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FEASIBILITY STUDY OF 5.56 MM FOLDED AMMUNITION/WEAPON SYSTEM

by

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Ammunition length reduction	

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

Folded Ammunition is a unique concept in ammunition design that relocates the propellant charge from the conventional position behind and coaxial with the projectile to one beside the projectile. For a given energy output, conventional axially symmetric ammunition cartridges do not provide the most efficient geometrical shape for a minimum system parametric profile (system length, weight and bulk). Reconfiguration

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Design Analysis	James R. Harris
Fabrication Processing	John F. Kloskey Samuel J. Marziano Albert Zalcmann
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20. ABSTRACT - Cont'd

of the cartridge using the Folded Ammunition approach makes possible now what had previously been unattainable in the way of weapon/ammunition system optimization. This report describes the concept, outlines its advantages and presents the results of a short-term analytical and experimental program that successfully demonstrated the feasibility of Folded Ammunition.

TABLE OF CONTENTS

List of Tables

List of Illustrations

List of Illustrations - Cont'd

INTRODUCTION

Folded Ammunition is a unique concept in ammunition design that relocates the propellant charge from the convention position behind and coaxial with the projectile to one beside the projectile (Figure 1). US Patent 3857339, shown in Appendix A, documents this concept. For a given energy output, conventional axially symmetric ammunition cartridges do not provide the most efficient geometrical shape for a minimum system parametric profile (system length, weight and bulk). Reconfiguration of the cartridge using the Folded Ammunition approach makes possible now what had previously been unattainable in the way of weapon/ammunition system optimization.

Figure 2 depicts the Weapon/Ammunition systems relationships in diagramed cross-sectional view. The basis for weight saving in the Folded Cartridge can be seen as the result of complete support afforded by the weapon which permits use of a uniformly thin-walled cartridge case. In addition to the significant savings in cartridge weight, the shortened cartridge length results in another important system improvement, i.e., shortened minimum bolt stroke of the weapon. At least two weapon benefits arise from this attribute. These are: (1) a greater range in cyclic rate capability including increased cyclic rate if desired, and (2) reduced bolt velocity for a given cyclic rate. This latter feature would be a direct contributing factor to increased weapons parts life.

Perhaps the most far-reaching attribute of the Folded Ammunition concept is the significant reduction in "packing volume" occupied by the cartridge in comparison to conventional axisymmetrically shaped ammunition. Figure 3 reveals the geometrical basis for this statement of fact. The packing volume occupied by the cartridge is defined as the minimum dimension rectangular solid encasing the cartridge. The shaded area around the cartridge represents dead space which detracts from packing efficiency. In this illustration, a conventional 5.56 mm FABRL cartridge is shown in side and end views with appropriate dimensions. The packing volume of this cartridge is:

$$V_p = l \times d^2 = 0.323 \text{ in}^3$$

where:

V_p = packing volume in inches^3

l = cartridge length in inches

d = cartridge case base diameter in inches

In contrast, the three views of a 5.56 mm Folded Cartridge represent the cartridge size in the folded configuration required to house the same propellant charge and fire the same projectile at the same velocity as

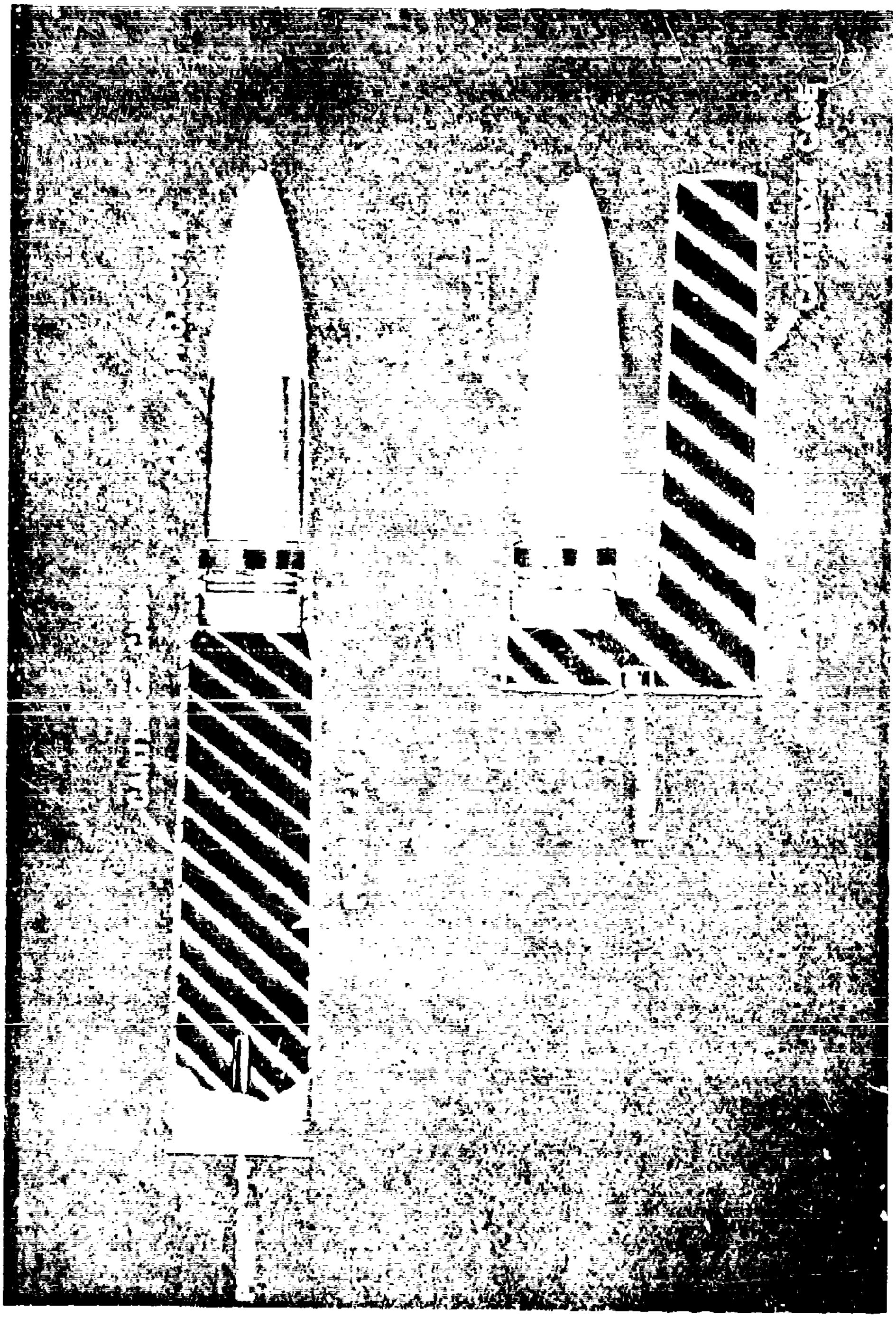


Figure 1. Ammunition Concept

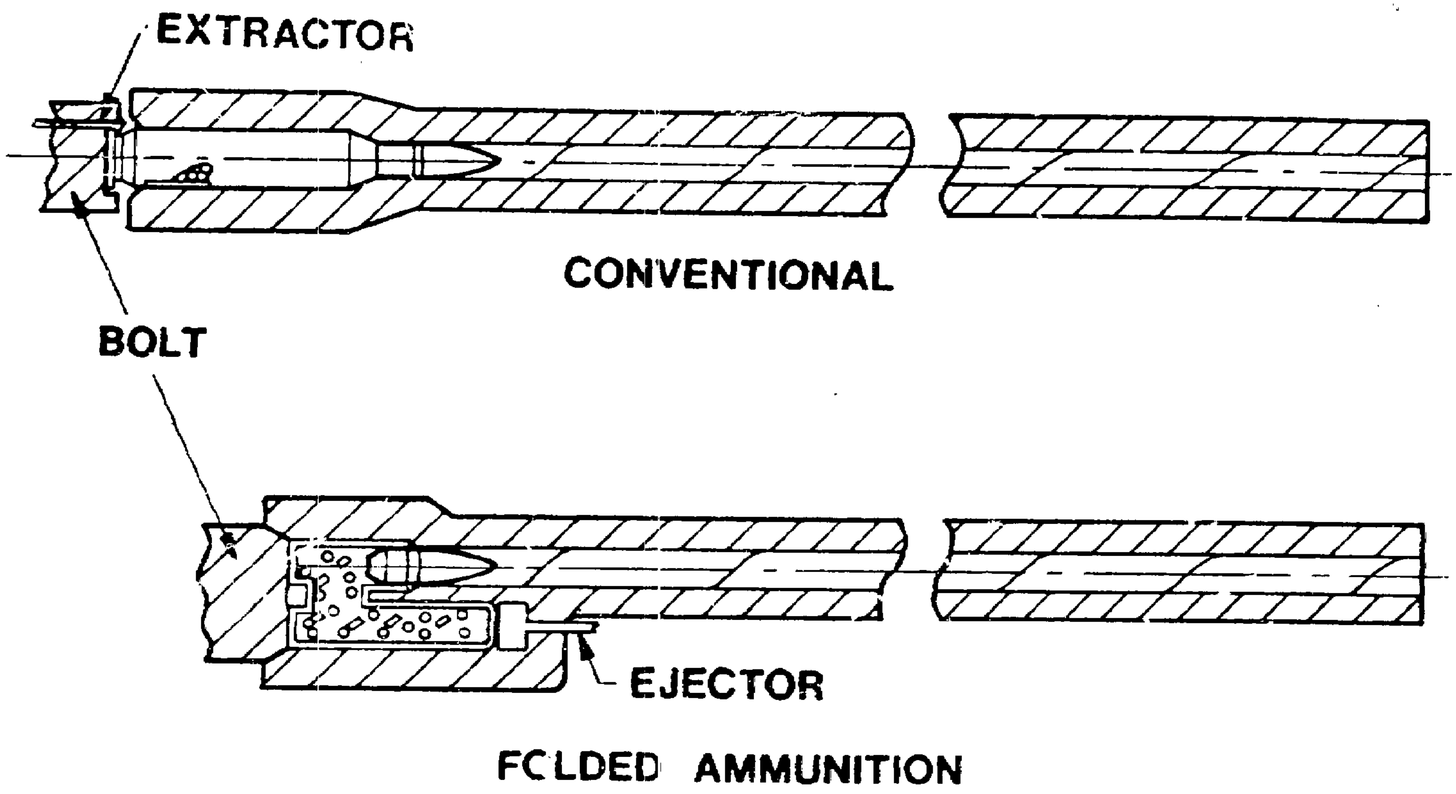


Figure 2. Ammunition/Weapon System Comparison

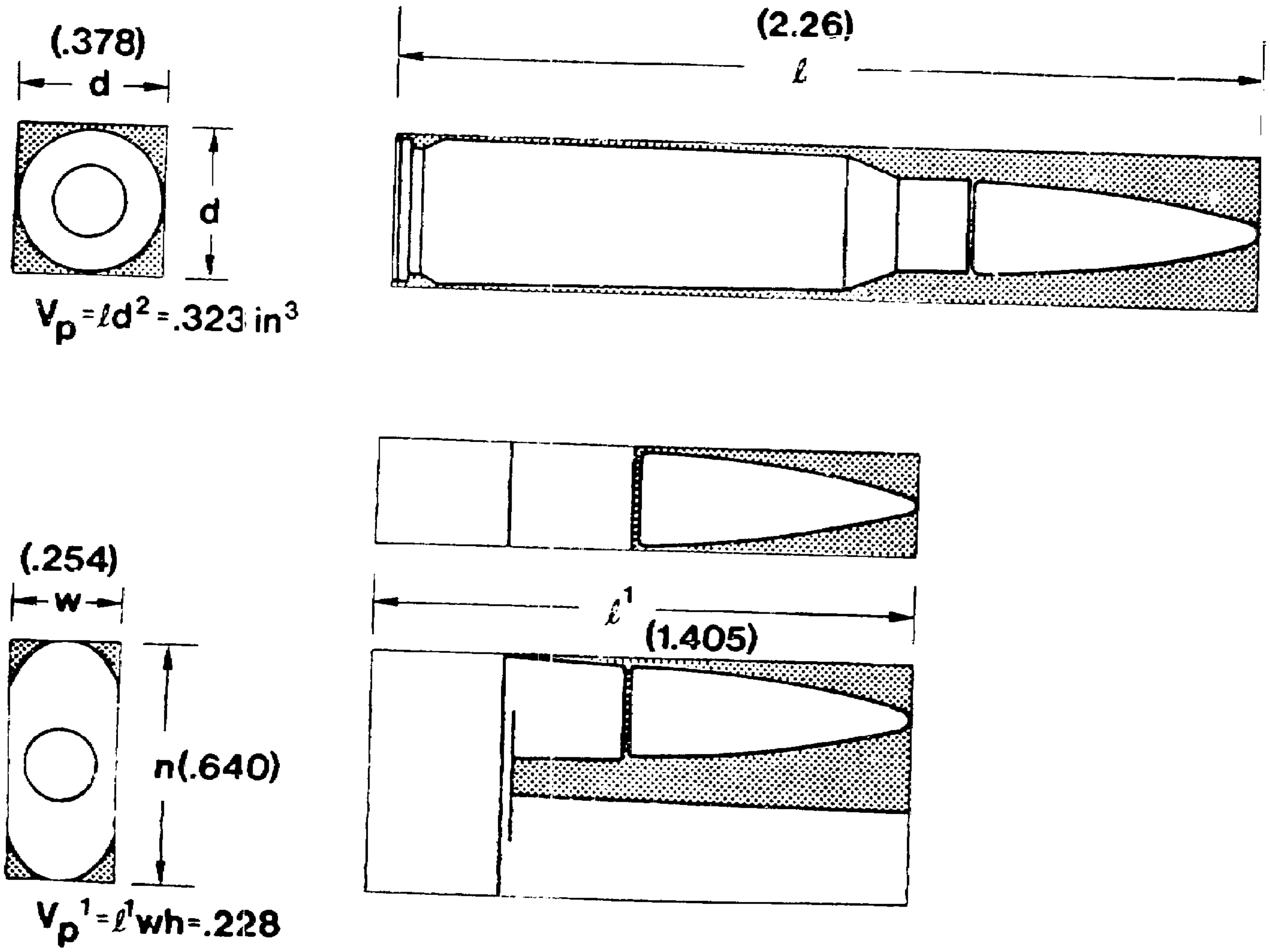


Figure 3. Conventional vs Folded Packing Volume Comparisons

the conventional. Using the same packing volume analogy as that for the conventional cartridge, it can be seen that the packing volume (rectangular volume or envelope occupied by the folded cartridge) is significantly smaller than that of the conventional cartridge. This is verified by calculating the new cartridge volume. Thus:

$$V'_p = l' w h = 0.228 \text{ in}^3$$

where:

V'_p = packing volume in inches^3

l' = cartridge length in inches

w = cartridge width in inches

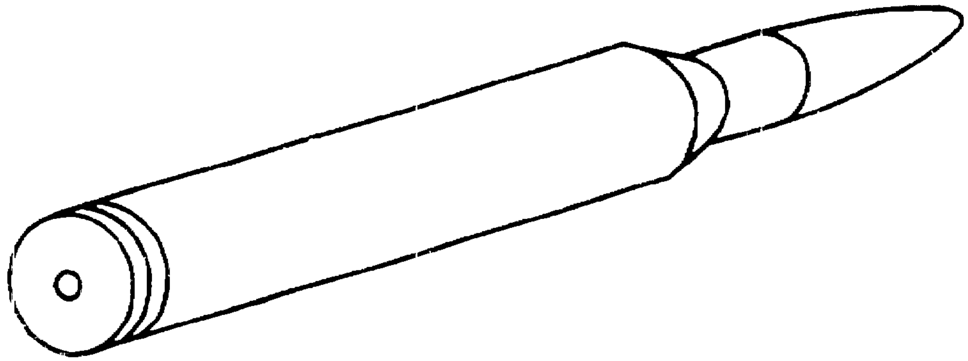
h = cartridge height in inches

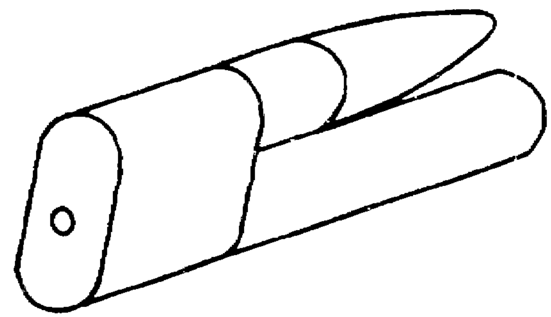
This represents about a 29 percent volume decrease based on the packing volume of the conventional 5.56 mm FABRL cartridge. This is the dramatic space saving result of Folded Ammunition.

Using examples in all three caliber regimes (small, automatic cannon and large), the comparisons shown in Figure 4 have been projected to show the universality of cartridge geometric and weight savings that can accrue using the folded design. It is interesting to note that even though the 30 mm GAU-8 cartridge has an aluminum case, a weight reduction is still indicated in the folded version utilizing a thin wall steel case. An excellent illustration of the operational potential of this new idea is to compare the effect it would have on the infantry soldier using the M16A1 rifle and 5.56 mm ammunition as a reference. In the infantry squad, the rifleman can carry 450 rounds comprising a weight of about 16.4 pounds. With Folded Ammunition, this weight is reduced to 13.5 pounds. Or, keeping the ammunition load at 16.4 pounds, he would carry approximately 574 rounds, an increase of 124 cartridges (27 percent of the basic load). In addition to this, it is estimated that weapon length could be decreased (due to reduced length of bolt stroke and chamber) with a resultant weight saving of about 1/4 pound.

In connection with the shortened bolt stroke of the weapon, at least two advantages are pertinent. Of course, rate of fire can be extended more easily into the higher ranges if that is desired. But, for a given rate of fire, the shortened bolt stroke should enable weapon designers to reduce acceleration of the bolt and associated parts with a resultant benefit to parts life.

From the systems viewpoint, and aside from the logistic aspects, improvement in space utilization is of particular importance equally in vehicle and tank turret application. This is true not only for ammunition oriented space utilization, but also for weapon intrusion into otherwide cramped quarters. Shortened ram stroke requirements





CONVENTIONAL DESIGN

FOLDED DESIGN

	VOLUME REDUCTION %	LENGTH REDUCTION %	WEIGHT REDUCTION %
5.56 MM M193	38	44	25
5.56 MM FABRL	30	38	22
7.62 MM M80	27	44	18
30 MM GAU-8	24	41	12
60 MM MC AAAC	42	41	22

Figure 4. Cartridge Comparisons

play a significant role here. Additionally, the advantages in system applications to aircraft where volume and/or weight savings can be critical should not be overlooked.

DISCUSSION

Based on the significant potential advantages offered by the concept of Folded Ammunition, a hardware-oreinted study was undertaken to investigate the basic feasibility of this new idea and determine the practicality of adapting it to a working system design. The feasibility investigation consisted of a series of interrelated activities combining analytical and hardware phases which served as the basis for the feasibility assessment. These included design analysis, ballistic studies, case fabrication processes and automatic firing fixture elevation.

Design Analysis

The experimental folded test weapon chamber and ammunition cartridge case were designed using the finite element stress analysis technique which took into account chamber and case deflections at peak pressure for satisfactory case performance. The analysis was made using a cartridge configuration designed around the 5.56 mm FABRL projectile. As illustrated in Figure 5, there is a significant difference in the weapon support given to the cartridge case in the folded configuration as opposed to conventional. In order to provide for extractor engagement with conventional design, the case head can be only partially supported. Thus, it must be relatively massive to withstand the pressure developed by the burning propellant. On the other hand, Folded Ammunition can be fully supported since the cartridge case is not extracted from the rear but is pushed out from the front of the propellant capsule. This permits the design of a case which is thin wall in construction in the head as well as the body. Since approximately 40 percent of conventional case weight is in the head region, a considerable weight saving is achieved.

The analysis required to design a Folded Ammunition case is less than that required for the conventional round because the folded case is completely inclosed by the chamber. The strength requirements in the case are determined solely by the need for case recovery after firing.

The first part of the analysis is calculation of the radial expansion of the inside chamber wall as a function of chamber pressure. Conventional weapon chambers are bodies of revolution with simple generating curves. Usually, the chamber may be approximated as an assembly of uniform cylinders. The deflection of a uniform cylinder under internal pressure is:

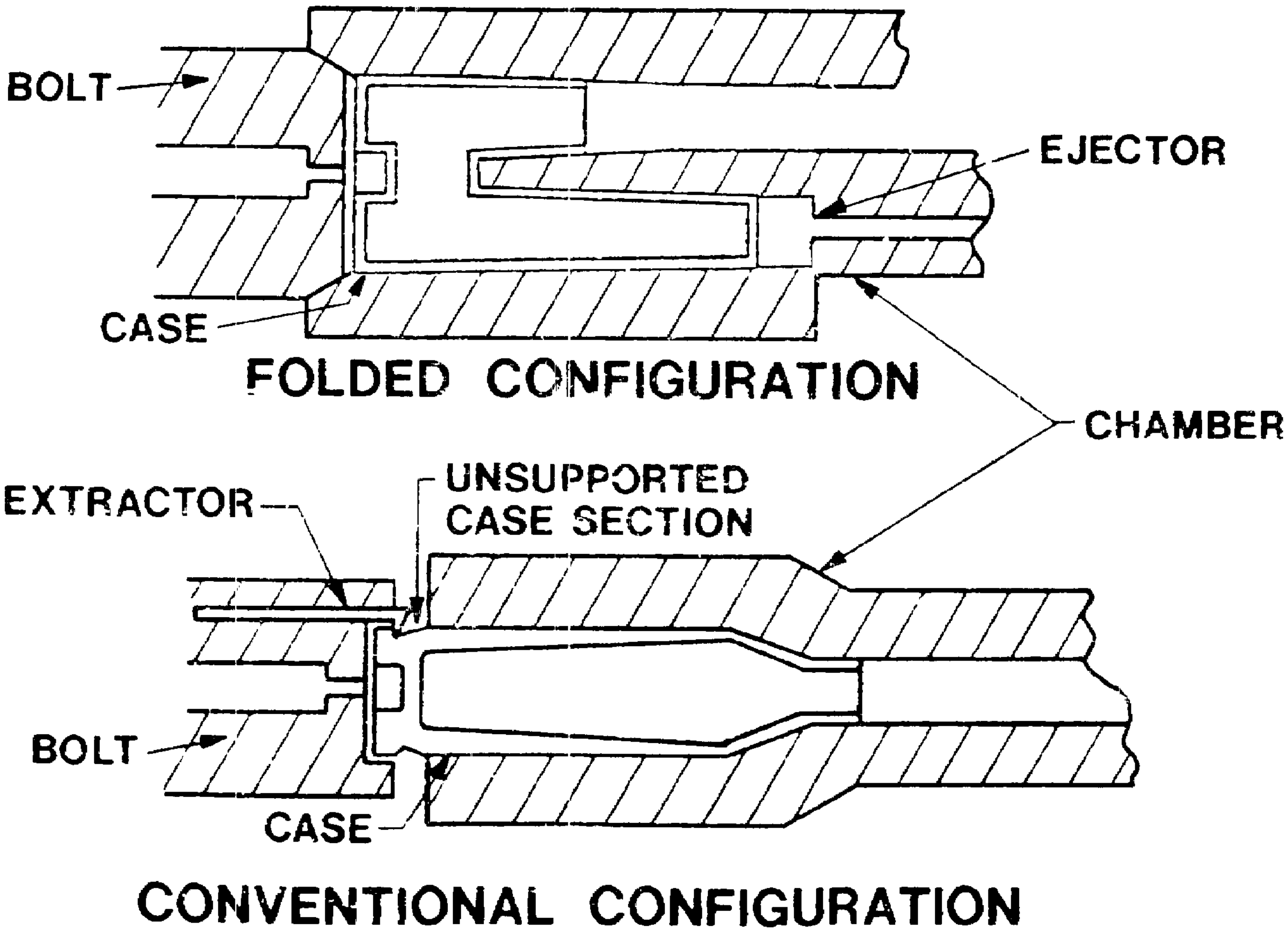


Figure 5. Design Analysis

$$\sigma = \frac{r_i P}{E} \left[\frac{1 + (r_i/r_o)^2}{1 - (r_i/r_o)^2} + \gamma \right]$$

where:

- E = Young's Modulus of Elasticity
- P = Chamber pressure in psi
- r_i = Inside chamber radius in inches
- r_o = Outside chamber radius in inches
- σ = Deflection of inside chamber radius in inches
- γ = Poisson's ratio

The Folded Ammunition case, however, is not a simple body of revolution. In fact, a complete stress analysis of the chamber or case would require solution of the three-dimensional Balltrami-Mitchell equations. However, an approximation of chamber deflection can be obtained by analyzing cross-sectional slices of the chamber as two-dimensional problems. Using this approach, considered sufficient for this analysis, two sections, one at the rear and the other at the mid-section of the chamber, were chosen. A finite element grid was prepared for each section. The starting grids are shown in Figures 6 and 7, and the results of the analyses are shown in Figures 8 and 9. These plots show lines of constant stress at intervals of 250 psi throughout each cross section. Figures 10 and 11 show a plot of the deformed geometry (solid lines) superimposed on a plot of the original grid (dashed lines). Both sections are assumed to be sections of long regular bodies, i.e., in plane strain. This means that the axial variation of stress in the weapon chamber is completely neglected and axial stress is assumed to be zero. This assumption gives radial chamber deflections that we estimate to be 10 to 20 percent greater than actually occur in the weapon, thus making the analysis conservative.

Table I presents the x and y components of the deformation vector of the nodal points on the interior radius of the chamber. The numbers may be combined vectorially to yield the radial deflection at each point. These, in turn, are averaged to determine the average radial deflection in the cross section.

Once the average radial deflections are known, case yield strength is determined so that the case will recover enough of its original shape after pressurization to insure extraction. Specifically, the requirement that case radial recovery be greater than chamber deflection implies that static extraction force is zero at zero chamber pressure.

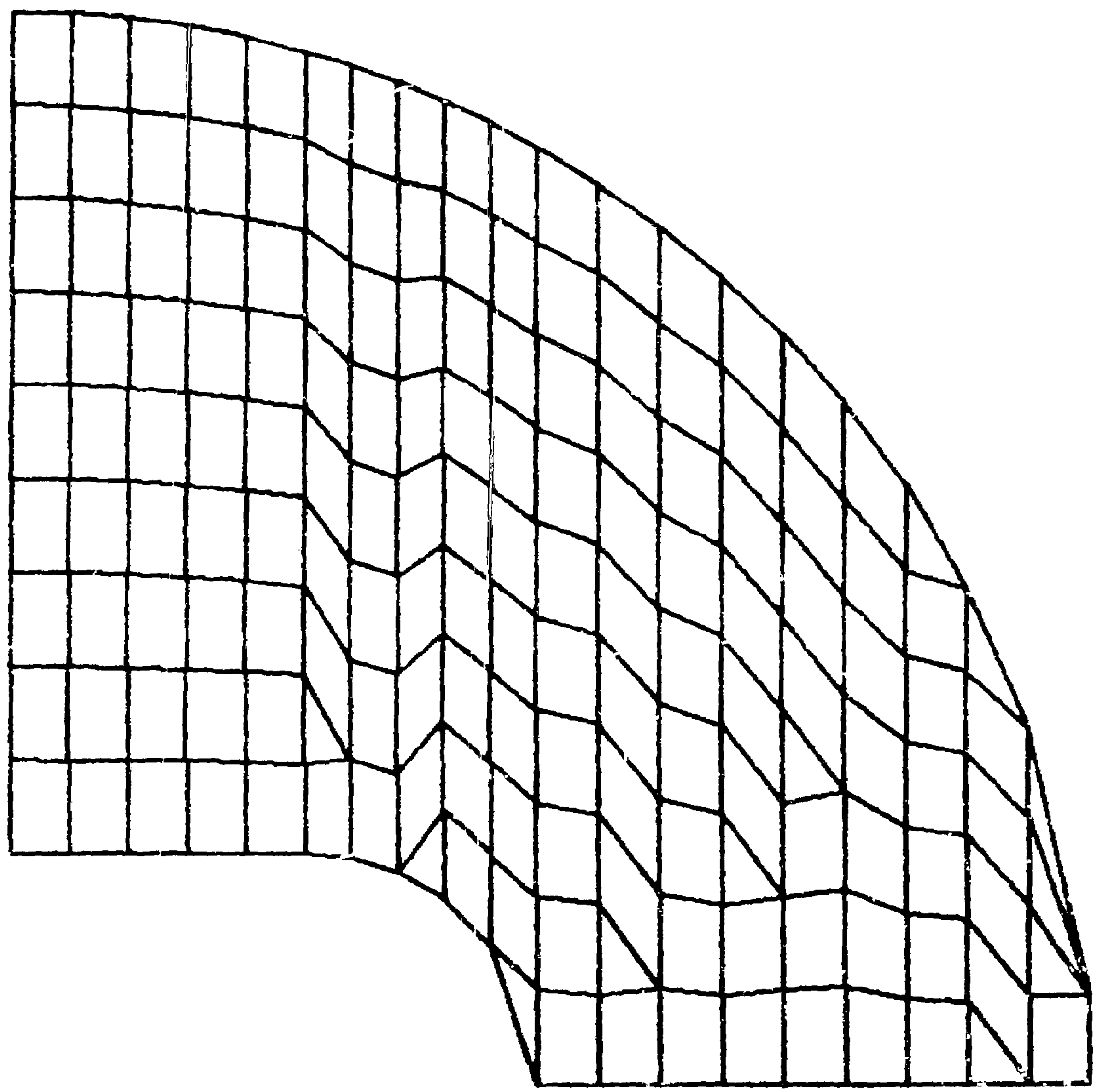


Figure 6. Folded Chamber Starting Grid (Rear Section)

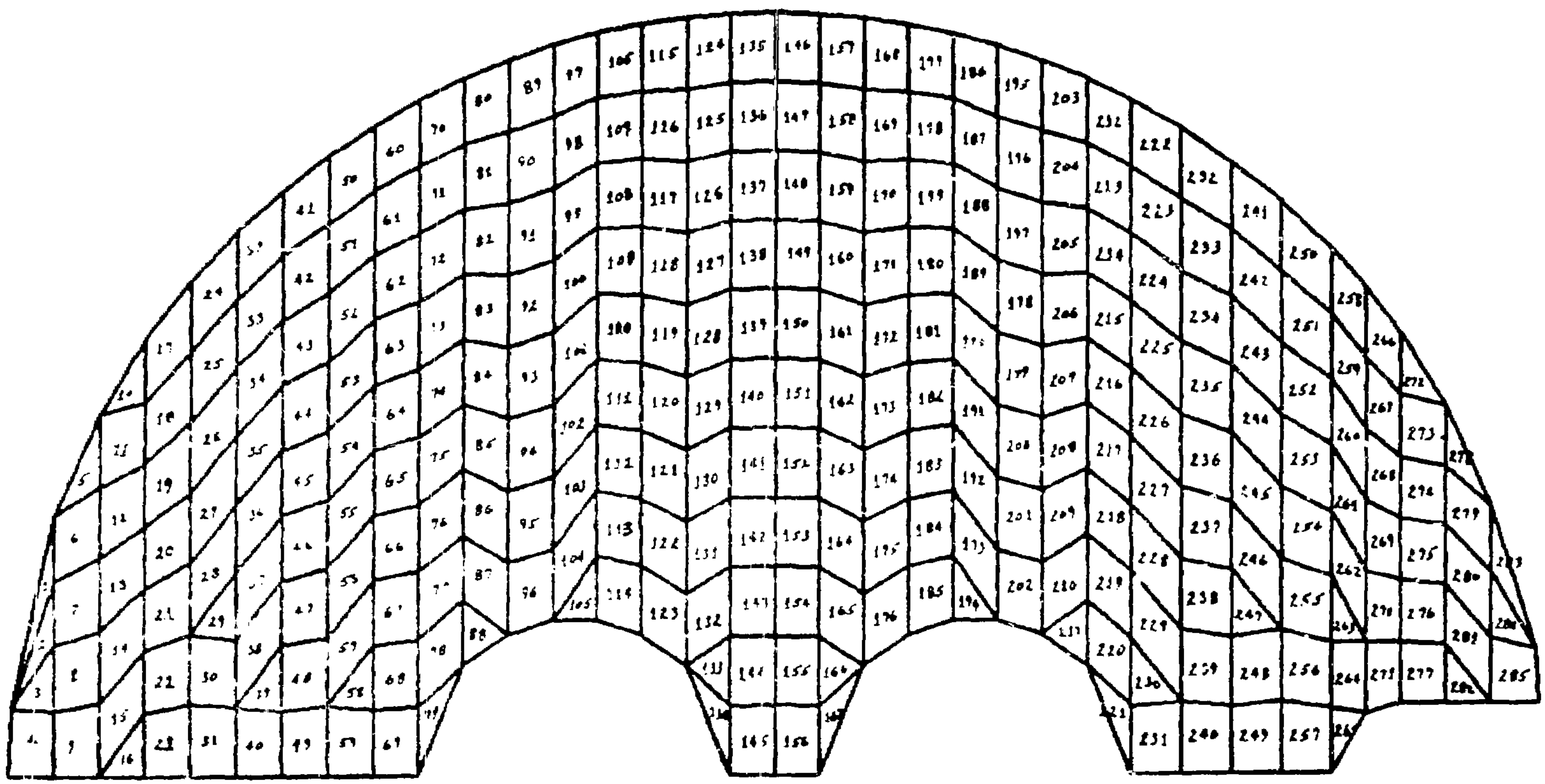


Figure 7. Folded Chamber Starting Grid (Mid-Section)

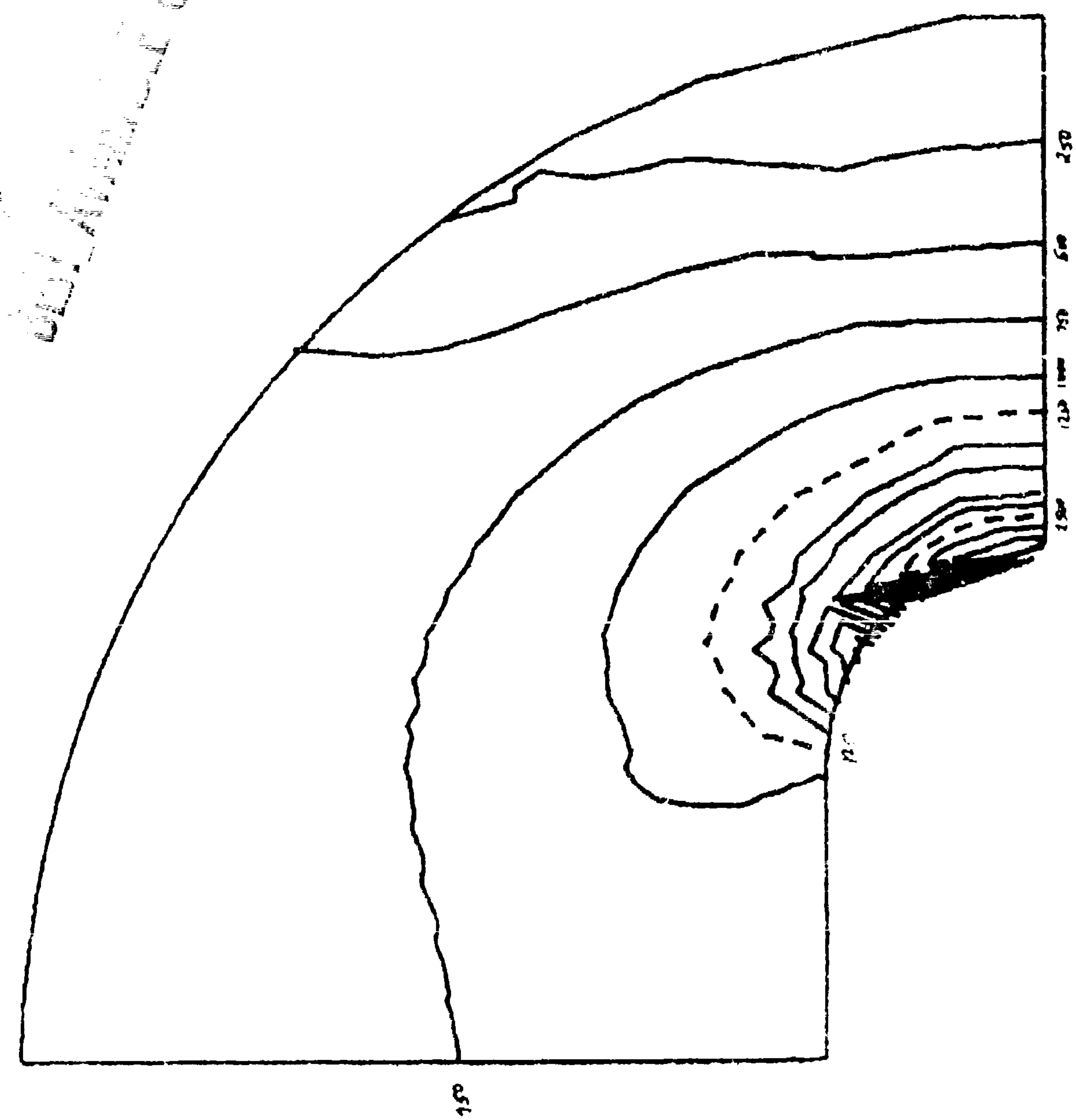


Figure 8. Folded Chamber Stress Plot (Rear Section)

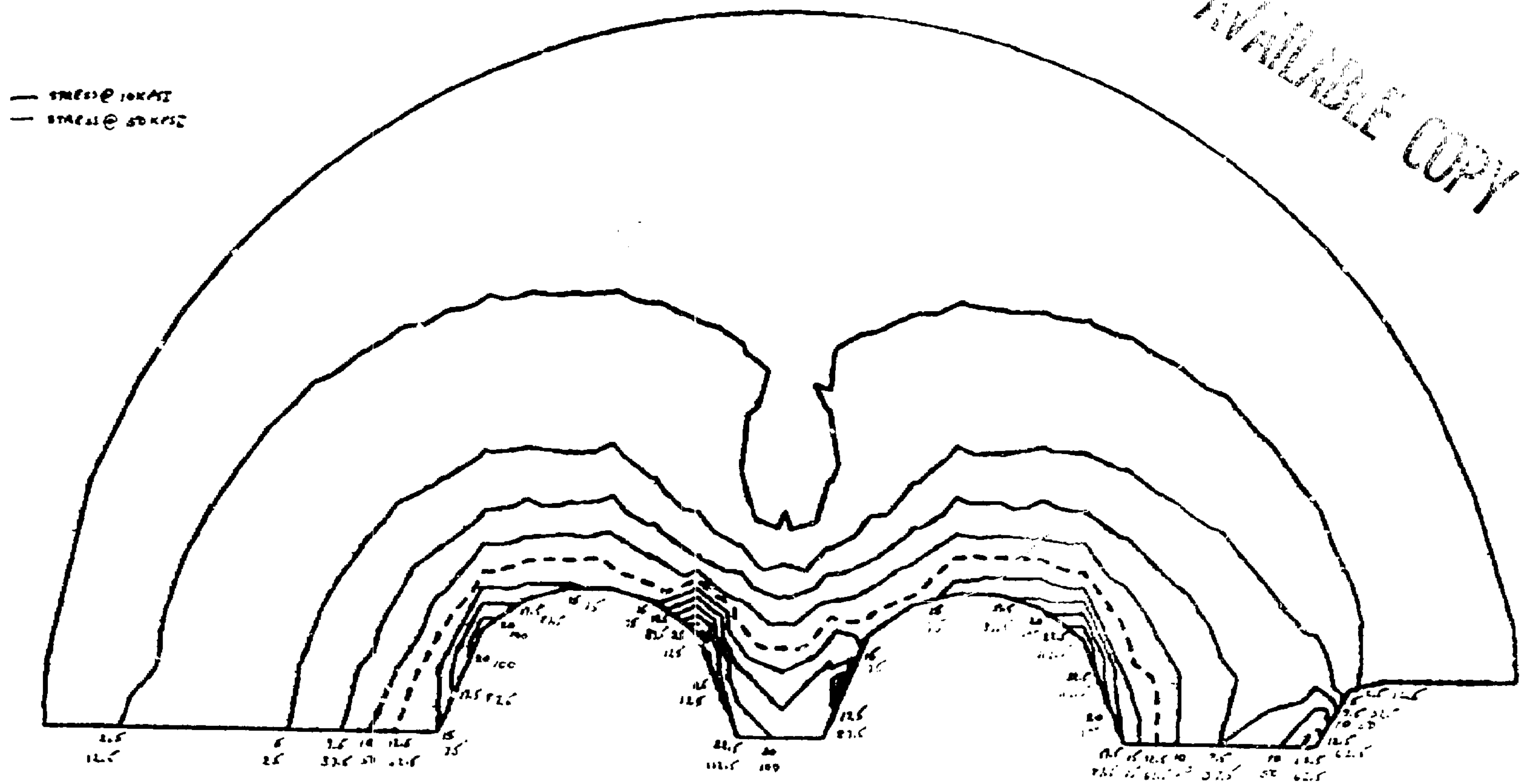


Figure 9. Folded Chamber Stress Plot (Mid-Section)

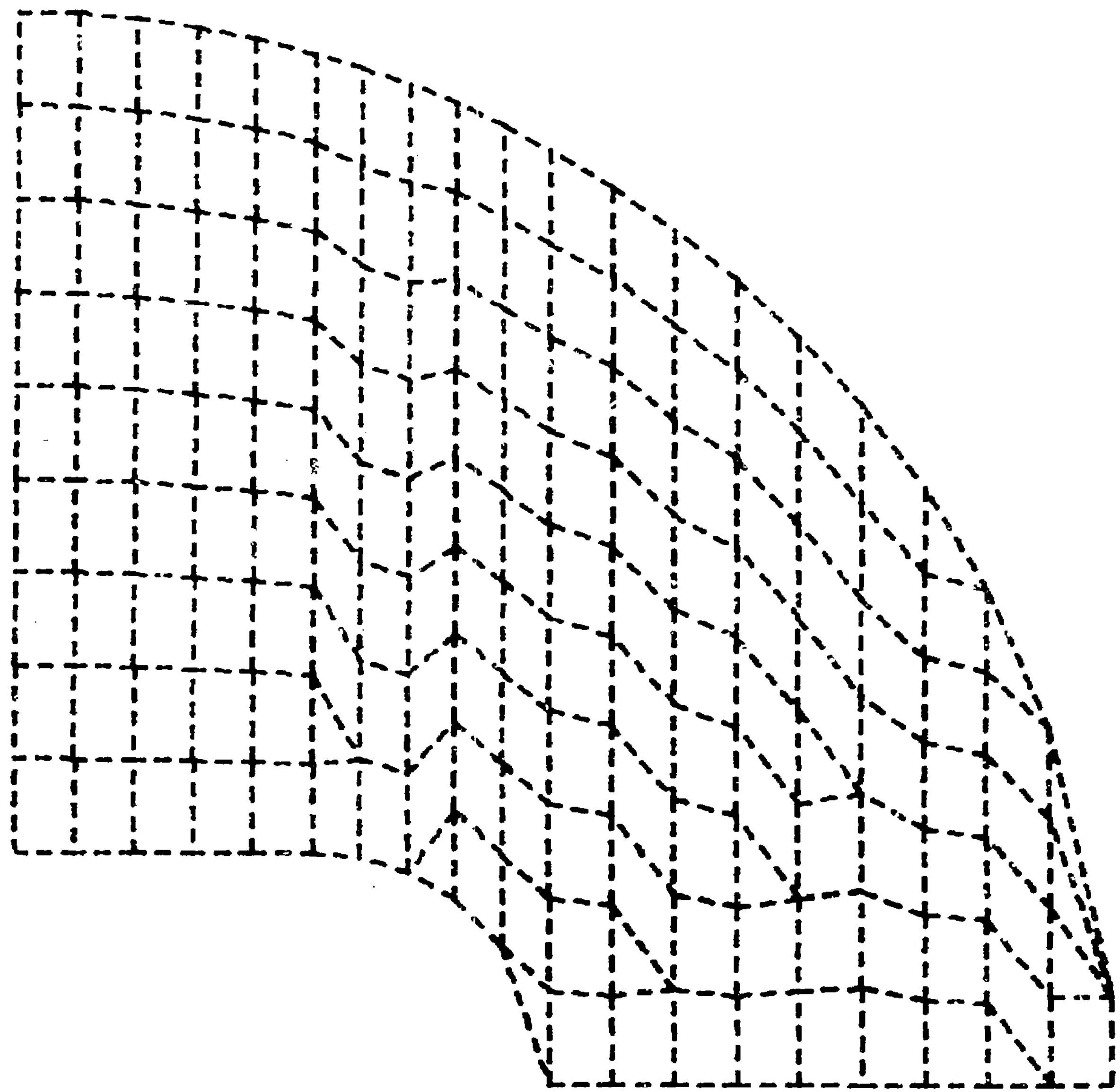


Figure 10. Folded Chamber Distortion Plot (Rear Section)

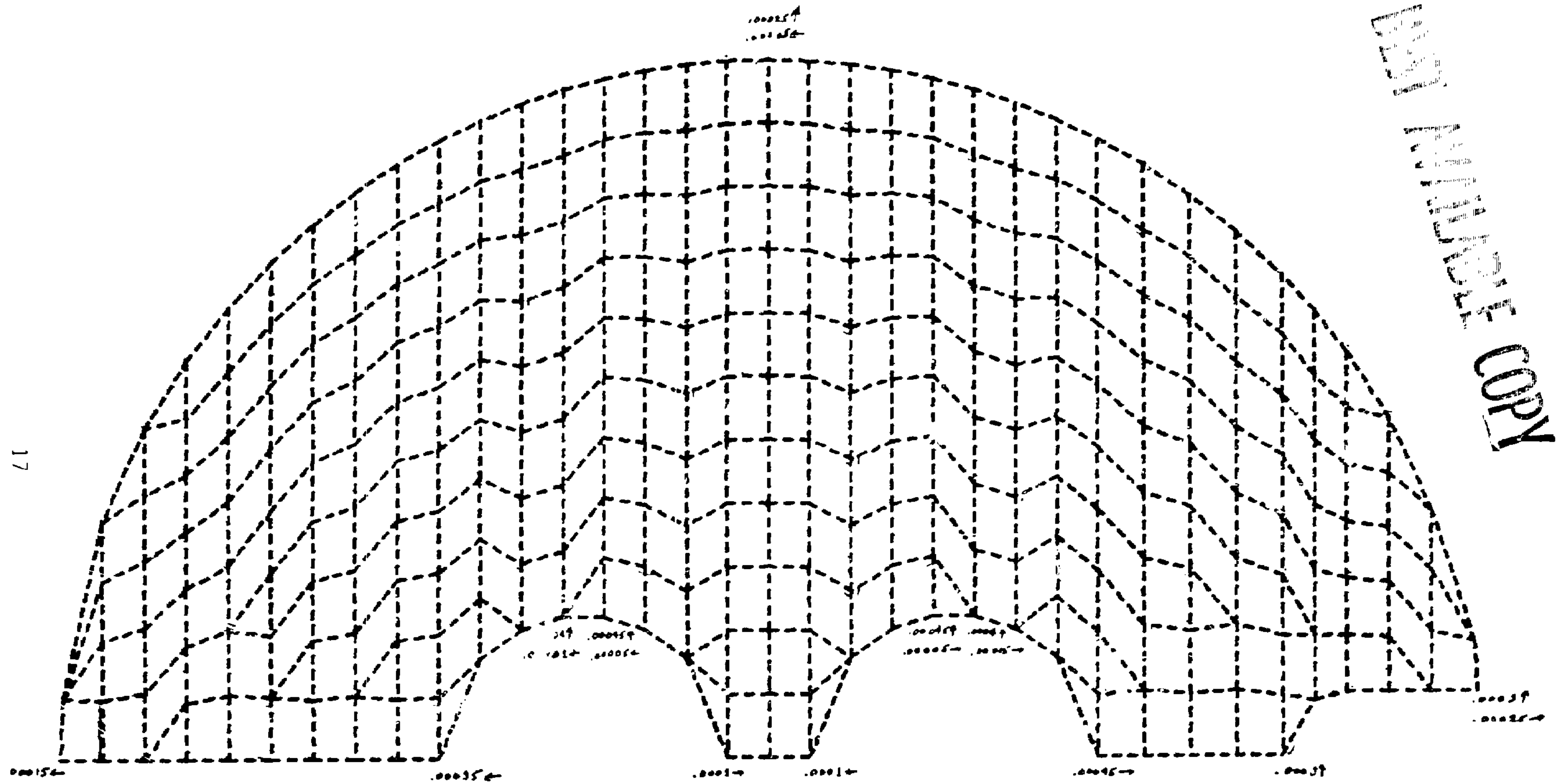


Figure 11. Folded Chamber Distortion Plot (Mid-Section)

TABLE I.
Chamber Deflection at Nodes Located on I.D.

Rear Section (Ellipse)		Middle Section (2 Holes)	
X(x 10^{-6} in.)	Y(x 10^{-6} in.)	X(x 10^{-6} in.)	Y(x 10^{-6} in.)
26	0.	4	-5
26	0.	6	-4
25	0.	7	-2
23	0.	7	-1
21	0.	7	-1
19	0.	7	0
16	0.	7	1
13	0.	7	1
9	0.	5	2
0	0.	0	2

Average radial deflection =

$19.7 \times 10^{-6} \ \frac{\text{inches}}{1000 \text{ psi}}$, $6.3 \times 10^{-6} \ \frac{\text{inches}}{1000 \text{ psi}}$.

Application of thin shell theory to the cylindrical portion of the Folded Ammunition case permits this criteria to be expressed as:

$$\left[\frac{2}{\sqrt{3}} - \frac{\gamma}{\sqrt{3}}\right] \frac{\sigma_{Yield}}{E} \geq \frac{u}{r}$$

where:

σ_{Yield} = Yield strength of cartridge case material

This approach in conjunction with the results from Table I gives a minimum yield strength of 102,000 psi for a chamber pressure of 65,000 psi. Similar calculations carried out for the rear section of the case indicate a minimum required yield strength of 164,000 psi.

The results of this analysis can be compared with the known solution for a thick-walled cylinder. The purpose of the comparison is to see how much effect increasing the barrel outside diameter has on reducing the minimum yield strength values required in the case. As the outside diameter of the thick cylinder increases, the internal deflection decreases and, in the limit, it approaches the value given by:

$$\delta = \lim_{r_o \to \infty} \left\{ \frac{r_i P}{E} \left[\frac{1 + (r_i/r_o)}{1 - (r_i/r_o)} + \gamma \right] \right\}$$

$$\delta = \frac{r_i P}{E} \left[1 + \gamma \right]$$

Comparison of both Folded Ammunition chamber sections with the cylinder equation shows that little can be gained by large increases in chamber outside diameter. The comparison is made by converting the Folded Ammunition to an area-equivalent cylinder and then calculating the limiting value of internal deflection of that thick cylinder. Results are summarized in Table II.

TABLE II.
Comparison of Internal Diameter Deflections

	Finite Element Value	Limiting Value
Section A-A	128×10^{-5} in.	104×10^{-5} in.
Section B-B	40.9×10^{-5} in.	34.4×10^{-5} in.

Ballistic Studies

Preliminary ballistic studies of the 5.56 mm Folded Ammunition were conducted in a heavy walled test weapon instrumented for measurement of chamber pressure. The weapon was designed to accept reuseable cartridge cases which were assembled from several components allowing variation of internal volume and propellant charge distribution. The components of a representative case are shown in Figure 12. Propellant granulation and ignition studies were performed with this test hardware to establish the desired performance level. In addition, a parametric study was conducted to evaluate the effect on interior ballistics of the 5.56 mm Folded Ammunition of varying the relative locations of the primer and propellant charge. Also studied was the effect of throttling gas flow from propellant bed to projectile using flow areas of 1/3, 2/3 and full bore area. A special breech for the test weapon and special case bases were fabricated to permit firing with the primer located on the axis of the cylindrical portion of the case. Also fabricated were liners for the rear portion of the case which confine the propellant charge to the cylindrical portion and permit gas bleed-off through areas of 1/3 and 2/3 bore area. A representative liner is shown in Figure 13. The cross-sectional area of the gas bleed-off control slot is shown elevated for clarity.

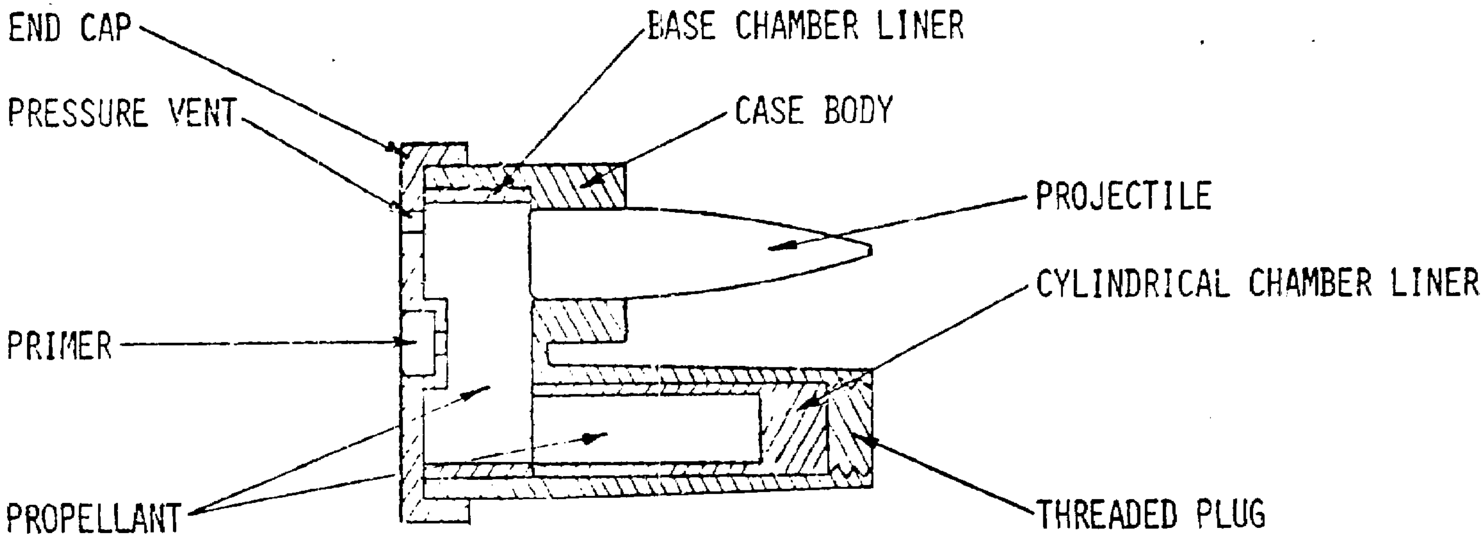


Figure 12. Ballistic Test Cartridge

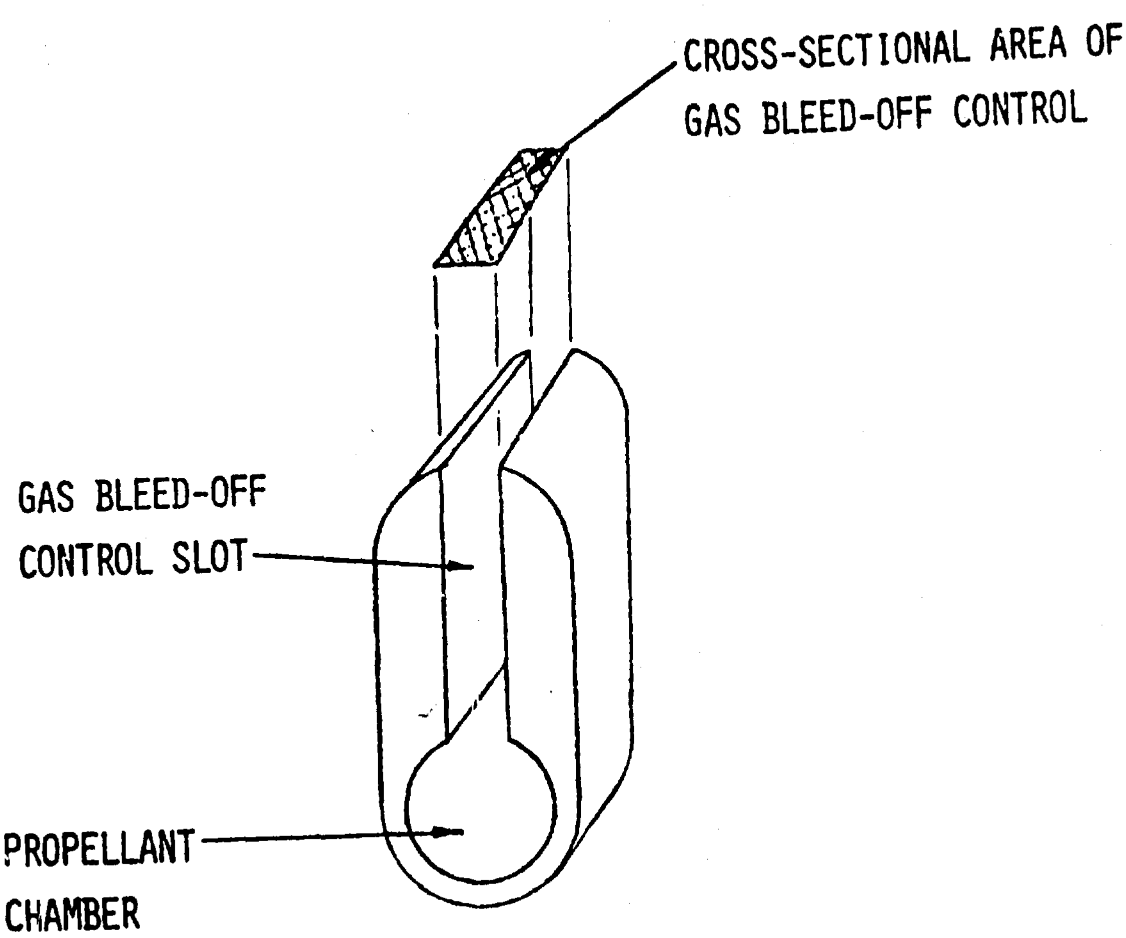


Figure 13. Gas Flow Control Liner

The modified cases were fired in an instrumented test weapon with the following results. The standard case configuration and loading with primer positioned on the axis of the cylindrical portion produced no detectable effect on either pressure or velocity. When the 2/3 bore area liner was inserted and the entire propellant charge confined to the cylinder, average peak pressure increased by approximately 8 percent and muzzle velocity increased by approximately 2 percent. Using the same configuration as above but loading propellant in both the cylinder and throat produced a 20 percent increase in average peak pressure. Average velocity was the same as before but uniformity was substantially degraded. Using the 1/3 bore area liner and the propellant charge again confined to cylindrical area of the case, average peak pressure rose 10 percent while velocity decreased 10 percent. Here again, ballistic uniformity was poor.

It was concluded from these firings that locating the entire propellant charge in the cylindrical portion of the case in combination with an axially positioned primer can provide a small increase in performance. However, the magnitude of this increase is such that other considerations such as case manufacturing procedures, may render its adoption impractical or cost-ineffective. It was also observed that restriction of gas flow from the propellant charge to the projectile tends to decrease performance and greatly degrades ballistic uniformity. However, this study was limited to the 5.56 mm caliber, and, specifically, the FABRL bullet, which has a comparatively low sectional density. More extensive studies will be required to determine whether specific ballistic advantages can be realized in other systems through variation of primer location, propellant position or gas bleed-off control.

Based on the preliminary ballistic studies in the test weapon and results of the design analysis, a prototype cartridge was designed and fabrication initiated. Concurrent with this, a test barrel was designed and fabricated to accept this ammunition and permit firing from a universal test fixture. This barrel, in addition to being instrumented for measurement of chamber pressure, also permitted port pressure measurement to obtain data required for automatic firing fixture operating mechanism design. In order to obtain a pressure gradient, port pressure taps were provided at the normal M16A1 position (6 1/2" from muzzle) and at a position three inches closer to the bolt face.

Test firings were conducted with pressure gages at the chamber and both port positions. Results of these tests indicated a pressure at the normal port position of 9000 psi for rounds fired at the desired performance level. This translates into a bolt cavity pressure of approximately 750 psi. Since the M16A1 normally operates at a bolt cavity pressure of 1600 to 2400 psi, a relocation of the pressure port was indicated. Figure 14 is a graph of bolt cavity pressure versus port position calculated from the pressures measured in these test firings. From this curve, a new port position was selected for the automatic Folded Ammunition firing fixture. This position is four inches to the rear of the original in order to produce an estimated average bolt cavity pressure of 1800 psi.

Interior ballistic studies in both the above test weapon and eventually in the automatic test fixtures resulted in selection of a propellant charge for the 5.56 mm folded FABRL cartridge that yields velocity and pressure levels comparable to those obtained with the conventional design. The data shown in Figure 15 compares interior ballistics of the conventional and folded designs using the same 5.56 mm FABRL bullet, 18 grains of propellant WC 680 and the standard FA 41 primer. These curves are derived from a series of test firings and are representative of these firings. Performance levels are statistically similar as are calculated efficiencies. The Folded Ammunition time-pressure curves showed no evidence of unusual spikes, pressure waves or ignition anomalies. Representative firing data are shown in Appendix B.

The conclusion can be drawn that the folded design does not appear to introduce any negative effects on ignition or propellant combustion. There has been some indication in limited studies of a 30 mm system that in the heavier, larger caliber projectiles improved ballistic efficiencies can be achieved with the Folded Ammunition design. Studies are being continued in the 30 mm experimental test fixtures to ascertain the validity of this preliminary evidence.

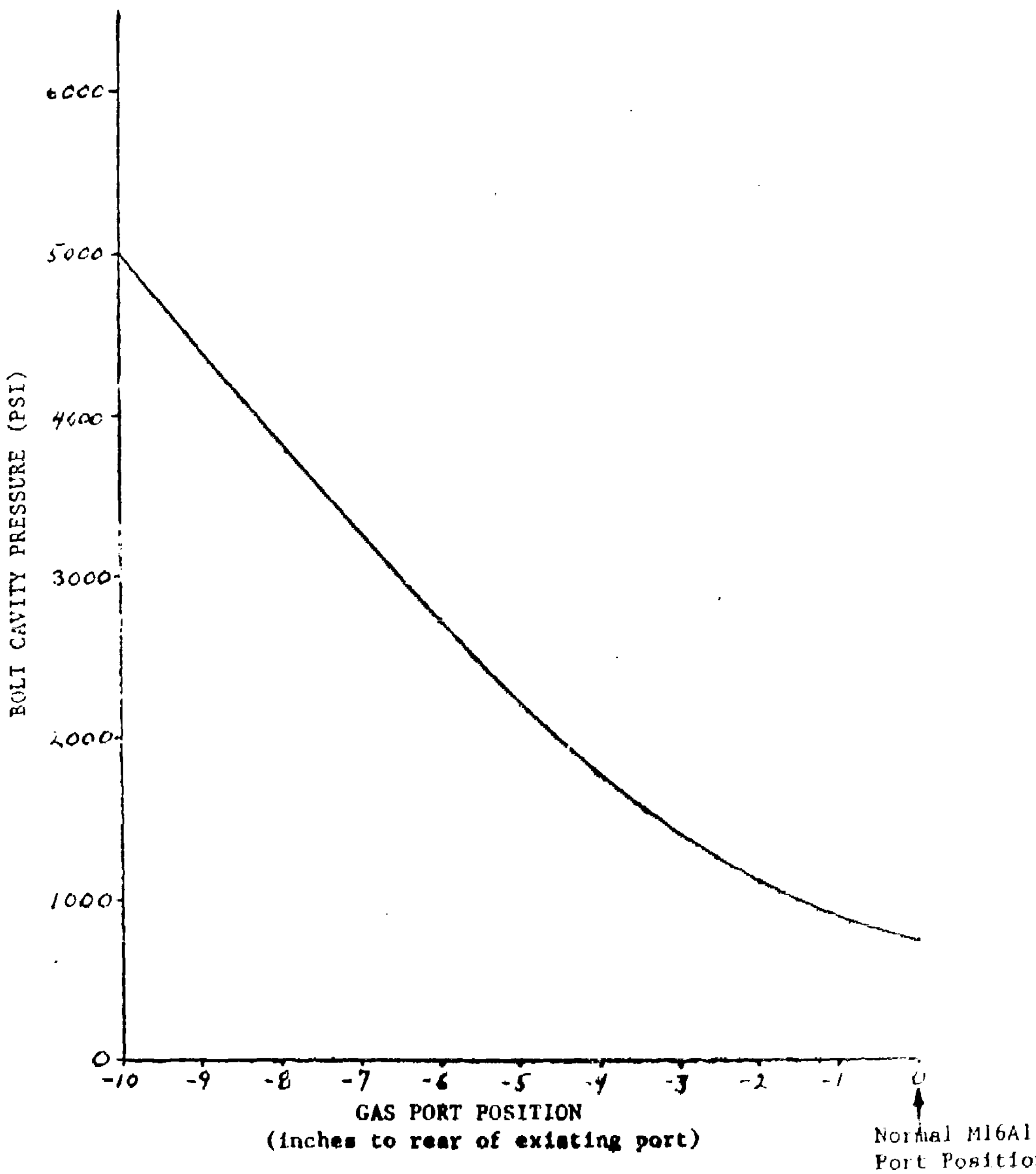
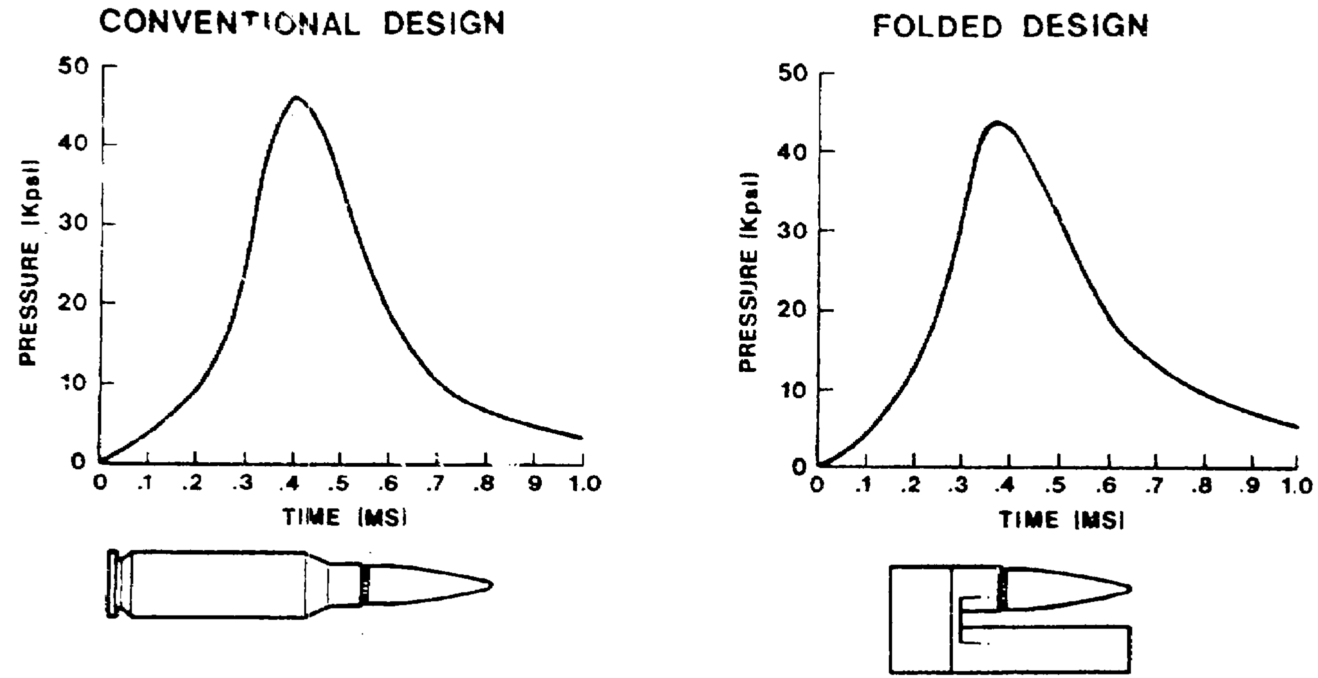


Figure 14. Bolt Cavity Pressure vs Gas Port Position



	CONVENTIONAL DESIGN	FOLDED DESIGN
BULLET WT	37.1 GR	37.1 GR
PROPELLANT	18 GR WC 680	18 GR WC 680
PEAK PRESS.	46125 PSI	44100 PSI
VELOCITY	3224 FT/SEC	3150 FT/SEC
BALLISTIC EFF. (μ_b)	0.337	0.322
PIEZOMETRIC EFF. (μ_p)	0.308	0.308

Figure 15. Interior Ballistics Comparison

Case Fabrication

Due to the unusual shape of a folded cartridge case, the ability to produce this case at a rate and cost comparable to those of a conventional case was a matter for serious concern in this feasibility study. Therefore, the establishment of a case fabrication process, that would indicate a high degree of case producibility, was considered an essential aspect in demonstrating the feasibility of Folded Ammunition.

Three decisions had to be made at the outset of this feasibility study with respect to the number of case components, the forming technique and the case material. A two-piece case was selected in lieu of either a one-piece or a three-piece case. The one-piece case was considered too difficult to mass produce while the three-piece, although easier to fabricate, was deemed too complex to meet the stringent requirements of a cartridge case. The forming technique chosen was an impact extrusion process (Figure 16) as the first approach in fabricating the unusually-shaped, two-piece folded case. For comparison, the standard blank cup and draw process used for fabricating the one-piece 5.56 mm bottleneck case, is shown in Figure 17. As can be seen, case processing steps have been reduced from 14 for the conventional to 8 for the folded. Of course, machine production rates must be taken into consideration as part of any comparative procedure, among other things, but the impact extrusion process used here enables a reduction in process steps when compared to conventional case fabrication. On the other hand, the folded case was fabricated in two parts and this then increased the number of fabrication steps for the total case. Even so, a decision was made and carried through which resulted in a practical experimental method for case fabrication. Steel was selected as the folded cartridge case material for its cost-savings potential since it is approximately 40 percent of the cost of brass, the material from which standard cases are made. Aluminum and plastics were considered as material candidates but were ruled out at this time although they could be considered as possible candidates in the future.

Having made these three crucial decisions, it remained to develop specific tooling and processing operations to fabricate the experimental Folded Ammunition cases. The tool drawings for the extrusion process for the 5.56 mm folded cartridge case are shown in Appendix B. Although many problems surfaced during this development, one of the major hurdles centered around extruding a steel with a high enough carbon content to achieve what were considered to be desired case mechanical properties (approximately 164 kpsi yield strength) through heat treatment. The lowest carbon steel which can be heat treated to the desired level is 1035, a steel which is not suitable for impact extruding at the degree of reduction required for the process. Thus, an investigation was conducted to develop a means for circumventing this problem. The approach taken utilized a carburizing technique which would be

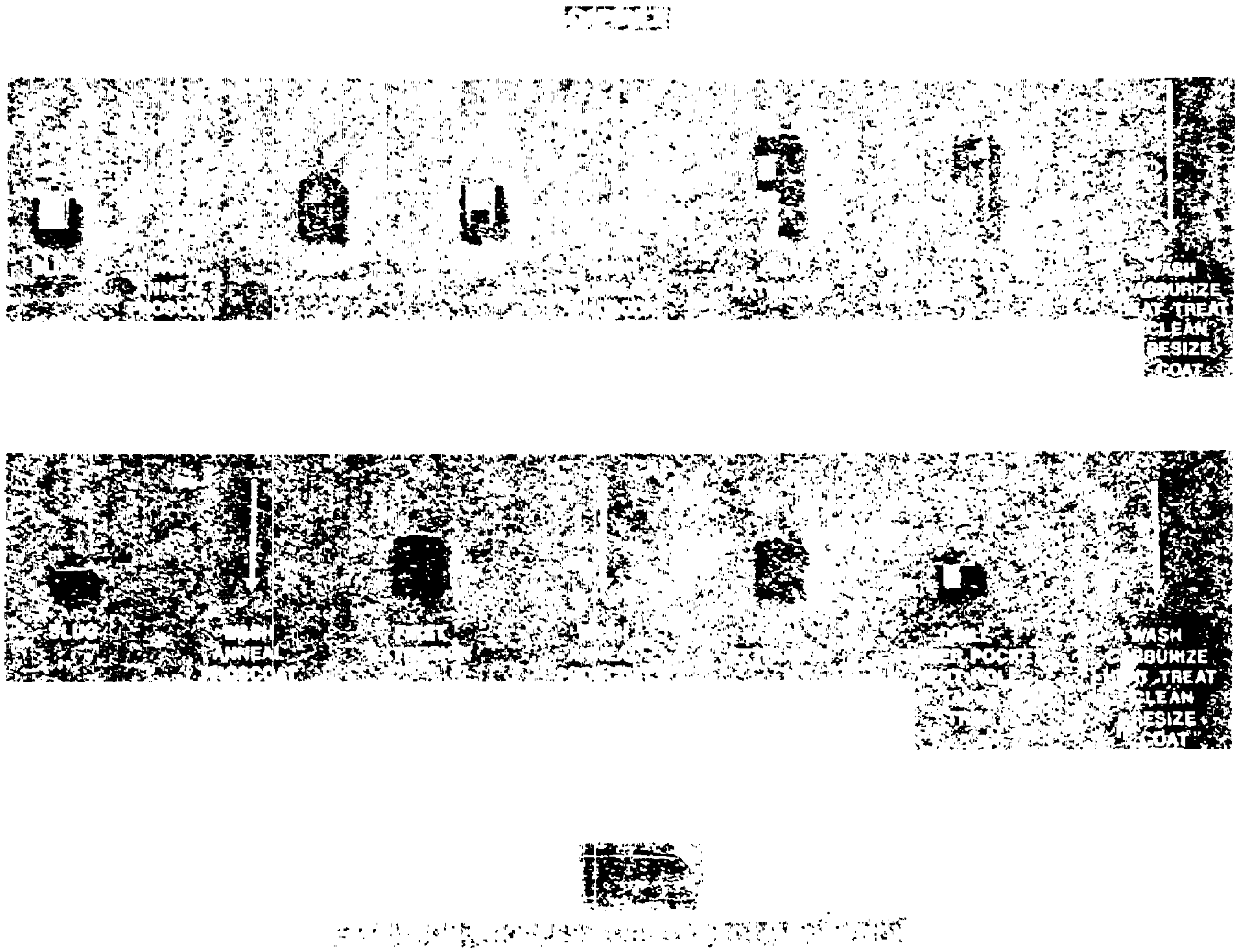


Figure 16. Initial Extrusion Process for Folded Cartridge Case

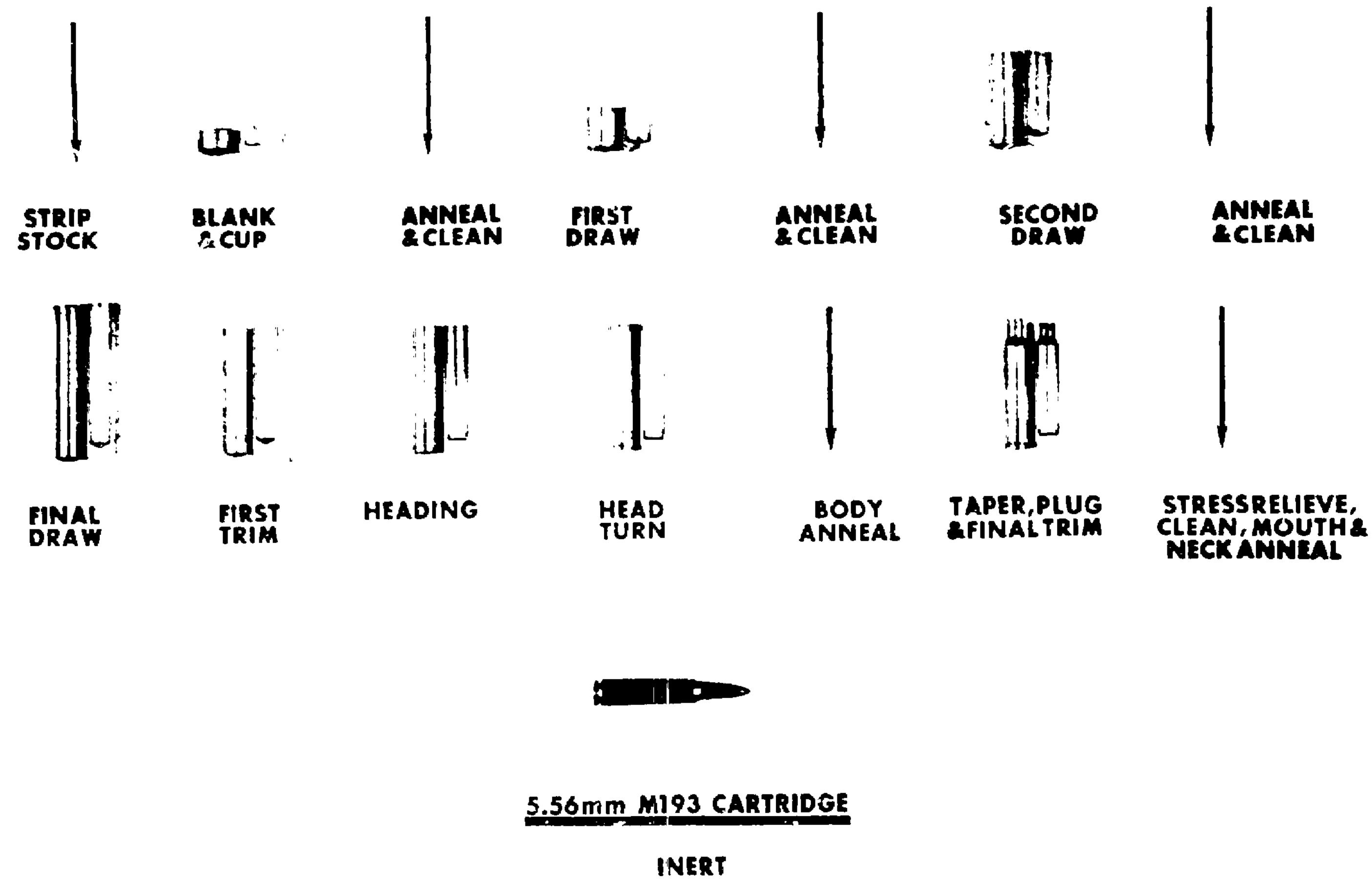
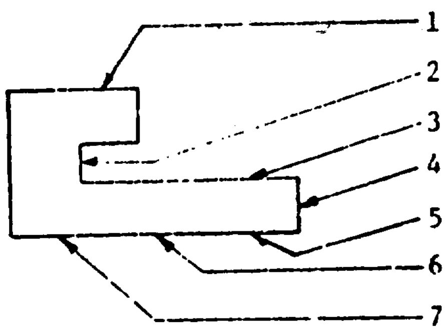


Figure 17. Blank, Cup, and Draw Process for Standard Ammunition

workable on a thin-walled structure such as the folded cartridge case. The case, therefore, was extruded from 1008 steel (the lowest carbon steel (commercially available and extrudable at the required degree of reduction), carburized to 1035 steel and then heat treated to the desired property levels. Figure 18 shows the uniformity or homogenity of such carburized microstructure and Table III lists the hardness readings obtained on the heat-treated carburized cases.

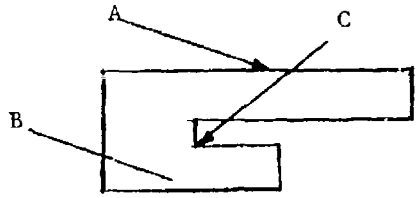
TABLE III.
Hardness Readings of Heat-Treated Carburized Cases



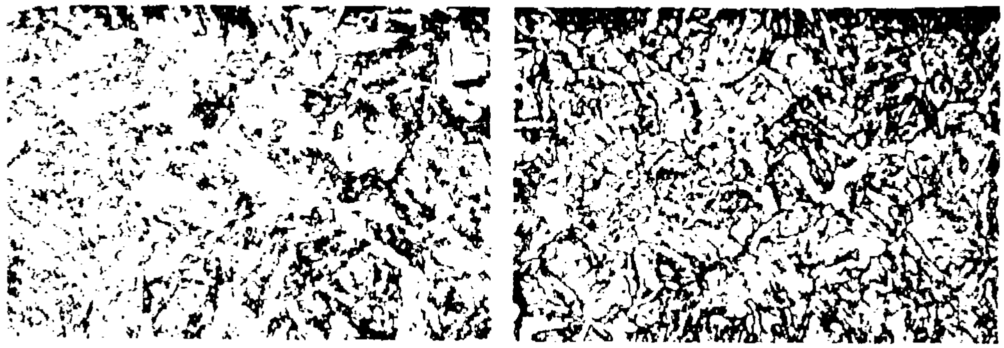
Reading Position	Hardness - Rc	
	Case 1	Case 2
1	29	32
2	35	34
3	39	41
4	32	33
5	38	38
6	36	36
7	34	34

It was found in subsequent testing that the carburized and heat treated cases were not sufficiently ductile to preclude splitting during test firings. In fact, it was found that uncarburized 1008 steel cases did possess sufficient ductility wherein the as-formed case could be successfully fired without splitting. This advantageous situation resulted in a significant simplification of the case process and it was found that satisfactory case ejection could be obtained in automatic test firing fixtures. The hardness pattern for this case is shown in Table IV. The final case process, then, is that shown in Figure 19.

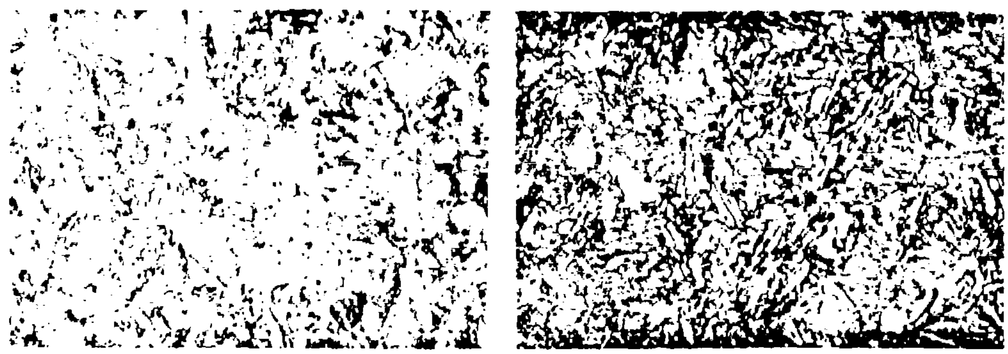
Loading and assembly of the experimental Folded Ammunition was accomplished in the manner depicted in Figure 20. The process consisted of inserting the projectile in the case to form a closed case body into which the propellant was loaded. The cap was primed separately and then joined to the loaded case body. Although this differs from the conventional cartridge assembly, these steps should be amenable to production processing. Shown in Figure 21 in both external and cutaway views is the assembled 5.56 mm folded cartridge used in this feasibility study. Details of cartridge and components are contained in Appendix C.



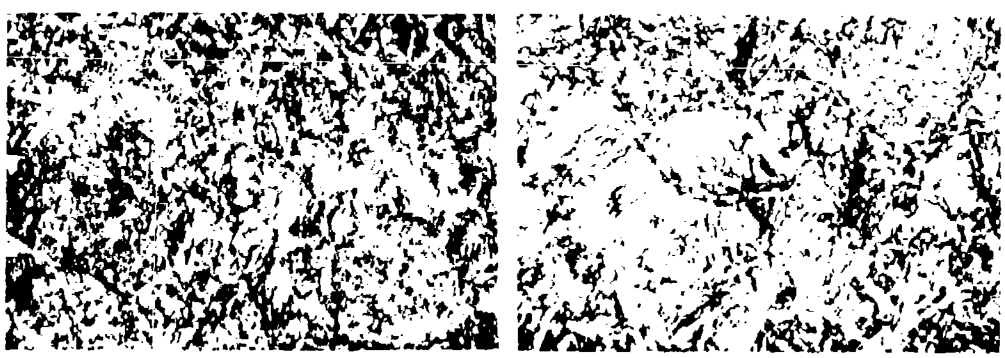
Case 1 Case 2



Location A



Location B



Location C

NOTE: Overall Carbon Content: 0.32%

Figure 18. Carburized Microstructure for Folded Cartridge Case

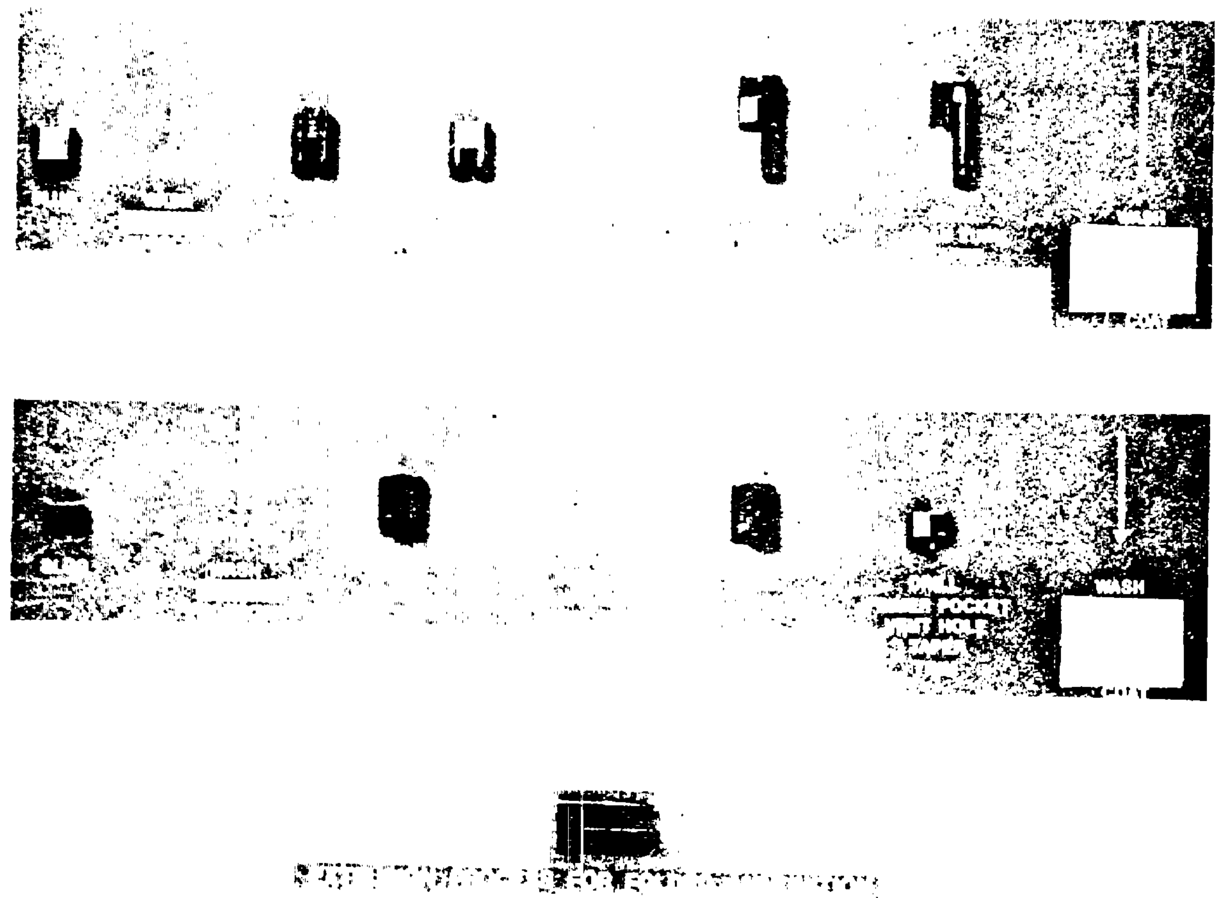


Figure 19. Final Extrusion Process for Folded Cartridge Case

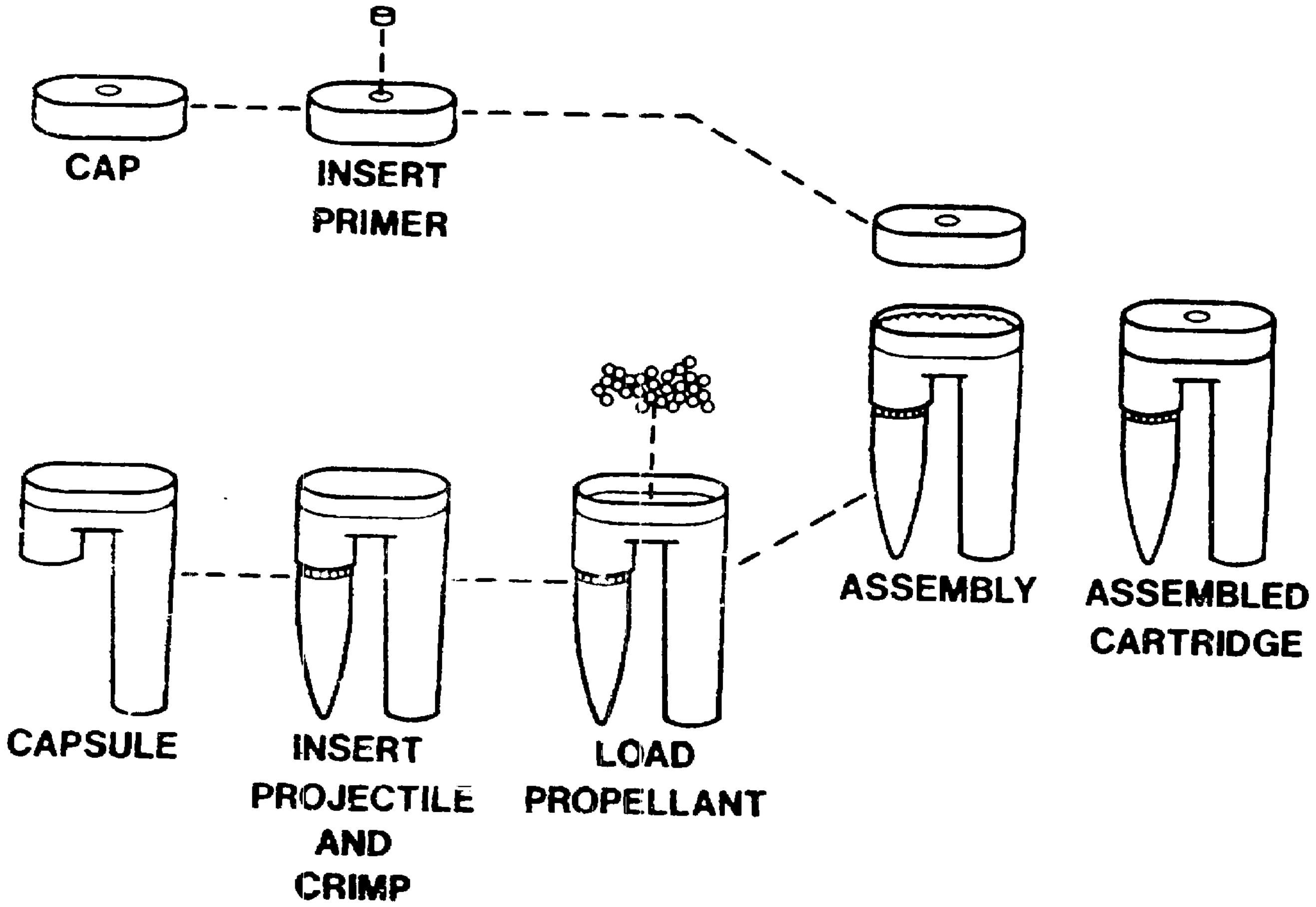
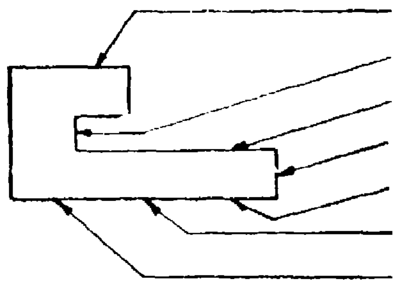


Figure 20. Load and Assembly Process

Hardness Readings of Heat-Treated Uncarburized Cases



Reading Position	Hardness - Rc Case 1	Hardness - Rc Case 2
1	B61	B58
2	B68	B74
3	24	B98
4	22	22
5	22	24
6	22	24
7	B59	B58

B - Rockwell "B" readings given where too low to read on "C" scale

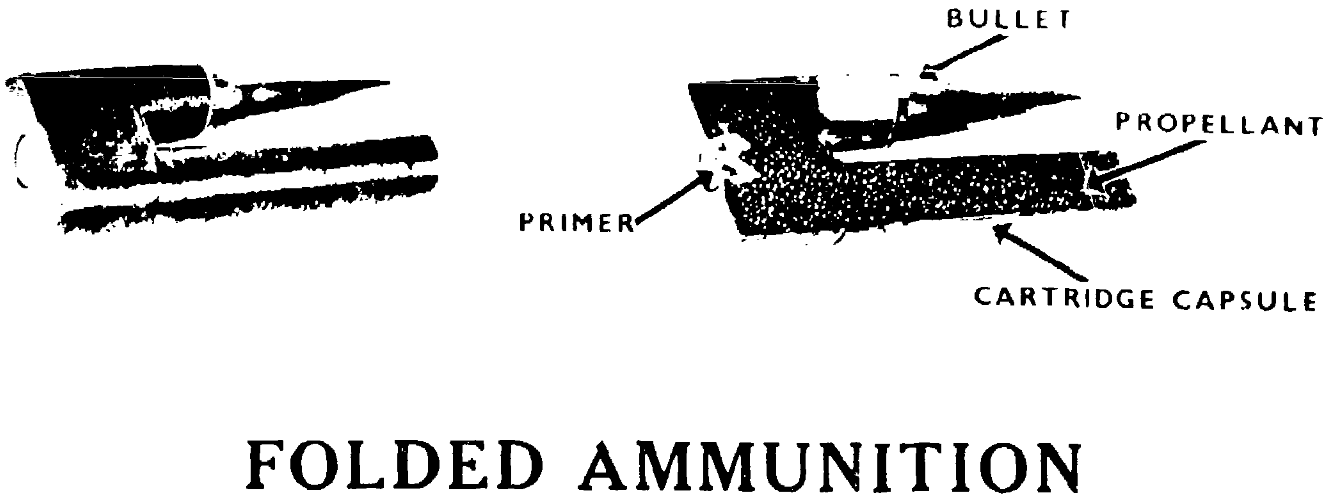


Figure 21. Assembled 5.56 mm Folded Cartridge

Automatic Firing Test Fixtures

The ability to feed a two-pronged folded cartridge on an automatic basis posed a question that could only be answered by actual experimentation. In the interest of minimizing cost and taking maximum advantage of existing hardware, automatic test fixtures were evolved through modification of standard weapons. Two weapons, the M16A1 and a Belgian Light Automatic rifle were chosen to provide latitude to pursue different design approaches based upon two significantly different operating mechanisms. In each case, the weapon was fitted with a 5.56 mm barrel chambered for the folded 5.56 mm FABRL cartridge. Magazines were designed for feeding the Folded Ammunition and appropriate modifications were made to the bolt and bolt carrier to provide the proper feed and mating with the folded design chamber. In order to make use of the highly desirable front end case ejection advantages of the folded system approach, ejector systems were fitted to the weapons and gas operating systems modified to provide satisfactory cartridge case removal. The modified weapons are shown in Figure 22. Details of the new and modified parts for both weapons are contained in Appendixes D and E.

Firing tests were conducted in both weapons to provide empirical data for refinement of operating mechanisms design resulting in evolution of fixtures which satisfactorily demonstrated that Folded Ammunition could be automatically fed, fired and ejected. Figure 23 shows a firing sequence representing a six-round burst from the modified M16A1 test fixture at a cyclic rate of 706 s.p.m.

The firing cycle shown starts with the bolt in battery with a round in the chamber. Propellant gas from the first round fired pressurizes the bolt carrier. Then in proper sequence, the bolt unlocks and the expeller lever engages the expeller shaft pushing the fired case out of the chamber. As the bolt continues rearward, it permits the next round to enter from the magazine which is located horizontally on the other side of the weapon. This round pushes the fired case from the bolt face and into the ejection port as it moves into position for chambering. The return stroke of the bolt completes the ejection of the fired case and chambers the next round completing the cycle.

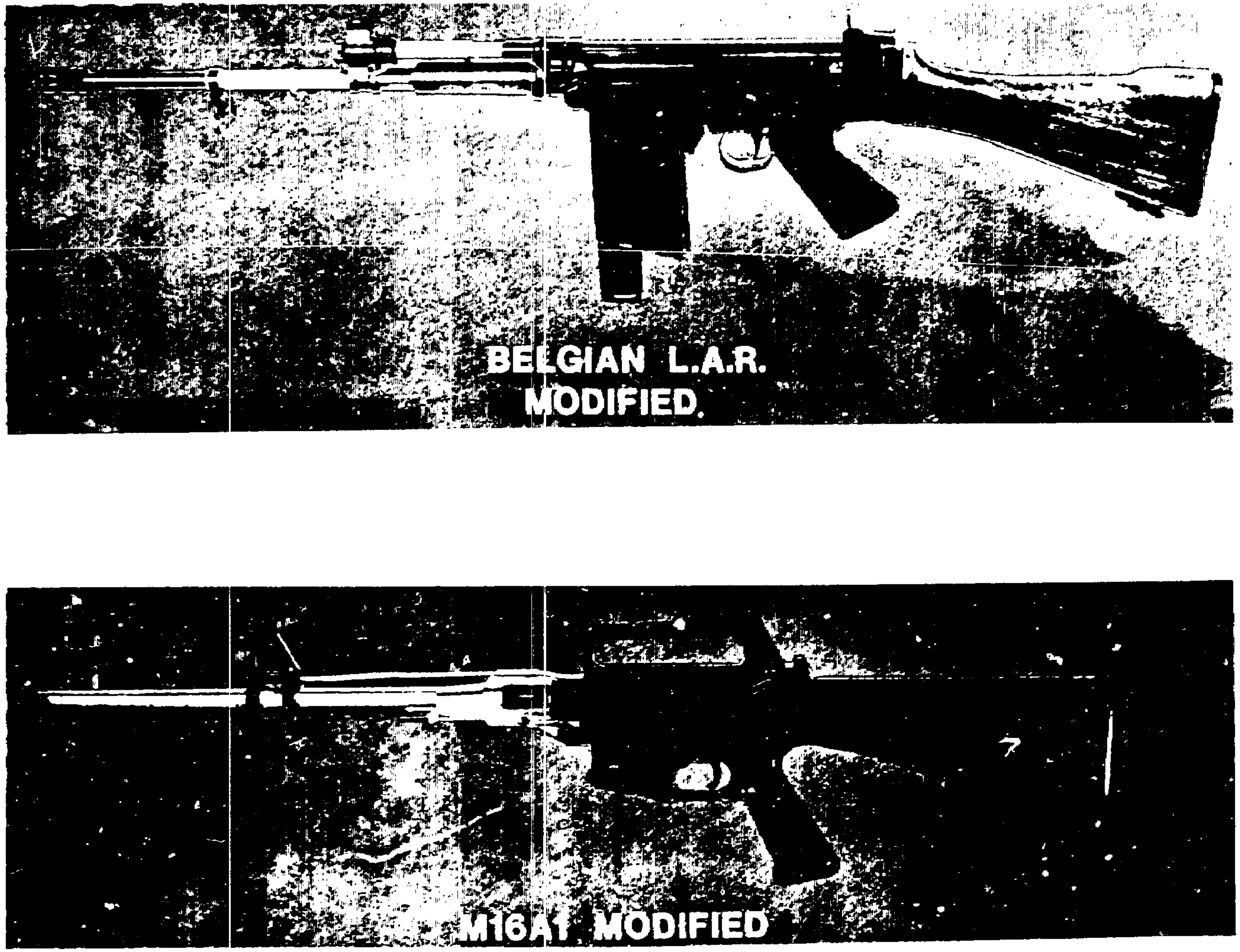


Figure 22. Automatic Firing Test Fixtures

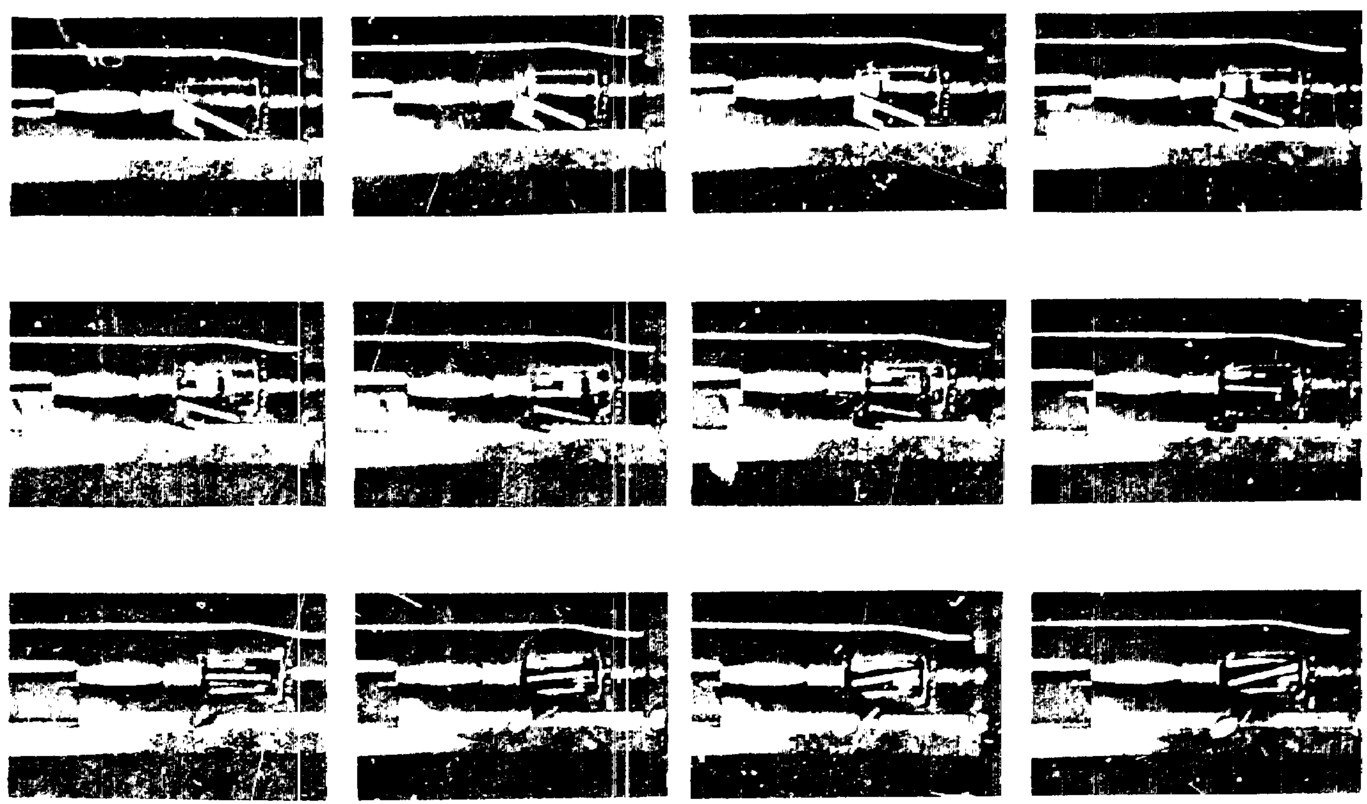


Figure 23 a.   Modified M16A1 Firing Sequence

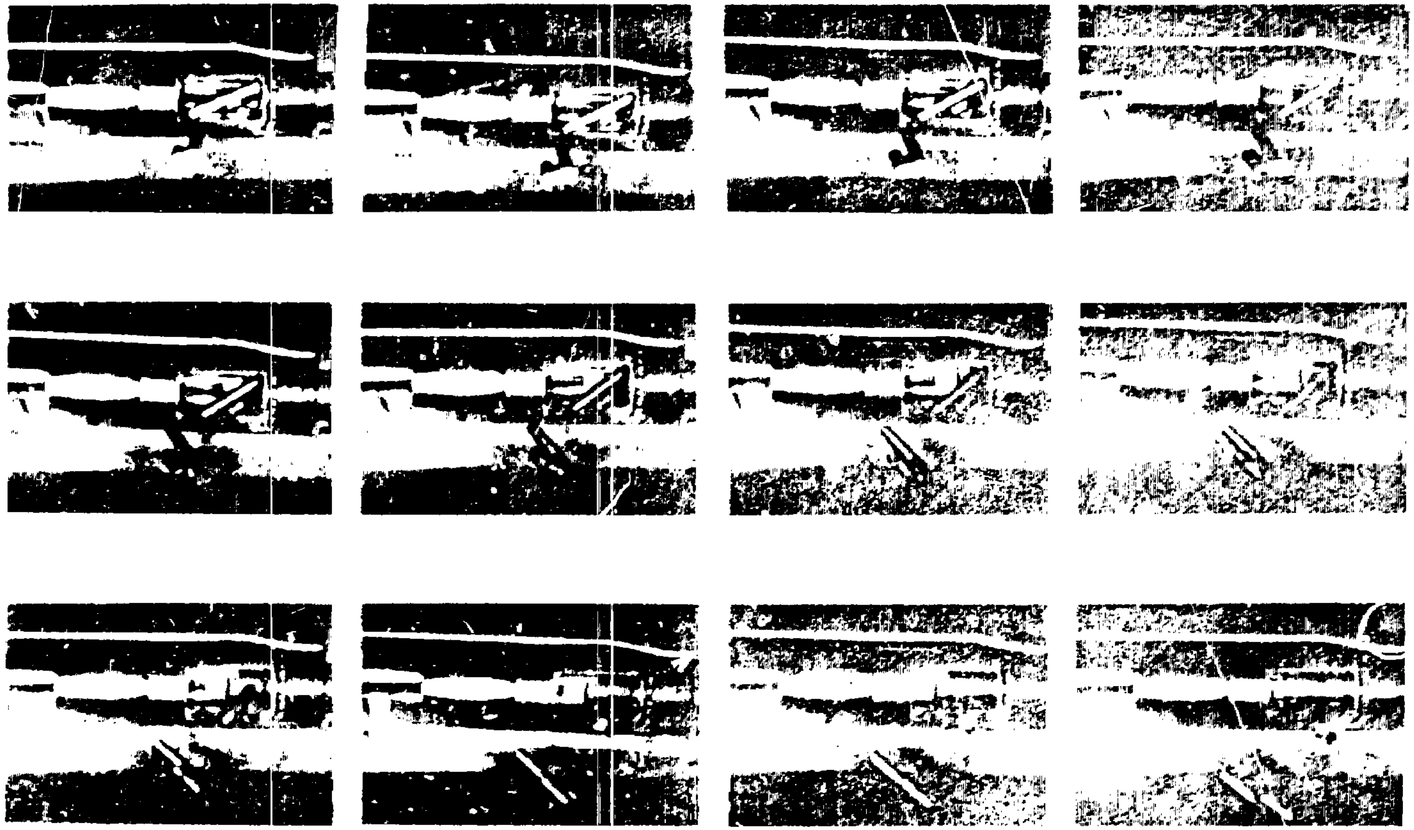


Figure 2 [illegible]

CONCLUSIONS AND RECOMMENDATIONS

The feasibility of the folded ammunition/weapon system has been demonstrated by automatic test firing of experimental prototype ammunition in automatic firing fixtures. Pertinent technology has been established in areas that are essential to the success of this new design approach. These include: first, capability to match ballistic performance of conventional ammunition. Secondly, utilization of a two-piece case which performed satisfactorily in the firing test. Thirdly, the ammunition was fabricated using state-of-the-art impact extrusion machinery. Finally, it was shown that the folded shape ammunition could be automatically fed, fired and ejected with indications that this would not offer a stumbling block in the development of systems using this principle.

As a result of the success experienced in the testing of experimental folded system hardware and the real promise of future system optimization as indicated by the advantages outlined in the introduction to this report, it is recommended that the conceptual phase of exploratory development be completed to provide combat development agencies with hardware oriented data to determine operational capabilities, doctrine and specific material requirements that will provide Army, and very possibly Tri-Service forces with the improved capabilities that can accrue from the folded system design principle. We recommend that the following approach be taken to achieve this goal.

It is felt that the most cost effective program would be to develop required hardware oriented data using small caliber as the test vehicle. In the small caliber test vehicle the common cartridge, common fed rifle and light machine gun approach would not only supply basic data but would be very advantageous in its applicability to the future small arms program. The utility of one common ammunition package unit suitable for use in the rifle or light machine gun would be joined to the most advanced projectile design. In addition to the general information that would be gleaned from a small caliber program, specific parametric studies should also be conducted in both cannon and large caliber to provide the widest spectrum of information.

APPENDIX A

US Patent No. 3857339

United States Patent [19]

Grandy

[11] 3,857,339
[45] Dec. 31, 1974

[54] **AMMUNITION AND WEAPON SYSTEMS**

[76] Inventor: **Andrew J. Grandy**, 2707 Grant Ave., North Hills, Pa. 19038

[22] Filed: **Mar. 30, 1972**

[21] Appl. No.: **239,595**

[52] **U.S. Cl.** **102/38**, 102/40, 102/43
[51] **Int. Cl.** **F42b 5/02**
[58] **Field of Search** .... 102/38, 40, 43, 43 P, 44, 89/35, 35 A, 33

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Primary Examiner—Benjamin A. Borchelt
Assistant Examiner—H. J. Tudor

[57] **ABSTRACT**

A weapon system employing encapsulated ammunition in which the pressure chamber, located axially rearward of the projectile, is longitudinally or axially offset from but in fluid communication with the propellant capsule chamber. This permits use of ammunition rounds having reduced length for given characteristics of prior rounds, resulting in lightest weight and improved bulk characteristics for the ammunition as well as associated weapon systems.

This ammunition concept is adaptable to recoilless, partially recoilless and closed breech ballistic systems in a variety of arrangements.

102 Claims, 67 Drawing Figures

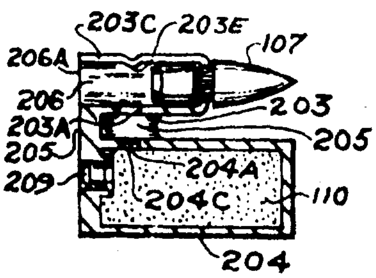


FIG.4

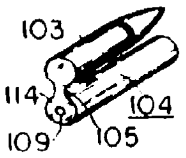


FIG.2

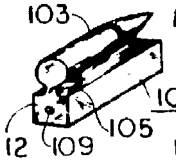


FIG.1

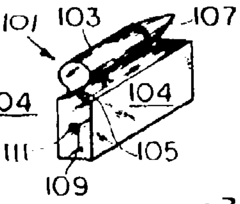


FIG.3

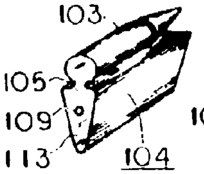
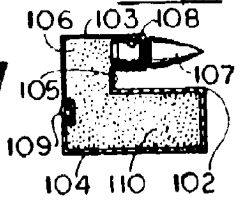


FIG.5



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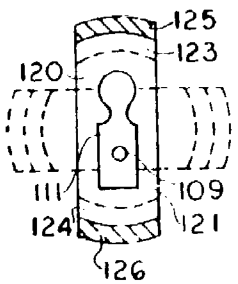

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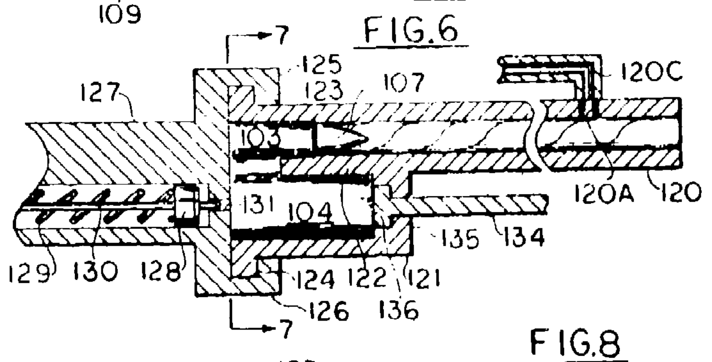

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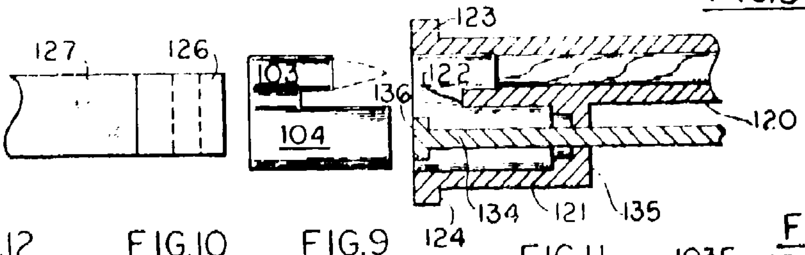


FIG.12

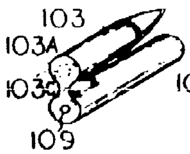


FIG.10

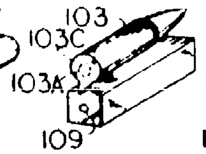


FIG.9

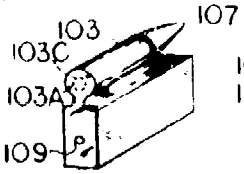


FIG.11

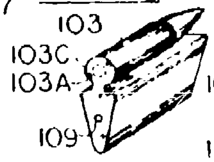


FIG.13

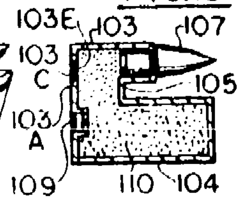


FIG.14

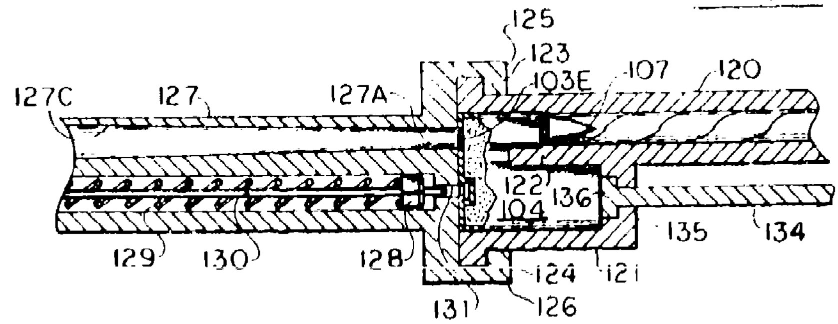


FIG.18

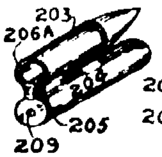


FIG.16

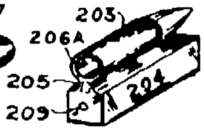


FIG.15

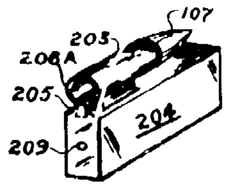


FIG.17

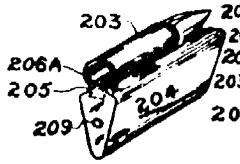
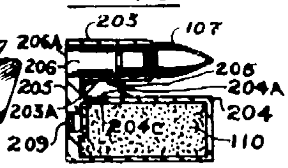


FIG.19



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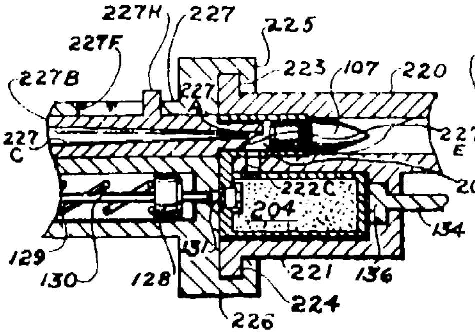

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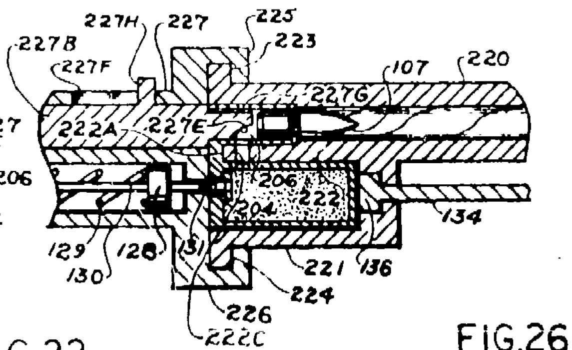

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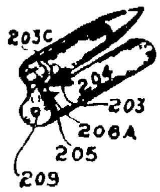
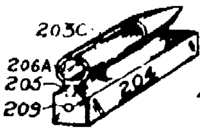


FIG.23



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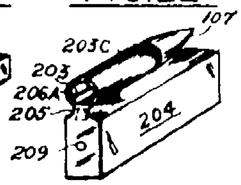


FIG.24

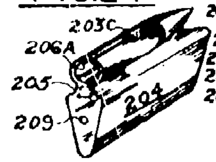


FIG.26

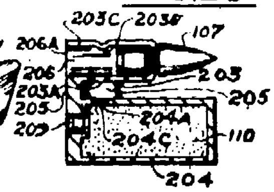
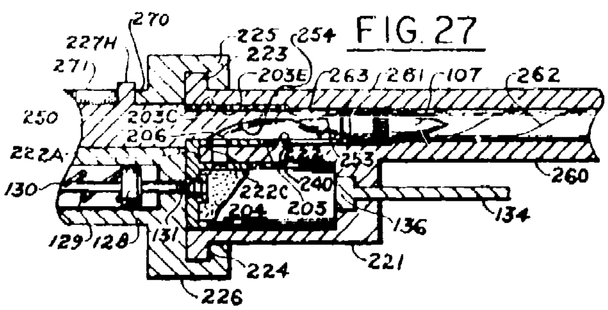


FIG.27



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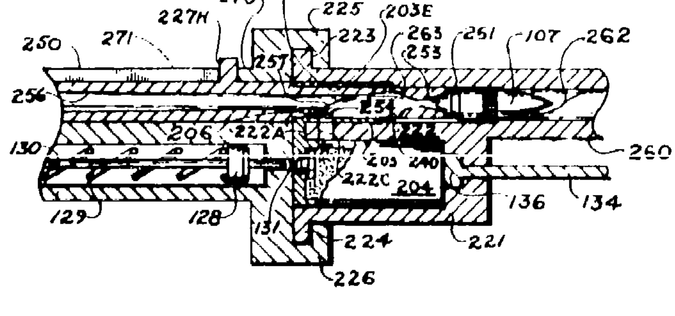


FIG. 32

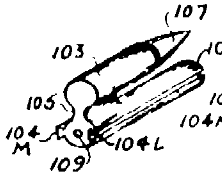
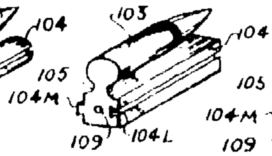


FIG. 30



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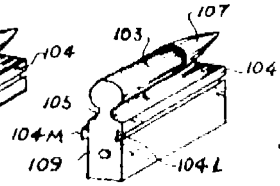

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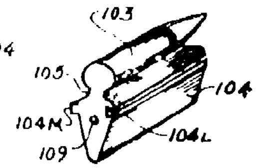

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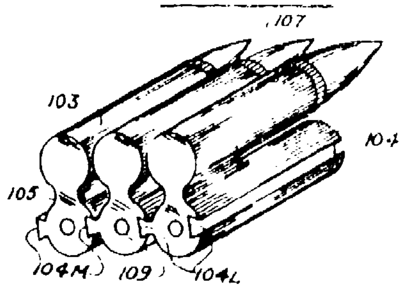


FIG. 33

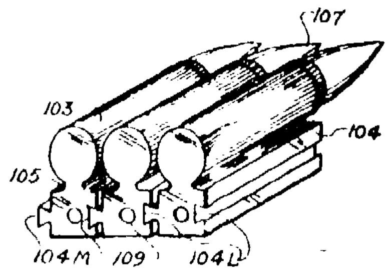


FIG. 35

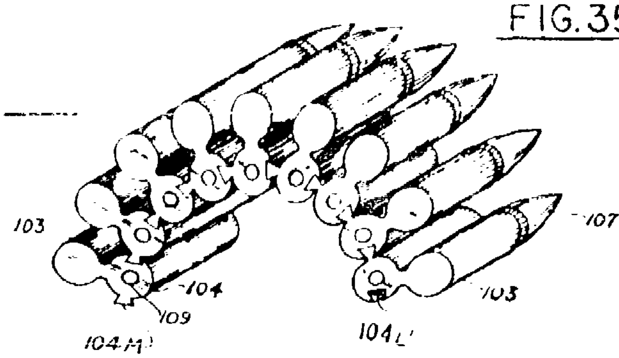


FIG. 36

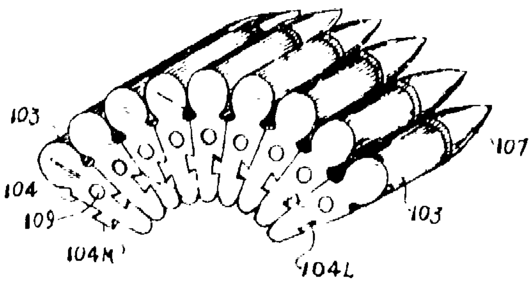


FIG. 38

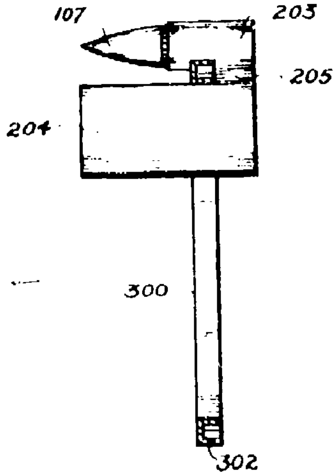


FIG. 37

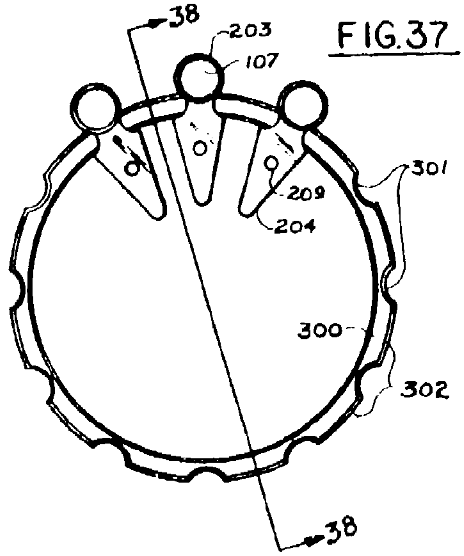
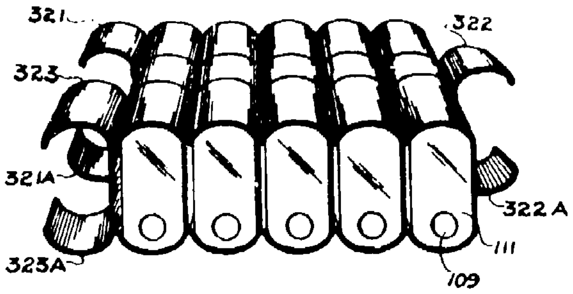
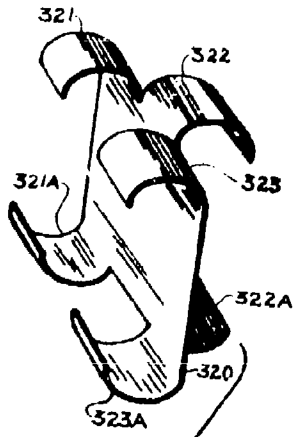


FIG. 39





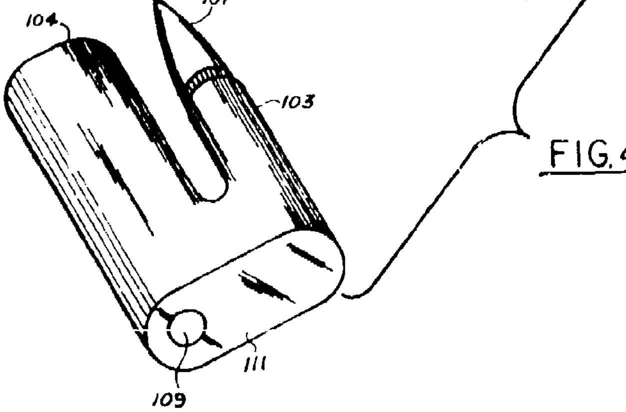


FIG. 40

FIG.44

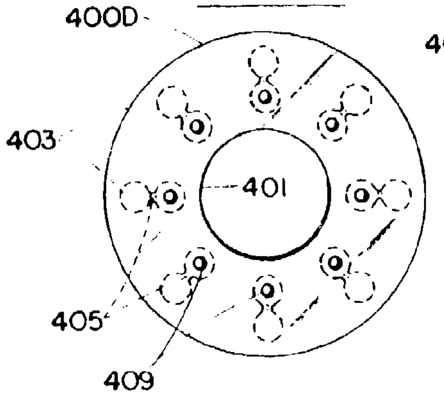


FIG.43

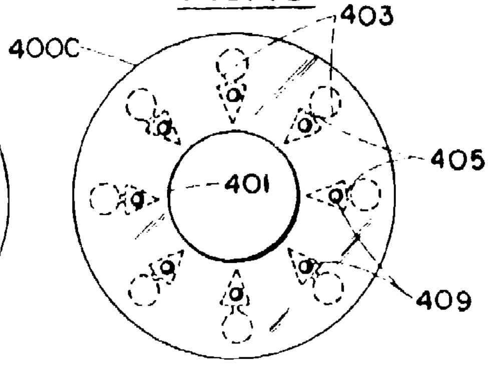


FIG.42

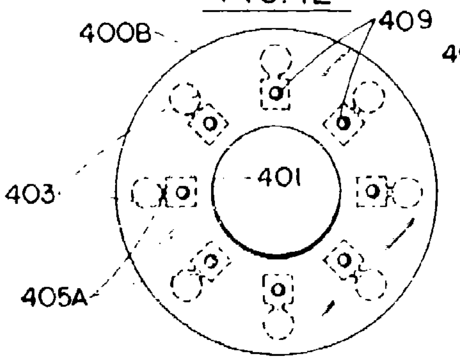


FIG.41

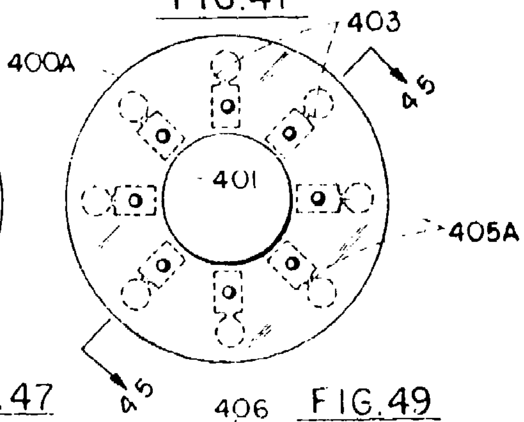


FIG.45

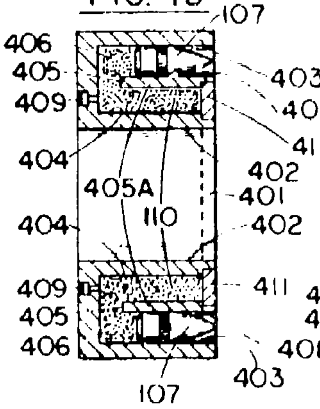


FIG.47

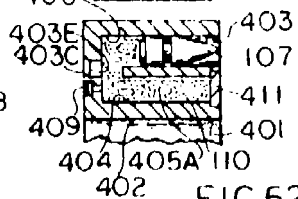


FIG.49

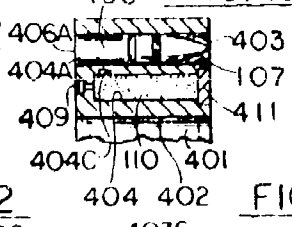


FIG.52

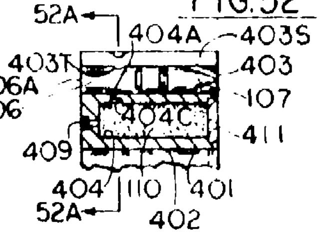


FIG.52A

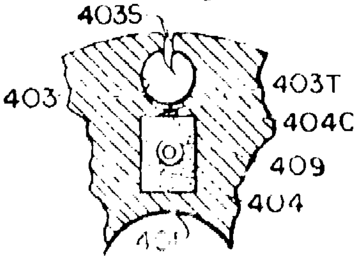


FIG. 46

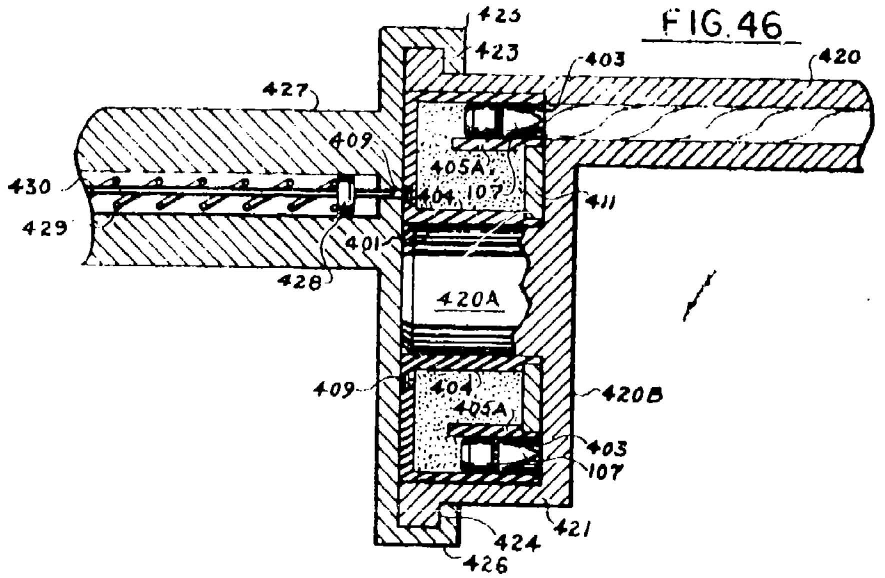
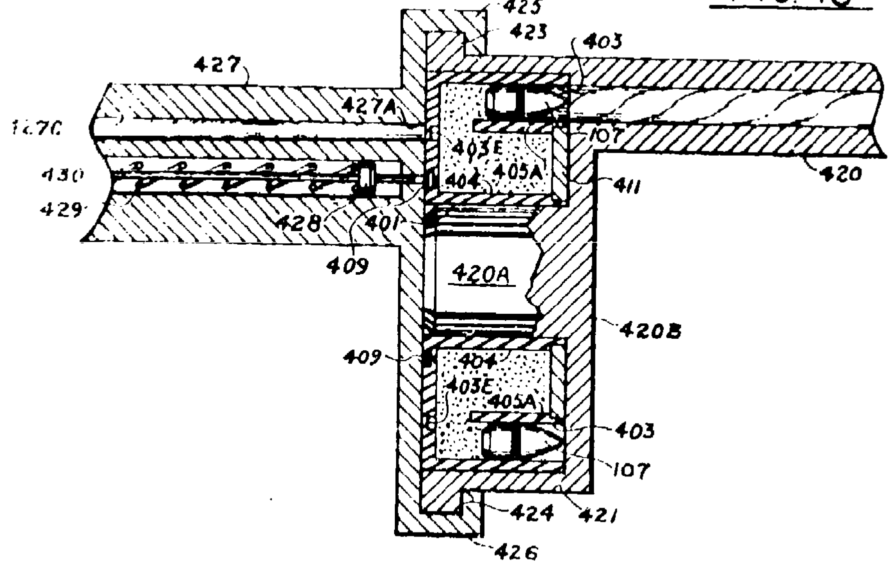

425
423
403
420
427
409
405A
430
404
107
411
429
401
428
420A
409
404
420B
405A
403
107
424
421
426

FIG. 48


425
423
403
427
427A
107
403E
430
404
405A
411
420
429
428
401
409
420A
420B
409
404
403E
405A
403
107
424
421
426

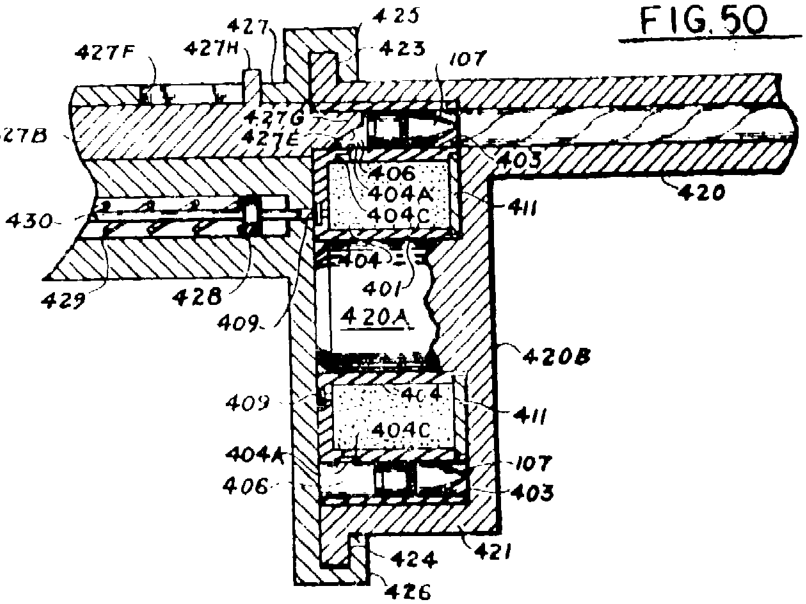
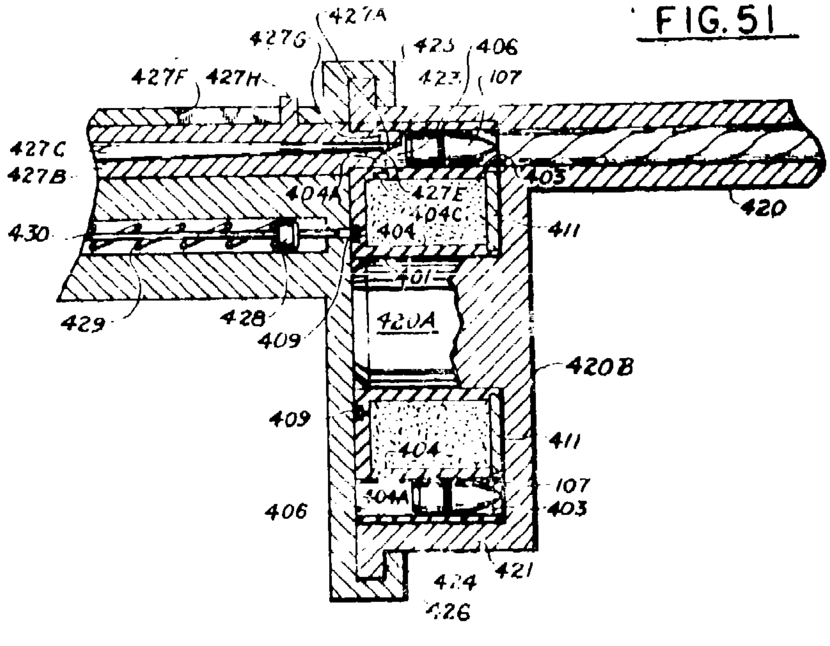

427F
427H
427
425
423
107
427B
427G
427E
406
404A
404C
403
420
411
430
404
401
420A
429
428
409
420B
409
404
404C
411
404A
107
406
403
421
424
426

FIG. 50


427A
427G
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406
427F
427H
423
107
427C
427B
404A
427E
404C
403
420
430
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420B
409
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411
404A
107
406
403
421
424
426

FIG. 51

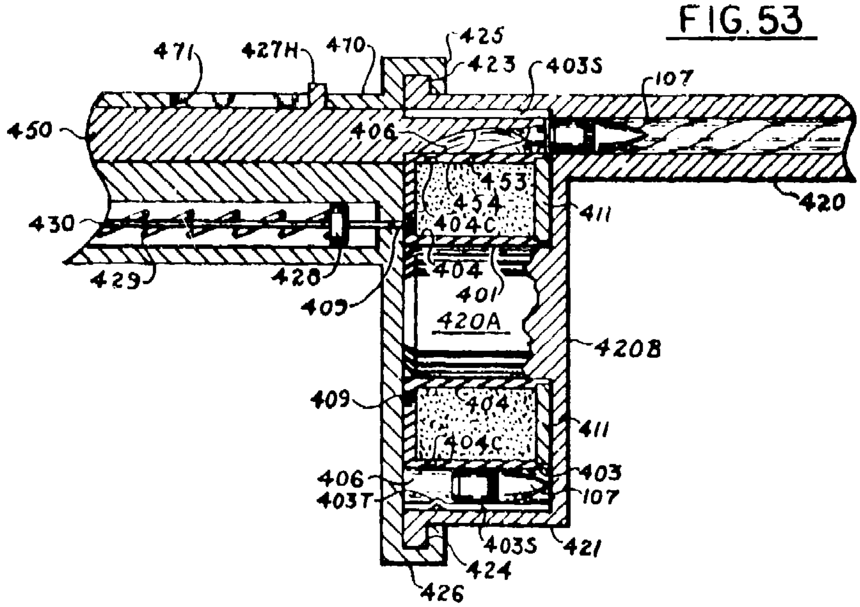
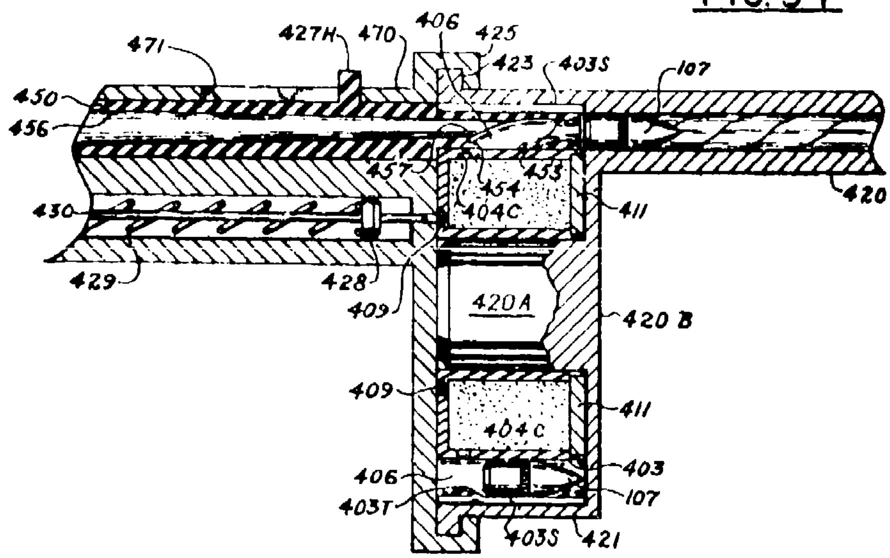

471
427H
470
425
423
403S
107
450
406
453
454
404C
411
420
430
429
428
404
401
409
420A
420B
409
404
404C
411
406
403T
403
107
403S
421
424
426

FIG. 53


471
427H
470
406
425
423
403S
107
450
456
457
454
453
404C
411
420
430
429
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409
420A
420 B
409
411
404C
406
403T
403
107
403S
421

FIG. 54

FIG. 56

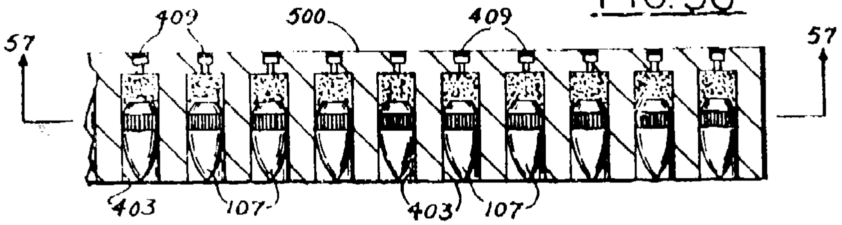


FIG. 57

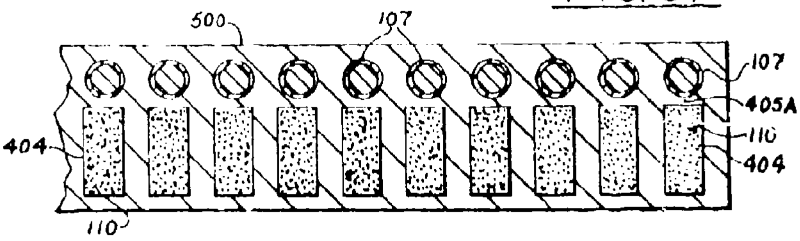


FIG. 55

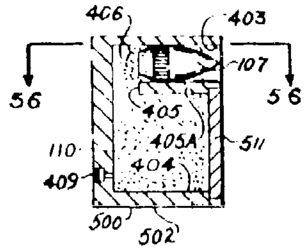


FIG. 59

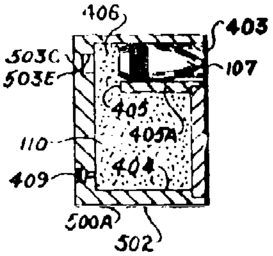


FIG. 60

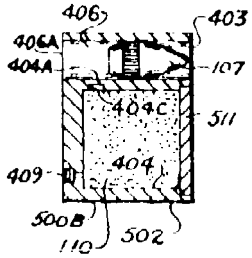


FIG. 61

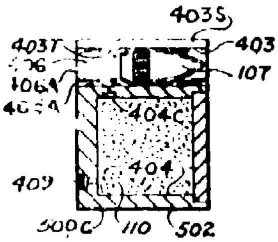


FIG. 58

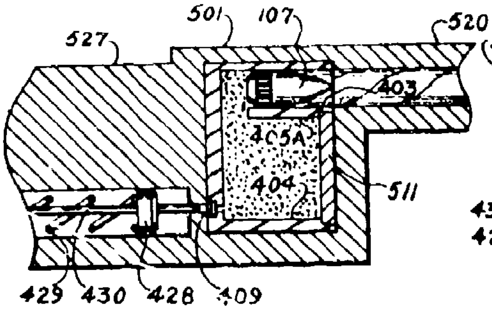


FIG. 62

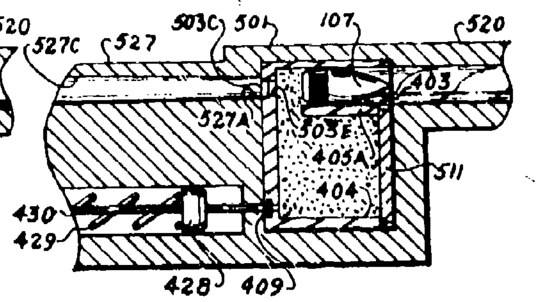


FIG. 63

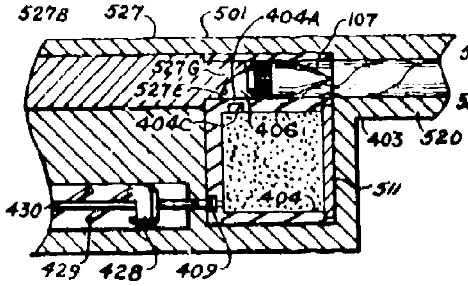


FIG. 64

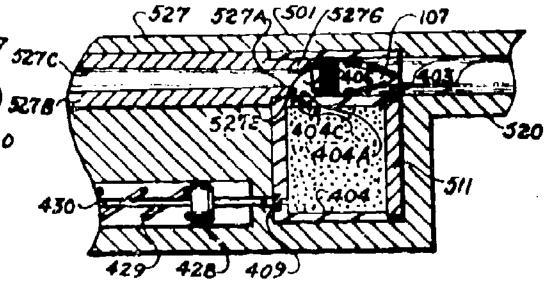


FIG. 65

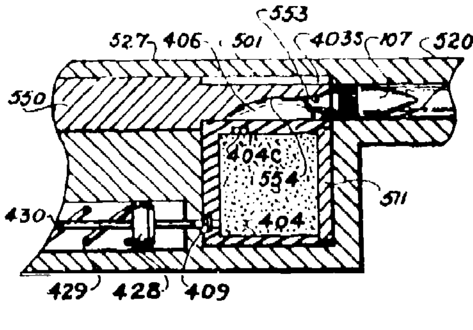
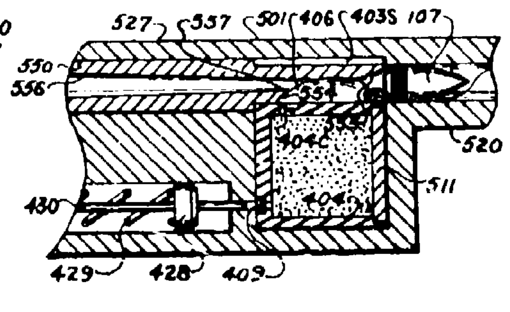


FIG. 66



AMMUNITION AND WEAPON SYSTEMS

The invention described herein may be manufactured, used, and licensed by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to ammunition and weapon systems therefor, and more particularly to a variety of such systems each having the capacity to utilize cartridge capsule ammunition.

Present day cylindrical ammunition does not represent the most efficient, over-all cartridge with respect to bulk and weight.

It is an object of the invention to provide weapon arrangements and cartridge capsule ammunition rounds for use therewith which are of lightness in weight and have improved bulk characteristics.

Another object of the invention is to provide such ammunition and weapon arrangements that can be advantageously used as partially recoilless, fully recoilless or closed breech ballistic systems.

A further object of the invention is to provide such arrangements that can be advantageously used in either fixed projectile or bolt rammed projectile systems.

A further object of the invention is to provide such arrangements that facilitate an improved manner of removing spent ammunition rounds from the firing chamber of the weapon.

A still further object of the invention is to provide means for attaching the cartridges in arrangements that can be advantageously used in single shot, semi-automatic and fully automatic weapons.

Another object of the invention is to provide specific capsule cartridge shapes resulting in efficient packaging arrangements which can be advantageously used in rotary fed and in-line fed single shot, semi-automatic and fully automatic weapons.

A further object of the invention is to provide both individual capsule cartridges and multi-cavity, unitized cartridge arrangements which can be advantageously used in rotary fed and in-line fed, single shot, semi-automatic and fully automatic weapons.

These and other objects, features and advantages will become apparent from the following description and accompanying drawings in which:

FIGS. **1-4** are perspective views of a variety of ammunition rounds embodying the principles of the invention.

FIG. **5** is a longitudinal sectional view of the FIG. **1** round.

FIG. **6** is a longitudinal sectional view of a portion of a closed breech weapon system for the FIG. **5** round.

FIG. **7** is a sectional view taken substantially along lines **7--7** of FIG. **6**.

FIG. **8** is an exploded view of certain portions of the FIG. **6** arrangement subsequent to firing.

FIGS. **9-13** are views, similar to FIGS. **1-5**, of a modified group of ammunition rounds.

FIG. **14** is a longitudinal sectional view of a portion of a recoilless or partially recoilless weapon system for the FIGS. **9-13** rounds.

FIGS. **15-19** are similar views of a modified group of ammunition rounds.

FIGS. **20** and **21** are longitudinal sectional views of modified portions of weapon systems associated with the rounds of FIGS. **15-19**.

FIGS. **22-26** are views, similar to FIGS. **15-19**, of a modified group of ammunition rounds.

FIGS. **27** and **28** are longitudinal sectional views of modified portions of weapon systems associated with the rounds of FIGS. **22-26**.

FIGS. **29-32** are perspective views of a further modified group of rounds.

FIGS. **33** and **34** are perspective views of clusters of capsules of the FIG. **30** and FIG. **32** rounds, respectively.

FIGS. **35** and **36** are perspective views of clusters of capsules of the FIG. **32** and FIG. **31** rounds, respectively.

FIG. **37** is an end view of a modified form of cluster arrangement.

FIG. **38** is a sectional view taken along line **38--38** of FIG. **37**.

FIG. **39** is a perspective view of a modified cluster arrangement.

FIG. **40** is an exploded perspective view of a linking clip member and ammunition round used in the FIG. **39** arrangement.

FIGS. **41-44** are end views of integral multiple cavity containers of cartridge capsule portions arranged in cylindrical form.

FIG. **45** is a sectional view taken along line **45--45** of FIG. **41**.

FIG. **46** is a longitudinal sectional view of a portion of a closed breech weapon system for the FIGS. **41-44** ammunition.

FIG. **47** is a longitudinal sectional view, partially broken away, of multi-cavity container modifications for the FIGS. **41-44** cylinders.

FIG. **48** is a longitudinal sectional view of a portion of a recoilless or partially recoilless weapon system for the FIG. **47** ammunition containers.

FIG. **49** is a view, similar to FIG. **47**, of further multi-cavity container modifications for the FIGS. **41-44** ammunition cylinders.

FIGS. **50** and **51** are longitudinal section views of modified portions of weapon systems associated with the FIG. **49** ammunition containers.

FIG. **52** is a view, similar to FIG. **49**, of further multi-cavity container modifications for the FIGS. **41-44** ammunition cylinders, and FIG. **52A** is a partial sectional view taken along line **52A—52A** of FIG. **52**.

FIGS. **53** and **54** are longitudinal sectional views of modified portions of weapon systems associated with the FIG. **52** ammunition containers.

FIG. **55** is a longitudinal sectional view of a propellant capsule portion of a multi-cavity rectangular prism ammunition cluster.

FIG. **56** is a partial sectional view taken along line **56—56** of FIG. **55**.

FIG. **57** is a sectional view taken along line **57—57** of FIG. **56**.

FIG. **58** is a longitudinal sectional view of a portion of a closed breech weapon system for the FIG. **55** ammunition prisms.

FIGS. **59-61** are views similar to FIG. **55** of modified arrangements.

FIG. **62** is a longitudinal sectional view of a portion of a recoilless or partially recoilless weapon system for the FIG. **59** ammunition prisms.

FIGS. **63** and **64** are longitudinal sectional views of modified portions of weapons systems associated with the FIG. **60** ammunition prisms.

FIGS. 65 and 66 are longitudinal sectional views of modified portions of weapon systems associated with the FIG. 61 ammunition prisms.

The FIG. 1 encapsulated ammunition round shown generally at 101 includes a thin capsule 102 (FIG. 5) of ferrous, non-ferrous or synthetic material of predetermined contour. Preferably ferrous, the cartridge capsule has an elongated substantially cylindrical chamber 103 and a propellant chamber 104 integral therewith but longitudinally offset therefrom. An intermediate necked down metering orifice 105 interconnects or fluidly communicates the propellant chamber 104 with the pressure chamber portion 106 of the cylindrical chamber 103. A projectile 107 is slidably received in the forward barrel portion 108 of chamber 103 in longitudinal alignment with the pressure chamber portion 106. An appropriate percussion primer 109 is secured in a suitably recessed and apertured rear wall portion of the capsule 102, preferably aligned with the propellant chamber 104 which contains the desired granular, flake, sheet or solid grain propellant 110. The transverse sections and end walls 111 of the FIG. 1 round propellant chamber are of substantially rectangular configuration. The embodiments of FIGS. 2, 3, and 4 are of substantially the same construction as the FIG. 1 round, but the transverse sections and corresponding end walls 112, 113, and 114 are of configurations which are substantially square, triangular, and cylindrical, respectively.

The portion of the closed breech weapon system (FIGS. 6–8) includes a substantially cylindrical barrel 120 having an axially offset capsule chamber 121 integral therewith, both the barrel and capsule chamber having a somewhat shortened common wall portion 122 to accommodate the FIG. 1 round prior to firing (FIG. 6) which function is accomplished after the barrel lug 123 and capsule chamber lug 124 are simultaneously engaged by the opposed hook or locking lugs 125, 126 of the rotatable and longitudinally translatable breech means or bolts 127. The closed breech type bolt 127 has a firing pin 128, biased by spring 129 surrounding the firing pin rod or stem 130, with its receptive breech opening 131 in operative alignment with the primer of the round to be fired. The barrel 120 has a transverse opening 120A and an appropriate conduit 120C to direct gas energy for further weapon operation. An ejection rod 134 is slidably mounted in an apertured forward wall 135 of capsule chamber 121 to rearwardly eject a fired or undesired round when the bolt 127 has been rotated out of locking engagement and translated rearward (FIG. 8). The chamber wall 135 is internally recessed to normally seat the ejection rod head 136. The capsule chamber 121 has a cross-section of substantially rectangular configuration to receive the propellant capsule portion of the FIG. 1 round. For firing of the FIGS. 2, 3, or 4 rounds, this transverse section configuration is substantially square, triangular or cylindrical, respectively.

The ammunition rounds of FIGS. 9–13 are distinguished from the FIGS. 1–5 rounds in that the upper cylindrical portion 103A of the thin capsule rearward walls each have a press fitted blow out disc 103C or a pre-formed weakened section as defined by an internal recess 103E (FIG. 13) in the pressure chamber rearward wall portions. The disc or weakened section 103C operatively aligns with the recoilless or partially recoilless weapon nozzle 127A (FIG. 14) of the rearwardly enlarging tapered recoil vent 127C provided in the breech or bolt 127. The forward internal surface of the nozzle 127A is formed with a substantially sharp annular edge to facilitate positive shearing action upon the operative portion of the weakened section 103C when sufficient propellant pressure is generated in the pressure chamber portion of cylindrical chamber 103 by the ignited propellant 110.

The ammunition rounds of FIGS. 15–19 contain several variations for their operative firings in the fixed projectile, inserted bolt weapon systems of FIGS. 20 and 21. The capsule cylindrical chamber 203 has an open rearward end 206A adjacent its pressure chamber portion 206, and contains a bottom gas vent 203A which is substantially in vertical alignment with the blow out disc or pre-formed weakened section 204A defined by internal recess 204C in the upper wall of capsule propellant chamber 204. A suitable primer 209 is located in the rearward wall of the propellant chamber which is integrally connected with chamber 203 by the forwardly opening cavity side and rearward walls 205.

In both the FIG. 20 closed breech and FIG. 21 recoilless or partially recoilless weapon systems the common wall portion 222, for the cylindrical barrel 220 and axially offset capsule chamber 221, terminates with a rearwardly extending tongue 222A that fits into the connecting cavity and abuts the cavity rear wall 205 upon loading of the round. Tongue 222A has a vertical gas vent passage 222C that places capsule chambers 203 and 204 in fluid communication upon firing of the round as the developed pressure gas blows out a portion of the weakened section 204A at the sharp edged passage 222C and enters the pressure chamber 206 adjacent the concave recess 227E provided in the forward face of the reduced tip portion 227G on the bolt 227B. The bolt 227B is longitudinally translatable in the rotational and longitudinally translatable breech member 227. With bolt lug or pin 227H slidable in longitudinal slot 227F of member 227, the bolt is withdrawn rearwardly prior to operative disengagement and engagement of the breech hooking or locking lugs 225, 226 with the barrel lug 223 and capsule chamber lug 224. A recoilless or partially recoilless weapon nozzle 227A (FIG. 21) is provided in bolt 227B at the juncture of the rearwardly enlarging tapered recoil vent 227C and the concave recess 227E.

The ammunition rounds of FIGS. 22–26 are distinguished from the FIGS. 15–19 rounds in that the upper portion of the capsule cylindrical chamber 203 has a lengthwise split or slotted wall 203C. A plurality of camming or dimple means 203E are provided on the internal surface of the pressure chamber portion 206 adjacent the slotted wall 203C and just rearward of projectile 107. This will facilitate the release and barrel chambering of the projectile as the longitudinally translatable bolt 250 (FIGS. 27 and 28) cams the dimple means 203E to spread the inwardly directed substantially annular flange 240 and pushes the projectile to its final pre-firing position in barrel 260. Cylindrical barrel 260 differs from barrel 220 in that an additional intermediate internal recessed surface 261 is provided rearwardly adjacent the rifling 262 to accommodate the forwardmost portion of bolt 250 in its firing position, while a further recessed surface 263 accommodates the spread portions of split chamber wall 203. The longitudinal slot 271 of the rotational an longitudinally translatable breech member 270 is substantially longer than slot 227F, such that the lug or pin 227H on bolt 250 can be accommodated for its intended full stroke. The forward end of bolt 250 has a forwardly opening nozzle surface 253 that intersects with a concave recess 254 provided on the underside of the bolt, so that the pressure chamber portion 206 fluidly communicates gas vent passage 222C with the rearward end of projectile 107 in both the FIG. 27 closed breech and FIG. 28 recoilless or partially recoilless weapon systems. The rearwardly enlarging tapered recoil vent 256 (FIG. 28) in bolt 250 intersects concave recess 254 at the effective recoilless nozzle throat 257.

The ammunition rounds of FIGS. 29–32 are each provided with a longitudinally extending groove 104L of dovetail transverse configuration throughout the entire length of a selected propellant capsule chamber wall portion 104, as well as a rib or tongue protuberance 104M of substantially similar dovetail configuration along the length of an opposed longitudinally extending wall portion. Where each substantially similar round has its corresponding tongue and groove surfaces 104M, 104L extending in parallel planes, successive similar cartridge capsules can be integrally linked or connected (FIGS. 33, 34) in a substantially straight line cluster pattern. The corresponding dovetailed tongue and groove surfaces of similar rounds can also be formed or oriented in non-parallel planes such that successive similar capsules can be integrally linked or matingly joined to form an arcuate or circular cluster pattern or array (FIGS. 35, 36). Each cluster may be held in an appropriate feeding and stripping mechanism (not shown) which will enable the corresponding breech member to longitudinally translate each stripped round into its weapon position prior to rotational locking motion of the breech member. It is contemplated that each of the previously described rounds (FIGS. 5, 13, 19, and 26) may be so dovetailed for integral linking or connecting purposes, and each fired in their respective weapons which can be slightly altered to accommodate the protruding rib or tongue. The breech locking arrangement on each of the respective weapons also can be relocated to a position somewhat rearward to enable the forward portion of the bolt to have a cross-sectional shape similar or identical to that of the particular cartridge to be chambered.

A modified cluster arrangement (FIG. 37) includes an annular linking member 300 of substantially rearwardly opening U-shaped configuration (FIG. 38) having a plurality of equally spaced arcuate or concave recesses 301 along its peripheral or outermost surface 302 to accommodate an arcuate undersurface portion of the capsule cylindrical chamber 203 on the FIG. 17 ammunition rounds. The rounds are slid forward onto the metal link ring 300 at each recessed surface 301 such that the ring cradles each round at the rearmost clearance between its propellant chamber 204 and projectile 107 or its supporting cylinder 203. It is contemplated that the ring 300 be formed to cluster similar rounds from any of the groups associated with FIGS. 5, 13, 19 or 26 and that the cluster can be suitably mounted and indexed on weapon system cylindrical stubs of the type to be later described with unitary and radially arranged ammunition containers or clusters.

The modified cluster arrangement (FIG. 39) employs a plurality of individual clip members 320 (FIG. 40) which are shown to be joined or linked by insertion of respective FIG. 1 capsule cartridges 101 into selected substantially C-shaped wings or clip portions of adjacent clips 320. Each link member 320 is formed from a pre-slotted blank or metal member and contains a substantially straight integral or common portion and upper and lower groups of alternately disposed loop portions 321, 322, 323 and 321A, 322A, 323A. The upper loops are formed to enable simultaneous reception of the cartridge capsule cylindrical chamber 103 and projectile 107 by longitudinally spaced loops 323, 321 of one link and intermediate loop 322 of an adjacent link, while the substantially rectangular propellant capsule portion 104 is clipped or received by respective loop portions 323A, 321A of the one link and middle loop 322A of the adjacent link. The substantially straight line type of cluster (FIG. 39) so formed can be used in the same manner as the unitary rectangular ammunition containers or clusters to be later described. Clip members 320 can also cluster separate groups of cartridges of FIGS. 9, 15, 22. The width of the straight common portion of the C-shaped clip portions can be reduced such that similar clips can cluster separate groups of cartridges of FIGS. 2, 10, 16, 23 as well as FIGS. 4, 12, 18, 25. The clipping or clustering of separate groups of cartridges of FIGS. 3, 11, 17, 24 can be accomplished where the pre-formed slits of the clip blank are of sufficient length that the lower loops can be bent or inclined to facilitate insertion of the rounds.

The integral or unitary multiple cavity containers 400A, 400B, 400C, 400D (FIGS. 41–44) are preferably made of ferrous, non-ferrous or synthetic material in cylindrical form to contain a cluster of cartridge capsule portions similar to the respective ammunition rounds of FIGS. 1–4. The annular container 400A has a central cylindrical opening 401 (FIGS. 41,45) and includes a plurality of circumferentially spaced cavities that are defined by integral cartridge capsule portions 402 each having a cylindrical chamber 403 and longitudinally offset propellant chamber 404 which is interconnected by metering orifice 405 at the rearmost edge of separating wall 405A. Orifice 405 fluidly communicates the propellant chamber 404 with the pressure chamber portion 406 of chamber 403 whose forward barrel portion 408 slidably receives projectile 107. A suitable primer 409 is secured in an appropriately recessed and apertured rear wall portion of each cartridge capsule portion 402, preferably aligned with propellant chamber 404 that contains the desired propellant 110. An appropriate substantially annular ring shaped end wall closure 411 is suitably secured with cement or the like to seal the forward end of each propellant chamber 404 having a rectangular transverse configuration. Containers 400B, 400C, and 400D will require similar ring end wall closures that suitably seal their respective propellant chambers of substantially square, triangular and cylindrical configurations.

The central opening 401 of each annular container 400A, 400B, 400C, 400D, is slidingly received on the cylindrical stub 420A (FIG. 46) that extends rearwardly from the weapon housing 420B and parallel to but substantially offset or below the barrel 420 of the closed breech weapon system for the FIGS. 41–44 cylindrical capsule containers or clusters. Preferably, stub 420A has a tapered rearward end and is centrally located within the rearwardly opening weapon housing annular wall 421 to facilitate the reception of the cylindrical or annular containers that can be delivered by the longitudinally translatable breech means or bolt **427** prior to rotation of the breech to simultaneously secure the opposed hook or locking lugs **425, 426** in engagement with the weapon housing lugs **423, 424.** After each successive cartridge capsule portion is suitably indexed to a firing position by means not shown, actuation of spring **429** surrounding the rod or stem **430** of firing pin **428** will initiate the aligned primer **409** to fire the round. When all of the rounds in the cluster or container have been fired, bolt **427** is rotated out of locking engagement and translated rearward to permit the spent container to be replaced by another multi capsule cluster or container.

The multi-cavity ammunition containers of FIG. **47** are distinguished from the FIG. **45** ammunition cylinders in that the rearward walls of each cartridge capsule portion **402** have a blow out disc or pre-formed weakened section **403C** as defined by internal recess **403E** adjacent the pressure chamber portion **406.** Each recess **403E** operatively aligns with the recoilless or partially recoilless weapon sharp edged nozzle **427A** (FIG. **48**) of the rearwardly enlarging tapered recoil vent **427C** provided in the breech or bolt **427.**

The ammunition containers of FIG. **49,** that are fired in the fixed projectile, inserted bolt weapon systems of FIGS. **50** and **51,** are distinguished from the FIG. **45** cylindrical clusters in that each cartridge capsule portion **402** has its cylindrical chamber **403** defined by a through bore to provide an open rearward end **406A** adjacent its pressure chamber portion **406** for reception of reduced tip portion **427G** (FIGS. **50, 51**) on the forward end of the bolt **427B** that is longitudinally translatable in the rotational and longitudinally translatable breech member **427.** Preferably, a rearward upper wall portion of each capsule propellant chamber **404** is internally recessed at **404C** to provide a preformed weakened section or blow-out disc **404A** in the full common wall that separates cavities **403** and **404.** When each primer **409** is actuated or initiated, developed pressure gas blows out the weakened section or disc **404A** and enters pressure chamber **406** adjacent the concave recess **427E** provided in the forward face of bolt tip **427G.** With bolt pin **427H** slidable in longitudinal slot **427F** of member **427,** the bolt is withdrawn substantially simultaneous with indexing of the associated ammunition cylinder by means not shown, and when a replacement ammunition cylinder is required, bolt withdrawal is followed by operative disengagement and engagement of the breech or locking lugs **425, 426** with the weapon housing lugs **423, 424.** A recoilless or partially recoilless weapon nozzle **427A** (FIG. **51**) is provided in bolt **427B** at the juncture of the rearwardly enlarging tapered recoil vent **427C** and the concave recess **427E.**

The multi-cavity ammunition containers of FIG. **52** are distinguished from the FIG. **47** ammunition cylinders in that each cartridge capsule portion **402** has the upper portion of its cylindrical chamber **403** provided with a lengthwise split or slotted wall **403S** (FIGS. **52, 52A**). A plurality of camming or dimple means **403T** are provided on the internal surface of each pressure chamber portion **406** adjacent the slotted wall **403S** just rearward of each projectile **107.** This facilitates the release and barrel chambering of the projectile as the longitudinally translatable bolt **450** (FIGS. **53** and **54**) cams the dimple means **403T** to spread the slotted wall and pushes the projectile to its final pre-firing position in barrel **420.** The internal surface of the housing annular wall **421** is of appropriate dimensions that sufficient clearance is provided for lateral spreading of the split cylindrical chambers **403** during the projectile barrel chambering operations. The longitudinal slot **471** of the rotational and longitudinally translatable breech member **470** is substantially longer than slot **427F** (FIGS. **50, 51**), such that the pin **427H** on bolt **450** can be accommodated for the intended full stroke of the bolt. The forward end of bolt **450** has a forwardly opening nozzle surface **453** that intersects with a concave recess **454** provided on the underside of the bolt so that each pressure chamber portion **406** fluidly communicates developed pressure gas from the respective propellant chamber **404** with the rearward end of the corresponding projectile **107** during operation of both the FIG. **53** closed breech and FIG. **54** recoilless or partially recoilless weapon systems. The rearwardly enlarging tapered recoil vent **456** (FIG. **54**) in bolt **450** intersects concave recess **454** at the effective recoilless nozzle throat **457.**

The unitary or integral multiple cavity ammunition cluster **500** (FIGS. **55–57**) is a rectangular prism which is made of materials similar to the aforementioned multi-cavity cylindrical ammunition containers and includes a plurality or cluster of cartridge capsule portions **502** that are integrally arranged in laterally spaced positions across the prism as it is successively moved or fed transversely through the firing chamber **501** (FIG. **58**) of a closed breech weapon system having an integral arrangement for the closed breech or bolt and barrel portions **527** and **520,** respectively. Each cartridge capsule portion **502** is very similar to the cartridge capsule portions **402** of the FIG. **45** ammunition cylinder. Preferably, a rectangular shaped or elongated cover **511** is cemented to an appropriate receptacle therefor extending across the forwardmost portions of the successively arranged propellant chambers **404.** While each of the propellant cavities **404** in the FIG. **55** elongated ammunition prism has been formed with a transverse section of substantially rectangular configuration, the propellant cavities **404** of the rectangular prism may also be of substantially square, triangular and cylindrical configuration, and the end wall closure or seal **511** would not require modification.

The type of multi-cavity ammunition prism **500A** (FIG. **59**) are distinguished from the FIG. **55** ammunition prisms **500** in that the rearward walls of each cartridge capsule portion **502** for each of the prisms is provided with a blow out disc or a pre-formed weakened section **503C** as defined by internal recess **503E** adjacent the pressure chamber portion **406.** Each recess **503E** operatively aligns with the recoilless or partially recoilless weapon sharp edged nozzle **527A** (FIG. **62**) of the rearwardly enlarging tapered recoil vent **527C** provided in the bolt portion **527.**

The type of ammunition prism **500B** (FIG. **60**), that are fired in the fixed projectile, inserted bolt weapon systems of FIGS. **63** and **64,** are distinguished from the FIG. **55** ammunition prisms **500** in that each cartridge capsule portion **502** has its cylindrical chamber **403** defined by a through bore to provide an open rearward end **406A** adjacent its pressure chamber portion **406** for reception of reduced tip portion **527G** (FIGS. **63, 64**) on the forward end of the bolt **527B** that is longitudinally translatable in breech portion **527.** A rearward upper wall portion of each capsule propellant chamber **404** is internally recessed at **404C** to provide a pre-formed weakened section or blow out disc **404A** in the full common wall that separates cavities **403** and **404**. When each primer **409** is actuated or initiated, developed pressure gas blows out the weakened section or disc **404A** and enters pressure chamber **406** adjacent the concave recess **527E** provided in the forward face of bolt tip **527G**. An appropriate pin and slot connection (not shown) between bolt **527B** and breech portion **527** enables the bolt to be withdrawn substantially simultaneous with indexing or feeding of the associated ammunition prism through chamber **501** by means not shown. Bolt **527B** is also withdrawn when a replacement ammunition prism is required. A recoilless or partially recoilless weapon nozzle **527A** (FIG. **64**) is provided in bolt **527B** at the juncture of the rearwardly enlarging tapered recoil vent **527C** and the concave recess **527E**.

The type of ammunition prism **500C** (FIG. **61**) are distinguished from the FIG. **60** ammunition prisms in that each cartridge capsule portion **502** has the upper portion of its cylindrical chamber **403** provided with a lengthwise split or slotted wall **403S** and a plurality of camming or dimple means **403T** are provided on the internal surface of each pressure chamber portion **406** adjacent the slotted wall **403S** just rearward of each projectile **107**. This facilitates the release and barrel chambering of the projectile as the longitudinally translatable bolt **550** (FIGS. **65** and **66**) cams the dimple means **403T** to spread the slotted wall and pushes the projectile to its final pre-firing position in barrel **520**. The internal upper surface of the firing chamber **501** is suitably dimensioned that sufficient clearance is provided for spreading of the slotted walls. A suitable pin and substantially long slot connection (not shown) between bolt **550** and breech portion **527** will enable full longitudinal motion of the bolt **550** throughout its intended full stroke. The forward end of bolt **550** has a forwardly opening nozzle surface **553** that intersects with a concave recess **554** provided on the underside of the bolt so that each pressure chamber portion **406** fluidly communicates developed pressure gas from the respective propellant chamber **404** with the rearward end of the corresponding projectile **107** during operation of both the FIG. **65** closed breech and FIG. **66** recoilless or partially recoilless weapon systems. The rearwardly enlarging tapered recoil vent **556** (FIG. **66**) in bolt **550** intersects concave recess **554** at the effective recoilless nozzle throat **557**.

Various modifications, changes and alterations may be resorted to without departing from the scope of the invention as defined by the appended claims.

I claim:

1. An ammunition capsule comprising,

a unitary capsule body having an elongated longitudinally extending cylindrical chamber, said chamber having a forward barrel portion for slidably receiving a projectile and a pressure chamber portion aligned with and rearward of said barrel portion,

a one-piece imperforate propellant capsule chamber which remains imperforate and is integral with and laterally offset from said elongated chamber,

said propellant capsule chamber having metering orifice means for fluidly communicating the propellant capsule chamber with said pressure chamber, and

a primer carried by an exterior surface of said ammunition capsule body for igniting a capsule propellant charge.

2. The structure in accordance with claim **1** wherein said propellant chamber has a transverse section of substantially rectangular configuration.

3. The structure in accordance with claim **2** wherein said transverse section is of substantially square configuration.

4. The structure in accordance with claim **1** wherein said propellant chamber has a transverse section of substantially triangular configuration.

5. The structure in accordance with claim **1** wherein said propellant capsule chamber has opposed longitudinally extending external wall portions, one of said wall portions having a longitudinally extending groove and the other wall portion having a tongue protuberance of a substantially similar configuration as said groove.

6. The structure of claim **5** wherein said propellant chamber has a transverse section of substantially rectangular configuration.

7. The structure of claim **6** wherein said transverse section is of substantially square configuration.

8. The structure of claim **5** wherein said propellant chamber has a transverse section of substantially triangular configuration.

9. The structure of claim **5** wherein said groove extends to the rearward edge of said capsule.

10. The structue of claim **5** wherein said propellant chamber has a transverse section of polygonal configuration.

11. The structure of claim **5** wherein said propellant chamber has a transverse section of substantially square configuration, and said pressure chamber portion has means spaced from said primer for rearwardly exhausting operatively developed pressure gas therefrom.

12. The structure of claim **5** wherein said pressure chamber has means spaced from said primer for rearwardly exhausting operatively developed pressure gas therefrom.

13. The structure in accordance with claim **12** wherein said propellant chamber has a transverse section of polygonal configuration.

14. The structure in accordance with claim **5** wherein a rearward wall of said pressure chamber portion has a pre-formed weakened section for use with a recoil vent in breech means of a recoilless system.

15. The structure of claim **14** wherein said propellant chamber has a transverse section of polygonal configuration.

16. The structure of claim **15** wherein said transverse section is of substantially triangular configuration.

17. The structure in accordance with claim **15** wherein said transverse section is of substantially rectangular configuration.

18. The structure of claim **17** wherein said transverse section is of substantially square configuration.

19. The structure of claim **14** wherein said propellant chamber has a transverse section of polygonal configuration.

20. The structure in accordance with claim **1** wherein said propellant chamber has a transverse section of polygonal configuration.

21. The structure in accordance with claim **20** wherein a rearward wall of said pressure chamber portion has a pre-formed weakened section for use with a recoil vent in breech means of a recoilless system.

22. The structure of claim 1 wherein said propellant chamber has a transverse section of substantially square configuration, and said pressure chamber portion has means spaced from said primer for rearwardly exhausting operatively developed pressure gas therefrom.

23. The structure of claim 1 wherein said metering orifice means is a necked down passage interconnecting said capsule propellant chamber and said pressure chamber.

24. The structure of claim 23 wherein said propellant chamber has a transverse section of substantially square configuration.

25. The structure in accordance with claim 1 wherein a rearward wall of said pressure chamber portion has a pre-formed weakened section for use with a recoil vent in breech means of a recoilless system.

26. The structure of claim 25 wherein said propellant chamber has a transverse section of polygonal configuration.

27. The structure in accordance with claim 25 wherein said propellant chamber has a transverse section of substantially rectangular configuration.

28. The structure of claim 27 wherein said transverse section is of substantially square configuration.

29. The structure of claim 25 wherein said propellant chamber has a transverse section of substantially triangular configuration.

30. The structure in accordance with claim 1 wherein wall portions of said elongated chamber and propellant capsule chamber are connected by a transversely extending wall, said chamber wall portions being transversely spaced from each other and having transversely aligned operative port means defining said metering orifice means.

31. The structure of claim 30 wherein said propellant chamber has a transverse section of polygonal configuration.

32. The structure of claim 30 wherein said propellant chamber has a transverse section of substantially square configuration, and said pressure chamber portion has means spaced from said primer for rearwardly exhausting operatively developed pressure gas therefrom.

33. The structure of claim 30 wherein said propellant chamber less has longitudinally extending external wall portions including means for connecting an adjacent capsule.

34. The structure of claim 30 wherein said pressure chamber portion has means spaced from said primer for rearwardly exhausting operatively developed pressure gas therefrom.

35. The structure in accordance with claim 34 wherein said propellant chamber has a transverse section of polygonal configuration.

36. The structure of claim 30 wherein said port means includes a gas vent in said elongated chamber wall portion and a pre-formed weakened section in said propellant capsule chamber wall portion.

37. The structure of claim 36 wherein said propellant chamber has a transverse section of polygonal configuration.

38. The structure of claim 36 wherein said propellant chamber has a transverse section of substantially square configuration, and said pressure chamber portion has means spaced from said primer for rearwardly exhausting operatively developed pressure gas therefrom.

39. The structure of claim 36 wherein said propellant chamber has longitudinally extending external wall portions including means for connecting and adjacent capsule.

40. The structure of claim 36 wherein said pressure chamber portion has means spaced from said primer for rearwardly exhausting operatively developed pressure gas therefrom.

41. The structure of claim 40 wherein said propellant chamber has a transverse section of polygonal configuration.

42. The structure in accordance with claim 30 wherein an upper surface of said propellant chamber has a pre-formed weakened section.

43. The structure of claim 42 wherein said propellant chamber has a transverse section of polygonal configuration.

44. The structure of claim 42 wherein said propellant chamber has a transverse section of substantially square configuration, and said pressure chamber portion has means spaced from said primer for rearwardly exhausting operatively developed pressure gas therefrom.

45. The structure in accordance with claim 42 wherein each propellant chamber has longitudinally extending external wall portions including means for connecting an adjacent capsule.

46. The structure of claim 42 wherein said pressure chamber portion has means spaced from said primer for rearwardly exhausting operatively developed pressure gas therefrom.

47. The structure of claim 46 wherein said propellant chamber has a transverse section of polygonal configuration.

48. The structure in accordance with claim 42 wherein said propellant chamber has a transverse section of substantially rectangular configuration.

49. The structure of claim 48 wherein said transverse section is of substantially square configuration.

50. The structure of claim 42 wherein said propellant chamber has a transverse section of substantially triangular configuration.

51. The structure in accordance with claim 1 wherein said pressure chamber portion has an open rearward end.

52. The structure of claim 51 wherein said propellant chamber has a transverse section of polygonal configuration.

53. The structure in accordance with claim 51 wherein said propellant chamber has longitudinally extending external wall portions including means for connecting an adjacent capsule.

54. The structure in accordance with claim 51 wherein said propellant chamber has a transverse section of substantially rectangular configuration.

55. The structure of claim 54 wherein said transverse section is of substantially square configuration.

56. The structure of claim 51 wherein said propellant chamber has a transverse section of substantially triangular configuration.

57. The structure in accordance with claim 51 wherein said propellant capsule chamber has opposed longitudinally extending external wall portions, one of said wall portions having a longitudinally extending

groove and the other wall portion having a tongue protuberance of a substantially similar configuration as said groove.

58. The structure of claim **57** wherein said propellant chamber has a transverse section of polygonal configuration.

59. The structure of claim **57** wherein said propellant chamber has a transverse section of substantially rectangular configuration.

60. The structure of claim **59** wherein said transverse section is of substantially square configuration.

61. The structure of claim **57** wherein said propellant chamber has a transverse section of substantially triangular configuration.

62. The structure in accordance with claim **51** wherein an upper surface of said propellant chamber has a pre-formed weakened section.

63. The structure in accordance with claim **62** wherein said propellant chamber has a transverse section of substantially rectangular configuration.

64. The structure of claim **63** wherein said transverse section is of substantially square configuration.

65. The structure of claim **62** wherein said propellant chamber has a transverse section of substantially triangular configuration.

66. The structure of claim **62** wherein said propellant chamber has a transverse section of polygonal configuration.

67. The structure of claim **62** wherein each propellant chamber has longitudinally extending external wall portions including means for connecting an adjacent capsule.

68. The structure of claim **1** wherein said propellant chamber has longitudinally extending external wall portions including means for connecting an adjacent capsule.

69. The structure in accordance with claim **68** wherein said connecting means is partially defined by a longitudinally extending groove in one of said external wall portions, said groove extending to the rearward edge of said capsule.

70. The structure of claim **69** wherein a rearward wall of said pressure chamber portion has a pre-formed weakened section for use with a recoil vent in breech means of a recoilless system.

71. The structure of claim **52** wherein inwardly protruding dimple means are located on the internal surface of said pressure chamber portion.

72. The structure of claim **71** wherein said propellant chamber has a transverse section of polygonal configuration.

73. The structure in accordance with claim **71** wherein each propellant chamber has longitudinally extending external wall portions including means for connecting an adjacent capsule.

74. The structure of claim **73** wherein inwardly directed flange means are provided on the forward end of said barrel portion.

75. The structure of claim **74** wherein said propellant chamber has a transverse section of polygonal configuration.

76. The structure of claim **74** wherein each propellant chamber has longitudinally extending external wall portions including means for connecting an adjacent capsule.

77. The structure of claim **74** wherein said elongated chamber has a longitudinally slotted wall portion.

78. The structure of claim **77** wherein said propellant chamber has a transverse section of polygonal configuration.

79. The structure of claim **77** wherein said propellant chamber has longitudinally extending external wall portions including means for connecting an adjacent capsule.

80. The structure in accordance with claim **77** wherein said propellant chamber has a transverse section of substantially rectangular configuration.

81. The structure of claim **80** wherein said transverse section is of substantially square configuration.

82. The structure of claim **77** wherein said propellant chamber has a transverse section of substantially triangular configuration.

83. The structure of claim **71** wherein said elongated chamber has a longitudinally slotted wall portion.

84. The structure of claim **83** wherein said propellant chamber has a transverse section of polygonal configuration.

85. The structure of claim **83** wherein each propellant chamber has longitudinally extending external wall portions including means for connecting an adjacent capsule.

86. The structure in accordance with claim **83** wherein said propellant capsule chamber has opposed longitudinally extending external wall portions, one of said wall portions having a longitudinally extending groove and the other wall portion having a tongue protuberance of a substantially similar configuration as said groove.

87. The structure in accordance with claim **86** wherein said propellant chamber has a transverse section of polygonal configuration.

88. The structure of claim **86** wherein said propellant chamber has a transverse section of substantially rectangular configuration.

89. The structure of claim **88** wherein said transverse section is of substantially square configuration.

90. The structure of claim **86** wherein said propellant chamber has a transverse section of substantially triangular configuration.

91. The structure in accordance with claim **80** wherein an upper surface of said propellant chamber has a pre-formed weakened section.

92. The structure of claim **91** wherein said propellant chamber has a transverse section of polygonal configuration.

93. The structure in accordance with claim **91** wherein said propellant chamber has a transverse section of substantially rectangular configuration.

94. The structure of claim **93** wherein said transverse section is of substantially square configuration.

95. The structure of claim **1** wherein said pressure chamber portion has means spaced from said primer for rearwardly exhausting operatively developed pressure gas therefrom.

96. The structure in accordance with claim **83** wherein an upper surface of said propellant chamber has a pre-formed weakened section, and said propellant chamber has a transverse section of polygonal configuration.

97. The structure of claim **96** wherein said propellant capsule chamber has opposed longitudinally extending external wall portions, one of said wall portions having a longitudinally extending groove and the other wall portion having a tongue protuberance of a substantially similar configuration as said groove.

98. The structure of claim **96** wherein wall portions of said elongated chamber and propellant capsule chamber are connected by a transversely extending wall, said chamber wall portions being transversely spaced from each other and having transversely aligned operative port means defining said metering orifice means.

99. The structure in accordance with claim **96** wherein said propellant chamber has a transverse section of substantially rectangular configuration.

100. The structure of claim **99** wherein said transverse section is of substantially square configuration.

101. The structure of claim **96** wherein said propellant chamber has a transverse section of substantially triangular configuration.

102. The structure of claim **95** wherein said propellant chamber has a transverse section of polygonal configuration.

* * * * *

APPENDIX B

Representative Firing Data

APPENDIX B

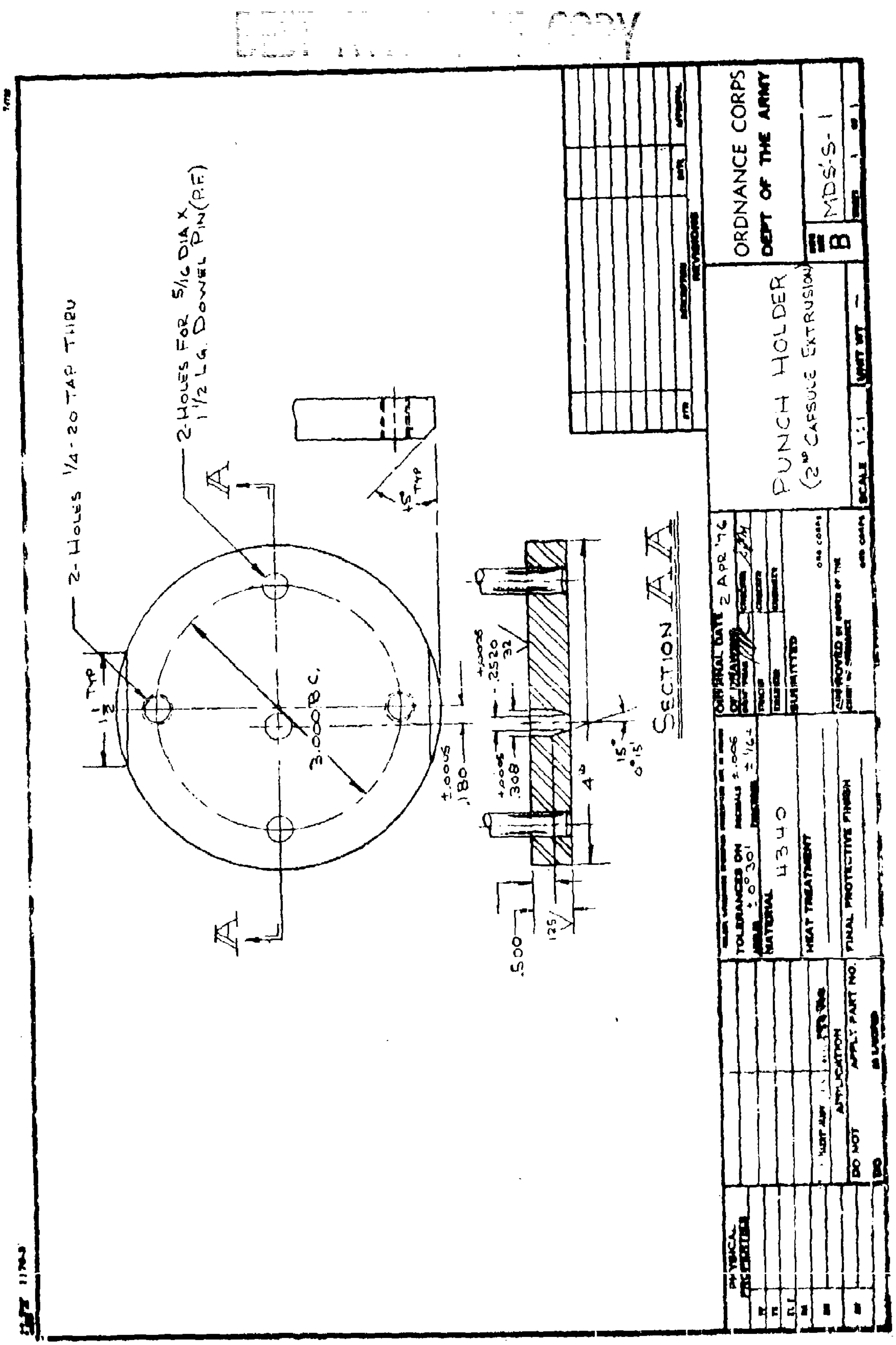
Representative Firing Data

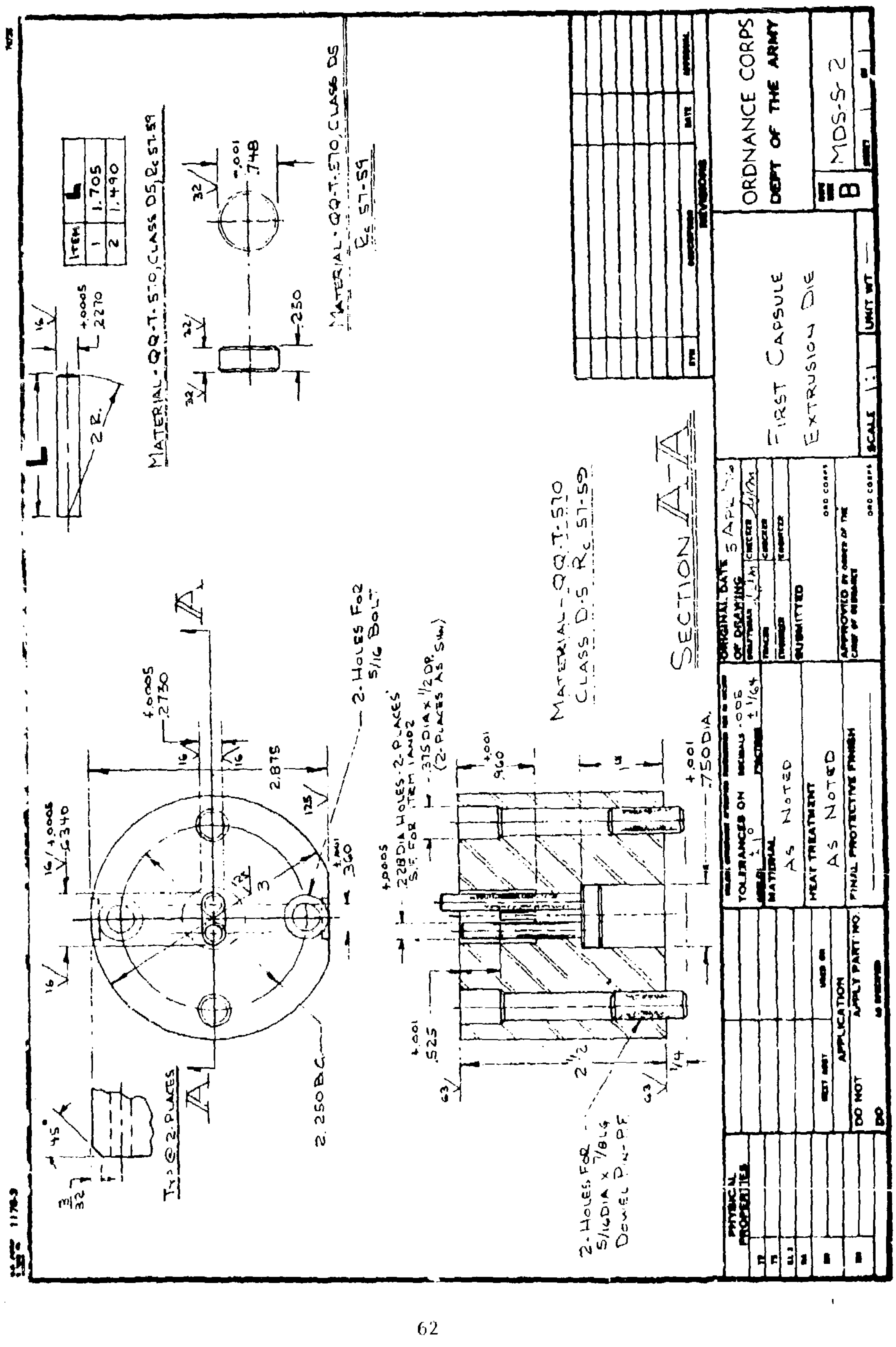
Rd No.	Weapon	Muzzle Velocity (fps)	Chamber Pressure (KPSI)	Bolt Cavity Pressure (KPSI)
391	Belgian LAR	3007	-	N
392	(Modified)	2966	45.0	"
393		3226	44.5	"
394		3262	50.0	"
395		3134	43.0	"
396		3028	39.5	"
397		3222	43.5	"
		$\overline{v}$ = 3121	$\overline{P}$ = 44.2	
398	Belgian LAR	2972	44.5	N
399	(Modified)	2874	48.0	"
400		3040	41.5	"
401		3228	41.5	"
402		3037	44.5	"
403		3166	44.5	"
404		3046	44.5	"
405		3105	43.0	"
		$\overline{v}$ = 3059	$\overline{P}$ = 44.0	
406	M-16 A1	3218	N	16.5
407	(Modified)	-	"	15.0
408		3169	"	11.0
409		3249	"	11.0
410		3211	"	19.5
411		3323	"	19.5
412		3174	"	20.0
413		3271	"	19.5
414		3213	"	19.5
		$\overline{v}$ = 3228		$\overline{P}$ = 16.8

N - Not Measured

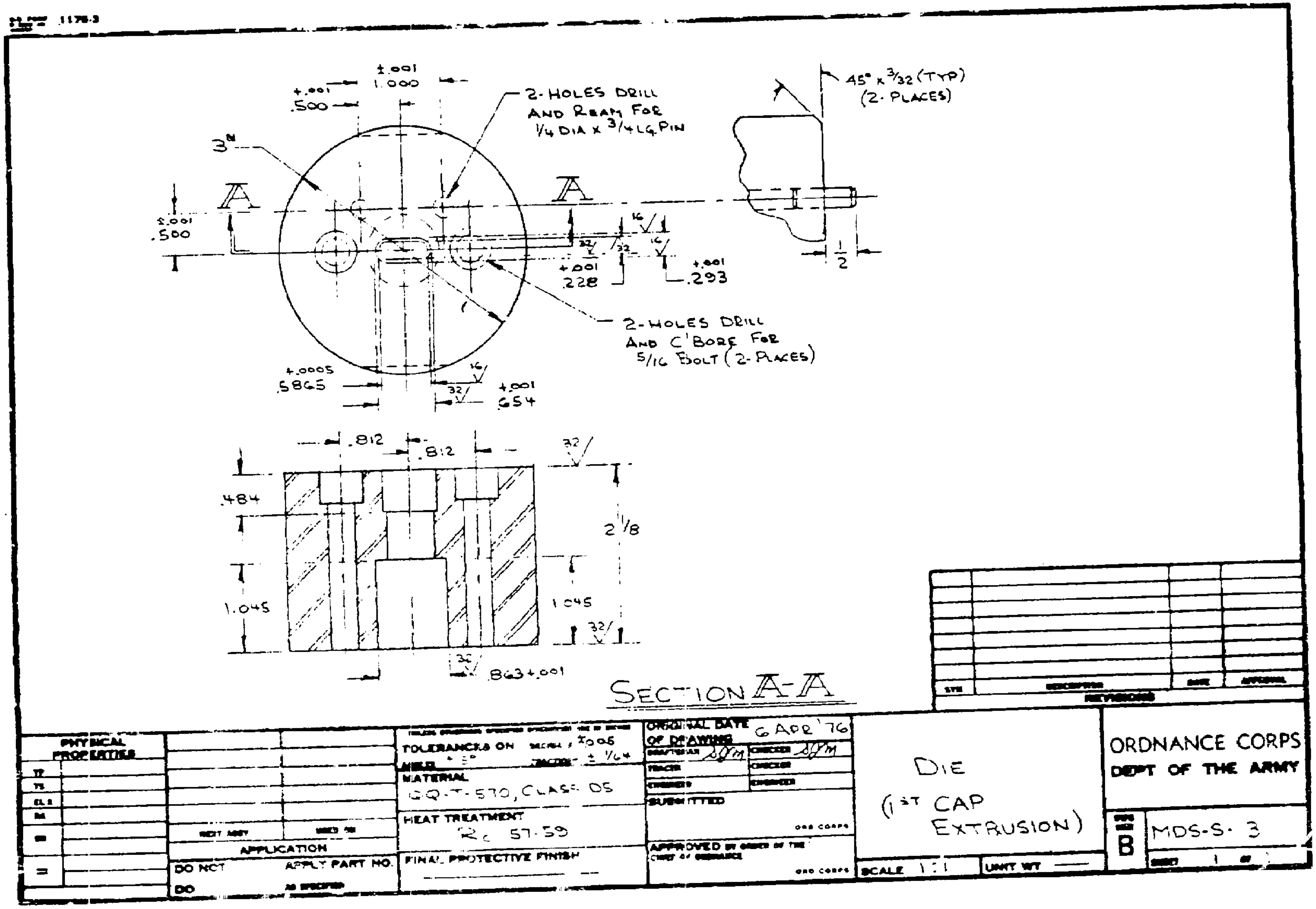
APPENDIX C

Tool Drawings for Case Extrusion Process

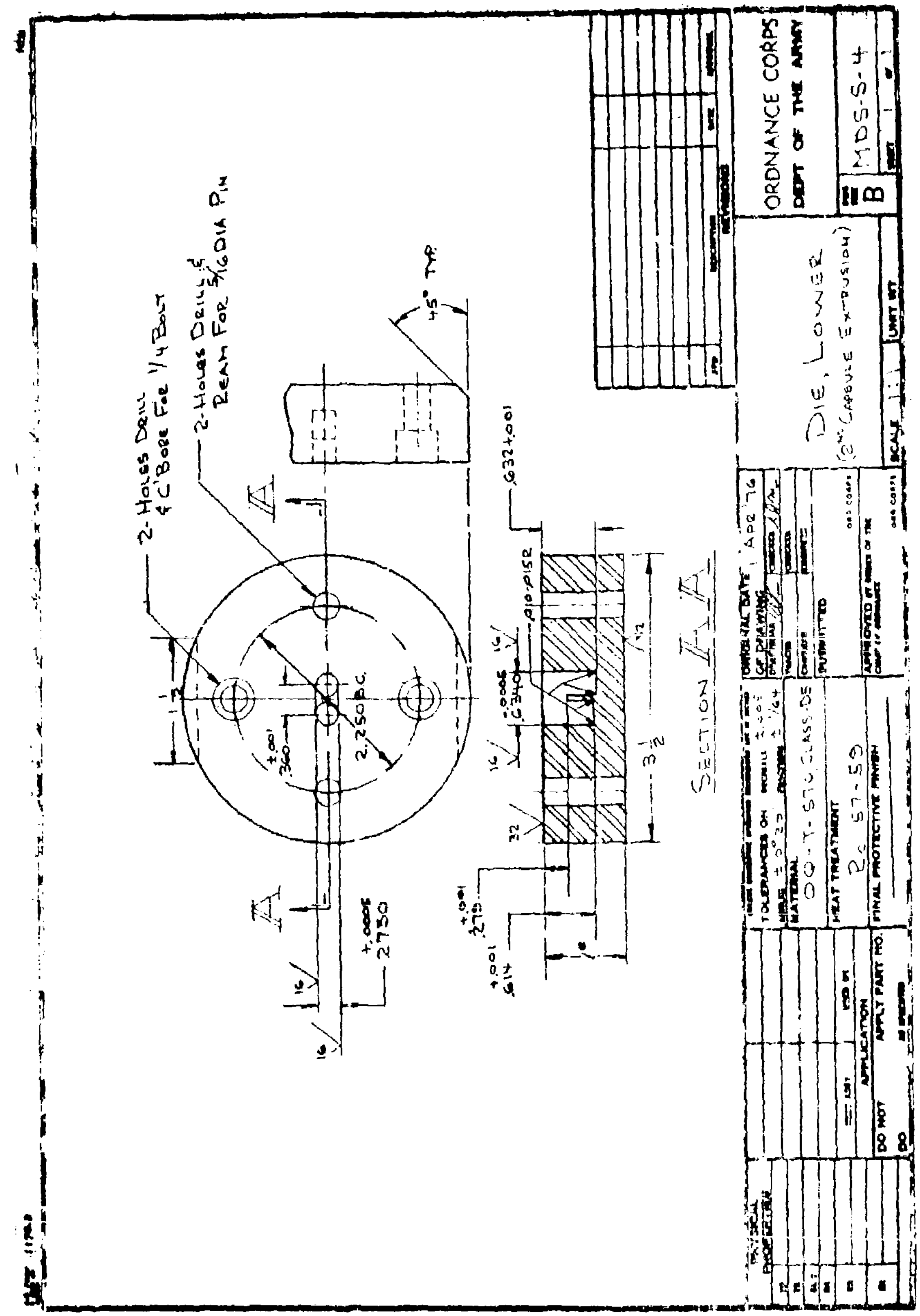

2-HOLES 1/4-20 TAP THRU
2-HOLES FOR 5/16 DIA X 1 1/2 LG. DOWEL PIN (P.F.)
3.000 B.C.
SECTION A-A
ORDNANCE CORPS
DEPT OF THE ARMY
PUNCH HOLDER
(2ND CAPSULE EXTRUSION)
MDS-S-1
4340
ORIGINAL DATE 2 APR '76
SCALE 1:1
TOLERANCES ON
MATERIAL
HEAT TREATMENT
FINAL PROTECTIVE FINISH
APPLICATION
PHYSICAL PROPERTIES
REVISIONS

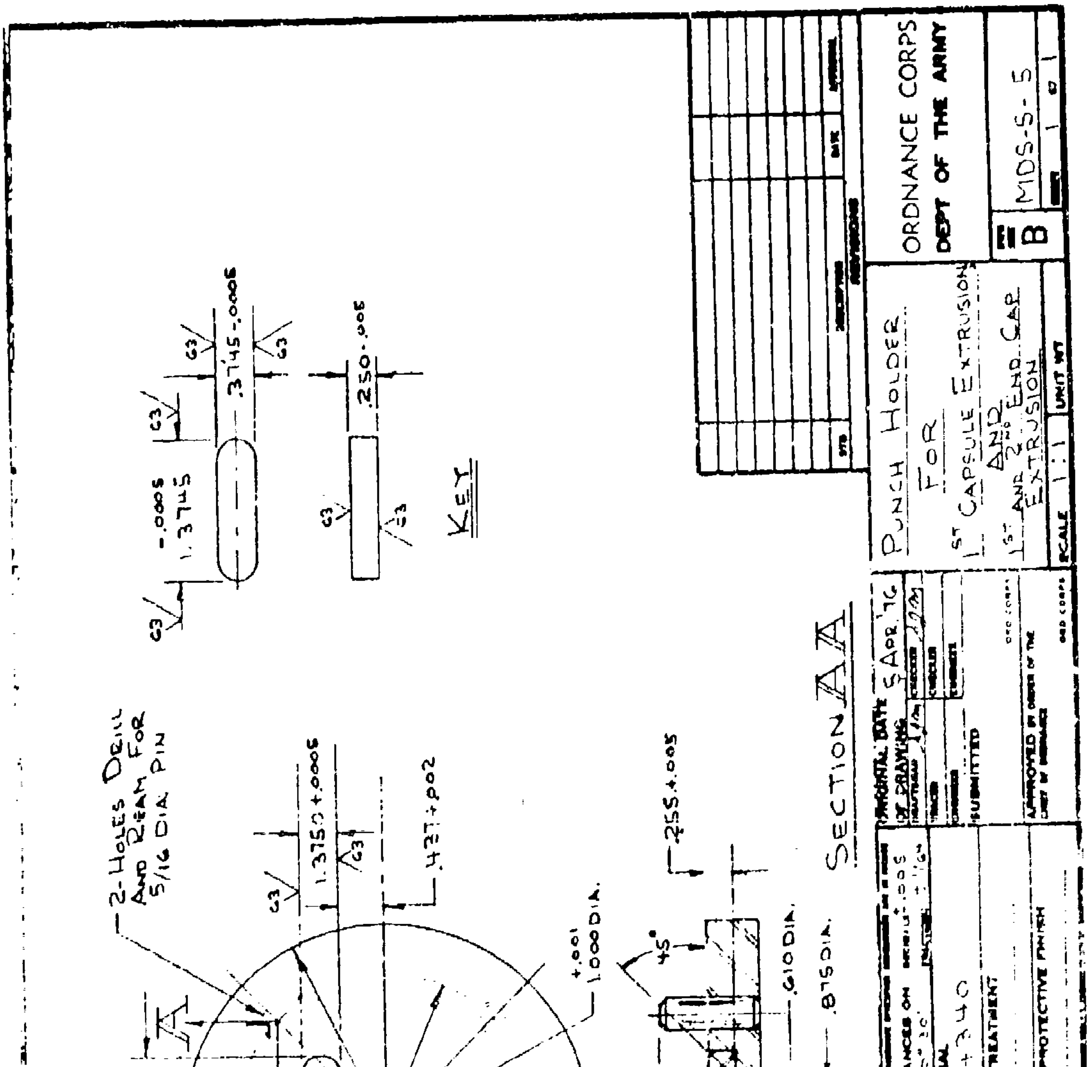


SECTION A-A
MATERIAL - QQ-T-570
CLASS D-5 Rc 57-59
2-HOLES FOR 5/16 BOLT
2-HOLES FOR 5/16 DIA x 7/8 LG DOWEL PIN-PF
2.250 B.C.
ORDNANCE CORPS
DEPT OF THE ARMY
FIRST CAPSULE
EXTRUSION DIE
MDS-S-2
SCALE 1:1
MATERIAL
AS NOTED
HEAT TREATMENT
AS NOTED
REVISIONS

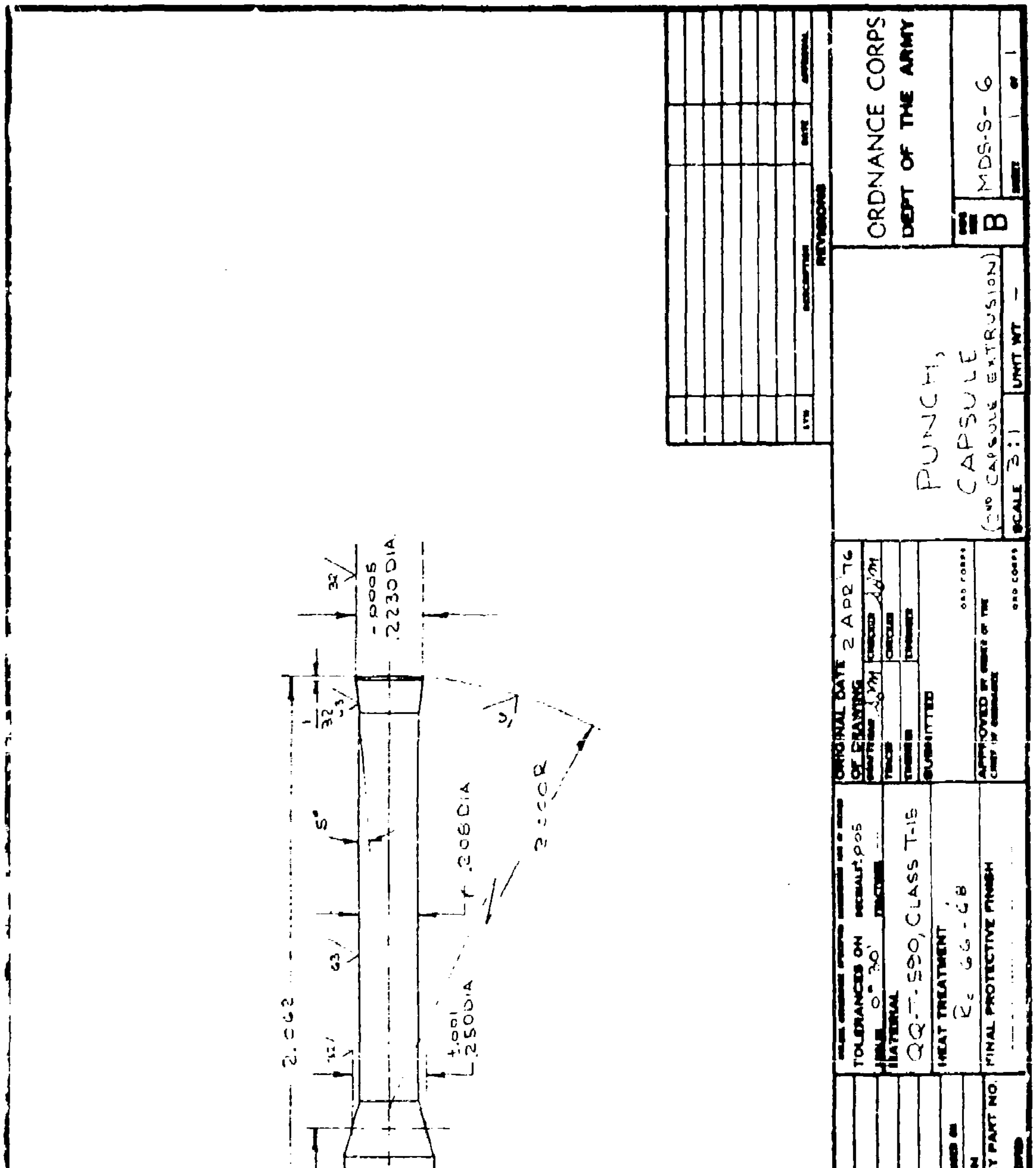


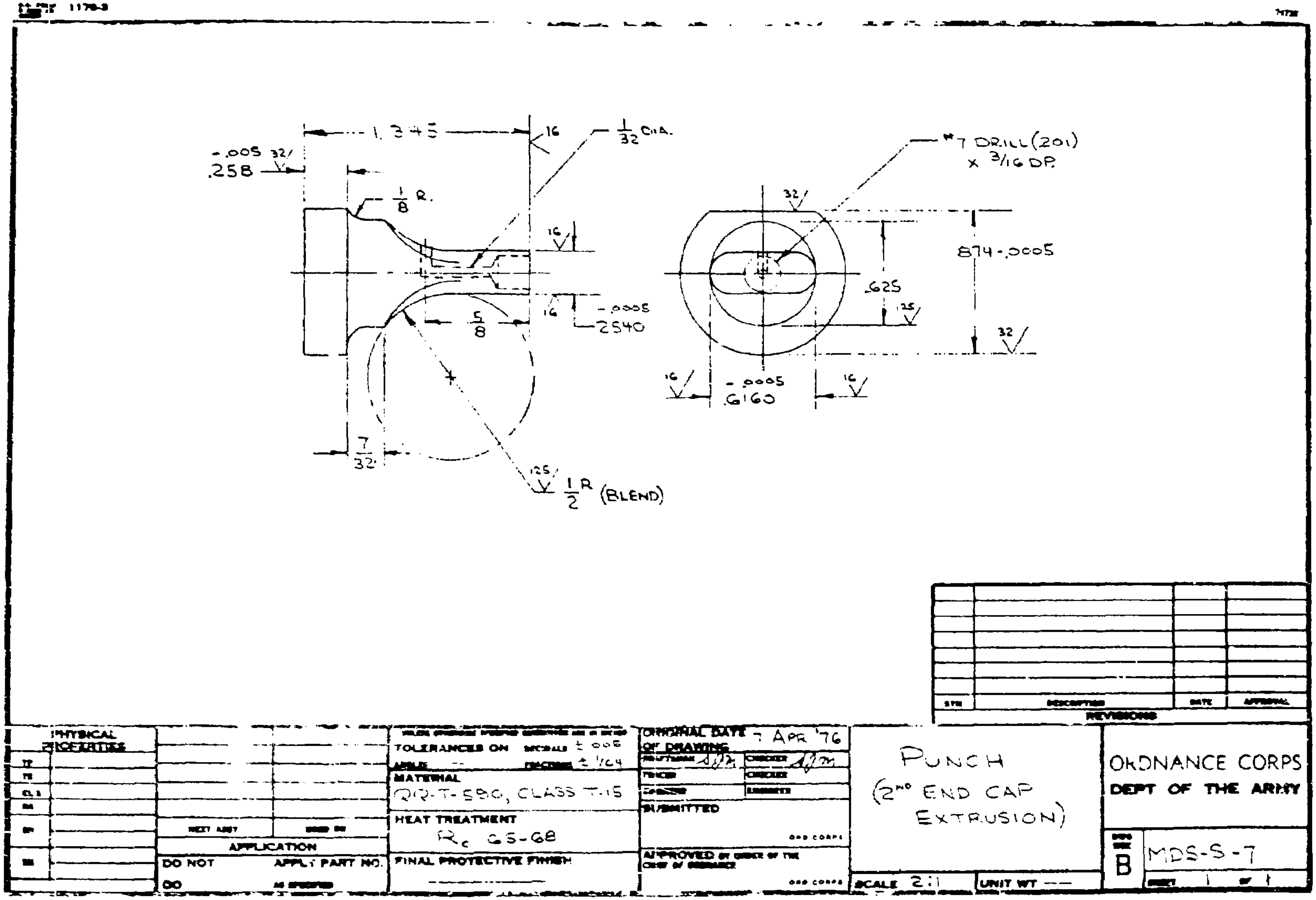
2-HOLES DRILL AND REAM FOR 1/4 DIA x 3/4 LG PIN
2-HOLES DRILL AND C'BORE FOR 5/16 BOLT (2-PLACES)
45° x 3/32 (TYP) (2-PLACES)
SECTION A-A
TOLERANCES ON DECIMALS ±.005 FRACTIONS ± 1/64 ANGLES ± 1°
MATERIAL QQ-T-570, CLASS O5
HEAT TREATMENT Rc 57-59
FINAL PROTECTIVE FINISH
ORIGINAL DATE OF DRAWING 6 APR '76
APPLICATION
DO NOT
DO
APPLY PART NO.
AS SPECIFIED
DIE (1ST CAP EXTRUSION)
ORDNANCE CORPS
DEPT OF THE ARMY
B
MDS-S-3
SCALE 1:1
UNIT WT
PHYSICAL PROPERTIES

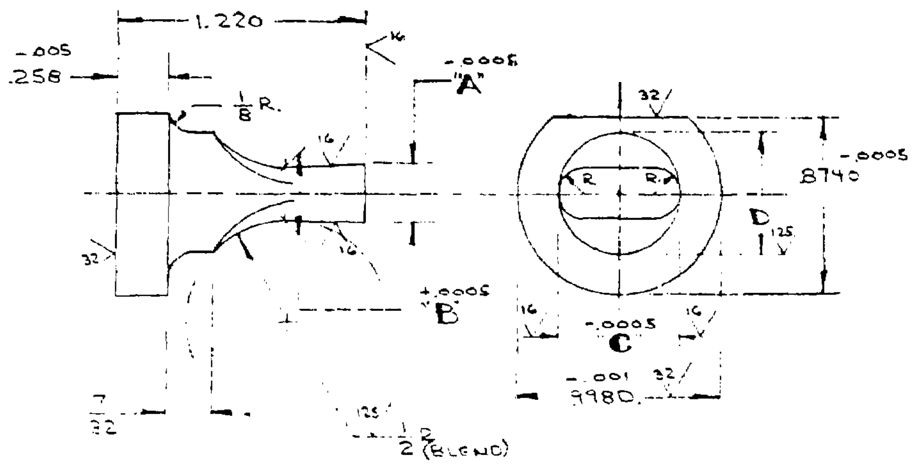

ORDNANCE CORPS
DEPT OF THE ARMY
DIE, LOWER
(2" CAPSULE EXTRUSION)
MDS-S-4
B
SECTION A-A
2-HOLES DRILL & C'BORE FOR 1/4 BOLT
2-HOLES DRILL & REAM FOR 5/16 DIA PIN
45° TYP
2.250 B.C.
3 1/2
OO-T-570 CLASS DE
Rc 57-59
MATERIAL
HEAT TREATMENT
FINAL PROTECTIVE FINISH
TOLERANCES ON
APPLICATION
REVISIONS
SCALE
UNIT WT



2-HOLES FOR 5/16-18 BOLT
2-HOLES DRILL AND REAM FOR 5/16 DIA PIN
3.000 B.C.
4 DIA.
1.000 DIA.
.610 DIA.
.875 DIA.
45°
SECTION AA
KEY
TOLERANCES ON
MATERIAL
4340
HEAT TREATMENT
FINAL PROTECTIVE FINISH
APPLICATION
PHYSICAL PROPERTIES
SUBMITTED
REVISIONS
PUNCH HOLDER
FOR
1ST CAPSULE EXTRUSION
AND
1ST AND 2ND END CAP EXTRUSION
ORDNANCE CORPS
DEPT OF THE ARMY
B
MDS-5-5
SCALE 1:1
UNIT WT


ORDNANCE CORPS
DEPT OF THE ARMY
PUNCH, CAPSULE
(END CAPSULE EXTRUSION)
MDS-S-6
B
SCALE 3:1
UNIT WT —
REVISIONS
ORIGINAL DATE OF DRAWING 2 APR 76
TOLERANCES ON
MATERIAL
QQ-T-590, CLASS T-15
HEAT TREATMENT
FINAL PROTECTIVE FINISH
APPLICATION
DO NOT
APPLY PART NO.
DO
PHYSICAL PROPERTIES
APPROVED BY ORDER OF THE CHIEF OF ORDNANCE
SUBMITTED
2.062
.500 (BASIC)
.3075 DIA
-.0005
.2230 DIA
.2500 DIA
.208 DIA
2.00 R
15°
5°


1.345
-.005
.258
32
16
1/32 DIA.
1/8 R.
-.0005
.2540
5/8
7/32
125
1/2 R (BLEND)
#7 DRILL (.201) x 3/16 DP.
.874-.0005
.625
-.0005
.6160
PHYSICAL PROPERTIES
APPLICATION
NEXT ASSY
USED ON
DO NOT
APPLY PART NO.
TOLERANCES ON DECIMALS ±.005 ANGLES -- FRACTIONS ±1/64
MATERIAL
QQ-T-590, CLASS T-15
HEAT TREATMENT
Rc 65-68
FINAL PROTECTIVE FINISH
ORIGINAL DATE OF DRAWING 7 APR '76
DRAFTSMAN
CHECKER
TRACER
SUBMITTED
APPROVED BY ORDER OF THE CHIEF OF ORDNANCE
ORD CORPS
PUNCH
(2ND END CAP EXTRUSION)
SCALE 2:1
UNIT WT --
ORDNANCE CORPS
DEPT OF THE ARMY
B
MDS-S-7
SHEET 1 OF 1
SYM
DESCRIPTION
DATE
APPROVAL
REVISIONS



ITEM	NAME	A	B	C	D
1	CAPSULE	.2250	.2200	.5855	.585
2	END CAP	.2340	-	.6160	.625

REVISIONS

SYM	DESCRIPTION	DATE	APPROVAL

TOLERANCES ON DECIMALS ±.005 FRACTIONS ±1/64

MATERIAL: QQ-T-580, CLASS T-15

HEAT TREATMENT: R_c 65-68

FINAL PROTECTIVE FINISH

ORIGINAL DATE OF DRAWING: 2 Apr. '76

PUNCH FOR CAPSULE AND END CAP

ORDNANCE CORPS
DEPT OF THE ARMY

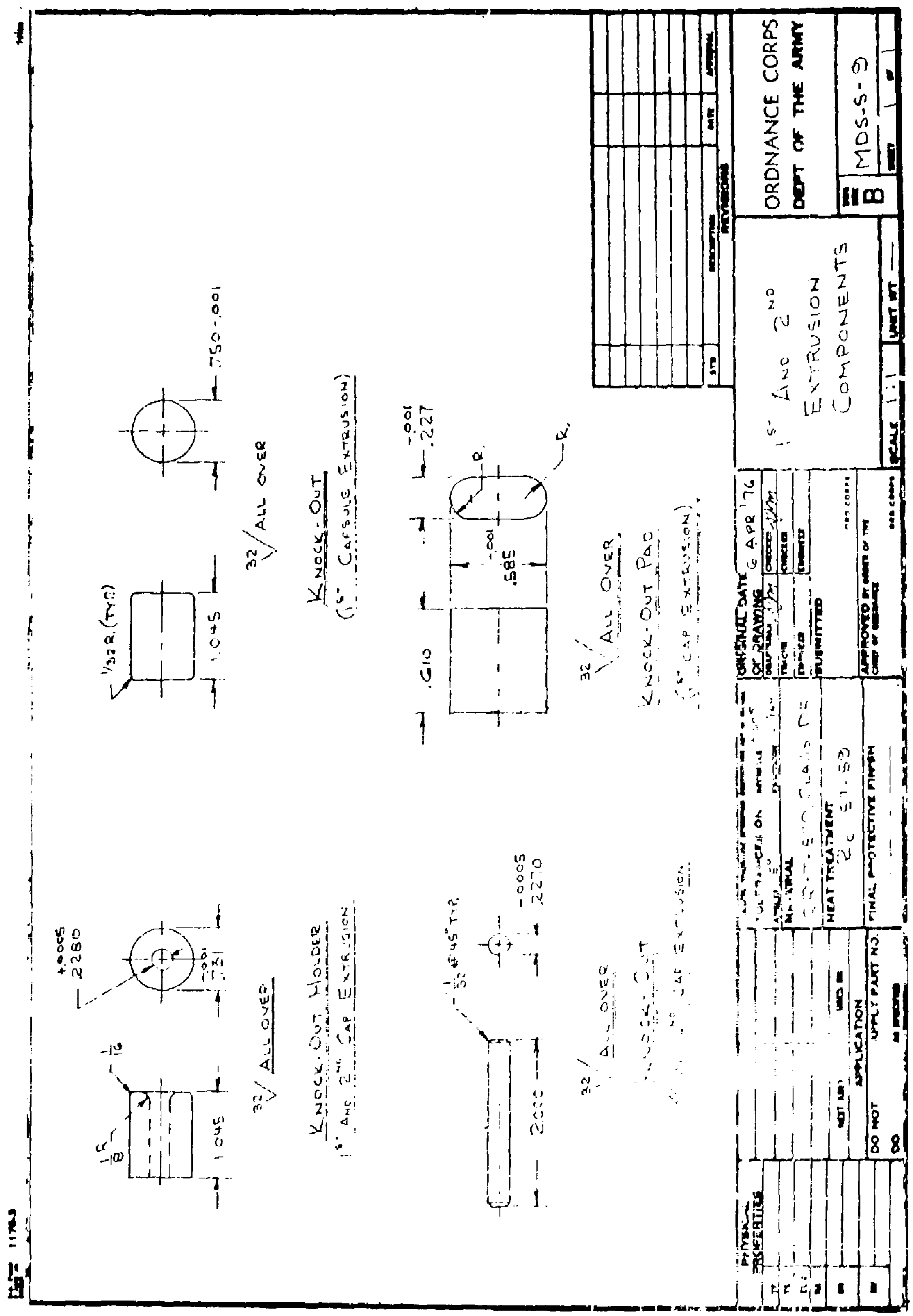
B MDS-S-8

SCALE 2:1 UNIT WT ——— SHEET 1 OF 1

PHYSICAL PROPERTIES

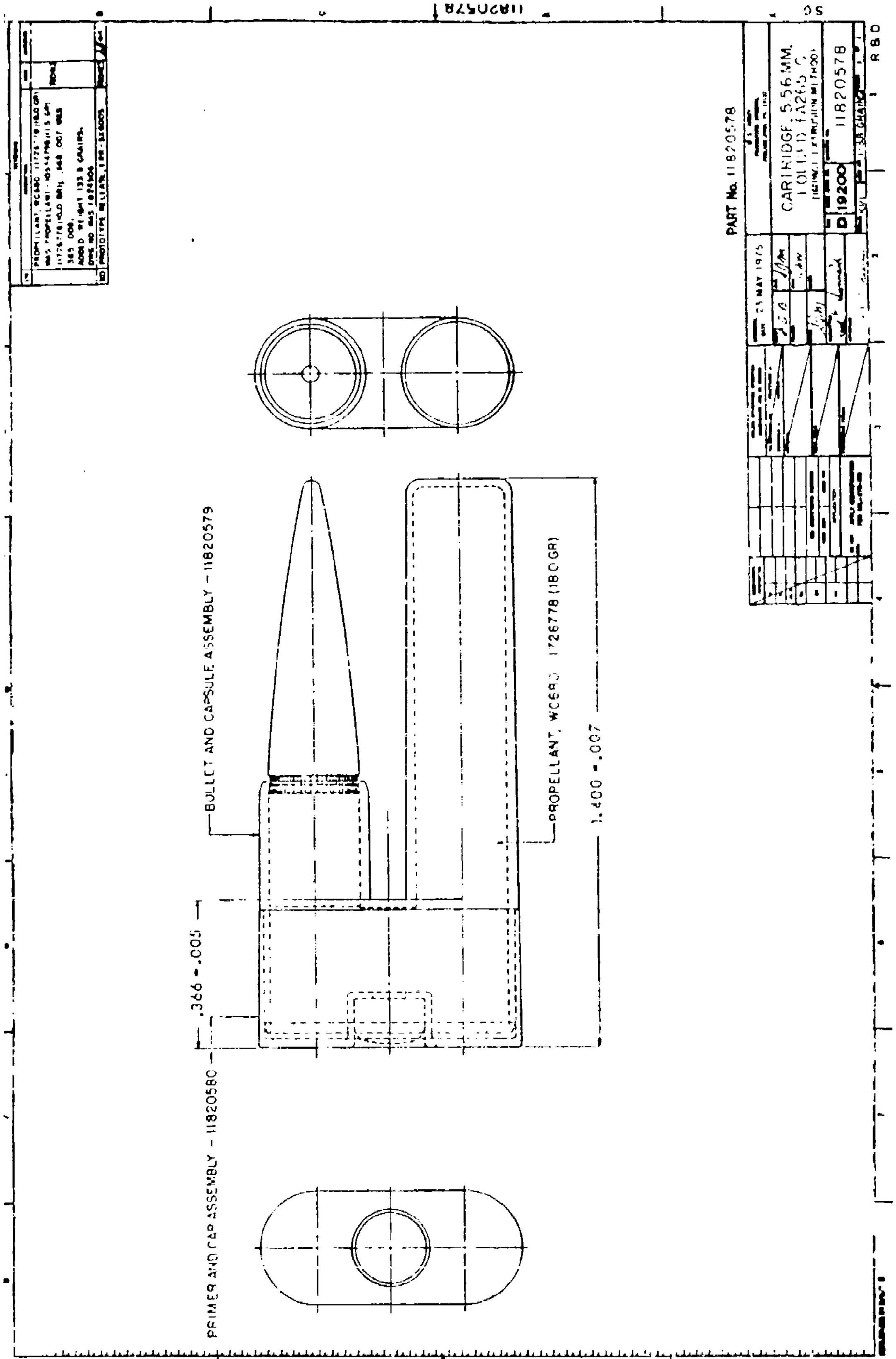
APPLICATION: NEXT ASSY / USED ON

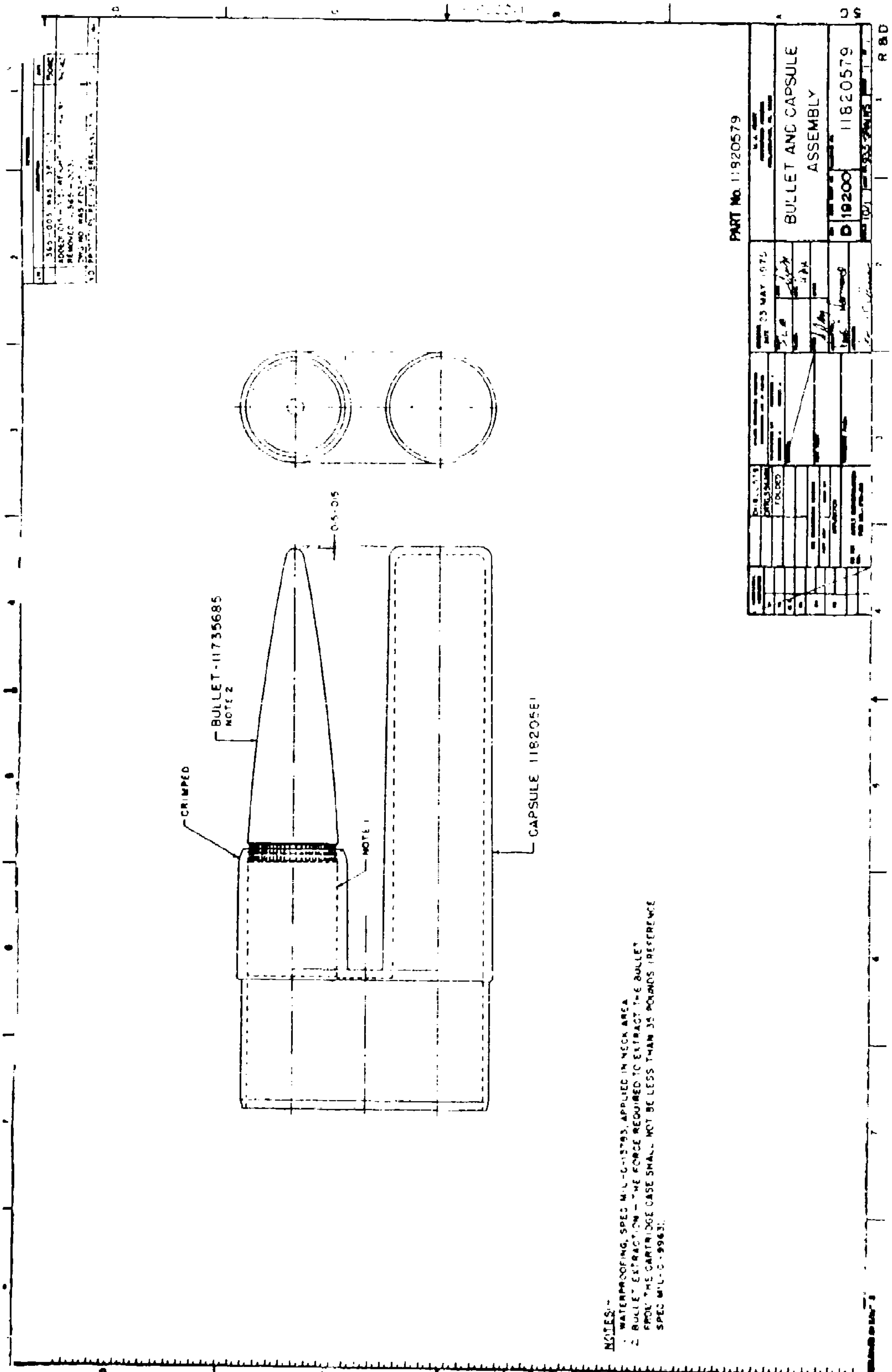
DO NOT APPLY PART NO. / DO AS SPECIFIED

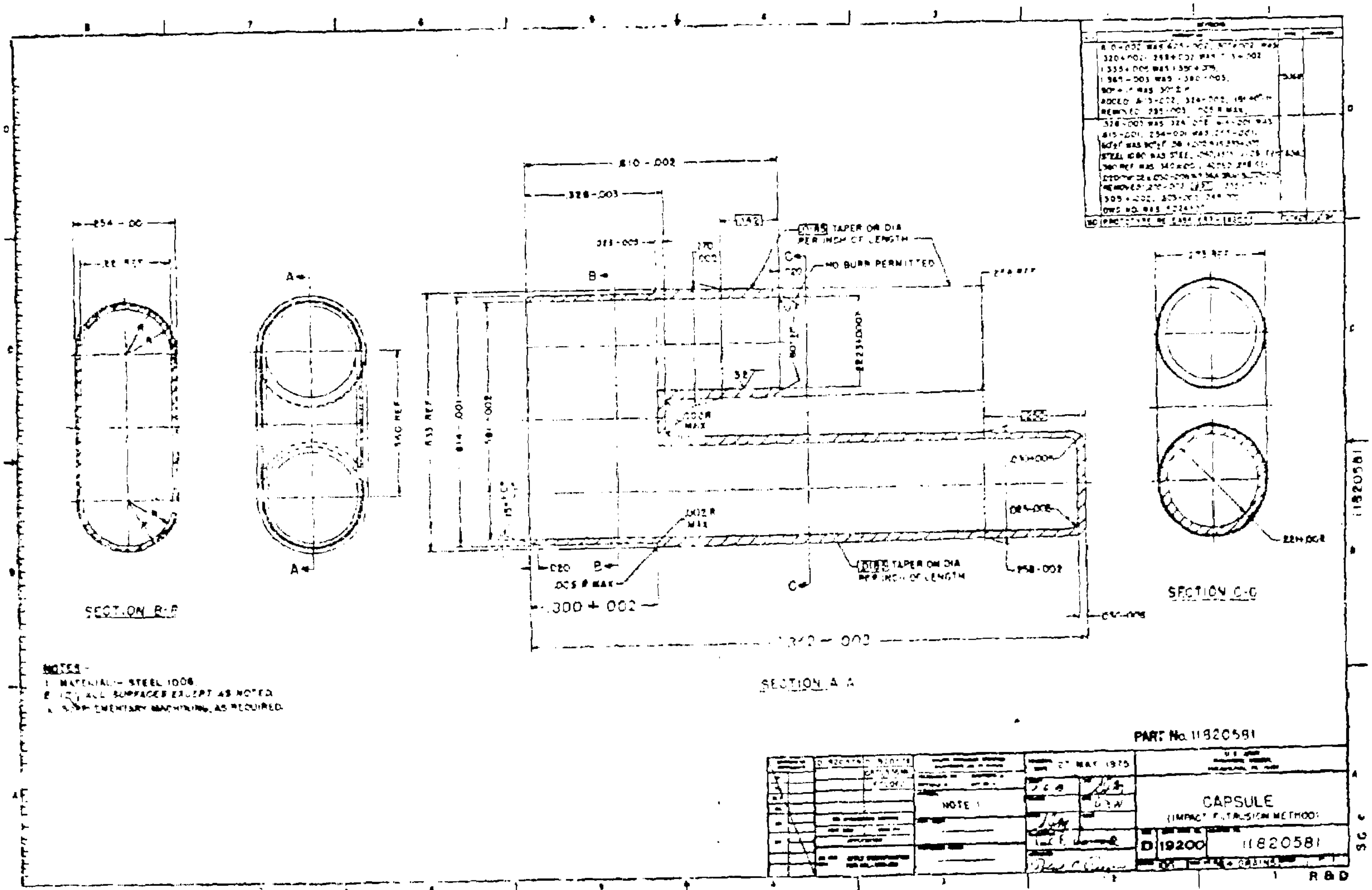

ORDNANCE CORPS
DEPT OF THE ARMY
MDS-S-9
1ST AND 2ND EXTRUSION COMPONENTS
SCALE 1:1
6 APR '76
KNOCK-OUT HOLDER
(1ST AND 2ND CAP EXTRUSION)
KNOCK-OUT
(1ST CAPSULE EXTRUSION)
KNOCK-OUT PAD
(1ST CAP EXTRUSION)
32/ALL OVER
1/32 R. (TYP.)
1.045
.750-.001
.610
.585
.227
.2280
.2270
2.000
HEAT TREATMENT
FINAL PROTECTIVE FINISH
MATERIAL
APPLICATION
PHYSICAL PROPERTIES
REVISIONS
SUBMITTED
APPROVED BY ORDER OF THE CHIEF OF ORDNANCE

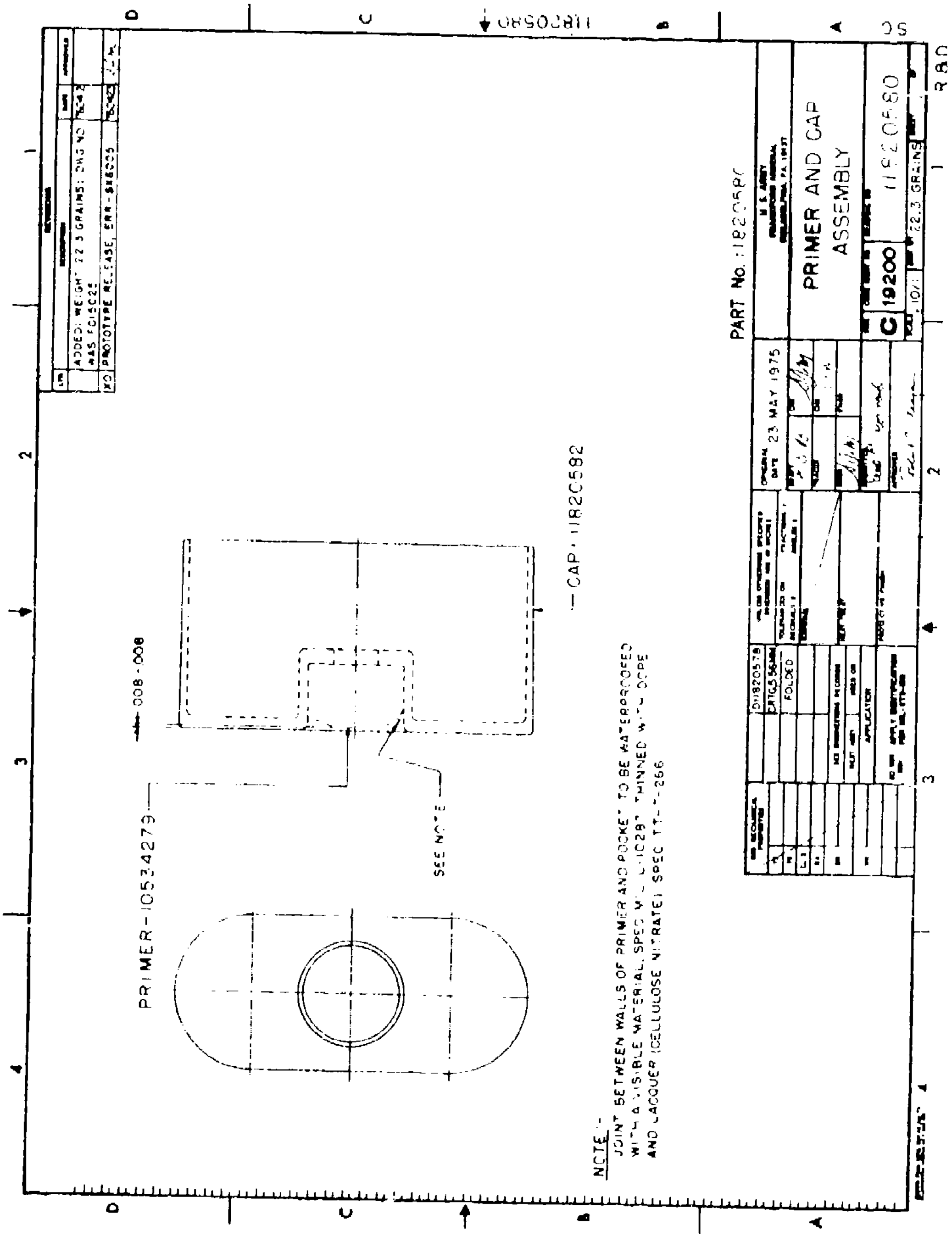
APPENDIX D

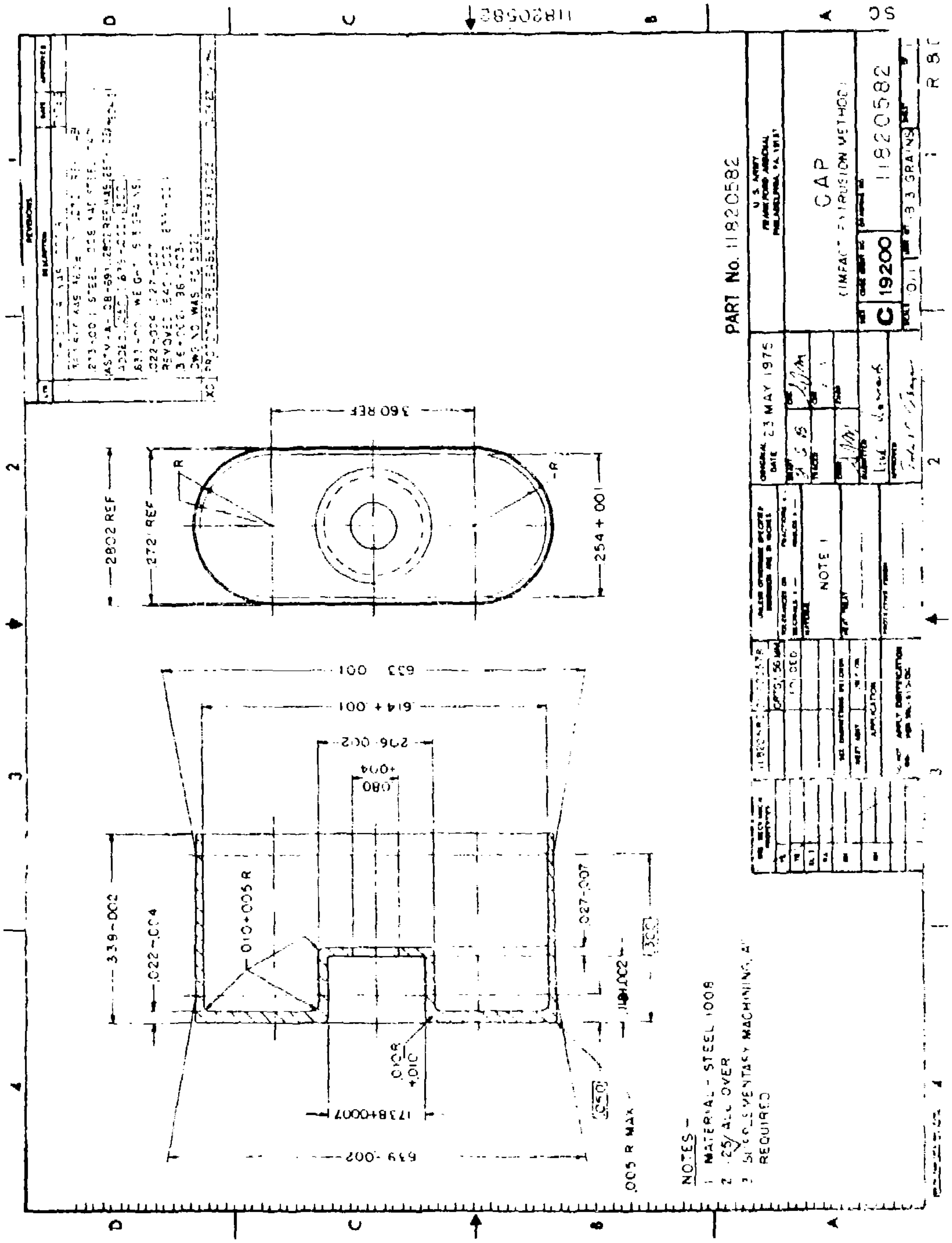
Folded Cartridge Details

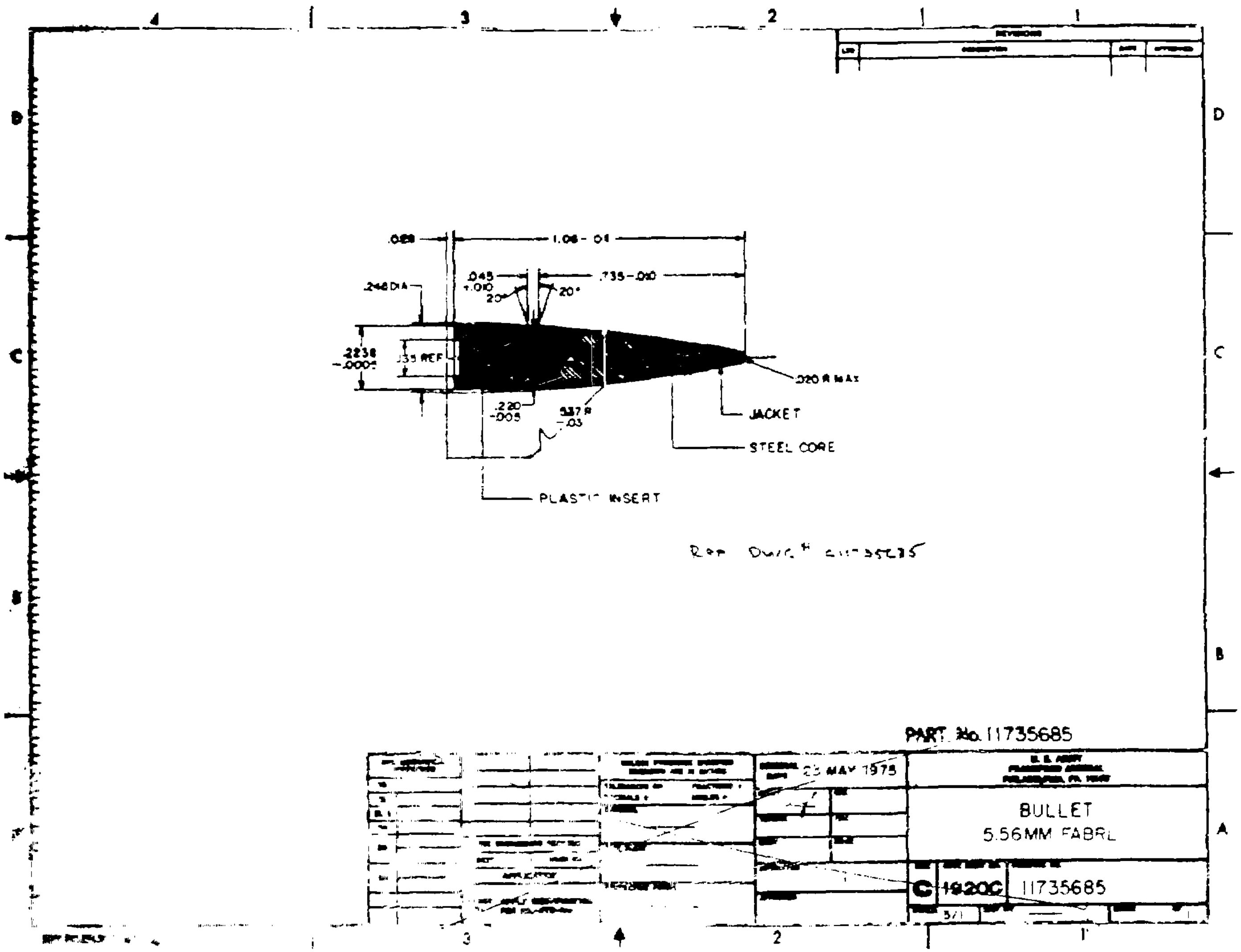

BULLET AND CAPSULE ASSEMBLY - 11820579
PROPELLANT, WC680 1726778 (18.0 GR)
1.400 ±.007
.366 ±.005
PRIMER AND CAP ASSEMBLY - 11820580
PART No. 11820578
11820578
D 19200


PART No. 11920579
BULLET AND CAPSULE ASSEMBLY
D 19200
11820579
BULLET-11735685
NOTE 2
CRIMPED
NOTE 1
CAPSULE 11820581
NOTES:-
1. WATERPROOFING, SPEC MIL-C-13795, APPLIED IN NECK AREA
2. BULLET EXTRACTION - THE FORCE REQUIRED TO EXTRACT THE BULLET FROM THE CARTRIDGE CASE SHALL NOT BE LESS THAN 35 POUNDS (REFERENCE SPEC MIL-C-9963).


SECTION B-B
SECTION A-A
SECTION C-C
.810 - .002
.328 - .003
.300 + .002
1.340 - .002
.002 R MAX
.005 R MAX
NO BURR PERMITTED
TAPER ON DIA PER INCH OF LENGTH
NOTES -
1. MATERIAL - STEEL 1006
3. SUPPLEMENTARY MACHINING AS REQUIRED.
PART No. 11820581
CAPSULE
(IMPACT EXTRUSION METHOD)
27 MAY 1975
NOTE 1
D 19200 11820581
R & D


PRIMER AND CAP ASSEMBLY
PART No.
PRIMER - 10534279
CAP - 11820582
SEE NOTE
NOTE:
23 MAY 1975
C
19200
FOLDED
APPLICATION


PART No. 11820582
U.S. ARMY
FRANKFORD ARSENAL
PHILADELPHIA, PA. 19137
CAP
(IMPACT EXTRUSION METHOD)
C 19200 11820582
23 MAY 1975
NOTE 1
NOTES -
1 MATERIAL - STEEL 1008
2 .25/ ALL OVER
3 SUPPLEMENTARY MACHINING, AS REQUIRED
.2802 REF
.272 REF
.360 REF
.254 + .001
.633 .001
.614 + .001
.206 .002
.339 -.002
.022 -.004
.010 +.005 R
.027 -.007
.1738+.0007
.639 .002
.005 R MAX



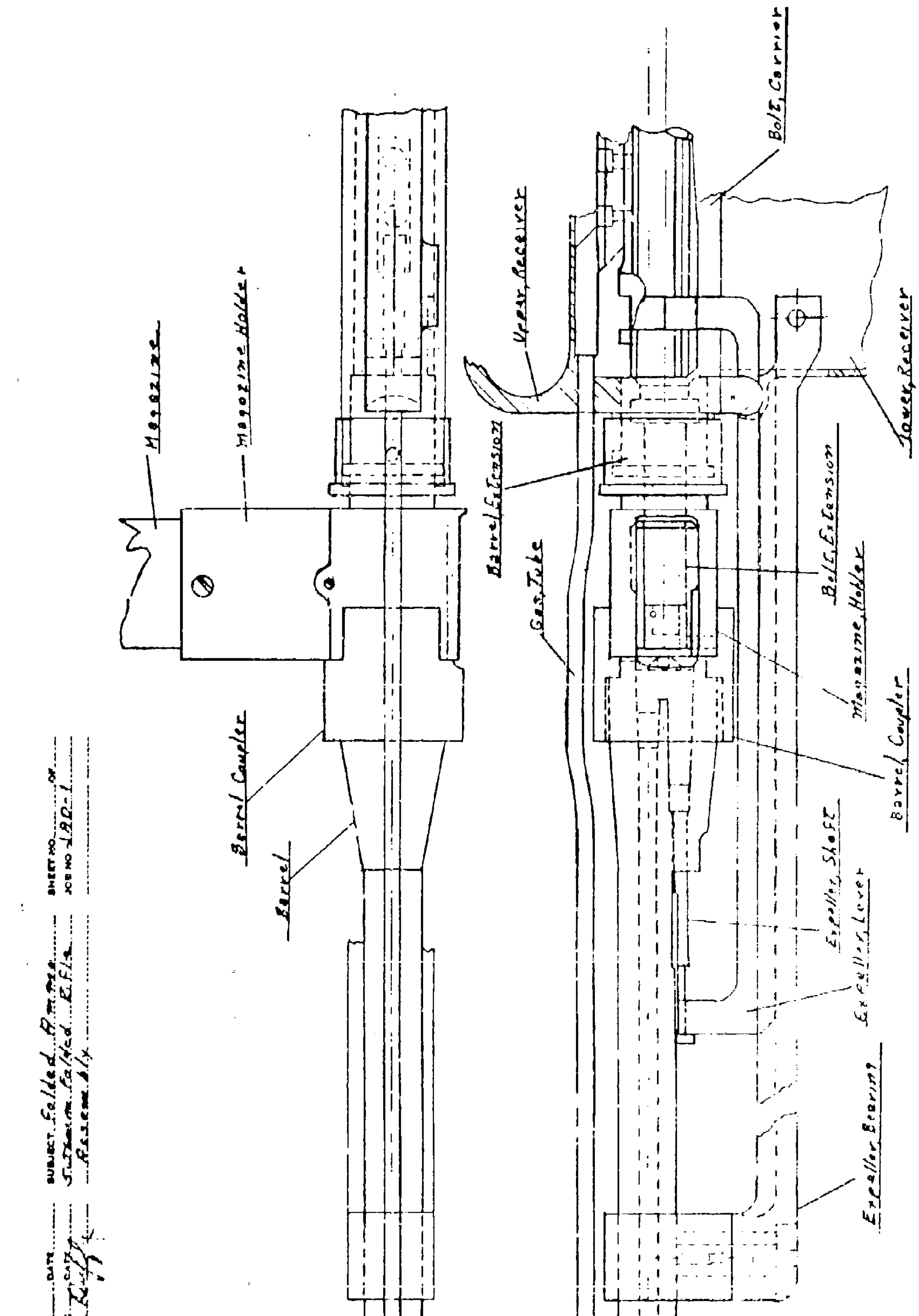
.028
1.06 - .01
.045
+.010
20°
20°
.735-.010
.248 DIA
.2238
-.0005
.135 REF
.020 R MAX
.220
-.005
.537 R
-.03
JACKET
STEEL CORE
PLASTIC INSERT
PART No. 11735685
23 MAY 1975
BULLET
5.56MM FABRL
C
19200
11735685

APPENDIX E

Modified M16A1 Details

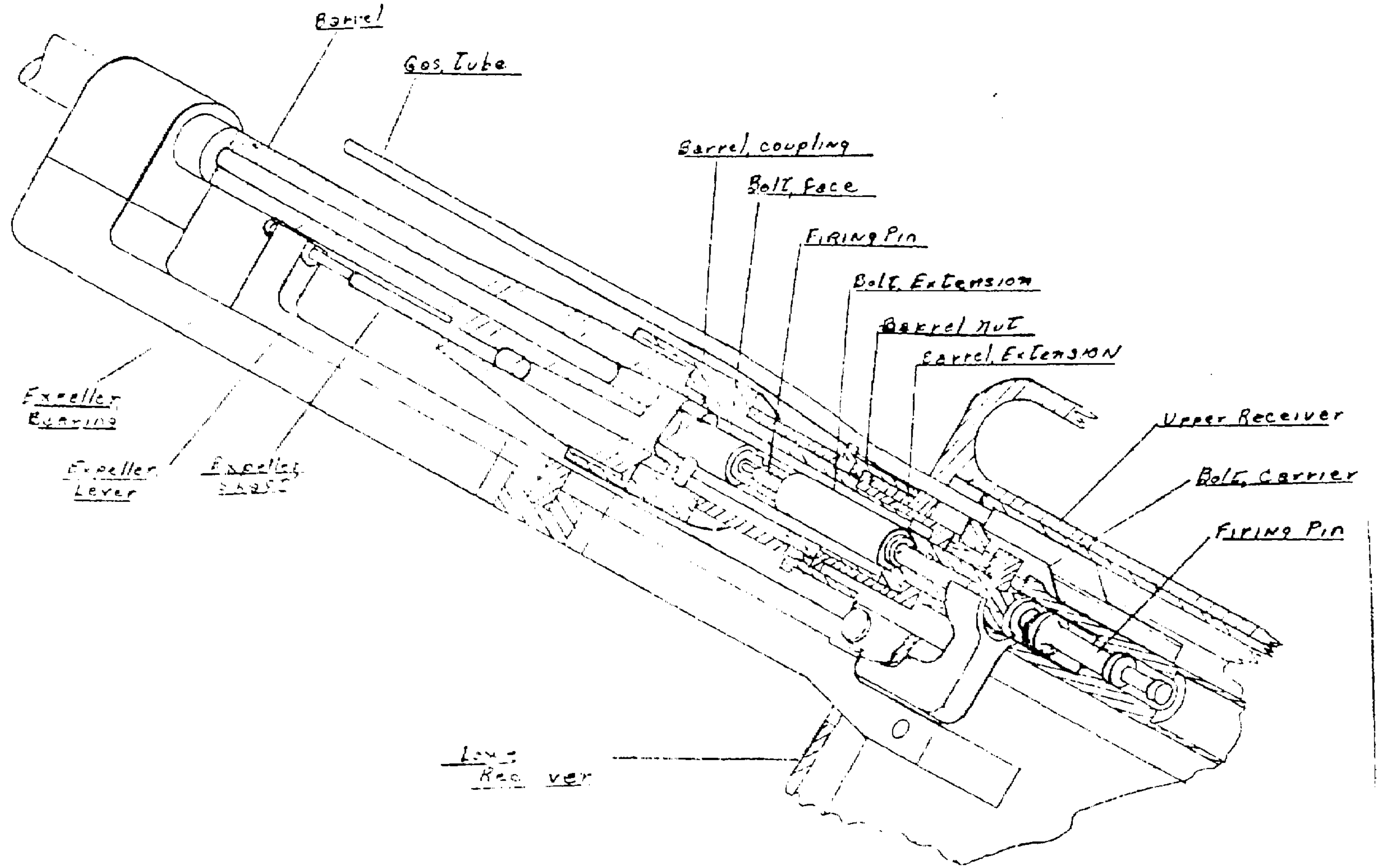
SKETCH LIST

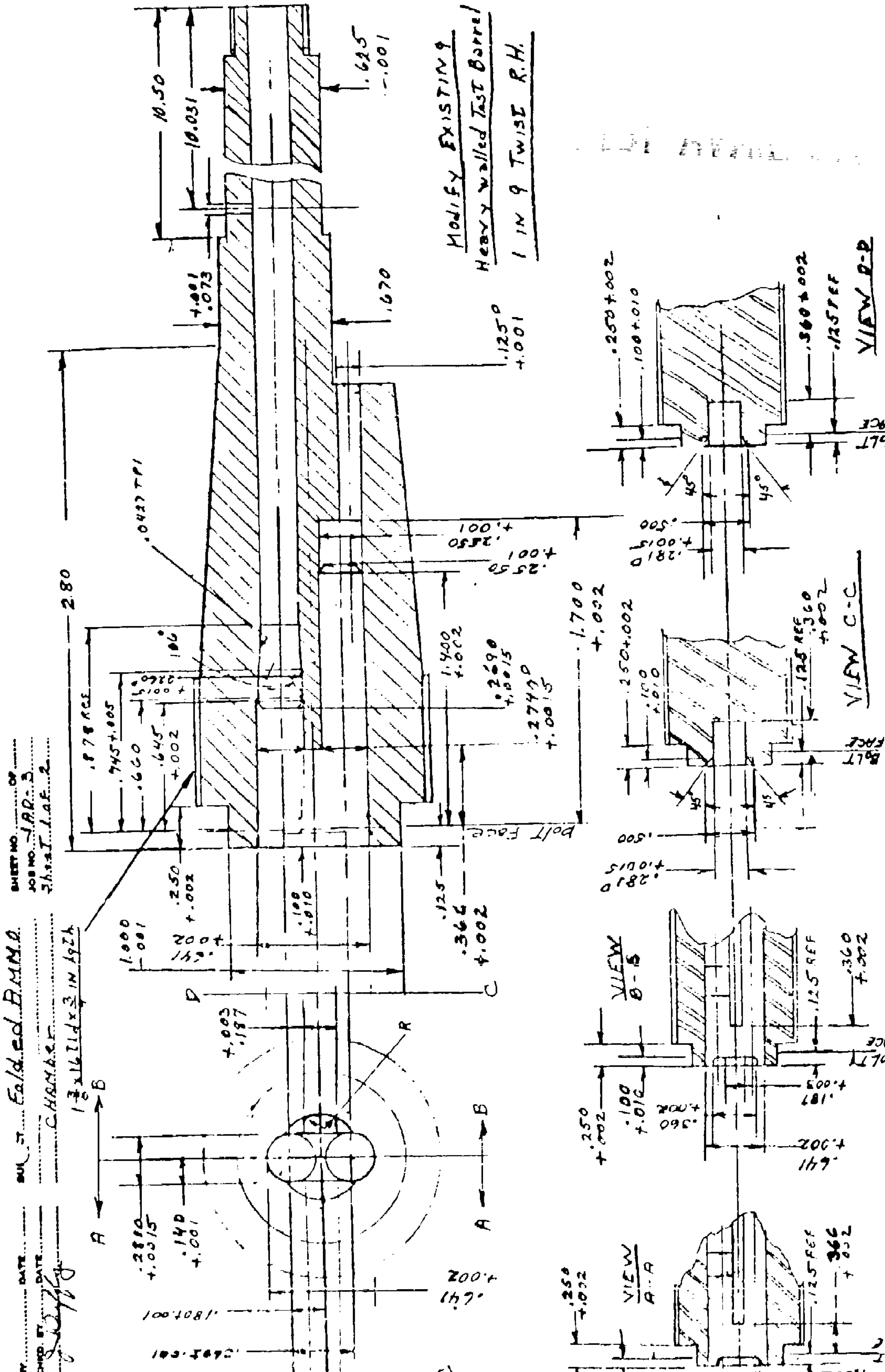
NO	NOMENCLATURE	SKETCH NO
1	5.56mm Folded Rifle, Assembly	JAD-1
2	5.56mm Folded Rifle, Sectioned Isometric Ass'y	JAD-2
3	Barrel (2 Sheets)	JAD-3
4	Firing Pin	JAD-4
5	Bolt Face	JAD-5
6	Bolt Extension	JAD-6
7	Bolt Carrier Modification	JAD-7
8	Upper Receiver Housing Modification	JAD-8
9	Barrel Coupling	JAD-9
10	Buffer	JAD-10
11	Expeller Lever	JAD-11
12	Expeller Shaft	JAD-12
13	Expeller Bearing	JAD-13
14	Magazine Housing	JAD-14
15	Lower Housing Modification	JAD-15
16	Sear, Automatic Modification	JAD-16
17	Pins, Lower Housing Assembly	JAD-17
18	Magazine, Assembly	JAD-18
19	Magazine, Body	JAD-19
20	Magazine, Spring	JAD-20
21	Magazine, Base	JAD-21
22	Magazine, Follower	JAD-22
23	Chamber, Reamers	JAD-23

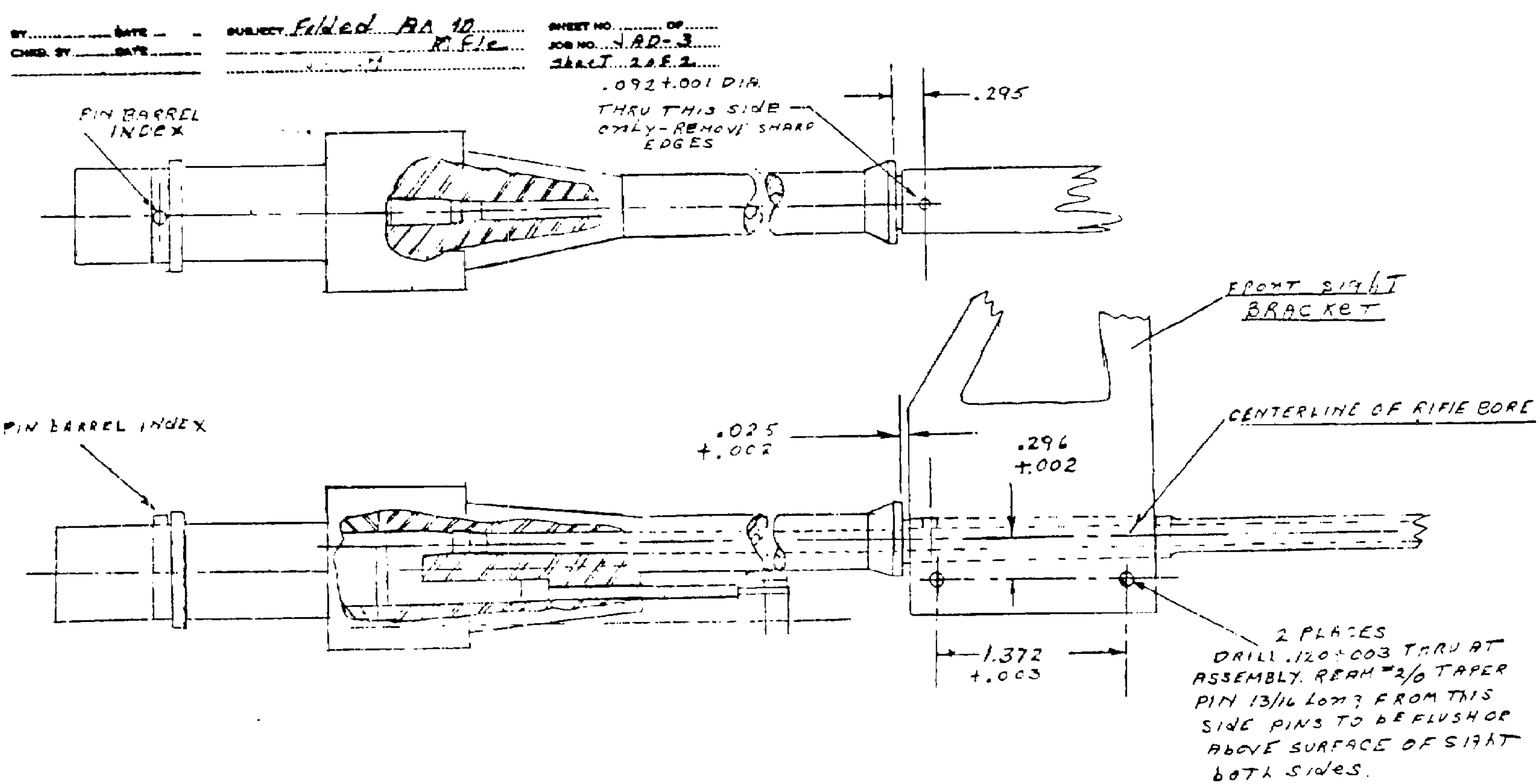

Magazine
Magazine Holder
Barrel Coupler
Barrel
Barrel Extension
Gas Tube
Upper Receiver
Bolt Carrier
Lower Receiver
Bolt Extension
Magazine Holder
Barrel Coupler
Expeller Shaft
Expeller Lever
Expeller Bearing

BY .... DATE .... SUBJECT Folded Primo Rifle .... SHEET NO .... OF ....

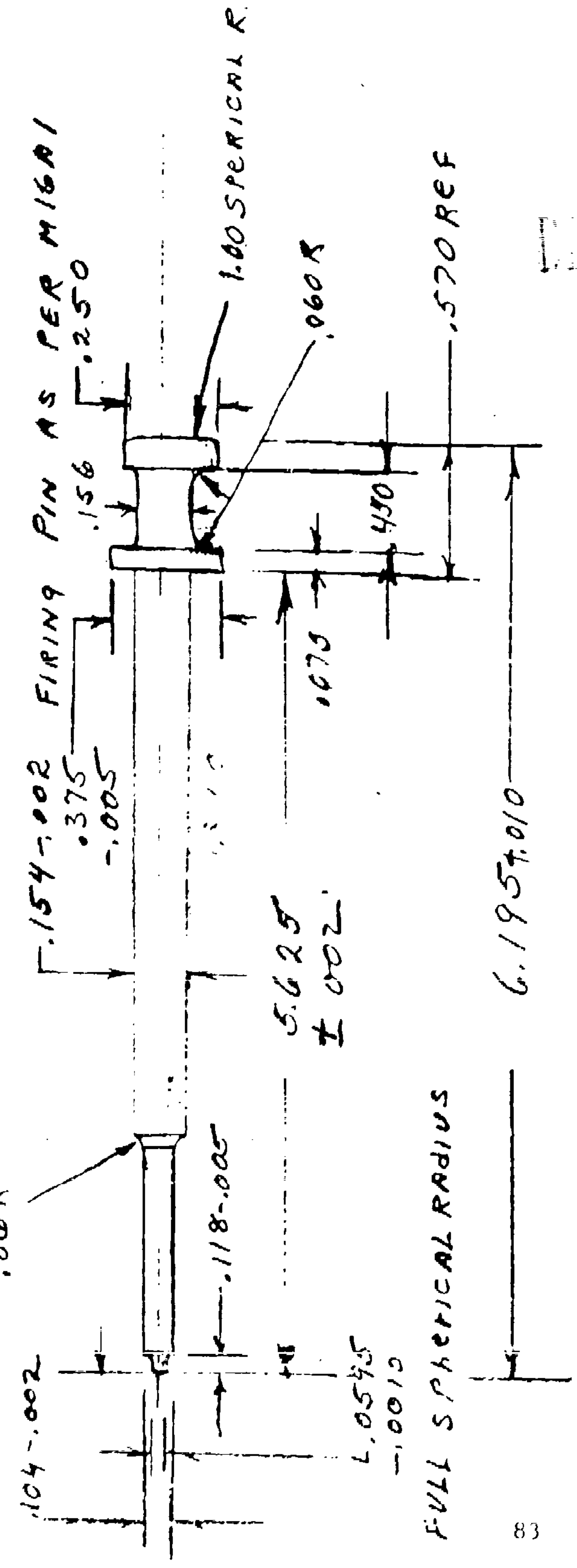
CHKD BY .... DATE .... Sectioned Isometric Assy .... JOB NO. IBD-2




Modify Existing
Heavy walled Test Barrel
1 in 9 Twist R.H.
Folded BMMO
CHAMBER
VIEW D-D
VIEW C-C
VIEW B-B
VIEW A-A
Bolt Face
10.50
10.031
2.80
1.700
+.002

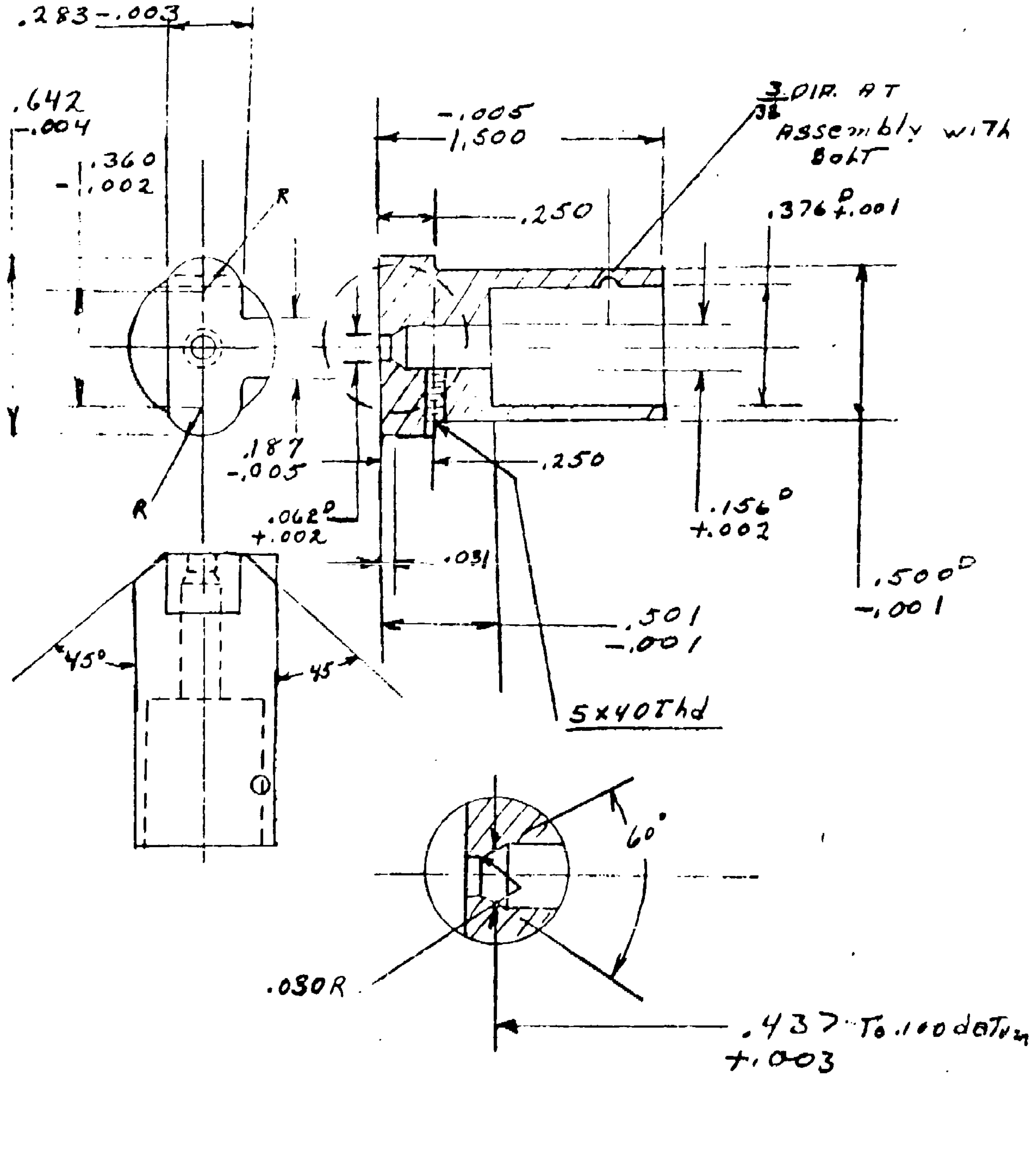


BY ____ DATE ____
CHKD. BY ____ DATE ____
SUBJECT Folded AR 10 Rifle
SHEET NO. ____ OF ____
JOB NO. JAD-3
sheet 2 of 2
.092 +.001 DIA.
THRU THIS SIDE ONLY - REMOVE SHARP EDGES
.295
PIN BARREL INDEX
FRONT SIGHT BRACKET
CENTERLINE OF RIFLE BORE
.025 +.002
.296 +.002
PIN BARREL INDEX
2 PLACES
DRILL .120 +.003 THRU AT ASSEMBLY. REAM #2/0 TAPER PIN 13/16 LONG FROM THIS SIDE PINS TO BE FLUSH OR ABOVE SURFACE OF SIGHT BOTH SIDES.
1.372 +.003



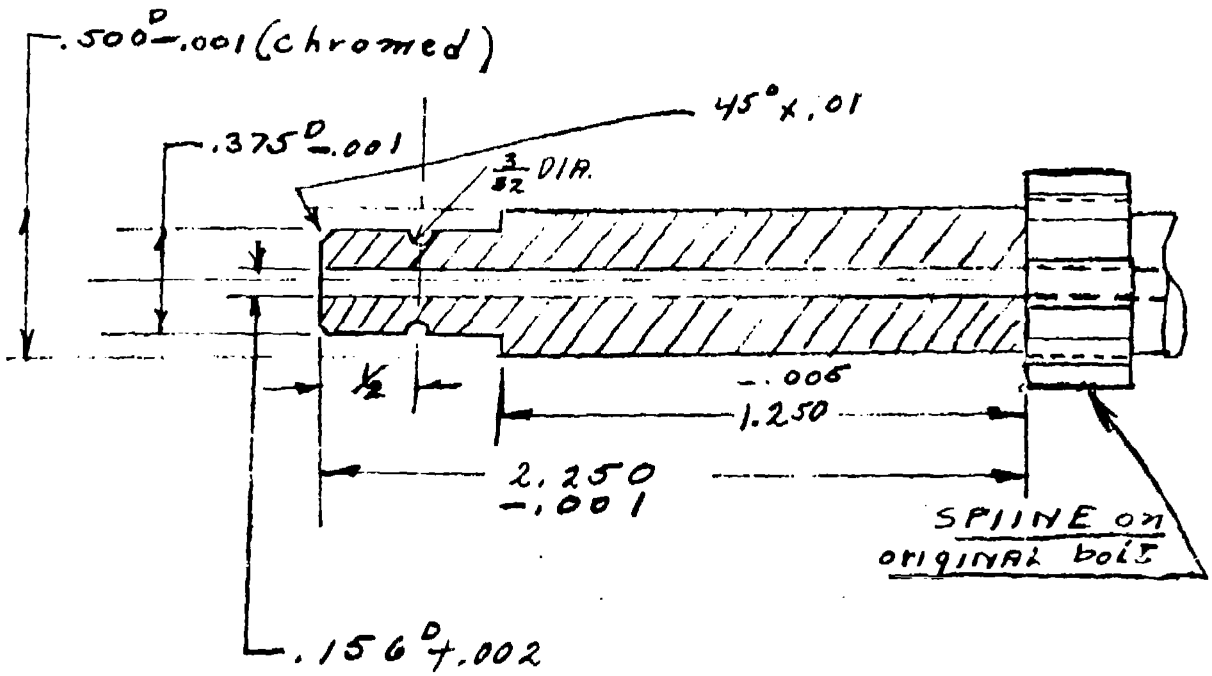
MATERIAL: Alloy Steel - R_c 30-35

BY ____ DATE   SUBJECT 5.56 mm Self Ammo Rifle Bolt Face   SHEET NO. ____ OF ____
CHKD. BY ____ DATE   JOB NO. JAD-5
EXT 5934



MATERIAL: Alloy Steel, R_c 38-42

BY ______ DATE ______ SUBJECT 5.56 MM ______ AMMO SHEET NO. ____ OF ____
CHKD. BY ______ DATE ______ JOB NO. ______AD-6
______ 5-9-34 ______ BOLT EXTENSION



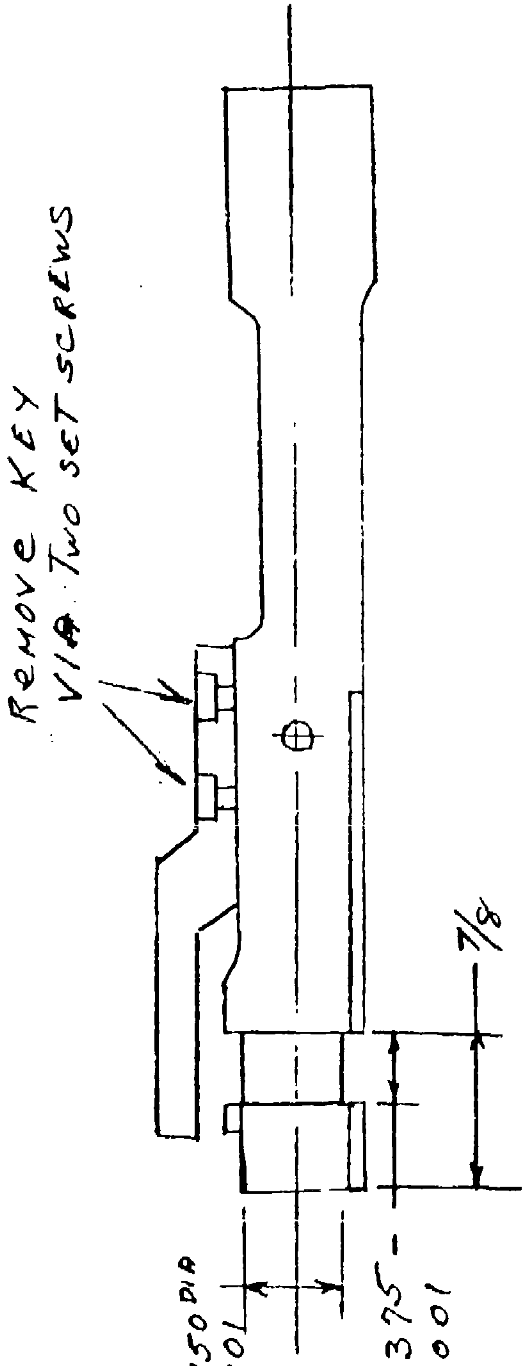
MATERIAL: Alloy Steel, R_c 38-42

J Duff

Folded Ammo

Bolt Carrier

JAD-2



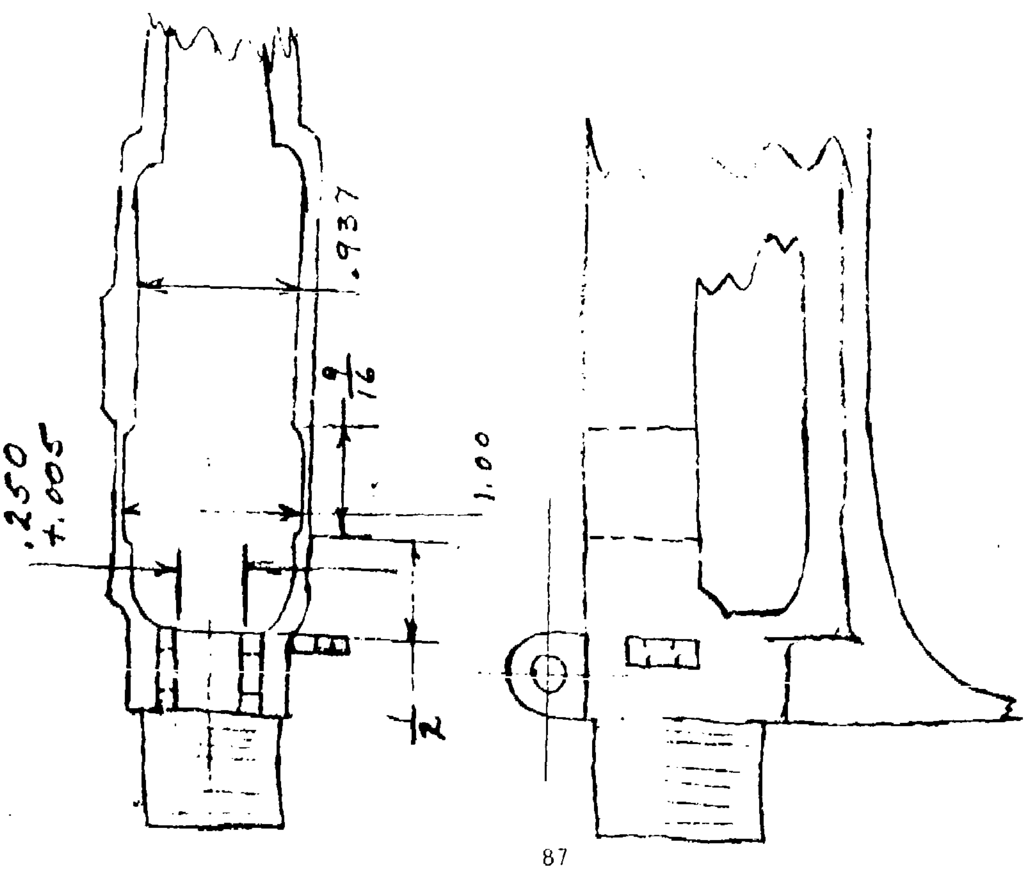
Modification - Grind a .375 inch wide groove having an .075 inch diameter.

JW. 70 C

Folded AMMO
Rifle

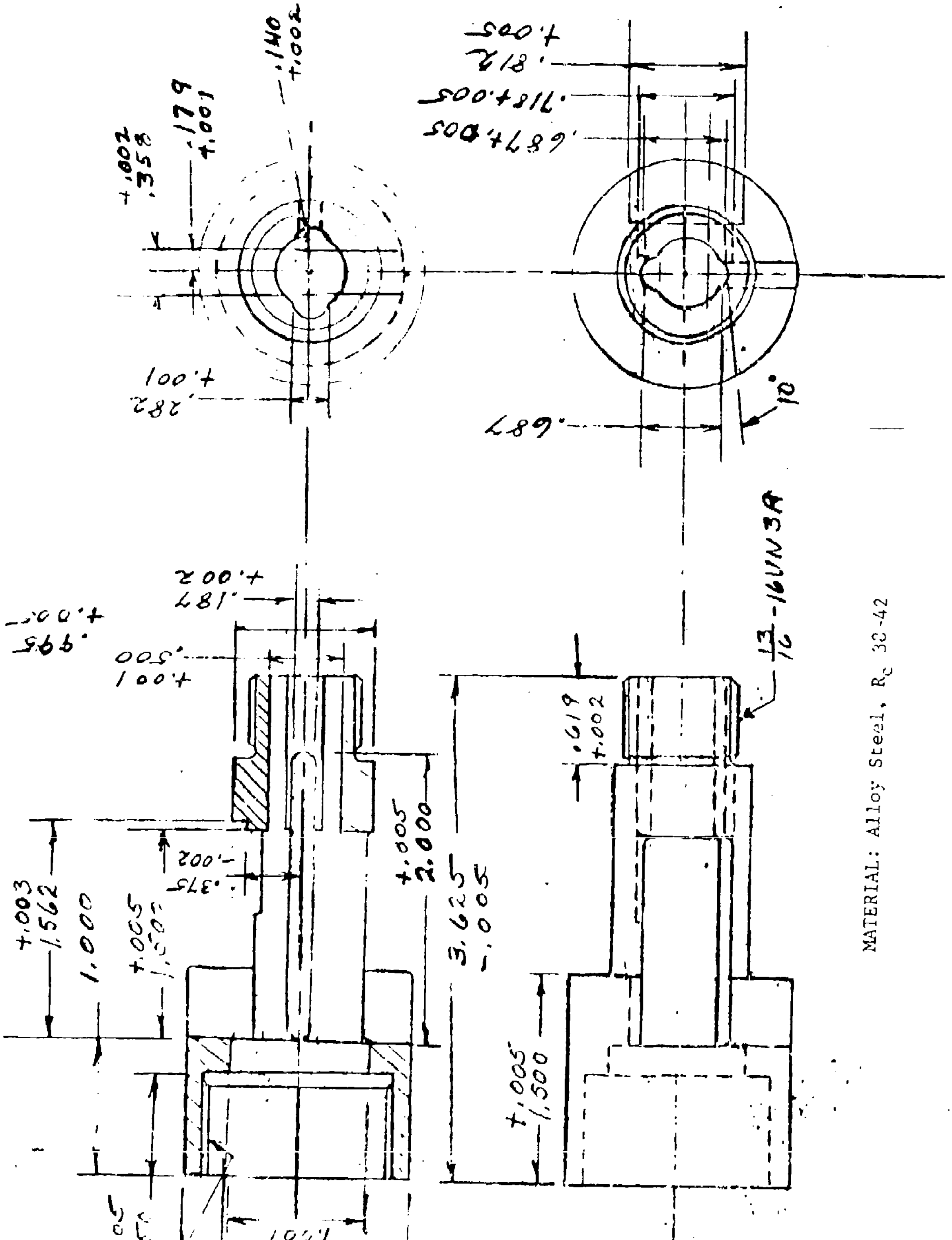
UPPER RECEIVER HOUSING

JAD-8



CHKD. BY ______ DATE ______ Rifle JOB NO. JAR-9

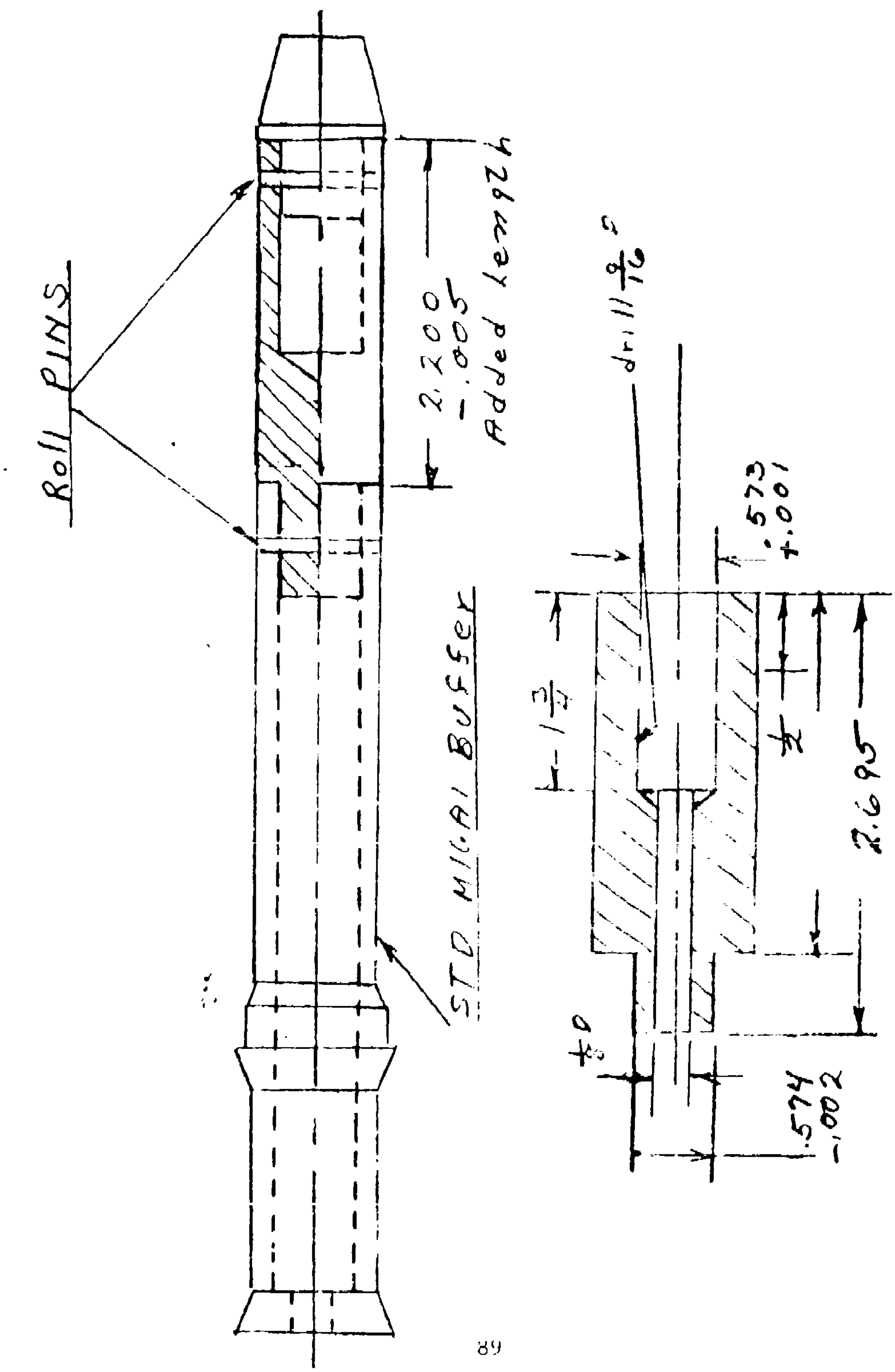
BARREL Coupling



MATERIAL: Alloy Steel, R_c 32-42

BY .... DATE .... SUBJECT Folded Ammo Rifle Buffer .... SHEET NO. .... OF ....

CHKD BY John .... DATE .... JOB NO. AR-10 5934

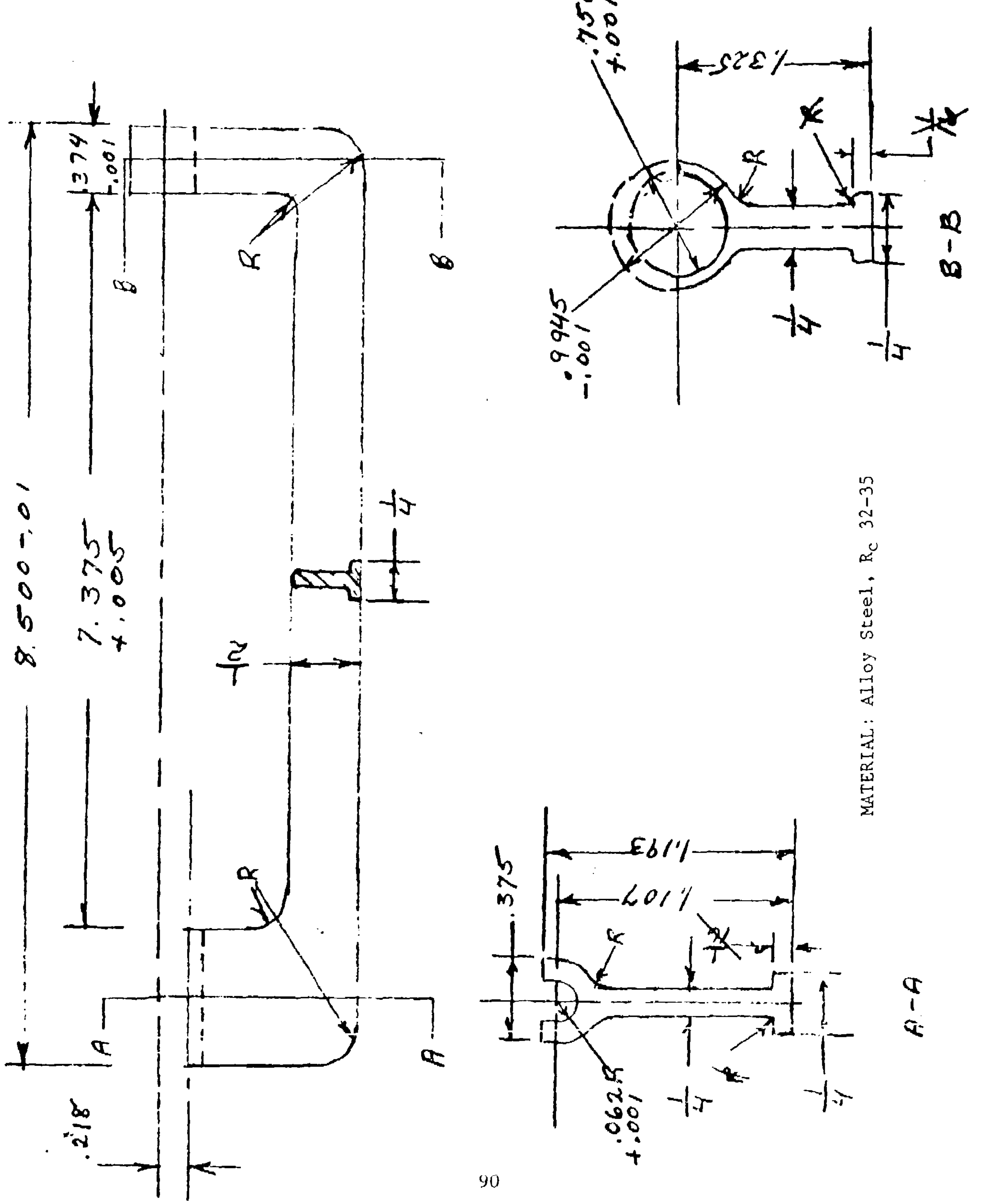


MATERIAL: Steel

BY .... DATE .... SUBJECT *Folded AMMO RIFLE* SHEET NO. ...... OF ......

CHKD. BY .... DATE .... JOB NO. *JBO-11*

John Duffy *EXT 5934*

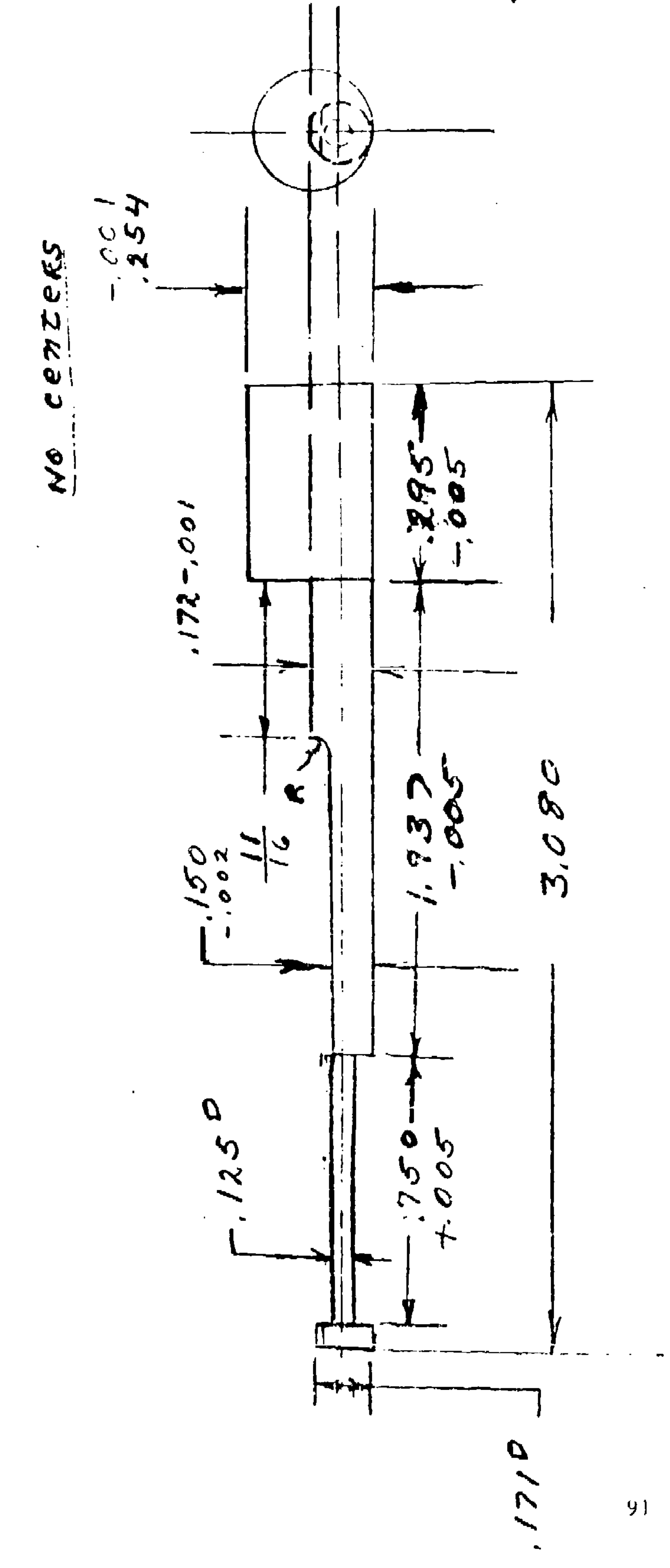


MATERIAL: Alloy Steel, R_C 32-35

BY .... DATE .... SUBJECT *Folded Ammo Rifle* .... SHEET NO. .... OF ....

CHKD. BY .... DATE .... *Expeller Shaft* .... JOB NO. *JAD-12*

E/T 5934

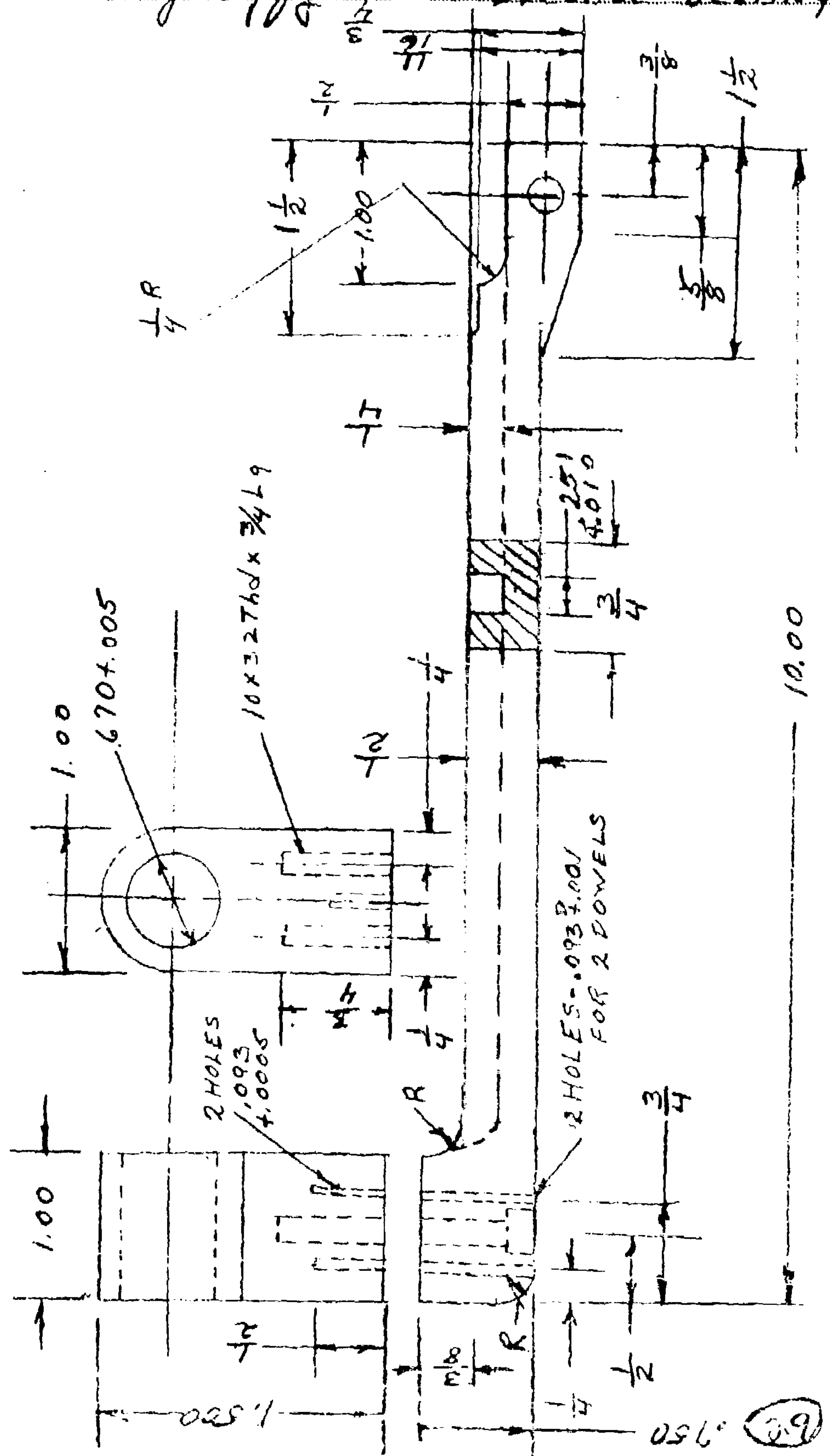


MATERIAL: Steel 4340 ; Heat-treated R_C 42 ± 2

CHKD. BY J. Duffy DATE

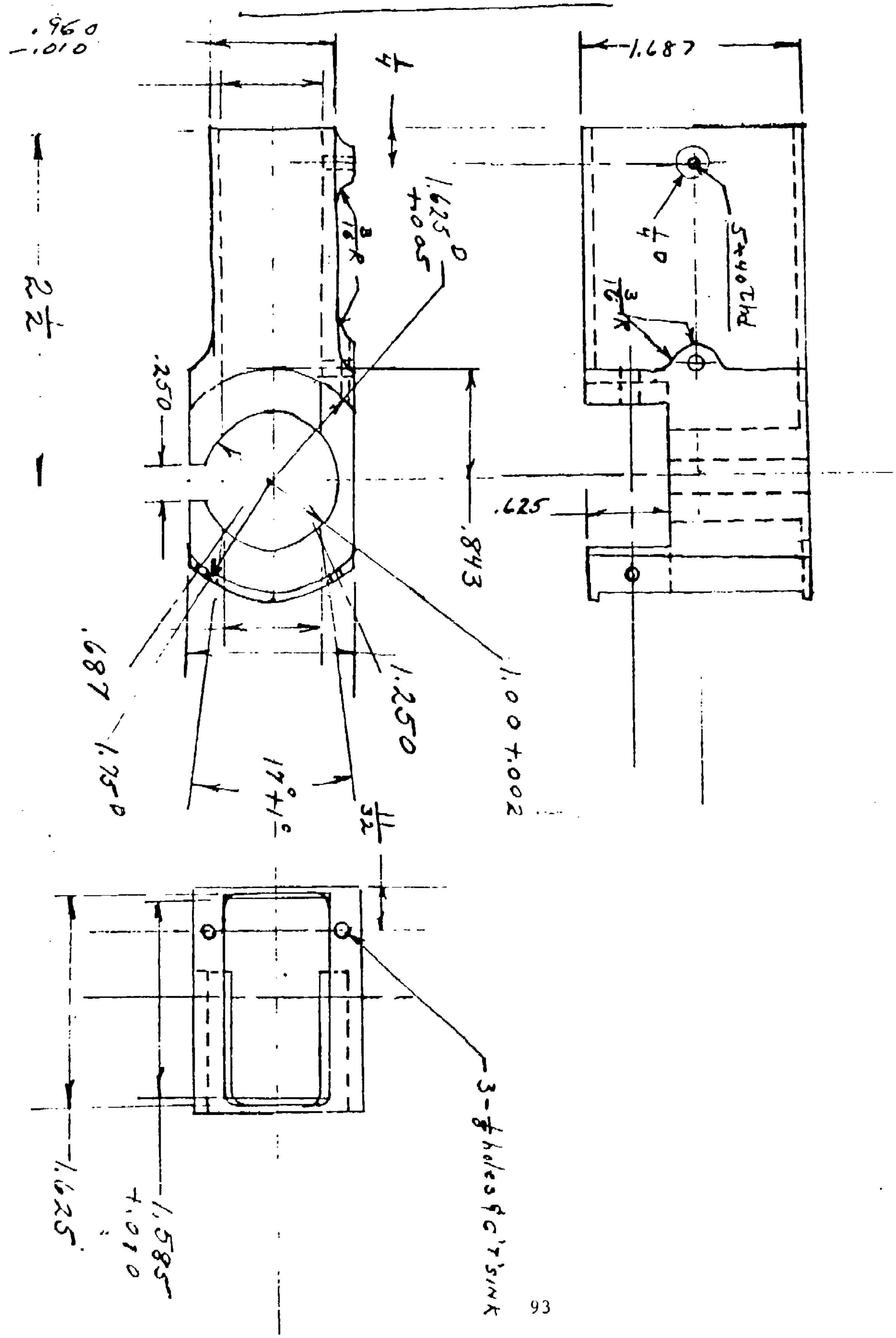
Expeller Bearing EXT. 5931

JAD-13



MATERIAL: Alloy Steel

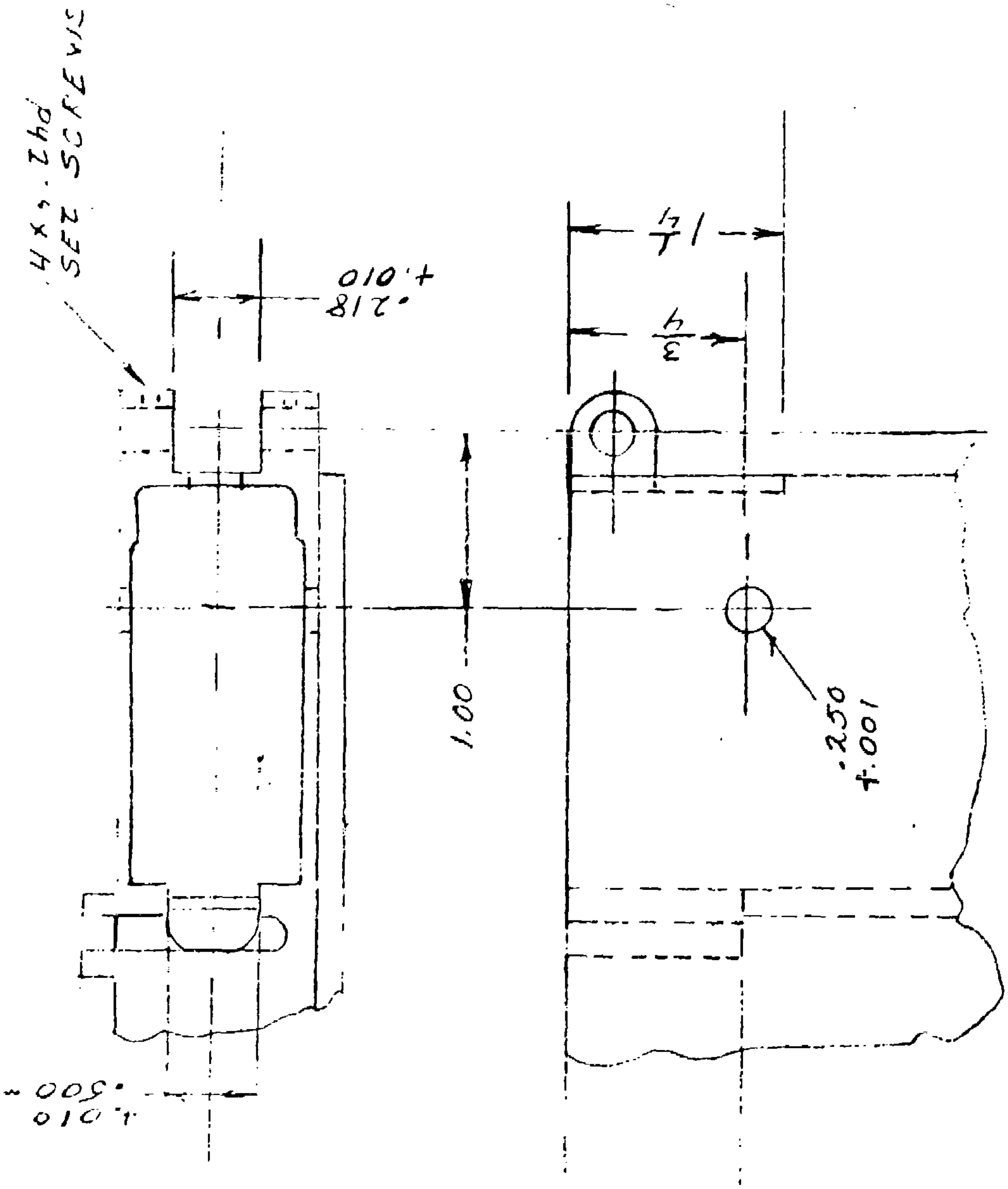
Folded AMMO Rifle JAD-14



FOLDED AMMO

Rifle JAD-15

LOWER HOUSING ASSEMBLY

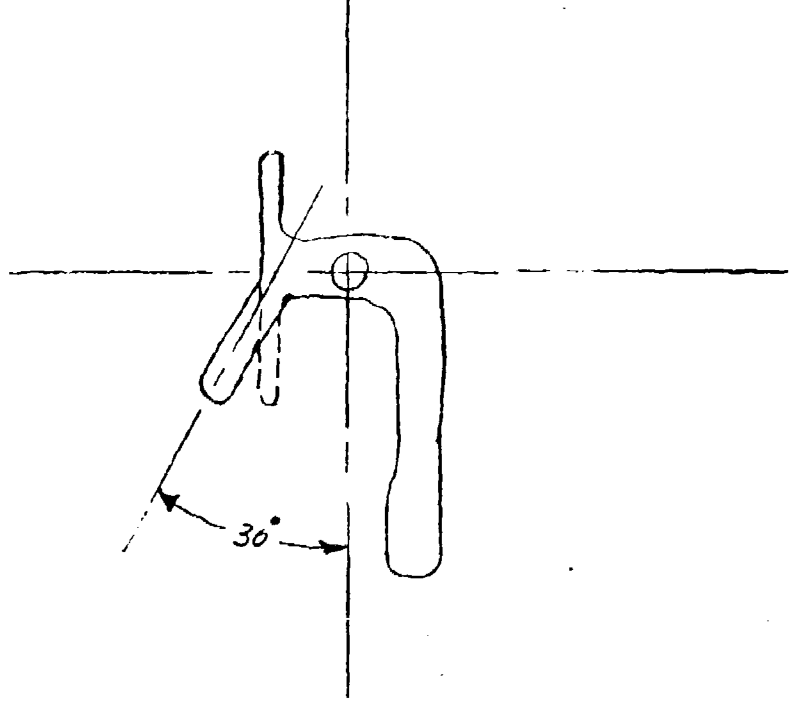


Folded AMMO Rifle

SEAR, AUTOMATIC

[illegible] 5934

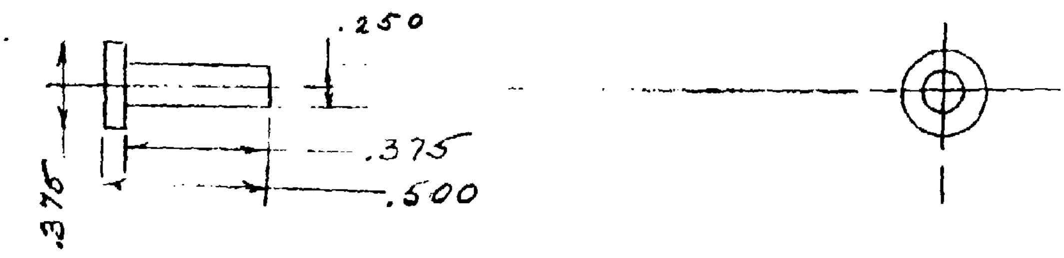
JAD-16

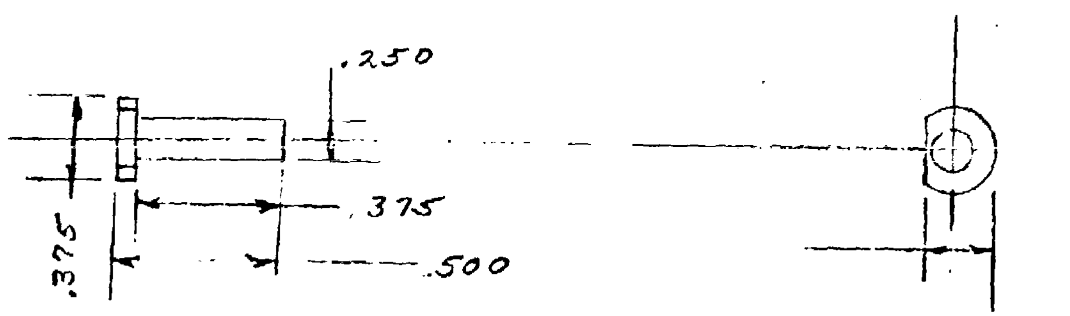


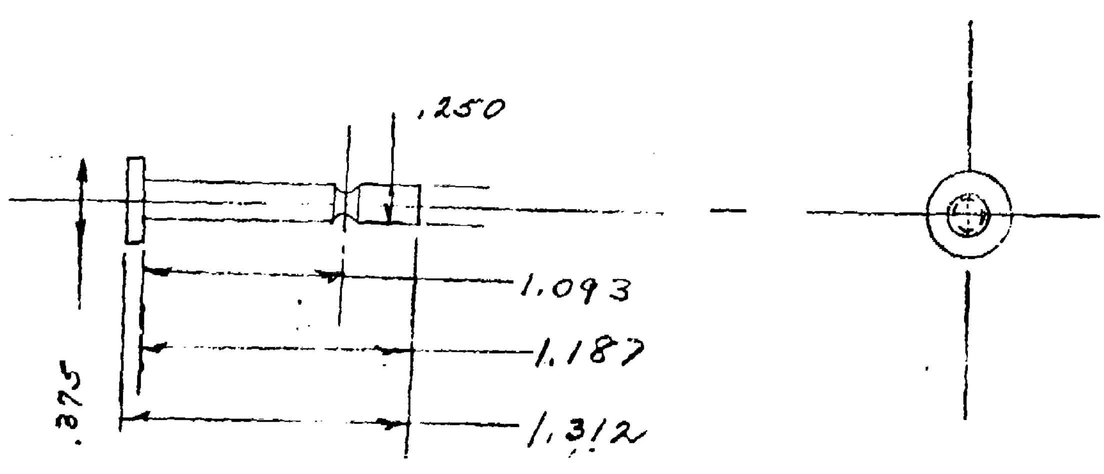
FOLDED AMMO

JAD-17

PINS, LOWER HOUSING ASSEMBLY





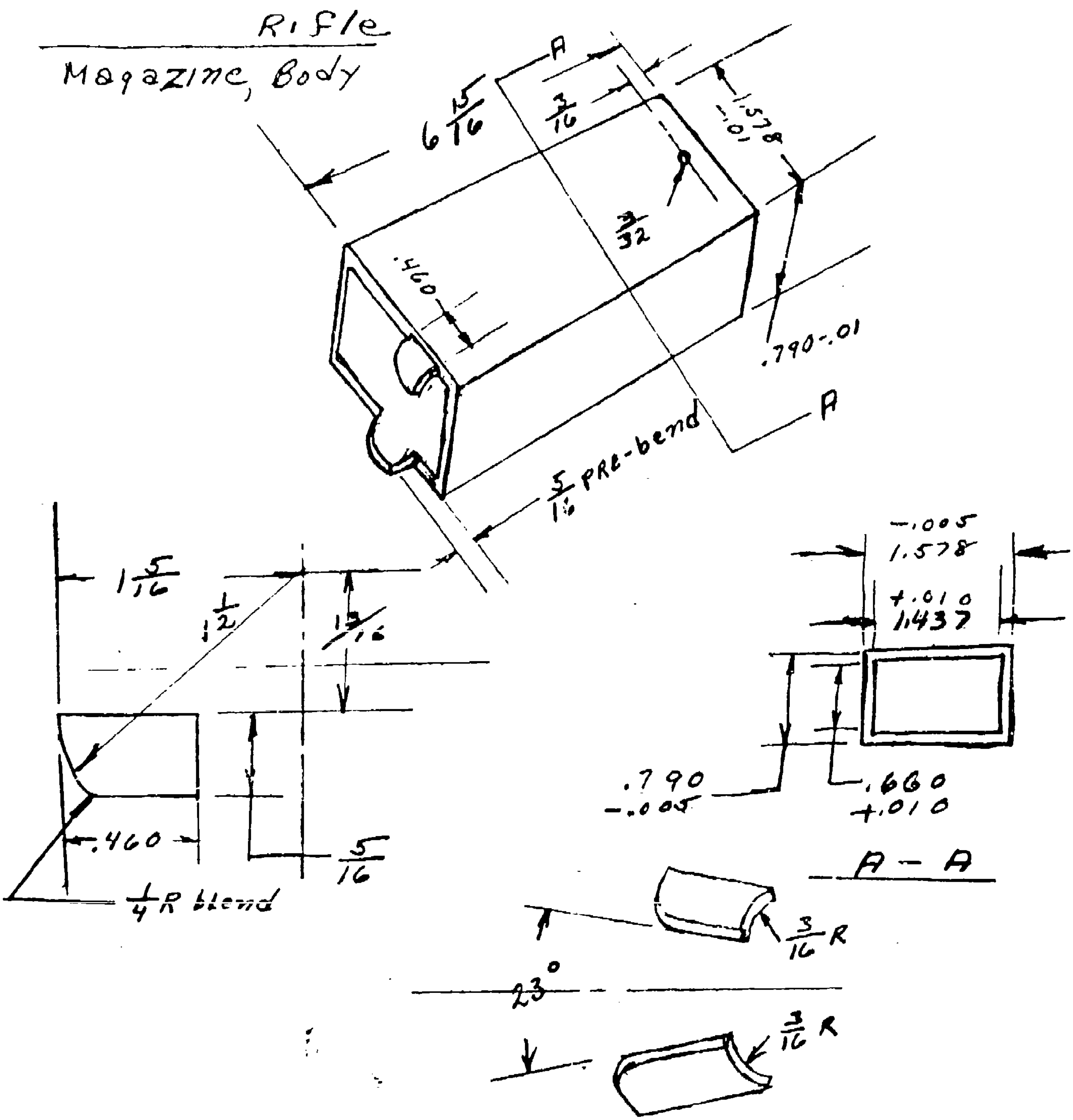


BY .... DATE .... SUBJECT Folded AMMO Rifle Magazine Assembly SHEET NO. ...... OF ......

CHKD. BY .... DATE .... JOB NO. JAD-18

1. Magazine body — JAD-19
2. Spring — JAD-20
3. Magazine base — JAD-21
4. Follower — JAD-22
5. Roll Pin

Folded Ammo JAD-19



MATERIAL: Steel/brass

John Duffy

Folded AMMO
Rifle

JAD-20

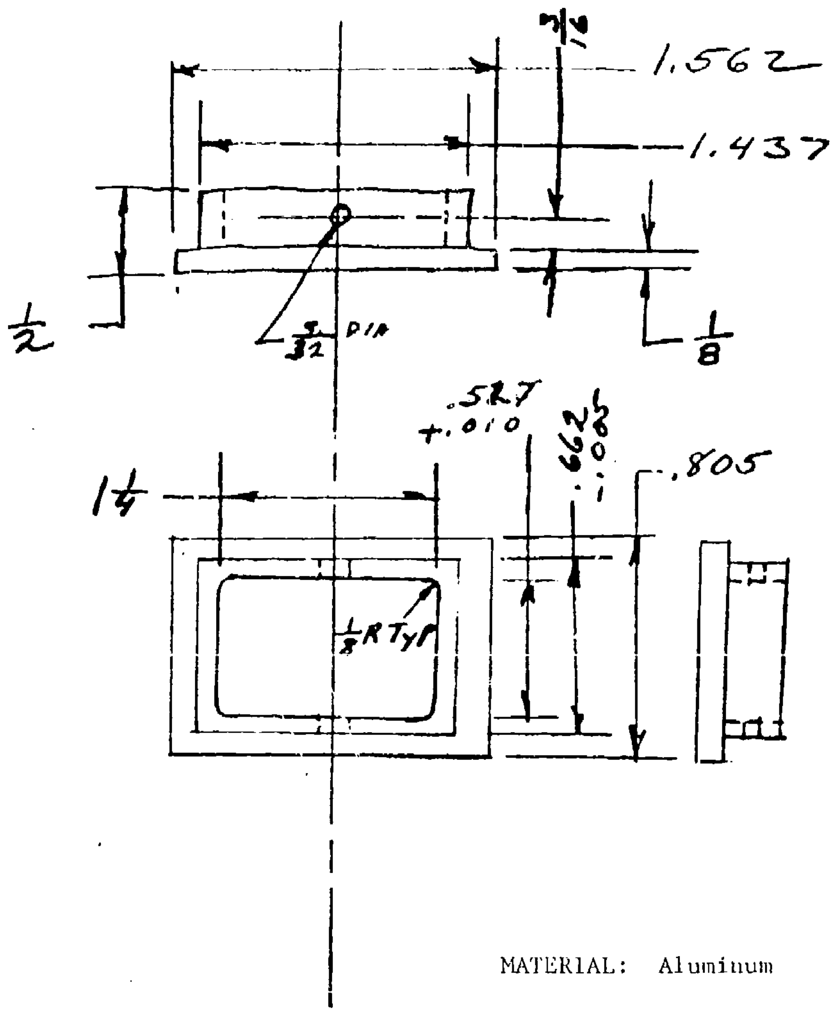
Magazine Spring

WIRE Diam — .054
NO coils — 13
length — 1 1/8
width — 5/8
Free length — 7 1/2
mat'l — music wire

John Duffy

Folded AMMO Rifle

BASE, MA9221.
JAD-21

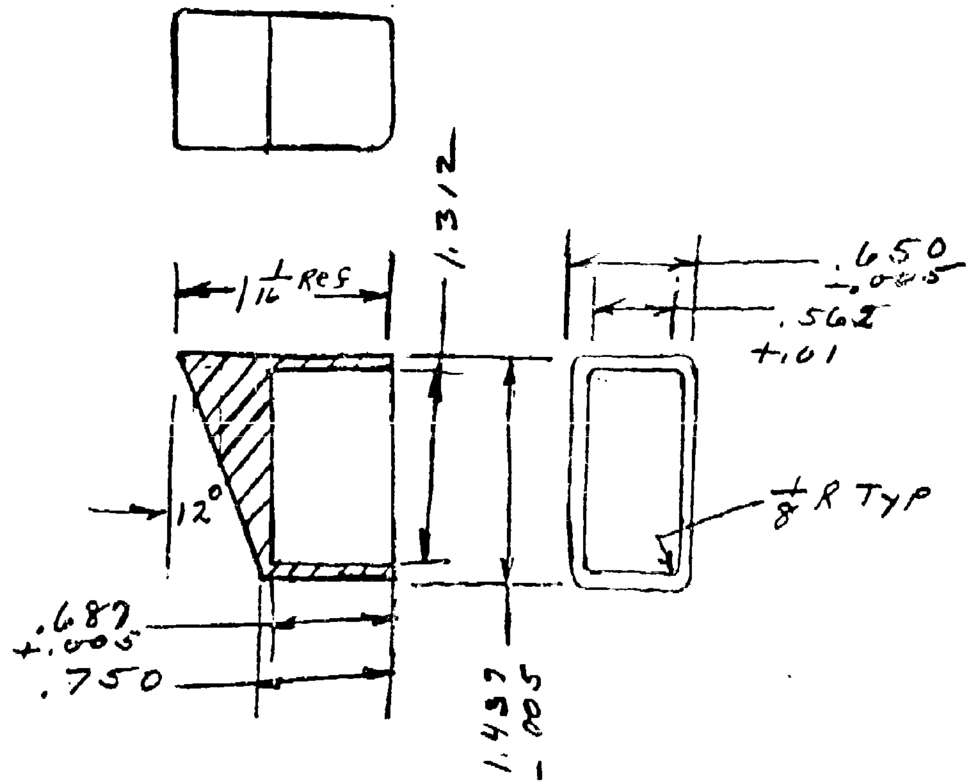


MATERIAL: Aluminum

John Duffy

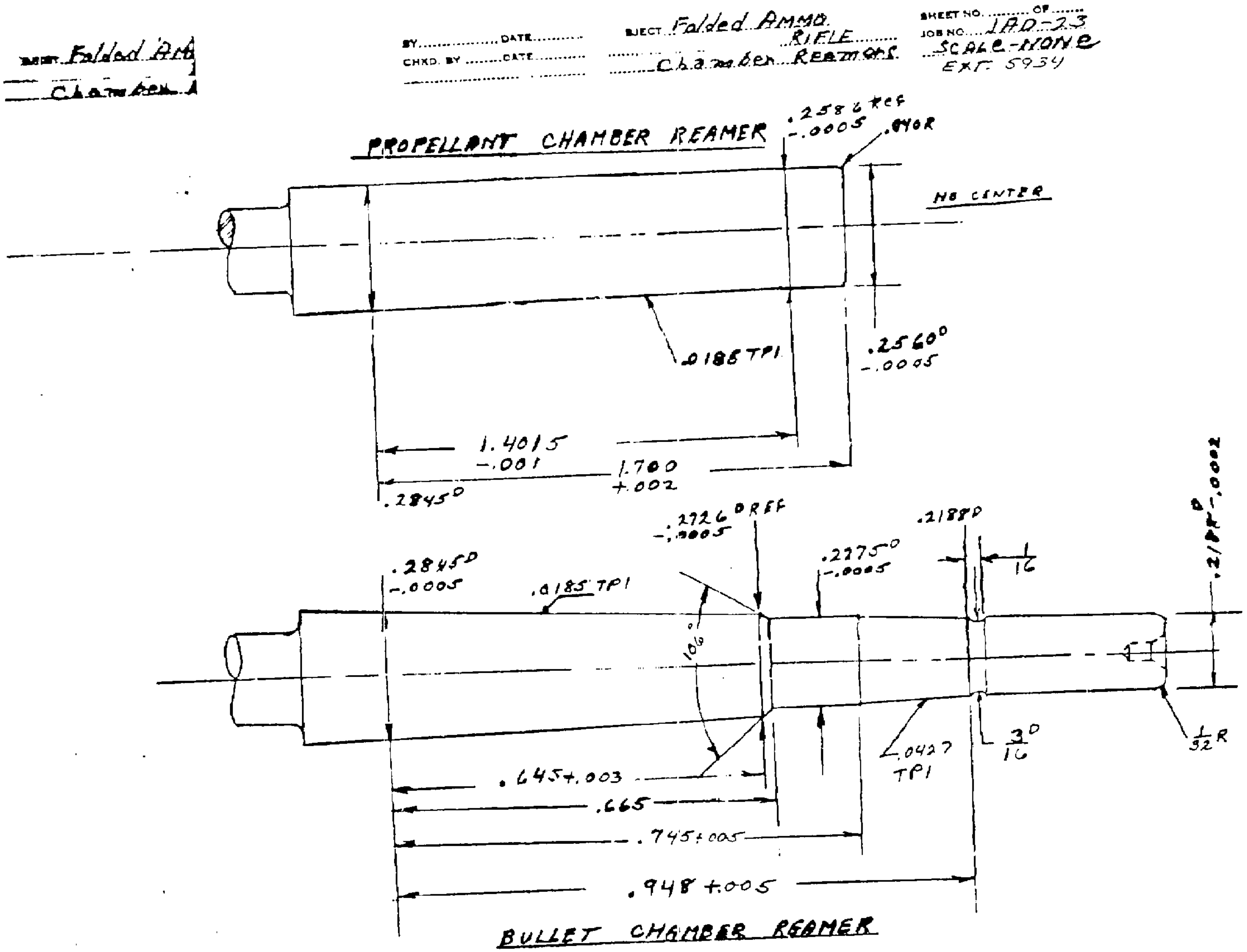
Folded Ammo
Rifle
Follower, Magazine

ABO-22



MATERIAL: Aluminum

John Ruffy

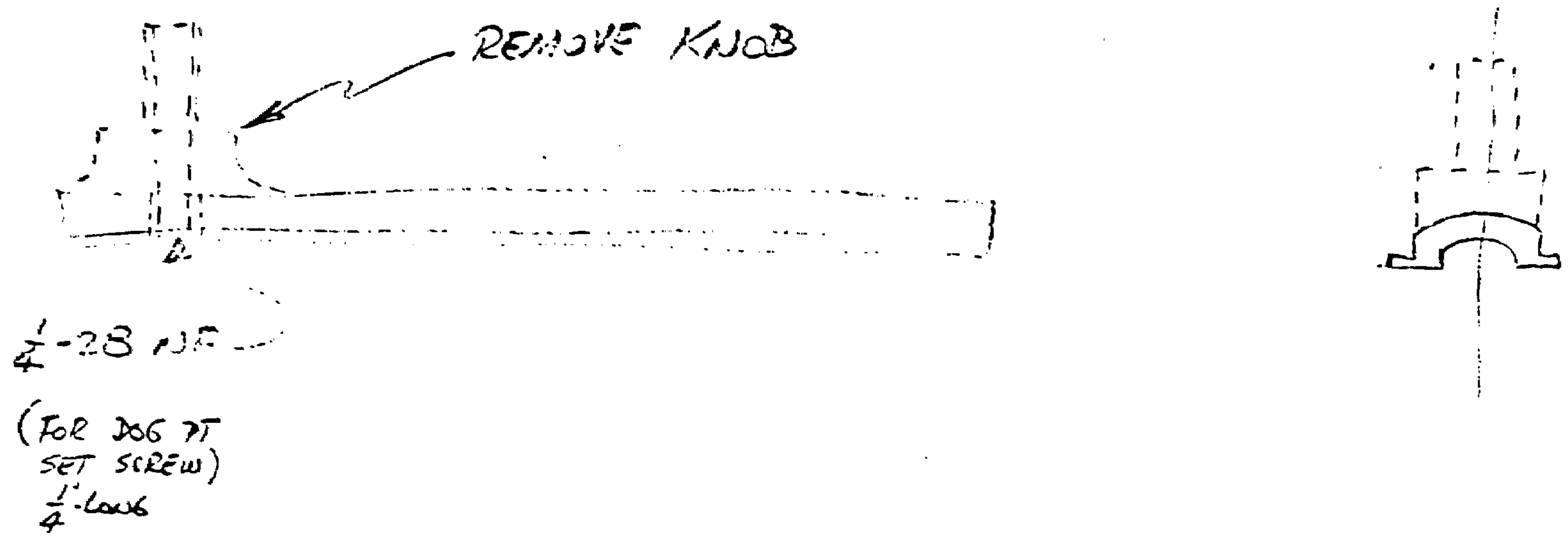

Folded Am
Chamber
BY .... DATE ....
CHKD. BY .... DATE ....
SUBJECT Folded AMMO. RIFLE
Chamber Reamers
SHEET NO. .... OF ....
JOB NO. IAD-23
SCALE-NONE
EXT. 5934
PROPELLANT CHAMBER REAMER
.2586 REF -.0005
.040R
NO CENTER
.0188 TPI
.2560 D -.0005
1.4015 -.001
1.700 +.002
.2845 D
.2726 D REF -.0005
.2188 D
.21875 D -.0002
.2845 D -.0005
.0185 TPI
10°
.2275 D -.0005
1/16
3° 16
.0427 TPI
1/32 R
.645 +.003
.665
.745 +.005
.948 +.005
BULLET CHAMBER REAMER

APPENDIX F

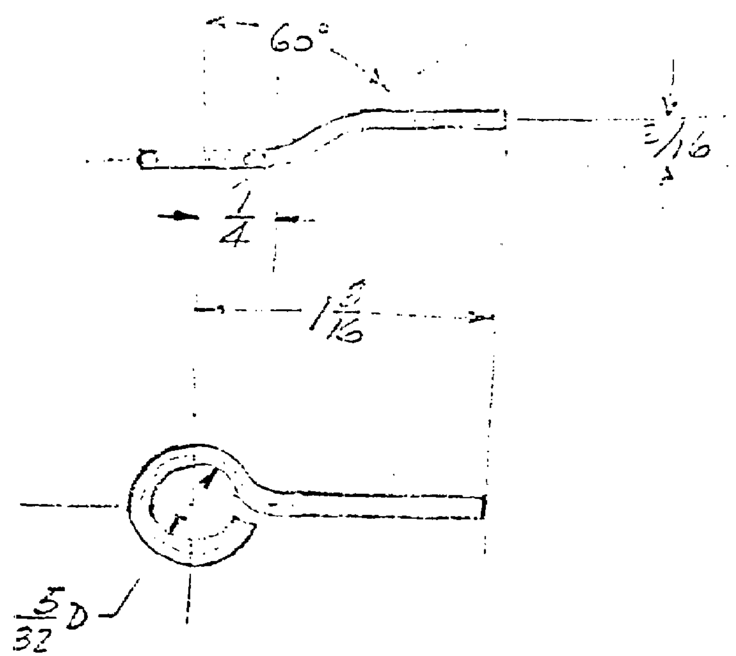
Modified Belgian LAR Details

SKETCH LIST

MKF Sketch No.	
1	Side Cover (Cocking Lever), Mod II
2	Detent, Magazine Catch
3	Latch, Magazine, Mod II
4	Sub-Assembly, Magazine, Adaptor
5	Back Magazine, Fln-Folded
6	Body Magazine, Fln-Folded
7	End, Magazine
8	Follower, Mod II
9	Spring, Magazine, Mod II
10	Tube, Magazine Sub-Assembly, Mod II
11	Rod, Piston
12	Adapter, Gas Cylinder, Mod II
13	Piston
14	Detail of Groove Cylinder, Gas, Mod II
15	Cylinder, Gas, Mod II
16	Sleeve, Mod II
17	Socket, Gas Tube, Mod II
18	Spring, Expeller Return
19	Extension, Expeller, Mod II
20	Expeller, Mod II
21	Spring, Pin, Bolt
22	Spring, Return Firing Pin
23	Pin, Bolt Support, Mod II
24	Carrier, Bolt, Mod II
25	Firing Pin, Mod II
26	Front Sight Sub-Assembly, Modified L.A.R.
27	Kicker
28	Handle, Mod II
29	Barrel (Detail), Mod II
30	Barrel, Mod II
31	Receiver, Kicker Slot Detail, Mod II
32	Pawl, Mod II
33	Bolt, Mod II
34	Magazine Adaptor, Fln 5.56 mm Folded
35	Sub-Assembly, Gas System
36	Bolt, Sub-Assembly
37	Bullet, Chamber, Reamer
38	Fore Arm, Mod II
39	Chamber, Mod II

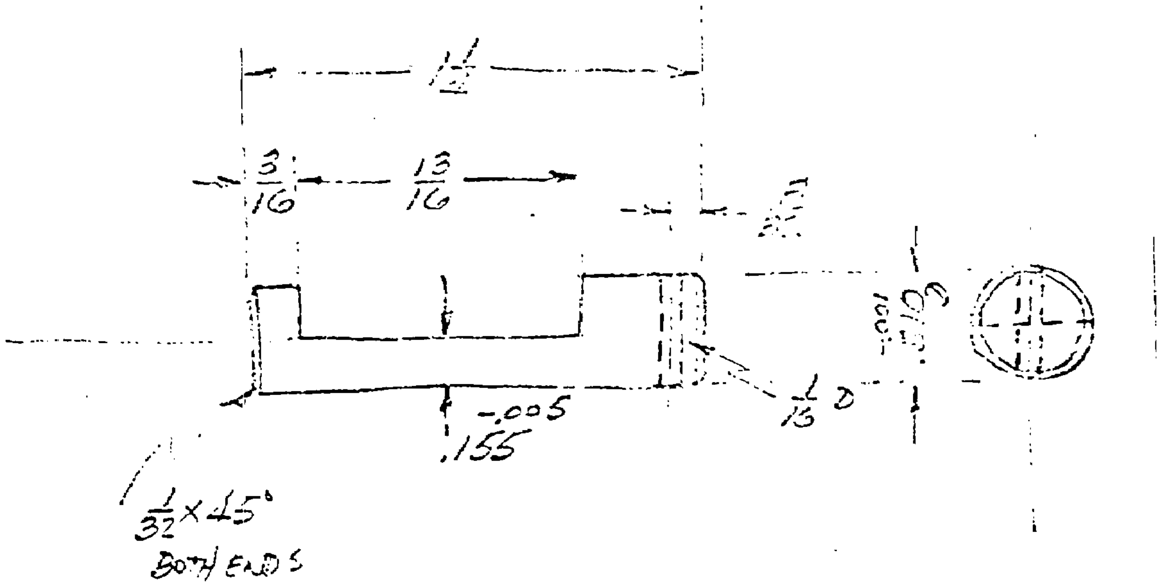


MKF No 1. Side Cover (Cocking Lever, Mod II



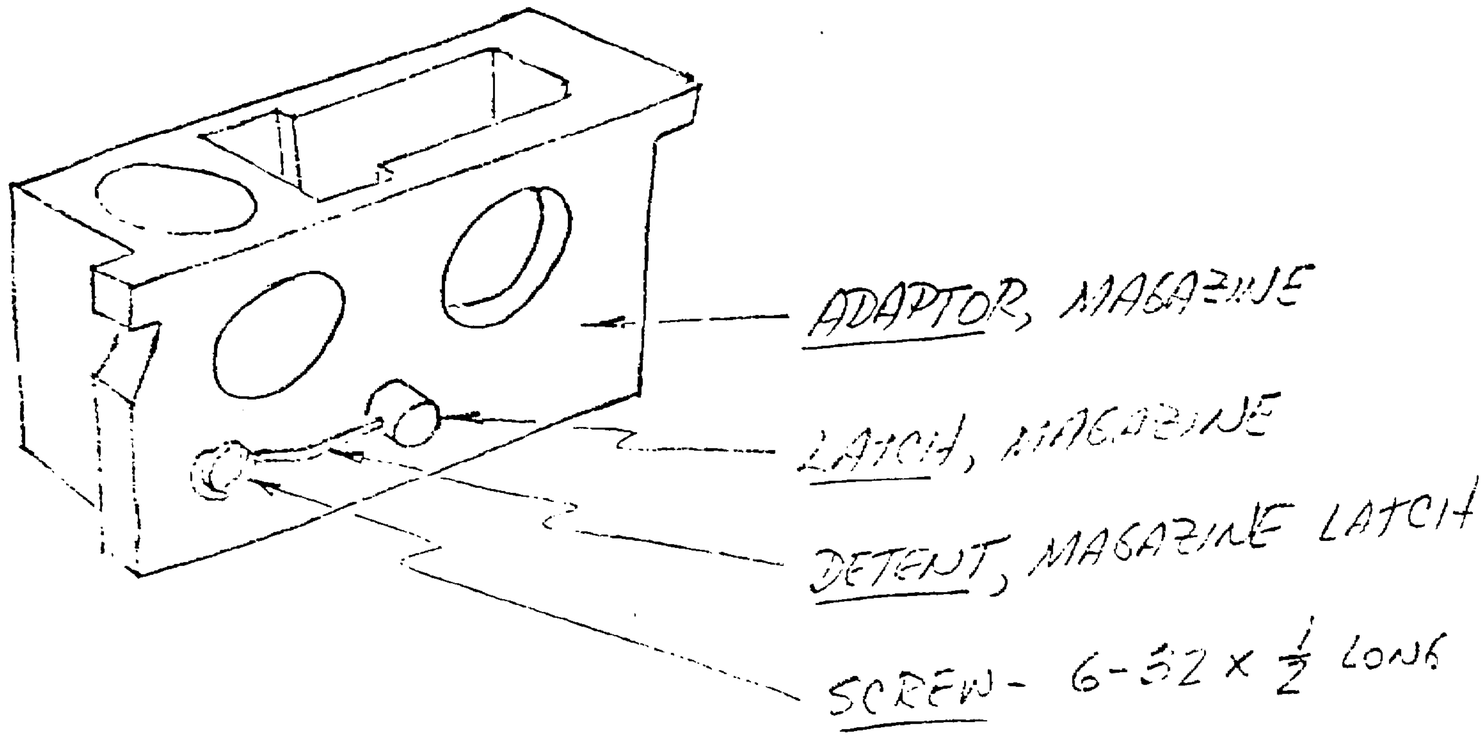
MATERIAL: Spring Wire - .0590

MKF No 2. Detent, Magazine Catch

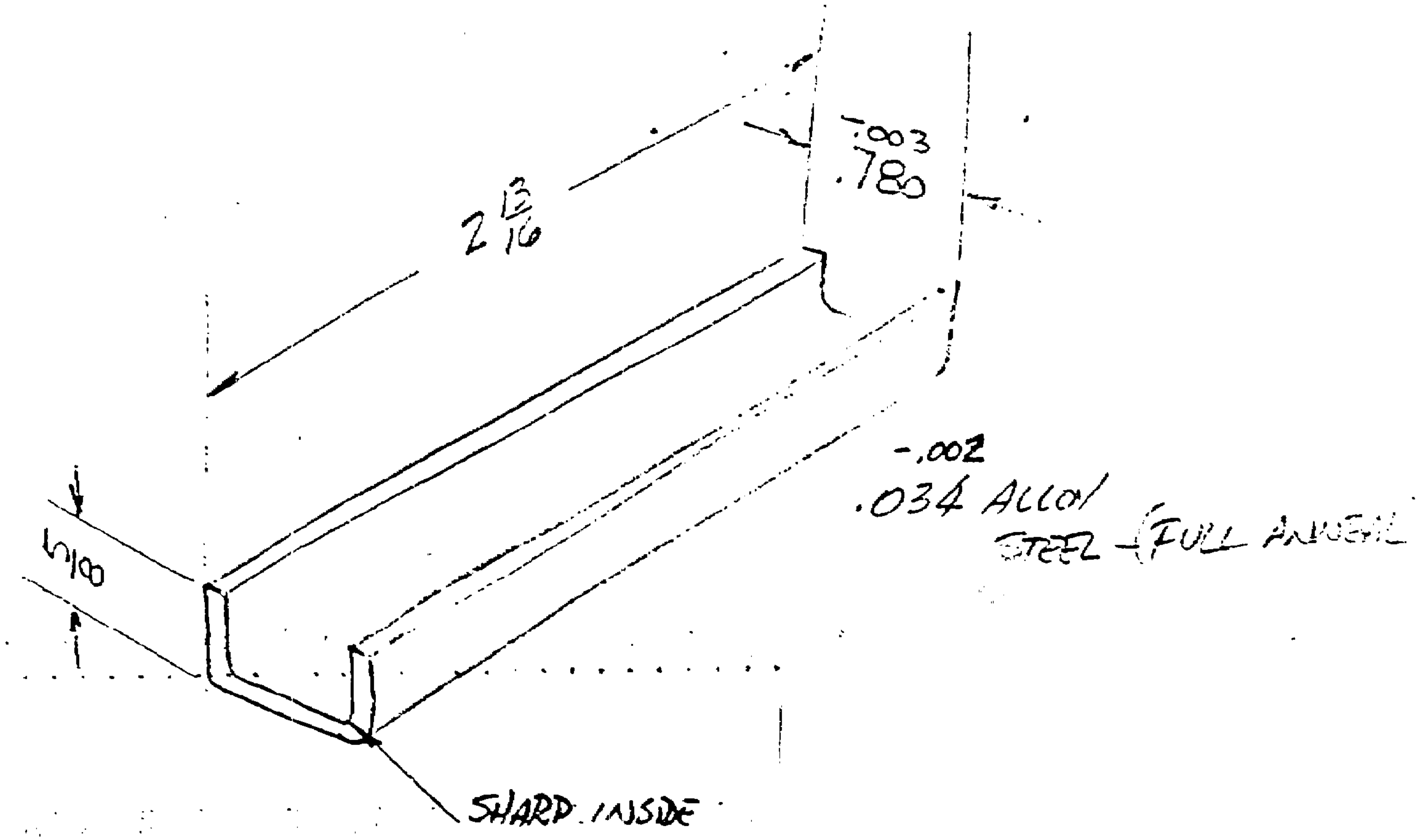


MATERIAL: Alloy Steel (R_c 48-50)

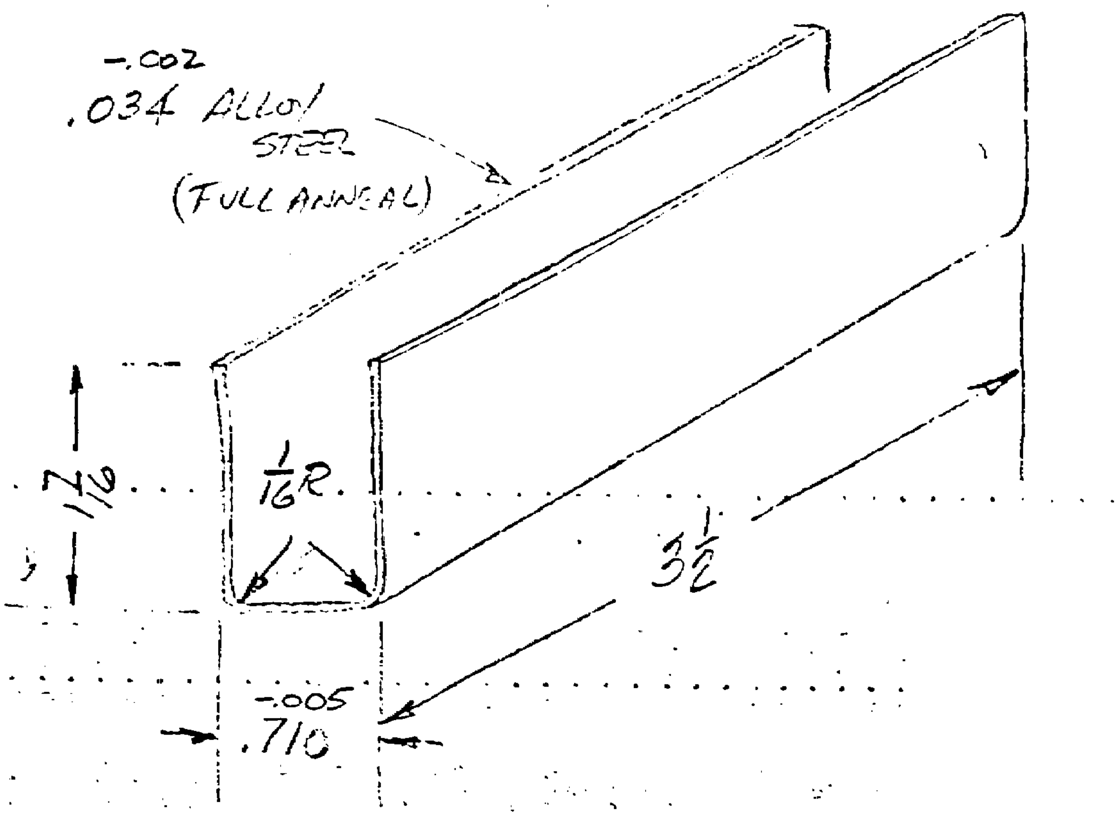
MKF No 3. Latch, Magazine, Mod II



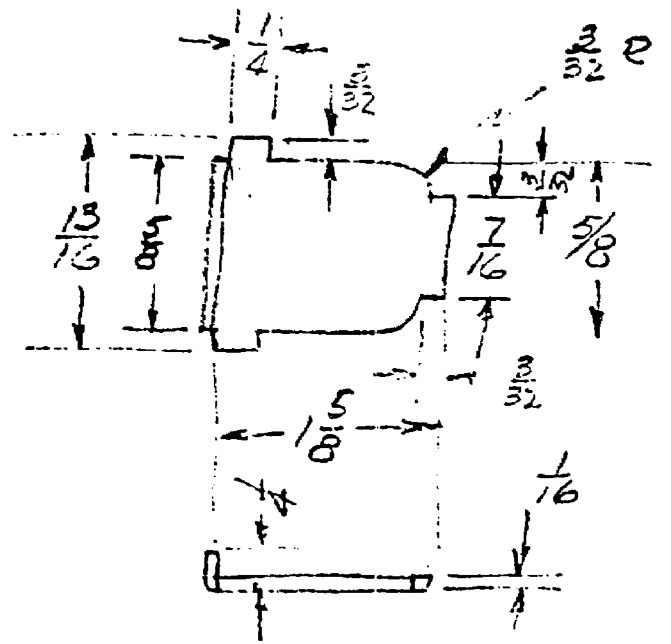
MKF No 4. Sub-Assembly, Magazine, Adaptor



MKF No 5. Back Magazine, Fln-Folded

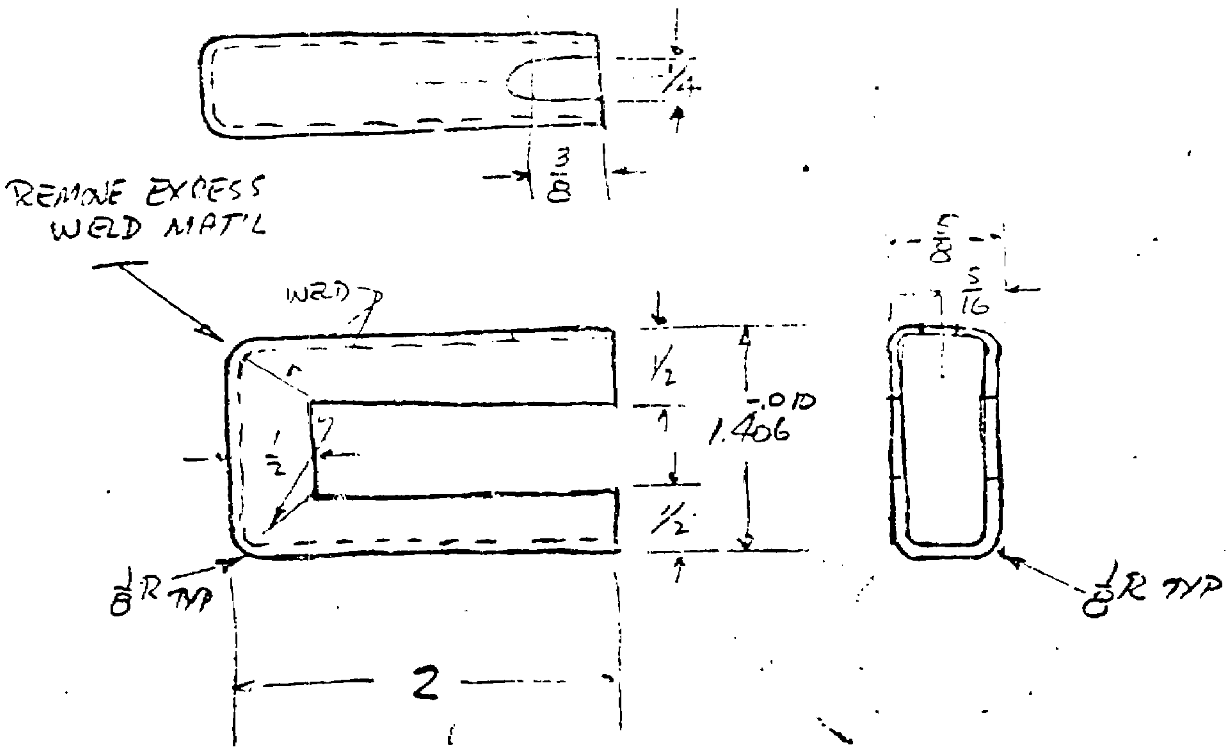


MKF No 6. Body Magazine, Fin-Folded



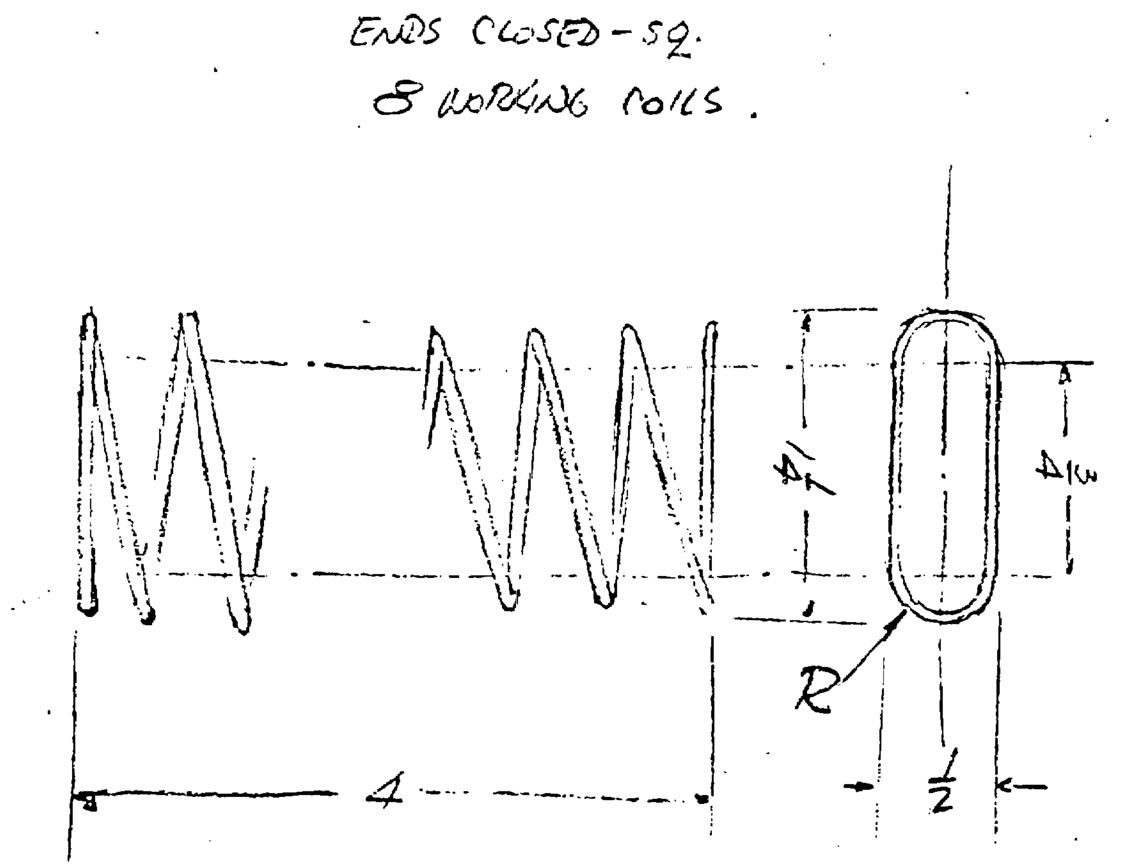
MATERIAL: Steel - 1/32" thick

MKF No 7. End, Magazine



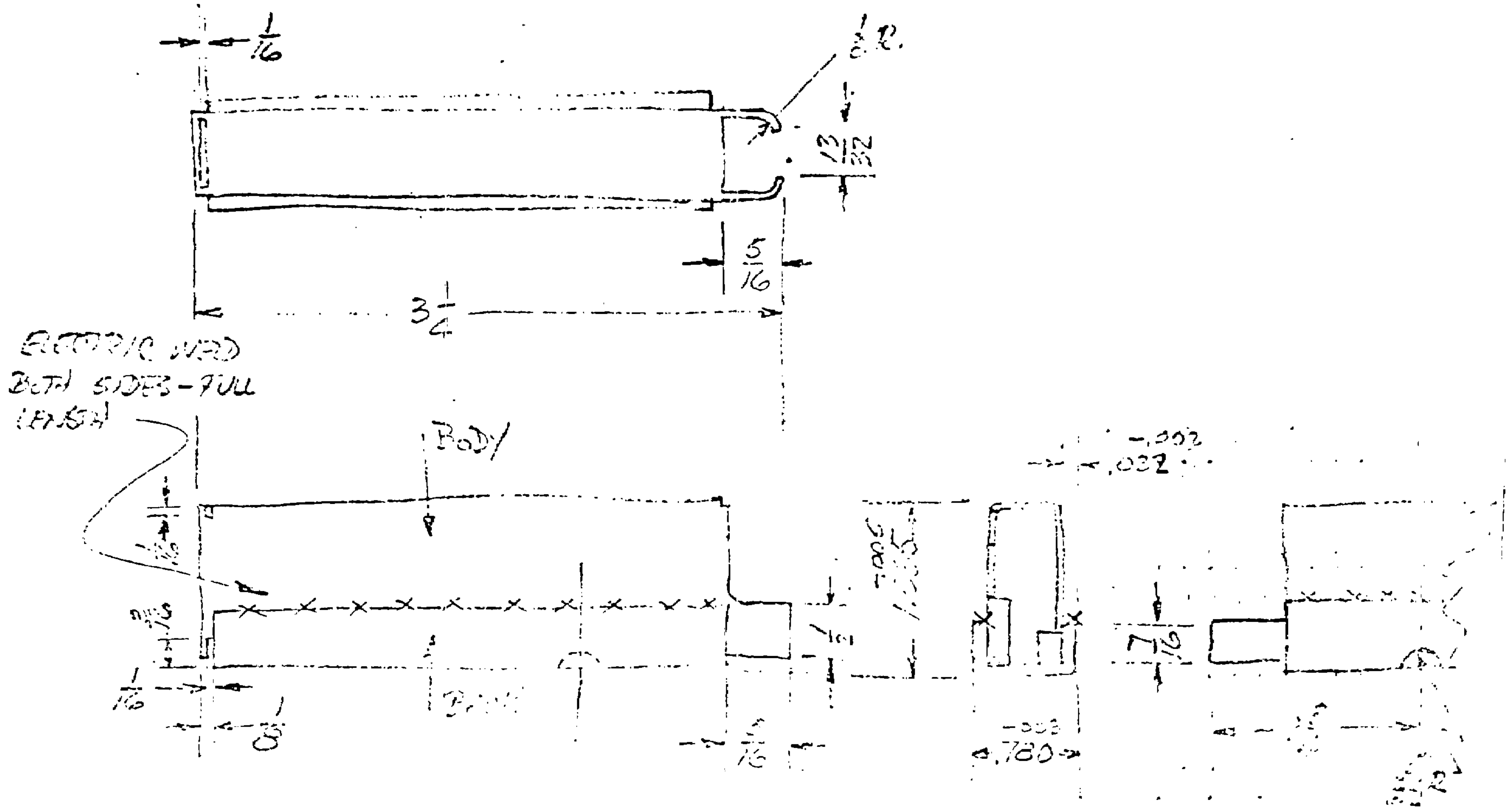
MATERIAL: .050 Aluminum

MKF No 8. Follower, Mod II

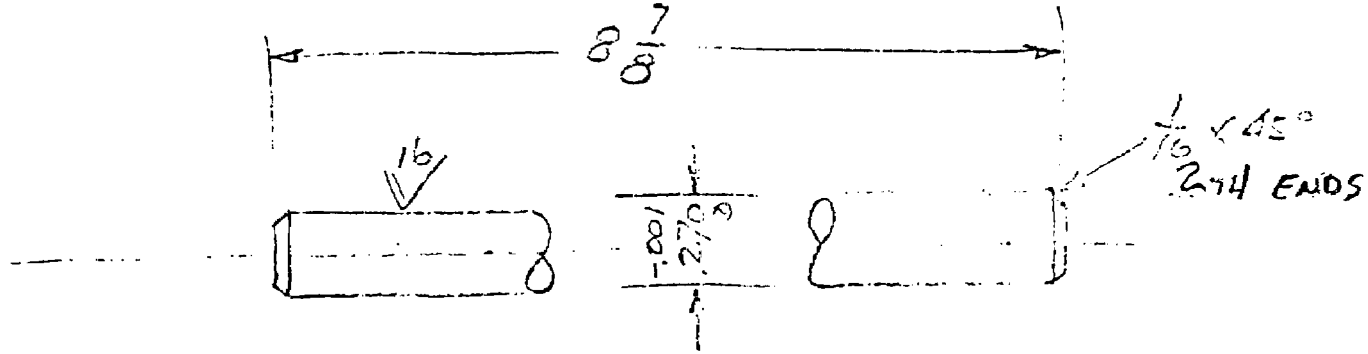


MATERIAL: Spring Wire - .059 dia.

MKF No 9. Spring, Magazine, Mod II

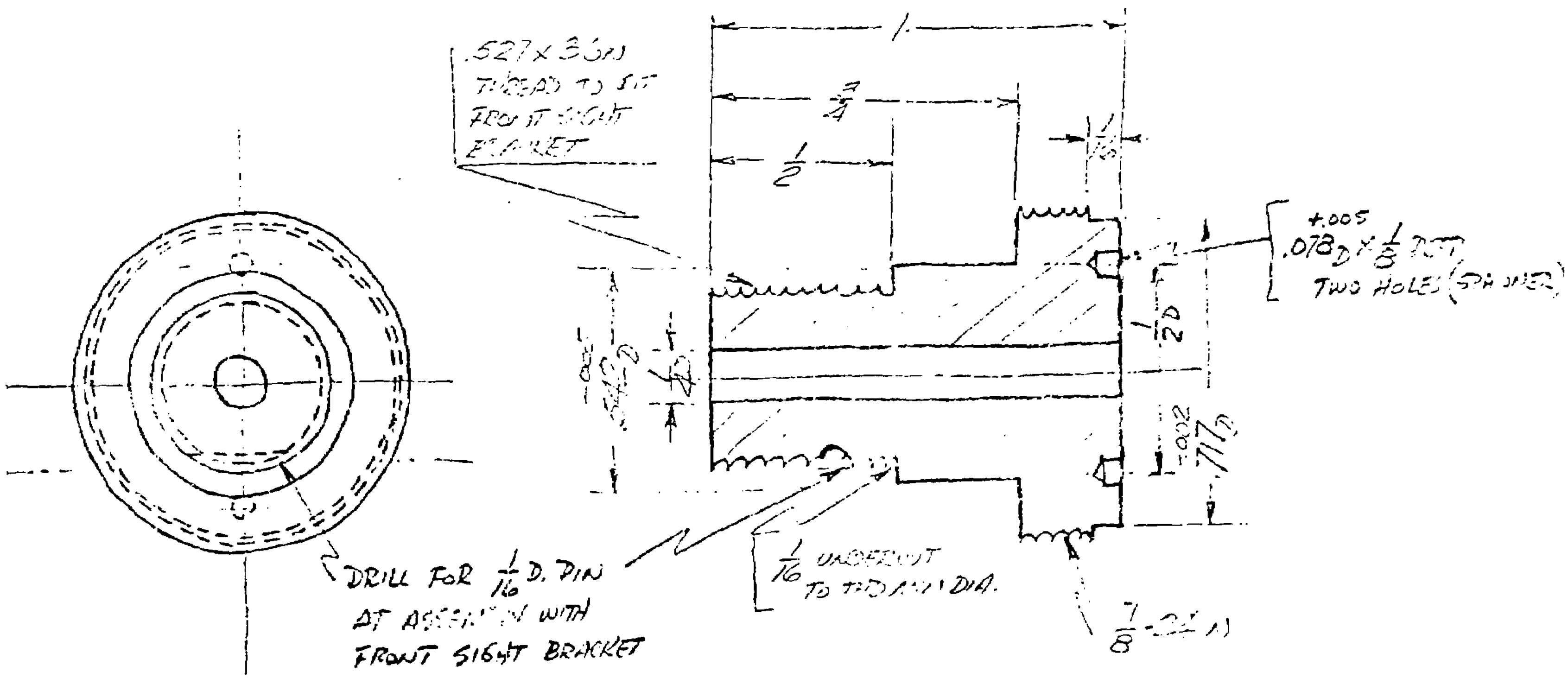


MKF No 10. Tube, Magazine Sub-Assembly, Mod II



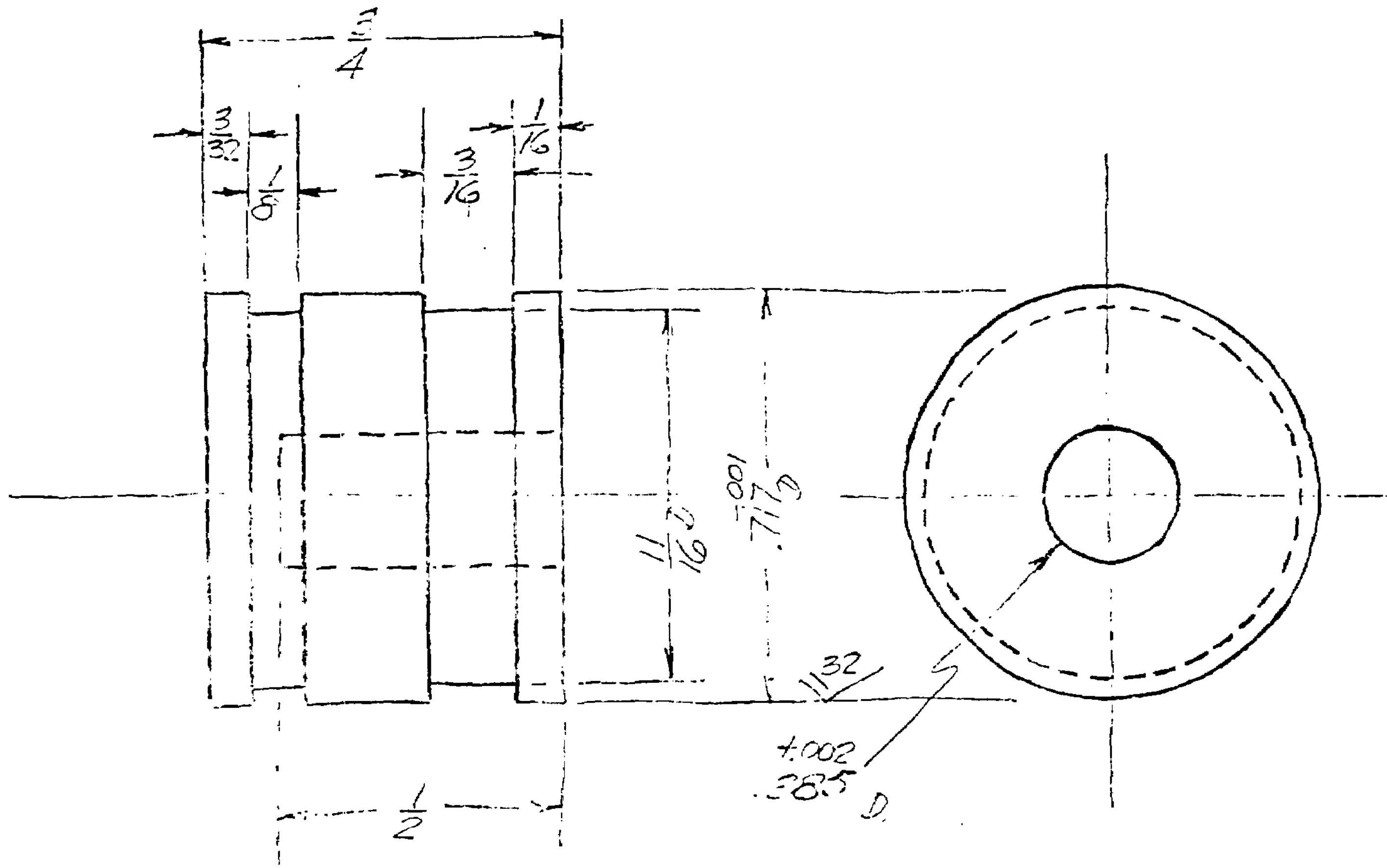
MATERIAL: Alloy Steel, Rc - 60

MKF No 11. Rod, Piston



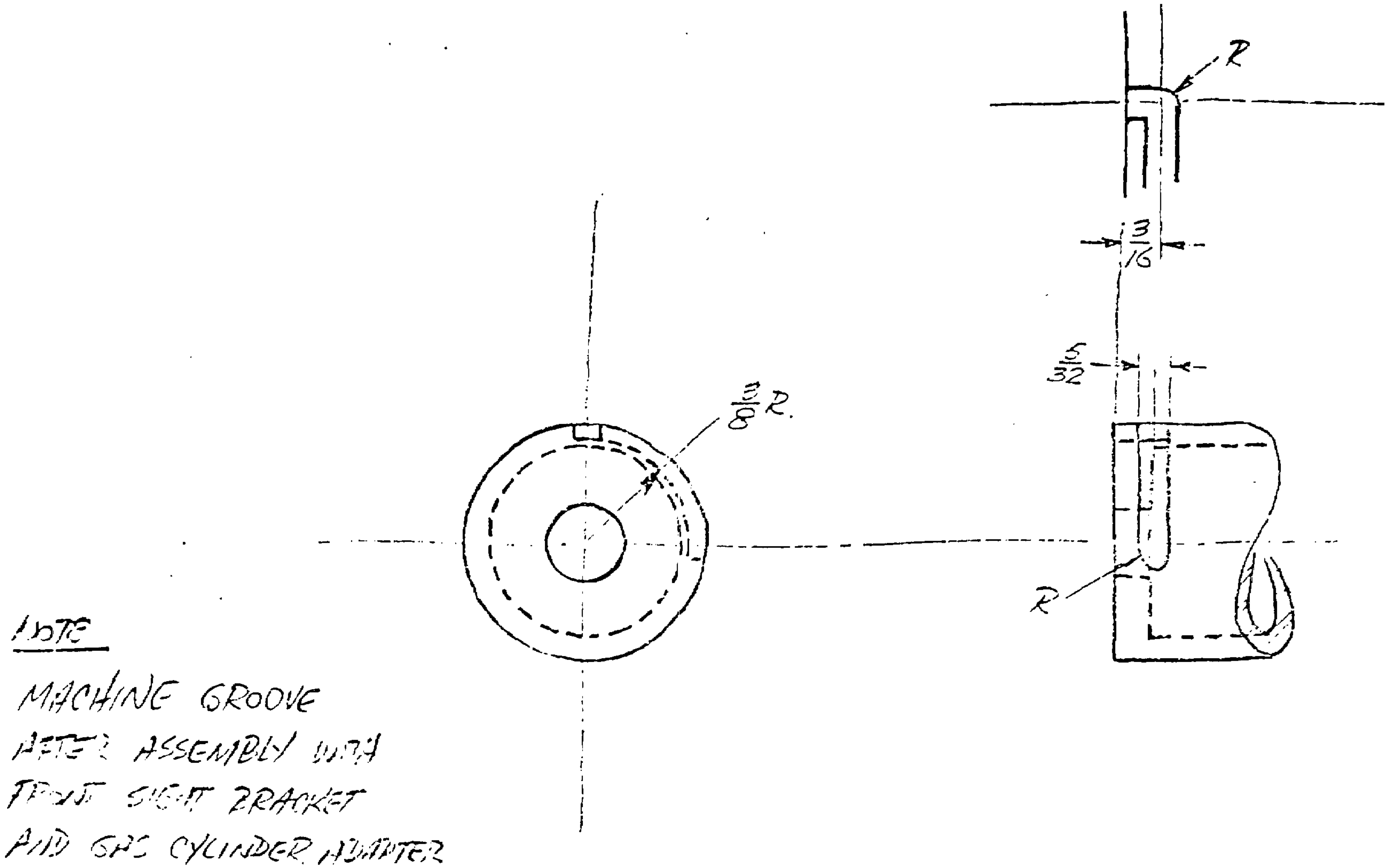
MATERIAL: Alloy Steel, R_c 45-45

MKF No 12. Adapter, Gas Cylinder, Mod II

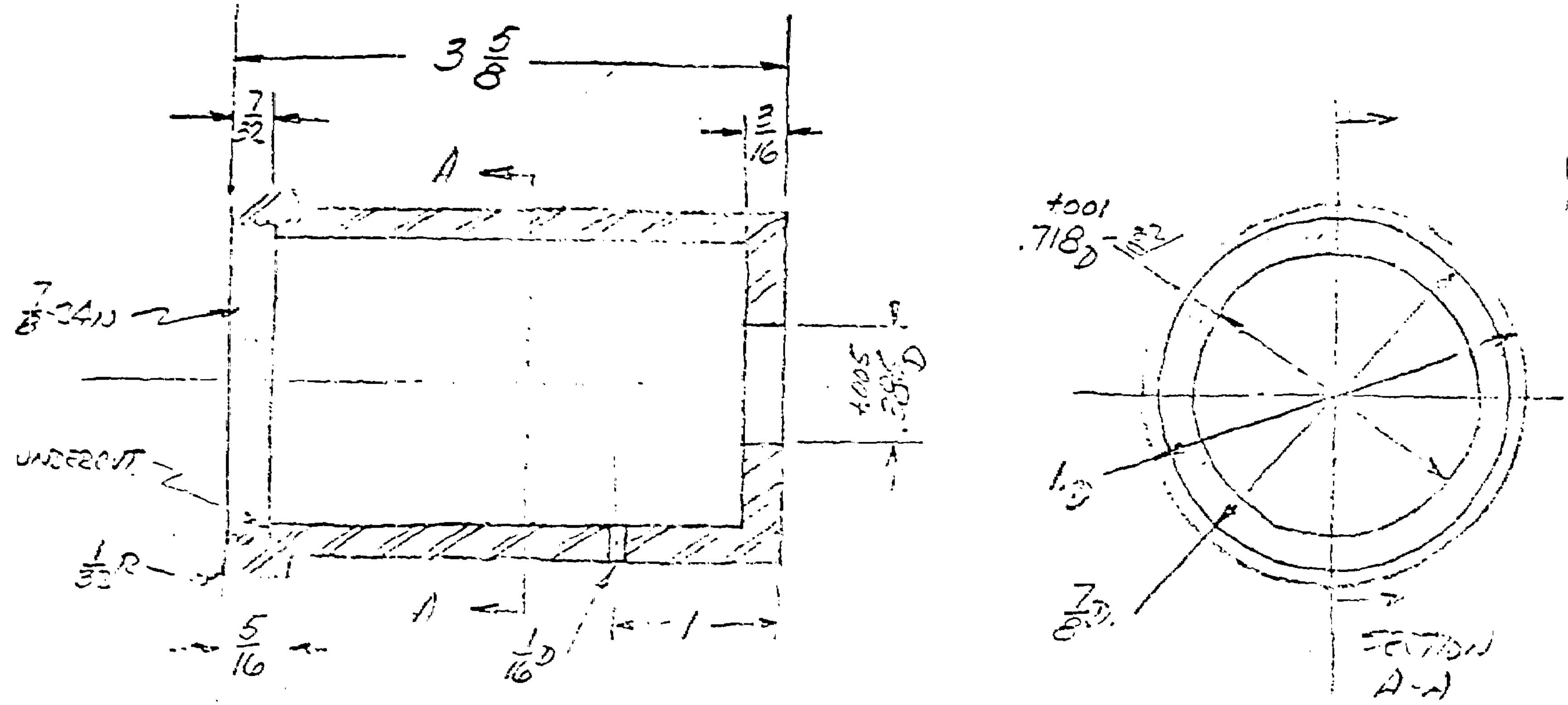


MATERIAL: Alloy Steel, R_c 58-60

MKF No 13. Piston

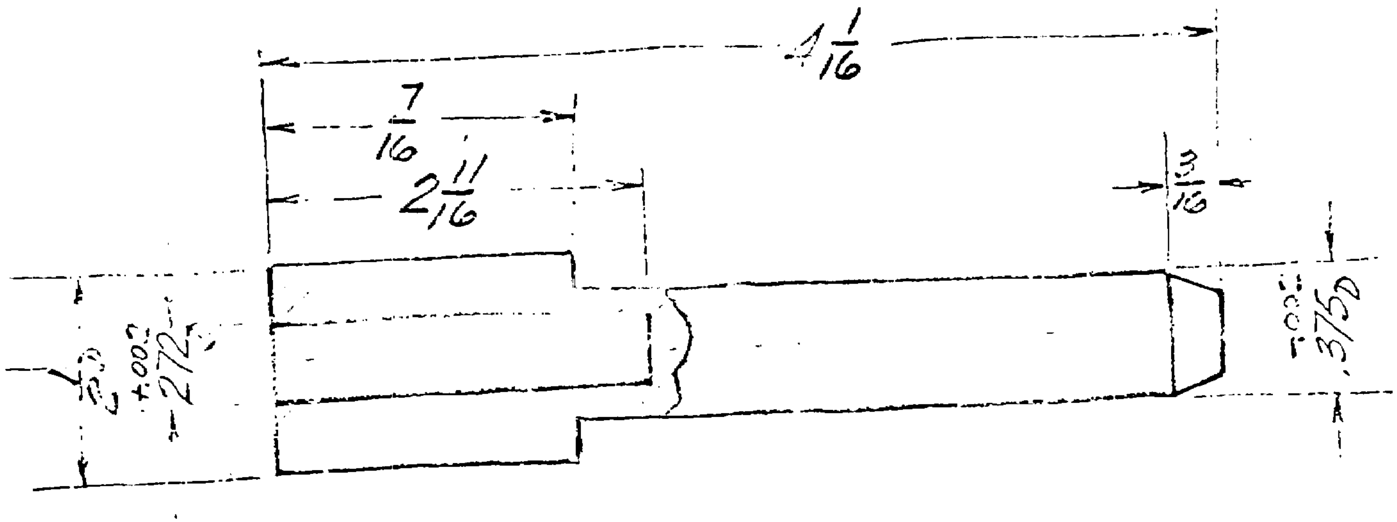


MKF No 14. Detail of Groove Cylinder, Gas, Mod II



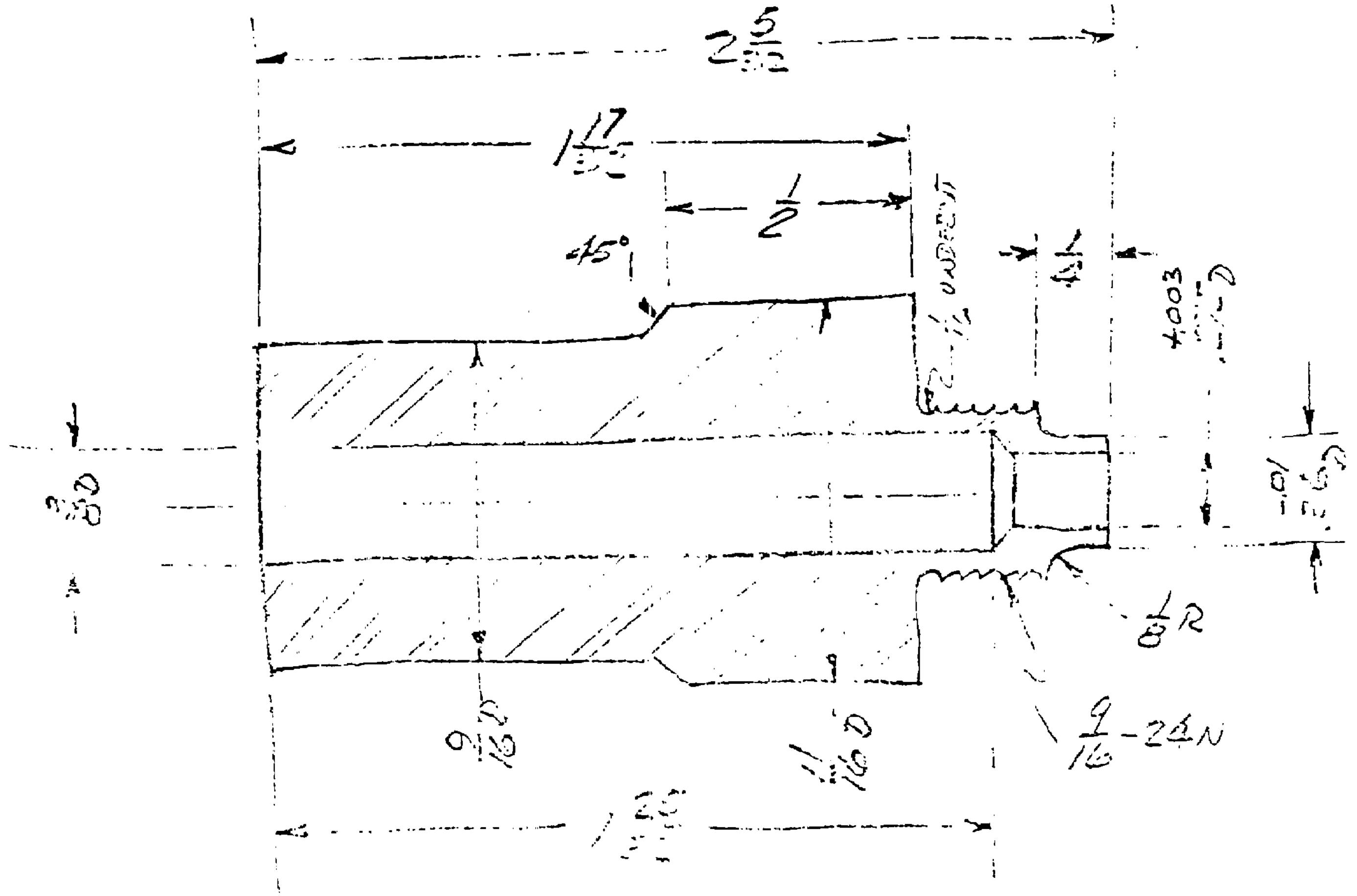
MATERIAL: Alloy Steel, R_c 45-48

MKF No 15. Cylinder, Gas, Mod II

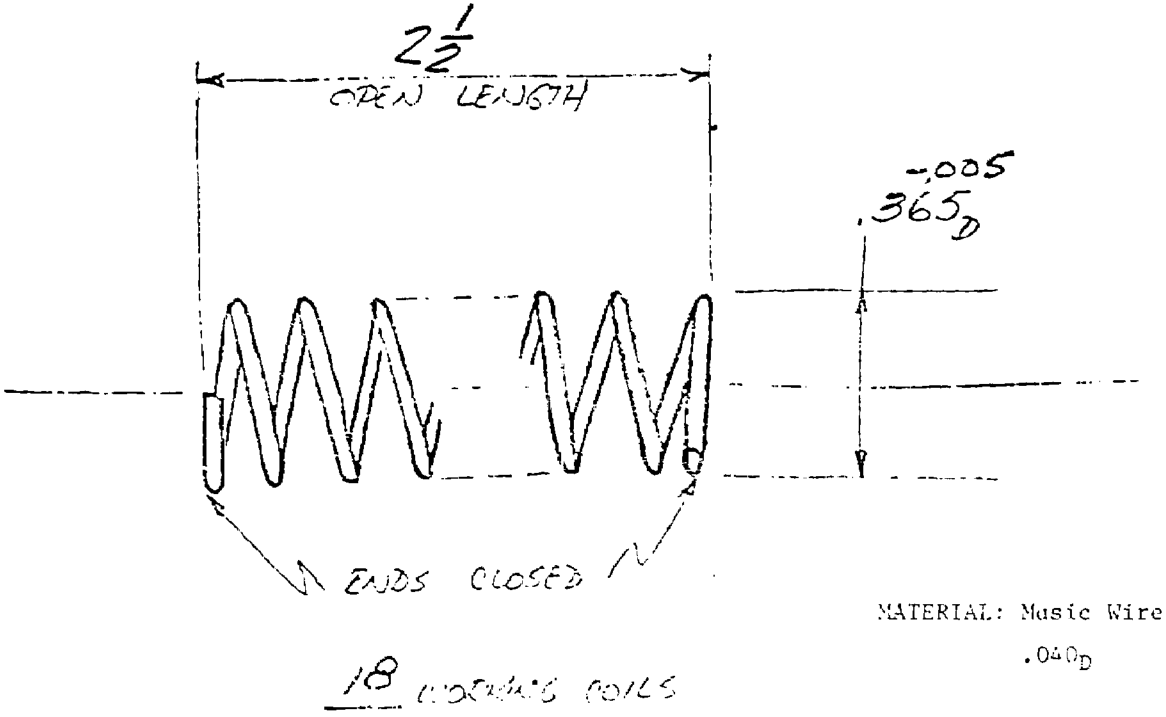


MATERIAL: Alloy Steel, R_c 55-60

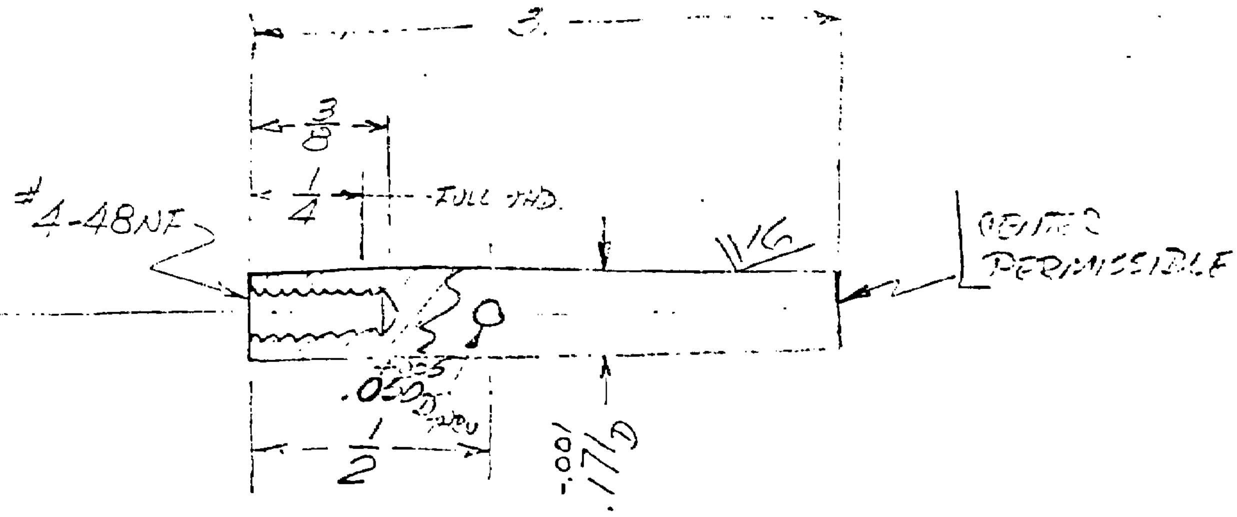
MKF No 16. Sleeve, Mod II



MKF No 17. Socket, Gas Tube, Mod II

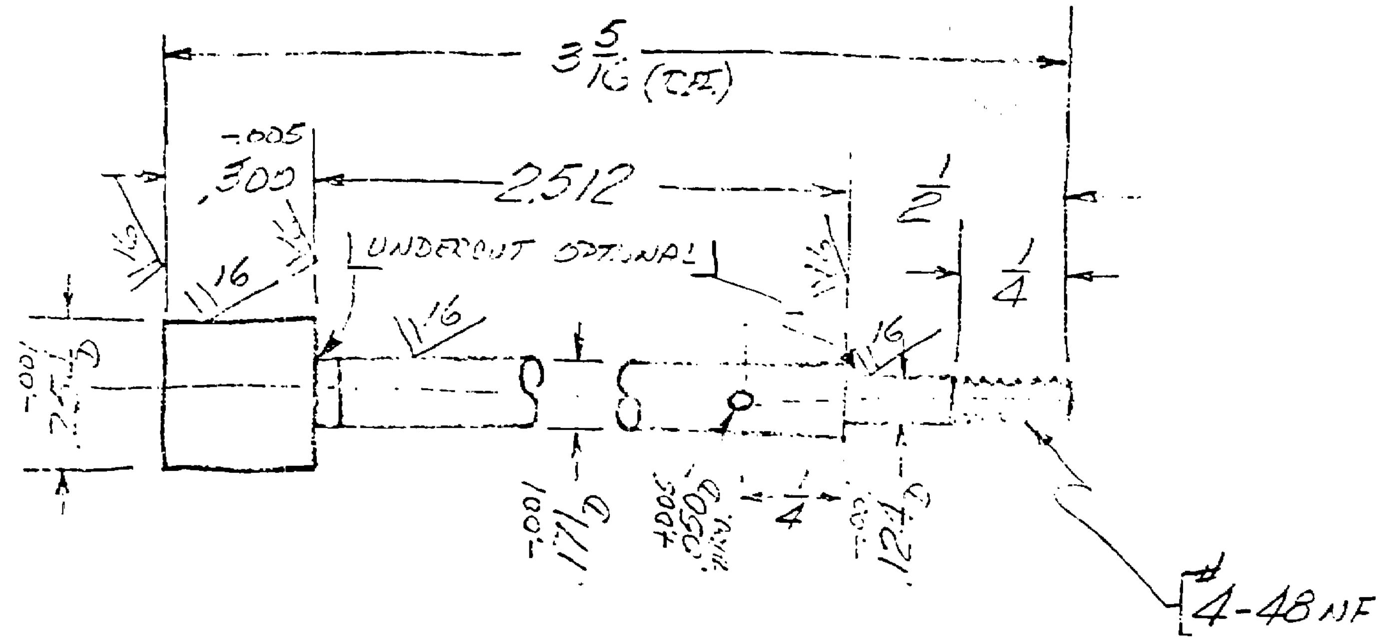


MKF No 18. Spring, Expeller Return



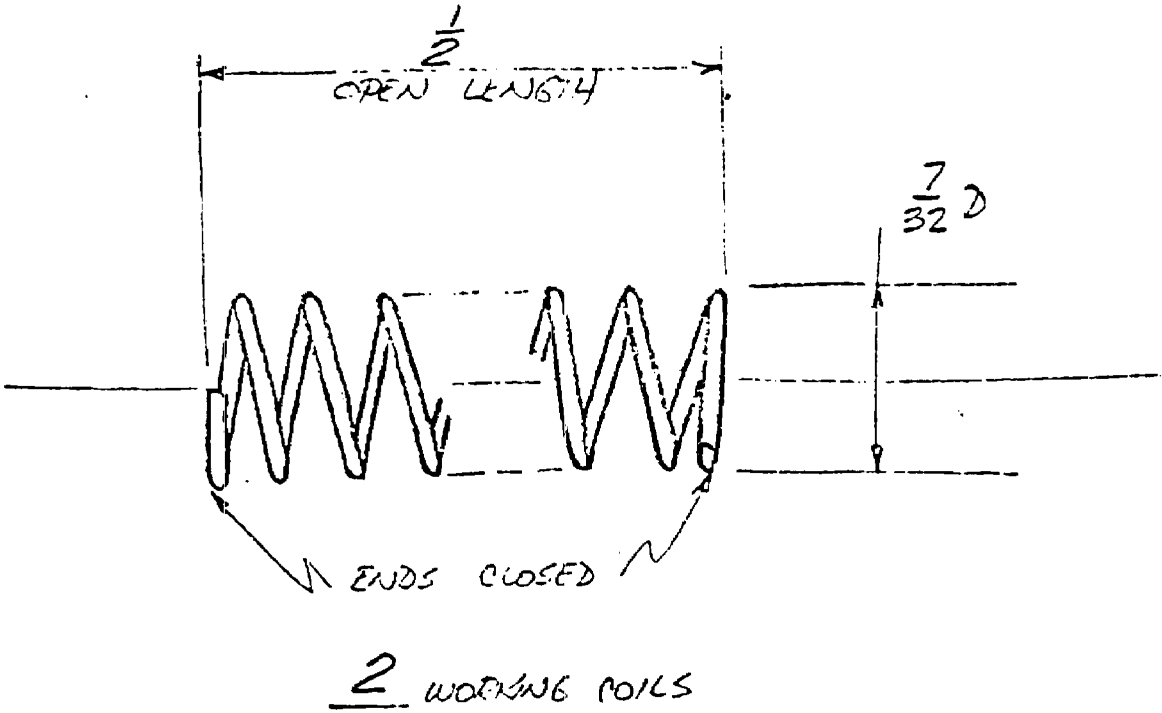
MATERIAL: Alloy Steel, R_c 53-55

MKF No 19. Extension, Expeller, Mod II



MATERIAL: Alloy Steel, R_C 53-55

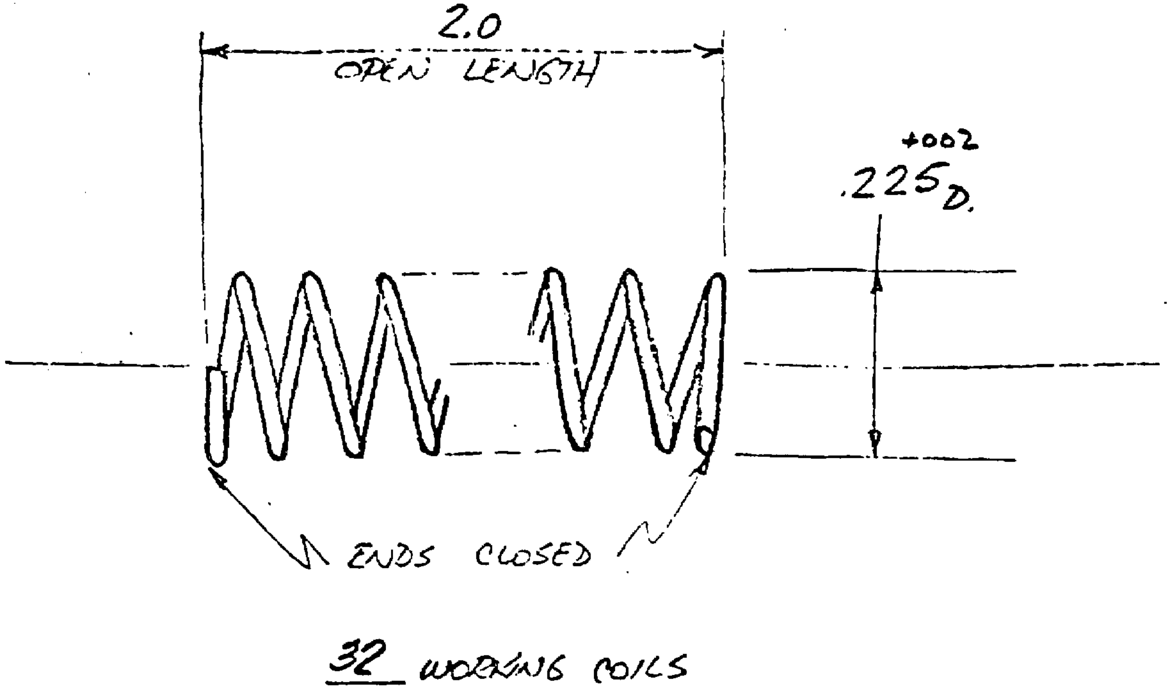
MKF No 20. Expeller, Mod II



$-.002$

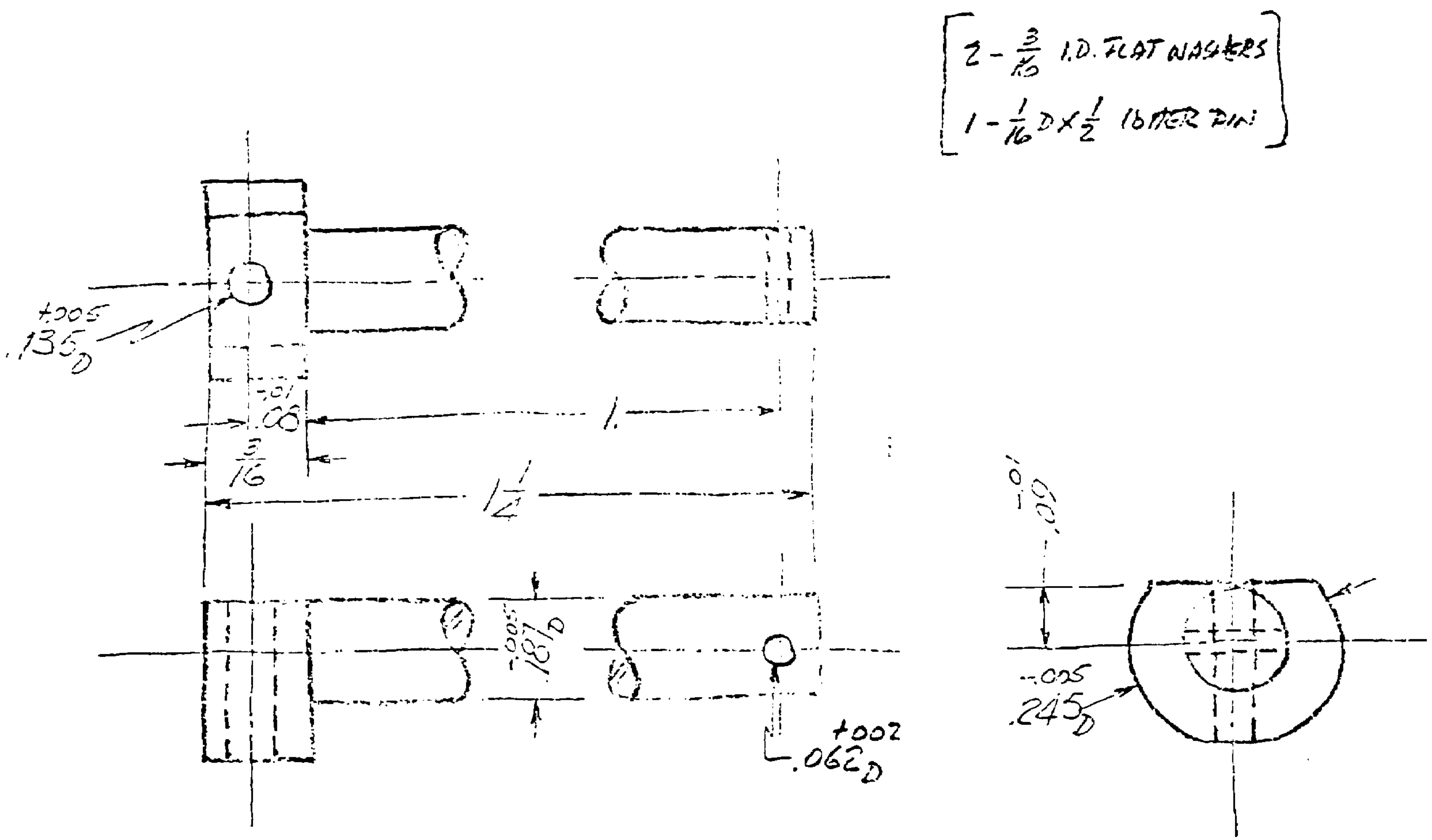
MATERIAL: Music Wire, $.015_D$

MKF No 21. Spring, Pin, Bolt



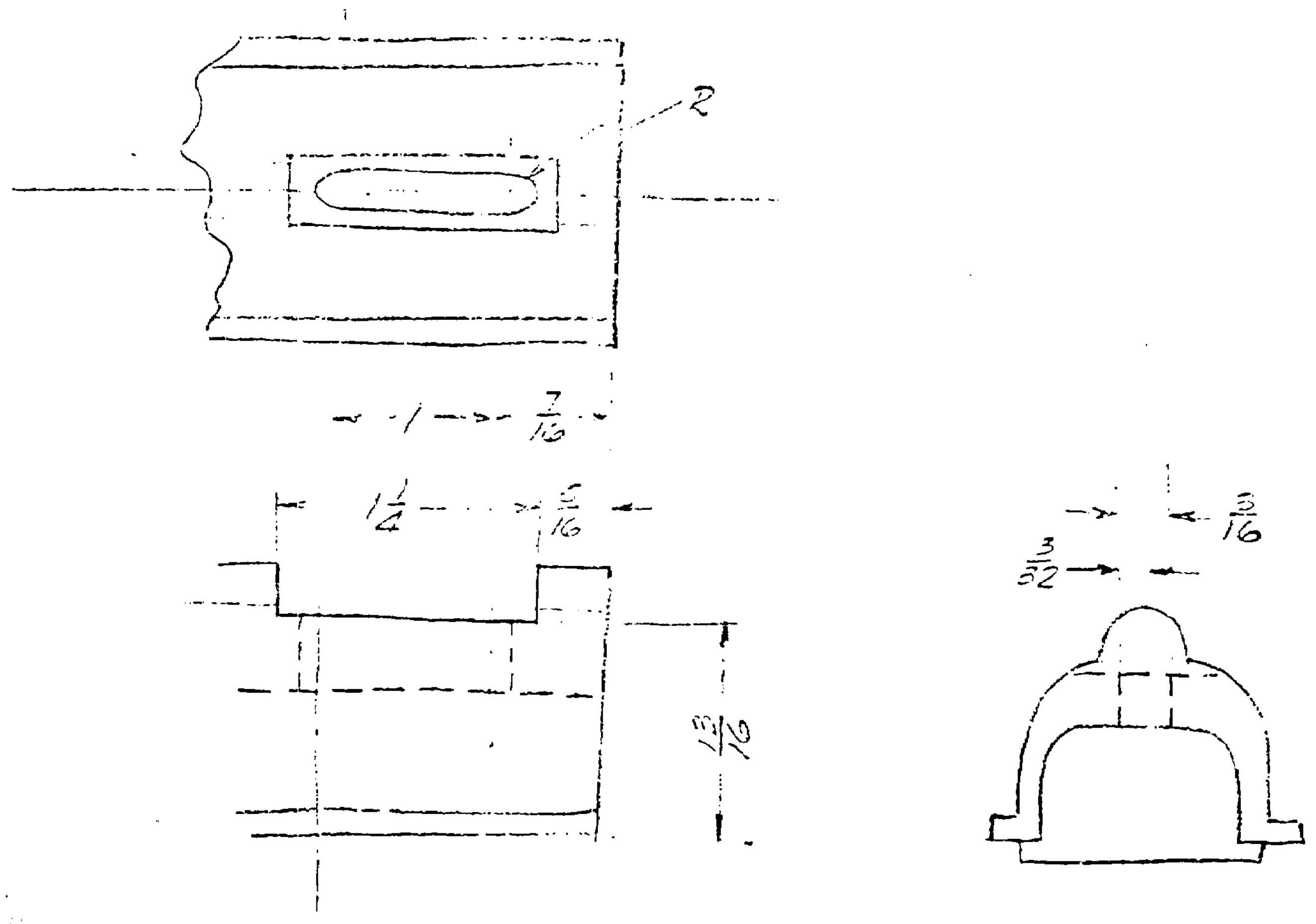
MATERIAL: Music Wire, $.032^{-002}_{D}$

MKF No 22. Spring, Return, Firing Pin

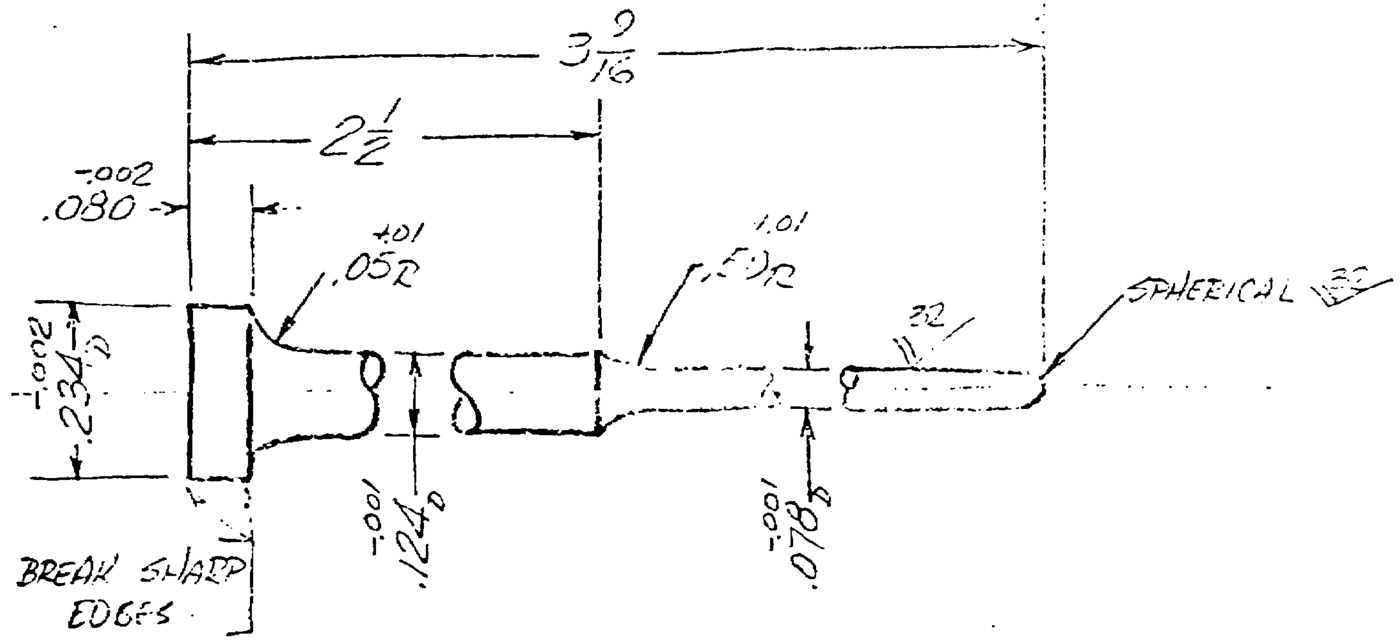


MATERIAL: Alloy Steel, R_c 45-48

MKF No 23. Pin, Bolt Support, Mod II

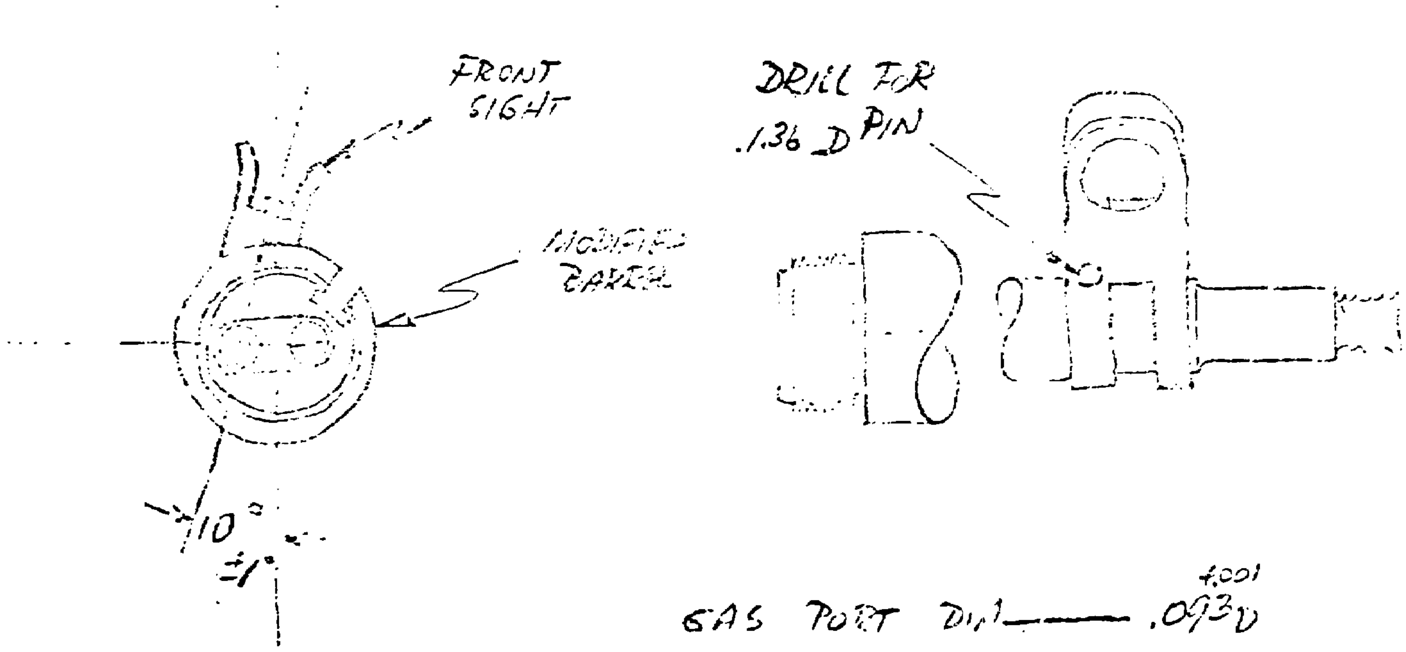


MKF No 24. Carrier, Bolt, Mod II

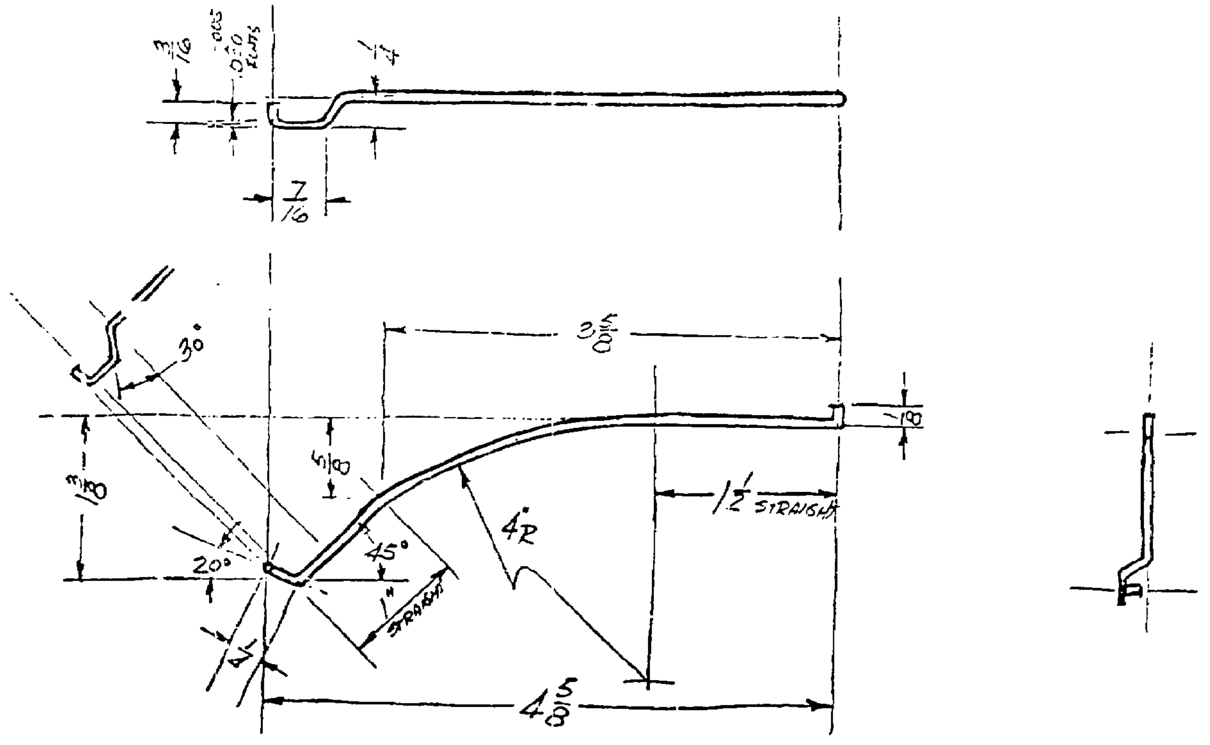


MATERIAL: Alloy Steel, R_c 55-58

MKF No 25. Firing Pin, Mod II

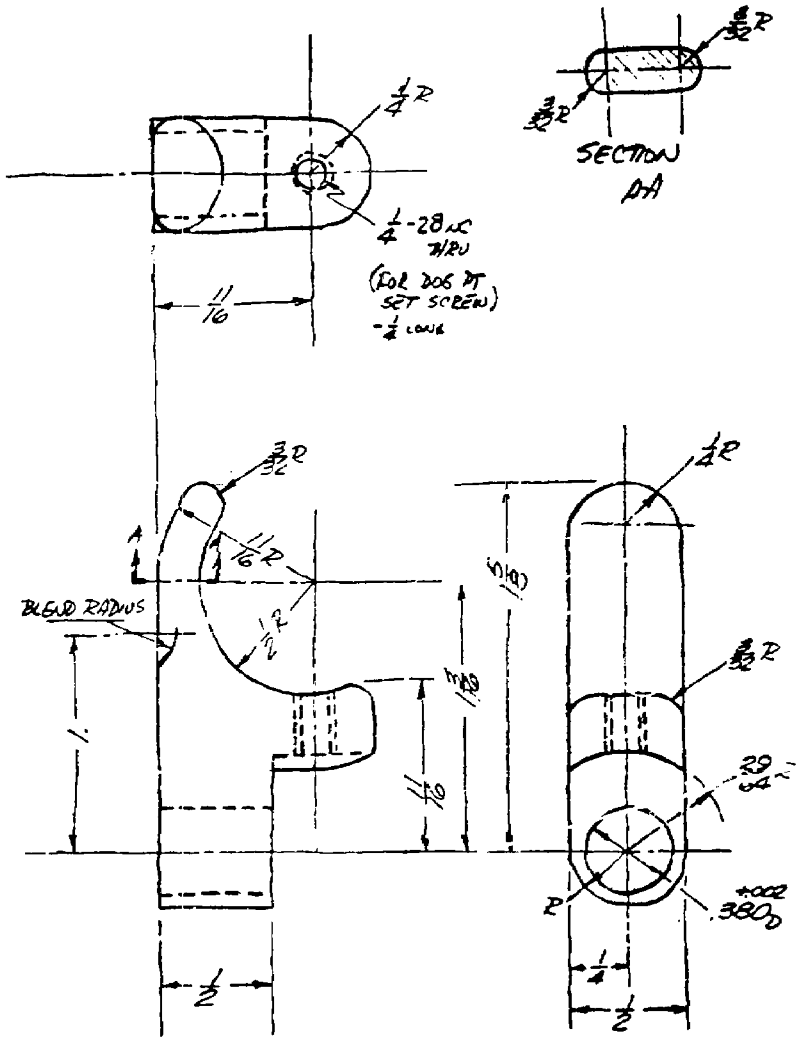


MKF No 26. Front Sight Sub-Assembly, Modified L.A.R.



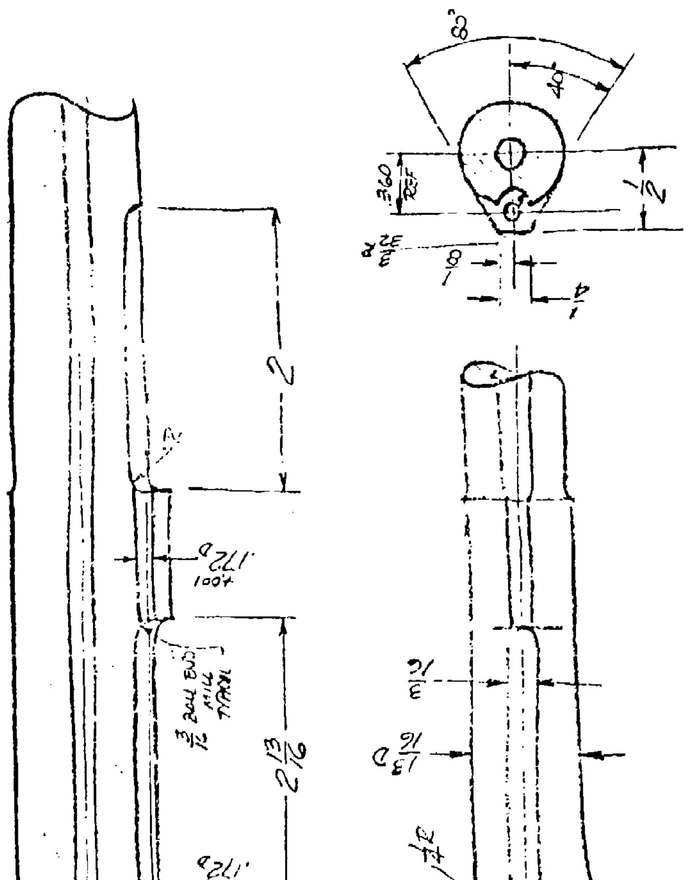
MATERIAL: Music Wire, $.059_D$

MKF No 27. Kicker

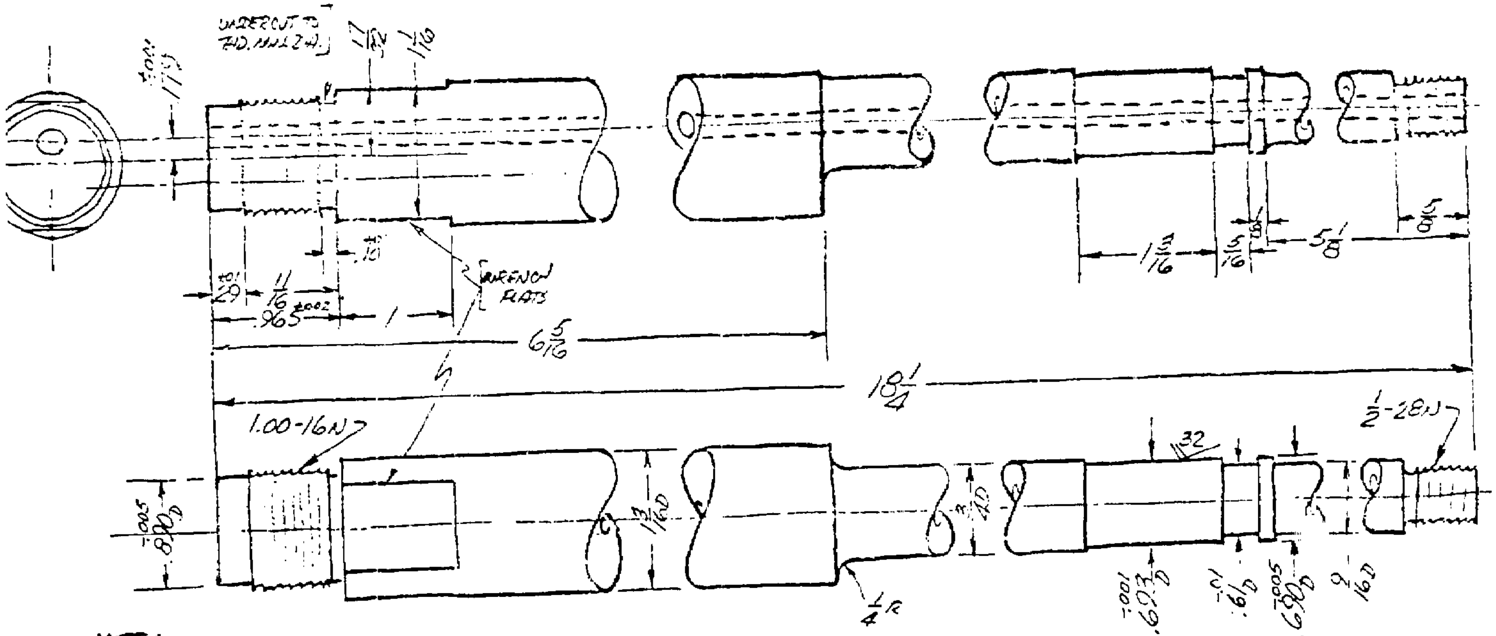


MATERIAL: Aluminum

MKF No 28. Handle, Mod II



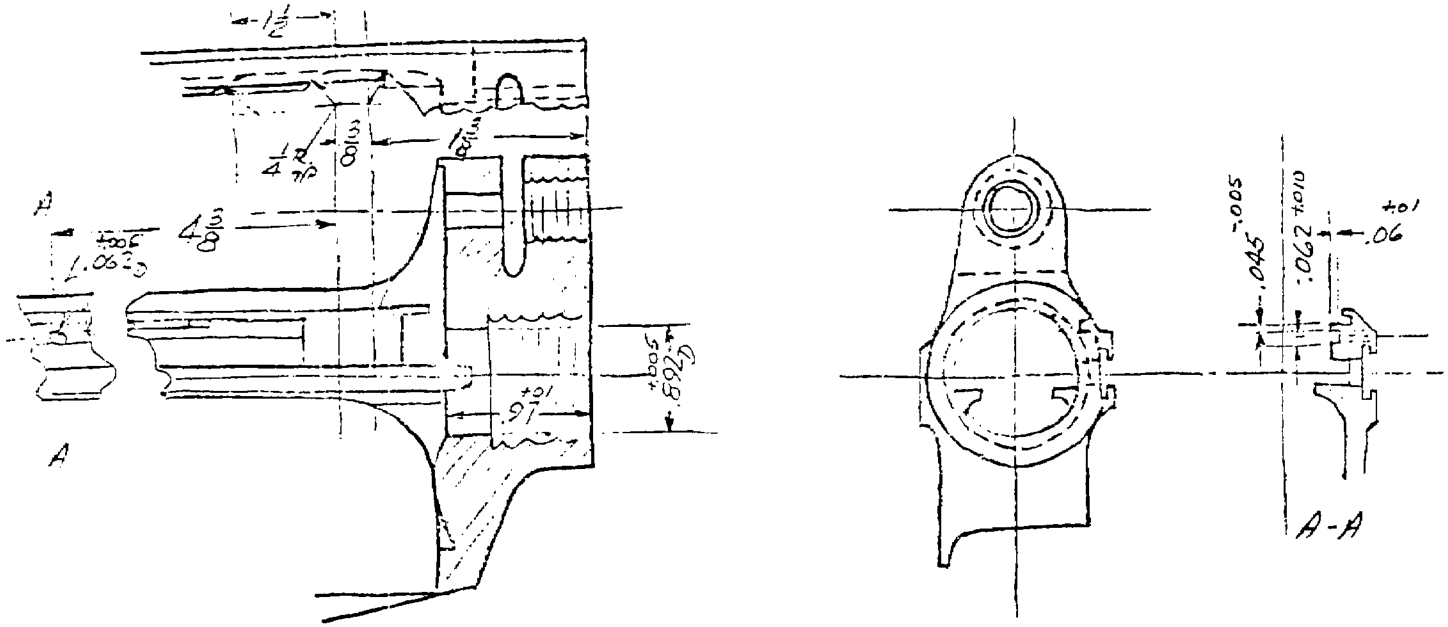
MKF No 29. Barrel (Detail), Mod II



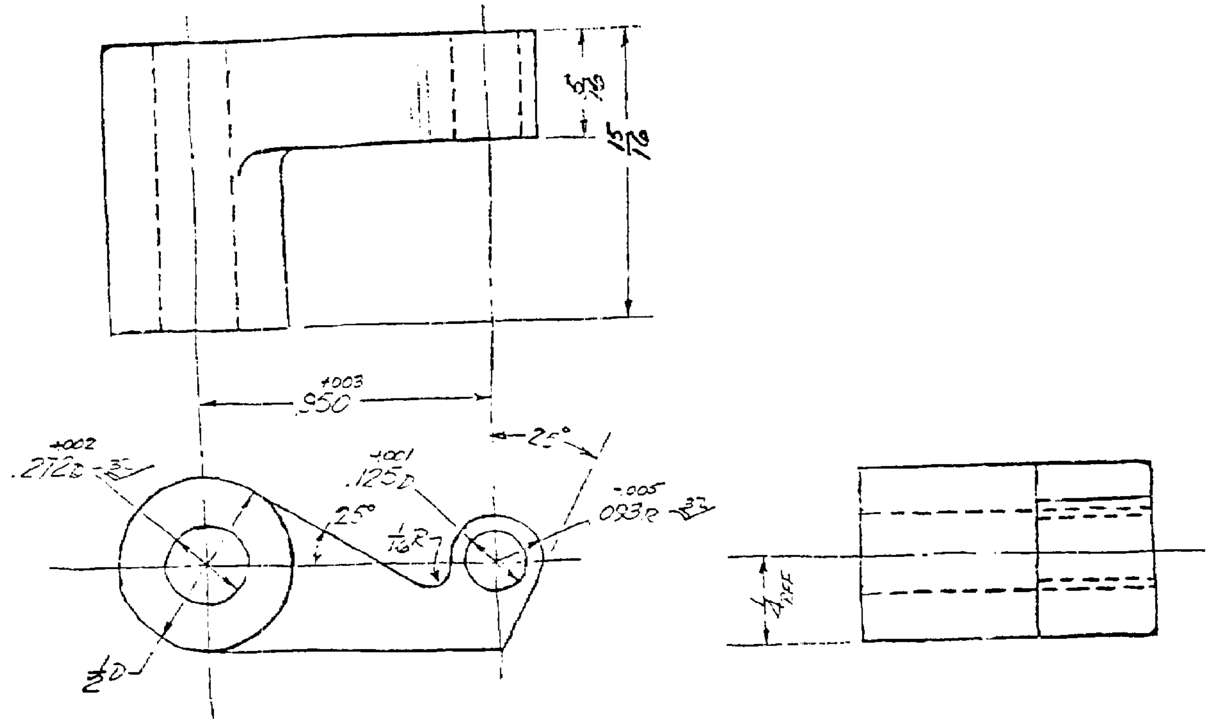
NOTES
1 - THREAD BBL BLANK WITH BORE OFFSET —
2 - ADJUST SHOULDER SO THAT OFFSET IS HORIZONTAL TO THE LEFT — USE FLN RECIEVER, WITH 150 FT. LBS TORQUE

5.56 mm - 1/9 Twist

MKF No 30. Barrel, Mod II

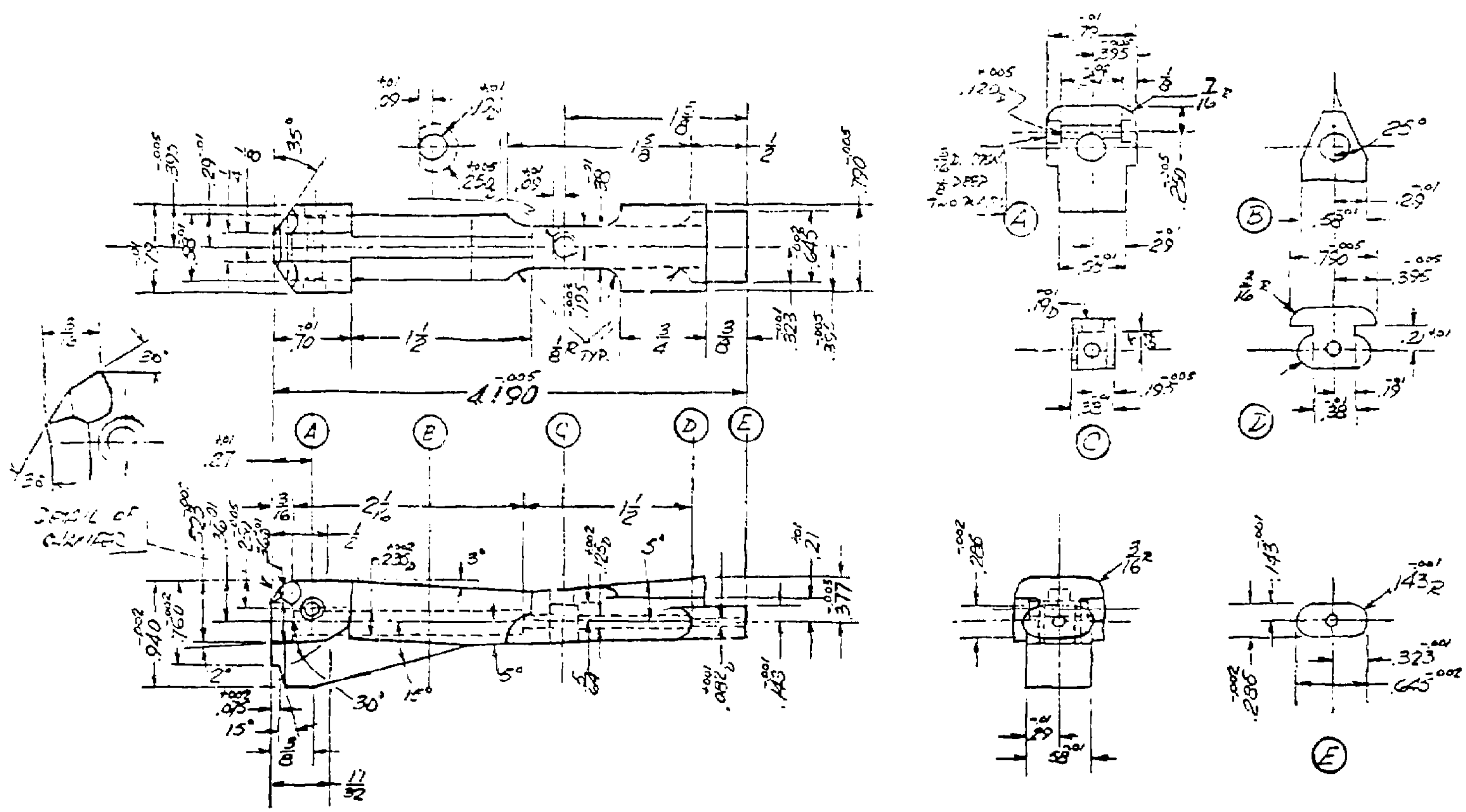


MKF No 31. Receiver, Kicker Slot Detail, Mod 11



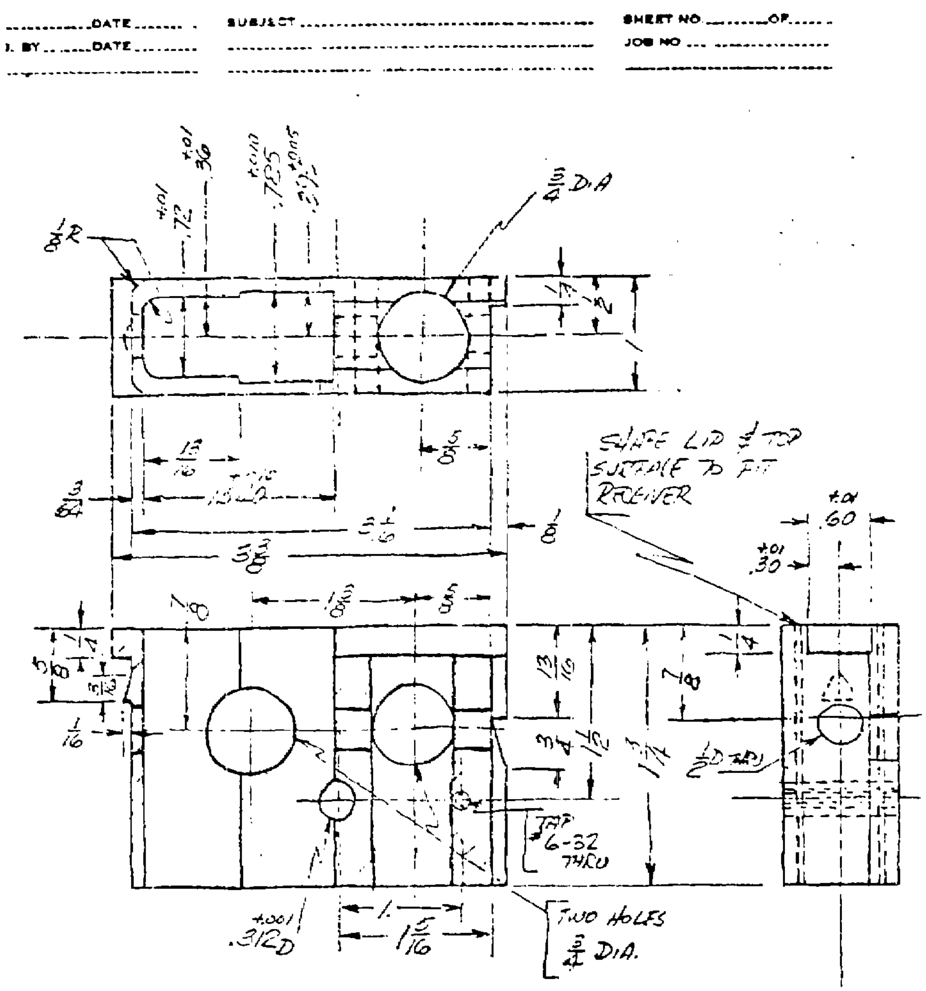
MATERIAL: Alloy Steel, R_c 55-60

THF No 32. Pawl, Mod II



MATERIAL: Alloy Steel, R_c 58-60

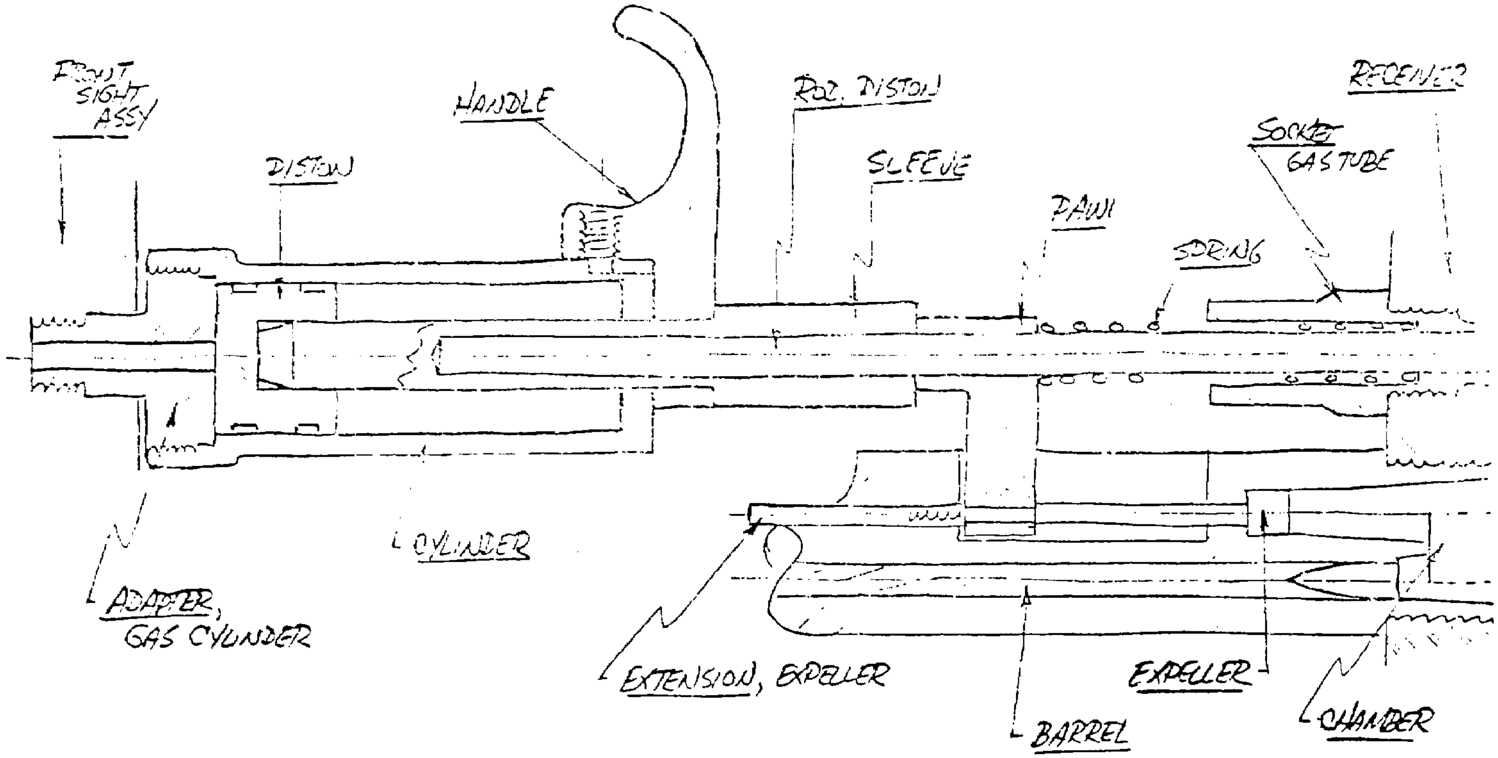
MKF No 33. Bolt, Mod II



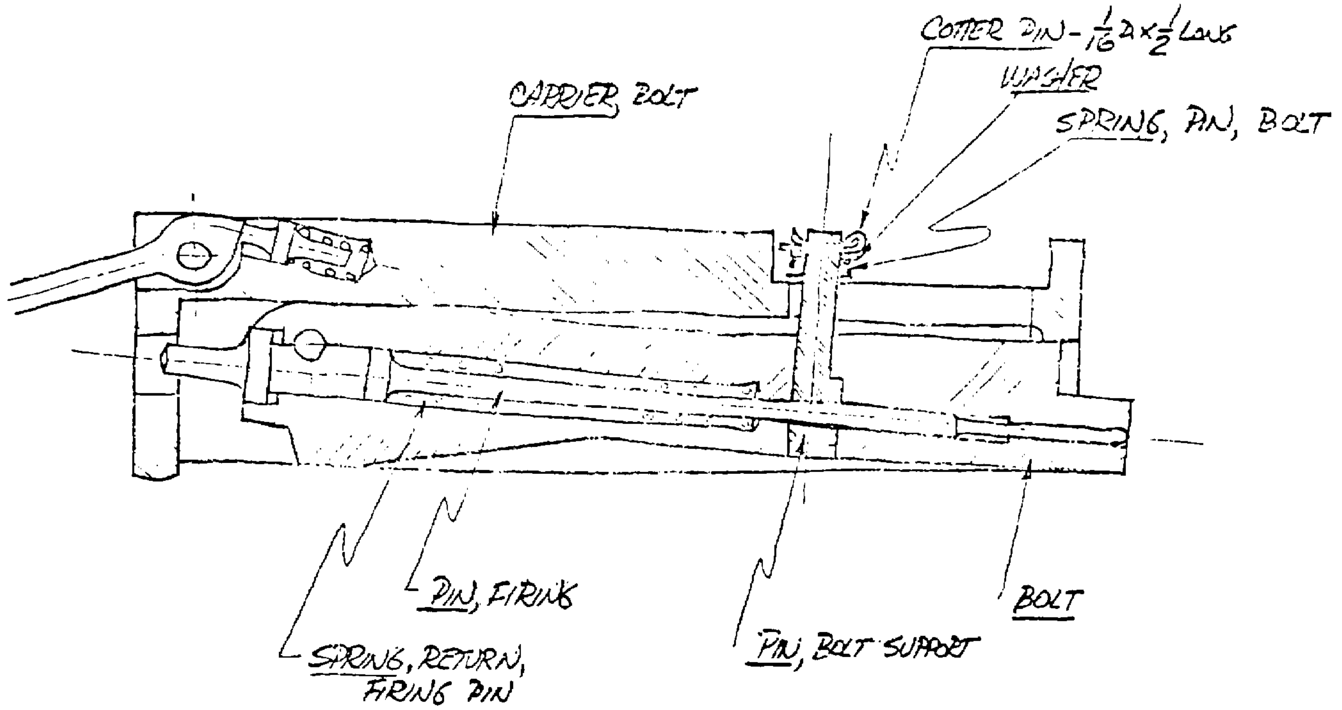
NOTE: Additional holes added
to reduce weight.

MATERIAL: Steel

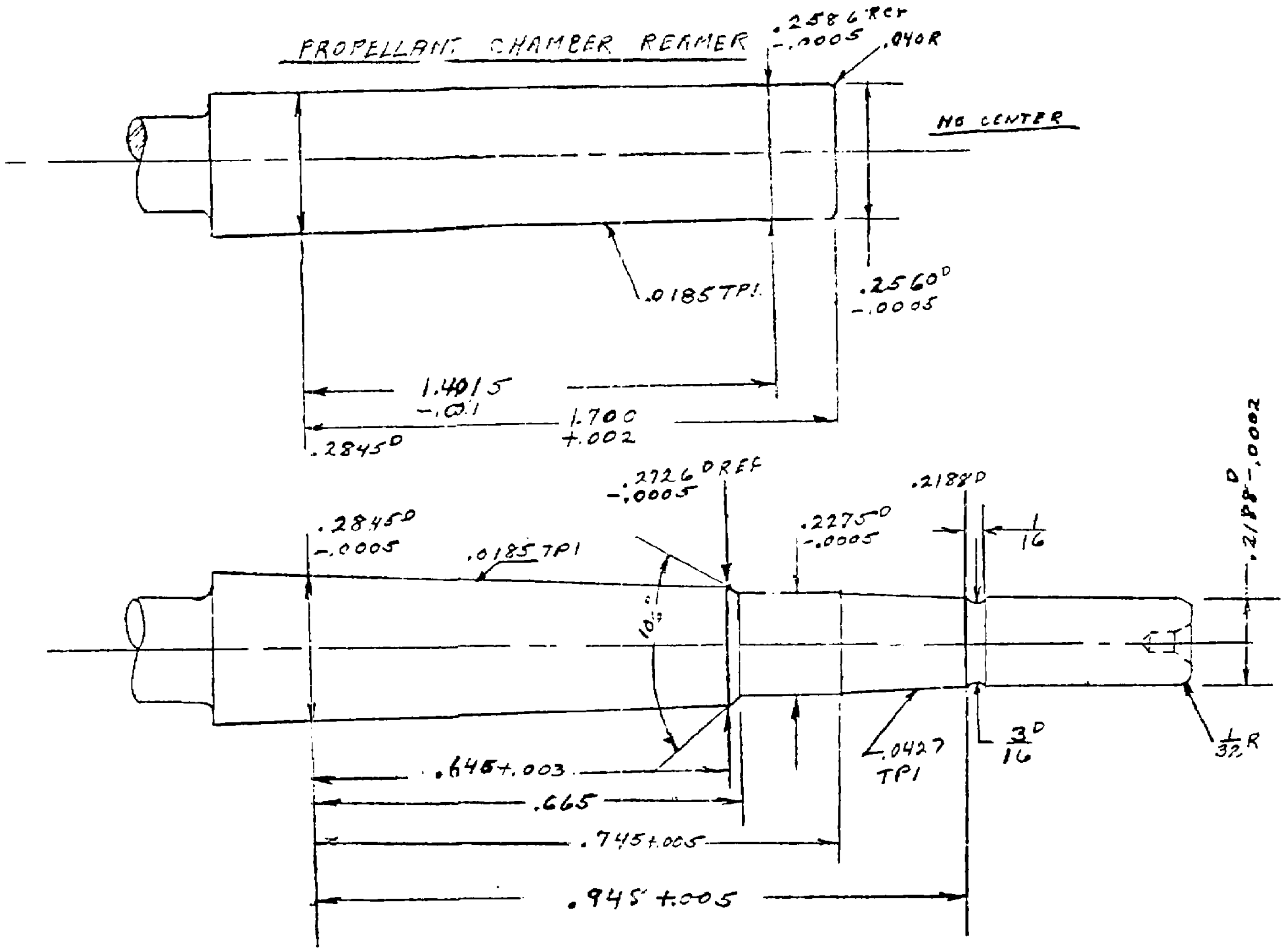
MKF No 34. Magazine Adaptor, Fln 5.56 mm Folded



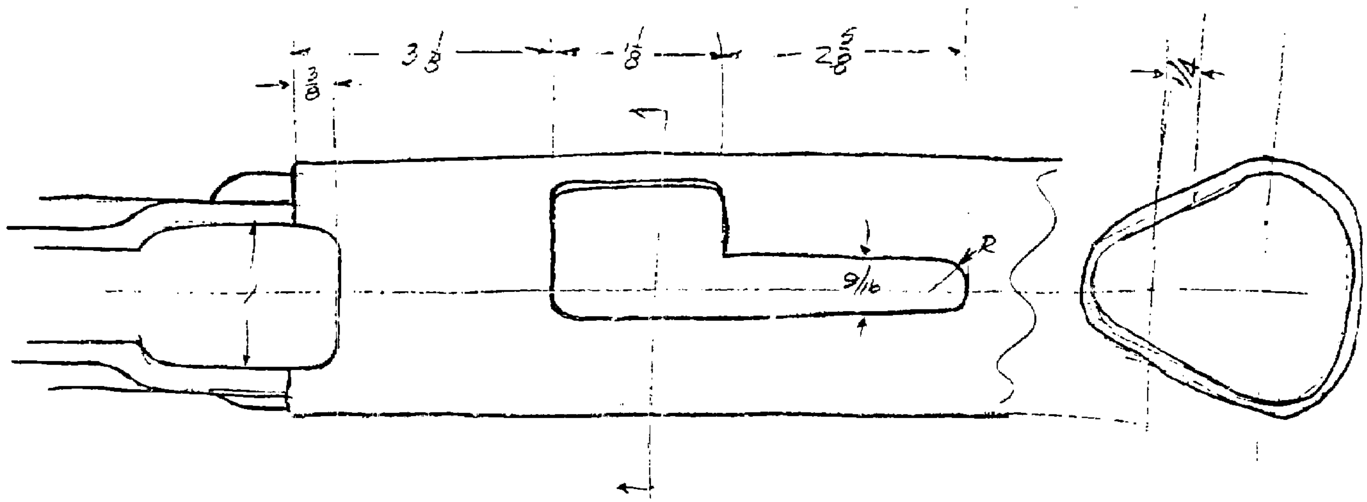
MKF No 35. Sub-Assembly, Gas System



MKF No 36. Bolt, Sub-Assembly

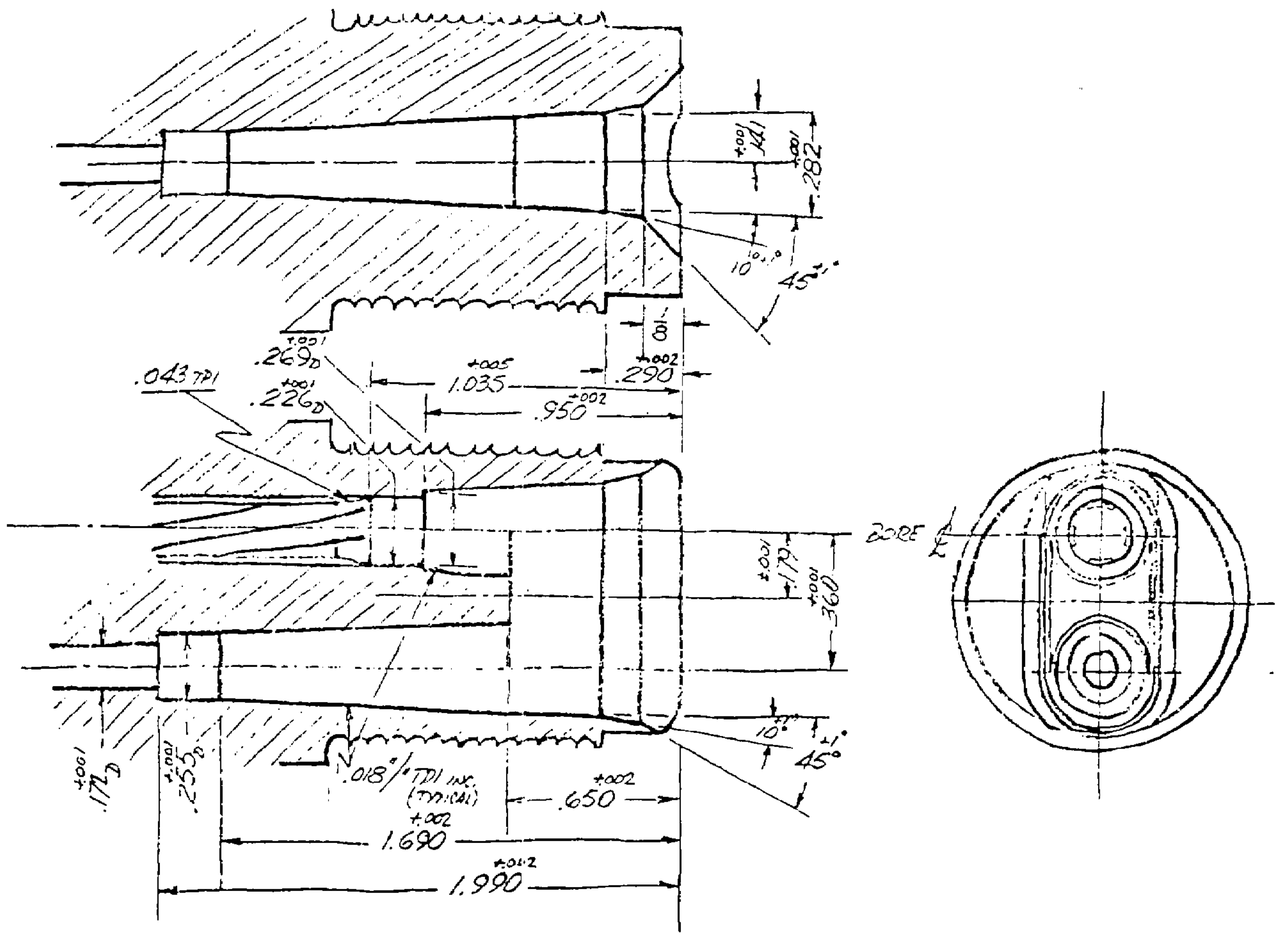


MKF No 37. Bullet, Chamber, Reamer



(Inside must be fit to barrel and cylinder)

MKF No 38. Fore Arm, Mod II



MKF No 39. Chamber, Mod II

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