U.S. Department of Justice

Office of Justice Programs

Washington, D.C. 20531

July 09, 2003

Mr. Edward Hammond
The Sunshine Project
101 West 6TH Street, Suite 607
Austin, Texas 78701

Re: OJP FOIA No. 03-00267 (Please reference this number on all future correspondence.)

Dear Mr. Hammond:

This letter acknowledges your Freedom of Information Act request received in this office on July 08, 2003, in which you request a copy of the contracts and all reports received to date for the following National Institute of justice grants: University of Arizona, University of California , Vanek Prototype Co, National Security Research Inc.

The records you seek are maintained outside of this office, and our staff has not yet been able to determine whether or not, or how many, records exist in response to your request. If we are unable to comply with the general, twenty-day turnaround time for production, as provided under applicable law, you will be notified.

In addition, this letter confirms your agreement to incur all applicable fees involved in the processing of your request as set forth in Department regulation 28 C.F.R. § 16.3(c), up to the amount of $25.00. Under 28 C.F.R. § 16.11(c), this fee represents the combination of search time, review and duplication of records which may or may not prove to be responsive to your request. As you might imagine, the $25.00 is expended rather quickly. If you wish to authorize us to produce documents in excess of this amount, or, if you wish to discuss reformulation of your request, please contact this office immediately at (202) 307-6235.

Sincerely,

Dorothy A. Lee

Dorothy A. Lee
Paralegal Specialist
Office of the General Counsel

APPLICATION FOR FEDERAL ASSISTANCE

OMB Approval No. 0348-0043

2. DATE SUBMITTED: March 25, 2002

Applicant Identifier: 2002-90[redacted]CA-IJ (0030)

1. TYPE OF SUBMISSION:
   - *Application*: ☐ Construction; ☒ Non-Construction
   - *Preapplication*: ☐ Construction; ☐ Non-Construction

3. DATE RECEIVED BY STATE:

State Application Identifier:

4. DATE RECEIVED BY FEDERAL AGENCY:

Federal Identifier:

5. APPLICANT INFORMATION

Legal Name: Vanek Prototype Co.

Organizational Unit:

Address (*give city, county, state, and zip code*):
1171 Redrock Ct.
Sunnyvale, CA 94089

Name and telephone number of the person to be contacted on matters involving this application (*give area code*):
Chester F. Vanek
(408) 738-2706

6. EMPLOYER IDENTIFICATION NUMBER (EIN): Sole Proprietor
52 – 7-7-6-4-4 8 1

7. TYPE OF APPLICANT: (*enter appropriate letter in box*) M

A. State	H. Independent School Dist.
B. County	I. State Controlled Institution of Higher Learning
C. Municipal	J. Private University
D. Township	K. Indian Tribe
E. Interstate	L. Individual
F. Intermunicipal	M. Profit Organization
G. Special District	N. Other (Specify): ______

8. TYPE OF APPLICATION:
☒ New ☐ Continuation ☐ Revision

If Revision, enter appropriate letter(s) in box(es): ☐ ☐

A. Increase Award B. Decrease Award C. Increase Duration
D. Decrease Duration Other (*specify*):

9. NAME OF FEDERAL AGENCY:
National Institute of Justice

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER: 16.560

TITLE: Justice Research, Development and Evaluation Project Grants

11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:
Proposal for a Multi-Shot Launcher with Advanced Less-Than-Lethal Ring Airfoil Projectiles
U.S. Department of Justice
1/1/02 -12/31/02

12. AREAS AFFECTED BY PROJECT (*cities, counties, states, etc.*):
Sunnyvale, City of
Santa Clara County, California

13. PROPOSED PROJECT:

Start Date	Ending Date
6/01/02	5/31/03

14. CONGRESSIONAL DISTRICTS OF:
a. Applicant: California District 15
b. Project: National

15. ESTIMATED FUNDING:

a. Federal	$ 339,000.00
b. Applicant	$ .00
c. State	$ .00
d. Local	$ .00
e. Other	$ .00
f. Program Income	$ .00
g. TOTAL	$ .00

16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?
a. YES. THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:
DATE ______
b. NO. ☐ PROGRAM IS NOT COVERED BY E.O. 12372
☒ OR PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

RECEIVED 2002 JUL 5 A 11:10 COMPTROLLER DESK

17. IS THE APPLICANT DELINQUENT ON ANY FEDERAL DEBT?
☐ Yes If "Yes," attach an explanation. ☒ No

18. TO THE BEST OF MY KNOWLEDGE AND BELIEF, ALL DATA IN THIS APPLICATION/PREAPPLICATION ARE TRUE AND CORRECT, THE DOCUMENT HAS BEEN DULY AUTHORIZED BY THE GOVERNING BODY OF THE APPLICANT AND THE APPLICANT WILL COMPLY WITH THE ATTACHED ASSURANCES IF THE ASSISTANCE IS AWARDED

a. Typed Name of Authorized Representative: Chester F. Vanek
b. Title: Proprietor
c. Telephone number: (408)738-2706
d. Signature of Authorized Representative: Chester F. Vanek
e. Date Signed: Mar. 22, 2002

Previous Editions Not Usable

Standard Form 424 (REV 4-88)
Prescribed by OMB Circular A-102

ABSTRACT

Project Goals and Objectives

The objective of this proposed, Less-Than-Lethal, weapon project is to demonstrate the superiority of a multi-shot launcher using an advanced ring airfoil projectile (RAP) as a chemical agent delivery projectile with an effective range of fifty meters, yet is less-than–lethal at the muzzle.

Proposed Research Design and Methodology

The method proposed to accomplish this goal is to design, fabricate, test, and demonstrate a carbine-sized, multi-shot RAP launcher that can deliver up to eight shots, no less than two seconds apart, plus an advanced RAP that is less-than-lethal at muzzle, and can effectively deliver a chemical agent to fifty meters

The Advantages of a Multi-shot Launcher For Advanced Less-Than-Lethal Ring Airfoil Projectiles

Introduction

State of the art weapons in the LTL role have limited usefulness due to two major drawbacks: These systems are range sensitive and range limited. An example of range sensitivity is the shot (bean) bag, which if fired at too close a target often results in death or severe injury. Yet at the range of a thrown rock, the shot bag's inaccuracy and lost velocity, due to drag, severely reduces its effectiveness. The stun gun is range limited, as are many other LTL projectors. These range and muzzle lethality drawbacks of current LTL systems are inherent in their basic functional concepts. In addition, many of them would be difficult to design as practical repeating systems.

What is needed in the field is an LTL system that is truly "less than lethal" at the muzzle, yet accurately delivers impact energy sufficient to disseminate a chemical agent at ranges of up to fifty meters, and can produce repeated LTL impacts seconds apart on a target. Having this capability would greatly enhance the usefulness of LTL technology. Law Enforcement personnel would not have to immediately resort to lethal means to protect themselves if the first LTL shot was ineffective, inasmuch as a repeating design would offer rapid follow-up shots. Further, if the impacting LTL package were designed to deliver an incapacitating substance, energy, or marker upon target impact, the effectiveness of the system would be intensified.

The Ring Airfoil Projectile (RAP) offers the basis for an LTL system with the ability to impact non-lethally at muzzle, together with aeroballistic characteristics that make it an impact deterrent and effective chemical agent delivery device to ranges up to (at least) fifty meters. The term 'aeroballistic' is required to define unusual flight characteristics that make the RAP superior to all other impact LTL technologies that are based on conventional ballistics. Figure 1 shows that the ring airfoil is like an airplane wing curled into a ring. Thus the spinning RAP can fly on a near straight-line trajectory, unlike a ballistic projectile.

Accordingly, this proposal is submitted with the intention of successfully demonstrating, within one year following funding, a multi-shot LTL weapon that can fire RAPs repeatedly, unlike the single-shot launchers that have been demonstrated to date. Included in this proposal is the intention to successfully demonstrate a payload-delivering Ring Airfoil Projectile. First effort would concentrate on the delivery of a chemical payload on and about the target. Payloads of incapacitants, irritants, malodorants, and marking agents would be of first interest, and could lead to a family of Ring Airfoil LTL rounds.

In view of the lengthy time that has recently been spent to solve materials and propulsion problems for a single-shot device, it is urged that future effort be concentrated on the multi-shot LTL design so as to be able to provide the Law Enforcement community with a useful weapon that combines a limited kinetic energy deterrent along with long-range precision delivery of a selected chemical agent.

It is the intent of Vanek Prototype Company to design, fabricate, and demonstrate a unique handheld multi-shot launcher that can fire RAPs rapidly and accurately. This launcher design represents a major step forward in the evolution and technology of LTL weaponry. It is intended to provide this demonstration within one year from the time that funding is received. Prior success with single-shot RAP launching mechanisms allows Vanek Prototype to anticipate rapid success in fabricating and validating key mechanical components of the proposed design. On this basis, the Company is confident that, by eight to nine months from start, an initial functioning demonstrator will exist. Vanek Prototype also intends to concurrently demonstrate a significantly improved LTL RAP design having increased accuracy and dissemination efficiency.

A Short History of Ring Airfoil Development

During the Vietnam War it became apparent that an effective, "less than lethal" (LTL), weapon system for the control of civil disturbances was needed. This need was emphasized by the tragedy at Kent State University, in May 1970, and resulted in the U.S. Army supporting the development of a unique LTL system based on a non-ballistic rubber projectile known as the Ring Airfoil Projectile (RAP). The RAP was derived from a prior project based on a lethal fragmentation design known as the RAG – Ring Airfoil Grenade. This initial application of the ring airfoil as the projectile in a self-contained munition appeared in the early 1970s (Flatau: U.S. Patents 3877383, 4115175).

The RAP was recognized to have unique aerodynamic characteristics: high lift, and low drag. By spinning the ring airfoil at launch, gyroscopic stability was achieved, and relatively flat trajectories with extended range were obtained. These attributes were seen to be ideal for LTL purposes, since a relatively low muzzle velocity, hence muzzle-safe, RAP made of rubber could nevertheless impact with effective incapacitant dissemination energy at beyond fifty meters.

Several designs appeared for use as a less-than-lethal (LTL) projectile by making the ring airfoil body of a rubber-like material and incorporating cavities to contain chemical-incapacitation agents (Flatau: U.S. Patents 3898932, 3951070, 4190476). The Army specified an LTL performance that drove the choice of diameter, mass, velocity, and material for these projectiles. For example, the RAP's diameter was chosen to be 2.5 inch in order to make it reasonably eye-safe. Impact velocity was limited to about 200 feet per second to avoid trauma in vulnerable impact areas. Upon target impact, the LTL RAP dispersed its load of agent on and about the target. The LTL system conceived by Flatau was type classified by the U.S. Army in May 1978, and consisted of two different "disturbance control" RAPs, the M742 and M743, and an adapter (M234) that mounted over the muzzle of the M16A1 rifle (Fig. 2), plus a blank cartridge (M755) to power the launch of the RAP.

The M234 was a single-shot muzzle-mounted device that was time consuming to load. The Army produced a large quantity of both the launcher (M234) and the projectile (M743 – known then by the acronym Sting RAG, for sting 'ring airfoil grenade'). Later modifications to the M16 made the M234 incompatible, at which point the Army obsoleted the system. Although 500,000 Sting RAPs were produced with the intention of using them for training, it appears that they were never used due to these modifications to the M16 (M16A2, M16A3).

No extensive research on the RAP was done after Type Classification of the M234/M743 in May 1978, until the fall of 1997, when interest in the RAP was shown by the National Institute of Justice. The RAP was seen as a promising candidate for use in the LTL field, and funding led to the successful demonstration of a handheld single-shot launcher and associated self-contained cartridge for the RAP, designed by Vanek Prototype. (Two single-shot launcher designs were introduced in the funded effort: one, by Guilford Engineering, the other by Vanek Prototype Co. acting as a subcontractor.)

The Proposed Launcher – Advantages over State of the Art

To date, all of the launchers associated with LTL ring airfoil projectile have been single-shot devices (U.S. Army M234 launcher-adapter for the M-16 rifle; Miller: U.S. Patent 4154012). Also, under NIJ Grant No. 97-IJ-CX-K109 to Guilford Engineering Inc., Vanek Prototype pursued the development of a self-contained ring airfoil cartridge, based loosely on Miller's concept, and a handheld launcher from which the cartridge could be fired. (See Fig. 3: Vanek Prototype designed, fabricated, and demonstrated these articles. The top photo shows the cartridge mounted in the launcher, and the bottom photo shows the cartridge disassembled.) The design was successfully exhibited at the 1999 FPED II conference at Quantico, in four separate live fire demonstrations.

The next step would be to demonstrate an effective, accurate, long-range LTL system for Law Enforcement based on a repeating ring airfoil launcher. A repeater would provide immediate follow-up shots, allowing rapid compensation for misses and to engage other targets. The intended integration of a state-of-the-art laser aiming/dazzling device will complete this system. Hence, the design of the proposed launcher would be a progressive step in LTL technology, and specifically for launching LTL ring airfoil projectiles.

Summary Description of the Proposed Design

What is proposed is a muzzle-safe, long range, repeating launch mechanism for the RAP, as an LTL means of riot-control and the subduction of belligerence when law officials deem the use of lethal force unnecessary. A novel cartridge enclosing the RAP for use with this invention is also proposed. Finally, improvements to the flight performance and terminal ballistics of the RAP are proposed.

The proposed launcher (Figure 4, lower drawing) would be approximately twenty-eight inches long, seven inches high, and four inches deep, and, loaded, weigh no more than ten pounds. It will have the feel of a carbine, except that the size of the RAP requires the launcher to be wider and thicker than a conventional firearm. This is not expected to detract from the ergonomics of handling. The mechanism of the proposed launcher is unique in its provision for smooth, efficient transport of a novel cartridge shape.

The design of the proposed RAP cartridge (Figure 5) is driven by the envelope of the saboted ring airfoil projectile it contains. Specifically, while in conventional small arms the length-to-diameter ratio of the bulleted cartridge is always greater than one, the proposed cartridge is unconventional, having a length-to-diameter ratio less than one. The cartridge would be roughly the shape and size of a hockey-puck. Up to eight such cartridges would be stacked in a cylindrical magazine, shown in the upper drawing of Figure 4. This magazine would be inserted in the upper butt-stock region of the launcher (note dotted lines) shown in the lower drawing of Figure 4.

The existing RAP is a well-developed LTL projectile, type-classified by the U.S. Army. Nevertheless, the design is more than twenty years old, and in the intervening time much new technology of materials, agents, and aerodynamic design has made certain advances obvious. It is the intention of Vanek Prototype Co. to carefully explore the possibility of improving the RAP. Original LTL characteristics that contributed to type classification will not be violated. While RAP improvement will not be the foremost thrust of the proposed project, a reasonable effort to advance RAP design will be included. For the purpose of cartridge design, the expected envelope of more advanced RAPs will pose no hazard of incompatibility with the old type-classified RAP. As a key consultant of the team proposing this project [redacted] would apply his b6 expertise toward an effort to demonstrate an effective RAP before the conclusion of one year following funding.

Detailed Description of Operating Principles and Mechanisms

Aeroballistics and Improvement of Ring Airfoil Flight Performance

The RAP is not a ballistic projectile. Its airfoil cross-section and circular or "ring-wing" shape results in aerodynamic properties that enable the RAP to substantially outperform a conventional spin-stabilized projectile of similar mass and muzzle energy. The upper graph in Fig.6 shows that an overturning moment acts on a ring airfoil in flight, thus sufficient spin must be given the airfoil to stabilize it against this force. So stabilized, the ring airfoil flies oriented to the axis of the launcher barrel and as gravity pulls it downward, its flight path deviates from the line of the bore. An angle (alpha in the figure) between the line of flight and the orientation of the airfoil opens up, which generates lift (C_L), as shown in the lower graph of Figure 6. The airfoil resists the ballistic trajectory it would follow if no lift existed. It flies a relatively straight path, like a glider. In general, a ring airfoil of the same mass and launch velocity as a ballistic projectile will travel three times as far, when each is launched at its characteristic elevation angle for maximum range. Another advantage of the ring airfoil is that, while this elevation angle is about 37 degrees for a ballistic projectile – a rainbow trajectory, the ring airfoil's elevation angle for maximum range is eleven degrees. This gives the ring airfoil a relatively flat trajectory out to maximum range. Figure 7 (upper right-hand corner) shows the relationship between the center of pressure in flight and the ring airfoil's center of gravity. As the length of the moment arm between them increases, the overturning moment increases, requiring greater spin to stabilize the airfoil. Also, a precession will set in, veering the airfoil's orientation, and causing dispersion from a straight flight path. For these reasons, it is important that the design of a ring airfoil require that the center of pressure and center of gravity be as coincident as possible, considering inevitable engineering tradeoffs.

Detailed aerodynamic studies of the RAP were conducted by Flatau (see references). However, in simplifying the manufacture of the current LTL RAP (Sting/Soft) external contour, as developed for the U.S. Army, a portion of the upper surface airfoil curvature was removed, leaving a straight surface section. This was done to achieve a relatively wrinkle-free outer surface after the RAP had undergone the banding process. While this resultant contour accommodated the paper wrap surface, it reduced the total lift and somewhat increased the drag. Further, by incorporating a series of rectangular cavities to house the selected chemical agent, the center of gravity (c.g.) was shifted relative to the projectile's center of pressure (c.p.). Since the RAP is considered to be neutrally stable for projectile applications, it requires spin for dynamic stability. Optimally, for minimum dispersion with range, the c.p. and the c.g. should be as near to coincident as possible. However, what with the geometry of the cavities and the agent payload re-distributing in-flight due to set-back forces at launch and the centrifugal force generated by the spin, there is in the present RAP a separation of c.p. and c.g. causing lateral dispersion (to the right as seen from behind the shooter) which appears to commence at approximately thirty meters downrange. It is intended to make several re-designs of the cavity geometry and location, mold these configurations, load them with simulant and conduct tests to evaluate the flight trajectories due to these parametric changes (i.e., shift of the c.g. and the mass distribution) upon the resultant dispersion. The re-designed projectiles will also have their moments of inertia measured by means of a special torsional pendulum. These data will be used as input in analytically and experimentally evaluating the performance of the re-designs.

In this manner it is intended to experimentally determine the center of pressure (c.p.) versus center of gravity (c.g.) relationship, and approach the desired co-location so as to have a near zero moment arm. This will also enable us to re-design the internal - payload storage volume for the chemical agent (powder or liquid). The target impact tests will provide the payload dissemination characteristics.

A re-designed interior should minimize the distance between the c.p. and c.g. and reduce lateral dispersion, thus improving the projectile accuracy. This should not affect the terminal ballistics or impact dynamics, thus allowing the RAP to retain its less-than-lethal status from muzzle to maximum range.

Proposed Improvements to RAP Design

As shown in Figure 8, there were originally two Less Than Lethal projectiles (Sting & Soft). The Sting was considered primarily to be a training round. It had no payload. The Soft carried a payload (initially CS powder).

The Soft RAP was intended to carry a limited payload in either powder or liquid form. Note the strip of payload "bubbles," in Figure 9, which are loaded and sealed, then inserted in the projectile cavities. A frangible paper was then wrapped over the major surface area of the projectile as shown in Figure 10. (This banding paper is no longer manufactured.) Upon target impact, the Soft RAP would expand radially as it compressed longitudinally, bursting the paper wrap and disseminating the payload on the target (FIG. 11). The challenge at present is in development of a reliable and cost-effective technology for packaging the payload.

First, note that, for the sake of the stiff paper wrap, the outer surface of the Sting and Soft RAPs were designed with a flattening of their aerodynamic (longitudinal) curvature. The paper could not curve in two dimensions without wrinkling, so some sacrifice of optimal airfoil contour was made. Originally, the RAP had an optimally curved upper surface, which gave it a higher lift coefficient and a lower drag coefficient.

The purpose of the paper wrap (see Fig. 10) was twofold. First, since the projectile body is elastic and is launched at approximately 4,000 RPM, the paper wrapping, or banding, keeps the projectile from "growing" or "expanding" due to centrifugal force as it flies downrange. Secondly, the paper (selected to fail in tension at impact, due to the combination of centrifugal force and sudden compression loading) breaks during target impact (Fig. 11). This will allow the centrifugal forces bearing on the payload to "break out" of its cavity (or "bubble" container).

A wrap of frangible paper was one means of accomplishing the RAP's goal. In considering other means of both retaining the initial diameter during flight as well as the band (or wrap) failing on target impact (see U.S. Patents 3,898,932 and 3,951,070 which show a band that has a combination of slits and perforations). These act as stress risers during target impact, causing the band to fail and allowing the payload to disseminate. (The problem also is to find a simple way that allows for projectile integrity from muzzle launch to the target, but at target impact the surface cover over the agent packed in the cavities can fail, thus allowing the agent to rapidly disseminate).

What is now necessary to develop is a means of efficiently loading the agent into the RAP and then cover (or band) the RAP with a material that performs as well or better than the paper originally used. Furthermore, such a material should be able to stretch in two dimensions to allow a redesigned RAP having higher lift, lower drag, and greater volume for payload. The wrap should be able to support slits and perforations on the outer band (per the referenced U.S. Patents) with the intention of creating reliable stress-risers over the center of each cavity in the RAP outer surface, such that upon target impact the band quickly fails at the designated locations allowing centrifugal force and impact compression to expel most of the agent from the RAP (Fig. 11).

At first it would be desirable to adhere the "bubble" strip cover to the inside surface of the outer wrap. Other designs for agent dissemination would later be investigated. A hollow toroidal front-end, for example, filled with agent and having stress risers placed around the outer diameter, may both fulfill the role of agent dissemination on impact and, through choice of dense materials for its construction and fill, allow design of a RAP having optimal relationship of c.p. and c.g.

Description of the Cartridge

The overall shape of the cartridge containing the ring airfoil is like a hockey puck. This makes the cartridge unique, since the normal shape of a bulleted cartridge is a cylinder whose length substantially exceeds its diameter. Fig 5 shows the cartridge in cross-section (middle drawing) plus top and bottom views. Referring to the cross-section drawing, the sectioned ring airfoil projectile (1) is shrouded in its sabot (2), and the assembly of these two parts is pressed into the case chassis (3). The chassis also holds, along its central bore, the propulsion subsystem. This subsystem is an assembly of the high-pressure chamber (4) and its cap (5), which thread together from opposite sides of the cartridge chassis at its base, thus clamping to it as shown in the figure. The rear of the high-pressure chamber is provided with a primer pocket of a type standard in the art, which communicates to the explosion chamber by means of a flash-hole.

In operation, a standard primer in the pocket struck by a firing pin and provides heat and pressure that ignites a measured quantity of smokeless powder in the chamber. High-pressure gas builds up as the nearly closed construction of the high-pressure chamber facilitates the efficient combustion of the powder. The small vent holes (6) communicate the generated hot high-pressure gas to the low-pressure chamber, where this gas then does the work of accelerating the sabot with its ring airfoil out of the cartridge mouth. A thin flap (7), attached to the front of the sabot for the purpose of protecting the ring airfoil during cartridge handling, accelerates in place with this assembly.

Description of the Launcher and its Operation

The proposed launcher, shown in Figure 4, would be a carbine-sized device, having a forearm grip, a pistol grip, and a butt-stock. The launcher would be fitted with a longitudinally sliding pistol grip, which would act as a pump-handle, and cause a reciprocating breechblock to unlock and be driven rearward to open the action. See Figure 12 for a section drawing, showing the major parts and their interrelationship.

In operation (Figure 12), the rearward travel of the unlocked breechblock (17) would cam a charging lever (14) downward, causing its attached wire-form follower (13) to pull the front cartridge in the magazine downward into alignment with the chamber. Lever 14 would simultaneously push any extracted (via a standard extractor, 18) cartridge down, and eject it from the mechanism (Figure 13). Lever (29) holds the next cartridge in the magazine from moving forward. A forward push on the pistol grip by the shooting hand would drive the breechblock forward, lift the follower into position above the next magazine-cartridge, and lock the breech behind the fresh cartridge in the chamber.

Operation of the long-draw double-action style trigger releases a firing pin to ignite the cartridge. The RAP in its sabot accelerates in the barrel to specified velocity, at which the sabot extractor at the muzzle stops the sabot abruptly, and the RAP is released to fly toward the target (Fig 14). The sabot extractor (19) is designed to swing open under residual gas pressure and momentum after the RAP has cleared the mechanism. This movement will allow the spent sabot to clear the barrel, thus ejecting it. The barrel now cleared, the spring-loaded sabot extractor will swing back to ready itself for the next shot. Firing completed, a second rearward pull on the pistol grip would draw the breechblock with the spent cartridge rearward. The charging lever, when actuated, would again push the spent cartridge downward to eject it at the same time as its attached follower pulls the next cartridge down into alignment with the chamber.

The mechanism is simple and direct. By utilizing hand-power to charge the mechanism, and a full double-action trigger to fire the cartridge, maximum reliability and safety is obtained. Also, this design for the proposed repeater is conservative and thus possesses greater certainty of timely success. The use of a novel cartridge and novel sabot ejection requirements militate against immediate attempts at a more ambitious design such as an autoloader.

Proposed Technical Approach and Developmental Timeline

Previous Work Preparatory to This Proposal

Launcher and Cartridge Experience: As stated in the introductory section of this proposal, Vanek Prototype successfully demonstrated a self-contained "barrel cartridge" to launch the RAP, plus a single-shot handheld or pistol-grip launcher to utilize this cartridge, as the Company's contribution to the goal of NIJ Grant No. 97-IJ-CX-K109. Experience gained from this effort will allow rapid concept development of the presently proposed goal, specifically in essential parts of cartridge design, such as RAP sabot design and hi/lo gas generation systems.

Experience from the previous effort will facilitate demonstration of a sabot dead-stop system for the launcher; also, valuable experience was gained in cartridge and launcher materials selection, and firing systems. Previous efforts in the field of launcher design in the firearms field has given[ ]mportant insight into the physics and mechanics of cartridge transport. The design concept now proposed, and shown in Figures 4,5,12,13,14, is the result of independent effort by Vanek Prototype. The Company considers this design to be in the "first test-bed' stage of development, in which hardware needs to be fabricated and tested to facilitate further progress.

RAP Projectile Experience:[ ]has the foremost background in the field of RAP design. His effort toward the demonstration of an improved LTL RAP will be invaluable to this proposed effort. Preliminary advanced concept designs are already under[ ]review.

Areas of Necessary Innovation

The proposed launcher is designed with simplicity and directness of function in mind. It is not anticipated that cartridge transport through the mechanism will contain any unusual problems. Though transport of an unusual 'hockey puck' cartridge is novel, it is felt that such a cartridge shape lends itself adroitly to the type of transport mechanism chosen for the proposed design.

The novel sabot ejection system is the one area in which interesting questions may arise. Experience gained with the test-bed 'barrel cartridge,' of Figure 3, showed that the sabot, on stopping at the cartridge's 'rim-stop' at the muzzle, transferred considerable forward momentum to the cartridge. Firing tests in which the 'barrel cartridge' was not locked to the hand-held launcher showed that, on stopping at the muzzle, the sabot gave enough velocity to the cartridge to make it fly six feet forward of the launcher. This indicates that the sabot carries more than enough energy to operate the proposed sabot forward eject mechanism. The design of a 'swinging block' eject mechanism for the proposed launcher is thought the best of several design options conceived to accomplish this novel task. Other concepts are: muzzle clearance before sabot dead-stop followed by gas driven lever-ejection, muzzle clearance and impact on a swinging dead-stop, self-discarding, 'flower-petal' sabot.

The U.S. Army type-classified RAP will provide the flight performance needed to fully demonstrate the cartridge and launcher. However, it is anticipated that this proposed effort will result in an advanced RAP design having improved flight characteristics and impact dissemination performance.

Broad Tasks Comprising This Proposal

- Develop CAD files of the Proposed Launch Mechanism, Cartridge, and RAP Designs
- Fabricate Test-Beds for Each in Minimum Sufficient Quantity for Test
- Perform Function Tests of Each of These Three Components, Report Progress
- Correct Design Flaws as They Become Apparent
- Build Demonstrator(s), Report and exhibit performance per Request

- Test and Iterate to Optimal Performance
- Report, Deliver Demonstrator per Request

Estimated costs to undertake this plan are given in the form: Budget Detail Worksheet, provided with this proposal.

It is anticipated that the Launcher, Cartridge, and RAP would be developed simultaneously, over the course of the first nine months, and that a successful demonstrator will be available before the end of a twelve-month period starting with the issuance of a grant to this proposal. A nine-month period is anticipated before an initial demonstrator can be made available.

Proposed Timeline

The proposed timeline is divided into sections for the launcher, the cartridge, and the Advanced RAP. At nine months these sections merge into an integrated, finishing phase. Each of the sections is detailed below, associating a task numeral with a description of the job to do. Accompanying bar charts, in Appendix 4 – Figures, show the temporal relationship of the individual tasks within each section, and together, between sections.

Launcher Tasks: **(Bar Chart – Figure 15)**

I **a.** Transfer launcher design to CAD files.

b. Finalize files for larger, more complex parts.

c. Initialize subcontracting fabricator to make these parts, especially the receiver.

II **a.** Fabricate rifled barrels for launcher. Use one for Cartridge Task II a.

b. Supervise fabrication of subcontracted parts, complete the receiver.

c. Fabricate, in house, smaller parts.

d. Fabricate first design sabot ejector, fit to muzzle of test fixture.

e. Redesign sabot ejector as necessary from Cartridge Task II c.

III a. Begin fitting parts to receiver and to each other.

b. Test parts/assemblies function. Minor part design changes made.

IV a. Integrate all parts. Evaluate first test-bed launcher for feel and function.

b. First test firing.

V. Design change as test firings indicate necessary.

VI. Demonstrate project final form of launcher with advanced RAP cartridge.

Cartridge Tasks: (Bar Chart – Figure 16)

I a. Transfer cartridge design to CAD files.

b. Finalize test-bed cartridge design

c. Fabricate cartridge case, sabot for old RAP, hi-lo system.

II a. Fabricate test fixture to fire-test cartridge.

b. Test cartridge and components using old RAP. Determine 200 fps charge.

c. Test sabot ejector on fixture. Determine if advanced diagnostics are needed.

III a. Fabricate sabots for initial test-bed of Advanced RAP.

b. Test cartridge and components with this projectile. Determine 200 fps charge.

IV a. Initialize advanced diagnostics subcontractor to obtain data with test fixture.

b. Use advanced diagnostics to perfect sabot ejector, if necessary.

V. Demonstrate cartridge as part of advanced RAP multi-shot system.

Advanced RAP Tasks: **(Bar Chart – Figure 17)**

I a. Transfer RAP design to CAD files, finalize.

b. Mold a series of inert RAPs with advanced external contour.

c. Determine mass, c.g. location, and moments of inertia.

d. Launch in test range, determine flight data.

e. Evaluate trajectory performance.

II a. Mold a series of RAPs with re-designed cavity geometry and location.

b. Determine c.g. location, and moment of inertia.

c. Range test w/o simulant

d. If data is promising, flight test with simulant.

e. Evaluate trajectory performance and dissemination characteristics.

III a. Using the new data, redesign RAP internally to achieve improved flight

b. Mold a series of the RAP bodies with the new internal design.

III c. Load simulant and conduct tests to verify performance characteristics.

IV a. Investigate multi-section RAP designs – fabricate, load, test, evaluate data.

b. Investigate different banding materials with various stress-riser designs.

V. Test, evaluate, and select most promising combination(s).

VI. Integrate advanced RAP with sabot/cartridge and launcher mechanism.

VII. Demonstrate integrated system of Advanced RAP and multi-shot launcher.

Critical Milestones

As shown in the above timelines, the three areas of developmental effort require sequential accomplishments toward their individual fruition, but they also interact – one area cannot progress beyond a critical point before a milestone is reached in another area. Detailed below are these choke points:

- Completion of CAD files for major parts to be fabricated by subcontractor(s).
- Completion of a Barrel piece: Needed before a test firing fixture can be built.
- Completion of the firing fixture: Needed before the cartridge can be proven.
- Proving the cartridge: Needed before initial charge/velocity tests.
- Proven cartridge/charge: Needed to develop the sabot ejector.
- Firing fixture with successful sabot ejector: Required to flight test Advanced RAPs.

Thus it is required to complete the above described portions of the launcher and cartridge to facilitate the RAP sub-program.

Another critical need is to quickly procure a finished test-bed receiver (in the form of two clamshell halves) since this major part is needed before all the working parts can be fabricated and fitted to operate together within it.

The timelines proposed in the bar-charts of Figures 15 –17 take into account the need to "front-load" these critical first demands, in order to efficiently use available time.

Appendix 4 – List of Figures

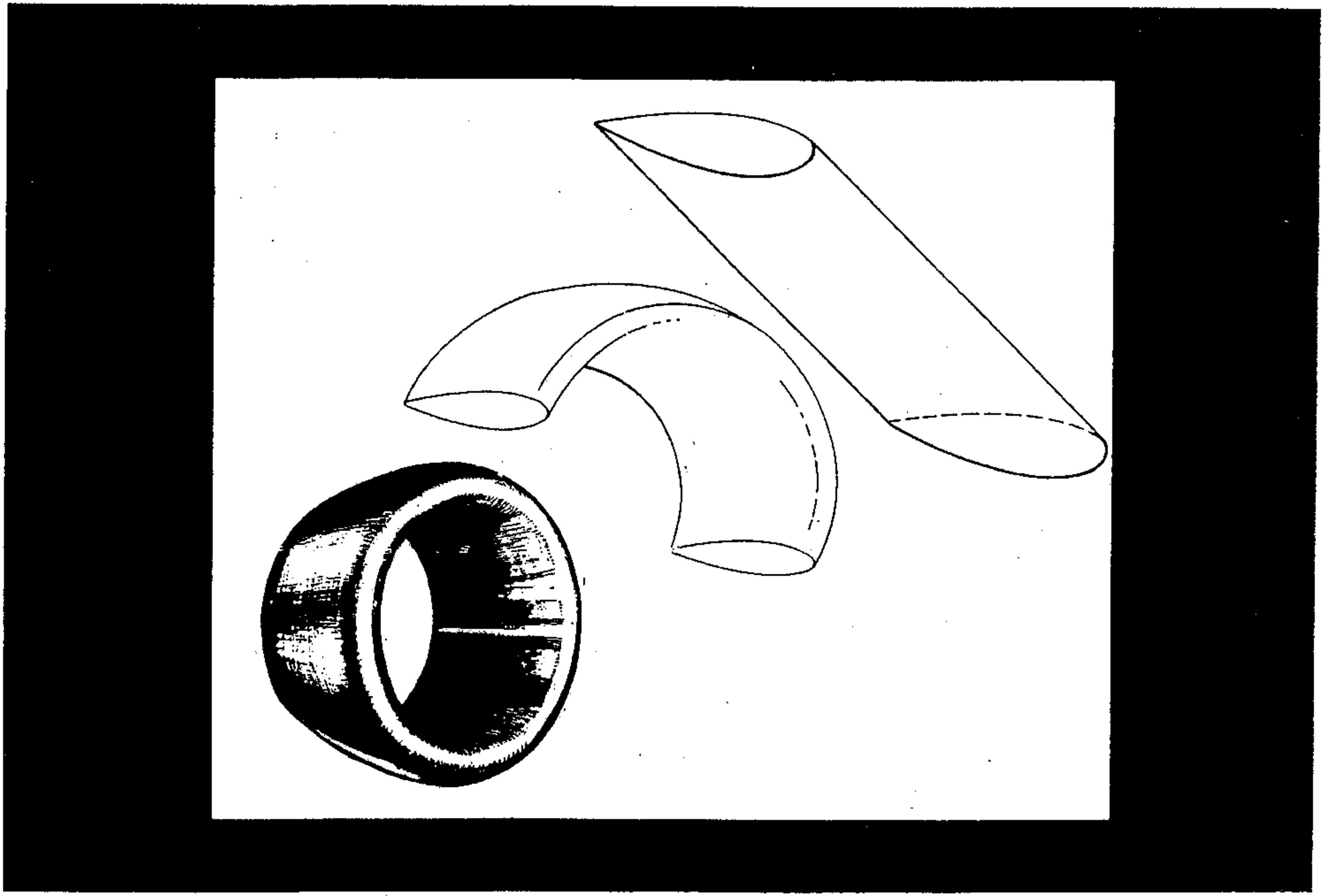


FIGURE 1: THE RING AIRFOIL

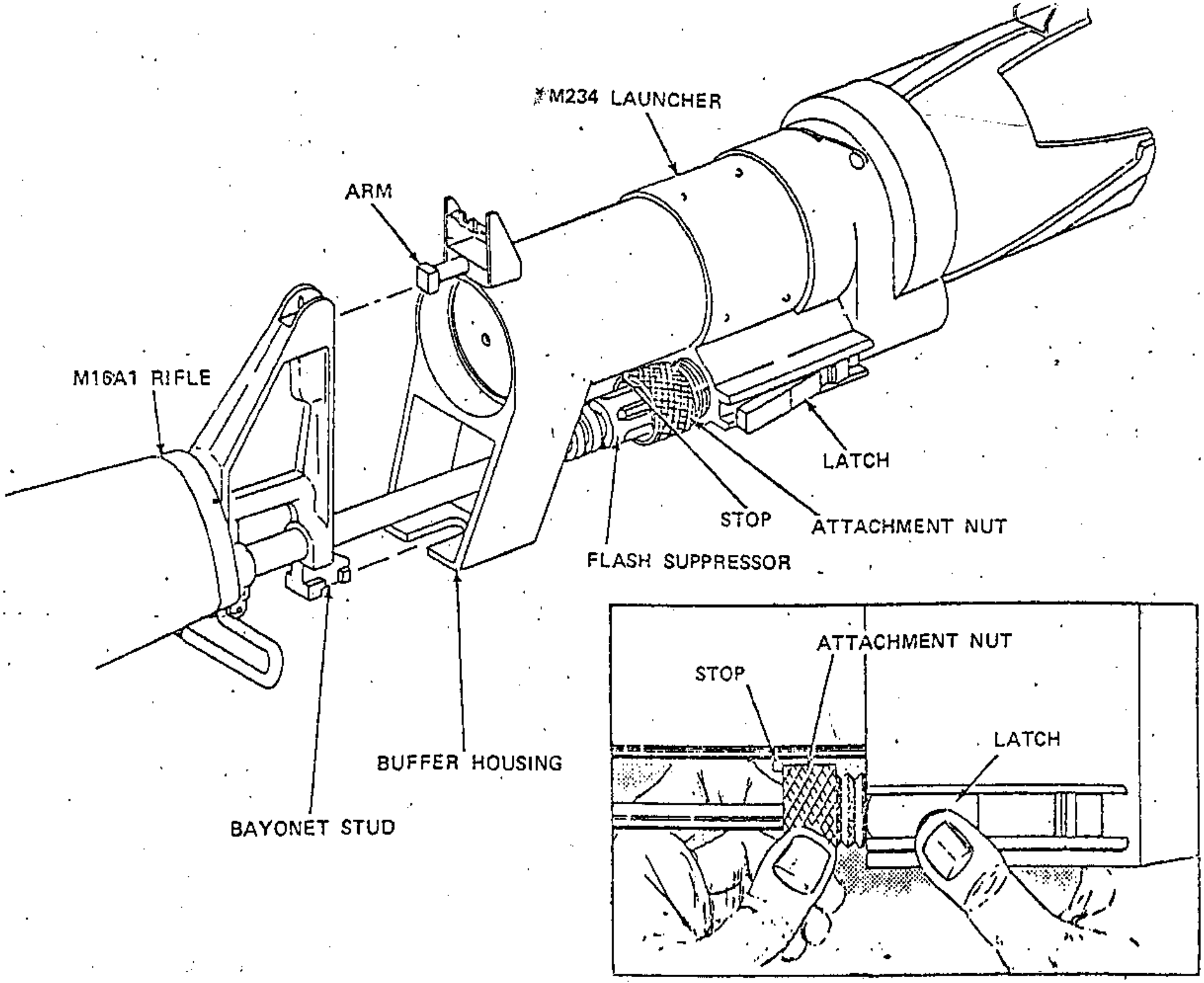


FIGURE 2: THE M234 ADAPTER

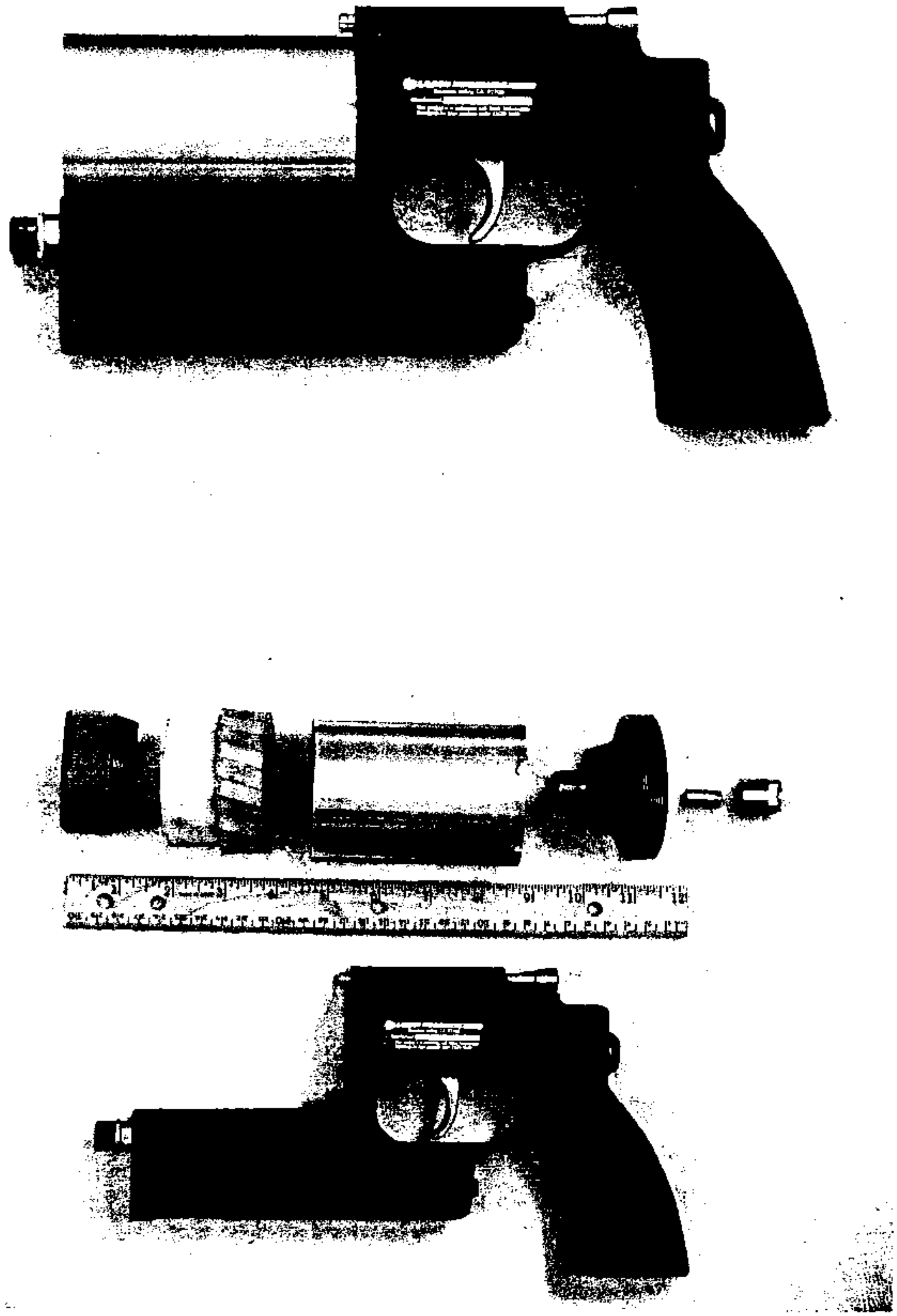


FIGURE 3: HANDHELD LAUNCHER AND 'BARREL' CARTRIDGE

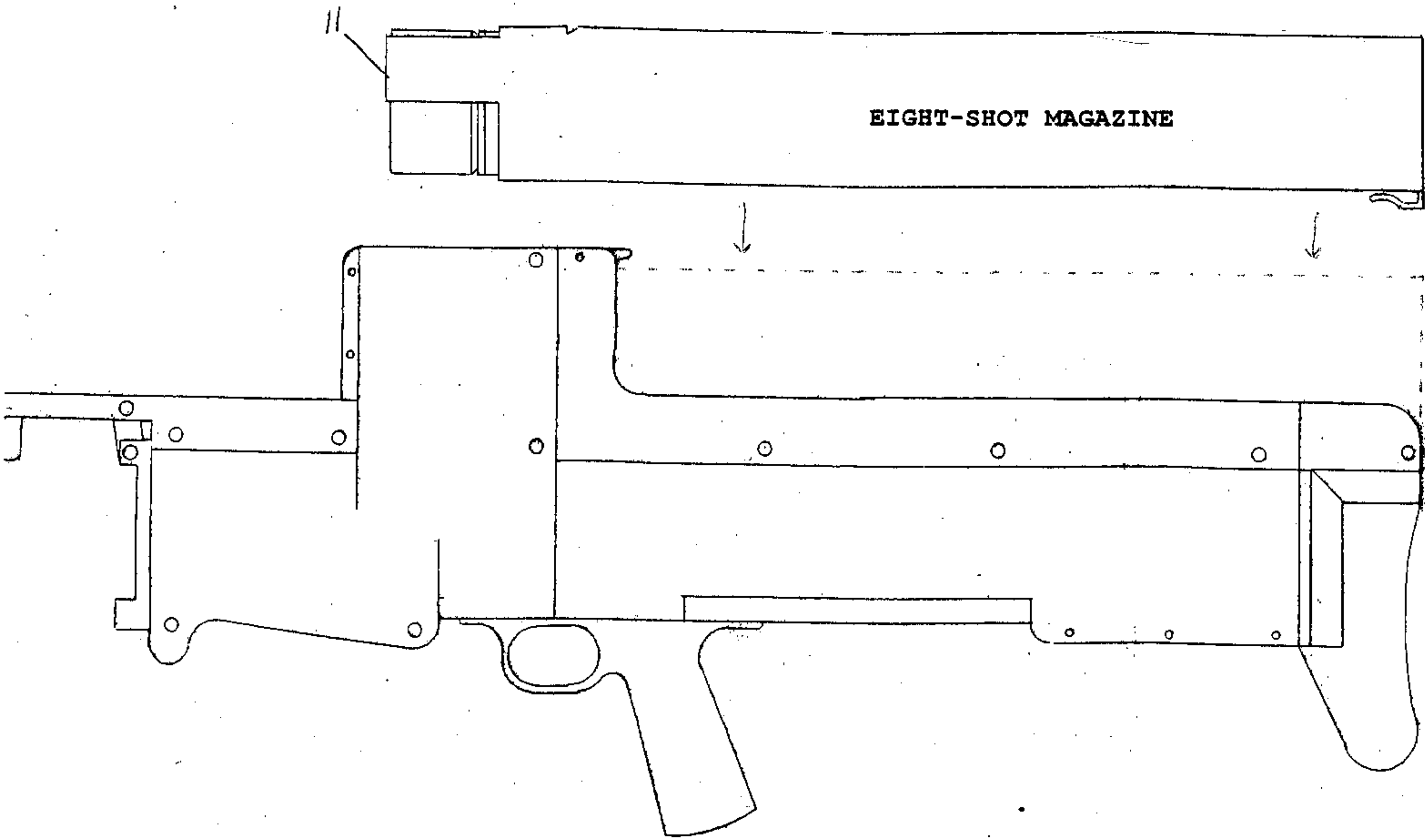


FIGURE 4: PROPOSED LAUNCHER (One Third Scale)

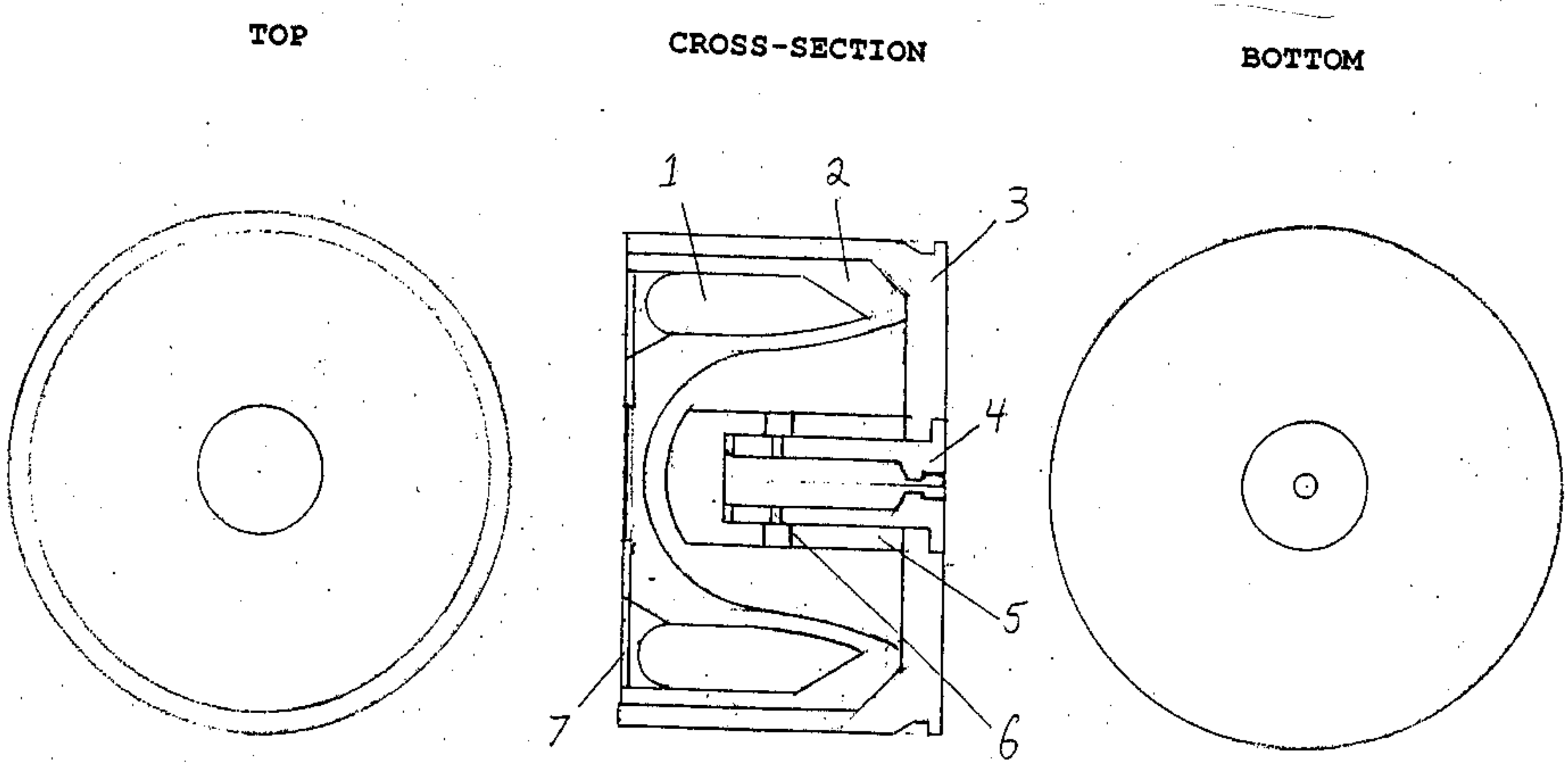
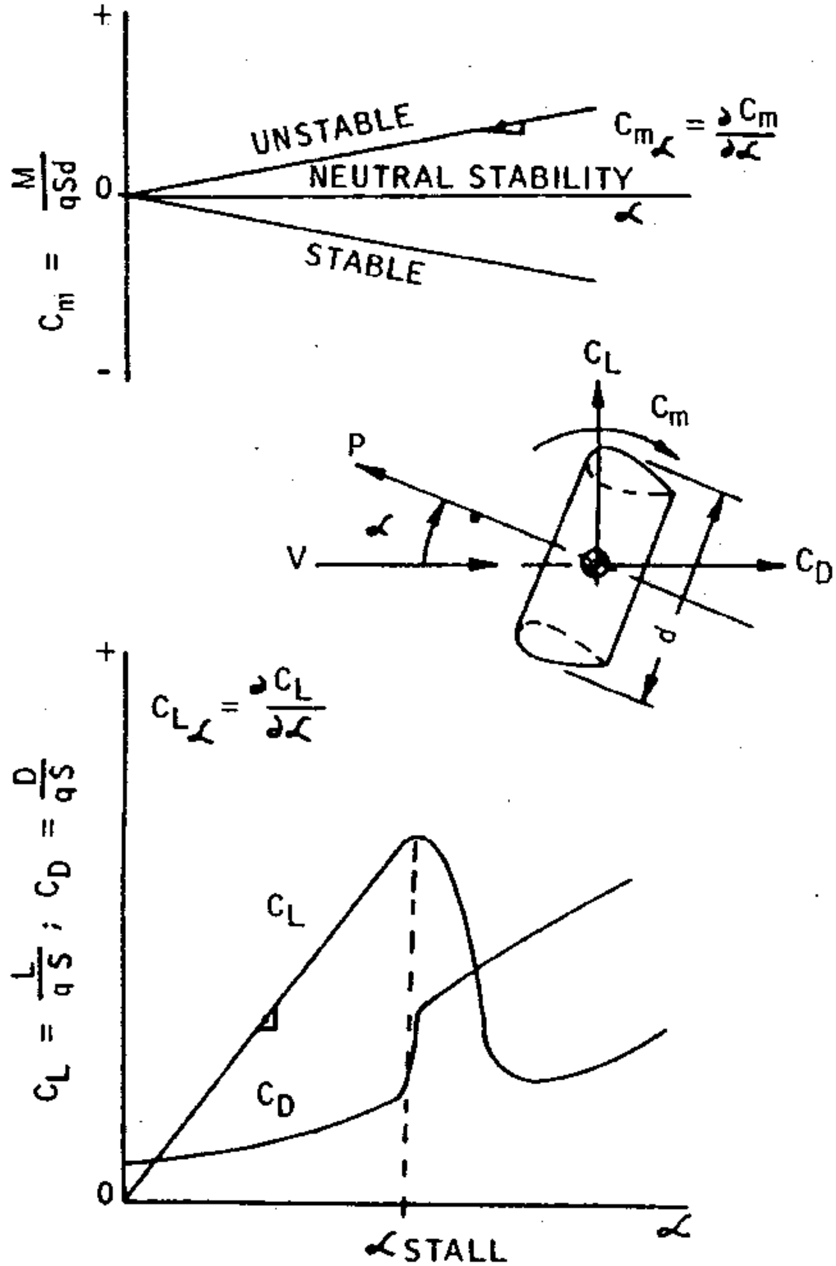


FIGURE 5: PROPOSED MULTI-SHOT CARTRIDGE
(Full scale)



NOTE: $S = \frac{\pi d^2}{4}$

$q = \rho \frac{V^2}{2}$

FIGURE 6: FACTORS AFFECTING RAP STABILITY AND LIFT

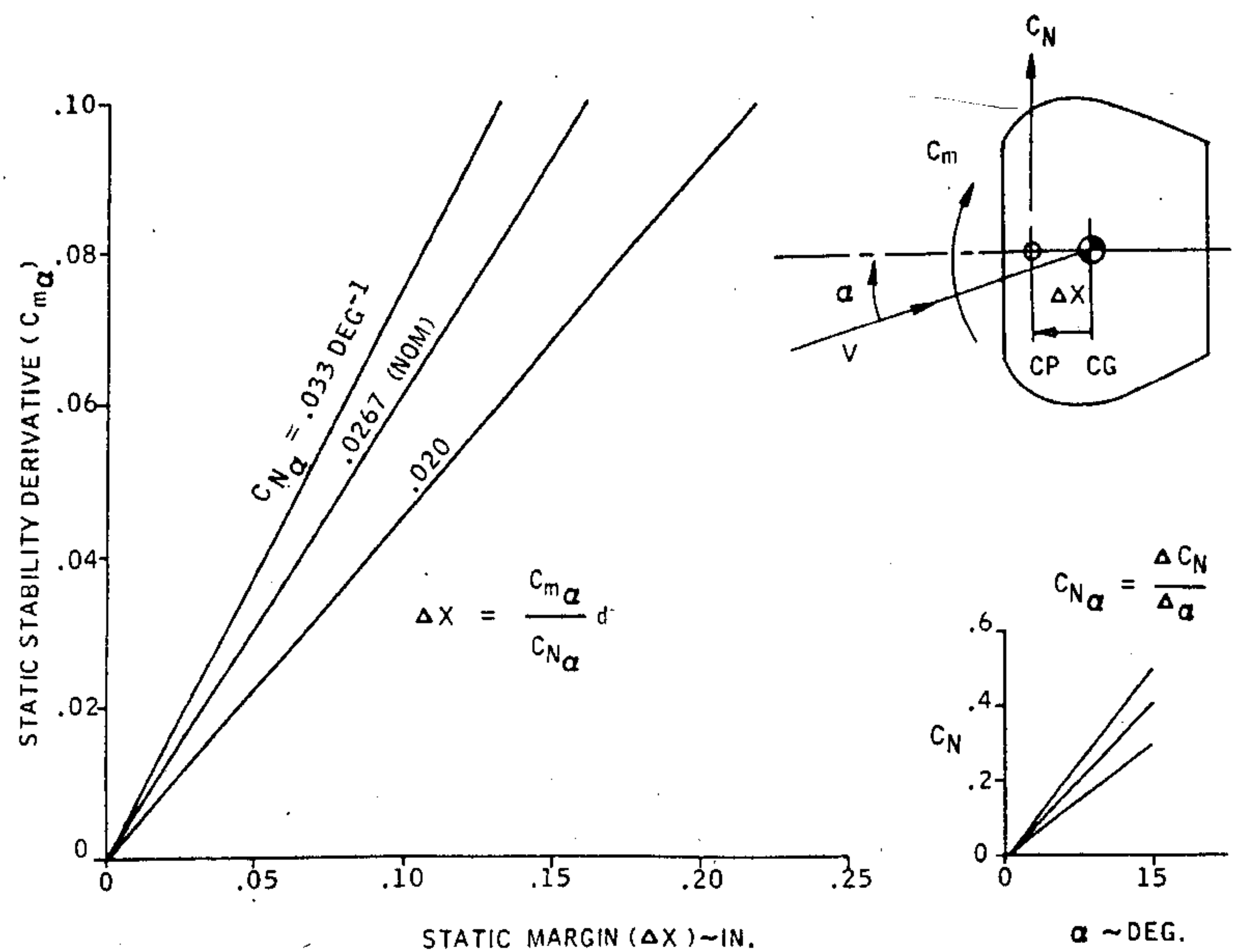
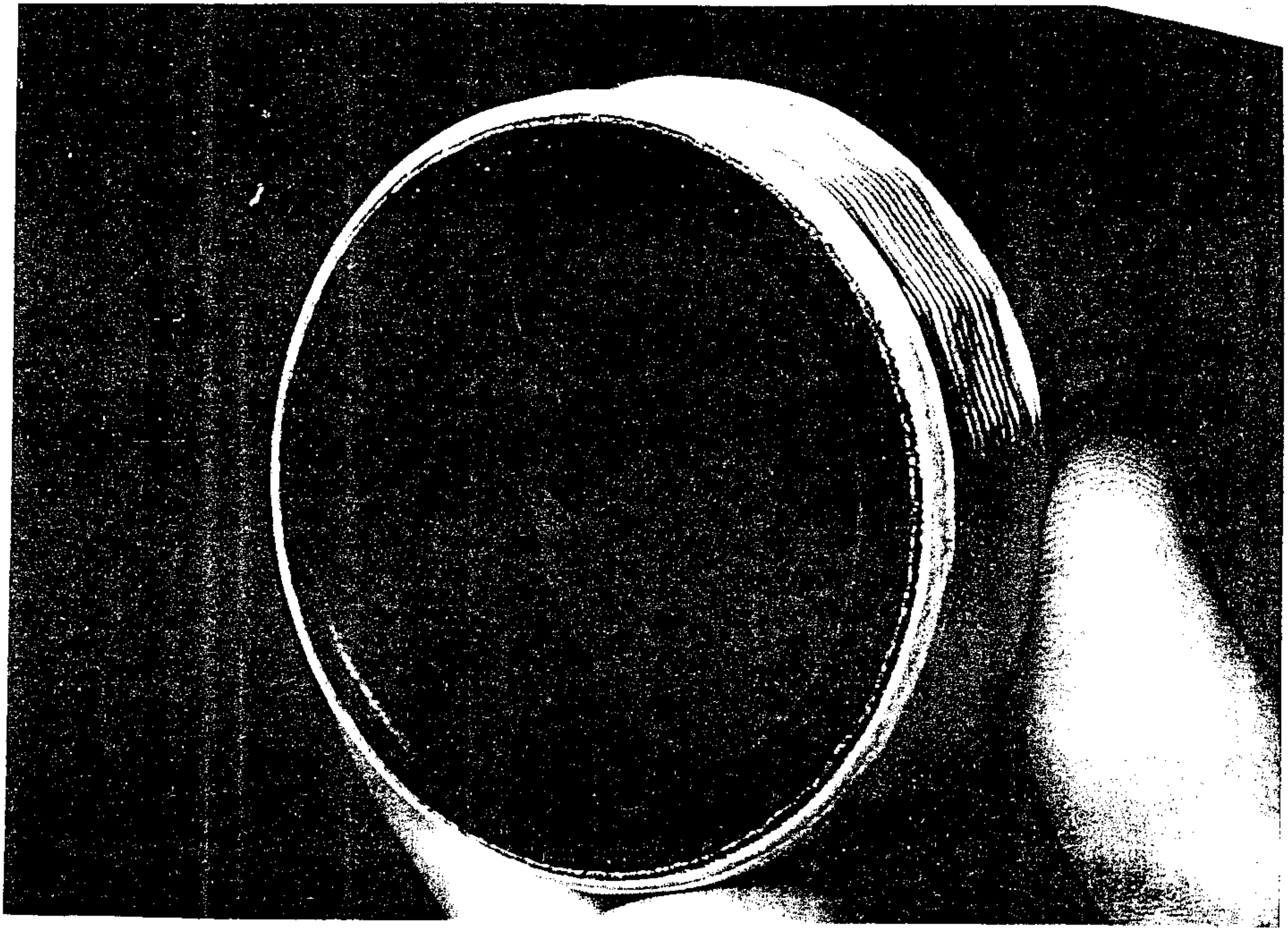


FIGURE 7: Cp TO Cg OFFSET EFFECTS ON RAP STABILITY

FIGURE 8: STING RAP AND SOFT RAP (Note: prior term for the Ring Airfoil Projectile was 'RAG')

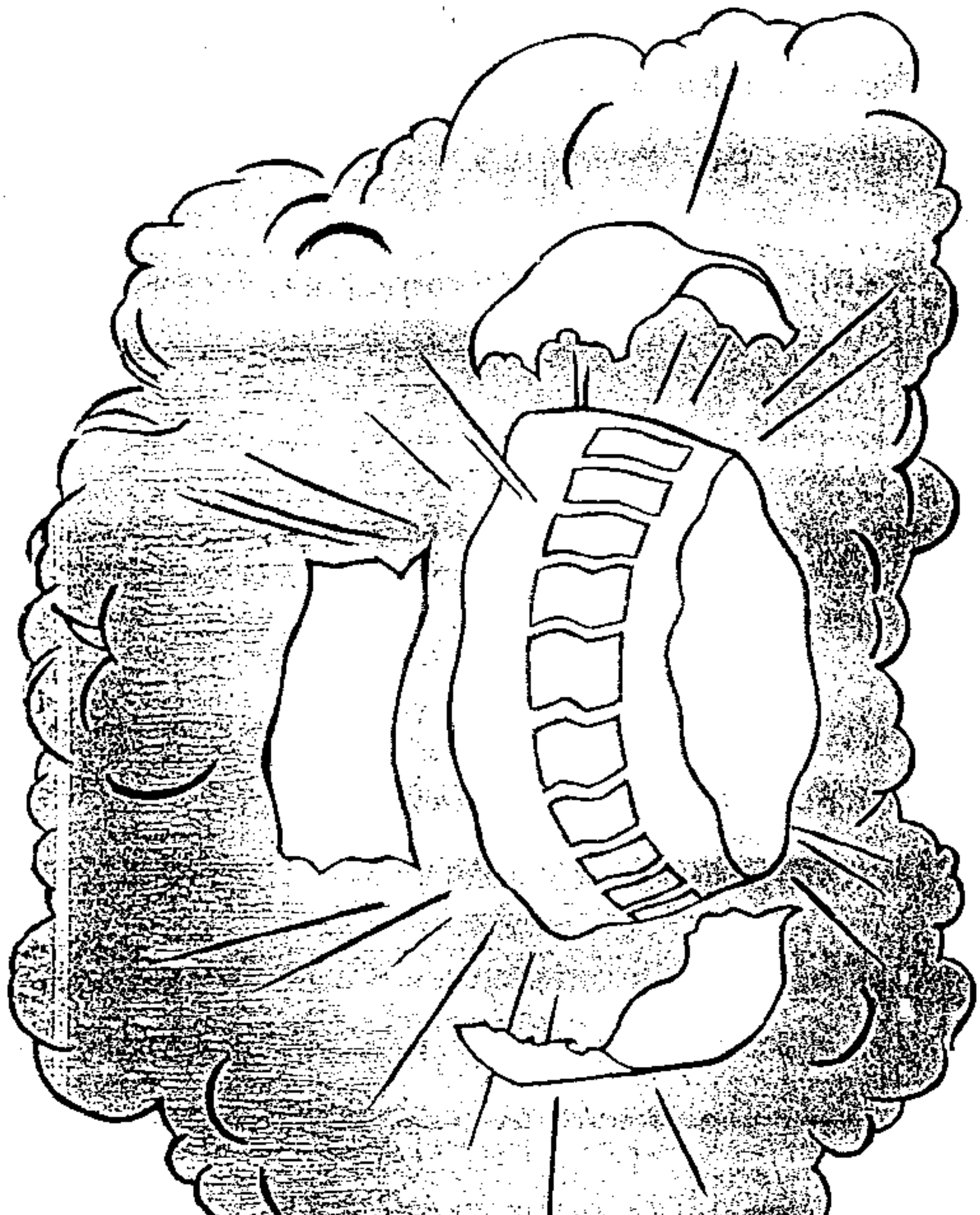
PROJECTILE, 64MM; RIOT CONTROL, CS1, M742

FIGURE 9: BUBBLE PACK



PROJECTILE, 64MM; RIOT CONTROL, KINETIC ENERGY, M743

FIGURE 10: PAPER BANDING



SOFT RAG
PROJECTILE
IMPACT

FIGURE 11: IMPACT DISSEMINATION

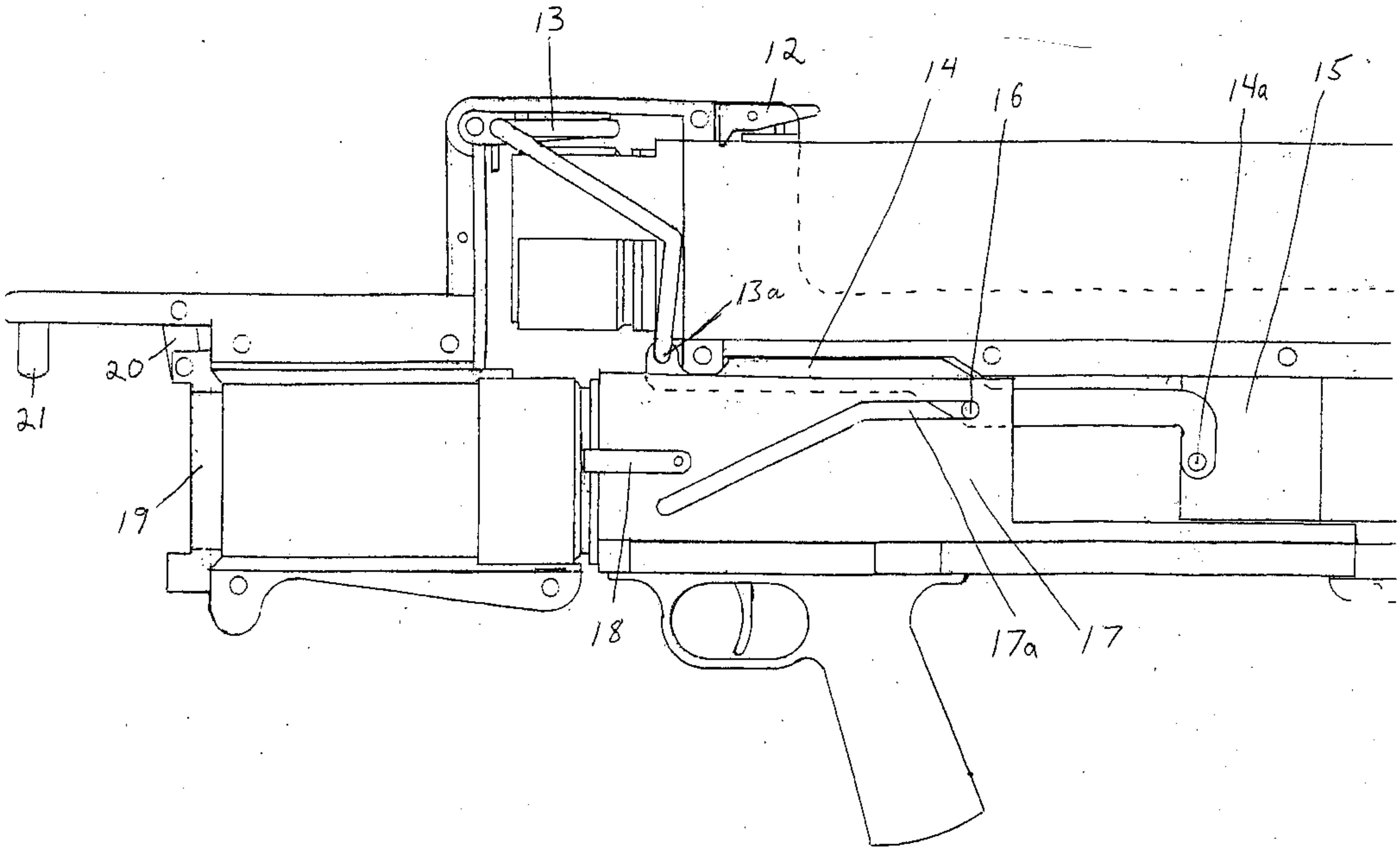


FIGURE 12: CROSS-SECTION VIEW OF PROPOSED LAUNCHER

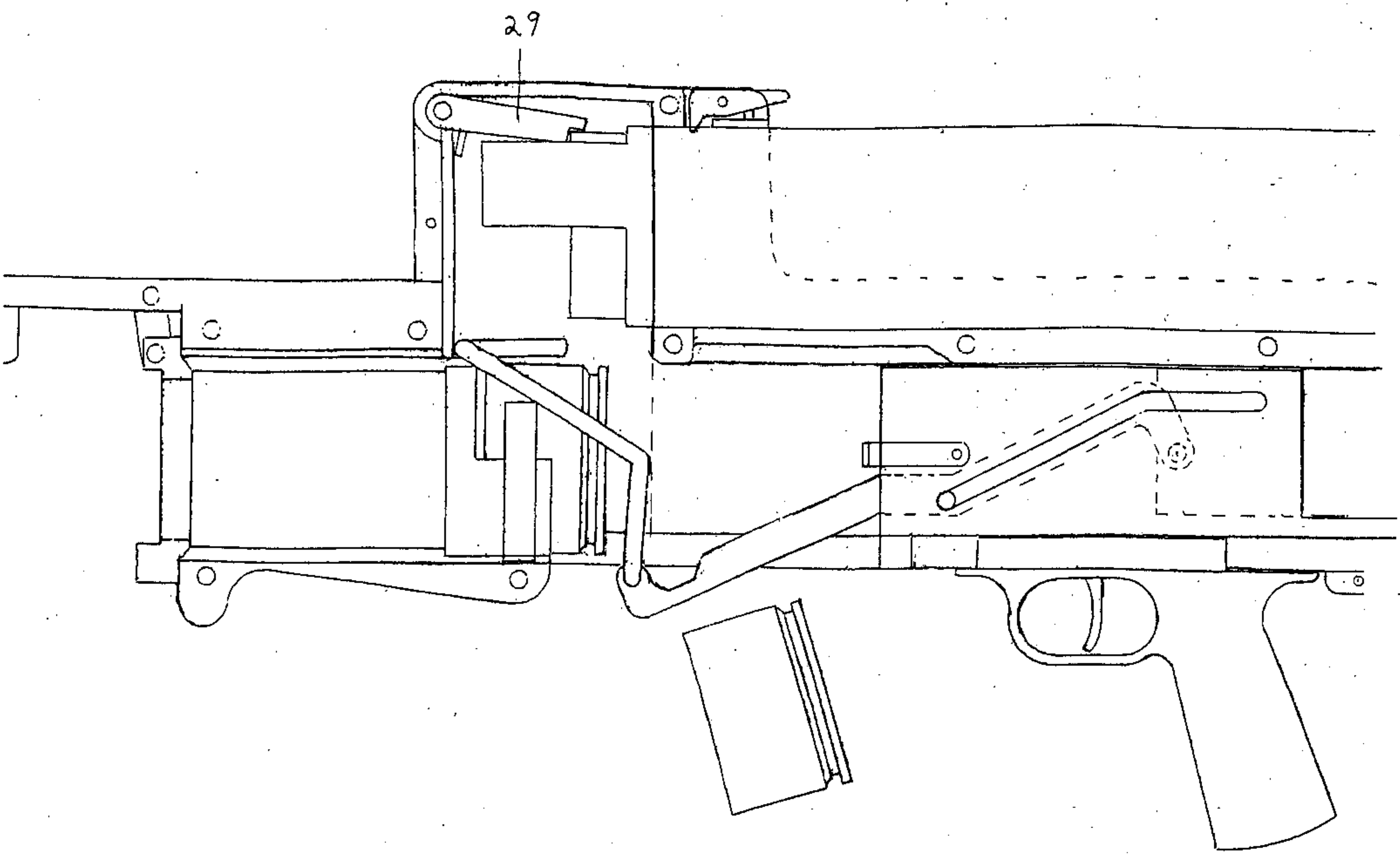


FIGURE 13: PROPOSED LAUNCHER - ACTION OPEN

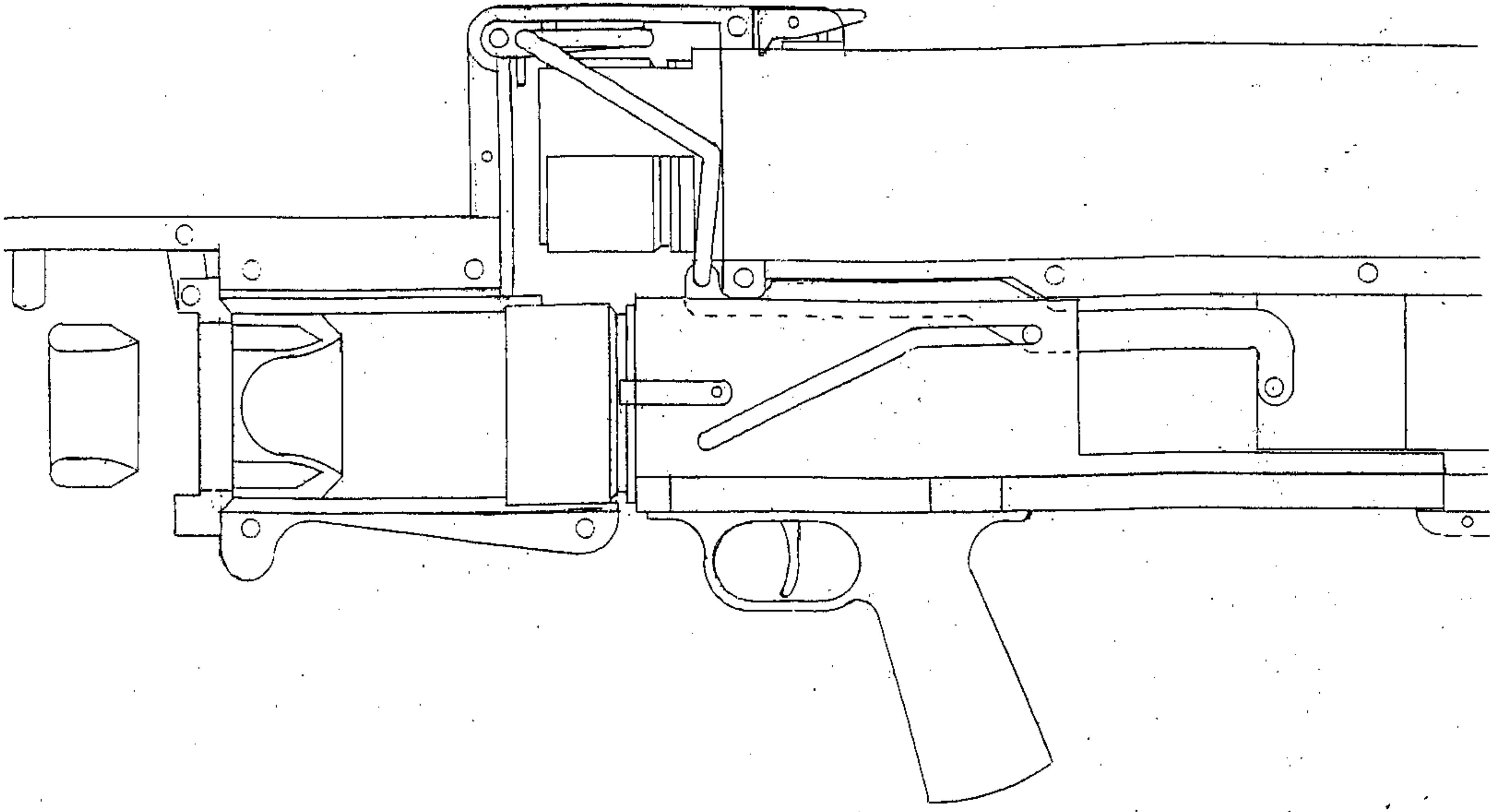


FIGURE 14: PROPOSED LAUNCHER - SABOT-STOP OPERATION

Figure 15: Multi-Shot Launcher Timeline

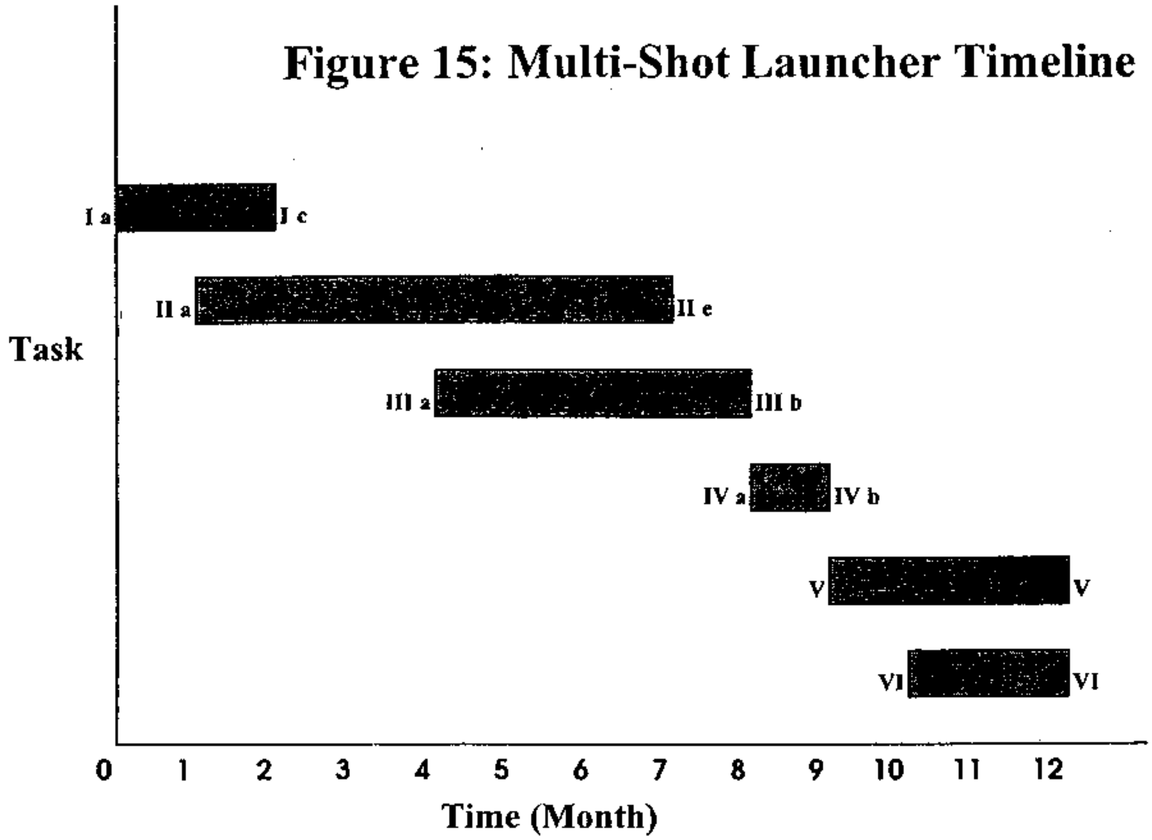


Figure 16: RAP Cartridge Timeline

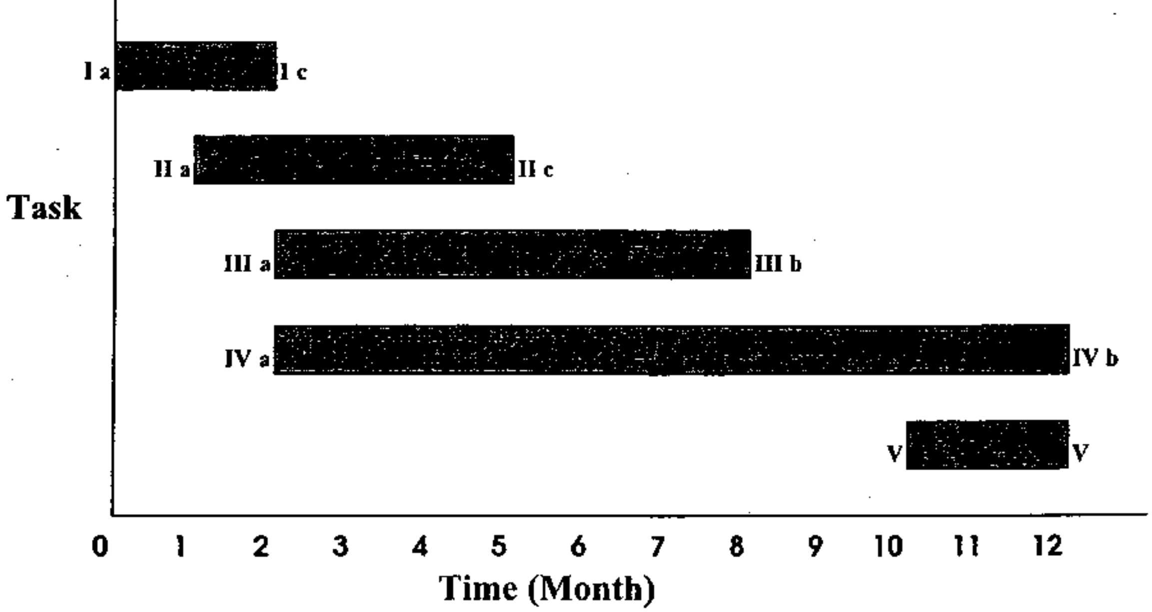


Figure 17: Advanced RAP Research Timeline