were prepared under Phase III, were tested for proper functioning after a six month storage period.

V. This data was evaluated and a packaging manual was prepared for the protection of packaged devices by the hot dip method.

SECTION I

MAXIMUM TEMPERATURE DETERMINATION FOR SHORT AND LONG TERM DIPS

The units which were considered in this investigation are the following:



Mock ups of some of the units were prepared and equipped with thermocouples to determine the rate of temperature rise and the maximum temperatures reached within the package during a

normal dipping operation and a long term immersion. A Minneapolis-Honeywell 12 channel recorder, Model Y153X(67)T-12-X-(106) was used to obtain the transient data during these dipping periods. A Fidelity Chemical Corporation Model 1362 Dip Tank, (Figure 1) was used for the short term dipping and an inexpensive expendable oven, of our design, the details of which are shown in Figure 2, was used for the long term cook-off characteristics of the various items.

Figure 1

Dipping Area and Dip Tank

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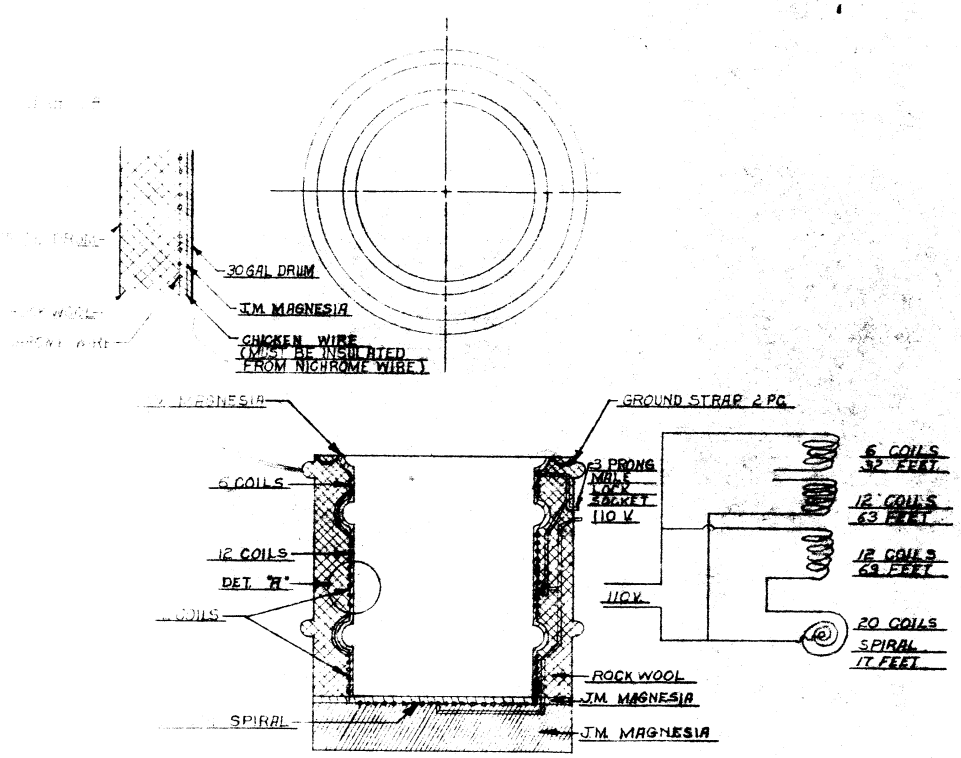


	1 BAG	J.M. MAGNESIA	
	1 BAG	ROCK WOOL	
	180 FT	NICHROME WIRE	
	1	30 GAL. DRUM	
	1	55 GAL. DRUM	
PART NUMBER	QUANTITY REQ	PART NAME	MATERIAL

MATERIAL AS SHOWN	FINISH
DRAWN BY J.P.	APPROVED BY
DATE 9/27/56	SCALE 1/8" = 1'0"
NEXT ASSEMBLY	MODEL

NO	DATE	REVISIONS	BY

UNLESS SPECIFIED ALL TOLERANCES ARE:
FRACTIONS ± DECIMALS ± ANGLES ±

DWG SIZE	DWG NO	ISSUE
B	1210-C-2-1	1

SHEET OF 1 SHEETS

SECRET

Figure 2

Figure 2
-5-

This unit is packaged in a rectangular metal box with a hinged flap top. The thermally sensitive components of the unit are the cellulose nitrate retaining disc at the firing pin and the M-34 detonator.

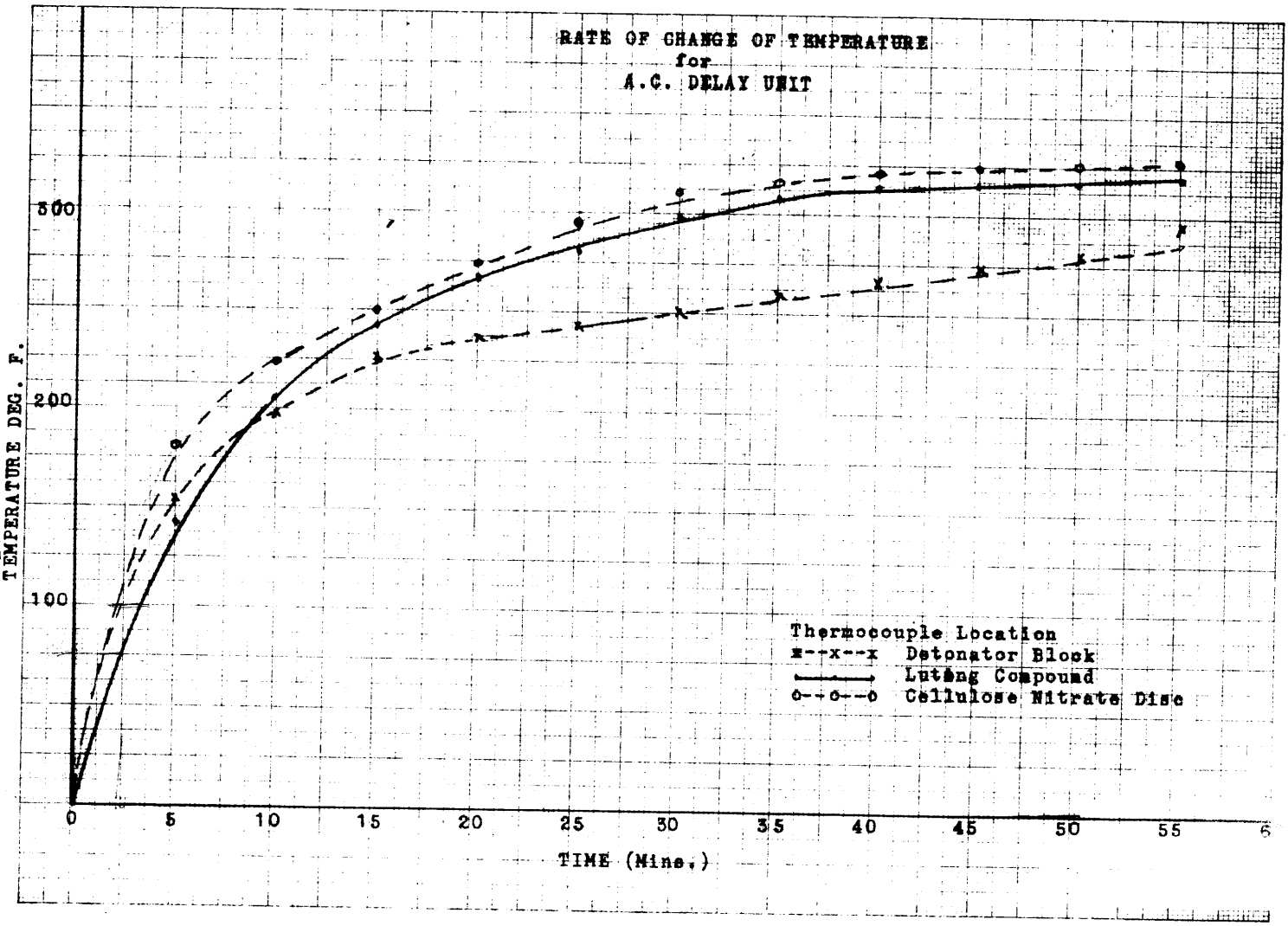
From the literature,(1) the melting range of cellulose nitrate is found to be 160 Deg. F - 170 Deg. F. Details on the composition and characteristics of the M-34 detonator will be found later in this section.

This unit was subjected to short and long term dips. The results of the long term dip and thermocouple locations are shown in Figure 3.

During the long term dip, the cellulose nitrate disc softened sufficiently to release the firing pin in the . This occurred after 11.5 minutes. All other components of this unit were unharmed from the one hour immersion.

The unit was then given a short term dip of five seconds. The maximum temperature obtained at the cellulose nitrate disc at thermal equilibrium was 115 Deg. F which is sufficiently below the lower limit of the melting range so that no damage would come to the unit.

From the experiments with this unit it can be concluded that the unit can be reclaimed if lost in the hot plastic but would be rendered useless if in the plastic for more than ten minutes.



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Head Incendiary Unit

Although the long term immersion temperature, measured at the point shown in Figure 4, reached the temperature of the plastic, no serious condition exists. The most sensitive element in the unit is the match compound used to initiate the thermit starter. The match compound is composed of various substances, out of which potassium chlorate (30% by weight) has the lowest melting point (400 Deg. F).(1), (5)

The head of the unit and cover glass were also equipped with thermocouples and the rate of change of temperature follows the same trend displayed by the match compound and is, therefore, not plotted.

No modification of the package is required and this device can be dipped without hazard and even used if lost in the plastic up to one-half an hour.

2-1/4 lb. Blocks of C-3 and C-4

These items are composed of RDX (85% - 95% by weight) and a material being composed of plasticizer and binder. At temperatures as high as 360 Deg. F,(3) these materials do not detonate. From the writer's personal experience of other RDX cook-off tests, it was found that temperatures up to 395 Deg. F could be encountered before detonation. These items were subjected to the long term immersion to verify the data contained in the literature. Neither package burned or exploded and the units were considered fit for hot dipping.

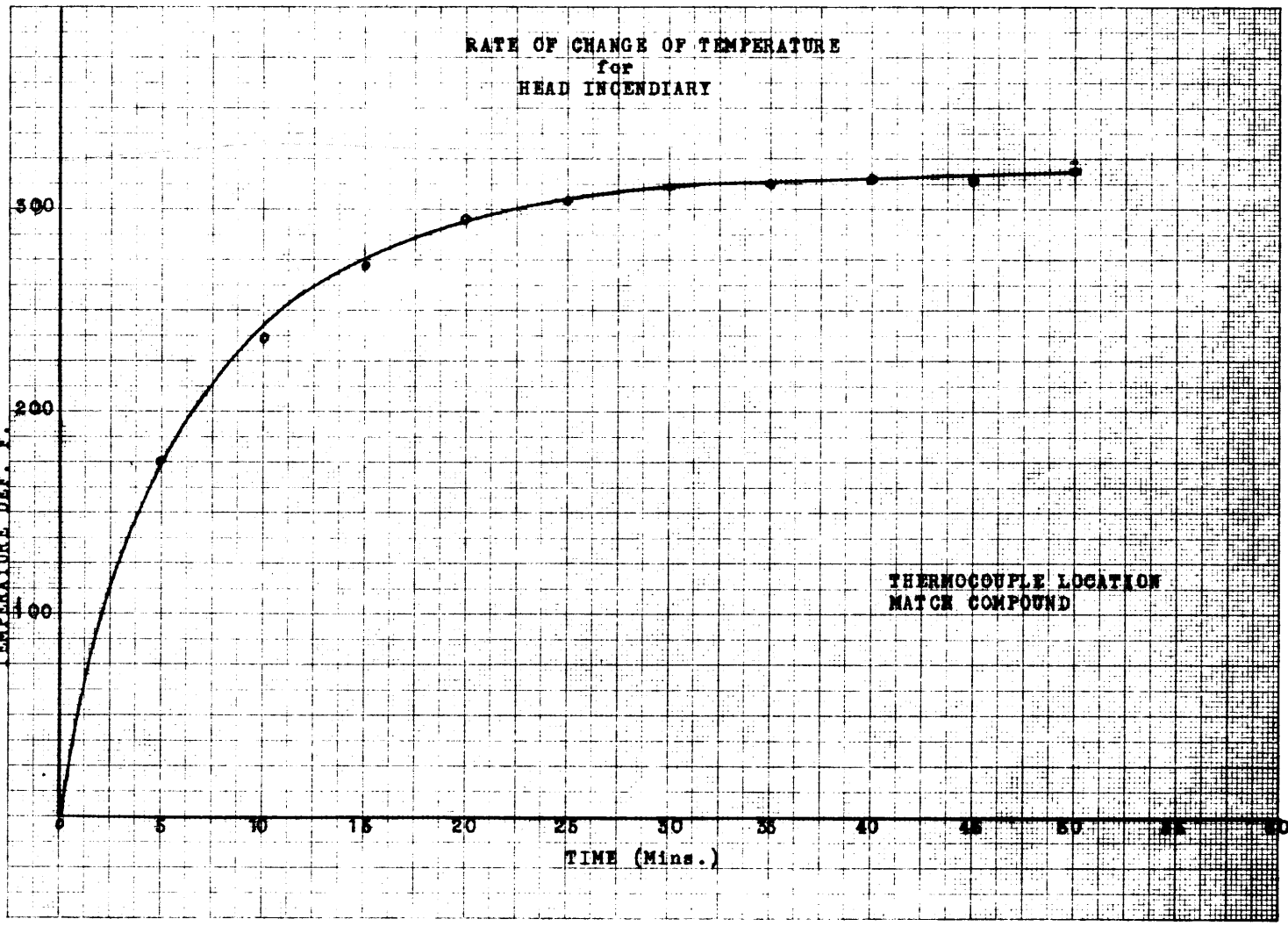


Figure 4

Mk II Pencils

Five pencils are packaged in a unit package, the medium being a two piece fitted metal container. Sensitive components of the item are the percussion cap and the plastic cap at the top of the pencil.

One unit package was immersed in the plastic for a one hour period to determine safe handling characteristics of the unit. As seen from Figure 5, the temperature attained within the package approached that of the hot plastic, however, none of the pencils fired while in the plastic bath. After this experiment, the pencils were examined for harmful thermal effects. None were observed and the pencils were then fired.

Therefore, a short term dip for this package is considered suitable without any packaging modification.

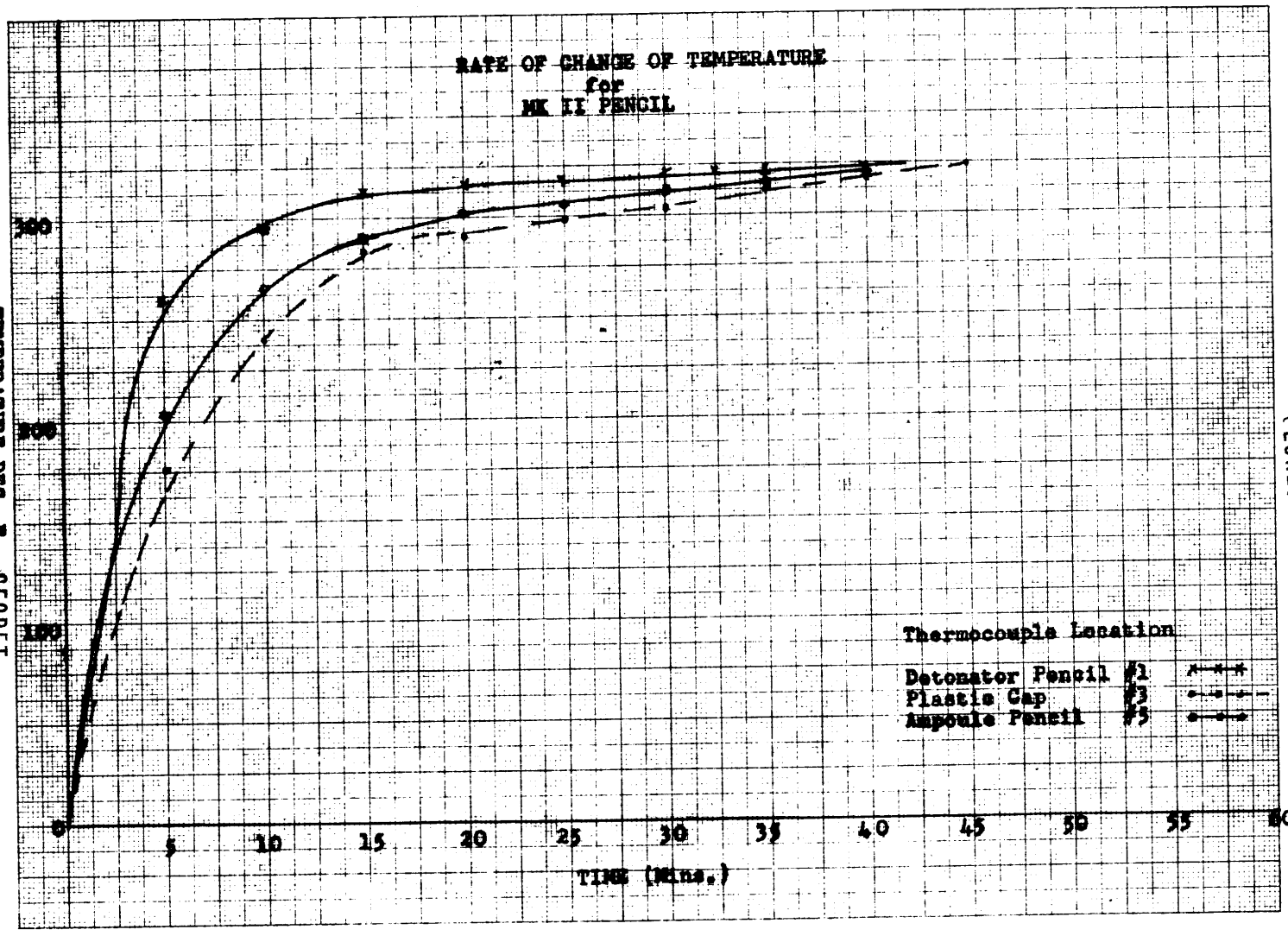


Figure 5

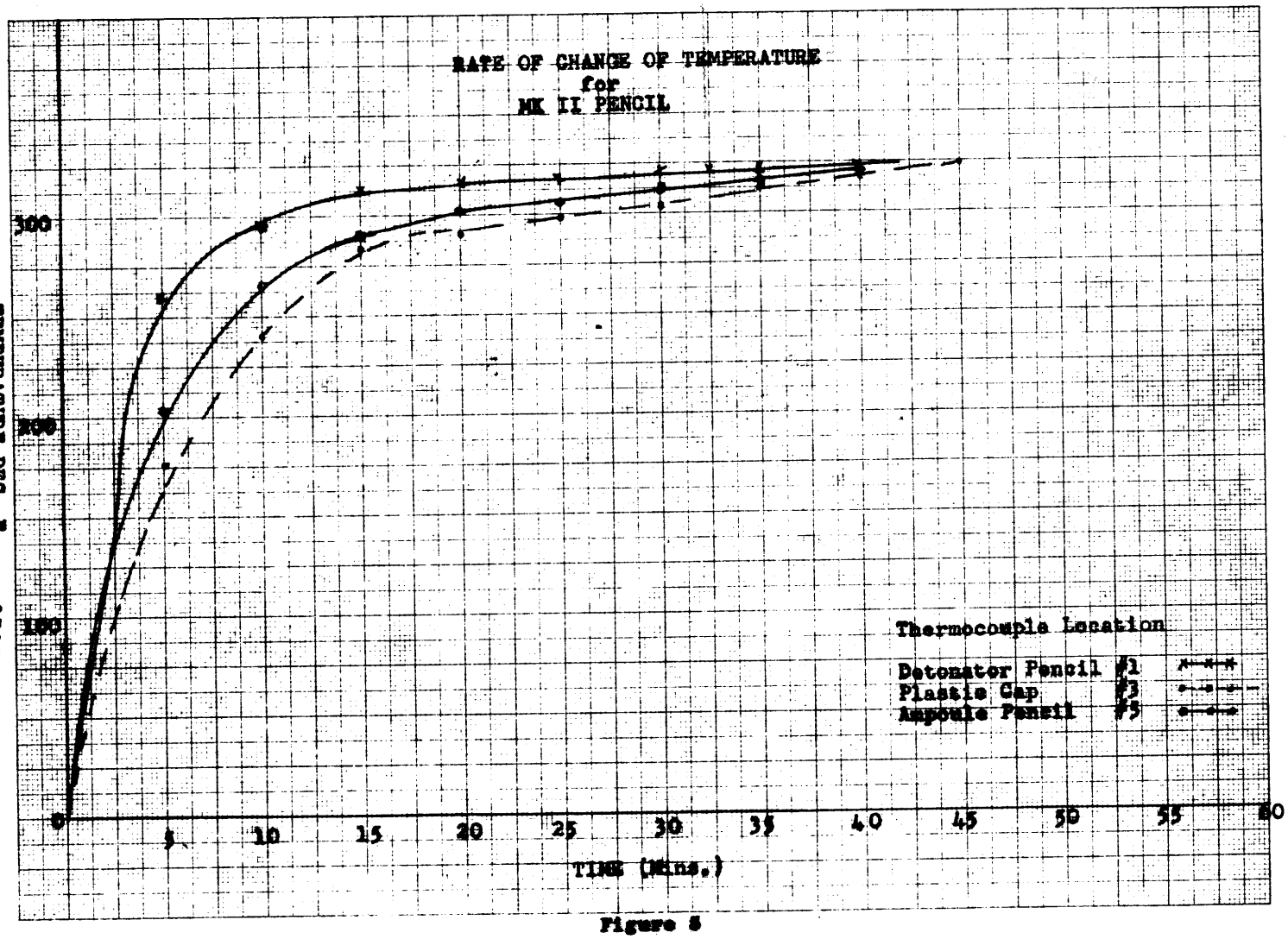


Figure 5

The Pocket Incendiary unit was equipped with thermocouples at the points noted in Figure 6. Two units are packaged in a rectangular metal can with rounded edges. A corrugated cardboard serves as an insulating barrier for this unit so that the standard container as received from stock is ready for hot dipping.

The data obtained on the pencil can be used to determine the feasibility of dipping the Mk I pencils so that a long term dip will not have to be immersed in plastic for the one hour period.

After the long term dip the container was opened and the contents examined. The only observation was the expansion of the case, but this was not of a serious nature and both units fired satisfactorily.

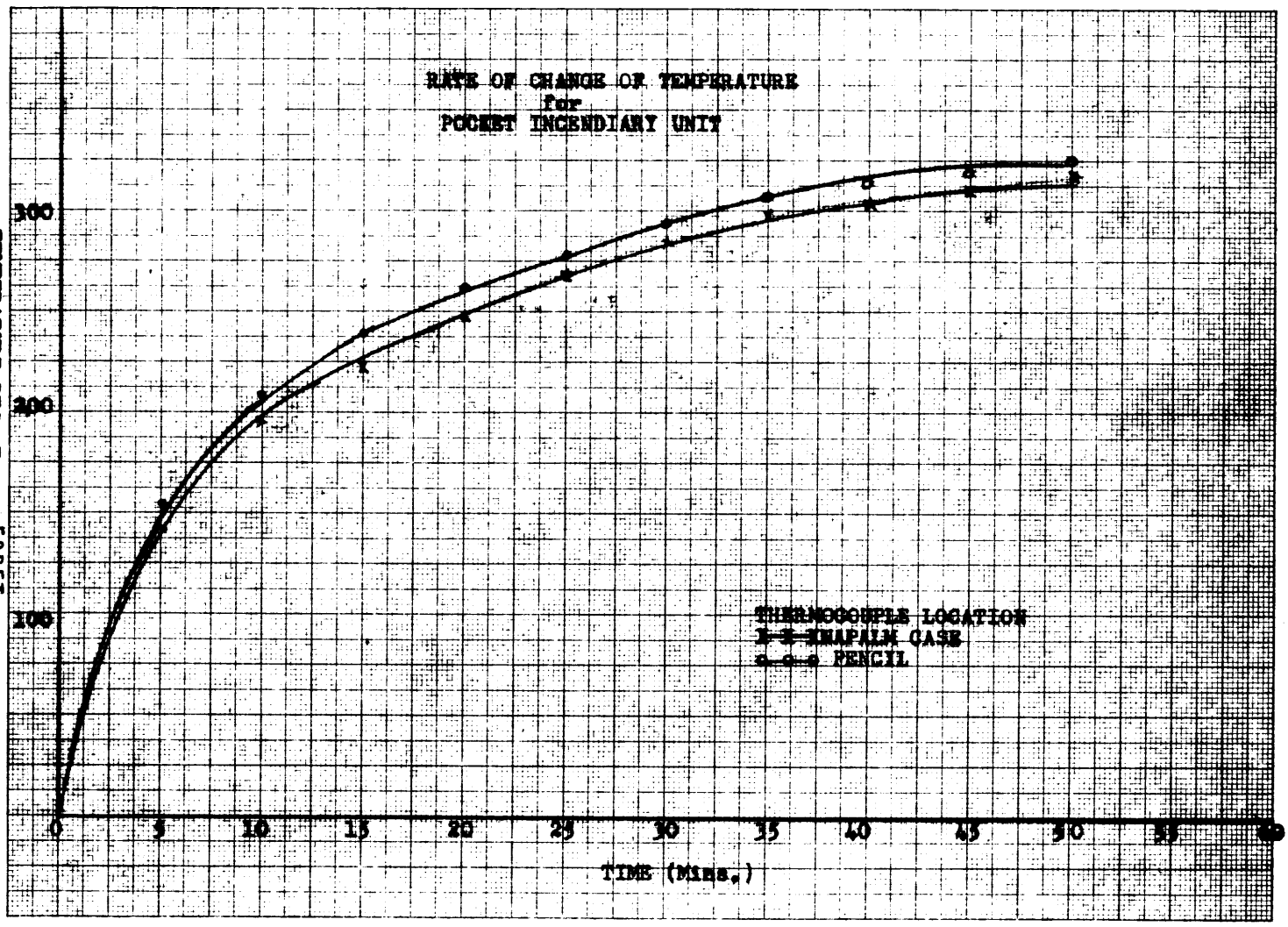


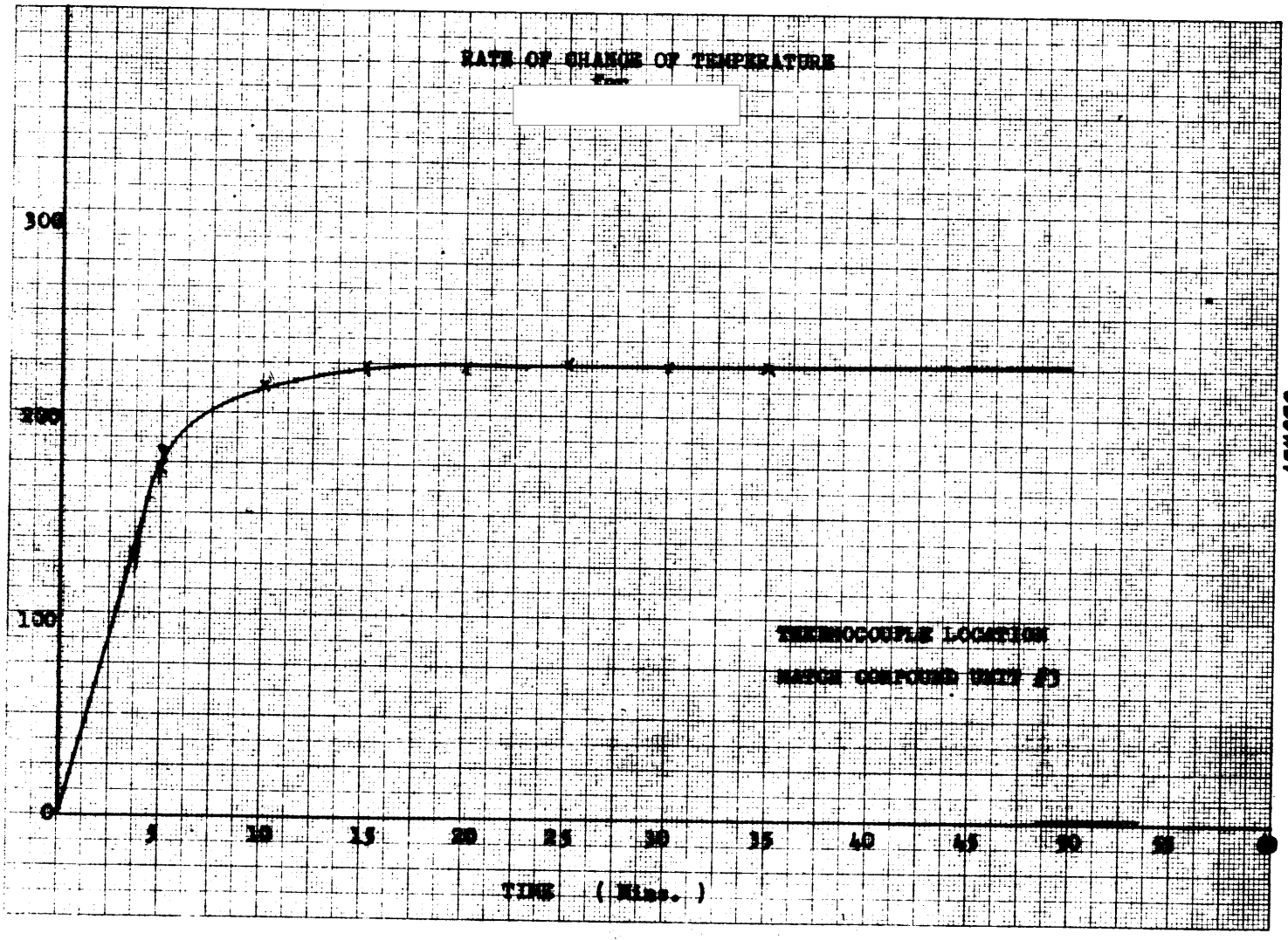
Figure 6

The rate of change of temperature of this unit, plotted in Figure 7, shows that the temperature throughout the container reached that of the plastic within the one hour immersion period.

The sensitive elements of an individual unit are three percussion caps and a length of black powder fuze. These components were dissembled from the main unit and the individual components cooked-off. The primer required a temperature in excess of 525 Deg. F and the fuze a temperature of 425 Deg. F to initiate burning.

This unit is, therefore, considered quite safe for the dipping operation even though it may be inadvertently lost in the tank for long periods.

Thermocouples were placed on the top of Units #1 and #5 and the temperature response was similar to that plotted in Figure 7.



TEMPERATURE DEG. F.

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Thermit Well

From information contained in the literature regarding composition and reaction temperatures of the various components, (1), (2), (4) and from other experiments performed in the course of this investigation no trouble was anticipated with this unit due to the extremely high ignition temperatures. The thermit well was immersed in the hot plastic for a one hour period to establish the safety of the operation and then examined. The results of the long term dip were that the wax on the cardboard container was melted and flowed toward the downward side of the unit. The sensitive items of this unit are the black powder fuze, the first fire and the thermit itself. All of these components are ignited by temperatures which are considerably above the plastic temperature and there is no problem encountered with these components.

Rocket Adapters

A 3.5" rocket adapter was immersed in hot plastic for one hour. Since this is essentially the same type of composition as the Thermit Well no difficulty was expected. This unit was immersed for safety purposes only. After immersion this unit fired satisfactorily.

One box of these units was immersed for one hour in the plastic. This item presented no problem since the Fuze Lighter is a paper tube containing friction powder which is mechanically lighted. The basic component is $KClO_3$ which has a decomposition temperature of 400 Deg. F.(1) After immersion approximately fifteen units were fired without any failures.

in a waterproof textile covering with a rough waxy finish. From the literature the ignition temperature (2), (3) which is approximately 100 Deg. F above the plastic temperature. This item offers no trouble. A 50 foot coil was given a one hour cook-off period in its final packaging configuration, and although there was no detonation, the waterproof covering and the wax finish of the outside strands were subject to decomposition.

The short term dip was quite satisfactory and this item can be dipped without difficulty.

Primacord Adapters

This device is packaged in a tear strip container with corrugated cardboard liners. From the results obtained with the 50 foot spool of primacord, this item was dipped immediately without a short or long term dip.

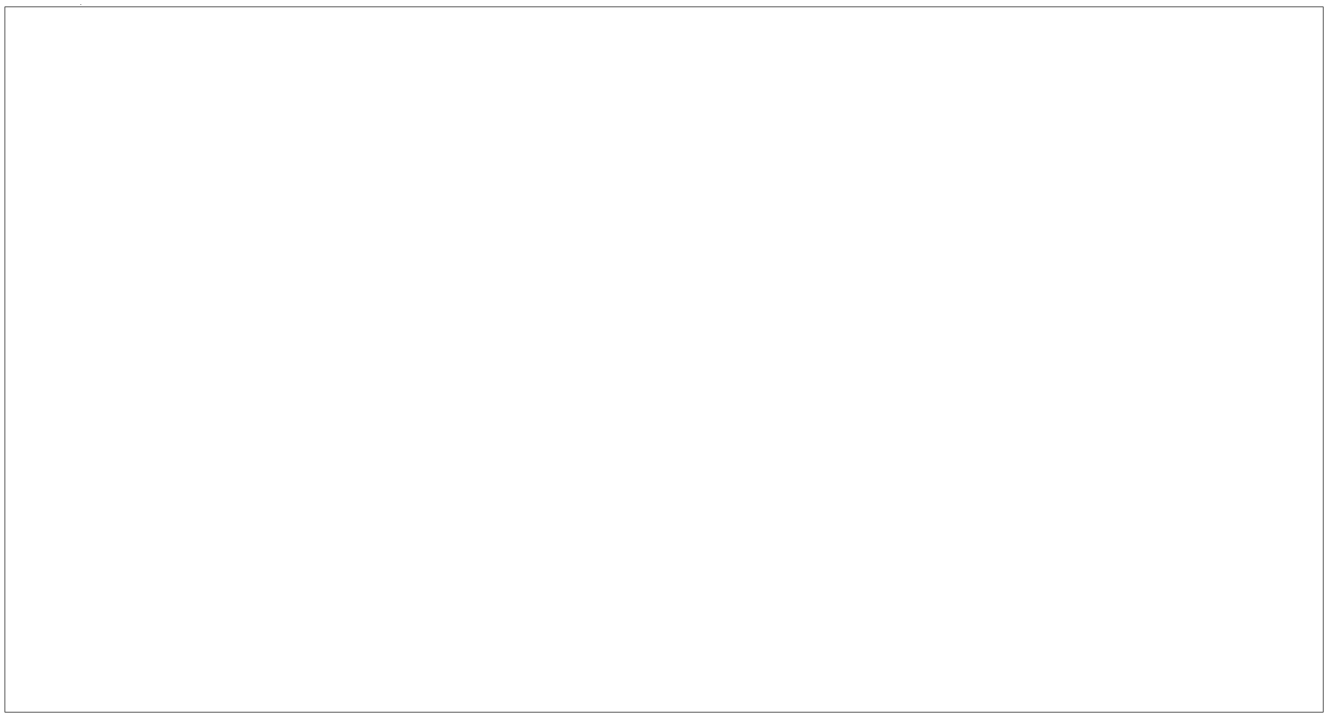
[redacted] is composed of [redacted] tightly wrapped with several layers of fabric and waterproofing materials.(2) [redacted]. These components are insulated by the waterproofing materials and all the materials but the sulfur have a melting point beyond the temperature range of the plastic. This material can be successfully dipped.

The long term dip was performed to establish the safety of the operation. The same physical changes noted with the primacord were observed in this experiment. The material was ignited and its burning rate was within satisfactory limits. This unit may remain in the plastic up to one hour without causing any hazard to personnel or property but it cannot be used after a 10 minute immersion since the protective covering melts.

Mk I Pencils

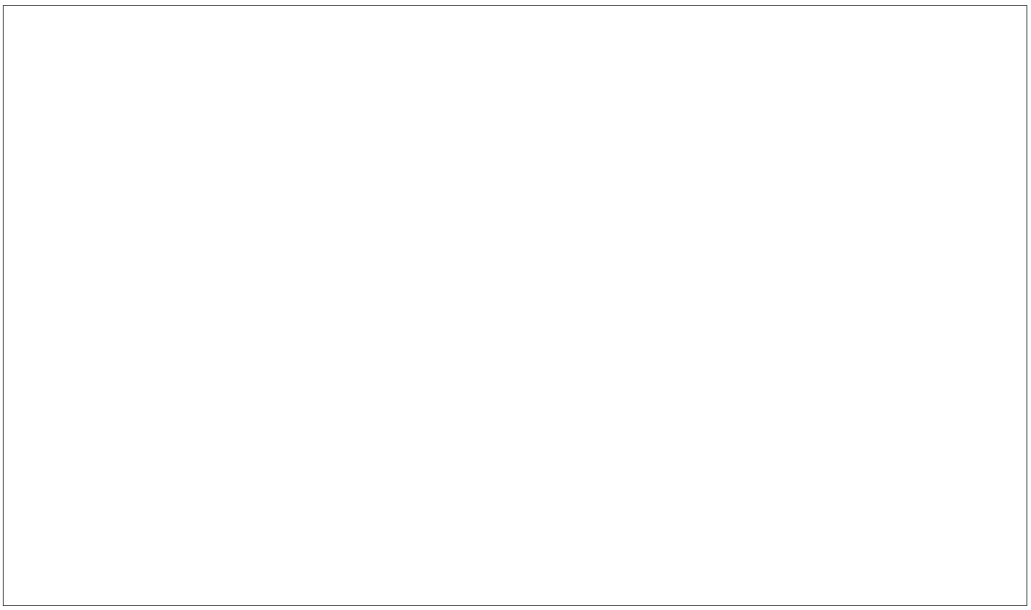
This item consists of a tube containing a percussion cap and a spring loaded striker cocked by a restraining wire. These units are packaged ten to a cardboard box. The sensitive item of this unit is the cap. The information obtained on the Pocket Incendiary could be applied to this unit with a very broad safety factor due to the different methods of packaging.

The unit package was subjected to cook-off without incident and the pencils fired yielding expected results. This unit was also considered satisfactory for coating with the plastic without change in the standard container.



Active components contained in this item are either potassium chlorate or potassium perchlorate and sulfur. The ignition point of these matches is in the range of 365 Deg. F to 380 Deg. F.(1) The active elements are approximately 50 per cent of the total weight of the match. This ignition temperature is sufficiently high not to cause any difficulties with immersing this packaged item in the hot plastic. Further, glue and other inert components of this item make it quite insensitive.

References



SECTION II

PREPARING, DIPPING AND TESTING OF SAMPLES

Units, other than those contained in tear strip cans, require preliminary preparation for several reasons. Foremost is the sealing off of crevices and folds in the containers to prevent the plastic from flowing into the unit, and secondly, the units must be sealed off as much as possible to prevent the air entrapped within the container from expanding due to the plastic temperature and forcing itself through the butyrate barrier.

The approach to this phase of the work was to establish a pre-dipping medium to overcome the obstacles mentioned above. Work was followed for several weeks towards obtaining a coating of Latex rubber over the units. However, this approach was abandoned as newer problems with the Latex were encountered. These problems included air bubbles in the cured Latex, selecting suitable coagulant, and obtaining the proper curing time. This media also did not appear feasible for production type work due to the number of operations and the time required to prepare an individual package.

Other media considered were aluminum foil and various waxes. The waxes were eliminated due to the low melting points. Aluminum foil still did not eliminate the expanding volume of air contained in the carton and did not seal off the paths through which the expanded air could be transmitted.

The use of scrim material was then considered. This material has several advantages over other media considered since a strong, completely sealed outer jacket could be formed about every package requiring this treatment.

The packaging manual, written under this task, contains details of the packaging method and materials necessary to obtain the required barrier layer and will not be dealt with in this report.

After establishing a suitable process for dipping the various items, twenty unit packages of each device were dipped in the hot plastic.

Test Schedule for Dipped Units

Testing of the hot dipped items was broken down into three phases. The experimental conditions and general results of this agenda are as follows:

1. Five unit packages were tested for proper functioning twenty-four to forty-eight hours after being dipped in the hot plastic. All units fired satisfactorily. The units investigated during this program are of such a nature that some will give quantitative results while others yield only qualitative results. Quantitative data and experimental procedures for all the units may be found in Section 4 of this report.
2. From the satisfactory results obtained under Schedule 1, five unit packages were subjected to the following conditions:
   a. Four hours at 120 Deg. F to 130 Deg. F and 90 per cent relative humidity.

b. Two hours at 70 Deg. F to 90 Deg. F and 90 per cent relative humidity.

c. Two hours at 0 Deg. F to -10 Deg. F or lower

d. Sixteen hours at 35 Deg. F to 50 Deg. F and 20 per cent relative humidity.

This cycle to be repeated three times.

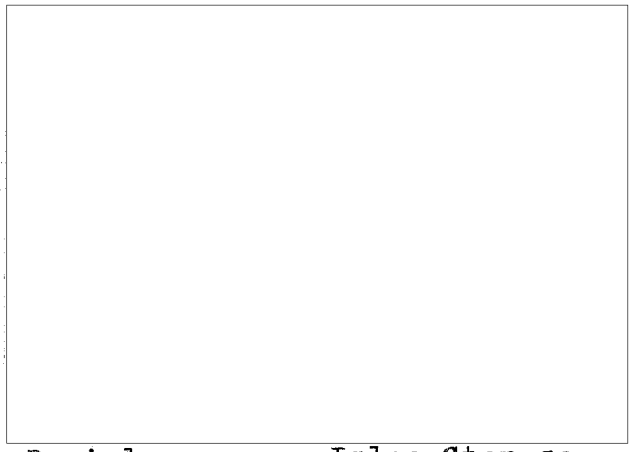
The plastic coating was still in excellent condition when removed from the above experimental conditions. These units all fired satisfactorily and the data for these units is contained in Section 4.

3. The satisfactory results obtained under Schedule 1 and 2 indicated that the extended evaluation of the barrier material could be started. This extended evaluation consisted of two phases:

a. Five unit packages to be placed in igloo storage for a period of at least six months.

b. Five unit packages to be buried in wet loam for a period of at least six months.

After the six month period, the items placed in experimental conditions under Schedule 3 were reclaimed. Figure 8 is a view of a Block of C-4 after being in igloo storage and burial.



Burial Igloo Storage

2-1/4# Blocks C-4

Figure 8

This part of the test agenda was modified to obtain a longer evaluation of the butyrate barrier. Due to this change, only two of the five test items were fired. All units which were fired, functioned properly, and the balance were returned to burial and storage.

It was planned to extend this phase of the evaluation to a nine month period but due to the favorable results, the project officer has requested this phase to be extended for an indefinite term under another contract which is being carried on at this time by . Under this program, it is the first time live packaged units have been buried and a more complete evaluation of the barrier material characteristics is desired.

SECTION III

SEALABLE ALUMINUM FOIL AS PRELIMINARY PREPARATION

An extension of the scope of work on this program was received February 28, 1956. The purpose of this extension was to investigate the use of sealable aluminum foil as a preliminary packaging medium instead of the scrim material described in Section I of this report. This material is of interest because it can be obtained at a price which is considerably less than the regular scrim material.

Units which were known to have no deleterious thermal effects were selected for this investigation since evaluation of the hot dip process had been established at this point. The units were of such a design that the range of small, large and odd shaped packages would be under consideration.

This investigation included the following items to be dipped in plastic with sealable aluminum foil preparation:

Three samples of each unit package were prepared with sealable foil and then dipped in plastic. These units were then subjected

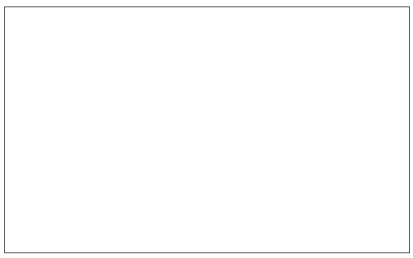
to the environmental conditions described under Schedule II for testing the various items dipped under the original scope of this contract.

The units were examined and all items functioned properly. The only device for which quantitative information could be obtained was the A. C. Delay. Red ampoules were used in this device and the recorded times are as follows:

4.6 hours
5.2 hours Temp. 65 Deg. F
6.0 hours
Mean 5.3 hours

Conclusions and Recommendations

1. From the experiments described in this report, all of the units were considered adaptable to coating with hot cellulose acetate butyrate using their standard container.
2. The units packaged in tear strip containers are suited to dipping immediately upon receipt from stock. These items are:



3. The remaining items will require some method of preliminary preparation to prevent the flow of plastic about the packaged unit and to prevent air bubbles from forming on the plastic coating and causing weak spots in the barrier material. This is considered in detail in the packaging manual.

4. All of the items are of such a nature that they will not be effected by the plastic temperature or else have adequate insulation inherent in their present packaging state and do not require any modification of their present configuration.

5. Of the various items, the following units will be damaged if exposed to the hot plastic for a period of over ten minutes and cannot be reclaimed for use:

However, if immersed for more than ten minutes, there is no danger to personnel or property.

6. The use of sealable aluminum foil instead of standard scrim is recommended for preliminary packaging due to the ease of handling, cheaper price, and its better conformance to the underpacking configuration.

7. Wherever possible, in the packing of new items in metal containers, corrugated cardboard liners should be incorporated to act as thermal insulators as well as preventing the units from moving within the container.

8. Although some units will be rendered useless after long term dips, the short dip has no effect on the items.

9. To date, the use of cellulose acetate butyrate as a barrier material has proved to be quite successful.

SECTION IV

The tables in this section are a compilation of test results obtained from units which had been coated with cellulose acetate butyrate.

Four evaluations of the various items which were dipped were made. The data in the first column entitled Test 1 was that obtained 24 to 48 hours after the items were dipped. Test 2 data was obtained after the units had passed through surveillance conditions and was not performed until the units had successfully passed Test 1.

Test 3 was igloo storage and Test 4 was burial. These two tests were performed simultaneously and were not started until all the units had passed the two previous tests. Units were placed in storage and burial on December 6, 1955. The temperature in the igloo ranged from 10 Deg. F to 65 Deg. F.

The soil at the cache site has a pH value in the range of 3-4.

TABLE 1

A. C. DELAY UNIT

Procedure: The A. C. Delay body was mounted in a wooden jig with a brass plug placed before the firing pin. The unit was then mounted opposite a micro-switch which was placed in the power line leading to an electric elapsed time meter. When the device fired the brass plug tripped the micro-switch into the "open" position and thereby stopped the meter. Figure 9 pictures the A. C. Delay units in position and the elapsed time meters.

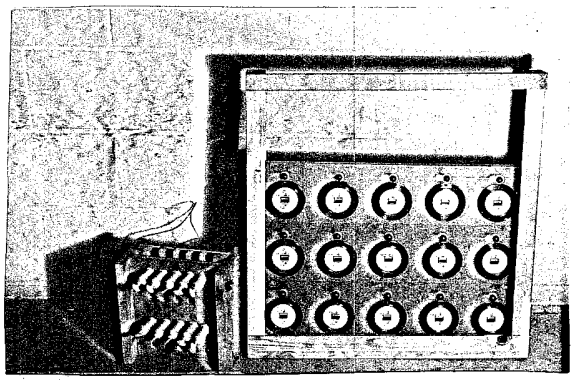


Figure 9

Test 1 Temp. 69-76°F	Test 2 Temp. 69-76°F	Test 3 Temp. 82-87°F	Test 4 Temp. 82-87°F
5.8 hours	5.3 hours	4.3 hours	4.0 hours
4.1	5.7	4.5	4.2
4.2	5.1	5.0	4.7
4.2	5.2	4.3	4.2
7.2	5.6	4.5	4.4
Mean: 5.1 hours	5.4 hours	4.5 hours	4.3 hours

Orange ampoules were also fired in units that were buried and stored for six months

	Test 3	Test 4
Temperature 75°F	24.3 hours	26.7 hours
	21.5	18.0
	18.8	24.0
	22.1	24.8
	21.5	21.3
Mean	21.64 hours	22.96 hours

The pencils were mounted in an aluminum jig with the percussion cap end (Figure 10) placed in a clearance hole drilled in an aluminum cross piece. A knife switch was mounted before the top of each pencil. The knife switches were placed in the electrical line leading to a series of clocks. When the unit fired, it was propelled from the jig hitting the knife switch and breaking the electrical connection to the proper clock. Figure 10 demonstrates the jigs and recording system.

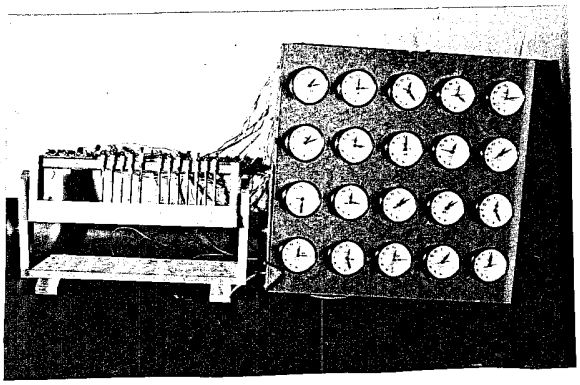


Figure 10

Mk II Delay Pencil

DATA

Test 1 Temp. 68°F.	Test 2 Temp. 68°F.	Test 3 Temp. 70°F.	Test 4 Temp. 70°F.
12 min. 48 sec.	16 min. 03 sec.	* min. * sec.	15 min. 39 sec
15 37	15 25	14 00	16 13
19 30	18 43	23 20	25 32
13 43	14 05	21 14	14 35
14 30	13 22	14 14	18 26
14 35	15 44	16 23	30 16
15 25	10 34	14 17	26 46
14 55	19 47	*	19 23

DATA
(continued)

Test 1 Temp. 68°F.	Test 2 Temp. 68°F.	Test 3 Temp. 70°F.	Test 4 Temp. 70°F.
17 min. 33 sec.	15 min. 53 sec.	18 min. 43 sec.	22 min. 17 sec.
12 23	13 32	18 57	17 43
19 20	23 05		
17 28	15 09		
17 45	7 58		
15 10	16 50		
13 35	13 45		
14 49	15 48		
17 14	15 55		
10 54	14 42		
11 39	14 47		
13 17	17 29		
13 39	15 23		
17 46	16 17		
17 20	14 30		
19 35	14 40		
	17 26		
Mean			
14 min. 35.8 sec.	15 min. 36 sec.	17 min. 39 sec.	20 min. 31 sec.

*Prefired in container.

TABLE III

Mk I Pencil Red Identification Strip

These units were activated and delay times were measured by means of a stop watch.

	Test 1 Temp. 36°F.		Test 2 Temp. 24°F.		Test 3 Temp. 93°F.		Test 4 Temp. 81°F.	
1.	49 min.	23 sec.	42 min.	18 sec.	17 min.	10 sec.	18 min.	55 sec.
2.	50	17	39	36	13	25	22	19
3.	52	36	42	21	18	49	23	01
4.	35	04	42	25	19	50	24	50
5.	56	41	43	35	22	34	19	45
6.	58	18	35	21	27	11	19	05
7.	58	23	57	41	24	46	20	00
8.	63	09	48	07	26	58	20	20
9.	64	51	53	29	24	37	20	23
10.	40	22	60	42	15	18	18	15
11.	40	03	72	03	27	42	21	37
12.	41	30	58	37	24	55	21	20
13.	43	27	42	47	31	20	15	30
14.	44	18	73	04	16	31	21	30
15.	45	22	* No Ampoule		21	26	19	17
16.	46	04	45	33	24	07	23	22
17.	46	19	35	29	16	24	25	30
18.	46	20	35	43	14	50	20	55
19.	46	38	60	49	17	44	25	19
20.	46	39	67	25	21	45	24	30
21.	47	19	72	18				
22.	49	07	55	40				

TABLE III
(continued)

	Test 1 Temp. 36°F.	Test 2 Temp. 24°F.	Test 3 Temp. 93°F.	Test 4 Temp. 81°F.
23.	50 min. 23 sec.	40 min. 28 sec.		
24.	52 17	49 04		
25.	52 39	55 23		
26.	No Ampoule	65 37		
27.	53 21	73 56		
28.	53 49	41 29		
29.	54 30	51 56		
30.	54 48	42 18		
31.	55 29	38 15		
32.	46 04	46 24		
33.	48 21	48 53		
34.	55 28	55 12		
35.	57 03	39 14		
36.	57 40	43 18		
37.	60 09	44 31		
38.	56 13	46 33		
39.	57 11	53 47		
40.	57 29	60 12		
41.	60 58	67 18		
42.	62 19	42 56		
43.	63 41	73 14		
44.	66 39	72 27		
45.	70 25	51 25		
46.	72 08	55 18		
47.	72 15	40 52		

TABLE III
(continued)

	Test 1 Temp. 36°F.	Test 2 Temp. 24°F.	Test 3 Temp. 93°F.	Test 4 Temp. 81°F.
48.	72 min. 19 sec.	49 min. 04 sec.		
49.	72 36	41 24		
50.	73 41	65 34		
Mean	54 min. 25 sec.	51 min. 29 sec.	21 min. 06 sec.	20 min. 42.5 sec.

TABLE IV

POCKET INCENDIARY

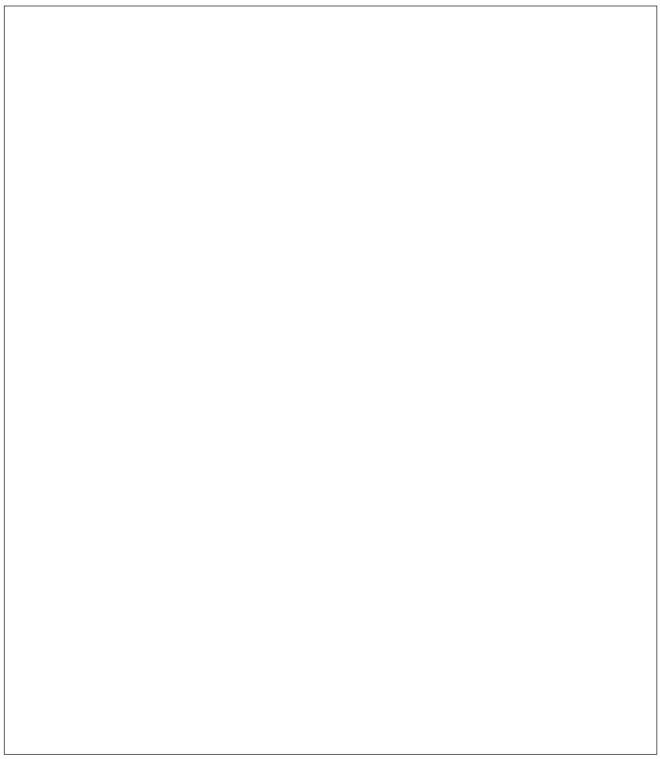
Both pencils at the side of the unit were crushed and delay times were measured by means of a stop watch. Red colored pencils were used.

	Test 1 Temp. 38°F.	Test 2 Temp. 43°F.	Test 3 Temp. 92°F.	Test 4 Temp. 92°F.
	35 min. 23 sec.	37 min. 41 sec.	18 min. 30 sec.	13 min. 50 sec.
	36 03	41 08	19 00	17 04
	36 30	41 39	11 00	16 51
	27 18	50 23	16 45	17 56
	30 08	23 52		
	40 19	30 19		
	37 15	32 14		
	30 45	34 27		
	31 10	37 08		
	32 58	39 43		
Mean	36 min. 30 sec.	33 min. 25 sec.	16 min. 19 sec.	15 min. 51 sec.

Five, three foot samples from each fifty foot roll were tested. All samples burned in exactly two minutes.

which had been dipped were used for initiation of the .

Performance of the following units could be observed in only a qualitative manner:



The experimental method of firing and results of these units will be given in the following pages.

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A six inch length of [redacted] was taped to the end of a Corps of Engineers Special Non-Electric Cap. A ten pound weight was allowed to fall on the dome of the [redacted] and satisfactory functioning was denoted by the initiation of detonating train.

All [redacted] functioned properly in all tests.

Figure 13 demonstrates the method of firing the [redacted].

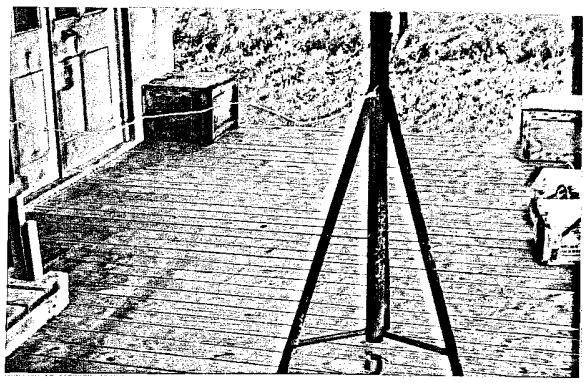

Figure 13

[redacted] and a Corps of Engineers [redacted] was taped to the primacord. These [redacted] fired satisfactorily.

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[redacted]

Samples from the [redacted] boxes were taken and fired by strapping a [redacted] to the top of the [redacted]. All samples fired properly.