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AD NUMBER
AD334799
CLASSIFICATION CHANGES
TO: unclassified
FROM: secret
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AD 334799

AUTHORITY: USARDCOM ltr, 15 Jun 82

REPORT R-1654

UNITED STATES ARMY MUNITIONS COMMAND

FRANKFORD ARSENAL

SILENT WEAPON SYSTEM
CARTRIDGE DESIGN AND DEVELOPMENT
Phase I: Design

BY

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[redacted]

OMS Code No. 5520.12.468A0.02
DA Project 596-10-001

November 1962

PHILADELPHIA 37, PA.

 DCN-1214-1220-63

REPORT R-1654

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SILENT WEAPON SYSTEM
CARTRIDGE DESIGN AND DEVELOPMENT
Phase I: Design

OMS Code 5520.12.468A0.02 DA Project 59610001

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FRANKFORD ARSENAL
Philadelphia 37, Pa.

November 1962

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ABSTRACT

(U) This report records, historically and chronologically, the design of a pressure-sustaining cartridge from initial concept to an interim working test design.

(S) A unique type of cartridge has been evolved which retains the propellent gases within the cartridge case. The projectile is telescoped within the case for maximum stroke, and is launched by a propelling piston which pushes the projectile to the desired muzzle velocity. The piston is then stopped at the end of the case by a bushing, sealing in the propellent gases.

(U) The evolution of design of the various components of this system, as modified by experimental test firings, is presented. Although not meeting proposed QMR's, a workable cartridge was produced.

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BACKGROUND AND QUALITATIVE MATERIEL REQUIREMENTS (U)

(S) Over the past several years Frankford Arsenal has been engaged in the development of a completely noiseless, flashless, and smokeless small arms round of ammunition. Under the "Whisper" program, a caliber .30 pressure-sustaining cartridge which meets these criteria has been developed. This cartridge, designated: "Cartridge, Caliber .30, XM76," is designed to be fired from the M1 rifle, and propells an 85-grain projectile at a muzzle velocity of 800 fps. In addition, a special caliber .38 cartridge has been developed along the same lines for revolver firing. This round fires a 125-grain projectile at 400 fps. Consideration of these two developments by the Special Warfare Forces has led to a request for the development of a semiautomatic silent weapon system.

(U) In response to the desires of the Special Warfare Forces, the Ordnance Corps (now U. S. Army Materiel Command) initiated a program known as "Silent Weapon System-Alpha." A special committee, established to develop parameters for such a system, was comprised of representatives from the Ordnance Weapons Command (now U. S. Army Weapons Command), Springfield Armory, Frankford Arsenal, and the Ballistic Research Laboratory of Aberdeen Proving Ground (now U. S. Army Test and Evaluation Command). This committee performed sufficient background studies to enable it to prepare a joint report which outlines the design parameters.(1)*

(S) Pertinent parameters selected by this committee are:

1. A pressure-sustaining cartridge will be utilized.

2. Projectile:

Weight	450 grains
Caliber	0.38 inch
Velocity	1000 fps
Material	dense (D38)
L/D ratio	~ 4

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*See References.

3. Cartridge:

Length	4 inches, max
Weight	1300 grains, max

4. Gun:

Operation	semiautomatic
Weight	7 lb, max
Feed	magazine (8 rounds/min)
Recoil	20 ft-lb, max

(U) At a conference held in November 1961, the "Silent Weapon System-Alpha" report was presented to Office, Chief of Ordnance (now Headquarters, U. S. Army Materiel Command), Dept of the Army staff, and U. S. Continental Army Command (USCONARC). Subsequently, project "Silent Weapon System-Alpha" was established by ORDTS (now AMCRD-DE-W) with the following areas of responsibility

Ordnance Weapons Command	- Administrative management.
Springfield Armory	- Design and development of gun.
Ballistic Research Laboratory	- Ballistic evaluation.
Frankford Arsenal	- Design and development of pressure-sustaining cartridge.

INITIAL CARTRIDGE CONCEPTS (U)

(U) This report records, historically and chronologically, the design of a pressure-sustaining cartridge from initial concept to an interim working test design.

(S) The heart of the silent weapon system is the pressure-sustaining cartridge which retains the propellent gases within the cartridge case. The projectile is launched by a propelling piston which pushes the projectile to the desired muzzle velocity. The piston is then stopped at the end of the cartridge case by a bushing, sealing in the propellent gases.

(S) Three preliminary, nonconventional, minimum cost concepts were first considered. These are sketched in Figure 1 (A, B, and C).

(S) In Figure 1A, a deep circular groove is cut in the projectile base and the case is fitted within the projectile. Other design features are similar to those for B and C of Figure 1. For these concepts (B & C), the projectile is telescoped within the case to provide a greater stroke within the specified over-all length. In Figure 1B, the projectile is inserted all the way back in the case with its base resting in a cylindrical piston depression, the forward bourrelet just touching a bushing. The bushing itself is pressed into the straight walled case so that matching grooves in each are aligned. A locking key wire is then inserted through a tangential hole in the case wall. Further support and sealing of the case-bushing joint is accomplished by using an epoxy adhesive. The lightweight piston contains a base cavity into which the propellant is preloaded. For more sophistication one may try to spin the projectile within the case - having then a miniature gun. Shown is a pre-engraved groove along the projectile, with spin bearings mounted in the bushing. In Figure 1C, the rotating band is placed as far forward as possible to locate it within the bushing. A small pusher rod is used to meet L/D ratio limits. This pusher rod is not to extend beyond the end of the cartridge.

(S) Several major problems immediately apparent are:

1. Exotic projectile and case design (Fig. 1A).

2. Passing the projectile rotating band through the bushing (Fig. 1B).

3. Weakening of case wall by groove (Fig. 1, B & C).

4. Retention of bushing against piston impact forces (Fig. 1, A, B, and C).

5. Strength vs weight for piston (Fig. 1C).

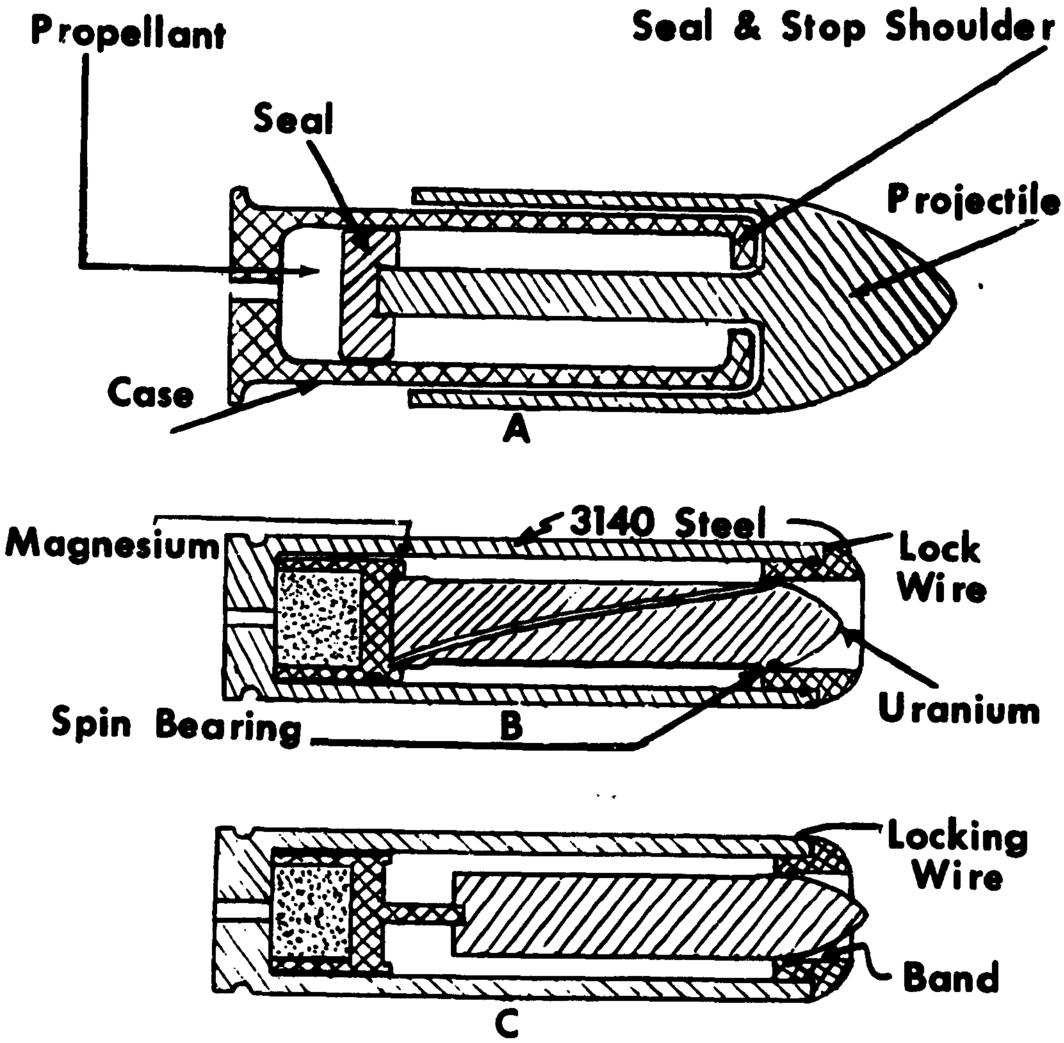

Figure 1. (SECRET) Initial Cartridge Concepts (U)

EXPERIMENTAL CARTRIDGE DESIGN (U)

(U) For the initial design, a combination of features of the concepts of Figure 1 were selected on the bases of being the least complicated and of most promising design, and of featuring economy of production. Two experimental cartridge designs were evolved. These are identified as the Alpha 1 and Alpha 2 and are shown in Figures 2 and 3, respectively.

(S) The designs feature the following:

1. The projectile is telescoped within the cartridge case.

2. Buffer seals guide the projectile and control the absorption of piston deceleration.

3. The case is pressure sustaining.

4. The piston does not extend beyond the case after firing.

5. The case has straight walls.

6. The use of threads is minimized.

Alpha 1 Cartridge Design (U)

Projectile (U)

(S) For purposes of design layout and initial firing programs, as well as simplicity of design, a simple right-circular projectile with a hemispherical nose was chosen. In this design, (Figure 2) lead gives the needed density, while a steel base plate and jacket support the lead during setback. The length of 5 calibers is over that specified (L/D = 4). This allows for a shorter piston shank. The projectile can still be stabilized and has merit with regard to projectile lethality (see section on Terminal Ballistics).

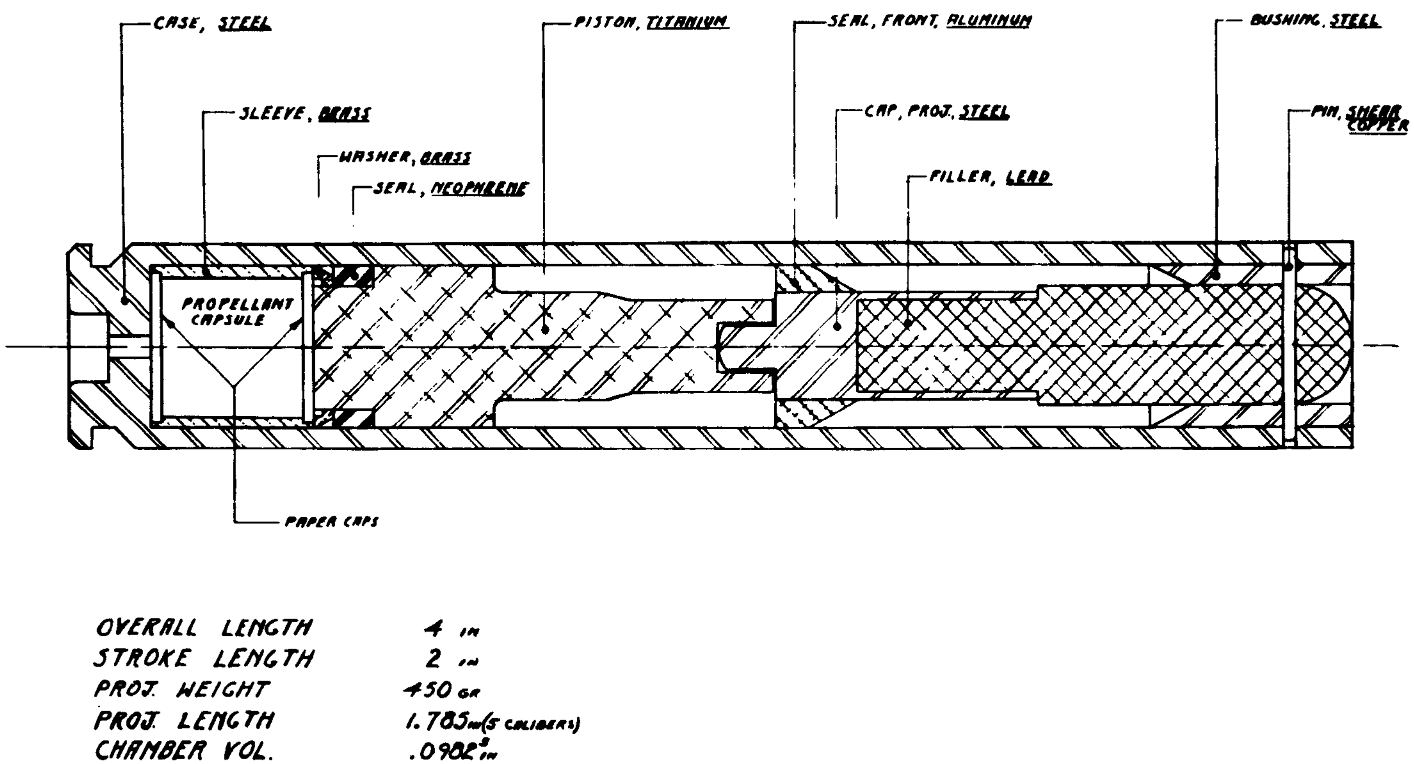

Figure 2. (SECRET) Alpha 1 Cartridge (design 1B) (U)

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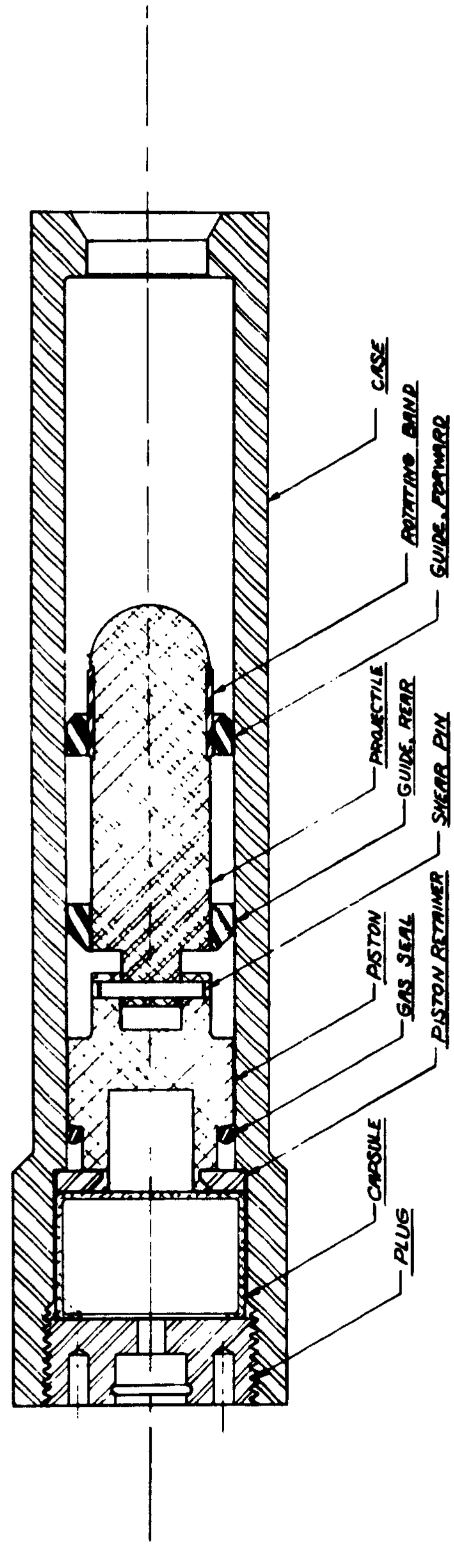

Figure 3. (SECRET) Alpha 2 Cartridge (design 1B) (U)

Piston (U)

(S) The piston, driven by the propellent gases, accelerates the projectile to its desired velocity and is then stopped by the bushing. It (the piston) is subjected to extremely high forces: compression stress on setback, shear stress from the bushing, and tensile stress from its own inertia during deceleration. These are all direct functions of the piston mass; therefore minimization of piston size and weight is extremely desireable. Titanium was chosen for its high strength-to-weight ratio. A stud on the projectile and a socket in the piston comprise the piston-projectile contact and alignment. A brass washer, mounted on the rear of the piston, is pushed by the initial gas pressure rise and compresses an O-ring to provide an instant gas seal.

Aluminum Front Seal (Buffer Seal) (U)

(S) Mounted on the rear of the projectile is an angled aluminum seal which serves a triple purpose. During the power stroke, it prevents the projectile from wobbling; upon impact with the bushing, it is stripped from the projectile and is crushed between the piston and bushing for controlled deceleration (deceleration being initiated by increasing sliding friction between the seal and the piston by the increase in piston shank diameter); and finally, it acts as a gas seal between the piston and the cartridge case mouth.

Case and Bushing (U)

(S) The case is a single piece of high strength steel, heat treated to approximately 200,000 psi. The knurled bushing is retained by an interference fit (Figure 4). In addition, an epoxy adhesive is applied between the bushing and the case. A shear pin serves as a component assembly lock and projectile shot-start. The bushing length and piston shank are adjusted so the piston will not extend beyond the case mouth at the end of the stroke.

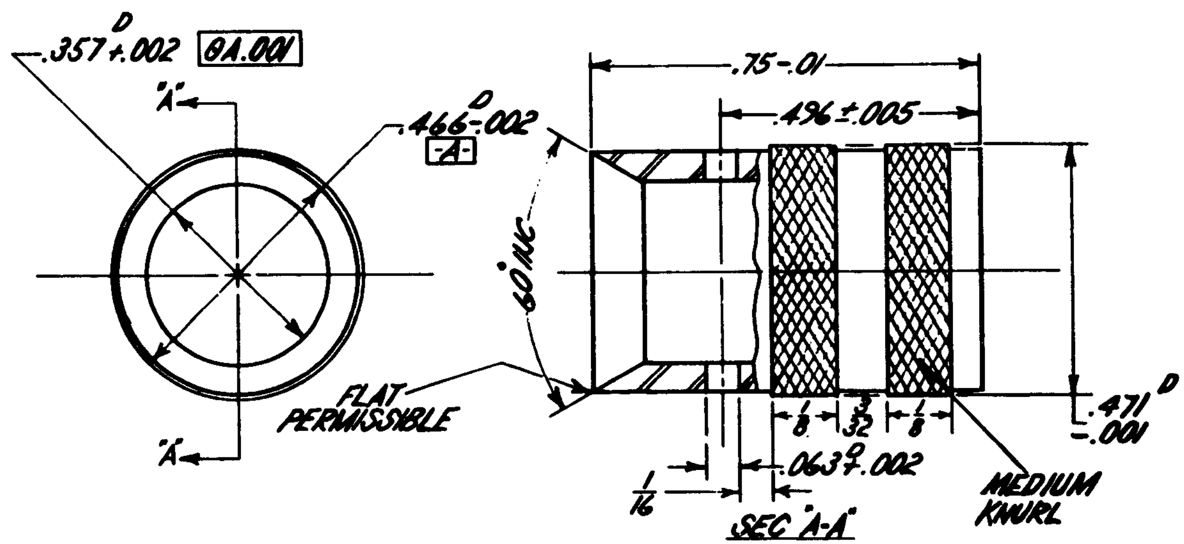

Figure 4. Bushing

Propellant Capsule (U)

(S) Our concept of an integral propellant capsule-piston has been eliminated in order to effect a necessary gas seal* and reduce the moving mass. The capsule consists simply of a thin walled brass or aluminum tube into which the propellant is loaded, the ends being capped by foiling paper.

Alpha 2 Cartridge Design (U)

(S) Extending the concept of telescoping the projectile within the cartridge case to its limit lead to the Alpha 2 cartridge design (Figure 3). Here the case is essentially the gun, and it might even be possible to spin the projectile within the case (as in the concept of Figure 1B) if rotation of the case within the gun can be prevented.

(S) The major advantage to this design is the much smaller and lighter piston. In our design we havc part of the initial chamber volume within the piston, approximating our concept idea of an integral piston-propellant capsule. (For adequate gas seal purposes it is still considered necessary to have separate units.) The brass washer for initial compression of the O-ring is eliminated by using Quad ring seals which have an X-shaped cross section. The cartridge is designed to be assembled from the rear end. While this makes for a stronger integral bushing for piston stopping purposes, we must thread this head and provide for gas sealing.

(S) Several other disadvantages are:

1. The projectile and, in particular, the rotating band must enter and pass through the bushing at 1000 fps. To this end, two buffer seal-and-guide supports are used. Here, again, problems of concentricity and binding arise.

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*Experience from the XM76 program has shown that O-rings placed as usual in a groove in the piston simply do not provide a sufficiently fast operating gas seal. The design of Figures 2 and 3 gives an almost instantaneous gas seal, but is not adaptable for use with an integral piston-propellant capsule unit.

2. There is the problem of how to provide hermetic sealing of the case mouth (to maintain safety of operation) without having foreign substances preceed the projectile down the barrel - an occurrance to be completely avoided if accuracy is to be maintained.

EXPERIMENTAL TEST FIXTURE (U)

(U) A special test fixture was designed for use in the initial charge development and design feasibility program. Essentially, this fixture is a combination heavy walled cartridge case and smooth bore gun. Figure 5 shows the fixture assembled and ready to fire the Alpha 1 design cartridge.

(U) With this test fixture, the propellant charge can be developed and the internal working components evaluated at minimum cost. The fixture can be easily modified to accommodate both a cartridge case and a rifled barrel, and it is anticipated that this will be done for case evaluation and projectile stability studies.

(S) The propellant chamber is monitored by a piezoelectric pressure gage. For firings with this test fixture, steel test slugs were used. Their length was chosen for convenience in the test fixture and to provide a 450-grain weight without regard to exterior ballistic considerations. Figures 6 and 7 both show the working component hardware; views A being the Alpha 1 design; views B, a modified version of the Alpha 1 design (which will be discussed in the next section); and views C, the Alpha 2 design. Figure 6 shows the components as assembled in the test fixture; Figure 7, an exploded view.

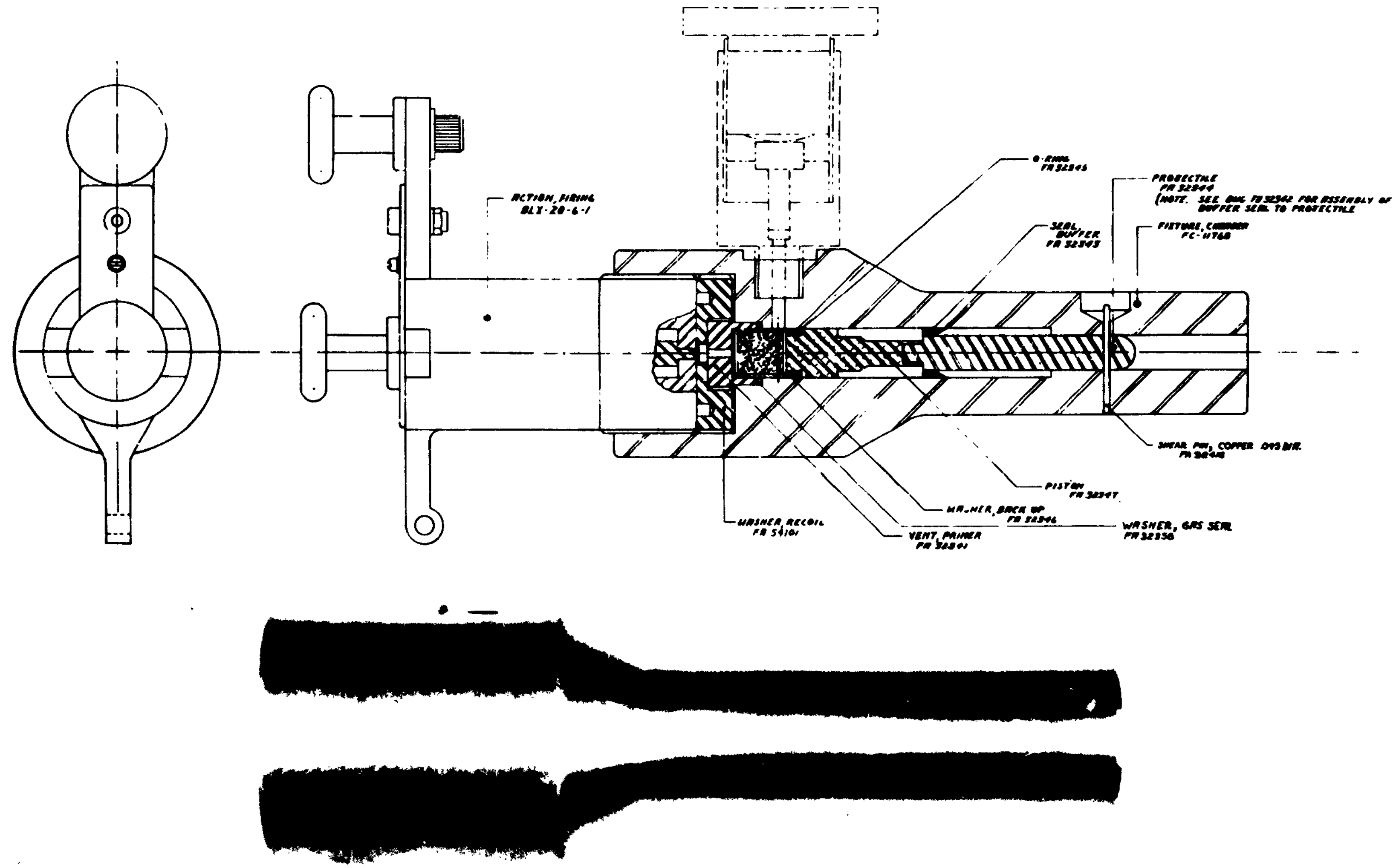

Figure 5. (SECRET) Alpha Cartridge System Test Fixture (U)

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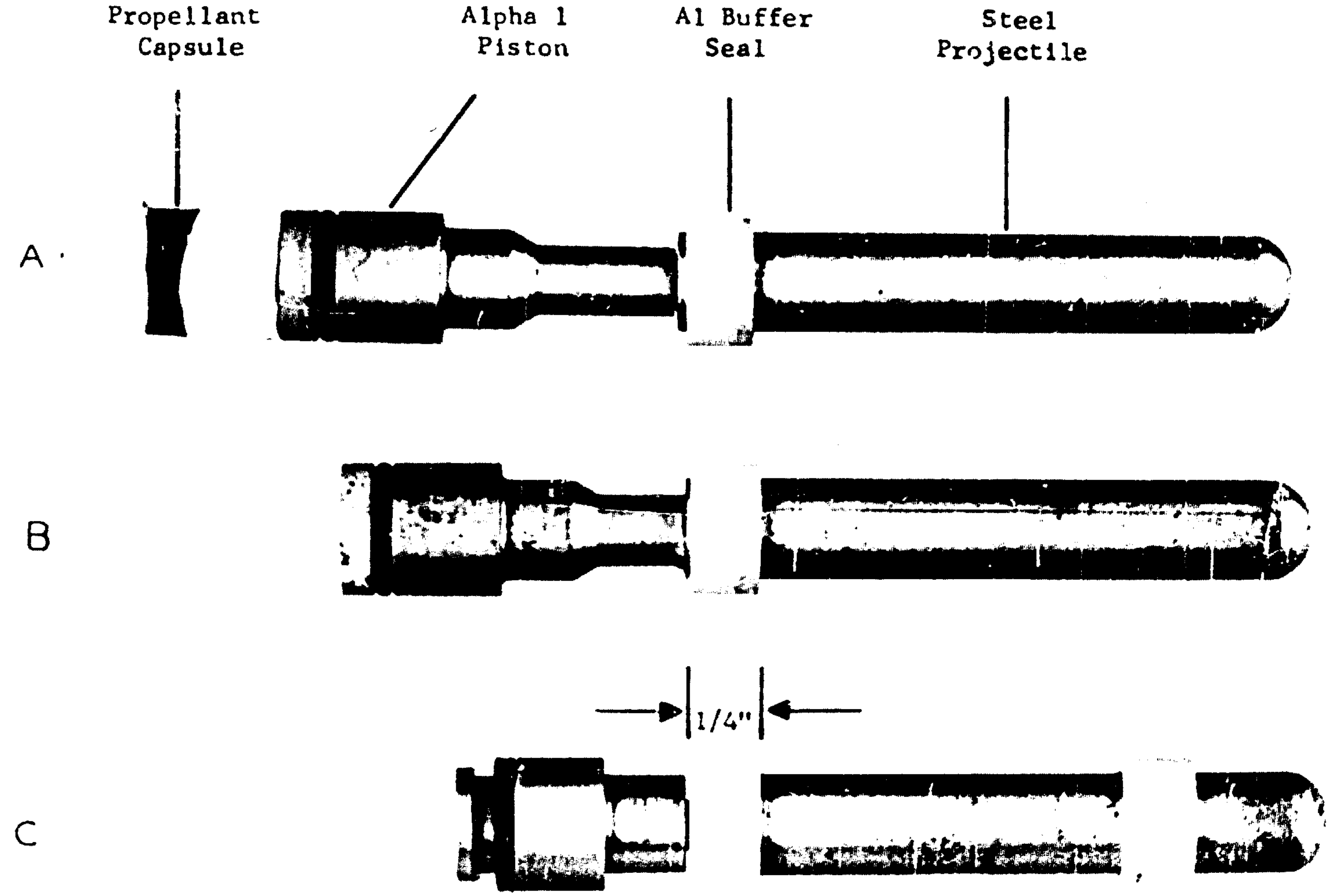

Figure 6. (SECRET) Assembled views, Alpha Cartridges
A - Alpha 1 System
B - Modified Alpha 1 System
C - Alpha 2 System (U)

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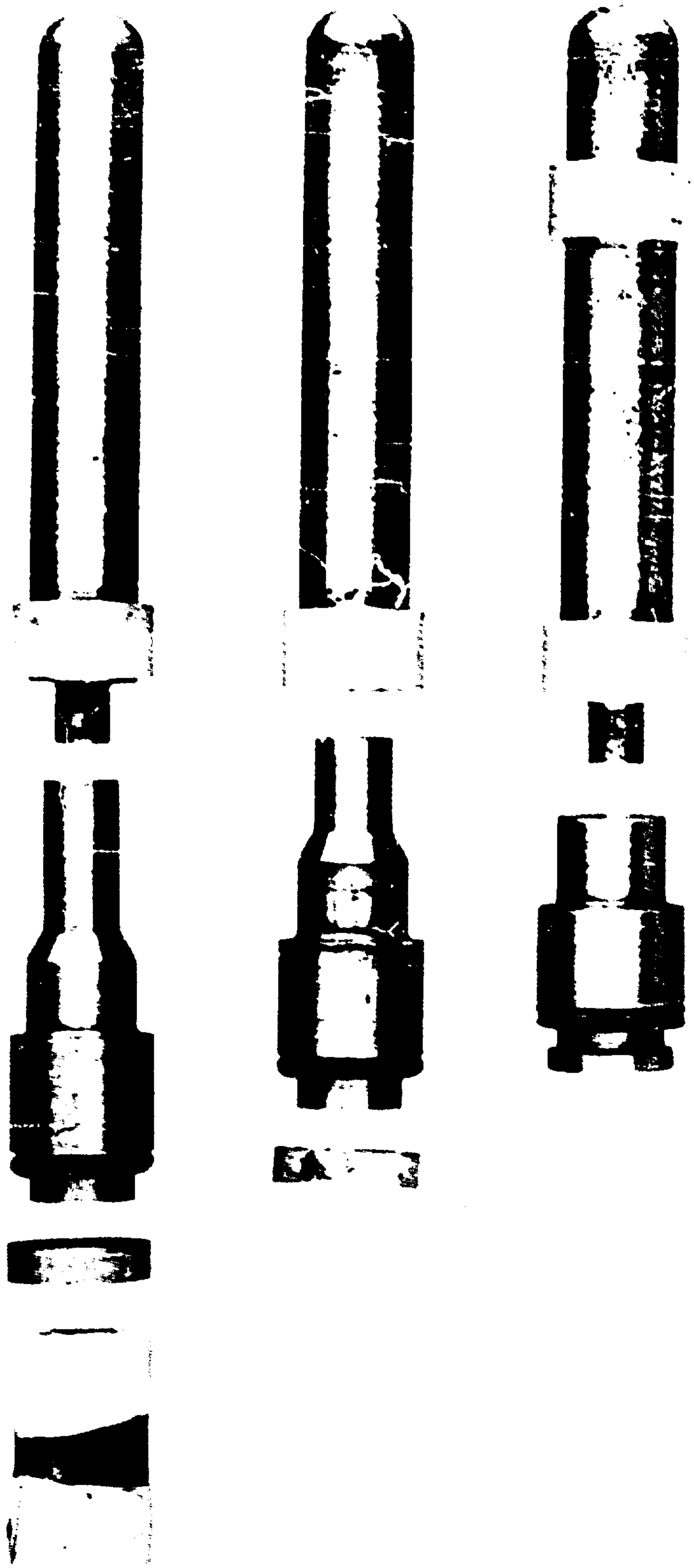

A B C

Figure 7. (SECRET) Exploded views, Alpha Cartridges (U)
A - Alpha 1 System
B - Modified Alpha 1 System
C - Alpha 2 System

CHARGE DEVELOPMENT AND COMPONENT EVALUATION (U)

Initial Firings (U)

(U) Firings were conducted, using the test fixture and the Alpha 1 cartridge design, for the purpose of charge establishment and piston evaluation. No shear pins were used for these or for most of the following firings. With the extremely fast propellants used and the heavy mass to be accelerated, a shear pin was not considered essential at this time.

(S) Various amounts and types of IMR propellant (such as IMR 4198 and IMR 4804) were tried. Velocities obtained ranged from 300 to 330 fps. The pistons showed no signs of damage, and were reused.

(S) It was concluded that the IMR propellants were not fast enough, so a change was made to a flake powder, Lot 41,* WC 330H (18% N/C, 35% nitroglycerine, 0.0069 inch web). Three rounds were then fired using 15 grains of the WC 330H propellant. For these rounds only, shear pins were used. Velocities of 691, 652, and 722 fps were obtained. Both the piston and projectile suffered considerable damage. The stud on the rear of the projectile was mashed flat and the associated socket on the piston was crushed. These effects are attributed to setback forces. In addition, the shank of each piston failed, following the projectile down range. Figure 8 shows these results.

(S) The Alpha 1 cartridge design was then modified (View B, Figures 6 and 7) by cutting off the socket on the piston shank and the stud on the projectile. This modification was expected to increase the velocity for a given charge since the projectile would not have to tear itself loose at end of stroke and the piston would weigh less. Further, the reduced mass of the piston shank would reduce the shearing forces. Firings of the modified Alpha 1 design, however, gave

*Manufacturer's analysis is listed in Appendix A.

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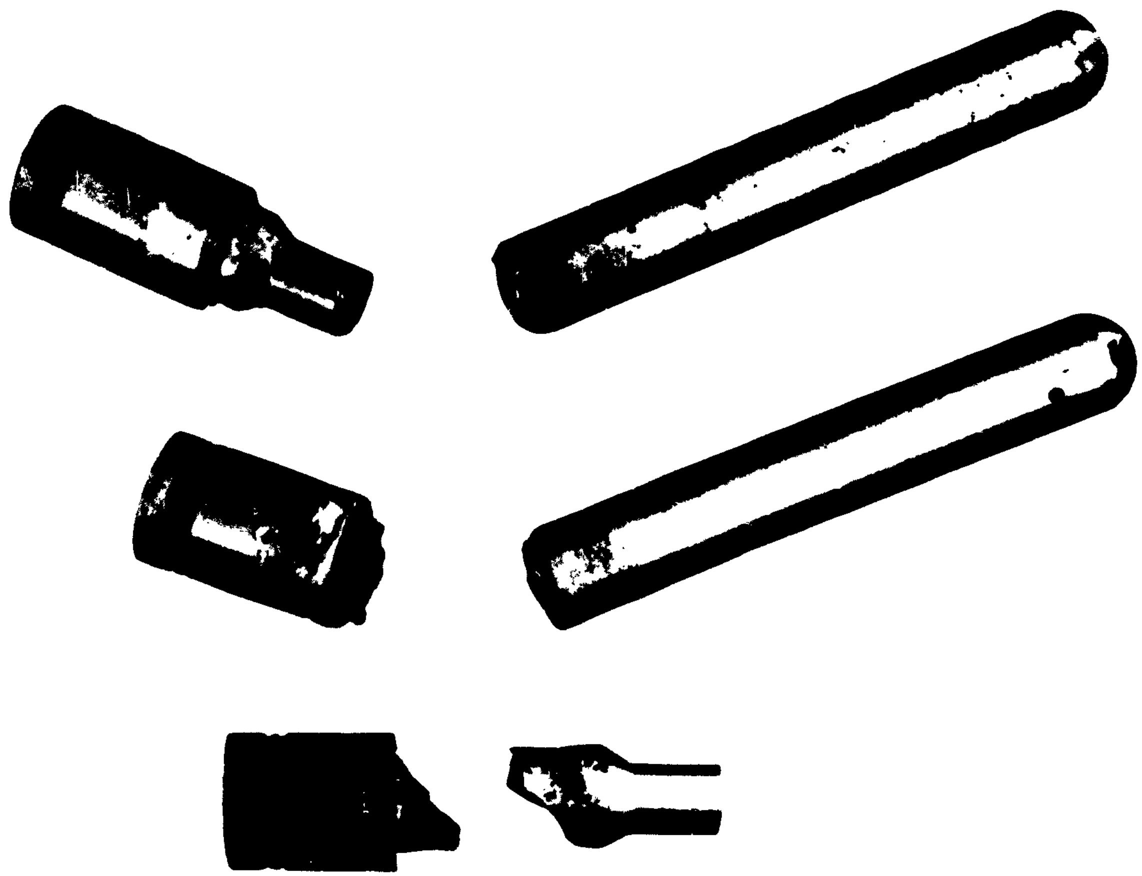

Figure 8. (SECRET) Alpha 1 Pistons and Projectiles, test fired (U)

essentially the same projectile velocity as before and shearing of the piston still occurred. It should be noted, however, that successful sealing of the propellent gases within the test fixture was accomplished.

(S) Since the Alpha 2 piston has a substantially shorter shank, it was decided to try it. Because of the long steel test slugs used, it was possible to use the Alpha 2 pistons as direct replacements for the Alpha 1 pistons merely by moving the projectile rearward, the forward end of the projectile still remaining within the barrel. For these firings, the gas seal was provided by Quad rings. Three firings were made, using 20 grains of WC 330H propellant, and velocities of 784 and 813 fps (one velocity was missed) were recorded. The pistons all remained intact. However, evidence of gas leakage past the piston was found and it was concluded that Quad rings alone were not usable in this system.

Piston Redesign (U)

(S) Based on the firings with the Alpha 2 cartridge and a thorough review of the Alpha 1 piston design, a new piston design, the Alpha 3 (Figure 9), was made. As can be seen, the shank length was reduced to the minimum consistant with projectile length and stroke, and by increasing the radius from the shank to the bore diameter shoulder, this shoulder was reduced in length. It was felt that this length could be reduced as shown because there was no evidence of incipient shear of the shoulder from any of the preceding firings. To spread the impact of setback over the entire cross-sectional area of the piston and projectile, the rear of the projectile was rounded so that it almost fit a concave cup at the forward end of the piston. This also provided self-alignment along the piston-projectile axis.

(S) In addition to these modifications, it was decided to use buffer seals made of cellular aluminum material.[2] The material is prepared by introducing salt crystals of the desired granualtion into the molten aluminum. When the salt is leached from the aluminum, a myriad of holes results (see Figure 10). Thus, the compressibility of this material can be varied, and it was expected that a more controlled deceleration of the piston would result. Using this cellular aluminum material,

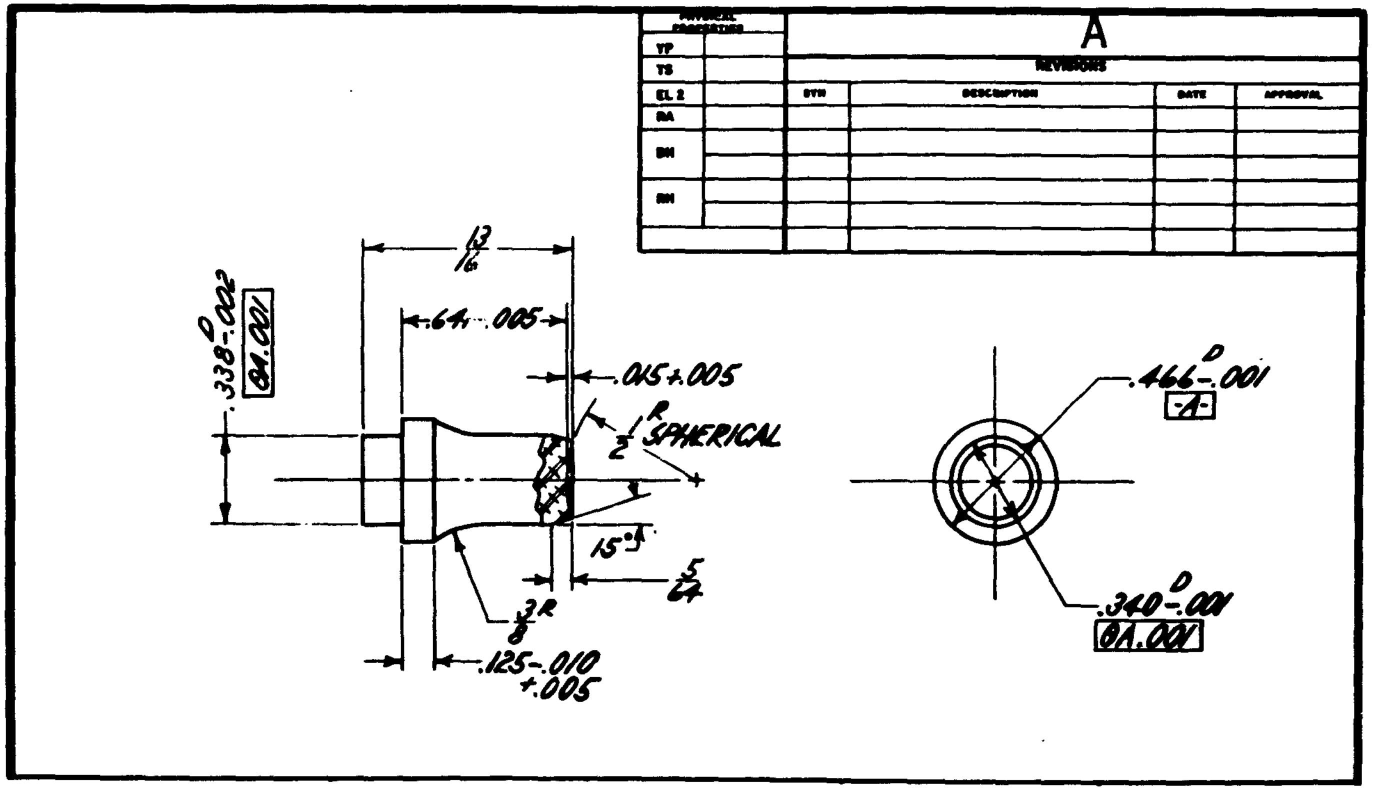

Figure 9. (Unclassified) Alpha 3 Piston (U)

Figure 10. Cellular Aluminum Buffer Seal

the buffer seal would collapse inward, upon itself, on impact with the bushing, instead of deforming outward and exerting pressure upon the case and piston.

Evaluation of Alpha 3 Piston (U)

(S) Previous examination of the pressure-time curves obtained during test firings revealed an extremely high initial pressure spike (over 100, 000 psi). At this time it was decided to evaluate slightly larger web propellants as well as the Alpha 3 piston design. Several firings, using 20 and 25 grain charges of WC 590 (N/C 15%, 0.012 inch web), gave velocities of only 200 to 500 fps. Repeat firings with WC 330H also gave low velocities - 256 and 426 fps. From examination of the test setup and loading and assembly proceedures, it was concluded that

1. The primer was spaced marginally with respect to the charge.

2. The piston and projectile were not always positioned for maximum stroke.

3. The inside of the test fixture was deforming and corroding.

(S) Two rounds were then fired to check out item 1 above. Several grains of black powder were positioned at the primer end of the charge. Velocities of 877 and 919 fps were obtained. The test fixture was subsequently modified to provide a different type of gas seal which relocated the primer closer to the propellant. A firing of 24 grains of WC 330H (no black powder) resulted in a velocity of 995 fps.

(S) A shot of particular interest was then made. Previously, two 1/4 inch long buffer seals had been used in tandem to give an equivalent 1/2 inch buffer seal. For this firing, one cellular aluminum buffer seal 1/2 inch long and one solid aluminum buffer seal 1/4 inch long were used. The cellular aluminum seal was mounted on the projectile as usual, while the solid aluminum seal was pushed tightly on the piston shank. The result is shown in Figure 11. The solid aluminum buffer seal seized the piston at its forward end - a very desireable result (except for shortening of the stroke). The velocity for this round, using 25 grains of WC 590, was 847 fps.

(S) Four identical rounds were now prepared. These consisted of:

1. 25 grains of WC 330H flake propellant.

2. Two 1/4 inch long cellular aluminum buffer seals mounted on the rear of the projectile with Duco household cement.

3. The Alpha 3 piston.

4. The O ring, brass washer, and piston, which were given a light coat of Marfax grease.

After each shot the test fixture was brush-cleaned with solvent.

(S) The following velocities were obtained using a ten-foot base line starting ten feet from the test fixture muzzle.

Rd No.	Velocity (fps)
1	1048
2	1051
3	1051
4	1021

A fifth round was then prepared, but was not fired until the following day, when a velocity of 911 fps was obtained.

(S) Retention of the gas pressure within the test fixture was observed on all firings. This pressure was released on removal of the pressure gage.

(S) All firings using the Alpha 3 piston were successful in that the pistons remained intact. They did show, however, the effects of their ordeal, and this may be seen in Figure 12. Also shown is the

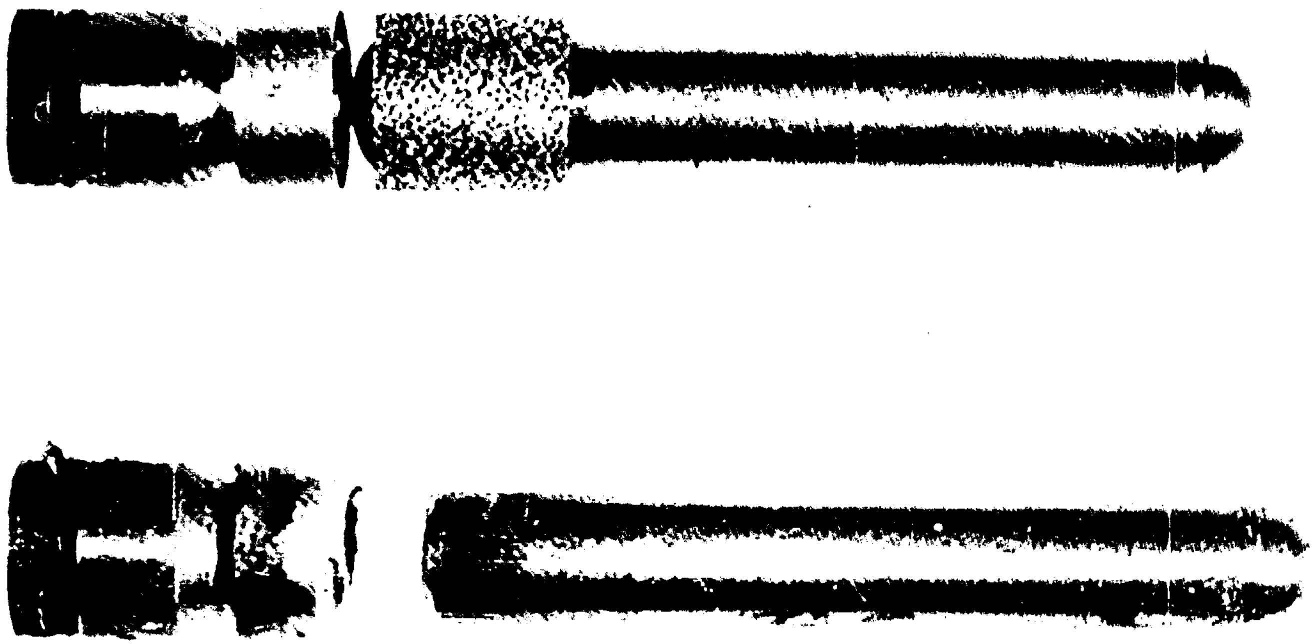

Figure 11. (SECRET) Combination Solid and Cellular Aluminum Buffer Seals, Alpha 3 Cartridge System - before and after firing (U)

995 fps

919 fps 995 fps 1048 fps

Figure 12. (SECRET) Alpha 3 Pistons fired at various velocities (U)

projectile which was driven by the middle piston at 995 fps. The rear has been expanded by setback forces. It should be noted, however, that these projectiles, although made of alloy steel (4340), were in the annealed state (YS = 65,000 to 70,000 psi).

(S) The titanium used for the pistons was not the best available. The physical properties of the titanium alloy used are given in Appendix B.

(U) It was noted from the pressure-time curves obtained that use of the larger web WC 590 propellant reduced the initial pressure spike to the order of 70,000 to 80,000 psi, but at the expense of several hundred feet per second slower velocity.

BALLISTIC PENDULUM FIRINGS (U)

(S) A further series of four firings was made with the test fixture mounted on a highly sensitive ballistic pendulum. This pendulum has a period of 3.5 seconds, and with the fully loaded test fixture mounted, it weighed 18 pounds. Its sensitivity was then 0.83 lb-sec per inch of recoil. It was hoped to obtain a measure of the differential recoil between the rearward momentum and the impact of the piston upon the bushing.

(U) To fire the FA #26 percussion primer without initiating movement of the pendulum, a T14 electric primer was used to drive a small rod which tripped the sear of the spring-loaded firing pin mechanism. Figure 13 shows the test fixture mounted on the ballistic pendulum.

(S) Unresolved instrumentation difficulties prevented obtaining any valid data except velocities (listed below) taken over a ten-foot base line starting ten feet from the muzzle.

Rd No.	Velocity (fps)
1	Lost
2	970
3	957
4	926

(S) High speed (~1000 frames per second) movies were taken which show the effective sealing of the propellent gases within the test fixture.

(S) A review of the results of the last two series of test firings shows two velocity levels for nine supposedly identical rounds, the first four having an average velocity of 1043 fps (std dev = 14.6 fps or 1.4%), while the other four (discarding the first pendulum firing, which was lost) have an average velocity of 941 fps (std dev = 27.3 fps or 2.9%). The only known difference in the rounds was the curing time for the Duco cement used to hold the buffer seals to the rear of each projectile. The first four rounds were each fired within 15 minutes after the buffer seal was assembled to the projectile; for the remaining rounds, one to three days elapsed between assembly

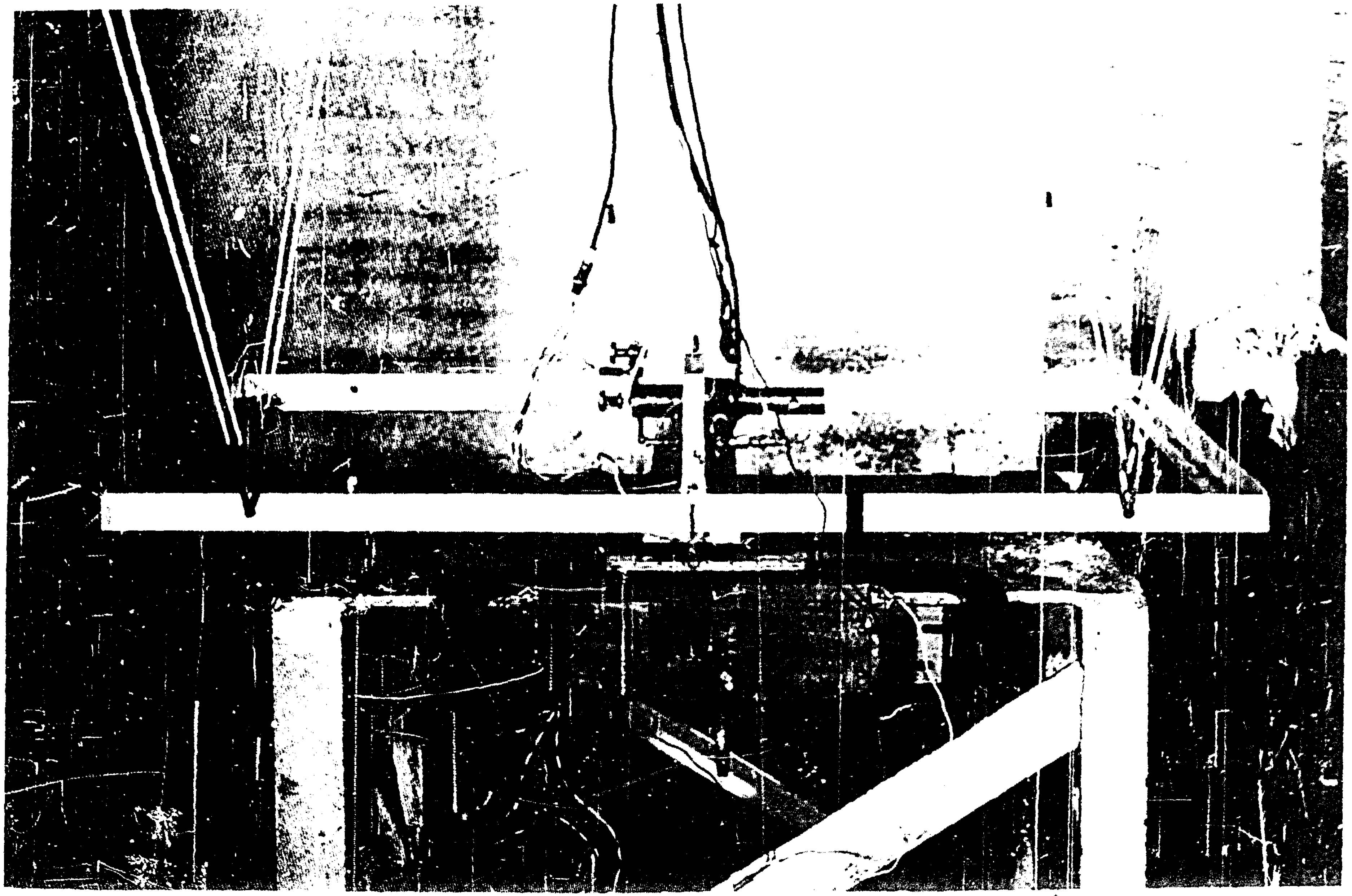

Figure 13. Alpha Test Setup on Pendulum

and firing. It is also appreciated that the piston and projectile may not always have been in direct contact or completely to the rear, although efforts were made to see that each round was assembled in the test fixture in the same manner. Accordingly, it is expected that assembled rounds using the cartridge case and shear pin will be more ballistically efficient and reproducible.

ALPHS 3 CARTRIDGE DESIGN (U)

(U) The successful Alpha 3 piston design was now incorporated into a complete cartridge. The Alpha 3 cartridge assembly is shown in Figure 14.

(S) The five caliber projectile has a body of Elkonite 6070 (density 11.5 gm/cc) with an aluminum nose. (See section "TERMINAL BALLISTICS" for further comment.) A geon rotating band for minimum friction was placed at the extreme forward end of the body and located just within the bushing. A special herringbone knurl (Fig 15) is used to prevent stripping. The rest of the assembly is essentially that used with the test fixture. (Note the angle on the bushing. This eliminates any sharp edge which might dig into the rotating band or projectile and, with a corresponding angle on the buffer seal, forces the buffer seal down toward the forward end of the piston shank.) The entire assembly is locked together by two shear pins through the case and bushing into the aluminum nose of the projectile. The bushing is knurled to a press fit into the case and is further held in place by an epoxy adhesive. Figure 16 shows an exploded view of the Alpha 3 cartridge.

(S) The total weight of this round is 1573.8 grains. Individual component weights (of a random sample) follow.

Projectile with geon band	450.0 gr
Bushing	98.5 gr
Piston with O-ring and brass washer	115.0 gr
Propellant capsule	29.5 gr
Propellant charge	15.1 gr
Buffer seal, graphite impregnated	11.0 gr
Cartridge case	849.2 gr
Primer (#26)	5.5 gr
Total	1573.8 gr

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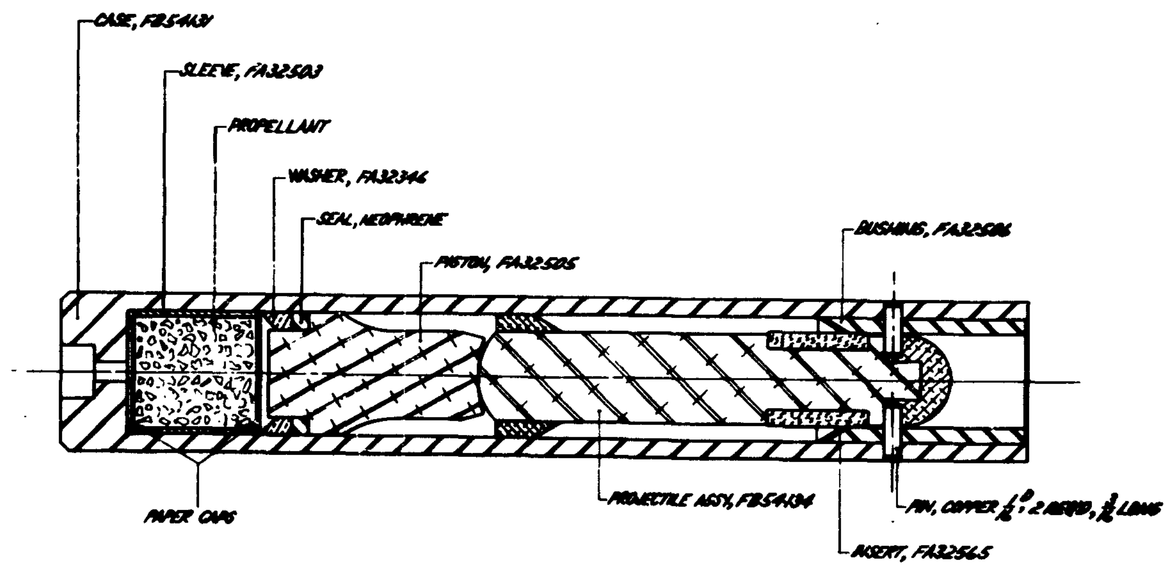

Figure 14. (SECRET) Alpha 3 Cartridge Assembly (U)

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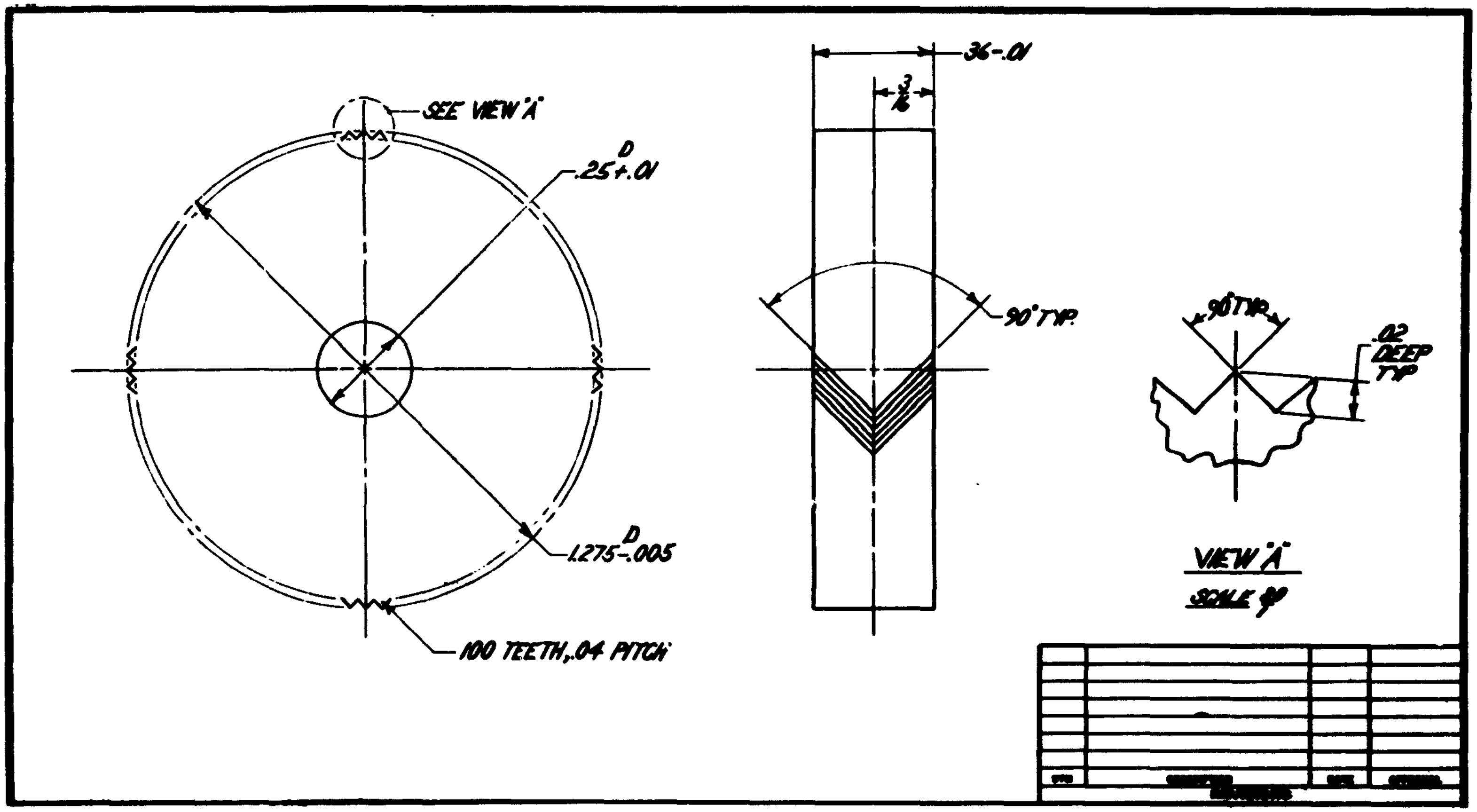

Figure 15. Knurling Tool

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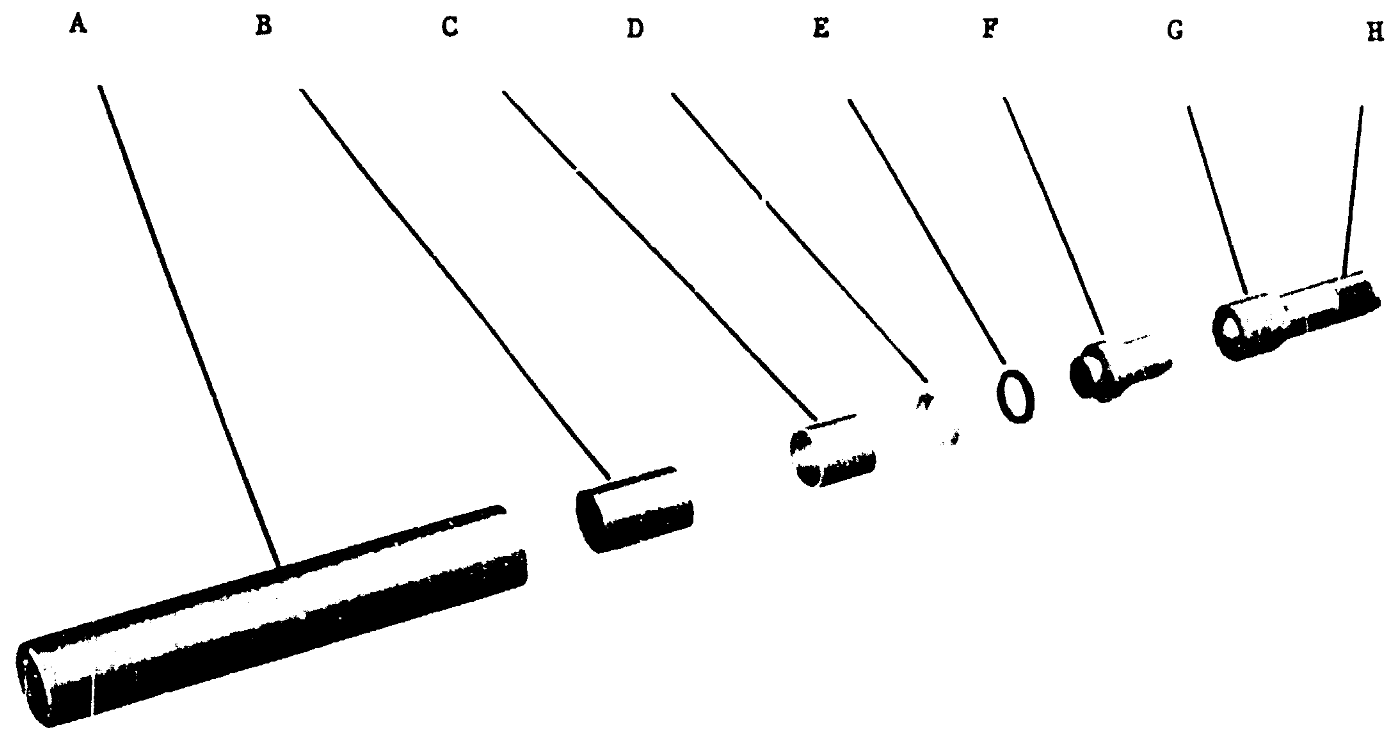


A - Case
B - Bushing
C - Propellent Capsule
D - Brass Washer
E - O-ring
F - Piston
G - Buffer Seal
H - Projectile

Figure 16. (SECRET) Exploded view, Alpha 3 Cartridge System (U)

Thus, we are approximately 275 grains over our design specification of 1300 grains. It is considered unlikely that this can be reduced much below 1500 grains.

TERMINAL AND EXTERIOR BALLISTICS (U)

(S) The Alpha Weapon System has as its main purpose the exploiting of its silent, flashless, and smokeless character in surprise and clandestine operations. It is necessary, however, that the system be effective in killing a human target. To this end, the kill probability of the Alpha projectile is determined as a function of range. The curve thus generated is compared to that for the 7.62 mm NATO fired from the M14 rifle.

(S) Before determining the actual P_k (probability of kill) values, let us consider some variables associated with projectile lethality. Two of the primary variables are muzzle velocity and projectile mass. A third variable, whose importance is becoming increasingly apparent (in accordance with Ballistic Research Laboratory wound ballistic criteria), is projectile tumbling in the target.

(S) A tumbling bullet will transfer a greater fraction of its kinetic energy to the medium and cause a more destructive effect. The NATO round is essentially stable in the target medium, while the Alpha round is specifically designed to be inherently unstable in a dense medium.

(S) One tentative Alpha projectile has a right-circular cylindrical body of Elkonite with a hemispherical nose of aluminum. The Elkonite and aluminum are proportioned to give a 450-grain projectile with an L/D of 5. It is fired with a minimum spin so as to be just sufficiently stable in flight. The heavy body-light nose design increases the moment coefficient and decreases the transverse moment of inertia to assure instability in the target medium. These design criteria are based on conclusions developed in Frankford Arsenal Report R-1569.[3]

(U) We now calculate the P_k for our two systems. To do this we must consider the variables of accuracy of fire and target size to arrive at a single shot probability. This, combined with a casualty criterion, leads to the killing probability. To make a meaningful comparison, it is essential that the same assumptions be applied in the same manner to each system under consideration. The mathematical technique used here for generating the P_k for a certain range is essentially that presented in Frankford Arsenal Report M61-34-1,(4) with certain variations pertinent to the problem at hand, the primary of these being a change in target configuration to simplify calculations. While this introduces an error (< 2%), it is considered negligible in relation to other standard assumptions. In addition, the casualty criterion used is based on unpublished figures obtained from the Ballistic Research Laboratory relating to recent work establishing a 30-second defense, 100% kill casualty criterion.

(U) The assumptions and their values used in this analysis are:

1. Accuracy of fire
   a. Round to round = 1/4 mil (std dev)
   b. Aiming error = 1 mil
   c. Battle sight range setting (BSRS) = 100 and 150, 175, and 200 meters.
2. Target size - radius - 1.25 ft.
3. Casualty criterion - 30-second defense, 100% kill

(NOTE: A single BSRS = 200 meters is used for the NATO round.)

(S) In addition, the following design parameters are used for each weapon system.

	7.62 mm NATO M59 Ball	Alpha
Projectile weight	150 gr	450 gr
Muzzle velocity	2800 fps	1000 fps
Ballistic coefficient (G_1)	.21	.32

(U) These values were supplied to the Univac Solid State 90 digital computer, programmed to supply the probability of killing as a function of range.[4] The values obtained for the two weapon systems are presented in Figures 17 and 18.

(S) The NATO round-M14 rifle with a single battle sight range setting (BSRS) = 200 meters is used as the standard against which the Alpha system is compared. In Figure 17 the Alpha is assumed to have BSRS = 100 and 150 meters, while in Figure 18, BSRS = 100 and 175 meters is used. The Alpha system is specifically designed to match the NATO and is seen to slightly exceed the NATO round in P_k to approximately 110 meters. An integration of each curve gives the relative total lethality effectiveness for each system. This is shown in Table I.

(S) Table I. Relative Total Lethality Effectiveness of Alpha and NATO Systems (U)

Weapon System	Battle Sight Range Setting (meter)	Lethality Effectiveness	% Effective (rel to NATO)
NATO	200	30	100
Alpha	100 and 150	29	97
	100 and 175	30	100

(U) Exterior ballistic calculations were also computed for the Alpha projectile for ranges of 300 yards and 300 meters, assuming a muzzle velocity of 1000 fps. Values for angle of elevation, angle of fall, time of flight, terminal velocity, and maximum ordinate vs range are given in Table II. The maximum ordinate vs range is plotted in Figure 19 for ranges of 300 yards and 300 meters.

36.231.S0538/ORD.62

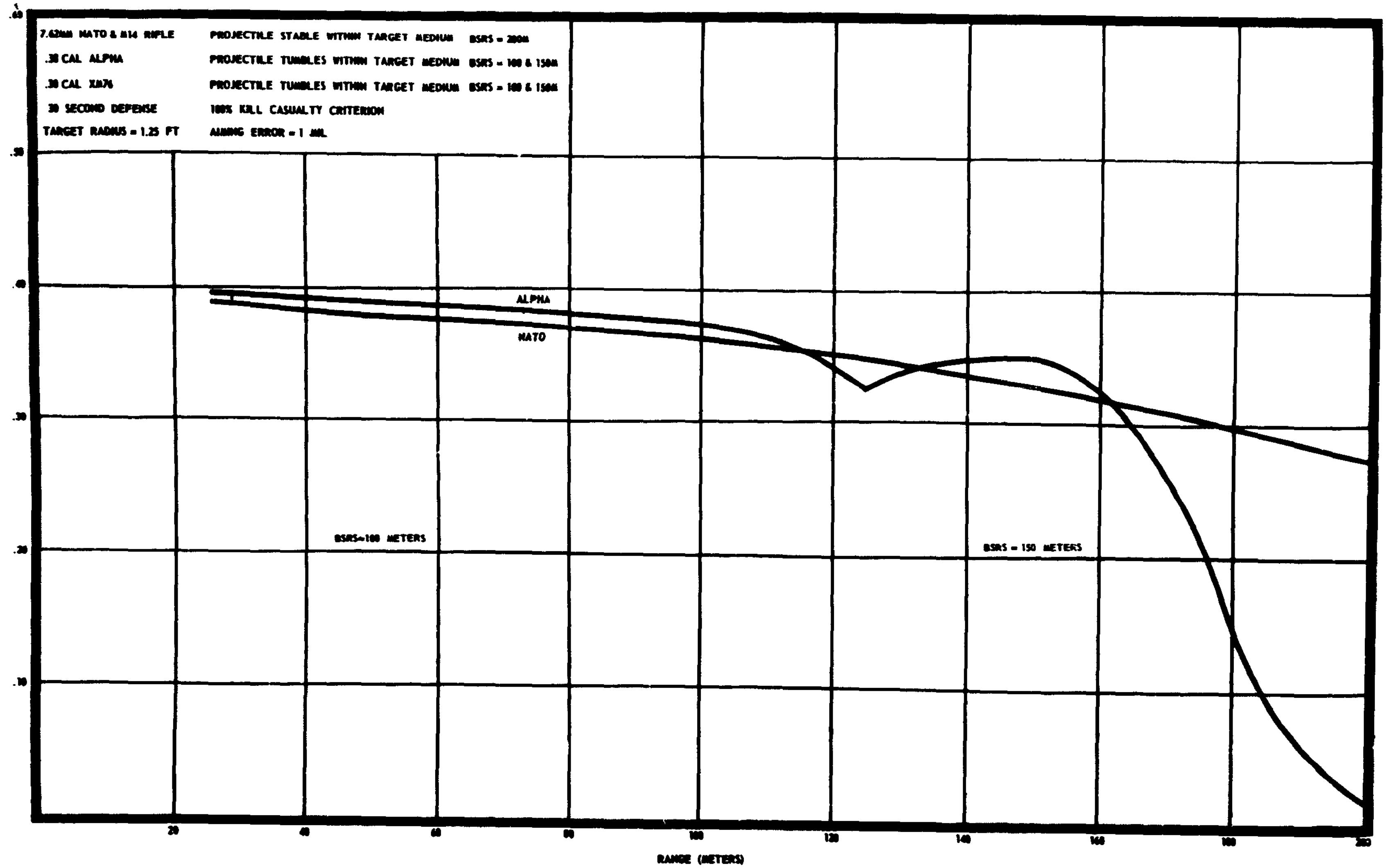


Figure 17. (SECRET) Single Projectile Incapacitation Probability (P_k) vs Range and Weapon System for Battle Sight Range Setting (BSRS) = 100 and 150 meters (U)

36.231.S0539/ORD.62

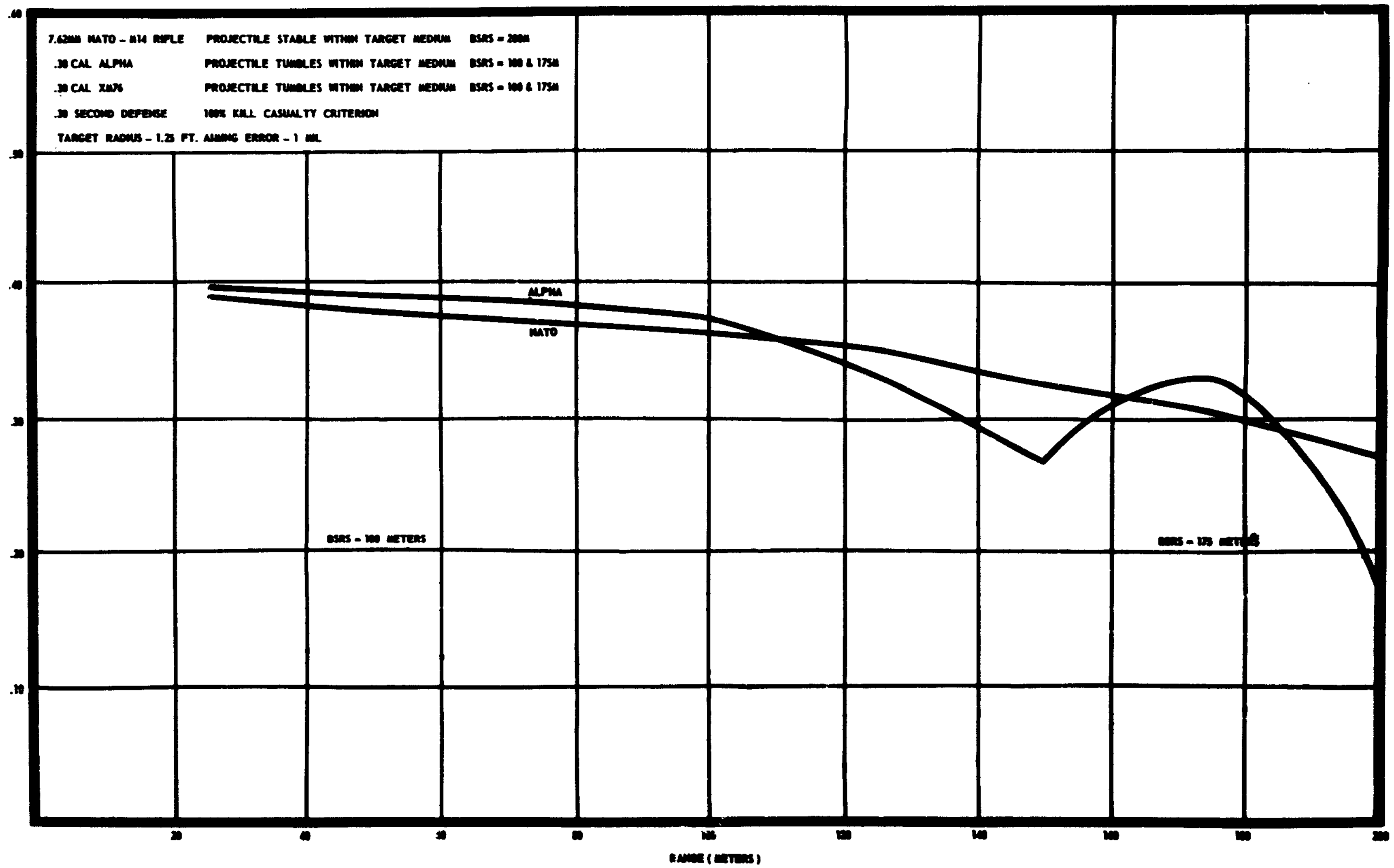


Figure 18. (SECRET) Single Projectile Incapacitation Probability (P_k) vs Range and Weapon System for Battle Sight Range Setting (BSRS) = 100 and 175 meters (U)

(S) Table II. Exterior Ballistic Parameters For the Alpha Cartridge (U)

Muzzle velocity - 1000 fps
Diameter - 0.357 in.

Weight - 450 gr
C - 0.32 lb/in.^{2}

Range (ft)	Range (yd)	Angle (mil) of Elevation	Angle (mil) of Fall	Time of Flight (sec)	Terminal Velocity (fps)	Maximum Ordinate (yd)
			Range - 300 yards			
400	133.3	6.80439	-7.40481	0.419	926.4	1.26
425	141.66	7.27299	-7.90637	0.445	922.6	1.29
450	150.	7.69159	-8.20793	0.473	918.4	1.30
475	158.3	8.21020	-8.70949	0.499	914.5	1.29
500	166.6	8.67881	-9.41108	0.525	910.7	1.28
550	183.3	9.43645	-10.45993	0.580	903.1	1.24
600	200.	10.59410	-11.50879	0.733	895.7	1.17
900	300.	16.56011	-18.39579	0.975	854.6	0
			Range - 300 meters (328.1 yards)			
400	133.3	8.04639	-8.75640	0.495	915.0	1.49
450	150.	9.22990	-9.84951	0.567	905.1	1.56
500	166.6	10.64508	-11.54325	0.643	894.3	1.57
550	183.3	11.79556	-13.07491	0.225	884.0	1.55
600	200.	13.66638	-14.84633	0.816	862.6	1.51
984.3	328.1	18.30855	-20.48477	1.075	843.9	0

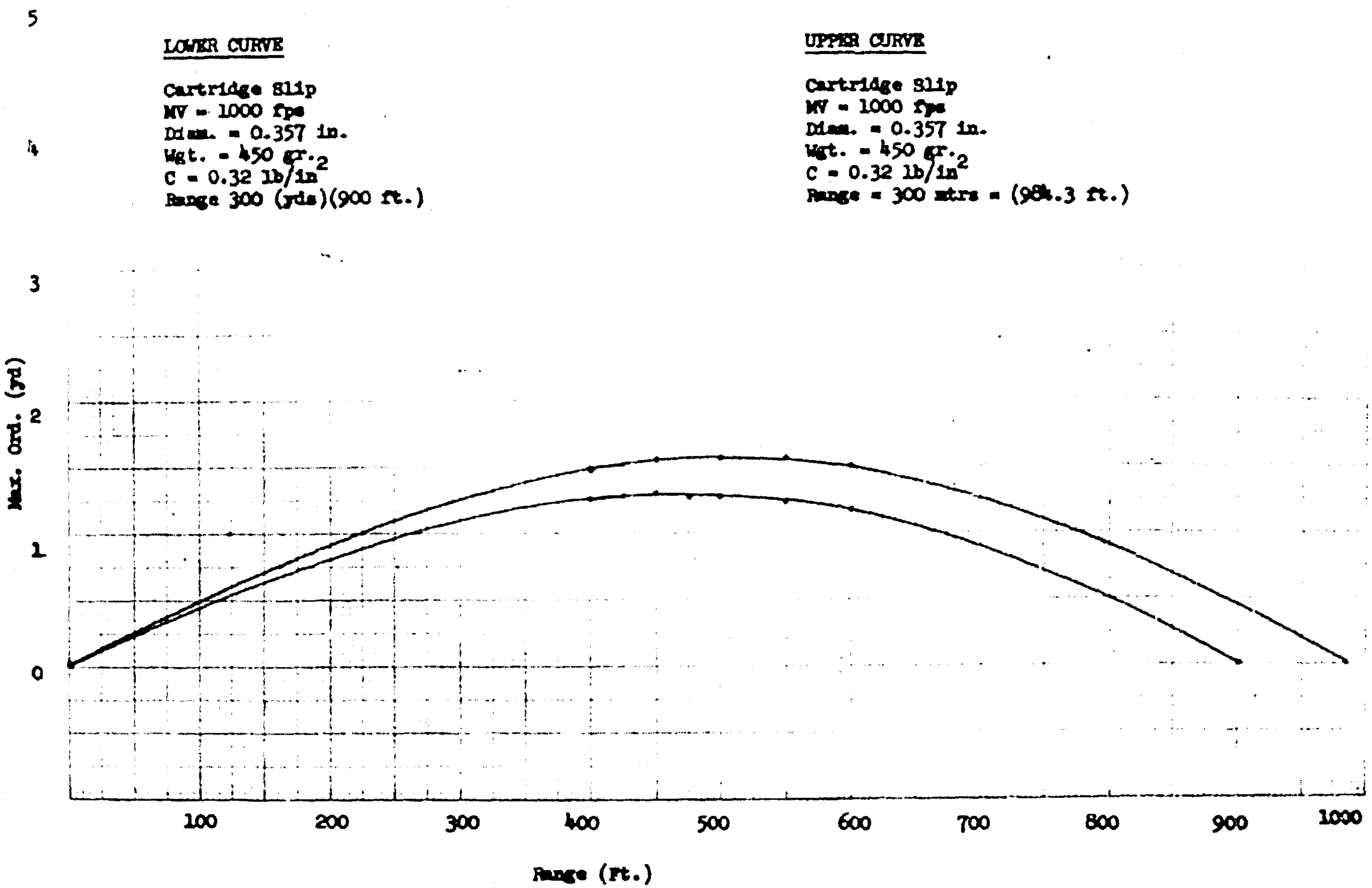


Figure 19. Maximum Ordinate vs Range, Alpha Cartridges

CONCLUSIONS AND RECOMMENDATIONS (U)

(S) It is concluded that it is entirely possible to develop a pressure-sustaining cartridge capable of accelerating a 450-grain projectile to 1000 fps or better. The weight of such a cartridge system is expected to be closer to 1500 grains than to the weight specified in the QMR.

(S) Major development problems are:

1. Case wall thickness vs weight, strength, and impact.

2. Retention of unsupported bushing.

3. Projectile design.

It is felt that all of these can be conquered with a properly supported and conducted development program.

(S) It is felt that some of the criteria laid down are possibly not applicable for a weapon system such as this. A silent, flashless gun would seem to have its most immediate use as a short range, direct-aimed weapon wherein the probability of a hit in a critical area is extremely high. One might take note of actual combat ranges for guerrilla warfare activities in Malaya, as reported by the British[5] and shown in Figure 20.

(U) It is recommended that development of the "Silent Weapon System - Alpha" continue.

(U) For general interest and to preserve our perspective, a translation of an Austrian Patent, #5478, "Device for Noise Abatement in Fire-Arms," is appended (Appendix C).

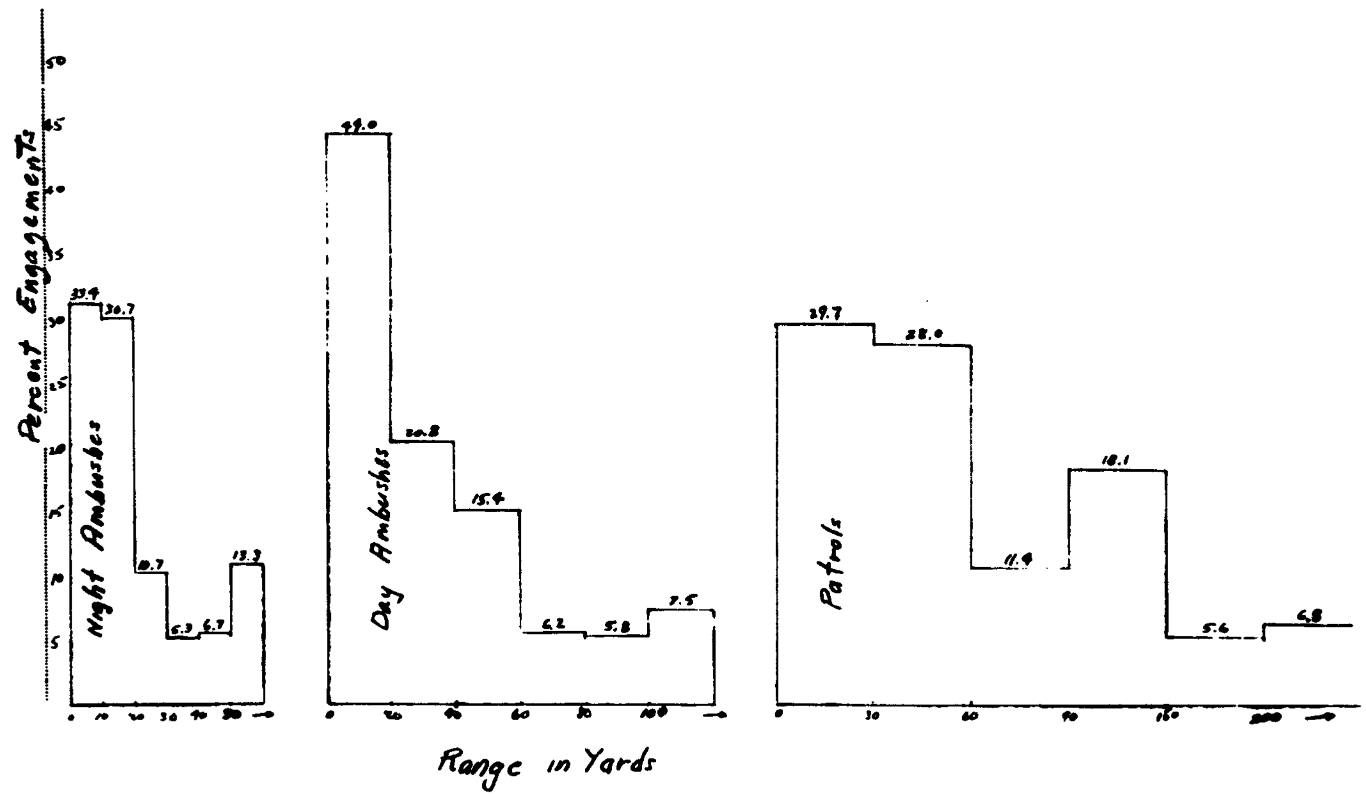


Figure 20. Guerilla Combat Ranges - Malaya

APPENDIX A

PROPELLANT ANALYSIS
LOT 41, WC 330H

Chemical Analysis

NG		18.80	
DNT		.59	
DPA		.69	
DBP		.11	
M&V		.83	
Stability at 120° C	SP	65	minimum
		300+	minimum

Screen Analysis

.0232	0.1
.0197	3.5
.0165	16.5
.0138	32.8
.0117	31.3
.0098	9.4
.0083	5.7
.0070	0.1
.0059	0.1
Pan	0.1

G.D.	.803
Granulation	.016/.009
Web	.0069

APPENDIX B

LABORATORY REPORT

No. 148023 24 May 1962

Material: Titanium Specimens

To: Mr. C. L. Fulton
CC 1480

W.O.: 43419-03-866

Mechanical Testing

Specimen	Yield Strength .1% Offset (lb/sq in.)	Tensile Strength (lb/sq in.)	% Elongation in 1.0 in.	% R.A.
		Longitudinal with Slab Dimensions		
Long 1	138,800	151,900	15	48
Long 2	140,200	154,700	11	34
		Transverse with Slab Dimensions		
Trans 1	120,800	143,500	11	41
Trans 2	125,300	148,900	10	26

For Information Only:

W. A. SHEBEST
Metallurgist

Report Approved:

/s/ R. D. France
R. D. FRANCE
Chief
Basic Mat'ls Eval. Br.

APPENDIX C

AUSTRIAN PATENT #5478

Class 72 - Fire-arms, shells, fortifications
a) Small arms and their respective parts

Patent application - 12 May 1900

Patent granted - 1 June 1901

Patent published - 10 October 1901

Patentee - Josef Hutfless, in Vienna

****

DEVICE FOR NOISE ABATEMENT IN FIRE-ARMS

The purpose of the present innovation is to lessen the sound effect on discharge of fire-arms, due to the sudden escape of gases, and is thereby characterized by the fact that the barrel is closed on emergence of the shell from the barrel mouth whereby the gases are not liberated until after travel through two or more tubes arranged parallel to the gun barrel and in this manner their pressure is so diminished that when they do escape only an unimportant sound effect is produced.

A barrel of this character is produced by this innovation which is especially useful for hunting guns and is shown in figures 1 to 4 of the attached drawing in longitudinal view, together with the pertinent profile and plan views, as well as a cross-sectional view through A - B of figure 1.

Translation No. 2808 - Translated from German by G. Silvius deVega-Gomez, Frankford Arsenal Library

As is apparent, the barrel mouth has been pressed into a funnel-shaped form; on the lower side of the barrel are arranged two parallel, thin-walled tubes b and c, also parallel to the barrel, and connected to one another on the ends turned away from the barrel mouth.

In regard to the ends at the barrel mouth, there is a tube c (sic b) placed in front of the funnel-shaped constricted part of the barrel a, while the similarly situated front end of the other tube b (sic c) is provided with a series of perforations d, figs. 1, 2.

Special shells are used to load this weapon. They consist of two parts (m, n) loosely connected to one another. Directly on loading, part m corresponds to the diameter of the unconstricted tube, while the forward shell part n is similar in diameter to the constricted barrel diameter and is connected to the larger shell part m by means of a simple pin, p.

****

The action of the device is as follows: On discharge of the weapon, both shell parts (m, n) are carried by the powder gases (forming in the barrel) to the constricted part (mouth) of the barrel. There, the larger shell m passes into the barrel constriction (position m') and is retained there, while the forward shell n, due to the velocity given to it, is liberated from the rearward shell m and, coursing through the remainder of the barrel, leaves the barrel (position n').

As a result of the obstruction of the barrel a, the powder gases do not pass through the mouth of the barrel into the open air, but reach it through the opening g in the tube c (sic b), then travel into the second tube b (sic c) and leave the latter with essentially diminished pressure through the perforations d, arranged on the forward top surface of tube b (sic c), whereupon there is produced a hissing noise.

As a result of this action, a loud explosion is avoided and the powder gases leave the tube causing a subdued, imperceptible noise. The shell part m', remaining in the barrel, is removed by driving it out with a rammer.

AUSTRIAN PATENT #5478

PATENT CLAIMS

1 - A device for subduing the report arising on discharge of fire-arms, characterized by the fact that the barrel is constricted near its mouth and anterior to this constriction is connected with one or several tubes, inserted behind one another, and from which the last one empties through several small perforations into the open air.

2 - Two-part shells for the device, characterized under CLAIM 1, whose rear part lying next to the powder charge has the diameter of the unconstricted barrel, while the forward shell diameter which corresponds to the loosely connected smaller shell part matches the constricted barrel diameter.

*****

JOSEF HUTFLESS in WIEN.

Vorrichtung zur Schalldämpfung bei Feuerwaffen.

Fig. 1.

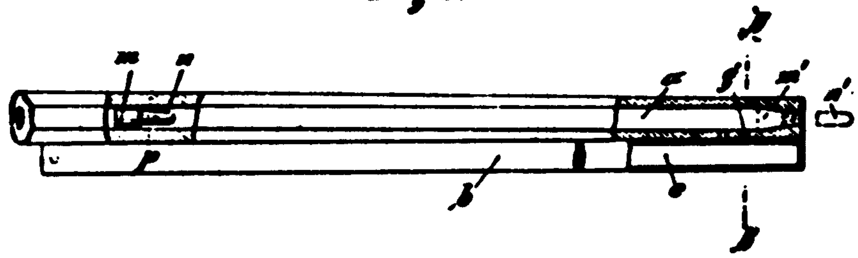
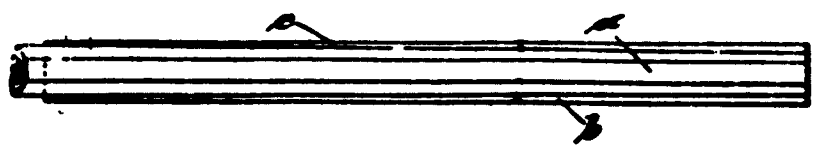


Fig. 2.

Fig. 4.

Fig. 3.



Zu der Patentschrift

Nº 5478.

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2. L. Polonsky and S. Lipson, "A New Lightweight Cellular Material," Frankford Arsenal Report R-1534, Apr 1960.

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5. "The Performance of Small Arms Weapons, Including the .280 (7 mm) Rifle, Used in the Machine Carbine Role in Malaya," Operational Research Unit Far East, Report No. 1/53, Mar 1953.

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(U) This report records, historically and chronologically, the design of a pressure-sustaining cartridge from initial concept to an interim working test design.

(U) The evolution of design of the various components of this system, as modified by experimental test firings, is presented. Although not meeting proposed QMR's, a workable cartridge was produced.

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