25MM AMMO
PHASE IV
TECHNICAL DATA

P.G.
See Sec.
1.3

SECTION III

TECHNICAL PROPOSAL

I. INTRODUCTION

1.0 INTRODUCTION AND SUMMARY

This proposal is presented in response to Aeronutronic Division, Philco-Ford Document SOW 6-71, dated 21 June 1971, titled Development of Ammunition Subsystem, 25mm for GAU-7/A Gun System, Phase IV, Statement of Work. The tasks described herein will be performed by Brunswick Corporation's Technical Products Division at its Sugar Grove, Virginia ordnance plant.

The proposal describes the development, qualification, and production programs necessary to meet the functional and schedule requirements for 25mm caseless ammunition for the GAU-7/A Gun System. Functional requirements are delineated in Section 2.0, Prime Item, Development Specification, Part I.

Feasibility and primary functional requirements for the ammunition were demonstrated during Phase III. Reproducibility of round performance parameters and reliability will be the subjects of major development and improvement during Phase IV.

The principal problem areas for the caseless ammunition are manifested by blowby (expulsion of unburned propellant ahead of the telescoped projectile) and poor reproducibility. Blowby results when initial chamber pressure rise rate is too high and the forward portion of the propellant charge collapses before the projectile reaches the barrel entrance. Reduction of initial chamber pressure rise rate can be effected easily, but at the expense of longer, less reproducible action times and in some instances, higher maximum chamber pressures. The blowby problem and the reproducibility problem are thus inter-related - - - initial chamber pressure must be held below the cartridge collapse pressure limit and above a lower limit which may result in projectile stoppage in the barrel entrance and subsequent long action times and high chamber pressures. The pressure-rise/blowby relationships are shown in Figure 1.1.

Other problem areas include moisture resistance, cook-off resistance, residue control, and the wide range of temperatures over which the round must perform satisfactorily.

The development plan proposal provides for systematic development of individual components, of integrated subsystems, and of complete rounds with emphasis on separation of variables to achieve design optimization and process control to achieve and maintain the optimized performance required.

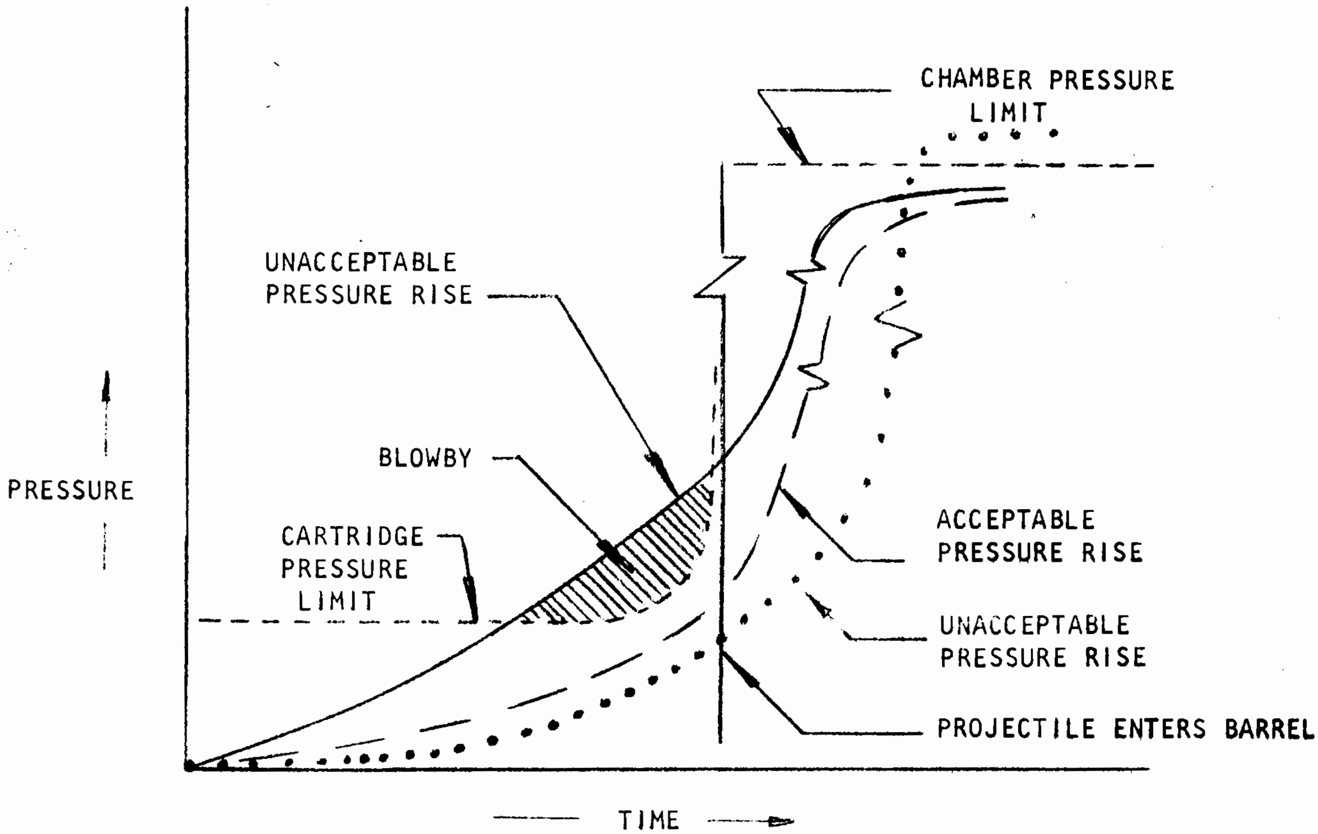
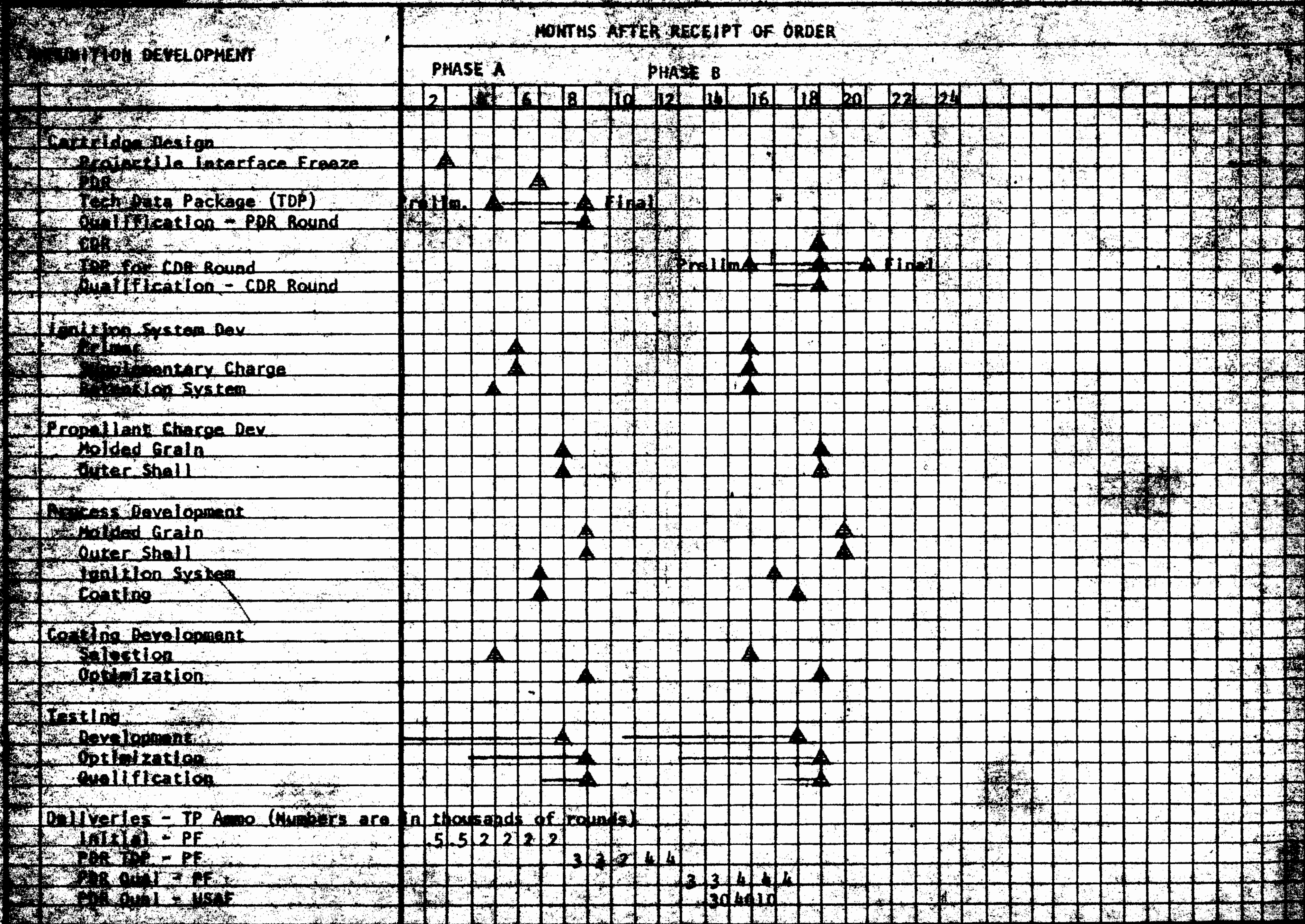


FIGURE 1.1

PRESSURE RISE - BLOWBY RELATIONS

[redacted]

MILESTONE SCHEDULE



GRID

[illegible] – [illegible] Ammo

CDR TCP – PF

CDR Qual – [illegible]

CDR Qual – USAF

2. PRIME ITEM DEVELOPMENT SPEC

SPECIFICATION NO.

CODE IDENTIFICATION 27665

BRUNSWICK CORPORATION

TECHNICAL PRODUCTS DIVISION

SUGAR GROVE, VIRGINIA

PRIME ITEM DEVELOPMENT SPECIFICATION

AMMUNITION, 25MM, CASELESS

FOR THE GAU-7/A GUN SYSTEM

PREPARED BY:____________________

CHECKED BY:____________________

APPROVED BY:____________________

____

Brunswick
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1.0 SCOPE

1.1 Purpose. This specification establishes the performance, design, development and test requirements for a fully-telescoped 25mm caseless ammunition subsystem for use in the GAU-7/A Gun System. The ammunition shall consist of Target Practice (TP) and High Explosive Incendiary (HEI) rounds. The requirements specified herein shall include both HEI and TP ammunition with exception to those requirements that relate to the projectile.

2.0 APPLICABLE DOCUMENTS

The following documents, of exact issue shown, form a part of this specification to the extend specified herein. In the event of conflict between requirements of these documents and the requirements of this specification, the requirement of this specification shall be considered a superseding requirement.

SPECIFICATIONS:

MIL-L-99312	Lot Numbering, Dating and Preparing Data Cards for Guided Missile Explosive Assemblies, Subassemblies and Parts, dated 26 April 1967
MIL-D-21625D Amendment 2	Design and Evaluation of Cartridges for Cartridge Actuated devices, dated 10 May 1967
MIL-D-1000	Drawing, Engineering and Associated List

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STANDARDS:

MIL-STD-100A	Engineering Drawing Practices
MIL-STD-129D	Marking for Shipment and Storage, dated 28 December 1964
MIL-STD-130C	Identification Marking of U.S. Military Property
MIL-STD-143A	Specification and Standards, Order of Precedence for the Selection of, dated May 1963
MIL-STD-286B	Propellant, Solid, Sampling, Examination and Testing, dated 1 December 1967
MIL-STD-331 Change 3	Fuze and Fuze Components, Environmental and Performance Tests for, dated 11 June 1969
MIL-STD-490	Specification Practices
MIL-STD-709	Ammunition Color Coding
MIL-STD-810B	Environmental Test Methods, dated 15 June 1967
MIL-STD-847	Preparation of Technical Reports, dated 25 February 1965
MIL-STD-1168	Lot Numbering of Ammunition, Dated 30 June 1965

DRAWINGS:

Number	Code Ident.	
400139	27665	Round Assy, 25mm, Caseless
?	?	Firing Pin Assy.
?	?	Projectile Assy.

OTHER PUBLICATIONS:

USAF Regulations AFR 127-4	Safety, Investigating and Reporting Accidents and Incidents
USAF Instructions AFATL 67-3	Instructions -- Contractor Prepared Technical Reports
ICC Regulations 49 CFR 71.90	ICC Regulation
AMC Regulations AMCR 715-505 Volume 8	Ammunition Ballistic Acceptance Test Methods dated October 1964

USAF RFP
RFP33657-71-R-0877, Annex 24

3.0 REQUIREMENTS

The ammunition shall comply with the listed drawings, parts list, referenced specifications, and requirements specified herein. Unless otherwise specified, all requirements shall be achieved before, during, and after exposure to the environmental conditions specified in paragraph 3.2.5.

3.1 Item Definition. The 25mm ammunition defined by this specification is to be integrated with the GAU-7/A Gun and Feed subsystems for employment on the F-15 aircraft. The manufacture-to-launch functional characteristics are shown in Figure 1.

3.1.1 Item Diagram. Item level functional characteristics from primer ignition to projectile launch are shown in Figure 2.

3.1.2 Interface Definition. The ammunition round shall be compatible with the projectile/warhead and GAU-7/A gun, and shall meet the performance requirements of this specification when fired from the GAU-7/A gun system.

3.1.2.1 System Physical and Functional Interface.

3.1.2.1.2 Gun Interface.

3.1.2.1.2.1 Dynamic Environment. The ammunition shall not explode, ignite, debullet, fracture or spill propellant when subjected to the following loads imposed by normal gun operation. All round velocities are based on a coefficient of friction of 0.2. -- TEST FLEETED

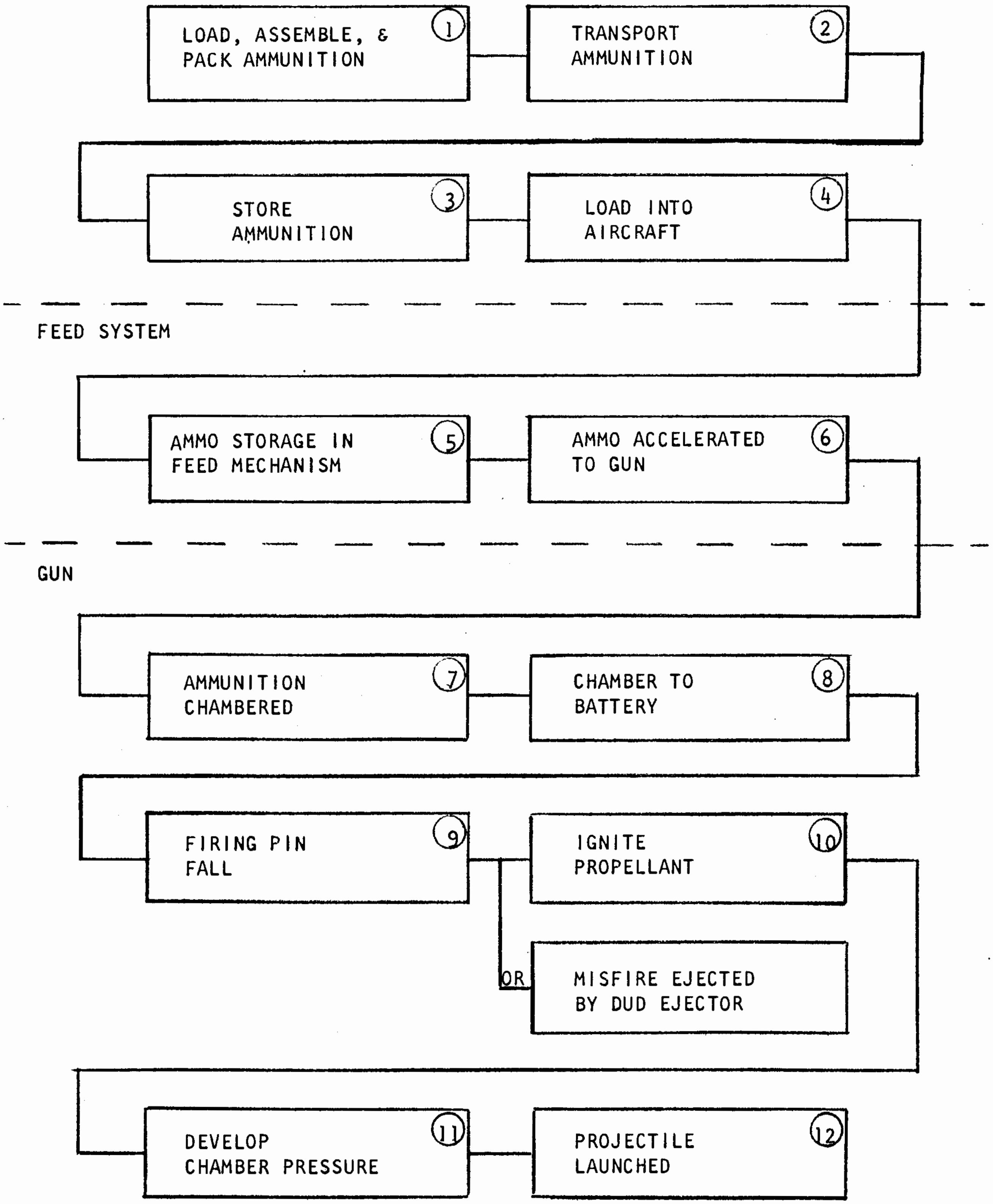

FIGURE 1

AMMUNITION MANUFACTURE-TO-LAUNCH FUNCTIONAL DIAGRAM

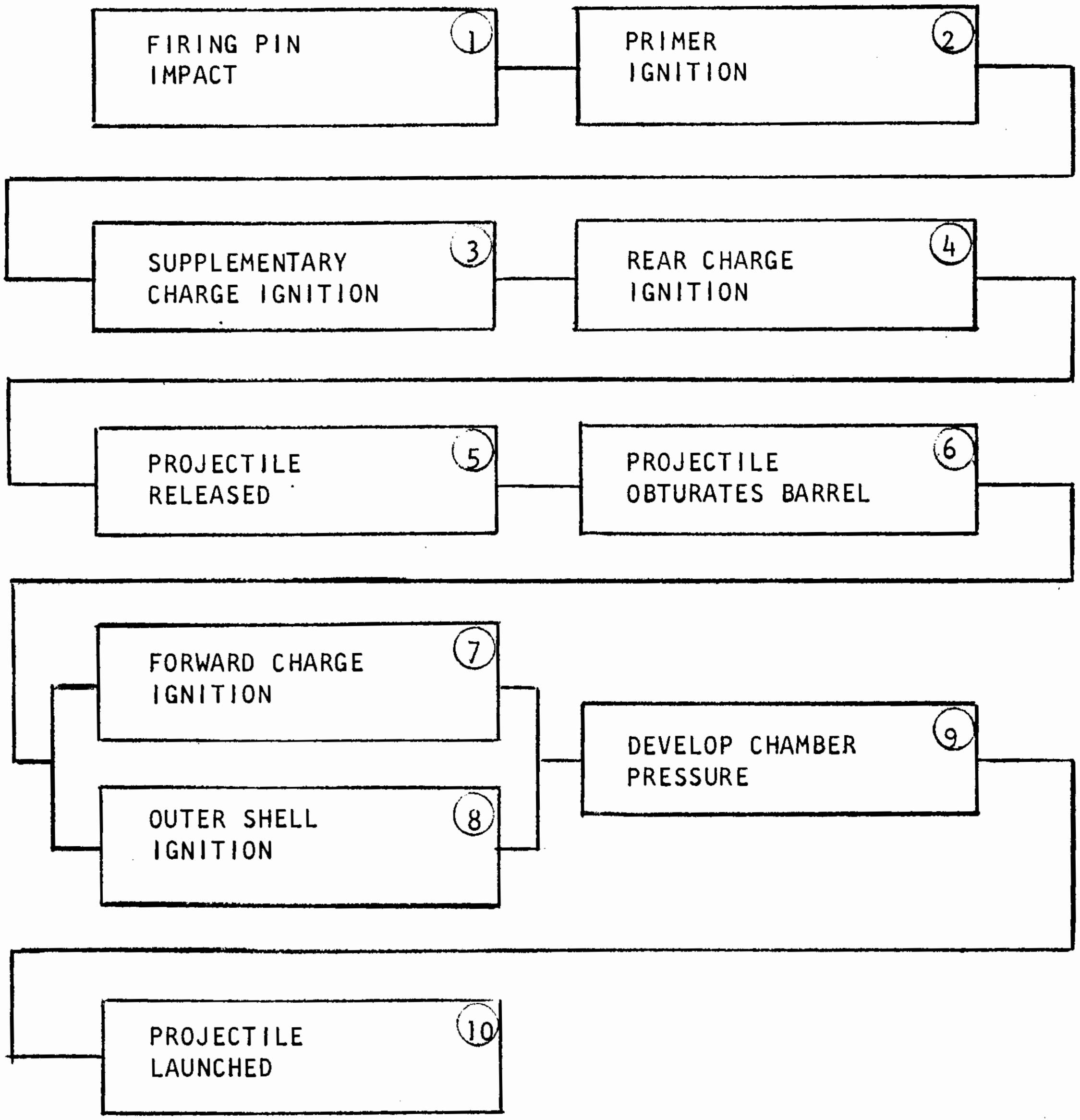

FIGURE 2

IGNITION-TO-LAUNCH FUNCTIONAL DIAGRAM

REFERENCE MAT'L

a. <u>Loader-Rammer</u>

Round Angular Velocity	3360 rpm
Round Maximum Axial Acceleration	150 g
Round Maximum Axial Velocity	31.3 ft/sec
Rammer-Round Impact Velocity	7.1 ft/sec
Round-Dud Round Impact Velocity	15.8 ft/sec
Round Stop Impact Velocity	22.2 ft/sec
Round-Round Stop Impact Time	21.9 msec
Round Deceleration	
Friction	18.41 g
Round Stop (Dependent upon Stop Material)	1146 to 1419 g
Round Centrifugal Acceleration	92.2 g
Maximum Loads in Round	
Axial Acceleration (1 round)	131.4 lbs
Axial Acceleration (2 rounds)	262.8 lbs
Centrifugal Force (Line Load)	72 lbs
Maximum Normal Radial Force (Line Load)	74 lbs

b. <u>Chamber</u>

Centrifugal Force	72 lbs
Centrifugal Acceleration	92.2 g

c. <u>Dud Ejector Assembly (Ref. Figure 3)</u>

Dud Ejector-Round Impact Velocity	6.3 ft/sec
Maximum Force on Round	131.4 lbs
Centrifugal Force	72.0 lbs

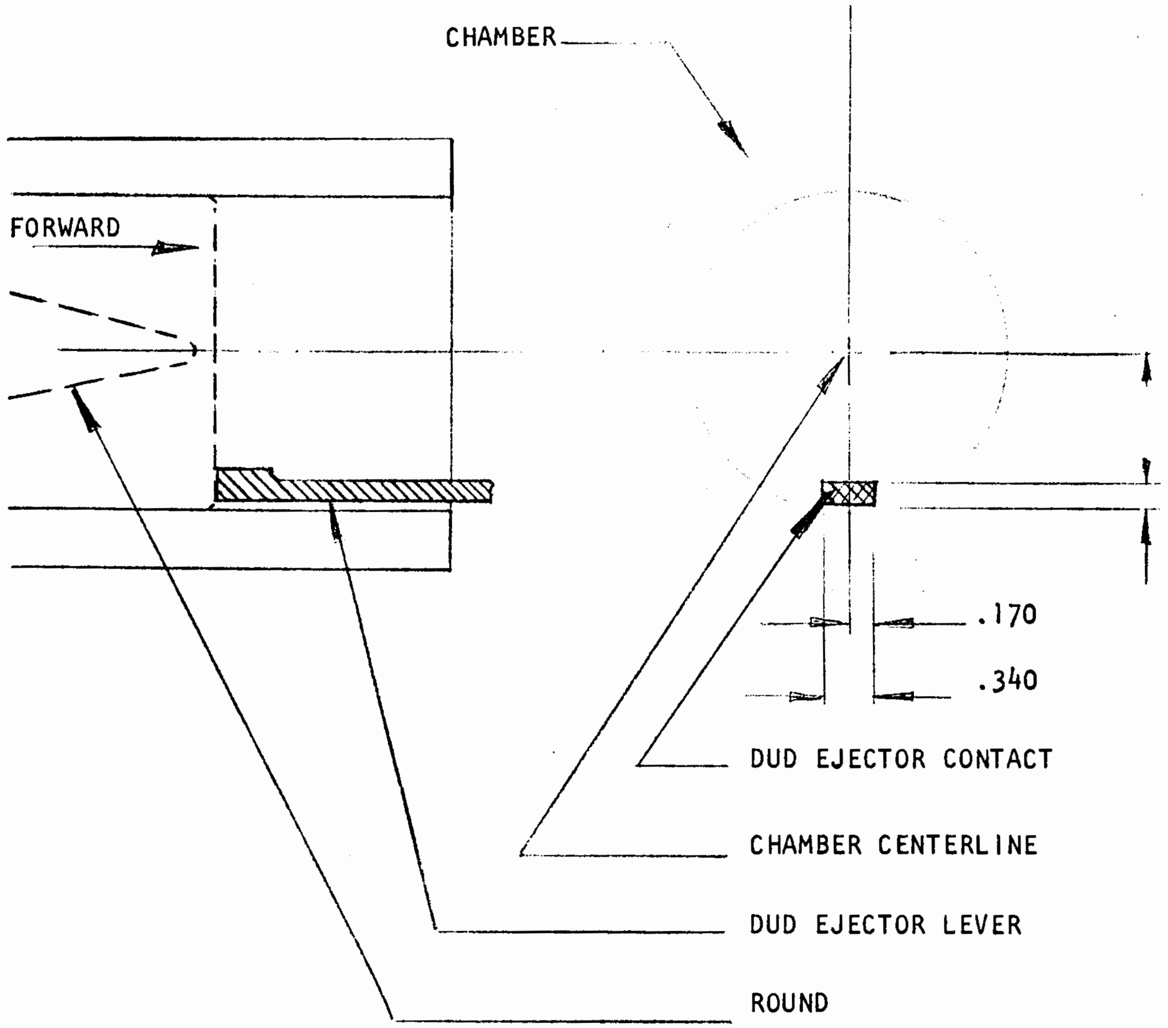

FIGURE 3

DUD ROUND EJECTOR

Round Axial Acceleration	150 g
Centrifugal Acceleration	92.2 g
Round Deceleration	300 g
Dud Extractor Loads	(To be determined)

3.1.2.1.2.2 Cookoff. The ammunition shall not ignite in the normal environment of the GAU-7/A Gun System as defined in 3.2.5, or during exposure to the following thermal environment imposed by the gun chamber. Refer to Figure 4 for definition of contact surfaces.

Contact Surface	Temperature	Exposure Time
Inside diameter of chamber	900°F	230 msec
Barrel face	1650°F	50 msec
Breech face	1150°F	50 msec

3.1.2.1.2.3 Firing Pin. The ammunition primer shall be compatible ~~with the firing pin defined by Philco-Ford Interface Drawing~~ ____________. The firing pin velocity on impact with the primer is 27 feet per second. Pin penetration into the chamber shall be 0.30 inch from the breech face.

3.1.2.1.2.4 Chamber Pressure. Chamber pressure shall be in accordance with the requirements of paragraph 3.2.1.2.

3.1.2.1.2.5 Action Time. Action time shall be in accordance with the requirements of paragraph 3.2.1.3.

FIRING PIN POSITION

POSITION	DISPLACEMENT	PRESSURE
(1)	.050 PROTRUSION	0 to 260 PSI
(2)	.40 DEPRESSION	2440 to 22800 PSI
(3)	.56 DEPRESSION	65,000 PSI

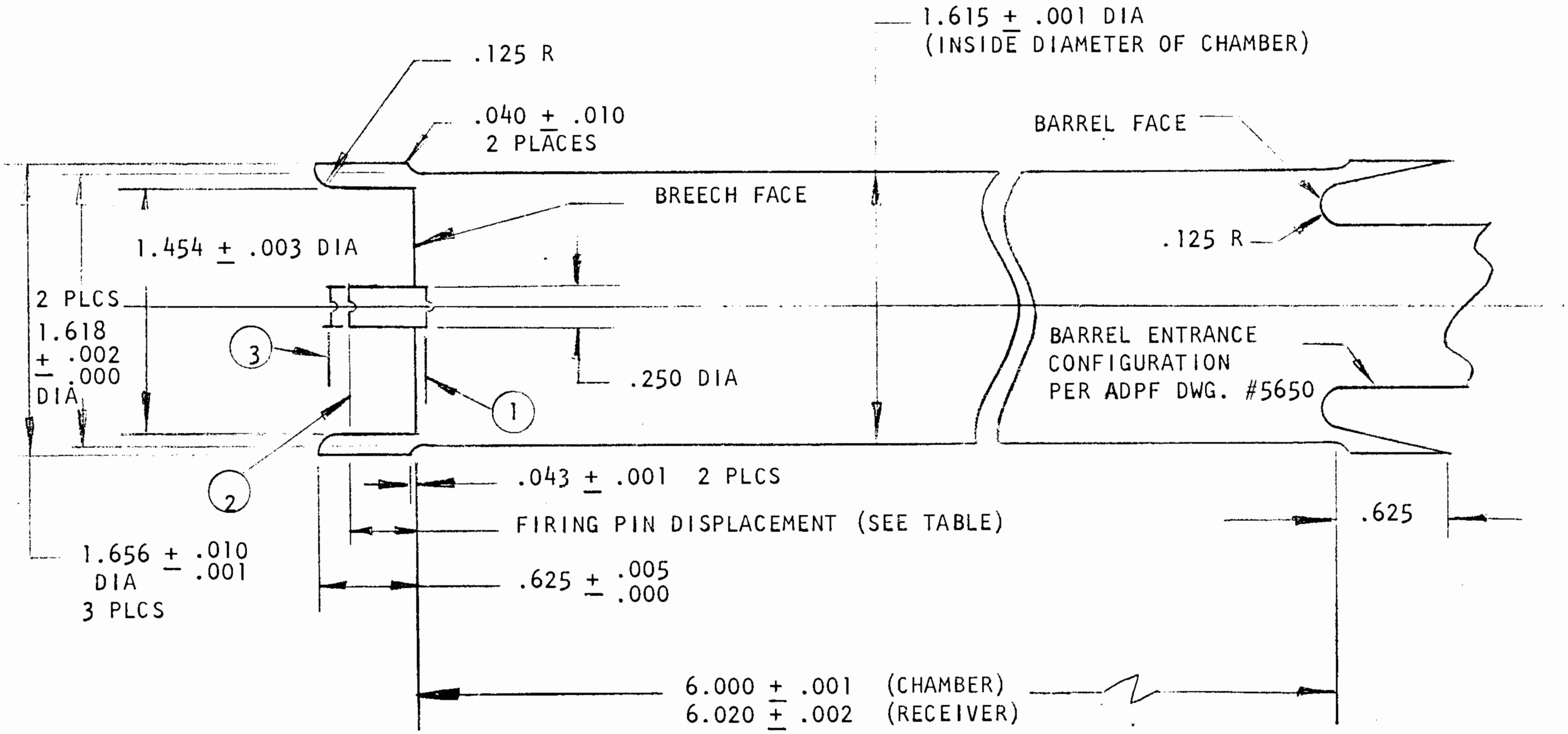

FIGURE 4

CHAMBER VOID PROFILE

3.1.2.1.2.6 Combustion Residue. The ammunition shall be completely consumed, and shall leave no cumulative detrimental residue when fired in the GAU-7/A Gun.

3.1.2.1.2.7 Muzzle Flash and Debris. The ammunition shall be designed to provide minimum muzzle flash when fired from the GAU-7/A gun. No debris shall be ejected from the gun muzzles.

3.1.2.1.2.8 Barrel Life. The ammunition shall ~~be compatible with~~ a gun barrel life of 1000 rounds minimum. The useful life of the barrel is defined as the number of rounds to a velocity degradation of 10%, or the number of rounds to a point where the projectile exhibits a yaw of 15° or more for 20% of the rounds fired during a burst.

3.1.2.1.2.9 Seals and Firing Pin Life. The ammunition shall ~~be compatible with the~~ seals and firing pin life of 1000 rounds minimum.

3.1.2.1.2.10 Chamber. The ammunition shall be compatible with the chamber-seal dimensions specified in Figure 4. The concentricity, roundness and projectile centering shall ensure that the projectile/barrel misalignment is minimal.

3.1.2.1.2.11 Accuracy. The ammunition shall be compatible with accuracy requirements of the gun. The gun, when hard mounted, shall fire 80% of a 100-round burst within a 3.0 mil diameter circle at the high rate of fire. The center of the 80% group shall be within 1.0 mil elevation and 1.0 mil aximuth of the true boresight point, defined as the mean impact point of the barrel cluster.

3.1.2.1.2.12 Muzzle Velocity. Muzzle velocity shall be in accordance with the requirements of paragraph 3.2.1.1.

3.1.2.1.2.13 Projectile/Barrel Concentricity. The ammunition round shall maintain projectile-barrel concentricity during expulsion of the projectile from the chamber into the barrel. [CONCENTRICITY BETWEEN AMMO & PROJECTILE ONLY]

3.1.2.1.3 Feed System Interface.

3.1.2.1.3.1 Dynamic Environment. The ammunition shall not explode, ignite, debullet, fracture, or spill propellant when subjected to the following loads imposed by normal feed system operation.

REFERENCE ONLY

a. Feed Machanism	
Round Velocity (lateral)	9.375 ft/sec
Maximum Radial Force (line load on turns)	19.4 lbs
Centrifugal Acceleration	22.9 g
b. Accelerator	
Round Initial Velocity (lateral)	9.375 ft/sec
Round Final Velocity (lateral)	23.5 ft/sec
Time to Final Velocity	40 msec
Round Angular Velocity (Initial, Maximum)	1340 rpm
Round Angular Velocity (Final, Maximum)	3360 rpm
Maximum Force on Round	
Auger (Point Contact/Auger)	50 lbs
Normal Force (per Support)	44 lbs
Maximum Accelerations	
Tangent to Path	100 g
Normal to Path	100 g

c. Hand-off Wheel/Round Guide.

Round Velocity (lateral)	23.5 ft/sec
Round Angular Velocity	3360 rpm
Centrifugal Acceleration	115 g .
Maximum Normal Force (Re: Figure 5) Three one-quarter-inch loads (at each end and center of round).	110 lbs
Maximum Change in Round Angular Velocity	6720 rpm

3.1.2.1.4 Aircraft Interface. The ammunition shall meet the performance requirements specified herein when subjected to the static and dynamic loads imposed by the normal operation of the gun and feed system during performance at rest, and performance under aircraft operating and limit loads.

3.1.2.1.4.1 Vibration. The ammunition shall operate during and after exposure to vibration levels up to 10 g at frequencies up to 2000 cps.

3.1.2.1.4.2 Shock. The ammunition shall withstand service shock conditions of 15 g and crash safety shock conditions of 30 g, both conditions having a nominal duration of 11 milliseconds.

3.1.2.2 Item Physical and Functional Interfaces.

3.1.2.2.1 Item Control Drawings. The functions and configurations of the major components shall properly interface as defined in the following drawings:

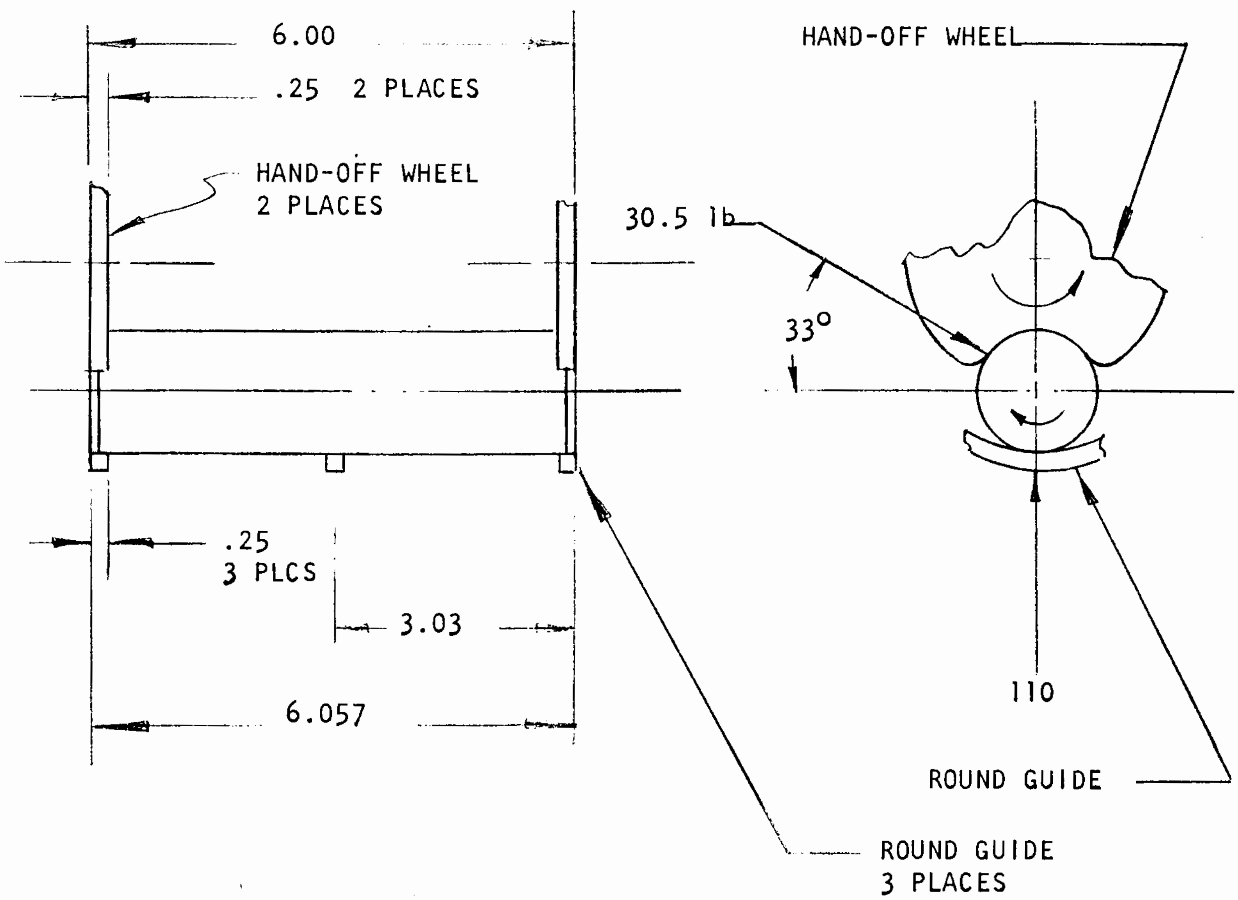

FIGURE 5

MAXIMUM ROUND LOADS -
HAND-OFF WHEEL/ROUND LOADS

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	Number	Code Ident
Round Assembly, 25mm, Caseless	400139	27665
Projectile Assembly	-----	-----
Primer, Combustible	200502-6	27665
Charge, Rear	200468-2	27665
Charge, Forward	200495-3	27665
Spacer, Front	200439-3	27665
Tube	200416	27665
Positioner, Nose	200438	27665
Shell-Molded	300090-2	27665

3.1.3 Major Component List. The round shall consist of the following major components:

Ammunition, 25mm, Caseless

- Primer
- Molded Propellant
- Retainer
- Shell
- Projectile

3.1.4 Government Furnished Property List.

	Item	Quantity
1.	Ammunition Rounds, 20mm, M50 Series TP	980 ea.
2.	HMX Explosive - development lot	500 lbs.
3.	RDX Explosive - development lot	500 lbs.
4.	HMX or RDX Explosive - production lot	1500 lbs.
5.	Primer Mix	(TBD)

3.1.5 Government Loaned Property List.

Item	Quantity
1. Single-shot ballistic test fixture for 20mm, MK50 ammunition (with spare parts)	1 ea.

3.1.6 Customer Furnished Property List.

1. Projectiles, TP - 25mm, GAU-7/A
2. Projectiles, HEI - 25mm, GAU-7/A
3. Single shot test fixture with spare parts - 25mm, GAU-7/A
4. Ignition Test Fixture with spare parts - 25mm, GAU-7/A
5. Gun Simulator with spare parts - 25mm, GAU-7/A

3.2 Characteristics.

3.2.1 Performance.

3.2.1.1 Muzzle Velocity. Muzzle velocity shall be in accordance with Annex 24, paragraph 3.1 of RFP 33657-71-R-0877. The average muzzle velocity mean variation shall be ± 100 ft/sec from required velocity.

3.2.1.2 Chamber Pressure. The average peak chamber pressure plus three (3) standard deviations of peak chamber pressure shall not exceed 65,000 psi (Kistler gage) under ambient conditions of 70°F, ± 5°F.

3.2.1.3 Action Time. Action time is defined as the time period between the initial contact of the firing pin against the primer until the projectile exits the muzzle. The mean action time shall be 8.5 milliseconds. The maximum acceptable deviation (three sigma) of the mean action time shall not exceed 2.0 milliseconds.

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3.2.1.4 Accuracy.

3.2.1.4.1 Mann Barrel Accuracy. The ammunition dispersion when fired from the single shot fixture shall be such that 80 percent of the projectiles shall fall within a 1 mil diameter circle around the mean impact point.

3.2.1.4.2 Automatic Gun Accuracy. Automatic gun accuracy shall be in accordance with paragraph 3.1.2.12.11.

3.2.2 Physical Characteristics.

3.2.2.1 Weight. The weight of the loaded round (including projectile shall not exceed 0.73 pound. The weight of the round (less projectile) shall not exceed 0.31 pound. 20 TO 30 GRAMS OVER NEED (155-156 GRAM)

3.2.2.2 Dimensional and Cube Limits.

3.2.2.2.1 Round Dimensions. The nominal telescoped round shall not exceed 1.6 inches in diameter by 6.0 inches in length.

3.2.2.2.2 Round CG. The center of gravity of the loaded round (including projectile) shall be located along the longitudinal centerline of the round, 3.3 inches from the forward end.

3.2.2.2.3 Cube Limits. The volume of (TBD) rounds of packaged ammunition shall not exceed (TBD) cubic feet.

3.2.2.3 Protective Coatings. The round may have a completely consumable protective coating for resisting or detering the adverse effects of the environmental conditions defined in 3.2.5. This coating shall also resist or deter the onset of auto-ignition.

3.2.2.4 Survivability/Vulnerability. The round shall be designed to minimize the probability of round ignition or functioning as a result of fire or projectile impact.

3.2.2.5 Shelf Life Stability. The design goal for the shelf life of the 25mm caseless ammunition shall be no less than current M50-series 20mm cased ammunition. The minimum acceptable shelf life for the 25mm ammunition shall be 10 years.

3.2.2.6 Storage Requirements. The environmental conditions for long term depot storage of the rounds shall be compatible with the ammunition components and in accordance with the established storage techniques for explosive loaded items.

3.2.2.7 Durability Requirements. The ammunition shall be capable of withstanding the rigors of rough handling and transportation, within the environments specified in paragraph 3.2.5 of this specification.

3.2.2.8 Health and Safety Criteria. The ammunition shall possess the durability characteristics specified above enabling safe transportation, handling and firing. The products of combustion shall not result in hazards greater than those normally associated with existing gun systems.

3.2.2.9 Structural Strength. The round shall not fracture or break up when subjected to static and dynamic loads imposed during normal operation of the GAU-7/A Gun and Feed System. Normal gun and feed system loads shall include performance at rest, and performance under aircraft operating and limit loads.

3.2.2.10 Debulleting. The projectile shall not debullet (dislodge) from the propellant cylinder when subjected to the static and dynamic loads imposed by the GAU-7/A Gun System in its normal operating environment.

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CLASS OF MALFUNCTION

DEFINATION

3.2.3 Reliability.

3.2.3.1 Malfunction Rate. The ammunition shall be designed to provide a failure rate not to exceed one malfunction per 250,000 rounds. A malfunction is defined as a premature ignition, hangfire, or misfire. Fractured or deformed rounds which inhibit feeding or chambering shall be considered as malfunctions of either the round, feed system or gun. Deformation or fracturing of the round caused by abnormal gun and/or feed system operation shall not be considered as a malfunction of the round.

?800?

3.2.4 Maintainability. (TBD)

JUST OPERATE?

3.2.5 Environmental Conditions. Unpackaged ammunition shall not suffer damage, deterioration, or degradation of performance beyond the limits of this specification during and after exposure to the following environmental conditions.

3.2.5.1 High Temperature.

3.2.5.1.1 Continuous. The ammunition shall operate after continuous exposure to a temperature of +185°F. +160

TBD

3.2.5.1.2 Flight Temperature. The ammunition shall operate following exposure to temperatures of +345°F for 10 minutes, cumulative to 47 hours total time; and +420°F for 1 minute, cumulative to 7 hours total time.

3.2.5.2 Low Temperature. The ammunition shall operate during and after continuous exposure to a temperature of -80°F. -65

3.2.5.3 Temperature Shock. The ammunition shall operate following exposure to temperature shock conditions during which the temperature changes form -80°F to +420°F in 200 seconds.

3.2.5.4 Humidity. The ammunition shall be operable after exposure to relative humidity conditions up to 100 percent. This includes conditions wherein condensation forms on the rounds.

3.2.5.5 Altitude. The ammunition shall operate during and after exposure to environmental conditions encountered from sea level to 75,000 feet altitude.

3.2.5.6 Salt, Fog, and Spray. The ammunition shall operate after exposure to salt-sea atmosphere.

3.2.5.7 Fungus. The ammunition shall operate after exposure to fungus growth as encountered in tropical climates.

3.2.5.8 Sand and Dust. The ammunition shall operate after exposure to sand and dust conditions as encountered in world-wide operational areas.

3.2.5.9 Temperature-Humidity-Altitude. The ammunition shall operate during and after exposure combinations of low temperature/low pressure and high temperature/high humidity environments in which the temperature ranges from -65°F to +149°F, humidity up to 95%, and altitudes up to 50,000 feet.

3.2.5.10 Sunshine. The ammunition shall operate after exposure to solar radiation as may be encountered in world-wide operational areas.

3.2.5.11 Rain. The ammunition shall operate following exposure to rain conditions up to 12 inches per hour.

3.2.5.12 Leakage (Immersion). The ammunition shall operate after being immersed in water to a depth of 36 inches minimum for a period of 120 minutes.

3.2.5.13 Handling Drop. The unpackaged ammunition shall withstand a five-foot drop test on a concrete surface.

3.2.6 Transportability. The ammunition shall be transported in accordance with regulations governing explosive-loaded devices. Preservation, packaging, packing and marking of the ammunition for transportation, storage, and handling shall be in accordance with Section 5 of this specification.

3.3 Design and Construction.

3.3.1 Materials, Processes and Parts.

3.3.1.1 Selection of Materials and Processes. Standard Materials and processes as required to meet the performance and environmental requirements shall be used. These materials and processes shall be controlled by specifications selected in accordance with MIL-STD-143. The use of strategic or critical materials shall be avoided where possible.

3.3.1.2 Fungus Resistance. Materials which are not nutrients for fungus shall be used wherever possible. If it is necessary to use nutrient materials, they shall be treated by a method that will render the exposed surface fungus resistant when tested in accordance with Method 508 of MIL-STD-810B.

3.3.1.3 Producibility. Component design, materials selection, processing, loading, and assembly operations shall be commensurate with mass production manufacturing methods.

3.3.2 Electromagnetic Radiation. Not applicable.

3.3.3 Nameplates and Product Marking. Caseless ammunition fabricated for evaluation testing shall be externally identified by sequential serial numbers, lot numbers, and model/design/series (MDS) designation in accordance with the requirements of MIL-STD-130C. Rounds fabricated for qualification testing shall be identified in the same manner except that sequential serial numbers shall not be required. Lot numbering shall be in accordance with MIL-STD-1168.

3.3.4 Workmanship. All components of the round shall be manufactured and shall be assembled in accordance with the applicable engineering drawings and engineering assembly procedures.

3.3.5 Interchangeability. Unless otherwise specified on the engineering drawings, all parts having the same part number shall be physically and funtionally interchangeable.

3.3.6 Safety.

3.3.6.1 Design Standards.

3.3.6.1.1 The ammunition shall be designed to prevent inadvertent or premature firing, release, or functioning in all ground and air environments.

3.3.6.1.2 The round shall be designed such that the safety features will not be degraded or negated throughout the manufacture-to-target environment.

3.3.6.1.3 The ammunition belt packaging machine and aircraft loading mechanism shall both employ positive means of preventing rounds from being loaded backwards.

3.3.6.1.4 The round shall be designed to present the minimum practical hazard during unnatural and accidental environments including accidental drop, improper storage, aircraft crash, fire, sympathetic detonation, and combat damage.

3.3.6.1.5 The munition shall be designed such that when components (or combinations thereof) are used that could conceivably fail during the manufacture-to-target environment, the failure of that component (or combination thereof) shall not cause a hazardous condition.

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3.3.6.1.6 The munition design shall be capable of being rendered safe unless specifically exempted for operational reasons.

3.3.6.1.7 On munitions that may be jettisoned, the design shall allow for the munition to be jettisoned in an unarmed condition upon demand.

3.3.6.2 Qualification/Verification Standards

a. Any munition shall be considered unsafe until adequate safety is verified by design analysis and qualification testing.

b. No munition shall be maintained, shipped, stored, handled, or employed except as was intended in the initial design and qualification program without adequate design reevaluation and necessary requalification by the Command having engineering responsibility.

c. The munition design shall be qualified through laboratory and flight testing that simulate the environments specified in the manufacture-to-target environmental definition.

d. The qualification testing shall also evaluate the munition's response to unnatural and accidental environments including accidental drop, improper storage, aircraft crash, fire, sympathetic detonation, and combat damage.

e. Adequate controls shall be placed on the manufacture of the munition to insure that the production meets the design specifications within acceptable limits.

3.3.7 Human Performance/Human Engineering.

3.3.7.1 Orientation Identification. The forward end of the round shall be readily identifiable by both visual and tactile means to preclude inadvertent mis-identification during handling and loading. Color coding within the provisions of MIL-STD-130C and MIL-STD-708 may be used for visual identification of the forward end of the round.

3.4 Documentation. Recommended documentation for the 25mm caseless ammunition development program is listed below. This list defines only the minimum requirements. In any event, the submission of data shall be commensurate with contractual requirements.

a. Engineering Drawings, Form 3, Category B for Preliminary Design Review. Drawings shall be prepared in accordance with MIL-STD-100A and MIL-D-1000.

b. Engineering Drawings, Form 1, Categories E and F for Critical Design Review. Drawings shall be prepared in accordance with MIL-STD-100A and MIL-D-1000.

c. Production Plan

d. Quality Program Plan

e. Acceptance Test Procedures

f. Safety Program Plan

g. Prime Item Fabrication Specification, Part II of two parts, in accordance with MIL-STD-490.

3.5 Logistics. The ammunition shall impose no new or unusual burdens on the normal logistics system.

3.5.1 Maintenance (TBD)

3.5.2 Supply (TBD)

3.5.3 Facilities and Facility Equipment. The ammunition shall present no new or unusual requirements for facilities or facility equipment.

3.6 Personnel and Training.

3.6.1 Personnel. (TBD)

3.6.2 Training. (TBD)

3.7 Major Component Characteristics. The 25mm caseless ammunition shall meet the performance requirements of this specification and shall conform to the envelop and interface dimensions of Drawing 400139.

3.7.1 Primer. The primer shall be stab-percussion initiated and shall be completely consumed in the firing of the round.

3.7.2 Molded Propellant. The propellant shall be stable and compatible with materials it contacts. The molded propellant shall be completely consumed in the firing of the round.

3.7.3 Retainer. The retainer shall secure the projectile within the round to withstand the torque loads imposed by the spin environment encountered in feeding and loading operations.

3.7.4 Shell. The shell shall be part of the main propellant charge and shall be completely consumed in the firing of the round.

3.7.5 Coefficient of Friction. The exterior surface of the round shall have a coefficient of friction of 0.20 maximum, based on a stainless steel plate having a 14-18 RMS finish.

3.7.6 Flame Temperature. The propellant used in the round shall have a flame temperature not to exceed 2800°K, isochoric. (CALCULATED)

3.8 Precedence.

3.8.1 Precedence of Functions and Characteristics Requirements. In the event of conflict between the requirements defined in this specification, the following order of precedence shall apply:

a. Safety
b. Performance
c. Reliability
d. Size/Weight
e. Configuration

3.8.2 Precedence of Document Requirements. In the event of conflict between the requirements of this specification, the contract, and/or applicable documents, the order of precedence shall be as follows:

a. Contract - Statement of Work
b. Drawings
c. This specification
d. Federal Standards
e. Military Standards
f. Other Publications

4.0 QUALITY ASSURANCE PROVISIONS

4.1 General. The requirements defined herein include engineering tests in support of design and development to verify the capability of the ammunition to meet the specified design, performance, and construction requirements.

4.1.1 Responsibility for Tests. Unless otherwise specified in the contract or order, the contractor shall be responsible for the performance of all tests specified herein. Except as otherwise specified, the contractor may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the tests set forth in this specification where such inspections are deemed necessary to assure that the ammunition conforms to prescribed requirements.

4.1.2 Special Tests and Examination.

4.1.2.1 Evaluation Tests. Evaluation tests are those tests conducted by the contractor, at facilities under his cognizance to evaluate design against performance and physical requirements.

4.1.2.2 Qualification Tests. Qualification tests are defined as those tests performed to verify compliance of the ammunition with all performance, physical and interface requirements of this specification. These tests shall be conducted on ammunition that is representative of the expected production rounds, using as much as possible the same manufacturing techniques and processes as intended for production.

4.1.2.2.1 Category I. These tests are defined as those qualification tests performed by the contractor at facilities under his cognizance to verify compliance with all performance and physical requirements of the specification. These tests shall consist of all tests defined in 4.2.

4.1.2.2.2 Category II. These tests are defined as those qualification tests that require the integration of the complete weapon, including items not under the contractor's cognizance. These tests are the responsibility of the buyer with contractor support as defined in the contract.

4.1.2.3 Test Procedures. Detailed test procedures shall be prepared by the supplier and approved by the buyer prior to any test being performed. The test procedures shall specify the test equipment, recording, and measuring equipment required; instrumentation locations; operating parameters to be measured, tolerances on operating parameters, environmental test conditions and operating ranges, etc., and detailed procedures for conducting such tests. The test procedures shall also include to mode of operation for each environmental exposure, as well as duration of test, number of cycles, number of samples, sample selection, and any other pertinent information.

4.2 Quality Conformance Inspections.

4.2.1 Test Provisions.

4.2.1.1 Test Conditions. Unless otherwise specified, the conditions for conducting tests shall be local ambient.

4.2.1.2 Test Fixtures. Tests shall be conducted utilizing appropriate test fixtures supplied to the contractor in accordance with paragraph 3.1.6.

4.2.1.3 Data Measurement of Error. The maximum allowable error for measurement of the following shall be:

Velocity ± 20 f/s

Pressure ± 5% = ± .028%

Time ± 5%

4.2.2 Tests. The ammunition shall be subjected to the Qualification Tests listed in Table I. These tests are divided into five groups as follows:

Group I	Performance
Group II	Environmental
Group III	Visual and Mechanical
Group IV	Reliability
Group V	Safety

4.3 Test Methods.

4.3.1 Performance Tests. This group of tests describe the procedures to be used to verify ammunition performance characteristics. The procedures outlined define the methods to be used to obtain the data designated as the primary objective of the test series. When desirable, additional data may be obtained from the same test series if the quality of data for the primary objective is not degraded.

4.3.1.1 Chamber Pressure. Chamber pressure shall be recorded under actual firing conditions using the necessary gun components or simulating equipment for performance of the test. A continuous trace of Pressure versus Time shall be made through a pressure transducer which is mounted flush with the chamber cavity. The maximum pressure, as taken from the pressure/time trace, shall be reported. The results of these tests shall meet the requirements of paragraph 3.2.1.2. All pertinent data shall be recorded for each test and shall include, as a minimum, the following:

a. Date of Test

b. Test Item Identification

c. Pressure Transducer Identification

d. Date of Equipment Calibration

4.3.1.2 Action Time. Action time shall be determined by firing the ammunition in the gun and measuring the time interval between firing pin fall and projectile exit from the muzzle. The firing pin fall and projectile exit times shall be established by electrical signals generated from two independent transducers on the same time trace. The first transducer shall be located to detect the firing pin striking the primer, and the second transducer shall be located two inches from the muzzle to detect projectile

In addition, a Kraft paper witness sheet, approximately 5 feet wide by 30 feet long shall be positioned on the ground below the muzzle and in the path of fire. The paper shall be examined after firings for evidence of debris.

4.3.1.5 Cookoff. The resistance of the ammunition to auto-ignition shall be verified by testing under conditions that duplicate the contact surfaces, temperatures, and exposure times defined in paragraph 3.1.2.1.2.2. Test equipment shall include a simulated chamber with breech and barrel contact surfaces, and a device for inserting the round into the chamber. Resistance to cookoff shall meet the requirements of paragraph 3.1.2.1.2.2.

4.3.1.6 Shelf Life Stability. Shelf life stability, as specified in paragraph 3.4.2.2.5, shall be verified in accordance with an approved test plan prepared by the contractor. Rounds selected for this test shall be of the design and construction approved at the Critical Design Review. Rounds shall be stored at ambient temperatures, both packaged and unpackaged. Ballistic tests and physical examinations shall be conducted on test rounds at selected intervals over a twenty year period. Quantities and test intervals shall be specified in the test plan, commensurate with contractual requirements.

4.3.1.7 Muzzle Velocity. The muzzle velocity shall be determined during firing tests that are conducted on a single-shot test fixture that simulates the GAU-7/A gun. The sensing equipment shall consist of light screens or grids positioned 30 feet and 60 feet from the muzzle. Time recording instruments shall record elapsed time from muzzle exit to each of the sensing screens or grids. The resultant muzzle velocity shall meet the requirements of paragraph 3.2.1.1.

4.3.2.3 Temperature Shock. The ammunition shall be subjected to the temperature shock tests using MIL-STD-810, Method 503, Procedure I as a guide, during which the temperature shall change from -80°F to +420°F in 200 seconds. The round shall have been exposed to the -80°F temperature for not less than 4 hours prior to test.

4.3.2.4 Humidity. The ammunition shall be subjected to the humidity test of MIL-STD-810, Method 507, Procedure I.

4.3.2.5 Altitude. The ammunition shall be subjected to the altitude test of MIL-STD-810, Method 500, Procedure II. The pressure altitude condition shall be 75,000 feet.

4.3.2.6 Salt, Fog and Spray. The ammunition shall be subjected to the salt fog test of MIL-STD-810, Method 509, Procedure I.

4.3.2.7 Fungus. The ammunition shall be exposed to the fungus test of MIL-STD-810, Method 508, Procedure I.

4.3.2.8 Sand and Dust. The ammunition shall be exposed to the sand and dust test of MIL-STD-810, Method 510, Procedure I.

4.3.2.9 Temperature-Humidity-Altitude. The ammunition shall be subjected to the temperature-humidity-altitude test of MIL-STD-810, Method 518, Procedure I.

4.3.2.10 Sunshine. The ammunition shall be subjected to the sunshine test of MIL-STD-810, Method 505, Procedure I.

4.3.2.11 Rain. The ammunition shall be subjected to the rain test of MIL-STD-810, Method 506, Procedure I.

4.3.2.12 Leakage (Immersion). The ammunition shall be subjected to the leakage test of MIL-STD-810, Method 512, Procedure I.

4.3.3.6 Packing and Packaging. The packing and packaging design shall conform to the requirements of paragraph 5.0. Compliance shall be verified by visual inspection of packaged ammunition.

4.3.4 Reliability. The reliability levels of paragraph 3.2.3, along with all listed functions shall be verified by examination of the data from the tests listed herein. No specific additional tests shall be required.

4.3.5 Safety. The safety of the ammunition shall be determined by examination of the test data from the tests listed herein. No specific additional tests shall be required to verify compliance with paragraph 3.3.6.

5.0 PREPARATION FOR DELIVERY

5.1 Preservation and Packaging. The ammunition shall be packaged to prevent deterioration and mechanical damage during shipment and storage. The ammunition may be packaged in a set-up box, carton or crate with optimum use made of cushioning material, pads, fillers, or other packaging aids. Containers shall be able to withstand storage, rehandling, and reshipment without the necessity of repacking. The shipping containers shall conform to the requirements of the Interstate Commerce Commission and Consolidated Freight Classification Rules in effect at time of shipment.

5.1.1 Packaging of Rounds. The ammunition rounds shall be packaged into an ammunition handling and storage plastic belt in accordance with Drawing (TBD). The rounds shall be individually sealed in rows, three abreast.

5.2 Packing. The exterior shipping container shall be packaged according to ICC Tariff No. 13 and shipped with the proper ICC explosive classification.

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6.1.3 Lot. A lot is defined as a stipulated quantity of units fabricated from the same batch of propellant materials and the same lot of primers, booster and igniter material produced as one continuous run by the same process, and submitted for acceptance at the same time.

6.1.4 Lot Number. Lot numbering is to be in accordance with MIL-L-9931. Each loaded component is to be identified on the item itself with the lot number as specified in MIL-STD-1168.

6.2 Accident Reporting. Part II, Section A, paragraphs 1, 2, and 3 of AFR 127-4 will be used to determine reportability of explosives accidents/incidents occurring at contractor facilities. Two copies of the contractor's report of explosives accident/incident investigation, which will include a determination of accident/incident cause and state corrective action taken to prevent a recurrence, will fulfill the reporting requirement of ASPR 7-104.79 (e) for ammunition and explosives. Reports will be forwarded to the procuring activity.

3. DEVELOPMENT PLAN

3.0 DEVELOPMENT PLAN

3.1 Introduction. Phase IV development of 25mm caseless ammunition for the GAU-7/A gun system will be concentrated on performance optimization and process improvements. Optimum round performance during Phase III was essentially up to specification requirements but reproducibility was not satisfactory and some basic performance deficiencies remain.

The primary reason for lack of adequate reproducibility is blowby, that is expulsion of propellant particles ahead of the projectile. Blowby causes low velocities because of loss of the effective energy of the expelled propellant and it also creates unacceptable muzzle debris.

Principal performance deficiencies of the round at the end of Phase III were lack of an effective environmental protective coating and inadequate operating temperature range capability.

The proposed development plan for Phase IV attacks the blowby and reproducibility problem component-by-component, in the critical ignition system subassembly, and with complete rounds. Sufficient data accumulation from varied component and subassembly tests will permit separation of the effects of interacting components so that the necessary design and control measures can be accomplished.

The development of an environmental protective coating will be pursued essentially as a separate program. Progress with coatings during Phase III was substantial and many successful firings were made after temperature-humidity cycling. Incorporation of an adequate coating on delivery rounds was hampered by dimensional limitations and resulting conflict with production and delivery requirements.

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The operating temperature range deficiency is the result of using projectile retainers made from sheet pyroxylin. These retainers were used because of the flexibility they afforded in ignition sequence design experiments. Completion of a wider temperature range retainer qualification program is straight-forward and is provided for in Phase IV.

3.2 Objectives. The principal objectives of this program are as listed below:

1. Provide Phase IV developmental support caseless ammunition for the GAU-7/A gun system.
2. Correct round deficiencies.
3. Optimize round performance.
4. Establish process limits.
5. Establish acceptable reliability levels.
6. Provide projectile, gun, and feed system interface services and support.
7. Provide documentation as required.
8. Identify long lead time items and plan for volume production.
9. Comply with safety and security requirements of the program.

3.3 Demonstrated Performance. During Phase III the 25mm caseless ammunition has been brought to an advanced level of performance. Table 3.1 shows ballistic data for three (3) groups of rounds in single-shot test fixture firing.

TABLE 3.1

NOMINAL C-7 ROUND PERFORMANCE

	Number Fired	Pressure KSI $\bar{x}$	Pressure KSI σ	Velocity ft/sec $\bar{x}$	Velocity ft/sec σ	Action Time, Milliseconds $\bar{x}$	Action Time, Milliseconds σ
Type C-7, Model 10 (with B.C. Primer)	49	50.0	5.8	- 99	125	9.9	1.8
Type C-7, Model 19	10	47.5	11.3	-128	195	9.7	2.7
Type C-7, Model 11 (with 30° Bevelled Fwd.Gr.)	10	50.0	2.2	- 30	87	9.1	1.1

In firing the forty-nine (49) rounds shown in the Table, five (5) rounds had blowby of unburned propellant and some remains of the pyroxylin retainer were found on witness boards approximately ten (10) feet down range from the gun. In firing the second ten (10) round group, witness boards were free of propellant and all ten (10) rounds were fired on the same board; some remains of retainers were collected.

Structural adequacy of the round has been demonstrated in automatic gun compatibility tests and firings and in simulated drop tests. Before each single shot firing, the round is dropped eight (8) feet basedown on a steel plate and then three (3) feet nosedown on a simulated rammer face. No significant damage is incurred although slight cracks near the base of the case are occasionally formed. In all of the structural tests, rounds have been examined for deformation or failure which will prevent successful operation in the gun. With one exception it has been concluded that the rounds will chamber and fire normally. The exception is the deformation formed in the outer shell as a result of the 45°

basedown handling drop. Such deformation has been handled well by the single shot test fixture, but must be tested in the accelerator rolls of the automatic gun. The deformation is readily apparent visually and use of ammunition with this fault can easily be avoided.

Tests have been conducted using rounds subjected to handling drop tests (45° nosedown, 45° basedown, and horizontal five (5) foot drops on a steel plate) with no significant variation from performance of undropped rounds. Transportation vibration tests (MIL-STD-810B, Method 514, Procedure X) have also been applied to the rounds without visual effect or measurable change in performance.

The effect of firing rounds at elevated and reduced temperatures has also been investigated. Rounds have been fired at 110°F, 160°F, 30°F and 65°F with results as shown in Table 3.2.

TABLE 3.2

ROUND PERFORMANCE VS TEMPERATURE

TYPE	TEMP.	NO. FIRED	AVERAGE CHAMBER PRESSURE KSI	σ KSI	AVERAGE VELOCITY FT/SEC	σ FT/SEC	AVERAGE ACTION TIME M/SEC	σ M/SEC
C-7 Mod 19	110°F	10	55.5	2.4	-236	145	6.7	1.3
	160°F	10	50.2	3.1	-220	202	6.4	0.8
	30°F	10	44.3	13.5	-255	261	11.6	3.8
	-65°F	10	42.9	15.3	-233	343	15.5	3.6

These results show a slowing of action times at lower temperatures and little effect under the other conditions.

Residue has been held within acceptable operating limits. Occasionally a small remnant from the rear bulkhead of the case has been found after firing. This residue is caused by a slow burning, high density region in which the fibrous character of the NC fiber is lost in molding. Residue has been increased somewhat by low temperature firings and after exposure to humidity cycles; however, rounds coated with 5 to 7 mils of RDX filled acrylic resin showed little or no residue.

Coatings have been found which give protection against the two major environmental requirements, ambient temperature and humidity cycling and gun cook-off. A spray on type coating consisting of an underlayer of RDX or HMX-loaded resin followed by a resin overcoat has satisfactorily protected the round from exposure to ten (10) cycles of the environment set forth in MIL-STD-810B, Method 507, Procedure V. Thin films have also shown promise for such protection. Table 3.3 gives results of firing coated rounds after humidity exposure.

TABLE 3.3

HUMIDITY TEST RESULTS

ROUND PROTECTION	HUMIDITY CYCLE	PRESSURE AVE.	PRESSURE σ	VELOCITY AVE.	VELOCITY σ	ACTION TIME AVE.	ACTION TIME σ	RESIDUE
7 mils RDX-Acrylic with 2 mils acrylic topcoat over dried outer case	10 of environment set forth in MIL-STD-810B, Proc. 507, Method V.	46.3	5.0	-153	90	7.1	0.9	Trace
None	Same	37.9	7.8	-368	202	9.6	1.0	Slight

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NOTE: The coated rounds gave substantially unchanged results from those of rounds not exposed to humidity.

Tests have also been made in special fixtures of the cook-off resistance of the bare and coated rounds. Considering the gun environmental temperature predictions, test results indicate that uncoated rounds will not cook-off after one hundred fifty (150) round bursts and rounds coated with HMX-Acrylic plus acrylic top coat will not cook-off after three hundred (300) round bursts. It is to be noted, that the acrylic dipped case of the current round adds to cook-off protection as compared to the uncoated round.

Basically the C-7 design duplex-type 25mm combustible cartridge has proved itself satisfactory or capable of further development to meet the basic requirements of such a round for successful operation in the GAU-7/A system.

3.4 Design and Development.

3.4.1 Cartridge Design. The C-7 Model 19 round, shown in Figure 3-1, is the configuration current at the end of Phase III development. Early in Phase IV, changes in projectile length and outer shell details will be incorporated in a new basic configuration designated C-8. The C-8 round as presently conceived, is shown in Figure 3-2. Minor modifications of the C-8 round will be identified by model number as was done with earlier development rounds.

Some of the differences between the C-7 and C-8 rounds were necessitated by interface requirements while others are required to correct C-7 round deficiencies. Brief discussions of the differences and their significances follow.

(a) Ignition System. Primer modifications will be made to optimize primer design. Principal changes will be in internal configuration and primer mix composition and weight. Development of a primer using low ash mix is highly

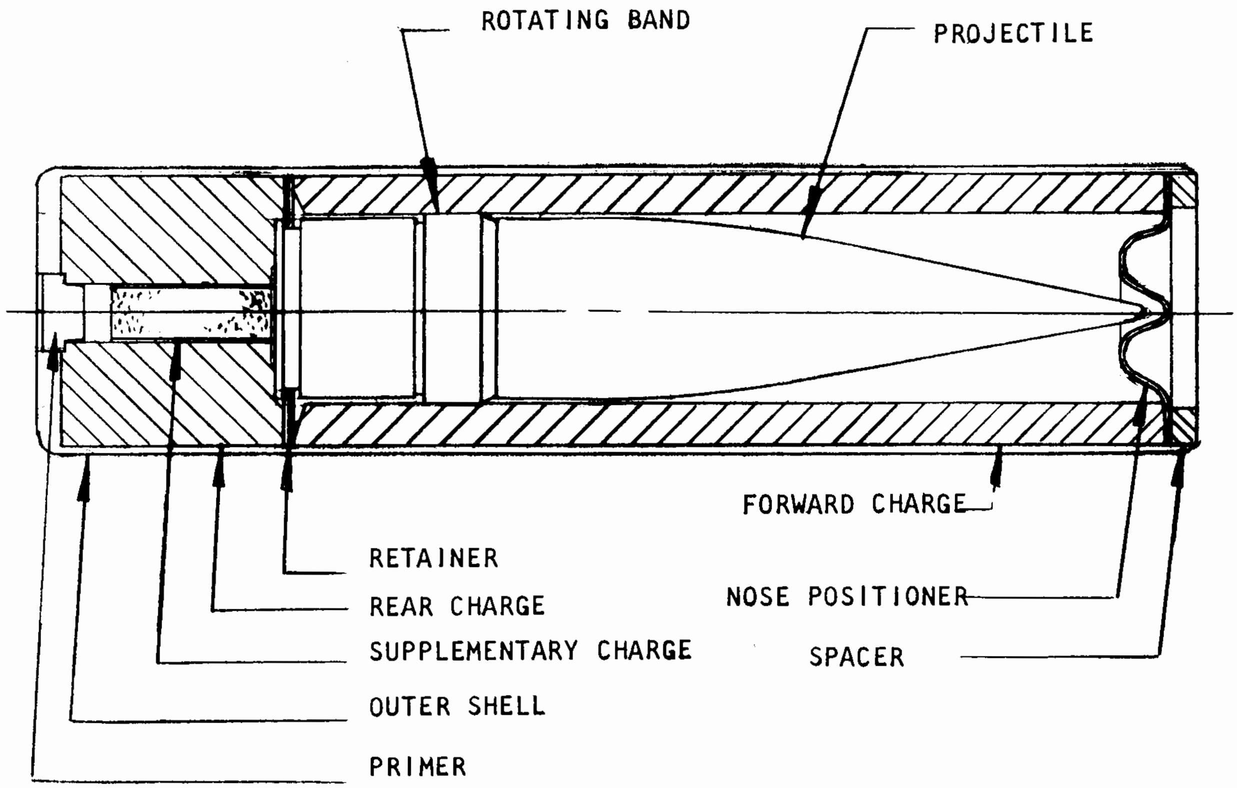


FIGURE 3.1

C7 MODEL 19 ROUND

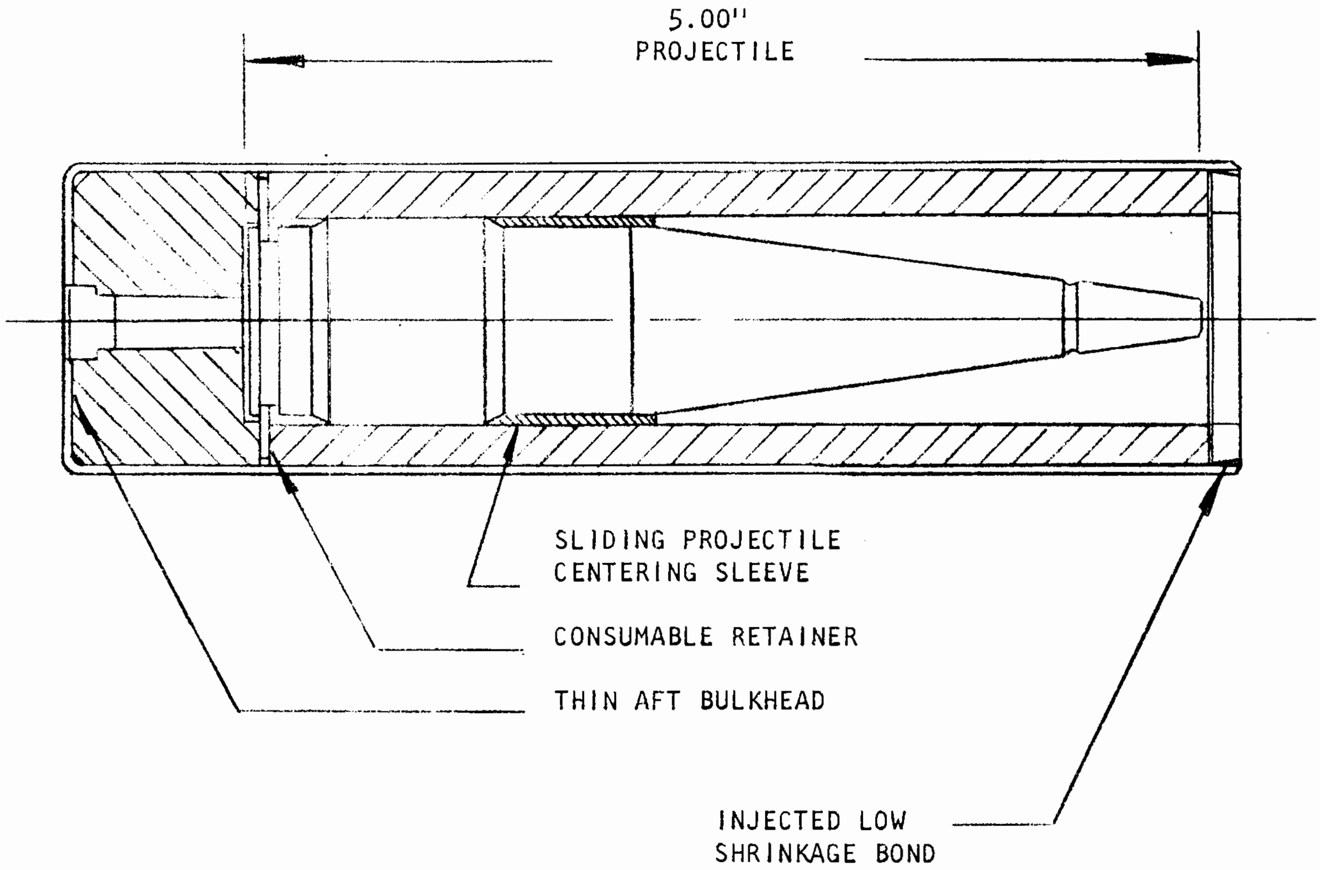


FIGURE 3.2

C-8 ROUND

desirable. The supplementary charge will also be modified. Replacement of the present black powder with a high heat output-low gas output thermite type material of low moisture content sensitivity will be investigated. Packaging of the supplementary charge with the primer as a subassembly to improve producibility is also a design goal. The present pyroxylin retainer will be replaced with a more consumable, wider temperature range material to eliminate undesirable muzzle debris and improve extreme temperature performance.

(b) Propellant Charge Components. The lengths of both the rear and forward charges will require modification to accommodate projectile length change. Detailed diametral dimensions must be changed to allow for adequate coating thickness. Details of internal interfaces with ignition system components, a projectile centering device, and redesigned forward closure will be reflected in the C-8. The C-8 outer shell will incorporate an aft bulkhead reduced to about 0.060" thickness compared with the C-7's 0.120". This change will improve moldability of the part by making the aft bulkhead thickness more nearly equal to that of the cylindrical wall.

(c) Projectile. The C-7 projectile is 4.57" long and incorporates a copper rotating band. The C-8 projectile, not yet finalized, will probably be 5.00" long and will employ a plastic rotating band. The plastic rotating band offers advantages of reduced engraving force and improved projectile stabilization prior to barrel entry.

(d) Coating. Coated C-7 rounds have an outside diameter too great for the GAU-7/A Feed System. Diameters of the major propellant charge components of the C-8 will be reduced to permit full moisture-residue-cookoff resistant coating to be applied without conflict with any gun system interface requirements.

(e) Projected Round Design Modifications. The primer and forward closure modifications contemplated for the basic duplex round are depicted in Figures 3.3 and 3.4. A forward closure incorporating a roll-crimped and bonded connection between the outer case, forward molded charge and membrane cover as shown in Figure 3.3 will offer important reliability advantages over the simple bonded spacer used on the basic C-8 round. A thin formed cover will be capable of resisting the pressure differential load developed by rapid ascent from sea level to 75,000 ft. and will provide maximum consumability. Figure 3.4 shows ignition system variations in which subassemblies of primer-rear grain or primer-supplementary charge are incorporated. Such subassemblies offer important production advantages and the primer-supplementary charge subassembly provides the added advantage of a moisture resistant encapsulation of the subassembly.

3.4.2 Cartridge Development. A large number of single shot ballistic firings has been planned for optimization of the total round assembly. Characterization of individual components is possible and indeed necessary, using otherwise baseline components but it is clear that when more than one component is changed in the total round assembly, the complex interactions are not totally predictable. Therefore provision is made for continuing ballistic firings throughout the design improvement and optimization periods.

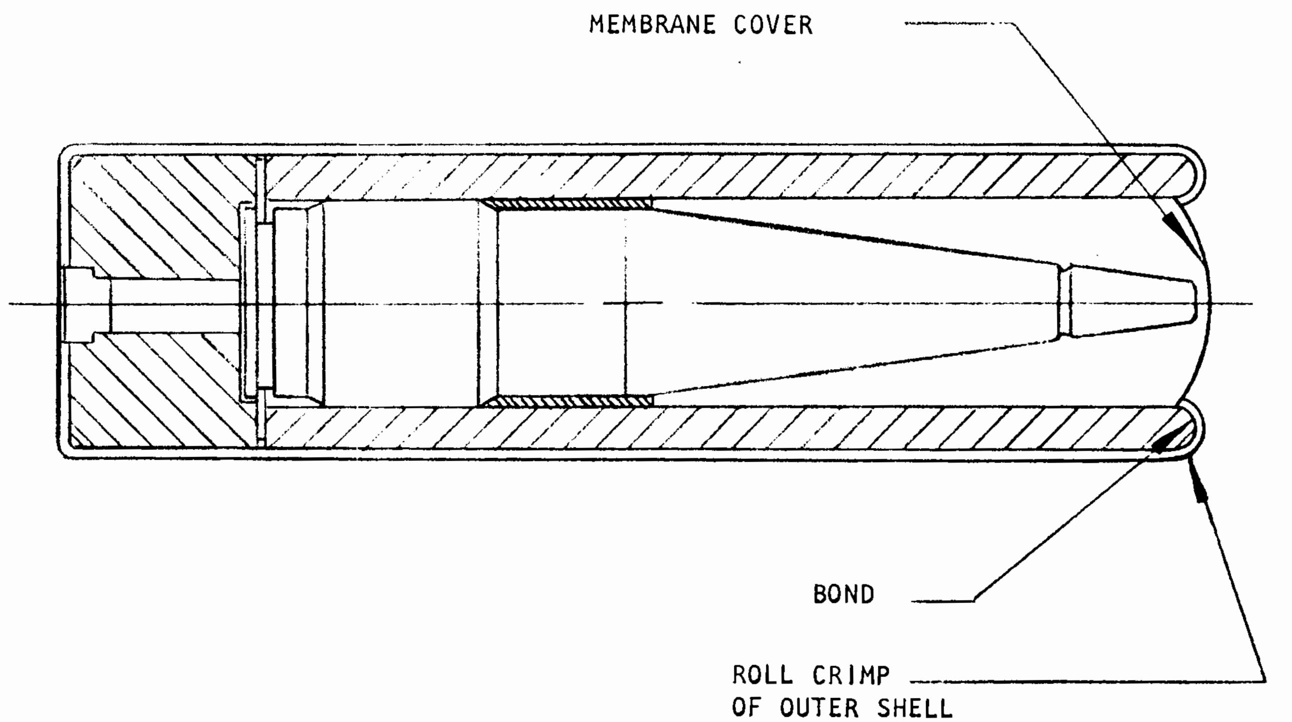
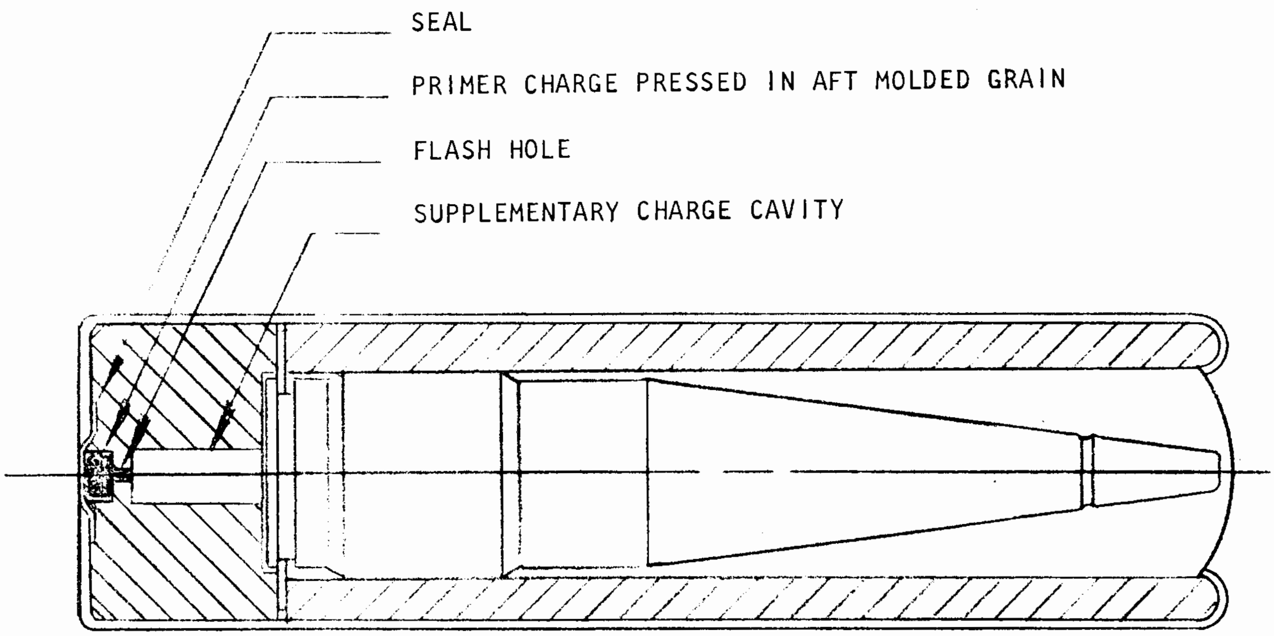
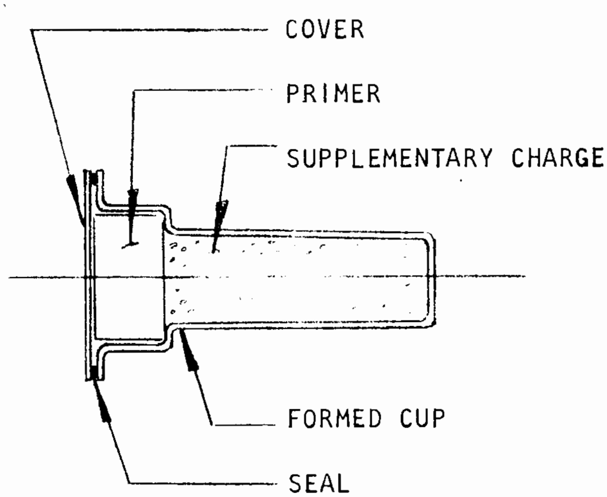


FIGURE 3.3

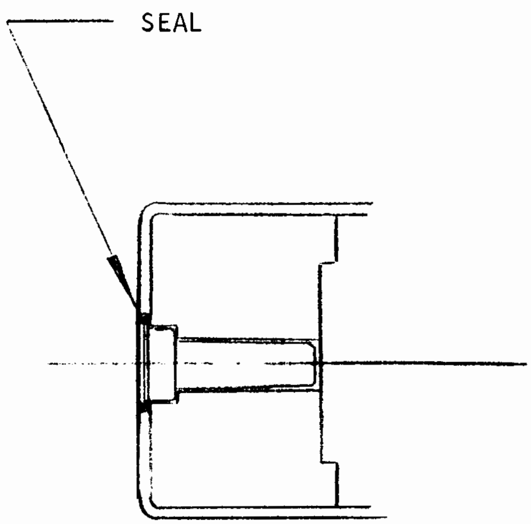
ROUND WITH NOSE CRIMP



PRIMER PRESSED IN AFT MOLDED GRAIN



IGNITION SUBASSEMBLY



INSTALLATION OF IGNITION SUBASSEMBLY

FIGURE 3.4

IGNITION SYSTEM SUBASSEMBLIES

Data analysis from these and round component tests will provide important insight into complex round component interactions. The effects of various changes in single component ballistic parameters on baseline rounds, ignition system assemblies, and, from this subtask, dual component ballistic parameter changes will be studied. Completion of the planned series of parametric ballistic firing studies should prove to be invaluable in the establishment of process variable limits.

TABLE 3.4

ROUND COMPONENT INTERACTION TESTS

PARAMETER	PHASE A	PHASE B
Environments (High Temp., Low Temp., Standard Temp.)	3	3
Rear Charge - 2 compositions x 2 configurations	4	2
Forward Charge - 2 compositions x 2 configurations	4	2
Nose Positioner/Forward Closure - 2 configurations	2	1
Outer Case - 2 compositions x 2 configurations	4	2
Ignition System - 3 systems	3	2
Replicates	10	10
Total Ballistic Firings (Not all possible combinations)	1500	1000

3.4.3 <u>Ignition System Development</u>.

a. <u>Integrated System</u>. The primer, supplementary charge, rear molded propellant charge, and the retainer are the principal contributors to the critical ignition sequence. The outer case and the forward charge also influence the ignition sequence but their contributions are considered to be minor.

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Another factor contributing strongly to ignition design problems is the projectile rotating band. The ignition system must impart sufficient energy to the projectile to engrave its rotating band without allowing the projectile to stop and without developing so much pressure that the forward propellant charge is expelled ahead of the projectile.

Two basic approaches can be taken to the proper firing of a telescoped cartridge. First, the projectile can be accelerated rapidly to the barrel where it stops or hesitates while awaiting the ignition and early burning of the propellant charge. The second approach is to obtain earlier controlled ignition of the charge while the projectile is enroute to the barrel and have it pass through with virtually no hesitation. The first system termed "stop" or "semi-stop", tends to obtain good velocities and eliminate blowby but gives relatively long action times which are difficult to control. The second, "non-stop" approach gives shorter action times, but must be carefully controlled to avoid blowby. If the early rate of pressure build-up is too high, blowby will result--if too low, the projectile will slip into the first mode, stop, and high chamber pressure will result.

It is therefore necessary in making the non-stop system perform well to understand the contribution of the burning of the primer, supplementary charge, rear charge, rear portion of the forward charge, and the outer case to the early pressure rise. The duplex round has the advantage of utilizing several components, making it possible to apply control in several ways. The disadvantage lies in the complexity of their interactions. A program will be carried out to determine the contributions of each component when varied and combined.

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Performance evaluations of the ignition system will be conducted in a specially designed ignition system test fixture as well as in the single shot test fixture.

The ignition system test fixture will be designed to accept selected components ..... primer, supplementary charge, rear charge and combinations including the retainer, and the rear portions of the forward charge and outer case. The fixture will utilize the required firing pin and fire standard projectiles or ballistically equivalent slugs. Pressure-time histories will be continuously recorded and a time signal will be recorded permitting accurate measurement from time of firing pin impact to any selected event. Breech pressure will be measured adjacent to the firing pin so that early pressures associated with primer and supplementary charge action can be recorded at a high gain. Chamber pressure will be recorded at additional selected locations.

The fixture shall also include provisions for measuring the travel-time characteristics of the projectile as it is expelled from the chamber. Analysis of data from ignition system test fixture firing of selected components along with data from all-up ballistic round firings will permit comprehensive evaluation of the various ignition system parameters. The ignition system development task will require the testing of approximately one thousand six hundred ten (1,610) rounds as shown in Table 3.5.

Detailed study of the ignition and expulsion sequences will also be undertaken through use of high speed photography through a transparent chamber. Brunswick has a unique capability to manufacture high strength pressure vessels with a high degree of transparency. The key tool is a vacuum winding machine which permits parts to be filament wound and cured under continuous vacuum.

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TABLE 3.5

IGNITION SYSTEM TEST MATRIX

DESIGN PARAMETER	IGNITION SYSTEM TEST FIXTURE		TRANSPARENT GUN		SINGLE SHOT TEST FIXTURE	
	PHASE A	PHASE B	PHASE A	PHASE B	PHASE A	PHASE B
Primer	4	2	2	2	3	2
Supplementary Charge	4	2	2	2	3	2
Rear Charge	3	1	2	1	2	1
Configuration	3	1	2	1	2	1
Retainer	3	2	3	2	2	1
Forward Charge	2	1	2	1	2	1
<u>Rounds Tested</u>						
Standard Condition	1200	50	100	30	1000	80
Temperature Extremes	100	100		30	200	200
Thermal Shock	20	30		10	50	80
Altitude	20	80	—	—	—	—
TOTALS	1340	260	100	70	1250	360

Under these conditions, wetting of glass reinforcement fibers is virtually complete, air entrapment is virtually eliminated, and resulting high strength filament wound laminates are essentially as clear as cast resin. Single shot fixture chambers with wall thicknesses of about 0.40" will withstand normal chamber pressures and provide sufficient optical quality for high speed photography. Data obtained from testing in the ignition system test fixture, the transparent chamber and the testing of complete rounds in the single shot test fixture will permit improved quantitative evaluation of the critical ignition cycle. The data from the ignition system tests described will permit separation of contributions from individual system components thus improving the efficiency of system optimization efforts.

b. Combustible Primer Development. The objective of this task is to establish the optimum combustible primer design with respect to ignition system performance and reliability requirements.

The primer development effort will include investigations into various primer cup configurations and materials, primer mix compositions and mass of primer mix.

The Phase III primer configuration is illustrated in Figure 3.5.a. Studies of variations in cup dimensions, particularly the input cavity, output cavity and hole diameter will be conducted. An improved moisture barrier or closure on the rear of the primer will be evaluated. A cup type arrangement such as that illustrated in Figure 3.5.b. which results in positive joining of the closure to the primer cup will be used.

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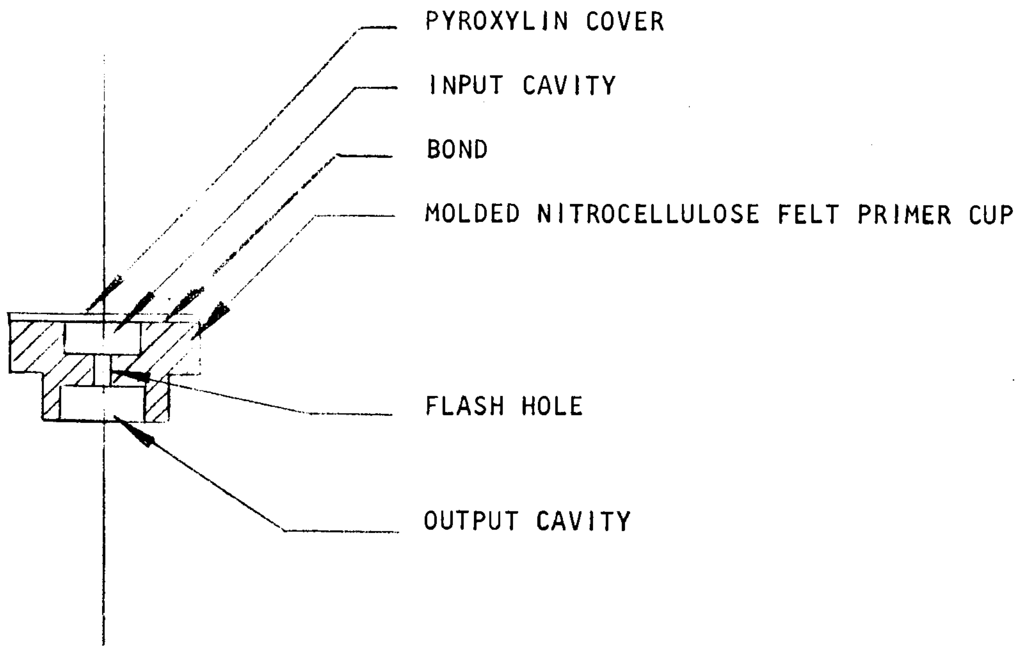
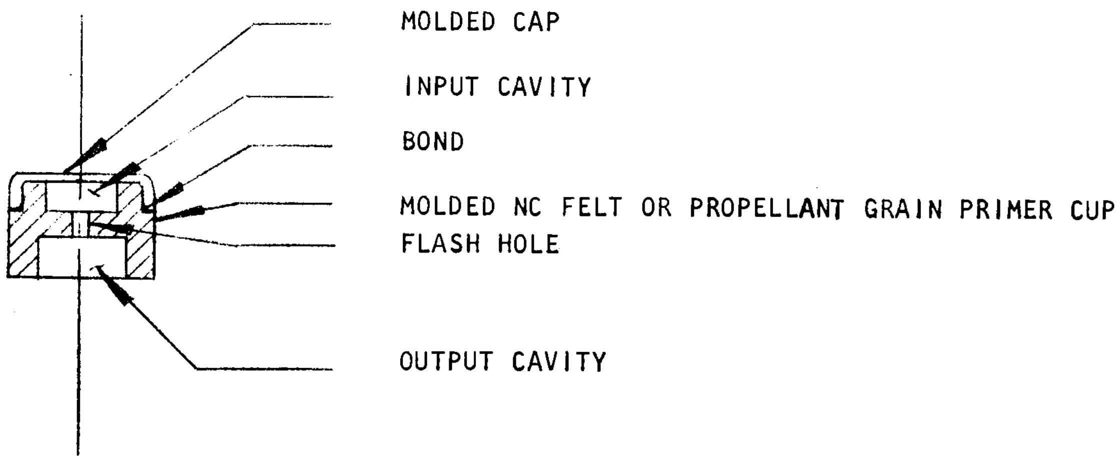


a. PHASE III CONSUMABLE PRIMER



b. PHASE IV CONSUMABLE PRIMER

FIGURE 3.5

PRIMER CONFIGURATIONS

TABLE 3.6

PRIMER MIX COMPOSITIONS

CONSTITUENT	FA 982	MIX A	MIX B	MIX C	MIX D
Lead Styphnate	36	40	45		40
Tetrazene	12	3	5		5
Barium Nitrate	22	42	33	9	20
Lead Dioxide	9	5			
Antimony Sulfide	7		20		15
Zirconium	9				
PETN	5				
Calcium Sulfide		10			
Mg/Al			5		
TNT				6	
Lead Azide					20
Gum Arabic	<1				
Potassium Chlorate				37	
Lead Thiocyanate				38	
Silicon				10	

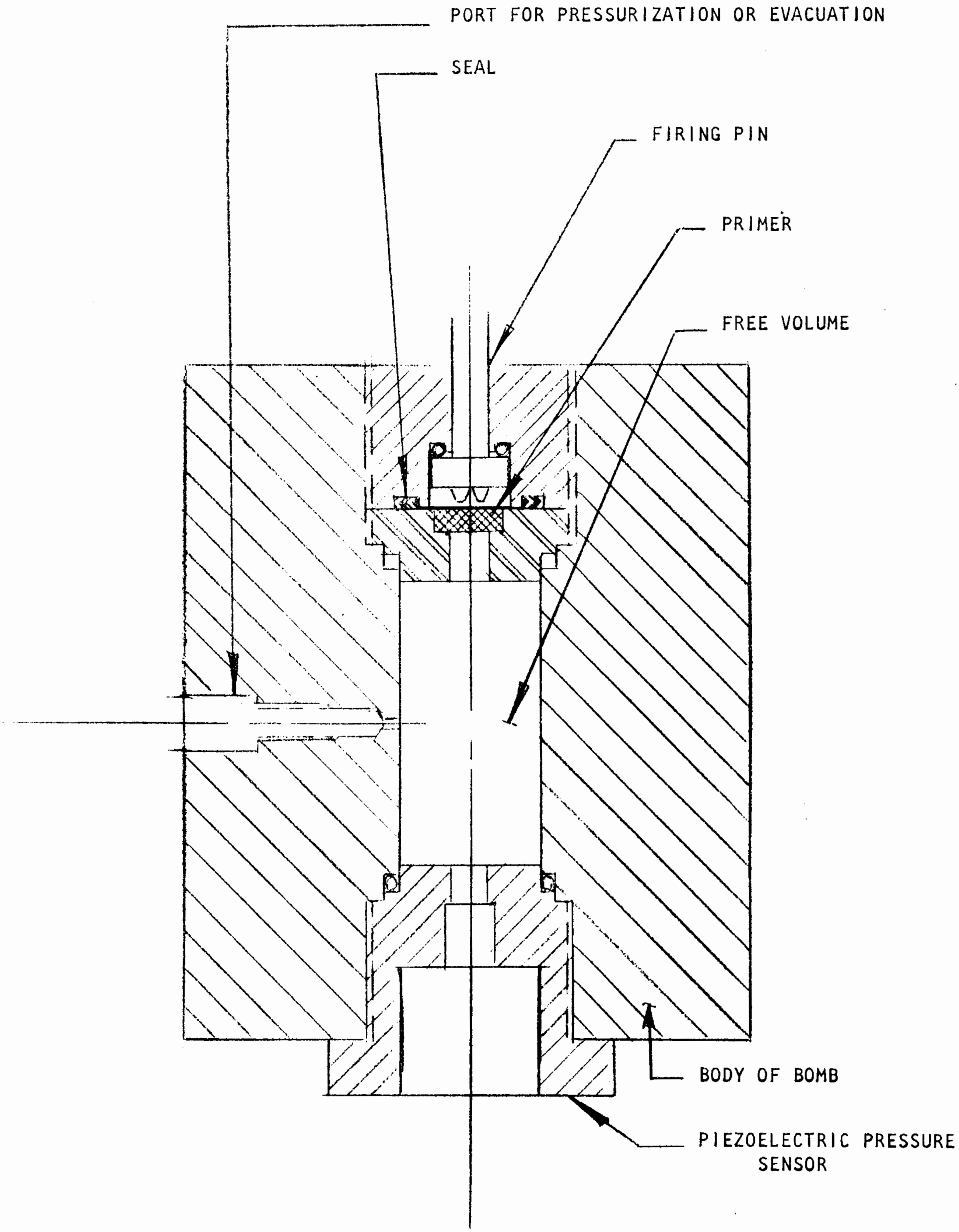


FIGURE 3.6

PRIMER BOMB

TABLE 3.7

PRIMER TEST MATRIX

	VARIABLES			
	PRIMER CLOSED BOMB		DROP TEST FIXTURE	
DESIGN PARAMETER	PHASE A	PHASE B	PHASE A	PHASE B
Mix Composition	3	2	2	1
Mix Mass	3	2	2	1
Cup Materials	3	1	3	2
Cup Configuration	3	2	3	2
Firing Pin Energy	2	3	3	6
PRIMER TESTED				
Standard Conditions	2100	100	1000	500
Temperature Extremes	500	200		100
Humidity	200	100		20
Thermal Shock	100	100		20
Altitude	30	100		
TOTALS	2930	600	1000	640

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Candidate primer mixes to be considered are presented in Table 3.6 in comparison to the baseline primer mix FA 982. Elimination of metal fuels from the primer mix such as zirconium would result in a low ash mix with minimal corrosive products of combustion.

Primer cup material studies will include fine web molded propellants and molded fibrous nitrocellulose compositions. The possibility of pressing the primer mix directly into the rear grain will also be examined. This approach is illustrated in Figure 3.4.

Evaluation of candidate primers will be conducted in both a static drop test fixture and a specially designed closed bomb. The drop test fixture will be used to provide sensitivity and reliability data for the primer. The effects of temperature extremes on primer sensitivity will be established.

The closed bomb will be used to measure primer functional characteristics . . . . peak pressure, ignition delay and rise time. The closed bomb tests will provide quantitative data on the output of the primer for correlation with ballistic tests. Primer output for the design variations will be studied with respect to initiation energy, temperature extremes, humidity, thermal shock and altitude. The ignition characteristics and the ability of the primer to ignite black powder (or other supplementary charges) at altitude is of particular interest. The primer closed bomb is shown in Figure 3.6 and provides for evacuation to simulate 75,000 feet. A test matrix for the primer development is presented in Table 3.7.

c. Supplementary Ignition Charge. Work during Phase III has indicated that good ignition and action time can be obtained using ignition charges other than black powder. Small amounts of material containing aluminum, boron and

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c. <u>Supplementary Ignition Charge</u>. Work during Phase III has indicated that good ignition and action time can be obtained using ignition charges other than black powder. Small amounts of material containing aluminum, boron and potassium perchlorate performed well. Because of the corrosive nature of the decomposition products of potassium perchlorate other materials will be evaluated. The advantage of these thermite-type materials is that they generate high temperatures with low gas output.

Other materials to be investigated include several granulations of black powder, Benite (a mixture of black powder and nitrocellulose), porous fast burning ignition powders, and fine web propellants.

Configurations of the supplementary charge will also be studied and tested to improve ignition. Simple modular construction of the entire primer-supplementary charge subsystem offers advantages in moisture protection and in round assembly.

Ignition system test fixture firings for optimization of supplementary charges are planned. Approximately four hundred twenty (420) firings are provided for this purpose. In addition, approximately one hundred twenty (120) complete round firings to confirm ignition test fixture results will be included in Phase A and two hundred forty (240) ballistic tests with the emphasis on temperature effects are planned for Phase B.

The supplementary ignition charge tests are included in the ignition system test matrix of Table 3.5.

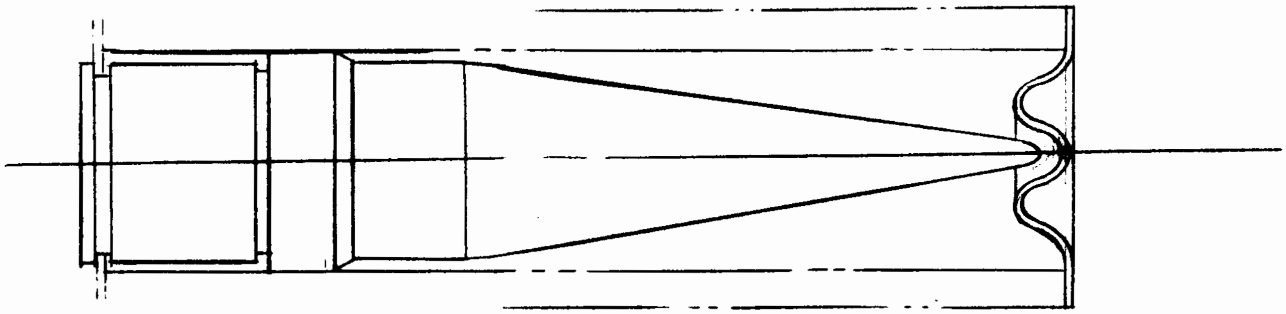
d. Retention System. The retention system provides the means of holding the projectile within the telescoped cartridge through the rigors of rough handling, transportation, vibration, and the dynamic action of the feed system and gun. The most severe environment is produced when the round is rammed into the chamber, impacts the round stop and rebounds, with the forward end of the round impacting the rammer.

The Phase III retainer consist of two (2) pyroxylin split rings housed in a groove in the projectile and restrained between the forward and rear grains. Although this retainer has the required structural characteristics to resist debulleting at ambient conditions, it does become brittle at low temperatures and fails when subjected to the loading environment. Also, the pyroxylin is not completely consumed during the ballistic cycle and pieces of retainer are ejected as muzzle debris.

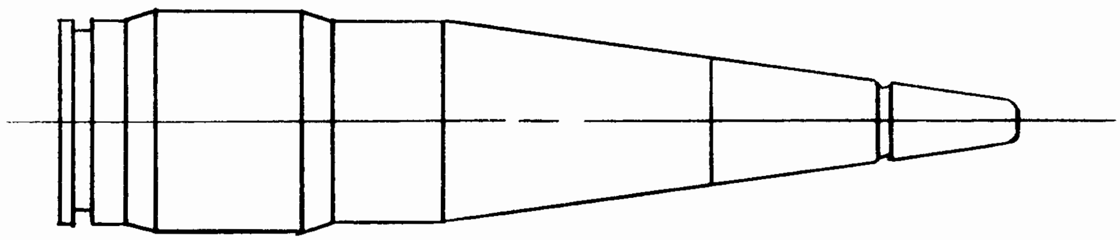
Utilization of fibrous materials for this application is particularly attractive because of resistance of such materials to crack propagation. Nitrocellulose felt compositions similar to those used in the outer case will be investigated. Adjustments to composition, density and ring thickness will ensure achievement of the required burning rate for complete combustion of this retainer. Another possible advantage of a fast burning retainer is that upon round ignition, initiation of burning of the combustible retainer takes place thereby reducing the retention force and permitting the projectile to be expelled at lower pressures. Initial projectile motion at low pressures allows the rotating band to enter the barrel and obturate resulting in minimal blowby.

Other retention systems will also be examined. One such design relies on the rammer itself by transmitting the barrel impact loads to the projectile through a forward closure on the round. This design is illustrated in Figure 3.8. The disadvantage of this approach is in difficulty in attaining complete combustion of the material located forward of the projectile.

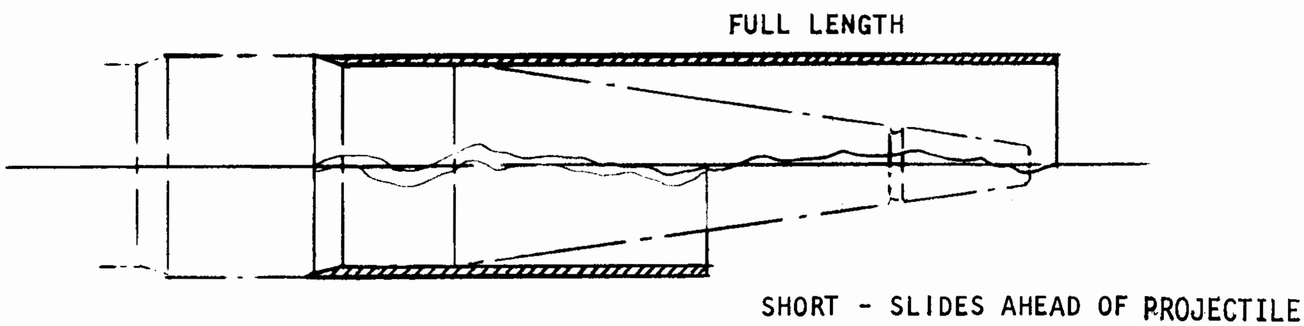
A. C7 PROJECTILE AND NOSE POSITIONER



B. PLASTIC ROTATING BAND PROJECTILE



C. CENTERING BANDS AHEAD OF ROTATING BAND



D. POSITIVE NOSE POSITIONER CONCEPT
CONVOLUTED PAPER SUCH AS NC FELT - MADE FLAT, TRIMMED, AND WRAPPED AROUND CONE

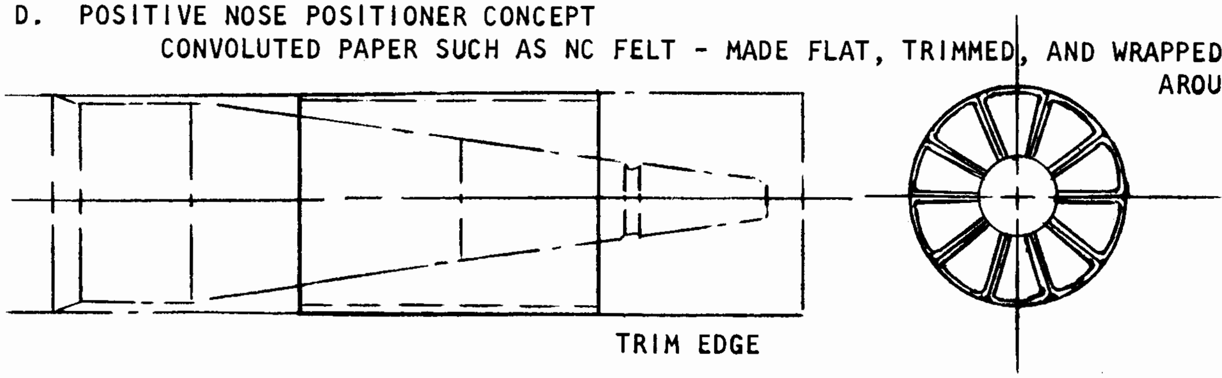


FIGURE 3-7

CONCENTRIC EXPULSION

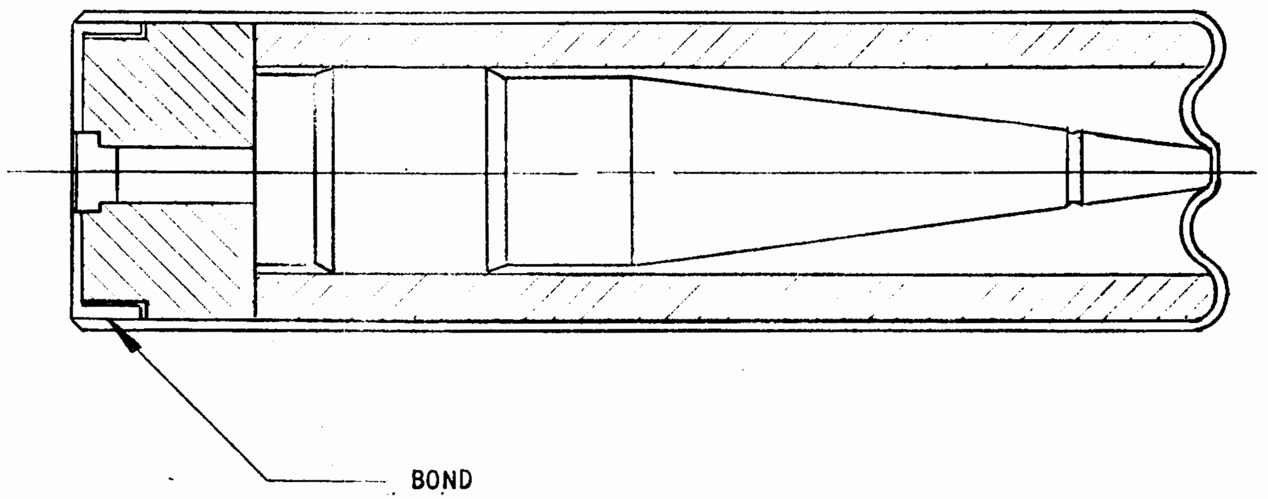


FIGURE 3-8

ROUND WITH FRONT RETENTION AND REAR CAP

Development testing of retainers is relatively simple. Static load-deflection shear test results have been found to be relatable to ignition characteristics influenced by the retention system. Nosedown drop testing establishes dynamic strength levels required for compatibility with the gun. Ballistic firings are used to confirm consumability of the retainers.

Accelerated aging tests will be performed to determine the effects of storage on the structural characteristics of candidate retainer materials.

Development and optimization plans provide for evaluation of materials, density, thickness and surface characteristics of retainers. The test matrix for the planned activity is presented in Table 3.8.

3.4.4 Propellant Charge Development. Characterization of propellant charge component performance parameters and optimization of component design are the goals of this portion of the program.

Major components of the propellant charge will be tested individually. Individual tests will include pertinent physical properties and burning characteristics, relative force and relative quickness. Individual component design parameters will be varied and tested with baseline round components to evaluate the total interaction effects.

Integrated interaction testing will also be performed on a parametric basis. In these tests, more than one component will be varied in a single round. Results of these tests, when compared with individual parametric tests performed with otherwise baseline rounds, will provide insight into synergistic relations not now well understood.

TABLE 3.8

RETAINER TEST MATRIX

	VARIABLES					
	LOAD DEFLECTION TESTS		DROP TESTS		BALLISTIC TESTS*	
DESIGN PARAMETER	PHASE A	PHASE B	PHASE A	PHASE B	PHASE A	PHASE B
Configuration	4	2	4	2	2	1
Material	3	2	3	2	1	1
Density	2	2	2	2	1	1
Thickness	3	2	3	2	1	1
Surface Finish	2	1	2	1	1	1
ROUNDS TESTED						
Standard Conditions	500	200	1500	300	1000	80
Temperature Extremes	300	100	600	120	200	200
Thermal Shock	100	50	100	60	50	80
Accelerated Storage	50	200	50	200		

* Conducted as part of Ignition System Tests

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a. Molded Grain Development. Molded rear and forward charges as the principal sources of energy in the duplex round, are critical characterization components. Intensive effort will be expended at the outset of the Phase IV program to control processes and properties of these components. Three (3) lots of forty (40) each of forward and rear charges will be made under carefully controlled conditions. Ten (10) from each lot will be tested for compressive strength and ten (10) will be tested for relative quickness and relative force in closed bomb tests. Maximum deviation from the average values in these tests will be held to ± 10% in the strength tests and ± 2% in the closed bomb tests. If the reproducibility is within the limits specified, the remaining twenty (20) each will be assembled with other baseline round components and fired in the single shot ballistic fixture. In the event that compressive and closed bomb test results are not satisfactory, the remainder of the original lots will be discarded and the experiment will be repeated.

After satisfactory baseline performance characterization has been established, modifications of molded propellant charges will be evaluated. A ballistic performance characterization and optimization program will be run using combinations of baseline propellant, modified burning rate baseline propellant, two (2) additional single base propellants, and two (2) modified charge configurations. Tests will include ballistic firings, ignition gun firings (involving rear charges only), closed bomb firings, and associated compressive strength tests during Phase A. During Phase B, effort will continue along the same lines at a reduced level - about 40% of the Phase A effort.

TABLE 3.9

MOLDED GRAIN DEVELOPMENT TEST MATRIX

	TEST VARIABLE	BALLISTIC FIRING PHASE A	BALLISTIC FIRING PHASE B	CLOSED BOMB PHASE A	CLOSED BOMB PHASE B	PHYSICAL & CHEMICAL PHASE A	PHYSICAL & CHEMICAL PHASE B
a.	Configuration 3 forward, 3 rear	180	180	360	140	150	150
b.	Propellant 3 webs, 3 modifications	130	130	360	140	150	150
c.	Combinations 3 config., 2 propellants	90	90	180	120		
d.	Temperatures $-80^{o}F$, $+185^{o}F$ Selected combinations	240	240				
e.	Altitude Selected Combinations @ 75,000 ft.		40				
	TOTALS	640	680	900	400	300	300

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Configuration modifications anticipated are: (1) changes in length of the molded charges to accommodate projectile length changes and change of thickness of the aft bulkhead of the outer shell, and (2) basic change in configuration using an extended forward charge with the rear charge inside. See Figure 3.9.

Advantages of the extended forward charge configuration include: (1) reduction of tolerance build-up at the front of the round by eliminating the rear charge as a contributor, (2) reduction of end load on the forward grain and thereby the tendencies toward blowby by reducing its pressure loaded area at the retainer station, (3) possible placement of two different burning rate materials, one within the other, and (4) minimizing size of the rear grain which breaks up under primer-supplementary charge reaction. The major difficulties are the possible increase in difficulty in molding the long forward (or outer) charge and the required change in retainer concept.

b. Outer Shell Development. Redimensioning of the outer shell to accommodate the necessary environmental protection coating will be done as soon as required thickness of the coating can be established. Nominal thickness of the cylindrical portion of the outer shell will be held at its present value (0.045"). Both outside and inside diameters of the shell will be reduced as required. The feasibility of reduction of the thickness of the aft bulkhead will be determined early in Phase A so that this change, if feasible, can be made at the same time as the diameter change.

Outer shell performance optimization will be pursued by evaluating changes in composition using physical strength and residue characteristics as trade-off

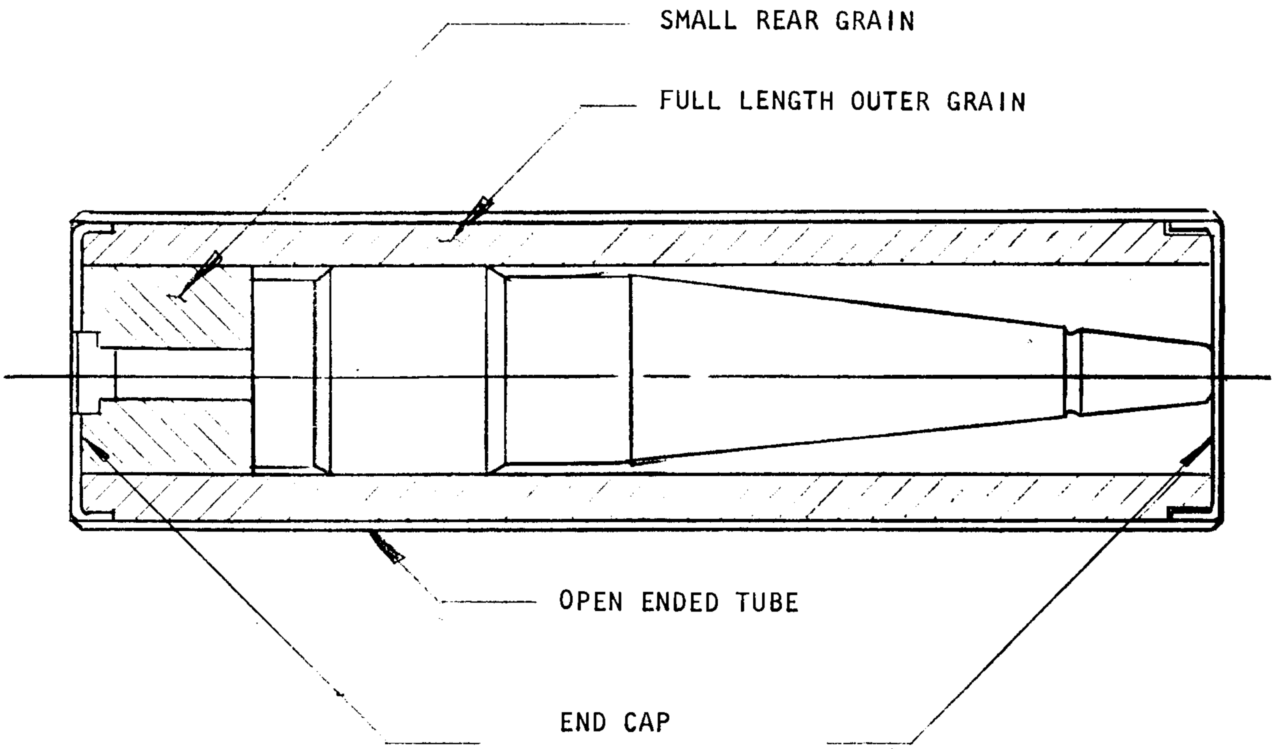

FIGURE 3.9

ROUND WITH EXTENDED OUTER GRAIN AND
OPEN TUBE-END CAP OUTER CASE

TABLE 3.10

OUTER SHELL DEVELOPMENT TEST MATRIX

	TEST VARIABLE	BALLISTIC FIRING PHASE A	BALLISTIC FIRING PHASE B	PHYSICAL AND CHEMICAL PHASE A	PHYSICAL AND CHEMICAL PHASE B
a.	Composition 4 Compositions	120	120	40	40
b.	Burn Rate Modifiers 5 Modifications	150	150	50	50
c.	Additives 3 Materials	90	90	30	30
d.	Configurations 2 Configurations	40	40	30	30
e.	Temperature -80°F and +185°F	180	180		
f.	Altitude 75,000 ft.		40		
	TOTALS	580	620	150	150

TABLE 3.11

PROJECTILE CENTERING TEST MATRIX

	TEST VARIABLE	BALLISTIC FIRING PHASE A	BALLISTIC FIRING PHASE B	TRANSPARENT CHAMBER PHASE A	TRANSPARENT CHAMBER PHASE B
a.	Configurations 5 Configurations	120	120	6	6
b.	Materials 3 Materials	80	80	6	6
c.	Temperatures -80°F and +185°F	80	80		
d.	Altitude 75,000 ft.		20		
	TOTALS	280	300	12	12

and (3) physical and chemical tests. The prime goals of the evaluations will be: First, to establish quantitative measures of component performance change on a round; and Second, to relate simplified test results for components to ballistic performance of rounds containing such components.

a. Molded Charge Development. The prime process variables for the molded grains are as listed below:

1. Solvent Composition - Ratio of acetone to alcohol.
2. Solvent application - Amount and time in contact prior to molding.
3. Solvent Removal - Removal agents and schedule.
4. Impregnation - Post molding impregnation of molded charge with resin.
5. Molding Pressure
6. Mold Temperature
7. Ambient Temperature
8. Ambient Humidity
9. Solvent Temperature
10. Volatile content and volatile fraction in finished molded grains - Volatiles depend on other process variables but are themselves extremely important to ballistic performance. Allowable limits must be determined.
11. Propellant Lot - Characterization of propellant lots with respect to molding characteristics.

In addition to the variables listed, it is anticipated that a change from the basic Phase III practice of adding solvent to propellant in an open vessel will be changed to a closed vessel injection and mixing process. In the closed vessel mixing process, the propellant-solvent combination will not be exposed to open air prior to changing the mold.

TABLE 3.12

MOLDED GRAIN PROCESS DEVELOPMENT TESTS

TEST VARIABLES	TEST: BALLISTIC FIRING PHASE A	BALLISTIC FIRING PHASE B	CLOSED BOMB PHASE A	CLOSED BOMB PHASE B	PHYSICAL AND CHEMICAL PHASE A	PHYSICAL AND CHEMICAL PHASE B
Solvent Composition	300		200		200	
Solvent Application	400	200	300		400	200
Solvent Removal	600	200	400	200	400	200
Impregnation	300		100		200	
Molding Pressure	100				200	
Mold Temperature	100				100	
Ambient Molding Conditions	200		200		100	
Solvent Temperature	100				100	
Volatiles	500	200	200	200	100	200
Propellant Lot	200	400	100	200	200	200
TOTALS	2800	1000	1500	600	2000	800

thickness and density, forward closure configuration and materials, and projectile centering device will be made in sufficient quantity to permit process definition.

In a similar sense, coating process development will be integrated in the coating design development task.

3.4.6 Coating Development. The 25mm duplex round requires protection against cook-off and moisture. The no-residue requirement for the round complicates the problem, inasmuch as coatings effective against moisture and heat may not be easily consumed. The products of combustion for the coating must be non-corrosive. Finally, the outer surface must be tough and provide a surface smoothness compatible with feed system requirements.

Rounds with moisture protective coatings, with combined moisture and anti-residue coatings, and with no coatings were fired during Phase III. Great progress was made in reducing the sensitivity of the round to moisture: uncoated rounds were exposed to ten (10) temperature-humidity cycles per MIL-STD-810B, Method 507, Procedure V and fired with only minor effects on ballistics or residue. Early in Phase III, similarly exposed unprotected rounds exhibited misfires, long action times, and generally very poor ignition characteristics. Increased moisture resistance requirements are implied by the Phase IV change in the temperature-humidity cycle requirement from Procedure V to Procedure I.

Residue control was found to be accomplished effectively by addition of a coating developed by New York University. This coating is an acrylic resin filled with RDX or HMX. The filler acts as an oxidizing agent. The coating also provides resistance to cook-off and some moisture protection.

evaporation of a solvent solution from a water surface, is virtually pin-hole free and clings tenaciously to itself and almost any substrate. Due to the elastic nature of the film, most complex shapes can be covered and overlaps tend to fuse and disappear.

b. Anti-Residue Coating. All the moisture protection coatings tend to increase the quantity of chamber residue because of the fuel-rich condition they produce at the cool chamber walls. Addition of an acrylic resin filled with RDX or HMX effectively eliminates the residue. The choice of acrylic resin, in the original development at NYU, was made because acrylics tend to reduce to monomeric gases and are therefore easily oxidized or expelled. The thickness of the anti-residue coating required is dependent on the moisture protection material and thickness selected. The filled acrylic resin must itself be coated with clear resin to prevent "dusting" or surface loss of oxidizer particles. The particles lost, whether RDX or HMX, are coated with acrylic resin and thus desensitized, but accumulations of such dust are potentially very hazardous and must be avoided.

c. Anti-Cook-off Coating. The same filled acrylic resin coating used to control residue is an effective anti-cook-off agent. The HMX or RDX is a crystalline material which is capable of absorbing substantial amounts of heat before melting. The cook-off and residue requirements are treated separately but concurrently.

d. Cook-off and Residue Testing. Seven (7) candidate materials possessing good moisture penetration resistance will be selected. Candidates include Mylar and polypropylene films, acrylic resin, wax-treated acrylic resin, wax-treated nitrocellulose lacquer, proprietary Dow Corning silicone resin and an ultra thin

TABLE 3.14

COOK-OFF AND RESIDUE TESTING

PARAMETER	COOK-OFF TESTS PHASE A	COOK-OFF TESTS PHASE B	RESIDUE TESTS (BALLISTIC FIRING) PHASE A	RESIDUE TESTS (BALLISTIC FIRING) PHASE B
a. Material - 7 moisture resistant coatings with 20 combinations of coating thickness and acrylic/RDX-HMX overcoat	100	120	150	200
b. Environment - 5 moisture resistant coatings with 10 combinations of coating thickness and acrylic/RDX-HMX overcoat. Rounds stabilized at 185°F for cook-off tests and at 70°F, -80°F, and +185°F for firing	60	60	400	400
c. Same as b. except rounds run through combinations of gun simulator, handling drop, and humidity tests prior to temperature stabilization and final test.	40	60	200	300
TOTALS	200	240	750	900

b. Projectile Interface. The ammunition interface engineer will maintain surveillance over projectile-ammunition interface activities. This activity will be emphasized particularly early in Phase IV when the projectile envelope is being finalized. Another critical interface activity relates to the HEI projectile. Safety, as related to shipping, receiving, storing, loading and firing HEI rounds will be given particular attention.

At the beginning of Phase IV, an in-depth review of interface definition and requirements will be made and an interface control document will be originated and maintained.

c. Aircraft Interface. No primary aircraft interface effort is anticipated or planned. A limited amount of effort is provided in this subtask to provide support as specifically requested by the gun system interface activity.

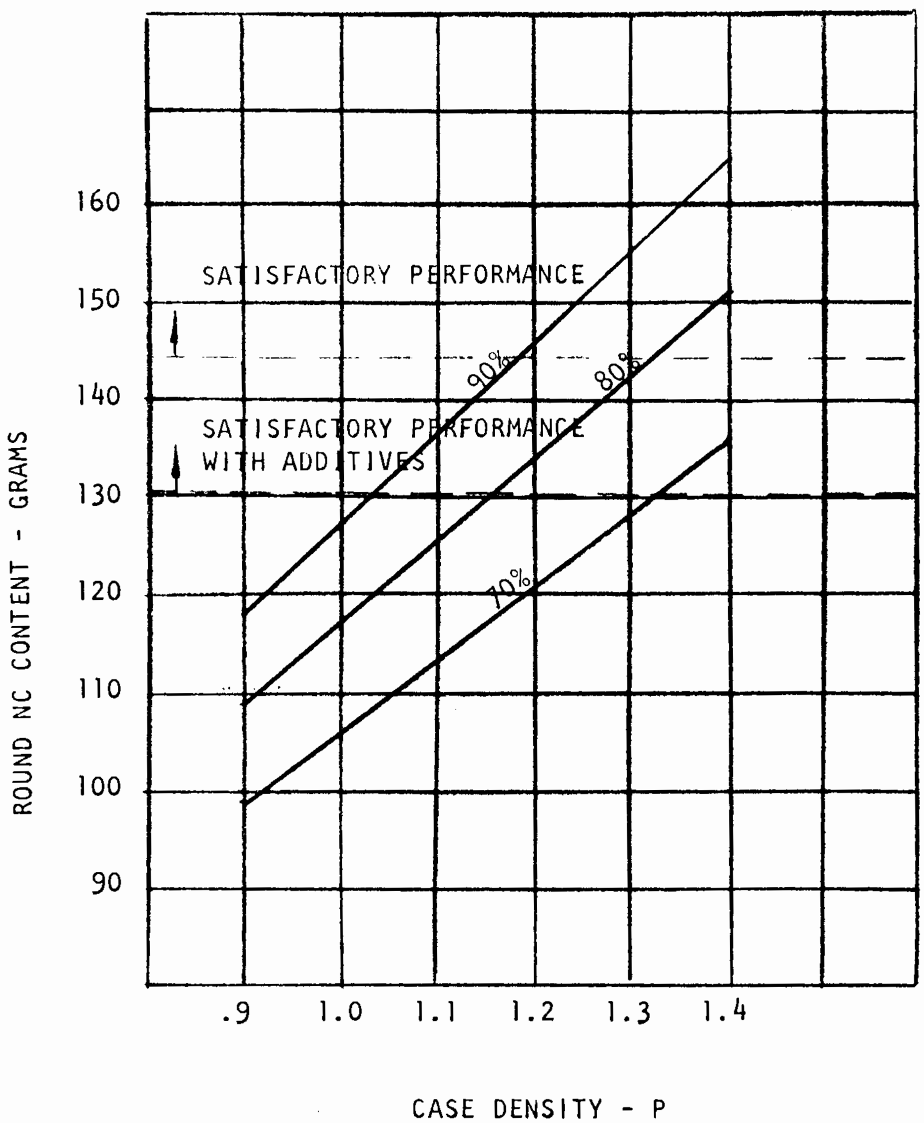

FIGURE 3.10

NC CONTENT - DENSITY REQUIREMENTS

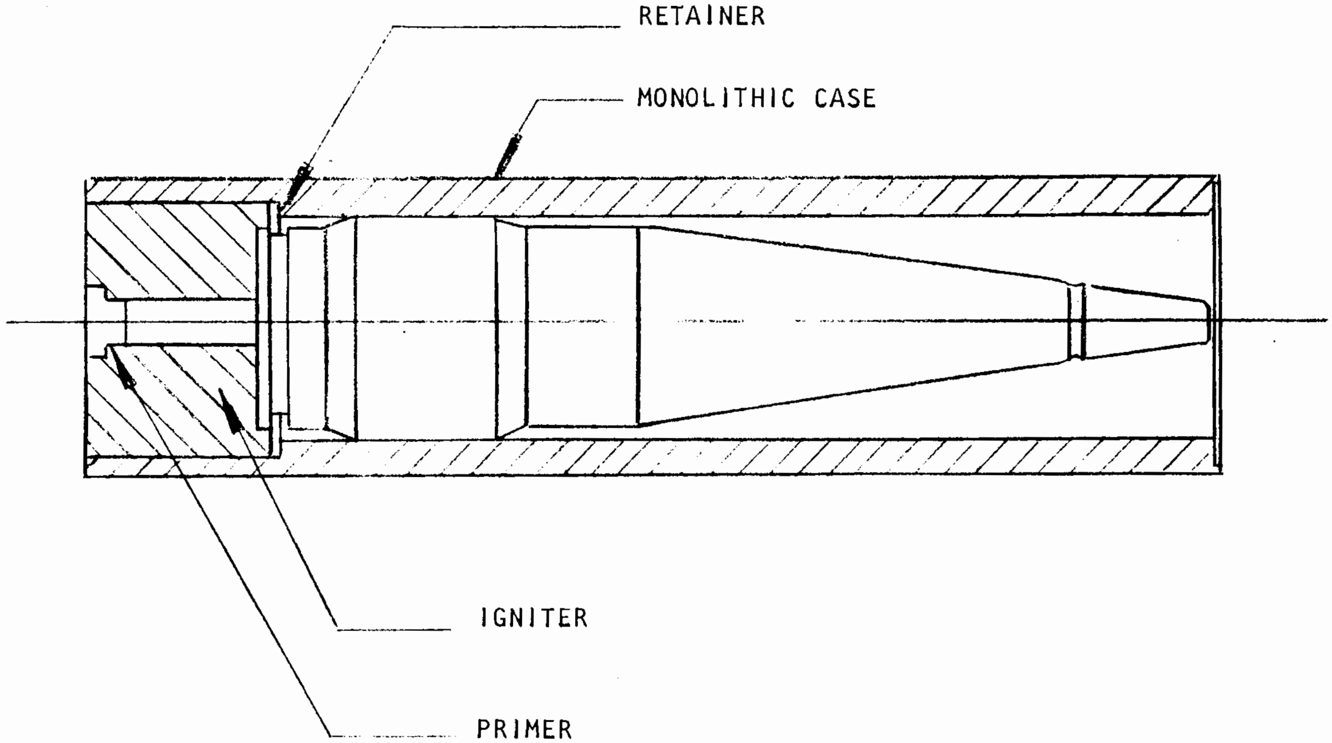

FIGURE 3.11

MONOLITHIC ROUND

for adding these materials, the "composite" approach in which NC propellant or other additives as shown in Table 3.15 are added randomly throughout the felt and the "jelly roll" concept in which the additive is sandwiched between convolutely wrapped felt. Both composite and jelly roll type rounds have been fired and show promise for further development.

Through flame temperature calculations for compositional purposes and actual closed bomb and gun testing, the optimum ratio of nitrocellulose, binder, filler, etc., can be achieved to give required ballistic performance. Igniters can be made of molded propellant grains similar to those presently used, from modified felt, or by using the composite concept.

Additives will be incorporated using a new design felting tank based on a previous pilot plant model in which felting can be accomplished using NC water with any water insoluble energy additive such as propellant grains, PETN, RDX, etc. These ingredients will be deposited along with NC fibers onto the felting screen. Dehy pressing and matched metal molding for final compaction and sizing will follow current processes.

Plasticizing of the NC filters will be accomplished by insitu-coating of the fibers in the water slurry. Plasticizers will be emulsified by surfactants or mechanical emulsification and added to the water slurry mixture. Deterrents which may also act as plasticizers (when in solution and incorporated with the NC fibers) can be added by charge attraction, solution in plasticizers and coated on in the water-slurry mixture, or by melting and absorption onto the NC fibers during heated pressing.

TABLE 3.16

TEST MATRIX - MONOLITHIC ROUND

	Test	GUN FIRINGS	BOMB FIRINGS
PHASE A	(1462 Propellant Molded Grain Igniter)		
1.	Unmodified Felted Case - 3 densities x 3 compositions	27	18
2.	Slow Burning Case - 3 modifiers x 5 compositions x 2 densities		60
	1 modifier x 3 compositions x 2 densities	18	
3.	Added Energy Case - 3 additives x 3 compositions x 3 application methods		54
	2 additives x 3 compositions	18	
4.	Felt/Composite Case (Propellant Additive) - 3 propellants x 3 compositions x 2 densities		36
	1 propellant x 3 compositions x 2 densities	18	
5.	Jelly Roll - 2 propellants x 2 compositions x 2 densities	24	40
6.	Duplex Modifications - 2 configurations	30	
PHASE B	(Each will use 2 best cases from Phase A)		
1.	Molded Grain Igniter - 3 propellants x 3 densities x 3 supplementary charges (gun only)	71	27
	NC Felt (If Required) - 3 densities x 3 compositions	27	18
	Slow Burning Felt (If Required) - 3 modifiers x 3 compositions x 2 densities		36
	1 modifier x 2 compositions x 2 densities	12	
	Felt/Composite (If Required) - 3 propellants x 3 compositions x 2 densities	24	16
PHASE C			
	Successive iterations of density, composition, and igniter design to optimize performance.	150	150

4. TEST & EVALUATION (QUAL) PLAN

4.0 TEST PLAN

4.1 Development Test Summary Sheet (Attached)

4.2 Test Procedures

4.2.1 Ballistic Firing Test

a. Objective. To determine ballistic, residue and muzzle debris characteristics of test rounds.

b. Test Equipment. Single shot test fixture supplied by gun system contractor. Instrumentation for measuring and recording ballistic parameters.

c. Procedure and Data. Fire round following an approved detailed procedure. Record continuous chamber pressure, barrel pressure 6" from breech, and barrel pressure 2" from muzzle using piezoelectric gages. Record on permanent paper with an accompanying reflectometer trace measuring projectile motion and a continuous time trace with time of firing pin-primer impact and time of projectile passage at stations 30' and 60' from the muzzle indicated. Examine chamber for residue, witness board and surrounding area for muzzle debris, and recover projectile if required. Maintain permanent record for each round fired.

4.2.2 Ignition Gun Firing Test

a. Objective. To determine ignition characteristics of selected round components in an environment closely simulating a ballistic firing.

b. Test Equipment. Single shot fixture supplied by gun system contractor with chamber and barrel modifications. Instrumentation for measuring and recording ballistic parameters.

c. Procedure and Data. Fire gun following an approved detailed procedure. Record continuous chamber pressure at two locations and barrel

4.1 DEVELOPMENT TEST SUMMARY

PHASE \ TEST	I BALLISTIC FIRING A	I BALLISTIC FIRING B	II IGNITION GUN FIRING A	II IGNITION GUN FIRING B	III CLOSED BOMB A	III CLOSED BOMB B	IV PHYSICAL AND CHEMICAL A	IV PHYSICAL AND CHEMICAL B	V STORAGE A	V STORAGE B	VI DROP TESTS A	VI DROP TESTS B	VIII COOKOFF A	VIII COOKOFF B	ENVIRONMENT
1. Cartridge Design	500 1000 100	250 750 500							750	750					Standard All Environments Storage
2. Ignition System Development	1000	80	1200	50	2100	100	500	200	RETAINERS ONLY 50	200	2250 Primers Only 1000	680 640			Standard
	200 50	200 80	100 20 20	100 30 80	500 100 30	200 100 100	300 100	100 50							Temperature Thermal Shock Altitude
			CHAMBER EVACUATED												
3. Charge Development	1000 500	1000 500 100			1000	500	500	500							Standard Temperature Altitude
4. Process Development — Grain Case	2800 1500	1000 500			1000	600	2000 1000	800 300							Standard
5. Coating Development	150	200											100	120	Standard
	600 Test @ 185°F	900											100	120	Tempt-Humidity Cycling
TOTALS	9400	6060	1340	260	5430	1700	4400	1950	800	950	3250	1320	200	240	

pressure 6" from the breech using piezoelectric gages. Record on permanent paper with an accompanying time trace with time of firing pin-primer impact indicated. Maintain permanent record for each firing.

4.2.3 Closed Bomb Firing Test

a. Objective. To determine buring rate and total force characteristics of propellants and round components (molded charges, outer shells, primers).

b. Test Equipment. Closed vessels of suitable sizes (3 cc, 200 cc, 1000 cc). Instrumentation for measuring pressure versus time and rate of pressure rise with respect to time as a function of pressure.

c. Procedure and Data. Fire closed vessel following an approved detailed procedure. Record $\frac{dp}{dt}$ vs P or p vs t on permanent paper using piezoelectric pressure gages. Maintain permanent record of each firing.

4.2.4 Cook-Off Test

a. Objective. To determine autoignition characteristics of rounds under time and temperature conditions simulating chamber, barrel entrance, and breech block of GAU-7/A gun.

b. Test Equipment. Insulated hollow steel chamber and end plate capable of being heated to controlled maximum gun temperatures with necessary cam-actuated handling devices to place subject round in chamber and in contact with end plate simulating barrel entrance or breech block for specified time periods at specified temperature levels.

c. Procedure and Data. Perform test according to approved detailed plan. Record test results, including time of ignition, if applicable, smoke generation description, and description of round at completion of test if no ignition occurs.

4.2.5 Flight Temperature Test

a. Objective. To determine response of rounds under conditions encountered in the feed system of the GAU-7/A gun as installed in the F-15 aircraft.

b. Test Equipment. Chamber with temperature capability to 420° F and device providing round support thermally similar to that of the GAU-7/A feed system.

c. Procedure and Data. Heat chamber to specified temperature. Expose specimen round to chamber environment by inserting round and its support into chamber for specified time period. Remove after specified time, allow round temperature to return to ambient then repeat. Examine round after each exposure.

4.2.6 Gun Simulator Test.

a. Objective. To provide dynamic load environment imposed on rounds by the feed system and gun under maximum flight load conditions.

b. Test Equipment. Specially designed dynamic load simulator to be provided by gun system contractor.

c. Procedure and Data. To be determined.

4.2.7 Ram Stop Drop

a. Objective. To provide developmental test simulation of primary dynamic loads imposed by the gun during chamber loading.

b. Test Equipment. Vented tube with provisions for remotely activated vertical dropping of rounds from a range of drop heights base down and nose down against ram stop and rammer simulating stop faces.

c. Procedure and Data. Drop fully assembled rounds base down, then nose down at specified heights to be determined. Examine rounds after each drop to determine if damage, either internal or external, was incurred. Record test conditions and damage if any.

4.2.8 Handling Drop Test

a. Objective. To provide developmental and qualification test simulation of loads imposed by inadvertent dropping of rounds during handling of unpackaged rounds.

b. Test Equipment. Device to hold and release rounds by remote control in a manner resulting in impact in prescribed attitudes against a hard surface.

c. Procedure and Data. Rounds to be dropped from prescribed heights to impact in prescribed altitudes to be determined. A total of nine rounds will be dropped in a test set, three each in each of three altitudes. Rounds to be examined after dropping and damage, if any, to be recorded.

4.2.9 Primer Sensitivity Test

a. Objective. To determine sensitivity limits within which the primer functions in order to provide assurance that: (1) the primer will be safe to handle, (2) the primer will fire in the cartridge for which it is intended.

b. Test Equipment. Falling weight test fixture (picatinny type) in which weight falls freely from prescribed height striking a firing pin simulating the GAU-7/A gun firing pin.

c. Procedure and Data. Primers to be inserted in holder simulating 25MM Caseless Cartridge. Ball of specified weight to be dropped from specified heights following a prescribed procedure and numbers of primers firing and misfiring to be recorded. The following sensitivity characteristics are to be calculated:

1) $\bar{H} = \Sigma p_i = (H_{100\%} + .5)$

2) $\sigma = \sqrt{\Sigma P_i k_i - \Sigma p_i^2}$

Where $\bar{H}$ = Mean critical height at which 50% of the primers misfire and 50% of the primers fire.

σ = Standard deviation

4.2.10 Mechanical Tests

a. Objective. To obtain static load-deflection and ultimate strength data for round components.

b. Test Equipment. Universal Test Machine, strain measuring devices, and special loading devices such as a Split-D tensile test fixture for outer case testing and a compression shear fixture for retainer testing.

c. Procedure and Data. Prepare specimen and test according to detailed test procedure. Record specimen identification, dimensions, and load deflection data as required by procedure.

Tests 4.2.11 through 4.2.22 are per MIL-STD-810B and test equipment and procedures will be in accordance with appropriate provisions of that document and the special provisions listed. Data obtained from the tests will be used for both development data generation and round design qualification purposes.

Test		Method	Procedure	Special Provisions
4.2.11	Temperature	501	I	Maximum temperature 185°F. Remove item from chamber and perform physical or ballistic evaluation tests after step 4, providing insulation to minimize heat transfer.
		502	I	Minimum temperature -80°F. Remove item from chamber and perform physical and ballistic evaluation test after step 4. Provide insulation to minimize heat transfer.
4.2.12	Humidity	507	I	After step 6, inspect item and perform physical or ballistic evaluation test.
4.2.13	Altitude	500		Place test item in chamber and reduce pressure to that encountered in a standard atmosphere at an altitude of 75,000 ft. and perform functional
4.2.14	Salt Fog and Spray	509		Perform ram stop drop and ballistic firing after completion of test
4.2.15	Fungus	508		Perform ram stop drop and ballistic firing after completion of test
4.2.16	Sand and Dust	510		Perform ram stop drop and ballistic firing after completion of test
4.2.17	Vibration	514		Perform ram stop drop and ballistic firing after completion of test
4.2.18	Temperature Shock	501		Place item in cold chamber and allow temperature to stabilize at -80°F for at least 4 hours. Transfer to hot chamber at a temperature of 420°F within 200 seconds and hold for 60 seconds. Remove from chamber examine and perform ballistic test. Round shall be supported in free air in the hot chamber using a support fixture simulating the GAU-7/A feed system support arrangement.

4.2.19	Temperature-Humidity-Altitude			To be determined
4.2.20	Sunshine	505	II	Perform ramstop and ballist firing after test
4.2.21	Rain	506		Perform ramstop and ballistic firing after test
4.2.22	Leakages	512	I	Perform ramstop and ballistic firing after test

4.3 Lot Acceptance Test Plan. A Lot Acceptance Test (LAT) will be conducted for each lot of rounds shipped to ADPF and USAF during Phase IV. A lot is defined as a monthly shipment fabricated from a single production run; however the maximum lot size for Phase IV will be 10,000 rounds. A lot will be further restricted in that single lots of each purchased raw material or component will be used in fabrication of the round lot.

Each round for the LAT will be selected at random from production runs and subjected to a ramstop drop test (Section 4.2.7) followed by a ballistic firing test (Section 4.2.1).

LAT quantity levels will be governed by MIL-STD-105D, Sampling Procedures and Tables for Inspection by Attributes. The normally accepted inspection level for destructive test, level 5-4, will be used to determine sample size selection. Exception to the above will be applied to the initial designs to ADPF, the initial PDR, TDP, TP rounds to ADPF and the initial CDR, TDP, TP and HEI rounds to ADPF for which the increased sampling level, Level I will be used.

Round and LAT quantities for the scheduled round deliveries to ADPF and USAF during Phase IV are contained in Table 4.4.

TABLE 4.4

LAT QUANTITY LEVELS

ROUND DELIVERIES									TOTAL
INITIAL DESIGN ADPF	Months ARO	2	3	4	5	6	7		
	Rounds	500	500	2000	2000	2000	2000		9000
	LAT	20	20	50	50	50	50		240
PDH TDP - AMMO TP ADPF	Months ARO	8	9	10	11	12			
	Rounds	3000	3000	2000	4000	4000			16000
	LAT	50	50	50	80	80			310
QUAL PDR TDP AMMO TP ADPF	Months ARO	13	14	15	16	17			
	Rounds	3000	3000	4000	4000	4000			18000
	LAT	32	32	32	32	32			160
QUAL PDR TDP AMMO TP USAF	Months ARO	14	15	16					
	Rounds	30000	40000	10000					80000
	LAT	96	128	32					256
CDR TDP AMMO TP ADPF	Months ARO	18	19	20					
	Rounds	4000	2000	1000					7000
	LAT	80	50	32					162
CDR TDP AMMO HEI ADPF	Months ARO	18							
	Rounds	1000							1000
	LAT	32							32
QUAL CDR TDP AMMO TP ADPF	Months ARO	22	24	27	28	29	30	31	
	Rounds	2000	1000	1000	10000	3000	3000	1500	30500
	LAT	32	20	32	32	32	32	32	212
QUAL CDR TDP AMMO HEI ADPF	Months ARO	22	24	31					
	Rounds	400	200	3000					3600
	LAT	13	13	32					58
QUAL CDR TDP AMMO TP USAF	Months ARO	23	24	25	26				
	Rounds	20000	20000	40000	40000				120000
	LAT	64	64	128	128				384
QUAL CDR TDP AMMO HEI USAF	Months ARO	23	29	30	31				
	Rounds	1000	10000	10000	10000				31000
	LAT	20	32	32	32				116

TOTAL ROUNDS	316,100
TOTAL LAT	1,930

4.4 Design Verification Test Plan. Ammunition Design Verification Tests (DVT) will be conducted prior to delivery of both the PDR and CDR qualification ammunition to ADPF. These tests will evaluate round ballistic characteristics following exposure to both natural and induced round environmental conditions.

All ammunition used in the DVT will be of one design and one lot selected at random from a preproduction run.

A DVT test scope depicting quantity, type test and test sequence is contained in Table 4.5. A description of the individual tests to be conducted during DVT is contained in Section 4.2.

TABLE 4.5 DESIGN VERIFICATION TEST SCOPE

Rounds	Test Sequence
10	Ramstop Drop - Ballistic Firing at Standard Condition
5	Handling Drop - Ramstop Drop - Ballistic Firing
10	Temperature Shock - Ramstop Drop - Ballistic Firing
10	Humidity - Ramstop Drop - Ballistic Firing
10	High Temperature - Ramstop Drop - Ballistic Firing
10	Low Temperature - Ramstop Drop - Ballistic Firing
10	Transportation-Vibration - Ramstop Drop - Ballistic Firing
10	Vibration - Ramstop Drop - Ballistic Firing
10	Shock - Ramstop Drop - Ballistic Firing
10	Altitude - Ramstop Drop - Ballistic Firing
10	Salt Fog - Ramstop Drop - Ballistic Firing
10	Fungus - Ramstop Drop - Ballistic Firing
10	Sand and Dust - Ramstop Drop - Ballistic Firing
10	Sunshine - Ramstop Drop - Ballistic Firing
10	Rain - Ramstop Drop - Ballistic Firing
10	Transportation Vibration - Temperature Shock - Handling Drop - Ramstop Drop - Ballistic Firing
159	TOTAL

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4.6 QUALIFICATION TEST SUMMARY

TEST	PHASE A	PHASE B
Ballistic Firing - Standard Conditions	40	400
Handling Drop - Ballistic Firing	9	
Temperature Shock - Ballistic Firing	20	80
Humidity - Ballistic Firing	30	120
High Temperature (185°F) - Ballistic Firing	30	200
Low Temperature (-80°F) - Ballistic Firing	30	200
Transportation-Vibration--Ballistic Firing	10	
Vibration - Ballistic Firing	10	
Shock - Ballistic Firing	10	
Altitude - Ballistic Firing	10	
Salt Fog - Ballistic Firing	10	
Fungus - Ballistic Firing	10	
Sand and Dust - Ballistic Firing	10	
Sunshine - Ballistic Firing	10	
Rain - Ballistic Firing	10	
Transportation-Vibration - Temp. Shock - Humidity - Ballistic Firing	20	100
Flight Temperature - Ballistic Firing	20	100
TOTALS	289	1,200

5. DATA REQUIREMENTS

1.0 BRUNSWICK QUALITY PROGRAM PLAN

1.1 Introduction Contained herein is Brunswick Corporation's Quality Plan to be implemented during Phase IV of the 25MM Caseless Ammunition Program. The plan is divided into two major sections. The first section describes, in general terms, the Quality Organization of Brunswick, Sugar Grove and how the Quality System functions. The second section describes the detailed inspections and controls that will be used to direct an effective Quality Program for the 25MM Caseless Ammunition.

1.2 Quality Plan, General

1.2.1 Top Management Statement of Quality Policy Brunswick Corporation shall continually strive for the development of a positive quality reputation through consistent, on-time delivery of conforming products. We have the firm conviction that a very important element of our plant's progress and growth is the maintenance of a level of quality which assures that all outgoing products will comply with those requirements which would influence the in-service performance of the item. We have committed ourselves to knowing and establishing the quality objectives of our plant and utilizing all the effort and knowledge available to attain these objectives. We recognize there are quality disciplines in all aspects of our management team which must be coordinated in an orderly fashion to fulfill our quality objectives.

1.2.2 Quality Organization The Brunswick Corporation has an established Quality Control Organization headed by a Quality Control Manager who reports to the Plant Manager. The departmental guidelines are established in the Quality Control Manual prepared in accordance with MIL-Q-9858A. The quality department

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consists of a Quality Engineering section, Product Inspection section and Tool and Gage section. Each section's supervisor has well defined responsibilities and sufficient authority to carry out his job function.

a. Quality Manager The Quality Manager has the overall responsibility for the Quality Program. His major function is to manage the Quality Program in such a manner to ensure that all contractual commitments are fulfilled. The Quality Manager serves as the interface with the Program Manager, Material Manager, Manufacturing Manager and Government and Customer Quality Representatives. He established the quality policies for top management and sets the guidelines to assure fulfillment of the quality policy.

The Quality Manager continually reviews the effectiveness of the Quality Program by utilizing quality cost reports, inspection reports, and quality audit reports.

b. Quality Engineering The Quality Engineering section has the responsibility for defining and implementing the quality controls for the program. These duties include a review of the contract requirements; preparation of Inspection Methods Bulletins, establishment of the inspection methods and procedures necessary to satisfy the contractual requirements; and development of a sound review, audit, and reporting program.

The contract review shall consist of a complete research of all documents and definition of the tasks required to satisfy these requirements.

The Inspection Methods Bulletins shall be prepared describing in detail the tests and inspections necessary to ensure compliance with the drawings and specifications. These documents will establish the classification of defects, the level of inspection, the gages required for inspection, the methods of inspection and the accept/reject criteria. The necessary forms for recording and reporting quality data shall be prepared as a supplement to these documents.

The Quality Engineer shall continually review the inspection records, trend charts and scrap reports to detect adverse trends and initiate corrective action to correct these trends.

Periodic quality audits shall be performed to determine the effectiveness and compliance with the current work instructions. These audits shall cover all functions affecting quality and shall be used by the Quality Manager's office as a tool for determining the effectiveness of the Quality Program.

The Quality Control Engineering section has the responsibility for approval of all vendors. The approval is made after the Quality Engineer has established that the supplier is qualified, has determined the quality system to be imposed on the supplier, and has defined the specific requirements necessary to ensure receipt of acceptable material.

The vendor qualification is established by an actual quality survey of the vendor's facility or by evaluating past performance on the same or similar products.

c. Product Inspection The Product Inspection section has the responsibility for all inspection and testing functions. These functions include receiving inspection, in-process inspection, final inspection, shipping inspection, and monitoring of the materials and end item acceptance testing.

(1) Receiving Inspection - The Receiving Inspection group has the responsibility for insuring acceptability of all incoming materials. This includes verification of purchase from an approved vendor, completeness of the vendor's certification and physical and/or chemical acceptability of the material as defined by the Inspection Methods Bulletins.

(2) In-process Inspection - The In-process Inspection group has the responsibility for insuring compliance with the approved Process Instructions and acceptability of the units at various stages of manufacture. It will be the In-process Inspector's responsibility to monitor the manufacture and assembly steps and to assure conformance to the process instruction sheets. All in-process instruction sheets will be approved by the Quality Control Engineer prior to their release or revisions.

Records indicating the type and number of observations made are maintained by the inspection group. These records are used by the Quality Engineering Group to evaluate the manufacturing process controls and to determine if a need for change exists.

(3) Final Inspection - The Final Inspection group performs a complete inspection of the final unit in accordance with the Inspection Methods Bulletins. This group also assembles and maintains records of lot acceptance tests, final inspection results, and configuration accountability records. These records are used to determine the Average Outgoing Quality Level, and for preparation of the certifications and the ammunition data cards.

(4) Shipping Inspection - The Shipping Inspection group performs an inspection for proper marking, packaging, proper documentation, adequate blocking and bracing of load and final release for shipment.

(5) Materials and End Item Acceptance Testing - Quality Control monitors performance of acceptance and qualification testing to insure that adequate and accurate records are maintained and that all established performance requirements are met. The Quality Control Department ensures that calibration is correct and current for equipment used in the performance of all testing.

d. Tool and Gage The Brunswick Tool and Gage section maintains a calibration system in compliance with MIL-C-45662A. To assure adequate record control of all tools and gages, it will be the responsibility of the Tool and Gage section to permanently identify all tools and gages with a numerical serial number or by the design drawing number. This number will be entered on the Tool and Gage Inspection Card (Form SG 549-1) and the card will be kept in the Tool and Gage Inspection files. In addition, a duplicate reference card file will be set up to be used as a recall or cycling interval guide. This reference card file will be arranged on a calendar basis such that a daily check will reveal the items requiring action that day.

Dimensional and visual data, etc., will be recorded on the Tool and Gage Inspection Record Card (Form SG-549-1) when a tool or gage is generated, has been reworked, or has been calibrated. This will apply to both Brunswick owned and government furnished tools and gages. All surveillance or calibration data will be recorded on this card for future reference.

Production tooling will be checked by the Production Inspector to ensure that (1) acceptable material is produced by the tool, (2) the tool has not been damaged, and (3) the tool is in proper working condition.

Dimensional accuracies of all material produced by the Sugar Grove Plant will be controlled through the use of appropriate tools and gages. All tools and gages will be subject to calibration at established periodic intervals or when it appears the accuracy of the calibration is questionable. Calibration of all tools and gages will be performed in accordance with the applicable drawings, government specifications, and customer specified requirements.

Calibration systems employed by suppliers are subject to review by Sugar Grove Quality Control and must be capable of maintaining the degree of accuracies established by applicable government specifications, etc.

Measurement and/or testing standards will be periodically calibrated against standards at a recognized and approved calibration laboratory, whose standards are directly traceable to the National Bureau of Standards. The calibrating laboratory will furnish appropriate records and certification indicating the degree of accuracies attainable by the standard.

All tools or gages must be routed to Tool and Gage Inspection before their release (except as noted elsewhere in this procedure). There they will be checked for compliance to the requirements of the applicable drawings, or specifications. The Inspector will record his findings on the Record Card (Form SG-549-1) for the particular tool or gage. The Receiving Record, and all applicable instruction paperwork must be made available prior to inspection of any tool or gage. Government furnished tools or gages, when received, will be visually checked only, unless otherwise specified. This inspection will be performed by a Tool and Gage Inspector and a Government Representative.

Tools and gages which are placed in storage for a prolonged time will be visually inspected at established intervals by Tool and Gage Inspection and dimensionally inspected prior to their release for use.

Defective tools and gages beyond capability of rework will be destroyed in accordance with the scrap procedures outlined in the Brunswick Quality Control Manual section QCD 011.

1.2.3 Drawing and Change Control Brunswick maintains a drawing and change control system in accordance with MIL-Q-9858A. Control of the drawings is established by the Configuration Management Group and changes are processed through the Change Control Board. The Board establishes a desired effectivity date and releases the change. Quality Control has an effectivity verification sheet attached to their copy. Quality Control is responsible for recording the actual effectivity and returning the change verification sheet to the Configuration Management group.

1.2.4 Records

a. Inspection and Test Records The results of all inspections and test performed as a part of the contractual requirements will be originated by the Quality Control technician responsible for the inspection or test. These records shall contain, as a minimum, the following information: the nature of the inspection, the number of observations made, the number and type of deficiencies found, the number of units inspected, the number accepted and rejected, the percent defective and the disposition of the material inspected.

Copies of the inspection records shall be forwarded to Quality Control Engineering for daily review. The review shall include analysis for rate of defectives and scrap rate. Unusually high rates will be subject to further investigation by Q.C. Engineering for probable cause and impact upon the program. Critical characteristics will be subjected to analysis for determination of statistical control. The results of these analysis will be summarized bi-weekly and forwarded to Quality Management, Program Engineering, Design Engineering, and Program Management for review. Results will be reviewed by the responsible activity with consideration given to design limitations, process capability, tolerance limits and level of process control. Quality Control Engineering will maintain records of corrective action taken.

b. Work Instruction Records Records will be kept daily of the work accomplished and compliance or non-compliance with the work instructions. Compliance records will be maintained by the responsible line inspection technician. These records will contain, as a minimum, the amount of work performed, the amount of work which is non-compliant and the degree of non-compliance.

A summary of these records will be prepared bi-weekly by Quality Engineering to identify the major areas of deficiency. This summary will be forwarded to Quality Management, Program Engineering, Industrial Engineering, and Program Management for review and corrective action. Quality Engineering will maintain records of corrective action.

1.2.5 Correction Action When discrepant material is found in Receiving Inspection, the Receiving Inspector will initiate a Discrepant Material Report. The Receiving Inspector will make copies of the DMR and will affix a six digit identification number. The original will be filed in the corrective action log and copies sent to the following: Receiving Inspection, Accounting, Project Engineering, and Purchasing.

The Project Engineer will fill out the disposition in its entirety and sign in the appropriate space with the Quality Control Engineer concurring. It is the Quality Control Engineer's responsibility to secure completion and concurrence by both parties.

The Quality Control Analyst shall initiate a "corrective action request" (CAR), notify Purchasing and forward the request to the appropriate vendor.

The Quality Control Analyst shall set-up and maintain a recall file on each CAR. The recall span shall be 15 working days from date of issuance of the Corrective Action Request.

Upon recall of the "Suspense" copy of the CAR with no reply from the vendor, the Quality Control Analyst shall initiate a follow-up letter referencing the CAR number and date. Recall date for the follow-up letter shall be 5 working days from date of issuance.

Upon recall of the follow-up letter with no reply from the vendor, the entire package shall be presented to the applicable Quality Control Engineer for action. The Quality Control Engineer shall evaluate the vendor's response and history and shall initiate of the following actions.

- Another follow-up letter with a 5 working day recall.
- A letter outlining the vendor's lack of response and citing vendor responsibility.
- A letter to the vendor requesting immediate action or removal from Brunswick Corporation Qualified Products List.

A copy of all correspondence between the Quality Control Engineer and the vendor will be forwarded to Purchasing.

When discrepant parts are generated in the manufacture of the item, the following corrective action procedure shall apply.

The Quality Engineer will be a member of the board that reviews all manufacturing discrepancies. Corrective action commitments will be made and dates for effectivity established. The diciplines for implementation of effective corrective action, as established by the Review Board, will be the responsibility of the Quality Control Engineer. Upon completion of his investigation and his satisfaction that the corrective action has been properly executed, he will record the method of implementation and outcome on the CAR.

1.2.6 Incoming Quality Control of incoming quality is separated into two basic sections: supplier control and receiving inspection. Each section is discussed below.

a. Supplier Control- Supplier control is accomplished in four basic areas: supplier survey, supplier ratings, supplier test and inspection records, and purchasing data.

(1) Survey of Suppliers - When the capability of a specific supplier is not known, a survey of the supplier's facility will be conducted to ascertain the adequacy of his facility, processes, controls, and quality requirements.

Adequacy of a supplier to furnish materials and services capable of meeting Brunswick's requirements will be based on analysis of the following factors (as applicable).

(a) Quality Program - The vendor's Quality Program will be reviewed in the following areas:

- Organization of Quality Control Department.
- Number of and qualifications of personnel performing Quality Control functions.
- Compliance with applicable Military Specifications.
- Supplier rating and supplier survey utilization.
- Control of all materials and special services, both in process and in storage.
- Adequacy of records, including traceability of materials.

- Inspection and test procedures and planning.
- Inspection and test of incoming materials, including laboratory Analysis.
- Inspection of packaging of materials for shipment, including inspection and approval of packaging materials and processes.
- Material Review Board procedures and requirements.
- Copy of his Quality Control Manual which outlines in detail his capabilities, intentions, how his Quality system is set up and maintained, etc.

(b) Facilities Checks of the vendor's facilities will include the following:

- Approximate size of Manufacturing, Assembly and Quality Control areas.
- Storage facilities - including areas for raw materials, materials awaiting special processing and servicing, purchased components, subassemblies, and assemblies, and special storage areas such as Rejected Materials Area, holding areas for products awaiting specific disposition.
- Tool and gaging as to ability to produce material or services meeting required tolerances and other specification.
- Control of processes and documentation, including operating instructions, drawing, etc.
- Drawing facilities, including reporduction and handling procedures.

(c) General Observations General observations to be made of the vendor's facility are listed below:

- Plant cleanliness
- Personnel, including such items as experience, attitude, moral, etc.

- Availability of manuals stating policies, handling procedures, techniques, etc.
- Training of personnel for particular assignments.

The above procedures are intended as a guide and should be considered in light of the materials or services which the supplier has contracted to furnish or perform. These procedures are not intended to preclude other pertinent observations that might have bearing on the supplier's ability to meet schedules and otherwise perform in a manner assuring products and services adequately meeting Brunswick Quality Objectives.

(2) Supplier Ratings A supplier rating system will be used to evaluate the ability of suppliers to submit acceptable material.

(a) Procedure - For supplier rating purposes, the following data is compiled:

- Date of receipt and process data on material found discrepant.
- The name of the supplier, the Purchase Order Number, and the Program Job Number.
- The tool, gage or material number, name and quantity involved.
- The quantity found discrepant.
- Disposition of the defective material, tools, and gages.
- Corrective action taken.

The supplier quality rating system established the performance of a given supplier as determined by the relative quality level of the material, tool or gage he is supplying and by receipt of all necessary certifications, test data,etc.

Supplier quality ratings are grouped into one of three categories; excellent, satisfactory, or unsatisfactory.

The rating is based on the percentage of discrepant materials, tools or gages and provides an indication of the level of quality that a particular supplier might be expected to achieve for any specific item. For material that is sample inspected or tested, the percent found defective for the sample will be assumed to be the percent defective for the lot.

Receiving Inspectors fill in a "Daily Receiving Inspection Report" (Form SG-549-3) for all material received. The Quality Control Analyst records this information daily onto a "Running Vendor Rating Sheet" (Form SG-549-5). On this same sheet, he records the suppliers who have had parts found discrepant in process or in storage, parts received without certifications or other necessary records, etc. This sheet is retained in the Quality Control files for use in publishing the monthly "Vendor Rating Report."

The Q.C. Analyst publishes a "Vendor Rating Report" every month. A copy of this report is sent to the Quality Control Manager, the Quality Control Engineers, the Quality Control Supervisor, the Purchasing and Materials Manager, and the Program Managers.

Suppliers whose products repeatedly fall into the unsatisfactory classification will be required to take necessary corrective action to improve their products. When a supplier's products continue to fall into the unsatisfactory classification due to his failure to take necessary corrective action, or otherwise lack of ability to produce products which comply with applicable specification, he will be removed from the list of approved vendors.

(3) Supplier Test and Inspection Records - Those suppliers found to be capable of producing acceptable material through survey or rating will be placed on an approved source list. Results of tests and inspection performed by these suppliers will form an integral part of the quality records, expecially in cases where it is impossible or impractical to duplicate them during receiving inspection.

Inspection and testing of all incoming material is conducted in accordance with requirements specified on drawings, specifications, in-house check lists, and other pertinent documentation.

Raw material will be subjected to a visual, chemical, and dimensional examination (where applicable). This examination will include careful comparison of material with that specified on the Purchase Order, test data, and certification. As required, comprehensive physical, chemical and metallurgical testing will be performed.

Finished detail parts, subassemblies, etc., will be subjected to chemical, visual, electrical, and dimensional checks as applicable to confirm compliance with the drawing, specifications, workmanship requirements, and/or other pertinent documentation.

It will be the initial responsibility of Receiving Inspection to maintain copies of all pertinent data and records on file in the respective folder for all incoming material. This will include the records listed below and other records and data as required.

- Purchase Order
- Supplier test data
- Supplier affidavits
- Supplier certifications
- X-Ray results
- Supplier test reports
- Supplier Material Reports
- Daily Receiving Inspection Reports
- Receiving Inspection Reports
- All Brunswick test and inspection reports pertaining to the incoming material.

Inspection and/or test bulletins, procedures, check lists, etc., will be provided by the Quality Control Engineering group to establish a standard method for performing the necessary inspection and/or testing of incoming material. All the essential information to aid and guide the inspectors in their duties will be included in these instructions. Sampling procedures will be listed.

Material which is Government furnished or Government source inspected will be checked for identification, quantity, and shipping damage when received from the supplier. The Brunswick Receiving Inspector will verify that the material has been accepted by the Government Source Inspector and will accept the material, if not damaged, on this basis.

(4) Purchasing Data - The purchase order will be used to convey to the supplier all the applicable requirements for the product. It shall include the following information: a complete description of the supplies ordered, including all pertinent drawings, engineering change orders, specifications, special revisions or model identification; quality program requirements including all inspection and testing to be performed, requirements for source inspection by Brunswick or Government personnel, special test or inspection equipment and, requirements for source inspection by Brunswick or Government personnel, special test or inspection equipment and, requirements for "First Article" inspection and other special requirements including reliability and safety.

Requirements may be included in purchase order information by attaching Brunswick Corporation standard form number 12606, Purchase Order Quality Assurance Provisions, and referencing the applicable paragraphs.

The original copy of the purchase requisitions shall be submitted to the Quality Control Engineering section for review. A copy of the purchase order will be forwarded to Quality Control Engineering for final review, then forwarded to Receiving Inspection for filing. Quality Control Engineering will check the purchase requisitions to verify that:

- Project Engineering and Purchasing have supplied the necessary drawings to the supplier.
- Applicable specifications and documentations are noted on the purchase order - also that copies of special specifications or documentation are forwarded to the supplier.
- Any special preservation, packaging, or packing requirements are noted on the purchase order.
- A note is added on the Purchase Requisition and Purchase Order requesting a certification be provided with each shipment, as applicable.
- A note is added to the Purchase Requisition and Purchase Order requesting that all test data (where applicable) be provided with each shipment.
- Requests for tools and gages have been reviewed for justification and adequacy prior to the placement of the order.

1.2.7 Quality Control Audit Program

a. Documentation Audit - A Quality Control Audit is performed periodically to provide evidence of compliance with such documents as the Quality Control Manual, Process Specifications, Manufacturing Procedures, Operating Sheets, Work Instructions, Line Check Sheets, and all other documentation. All documentation, etc. used by any activity items that affect the quality and reliability of the Company's products will be subject to audit. Through such examination, any deviations that may in any manner contribute to quality or reliability deficiencies will be brought to the attention of management for immediate correction.

The audit will be made of all documentation used in the following areas:

- Production Area
- Tool and Gage Inspection
- Test Areas
- Inspection Areas
- Quality Control Office
- Materials Handling Storage Areas
- Quality Control Storage Areas

Such audit will serve to determine that documentation in use is of the latest issue.

b. Materials Audit

(1) Materials Stockroom and Receiving Area All materials in the stockroom and receiving area will be audited to determine that they are properly segregated and are safely stored in acceptable containers which are properly identified by the part number, part name, stock number, subletter, etc. The audit will consist of determining that materials of difference categories are not intermingled and that manufactures certifications are located in files for ready reference. Materials will be checked for protection against damage, corrosion, rust, etc. Materials found deficient, obsolete due to documentation changes or expiration of shelf life will be audited to determine that they are segregated into a special area

and properly documented as to their intended disposition. Checks will be made of Receiving Inspection to verify they are performing their duties and functions as required. Checks will also be made to verify proper handling of material.

(2) In-Process All materials in-process will be audited to determine if they conform to the latest drawing and/or specification. Material in containers will be examined to determine conformity to the labels displayed on the containers and that there is no intermingling of dissimilar material. Materials in-process will be examined to determine they exhibit proper code identification or are otherwise identified. Checks will be made to assure that all personnel are using the correct documentation and proper care in handling materials, subassemblies, and final products. Further checks will be made to assure that the end item is properly manufactured, packaged, and shipped. Checks will be made at the inspection stations at all points of manufacturing and shipping to verify these personnel are performing their duties and functions in the required manner.

Materials in segregated storage areas (awaiting disposition, rework, scrap, etc.) will be examined to determine that the areas are clearly identified and that appropriate documentation such as Reject Tags, DMRs, Scrap Tickets, or other appropriate documentation is present to support the assignment of the material to the area.

The audit of tools and gages will consist of an examination of the tool or gage for satisfactory operation, safety, and compliance and calibration requirements established in QCD 007. The proper calibration label must be affixed to the tool or gage and entries on the label must be in order. Records pertaining to the calibration must be up to date and in order. Tools or gages in storage awaiting repairs, calibration, or otherwise not available for service will be examined for proper identification as to their condition, or to determine they are in properly segregated areas indicating their non-usable condition. Personnel performing an audit may request recalibration of any tool or gage.

Control of the Quality Audit will be established through a Master Log. The log will form a record to include the following:

(1) Date of Audit

(2) Description of audit performed

(3) Discrepancies Noted

(4) Corrective Action

(5) Corrective Action Follow-up

(6) Corrective Action Accomplishment

A minimum of two audits per month will be performed at random in any section listed herein. Audits will be conducted at random and at no preselected time.

A report showing the audits as recorded in the log will be prepared in duplicate not later than five days after the audit is performed. The original copy will be furnished to the Quality Control Manager and the duplicate maintained on file in the Quality Control Engineering Section.

1.2.8 Statistical Quality Control Sampling plans will be used for destructive testing and for inspection of noncritical characheristics when records or design considerations indicate that a reduction in inspection or testing can be achieved without jeopardizing quality. Sampling will be conducted in accordance with MIL-STD-105, MIL-STD-1235 or plans designed for special situations. If a plan is used which is not covered in a military standard, confidence and quality levels will be defined, and the plan submitted to the customer for approval.

Inspection and test results will be subjected to statistical analysis where suitable in order to determine necessary inspection levels and level of process control and to identify areas requiring special attention. Statistical analysis will include calculation of percent defectives and statistical control limits. Quality Engineering will be responsible for determination of the level of process control and will review these requirements on a continuing basis.

1.2.9 Control of Nonconforming Material A Material Review Board (MRB), when authorized, will be used for the purpose of reviewing defective materials and recommending disposition and corrective actions. The Board consists of the Program Manager, Project Engineer, Q.C. Engineer, Government and/or Customer Representative. The MRB disposition of material will be consistent with the constraints applied by the Customer's Purchase Order.

When materials or supplies are rejected they shall be identified by attaching a Reject Tag, Form 15-154. The material shall then be placed in a hold area until disposition is made. A Discrepant Material Report (DMR) form shall be completed and forwarded along with one copy of the inspection record to the MRB.

Upon receipt of the DMR, the MRB shall conduct such investigations as necessary to determine the cause and affect of the discrepancy. The MRB will then either recommend scrap, rework, or use without rework. Any disposition, other than scrap or return to Vendor will be subject to customer approval before becoming final.

If the material has been dispositioned to scrap, Quality Control will complete a Scrap Ticket, Form 126-05, and obtain the required approvals.

Upon receipt of the Scrap Ticket, Production Control will turn the material over to Material Control for removal from production.

If the material has been dispositioned to be either reworked or screened, the rework instructions, indicated on the DMR, will be effected and the material submitted for re-inspection of the non-conforming characteristics.

If the material has been dispositioned to use without rework, Production Control will, upon receipt of the approved DMR, release the material to Production.

1.3 Quality Plan, 25MM Caseless Ammunition (Specific)

1.3.1 Purchased Material Control Purchased material control activities are planned to provide adequate Quality Control Surveillance over the procurement and receipt of all items used in the fabrication of the 25MM Caseless Cartridge, Specific receiving inspection procedures are included herein for the items ordered for use by and received by Brunswick Corporation

1.3.1.1 Responsibility Quality Control Inspection personnel will perform or observe all inspection and test operations required herein.

1.3.1.2 Sample Selection Instructions for selection of samples will be contained with the instructions for various items.

1.3.1.3 Records The results of all inspections and tests are to be recorded on QCF Form 500 unless otherwise directed. These forms will be filed in separate files for each part and customer, along with other pertinent information such as results of suppliers test or inspection and certificate of compliance.

1.3.1.4 Inspection Frequency Each shipment received will be inspected in accordance with instructions provided herein.

1.3.1.5 General Requirements All shipments will be checked for the following:

(a) Acceptability of packaging.

(b) Workmanship of parts. AQL will be the same as for dimensional characteristics.

(c) Materials or parts which exhibit defects not listed in the characteristics to be checked are also to be rejected.

(d) All samples are to be checked visually for obvious defects.

1.3.1.6 Lot Control Procedure Materials requiring or affecting lot control will be identified as follows: Each container of material which does not already have the lot number indicated is to be identified by the attachment of QCF 506 to each container. The QCF 506 is to be completely filled out. All containers must have lot numbers.

1.3.1.7 Purchased Materials Index The following lists the Drawing or Specification Number, Part Name, and Paragraph Number which outlines the inspection requirements for each purchased item for use by Brunswick Corporation in fabrication of the 25MM Cartridge:

Part No.	Drawing or Spec. Number	Nomenclature	Paragraph Number	Lot Control Required
	MIL-N-244A	Nitrocellulose, Grade A Type II	1.3.1.8.3	Yes
	MIL-F-50260	Acrylic Fiber, 100% fiber, 5 Denier, bright, 3/8" cut length fibrillated per MIL-F-50533	1.3.1.8.1	Yes
	Commercial	Resin, Hycar 2600 x 186 nitrile latex, 49.6% solids	1.3.1.8.2	Yes
	Commercial	Lufax 295	1.3.1.8.2	Yes
	MIL-E-255A	Ethyl Centralite	1.3.1.8.1	Yes
	Commercial	Dow Corning Antifoam B	1.3.1.8.3	Yes
	1462	Propellant, SPDM	1.3.1.8.3	Yes
		Black Powder, Class 3	1.3.1.8.3	Yes
	Commercial	Acetone	1.3.1.8.2	No

Part No.	Drawing or Spec. Number	Nomenclature	Paragraph Number	Lot Control Required
	Commercial	Alochol	1.3.1.8.2	No
	MIL-B-10854	Pyroxolyn, Crystal 150, Sheet	1.3.1.8.4	Yes
	Commercial	Cement, Duco, DuPont	1.3.1.8.2	No
	200391	Projectile	1.3.1.8.5	Yes
2402	Commercial	Bag, Poly, Conductive 3" W x 12" L	1.3.1.8.2	No
2403	PPP-B-636	Box, Fiberboard I.D.: 8 7/8" w x 17 3/4" L x 7 5/8" D ± 1/16	1.3.1.8.2	No
2404	VV-C-282	Separator, Chipboard	1.3.1.8.2	No
2405	MIL-L-46842	Cushion, Foam	1.3.1.8.2	No
2406	PPP-F-320	Filler Fiberboard 8 3/16 x 17 1/16	1.3.1.8.2	No
2407	PPP-B-601	Box, Wood	1.3.1.8.2	No
2408	PPP-F-320	Filler, Fiberboard 8 1/16 x 18 9/16	1.3.1.8.2	No
2409	PPP-F-320	Filler, Fiberboard 8 1/16 x 9	1.3.1.8.2	No
2410	MMM-A-250	Adhesive	1.3.1.8.2	No

1.3.1.8 Inspection Instructions

1.3.1.8.1 Acceptance by Certification of Test/Analysis Items in this category must be accompanied, upon receipt of shipment, a signed certification of compliance which also includes the results of inspection or test performed to determine compliance with specifications.

1.3.1.8.2 Acceptance by Certification Materials in this category may be accepted by proper certification. Such items shall be examined for damage. One piece from each lot of detail type items shall be checked to its applicable requirements.

1.3.1.8.3 Acceptance by Bomb Test and Certification Material in this category must be accompanied by a certification of compliance. In addition, samples shall be drawn from each shipment for performance of the bomb test.

1.3.1.8.4 Pyroxolyn, Crystal 150, Sheet
Sample Plan: Each Sheet

Characteristics:	Method
Cut three 1/2" tensile specimens from each sheet, two from diagonally opposite corners and one from the center of the sheet using the die-cutter. Check thickness of each specimen and subject to tensile test.	Test

Record results on QCF 500.

1.3.1.8.5 Projectile, Text (No. 200463)
Sample Plan: MIL-STD-105, Level II

Characteristics:	Method
Body diameter .984 $^{+.000}_{-.002}$	Caliper
Band diameter 1.0280/1.0255	Caliper
Length 4.570 Ref	Caliper
Point runout	SME
Groove diameter .863 $^{+.000}_{-.010}$	Caliper
Groove width .090 $^{+.010}_{-.000}$	Caliper
Location of groove .050	Caliper
Band Location .600	Caliper

Record results on QCF 500.

1.3.2 In-Process Controls In-process controls are planned to provide Quality Control surveillance over the production processes and component assembly operations used in the fabrication of the 25MM Caseless Cartridge.

1.3.2.1 Responsibility Quality Control Inspection personnel will perform or observe all inspections indicated, and will record results on the respective forms, for all parts, processes and assemblies which will be shipped to the customer.

1.3.2.2 Lotting

1.3.2.2.1 Felt Each batch of felt will be assigned a batch number consisting of an interfix number, a serial number and a sub-lot number. The interfix number will be determined by the felt formulation. Serial numbers beginning with one will be assigned in sequence to all batches of the same interfix number containing the same lot numbers of raw material. Sub-lot numbers will be assigned to successive batches of the same interfix and lot number. No batch will contain more than one lot number of ingredients.

1.3.2.2.2 Components Each component part will be lotted sequentially. A lot shall consist of all the parts manufactured in one continuous run from the same lots of raw materials.

Each component part to be inspected on a sampling plan will be assigned an inspection sub-lot number. A sub-lot shall consist of all the parts from the same lot presented at one time for inspection.

Upon completion of inspection, each sub-lot container shall be identified by attaching a completed traveler form SG-549-85.

1.3.2.2.3 Projectile Assemblies Projectile Assembly sub-lots shall consist of all the assemblies fabricated using the same retainer sub-lots.

1.3.2.2.4 Final Assembly A lot shall consist of those completed round assemblies of one design, fabricated in one continuous process, and shall not contain more than one lot of any component part.

1.3.2.3 Physical Testing

1.3.2.3.1 Sample for Test Samples for forward and rear charge and molded shell for destructive testing shall be selected in accordance with instructions for the individual component.

1.3.2.3.2 Recording Test Data Two copies of the dimensional inspection record for the applicable sub-lot shall be forwarded with the samples for strength testing. Upon completion of testing, one copy of the test results shall be attached to each inspection record, one set being returned to the responsible inspector and the other to the Quality Control Engineer.

1.3.2.4 Inspection Instructions

1.3.2.4.1 N.C. Batch Mixing

Sample Plan - One per batch

Characteristics:	Method
Record batch number, lot number and wet and dry weights of all ingredients	
Perform bottle test as required until test shows fibers are free	Test
Check consistency of batch after mixing	Test

Record results on QCF 600.

(a) Bottle or Knot Test for Determination of Freeness of Fibers in Solution

Take a sample in a clear jar when it is deemed that the slurry is properly processed. Shake the jar so the ingredients are moving quite rapidly. Hold the jar up to a light source. If the fibers are free from each other and there are no aglomerations of material, the batch is adequately processed. Perform this test three times consecutively to verify batch acceptability.

If the test proves satisfactory, record results, date, etc. on form QCF 615 and release the batch to production (for this check only). If the test proves unsatisfactory, production personnel shall continue processing the material until the test proves satisfactory.

(b) Consistency Test for Determination of the Solids Content in Suspense in the Slurry Mix Take a sample in a 1,000 cc container from the slurry mix tank for this consistency check. Make sure the 1,000 cc container is clean.

Clean the glass cylinder of the freeness tester. Close the valve on the freeness tester. Place a clean #80 mesh Williams Freeness Tester Screen between the base and the glass cylinder and clamp the two together onto the screen. Check to see that the valve on the tester is closed. Stir the 1000 cc sample into the glass cylinder of the tester. Turn the valve on the Tester to open and allow the water to drain off, collecting the pulp on the screen. Note the time of flow for reference purposes only. After all the water has drained off, remove the screen and pulp from the freeness tester.

Place the consistency pulp sample in the drying device and bake same approximately 10 minutes, or until 0% moisture is obtained. Open the drying device and remove sample. "Observe all safety regulations."

Remove the dry sample (Consistency pad) and weigh accurately to the nearest .05 gram to determine the solids content. The accurate weight of this sample in grams divided by ten is equal to the consistency as a percentage of pulp in the mixture (or in the solids content).

1.3.2.4.2 Felting Process (All)

Sample Plan - At the beginning of each shift and every two hours thereafter

Characteristics:	Method
Concentrate Time	Timer
Screen Time	Timer
Vacuum	Gage
Consistency	Test

Record results on QCF 613.

1.3.2.4.3 Dehydration Pressing

Sample Plan - At the beginning of each run and every 2 hours thereafter

Characteristics:	Method
Mold Temperature	Gage
Air Pressure	Gage
Time part is in press	Timer
Lot number of parts	

Record results on QCF 611

1.3.2.4.4 Molding, Outer Shell

Sample Plan - At the beginning of each Run and every 2 hours thereafter

Characteristics	Method
Mold Temperature	Gage
Mold Pressure	Gage
Residence Time	Timer
Lot numbers of parts	

Record results on QCF 612.

1.3.2.4.5 Molded Shell

Characteristics:	Method
Sample Plan - 100% Inspection	
Cracks, Burrs and Irregularities	Visual
Sample Plan - Level II MIL-STD-1235	
Weight	Scales
Length	Caliper
Outside Diameter	Ring Gage
Wall Thickness	Snap Gage
Primer Cavity Diameter	Plug Gage
Thickness of Bottom	Gage
Chamfer	Template

Record results on QCF SG-549-54.

1.3.2.4.6 Case Dipping

Sample Plan - Every four hours during production

Characteristics:	Method
Dip composition	Moisture Balance
Dip Temperature	Thermometer
Humidity	Gage
Dip Time	Timer
Drying Time	Timer

Record results on QCF 508.

1.3.2.4.7 Dipped Case

Sample Plan - MIL-STD-105, Level II

Characteristics:	Method
Weight	Scales
Outside diameter	Ring Gage

Characterisitcs (Continued)	Method
Cracks, burrs and irregularities	Visual
Weight before dip	Scales
Weight gain	Calculate
Wall thickness	Snap gage
Primer hole diameter	Plug Gage
Bottom thickness	Gage
Chamfer	Template
Test Samples	

Sample Plan - MIL-STD-105, Level S-3

Characteristics	
Combined strength, density and volatiles	Test

Record results on QCF SG-549-66

1.3.2.4.8 Felted Sheets, Primer Cup and Front Spacer

Sample Plan - Each Sheet

Characteristics	Method
Thickness	Snap gage
Weight	Scales
Density of core sample	Calculate

Record results on QCF 508.

1.3.2.4.9 Primer Cup

Sample Plan - MIL-STD-105, Level II

Characteristics	Method
Thickness, overall	Calipers
Input cavity depth	Depth Mic
Output cavity depth	Depth Mic
Weight	Scales
Outside diameter, major	Gage

Characteristics (Continued)	Method
Outside diameter, minor	Gage
Input cavity diameter	Plug Gage
Output cavity diameter	Plug Gage
Connecting cavity diameter	Plug Gage
Concentricity	Gage

Sample Plan - MIL-STD-105, Level S-3

Characteristics	Method
Dry weight	Scales
Hardness	Test
Strength	Test
Volatiles	Test

Record results on QCF SG-549-56.

1.3.2.4.10 Primer, Loaded

Sample Plan - 100% Inspection

Characteristics	Method
Low mix level in input, voids in mix load	Fluoroscope
Cracks	Magnifying lens
Adhesive in input cup	Visual
Disc missing or incorrectly assembled	Visual

Sample Plan - MIL-STD-105, Level II

Characteristics	Method
Major diameter, minor diameter, height	Gage
Mix weight	Scales
Total Weight	Scales

Sample Plan - Every four hours during production

Characteristics	
Oven temperature Pressure records	Chart recorders for continuous record

Sample Plan - MIL-STD-105, Level S-3

Characteristic	Method
Sensitivity Test	Test

Record results on QCF SG-549-69

1.3.2.4.11 Igniter Assembly

Sample Plan - MIL-STD-105, Level S-3

Characteristics	Method
Weight of Black Powder	Scales
Black Powder M & V	Test
Igniter Cup Thickness	Gage
Primer to cup bond	Test

Record results on QCF 508.

1.3.2.4.12 Front Spacer

Sample Plan - MIL-STD-105, Level I

Characteristics	Method
Outside Diameter	Gage
Inside Diameter	Gage
Thickness	Gage
Dry weight of part	Scales
Density	Calculate

Sample Plan - MIL-STD-105, Level S-3

Characteristics	Method
Volatiles	Test
Strength	Test

Record results on QCF 602.

1.3.2.4.13 Projectile Assembly

Sample Plan - 100% Inspection

Characteristic	Method
Component missing or incorrectly assembled	Visual

Sample Plan - MIL-STD-105, Level S-3

Characteristic	Method
Retainer Pull Test	Test

Record results on QCF 508.

1.3.2.4.14 Nose Positioner

	Method
At the beginning of each production run check five parts for compliance with all dimensional requirements of the drawing.	Gage
On each 200 parts thereafter, during production, check fiver parts for the following:	
Material thickness (.015)	Caliper
Overall thickness (.250")	Caliper

Record results on QCF 614.

1.3.2.4.15 Retainer (Shear)

Sample Plan - Five at beginning of each run and five every 200 thereafter

Characteristics	Method
Inside diameter	Caliper
Outside diameter (Dim. A)	Caliper

Sample Plan - 100% Inspection

Characteristic	Method
Thickness (Dim. B)	Caliper

Record results on QCF 503.

1.3.2.4.16 Charge Mixing, Forward and Rear

Sample Plan - Each four hours during production

Characteristics	Method
Solvent mix ratio and moisture	Chemical Analysis
Solvent charge weight	Scales
Powder volatiles	Scales
Powder charge weight	Scales
Mixed charge solvent content	Differential Thermal Analysis

Record results on QCF 508.

1.3.2.4.17 Charge Molding

Sample Plan - Each four hours during production

Characterisics	Method
Mold temperature	Gage
Press Pressure	Force Gage
Press Dwell Time	Observation
Time in water	Observation
Drying time	Observation
Oven temperature	Thermocouple Recorded

Record results on QCF 508.

1.3.2.4.18 Rear Charge

Sample Plan - MIL-STD-105, Level II

Characteristics	Method
Outside diameter	Gage
Igniter charge cavity diameter	Gage
Thickness	Gage

Characteristics (Continued)	Method
Primer cavity diameter	Gage
Primer cavity depth	Gage
Projectile recess diameter	Caliper
Projectile recess depth	Scales
Chips, cracks, burrs	Visual
Density	Calculate

Sample Plan - MIL-STD-105, Level S-3

Characteristics	Method
Structural Strength	Test
Volatiles	Test

Record results on QCF SG-549-58.

1.3.2.4.19 Forward Charge

Sample Plan - MIL-STD-105, Level II

Characteristics	Method
O.D.	Gage
I.D.	Gage
Length	Calipers
Chamfer width and angle	Template
Dry weight of part	Scales
Cracks, chips and irregularities	Visual
Density	

Sample Plan - MIL-STD-105, Level S-3

Characteristics	Method
Axial load	Test
Volatiles	Test

Record results on QCF 606.

Brunswick Corporation

DATA ITEM A061

Preliminary
System Safety Program
Plan

1.0 Introduction

This preliminary Systems Safety Program Plan contains the methods to be used by Brunswick Corporation, Sugar Grove, Virginia, to insure the safe development and manufacture of and provide information for the safe integration of GAU-7/A 25mm Caseless Ammunition. The Systems Safety Plan will be incorporated as an integral part of each step of development and production for this phase of the program.

2.0 Applicable Reference Documents

1. DOD Contractor's Safety Manual for Ammunition, Explosives and Related Dangerous Material, DOD 4145.26M dated October 1, 1968
2. Master Safety Program, Brunswick Corporation, Sugar Grove, Virginia.
3. Military Standard-System Safety Program for Systems and Associated Subsystems and Equipment: Requirements for MIL-STD-882 dated 15 July 1969.
4. Safety Manual, AMCR 385-100 dated April, 1970.
5. Technical Order - Explosives Hazard Classification Procedures, TO 11A-1-47 dated 19 May 1967.
6. National Fired Codes and national concensus standards as applicable.
7. Preliminary Hazard Analysis for Continuation of Phase III, GAU-7/A 25mm Caseless Ammunition Development Program BTP 201-555-004 dated April 9, 1971.

final system plan will appear. There are, however, some general aspects of the components and processes utilized in the 25mm ammunition that will have profound influence on safety throughout the program. These aspects and their influence on the facility layout and production aspects are discussed in the following sections.

It should be stated here that the production facility layouts presented in this proposal are not necessarily definitive and their ultimate configuration will depend on the outcome of further process and tooling development.

4.1 Round Assembly

4.1.1 TP Ammunition

The major source of energy in this round configuration is the front and rear charge. Although not by themselves highly sensitive to initiation, when assembled in the finished round with the igniter assembly, they should be considered reasonably sensitive, particularly as regards impact or puncture in the primer face. Therefore, once primed, handling orientation will be of particular importance to minimize contact with the primer area.

The rate of energy release in this configuration, when confined, constitutes principally a low flame temperature fire hazard. Shielding where necessary, and building layout will be applied with this in mind. Rapid gas venting to prevent pressure rise and flame deflection will be the major criteria used in tooling and facility design. The number of ammunition assemblies and components localized in any one production area will be limited to a few hundred rounds, and these areas will be effectively isolated from each other by substantial dividing walls. Where these walls must be penetrated, fast acting, guillotine doors will be used to close the openings, be performed in the pressing area while the presses are in operation.

The drying ovens may be located inside the structure (as shown) or may be isolated from it, depending on the outcome of process development in regard to charge drying time and production rates.

4.2.2 Igniter Assembly Manufacture

The basic safety requirements that apply to igniter manufacture and some of the safety aspects of the tooling have been discussed in the Production Plan. Special attention will be given to safety training and indoctrination of employees working in this area.

5.0 Ammunition and Components Testing

5.1 Ballistics Range

The safety plan now in effect will be applied to test firing of TP ammunition.

For the firing of high explosive projectiles, another ballistics range will be constructed incorporating provisions to assure adequate protection for the operators. The proposed area will be bounded by a chain link fence with a remote controlled gate operated from the control room. The facility shall have a separate storage magazine the proper distance from the other buildings for test ammunition. The drop test facility will be a separate structure with provisions for completely remote ammunition drop testing.

The gun house, tunnel, and impact area will be constructed of steel reinforced concrete with vents in appropriate locations along the tunnel and in the gun house.

will be used where practical to reduce materials handling. Partially completed assemblies requiring transportation between production buildings will be moved in closed containers inside a closed vehicle having all ferrous metal covered with non-sparking material in addition to other safety requirements. The motor of the vehicle will be switched off when loading and unloading hazardous material. All complete items will be packaged in accordance with Department of Transportation regulations when removed from the production building to the finished goods storage area or the loading area.

7.0 Training

Employee training is one of the most important tools available to insure the safe and efficient operation of the 25mm Caseless Ammunition Program. Presented below is a short listing of the principle criteria to be applied in employee training:

a. Each new employee is given safety indoctrination within a week of his hire date. Certain employees wuch as production machine operators, inspectors, etc., will receive more comprehensive preoperational training.

b. The job supervisor will acquaint the new hire with any and all hazards associated with his job, safety measures and precautions to be observed, and follow accepted supervisory techniques in assigning and reinstructing the employee.

c. Safety instructions, protective devices, and specialized tooling will be itemized in the operating procedures.

d. Periodic supervisory training will be scheduled and conducted for all levels of supervision based on needs.

e. Employee group meetings will be held on a regular scheduled basis. Agenda will be prepared by supervisors responsible for holding safety meetings.

Preliminary investigations have already been performed in Phase III of this program with regard to the safety characteristics of the TP ammunition and its components. Further tests will be required to more definitely and completely characterize the safe operating conditions and limitations for this type of ammunition.

A complete series of tests will be completed to determine the safety characteristics of the HEI ammunition. These tests include but are not limited to:

a. Explosive Ordnance Disposal procedures;

b. A complete hazard mode and effect analysis;

c. An investigation of the characteristics of the HEI Projectile as regards manufacturing safety.

10.0 Conclusion

Throughout the preparation, implementation, and operation of all aspects of this program, Brunswick will apply the principles and methods outlined here to develop, advance, and rigoriously utilize the System Safety Program Plan. This will assure the customer a safe, reliable, and consistent item of ammunition capable of being produced and utilized effectively and efficiently at a minimum of physical risk to personnel and facilities.

3.7.2 PRELIMINARY

RELIABILITY PROGRAM PLAN

FOR

PHASE IV

GAU-7/A 25MM CASLESS AMMUNITION DEVELOPMENT PROGRAM

3.7.2.2 References

3.7.2.2.1 SOW-6-71, Development of Ammunition Subsystem, 25MM, for GAU-7/A Gun System - Phase IV Statement of Work, dated 21 June 1971.

3.7.2.2.2 DWS-114, Documentation Work Statement GAU-7/A Program-Phase IV, dated 22 June 1971.

3.7.2.2.3 RFP F33657-71-R-0877, Request for Proposal for Development of Ammunition Subsystem, 25MM, for GAU-7/A Gun System - Phase IV, dated 18 June 1971.

3.7.2.2.4 Statistical Methods Appropriate for Evaluation of Fuze Explosive-Train Safety and Reliability. NAVORD Report 2101. U.S. Naval Ordnance Laboratory, White Oak, Maryland, dated 13 October 1953.

3.7.2.2.5 Military Standard - Reliability Program for Systems and Equipment Development and Production. MIL-STD-785A dated 28 March 1969.

3.7.2.2.6 Military Standard - Environment Test Methods, MIL-STD-810B, dated 15 June 1967.

3.7.2.2.7 Reliability - Confidence Combination for Small-Sample Tests of Aerospace Ordnance Items, A.G. Benedict, NASA Technical Report 32-1165, Rev. 1, dated 1 July 1960.

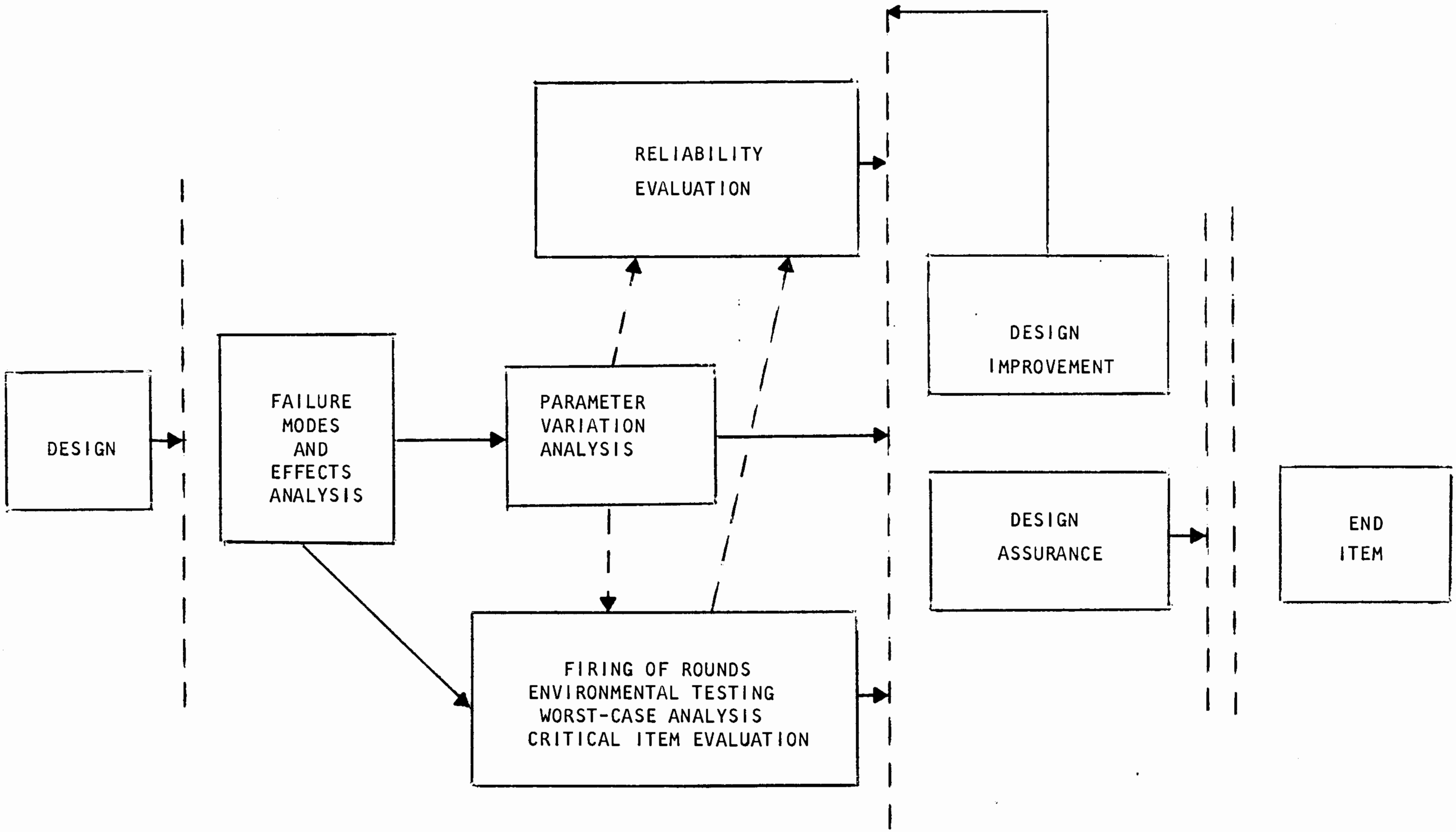

FIGURE 3.7.2.3.1.2.1

CLOSED LOOP EVALUATION SYSTEM FOR PHASE IV OF GAU-7/A CASELESS AMMUNITION PROGRAM

Thus the final reliability/confidence levels determined during Phase IV will be established primarily from tests performed on the total system (firing of rounds). To augment these predictions and to isolate and improve performance of critical elements, tests as feasible will be performed on individual functional elements such as the combustible primer, projectile retainer, the rear and forward grains and the environmental coating system.

For testing by variables or attributes, the relationship between reliability and confidence level is characterized by the equation (Reference 2.10):

$$1 - \gamma = \sum_{f=0}^{f=F} \left(\frac{n!}{(n-f)!\, f!} \right) (1 - R)^{f} R^{n-f} \qquad (1)$$

where

γ = Confidence Level
f = Assumed number of failures
F = Actual number of failures
n = Number of test items
R = Reliability

and where F = 0

$$1 - \gamma = R_n \qquad (2)$$

The required demonstrated reliability for Phase IV is 7800 MRBF at a .90 confidence level. Since the effect of shelf life on the round for extended periods (10 years) can not be determined at present the above failure rate will be assumed constant for purposes of calculations, i.e., no exponential decay in the MRBF can be predicted. From this the MRBF is then the reciprocal of the constant failure rate or the ratio of the total failures to the total number of rounds fired.

Failure Rate $\frac{1}{7800}$

Reliability .999872

The majority of the reliability values established during Phase IV will be based on equations (1) and (2) as listed. Additionally, such methods as the Bruceton Up-Down Test as described in Reference 3.7.2.2.4 will be utilized for the projectile retainer reliability demonstration.

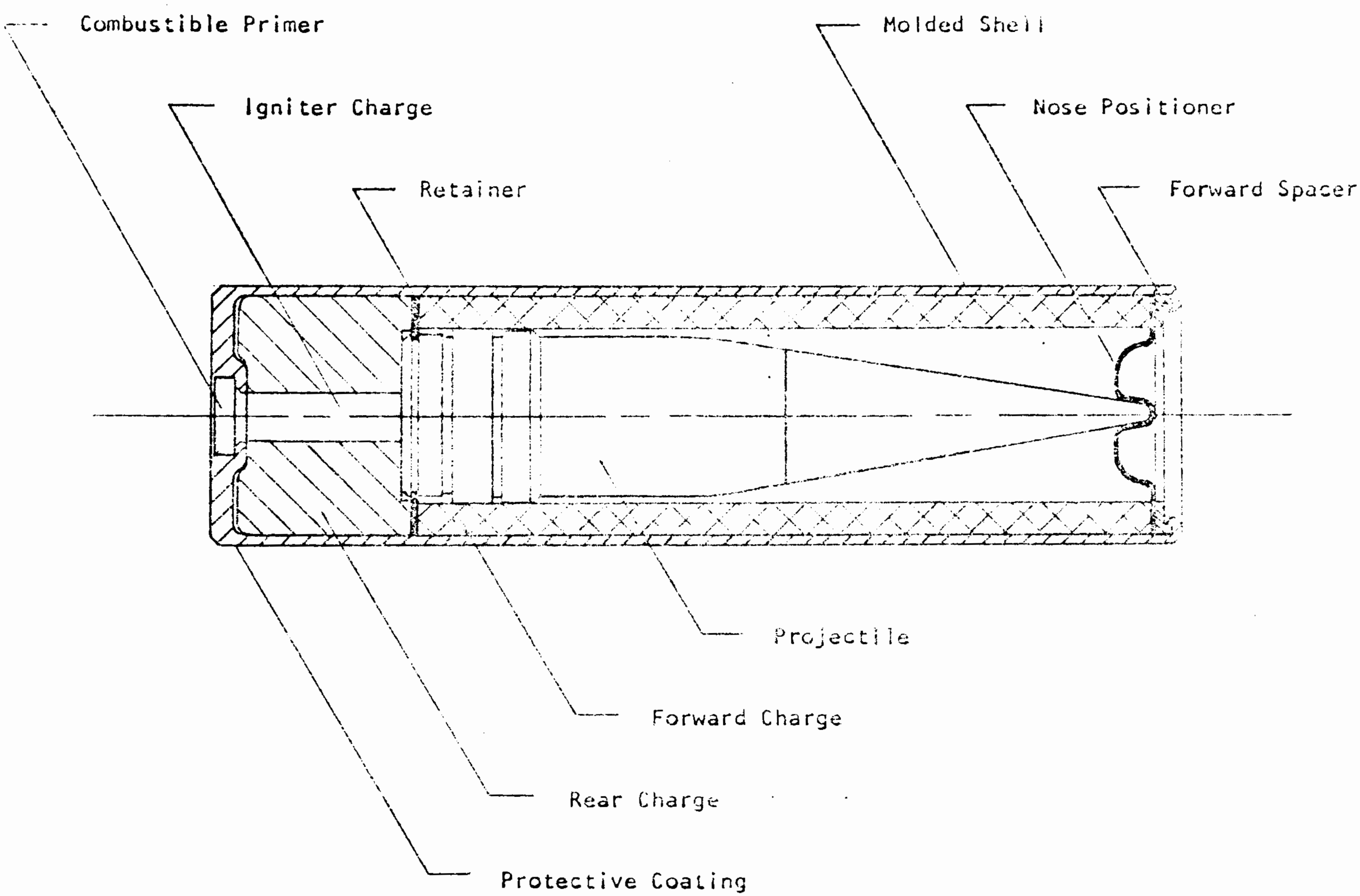

Figure 3.7.2.3.2.1

PRELIMINARY GAU - 7/A CASELESS CARTRIDGE

TABLE 3.7.2.3.2.2

SUB SYSTEM	FUNCTIONAL ELEMENT	FUNCTION	FAILURE MODE	EXTERNAL SYSTEM ENVIRONMENTAL STRESSES	FUNCTIONAL ELEMENT STRESSES	REQUIRED SYSTEM PROBABILITY OF SUCCESS	
Ignition System	Combustible Primer	Set Off Igniter Charge	A B C D	Environmental Conditions of MIL-STD-810B, Table I Group II, Column h per Reference 2.1	Fire with Firing Pin Impact Velocity of 27 ft/sec	Demonstrate .999872 Reliability at .90 Confidence Level	Mature System Goal Reliability .999996
	Igniter Charge	Set Off Propellant Push Projectile Forward	A B C				
Propellant Charge	Moulded Shell	Encasement Propellant	A B D				
	Rear Charge	Propellant	A B D	5' Handling Drop			
	Forward Charge		A B D	Transportability Per MIL-STD-490			
	Forward Ring		A B D				
Retention System	Projectile Retainer	Retain Projectile	B D		Gun and Feed Mechanism Dynamic Action		
Environmental	Coating	Thermal and Moisture Protection	A C D		Coating 900°F 230 MSEC Nose 1650°F 50 MSEC Base 1150°F 50 MSEC		
	Nose Positioner		A C D				

A - Premature Ignition
B - Hang Fire
C - Misfire
D - Fractured or Deformed Round

Special attention will be directed to the above items in the reliability analysis (Note Section 3.7.2.3.3). Quality Control and quality assurance will ensure that all purchased parts meet stringent requirements and that process variations are eliminated during fabrication of the combustible cartridge.

3.7.2.3.2.6 Effects of Storage, Shelf-Life, Packaging, Transportation, Handling and Maintenance

Storage, Shelf-Life

The design goal for the shelf life of the 25MM caseless ammunition is to match that of the current M50-series cased ammunition - ten (10) years minimum requirement. Detailed procedures and sampling criteria for shelf life evaluation are contained in the Shelf Life Test Plan.

Packaging

Rounds will be packaged to eliminate the possibility of static build up and ensure the integrity of rounds. The packaging shall conform to requirements such as those established in FED-STD-406 and Naval Air System Command Specification XAS-1152.

Transportation

Effects of Transportation will be evaluated per MIL-STD-810B (Reference 3.7.2.2.6).

Handling

Effects of handling will be evaluated per the Handling Drop Test Procedure in MIL-STD-810B (Reference 3.7.2.2.6).

Maintenance (NA)

3.7.2.3.2.7 Design Reviews

The reliability program will be continually evaluated as various design modifications are implemented. Reliability design reviews will be conducted on a regularly scheduled basis and potential design or production problem areas, reliability critical items, engineering decisions and the status of subcontractor and supplier reliability orientated problem areas will be direcred to ADPF during the design reviews and the Monthly Progress Reports.

A preliminary summary of the applicable tests to be performed to evaluate the possibility of occurance of failures is contained in Table 3.7.2.3.3.2. Note Section 3.7.2.3.2.2 and Table 3.7.2.3.2.2 for failure definitions.

3.7.2.3.3.2 Reliability Demonstration

Preliminary final round configuration reliability computations will be made based on rounds fired at Brunswick, however these values will be of lower confidence levels based on the magnitude of required tests (Section 3.7.2.3.2.1). The formal qualification reliability values will of necessity include firing data of both PDR and CDR rounds at ADPF and USAF. These quantities will be sufficient to ensure a high confidence end item reliability.

FUNCTIONAL ELEMENT	FAILURE	APPLICABLE TEST	SECTION	MINIMUM TEST UNITS
Projectile Retainer	B	Ballistic Firing	4.1.1	4,000
		Firing of Rounds		319,000
		Static Shear	4.1.10	180
	D	Ramstop Drop	4.1.7	4,000
		Handling Drop	4.1.8	50
		Transportation Vibration	4.1.19	20
		Shock	4.1.21	20
		Vibration	4.1.22	20
Environmental	A	Cook-Off	4.1.5	90
		High Temperature	4.1.15	50
(Coating Nose Positioner)	C	Low Temperature	4.1.18	20
		Temperature Shock	4.1.15	20
		Humidity	4.1.16	50
		Salt Fog	4.1.23	20
		Fungus	4.1.24	20
		Sand and Dust	4.1.25	20
		Sunshine	4.1.26	20
		Rain	4.1.27	20
		Shelf Life		TBD
		Ballistic Firing	4.1.1	4,000
		Firing of Rounds		319,000
	D	Ramstop Drop	4.1.7	4,000
		Handling Drop	4.1.8	50
		Transportation Vibration	4.1.19	20
		Shock	4.1.21	20
		Vibration	4.1.22	20

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3.7.2.3.4 Failure Data

3.7.2.3.4.1 Failure Data Collection, Analysis and Corrective Action

A closed loop system for collecting, analyzing and recording all failures that occur during in-plant tests is an integral part of the over-all evaluation system. Process Data Sheets (PDS) which include round number, component identification, part numbers, process identification, a remarks section, reference drawing numbers and ballistic information are detailed for each round fired at Sugar Grove. PDS summary data sheets for all firings at Sugar Grove are forwarded to ADPF in the monthly progress reports. Additionally, a failure summary sheet will be included in the monthly progress reports to document the occurance of any of the failure modes defined in Reference 3.7.2.2.3. Supplier failure summaries will be required for all reliability demonstration tests performed on purchased components such as the combustible primer. This information along with failure summaries on firings at ADPF and Eglin AFB will be incorporated into the final technical report.

3.7.2.3.4.2 Failure Summaries

The failure summary sheet depicted in Figure 3.7.2.3.4.1 will be used for failure reporting to ADPF (Note: Section 3.7.2.3.4.1)

3.7.2.3.5 Production Reliability

Procedures for manufacturing process controls to prevent degradation of system reliability during the transition from development to production are contained in Section 3.6.

3.7.2.3.6 Status Reports

Results of reliability analyses, critical reliability items and failure reports will be disseminated to ADPF in the monthly progress reports and during the formal program design reviews.

GAU - 7/A 25 MM AMMUNITION DEVELOPMENT

Brunswick Corporation

FAILURE SUMMARY SHEET

BRUNSWICK CORPORATION
TECHNICAL PRODUCTS DIVISION
SUGAR GROVE, VIRGINIA

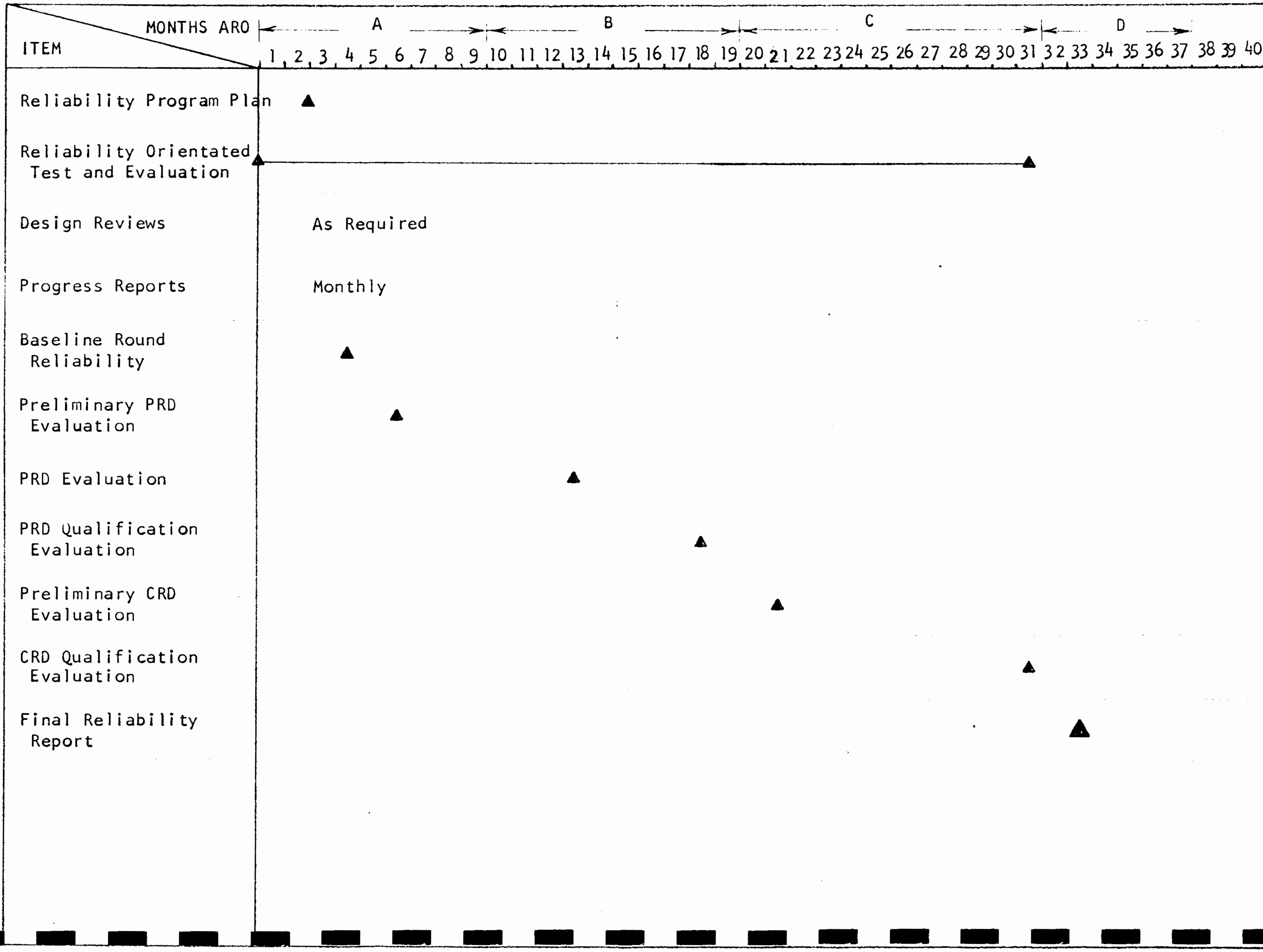
	FAILURE	NO.
A	Premature Ignition	
B	Hang Fire	
C	Misfire	
D	Fractured or Deformed Round	
E	Other as Specified	

Report Period: ____________

PDS No.	ROUND NO.	FAILURE	REMARKS	CORRECTIVE ACTION

FIGURE 3.7.2.3.4.1

RELIABILITY ORIENTATED PROGRAM ACTIVITIES SCHEDULE



DATE ITEM A005

CONFIGURATION MANAGEMENT PROCEDURES

FOR

GAU-7/A CASELESS AMMUNITION ROUND

Submitted by:

BRUNSWICK CORPORATION

TECHNICAL PRODUCTS DIVISION

SUGAR GROVE, VIRGINIA

23 JUNE 1971

Brunswick CORPORATION

The Technical Products Division of the Brunswick Corporation currently utilizes a Configuration Management System that is totally responsive to the requirements of DOD Directive 5010.19 "*Configuration Management*" and DOD Instructive 5010.21 "*Configuration Management Implementation guidance*".

Brunswick's standard configuration management practices satisfy the greatest majority of the requirements delineated in RFP F 33657-71-R-0877. Internal directives will be issued to align all procedures in complete accordance with the specific requirements of this program. This "tailored" system will provide optimum configuration management interface between Brunswick, Philco-Ford, and the Government.

1.0 ORGANIZATION

Brunswick's Configuration Management Organization for this program shall consist of a Configuration Manager and formally appointed members from, but not limited to, the following departments:

Program Management
Project Engineering
Tech Data Control
Manufacturing
Quality Control
Purchasing
Contracts Administration
Accounting

Individual membership appointments to this organization are directed by top divisional management. Consideration is given to inter-related functions of program involvement and systems engineering management to obtain the best program-knowledgeable configuration management team.

Membership is established through formal directives, and the terms of Brunswick's Configuration Management Operating Procedures are imposed on each member.

These appointed representatives shall also be designated as permanent members of the Change Control Board (CCB) for this program. Each member will have an officially designated alternate that has equal authority to commit his represented department in CCB matters. Representatives from other departments (parallel or subordinate) shall be utilized as required.

Activities of the CCB shall be governed by formal CCB operating procedures that define, in part; scheduled meeting dates and locations, notification methods for emergency meetings, standard agenda formats, change impact analysis, requirements, and the directions for establishing classification, justification and priority codes for proposed engineering changes.

2.0 RESPONSIBILITIES

2.1 Program Manager. The Configuration Manager for the GAU-7/A Caseless Ammunition program shall serve in dual capacities as the Program Manager/Configuration Manager. He shall bear program responsibilities in establishing documentation for contractual baselines and allocated and product configuration identifications, and shall insure that resultant designs remain within the constraints imposed by respective functional and physical baselines.

The Configuration Manager/Program Manager shall, in addition, serve as chairman of the Change Control Board and shall direct and monitor Tech Data Control activities relative to this program.

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2.2 Change Control Board. The CCB shall be responsible for accurately describing, analyzing, and evaluating the impacts of proposed changes on all aspects of the program including, but not limited to, the following:

Compliance with baseline requirements
Cost
Schedule
Logistics

In addition, the CCB shall establish classification, justification, and priority codes for all Brunswick approved ECP's in accordance with MIL-STD-480 and Annex 15 of the RFP statement of work. Submit-al of Advance Change Notices (ACN's), Engineering Change Proposals (ECP's), Deviation/Wavers, and Specification Maintenance Documents shall be in compliance with the statement of work, Annex 15, and the Contract Data Requirements List (DD Form 1423).

2.3 Tech Data Control. Tech Data Control is an independent group that provides Identification and Documentation, Change Control, and Status Accounting Services for both configuration and program management. It is essentially a record-keeping function created in response to configuration management requirements.

Although Tech Data Control is not directly involved in the preparation of configuration documents (specifications, engineering drawings, ECP's, ECN's, SCN's, etc.), its importance lies in the fact that these documents are physically transferred to the custody of Tech Data Control from initial release through the configuration management life cycle of the program. Tech Data Control shall be responsible, in part, for the following:

A. The release of configuration documents as directed by the Program/Configuration Manager.

B. The maintenance of controlled document files, including master files and working files.

C. Establishing index control cards for each released document.

D. Establishing manual print-out configuration identification records for each configuration item.

E. The assignment and recording of all change control numbers for ECP's, ECN's, ACN's, SCN's, etc.

F. Maintaining manual print-out status accounting logs of all changes to configuration identification, from release of revised documents through hardware implementation and verification,

G. Updating controlled document files with revised documents and removing superceded copies from circulation.

H. Updating configuration identification records commensurate with verified change incorporation records.

The possession of originals by Tech Data Control circumvents the possibility of unauthorized changes being incorporated on configuration documents. Possession of originals is only relinguished in view of an approved and authorized change document.

In providing these services, Tech Data Control is the focal point for Configuration Identification and Documentation, Change Control, and Status Accounting records.

3.0 PROGRAM PLAN AND PROCEDURES

3.1 Initial Functional Baseline. Upon contract award for development and production of the GAU-7/A Caseless Ammunition Round, the initial functional baseline will have been established by an approved Prime Item Specification, Type Bl, Part I of two parts.

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Initial contractual documents (statement of work, ammunition prime item specification, system specification, etc.) will be designated for release by the Program/Configuration Manager by preparing a Release ECN. The ECN and document copies and originals are submitted to Tech Data Control for release and custody. Tech Data Control then releases the number of file copies of each document to satisfy program requirements. The number of released copies and locations of working files are pre-established to satisfy program requirements.

Copies of each document are identified as "CONTROLLED DOCUMENT - COPY___ OF____." Each copy number is related to a specific file, and each file compartment contains a document sign-out card that must be signed by anyone removing the copy from the file. In this manner, the quantity and location of all documents are traceable and retrievable.

Simultaneously with the release distribution of documents, Tech Data Control shall prepare an index card for each document. Each card shall contain the number and nomenclature of its document, along with the release data, revision status, and a listing of attachments (EO's, SCN's, etc.) These index cards are filed alpha-numerically by program, and will be updated with each subsequent release of attachments or revision. Index control cards provide finger-tip reference to the latest revision level and attachments for each controlled document.

Any proposed changes to baseline documents by Brunswick shall be requested and coordinated through Philco-Ford prior to the preparation and submittal of Advance Change Notices (ACN's) and formal Engineering Change Proposals (ECP's) to Philco-Ford. Formats of proposed changes shall be consistent with the requirements of the contractual SOW, its applicable annexes, and 1423 data items.

The Configuration/Program Manager shall insure that product development proceeds in consonance with the Technical Development Plan (TDP) and initial functional baseline requirements.

3.2 Preliminary Design Review (PDR). In accordance with the program schedule and SOW, Brunswick shall provide Form 3, Category B Interface drawings as required; design drawings intended for release for fabrication of test rounds; and recommendations for changes to baseline documentation.

Following written customer approval of PDR documentation, the Program/Configuration Manager shall authorize the release of detail design drawings for fabricating test rounds.

Upon receipt of engineering drawings and the Release ECN from project engineering, Tech Data Control shall release "controlled document" prints to the program files, and shall generate index control cards as described above. In addition, an initial configuration identification listing of the CI shall be made concurrent with the release of fabrication drawings. The configuration identification listing shall list all drawings and related material specifications and process specifications required in fabrication, and shall include the revision status and attachments thereto for each document.

Configuration of the test rounds is therein identified, controlled, and recorded through established configuration management channels. Program management activities shall insure that hardware is fabricated in accordance with its documentation.

Subsequent changes to configuration-controlled documents shall be directed to, and coordinated with, Philco-Ford in a manner commensurate with total program contractual requirements.

All proposed changes shall be processed through Brunswick's Change Control Board, wherein they will be evaluated and classified through standard Change Control Board Operating Procedures. When approved, they will be submitted to Philco-Ford for disposition.

Changes classified as Emergency or Urgent shall be submitted to Philco-Ford in message form within twenty-four hours of the time the need for change is recognized, followed by formal ECP's in accordance with the SOW and Annex 15 of the RFP. ECP's classified as Routine shall be preceeded by an Advance Change Notice (ACN), and formal ECP's shall only be prepared upon receipt of approval of the ACN.

Formats for the preparation of ACN's, ECP's. Specification Change Notices (SCN's), and other specification maintenance documents shall be in accordance with the requirements of the RFP statement of work, Annex 15, and the applicable contract data item descriptions.

After proposed engineering changes have formally approved by the customer and returned to Brunswick, Project Engineering requests an ECN number from Tech Data Control for each document authorized for change by the ECP. The ECN shall describe the exact change to the document, provide the firm effectivity point of change incorporation, and identify the authorizing ECP's number.

Document masters are then requested from Tech Data Control for incorporation of changes in accordance with the ECN's. When the documents have been revised and approved, the masters and ECN's are returned to Tech Data Control for release as directed by Program/Configuration Management.

Brunswick Corporation

Tech Data Control makes release copies of the revised documents and performs the following tasks:

1. Withdraws the superceded copies from all controlled document files, and inserts the latest copies.

2. Either destroys or places the obsolete copy in archive files in accordance with program directives.

3. Updates index control cards to latest revision level.

4. Logs ECN data in program log book for status accounting of changes-in-process.

5. Distributes release copies of the ECN only to all affected departments as notice of change release.

6. Prepares and attached Change Verification Notice Form (CVN) to Quality Control's release copy of the ECN.

7. Upon receipt of CVN from quality control, updates configuration identification records in accordance with serial number and/or lot number point of change incorporation as verified by Quality Control.

NOTE: During fabrication of rounds for development and qualification testing, all rounds will be identified externally by sequential serial numbers, lot numbers, and model/design/series (MDS) designation.

Production items shall only carry lot numbers, MDS designation and part number identification in accordance with MIL-STD-130.

Exact traceability to the configuration identification of each test round is therein provided. In addition, manufacturing and Quality Control will maintain serial number identification of all projectiles with respect to ammunition serialization during the test program for optimum correlation of test data throughout development and qualification testing.

3.3 Critical Design Review. Prior to the scheduled CDR, Brunswick shall prepare preliminary Form i, Category E and F engineering drawings of the design to be released for fabrication of TP and HEI rounds for qualification testing.

Brunswick shall also present preliminary product configuration data in the form of a Prime Item Product Specification, Part II of two parts. This preliminary specification shall be commensurate with the design to be released above.

Configuration Identification records of development test hardware shall be made available for comparison with development test data, and test results shall be measured against the functional baseline.

At the conclusion of the CDR, the preliminary product baseline will be established and authorization will be given for the fabrication of qualification test rounds in accordance with the reviewed form 1 drawings.

The new drawing package, along with supporting material specifications and process specifications shall be released under new configuration identity. Change Control, Identification and Documentation, and Status Accounting functions shall be implemented as previously described.

3.4 Functional and Physical Configuration Audits (FCA and PCA). At the conclusion of qualification testing, and FCA and PCA will be conducted to:

A. Assure that the CI has achieved the performance specified in the Allocated Configuration Identification (ACI).

B. Assure that Brunswick's internal technical documentation describes the physical configuration of each CI for which qualification test data is verified.

C. Insure that final PCI documentation (Formal Form 1 Engineering Drawing Package and the Prime Item Specification, Part II) submitted for approval during the PCA, completely and accurately describes the physical characteristics of the GAU-7/A Caseless Ammunition Round.

D. Insure that acceptance test requirements prescribed by the PCI documentation are adequate for acceptance of production items by quality assurance activities.

In preparation for the configuration audits, Brunswick shall prepare the Part II Prime Item Specification in accordance with MIL-STD-490, based on the final configuration of the CI as described by the Form 1 engineering drawings. Brunswick shall also make available any and all configuration identification print-outs required by the customer and/or Government for Item Configuration/Test Result comparisons.

Upon approval of the PCI documentation, the product baseline is formally established, resulting in a complete production procurement package. Any subsequent changes are then measurable to the complete PCI.

Configuration management practices during the production phase shall consist of the Configuration Identification, Documentation, Status Accounting and Change Control practices defined above.

Reporting procedures during the entire Phase IV program shall be commensurate with contractual requirements between Brunswick and Philco-Ford, consistent with the requirements of the Air Force in administering this program.

DATA ITEM A050

Brunswick CORPORATION

HUMAN ENGINEERING

PRELIMINARY TEST PLAN

Reference Documents - AFSCM/AFLCM 310-1
Q-111-1
Q-109-1
Q-103-1
Q-104-1

The present preliminary test plan proposes that the human engineering detailed test plan be implemented and submitted during the course of the Phase IV program for the 25MM caseless ammunition.

During Phase IV design of all equipment, general and specific, will be completed. The equipment will be designed allowing the most efficient use of space, manpower and logistics. During this period a complete drawing package of all equipment will be submitted for review and approval. A detailed plan covering plant layout for the most efficient use of manpower and plant equipment will be documented and submitted to the cognizant authority for review and evaluation. This package will be part of the detailed human engineering plan. This plan will include detailed procedures and milestones in the following areas:

a. System analyses

b. Equipment detail design

c. Work environmental and facilities design

d. Detailed performance and design specification

e. Vendor and subcontractor efforts

f. General studies

g. Progress and deviation reports

h. Design review

i. Documentation

j. Test and evaluation

In addition the plan will reflect how the contractor system design review meetings will be used to evaluate human engineering considerations in the design. It will reflect functions and equipment to evaluate procedures, techniques and checklist to be used.

The plan will also reflect how the equipment will be evaluated to determine whether human engineering design requirements have been met.

Whenever significant changes in the approved plan become necessary, the contractor's report will include appropriate justification with a request for approval before deviating from the approved plan.

During the Phase IV program the reason for selection for each piece of equipment for use through the logistic movement of the system, including subsystem component equipment, will be fully covered. The reason for selection will be given and the greatest attention will be given to its use, its maintainability, and its function in conjunction with the human element.

A complete description of each piece of equipment in the fabrication and logistic movement will be given. The reasons why it was design as it is and its use will be clearly defined. The functionality of the equipment will be covered in detail with the man/machine interface clearly called out. Complete and applicable system equipment specifications will be written and identified. A complete description of the functionality of each piece of equipment and its interrelationship with the various subsystems that go to make up the whole will be covered. The impact of subsystem equipment failure because of changed conditions or maintenance design will be evaluated. The effect on manpower distribution as to efficient use and interrelationship with the subsystem equipment and logistics will be studied and evaluated for improved efficiency.

A planned schedule of monthly reviews will be held in order to evaluate human engineering covering subassemblies, identification of specific equipment and the various operations and efficiencies. The human factor in connections with the equipment and subassemblies and complete unit assembly will be studied closely, evaluated and changes recommended, where needed, to improve efficiency.

Monthly reports of the human engineering design system will be made. The reports will cover evaluation of system equipment their operations and efficiencies. Recommended design changes and more efficient use of personnel for increased efficiency will be documented and reported.

MASTER SCHEDULE

PROGRAM NAME: 25MM CASELESS CARTRIDGE

PROGRAM MANAGER: R. W. ROGERS

CUSTOMER FURNISHED EQUIPMENT

LEGEND: MILESTONE — PLAN △ SLIP ◇ ACTUAL ▲◆; BAR — PLAN, SLIP, ACTUAL

ORIGINAL ISSUE DATE

MAJOR CHANGE NO.

WORK PACK. NO.	MAJOR PROGRAM ELEMENTS AND WORK PACKAGE DESCRIPTION	Phase A	Phase B	Phase C	Phase D
I	Projectile Requirements				
	A. R & D @ B.C. Sugar Grove				
	1. Target Practice				
	2. HEI				
	B. Delivery				
	1. Initial Design - TP				
	2. PDR TDP Ammo-TP				
	3. Qual PDR TDP-TP				
	4. Qual PDR TDP-USAF-TP				
	5. CDR TDP Ammo-TP				
	6. CDR TDP Ammo-HEI				
	7. Qual CDR TDP-TP				
	8. Qual CDR TDP-HEI				
	9. Qual CDR TDP-USAF-TP				
	10. Qual CDR TDP-USAF-HEI				
	11. Production Ammo 275,000 TP				
	12. Option Quantities				
	a) Item 10 25,000 HEI				
	b) Item 12 300,000TP				
	200,000HEI				

CUT OFF DATE

MASTER SCHEDULE

PROGRAM NAME: 25MM CASELESS CARTRIDGE

PROGRAM MANAGER: R. W. ROGERS

CUSTOMER FURNISHED EQUIPMENT

LEGEND: MILESTONE — PLAN △, SLIP ◇, ACTUAL ▲◆; BAR — PLAN ▭, SLIP ⬚, ACTUAL ■

ORIGINAL ISSUE DATE:

MAJOR CHARGE NO.:

PREPARED BY:

WORK PACK. NO.	MAJOR PROGRAM MILESTONES AND WORK PACKAGE DESCRIPTIONS	RESP. ORG.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	TOTAL
			Phase A									Phase B										Phase C												Phase D												
			1971		JAN						1972					DEC	JAN					1973						DEC	JAN					1974						DEC	JAN		1975		MAY	
II	Single Shot Test Fixture				▼		▼				▼							▼																												4
	A. Spare Parts, Sets		2	2	2	2	2	2	2	2	2	2	2		2		2		2		2						1						1			1			1			1		1		36
	B. Barrels			1	1	1	1	1	1	1	1	1	1		1		1		1		1												1						1					1		17
III	Ignition Test Fixture			▼			▼																																							2
	A. Spare Parts, sets		1	2	2	2	1	1	1		1		1																																	12
IV	Gun Simulator				▼		▼											▼																												3
	A. Spare Parts, sets			1		1		1		1		1			1			1			1						1						1						1					1		12

← OPTION → (months 31–37)

← OPTION → (months 38–43)

CUT-OFF DATE →

Brunswick Corporation

PRODUCTION ANALYSIS REPORT

1. Production Analysis graph will be furnished per P-109.

2. A narrative statement will be furnished and contain data on each shortage item or problem reported on the production analysis report in the following outline:

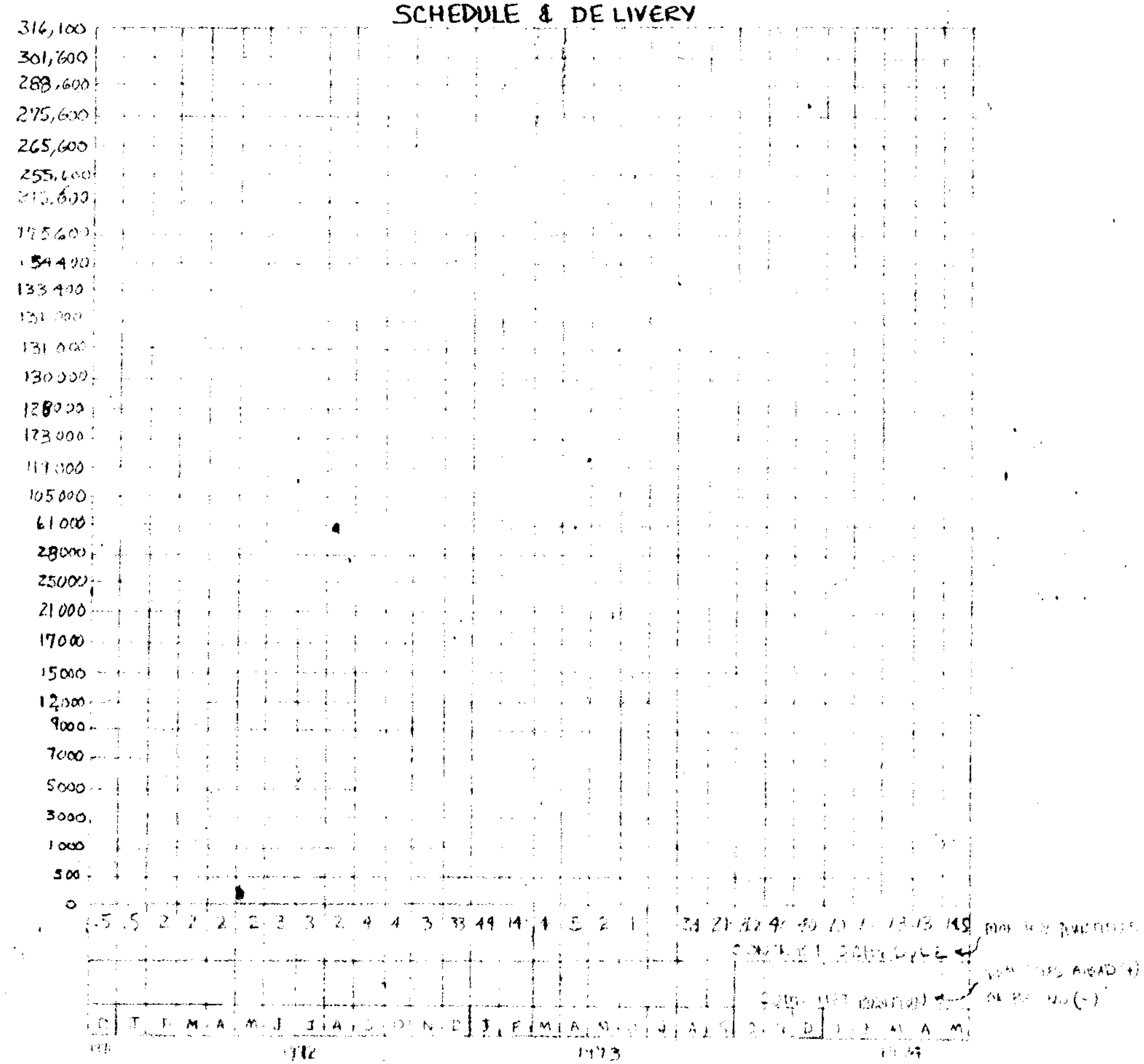
   A. A brief statement as to the difficulty being encountered on all items below the line of balance.

   B. Action taken to alleviate the problem. A statement as to the corrective action being taken with forecast "get well" dates.

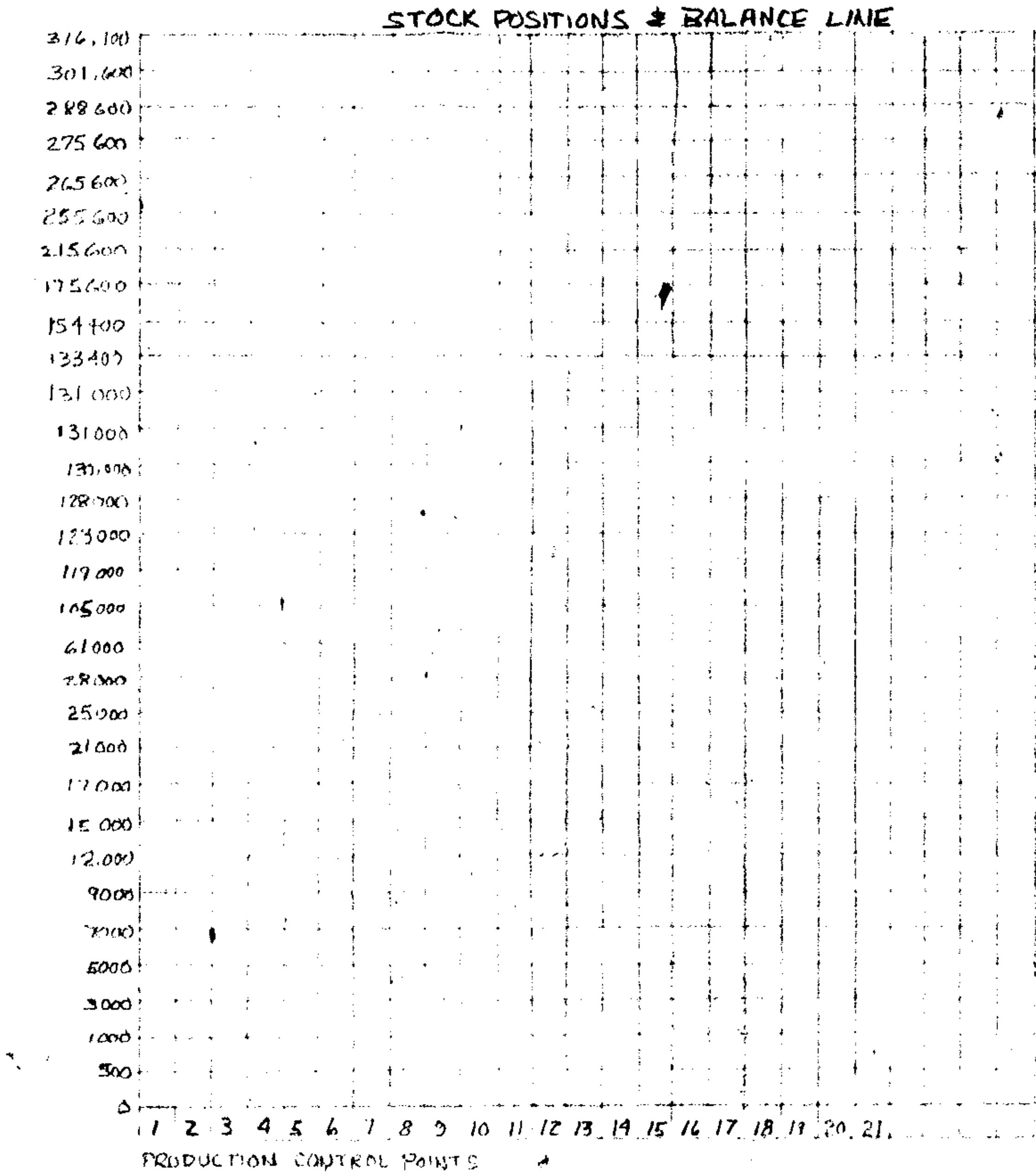
   C. Forecast recovery date. Any other pertinent information of the problem which the contractor thinks should be brought to the attention of management.

PRODUCTION ANALYSIS GRAPH - 25MM CASELESS CARTRIDGE PROGRAM

I. QUANTITY SCHEDULED



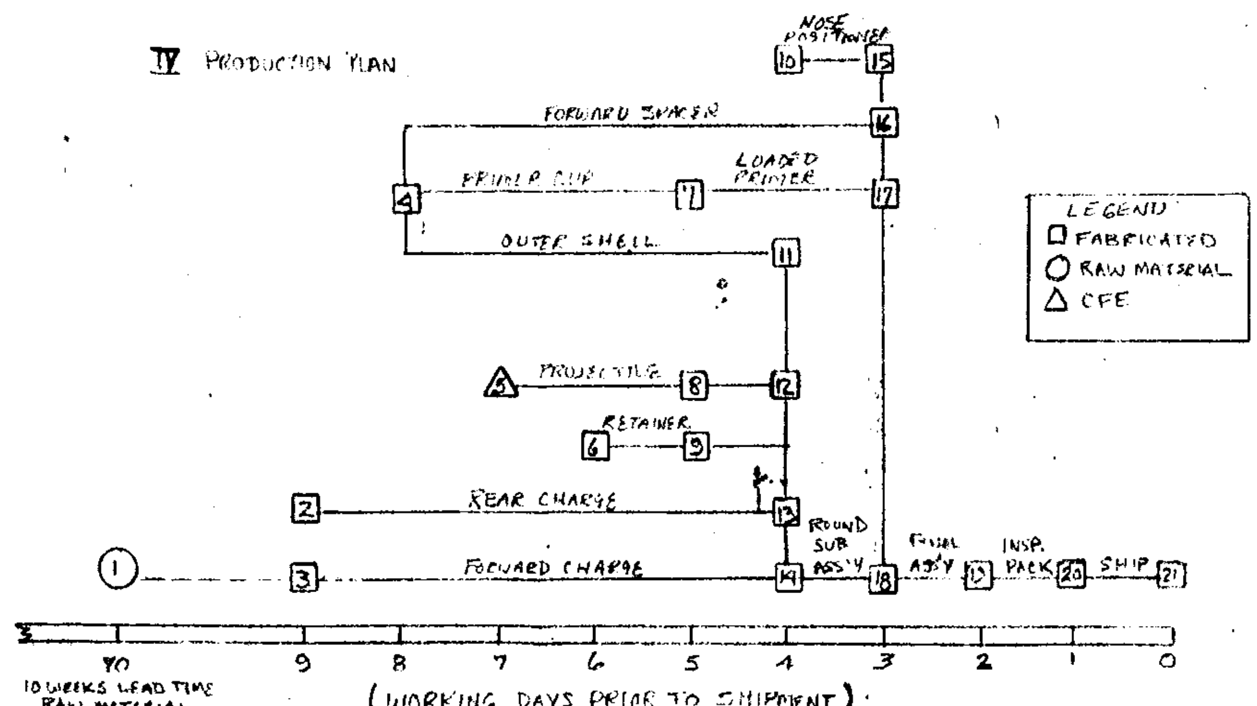
II.



III. PRODUCTION CONTROL POINTS

1. RAW MATERIALS
2. START AFT CHARGE
3. START FORWARD CHARGE
4. START FELTING OPERATIONS
5. RECEIVE PROJECTILES
6. START RETAINERS
7. PRIMER CUP COMPLETE
8. INSPECT PROJECTILES
9. RETAINER COMPLETED
10. START NOSE POSITIONER
11. OUTER SHELL COMPLETE
12. PROJECTILE & RETAINER ASS'Y COMPLETE
13. AFT CHARGE COMPLETE
14. FORWARD CHARGE COMPLETE
15. NOSE POSITIONER COMPLETE
16. FORWARD SPACER COMPLETE
17. LOADED PRIMER COMPLETE
18. SUB-ASS'Y ROUND COMPLETE (LESS NOSE POSITIONER FWD SPACER & PRIMER)
19. FINAL ASSEMBLY AND PRIME ROUND
20. FINAL INSPECTION AND PACK
21. SHIP

IV PRODUCTION PLAN



DATA ITEM A067

Brunswick CORPORATION

EQUIPMENT TEST PLAN

(PRELIMINARY)

Equipment will be qualified utilizing existing Brunswick Standard Practice Instructions. After receipt of contract, a detailed plan will be furnished on each item. The following SPI's will be used.

1. SPI-QC-2 Tool and Gage Inspection (Calibration Methods)
2. SPI-QC-3 Tool and Gage Inspection and Calibration Procedures - Standards
3. SPI-QC-4 Tool and Gage Inspection (Cycling Schedule)
4. SPI-QC-5 Productive Tooling (Inspection of)
5. SPI-QC-6 Tool Control Procedure
6. SPI-QC-7 Control of Government-Owned Property
7. SPI-QC-8 Tool and Gage Inspection & Calibration Procedure "General"
8. SPI-QC-9 Control of Inspection Tools & Equipment

INTEGRATED LOGISTIC SUPPORT

Preliminary Plan

The Integrated Logistic Support Plan for the 25MM caseless ammunition will be based primarily on support to the gun facility and the various facilities eventually to be involved in the numerous handling and testing of the caseless ammunition.

A detailed plan will be written covering the logistic support during Phase IV. This detailed plan need be during Phase IV. The detailed plan need be written based on the interrelation requirements with the afore mentioned facilities and an exact detailed plan must be based on their requirements and needs which will be spelled out early in the Phase IV part of the systems engineering program.

Generally the areas to be covered under this plan will include the following:

(a) Preparation of detailed schedules and delivery requirements.

(b) A detailed plan correlating interplant movement with interplant fabrication and off-plant shipment.

(c) Detailed procedures covering space and storage requirements at both on-plant and on-site test facilities.

(d) Preparation of requisition procedures.

(e) Detailed procedures for supplying, resupplying and emergency procurement requirements.

6. PRODUCTION PLAN

6.0 PRODUCTION PLAN

6.1 Introduction This production plan is submitted in response to RFQ F33657-71-R-0877 issued by AFSC Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio. The basic guide lines for the plan are defined in Philco-Ford Statement of Work 6-71 dated 21 June 1971.

Presented herein is a detailed description of the production techniques that will be employed by Brunswick in the manufacture of 25mm Caseless Ammunition to comply with the requirements of the above referenced document.

The plan presents general information to show Brunswick's experience and capabilities in the manufacture of 25mm Caseless Ammunition and related items as well as detailed processing information to demonstrate an understanding and appreciation of the basic parameters which relate to high production rates.

6.2 Technical

6.2.1 Manufacturing Plan

a. Producibility Engineering The producibility of the caseless ammunition will be given major consideration in the initial phase of the program. This effort will be directed in three principal areas. These areas are: (1) baseline design considerations and the effects of design changes on producibility; (2) process methods and means of optimizing producibility through process studies; and (3) production techniques for achieving maximum producibility during the manufacturing process.

The above considerations are, of course, interrelated and each has direct affect on the others. Therefore, consideration will be given to all areas when producibility studies are being made. Obviously, cost is another important factor in producibility studies and will be given prime consideration.

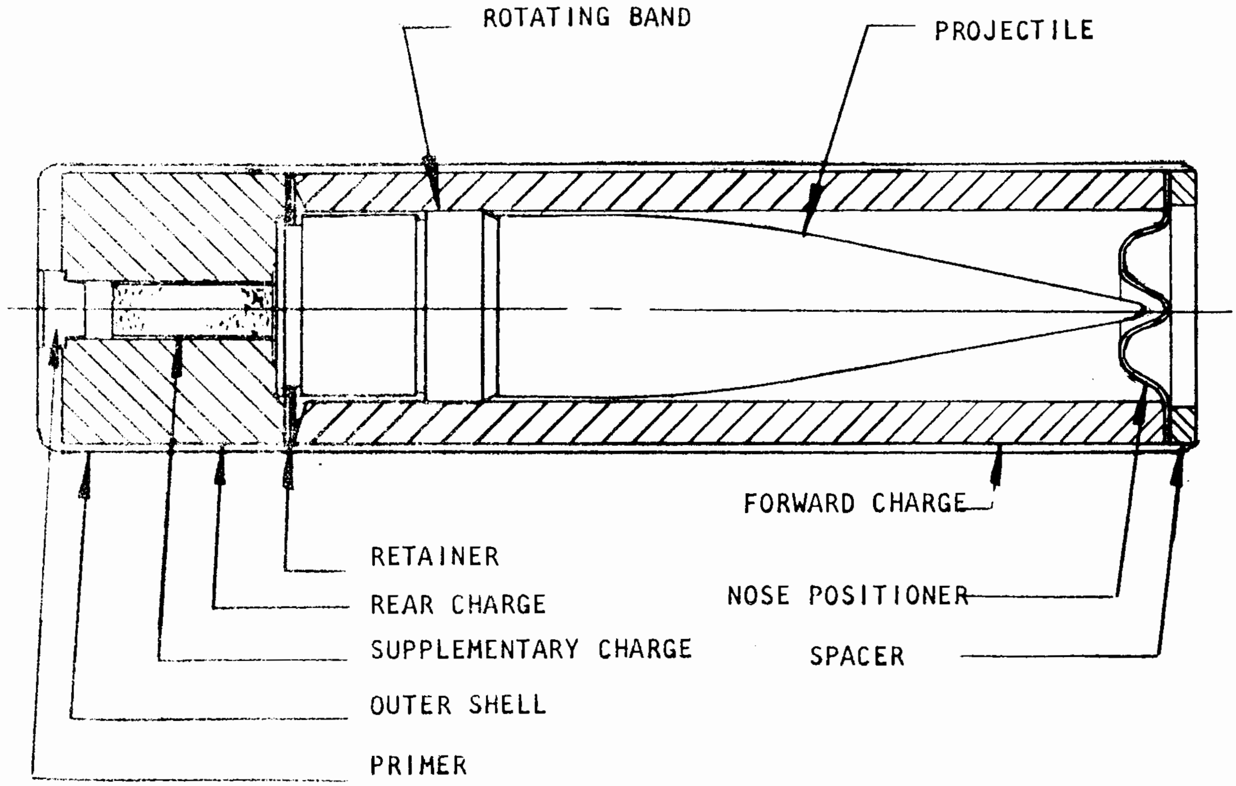


FIGURE 6-1

C7 MODEL 19 ROUND

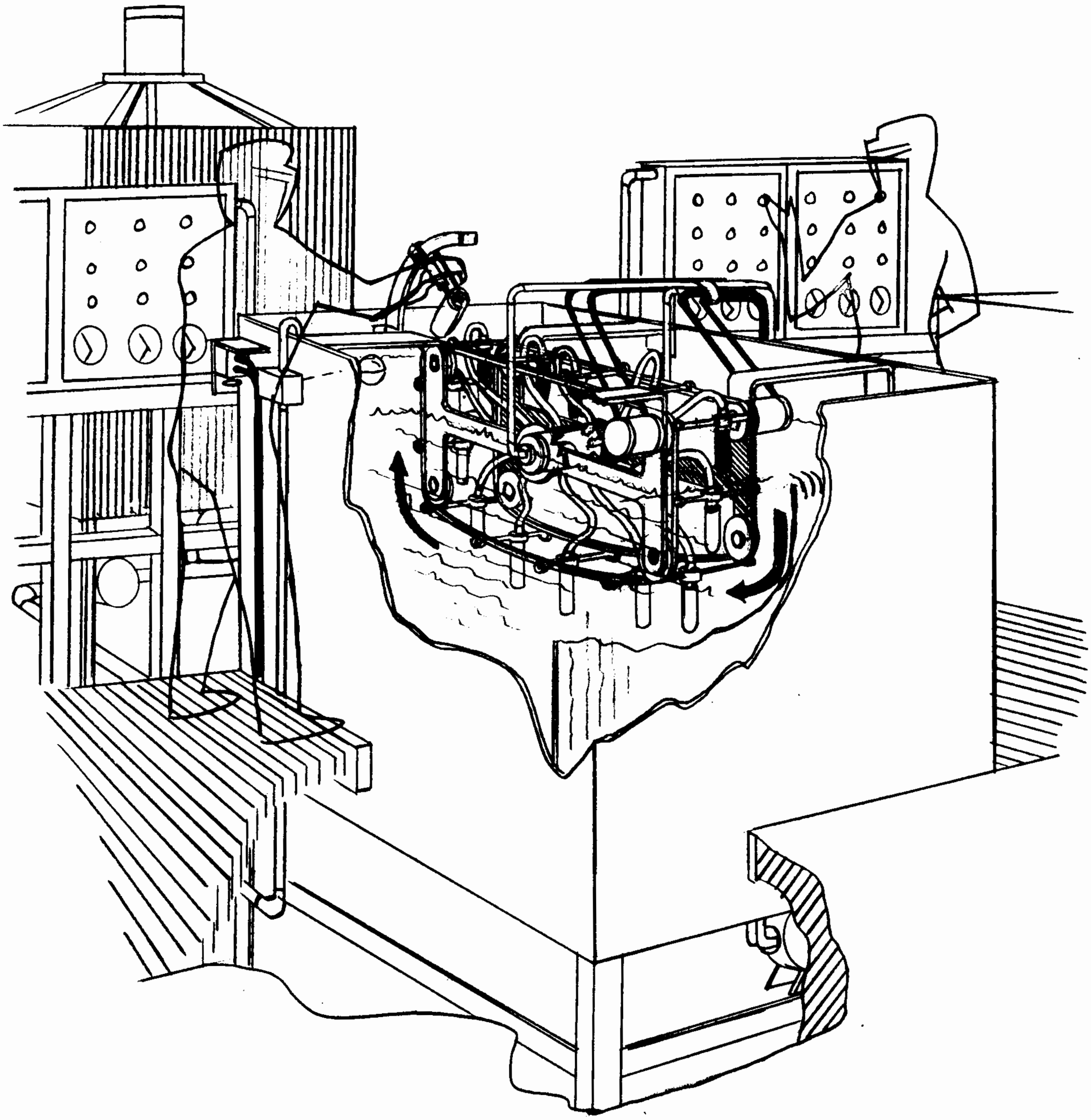


Figure 6-2
Automatic Felting,
Outer Shell

The prototype continuous felting operation should provide a part each 10 seconds or less, or 2400 units per shift. Once operable, larger and faster felting machines are planned.

2. Dehydration and Final Molding A special machine will be designed and fabricated to accomplish these operations which are now being performed in a single station set-up. A rotary table approximately 10 feet in diameter and with 48 molds mounted on a steel indexing plate shielded into four equal quadrants is planned. The first group of 12 molds will be in close proximity to the felting machine, see Figure 6-3.

As the operator takes the felted shells from the screens and determines the wet weight, he places it into one of the 12 empty stations. After all 12 are loaded, he trips a switch which causes the machine to index one-quarter revolution behind a safety shield for the first dehydration step. As the machine nears its final index point, another switch is tripped automatically causing a cylinder activated shot-pin to move forward and engage a locating hole to positively position the molds and lock them in place.

The molds are provided with vent holes in the bottom to allow moisture to escape and a heating system which maintains a temperature of 250°F. Alternate methods of heating the molds are under consideration, either interconnecting them via an unbilical for the steam or electrical circuits.

As the shot-pin engages, a pneumatic circuit is completed and gang mounted air controlled hydraulic presses descend. The ram is equipped with a pressure bag and once the mold closes, it is pressurized to 60 psi in conjunction with a vacuum which operates through the female mold. An automatic timer is employed to return the press upon completion of the dwell period.

The machine is automatically indexed another quarter of a revolution to the final molding station. An interlock switch will be provided to preclude the operator indexing the machine until the rams are up. As previously mentioned, the table has been shielded into quadrants with each operation phase separated from the other. In the final molding position, because of special hazards involved, additional shielding is provided to separate the 12 molds from each other. Most of the water has been taken from the part at this stage and because of the high temperature, 250°F, and relatively high pressures required, special provisions including deluge system are required.

Essentially the same operation is involved in final molding as in the dehydration phase except the pressure bag is not employed. A polished stainless steel mandrel of the final item inside diameter is used. Using approximately 2500 pounds dead load pressure, the rams descent into the parts and dwell for one and one-half minutes.

With one and one-half minutes dwell time and allowing 30 additional seconds for indexing and handling, the total cycle time is at maximum two minutes for 12 parts. Using seven working hours in a shift, over 2500 parts can be produced per shift from one machine. In addition, it is very likely that the dwell time previously mentioned can be significantly reduced by using slightly higher pressures and temperatures.

Quality Control checks will include monitoring temperature, pressure, and time. Sample parts will be checked for a maximum and minimum percent moisture after final molding and 100 per cent inspection will be performed for visual flaws.

Special safety precautions include:

(1) Gloves will be worn when working around heated molds.

(2) Molds will be kept clean and free from residual felted material or other foreign matter.

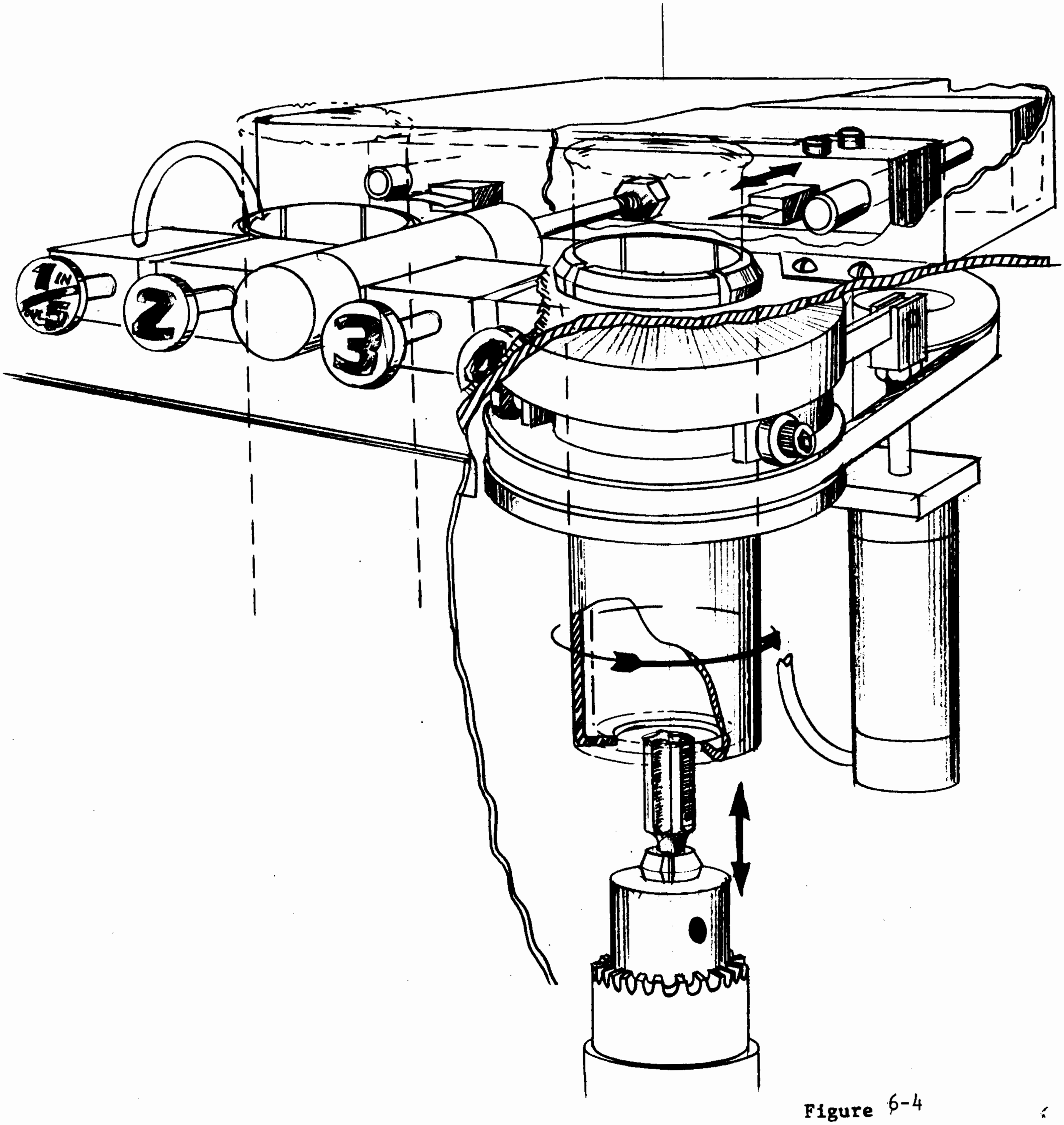


Figure 6-4
Final Machining,
Outer Shell

2. Sheet Pressing The felted sheet will be placed on a flat platen and pressed to stops in order to produce the final thickness of the primer. The platen molds will be maintained at a temperature of 230-235°F. The mold will close remotely and will dwell for a 2 to 3 minute timed cycle.

After removal from the mold, the sheet will be visually inspected for evidence of inconsistencies in density.

The safety precautions described under Dehydration and Final Molding of Outer Case will apply to the sheet molding operation.

Assuming a total cycle time of four minutes, one minute for installation and removal and three minutes dwell, one press and operator can produce sufficient material for 2160 primer cups per hour (144 primer cups per sheet). Thus, a single operator on a one shift basis can meet the required production rates.

3. Machining Finished primers will be obtained by a two step machining operation performed on the pressed sheet. Prior to machining, four mastered holes will be drilled in the corners of the sheet.

The sheet will be positioned in a special drill fixture which employs four pins to receive the mastered holes.

Thirty-six stepped drills will be gang mounted on the fixture as shown in Figure 6-5. With the drills rotating, the felted sheet will be drilled to effect 36 each .093 inch diameter holes through the sheet with .125 inch diameter counterbore, .035 inches deep. The 36 holes will be located on one inch centers and will provide holes in only one quadrant of the panel. After drilling of the first quadrant, the panel will be rotated 90° and relocated on the mastered pins in three successive operations to produce 144 counterbored holes.

The panel will then be turned over and positioned in another special drill fixture which is also mastered to the four location holes in the panel. This fixture will be equipped with 36 tools which are mastered the same as the 36 tools in the first drill fixture. Each of the tools in the second drill fixture will be provided with a .181 diameter counterbore tool and special cutting tool which rotates on a .157 radius. The counterboring and outside diameter cutting tool are positioned to effect a .116 depth of counterbore when the cutting tool breaks through the panel. Each tool is provided with a pilot to locate in the .093 diameter hole obtained in the proceeding operation. A sketch of the second machine operation is shown in Figure 6-6. The second machining operation will also be done in four steps with each step performing operations on one quadrant of the panel. Upon completion of the second machining operation, the finished primer is produced. All excess material, including the outer one inch around the periphery of the panel, will be discarded.

A sample will be taken from the 144 primers that are produced from each sheet and checked for conformance to the specified dimensions and weight.

All machining operations will be done behind shields with remote actuation. The cutting tools will be kept sharp and the rates of rotation and feed of the cutting tools will be such that the hazard of igniting the material is minimized. The machine will be equipped with a special deluge system and sensor for automatic actuation in case of fire.

The total cycle time to perform the two operations on all four quadrants of the panel is estimated to be four minutes. This can be cut in half if the two machining operations are done simultaneously. A maximum production rate of 5000 per day can be exceeded in a single shift, even if a four minute cycle is assumed.

(c) Forward Spacer

1. Felting The forward spacer will be felted in sheet form in the same manner

as the primer, described above. Again, a 14" x 14" panel will be felted and the outer one inch discarded from each side. Since the degree of compaction is less than that for the primer, the amount of deposited material will be less for a given thickness.

The felting heights will be approximately gaged by comparison with the dam height. Continuous checks will be made to assure that the proper solids concentration for a given felting time is maintained.

All general safety regulations will be followed in performing the felting operation. Due to the high water content in the panel, as felted, no special safety regulations will be required.

The estimated time for felting is two minutes, which includes one minute in the felting tank. Each panel will produce 49 front spacer; therefore, the hourly felting rate per tank will be 1470. Thus, a rate of 5000 per day can be produced in a single tank on a one shift basis.

2. Sheet Pressing The felted sheet will be pressed to the required thickness and density using heated flat platens in a press. After removal from the press, each panel will be visually inspected for uniform density.

The same safety precautions described under Dehydration and Final Molding of Outer Shell will apply to the front spacer molding. The mold will be located in a bunkered cubicle with remote activating controls.

The total molding cycle is estimated to be two minutes. Since each panel contains 49 forward spacers, the production rate per press is 1470 per hour. This would allow a single press operating on a one shift basis to produce up to 5000 per day.

3. Punching The forward spacers will be punched from the sheet in a press using a compound die. An indexing fixture will be used to position the panel to

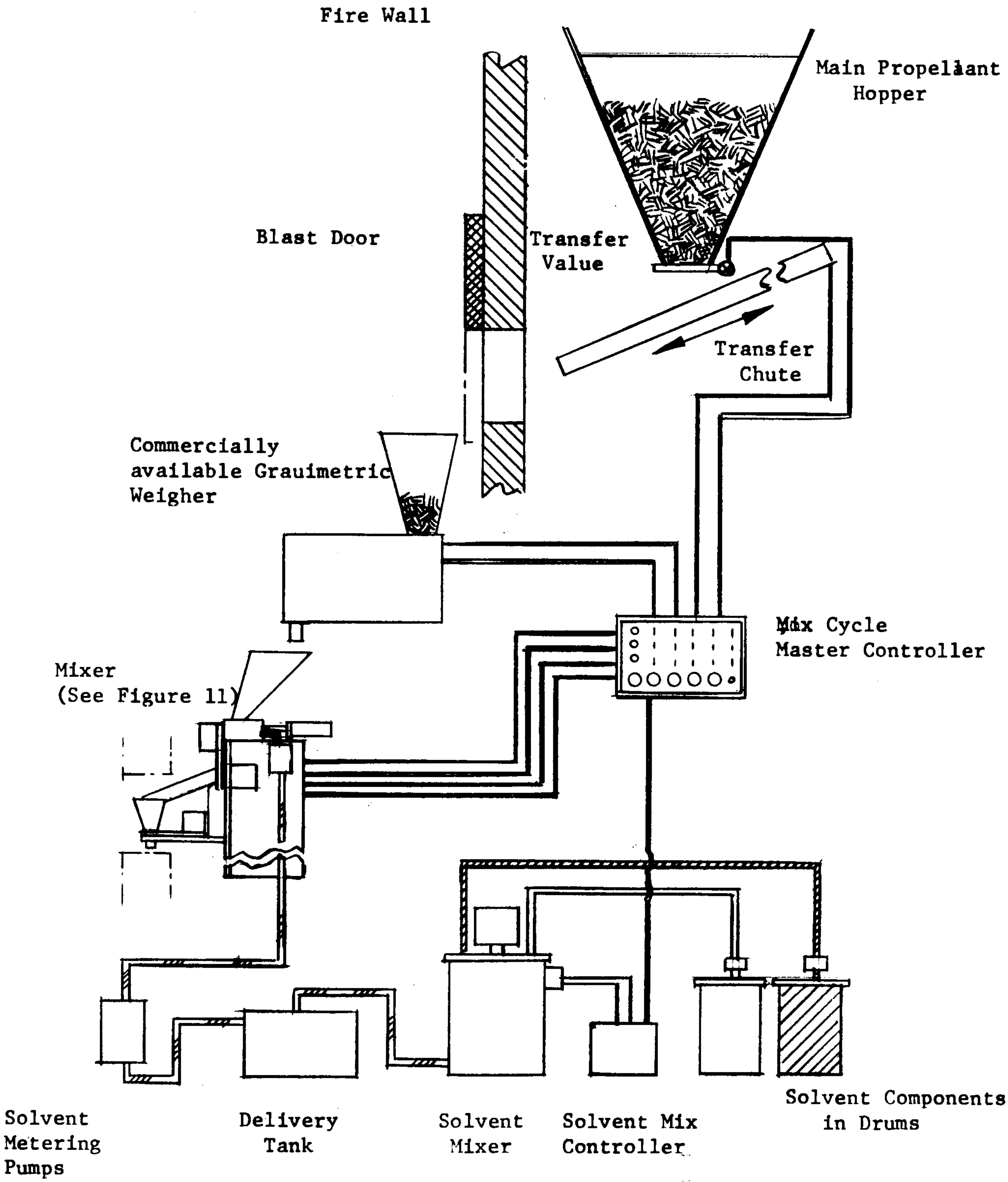


Figure 6-7
Schematic,
Propellant Charge Mixing

An expansion to 5000 units per day will require an additional six weighers, six mixers, and six solvent injection pumps plus any additional controls that will be necessary.

Process control will be provided by periodic analysis of the charge leaving the mixer. This, plus automatic controls in the solvent system to indicate empty tanks, no flow, etc., and interlocks on the other mixing functions to stop processing when component cycle failure occurs, will enable rapid indication and insolation of process malfunctions.

All mixing of large batches of solvent and the main storage for the dry propellant is separated from the loading operation by a fire wall with an interlocked blast door for transfer of material through the wall. Only a small quantity of the propellant and solvent will be in the mixing bay at any time. All equipment will be electrically interconnected and grounded as necessary to prevent the generation of static discharge. Any scrap propellant and/or solvent will be placed in suitable safety containers properly installed. A special water deluge system with fast acting initiation will be designed and installed in areas where mixing and pressing of propellant charges is performed.

2. Pressing Pressing of the solvated charge will be carried out in molds mounted on the dial of a rotary table, see Figure 6-9. Each set of molds has its own hydraulic pressure cylinder, the operation of which is controlled by a position controller located on the table dial. This controller senses the position of each press around the dial at any time in relation to a fixed point off the dial.

The operation cycle for each mold set is as follows (dwell + index time = $\approx$ 48 seconds):

(1) Index under loaders, fill charge cavities.

(2) Index from under loaders, apply hydraulic pressure to cylinders and close rams.

(3) Index through two stations with ram closed under pressure.

(4) Index, open rams.

(5) Index, strip part from cavity.

(6) Index, clean molds (2 positions).

(7) Repeat cycle.

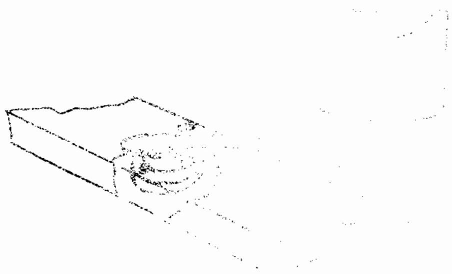
Four cavities are traversed at each index; this permits one part every 12 seconds of 2000 units in a nominal 400 minute shift. A 72" diameter dial will be required for this operation.

To increase the production rate to 5000 units per day, an additional rotary table with an 84" dial, traversing six cavities at each index, will be required. The station to station time will be the same (48 seconds).

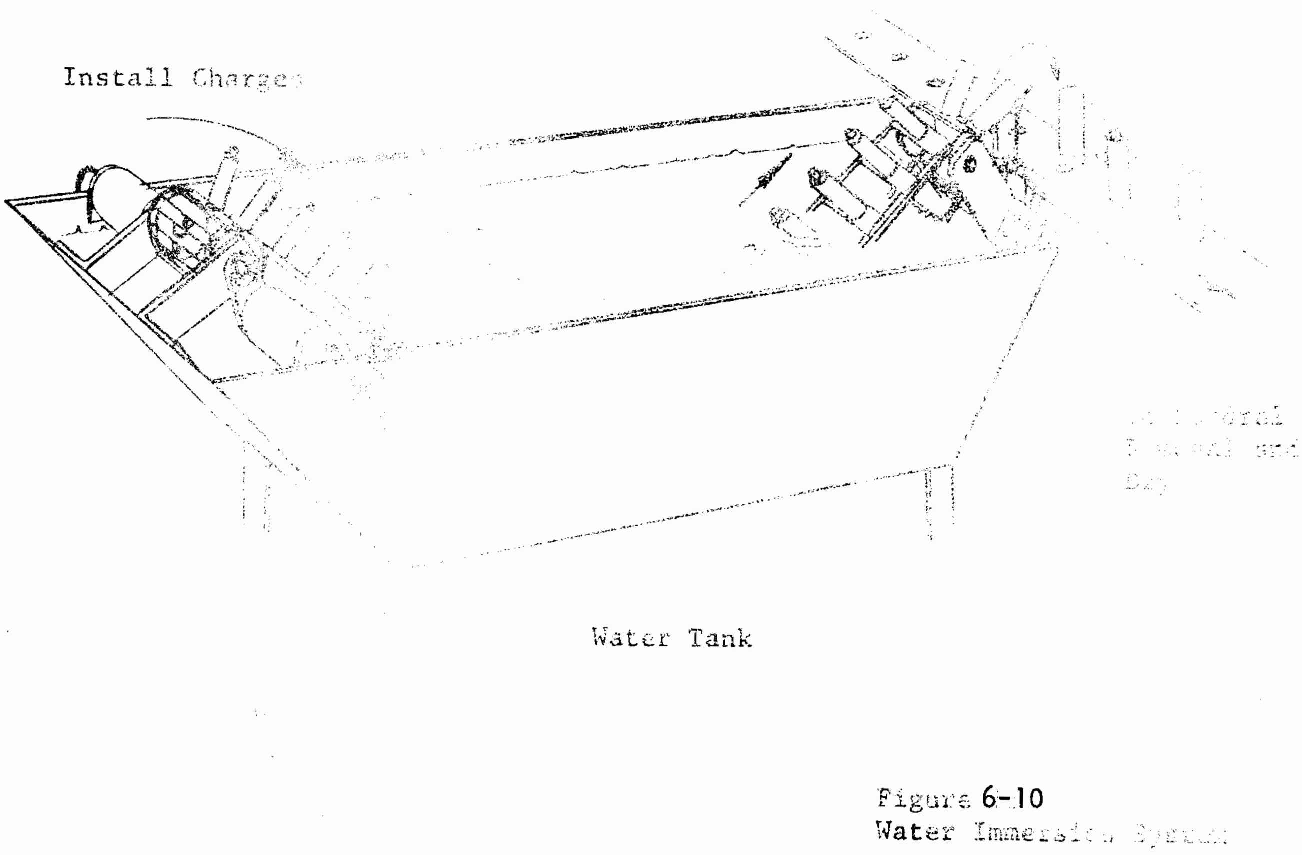
After the parts are stripped from the mold cavity, they are deburred and transferred to the immersion tank. The water immersion system (see Figure 6-10) consists of a link belt with mandrels secured to the links running through the water tank. Dual pulleys are provided to clear the mandrels and the charge on the return run. The active belt length is approximately 22 feet and the speed between four and five feet per minute. After immersion, the charge mandrels are released from the belt, the charges stripped from the mandrels and oven dried.

The parts will be inspected for visual defects on removal from the molding cavity. Process control tests for dimensions and strength will be periodically performed after the water immersion cycle. Energy content and rate of release (closed bomb) testing will be performed on the charges after a short period in the drying oven.

The mix delivery to the charge cavity will be provided with fume hoods to remove solvent vapors from the area. All scrap propellant and components will be



Pictorial -



Water Tank

Figure 6-10
Water Immersion System

stored under water. Mold closing, initial pressing and opening will be done remotely with shielding provided. Deburring operations will be isolated from pressing and immersion.

Of principal importance with regard to safety is to maintain the rate of flow of material. This will prevent a buildup at any operation. Although the amount of material handled can be high, the quantity in process at any station will be at an acceptably low level.

(b) Rear Charge

1. Mixing Exactly the same mixing procedure will be utilized as on the forward charge. The same number of mixers for each assumed production quantity (2000 per day and 5000 per day) of rear charges will be required as for the forward charges. They will differ only in detail to accommodate the smaller propellant quantity in the rear charge.

Process control and safety aspects are essentially the same as for the forward charge.

2. Pressing The same process concepts as used on the forward charge are applied here. The basic differences are due to the different configuration of the rear charge.

Due to the shorter dwell time required under pressure for molding, the rotary table dials needed are smaller - one 60" dial table for 2000 per day and an additional 84" dial table for 5000 per day.

The principal difference for the rear charge is that no water immersion will be required; therefore, dimensional and strength testing will be performed after a short period of drying.

Otherwise, Quality Control and safety aspects are basically the same as for the forward charge.

(c) Primer and Ignition Assembly

1. Primer Loading Primer loading will be carried on in a series of shielded bays. Each bay having one work station and vented to atmosphere through a frangible wall, see Figure 6-23. The tooling cycles are interlocked between the bays and each bay has a blastproof door which is automatically closed when the tooling is operated. Conductive floors, electrical systems satisfying DOD requirements, spark-proof tools, etc., are standard in operations such as this.

The first bay contains charge plate loading operation, see Figure 6-11. In this bay and in the second bay the humidity is maintained as near as possible to 100% relative by water spray nozzles near the top of the tank. The operator first locks the graphitized hard rubber charge plate in place in the machine and cycles the filling operation. The charge plate is retracted under the charge loading cylinder and a specified air pressure is applied to the loading piston. This forces the primer mix through the filling plate and into the cavities in the charge plate. The device dwells under this pressure for approximately 30 seconds. The pressure is then released and the charge plate returned to its original position. The operator opens the blast door, removes the charge plate, and inspects the cavities for proper filling.

In the second bay, the mix is pressed from the charge plate into the primer cup, see Figure 6-12. The primers, after pressing, are transferred to another clean press plate and into the drying oven where the water is removed from the mix. This change of press plates is a safety precaution to prevent accumulation of dried and thus highly sensitive mix on the exterior surfaces of the plate.

After drying, the pyroxylin primer shield material, to which the adhesive has been previously applied, is attached to the primer cups still in the press plate. After a short drying period (5 to 10 minutes) in ambient air, the primers in the

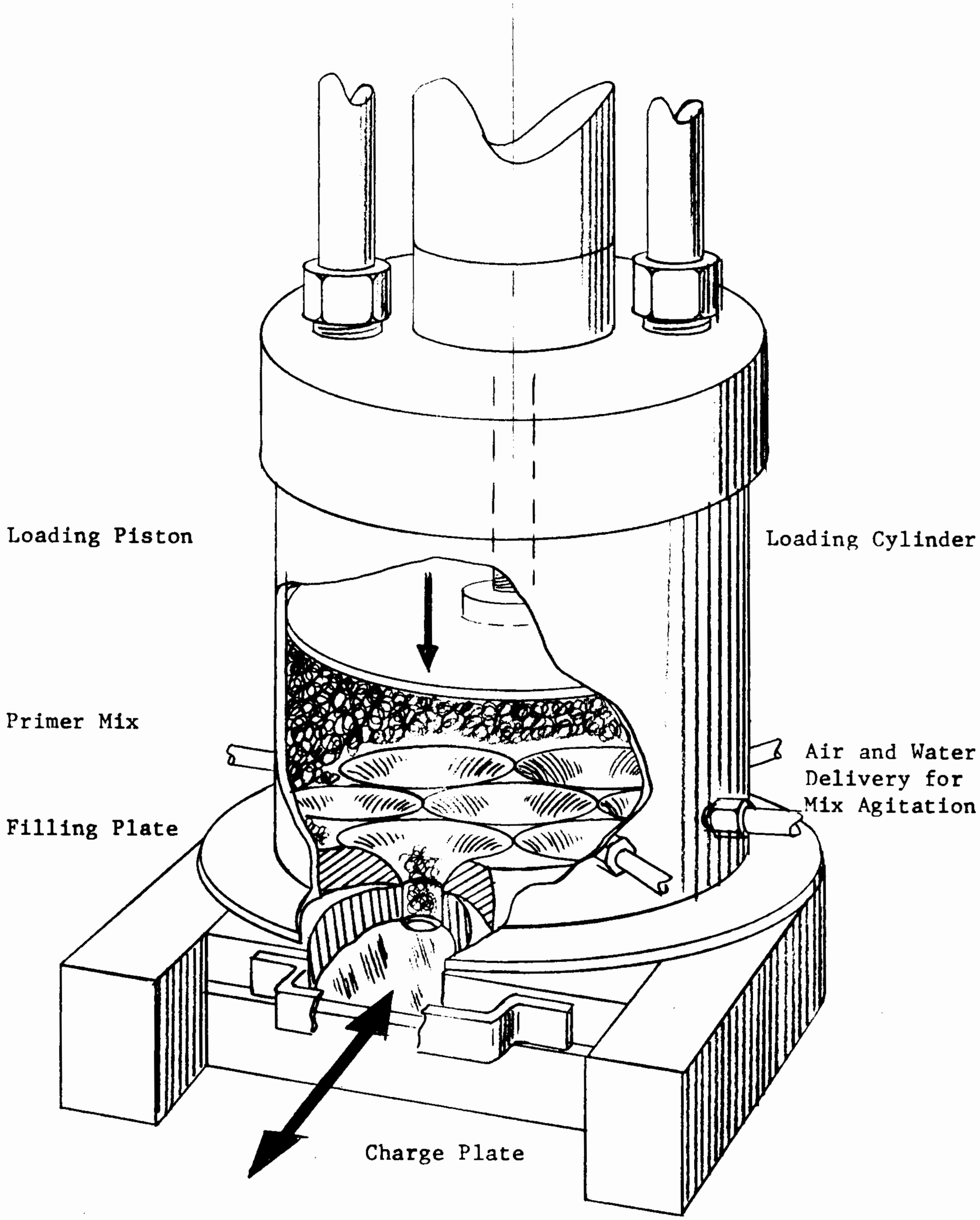


Figure 6-11
Charge Plate Loading

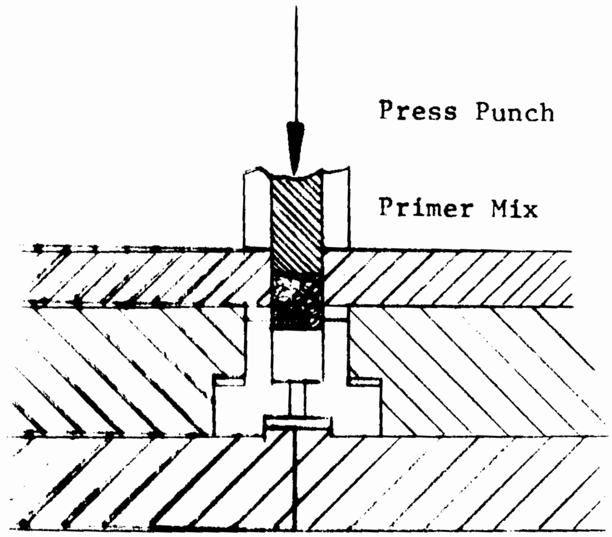


Figure 6-12
Primer Pressing

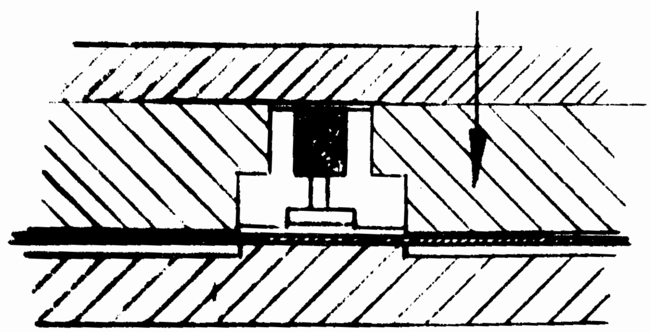


Figure 6-13
Primer Shield Shearing

press plate are mounted over the shear plate and the pyroxylin is sheared by the press plate acting against the shear plate to form the primer shield, see Figure 6-13. This operation is carried on in a third bay in which the humidity is maintained as high as possible without affecting primer performance. After the pyroxylin has been sheared, the primers are removed and placed in process trays and the press plates are cleaned in solvent to remove the remaining pyroxylin.

Assuming 10 holes per charge plate, a one minute cycle time, and allowing approximately 10 minutes per hour for cleanup, the production rate is 4000 primers per 400 minute shift. To accommodate higher rates with the same tooling, automatic transfer of the parts from station to station will greatly reduce the cycle time. Increasing the number of units per plate or paralleling the plates can also greatly increase the output. Two primers from each charge plate shall be weighed for compliance with the fill requirements and one shall be radiographically examined. When process confidence is established, this number can be reduced.

All bulk primer mix will be handled and maintained in a wet state. Loading and pressing is done in a saturated atmosphere with the mix wet. All equipment will have provisions for periodic automatic washdown. Wash water and vapor condensate from inside the tanks will be processed through filters which will be kept wet and destroyed by burning when contaminated.

2. Igniter Assembly For production rates up to 5000 units per day, it is most economical to assemble the igniter in a series of hand operations. The igniter cups are first arranged on a process tray, open end up. These are then charged with black powder from a conventional powder loader. Another operator applies cement to the primer and assembles this with the cup, completing the assembly.

The output of the black powder loader will be periodically checked for proper weight. A quantity of igniter assemblies from each day's production will be fired to determine energy output, action time, and establish reliability.

For larger production rates, a semi-automatic operation based around a rotary table is envisioned. The igniter cups are loaded into cavities in the dial of the table. They are carried under the loader for filling with the specified quantity of black powder and then under the primer module.

The primer module is loaded with primers still in the process trays from the primer loading operation. The primer module consist basically of the following items: a device to transfer the primers from the process trays into a track; an apparatus on the track consisting of a capstan and a nozzle to rotate and apply cement to the primer; and a device to transfer the primers from the track and place them into the igniter cup. The latter consists of an escapement mechanism and a vacuum punch to set the primers.

The output of a machine such as this can be as high as 25,000 in a nominal 400 minute shift.

The principal requirement for the safety in this operation will be to maintain the number of primers and exposed black powder in process at any time to a minimum. This, of course, will be more easily obtainable with the automatic operation. A special high speed deluge system will be provided for these operations.

Due to the presence of the dry inflammatory primer mix, cleanliness will be especially important. All equipment will be cleaned periodically and work in process will be conducted to maintain a high degree of cleanliness. Adequate shielding for all operations will, of course, be provided.

(3) Manufacture of Nose Positioner and Retainer The nose positioner will be made by vacuum forming sheets of pyroxylin to produce 100 closures (10 rows of 10) per vacuum draw. The sheet material will first be heated and then fed to the multiple cavity mold. The temperature of the forming mold will be closely monitored to assure that the ignition temperature of the pyroxylin is not reached. Air cylinders will be used to clamp the edges of the sheet immediately after it traverses

to the mold. Vacuum will then be applied to the cavity between the sheet and the mold. The time to clamp and form will be such that sufficient heat is maintained in the pyroxylin to permit forming. The forming mold will be provided with indexing tabs on both ends of each row of spacers. When the sheet is formed, the index impressions are formed in the sheet to facilitate positioning of the sheet in the subsequent punching operation. Upon removal from the vacuum mold, the formed sheet will be placed in a punch press and subjected to successive punching operations in which each operation will punch one row of spacers from the panel. The operator will feed the panel each time a row of nose positioners is punched, locating, each time, from the indexing tabs which were formed at the end of each row in the vacuum forming operation.

The retainer will be punched from the pyroxylin sheet on a three stage pierce and blank die. The first stage will punch an indexing hole and provide the 45° cut between diameters. Subsequent stages will punch the inside diameter and outside diameter.

These proposed production methods can meet any foreseeable production rate on a single shift basis.

(4) Round Assembly The various components and subassemblies will be assembled in the sequence shown below:

(1) Placement of aft charge in outer shell.

(2) Placement of retainer on projectile and installation of projectile/retainer in outer shell.

(3) Placement of forward charge in outer shell.

(4) Bonding of nose positioner and front spacer to outer shell and forward charge.

(5) Bonding of igniter assembly into aft end of case.

These operations will be performed in line and will be followed by a 30 minute curing cycle. After curing, the units will be trimmed to length, sealed, marked, and packaged.

A brief description of each of the above listed operations follows:

(a) Placement of Aft Charge in Outer Shell The aft charge will be placed in the outer shell to start the accumulative assembly of parts. The outer shell first will be placed on a conveyor which is provided with adapters to position the shell with the open end up. The aft charge will then be placed in the shell and the parts conveyed to the next assembly operation.

(b) Placement of Retainer on Projectile and Installation of Projectile/Retainer in Outer Shell Two retainers will be placed in the aft groove of the projectile by twisting both retainers and inserting them in the groove of the projectile. This operation will be done manually by an operator which will also place the parts in the outer shell as it is conveyed past the assembly station.

By allowing each operator to perform more than one operation, handling of parts is minimized. Operators can be added as necessary to meet the required rates.

(c) Placement of Forward Charge in Outer Shell An operator will place the forward charge in the outer shell as the assembly (shell, aft charge, projectile, and retainers) is passed through the forward charge storage cubicle. A gage will be provided to allow the operator to verify that the forward charge has seated against the retainers.

(d) Bonding of Nose Positioner and Forward Spacer The bonding of the nose positioner and forward spacer will be performed in the following steps:

(1) The assembly will be positioned under an automatic dispensing head which will deposit a metered amount of adhesive around the inner surface of the outer shell near the top.

(2) The nose positioner will be seated against the forward charge. This will sweep the adhesive down the walls of the outer shell and onto the forward charge.

(3) Step (1) will be repeated to redeposit adhesive on the inside of the outer shell.

(4) The forward spacer will be seated against the nose positioner, again sweeping adhesive down the walls of the shell and onto the nose positioner.

The above steps are presented pictorially in Figure 6-14.

After application of the adhesive and assembly of the parts described above, the unit will be placed in a curing fixture which holds the unit in an upright position, aft end up. Each fixture will hold approximately 50 assemblies and will be provided with screw clamps for applying load during curing of the adhesive.

(e) Bonding of Primer Assembly A bead of adhesive will be applied around the primer cup and the assembly seated into the cavity provided in the aft end of the case. The seven clamps will then be tightened down to apply pressure to the adhesive in the forward end - no pressure will be applied to the primer. The force will remain for 30 minutes to effect complete cure under pressure. Figure 6-15 shows the assemblies clamped for curing.

(f) Trimming The cured assembly will be taken from the curing rack and placed on a fixture which trims the unit to the 5.965 ± .010" length. The fixture is provided with rollers which clamp and rotate the assembly. A cutter plunges to trim the unit and provide a chamber to the forward surface. Figure 6-16 shows the fixture for trimming the round.

(g) Application of Seal Coat The trimmed rounds will be provided with

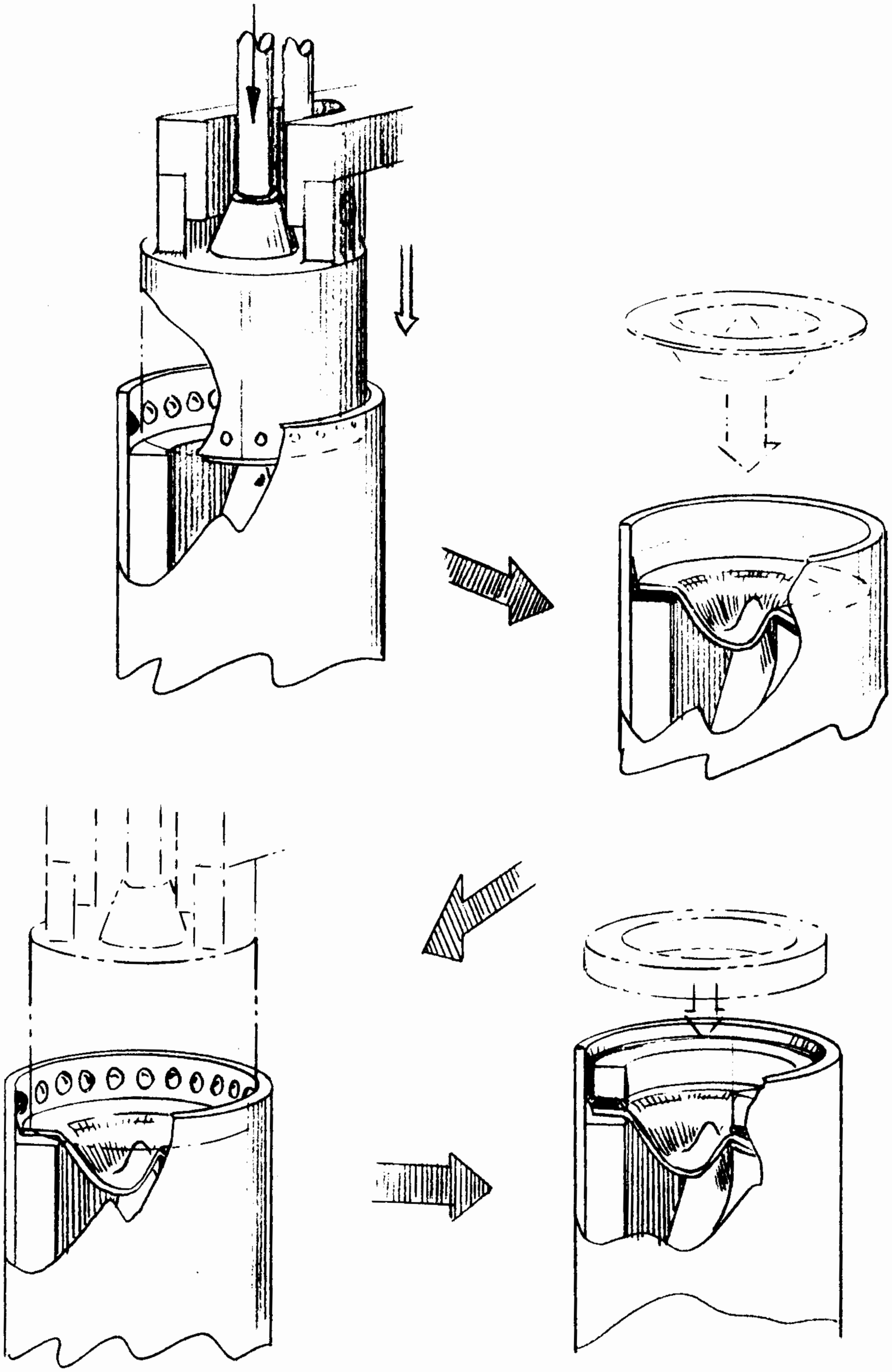


Figure 6-14
Assembly Steps
Bonding of Nose Positioner
and Forward Spacer

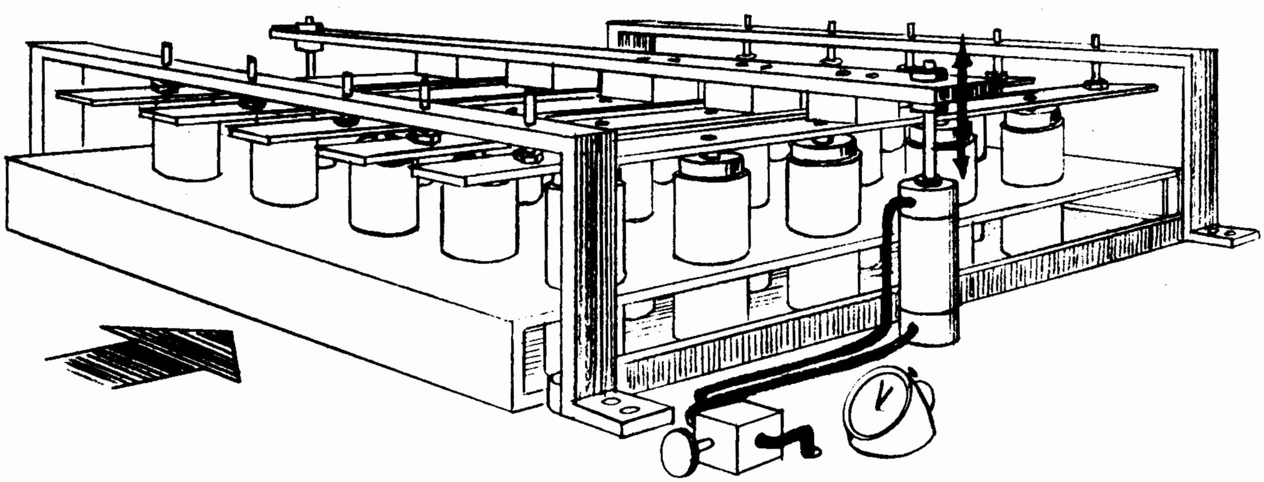


Figure 6-15
Bonding Fixture
Nose Positioner and
Forward Spacer

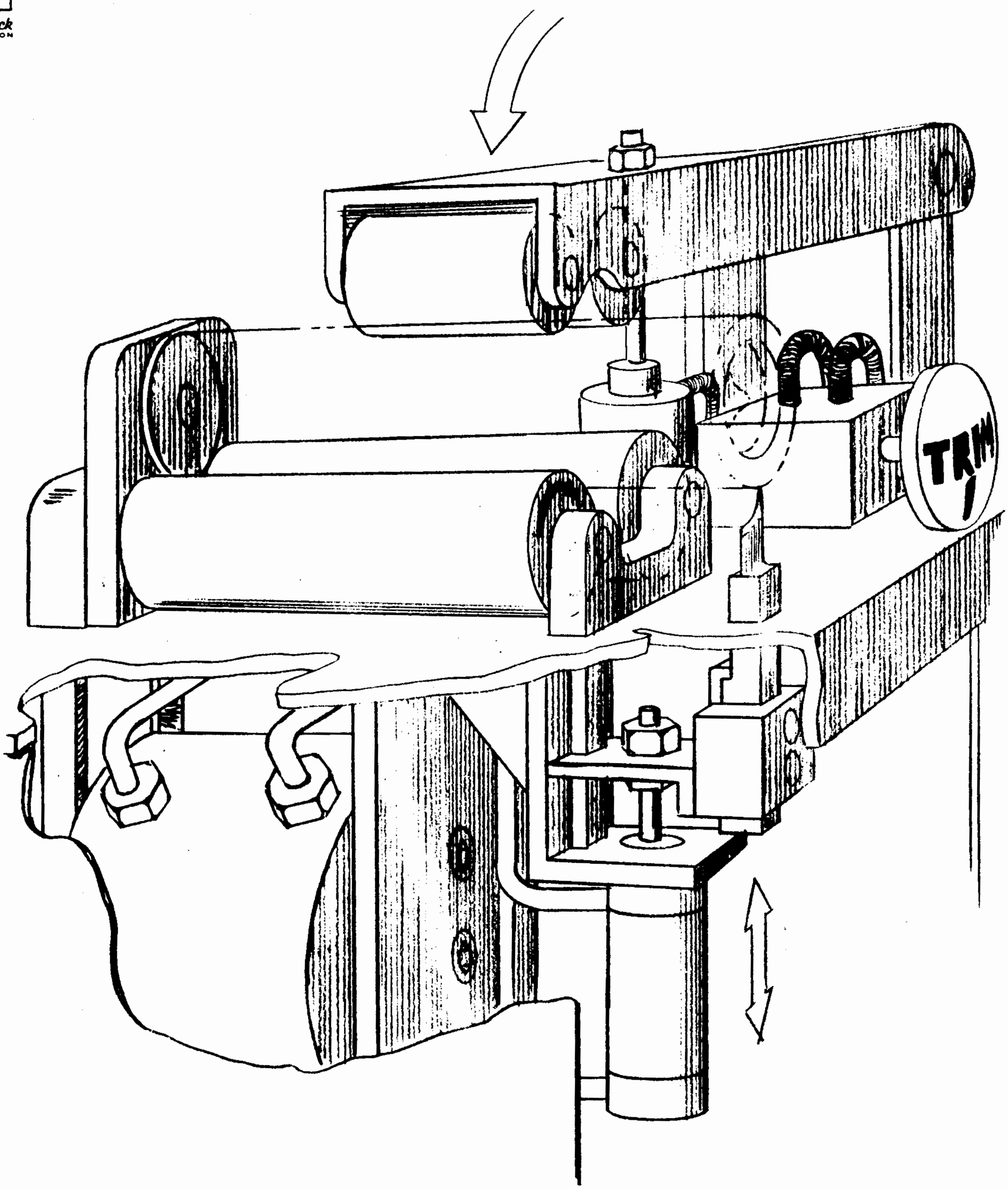


Figure 6-16
Fixture for Trimming
Assembled Round

a protective coating which will be applied in two stages. The first stage will consist of spraying the case with a solution of RDX, acrylic and toluene in three coats to provide approximately .007" of buildup. A short drying period will be effected between each of the three RDX applications to prevent the sprayed acrylic from dislodging the deposited RDX. Also, the final spray coating will be thoroughly dried prior to packaging the rounds.

The method used for applying both coatings is shown in Figure 6-17. The rounds will be secured to the rotating hangers by means of spring wire which pricks the front spacer at three points on its inner surface. The spray nozzles will be directed to given equal coverage in all areas.

Each round will be rotated by a belt as the spray coating is being applied. The feed chain will trip switches which activates the nozzles for each round.

The water collection tanks will be provided with a removable strainer which will collect the RDX that is suspended in the overspray. These strainers will be removed and destroyed as necessary to provide safe working conditions. The proposed spray system contains only standard equipment which is readily available. Increased production quantities can be easily accommodated by equipment modification or the installation of additional equipment.

(h) Marking Each round of caseless ammunition will be marked to identify the item and to show manufacturing lot number. The units will be fed to an automatic marking machine which is equipped with a roller conveyor to feed the round and marking heads to apply the proper identifying information. The marking heads rotate to collect ink on the raised letters and apply the ink to the round. While the marking is being applied, the round is free to spin on the conveying rollers.

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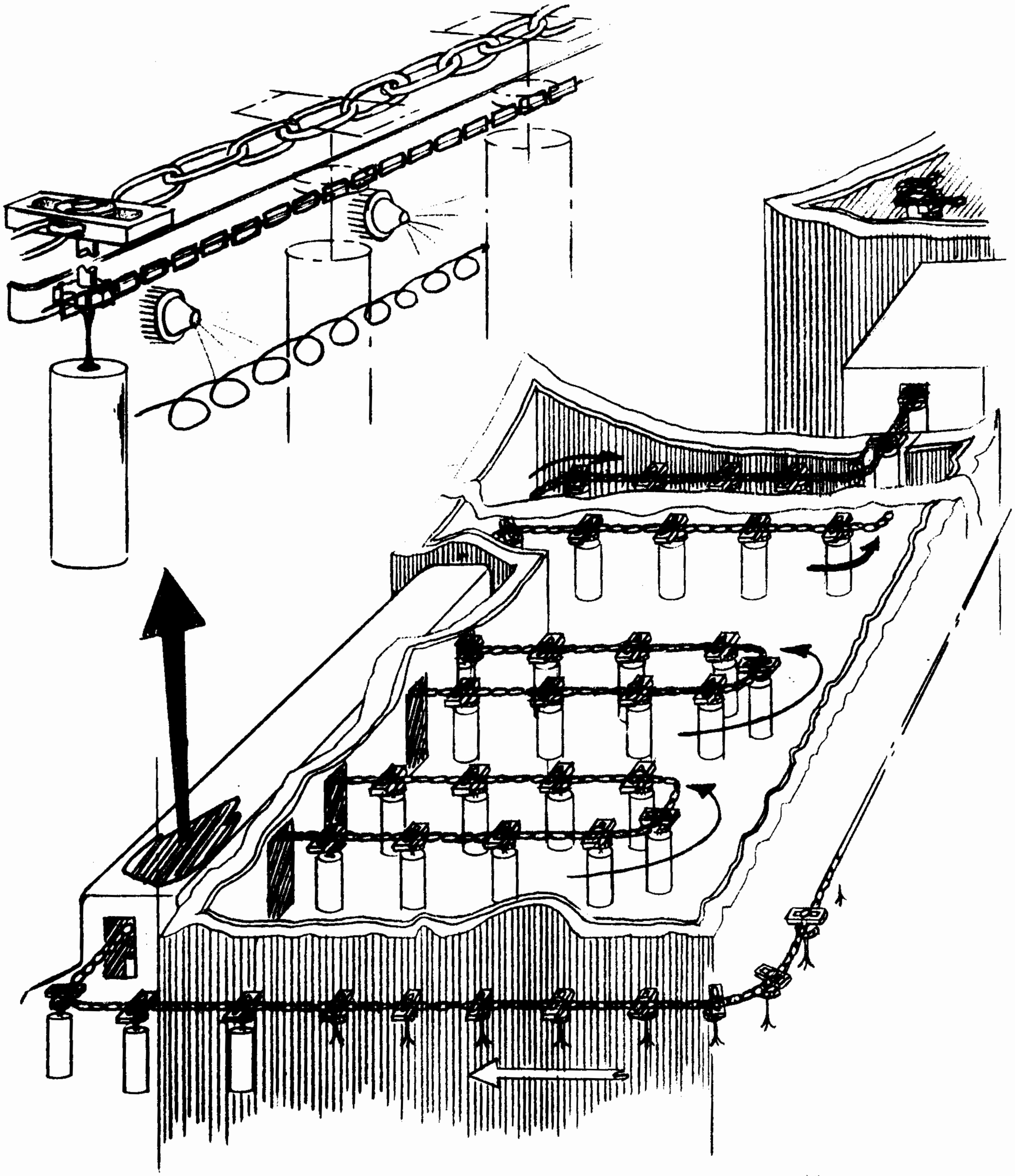

Figure 6-17
Application of Seal Coat
Assembled Round

(i) Packaging The rounds will be packaged in a manner that most effectively fulfills the requirements of logistics and interface with the feed system and aircraft. These specific requirements will be established in subsequent stages of the program through joint efforts of the system participants. The packaging method proposed herein is offered as an interim method so that pricing data can be submitted. When more detailed packaging information is engendered, the necessary modification will be made to arrive at a packaging system that will satisfy the requisite parameters for transporting, storing, handling, and loading the ammunition.

The interim packaging plan is based on 51 rounds being packaged to an individual fiberboard carton. Two cartons will then be packed into a wirebound box. The 51 rounds will be sandwiched between two sheets of plastic in three rows of 17 units each. The area between rounds will be heat sealed (or glued) to form individual pockets. The 51 round package is then placed in an "S" configuration in the fiberboard carton. Cushion material will be added as necessary to provide an adequate pack. The carton will be closed and then sealed in a moisture proof barrier bag.

Two moisture sealed cartons will be placed in a wirebound box with filler pads used as necessary to provide a tight pack.

The carton, barrier bag, and wirebound box will be appropriately marked to identify the item and show manufacturing data.

c. Tooling Plan This proposal is submitted on the basis of delivery of a defined quantity of units, approximately 300,000 rounds at a peak rate of 40,000 rounds per month and option quantity of approximately one million rounds at a peak rate of 100,000 rounds per month plus an additional 50 per cent option at an unspecified delivery rate. As the peak specified delivery rate is approximately ten times greater than that of current pilot production, it becomes important to describe, at least generally, the process by which it is planned to reach this production rate and increase, if necessary, for the option quantities.

Although not a stated requirement of this proposal, it is important to consider future delivery requirements for quantities at least an order of magnitude greater than those specified. It is necessary, then, to develop tooling suitable to, and capable of, being scaled into considerably larger quantities than those of immediate concern. This philosophy is reflected in the anticipated chronology of events depicted in the manufacturing milestone schedule, see Table 6.1.

To date, fabrication of the 25mm Caseless Ammunition has been limited to pilot plant operations directed toward the development of a fixed round design meeting prescribed functional requirements.

To meet the production requirements of RFQ F33657-71-R-0877, 2000 units per day for Items 0003AA, 0003AB, and 0003AC with options of 5000 units per day for Items 0010 and 0012, much more advanced tooling techniques and processes will be required. Where manpower has been employed to felt and dehydrate an outer shell, solvate and press the propellant charge, etc., automatic and semi-automatic equipment will be employed; inspections performed manually now will be automated. The design of these new tools will be oriented not only to accomplishment of Phase IV, but to provide the basic framework of the high volume production facility required for total system support in the decade ahead.

Basic processing data developed in Phase III will not in any instance be discarded, but will be refined and adapted to production methods compatible with the goal cited above. This tooling system approach will be designed to assure a quality production at the lowest possible cost consistent with safe operating conditions and conformance to minimum Air Force ammunition reliability standards.

Tooling development will be initiated immediately and will be pursued in two principal avenues. These approaches are as follows:

(1) Automatic Duplication of Existing Processing

(a) Based on process data and information already obtained in the pilot phase of production, conceptualize possible techniques and mechanism whereby these known processes can be reproduced automatically and consistently. A great deal of this has, of course, already been done in the generation of this proposal.

(b) Design and build experimental tooling to check the performance and feasibility of the concept.

(2) Revised Processing

(a) Keeping in mind the necessity for eventually being able to produce rounds at a high rate, identify those techniques from (1)(a) above which are incompatible with high volume processing, and consider possible process changes to increase the rounds producibility.

(b) Perform the adjusted process techniques on existing tooling concurrent with regular production and test the technique's effect on round performance.

Based on the outcome of these investigations, the actual design and fabrication of equipment will be initiated. As this equipment becomes operational, it will be integrated into the production facility.

The development of techniques of tooling and processing will be continued throughout the period of production for the firm quantity so that transition to greater production rates can be made smoothly and quickly if necessary.

The basic concepts for the major items of tooling that are planned at this time are described in the Manufacturing Process section of this proposal, see section (b) above.

The responsibility for coordinating and implementing the tooling plan will lie with the production control group. This group will prepare schedules and continuously monitor activities to assure that planned events are effected within their scheduled time. A more detailed description of the production control function as it relates to tooling is offered in Section 3.2 of this proposal.

d. High Risk/Long Lead Times All direct materials that go into the 25mm Caseless Ammunition are readily available and thus none are considered high risk or long lead items. The tooling, however, is a first generation item in many instances and will require careful consideration from the risk/time standpoint.

The tooling concepts, described in Section 2.1.c of this proposal, were established to minimize as much as possible this risk/time element. All items of tooling employ standard components that can be readily obtained on relatively short notice. Notwithstanding this fact, certain risks are involved in the transition from hand operations to automated tooling. As explained in the preceding section, pilot tooling must be used to prove out concepts prior to purchase of full scale tooling.

It is difficult to isolate potential risks at this time. It is expected, however, that through careful planning and review of tooling, the delivery schedule of the caseless ammunition will be met and very likely exceeded.

e. Manufacturing Plan of Complex Parts No component in the 25mm Caseless Ammunition is complex, except as it relates to the rate of production and the control of functional parameters. It can be seen from the process description, Section 2.1.b that long dwell, soak and cure times are involved in the manufacturing processes. Thus, the complexity relates to processing and how to speed it up while maintaining uniformity of the end product. An example of this is the molding of the forward and rear charges. During Phase III, the forward and rear charges were molded to the final configuration with the dimensional tolerances being held. This required special controls including water immersion to fix the dimensions immediately after molding but prior to drying. This same processing is described in Section 2.1.b.2 for Phase IV units. Investigation will be conducted, however, into the feasibility of molding the forward charge oversize and machining to final dimensions. This method of processing would eliminate certain controls that now must be closely monitored and would also eliminate manufacturing operations, thereby contributing to an increased production rate and lower costs.

The mixing of the felting slurry also offers several possibilities for process improvement. Consideration is being given to mixing as a continuous operation. To accomplish this, Brunswick plans to pre-mix the solids either with a helical ribbon mixer or rotating pan with offset blades. The helical ribbon is preferred as it lends itself to automatic feeding and either continuous or batch type discharge. By coupling the ribbon mixer to a continuous turbomixer via a constant weight feeder and introducing water, the retention aid (Lufax 295) and Hycar Resin, in the same manner, continuous makeup for the felting tanks can be achieved at a modest set-up cost and almost negligible operating costs. One hundred gallon capacity turbomixers are easily capable of mixing 10,000 gallons per hour. It may become necessary to eject the solution from the turbomixer into intermediate agitation tanks to provide time for the retention aid and resin to fulfill their function.

To fulfill Brunswick's objective of quality ammunition at a minimum cost, an intensive study of the paper making process will be conducted. In theory, the 25mm case could be fabricated from laminated nitrocellulose paper stock and would be similar to the common cardboard tube. While major modifications would be required for conventional paper making equipment, vast savings are possible.

Another area for significant savings, especially for high volume production, would be the procurement of basic acrylic filament, and fibrillating in-house, thereby eliminating several manufacturing operations and increasing control over the final end item.

6.2.2 Facilities The basic effort on the continued development and production of the 25mm Caseless Ammunition has been conducted at the Sugar Grove facility. Located in Southwest Virginia, the facility is situated on a 470 acre tract remote enough to assure safety of operations and adherence to applicable explosives quantity distance regulations yet easily accessible to major transportation facilities. Comprised of over 30 separate buildings, the plant has over 80,000 square feet of manufacturing area coupled with approximately 50,000 square feet of warehouses, offices, and R & D and Quality Control labs. A plat of the Sugar Grove facility is shown in Figure 6-18.

The production of the 25mm Caseless Ammunition, through Phase D, will be performed in three (3) separate building complexes.

Building complex number 1 will be used for all felting operations, i.e., outer shell, primer cup, and forward spacer, plus the necessary subsequent operations to complete each component. Secondary operations include trimming and dipping the outer shell, pressing and machining the primer cup, and pressing and punching the forward spacer. Building complex number 1 is located as shown in Figure 6-18.

All propellant components will be manufactured in building complex number 2. These operations include pressing of the forward and aft charge plus subsequent drying in one building and loading of the primer cup, loading of the supplemental

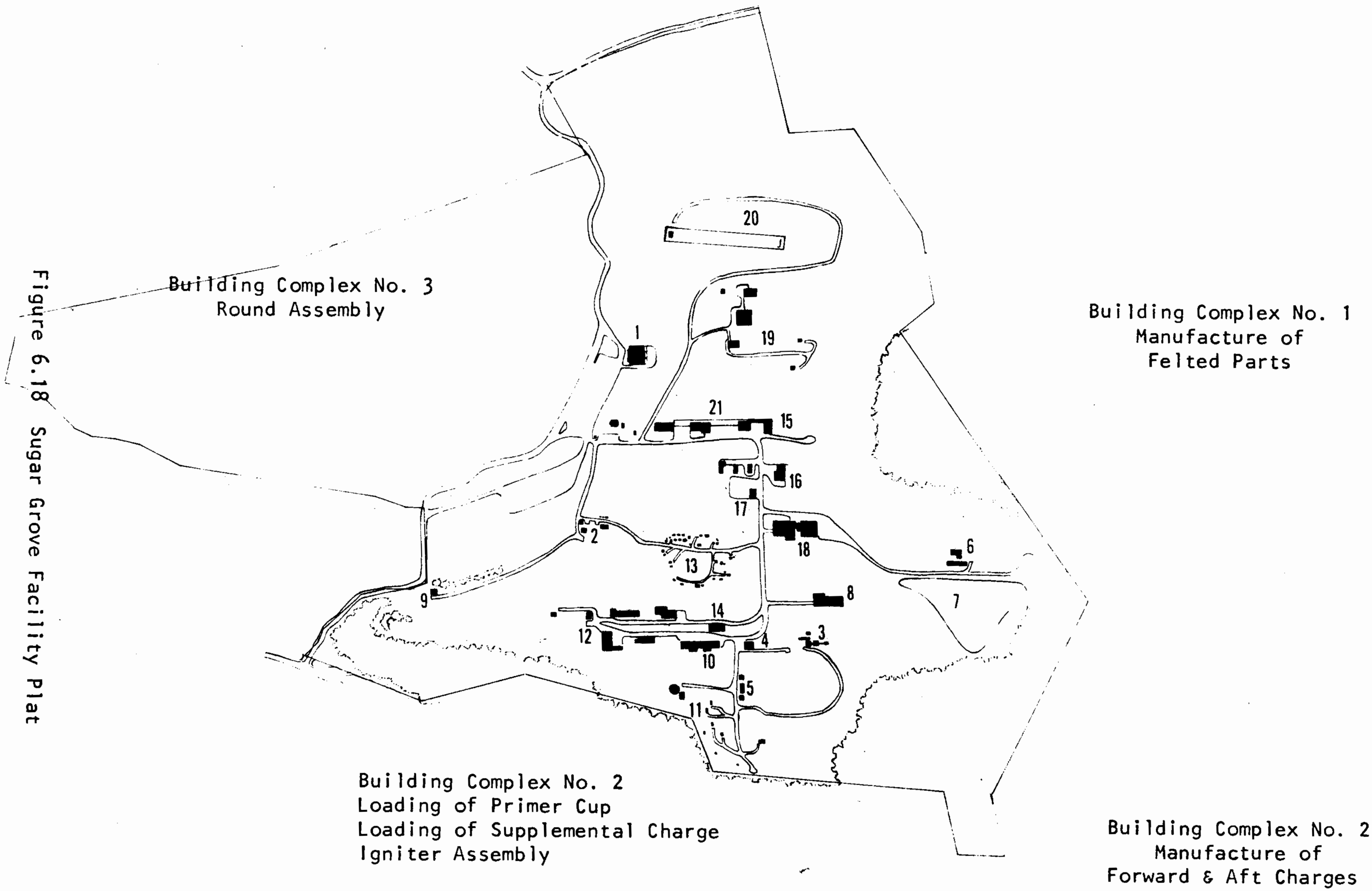

Figure 6.18 Sugar Grove Facility Plat

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charge, and assembly of the igniter in a separate building. Figure 6-18 shows the location of the buildings that will be used for these operations.

Building complex number 3 will be used for round assembly, including application of protective coating and packaging. Building complex number 3 is also identified in Figure 6-18.

Fabrication of the Nose Positioner and Retainer will be done in an area which is contiguous with production operations not necessarily related to the 25mm Caseless Ammunition.

Brunswick's facilities are adequate for production of 25mm Caseless Ammunition far in excess of quantities discussed in this proposal. Many other buildings are available for use. Preliminary planning is now being conducted to allow expansion of the 25mm production facility to meet much higher production rates than are required under Phase IV.

6.3 Manufacturing Program Plan

6.3.1 Production Plan

a. Manufacturing Organization During Phase IV of the 25mm program a transition will be made from the development phase to the production phase. Brunswick's organizational structure will change at this time and prime responsibilities will shift from the Technical Director to the Plant Manager. Organizational charts are attached for both organizational structures. Two charts, Figures 6-19 and 6-20 show the organizational structure during the development phase and Figure 6-21 shows the organizational structure during the production phase.

b. Master Schedule The following chart, Table 6-1, shows a chronological listing of events and anticipated time frames necessary to meet firm delivery requirements, to construct a facility for manufacture of option quantities, and to plan a facility for much higher production quantities. Required deliveries for

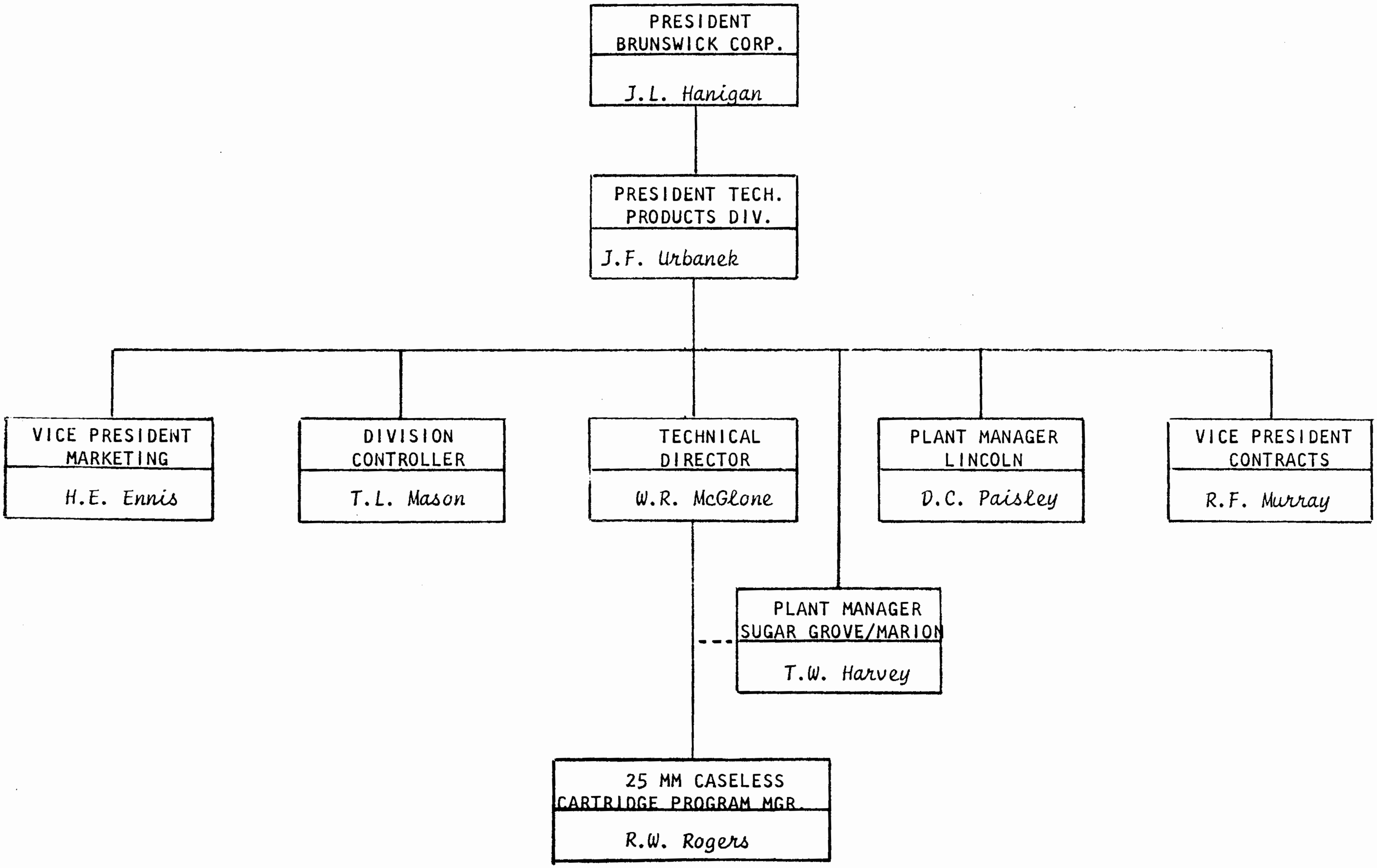

Figure 6-19

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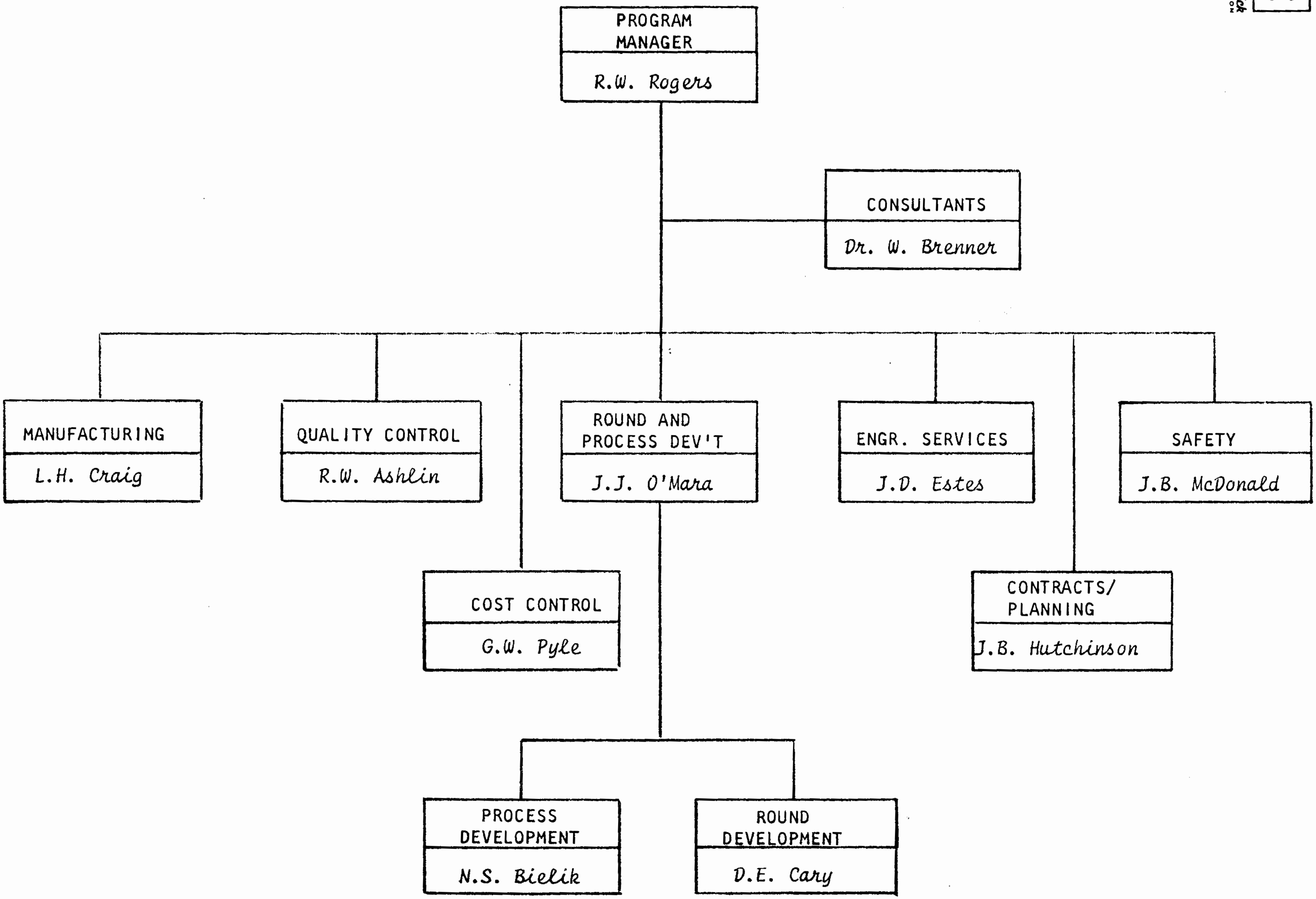
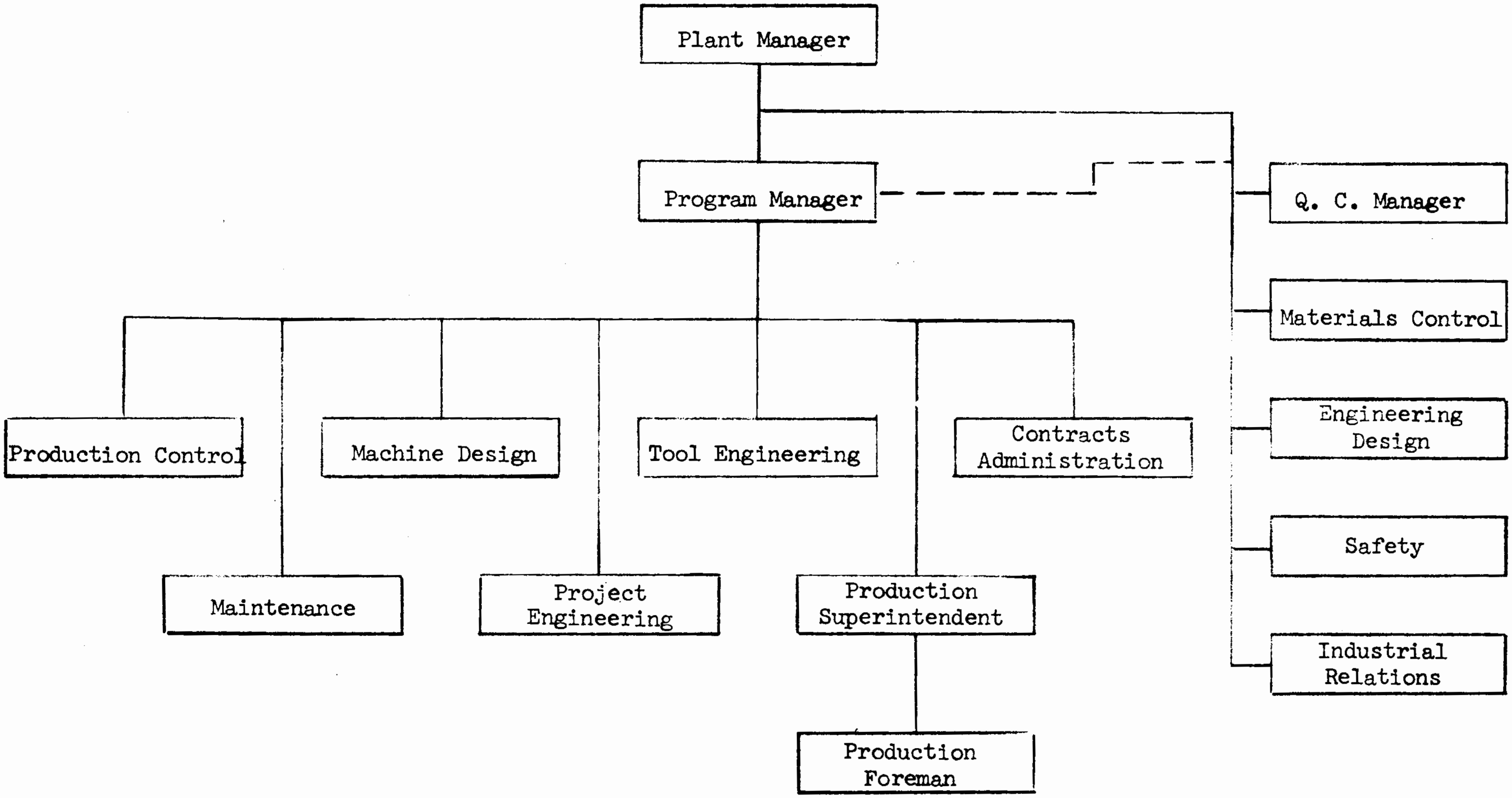

PROGRAM MANAGER
R.W. Rogers
CONSULTANTS
Dr. W. Brenner
MANUFACTURING
L.H. Craig
QUALITY CONTROL
R.W. Ashlin
ROUND AND PROCESS DEV'T
J.J. O'Mara
ENGR. SERVICES
J.D. Estes
SAFETY
J.B. McDonald
COST CONTROL
G.W. Pyle
CONTRACTS/ PLANNING
J.B. Hutchinson
PROCESS DEVELOPMENT
N.S. Bielik
ROUND DEVELOPMENT
D.E. Cary

Figure 6-20



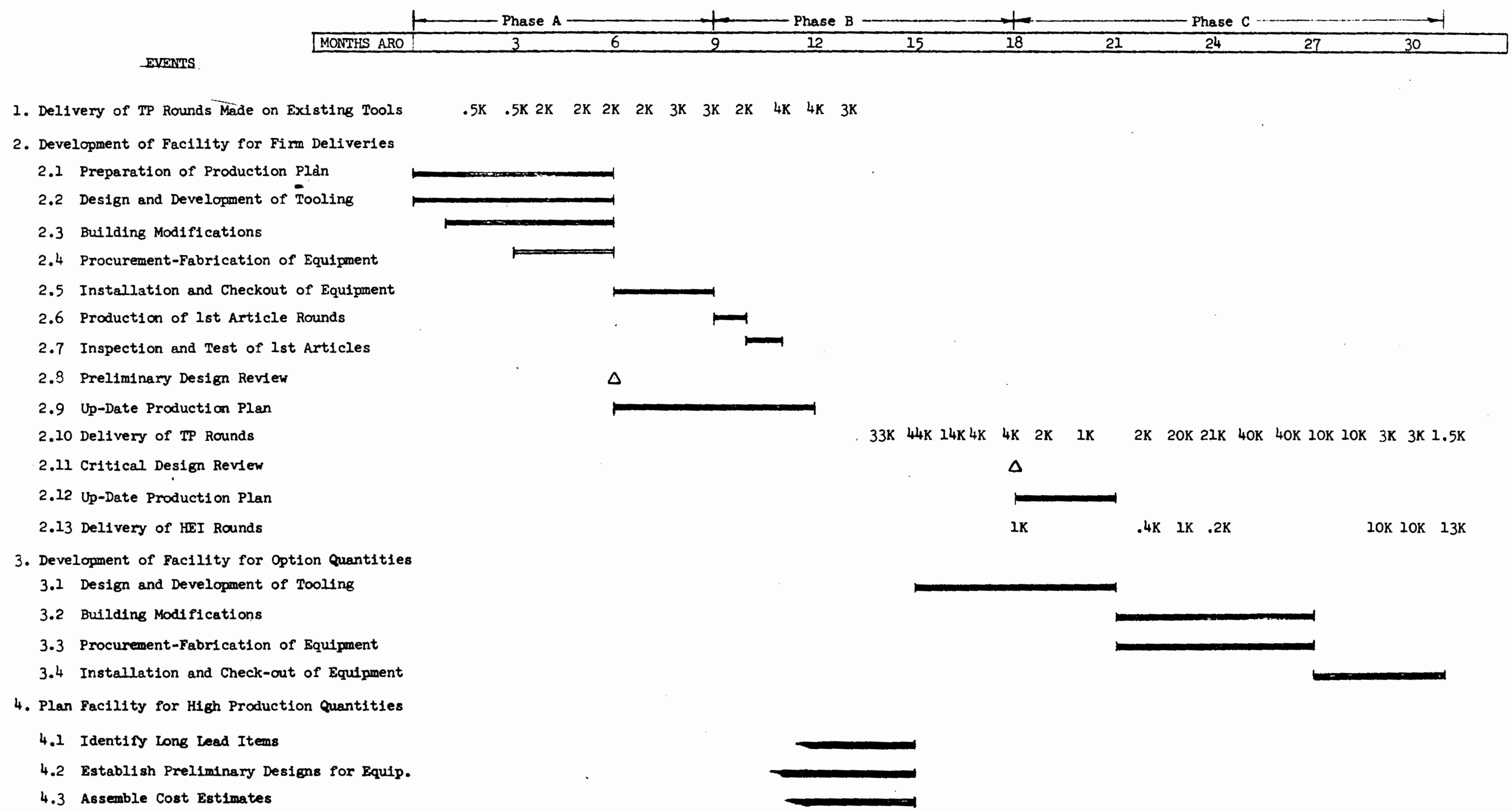
ORGANIZATIONAL CHART

PRODUCTION PHASE

FIGURE 6-21

TABLE 6-1

PRODUCTION MILESTONE CHART



option quantities are not shown.

6.3.2 Production Control Plan Production control will have direct responsibility for scheduling and controlling all production events. The production control scheduling activity begins with a master schedule which presents the broad manufacturing plan and the time of accomplishment. The master schedule will be broken down to include detailed schedules for specific categories of events. PERT and Critical Path schedules will be used as a vehicle for continuous review of the program progress. A Bill of Material and sequence of operations will be prepared and fed directly into the PERT and Critical Path charts. A direct result of the PERT and Critical Path reviews will be the establishment of long lead items and high risk items. Projections will be made and continuously updated to establish as nearly as possible firm delivery dates for long lead items. High risk items will be constantly reviewed in order to provide a basis for predicting the probability of success.

Production control directed toward the implementation of the manufacturing endeavor will involve process instructions with the necessary follow-up to assure proper execution of planned activities. Detailed processing sheets will be prepared to delineate the step-by-step tasks involved in effecting the total program, from the definition of production events to delivery of packaged rounds.

Constant reporting of materials used, tools used, production progress, time allowance, etc. will be fed back for evaluation of physical control and accountability of pieces.

A major effort will be directed toward the elimination of prevention of delays and bottlenecks. All production control data will be reviewed by management upon whom the burden of major decisions will rest.

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6.3.3 Management Techniques

a. Cost Controls Brunswick's cost accounting system is controlled and administered by the Accounting Department. It is designed to provide the necessary cost data to comply with sound accounting principles and has been proven acceptable and effective in the performance of both military and commercial contracts. The system is designed to provide cost data for each contract item and normally consists of:

(1) Materials Costs

(2) Direct Labor Costs

(3) Indirect Labor Costs

(4) Overhead Costs

(5) Other Direct Costs

Financial reports are provided monthly (or more frequently if required) to the Program Manager covering all expenditures against the program.

b. Material Cost Collection System Brunswick's Sugar Grove plant uses a job cost method of collecting and reporting cost against a program.

Upon receipt of a contract, a job number (3 digits) is assigned. A Work Order is written against the job number and assigned a number (5 digits) which reflects the job number, first three digits, and a two digit Work Order Number. The Work Order Numbers are assigned numerically, beginning with 00 and ending with 99. Thus, one hundred Work Orders are available for each job. Should more than one hundred Work Orders be needed for a job, an alternate job number is assigned thereby making another hundred Work Orders available. The alternate job number is coded so that all charges against it are booked against the original job.

Issuance of Work Orders is the responsibility of the Program Manager. Work Orders may be written to collect broad costs or to collect cost on a special item.

Example: A Work Order may be written for Quality Control Technician costs or several Work Orders could be written for the same cost collection only on a more refined basis, such as, inspection of incoming material, tool inspection, inspection of various phases of fabrication, assembly inspection, final inspection, technical reports, etc..

This system enables the Program Manager to collect costs on any phase of production or engineering as he may deem desirable.

Tooling costs are collected against Tool Work Orders. This is a six digit number with the job number being the first three digits. The last three digits are coded as follows: 100 through 499 - fabrication; 500 thru 699 - rework; 700 through 799 - redesign; 800 through 999 - design. Work Orders are assigned in sequence according to the type of Work Order. If required, the Tool Work Order can be identified by Government drawing, tool number, etc..

Time and material are reported against the proper Work Order. Labor charges are collected weekly on hourly and salary personnel, and journalized monthly. Each employee is required to fill out a time ticket and have it approved by his immediate supervisor. Weekly labor distribution reports are prepared and audited for correct charge numbers.

Requisitions for withdrawal of material from the stock room are prepared as the material is needed in production. The original copy of the requisition is forwarded to the Accounting Department where it is checked and priced. Weekly reports on material distribution are prepared and journalized.

Material charges from the voucher register are journalized weekly. These include charges for material, tooling, travel, etc.. Material of a direct production nature is charged to raw material stockrooms.

c. Unique Control System The system is flexible to the point of being able to provide for special or unusual type of required controls. For example, the 25mm program needed costs collected by phase and activity. So a special system was devised to allow for this unique control. The system provided a seven digit Work Order number. The first three digits represented a special job number completely foreign to any existing job number which might be active. The third digit represented the phase; the fourth and fifth digits represented the tasks within the phase; sixth and seventh digits were for sub-tasks within the task. Thus, the system allowed for nine phases, 99 tasks within each phase, and 99 sub-tasks within each task.

d. Procurement Controls The initial consideration in the procurement of materials is the segregation of items that should be fabricated or manufactured in-house and those that should be procured from vendors. Careful consideration will be given to delivery, cost, and complexity of part in arriving at a decision to make or buy.

All purchased items will be procured from vendors that are either on Brunswick's approved vendor list or demonstrate adequate facilities and capabilities in a vendor survey. The initial step in the purchase of material is the issue of a traveling requisition. This requisition defines all pertinent information such as applicable drawings, quantity required, special finishes, delivery schedule, etc.. Purchasing uses this information in issuing requests for quotation. The RFQs will serve to locate potential vendors and to allow a broad base in the selection and evaluation of suppliers. After a vendor is selected, a Purchase Order will be issued, outlining all essential terms of the agreement. Definite schedules for delivery will be outlined with penalties for late delivery clearly defined.

Materials or components that are manufactured in-house will be treated in the same general manner as purchased, i.e., firm deliveries, high quality, and low costs will be insisted upon.

e. <u>Manufacturing Process Package</u> The manufacturing process will be closely supervised to be sure that all information is promptly conveyed to the proper people. A process instruction sheet is prepared for each operation involved in the manufacturing process. The process instruction describes, in simple and concise terms, the step-by-step procedure for each operation and lists any special precautions or restrictions that are unique to the operation. The production foreman is required to review the process with the production operators and verify that all aspects of the process are fully understood. In the event that the process is changed, the review must be repeated.

The responsibility for validating that all manufacturing operations are being properly performed, lies with the Quality Control Department. In-process inspectors constantly monitor the production process to assure that the process instruction sheets are current and are being properly followed.

Further responsibility of the Quality Control Department is the dimensional and workmanship checks made both during and after fabrication of the round. Inspection instruction sheets are prepared to provide instructions to the process inspectors. These instruction sheets define the inspection stations, sampling plans for selecting units for inspection, recommended inspection techniques, and acceptance criteria.

f. <u>Inventory Control</u>

(1) <u>Materials Receiving</u> The receiving group has the responsibility for making an accurate count and correct identification of all materials received in the plant. All materials received will be recorded on a receiving report with reference

to Purchase Order number, vendor, quantity, condition of material, etc.. Copies of the receiving report are sent to the Purchasing Department and the Accounting Department with a copy retained in receiving.

(2) Storage After receipt of the material and proper reporting to verify conformance with Purchase Order requirements, the material will be stored in an area where the necessary environmental protection is provided. The parts storage will be organized to offer maximum access with particular emphasis given to high usage parts.

(3) Dissemination Materials will be issued from stores when requested in the form of a written requisition. The requisition will identify the materials and specify quantity. Permanent records will be maintained to show usage rates for all materials in storage.

(4) Inventory All materials that are requisitioned from stores will be deducted from inventory on a daily basis. Likewise, all materials received will be added to inventory on a daily basis. By continuously updating the inventory records, production planning can be enacted with the most current information. Physical counts will be performed on a monthly basis for the verification of inventory records.

6.4 Manufacturing Qualifications

6.4.1 Related Experience Brunswick Corporation, through its Technical Products Division, has supplied military components and systems to the Government for over 20 years. Brunswick offers established capabilities in design and manufacture of ordnance products utilizing metals, reinforced plastics, metal honeycomb bondings, fibers, pyrotechnics, and explosives.

Past and present contract related to the mass production of the 25mm Caseless Ammunition program includes:

(1) E8 Cartridge Launcher - Production rate of over

10,000 submunitions per shift established along with the processing of thousands of pounds of Class 7 explosives safely each day.

(2) E158 and XM15 Cluster - Production rate of over. 10,000 submunitions per shift established along with the processing of thousands of pounds of Class 7 explosives safely each day.

(3) M18 Colored Smoke Grenade - Production rate of 10,000 units per shift established along with the processing of thousands of pounds of Class 7 explosives each day.

(4) M201A1 Delay Fuze - Production rate of over 20,000 per shift with Class 2 and Class 7 material.

(5) M213 HE Delay Fuze - Production rate of over 30,000 per shift with Class 7 explosives.

(6) XM9 4.2" CS Canister - Production rate of over 10,000 per shift.

(7) XM200 Launcher Rocket Aircraft - Established metal working capabilities for stringent 2.75 inch rocket system.

(8) LAU 68A/A - Established metal working capabilities for stringent 2.75 inch rocket system.

(9) M127 Flare - Production rate of 5,000 per shift processing highly sensitive flare composition.

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(10) M117, M118, and M119 Simulators - Production rate of 10,000 units per shift processing sensitive Class 7 explosives.

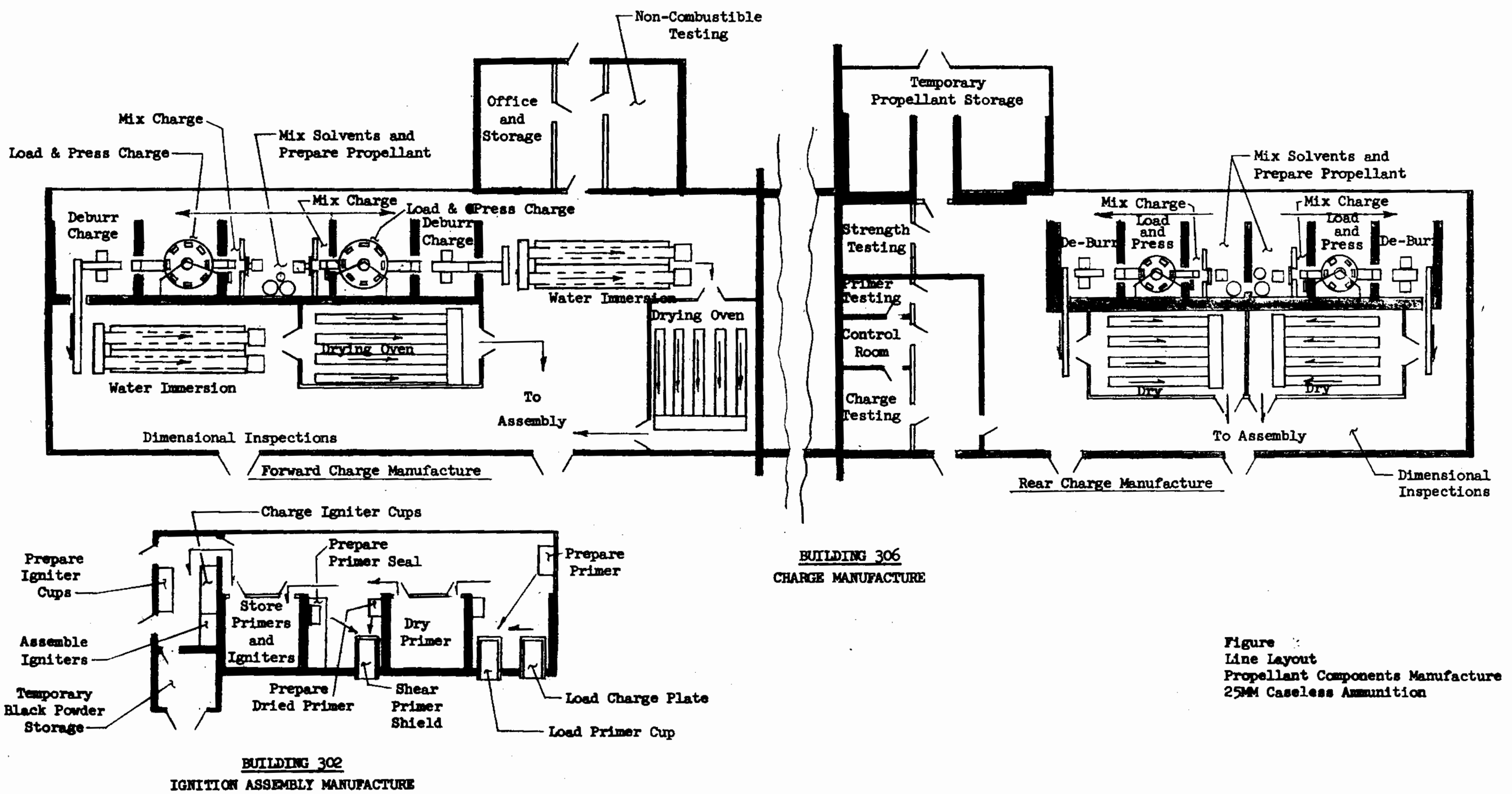
(11) XM191 Multi-Shot Flame Weapon - Production of rocket propelled, pyrophoric ammunition and launching system.

6.4.2 Manufacturing Facility The layouts of the production facility must be carried out with the same goals in mind as will be used to develop the individual items of production equipment.

Detailed layouts of the proposed production facility are presented herein as examples of the type of facility that will be utilized for production of the option quantities. These layouts shown in Figures 6-22, 6-23, and 6-24 are based on the daily production requirement necessary to meet the option quantities. Existing structures are utilized and their relative locations can be seen on the Facility Site Plan.

For the production of the firm quantities, a required production rate of about 2000 units per day is anticipated. This facility will be located in the same structures as for the larger quantites and will permit the gradual phase-in of equipment, concurrent with production on existing tooling. It is anticipated the same principles of operation with accentuated process controls will be utilized for all quantities. It should also be stated that the preliminary design effort has been initiated on a caseless ammunition facility fully capable of producing units far in excess of stated option quantities.

6.4.3 Personnel The experience and capabilities of the key personnel that will be involved in the production of the 25mm Caseless Ammunition are shown in the attached resumes.



BUILDING COMPLEX NO. 2

FIGURE 6-22

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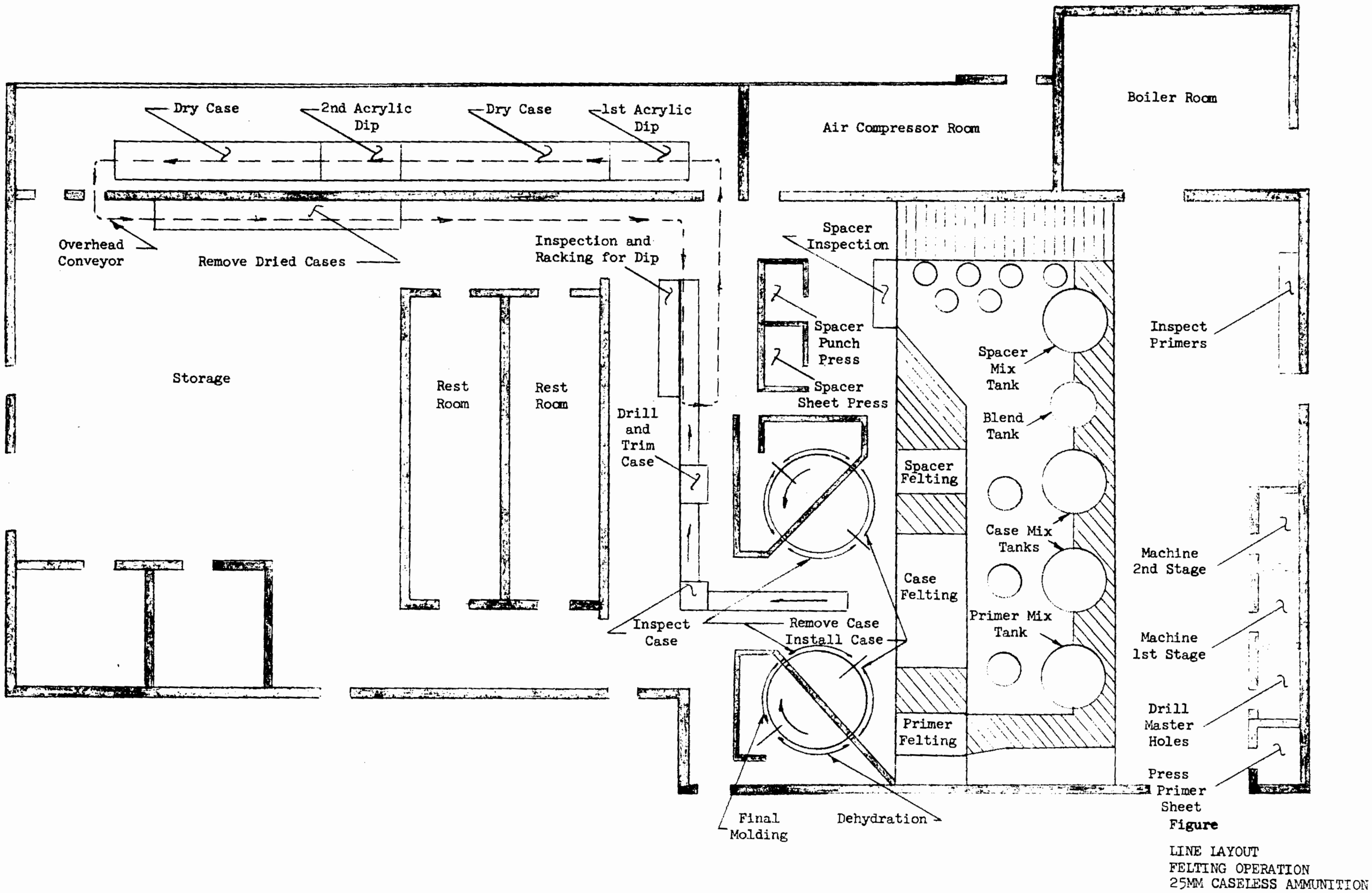

FIGURE 6-23

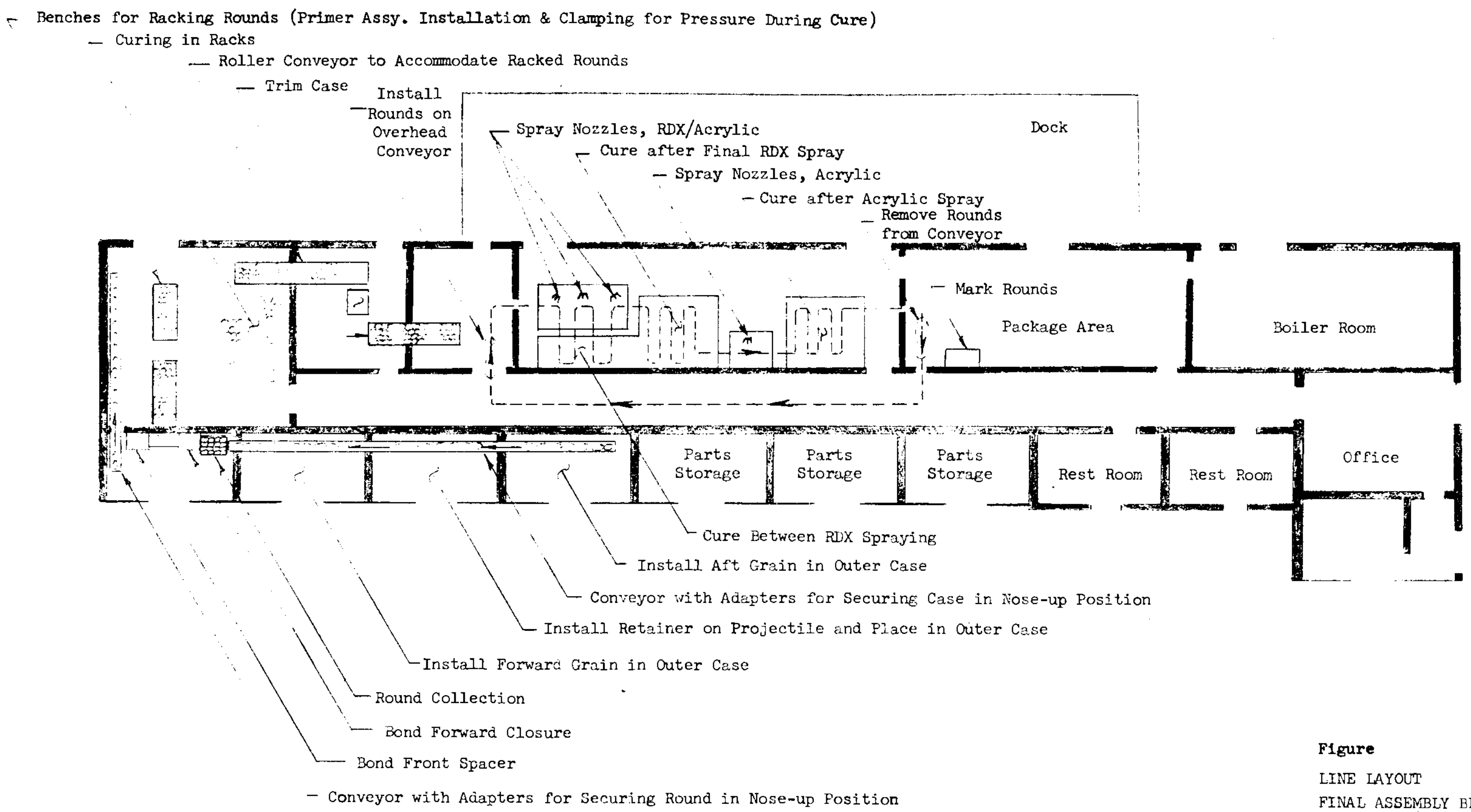

Figure
LINE LAYOUT
FINAL ASSEMBLY BLDG.
25MM CASELESS AMMUNITION

FIGURE 6-24

7. ORGANIZATION

PROGRAM ORGANIZATION

All Brunswick activities on the 25MM Caseless Cartridge Program will be organized on a project team basis. Personnel will be drawn from various departments such as Engineering, Quality Control, and Production and assigned to the program team under the direction of a Program Manager. The program will be under the direction of Mr. R. W. Rogers. Other key personnel, many of whom worked in Phase III, are Messrs. D. Cary (Research and Development); J. O'Mara (Process Development); R. Ashlin (Quality Control); L. Craig (Production); J. Hutchinson (Contracts Administration); J. McDonald (Safety); and J. Estes (Configuration Control and Documentation).

Other laboratories having specialized skills will be solicited for technical assistance in conjunction with certain specific problem areas as follows:

IITRI	Cook-off studies, case materials improvement
Franklin Institute	Coatings
Cornell Aeronautical Labs	Coatings
New York University	Coatings
Dow Corning Corporation	Coatings
Canadian Industries, Ltd.	Vented chamber development, closed bomb procedure, ignition study, grain characterization tests.

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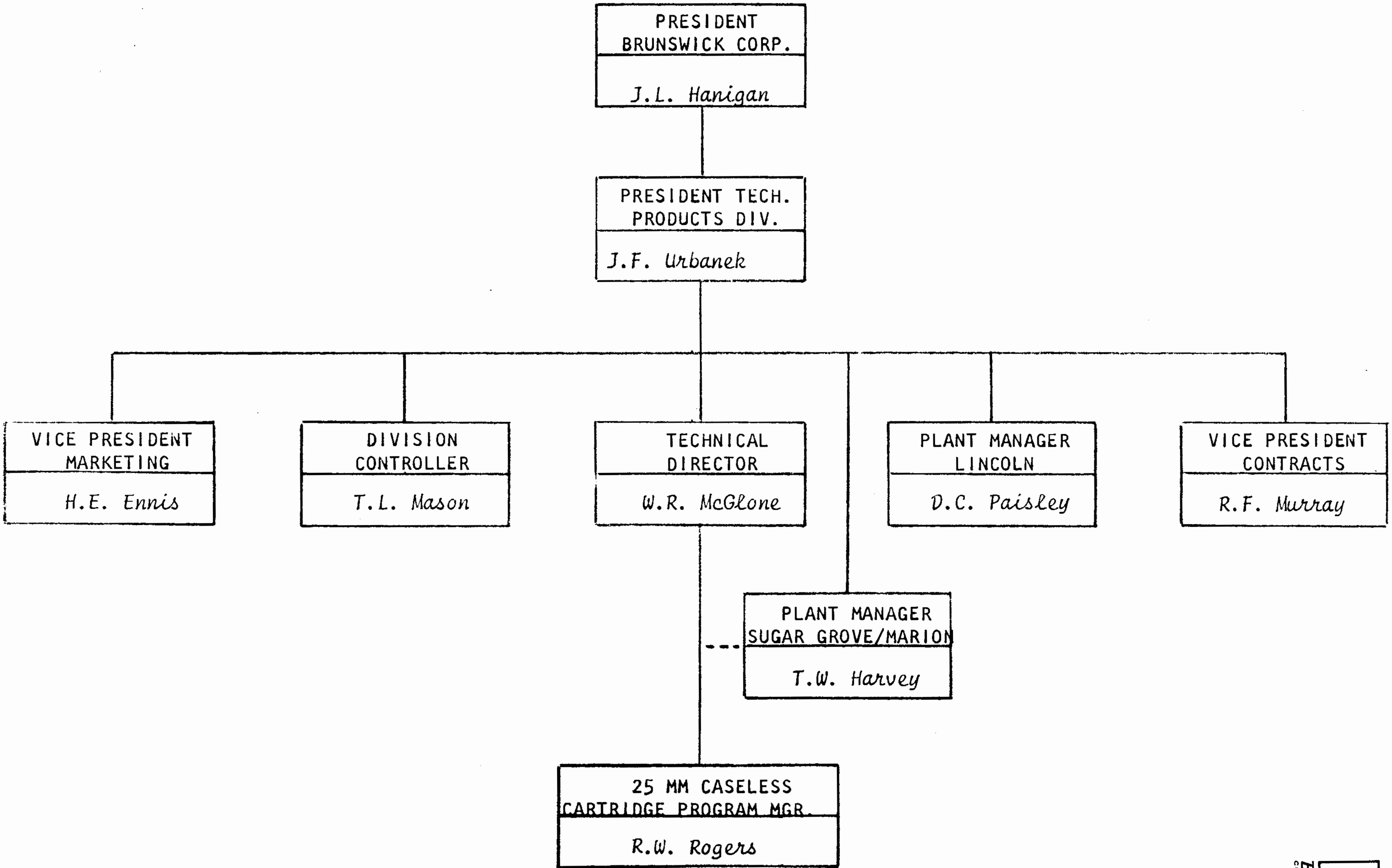
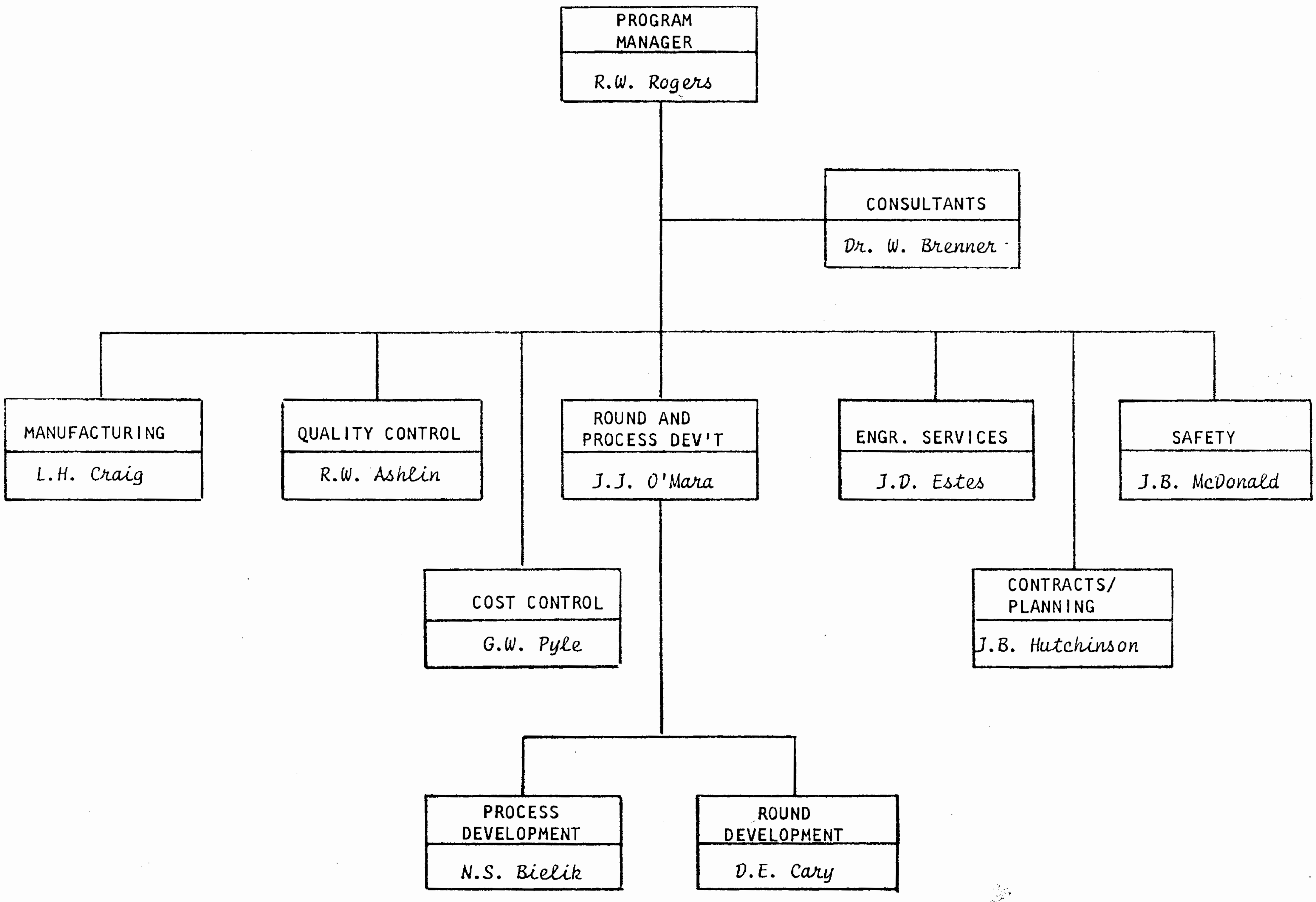
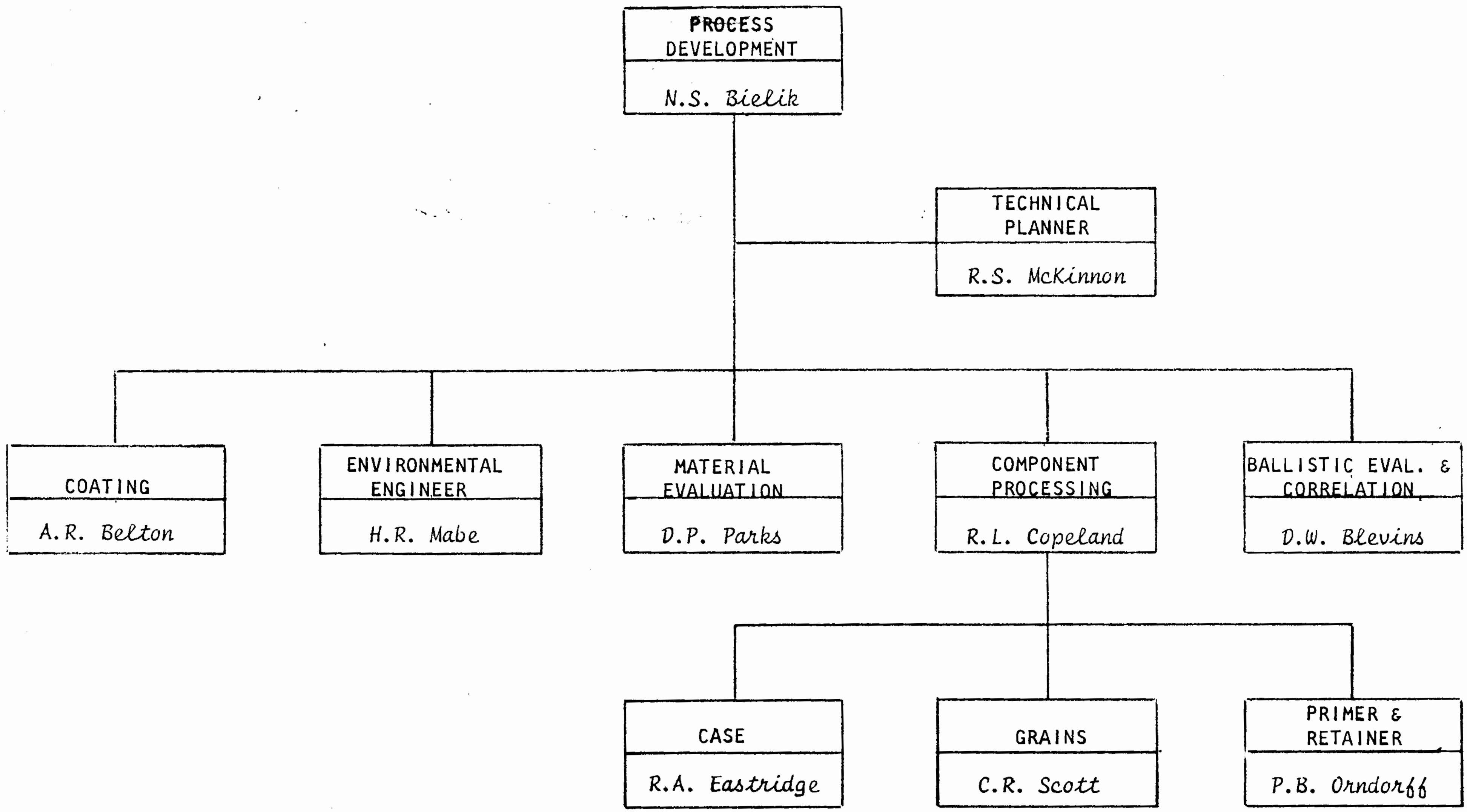
Technical supervision of these proposed subcontracts will be by the appropriate technical specialists within the development team. Personnel operating under the direction of the program team are shown in the charts; numerous other support functions such as purchasing, maintenance, and personnel relations will be obtained from the normal plant operations. Brunswick personnel are shown on the organizational charts to demonstrate ability of the company to fill these posts with qualified personnel. However, depending on contract timing, some of these positions may be filled with others from the corporation or from industry.


PRESIDENT BRUNSWICK CORP.
J.L. Hanigan
PRESIDENT TECH. PRODUCTS DIV.
J.F. Urbanek
VICE PRESIDENT MARKETING
H.E. Ennis
DIVISION CONTROLLER
T.L. Mason
TECHNICAL DIRECTOR
W.R. McGlone
PLANT MANAGER LINCOLN
D.C. Paisley
VICE PRESIDENT CONTRACTS
R.F. Murray
PLANT MANAGER SUGAR GROVE/MARION
T.W. Harvey
25 MM CASELESS CARTRIDGE PROGRAM MGR.
R.W. Rogers


PROGRAM MANAGER
R.W. Rogers
CONSULTANTS
Dr. W. Brenner
MANUFACTURING
L.H. Craig
QUALITY CONTROL
R.W. Ashlin
COST CONTROL
G.W. Pyle
ROUND AND PROCESS DEV'T
J.J. O'Mara
PROCESS DEVELOPMENT
N.S. Bielik
ROUND DEVELOPMENT
D.E. Cary
ENGR. SERVICES
J.D. Estes
CONTRACTS/ PLANNING
J.B. Hutchinson
SAFETY
J.B. McDonald



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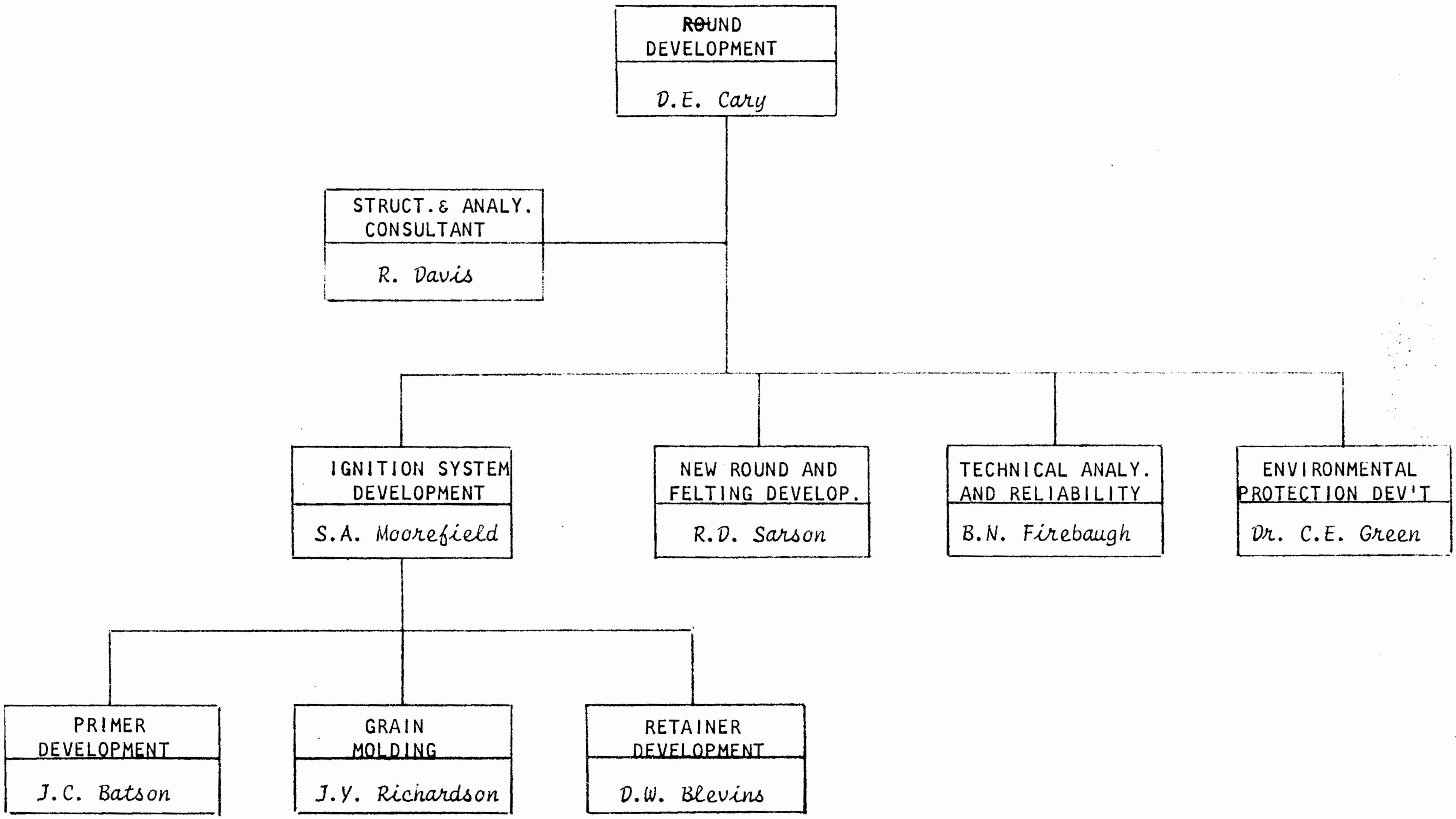
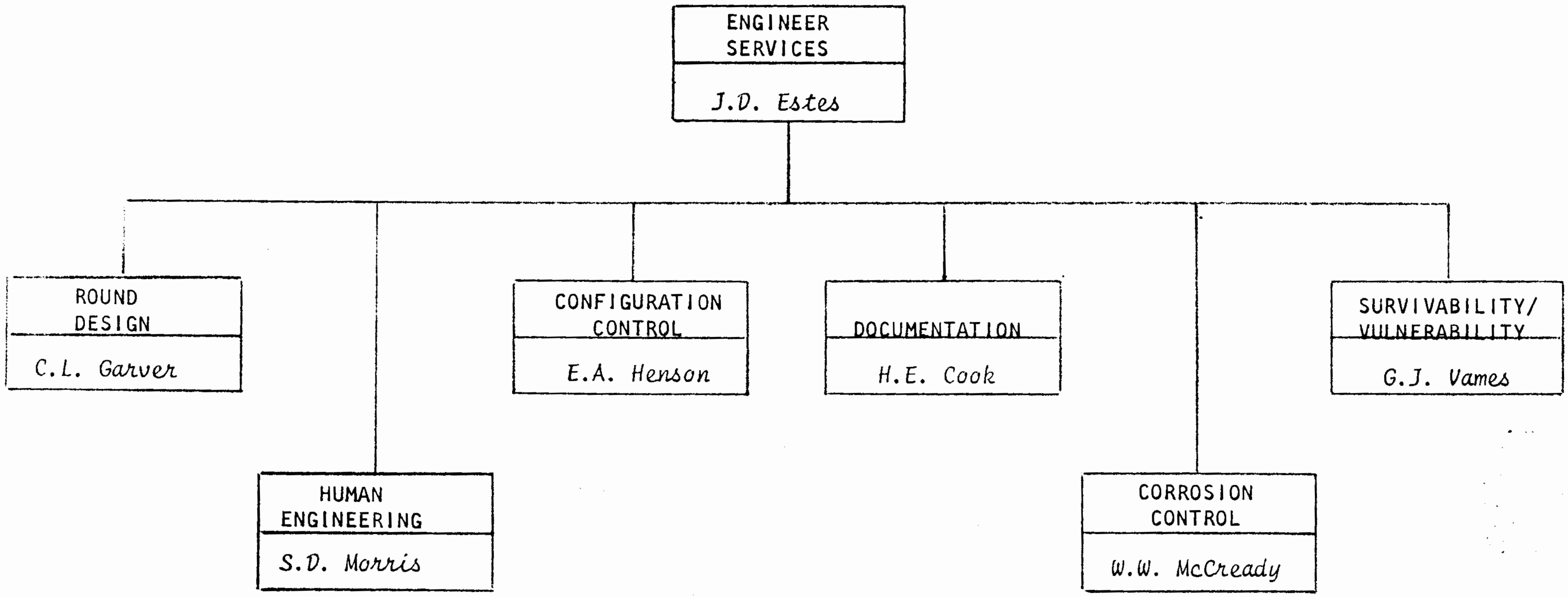
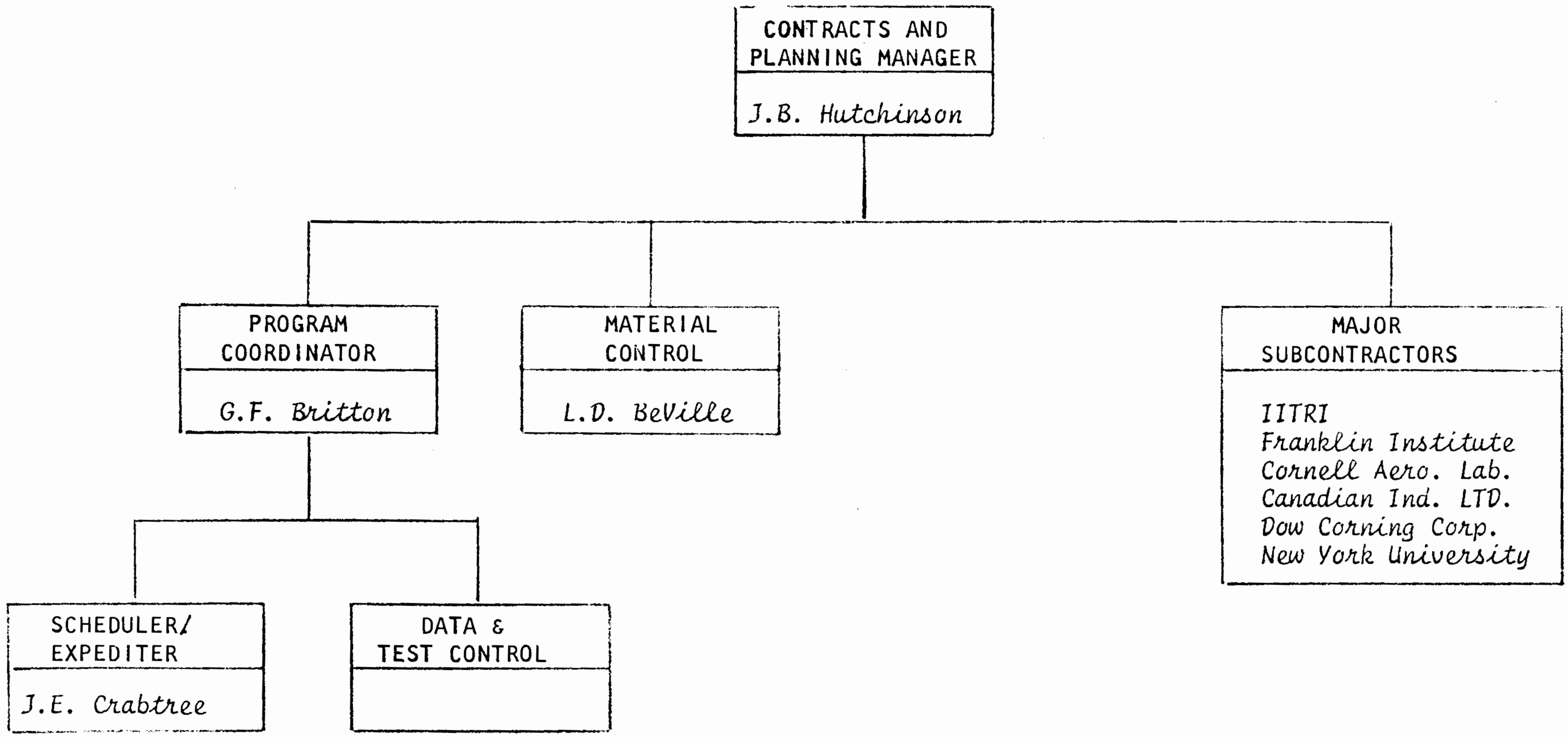
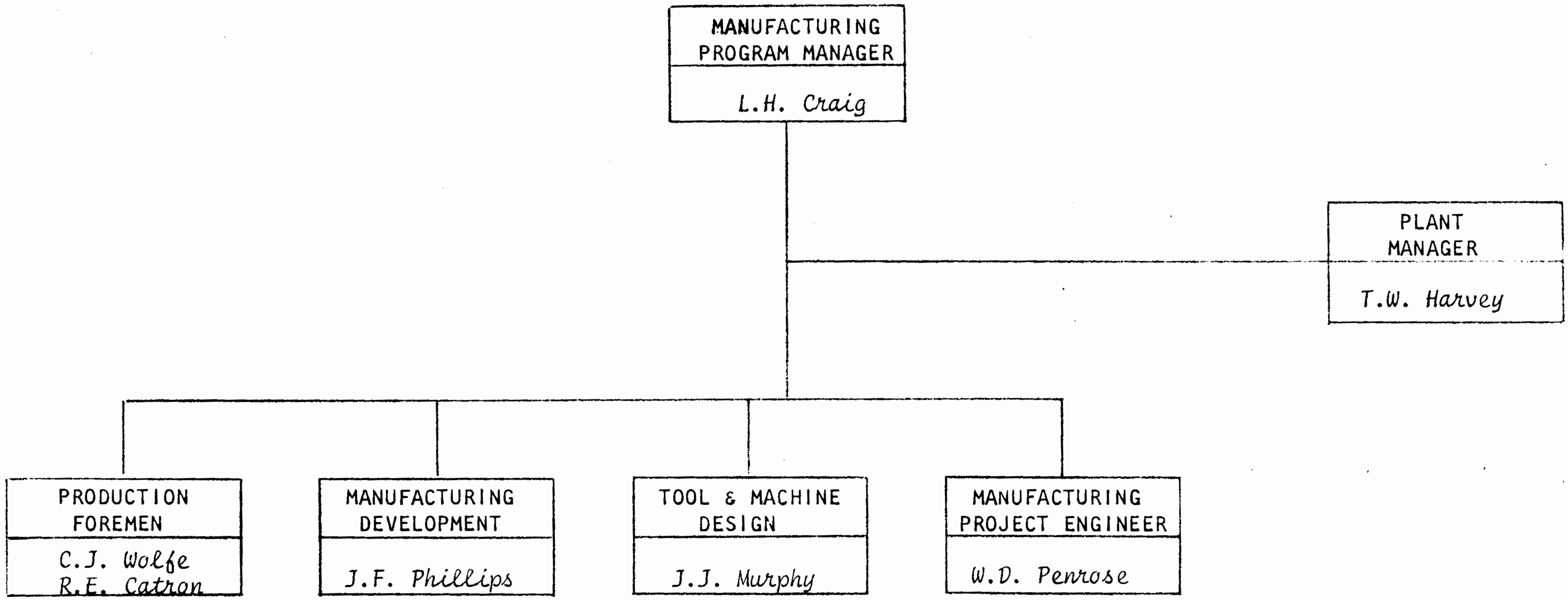

ROUND DEVELOPMENT
D.E. Cary
STRUCT.& ANALY. CONSULTANT
R. Davis
IGNITION SYSTEM DEVELOPMENT
S.A. Moorefield
NEW ROUND AND FELTING DEVELOP.
R.D. Sarson
TECHNICAL ANALY. AND RELIABILITY
B.N. Firebaugh
ENVIRONMENTAL PROTECTION DEV'T
Dr. C.E. Green
PRIMER DEVELOPMENT
J.C. Batson
GRAIN MOLDING
J.Y. Richardson
RETAINER DEVELOPMENT
D.W. Blevins


ENGINEER SERVICES
J.D. Estes
ROUND DESIGN
C.L. Garver
HUMAN ENGINEERING
S.D. Morris
CONFIGURATION CONTROL
E.A. Henson
DOCUMENTATION
H.E. Cook
CORROSION CONTROL
W.W. McCready
SURVIVABILITY/ VULNERABILITY
G.J. Vames


CONTRACTS AND PLANNING MANAGER
J.B. Hutchinson
PROGRAM COORDINATOR
G.F. Britton
MATERIAL CONTROL
L.D. BeVille
MAJOR SUBCONTRACTORS
IITRI
Franklin Institute
Cornell Aero. Lab.
Canadian Ind. LTD.
Dow Corning Corp.
New York University
SCHEDULER/ EXPEDITER
J.E. Crabtree
DATA & TEST CONTROL



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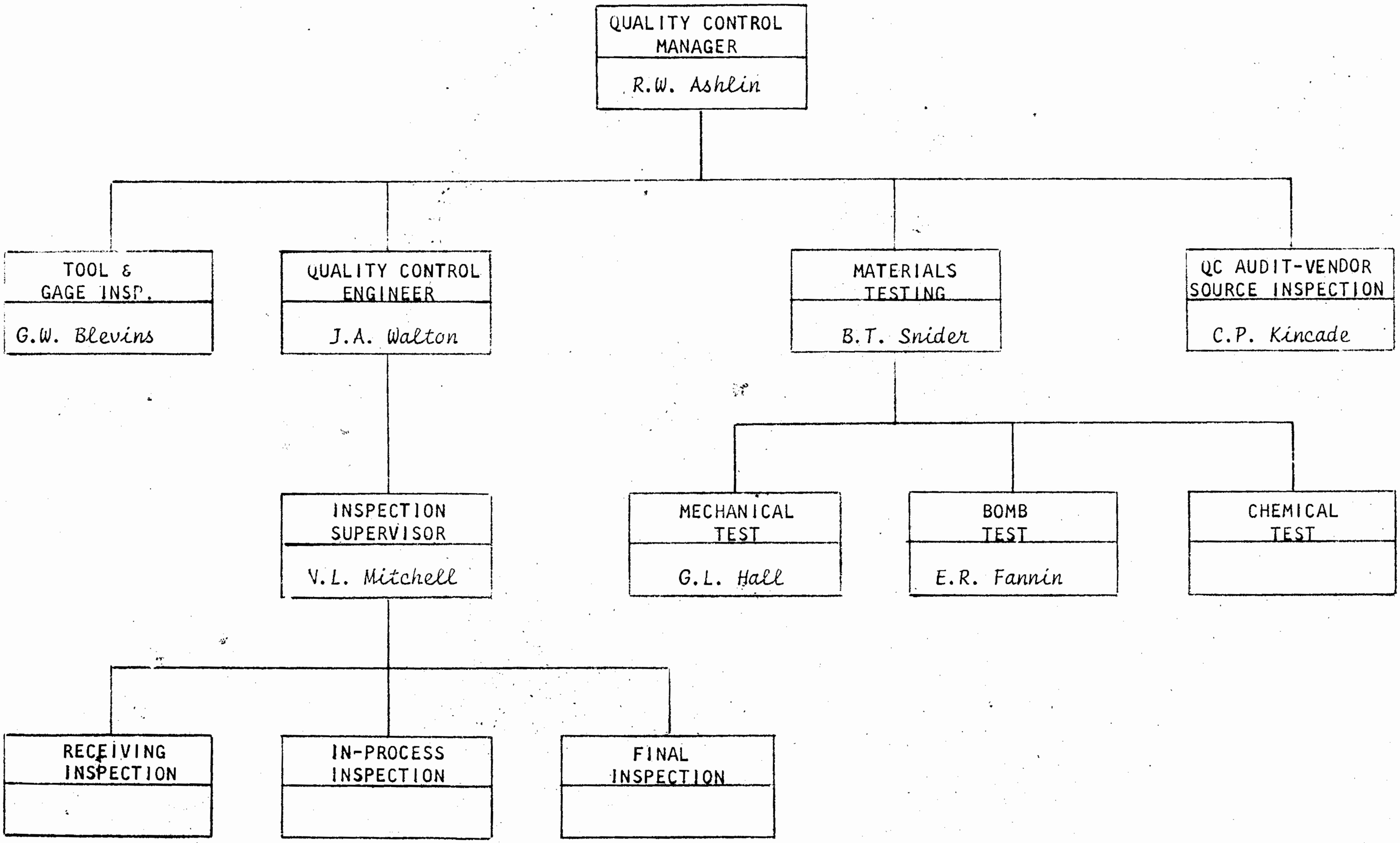
QUALITY CONTROL MANAGER
R.W. Ashlin
TOOL & GAGE INSP.
G.W. Blevins
QUALITY CONTROL ENGINEER
J.A. Walton
MATERIALS TESTING
B.T. Snider
QC AUDIT-VENDOR SOURCE INSPECTION
C.P. Kincade
INSPECTION SUPERVISOR
V.L. Mitchell
MECHANICAL TEST
G.L. Hall
BOMB TEST
E.R. Fannin
CHEMICAL TEST
RECEIVING INSPECTION
IN-PROCESS INSPECTION
FINAL INSPECTION