

ADP 43905

NOLTR 72-95

EXPLOSIVES FOR LUNAR SEISMIC PROFILING  
EXPERIMENT

By  
Carroll C. Misener

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NAVAL ORDNANCE LABORATORY, WHITE OAK, SILVER SPRING, MARYLAND

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Naval Ordnance Laboratory Silver Spring, Maryland		20. REPORT SECURITY CLASSIFICATION Unclassified	
20. GROUP			
3. REPORT TITLE Explosives for Lunar Seismic Profiling Experiment (U)			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)			
5. AUTHOR(S) (First name, middle initial, last name) Carroll C. Misener			
6. REPORT DATE 15 May 1972		7a. TOTAL NO. OF PAGES 15	7b. NO. OF REFS --
8a. CONTRACT OR GRANT NO.		9a. ORIGINATOR'S REPORT NUMBER(S) NOLTR 72-95	
b. PROJECT NO. NOL Task NOL-998/NASA		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
c.			
d.			
10. DISTRIBUTION STATEMENT Approved for public release; distribution unlimited.			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY National Aeronautics and Space Administration, Washington, D. C.	
13. ABSTRACT (U) This report describes the procedures involved in the preparation of explosive charges for use in the seismic studies conducted on the surface of the moon. It deals with the scaling up of the blending of materials for the inert simulant as well as the HNS/Teflon explosive. It describes the pressing, machining and assembling of the charges into hardware furnished.			

Details of illustrations in this document may be better studied on microfiche

**UNCLASSIFIED**

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Explosive - Temperature Resistant						
Blending						
Charge Preparation						
Lunar Seismology						
HNS/Teflon						

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Prepared by:  
Carroll C. Misener

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NOLTR 72-95

15 May 1972

Explosives for Lunar Seismic Profiling Experiment

(U) This report describes the fabrication of explosives for the LSPE project, including inert charges and explosive charges for preliminary testing. This work is supported by NOL Task NOL-998/NASA.

ROBERT WILLIAMSON II  
Captain, USN  
Commander

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By direction

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## INTRODUCTION

The technical objective of this project was to prepare explosive charges for use in studying the seismic structure of the moon. This was to be approached by making combinations of HNS and Teflon and incorporating them into molded explosive charges capable of surviving 150°C and the atmosphere of the moon's surface. These charges were to be assembled into NASA supplied S and A devices and assessed for safety and reliability. If found safe and reliable they were to be tested for environment and rough handling, field tested for performance and qualified for carrying on an Apollo moon flight. If found unsafe or unreliable, a new S and A device was to be designed.

## BACKGROUND

NOL has determined, through previous work with NASA, that HNS/Teflon 90/10 is acceptable for aerospace applications. Apollo XIV carried a set of seismic charges which were placed on the moon to be fired at some later time.

The work covered in this report is part of a more advanced active seismic experiment with a different method of deployment of the charges. NOL has completed the design of the explosive charges and they have been approved by NASA. A new S and A device has been designed because the S and A from the ALSEP program was not sufficiently reliable. Physical properties of HNS/Teflon were measured and an inert simulant with similar properties of interest was developed. Standard operating procedures and the necessary specifications were prepared. Arrangements were made for environmental tests at the Naval Weapons Laboratory, Dahlgren, Va., and assistance was provided in preparation for the field tests.

This document is particularly concerned with the scaling up of the blending operations, the fabrication of the molded inert and explosive charges, and the inspection and assembling of the charges into the hardware furnished by the NASA contractor.

## EXPERIMENTAL PROCEDURE

There were six sets of charges required. Two sets were to be made of inert material for various tests of a physical nature. The four sets of explosive material were two prototype, one qualification and one for flight on the Apollo. Each set consists of two 1/8-pound charges, two 1/4-pound charges, one 1/2-pound charge, one 1-pound charge, one 3-pound charge, and one 6-pound charge (Figure 1). The six pound charge was to be cubical in shape, and all others cylindrical.

### 1. Blending

A good blend of several powders may be obtained with small quantities by confining them in a closed cylinder and rolling the container. When rolled at the proper speed the powders are thoroughly



mixed by being carried up the surface of the cylinder and rolling and tumbling over each other down the pile until they meet the surface of the container again. The time for thorough blending is dependent on the relative size of the particles and their tendency to agglomerate or "ball-up". It is sometimes necessary to introduce heavy spheres of a hard substance to break up this "balling" action. Ceramic balls are usually quite effective.

Scaling up to larger quantities presents a few problems. A large quantity of material in a large drum has a tendency to ride up the side of the drum and slide down over and over again, rather than roll and tumble over itself. It has been found that baffles set at regular intervals on the inside surface of the drum pick up the powders and drop them in a spreading action onto the opposite or bottom side. The mixing thus is more thorough and much more rapid. There is still some balling action and ceramic or steel balls are effective in breaking it up. When explosives are being blended the abrasive action of ceramic balls or the possibility of an impact problem with steel might cause a safety hazard. In this case materials such as nylon or teflon may be used.

### 1.1 Inert Simulant

In order to produce charges of similar physical properties to the explosive three powders were blended together: Melamine 10%, Teflon 2%, and Vinylidene Fluoride Resin 6%. Attempts to get a homogeneous blend in a smooth drum were unsuccessful, but with the baffled drum (Figure 2) the resulting blend passed the necessary tests. Ceramic balls were used to prevent agglomeration. Detailed procedure is recorded in Appendix A.

### 1.2 PBXW-1 (HNS/Teflon 90/10)

Based on results with the inert materials the baffled drum was used for all the explosive blending. Teflon cylinders were used instead of ceramic balls to prevent agglomeration. Using the technique employed with the inert materials sufficient molding powder was blended to produce the required charges. Details are recorded in Appendix B.

## 2. Isostatic Pressing

It was required that these charges have a very uniform density and that they be entirely free of cracks. Cylindrical pellets pressed in a regular hydraulic press to a pressure of over 10,000 psi have a great tendency to crack (at least internally) and usually on shear lines from the corners. The density varies from the end to the middle due to the movement of the rams. In the isostatic press (Figure 3) the molding powder is packed into a rubber mold, the air evacuated, and the loaded mold immersed in the liquid pressing medium. The fluid is subjected to the proper pressure, compacting the molding powder from all directions at once. This provides a pellet of extremely uniform density and a minimum tendency to cracks. The

resulting pellet must be machined to the proper dimensions, but this poses no unusual problems.

Both the inert and the explosive charges were made of pellets pressed isostatically. The explosive powder required 30,000 psi and the inert powder 20,000 to 25,000 psi to obtain charges of the required density. Detailed pressing procedure is outlined in Appendix C.

### 3. Machining

Pressed pellets are machined by methods similar to those used on metal castings. The rough cylinders are cut to approximate length on the bandsaw (Figure 4), diameters are turned on the lathe (Figure 5), and flat surfaces are finished on the milling machine (Figure 6). Speeds and feeds are slightly faster on pressed powders than on denser materials, and care must be taken not to use too much pressure with holding devices. Cutting tools are very much the same as those used on metals. The required charges were made on these machines following the standard procedures outlined in Appendix D.

### 4. Inspection and Assembling

The dimensions and weights of all charges were required to be checked with certified instruments under direction of NASA and contractor personnel. All charges were x-rayed to ascertain that there were no cracks.

The charge containers were supplied by the contractor. Each cylindrical charge was inserted in a hole in flexible foam held in the container by the cover. The cubical charge was held in place by potting compound at the corners. The potting compound was applied by means of an air operated syringe while the charge was held down to the proper height. This height had to be maintained while the compound cured over night.

### CONCLUSION

A satisfactory method of blending the materials for both the inert charges and the explosive charges was developed. The required quantities of inert and explosive molding powders were blended. The necessary charges were made by isostatically pressing the powders, and machining the pellets. All charges successfully passed the inspection and were made ready for delivery.

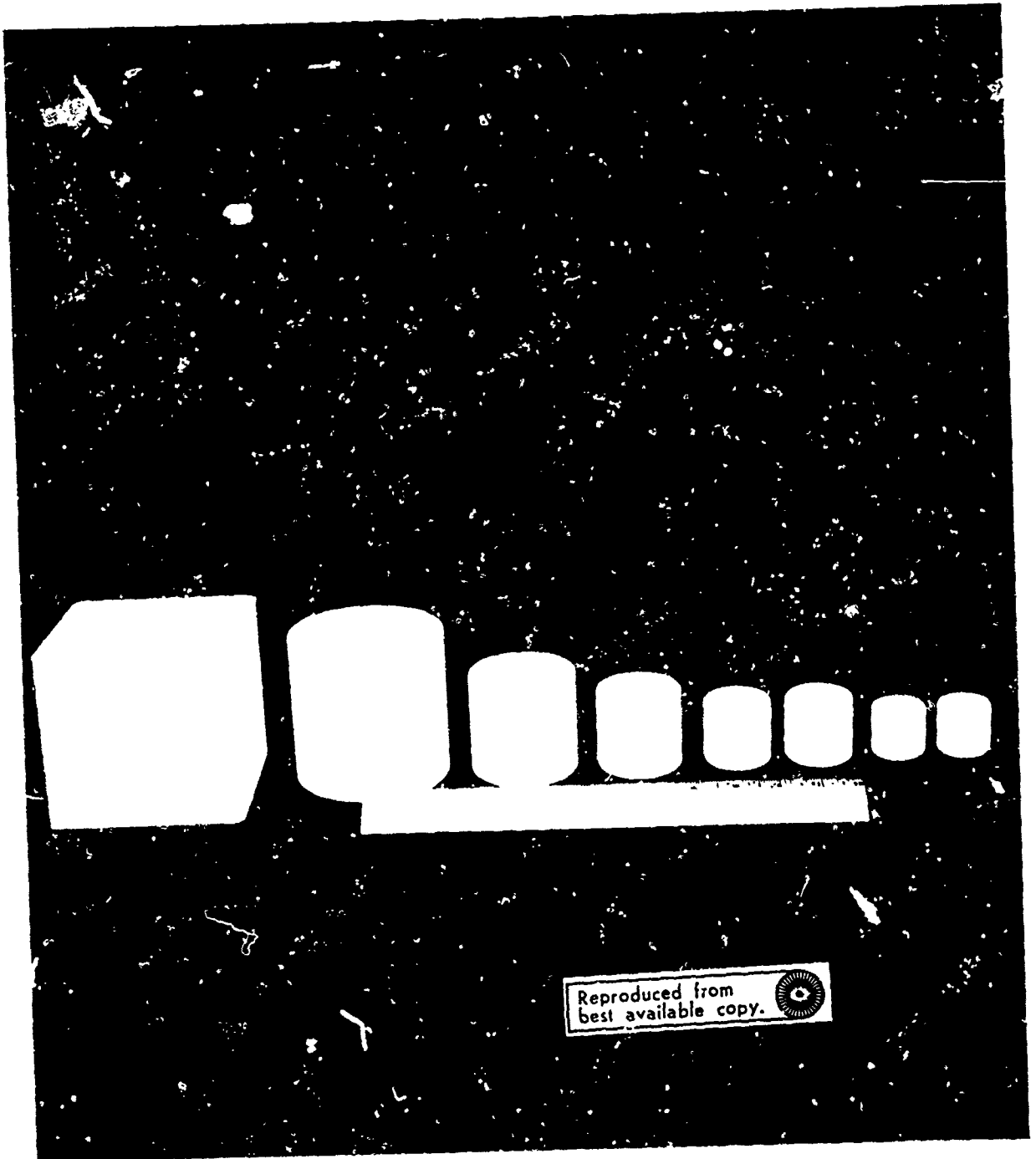


FIGURE 1 EXPLOSIVE CHARGES

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FIGURE 2 BAFFLED DRUM AND ROLLER

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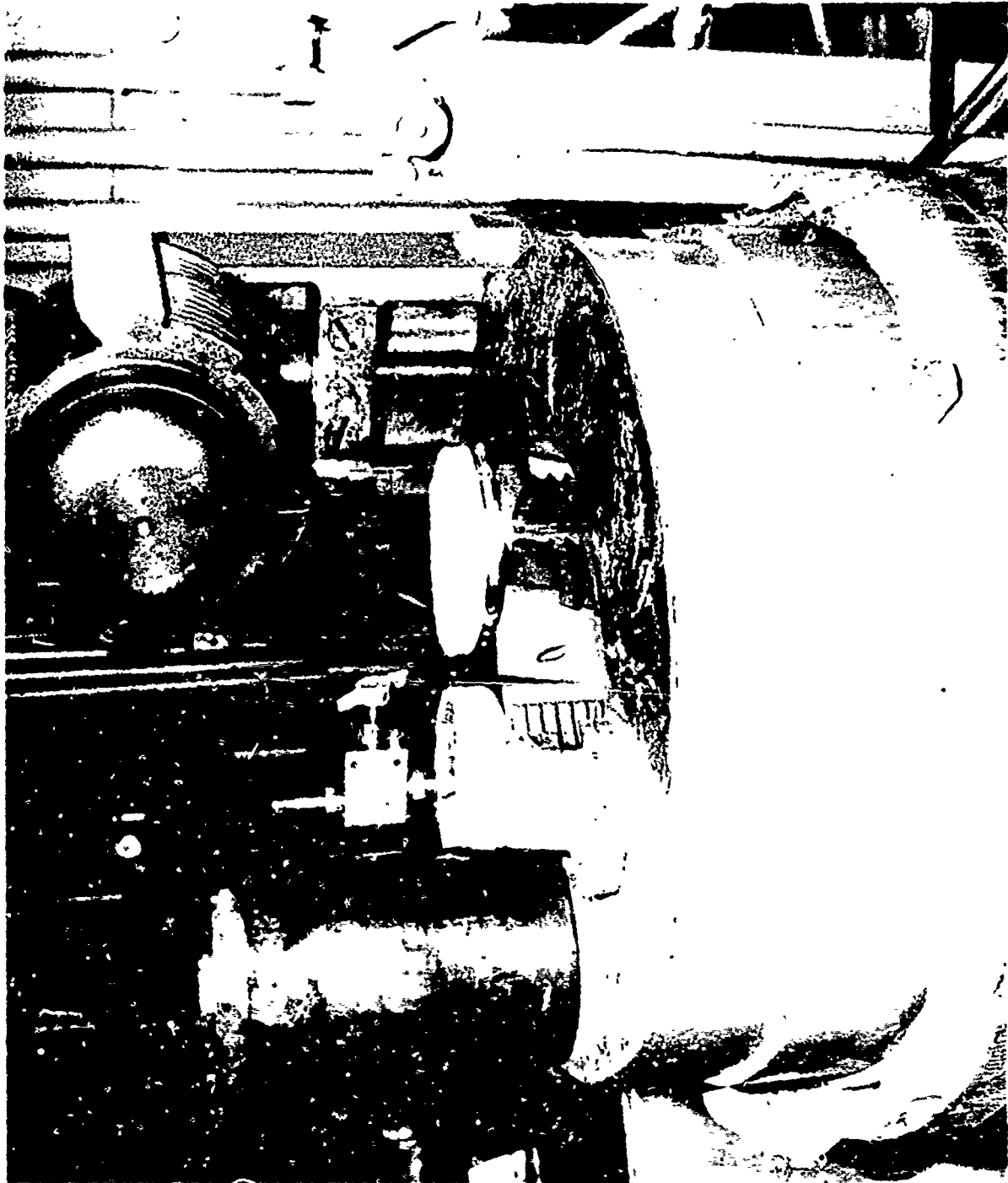


FIGURE 3 ISOSTATIC PRESS AND RUBBER MOLD

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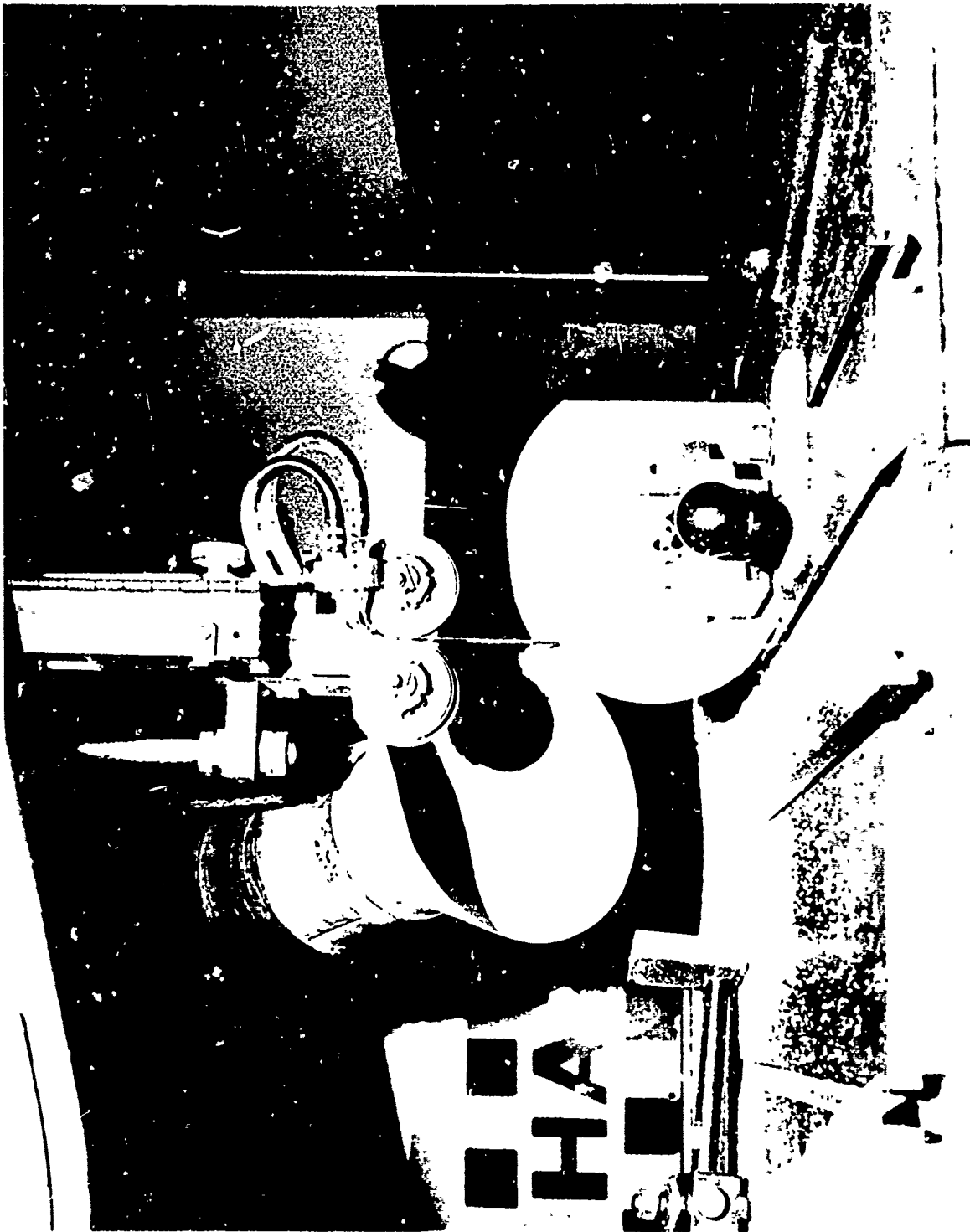


FIGURE 4  
BANDSAW

FIGURE 4 BANDSAW

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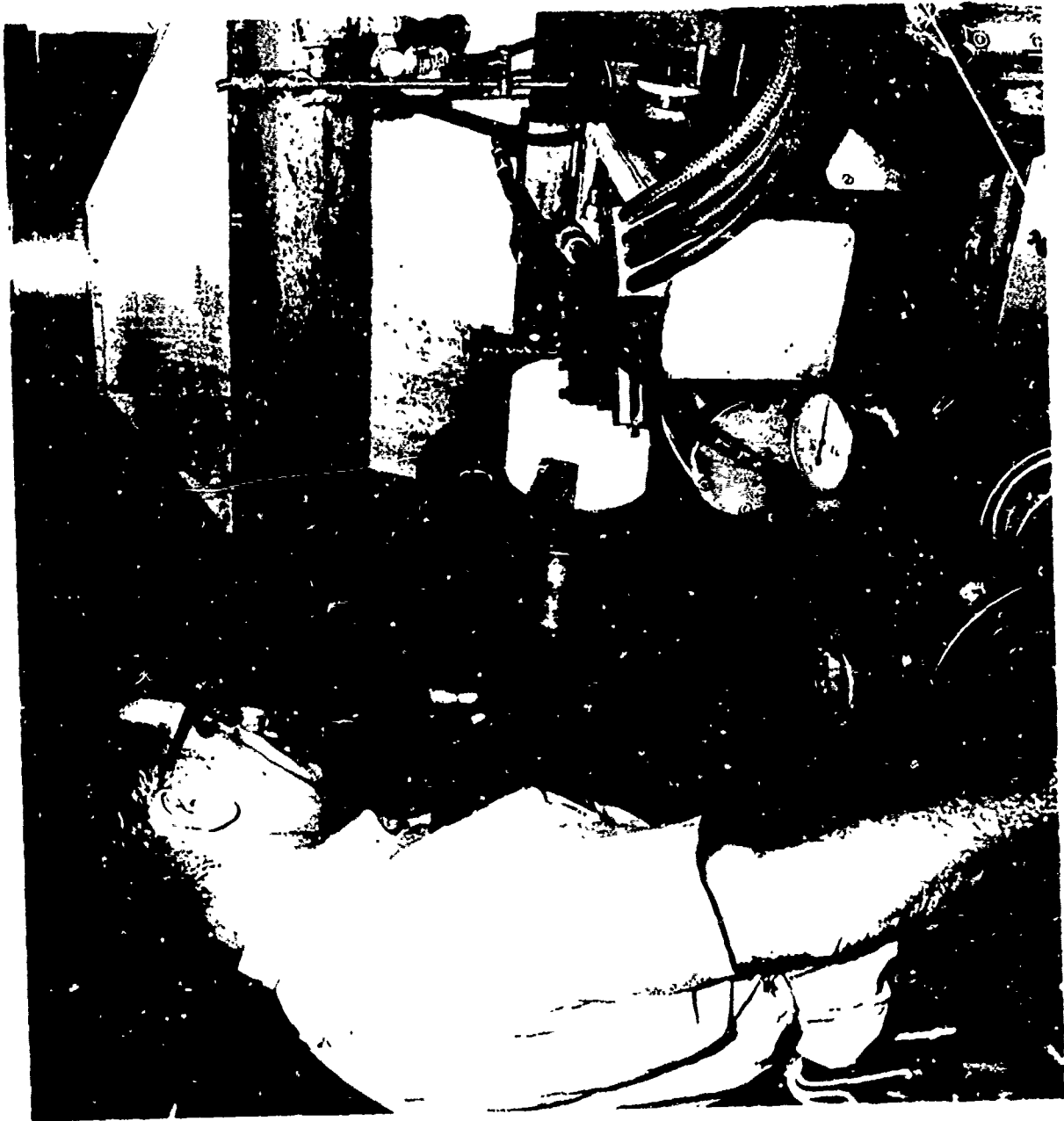


FIGURE 5 LATHE

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FIGURE 6 MILLING MACHINE



APPENDIX A  
PREPARATION OF INERT SIMULANT

1.0 Purpose - It is the purpose of this document to outline a suggested method of preparing an inert simulant for PBXW-1 (HNS-II/Teflon - 90/10).

2.0 Scope - This procedure only covers the blending together of dry ingredients to produce a molding powder suitable for the manufacture of inert charges having physical characteristics similar to PBXW-1.

3.0 Equipment Identification

Triple Beam Balance - Ohaus - Capacity 2610 g.

Double Beam Balance - Ohaus - Capacity 16 Kg.

Blending Drum - Capacity 55 gal.

Barrel Roller

4.0 Procedure

1. This procedure provides for a 75 pound (34 kg) batch of inert simulant consisting of:

Melamine (Eastman 1540; lot #702-1)	10.0 ± 0.5%
Teflon (DuPont 7C; lot #10001)	24.0 ± 0.5%
Vinylidene Fluoride Resin (Pennwalt RC 2525; Grade 301; lot 69 0579)	66.0 ± 0.5%

The blending drum is a stainless steel cylinder 22½" diameter, 33-3/4" long, with 5" wide baffles 120° apart running lengthwise the entire length of the drum. It is rotated at 11 rpm.

2. With a separate scoop for each material, the ingredients are weighed into polyethylene bags (or directly into the blender):

3400 g Melamine  
8160 g Teflon  
22440 g Vinylidene Fluoride Resin (VFR)

3. To aid in breaking up and/or eliminating lumps, 208 1" diameter ceramic balls are added to the ingredients in the drum.

4. The blender is closed and placed on the roller and rotated for 8 hours. It is stopped twice during this blending period and turned end over end 6 times to make sure no material has isolated itself on the ends of the drum and not become blended.

5. The drum is removed from the roller in a horizontal position and the lid removed. Representative samples are taken from both ends and the middle of the drum to be used in physical and thermal tests and chemical analysis. The blended powder is loaded into moisture proof containers.

6. The blender, hand tools, and the area are cleaned with soap and plenty of water and the blender rinsed with acetone.

#### 5.0 Special Instructions

5.1 Safety - Because the ingredients are finely divided and slightly toxic, an appropriate respirator should be worn at all times during weighing, loading and unloading the blender. Good ventilation is required.

APPENDIX B

PREPARATION OF HNS/TEFLON 90/10 (BLENDING PROCEDURE)

1.0 Purpose - It is the purpose of this document to outline a suggested method of blending the HNS and Teflon to make an adequate molding powder.

2.0 Scope - This procedure covers only the blending of HNS-II and Teflon 7C to make a molding powder for the explosive charges for the LSPE program.

3.0 Equipment Identification

Ohaus Triple Beam Balance - cap. 2610 g.

Ohaus Double Beam Balance - cap. 16 Kg.

Blending Drum - cap. 55 gal.

Blending Drum - cap. 109 gal.

Barrel Roller

4.0 Procedure

4.1 This procedure provides for a 200 pound batch of explosive consisting of:

HNS-II - 90%

Teflon (DuPont 7C: Lot #10001) - 10%

Two blending drums are used: the 55 gal. drum is 22½" diameter x 32-¾" long with 5" wide baffles 120° apart running lengthwise the entire length of the drum. The 109 gal. drum is 27½" diameter x 42½" long with 4" wide baffles 120° apart running the length of the drum. The smaller drum rotates at 11 RPM, and the larger drum turns at 9 RPM.

4.2 With a clean, separate scoop for each material 20,412 g. (45 lb.) of HNS-II and 2,268 g. (5 lb.) of Teflon are weighed and loaded into the 55 gal. drum. Forty-six teflon cylinders 1¼" dia. x 2" long each weighing about 90 g. were added to break up any agglomerates which might start to form.

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4.3 The drum is closed, placed on the roller and rotated for at least four hours.

4.4 The roller is stopped, the drum is opened, and the blended powder placed in a moisture proof container, after representative samples are taken for impact test and chemical analysis.

4.5 Operations 4.2, 4.3, and 4.4 are repeated three times.

4.6 All four batches are loaded into the 109 gal. drum and 46 more teflon cylinders added. This 200 pound batch is rotated for eight hours.

4.7 The roller is stopped, the drum is opened, representative samples are taken for chemical analysis, impact sensitivity, differential thermal analysis, and small scale gap test. The powder is stored in moisture proof containers, and is ready for pressing.

5.0 Special Instructions

5.1 Safety - This operation is done in a well barricaded area. The roller is put in motion and stopped by remote control from a safe distance. Any necessary hand tools are made of non-sparking materials. A respirator should be worn while loading and unloading the drum and the area should be well ventilated.

5.2 In order to easily separate the teflon cylinders from the molding powder it is loaded into the containers through a very coarse screen ( $\frac{1}{2}$ " mesh).

APPENDIX C

PRESSING OF EXPLOSIVE CHARGES (ISOSTATIC)

1.0 Purpose - This document provides a procedure for pressing the PBXW-1 (HNS-II/Teflon 7C 90/10) molding powder into explosive charges for the LSPE program.

2.0 Scope - This procedure covers only the pressing of HNS-II/Teflon 7C 90/10 by means of the isostatic press.

3.0 Equipment Identification

6" Isostatic Press

16" Isostatic Press

Rubber Molds of 3", 4", 6", and 9½" diameters.

4.0 Procedure

4.1 With the rubber mold standing inside a metal cylinder, hand pack it with the HNS-II/Teflon 7C to a point 1" from the top.

4.2 Place the top plate with valve attached on the top surface of the material and assemble it with the ring clamp.

4.3 Connect the valve to the vacuum system and evacuate the mold to 29" of mercury. Close the valve, and disconnect the mold from the vacuum system.

4.4 Immerse the mold in the press fluid, close the press and subject the fluid to the proper pressure (25-30 Kpsi) to produce a charge density of approximately 1.69 g/cc. Hold the pressure a full minute, and slowly release it to atmospheric.

4.5 Open the press, remove the mold, and separate the mold from the pressed charge.

5.0 Special Instructions

5.1 Safety - Since the dusty materials are slightly toxic a respirator and rubber gloves should be worn while hand packing the mold. Good ventilation is necessary.

5.2 Operation of the press is done remotely.

APPENDIX D

MACHINING OF EXPLOSIVE CHARGES

1.0 Purpose - The purpose of this document is to outline a suggested method for machining the pressed billets to the specified dimensions on BXA drawings 2348424 and 2348425.

2.0 Scope - This procedure covers the machining of the explosive charges of PBXW-1 (HNS-II/Teflon 7C 90/10) for the LSPE program.

3.0 Test Articles Identification

Nomenclature

- a. Ohaus Balance Triple Beam - cap. 2610 g.
- b. Ohaus Balance Double Beam - cap. 16 kg.
- c. Micrometer Calipers - Serial Nos. 2 to 5.

4.0 Equipment Identification

Air Tracer Lathe

Milling Machine

Band Saw

5.0 Procedure

5.1 Cylindrical charges - BXA Part Nos. 1 through 5.

5.1.1 The billet is turned on the lathe to a little larger than the finished diameter.

5.1.2 The cylinder is cut on the bandsaw to a little longer than the finished length.

5.1.3 The ends are faced off on the lathe to make a right cylinder.

5.1.4 The right cylinder is weighed and its diameter and length are measured in order to calculate the density.

5.1.5 The cylinder is machined in the lathe to the exact dimensions and the radii are made on the ends.

5.1.6 The finished weight of the charge is determined.

5.2 Cube Charge - BXA No. 2348425

5.2.1 The billet is turned on the lathe to a right cylinder of the proper height.

5.2.2 It is weighed and its diameter and height are measured for density calculation.

5.2.3 The cylinder is cut on the bandsaw to an oversized cube.

5.2.4 The cube is machined to the proper size, the radii are put on the corners, and the recesses machined in the four top corners, all on the milling machine.

5.2.5 The finished weight is determined and dimensions checked.

#### 6.0 Special Instructions

6.1 If pressing molds are long enough, more than one of the smaller cylinders can be made of one pressing.

6.2 Safety - Since the ingredients of this blend are slightly toxic, a good ventilation system and dust elimination system are necessary.