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Progress Report No. 91-1



UNITED STATES ARMY

AD No. 439662

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# FRANKFORD ARSENAL

PROPELLANT ACTUATED DEVICES

PROGRESS REPORT

ON

U. S. AIR FORCE PROJECTS

NOVEMBER-DECEMBER 1963

Report No. 91-1



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FRANKFORD ARSENAL

PROPELLANT ACTUATED DEVICES

PROGRESS REPORT

FOR

NOVEMBER-DECEMBER 1963

38 350

Army Frankford Arsenal, Philadelphia, Pa.

PROPELLANT ACTUATED DEVICES.

Progress rept. Nov-Dec 63.

PROPELLANT ACTUATED DEVICES DIVISION

RESEARCH AND DEVELOPMENT GROUP

## FOREWORD

This report is one of a continuing series describing the progress of certain development programs relating to propellant actuated devices (PAD) being conducted by Frankford Arsenal. The work covered includes the design and development of specific devices, such as thrusters, catapults, and initiators; investigations of related subjects, such as propellants and structural materials; and feasibility studies, aimed at improving the performance of propellant actuated devices and extending their application.

The programs reported are being conducted by the Research and Development Group at Frankford Arsenal for the following agencies.

### Aeronautical Systems Division:

Deputy for Technology  
Flight Dynamics Laboratory  
Dynamics Branch

Deputy For Systems Engineering  
Directorate of Operational Support Engineering  
Crew Equipment Division  
Escape Section

Deputy For Systems Engineering  
Directorate of Operational Support Engineering  
Crew Equipment Division  
Parachute Branch

TABLE OF CONTENTS .

<u>Job No.</u>	<u>Title</u>	<u>Page</u>
<del>DEPUTY FOR TECHNOLOGY</del>		
C171	<del>Investigation of</del> High Temperature Propellants for Crew Escape System Rockets . . . . .	2
C251	Feasibility <del>Study</del> of a Hybrid Rocket for Crew Escape Capsule Application; . . . . .	4
C301	<del>Investigation of</del> Propellant Actuated Devices in Space Environment ( <del>Phase</del> ) . . . . .	11
C306	<del>Investigation of a</del> Close Tolerance Delay; . . . . .	13
<del>ESCAPE AND SURVIVAL BRANCH</del>		
C164	<del>Evaluation and Qualification of</del> Ancillary Components for Escape Systems; . . . . .	16
C206	<del>Improvement of</del> Mild Detonating Fuse (MDF); . . . . .	20
C222	<del>Improvement of</del> Components for Electrically Initiated Escape Systems . . . . .	27
C237	<del>Standardization of</del> Co-Axial Catapult; . . . . .	29
C238	<del>Improvement of</del> Time Delay Mechanism . . . . .	40
C272	Dyna-Soar Technical Assistance; . . . . .	41
C277	<del>Development and Standardization of</del> XM18 Gas Generator; . . . . .	42
C279	<del>Determination and Evaluation of the</del> Performance Characteristics of Dynamic Seals, Sealing Materials, and Sealing Techniques for PAD; . . . . .	45
C280	Improved Propellants and Primers for PAD Application . . . . .	47

TABLE OF CONTENTS (Cont'd)

<u>Job No.</u>	<u>Title</u>	<u>Page</u>
<b>ESCAPE AND SURVIVAL BRANCH (Cont'd)</b>		
C281	Investigation of Recently Developed Materials and Manufacturing Techniques for Application to PAD . . . . .	51
C284	Improvement of PAD to Eliminate Toxic Propellant Gases . . . . .	54
C287	Medium Performance Miniature Initiator' . . . . .	58
C288	<del>Improvement of PAD to Eliminate or Minimize Toxic Propellant Gases . . . . .</del>	65
C290	Development of Ballistic Reel' . . . . .	68
C291	Gun Launched Rocket ' . . . . .	69
C292	Rocket Altitude Sensing and Thrust Direction Control ' . . . . .	71
C293	Development of Twenty-Man Life Raft Ejector' . . . . .	73
<del><b>PARACHUTE BRANCH</b></del>		
C230	<del>Development of a Heavy-duty Pyrotechnic Delay Reefing Line Cutter' . . . . .</del>	76
<del><b>KIRTLAND AIR FORCE BASE</b></del>		
C294	<del>Development of a Bomb Ejector Cartridge for MAU-12/A Bomb Rack, . . . . .</del>	79
	DISTRIBUTION . . . . .	82

DEPUTY FOR TECHNOLOGY  
FLIGHT DYNAMICS LABORATORY  
DYNAMICS BRANCH

**TITLE:** Investigation of High Temperature Propellants for Crew  
Escape System Rockets

**JOB NO.:** C171

**PROJECT ENGINEER:** H. D. MacDonald, Jr., 1410

**AUTHORIZATION:** MIPR 33-(657)-3-R&D-116, MIPR AS-4-63

**INITIATION DATE:** October 1962

**ESTIMATED COMPLETION DATE:** Continuous

**OBJECTIVE:** To investigate and evaluate propellants for use in escape rockets capable of operating over the temperature range of -100° F to 400° F.

**PREVIOUS BI-MONTHLY SUMMARY:**

The test motor was designed as a tie rod assembled unit instead of a threaded unit. Procurement of the motor was initiated.

AK14 Mod 1 propellant was ordered from the Naval Propellant Plant (NPP), Indianhead, Maryland.

Modification of the T20 test stand was initiated.

**PROGRESS:**

All test motor procurements were placed with contractors. Although some parts have been received, the longest lead times are associated with the head cap, motor tube, nozzle, tail cap, and nozzle insert; these are scheduled for delivery the week of 16 February 1964.

The delivery of the AK14 Mod 1 grains was extended and rescheduled as follows: 30 ea. during the week of 6 January 1964 and the balance on demand. This rescheduling was made to bring the grain delivery into phase with the delivery of the metal parts.

The conditioning box for the pressure tester was received on 27 November 1963.

Modification of the test stand was completed in December 1963. The cold chamber for this test stand is under construction.

**NEXT BI-MONTHLY PLAN:**

Continue procurement of rocket motor components and test equipment.

Start set up of test stand in firing site.

Install conditioning box with Instron tester and shake down.

TITLE: Feasibility Study of a Hybrid Rocket for Crew Escape Capsule Application.

JOB NO.: C251

PROJECT ENGINEER: J. F. Clark, 1450

AUTHORIZATION: MIPR-33-(657)-3-R&E-116

INITIATION DATE: February 1961

ESTIMATED COMPLETION DATE: January 1964

OBJECTIVE: To investigate and determine the technical feasibility of a "controllable thrust hybrid rocket" for crew emergency escape systems for advanced aerospace vehicles.

PREVIOUS BI-MONTHLY SUMMARY:

Three oxidizers, nitrogen tetroxide, red fuming nitric acid, and chlorine trifluoride were subjected to high temperature storage testing up to 500° F.

Vented vessel testing to confirm the hypergolicity of the propellant systems being considered for the sub-scale motor program was completed. Design, fabrication and procurement for the sub-scale motor was in progress.

A mixing procedure was developed for five-pound lithium hydride fuel mixes having a 25% binder level. Fuel samples from this mix were pressure molded without difficulty.

PROGRESS:

Films of the vented vessel tests listed in Table I of the previous report were reviewed. The purpose of the tests was to determine the reactivity of the fuel systems being considered for test in the sub-scale motor program. The films showed that chlorine trifluoride ( $\text{ClF}_3$ ) reacted vigorously with both the castable and moldable lithium hydride (LiH) fuels (tests 36 and 37) with less than 30 milliseconds ignition delay. (The film speed was 32 frames per second and delays were less than one frame.)

The test of  $\text{ClF}_3$  with the aluminum/biurea fuel and atmospheric pressure in the chamber (test no. 35) showed a glowing reaction. The delay time could not be ascertained. However, with 75 psi chamber pressure and 150 psi oxidizer pressure (test no. 34) flame was evident after a delay of two frames or about 1/16 second.

The test of red fuming nitric acid (RFNA) and paramino phenol/magnesium/aluminum (PAP/Mg/al) fuel (test no. 32) showed a delay of six frames or about 3/16 seconds. For this test, 75 psi chamber pressure and 150 psi oxidizer pressure were used.

The test of  $\text{ClF}_3$  with polybutadiene styrene (PBDS) binder alone (test no. 38) started without delay, but six frames elapsed before a vigorous flame was noted.

Several formulations were mixed and processed into fuel grains for the sub-scale motor tests. Two grains were pressure molded from the 75% LiH mix (X-611-39) previously formulated. The length to diameter ratio of the fuel charge precluded a single pressing of the powdered mix. Rings of 1/2 inch length were pressure molded and stacked in the inhibitor tube for final pressing. Figure 1 shows a sample of the mix, a pressed ring, and a sectioned fuel charge.

To prevent reaction of the hydride with atmospheric moisture, processing of the LiH charge was done in a nitrogen atmosphere. This was accomplished by enclosing the press in a polyethylene shroud and maintaining a slight positive nitrogen pressure during the pressing operation. A pressure of 24,000 psi was used to compact the rings, and the same pressure was used to stack the rings into a single charge. The resultant fuel charges were tough and somewhat flexible.

Formulations of the 95% aluminum/biurea fuel identical to mix X-611-29 previously reported were also processed. Three fuel charges were pressure molded from this material. The rings were pressed at 24,000 psi and were hard and tough. A thin coat of the PBDS binder was applied to the rings to bond them together. They were then stacked in the inhibitor tube, pressed at 44,000 psi, and the resulting charge was cured at 200° F for 16 hours.

A PAP/Mg/Al fuel with 5% PBDS binder (designation X-605-38) was also formulated and pressed into charges in the same manner as described in the preceding paragraph. Some difficulty was

encountered with pressure molding of this mix. The rings were rather fragile and tended to split when ejected from the mold. Acceptable rings were obtained by first disassembling the split mold, and then removing the center core. The rings were stacked and pressed at 44,000 psi to form the charge which was then cured at 180° F for 16 hours. The finished fuel charge was brittle but appeared to be satisfactory for static testing.

An attempt was made to cast fuel charges containing 60 percent LiH with PBDS binder (X-611-1). The mix proved too viscous to pour properly and would not flow into the annulus of the mold. An attempt was also made with a 55% LiH mix (X-611-14) which was kept at a temperature of 115° F during the mixing cycle. This mix also was not castable, and fuel grains could only be produced by hand filling the molds and tamping. The resulting grains were not properly consolidated, but they were deemed suitable for testing in the sub-scale motor.

Design of a sub-scale motor based on an oxidizer volume of 50 ml. and a burning time of one second was completed. For  $\text{ClF}_3$  this results in an oxidizer weight rate of flow of approximately 0.2 lb/second. An eight orifice pattern was arbitrarily selected for the injector. The streams from the four outer orifices impinge on the fuel grain near the head end. The inner orifices impinge on the fuel just aft of the center of the grain. Using the same size orifices for RFNA, the computed flow is 0.19 lb/second.

The fuel charge weight was fixed to provide an excess of fuel at the lowest oxidizer to fuel ratio anticipated. The fuel charge configuration is a right cylinder 1.0 inches inside diameter, 1.5 inches outside diameter, and 5 inches long. It is contained in a steel tube which also serves to inhibit the outside surface. The motor envelope was dictated by the fuel charge design. The motor assembly is shown in Figure 2. The gaskets are aluminum, the shear disc is 1020 steel, and all other parts are stainless steel. The stainless steel nozzle is for use with RFNA; a carbon nozzle is used when  $\text{ClF}_3$  is the oxidizer. The forward closure of the motor is tapped for a pressure connection, an oxidizer feed line, and an oxidizer flow sensing device. The oxidizer is fed under nitrogen pressure from a stainless steel tank through a remotely operated valve to the combustion chamber. The major components (oxidizer tank, remote operated solenoid valve, and the motor assembly) were fastened to a steel wall panel in the firing bay.

Prior to the start of testing, 90 grams of  $\text{ClF}_3$  were purposely spilled in the test bay. A vapor cloud formed above the bay and gradually dissipated. Three minutes after the spill the bay was entered and the concentration measured was less than three parts per million. After eight minutes the indication was less than 0.5 parts per million. Based on the test, safety procedures were established to keep unprotected personnel a minimum of 100 feet from those operations where up to 90 grams of  $\text{ClF}_3$  were being handled. It was also determined that such operations would only be performed when the atmospheric conditions were conducive to rapid dissipation of the resulting vapors.

Four firings were attempted utilizing  $\text{ClF}_3$  as the oxidizer. They were conducted after working hours to minimize the hazard to personnel working in the immediate vicinity of the test area. The fuel used for the four firings was a pressed grain of 75% LiH. The first firing test (Round no. A-2668) was successful in that hypergolic ignition was achieved with only a 0.018 second ignition delay. The motor components were in good condition after the test except for some erosion of the aluminum oxidizer spray plate gasket. The fuel charge burned in an even tapered pattern except where the oxidizer jets impinged on the forward portion of the grain. At these points a slight amount of erosive burning was indicated.

The second test (round no. A-2735) resulted in overpressurization of the motor which caused ejection of the nozzle and fuel charge. Post firing examination showed that the Teflon gasket for the spray plate nozzle (substituted for the aluminum gasket to obtain a better seal) was partially melted, the oxidizer spray plate was consumed, and the oxidizer passage in the forward closure was destroyed. Failure of the Teflon gasket was believed due to the high velocity  $\text{ClF}_3$  flow which apparently ignited the Teflon, caused a loss of sealing, and allowed the oxidizer to flood the motor chamber. The excessively high rate of oxidizer flow resulted in a higher rate of gas production which overpressurized the chamber.

The third and fourth firings (round nos. A2755 and 2756) were conducted with the same fuel grain and two separate oxidizer charges. For round no. 2755, the motor set-up was identical to that which was used for the first firing (round no. A2668). The firing was successful and the expended oxidizer tank was replaced with one containing another charge. The next firing (round no. 2756) was accomplished 35 minutes after round no. 2755. It, too, was successful although a delay of 0.423

seconds occurred before pressure rise during which time the chamber pressure was about 15 psig. The chamber pressure traces were also more erratic than for round no. 2755. The two firings served to demonstrate that the 75% LiH, 25% PBDS fuel and chlorine trifluoride has restart capability.

Post firing examination after round no. 2756 revealed that the aluminum oxidizer spray plate and gasket were consumed during firing, and that the forward closure and spray plate holder were partially eroded. The internal components of the pressure transducer in the oxidizer line were also completely consumed by the oxidizer. It is theorized that the Teflon grease packed in the gage cavity and outlet branch of the connecting tee fitting burned when in contact with  $\text{ClF}_3$  under conditions of pressure and velocity. Removal of this gage from the oxidizer line and its installation in the nitrogen pressurizing system is planned for future firings to correct this condition.

Action on supplementing the present contract to provide for the Phase III program is pending review by Air Force - Frankford Arsenal Phase II activity.

**NEXT BI-MONTHLY PLAN:**

- a. Revise test set-up to eliminate gage failure in oxidizer line.
- b. Continue testing of fuel-oxidizer systems in the sub-scale motor.
- c. Continue contract action for Phase III program.

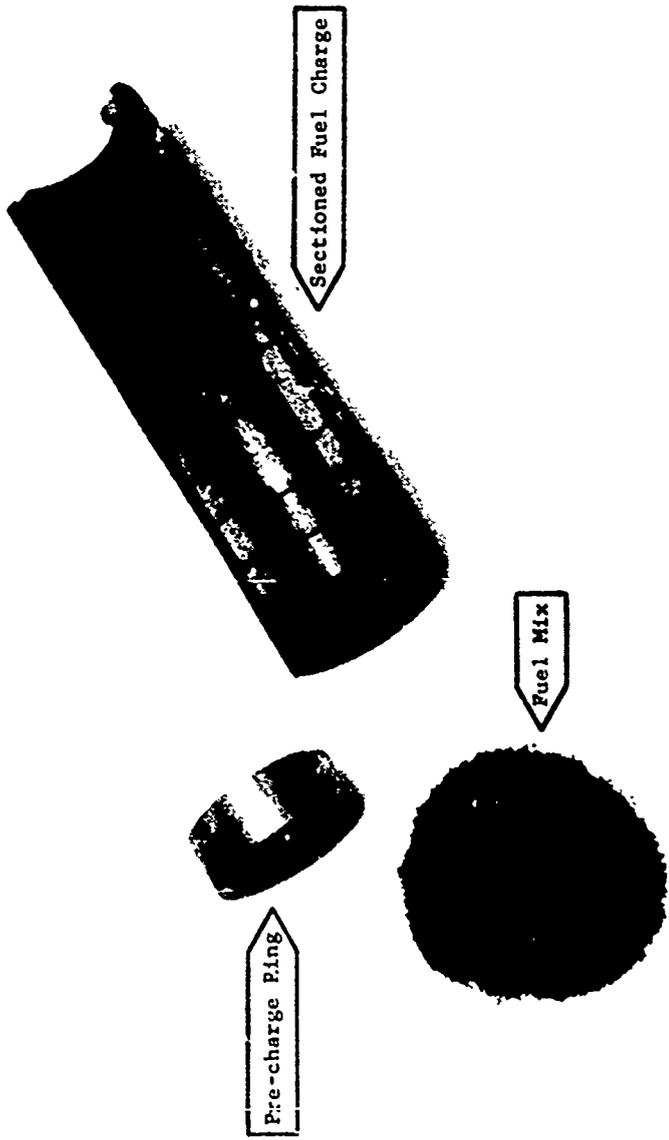


Figure 1. Hybrid Pressed Fuel Charge

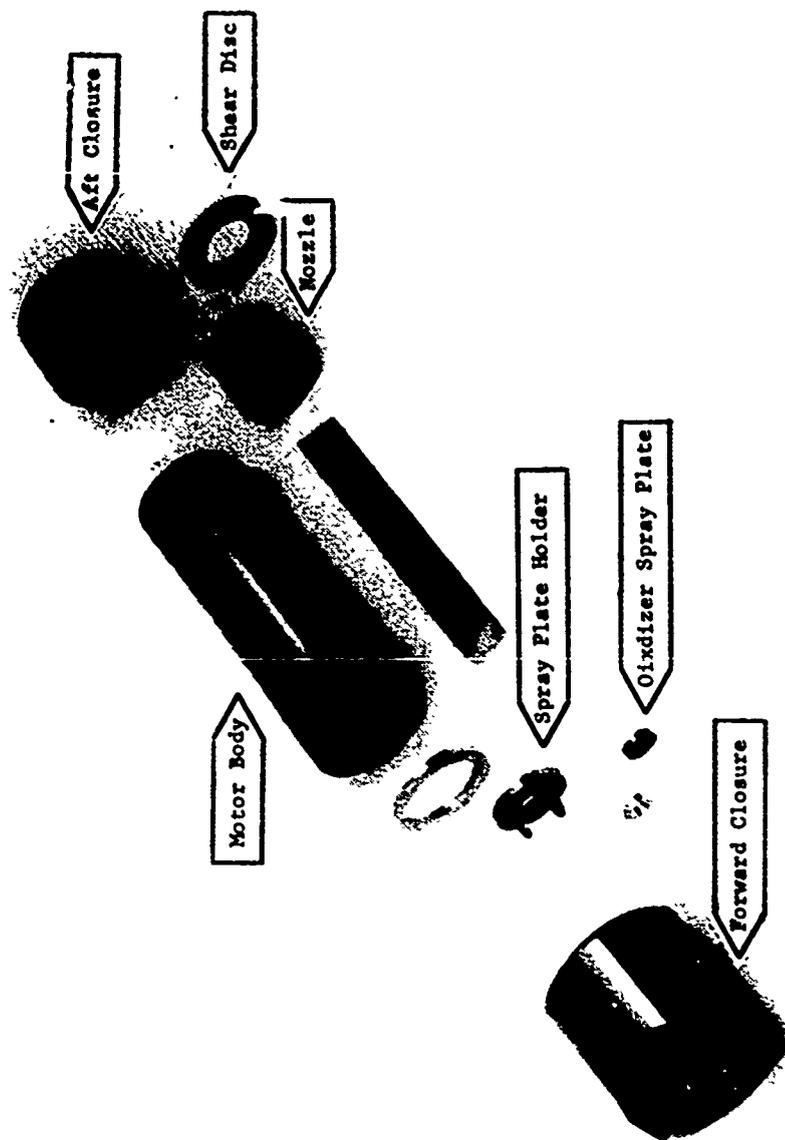


Figure 2. Hybrid Sub-scale Motor

**TITLE:** Investigation of PAD in Space Environment, (Vacuum Phase)

**JOB NO.:** C301

**PROJECT ENGINEER:** G. Miller, 1450

**AUTHORIZATION:** MIPR AS-4-109

**INITIATION DATE:** May 1962

**ESTIMATED COMPLETION DATE:** December 1964

**OBJECTIVE:** The objective of this program is to investigate and determine the limits of operation of PAD exposed to environmental conditions which may be expected in a space mission.

**PREVIOUS BI-MONTHLY SUMMARY:**

Serviceing of the vacuum equipment was near completion.

**PROGRESS:**

The proposed vacuum-firing chamber was designed and sketches completed for contractors proposal. Specifications for the construction are being prepared and requests for bids are being initiated. Figure 1 (Dwg No. 610-8) shows a schematic assembly of the proposed firing chamber.

During check-out of the entire system following completion of repairs, two new gauges burned out within a twenty hour service period. As a result, the existing wiring system is being checked for possible malfunction and various tube specifications will be further investigated to determine if longer-life parts are available.

**NEXT BI-MONTHLY PLAN:**

Contract for fabricating firing chamber should be ready for award.

DATE: 9-11-53  
 DRAWN BY: [Signature]  
 CHECKED BY: [Signature]  
 APPROVED BY: [Signature]  
 PROJECT: VACUUM MACHINING - BIPOLAR  
 DRAWING NO. G-201  
 DEPARTMENT: PEANUTBARR-ARTS/ENGR.

**GENERAL NOTE:**  
 Pressure Vacuum Chamber to be removable from main system - with minimum effort.

**Flanged Joints:** Existing Jointing system to be duplicated to use existing type of Gaskets

**Port Openings:** are to match MRC, Cora, Orangeburg, N.Y. Units and following units are to be furnished.

- 4- Blank Off flanges V-4-100
- 1- sized Valve Assembly V-4-100
- 1- 20' Cone Manipulator V-4-100
- 1- Rotary seal V-4-100
- 1- Push Pull seal V-4-100
- 2- Electrical Feed Thru V-4-100-2
- 1- Liquid Nitrogen Feed V-4-170
- Ion Gauge: 2- Ion gauge spaces are to be furnished and all wiring plus 3-way switch to be installed.

**Construction Note:** Pressure chamber and parts to be constructed of stainless steel wherever possible. Pressure Chamber System to be added and to be removed with minimum effort. Switch to be provided to isolate all shut off valves from central source.

**ULTRA HIGH  
 4" VACUUM SYSTEM  
 DRWG NO 610-8**

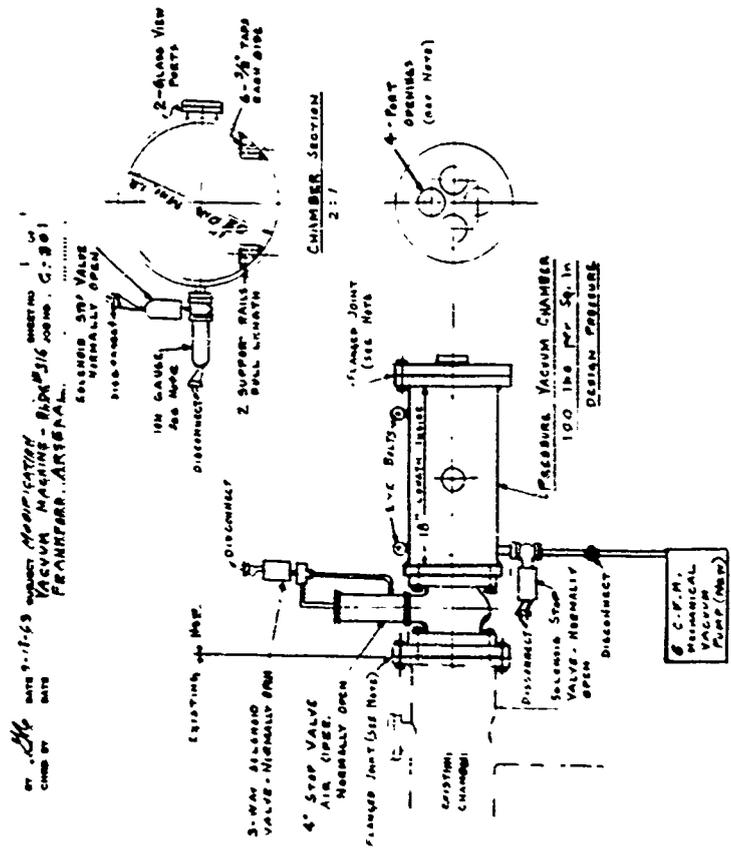


Figure 1.

**TITLE:** Investigation of a Close Tolerance Delay Element

**JOB NO.:** C306

**PROJECT ENGINEER:** W. Peterson, 1430

**AUTHORIZATION:** MIPR AS-4-109

**INITIATION DATE:** December 1963

**ESTIMATED COMPLETION DATE:** June 1964

**OBJECTIVE:** To conduct studies to establish the feasibility of a close tolerance time delay element which is capable of operation after exposure to, and under, extremes of temperature.

**PREVIOUS BI-MONTHLY SUMMARY:**

None. Initial Report.

**PROGRESS:**

This is the first report of the resumption of a program to develop an improved time delay element using a new material, namely, pyrofuze wire. Feasibility of this type of delay has been established and the results are summarized in F.A. Report R-1693.

The feasibility tests were conducted with bare fuze wire that was either suspended or wrapped in a thread helix around a mandrel. During this type of testing, the fuze wire was susceptible to the temperature changes of the adjacent material; when subjected to very low temperatures the fuze wire would become covered with frost.

To eliminate these problems, braided eight stranded fuze wire of 0.004 inch diameter was covered with fiberglass tubing and vinyl shrink tube was used to cover the fiberglass tubing. Three tests were conducted using 10 inch lengths of this covered fuze wire. The burning time at ambient temperature was 0.802 seconds, at -65° F 0.809 seconds, and at 200° F 0.802 seconds. Additional testing using covered fuze wire will be conducted.

A wire covering manufacturer is now in the process of fabricating samples of coverings for fuze wire.

**NEXT BI-MONTHLY PLAN:**

To test and evaluate samples of covered fuze wire; and design and manufacture prototype delay elements.

DEPUTY FOR SYSTEMS ENGINEERING  
DIRECTORATE OF OPERATIONAL SUPPORT ENGINEERING  
CREW EQUIPMENT DIVISION  
ESCAPE AND SURVIVAL BRANCH  
ESCAPE SECTION

**TITLE: Evaluation and Qualification of Ancillary Components for  
Escape Systems**

**JOB NO.: C164**

**PROJECT ENGINEER: E. J. Doebley, 1440**

**AUTHORIZATION: MIPR AS-4-63**

**INITIATION DATE: July 1956**

**ESTIMATED COMPLETION DATE: Continuous**

**OBJECTIVE: To qualify Teflon Hose and PAD system components.**

**PREVIOUS BI-MONTHLY SUMMARY:**

Reply was made to an inquiry from Tinker Air Force Base, Oklahoma, concerning a Quick Disconnect. A copy of the reply was forwarded to ASD.

A Frankford Arsenal representative attended a conference on Design of Experiments in Army Research, Development and Testing.

**PROGRESS:**

A gas operated quick disconnect was forwarded by ASD for evaluation.

The disconnect, which utilized shear pins, was designed to separate at 1000 psi after passing sufficient gas to function a PAD device (approximately 500 psi). The disconnect was integrated into a system consisting of an M3 initiator, 13 ft Teflon hose and a terminal pressure chamber with a volume of 0.062 cubic inches (Figure 1).

The system was activated and a pressure-time trace obtained (Figure 2a). A second firing was conducted using the same system but the disconnect was reversed to allow gas to flow through this disconnect in the opposite direction. This was done to determine whether the disconnect was uni-directional (Figure 2b).

On both firings, the disconnect separated at approximately 2100 psi; however, the maximum pressure attained at the end of the hose was only approximately 330 psi. Data obtained from the firings are presented in Table 1.

Table 1. Data for Pressure Operated Disconnect

Firing No.	Maximum Pressure (PSI)			Time* (MS)		
	P-1	P-2	P-3	T-1	T-2	T-3
1	2120	1940	350	34	34	41
2	2090	1990	310	31	31	37

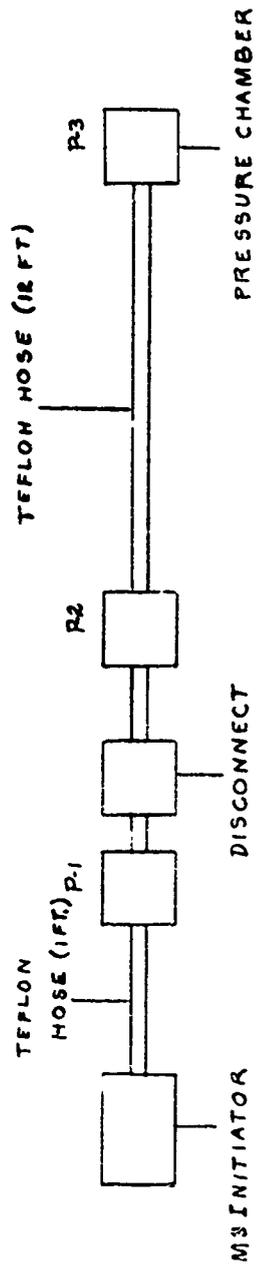
\*T-1 = Time from ignition of system to maximum pressure at P-1

T-2 = Time from ignition of system to maximum pressure at P-2

T-3 = Time from ignition of system to maximum pressure at P-3

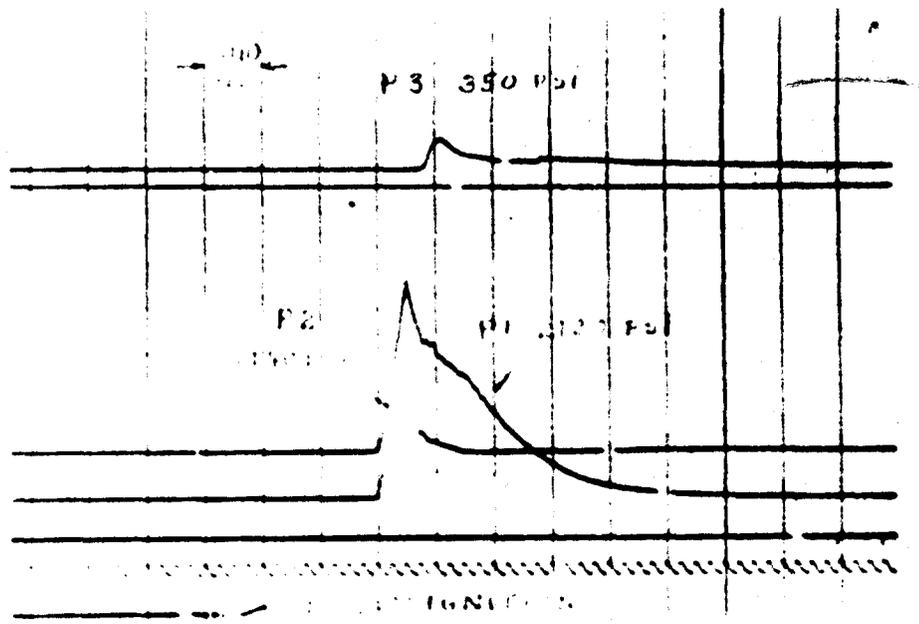
**NEXT BI-MONTHLY PLAN:**

It is anticipated that additional disconnects will be received for further evaluation tests.

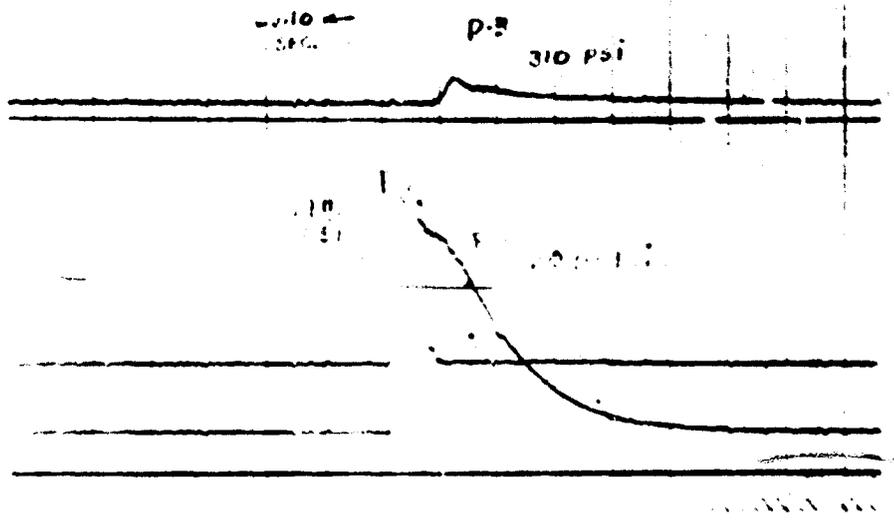


18

Figure 1. System used for Evaluation of Pressure Operated Disconnect



A



B

Figure 2. Pressure-Time Trace Obtained from Firing of Gas Oper Disconnect

**TITLE:** Development of Mild Detonating Fuze (MDF) Transmission System

**PROJECT NO.:** C206

**PROJECT ENGINEER:** A. E. White, 1450

**AUTHORIZATION:** MIPR 33-(657)-3-1375A-188  
MIPR AS-4-63

**INITIATION DATE:** October 1962

**ESTIMATED COMPLETION DATE:** November 1964

**OBJECTIVE:**

1. Improvement of MDF transmission system.
2. Conduct qualification tests of the improved MDF systems.

**PREVIOUS BI-MONTHLY SUMMARY:**

A quantity of sample lengths of the new MDF with high temperature vinyl outer jacket was assembled with FA end booster caps and newly designed booster end caps. These samples were subjected to various environmental conditions and tested.

**PROGRESS:**

In an attempt to provide a satisfactory MDF transmission system with previously designed components using the newly developed MDF confining structure, samples were assembled and tested under the same conditions as for samples of the new MDF assembled with the newly designed end booster assemblies.

The environmental test program consisted of the following tests; high temperature, low temperature, temperature-humidity cycling, water spray and immersion. A summary of the tests and results are presented in Table 1, and a discussion of each test follows.

High Temperature Test

Part I. Using the newly developed MDF confining structure, sample lengths were assembled in three aluminum cross fittings which had

been used in a previous test. The assemblies were conditioned at 200° F for one hour and then detonated. In two assemblies, the two booster caps positioned 90° from the initiating lead failed to initiate. Failure of the booster caps in these assemblies was attributed to misalignment caused by the cross fittings' use in previous tests. In the third assembly all four MDF leads detonated but were blown out of the fittings.

A modification to the assembly procedure was conducted as follows: 0.3" of outer plastic jacket was removed from the confining structure within the brass retaining sleeve and epoxy resin was applied to the fiberglass braid; additionally, a third crimp was added at the end of the sleeve for further holding power.

Two previously used aluminum cross fittings were assembled with MDF samples using the above procedure. The assemblies were conditioned at 200° F for one hour and then detonated. In the first test, three of the cross fitting arms broke off after detonation; however, the MDF leads had not pulled out of the brass retaining sleeves. The second test was partially successful in that all leads were retained. One lead positioned 90° from the initiating line failed to initiate. It was attributed to the misalignment of the lead in the used fitting.

Part II. A new aluminum cross fitting was assembled with newly designed end fittings, and conditioned at 200° F for one hour and then detonated. All components were retained and transfer of detonation was complete. MDF assembled with the new end booster is shown schematically in Figure 1.

#### Low Temperature Test

An aluminum cross fitting was assembled with the new type end fitting, conditioned at -65° F for one hour and then detonated. One cross fitting arm broke off. This failure was attributed to weakening caused by the use of the fitting in a previous test. All components were retained in their sleeves and detonation was complete. The plastic jacket on all MDF lines shattered but no ruptures occurred in the braid. This shattering of the jackets at -65° F was expected and has been the rule in previous tests under similar conditions.

### Temperature-Humidity Cycling

An aluminum cross fitting and ten sample lengths of MDF lines were assembled with new end fittings as well as ten sample lengths of MDF with the old end fittings using the modified procedure. All units were subjected to two temperature-humidity cycles. A cycle consisted of conditioning at 200° F and 95% relative humidity for nine hours, then at -65° F for fifteen hours. The samples were then removed and inspected. Longitudinal ripples in the plastic jacket were observed on many MDF lines. The ripples disappeared after samples warmed to room temperature. No other noticeable effect of cycling was observed.

The cross fitting assembly was detonated at room temperature. All units were retained in the fitting and detonation was complete. One split in the plastic jacket was observed; however, there was no rupturing of the overbraid.

Four sample lengths of MDF lines with new end fittings and four with the old end fittings were detonated at room temperature. All units detonated and confinement was complete.

### Water Spray Test

Three sample lengths of MDF lines assembled with old, and three with new end fittings which had been subjected to temperature-humidity cycling were placed under a water shower for four hours. The samples were then removed from the spray and detonated. Detonation and confinement were complete on all samples.

### Immersion Test

The remaining six samples of MDF three each with each type of end fitting were immersed in water at 120 psi for four hours. Upon removal, two of each type had evidence of water seepage into the fiberglass structure of the MDF. After detonation, those lines having the wet fiberglass had ruptured. The extent of rupture appeared to be dependent upon the amount of water seepage into the fiberglass braiding. In addition, two of the old and one of the new type end booster had failed to detonate. Radiographic analysis prior to testing of the MDF line with the new type end fitting revealed that the epoxy resin seal was not complete at the MDF end of the retaining sleeve. It is concluded that water

seeped into the base charge of the booster cap desensitizing the booster charge. It is also concluded that water seepage into the old end fittings occurred where the booster cap was crimped onto the MDF. Radiographic analysis did not reveal a defective crimp in the old fittings; however, it would appear that this was the logical place for such seepage to occur.

#### Conclusions

A high temperature completely confined mild detonating fuze and low brisance end fittings capable of staying confined in the Frankford Arsenal present MDF fittings within the temperature range -65° F to 200° F appears feasible. In addition, a modification to the assembly procedure for the original end fittings was made which when used with the newly developed completely confined MDF, may prove to be satisfactory for the original transmission system.

A project engineers planning sheet has been prepared and is being processed for the continuation of effort on this program.

Fabrication of prototype hardware and MDF sample assemblies for delivery to ASD is nearing completion.

#### NEXT BI-MONTHLY PLAN:

Survey existing pyrotechnic delay compositions for use in the development of an in-line time delay for MDF transmission systems.

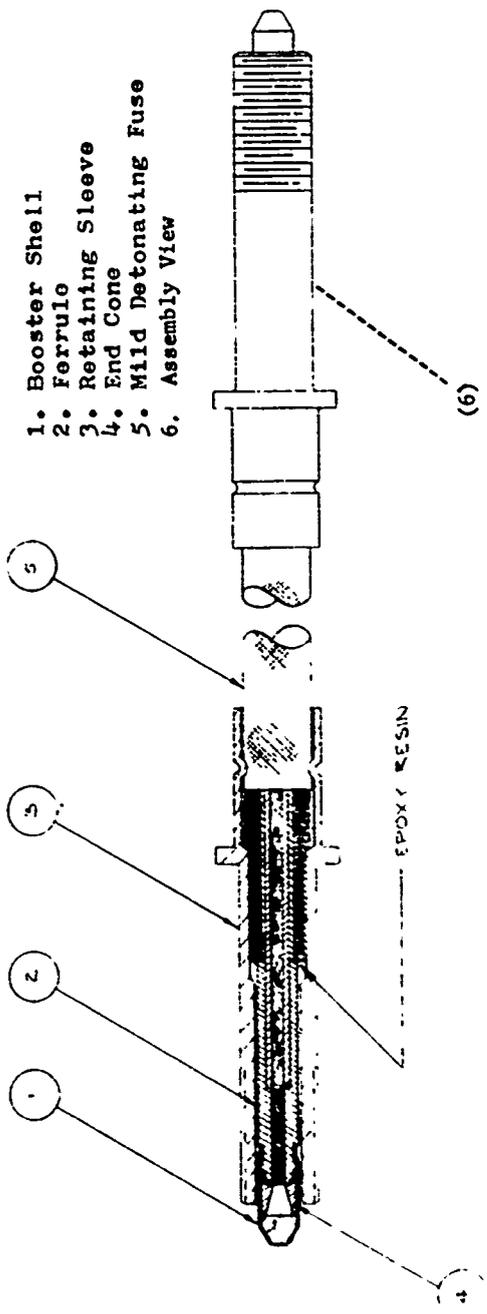
Initiate procurement of high temperature, completely confined MDF, and prepare a test program request for engineering tests on components for a typical MDF emergency escape system.

Table 1. Summary of MDF Tests and Results

<u>Test</u>	<u>Test Item</u>	<u>Test Conditions</u>	<u>Time (hrs)</u>	<u>Results</u>
Hi-Temp Part I	2-MDF w/old booster & Used Cross Fittings	200° F	1	Two boosters at 90° to initiating lead failed to detonate
	1-MDF w/old booster & used cross fittings	200° F	1	All leads detonated, but all leads blew out of fittings.
	1-MDF w/modified booster assembly and used cross fitting	200° F	1	All MDF leads retained in sleeve, but three arms of cross fitting broke.
	1-MDF w/modified booster assembly and used cross fitting	200° F	1	All MDF leads retained in cross fitting. One booster 90° to initiating lead failed to detonate.
Part II	1-MDF w/ new end fitting and new cross fitting	200° F	1	All MDF leads retained in cross fitting. All leads detonated.
Lo-Temp	1-MDF w/ new end fitting and used cross fitting	-65°	1	All MDF leads retained. All leads detonated. One arm of fitting broke.
Temp-Hum. Cycling (2 cycles)	1-MDF w/ new end fitting & new cross fitting	200° F a*	9	All MDF leads retained. All leads detonated. No rupture of MDF leads.
		95% RH -65°	15	

Table 1. (Cont'd)

<u>Test</u>	<u>Test Item</u>	<u>Test Conditions</u>	<u>Time (hrs)</u>	<u>Results</u>
Temp-Hum. Cycling (2 cycles)	4-Sample MDF w/new end fittings	200° F at 95% RH -65°		All samples de- tonated. No rupture of MDF leads.
	4-Sample MDF w/old end fittings (modified assem- bly)	"		"
Water Spray	3-sample MDF w/new end fit- tings	200° F at 95% RH -65° F (2 cycles) Water spray	9 15 4	All samples de- tonated. No rupture of MDF leads.
	3-sample MDF w/old end fittings (mod. assembly)	"		"
Immersion	3-sample MDF w/new end fit- tings	200° F at 95% RH -65° F (2 cycles) Immersed in water under 120 psi	9 15 4	Fiberglass braid wet in 2 samples Wet samples rup- tured. Booster of one wet sample did not detonate
	3-sample MDF w/old end fittings (mod. assembly)	"		Fiberglass braid wet in 2 samples. Wet samples rup- tured. Boosters of wet samples did not detonate.



- 1. Booster Shell
- 2. Ferrulo
- 3. Retaining Sleeve
- 4. End Cone
- 5. Mild Detonating Fuse
- 6. Assembly View

Figure 1. MDF and New End Booster Assembly

**TITLE:** Improvement of Components for Electrically Initiated Escape Systems

**JOB NO.:** C222

**PROJECT ENGINEER:** A. E. White, 1450

**AUTHORIZATION:** OMS 5110.22.01117.20  
MIPR AS-4-63

**INITIATION DATE:** March 1959

**ESTIMATED COMPLETION DATE:** September 1964

**OBJECTIVE:** Complete the development and conduct a complete qualification test program of the XM47 ignition element. Provide user system hardware. Provide components for a typical electrical escape system.

**PREVIOUS BI-MONTHLY SUMMARY:**

Drawings of the final design assembly of the XM47 ignition element were completed. A procurement package for XM47 ignition element test hardware was being prepared.

**PROGRESS:**

Program authority for the FY-64 effort was received.

Due to redirection of effort, all work on the XM47 ignition element has been stopped.

Review of the final report on previously developed ignition elements and pulse generators was completed.

The technical data package on the pulse generators was completed and processed to the Procurement and Production Group.

Preparation of a request for type classification of pulse generators and ignition elements is continuing.

The project engineers planning sheet for continued effort on this program has been prepared and is being processed.

**NEXT BI-MONTHLY PLAN:**

Continue preparation of the request for standardization of the pulse generators and ignition elements.

Prepare a schematic diagram of a mock-up T33 airplane emergency escape system for electrical initiation.

Start fabrication and assembly of components to be used in the mock-up of the system.

**TITLE:** Standardization of Co-Axial Catapult

**PROJECT NO.:** C237

**PROJECT ENGINEER:** N. Waecker, 1450

**AUTHORIZATION:** OCMS 4110.16.8500.1.12  
MIPR 33-(657)-3-1375A-188  
MIPR AS-4-63

**INITIATION DATE:** January 1960

**ESTIMATED COMPLETION DATE:** December 1964

**OBJECTIVE:** To apply advanced design, material and propellant manufacturing techniques to rocket catapults to realize the following:

- a. Increased performance in the form of higher trajectory as a result of higher catapult velocity and additional rocket propellant.
- b. Higher reliability through use of advanced design concepts.
- c. Operation at 200° F by use of a composite propellant for both catapult charge and rocket motors.

**PREVIOUS REPORT SUMMARY:**

Firings were conducted at various temperatures to check rocket ignition characteristics. The nozzle retainer design with a 9/16-inch diameter gas operated piston provided reliable swivel action.

**PROGRESS:**

A. User-Tests at ASD

Four complete rocket catapults were loaded, with HEX-12 propellant in the rocket motors; two were shipped to ASD for user tests after the following:

1. All units were hydro-tested to assure nozzle swivel action. All units were tested to 4000 psi and swivel action occurred in all instances. In this test, the nozzle and retainer assembly is subjected to a hydro-pressure to simulate rocket pressure. The test is both structural and functional.

2. One unit was fired on a free-flight fixture at Fort Dix. A 360 lb mass simulating a seat-man combination was lifted approximately 300 feet in height. The nozzle was directed under the center of gravity which caused the mass to rotate backwards at about 45 rps and a resultant loss in overall height. Otherwise, all aspects of function were satisfactory.

3. One unit was fired on the horizontal test fixture at Bldg 316. High speed photo coverage of nozzle swivel action indicated complete rotation of  $36^{\circ} : 20'$  occurred in .002 seconds as planned.

The tests at ASD originally scheduled for early November 1963 were postponed until Feb 1964 at ASD's request.

#### B. Design and Development

Two complete XM27 catapult units were loaded with 3-1/4 inch diameter rockets containing composite propellant. Two different retainer designs were used:

1. Retainer with baffle to deflect erosive gases from the external surface of the nozzle which deteriorates during firing.

2. Retainer without baffle, but fitted with a nozzle cut away so that at completion of swivel action, a direct flow-path exists for travel of rocket exhaust gases.

Both units were fired in the horizontal test fixture and high-speed photo coverage was used to determine nozzle swivel and erosion characteristics. Test results indicated that neither design modification lessened erosion and that it started approximately .075 seconds after rocket ignition.

Several nozzles were fabricated from a refractory material, Alumina Oxide, AL2O3. This material was also used in manufacture of covers to be applied in the interior surface of the retainer which is exposed to erosion.

A complete procurement package was prepared, and procurement of 100 complete items for engineering tests was initiated. The drawings were product engineered and because of slight design and tolerance changes (non-functional), the unit designation was changed from XM26 to XM30 catapult. No changes were made in performance and/or installation dimensions, and until the XM30 hardware becomes available, this unit will continue to be reported as the XM26 catapult development.

### C. Development Test Summary

The data obtained from all test firings of the XM26 catapult, with the exception of three firings with 3.25 inch OD motors, has been reduced. Approximately 100 firings were conducted, with partial and complete items being evaluated. Sixty-three of these firings were conducted on the vertical test tower with catapult booster assemblies. Six firings were conducted on a "g" loading fixture with catapult booster assemblies. The remainder were conducted as complete item tests with the units mounted on the horizontal test fixture.

The data obtained during these tests were reviewed to determine the capability of the XM26 catapult to meet the following set of tentative performance requirements.

- a. acceleration: 20 g max.
- b. rate of acceleration: 250 g/sec max.
- c. separation velocity: 35 feet/sec min.
- d. total sustainer impulse: 1500 lb sec min.

Based on a review of the results of these firings it can be stated that the catapult meets the ballistic performance requirements. This is based on the evaluation of data from 48 booster assembly firings and 25 firings of complete units.

A summary of the results of the tower firings are presented in two tables. Table I presents data obtained in tests with a tentatively selected propellant charge. Table 2 is a summary of additional evaluation firings at the temperature extremes to enlarge the sample size.

Table I. DATA SUMMARY WITH TENTATIVE CHARGE

<u>Temp</u> <u>°F</u>	<u>Max.</u> <u>Acceleration</u> <u>(g)</u>	<u>Max. rate of</u> <u>Acceleration</u> <u>(g/sec)</u>	<u>Vel.</u> <u>(fps)</u>
70 max.	12.5	100	40.2
min.	11.4	80	36.3
avg.	11.9	90	38.4
No. of firings: 5 ea.			
-65 max.	9.4	110	38.3
min.	8.2	70	35.7
avg.	8.8	90	37.1
No. of firings: 5 ea.			
200 max.	15.8	160	42.1
min.	13.6	140	38.9
avg.	14.7	155	40.4
No. of firings: 5 ea.			

Table II. DATA SUMMARY OF ADDITIONAL EVALUATION FIRINGS

<u>Temp</u> <u>°F</u>	<u>Max.</u> <u>Acceleration</u> <u>(g)</u>	<u>Max. rate of</u> <u>Acceleration</u> <u>(g/sec)</u>	<u>Vel.</u> <u>(fps)</u>
-65 max.	11.5	170	42.8
min.	8.9	70	38.6
avg.	10.3	120	40.3
No. of firings: 16 ea.			
200 max.	15.8	190	45.0
min.	11.1	140	38.3
avg.	14.3	170	41.5
No. of firings: 17 ea.			

The tabulated data for these firings are contained in Appendix I(a) under programs B1, 2, 4 and 11 to 16 incl.

The separation velocities obtained in firings on the "g" load fixture were below normal, as anticipated. This was due to the resistive loading in addition to the mass load. With a 2000 lb resistive load the velocity was decreased approximately 25%. The 3000 lb resistive load reduced the velocity better than 40 percent. However, the peak accelerations and onset rates recorded were well within the specified limits. These data are tabulated in Appendix Ia under Program B6.

The firings with complete units were conducted with both double base (HEX-12) and composite (Thiokol) propellant rocket motors. In all of the firings, the total impulse was in excess of the 1500 lb sec requirement. No unfavorable burning characteristics were noticeable in any of the firings. The tabulated data from these firings are in Appendix I(b).

Four tests were conducted with a smaller size propellant motor. These motors were designed to deliver a total impulse of 1100 lb sec and were fired for a special test application. These data are contained in Appendix I(b), under programs B7 and B19.

Generally it can be concluded that the XM26 rocket catapult, with the present catapult and rocket motor configuration, does meet the specified ballistic requirements over the operational temperature range. At present, there are no recommendations for the improvement of either the catapult or rocket motor configuration.

#### NEXT BI-MONTHLY PLAN:

Conduct firing tests at ambient temperature using AL203 components in areas exposed to erosion. Pending elimination of excess erosion, conduct additional firing at -65 and 200° F.

APPENDIX I (a)

PERFORMANCE DATA - XM26 CATAPULT (BOOSTER ONLY)

Propellet Weight: 410 pounds (vertically upward)  
 Propellant Charge: TPL 3014 (TEX-506)  
 3 pieces, 2.4 inches long  
 0.625 inch O. D., 1NH; 0.10 inch I. D.  
 Weight, excluding inhibitor: approx. 39 grams  
 Igniter Charge: 4 grams BKNO<sub>3</sub> (2R pellets)

Round No.	Firing Temp. (°F)	Pmax (psi)	Pend (psi)	Max. Accel. (g)	Rate of Onset (g/sec)	Ball. Cycle Time (sec)	Vel. (fps)
B1-1	70	6520	3340	11.4	80	.195	36.3
-2	70	7100	3720	12.5	90	.185	40.2
-3	70	NR	NR	NR	NR	NR	NR
-4	70	6770	3500	11.7	90	.180	38.9
-5	70	7100	3730	12.0	90	.200	38.3
-6	70	6910	3630	11.8	100	.180	38.3
B2-1	-65	5380	3710	8.8	110	.190	36.3
-2	-65	5300	3650	8.6	70	.200	37.3
-3	-65	5480	3650	9.2	100	.185	37.9
-4	-65	5400	3690	9.4	80	.190	38.3
-5	-65	NR	NR	NR	NR	NR	NR
-6	-65	5120	3520	8.2	80	.190	35.7
B4-1	200	8580	3920	15.0	160	.175	40.8
-2	200	8480	3830	14.5	160	.190	40.2
-3	200	8770	3960	15.8	160	.170	42.1
-4	200	NR	NR	NR	NR	NR	NR
-5	200	7720	3690	13.6	140	.190	38.9
-6	200	8200	3690	14.6	160	.185	39.9

Note: NR = No record obtained.  
 1 = Severe leak around valve assembly.

PERFORMANCE DATA - XM26 CATAPULT (BOOSTER ONLY) (Cont'd)

Round No.	Temp. (°F)	Resistive* Load (lb)	Pmax (psi)	Pend (psi)	Max. Accel. (g)	Rate of Onset (g/sec)	Ball. Cycle Time (sec)	Vel. (fps)
B6-1	70	2000	8650	3240	NR	NR	.210	-
-2	70	2000	8870	3020	11.3	120	.230	28.3
-3	70	2000	9090	3140	11.9	130	.225	29.3
-4	70	3000	8870	2920	10.1	110	.260	23.2
-5	70	3000	9300	2810	9.7	120	.270	21.5
-6	70	3000	6540	NR	5.2	50	NR	-

\*These firings conducted in horizontal constant force fixture; total opposing load consists of specified resistive load plus 410 pound mass load.

35

Round No.	Temp. (°F)	Pmax (psi)	Pend (psi)	Max. Accel. (g)	Rate of Onset (g/sec)	T <sub>b</sub> (sec)	Vel. (fps)
B9-1	200	8870	3020	14.8	160	.175	41.8
-2	200	7690	1190	12.9	120	.200	32.8
-3	200	7100	860	12.3	120	.190	31.5
-4	-65	6040	3580	9.7	90	.175	38.6
-5	-65	5770	3550	8.7	80	.190	37.9
-6	-65	6430	3580	10.0	100	.175	39.2
B10-1	200	*	?	15.6	150	NR	43.7
-2	200	*	?	NR	NR	NR	38.6
-3	-00	*	?	15.2	120	NR	39.9

\*Pressure not recorded.

Note: NR = No record obtained.

I = Severe leak around valve assembly.

PERFORMANCE DATA - XM26 CATAPULT (BOOSTER ONLY) (Cont'd)

<u>Round No.</u>	<u>Pmax (psi)</u>	<u>Pend (psi)</u>	<u>Max. Accel. (g)</u>	<u>Rate of Onset (g/sec)</u>	<u>Ball. Cycle Time (sec)</u>	<u>Vel. (fps)</u>
<u>FIRING TEMPERATURE: -65° F</u>						
B11-1	7520	3640	11.5	160	.160	41.8
-2	6140	3730	8.9	110	.180	39.2
-3	6780	3640	10.9	120	.170	41.8
-4	6040	3640	9.9	110	.185	39.9
-5	5730	3730	9.7	90	.190	38.9
-6	6350	3550	10.6	120	.170	40.8
B13-1	5720	3150	9.7	140	.180	38.9
-2	8310	3770	10.1	130	.180	40.2
-3	6220	3640	10.8	130	.175	42.8
-4	5590	3720	9.7	90	.195	41.5
-5	6580	3770	11.4	150	.170	42.4
-6	5590	3420	9.5	70	.205	39.2
B15-1	6550	3680	10.9	130	.180	39.6
-2	6040	3680	NR	NR	.180	NR
-3	NR	NR	NR	NR	NR	NR
-4	5550	3590	9.5	90	.205	38.6
-5	5770	3720	9.8	70	.215	39.9
-6	6220	3420	11.3	170	.180	39.6

Note: NR = No record obtained.

PERFORMANCE DATA - XM26 CATAPULT (BOOSTER ONLY) (Cont'd)

<u>Round No.</u>	<u>P'max (psi)</u>	<u>Pend (psi)</u>	<u>Max. Accel. (g)</u>	<u>Rate of Onset (g/sec)</u>	<u>Ball. Cycle Time (sec)</u>	<u>Vel. (fps)</u>
<u>FIRING TEMPERATURE: 200° F</u>						
B12-1	8780	3590	14.4	140	.180	42.8
-2	9050	3640	11.1	170	.190	38.3
-3	NR	NR	NR	NR	NR	NR
-4	8590	3460	12.4	140	.195	38.9
-5	8740	3550	12.8	150	.185	38.9
-6	9050	3820	15.1	180	.185	42.8
B14-1	8520	3640	14.1	160	.185	41.8
-2	8790	3730	14.1	160	.185	41.8
-3	9180	3820	15.2	190	.175	45.0
-4	8860	3740	13.7	160	.175	39.9
-5	8630	3650	14.6	160	.180	42.1
-6	9080	3780	14.4	180	.190	44.4
B16-1	8840	3660	14.4	160	.185	47.1
-2	8950	3210	15.4	160	.190	39.2
-3	8610	3800	14.8	160	.190	43.1
-4	8950	NR	15.4	180	.185	39.6
-5	9290	3900	15.8	180	.170	42.8
-6	9050	3800	15.4	190	.185	42.4

Note: NR = No record obtained.

APPENDIX 1 (b)

PERFORMANCE DATA - XM26 CATAPULT (COMPLETE UNIT)

Firings Conducted with HE-X-12 Propellant Rocket Motors

Round No.	Temp. (°F)	Pmax (psi)	Pend (psi)	Booster			Ball. Cycle Time (sec)	[adt (g-sec)	Rocket +			
				Max Accel. (g)	Rate of Onset (g/sec)	Rate (g/sec)			Pmax (psi)	Fmax (lb)	∫ Fdt (lb-sec)	Action Time (sec)
B3-1	70	NR	NR	12.1*	120*	.175	**	NR	4080	1790	.545	0
-2	70	5160	2700	11.9*	80*	.205	**	3500	4680	1810	.550	0
B5-1 <sup>1</sup>	70	5350	1635	9.0*	80*	.195	**	3360	3820	1670	.550	0
-2	70	5570	2970	9.2*	70*	.205	**	3250	4080	1750	.555	0
-3	70	5350	2750	8.8*	90*	.190	**	3300	4080	NR	NR	0
-4 <sup>1,2</sup>	70	NR	NR	NR	NR	NR	**	NR	NR	NR	NR	0
B8-1	70	6220	3280	9.9	60	.215	1.13	3750	2320	1130	.555	50
-2	70	6230	3410	10.1	70	.200	1.09	3680	2540	1230	.540	50
B17-1	70	6280	3340	NR	NR	.205	NR	3420	2470	1160	.555	50
-2	70	6480	3460	10.4	90	.183	1.20	3460	2280	1160	.545	50
-3	70	6200	3220	10.7	100	.180	1.22	3460	2270	1090	.545	50
-4	70	5400	2940	9.0	60	.205	1.20	3230	3850	1290	.550	50
B21-1	70	6350	3460	9.8	70	.210	1.11	3700	3390	1400	.570	36
-2	70	6100	3370	7.3	60	.210	1.04	3740	3250	1320	.575	36

\* Fmax & ∫ Fdt are axial measurements.

† Derived from thrust time trace.

\*\* Acceleration not recorded.

NR No record obtained.

1 Leak at valve assembly.

2 Grain did not ignite.

PERFORMANCE DATA - XM26 CATAPULT (COMPLETE UNIT)

Firings Conducted with TFL-3014 Propellant Rocket Motor

Round No.	Temp (°F)	Pmax (psi)	Pwtd (psi)	Max. Accel. (g)	Booster		Rail		Rocket				
					Rate of Onset (g/sec)	Cycle Time (sec)	Rate of Onset (g/sec)	Cycle Time (sec)	Pmax (psi)	Fmax (lb)	Fdt (lb-sec)	Action Time (sec)	Nozzle Angle (deg)
B7-1	70	*	*	*	*	*	*	*	2600	3690	1170	415	0
B19-1	-65	5030	3100	8.2	60	.210	1.07	2120	3120	1170	.415	0	
-2	-65	4700	3020	7.8	60	.215	1.02	2160	3070	1230	.495	0	
-3	-65	4860	2930	8.0	50	.210	1.01	2080	3100	1170	.460	0	
Firings With 2.750 Inch O.D. Motor													
B18-1	-65	4890	3300	8.1	90	.200	1.02	1830	2570	1830	.815	0	
-2	-65	5540	2930	6.5	130	.180	1.06	1870	2520	1720	.825	0	
-3	-65	4890	3260	7.7	60	.210	1.02	1850	2600	1760	.790	0	
-4	-65	5620	3430	9.1	110	.185	1.17	1850	2540	1780	.785	0	
B20-1	70	5950	3110	9.4	60	.210	1.08	2960	2740	1260	.680	16	
-2	70	6040	3210	9.9	70	.195	1.12	2200	3140	1880	.685	0	
-3	70	3470	830	5.2	60	.225	.79	NR	NR	NR	NR	0	
-4	70	4220	2320	16.9	80	.205	.95	2230	3230	1880	.695	0	
-5	70	7850	3470	11.5	140	.200	1.19	4620	3950	1410	.750	36	
B22-1	70	4280	1110	6.7	70	.205	.88	NR	NR	NR	NR	36	
-2	70	5960	3300	9.6	7	.200	1.10	4830	4320	1300	.605	36	

Firings With 3.125 Inch O.D. Motor

\* Fmax & ∫ Fdt are axial measurements.  
\* Not recorded.

NR No record obtained.

1 Leak at valve assembly.

2 Grain did not ignite.

**TITLE:** Improvement of Time Delay Mechanism

**JOB NO.:** C238

**PROJECT ENGINEER:** A. White, 1450

**AUTHORIZATION:** OMS 5110.22.01117.24  
MIPR 33-(657)-3-1375A-188

**INITIATION DATE:** November 1962

**ESTIMATED COMPLETION DATE:** December 1963

**OBJECTIVE:** To conduct functional and environmental tests and prepare a final report.

**PREVIOUS BI-MONTHLY SUMMARY:**

Four each of three time delay mechanisms were assembled and were undergoing environmental tests.

**PROGRESS:**

Completion of the environmental tests of the time delay mechanisms has been delayed due to a breakdown of the temperature-altitude chamber. All other environmental tests have been completed. Results will be reported in the next bi-monthly report.

**NEXT BI-MONTHLY PLAN:**

All tests will be completed and a draft of the final report will be prepared.

**TITLE:** Dyna-Soar Technical Assistance

**JOB NO.:** C272

**PROJECT ENGINEER:** R. Sutter, 1450

**AUTHORIZATION:** MIPR 33-(657)-3-R&D-210

**INITIATION DATE:** March 1962

**ESTIMATED COMPLETION DATE:** Continuous

**OBJECTIVE:** To provide technical assistance and liaison to Dyna-Soar S.P.O. in the development of the various PAD used in the Dyna-Soar.

**PREVIOUS BI-MONTHLY SUMMARY:**

Work was suspended pending receipt of additional program authority.

**PROGRESS:**

Work was resumed when additional program authority was received from ASD. Drawings on both the XM96 and XM97 initiators were completed. Fifty sets of initiator hardware were ordered for use in qualification testing of the initiators. Development work on this project has been stopped due to cancellation of the X20 program.

It is planned to prepare a final summary report covering the X20 escape system PAD.

**NEXT BI-MONTHLY PLAN:**

Work will begin on the summary report.

**TITLE:** Development and Standardization of XM18 Gas Generator

**JOB NO.:** C277

**PROJECT ENGINEER:** R. Sutter, 1450

**AUTHORIZATION:** ACMS 4110.16.8500.1.27  
MIPR 33-(657)-3-1375A-188  
MIPR AS-4-63

**INITIATION DATE:** November 1962

**ESTIMATED COMPLETION DATE:** November 1964

**OBJECTIVE:** To complete development and qualification of a one-man life raft inflation device and recommend type classification in accordance with Air Force-Army regulations.

**PREVIOUS BI-MONTHLY SUMMARY:**

Design changes were made as suggested by the Escape and Survival Section at ASD, and ballistic tests were conducted using double base propellant. Fifteen single perforated grains of slow burning ammonium nitrate propellant were ordered from Amoco Chemical Corp.

**PROGRESS:**

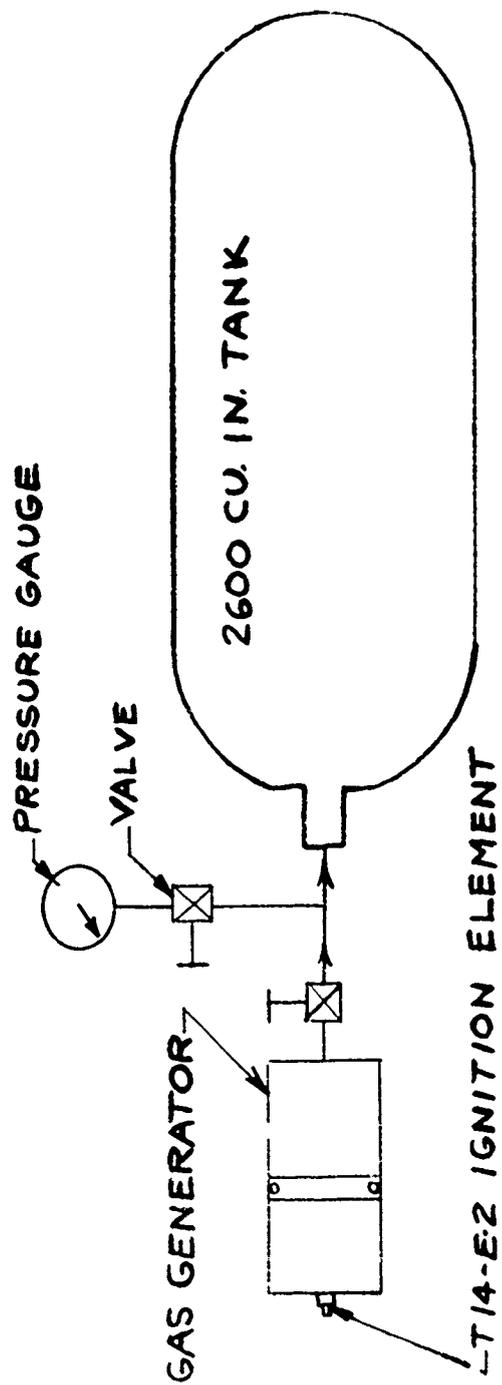
Drawings were completed for the prototype (concentric chamber design) XM18 gas generator. Fabrication was delayed, however, pending testing of a floating piston design concept; this design, when completed, will be submitted to the Escape and Survival Section at ASD for evaluation by technical personnel.

The advantages of the floating piston design over the present XM18 configuration are considered significant and are believed to justify pursuit of a determination of its possible use with the one-man life raft inflation system. The following work has been accomplished towards this determination. Fifteen single perforated grains of ammonium nitrate propellant were received from Amoco Chemical Corp. Ballistic tests were conducted with these uninhibited grains using the floating piston 3-man life raft inflator. An aluminum sleeve was used to reduce

the volume in the propellant chamber. In order to measure the amount of gas produced by the gas generator, the unit was connected to a 2600 cubic inch tank and instrumented with a bourdon-type pressure gauge (See figure 1). During the tests, pressure readings were taken in both the propellant and coolant chamber. The pressure in this tank was measured fifteen minutes after the gas was generated to allow the gas to reach ambient temperature. Data from tests conducted indicated that the ammonium nitrate propellant ignited fast and burned well in the test generator. Comparison tests were conducted using an identical charge of double base propellant inhibited on the outside diameter. These tests showed that the double base propellant produced more gas, believed due to (1), the higher temperature gas produced by this propellant decomposing more of the coolant and (2), the lower moisture content of the gas produced.

#### NEXT MONTHLY PLAN:

Initiate fabrication of prototype XM18 gas generators and continue ballistic testing.



44

COOL GAS GENERATOR TEST SET UP

FIG I

**TITLE:** Determination and Evaluation of the Performance Characteristics of Dynamic Seals, Sealing Materials and Sealing Techniques for PAD

**JOB NO.:** C279

**PROJECT ENGINEER:** A. E. Larsen, 1410

**AUTHORIZATION:** MIPR 33-(657)-3-1375A-188

**INITIATION DATE:** November 1962

**ESTIMATED COMPLETION DATE:** Continuous

**OBJECTIVE:** To determine by suitable investigations the measurable sealing characteristics of available dynamic and static seals, sealing materials, and techniques suitable for use in PAD over the temperature range of -65° F to 300° F with a goal of -100° F to 500° F.

Also, to determine the effects expected from exposure of such seals, materials and techniques to nuclear radiation and Ozone Concentration.

**PREVIOUS BI-MONTHLY SUMMARY:**

In response to the invitations for bid there were seventeen refusals, one interested response. The one company whose technical proposal showed merit was evaluated. The company was re-contacted for a second proposal, including costs on a fixed-price basis and a firm delivery date. Three additional companies manufacturing testing fixtures for large manufacturers of seals were also solicited, with no response.

Concurrently, in-house design efforts produced a design concept which utilizes a modified Frankford Arsenal rocket catapult test fixture.

**PROGRESS:**

Technical evaluation of the Industry proposal and the Frankford Arsenal in-house proposed design, with an alternate, were completed and evaluation of both were considered before determining to procure from Industry.

On 15 November, two technical representatives of the acceptable Industry proposal, the Illinois Institute of Technology, visited FA to reconcile questions which arose. A final re-submission of their proposal resulted in technical acceptance and in the placement of procurement contract No. DA-36-038-AMC-939A on 13 December 1963.

Technical data and procurement sources of the appropriate alloy steel and alloy aluminum tubes were submitted to IIT, upon their request, in order to expedite fabrication of those portions of the test fixture utilizing these standard parts.

Subsequently, on 17 December 1963, the program of modification and testing of an M9 initiator charge to operate the PAD Seals testing fixture (as CFE) was completed. Installation drawings of this unit have been completed and forwarded.

#### NEXT BI-MONTHLY PLAN:

Work will proceed at Frankford Arsenal in executing the modification and test of the Modified M9 Initiator to meet the proposed specifications of its special testing performance. Completion of this task is scheduled for February 1964.

Close contact and cooperation with IIT will continue to be maintained.

**TITLE:** Improved Propellants and Primers for PAD Applications

**JOB NO.:** C280

**PROJECT ENGINEER:** H. D. MacDonald, Jr., 1410

**AUTHORIZATION:** MIPR 33-657-3-1375A-188  
MIPR AS-4-63

**INITIATION DATE:** November 1962

**ESTIMATED COMPLETION DATE:** Continuous

**OBJECTIVE:** To make available for application to PAD developments propellants and primers with improved performance characteristics and extended storage capabilities.

**PREVIOUS BI-MONTHLY SUMMARY:**

**Task 1 - PAD Applications of Experimental Propellant**

Firing of MDB-7 propellant was made in M3 initiators. It was concluded that this propellant is more suited to gas generators because of the low burning rate.

Pellets of B-KNO<sub>3</sub> were evaluated as initiator propellant. The low slope of burning rate vs. pressure makes the material desirable for initiators. Its low impetus limits the peak pressures in the system to about 10,000 psi. Increase of loading density creates potential post firing strength problems with cadmium plated steel because of high temperature.

**Task 2 - Application of High Density Impulse Propellant to Rocket Catapults**

A propellant formulation was developed in small strands which appears to fulfill the requirements of a rocket for personnel escape.

Twenty-five motor tubes were shipped to NOTS, China Lake.

### Task 3 - PAD Application of Percussion Primers with High Temperatures Stability

The fixture required for drop testing primers at elevated temperatures was in the process of being manufactured.

G-16 primers assembled in 7.62mm cases with aluminum disc were subjected to temperature stability tests at 550° F. Results show that the primers decrease in sensitivity during storage. The all-fire height of the primers exceeded the specification limit after 4 hours.

#### PROGRESS:

### Task 1 - PAD Applications of Experimental Propellant

The .090 dia. x 0.090 long HEN12 propellant (125 grams) was received from Picatinny Arsenal. Bids were received on the experimental throw-away initiator body. Technical evaluation was made 18 December 1963 on the basis of bid submissions.

Discussions were held with personnel at Picatinny Arsenal on advanced propellants for gas generators with temperature resistant characteristics. Some strand samples will be obtained to test in devices.

A fixture has been designed which will serve as a thrust mount for the M9 initiator. The present charge in the M9 initiator will be modified with a suitable experimental propellant and will also consist of a substantial increase in the present charge weight. No changes to the metal parts are anticipated. It is planned to use this initiator for the purpose of supplying the operating gases to the sea's testing fixture being procured on contract for Job No. C279.

### Task 2 - Application of High Density Impulse Propellant to Rocket Catapults

Firings were made in a 5.1 inch test motor of the formulation reported last month. The desired increase in impulse was obtained. A detailed report will be published under separate cover.

Task 3 - PAD Application of Percussion Primers with High Temperature Stability

The fixture required for drop testing primers at elevated temperatures has been manufactured.

G-16 primers assembled in 7.62mm cases using a .010 inch thick aluminum disc were subjected to temperature stability tests at 500° F. The primed cases were preheated to 450° for 30 minutes and then placed in an oven at 500°. Samples were withdrawn at 2 hour intervals. A run down drop test (dropping 25/height) was performed on these samples using a 4 ounce ball. Table I gives the results of these tests.

TABLE I

<u>Storage Time</u> <u>Hours</u>	<u>H</u> <u>inches</u>	<u><math>\sigma</math></u> <u>inches</u>	<u><math>\bar{H} + 3\sigma</math></u> <u>inches</u>
0	9.08	1.34	13.20
2	9.32	1.41	13.55
4	9.02	1.36	13.10
6	9.68	1.37	13.79
8	9.62	1.31	13.55
10	9.60	1.20	13.20
12	10.18	1.09	13.45
14	10.00	1.08	13.24
16	10.04	1.19	13.61
18	10.10	1.39	14.70
20	10.78	1.48	15.22
22	10.82	1.29	14.69
24	11.22	1.43	15.51

There was no apparent change in impact sensitivity of the primers during the first 16 hours of storage. The  $\bar{H}$  and all-fire height tend to increase slightly as the storage time increases from 16 to 24 hours.

For additional studies at elevated temperatures new lots of G-16 and G-11 primers have been manufactured.

**NEXT BI-MONTHLY PLAN:**

**Task 1 - PAD Applications of Experimental Propellant**

Complete procurement action on initiator test bodies.

Place experimental order with Picatinny Arsenal.

**Task 2 - Application of High Density Impulse Propellant to Rocket Catapults**

Prepare to cast 25 RAPEC type motors using the high density formulation.

**Task 3 - PAD Application of Percussion Primers with High Temperature Stability**

Calibrate fixtures used for drop testing primers at elevated temperatures. Continue temperature stability tests on G-11 primers at 500° F.

**TITLE:** Investigation at Recently Developed Materials and Manufacturing Techniques for Application to PAD

**JOB NO.:** C281

**PROJECT ENGINEER:** A. M. Halstead, 1410

**AUTHORIZATION:** MIPR 33-(657)-3-1375A-188  
MIPR AS-4-63

**INITIATION DATE:** November 1962

**ESTIMATED COMPLETION DATE:** Continuous

**OBJECTIVE:** To investigate recently developed materials and manufacturing techniques and apply those to PAD which will result in improved performance characteristics and/or reliability, as well as significant reductions in weight and/or costs.

**PREVIOUS BI-MONTHLY SUMMARY:**

Major effort was placed on obtaining erosion-resistant materials for rocket nozzles on Job C237. Silver-infiltrated tungsten inserts apparently did not erode during firing, but this material experiences a sintering shrinkage. Nozzles machined from centrifugally cast 854-15M0 refractory alloy suffered no apparent erosion, but all three fired cracked at the lug holes. One was returned to the supplier for examination.

In an effort to contain the decomposition products of the coolant material used on Job C277, special O-rings were selected for evaluation and ordered.

**PROGRESS:**

Information was received from the supplier of the silver-infiltrated tungsten, confirming that this material shrinks when subjected to temperatures of about 2000° C. A dimensional change of 1% is not unusual under these conditions, and care must be taken when designing these parts to allow for this.

A report was received from the supplier of the 85W-15M0 alloy nozzles which did not erode but cracked during firing. The results of their analysis indicate that the most probable reason for cracking was exceeding the ultimate strength of the alloy. Thermal stresses probably did not enter into initial cracking but would cause crack propagation on nozzle cooling. It was recommended that modifications be made to improve the physical characteristics of the assembly in an effort to preclude excessive stresses.

Four sample nozzles were received from a supplier of a lightweight ceramic which is 94% alumina ( $Al_2O_3$ ). The properties of this material as reported by the producer are presented in Table I. This material shrinks about 17% during the final firing (heating) in a kiln. Although this was considered in making these nozzles, the round lug holes became oval. Three nozzles have been returned, to have these holes drilled through to the inner surface. Sample inserts for the nozzle retainer, made from the same ceramic, have also been received.

Rocket nozzle inserts made of the TZM refractory alloy previously reported were designed and are being machined.

Tension specimens of 18 Ni Cr Mo (300) maraging steel have been tested at elevated temperatures up to 1,000° F (i. e., four hours each at 200, 400, 600, 800 and 1,000° F) and the results are being correlated.

TABLE I. Typical Properties of 94% Alumina ( $Al_2O_3$ )

<u>Property</u>	<u>Value</u>
True Specific Gravity	3.88
Bulk Specific Gravity	3.73
Weight (lb/in <sup>3</sup> )	0.135
Water Absorption (%)	None
Linear Coef. Expan. ( $\times 10^{-6}$ ) 25° - 100° C	3.60
25° - 400° C	6.11
25° - 700° C	7.29

TABLE I. (Cont'd)

<u>Property</u>	<u>Value</u>
Compressive Strength (psi)	425, 000
Flexural Strength (psi)	55, 000
Charpy Impact (in/lbs)	7
Mohs Hardness	9

NEXT BI-MONTHLY PLAN:

Continue investigation of erosion-resistant materials for rocket nozzles and/or inserts.

Continue study of elevated temperature properties of high strength (maraging) steels.

TITLE: Improvement of PAD to Eliminate Toxic Propellant Gases

JOB NO.: C284

PROJECT ENGINEER: A. M. Halstead, 1410

AUTHORIZATION: MIPR 33-(657)-3-1375A-188

INITIATION DATE: March 1963

ESTIMATED COMPLETION DATE: March 1964

OBJECTIVE: To determine means of eliminating or minimizing the toxic constituents of PAD propellant gases which will be applicable to the development of replacement charges for the M80, XM87, XM88 and XM89 initiators.

PREVIOUS BI-MONTHLY SUMMARY:

Gas analysis results were reported for HES 6573 and P-1 propellants that had been fired previously. Experimental results were also given for studies in which the effect of certain coolants on the product gas composition was investigated. It was found that no substantial increase in CO content occurred as a result of replacing approximately 20% of the charge with coolant. Tests of pelletized P-1 propellant indicated that charges with higher mass burning rates would be required. Although the CO contents of the product gases from these firings was zero, the NO content was quite high, ranging from 7 to 10%. It was also found that 2D igniter material produces gases containing from 35 to 40% carbon monoxide. Finally, a discussion was presented describing the computer program which is being readied in order to carry out performance calculations on candidate propellant formulations.

PROGRESS:

In order to evaluate a propellant charge in which the igniter constitutes a substantially smaller percentage of the total charge than that used with the M27 initiator, M69 cartridges were loaded with 4.6 and 8 grams, respectively, of HES 5808 propellant and 0.7 grams of type C igniter (41% zirconium - 59% barium nitrate). These have not yet been fired.

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In view of the fairly high amounts of nitric oxide (NO) present in the product gases produced by the P-1 propellant, it was decided to compare the known toxic effects of this gas with that of CO, according to authoritative sources. The following effects have been published:

1. According to Sax<sup>1</sup> "A concentration of 400 to 500 ppm in the air can be inhaled for one hour without appreciable effect. An hour's exposure to 600 to 700 ppm will cause barely appreciable effects and an exposure to 1,000 to 1,200 ppm is dangerous; concentrations of 4,000 ppm and over are fatal in less than an hour." Similar data are reported by Henderson and Haggard<sup>2</sup>.

2. Apparently NO is more toxic than CO. Sax states that concentrations of 60 to 100 ppm of this gas can result in serious physiological effects. Exposure to 200 to 700 ppm may be fatal, after even very short periods of time.

In the system used under this project to collect the product gases for analyses, atmospheric air is present in relatively small quantities. Consequently, NO remains as such in the gas sampling bulb. However, if NO is released into the air, nitrogen dioxide (NO<sub>2</sub>) is formed which converts to nitrogen tetroxide (N<sub>2</sub>O<sub>4</sub>) to some degree, depending on the ambient temperature. The NO<sub>2</sub> and the N<sub>2</sub>O<sub>4</sub> react with oxygen and moisture to form nitrous and nitric acid which are the actual irritants. According to Henderson and Haggard, the nitrogen oxide fumes are the most insidious of all irritant gases, because of a delayed reaction. A peculiarity of these fumes is that their irritant ---- (cont'd on next page).

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1. N. Irving Sax, "Dangerous Properties of Materials", Second Edition, Reinhold Publishing Corp., New York, 1963.
  2. Y. Henderson and H. W. Haggard, "Noxious Gases, and the Principles of Respiration Influencing Their Action". American Chemical Society, Monograph Series No. 35, The Chemical Catalog Company, Inc., New York, 1927.

effect occurs deep in the respiratory system while they are only slightly irritating to the mucous membranes of the upper respiratory tract.

Their warning power, therefore, is low so that the victim can breathe dangerous quantities before any discomfort is noticed. It is well known that carbon monoxide, being colorless and odorless, offers a special hazard. Care must be taken to monitor the NO concentrations in the product gases since elimination of NO is as important as the elimination of CO. Consequently, the pelleted P-1 propellant, which produces from seven to ten per cent NO and no CO, appears to be a particularly poor candidate for a non-toxic propellant system.

Examination of the experimental results obtained to date indicates that the HES 5808 composition which contains 84% ammonium perchlorate (AP) and 16% cellulose acetate binder and plasticizer produces less than one mole per cent of CO (NO percentage negligible). The HES 6573, on the other hand, which contains 84% potassium perchlorate (KP) and also 16% organic binder, (in this case Hycar rubber) produces up to five mole percent CO. At first it was believed that this difference was mainly attributable to the extra oxygen of the acetate binder. Calculations, however, indicate that the 84% AP corresponds to 17% more oxygen than the 84% KP which has a higher molecular weight. Furthermore, calculation of the product gas composition (assuming complete oxidation to CO<sub>2</sub>) indicates that the AP formulation produces 0.038 moles of gas per gram of propellant while the KP formulation produces only 0.018 moles of gas per gram of propellant. (KCl is assumed to be in a condensed phase). Any CO produced as a result of the presence of 16% organic material in the compositions would be magnified in the KP formulation when reported on a mole percent basis.

Preliminary information has been received about a series of new catalysts which may help to control the CO content of PAD propellant gases. Practically all available propellants contain C, O and H, and the following water-gas equilibrium exists in the product gas:



It has been reported that these catalysts shift this equilibrium away from the H<sub>2</sub>O and CO side toward the H<sub>2</sub> and CO<sub>2</sub> direction. Efforts are being made to obtain more detailed data on these materials.

• NEXT BI-MONTHLY PLAN:

• The M69 cartridge loaded with HES 5808 propellant and small percentages of igniter will be test fired and the product gas will be analyzed. The data obtained under this project will be summarized and correlated, conclusions and recommendations will be made and a final report will be initiated.

**TITLE:** Medium Performance Miniature Initiator

**JOB NO.:** C287

**PROJECT ENGINEER:** E. J. Doebly, 1747

**AUTHORIZATION:** MIPR AS 4-63

**INITIATION DATE:** November 1963

**ESTIMATED COMPLETION DATE:** November 1964

**OBJECTIVE:** To develop and qualify a cartridge for reducing the pressure output of the M27 initiator.

**INTRODUCTION:**

The M27 initiator was designed to produce sufficient pressure (approximately 1000 psi) at the end of 15 feet of rubber hose to actuate another PAD. Currently, this initiator is being installed in more complex escape systems and the hose lengths employed are considerably shorter. Also, a more efficient hose (Teflon) has been substituted for the rubber hose. As a result of these changes, excessive pressures have been developed. In some instances hose failure has occurred.

A new cartridge is being developed for the M27 initiator. This cartridge will produce a minimum of 1000 psi at the end of 8 feet of size four Teflon hose and will not exceed 6000 psi when used with six inches of the hose.

**PROGRESS:**

Charge development has been initiated. Three different gradations of Potassium Nitrate type 20 grains were selected. These are: 2K granules (spherical) having particle size ranging between 4 and 50 mesh (U.S. standard size) and composed of potassium nitrate, boron and tetrahydrocarbazole binder; 2D granules (cylindrical with convex ends) having 0.125 inch diameter and 0.130 inch overall thickness and composed of potassium nitrate and boron intimately blended with iodine as a binder; 2R granules which are identical in composition and shape to the 2D granules but have 0.125 inch diameter and 0.115 inch overall thickness.

For the initial firings approximately 2.5 grams of each type of granulation were loaded into M91 cartridge cases. Six firings were conducted with each granulation, three with six inches of size four Teflon hose and three with 8 feet of size four Teflon hose. A pressure chamber with a volume of 0.06 cubic inches was used. Data obtained is shown in Table I; typical curves are shown in Figures 1 and 2.

The results of the preliminary firings indicated that the desired performance could be obtained with the ignition granules.

To ascertain the amount of propellant required, a charge development program was conducted. Charge weights of 1.75, 2.0 and 2.25 grams for both the 2D and 2R grain size were selected. Three firings of each combination were conducted using eight feet of Teflon hose and the 0.06 cubic inch pressure chamber. The data obtained are presented in Table II.

The data obtained for both the 2D and 2R granulation are presented graphically in Figure 3. The pressure is a linear function of the charge weight as expected. From this graph a charge weight and granulation will be selected and tests will be conducted at the temperature extremes.

TABLE I.

<u>Firing No.</u>	<u>Grain Size</u>	<u>Hose Length</u>	<u>Maximum Pressure (psi)</u>	<u>Time (ms)*</u>
1	2K	8 ft.	5430	7
7	2K	8 ft.	5770	8
4	2K	6 in.	9090	..**
10	2K	6 in.	8700	..**
3	2R	8 ft.	3550	22
9	2R	8 ft.	3500	20
6	2R	6 in.	6670	23
12	2R	6 in.	6570	23

TABLE I. (Cont'd)

<u>Firing No.</u>	<u>Grain Size</u>	<u>Hose Length</u>	<u>Maximum Pressure (psi)</u>	<u>Time (ms)*</u>
2	2D	8 ft.	3240	35
8	2D	8 ft.	2870	33
5	2D	6 in.	6040	30
11	2D	6 in.	5660	30

\*Time from initial rise to maximum pressure in the pressure chamber.

\*\*Hose ruptured.

NOTE: All firings conducted at 70° F.

TABLE II.

<u>Firing No.</u>	<u>Charge Weight (gms)</u>	<u>Maximum Pressure (psi)</u>	<u>Time (ms)</u>
	<u>2R Grain Size</u>		
5	1.75	2060	28
11	1.75	NR	NR
17	1.75	1930	25
3	2.00	2430	23
9	2.00	2390	23
15	2.00	2310	20
1	2.25	2900	23
7	2.25	2710	25
13	2.25	2950	23

TABLE II. (Cont'd)

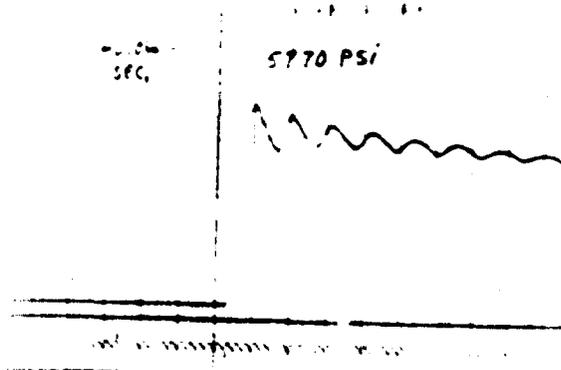
<u>Firing No.</u>	<u>Charge Weight (gms)</u>	<u>Maximum Pressure (psi)</u>	<u>Time (ms)</u>
	<u>2D Grain Size</u>		
6	1.75	1780	38
12	1.75	1760	33
18	1.75	1640	40
4	2.00	2110	38
10	2.00	2010	28
16	2.00	2070	30
2	2.25	2530	38
8	2.25	2620	38
14	2.25	2560	35

NR - No Record.

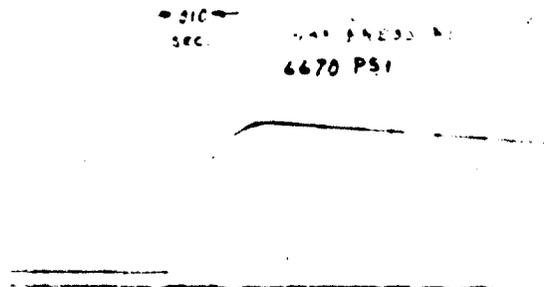
**NEXT BI-MONTHLY PLAN:**

Development firings will continue. Firings will be conducted at the temperature extremes of -65° F and 200° F. Various hose lengths will be used.

**No. 1. Pressure-Time Trace for 2K Granules  
and 8 Feet of Teflon Hose**

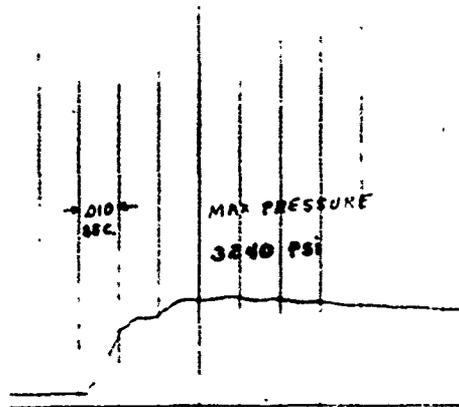


**No. 2. Pressure-Time Trace for 2R Granules  
and 8 Feet of Teflon Hose**

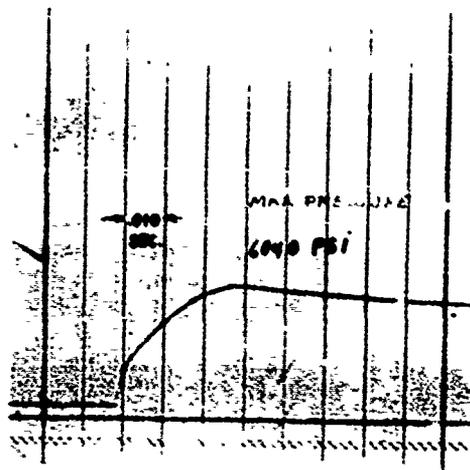


**No. 3. Pressure-Time Trace for 2R Granules  
and 6 Inches of Teflon Hose**

**Figure 1. Typical P-T Traces for 2K and 2R Granules  
and Teflon Hose (3 Rds)**



No. 4. Pressure-Time Trace for 2D Granules and 8 Feet of Teflon Hose



No. 5. Pressure-Time Trace for 2D Granules and 6 Inches of Teflon Hose

Figure 2. Pressure-Time Trace Obtained from Firing of Gas Operated Disconnect

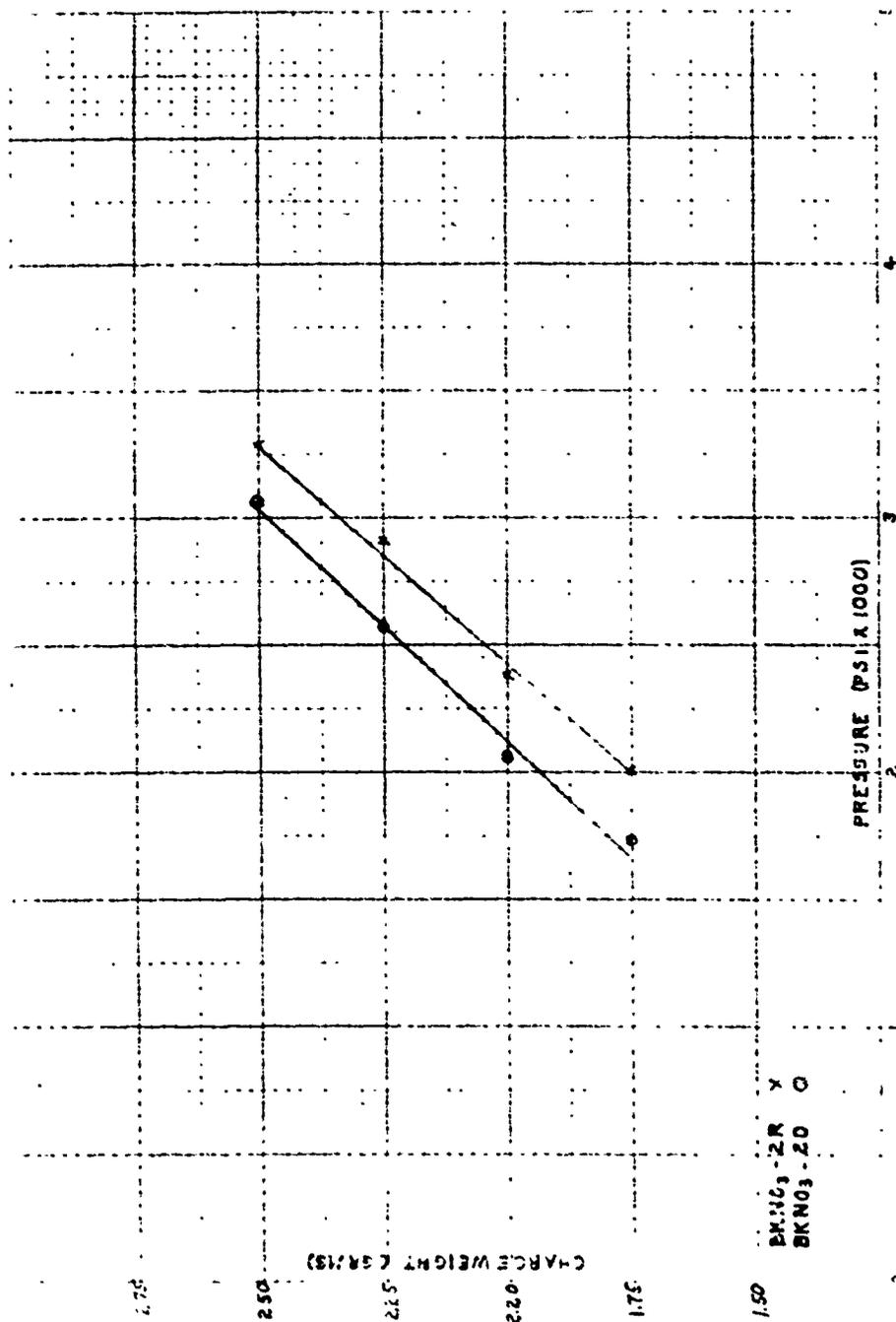


Figure 3. Charge Weight Versus Pressure for BKNO<sub>3</sub> Ignition Granules when used with the M27 Initiator and Eight Foot Size 4 Teflon Hose

**TITLE: Improvement of PAD to Eliminate or Minimize Toxic Propellant Gases**

**PROJECT NO.: C288**

**PROJECT ENGINEER: J. F. Clark, 1450**

**AUTHORIZATION MIPR AS-4-64**

**INITIATION DATE: December 1963**

**COMPLETION DATE: January 1964**

- OBJECTIVE:**
- a. To determine means of eliminating or minimizing the toxic constituents of PAD propellant gases which will be applicable to the development of replacement charges for the M80, XM88 and XM89 initiators.
  - b. To improve the design of XM87, XM88, XM89 and XM80 initiators and conduct a qualification program for each, using improved low toxic propellant developed under job no. C284.
  - c. Conduct system tests to verify performance and determine concentration of propellant gases in escape capsule.

**PREVIOUS P1-MONTHLY SUMMARY:**

None. New Project.

**INTRODUCTION:**

In the initial development of the emergency escape capsule for the B58 aircraft, "off-the-shelf" PAD were utilized. These standard PAD were not completely leakproof items. Since the products of combustion are dispersed in an unlimited atmosphere in the usual escape installation, gas tight designs are not a normal PAD requirement.

In the B58 system, however, a number of PAD initiators are contained within the pressurized capsule. Here leakage definitely presents a toxic hazard to personnel because it contaminates the very limited

volume of air within the capsule during the ejection and recovery phases. Additional seals were incorporated in the standard units to improve this condition.

Another problem encountered during the capsule development program was leakage and rupture of hoses, tubing and fittings in the propellant gas transmission system. Replacement of the composite propellant in the miniature initiators with single base M10 propellant greatly reduced transmission line failures and attendant leakage.

With these design changes, toxic gas leakage was reduced to an acceptable level. The measures taken to improve the leakage conditions, i. e., additional seals and propellant replacement in standard initiators, were interim solutions dictated by the tight delivery requirements and "crash" nature of the capsule development program.

Since completion of the capsule development, the B58 Systems Project Office has authorized Frankford Arsenal to develop propellant systems which minimize or eliminate the toxic constituents in PAD propellant gases. The utilization of such propellants in the B58 capsule initiators is the immediate program objective. This task, Job C284, "Improvement of PAD to Eliminate or Minimize Toxic Propellant Gases," is now in progress.

#### PROGRESS:

It is planned under the program described herein to review present B58 initiator and cartridge designs, and where feasible to incorporate design changes which improve their sealing characteristics. The propellant systems of reduced toxicity established under Job C284 will be used in the development of the basic systems for these devices.

Upon completion of the development, system tests will be conducted in B58 capsules to verify performance and determine concentrations of toxic gas.

Qualification of initiators to replace the M86, XM87, XM88 and XM89 initiators will be accomplished unless the redesign of such magnitude that hardware costs become prohibitive. In this event, a reduction in the number of units that can be qualified may be necessary.

Program planning was completed upon receipt of an approved work statement from the Aeronautical Systems Division, and work commenced in December 1963.

A review of the sealing characteristics of the present initiator designs is in progress.

Test program requirements (TPR) are being established, and procurement of hardware for ballistic charge development has been initiated.

Initial contact has been made with General Dynamics and the Denver Air Procurement District to obtain two B58 capsules for program use.

**NEXT BI-MONTHLY PLAN:**

Complete arrangements for obtaining capsules.

Complete TPR and hardware procurement for ballistic charge development.

Start charge development when a non-toxic propellant is selected from Job C284.

**TITLE:** Development of Ballistic Reel

**JOB NO.:** C290

**PROJECT ENGINEER:** C. Miller, 1450

**AUTHORIZATION:** MIPR AS-4-63

**INITIATION DATE:** December 1963

**ESTIMATED COMPLETION DATE:** December 1964

**OBJECTIVE:** To design and develop a propellant actuated device to wind in the harness belt on the inertia reel.

**INTRODUCTION:**

In a military aircraft seat system the inertia reel is attached to the harness of the seat occupant. It is designed to permit normal free movement, and locking under suddenly applied loads. The lock is mechanically released after the "g" loads subside. However, prior to ejection, the occupant must be properly positioned irrespective of "g" loading, i. e., the reel must be completely retracted by an independent power system. There are several satisfactory inertia reels used and it is the objective of this project to develop a propellant gas operated positioning feature which can be added to an acceptable inertia reel. Specifically, this power feature will be added to a Pacific spool type (Model No. 0101 series) harness reel. The operation of this power feature could be sequenced to the regular ejection system.

**PROGRESS:**

Feasibility studies have been initiated to develop systems whereby a power unit could be added to an inertia reel. The high "g" loads plus the minimum spatial factor add complexity to the solution of a compatible design. Several tentative design approaches are currently being evaluated.

**NEXT BI-MONTHLY PLAN:**

Analytical studies and evaluations will continue in resolution of a workable gas powered operated inertia reel.

**TITLE:** Gun Launched Rocket

**JOB NO.:** C291

**PROJECT ENGINEER:** F. Pisano, 1462

**AUTHORIZATION:** MIPR AS-4-63

**INITIATION DATE:** December 1963

**COMPLETION DATE:** November 1964

**OBJECTIVE:** Investigate and determine technical feasibility of a gun-launched rocket seat ejector for personnel emergency escape systems.

**PREVIOUS BI-MONTHLY SUMMARY:**

None. New project.

**INTRODUCTION:**

A catapult or rocket catapult is employed in personnel emergency escape system to eject the seat-man from the aircraft. The rocket catapult is the preferred ballistic system because it has a longer operating time period and hence greater seat-man altitude is attained. This device contains two ballistic systems, catapult propellant and its ignition system and a rocket grain and its ignition system. This device is operated by firing the catapult portion and subsequently the rocket motor.

The integral ballistic systems comprise a complicated device from both mechanical and pyrotechnic considerations. The desired qualities of this system are longer operating time period and the additional impulse supplied by the rocket portion.

Assuming that performance characteristics of the device can be very nearly duplicated by inserting the rocket motor into a gun tube, the design would be significantly simplified mechanically and ballistically. This design advance would also effectively increase the functional reliability.

**PROGRESS:**

Plans and a work statement have been finalized.

**NEXT BI-MONTHLY PLAN:**

Design studies will be initiated for determination of ideal physical characteristics of the gun.

**TITLE:** Rocket Altitude Sensing and Thrust Direction Control

**JOB NO.:** C292

**PROJECT ENGINEER:** G. Meranshian, 1450

**AUTHORIZATION:** MIPR ASD 4 63

**INITIATION DATE:** November 1963

**ESTIMATED COMPLETION DATE:** November 1964

**OBJECTIVE:** To conduct a study for a fully automated emergency escape system using a computer in conjunction with the aircraft navigational system.

**PREVIOUS MONTHLY SUMMARY:**

None. New Project.

**INTRODUCTION:**

With the advent of higher speed manned aircraft whose tactical missions involve increasingly hazardous flight profiles, the need for completely automated ejection systems becomes essential. It is the purpose of this project to define and theoretically resolve the problems of successfully implementing such a system. It will be the intent to monitor this system and to tailor the design of the system components for universal application. Also maximum consideration will be given to retrofitting features for current systems whose performance may now or eventually demand such flight safety.

**PROGRESS:**

A meeting was held with Republic personnel on the possible use of the F105 aircraft as a research tool for the study. Republic personnel stated a pyrotechnic gyro is available weighing one pound, about the size of a softball. The gyro would require a 20ms time delay prior to operation and would be accurate for one minute. Therefore this gyro would be adequate for a personnel escape system. Republic will investigate the price and availability of this gyro. A power source would be required to amplify the gyro signal. There are

many types of batteries available which are suitable for this system, that can be charged from the main power source prior to use. The battery package would weigh approximately one pound. A direct current servo system would be required for operation of the linkage for nozzle orientation. This unit would weigh about one pound. A linkage would be required to rotate the nozzle. The nozzle should be designed to rotate in two planes (pitch and roll) in order to orient the seat in the proper escape trajectory. Republic suggested other alternate methods, i. e., stabilizing the seat by having two thrust jets at the seat extremities, (propellant gas would be supplied by a generator to accomplish the required impulse for the thrust jets); and proper nozzle angle accomplished by a digital computer from input information of the gyro signal.

**NEXT BI-MONTHLY PLAN:**

1. To contact ASD for guidance.
2. To continue survey of components for this study.

**TITLE:** Development of Twenty-Man Life Raft Inflator

**JOB NO.:** C293

**PROJECT ENGINEER:** R. Sutter, 1450

**AUTHORIZATION:** ACMS 4110.16.8500.1.69  
ACMS 4110.16.8500.1.50  
MIPR AS-4-63

**INITIATION DATE:** March 1963

**ESTIMATED COMPLETION DATE:** March 1964

**OBJECTIVE:** To design, fabricate and perform engineering development tests on a cool gas generator capable of inflating the Air Force twenty-man life raft.

**PREVIOUS REPORT:**

None. New project.

**INTRODUCTION:**

The feasibility of inflating life rafts using chemically cooled propellant gas has been proven with the development of the XM18 gas generator for inflating the one-man life raft. Preliminary studies indicate that a cool gas generator for inflating the twenty-man life raft is feasible and would weigh about 5 lbs less and inflate the raft in less time than the CO<sub>2</sub> system now used.

**PROGRESS:**

Design studies were initiated for a test generator that would be suitable for a charge development program for inflating the 20-man life raft. Of the several design concepts studied, one was the concentric chamber design as used for the one-man life raft. Preliminary calculations have indicated that a weight saving of approximately 15% over present systems could be realized with this design.

Another design concept under consideration was a single cylinder or tube device with a floating piston between the propellant chamber and the coolant chamber. The propellant gas is bled through

a control orifice located in the piston, gas pressure on this piston in turn places the coolant under compression and prevents channeling of the coolant. A weight saving of approximately 30% over present CO<sub>2</sub> system could be realized using this design.

Feasibility of this type design has been established on project C431, "Development of 3-Man Life Raft Inflator".

**NEXT MONTH'S PLAN:**

Complete design studies and review the design with ASD personnel.

DEPUTY FOR SYSTEMS ENGINEERING  
DIRECTORATE OF OPERATIONAL SUPPORT ENGINEERING  
CREW EQUIPMENT DIVISION  
PARACHUTE BRANCH

TITLE: Development of a Heavy-Duty Pyrotechnic Delay Reefing  
Line Cutter

JOB NO.: C230

PROJECT ENGINEER: L. Triscob, 1440

AUTHORIZATION: USAF P.O. (33-600) 59-197

INITIATION DATE: September 1959

ESTIMATED COMPLETION DATE: Not Determined

OBJECTIVE: To redesign and develop delay cartridges and a  
heavy-duty reefing line cutter.

PREVIOUS BI-MONTHLY SUMMARY:

The ability of the M9 Reefing Line Cutter to resist  
high "g" forces (to 500 g) was demonstrated.

PROGRESS:

Four hundred and fifteen (415) M129 cartridges (2 sec  
delay) have been assembled. Fifteen of this group were fired in M9  
Reefing Line Cutters for lot acceptance tests. Results are shown in the  
following table.

TABLE .. M129 CARTRIDGE DELAY TESTS

Lot FA-X1

<u>Round</u>	<u>Ser.</u>	<u>Temperature</u>	<u>Delay Time (Sec)</u>
1	133	70.0	1.988
2	171	70.0	1.946
3	81	70.0	1.750
4	69	70.0	1.940
5	125	70.0	2.073

TABLE I. (Cont'd)

<u>Round</u>	<u>Ser.</u>	<u>Temperature</u>	<u>Delay Time (Sec)</u>
6	59	-65° F	2.101
7	70	"	2.229
8	122	"	2.304
9	123	"	2.337
10	129	"	2.122
11	56	70° F	2.063
12	87	"	1.990
13	66	"	1.814
14	117	"	1.680
15	55	"	1.960

This data shows that the delay time of 2 sec.  $\pm 20\%$  was met over the extreme temperature range of -65° F to 160° F. It is also noted that one firing (test #14) failed to meet the required limit of 2 sec.  $\pm 10\%$  in the temperature range of 20° F to 120° F. Present state of the art of manufacturing pyrotechnic delays makes deviations of this magnitude unavoidable.

Two hundred each of these M129 cartridges have been shipped to WPAFB Attn: Mr. Varble; two hundred each have also been shipped to Natick Laboratories Attn: Mr. Barnicle.

**NEXT BI-MONTHLY PLAN:**

Assemble and ship 100 ea. M129 and 300 ea. M133 Cartridges to WPAFB.

Assemble and ship 300 ea. M129 Cartridges to Natick Laboratories.

AIR FORCE WEAPONS LABORATORY

KIRTLAND AIR FORCE BASE

**TITLE:** Development of a Bomb Ejector Cartridge for MAU-12/A  
Bomb Rack

**JOB NO.:** C294

**PROJECT ENGINEER:** G. P. Catrambone, 1430

**AUTHORIZATION:** Project Order - AF(29-601)-64-PO-5

**INITIATION DATE:** November 1963

**ESTIMATED COMPLETION DATE:** November 1964

**OBJECTIVE:** To develop an electroexplosive bomb ejector cartridge for operation of the MAU-12/A universal bomb rack.

**PREVIOUS BI-MONTHLY SUMMARY:**

None. Initial report.

**INTRODUCTION:**

In bomb rack design, several means may be employed to unlatch the store carrying hooks. Primary among these methods is the use of solenoids, springs, and electroexplosive cartridges. An electroexplosive cartridge was selected for the MAU-12/A bomb rack because a cartridge can provide the energy for the functions of release and forced ejection. It also affords a higher degree of simplicity and will optimize reliability and nuclear safety. In addition, a cartridge operated ejection system was considered mandatory due to the very high ejection forces anticipated for future systems.

In 1956 Frankford Arsenal began a laboratory investigation on the nature and hazards of propellant exposed to high temperatures. In the early phases of this program, it was found that degradation of propellant occurs in two danger zones. A propellant study was undertaken with several selected objectives.

The high temperature propellant work accomplished under this program was related to various small grain geometry. It was concluded that the PAD (Propellant Actuated Devices) demonstrated their ability to perform satisfactorily after being exposed to 400° F for four (4) hours.

Other propellant studies now under way relate to improving the performance of existing PAD through the use of new propellants and to investigation of the use of high density propellants.

#### PROGRESS:

In November 1963 the A. F. Special Weapons Command (AFSWC) assigned Frankford Arsenal the project of developing an electroexplosive cartridge for use in the MAU-12/A bomb rack. This initial report covers the effort directed toward the development of this cartridge.

A plan for the project was prepared and approved. Inquiries were made on a new technique for sealing a cartridge. This new process of Ultra-sonic welding is known as "Ring-Seal". This technique appears to have many advantages over other methods presently used, and since this process would be particularly applicable to this cartridge, it is intended to investigate this technique further.

An initial design study is being conducted. The physical size and location of the ignition element has not as yet been established. Upon receiving this information from Kirtland AFB (KAFB), a preliminary assembly drawing of the electroexplosive cartridge will be prepared.

A propellant survey is being conducted regarding the selection of a high temperature propellant having relatively clean burning and noncorrosive characteristics. The erosion shall not exceed that resulting from use of the ARD-440 cartridge.

Several firings were conducted to determine the high pressure stability and pressure variation with loading density for B-KNO<sub>3</sub> - 2D pellets. A miniature type initiator was utilized for these tests because of the ease in handling and the smaller volume which required less propellant per test. At a loading density of 7.4 gms/in<sup>3</sup>, the maximum pressure recorded was 14300 psi; at this pressure the chamber bulged and finally a pin size hole developed. As a result of the limited number of firings conducted it is determined that the B-KNO<sub>3</sub> pellets were stable at 10,000 psi. The reconditioned initiators appear to have a useful test pressure range of approximately 10,000 psi when using B-KNO<sub>3</sub>; therefore, tests with this type of igniter will be conducted with the actual hardware to determine later date.

**NEXT BI-MONTHLY PLAN:**

1. Continue propellant survey.
2. Prepare preliminary design.

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